Sea Engineering, Inc.

41-305 Kalanianaole Hwy • Waimanalo, Hawaii 96795
Phone: (808) 536-3603 • Email: hi.engineering@seaengineering.com • Website: www.seaengineering.com

October 15, 2024

TO: Mary Alice Evans, Director
Office of Planning and Sustainable Development
Environmental Review Program
235 S. Beretania Street, Room 702
Honolulu, HI 96813

FROM: David A. Smith, PhD, PE
Sea Engineering, Inc.
41-305 Kalanianaʻole Hwy.
Makai Research Pier
Waimānalo, HI 96795

SUBJECT: Transmittal of Final Programmatic Environmental Impact Statement (FEIS)
Waikīkī Beach Improvement and Maintenance Program
Honolulu District, Island of Oʻahu

Dear Director Evans,

On behalf of the Applicant, the Department of Business, Economic Development, and Tourism (DBEDT), Sea Engineering, Inc. requests that the Final Programmatic Environmental Impact Statement (FEIS) for the proposed Waikīkī Beach Improvement and Maintenance Program be published in the next issue of the Environmental Review Program's (ERP) periodic bulletin, *The Environmental Notice*.

The FEIS has been prepared pursuant to Chapter 343, Hawaiʻi Revised Statutes (HRS) and Title 11, Chapter 200.1, Hawaiʻi Administrative Rules (HAR). The FEIS consists of four volumes and includes copies of all comments received during the 45-day public consultation period for the Draft EIS, as well as responses to all comments. The required publication forms and files, including electronic copies of the FEIS and appendices, have been provided via the ERP online submittal platform.

Should you have any questions regarding this request, please contact me at (808) 536-3603 or dsmith@seaengineering.com.

Sincerely,

David A. Smith

David A. Smith, PhD, PE
Sea Engineering, Inc.

JOSH GREEN, M.D.
GOVERNOR | KE KIAʻĀINA

SYLVIA LUKE
LIEUTENANT GOVERNOR | KA HOPE KIAʻĀINA

STATE OF HAWAIʻI | KA MOKUʻĀINA ʻO HAWAIʻI
DEPARTMENT OF LAND AND NATURAL RESOURCES
KA ʻOIHANA KUMUWAIWAI ʻĀINA
P.O. BOX 621
HONOLULU, HAWAII 96809

DAWN N.S. CHANG
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

RYAN K.P. KANAKAʻOLE
FIRST DEPUTY

DEAN D. UYENO
ACTING DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

Jul 5, 2024

MEMORANDUM

TO: James K. Tokioka, Director
Department of Business, Economic Development and Tourism

FROM: Dawn N.S. Chang, Director
Department of Land and Natural Resources

SUBJECT: Waikiki Beach Improvement and Maintenance Program
Environmental Impact Statement

The Department of Land and Natural Resources (DLNR) initiated the preparation of a Programmatic Environmental Impact Statement for the Waikiki Beach Improvement and Maintenance Program in compliance with HRS Chapter 343 and HAR 11-200.1.

The Department of Land and Natural Resources acknowledges that the Department of Business, Economic Development and Tourism (DBEDT), as provided in HRS Ch. 26-18 and Ch. 201, is charged with undertaking statewide business and economic development activities, including supporting the visitor industry.

Waikiki is an important commercial center of the visitor industry. Waikiki Beach is a critical element in the success of Waikiki in creating jobs and generating income for residents. Waikiki Beach needs to be restored and maintained in order to continue to support the state's economy.

Therefore, DLNR is requesting DBEDT to serve as the Proposing Agency to propose an action subject to disclosure of impacts as provided in HRS Chapter 343 and HAR 11-200.1. Please indicate acceptance of the role of Proposing Agency by signing below.

ACCEPTED: DATE:

________________________ Jul 8, 2024
James Kunane Tokioka

From:	webmaster@hawaii.gov
To:	DBEDT OPSD Environmental Review Program
Subject:	New online submission for The Environmental Notice
Date:	Tuesday, October 15, 2024 1:00:54 PM

Action Name

Waikīkī Beach Improvement and Maintenance Program

Type of Document/Determination

Final environmental impact statement (FEIS)

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
- (5) Propose any use within the Waikīkī area of Oʻahu

Judicial district

Honolulu, Oʻahu

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

(1) 2-6-001:003; (1) 2-6-004:007; (1) 2-6-005:001; (1) 2-6-008:029; (1) 2-6-002:026; (1) 2-6-001:019; (1) 2-6-004:012; (1) 2-6-002:017; (1) 2-6-001:013; (1) 2-6-001:012; (1) 2-6-001:002; (1) 2-6-001:015; (1) 2-6-001:008; (1) 2-6-004:006; (1) 2-6-004:005; (1) 2-6-001:017; (1) 2-6-004:008; (1) 2-6-004:009; (1) 2-6-004:010; (1) 2-6-001:018; (1) 2-6-005:006; (1) 2-6-001:004; (1) 2-6-002:006; (1) 2-6-002:005

Action type

Agency

Other required permits and approvals

Multiple (see Chapter 17 of the FEIS)

Proposing/determining agency

Department of Business, Economic Development & Tourism

Agency contact name

Mary Alice Evans

Agency contact email (for info about the action)

maryalice.evans@hawaii.gov

Email address for receiving comments

waikiki@seaengineering.com

Agency contact phone

(808) 587-2833

Agency address

No. 1 Capitol District Building
250 S. Hotel Street

Honolulu, Hawaiʻi 96813
United States
Map It

Accepting authority

Governor, State of Hawaiʻi

Accepting authority contact name

Josh Green

Accepting authority contact email or URL

https://governor.hawaii.gov/contact-us/contact-the-governor/

Accepting authority contact phone

(808) 586-0034

Accepting authority address

Executive Chambers, State Capitol
415 South Beretania St.
Honolulu, Hawaiʻi 96813
United States
Map It

Is there a consultant for this action?

Yes

Consultant

Sea Engineering, Inc.

Consultant contact name

David Smith

Consultant contact email

dsmith@seaengineering.com

Consultant contact phone

(808) 259-7966

Consultant address

Makai Research Pier
41-305 Kalanianaʻole Highway
Waimānalo, Hawaiʻi 96795
United States
Map It

Action summary

The Hawaiʻi Department of Land and Natural Resources proposes beach improvement and maintenance projects in the Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō beach sectors of Waikīkī. Projects would include the construction of new beach stabilization structures, and the recovery of offshore sand and its placement on the shoreline. The objectives of the proposed actions are to restore and improve Waikīkī's public beaches, increase beach stability through improvement and maintenance of shoreline structures, provide safe access to and along the shoreline, and increase resilience to coastal hazards and sea level rise.

Attached documents (signed agency letter & EA/EIS)

- 2024-10-23-OA-FEIS-Waikiki-Beach-Improvement-and-Maintenance-Program-Volume-4-of-4.pdf
- 2024-10-23-OA-FEIS-Waikiki-Beach-Improvement-and-Maintenance-Program-Volume-3-of-4.pdf
- 2024-10-23-OA-FEIS-Waikiki-Beach-Improvement-and-Maintenance-Program-Volume-2-of-4.pdf
- 2024-10-23-OA-FEIS-Waikiki-Beach-Improvement-and-Maintenance-Program-Volume-1-of-4.pdf
- 2024-10-23-OA-FEIS-Waikiki-Beach-Improvement-and-Maintenance-Program-Transmittal-Letter.pdf
- 2024-07-23-OA-Waikiki-EIS-DLNR-to-DBEDT-Memo.pdf

Shapefile

- The location map for this Final EIS is the same as the location map for the associated Draft EIS.

Action location map

- SHP-KMZ.zip

Authorized individual

David A. Smith

Authorization

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

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Waikīkī Beach Improvement and Maintenance Program

October 2024

Prepared for:
Hawai'i Department of Land and Natural Resources
Office of Conservation and Coastal Lands
1151 Punchbowl Street, Suite 131
Honolulu, Hawai'i 96813

Partnered with:
Waikīkī Beach Special Improvement District Association
2250 Kalākaua Ave. Suite 315
Honolulu, Hawai'i 96815

Prepared by:
Sea Engineering, Inc.
Makai Research Pier
41-305 Kalaniana'ole Hwy
Waimānalo, Hawai'i 96795

VOLUME I

Final Programmatic Environmental Impact Statement

Waikīkī Beach Improvement and Maintenance Program

Prepared By: Sea Engineering, Inc.

~~DRAFT~~ FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Waikīkī Beach Improvement and Maintenance Program

~~June 2021~~October 2024

Prepared for:
Hawai‘i Department of Land and Natural Resources
Office of Conservation and Coastal Lands
1151 Punchbowl Street, Suite 131
Honolulu, Hawai‘i 96813

Partnered with:
Waikīkī Beach Special Improvement District Association
2250 Kalākaua Ave. Suite 315
Honolulu, Hawai‘i 96815

Prepared by:
Sea Engineering, Inc.
Makai Research Pier
41-305 Kalaniana‘ole Hwy
Waimānalo, Hawai‘i 96795

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WAIKĪKĪ BEACH IMPROVEMENT AND MAINTENANCE PROGRAM

Final Programmatic Environmental Impact Statement

Proposing Agency:

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

This document and all ancillary documents were prepared under my direction and in accordance with the content requirements of Chapter 343, Hawaiʻi Revised Statutes, Title 11, Chapter 200.1, Hawaiʻi Administrative Rules.

Jul 30, 2024

James Kunane Tokioka — Date

Accepting Authority:

GOVERNOR, STATE OF HAWAIʻI

Prepared By:

SEA ENGINEERING, INC.

August 2024

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ACKNOWLEDGEMENTS

Hawai‘i State Legislature
Appropriating funds to support beach improvement and maintenance actions in Waikīkī.

Hawai‘i Department of Land and Natural Resources (DLNR)
Providing funding, leadership, and staff resources to support beach improvement and maintenance actions in Waikīkī. Special thanks to Sam Lemmo ~~(Administrator)~~, Michael Cain, Tiger Mills ~~(Senior Planner)~~, Valerie Suzuki, James Kurata, Melissa Agbayani, and Troy Thompson.~~, and Dr. Shellie Habel (Coastal Lands Program Coordinator).~~

Waikīkī Beach Special Improvement District Association (WBSIDA)
Generating tax revenue and project coordination to support beach improvement and maintenance actions in Waikīkī. Establishing the Waikīkī Beach Community Advisory Committee. Special thanks to Rick Egged and Jim Fulton.

Waikīkī Beach Community Advisory Committee (WBCAC)
Establishing the priorities and objectives for each beach sector, establishing planning and design criteria, evaluating conceptual options, and providing feedback on the conceptual designs for the proposed actions. Special thanks to all WBCAC members.

University of Hawai‘i Sea Grant Program
Providing staff resources to support beach improvement and maintenance actions in Waikīkī. Special thanks to Dolan Eversole ~~(Waikīkī Beach Management Coordinator)~~, Dr. Bradley Romine ~~(Coastal Processes Specialist)~~, and Dr. Shellie Habel.

University of Hawai‘i Coastal Geology Group
Providing research and data for historical and projected shoreline change, sea level rise, and beach profile monitoring. Special thanks to Dr. Chip Fletcher and Dr. Tiffany Anderson.

University of Hawai‘i Coastal Groundwater Research Group
Providing opinions regarding submarine groundwater discharge at Kawehewehe. Special thanks to Dr. Henrietta Dulai and Dr. Craig Glenn.

AECOS, Inc.
Conducting the ~~Ocean Recreation Study~~Marine Biological Assessment ~~for the DPEIS~~.

International Archaeology LLC
Conducting the Cultural Impact ~~Assessment~~, Archaeological, and Architectural Assessments ~~for the DPEIS~~.

John Clark
Conducting the Ocean Recreation Study ~~for the DPEIS~~.

Jonathan Quach
Providing conceptual renderings for the proposed actions ~~for the DPEIS~~.

ACRONYMS AND ABBREVIATIONS

ADA	Americans with Disabilities Act
AMAP	Applicable Monitoring and Assessment Plan
AIS	Archaeological Inventory Study
AMP	Archeological Monitoring Plan
BLNR	Board of Land and Natural Resources
BMP	Best Management Practices
BMPP	Best Management Practices Plan
BWS	Board of Water Supply
CAA	Clean Air Act
CDP	Community Development Plan
CDUA	Conservation District Use Application
CDUP	Conservation District Use Permit
cf	Cubic feet
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
cm	Centimeters
CRAMP	Coral Reef Assessment and Monitoring Program
CWA	Clean Water Act
CWB	Clean Water Branch
cy	Cubic yards
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act of 1977
DA	Department of the Army
DAGS	Department of Accounting and General Services
DAR	Division of Aquatic Resources
dBA	Decibels
DBEDT	State of Hawaiʻi Department of Business, Economic Development &Tourism
Deg	Degrees
DEIS	Draft Environmental Impact Statement
DLNR	State of Hawaiʻi Department of Land and Natural Resources
DO	Dissolved Oxygen
DOBOR	Division of Boating and Ocean Recreation
DOCARE	Division of Conservation and Resources Enforcement
DOH	State of Hawaiʻi Department of Health
DPEIS	Draft Programmatic Environmental Impact Statement
DQO	Data Quality Objectives
E	Existing
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EISPN	Environmental Impact Statement Preparation Notice
EMS	Emergency Medical Services
EPA	United States Environmental Protection Agency
ERP	Environmental Review Program

ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FEP	Fishery Ecosystem Plan
FIRM	Flood Insurance Rate Map
FMP	Fishery Management Plan
FPEIS	Final Programmatic Environmental Impact Statement
ft	Feet
ft/yr	Feet Per Year
FWCA	Fish and Wildlife Coordination Act
GMSL	Global Mean Sea Level
GPS	Global Positioning System
HAPC	Habitat Areas of Particular Concern
HAR	Hawaiʻi Administrative Rules
HDPE	High-Density Polyethylene
HECO	Hawaiian Electric Company
HEPA	Hawaiʻi Environmental Policy Act
HRS	Hawaiʻi Revised Statutes
HSBPA	Hawaiʻi Shore and Beach Preservation Association
HST	Hawaiʻi Standard Time
Hz	Hertz
IA	International Archaeology, LLC
in	Inches
IPCC	Intergovernmental Panel on Climate Change
LiDAR	Light Detection and Ranging
m	Meters
MBTA	Migratory Bird Treaty Act
mgd	Million Gallons Per Day
MHHW	Mean Higher High Water
mi	Miles
MLCD	Marine Life Conservation District
MLLW	Mean Lower Low Water
mm	Millimeters
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
mph	Miles Per Hour
MSA	Magnuson-Stevens Conservation Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MUS	Management Unit Species
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NHPA	National Historic Preservation Act
NO_2	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration

NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NTU	Nephelometric Turbidity Units
NWP	Nationwide Permit
OCCL	Office of Conservation and Coastal Lands
~~OEQC~~	~~Office of Environmental Quality Control~~
OPSD	Office of Planning and Sustainable Development
ORMP	Ocean Resources Management Plan
P	Proposed
PacIOOS	Pacific Islands Ocean Observing System
PIRO	Pacific Islands Regional Office
PM	Particulate Matter
ROE	Right~~-~~ of~~-~~ Entry
ROH	Revised Ordinances of Honolulu
RTE	Rare, Threatened, and Endangered
SEI	Sea Engineering, Inc.
SHOALS	Scanning Hydrographic Operational Airborne LiDAR Survey
SHPD	State Historic Preservation Division
SLR	Sea Level Rise
SLR-XA	Sea Level Rise Exposure Area
SLUD	State Land Use District
SMA	Special Management Area
SO_2	Sulfur Dioxide
SOEST	School of Ocean and Earth Science and Technology
SSBR	Small Scale Beach Restoration
SSV	Shoreline Setback Variance
SWAN	Simulating Waves Nearshore
SWASH	Simulating Waves Till Shore
TMDL	Total Maximum Daily Load
TMK	Tax Map Key
TN	True North
TSS	Total Suspended Solids
TTS	Temporary Threshold Shifts
UH	University of Hawaiʻi
UHCDC	University of Hawaiʻi Community Design Center
UHCGG	University of Hawaiʻi Coastal Geology Group
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	Ultraviolet
VOC	Volatile Organic Compound
WBCAC	Waikīkī Beach Community Advisory Committee
WBSIDA	Waikīkī Beach Special Improvement District Association

WIA	Waikīkī Improvement Association
WNB	Waikīkī Neighborhood Board
WPRFMC	Western Pacific Regional Fishery Management Council
WQC	Water Quality Certification
WQS	Water Quality Standards
yr	Years

PROJECT SUMMARY

Project:	Waikīkī Beach Improvement and Maintenance Program
Proposing Agency	Office of Planning and Sustainable Development Department of Business, Economic Development & Tourism State of Hawaiʻi No. 1 Capitol District Building 250 S. Hotel Street Honolulu, Hawaiʻi 96813 Contact: Mary Alice Evans (808) 587-2833 Email: maryalice.evans@hawaii.gov ~~Office of Conservation and Coastal Lands~~ ~~Department of Land and Natural Resources~~ ~~State of Hawaiʻi~~ ~~1151 Punchbowl Street, Room 131~~ ~~Honolulu, Hawaiʻi 96813~~ ~~Contact: Sam Lemmo (808) 587-0377~~ ~~Email: sam.j.lemmo@hawaii.gov~~
Approving Authority:	The Honorable ~~David Y. Ige~~ Josh Green, Governor Executive Chambers State Capitol 415 South Beretania St. Honolulu, Hawaiʻi 96813 Contact: (808) 586-0034 http://governor.hawaii.gov/contact-us/contact-the-governor/
Consultant:	Sea Engineering, Inc. 41-305 Kalanianaʻole Hwy Waimānalo, Hawaiʻi 96795 Contact: David Smith, Ph.D., P.E. (808) 259-7966 Email: waikiki@seaengineering.com
Location:	Waikīkī Beach, Honolulu, Oʻahu, Hawaiʻi
State Land Use District:	Conservation (Resource Subzone)
Tax Map Keys:	~~(seaward of)~~ (1) 2-6-001:003, 1) 2-6-004:007, (1) 2-6-005:001, (1) 2-6-008:029, (1) 2-6-002:026, (1) 2-6-001:019, (1) 2-6-004:012, (1) 2-6-002:017, (1) 2-6-001:013, (1) 2-6-001:012, (1) 2-6-001:002, (1) 2-6-001:015, (1) 2-6-001:008, (1) 2-6-004:006, (1) 2-6-004:005, (1) 2-6-001:017, (1) 2-6-004:008, (1) 2-6-004:009, (1)

2-6-004:010, (1) 2-6-001:018, (1) 2-6-005:006, (1) 2-6-001:004, (1) 2-6-002:006, (1) 2-6-002:005

County Zoning: Public Precinct (Waikīkī Special District)

Proposed Action: The Hawai‘i Department of Land and Natural Resources proposes beach improvement and maintenance projects in the Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō beach sectors of Waikīkī. Projects would include the construction of new beach stabilization structures, and the recovery of offshore sand and its placement on the shoreline. The objectives of the proposed actions are to restore and improve Waikīkī's public beaches, increase beach stability through improvement and maintenance of shoreline structures, provide safe access to and along the shoreline, and increase resilience to coastal hazards and sea level rise.

Required Permits And Approvals:
Programmatic Environmental Impact Statement
Conservation District Use Permit
~~Small-scale Beach Nourishment Permit~~
Department of the Army Permit (Section 10 and Section 404)
Coastal Zone Management Act Consistency Determination
Clean Water Act Section 401 Water Quality Certification
National Pollutant Discharge Elimination System Permit
State of Hawai‘i, Hawai‘i Revised Statutes Chapter 6E Review
~~City and County of Honolulu,~~ Special Management Area Use Permit

Actions Requiring Environmental Assessment:
Work within the Conservation District~~.~~
Use of State Lands
Use of State Funds
Work within the Shoreline Area
Waikīkī Special District

CONTENT CHECKLISTS

Pursuant to §11-200.1-24, Hawaiʻi Administrative Rules (HAR), ~~T~~the Draft EIS, at a minimum, shall contain the following information. ~~required in this section~~ (~~Hawaiʻi Administrative Rules (HAR) 11-200.1-24)~~

Section	Requirement	Chapters / Sections
(d)(1)	Brief description of the proposed action.	Project Summary Executive Summary
(d)(2)	Significant beneficial and adverse impacts.	Executive Summary Chapter 8 Chapter 9 Chapter 10 Chapter 11
(d)(3)	Proposed mitigation measures.	Chapter 8 Chapter 9 Chapter 12
(d)(4)	Alternatives considered.	Section 3.~~4~~5 Section 3.8 Section 4.4 Section 5.4 Section 6.4 Section 7.4 Section 7.6
(d)(5)	Unresolved issues.	Executive Summary Chapter 15
(d)(6)	Compatibility with land use plans and policies, and a list of permits or approvals.	Executive Summary Chapter 16 Chapter 17
(d)(7)	A list of relevant EAs and EISs considered in the analysis of the preparation of the EIS.	Executive Summary
(e)	Table of contents.	Table of Contents
(f)	Statement of purpose and need for the proposed action.	Executive Summary Section 2.2
(g)(1)	Detailed maps.	Figure 2-1 Figure 2-2 Figure 8-23 Figure 8-24 Figure 8-25 Figure 8-26
(g)(2)	Objectives of the proposed action.	Section 2.3 Section 4.2 Section 5.2 Section 6.2 Section 7.2

Section	Requirement	Chapters / Sections
(g)(3)	General description of the action's technical, economic, social, cultural, and environmental characteristics.	Executive Summary Chapter 2 Chapter 3 Section 4.3 Section 5.3 Section 6.3 Section 7.3 Section 7.5 Chapter 8 Chapter 9
(g)(4)	Use of state of county funds or lands for the action.	Section 2.2
(g)(5)	Phasing and timing of the action.	Executive Summary Section 3.4 Section 4.3.4 Section 5.3.4 Section 6.3.4 Section 7.3.4 Section 7.5.4 Chapter 10 Chapter 15
(g)(6)	Summary of technical data, diagrams, and other information necessary to enable an evaluation of potential environmental impact by commenting agencies and the public.	Section 4.3 Section 5.3 Section 6.3 Section 7.3 Section 7.5 Appendix B Appendix C Appendix D Appendix E Appendix F
(g)(7)	Historic perspective	Section 2.1 Section 4.1 Section 5.1 Section 6.1 Section 7.1 Section 9.2 Appendix D
(h)(~~1~~)	No action alternative.	Section 3.~~4~~5.1
(h)(~~2~~1)	Alternatives requiring actions of a significantly different nature that would provide similar benefits with different environmental impacts.	Section 3.~~4~~5 Section 4.4 Section 5.4 Section 6.4 Section 7.4 Section 7.6 Chapter 10

Section	Requirement	Chapters / Sections
(h)(32)	Alternatives related to different designs or details of the proposed action that would present different environmental impacts.	Section 3.54 Section 3.8 Section 4.4 Section 5.4 Section 6.4 Section 7.4 Section 7.6 Chapter 10
(h)(43)	Alternative locations for the proposed action.	Section 2.5 Section 2.6
(i)	Description of the environmental setting, including a description of the environment in the vicinity of the action, as it exists before commencement of the action, from both a local and regional perspective.	Section 2.1 Section 4.1 Section 5.1 Section 6.1 Section 7.1 Appendix B Appendix C Appendix D Appendix E Appendix F
(i)	Environmental resources that are rare or unique to the region and the action site.	Section 2.1 Section 4.1 Section 5.1 Section 6.1 Section 7.1 Section 9.2 Section 9.4 Appendix B
(i)	Related projects, public and private, existent or planned in the region.	Executive Summary Section 2.6
(i)	Population and growth characteristics, assumptions, and impacts.	Section 9.1.2 Section 9.1.5
(i)	Sources of data used to identify, qualify, or evaluate any and all environmental consequences.	References Appendix B Appendix C Appendix D Appendix E Appendix F
(j)	Description of the relationship of the proposed action to land use and natural or cultural resource plans, policies, and controls for the affected area.	Executive Summary Chapter 16 Chapter 17
(k)	List of necessary approvals and status of each.	Executive Summary Section 4.3.5 Section 5.3.5 Section 6.3.5

Section	Requirement	Chapters / Sections
		Section 7.3.5 Section 7.5.5 Chapter 16 Chapter 17
(l)	Analysis of the probable impact of the proposed action on the environment and impacts of the natural or human environment on the action.	Chapter 8 Chapter 9 Chapter 10 Chapter 11 Chapter 12 Chapter 13 Chapter 14
(l)	Consideration of all phases of the action.	Executive Summary Section 3.3 Section 3.4 Section 4.3.4 Section 5.3.4 Section 6.3.4 Section 7.3.4 Section 7.5.4 Chapter 10 Chapter 15
(l)	Consideration of all consequences on the environment, including direct and indirect effects.	Chapter 8 Chapter 9 Chapter 10 Chapter 11 Chapter 12 Chapter 13 Chapter 14
(l)	Interrelationships and cumulative environmental impacts of the proposed action and other related actions.	Executive Summary Section 2.6 Chapter 8 Chapter 9 Chapter 10 Chapter 11 Chapter 12 Chapter 13 Chapter 14
(l)	Secondary effects.	Chapter 11
(l)	Estimated population impacts.	Section 9.1.2 Section 9.1.5
(l)	Direct or indirect sources of pollution.	Section 8.7 Section 8.8 Section 8.9 Section 8.10 Section 8.11

Section	Requirement	Chapters / Sections
		Section 9.6 Section 9.7
(m)	Relationship between local short-term uses of humanity's environment and the maintenance and enhancement of long-term productivity.	Chapter 13
(m)	Trade-offs among short-term and long-term gains and losses	Section 13.1
(m)	Extent to which the proposed action forecloses future options	Section 13.2
(m)	Extent to which the proposed action narrows the range of beneficial uses	Section 13.3
(m)	Extent to which the proposed action poses long-terms risks to health and safety	Section 13.4
(n)	Unavoidable impacts.	Chapter 10
(n)	Use of non-renewable resources.	Chapter 10 Section 13.2
(n)	Irreversible curtailment of the range of beneficial uses of the environment.	Section 14.2
(n)	Possibility of environmental accidents.	Section 14.3
(o)	Rationale for proceeding with Proposed Action, notwithstanding adverse effects.	Executive Summary Section 2.2 Section 4.2 Section 5.2 Section 6.2 Section 7.2 Chapter 10 Chapter 11 Chapter 12 Chapter 13 Chapter 14
(o)	Other public policies that offset adverse environmental effects of the Proposed Action.	Chapter 12 Chapter 16
(o)	Ability of reasonable alternatives to achieve countervailing benefits to avoid adverse effects.	Executive Summary Section 3.54 Section 4.4 Section 5.4 Section 6.4 Section 7.4 Section 7.6 Chapter 10
(p)	Description of mitigation measures in action plan to reduce significant, unavoidable, adverse impacts to insignificant levels and basis for considering these levels are acceptable.	Chapter 8 Chapter 9 Chapter 10 Chapter 11
(p)	Timing of each mitigation step to assuring mitigation.	Chapter 8 Chapter 9 Chapter 10

Section	Requirement	Chapters / Sections
		Chapter 12
(q)	How unresolved issues will be resolved prior to commencement of Proposed Action.	Executive Summary Chapter 15
(r)	List of all government agencies, other organizations and private individuals consulted in preparing this statement.	Executive Summary Section 2.4 Chapter 19 Chapter 20 Appendix A Appendix G Appendix H Appendix I
(s)(1)	Reproductions of substantive comments and responses made during consultation.	Appendix G Appendix H Appendix I
(s)(2)	Responses to all substantive written comments made during the consultation period required in section 11-200.1-23.	Appendix G Appendix H Appendix I
(s)(4)	A summary of any EIS public scoping meetings, including a written general summary of the oral comments made, and a representative sample of any handout provided by the proposing agency or applicant related to the action provided at any EIS public scoping meeting.	Section 19.3 Appendix H
(s)(5)	A list of those persons or agencies who were consulted and had no comment in a manner indicating that no comment was provided.	Chapter 19 Chapter 20
(s)(6)	A representative sample of the consultation request letter.	Appendix H

Pursuant to §11-200.1-27, HAR, the Final EIS, at a minimum, shall contain the following information.

Section	Requirement	Chapters / Sections
(a)	The contents shall fully declare the environmental implications of the proposed action and shall discuss all reasonably foreseeable consequences of the action.	✓
(a)	In order that the public can be fully informed and the accepting authority can make a sound decision based upon the full range of responsible opinion on environmental effects, an EIS shall include responsible opposing views, if any, on significant environmental issues raised by the proposal.	Appendix A Appendix D Appendix G Appendix H Appendix I
(b)(1)	The Draft EIS prepared in compliance with this subchapter, as revised to incorporate substantive comments received during the review processes in conformity with section 11-200.1-26, including the reproduction of all comments and responses to substantive written comments.	✓
(b)(2)	A list of persons, organizations, and public agencies commenting on the draft EIS.	Section 19 Section 20 Appendix G Appendix H Appendix I
(b)(3)	A list of those persons or agencies who were consulted in preparing the final EIS and those who had no comment shall be included in a manner indicating that no comment was provided.	Section 19 Section 20 Appendix I
(b)(4)	A written general summary of oral comments made at any EIS public scoping meeting.	Appendix H
(b)(5)	The text of the final EIS written in a format that allows the reader to easily distinguish changes made to the text of the draft EIS.	✓

1. EXECUTIVE SUMMARY

Waikīkī is a predominantly engineered shoreline. The beaches of Waikīkī are almost entirely composed of imported sand and the current shoreline configuration is largely the result of past efforts to widen and stabilize the beaches. The beaches of Waikīkī are chronically eroding, and the backshore (landward of the beach) is frequently flooded, particularly during high tide and high surf events. Over the past several years, Hawaiʻi has experienced record high tides (referred to as *King Tides*) that have exacerbated erosion and flooding in Waikīkī. These events have highlighted the impacts of sea level rise on the beaches of Waikīkī. As sea levels continue to rise, beach loss will progressively degrade the recreational, social, cultural, environmental, aesthetic, and economic value of Waikīkī.

Almost the entire length of Waikīkī is armored by seawalls, many of which are in various states of disrepair. As the beaches continue to erode, and flooding occurs more frequently, the shoreline will migrate further landward. These processes are likely to accelerate as sea levels continue to rise. As the beaches continue to erode and flooding occurs more frequently and extends further landward, processes that are likely to accelerate as sea levels continue to rise, the shoreline will migrate further landward. As the shoreline approaches the existing shoreline armoring, there will be incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016). While it is possible that some sand may remain in front of the existing shoreline armoring, what remains of the beaches will be narrow, submerged, unstable, inaccessible, and unusable.

Without beach improvements and maintenance, sea level rise will cause substantial beach loss in Waikīkī. For discussion purposes in this Draft Final Programmatic Environmental Impact Statement (FPEISDPEIS), *beach loss* is defined as the loss of dry recreational beach area and lateral shoreline access during typical wave and tidal conditions.

Beach erosion threatens to diminish the economic viability of Waikīkī. A recent study found that the loss of Waikīkī Beach would result in an annual loss of $2.223 billion in visitor expenditures (Tarui et al. 2018). Beach improvements and maintenance actions are urgently needed to restore and maintain the beaches of Waikīkī to continue to support Hawaii's tourism-based economy and preserve the recreational, social, cultural, environmental, aesthetic, and economic value of Waikīkī for future generations.

For discussion purposes in this DPEISFPEIS, *beach maintenance* refers to actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. Beach maintenance options include beach nourishment, sand backpassing, sand pushing, and sand pumping. The proposed beach maintenance actions are intended to be conducted on a periodic basis and may be adapted as sea levels continue to rise. *Beach improvements* refer to actions that involve adding new sand, constructing new structures, and/or modifying existing structures. Beach improvement options include beach nourishment with stabilizing groins, segmented breakwaters, and modifications to existing structures. The proposed beach improvements actions are designed to account for 1.5 ft of sea level rise and may be adapted as sea levels continue to rise.

Beach maintenance actions are proposed in three beach sectors of Waikīkī:

- Fort DeRussy Beach Sector – Small-scale Beach Nourishment and Periodic Sand Backpassing
- Royal Hawaiian Beach Sector – Beach Nourishment without Stabilizing Structures
- Kūhiō Beach Sector: Diamond Head (east) Basin – Sand Pumping

Beach improvement actions are proposed in two beach sectors of Waikīkī:

- Halekūlani Beach Sector – Beach Nourishment with Stabilizing Groins
- Kūhiō Beach Sector: ʻEwa (west) Basin – Beach Nourishment with Modified Groins and a Segmented Breakwater

The primary objectives of the proposed actions are to:

- Restore and improve Waikīkī's public beaches.
- Increase beach stability through improvement and maintenance of shoreline structures.
- Provide safe access to and along the shoreline.
- Increase resilience to coastal hazards and sea level rise.

The proposed actions were developed in collaboration with public and private stakeholders with the shared goal and vision of making the beaches of Waikīkī sustainable and resilient for current and future generations. Selection of the proposed beach improvement and maintenance actions was a primarily stakeholder-driven process. The project proponents relied heavily on feedback and direction from local stakeholders to identify issues, needs, priorities, and design criteria for each beach sector.

Significant Beneficial Impacts

Improving and maintaining the beaches of Waikīkī will support existing uses and preserve the recreational, social, cultural, environmental, aesthetic, and economic value of Waikīkī. The proposed actions will also decrease vulnerability to coastal hazards, increase resilience to sea level rise, and have a substantial positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed actions are consistent with the existing environment and surrounding uses and will not fundamentally alter the character of Waikīkī. The proposed actions will not narrow or curtail the range of beneficial uses in the area.

Potential Adverse Impacts

The proposed actions have the potential to temporarily impact coastal processes, bathymetry, marine habitat and species, water quality, noise, and air quality. The proposed actions also have the potential to temporarily impact commercial operations, shoreline access, ocean recreation, scenic and aesthetic resources, and public services and infrastructure. These impacts are primarily associated with construction activities and are anticipated to be minor and temporary in nature. The potential adverse impacts of the proposed actions are countervailed by the beneficial impacts of preserving and enhancing the recreational, social, cultural, environmental, and aesthetic value of Waikīkī.

Proposed Mitigation Measures

Best Management Practices (BMPs) will be utilized to mitigate or minimize potential impacts to the maximum extent practicable.

Alternatives Considered

A variety of alternatives were evaluated during the project selection and conceptual design process. These alternatives include No Action, Managed Retreat, Repair, Modification, Replacement, or Removal of Existing Structures, Beach Maintenance, and Beach Nourishment with or without Stabilizing Structures. Selection of the proposed beach improvement and maintenance actions was a primarily stakeholder-driven process. The project proponents relied heavily on feedback and direction from the Waikīkī Beach Community Advisory Committee (WBCAC) to identify issues, needs, priorities, and design criteria for each beach sector.

Unresolved Issues

Several issues were unresolved at the time that the DPEIS was published on June 8, 2021. Issues that have been resolved and the methods of resolution are presented below.

Project Phasing (Status: Unresolved)

The proposed beach maintenance actions are intended to be conducted on a periodic basis and may be adapted as sea levels continue to rise. The proposed beach improvement actions are designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the projects could be effective until about the year 2080, or 50-years post-construction. Sea level rise projections continue to evolve as new and improved sea level and climate change research becomes available. It is also important to recognize that global sea level rise will not stop within these timeframes but will very likely continue for centuries. As a result, there is uncertainty regarding precisely when and the degree to which the designs will need to be adapted. As sea levels continue to rise, additional beach improvement and maintenance actions may be required in the other beach sectors of Waikīkī.

> Resolution: The Waikīkī Beach Improvement and Maintenance Program consists of five (5) individual actions (projects) that are intended to be implemented in phases. The timing and sequencing for project implementation has yet to be determined and will be dependent on stakeholder feedback and availability of funding. The objective of the Program is to complete all of the proposed actions within approximately one decade and to sequence the projects in a manner that will minimize and isolate disruptions to specific areas for discrete periods of time. This approach will also help to minimize and distribute the cumulative impacts of the proposed actions.

Sand Recovery (Status: Partially Resolved)

The offshore sand deposits that will be used to support the proposed beach improvement actions in the Halekūlani beach sector and Kūhiō beach sector ʻEwa (west) basin have yet to be confirmed. The dredging methods to recover the offshore sand and transport it to the shoreline for placement have also not been confirmed. These determinations will be made based on feedback obtained during the public review of the DPEIS and will be confirmed during the final design and permitting process.

> Resolution: The beach maintenance action in the Fort DeRussy beach sector will involve hydraulic suction dredging to recover approximately 3,000 cy of sand from the *Hilton* offshore sand deposit. The beach maintenance action in the Royal Hawaiian beach sector will involve hydraulic suction dredging to recover approximately 30,000 cy of sand from

the *Canoes/Queens* offshore sand deposit. The proposed beach maintenance action in the Diamond Head (east) basin of the Kūhiō beach sector will involve sand pumping to recover approximately 4,500 cy of submerged sand from within the basin.

Costs and Funding (Status: Unresolved)
The proposed beach improvement and maintenance actions in the DPEIS were presented at a conceptual level. The estimated costs for construction for the proposed actions have yet to be confirmed. Actual construction costs will depend on the final plans and specifications and permit conditions, which will be confirmed during the final design and permitting phase. Initial construction costs will depend on a variety of factors including but not limited to the selected offshore sand deposits, sand recovery and transport methodologies, project timing and sequencing, and monitoring requirements. Recurring construction costs will depend on the frequency of beach maintenance activities and unforeseen maintenance costs. For example, an extreme episodic event (e.g., hurricane or tsunami) could result in unpredicted costs for repair and maintenance. Adaptation costs are similarly difficult to project. As sea levels continue to rise, there is uncertainty regarding precisely when and the degree to which the structures will need to be adapted. The cumulative costs over the life of the Program will continue to be adjusted to account for inflation/deflation.

Monitoring (Status: Unresolved)
The monitoring and assessment plans for the proposed actions include beach profile monitoring, water quality monitoring, and marine biological monitoring (see Chapter 12). At this time, it is unclear if any additional monitoring will be required. Monitoring requirements will be confirmed during the final design and permitting process.

Required Permits and Approvals (Status: Partially Resolved)
Due to recent statutory changes and ongoing policy changes, there is uncertainty in terms of the permits and approvals that will be required for the proposed actions. Regulatory requirements will be confirmed during the final design and permitting process.

Resolution: The applicant confirmed that the proposed actions will require a Conservation District Use Permit (CDUP. A current Certified Shoreline will be required as a prerequisite of the CDUP. On March 9, 2023, Mayor Rick Blangiardi enacted Ordinances 23-3 and 23-4, which amended the Revised Ordinances of Honolulu (ROH), Chapter 25 Special Management Area and Chapter 26 Shoreline Setbacks, respectively. At this time, it is unclear if any of the proposed actions will require a Special Management Area Use Permit (SMA) or a Shoreline Setback Variance (SSV). The applicant will consult with the City and County of Honolulu, Department of Planning and Permitting to confirm these requirements during the final design and permitting phase.

Existing Structures (Status: Partially Resolved)
The proposed actions were developed as mandated in Governor David Ige's August 2018 directive to include a sea level rise analysis in Environmental Impact Statements. The proposed actions will be located primarily on submerged lands makai (seaward) of the shoreline; however, some aspects of the proposed actions (e.g., laydown and staging areas) may extend mauka (landward) of the shoreline. Most of the existing seawalls that span nearly the entire length of the Waikīkī shoreline are privately-owned structures ~~and are located outside of the Conservation~~

District. Some of these structures will need to be modified to accommodate the proposed actions. The Applicant will coordinate with the affected landowners during the final design and permitting phase. During the final design phase, it may be determined that the existing seawalls may need to be modified to accommodate increased beach elevation. The seawalls may also need to be modified or replaced to accommodate a beach walkway in the Halekūlani beach sector. The seawalls are privately-owned structures and are located outside of the Conservation District. The DLNR does not regulate land uses mauka (landward) of the shoreline.

Compatibility with Existing Land Use Plans and Policies
The proposed actions are compatible with the following land use plans and policies:

- Coastal Zone Management Act of 1972 (16 USC §§1451-1464)
- Conservation District (§13-5, HAR)
- Shoreline Certification (§13-222, HAR)
- Hawaiʻi State Plan (Chapter 226, HRS)
- Hawaiʻi 2050 Sustainability Plan
- Conservation Lands State Functional Plan (1991)
- Recreation State Functional Plan (1991)
- Hawaiʻi State Tourism Functional Plan (1991)
- General Plan for the City and County of Honolulu
- Primary Urban Center Development Plan
- Oʻahu Resilience Strategy
- Chapter 25, Revised Ordinances of Honolulu (Special Management Area)
- Chapter 2326, Revised Ordinances of Honolulu (Shoreline Setbacks)

Required Permits and Approvals
The primary following Federal approvals are anticipated to be required for the proposed actions are:

- Section 10, Rivers and Harbors Act (U.S. Army Corps of Engineers)
- Section 404, Clean Water Act (U.S. Army Corps of Engineers)

Other Federal laws that may affect the proposed actions include:

- Archaeological and Historic Preservation Act (16 USC § 469a-1)
- National Historic Preservation Act of 1966 (16 USC § 470(f))
- Native American Graves Protection and Repatriation Act of 1990 (25 USC § 3001)
- Clean Air Act (42 USC § 7506(C))
- Coastal Zone Management Act (16 USC § 1456(C) (1))
- Endangered Species Act (16 U.S.C. 1536(A) (2) and (4))
- Fish and Wildlife Coordination Act of 1934, as amended (16 USC §§ 661-666[C] et seq.)
- Magnuson-Stevens Fishery Conservation and Management Act (16 USC § 1801 et seq.)
- Marine Mammal Protection Act of 1972, as amended (16 USC §§ 1361-1421(H) et seq.)
- EO 13089, Coral Reef Protection (63 FR 32701)
- Migratory Bird Treaty Act of 1918, as amended (16 USC §§ 703-712)

The primary following State of Hawaiʻi approvals are anticipated to be required for the proposed actions are:

- Conservation District Use Permit – Hawaiʻi Department of Land and Natural Resources
- Small-scale Beach Nourishment Permit – Hawaiʻi Department of Land and Natural Resources
- Small-scale Beach Restoration Permit – Hawaiʻi Department of Land and Natural Resources
- Shoreline Certification – Hawaiʻi Department of Land and Natural Resources
- Right of Entry Permit – Hawaiʻi Department of Land and Natural Resources
- Section 401 Water Quality Certification – Hawaiʻi Department of Health
- National Pollutant Discharge Elimination System Permit – Hawaiʻi Department of Health
- Air Pollution Permit – Hawaiʻi Department of Health
- Community Noise Permit – Hawaiʻi Department of Health
- Coastal Zone Management Consistency Review – Hawaiʻi Department of Business, Economic Development, and Tourism, Office of Planning and Sustainable Development

The primary following City and County of Honolulu approvals are anticipated to be required for the proposed actions are:

- Special Management Area Use Permit
- Shoreline Setback Variance
- Grubbing, Grading and/or Stockpiling Permit
- Building Permit

Relevant EAs and EISs Considered in the Analysis of the Preparation of the DPEISFPEIS.

- *Environmental Assessment for Fort DeRussy Beach Restoration*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by United States Army Corps of Engineers, Honolulu District. (December 1993).
- *Environmental Assessment/Environmental Impact Statement Preparation Notice for Gray's Beach Restoration Project*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by Planning Solutions and Sea Engineering, Inc. (August 2008).
- *Final Environmental Assessment for Waikīkī Beach Maintenance*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by Sea Engineering, Inc. (June 2010).
- *Final Environmental Assessment for Iroquois Point Beach Nourishment and Stabilization: ʻEwa Beach, Oʻahu, Hawaiʻi*. Prepared by Sea Engineering, Inc. (January 2012).
- *Final Environmental Assessment for Royal Hawaiian Groin Replacement Project*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by Sea Engineering, Inc. (May 2016).
- *Final Supplemental Environmental Impact Statement for Waikīkī Beach Walk* – Outrigger Reef Waikīkī Beach Resort. Prepared by Group 70 International, Inc. (October 2016).
- *Draft Final Environmental Assessment and Finding of No Significant Impact for Waikīkī (Queen's Surf) Seawall Mitigative Improvements*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by Oceanit, Inc. (NovemberJune 2017).
- *Final Environmental Impact Statement for Ala Moana Regional Park and Magic Island Improvements*: *Honolulu, Oʻahu, Hawaiʻi*. Prepared by Belt Collins. (August 2019).
- *Final Environmental Impact Statement for the Waikīkī War Memorial Complex*: *Waikīkī, Oʻahu, Hawaiʻi*. Prepared by AECOM Technical Services, Inc. (October 2019).
- *Second FinalDraft Environmental Impact Statement for Kāʻanapali Beach Restoration and Berm Enhancement*. Prepared by Sea Engineering, Inc. (August July 20222020).

2. INTRODUCTION

2.1 Project Area Description

Waikīkī Beach extends along the shoreline of Mamala Bay on the south shore of the island of Oʻahu, Hawaiʻi (Figure 2-1 and Figure 2-2). The Waikīkī shoreline originally consisted of a narrow barrier beach backed by wetlands, duck ponds, taro farms, and fishponds. In the late 1800s, the first tourist attractions were established in Waikīkī. Development of beachfront hotels such as the Sans Souci, Moana Surfrider, and Honolulu Seaside soon followed.

In 1881, Long Branch Baths bathhouse was built on the beach at the water's edge, near the present-day Moana Surfrider Hotel (Wiegel, 2008). The bathhouse serviced visitors by providing changing rooms, towels, swimsuits, and access to the beach, all for a fee, which caught the attention of Waikīkī businessmen and developers (Miller and Fletcher, 2003).

In 1890, a seawall was constructed to protect Waikīkī Road (now Kalākaua Avenue) at the entrance to Kapiʻolani Park. In 1901, the Moana Hotel (now Moana Surfrider Hotel) opened with a restaurant on piles over the beach and water (Wiegel, 2008; Cohen, 2000). Seawalls rapidly proliferated and their adverse impacts on the sandy shoreline were immediately apparent.

In the early 1900s, the wetland areas were declared a public health hazard, and the government decided to dredge the Ala Wai Canal to drain the wetlands and use the dredge material to fill in the low-lying areas (Miller and Fletcher, 2003). In the early 1900s, much of the beach at Waikīkī disappeared under structures and landscaping, and significant volumes of sand were reportedly removed from the beach and adjacent backshore area (Wiegel, 2008). In later years, sand was imported into Waikīkī to increase beach width, and numerous shore perpendicular and shore parallel channels were dredged in the reef for navigation, ocean recreation, and fill material to increase the width of the historically narrow beaches.

In 1917, the Hawaiʻi Board of Harbor Commissioners prohibited construction of seawalls along the shoreline; however, the prohibition was widely ignored. A total of 37 seawalls were constructed in Waikīkī, and by about 1920 seawalls lined most of Waikīkī Beach (Crane, 1972; Miller and Fletcher, 2003; Wiegel, 2008).

A 1926 investigation of Waikīkī Beach by the Engineering Association of Hawaiʻi concluded that seawalls were the primary cause of beach erosion and that beach nourishment and groins could be used to rebuild the beach (Gerritsen, 1978; Miller and Fletcher, 2003). A total of 42 groins or groin-like structures have been constructed in Waikīkī. Only the larger groins have been effective in stabilizing the beach. Most of the smaller groins are deteriorated or have been removed (Crane, 1972). Eight groins remain functional today. These groins compartmentalize the beaches of Waikīkī into discrete sectors that are similar to littoral cells (see Section 2.5).

In 1928, the Waikīkī Beach Reclamation agreement was established between the Territory of Hawaiʻi and various property owners in Waikīkī. The agreement recognized the need to control and limit seaward development on Waikīkī Beach and established limitations on construction along the beach in response to the proliferation of seawalls and groins in Waikīkī. The agreement provided that the Territory of Hawaiʻi would build a beach seaward from the existing high water mark and that title of the newly created beach would be vested by the abutting landowners. The Territory of Hawaiʻi and private landowners further agreed that no new structures would be built on the beach in Waikīkī. The private landowners agreed to provide a 75-ft-wide public easement along the beach inshore of the new mean high water mark.

The 1928 agreement covers the Waikīkī beach area from the Ala Wai Canal to the Elks Club at Diamond Head. The 1928 agreement consists of a) the October 19, 1928 main agreement between the Territory and Waikīkī landowners, b) the October 19, 1928 main agreement between the Territory and the Estate of Bernice Pauahi Bishop, and c) the July 5, 1929 Supplemental Agreement between the Territory and Waikīkī landowners. The area between the Royal Hawaiian Hotel and the Moana Surfrider Hotel is the subject of a separate agreement between the State of Hawaiʻi and the subject Waikīkī landowners established on May 28, 1965.

From about 1930 until the late 1970s, it is estimated that over 400,000 cy of sand was placed on Waikīkī Beach, from a variety of sources including other beaches on Oʻahu and Molokaʻi, backshore dune deposits, and crushed coralline limestone. Between 1925 and 2001, the Waikīkī shoreline moved about 40 ft seaward, reflecting the extensive human alteration of the shoreline (Miller and Fletcher, 2003). Despite past beach nourishment efforts, Miller and Fletcher (2003) estimate that, between 1951 and 2001, at least 100,000 cy of sand has been lost to erosion.

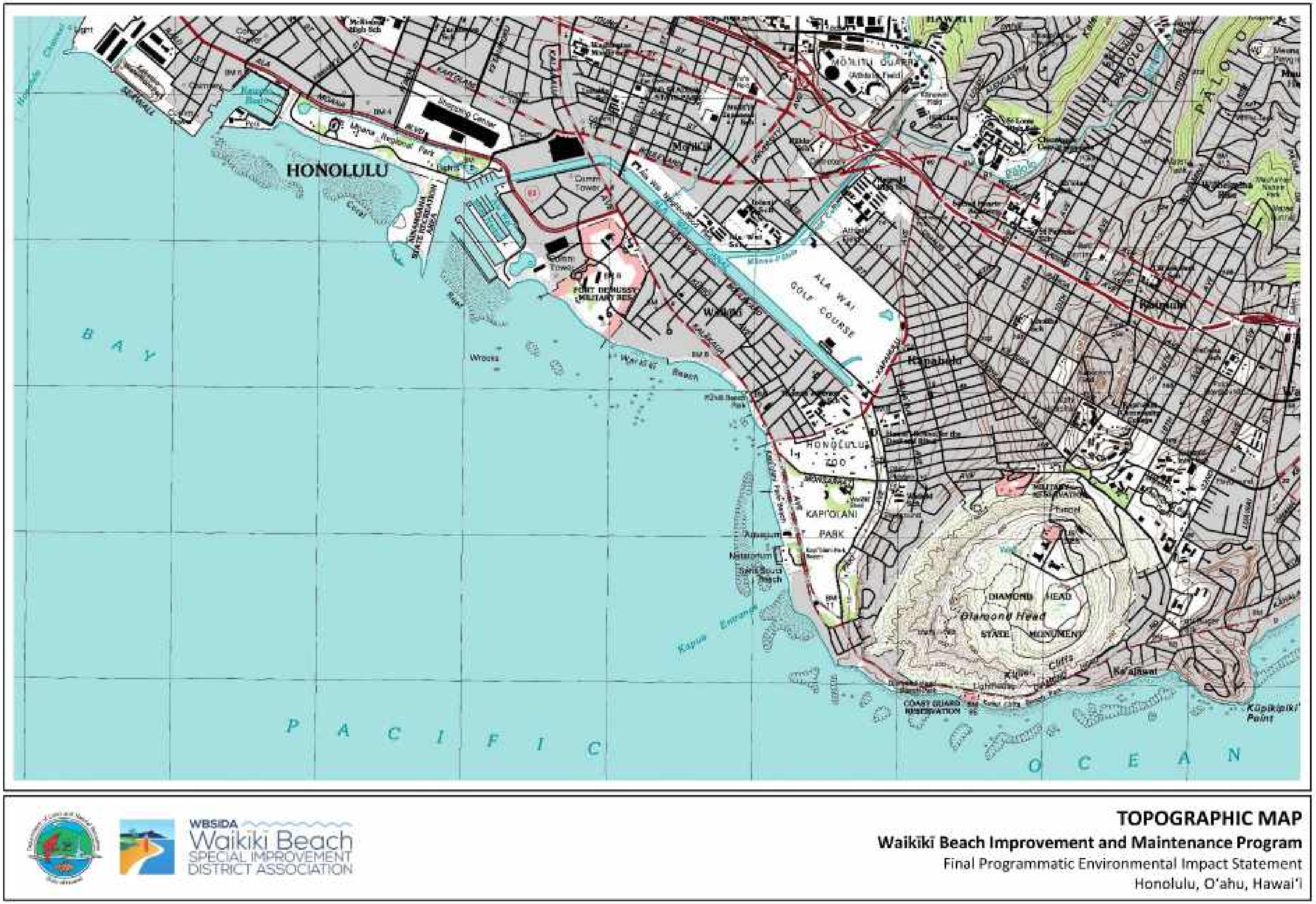


Figure 2-1 Topographic map of Waikīkī (USGS)

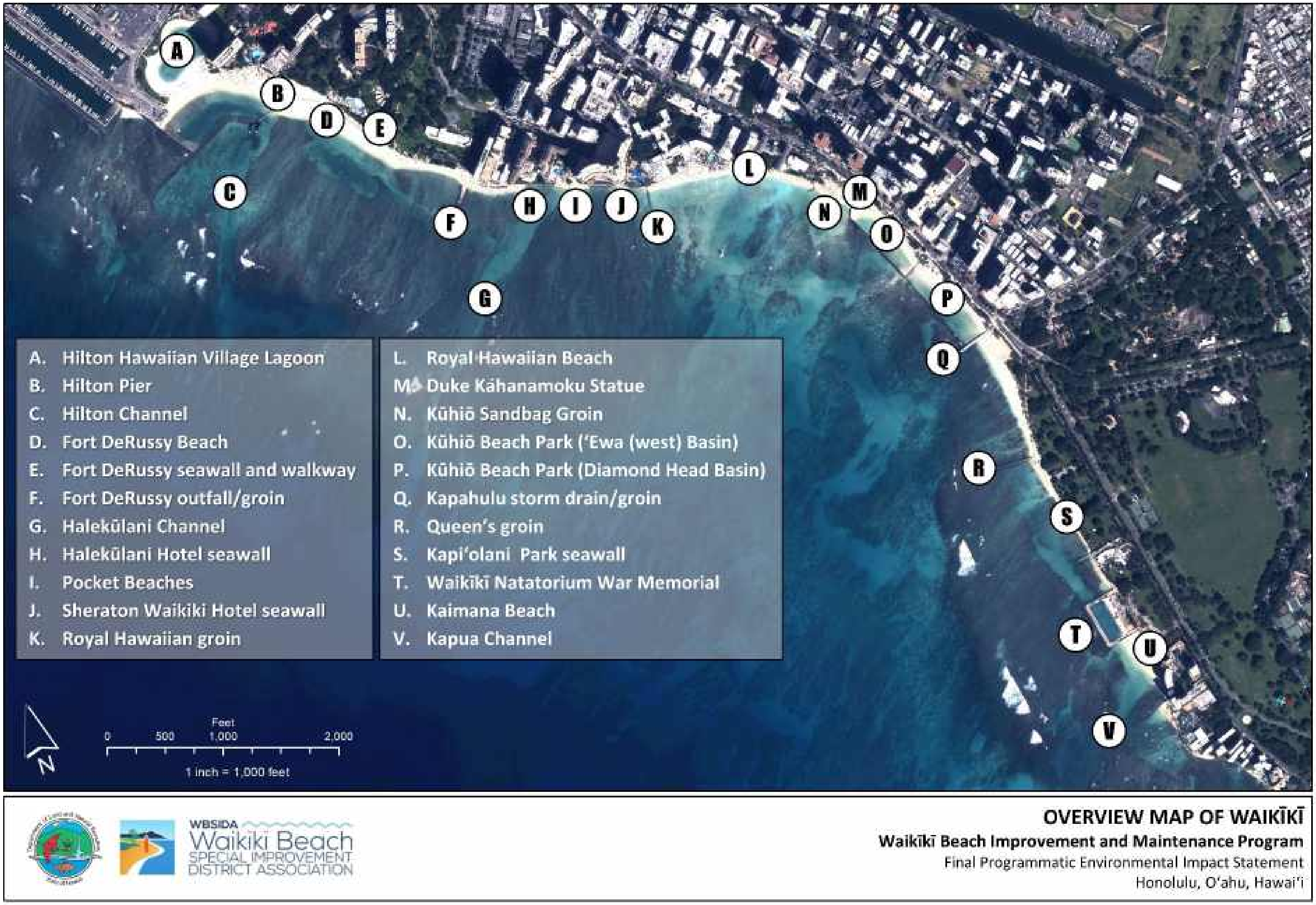


Figure 2-2 Overview map of Waikīkī

2.2 Purpose and Need for the Program

Waikīkī is a predominantly engineered shoreline. Almost the entire length of Waikīkī is armored by seawalls that were constructed in the early 1900s, many of which are in various states of disrepair. The beaches of Waikīkī are primarily man-made and composed almost entirely of sand that has been imported from various terrestrial sources, other beaches, and dredged from offshore deposits. Beach stability is largely dependent on the presence of numerous groins, breakwaters, and other structures that stabilize the sand along the shoreline.

Waikīkī is recognized as Hawaii's primary visitor destination and has more than 30,000 visitor accommodation units including resorts, hotels, and condominiums, which account for 90% of all units on Oʻahu and nearly half of all units in the State of Hawaiʻi (HTA, 2018). In 2002, tourism-related activities in Waikīkī accounted for an estimated $3.6 billion, which was 8% of Hawaii's Gross State Product. In addition, 12% of all State and County tax revenues and 10% of all civilian jobs statewide can be attributed to Waikīkī's attraction of visitors (DBEDT, 2003). In 2015, Waikīkī generated 41% of the state's visitor industry activity and contributed 7% to Hawaii's Gross State Product (State of Hawaiʻi, 2015; Porro, 2020).

The beaches of Waikīkī have tremendous historical, cultural, and recreational value and are the primary amenity that supports the tourism-based economies of Waikīkī, the City and County of Honolulu, and the State of Hawaiʻi. Hospitality Advisors LLC (2008) found that more than 90% of visitors considered beach availability in Waikīkī as very important or somewhat important.

Erosion is a serious threat to beach-related tourism and public shoreline access (USACE, 1994). Beach loss results in a variety of negative economic, social, cultural, environmental, recreational, and aesthetic impacts. These impacts highlight the need for continuous long-term capital improvements and comprehensive beach management to sustain the unique qualities and values of Waikīkī Beach. Many of Hawaii's sandy beaches are suffering from erosion. Fletcher et al. (2012) found that 70% of beaches in Hawaiʻi are undergoing chronic (long-term) erosion and over 10% (13 miles) of Hawaii's beaches have been completely lost to erosion over the past century. The Island of Oʻahu has 66.5 miles of sandy beaches, approximately 60% of which are experiencing erosion (Fletcher et al. 2011).

Sea level rise has emerged as a serious threat to the beaches of Waikīkī. The earth is experiencing climatic changes that are unprecedented in modern history. The earth and oceans are rapidly warming, and one inexorable result of this is an accelerating rise in global mean sea level as seawater expands and as glaciers and ice sheets melt. Vousdoukas et al. (2020) found that a substantial proportion of the world's sandy coastlines are eroding, and that sea level rise could result in the near extinction of 35.7% to 49.5% of the world's sandy beaches by the end of the century. Hawaiʻi is uniquely vulnerable to sea level rise due to a combination of our geography, topography, wave climate, and coastal development patterns. Erosion and beach loss in Hawaiʻi are expected to increase significantly as rates of sea level rise increase. Anderson et al. (2015) found that, due to sea level rise, the average shoreline recession in Hawaiʻi by 2050 is projected to be nearly twice the historical rates, and nearly 2.5 times the historical rates by 2100.

The *Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report* (2017) found that 3.2 ft of sea level rise will have profound impacts on Oʻahu. $12.9 billion in structures and land could be lost; 3,800 structures could be flooded, including hotels and resorts in Waikīkī; over 13,000 residents could be displaced; and nearly 18 miles of major roads could be flooded. The 2017 report estimates that, due to the density of development and economic assets, Oʻahu will account for an estimated 66% of the total statewide economic losses due to sea level rise. The State of Hawaiʻi recommended that private and public entities in Waikīkī should begin planning for sea level rise adaptation, including beach restoration, to prepare for higher sea levels in the future.

~~The beaches of Waikīkī are chronically eroding, and the backshore is frequently flooded, particularly during high tides and high surf events.~~ The beaches of Waikīkī are critical infrastructure and the primary amenity that has established Waikīkī as a world-class tourism destination. Complete erosion of Waikīkī Beach may result in an annual loss of $2.223 billion in visitor expenditures (Tarui et al. 2018). Despite being such a critical component of Hawaii's tourism-based economy, relatively little has been spent on improving and maintaining the beaches of Waikīkī. From 2006 to 2021, approximately $10 million dollars has been invested in beach improvement projects in Waikīkī. In 2019, the Hawaiʻi State Legislature appropriated $8.85 million to support beach improvement and maintenance projects in Waikīkī with up to $3 million of this support provided by the Waikīkī Beach Special Improvement District Association (WBSIDA).

The Oʻahu Resilience Strategy prepared by the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency (2019) defines resilience as "the ability to survive, adapt and thrive regardless of what shocks or stresses come our way." Healthy, stable beaches provide a first line of defense against coastal flooding and inundation by rising sea levels and hurricane storm waves. Beach improvements are necessary to ensure that the beaches and economy of Waikīkī are sustainable and resilient to sea level rise. The proposed actions directly support the recommendations and goals of the State of Hawaiʻi and City and County of Honolulu to increase resilience to sea level rise.

2.3 Objectives of the Proposed Actions

~~The beaches of Waikīkī are chronically eroding, and the backshore is frequently flooded, particularly during high tides and high surf events. The loss of Waikīkī Beach would result in a loss of $2.223 billion in in visitor expenditures (Tarui et al. 2018).~~ Improvements and maintenance are necessary to restore and maintain the beaches of Waikīkī to continue to support Hawaii's tourism-based economy and preserve the recreational, social, cultural, environmental, and aesthetic value of Waikīkī for future generations.

For discussion purposes in this ~~DPEIS~~FPEIS, *beach maintenance* refers to actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. Beach maintenance options include beach nourishment, sand backpassing, sand pushing, and sand pumping. *Beach improvements* refer to actions that involve adding new sand, constructing new structures, and/or modifying existing structures. Beach improvement options include beach nourishment with stabilizing groins, segmented breakwaters, and modifications to existing structures.

Beach maintenance actions are proposed in three beach sectors of Waikīkī:

- Fort DeRussy Beach Sector – Small-scale Beach Nourishment and Periodic Sand Backpassing
- Royal Hawaiian Beach Sector – Beach Nourishment without Stabilizing Structures
- Kūhiō Beach Sector: Diamond Head (east) Basin – Sand Pumping

The proposed beach maintenance actions are intended to be implemented periodically on an as-needed basis. Beach maintenance would be conducted when beach conditions reach some pre-defined topographic triggers. Beach monitoring would be required to determine when the triggers have been met. The proposed beach maintenance actions are not designed to account for sea level rise.

Beach improvement actions are proposed in two beach sectors of Waikīkī:

- Halekūlani Beach Sector – Beach Nourishment with Stabilizing Groins
- Kūhiō Beach Sector: ʻEwa (west) Basin – Beach Nourishment with Modified Groins and a Segmented Breakwater

The proposed beach improvement actions are designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise; thus, in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the projects could be effective until about the year 2080, or 50-years post-construction. It is important to note that sea level rise projections continue to evolve as new and improved sea level and climate change research becomes available. It is also important to recognize that global sea level rise will not stop within these timeframes but will very likely continue for centuries.

The primary objectives of the proposed beach improvement and maintenance actions are to:

- Restore and improve the beaches of Waikīkī.
- Increase beach stability through improvement and maintenance of shoreline structures.
- Provide safe access to and along the shoreline.
- Increase resilience to coastal hazards and sea level rise.

2.4 Project Stakeholders and Proponents

The actions proposed for implementation in Waikīkī will be undertaken by the State of Hawai‘i Department of Land and Natural Resources (DLNR), which is responsible for overseeing beaches and submerged lands out to the seaward extent of the State's jurisdiction. The proposed actions were developed in collaboration with public and private stakeholders with the shared goal and vision of improving the beaches of Waikīkī for current and future generations.

Project coordination and implementation is being done in collaboration with the Waikīkī Beach Special Improvement District Association (WBSIDA), which is a private non-profit organization that was created in 2015 by City and County of Honolulu ordinance to preserve and restore Waikīkī Beach, and to serve as a cost-share partner in a public-private partnership with the DLNR. The WBSIDA is governed by a Board of Directors that consists of representatives of Waikīkī's major resorts, property owners, State and County government designees, and other stakeholders. The WBSIDA provides a mechanism for coordination of the proposed actions with a broad spectrum of Waikīkī stakeholders and securing private funding to support project implementation.

The proposed actions were developed in close collaboration with the Waikīkī Beach Community Advisory Committee (WBCAC), which was formed in 2017 to provide a forum to engage stakeholders and provide guidance and feedback on design criteria and rationale for beach improvement and maintenance projects in Waikīkī. The WBCAC is composed of various stakeholders representing business (~~34~~29%), government (~~30~~29%), hotels and resorts (~~15~~11%), non-profit organizations (~~12~~14%), and science and engineering (~~9~~17%). The WBCAC serves as a representative body to communicate the diversity of perspectives and priorities in the broader Waikīkī community, provide guidance and feedback for beach management and planning activities in Waikīkī, and ensure that future beach management projects address the issues and concerns of the Waikīkī community and local stakeholders.

The WBCAC has and continues to serve a vital role in the planning process that led to the selection of the proposed actions. The WBCAC was directly involved in determining the priorities and objectives for each beach sector, establishing planning and design criteria, evaluating conceptual options, and providing feedback on the conceptual designs for the proposed actions. The function of the WBCAC is further enhanced by the role of the University of Hawai‘i Sea Grant Program's Waikīkī Beach Management Coordinator, who provides technical support, education and outreach, and project coordination. The WBCAC held eight (8) formal meetings from 2017 to 2022. The meeting agendas and outcomes are included as Appendix A. The WBCAC will continue to provide feedback on the proposed actions throughout the environmental review, final design, and permitting processes.

2.5 Waikīkī Beach Sectors

Waikīkī is a predominantly engineered shoreline, and the beach is almost entirely composed of imported sand. Almost the entire length of Waikīkī is armored by seawalls, many of which are in various states of disrepair. The beaches of Waikīkī are primarily man-made and are largely dependent upon the presence of groins that stabilize the sand. The groins compartmentalize the Waikīkī shoreline into discrete units that are semi-contained with limited sediment transport between adjacent sectors. For the purposes of this DPEISFPEIS, the Waikīkī shoreline is divided into eight discrete *beach sectors* that have unique physical characteristics.

The *beach sectors* are similar to *littoral cells*, which are defined as coastal compartments that contain a complete cycle of sedimentation including sources, transport paths, and sinks (Inman, 2005). The cell boundaries delineate the geographical area within which the budget of sediment is balanced, providing the framework for the quantitative analysis of coastal erosion and accretion. The sediment sources are commonly streams, sea cliff erosion, onshore migration of sand banks, and material of biological origin such as shells, coral fragments, and skeletons of small marine organisms".

The natural shoreline of Waikīkī pre-development consisted of combination of pocket beaches, streams, and wetlands. It is possible that Mamala Bay was originally a single littoral cell, bounded on the east by Diamond Head, and on the west by Kalaeloa (Barbers Point). The shoreline of Waikīkī has been engineered and significantly modified over the past century, when streams were diverted, wetlands were filled, shoreline structures (e.g., seawalls, storm drains, groins, and breakwaters) were constructed, and sand beaches were built. The present-day shoreline of Waikīkī is compartmentalized by engineered structures, many of which were constructed with the specific intent of stabilizing the beaches. For the purposes of this DPEISFPEIS, these compartments are referred to as *beach sectors*. The beach sectors are shown in Figure 2-3 and summarized below (from west to east).

- ***Duke Kahanamoku (Hilton) Beach*** consists of approximately 1,100 ft of shoreline extending from a rubblemound breakwater to the Hilton pier/groin.

- ***Fort DeRussy Beach*** consists of approximately 1,680 ft of shoreline extending from the Hilton pier/groin to the Fort DeRussy outfall/groin.

- ***Halekūlani Beach*** consists of approximately 1,450 ft of shoreline extending from the Fort DeRussy outfall/groin to the Royal Hawaiian groin.

- ***Royal Hawaiian Beach*** consists of approximately 1,730 ft of shoreline extending from the Royal Hawaiian groin to the 'Ewa (west) groin at Kūhiō Beach Park

- ***Kūhiō Beach*** consists of approximately 1,500 ft of shoreline extending from the 'Ewa (west) groin at Kūhiō Beach Park to the Kapahulu storm drain/groin.

- ***Queen's Beach*** consists of approximately 1,050 ft of shoreline extending from the Kapahulu storm drain/groin to the Queen's Surf groin.

- ***Kapi'olani Beach*** consists of approximately 1,250 ft of shoreline extending from the Queen's Surf groin to the north wall of the Waikīkī Natatorium War Memorial.

- ***Kaimana (Sans Souci) Beach*** consists of approximately 500 ft of shoreline extending from the north wall of the Waikīkī Natatorium War Memorial to the groin fronting the New Otani (Kaimana) HotelColony Surf Condominium.

The relative independence of the beach sectors allows for improvements to be made incrementally, rather than all at once. This will enable prioritization, funding, final design, permitting, and construction to be phased over time, while limiting impacts to one beach sector at a time.

2.6 Sectors Selected for Beach Improvement and Maintenance Actions

Selection of the proposed beach improvement and maintenance actions was primarily a stakeholder-driven process. The project proponents relied heavily on feedback and direction from the WBCAC to identify issues, needs, priorities, and design criteria for each beach sector. Four beach sectors were identified as being the highest priorities for beach improvements and maintenance (Figure 2-4): Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō.

While the other beach sectors of Waikīkī – Duke Kahanamoku, Queens, Kapi‘olani, and Kaimana – were not selected for beach improvement and maintenance actions, these areas are clearly important and, as sea levels continue to rise, additional actions may be necessary in these beach sectors in the future. For additional information about the WBCAC and the project selection process, see Appendix A.

The proposed actions are intended to compliment recent efforts to improve the condition and stability of the beaches in Waikīkī including:

- Waikīkī Beach Maintenance I (completed May 2012)
- Waikīkī Beach Management Plan (completed May 2018)
- Kūhiō Sandbag Groin (completed November 2019)
- Royal Hawaiian Groin Replacement (completed August 2020)
- Waikīkī Beach Maintenance II (completed May 2021)

Waikīkī Beach Maintenance I

In 2012, the DLNR conducted the Waikīkī Beach Maintenance I project. Approximately 24,000 cy of sand was dredged from an offshore sand deposit near the *Canoes* and *Queens* surf breaks. Sand recovery was accomplished with the use of a Toyo DB 75B 8-inch pump with ring jet attachment suspended from an 80-ton capacity crawler crane on a barge. The average rate of sand recovery was approximately 500 cy per day. The sand discharge pipeline was an 8-inch high-density polyethylene (HDPE) pipe with a total length of 3,200 ft. Sand was pumped into a dewatering basin that was constructed in the Diamond Head (east) basin of Kūhiō Beach Park. The dewatering basin measured approximately 100 ft wide and 400 ft long. Sand was pushed into large piles with an excavator and bulldozer and then transported by dump trucks to the sand placement area on Royal Hawaiian Beach. The project widened the beach by an average of 37 ft, which aligned with the position of the shoreline in 1985. The project was completed in June 2012 (Figure 2-5 and Figure 2-6). The permits included a second nourishment effort approximately 10 years after the initial nourishment.

Beach monitoring following the 2012 Waikīkī Beach Maintenance I project showed continued erosion and beach recession at the east and west ends of the Royal Hawaiian beach sector. Habel (2016) found that beach recession ranged from 5.2 to 9.5 ft/yr at the east end fronting the beach concessions. This erosion exposed the old concrete foundation of the Waikīkī Tavern, creating a

~~hazardous condition for beach users, and has resulted in damage and flanking of the Kūhiō Beach ʻEwa (west) groin. In January 2018, the City and County of Honolulu funded construction of a temporary erosion control structure built of sand-filled geotextile mattresses to cover the tavern foundation and prevent erosion of terrigenous sediment from the backshore.~~

Waikīkī Beach Management Plan

The WBSIDA provides a unique opportunity for public-private partnerships to support policy, planning, research and scientific studies in Waikīkī Beach and the Ala Wai Canal. The WBSIDA has provided leadership, coordination and cost sharing that has improved the ability of State and local stakeholders to secure funding for beach improvement and maintenance projects in Waikīkī. The WBSIDA has also taken a lead role in facilitating, coordinating, and supporting beach improvement projects in Waikīkī.

The WBSIDA, in partnership with the University of Hawaiʻi Sea Grant Program, has developed the Waikīkī Beach Management Plan, which provides a management framework and strategies to ensure that prioritized beach improvement and maintenance projects are consistent with vision, goals, and expectations of the broader Waikīkī community. The primary goal of the plan is to improve the quality, sustainability, and stability of the public beaches and nearshore resources in Waikīkī. The Waikīkī Beach Management Plan is part of a broader environmental initiative, *Hoʻomau ʻO Waikīkī Kahakai*, which serves as a guiding principle for the community visioning process for beach management, improvement, and maintenance projects in Waikīkī.

The Waikīkī Beach Management Plan was completed in May 2018, approved by the WBSIDA Board of Directors and the Association members, and submitted to the Honolulu City Council as part of the 2017-18 Annual Report to the Council. The Waikīkī Beach Management Plan is intended to support and compliment the beach improvement and maintenance actions proposed in this ~~DPEIS~~FPEIS.

Kūhiō Sandbag Groin

Beach monitoring following the 2012 Waikīkī Beach Maintenance I project showed continued erosion and beach recession at the east and west ends of the Royal Hawaiian beach sector. Habel (2016) found that beach recession ranged from 5.2 to 9.5 ft/yr at the east end fronting the beach concessions. This erosion exposed the old concrete foundation of the Waikīkī Tavern, creating a hazardous condition for beach users, and has resulted in damage and flanking of the Kūhiō Beach ʻEwa (west) groin.

A sandbag groin was placed 140 ft west of the existing ʻEwa (west) groin of Kūhiō Beach Park. The purpose of the groin is to stabilize the east end of Royal Hawaiian Beach and cover the remnants of the concrete foundation of the Waikīkī Tavern with sand. The designed 95-ft groin length was the minimum length necessary to ensure adequate beach width to keep the concrete rubble covered. At the time of construction, the groin was extended 16 ft on the inshore end to address additional beach erosion.

The Kūhiō Sandbag Groin was completed in November 2019 (Figure 2-7 and Figure 2-8). The groin consists of 83 ElcoRock containers and 275 cy of sand to fill the containers. Each sand container holds 2.5 m^3 of sand and weighs over 10,000 lbs when full. The non-woven geotextile fabric is UV and puncture resistant, has excellent abrasion resistance, and its soft finish is attractive and non-abrasive. Approximately 750 cy of sand was excavated from Kūhiō Beach Park and placed to cover the concrete rubble and fill the cell between groins to its design shape.

The University of Hawai'i Coastal Geology Group (UHCGG) has and is continuing to conduct periodic monitoring of the Kūhiō Sandbag Groin. Initial findings based on approximately one year of survey data indicate that the groin is functioning as intended. The efficacy of the groin is evident by significant sand accumulation on the Diamond Head (east) side of the structure throughout the year, indicating that longshore sediment transport was altered as intended to mitigate extreme erosion along this section of beach. Sediment capture by the groin has not resulted in significant erosion on the 'Ewa (west) side of the structure, which would be evidenced by sediment depletion and flanking directly adjacent to the structure. Overall, one year following completion, the structural integrity and efficacy of the groin structure has been confirmed. No adverse effects of the project have been observed. No significant deficiencies with the ElcoRock sandbags and/or the overall groin performance have been observed.

Royal Hawaiian Groin Replacement

As of 2020, the original Royal Hawaiian groin was in an extremely deteriorated condition. Its failure could have destabilized 1,730 ft of sandy shoreline east of the groin in the Royal Hawaiian beach sector. The Hawai'i Department of Land and Natural Resources (DLNR) initiated design and construction of a new groin to replace the original Royal Hawaiian groin. The objective of the project was to reinforce the existing groin to stabilize the beach on the Diamond Head (east) side of the groin so that it could provide its intended recreational and aesthetic benefits. The new groin was designed to maintain the approximate beach width of the 2012 Waikīkī Beach Maintenance I project.

Replacement of the Royal Hawaiian groin was completed in August 2020 (Figure 2-9 and Figure 2-10). The new groin was constructed along the alignment of the original groin and incorporated a portion of the original groin as a core wall to prevent sand movement through the groin. The new groin is of rock rubblemound construction and incorporates a cast-in-place concrete crown wall. The new groin extends 125 ft from the seawall fronting the Sheraton Waikiki Hotel, and then angles to the southeast to create a 50-ft-long L-head, for a total crest length of 175 ft. The new groin was constructed of a single layer of keyed and fit 3,200 to 5,400 lb armor stone over 300 to 600 lb underlayer stone and 30 to 100 lb core stone.

Following stone placement, a 5-ft wide by 5-ft-thick concrete crown wall was constructed to stabilize the crest and provide a foundation should a future increase in crest elevation be necessary to accommodate sea level rise. The concrete crown wall elevation is +9 ft MSL for its first 40 ft, then transitions down to +6 ft MSL on a 1V:8H (vertical to horizontal) slope, then remains at +6 ft MSL for the remainder of its length. The stone crest elevation is +7 ft MSL for the first 40 ft and then transitions down to +4 ft MSL for the remainder of the groin length. The existing concrete block groin was reduced in elevation to a maximum elevation of +4 to +1 ft MSL to facilitate construction of the new groin. Approximately 40 ft of the original groin, beginning at about 120 ft from shore, was removed to construct the transition to the L-head portion of the new groin. The remainder of the original groin, seaward of the new groin head, was left in place. Initial observations indicate that the groin is performing its primary function to stabilize the beach on the Diamond Head (east) side of the groin. The beach in this area is currently wider than it was pre-construction, and the shoreline has naturally taken the arc-shape anticipated from the groin design.

Waikīkī Beach Maintenance II

The permits for the 2012 Waikīkī Beach Maintenance I project authorized a second nourishment effort to be performed within 10 years. The project consisted of recovery of approximately 20,000 cy of sand from the same offshore sand deposit that was used in the 2012 project. Sand was pumped into a dewatering basin in the Diamond Head (east) basin of Kūhiō Beach Park. The dewatering basin was approximately 100 ft wide and 300 ft long. Sand was pushed into large piles with an excavator and bulldozer and then transported by dump trucks to the sand placement area on Royal Hawaiian Beach. The project was completed in May 2021 (Figure 2-11 and Figure 2-12).

Related Projects in The Area

Queen's Surf Seawall Repairs

The City and County of Honolulu recently performed improvements to the deteriorated seawall fronting the Queen's beach sector. The seawall was deteriorated and had been damaged by wave action. A Final Environmental Assessment (FEA) for the proposed action was published on December 8, 2017, and the repairs were performed in 2021.

Waikīkī Natatorium War Memorial Complex

The City and County of Honolulu is proposing to rehabilitate the deteriorated Waikīkī Natatorium War Memorial Complex (WMMC) in the Kapiʻolani beach sector The proposed plan consists of demolishing the submerged structures and reconstructing the deck on support piles to allow free flow of water between the ocean and a swim basin. A Final Environmental Impact Statement (FEIS) for the proposed action was approved on November 23, 2019.

Waikīkī Resilience & Sea Level Rise Adaptation Project

The State of Hawaiʻi Department of Business, Development, Economics & Tourism (DBEDT) Office of Planning & Sustainable Development (OPSD) is currently partnering with the University of Hawaiʻi College of Architecture, Community Design Center and the Hawaiʻi Sea Grant Program on the Waikīkī Resilience & Sea Level Rise Adaptation Project (WRAP). The objective of the WRAP project is to develop a framework for a future Waikīkī adaptation and resilience plan that addresses the projected impacts of climate change and sea level rise in the Waikīkī Special District and beyond (UHCDC, 2024).

Adapt Waikīkī 2050

The City and County of Honolulu Department of Planning and Permitting recently initiated the Adapt Waikīkī 2050 project to develop a climate adaptation plan for the Waikīkī Special District. The objective of the project is to engage stakeholders, envision scenarios, and identify recommendations to increase resilience in the Waikīkī Special District over the next 30 years (City and County of Honolulu, 2024).

These projects are not directly related to the Waikīkī Beach Improvement and Maintenance Program as they are located outside of the project area and are not intended to improve the condition of the beaches or improve lateral shoreline access. These projects are not anticipated to have any direct or secondary effects on the actions proposed in this ~~DPEIS~~FPEIS.

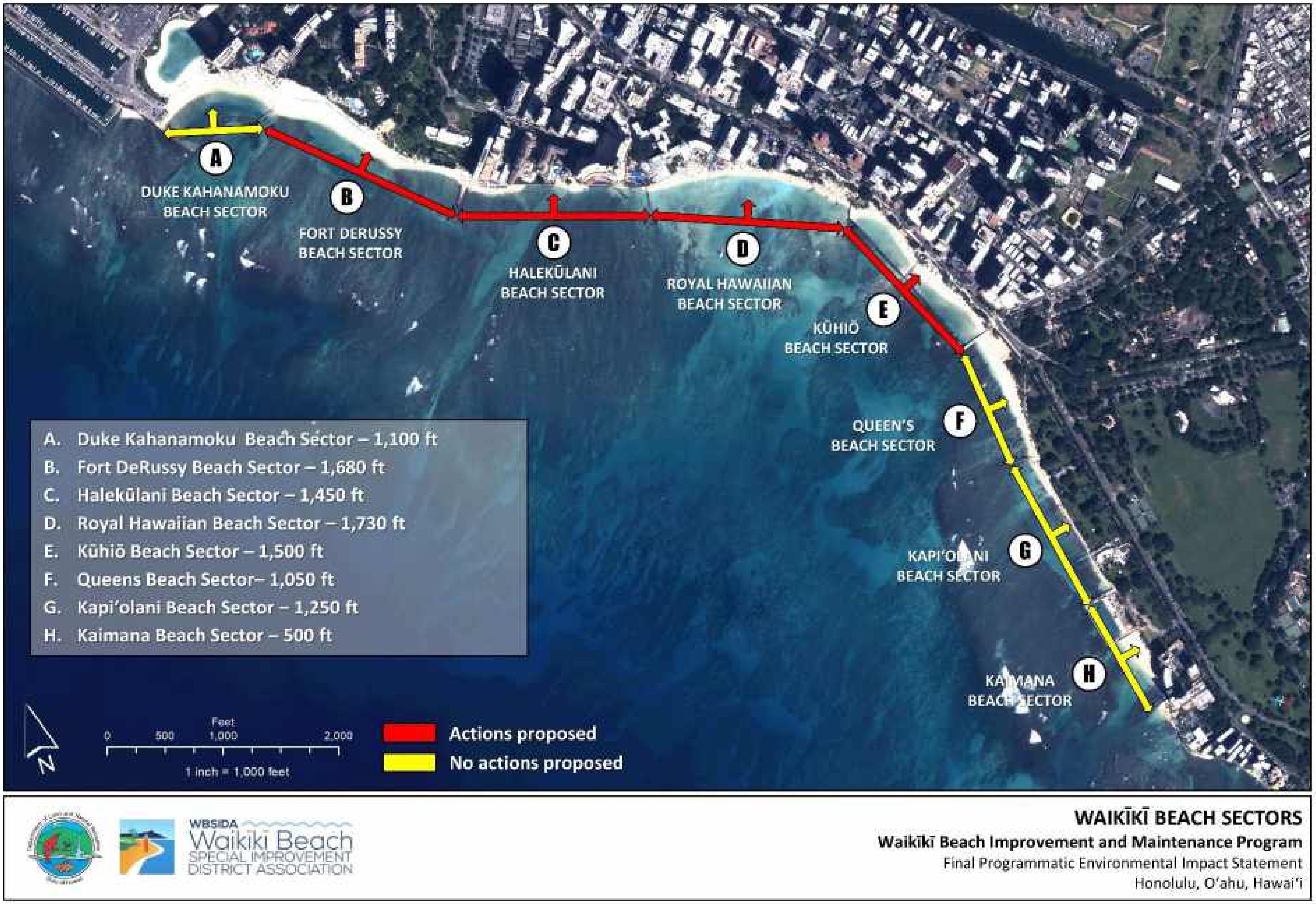


Figure 2-3 Waikīkī beach sectors

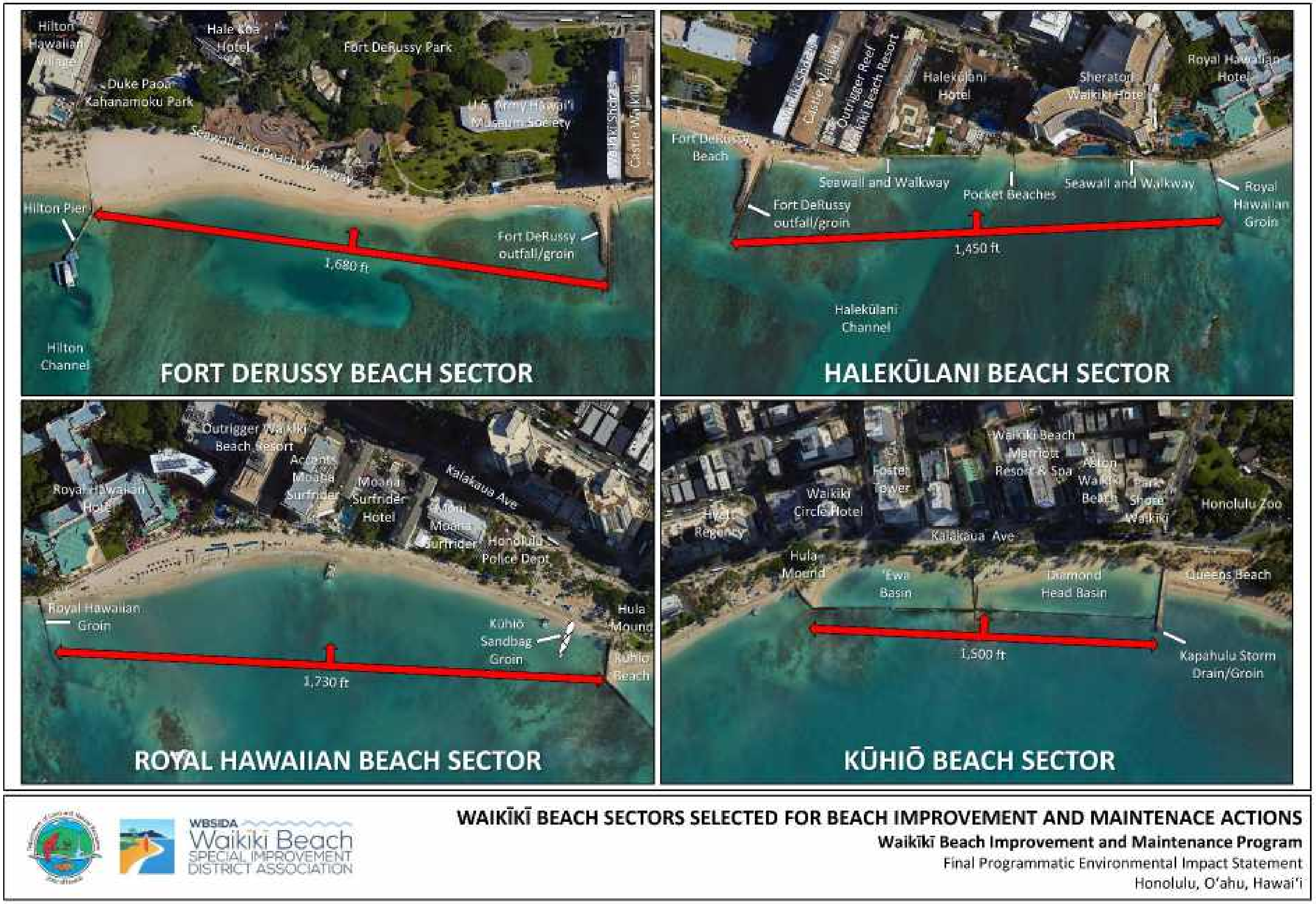


Figure 2-4 Waikīkī beach sectors selected for improvement and maintenance actions

Figure 2-5 Conditions before Waikīkī Beach Maintenance I (Sep 2009)

Figure 2-6 Conditions after Waikīkī Beach Maintenance I (Nov 2019)

Figure 2-7 Conditions before construction of Kūhiō Sandbag Groin (Nov 2017)

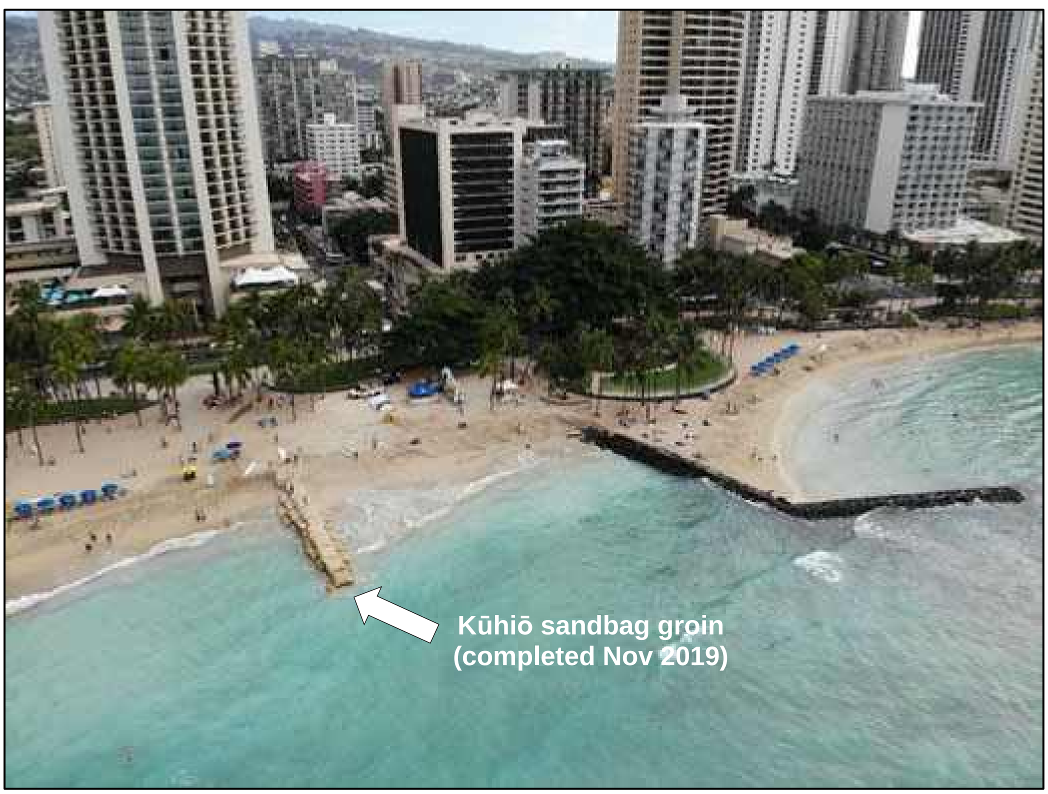


Figure 2-8 Conditions after construction of Kūhiō Sandbag Groin (Nov 2019)

Figure 2-9 Conditions before reconstruction of Royal Hawaiian groin (May 2020)

Figure 2-10 Conditions after reconstruction of Royal Hawaiian groin (August 2021)

Figure 2-11 Conditions before Waikīkī Beach Maintenance II (May 1, 2021)

Figure 2-12 Conditions after Waikīkī Beach Maintenance II (May 5, 2021)

3. SUMMARY OF PROPOSED ACTIONS

3.1 Introduction

The DLNR is proposing beach improvement and maintenance actions in four beach sectors in Waikīkī – Fort DeRussy Beach, Halekūlani Beach, Royal Hawaiian Beach, and Kūhiō Beach. These beach sectors were selected based on the issues and priorities established by the WBCAC. Beach improvements or maintenance actions are not being proposed at this time for the other beach sectors – Duke Kahanamoku Beach, Queen's Beach, Kapiʻolani Beach, and Kaimana Beach. This chapter provides information on the primary planning and design considerations involved in formulating the proposed actions and summarizes the improvements being proposed.

3.2 Planning and Design Considerations

The following general planning and design considerations for the proposed beach improvement and maintenance actions were developed in collaboration with the DLNR, the WBSIDA, and the WBCAC:

- Actions are designed to increase beach stability and sand retention.
- Actions are designed to increase the resilience and sustainability of the Waikīkī shoreline.
- A primary design consideration is predicted future sea level rise and the associated increasing rates of beach erosion and increasing frequency and severity of coastal flooding.
- Initial design of beach improvements, and stabilizing structures, should consider sea level rise projections through the year 2060, with provisions for extending their functional life until 2080. Assuming improvements are constructed by about 2030 this would give them an approximately 50-year functional life.
- Improvements are programmatic in nature and together form an overall plan to restore and maintain the Waikīkī shoreline for approximately 50 years.
- Improvements may be implemented concurrently or sequentially and be scaled and/or adapted based on changing conditions.
- Improvements must be stakeholder driven and support or improve the widest possible array of existing and future uses.
- Existing beach and ocean-based recreational activities shall be preserved or improved to the maximum extent practicable.

3.3 Anticipated Project Lifespans

Consideration of sea level rise is a key component in the design of coastal structures today. Sea level rise affects nearshore water depths, and the design wave height for rock rubblemound structure stability is a direct function of the water depth (i.e., the deeper the water the larger the possible wave height). Wave runup on the beach is also a direct function of the incident wave height. As sea levels continue to rise, the magnitude and frequency of erosion and flooding will increase with increasing water levels and wave energy at the shoreline, beaches will become narrower and more submerged, and low-lying shoreline areas will be inundated more frequently.

The proposed actions will be designed for a nominal 50-year lifespan, assuming maintenance is conducted when necessary.

~~For discussion purposes in this DPEIS, *beach maintenance* refers to actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. Beach maintenance options include beach nourishment, sand backpassing, sand pushing, and sand pumping.~~

This ~~DPEIS~~FPEIS proposes beach maintenance actions in ~~two~~ three sectors of Waikīkī:

- Fort DeRussy Beach Sector – Small-scale Beach Nourishment and Periodic Sand Backpassing
- Royal Hawaiian Beach Sector – Beach Nourishment without Stabilizing Structures
- Kūhiō Beach Sector: Diamond Head (east) Basin – Sand Pumping

The proposed beach maintenance actions are intended to be implemented periodically on an as-needed basis. Beach maintenance would be conducted when beach conditions reach some pre-defined topographic triggers. Beach monitoring would be required to determine when the triggers have been met. The proposed beach maintenance actions may be adapted as sea levels continue to rise.

~~For discussion purposes in this DPEIS, *beach improvements* refer to actions that involve adding new sand, constructing new structures, and/or modifying existing structures. Beach improvement options include beach nourishment with stabilizing groins, segmented breakwaters, and modifications to existing structures.~~

This ~~DPEIS~~FPEIS proposes beach improvement actions in two beach sectors of Waikīkī:

- Halekūlani Beach Sector – Beach Nourishment with Stabilizing Groins
- Kūhiō Beach Sector: ʻEwa (west) Basin – Beach Nourishment with Modified Groins and a Segmented Breakwater

The proposed beach improvement actions are designed based on the most recent sea level rise predictions by the National Oceanic and Atmospheric Administration (~~NOAA, 2017~~Sweet et al. 2022). Assuming construction is completed by 2030, the NOAA sea level rise predictions for Honolulu 30 and 50 years later are shown in Table 3-1.

Table 3-1 NOAA sea level rise projections (in ft, relative to MSL) for Honolulu, Hawaiʻi

Year	Low	Intermediate-Low	Intermediate	Intermediate-High	High
2060	~~0.8~~0.79	1.06	~~1.7~~1.38	1.94	~~3.4~~2.47
2080	~~1.0~~1.02	1.52	~~2.7~~2.34	3.78	~~5.8~~4.96

The proposed beach improvement actions are designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the projects could be effective until about the year 2080, or 50-years post-construction. It is important to note that sea level rise projections continue to evolve as new and improved sea level and climate change research becomes available. It is also important to recognize that global sea level rise will not stop within these timeframes but will very likely continue for centuries.

3.4 Anticipated Project Phasing

The Waikīkī Beach Improvement and Maintenance Program consists of five (5) individual actions (projects) that are intended to be implemented in phases. The timing and sequencing for project implementation has yet to be determined and will be dependent on stakeholder feedback and availability of funding. The objective of the Program is to complete all of the proposed actions within approximately one decade and to sequence the projects in a manner that will minimize and isolate disruptions to specific areas for discrete periods of time. This approach will also help to minimize and distribute the cumulative impacts of the proposed actions.

~~3.4~~3.5 Alternatives Considered

The primary objectives of the proposed beach improvement and maintenance actions are to:

- Restore and improve the beaches of Waikīkī
- Increase beach stability through improvement and maintenance of shoreline structures
- Provide safe access to and along the shoreline
- Increase resilience to coastal hazards and sea level rise

To achieve these objectives, the following alternatives were considered:

- No Action
- Managed Retreat
- Beach Maintenance
- Beach Nourishment without Stabilizing Structures
- Beach Nourishment with Stabilizing Structures

~~3.4.1~~3.5.1 No Action

The No Action alternative would consist of not implementing the proposed actions and allowing the beaches to migrate and erode naturally. No Action could occur if 1) the ~~DPEIS~~FPEIS is withdrawn by the applicant, 2) the FPEIS is denied by the approving authority, or 3) the FPEIS is accepted by the approving authority, but the applicant is unable to obtain the necessary funding and approvals to implement the proposed actions.

Without the proposed actions, existing shoreline processes would continue, and the beaches would continue to erode. This would result in a continued decrease in usable dry beach area and substantial economic losses. Based on historical and projected erosion rates, the narrower portions of the beaches (e.g., the east ends of the Fort DeRussy and Royal Hawaiian beach sectors) can be expected to be completely gone in 15 to 30 years, with total beach loss occurring before the end of the century. The majority of the backshore area (landward of the beach) is completely developed and is protected by old seawalls, many of which are currently buried by sand. As the beaches continue to erode, the erosion can be expected to begin to expose these seawalls, which will exacerbate the erosion problem due to wave impacts and reflection and could result in wall damage and the need for repair, modification, or replacement of the structures to protect backshore land and infrastructure.

The existing beach and offshore sand deposits have a negligible effect on coastal water quality. During periods of high surf there is typically a general increase in nearshore turbidity due to the suspension of fine bottom material by wave action, and this can be expected to continue with or without the proposed actions. Thus, the No Action alternative would be expected to have no significant effect on existing water quality in the project area.

No Action would also have a negligible effect on the nearshore biological environment. Not implementing the proposed actions would simply result in the continued deterioration of the marine biological environment in Waikīkī, and the potential continued growth of invasive algae. In the same way, No Action would have a negligible effect on marine protected species, or historic, cultural, and archaeological resources.

No Action will ultimately have a very significant impact on beach-related recreation. The diminishing beach area will severely limit sunbathing, decrease access for swimming, surfing, paddling and other ocean-based recreation activities, and reduce commercial recreational opportunities for the beach concessions, catamarans, and adjacent hotels and resorts.

The socioeconomic impacts resulting from the loss of Waikīkī Beach would be substantial. In 2008, the Waikīkī Improvement Association commissioned Hospitality Advisors, LLC to conduct an economic impact analysis of the effect of the complete erosion of Waikīkī Beach (Hospitality Advisors, 2008). A summary of the study results are as follows.

Waikīkī Beach is recognized as a major tourism destination in Hawai'i, as well as a popular recreational spot for visitors and residents. On average, there are 25,600 hotel rooms available in Waikīkī on a daily basis, 87% of the total hotel supply on O'ahu. Anthology Group (2019) reported that 48.9% of O'ahu visitors participate in snorkeling activities, 68% participate in swimming activities, and 84% participate in beach and sunbathing activities. More than one-third of westbound (e.g., mainland) and Japanese visitors cited beach or swimming as their primary reason for staying in Waikīkī. The top four planned activities for both westbound and Japanese visitors were swimming, sunbathing, surfing and snorkeling. An overwhelming majority, 76% to 79%, of all visitors consider beach availability to be very important. When presented with the possibility of the complete erosion of Waikīkī Beach, 58% of all westbound visitors and 14% of Japanese visitors said they would not consider staying in Waikīkī without the beach.

There has been substantial recent capital investment to ensure that Waikīkī remains competitive as a visitor destination; examples include the Outrigger Waikīkī Beach Walk and Starwood property renovations/upgrades (Sheraton Waikiki Hotel, Royal Hawaiian Hotel, and the Moana Surfrider Hotel). The loss of Waikīkī Beach would result in significant socioeconomic losses to the State of Hawai'i. Tarui et al. (2018) found that complete erosion of Waikīkī Beach would result in a loss of approximately $2.223 billion in annual visitor expenditures.

3.4.23.5.2 Managed Retreat

Managed retreat is a coastal management strategy that focuses on strategic relocation of existing and new development away from the shoreline and out of vulnerable areas and is intended to allow the shoreline to naturally move inland rather than fixing the shoreline with engineered shore protection structures. Managed retreat in a heavily developed urban area, like Waikīkī, will likely require a phased approach that may be implemented over the course of several decades. This will require extensive planning and coordination between government agencies, the community, affected landowners, major resorts, and the general public.

The proposed beach improvement and maintenance actions focus on interim solutions to allow sufficient time for long-term sea-level rise adaptation plans to be developed and implemented. These long-term plans may include strategic retreat of Waikīkī's resort infrastructure away from the shoreline or a combination of strategies such as continued beach restoration combined with incremental movement of structures and facilities away from the shoreline triggered by recurring erosion and flooding impacts and/or coinciding with permitting for planned improvements to individual properties.

From the perspective of adapting a densely developed resort community, like Waikīkī, the discussion of alternatives is based on conservation and preservation of the beaches in the near to mid-term while longer-term adaptation plans and supporting government policies and programs are developed to address relocation of vulnerable development landward of the shoreline.

Managed retreat is a long-term process focused on large scale development of the terrestrial area landward the shoreline, whereas the proposed beach improvement and maintenance actions are interim solutions that focus on management of a natural environmental and public resource. Managed retreat in Waikīkī would consist of a long-term planning, legal, financial, political, land use, and regulatory process that should be coordinated and guided by the appropriate agencies, driven by community engagement, and facilitated by landowner participation.

The report, *Assessing the Feasibility and Implications of Managed Retreat Strategies for Vulnerable Coastal Areas in Hawaiʻi* (Hawaiʻi Office of PlanningOPSD, 2019) presented next steps for the State of Hawaiʻi to develop a managed retreat plan. The report states that "… to have a cogent and comprehensive retreat plan, it requires long-range planning, legal changes, funding, and some level of community agreement, understanding and support for retreat." The report also noted that retreat from chronic coastal hazards (e.g., erosion and sea level rise) can be incremental and may take decades to complete. Based on these findings, the report suggests the following next steps to develop a statewide managed retreat plan:

- Determine the feasibility and implication of additional managed retreat tools.
- Establish criteria for areas to be retreated and priority list(s).
- Identify funding to retreat areas and review tax implications of retreat.
- Review State and County land uses to determine where it may be possible to retreat to.
- Review State and County plans to determine where they may be amended or updated or both to support retreat.
- Review laws and regulations that may have to be amended or adopted or both to facilitate retreat at the State or County or both levels.

- Engage in outreach to the communities to obtain their input and buy-in for retreat strategies to be adopted.

Until managed retreat policies, regulations, tools, and programs are in place to implement managed retreat in a heavily developed urban community like Waikīkī, other appropriate solutions should be considered. The proposed beach improvement and maintenance actions are interim solutions and will not preclude the implementation of other sea level rise adaptation strategies in Waikīkī. The proposed beach improvement and maintenance actions will help to maintain the economic, social, cultural, environmental, and recreational value of Waikīkī, while providing a protective buffer to reduce impacts from erosion and flooding. The multi-decadal process of planning for and implementing managed retreat should not preclude the State of Hawaiʻi fulfilling its responsibility for overseeing beaches and submerged lands out to the seaward extent of the State's jurisdiction and, where feasible, conserve and enhance beach resources and shoreline public access.

<u>Managed retreat should be part of the community development planning process.</u>
Managed retreat will likely require substantial redevelopment or relocation of the major resorts that currently operate along Waikīkī Beach. Relocation at this scale would, at a minimum, require substantial redevelopment of approximately 120 acres of land between Kalākaua Avenue and the shoreline, affecting over 65 public and private landowners and resorts, as well as the economies of the City and County of Honolulu and the State of Hawaiʻi. A project of this magnitude would fundamentally alter nearly every aspect of the natural and built environments, and the appearance and character of the Waikīkī community as it exists today.

Managed retreat plans should be developed in coordination and collaboration with State and County agencies, the community, existing landowners, and other stakeholders that would be affected. Ideally, managed retreat would be initially evaluated as part of the Community Development Planning (CDP) process, which is coordinated by the City and County of Honolulu. Waikīkī is part of the Primary Urban Center Development Plan, which is currently in the process of being updated and may provide an opportunity for a more in-depth analysis of managed retreat options for Waikīkī.

<u>The geographic scale of managed retreat is disproportionately larger than the proposed actions.</u>
The beaches of Waikīkī are a Public Trust resource and occupy approximately 12 acres of submerged land seaward of the shoreline, whereas the terrestrial area occupies approximately 120 acres of fast land between Kalākaua Avenue and the shoreline. Thus, the geographic scale of managed retreat at Waikīkī is 10 times greater than the proposed beach improvement and maintenance program, affects over 65 public and private landowners and resorts, and would require substantial redevelopment of a substantial portion of Waikīkī.

<u>Current retreat options within existing regulations.</u>
Managed retreat for individual land uses would involve modification, relocation, or removal of existing structures to reduce hazard exposure and maintain a natural shoreline. Shoreline setbacks are an existing regulation that requires development to be set back a minimum distance from the shoreline, creating a buffer zone that reduces the potential for shorefront development to be exposed to erosion and flooding. The City and County of Honolulu requires shoreline setbacks

for new development (and redevelopment) along the shoreline. The purpose of the shoreline setback area is to protect and preserve the natural shoreline, lateral shoreline access, and open space along the shoreline while minimizing exposure of the built environment to coastal hazards.

Setbacks for development in the backshore are calculated and implemented during the County permitting process, prior to construction. These setbacks are calculated based on the location of a certified shoreline. A certified shoreline will be completed as part of the permit process prior to the proposed beach improvement and maintenance actions, establishing a pre-construction baseline for shoreline setback calculations. The proposed beach improvement and maintenance actions will not move the certified shoreline or the shoreline setback area further seaward. Setback requirements based on certified shorelines will continue to be applied in Waikīkī, regardless of implementation of the proposed actions.

The proposed beach improvement and maintenance actions will increase recreational dry beach area and stability, reducing the impacts of erosion for the coming years to decades; however, the certified shoreline location will be based on current conditions. This provides the double benefit of mitigating the negative impacts of erosion while maintaining the existing shoreline location for setback determinations for any potential future development projects in the area.

Managed retreat is not the only option to adapt to sea level rise.

Managed retreat is an example of an adaptation strategy, which is one of three primary strategies for developed coastal areas – along with protection and accommodation – to respond to sea-level rise. It is not the only option, and the other options may be assessed for implementation as stand-alone approaches or as a combination of two or more approaches to address local needs and in consideration of feasibility. Beach nourishment is considered a nature-based adaptation strategy and, like any coastal management strategy, has tradeoffs and limitations. However, beach nourishment has proven to be a cost-effective strategy for maintaining beaches (Porro, 2020). While periodic nourishment efforts may be required, the economic, social, cultural, and environmental impacts of beach restoration are low compared to the impacts and costs associated with continued beach erosion given the economic significance of Waikīkī Beach to the economies of the City and County of Honolulu and the State of Hawaiʻi, and the environmental impacts of materials and structures encroaching and collapsing onto the beach with ongoing, unmitigated shoreline erosion.

The timeline for managed retreat is disproportionately longer than beach restoration.

Managed retreat should be evaluated through long-range planning beginning with the community planning process. One suitable venue for assessment, community input, and prioritization of managed retreat could be the Primary Urban Center Development Plan, which is in the process of being updated. It will take decades to envision, plan, fund, and implement a managed retreat plan for Waikīkī and the community planning provides an appropriate multi-decadal planning outlook. Beach restoration can be completed in a matter of years as an iterative, interim mitigation and adaptation measure. Multiple beach restoration efforts, nature-based sea-level rise adaptation measures, could be completed in the time it will take to implement a comprehensive and holistic managed retreat plan at Waikīkī. Moreover, beach restoration can be an integral step in a broader and more inclusive managed retreat plan, providing a nature-based solution and allowing additional time for other sea-level rise adaptation measures on a coastline.

~~3.4.3~~3.5.3 Beach Maintenance

Beach maintenance refers to actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. Beach maintenance options include sand backpassing, sand pushing, sand pumping, and beach nourishment without stabilizing structures.

Sand Pushing

Sand pushing is a beach maintenance strategy that typically involves moving sand from the lower beach face to the upper beach to restore an eroded beach profile and reduce exposure of the backshore to wave action. Sand pushing has been a successful beach maintenance strategy at various beaches throughout Hawaiʻi. An example of a sand pushing project at Sunset Beach, Oʻahu, is shown in Figure 3-1. Agencies are generally supportive of sand pushing as a beach maintenance strategy on a case-by-case basis with conditions and limitations to prevent potential impacts to adjacent shorelines and properties. Authorizations for sand pushing are typically limited to the beach immediately fronting the adjacent property or properties.

Figure 3-1 Sand pushing at Sunset Beach, Oʻahu (2014)

While sand pushing may temporarily restore the beach profile, the pushed sand would be expected to mobilize and move alongshore and offshore. The construction process is relatively timely and efficient and is often the least expensive alternative for beach maintenance. However, sand pushing would be disruptive to beach users and commercial operations, and the cumulative costs for recurring sand pushing efforts could be substantial. Sand pushing could be performed routinely when a sufficient volume of sand is present along the shoreline. Sand pushing may provide a temporary increase in dry beach volume and elevation and may provide some temporary relief from erosion and wave runup; however, the sand is likely to mobilized by natural processes, and ongoing seasonal or chronic erosion and beach loss is likely to continue.

Sand Backpassing

Sand backpassing involves recovering sand from portions of a beach where sand has accreted and placing it in areas that are subject to erosion and beach loss. Sand backpassing counters the natural longshore movement of sand and can be an effective beach maintenance strategy in areas with dominant seasonal or long-term erosion and sand transport in a particular direction along the shoreline and a surplus of sand accumulating in the area of accretion. For sand backpassing to be feasible in Waikīkī, an adequate volume of sand would need to be available from another area within the same beach sector. This is unlikely as most of the beaches in Waikīkī are experiencing erosion. Similar to sand pushing, the construction process for sand backpassing is relatively straightforward but would be temporarily disruptive to beach users and commercial operations, and the cumulative costs for recurring sand backpassing efforts could be substantial. Sand backpassing may provide a temporary increase in beach volume and width and may provide some temporary relief from erosion; however, without the addition of stabilizing structures, the sand is likely to mobilize, and erosion and beach loss is likely to continue and accelerate as sea levels continue to rise.

Sand Pumping

Sand pumping involves recovering sand from the nearshore waters and placing it on the beach. Sand pumping counters the natural cross-shore (seaward) movement of sand and can be an effective beach maintenance strategy in areas where eroded sand is accumulating in shallow submerged areas adjacent to the dry beach. There are three options for sand pumping in Waikīkī: 1) suction dredge, 2) floating platform dredge, or 3) diver-operated dredge.

A small suction dredge could be used to recover limited volumes of sand from shallow nearshore deposits adjacent to the dry beach. A Piranha PS165-E suction dredge would be capable of recovering about 60 to 100 cubic yards of sand per day. This operation would be conducted on an as-needed basis to restore the beach profile. Sand slurry would be impounded within small dewatering basins trenched into the upper beach face and located entirely above the mean higher high water (mhhw) line. The purpose of the dewatering basins is to allow the water portion of the sand slurry to percolate through the sandy beach substrate, which acts as a natural filter. After the water has percolated from the basins, the dewatered sediment would be distributed across the adjacent beach face. A small Bobcat loader would be used to push sand from the lower beach face (above mhhw) to the upper beach face. A small berm would be created along the back beach to maximize the volume of sand on the upper beach profile. Figure 3-2 shows an example of a small-scale suction dredging operation at Koʻolina, Oʻahu.

Another alternative for sand pumping is a floating platform dredge or submersible diver-operated dredge. An Eddy Pump© diver operated dredge is a mobile system that is fully submersible and designed for pumping production rates of approximately 50 to 100 cy of material per hour. The system can be powered electrically or hydraulically. A single system can allow up to three suction hoses and divers to operate simultaneously. Suction hoses are 200 ft long with a maximum pumping distance of 2,500 ft.

Sand pumping is a maintenance activity that could be performed periodically on an as-needed basis when sand is available, and the dry beach is narrowed beyond a predetermined threshold. The construction process would be more time-consuming than sand pushing or sand backpassing, which would be more disruptive to beach users and commercial operations.

Given the recurring costs for periodic maintenance, sand pumping would likely be the most expensive alternative for beach maintenance in Waikīkī. Sand pumping may provide a temporary increase in beach volume and width and may provide some temporary relief from erosion; however, without the addition of stabilizing structures, the sand is likely to mobilize, and erosion and beach loss is likely to continue and accelerate as sea levels continue to rise.

Figure 3-2 Sand pumping at Koʻolina, Oʻahu (2017)

~~3.4.4~~3.5.4 Beach Nourishment without Stabilizing Structures

Beach nourishment typically involves placement of beach fill to specified design profiles. Beach nourishment is intended to augment the natural morphology of the beach to offset the effects of chronic, seasonal, or episodic erosion. Agencies are generally supportive of beach nourishment because it has minimal environmental impacts and is consistent with City and State policies that seek to preserve and enhance beach resources. An example of a small-scale beach restoration project at Sugar Cove (Pā'ia, Maui, Hawaiʻi), is shown in Figure 3-3.

The Hawaiʻi Department of Land and Natural Resources, Office of Conservation and Coastal Lands (DLNR-OCCL) authorizes beach nourishment projects through the Small-Scale Beach Nourishment (SSBN) program, which allows placement of compatible beach quality sand makai (seaward) of the shoreline in the State Conservation District. There are two categories of SSBN permits: Category I (up to 500 cy of sand), and Category II (up to 10,000 cy of sand). A Category I SSBN may provide sufficient volume to temporarily increase beach width over relatively small reaches of the shoreline; however, restoring beach width for an entire beach sector would require a Category II SSBN. Large-scale beach nourishment projects, such as those being proposed in the Halekūlani, Royal Hawaiian, and Kūhiō beach sectors, are beyond the scope of the existing SSBN program. The DLNR is in the process of updating the SSBN program through a statewide Programmatic Environmental Assessment (PEA). The new program will be referred to as the Small Scale Beach Restoration (SSBR) program.

Figure 3-3 Small-scale beach restoration at Pā'ia, Maui (2016)

3.4.53.5.5 Beach Nourishment with Stabilizing Structures

Ongoing erosion can limit the effectiveness of beach nourishment projects. Without additional mitigative measures, rates of pre-project beach erosion should be expected to continue following a beach nourishment project. Some areas have natural features such as headlands, embayments, or reefs that disrupt sediment transport and naturally stabilize the sand. In some cases, engineered beach stabilizing structures that mimic these natural features, such as T-head groins, can be constructed to maintain a stable beach. T-head groins decrease and reorient the amount of wave energy reaching the beach and create artificial littoral cells to stabilize the sand. An example of regional beach nourishment with stabilizing T-head groin structures is shown in Figure 3-4.

The knowledge gained from studying natural crenulate-shaped bays provides a design tool for coastal engineers to produce stable sandy shorelines. Silvester and Hsu (1993) present methods for determining the stable beach planform adjacent to rocky headlands, thus facilitating the engineering use of artificial headlands as beach stabilizing structures. Whereas natural beaches obtain a stable shape in response to the wave climate and headland orientation, beaches can also be stabilized by engineering artificial headlands with positions and orientations that produce the desired beach shape.

Figure 3-4 Beach nourishment with T-head groins at Iroquois Point, O‘ahu

Klein et al (2003) proposed methods for using locations of upcoast and downcoast control points, along with incident wave angle, to approximate the stable shoreline position for an embayed beach. Bodge (2003) proposed the use of T-head groins as artificial headlands to produce stable beaches, an approach that has been implemented successfully on numerous beaches in Florida and the Caribbean (Bodge, 1998), and more recently at Iroquois Point on O‘ahu (Figure 3-4).

A schematic of the components of a tuned T-head groin system is presented as Figure 3-5. The heads of the T-groins can be aligned (tuned) according to the prevailing wave crest orientation to produce the desired beach configuration. Rubblemound T-head groins are recommended to reduce rip currents, wave reflection, and the loss of sand via cross-shore transport. The beach should be nourished with sand to achieve the predicted shoreline shape. According to Bodge (1998), tuned structures work well when the erosion is so severe that renourishment would be too frequent to be economical or practical, or when the shoreline is no longer conducive to having beaches, such as along hardened shorelines.

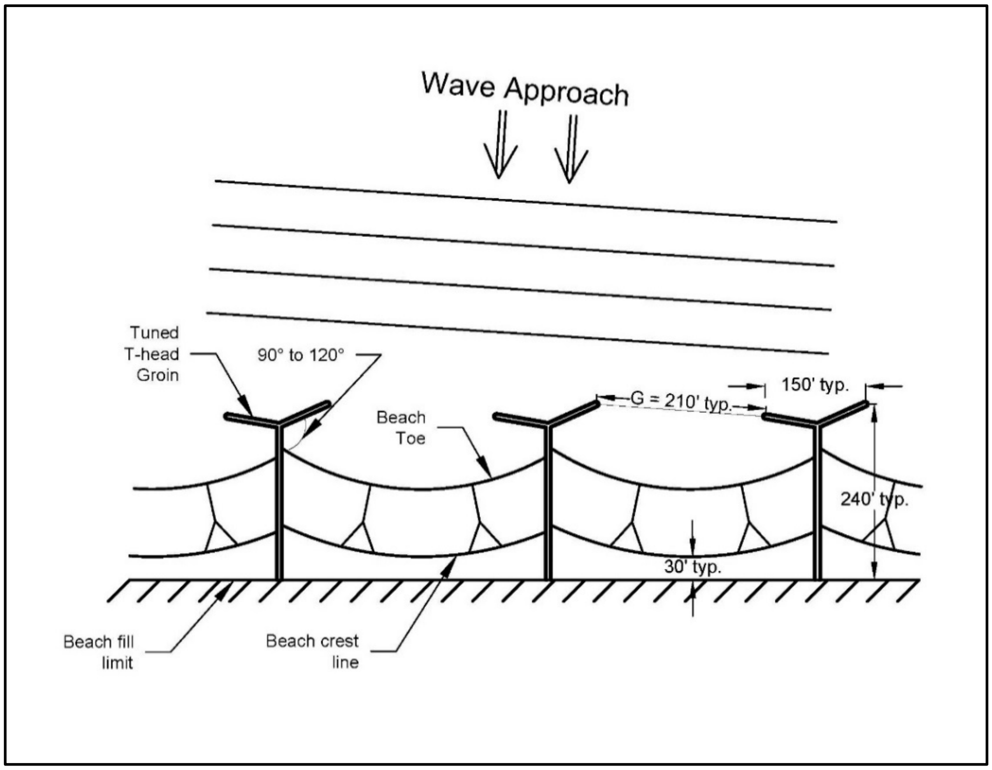


Figure 3-5 Schematic of a typical tuned T-head groin system

Key design parameters for T-head groin design include groin length, head length and orientation, armor stone sizing, and desired beach shape and width. In general, the beach shape responds more to the gap width (opening) between the groin heads than it does to the structure heads themselves. Thus, the stable beach is a function of the length and orientation of the gaps. Orientation of the gaps is primarily dictated by the shape of the shoreline and the prevailing direction of wave approach.

The groin layout and head angles should be oriented such that the gap opening is approximately parallel with the average prevailing wave crest. This "tuning" of the heads helps to ensure the predictability of the beach shape and yields greater shoreline stability within the beach cell. In many cases, it is not possible to achieve a perfect match between gap orientation and incident wave crest, because of the directional variability of waves approaching the shoreline. In practice, this difference should be no more than 25 deg, and differences of up to 15 deg have been consistently shown to produce a stable beach (Bodge, 2012).

The beach design process includes establishing the desired physical characteristics of the beach, and then applying coastal engineering analysis to orient structures to achieve the desired beach planform. Deviation of the gaps from parallel with the wave crests will result in a less uniform beach in the planform view, and wave modeling may be necessary to approximate the stable beach configuration. Physical beach characteristics include crest height, dry beach width, beach slope, and sand grain size. Standard methodology typically involves trying to match adjacent beach characteristics because this indicates what is naturally stable for local conditions and it is aesthetically more pleasing to match the adjacent beach.

The empirical relationships show that the mean low water (low tide) shoreline will be located between one-third and two-thirds of the gap length (*G*) behind the groin head (i.e., 0.35*G* to 0.65*G*). Larger values in this range are appropriate for 1) energetic open coasts that are directly exposed to wave action, 2) larger gap widths, 3) larger angles between the wave approach and the gap orientation, 4) reduced beach fill sand compatibility, and 5) a higher degree of conservatism. The groin head lengths should be long enough so that the mean low water shoreline approaches the groin head, while maintaining a minimum ratio of gap width to head width of about 60:40 for aesthetic reasons so that the groins do not dominate the viewplanes.

The groin stems should extend landward of the design beach crest to mitigate flanking and loss of sand from the cell around the back of the groin. The groin crest elevation should be above the high tide elevation and high enough to prevent significant overtopping during prevailing (non-storm) water levels and wave conditions. Experience at Iroquois Point, Oʻahu suggests that a stable beach crest elevation would be approximately +8 to +9 ft MLLW, and the beach foreshore slope would be approximately 1V:8H (vertical to horizontal).

3.53.6 Sand Sources

3.5.13.6.1 Introduction

A key component to the success of the proposed actions is the availability of a suitable sand source to support beach nourishment. The majority of Hawaii's beaches are composed of calcareous (calcium carbonate) sand, which is primarily composed of skeletal fragments of marine organisms such as corals, coralline algae, mollusks, echinoids, forams, with minor fractions of terrigenous (i.e., volcanic) sediment. The composition of sand is determined by the relative abundance of each contributing material and varies by location. The density of calcium carbonate is more than 2.7 g/cm^3; however, microscopic pores and hollow grains make the effective density somewhat lower. The density and shape of the individual particles affects the transport characteristics when compared to silica beach sand that is derived from inland sources characteristic of most beaches on continental U.S. coastlines (Smith and Cheung, 2003).

In the past, sand for beach nourishment was typically obtained from other beaches on Oʻahu and Molokaʻi or from inland deposits of relict beach and dune sands that were commercially available. Mokulēʻia sand, previously mined by Hawaiian Cement, was a high-quality relict beach sand deposit located several hundred meters inland of the beach on the North Shore of Oʻahu. Mokulēʻia sand is moderately sorted, and the median grain size (D_{50}) is 0.60 mm. This sand has reportedly been used for beach nourishment projects at the Hilton Hawaiian Village and Kūhiō Beach but is no longer commercially available.

Maui dune sand was previously mined by Hawaiian Cement and HC&D (formerly Ameron). Class A Maui dune sand is a fine-to-medium grain sand with a median grain size (D_{50}) of 0.25 mm. The sand contains a relatively high percentage of fines, contains terrigenous sediment (dirt), and has a medium to dark brown color. Class A Maui dune sand has been used in previous beach nourishment projects on Maui but has never been used on Oʻahu. In 2017, the County of Maui placed a moratorium on mining of inland dune sand, so this sand is no longer commercially available.

Imported sand has been commercially available for many years to support various industries including but not limited to construction, landscaping, and golf courses. These sands are often composed of quartz minerals and can be ordered to desired sand composition, grain size, density, texture, angularity and color specifications. However, the use of imported sand from outside Hawaiʻi that is not composed of calcium carbonate does not comply with State of Hawaiʻi standards and guidelines for beach nourishment projects.

Offshore marine deposits present an alternative source of sand. These deposits have been dredged and transported to shore to support various beach nourishment projects in Hawaiʻi. Offshore sand deposits occurring within the same beach sector or littoral cell can often have grain size characteristics and composition that are similar to the adjacent beach sand. Offshore sands were utilized in the 2006 Kūhiō Beach Nourishment project, and the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively.

3.5.23.6.2 Sand Characteristics and Quality

The State of Hawaiʻi Department of Land and Natural Resources (DLNR) established standards and guidelines, which specify that fill sand used for beach nourishment projects must meet several requirements:

- Sand shall contain no more than 6% fine material (grain size < 0.074 mm).
- Sand shall contain no more than 10% coarse material (grain size > 4.76 mm).
- The grain size distribution will fall within 20% of the existing beach sand.
- The overfill ratio of the fill sand to existing sand shall not exceed 1.5.
- Sand will be free of contaminants such as silt, clay, sludge, organic matter, turbidity, grease, pollutants, and others.
- Sand will be primarily composed of naturally occurring carbonate beach or dune sand.

The majority of the current requirements for beach fill sand are related to grain size. To determine the grain size characteristics, a sieve analysis is performed by mechanically shaking a sand sample through a series of sieves of decreasing screen size. The material captured on each sieve is weighed to establish grain size distribution curves. The median grain size (D_{50}), which represents the grain diameter that is finer than 50 percent of the sample, is often used to quantify the grain size of a sample. Other important characteristics of fill sand include color, texture, density, angularity, sphericity, and abrasion resistance.

Color is an important consideration when determining whether sand is suitable for beach nourishment. While natural calcareous sand beaches range in color from light brown to white, sand in offshore deposits is typically grayish in color, primarily as a result of anoxic conditions produced by biologic activity and a lack of wave action and associated mixing. Even though an offshore sand source may be suitable in terms of grain size characteristics, as illustrated in several offshore dredging and beach restoration projects in Waikīkī, a persistent gray color can be undesirable. During the 2012 Waikīkī Beach Maintenance I project, the offshore sand was noticeably grayer than the existing beach sand after initial recovery and placement; however, after several weeks of prolonged exposure to subaerial conditions and ultraviolet radiation from the sun, the gray color faded and is no longer discernable from the existing beach sand.

3.5.33.6.3 Representative Waikīkī Offshore Sand Deposits

A number of offshore sand deposits are located along the South Shore of O‘ahu from the Pearl Harbor entrance channel to Diamond Head. Multiple offshore sand investigations have been done over the years to determine if the deposits are suitable to support beach nourishment projects in Waikīkī. The following discussion focuses on six offshore sand deposits that were evaluated as potential sand sources to support the proposed beach improvement and maintenance actions (see Appendix B). The estimated area and volume of each deposit are shown in Table 3-2. The locations of the deposits are shown in Figure 3-6.

Table 3-2 Estimated volume and area of South Shore O‘ahu offshore sand deposits

Offshore Deposit	Estimated Volume (cy)	Estimated Area (acres)
Reef Runway	250,000	79
Ala Moana	190,000	26
Hilton Channel	45,000	11
Halekūlani Channel	580,000	28
Canoes/Queens	50,000	10
Diamond Head	110,000	26
TOTAL	**1,225,000**	**180**

Reef Runway

Two deposits are located approximately 1,500 ft offshore of the west end of the Reef Runway at Daniel K. Inouye International Airport in water depths of 20 to 70 ft. The deposits cover approximately 79 acres and contain an estimated 250,000 cy of sand that varies in thickness from 2 to 8 ft. The typical median grain size (D_{50}) ranged from 0.24 mm to 0.41 mm, and fine material ranged from 2.1% to 6.6%. The deposits were quite thin, with an average thickness of less than 4 ft. Due to the limited sand thickness and higher percentage of fine material, these deposits are not proposed for use in Waikīkī.

Ala Moana

This deposit is located approximately 3,700 ft offshore of Ala Moana Regional Park in water depths of 75 to 120 ft. The deposit covers more than 25 acres and contains an estimated 190,000 cy of sand that varies in thickness from 5 to 15 ft. The typical median grain size (D_{50}) is 0.4 mm. The sand becomes progressively finer in deeper water. The central portion of the deposit contains more than the 70,000 cy of sand that is currently proposed for use by the City and County of Honolulu to nourish the beach at Ala Moana Regional Park. The sand at the *Ala Moana* deposit complies with State of Hawai‘i requirements and, if not used for beach nourishment at Ala Moana Regional Park, could potentially support beach nourishment in the Halekūlani and Kūhiō beach sectors. However, there may not be an adequate volume of beach quality sand in this deposit to support beach nourishment projects at both Ala Moana and Waikīkī.

Hilton

This deposit is located approximately 2,700 ft offshore of the Hilton Hawaiian Village in water depths of 40 to 60 ft. The deposit covers approximately 11 acres and contains an estimated 45,000 cy of sand that varies in thickness from 4 to 8 ft. The median grain size (D_{50}) is 0.6 mm, which is relatively coarse in comparison to the existing beach sand. The sand at the *Hilton* deposit complies with State of Hawai'i requirements and could potentially support beach nourishment in the Fort DeRussy, Halekūlani, and Kūhiō beach sectors.

Halekūlani Channel

This deposit is located in the Halekūlani Channel, which extends approximately 4,000 ft offshore from the Halekūlani Hotel where it widens into a broad sand field in 40 to 80 ft of water. This sand source has been investigated numerous times since the 1970s. The deposit is very large and contains an estimated 580,000 cy of sand. The current study investigated a portion of this larger deposit that covers approximately 28 acres and contains an estimated 200,000 cy of sand that is up to 40 ft thick. The median grain size (D_{50}) ranged from 0.2 mm to 0.4 mm, with coarser sand nearshore in shallower water. The sand quantity and grain size in the Halekūlani Channel varies with distance offshore. The shallower deposits comply with State of Hawai'i requirements and could potentially be used to support beach nourishment in the Halekūlani beach sector. The deeper deposits contain a substantial volume of sand; however, the sand is generally finer than the existing beach sand in Waikīkī.

Canoes/Queens

This deposit is located approximately 1,200 ft offshore of Royal Hawaiian Beach in water depths of 10 to 20 ft. The deposit covers approximately 10 acres and contains an estimated 25,000 to 50,000 cy of sand that varies in thickness from 3 to 7 ft. The typical median grain size (D_{50}) is 0.3 mm, which is similar to the existing beach sand in Waikīkī. This sand deposit was used by the DLNR for beach nourishment projects at Kūhiō Beach Park (2006) and Royal Hawaiian Beach (2012, 2021). The sand at the *Canoes/Queens* deposit complies with State of Hawai'i requirements and could potentially support beach nourishment in the Kūhiō and Halekūlani beach sectors; however, it is best suited as a "recycled" sand source to support periodic renourishment in the Royal Hawaiian beach sector.

Diamond Head

This deposit is located approximately 1,600 ft offshore of the Diamond Head Lighthouse in water depths of 20 to 40 ft. The deposit covers approximately 26 acres and contains an estimated 110,000 cy of sand that varies in thickness from 3 to 9 ft. The typical median grain size (D_{50}) is 0.4 mm. The sand at the *Diamond Head* deposit complies with State of Hawai'i requirements and could potentially support beach nourishment in the Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō beach sectors.

Figure 3-6 Representative Waikīkī offshore sand deposits

3.63.7 Offshore Sand Recovery and Transport Methodology

Several of the proposed actions will require sand to be recovered from deposits located offshore of the project area. A variety of methods are available to recover the offshore sand. Each method has inherent advantages, disadvantages, and ranges of applicability. The three most common forms of dredging used in Hawaiʻi are 1) submersible slurry pumps, 2) self-contained hydraulic suction dredges, and 3) clamshell buckets.

3.6.13.7.1 Submersible Slurry Pumps

Submersible slurry pumps are lowered from a boat or barge and suspended above the seafloor. The pumps can be hydraulically or electrically driven and are available in a range of sizes. The pump is connected to a pipeline that transports the slurry to a dewatering basin onshore. An example of a submersible slurry pump is shown in Figure 3-7. An advantage of a submersible slurry pump is its precise positioning and ability to reach into tight spaces. Using a crane-tip GPS unit to locate the pump, the operator can accurately position the pump to within a few feet of any location to effectively recover sand from near the edge of the reef. Since many of the nearshore sand deposits off Waikīkī are relatively small in area and bordered by hard reef-rock bottom, a smaller, more precise methodology like the submersible pump is advantageous.

A disadvantage of a submersible slurry pump is the significant volume of seawater recovered with the sand (typically, 1-part sand to 10-parts water), and the need to contain and control the dewatering of the sand onshore in accordance with State of Hawaiʻi water quality requirements. A submersible slurry pump was used for the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. Sand was recovered from the *Canoes/Queens* offshore deposit and pumped to a dewatering basin that was constructed in the Diamond Head (east) basin at Kūhiō Beach Park.

3.6.23.7.2 Hydraulic Suction Dredge

A hydraulic section dredge is a more traditional dredging method that has proven to be effective for beach nourishment projects. A hydraulic section dredge functions similarly to a submersible slurry pump, except that the pump is located above water on a surface platform (e.g., boat or barge), and a rigid suction pipe is lowered from the surface platform down to the seafloor. Dredged material is typically discharged as a sand-water slurry through a pipeline to shore. An example of hydraulic section dredging is shown in Figure 3-8.

Hydraulic section dredges come in a wide range of sizes, from large ocean-going dredges for maintaining commercial ports and waterways, to small, trailerable units that are typically used for lake and reservoir clearing or small marina maintenance. A small hydraulic suction dredge (Mud Cat) was used in a small-scale sand pumping demonstration project conducted by the DLNR in February 2000 (Noda, 2000). Approximately 1,400 cy of sand was dredged from a deposit located 1,500 ft offshore of Kūhiō Beach and pumped to a dewatering basin excavated into the dry beach area within the Diamond Head (east) basin of Kūhiō Beach Park. Hydraulic suction dredges are less common in Hawaiʻi in comparison to submersible slurry pumps.

Figure 3-7 Example of a submersible slurry pump (Healy Tibbitts Builders, Inc.)

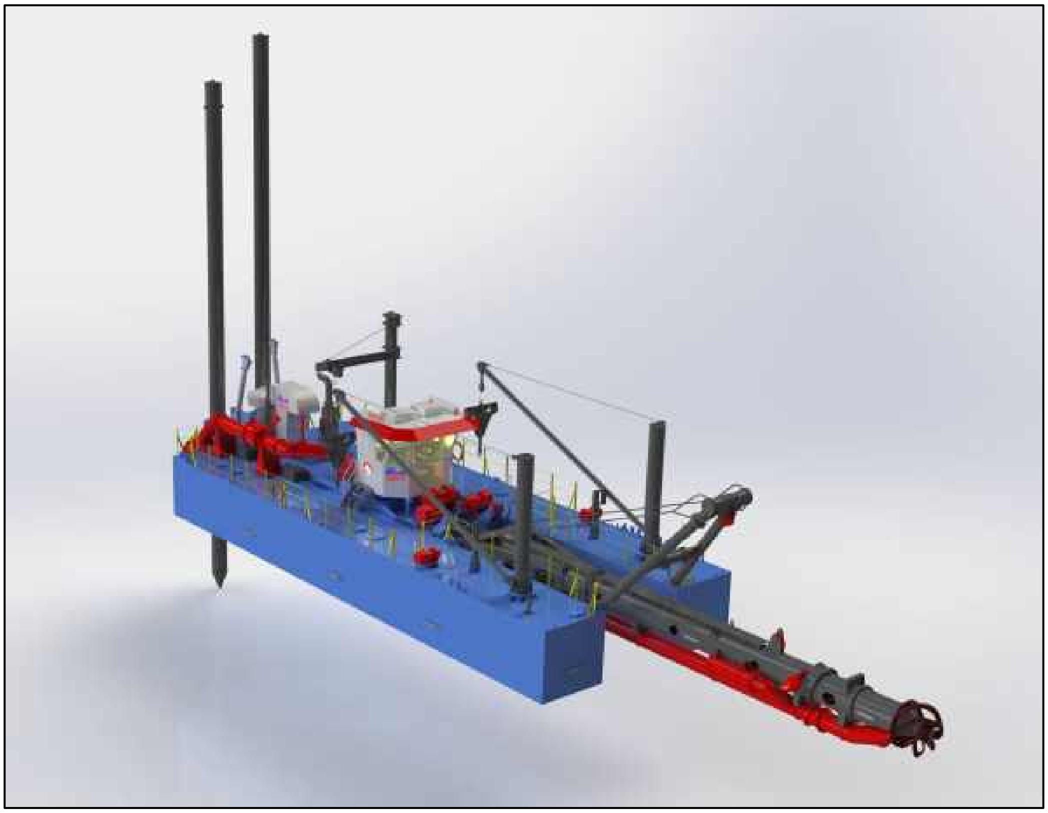


Figure 3-8 Example of a hydraulic suction dredge (Ellicott Dredges, LLC)

~~3.6.3~~3.7.3 Clamshell Dredging

Clamshell dredging involves mechanically scooping and lifting sediment, in this case sand, from the seafloor. Clamshell dredging is often conducted with a large barge upon which the recovered sediment is deposited. A clamshell bucket is lowered with a crane in the open position. Upon reaching the seafloor, the crane operator closes the clamshell jaws, lifts the material out of the water, and opens the bucket over a barge. Once the sand is deposited onto the barge, the barge transits to a dock where the sand can be offloaded and transported to a stockpiling area or dewatering basin. An example of clamshell dredging is shown in Figure 3-9.

Figure 3-9 Example of clamshell dredging (IP Subsea)

The advantages of clamshell dredging are that it is very mobile, it can operate at any depth that the crane cable can reach, it can be used in moderate swell conditions, and it can recover a wide variety of material types. Environmental buckets that seal when closed help to reduce environmental impacts associated with turbidity and increase efficiency in recovering sand, thereby reducing the overall time and cost of the operation. Additionally, the amount of water that is accumulated from the clamshell dredging process is much less than with hydraulic dredging, and the small amount of water can be discharged at an approved location.

The disadvantages of clamshell dredging are that it is less efficient than other dredging systems, such as submersible slurry pumps or hydraulic suction dredges. Clamshell dredging is also less precise in terms of positioning and requires the sand deposits to be thick enough that the clamshell does not encounter hard substrate.

3.6.43.7.4 Small-scale Maintenance Dredging

Nearshore sand deposits are typically too far from the coastline to be recovered using land-based equipment, such as cranes and excavators, and too shallow to access via work vessels. Sand deposits located within approximately 1,000 ft of the shoreline may be viable for small scale beach maintenance purposes, as this sand is likely eroded from the beach.

Potential nearshore sand sources in Waikīkī include:

- Fort DeRussy Beach Sector – Hilton Channel
- Halekūlani Beach Sector – Halekūlani Channel
- Royal Hawaiian Beach Sector – Royal Hawaiian Sandbar
- Kūhiō Beach Sector – Diamond Head (east) Basin

Novel dredging approaches must be utilized to recover sand from these nearshore deposits. Two examples of equipment that could potentially be used for nearshore dredging projects are an ROV subdredge and a diver-operated dredge.

3.6.53.7.5 Remote Operated Submersible Dredge

A Remote Operated Submersible Dredge (ROV subdredge) is an electrically powered tracked hydraulic pump manufactured by EddyPump© Corporation (Figure 3-10). The pump was developed for the U.S. Army and U.S. Navy for Logistics-Over-the-Shore (LOTS) operations for early entry forces and areas that are too dangerous for human operators. It is fully submersible and capable of being operated remotely from shore. An umbilical runs along the pipeline providing power and control to the ROV subdredge. The pump is powered by an electric power unit located on shore and a small submersible hydraulic power unit mounted on the ROV subdredge. A Real-time Kinematic (RTK) Global Positioning System (GPS) provides precise location data to the landside operator.

An advantage of an ROV subdredge is that it can be operated in shallow water that cannot be accessed by barges. To recover nearshore sand deposits in Waikīkī, an ROV subdredge would be deployed and operated from shore. A pipeline would transport slurry from the ROV subdredge to two dewatering basins on shore. The pipeline would float on the water surface. A small support vessel (e.g., small boat or jet ski) would be used to maintain a safety buffer and assist with maneuvering the dredge pipeline. The operator would move the ROV subdredge through the sand deposit until a sufficient volume of sand was recovered. A camera mounted on the ROV subdredge allows the operator to direct the dredge head to the sand deposit to maximize efficiency. The production rate for the ROV subdredge is expected to be up to 30 to 50 cy of sand per hour.

Additional equipment would be required for proper operation of the ROV subdredge. A 100-kW diesel generator would be located onshore and provide power to the ROV via the umbilical. 1,000 ft of floating pipeline would connect to the ROV subdredge. A bulldozer and skid-steer would be required to excavate the dewatering basins and push sand to the desired grade. The primary disadvantage of an ROV subdredge is the initial cost for the equipment. The ROV subdredge itself would cost approximately $1 million.

Figure 3-10 Remote Operated Submersible Dredge (Eddy Pump©, 2021)

3.6.6 3.7.6 Diver-operated Dredge

A diver-operated dredge is a dredge system that can be manipulated and operated by divers. Diver-operated dredges are typically used in shipyard operations and the mining and fracking industries. Using divers to manipulate the suction hose offers a level of precision that cannot be achieved by lowering a pump over the side of a vessel. Figure 3-11 shows a diver-operated dredge pump manufactured by EddyPump© Corporation. The diver-operated dredge pump is about 6 ft long, 3 ft wide, and 3 ft tall, but dimensions vary depending on the size of the pump. Figure 3-12 shows a diver on surface supplied air (SSA) manipulating a diver-operated dredge nozzle.

Sand recovery would require a 4-person dive team working from shore for Occupational Safety and Health Administration (OSHA) compliance. The dredge pump could be placed on shore on the beach face, or on a small vessel or float. A floating slurry pipeline and power cable would extend from the dredge pump to the sand recovery area. The pump would be powered by a 100kW generator located on shore. A suction hose would be connected to the dredge pump. The suction hose would be controlled by a single diver. The hose would have a length of 100 ft, which would enable the diver to dredge sand within a 100-ft radius of the pump. Once the sand is dredged to the desired depth, the pump would be relocated to another area. The 6-in pump system can accommodate two divers and two hoses for greater efficiency. A bulldozer and/or skid-steer would be required to spread the sand to the design grade. The production rate for one diver is expected to be 20 to 40 cy of sand per hour.

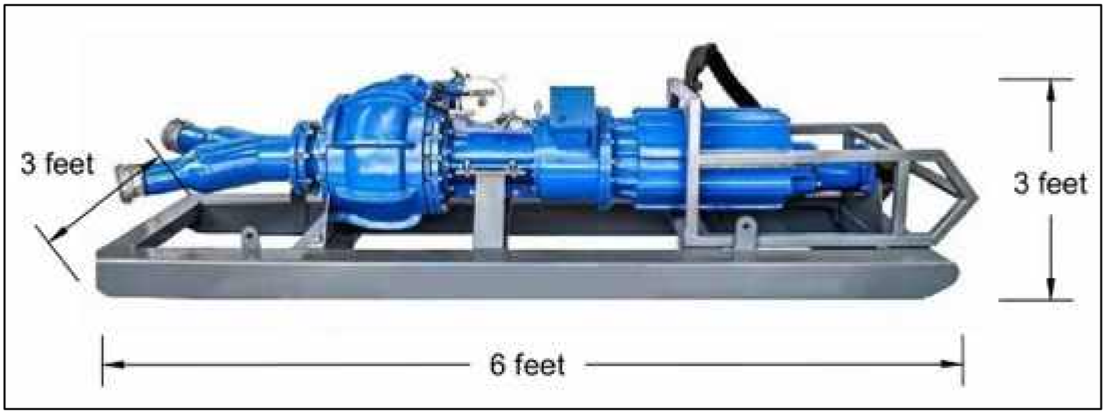


Figure 3-11 Diver-operated dredge pump

Figure 3-12 Surface supplied air (SSA) diver using a diver-operated dredge

3.6.73.7.7 Excavator with Dredge Pump Attachment

An excavator with a dredge pump attached to the boom is a direct method of dredging sand from nearshore onto the beach. The system would include an excavator, a submersible pump, a slurry pipeline to shore, and power for the pump. The pump could hang from or be attached to the excavator boom. The pump would be lowered into the water into contact with the sand and moved around by the excavator, as necessary.

This method has been used successfully for ongoing beach maintenance at the Ko'Olina lagoons, where sand regularly migrates (slumps) from the beach face into the water due to the low wave energy within the lagoons. The excavator is positioned near the water line and a Toyo submersible pump is lowered into the water. The sand/water slurry is pumped to shore into dewatering basins that are trenched into the upper beach face. Sand recovery typically extends about 60 ft from the waterline into the lagoon.

An excavator equipped with a cutterhead pump attachment is potentially a more-efficient method for sand recovery. Eddy Pump© makes an excavator attachment that is specifically designed to connect to the excavator bucket linkage. The pump can also be powered by the excavator's hydraulics, eliminating the need for shore-side power. This configuration reduces crew size and allows the excavator operator to dredge sand by sweeping back-and-forth with the excavator arm. The system could extend further from the waterline by placing the excavator on a Flexifloat system or in very shallow water by building a platform that rests on the sand. A minimum 40-ton class excavator is recommended. The coverage area could be extended by using a long-reach excavator, provided that it can remain balanced. An example of an excavator-mounted pump is shown in Figure 3-13.

Advantages of an excavator with a dredge pump are that the equipment is available on-island, is relatively simple to maneuver and operate, and can be powered by the excavator (no additional power required). A disadvantage of an excavator is that it has limited reach. Extending the reach of the excavator would require a platform, such as Flexifloats, or construction of a berm to drive on. Additionally, a dewatering basin on land would be required. Production rates are dependent on the pump size and are expected to be 20 to 40 cy per hour.

Figure 3-13 Excavator with 10-in dredge pump and power pack (EddyPump©, 2021)

3.8 Alternative Armor Units

Concrete Armor Units

Man-made concrete armor units have been developed for use when stone of large enough size is not available to meet the design requirements. These concrete units have larger stability coefficients (i.e., greater interlocking and ability to withstand wave attack) than stone. Thus, the concrete units can be smaller than the required stone size for a given wave height. Tribar concrete armor units (Figure 3-14) have been used with considerable success for projects with similar design conditions and are an alternative to stone for this project.

Tribar armor units are implemented as a single layer and, like a rubblemound revetment, the armor units are placed over an underlayer and filter designed to distribute the weight of the armor layer and to prevent loss of fine shoreline material through voids in the Tribars. The underlayer is sized at 1/10 the Tribar weight and is at a minimum two stone diameters thick. Because Tribar units depend on interlocking for stability, the sides, toe, and crest of the structure must be securely tied in and fixed to the surrounding environment. Typically, the toe of the structure is entrenched and grouted into the seafloor. While concrete armor units perform well from an engineering perspective, they can be perceived as having an industrial appearance that may not be desirable in Waikīkī.

Figure 3-14 Tribar concrete armor units in American Samoa

Environmentally Friendly Armor Units

Construction of the proposed actions will cover portions of submerged lands with either sand or rock. The rock rubblemound structures are expected to increase biodiversity of the area based on the monitoring results following the 2013 Iroquois Point Beach Nourishment and Stabilization project. Alternative materials are being considered to further mitigate potential impacts by providing ecologically sensitive solutions, where possible. One option is to add environmentally friendly armor units to the groins where conditions allow. The discussion below focuses on ECOncrete and their products; however, there are other concrete units available that can be considered during the final design phase, including those from Volvo, University of Washington, Reef Design Lab, Intellareef, and others.

ECOncrete

ECOncrete is marketed as an eco-engineered solution for both marine life and humans. Products include ecological armoring units, seawall panels, designed tidepools, and articulated marine mattresses. ECOncrete reportedly achieves their success from a combination of concrete additives and unit design and texture. The concrete armoring units are produced with a proprietary concrete mix with enhancing admixture that complies with marine construction regulations. When compared to standard concrete used in other armor units, ECOncrete reportedly provides higher compressive strength and lower pH levels. The low pH levels reportedly promote better coral growth. Each of the products has unique textured surfaces that reportedly improve marine life and coral structure growth. Production of calcium carbonate from higher levels of marine life provides an additional bond between concrete armoring units, strengthening and stabilizing the structure.

ECOncrete units have been used in multiple locations in the continental U.S. and throughout Europe, and thus far have only been used in calm environments with low wave energy. Intense review of hydraulic stability is currently being performed by ECOncrete through computational modeling and physical testing to determine if their concrete armor units are applicable in high wave energy environments. Costs associated with purchasing ECOncrete units may be similarly priced to standard concrete units if the units can be cast locally. Figure 3-16 through Figure 3-18 show examples of armor units that are marketed as being environmentally friendly.

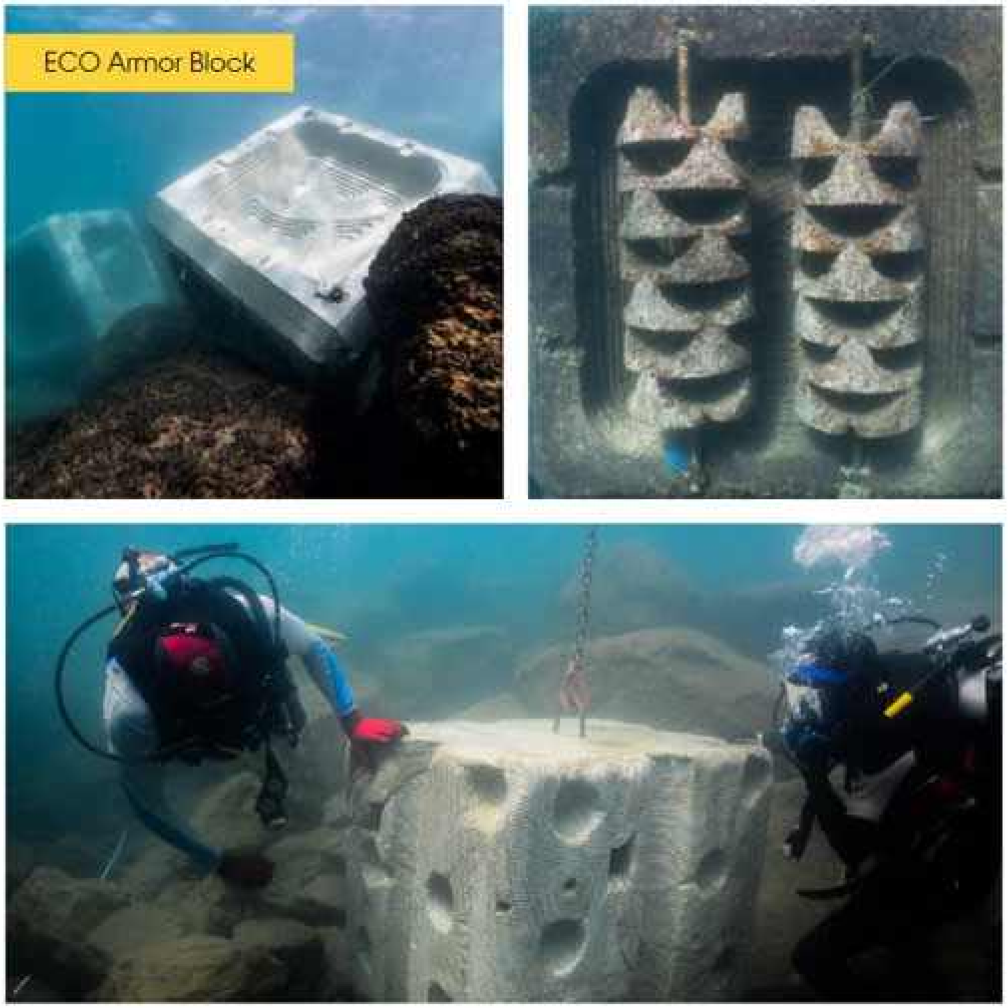


Figure 3-15 ECO Armor Block (www.econcretetech.com)

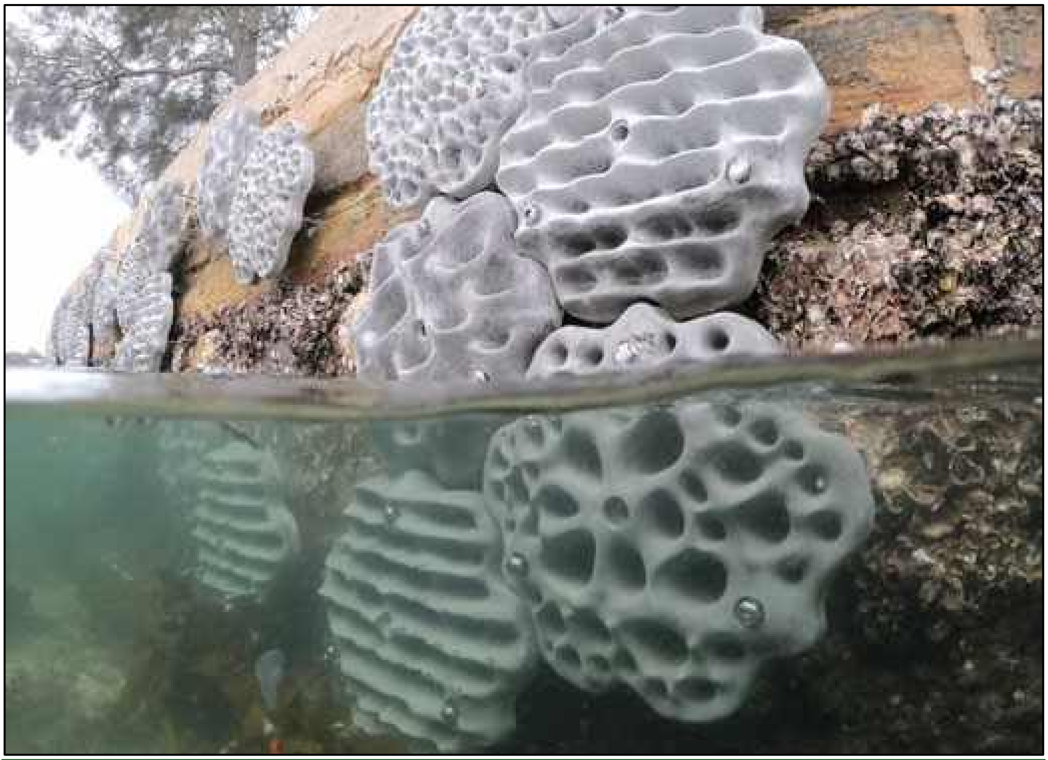


Figure 3-16 "The Living Seawall Project" (www.reefdesignlab.com)

Figure 3-17 ECOncrete Coastalock (www.econcretetech.com)

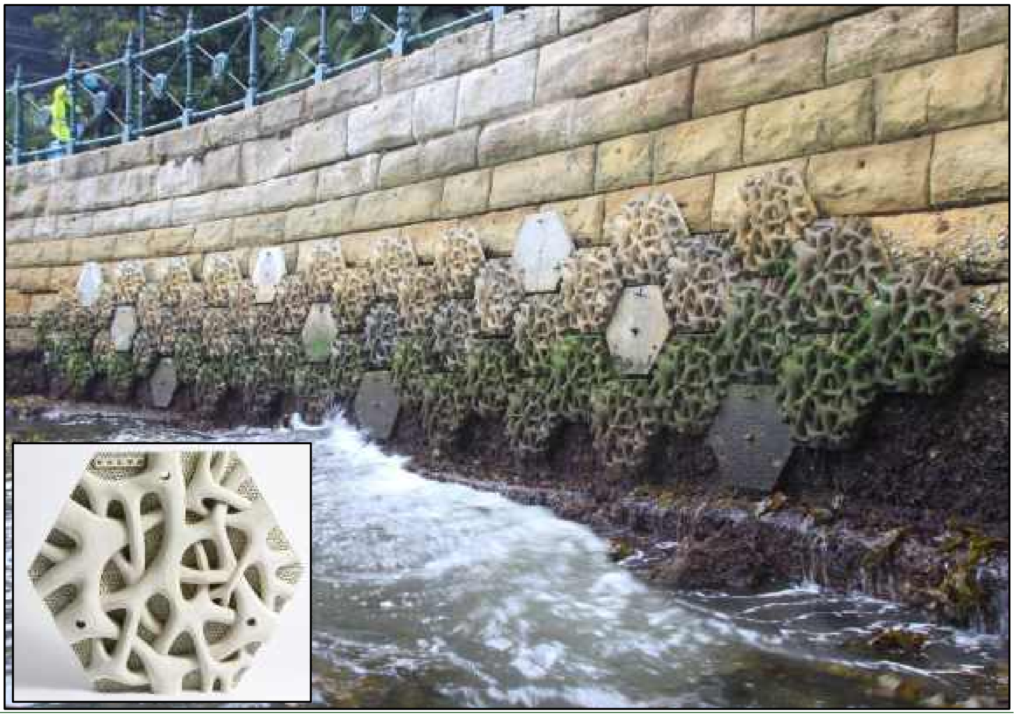


Figure 3-18 Volvo 3D-printed Living Seawall (www.reefdesignlab.com)

4. PROPOSED ACTION: FORT DERUSSY BEACH SECTOR

4.1 General Description

The Fort DeRussy beach sector spans approximately 1,680 ft of shoreline that extends from the Hilton pier/groin east to the Fort DeRussy outfall/groin. Prominent features in this sector include the Fort DeRussy beach walkway, Duke Paoa Kahanamoku Park, Hale Koa Hotel, Fort DeRussy Park, and the U.S. Army Museum of Hawaiʻi. An overview map of the Fort DeRussy beach sector is shown in Figure 4-1.

History

Modifications to the Fort DeRussy beach sector began in the early 1900s with dredging and seawall construction extending to the present location of the Sheraton Waikiki Hotel. The backshore, which was primarily wetlands, was filled with crushed coral material that was dredged from the adjacent reef. In the 1950s, the Hilton pier/groin and Hilton Channel were constructed at the west end of the sector. The beach was constructed in 1969 using approximately 160,000 cy of crushed coral material that was dredged from the nearshore reef (USACE, 1993). In 1976, a 2-ft-thick layer of carbonate sand was placed over the crushed coral base (USACE, 2002). Sand was periodically placed on the beach through the mid-1990s, but no beach improvements or maintenance has been conducted since then. The history of coastal engineering in the Fort DeRussy beach sector is summarized in Figure 4-2. Historical photographs of the Fort DeRussy beach sector are shown in Figure 4-3. Aerial photographs comparing the shoreline conditions in the Fort DeRussy beach sector in 1949 and 2015 are shown in Figure 4-4.

Existing Conditions

The Fort DeRussy beach sector is an entirely engineered shoreline. The west end of the sector is bounded by a concrete rubble masonry (CRM) groin that is buried in the beach and connects to the Hilton pier. The central portion of the sector consists of a man-made beach that is backed by a concrete seawall that was constructed in 1916. The seawall spans the entire length of the Fort DeRussy beach sector. The east end of the sector is bounded by the Fort DeRussy outfall/groin, which consists of a concrete box culvert and a rock rubblemound groin.

The existing shoreline is a man-made sandy beach that is composed of a combination of sand and coral that was dredged from offshore. The beach is widest at the west end and narrowest at the east end. At the west end of the beach, adjacent to the Hilton pier/groin, the sand is compacted and hardened over much of the dry beach area. The eastern portion of the sector consists of a narrow sandy beach with steeper slopes that is subject to chronic erosion. The Fort DeRussy seawall is frequently exposed by erosion along this portion of the shoreline.

The Fort DeRussy beach walkway provides lateral access along the shoreline from Hilton Hawaiian Village to the Castle Waikīkī Shore. Perpendicular access to the shoreline is available through Fort DeRussy Park and a public beach access located at the intersection of Kālia Road and Saratoga Road. There are no lifeguard towers in the Fort DeRussy beach sector. The existing beach walkway has a ground elevation of about +5 ft MSL. Along the Diamond Head (east) end of the beach sector, sand is often pushed landward over the beach walkway by wave action, particularly during high tides and high surf events. The beach fronting the Fort DeRussy tennis courts has been significantly eroded in recent years and appears to be increasingly unstable with the beach being completely eroded along a 200-foot reach and waves frequently overtopping the beach walkway. It appears that what has traditionally been a seasonal erosion pattern has transitioned into a semi-permanent state of erosion. Beach rental concessions, beach pavilions and tennis (pickle ball) courts back this section of the beach walkway. Behind the concessions is Fort DeRussy Park and the U.S. Army Hawai‘i Museum of History.

Adjacent to the pier is a wide sand channel (Hilton Channel) with scattered rubble and sandy seafloor. East of the Hilton Channel, rubble covered in macroalgae extends east to the Fort DeRussy outfall/groin. The Hilton pier and Hilton Channel are located within the Waikīkī Ocean Water Restricted Zone B, which is under the jurisdiction of the DLNR Division of Boating and Ocean Recreation (DOBOR). DOBOR rules prohibit vessels from operating within this area except for outrigger canoes, authorized sailing catamarans, and other vessels operating from the Hilton pier. Photographs of existing conditions in the Fort DeRussy beach sector are shown in Figure 4-5.

Historical and Projected Shoreline Change

The University of Hawai‘i Coastal Geology Group (UHCGG) historical shoreline change trend for the Fort DeRussy beach sector (transects 141 to 169) from 1927 to 2015 2021 has been erosion at an average rate 0.4 370.37 ft/yr (UHCGG, 20192021). Beach erosion does not occur uniformly throughout the sector. The east end of the beach (transects 141 to 153149) has been eroding at an average rate of 1.2 6 1.6 ft/yr, whereas the west end of the beach (transects 154 151 to 169) has been accreting at an average rate of 0.4 80.3 ft/yr. The erosion is more pronounced at the east end of the beach because the predominant direction of sediment transport is from east to west along this portion of the Waikīkī shoreline (Miller and Fletcher, 2003). As sand is transported from east to west along the beach, the east end of the beach narrows and there is no mechanism to transport sand back to the eroding area.

Erosion, coastal flooding, and beach loss in the Fort DeRussy beach sector are projected to increase as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to 30.828.228.2 ft (9.48.6 m) by 2050 and up to 81 89.6121.7 ft (247.73 meters) by 2100 (UHCGG, 20192021). These projections do not account for the presence of the existing seawall that spans the entire length of the Fort DeRussy beach sector. As the shoreline approaches the existing seawall, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016).

There have been no beach improvement or maintenance projects in the Fort DeRussy beach sector since the mid-1990s. Recent observations indicate that beach loss is already accelerating in the eastern portion of the Fort DeRussy beach sector. Without beach improvements and/or maintenance, it is likely that sea level rise will result in total beach loss at the east end of this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beach is already narrow and often submerged during high tides and high surf events.

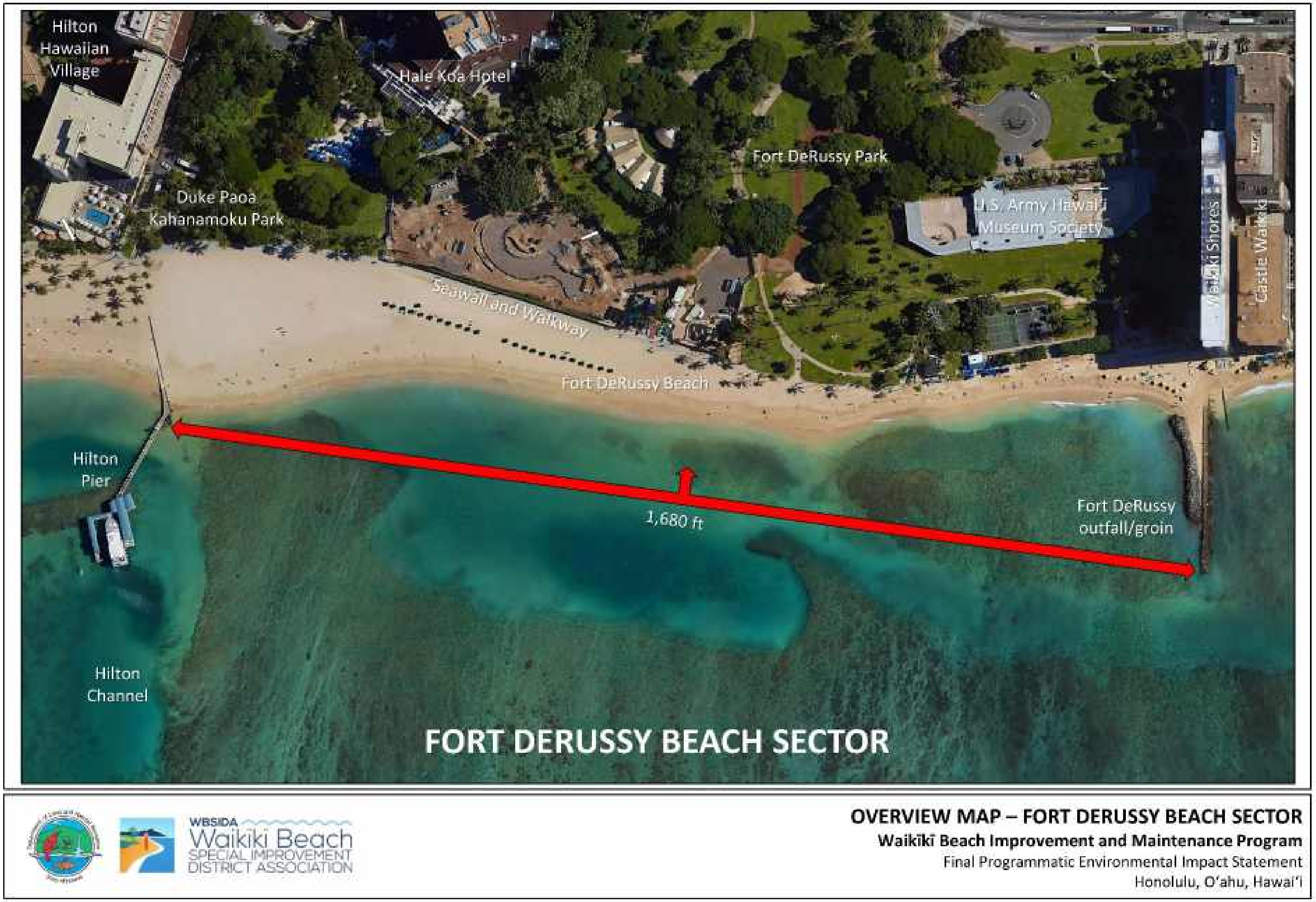


Figure 4-1 Overview map – Fort DeRussy beach sector

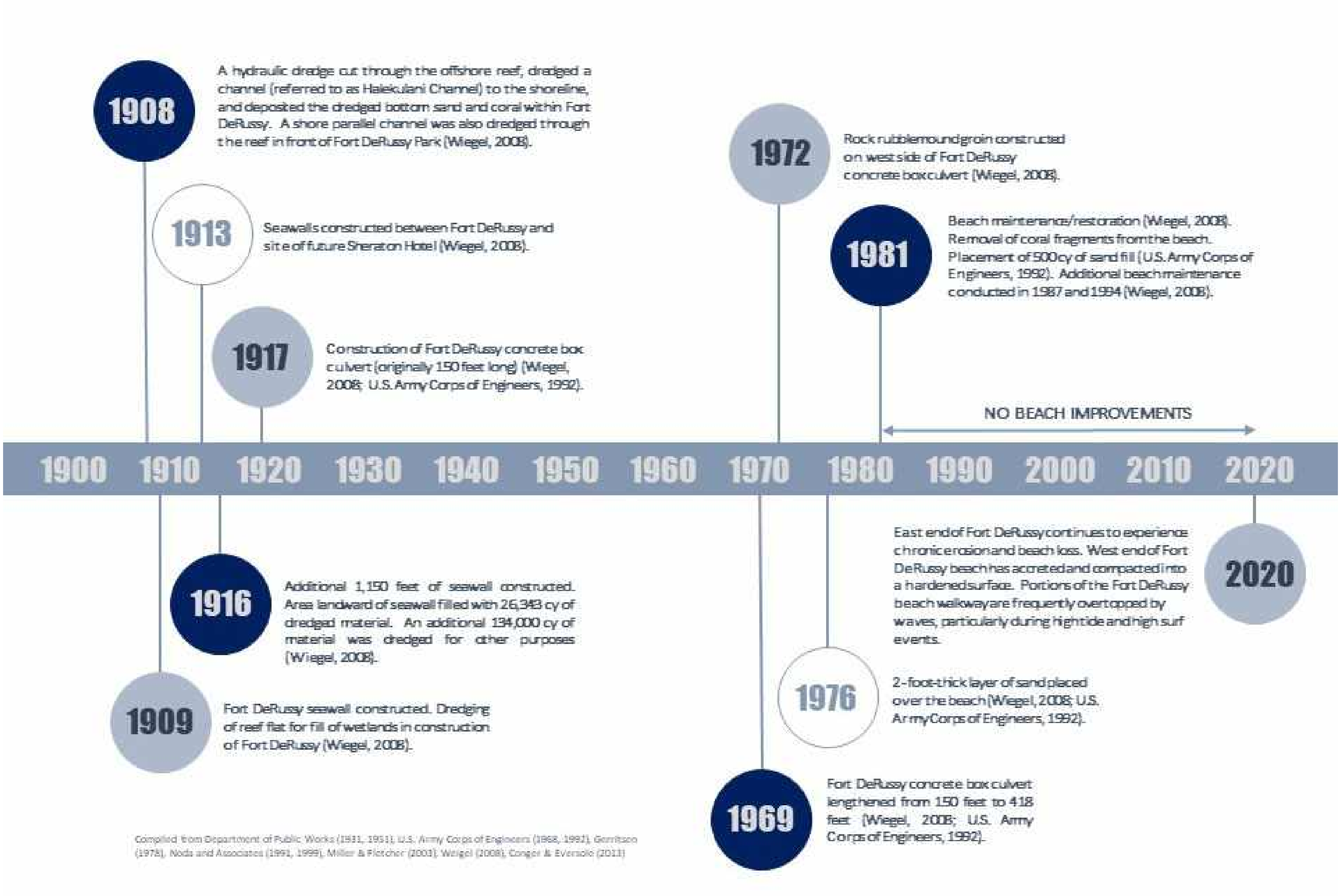


Figure 4-2 History of coastal engineering – Fort DeRussy beach sector

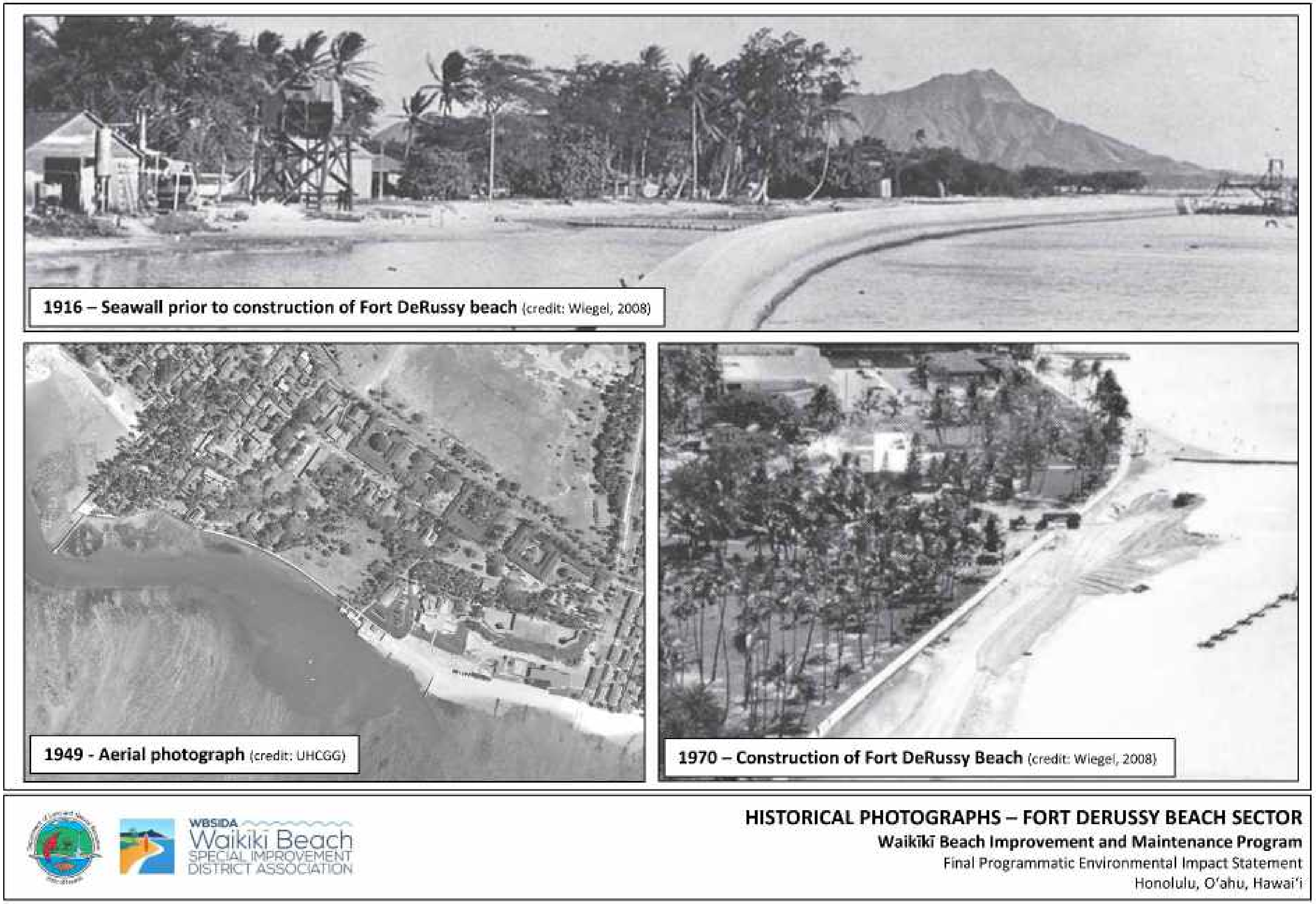


Figure 4-3 Historical photographs – Fort DeRussy beach sector

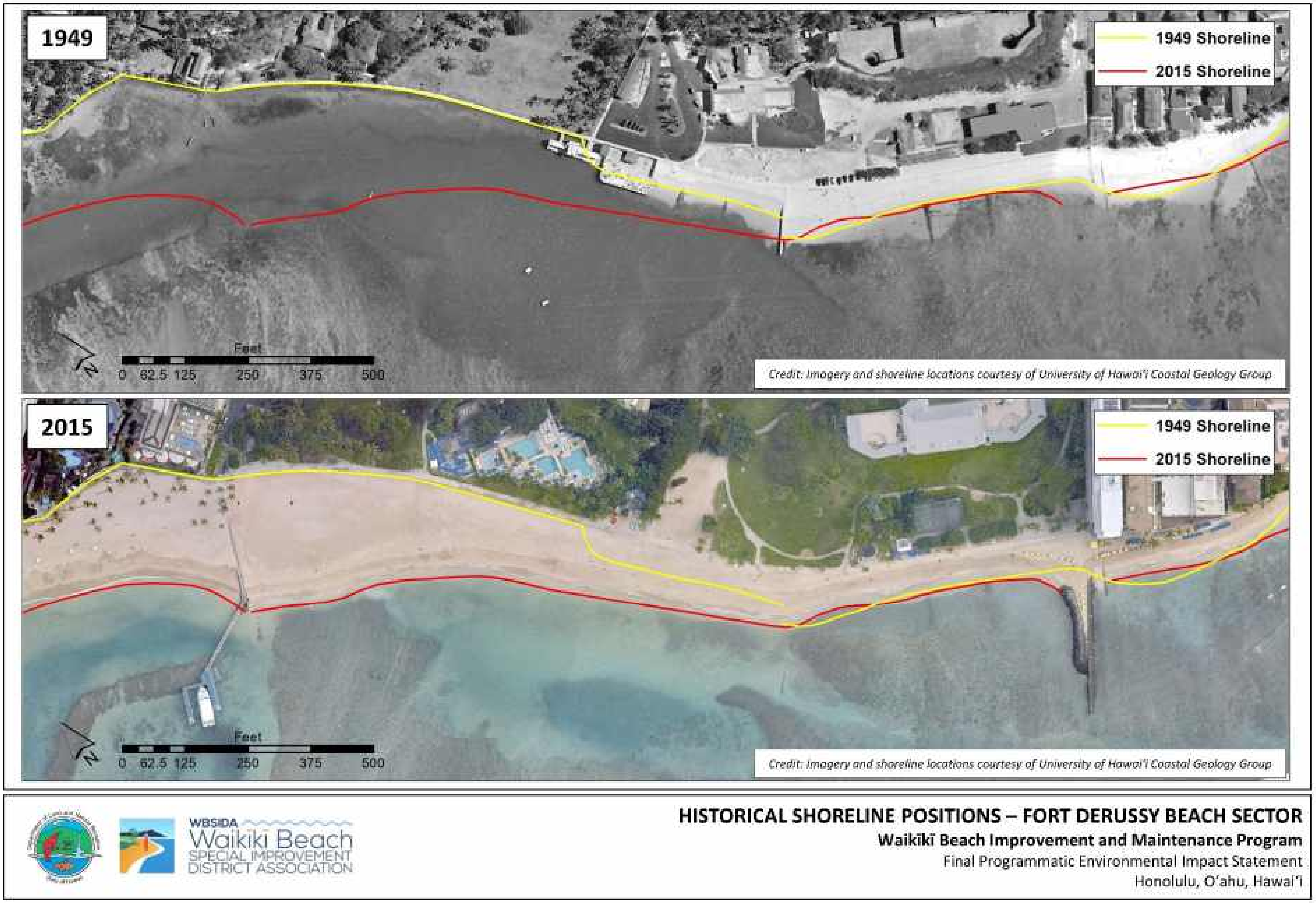


Figure 4-4 Comparison of 1949 and 2015 shoreline positions – Fort DeRussy beach sector

Figure 4-5 Existing conditions – Fort DeRussy beach sector

4.2 Purpose and Need for the Proposed Action

Waves from the south approach the beach at an oblique angle pushing sand from the east end to the west end, which causes erosion and beach narrowing at the east end of the sector. The Fort DeRussy beach walkway runs along the inshore side of the beach and is fronted by a low crested seawall that was constructed in 1916. The majority of the seawall is buried flush with the beach walkway and provides protection from scour and undermining. However, the elevation of the beach walkway is currently at the wave run-up elevation and waves periodically overtop the beach crest pushing sand over the beach walkway. Without beach improvements or maintenance, the seawall will become more exposed to wave action and the beach walkway will experience more frequent overtopping as sea levels continue to rise.

Erosion along the Fort DeRussy shoreline threatens to expose the seawall fronting the beach walkway, which extends along the entire length of the shoreline. Beach widths are narrow (on the order of 30 ft) at the east end of the sector. Wave overwash on the mauka (landward) side of the beach is problematic where beach widths are narrow (USACE, 2009). There is evidence that the Fort DeRussy outfall/groin is also being flanked by erosion, thereby reducing its effectiveness as a beach stabilizing structure. Photographs of existing issues and problems in the Fort DeRussy beach sector are shown in Figure 4-6.

In collaboration with the WBCAC, the project proponents determined that the primary issues and problems in the Fort DeRussy beach sector are:

- Erosion and beach narrowing.
- Wave runup and overtopping of the Fort DeRussy beach walkway.
- Deterioration and failure of the Fort DeRussy seawall.
- Environmental degradation.
- Lack of amenities.

The highest priorities in the Fort DeRussy beach sector are to:

- Address beach loss at the east end of Fort DeRussy Beach.
- Prevent the existing seawall from becoming exposed by erosion.
- Prevent wave overtopping of the Fort DeRussy beach walkway.

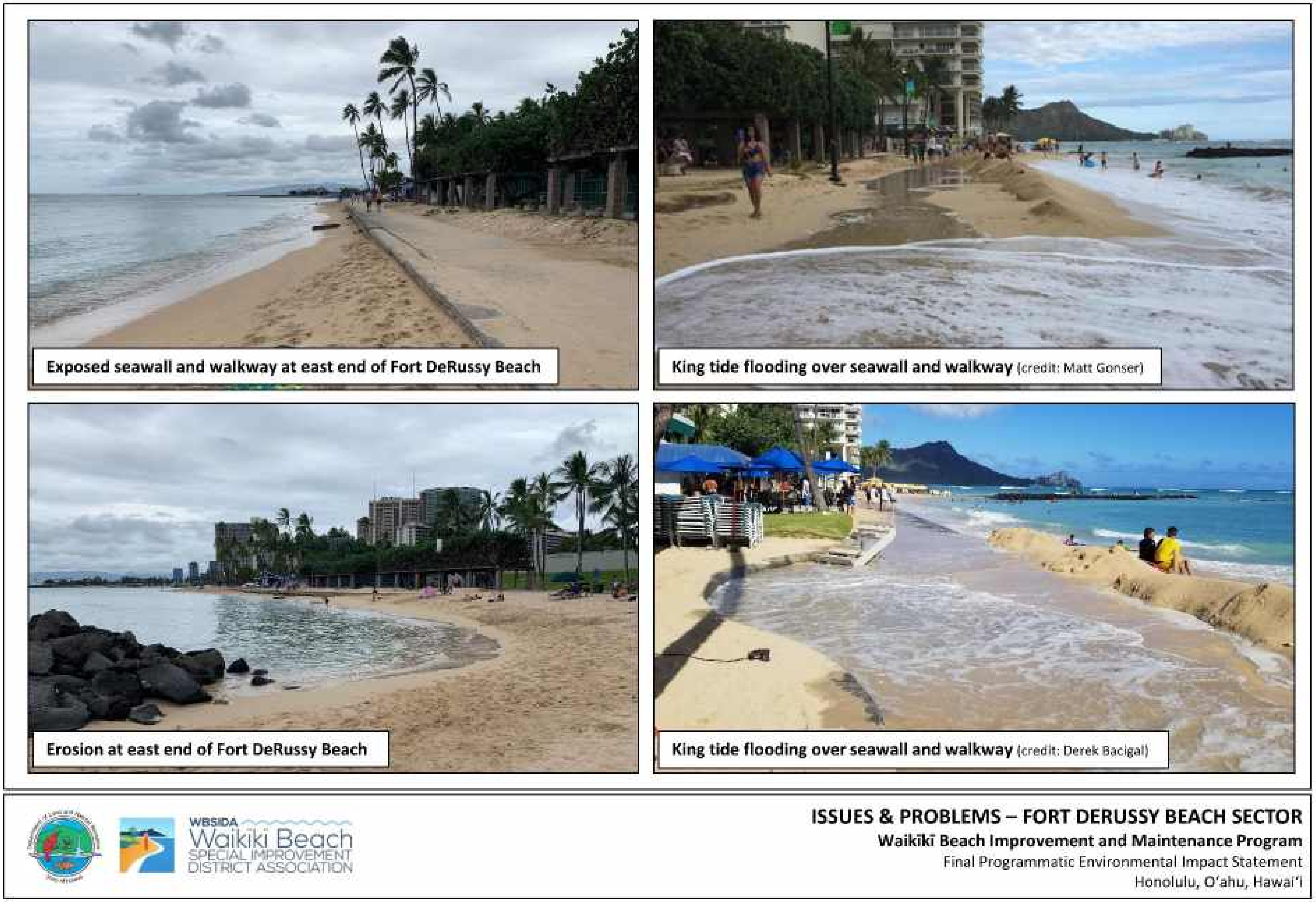


Figure 4-6 Issues and problems – Fort DeRussy beach sector

4.3 Proposed Action

4.3.1 Description of the Proposed Action

The proposed action for the Fort DeRussy beach sector is beach maintenance consisting of an initial small-scale beach nourishment effort followed by ~~and~~ periodic sand backpassing ~~with no improvements or modifications to existing structures~~. The purpose of the proposed ~~sand backpassing~~action is to widen the east end of Fort DeRussy Beach, which is chronically eroding and in a narrow, deteriorated condition. The proposed action will be implemented in phases. The first phase will consist of small-scale beach nourishment will involve placement of approximately 3,000 cy of ~~approximately 1,500 cy of~~ sand recovered from the *Hilton* offshore sand deposit. The second phase will consist of periodic backpassing of existing beach sand to maintain the desired beach width and profile. No new structures or modifications to existing structures are proposed.

Phase 1: Small-Scale Beach Nourishment

Approximately 3,000 cy of ~~S~~sand will be recovered from the *Hilton* offshore sand deposit and ~~transported from the accreted area at the west end of the beach to the eroding area at the east end of the beach to increase dry beach width and mitigate wave overtopping~~pumped directly to shore~~. –~~. The sand will be dewatered in a dewatering basin on the existing beach ~~and~~prior to being transported ~~from the dewatering basin~~ to the placement site. ~~The sand will be placed inshore of the “offshore fill limit” and the beach crest will be +5 ft MSL to match the elevation of the existing seawall and beach walkway.~~ The initial phase of the project will widen the dry beach to achieve an average 15- to 20-foot-wide crest and 50 to 60 foot-width, measured from the seawall and beach walkway to the waterline. Assuming a sand recovery rate of approximately 250 cy per day, the initial small-scale beach nourishment effort will require a total of 30 construction days.~~Sand will be obtained from the beach face on the east side of the Hilton pier/groin, where sand has accreted over the years. Sand will be excavated from the beach face extending inshore only as far as necessary to obtain the required volume of sand.~~

~~The purpose of the proposed sand backpassing is to widen the east end of Fort DeRussy Beach, which is chronically eroding and in a narrow, deteriorated condition. Sand will be transported from the borrow site to the placement site, where it will be placed along the beach face from the beach toe to the crest, widening the dry beach with an average 15 to 20 ft wide crest and measuring 50 to 60 ft from the seawall and walkway to the waterline.~~ The proposed action is based on a design fill template (footprint and profile) that is based on the historical position of the beach and walkway. The exact volume of sand required to achieve the design fill template will depend on conditions at the ~~borrow site and placement site~~ at the time of construction. This will provide flexibility in terms of when the sand backpassing can be performed.

The orientation of sandy shorelines is a function of the wave angle approaching shore. The shoreline is shaped by the incident waves passing over the reef and undergoing the processes of breaking, refraction, and diffraction. Wave modeling for a prevailing south swell was performed. The model results indicate that the waves closest to the shoreline have a slight arc shape, which is consistent with the shape of the historical shoreline. In addition to the waves, the seafloor near the beach can determine the fill footprint. Ideally, the fill sand will be placed on existing sandy substrate rather than reef.

The beach widening is not anticipated to alter existing sediment transport patterns. The beach at the placement site will continue to be subject to erosion; however, large wave events such as hurricanes could result in significant loss of sand in a short period of time. Due to the narrow width of the existing beach, some sand will need to be placed in the ocean to achieve an initially stable beach profile.

Phase 2: Sand Backpassing

The proposed beach widening could be performed as a single project but is intended to be implemented as the initial phase of an ongoing beach maintenance program. The proposedFollowing the initial small-scale beach nourishment, -sand backpassing will be performed periodically on an as-needed basis to maintain adequate beach width at the east end of the Fort DeRussy beach sector. The beach maintenance program will allow for sand backpassing to be conducted when beach conditions reach some pre-defined topographic and/or volumetric triggers. Beach monitoring will be required to determine when the trigger(s) have been met. include relocating approximately 1,500 cy of sand. The fill sand will be placed inshore of the "offshore fill limit" and the beach crest will be +5 ft MSL to match the elevation of the seawall and beach walkway in the placement site. The volume of sand required is based on a December 2019 topographic survey (Figure 4-7). Recent observations indicate that Profiles 3 and 4 are significantly more eroded now and there is almost no sand fronting the seawall and walkway. An updated topographic survey will be conducted during the final design and permitting phase to confirm the volume of sand required to achieve the design beach profile.

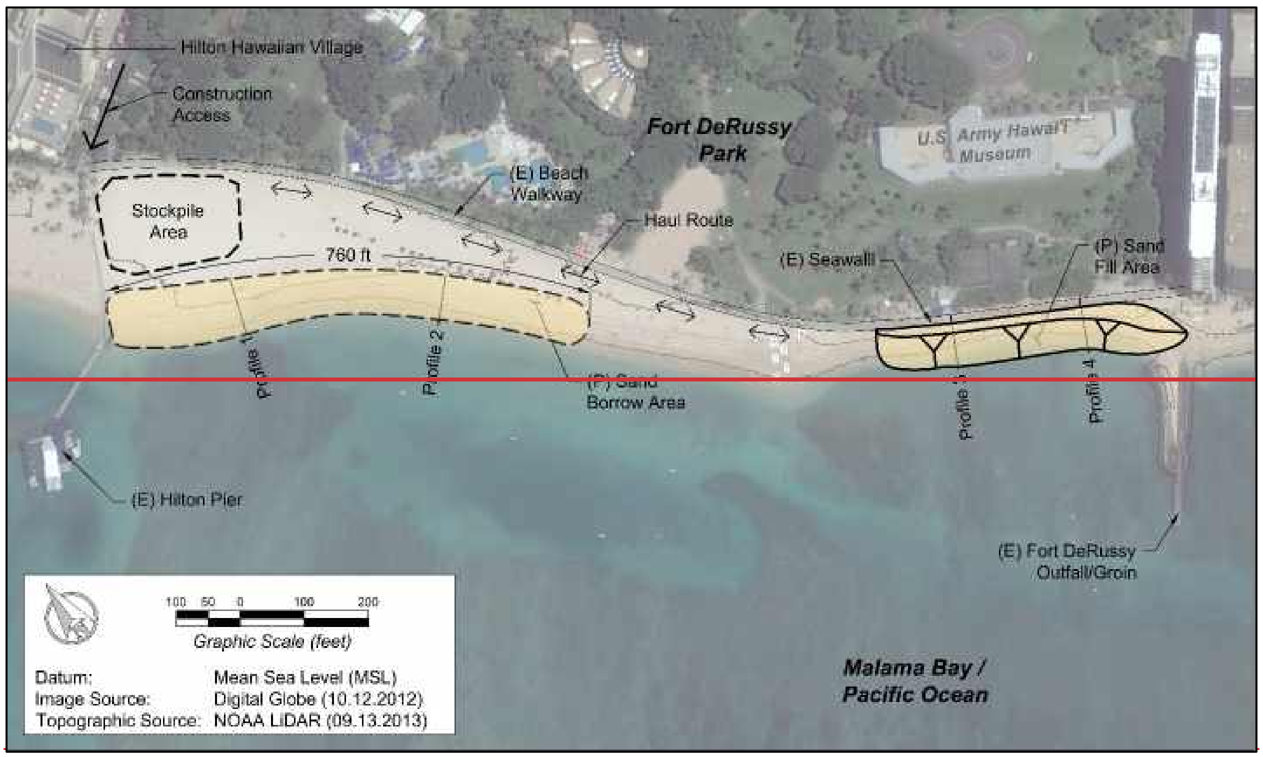
Sand for the periodic sand backpassing will be obtained from the beach face berm over an approximate 700-ft reach1.5-acre area on the Diamond Head (east) side of the Hilton pier/groin where the beach is currently more than 250 ft wide. A reduction in beach width elevation of 68 inches 7.5 ft (3%) over the 700 ftthis area will produce approximately 81,51,500 cy of sand. The sand will be manually transported from the borrow site to the placement site, where it will be placed along the shoreline to produce a beach with a 15 to 20 ft wide crest and measuring 50 to 60 ft from the seawall and walkway to the waterline. Post-construction beach width will depend on beach conditions at the time of the sand backpassing. Ideally, the initial sand backpassing will occur when approximately 50% of the sand from the initial beach nourishment has eroded. The beach fill template for the sand backpassing will be similar to the initial beach nourishment template, and the backpassed sand will be subject to similar erosion rates.

The project layout and design beach profiles for the proposed action are shown in Figure 4-7 and Figure 4-8, respectively. Conceptual renderings of the proposed action are shown in Figure 4-9 and Figure 4-10.

Sand backpassing is not anticipated to alter existing sediment transport patterns. The beach at the placement site will continue to be subject to erosion; however, large wave events such as hurricanes could result in significant loss of sand in a short period of time. Due to the narrow width of the existing beach, some sand will need to be placed in the ocean to achieve an initially stable beach profile.

~~The proposed sand backpassing could be performed as a single project but is intended to be implemented as an ongoing maintenance program. Periodic backpassing would be performed on an as-need basis to maintain adequate beach width at the east end of the beach sector. The maintenance program would allow for sand backpassing to be conducted when beach conditions reach some pre-defined topographic triggers without having to repeat the permit process. Beach monitoring will be required to determine when the triggers have been met.~~

The UHCGG estimates that the average annual erosion rate at the east end of the Fort DeRussy beach sector with 3.2 ft of sea level rise will be 2.7 ft/yr (mid-range, 80% confidence) (UHCGG, ~~2019~~2021). Based on this estimate, sand backpassing will need to be conducted approximately every 3 years. Sand backpassing will be initiated approximately 10 years after the initial beach nourishment effort, resulting in a total of ~~Over a period of 50 yrs, this will result in a total of 17~~ 14 individual sand backpassing events and a total of ~~1~~70 days of construction.



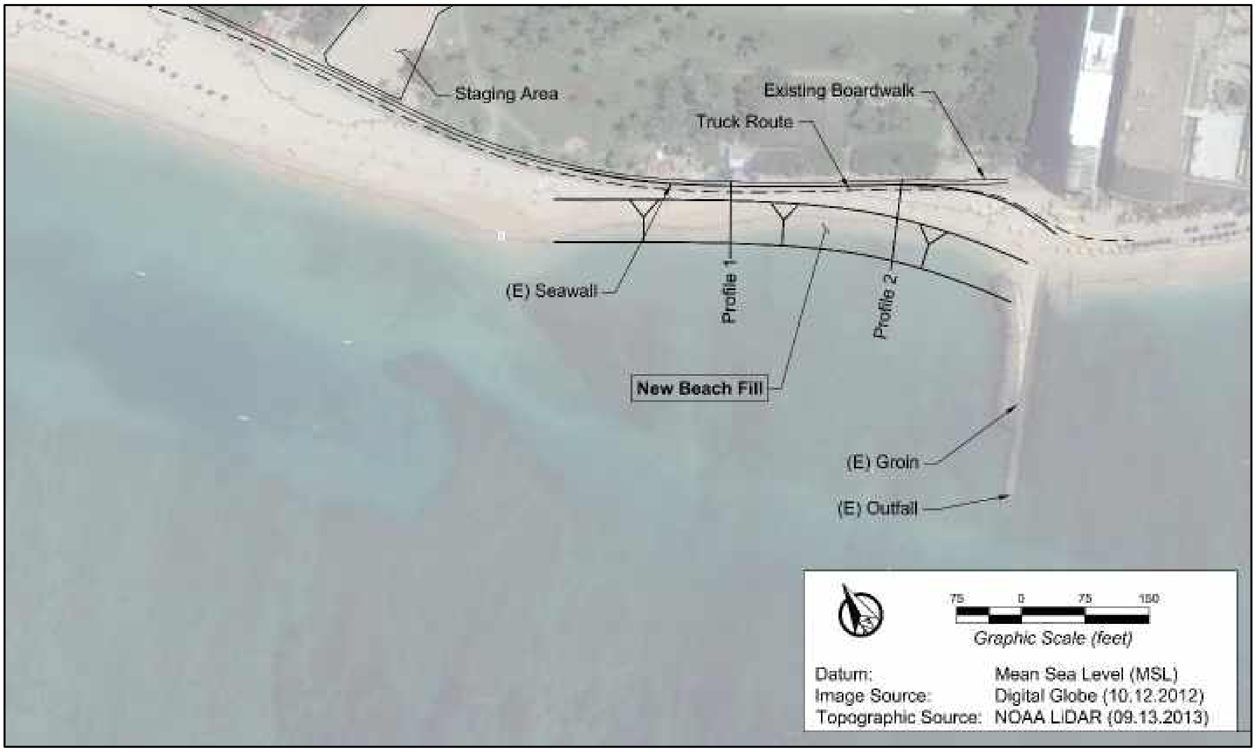
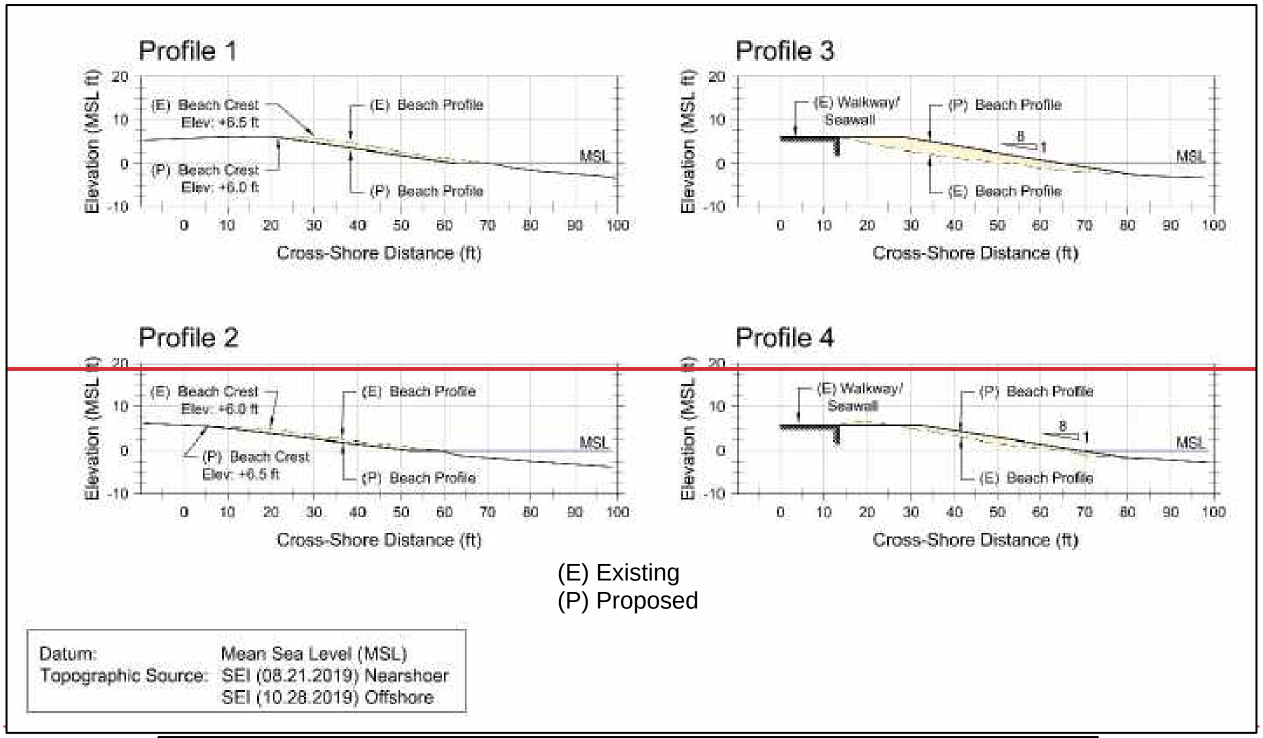


Figure 4-7 Project layout for proposed action – Fort DeRussy beach sector



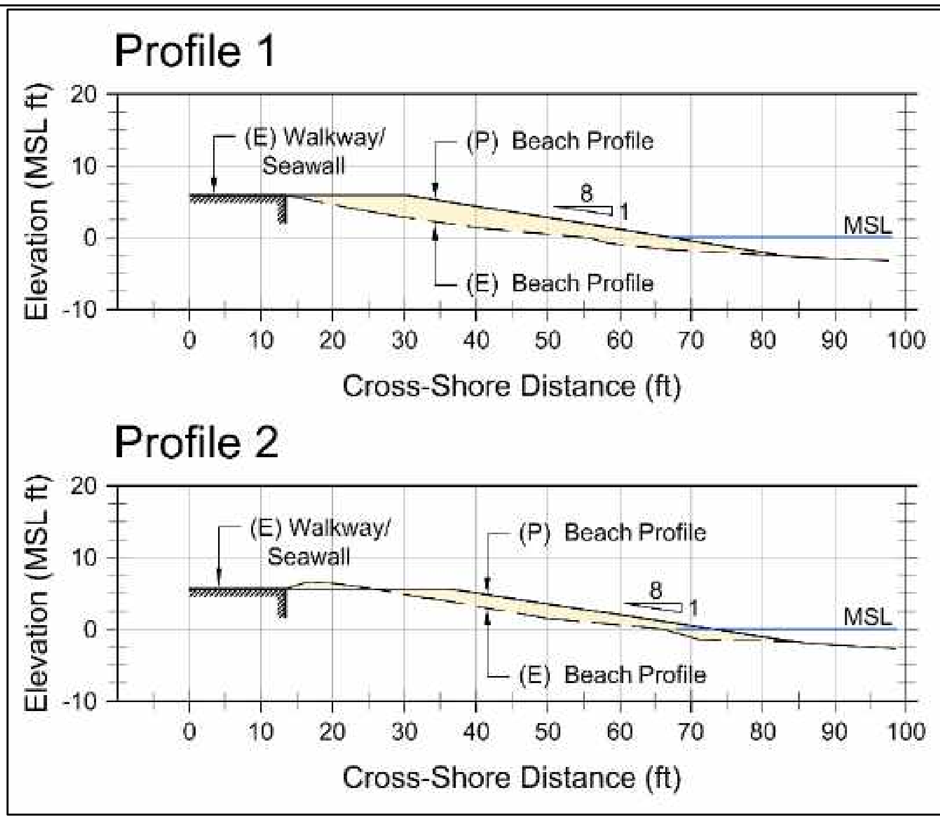


Figure 4-8 Beach profiles for proposed action – Fort DeRussy beach sector

WBSIDA Waikiki Beach SPECIAL IMPROVEMENT DISTRICT ASSOCIATION

CONCEPTUAL PLAN VIEW OF PROPOSED ACTION – FORT DERUSSY BEACH SECTOR
Waikīkī Beach Improvement and Maintenance Program
Final Programmatic Environmental Impact Statement
Honolulu, Oʻahu, Hawaiʻi

Figure 4-9 Conceptual plan view of proposed action – Fort DeRussy beach sector

Figure 4-10 Conceptual oblique view of proposed action – Fort DeRussy beach sector

4.3.2 Sand Source

The proposed action in the Fort DeRussy beach sector involves ~~moving~~ placing sand ~~from~~ on the eroded portion of the beach ~~face east of the Hilton pier/groin to the beach~~ fronting the U.S. Army Hawaiʻi Museum. Two sand samples were obtained from the beach face at each end of the beach sector in February 2021. Figure 4-11 shows the composite grain size distribution for the existing sand at the Diamond Head (east) end of the beach sector, which has a median grain size (D_{50}) of 0.~~35~~ 35 mm. Figure 4-11 also shows the composite grain size distributions for two samples of sand from the ʻEwa (west) end of the beach sector, which is slightly coarser but would be expected to be more stable on an eroding beach. This is particularly true for the Fort DeRussy beach sector where no additional beach stabilizing structures are proposed.

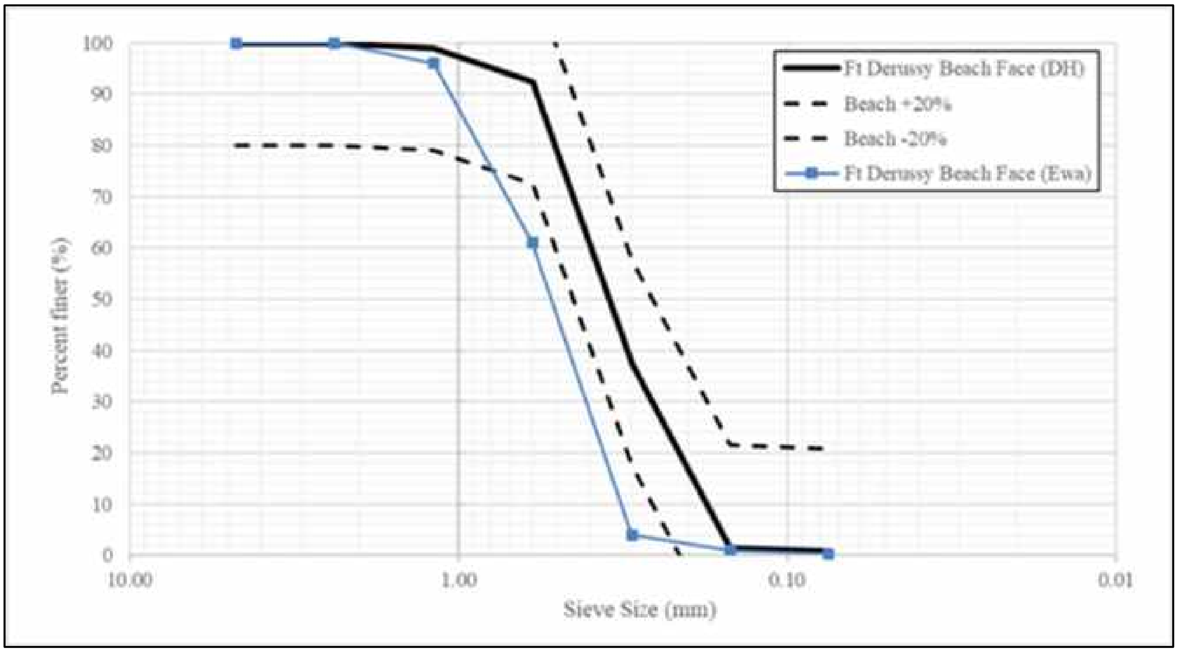


Figure 4-11 Grain size comparison of existing beach sand at borrow site and fill site

Figure 4-12 shows the composite grain size distributions for the offshore sand deposits investigated in this project. Nearly all the offshore sand falls within ±20% of the Fort DeRussy beach sand grain size distribution. Sand from the *Hilton* deposit falls on the coarser side; however, slightly coarser sand would be expected to be stable on an eroding beach.

Potential sand sources for the Fort DeRussy beach sector include the *Ala Moana*, *Hilton*, and *Canoes/Queens* offshore sand deposits. Figure 4-13 and Table 4-1 present the grain size distributions and statistics for the beach and the potential offshore sand sources. Sand from any of the three sources presented (*Ala Moana*, *Hilton*, and *Canoes/Queens*) could be used with no required overfill.

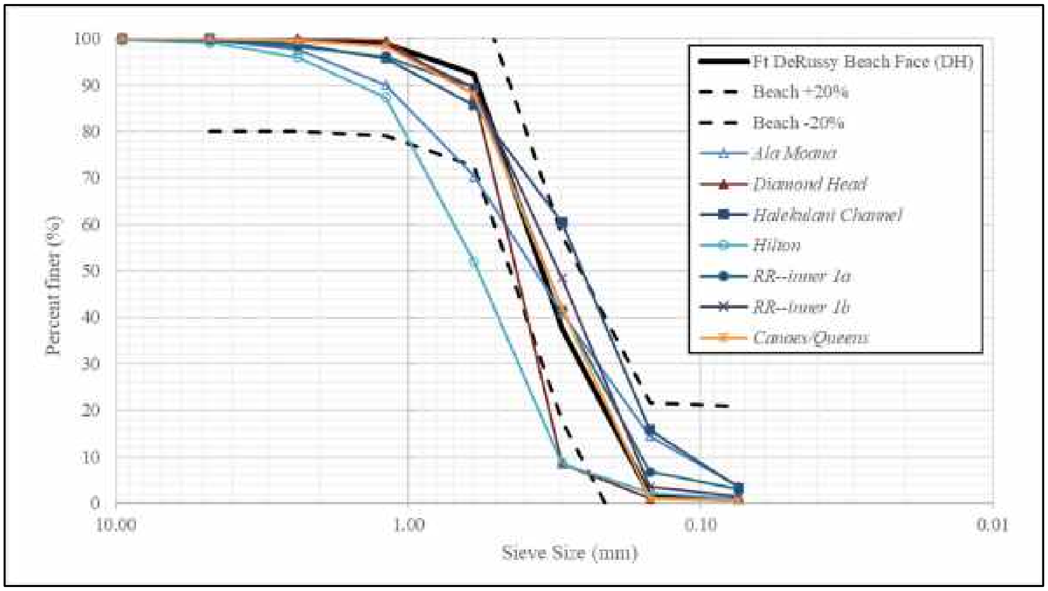


Figure 4-12 Comparison of grain size distributions for existing beach sand and offshore sand – Fort DeRussy beach sector

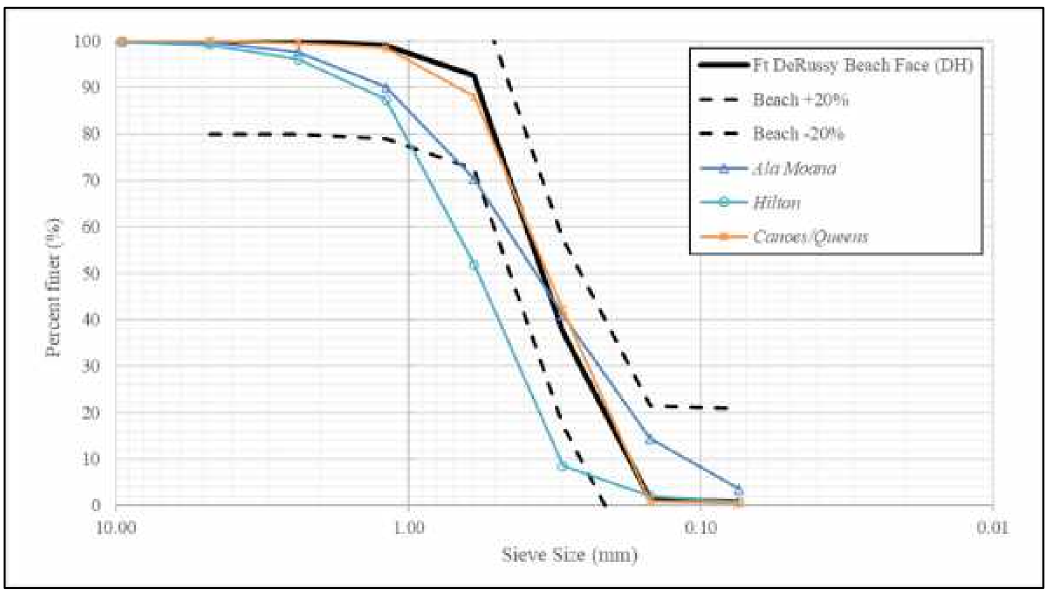


Figure 4-13 Grain size distributions for potential sand sources – Fort DeRussy beach sector

Table 4-1 Comparison of sand parameters – Fort DeRussy beach sector

	Existing Beach Sand	*Ala Moana*	*Hilton*	*Canoe/Queens*
Median diameter, D_{50} (mm)	0.35	0.37	0.59	0.34
Sorting	N/A	1.42	1.02	0.82
Overfill factor	N/A	1.10	1.00	1.50
Estimated sand required (cy)	3,5000	3,5000	3,0500	3,0500
Estimated sand available (cy)	N/A	86,000	40,000	40,000

4.3.3 Construction Methodology

The methodology for sand recovery will depend on the sand source. The *Ala Moana*, *Hilton*, and *Queens/Canoes* deposits were presented previously as suitable sand sources; however, only the *Hilton* sand deposit allows for pumping of the sand directly to the project shoreline. The conceptual layout for a sand recovery operation from the *Hilton* deposit is shown in ~~Sand for the proposed action would be obtained from the *Hilton* offshore sand deposit. The *Ala Moana*, *Hilton*, and *Queens/Canoes* deposits were presented previously as suitable sand sources; however, only the *Hilton* sand deposit allows for pumping of the sand directly to the project shoreline. The conceptual layout for the proposed sand recovery operation is shown in~~ Figure 4-14. A barge with a submersible slurry pump will be anchored over the sand deposit and a pipeline to shore will be placed within the channel that leads to the Hilton pier. The pipeline will extend onto shore and the sand/water slurry will be pumped into a dewatering basin on the beach, where the sand will be dewatered and stockpiled prior to placement.

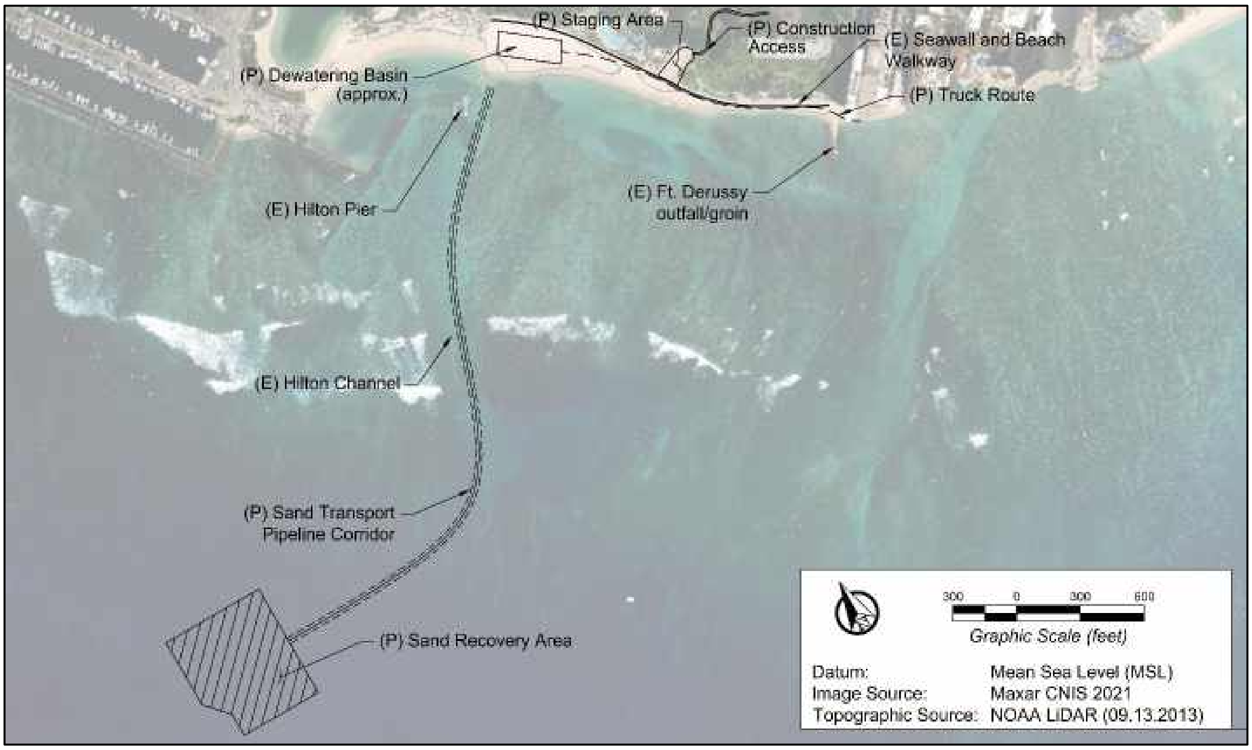


Figure 4-14 Sand recovery schematic for the *Hilton* offshore sand deposit

The dewatered sand will be loaded into dump trucks, transported down the beach along the makai (seaward) side of the existing seawall and beach walkway, and offloaded at the placement area, where it will be graded by a bulldozer to achieve the design beach profiles. Depending on the size and capacity of the dump trucks, approximately ~~20~~150 to ~~3~~250 truckloads will be required to move 3,~~5~~000 cy of sand. Based on this volume of sand, the construction duration will be approximately 30 days.

The distance between the *Ala Moana* sand deposit and the Fort DeRussy placement area is too extensive to allow the sand to be pumped to shore. A clamshell dredge would be used to recover the sand, which would eliminate the need for a pipeline to shore and a dewatering basin. A crane barge to dredge the sand and a scow and tugboat to transport the sand to an offloading site would be required. Sand would be offloaded at Magic Island. This sand recovery method was evaluated for the EIS for the City and County of Honolulu's "Ala Moana Regional Park and Magic Island Improvements" project (Belt Collins Hawaii, 2019). The sand would then be loaded in dump trucks and trucked to Fort DeRussy beach, offloaded at the placement area, and graded by a bulldozer to achieve the design beach profiles.

Access to the placement site may be limited due to beach conditions at the time of construction. If the beach is narrow, sand placement will begin at the west end of the placement site and proceed from west to east, with the newly placed sand providing access for trucking.

Access between the dewatering site and placement site may be limited due to beach conditions at the time of construction. If the beach is narrow, sand placement will begin at the west end of the placement site and proceed from west to east, with the newly placed sand providing access for trucking.

Best Management Practices (BMPs) will be employed as required by the permits. BMPs may include turbidity curtains surrounding the borrow and fill sites, silt fencing, and biosocks. Signage and barriers will be used to divert beach users away from active work areas, and the dump trucks will be escorted down the beach to ensure public health and safety.

Heavy equipment such as excavators, front end loaders, and dump trucks will access the site either through Paoa Place between Hilton Hawaiian Village and the Hale Koa Hotel, or through Fort DeRussy Park between the Hale Koa Hotel swimming pool and the U.S. Army Museum of Hawaiʻi.

Heavy equipment such as excavators, front end loaders, and dump trucks will access the site either through the parking lot makai (seaward) of the Duke Kahanamoku Lagoon or through Paoa Lane between Hilton Hawaiian Village and the Hale Koa Hotel. Sand will be excavated from the beach face at the borrow site on the east side of the Hilton pier/groin using an excavator situated on the dry beach. The borrow site is approximately 700 ft long, and removal of sand equating to a 7.5-ft reduction in beach width will produce around 1,500 cy of sand. The sand will be taken from the beach face and will not reduce the beach crest elevation at the borrow site. The proposed project layout is shown in Figure 3-7.

The borrow sand will be obtained by the excavator scooping sand from the beach face, both above and below the waterline, and placing the sand directly into dump trucks or stockpiling it temporarily on the back beach prior to transport. The dump trucks will then transport the sand down the beach along the makai (seaward) side of the seawall and walkway and place the sand in the placement area, where it will be graded by a bulldozer to achieve the design beach profiles. Depending on the size and capacity of the dump trucks, approximately 50 to 100 truckloads will be required to move 1,500 cy of sand. Based on this volume of sand, the construction duration will be approximately 10 days.

~~Access between the borrow site and placement site may be limited due to beach conditions at the time of construction. If the beach is narrow, sand placement will begin at the west end of the placement site and proceed from west to east, with the newly placed sand providing access for trucking.~~

~~Best Management Practices (BMPs) will be employed as required by the permits. BMPs may include turbidity curtains surrounding the borrow and fill sites, silt fencing, and biosocks. Signage and barriers will be used to divert beach users away from active work areas, and the dump trucks will be escorted down the beach to ensure public health and safety.~~

4.3.4 Estimated Timing, Phasing, and Duration

The timeframe for implementing the proposed action in the Fort DeRussy beach sector has yet to be determined. The proposed action will be implemented in phases. The first phase will consist of beach nourishment, which will involve placement of ~~approximately 3,500 cy of~~ sand recovered from the *Hilton* offshore sand deposit. The proposed initial beach nourishment will be conducted as soon as the required permits and approvals are obtained and will be performed concurrent with the Halekūlani improvement presented in Chapter 5. The second phase will consist of periodic sand backpassing to maintain the desired beach width and profile. Sand backpassing will be conducted when beach conditions reach some predetermined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. The estimated construction duration for the proposed sand backpassing is 5~~10~~ days.

~~The proposed sand backpassing is designed to be implemented periodically on an as-needed basis. Sand backpassing will be conducted when beach conditions reach some predetermined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. The estimated construction duration for the proposed sand backpassing is 10 days.~~
The UHCGG estimates that the average annual erosion rate at the east end of the Fort DeRussy beach sector with 3.2 ft of sea level rise will be ~~2.7~~~~2.1~~2.1 ft/yr (mid-range, 80% confidence) (UHCGG, ~~2019~~2021). Based on this estimate, sand backpassing will need to be conducted approximately every 3 years. Sand backpassing will be initiated approximately 10 years after the initial beach nourishment effort, resulting in a total of 14 ~~Over a period of 50 yrs, this will result in a total of 17~~ ~~15~~ individual sand backpassing events and a total of ~~170~~ ~~70 to xx~~70 days of construction.

4.3.5 Required Permits and Approvals

The proposed action is anticipated to require the following permits and approvals:

- Department of the Army Permit (Section 10 and Section 404)
- Clean Water Act, Section 401 Water Quality Certification
- Clean Water Act, Section 402 National Pollutant Discharge Elimination System Permit
- Coastal Zone Management Act Consistency Review
- ~~Small Scale Beach Nourishment (SSBN) or Small Scale Beach Restoration (SSBR) Permit~~
- Conservation District Use Permit ~~for the Programmatic Waikīkī Beach Improvement and Maintenance Program~~
- Right of Entry Permit

- Shoreline Certification
- Special Management Area Use Permit
- Grading Permit and/or Stockpiling Permit
- Air Pollution Permit
- Community Noise Permit

4.4 Alternatives to the Proposed Action

The following alternatives were considered for the Fort DeRussy beach sector:

- ~~Beach Nourishment without Stabilizing Structures~~
- Beach Nourishment with Stabilizing Structures

~~4.4.1 Beach Nourishment without Stabilizing Structures~~

~~An alternative to sand backpassing is beach nourishment without stabilizing structures, which would involve obtaining offshore sand and placing it on the beach at the Diamond Head (east) end of the Fort DeRussy beach sector. Depending on the desired beach width and crest elevation, the project would involve placement of approximately 6,300 to 13,700 cy of offshore sand on the beach. The beach would be widened to approximately 165 ft as measured from the beach walkway to the waterline. A topographic survey would be required to confirm the final design profiles.~~

~~Potential sand sources for beach nourishment in the Fort DeRussy beach sector are the *Hilton* and *Ala Moana* offshore deposits (see Section 3.5). Sand recovery would likely be performed using a clamshell dredging system, with the sand loaded onto a barge, transported to shore, and offloaded into dump trucks. Consultations with the Hawaiʻi Department of Transportation determined that pier space at Honolulu Harbor is not available; therefore, the most likely sand offloading site would be the Ala Wai Small Boat Harbor and Magic Island parking lot. This is the same offloading location that is proposed for the Ala Moana Regional Park beach nourishment project. The sand would be trucked into Fort DeRussy through Paoa Lane or through the U.S. Army Hawaiʻi Museum property. The sand would be placed on the beach and spread using bulldozers.~~

~~Beach nourishment without stabilizing structures would not alter existing sediment transport patterns and the beach would continue to erode; however, large events such as hurricanes could result in significant loss of sand in a short period of time.~~

~~The estimated construction duration for beach nourishment without stabilizing structures is 120 days, and the estimated recurrence interval is 10 yrs. Assuming that renourishment is conducted over a period of 50 yrs, this would result in a total of 5 individual renourishment events and a total of 600 days of construction.~~

~~4.4.2~~4.4.1 Beach Nourishment with Stabilizing ~~Groins~~Structures

An alternative to the proposed small-scale beach nourishment and periodic sand backpassing would be to nourish the beach and construct 2 to 3 groins to stabilize the sand fill. Stabilizing groins are necessary to maintain a stable beach profile and prevent the sand from eroding. Guidance for T-head groin design is provided in Section 3.4.5.

Figure 4-15 presents two conceptual layouts for beach nourishment with stabilizing groins that would produce one or two stable beach cells fronting the U.S. Army Hawaiʻi Museum property. The conceptual layout presented in Figure 4-15 (a) would require construction of one L-head groin and adding an angled head to the existing rock rubblemound groin on the ʻEwa (west) side of the existing Fort DeRussy outfall/groin. This option would create one stable, arc-shaped beach cell that would be approximately 50 ft wide in the center and widen to approximately 83 ft near the groins. The project would place approximately 8,500 cy of offshore sand on the beach.

The conceptual layout presented in Figure 4-15 (b) would require construction of one T-head groins and one L-head groin and adding an angled head to the existing rock rubblemound groin on the ʻEwa (west) side of the existing Fort DeRussy outfall/groin. This option would create two stable, arc-shaped beach cells that would be approximately 38 to 53 ft wide in the center and widen to approximately 92 to 97 ft near the groins. The project would place approximately 14,000 cy of offshore sand on the beach.

The groins would be designed for an initial +8.5 ft MSL beach crest elevation to account for 1.5 ft of sea level rise, with the ability to increase the beach crest elevation to +10 ft MSL to account for additional future sea level rise. The groin stems would be up to about 200 ft long and would be sufficient to stabilize up to a +10-ft MSL beach crest elevation. The minimum beach crest width at its narrowest point midway between the groins would be about 20 to 30 ft, and the beach slope would be 1V:8H (vertical to horizontal).

Figure 4-16 presents a design to stabilize the beach with smaller structures and less sand. The design includes a groin head added to the Fort DeRussy outfall groin, similar to the one shown in Figure 4-15 and a stub groin locate 500 feet in the ʻEwa direction. The design of this system is guided by the program MEPBAY (Klein et al. 2003), which models the shoreline position created between a headland (groin head) and downdrift control point (new stub groin). The stub groin is positioned at an inflection in the shoreline west of the eroding beach.

The new groin head would be constructed to elevation +8.5 ft MSL to account for sea level rise; however, the smaller groin could be constructed to a lower elevation, such as +6 ft MSL, to be only slightly higher than the beach sand. This design would produce a stable beach fronting the U.S. Army Museum of Hawai'i and only occasional maintenance would be expected. The smaller groin could be easily accessed for modification for sea level rise in the future.

~~The proposed sand backpassing is designed to be implemented periodically on an as-needed basis. Sand backpassing will be conducted when beach conditions reach some predetermined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. The proposed sand backpassing will involve moving approximately 1,500 cy of existing beach sand from one end of the beach to the other. No dredging is proposed and the volume of sand in the littoral system will not be altered. The estimated construction duration for the proposed sand backpassing is 10 days.~~

~~The UHCGG estimates that the average annual erosion rate at the east end of the Fort DeRussy beach sector with 3.2 ft of sea level rise is 2.7 ft/yr (mid-range, 80% confidence) (UHCGG, 2019). Based on this estimate, sand backpassing will need to be conducted every 3 years. Over a period of 50 yrs, this will result in a total of 17 individual sand backpassing events and a total of 170 days of construction.~~

When compared to the alternatives of beach nourishment with or without stabilizing structures, the proposed action has less cumulative impacts. The proposed small-scale beach nourishment and periodic sand backpassing requires fewer individual events, fewer construction days, fewer beach closures, no offshore dredging, and no increase in the volume of sand in the littoral system. While larger-scale beach nourishment is technically feasible, it is not being proposed due to the relatively isolated scope of the erosion problem. Furthermore, beach nourishment may not be a viable long-term solution due to the limited volume of compatible offshore sand to support periodic renourishment efforts in Waikīkī.

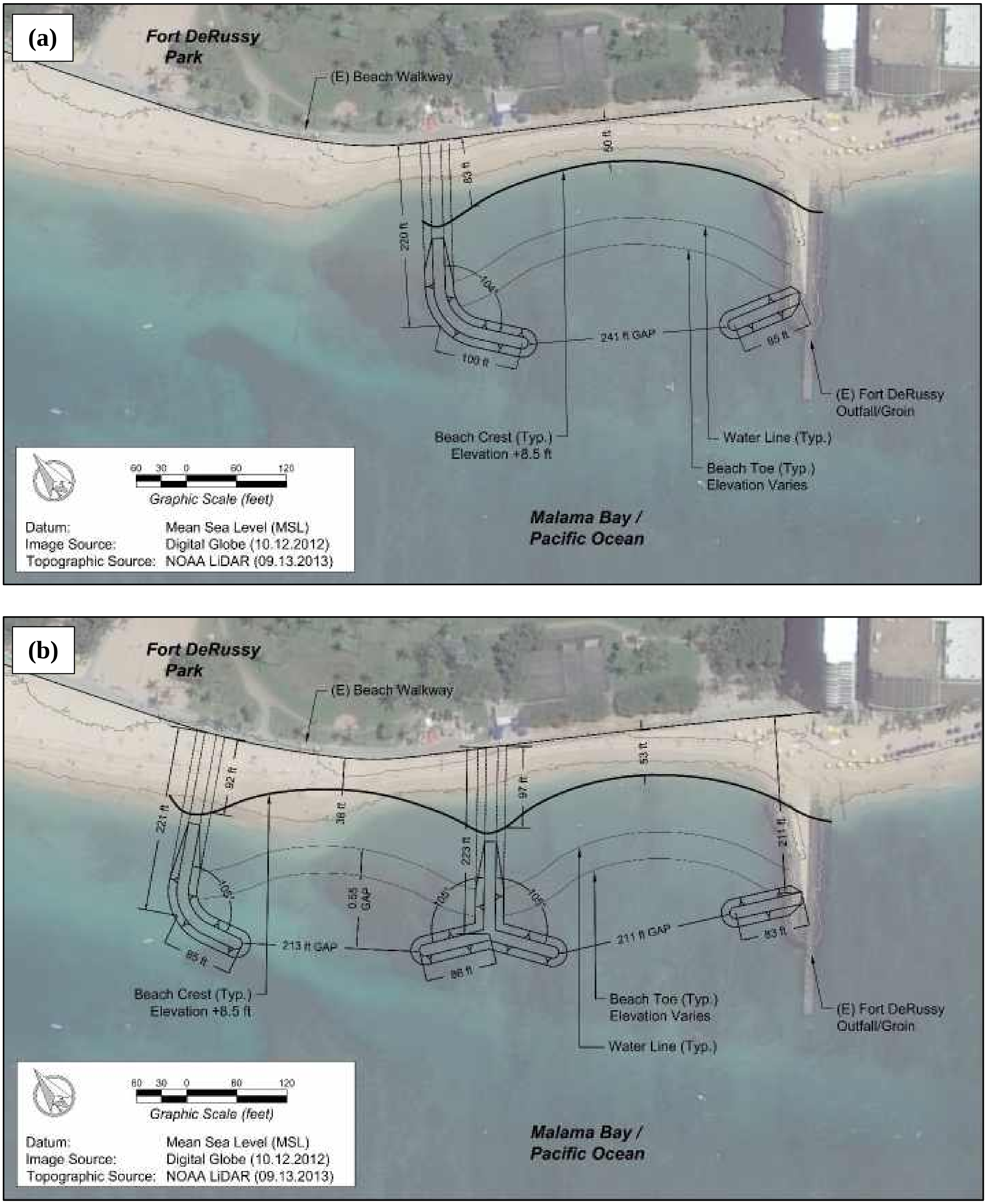


Figure 4-15 Conceptual layouts for beach nourishment with stabilizing groins – Fort DeRussy beach sector

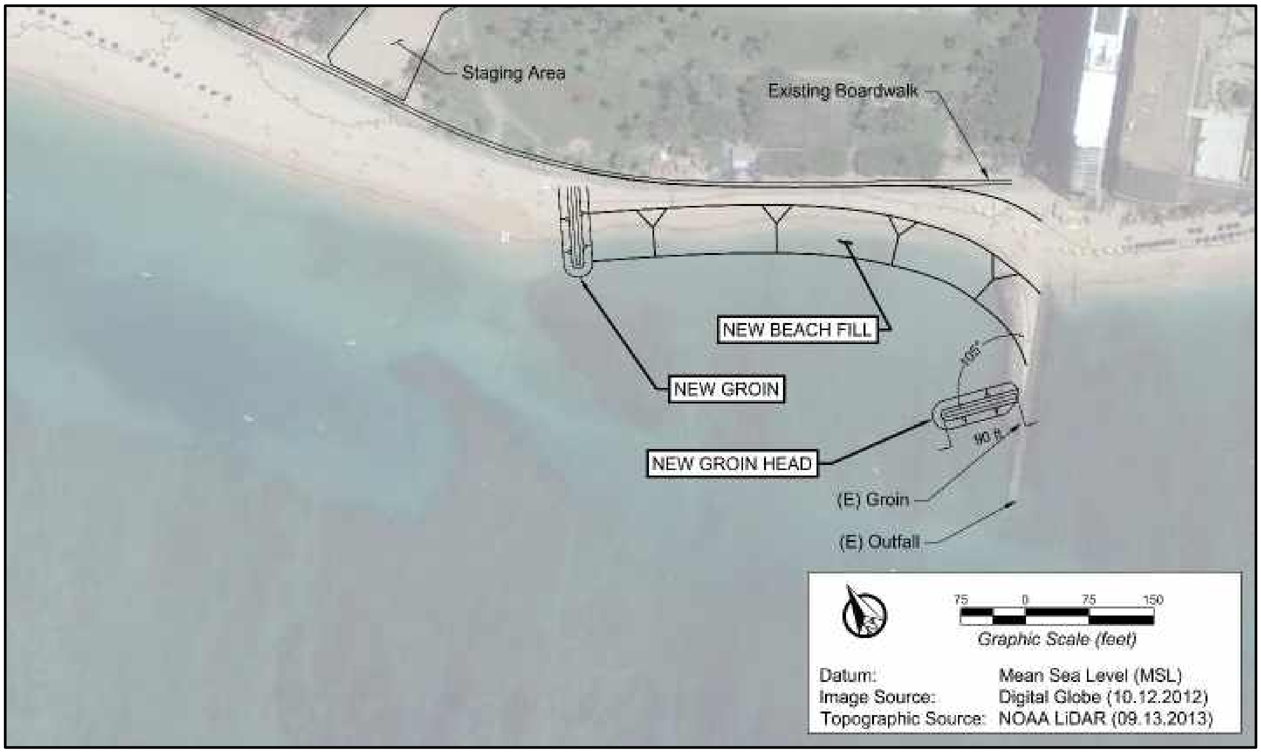


Figure 4-16 Conceptual layout of beach nourishment, new groin head, and stub groin – Fort DeRussy beach sector

5. PROPOSED ACTION: HALEKŪLANI BEACH SECTOR

5.1 General Description

The Halekūlani beach sector spans approximately 1,450 ft of shoreline extending from the Fort DeRussy outfall/groin east to the Royal Hawaiian groin. Prominent features in this sector include the Castle Waikīkī Shore, Outrigger Reef Waikīkī Beach Resort, Halekūlani Hotel, and the Sheraton Waikiki Hotel. The Halekūlani Channel extends perpendicular from the shoreline fronting the Halekūlani Hotel. An overview map of the Halekūlani beach sector is shown in Figure 5-1.

History
Shoreline modifications in the Halekūlani beach sector occurred generally coincident with modifications in the Fort DeRussy beach sector. In the early 1900's, the Halekūlani Channel was dredged, the material was used as fill for Fort DeRussy, and a series of seawalls were constructed along the shoreline. The Royal Hawaiian groin was constructed in 1927 and, soon after, sand was pumped to the shoreline to construct a beach. Eight small groins were constructed between Fort DeRussy and the Royal Hawaiian groin to stabilize the sand. The history of coastal engineering in the Halekūlani beach sector is summarized in Figure 5-2. Historical photographs of the Halekūlani beach sector are shown in Figure 5-3. Aerial photographs comparing the shoreline conditions in the Halekūlani beach sector in 1949 and 2015 are shown in Figure 5-4.

Existing Conditions
The Halekūlani beach sector is an entirely engineered shoreline. The west end of the sector is bounded by the Fort DeRussy outfall/groin, which consists of a concrete box culvert and a rock rubblemound groin. A narrow beach extends approximately 375 ft east from the Fort DeRussy outfall/groin fronting the Castle Waikīkī Shore and Outrigger Reef Waikīkī Beach Resort. The beach terminates at the west end of a vertical seawall that spans approximately 335 ft of shoreline fronting the Halekūlani Hotel. A concrete sidewalk constructed on top of the seawall provides limited lateral access along the shoreline. The seawall varies in height between +5.2 to +5.6 ft MSL and is frequently overtopped by waves during high tides and high surf events.

Two small pocket beaches, backed by vertical seawalls, are located between the Halekūlani and Sheraton Waikiki hotels. This area is often referred to as "Gray's Beach" in reference to a boardinghouse called "Gray's by the Sea" that existed at this site in the early 1900s. The west pocket beach spans approximately 100 ft of shoreline. The beach has a crest elevation up to approximately +7.5 ft MSL and a crest width of about 5 to 10 ft. The beach crest is regularly overtopped by waves and is frequently flooded, particularly during high tide and high surf events. A relict concrete groin is located near the center of the pocket beaches and extends approximately 125 ft seaward of the shoreline. The groin is almost entirely submerged. Due to the lack of a walkway in this area, lateral shoreline access is discontinuous, and people must traverse the intertidal beach in this area.

The east pocket beach spans approximately 125 ft of shoreline. The beach has a beach crest elevation between +5.5 to +6.5 ft MSL. The crest width varies from 0 to 25 ft. The beach terminates at the west end of a vertical seawall that spans approximately 500 ft of shoreline fronting the Sheraton Waikiki Hotel. The seawall continues east and terminates at the existing Royal Hawaiian groin, which marks the east boundary of the Halekūlani beach sector. A concrete walkway on top of the seawall provides the only lateral shoreline access between the east and west portions of Waikīkī Beach. Stairs are located at the ends of the seawalls east and west of the pocket beaches. An approximately 150-ft-long section of the walkway along the seawall has been closed to the public since 2017 and there is no lateral access along this portion of the shoreline except through the Sheraton Waikiki Hotel pool deck area. Closure of this area inhibits lateral shoreline access between the east and west portions of Waikīkī Beach.

The Royal Hawaiian groin was originally constructed as a concrete wall groin in 1927. The groin was recently replaced with a rock rubblemound L-head groin that was constructed in 2020. There are eight additional (8) relict groins in the Halekūlani beach sector that were constructed in the early 1900s. The groins are deteriorated, largely submerged, and do not appear to perform any significant function. Photographs of existing conditions in the Halekūlani beach sector are shown in Figure 5-5.

Historical and Projected Shoreline Change

The historical shoreline change analysis for the Halekūlani beach sector (transects 118 to 140) determined that, from 1927 to ~~2015~~2021, the shoreline has been relatively stable with slightly more pronounced accretion at the east end of the sector fronting the Sheraton Waikiki Hotel (UHCGG, ~~2019~~2021). Miller and Fletcher (2003) found that sediment transport in the Halekūlani beach sector varies according to the seasonal wave regime. The relative stability of the shoreline can be attributed to the limited volume of sand and the presence of the seawalls that artificially fix the shoreline. At the west end of the sector (transects 133 to 140), sand is impounded on the updrift side of the Fort DeRussy outfall/groin. The beach in this area is narrow and beach width fluctuates seasonally.

The pocket beaches in the central portion of the sector (transects 126 to 129), between the Halekūlani and Sheraton Waikiki hotels, are aligned with the Halekūlani Channel and have experienced moderate erosion at a rate of 0.2 ft/yr (UHCGG, ~~2019~~2021). The pocket beaches are dynamic and sand volumes and beach width often fluctuate. The pocket beaches are often completely submerged during high tides and high surf events, and waves frequently overtop the existing walls in this area. The east end of the sector (transects 118 to 125) is dominated by a seawall fronting the Sheraton Waikiki Hotel. Sand occasionally accumulates in front of the seawall where it is impounded by the Royal Hawaiian groin; however, the sand is unstable and there is typically little or no dry beach in this area.

Erosion, coastal flooding, and beach loss in the Halekūlani beach sector are projected to continue and accelerate as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to ~~3.9~~16.1 ft ~~(1.2 m)~~ by 2050 and up to ~~14.1~~88.0 ft ~~(4.3 m)~~ by 2100 (UHCGG, ~~2019~~2021). It is important to note that the long-term historical shoreline change rates for Waikīkī are influenced by efforts over the past century to stabilize and restore the beaches, which influences the future erosion projections. These projections also do not account for the presence of the existing seawalls that span the entire length of the Halekūlani beach sector. As the shoreline approaches the existing seawalls, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016).

Without beach improvements and maintenance, it is likely that sea level rise will result in total beach loss this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged during high tide and high surf events. Recent observations indicate that beach loss is already accelerating in the western portion of the Halekūlani beach sector.

Beach Improvements and Maintenance

The most recent beach improvement project in the Halekūlani beach sector was the replacement of the Royal Hawaiian groin, which was completed in August 2020. The original Royal Hawaiian groin was in a severely deteriorated condition. Its failure would have destabilized 1,730 ft of sandy shoreline east of the groin in the Royal Hawaiian beach sector. The DLNR initiated design and construction of a new groin to replace the original Royal Hawaiian groin. The objective of the project was to stabilize Royal Hawaiian Beach to maintain its intended recreational, aesthetic, and economic values, and improve lateral access along the shoreline. The new groin was designed to maintain the approximate beach width of the 2012 Waikīkī Beach Maintenance I project.

The new groin was constructed along the alignment of the original groin and incorporated a portion of the original groin as a core wall to prevent sand movement through the groin. The new groin is of rock rubblemound construction and incorporates a cast-in-place concrete crown wall. The new groin extends 125 ft from the seawall fronting the Sheraton Waikiki Hotel, and then angles to the southeast to create a 50-ft-long L-head, for a total crest length of 175 ft. The new groin was constructed of a single layer of keyed and fit 3,200 to 5,400 lb armor stone over 300 to 600 lb underlayer stone and 30 to 100 lb core stone.

Following stone placement, a 5-ft wide by 5-ft-thick concrete crown wall was constructed to stabilize the crest and provide a foundation should a future increase in crest elevation be necessary to accommodate sea level rise. The concrete crown wall elevation is +9 ft MSL for its first 40 ft, then transitions down to +6 ft MSL on a 1V:8H (vertical to horizontal) slope, then remains at +6 ft MSL for the remainder of its length. The stone crest elevation is +7 ft MSL for the first 40 ft and then transitions down to +4 ft MSL for the remainder of the groin length.

The existing concrete block groin was reduced in elevation to a maximum elevation of +4 ft MSL to +1 ft MSL to facilitate construction of the new groin. Approximately 40 ft of the existing groin, beginning at about 120 ft from shore, was removed as necessary to construct the transition to the L-head portion of the groin. The remaining portion of the existing groin, makai (seaward) of the new groin head, was left in place.

Figure 5-1 Overview map – Halekūlani beach sector

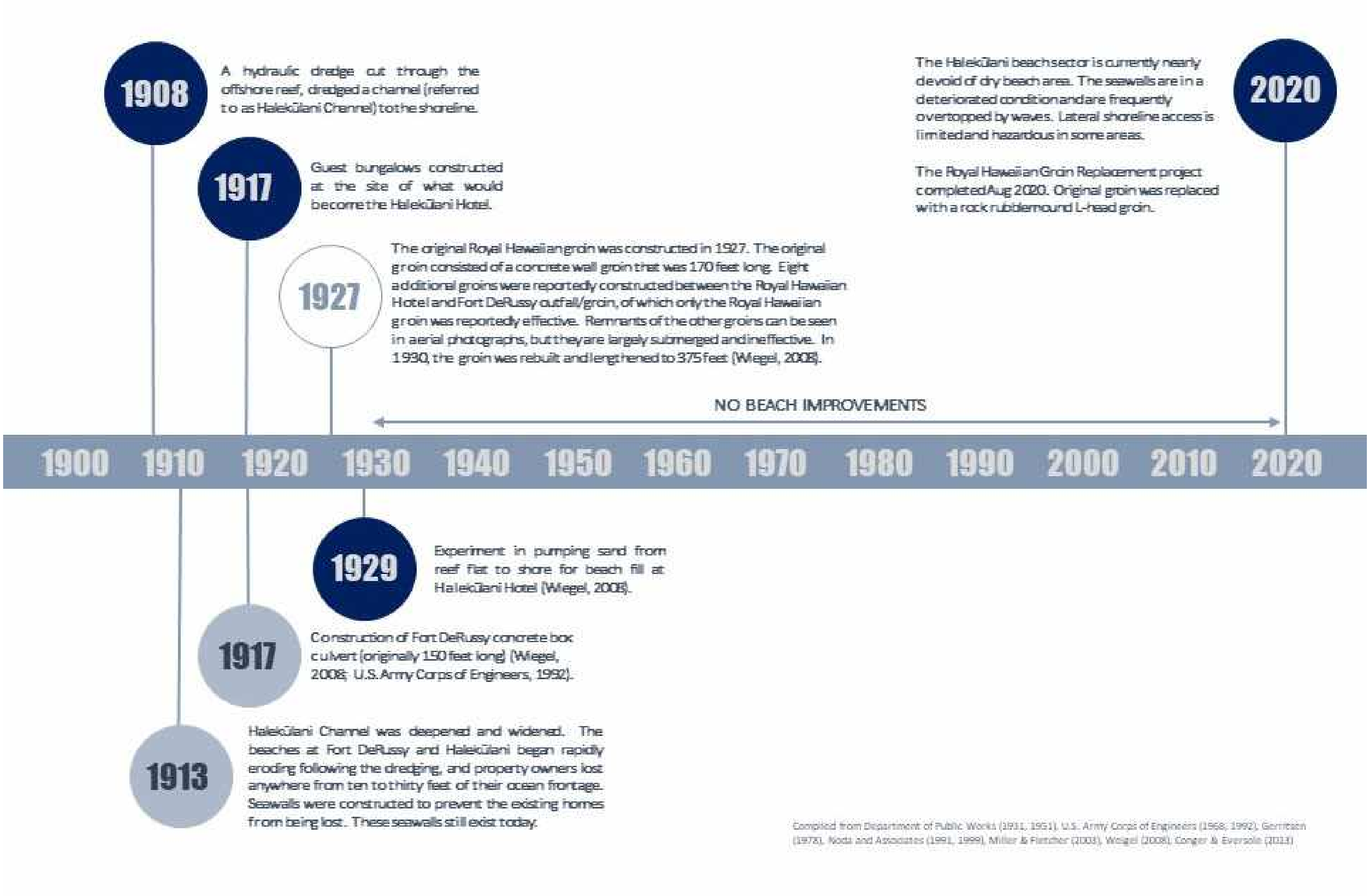


Figure 5-2 History of coastal engineering – Halekūlani beach sector

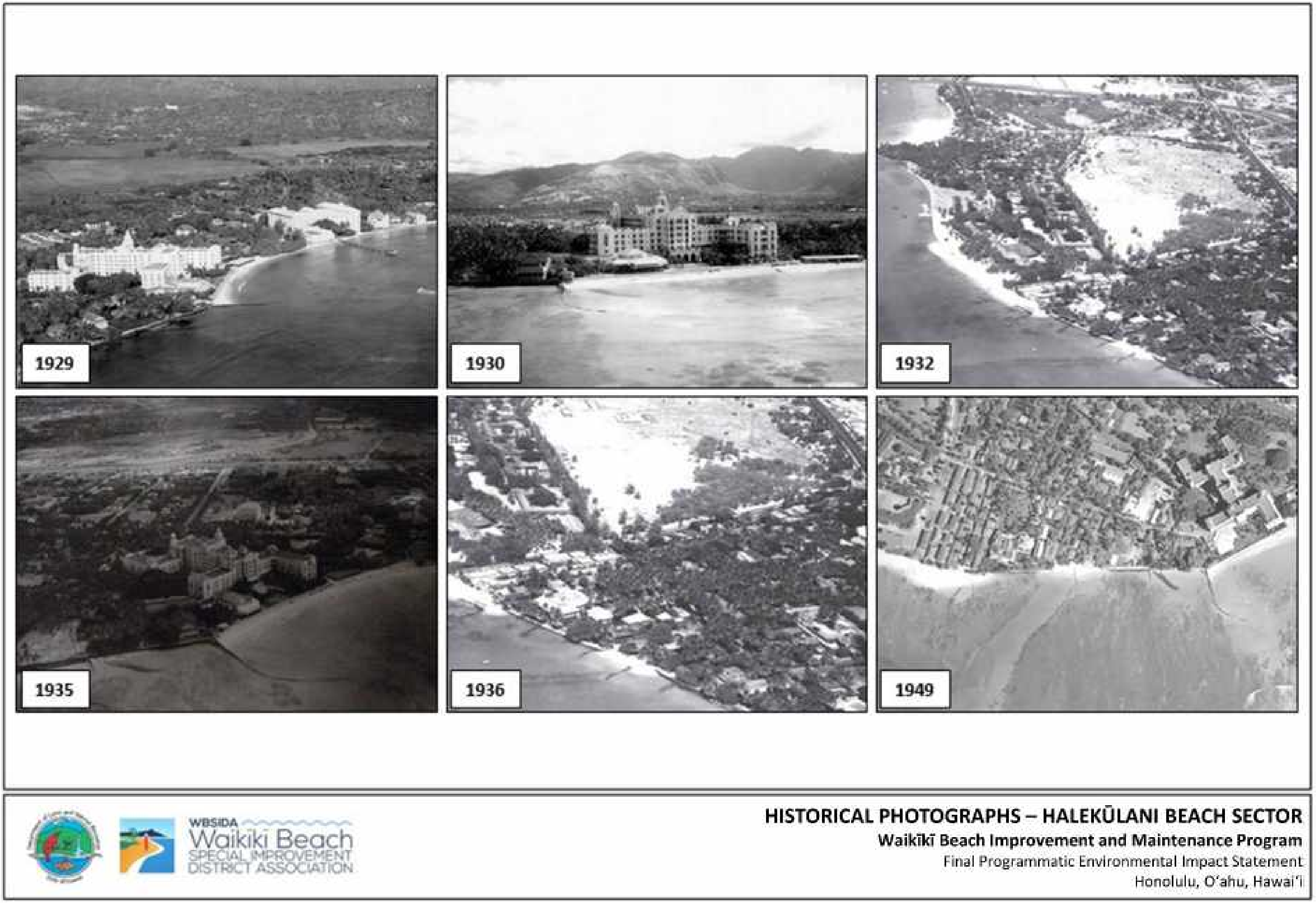


Figure 5-3 Historical photographs – Halekūlani beach sector

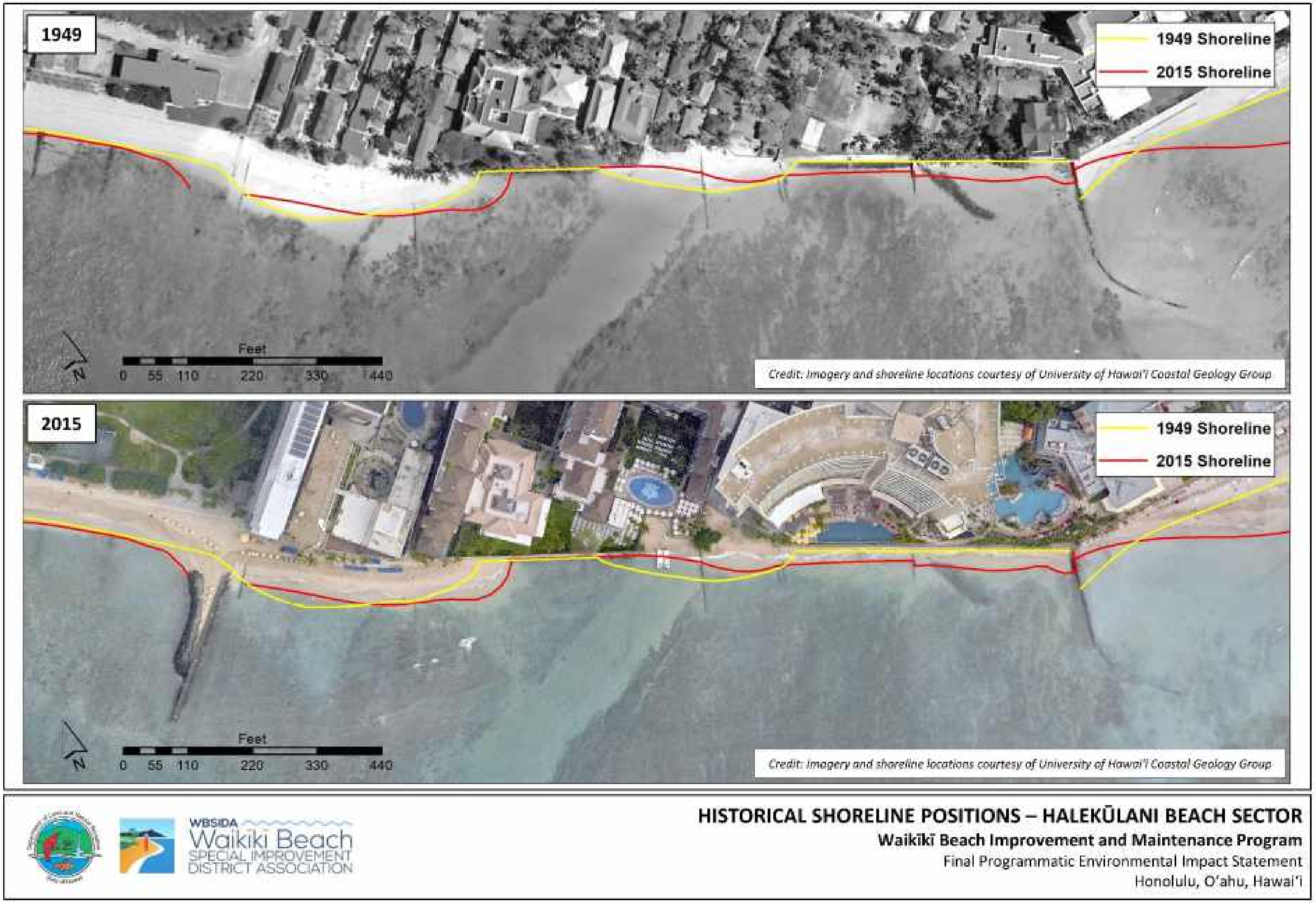


Figure 5-4 Comparison of 1949 and 2015 shoreline positions – Halekūlani beach sector

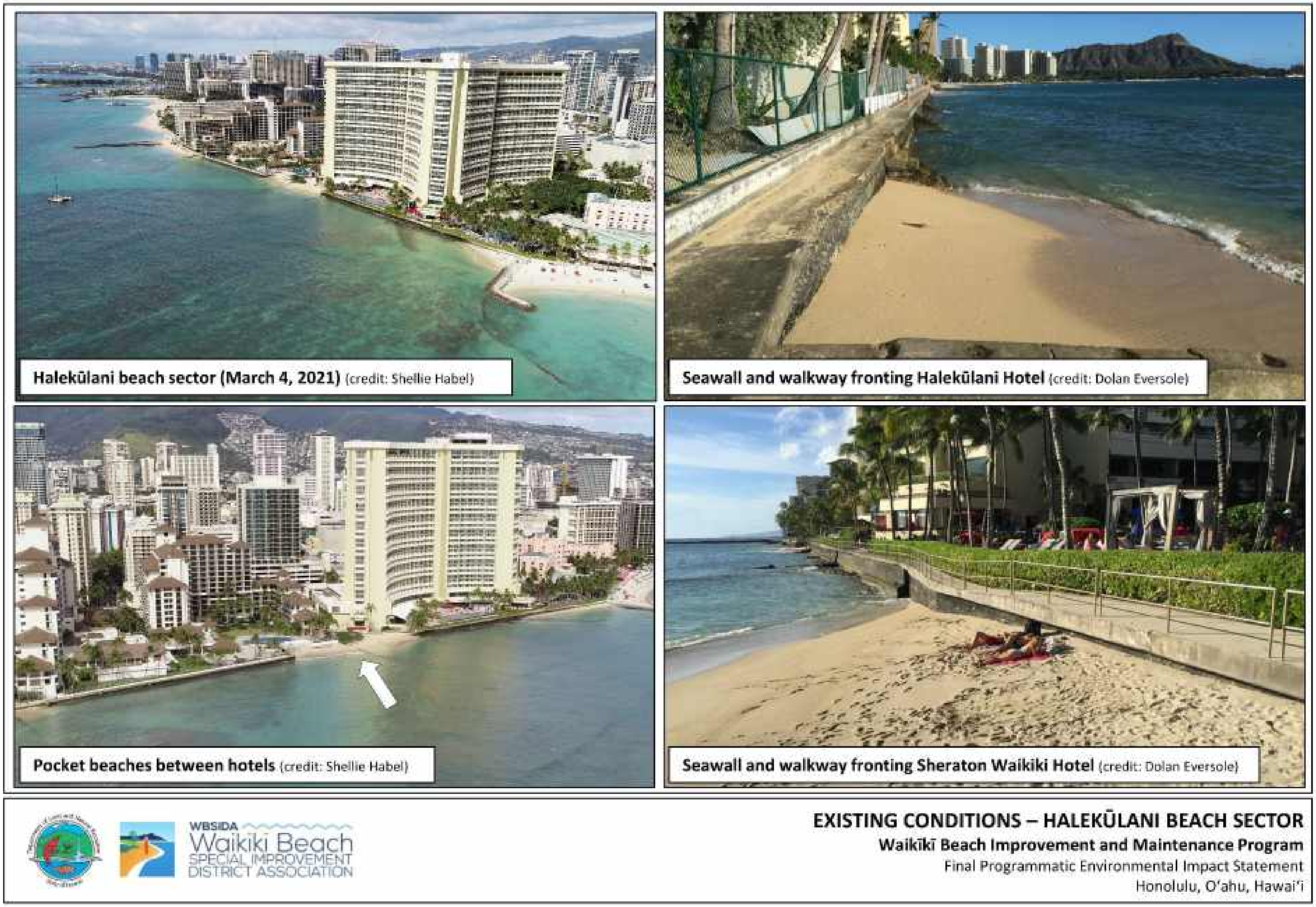


Figure 5-5 Existing conditions – Halekūlani beach sector

5.2 Purpose and Need for the Proposed Action

The Halekūlani beach sector essentially bifurcates shoreline access and viewplanes between the western portion of Waikīkī Beach (Hilton Hawaiian Village to Fort DeRussy) and the eastern portion of Waikīkī Beach (Royal Hawaiian Beach to Kaimana Beach). Walkways on top of the seawalls fronting the Halekūlani and Sheraton Waikiki hotels provide limited and discontinuous lateral access along the shoreline. The walkways are very narrow, are not ADA-accessible, and are subject to wave overtopping during high tides and high surf events. Structural damage has repeatedly resulted in closure of the walkways, which effectively prohibits lateral shoreline access between the Fort DeRussy and Royal Hawaiian beach sectors. There are no walkways across the small pocket beaches between the Halekūlani and Sheraton Waikiki hotels making access extremely challenging for those with limited mobility. Lateral access is currently accomplished by walking around the landward portion of the intertidal beach which, given its low elevation, is frequently flooded and often submerged during high tides and high surf events.

Perpendicular access to the shoreline is limited due to the density of development in the backshore. The only perpendicular access is a privately owned pathway where access by the public is presently allowed between the Halekūlani and Sheraton Waikiki hotels, extending from Kālia Road to the small pocket beaches between the hotels. There are no lifeguard towers in the Halekūlani beach sector.

There has historically been a limited amount of stable dry beach in the Halekūlani beach sector, with the exception of a 375-ft-long stretch of narrow beach at the west end of the sector, which is stabilized by the Fort DeRussy outfall/groin and wave refraction along the west edge of the Halekūlani Channel, and two small pocket beaches at the head of the channel between the Halekūlani and Sheraton Waikiki hotels. With the exception of the replacement of the Royal Hawaiian groin, which was completed in August 2020, there have been no substantial beach or structural improvements in this sector in nearly a century. Photographs of existing issues and problems in the Halekūlani beach sector are shown in Figure 5-6.

In collaboration with the WBCAC, the project proponents determined that the primary issues and problems in the Halekūlani beach sector are:

- Erosion and beach narrowing.
- Limited lateral access along the shoreline.
- Wave overtopping and wave reflection of existing seawalls.
- Deterioration and potential failure of existing seawalls.

The highest priorities in the Halekūlani beach sector are to:

- Increase dry beach width and stability.
- Improve lateral shoreline access.
- Maintain or improve mixed recreational uses (swimming, surfing, bathing).
- Maintain or improve water quality.
- Preserve submarine groundwater discharge at Halekūlani Channel (Kawehewehe).
- Preserve and protect surf sites (*Populars, Threes, Fours*).

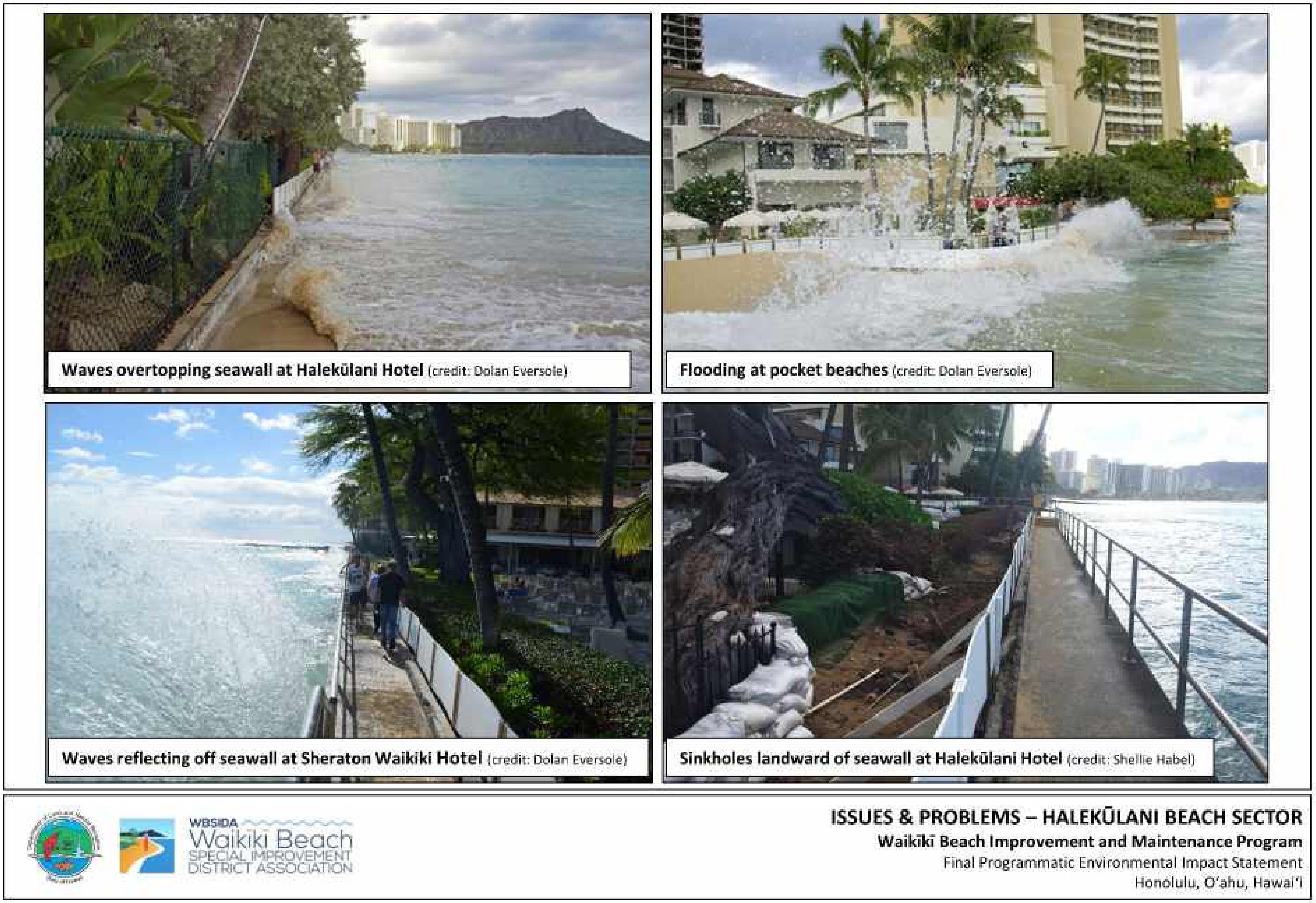


Figure 5-6 Issues and problems – Halekūlani beach sector

5.3 Proposed Action

5.3.1 Description of the Proposed Action

The proposed action for the Halekūlani beach sector is beach improvements consisting of beach nourishment with stabilizing groins. Constructing a beach by placing suitable sand in an appropriately designed manner along a shoreline can be an effective means of providing additional recreational dry beach area, improving lateral access, and providing a buffer against storm waves and sea level rise. On chronically eroding shorelines, such as Waikīkī, engineered structures can be used to stabilize the beach fill and significantly reduce sand loss and the need for future repair and maintenance. A groin is a shore-perpendicular structure designed to prevent longshore transport of sand and mitigate erosion. A T-head groin system combines a groin with angled heads that can be designed for the existing wave environment to create stable arc-shaped beaches between the groins.

The proposed action will consist of construction of three new sloping rock rubblemound T-head groins, a new L-head groin adjacent to the existing Fort DeRussy outfall/groin, and modification of the recently replaced Royal Hawaiian groin. The groins and beach fill will create four stable beach cells in an area that has previously had limited beach resources. The proposed action will require approximately 60,000 cy of sand fill and will create approximately 3.8 acres of new dry beach area. The project layout for the proposed action is shown in Figure 5-7. The dimensions for the proposed groin heads and stems are shown in Figure 5-8 and Figure 5-9, respectively. Conceptual renderings of the proposed action are shown in Figure 5-12 and Figure 5-13.

The groins are designed for an initial +8.5 ft MSL beach crest elevation (existing Waikīkī beaches are about +7 ft MSL) to account for 1.5 ft of sea level rise, with the ability to increase the beach crest elevation to +10 ft MSL to account for additional sea level rise. The groin stem length (distance seaward from the shoreline) will be up to about 200 ft and will also be sufficient to stabilize a beach crest elevation up to +10 ft MSL. The minimum beach crest width at its narrowest point midway between the groins will be about 20 to 30 ft, and the beach slope will be 1V:8H (vertical to horizontal). The Halekūlani Channel will remain unobstructed for catamaran navigation.

A sand retaining wall will be required along the mauka (landward) limit of the beach cell to prevent the beach sand from spilling into the lower elevation backshore area and separate the project from the backshore private properties. The sand retaining wall will extend the entire length of the beach sector. The sand retaining wall will be constructed makai (seaward) of the seawalls fronting the Sheraton Waikiki and Halekūlani hotels (Figure 5-10) and at the west end the wall will extend in front of the Outrigger Reef and Castle Waikīkī Shore hotels (Figure 5-11).

~~The top of the sand retaining wall will also function as a walkway to improve lateral shoreline access between the Royal Hawaiian, Halekūlani, and Fort DeRussy beach sectors.~~A beach mat walkway could be installed on the sand beach ~~along the wall~~s makai (seaward) of the sand retaining wall ~~The walkway will~~to provide lateral access along approximately 1,500 feet of shoreline. The beach mat walkway will~~ould~~ need to be wide enough to be ADA-compliant and could include optional features, such as turnouts, to allow users to stop while not affecting pedestrian traffic. Access points could be constructed to allow beach access from the City's

Kalia Road ~~public~~ beach right-of-way and from the hotels, and the walkway would transition to Royal Hawaiian Beach on the east and Fort DeRussy Beach on the west.
~~An optional component of the design is the addition of a beach walkway to improve lateral shoreline access between the Royal Hawaiian, Halekūlani, and Fort DeRussy beach sectors. The beach walkway would likely follow the alignment of the existing seawalls, providing continuous lateral access along approximately 4,500 ft (0.85 mi) of shoreline. The beach walkway would need to be wide enough to be ADA-compliant and could include optional features, such as turnouts, to allow users to stop while not affecting pedestrian traffic. The existing seawalls may need to be modified or replaced to accommodate a beach walkway in this sector.~~

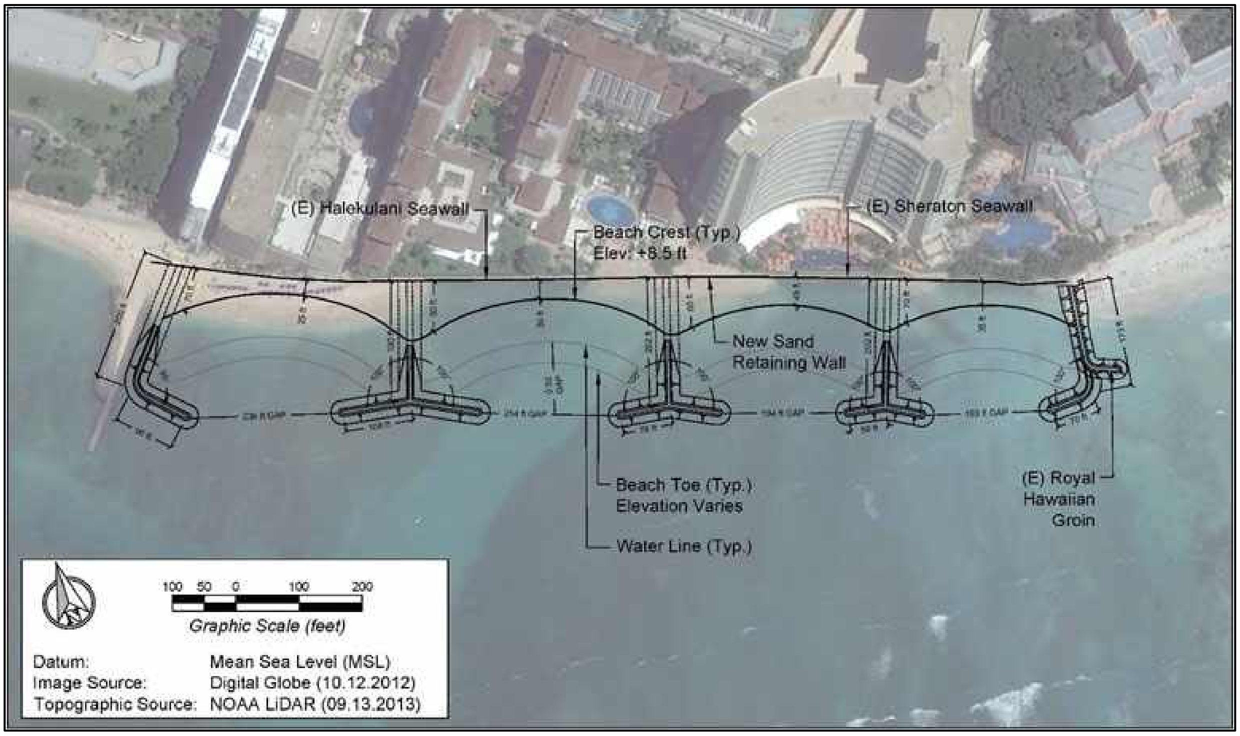


Figure 5-7 Proposed project layout – Halekūlani beach sector

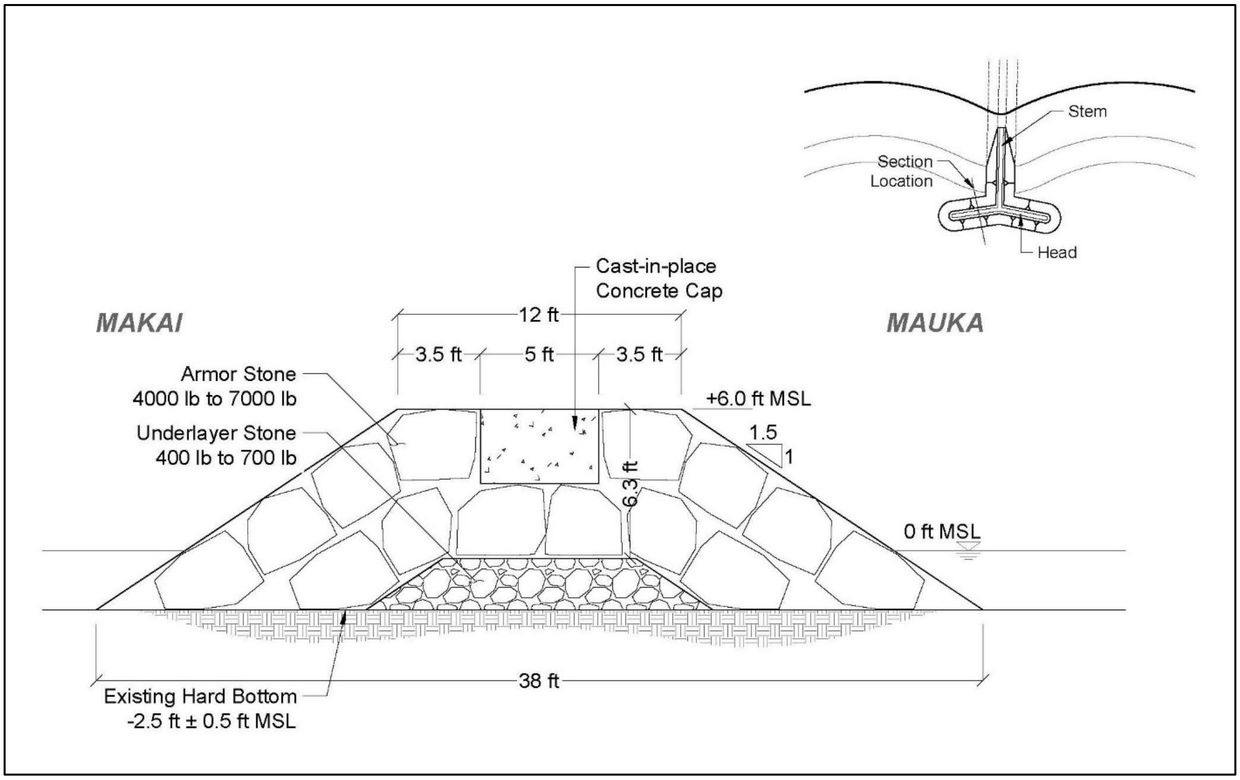


Figure 5-8 Section views of proposed groin heads – Halekūlani beach sector

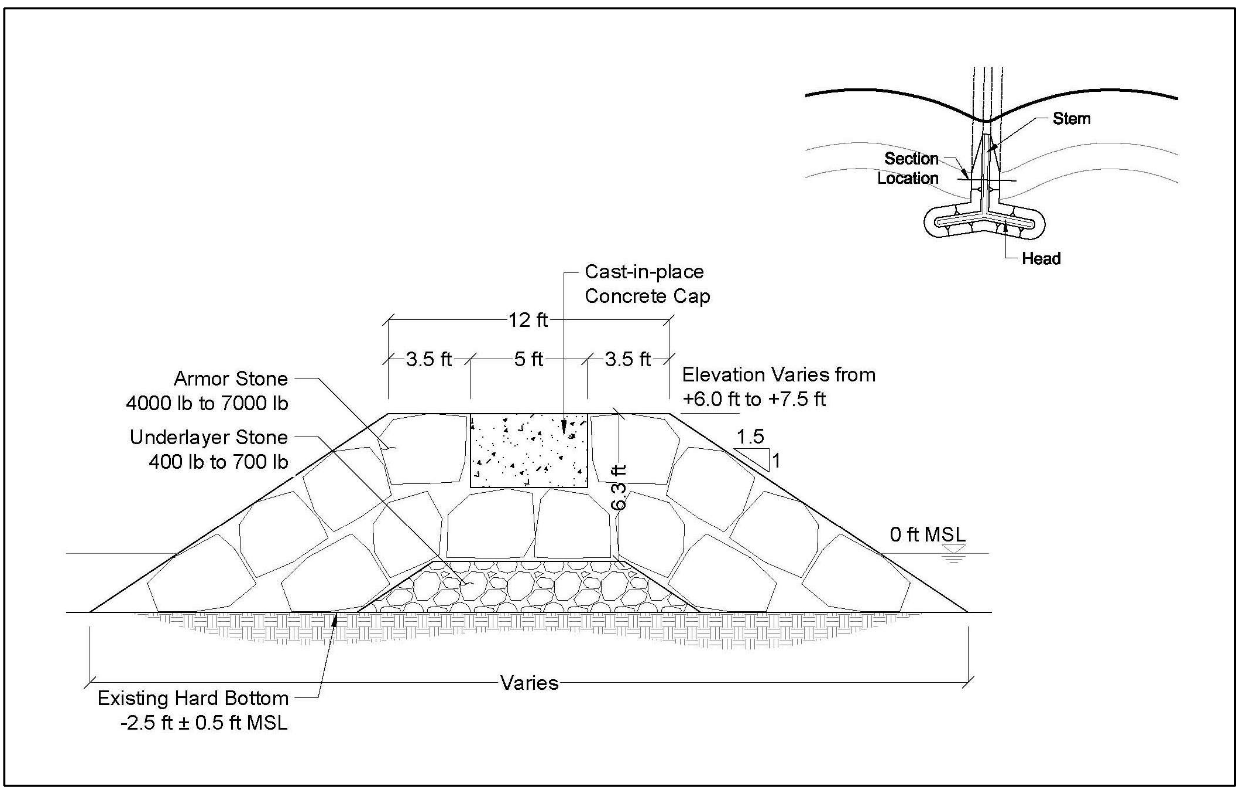


Figure 5-9 Section view of typical groin stems – Halekūlani beach sector

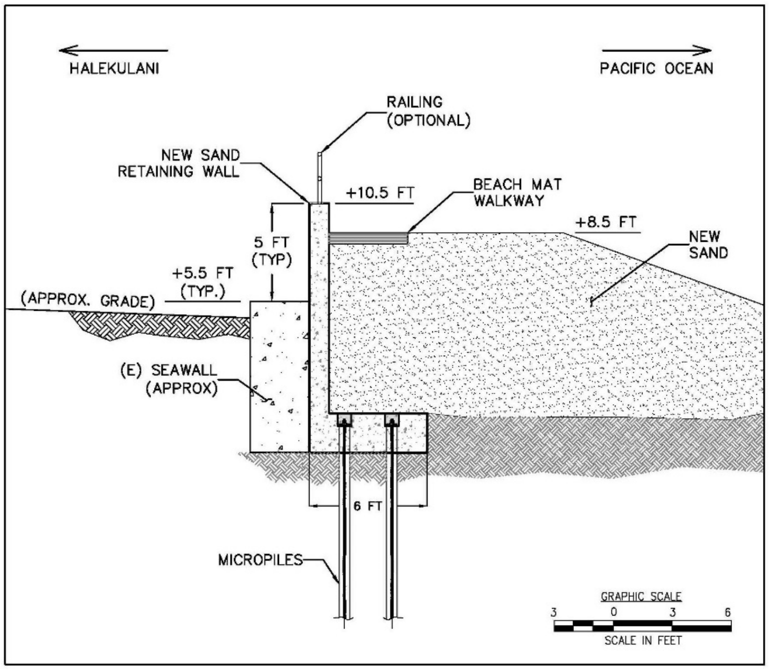


Figure 5-10 Cross-section of proposed action in the Halekūlani beach sector fronting the Halekūlani Hotel (facing east)

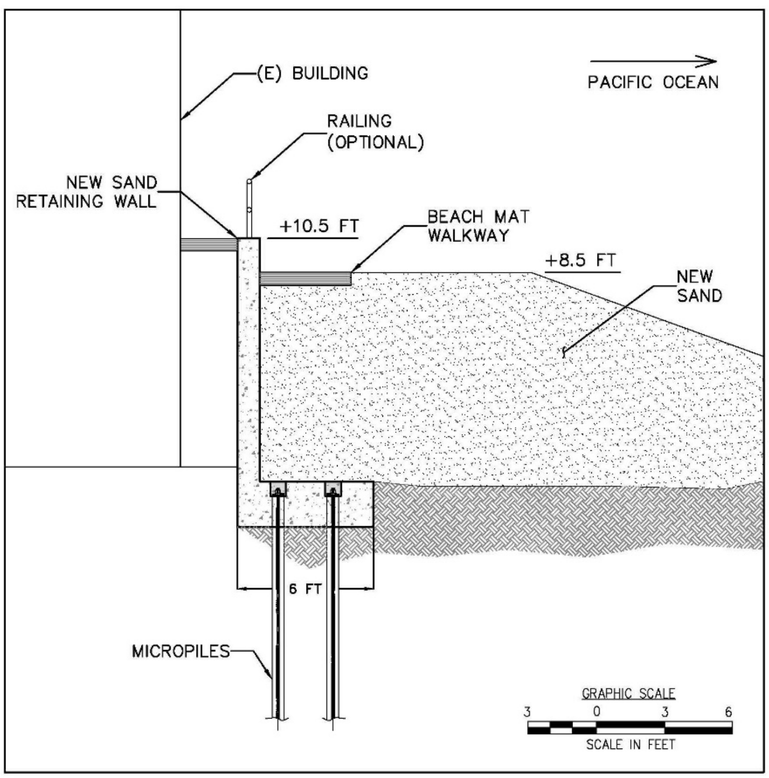


Figure 5-11~~11~~~~10~~ Cross-section of proposed action in the Halekūlani beach sector fronting the Outrigger Reef Waikīkī Beach Resort (facing east)

WBSIDA Waikiki Beach SPECIAL IMPROVEMENT DISTRICT ASSOCIATION

CONCEPTUAL PLAN VIEW OF PROPOSED ACTION – HALEKŪLANI BEACH SECTOR

Waikīkī Beach Improvement and Maintenance Program

Final Programmatic Environmental Impact Statement

Honolulu, Oʻahu, Hawaiʻi

Figure 5-12~~11~~ Conceptual plan view of proposed action – Halekūlani beach sector

Figure 5-1312 Conceptual oblique view of proposed action – Halekūlani beach sector

5.3.2 Sand Source

One sand sample was obtained from the beach face fronting the Halekūlani Hotel in February 2021. Figure 5-14 shows the composite grain size distribution for the existing beach sand, which has a median grain size (D_{50}) of 0.35 mm. Figure 5-14 also shows the composite grain size distributions for the offshore sand deposits investigated in this project. Nearly all the offshore sand falls within ±20% of the Halekūlani beach sand grain size distribution. Sand from the *Hilton* deposit falls on the coarser side; however, slightly coarser sand would be expected to be stable on an eroding beach with stabilizing groins. This would be especially important with sea level rise, at which point waves are expected to be more energetic closer to the shoreline.

Potential sand sources for the Halekūlani beach sector include the *Hilton*, *Ala Moana*, and *Canoes/Queens* offshore deposits. Figure 5-15 and Table 5-1 present the grain size distributions and statistics for the beach and the potential offshore sand sources. Sand from any of the three sources presented (*Ala Moana*, *Hilton*, and *Canoes/Queens*) could be used with no required overfill. Furthermore, given the volume of sand required, a combination of sand from both the *Hilton* and *Ala Moana* sand deposits would be suitable for use in this sector.

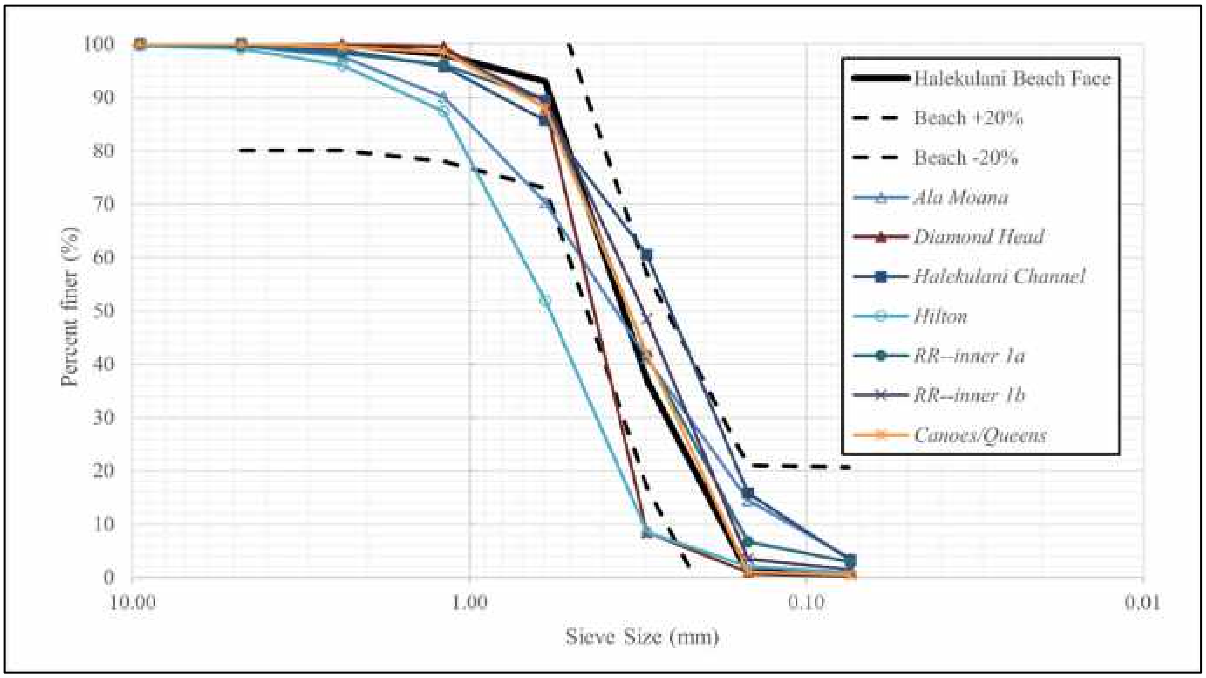


Figure 5-1413 Comparison of grain size distributions for existing beach sand and offshore sand – Halekūlani beach sector

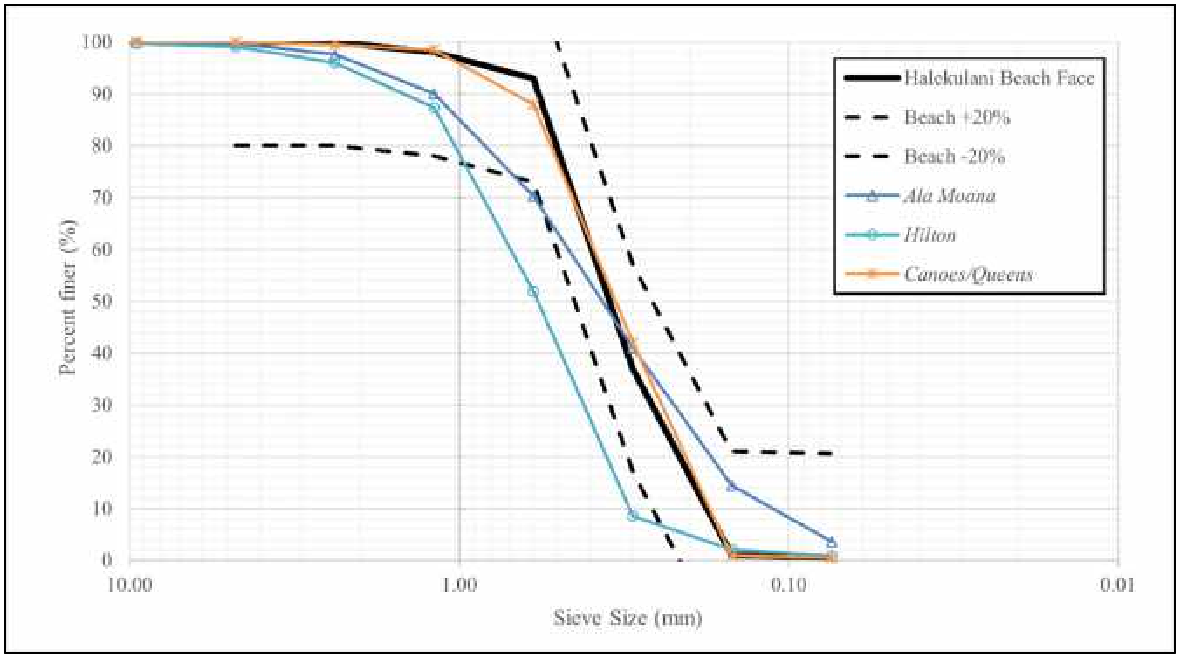


Figure 5-15~~14~~ Grain size distributions for potential sand sources – Halekūlani beach sector

Table 5-1 Comparison of sand parameters – Halekūlani beach sector

	Existing Beach Sand	*Ala Moana*	*Hilton*	*Canoe/Queens*
Median diameter, D_{50} (mm)	0.35	0.37	0.59	0.34
Sorting	N/A	1.42	1.02	0.82
Overfill factor	N/A	1.10	1.00	1.50
Estimated sand required (cy)	60,000	60,000	60,000	60,000
Estimated sand available (cy)	60,000	86,000	40,000	40,000

5.3.3 Construction Methodology

The methodology for sand recovery will depend on the sand source. The *Ala Moana*, *Hilton*, and *Queens/Canoes* deposits were presented previously as suitable sand sources; however, only the *Hilton* sand deposit allows for pumping of the sand directly to the project shoreline. The conceptual layout for a sand recovery operation from the *Hilton* deposit is shown in Figure 5-16. A barge with a submersible slurry pump would be anchored over the sand deposit and a pipeline to shore would be placed within the channel that leads to the Hilton pier. The pipeline would extend onto shore and the sand/water slurry would be pumped into a dewatering basin on the beach, where the sand would be dewatered and stockpiled prior to placement.

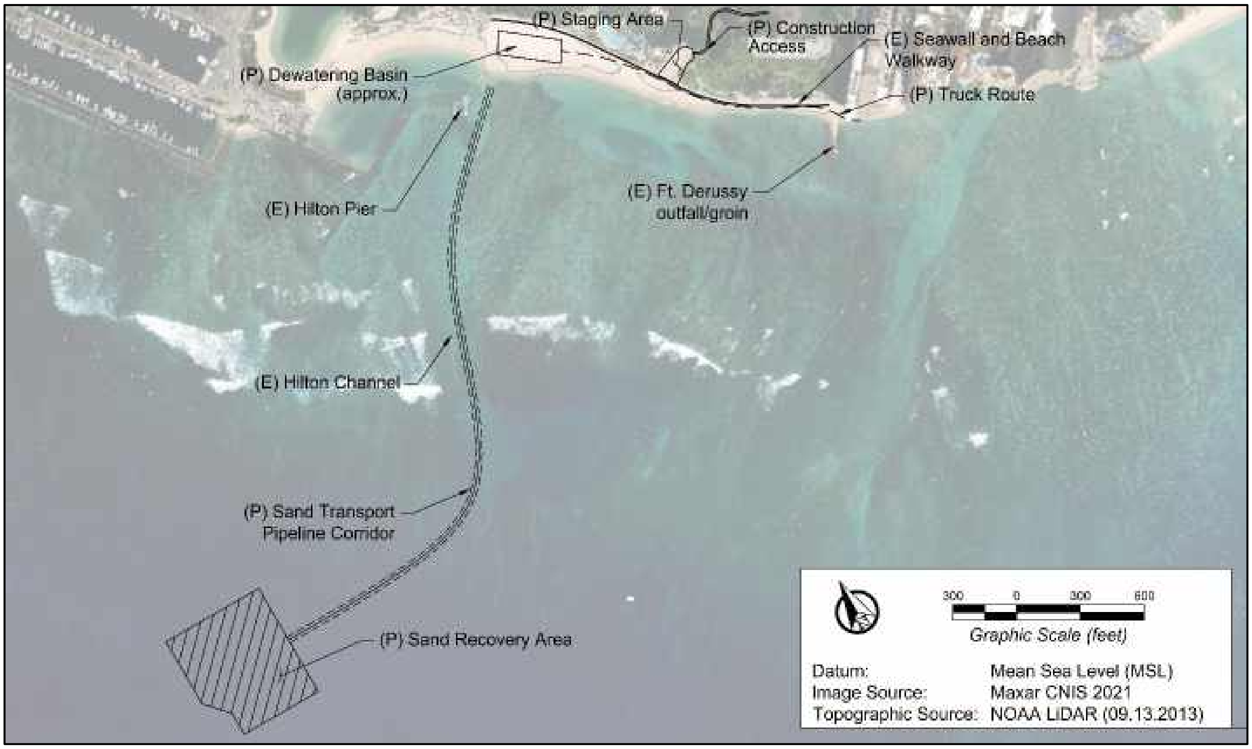


Figure 5-1614 Sand recovery schematic for the *Hilton* offshore sand deposit

The dewatered sand will be loaded into dump trucks, transported down the beach along the makai (seaward) side of the existing seawall and beach walkway, and offloaded at the placement area, where it will be graded by a bulldozer to achieve the design beach profiles. The Hilton deposit does not appear to contain sufficient sand for the entire action in the Halekūlani beach sector.

Sand could also be obtained from the *Ala Moana* sand deposit. The distance between the *Ala Moana* sand deposit and the Fort DeRussy placement area is too extensive to allow the sand to be pumped to shore. A clamshell dredge would be used to recover the sand, which would eliminate the need for a pipeline to shore and a dewatering basin. A crane barge to dredge the sand and a scow and tugboat to transport the sand to an offloading site would be required. Sand would be offloaded at Magic Island. This sand recovery method was evaluated for the EIS for the City and County of Honolulu's "Ala Moana Regional Park and Magic Island Improvements" project (Belt Collins Hawaii, 2019). The sand would then be loaded in dump trucks and trucked to Fort DeRussy beach.

~~The methodology for sand recovery will depend on the sand source. Hydraulic suction dredging is not feasible because the distances between the sand recovery and placement areas is are too long extensive to allow the sand to be pumped to shore. A clamshell dredge will be used to recover the sand, which will eliminate the need for a pipeline to shore and a dewatering basin. A crane barge to dredge the sand and a scow and tugboat to transport the sand to an offloading site will be required. Sand will be offloaded at an approved site and trucked to the shoreline.~~

Depending on the size of the dump trucks, approximately 4,000 to 6,000 truckloads of sand will be required.

Access to the shoreline in the Halekūlani beach sector is limited, particularly during high tides and high surf events. Two narrow walkways provide access to the shoreline: one privately owned pathway where access by the public is presently allowed between the Halekūlani Hotel and Sheraton Waikiki Hotel, extending from Kālia Road to the small pocket beaches between the hotels; and the other between the Halekūlani Hotel and Outrigger Reef Waikīkī Beach Resort. The only access for construction equipment and materials is across the east end of the Fort DeRussy beach sector, adjacent to the Castle Waikīkī Shore. Construction access from the ocean side via barge will be further evaluated; however, access from the ocean may not be feasible due to the shallow water depths in the nearshore.

Widening of the beach in front of the U.S. Army Museum of Hawaiʻi will be necessary to provide a corridor for vehicles and equipment to access the Halekūlani beach sector. A temporary rock rubblemound construction access berm will be constructed along the shoreline from the Fort DeRussy outfall/groin to the Royal Hawaiian Groin. A temporary construction access road will be constructed from Kālia Road to the beach, and then a temporary rock rubblemound construction access berm will be constructed along the shoreline from the Fort DeRussy outfall/groin to the Royal Hawaiian groin. The stone used to construct the access berm will be dismantled and used later to construct the groins. Groin construction will proceed from the head of the Royal Hawaiian groin and progress from east to west, using the stone in the access berm to construct the groins and removing any excess stone. The final groin will be constructed alongside the existing Fort DeRussy outfall/groin. The structures will not be connected and no modifications to the existing Fort DeRussy outfall/groin are proposed. Sand fill will be placed following completion of the groins, moving west to east with the new beach providing access for sequential placement of sand fill.

The groins will be constructed of two-stone-thick rock rubblemound with a median armor stone size of 5,100 lbs. The groin heads will be constructed with a crest elevation of +6 ft MSL, consistent with the existing concrete crown wall of the Royal Hawaiian groin. The groin heads will have a core of concrete at +6 ft MSL that will allow for a vertical extension of up to 1.5 ft in the future to mitigate the effects of sea level rise. The groin stems on the inshore ends will be +8 ft MSL for about 30 ft, slightly below the +8.5 ft MSL beach elevation to give the appearance of a continuous beach. The stems will then taper down to meet the heads at +6 ft MSL. All rubblemound structures will have 1V:1.5H (vertical to horizontal) side slopes. Groin construction will require approximately 15,000 cy of rock and 810 cy of concrete to construct the crown walls.

The new groin stem along the Fort DeRussy outfall/groin will be higher than the other groins to prevent sand from spilling over. The groin head will be +6 ft MSL and the stem elevation will increase to +9.5 ft MSL near the beach crest. The sand retaining wall will be constructed prior to sand placement in each cell. Approximately 600 cy of concrete will be required to construct the sand retaining wall. The construction sequence will be determined by the contractor.

Following completion of the groins and sand retaining wall in each beach cell, sand will be placed to the approximate lines and grades shown on Figure 5-7. The beach and groin system is designed to produce a minimum dry beach width of 30 ft with a foreshore slope of 1V:8H (vertical to horizontal). ~~The elevation of the sand in the backshore will be higher than some points of the hotel properties. In these areas, it may be necessary to increase the height of the existing seawalls or construct new walls to retain the sand fill and prevent wave overtopping.~~

~~*5.3.3.11.1.1.1 Alternative Armor Units*~~

~~***Concrete Armor Units***~~

~~Man-made concrete armor units have been developed for use when stone of large enough size is not available to meet the design requirements. These concrete units have larger stability coefficients (i.e., greater interlocking and ability to withstand wave attack) than stone. Thus, the concrete units can be smaller than the required stone size for a given wave height. Tribar concrete armor units (Figure 5-14) have been used with considerable success for projects with similar design conditions and are an alternative to stone for this project.~~

~~Tribar armor units are implemented as a single layer and, like a rubblemound revetment, the armor units are placed over an underlayer and filter designed to distribute the weight of the armor layer and to prevent loss of fine shoreline material through voids in the Tribars. The underlayer is sized at 1/10 the Tribar weight and is at a minimum two stone diameters thick. Because Tribar units depend on interlocking for stability, the sides, toe, and crest of the structure must be securely tied in and fixed to the surrounding environment. Typically, the toe of the structure is entrenched and grouted into the seafloor. While concrete armor units perform well from an engineering perspective, they can be perceived as having an industrial appearance that may not be desirable in Waikīkī.~~

Figure 5-14 Tribar concrete armor units in American Samoa

Environmentally Friendly Armor Units

Construction of the proposed actions will cover portions of submerged lands with either sand or rock. The rock rubblemound structures are expected to increase biodiversity of the area based on the monitoring results following the 2013 Iroquois Point Beach Nourishment and Stabilization project. Alternative materials are being considered to further mitigate potential impacts by providing ecologically sensitive solutions, where possible. One option is to add environmentally friendly armor units to the groins where conditions allow. The discussion below focuses on ECOncrete and their products; however, there are other concrete units available that can be considered during the final design phase, including those from Volvo, University of Washington, Reef Design Lab, Intellareef, and others.

ECOncrete

ECOncrete is marketed as an eco-engineered solution for both marine life and humans. Products include ecological armoring units, seawall panels, designed tidepools, and articulated marine mattresses. ECOncrete reportedly achieves their success from a combination of concrete additives and unit design and texture. The concrete armoring units are produced with a proprietary concrete mix with enhancing admixture that complies with marine construction regulations. When compared to standard concrete used in other armor units, ECOncrete reportedly provides higher compressive strength and lower pH levels. The low pH levels reportedly promote better coral growth. Each of the products has unique textured surfaces that reportedly improve marine life and coral structure growth. Production of calcium carbonate from higher levels of marine life provides an additional bond between concrete armoring units, strengthening and stabilizing the structure.

ECOncrete units have been used in multiple locations in the continental U.S. and throughout Europe, and thus far have only been used in calm environments with low wave energy. Intense review of hydraulic stability is currently being performed by ECOncrete through computational modeling and physical testing to determine if their concrete armor units are applicable in high wave energy environments. Costs associated with purchasing ECOncrete units may be similarly priced to standard concrete units if the units can be cast locally. Figure 5-16 through Figure 5-18 show examples of armor units that are marketed as being environmentally friendly.

Figure 5-15 ECO Armor Block (www.econcrete.com)

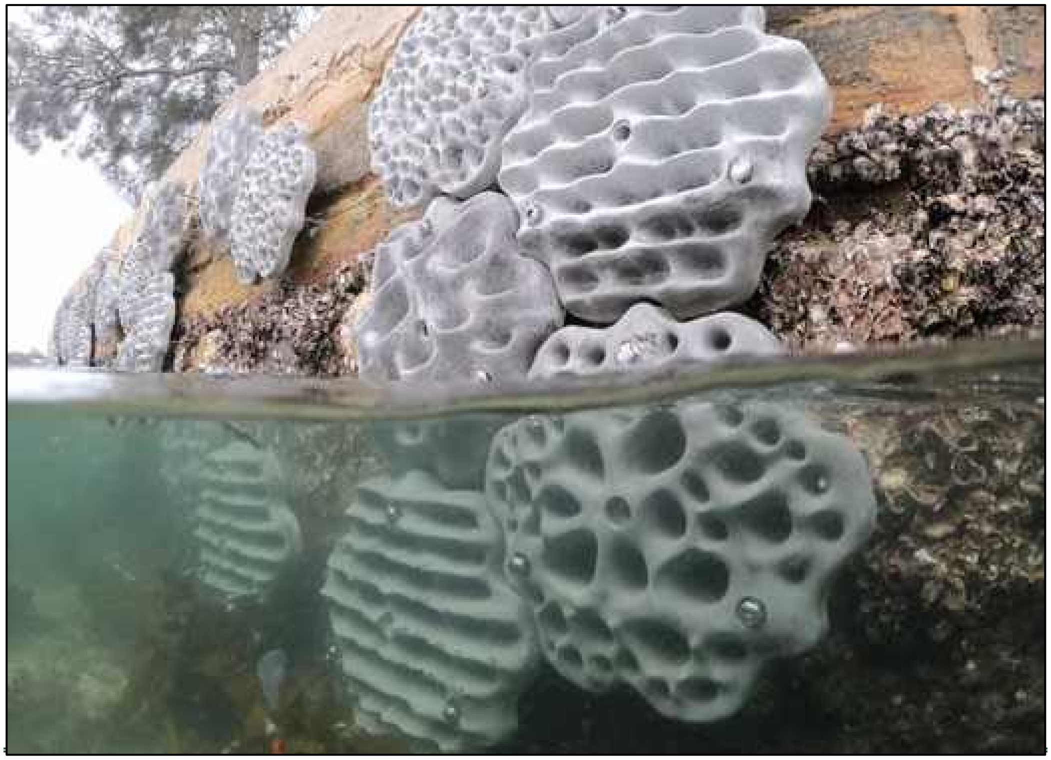


Figure 5-16 "The Living Seawall Project" (www.reefdesignlab.com)

Figure 5-17 ECOncrete Coastalock (www.econcretetech.com)

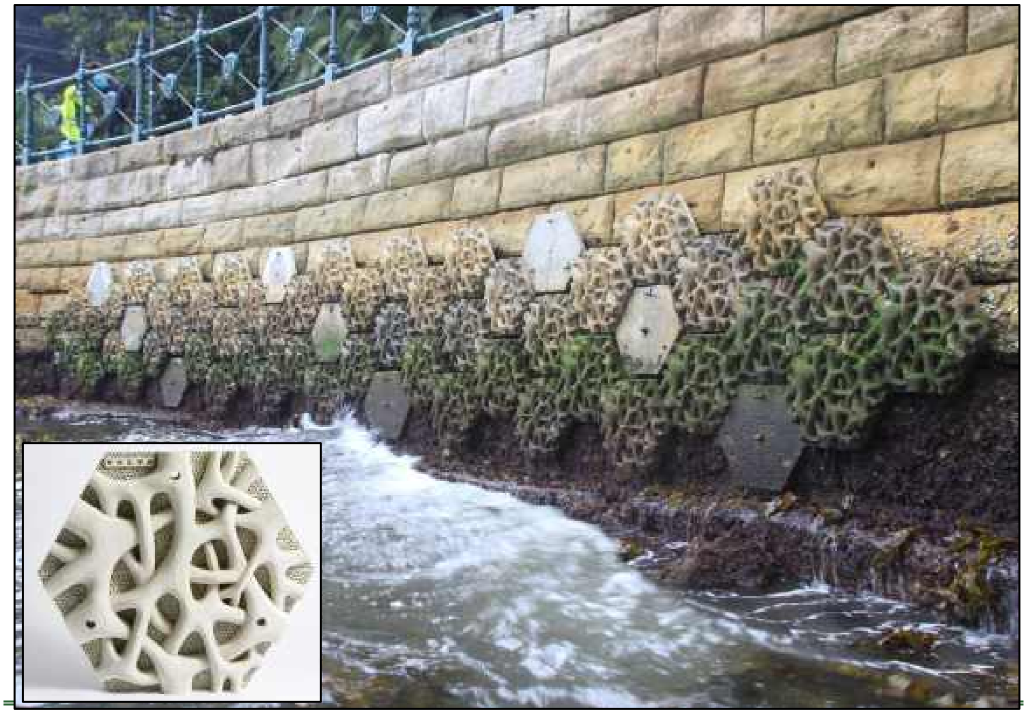


Figure 5-18 Volvo 3D-printed Living Seawall (www.reefdesignlab.com)

5.3.4 Estimated Timing, Phasing, and Duration

The timeframe for implementing the proposed action in the Halekūlani beach sector has yet to be determined. The proposed beach improvement action is designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the project could be effective until about the year 2080, or 50 yrs post-construction. The estimated construction duration for the proposed action is 500 days.

The proposed action will also be phased by initially constructing one beach cell and then constructing the remaining beach cells at a later date. This approach will reduce the initial environmental and economic impacts when compared to the complete proposed action. Additionally, the construction of one beach cell will make future construction of the remaining groins and beach cells more efficient and cost-effective.

This is the most achievable project based on available funds and is intended to address the most severely eroded portions of Waikiki Beach where there are existing concerns regarding risks to public health and safety. Prioritizing this project would allow us to begin monitoring of the initial groin cell in the Halekūlani beach sector to evaluate project performance, identify potential impacts, and make any necessary design modifications prior to completing the remaining phase of the project. This approach would also provide additional time to address unresolved issues regarding the existing seawalls and evaluate options to incorporate a walkway to provide continuous ADA-compliant lateral shoreline access.

The proposed phased approach integrates two alternatives presented earlier for the Fort DeRussy beach sector (Section 4.3) and Halekūlani beach sector (Section 5.3). Implementing the proposed actions in both beach sectors concurrently is advantageous because improvements to the Fort DeRussy beach sector are required in order to allow for phased implementation of the proposed action in the Halekūlani beach sector. The proposed action would involve placement of 1,500 cy of sand fill in the Fort DeRussy beach sector fronting of the U.S. Army Museum of Hawaiʻi, as presented in Section 4.3. The widened beach would serve as the transit corridor to provide ingress and egress for equipment and materials to the Halekūlani beach sector. The proposed action in the Halekūlani beach sector will include one new L-head groin adjacent to the Fort DeRussy outfall/groin, one new T-head groin approximately 400 feet to the east, and placement of approximately 15,000 cy of sand fill. A schematic of the initial phase of the proposed action is shown in Figure 5-15.

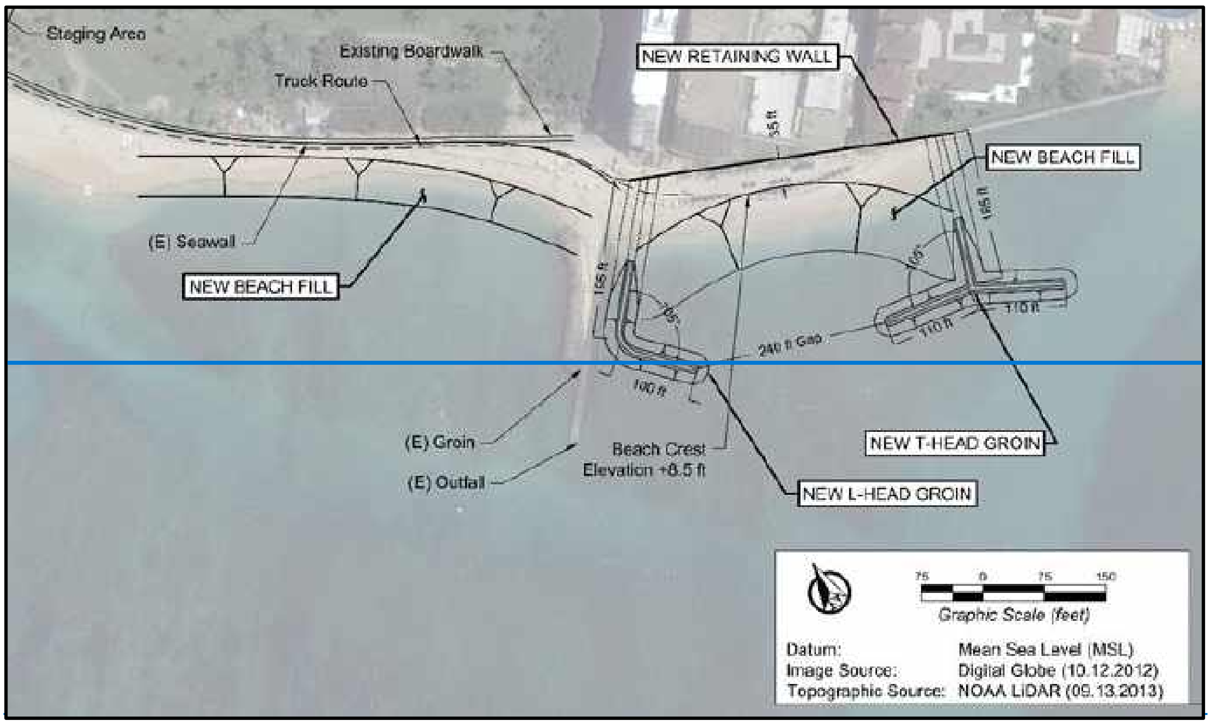


Figure 5-15. Proposed action for the Fort DeRussy and Halekulani beach sectors.

The initial phase of the proposed action in the Halekūlani beach sector is anticipated to be implemented in 2023 to 2025. Construction of the remaining beach cells is anticipated to be implemented in 2030 to 2032.

5.3.5 Required Permits and Approvals

The proposed action is anticipated to require the following permits and approvals:

- Department of the Army Permit (Section 10 and Section 404)
- Clean Water Act Section 401 Water Quality Certification
- Clean Water Act Section 402 National Pollutant Discharge Elimination System Permit
- Coastal Zone Management Act Consistency Review
- Conservation District Use Permit
- Right of Entry Permit

- Shoreline Certification
- Special Management Area Use Permit
- Building Permit
- Grading Permit and/or Stockpiling Permit
- Air Pollution Permit
- Community Noise Permit

5.4 Alternatives to the Proposed Action

The following alternatives were considered for the Halekūlani beach sector:

- Beach Nourishment without Stabilizing Structures

5.4.1 Beach Nourishment without Stabilizing Structures

This alternative would consist of placing sand directly along the shoreline without any structures to stabilize the sand. The sand would be placed along the entire 1,450-ft length of the beach sector with a beach crest elevation of +8.5 ft MSL and a beach slope of 1V:8H (vertical to horizontal). The Royal Hawaiian groin and the Fort DeRussy outfall/groin would help to stabilize the sand fill at the ends of the beach sector; however, the sand in the central portion of the beach sector would be unstable and subject to erosion. This concept would require approximately 40,000 cy of sand and would create approximately 45,000 sf (1 acre) of new dry beach area. The estimated construction duration for this alternative is 240 days.

Beach nourishment without stabilizing structures would increase dry beach width but would not increase beach stability or prevent erosion. The advantages of this option are that it would require less sand and no groins, which would decrease the overall footprint of the project. This option would be less expensive initially; however, the cumulative costs of periodic renourishment would be substantial.

The UHCGG estimates that the average annual erosion rate in the Halekūlani beach sector with 3.2 ft of sea level rise will be 1.01.2 ft/yr (mid-range, 80% confidence) (UHCGG, 20192021). Based on this estimate, in order to maintain a minimum beach width of 20 ft, the beach would need to be renourished every 5 years. Due to the combination of nearshore wave patterns, seawalls, and the Halekūlani Channel, it is possible that the beach could erode more rapidly, in which case renourishment would need to be conducted more frequently. Assuming that renourishment was conducted every 5 yrs over a period of 50 yrs, this would result in a total of 10 individual renourishment events and a total of 2,400 days of construction.

When compared to the alternative of beach nourishment without stabilizing structures, the proposed action has less cumulative impacts as it will require fewer dredging events, fewer construction events, fewer construction days, and fewer beach closures. While beach nourishment without stabilizing structures is technically feasible, it is not being proposed due to the cumulative impacts associated with periodic dredging and renourishment. Furthermore, beach nourishment without stabilizing structures may not be a viable long-term solution due the limited volume of compatible offshore sand to support periodic renourishment efforts in Waikīkī.

6. PROPOSED ACTION: ROYAL HAWAIIAN BEACH SECTOR

6.1 General Description

The Royal Hawaiian beach sector spans approximately 1,730 ft of shoreline extending from the Royal Hawaiian groin east to the ʻEwa (west) groin at Kūhiō Beach Park. Prominent features in this sector include the Royal Hawaiian Hotel, Outrigger Waikīkī Beach Resort, Moana Surfrider Hotel, Honolulu Police Department substation, and the Duke Kahanamoku statue. An overview map of the Royal Hawaiian beach sector is shown in Figure 6-1.

The Royal Hawaiian beach sector is adjacent to the core of traditional and historical activity in Waikīkī. It falls within portions of the traditional ʻili of Helumoa and Hamohamo. Royal Hawaiian Beach is also an important symbol of the history and lifestyle of Waikīkī with a long history of beach boys and surfing in this reach. ʻĀpuakēhau Stream once flowed into the ocean near the northern edge of the sector (near the present location of the Royal Hawaiian Hotel). When many people think of Waikīkī, they typically envision this stretch of beach with Diamond Head framed in the background.

History

In the early 1900s, Royal Hawaiian Beach was relatively narrow, and portions of the beach were submerged at high tide. Seawalls were constructed along nearly the entire length of the shoreline mauka (landward) of the beach, and most of the walls remain in place today. The Royal Hawaiian groin was built in 1927 to stabilize the beach. In 1971, the vegetation line began shifting mauka (landward) and the beach has been chronically eroding since 1985 (Miller and Fletcher, 2003). The history of coastal engineering in the Royal Hawaiian beach sector is summarized in Figure 6-2. Historical photographs of the Royal Hawaiian beach sector are shown in Figure 6-3. Aerial photographs comparing the existing shoreline conditions in the Royal Hawaiian beach sector in 1949 and 2015 are shown in Figure 6-4.

Existing Conditions

The Royal Hawaiian beach sector is an entirely engineered shoreline. The west end of the sector is bounded by the Royal Hawaiian groin, which was originally constructed as a concrete wall groin in 1927 and replaced with a rock rubblemound L-head groin that was constructed in August 2020. The Royal Hawaiian groin functions as a terminal groin that stabilizes approximately 1,730 ft of sandy beach east of the groin. The east end of the sector is bounded by a rock rubblemound groin at the west end of Kūhiō Beach Park.

Royal Hawaiian Beach provides lateral shoreline access along the entire length of the beach sector. Perpendicular shoreline access to the shoreline is limited due to the density of development in the backshore. Perpendicular access is available from Kalākaua Avenue at two locations: one between the Royal Hawaiian Hotel and the Outrigger Waikīkī Beach Resort, and one between the Moana Surfrider Hotel and the Honolulu Police Department substation. Public access is more abundant east of this sector throughout Kūhiō Beach Park. Two City and County of Honolulu lifeguard towers are located in the Royal Hawaiian beach sector: one fronting the Honolulu Police Department substation, and one fronting the Moana Surfrider Hotel. Photographs of existing conditions in the Royal Hawaiian beach sector are shown in Figure 6-5.

Historical and Projected Shoreline Change

The UHCGG historical shoreline change trend for the Royal Hawaiian beach sector from 1927 to ~~2015~~ 2021 has been accretion at an average rate ~~0.19~~0.6 ft/yr (UHCGG, ~~2019~~2021). The accretion is attributable to the repeated addition of sand from previous beach nourishment projects. Miller and Fletcher (2003) found that sediment transport is predominantly in a northwesterly direction and that a reef channel rip current in the central portion of the beach may contribute to the loss of sand in the Royal Hawaiian beach sector. These currents transport sand offshore, which often results in the formation of a shallow sandbar in this area.

Sea Engineering, Inc. conducted a shoreline change analysis for the Royal Hawaiian beach sector using the UHCGG shoreline positions from 1985 to 2005. The year 1985 was chosen as the initial year since no significant human alterations of the beach had occurred since then. From 1985 to 2005, reflecting the modern history of beach erosion, the dominant trend was shoreline erosion at rates of 1 ft to nearly 3 ft/yr. The highest erosion rates were found in front of the Diamond Head Tower of the Moana Surfrider Hotel and in front of the east wing of the Royal Hawaiian Hotel. The exception to this trend is found at three transects adjacent to the Royal Hawaiian groin, which show accretion of up to 1.5 ft/yr. Thus, it appears likely that some of the eroding sand has been moved west and is impounded by the groin, which is consistent with findings by Miller and Fletcher (2003).

Erosion, coastal flooding, and beach loss in the Royal Hawaiian beach sector are projected to continue and accelerate as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to ~~87.3~~1.3 ft ~~(26.6 m)~~ by 2050 and up to ~~216.2~~43.6 ft ~~(65.9 m)~~ by 2100 (UHCGG, ~~2019~~2021). It is important to note that the long-term historical shoreline change rates for Waikīkī are influenced by efforts over the past century to stabilize and restore the beaches, which influences the future erosion projections. These projections also assume that the backshore is composed of non-cohesive erodible substrate and do not account for the presence of the existing seawalls that span nearly the entire length of the shoreline in the Royal Hawaiian beach sector. As the shoreline approaches the existing seawalls, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016).

Without beach improvements or maintenance, it is likely that sea level rise will result in total beach loss in this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged during high tides and high surf events. Loss of recreational dry beach area and lateral shoreline access in the vicinity of the Moana Surfrider Hotel could occur in the next several decades, potentially sooner, as waves currently overtop the seawalls in this area during high tides and high surf events.

Beach Improvements and Maintenance

Recent beach improvements and maintenance projects in the Royal Hawaiian beach sector include Waikīkī Beach Maintenance I (2012), Kūhiō Sandbag Groin (2019), Royal Hawaiian Groin Replacement (2020), and Waikīkī Beach Maintenance II (completed May 2021).

Waikīkī Beach Maintenance I (2012)

In 2012, the DLNR conducted the Waikīkī Beach Maintenance I project. Approximately 24,000 cy of sand was dredged from an offshore sand deposit near the *Canoes* and *Queens* surf breaks. Sand recovery was accomplished with the use of a Toyo DB 75B 8-inch pump with ring jet attachment suspended from an 80-ton capacity crawler crane on a barge. The average rate of sand recovery was approximately 500 cy per day. The sand discharge pipeline was an 8-inch high-density polyethylene (HDPE) pipe with a total length of 3,200 ft. Sand was pumped into a dewatering basin that was constructed in the Diamond Head (east) basin of Kūhiō Beach Park. The dewatering basin measured approximately 100 ft wide and 400 ft long. Sand was pushed into large piles with an excavator and bulldozer and then transported by dump trucks to the sand placement area on Royal Hawaiian Beach. The project widened the beach by an average of 37 ft, which aligned with the position of the shoreline in 1985. The project was completed in June 2012 (see Section 2.6, Figure 2-5 and Figure 2-6). The permits included a second renourishment effort approximately 10 years after the initial nourishment.

Beach monitoring following the 2012 Waikīkī Beach Maintenance I project showed continued erosion and beach recession of the east and west ends of the Royal Hawaiian beach sector. Habel (2016) found that beach recession ranged from 5.2 to 9.5 ft/yr at the east end fronting the beach concessions. This erosion exposed the old concrete foundation of the Waikīkī Tavern, creating a hazardous condition for beach users, and has resulted in damage and flanking of the Kūhiō Beach ʻEwa (west) groin. In January 2018, the City and County of Honolulu funded construction of a temporary erosion control structure built of sand-filled geotextile mattresses to cover the tavern foundation and prevent erosion of terrigenous sediment from the backshore.

Kūhiō Sandbag Groin (2019)

A sandbag groin was placed 140 ft west of the existing ʻEwa (west) groin of Kūhiō Beach Park. The purpose of the groin is to stabilize the east end of Royal Hawaiian Beach and cover the remnants of the concrete foundation of the Waikīkī Tavern with sand. The designed 95-ft groin length was the minimum length necessary to ensure adequate beach width to keep the concrete rubble covered. At the time of construction, the groin was extended 16 ft on the inshore end to address additional beach erosion.

The Kūhiō Sandbag Groin was completed in November 2019 (see Section 2.6, Figure 2-7 and Figure 2-8). The groin consists of 83 ElcoRock sand containers and 275 cy of sand to fill the containers. Each sand container holds 2.5 m^3 of sand and weighs over 10,000 lbs when full. The non-woven geotextile fabric is UV and puncture resistant, has excellent abrasion resistance, and its soft finish is attractive and non-abrasive. Approximately 750 cy of sand was excavated from Kūhiō Beach Park and placed to cover the concrete rubble and achieve the design beach profile.

The University of Hawaiʻi Coastal Geology Group (UHCGG) has and is continuing to conduct periodic monitoring of the Kūhiō Sandbag Groin. Initial findings based on approximately one year of survey data indicate that the groin is functioning as intended. The efficacy of the groin is evident by significant sand accumulation on the Diamond Head (east) side of the structure throughout the year, indicating that longshore sediment transport was altered as intended to mitigate extreme erosion at this section of beach. Sediment capture by the groin has not resulted in significant erosion on the ʻEwa (west) side of the structure, which would be evidenced by sediment depletion and flanking directly adjacent to the structure. Overall, one year following completion the structural integrity and efficacy of the groin structure has been confirmed. No adverse effects of the project have been observed. No significant deficiencies with the ElcoRock sandbags and/or the overall groin performance have been observed.

Royal Hawaiian Groin Replacement (2020)

As of 2020, the original Royal Hawaiian groin was in a severely deteriorated condition. Its failure could have destabilized 1,730 ft of sandy shoreline east of the groin in the Royal Hawaiian beach sector. The DLNR initiated design and construction of a new groin to replace the original Royal Hawaiian groin. The objective of the project was to reinforce the existing groin to stabilize the beach on the Diamond Head (east) side of the groin so that it could provide its intended recreational and aesthetic benefits. The new groin was designed to maintain the approximate beach width of the 2012 Waikīkī Beach Maintenance I project.

Replacement of the Royal Hawaiian groin was completed in August 2020 (see Section 2.6, Figure 2-9 and Figure 2-10). The new groin was constructed along the alignment of the original groin and incorporated a portion of the original groin as a core wall to prevent sand movement through the groin. The new groin is of rock rubblemound construction and incorporates a cast-in-place concrete crown wall. The new groin extends 125 ft from the seawall fronting the Sheraton Waikiki Hotel, and then angles to the southeast to create a 50-ft-long L-head, for a total crest length of 175 ft. The new groin was constructed of a single layer of keyed and fit 3,200 to 5,400 lb armor stone over 300 to 600 lb underlayer stone and 30 to 100 lb core stone.

Following stone placement, a 5-ft wide by 5-ft-thick concrete crown wall was constructed to stabilize the crest and provide a foundation should an increase in crest elevation be necessary to accommodate future sea level rise. The concrete crown wall elevation is +9 ft MSL for its first 40 ft, then transitions down to +6 ft MSL on a 1V:8H (vertical to horizontal) slope, then remains at +6 ft MSL for the remainder of its length. The stone crest elevation is +7 ft MSL for the first 40 ft and then transitions down to +4 ft MSL for the remainder of the groin length. The existing concrete block groin was reduced in elevation to a maximum elevation of +4 ft MSL to +1 ft MSL to facilitate construction of the new groin. Approximately 40 ft of the original groin, beginning at about 120 ft from shore, was removed to construct the transition to the L-head portion of the new groin. The remainder of the original groin, makai (seaward) of the new groin head, was left in place. Initial observations indicate that the groin is performing its primary function to stabilize the beach on the Diamond Head (east) side of the groin. The beach in this area is currently wider than it was pre-construction, and the shoreline has naturally taken the arc-shape anticipated from the groin design.

Waikīkī Beach Maintenance II (2021)

The permits for the 2012 Waikīkī Beach Maintenance I project authorized a second renourishment effort to be performed within 10 years. The project consisted of recovery of approximately 20,000 cy of sand from the same offshore sand deposit (*Canoes/Queens*) that was used in the 2012 project. The project was completed in May 2021 (see Section 2.6, Figure 2-11 and Figure 2-12).

WBSIDA Waikiki Beach SPECIAL IMPROVEMENT DISTRICT ASSOCIATION

OVERVIEW MAP – ROYAL HAWAIIAN BEACH SECTOR
Waikīkī Beach Improvement and Maintenance Program
Final Programmatic Environmental Impact Statement
Honolulu, Oʻahu, Hawaiʻi

Figure 6-1 Overview map – Royal Hawaiian beach sector

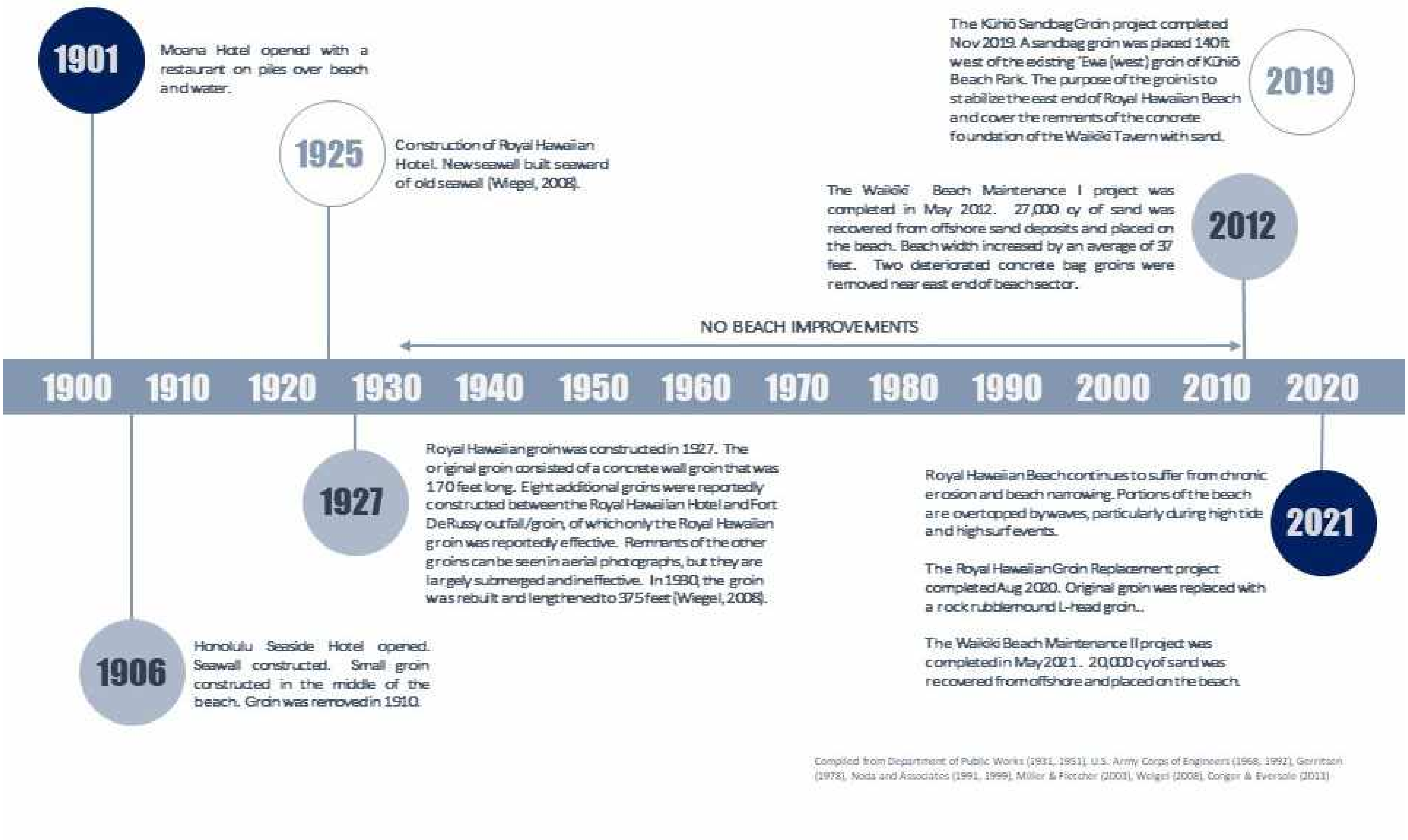


Figure 6-2 History of coastal engineering – Royal Hawaiian beach sector

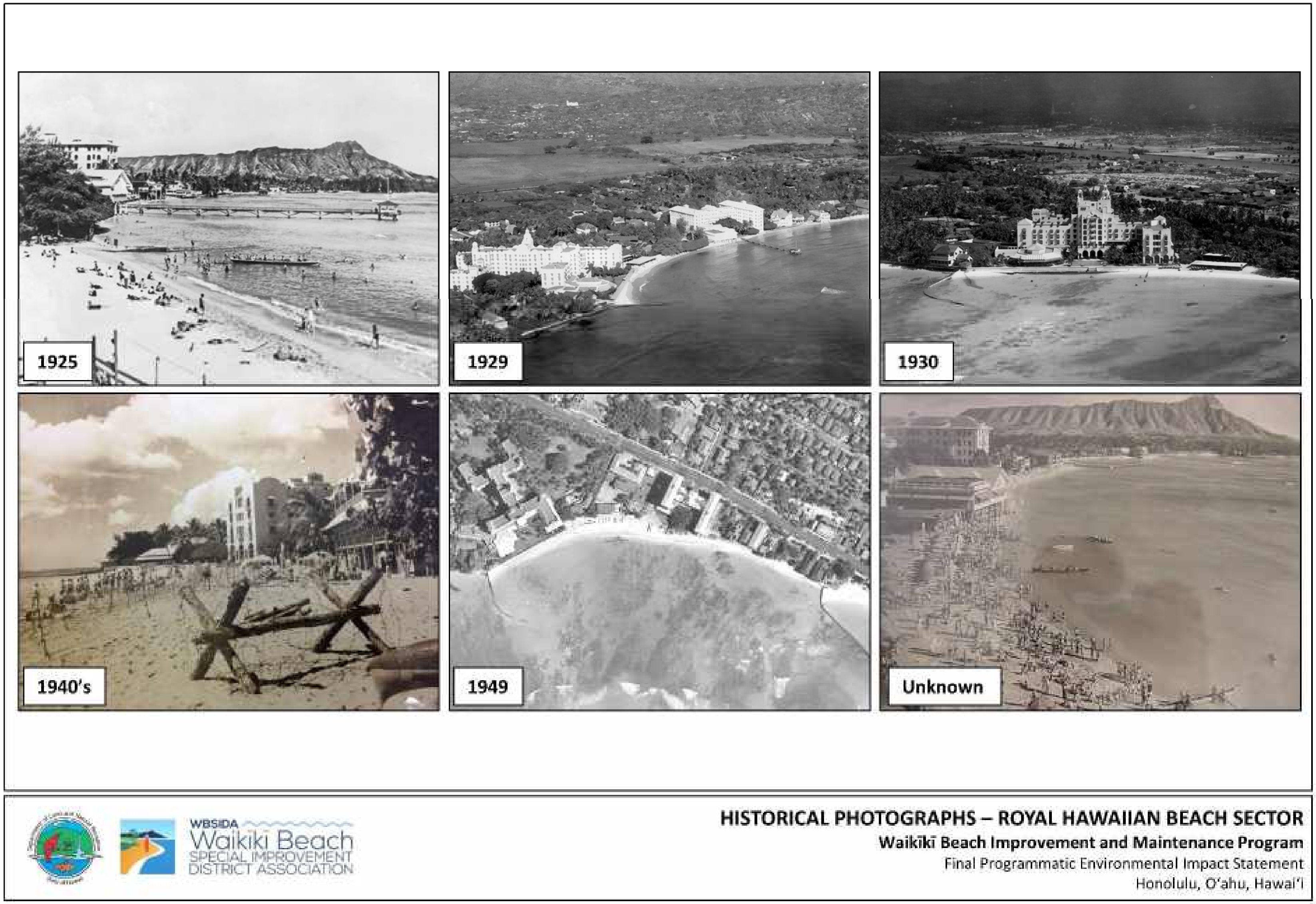


Figure 6-3 Historical photographs – Royal Hawaiian beach sector

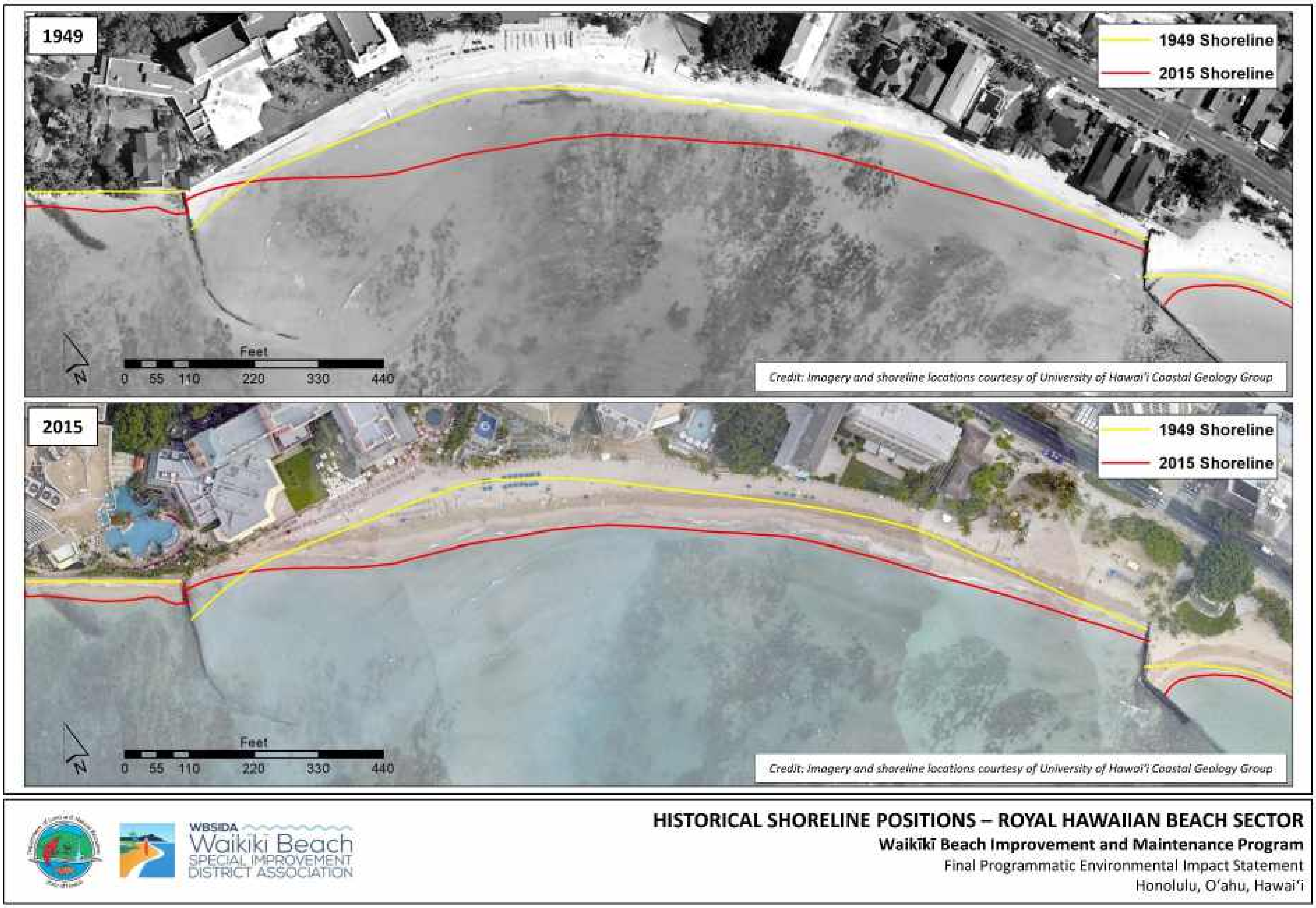


Figure 6-4 Comparison of 1949 and 2015 shoreline positions – Royal Hawaiian beach sector

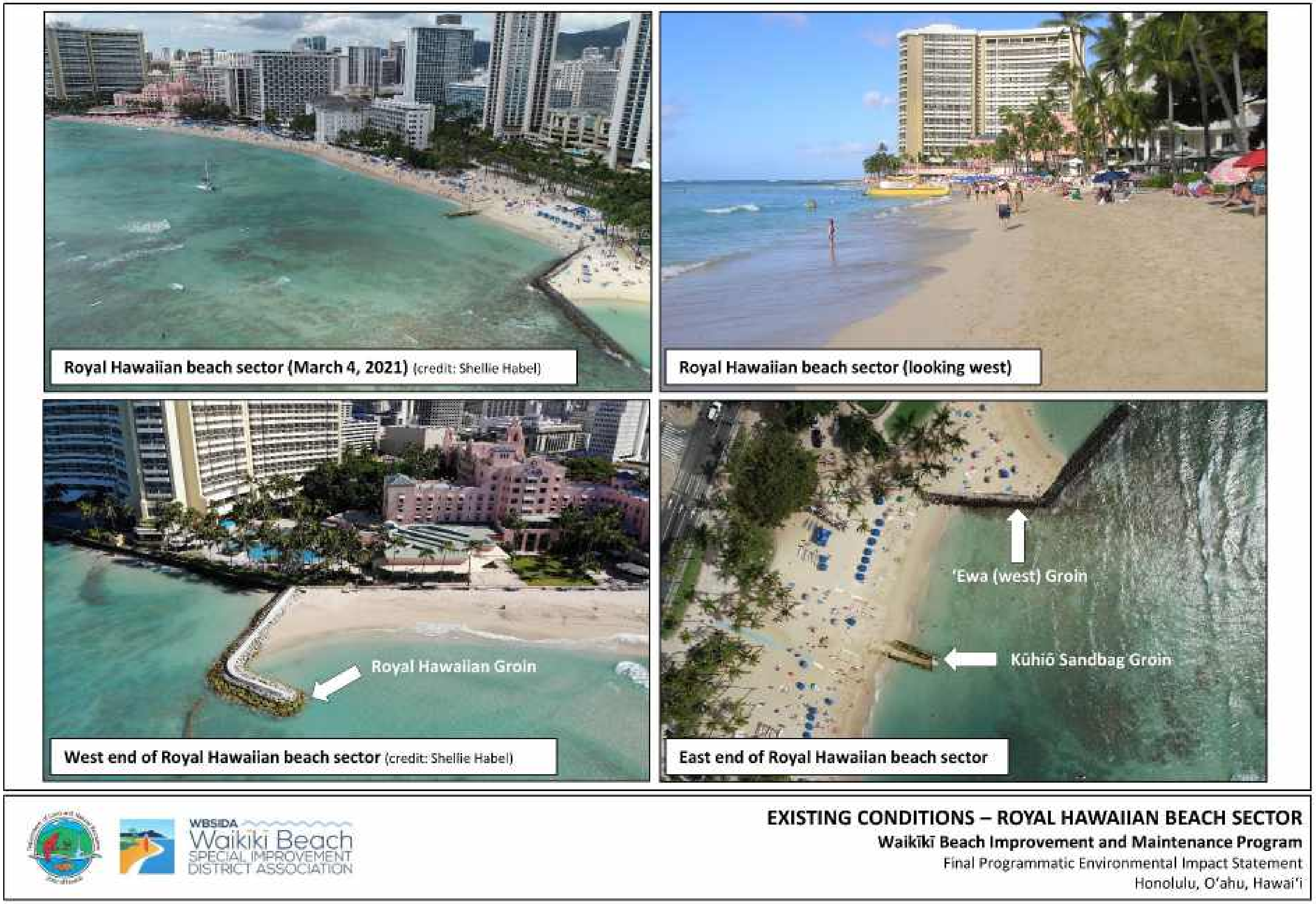


Figure 6-5 Existing conditions – Royal Hawaiian beach sector

6.2 Purpose and Need for the Proposed Action

Royal Hawaiian Beach is the most popular beach in Waikīkī. The beach is heavily used for numerous beach and ocean-based recreation activities, so the use of beach stabilizing structures (e.g., groins) is less desirable in this area. Erosion and beach narrowing have reduced the amount of dry beach available, which negatively impacts the recreational value and aesthetic quality of the beach. Photographs of existing issues and problems in the Royal Hawaiian beach sector are shown in Figure 6-6.

The State of Hawaiʻi recognizes that, given the chronic nature of the erosion and the expressed desire to maintain the beach without stabilizing structures, there is a need to develop a strategy for using offshore sand to periodically renourish the beach in this sector. This involves identification, mapping, and analysis of offshore sand deposits, and recovery of this sand and its placement on the beach. This "recycling" strategy provides a sustainable and efficient method of maintaining the recreational beach using existing local sand sources as well as mitigating some of the environmental effects of sand imported to Waikīkī over the past century. Wave-induced currents predominate inside the breaker zone, generating longshore (shore parallel) currents moving sand primarily from east to west. During high wave conditions, cross-shore (rip) currents can transport significant volumes of sand offshore, which causes erosion and beach narrowing. This sand can be periodically recovered and recycled back to the beach.

In collaboration with the WBCAC, the project proponents determined that the primary issues and problems in the Royal Hawaiian beach sector are:

- Chronic erosion and beach narrowing.
- Seasonal beach erosion.
- Deterioration and potential failure of existing structures.
- Limited lateral shoreline access.
- Beach loss at the Diamond Head (east) end of the beach sector.
- Overcrowding and beach use conflicts.

The highest priorities in the Royal Hawaiian beach sector are to:

- Maintain or improve active uses and dynamic beach-ocean interaction.
- Maintain or improve mixed recreational uses (swimming, surfing, bathing).
- Maintain or improve commercial uses (catamarans, canoes, beach concessions).
- Maintain cultural/historical sense of place.
- Maintain or improve vessel ingress/egress through the channel.
- Preserve and protect surf sites (*Canoes*, *Queens*, *Baby Queens*).
- No additional/new shoreline structures in the beach sector.

Figure 6-6 Issues and problems – Royal Hawaiian beach sector

6.3 Proposed Action

6.3.1 Description of the Proposed Action

The proposed action for the Royal Hawaiian beach sector is beach maintenance consisting of beach nourishment with no additional improvements or modifications to existing structures. The proposed action will require periodic renourishment to maintain the beach at its 1985 location. Through the permitting process for the 2012 Waikīkī Beach Maintenance I project, the Department of the Army permitted widening the beach to the approximate 1985 position which is the widest natural location of the shoreline in recent history.

The proposed action will involve recovering sand from deposits located directly offshore and placing it on the beach, as was done previously during the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. The current beach crest is approximately +7 ft MSL. The proposed action will increase the beach crest elevation to +8.5 ft MSL to protect against wave overtopping and flooding. Based on a beach survey conducted in August 2019, approximately 30,000 cy of sand will be required to widen the beach to the historical 1985 and 2012 and 2021 post-nourishment shoreline position, and increase the beach crest elevation by 1.5 ft. The project layout for the proposed action is shown in Figure 6-7. Conceptual renderings of the proposed action are shown in Figure 6-8 and Figure 6-9.

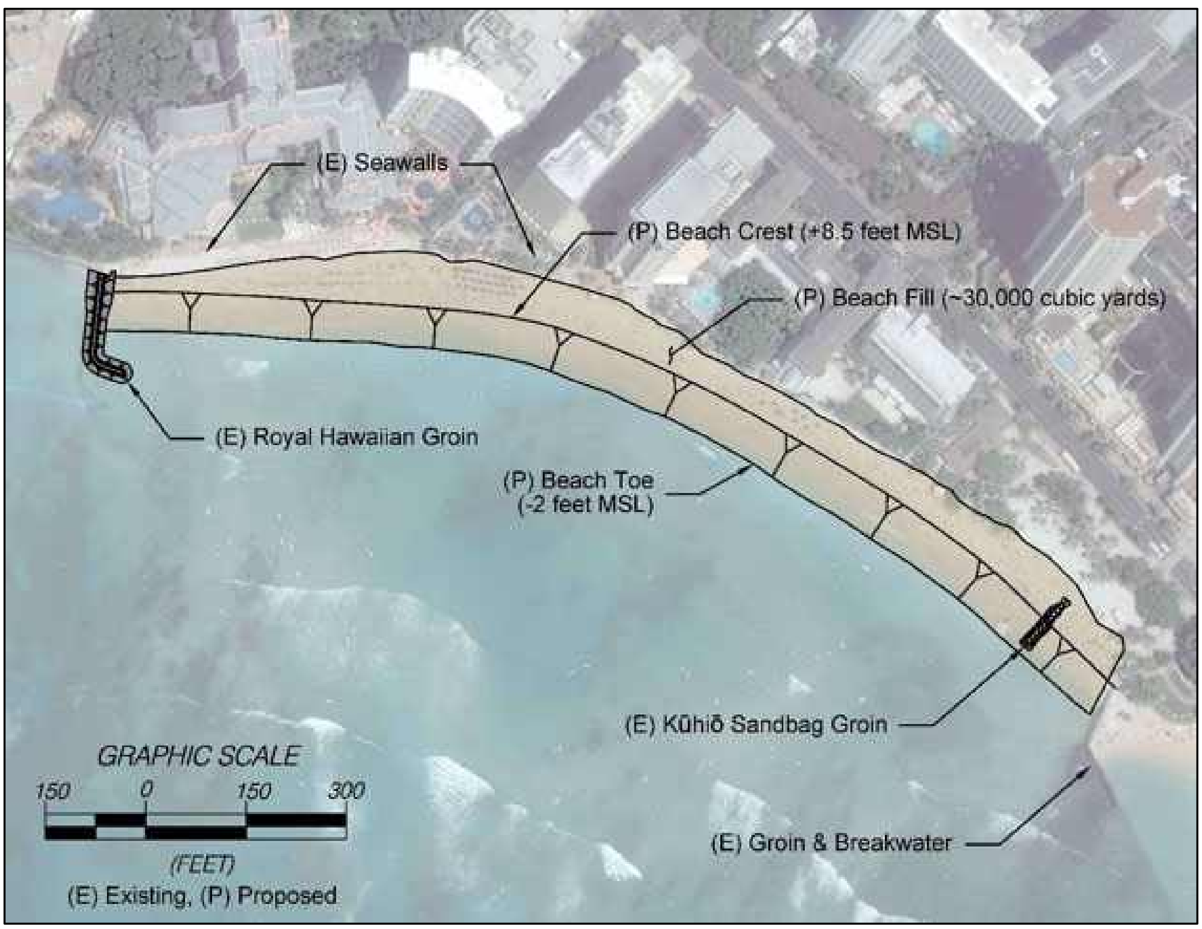


Figure 6-7 Project layout for the proposed action - Royal Hawaiian beach sector

WBSIDA Waikiki Beach SPECIAL IMPROVEMENT DISTRICT ASSOCIATION

CONCEPTUAL PLAN VIEW OF PROPOSED ACTION – ROYAL HAWAIIAN BEACH SECTOR
Waikīkī Beach Improvement and Maintenance Program
Final Programmatic Environmental Impact Statement
Honolulu, Oʻahu, Hawaiʻi

Figure 6-8 Conceptual plan view of proposed action - Royal Hawaiian beach sector

WBSIDA Waikiki Beach SPECIAL IMPROVEMENT DISTRICT ASSOCIATION

CONCEPTUAL OBLIQUE VIEW OF PROPOSED ACTION – ROYAL HAWAIIAN BEACH SECTOR

Waikīkī Beach Improvement and Maintenance Program

Final Programmatic Environmental Impact Statement

Honolulu, O'ahu, Hawai'i

Figure 6-9 Conceptual oblique view of proposed action - Royal Hawaiian beach sector

6.3.2 Sand Source

The preferred sand source for the proposed beach nourishment action is the *Canoes/Queens* offshore deposit, which is the same sand source that was used in the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. The similar sand characteristics to the existing beach, close proximity to the shoreline, and small percentage of fine material in the *Canoes/Queens* offshore sand deposit makes it ideally suited for this beach sector.

Sand from the *Hilton* and *Ala Moana* offshore sand deposits are also viable options. Sand in the *Hilton* deposit is coarser and may be more stable on the beach. Utilizing clamshell dredging to recover sand from either of these deposits and trucking it to the project site may be more economical when compared to hydraulic dredging due to increased production and less projected downtime due to pipe plugging.

6.3.3 Construction Methodology

The construction methodology is expected to be similar to that of the Waikīkī Beach Maintenance I (2012) and II (2021) projects, during which sand was recovered from a deposit located directly offshore near the *Canoes* and *Queens* surf sites. Sand will be dredged using a submersible slurry pump mounted on a crane barge. The recovered sand will be pumped to shore through a bottom-mounted 12-inch diameter high-density polyethylene (HDPE) pipeline. The sand/water slurry will be pumped into a dewatering basin constructed in the Diamond Head (east) basin of Kūhiō Beach Park. The sand will be stockpiled and placed into dump trucks and transported along the beach where bulldozers will level the sand to achieve the design profiles.

Clamshell dredging is an alternative method of recovering offshore sand that will require a crane barge to dredge the sand and a scow and tugboat to transport the sand to an offloading site. Clamshell dredging will eliminate the need for the pipeline to shore and dewatering basin at Kūhiō Beach Park. Sand will be offloaded and trucked to the shoreline where the sand will be placed on the beach.

6.3.4 Estimated Timing, Phasing, and Duration

The timeframe for implementing the proposed action in the Royal Hawaiian beach sector has yet to be determined. The estimated construction duration for beach nourishment without stabilizing groins is 120 days, and the estimated recurrence interval is 10 yrs. Assuming that renourishment is conducted over a period of 50 yrs, this will result in a total of 5 individual renourishment events and a total of 600 days of construction.

6.3.5 Required Permits and Approvals

The proposed action is anticipated to require the following permits and approvals:

- Department of the Army Permit (Section 10 and Section 404)
- Clean Water Act Section 401 Water Quality Certification
- Clean Water Act Section 402 National Pollutant Discharge Elimination System Permit
- Coastal Zone Management Act Consistency Review
- Conservation District Use Permit

- Shoreline Certification
- Right of Entry Permit
- Air Pollution Permit
- Community Noise Permit

6.4 Alternatives to the Proposed Action

The following alternatives were considered for the Royal Hawaiian beach sector:

- Beach Maintenance
- Beach Nourishment with Stabilizing Structures

6.4.1 Beach Maintenance

Sand backpassing would involve moving sand from wide portions of the beach to areas that are eroded and narrow. Presently, erosion is occurring at the Diamond Head (east) end of the beach adjacent to the ʻEwa (west) groin at Kūhiō Beach Park. A sand backpassing program could periodically add sand to this eroded area. While sand backpassing is technically feasible, it may not be a viable long-term option. The beach adjacent to the Royal Hawaiian groin is the only site in the Royal Hawaiian beach sector where a sufficient volume of sand would be available to support sand backpassing. However, the volume of sand present in this area is not sufficient to support periodic sand backpassing.

Sand pumping would involve recovering sand from the shallow sandbar that occasionally forms fronting the Royal Hawaiian Hotel. The sandbar has formed periodically in the past and is believed to consist of beach sand that has been transported offshore since the 2012 Waikīkī Beach Maintenance I project. As a demonstration project, sand could be recovered from the sandbar and placed back on the beach fronting the Royal Hawaiian Hotel, Outrigger Waikīkī Beach Resort, and Moana Surfrider Hotel.

A topographic survey was performed immediately prior to Hurricane Lane in 2019. Sand volume estimates ranged from 1,500 to more than 5,000 cubic yards. A demonstration project would involve recovery of approximately 2,400 cy of sand (if available), which is the volume required to raise the beach crest by approximately 6 in fronting the Royal Hawaiian Hotel, the Outrigger Waikīkī Beach Resort, and the Moana Surfrider Hotel (Figure 6-10). The concept does not include widening of the beach.

The concept assumes that a pipeline would carry the sand to shore, where the sand/water slurry would enter one of two dewatering basins fronting the Royal Hawaiian Hotel and the Outrigger Waikīkī Beach Resort. As one dewatering basin is being filled, the other would be excavated and sand would be placed on the beach. The dewatering basins would be approximately 120 ft long, 30 ft wide, and 3 ft deep and would provide dewatering capacity for up to 400 cy of sand. Precise dewatering basin size and location would be contingent on additional beach investigations.

The project could be accomplished using a diver-operated dredge (see Section 3.7.63.6.67.6), or another method that could achieve similar results. The project could be refined and potentially expanded when the sand source is better defined. While sand pumping is technically feasible, it may not be a viable long-term option. The sandbar is the only site in the Royal Hawaiian beach sector where sand pumping is feasible. However, the sandbar is an ephemeral feature that contains a limited volume of sand and may not be a sustainable sand source over the lifespan of the Program.

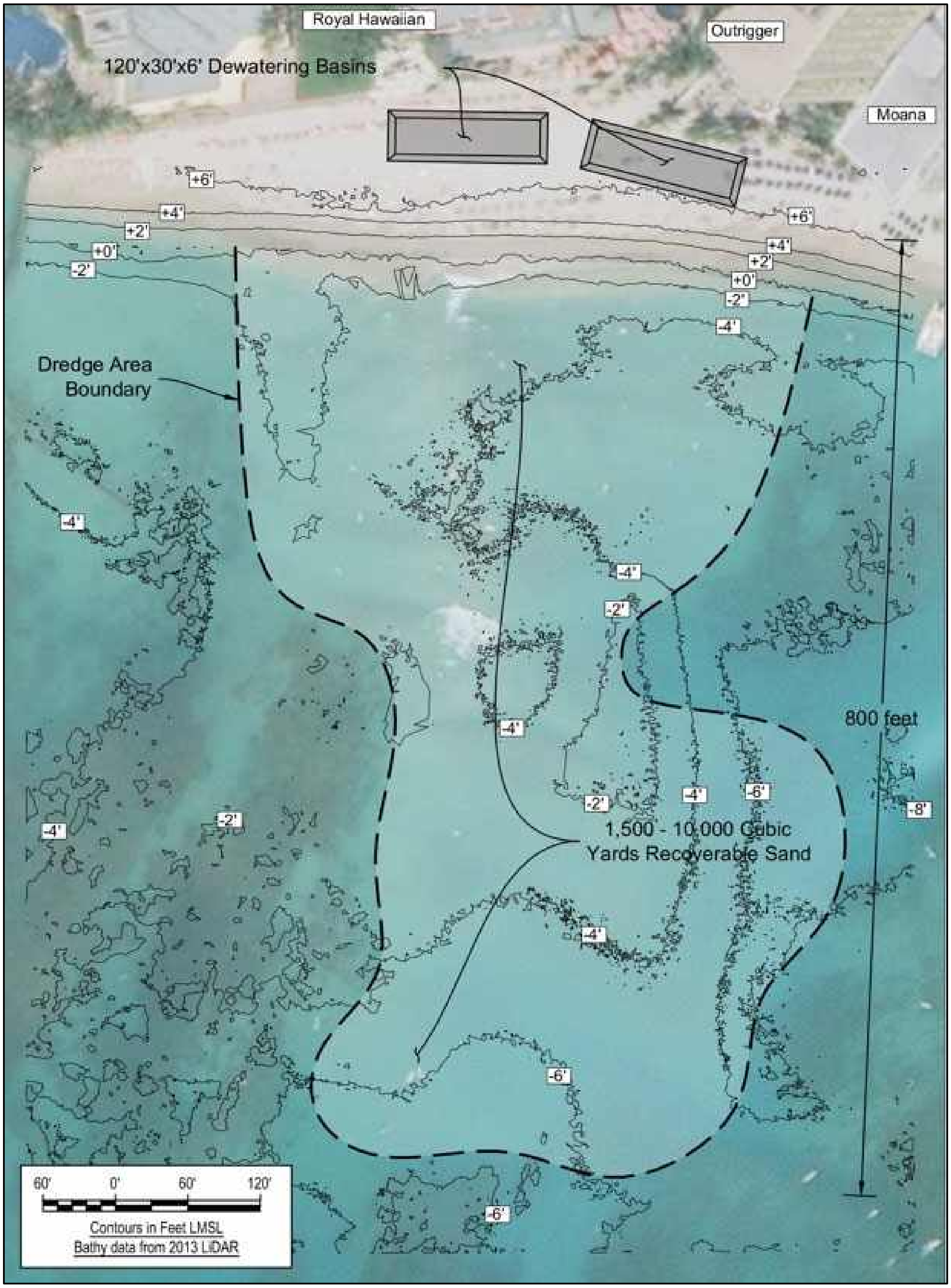


Figure 6-10 Dredge area and dewatering basins for sandbar recovery demonstration project

6.4.2 Beach Nourishment with Stabilizing Structures

This alternative would consist of constructing four new groins and modifying the ʻEwa (west) groin at Kūhiō Beach Park. A combination of T-head groins and beach fill would produce a wide, stable beach in an area where the beach has historically been narrow and subject to chronic erosion. This alternative would require approximately 45,000 cy of sand fill and would create approximately 3.8 acres of new dry beach area.

The groins could be designed for an initial beach crest elevation of +8.5-ft MSL (existing Waikīkī beaches are about +7 ft MSL) to account for 1.5 ft of sea level rise, with the ability to increase the beach crest elevation to +10 ft MSL to account for additional future sea level rise. The groin stem lengths (distance seaward from the shoreline) would be up to about 200 ft and would also be sufficient to stabilize up to a beach crest elevation of +10 ft MSL. The minimum beach crest width at its narrowest point midway between the groins would be about 20 to 30 ft, and the beach slope would be 1V:8H (vertical to horizontal).

This alternative would be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the project could be effective until about the year 2080, or 50-years post-construction. The estimated construction duration for beach nourishment with stabilizing structures is 240 days.

Beach nourishment with stabilizing structures would produce a wide, stable beach and eliminate the need for periodic renourishment. However, based on feedback from the WBCAC, the majority of stakeholders prefer that Royal Hawaiian Beach should be maintained without any additional shoreline structures. As a result, beach nourishment with stabilizing structures was ruled out in the early stages of the conceptual design and project selection process.

7. PROPOSED ACTION: KŪHIŌ BEACH SECTOR

7.1 General Description

The Kūhiō beach sector spans approximately 1,500 ft of shoreline extending from the ʻEwa (west) groin at Kūhiō Beach Park east to the Kapahulu storm drain/groin. Prominent features in this sector include Kūhiō Beach Park, the Hula Mound, and the Kūhiō Promenade. The backshore area mauka (landward) of Kalākaua Avenue is densely developed with shops, restaurants, hotels and resorts including the Aston Waikīkī Circle, ʻAlohilani Resort, Waikīkī Beach Marriott, Aston Waikīkī Beach, and Park Shore Waikīkī. An overview map of the Kūhiō beach sector is shown in Figure 7-1.

History
The Kūhiō beach sector has been the subject of numerous modifications attempting to produce stable beach cells. The modifications began in the early 1900s with seawall construction to protect Kalākaua Avenue (Waikīkī Avenue at the time). The ʻEwa (west) breakwater was constructed in 1939, followed in the 1950s by construction of the Kapahulu storm drain/groin and a series of new groins and modifications. No structural improvements have been made since 1975; however, sand has periodically been placed on the beach. The history of coastal engineering in the Kūhiō beach sector is summarized in Figure 7-2. Historical photographs of the Kūhiō beach sector are shown in Figure 7-3. Aerial photographs comparing the shoreline conditions in the Kūhiō beach sector in 1949 and 2015 are shown in Figure 7-4.

Existing Conditions
The Kūhiō beach sector is an entirely engineered shoreline. The west end of the sector is bounded by an old rock rubblemound groin that was constructed in 1939 and separates the Kūhiō and Royal Hawaiian beach sectors. The landward stem of this groin is composed of concrete filled sandbags that are severely deteriorated. The central portion of the sector consists of two basins that are separated by a rock rubblemound groin with a concrete walkway on top. The east end of the sector is bounded by the Kapahulu storm drain/groin, which separates the Kūhiō and Queen's beach sectors. The seaward portion of the sector is bounded by a concrete breakwater (often referred to as "crib walls"). The mauka (landward) portion of the sector is bounded by a series of nearly continuous seawalls that are of concrete rubble masonry (CRM) construction. The beach itself consists of sand fill that was imported from various sources and placed along the shoreline during a series of beach construction and maintenance efforts that began in 1939.

The existing groins and attached offshore breakwaters create two distinct basins, each with different beach configurations that reflect the impact of the different stabilizing structure configurations. The Diamond Head (east) basin is approximately 740 ft long, bounded by the Kapahulu storm drain/groin to the southeast, a rock rubblemound groin that separates the two basins, and a concrete breakwater ((referred to as "slippery wall" due to its slippery covering of algae)) along the makai (seaward) side with a crest elevation of about +3 ft MSL. Narrow offset gaps at either end of the breakwater allow for ocean water to flow in and out of the basin largely due to wave and tidal forcing. The gaps, combined with the low crest elevation of the breakwater, allows wave overtopping that facilitates circulation and water exchange in the basin.

Conditions within the basin are typically shallow and calm, which makes it very popular for sunbathing, wading, floating, and swimming, especially for families with young children. The dry beach is typically 20 to 30 ft wide at the east end, and gradually widens to about 90 ft at the west end. The basin is well protected from incident wave energy and most of the central and east end of the beach is inundated when tide levels exceed +2.0 ft MSL. The beach face is aligned approximately parallel to the incident wave crests along the breakwater. While water circulation is limited, routine water quality testing by the Hawaiʻi Department of Health has not indicated water quality issues except after heavy rain events.

The ʻEwa (west) basin is about 680 ft long, bounded by a rock rubblemound groin at the east end that separates the two basins, a rock rubblemound groin at the west end, and a breakwater along the makai (seaward) side. There is a 220-ft-wide gap in the breakwater, with a concrete sill extending across the gap with an elevation approximately equal to the low tide level. The dry beach width on the east side of the basin is approximately 80 ft, and ranges from 40 to 80 ft on the west side. Opposite the gap in the breakwater, the dry beach is typically very narrow (10 to 20 ft) and is completely inundated during medium to high tides due to the narrow beach width and low elevation. The cuspate beach shape within the basin indicates some wave influence at the beach.

Kūhiō Beach provides lateral shoreline access from the terminal groin at the west end of the ʻEwa (west) basin to the Kapahulu storm drain/groin at the east end of the Diamond Head (east) basin. A concrete sidewalk along Kalākaua Avenue provides ADA-compliant lateral access mauka (landward) of the shoreline along the entire beach sector. Most of Kūhiō Beach Park is backed by a series of seawalls that are of concrete rubble masonry (CRM) construction. A series of openings in the seawalls, most with stairs, provide access from the sidewalk to the beach. Three City and County of Honolulu lifeguard towers are located in the Kūhiō beach sector: one in the ʻEwa (west) basin, and two in the Diamond Head (east) basin.

The Kūhiō beach Sector is heavily utilized by sunbathers and people floating, wading and swimming in the calm, protected waters within the basins. At the west end of the sector, beach concessionaires offer a variety of ocean recreation instruction and equipment rentals. This is also the site of the Hula Mound, which regularly hosts free music and dance shows. The surf site known as *Baby Queens*, a popular break for visitors and beginner surfers, is located makai (seaward) of the west end of the ʻEwa (west) basin. Surfers commonly access the nearby surf sites through this area and paddle through the gaps in the breakwater to shorten the paddle out. At the east end of the beach sector, seaward of the Diamond Head (east) basin breakwater, adjacent to the Kapahulu storm drain/groin, is a very popular body surfing and boogie boarding site known as *Walls*, where intrepid wave riders ride up to (and sometimes over) the breakwater. The area inshore of a series of buoys is a “no surfboard” zone and only bodyboarding and bodysurfing area allowed in this area.

The nearshore bathymetry makai (seaward) of the breakwater is very irregular, with shallow reef rock bisected by deeper sand bottom channels, which results in considerable wave refraction and a variable wave approach direction along the breakwater. The wave approach varies from nearly parallel to the breakwater to a nearly 45 deg angle to the walls. Even though the breakwater greatly reduces wave energy reaching the shoreline, the beach orientation inside mimics the incident wave crest orientation. In the ʻEwa (west) basin, the beach is very narrow opposite the gap in the breakwater as a result of relatively high wave energy passing through the gap and wave diffraction around the breakwater structures on either side of the gap. Photographs of existing conditions in the Kūhiō beach sector are shown in Figure 7-5.

Historical and Projected Shoreline Change

The UHCGG historical shoreline change trend for the Kūhiō beach sector from 1927 to 2015 2021 has been erosion at an average rate 0.11 0.02 ft/yr (UHCGG, 20192021). The erosion is more pronounced in the Diamond Head (east) basin with the predominant direction of sediment transport being from east to west (Miller and Fletcher, 2003). As sand is transported from east to west along the beach, the east end of the beach narrows and there is no natural mechanism to transport sand back to the eroding area. The erosion is less pronounced in the ʻEwa (west) basin where the sand is impounded on the updrift side of the groin at the west end of the sector.

As sea levels continue to rise, the Kūhiō beach sector is projected to erode 33.119.3 ft (10.1 m) by 2050 and 86.695.6 ft (26.4 m) by 2100 (UHCGG, 20192021). It is important to note that the long-term historical shoreline change rates for Waikīkī are influenced by efforts over the past century to stabilize and restore the beach, which influences the future erosion projections. These projections also assume that the backshore is composed of non-cohesive erodible substrate and do not account for the presence of the existing seawalls that span nearly the entire length of the shoreline in the Kūhiō beach sector. As the shoreline approaches the existing seawalls, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016).

Without beach improvements and/or maintenance, it is likely that increasing erosion and coastal flooding with sea level rise will result in total beach loss in the middle of this sector within several decades. Erosion and flooding may be less severe at the west ends of the basins where the beach is currently widest; however, total beach loss will still likely occur in these areas before the end of the century if erosion continues at historical rates.

Beach Improvements and Maintenance

Over the years, various improvements to Kūhiō Beach have been considered but never implemented (Figure 7-6). In 1999, Edward K. Noda & Associates, Inc. (EKNA) published an Environmental Assessment for Kūhiō Beach Improvements (Noda, 1999), which consisted of replacing the existing breakwater with segmented breakwaters to form a larger and more stable beach configuration (Figure 7-6B). In 2000, Olsen Associates, Inc. (Bodge) proposed an alternative design using a series of T-head groins and beach nourishment (Figure 7-6C).

The most recent beach improvement project in the Kūhiō beach sector was conducted by the DLNR in 2006. The project consisted of the recovery of approximately 10,000 cy of sand from deposits located immediately offshore of Kūhiō Beach, pumping it to shore for dewatering, and placing it on the beach to nourish and widen the beach (USACE, 2006). The sand was primarily placed within the confines of the breakwater; however, approximately 20% of the sand was placed on the beach west of the breakwater, fronting the Duke Kahanamoku statue.

Figure 7-1 Overview map – Kūhiō beach sector

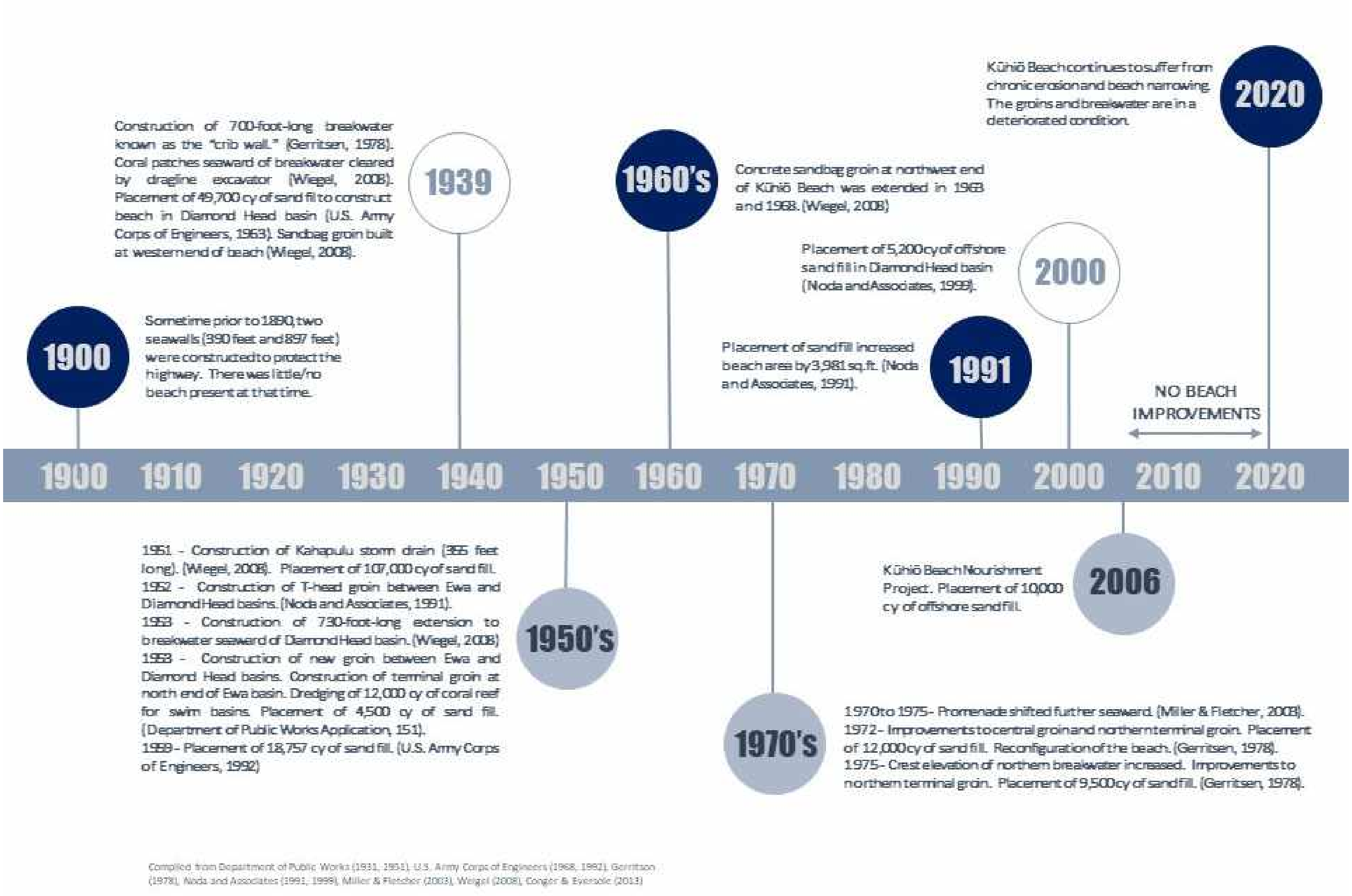
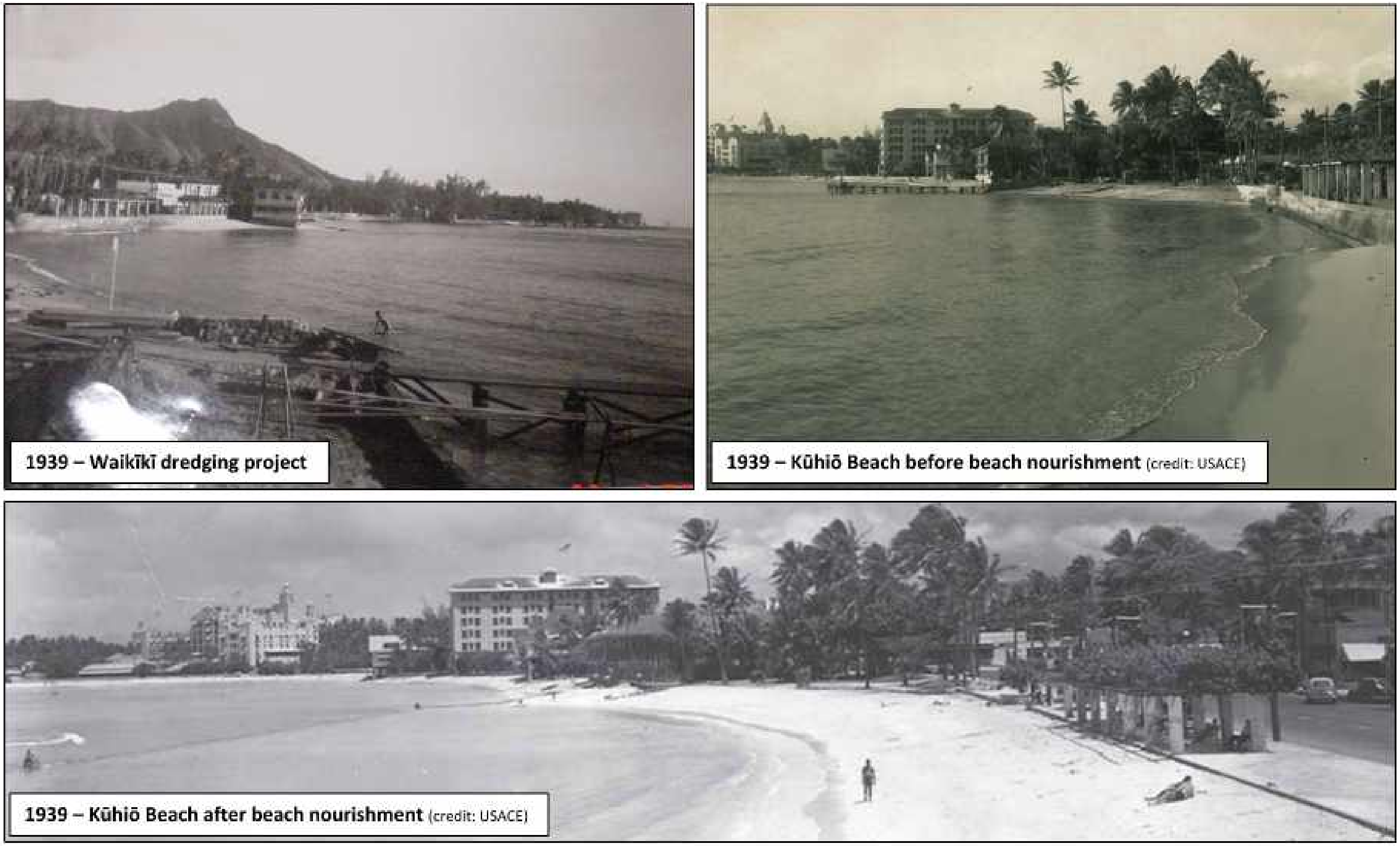


Figure 7-2 History of coastal engineering – Kūhiō beach sector



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HISTORICAL PHOTOGRAPHS – KŪHIŌ BEACH SECTOR
Waikīkī Beach Improvement and Maintenance Program
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Figure 7-3 Historical photographs – Kūhiō beach sector

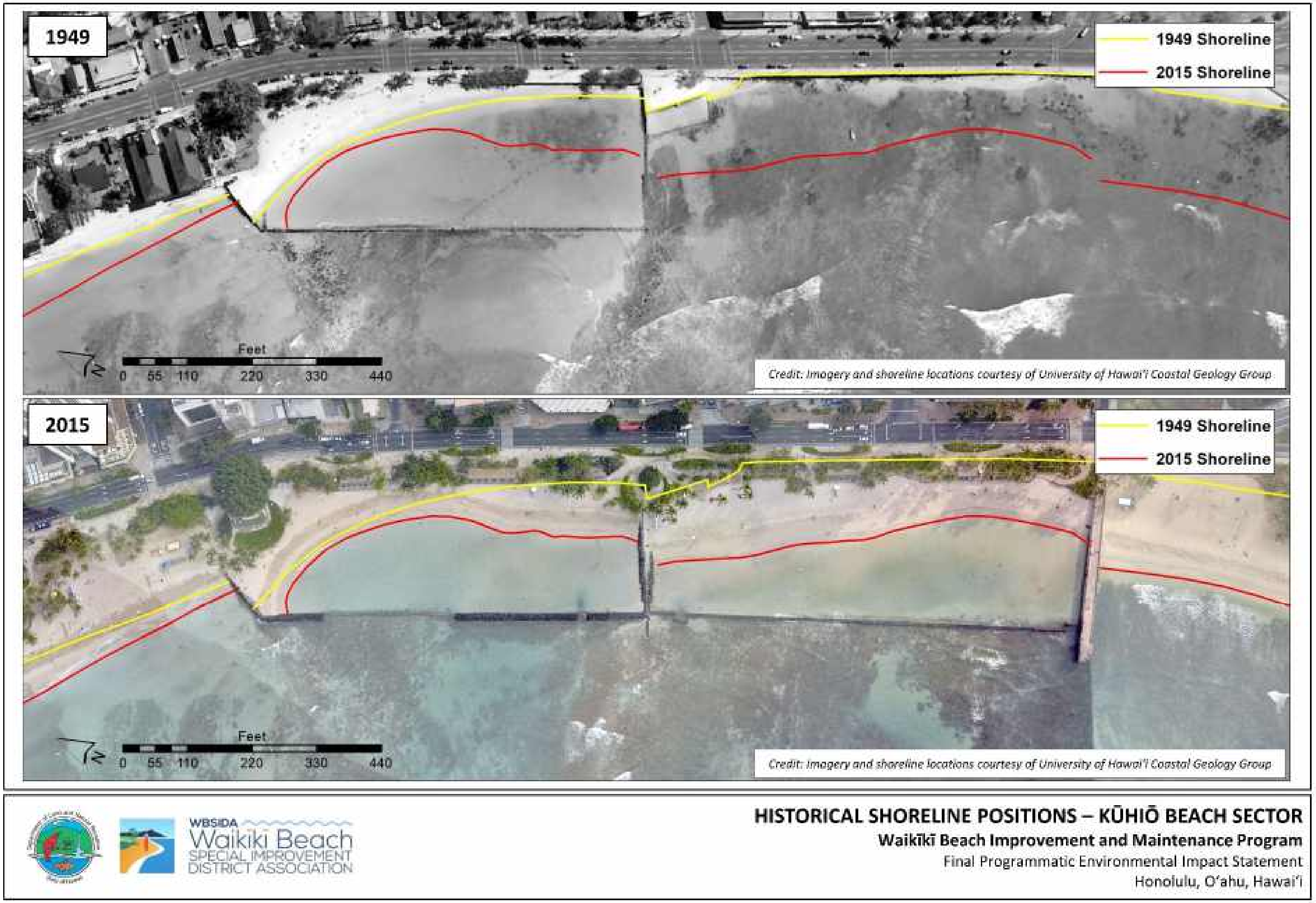

Figure 7-4 Comparison of 1949 and 2015 shoreline positions – Kūhiō beach sector

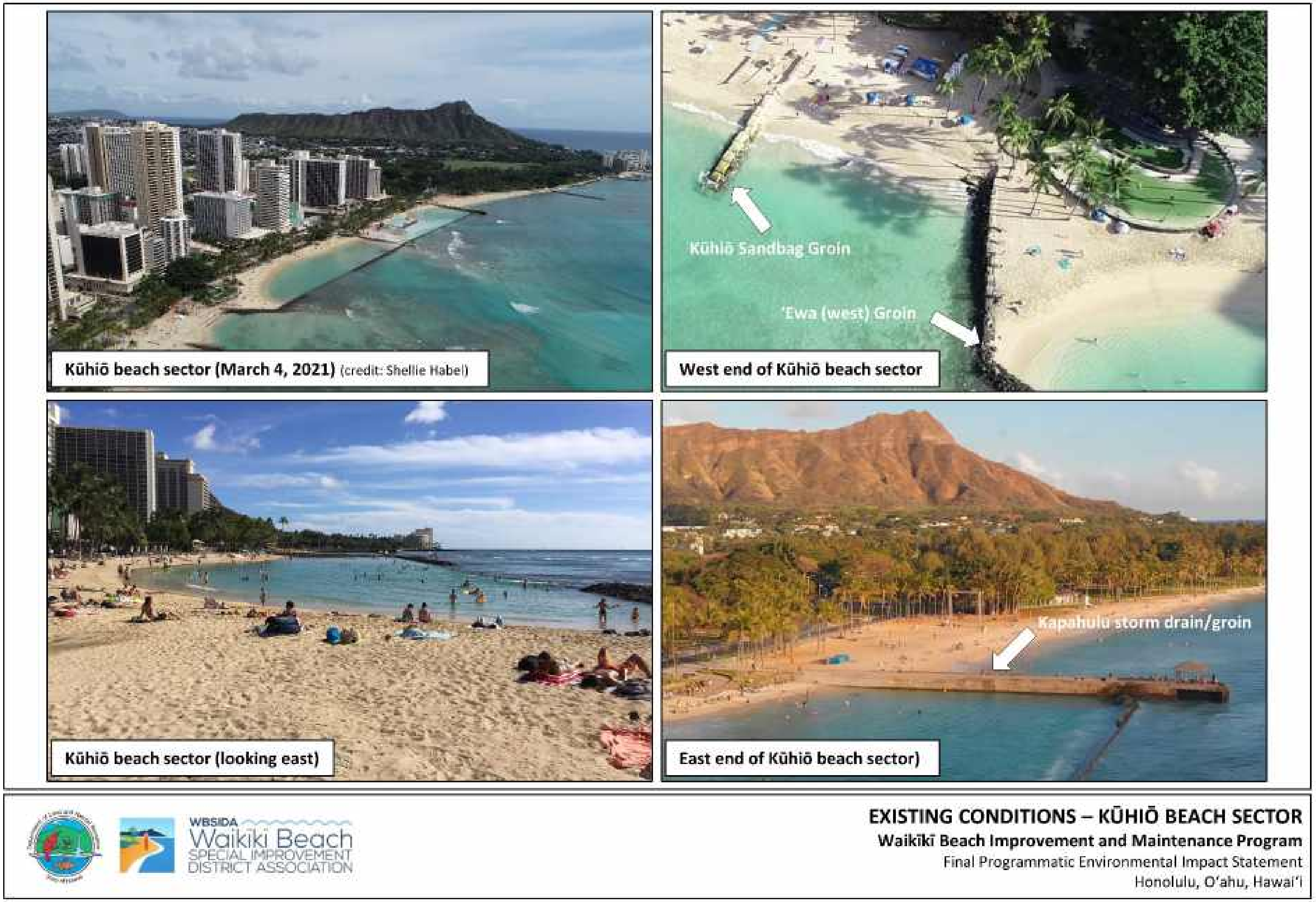

Figure 7-5 Existing shoreline conditions – Kūhiō beach sector

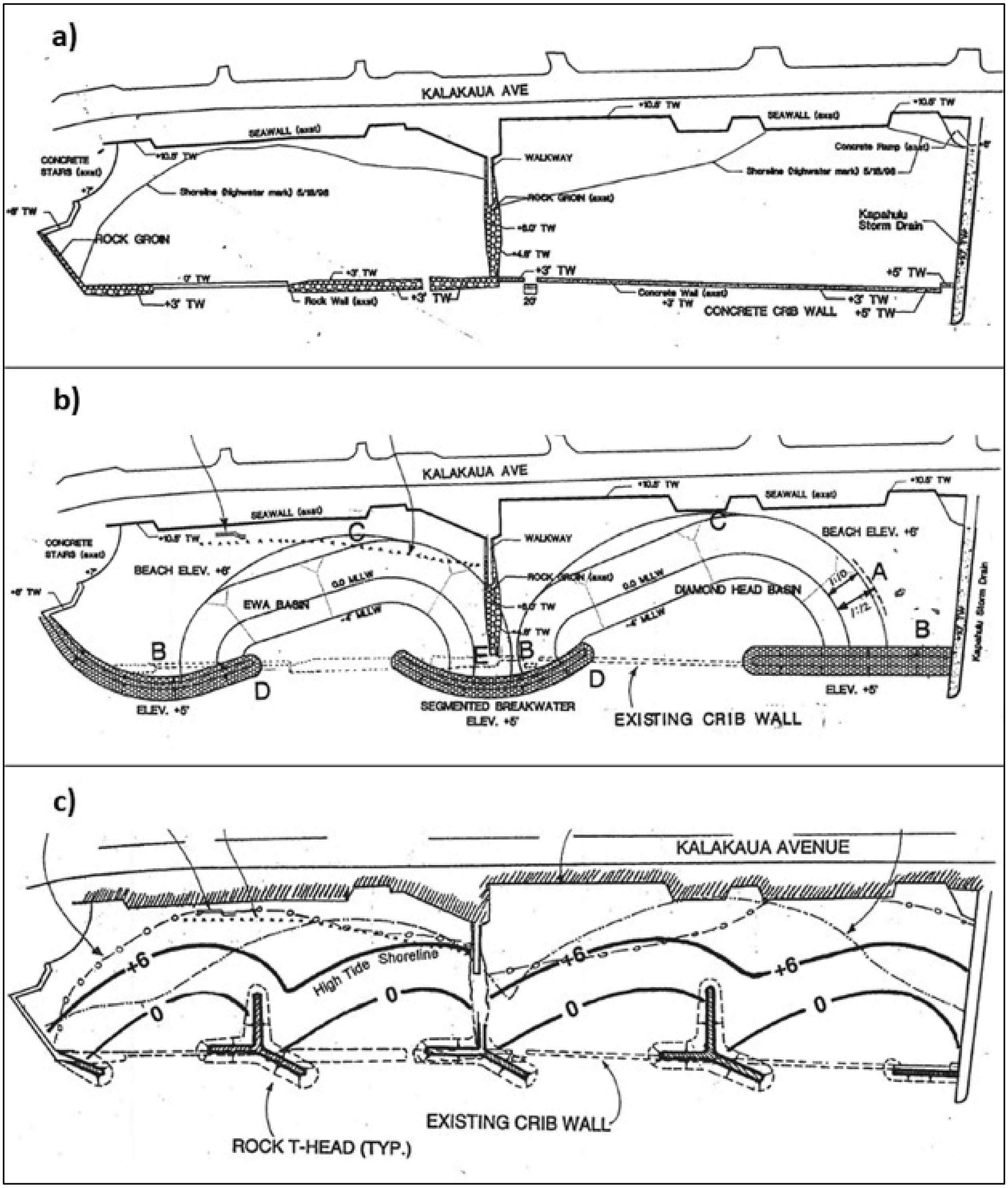

Figure 7-6 (a) existing, b) EKNA proposed (1999), and c) Bodge proposed (2000)

7.2 Purpose and Need for the Proposed Actions

Despite being bounded by offshore breakwaters and groins, the beach in both basins experiences chronic erosion and beach narrowing, some of which can be attributed to water circulation through the wall openings during periods of high surf. In addition, the breakwater significantly reduces wave action on the beach, which causes the sand to migrate (slump) makai (seaward) into the basins, flattening the beach profile, reducing the amount of dry beach area, and decreasing water depths. This was evident following the 2006 Kūhiō Beach Nourishment project. Although the dry beach area rapidly diminished, beach profiles showed that the volume of sand in the basins had not decreased; rather, the sand had migrated into the basins below the waterline.

Other issues with the existing configuration of the basins include safety hazards due to the low, slippery breakwater and narrow gaps for water circulation, and reports of poor water quality due to limited circulation and exchange of ocean water. Strong currents through the gaps in the breakwater produce deep scour trenches that may pose a hazard for unaware waders and swimmers. Despite the extensive breakwater enclosing the basins, there is a slow but chronic loss of sand, and a limited amount of dry beach area. Although the Kūhiō beach sector is nearly 1,500 ft long, the amount of dry beach area at high tide is often very small. Photographs of existing problems in the Kūhiō beach sector are shown in Figure 7-7.

In collaboration with the WBCAC, the project proponents determined that the primary issues and problems in the Kūhiō beach sector are:

- Beach narrowing and makai (seaward) migration (slumping) of the beach profile.
- Seasonal beach erosion.
- Water quality impacts.
- Lack of maintenance of existing infrastructure and amenities.
- Public safety hazard on the existing breakwater and groins.
- Beach narrowing in the Diamond Head (east) basin.

The highest priorities in the Kūhiō beach sector are to:

- Maintain calm and shallow water uses and beach/ocean interaction (swimming, bathing).
- Maintain or improve ocean access at the 'Ewa (west) basin (surfing, paddling).
- Maintain or improve existing commercial uses.
- Maintain cultural/historical sense of place.
- Maintain or improve public access along the Kapahulu storm drain/groin and Esplanade.
- Preserve and protect surf sites (e.g., *Walls*, *Queens*, *Baby Queens*, *Cunha's*).

The highest priorities for the Kūhiō beach sector 'Ewa (west) basin are to maintain a moderately-energetic wave environment, maintain ocean access, reduce sand loss through the breakwater channel, and stabilize seasonal beach dynamics. The highest priority for the Diamond Head (east) basin is to maintain calm and shallow water uses and beach-ocean interaction (e.g., swimming, wading).

Figure 7-7 Issues and problems – Kūhiō beach sector

7.3 Proposed Action - ‘Ewa (west) Basin

Kūhiō Beach Park has been considered as a location where beach maintenance could be performed using existing sand from within the basins. Many features of the basins make them a desirable location for experimenting with novel dredging methods. The basins contain a substantial volume of beach quality sand, are subject to minimal wave action, and are almost completely enclosed by existing structures. The proposed actions for the Kūhiō beach sector are divided into actions for the ‘Ewa (west) basin, and the Diamond Head (east) basin.

7.3.1 Description of the Proposed Action

The proposed action for the Kūhiō beach sector ‘Ewa (west) basin is beach improvements consisting of beach nourishment with modified groins and a segmented breakwater. The proposed action will involve removing portions of the existing structures, construction of a new groin and segmented breakwater system, and placement of sand fill to increase beach width. The conceptual layout for the proposed action is shown in Figure 7-8. Section views of the groin heads and stems are shown in Figure 7-9 and Figure 7-10, respectively. Conceptual renderings of the proposed action are shown in Figure 7-12 and Figure 7-13.

The groin heads and detached breakwater are designed with crest elevations of +6 ft MSL, which is consistent with the head elevation of the Royal Hawaiian groin. This crest elevation will allow some wave overtopping during high surf events without sacrificing beach stability. The structures are designed to be modified as sea levels continue to rise. The structures will have cast-in-place concrete cores as shown in Figure 7-9, which will serve as bases for groin expansion as sea levels continue to rise. When sea level has risen and vertical extension is required, crown walls can be constructed on top of the concrete cores to effectively raise the height of the structures. Designing the structures in this manner keeps the heights lower and the viewplanes more open initially, as opposed to designing the elevations for 3.2 ft of sea level rise now, as suggested by various agencies, and having the structures with elevations likely exceeding +9 ft msl. Future vertical extension of the structures could be accomplished with manual labor and small equipment. Heavy equipment such as bulldozers and excavators would not be required.

The groin heads and breakwater will have crest elevations of +6 ft MSL, crest widths of 12 ft, base widths of 36 to 38 ft, and side slopes of 1V:1.5H (vertical to horizontal). The ‘Ewa (west) groin stem elevations will increase from +6 ft MSL at the heads to +7.5 ft MSL at the inshore end. A concrete crown wall will be constructed on the center groin to contain sand within the ‘Ewa (west) basin.

The ‘Ewa (west) groin is designed with consideration of the beach on each side of it. The head (seaward portion) of the groin is oriented to stabilize that end of the beach inside the basin. The beach on the ‘Ewa (west) side, however, is subject to chronic erosion and the Waikīkī Tavern foundation is frequently exposed. This is occurring because incoming waves approach parallel to the groin stem and wave energy is not dissipated as the waves propagate to shore. This has resulted in erosion of the beach along the ‘Ewa (west) side of the groin stem and has also caused undermining of the groin stem.

To mitigate these erosion effects, a recessed head will be constructed on the west side of the ʻEwa (west) groin. This alternative was investigated at a conceptual level during the design phase of the 2019 Kūhiō Sandbag Groin project. The recessed head will be about 50 ft long and is designed to diffract the approaching waves to create a wave approach pattern that will reduce the longshore current and produce a more stable, arc-shaped beach. The recessed head will also help to reduce erosion and flanking of the ʻEwa (west) groin stem. Portions of the old Waikīkī Tavern concrete foundation wall may need to be removed to maintain a stable beach profile in this area as shown in Figure 7-11.

Approximately 4,000 cy of stone and 250 cy of concrete will be required to construct the groins. The median armor stone weight will be approximately 6,300 pounds. A range of ±25% of the median weight is typically utilized, which yields a stone size range of 4,700 to 7,900 pounds. A two-stone thick layer will be about 6.6 ft thick. The armorstone will be keyed and fit to increase stability.

The proposed action will require approximately 28,000 cy of sand fill that will be placed between the groins to create a beach that will be a minimum of 30 ft wide with a crest elevation of +8.5 ft MSL and a slope of 1V:8H (vertical to horizontal) from the beach crest to the beach toe. The total dry beach area inshore of the waterline will be about 44,000 sf (1 acre). The ʻEwa (west) groin stem will be lower than the beach crest elevation, thus approximately half of the groin stem will be covered by sand, with the groins gradually emerging as they progress further makai (seaward). This should help to improve lateral access along this reach of shoreline. The beach elevation will be higher in the ʻEwa (west) basin than in the Diamond Head (east) basin. A concrete crown wall will be constructed along the center groin to contain the sand in the ʻEwa (west) basin.

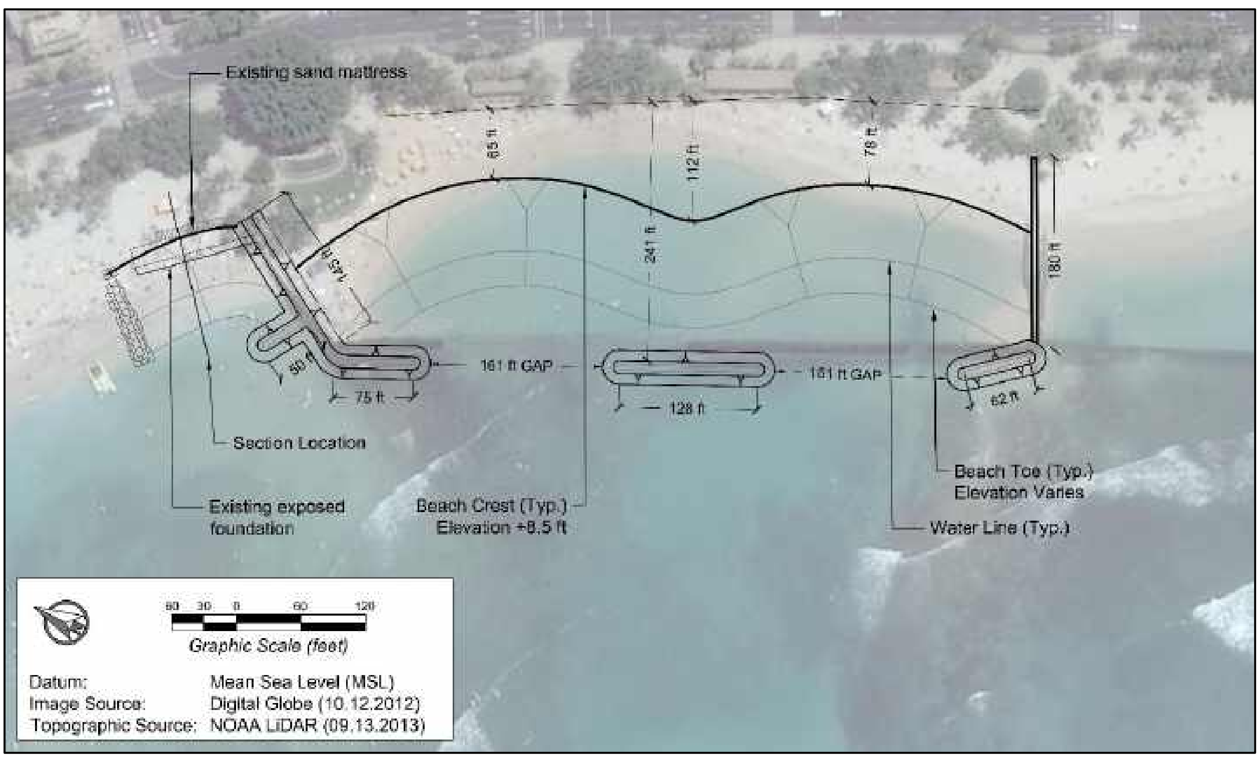

Figure 7-8 Conceptual layout for proposed action - Kūhiō beach sector ʻEwa (west) basin

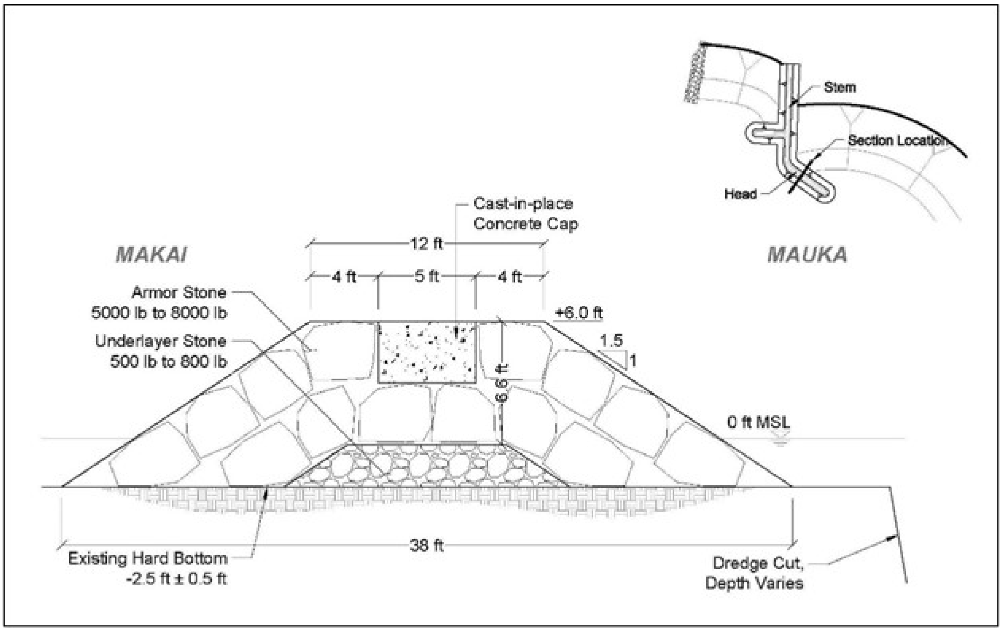

Figure 7-9 Section view of typical groin head <u>or breakwater</u>

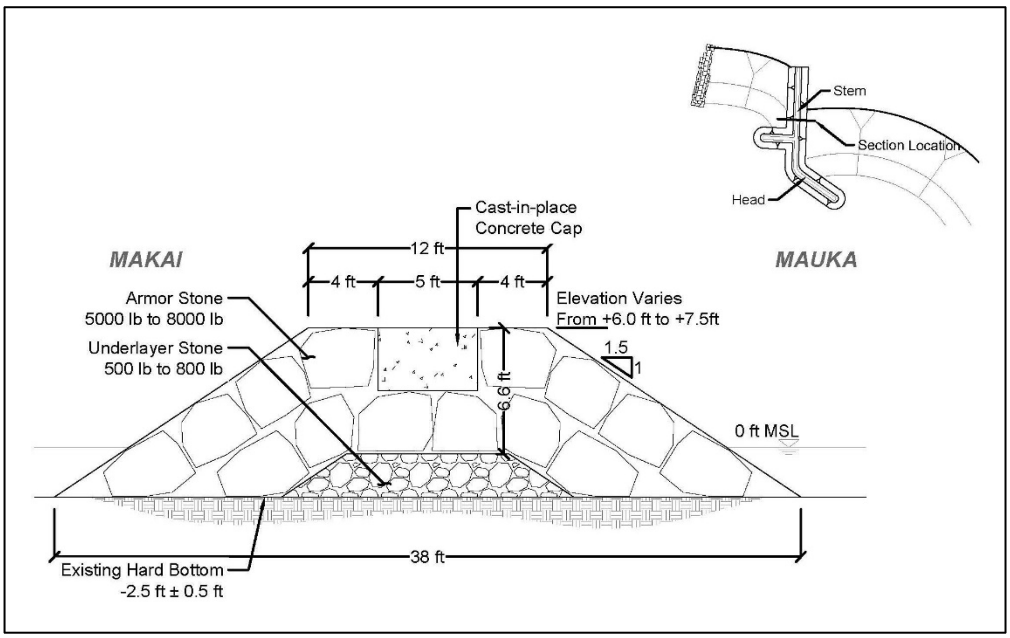

Figure 7-10 Section view of typical groin stem

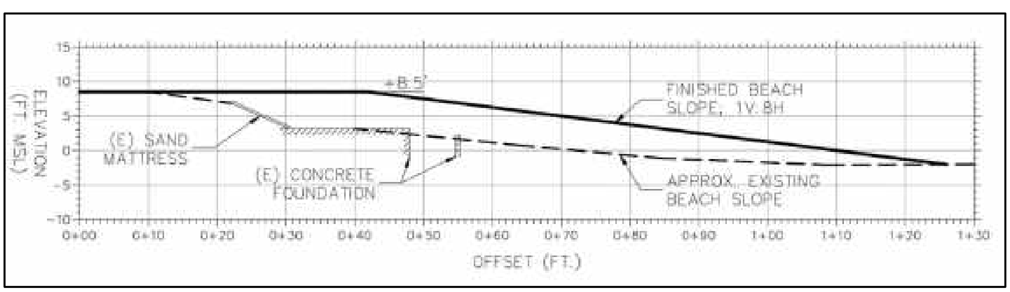

Figure 7-11 Section view of proposed beach fill covering Waikīkī Tavern Foundation

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CONCEPTUAL PLAN VIEW OF PROPOSED ACTION – KŪHIŌ BEACH SECTOR
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Figure 7-12 Conceptual plan view of proposed action for Kūhiō beach sector (ʻEwa basin)

Figure 7-13 Conceptual oblique view of proposed action for Kūhiō beach sector (‘Ewa basin)

7.3.2 Sand Source

Two sand samples were obtained from the beach face in the ʻEwa (west) basin of Kūhiō Beach Park in February 2021. Figure 7-14 shows the composite grain size distribution of those two samples, which have a median grain size (D_{50}) of 0.43 mm. Figure 7-14 also shows the composite grain size distributions for the offshore sand deposits investigated in this project. The best match for the beach is the *Diamond Head* offshore sand deposit. The *Ala Moana* and *Canoes/Queens* offshore sand are reasonable matches for the coarser part of the distribution, before exceeding the ±20% guideline for finer sand. The *Hilton* offshore sand falls on the coarser side; however, slightly coarser sand would be expected to be more stable on an eroding beach.

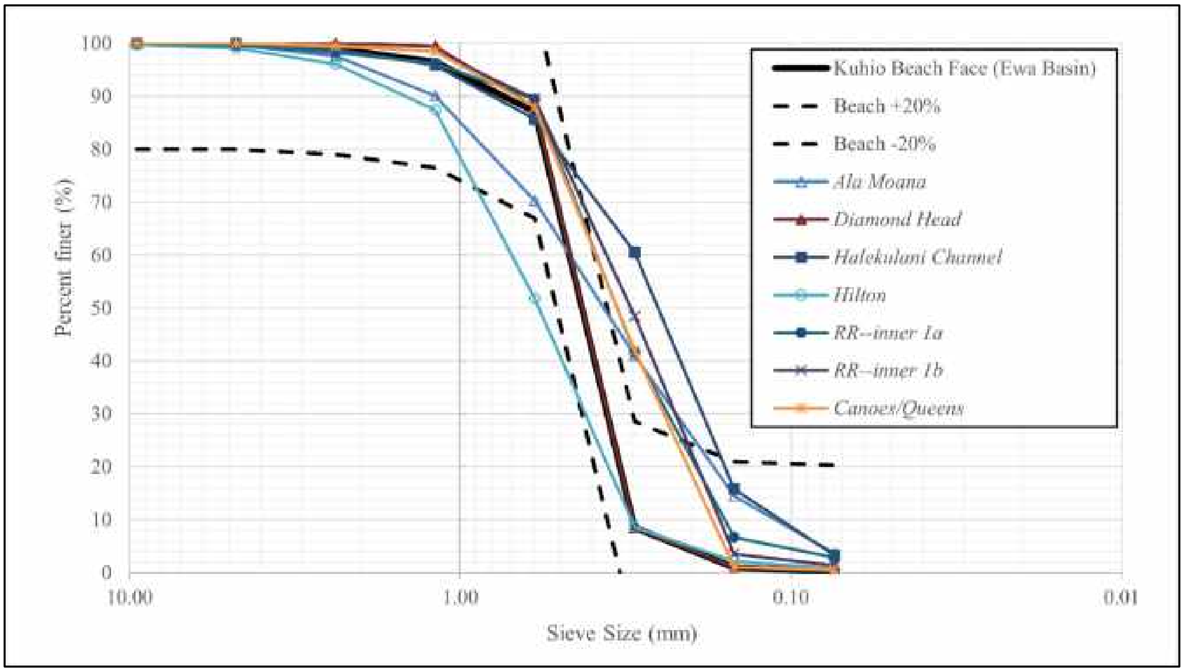


Figure 7-14 Grain size distributions: Kūhiō Beach Park, ʻEwa Basin and offshore sand sources

Given the logistical challenges of obtaining sand from the *Diamond Head* offshore deposit, the preferred sand sources for the Kūhiō beach sector are the *Hilton*, *Ala Moana*, and *Canoes/Queens* offshore deposits. Figure 7-15 and Table 7-1 present the grain size distributions and statistics for the beach and the recommended sources. Sand recovered from the *Ala Moana* and *Hilton* offshore deposits could be used with only minimal overfill, whereas sand from the *Canoes/Queens* offshore deposit would require an additional 12,500 cy sand (total of 40,500 cy) due to the finer sand grain size and increased overfill ratio. Furthermore, the *Canoes/Queens* deposit contains a limited volume of sand, has been dredged multiple times, and is better suited for use in the Royal Hawaiian beach sector. The proposed beach nourishment and structural modifications should result in slightly reduced wave energy in the ʻEwa (west) basin. Additionally, the sand would be contained within the basin by the historical dredge cut in the reef along the makai (seaward) margin of the basin.

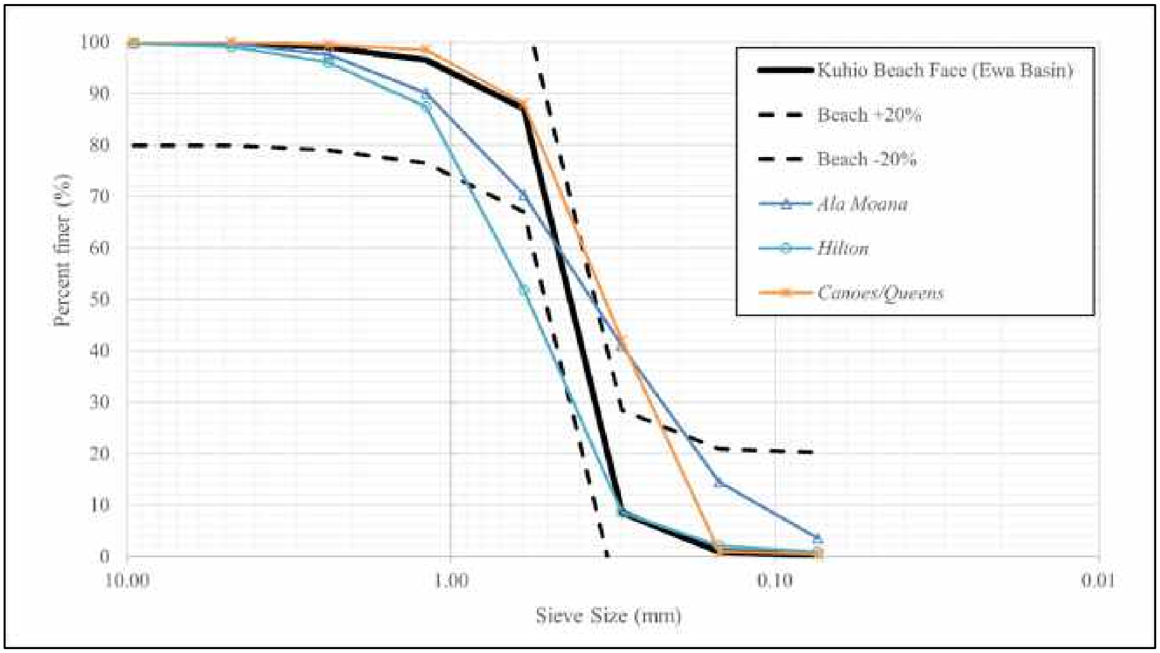


Figure 7-15 Grain size distributions: Kūhiō Beach Park, ‘Ewa Basin, Beach Face and recommended sand sources

Table 7-1 Comparison of sand parameters for Kūhiō Beach Park

	‘Ewa Basin	Canoes/Queens	Ala Moana	Hilton
Median diameter, D_{50} (mm)	0.43	0.34	0.37	0.59
Sorting	N/A	0.82	1.42	1.02
Overfill factor	N/A	1.50	1.10	1.00
Estimated sand required (cy)	25,000	37,500	27,500	25,000
Estimated sand available (cy)	N/A	40,000	86,000	40,000

7.3.3 Construction Methodology

The methodology for sand recovery will depend on the sand source. Sand from the *Canoes/Queens* offshore deposit could be pumped into the Diamond Head (east) basin and dewatered as was done for the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. The sand would then be placed in the ‘Ewa (west) basin. Heavy equipment such as excavators, front end loaders, and bulldozers, would be used to spread the sand to achieve the design beach profiles. If the *Ala Moana* or *Hilton* offshore deposits are used, the sand would be trucked from the offloading point to Waikīkī and placed along the shoreline using the equipment mentioned previously.

Access to the shoreline is possible through the central portion of the park near the center groin or along the shoreline past the Duke Kahanamoku statue. Demolition and construction are expected to be performed using an excavator. The existing groins and breakwater will be removed, as necessary, as the excavators progress along the groin alignment. Underlayer and possibly armor stones will be placed on the seafloor to form a work platform to keep the excavator out of the water. The platform will need to be extended to the detached breakwater. Armor stone will be placed beginning at the head and progress mauka (landward). Any excess material will be removed. The sand fill will be placed following completion of the structures.

7.3.3.1 Alternative Armor Units

Alternative armor units were discussed previously in Section 5.3.3.1. The offshore breakwater offers a potential opportunity for inclusion of environmentally friendly armor units into the design. Coastalock armor units have been developed and deployed internationally; however, they have only been deployed in low wave energy environments, such as harbors. The manufacturer (ECOncrete) has reported that they are undergoing hydrodynamic testing and stability analyses for inclusion in high wave energy environments. Until this testing is concluded, the potential applications would be limited to the leeward side of the structures or placement that does not otherwise affect structural integrity and stability.

Placing the armor units on the inshore side of the groin heads, however, would likely result in the blocks being buried in sand, thereby diminishing their ecosystem services. The inshore side of the offshore breakwater is the only protected area where sand accumulation would not be an issue. Figure 7-16 shows a section view through the breakwater with the Coastalock units, which would be used along the toe of the structure and would be keyed into the fossil reef for stability, as shown previously in Figure 3-17. The Coastalock units would be expected to be stable above the sand layer and would offer the opportunity to attract marine biota and increase biodiversity. An effective use of these units could result in fish aggregation and improved snorkeling in the area.

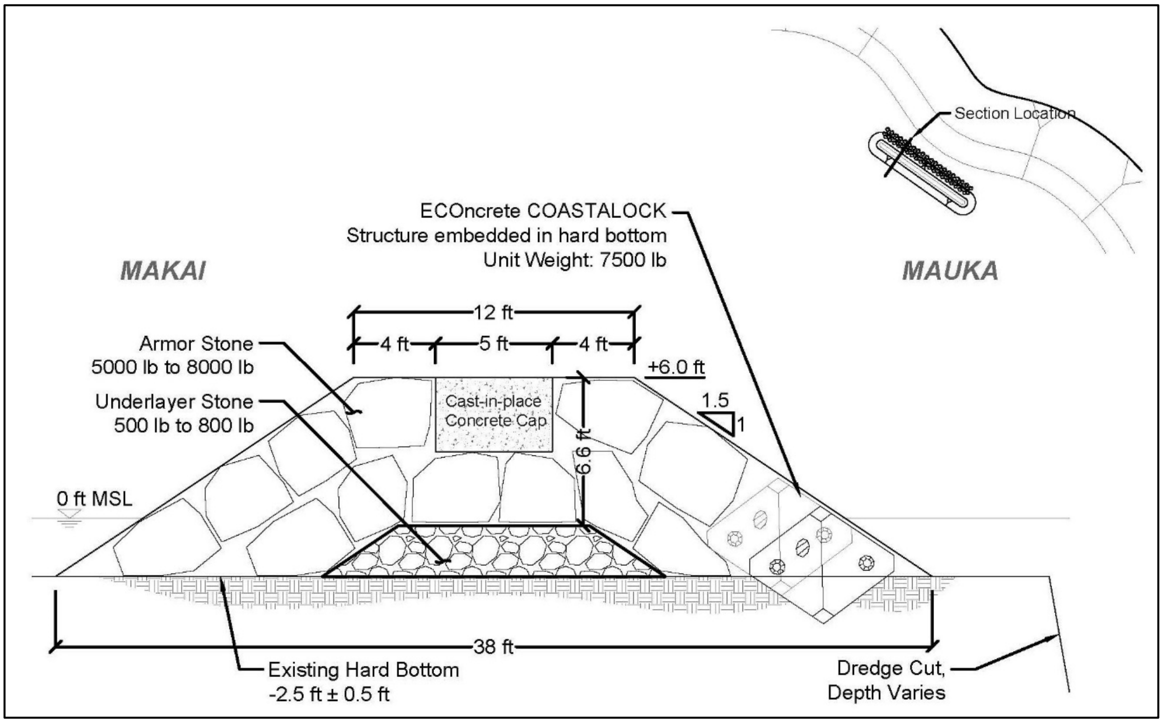


Figure 7-16 ~~Groin head~~Breakwater section with ECOncrete modules

7.3.4 Estimated Timing, Phasing, and Duration

The timeframe for implementing the proposed action in the Kūhiō beach sector has yet to be determined. The proposed beach improvement action is designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 yrs following construction it may be necessary to raise the project elevations. If then raised by several feet, the project could be effective until about the year 2080, or 50 yrs post-construction. The estimated construction duration for the proposed action is 500 days. There is limited space and depth to accommodate additional sand fill in the ʻEwa (west) basin, so no future renourishment efforts are proposed.

7.3.5 Required Permits and Approvals

The proposed action is anticipated to require the following permits and approvals:

- Department of the Army Permit (Section 10 and Section 404)
- Clean Water Act Section 401 Water Quality Certification
- Clean Water Act Section 402 National Pollutant Discharge Elimination System Permit
- Coastal Zone Management Act Consistency Review
- Conservation District Use Permit
- Shoreline Certification
- Right of Entry Permit
- Special Management Area Use Permit
- Shoreline Setback Variance
- Grading and/or Stockpiling Permit
- Building Permit
- Air Pollution Permit
- Community Noise Permit

7.4 Alternatives to the Proposed Action

The following alternatives were considered for the Kūhiō beach sector ʻEwa (west) basin:

- Beach Maintenance
- Beach Nourishment

7.4.1 Beach Maintenance

The current configuration of the ʻEwa (west) basin has resulted in narrowing of the beach inshore of the gap in the breakwaters, while sand has accreted to some extent at the west end of the beach and below the water surface along the center groin. Beach maintenance could involve recovering sand from along the center groin and placing it along the shoreline at the center of the beach. The estimated construction duration for beach maintenance is 30 days, and the estimated recurrence interval is 5 yrs. Assuming that maintenance is conducted over a period of 50 yrs, this will result in a total of 10 individual maintenance events and a total of 300 days of construction. While beach maintenance is technically feasible, it may not be a viable option. The area adjacent to the center groin in the ʻEwa (west) basin is the only site in the Kūhiō beach sector where a sufficient volume of sand would be available to support beach maintenance.

However, the volume of sand present in this area is limited and may not be sufficient to support continued maintenance.

7.4.2 Beach Nourishment without Stabilizing Structures

This alternative would consist of placing sand directly along the shoreline without any structures to stabilize the sand. The sand would be placed along the shoreline in the same approximate footprint as in the proposed action. This concept would require approximately 28,000 cy of sand and would create approximately 40,000 sf (0.92 acres) of dry beach area. An advantage of this option is that it would not require modification of the existing structures. This alternative would increase dry beach width but would not increase beach stability or prevent erosion.

There is limited space and depth to accommodate additional sand fill in the ʻEwa (west) basin, so there would be no future renourishment efforts and periodic maintenance (e.g., sand pumping or sand backpassing) would be required to maintain the desired beach width. Beach nourishment without stabilizing structures would also fundamentally alter the character of the basin. Without the proposed segmented breakwater, the beach would migrate (slump) makai (seaward), the beach profile would flatten, and water depths inside the basin would become very shallow.

The estimated construction duration for beach nourishment without stabilizing structures is 100 days. Assuming that maintenance is conducted every 5 yrs following the initial beach nourishment, over a period of 50 yrs, this would result in a total of 8 individual maintenance events and 240 additional days of construction (total of 340 days).

While this option would be less expensive initially, the cumulative costs of periodic maintenance would be substantial. When compared to beach nourishment without stabilizing structures, the proposed action will have less cumulative impacts as it will require fewer dredging events, fewer construction days, and fewer beach closures.

7.5 Proposed Action - Diamond Head (east) Basin

7.5.1 Description of the Proposed Action

The proposed action in the Kūhiō beach sector Diamond Head (east) basin is beach maintenance consisting of sand pumping with no additional improvements or modifications to existing structures. In collaboration with the WBCAC, the project proponents determined that the Diamond Head (east) basin should remain a safe, calm, and protected area. While the low wave energy produces the calm environment that is enjoyed by many beach users, the wave energy is too low to produce a stable beach profile. Over time, the beach face has migrated (slumped) into the basin below the waterline, with no natural means to transport the sand back onto the beach face. This makai (seaward) migration of sand has flattened the beach profile and decreased water depths in the basin. To increase dry beach width, the sand will need to be manually recovered and placed back onto the beach. The conceptual project layout is shown in Figure 7-17.

In 2018, SEI conducted air jet probing and push core sampling in the Diamond Head (east) basin. Sand thickness in some areas of the basin was measured to be greater than 8 ft (Figure 7-18).

The basin was estimated to contain approximately 4,500 cy of sand makai (seaward) of the waterline. The sand within the basin was found to be beige to dark grey, but the color lightened rapidly when exposed to sunlight.

The proposed action will involve recovery of approximately 4,500 cy of submerged sand from within the Diamond Head (east) basin and placement of that sand on the beach. This will lower the depth of the basin to a uniform bottom elevation of -4 ft MSL and widen the dry beach by approximately 18 and 26 ft along the length of the basin. Because the basin is nearly enclosed, turbidity curtains would only be deployed at the offshore breakwater openings on the north and south ends of the basin during sand recovery and placement. This plan replaces sand on the narrow east end of the basin to produce a more linear shoreline configuration. Toward the center groin, the shoreline turns slightly makai (seaward) to account for the existing palm trees and lifeguard tower. The existing and design profiles are shown in Figure 7-19.

Figure 7-17 Conceptual project layout – Kūhiō Beach sector (Diamond Head (east) basin)

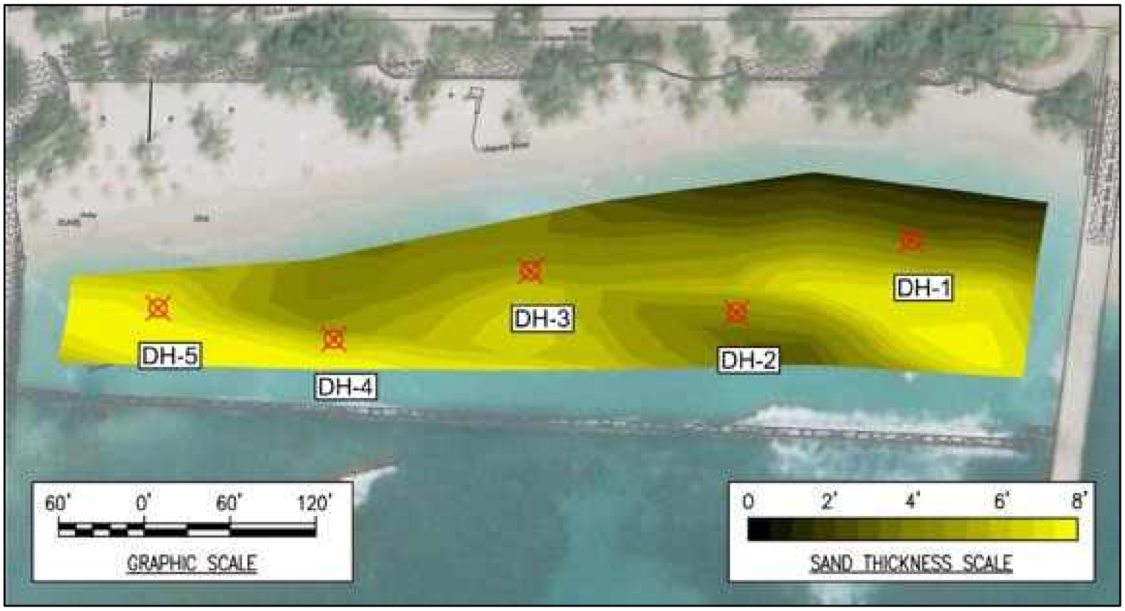


Figure 7-18 Sand thickness – Kūhiō Beach sector (Diamond Head (east) basin)

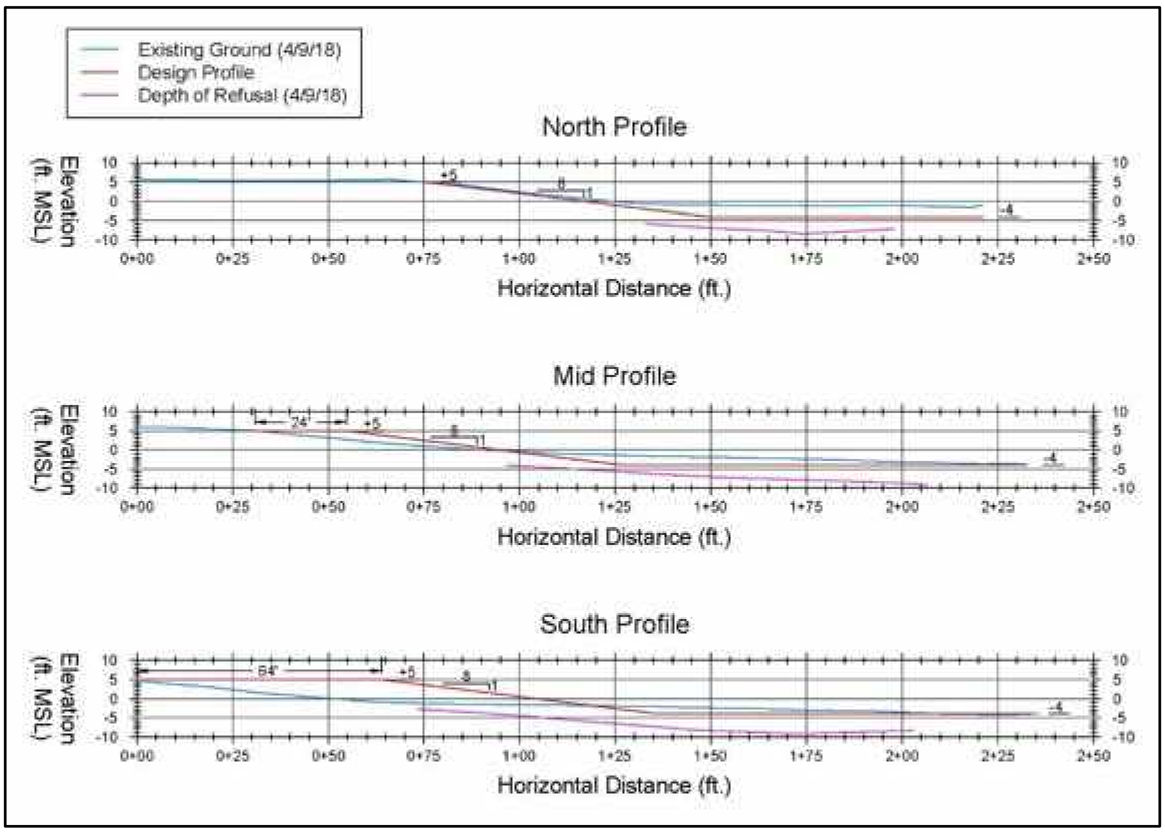


Figure 7-19 Beach nourishment profiles – Kūhiō Beach sector (Diamond Head (east) basin)

7.5.2 Sand Source

Sand will be obtained from within the Diamond Head (east basin). Investigation during the 2019 Kūhiō Sandbag Groin project found an average median grain size of 0.42 mm, and percent fine material (<0.074mm) ranging from 1.2 to 3.2. The sand was considered moderately sorted.

7.5.3 Construction Methodology

Two possible methods are presented to recover sand from within the Diamond Head (east) basin: 1) long-reach excavator or crane, and 2) diver-operated dredge.

Excavator / Crane Method

Recovering sand from within the Diamond Head (east) basin could be accomplished using a long-reach excavator (Figure 7-20), which has a longer arm than a traditional excavator, allowing it to reach further. Long-reach excavators are available for rent on-island and would not require equipment to be shipped in from out of state. To recover sand, the excavator would reach into the basin from the beach face and scoop sand with the bucket. Sand would then be placed directly on the beach face. To reach the offshore limits of the basin, the excavator could build a sand causeway using the recovered sand. A bulldozer and/or skid-steer would be required to spread the sand to achieve the design beach profiles.

A long-reach excavator is limited by the amount of weight it can lift at distances from the cab to prevent the machine from tipping over. For this reason, the buckets are generally quite small (e.g., 0.3 cy). Due to the limited bucket size, sand recovery operations would be relatively slow, which would increase the duration and costs of construction, as well as disruptions to beach users and shoreline access.

Recovering sand from within the Diamond Head (east) basin could also accomplished using a heavy-duty crane (Figure 7-21). An advantage of a crane is that it has a higher load capacity and can use a larger clamshell bucket to recover sand at a much faster rate. This method could utilize a bucket with capacity of several cubic yards. A crane would recover sand like an excavator, moving through the basin on temporary sand causeways. A disadvantage of a crane is that it is larger in size, which could make access challenging. A crane may need to be disassembled and reassembled to access the shoreline, which would increase the duration and costs of construction.

Figure 7-20 CAT 352F LRE long reach excavator (www.caterpillar.com)

Figure 7-21 Sennebogen 6130 HD duty cycle crawler crane (www.sennebogen.com)

Diver-Operated Dredge Method

An alternative method of sand recovery for the Diamond Head (east) basin would be a diver-operated dredge system. A diver-operated dredge has a suction head that can be manipulated and operated by a diver without assistance from a support vessel or construction equipment. Diver-operated dredges are used in shipyard operations and the mining and fracking industries. Using a diver to manipulate the suction hose offers a level of precision that cannot be achieved by lowering a pump over the side of a vessel (i.e., a Toyo pump).

Figure 7-22 shows a diver-operated dredge pump manufactured by Eddy Pump© Corporation (Eddy Pump). The diver-operated dredge pump is roughly 6 ft long, 3 ft wide, and 3 ft tall, but dimensions vary depending on the output of the selected pump. Sand recovery would require a 4-person dive team working from shore for Occupational Safety and Health Administration (OSHA) compliance. The dredge pump could be placed on shore or on the beach face. A floating slurry pipeline and power cable would extend from the dredge pump to the sand recovery area. The pump would be powered by a 100kW generator located on shore. A suction hose would be connected to the dredge pump. The suction hose would be controlled by a single diver. The hose would have a length of 100 ft, which would enable the diver to dredge sand within a 100-ft radius of the pump. Sand production is estimated to be 20 to 40 cy per hour. Once the sand is dredged to the desired depth, the pump would have to be relocated to another area. A bulldozer and/or skid-steer would be required to spread the sand to the design grade.

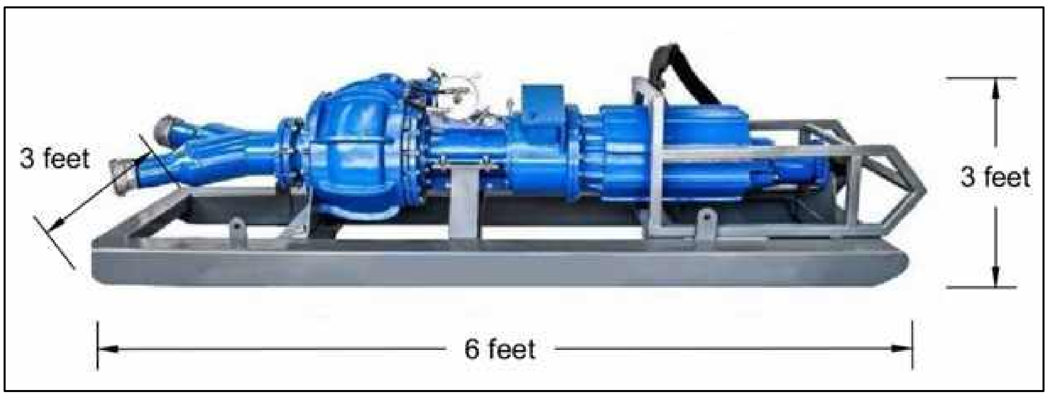


Figure 7-22 Diver-operated dredge pump (Eddy Pump)

7.5.4 Estimated Timing, Phasing, and Duration

The estimated construction duration for the proposed sand pumping is 10 days, and the estimated recurrence interval is 5 yrs. Assuming that maintenance is conducted over a period of 50 yrs, this will result in a total of 10 individual sand pumping events and a total of 100 days of construction.

7.5.5 Required Permits and Approvals

The proposed action is anticipated to require the following permits and approvals:

- Department of the Army Permit (Section 10 and Section 404)
- Clean Water Act Section 401 Water Quality Certification

- Coastal Zone Management Act Consistency Review
- Small Scale Beach Nourishment (SSBN) or Small Scale Beach Restoration (SSBR) Permit Programmatic Conservation District Use Permit CDUP
- Shoreline Certification
- Right of Entry Permit
- Special Management Area Use Permit
- Grading and/or Stockpiling Permit
- Air Pollution Permit
- Community Noise Permit

7.6 Alternatives to the Proposed Action

The following alternatives were considered for the Kūhiō beach sector Diamond Head (east) basin:

- Beach Nourishment without Stabilizing Structures
- Beach Nourishment with Stabilizing Structures

7.6.1 Beach Nourishment without Stabilizing Structures

Beach nourishment could also be performed, where sand would be imported to the Diamond Head (east) basin and spread on the beach. The same dry beach width and configuration could be accomplished with about 4,500 cy of offshore sand; however, no sand would be recovered from within the basin. Water depths would become progressively shallower over time as the new sand added to the beach would be expected to migrate makai (seaward) into the water. The beach width and elevation could also be expanded by adding more sand. Increasing the dry beach elevation by 1 ft would require about 1,500 cy of sand, while widening the beach by 5 ft would require about 2,000 cy of sand.

7.6.2 Beach Nourishment with Stabilizing Structures

Stabilizing the beach in the Diamond Head (east) basin would require reconfiguring the offshore breakwater to be a series of breakwaters or groins. These alternatives were previously investigated by Noda (1999) and Bodge (2000) shown previously in Figure 7-6. Both plans involved removing the offshore wall. The Noda (1999) plan included adding heads to the Kapahulu storm drain/groin and the center groin to produce a more open swimming area. Bodge (2000) recommended smaller heads and the addition of small T-head groin in the gap between the new groin heads. The Bodge (2000) plan is more consistent with the proposed action for the ʻEwa (west) basin.

Beach nourishment would require dredging to recover approximately 4,500 cy of sand from offshore and placing it on the beach. This would produce the same dry beach width and configuration as the proposed action; however, no sand would be recovered from within the basin. By increasing the volume of sand within the basin, water depths would become progressively shallower over time as the new sand added to the beach would be expected to migrate makai (seaward) into the water. The beach width and elevation could also be expanded by adding more sand. Increasing the dry beach elevation by 1 ft would require about 1,500 cy of sand, while widening the beach by 5 ft would require about 2,000 cy of sand.

The highest priorities for the Diamond Head (east) basin are to maintain the basin as a calm, safe environment for swimming and wading. Reconfiguring the existing breakwater would create a more energetic wave environment, which would fundamentally alter the character of the basin. Without reconfiguring the existing breakwater, the beach would migrate makai (seaward), the beach profile would flatten, and water depths inside the basin would become very shallow. As a result, beach nourishment with or without stabilizing structures was ruled out in the early stages of the conceptual design and project selection process.

When compared to the alternatives of beach nourishment with or without stabilizing structures, the proposed action will have less cumulative impacts as it will require fewer construction days, fewer beach closures, no offshore dredging, and will not increase in the volume of sand in the littoral system.

8. NATURAL ENVIRONMENT

8.1 Climate

The Hawaiian Island chain is situated south of the large eastern Pacific semi-permanent high-pressure cell, the dominant feature affecting air circulation and climate in the region. Over the Hawaiian Islands, this high-pressure cell produces persistent northeasterly winds called *tradewinds*. During the winter months, cold fronts sweep across the north-central Pacific Ocean, bringing rain to the Hawaiian Islands and intermittently modifying the tradewind regime. Thunderstorms, which are rare but most frequent in the mountains, also contribute to annual precipitation.

8.1.1 Temperature and Rainfall

Due to the tempering influence of the Pacific Ocean and their low-latitude location, the Hawaiian Islands experience extremely small diurnal and seasonal variations in ambient temperature. Average temperatures in the coolest and warmest months at Honolulu International Airport are 72.9˚ Fahrenheit (F) (January) and 81.4˚F (July), respectively. These temperature variations are quite modest compared to those that occur at inland continental locations. Temperature data from Honolulu International Airport are summarized in Table 8-1 and Table 8-2.

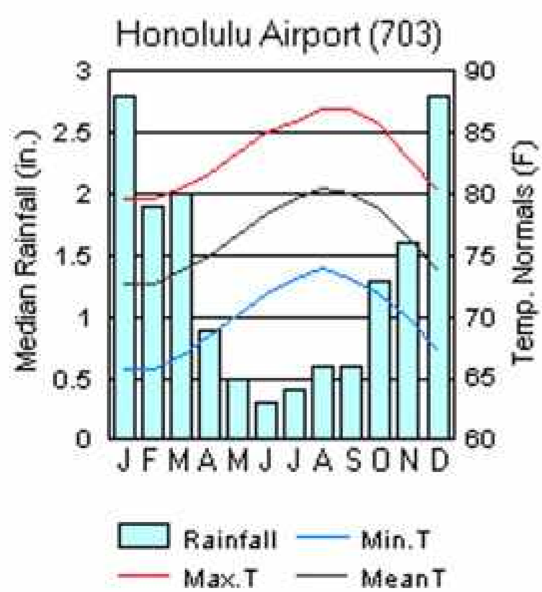
Topography and the dominant northeasterly tradewinds are the two primary factors that influence the amount of rainfall that falls at any given location on Oʻahu. Near the top of the Koʻolau Range on the windward side of Oʻahu that is fully exposed to the tradewinds, rainfall averages nearly 250 in per year. On the leeward side of the island, where the project area is located, the rainfall is much lower. Average annual rainfall in Waikīkī is less than 20 in/yr. Although the project area is on the leeward side of the island, the humidity is still moderately high, ranging from mid-60 to mid-70 percent.

Table 8-1 Average Monthly Temperature, Rainfall, and Humidity

Month	Normal Ambient Temperature, ºFahrenheit		Average Monthly Rainfall (inches)		Average Relative Humidity (%)
	Daily Minimum	***Daily Maximum***	***Monthly Minimum***	***Monthly Maximum***	
January	65.7	80.4	0.18	14.74	71
February	65.4	80.7	0.06	13.68	69
March	66.9	81.7	0.01	20.79	65
April	68.2	83.1	0.01	8.92	62.5
May	69.6	84.9	0.03	7.23	60.5
June	72.1	86.9	T	2.46	59
July	73.8	87.8	0.03	2.33	60
August	74.7	88.9	T	3.08	60
September	74.2	88.9	0.05	2.74	61.5
October	73.2	87.2	0.07	11.15	63.5
November	71.1	84.3	0.03	18.79	67
December	67.8	81.7	0.04	17.29	74.75

Note: "T" signifies a trace amount of rainfall (i.e., less than 0.01 inch).
Source: State of Hawaiʻi Data Book 2003 (Data from Honolulu International Airport)

Table 8-2 Seasonal Rainfall and Temperature Patterns



Station Key: 703 (Honolulu Airport Station)

Coordinates: 21.33138°, 157.91862°

Elevation: 5 feet

Temperature Records: 30 years, 1941 to ______.

Rainfall Records: 29 years

Source: http://hikawa.htohananet.com/climate-oahu/grids/whonolulu.html

8.1.2 Wind

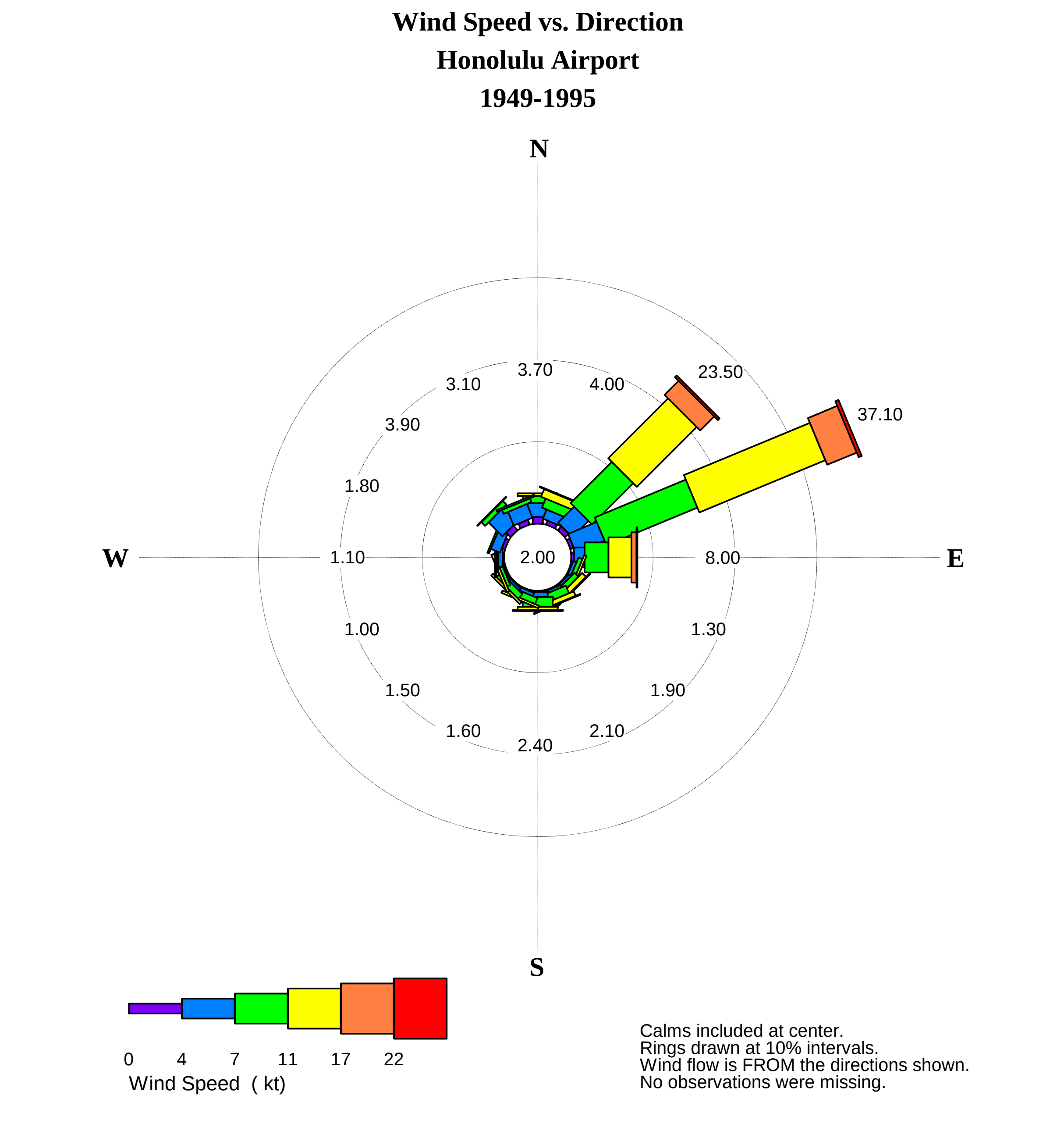
The prevailing winds throughout the year are the northeasterly tradewinds. Average tradewind frequency varies from more than 90% during the summer season to only 50% in January, with an overall annual frequency of 70%. Westerly, or Kona, winds occur primarily during the winter months, generated by low pressure or cold fronts that typically move from west to east past the Hawaiian Islands. Figure 8-1 shows a wind rose diagram applicable to the project area based on wind data recorded at Honolulu International Airport between 1949 and 1995.

Tradewinds are produced by the outflow of air from the Pacific Anticyclone high pressure system, also referred to as the Pacific High. The center of this system is located well north and east of the Hawaiian Islands and moves to the north and south seasonally. In the summer months, the center moves to the north, causing the tradewinds to be at their strongest from May through September. In the winter, the center moves to the south, resulting in decreasing tradewind frequency from October through April. During these months, the tradewinds continue; however, their average monthly frequency decreases to 50%.

During the winter months, wind patterns of a more transient nature increase in prevalence. Winds from extra-tropical storms can be very strong from almost any direction, depending on the strength and position of the storm. The low-pressure systems associated with these storms typically track west to east across the North Pacific north of the Hawaiian Islands. At Honolulu International Airport, wind speeds resulting from these storms have on several occasions exceeded 60 mph. Kona winds are generally from a southerly to southwesterly direction, usually associated with slow-moving low-pressure systems known as Kona lows situated to the west of the Hawaiian Islands. These storms are often accompanied by heavy rains.

8.1.3 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a negligible impact on the climate. No mitigation measures are proposed.



PERCENT OCCURRENCE: Wind Speed (kt)
LOWER BOUND OF CATEGORY

DIR	0	4	7	11	17	22
N	0.80	1.70	0.90	0.30	0.00	0.00
NNE	0.50	1.20	1.20	1.00	0.10	0.00
NE	0.60	2.80	7.10	10.30	2.40	0.30
ENE	0.40	3.80	12.00	16.60	3.90	0.40
E	0.30	1.30	2.90	2.80	0.60	0.10
ESE	0.10	0.40	0.50	0.30	0.00	0.00
SE	0.10	0.30	0.70	0.70	0.10	0.00
SSE	0.10	0.30	1.00	0.60	0.10	0.00

TOTAL OBS = 134736 MISSING OBS = 0

PERCENT OCCURRENCE: Wind Speed (kt)
LOWER BOUND OF CATEGORY

DIR	0	4	7	11	17	22
S	0.10	0.60	1.20	0.40	0.10	0.00
SSW	0.10	0.40	0.80	0.30	0.00	0.00
SW	0.10	0.30	0.80	0.30	0.00	0.00
WSW	0.10	0.20	0.40	0.30	0.00	0.00
W	0.20	0.50	0.20	0.20	0.00	0.00
WNW	0.40	1.20	0.20	0.00	0.00	0.00
NW	0.80	2.40	0.60	0.10	0.00	0.00
NNW	0.60	1.80	0.50	0.20	0.00	0.00

CALM OBS = 2695 PERCENT CALM = 2.00

Figure 8-1 Wind rose for Honolulu Airport (1949 to 1995)

8.2 Waves

8.2.1 General Wave Climate

The wave climate in Hawaiʻi is typically characterized by four general wave types. These include tradewind waves, southern swell, North Pacific swell, and Kona wind waves. Tropical storms and hurricanes also generate waves that can approach the islands from virtually any direction. Unlike winds, any and all of these wave conditions may occur at the same time. The dominant swell regimes for Hawaiʻi are shown on Figure 8-2.

Tradewind waves occur throughout the year and are most persistent from April through September when they usually dominate the local wave climate. They result from the strong and steady tradewinds blowing from the northeast quadrant over long fetches of open ocean. Tradewind deepwater waves are typically between 3 to 8 ft high with periods of 5 to 10 sec, depending upon the strength of the tradewinds and how far the fetch extends east of the Hawaiian Islands. The direction of approach, like the tradewinds themselves, varies between north-northeast and east-southeast and is centered on the east-northeast direction. The project area is well sheltered from the direct approach of tradewind waves by the island itself, and only a portion of the tradewind wave energy refracting and diffracting around the southeast end of the island reaches Waikīkī.

Southern swell is generated by storms in the southern hemisphere and is most prevalent during the summer months of April through September. Traveling distances of up to 5,000 mi, these waves arrive with relatively low deepwater wave heights of 1 to 4 ft and periods of 14 to 20 sec. Depending on the positions and tracks of the southern hemisphere storms, southern swells approach between the southeasterly and southwesterly directions. The project area is directly exposed to swell from the southerly direction and these waves represent the greatest source of wave energy reaching Waikīkī.

During the winter months in the northern hemisphere, strong storms are frequent in the North Pacific in the mid latitudes and near the Aleutian Islands. These storms generate large North Pacific swells that range in direction from west-northwest to northeast and arrive at the northern Hawaiian shores with little attenuation of wave energy. These are the waves that have made surfing waves on the north shores of the island of Oʻahu so famous. Deepwater wave heights often reach 15 ft and in extreme cases can reach 30 ft. Periods vary between 12 and 20 sec, depending on the location of the storm. The project area is sheltered by the island itself from swell approach from the north and northwest. Refracted waves from large swells with a more westerly angle occasionally affect Waikīkī during the winter months.

Kona storm waves also directly approach the project area; however, these waves are relatively infrequent, occurring only about 10 percent of the time during a typical year. Kona waves typically range in period from 6 to 10 sec with heights of 5 to 10 ft, and approach from the southwest. Deepwater wave heights during the severe Kona storm of January 1980 were about 17 ft. These waves had a significant impact on the south and west shores of Oʻahu.

Severe tropical storms and hurricanes obviously have the potential to generate extremely large waves, which in turn could potentially result in large waves at the project site. Major hurricanes that have impacted the Hawaiian Islands include Hurricane Iwa (1982) and Hurricane Iniki (1992). Iniki directly hit the island of Kauaʻi and resulted in large waves along the southern shores of all the Hawaiian Islands. Damage from these hurricanes was extensive. Although not a frequent or even likely event, they should be considered in the project design, particularly with regard to shoreline structures, both in the water and on land near the shoreline.

During high wave events, the water level shoreward of the breaker zone may be elevated above the tide level as a result of the wave breaking process. This water level rise, referred to as *wave setup*, may be as much as 10 to 12% of the breaker height. This water level rise results in an increase in the height of the maximum wave that can propagate toward shore. This produces an increase in design wave height, an increase in breaking wave forces, and an increase in stable stone size.

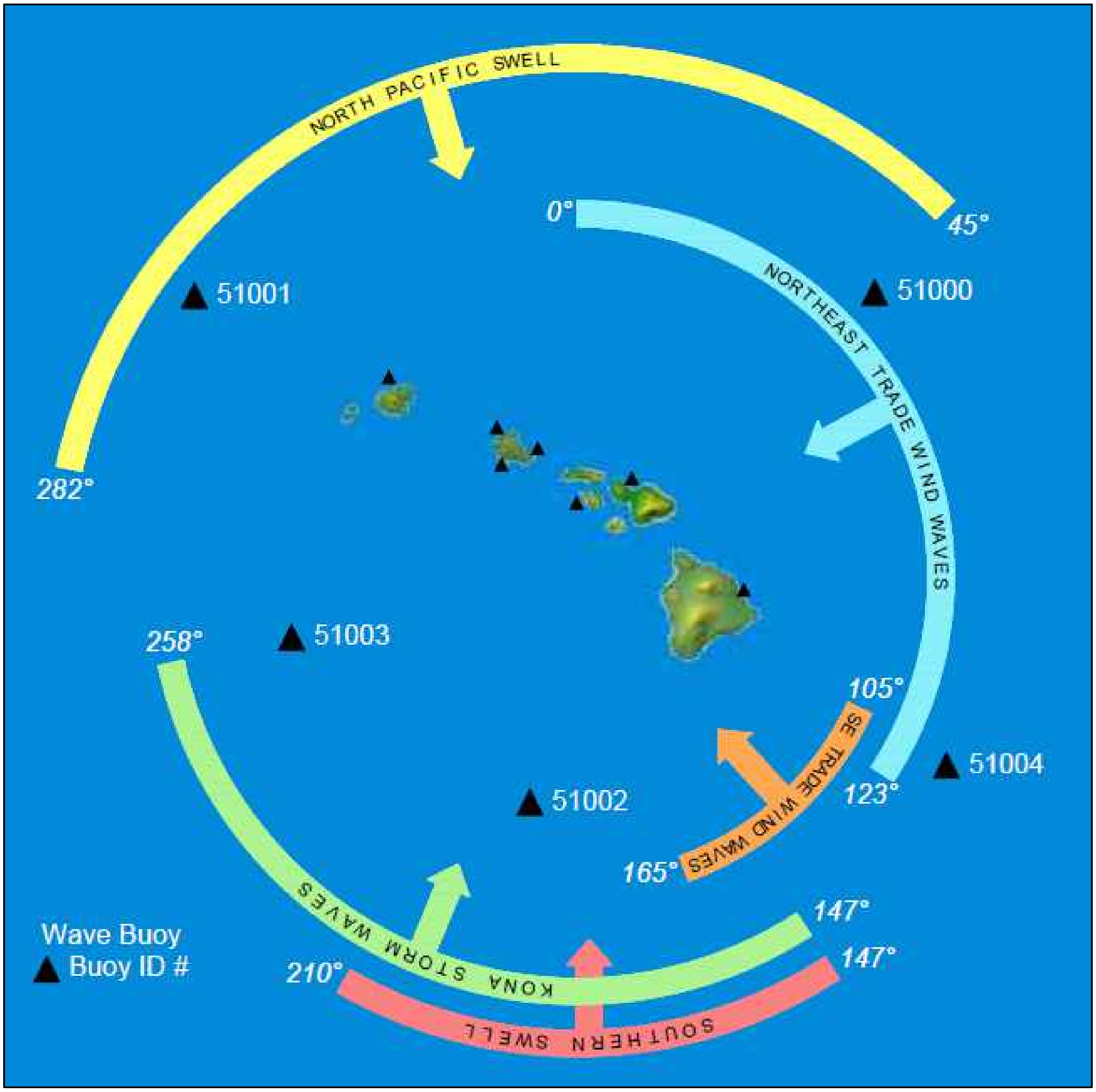


Figure 8-2 Hawaiʻi dominant swell regimes (Vitousek and Fletcher, 2008)

8.2.2 Prevailing Deepwater Waves

Wave conditions for the project area have been measured by the Coastal Data Information Program (CDIP), at two nearby locations, designated as Station 165 (Barbers Point), and Station 238 (Barbers Point, Kalaeloa). Station 165, which was located approximately 19.2 mi west of the project area in a water depth of roughly 990 ft (300 m), recorded data from 2010 to 2017. Station 238 is located approximately 21 mi west-northwest of the project area in a water depth of roughly 920 ft (280 m) and has been recording data since 2018. Buoy locations relative to the project area are shown in Figure 8-3.

Each buoy measures and records its motion due to passing waves. This data is used to compute spectral wave energy and direction at half-hour increments and derives important wave parameters such as significant wave height, peak period, and direction from those measurements. Wave data during the summer months from Station 165 and Station 238 was utilized to generate summer swell wave height and period rose plots, which are a form of histogram that conveys a parameter's directional dependence (Figure 8-4 and Figure 8-5). In general, the plots show peak values centered on south swell from 180 deg. This indicates that the project area is susceptible to elevated surf during the summer months due to its exposure to southern swell. The wave period rose plot shows that the south swell peaks are primarily of longer period (>16 sec) swell, as would be expected. Based on the summer data, the prevailing summer south swell has a direction from 190 deg True North (TN), and a significant wave height of 2.3 ft with a period of 15 sec , and the high-prevailing summer south swell has a significant wave height of 3.0 ft with a period of 16 sec.

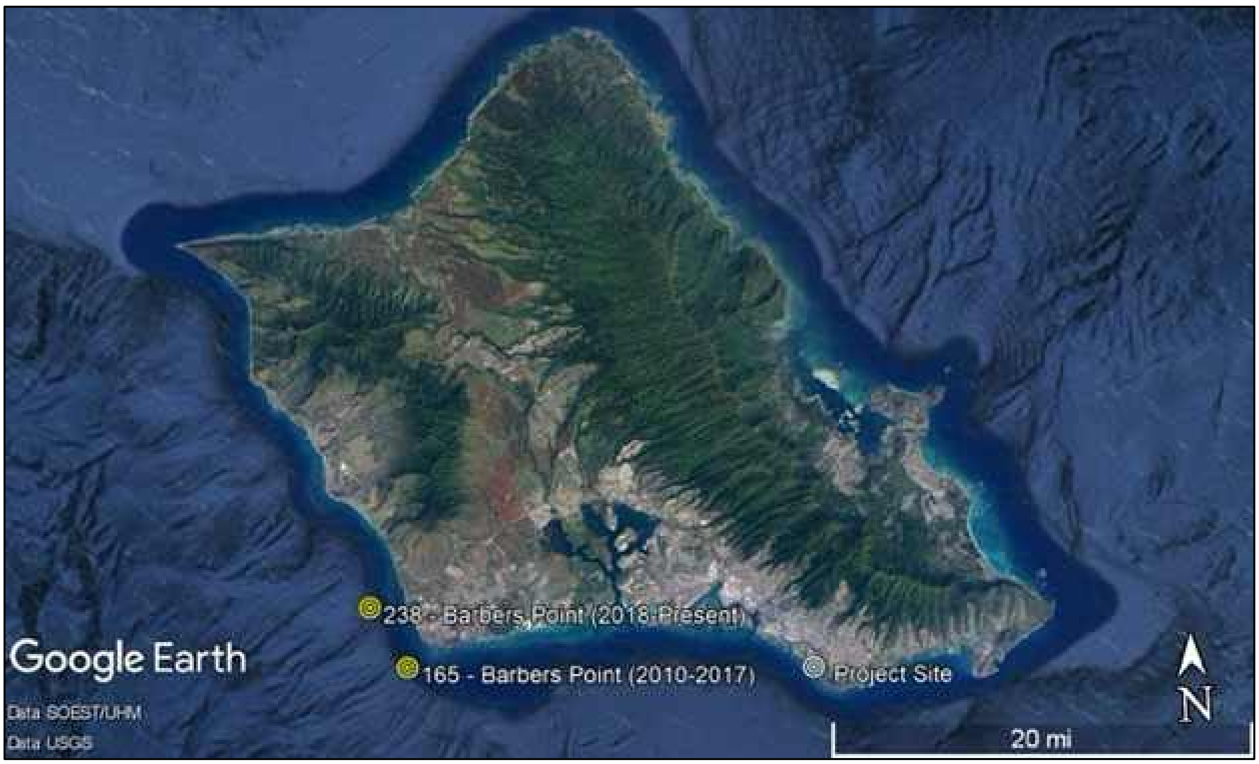


Figure 8-3 Location of CDIP buoys in relation to the project area

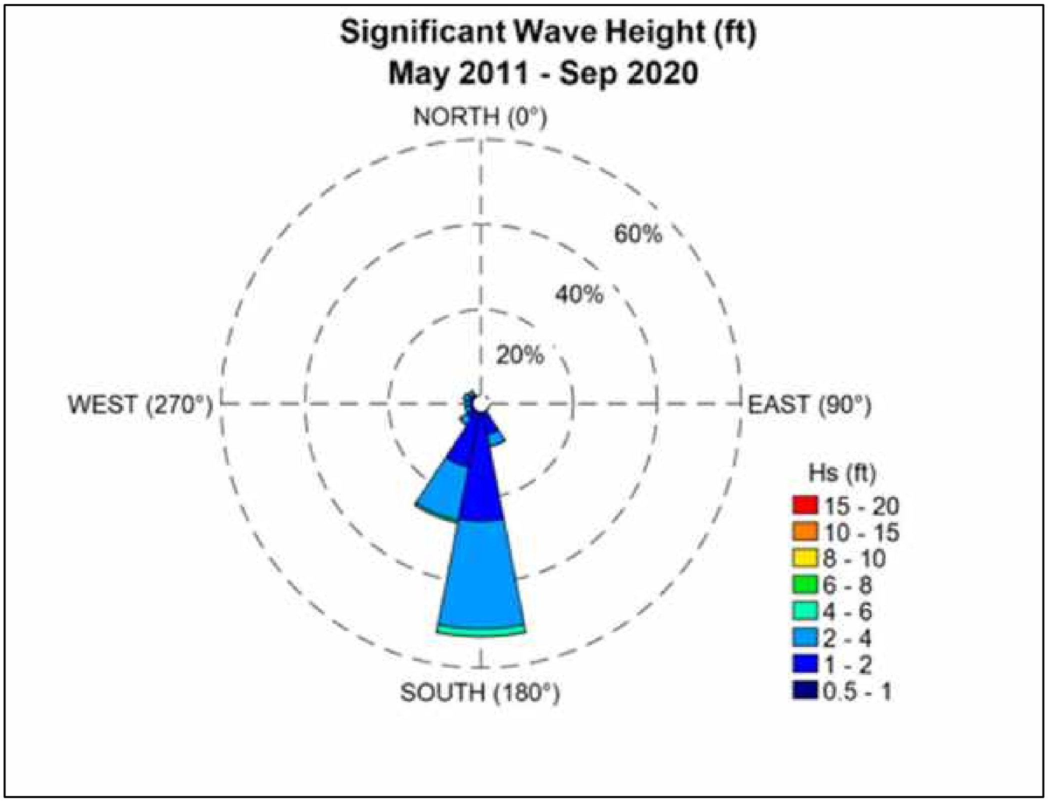


Figure 8-4 CDIP buoy 165 and 238 south swell wave height rose (Oct 2010 to Sep 2020)

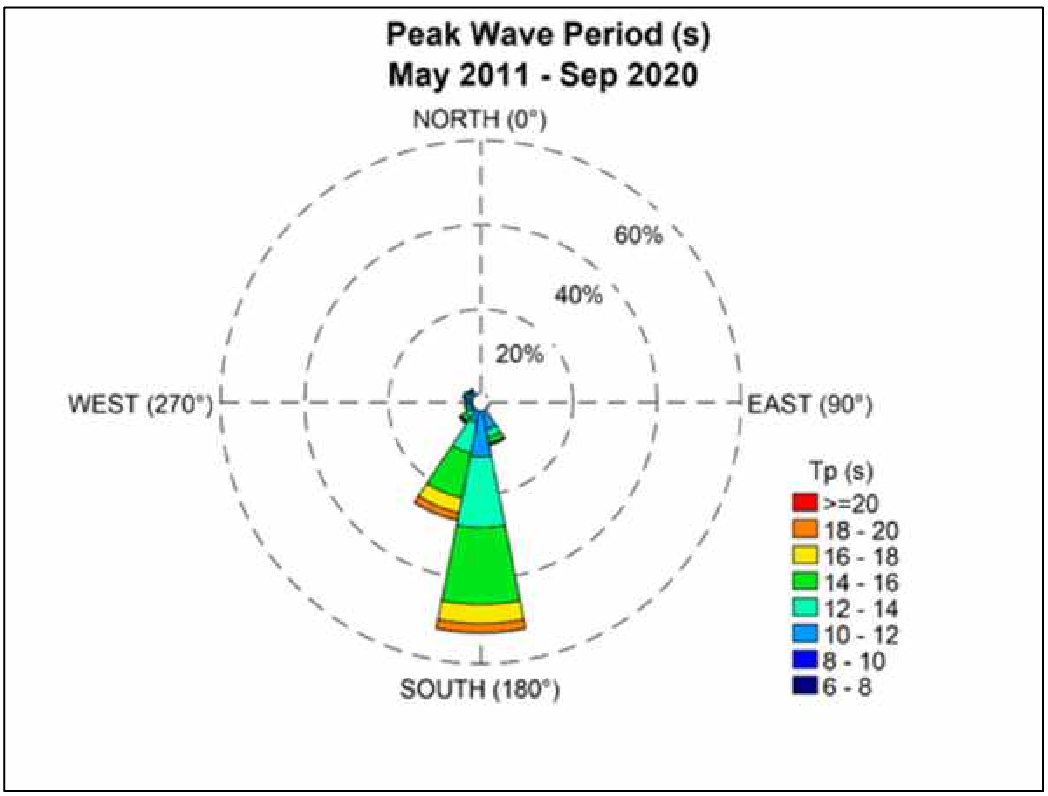


Figure 8-5 CDIP buoy 165 and 238 south swell wave period rose (Oct 2010 to Sep 2020)

As deepwater waves propagate toward shore, they begin to encounter and be transformed by the ocean bottom. In shallow water, the wave speed becomes related to the water depth. As waves slow down with decreasing depth, the process of wave shoaling steepens the wave and increases the wave height. Wave breaking occurs when the wave profile shape becomes too steep to be maintained. This typically occurs when the ratio of wave height to water depth is about 0.78 and is a mechanism for dissipating the wave energy. Wave energy is also dissipated due to bottom friction. The phenomenon of wave refraction is caused by differential wave speed along a wave crest as the wave passes over varying bottom contours and can cause wave crests to converge or diverge and may locally increase or decrease wave heights. Not strictly a shallow water phenomenon, wave diffraction is the lateral transmission of wave energy along the wave crest and would cause the spreading of waves in a shadow zone, such as occurs behind a breakwater or other barrier. Two numerical wave models, SWAN and XBeach-NH were utilized for this study to simulate the wave transformation from deep water to the project area.

Simulating Waves Nearshore (SWAN)

Simulating Waves Nearshore (SWAN) is a third-generation wave model developed by Delft University of Technology that computes random, short-crested wind-generated waves in coastal regions and inland waters (Booij et al, 1999). The SWAN model can be applied as a steady state or non-steady state model and is fully spectral (over the total range of wave frequencies). Wave propagation is based on linear wave theory, including the effect of wave generated currents. SWAN provides many output quantities, including 2-dimensional spectra, significant wave height and mean wave period, and average wave direction and directional spreading. For this project, the SWAN model was used to transform waves from deep water to intermediate water depths just offshore from the project area. SWAN model results were used to provide wave parameter input for a nearshore numerical wave model, XBeach-NH.

XBeach-NH

As waves move into shallow water, bathymetry has a greater influence on wave behavior. Waves interact with the bottom, dissipating more energy through depth-induced breaking and bottom friction. Results of the SWAN model for the prevailing wave, annual wave, and 50-yr wave conditions were modeled from just offshore of the project area into the nearshore region using the XBeach non-hydrostatic (XBeach-NH) numerical model. XBeach is an open-source numerical wave model originally developed to simulate hydrodynamic and morphological processes along sandy shorelines. The XBeach-NH module (Stelling and Zijlema, 2003) computes the depth-averaged flow due to waves and currents using the non-linear shallow water equations and includes a non-hydrostatic pressure term. The governing equations are valid from intermediate to shallow water and can simulate most of the phenomena of interest in the nearshore zone and in harbor basins, including shoaling and refraction over variable bathymetry, reflection and diffraction near structures, energy dissipation due to wave breaking and bottom friction, breaking-induced longshore/cross-shore currents, and harbor oscillations. XBeach-NH is a phase resolving model, meaning that wave crests and troughs are modeled and propagated in time and space. The result is an accurate representation of wave heights and wave patterns across the domain. The XBeach-NH model was utilized to assess the complex wave pattern along the Waikīkī shoreline. Figure 8-6 shows the XBeach-NH output of wave patterns for a high-prevailing south swell. Figure 8-7 through Figure 8-10 show the XBeach-NH output of wave patterns for a high-prevailing south swell for the four selected beach sectors.

Figure 8-6 XBeach-NH wave pattern output for high-prevailing SSW swell

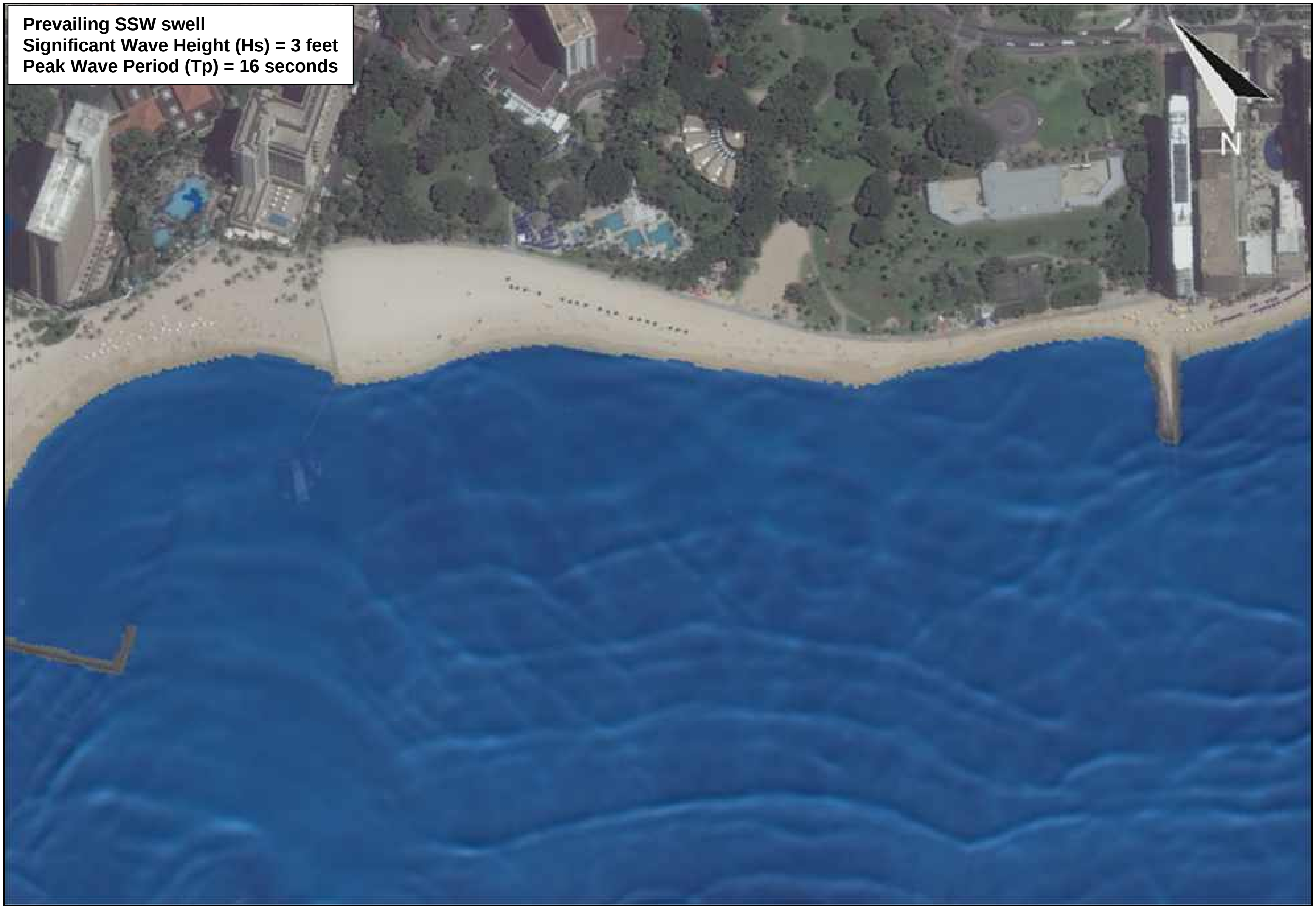


Figure 8-7 XBeach-NH wave pattern for high-prevailing SSW swell – Fort DeRussy beach sector

Figure 8-8 XBeach-NH wave pattern for high-prevailing SSW swell – Halekūlani beach sector

Figure 8-9 XBeach-NH wave pattern for high-prevailing SSW swell – Royal Hawaiian beach sector

Figure 8-10 XBeach-NH wave pattern for high-prevailing SSW swell – Kūhiō beach sector

8.2.3 Extreme Deepwater Waves

The Hawaiian Islands are annually exposed to severe storms and waves generated by tropical cyclonic storms (hurricanes). Hurricanes, the worst-case tropical cyclones, are caused by intense low-pressure vortices that are usually spawned in the eastern tropical Pacific Ocean and travel westward. Along with damaging winds and rains, hurricanes bring the threat of elevated sea level, commonly referred to as *storm surge*.

Storm surge is composed of three elements: wave setup, wind setup, and pressure setup. Wave setup is a phenomenon where the water level shoreward of the breaker zone may be elevated above the tide level due to breaking waves offshore. Wind setup is an increase in water level rise due to wind stress acting on the water surface and will only occur when winds are blowing towards the shore. Typically, wind setup is negligible in Hawaiʻi because it requires a long shallow shelf to help hold water against the shore. Pressure setup is an increase in water level due to reduced atmospheric pressure surrounding the storm. Pressure setup is a function of the center pressure of the storm and the distance from the center of the storm.

While it is not uncommon for hurricanes to pass near Hawaiʻi, they often change course or deteriorate by the time they reach Hawaiian waters. Figure 8-11 shows the historical tracks of tropical storms and hurricanes in the central Pacific from 1949 to 2018. While direct hits to the islands are rare, hurricane tracks to the north or south of the Hawaiian Islands are not infrequent and can generate large, damaging waves that can impact shorelines throughout Hawaiʻi. The historical tracks of hurricanes that have passed near the Hawaiian Islands between 1948 to 2018 are shown in Figure 8-12, and the tracks of tropical storms and tropical depressions that have passed near Hawai'i are shown in Figure 8-13.

Four model hurricane tracks were developed based on similar characteristics of Hurricane Lane in August 2018. Scenario tracks were developed specifically for the west and south facing shores of the island of Oʻahu. The model results for the direct strike scenario track, referred to as *3ab 12kt*, was chosen for this study to assess a worst-case scenario impact to the project area. The modeled wind field and wave height from the previous study are shown in Figure 8-14 and Figure 8-15 respectively. The modeled deepwater significant wave height offshore from the project area at peak conditions is 42 ft with a peak wave period and direction of 14 sec and 215 deg, TN, respectively.

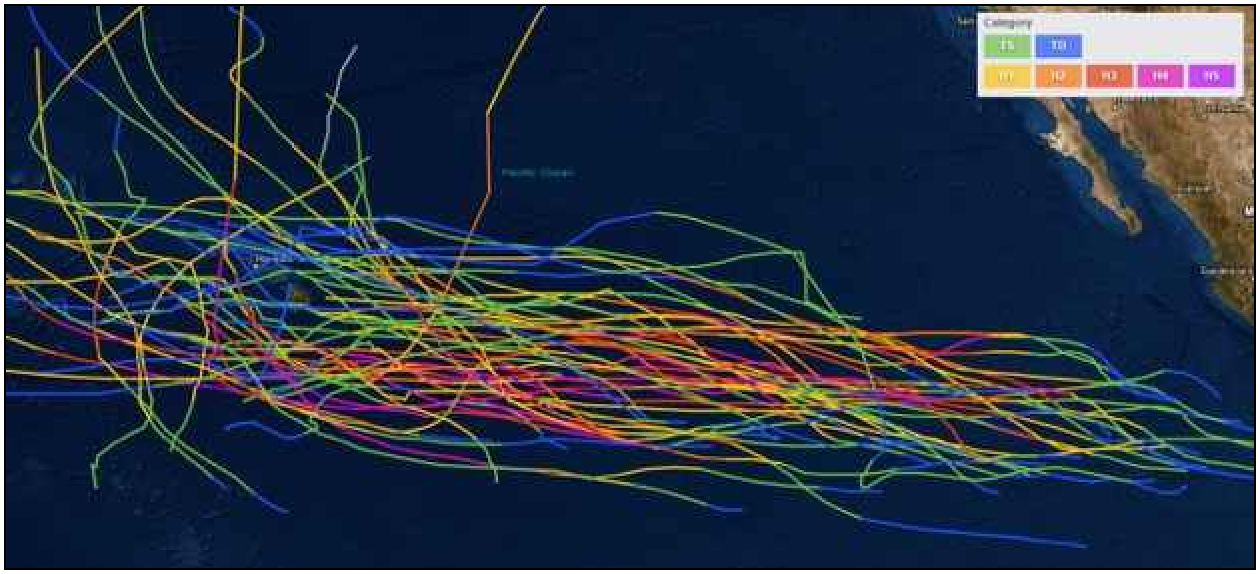


Figure 8-11 Central Pacific historical hurricane tracks (1949 to 2018)

Source: https://coast.noaa.gov/hurricanes/

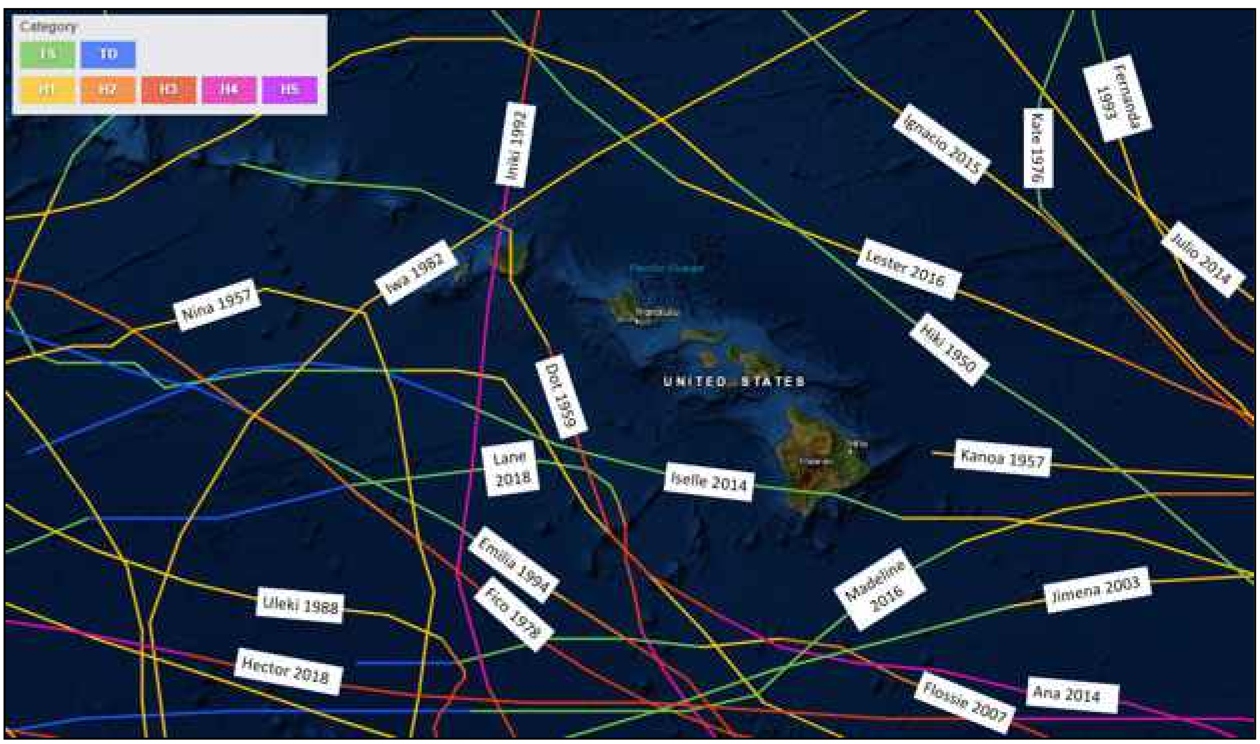


Figure 8-12 Hawaiʻi historical hurricane tracks (1949 to 2018)

Source: https://coast.noaa.gov/hurricanes/

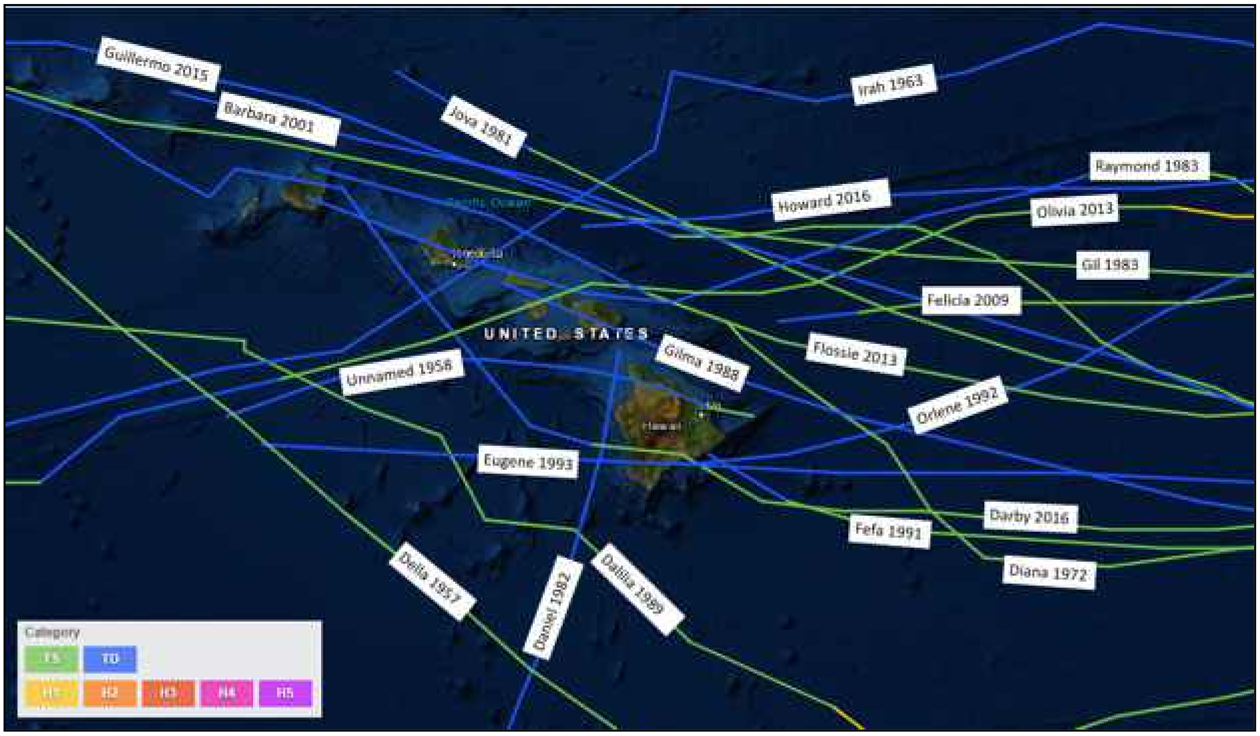


Figure 8-13 Hawai'i historical tropical storms and depressions (1949 to 2018)

Source: https://coast.noaa.gov/hurricanes/

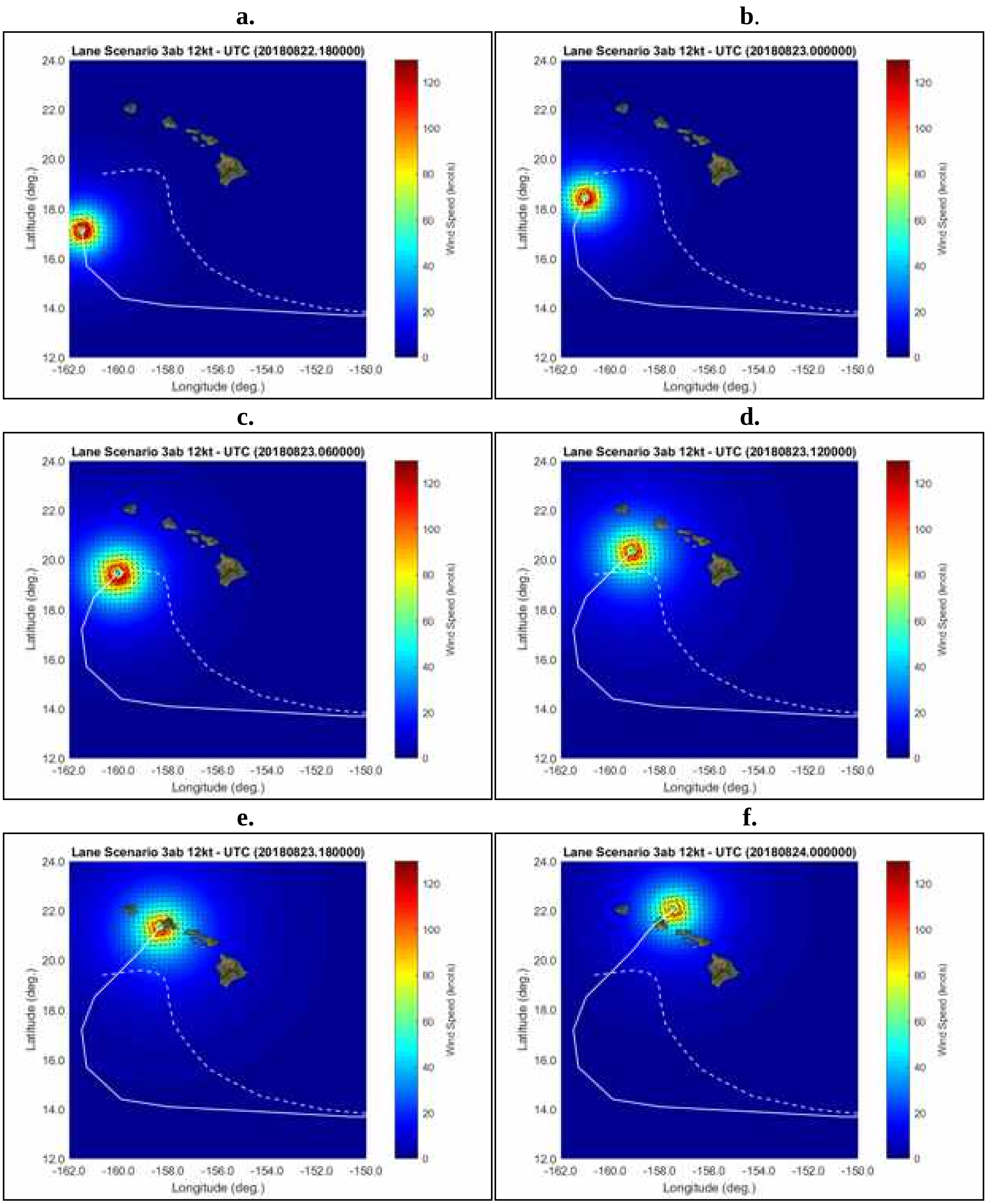


Figure 8-14 Hurricane scenario 3ab_12kt modeled wind field through the Hawaiʻi domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

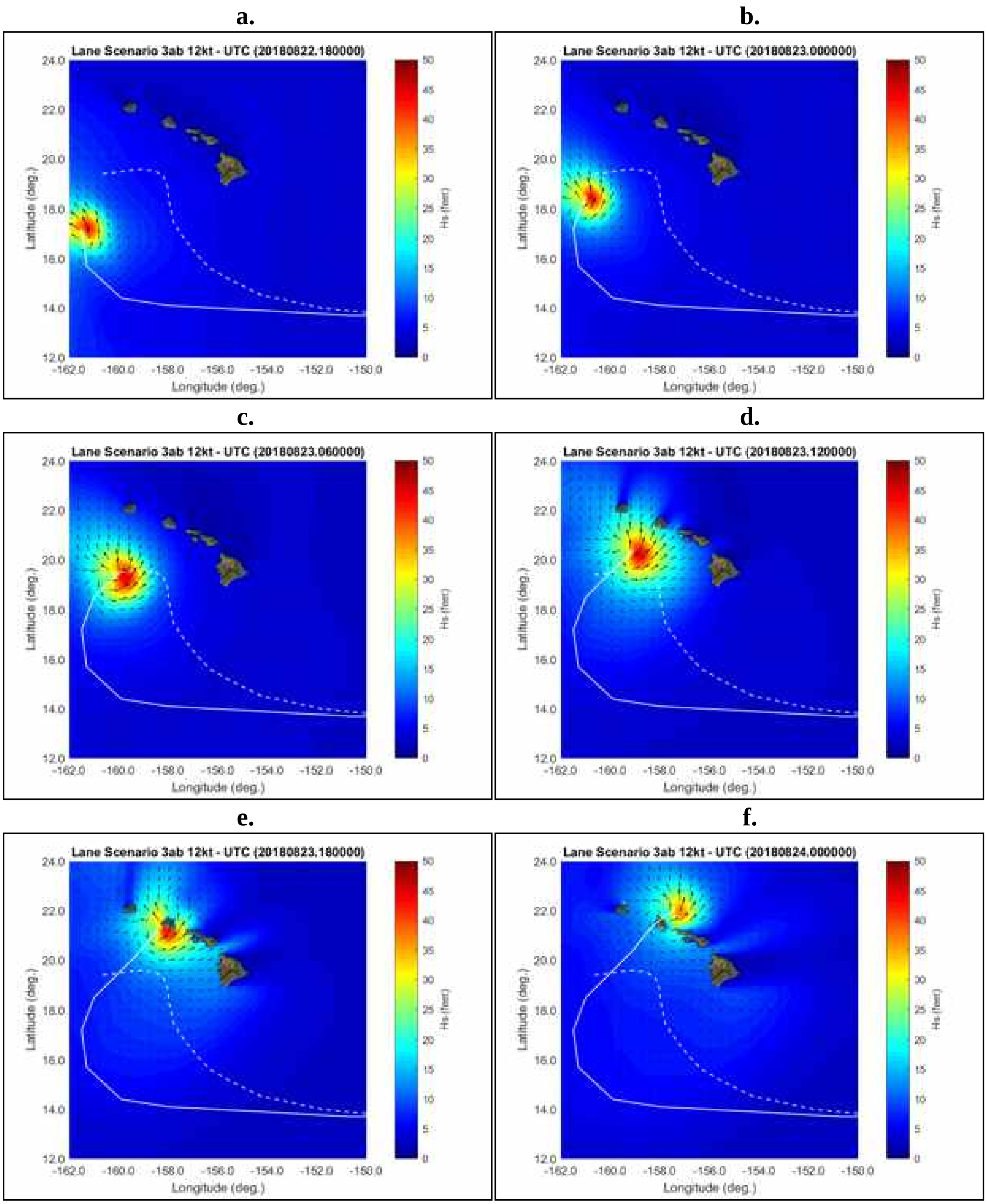


Figure 8-15 Hurricane Lane Scenario 3ab 12kt modeled significant wave height through the Hawaiʻi domain (solid line indicates hurricane scenario track; dashed line indicates original Hurricane Lane track

Historical wave buoy and hindcast data allows the prediction of extreme wave events. These are infrequent, large, powerful, low probability wave events that are typically used for design purposes. For example, a 50-yr return period wave event is an extreme event with a 1/50 (i.e., 2%) chance of occurring in any given year. Because the project area shoreline is vulnerable to multiple wave regimes (southern swell, Kona storm waves, refracted westerly waves, hurricane waves) extreme deep water wave heights for each event were determined based on available buoy data (seasonal waves) or previous model study results (hurricane waves).

The available buoy wave height data was used to generate a Weibull extreme value distribution for return period wave heights. The Weibull Distribution is a tool for relating the size of wave to the frequency of occurrence at a given location. The analysis requires a long-term dataset with well-documented wave events. These events are then sorted by size and frequency of occurrence and can be assessed by how often these events occur in the historical record. The relationship is logarithmic, and a linear fit can be established with a best fit linear regression of the data. Though not all wave events will be co-located on the line, its general trend represents the nature of the size and frequency relationship of wave events at a specific location. An extreme wave return period analysis using the Weibull Distribution was performed for waves associated with southern swell, and Kona storm waves.

Southern Swell

For extreme deepwater waves associated with southern swell, wave buoy data was compiled from CDIP buoy stations 165 and 238 located offshore from Barbers Point approximately 19.2 to 21 mi to the west-northwest of the project area (shown previously in Figure 8-3). Wave data for these buoys spans a 10-yr period between October 2010 and March 2021. Extreme wave heights were investigated by filtering the buoy data by direction and period for waves approaching from the south to southwest directions, with periods of 12 sec or greater. Wave height versus return period is shown on Figure 8-16 and Table 8-3. The ten largest wave events associated with south swell during the period of record are shown in Table 8-4.

Kona Storm Waves

For extreme deepwater waves associated with Kona storm waves (seas), wave buoy data was compiled from CDIP buoy stations 165 and 238 located offshore from Barbers Pt. approximately 19.2 to 21 mi to the west-northwest of the project area (shown previously in Figure 8-3). Wave data for these buoys spans a 10-yr period between October 2010 and March 2021. Extreme wave heights were investigated by filtering the buoy data by direction and period for waves approaching from the west to south directions, with periods of 10 sec or less. Wave height versus return period is shown on Figure 8-17 and Table 8-5. The ten largest wave events associated with Kona seas during the period of record are shown in Table 8-6.

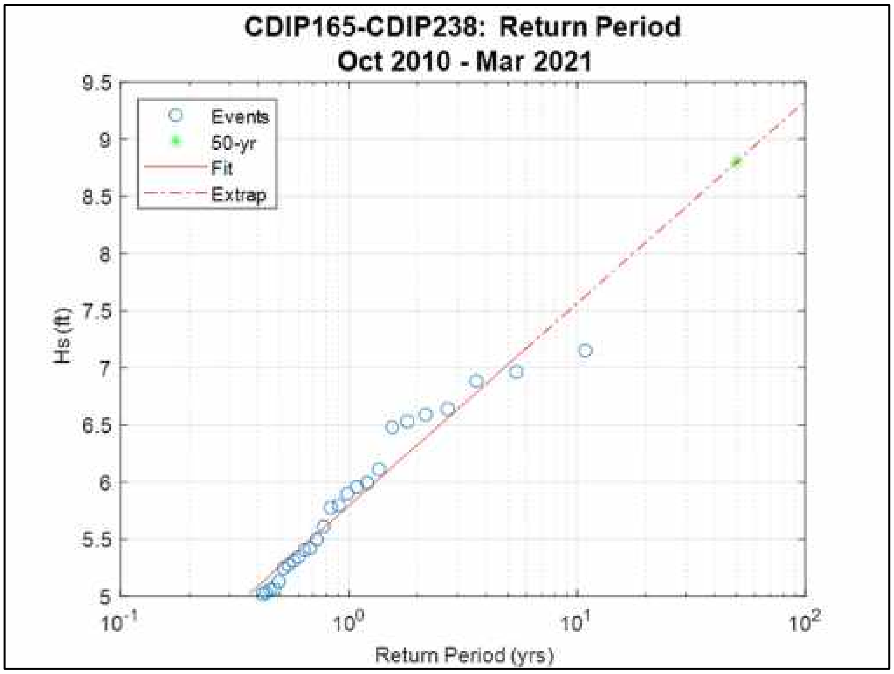


Figure 8-16. Significant wave height vs. return period, CDIP 165/238 (Barbers Point buoy), filtered for south swell, October 2010 to March 2021

Table 8-3. Significant wave height vs. return period, CDIP 165/238 (Barbers Point buoy), filtered for south swell, October 2010 to March 2021

Return Period	Hs (ft)
1	5.8
2	6.3
5	7.0
10	7.6
25	8.3
50	8.8

Table 8-4. Top 10 south swell events recorded at CDIP 165/238 (Barbers Point buoy)

Date	Hs (ft)	Tp (sec)	Dp (deg. TN)
2013-06-06	7.2	17	186
2018-08-23	7.0	13	167
2020-03-24	6.9	15	188
2013-05-19	6.6	15	175
2015-07-26	6.6	17	193
2011-08-31	6.5	18	181
2018-10-04	6.5	14	219
2020-06-03	6.1	17	188
2011-09-11	6.0	17	192
2018-06-10	6.0	15	178

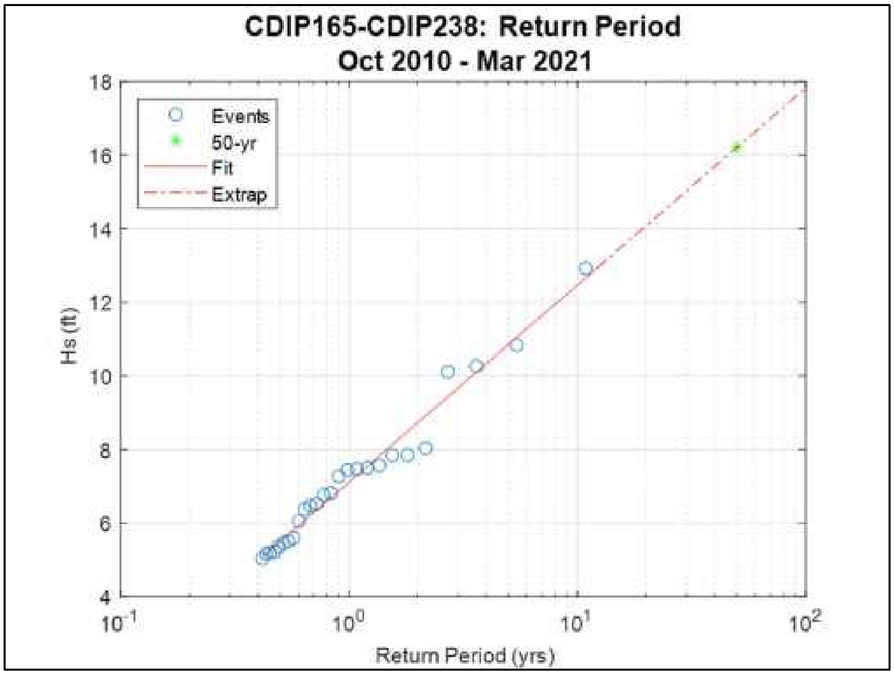


Figure 8-17. Significant wave height vs. return period, CDIP 165/238 (Barbers Point buoy), filtered for Kona storm waves, October 2010 to March 2021

Table 8-5. Significant wave height vs. return period, CDIP 165/238 (Barbers Point buoy), filtered for Kona storm waves, October 2010 to March 2021

Return Period	Hs (ft)
1	7.1
2	8.7
5	10.9
10	12.5
25	14.6
50	16.2

Table 8-6. Top 10 Kona storm waves events recorded at CDIP 165/238 (Barbers Point buoy)

Date	Hs (ft)	Tp (sec)	Dp (deg. TN)
2019-02-11	12.9	10	276
2015-01-03	10.8	8	245
2015-02-14	10.3	8	247
2014-01-22	10.1	8	269
2015-02-03	8.0	7	249
2020-02-10	7.8	6	279
2021-02-04	7.8	7	276
2014-01-03	7.6	6	231
2011-03-04	7.5	6	200
2014-10-19	7.5	8	202

8.2.4 Potential Impacts and Mitigation Measures

Detailed wave modeling was conducted to evaluate the potential for the proposed actions to impact waves in Waikīkī (see Sections 8.2.2 and 9.4.6). Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or altering the bathymetry. Dredging could occur at the *Ala Moana*, *Canoes/Queens*, or *Hilton* offshore sand deposits. Wave modeling was used to assess the potential impacts of dredging on nearby surf sites. A wave reflection analysis was also conducted to evaluate the potential for the proposed structures in the Halekūlani and Kūhiō beach sectors to reflect waves that could negatively impact surf sites. To evaluate potential impacts, wave modeling of the existing conditions and with the proposed structures was performed. Based on the results of the wave modeling, the dredge analysis, and the wave reflection analysis, no significant impacts to waves of surf sites in Waikīkī are anticipated.

8.3 Sea Level

8.3.1 Still Water Level

The total water depth at a particular location is composed of the depth below the nearshore bottom relative to sea level datum, plus factors that add to the still water level (SWL) such as the astronomical tide, mesoscale eddies and other oceanographic phenomena, wave setup, storm surge (pressure setup and wind setup), and potential sea level change over the life of a project. The sea level datum used for this project is mean sea level (MSL)

8.3.2 Tides

Hawaiʻi tides are semi-diurnal with pronounced diurnal inequalities (i.e., two high and low tides each 24-hr period with different elevations). Variation of the tidal range results from the relative position of the moon and sun. During full moon and new moon phases, the moon and sun act together to produce larger *spring tides*, where the difference between high and low tide is the greatest. When the moon is in its first or last quarter, smaller *neap tides* occur, where the difference between high and low tide is the least. The cycle of spring to neap tides and back is half the 27-day period of the moon's revolution around the earth and is known as the *fortnightly cycle*. The combination of diurnal, semi-diurnal and fortnightly cycles dominate variations in sea level throughout the Hawaiian Islands.

King Tides is a non-scientific term that has become increasingly common in recent years. Often associated with coastal flooding, *King Tides*, or perigean spring tides, are strictly an astronomical phenomenon. *King Tides* generally refers to the highest tide levels of the year that are a result of the alignment of the earth, sun, and moon during the winter and summer months. During these times, high tide can reach an elevation of as much as +2.7 ft MLLW in Honolulu.

Tidal predictions and historical extreme water levels are provided by the National Ocean and Atmospheric Administration (NOAA), NOS (National Ocean Service), Center for Operational Oceanographic Products and Services (CO-OPS). The nearest NOAA tide station is located at Honolulu Harbor (Station ID: 1612340). Water level data from Station 1612340, based on the 1983 to 2001 tidal epoch, is shown in Table 8-7.

Table 8-7 Water level data for Honolulu Harbor (NOAA Station 1612340)

Datum	Elevation (ft MLLW)	Elevation (ft MSL)
Highest Astronomical Tide	+2.71	+1.89
Mean Higher High Water	+1.90	+1.08
Mean High Water	+1.44	+0.62
Mean Sea Level	+0.82	0.00
Mean Low Water	+0.16	-0.66
Mean Lower Low Water	0.00	-0.82
Lowest Astronomical Tide	-0.43	-1.25

8.3.3 Sea Level Anomalies

The ocean surface does not have a consistent elevation. Sea level anomalies (SLA) are defined as the difference between the measured and predicted tides recorded. SLA are caused by climatic and oceanographic processes such as global warming, the El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), geostrophic currents due to the rotation of the earth, and mesoscale eddies that propagate across the ocean.

Hawaiʻi is subject to periodic extreme tide levels due to large oceanic eddies and other oceanographic phenomena that have recently been recognized and that sometimes propagate through the islands. Mesoscale eddies produce tide levels that can be up to 0.5 ft higher than normal for periods up to several weeks (Firing and Merrifield, 2004). An additional temporary sea level rise on the order of 0.5 ft has also been associated with phenomena related to the El Niño-Southern Oscillation.

In 2017, Hawaiʻi experienced anomalous sea levels which caused significant inundation of low-lying urban areas such as Waikīkī, Ala Wai Boulevard, and Mapunapuna. The daily maximum recorded tides at Honolulu Harbor from February through October 2017 are show in Figure 8-18. The plot also shows the corresponding predicted tide and SLA for the daily maximum recorded tide. Table 8-8 extends this data, presenting the recorded and predicted tides at Honolulu Harbor from February 2017 to present.

The media widely reported that the flooding was the result of *king tides*; however, sea level anomalies during the high-water events ranged from approximately 0.5 ft to 1 ft above the astronomical tide. The occurrence of summer swells during this period of elevated water levels further exacerbated the inundation. The end of 2019 also marked an extended period of pronounced SLA. Figure 8-19 shows the extreme water levels from December 24 to 27, 2019. During this time period, SLA of +0.6 to +1.1 ft added to the winter *King Tides* resulting in the highest recorded water level at Honolulu Harbor of +3.4 ft MLLW.

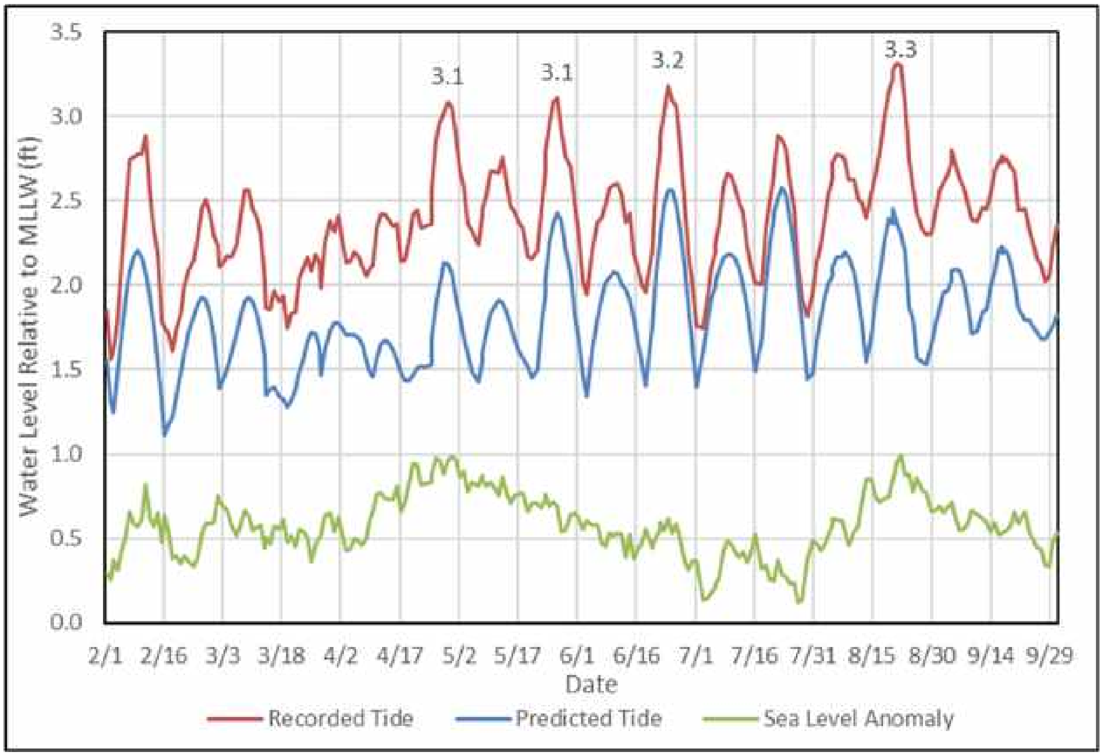


Figure 8-18 Daily maximum measured tides at Honolulu Harbor and corresponding predicted tides and sea level anomaly (February 1-October 1, 2017)

Table 8-8 Peak recorded tide levels at Honolulu Harbor from 2017 to 2020

Date	Recorded Tide (ft MLLW)	Predicted Tide (ft MLLW)	SLA (ft)
12/25/2019	3.4	2.4	1.0
08/20/2017	3.3	2.4	0.9
08/21/2017	3.3	2.3	1.0
08/19/2017	3.3	2.4	0.9
07/19/2020	3.3	2.4	0.9
07/20/2020	3.3	2.5	0.8
12/26/2019	3.3	2.4	0.9
07/21/2020	3.2	2.4	0.8
07/04/2020	3.2	2.5	0.7
11/15/2020	3.2	2.5	0.7

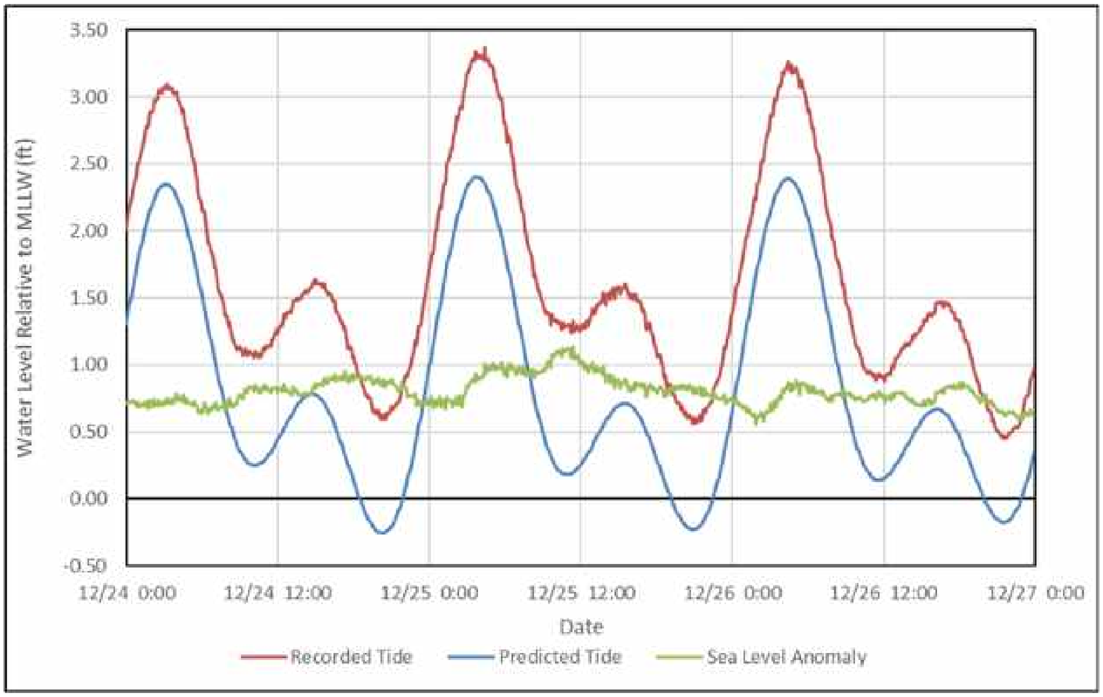


Figure 8-19 Predicted and measured tides at Honolulu Harbor (Dec 24-26, 2019)

8.3.4 Combined Stillwater Level

The aforementioned water level rise phenomena are additive and may occur at a given time. The total still water level, *S*, at a given time, therefore, can be a linear combination of:

- Astronomical tide and other oceanographic phenomena (S_a)
- Sea level rise due to atmospheric pressure reduction (S_p)
- Wind tide caused by wind stress component perpendicular (S_x) to the coastline and parallel to the coastline (S_y)
- Wave set-up in the breaker zone (S_w)
- Sea level rise (S_{SLR})

or,

$$S = S_a + S_p + S_x + S_y + S_w + S_{SLR}$$

The linear superposition of water level components is an empirical method of determining total still water during a model event. As it does not consider the joint probability of components included, it is a conservative method and can be used to estimate a "worst-case" scenario for water levels.

8.3.5 Sea Level Rise

The present rate of global mean sea level change is +3.~~3~~ 1 ~~± 0.4~~ mm/yr (Sweet et al. 2022~~NASA, 2020~~), where a positive number represents a rising sea level. Global mean sea level rise has accelerated over preceding decades compared to the mean of the 20th century. Factors contributing to the rise in sea level include melting of land-based glaciers and ice sheets and thermal expansion of the ocean water column.

The relative sea level trend for Honolulu Harbor for the period of 1905 to ~~present~~ 2024 is shown in Figure 8-20 (NOAA, ~~2020~~2024). The rate of sea level change is +1.~~51~~ 54 ± 0.~~21~~ 20 mm/yr based on monthly data from 1905 to present. Figure 8-20 also shows interannual anomalies exceeding 0.5 ft (15 cm) in magnitude due to natural oceanic variability from processes such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).

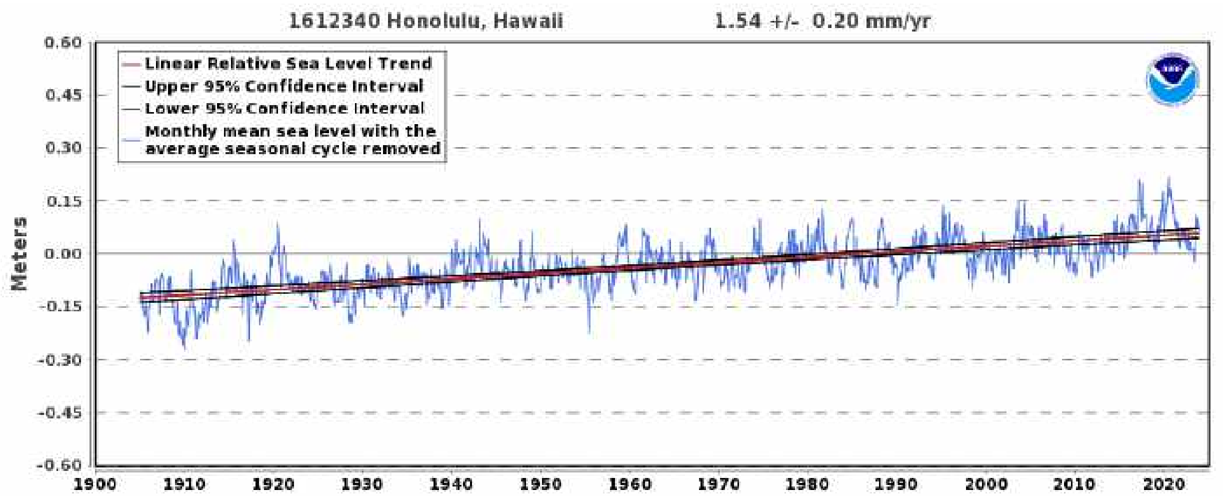


Figure 8-20 Relative sea level trend, Honolulu Harbor, 1905 to ~~present~~ 2024 (NOAA, ~~2021~~2024)

NOAA recently revised their sea level change projections through 215~~0~~0 taking into account up-to-date scientific research and measurements (Sweet et al. ~~2017~~2022). The NOAA *Intermediate* scenario represents approximately 3.~~3~~ 8 ft of sea level rise by 2100 and their *Extreme* scenario represents more than ~~8~~ 7.9 ft of sea level rise by 2100 (Table 8-9). NOAA (2017) describes the *Extreme* scenario as "physically plausible" and corresponds to a "business as usual" trajectory for increasing greenhouse gas emissions (i.e., no reductions in the increasing rate of emissions) and worst case for glacier and polar ice loss in this century.

Hawaiʻi thus far has seen a rate of sea level rise (+1.54 ± 0.20 mm/yr) that is less than the global average (+3.1 mm/yr); however, this is expected to change as Hawaiʻi is in the "far field" of the effects of melting land ice. This means that those effects have been significantly less in Hawaiʻi compared to areas closer to the ice melt. Over the next few decades, this effect will spread to Hawaiʻi, which is projected to experience sea level rise greater than the global average due to global-scale gravitational effects related to the shrinking of polar sheets. Table 8-9 shows NOAA's most recent global mean sea level rise scenarios. Table 8-10 and Figure 8-21 present mean sea level rise scenarios for Honolulu based on the revised NOAA (2022) projections, taking into account the far field effects.

Table 8-9 Global mean sea level rise scenarios (~~NOAA,~~Sweet et al. ~~2017~~2022)

~~Scenario (ft)~~	~~2010~~	~~2020~~	~~2030~~	~~2040~~	~~2050~~	~~2060~~	~~2070~~	~~2080~~	~~2090~~	~~2100~~
~~Low~~	~~0.1~~	~~0.2~~	~~0.3~~	~~0.4~~	~~0.5~~	~~0.6~~	~~0.7~~	~~0.8~~	~~0.9~~	~~1.0~~
~~Intermediate-Low~~	~~0.1~~	~~0.3~~	~~0.4~~	~~0.6~~	~~0.8~~	~~1.0~~	~~1.1~~	~~1.3~~	~~1.5~~	~~1.6~~
~~Intermediate~~	~~0.1~~	~~0.3~~	~~0.5~~	~~0.8~~	~~1.1~~	~~1.5~~	~~1.9~~	~~2.3~~	~~2.8~~	~~3.3~~
~~Intermediate-High~~	~~0.2~~	~~0.3~~	~~0.6~~	~~1.0~~	~~1.4~~	~~2.0~~	~~2.6~~	~~3.3~~	~~3.9~~	~~4.9~~
~~High~~	~~0.2~~	~~0.4~~	~~0.7~~	~~1.2~~	~~1.8~~	~~2.5~~	~~3.3~~	~~4.3~~	~~5.6~~	~~6.6~~
~~Extreme~~	~~0.2~~	~~0.4~~	~~0.8~~	~~1.3~~	~~2.1~~	~~3.0~~	~~3.9~~	~~5.2~~	~~6.6~~	~~8.2~~

Scenario/Year (ft)	2030	2040	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150
Low	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.2	1.3	1.4
Int-Low	0.4	0.5	0.7	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.3	2.5	2.7
Int	0.4	0.7	0.9	1.3	1.7	2.2	2.7	3.3	3.9	4.5	5.0	5.6	6.2
Int-High	0.5	0.8	1.2	1.8	2.5	3.2	4.1	4.9	5.7	6.6	7.4	8.1	8.8
High	0.5	0.9	1.4	2.2	3.2	4.2	5.4	6.6	7.7	8.9	10.0	11.1	12.1

Table 8-10 ~~Hawaiʻi~~ Honolulu local mean sea level rise scenarios (adapted from ~~NOAA~~Sweet et al.~~,~~ ~~2017~~2022)

~~Scenario (ft)~~	~~2010~~	~~2020~~	~~2030~~	~~2040~~	~~2050~~	~~2060~~	~~2070~~	~~2080~~	~~2090~~	~~2100~~
~~Low~~	~~0.1~~	~~0.2~~	~~0.3~~	~~0.5~~	~~0.6~~	~~0.7~~	~~0.9~~	~~1.0~~	~~1.2~~	~~1.3~~
~~Intermediate-Low~~	~~0.1~~	~~0.3~~	~~0.5~~	~~0.7~~	~~0.9~~	~~1.1~~	~~1.4~~	~~1.6~~	~~1.9~~	~~2.1~~
~~Intermediate~~	~~0.1~~	~~0.4~~	~~0.6~~	~~1.0~~	~~1.3~~	~~1.8~~	~~2.3~~	~~2.9~~	~~3.5~~	~~4.2~~
~~Intermediate-High~~	~~0.2~~	~~0.4~~	~~0.7~~	~~1.1~~	~~1.7~~	~~2.4~~	~~3.2~~	~~4.1~~	~~5.0~~	~~6.3~~
~~High~~	~~0.2~~	~~0.4~~	~~0.8~~	~~1.4~~	~~2.1~~	~~3.0~~	~~4.0~~	~~5.3~~	~~7.0~~	~~8.4~~
~~Extreme~~	~~0.2~~	~~0.4~~	~~0.9~~	~~1.6~~	~~2.4~~	~~3.5~~	~~4.8~~	~~6.5~~	~~8.3~~	~~10.5~~

Scenario/Year (ft)	2030	2040	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150
Low	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Int-Low	0.4	0.6	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.2
Int	0.5	0.7	1.0	1.3	1.8	2.3	3.0	3.8	4.6	5.3	6.0	6.6	7.3
Int-High	0.5	0.8	1.2	1.9	2.7	3.7	4.7	5.8	6.8	7.6	8.4	9.1	9.9
High	0.6	0.9	1.5	2.4	3.5	4.9	6.4	7.9	9.4	10.7	11.9	13.0	14.1

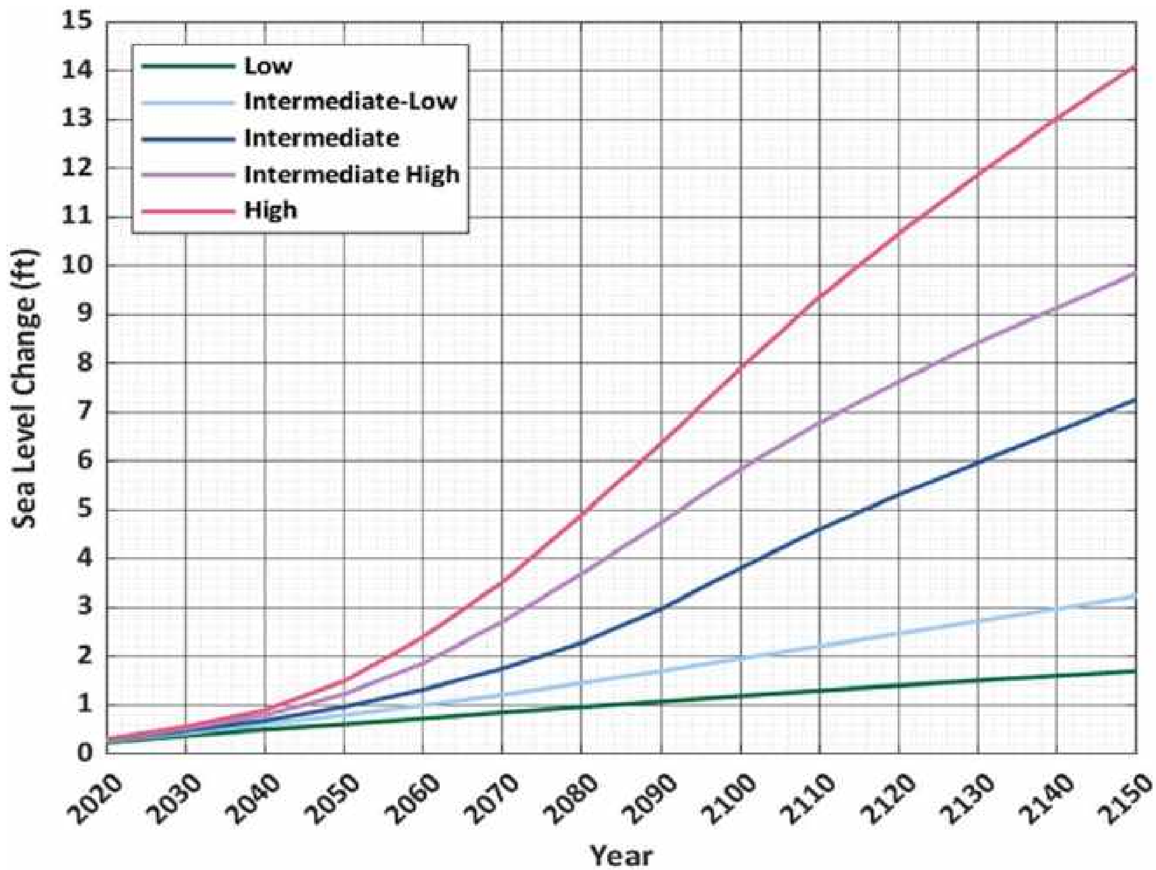


Figure 8-21 Honolulu local mean sea level rise projections (adapted from ~~NOAA, 2017~~Sweet et al. 2022)

Sea level rise is negatively impacting beaches and shorelines in Hawaiʻi. Impacts include beach narrowing and beach loss, permanent loss of terrestrial land due to erosion, and infrastructure damage due to wave inundation and flooding. Anderson et al. (2015) found that, due to sea level rise, the average shoreline recession in Hawaiʻi is projected to be nearly twice the historical rates by 2050, and nearly 2.5 times the historical rates by 2100. The impacts from anomalous sea level events (e.g., El Niño, king tides, mesoscale eddies, storm surge) are also likely to increase.

The *Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report* (2017) discusses the anticipated impacts of projected future sea level rise on coastal hazards, and the potential physical, economic, social, environmental, and cultural impacts of sea level rise in Hawaiʻi. The report concluded that the potential impacts of 3.2 ft of sea level rise on Oʻahu include the loss of $12.9 billion in structures and land; 3,800 structures, including hotels and resorts in Waikīkī; the displacement of 13,300 residents; and the loss of 17.7 miles of major roads. (State of Hawaiʻi, 2017). The report estimates that, due to the density of development and economic assets, Honolulu will account for an estimated 66% of the total statewide economic losses due to sea level rise. Public and private facilities and infrastructure in Waikīkī are particularly vulnerable to sea level rise given their relatively low elevation and close proximity to the shoreline.

A key component of the report was a numerical modeling effort by the University of Hawaiʻi Coastal Geology Group (UHCGG) to estimate the potential impacts of a 3.2-ft rise in sea level.

UHCGG used the most current available information on climate change and sea level rise from the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5). The UHCGG numerical modeling is based on the upper end of the IPCC AR5 representative concentration pathway (RCP) 8.5 sea level rise scenario, which predicts up to 3.2 ft of global sea level rise by the year 2100. However, based on recent peer-reviewed publications, it is possible that sea level rise could be significantly greater than the RCP 8.5 sea level rise scenario by the end of this century. Sweet et al. (~~2017~~2022) suggest that global mean sea level rise in the range of ~~6.4~~5.8 ft to ~~8.8~~7.9 ft is physically plausible by the end of this century, which is significantly higher than the worst-case IPCC AR5 projections.

UHCGG modeled the potential impacts that a 3.2-ft rise in sea level will have on coastal hazards including passive flooding, annual high wave flooding, and coastal erosion. The footprint of these three hazards were combined to map the projected extent of chronic flooding due to sea level rise, referred to as the *sea level rise exposure area (SLR-XA)*. Flooding in the SLR-XA is associated with long-term, chronic hazards punctuated by annual or more frequent flooding events.

The SLR-XA study used the X-Beach wave model, which is commonly used to assess wave inundation in coastal areas because it captures the contribution of waves to water levels. Figure 8-22 shows a diagram of the elements of wave runup and inundation as modeled in the SLR-XA study. The UHCGG modeling results can be explored in the Hawaiʻi Sea Level Rise Viewer (hawaiisealevelriseviewer.org) and are shown in Figure 8-23 through Figure 8-26.

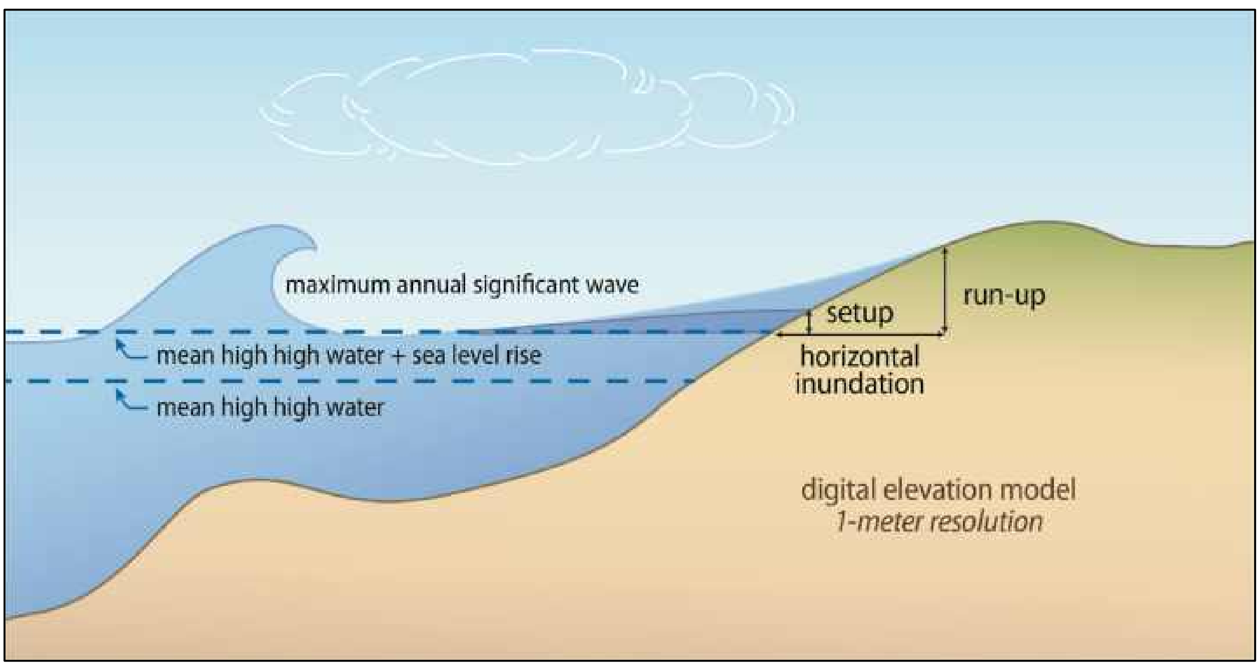


Figure 8-22 Diagram of wave runup (Hawaiʻi Climate Change Commission, 2017)

Figure 8-23 depicts the potential for passive flooding with 3.2 ft of sea level rise. Passive flooding includes areas that are hydrologically connected to the ocean (marine flooding) and low-lying areas that are not hydrologically connected to the ocean (groundwater flooding). The model projects minimal passive flooding in Waikīkī with 3.2 ft of sea level rise.

Figure 8-24 depicts the potential for annual high wave flooding with 3.2 ft of sea level rise. The annual high wave flooding model propagates the maximum annually recurring wave, calculated from historical wave buoy data, over the reef and to the shore along 1-dimensional cross-shore profiles extracted from a 1-m digital elevation model (DEM). The model results depict the spatial extent of inundation that is greater than 10 cm in depth from that annually recurring high wave event with 3.2 ft of sea level rise. The model projects extensive annual high wave flooding in Waikīkī with 3.2 ft of sea level rise.

Figure 8-25 depicts the estimated area that could be exposed to erosion with 0.5 to 3.2 ft of sea level rise. The results of the erosion model represent the combined results of measured historical erosion rates and a model of beach profile response to sea level rise. The projected erosion hazard lines for Waikīkī are derived, in part, from historical erosion rates that are based on shoreline locations that are digitized (mapped) from aerial photographs and earlier coastal survey charts dating back to the early 1900s and measured at individual transects located 20 meters apart along the coastline. The model projects extensive erosion in Waikīkī with 3.2 ft of sea level rise.

It is important to note that the long-term historical shoreline change rates for Waikīkī are influenced by human efforts over the past century to engineer and stabilize the beaches, which influences the projected rates of future erosion. These projections also assume that the terrestrial area is composed of non-cohesive erodible substrate and do not account for the presence of the existing seawalls that span nearly the entire length of the Waikīkī shoreline. While it is unlikely that erosion would extend significantly mauka (landward) of the existing seawalls, the potential for structural damage and wall failure will increase as the structures become more exposed to wave action. There is evidence of this occurring in the Halekūlani beach sector where undermining and scour have caused sinkholes to form mauka (landward) of the exposed portions of the seawalls. Without beach improvements and/or maintenance, it is likely that sea level rise will result in total beach loss in many areas of Waikīkī within this century as the beaches are "squeezed" between rising water levels and seawalls in the backshore.

Figure 8-26 depicts the projected extent of chronic flooding with 3.2 ft of sea level rise, referred to as the sea level rise exposure area (SLR-XA). The SLR-XA represents the combined footprint of the three individual hazards that were modeled - passive flooding, annual high wave flooding, and coastal erosion. The model results indicate that coastal flooding in Waikīkī, particularly annual high wave flooding, will increase significantly as sea levels continue to rise.

Sea level rise also has the potential to significantly alter the wave climate in Waikīkī. As water depths increase, the fringing reef will be less effective in dissipating wave energy. As a result, waves will break further inland and swells will have to be larger to break in the deeper water (Honolulu Civil Beat, 2019). This could potentially eliminate some of the surfable waves at certain locations in Hawaiʻi, including those in Waikīkī. A recent study found that 16% of surf sites in California would be eliminated with 3 ft of sea level rise and 18% would be threatened (Reineman et al. 2017).

8.3.6 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a negligible impact on global, regional, or local sea level. Rather, the proposed actions are anticipated to have a positive impact by improving beach stability, improving lateral shoreline access, and providing a natural buffer to reduce the potential for wave overtopping and marine flooding.

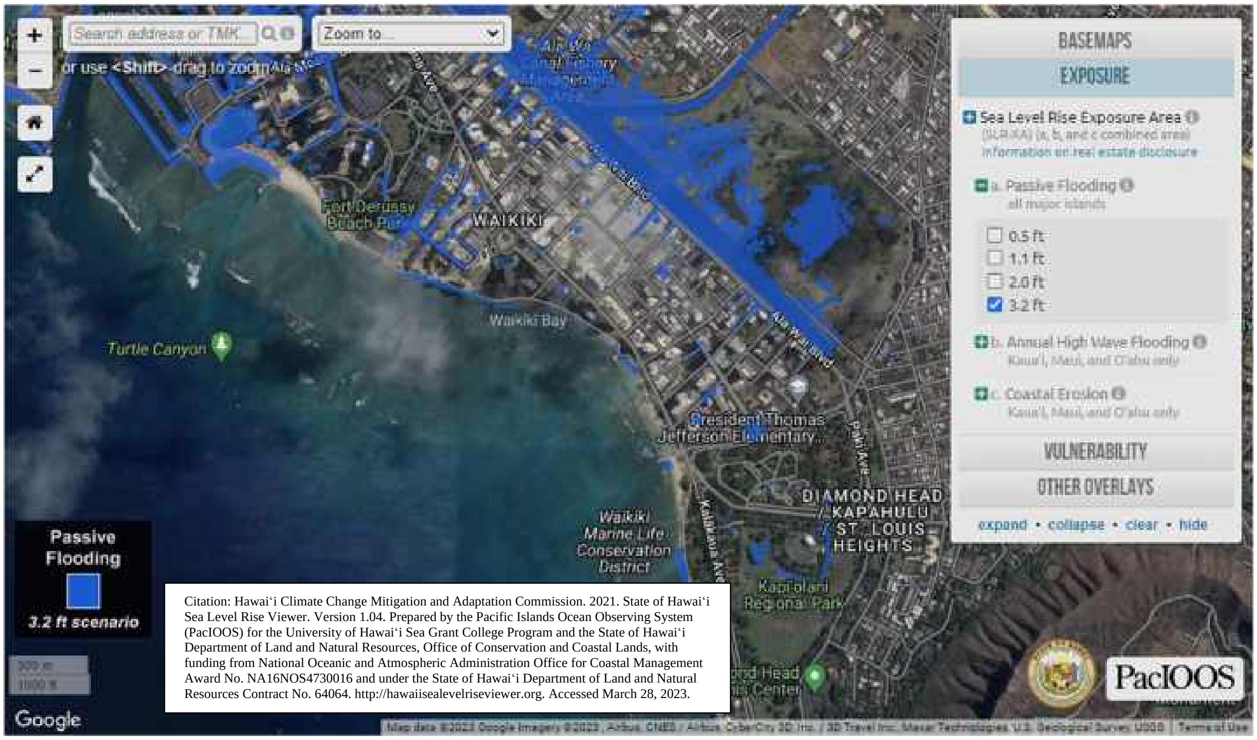


Figure 8-23 Projected passive flooding with 3.2 ft of sea level rise

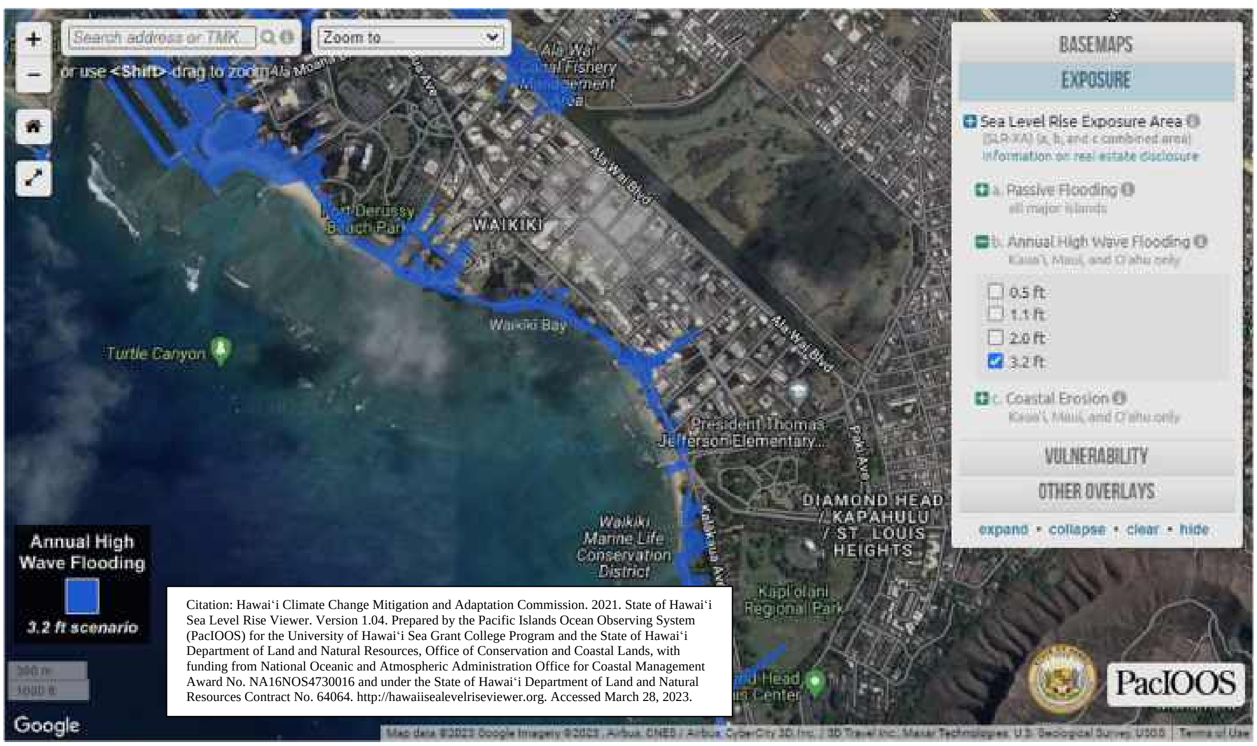


Figure 8-24 Projected annual high wave flooding with 3.2 ft of sea level rise

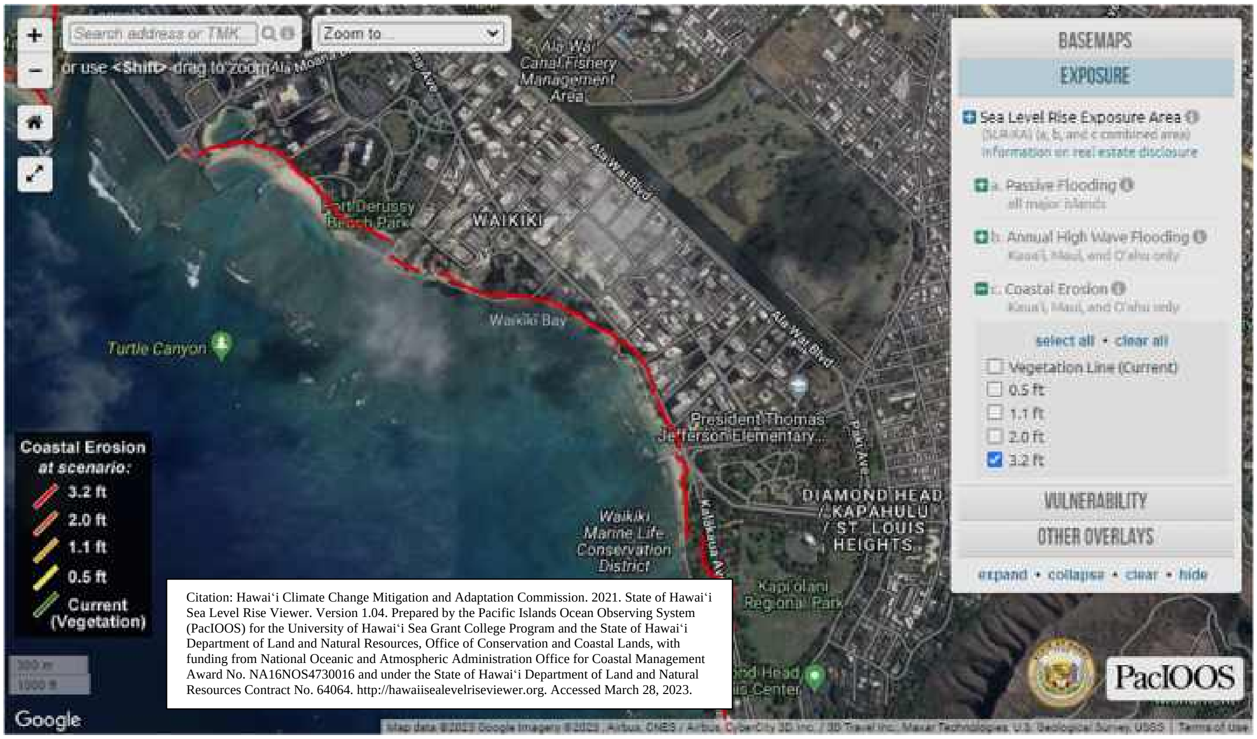


Figure 8-25 Projected coastal erosion with 3.2 ft of sea level rise

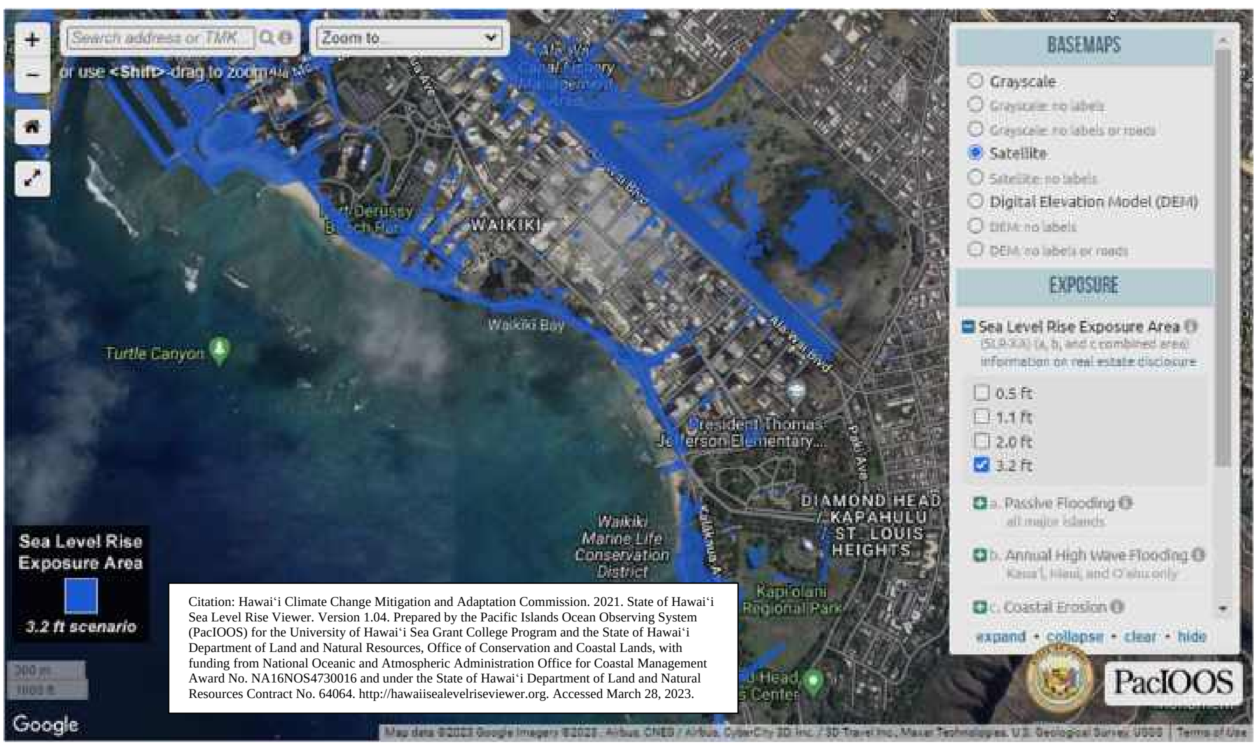


Figure 8-26 Projected Sea Level Rise Exposure Area (SLR-XA) with 3.2 ft of sea level rise

8.4 Coastal Hazards

8.4.1 Coastal Flooding

Flood hazards for the project area are depicted on Flood Insurance Rate Map (FIRM) 15003C0370F. That map indicates that there are moderate threats of flooding from streams, but that the shoreline is exposed to flooding caused by storm waves and tsunami. The area makai (seaward) of the shoreline is the VE Zone with a Base Flood Elevation (BFE) of +11 to +12 ft MSL. The area immediately mauka (landward) of the shoreline is in Zone AE with a BFE of +7 to +8 ft MSL.

During extreme high tides (often referred to as *king tides*), the still water level can exceed an elevation of as much as +3 ft MLLW in Honolulu. Some of the highest tides of the year overlap with the prevailing occurrence of south swell during the summer months, which leaves shoreline property in Waikīkī vulnerable to flooding. Elevated water levels associated with El Niño, king tides, and sea level rise allow more wave energy to pass over the reef and reach the shoreline. This results in higher wave runup and overtopping of the beaches that can result in flooding of the backshore. Previous studies of the Waikīkī area have examined wave runup and inundation for annual return period waves and for a worst-case direct hit hurricane scenario.

8.4.2 Storm Waves

The wave regime along the project area shoreline is discussed in considerable detail in Section 8.2. Fletcher et al. 2002 rates the threat from high waves along the Waikīkī shoreline as moderate to high because this region regularly receives nearshore breaking wave heights on the order of 6 ft from south swell. Severe tropical storms and hurricanes have the potential to generate extremely large waves, which in turn can generate large waves and high water levels in Waikīkī. Recent hurricanes that impacted the south shore of Oʻahu include Hurricane Iwa (1982) and Hurricane Iniki (1992). Although not frequent events, they should be considered in coastal management and engineering design. Climate change and ocean warming may increase the likelihood of hurricane events in the Hawaiian Islands (Murakami et al. 2017).

8.4.3 Tsunami

Tsunamis are sea waves that result from large-scale displacements of the seafloor. They are most commonly caused by earthquakes (magnitude 7.0 or greater) that occur adjacent to or under the ocean. If the earthquake involves a large segment of land that displaces a large volume of water, the water will travel outwards in a series of waves, each of which extends from the ocean surface to the seafloor where the earthquake originated. Tsunami waves are only a foot or so high at sea but can have wavelengths of hundreds of miles and travel at 500 mph. As they approach shore, the waves slow down as they begin to feel bottom, increase significantly in height, and push inland at considerable speed. The water then recedes, also at considerable speed, and the recession often causes as much damage as the original wave front itself.

Most tsunamis in Hawaiʻi originate from the tectonically active areas located around the Pacific Rim (e.g., Japan, Alaska, and Chile). Waves originating from earthquakes in these areas take hours to reach Hawaiʻi, and the network of sensors that is part of the U.S. Tsunami Warning System in the Pacific can give Hawaiʻi several hours advance warning of tsunami from these locations. Less commonly, tsunamis originate from seismic activity in the Hawaiian Islands. These events occur with little or no advance warning. For example, the 1975 Halapē earthquake (magnitude 7.2) produced a wave that reached Oʻahu in less than 30 min.

Fletcher et al. (2002) reported that 10 of the 26 tsunamis with flood elevations greater than 3.3 ft that have made landfall in the Hawaiian Islands during recorded history have had "significant damaging effects on Oʻahu". This means that, on average, one damaging tsunami reaches Oʻahu every 19 years. The recent record (1946 to the present) has seen four tsunami cause damage on Oʻahu, a rate that is very close to the longer-term average. Fletcher et al. (2002) also noted that, while observations of tsunami flooding have not exceeded 8 ft along the south shore of Oʻahu, much of the Waikīkī shoreline is below that elevation.

8.4.4 Potential Impacts and Mitigation Measures

The proposed beach improvement and maintenance actions are intended to reduce exposure to wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed actions are anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.

8.5 Coastal Processes

Waikīkī is a predominantly engineered shoreline, and the beach is composed almost entirely of imported sand. Almost the entire length of Waikīkī is armored by seawalls, many of which are in various states of disrepair. The beaches of Waikīkī are primarily man-made and are largely dependent upon the presence of groins that stabilize the sand. The groins compartmentalize the Waikīkī shoreline into discrete units that are semi-contained with limited sediment transport between adjacent sectors. For the purposes of this DPEISFPEIS, the Waikīkī shoreline is divided into eight discrete *beach sectors* that have unique physical characteristics.

The *beach sectors* are similar to *littoral cells*, which are defined as "a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks" (Inman, 2005). The cell boundaries delineate the geographical area within which the budget of sediment is balanced, providing the framework for the quantitative analysis of coastal erosion and accretion. The sediment sources are commonly streams, sea cliff erosion, onshore migration of sand banks, and material of biological origin such as shells, coral fragments, and skeletons of small marine organisms".

The natural shoreline of Waikīkī pre-development consisted of a combination of pocket beaches, streams, and wetlands. It is possible that Mamala Bay was originally a single littoral cell, bounded on the east by Diamond Head, and on the west by Kalaeloa (Barbers Point). The shoreline of Waikīkī has been engineered and modified over the course of the past century, when streams were diverted, wetlands were filled, shoreline structures (e.g., seawalls, storm drains, groins, and breakwaters) were constructed, and sand beaches were built. The present-day shoreline of Waikīkī is compartmentalized by engineered structures, many of which were constructed with the specific intent of stabilizing the beaches. For the purposes of this DPEISFPEIS, these compartments are referred to as *beach sectors*.

The primary coastal processes that affect beaches in Waikīkī are waves, tides, and currents. As deepwater waves approach the shoreline, they begin to transform due to the effects of shoaling, bottom friction, refraction, and diffraction. As waves shoal, heights increase and the wave crests steepen to the point that the waves become unstable, leading to breaking and dissipation of wave energy. Wave energy is also attenuated due to bottom friction. The approach direction can change as the wave front refracts or becomes oriented parallel to the existing bathymetric contours. Diffraction, the lateral spreading of wave energy, can occur behind natural or man-made barriers.

Offshore tidal driven currents in Waikīkī generally flow toward the north-northwest during rising tides and south-southwest during falling tides, generally flowing parallel with the bottom contours (Noda, 1991). Currents inshore of the 30-ft bottom contour are weaker than the currents further offshore with typical velocities of 0.15 to 0.50 ft/sec (0.1 to 0.3 knots). Wind speed and direction influences the surface currents (upper 3 ft), creating eddies when opposed to the tidal flow and enhancing it when blowing in the same direction.

Wave-induced currents predominate inside the breaker zone, generating both longshore (shore parallel) and cross-shore currents, which are a primary driver of sediment transport, along with suspension and transport from the swash zone and beach face. From Gerritsen (1978): “In agreement with the dominant directions of the incoming waves, the longshore currents inside the surf zone flow from southeast to northwest most of the time. The wave-induced longshore current is a major cause for the direction and magnitude of the littoral sediment transport. Along Waikīkī Beach the littoral drift is therefore mostly in the westerly direction”.

Accumulations of sand on the updrift (east) side of the existing structures (i.e., Queen’s surf groin, Kapahulu storm drain/groin, Royal Hawaiian groin, Fort DeRussy outfall/groin, Hilton pier/groin) are indications of a predominantly westerly littoral drift. Occasionally waves from opposite directions cause a reversal of the littoral drift pattern. During high wave conditions a cross-shore (rip) current typically forms fronting the Royal Hawaiian Hotel, with current speeds sufficient to transport sand offshore. The result of this can be seen as a shoal or sandbar forms immediately offshore, which is popular with beach users. This sandbar appears to be most pronounced during the Spring when a bimodal swell direction is most dominant (Habel et al. 2016). A cross-shore current is also typical in the deeper channel fronting the Outrigger Waikīkī Beach Resort and the Moana Surfrider Hotel, which is used by beach catamarans.

8.5.1 Fort DeRussy Beach Sector

The Fort DeRussy beach sector spans approximately 1,680 ft of shoreline that extends from the Hilton pier/groin east to the Fort DeRussy outfall/groin. Modifications to the Fort DeRussy beach sector began in the early 1900s with dredging and seawall construction extending to the present location of the Sheraton Waikiki Hotel.

The Fort DeRussy beach sector is an entirely engineered shoreline. The west end of the beach sector is bounded by a rock rubblemound groin that is buried in the beach and connects to the Hilton pier. The central portion of the beach sector consists of a man-made beach that is backed by a concrete seawall that was constructed in 1916 and spans the entire length of the shoreline. The east end of the beach sector is bounded by the Fort DeRussy outfall/groin, which consists of a concrete box culvert and a rock rubblemound groin.

The existing shoreline is a man-made sandy beach that is composed of a combination of sand and coral that was dredged from offshore. The beach is widest at the west end and narrowest at the east end. At the west end of the beach, adjacent to the Hilton pier/groin, the sand is compacted and hardened over much of the dry beach area. On the eastern portion of the sector is a narrow sandy beach with steeper slopes.

The nearshore reef extends up to about 1,300 ft from the shoreline. Several popular surf sites, including *Kaisers* and *Fours*, are located along the outer edge of the reef. The waves patterns produced as waves propagate over the reef are shown in Figure 8-27. The waves from the *Kaisers* surf site have an arc shape that is maintained to the shoreline. The waves passing through the rest of the sector are slightly concave, while some waves also propagate from the Halekūlani beach sector to Fort DeRussy beach. These waves interact to produce the convergence and divergence patterns shown in Figure 8-27. The most significant area of divergence is on the west side of the Fort DeRussy outfall/groin where the beach has eroded back to the seawall and walkway in front of the U.S. Army Museum of Hawaiʻi.

Figure 8-27 Wave model output for prevailing SSW swell – Fort DeRussy beach sector

8.5.2 Halekūlani Beach Sector

The Halekūlani beach sector spans approximately 1,450 ft of shoreline extending from the Fort DeRussy outfall/groin east to the Royal Hawaiian groin. The shoreline consists of a combination of seawalls and pocket beaches. A narrow beach extends approximately 375 ft east from the Fort DeRussy outfall/groin and terminates at the west end of a vertical seawall that span approximately 335 ft of shoreline fronting the Halekūlani Hotel. Two small pocket beaches, backed by vertical seawalls, are located between the Halekūlani and Sheraton Waikiki hotels. The adjacent pocket beaches span approximately 225 ft of shoreline. The pocket beaches terminate at the west end of a vertical seawall that spans approximately 500 ft of shoreline fronting the Sheraton Waikiki Hotel. The seawall continues east and terminates at the Royal Hawaiian groin, which marks the east boundary of the Halekūlani beach sector.

The nearshore is characterized by a wide and shallow reef containing a relict stream bed, referred to as the Halekūlani Channel. The nearshore reef is more than 1,500 ft wide with typical water depths of 5 ft or less over the reef. Waves break on the reef at several notable surf sites including *Threes*, *Populars*, and *Fours*, then propagate to shore, producing wave patterns with low energy waves crossing throughout the sector. These complex wave patterns are shown in Figure 8-28. The reef edges and channel also cause wave refraction. The pocket beaches are produced by wave convergence, while eroded areas fronting the seawalls are areas of wave divergence. Wave modeling and aerial imagery indicate that the eroded areas fronting the Halekūlani and Sheraton Waikiki hotels are a byproduct of the nearshore bathymetry and subsequent wave patterns. The seawalls were built in response to the erosion, rather than being the cause of the erosion.

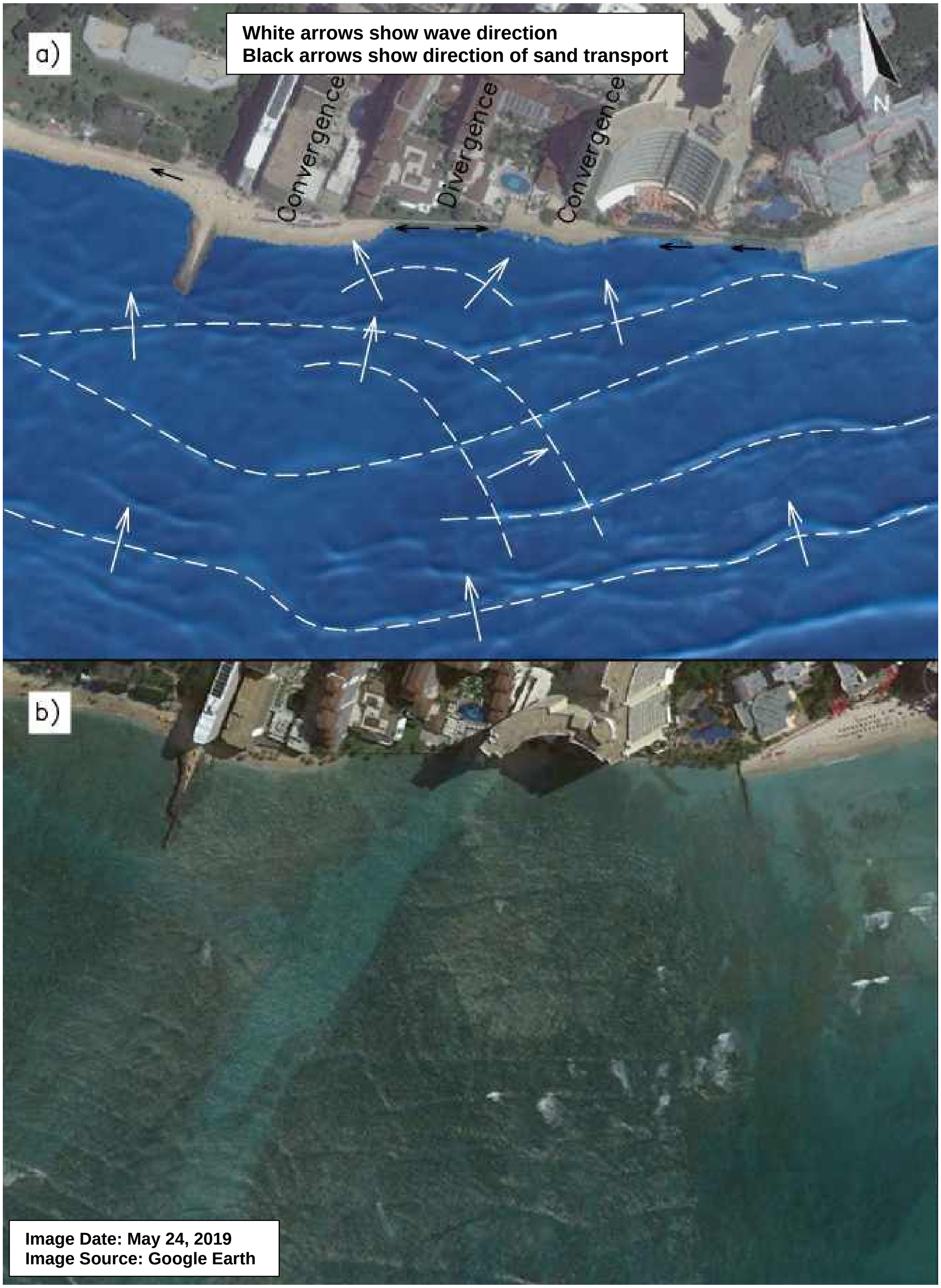


Figure 8-28 Wave model output for prevailing SSW swell - Halekūlani Beach Sector

8.5.3 Royal Hawaiian Beach Sector

The Royal Hawaiian beach sector contains a 1,730-foot-long beach between Kūhiō Beach Park and the Royal Hawaiian groin. This sector is exposed to waves that are transformed as they pass over the nearshore reef, and these waves shape the shoreline. The Kūhiō Sandbag Groin was constructed in November 2019, approximately 140 ft west of the ʻEwa (west) groin at Kūhiō Beach Park, to stabilize the east end of Royal Hawaiian Beach. The Royal Hawaiian groin was replaced in 2020 and stabilizes the west end of Royal Hawaiian Beach.

Royal Hawaiian Beach is highly dynamic as a result of the complex wave field. Waves approaching the central part of the sector propagate to shore, passing between the *Canoes* surf site and the Royal Hawaiian sandbar. The waves are slightly arc shaped, creating a concave beach shape and somewhat of a divergence point fronting the Outrigger Waikīkī Beach Resort. From here, sand moves east and west in reaction to the wave crest shape.

The west end of the beach is stabilized by the Royal Hawaiian groin, which supports sand that is transported from east to west. The groin also blocks waves approaching from the west that would otherwise move sand away from the groin in the easterly direction. This situation was more prevalent in the past prior to reconstruction of the groin in 2020. Waves from the *Populars* surf site approach obliquely from the southwest and impact the beach.

The west end of the beach and the Royal Hawaiian sandbar are shaped by the central waves and the waves that propagate into the Royal Hawaiian beach sector from the Halekūlani beach sector. These waves work in conjunction to form the Royal Hawaiian sandbar and produce a slight bulge along the shoreline inshore of the sandbar. A bimodal wave direction spectrum (e.g., waves approaching from the southwest and southeast at the same time) can produce the same results.

The east end of the beach bordering Kūhiō Beach Park has been highly dynamic following the 2012 Waikīkī Maintenance I project (Habel et al. 2016). Waves approaching from the *Queens* and *Baby Queens* surf site propagate to shore at an angle toward the west, moving sand away from the ʻEwa (west) groin at Kūhiō Beach Park. This has resulted in chronic erosion, beach narrowing, and damage to the groin. The waves from the central part of the beach sector refract and diffract toward Kūhiō Beach where they interact with the waves from *Queens* and *Baby Queens*. The wave from *Canoes* transports sand toward Kūhiō Beach, while the wave from *Queens*, which has a distinct arc shape, travels along the ʻEwa (west) groin stem and transports sand to the east, exposing the foundation wall of the old Waikīkī Tavern.

Each of these waves that intersect near the Kūhiō Sandbag Groin begins with the same offshore wave and, depending on the offshore wave direction, the inshore waves can have different relative effects. These two waves converge in the area shown on Figure 8-29 and Figure 8-30. The location of this convergence shifts slightly to the east or west, depending on the wave conditions at the time. The relative wave energy compared to the *Queens* wave dictates if sand moves toward the Ewa (west) groin or away from it.

The optimal location for the Kūhiō Sandbag Groin is in the zone where these two waves converge. There is no single correct location for the groin, as the wave convergence point varies. With this in mind, the Kūhiō Sandbag Groin was designed and constructed within that convergence zone. Habel et al. (2016) observed the seasonality of the sand movement in this area. During periods of strong westerly waves, sand moves east toward the ʻEwa (west) groin. During periods of south or southeast waves, or when tradewind wrap dominates, sand is transported to the west, away from the ʻEwa (west) groin (Figure 8-31). While the Kūhiō Sandbag Groin helped to retain sand, the wave angle propagating along the ʻEwa (west) groin was unchanged. A recessed head on the ʻEwa (west) groin to diffract the incident waves and accrete sand against the groin is discussed in Section 7.3.

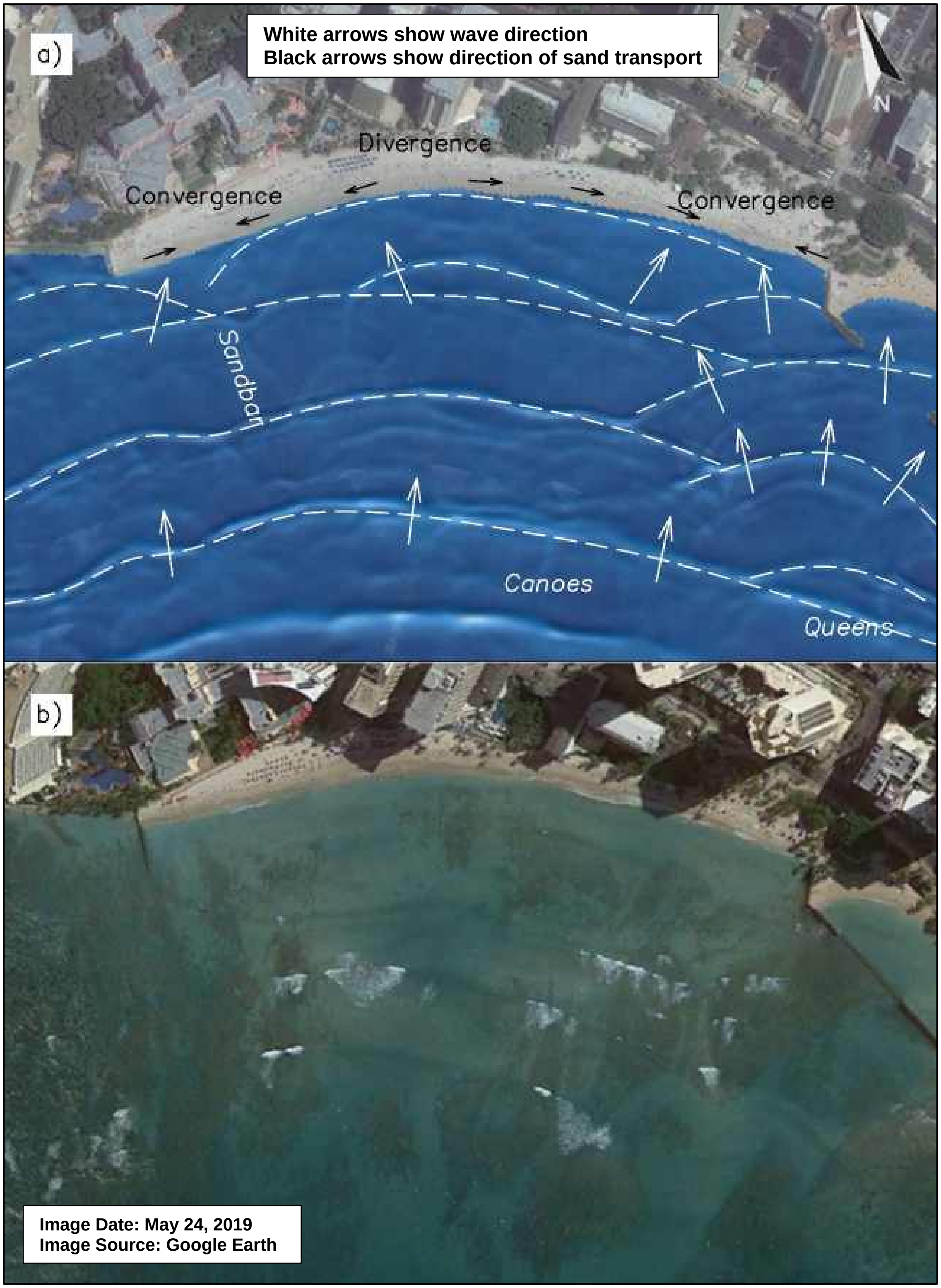


Figure 8-29 Wave model output for prevailing SSW swell - Royal Hawaiian beach sector

Figure 8-30 Converging wave patterns at east end of Royal Hawaiian beach sector

Figure 8-31 Wave patterns during strong tradewinds in the Royal Hawaiian beach sector

8.5.4 Kūhiō Beach Sector

The Kūhiō beach sector is divided into two sub-sectors: the ʻEwa (west) basin and the Diamond Head (east) basin of Kūhiō Beach Park. The natural shoreline through this area was once a narrow beach with a stream mouth near the center of the park (Clark, 2021). Construction of Kalākaua Avenue (originally Waikīkī Avenue) prompted a series of attempts to stabilize the shoreline and provide a recreational amenity.

The ʻEwa (west) basin is bounded by two offshore breakwaters with a gap in between to allow some wave energy into the basin. Waves passing through the gap diffract, producing an arc-shaped shoreline. The incident wave angle increases progressively from east to west along the breakwaters and is as much as about 35 deg at the center of the basin. Additionally, the *Queens* surf site produces arc-shaped waves that propagate through slightly deeper water leading to the gap in the breakwaters. These waves enter the basin with enough energy to erode the shoreline opposite the gap. This area often has little or no dry beach at high tide.

The Diamond Head (east) basin is enclosed by a low, straight breakwater along the makai (seaward) edge of the basin. Two small openings in the breakwater allow some exchange of ocean water but the basin is otherwise enclosed. The breakwaters are aligned parallel to Kalākaua Avenue, rather than the incident waves; thus, waves approach the basin with angles of up to about 20 deg as shown in Figure 8-32. Enough wave energy is transmitted over the breakwater at higher water levels that waves can propagate to shore with enough energy to transport sand to the northwest. While this is a relatively slow process, the incremental movement of sand results in beach narrowing along the eastern portion of the basin.

Gravity also moves sand from the beach face into the basin waters due to the lack of sufficient energy to support a stable beach profile. The transmitted waves lack sufficient energy to transport sand back up the beach face. As the beach migrates makai (seaward), the beach profile flattens, and water depths inside the basin become shallower. This process has resulted in the accumulation of a significant volume of sand within the basin and a noticeable shallowing of the water depths.

Compared to the other beach sectors, the Kūhiō beach sector is less susceptible to variations in the wave climate that can alter sediment transport patterns. The existing structures limit the effect of winter wave conditions, including large westerly swells and southwesterly (Kona) wind swells, which can result in significant easterly transport of sand in the other sectors.

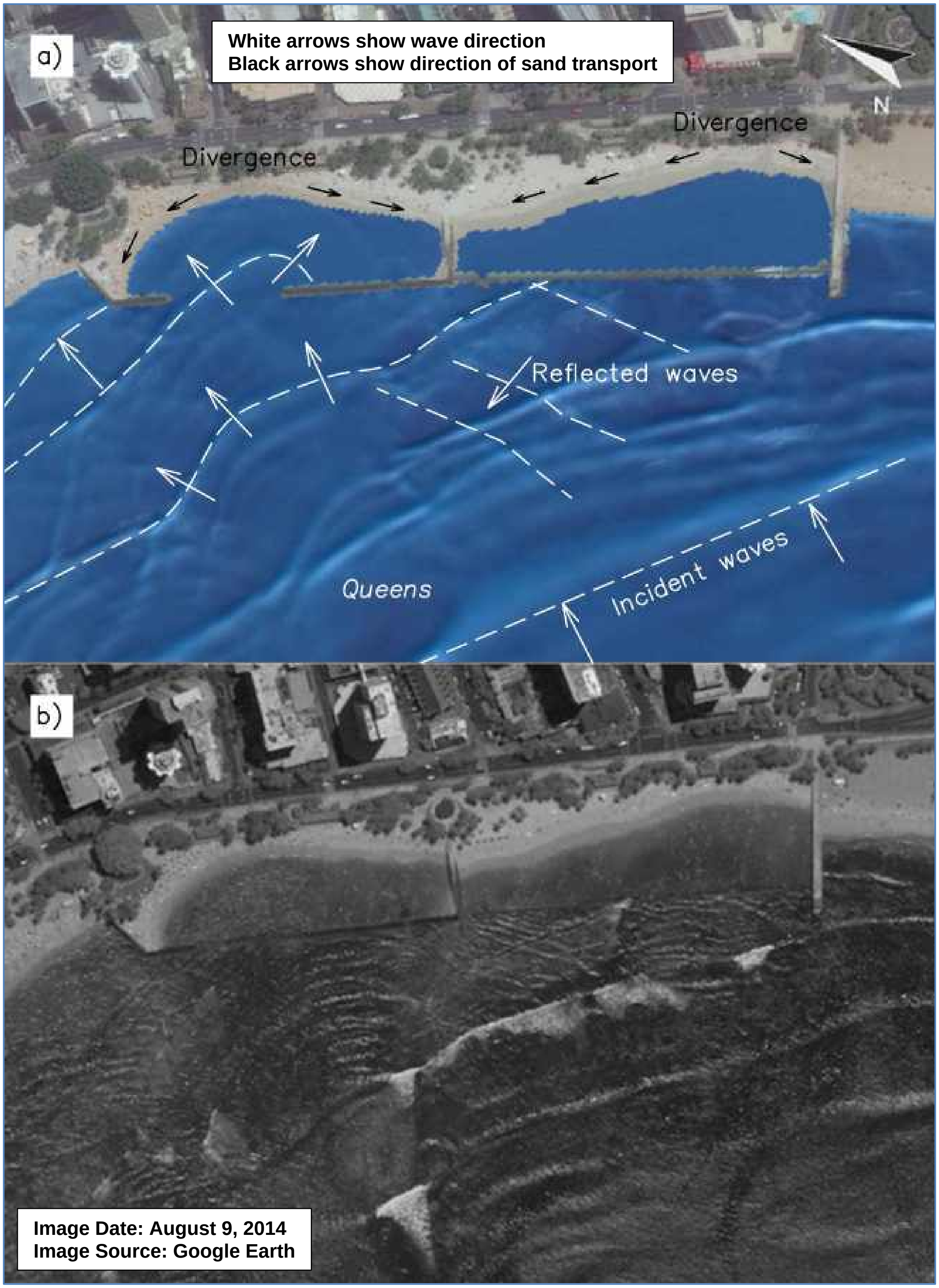


Figure 8-32 Wave model output for prevailing SSW swell - Kūhiō beach sector

8.5.5 Potential Impacts and Mitigation Measures

The proposed beach maintenance actions in the Fort DeRussy and Royal Hawaiian beach sectors, and the Diamond Head (east) basin of the Kūhiō beach sector, are not anticipated to significantly alter or affect presently ongoing sediment transport, wave-driven currents, circulation patterns, or offshore wave breaking. The proposed actions are intended to increase dry beach width and produce a more linear beach planform. Sediment (sand) within these beach sectors will be subject to the same coastal processes that exist under the current conditions.

The proposed beach improvement action in the Halekūlani beach sector is anticipated to alter or affect presently existing sediment transport, wave-driven currents, and circulation patterns. The proposed groins will inhibit longshore sediment transport and alter wave-driven currents and circulation patterns within the beach cells between the groins. Existing current velocities within the project footprint are relatively weak, therefore the proposed action is not anticipated to significantly alter wave-driven currents and circulation patterns in the vicinity of the groins. The proposed groins will provide superior stability for the beach, and the sand fill will mitigate the reflection of wave energy from the existing seawalls. The groins heads will help prevent the formation of cross-shore (rip) currents along the groin stems, minimizing the loss of sand due to cross-shore sediment transport. The groins will terminate well inshore of the offshore surf breaks and are not anticipated to alter the bathymetry or wave formation characteristics of the surrounding seafloor.

The proposed beach improvement action in the ʻEwa (west) basin of the Kūhiō beach sector is anticipated to alter or affect existing sediment transport and wave-driven currents. The proposed groin and breakwater system is designed to alter existing wave patterns within the basin to maintain a more stable, arc-shaped beach profile. Existing current velocities within the basin are relatively weak, therefore the proposed action is not anticipated to significantly alter wave-driven currents and circulation patterns within the basin. The groins and breakwater system will not alter the bathymetry or wave formation characteristics of the seafloor outside of the basin.

8.6 Bathymetry

Waikīkī is located on the south shore of Oʻahu, west of Diamond Head, along a pronounced embayment in the shoreline (Māmala Bay). This embayment is evident in the 18-ft depth contour, located approximately 0.5 mi offshore (Figure 8-33). Seaward of this, contours become straighter and bottom slope increases. A fringing fossil reef intersected by several relict stream channels extends approximately 1 mi offshore. The shoreline is fronted by a shallow fossil limestone reef including channels and pockets filled with sand. This extends approximately 1,500 ft offshore, with depths generally 5 ft or less. Seaward of the surf zone (approximate 10-ft depth), to a depth of 40 ft, the average bottom slope is very gradual, 1V:100H (vertical to horizontal). Between the 40 and 60-ft depth contours, bottom slopes increase to 1V:50H and further increase seaward of the 60-ft contour to 1V:15H. The nearshore bathymetry in Waikīkī is very complicated, with shallow fossil reef bisected by paleo stream channels. This results in complex nearshore wave patterns. Bathymetric maps for the four selected beach sectors are shown in Figure 8-34 through Figure 8-37.

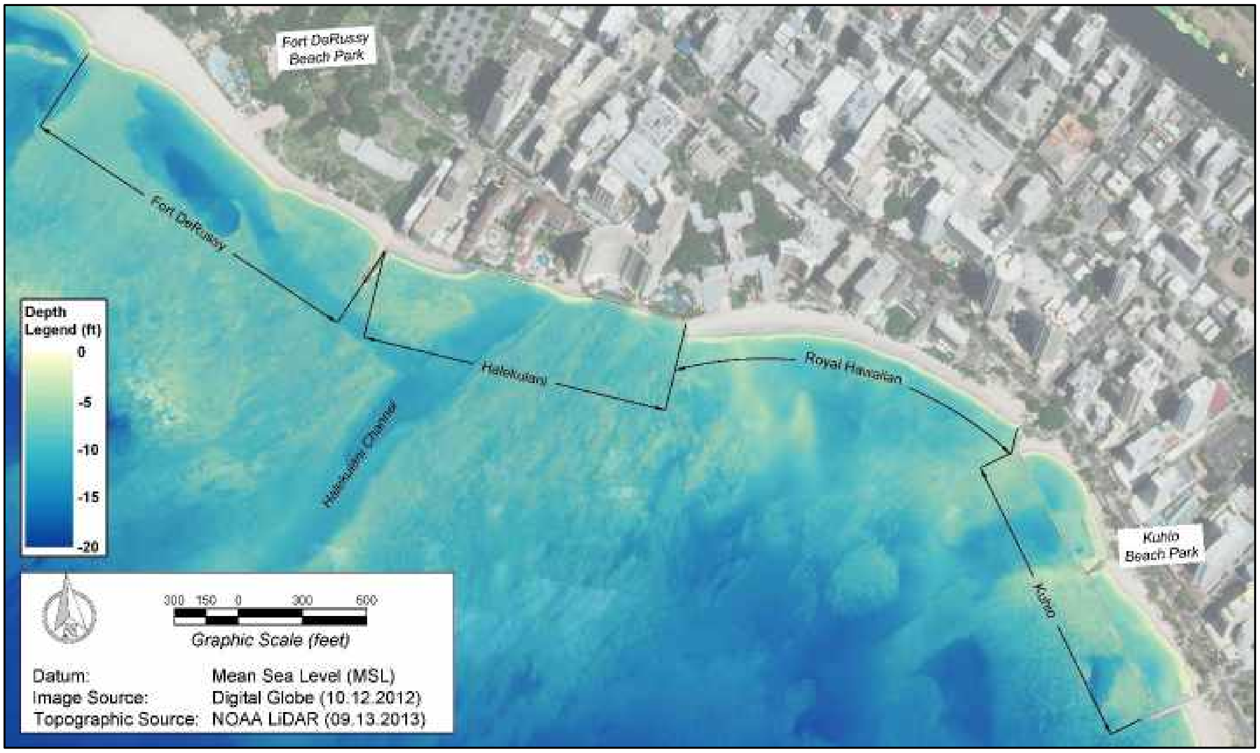


Figure 8-33 Bathymetric map of the project area

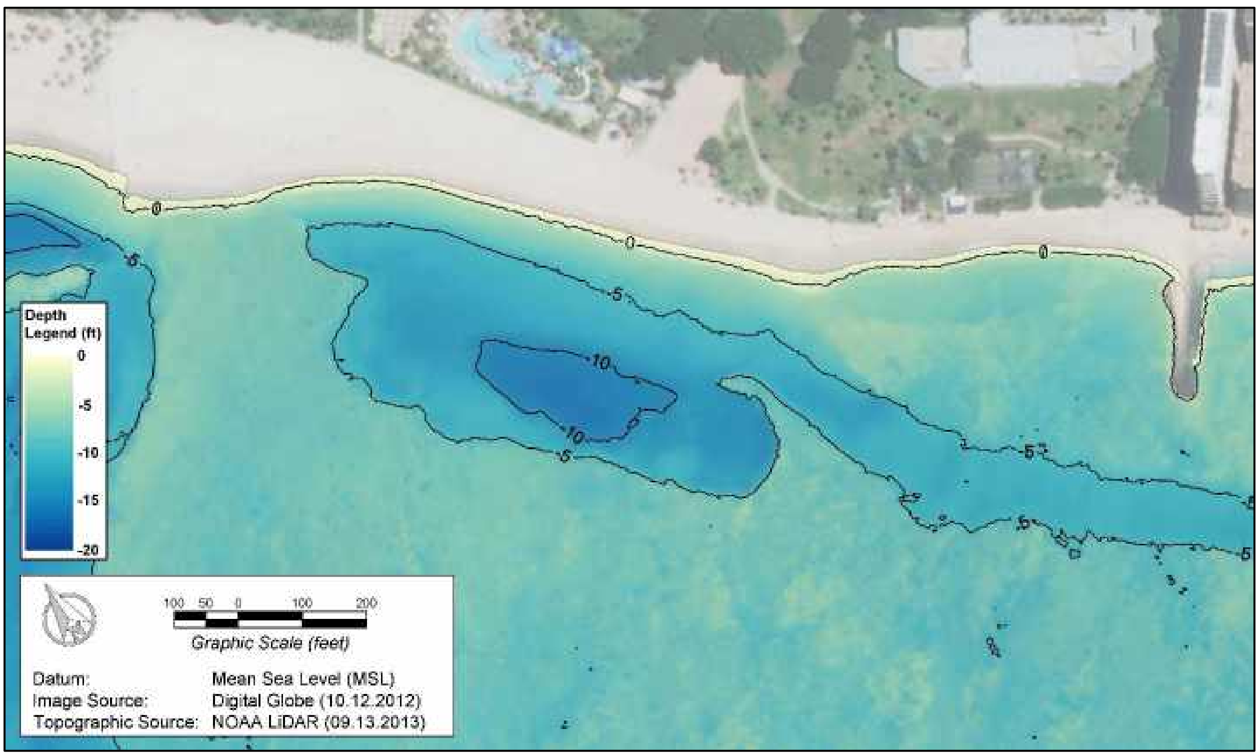


Figure 8-34 Bathymetric map – Fort DeRussy beach sector

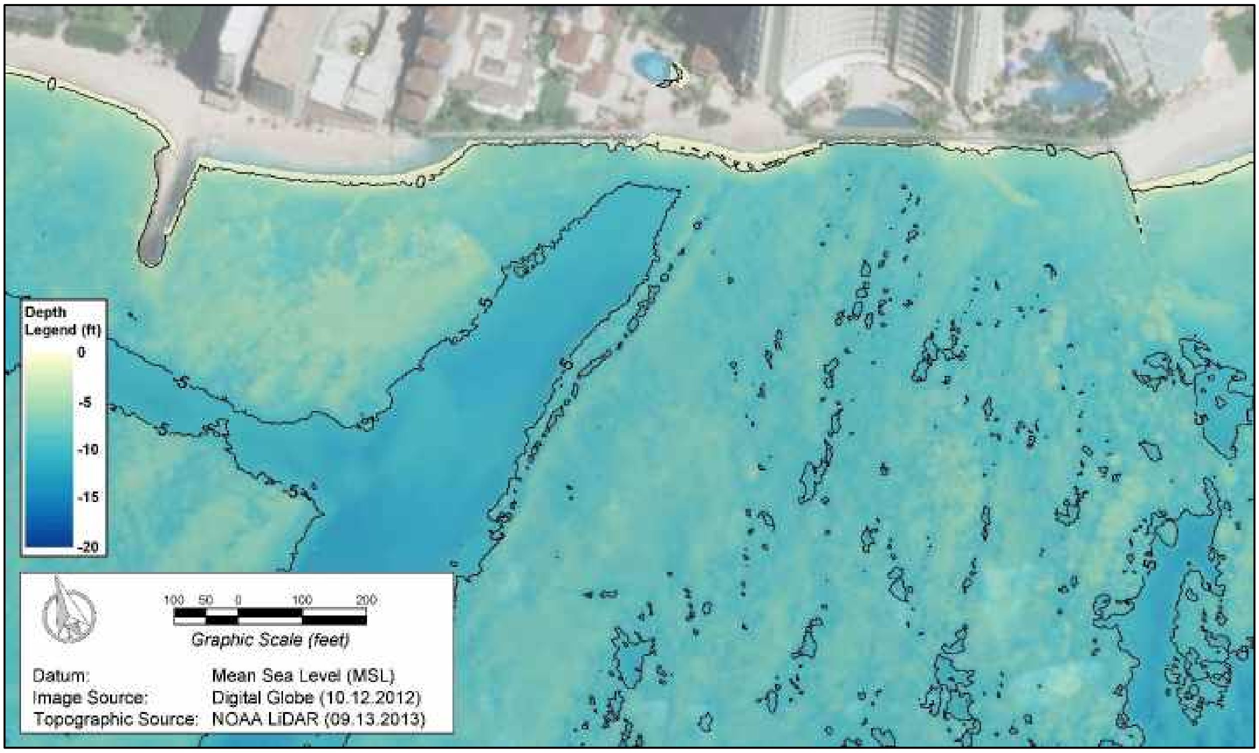


Figure 8-35 Bathymetric map – Halekūlani beach sector

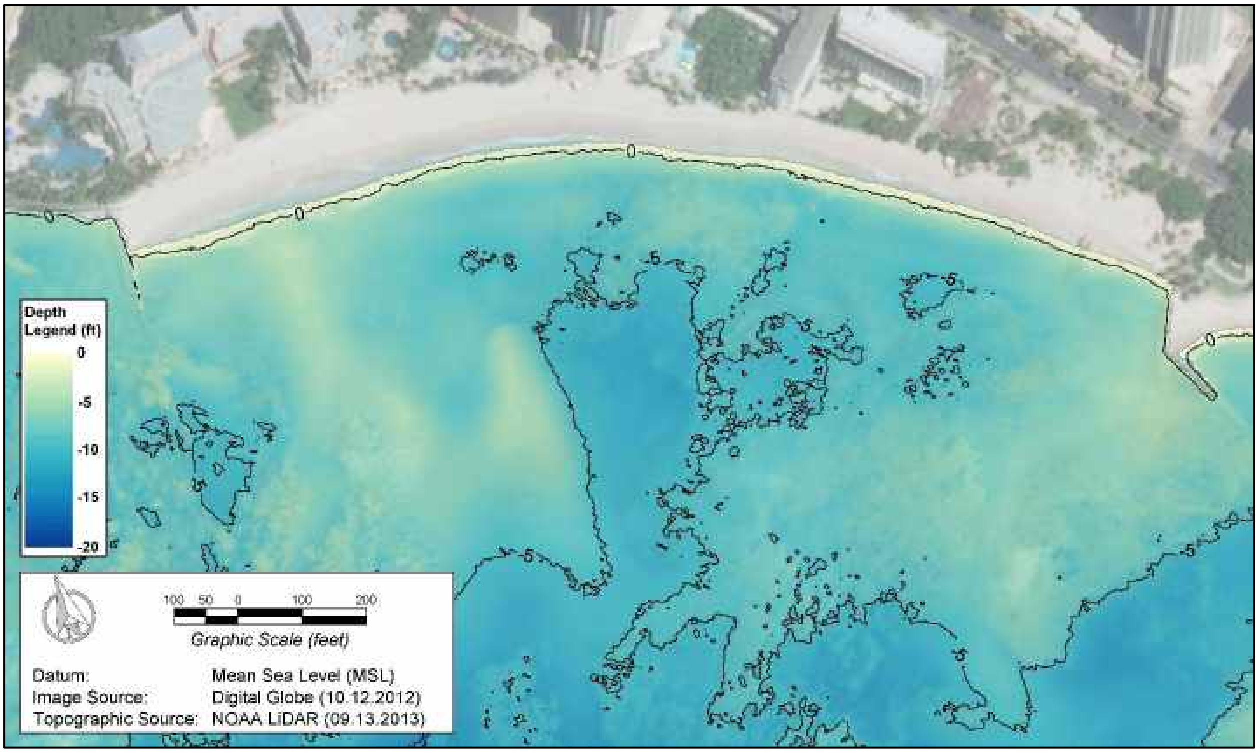


Figure 8-36 Bathymetric map – Royal Hawaiian beach sector

Figure 8-37 Bathymetric map – Kūhiō beach sector

8.6.1 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a temporary impact on bathymetry and seafloor conditions and will alter the foreshore topography along Waikīkī Beach by increasing dry beach width and elevation compared to the existing shoreline configuration.

Nearshore sandbars, sand waves, and sand ripples are currently present in the natural beach system in Waikīkī. These sandy features develop, move across, and disappear on both sandy and hard seafloor substrates in the Waikīkī nearshore environment. Following sand placement, there will be a period of beach equilibration, during which the beach profile and nearshore water depths can be expected to vary as the beach adjusts to the prevailing wave conditions and the beach assumes its stable configuration. Chronic erosion would continue to affect the shoreline along portions of Waikīkī Beach, as would seasonal and episodic erosion and beach adjustment events due to natural variability.

Short-term Impacts

In-water construction impacts will be limited to the immediate areas of groin and breakwater construction. The new structural footprints will be carefully delineated, and no construction activities or in-water material storage will be permitted outside of these areas. Construction of the proposed groins and segmented breakwater will alter the bathymetry of the areas they cover. Construction will be in accordance with all necessary permits and approvals required for the proposed actions. Short-term changes in nearshore bathymetry and coastal processes are anticipated as the beaches equilibrate after sand placement.

Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or alteration of the bathymetry. Dredging could occur at the *Ala Moana*, *Canoes/Queens*, or *Hilton* offshore sand deposits. Detailed wave modeling was conducted to evaluate potential impacts to bathymetry and wave formation at the offshore sand recovery areas (see Sections 8.2.2 and 9.4.6). Based on the results of the wave modeling and dredge analysis, no significant impacts to bathymetry are anticipated.

The modeling results show that the sand borrow pit at the *Ala Moana* offshore sand deposit causes decreases in wave heights of less than 1 in at the *Courts* surf site. For the BOUSS-2D model, the breaking wave height at *Courts* decreased by 0.8 in, or 1.1%, due to the dredge pit, and for the SWAN model, the breaking wave height at *Courts* decreased by 0.5 in, or 1.0%, due to the sand borrow pit. Conversely, model output shows that the wave heights at the *Concessions* and *Baby Haleʻiwa* surf sites would be expected to increase by up to 1 in.

The modeling results show that the sand borrow pit at the *Hilton* offshore sand deposit causes an increase in significant wave heights of less than 2 in at the *Bowls* and *Kaisers* surf sites. Inspection of the wave patterns reveals no noticeable change in the structure of the wave. Other surf sites, including *Threes*, *Fours*, and *Populars*, are more than 1,000 ft to the southeast of the *Hilton* offshore sand deposit, therefore dredging is not anticipated to have any impacts to bathymetry or surfing waves at these locations.

The modeling results show that the sand borrow pit at the *Canoes/Queens* offshore sand deposit causes an increase in significant wave heights of about 1.8 in at the *Canoes* surf site and a decrease in significant wave heights of about 1.6 in at the *Queens* surf site. As a result, the proposed actions are not anticipated to have any significant impacts on surfing waves in these areas.

<u>Long Term Impacts</u>

The new beach stabilizing structures proposed in the Halekūlani and Kūhiō beach sectors are anticipated to significantly reduce chronic beach erosion rates in these areas. In addition to these natural phenomena, the beach sectors may also be impacted by large magnitude events such as strong Kona storms, hurricanes, tsunamis, extreme water level changes, sea level anomalies, and other oceanographic and atmospheric events. Any and all of these natural phenomena can alter the beach configuration, as the project area is located on an open ocean coastline that is exposed to a wide range of wave and water level events and coastal hazards.

Long term impacts to bathymetry and seafloor conditions will be limited to the actual footprints of the structures. The Halekūlani beach sector is bounded by the Royal Hawaiian groin and the Fort DeRussy outfall/groin. These structures form hard boundaries that limit interaction between the Halekūlani beach sector and the adjacent beach sectors. Constructing rock rubblemound groins will provide superior stability for the beach, and the sand fill will mitigate reflected wave energy from the existing seawalls. The groins heads will help prevent the formation of cross-shore (rip) currents along the groin stems, minimizing the loss of sand due to cross-shore sediment transport. The groins will terminate well inshore of the offshore surf breaks and are not anticipated to alter the bathymetry or wave formation characteristics of the surrounding seafloor.

8.7 Water Quality

The waters offshore of Waikīkī are classified in the Hawaiʻi Water Quality Standards as (a) marine waters, (b) open coastal, (c) reef flat, (d) Class A, and (e) Class II marine bottom ecosystem (DOH, 2012). It is the objective of Class A waters that their use for recreational purposes and aesthetic enjoyment be protected. Other uses are permitted as long as they are compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. Class A waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control.

State water quality criteria for open coastal marine waters incorporate "wet" and "dry" criteria values based on average percent of freshwater inflow, where terrestrial freshwater input exceeds three million gallons per day, wet criteria are applied, where freshwater input is less than three million gallons per day, dry criteria apply. In this case, dry criteria apply, based upon the salinity results that show no significant dilution from oceanic salinity (35.2 PSU) for this region of the Pacific (SOEST, 1996).

The Hawaiʻi Department of Health, Clean Water Branch (DOH-CWB), monitors nearshore water quality in Waikīkī, including Waikīkī Beach Center and Kūhiō Beach. These two areas have been listed as impaired water bodies, meaning they do not meet State of Hawaiʻi water quality standards, particularly during the wet season. Applicable State of Hawaiʻi water quality criteria for the proposed beach improvement and maintenance actions are shown in Table 8-11.

Table 8-11 State of Hawaiʻi water quality criteria (dry season) for open coastal marine waters

Parameter	Geometric Mean value not to exceed this value	Value not to be exceeded more than 10% of the time	Value not to be exceeded more than 2% of the time
Total Nitrogen (μg N/L)	110.0	180.0	350.0
Ammonia (μg N/L)	2.0	5.0	9.0
Nitrate+Nitrite (μg N/L)	3.5	10.0	20.0
Total Phosphorus (μg/L)	16.0	30.0	45.0
Chlorophyll α (μg/L)	0.15	0.50	1.00
Turbidity (NTU)	0.20	0.50	1.00
Other "standards": • pH units shall not deviate more than 0.5 units from ambient and not lower than 7.0 nor • higher than 8.6. • Dissolved oxygen shall not decrease below 75% of saturation. • Temperature shall not vary more than 1Co from ambient conditions. • Salinity shall not vary more than 10% from ambient.			

8.7.1 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a temporary impact on water quality. Sand recovered from the ocean, though highly compatible with the existing dry beach sand, would still have some naturally occurring fine carbonate content that would be winnowed from the beach system and moved offshore during the initial equilibration process and beach erosion events.

Dredging, transport, and placement of carbonate sand can also increase the percent of fines through mechanical abrasion of the friable sand grains. Turbidity, or a reduction in water transparency, occurs when fine sediment particles are suspended in the water column. Turbidity can occur at the offshore sand dredging sites or along the beach where the offshore sand is placed.

Turbidity at Offshore Dredging Sites

Increased turbidity is anticipated at the offshore dredging sites during sand recovery operations. As the clamshell bucket recovers sand from the seafloor, it will disturb fine particles adjacent to the bucket. As the bucket is raised through the water column, minor volumes of sand containing fine particles would be released into the water column. Turbidity at the dredging sites will be reduced by using an environmental clamshell bucket, which is an industry-standard Best Management Practice that has been used to minimize turbidity during dredging of harbor channels in Hawaiʻi. Environmental clamshell buckets typically have tighter seals and overlapping sides. These buckets are designed to minimize sediment loss from within the bucket, resuspension at the dredging sites, and water entrainment with each grab. A conservative estimate of the amount of material that leaks from an environmental clamshell bucket is only 0.5% (Palermo et al. 2008). This material is expected to fall out of suspension rapidly near the dredging sites.

The use of a hydraulic suction dredge would result in the majority of bottom material disturbed being drawn into the dredge pipeline, with only a small amount of disturbed material escaping the dredge to potentially affect adjacent areas or water quality. Loss rates for hydraulic suction dredges have been estimated to be less than 0.1% (Hayes and Wu, 2001). Careful placement of anchors and cables would ensure that they do not move or disturb/suspend bottom material.

Turbidity generated from dredging operations is expected to be transported by currents moving parallel to shore. Wave action has the potential to transport turbidity inshore. These water quality impacts are expected to be temporary, occurring only during dredging operations, and are expected to be localized to the immediate vicinity of the dredging sites. Best Management Practices (BMPs) will be followed throughout the sand recovery operations, consistent with the requirements of the Hawaiʻi Department of Health Section 401 Water Quality Certification.

Turbidity at Sand Placement Sites

Beach nourishment projects can generate turbidity plumes that can be unsightly and affect water clarity. Although sand fill placed on a beach must closely match the existing beach sand with respect to grain size, offshore sand will typically have a higher percentage of fines than dry beach sand. Additionally, fines may be generated during dredging and placement of offshore sand onto the beach. After placement, wave action can suspend the fines creating milky-white turbidity plumes immediately offshore of the nourished beach. The turbidity decreases over time as fine material is winnowed out of the active beach face.

Turbidity containment barriers will be deployed along the shoreline during sand placement operations. Following placement of sand on the beach, there will likely be periodic turbidity associated with equilibration of the beach profile and planform and during large wave events, as sand moves alongshore and cross-shore.

Turbidity is a complex phenomenon that is dependent on both the optical and physical properties of suspended particles. To evaluate potential impacts, pre- and post-project conditions in Waikīkī were examined using available high elevation photographs, and laboratory turbidity analyses were conducted to compare the borrow sand and existing beach sand.

Laboratory Turbidity Analysis Results

Turbidity test results for sand samples obtained from *Ala Moana*, *Halekūlani Channel*, *Hilton*, *Reef Runway* (*RR Inner-1a*, *RR Inner-1b)*, and *Canoes/Queens* offshore deposits are plotted in Figure 8-38 through Figure 8-43. Data are plotted as turbidity versus time. The average value for each deposit is plotted in Figure 8-44 for comparison amongst the sand deposits. The turbidity results should not be considered indicative of turbidity levels that are to be expected during the actual beach nourishment because they result from artificial experiments in a small sample bottle. Rather, they are useful to evaluate differences between the existing beach sand and the potential borrow sand sources.

All samples tested showed initial turbidity that decreased exponentially with time. Samples from the *Canoes/Queens* offshore deposit had the lowest initial turbidity, which should be expected, since this is likely sand that had been recently transported and some of the fine material had already been winnowed out. The *Halekūlani Channel* offshore deposit had the second lowest turbidity; however, that was due to a very low value for one of the samples. That sample was obtained from the top of a core, so much of the fines may have been washed out. Sand from the other samples had significantly higher turbidity. The *Hilton* and *Ala Moana* offshore deposits had the highest initial turbidity values; however, the values decreased rapidly over the first 2 hrs. Even though the *Hilton* samples were the coarsest of the sites, three of the five samples had initial turbidity in excess of 1,000 NTU, while the other two were in excess of 850 NTU.

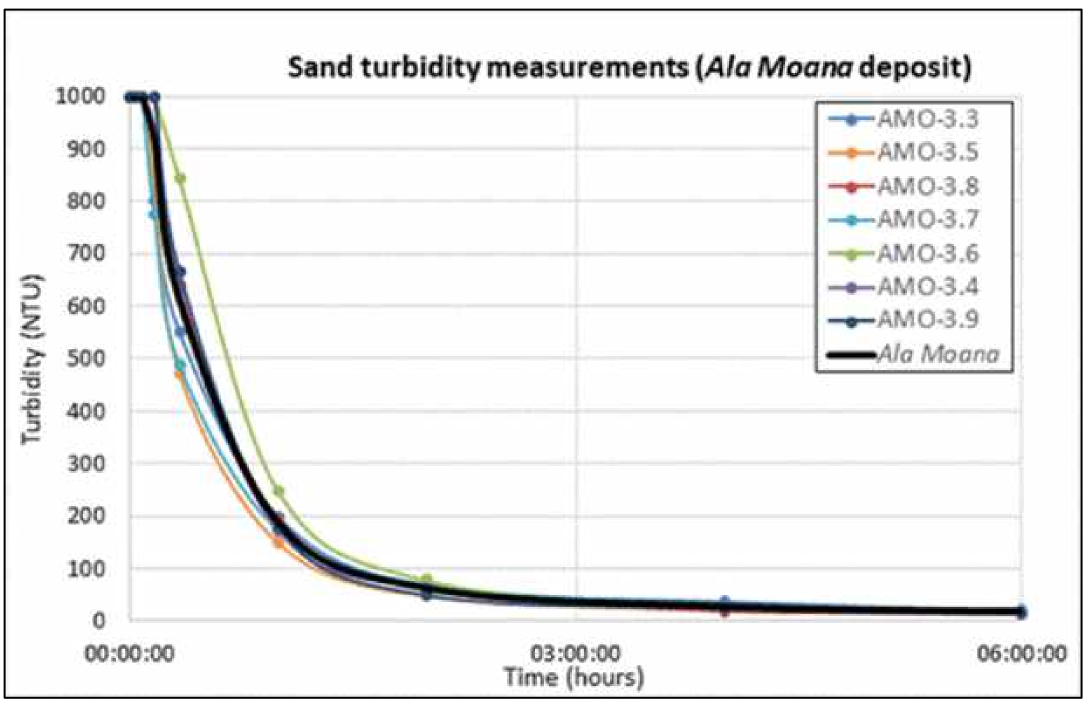


Figure 8-38 Turbidity results for *Ala Moana* offshore sand deposit

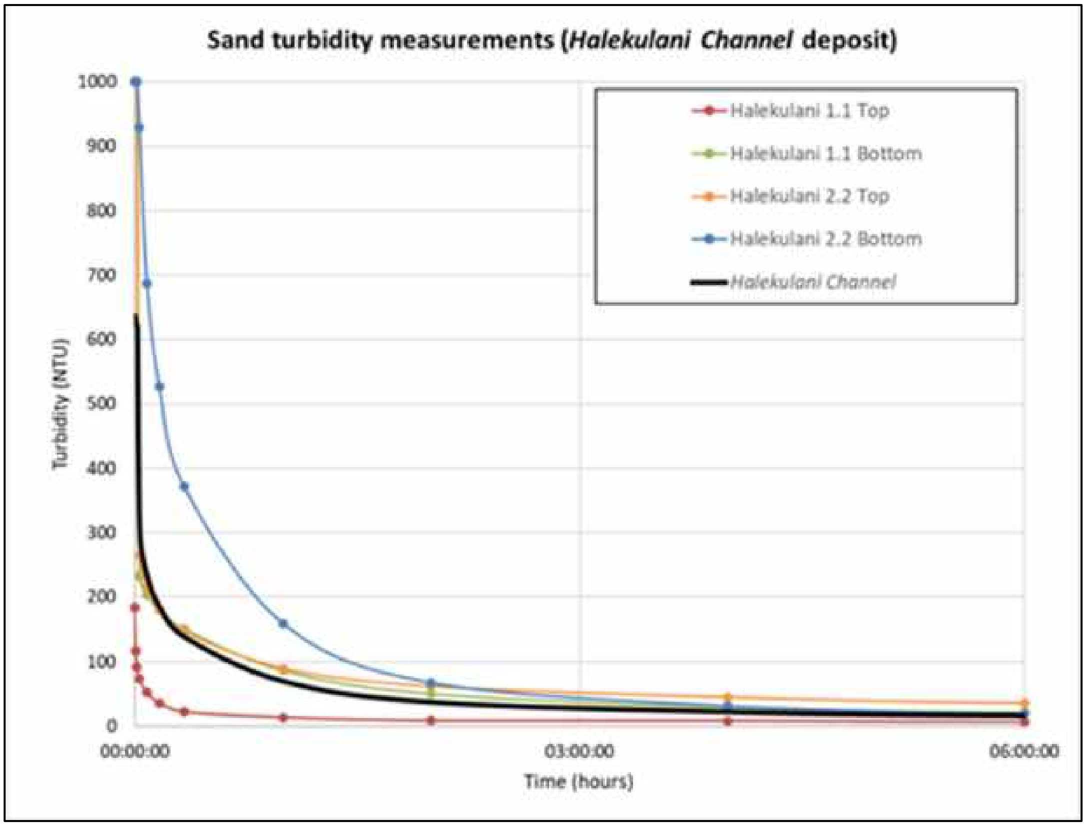


Figure 8-39 Turbidity results for *Halekūlani Channel* offshore sand deposit

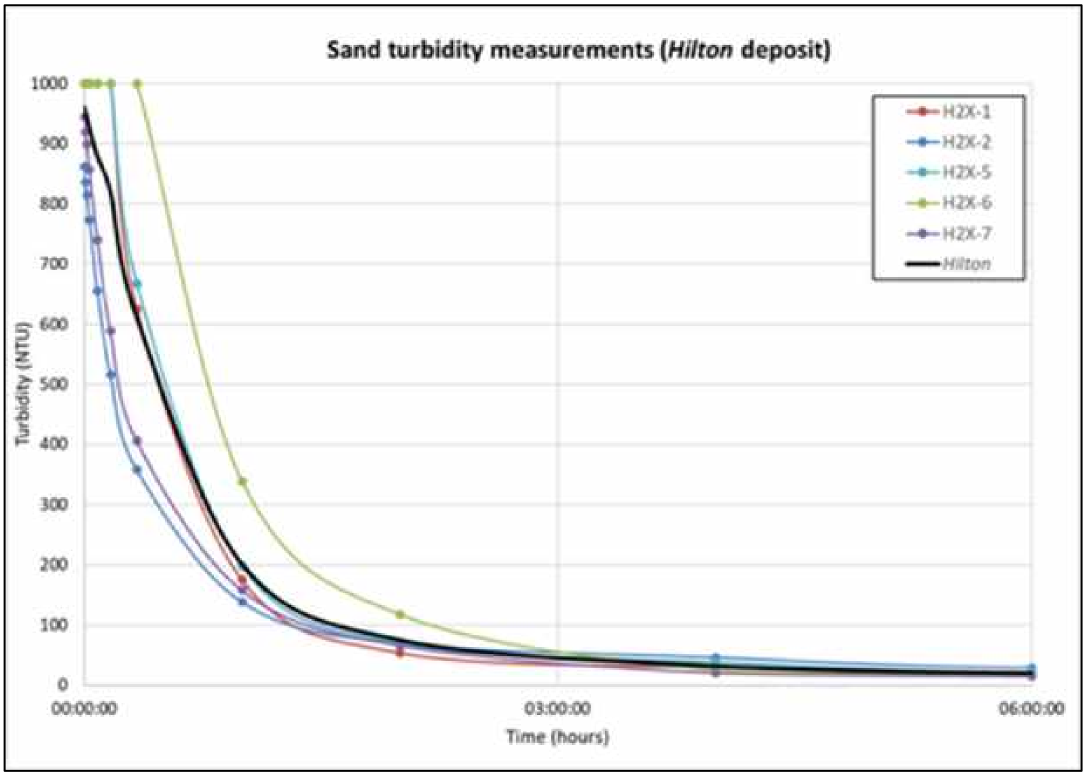


Figure 8-40 Turbidity results for *Hilton* offshore sand deposit

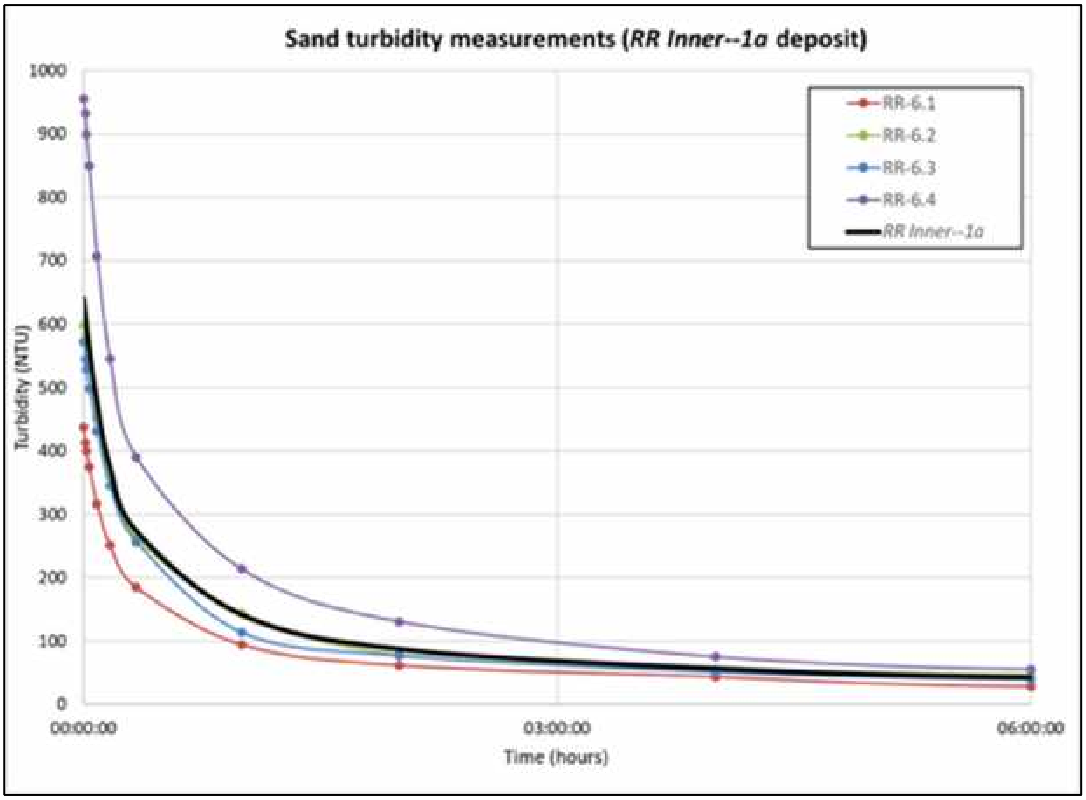


Figure 8-41 Turbidity results for *Reef Runway Inner 1a* offshore sand deposit

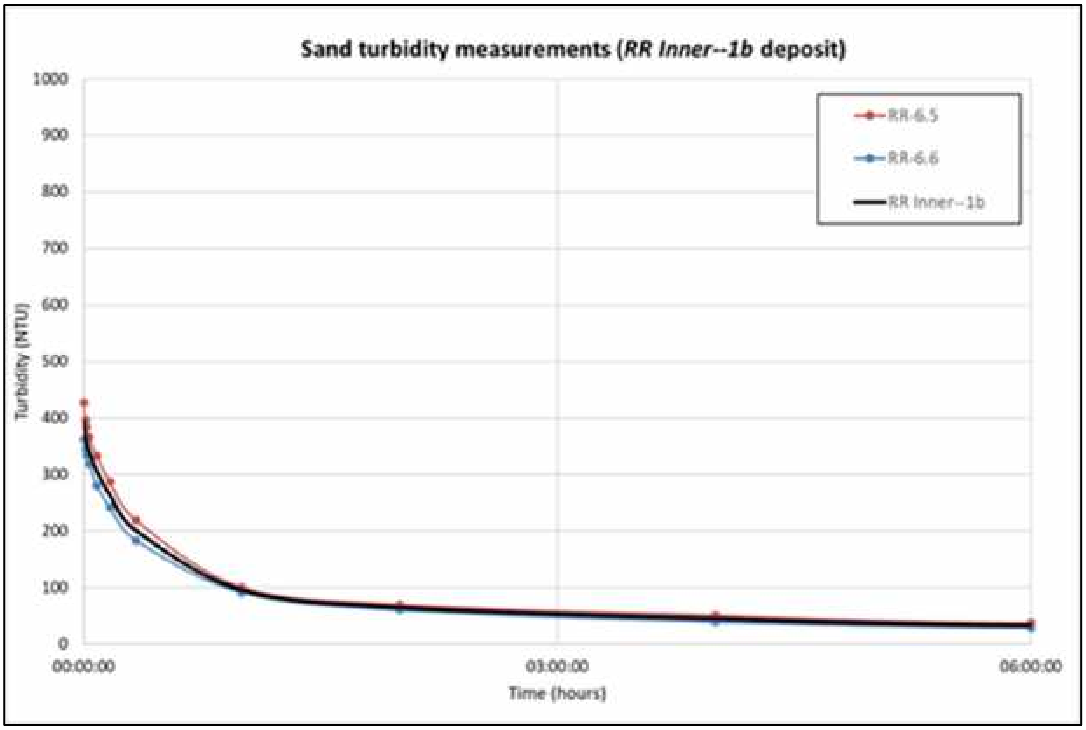


Figure 8-42 Turbidity results for Reef Runway Inner 1b offshore sand deposit

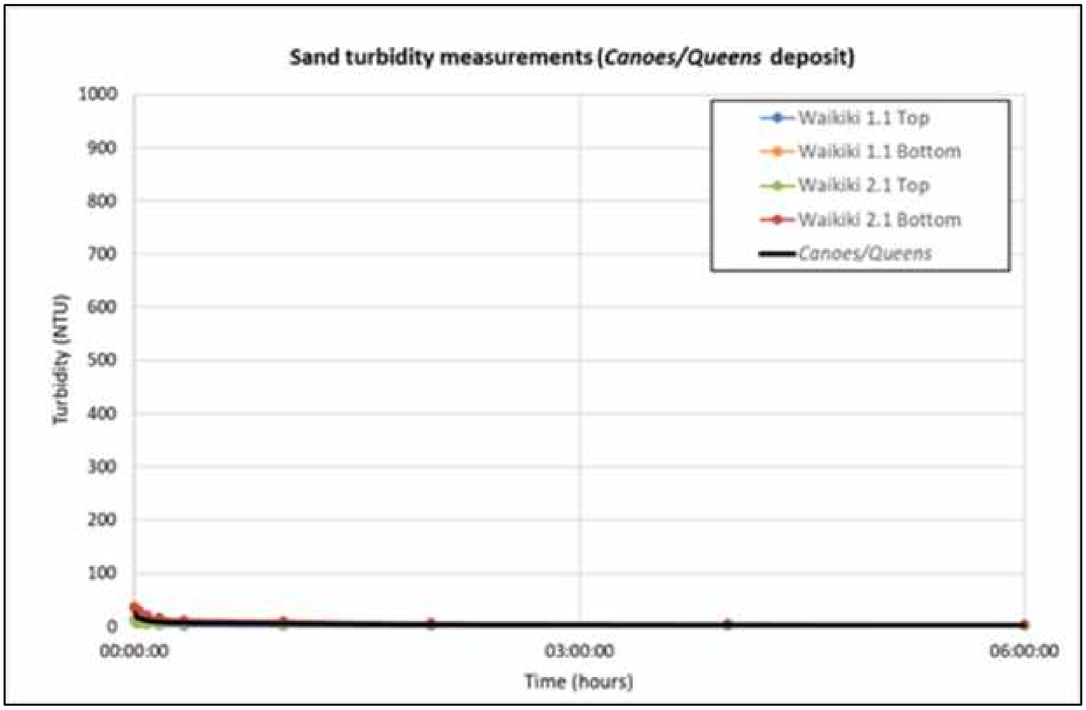


Figure 8-43 Turbidity results for *Canoes/Queens* offshore sand deposit

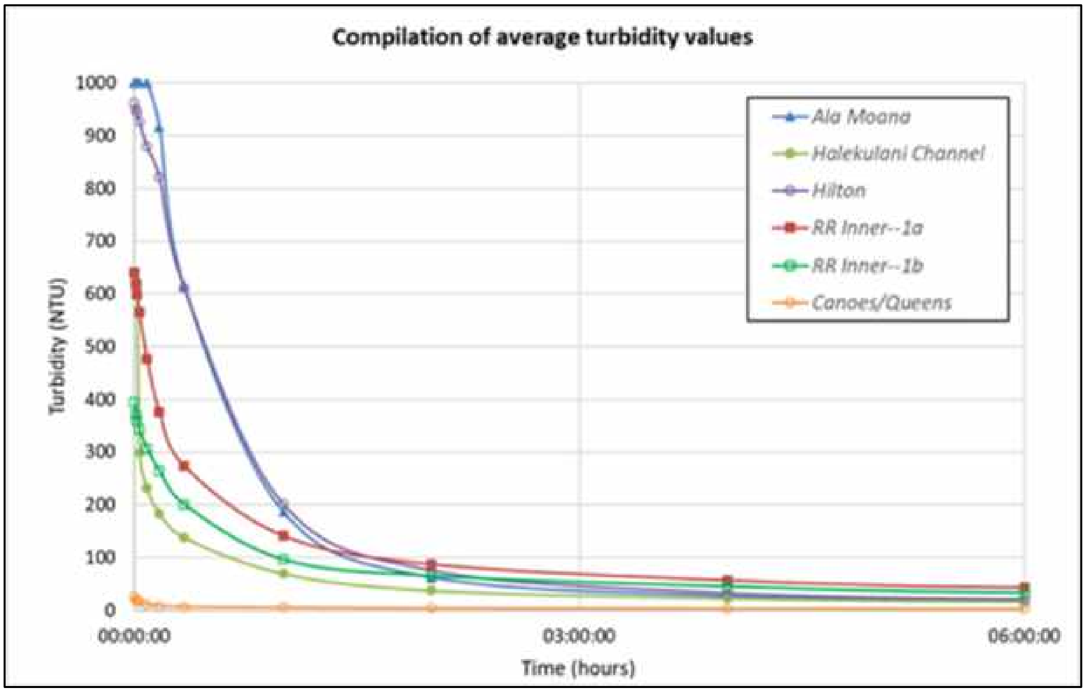


Figure 8-44 Compilation of average turbidity measurements for offshore sand sources

Turbidity During the 2012 Waikīkī Beach Maintenance I Project

The Waikīkī Beach Maintenance I project was completed in June 2012, when about 24,000 cy of sand was recovered from the *Canoes/Queens* offshore deposit, pumped to shore, dewatered, and placed on Royal Hawaiian Beach. The placement of the sand produced elevated levels of turbidity and, immediately following the completion of sand placement, the project area experienced a series of summer south swell events that further exacerbated the turbidity.

Turbidity was assessed visually from photographs obtained via a University of Hawaiʻi webcam mounted on the Sheraton Waikiki Hotel. Turbidity levels appeared to decrease in general following completion of sand placement on April 25, 2012. By November 2012, turbidity on calm days appeared to have decreased to pre-project levels, though turbidity was still elevated during higher wave conditions which are responsible for washing fine material from the beach and resuspending sediment. A June 24, 2019 view from the Sheraton Waikiki Hotel shows the nearshore water clarity to be comparable to pre-project levels.

Turbidity During the 2021 Waikīkī Beach Maintenance II Project

The Waikīkī Beach Maintenance II project was completed May 7, 2021, when about 20,000 cy of sand was recovered from the *Canoes/Queens* offshore deposit, pumped to shore, dewatered, and placed on Royal Hawaiian Beach. The placement of the sand again produced elevated levels of turbidity. Turbidity plumes were observed on May 10, 2021 originating from the ʻEwa (west) basin of the Kūhiō beach sector and the central channel in the Royal Hawaiian beach sector. The plumes were observed using surf cameras located on top of the Sheraton Waikiki Hotel. The plume originating from the ʻEwa (west) basin consisted of a narrow band of suspended fine sediment that slowly moved offshore from the beach. Once it reached the submerged breakwater that separates the ʻEwa (west) basin from the offshore waters, the plume accelerated makai (seaward) between the *Canoes* and *Queens* surf sites. The plume then curved slightly north before turning south in a circular pattern just outside of the *Queens* surf site.

The numerical wave model (SWASH) was used to simulate the exact wave and tide conditions occurring at the time of the plume observations. The full development of the plume shape occurred at approximately 4:30pm HST where the tide measured +1.28 feet MSL at the Honolulu Harbor tide station. Wave conditions during this time were measured at the offshore wave buoy station 238 located approximately 2 mi west of Barbers Point. The primary wave component measured at station 238 was a south swell with a significant wave height of 1.9 ft and peak period of 14 sec. There was also a small northwest swell measured at the buoy; however, this specific swell was expected to have little to no impact to the nearshore waves at Waikīkī at the time. The measured oceanographic parameters were used as input to the SWASH model which simulated nearshore wave transformation and wave generated currents along the Waikīkī shoreline.

The modeled current vectors closely matched the observed plume shape at the time of the observation (Figure 8-45). The modeled currents also closely matched the path of the turbidity plumes to the north along Royal Hawaiian Beach. The model results confirmed that, when beach erosion occurs, the fine sediment contained in the offshore borrow sand follows distinct and relatively narrow sediment pathways before being deposited in the sediment sink between the *Canoes* and *Queens* surf breaks.

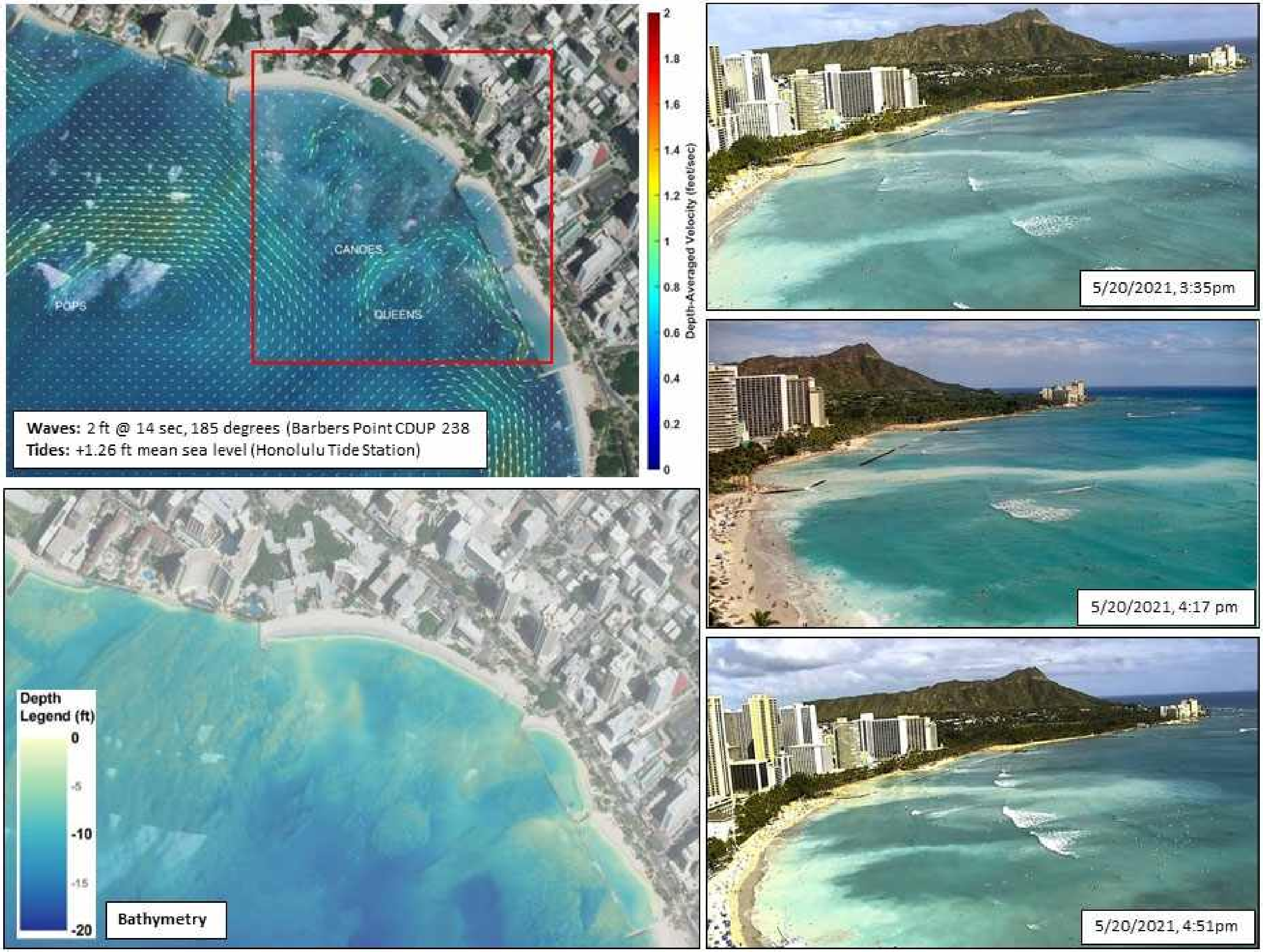


Figure 8-45 Comparison of sediment plume observations and SWASH model results (5/10/2021)

Turbidity Impacts Analysis

Sand from within the offshore sand deposits is expected to become well mixed during recovery, transport, and placement on the beach. Average turbidity values for the targeted areas in the deposits are important, as they are representative of the material that will eventually be placed on the beach. Initial elevated turbidity levels are expected during sand placement and periodically during larger wave events. The laboratory turbidity analyses indicated that the turbidity should return to typical existing levels after a short period of adjustment. Observations from the Waikīkī Beach Maintenance I and II projects, and results of the turbidity experiments described above suggest that elevated turbidity following sand placement should be expected.

A temporary increase in turbidity levels is anticipated in the immediate areas of construction; however, these impacts will be mitigated by the employment of Best Management Practices (BMPs). The proposed actions will require a Clean Water Act Section 401 Water Quality Certification (WQC), which will include an Applicable Monitoring and Assessment Program (AMAP) and Data Quality Objectives (DQO). The AMAP and DQO will be reviewed and approved by the Hawaiʻi Department of Health, Clean Water Branch (DOH-CWB). The contractor will utilize appropriate BMPs to minimize potential impacts to water quality during construction including but not limited to sand dewatering, silt fencing, and turbidity curtains.

Water quality protection measures will include the following general requirements:

- Turbidity containment barriers shall be installed and maintained to completely surround the work area so as to control and contain construction generated turbidity.
- The water area affected by construction shall be monitored, and if monitoring indicates that the turbidity standards are being exceeded, construction shall be suspended until the condition is corrected.
- The construction contractor shall be required to employ standard 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 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.
- All construction activities shall be confined to the immediate area of construction, and no excess construction material shall be stockpiled in the water.
- Construction materials (e.g., sand, stone, concrete) shall be inert and free of earthen and any other deleterious substances.
- Water quality monitoring will be performed before, during, and after construction.

8.8 Shoreline Change

The University of Hawaiʻi Coastal Geology Group (UHCGG) conducted a historical analysis of sandy shorelines on Oʻahu and produced shoreline change maps based on survey data and aerial imagery from 1927 to ~~2015~~2021. Their analysis used the beach toe as the reference feature to measure changes in the position of the shoreline over time. The results of the UHCGG historical shoreline change analysis for Waikīkī are shown in Figure 8-46 and Table 8-12. The rates presented in Table 8-12 represent the average shoreline change rates from 1927 to ~~2015~~ 2021 for the selected beach sectors; however, rates can be substantially higher in smaller areas that are more susceptible to erosion. Since 2015 ~~(the most recent data point in the analysis)~~, most beaches throughout Waikīkī appear to be experiencing an increase in erosion that appears to well exceed the historical rates.

Erosion, coastal flooding, and beach loss are expected to continue and accelerate in Waikīkī in the coming decades as rates of sea levels continue to increase. Recent record high water levels and severe erosion events indicate that this acceleration may already be occurring. Anderson et al. (2015) projected future shoreline change in Hawaiʻi by combining historical shoreline trends with projected sea level rise using the Davidson-Arnott profile model. The analysis found that, due to sea level rise, average shoreline recession in Hawaiʻi is projected to be nearly double the historical rates by 2050, and nearly 2.5 times the historical rates by 2100 (Anderson et al. 2015).

The UHCGG calculated projected future exposure to erosion and annual high wave flooding to account for sea level rise (UHCGG, ~~2019~~2021). All of the beach sectors in Waikīkī are projected to experience erosion and increased coastal flooding as sea levels continue to rise (State of Hawaiʻi, 2017, Anderson et al. 2015). The erosion projections for the Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō beach sectors are shown in Table 8-13. These projections do not account for the presence of shoreline armoring, which spans nearly the entire length of the Waikīkī shoreline. Based on the erosion projections, without mitigative actions, sea level rise will likely result in total beach loss in Waikīkī by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged, particularly during high tides and high surf events.

8.8.1 Fort DeRussy Beach Sector

The historical shoreline change trend for the Fort DeRussy beach sector (transects 141 to 169) from 1927 to ~~2015~~ 2021 has been erosion at an average rate of ~~0.4~~ 0.37 ft/yr (UHCGG, ~~2019~~2021). Beach erosion does not occur uniformly throughout the sector. The east end of the beach (transects 141 to ~~153~~149) has been eroding at an average rate of ~~1.2~~ 1.6 ft/yr, whereas the west end of the beach (transects ~~154~~ 151 to 169) has been accreting at an average rate of ~~0.4~~ 0.3 ft/yr. The erosion is more pronounced at the east end of the beach because the predominant direction of sediment transport is from east to west along this portion of the Waikīkī shoreline (Miller and Fletcher, 2003). As sand is transported from east to west along the beach, the east end of the beach narrows and there is no natural mechanism to transport sand back to the eroding area. Waves currently overwash the beach walkway at the east end of this sector during high tides and high surf events.

Erosion, coastal flooding, and beach loss in the Fort DeRussy beach sector are projected to increase as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to ~~30.8~~28.2 ft ~~(9.4 m)~~ by 2050 and up to ~~81~~ 121.7 ft ~~(24.7 m)~~ by 2100 (UHCGG, ~~2019~~2021). The entire length of the shoreline in the Fort DeRussy beach sector is armored by a seawall that was constructed in 1916. As the shoreline approaches the existing seawall, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016). Without beach improvements and/or maintenance, it is likely that sea level rise will result in total beach loss in the east end of this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged during high tides and high surf events.

8.8.2 Halekūlani Beach Sector

The historical shoreline change analysis for the Halekūlani beach sector (transects 118 to 140) determined that, from 1927 to 20152021, the shoreline has been relatively stable with slightly more pronounced accretion at the east end of the sector fronting the Sheraton Waikiki Hotel (UHCGG, 20192021). Miller and Fletcher (2003) found that sediment transport in the Halekūlani beach sector varies according to the seasonal wave regime. The relative stability of the shoreline can be attributed to the limited volume of sand in the narrow sections of beach that are stabilized by groins and the presence of the seawalls that artificially fix the shoreline where no beach is present.

At the west end of the sector (transects 133 to 140), sand is impounded on the updrift side of the Fort DeRussy outfall/groin. The beach in this area is narrow and fluctuates seasonally but has been relatively stable over the long-term. The pocket beaches in the central portion of the sector (transects 126 to 129), between the Halekūlani Hotel and the Sheraton Waikiki Hotel, are aligned with the Halekūlani Channel and have experienced moderate erosion at a rate of 0.2 ft/yr (UHCGG, 20192021). The pocket beaches are dynamic and sand volumes and beach width often fluctuate. The pocket beaches are often completely submerged during high tides and high surf events, and waves frequently overtop the existing walls in this area. The east end of the sector (transects 118 to 125) is dominated by a seawall fronting the Sheraton Waikiki Hotel. Sand occasionally accumulates in front of the seawall where it is impounded by the Royal Hawaiian groin; however, the sand is unstable and there is typically no dry beach in this area.

Erosion, coastal flooding, and beach loss in the Halekūlani beach sector are projected to continue and accelerate as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to 3.916.1 ft (1.2 m) by 2050 and up to 14.188.0 ft (4.3 m) by 2100 (UHCGG, 20192021). These projections do not account for the presence of the existing seawalls that span the entire length of the Halekūlani beach sector. As the shoreline approaches the existing seawalls, there is an incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016). Without beach improvements and/or maintenance, it is likely that sea level rise will result in total beach loss in this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged during high tides and high surf events.

8.8.3 Royal Hawaiian Beach Sector

The historical shoreline change trend for the Royal Hawaiian beach sector from 1927 to 2015 2021 has been accretion at an average rate of 0.19 0.6 ft/yr (UHCGG, 20192021). This long-term accretion rate is likely attributable to the addition of beach sand during previous beach nourishment efforts over the past century. Miller and Fletcher (2003) found that sediment transport is predominantly in a northwesterly direction and that a cross-shore current in the eastern portion of the beach may contribute to the loss of sand in the in the Royal Hawaiian beach sector. These currents transport sand offshore, which often results in the formation of a shallow sandbar in this area. Habel et al. (2016) also confirmed predominant westerly sediment transport and noted that cross-shore sediment transport occurs through an offshore channel that acts as both a sediment source and sink depending on seasonal wave conditions: a source during seasonal and storm-related swell events, and a sink otherwise.

Beach profile monitoring following the 2012 Waikīkī Beach Maintenance I project found that the beach volume decreased at a rate of 760 ± 450 m^3/yr over the 2.7 yr monitoring period, consistent with the design rate of 1,070 m^3/yr. Seasonal cycles caused beach volume to fluctuate between 2,000 m^3 to 4,000 m^3, i.e., 15% to 30% of total nourishment volume (Habel et al. 2016).

Erosion, coastal flooding, and beach loss in the Royal Hawaiian beach sector are projected to continue and accelerate as sea levels continue to rise. The UHCGG shoreline change projections estimate that the shoreline could erode up to ~~87.3~~1.3 ft ~~(26.6 m)~~ by 2050 and up to ~~216.2~~43.6 ft ~~(65.9 m)~~ by 2100 (UHCGG, ~~2019~~2021). These projections do not account for the presence of the existing seawalls that span nearly the entire length of the shoreline in the Royal Hawaiian beach sector or the compounding effects of erosion and increasing coastal flooding. Without beach improvements and/or maintenance, it is likely that sea level rise will result in total beach loss in this sector by mid-century or sooner due to the combined effects of increasing erosion and increasing frequency and severity of coastal flooding, particularly in areas where the beaches are already narrow and often submerged during high tides and high surf events. The loss of the recreational dry beach and lateral shoreline access in the vicinity of the Moana Surfrider Hotel could occur in the next several decades as waves currently overtop the seawalls in this area during extreme high tides and high surf events.

8.8.4 Kūhiō Beach Sector

The historical shoreline change trend for the Kūhiō beach sector from 1927 to ~~2015~~ 2021 has been erosion at an average rate of ~~0.11~~ 0.02 ft/yr (UHCGG, ~~2019~~2021). The erosion is more pronounced in the Diamond Head (east) basin where the predominant direction of sediment transport is from east to west (Miller and Fletcher, 2003). As sand is transported from east to west along the beach, the east end of the beach narrows and there is no natural mechanism to transport sand back to the eroding area. The erosion is less pronounced in the ʻEwa (west) basin where the sand is impounded on the updrift side of the groin at the west end of the sector.

As sea levels continue to rise, the Kūhiō beach sector is projected to erode ~~33.1~~19.3 ft ~~(10.1 m)~~ by 2050 and ~~86.6~~95.6 ft ~~(26.4 m)~~ by 2100 (UHCGG, ~~2019~~2021). The majority of the shoreline in the Kūhiō beach sector is armored by seawalls and the middle of the beach is often completely submerged during high tides and high surf events. Without beach improvements and/or maintenance, it is likely that increasing erosion and coastal flooding with sea level rise will result in total beach loss in the middle of this sector within several decades. Erosion and flooding may be less severe at the west and east ends of the sector where the beach is currently widest; however, total beach loss will still likely occur in these areas before the end of the century.

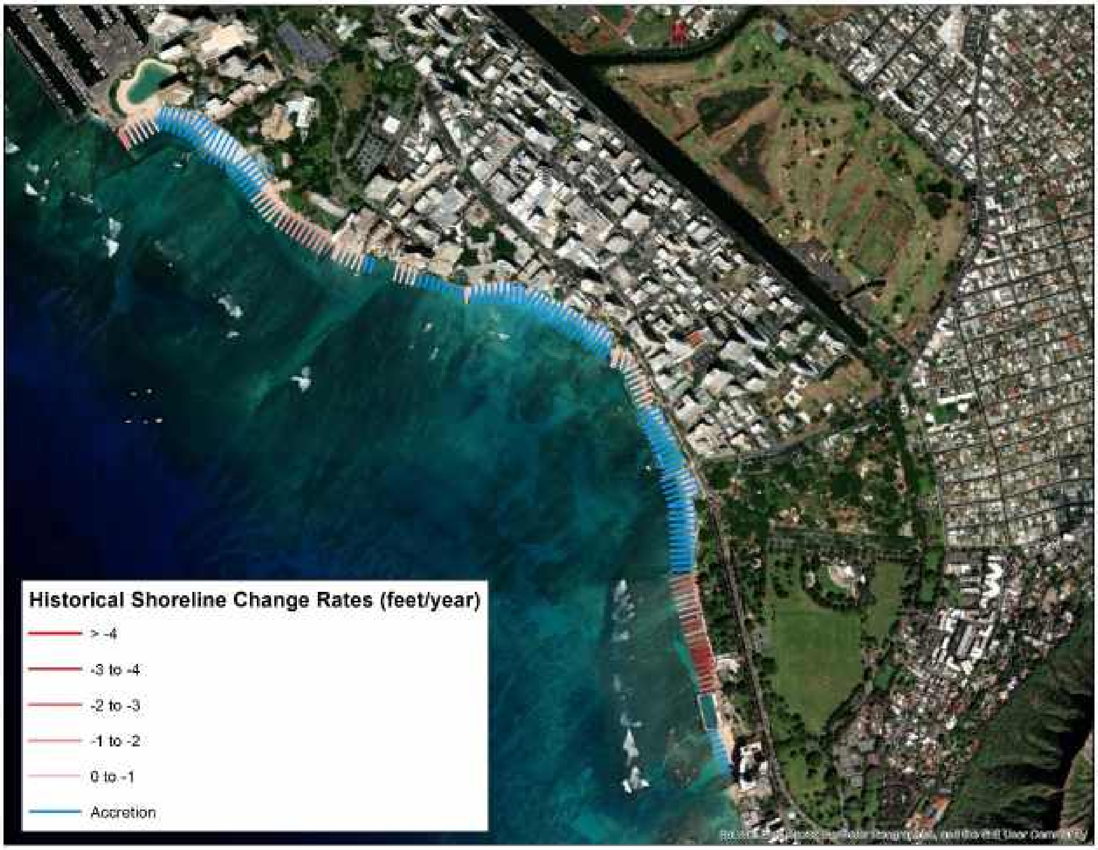


Figure 8-46 Waikīkī historical shoreline change rates,1927 to ~~2015~~ 2021 (UHCGG, ~~2019~~2021)

Table 8-12 Waikīkī historical shoreline change rates,1927 to ~~2015~~ 2021 (UHCGG, ~~2019~~2021)

Beach Sector	Historical Trend	Historical Rate (ft/yr)
Fort DeRussy	Erosion	~~0.4~~0.37
Halekūlani	~~Erosion~~N/A	0.0
Royal Hawaiian *	Accretion	0.6
Kūhiō	Erosion	0.02

* Long-term accretion rate is likely influenced by previous beach nourishment efforts.

Table 8-13 Waikīkī projected shoreline change with sea level rise (UHCGG, ~~2019~~2021)

Beach Sector	Projected Erosion by 2050 (ft)	Projected Erosion by 2100 (ft) *
Fort DeRussy	~~30.8~~28.2	~~81.0~~121.7
Halekūlani	~~3.9~~16.1	~~14.1~~88.0
Royal Hawaiian	~~87.3~~1.3	~~216.2~~43.6
Kūhiō	~~33.1~~19.3	~~86.6~~95.6

* Erosion projections do not account for existing shoreline armoring (i.e., seawalls).

8.8.5 Potential Impacts and Mitigation Measures

The proposed action in the Fort DeRussy beach sector is beach maintenance consisting of small-scale beach nourishment and periodic sand backpassing. Periodic sand backpassing will improve lateral shoreline access and reduce the potential for the seawall and beach walkway to become exposed by erosion and overwashed by wave runup. While sand backpassing will not prevent future beach erosion, it will balance the sediment budget within the beach sector, which will help to maintain a more linear beach planform.

The proposed action in the Halekūlani beach sector is beach nourishment with stabilizing groins. The project will produce four stable beach cells in an area that has historically been largely devoid of sand. The groins will stabilize the sand so long-term erosion rates will decrease when compared to historical rates.

The proposed action in the Royal Hawaiian beach sector is beach nourishment without stabilizing structures. The project will be similar in size and scope to the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. While beach nourishment will not prevent future beach erosion, it will balance the sediment budget within the beach sector, which will help to maintain a wider, more linear beach planform.

The proposed action in the Kūhiō beach sector ʻEwa (west) basin is beach nourishment with modified groins and a segmented breakwater. The segmented breakwater will alter wave patterns to produce a more stable beach profile, which will reduce long-term erosion rates when compared to historical rates.

The proposed action in the Kūhiō beach sector Diamond Head (west) basin is beach maintenance. While beach maintenance will not prevent future beach erosion, it will balance the sediment budget within the basin, which will help to maintain a wider, more linear beach planform.

Beach profile monitoring will be conducted before and after construction. The monitoring plan will be reviewed and approved by the Hawaiʻi Department of Land and Natural Resources, Office of Conservation and Coastal Lands (DLNR-OCCL). Requirements for post-construction beach profile monitoring will be confirmed during the final design and permitting process.

8.9 Sand Characteristics

The beaches of Waikīkī are composed primarily of calcareous (calcium carbonate) sand with minimal fine material. Carbonate sand is the most common type of beach sand along shorelines of the Hawaiian Islands and is the product of bioerosion and biological production on offshore reefs and marine waters. Carbonate sand is primarily composed of skeletal fragments of marine organisms such as corals, coralline algae, mollusks, echinoids, forams, with minor fractions of terrigenous (i.e., volcanic) sediment. The composition of sand is determined by the relative abundance of each contributing material and varies by location.

Carbonate sands range in color from pure white to yellow, brown, and dark grey. Beyond the aesthetic value, color also affects temperature, as darker sands achieve higher temperatures under the bright tropical sunlight than a lighter shade of sand. Native beach sand in Waikīkī is typically gold or tan in color.

Both density and grain size play an important role in how sand behaves on a beach. Grain size in beaches within the Hawaiian Islands can range from a very fine silt to large coral cobbles. The density of calcium carbonate crystals is roughly a constant 2.72 g/cm^3; however, microscopic pores and hollow grains make the effective density of individual grains somewhat lower. Smith and Cheung (2002) found the effective density of carbonate sand grains to be 2.4 g/cm^3.

The grain size characteristics of sand are typically determined by passing or shaking a sand sample through a series of sieves with progressively smaller openings. The amount of sand remaining on each sieve is weighed, and the corresponding percentage that this weight represents of the entire sample weight is computed. The results are presented graphically by plotting the percentage of the sample that is collected at each particular grain size on a logarithmic graph, with grain size plotted on a log base 10 x-axis.

The median diameter (diameter at which 50% of the sample's mass is composed of particles less than this value), or D_{50}, is often used by engineers to represent the grain size of a sample. D_{16} (diameter at which 16% of the sample's mass is composed of particles less than this value) and D_{84} (diameter at which 84% of the sample's mass is composed of particles less than this value) are used to quantify the range of grain sizes present in a sample known as sorting, σ, defined by:

$$\sigma = \frac{\varphi_{84} - \varphi_{16}}{2}$$

where $\varphi = \log_2(D)$, where D is diameter in millimeters. Descriptive sorting values are presented in Table 8-14.

Table 8-14 Sorting value descriptions

Sorting Range (Φ)	Description
0.00 – 0.35	very well sorted
0.35 – 0.50	well sorted
0.50 – 0.71	moderately well sorted
0.71 – 1.00	moderately sorted
1.00 – 2.00	poorly sorted
2.00 – 4.00	very poorly sorted
> 4.00	Extremely poorly sorted

Composite beach samples containing sand from the beach berm, beach crest, beach face, and beach toe were taken at various locations along the Waikīkī shoreline. Grain size analysis of representative sand samples indicates that the average median grain size is approximately 0.35 mm to 0.60 mm. Both of these average sizes are considered medium-grained sand according to the Wentworth Grain Size Classification.

Beaches typically have a higher degree of sorting (i.e., a narrower distribution of grain size) than other environments due to predominant waves, currents, and wind that naturally sort the sediment. In addition, open ocean beaches tend to have a relatively low percentage, by mass, of fines, as wave energy and currents mobilize these smaller grains and transport them away from the beach face into deeper water. Wind can also deliver finer grains across the backshore to dune systems. The existing beach sand in Waikīkī is well to moderately-well sorted with a very low percentage of fines (0 to 5%).

8.9.1 Potential Impacts and Mitigation Measures

A critical component of successful beach nourishment projects is the availability of suitable sand fill that is compatible with the existing beach sand. Sand fill should closely match the grain size distribution, color, composition, and density of the existing beach sand. Deviation from these characteristics may result in unpredictable behavior of the beach. The State of Hawai‘i Department of Land and Natural Resources (DLNR) established standards and guidelines, which specify that fill sand used for beach nourishment projects must meet several requirements:

- Sand shall contain no more than 6% fine material (grain size < 0.074 mm).
- Sand shall contain no more than 10% coarse material (grain size > 4.76 mm).
- The grain size distribution will fall within 20% of the existing beach sand.
- The overfill ratio of the fill sand to existing sand shall not exceed 1.5.
- Sand will be free of contaminants such as silt, clay, sludge, organic matter, turbidity, grease, pollutants, and others.
- Sand will be primarily composed of naturally occurring carbonate beach or dune sand.

Sand sources that have been determined to be suitable for placement can have undesirable characteristics that are difficult to fully identify prior to sand recovery or mitigate during sand placement. Potential problems include compaction and lithification of placed sand; coral cobbles in the placed sand; anoxic conditions in the recovered sand; change in beach color; and other issues dependent on the site and conditions.

Compaction occurs when grains are pressed together, reducing pore space between them. Heavily compacted sand can become partially or wholly lithified (solidified), having a consistency ranging from compact but friable (able to be easily broken down into sand grains), to more rock-like. Indurated (hardened) beach rock cannot be easily broken up into individual sand grains.

Sand compaction was observed following the 2012 Waikīkī Beach Maintenance I project along the truck haul route between the dewatering basin and the sand placement area. A 1- to 3-ft tall, hardened berm formed along the seaward edge of the truck haul route. This compaction is likely the result of heavy loaded dump trucks repeatedly traveling over the sand fill. Additionally, chemical processes in the form of carbonate dissolution and precipitation likely contributed to the hardening of the sand fill.

The sand fill for the proposed actions will be transported along the beach using equipment similar to that used in the Waikīkī Beach Maintenance I and II projects in 2012 and 2021, respectively. The combination of pressure, dissolution of calcium carbonate material from freshwater, and the presence of fines could increase the chances of induration (hardening) of the placed sand. Compaction from trucks will be minimized by mechanically loosening or turning the sand along the truck haul route at regular intervals. Moreover, truck haul routes can be monitored and plowed after project completion, if necessary.

Coral cobbles and rubble, which occur naturally in offshore sand deposits, were an issue during the 2012 Waikīkī Beach Maintenance I project. These larger cobbles accumulated along the beach toe and were uncomfortable for beach users. The potential for coral rubble was addressed during the design process, and efforts were made to reduce the recovery of large pieces of rubble from the offshore sand deposits. However, the amount of rubble reaching the beach still exceeded construction specifications, specifically for long and narrow pieces of rubble that were able to fit through a screen on the hydraulic sand pump. After placement, the rubble became concentrated along the beach toe, just below the waterline. The contractor removed coral rubble by hand, and the Hawai‘i Department of Land and Natural Resources (DLNR) organized volunteer rubble removal efforts after construction was completed.

Though the grain size distribution of the offshore sand proposed for use in the proposed actions has been thoroughly investigated, coral rubble, or sediment grains that are cobble-sized or larger, may exist sporadically within the sand deposits. During offshore sand sample recovery, no coral rubble larger than 1 inch in diameter was encountered at the offshore sand deposits. Additionally, air-jet probing encountered no layers of coral rubble between the sand surface and up to 8 ft below the seafloor. However, rubble may exist in discreet pockets within the sand deposits.

One of the disadvantages of clamshell dredging is that there is no method to screen coral rubble from the recovered sand at the dredge site. The contractor, therefore, should monitor the sand for coral rubble as the clamshell bucket empties the sand onto the barges, transfers the sand to the shore, and then places the sand on the beach. If excessive coral rubble is encountered in an area within the offshore sand deposits, sand recovery operations will move to a different location within the deposits.

The dewatered sand in the current 2021 Waikīkī Beach Maintenance II project was passed through a screen to remove particles larger than 1 in diameter prior to transport to the beach (Figure 8-47). Additionally, sieve testing was performed periodically on the deck barge as sand was being recovered. A relatively small volume of cobble was effectively screened and removed prior to sand placement. No cobble was placed on the beach.

Figure 8-47 Screening process to remove cobble from offshore sand

Borrow sand from offshore deposits would preferably match the color of the existing beach sand. While natural calcareous beaches can range in color, sand in offshore deposits usually turns a gray color as a result of anoxic conditions that occur due to a lack of wave action and associated mixing and aeration of the sand, or with depth within the deposits. Sand samples were taken from various layers in the offshore sand deposits and dried under direct sunlight. The color of the offshore samples, after several days of drying, closely matched the existing beach sand, though some samples had a slightly grayer color. Color comparison tests and drying, and experience with past projects in Waikīkī and elsewhere, indicate that the gray will fade over time when exposed to direct sunlight. In addition, the mixing of offshore sand and existing beach sand is expected to produce a final color that should be closer to that of the existing beach. Sand recovered from anoxic environments can also have an unpleasant odor. Based on previous sand recovery efforts in the Hawaiian Islands, any odor from recovered sand is anticipated to diminish with exposure to sun and air.

Borrow sand from offshore deposits is not anticipated to contain hazardous materials or contaminants. There have been no significant environmental contamination events in close proximity to the offshore deposits, and there are no known point sources of pollution that could potentially contaminate the sand. Thus, there is no reason to anticipate that sand recovered from the offshore deposits will contain contaminants.

Proposed Mitigation Measures

The contractor will monitor and screen the sand for coral rubble during sand recovery operations. If excessive coral rubble is encountered in an area within the offshore sand deposits, sand recovery operations will move to a different location within the deposits. The contractor will also monitor and screen the sand for coral rubble prior to and during sand placement operations.

8.10 Marine Biota

The U.S. Fish and Wildlife Service classifies the marine environment in Waikīkī as estuarine and marine deepwater habitat. The nearshore area along the shoreline is classified as marine, intertidal, unconsolidated shore that is regularly flooded. The offshore area is classified as marine, subtidal, coral reef (Figure 8-48).

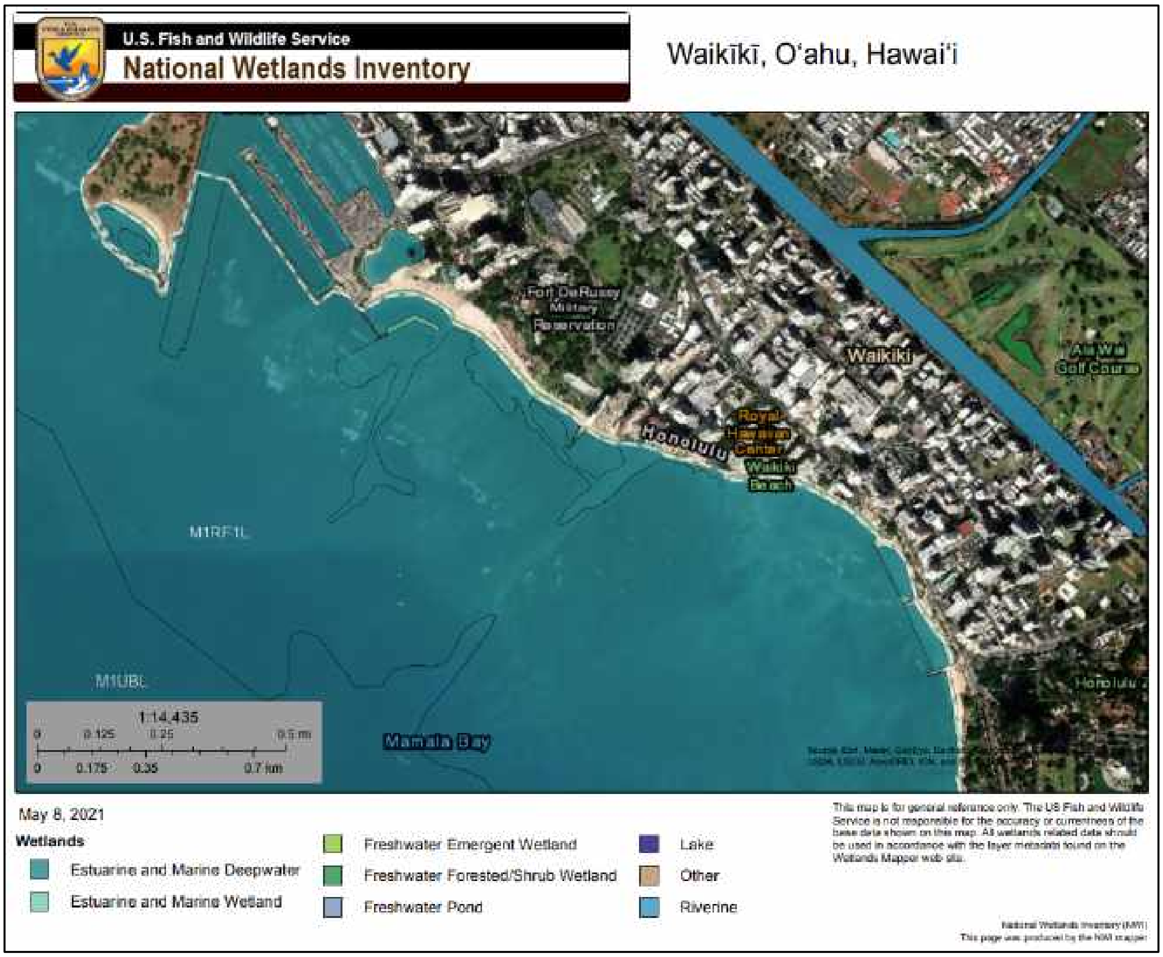


Figure 8-48 National Wetlands Inventory water classifications (USFWS)

The National Oceanographic and Atmospheric Administration (NOAA) defines the benthic habitat geomorphology offshore of Waikīkī as pavement, sand, and reef rubble (Figure 8-49). Benthic habitat biology is characterized by a combination of coralline algae, turf algae, and uncolonized seafloor (Figure 8-50).

Figure 8-49 Benthic habitat geomorphology (PacIOOS)

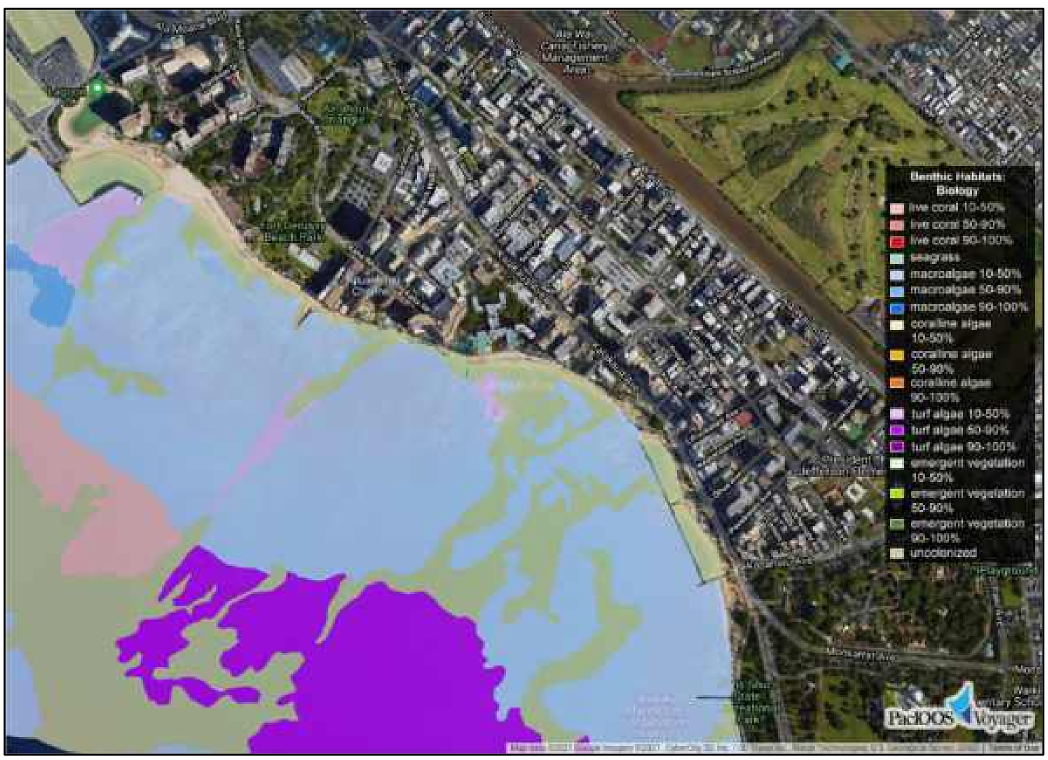


Figure 8-50 Benthic habitat biology (PacIOOS)

A Baseline Assessment of the Marine Biological Environment was prepared by AECOS, Inc. in April 2021 (see Appendix C). Biologists conducted surveys to inventory marine assemblages in the nearshore waters off the Project. Biologists used snorkel gear to collect data on bottom type, coral colony size-frequency (size, diversity, new recruits, large colonies, health); diversity, dentification and categorization (common vs. uncommon) of algae (including crustose coralline algae) and seagrass; and non-coral macro-invertebrates greater than 3 cm.

The point intercept method (also termed a line-point intercept method) was used to assess benthic composition on each transect. This protocol uses meter marks on the transect line as sample points. At 0.5-m intervals, the nature of the bottom under each "point" is identified and assigned to one of the following categories: sand, rubble, limestone (rock or pavement), turf algae, crustose coralline algae (CCA), live coral, or macroinvertebrate. Benthic percent cover was calculated by dividing the total number of points for each category by the total number of points sampled times 100.

A two-meter belt survey of coral colonies was conducted on each transect. All corals 1 m to either side of the transect line were counted. Coral abundance was determined as the number of individuals observed for each transect normalized to number of individuals per m^2. Coral heads were identified to species and assigned to a size class (1- to 5-cm; 6- to 10-cm; 11- to 20-cm; 21- to 40-cm; 41- to 80-cm; 81- to 160-cm; or >160-cm) based on the largest horizontal dimension of the colony. Coral size-class distribution was determined for each coral species recorded. Percent morbidity (amount of coral colony not alive) and any signs of disease were also recorded.

General Conditions

The dominant benthic organisms on the reef platform off Waikīkī Beach are marine macro-algae or *limu*, which cover most exposed hard surfaces not scoured or buried by shifting sand. Nearshore algal cover is 75 to 100% (based on visual estimates), except in areas exposed to sand scour (such as channel margins and limestone outcrops in sand fields) where algae coverage is less than 25% of the hard bottom. The growth form of these algae is typically low-growing or turf-like.

Up to 87 different species of algae have been reported from the Waikīkī reef since 1969 (Doty, 1969; Chave et al. 1973; OI, 1991; Huisman et al. 2007; MRC, 2007; and AECOS, 2007, 2008, 2009, 2010). Although the flora of Waikīkī reef remains relatively diverse today, two invasive red algae (*Rhodophyta*): *Acanthophora spicifera* and *Gracilaria salicornia*, dominate the benthic flora (Smith et al. 2004; Huisman et al. 2007; MRC, 2007; AECOS, 2007a, 2008, 2009a).

Common macro-invertebrates observed in various surveys on the reef flat off Waikīkī include *Holothuria atra*, *H. nobilis*, *Echinothrix diadema*, *Tripneustes gratilla*, *Echinometra mathaei*, *Echinostrephus aciculatus*, and various sponges (OI, 1991); *E. matheai*, *E. aciculatus*, and *H. atra* (MRC, 2007, AECOS, 2007a, 2008, 2009a).

The most common (although total cover comprising less than one percent of the bottom) hermatypic corals found on the reef flat off Waikīkī Beach are *Pocillopora meandrina* and *Porites lobata* (OI, 1991; MRC, 2007; and AECOS, 2007, 2008, 2009). In addition, *Cyphastrea* *ocellina* (MRC, 2007; AECOS, 2007, 2008, 2009), *Montipora capitata*, *M. patula*, *P. evermanni*, *Psammocora stellata*, *Leptastrea purpurea* (AECOS, 2007, 2008, 2009), and *L. bewickensis* (2009 and 2010 surveys) have been recorded.

Distribution of fishes on the reef flat off Waikīkī is largely determined by local topography and bottom composition. Fishes are generally uncommon in keeping with the mostly low topography on this inner reef flat. Surveys off Waikīkī (MRC, 2007; AECOS, 2009) found the most common species to be wrasses (*Thalassoma duperrey*, *T. trilobatum*, *Stethojulis balteata*), *Acanthurus triostegus* (manini), and *Rhinecanthus rectangulus* (reef triggerfish). These surveys also found several species of small juvenile fishes inhabiting small holes and spaces in the reef structure.

Fort DeRussy Beach Sector
Biologists surveyed the sand placement area of the Fort DeRussy beach sector. The survey consisted of a qualitative, reconnaissance snorkeling survey between the Fort DeRussy outfall/groin and the west end of the sand placement area, and out to approximately 25 m from the shoreline. The dominant substrate here is sand, with patches of rubble and limestone outcrops. Algal growth on the hard bottom was primarily *Padina* sp. and *A. spicifera*. One *Porites* sp. coral colony in the 6-10 cm size class was observed in this beach sector. Fishes were rare here and included threadfin butterflyfish (*Chaetodon Auriga*), Hawaiian sergeant (*Abudefduf abnominalis*), and spotted boxfish (*Ostracion meleagris*). One coral colony was observed in the Fort DeRussy beach sector.

Halekūlani Beach Sector
Six (6) survey stations were established at each of the potential groins and groin heads. One additional station was placed directly in front of the Halekūlani Hotel, traversing the sand channel. At the groin stations and Halekūlani station, a 60-m transect was run perpendicular to the shore from the beach crest and terminating near the end of the future groin footprint. At the proposed head stations, a 20-m transect was run parallel to the beach. A survey of benthic composition and coral size class and abundance (as described below) was undertaken along each 60-m "groin" transect and 20-m "head" transect.

Two invasive red algae, *Acanthophora spicifera* and *Gracilaria salicornia* are abundant on the reef flat off the Halekūlani sector of Waikīkī Beach. In addition to these two invasive algal species, other common species include: *Dictyota* spp., *Neomeris* sp., *Codium edule, Padina australis, Tubinaria ornata*, and *Asparagopsos taxifolia*. Another invasive species, *Avrainvillea amadelpha*, is present. Sea urchins are the most conspicuous invertebrates on the reef flat, particularly *Echinometra mathaei*, which burrows into the limestone, and *Tripneustes gratilla*, which grazes open hard bottom areas. *Holothuria atra*, the black sea cucumber or *loli*, is the most common sea cucumber here. Scattered coral colonies (*Porites* spp. and *Pocillopora damicornis*) occur on the reef flat in the Halekūlani beach sector.

Thalassoma duperrey (saddle wrasse) is the most common species on the reef flat in the project area. *Acanthurus triostegus sandvicensis* (manini) is also commonly seen in small schools feeding on benthic algae, and *Thalassoma trilobatum* (Christmas wrasse), *Stethojulis balteata* (belted wrasse), and *Rhinecanthus rectangulus* (reef triggerfish) are commonly seen solitarily scavenging for algae and benthic invertebrates. *Naso unicornis* (kala) and *Arothron hispidus* (ʻoʻopu hue) are encountered occasionally farther offshore.

Four 60-m transects and two 25-m transects were used to assess the benthic community of the seafloor in the Halekūlani beach sector. The dominant bottom type is rubble, at 24%, closely followed by sand and macroalgae, with similar covers at 23% and 19%, respectively. Live coral is low across the transects, at less than 1% of the total.

A total of 28 colonies were counted on the six transects. Density of corals in the proposed groin and T-head footprints of the Halekūlani beach sector is low, with an average of 0.1 colony/m^2. A total of 28 coral colonies, representing at least three coral taxa (*Pocillopora damicornis*, *Porites compressa* and *Porites* sp.) were recorded. The most common species was *Porites* sp. at 57% of the total. The most common colony size was the 1- to 5-cm class (39% of the total). Large (41- to 80- cm) colonies were rare (one *Porites* sp. colony). No colonies greater than 80 cm were recorded.

Overall coral cover at the proposed groin locations is very low (mean of 0.1 colony/m^2). In general, coral colonies here are small, with 64% being less than 10 cm in diameter. The lack of large coral heads is evidence that the Waikīkī marine environment is not particularly favorable to coral growth. Coral settlement and growth are limited by impinging waves, scour by rubble and sand, reduced light conditions associated with turbid water events, and burial with fine sediment. The proposed rock rubblemound groins and sand fill will bury a portion of the existing subtidal environment of primarily low relief sand, rubble, and limestone. This limestone provides substrate for macroalgae and coralline algae growth, as well as habitat for macroinvertebrates. Placement of boulders and sand will result in loss of some benthic organisms, including corals. These corals provide ecological services to the coral reef ecosystem: shelter, reef consolidation, food for corallivores, or coral gametes.

Impacts to corals could be avoided by relocating the few scattered corals that occur in the footprint of the placed sand and groins. Benthic invertebrates will repopulate from surrounding habitat after construction is completed and sessile organisms will colonize new hard surfaces (*AECOS*, 2014-2020). Additionally, the proposed groins and sand fill will provide stable, hard bottom for coral settlement and possibly calmer waters for coral development, but coral assemblage development may be compromised by competition for space, freshwater influence, sediment transport, and heavy utilization of the nearshore by the human population.

Fish abundance and diversity are directly correlated with topographical structure and complexity (Friedlander and Parrish, 1998; Ménard et al. 2012). Fish species richness, biomass, and diversity tend to be highest in environments with considerable spatial relief such as along limestone outcrop/sand bottom interfaces; fish biomass is lowest on shallow reef flats (Friedlander and Brown, 2006) of the sort in the project area. Although most of project area reef has low topographic relief, where vertical structure does occur, fishes are present and sometimes in high numbers. The distribution of topographical relief on this reef is highly patchy and weakly captured by our transect locations and survey areas. Stations with visibly greater relief, in the form of limestone outcrops, existing breakwaters and groins had greater fish abundance than the reef flat. The substantial structural complexity and topographical relief offered by the groins is expected to provide habitat for fishes and an increase in fish species richness, biomass, and abundance can be anticipated (AECOS, 2020).

Two common algae species found in Waikīkī are non-native and invasive: *A. spicifera* and *G. salicornia*. These species are widespread off the shores of the Hawaiian Islands and *A. spicifera* is a food favored by green sea turtles. The groin structures are not anticipated to affect species introductions to Hawaiʻi but may serve as habitat for existing introduced species. Future monitoring events should note any changes in the distribution of *A. spicifera* and other invasive species in Waikīkī.

The proposed action is not anticipated to result in any significant long-term degradation of the environment or loss of habitat. Rather, by the construction of the proposed groins, the proposed action will improve the shoreline conditions, restore the beach, and increase potential biological habitat in a relatively barren reef flat area. Ecological services of reef flat habitat will be lost under the project footprints (sand and groins) but are anticipated to recover over time as the benthic community re-establishes. A biological and water quality monitoring program will be implemented to enhance control over construction impacts.

<u>Royal Hawaiian Beach Sector</u>
Biologists surveyed the Royal Hawaiian beach sector, conducting qualitative surveys of the seafloor. The qualitative survey extended east from the Royal Hawaiian groin to the Kūhiō crib wall, and approximately 20 m out from the shoreline. The Royal Hawaiian beach sector is sand with occasional limestone outcrops with algae (*Acanthophora spicifera*, *Padina* sp., and patches of *Gracilaria salicornia*). Corals are absent in this beach sector. Much of this area is intertidal or shallow subtidal marked by small, breaking waves most days of the year.

<u>Kūhiō Beach Sector</u>
Biologists surveyed the entire existing breakwater structures and immediate surrounding basin floor for corals and other marine biota. A census of corals was made along the entirety of the existing groin. The intertidal zone of the existing structures is covered with small numbers of nerite snail (*Nerita picea*), thin shelled rock crab (*Grapsus tenuicrustatus*), and macroalgae (*Cladophora* sp. *Hydrolithon onkodes*, *Dictyota acutiloba*, *Laurencia nidifica*, *Acanthophora spicifera*, and *Gracilaria salicornia*). Invertebrates common here include urchins (*E. mathaei* and *Diadema paucispinum*) and sea cucumbers (*Holothuria atra* and *H. cinerascens*).

A census of corals was made along the entirety of the existing crib wall. No corals were observed on the existing structure. Several coral colonies (*Pocillopora damicornis*) in the <5 cm size class were observed on the outside of the seafloor beyond the crib wall, approximately 10 ft (3 m) seaward from the structure.

A total of 17 species of fishes were identified in and around the basin. Fishes closely associated with the structures included: trumpetfish (*Alustomus chinensis*), Hawaiian gregory (*Stegastes marginatus*), yellowfin goatfish (*Mulloidichthys vanicolensis*), and tobies (*Canthigaster amboinensis*, and *C. jacator*). Other fishes observed included: surgeonfishes (*Acanthurus triostegus*, *Acanthurus blochii*, juvenile *Naso unicornis*), wrasses (*Stethojulis balteata*, *Thalassoma duperrey* and *T. purpurem*), schools of flagtail (*āholehole* or *Kuhlia xenura*), schools of goatfishes (*Parupeneuss multifasciatus* and *P. porphyreus*).

8.10.1 Potential Impacts and Mitigation Measures

Mitigating impacts to marine resources is a sequential process of avoiding impacts, minimizing impacts, and then compensating for unavoidable adverse impacts. The first step is to avoid impacts through project design. The second step, after avoidance measures have been incorporated, is to minimize remaining impacts. If unavoidable impacts still exist after avoidance and minimization, then replacement of lost ecosystem functions and values is appropriate. This last step is called compensatory mitigation (Bentivoglio, 2003). Project design decisions should incorporate measures to avoid and minimize impacts to marine communities associated with beach stabilization to the extent possible. In particular, impacts to corals in the footprint of the proposed sand borrow margins should be avoided by excluding those areas from the dredging limits.

The United States Coral Reef Task Force (USCRTF) has identified a portfolio of compensatory mitigation and restoration options (USCRTF, 2016) and a list of Best Management Practices (BMPs) that could be implemented to offset adverse impacts on coral reef communities from projects. The USCRTF list was reviewed and screened for appropriateness to anticipated project-related impacts, ability to successfully implement, and impacts already minimized by project specific BMPs.

The proposed actions have the potential to affect marine biota. Potential impacts include:

- Direct physical disturbance of the seafloor and water column during construction.
- Indirect effects associated with project related changes in water quality.
- Indirect effects related to re-colonization patterns as biota re-establishes itself in areas that were disturbed by temporary construction activities following the completion of construction.

Potential biological effects are considered to be significant to the extent that they exceed the following criteria:

- Change environmental conditions (e.g., water quality, ambient noise level, wave energy, etc.) within a substantial part of the range of an important marine community.
- Involve work in a habitat believed to be used by known sensitive species (Federal or State listed endangered, essential fish habitat, etc.) or in a conservation district.
- Substantially affect the spawning area available to a marine species.

<u>Sand Recovery Effects on Benthic Habitat</u>

Dredging operations have the potential to impact benthic habitat in the vicinity of the sand recovery areas. Analytical modeling was conducted to evaluate the potential impacts of sedimentation on benthic habitat resulting from clamshell dredging for the *Ala Moana* and *Hilton* offshore sand deposits. (see Figure 8-51 and Figure 8-52). The modeling results indicate that there would be no anticipated impacts to benthic habitat in the vicinity of the sand recovery areas.

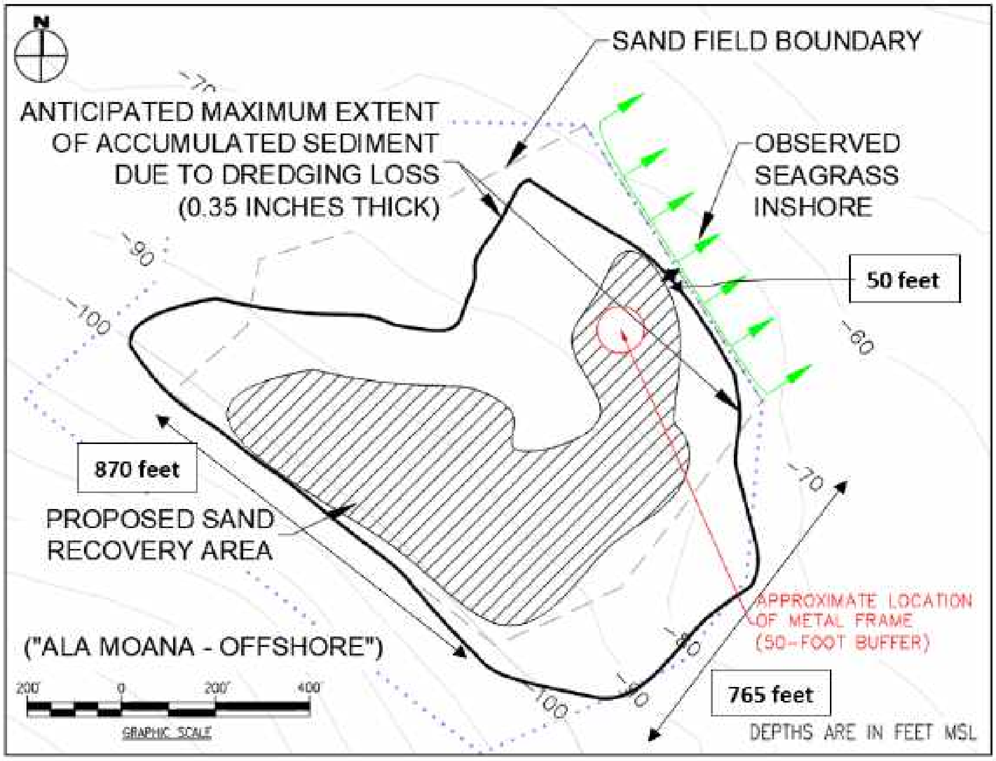


Figure 8-51 Sediment plume modeling results for *Ala Moana* offshore sand deposit

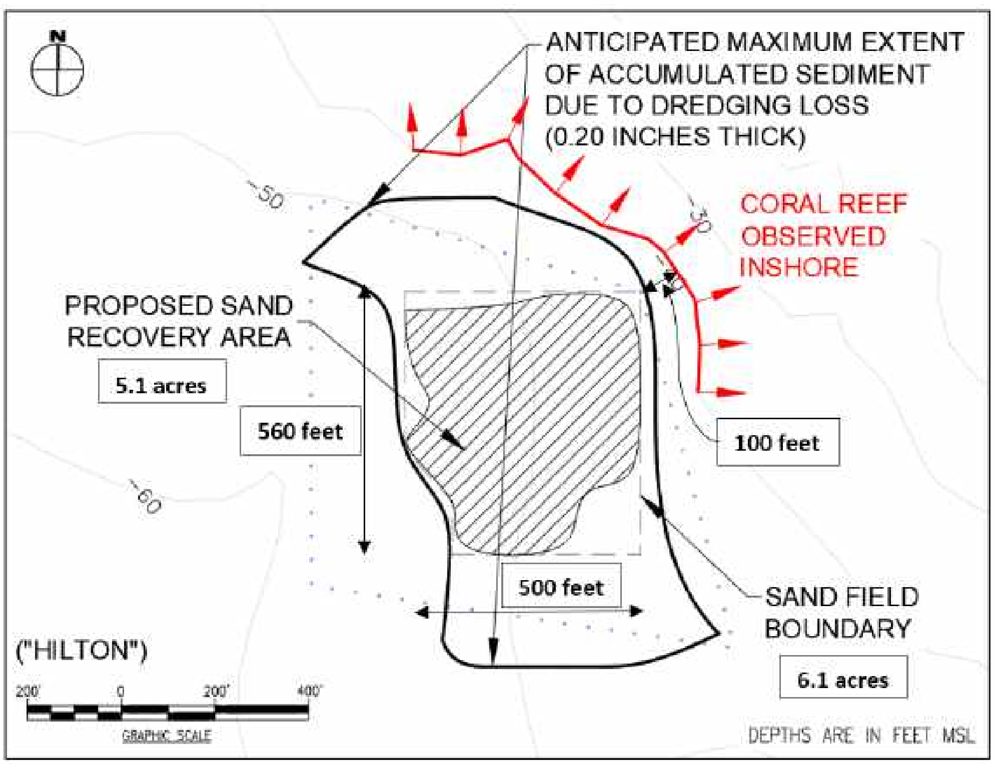


Figure 8-52 Sediment plume modeling results for *Hilton* offshore sand deposit

Analytical modeling was not conducted to evaluate the potential impacts of sedimentation on benthic habitat resulting from dredging activities for the *Canoes/Queens* and *Diamond Head* offshore sand deposits. The *Canoes/Queens* deposit has been used in previous beach nourishment projects in 2012 and 2021. Sand recovery for those projects was accomplished using a hydraulic suction dredge and pumping the sand through a high-density polyethylene (HDPE) pipe to a dewatering basin in the Diamond Head (east) basin of Kūhiō Beach Park. When compared to clamshell dredging, hydraulic suction dredging significantly reduces the potential for sedimentation that could impact benthic habitat.

<u>Sand Recovery Effects on Infauna</u>

Investigation of infauna in the Halekūlani Channel sand deposits identified 31 species of infauna (Bailey-Brock and Krause, 2008). The most abundant taxa observed are the nematodes (round worms, phylum *Nematoda*; 62 percent), followed by oligochaete worms (earth worm relatives, phylum *Annelida*, subclass *Oligochaeta*, 12 percent) and copepods (tiny crustaceans, phylum *Arthropoda*; 8 percent). While the sand deposits may contain a diverse assemblage of infaunal invertebrates, none have been listed as threatened or endangered by Federal or State agencies and none of the infaunal species found are known to be preyed on by typical reef fish. Moreover, the types of organisms that are present have a relatively fast reproductive cycle and those organisms that survive the dredging typically repopulate areas within a relatively short period of time. Dredging will remove sand from the recovery sites, and thus disturbance to infauna in the respective sand deposits will be significant. However, based on the recent 2006 Kūhiō Beach Restoration project, the sand deposits can be expected to fill back up with sand over time, and possibly quite rapidly, and infauna can be expected to rapidly repopulate the deposits.

<u>Sand Recovery Effects on Corals</u>

Studies conducted for the State's 2006 Kūhiō Beach Restoration project provide an excellent model for evaluating potential effects on coral and other marine biota (AECOS, 2007, 2008). The sand recovery sites are bordered by fossil limestone reef rock with less than 1 percent live coral cover. A survey conducted soon after the sand recovery work was completed identified some damage to individual coral colonies, with the condition of individual coral colonies varying greatly. Some corals were in pristine condition, others were mildly damaged (some branches broken, but colony mostly intact), and some were severely damaged or missing entirely. The majority of damage to corals appeared to be the result of equipment movement (pipeline, anchor lines), and much of this appeared to have occurred during an unseasonable south swell event that occurred during the dredging operations.

Biologists re-surveyed the sand recovery area approximately one year following the completion of the work and prepared a final post-construction survey report (Laing, February 22, 2008). Two divers snorkeled the area to inspect individual coral colonies for signs of previously existing damage and for signs of new damage. No recent coral damage was observed during the one-year survey. Previously damaged coral colonies and their cast off fragments experienced varying degrees of recovery success. They found that some coral colonies had succumbed to mechanical damage and died while others had responded with copious growth leading to a more robust growth form. A few previously damaged coral colonies with branches missing were revisited several times. The observations indicated illustrate that there was mixed success in coral fragment survival. Cast-off fragments either fell from the parent colony into a location that promoted growth or into a location that did not. Fragments that landed on sand died without having a stable place to become established. Fragments that landed on hard substrate sometimes survived initially, but later became overgrown with turf algae and died. Other live fragments observed in the 1-year survey were located in small shallow depressions in the reef that are protected during periods of elevated wave energy allowing them continued growth.

Measures proposed to be exercised to protect corals during construction activities include:

- Locating and marking significant corals in the vicinity of the sand recovery areas;
- Identifying pipeline route corridors to minimize the potential for damage to coral and other benthic fauna; and
- Transplanting corals, as necessary and where practicable, to relocate them from the construction site, particularly along the pipeline route.

Sand Recovery Effects on Fishes

The sand deposits are typically home to a relatively small and depauperate resident fish population. None of the fish species that have been observed are listed as rare or endangered. Neither are they considered particularly desirable by fishermen nor by those who conduct subsistence fishing along the shoreline. The Hawaiʻi Coral Reef Assessment and Monitoring Program (CRAMP, 2008) ranked Waikīkī low in mean number of species (55th) and fish biomass (51st) when compared to 56 other CRAMP sites throughout the main Hawaiian Islands. These fish are mobile, as evidenced by the fact that fish ingestion during sand pumping operations was not reported during the State's 2006 Kūhiō Beach Restoration project. The vast majority of fishes are capable of avoiding the equipment used to recover and transport sand from offshore to the shoreline. Sand recovery operations will temporarily displace fish in the vicinity of the operations but are unlikely to injure or kill a substantial number of fish. Furthermore, because the resident fish population is small, the number of affected individuals will be small as well. Consequently, no significant effects to fish are anticipated.

Sand Placement Effects

Sand placement to widen the beaches will take place almost completely on existing sand bottom or barren reef flat. Site investigations show that only about 5 percent of the project footprint may cover exposed limestone reef rock bottom, and even this nearshore hard bottom is regularly scoured and sometimes covered by sand. The new beach will replace in kind the sand bottom to be covered by the beach widening.

Short-term Impacts

The proposed action in the Halekūlani beach sector is not anticipated to result in any significant long-term degradation of the environment or loss of habitat. Rather, by the construction of the proposed groins, the proposed action will improve the shoreline conditions, restore the beach, and increase potential biological habitat in a relatively barren reef flat area. Ecological services of reef flat habitat will be lost under the project footprints (sand and groins) but are anticipated to recover over time as the benthic community re-establishes. Most adult fish in the project vicinity are mobile and will actively avoid direct impacts from project activities. There is potential for demersal fish eggs to be buried; however, new hard substrata created by the groins will provide greater surface area for these species to lay eggs in the future. Some impairment of ability of

EFH managed species to find prey items could occur, but this effect should be temporary and spatially limited to the immediate vicinity of construction activities. Turbidity containment barriers will effectively isolate the construction activities from the adjacent seafloor and water column; thus, impacts to marine biota will be limited to the immediate construction area. A biological and water quality monitoring program will be implemented to enhance control over construction impacts.

Long-term Impacts

The proposed action in the Halekūlani beach sector will create approximately 3.8 acres of new dry beach area. Marine habitat in this area consists of a relatively barren reef flat. The groins will provide bare, stable surfaces for recruitment of corals, algae, and other invertebrates. The groins will be porous, permeable, with approximately 37 percent interstitial void space between stones. Obligate reef dwellers are often limited by the availability of suitable shelter, especially juveniles. Reef fishes prefer reef holes and crevices commensurate with the size of the fish. The interstitial spaces between stones will also provide habitat for benthic (crabs, shrimps, worms, etc.) and sessile organisms (sponges and tunicates) which will provide additional foraging resources for fishes. The boulders also provide a hard, stable surface for coral colonization, and elevates them above the shifting sand and rubble bottom.

The Iroquois Point Beach Nourishment and Stabilization project, which was completed in 2013, involved the construction of nine rock rubblemound groins very similar in size and construction to the proposed groins in the Halekūlani beach sector. Extensive marine ecosystem monitoring is being accomplished for that project (AECOS, 2014). The 1-year post-construction marine ecosystem monitoring shows that the project has resulted in a significant increase in marine species diversity and density. In the vicinity of the groins there has been a 25-fold increase in fish abundance, not counting small baitfish, and a tripling of species richness (number of species). Fish biomass is more than six times greater than prior to construction. Prior to construction of the groins, fish biomass at Iroquois Point was considered low compared to island averages around the state, roughly on par with the shallow reef flats off Waikīkī (AECOS, 2009b, 2011, 2014). After construction, the biomass at the groins is on par with maximum values observed around the state (AECOS, 2014). Other changes in the vicinity of the groins includes an increase in crustose coralline algae cover from 1% to 60%, coral cover increase from 0 to 0.6% and macroinvertebrate cover from 1.4% to 6.3%. Coral abundance in the groin vicinity increased from 0 to 16 colonies per 10 m^2, with the most common coral species being *Pocillopora damicornis*. These changes are attributable to the creation of hard, stable habitat for colonization.

The proposed actions have the potential to increase the spread of invasive species, particularly *A. erecta*. Areas where *A. erecta* have been observed will be identified and avoided during sand recovery operations. Two common algae species found in Waikīkī are non-native and invasive: A. *spicifera* and *G. salicornia*. These species are widespread off the shores of the Hawaiian Islands and *A. spicifera* is a food favored by green sea turtle. The proposed groins in the Halekūlani beach sector are not anticipated to affect species introductions to Hawaiʻi but may serve as habitat for existing introduced species. Future monitoring events will note any changes in the distribution of *A. spicifera* and other invasive species in Waikīkī.

8.11 Essential Fish Habitat

The 1996 Sustainable Fishery Act amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and subsequent Essential Fish Habitat (EFH) Regulatory Guidelines (NOAA, 2002) describe provisions to identify and protect habitats of federally-managed marine and anadromous fish species. Under the various provisions, federal agencies that fund, permit, or undertake activities that may adversely affect EFH are required to consult with the National Marine Fisheries Service (NMFS).

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH is further defined by existing regulations as (MSFCMA, 1996; NOAA, 2002). "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" is defined as required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' life cycle.

The proposed actions are located within waters designated as EFH (including water column and all bottom areas) for coral reef ecosystem, bottomfish, pelagic, and crustacean MUS. Of the thousands of species which are federally managed under the coral reef fishery management plan (FMP), at least 58 (juvenile and adult life stages) are known to occur in the general vicinity of Waikīkī Beach (MRC, 2007; AECOS, 2009, 2010, 2012).

The Western Pacific Regional Fishery Management Council (WPRFMC) has restructured its management framework from species-based fishery management plans (FMPs) to place-based fishery ecosystem plans (FEPs). The Hawaiian Archipelago FEP establishes the framework under which the WPRFMC will manage fishery resources and begin the integration and implementation of ecosystem approaches to management in the Hawaiian Archipelago. This FEP does not establish any new fishery management regulations, but rather consolidates existing fishery regulations for demersal species. Specifically, this FEP identifies as MUS those species known to be present in waters around the Hawaiian Archipelago and incorporates all of the management provisions of the Bottomfish and Seamount Groundfish FMP, the Crustaceans FMP, the Precious Corals FMP, and the Coral Reef Ecosystems FMP that are applicable to the area.

In addition to EFH, the WPRFMC identifies Habitat Areas of Particular Concern (HAPC) within EFH for all FEPs. Specific subsets of EFH, HAPCs are areas within EFH that are essential to the life cycle of federally managed coral reef species. In determining whether a type or area of EFH should be designated as a HAPC, one or more of the following criteria established by NMFS should be met: (a) the ecological function provided by the habitat is important; (b) the habitat is sensitive to human-induced environmental degradation; (c) development activities are, or will be, stressing the habitat type; or (d) the habitat type is rare.

8.11.1 Potential Impacts and Mitigation Measures

The proposed actions have the potential to affect EFH. Potential impacts include:

- Direct physical disturbance of the bottom during sand dredging and pumping, and sand placement on the beach.
- Direct physical disturbance of biota in the water column and the disturbed sand substrate as a result of project-related construction activities.
- Indirect effects associated with project related changes in water quality.
- Indirect effects related to re-colonization patterns as biota re-establishes itself in areas that were disturbed by temporary construction activities following the completion of construction.

This section of the ~~DPEIS~~FPEIS describes those potential biological effects. Effects are considered to be significant to the extent that they exceed the following criteria:

- Change environmental conditions (e.g., water quality, ambient noise level, wave energy, etc.) within a substantial part of the range of an important marine community.
- Involve work in a habitat believed to be used by known sensitive species (Federal or State listed endangered, essential fish habitat, etc.) or in a conservation district.
- Substantially affect the spawning area available to a marine species.

Sand Recovery Effects on Infauna

Investigation of infauna in the nearby Halekūlani Channel sand deposits identified 31 species of infauna (Bailey-Brock and Krause, 2008). The most abundant taxa observed are the nematodes (round worms, phylum Nematoda; 62 percent), followed by oligochaete worms (earth worm relatives, phylum Annelida, subclass Oligochaeta, 12 percent) and copepods (tiny crustaceans, phylum Arthropoda; 8 percent). While the sand deposits may contain a diverse assemblage of infaunal invertebrates, none have been listed as threatened or endangered by Federal or State agencies and none of the infaunal species found are known to be preyed on by typical reef fish. Moreover, the types of organisms that are present have a relatively fast reproductive cycle and those organisms that survive the dredging typically repopulate areas within a relatively short period of time. Dredging will remove about 35 percent of the total estimated sand available from the recovery sites, and thus disturbance to infauna in the respective sand deposits will be substantial and significant. However, based on the recent Kūhiō Beach experience, the sand deposits can be expected to fill back up with sand over time, and possibly quite rapidly, and infauna can be expected to rapidly repopulate the deposits.

Sand Recovery Effects on Corals

Studies conducted for the State's 2006 Kūhiō Beach Restoration Project, which involved nearly identical activity in the same area, provide an excellent model understanding possible effects on coral and other marine biota (AECOS, 2007, 2008). The sand recovery sites are bordered by fossil limestone reef rock with less than one percent live coral cover. A survey conducted soon after the sand recovery work was completed identified some damage to individual coral colonies, with the condition of individual coral colonies varying greatly. Some corals were in pristine condition, others were mildly damaged (some branches broken, but colony mostly intact), and some were severely damaged or missing entirely. The majority of damage to corals appeared to be the result of equipment movement (pipeline, anchor lines), and much of this appeared to have occurred during an unseasonable south swell event mid-way during the dredging operations.

Biologists re-surveyed the sand extraction area approximately one year following the completion of the work and prepared a final post-construction survey report (Laing, February 22, 2008). Two divers snorkeled the area to inspect individual coral colonies for signs of previously existing damage and for signs of new damage. No recent coral damage was observed during the one-year survey. Previously damaged coral colonies and their cast off fragments experienced varying degrees of recovery success. They found that some coral colonies had succumbed to mechanical damage and died while others had responded with copious growth leading to a more robust growth form. A few previously damaged coral colonies with branches missing were revisited several times. The observations indicated illustrate that there was mixed success in coral fragment survival. Cast-off fragments either fell from the parent colony into a location that promoted growth or into a location that did not. Fragments that landed on sand died without having a stable place to become established. Fragments that landed on hard substrate sometimes survived initially, but later became overgrown with turf algae and died. Other live fragments observed in the 1-year survey were located in small shallow depressions in the reef that are protected during periods of elevated wave energy allowing them continued growth.

Measures proposed to be exercised to protect corals during construction activities include:

- Locating and marking significant corals in the vicinity of the areas to be dredged;
- Identifying a specific pipeline route corridor which minimizes the potential for damage to coral and other benthic fauna; and
- Transplanting corals as necessary and where practicable to relocate them from the construction site, particularly along the pipeline route.

Sand Recovery Effects on Fish and Essential Fish Habitat

The sand deposits are typically home to a relatively small and depauperate resident fish population. None of the fish species that have been observed is listed as rare or endangered. Neither are they considered particularly desirable by fishermen nor by those who conduct subsistence fishing along the shoreline. The Hawai‘i Coral Reef Assessment and Monitoring Program (CRAMP, 2008) ranked Waikīkī low in mean number of species (55th) and fish biomass (51st) when compared to 56 other CRAMP sites throughout the Main Hawaiian Islands. These fish are mobile. As evidenced by the fact that fish ingestion by a similar pump was not reported during the 2006 Kūhiō Beach Nourishment project, the vast majority of fishes are capable of avoiding the suction intake. Thus, the sand recovery operation will temporarily displace fish in the vicinity but is unlikely to injure or kill a substantial portion of the population. Furthermore, because the resident fish population is small, the number of affected individuals will be small as well. Consequently, no significant effect is anticipated.

Long-term Effects

The bottom composition in the nearshore environment of Waikīkī and the project vicinity consists of a highly bioeroded fossil limestone reef platform with sand channels and deposits. The benthic community structure is heavily influenced by the scouring action of wave driven sand. The dominant taxa of benthic organisms are algae; corals and other macroinvertebrates are relatively rare. The greatest density and diversity of biota is found in areas where high vertical relief provides protection from sand scour. The Waikīkī sea bottom is dominated by two introduced and invasive algal species: *Acanthophora spicifera* and *Gracileria salicornia*. Another invasive algal species, *Avrainvillea amadelha*, is also becoming more common.

AECOS (2007, 2008) conducted post-project marine monitoring for the 2006 Kūhiō Beach Nourishment project at intervals of 3, 6, 12 and 15 months. Four "impact" monitoring sites were located offshore of the Kūhiō Beach crib walls, one site was located midway along the proposed project reach (offshore of the Moana Surfrider Hotel), and control sites were located to the east in the Waikīkī Marine Life Conservation District and to the west offshore of the Sheraton Waikiki Hotel. The post-construction monitoring showed a significant increase in the percent coverage of algae over the 15-month period, and other changes throughout the study area, however the changes were also evident at the control sites outside of the presumed influence of the project, thus it was concluded that the observed changes are due to factors other than the beach nourishment project. Based on this past experience, no significant long-term impacts are anticipated from the proposed action.

8.12 Protected Species

The nearshore area off Waikīkī is frequented by the threatened green sea turtle (*Chelonia mydas*), which feeds on the algae covered bottom. Hawaiian monk seals (*Monachus schauinslandi*) have been seen in Waikīkī on rare occasions, and they have not been reported in the vicinity of the proposed actions. No other listed species have been observed.

Biologists have noted the regular presence of sea turtles in the project area. No obvious congregation or resting areas have been seen, but the turtles clearly forage on the algae that grows in the nearshore area. Turtle surveys in the general area indicate that turtle abundance is not negatively affected by the number of people in the water or all the ocean recreation activities which occur in Waikīkī.

Green Sea Turtles

The distinct population segment (DPS) of green sea turtle that occurs in Hawaiʻi is federally-listed as a threatened species (USFWS and NOAA-NMFS, 2016; UFWS, 2018) and as a threatened subspecies (*Chelonia mydas agassizi*) under Hawaiʻi regulations (DLNR, 2014).

Threats to the green sea turtle in Hawaiʻi include: disease and parasites, accidental fishing take, boat collisions, entanglement in marine debris, loss of foraging habitat to development, and ingestion of marine debris. Throughout the global range of green sea turtle, nesting and foraging habitats are being altered and destroyed by coastal development, beach armoring, beachfront lighting, vehicular/pedestrian traffic, invasive species, and pollution from discharges and runoff (NOAA and USFWS, 2007a, 2007b). Adult green sea turtles forage in shallow nearshore areas and on coral reefs. Contamination from effluent discharges and runoff has degraded these environments, and invasive species may reduce native algae species preferred by green sea turtles or could exacerbate susceptibility to, or development of disease (NOAA-NMFS and USFWS, 2007a). Fibropapillomatosis, a disease characterized by the presence of internal and/or external tumors that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators continues to be a major threat to green sea turtles. Extremely high incidence has been reported in Hawaiʻi, where affliction rates peaked at 47-69% in some turtle foraging areas (Murakawa et al. 2000).

Hawksbill Sea Turtles

The Hawksbill sea turtle is distributed across the Pacific, Indian, and Atlantic oceans. Hawksbill sea turtle is much less common in the Hawaiian Islands than green sea turtle and is known to nest only in the southern reaches of the state (NOAA-PIFSC, 2010). Hawksbill sea turtle is federally-listed as endangered and is also listed as an endangered subspecies (*Eretmochelys imbricata bissa*) under Hawaiʻi regulations (DLNR, 2014). Hawksbill sea turtle faces many of the same threats affecting green sea turtle (see above section; NOAA and USFWS, 2007b).

Hawaiian Monk Seals

The endangered Hawaiian monk seal (*Monachus schauinslandi*) is known to occur in the project vicinity. The Hawaiian monk seal was first listed as an endangered species pursuant to the ESA on November 23, 1976 (41 FR 51612) and remains listed as endangered. In that same year, the Hawaiian monk seal population was designated as "depleted" under the Marine Mammal Protection Act (MMPA).

The majority of monk seal sighting information collected in the main Hawaiian Islands is reported by the general public and is highly biased by location and reporting effort. Systematic monk seal count data come from aerial surveys conducted by the Pacific Islands Fisheries Science Center (PIFSC). Aerial surveys of all the main Hawaiian Islands were conducted in 2000-2001 and in 2008 (Baker and Johanos, 2004, PIFSC unpublished data). One complete survey of Oʻahu was conducted for each of these years. The 2000 survey was conducted from an airplane and the 2001 and 2008 surveys were conducted by helicopter. No Hawaiian monk seals were sighted off Waikīkī during any of the three surveys.

Reports by the general public, which are non-systematic and not representative of overall seal use of main Hawaiian Islands shorelines, have been collected in the main Hawaiian Islands since the early 1980s. In total, seventy-six Hawaiian monk seal sightings have been reported off Waikīkī, east of the project vicinity between Queen's Beach and Sans Souci Beach, between 2002 and 2011. A sighting is defined as a calendar day during which an individual seal was documented as present at a given location. It should be noted that the majority of monk seal sightings are reported when seals are sighted onshore. No births were documented for the area during this period. Additional sightings, including at least three seal pup births, are known to have occurred in Waikīkī since these surveys were conducted.

Critical habitat for Hawaiian monk seals has been designated (NOAA-NMFS, 2015) and includes the seafloor and marine environment to 10 m above the seafloor from the 200 m depth contour, through the shoreline and extending onto the land 5 m inland from the shoreline between identified boundary points. These terrestrial boundary points define preferred pupping areas and significant haul-out areas. Waikīkī is excluded from terrestrial critical habitat designation (NOAA-NMFS, 2015).

Humpback Whales

The humpback whale or *koholā* (*Megaptera novaeangliae*) was listed as endangered in 1970 under the ESA. In 1993 it was estimated that there were 6,000 humpback whales in the North Pacific Ocean, and that 4,000 of these regularly came to the Hawaiian Islands. The population is estimated to be growing at between 4 and 7% per year. Today, as many as 10,000 humpback whales may visit Hawaiʻi each year (HIHWNMS, 2014).

The waters of Maunalua Bay and offshore of Diamond Head but outside of the project area are within the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). Humpback whales normally occur in Hawaiian waters annually from November to May with the peak between January and March (HIHWNMS, 2014). The proposed actions will not directly affect humpback whales, and sounds generated from groin improvement activities are not anticipated to be substantial enough to cause an acoustic disturbance to protected species in nearshore waters. The effects thresholds currently used by NMFS are marine mammal specific and based on levels of harassment as defined by the Marine Mammal Protection Act (MMPA). For exposure to sounds in water, >180 dB and >190 dB are the thresholds for Level A harassment (i.e., injury and/or PTS) for cetaceans and pinnipeds, respectively. The thresholds for Level B harassment for all marine mammals in the form of temporary threshold shifts (TTS)and other behavioral impacts are >160 dB for impulsive noises and >120 dB for continuous noises (NOAA, 2013).

Invertebrates

The Hawaiʻi Department of Land and Natural Resources (DLNR) regulates shellfishes such as pearl oysters (DLNR, 1987) and ʻopihi (DLNR, 1989). No ʻopihi species or pearl oyster (*Pinctada margaritifera*) were observed in our survey of the Project area.

Coral species are protected under Hawaiʻi State law, which prohibits "breaking or damaging, with any implement, any stony coral from the waters of Hawaiʻi, including any reef or mushroom coral" (§13-95-70, HAR, DLNR, 2010). It is also unlawful to take, break or damage with any implement, any rock or coral to which marine life of any type is visibly attached (§13-95-71, HAR, DLNR, 2002).

In February 2010, 83 species of corals world-wide were petitioned for listing as threatened or endangered under ESA (NOAA-NMFS, 2010). In response to the petition, the National Oceanic and Atmospheric Administration (NOAA) completed a status review report (Brainard et al. 2011) in March 2011 and a management report of the candidate species (PIRO-NOAA, 2012) in November 2012. A proposed rule was published in December 2012 (NOAA-NMFS, 2012) with public comment extended through April 6, 2013 (NOAA-NMFS, 2013). On August 27, 2014, NOAA issued a final rule for listing 20 coral species as threatened under the Endangered Species Act (ESA; NOAA-NMFS, 2014), but none of these listed coral species occurs in Hawaiʻi. On September 20, 2018, NOAA issued a proposed rule for listing the cauliflower coral (*Pocillopora meandrina*) as an endangered or threatened species under ESA (NOAA-NMFS, 2018). A global status review has been initiated by NOAA to determine whether listing throughout the species range is warranted.

8.12.1 Potential Impacts and Mitigation Measures

The proposed actions have the potential to affect protected species. Dredging activities will produce an underwater sound that can be perceived by marine creatures. The ears of marine mammals and sea turtles are sensitive to changes in sound pressure which is produced by the amplitude, wavelength, and frequency of a sound wave. While audiograms are not available for whales and sea turtles, it is generally accepted that 120 dB causes disturbance to these sea creatures.

The underwater sound intensity level of a pump has not presently been determined; however, the level can be inferred based on the sound intensity level of the pump in air. The following relationship can be used to convert the source in-air sound level intensity to the source underwater sound level intensity:

$$dB\ (water) = dB(air) + 62$$

Pumps with power ratings of 75 Hp like the one used for the 2006 Kūhiō Beach project are reported to generally produce in-air sound levels of about 90 dB; the corresponding source underwater sound level will be 152 dB. Propagation losses are primarily caused by spherical spreading and can be calculated using the following relationship:

$$\text{Propagation Losses} = 20\log(r)$$

where

r = radial distance from the source in meters

Using 152 dB as the source underwater sound level and using a threshold level of 120 dB for continuous noise for marine creature disturbance, the resulting operational clearance distance is found from:

$$20\log(r) = 152-120$$

which gives

r = 40 m (131 ft).

Thus, sea turtle disturbance will be limited to within about a 130-ft radius of the sand recovery operations. Turtles would be expected to move away from the disturbance, and as the impact area is relatively small and primarily in sandy bottom, it is not anticipated to affect turtle foraging.

The following Best Management Practices (BMPs) as typically recommended by the National Marine Fisheries Service (NMFS) will be adhered to during construction of the proposed actions to avoid impacts to protected species:

1. Conduct a survey for marine protected species before any work in the water starts, and if a marine protected species is in the area, a 150-ft buffer must be observed between the protected species and the work zone.
2. Establish a safety zone around the project area whereby observers will visually monitor this zone for marine protected species 30 minutes prior to, during, and 30 minutes post project in-water activity. Record information on the species, numbers, behavior, time of observation, location, start and end times of project activity, sex or age class (when possible) and any other disturbances (visual or acoustic).
3. Conduct activities only if the safety zone is clear of turtles.
4. Upon sighting of a turtle within the safety zone during project activity, immediately halt the activity until the animal has left the zone. In the event a marine protected species enters the safety zone and the project activity cannot be halted, conduct observations and immediately contact NMFS staff in Honolulu to facilitate agency assessment of collected data.
5. For on-site project personnel that may interact with a protected species potentially present in the project area, provide education on the status of any listed species and the protections afforded to those species under Federal laws.

Potential effects on protected species will be mitigated as follows:

- By using the above BMPs noise/physical disturbance to green sea turtles is expected to be temporary and insignificant and not result in adverse behavioral changes.
- Based on the in-water work being conducted in relatively shallow water with silt curtains confining the sediment, any exposure of marine protected species to turbidity and sedimentation will be temporary and not significant.
- The sand recovery site is not frequented by turtles or used as a foraging area due to a lack of algae on the sand bottom, the sand recovery equipment will be fitted with fences/barriers to prevent turtle entanglement or entrapment, and the above discussed BMPs will be implemented, thus physical disturbance to turtles is anticipated to be temporary and not significant during the sand recovery operations.

Given the extensive turtle foraging area in Waikīkī, and the relatively small percent loss which will result from the proposed actions, the change in turtle foraging habits and habitats is not anticipated to be significant.

9. BUILT ENVIRONMENT

9.1 Socioeconomic Setting

9.1.1 General Overview

Waikīkī is a densely developed urban area that supports a wide variety of commercial, recreational, and residential uses. Waikīkī Beach is recognized as the State's primary tourist destination, attracting millions of visitors yearly. The Waikīkī shoreline is dominated by a series of major hotels and resorts that extend from Ala Wai Boat Harbor to Kapiʻolani Park.

9.1.2 Population and Growth

In 2016, the resident population of the City and County of Honolulu was 992,605. The de facto population, which accounts for the number of residents and visitors present at a given time, was 12.1 percent higher at that time (DBEDT, 2019). The number of annual visitors to Hawaiʻi has steadily increased since the 1970s. The total number of Oʻahu visitors increased by 18.5% between 2007 and 2016, and the State of Hawaiʻi set a new record in 2019 with 10.4 million visitors. The resident and de facto populations of the City and County of Honolulu are projected to grow at an annual rate of 0.3 and 0.1 percent, respectively, through 2045 (DBEDT, 2019).

The proposed actions are intended to restore and improve the beaches of Waikīkī. The proposed actions are intended to increase beach width and stability and improve lateral shoreline access and support ongoing recreational and commercial uses in Waikīkī. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed actions are not anticipated to increase the resident or de facto populations of the City and County of Honolulu.

9.1.3 Land Ownership

Waikīkī is a densely developed urban, commercial area. The Waikīkī shoreline is dominated by a series of major hotels and resorts that extend from Ala Wai Boat Harbor to Kapiʻolani Park. There are 21 individual public and privately-owned parcels within the project area. A summary of the major landowners in the project area is shown in Table 9-1.

Table 9-1 Summary of land ownership in the project area

Beach Sector	Tax Map Key	Address	Owner
Fort DeRussy	(1) 2-6-005:001	2066 Kālia Road	United States of America
Fort DeRussy	(1) 2-6-005:006	192 Paoa Place	State of Hawai‘i
Halekūlani	(1) 2-6-004:012	2161 Kālia Road	Waikīkī Shore
Halekūlani	(1) 2-6-004:010	2169 Kālia Road	ORTG ORF LLC
Halekūlani	(1) 2-6-004:008	2199 Kālia Road	Halekūlani Corporation
Halekūlani	(1) 2-6-004:007	2199 Kālia Road	Halekūlani Corporation
Halekūlani	(1) 2-6-004:006	2199 Kālia Road	Halekūlani Corporation
Halekūlani	(1) 2-6-004:005	2199 Kālia Road	Multiple Owners
Halekūlani	(1) 2-6-002:026	Undefined	Multiple Owners
Halekūlani	(1) 2-6-002:006	2255 Kalākaua Ave.	Kyo-ya Resorts & Hotels LP
Royal Hawaiian	(1) 2-6-002:005	2255 Kalākaua Ave	Bishop Estate Trust
Royal Hawaiian	(1) 2-6-002:017	2325 Kalākaua Ave	Queen Emma Land Company
Royal Hawaiian	(1) 2-6-001:013	2353 Kalākaua Ave	Kyo-ya Resorts & Hotels LP
Royal Hawaiian	(1) 2-6-001:012	2371 Kalākaua Ave	Kyo-ya Resorts & Hotels LP
Royal Hawaiian	(1) 2-6-001:015	Undefined	State of Hawai‘i
Royal Hawaiian	(1) 2-6-001:018	2403 Kalākaua Ave	City and County of Honolulu
Royal Hawaiian	(1) 2-6-001:008	2401 Kalākaua Ave	City and County of Honolulu
Kūhiō	(1) 2-6-001:017	Undefined	City and County of Honolulu
Kūhiō	(1) 2-6-001:004	2479 Kālia Ave	City and County of Honolulu
Kūhiō	(1) 2-6-001:003	2501 Kālia Ave	City and County of Honolulu
Kūhiō	(1) 3-1-030:005	Undefined	State of Hawai‘i

Shorelines, beaches, and nearshore waters in Hawai‘i are considered part of the Public Trust, with access and use available to all people. As a result, Hawaii's shorelines are heavily regulated. The current definition of the "shoreline" in Hawai‘i is as follows:

> "*Shoreline* means the upper reaches of the wash of the waves, other than storm or seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves (§13-222, HAR)."

Generally, County jurisdiction begins at the shoreline and extends mauka (landward). State jurisdiction begins at the shoreline and extends makai (seaward). Federal jurisdiction begins at the mean higher high water (MHHW) line and extends out to the 200 nautical mile limit of the U.S. exclusive economic zone (EEZ); this area is also defined as "navigable waters of the United States". The relevant jurisdictional boundaries for coastal construction in Hawai‘i are shown in Figure 9-1.

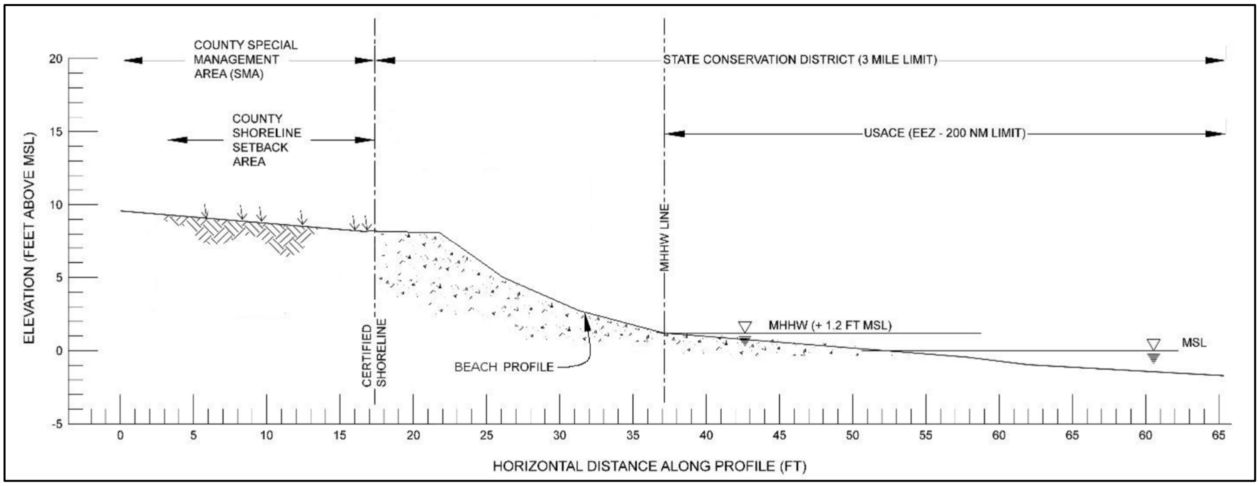


Figure 9-1 Jurisdictional boundaries for coastal construction in Hawaiʻi

The Federal, State, and County governments all have different objectives and rules regulating what activities are permissible along the shoreline. Therefore, the definition and location of the “shoreline” is critical for the planning and permitting of coastal construction projects. The certified shoreline is a line established by a licensed land surveyor and certified by the State of Hawaiʻi, which reflects the shoreline definition stated above. The certified shoreline is valid for 12 months from the date of issuance and is used to establish State and County jurisdiction and shoreline setbacks.

Fort DeRussy Beach Sector

Fort DeRussy is a U.S. military reservation that is under the jurisdiction of the United States Army. Most of the backshore area between the shoreline and Kālia Road is owned and maintained by the Federal government. Notable features include the Fort DeRussy beach walkway, Duke Paoa Kahanamoku Park, Hale Koa Hotel, Fort DeRussy Park, the Daniel K. Inouye Asia-Pacific Center for Security Studies, and the U.S. Army Museum of Hawaiʻi.

Halekūlani Beach Sector

The backshore area between the shoreline and Kālia Road is privately owned and densely developed with hotels, resorts, shops, and restaurants. Major resorts in this sector include the Castle Waikīkī Shore, Outrigger Reef Waikīkī Beach Resort, Halekūlani Hotel, and the Sheraton Waikiki Hotel.

Royal Hawaiian Beach Sector

The backshore area between the shoreline and Kalākaua Avenue is almost entirely privately owned and densely developed with hotels, resorts, shops, and restaurants. Major development in this sector includes the Royal Hawaiian Hotel, Outrigger Waikīkī Beach Resort, and Moana Surfrider Hotel. The Honolulu Police Department is located east of the Moana Surfrider Hotel. At the east end of the sector, there is an open area of public beach park seaward of Kalākaua Avenue that is managed by the City and County of Honolulu Department of Enterprise Services. The area is leased to beach concessionaires that conduct commercial ocean recreation activities and equipment rentals (e.g., surfboards, paddleboards, snorkeling, outrigger canoe rides, and beach catamaran rides).

Kūhiō Beach Sector

The backshore area immediately mauka (landward) of the shoreline consists of a sidewalk that provides lateral access along Kalākaua Avenue. The area mauka (landward) of Kalākaua Avenue is privately owned and densely developed with hotels, resorts, shops, and restaurants. Major development in this sector includes the Aston Waikīkī Circle, ‘Alohilani Resort, Waikīkī Beach Marriott, Aston Waikīkī Beach Resort, and the Park Shore Hotel.

Waikīkī Beach Reclamation Agreement

In 1928, the Waikīkī Beach Reclamation agreement was established between the Territory of Hawai‘i and property owners in Waikīkī. The agreement recognized the need to control and limit seaward development on Waikīkī Beach and established limitations on construction along the beach in response to the proliferation of seawalls in Waikīkī. The agreement provided that the Territory of Hawai‘i would build a beach seaward from the existing high water mark and that title of the newly created beach would be vested by the abutting landowners. The Territory of Hawai‘i and the private landowners further agreed that they would not build any new structures on the beach in Waikīkī. The private landowners agreed to allow a 75-ft-wide public easement along the beach measured from the new mean high water mark.

The Waikīkī Beach Reclamation agreement covers the beach area including the area from the Ala Wai Canal to the Elks Club at Diamond Head. The agreement consists of a) the October 19, 1928 main agreement between the Territory and Waikīkī landowners, b) the October 19, 1928 main agreement between the Territory and the Estate of Bernice Pauahi Bishop, and c) the July 5, 1929 Supplemental Agreement between the Territory and Waikīkī landowners. The shoreline area between the Royal Hawaiian Hotel and the Moana Surfrider Hotel is the subject of a separate agreement between the Territory and the subject Waikīkī landowners entered into on May 28, 1965.

9.1.4 Economy

Waikīkī Beach is recognized as the State’s primary tourist destination, attracting millions of visitors yearly. Waikīkī contains approximately 44 percent of the rooms/lodging units available in the State. The Waikīkī Beach Erosion Control Reevaluation Report prepared by the U.S. Army Corps of Engineers contains an extensive economic analysis of the costs and benefits of beach restoration and erosion control along all of Waikīkī Beach (Lent, 2002, and USACE, 2002). Some of the findings of this analysis include the following.

Visitor surveys indicate that 12.6 percent of tourists cited crowding and congestion (considered to be of the beach) as the primary reasons for not revisiting Waikīkī. This is equivalent to about 250,000 visitors, or 3.6 percent of the total visitors to the State in a year. These visitors, were they to revisit Waikīkī, would spend an estimated $181 million/yr.

A benefit to cost ratio analysis was completed to determine Federal interest in restoring and improving Waikīkī Beach, with a ratio greater than one indicating that benefits exceeded costs. The overall benefit to cost ratio for all of Waikīkī was about 6. The total Waikīkī Gross National Product (GNP) contribution to the annual Federal economy is an estimated $3.3 billion. This estimate excludes spending by mainland west coast visitors (USACE, 2002).

An economic analysis of the importance of Waikīkī Beach conducted by Hospitality Advisors LLC (2008) showed that an overwhelming majority of all visitors consider beach availability to be very important. When presented with the possibility of the complete erosion of Waikīkī, 58% of all westbound visitors said they would not consider staying in Waikīkī without the beach.

9.1.5 Potential Impacts and Mitigation Measures

The proposed actions will restore and stabilize existing public beaches in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. A study by Hospitality Advisors, LLC (2008) determined that if Waikīkī Beach is not maintained and allowed to erode away it could result in a $150 million annual loss in State tax revenue, and a loss of 6,350 jobs in the hotel industry alone. A more recent study by Tarui et al. (2018) determined that complete erosion of Waikīkī Beach would result in an annual loss of $2.223 billion in visitor expenditures.

The proposed actions will not alter existing land use patterns seaward of the shoreline and no changes in beach use patterns are anticipated. Some negative economic impact on commercial activities may occur during construction; however, every effort will be made to minimize adverse economic impacts, particularly during the prime daytime beach use hours.

The direct socio-economic effects of the proposed actions are limited primarily to construction employment and related business activity. The direct construction employment and business expenditures are not large enough to affect the larger socio-economic context of the Waikīkī area. Overall, the economic effect on existing land uses is anticipated to be positive. The No Action alternative would have a significant negative impact on the economies of the State of Hawaiʻi and City and County of Honolulu. Waikīkī has 87% of the total hotel rooms on Oʻahu, and approximately 69% of all Oʻahu visitors participate in swimming/sunbathing/beach activities (Hospitality Advisors, LLC, 2008).

The resident and de facto populations of the City and County of Honolulu are projected to grow at an annual rate of 0.3 and 0.1 percent, respectively, through 2045 (DBEDT, 2019). Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed actions are not anticipated to increase the resident or de facto populations of the City and County of Honolulu.

9.2 Historical, Cultural and Archaeological Resources

A Cultural Impact Assessment (CIA) was prepared by International Archeology, LLC. (IA, 2021) for the proposed beach improvement and maintenance actions to comply with the State of Hawaii's environmental review process under Chapter 343, HRS and §11-200.1, HAR. The CIA is included as Appendix D. In addition, a Ka Paʻakai Cultural Impact Analysis was prepared by SEI. The results of these assessments are summarized below.

9.2.1 Cultural Geography

This section provides an overview of the cultural geography of the Waikīkī area and the Waikīkī beach sectors that will be affected by the proposed beach improvement and maintenance program. Components of this section are 1) place names that indicate connections between physical locations in Waikīkī and traditional Hawaiian cultural practices, notable people, and important events; 2) the traditional history of Waikīkī, reflecting its political, economic, and spiritual significance in Hawaiian society before European contact; and 3) the history of Waikīkī following European contact in 1778, and its subsequent transformations in the approximately 200-year span through the mid-20th century.

This section has largely been adapted from Tomonari-Tuggle (2017) and Lauer et al. (2019). Both reports relied on primary references from Bishop (1881)1, Kamakau (1976, 1991, 1992), Pukui et al. (1974), and Sterling and Summers (1978). Historical information was also obtained from books and reports held in the IA library, the State Historic Preservation Division (SHPD) Kapolei Library, and the State Office of Planning and Sustainable Development's Environmental Review Program's ~~Quality Control~~ online library of environmental assessments and environmental impact statements (archaeological reports and CIAs are generally included as appendices).

Place Names

The project area falls within the *ahupuaʻa* of Waikīkī in the traditional district of Kona. Originally Waikīkī included the seven valleys from Makiki on the west to Wailupe on the east; in contrast, the western half of the Kona district consists of smaller *ahupuaʻa* whose boundaries are generally coterminous with valley areas (e.g., Nuʻuanu, Kalihi, Kahauiki, and Moanalua). The reasoning behind this difference in *ahupuaʻa* size is unknown, although the political prominence of Waikīkī and the concentration of chiefs who came to live and play in this area may have been a factor (Tomonari-Tuggle and Blankfein 1998).

Waikīkī translates as "spouting water" (Pukui and Elbert 1986:223), in reference to the wetlands and abundant water sources of this region. Many traditional place names in Waikīkī relate to agriculture or the requirements for successful agriculture. Three place names (Waiʻaʻala, Waiaka, and Waikīkī) reference water (*wai*), one (ʻĀpuakēhau) may be the name of a rain, two refer to soil or sand (Kapahulu and Keʻokea), and three relate to food plants, *niu* (*Cocos nucifera*) (Niukūkahi and Uluniu) and *ʻuala* (*Ipomoea batatas*) (Kalauʻuala). The sea (ʻAuʻaukai and Hamohamo) is another theme; the place name Kanukuāʻula refers to a very fine-meshed fishing net. A single place name, Kaluaʻolohe, relates to a historical event and person.

Other Waikīkī place names refer to locations where events recounted in Hawaiian traditions occurred, or places that are related to Hawaiians of historical note. An example of the former is ʻĀpuakēhau (in the Royal Hawaiian sector, roughly where the Royal Hawaiian Hotel sits), which is said to be where the Maui king Kahekili landed his invasion force in his successful conquest of Oʻahu (Fornander 1919:VI-2:289; Kanahele 1995:79); the general area was called Helumoa and was the site of royal residences, a heiau, athletic grounds, and a royal coconut grove. Another example is Kawehewehe (at the boundary between Halekūlani and Fort DeRussy sectors), which was the residence of the Luluka family of noted Hawaiian historian, John Papa ʻĪʻī. The family moved to Oʻahu in the early 1800s, in the company of Kamehameha who was preparing for the invasion of Kauaʻi (ʻĪʻī 1959:15); Papa ʻĪʻī's uncle was a member of the royal court, and members of the Luluka family were responsible for the royal residence of Kamehameha at Puaʻaliʻiliʻi at Helumoa.

Traditional place names are associated with each of the Waikīkī Beach sectors included in the proposed project area. In the Fort DeRussy beach sector, the two place names are Kālia, which is the traditional Hawaiian name for this general area, and Kawehewehe, which is the name of the former drainage that marks the east side of the beach sector (roughly the alignment of Saratoga Road).

Prior to modern development, the Halekūlani beach sector lay between two drainages, ʻĀpuakēhau to the east (in the Royal Hawaiian sector) and Kawehewehe to the west (along the boundary with the Fort DeRussy sector). Kawehewehe was the outflow from the large fishpond complex of Kālia, the inland area of present Fort DeRussy. As markers of a former landscape, ʻĀpuakēhau and Kuʻekaunahi are important as the names of two of the three major drainages that once cut through the Waikīkī coastal plain. The single place name in the Halekūlani beach sector is Kawehewehe, which refers to the land and sea area at the west end of the sector, as well as to the mouth of a drainage that emptied the fishponds of inner Kālia (roughly along the present alignment of Saratoga Road). It might also be the name of the channel through the reef in front of the present Halekūlani Hotel (Pukui et al. 1974:99).

Place names in the Royal Hawaiian beach sector reflect the *aliʻi* connections to the area: Helumoa as the royal center, Helumoa Heiau and Kahuamokomoko as adjuncts to the royal center, Hamohamo along the coast as part of Liliʻuokalani's birthright, and Pualeilani as the first beach home of Prince Kūhiō. Another historical place is Muliwai ʻĀpuakēhau, which was the mouth of ʻĀpuakēhau Stream, which was one of three major drainages that flowed into Waikīkī waters.

The Kūhiō beach sector contained Liliʻuokalani's beachside residence, Kealohilani (Kanahele 1928b), which was subsequently the Pualeilani home of Prince Jonah Kūhiō Kalanianaʻole. In the midcentury Māhele, the *ʻili* of Hamohamo was awarded to the high chief Keohokālole. In 1859, Keohokālole transferred the land to her daughter Liliʻuokalani (future queen of Hawaiʻi), who established a residence at Paoakalani (makai of the present Ala Wai Canal) and a beachside cottage that she called Kealohilani. In 1918, Prince Kūhiō acquired Kealohilani through an out-of-court settlement of his challenge to Liliʻuokalani's establishment of a trust (Hibbard and Franzen 1986:37), and built a new home called Pualeilani on the property. Until the late 1800s, Kuʻekaunahi Stream flowed as a wide and slow-moving estuary into the ocean in the southern portion of the Kūhiō beach sector (the Diamond Head (east) basin, around the present alignment of Paoakalani Avenue). Another historical place in the Kūhiō beach sector is Muliwai Kuʻekaunahi, which was the mouth of Kuʻekaunahi Stream. This stream was one of three major drainages that flowed into Waikīkī waters.

Traditions

The chronology of pre-Contact occupation along the Waikīkī shoreline is based on a suite of 16 radiocarbon determinations obtained from previous archaeological investigations in the area. The radiocarbon determinations are problematic in that most samples were run on unidentified charcoal which has potential to produce dates with inbuilt age (i.e., dates that are older than the target event). Considering this limitation, the use of Bayesian modeling provides the best current estimate for occupation along the Waikīkī shoreline of no later than AD 1350–1610 (95.4%), and likely AD 1379–1600 (68.2%) (Tomonari-Tuggle 2017).

The earliest Hawaiian settlers probably made their homes on the windward shores of the islands and visited the drier southern and western areas only for selected resources like fish and birds. As time passed and settlers eventually migrated to other parts of Oʻahu, coastal Waikīkī was probably one of the earliest areas occupied as it offered easy access to rich ocean resources, a ready freshwater supply from springs and streams, level and easily developed lands for cultivation and aquaculture, and a bounty of game foods like ducks and other wildfowl. Some cultivation probably followed the stream courses into valleys like Mānoa, which were also sources for items like hardwood (for tools, weapons, and building materials) and birds (for feathers) (Tomonari-Tuggle and Blankfein 1998).

The traditions of Waikīkī indicate its significance as a nexus of interconnected *aliʻi* histories and as a highly productive agricultural region. In ancient times, Waikīkī was a center of *aliʻi* power, “a land beloved of the chiefs” who resided there because the lands were rich and the surfing was excellent (Kamakau 1991:44).

Chiefly Associations

It is said that Māʻilikūkāhi, the ruling chief of Oʻahu in the mid-14th century (based on genealogical reckoning), made Waikīkī the royal seat of chiefs (Beckwith 1970:383). From that time, it was the residence, either permanently or part-time, of the high *aliʻi*. In the 16th century, the Maui chief Kiha-a-Piʻilani was born at ʻĀpuakēhau (Kamakau 1991:50). In the 18th century, after his conquest of the island, Maui king Kahekili made his home at Waikīkī, as did Kamehameha after he succeeded in wresting control of the island from Kahekili’s successor. Kamakau (1992:394) writes that Kamehameha made Kekāuluohi his wife at ʻĀpuakēhau; she later became one of Liholiho’s five wives and through a later husband, Kanaʻina, she bore Lunalilo, who would become the first elected Hawaiian king after the death of Kamehameha V in 1872.

Helumoa and Ulukou, areas at the mouth of ʻĀpuakēhau Stream, were the focal points of chiefly residence. The stream emptied into a protected curve of the shoreline that created a “famous surfing spot called Kalehuawehe” (Nāpōkā 1986:2). Rich fishponds lay to the west, and the expansive inland wetlands produced a bounty of *kalo* and other crops. The ocean provided an array of fish. A visitor in the 1850s described a typical catch (Nāpōkā 1986:3, quoting Harriet Newell Foster Deming):

> *Sometimes four canoes would be drawn up on the beach at once, filled with shining beauties in nets … the wealth of color fascinated us as we hung over the sides of the canoes watching the bronzed fishermen who, naked except for a loincloth, scooped up the fish in their hands and laid them in piles on the sand.*

Agriculture and Fishpond

Waikīkī was famous for its extensive irrigated pondfields and fishponds that covered the coastal plain "from the inland side to the coconut grove beside the sea" (Kamakau 1991:45). Fed by the waters of Mānoa and Pālolo Valleys and by the numerous springs that gave Waikīkī its name, the wetland system of expansive *loʻi* is credited to the 15th century ruling chief Kalamakua-a-Kaipūhōlua (Kamakau 1991:45):

> *He was noted for cultivating, and it was he who constructed the large pond fields Keʻokea, Kūalulua, Kalāmanamana, and the other loʻi in Waikīkī. He traveled about his chiefdom with his chiefs and household companions to cultivate the land and gave the produce to the commoners, the makaʻāinana.*

Kamakau (1992:192) also credits Kamehameha with the creation of the extensive pondfield system, including the pondfields attributed to Kalamakua-a-Kaipūhōlua, but this likely reflects Kamehameha's modification or expansion of extant *loʻi*.

Heiau

The significance of Waikīkī Ahupuaʻa is also emphasized by the number and kinds of *heiau* distributed across this area, particularly along the coast (Kamakau 1976:144; Thrum 1907:44-45). Three of the eight *heiau* identified by Thrum (1907) (Table 2) are of the *poʻo kanaka* class, i.e., sacrificial *heiau* that were "only for the paramount chief, the *aliʻi nui*, of an island or district (*moku*)" (Kamakau 1976:129).

Battles

In the late 1700s, warfare in the islands raged. High chiefs amassed huge armies and sailed flotillas of war canoes between islands in a quest for territorial expansion. At least two assaults on Oʻahu took place on the beaches of Waikīkī. From Maui in 1779 came the warrior-chief Kahekili, who conquered Oʻahu after three years of fighting. With victory, the high chief made Waikīkī his home, specifically at Helumoa near the mouth of ʻĀpuakēhau Stream (the location of Helumoa Heiau). After some time on Maui and Hawaiʻi, Kahekili returned to Waikīkī, where he died in 1794. He was succeeded by his son, Kalanikūpule.

A year later, in 1795, Kahekili's chief rival for power, Kamehameha, staged an attack on Oʻahu. It is said that his armada, which included 1,200 double canoes and 10,000 warriors, landed at Waikīkī, a beachhead of relatively calm waters and sandy beaches that offered abundant water, *kalo*, and other supplies for his vast army (Kanahele 1995:87). Unlike Kahekili's three-year battle, Kamehameha was quickly successful in defeating his adversary, Kalanikūpule, and taking control of Oʻahu. Like the Maui chief, Kamehameha settled in Waikīkī near the mouth of

ʻĀpuakēhau Stream. Along with Kona on Hawaiʻi Island and Lāhaina on Maui, this served as one of the capitals of his unified (except for Kauaʻi) kingdom.

9.2.2 Historical Background

In 1778, British Captain James Cook made first Western landfall in Hawaiʻi, and other European and American explorers, traders, and missionaries followed. Many wrote accounts and journals that provide an image of the wetland agricultural landscape of Waikīkī. For example, Archibald Menzies (1920:23-24), an early Western visitor who was naturalist and surgeon on board the *HMS Discovery* captained by George Vancouver (in Hawaiʻi in 1792-1793), described a visit to Waikīkī:

> *The verge of the shore was planted with a large grove of coconut palms, affording a delightful shade to the scattered habitations of the natives.… We pursued a pleasing path back to the plantation, which was nearly level and very extensive, and laid out with great neatness into little fields planted with taro, yams, sweet potatoes, and the cloth plant. These, in many cases, were divided by little banks on which grew the sugar cane and a species of Draecena without the aid of much cultivation, and the whole was watered in a most ingenious manner by dividing the general stream into little aqueducts leading in various directions so as to be able to supply the most distant fields at pleasure, and the soil seemed to repay the labor and industry of these people by the luxuriance of its productions. Here and there we met with ponds of considerable size, and besides being well stocked with fish, they swarmed with waterfowl of various kinds such as ducks, coots, water hens, bitterns, plovers and curlews.*

Although Waikīkī was the initial capital and residence of Kamehameha on Oʻahu, the growing number of American and European traders looked to the harbor at Kou (present Honolulu) as a safer and therefore favored berth for their deeper draft ships. In the first decade of the 19th century, Kamehameha gradually shifted his capital to that once rural village, and by 1809, he had an established residence near the Honolulu harbor frontage. His family and members of court and government also made the move, leaving Waikīkī in the care of lesser chiefs and land managers (Kanahele 1995:104-105).

Waikīkī, however, remained an attraction for the *aliʻi*. Only three or so miles from Honolulu, it was the only place near the city with beaches and surf that provided an easy escape from the increasingly Western atmosphere of the new capital (Hibbard and Franzen 1986:10). *Aliʻi*, particularly members of the Kamehameha extended family, built beach cottages on the ocean front. As the 19th century progressed, they replaced their grass roofed, wooden buildings with more elaborate and modern homes. Hawaiian chiefs and royalty were joined by *haole* residents and visitors to form a relaxed community. By the late 19th century, the homes of *aliʻi* like Emma (wife of Kamehameha IV), Kapiʻolani (wife of Kalākaua), and Liliʻuokalani (Queen of Hawaiʻi) were located between ʻĀpuakēhau and the present Kapiʻolani Park, and residences of *haole* businessmen like Davies, Robinson, Brown, and Damon were on the beachfront west of ʻĀpuakēhau (Wall 1893). The beginnings of the Waikīkī tourist trade were also represented at this time by the presence of the Long Branch, the earliest known bathing establishment at which visitors were provided "a towel, bathing suit, dressing rooms and a stretch of beach and ocean to enjoy" (Hibbard and Franzen 1986:52), and the W.C. Peacock property ("Peacock's"), which would become the site of the first major hotel in Waikīkī, the Moana Hotel, in 1901.

Mid-19th Century Land Parcels

In the mid-19th century, major structural changes were made to the ways land was held in Hawaiʻi. In 1848, the traditional system of land tenure was replaced with a Western system of fee-simple land ownership. This radical restructuring, called the Māhele, divided all lands between the king and 245 high ranking *aliʻi*; the king later divided his lands between himself (called Crown Lands) and the government (Kameʻeleihiwa 1992). Subsequently, commoners were offered the opportunity to claim fee-simple title to the land on which they lived or improved; these became known as *kuleana* lands and were awarded in the form of Land Commission awards (LCAs; often referred to as *kuleana* lands).

Unlike most *aliʻi* land awards that were for entire *ahupuaʻa*, *aliʻi* awards in the ahupuaʻa of Waikīkī were for *ʻili*. As Kameʻeleihiwa (1992:232) explains, land on Oʻahu was desirable and therefore *ʻili* on Oʻahu were as valuable as *ahupuaʻa* on the other islands:

> *On Oʻahu, the moku of Kona (especially in Honolulu and Waikīkī), ʻEwa, and Koʻolaupoko were defined predominantly by ʻili. This division of ʻĀina into a great number of rather small areas indicates that Oʻahu was not only more populated, but its ʻĀina were more desired by the Aliʻi and konohiki.… Although an ʻili was almost always smaller in size than an ahupuaʻa, an ʻili on Oʻahu was considered as desirable as an ahupuaʻa on the outer islands.*

About 250 Land Commission awards (to six *aliʻi* and the remaining to local land managers and commoners) were made in Waikīkī (Kanahele 1995:115). The *aliʻi* awardees included Kauikeauoli (Kamehameha III) (62 acres), high chiefs William Lunalilo (2,229 acres) and Ana Keohokālole (100 acres), and three lesser-ranked chiefs, Mataio Kekūanaōʻa (133 acres), Keoni Ana (11 acres), and Kaisara Kapaʻakea (9 acres). As noted by Kanahele (1995:116), "Their properties all included choice spots located near the beach, streams or fishponds." It is notable that the heirs of these *aliʻi* awardees include the monarchs Kamehameha V, David Kalākaua, and Liliʻuokalani; queen consorts Emma Rooke and Kapiʻolani; Princesses Ruth Keʻelikōlani, Likelike, and Kaʻiulani; and Prince Jonah Kūhiō Kalanianaʻole.

Kuleana awards, most of which were generally less than an acre, lined the Waikīkī shore, with associated inland pieces that provided land for farming. Of the shoreline *ʻāpana*, two fall in the Fort DeRussy beach sector, ten in the Halekūlani beach sector, three in the Royal Hawaiian beach sector, and one in the Kūhiō beach sector. There were no LCAs awarded south of Kuʻekaunaha Stream (roughly the alignment of present Paoakalani Avenue).

Late-19th Century

In the second half of the 19th century, changes to the Waikīkī landscape entailed improvements to transportation connections between Waikīkī and Honolulu, including construction of a tram line between the two areas, and the development of Kapiʻolani Park and an associated residential neighborhood on June 11, 1877 (Brown and Monsarrat 1883).

In the 1860s, rice cultivation experienced a boom across the islands, directed at two markets: export to California for Chinese emigrants who had settled there after the mid-century Gold Rush and local consumption by a growing number of Chinese contract laborers who had come to Hawaiʻi to work on the sugarcane plantations (by 1884, there were 18,254 Chinese in the islands; see Coulter and Chun 1937:13). Rice was second only to sugar in the economic hierarchy in the islands (Haraguchi 1987:xiii). Like sugar, Hawaiʻi's rice production filled the void created by the U.S. Civil War, when rice farming in the southern United States was severely curtailed (Coulter and Chun 1937:13). During negotiations for the Reciprocity Treaty between the U.S. and Hawaiian governments, efforts were made to ensure that rice shared the same protection as sugar.

Land speculators purchased *kalo* fields, and in some cases, pulled up young *kalo* plants to replace them with rice seedlings (Haraguchi 1987:viv). Many *kuleana* owners leased their former *kalo* fields to rice entrepreneurs, although in some cases, they retained land for the Hawaiian staple food. By 1892, there were 542 acres in Waikīkī planted in rice, representing almost 12 percent of the total 4,659 acres in rice cultivation on Oʻahu (Hammatt and Shideler 2007:17). Nakamura (1979:20, quoting Iwai 1933:80, brackets added) notes that Waikīkī was one of "the most important [rice] growing districts on Oʻahu."

At the end of the 19th century, Waikīkī Road (roughly the alignment of the present Kalākaua Avenue) marked the boundary between fishponds and beach lots to the makai, and rice fields to the mauka (landward) (Monsarrat 1897). Kapahulu Avenue was the southeastern boundary of the rice fields, with the gridded Kapahulu house lots and Kapiʻolani Park extending toward the base of Diamond Head (the Kapahulu lands to the east of the present Kapahulu Avenue appear to have been planned for subdivision in 1899, see Monsarrat 1899).

20th Century Landscape Changes

The 20th century saw the definitive transformation of Waikīkī from quiet retreat and agricultural breadbasket to a bustling tourist destination. As the popularity of Waikīkī among residents—particularly the foreign/haole population—and visitors grew, the region was eyed for development. Kapiʻolani Park in 1877 was originally developed as a private recreational/open space amenity for high-end residences at the base of Diamond Head and along the coast (Brown and Monsarrat 1883). In the early 20th century, the extensive wetlands complex on the coastal plain was valuable for rice cultivation and raising ducks but was described as "swamp lands" by those who had visions of development. As noted by Steele (1992:8-3), "in the eyes of many in Honolulu, [it could] be put to better use … but only if the land could be 'reclaimed' (filled in)." The first effort in Waikīkī reclamation was by the U.S. Department of War in its development of Fort DeRussy at the western end of Waikīkī, which required filling in a large portion of the fishponds. The agricultural landscape of Waikīkī was nearing its end, victim to the allure of Waikīkī as a resort destination. Nakamura (1979:34) writes:

> *A conflict was developing at Waikīkī between wet agriculture and aquaculture, on the one hand, and urbanization on the other. Urbanization was adversely affecting the good and proper drainage of surface water flowing from the mountains to the sea. This restricted water, in turn, was labeled unsightly and unsanitary by those who wished to see wet agriculture and aquaculture at Waikīkī destroyed.*

By the end of the first decade of the 20th century, the rice fields and duck ponds that once covered the entire coastal plain inland of Kalākaua Avenue appear to have been contracted to the northwest, leaving the eastern portion of the wetlands complex as pasture or open fields, with scattered buildings and a network of dirt roads (U.S. Army 1909-1913).

Ala Wai Canal

The primary impetus for landscape change was construction of the Ala Wai Canal in the 1920s. The canal effectively cut off Waikīkī from the rest of the Honolulu urban and suburban landscape and created developable lands where before there were the expansive wetland agricultural fields. In addition, the canal was seen as remedying a perceived impact of outflow from the wetlands on the growing bathing industry: "the proposed drainage canal would carry the runoff away from the Waikīkī beaches" (Steele 1992:8-4).

Using so-called unsanitary conditions as a justification, the government (first the post-overthrow Hawaiian Republic and then the Territorial Government) enacted legislation that forced landowners to fill in the wetlands, and if they did not, the government would do so and put a lien on the property to pay for the "improvements." The end result was the destruction of the agricultural system and in many cases, the loss of land (Nakamura 1979:67-68).

> *The Sanitary Commission of 1912 estimated that, of the total amount of land in the district of Honolulu located below the foothills, one third was wet land. This wet land, which was used for agriculture and aquaculture, represented, then, a considerable amount of urban real estate if filled in.*
>
> *Such laws as Chapter 83, R.L. 1905 already existed to deal with filling in wet land. The justification for such actions would be sanitation, that is, if wet lands were allowed to exist within the district of Honolulu, the public health would be endangered, for mosquitoes, carriers of dangerous diseases, would continue to breed.... Thus, sanitation was presented as the primary motive in the destruction of wet agriculture and aquaculture while the profitability of reclaimed was hardly mentioned at all.*

Land acquisition for the two-mile long canal began in 1918, either through voluntary purchase or condemnation (Steele 1992:8-5). Construction began in 1921, with Walter F. Dillingham's Hawaiian Dredging Company contracted by the Territory of Hawaiʻi to carry out the work (Nakamura 1979:90). By 1924, the entire length of the canal from its outflow at the west end of Waikīkī to its head at Kapahulu Road was excavated; a proposed outflow from Kapahulu Road to the eastern end of Waikīkī was never completed, aborted by a concern that the onshore current would take canal runoff west onto the pristine beaches (Cocke, 2013). Although the canal was dredged as planned, additional fill was needed to "reclaim" adjacent lands and additional funds were authorized to widen the canal from 150 to 250 ft. In 1928, the canal was completed. Steele (1992:8-7) describes the resultant changes in land values and tourism:

> *… land values had gone from $500 an acre for a piece of agricultural property prior to the construction of the canal to up to $4 a square foot for business property in 1928. With a great increase in available property, numerous residential development projects were undertaken in Waikīkī. The number of visitors was also on the rise since the*

beginning of the reclamation project. Between 1921 and 1927, the number of visitors to Waikīkī doubled from 8,000 to 17,451 according to the Hawaiʻi Visitors Bureau.

In addition to the dredge and fill operations related to the Ala Wai Canal, the Waikīkī portions of natural drainages, like ʻĀpuakēhau and Kuʻekaunahi Streams, were also filled.

Beach Control Infrastructure

In the mid- to late 19th century, Waikīkī became a retreat for town dwellers in Honolulu who wearied of dry, dusty urban life. Royalty escaped to their beachfront estates. Families began to frequent the beach on weekend bathing trips. In 1881, James Dodd opened the first commercial hospitality operation, the Long Branch, which was a small cottage where visitors could change their clothes for a small fee (Kanahele 1995:152). Modest residences were common, and it was not until the 1890s that sumptuous homes began to appear along the beachfront (Hibbard and Franzen 1986:27).

As more visitors frequented Waikīkī and more properties developed along the coast, shoreline improvements were made to enhance the visitors' beach experience (the chronology of shore improvements is primarily from Wiegel 2008:26-27). One of the first infrastructure projects was construction of a bridge/causeway at the entrance to the new Kapiʻolani Park around 1880, a portion of which was replaced in 1890 by a seawall to protect Waikīkī Road (now Kalākaua Avenue near Kapahulu Avenue). Also in 1890, picturesque piers were built at Queen Liliʻuokalani's Kealohilani beach home and at W.C. Peacock's residence; both structures graced the Waikīkī shoreline for over 40 years. When the Moana Hotel was constructed on Peacock's property in 1901, the pier became known as Moana Pier.

In the first three decades of the 20th century, seawalls were constructed at various locations, but with no apparent overall design or strategy. The earliest record of a constructed retaining wall at a specific property is an 1897 map showing a wall fronting Liliʻuokalani's property at Kealohilani, adjoining the inland end of her pier (Kanakanui 1897). As hotels began to develop, each protected its shorefront with a seawall: the Moana Hotel in 1901, the Seaside in 1906, Gray's Hotel (now the Halekūlani) in 1916, and the Royal Hawaiian Hotel in 1925-1926. When the U.S. War Department acquired lands at Kālia for Fort DeRussy, it too protected its beachfront with walls built in 1909 and 1916. By 1920, almost the entire shorefront of Kapiʻolani Park was lined in seawalls.

Groins were also built to protect and enhance the beach, and many have come and gone, leaving only the present five groins in the project area. The first was a concrete wall projecting into the shallows at the mouth of ʻĀpuakēhau Stream, built sometime between 1906 and 1910, presumably by Moana Hotel; it was removed in 1927. Between 1917 and 1930, nine groins were built along the shore between the Royal Hawaiian Hotel and Fort DeRussy, and experimental sandbag groins were installed between the Royal Hawaiian Hotel and Gray's Hotel. Groins were also constructed at the original Honolulu Aquarium; they appear on a 1928 map of the Waikīkī shoreline (Kanahele 1928c).

9.2.3 Archaeological Resources

9.2.3.1 General Overview

The archaeological record of the Waikīkī shoreline is fragmented, disturbed, and damaged by over a century of urbanization. Nonetheless, archaeological investigations have shown that remnants of the former landscape lie beneath the asphalt and concrete of the modern resort area. This record can be characterized as an extensive but discontinuous buried A-horizon, with high-density clusters of archaeological material and burials representing the most intensive pre-Contact and historical-period occupations.

There are 15 sites that contain human skeletal remains, including at least 97 identifiable individuals. The largest burial clusters include Sites 50-80-14-1974 and 50-80-14-5860, each of which contained 24 discrete burials. Site 50-80-14-1974 is on the grounds of the Moana Surfrider Hotel, while Site 50-80-14-5860 is at the intersection of Kalākaua Avenue and Kealohilani Avenue. Also, along Kalākaua Avenue are Sites 50-80-14-5858 and 50-80-14-5859, which include eight burials each. Site 50-80-14-5861 at the intersection of Kalākaua and ʻŌhua Avenues includes seven burials. There are also 10 sites that are buried archaeological deposits or discrete features (Table 6). Of particular note is Site 50-80-14-5940, which is described as a discontinuous deposit of very dark-stained sand containing diffuse charcoal flecks, traditional Hawaiian artifacts, midden, firepits, hearths, and other pits. It is a linear site that runs along Kalākaua Avenue between Kaʻiulani and Liliʻuokalani Avenues. This delineation of a site boundary is deceptive in two respects: (1) burial Sites 50-80-14-5857 through 50-80-14-5859, as well as the inland edge of Site 50-80-14-5863, fall within the same area and thus could be included as clusters within the site; and (2) archaeological deposits have been identified with burial associations at the not-distant Sites 50-80-14-5860 and 50-80-14-5861 to the south and Sites 50-80-14- 1974, 50-80-14-3705, 50-80-14-4570, and 50-80-14-9975 to the north and northwest. Thus, in actuality, it could be argued that the pre-Contact and historical-era occupation of Waikīkī Beach encompasses the entire length of the shoreline adjacent to the project area, with probable concentrations of occupation at advantageous locations near stream mouths, fishing grounds, or easy canoe access to the open ocean.

Ten radiocarbon dates have been obtained from archaeological sites near the Waikīkī Beach Improvement and Maintenance Program area. The earliest radiocarbon determination for the shoreward area is 410±50 BP (Davis 1989), obtained on a piece of unidentified charcoal from a hearth, which produces a bi-modal calibrated date of AD 1422-1529 and AD 1546-1635. Most dates indicate that the shoreline was occupied by the 15th or 17th centuries AD. It reasonable to assume, however, given the lack of extensive archaeological investigations in this area and the presence of earlier dates elsewhere on the Fort DeRussy property, that the immediate area was settled even earlier.

9.2.3.2 Fort DeRussy Beach Sector

The Fort DeRussy beach sector consists of approximately 510 m (1,680 ft.) of shoreline extending from the Hilton pier/groin to the Fort DeRussy outfall/groin. The southwest-facing shoreline is a continuous sand beach that fronts a landscaped open space of tended lawn and coconut trees in the Fort DeRussy Armed Forces Recreation Center. Until the early 20th century, Kawehewehe Stream, the outlet for the Kālia fishponds, ran into the sea along the southern edge of this sector. Piʻinaio Stream entered the sea at a broad delta or estuary approximately 350 m north of the sector, near the southern end of the Ala Wai Boat Harbor. This beach sector is within the traditional ʻili of Kālia. Today, the Hale Koa Hotel is just inland of the western portion of the sector and the U.S. Army Museum of Hawaiʻi, housed in the historic 1914 Battery Randolph, is at the eastern end of the sector. A wide concrete promenade runs along the inland edge of the beach.

The shoreline within the Fort DeRussy sector was further removed from the Waikīkī chiefly center at the mouth of ʻĀpuakēhau Stream; nevertheless, this land near Piʻinaio Stream and the Kālia fishponds was likely associated with noble families.

Like the Halekūlani beach sector, the Fort DeRussy beach sector includes portions of Kawehewehe. As noted above, Kawehewehe was known as the residence of the Luluka family, which moved to Oʻahu from Lāhainā with Kamehameha around 1803. The family maintained the royal residence at Puaʻaliʻiliʻi as retainers of Kamehameha (ʻĪʻī 1959:17).

During the mid-19th century land division, Kālia, including the large complex of six fishponds inland of the Fort DeRussy beach sector, was awarded to the high chief Mataio Kekūanaōʻa as LCA 104 FL:6 (Davis 1989:14). Five *kuleana* awards and five land grants were made along the coast. LCA 867:1 to Nihopuʻu, located at the middle of the sector, was a small house lot at the shore, with separate inland taro patches and an ʻauwai; the house lot contained one house surrounded by a wooden fence (Davis 1989:83). LCA 1515:2 to Kaihoʻolua, seaward of Battery Randolph, was also a fenced house lot (Davis 1989:87). The five land grants were also awarded in the mid-19th century. Grant 2880 to H.J.K. Holdsworth, which is at the southern edge of the sector, overlaps slightly with the project area.

The U.S. Army began to acquire land in the Kālia area in 1904. Extensive dredging of the reef off Fort DeRussy was conducted between 1908 and 1910, with the dredged coral used to infill the Kālia fishponds (Wiegel 2008:10). In 1913, a “deep channel was dredged through the reef in front of Fort DeRussy” to facilitate the arrival of a bargeload of 69-ton guns (Thompson 1985:37). The dredging is said to have contributed significantly to the erosion of beach sand along the Waikīkī shoreline by altering the currents (see discussion in Halekūlani sector section, below).

Battery Randolph was completed and armed by 1914. Battery Dudley, which was adjacent to and northwest of Randolph, was armed in 1916. To protect the remaining beach in front of Fort DeRussy, a 1,150-ft-long seawall was built on the reef in 1916; the area behind the seawall was later infilled with dredged coral to significantly expand the active beach (Wiegel 2008:12). A 70-ft-long box culvert and groin at the Diamond Head edge of the Fort DeRussy sector, originally built in 1917, was lengthened to 300 ft in 1969 and supplemented by a rubble mound groin ca. 1971 (Wiegel 2008:22). Both batteries were decommissioned in 1944, and Battery Dudley was demolished in 1970 (Davis 1989:21). Battery Randolph has housed the U.S. Army Museum of Hawaiʻi since 1976. The Artillery District of Honolulu (Site 50-80-14-1382), which includes Battery Randolph, was listed on the NRHP in 1984.

The Fort DeRussy shoreline is an almost completely constructed beach. A narrow strip of coastal land formerly separated a large complex of fishponds from the ocean; immediately inland of the Fort DeRussy beach sector was one of the larger ponds, Loko Kaʻihikapu. Bishop's (1881) map of Waikīkī shows that the shoreline at the western boundary of the sector was over 150 m inland of its present location. The outlet of a small waterway identified on Bishop's (1882) map as Kawehewehe was on the Diamond Head boundary of the beach sector. Known shoreline structures in the Fort DeRussy beach sector include a seawall built in 1916 and a box culvert and groin built in 1917 (subsequently extended in 1969 and supplemented by a rubble-mound groin in 1971).

No archaeological sites have been identified within the Fort DeRussy beach sector. Site 50-80-14-4570, a multi-component deposit with traditional Hawaiian and historical-period layers (Davis 1989, 1992; Denham and Pantaleo 1997a, 1997b, 1998), is along the inland boundary of the eastern portion of the sector. This site is within LCA 1515:2, awarded to Kaihuoloa, and Grant 2880, purchased by H.J.H. Holdsworth. Davis' (1989) trenches revealed two distinct archaeological layers, the uppermost of which (Layer II) contained an *imu* and other pit features, as well as historical artifacts. Subsequent data recovery documented 40 features, including 24 hearths, 12 pits of unknown function, three post molds, and a historical-period burial pit. Unidentified charcoal from Layer III, the earliest archaeological deposit, produced a radiocarbon determination of 410±50 BP (Beta-31310), which provides a calibrated date of AD 1422-1529 and AD 1546-1635.

BioSystems Analysis, Inc., conducted monitoring and data recovery at Fort DeRussy in association with the realignment of Kālia Road and construction at the Hale Koa Hotel (Denham and Pantaleo 1997a, 1997b, 1998). Site 50-80-14-4570 was assigned to "all non-spatially contiguous features on the former spit" and encompasses numerous pre-Contact-era to historical-era subsurface features dispersed across the Fort DeRussy property (Denham and Pantaleo 1998:I), along with Davis' (1989, 1992) previous finds.

BioSystems' Feature 23, a group of five burials, was near the Fort DeRussy sector. The burials appeared to have been previously disturbed by landscaping activities and were associated with both traditional Hawaiian and historical-period artifacts (Denham and Pantaleo 1998:28).

Site 50-80-14-9500 falls outside of the Fort DeRussy beach sector but is worthy of mention based on its proximity and its ability to inform on the potential for human burials along the Fort DeRussy coastline. This site designation was assigned to six burials encountered during construction of the Hale Koa Hotel in 1976. Five of the burials were identified as pre-Contact or early post-Contact, and one burial immediately beneath a 20th century pavement was thought possibly to represent a homicide victim (Kimble 1976, cited in Armstrong and Spear 2009:6-7).

9.2.3.3 Halekūlani Beach Sector

The Halekūlani beach sector consists of approximately 440 m (1,450 ft.) of shoreline extending from the Fort DeRussy outfall/groin to the Royal Hawaiian groin. This sector includes Halekūlani Beach, formerly known as Gray's Beach. The south-facing shoreline is a mix of seawalls and discontinuous, small, narrow sand beaches that front a fully developed urban landscape. Prior to modern development, the Halekūlani sector lay between two drainages, ʻĀpuakēhau to the east (in the Royal Hawaiian beach sector) and Kawehewehe to the west (along the boundary with the Fort DeRussy sector). Kawehewehe was the outflow from the large fishpond complex of Kālia, the inland area of present Fort DeRussy. This beach sector comprises portions of the traditional ʻili of Helumoa and Keōmuku. Like the Royal Hawaiian beach sector, the Halekūlani beach sector contains the beachfronts of major Waikīkī hotels. From south to north, the hotels are the Sheraton Waikiki Hotel, the Halekūlani Hotel, and the Outrigger Reef Waikīkī Beach Resort.

The Halekūlani beach sector was immediately ʻEwa of the mouth of ʻĀpuakēhau Stream (within the Royal Hawaiian sector), which served as the seat of the Waikīkī chiefs as early as the mid-1400s. ʻĪʻī (1959:15) records that the area near the mouth of Kawehewehe Stream became the residence of the Luluka family, of which he was a member, when they moved to Oʻahu in the company of Kamehameha who was preparing for the invasion of Kauaʻi around 1803. ʻĪʻī's uncle was a member of the royal court, and members of the Luluka family were responsible for the royal residence at Puaʻaliʻiliʻi at Helumoa (in the Royal Hawaiian beach sector).

Twelve LCAs were awarded along the shoreline of the Halekūlani sector. An *aliʻi* award of Keōmuku was made to Samuel Kuluwailehua (LCA 1281:1). Unlike the other beach sectors, the shoreline within the Halekūlani beach sector is almost completely encompassed by *kuleana* awards. These awards are primarily house lots, although the Māhele claims indicate farming was also undertaken.

In 1907, a small hotel called the Hau Tree opened in the former home of Robert Lewers. The Hau Tree, which became the Halekūlani in 1917, continued to grow in size and eventually incorporated the neighboring resort property Gray's-By-the-Sea. The Gray's-By-the-Sea boarding house was established by La Vancha Maria Chapin Gray in a two-story house built by Minnie Gilman (Mrs. Joseph A. Gilman) in 1903 and is the source of the name "Gray's Beach" sometimes used for this area (Clark 1977:56). A new Halekūlani Hotel was opened in 1932; the hotel was completely rebuilt in the 1980s to accommodate over 600 rooms.

The first seawalls in this vicinity were built in front of the S.C. Wilder home and Gray's By-the-Sea in 1913-1914, and in 1916 a 1,150-ft-long seawall was built along the shoreline in front of Fort DeRussy (Wiegel 2008: 26). The seawalls were constructed after offshore dredging in front of Fort DeRussy reportedly destabilized the coastline (Wiegel 2008:11). Kīnaʻu Wilder (quoted in Wiegel 2008:11) describes the drastic changes of that period to the shoreline:

> A*fter the dredging, the] beach at Waikīkī was never the same. Instead of the reef holding the sands of the beach and preventing them from being carried out by the changing tides, the sand was swept through the hole in the reef, never to return. What had been a glorious beach – which no other beach on earth could touch – was nothing. Property owners lost anywhere from ten to thirty feet of their frontage. Everyone was forced to put up seawalls to keep from losing their houses as well. Instead of running from the grass right out to the ocean, we had to go down slippery steps to a miserable little strip of sand which, during certain months, was non-existent. At times I could jump from our seawall right into the water…*

According to Wiegel (2008:26), eight groins were built "between [the] Royal Hawaiian Hotel and Fort DeRussy" between 1926 and 1929. Four groins are said to have been removed from this area in 1970 (Wiegel 2008:22). An aerial photograph taken in 1932 shows five groins in the vicinity. The ʻEwa groin may be the original Fort DeRussy outfall/groin at the boundary of the Halekūlani and Fort DeRussy beach sectors; the original Fort DeRussy outfall, built in 1917, was 70 ft long (Wiegel 2008:22).

The Halekūlani beach sector contains minimal beach, with sections in front of the Sheraton Waikiki Hotel and the Halekūlani Hotel fronted by seawalls. Several shoreline structures were built during the early 20th century and the small beach in front of the Outrigger Reef Waikīkī Beach Resort developed after ca. 1881. This is the former location of the outlet of a small waterway identified on Bishop's (1882) map as Kawehewehe (Bishop 1882), which may have drained the Kālia fishponds. This waterway, which may have been a small stream or artificial watercourse, may have been filled along with the Kālia fishponds in conjunction with the construction of Fort DeRussy. Seawalls were built as early as 1914 after dredging offshore of Fort DeRussy initiated nearby beach erosion. Eight groins were built in this vicinity in the 1920s, four of which were removed in 1970.

No archaeological sites are known to be within the Halekūlani beach sector, with one site abutting a portion of the inland sector boundary. Site 50-80-14-9957 was mapped and excavated in 1981-1982 during renovations to the Halekūlani Hotel (Davis 1984). A major portion of the site lies just inland of the seawall at the southwest corner of the hotel property (now occupied by the ʻEwa hotel tower). Murabayashi and Dye (2014:10-11) summarize the results:

> *While most of the property was disturbed by recent construction, an area along the beach and an isolated area in the center of the property remained relatively intact. Excavations uncovered 32 features, including human skeletal remains, a dog burial, postholes, trash pits, privies, and several pits. Most of the trash pits contained bottles, ceramics, and metal. Although the area had been heavily disturbed by the recent construction, significant cultural materials dating to the late 1800s remained intact.*

Additional archaeological finds include human skeletal remains recovered on the grounds of the Sheraton Waikiki Hotel. The skeletal remains of eight individuals were collected in 1970 (NPS 1998:4282), and a single female "forearm bone" was collected in 1993 (Hammatt and Shideler 2007c:59).

9.2.3.4 Royal Hawaiian Beach Sector

The Royal Hawaiian beach sector is approximately 530 m (1,730 ft.) of shoreline extending from the ʻEwa (west) basin of the Kūhiō groin complex to the Royal Hawaiian groin. It lies at an inward curve in the Waikīkī coastline that allows the development of a wide sand beach and sits between two of the three former major stream outlets (Kuʻekaunahi and ʻĀpuakēhau) that once flowed into the ocean. ʻĀpuakēhau Stream once flowed into the ocean near the northern edge of the sector (near the present location of the Royal Hawaiian Hotel). The Royal Hawaiian beach sector is adjacent to the core of traditional and historical activity in Waikīkī. It falls within portions of the traditional ʻili of Helumoa and Hamohamo.

The Royal Hawaiian beach sector contains the beachfront of several prominent hotels and resorts, including the Royal Hawaiian Hotel, the Outigger Waikīkī Beach Resort, and the Moana Surfrider Hotel. The southern end of the sector is the Kūhiō Beach Park and the Waikīkī Beach Center, which contains the Honolulu Police Department's Waikīkī Substation, and the Duke Paoa Kahanamoku Statue.

ʻĀpuakēhau Stream was the major outlet of drainages originating in Mānoa and Pālolo Valleys and was the focus of *aliʻi* activity along the Waikīkī shoreline. Waikīkī was the home of Oʻahu ruling chiefs from at least the 1400s, during which Maʻilikūkahi moved the political center of Oʻahu to Waikīkī (Nāpōkā 1986:2; Beckwith 1970:383). From that time, it was the residence, either permanently or part-time, of the high *aliʻi*; the mouth of ʻĀpuakēhau Stream was the focal point of chiefly residence.

Around 1783, Maui king Kahekili landed an invasion force at Waikīkī and encamped at ʻĀpuakēhau. After successfully conquering the island, Kahekili established his residence on the bank of ʻĀpuakēhau Stream (Fornander 1919:VI-2:289; Kanahele 1995:79). After some time on Maui and Hawaiʻi, Kahekili returned to Waikīkī, where he died in 1794.

In 1795, following the death of Kahekili, Waikīkī was the landing for an invading force led by Kamehameha. Although the invasion was successful, it was not until 1803 that Kamehameha moved permanently to Oʻahu (ʻĪʻī 1959:16). He established his capital at Waikīkī and set up a residence, named Kūihelani, at Puaʻaliʻiliʻi on the northwest side of ʻĀpuakēhau Stream just inland of the shore (ʻĪʻī1959:17; Kanahele 1995:91, 92). The residence would have been between the present-day locations of the Moana Surfrider Hotel and the Royal Hawaiian Hotel on the west side of ʻĀpuakēhau Stream just inland of the shore (ʻĪʻī 1959:17; Kanahele 1995:91, 92). ʻĪʻī (1959:17) describes the compound, which was surrounded by the houses of his wife Kaʻahumanu and his retainers:

> *Kamehameha's houses were at Puaaliilii, makai of the old road, and extended as far as the west side of the sands of Apuakehau. Within it was Helumoa, where Kaʻahumanu ma went to while away the time. The king built a stone house there, enclosed by a fence; and Kamalo, Wawae, and their relatives [the Luluka family of John Papa ʻĪʻī] were in charge of the royal residence.*

During the Māhele, four LCAs were recorded in or adjacent to the shoreline within the Royal Hawaiian sector . An *aliʻi* land award for the coastal portion of Hamohamo was made to Keohokālole (LCA 8452:1). Three *kuleana* awards on the shoreline include LCAs 6616:4 and 7597:3 at the east end of the sector, and LCA 1445:1 at the west end; all three are described as house lots in land claims and testimonies. The mauka (landward) portion of the Royal Hawaiian sector overlaps slightly with the makai edge of these awards.

In the 19th century, this area became the beachside retreat for the *aliʻi*. Liliʻuokalani received the land of Hamohamo from her mother, Keohokālole, in 1859. Kamehameha V purchased property, including the former LCA 1445:1 at Helumoa, in 1866 on the northwest side of ʻĀpuakēhau Stream. This land was subsequently bequeathed to Bernice Pauahi Bishop, who built a house on the property. Land was purchased at Uluniu (at the southern end of the Hamohamo coastal strip) by Kalākaua and his wife Kapiʻolani, which was later inherited by Prince Kūhiō. Kūhiō built a home he called Pualeilani.

The ʻĀpuakēhau Stream outlet to the ocean transitioned from the focus of Waikīkī's *aliʻi* residences to the heart of the region's hospitality. The Long Branch Bathhouse, where bathers could change their clothes for a small charge, was established in 1881 at Ulukou (Hibbard and Franzen 1986:53). The first building at the location of the present Waikīkī Beach Center, the Ilaniwai Baths, was built in 1884 (Clark 1977:54; Hibbard and Franzen 1986:53).

In 1901, the first major hotel, the Moana, opened on the grounds of W.C. Peacock's home on the south side of the river. The hotel was originally outfitted with a 300-ft-long pier, originally called Peacock Pier, that was a landmark of the Waikīkī shoreline until it was demolished in 1931 (Wiegel 2008:21). Two concrete five-story wings were added to the original four-story wooden structure in 1918, doubling the hotel's capacity (Hibbard and Franzen 1986:77). Five years after the establishment of the Moana Hotel, the cottage-style Seaside Hotel opened on Bernice Pauahi's property in Helumoa.

One of the earliest known seawalls in Waikīkī was a 230-ft-long seawall that was built ca. 1901 in front of the Moana Hotel (Hibbard and Franzen 1986:58-59; Wiegel 2008:21, 26). A concrete groin reportedly built between the Moana Hotel and Royal Hawaiian Hotel at an unknown date had been removed by 1927 (Wiegel 2008:26). The Moana Groin was a concrete wall built into the ocean on the Diamond Head side of ʻĀpuakēhau Stream sometime between 1906 and 1907; it was removed in 1927 (Kanahele 1928c; Wiegel 2008:26).

The 21-story Surfrider Hotel opened on the western side of the Moana Hotel in 1969 (Wiegel 2008:21); the original Moana Hotel has been replaced by a newer building, and the Moana and Surfrider today operate as a single establishment called the Moana Surfrider Hotel.

Construction of the Royal Hawaiian Hotel on the grounds of the former Seaside Hotel began in 1925 and the hotel opened in 1927. The distinctive six-story building, with its pink-colored stucco concrete façade, contributed to the coastline's growing allure as a glamorous tourist destination. The hotel continues to operate in its original building. According to Hibbard and Franzen (1986:95):

> *The 'pink palace' towered over its neighbors and had a majestic aura new to Waikīkī. Sheer massiveness, capped by a central tower that soared 150 feet above the street, enabled the Royal Hawaiian to join the Moana in dominating the beach's palm-filled skyline. Furthermore, its four hundred rooms, each with a bath, balcony, and view of either mountains or ocean, almost doubled the guest capacity of Waikīkī.*

A second seawall was built shoreward of the old seawall during the construction of the Royal Hawaiian Hotel ca. 1925-1927, and the 170-ft-long Royal Hawaiian groin was added west of the hotel in 1927. The groin was extended to a length of 368 ft in 1930 and was substantially rebuilt in 2020 (Morrison 2020; Wiegel 2008:21, 26).

The Waikīkī Tavern was operating on the Diamond Head-end of the Royal Hawaiian sector by the 1920s, at which time it was known as the "only place other than hotel dining rooms [along Kalākaua Avenue] where a person could obtain a meal" (Hibbard and Franzen 1986:117). The Waikīkī Tavern was demolished in 1960 (Clark 1977:54). Kūhiō Beach Park, which occupies the southern portion of the sector, was dedicated in 1940 (Clark 1977:52).

A comparison of the historical and contemporary shorelines within the Royal Hawaiian sector shows that several shoreline structures were built during the early 20th century and that the beach has expanded considerably since ca. 1880s, especially on the ʻEwa side in front of the Royal Hawaiian Hotel. This beach sector was the location of the mouth (*muliwai*) of ʻĀpuakēhau Stream. Based on historical photographs, the stream mouth was nearly blocked by sand by the end of the 19th century (Wiegel, 2008); the stream was made obsolete by the construction of the Ala Wai Canal in the 1920s.

The earliest shoreline structure was a seawall built in front of the Moana Hotel in 1901; it was followed by a second seawall in front of the Royal Hawaiian Hotel in 1925-1926. A groin between the Moana Hotel and Royal Hawaiian Hotel was demolished in 1927. The Royal Hawaiian groin, built in 1927, was substantially rebuilt in 2020 but remains a prominent feature of the Waikīkī shoreline.

One archaeological site overlaps with the Royal Hawaiian sector with two sites and one burial adjacent to the inland margin. At least 33 burials have been identified within approximately 50 m of the project area. Twenty-four burials (Site 50-80-14-1974) were identified on the grounds of the Moana Hotel, along with a possible pre-Contact archaeological deposit extending under both wings of the hotel. Site 50-80-14-5863, which contains two burials, overlaps with the beach sector boundary. This site is within LCA 6616:4, which later became the residence of Kalākaua and Kapiʻolani and which was eventually developed by Prince Kūhiō as his beachside home Pualeilani. Non-burial sites include Site 50-80-14-5940 (an extensive archaeological deposit), Site 50-80-14-7068 (a historical-period archaeological layer), and Site 50-80-14-7069 (a historical-period trash pit). Site 50-80-14-9980 was assigned to numerous *ʻulu maika* collected during the construction of the Royal Hawaiian Hotel (see Kanahele 1995:99).

Investigations by Simons et al. (1991) on the grounds of the Moana Hotel revealed layers of historical-era fill overlying discrete archaeological deposits dating to the post-Contact and pre-Contact periods. Two radiocarbon dates were obtained from the unidentified charcoal recovered from the pre-Contact layer. One sample from an ash lens produced a determination of 350±90 BP, which calibrates to AD 1408-1684, AD 1735-1803, and AD 1930-1950. Another charcoal specimen from an unspecified context produced a determination of 300±130 BP, which calibrates to AD 1424-1895 and AD 1903-1950. Because the Moana Hotel has occupied the site since 1901, the post-1900 probability ranges can be discarded for both dates. Archaeological features included firepits, post molds, unidentified pit features, animal burials (cat), and planting pits. The cat burials were thought to be associated with the Peabody family residence, and the planting pits were associated with early 20th century use of the property.

Burial 3 of Site 50-80-14-5863 was found at the mauka (landward) edge of the Royal Hawaiian sector, near the Waikīkī Police Station. Burial 3 is a modified human femur fragment moved by grading activities. The femur fragment was found to have been "deeply scored and snapped by a sawing or cutting instrument just below the lesser trochanter at the pectineal line" and thought to have been used in the manufacture of fish hooks (Winieski, Perzinski, and Souza et al. 2002:25). The original location of the femur fragment (prior to disturbance by grading) could not be identified and it was recovered for reburial at a dedicated off-site interment location.

The Moana Hotel, which opened in 1901 on the site of the former W.C. Peabody home as the first major hotel in Waikīkī, has been designated as Site 50-80-14-9901. The Moana Hotel was placed on the National Register of Historic Places (NRHP) in 1972.

Also within this sector is a portion of a buried seawall its Diamond Head end, immediately west of the hula mound. The buried seawall was observed by SHPD staff (Nick Belluzzo, personal communication 2016) and is likely associated with a structure illustrated on Kanahele's (1928c) map of Waikīkī. A recent news article (Davis 2017) identifies the exposed concrete structure as part of the foundation of the Waikīkī Tavern.

Helumoa Heiau was placed by Thrum (1906:44) at ʻĀpuakēhau. Based on a field inspection, Hammatt and Shideler (2007c:33) suggest its likely location as "the prominent point just on the Sheraton side of the Royal Hawaiian Hotel."

9.2.3.5 Kūhiō Beach Sector

The Kūhiō beach sector is immediately south-southeast of the former mouth of ʻĀpuakēhau Stream, which served as the royal center of Hawaiian rulers in Waikīkī since the mid-1400s based on oral traditions. Lands within and near the sector were transferred during the Māhele via three *aliʻi* land awards and seven *kuleana* awards. The *aliʻi* awards included Kapuni/Uluniu in the north to Mataio Kekūanaōʻa (LCA 104FL:5); Hamohamo in the center (on the north side of Kuʻekaunahi Stream) to Keohokālole (LCA 8452:1), and Kekio in the south (on the south side of the stream) to Pehu for his wife Keʻekapu (LCA 5931:2). Hamohamo, which encompassed extensive inland lands, also included the coastal strip between Kuʻekaunahi and ʻĀpuakēhau Stream—nearly all of the Kūhiō Beach and Royal Hawaiian beach sectors—and as a result, Kapuni/Uluniu did not have any coastal access in this area.

No *kuleana* awards were made within the Kūhiō Beach sector, though several were nearby. These clustered in two locations along the coast, one along the north side of Kuʻekaunahi Stream and the other about 80 m farther to the north. The southern cluster falls at the present intersection of Kalākaua and ʻŌhua Avenues. The northern cluster is at the intersection of Kalākaua and Liliʻuokalani Avenues. All are described in claims and testimonies as house lots.

LCA 1433:1, originally awarded to Kaluhi, is particularly notable because it is just inland of the location of Liliʻuokalani's beachside residence Kealohilani, which was subsequently the second Pualeilani home of Prince Jonah Kūhiō Kalanianaʻole. In the mid-century Mahele, the ʻili of Hamohamo was awarded to the high chief Keohokālole. In 1859, Keohokālole transferred the land to her daughter Liliʻuokalani (future queen of Hawaiʻi), who established Waikīkī residences at Paoakalani (makai of the present Ala Wai Canal) and a beachside cottage on the former LCA 1433:1 that she called Kealohilani.

One of the earliest structures to modify the shoreline was a bridge and causeway built across the mouth of Kuʻekaunahi Stream at the entrance to Kapiʻolani Park, which opened in 1877. In 1890, a 390-ft-long retaining wall was built to protect Waikīkī Road (now Kalākaua Avenue), replacing part of the original bridge and causeway. The 1890 retaining wall is said to have been removed in 1972 (Wiegel 2008: 27); as discussed below, an existing portion of the wall may have been discovered during construction along Kalākaua Avenue.
An approximately 130-ft-long timber pier on piles was built sometime prior to 1890 off of Liliʻuokalani's Kealohilani residence. Known as Queen Liliʻuokalani or Kūhiō Pier, it was demolished in 1934 (Kanahele 1995:136; Wiegel 2008:17).

Prince Kūhiō acquired Kealohilani in 1918 through an out-of-court settlement from his challenge to Liliʻuokalani's establishment of a trust (Hibbard and Franzen 1986:37). He built a new home called Pualeilani on the property. This Pualeilani was the second home of this name owned by Kūhiō; his former Pualeilani home was approximately 300 m to the north (in the Royal Hawaiian sector). In 1922, the Paradise of the Pacific magazine noted that it was the last space in Waikīkī that was retained by a member of the royal family (Hibbard and Franzen 1986:38). The property was acquired by the City and County of Honolulu in 1934-1935 and the house was demolished for beach improvements (Hibbard and Franzen 1986:38).

Preparations for the opening of Kūhiō Beach Park in 1940 included the construction of a 650-ft-long crib wall built in 1939 200 ft from shore (parallel to shore) off the ʻEwa end of Kūhiō Beach, with shore return structures at each end of the seawall (Wiegel 2008:17). The 355-ft-long Kapahulu storm drain/groin was built in 1951 at the end of Kapahulu Avenue. The structure is an extension of the storm drain running under Kapahulu Avenue; the storm drain and groin, which is still a prominent feature of the Waikīkī Beach shoreline, is commonly referred to as "The Wall" (Clark 1977:53). Other improvements included construction of a retaining wall on the Diamond Head side of the groin and importing sand.

In 1953, a 750-ft-long retaining wall was built between the 1939 crib wall and the Kapahulu storm drain/groin to keep sand from eroding. This wall, also still extant, is called "Slippery Wall" because of its very slick surface when wet due to the growth of fine seaweed (Clark 1977:53; Wiegel 2008:17, 27). It forms the boundary of Kūhiō Beach's Diamond Head (east) basin. The beach sand has been further supplemented several times, including through off-shore dredging ca. 2000 (Wiegel 2008:19).

The Kūhiō beach sector has seen extensive modification over the past century and a half. A comparison of the historical and contemporary coastlines shows that the present project area is entirely within beach that has been added since ca. 1880s . 19th century maps of the Waikīkī coastline show that this sector contained the mouth (*muliwai*) of Kuʻekaunahi Stream. Kuʻekaunahi Stream ceased to flow in the 1920s after it was cut off from the upland waterways by the Ala Wai Canal.

~~Over the years, various structures have been built along the shoreline in the Kūhiō beach sector. The earliest of these was a bridge or causeway built along Kalākaua Avenue at the entrance to Kapiʻolani Park. Subsequent structures include Liliʻuokalani Pier (removed in 1934), a retaining~~

~~wall along Kalākaua Avenue (possibly removed in 1972), and the structures of the Kūhiō groin complex, which include two shore-parallel seawalls enclosing a protected swimming area supplemented by groins. The most prominent of these groins is the Kapahulu storm drain/groin at the Diamond Head end of the complex.~~

No known archaeological sites are within the Kūhiō beach sector. Eleven sites, inclusive of 52 burials, have been recorded within 50 m of the project area. Site 50-80-14-5859 is a cluster of eight burials near the intersection of Kalākaua and Liliʻuokalani Avenues, which is the location of LCA 1433:1 and a group of nearby *kuleana* awards (LCAs 5FL:1, 1437:1, 1459, and 1468); it is also the location of Liliʻuokalani's beach residence, Kealohilani. Non-burial sites include Site 50-80- 14-5940 (an extensive but discontinuous archaeological deposit along Kalākaua Avenue between Kaʻiulani and Liliʻuokalani Avenues), Site 50-80-14-5941 (historical trash pit), Site 50-80-14-5942 (remnant of light-gauge rail), Site 50-80-14-5943 (low-energy alluvial deposits related to Kuʻekaunahi Stream), and Site 50-80-14-5948 (an exposed seawall that might date to around 1890).

9.2.4 Architectural Resources

9.2.4.1 General Overview

Architectural resources within and adjacent to the Waikīkī shoreline project area consist of beach infrastructure (groins and seawalls) and adjacent buildings. The groins (including storm drains) form the boundaries between each of the sectors: Kapahulu storm drain/groin, ʻEwa Kūhiō groin, Royal Hawaiian groin, and Fort DeRussy outfall/groin. They were built at different times, with dates of origin from 1917 (Fort DeRussy) to 1951 (Kapahulu storm drain/groin). A complex of shore-parallel seawalls in the Kūhiō Beach sector was built in 1939 and extended in 1953. Estimates of construction dates have been made using historical maps and photographs, as well as references in Waikīkī historical sources (e.g., Clark 1977; Wiegel 2008).

With one exception (Site 50-80-14-5948), these beach infrastructure features have not been recorded in detail nor assigned State Inventory of Historic Places (SIHP) numbers. However, based on age (at least 50 years old) and their relevance to Waikīkī's history they may be considered historic properties. Inland of the shoreline maintenance program areas are three important historic buildings, which will not be physically affected by beach improvement activities but warrant mention: Battery Randolph (Site 50-80-14-1382), the Moana Hotel (Site 50-80-14-9901), and the Royal Hawaiian Hotel (no SIHP number). Both Battery Randolph and the Moana Hotel are listed on the NRHP.

9.2.4.2 Fort DeRussy Beach Sector

The Fort DeRussy sector contains the Fort DeRussy Groin beach control structure with Battery Randolph just inland of the sector's northeastern boundary, and the Fort DeRussy seawall.

<u>Fort DeRussy Outfall/Groin</u>
A 70-ft-long box culvert at the Diamond Head end of the sector was built in 1917. The box culvert was lengthened to 300 ft in 1969 and supplemented by a rubble mound groin ca. 1971

(Wiegel 2008:22). It is unclear whether the existing groin immediately south of the Fort DeRussy Groin is the original 1917 groin, or if the 1917 groin was destroyed or covered during the 1969 extension of the structure.

Fort DeRussy Seawall

In 1916, a 1,150-ft-long seawall was built along the entire Fort DeRussy shoreline. The seawall was built on the coral reef where there was no sand, and the area behind it was filled with coral rock and rubble dredged from the reef (Wiegel 2008:11). The batteries and seawall are estimated to lie just seaward of the present promenade.

Battery Randolph (Site 50-80-14-1382)

Construction of Battery Randolph was begun in 1910 by the U.S. Army as part of the Artillery District of Honolulu (later renamed the Headquarters Coast Defense of Oʻahu) intended to protect the coast of Oʻahu, including Honolulu Harbor. The Artillery District included Forts Armstrong, DeRussy, Kamehameha, and Ruger. Battery Randolph was completed and armed by 1914. Battery Dudley, which was adjacent to and northwest of Battery Randolph, was armed in 1916. A deep channel was cut into the reef to facilitate the installation of two 14-inch guns. Battery Randolph is built of reinforced concrete, with its design intended to camouflage it from military attack. The appearance of the building is described in its NRHP nomination:

> *In contrast to the stark, vertical walls of older forts, the new works of reinforced concrete [at Fort DeRussy, including Battery Randolph, and Fort Kamehameha] were designed to blend, so far as possible, into the surrounding landscape. The low profile, massive emplacements all possess concrete frontal walls as much as twenty feet thick behind 30 or more additional feet of earth. The batteries were (and still are) all but invisible and invulnerable from the seaward direction. The permanency of construction is also evident by their present condition (Char 1983:4).*

Battery Randolph was deactivated in 1944, and its guns and mounts were removed. Since 1976, the building has housed the U.S. Army Museum of Hawaiʻi. It was entered on the NRHP in 1984 as part of the Artillery District of Honolulu (Site 50-80-14-1382) along with Batteries Selfridge, Jackson, Hawkins, Hawkins Annex, and Hasbrouck at Fort Kamehameha.

9.2.4.3 Halekūlani Beach Sector

In addition to the Royal Hawaiian groin (at the east end), five concrete block groins are visible in aerial photographs of the Halekūlani beach sector and may be historical structures. Similar groins can be seen in a 1932 aerial photograph. Eight groins were built between the Royal Hawaiian Hotel and Fort DeRussy from 1926 to 1929 (Wiegel 2008:26). Four groins in this area were removed in 1970 (Crane 1972, cited in Wiegel 2008:22).

9.2.4.4 Royal Hawaiian Beach Sector

The Royal Hawaiian beach sector contains two beach stabilization structures and has two historic buildings, the Moana Hotel and the Royal Hawaiian Hotel, immediately inland of the sector's northern margin. The beach infrastructure consists of the Royal Hawaiian groin (built in 1927), which marks the boundary with the Halekūlani sector, and a buried seawall at the southern end of the sector.

Royal Hawaiian Groin
The 170-ft-long Royal Hawaiian groin, which marks the boundary of the Royal Hawaiian and Halekūlani sectors, was built to the west of the Royal Hawaiian Hotel in 1927. The groin was extended to a length of 368 ft in 1930 (Wiegel 2008:21, 26) and substantially rebuilt in 2020. The recent groin expansion included the construction of a 125-ft-long boulder rubble-mound groin overlying a portion of the existing Royal Hawaiian groin and a 50-ft-long dogleg to the east. Archaeological monitoring conducted during the groin expansion yielded no significant finds (Morrison 2020).

Buried Seawall
A buried concrete slab was examined by SHPD staff in 2013 at the Diamond Head end of the sector, immediately west of the Kūhiō Beach Hula Mound (Nick Belluzzo, personal communication 2017). Subsequent beach erosion has exposed a larger portion of the concrete slab, which is in the same location as the Waikīkī Inn (part of the Waikīkī Tavern) as shown on a 1950 Sanborn Fire Insurance map. The buildings of the Waikīkī Tavern were built in the 1920s and demolished ca. 1960 for the development of Kūhiō Beach Park. The buried seawall may be associated with a structure illustrated on Kanahele's (1928c) map of Waikīkī.

Moana Surfrider Hotel (Site 50-80-14-9901)
In 1901, Waikīkī's first major hotel, the Moana, opened on the grounds of W.C. Peacock's former home on the south side of the ʻĀpuakēhau Stream mouth. The Moana Hotel, which was designed by O.G. Traphagen, "features an elaborately designed lobby which extends to open lanais and is open to the Banyan Court and the sea" (Riconda 1972:3). The hotel was outfitted with a 300-ft-long pier, originally called Peacock Pier, that was a landmark of the Waikīkī shoreline until it was demolished in 1931 (Wiegel 2008:21). The Moana Groin was a concrete wall built into the ocean on the Diamond Head side of ʻĀpuakēhau Stream sometime between 1906 and 1907; it was removed in 1927 (Kanahele 1928c; Wiegel 2008:26). During the early 20th century, the hotel's dining room was built on piles and extended nearly to the water; this dining room has since been removed. Two concrete five-story wings were added onto the original four-story wooden structure in 1918, doubling the hotel's capacity (Hibbard and Franzen 1986:77). The 21-story Surfrider Hotel opened on the western side of the Moana Hotel in 1969 (Wiegel 2008:21); the Moana and Surfrider today operate as a single establishment known as the Moana Surfrider Hotel. The Moana Hotel, which has been designated as Site 50-80-14- 9901, was listed on the NRHP in 1972. According to the NRHP nomination form (Riconda 1972:3):

> *The original wooden center structure of the Moana Hotel, built in 1901, is the oldest existing hotel in Waikīkī. As such, it deserves recognition as a landmark in Hawaii's tourist industry. The Moana was one of the earliest "high-rise" buildings in Hawaiʻi and was the costliest and most elaborate hotel in the islands. In spite of numerous renovations and changes, it has retained its tropical openness and is a welcome change from the more modern highrises [sic] that surround it. The Moana represents an important architectural link in the development of Waikīkī.*

Royal Hawaiian Hotel

In 1925-1926, the iconic Royal Hawaiian Hotel was built on the grounds of the former Seaside Hotel, and it opened in 1927. The distinctive six-story building, with its pink stucco concrete façade, contributed to the coastline's growing allure as a glamorous tourist destination. According to Hibbard and Franzen (1986:95):

> *The 'pink palace' towered over its neighbors and had a majestic aura new to Waikīkī. Sheer massiveness, capped by a central tower that soared 150 feet above the street, enabled the Royal Hawaiian to join the Moana in dominating the beach's palm-filled skyline. Furthermore, its four hundred rooms, each with a bath, balcony, and view of either mountains or ocean, almost doubled the guest capacity of Waikīkī.*

The Royal Hawaiian Hotel continues to operate in its original building. Although undoubtedly a historically significant structure, it has not been assigned an SIHP number or evaluated in terms of its eligibility for the NRHP.

9.2.4.5 Kūhiō Beach Sector

There are four known historical architectural structures within the Kūhiō beach sector, all of which are beach stabilization structures: 1) Site 50-80-14-5948 is a buried remnant of the seawall constructed in 1890, 2) the ʻEwa (west) basin of the Kūhiō groin complex constructed in 1939, 3) "Slippery Wall" (forming the Diamond Head (east) Basin of the Kūhiō groin complex) constructed in 1951-1953, and 4) the Kapahulu storm drain/groin constructed in 1951.

Site 50-80-14-5948

The site consists of remnants of a buried historical seawall approximately 4 m seaward of the Kalākaua Avenue curb near the intersection of Kalākaua and Kapahulu Avenues (Winieski et al. 2002:55). The top of the 15 m long wall, which is built of mortared large basalt boulders, was exposed by construction excavation at about 1 m below the surface and the base of the wall, extended below the base of excavation at 2.2 m below surface. The wall is also shown on Kanahele's (1928d) map of Waikīkī beach. The seawall was evaluated as significant under the State of Hawaii's Criterion d1.

ʻEwa (west) basin of the Kūhiō Groin Complex

In 1939, preparations for the opening of Kūhiō Beach Park in 1940 included the construction of a 650-ft-long breakwater built 200 ft from shore (parallel to shore) along the ʻEwa end of Kūhiō Beach, with shore return structures at each end of the seawall. The breakwater is known as the "crib wall." At least 7,000 cy of sand was also placed on the beach around the same time (Wiegel 2008:17).

Kapahulu Storm Drain/Groin

The 355-ft-long Kapahulu storm drain/groin was built in 1951 at the end of Kapahulu Avenue. Other improvements included construction of a retaining wall on the Diamond Head side of the Kapahulu storm drain/groin and importing sand. The structure is an extension of the storm drain running under Kapahulu Avenue, which discharges storm water at its seaward end. The Kapahulu storm drain/groin, which is still a prominent feature of the Waikīkī Beach shoreline, is commonly referred to as "The Wall" (Clark 1977:53).

“Slippery Wall”

In 1953, a 750-ft-long retaining wall was built between the 1939 crib wall and the Kapahulu storm drain/groin to keep sand from eroding away. This wall is called “Slippery Wall” because of its slick surface when wet due to the growth of fine seaweed (Clark 1977:53; Wiegel 2008:17, 27). It forms the boundary of the Diamond Head (east) basin of the Kūhiō groin complex. The beach sand along Kūhiō Beach has been supplemented several times, including through offshore dredging ca. 2000 (Wiegel 2008:19).

9.2.5 Ka Paʻakai Cultural Impact Analysis

The State of Hawaiʻi has a responsibility to promote and preserve cultural beliefs, practices, and resources of Native Hawaiians and other ethnic groups. This includes ensuring that legitimate customary and traditional practices of Native Hawaiians be protected to the extent feasible.

The Hawaiʻi Supreme Court in *Ka Paʻakai O Ka `Aina v. Land Use Commission* (2000) suggested three tests for agencies to protect traditional and customary Native Hawaiian practices to the extent feasible. The tests include assessment of the following:

A. The identity and scope of valued cultural and historical or natural resources in the petition area including the extent to which traditional and customary Native Hawaiian rights are exercised in the petition area;
B. The extent to which those resources including traditional and customary Native Hawaiian rights will be affected or impaired by the proposed action; and
C. The feasible action, if any, to be taken by the state to reasonably protect Native Hawaiian rights if they are found to exist.

Waikīkī is a predominantly engineered shoreline. The current shoreline configuration is largely the result of past efforts to widen and stabilize the beaches. The project area consists of eight littoral cells (beach sectors), four of which have been selected for beach improvement and maintenance actions. The boundaries of the beach sectors are primarily defined by engineered structures (e.g., groins, breakwaters, seawalls) that influence coastal processes. Beach width and stability vary by sector.

The project area falls within the *ahupuaʻa* of Waikīkī in the traditional *moku* (district) of Kona. The traditions of Waikīkī indicate its significance as a nexus of interconnected *aliʻi* histories and as a highly productive agricultural region. In ancient times, Waikīkī was a center of *aliʻi* power, “a land beloved of the chiefs” who resided there because the lands were rich, and the surfing was excellent (Kamakau 1991:44). The significance of Waikīkī *ahupuaʻa* is also emphasized by the number and kinds of heiau distributed across this area, particularly along the coast (Kamakau 1976:144; Thrum 1907:44-45).

During the past 130 years, the Waikīkī shoreline has been substantially engineered to create larger sandy beaches for recreation and tourism. As such, most of the proposed beach improvement and maintenance program will occur within modern beach deposits seaward of the 19th century and early 20th century shorelines.

A. The identity and scope of valued cultural and historical or natural resources in the petition area including the extent to which traditional and customary Native Hawaiian rights are exercised in the petition area.

Traditional cultural practices in the Waikīkī area include gathering, fishing, diving, contemplation, spiritual and physical healing, canoe paddling, surfing, and other ocean activities. There have been numerous Cultural Impact Assessments (CIA) for previous projects in Waikīkī, some of which address the shoreline and areas immediately inshore of the active beach system, including portions of the four Waikīkī beach sectors selected for improvement and maintenance actions (Fort DeRussy, Halekūlani, Royal Hawaiian, and Kūhiō Beach). The CIA for the Waikīkī Beach Improvement and Maintenance Program was completed by International Archaeology, LLC in March 2021, and is included as Appendix D.

The most frequently mentioned concern in the previous and current CIA studies was the inadvertent exposure of cultural material, particularly iwi kūpuna (ancestral remains or bones), during ground-disturbing construction work along the shoreline or in the offshore sand deposits that will be dredged to expand and replenish the beaches.

The second most frequently mentioned concern in the previous and current CIA studies involved past and present ocean and shoreline cultural-natural resources, particularly fishing, gathering, and potential impacts to marine habitat. Kawehewehe (at the boundary between the Fort DeRussy and Halekūlani beach sectors) was also frequently mentioned as both a historical and ongoing place of spiritual and physical healing, where the sick undergo ritual bathing. Traditional Native Hawaiian healing and purification rituals are still practiced in the waters of Kawehewehe, and *limu kālā*—a plant used in healing and *hoʻoponopono* ceremonies—may still grow in the area.

The third most frequently mentioned concern was the ongoing development of Waikīkī, particularly obstruction of mauka-to-makai (landward-to-seaward) view corridors by tall buildings/hotels, harm to associated cultural features on the landscape, increasing demands on infrastructure in Waikīkī, including traffic, noise and waste management problems, and most critically, the loss of a "Hawaiian sense of place" and the feel of "old Waikīkī."

A. The extent to which those resources including traditional and customary Native Hawaiian rights will be affected or impaired by the proposed action.

Iwi Kūpuna

The proposed actions have the potential to encounter or disturb iwi kūpuna at three potential locations: 1) backshore (mauka (landward) of the shoreline), 2) foreshore (active beach system), and 3) offshore (sand deposits).

<u>Backshore (Terrestrial Area)</u>

Surface and subsurface cultural resources have been identified in the backshore (terrestrial) area inshore of the project area (active beach system). Resources in the backshore (terrestrial) area have been heavily impacted by previous and ongoing development activities. The most predominant resource in the backshore, based on previous investigations, are in situ and disturbed iwi kūpuna. The resources are located mauka (landward) of the proposed actions, and no excavation or ground-disturbing activities are proposed in the backshore (terrestrial) portion of the project area. The proposed beach improvement and maintenance actions will widen and stabilize the existing beaches, thereby providing a protective buffer for any burials or cultural materials that may exist inshore of the active beach system.

Foreshore (Beach)

While the beaches of Waikīkī are almost entirely composed of imported sand and unlikely to contain primary burials, there are concerns regarding the history and sources of the sand used to build and replenish the beaches during the 20th century.

From about 1930 until the late 1970s, it is estimated that over 400,000 cy of sand has been placed on Waikīkī Beach, from a variety of sources including other beaches on Oʻahu and Molokaʻi, inland dune deposits, and even crushed coralline limestone. It is not known whether sand containing iwi kūpuna has ever been redeposited in the project area or has eroded into offshore deposits. Much of the information regarding historical beach nourishment efforts is anecdotal and based on oral accounts. Given the lack of historical data, it would be difficult to ascertain where and when the sand was acquired and imported into Waikīkī.

While no cultural or archaeological resources (including iwi kūpuna) have currently been discovered within the project area, the applicant is aware that cultural or archaeological resources may be identified during public notices and community meetings. If iwi kūpuna were encountered in the foreshore (active beach system), it would be difficult or impossible to confirm the ancestry of the remains or identify lineal descendants. In summary, the proposed actions are not anticipated to encounter or affect iwi kūpuna in the foreshore (active beach system).

Offshore (Sand Deposits)

The sand required for the proposed beach nourishment and maintenance actions would be almost exclusively recovered from submerged deposits located offshore of Waikīkī. Sand would be recovered using submersible slurry pumps, self-contained hydraulic suction dredges, and/or clamshell buckets. There are concerns regarding the potential disturbance of modern human remains in the submerged sand deposits immediately offshore of Waikīkī where cremated human remains are frequently spread.

The applicant acknowledges the history and practice of spreading cremated human remains in the offshore waters of Waikīkī. However, the likelihood of encountering iwi kūpuna in these areas is considered to be relatively low and it would be very difficult to differentiate cremated remains from marine carbonate sand. The cremation process applies extreme temperature to the body, completely incinerating everything and reducing the body to bone fragments, which are mechanically pulverized down to a coarse, sand-like material. The cremated remains (commonly referred to as “ashes”) consist of inorganic material largely composed of Calcium Phosphate, which is typically a pale to dark gray powder that is similar in texture and appearance to coarse sand. Given the similarities between cremated remains and marine carbonate sand in terms of particle size and color, it would be difficult or impossible to identify or differentiate cremated remains from marine carbonate sand.

The proposed sand recovery areas located offshore of Waikīkī are dynamic and mobile. The *Ala Moana* and *Hilton* sand deposits are reef-generated deposits, so the potential for these deposits to contain iwi kūpuna is considered to be relatively low. The *Canoes/Queens* sand deposit is closer to the shoreline; however, this deposit is very mobile and has been dredged multiple times during previous beach nourishment projects.

It is likely that any cremated remains spread within the vicinity of the proposed sand recovery areas would be immediately dispersed within the water column. The non-uniform dispersion of the cremated remains reduces the likelihood of encountering in situ deposits. If iwi kūpuna were encountered in the offshore sand deposits, it would be difficult or impossible to confirm the ancestry of the remains or identify lineal descendants. In summary, the proposed actions are not anticipated to encounter or affect iwi kūpuna in the offshore sand recovery areas.

Traditional and Cultural Practices

The applicant recognizes and appreciates the various Native Hawaiian traditional and cultural activities that are practiced in Waikīkī, particularly surfing, fishing, gathering, and spiritual and physical healing. The proposed actions may temporarily curtail these activities. During construction, the use of some portions of the shoreline and offshore sand recovery areas may be prevented for public health and safety reasons. In addition, dredging operations will be visible from the shoreline. These impacts will be short-term in nature. Upon completion, the proposed actions will not curtail these activities. In summary, valued Native Hawaiian traditional and cultural practices are not anticipated to be adversely affected should the proposed actions be approved and implemented.

Natural Resources

. The proposed actions have the potential to temporarily affect marine species and habitat. *Honu* (green sea turtles) are regularly observed swimming and foraging in the nearshore waters within the project area; however, no obvious *honu* congregation or nesting areas have been observed. Hawaiian monk seals (*Monachus Schauinslandi*) have also been observed in Waikīkī. The seafloor and all subsurface waters and marine habitat within 10 m of the seafloor, through the water's edge 5 m into the terrestrial environment from the shoreline are considered critical habitat for Hawaiian monk seals.

The proposed actions may temporarily inhibit foraging opportunities for marine species. In-water construction work (e.g., dredging, groin construction) may result in significant underwater sound that could potentially affect marine species. The following Best Management Practices (BMPs) and avoidance and minimization measures will be implemented to mitigate potential effects on marine species and habitat to the maximum extent practicable.

1. Turbidity containment devices (e.g., silt fencing, turbidity curtains) shall be installed around the areas of groin construction and sand placement.
2. Visual monitoring for turbidity outside the confines of the turbidity curtains shall be conducted. In the event that turbidity is observed outside of the turbidity curtains, work shall stop, and the turbidity curtains shall remain in place until the turbidity dissipates. turbidity curtains shall be inspected after dissipation and prior to returning to project operations.

3. All construction personnel on site shall be informed of the potential for federally protected marine species that may occur within or transit through the project area. It shall be made clear that any intentional physical interactions with any identified federally protected marine species is explicitly prohibited.
4. A competent observer shall be designated to observe the construction work areas and areas immediately adjacent to the work for the presence of federally protected marine species, including but not limited to, green sea turtles, hawksbill sea turtles, and Hawaiian monk seals. Visual surveys for these species shall be made prior to the start of work each day, and prior to resumption of work following any break of more than one half hour, to ensure that no federally protected marine species are within 150 ft of the work area.
5. A 150ft safety zone shall be established around the project areas where a competent observer shall visually monitor the zone for the presence of federally protected marine species 30 minutes prior to, and 30 minutes post project in-water activity. The observer shall record information on the species, numbers, behavior, time of observation, location, start and end time of project activity, characteristics of the marine species, and any observed disturbances of the work on the species (visual or acoustic).
6. Activity shall be conducted only if the safety zone is clear of all marine federally protected species.
7. Upon sighting of a federally protected marine species within the safety zone during project activity the activity shall immediately halt until the animal has left the zone. In the event that a federally protected marine species enters the safety zone and the project activity cannot be halted, observations shall be made and NOAA-NMFS staff in Honolulu shall be immediately contacted to facilitate agency assessment of collected data. Work may continue only if there is no possibility for the activity to adversely affect the animal.
8. All equipment and material shall be free of contaminants of any kind including but not limited to excessive silt, sludge, anoxic or decaying organic matter, clay, dirt, oil, floating debris, grease or foam or any other pollutant that would produce an undesirable condition to the shoreline or water quality.
9. Cease construction work if unusual conditions, such as large tidal events or high surf conditions affect the project site, except for efforts to avoid or minimize damage to natural resources, such as the temporary removal of turbidity curtains.
10. Construction site inspections and debris sweeps will be made at the end of each workday, and all project related debris and trash shall be removed and disposed of. Equipment that is not actively being used shall be properly stored and secured so as not to cause unintended damage to the beach or adversely affect any federally protected marine species. A full inspection of the project site shall be conducted at the end of the project to ensure that no visible debris or project waste is present upon completion of the project.
11. Nighttime work and/or work requiring artificial light sources is prohibited. No new permanent lighting shall result from the proposed actions.
12. Any incidental injuries or take of green or hawksbill sea turtles on land shall be immediately reported to the U.S. Fish and Wildlife Service.
13. Any incidental injury or take of green or hawksbill sea turtle or Hawaiian monk seal in the water shall be immediately reported to NOAA-NMFS and the Pacific Island Protected Species Program Manager, Southwest Region.

By using the above BMPs, noise/physical disturbance to *honu* and Hawaiian monk seals is anticipated to be temporary and unlikely to result in adverse behavioral changes. Based on the in-water work being conducted in very shallow water with turbidity containment barriers surrounding the work areas, any exposure of federally protected marine species to turbidity is expected to be temporary and not significant. No significant loss of foraging area is anticipated.

The structures proposed in the Halekūlani and Kūhiō beach sectors have the potential to improve biodiversity and habitat for marine species. The interstitial spaces between the armor stones provide additional habitat for cryptic benthic (crabs, shrimps, worms, etc.) and sessile organisms (sponges and tunicates) that provide additional foraging resources for fishes. The Iroquois Point Beach Nourishment and Stabilization project, which was completed in 2013, utilized groins that are similar to those being proposed in Waikīkī. Post-construction monitoring from 2013-present found a 25-fold increase in fish abundance, not counting small baitfish, and a doubling of species richness (number of species). Fish biomass is more than 6 times greater than prior to construction. The greatest change occurred in the vicinity of the new habitat created by the groin structures. Other changes in the vicinity of the groins include an increase in crustose coralline algae cover from 1% to 60%, coral cover increase from 0 to 0.6% and macroinvertebrate cover from 1.4% to 6.3%. Coral abundance in the groin vicinity increased from 0 to 16 colonies per $10m^2$. These changes are attributable to the creation of hard, stable habitat for colonization. In summary, the proposed actions are not anticipated to adversely affect federally protected marine species or habitat.

Kawehewehe

The applicant recognizes and appreciates the cultural significance of Kawehewehe as a historical and ongoing place of spiritual and physical healing. Kawehewehe was the residence of the Luluka family of noted Hawaiian historian, John Papa ‘Ī‘ī. The family moved to O‘ahu in the early 1800s, in the company of Kamehameha who was preparing for the invasion of Kaua‘i (‘Ī‘ī 1959:15); Papa ‘Ī‘ī’s uncle was a member of the royal court, and members of the Luluka family were responsible for the royal residence of Kamehameha at Pua‘ali‘ili‘i at Helumoa. Kawehewehe was the outflow from the large fishpond complex of Kālia and marks the ‘Ewa (west) end of the Halekūlani beach sector (roughly the alignment of Saratoga Road).

The proposed action in the Halekūlani beach sector may temporarily curtail these uses. During construction, access and use of some portions of the shoreline and offshore areas may be prevented for public health and safety reasons. In addition, dredging operations will be visible from the shoreline. These impacts will be short-term in nature. Upon completion, the proposed action will not curtail these activities. In summary, valued Native Hawaiian traditional and cultural practices at Kawehewehe are not anticipated to be adversely affected should the proposed actions be approved and implemented.

Development

The applicant understands concerns that have been expressed in regard to the intensity of past and ongoing development in Waikīkī. Impacts to viewplanes, increasing demands on infrastructure, and the loss of a “Hawaiian sense of place” and the feel of “old Waikīkī” are recognized issues in Waikīkī. The applicant also acknowledges that the beaches are intrinsically linked to the development of Waikīkī. Without the beaches, it is unlikely that Waikīkī would have evolved into the world-class tourism destination that it is today.

The proposed actions are limited to the foreshore (active beach system) makai of the shoreline and are consistent with historical and ongoing uses in this area. The proposed actions will improve the condition of the Waikīkī shoreline by increasing recreational dry beach area, increasing beach stability, improving lateral shoreline access, and enhancing existing viewplanes. The proposed structures (i.e., groins, segmented breakwater) will be similar in size and appearance to the structures that currently exist in Waikīkī. While the proposed actions are unlikely to restore a "Hawaiian sense of place" or the feel of "old Waikīkī", they will not negatively affect the intrinsic value of Waikīkī. In summary, the proposed actions are not anticipated to affect or intensify existing or future development patterns in Waikīkī.

B. The feasible action, if any, to be taken by the state to reasonably protect Native Hawaiian rights if they are found to exist.

To address these concerns, the applicant will take the following actions:

1. *Carefully evaluate new sources of replenishment sand to confirm they do not contain iwi kūpuna or other cultural material.*

   The applicant will develop and implement an archaeological monitoring plan. An archaeological monitor will be present during implementation of the proposed actions. While no excavation is proposed, the applicant acknowledges that the installation of certain environmental Best Management Practices (e.g., silt fencing, turbidity curtains) may constitute "ground alteration", and that an archaeological monitor should be present. Should any iwi kūpuna or cultural materials be discovered, the proper authority shall be notified. The proposed beach improvement and maintenance actions will widen and stabilize the existing beaches, thereby providing a protective buffer for any burials or cultural materials that may exist inshore of the active beach system.

2. *Monitor all ground-disturbing project work within the historical (pre-20th century) shoreline areas for exposed or disturbed cultural material and develop a plan to protect these resources in consultation with cultural stakeholders/organizations and appropriate government agencies.*

   The applicant will develop and implement an archaeological monitoring plan. An archaeological monitor will be present during implementation of the proposed actions. While no excavation is proposed, the applicant acknowledges that the installation of certain environmental Best Management Practices (e.g., silt fencing, turbidity curtains) may constitute "ground alteration", and that an archaeological monitor should be present. Should any iwi kūpuna or cultural assets be discovered, the proper authority shall be notified.

3. ~~*Reasonably address concerns from community members about the disposition of cremated remains.*~~

~~The applicant will continue to engage the community and local stakeholders to address the concerns related to the disposition of cremated remains. A public scoping meeting will be held during the 45-day public comment period for the Draft Programmatic Environmental Impact Statement (DPEIS).~~

~~4.~~3. *Protect Kawehewehe from damage and allow cultural practitioners reasonable access to the area during construction work.*

The applicant will seek to minimize potential impacts to Kawehewehe to the maximum extent practicable. The project is designed to avoid contact with any portion of Kawehewehe, and to minimize impacts to Native Hawaiian practitioners at the site. The Kawehewehe area will be clearly delineated in project plans, and efforts will be made to avoid burying or damaging the area during construction. The applicant will make a good faith effort to accommodate the needs of Native Hawaiian practitioners in the region during construction. Native Hawaiian practitioners will be provided regular and reasonable access to the waters throughout the duration of the project; however, access to certain areas will be temporarily restricted in order to ensure public health and safety. Upon completion, the proposed action will not curtail any of these important cultural activities and practices.

~~5.~~4. *Regularly engage cultural stakeholders and the local community in future project planning.*

The applicant has conducted extensive outreach and stakeholder engagement in development of the Waikīkī Beach Improvement and Maintenance Program. A critical component of the project was the establishment of the Waikīkī Beach Community Advisory Committee (WBCAC), which was formed in 2017 to provide a forum to engage stakeholders and provide guidance and feedback on design criteria and rationale for beach improvement and maintenance projects in Waikīkī. The WBCAC is composed of various stakeholders representing business (~~34~~29%), government (~~30~~29%), hotels and resorts (~~15~~11%), non-profit organizations (~~12~~14%), and science and engineering (~~9~~17%).

The WBCAC serves as a representative body to communicate the diversity of perspectives and priorities in the broader Waikīkī community, provide guidance and feedback for beach management and planning activities in Waikīkī, and ensure that future beach management projects address the issues and concerns of the Waikīkī community and local stakeholders. The WBCAC was directly involved in determining the priorities and objectives for each beach sector, establishing planning and design criteria, evaluating conceptual options, and providing feedback on the conceptual designs for the proposed actions. The WBCAC held ~~six (6)~~eight (8) formal meetings from Nov 2017 to Jan ~~2021~~2022. The WBCAC meeting agendas and outcomes are included as Appendix A of the ~~DPEIS~~FPEIS.

In addition, the applicant held two (2) public scoping ~~meetings and will continue to solicit guidance and feedback from the community regarding the potential impacts of the proposed actions~~. ~~A public scoping meeting will be held during the 45-day public comment period for the Draft Programmatic Environmental Impact Statement (DPEIS).~~ The applicant will ~~also~~ engage in a formal consultation with the Hawaiʻi Department of Land and Natural Resources, State Historic Preservation Division (SHPD) during the final design and permitting phase to determine if any additional cultural Best Management Practices are recommended or required. If cultural assets are discovered, all work will cease and SHPD will be notified.

9.2.6 Potential Impacts and Mitigation Measures

Waikīkī has a rich historical and cultural legacy. There do not appear to be any known traditional Hawaiian cultural practices that would be adversely affected by the proposed actions, nor does it appear that the activities associated with the proposed actions will conflict with traditional cultural practices as expressed in legend. The proposed actions will be implemented in an area that has been substantially altered over more than a century and is entirely makai (seaward) of the shoreline where the existence of any cultural artifacts or remains is unlikely.

Four aspects of the program make it unlikely that the proposed beach improvement and maintenance actions will have a significant adverse effect on historical, cultural, archaeological, or architectural resources, or any on rights customarily and traditionally exercised for subsistence, cultural and religious purposes:

1. Implementation of the proposed actions does not involve construction on or excavation of backshore land areas that might contain physical remains. Work on land will take place only on the beach and submerged lands. Care will be taken when working on the beach to avoid disturbing previously undisturbed sandy sediments that might hide subsurface deposits.

2. Construction of the new structures (groins, sand retaining wall, and segmented breakwater) will take place completely on submerged lands, seaward of the shoreline, and will not involve modification of soft deposits which could reasonably be expected to have the potential to hide archaeological materials or burials.

3. The likelihood of encountering iwi kūpuna in the offshore deposits is considered to be relatively low. The cremation process applies extreme temperature to the body, completely incinerating everything and reducing the body to bone fragments, which are mechanically pulverized down to a coarse, sand-like material. The cremated remains (commonly referred to as “ashes”) consist of inorganic material largely composed of Calcium Phosphate, which is typically a pale to dark gray powder that is similar in texture and appearance to coarse sand. Given the similarities between cremated remains and marine carbonate sand in terms of particle size and color, it would be difficult or impossible to identify or differentiate cremated remains from marine carbonate sand. It is not known whether sand containing iwi kūpuna has ever been redeposited in the project area or has eroded into offshore deposits. Much of the information regarding historical beach nourishment efforts is anecdotal and based on oral accounts. Given the lack of historical data, it would be difficult to ascertain where and when the sand was acquired and imported into Waikīkī. If human remains were encountered, it would be very difficult to confirm the identity of the deceased or lineal descendancy.

4. Construction of the new groins, sand retaining wall, and beach fill in the Halekūlani beach sector is not anticipated to affect submarine groundwater discharge at

Kawehewehe. The proposed action does not include shore parallel structures penetrating to depths that would prevent submarine groundwater discharge, including tidal pumping. Sand would not be a barrier to flow, it would just make the seepage more diffuse, so submarine groundwater discharge would be significantly altered (H. Dulai, personal communication, April 19, 2021). If there is submarine groundwater discharge coming out of this sector, the ocean current-dampening action of adding groins (as is its function) would pond (decrease oceanic mixing) and thus increase the residence time of any groundwater that has been discharged (C. Glenn, personal communication, April 19, 2021). As a result, the proposed action is not anticipated to affect submarine groundwater discharge or any ongoing Native Hawaiian cultural practices at Kawehewehe.

9.2.6.1 Fort DeRussy Beach Sector

The proposed action for the Fort DeRussy beach sector includes the addition of approximately 1,5003,000 cy of sand fill near the Diamond Head edge using sand sourced from the *Hilton* offshore deposit. A sand borrow area is proposed at the ʻEwa end of the sector adjacent to the Hilton pier/groin. The proposed action will be confined to the area makai of the Fort DeRussy seawall, which consists of beach constructed during the 20th century. Any ground disturbance makai of the ca. 1881 and ca. 1928 shorelines has the potential to encounter archaeological deposits; Site 50-80-14-4570 at the Diamond Head end of the sector is inland of the present promenade.

The addition of sand fill is unlikely to result in significant ground disturbance. However, due to the proximity of previously recorded buried deposits and burials, archaeological monitoring will be conducted during all work within the historical shorelines. Monitoring will not be conducted for work at the sand borrow area since this is an area of relatively recent sand accretion. Prior to commencement of the proposed action, the applicant will prepare a Historic American Engineering Record (HAER) for the Fort DeRussy outfall/groin.

9.2.6.2 Halekūlani Beach Sector

The proposed action for the Halekūlani beach sector will include the addition of approximately 60,000 cy of sand fill between +8.5 ft and -3 ft MSL, and construction of five groins and a sand retaining wall between the Royal Hawaiian groin and the Fort DeRussy outfall/groin. Because the proposed work is expected to occur makai of the existing seawalls, shown in a 1932 photograph with no beach on its seaward side, there is a negligible likelihood of archaeological materials in the present active beach.

Given the proximity of cultural deposits and burials associated with Sites 4570 and 9957, ground disturbance mauka (landward) of the ca. 1881/ca. 1928 shorelines has the potential to encounter cultural deposits or burials. Because the area makai of the existing seawall is unlikely to contain beach sand or natural sediments pre-dating the 1930s, project work in this location has little potential to encounter archaeological resources or burials.

The addition of sand fill is unlikely to result in significant ground disturbance. However, due to the proximity of previously recorded buried deposits and burials, significant traditional places, and multiple LCA lots, archaeological monitoring will be conducted during all work within the historical shorelines. Prior to commencement of the proposed action, the applicant will prepare a Historic American Engineering Record (HAER) for the existing groins.

9.2.6.3 Royal Hawaiian Beach Sector

The proposed beach nourishment action for the Royal Hawaiian beach sector will include the addition of approximately 25,000 cy of sand fill between +8.5 and -2 ft MSL. The proposed action will partially overlap the ca. 1881 and ca. 1928 shorelines as illustrated by Bishop (1881) and Kanahele (1928c). Any ground disturbance makai of the ca. 1881/ca. 1928 shorelines in the Royal Hawaiian beach sector has the potential encounter cultural deposits or burials. The presence of a partially buried seawall and possible Waikīkī Tavern foundation at the Diamond Head end of the Royal Hawaiian sector suggests that intact beach sediments may extend into the mauka (landward) portion of the project area; as a result, cultural deposits and burials such as those found along Kalākaua Avenue may occur within the beach nourishment area.

The addition of sand fill is unlikely to result in significant ground disturbance. However, due to the proximity of previously recorded buried deposits and burials, significant traditional places, and chiefly residences, archaeological monitoring will be conducted during all work within the historical shorelines. Prior to commencement of the proposed action, the applicant will conduct a historic preservation documentation and review of the remaining portions of the original Royal Hawaiian groin, the exposed seawall, and the Waikīkī Inn/Tavern foundation.

9.2.6.4 Kūhiō Beach Sector

Beach improvement and maintenance actions are proposed at both basins of the Kūhiō groin complex. In the Diamond Head (east) basin, the proposed action includes the addition of approximately 4,500 cy of sand between +5 and -4 ft MSL. No alterations to the existing structures are proposed. In the ʻEwa (west) basin, the proposed action includes the addition of approximately 26,000 cy of sand between +8 and -3 ft MSL, along with modified groins and construction of a segmented breakwater partially overlapping the existing 1939 "crib wall" and adjacent shore return structures.

The proposed work in the Diamond Head (east) basin, which consists of sand fill only, will occur makai of the ca. 1881 and ca. 1928 coastlines as depicted by Bishop (1881) and Kanahele (1928c), respectively. The location of Site 50-80-14-5948, a retaining wall thought to be the 1890 wall replacing the ca. 1880 bridge/causeway to Kapiʻolani Park, is approximately 27 m mauka (landward) of the Kūhiō Beach sector. The buried wall is beneath the seaward sidewalk of Kalākaua Avenue, so any intact archaeological deposits would lie inland of this wall and thus, under the roadway. While several archaeological sites, including burials, have been identified along Kalākaua Avenue near the Diamond Head (east) basin, the proposed action will be limited to an area of imported beach sand that likely post-dates the 1950s.

The proposed action in the ʻEwa (west) basin, which includes beach nourishment with modified groins and construction of a segmented breakwater, will also occur makai (seaward) of the ca. 1881 coastline and primarily seaward of the ca. 1928 coastline, although the sand fill area extends mauka (landward) of a "masonry wall" depicted on Kanahele's (1928c) map on the north side of the ʻEwa (west) basin.

The applicant will conduct periodic spot-check monitoring for the proposed beach maintenance action within the Diamond Head (east) basin since all work is within the post-late-19th century shoreline. The applicant will also conduct scheduled monitoring during ground-disturbing activities within the historical shorelines within the ʻEwa (west) basin. Given the presence of potentially significant existing beach infrastructure, including the Kapahulu storm drain/groin ("The Wall"), "Slippery Wall," the "crib wall," and the shore return structures on either side of the crib wall, the applicant will conduct historic preservation documentation and evaluations of the existing beach infrastructure prior to commencement of the proposed action. The applicant will also conduct formal consultations with the State Historic Preservation Division (SHPD) to further evaluate potential impacts of the proposed actions on historical, cultural, architectural, and archaeological resources, and possible measures to mitigate any potential adverse impacts.

9.3 Scenic and Aesthetic Resources

The gentle curve of the Waikīkī shoreline, the wide expanse of turquoise waters with multiple world-famous surf breaks, the changing colors resulting from the varying water depths and bottom types, and the picturesque backdrop of Diamond Head make the seaward and alongshore views from the shoreline spectacular. At the same time, the tall buildings that have been developed relatively close to the ocean along portions of the shoreline disrupt viewplanes from various perspectives. As a result, views inland from the shoreline are not one of the "significant panoramic views" identified in the City and County of Honolulu's *Primary Urban Center Development Plan*. The appearance of the beach is of significant interest to the resorts and commercial enterprises that operate in the project area, as their guests represent the most numerous and closest viewers. However, it is also of considerable interest to those who own and/or use adjacent areas and the walkway along Kalākaua Avenue.

Both residents and the tourist industry depend on Waikīkī's scenic resources. The beauty of its coastline draws millions of tourists to its sights and beaches each year. Map A-1 of the City and County of Honolulu's *Primary Urban Center Development Plan* identifies all of Waikīkī as being within a "Significant Panoramic View" zone. The *Waikīkī Special Design Guideline*'s Urban Design Control Map also identifies the area within which the access right-of-way and construction staging area are located as being within the Waikīkī Special Design district "Major View Corridor".

The City and County of Honolulu Land Use Ordinance (LUO) §9.80-3(a) designates some of the visual landmarks and significant vistas to be protected in the Waikīkī area, as:

- Views of Diamond Head from many vantage points,
- Continuous views of the ocean along Kalākaua Avenue from Kūhiō Beach to Kapahulu Avenue,
- Intermittent ocean views from Kālia Road across Fort DeRussy Park, Ala Wai Yacht Harbor, and the Ala Wai Bridge on Ala Moana Boulevard,
- Mauka views from streets mauka of Kūhiō Avenue, and

- Views towards Ala Wai Yacht Harbor from Magic Island Park.

9.3.1 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have short-term negative impacts and positive long-term impacts on scenic and aesthetic resources. Waikīkī is a predominantly engineered shoreline. Almost the entire length of Waikīkī is armored by seawalls that were constructed in the early 1900s, many of which are in various states of disrepair. The beaches of Waikīkī are primarily man-made and composed almost entirely of sand that has been imported from various terrestrial sources, other beaches, and dredged from offshore deposits. A total of 42 groins or groin-like structures have been constructed in Waikīkī. Due to its low elevation and profile, the proposed actions are not anticipated to adversely affect existing viewplanes. The beach stabilizing structures (i.e., groins, sand retaining wall, and segmented breakwater) will have a low profile and substantial portions of these structures will be below the waterline or covered with sand. Viewplanes toward the ocean and along the shoreline will be uninterrupted and similar to what exists today. Construction equipment, material stockpiles, and construction activities will be present within the project area during construction. Additionally, the dredging equipment will be visible from the shoreline during sand recovery options. These impacts are temporary in nature and will not be present once the construction phase of the project is completed. The proposed actions are anticipated to have a long-term positive impact on scenic and aesthetic resources. While the offshore sand is slightly greyer than the existing beach sand, the color difference is anticipated to be negligible after a season of mixing and fading due to UV exposure.

9.4 Recreation

An Ocean Recreation Study (Clark, 2021) was conducted by John Clark, a locally recognized expert on ocean recreation and cultural activities in Hawai'i. Mr. Clark has completed several assessments of ocean recreation activities in the Waikīkī Beach vicinity for recent beach improvement projects (FEA, Waikīkī Beach Maintenance, 2010 and FEA Royal Hawaiian Groin Improvement Project, 2016).

Mr. Clark conducted an Ocean Recreation Study for this ~~DPEIS~~FPEIS. Site visits and interviews were conducted during February, March and April 2021. The purpose of the current study was to identify potential recreational impacts associated with the proposed beach improvement and maintenance actions. The study consisted of: 1) observing ocean activities and ocean conditions during field trips to the four beach sectors, 2) interviewing shoreline users, including surfers, swimmers, snorkelers, fishers, staff of the catamaran concessions, staff of the beach concessions, and City and County of Honolulu lifeguards, 3) identifying cultural practices in the project area and determining whether the proposed action affects cultural resources or practices, and 4) describing possible impacts of the project that were reported by the ocean recreation users in the four beach sectors. The findings of the study are presented below.

9.4.1 General Overview

Waikīkī Beach, including the waters offshore, is the most heavily used shoreline area in Hawai'i and supports a diverse array of shoreline and ocean-based recreation activities. These include but are not limited to sunbathing, swimming, surfing, canoe paddling and canoe surfing, standup paddling, bodyboarding, sand skimming, snorkeling, diving, spear fishing, pole fishing, walking, wading and metal detecting. Annual recreation events such as canoe regattas and surf contests are held in the project area. Numerous beach concessions are located along the shoreline, providing beach umbrella and surfboard and paddleboard rentals, surfing lessons, and canoe rides. Commercial sailing catamarans are permitted to operate on Waikīkī Beach. Beach concessions in the Fort DeRussy and Duke Kahanamoku beach sectors contract their leases through the State of Hawaiʻi, while those along the Royal Hawaiian beach sector lease through the adjacent hotels, and those in the Kūhiō beach sector lease through the City and County of Honolulu. Sailing catamarans are permitted by the Hawaiʻi Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DLNR-DOBOR).

Sunbathing
Sunbathing in the project area is possible from one end to the other. The best time for sunbathing is at low tide during periods of little or no surf. At high tide the dry beach area is significantly reduced along much of the shoreline, and if high surf combines with a high tide, waves may overrun the entire beach, precluding all opportunities for sunbathing.

Swimming
Swimming occurs in all four beach sectors. The greatest concentration of swimmers tends to be in Kūhiō Beach Park, Royal Hawaiian Beach, and Fort DeRussy Beach.

Snorkeling
The Waikīkī shoreline is not known as a good site for snorkeling. The inner portions of the reef are largely covered with sand and do not attract the volume or variety of fish that other reefs do. During periods of low or no surf, there is some snorkeling for lost valuables such as rings, watches, and coins occurs, an extension of the treasure hunting with metal detectors that takes place on the beach. Snorkeling in Waikīkī can be hazardous due to the number of surfers, paddlers, and vessels present in the water. In addition, during periods of high surf, visibility over the reef is poor due to wave agitation of the ocean bottom. Recognizing these hazards, beach concessions do not rent snorkel gear. Snorkeling is much better suited to the fringing reef areas in the Kapiʻolani beach sector and areas surrounding the Waikīkī Natatorium War Memorial.

Surfing
In pre- and early post-contact Waikīkī, surfing was popular to both chiefs (*aliʻi*) and commoners (*makaʻāinana*). So important was surfing that there is a major heiau dedicated to the *nalu* (surf) and its riders. Papaʻenaʻena, a terraced structure built at the ft of Diamond Head, is where surfers came to offer their sacrifices in order to obtain *mana* (supernatural and divine power) and knowledge of the surf. The site overlooked what is today referred to as First Break, which marks the start of the Kalehuawehe surfing course which extended to Kawewehi (the deep, dark surf) at Kālia.

Although everyone, including women and children, surfed, it was the chiefs who dominated the sport. One of the best among Waikīkī's chiefs was Kalamakua; he came from a long ancestry of champion surfers whose knowledge, skill, and *mana* were handed down and passed on from generation to generation. The story of his romantic meeting with Keleanuinohoanaapiapi has been preserved as a reminder of the role that surfing played in the history of Waikīkī (Kanahele 1995:56-58).

Surf historians agree that, among the documented forms of surfing that existed independently in pre-contact times, the highest development of the sport was in Hawaiʻi, where surfing was a national pastime. Native Hawaiians surfed at hundreds of surf spots on all eight of the Main Hawaiian Islands, but Waikīkī stood out above the rest as a hub for surfing. Waikīkī is often referred to as the birthplace of modern surfing, and Hawaiian surfers like Duke Kahanamoku helped spread the sport to locations around the world. However, surfing was beyond just a sport for Native Hawaiians. Wave-riding and surfboard-crafting were both ceremonious and skillful arts that demonstrated the important connection between Native Hawaiians and their environment, which served as a foundation for their traditional land stewardship model and lifestyle.

There are over 30 recognized surfing sites in Waikīkī (Figure 9-2). Notable surfing sites offshore of the project area include:

- Fort DeRussy Beach Sector – *Kaiser Bowls, Fours, Threes*
- Halekūlani Beach Sector – *Wanas, Paradise, Cornucopia, Populars, Zeros, First Break*
- Royal Hawaiian Beach Sector – *Canoes, Baby Canoes, Queens, Baby Queens*
- Kūhiō Beach Sector – *Cunha's, Baby Cunha's, The Wall*

Figure 9-2 Approximate locations of surfing sites in Waikīkī

There are numerous popular surf sites in the vicinity of Waikīkī Beach. Surfers have reported concerns that a change to the bathymetry might affect the characteristics of the surfing waves. A surfing wave is the result of complex interactions between wind, water, seafloor, other waves, and currents. Waves at a particular site may change many times over the course of a day, either subtly or dramatically due to changes in the tide level, wind, swell direction, and wave period. Waves entering shallow water are transformed by shoaling, refraction, breaking, and energy dissipation. All of these factors would have to be considered to assess possible impacts on surfing waves.

Wave modeling can be performed to try to understand the effect, if any, sand dredging will have on waves passing over the dredge site and propagating toward shore. To approximate the sand borrow pit, the bathymetry of the sand deposit can be reduced depending on the amount of sand needed. The boundary of the sand borrow pit sloped by 1V:3H (vertical to horizontal) to represent the stable slope of sand. Wave models were run using the same input wave conditions over the pre- and post-dredge bathymetry. Input wave conditions were a high-prevailing south swell with deepwater significant wave height H_s = 3 ft, period T = 16 s, and direction south-southwest. The model output in the form of wave energy at each grid point throughout the model domain were produced. This energy was converted into wave height for comparison of the effects of the sand borrow pit. In each of the scenarios presented in Section 9.4.6, the change in wave height at the surf sites was found to be less than 2 inches. Small differences in wave height due to dredging are considered to be significantly less than the change from wave to wave, and the results indicate that these dredging scenarios are not expected to result in a noticeable change to the surf.

It is anticipated that the actual dredging would be slightly different than the scenario presented, likely covering a larger area with a shallower depth of pit. That scenario would be expected to have even less impact on the wave heights. Over time, the dredge pit is expected to gradually fill in, further diminishing any differences with the pre-dredge condition.

Canoe Surfing

Catching waves with an outrigger canoe in Waikīkī primarily takes place at *Canoes* (originally known as *Kapuni*), and *Populars* (originally known as *Kawehewehe*), seaward of the Royal Hawaiian Hotel. The waves on the west edge of *Canoes* are ideal for canoe surfing and often have enough momentum to carry the canoes all the way to shore.

Most of the beach concessions offer outrigger canoe rides. Use of the commercial canoes is controlled by the Division of Boating and Ocean Recreation (DOBOR), Department of Land and Natural Resources (DLNR), State of Hawaiʻi. DOBOR controls boating in Waikīkī shore waters and their administrative rules regarding commercial outrigger canoe operations may be accessed through their homepage under Title 13, Subtitle 11, Parts 2 and 3.

Canoe surfing is a feature in the Outrigger Canoe Club's annual Fourth of July canoe races in Waikīkī. Known as the Walter J. MacFarlane Regatta, the racecourse begins on the beach fronting the Moana Surfrider Hotel and then turns around a buoy offshore which brings the canoes back to the beach through the waves of *Canoes*.

Catamaran Rides

Catamaran rides are a popular activity on Waikīkī Beach. The catamarans park on the beach, where they load and unload passengers. They motor in and out of the beach and sail up and down the Waikīkī coast for specified periods of time. The Division of Boating and Ocean Recreation (DOBOR), Department of Land and Natural Resources (DLNR), State of Hawaiʻi, controls boating in Waikīkī shore waters. Administration of the beach landing areas for the catamarans in the project site comes under DOBOR's Oʻahu District Manager. DOBOR's administrative rules regarding commercial catamaran operations are noted as Title 13, Subtitle 11, Parts 2 and 3, HAR.

Ocean Recreation Events

In addition to the annual Walter J. MacFarlane Regatta, which is held every July 4, a number of other ocean recreation events are held in the project site. These are primarily surf contests, which are run at the surf spot *Queens* during the spring and summer months. Contest organizers set up their staging area on the beach at the east end of the project site between the Hula Mound and the Duke Kahanamoku Statue. The staging area includes judging towers and a number of tents for t-shirt concessions, food concessions, and competitors.

Fishing and Gathering

Two types of fishing occur in the project site, spear fishing and pole fishing, but both are infrequent. During the field trips for this report, no spear fishers or pole fishers were observed, but one respondent said that he goes spearing perhaps once a month for fish and octopus. The intensive use of the beach and the ocean in the project site by all of the other ocean users is a major deterrent to activities involving spears and fishhooks. Waikīkī was once known as a good place to gather edible *limu* (seaweeds), especially *limu lipoa*, but little if any edible seaweed seems to remain in Waikīkī today. No gathering activities of seaweed, shellfish, or other marine species were observed during the field trips or noted by the respondents.

Marine Managed Areas

There are two designated Waikīkī Marine Managed Areas (MMA): the Waikīkī Marine Life Conservation District (MLCD) and the Waikīkī-Diamond Head Fisheries Management Area (FMA). The project area is not included in the Waikīkī MMA.

Boating

The Division of Boating and Ocean Recreation (DOBOR), Department of Land and Natural Resources (DLNR), State of Hawai'i, controls boating in Waikīkī shore waters. . DOBOR's administrative rules also regulate power boating in Waikīkī shore waters. The authorized commercial catamarans and personal watercrafts operated by the lifeguards are the only vessels under power that are permitted in the project site. Non-motorized boats such as surf skis (racing kayaks) and ocean kayaks (recreational kayaks) are permitted. A large pocket of sand outside of the *Queens* surf site is called the *Sand Spit*. It is a popular anchorage for boats, especially in the evening and at night. On weekends and holidays, sometimes as many as 30 boats may be anchored there.

9.4.2 Fort DeRussy Beach Sector

The Fort DeRussy beach sector consists of approximately 1,680 ft of shoreline extending from the Fort DeRussy outfall/groin to the Hilton pier/groin. There are no lifeguard towers in this sector. There are two beach concessions, both operated by Dive Oahu & Surf.

Ocean Activities in the Fort DeRussy Beach Sector

Sunbathing, Swimming, and Snorkeling
Sunbathing, swimming, and snorkeling are all activities that take place in this beach sector. Some beach goers call an area outside the reef *Turtle Canyons* for its abundance of sea turtles. Dive Oʻahu and Surf offers this description of the site:

> "*Turtle Canyons* is a finger reef system divided by sandy bottoms between each of the reefs. One of the canyons in particular is known for the Hawaiian green sea turtles (*honu*) that consistently frequent the reef to get their shells cleaned. Commonly, the endemic gold ring surgeon fish can be seen snacking on/cleaning the algae off of their shells and bodies. This site also offers a range of reef fish".

Surfing
Two surf breaks are located in this beach sector: *Threes* at its east end and *Fours* at its west end. *Threes* is the third surf site from east to west on the reef that begins off the Sheraton Waikiki Hotel and ends at the Hilton Channel. The two surf breaks that precede it are *Populars* and *Paradise*. During large south swell events, many surfers consider *Threes* to be the best location to catch a wave that is breaking to the right when facing the shore in Waikīkī. They access the site from the Royal Hawaiian beach sector or by walking through Fort DeRussy Park.

Fours is the fourth surf site from east to west on the reef that begins off the Sheraton Waikiki Hotel and ends at the Hilton Channel. It is located outside the reef just east of the channel, where the depth of the ocean is deeper than the other surf sites along this reef. For this reason, *Fours* only breaks on big south swells. Otherwise, it is generally flat. Surfers access *Fours* from the Duke Kahanamoku Beach area fronting the Hilton Hawaiian Village.

Fishing
One respondent, who has been fishing the shoreline of Waikīkī since the early 1970s, noted that fishing for *omilu* and *awaawa* from his kayak around the *Threes* surf site was productive when he fished there in the 1990s.

Catamarans
The Spirit of Aloha, a 65-foot catamaran, operates from the Hilton pier. It docks at the pier to load and land its passengers. It does not park on the beach in the Fort DeRussy beach sector. The Spirit of Aloha offers snorkel tours, fireworks dinner cruises, turtle and whale watching excursions, and sailing trips off Waikīkī.

Survey Results
Respondents for this beach sector were in favor of the proposed action. No concerns or potential impacts were identified.

9.4.3 Halekūlani Beach Sector

The Halekūlani beach sector consists of approximately 1,450 ft of shoreline extending from the Royal Hawaiian groin to the Fort DeRussy outfall/groin. There are no lifeguard towers in this beach sector. There are two beach concessions, one for the *Maita'i* catamaran at Gray's Beach in the Sheraton Waikiki Hotel and one at the Castle Waikīkī Shore Hotel, the Waikīkī Shore Beach Service. Due to the severe deterioration of the seawall fronting the Sheraton Waikiki Hotel, the general public's former lateral access through this section of the shoreline, which was across the top of the seawall, is permanently closed. The only way to transit this area now is to walk through the Sheraton Waikiki Hotel property.

A small pocket sand beach, commonly known as Gray's Beach, fronts both the Sheraton Waikiki Hotel and the Halekūlani Hotel at their common boundary. Another small sand beach fronts the Outrigger Reef Waikīkī Beach Resort and the Castle Waikīkī Shore Hotel at the west end of the sector. Another smaller pocket of sand is at the east end of the sector, where the Royal Hawaiian groin meets the seawall fronting the Sheraton Waikiki Hotel. The pocket beach accreted in January during an extended period of strong westerly winds.

Ocean Recreation Activities in the Halekūlani Beach Sector

Sunbathing, Swimming, and Snorkeling

Sunbathing in this sector is possible at the three small beaches. The best time for sunbathing is at low tide during periods of little or no surf. High tides cover at least half of the beaches. The Halekūlani Channel fronting Gray's Beach is a long, wide, sand-filled channel that passes through the shallow reef flat fronting the beach and ends in deep water offshore. It is the best area in this sector for swimming. The reef flat on either side of the channel attracts snorkelers looking for sea turtles and other marine life. Green sea turtles (*honu*) are seen at all times of the day, often close to shore, foraging on seaweed and algae that grows on the reef.

Surfing

There are two surf sites in the Halekūlani beach sector: *Populars* and *Paradise*. *Populars* is located directly offshore of the Sheraton Waikiki Hotel. The break was named in the early 1900s when it became a "popular" spot with Waikīkī surfers. Today, *Populars*, or "*Pops*", is heavily used. Its popularity is due to its long, rolling waves that accommodate all levels of surfing ability from beginners to experts. *Paradise* is a secondary break between *Populars* and the Halekūlani Channel. Commercial surfing instructors who give surfing lessons bring their students to the inside sections of *Populars*. The instructors are from the beach concessions or nearby surf shops in Waikīkī.

Fishing

At certain times of the year, schools of *nehu*, small anchovy-sized fish, congregate near shore in the Halekūlani Channel fronting Gray's Beach. The *nehu* attract larger predators like *papio* and *ulua*, which are prized eating fish. The *papio* and *ulua* in turn attract pole fishermen. Pole fishermen whip for *papio* and cast for *ulua*.

Many areas of Waikīkī, including this sector, were once known as good places to gather edible seaweeds (*limu)*, but little if any edible seaweed seems to remain in Waikīkī today. No gathering activities of seaweed, shellfish, or other marine species were observed during the field trips for this study, and none were noted by respondents.

The Waikīkī Marine Managed Areas (MMA) consists of two parts: the Waikīkī Marine Life Conservation District (MLCD) and the Waikīkī-Diamond Head Fisheries Management Area (FMA). The project area is not included in the Waikīkī MMA.

Catamarans

Catamaran rides are a popular activity on Waikīkī Beach. Two catamarans operate out of the Halekūlani beach sector: the *Maitaʻi* and the *Holokai*. These two catamarans park on the beach, where they load and unload passengers. They motor in and out of the beach to sail up and down the Waikīkī coast for specified periods of time. The *Maitaʻi* operates at Gray's Beach, the pocket of sand between the Sheraton Waikiki Hotel and the Halekūlani Hotel. The *Holokai* operates from the beach fronting the Outrigger Reef Waikīkī Beach Resort. At the time of the current study, the *Maitaʻi* was available for daily sails, but the *Holokai* was available for private charters only.

The Division of Boating and Ocean Recreation (DOBOR), Department of Land and Natural Resources (DLNR), State of Hawaiʻi, controls boating in Waikīkī shore waters. The catamarans and personal watercrafts operated by the lifeguards are the only vessels under power that are permitted in the project site. Non-motorized boats such as surf skis (racing kayaks) and ocean kayaks (recreational kayaks) are permitted.

The proposed action for the Halekūlani beach sector is beach improvements consisting of beach nourishment with stabilizing groins. The Halekūlani Channel will remain unobstructed for beach catamaran navigation. An optional component of the design is the addition of a beach walkway to provide ADA-accessible lateral shoreline access between the Royal Hawaiian and the Fort DeRussy beach sectors, a distance of approximately 0.85 miles.

Survey Results

Most respondents for this sector liked the proposed actions, noting that they will create a new beach for Waikīkī where one does not exist now.

One respondent is completely opposed to the proposed T-groin system for this sector. The respondent stated that "each T-groin is designed with two arms to hold sand and when incoming waves strike these arms, their impact against the boulders may generate reflected waves. These waves will travel seaward into the surf breaks at *Populars*, *Paradise*, and *Threes*, disrupting the wave faces for surfers". The respondent also stated that "the original beaches here were seasonal, forming only during the winter and disappearing during the summer and suggested that "the proposed T-groin system will block the natural lateral movement of sand in this sector".

Other respondents believe that the T-groins are far enough away from the surf breaks that reflected waves are not an issue. One respondent noted that similar concerns regarding reflected waves were raised about the construction of the Royal Hawaiian groin, but that those concerns have not materialized with the new groin.

A common concern shared by all respondents is the lateral shoreline access from one end of this sector to the other. Shoreline access is currently marginal fronting the Halekūlani Hotel and non-existent fronting the Sheraton Waikiki Hotel. They would like to see this issue addressed in the proposed actions for this sector.

One respondent noted that "the new beach and groins will cover sections of the existing reef, a known foraging area for green sea turtles (*honu*). Episodes of high surf may also erode sand from the new beach and deposit it on the adjoining reef".

The one cultural activity associated with the ocean in this study, a traditional Hawaiian cleansing ceremony in the Halekūlani Channel fronting Gray's beach, was discontinued by the woman who performed it. In the event that someone wanted to resume the practice, the introduction of a new beach would not prevent it.

The new beach will provide sunbathing, swimming, and snorkeling opportunities for large numbers of beach goers. If the proposed actions are implemented, the City and County of Honolulu Ocean Safety and Lifeguard Services Division anticipates that its presence will be required on the new beach, which would include the addition of personnel, ~~a~~ lifeguard towers, appropriate signage, robust communication, and beach access for their mobile beach vehicles (e.g., jet skis and trucks). The Ocean Safety and Lifeguard Services Division would need additional funding in their annual budget for the new personnel, ~~a~~ lifeguard towers, and equipment, including mobile vehicles (e.g., jet skis and trucks). They noted that seven lifeguards are needed to meet the staffing requirements for each two-person tower.

One respondent, a catamaran crew member, noted that sometimes during the summer months, the sand in this sector, including at Gray's beach, experiences severe seasonal erosion. When this occurs, the *Maitaʻi* and the *Holokai* relocate their landing and departing operations to the Fort DeRussy beach sector, specifically on the ʻEwa (west) side of the Fort DeRussy outfall/groin. The catamarans access this site via a small channel that joins the west side of the Halekūlani Channel and leads to Fort DeRussy Beach. This respondent noted that "the new beach and groins should eliminate the seasonal erosion in this sector and their occasional need to relocate their operations".

One respondent noted that pole fishermen after *ulua* come to the beach late in the afternoon to cast, when most sunbathers and swimmers have left. Pole and occasionally spear fishermen usually access the area from a privately owned pathway where access by the public is presently allowed to Gray's Beach between the Sheraton Waikiki Hotel and the Halekūlani Hotel. Another respondent noted that for many years he fished the Halekūlani Channel in the early evenings and almost always caught white *papio* and *oio*. He also caught *pualu* and *enenue* there.

Opportunities for gathering shellfish and seaweed are minimal to non-existent in this sector. No gathering activities were observed or reported by respondents.

9.4.4 Royal Hawaiian Beach Sector

The Royal Hawaiian beach sector consists of approximately 1,730 ft of shoreline extending from the ʻEwa (west) groin at Kūhiō Beach Park to the Royal Hawaiian groin, which was completed in 2020. It includes the Kūhiō Sandbag groin, which is 140 ft west of the ʻEwa (west) groin and consists of 83 sandbags that weigh approximately 10,000 pounds each. It was completed in November 2019 when erosion in this area of the beach exposed the concrete remnants of the former Waikīkī Tavern. Lifeguard tower 2B is situated on the shoreline fronting the Waikīkī Beach Center, and lifeguard tower 2A is situated on the shoreline fronting the Moana Surfrider Hotel. When the field trips for this study were conducted, a beach nourishment project for the Royal Hawaiian beach sector was underway.

Ocean Activities in the Royal Hawaiian Beach Sector
The shoreline in the Royal Hawaiian beach sector is the most heavily used portion of Waikīkī Beach. Ocean recreation activities include sunbathing, swimming, snorkeling, surfing, outrigger canoe rides, and catamaran rides. This beach sector also includes the largest concentration of commercial beach concessions, which offer surfboard rentals, surfing instructions, and canoe rides. Four catamaran concessions also operate in this beach sector.

During the course of this study, Dive Oʻahu and Surf, the main beach concession near the Duke Kahanamoku statue, was closed until further notice due to the COVID-19 pandemic. However, in the interim, they have relocated to the Fort DeRussy beach sector, where they opened two beach concessions on federal property. The catamaran concessions remain operational in the Royal Hawaiian beach sector, along with two beach concessions at the west end of the beach: Aloha Beach Services and Waikīkī Beach Services. Surfboard rentals are also available at nearby surf shops in Waikīkī, such as those located on Koa Avenue.

The COVID-19 pandemic with its devastating impact on Hawaii's visitor industry resulted in a dramatic reduction of tourists on local beaches and in local surf breaks. The lack of visitors, however, did not reduce the numbers of surfers in local breaks, but rather increased them. Local surfers returned in force to many Waikīkī surf sites, such as *Canoes* and *Queens*, often creating what some local surfers call "COVID crowds."

Sunbathing, Swimming and Snorkeling
Sunbathing and swimming are the main near shore activities in this sector. Some snorkeling occurs here, too. Daily beach counts here were much lower than they were prior to the COVID-19 pandemic. Prior to the pandemic the heaviest concentration of sunbathers in Waikīkī was at the west end of this sector, near the Royal Hawaiian groin. This is where the beach is widest, fronting the Outrigger Waikīkī Beach Resort and the Royal Hawaiian Hotel. This section of beach was and continues to be most crowded with sunbathers at low tide during periods of little or no surf.

Swimming occurs from one end of the beach to the other, but the greatest concentration of swimmers tends to be in the middle of the beach, fronting the Moana Surfrider Hotel. With surfboard rental, canoe ride, and catamaran ride concessions concentrated at the ends of the sector, the least amount of traffic that might interfere with or endanger swimmers is in the center of the beach.

Snorkeling is an infrequent activity in this sector. With its predominance of sand on the ocean bottom rather than reefs that would attract marine life and the heavy traffic from surfboards, outrigger canoes and catamarans, most snorkelers prefer the conditions on the west side of the Royal Hawaiian groin.

Surfing

The main surf sites in the Royal Hawaiian beach sector are *Canoes* and *Queens*. Secondary surf sites include *Baby Queens*, *Baby Canoes*, and *Sandbars*, which is also known as *Baby Royals*. During the course of the current study, the absence of tourists in the surf breaks was evident, but the surf breaks were still crowded with local surfers.

Canoes is the name of the surf site located directly off the Moana Surfrider Hotel. *Canoes* is the most heavily used surf spot in Waikīkī for commercial surfing activities, including surfboard rentals, surfing lessons, and outrigger canoe rides. Beginning surfers and surf instructors with beginners receiving lessons are concentrated on the smaller inside waves, which is known as *Baby Canoes*, while intermediate and advanced surfers ride the bigger waves outside.

Queens is the name of the surf site located directly off the Duke Kahanamoku statue. The waves at *Queens* are steeper than those at *Canoes* and are concentrated in a much smaller area, so beginning surfers and surf instructors with beginners receiving lessons generally do not surf here. Outrigger canoes usually do not surf here either. When waves at *Queens* die out, they reform near shore on the shallow reef at the east end of the sector. This surf site is known as *Baby Queens* and attracts beginning surfers and surf instructors with beginners receiving lessons.

Sandbars is the name of the surf site located directly off the Royal Hawaiian hotel. It is also known as *Baby Royals*. As the size of the sandbar has increased in recent years, this break has evolved into a popular spot for beginning surfers and surf instructors with beginners receiving lessons.

Canoes, *Queens* and *Sandbars* are located on the south shore of Oʻahu, which generally receives its biggest surf during the spring and summer months. However, there is almost always enough surf at each of these spots in the fall and winter to sustain commercial and non-commercial surfing activities throughout the year.

Canoe Surfing

Catching waves with an outrigger canoe in Waikīkī takes place at *Canoes*, the famous surf site off the Moana Surfrider Hotel that was named for this activity. The waves on the west side of *Canoes* are ideal for canoe surfing and often have enough momentum to carry the canoes all the way to shore.

During the course of the current study, only two beach concessions, Aloha Beach Services at the Moana Surfrider Hotel and Waikīkī Beach Services at the Royal Hawaiian Hotel, were offering canoe rides, a normally popular activity in this sector. During the COVID-19 pandemic restrictions, the concessionaires were limited to two unrelated passengers or small groups of related passengers or traveling companions. With these restrictions and the small numbers of visitors on the beach, there was little demand for canoe rides.

Catamarans

Catamaran rides are normally a popular activity on Waikīkī Beach. The catamarans park on the beach, where they load and unload passengers. They motor in and out of the beach, then sail up and down the Waikīkī coast for specified periods of time. Four catamaran concessions offer rides in the Royal Hawaiian beach sector: the *Mana Kai* at the east end of the beach and the *Manu Kai*, *Na Hoku II*, and the *Kepoikai II* at the west end of the beach. When the current study was conducted, the COVID-19 pandemic restrictions only allowed catamarans to carry ¼ of their permitted capacity. Catamarans that are permitted to carry 49 passengers, for example, are only allowed to carry 12.

The Division of Boating and Ocean Recreation (DOBOR), Department of Land and Natural Resources (DLNR), State of Hawai‘i, controls boating in Waikīkī waters. The catamarans and personal watercrafts operated by the lifeguards are the only vessels under power that are permitted in the project area. Non-motorized boats such as surf skis (racing kayaks) and ocean kayaks (recreational kayaks) are permitted.

Fishing

One respondent, who has been fishing the shoreline of Waikīkī since the early 1970s, noted that "fishing for *o'io* from the beach was productive in the Royal Hawaiian channel at the end of the old groin". The respondent stated that "he would wade out and stand on the submerged portions of the old groin and caught several 10-pounders there".

Several respondents believe that sand deposited from the 2012 Waikīkī Beach Maintenance I project resulted in too much sand being placed on the beach in this sector. When two old sandbag groins were removed from the east end of the sector, beach recession was severe, which exposed the old concrete foundation of the Waikīkī Tavern. The eroded sand traveled laterally along the beach and created a large, shallow sandbar at the west end of this sector.

The objectives of the Kūhiō Sandbag Groin project were to stabilize the east end of the Royal Hawaiian beach sector and to ensure that the Waikīkī Tavern concrete foundation remnants remained covered with sand. All respondents commenting on this sector agree that the sandbag groin has stabilized the east end of the beach, but the ocean has again eroded the sand covering the concrete foundation remnant, leaving it exposed. Some respondents are concerned that placing additional sand in the cove between the Kūhiō Beach sector's ‘Ewa groin and the Kūhiō sandbag groin will simply add to the sand that has already eroded and drifted west. One respondent recommended replacing the sandbag groin with a boulder groin and redesigning the angle of the new groin to contain sand in this cove.

Some respondents question the advisability of designing proposed actions, such as the addition of additional sand, for a 50-year lifespan in anticipation of sea level rise. They point out that so much sand has already been added to the beach that normal wave runup from the present level of the sea is no longer effective in reaching the crest of the beach, which they believe is necessary to maintain a gradual slope and the width of the beach. This has resulted in a steeper foreshore, a narrower beach crest, and a sloping backshore.

The additional sand has buried a sidewalk and steps that front the Moana Surfrider Hotel Beach Bar with approximately 4 ft of sand and has buried the lower steps of lifeguard tower 2A, along with reducing the storage area under the tower. It has also increased the level of sand fronting the seawall fronting the Royal Hawaiian Hotel, raising it almost to the top of the wall, which is approximately 6 ft above its former level. In response, the Royal Hawaiian Hotel installed an iron railing on top of the wall to deter beach users from climbing over it.

The high crest of the beach with its sloping backshore has contributed to flooding in properties behind the beach. During periods of extreme inundation from the ocean, such as high surf during king tides and severe storm surf, wave surges overtop the crest and spill through the backshore into adjoining properties.

Given the conditions that exist now, several respondents do not see the value of placing additional sand on the beach crest. They see it as exacerbating an existing problem. They recommend that bulldozers or graders be used to push the sand on top of the crest seaward to widen the beach and restore it to its former lower level. They believe that additional sand may result in an even narrower crest. This would reduce the area for sunbathing and result in a steeper foreshore, which will make accessing the ocean more difficult for all beach users and for launching and landing outrigger canoes.

One respondent pointed out that a proposed action for the Fort DeRussy beach sector is "backpassing," or moving sand from one area of the beach to another. He recommended the same action for the Royal Hawaiian beach sector, but instead of moving the sand laterally from one end of the beach to the other, moving it seaward.

Several respondents believe that sand from past beach nourishment projects has drifted into the surf zone and settled in and around *Canoes*, impacting the entire surf break. The right at *Canoes*, which was once a fast, steep wave, no longer breaks the same. The same is true for the left at *Canoes*. It no longer breaks the same. One respondent said, "now the left is more like a windward Oʻahu beach break".

Several respondents noted that drifting sand also occasionally creates a shallow sandbar in *Baby Royals*, the surf site at the west end of the Royal Hawaiian beach sector, which is also known as *Sandbars*. When this occurs, the sandbar is so shallow at low tide beach goers can walk out on it into the surf zone.

The predominantly westerly littoral drift of eroding sand has also settled in the channel between *Canoes* and *Baby Royals*, the channel that catamarans in this sector use to access the beach. Catamaran crew members reported that the channel and adjoining sandbar are sometimes difficult to negotiate at low tide, especially with a full load of passengers. Occasionally, they have hit bottom. When the current study was conducted, this problem was of less concern.

In January 2021, during an extended period of strong westerly winds, wave-induced currents reversed the normal westerly longshore current flow. Several respondents noted that these easterly currents coming around the Royal Hawaiian groin created a strong eddy on its east side that eroded the beach, creating a vertical sandbank in the foreshore approximately 4-ft high. With the return of the trade winds, however, the normal longshore currents eventually restored the beach. This episode also created a small pocket beach on the west side of the Royal Hawaiian groin in the Halekūlani beach sector.

9.4.5 Kūhiō Beach Sector

The Kūhiō Beach Sector consists of approximately 1,500 ft of shoreline extending from the Kapahulu groin to the ʻEwa (west) groin at Kūhiō Beach Park. This beach sector consists of two enclosed basins. The Diamond Head (east) basin begins at the Kapahulu groin and is defined by a 740-ft-long breakwater, or crib wall. The ʻEwa (west) basin begins at the west end of the Diamond Head (east) basin and is defined by a 700-ft-long breakwater. A 185-ft-long rubblemound groin separates the two basins. Lifeguard tower 2D is situated on the shoreline inland of the rubblemound groin and lifeguard tower 2C is situated on the shoreline of the ʻEwa basin.

When the field trips for the current study were conducted (February and March 2021), a beach nourishment project for the Royal Hawaiian beach sector was underway. The west half of the Diamond Head (east) basin was secured as a construction site for dewatering sand that was being delivered from a dredge anchored offshore. Lifeguard tower 2D was closed and unmanned. The ʻEwa basin was open for ocean recreation. Lifeguard tower 2C was manned.

Ocean Activities in the Diamond Head (East)Basin

<u>Sunbathing, Swimming, and Snorkeling</u>
The shoreline in the Diamond Head Basin is used mainly by sunbathers and swimmers. Some snorkeling occurs here. With a shallow sand bottom, this protected basin is popular for families with young children.

<u>Surfing</u>
The surf breaks around the Kapahulu storm drain/groin comprise the most popular bodyboarding area in Waikīkī. These breaks are limited to bodysurfers and bodyboarders and are off limits to anyone using a surfboard. The State of Hawaiʻi placed a line of white buoys offshore the Kapahulu storm drain/groin from approximately Lifeguard Tower 2D to 2E to delineate this restricted area.

Two surf sites are located outside the breakwater that defines the Diamond Head (east) basin. The first is *Graveyards*, which is just to the west of the Kapahulu storm drain/groin. It is the most popular and the most heavily used of the different breaks around the groin. A shallow reef separates *Graveyards* from the second break, which is called *Ins-and-Outs*.

Ins-and-Outs, which is also known as *Baby Cunha's*, is off the west end of the Diamond Head (east) basin's breakwater. The name *Ins-and-Outs* refers to the reflected waves that form when incoming waves strike the breakwater and are reflected seaward into the surf zone. Reflected waves occur frequently here and travel out far enough to disrupt the faces of incoming waves. *Ins-and-Outs* also lays within the restricted area delineated by the white buoys. Bodyboarders do not surf this break often.

Ocean Activities in the 'Ewa Basin

Sunbathing, Swimming, and Snorkeling
The shoreline in the 'Ewa (west) basin is used mainly by sunbathers and swimmers. Some snorkeling occurs here. With a shallow sand bottom, this basin is more heavily used now than the Diamond Head (east) basin because of the active sand nourishment project. The breakwater that defines this basin has two gaps: a short gap at the east end of the basin and a long segment of submerged breakwater at the west end.

Surfing
The famous *Queens* surf site is located directly offshore of the 'Ewa (west) basin. The right at *Queens* ends at a shallow reef just seaward of the breakwater. Some surfers use the long gap in the breakwater to access *Queens*, one of the most popular surf breaks in Waikīkī. A shallow sandbar seaward of the gap and near the edge of shallow the reef inside of *Queens* forms a surf site called *Pockets*, a left. This is a new break that forms on sand that may have eroded seaward from the Kūhiō beach sector. Surfers also report that there are other new small unnamed sandbars in the *Queens* and *Canoes* area that were not there historically.

Fishing
Several fishers noted that *papio* (juvenile jack fish) congregate around the sandbar at *Pockets*.

Survey Results
Several respondents recommended that the proposed beach maintenance for the Diamond Head (east) basin include adding sand to the east section of the basin that is currently in use by the public. They noted that this basin has lost a lot of sand and that at high tide there are only two small pocket beaches for sunbathers at either end of the vertical seawall supporting Kūhiō Beach Park. At medium to high tides the ocean overruns the center of the beach, washing against the seawall, and this wave action is beginning to undermine the seawall. They suggest that the active beach nourishment project be amended to include adding sand to the center of the beach.

Several respondents noted that the small sandbars that have formed in the area of the *Queens* and *Canoes* surf sites seem to have formed from sand eroded from the 'Ewa (west) basin. They are concerned that additional sand from the proposed beach nourishment will also end up in the surf zone.

9.4.6 Potential Impacts and Mitigation Measures

The proposed action is anticipated to have a positive impact on recreation in the Royal Hawaiian beach sector. Providing a wider, more stable beach will support or enhance continued recreational and commercial uses (present and future) in Waikīkī.

Potential Impacts on Sunbathing
Active construction areas will not be available for sunbathing for the duration of construction operations. To the extent practicable, beach closure areas will be confined to the immediate vicinity of construction operations to maximize the available dry beach area. Turbidity containment barriers will surround the in-water construction activities to prevent the work from

people in the water, impacting swimming in the immediate vicinity of the construction areas. These impacts to recreation will be temporary.

Potential Impacts to Catamarans

A total of six catamans operate on Waikīkī Beach. Four catamaran concessions offer rides in the Royal Hawaiian beach sector: the *Mana Kai* at the east end of the beach and the *Manu Kai*, *Na Hoku II*, and the *Kepoikai II* at the west end of the beach. Two catamarans operate out of the Halekūlani beach sector: the *Maitaʻi* and the *Holokai*. The *Maitaʻi* operates at Gray's Beach, the pocket of sand between the Sheraton Waikiki Hotel and the Halekūlani Hotel. The *Holokai* operates from the beach fronting the Outrigger Reef Waikīkī Beach Resort.

The proposed beach maintenance in the Royal Hawaiian beach sector is anticipated to have a positive impact on catamaran operations. There are no structures being proposed that will inhibit safe navigation, and maintaining a wide, stable beach profile will provide additional space for the catamarans to tie up and safely load and offload guests.

The proposed beach improvements in the Halekūlani beach sector are also anticipated to have a positive impact on catamaran operations. The minimum beach crest width at its narrowest point midway between the groins will be about 20 to 30 ft, and the beach slope will be 1V:8H (vertical to horizontal). Maintaining a stable beach with a gentler slope will provide additional space for the catamarans to tie up and safely load and offload guests. The Halekūlani Channel will remain unobstructed to allow for safe navigation. The groin stem length (distance seaward from the shoreline) will be up to about 200 ft and the gaps between the groin heads will be approximately 200 ft wide.

The catamarans are approximately 45 ft long and 25ft wide, so the gaps between the groin heads should be sufficiently wide to provide safe ingress and egress for catamaran access to/from the shoreline (Figure 9-3). The current travel path for the catamarans would shift slightly to the west to align with the gap between the groins on either side of the Halekūlani Channel (Figure 9-4). The new beach and groins will also eliminate the seasonal erosion that forces the catamarans to relocate their operations to the Fort DeRussy beach sector. Thus, no negative impacts to navigation or catamaran operations are anticipated.

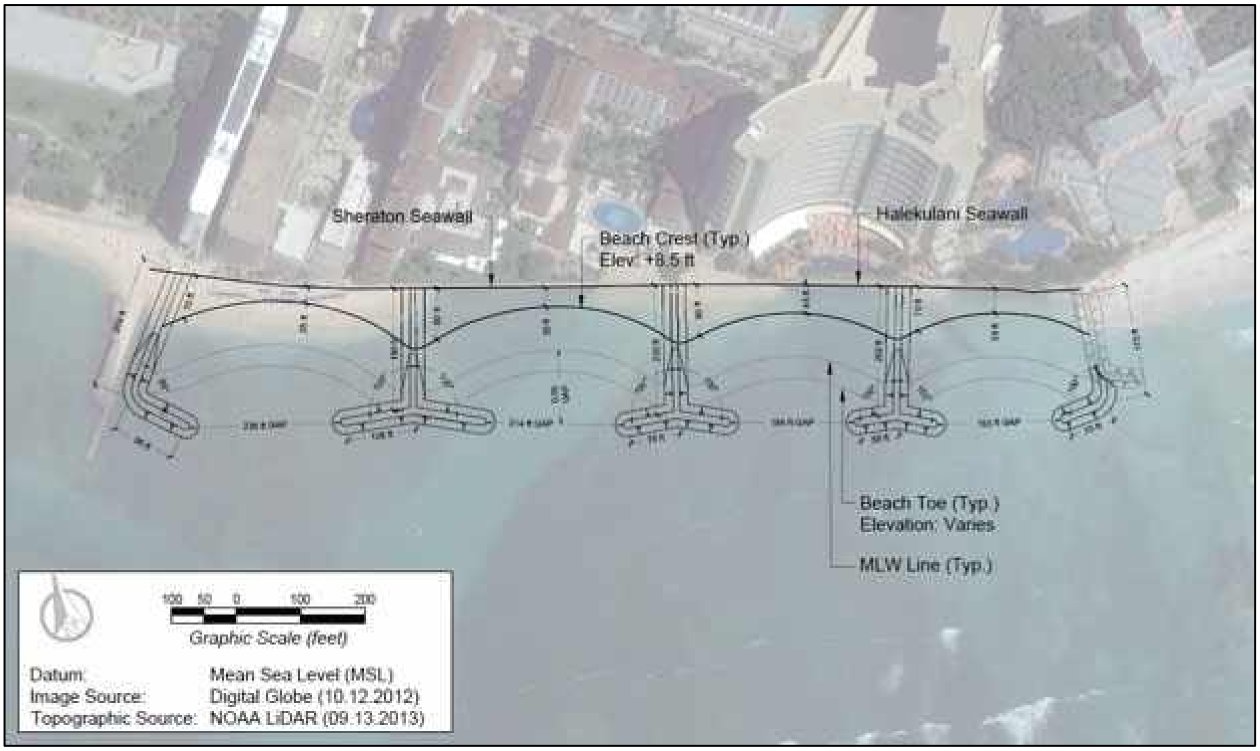


Figure 9-3 Proposed project layout - Halekūlani beach sector

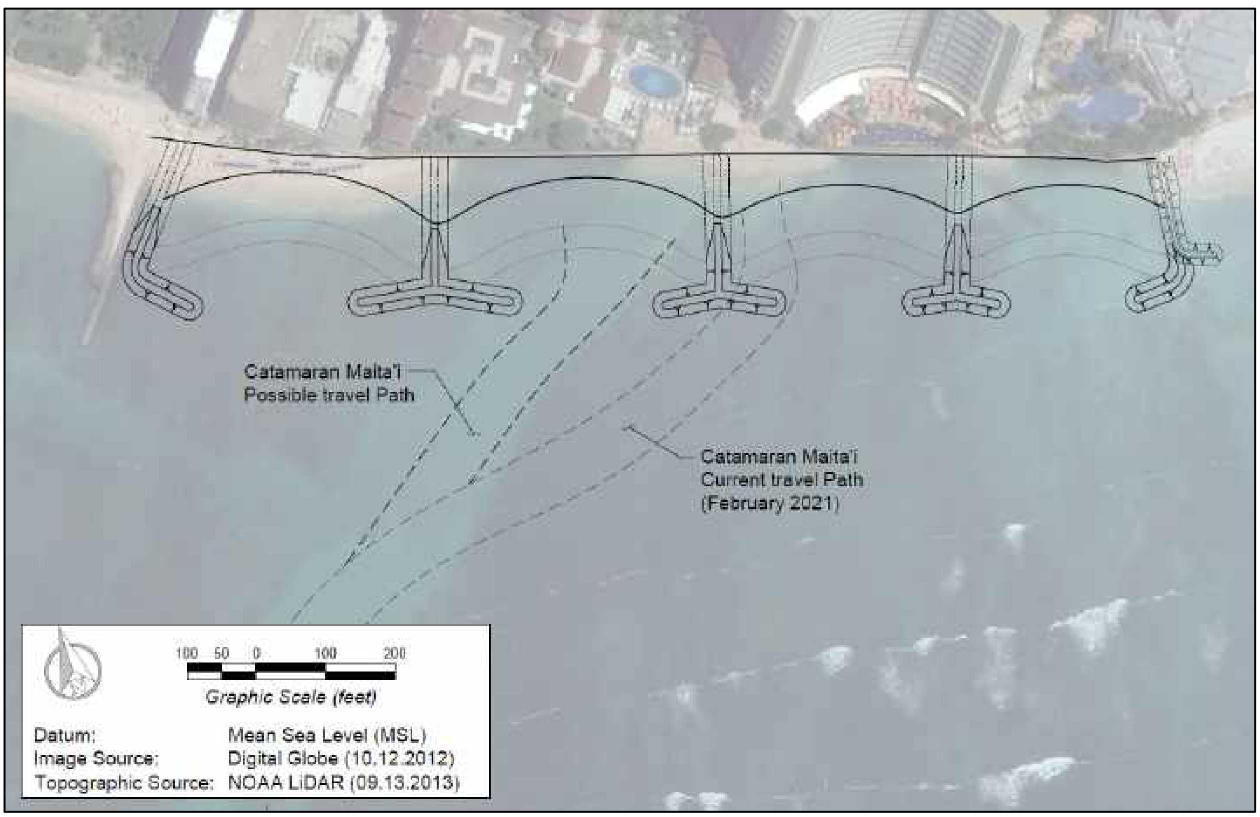


Figure 9-4 Navigation routes for *Maitaʻi* and the *Holokai* catamarans

Potential Impacts to Beach Concessions

Beach concessions currently operate in the Fort DeRussy and Royal Hawaiian beach sectors. The proposed action will temporarily impact the beach concessions during construction, as a portion of these areas will be utilized for access and equipment/material storage. These impacts will cease immediately following completion of construction, and every effort will be made to minimize potential impacts to beach concessions.

Potential Impacts to Snorkeling

The shallow reef in the project area is not known as a particularly good site for snorkeling, and the surfing, canoes, catamarans, and other recreational craft make snorkeling somewhat risky. The reef does not seem to attract the volume or variety of fish that other reefs in Hawaiʻi do, and for this reason snorkeling is an infrequent activity in Waikīkī. In addition, during periods of high surf, visibility over the reef is poor due to wave agitation of the ocean bottom. Turbidity containment barriers will surround the in-water construction activities and effectively cordon off the work from people in the water. Hence, the proposed actions are not anticipated to have any negative impacts on snorkeling activities.

Potential Impacts to Kayaking

Touring kayaks are not common in Waikīkī. However, they are available for rent from the ocean activity desk in the Fort DeRussy beach sector and are occasionally seen in the project area. However, as with snorkeling, the construction area will be cordoned off and easy to avoid.

Potential Impacts to Fishing and Gathering

Two types of fishing occur in the project area, spear fishing and pole fishing, but both are infrequent. The offshore hard bottom was once noted octopus grounds, but they do not have that reputation today. Nonetheless, some spear fishermen still try their luck in these areas. The reef fronting the project area is not known as a productive fishing area, so pole fishing is an infrequent activity. However, at certain times of the year, schools of *nehu*, small anchovy-sized fish, may congregate near shore. The *nehu* attract larger predators like *papio*, which are prized eating fish, which in turn attract pole fishermen. Pole fishermen whip for *papio*, which has the potential to create conflicts between them and swimmers. The proposed actions are not anticipated to significantly affect fishing during construction.

Many areas of Waikīkī were once known as good places to gather edible seaweeds, or *limu*, but little if any edible seaweed seems to remain in Waikīkī today. No gathering activities of seaweed, shellfish, or other marine species were observed during the field trips or noted by the respondents. The recovered sand will be placed on the existing beaches and submerged areas that consist of relatively barren reef flats, where *limu* does not grow. Hence, no significant adverse effects on *limu* are anticipated.

Potential Impacts to Marine Managed Areas

The Waikīkī Marine Managed Areas (MMA) consists of two parts: the Waikīkī Marine Life Conservation District (MLCD) and the Waikīkī -Diamond Head Fisheries Management Area (FMA). As the project area is not included in the Waikīkī MMA, no effects are anticipated.

Potential Impacts to Surf Sites

Detailed wave modeling was conducted to evaluate the potential for the proposed beach improvement and maintenance actions to impact surf sites in Waikīkī (see Section 8.2). Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or changing the bathymetry. Dredging could occur at the *Ala Moana*, *Canoes/Queens*, or *Hilton* deposits. Wave modeling was used to assess the impact of dredging on nearby surf sites. A wave reflection analysis was also conducted to evaluate the potential for the proposed structures in the Halekūlani and Kūhiō beach sectors to reflect waves that could negatively impact surf sites, primarily in the Halekūlani beach sector. To evaluate potential impacts, wave modeling of the existing conditions and with the proposed structures was performed. Based on the results of the wave modeling, the dredge analysis, and the wave reflection analysis, no significant impacts to surf sites in Waikīkī are anticipated.

Concerns regarding impacts to surfing waves in Waikīkī extend well beyond the proposed beach improvement and maintenance actions. The quality of surfing waves in Waikīkī as they exist today is expected to change as sea levels continue to rise. As water depths increase, the fringing reef will be less effective in dissipating wave energy. As a result, waves will break further inland and swells will have to be larger to break in the deeper water (Honolulu Civil Beat, 2019). This could potentially eliminate some of the surfable waves at certain locations in Hawaiʻi, including those in Waikīkī. A recent study found that 16% of surf sites in California would be eliminated with 3 ft of sea level rise and 18% would be threatened (Reineman et al. 2017).

Dredge Analysis

Ala Moana

The *Courts* surf site is located about 2,000 ft directly inshore of the *Ala Moana* offshore sand deposit (see Section 3.6). Additional nearby surf sites include *Concessions* and *Baby Haleʻiwa*. Surfers have expressed concerns that changes in bathymetry associated with sand recovery operations may affect the characteristics of the surfing waves, particularly at *Courts*.

To approximate the sand borrow area, the bathymetry of the central portion of the sand deposit was reduced by 4 ft, which is considered to be a reasonable scenario. This would produce approximately 52,000 cy of sand. The boundary of the sand borrow pit sloped by 1V:3H (vertical to horizontal) to represent the stable slope of sand.

Wave models BOUSS-2D and SWAN were run independently, using the same input wave conditions over the pre- and post-dredge bathymetry. The two models agree well in spatial pattern and in magnitude. The results show that the sand borrow pit causes decreases in wave heights of less than 1 in at *Courts*. For the BOUSS-2D model, the breaking wave height at *Courts* decreased by 0.8 in, or 1.1%, due to the dredge pit, and for the SWAN model, the breaking wave height at *Courts* decreased by 0.5 in, or 1.0%, due to the sand borrow pit. Conversely, model output shows that the wave heights at *Concessions* and *Baby Haleʻiwa* would be expected to increase by up to 1 in.

Hilton

The *Ala Moana Bowls* surf site is located about 1,500 ft north of the *Hilton* offshore sand deposit (see Section 3.6). Additional nearby surf sites include *Rock Piles*, *In Betweens*, and *Kaisers*. To approximate the sand recovery area, the LiDAR bathymetry in the region of the sand deposit was reduced by 4 ft to represent the anticipated change to the seafloor, which is considered to be a practical dredging scenario. This scenario would produce approximately 40,000 cy of sand. The boundary of the sand borrow pit was sloped by 1V:3H (vertical to horizontal) in the bathymetry set to represent the stable slope of sand.

The phase-resolving wave model SWASH was used to simulate wave transformation over both the existing bathymetry and imposed dredge pit bathymetry using the south swell conditions presented earlier. The results show that the sand borrow pit causes an increase in significant wave heights of less than 2 in at the *Bowls* and *Kaisers* surf sites. Inspection of the wave patterns reveals no noticeable change in the structure of the wave. Other surf sites, including *Threes*, *Fours*, and *Populars* are more than 1,000 ft to the southeast of the *Hilton* offshore sand deposit, therefore dredging is not anticipated to have any impacts to surfing waves at these locations.

Canoes and Queens

The *Canoes* and *Queens* surf sites are located about 200 ft east and 150 ft north, respectively, of the sand recovery area used for the Waikīkī Maintenance I and II projects in 2012 and 2021, respectively (see Section 3.6). To approximate the sand recovery area, the LiDAR bathymetry in the area of the sand deposit was reduced by 4 ft to represent the anticipated change to the seafloor, which is considered to be a reasonable scenario. This would produce approximately 20,000 cy of sand. The boundary of the sand borrow area sloped by 1V:3H (vertical to horizontal) to represent the stable slope of sand.

The phase-resolving wave model SWASH was used to simulate wave transformation over both the existing bathymetry and imposed dredge pit bathymetry using the south swell conditions presented earlier. The results show that the sand borrow pit causes an increase in significant wave heights of about 1.8 in at the *Canoes* surf site and a decrease in significant wave heights of about 1.6 in at the *Queens* surf site. As a result, the proposed actions are not anticipated to have any significant impacts on surfing waves in these areas.

<u>Wave Reflection Analysis</u>

Concerns were expressed regarding the potential for the proposed structures in the Halekūlani and Kūhiō beach sectors to reflect waves that could negatively impact surf sites, primarily in the Halekūlani beach sector. To evaluate potential impacts, wave modeling of the existing conditions and with the proposed structures was performed.

The numerical model SWASH was utilized for this study. SWASH is a phase-resolving non-hydrostatic wave model that computes the depth-averaged flow due to waves and currents using the non-linear shallow water equations. The governing equations are valid from intermediate to shallow water and can simulate most of the phenomena of interest in the nearshore zone and in harbor basins, including shoaling and refraction over variable bathymetry, reflection and diffraction near structures, energy dissipation due to wave breaking and bottom friction, breaking-induced longshore/cross-shore (rip) currents, and harbor oscillations. Various types of structures can be included in the model from porous rock structures to impermeable vertical walls. A key strength of this model is the ability to adjust porosity of different types of structures being imposed into the model.

Model bathymetry was adapted from the USACE SHOALS LiDAR dataset and modified to include the most recent beach survey along Waikīkī Beach and the newly constructed Royal Hawaiian Groin. Existing wall structures were incorporated into the model with low porosities (<0.1) as recommended in the SWASH user manual (The SWASH Team, 2020). Existing rubblemound structures were incorporated with porosities ranging from 0.4 to 0.45, typical for these types of structures (The SWASH Team, 2020). The model was validated against measured wave buoy data collected by Sea Engineering in 2009 at four locations along the Waikīkī shoreline where the shoreline contained rubblemound structures, vertical walls, or sandy beaches.

The validated SWASH model was used to simulate a prevailing summer south-southwest swell during mid-tide for the existing and proposed shoreline configurations. Observation points were included in the model and were positioned at four popular surf sites *Threes, Populars, Canoes,* and *Queens*. These sites were chosen based on their popularity and their location relative to the proposed shoreline structures. Other nearby surf sites were expected to have similar impacts.

Halekūlani Beach Sector

The *Threes* and *Populars* surf sites are located more than 1,000 ft offshore of the proposed structures in the Halekūlani beach sector. The shoreline in this sector consists of a combination of seawalls and narrow beaches. The wave modeling showed that there is presently some wave reflection originating from the shoreline in the Halekūlani beach sector. The modeling showed this reflected wave energy to be about 0.4 ft (5 in) at *Threes* and *Populars*.

The wave modeling for the proposed beach improvements shows that no change in wave energy is anticipated at *Threes* and a minor decrease in wave energy is anticipated at *Populars*. The similar or decreased wave energy indicates that, while the proposed beach improvements would shift the shoreline further seaward, the effect of the structures is negligible when compared to the existing conditions.

Kūhiō Beach Sector

The model results for the Kūhiō beach sector show that there would currently be a reflected wave of 0.4 ft (5 in) at *Queens* and 0.6 ft (7 in) at *Canoes* under the model conditions. The water surface animation shows that the reflected waves affecting *Canoes* and *Queens* come from the Kūhiō Beach Park offshore breakwaters. The incident wave angle at those structures indicates that *Queens* would be affected by the reflection from the breakwater in the Diamond Head (east) basin, while *Canoes* could be affected by reflection off the breakwater in both basins.

The model results for the proposed beach improvements indicate that there would be no change in the amount of reflected wave energy at *Queens,* likely because the origin of the reflection, the Diamond Head (east) basin breakwater, would not be altered. The reflected wave energy at *Canoes* increases by 0.2 ft (2.5 in) due to the improvements to the ʻEwa (west) basin. Based on the results of the wave modeling, the dredge analysis, and the wave reflection analysis, no significant impacts to surf sites in Waikīkī are anticipated.

9.5 Shoreline Access

The shorelines of Hawaiʻi are a public resource that provides significant economic, social, recreational, and environmental benefits. The public's right to access the shoreline is rooted in common law and the Public Trust Doctrine. Public access to and along the shorelines of Hawaiʻi is an indisputable right of every citizen and is regarded by the courts and State law as inviolable. The Hawaiʻi Supreme Court has consistently ruled in support of the important public policy of "extending to public use and ownership as much of Hawaii's shoreline as is reasonably possible" and the long-recognized common law principle, now enshrined in the Hawaiʻi Constitution, that the lands below the shoreline are held by the state as a public trust for the people of Hawaiʻi.

State and local governments have the duty to maintain both perpendicular and lateral access to the shoreline to ensure that the public has adequate access to this valuable public resource. While the counties have the primary authority and duty to develop and maintain public access to and along the shorelines, primarily via shore-perpendicular public rights-of-way (§46-6.5, HRS), the State of Hawaiʻi has the primary authority and responsibility to maintain lateral shoreline access within *beach transit corridors* (§115-5 and §115-7, HRS), which is the area seaward of the *shoreline* (Chapter 205A, HRS and§13-222, HAR). The DLNR is the lead agency with regulatory authority for maintaining access within *beach transit corridors*.

The Waikīkī shoreline is relatively accessible. The east and west ends of the project area consist of public parks with more open space and a wider buffer between the existing development and the shoreline. Perpendicular and lateral shoreline access are more limited in the central portion of the project area, particularly in the Halekūlani beach sector. The following discussion summarizes existing shoreline access in each beach sector.

9.5.1 Fort DeRussy Beach Sector

The Fort DeRussy beach sector spans approximately 1,680 ft of shoreline that extends from the Hilton pier/groin east to the Fort DeRussy outfall/groin. Perpendicular access to the shoreline is available through Fort DeRussy Park. The Fort DeRussy beach walkway provides lateral access along the shoreline from Hilton Hawaiian Village to the Castle Waikīkī Shores. Sand often gets pushed landward over the beach walkway by wave action, particularly during high tides and high surf events.

9.5.2 Halekūlani Beach Sector

The Halekūlani beach sector spans approximately 1,450 ft of shoreline extending from the Fort DeRussy outfall/groin east to the Royal Hawaiian groin. Perpendicular access to the shoreline is available at three locations: Fort DeRussy Park at the ʻEwa (west) end of the sector, a public beach right-of-way between the Outrigger Reef Waikīkī Beach Resort and the Halekūlani Hotel, and a privately-owned perpendicular access between the Halekūlani Hotel and the Sheraton Waikiki Hotel.

Lateral shoreline access throughout the Halekūlani beach sector is more limited than the rest of Waikīkī due to the lack of dry beach area and the density of development immediately adjacent to the shoreline. Lateral access is available along the beach at the ʻEwa (west) end of the sector. Access past the Halekūlani Hotel is available via a discontinuous, narrow walkway on top of the low elevation seawall, which is constantly wet due to wave splash and overtopping. There is no walkway across the small pocket beaches between the Halekūlani Hotel and the Sheraton Waikiki Hotel. Lateral access is accomplished by walking around the back of the beach which, given its low elevation, is often submerged during high tides and high surf events. A narrow walkway on the top of the seawall fronting the Sheraton Waikiki Hotel had provided a small measure of wave-splashed lateral access but has been closed since 2017 due to hazardous conditions, forcing people to walk through the hotel grounds. Closure of this area inhibits lateral shoreline access between the east and west portions of Waikīkī Beach.

9.5.3 Royal Hawaiian Beach Sector

The Royal Hawaiian beach sector spans approximately 1,730 ft of shoreline extending from the Royal Hawaiian groin east to the ʻEwa (west) groin at Kūhiō Beach Park. Perpendicular access to the shoreline is limited due to the density of development in the backshore. Perpendicular shoreline access is available from Kalākaua Avenue at two locations: one between the Royal Hawaiian Hotel and Outrigger Waikīkī Beach Resort, and one between the Moana Surfrider Hotel and the Honolulu Police Department substation. Royal Hawaiian Beach provides continuous lateral shoreline access along the entire sector but has no walkway to provide ADA-compliant lateral access. Lateral non-beach access between the Sheraton Waikiki Hotel and Kuhio Beach Park requires utilizing the ADA-compliant public sidewalks along Kalākaua Ave.

9.5.4 Kūhiō Beach Sector

The Kūhiō beach sector spans approximately 1,500 ft of shoreline extending from the ʻEwa (west) groin at Kūhiō Beach Park east to the Kapahulu storm drain/groin. A wide concrete sidewalk and esplanade along Kalākaua Avenue provides perpendicular access to the shoreline at multiple locations, as well ADA-compliant lateral access landward of the shoreline along the entire beach sector. The Kūhiō beach sector offers the most abundant access to and along the Waikīkī shoreline since it is entirely a public beach park.

9.5.5 Potential Impacts and Mitigation Measures

Construction is anticipated to have short-term impacts on shoreline access. During construction, the use of some portions of the shoreline and offshore sand recovery areas may be prevented for public health and safety reasons. The proposed actions are anticipated to have a long-term positive impact on lateral shoreline access by increasing beach width and stability. The applicant will notify adjacent landowners and the public prior to commencement of construction activities. Beach closures will be minimized to the extent practicable. Crossing guards will be on-site to divert beach goers away from active work areas.

9.6 Air Quality

The U.S. Environmental Protection Agency (EPA) has established national ambient air quality standards (NAAQS) for ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, 2.5-micron and 10-micron particulate matter ($PM_{2.5}$ and PM_{10}), and airborne lead. These ambient air quality standards establish the maximum concentrations of pollution considered acceptable, with an adequate margin of safety, to protect the public health and welfare. The State of Hawaiʻi has also adopted ambient air quality standards for some pollutants. In some cases, these are more stringent than the Federal standards. The State of Hawaiʻi has established standards for five of the six criteria pollutants (excluding $PM_{2.5}$), in addition to hydrogen sulfide (DOH, 2003).

In general, air quality in the Waikīkī area is excellent. The State of Hawaiʻi Department of Health (DOH) monitors ambient air quality on Oʻahu using a system of nine monitoring sites. The primary purpose of the monitoring network is to measure ambient air concentrations of the six criteria NAAQS pollutants. DOH monitoring data for 2008 shows that air quality in the Waikīkī area during that year never exceeded the short-term or long-term State or National standards for the six pollutants measured [particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2) sulfur dioxide (SO_2), carbon monoxide, and hydrogen sulfide]. The only ozone monitoring station on Oʻahu is located on Sand Island, west of Waikīkī. Existing ozone concentrations at that location also meet State and Federal ambient air quality standards.

9.6.1 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have short-term impacts on air quality. Because most of the work that will take place in the water, or on the sandy shoreline, the proposed actions differ from many construction projects in that they involve little or no soil disturbance that could result in particulate emissions. Potential sources of air pollution as a result of the proposed actions are related to the construction phase.

During the actual construction process beach nourishment activities will create temporary degradation in air quality in the immediate vicinity of the project areas. This negative impact to air quality will be limited to typical work hours and will end once the sand is in place. The emissions from these internal combustion engines are far too small to have a significant or lasting effect on air quality. As part of the construction process, the contractor will observe all BMPs to keep construction related emissions to the lowest practicable levels.

Short-term degradation of air quality may occur due to emissions from construction equipment and would include carbon monoxide (CO), nitrogen oxides (NO_2), volatile organic compounds (VOCs), directly emitted particulate matter (PM_{10} and $PM_{2.5}$), and toxic air contaminants such as diesel exhaust particulate matter. Sulfur dioxide (SO_2) is generated by oxidation during combustion of organic sulfur compounds contained in diesel fuel. Off-road diesel fuel meeting Federal standards can contain up to 5,000 parts per million (ppm) of sulfur, whereas on-road diesel is restricted to less than 15 ppm of sulfur. These construction impacts to air quality are short-term in duration and, therefore, will not result in adverse or long-term conditions.

Implementation of the following measures will reduce any air quality impacts resulting from construction activities:

- Apply water or dust palliative to the site and equipment as frequently as necessary to control fugitive dust emissions.
- Properly tune and maintain construction equipment and vehicles.
- Locate equipment and materials storage sites as far away from hotels and commercial uses as practical. Keep construction areas clean and orderly.

During the previous 2012 Waikīkī Nourishment I Project it was noted that the sand dewatering site emitted an unpleasant odor as the sand dried. It is likely that this odor will be present during construction; however, it ends quickly once the sand is exposed to the air. The sand to be recovered has a very low percentage of material smaller than sand size, and it will be wet, thus fugitive dust susceptible to airborne dispersion is not expected to be significant. Once construction is completed the beach will have no long-term air emissions or impact on air quality.

9.7 Noise

The proposed actions are anticipated to have short-term impacts on noise associated with construction. §11-46, HAR, "Community Noise Control" establishes maximum permissible sound levels (Table 9-2) and provides for the prevention, control, and abatement of noise pollution in the State from stationary noise sources and from equipment related to agricultural, construction, and industrial activities. The standards are also intended to protect public health and welfare, and to prevent the significant degradation of the environment and quality of life. The limits are applicable at the property line rather than at some predetermined distance from the sound source.

The project area is in the Conservation District, but there are no noise-sensitive uses at the present time. Because of that, the Class B limits applicable to land zoned for resort use appear the most applicable for the proposed actions. §11-46-7, HAR, grants the Director of the Department of Health the authority to issue permits to operate a noise source which emits sound in excess of the maximum permissible levels specified in Table 9-2 if it is in the public interest and subject to any reasonable conditions. Those conditions can include requirements to employ the best available noise control technology.

Existing ambient noise levels vary considerably within the project area both spatially (i.e., from place to place) and temporally (i.e., from one time to another). In general, existing background sound levels along Waikīkī Beach are relatively high, 55 to 60 dBA, due to surf, traffic, aircraft, and on-going maintenance and construction equipment. In the vicinity of significant construction activity noise levels can intermittently reach 80 dBA.

Table 9-2 Maximum Permissible Sound Levels in dBA

Zoning Districts	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Class A	55	45

Class B	60	50
Class C	70	70
Notes: (1) Class A zoning districts include all areas equivalent to lands zoned residential, conservation, preservation, public space, open space, or similar type. (2) Class B zoning districts include all areas equivalent to lands zoned for multi-family dwellings, apartment, business, commercial, hotel, resort, or similar type. (3) Class C zoning districts include all areas equivalent to lands zoned agriculture, country, industrial, or similar type. (4) The maximum permissible sound levels apply to any excessive noise source emanating within the specified zoning district, and at any point at or beyond (past) the property line of the premises. Noise levels may exceed the limit up to 10% of the time within any 20-minute period. Higher noise levels are allowed only by permit or variance issued under sections 11-46-7 and 11-46-8. (5) For mixed zoning districts, the primary land use designation is used to determine the applicable zoning district class and the maximum permissible sound level. (6) The maximum permissible sound level for impulsive noise is 10 dBA (as measured by the "Fast" meter response) above the maximum permissible sound levels shown.		
Source: §11-46, HAR, "Community Noise Control"		

9.7.1 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have short-term negative impacts on noise levels. Noise from diesel powered equipment operating on the sand recovery vessel offshore can be expected to attenuate with distance such that it will be less than background levels along the shoreline. Equipment operation in the vicinity of the dewatering site and being used in the sand placement operations along the shoreline, however, will be audible and may exceed current background noise levels. As the separation distance from the operating equipment decreases, very high noise levels (80+ dBA) can be expected to occur. Back up alarms which use beeping high frequency signals near 1,000 Hz can be relatively loud and tend to be intrusive because they occur in the high frequency band where the background ambient noise level tends to be lower.

It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing background noise levels or is inaudible to beach users, hotel guests, etc. Some reduction is practical, however, and the following measures will be implemented.

- Equipment operation on the shoreline will be limited to daylight hours.
- Broadband noise backup alarms in lieu of higher frequency beepers will be required for construction vehicles and equipment. Broadband noise alarms tend to be less audible and intrusive with distance as they blend in with other background noise sources.
- The project will specify use of the quietest locally available equipment, e.g., high insertion loss mufflers, fully enclosed engines, and rubber-tired equipment when possible.
- The use of horns for signaling will be prohibited.
- Worker training on ways to minimize impact noise and banging will be required.

- A noise complaint hot line will be provided at the job site to allow for feedback from the hotel operators, which can be used to help develop modifications to construction operations whenever feasible.
- Construction operations will cease in the vicinity of scheduled performances, such as the nightly hula show at the west end of Kūhiō Beach.

9.8 Public Services

9.8.1 Solid Waste

The City and County of Honolulu, Department of Environmental Services manages Honolulu's municipal solid waste system, including the H-POWER resource recovery facility and one sanitary landfill. A private company operates a construction debris landfill in Nānākuli, and private companies are responsible for solid waste collection from virtually all of the island's commercial organization.

9.8.2 Water Supply

The Honolulu Board of Water Supply (BWS) is responsible for the management, control and operation of Oʻahu's municipal water system that serves the entire Primary Urban Center Development Plan area. The BWS system is an integrated, island-wide system with interconnections between water sources and service areas. Water is exported from areas of available supply to areas of municipal demand. None of the BWS facilities are present seaward of the shoreline where the proposed beach improvement and maintenance actions will occur. Neither does it maintain nor operate any pipelines or other water supply facilities within the area that will be used by construction equipment.

9.8.3 Police, Fire, Emergency Medical Services, and Ocean Safety

Police Protection

The Hawaiʻi Department of Land and Natural Resources Division of Conservation and Resources Enforcement (DLNR-DOCARE) is responsible for enforcement activities in areas controlled by the DLNR, which includes the area seaward of the certified shoreline where the proposed actions will take place. In addition, Honolulu Police Department officers patrol accessible areas of the beach on all-terrain vehicles. Presently, officers only patrol as far as the Royal Hawaiian due to the limited shoreline access. The proposed actions will improve lateral access and thus facilitate police patrolling along the beach. The nearest police station is located at the Waikīkī Beach Center (Police Sub-Station) on Kalākaua Avenue adjacent to the Moana Surfrider Hotel. Police headquarters is located on Beretania Street near its intersection with Alapaʻi Street.

Fire Protection

The three nearest Fire Stations are on Makaloa Street, at the intersection of University and Date Streets, and at the intersection of Kapahulu Avenue and Ala Wai Boulevard. All are roughly 1.5 miles by road from the project site.

Emergency Medical Services

The three hospitals nearest to the project site are Kapiʻolani Women's and Children's Hospital on Punahou Street, Straub Hospital on King Street, and Queen's Hospital on Punchbowl Street. All three hospitals provide emergency medical services (EMS) to the area, as do the Fire Stations mentioned above.

Ocean Safety

The two city lifeguard towers nearest the project are on the sand nearest the Royal Hawaiian and Moana Surfrider hotels. Mobile city Ocean Safety Division teams (using jet skis and trucks) are available to respond during daylight hours 7:00 a.m. to 7:00 p.m. The project may force beach users into other areas of Waikīkī and may impact Ocean Safety services with respect to shoreline access, or delivery of patients to suitable landing areas for coordination with EMS or the Honolulu Fire Department.

9.8.4 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a moderate but acceptable~~negligible~~ impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which could increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this could also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, and Emergency Medical Services will be informed of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed actions do not involve any activities that will permanently alter the need for, or ability to provide, emergency services.

9.9 Public Infrastructure

9.9.1 Transportation

Vehicular and Pedestrian Access

Pedestrian access to the beach is available from Kalākaua Avenue through public rights-of-way, and the large open spaces located at intervals along the shoreline. A shoreline sidewalk extends from the Waikīkī Natatorium War Memorial to the Queen's Surf groin, and then merges into the sidewalk along Kalākaua Avenue up to the Moana Surfrider Hotel. Lateral pedestrian shoreline access is then only available by walking along Royal Hawaiian Beach makai (seaward) of the hotels. During high tides and periods of high surf, this beach is narrow and lateral access is difficult. From the Royal Hawaiian Hotel to Fort DeRussy there is a narrow walkway on top of the existing seawalls, however wave splash often makes this very wet, and the walkway is frequently closed due to safety concerns. The beach walkway resumes at the east end of the Fort DeRussy beach sector and extends west to the Hilton Hawaiian Village.

Harbors

The nearest harbor is the Ala Wai Harbor, which is owned and operated by the State of Hawaiʻi. Commercial cargo arrives and departs through Honolulu Harbor.

Airports

Honolulu International Airport is approximately six miles west of the project area.

9.9.2 Water System

The Honolulu Board of Water Supply (BWS) is responsible for the management, control and operation of Oahu's municipal water system that serves the entire Primary Urban Center Development Plan area. The BWS system is an integrated, island-wide system with interconnections between water sources and service areas. Water is exported from areas of available supply to areas of municipal demand. None of the BWS facilities are present makai of the shoreline where the proposed actions will occur. Neither does it maintain nor operate any pipelines or other water supply facilities within the area that will be used by construction equipment.

9.9.3 Sanitary Wastewater Collection and Treatment Facilities

The City and County of Honolulu Department of Environmental Services manages the municipal wastewater collection, treatment, and disposal system that serves the hotels surrounding the project site. The project site lies within the East Mamala Bay service area, with outflows processed through the Sand Island Wastewater Treatment Plant. The nearest City and County of Honolulu sanitary sewer line is located inland from the project area.

9.9.4 Solid Waste Collection and Disposal

The City and County of Honolulu Department of Environmental Services manages Honolulu's municipal solid waste system, including the H-POWER resource recovery facility and one sanitary landfill. A private company operates a construction debris landfill in Nānākuli, and private companies are responsible for solid waste collection from virtually all of the island's commercial organizations.

9.9.5 Electrical and Telecommunications System

Telecommunication Facilities

There are no telecommunication lines within the shoreline area or in the area which will be used by construction equipment.

Electric Power

The Hawaiian Electric Company (HECO) provides electrical service to the project area. Most of the electrical power that is consumed in Waikīkī comes from fossil fuel-fired generating units located at Waiau, Campbell Industrial Park, and Kahe. Power is delivered to customers by a system of underground and overhead transmission and distribution lines, none of which are in the project area.

9.9.6 Potential Impacts and Mitigation Measures

The proposed actions are anticipated to have a negligible impact on public infrastructure. The proposed actions will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are no anticipated effects to stormwater runoff that will affect the City and County of Honolulu stormwater drainage system. Most people visiting Waikīkī Beach travel by foot rather than in vehicles, and the proposed actions are not anticipated to increase the resident or visitor population of the island.

During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of the onshore equipment and materials will involve some heavy vehicle traffic through Waikīkī; however, this will be of limited duration. Equipment and materials will be transported along Waikīkī Beach to the project sites, which will require secure trucking lanes on the beach. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable. Upon completion of the projects, the number of trips along the beach will be less, as only the equipment and a fraction of the materials will need to be removed. Because of the small number of vehicle trips involved, construction worker and equipment/material delivery trips do not have the potential to substantially affect traffic volumes and/or the level of service on area roadways.

10. UNAVOIDABLE AND CUMULATIVE IMPACTS

Cumulative impacts, as defined in §11-200.1-2, HAR:

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

Cumulative impacts can be viewed as sum product of actions, past and present, on the project site and resources within the project site. Past beach improvement and maintenance projects in Hawaiʻi and domestically have generated data on potential project-related impacts. This section discusses potential adverse impacts which likely cannot be avoided.

10.1 Fort DeRussy Beach Sector

The proposed action for the Fort DeRussy beach sector is beach maintenance consisting of small-scale beach nourishment and periodic sand backpassing with no additional improvements or modifications to existing structures. The proposed action will be implemented in phases. The first phase will consist of small-scale beach nourishment, which will involve placement of approximately 3,000 cy of sand recovered from the *Hilton* offshore sand deposit. The second phase will consist of periodic backpassing of existing beach sand to maintain the desired beach width and profile. Sand will be transported from the accreted area at the west end of the beach to the eroding area at the east end of the beach to increase dry beach width and mitigate wave overtopping. Sand will be obtained from the beach face on the east side of the Hilton pier/groin, where sand eroded has accreted over the years. Sand will be excavated from the beach face extending inshore only as far as necessary to obtain the required volume of sand.

10.1.1 Unavoidable Impacts

- The proposed action will use a non-renewable resource (sand).
- Approximately 3,000 cubic yards of sand will be recovered from the *Hilton* offshore sand deposit and placed on the Diamond Head (east) end of the Fort DeRussy beach sector, which will alter the existing beach profile in this area.
- Approximately 1,500 cubic yards of sand will be recovered from the borrow area at the west end of the Fort DeRussy beach sector, which will alter the existing beach profile in this area.
- Sand compaction can occur in high traffic areas during sand transport and placement operations.
- Machinery operating on the beach will generate noise and may temporarily impact air quality.
- Sand transportation and placement operations on the beach will require portions of the shoreline to be cordoned off to ensure public health and safety. Access across the cordoned off areas will be limited to specific crossing points with crossing guards.

- Bathymetry at and adjacent to the nourishment efforts will be temporarily perturbated while the beach equilibrates to the new sand volume.

10.1.2 Cumulative Impacts

The initial small-scale beach nourishment will involve recovery of approximately 3,000 cy of sand. Assuming a sand recovery rate of approximately 250 cy per day, the initial small-scale beach nourishment effort will require a total of 30 construction days. The periodic sand backpassing is designed to be implemented periodically on an as-needed basis. Sand backpassing will be conducted when beach conditions reach some pre-defined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. The proposed sand backpassing will involve moving approximately 1,500 cy of existing beach sand from one end of the beach to the other. No dredging is proposed and the volume of sand in the littoral system will not be altered. The estimated construction duration for the proposed sand backpassing is 5 days.

The UHCGG estimates that the average annual erosion rate at the east end of the Fort DeRussy beach sector with 3.2 ft of sea level rise is 2.7 ft/yr (mid-range, 80% confidence) (UHCGG, ~~2019~~2021). Based on this estimate, sand backpassing will need to be conducted every 3 years. Sand backpassing will be initiated approximately 10 years after the initial beach nourishment effort, resulting in a total of ~~Over a period of 50 yrs, this will result in a total of 17~~ 14 individual sand backpassing events and a total of ~~85~~ 70 days of construction.

An alternative to sand backpassing is beach nourishment with stabilizing structures. Beach nourishment would involve recovering approximately 20,000 cy of sand from offshore and placing it on the beach. This alternative would require dredging to recover sand from offshore and would increase the volume of sand in the littoral system; however, no sand would be removed from the ʻEwa (west) end of the beach sector. Like the sand backpassing plan, beach nourishment would widen the beach to a prescribed width and profile. The beach would be widened to approximately 70 ft as measured from the beach walkway to the waterline.

~~The estimated construction duration for beach nourishment without stabilizing structures is 120 days, and the estimated recurrence interval is 10 yrs. Assuming that renourishment is conducted over a period of 50 yrs, this would result in a total of 5 individual renourishment events and a total of 600 days of construction. The estimated construction duration for beach nourishment with stabilizing structures is 240 days.~~

When compared to the alternative of beach nourishment with stabilizing structures, the proposed action has less cumulative impacts. The proposed small-scale beach nourishment and periodic sand backpassing requires fewer construction days, and fewer beach closures, ~~no offshore dredging,~~ and ~~no~~a negligible increase in the volume of sand in the littoral system. While larger-scale beach nourishment is technically feasible, it is not being proposed due to the relatively isolated scope of the erosion problem. ~~Furthermore, beach nourishment may not be a viable long-term solution due to the limited volume of compatible offshore sand to support periodic renourishment efforts.~~

When compared to the alternative of beach nourishment with stabilizing structures, the proposed action has less cumulative impacts. The proposed action will require fewer individual dredging events, fewer construction days, and fewer beach closures. While beach nourishment with stabilizing structures is technically feasible and would produce a stable beach, it is not being proposed due to the cumulative impacts associated with construction. Furthermore, based on feedback from the WBCAC, the majority of stakeholders prefer that, where possible, beaches in Waikīkī should be maintained without any additional shoreline structures. While sand backpassing will need to be conducted periodically, it would not fundamentally alter the character or appearance of the shoreline as it exists today.

10.2 Halekūlani Beach Sector

The proposed action for the Halekūlani beach sector is beach improvements consisting of beach nourishment with stabilizing groins and a sand retaining wall. The proposed action will consist of construction of three new sloping rock rubblemound T-head groins, a new L-head groin adjacent to the existing Fort DeRussy outfall/groin, and modification of the recently replaced Royal Hawaiian groin. The proposed action will include construction of a sand retaining wall to stabilize the beach fill. The groins, sand retaining wall, and beach fill will create four stable beach cells in an area that has previously had limited beach resources. The proposed action will require approximately 60,000 cy of sand fill and will create approximately 3.8 acres of new dry beach area.

10.2.1 Unavoidable Impacts

- The proposed action will use non-renewable resources (sand, stone, concrete). The estimated volume of sand required to nourish the beach is approximately 60,000 cy. The estimated volume of stone required to construct the groins is approximately 15,000 cy. The estimated volume of concrete required to construct the crown walls is approximately 810 cy. The estimated volume of concrete required to construct the sand retaining wall is approximately 600 cy.
- Approximately 60,000 cubic yards of sand will be recovered from an offshore deposit, which has the potential to temporarily alter the bathymetry and temporarily disrupt the ecology in the dredge extents.
- Sand recovered from the ocean, though highly compatible with the dry beach sand, may still have some fine content that will be winnowed from the beach system and moved offshore during the initial equilibration process and consequent beach erosion events.
- Dredging, transportation, and placement of carbonate sand can increase the percentage of fine sediment through mechanical abrasion of friable grains.
- Particles greater than one inch in diameter may be present in the recovered and placed sand.
- Sand compaction can occur in high traffic areas during sand transportation and placement operations.
- When sand is recovered from anoxic environments, such as offshore deposits, it will typically have a grey color and unpleasant scent immediately after recovery.

- During sand recovery operations, minor turbidity is anticipated as sand is brought from the seafloor to the barge.
- Anchor lines around the sand recovery area will be in place for the duration of sand recovery operations.
- Dredging and sand transportation operations will temporarily disrupt marine ecology and ocean recreation in the area during construction.
- Machinery operating on the barge will generate noise and may temporarily impact air quality.
- Any construction activities taking place in the nearshore waters are anticipated to temporarily impact marine ecology, ocean recreation and access in the area.
- Sand placement operations on the beach will require portions of the shoreline to be cordoned off to ensure public health and safety. Access across the cordoned off areas will be limited to specific crossing points with crossing guards.
- Ecological services of reef flat habitat will be lost within the project footprints (sand fill and groins) but are anticipated to recover over time as the benthic community re-establishes.
- Bathymetry within the project footprints (sand fill and groins) will be permanently altered.
- The current travel path for the catamarans would shift slightly to the west to align with the gap between the groins on either side of the Halekūlani Channel.

10.2.2 Cumulative Impacts

The proposed beach improvement action is designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the project could be effective until about the year 2080, or 50-years post-construction. The estimated construction duration for the proposed action is 500 days.

An alternative to the proposed action is beach nourishment without stabilizing structures (see Section 5.4.1). Beach nourishment would involve recovering approximately 60,000 cy of sand from offshore and placing it on the beach. The estimated construction duration for beach nourishment without stabilizing structures is 240 days.

The UHCGG estimates that the average annual erosion rate in the Halekūlani beach sector with 3.2 ft of sea level rise will be ~~1.0~~1.2 ft/yr (mid-range, 80% confidence) (UHCGG, ~~2019~~2021). Based on this estimate, in order to maintain a minimum beach width of 20 ft, the beach would need to be renourished every 5 years. Due to the combination of nearshore wave patterns, seawalls, and the Halekūlani Channel, it is possible that the beach could erode more rapidly, in which case renourishment would need to be conducted more frequently. Assuming that renourishment was conducted every 5 yrs over a period of 50 yrs, this would result in a total of 10 individual renourishment events and a total of 2,400 days of construction.

When compared to the alternative of beach nourishment without stabilizing structures, the proposed action has less cumulative impacts. The proposed action will require fewer individual dredging events, fewer construction days, and fewer beach closures. While beach nourishment without stabilizing structures is technically feasible, it is not being proposed due to the cumulative impacts associated with periodic dredging and renourishment. Furthermore, beach nourishment may not be a viable long-term solution due the limited volume of compatible offshore sand to support periodic renourishment efforts.

10.3 Royal Hawaiian Beach Sector

The proposed action for the Royal Hawaiian beach sector is beach maintenance consisting of beach nourishment with no additional improvements or modifications to existing structures. The proposed action will require periodic renourishment to maintain the beach at its 1985 location.

10.3.1 Unavoidable Impacts

- The proposed action will use a non-renewable resource (sand).
- Approximately 25,000 cy of sand will be dredged from the *Canoes/Queens* offshore deposit, temporarily altering the bathymetry and temporarily disrupting the ecology in the dredge extents.
- Sand recovered from the ocean, though highly compatible with the dry beach sand, will still have some fine content that will be winnowed from the beach system and moved offshore during the initial equilibration process and consequent beach erosion events.
- Dredging, transportation, and placement of carbonate sand can increase the percentage of fine sediment through mechanical abrasion of friable grains.
- Particles greater than one inch in diameter may be present in the recovered and placed sand.
- Sand compaction can occur in high traffic areas during sand transportation and placement operations.
- When sand is recovered from anoxic environments, such as the *Canoes/Queens* offshore deposit, it will typically have a grey color and unpleasant scent immediately after recovery.
- During sand recovery operations, minor turbidity is anticipated as sand is brought from the seafloor to the barge.
- Anchor lines around the sand recovery area will be in place for the duration of sand recovery operations.
- Dredging and sand transportation operations will likely disrupt marine ecology and ocean recreation in the area during construction.
- Machinery operating on the barge and the beach will generate noise and may temporarily impact air quality.
- Any construction activities taking place in the nearshore waters are anticipated to temporarily impact marine ecology, ocean recreation and access in the area.
- Sand placement operations on the beach will require portions of the shoreline to be cordoned off to ensure public health and safety. Access across the cordoned off areas will be limited to specific crossing points with crossing guards.
- Bathymetry at the sand recovery area and along the beach toe will be temporarily altered while the beach equilibrates to the new sand volume.

10.3.2 Cumulative Impacts

The proposed action is designed to be implemented periodically on an as-needed basis. Beach nourishment will be conducted when beach conditions reach some pre-defined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. The proposed action will involve recovering approximately 25,000 cy of sand from the *Canoes/Queens* offshore sand deposit and placing it on the beach. The volume of sand in the littoral system would not be altered.

The estimated construction duration for beach nourishment without stabilizing structures is 120 days, and the estimated recurrence interval is 10 yrs. Assuming that renourishment is conducted over a period of 50 yrs, this will result in a total of 5 individual renourishment events and a total of 600 days of construction.

Alternatives to the proposed action include beach maintenance (sand backpassing or sand pumping) and beach nourishment with stabilizing structures (see Section 6.4). Sand backpassing would involve moving sand from wide portions of the beach to areas that are eroded and narrow. Presently, erosion is occurring at the Diamond Head (east) end of the beach along the Kūhiō Beach Park ʻEwa (west) groin. A backpassing program could periodically add sand to this eroded area. While sand backpassing is technically feasible, it may not be a viable option. The beach adjacent to the Royal Hawaiian groin is the only site in the Royal Hawaiian beach sector where a sufficient volume of sand would be available to support sand backpassing. However, the volume of sand present in this area is not sufficient to support continued sand backpassing.

Sand pumping would involve recovering sand from the shallow sandbar that occasionally forms fronting the Royal Hawaiian Hotel, adjacent to the *Canoes* surf site. The sandbar has formed periodically in the past and is believed to consist of beach sand that has been transported offshore since the 2012 Waikīkī Beach Maintenance I project. As a demonstration project, sand could be recovered from the sandbar and placed back on the beach fronting the Royal Hawaiian Hotel, Outrigger Waikīkī Beach Resort, and Moana Surfrider Hotel. This would involve recovery of approximately 2,400 cy of sand, if available, which is the volume required to raise the beach crest by approximately 6 in fronting the Royal Hawaiian Hotel, Outrigger Waikīkī Beach Resort, and Moana Surfrider Hotel. While sand pumping is technically feasible, it may not be a viable option. The sandbar is the only site in the Royal Hawaiian beach sector where sand pumping is feasible. However, the sandbar is an ephemeral feature that contains a limited volume of sand and may not be a sustainable sand source over the lifespan of the program.

Another alternative for the Royal Hawaiian beach sector is beach nourishment with stabilizing structures. This alternative would consist of constructing four new groins and modifying the ʻEwa (west) groin at Kūhiō Beach Park. A combination of T-head groins and beach fill would produce a wide, stable beach in an area where the beach has historically been narrow and subject to chronic erosion. This alternative would require approximately 45,000 cubic yards of sand fill and would create approximately 3.8 acres of new dry beach area. The *Canoes/Queens* offshore sand deposit contains an estimated 25,000 to 50,000 cy of sand, so this alternative would require removal of nearly the entire sand deposit. This would increase the potential for environmental impacts and may not be technically feasible. This alternative would be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 yrs following construction it may be necessary to raise the project elevations. If then raised by several feet, the project could be effective until about the year 2080, or 50 yrs post-construction.

Beach nourishment with stabilizing structures would produce a wide, stable beach and eliminate the need for periodic renourishment. However, based on feedback from the WBCAC, the majority of stakeholders prefer that Royal Hawaiian Beach should be maintained without any additional shoreline structures. Furthermore, this alternative may not be feasible due to the limited volume of sand in the *Canoes/Queens* offshore sand deposit. As a result, beach nourishment with stabilizing structures was ruled out in the early stages of the conceptual design and project selection process.

10.4 Kūhiō Beach Sector - ʻEwa (west) Basin

The proposed action for the Kūhiō beach sector ʻEwa (west) basin is beach improvements consisting of beach nourishment with modified groins and a segmented breakwater. The proposed action will involve removing portions of the existing structures, modifying the groins, construction of a new ~~groin and~~ segmented breakwater, and placement of sand fill to increase beach width.

10.4.1 Unavoidable Impacts

- The proposed action will use non-renewable resources (sand, stone, concrete). The estimated volume of sand required to nourish the beach is approximately 28,000 cy. The estimated volume of stone required to ~~construct~~ modify the groins and construct the segmented breakwater is approximately 4,000 cy. The estimated volume of concrete required is -approximately 250 cy.
- Approximately 28,000 cubic yards of sand will be recovered from an offshore deposit, temporarily altering the bathymetry and temporarily disrupting the ecology in the dredge extents.
- While these non-renewable resources will be moved from their current locations, the sand and rocks will continue to serve as environmental resources. The sand will expand beach resources and form the foundation of a shoreline berm ~~vegetated with native plants~~. The rocks will help to control the effects of beach erosion and provide additional benthic habitat.
- Sand recovered from the ocean, though highly compatible with the dry beach sand, will still have some fine content that will be winnowed from the beach system and moved offshore during the initial equilibration process and consequent beach erosion events.
- Dredging, transport, and placement of carbonate sand can increase the percentage of fine sediment through mechanical abrasion of friable grains.
- Particles greater than one inch in diameter may be present in the recovered and placed sand.
- Sand compaction can occur in high traffic areas during sand transportation and placement operations.

- When sand is recovered from anoxic environments, such as offshore deposits, it will typically have a grey color and unpleasant scent immediately after recovery.
- During sand recovery operations, minor turbidity is anticipated as sand is brought from the seafloor to the barge.
- Anchor lines around the offshore deposit will be in place for the duration of sand recovery operations. Anchor lines will be in place at the active sand offloading site.
- Dredging and sand transportation operations may temporarily disrupt marine ecology and ocean recreation in the area during construction.
- Machinery operating on the barge and the beach will generate noise and may temporarily impact air quality.
- Delivery to shore will require the emplacement of bridge structures, floats, or pipelines from the shoreline to at least 15 feet of water depth. Bridge structures could disrupt marine ecology and ocean recreation in the area during construction.
- Any construction activities taking place in the nearshore waters are expected to directly impact marine ecology, ocean recreation and access in the area.
- Placement operations on the beach will require lengths of the coast to be cordoned off during trucking operations. Access across the cordoned off area will be limited to specific crossing points with crossing guards.
- Bathymetry within the existing basin will be temporarily altered while the beach equilibrates to the new sand volume.

10.4.2 Cumulative Impacts

The proposed action beach improvement action in the Kūhiō beach sector 'Ewa (west) basin will involve removing portions of the existing structures, modification of the groins, construction of a new ~~groin and~~ segmented breakwater, and placement of approximately 28,000 cy of sand fill to increase beach width. The groin heads will have cast-in-place concrete cores that will serve as a base for groin expansion as sea levels continue to rise. Approximately 4,000 cy of stone and 250 cy of concrete will be required to ~~construct~~ modify the groins and construct a segmented breakwater. The proposed action will create a beach that will be a minimum of 30 ft wide. The total dry beach area inshore of the waterline will be about 44,000 sf (1 acre). The estimated construction duration for beach nourishment with modified groins and a segmented breakwater is 240 days.

Alternatives to the proposed beach improvement action include beach maintenance (sand backpassing or sand pumping) and beach nourishment with stabilizing structures (see Section 7.4). The current configuration of the 'Ewa (west) basin has resulted in narrowing of the beach inshore of the gap in the breakwaters, while sand has accreted to some extent at the 'Ewa (west) end of the beach and below the water surface along the center groin. Beach maintenance could involve recovering sand from along the center groin and placing it along the shoreline at the center of the beach.

The estimated construction duration for beach maintenance is 30 days, and the estimated recurrence interval is 5 yrs. Assuming that maintenance is conducted over a period of 50 yrs, this would result in a total of 10 individual maintenance events and a total of 300 days of construction. While beach maintenance is technically feasible, it may not be a viable option. The area adjacent to the center groin in the ʻEwa (west) basin is the only site in the Kūhiō beach sector where a sufficient volume of sand would be available to support beach maintenance. However, the volume of sand present in this area is limited and may not be sufficient to support continued maintenance.

Another alternative for the Kūhiō beach sector ʻEwa (west) basin is beach nourishment without stabilizing structures. This alternative would consist of placing sand directly along the shoreline without any structures to stabilize the sand. This concept would require approximately 28,000 cy of sand and would create approximately 40,000 sf of dry beach area. This alternative would increase dry beach width but would not increase beach stability or prevent erosion. An advantage of this option is that it would not require modification of the existing structures. However, the sand would be unstable and subject to continued erosion.

There is limited space and depth to accommodate additional sand fill in the ʻEwa (west) basin, so there would be no future renourishment efforts. Periodic maintenance (e.g., sand pumping or sand backpassing) would be required to maintain a stable beach profile. The estimated construction duration for beach nourishment without stabilizing structures is 100 days. Assuming that maintenance is conducted every 5 yrs following the initial beach nourishment, over a period of 50 yrs, this would result in a total of 8 individual maintenance events and 240 additional days of construction (total of 340 days). While this option would be less expensive initially, the cumulative costs of periodic maintenance would be substantial. When compared to beach nourishment without stabilizing structures, the proposed action will have less cumulative impacts. The proposed action will require fewer dredging events, fewer construction days, and fewer beach closures.

Beach nourishment without stabilizing structures would also fundamentally alter the character of the basin. Without the proposed segmented breakwater, the beach would migrate (slump) makai (seaward) into the basin, the beach profile would flatten, and water depths inside the basin would become very shallow. In collaboration with the WBCAC, the project proponents determined that the highest priorities for the ʻEwa (west) basin are to maintain the basin as a moderately energetic wave environment with direct access to the ocean, while minimizing the amount of structural and visual change.

10.5 Kūhiō Beach Sector – Diamond Head (east) Basin

The proposed action in the Kūhiō beach sector Diamond Head (east) basin is beach maintenance consisting of sand pumping with no additional improvements or modifications to existing structures. In collaboration with the WBCAC, the project proponents determined that the Diamond Head (east) basin should remain a safe, calm, and protected area. While the low wave energy produces the calm environment that is enjoyed by many, the wave energy is too low to produce a stable beach profile. Over time, the beach face has migrated (slumped) makai (seaward) into the basin, with no natural means to return sand to the beach face. This seaward migration of sand has flattened the beach profile and decreased water depths in the basin. To increase dry beach width, the sand will need to be manually recovered and placed back on the beach.

10.5.1 Unavoidable Impacts

- The proposed action will use a non-renewable resource (sand).
- Approximately 4,500 cubic yards of sand will be pumped from within the existing basin, altering the bathymetry and temporarily disrupting the ecology in the vicinity of the dredge area.
- Sand recovered from within the basin may still have some fine content that will be winnowed from the beach system during the initial equilibration process and consequent beach erosion events.
- When sand is recovered from anoxic environments, such as within the existing basin, it will typically have a grey color and unpleasant scent immediately after recovery.
- During sand recovery operations, minor turbidity is anticipated as sand is brought from the basin floor to the beach.
- Machinery operating on the beach will generate noise and may temporarily impact air quality.
- Any construction activities taking place in the nearshore waters are anticipated to directly impact marine ecology, ocean recreation and access in the existing basin.
- Sand pumping operations will require portions of the shoreline to be cordoned off during sand pumping and placement operations. Access across the cordoned off areas will be limited to specific crossing points with crossing guards.
- Bathymetry within the existing basin will be temporarily altered while the beach equilibrates to the new sand volume.

10.5.2 Cumulative Impacts

The proposed sand pumping is designed to be conducted periodically on an as-needed basis. Sand pumping will be conducted when beach conditions reach some pre-defined topographic triggers. Beach monitoring will be required to determine when the triggers have been met. Sand pumping will involve recovering approximately 4,500 cy of existing sand from within the basin onto the dry beach. The volume of sand in the littoral system will not be altered.

The estimated construction duration for the proposed sand pumping is 10 days, and the estimated recurrence interval is 5 yrs. Assuming that maintenance is conducted over a period of 50 yrs, this will result in a total of 10 individual sand pumping events and a total of 100 days of construction.

Alternatives to the proposed sand pumping consist of beach nourishment with or without stabilizing structures (see Section 7.6). Beach nourishment would require dredging to recover approximately 4,500 cy of sand from offshore and placing it on the beach. This would produce the same dry beach width and configuration as the proposed action; however, no sand would be recovered from within the basin. By increasing the volume of sand within the basin, water depths would become progressively shallower over time as the new sand added to the beach would be expected to migrate makai (seaward) into the basin. The beach width and elevation could also be expanded by adding more sand. Increasing the dry beach elevation by 1 ft would require about 1,500 cy of sand, while widening the beach by 5 ft would require about 2,000 cy of sand.

The beach in the Diamond Head (east) basin could be stabilized by reconfiguring the offshore breakwater to be a series of breakwaters or groins. These alternatives were previously investigated by Noda (1999) and Bodge (2000). Both plans involved removing the offshore breakwater. The Noda (1999) plan included adding heads to the Kapahulu storm drain/groin and the center groin to produce a more open swimming area. Bodge (2000) recommended smaller heads and the addition of small T-head groin in the gap between the new groin heads. The Bodge (2000) plan is more consistent with the proposed action for the ʻEwa (west) basin.

The highest priorities for the Diamond Head (east) basin are to maintain the basin as a calm, safe environment for swimming and wading. Reconfiguring the existing breakwater would create a more energetic wave environment, which would fundamentally alter the character of the basin. Without reconfiguring the existing breakwater, the beach would migrate makai (seaward), the beach profile would flatten, and water depths inside the basin would become very shallow. As a result, beach nourishment with or without stabilizing structures was ruled out in the early stages of the conceptual design and project selection process.

When compared to the alternatives of beach nourishment with or without stabilizing structures, the proposed action will have less cumulative impacts. The proposed sand pumping will require fewer construction days, fewer beach closures, no offshore dredging, and will not increase the volume of sand in the littoral system.

11. SECONDARY IMPACTS

Secondary impact, as defined in §11-200.1-2, HAR:

> *"means an effect that is caused by the action and is later in time or farther removed in distance, but is still reasonably foreseeable. An indirect effect may include a growth-inducing effect and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air, water, and other natural systems, including ecosystems."*

Secondary impacts can be viewed as actions of others that are taken because of the presence of the project. Secondary impacts from highway projects, for example, can occur because they can induce development by removing one of the impediments to growth.

11.1 Fort DeRussy Beach Sector

The proposed action in the Fort DeRussy beach sector is beach maintenance consisting of small-scale beach nourishment and periodic sand backpassing with no additional improvements or modifications to existing structures. The proposed action will be implemented in phases. The first phase will consist of small-scale beach nourishment, which will involve placement of approximately 3,000 cy of sand recovered from the *Hilton* offshore sand deposit. The second phase will consist of periodic backpassing of existing beach sand to maintain the desired beach width and profile. Sand will be transported from the accreted area at the west end of the beach to the eroding area at the east end of the beach to increase dry beach width and mitigate wave overtopping. Sand will be obtained from the beach face on the east side of the Hilton pier/groin, where sand eroded has accreted over the years. Sand will be excavated from the beach face extending inshore only as far as necessary to obtain the required volume of sand. The anticipated secondary impacts of the proposed action in the Fort DeRussy beach sector are summarized in Table 11-1.

Table 11-1 Anticipated secondary impacts - Fort DeRussy beach sector

Resource	Secondary Impact
8.4 Coastal Hazards	The proposed action is intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed action is anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.
8.5 Coastal Processes	The proposed action is not anticipated to significantly alter or affect presently ongoing sediment transport and shoreline processes, wave-driven currents, circulation patterns, or offshore wave breaking. The proposed action is intended to increase dry beach

Resource	Secondary Impact
	width and produce a more linear beach planform. Sediment (sand) will be subject to the same coastal processes that exist under the current conditions.
8.7 Water Quality	The proposed action is anticipated to have a temporary impact on water quality during sand placement operations. However, the proposed action does not involve using offshore sand, so the percentage of fine carbonate content in the sand will be lower, which will decrease the potential to generate turbidity. Industry-standard Best Management Practices (BMPs) will be utilized to minimize the potential for turbidity during sand recovery and placement operations.
8.8 Shoreline Change	The proposed action is anticipated to have a positive impact on shoreline change. Conducting small-scale beach nourishment and periodic beach maintenance will improve lateral shoreline access and reduce the potential for the seawall and beach walkway to become exposed by erosion and over washed by wave runup. While beach maintenance will not prevent future beach erosion, it will balance the sediment budget within the beach sector, which will help to maintain a more linear beach planform.
9.1 Socioeconomic Setting	The proposed action is anticipated to have a positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed action will restore an existing public beach in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed action may temporarily disrupt commercial activities (e.g., beach concessions) during construction; however, every effort will be made to minimize adverse economic impacts, particularly during the prime daytime beach use hours.
9.3 Scenic and Aesthetic Resources	The proposed action is anticipated to have a positive impact on view planes in the Fort DeRussy beach sector. The beach at the east end of the sector is severely eroded and the existing seawall is exposed, which has degraded the aesthetics of the area. Increasing dry beach width will improve view planes along the shoreline.
9.4 Recreation	The proposed action is anticipated to have a positive impact on recreation. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī. Shoreline access may be temporarily disrupted during construction; however, the duration of construction is very short (estimated 10 days) and every effort will be made to maintain shoreline access, particularly during the prime daytime beach use hours.
9.5 Shoreline Access	The proposed action is anticipated to have a positive impact on shoreline access. The beach at the east end of the sector is severely eroded and the existing seawall is exposed, which limits lateral shoreline access in this area. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users in Waikīkī. Shoreline access may be temporarily disrupted during construction; however, the duration of construction is very short (estimated 10 days) and every effort will be made to maintain shoreline access, particularly during the prime daytime beach use hours.
9.6 Air Quality	The proposed action is anticipated to have a short-term impact on air quality. Because most of the work will take place on the sandy shoreline, the proposed action will involve little or no soil disturbance that could result in particulate emissions. During construction, sand recovery and placement operations may result in a temporary degradation in air quality in the immediate vicinity of the project area. This negative

Resource	Secondary Impact
	impact to air quality will be limited to typical work hours and will end once the sand is in place. Short-term degradation of air quality may occur due to emissions from construction equipment. However, emissions from internal combustion engines are far too small to have a significant or lasting effect on air quality.
9.7 Noise	The proposed action is anticipated to have a short-term impact on noise. The equipment used during sand recovery and placement operations along the shoreline will be audible and may exceed current background noise levels. It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing background noise levels or is inaudible to beach users, hotel guests, etc. Appropriate measures will be taken to minimize noise levels to the extent practicable.
9.8 Public Services	The proposed action is anticipated to have a negligible moderate but acceptable impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which may increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this may also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, Ocean Safety and Lifeguard Services Division, and Emergency Medical Services will be informed of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed action does not involve any activities that would permanently alter the need for, or ability to provide, emergency services.
9.9 Public Infrastructure	The proposed action is anticipated to have a negligible impact on public infrastructure. The proposed action will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are no anticipated effects to stormwater runoff that would affect the City and County of Honolulu stormwater drainage system. During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of equipment and materials will involve some heavy vehicle traffic through Waikīkī; however, this would be of limited duration. Equipment and materials will be transported along Fort DeRussy Beach, which will require secure trucking lanes on the beach. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable. Because of the small number of vehicle-trips involved, construction worker and equipment/material delivery trips do not have the potential to substantially affect traffic volumes and/or the level of service on area roadways.

11.2 Halekūlani Beach Sector

The proposed action for the Halekūlani beach sector is beach improvements consisting of beach nourishment with stabilizing groins and a sand retaining wall. The proposed action will consist of construction of three new sloping rock rubblemound T-head groins, a new L-head groin adjacent to the existing Fort DeRussy outfall/groin, a sand retaining wall, and modification of the recently replaced Royal Hawaiian groin. The groins, sand retaining wall, and beach fill will create four stable beach cells in an area that has previously had limited beach resources. The proposed action will require approximately 60,000 cy of sand fill and will create approximately 3.8 acres of new dry beach area. The anticipated secondary impacts of the proposed action in the Halekūlani beach sector are summarized in Table 11-2

Table 11-2 Anticipated secondary impacts - Halekūlani beach sector

Resource	Secondary Impact
8.4 Coastal Hazards	The proposed action is intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed action is anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions. The proposed sand retaining wall may reduce the amount of inshore flooding during a hurricane or tsunami.
8.5 Coastal Processes	The proposed action is anticipated to alter or affect presently existing sediment transport and shoreline processes, wave-driven currents, and circulation patterns. The proposed groins will prevent longshore sediment transport and alter wave-driven currents and circulation patterns within the beach cells between the groins. Existing current velocities within the project footprint are relatively weak, therefore the proposed action is not anticipated to significantly alter wave-driven currents and circulation patterns in the vicinity of the groins. The proposed groins will provide superior stability for the beach, and the sand fill will mitigate wave energy reflection from the existing seawalls. The heads of the new groins will help prevent the formation of offshore rip currents along the groin stems, and thus reduce cross-shore sediment transport. The groins will terminate well inshore of the offshore surf breaks and are not anticipated to alter the bathymetry or wave formation characteristics of the surrounding seafloor.
8.6 Bathymetry	In-water construction impacts will be limited to the immediate areas of groins. The new structural footprints will be carefully delineated, and no construction activities or in-water material storage will be permitted outside of these areas. Construction of the proposed new groins will alter the bathymetry of the areas they cover. Short-term changes in nearshore bathymetry and coastal processes are anticipated as the beach equilibrates after sand placement. Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or changing the bathymetry. Dredging

Resource	Secondary Impact
	could occur at the *Ala Moana* or *Hilton* offshore sand deposits. Detailed wave modeling was conducted to evaluate the potential impacts to bathymetry and wave formation at the offshore sand recovery areas (see Section 8.2.2 and Section 9.4.6). Based on the results of the wave modeling and dredge analysis, no significant impacts to bathymetry are anticipated.
8.7 Water Quality	The proposed action is anticipated to have a temporary impact on water quality. Sand recovered from the ocean, though highly compatible with the existing dry beach sand, would still have some naturally occurring fine carbonate content that would be winnowed from the beach system and moved offshore during the initial equilibration process and beach erosion events. Dredging, transport, and placement of carbonate sand can also increase the percent of fines through mechanical abrasion of the friable grains. Turbidity, or a reduction in water transparency, occurs when fine sediment particles are suspended in the water column. Turbidity can occur at the offshore sand dredging site or along the beach where sand is placed. Industry-standard Best Management Practices (BMPs) will be utilized to minimize the potential for turbidity during sand recovery and placement operations. Water quality monitoring will also be conducted before, during, and after construction.
8.8 Shoreline Change	The proposed action is anticipated to have a positive impact on shoreline change. The project will produce four stable beach cells in an area that has historically been devoid of sand. The groins and sand retaining wall will stabilize the sand so long-term erosion rates will decrease when compared to historical rates. Beach profile monitoring will be conducted before and after construction.
8.10 Marine Biota	The proposed action is not anticipated to result in any significant long-term degradation of the environment or loss of marine habitat. Construction of the proposed groins will improve the shoreline conditions and increase potential biological habitat in a relatively barren reef flat area. Ecological services of reef flat habitat will be lost under the project footprints (sand and groins) but are anticipated to recover over time as the benthic community re-establishes. Most adult fish in the project vicinity are mobile and will actively avoid direct impacts from project activities. There is potential for demersal fish eggs to be buried; however, new hard substrata created by the groins would provide greater surface area for these species to lay eggs in the future. Some impairment of ability of EFH managed species to find prey items could occur, but this effect should be temporary and spatially limited to the immediate vicinity of construction activities. The groins will provide bare, stable surfaces for recruitment of corals, algae, and other invertebrates. The groins will be porous, permeable, with approximately 37 percent interstitial void space between stones. Obligate reef dwellers are often limited by the availability of suitable shelter, especially juveniles. Reef fish prefer reef holes and crevices commensurate with the size of the fish. The interstitial spaces between stones will also provide habitat for benthic (crabs, shrimps, worms, etc.) and sessile organisms (sponges and tunicates) which would provide additional foraging resources for fishes. The boulders will also provide a hard, stable surface for coral colonization, and elevates them above the shifting sand and rubble bottom. Turbidity containment barriers will effectively isolate the construction activities from the adjacent seafloor and water column; thus, impacts to marine biota will be limited to the immediate construction area. A marine biological and water quality monitoring program will be implemented to enhance control over construction impacts.

Resource	Secondary Impact
9.1 Socioeconomic Setting	The proposed action is anticipated to have a positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed action will restore an existing public beach in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed action may temporarily disrupt commercial activities during construction; however, every effort will be made to minimize adverse economic impacts, particularly during the prime daytime beach use hours.
9.3 Scenic and Aesthetic Resources	The proposed action is anticipated to have short-term negative impacts and positive long-term impacts on scenic and aesthetic resources. Due to its low elevation and profile, the proposed action is not anticipated to adversely affect existing viewplanes. Construction equipment, material stockpiles, and construction activities will be present within the project area during construction. Additionally, the dredging equipment will be visible from the shoreline during sand recovery options. These impacts are temporary in nature and will not be present once the construction phase of the project is completed. The proposed action is anticipated to have a long-term positive impact on scenic and aesthetic resources. While the offshore sand is slightly greyer than the existing beach sand, the color difference is anticipated to be negligible after a season of mixing and fading due to UV exposure. The groins, sand retaining wall, and beach fill would create four stable beach cells. The structures will have a low profile and substantial portions of the structures will be below the waterline or covered with sand. Viewplanes toward the ocean and along the shoreline will be uninterrupted and similar to what exists today.
9.4 Recreation	The proposed action is anticipated to have a positive impact on recreation. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī.
9.5 Shoreline Access	The proposed action is anticipated to have short-term negative impacts and positive long-term impacts on shoreline access. The Halekūlani beach sector essentially bifurcates shoreline access between the east and west portions of Waikīkī Beach. Walkways on top of the seawalls fronting the Halekūlani and Sheraton Waikiki hotels provide limited and discontinuous lateral access along the shoreline. The walkways are very narrow, are not ADA-accessible, and are subject to wave overtopping during high tide and high surf events. Structural damage has repeatedly resulted in closure of the walkways, which effectively prohibits lateral shoreline access between the Fort DeRussy Beach and Royal Hawaiian beach sectors. Shoreline access will be temporarily disrupted during construction. However, shoreline access will be permanently improved after construction is completed. Increasing dry beach area will significantly improve lateral shoreline access and provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī.
9.6 Air Quality	The proposed action is anticipated to have a short-term impact on air quality. Because most of the work will take place on the sandy shoreline, the proposed action will involve little or no soil disturbance that could result in particulate emissions. During construction, sand recovery and placement operations may result in a temporary

Resource	Secondary Impact
	degradation in air quality in the immediate vicinity of the project area. This negative impact to air quality will be limited to typical work hours and will end once the sand is in place. Short-term degradation of air quality may occur due to emissions from construction equipment. However, emissions from internal combustion engines are far too small to have a significant or lasting effect on air quality.
9.7 Noise	The proposed action is anticipated to have a short-term impact on noise. The equipment used during sand recovery and placement operations along the shoreline will be audible and may exceed current background noise levels. It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing background noise levels or is inaudible to beach users, hotel guests, etc. Appropriate measures will be taken to minimize noise levels to the extent practicable.
9.8 Public Services	The proposed action is anticipated to have a moderate but acceptable negligible impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which may increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this may also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, Ocean Safety and Lifeguard Services Division, and Emergency Medical Services will be informed of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed action does not involve any activities that would permanently alter the need for, or ability to provide, emergency services.
9.9 Public Infrastructure	The proposed action is anticipated to have a negligible impact on public infrastructure. The proposed action will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are no anticipated effects to stormwater runoff that would affect the City and County of Honolulu stormwater drainage system. During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of equipment and materials will involve some heavy vehicle traffic through Waikīkī. Equipment and materials will be transported through Waikīkī and along the shoreline, which will require secure trucking lanes. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable. Because of the large number of vehicle-trips involved, construction worker and equipment/material delivery trips will have the potential to affect traffic volumes and/or the level of service on area roadways.

11.3 Royal Hawaiian Beach Sector

The proposed action for the Royal Hawaiian beach sector is beach maintenance consisting of beach nourishment with no additional improvements or modifications to existing structures. The proposed action will require periodic renourishment to maintain the beach at its 1985 location. The anticipated secondary impacts of the proposed action in the Royal Hawaiian beach sector are summarized in Table 11-3.

Table 11-3 Anticipated secondary impacts - Royal Hawaiian beach sector

Resource	Secondary Impact
8.4 Coastal Hazards	The proposed action is intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed action is anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.
8.5 Coastal Processes	The proposed action is not anticipated to significantly alter or affect presently ongoing sediment transport and shoreline processes, wave-driven currents, circulation patterns, or offshore wave breaking. The proposed actions are intended to increase dry beach width and produce a more linear beach planform. Sediment (sand) will be subject to the same coastal processes that exist under the current conditions.
8.6 Bathymetry	The proposed action is anticipated to temporarily alter bathymetry at the offshore sand recovery areas. Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or changing the bathymetry. Dredging will occur at the *Canoes/Queens* offshore sand deposit. Detailed wave modeling was conducted to evaluate the potential impacts to bathymetry and wave formation at the offshore sand recovery areas (see Section 8.2.2 and Section 9.4.6). Based on the results of the wave modeling and dredge analysis, no significant impacts to bathymetry are anticipated. Bathymetry along the beach toe will also be temporarily altered while the beach equilibrates to the new sand volume.
8.7 Water Quality	The proposed action is anticipated to have a temporary impact on water quality. Sand recovered from the ocean, though highly compatible with the existing dry beach sand, would still have some naturally occurring fine carbonate content that would be winnowed from the beach system and moved offshore during the initial equilibration process and beach erosion events. Dredging, transport, and placement of carbonate sand can also increase the percentage of fines through mechanical abrasion of the friable grains. Turbidity, or a reduction in water transparency, occurs when fine sediment particles are suspended in the water column. Turbidity can occur at the offshore sand dredging site or along the beach where sand is placed. Industry-standard Best Management Practices (BMPs) will be utilized to minimize the potential for turbidity during sand recovery and placement operations. Water quality monitoring will also be conducted before, during, and after construction.

Resource	Secondary Impact
8.8 Shoreline Change	The proposed action is anticipated to have a positive impact on shoreline change. Conducting periodic beach nourishment will improve lateral shoreline access and countervail the long-term effects of erosion. While beach nourishment will not prevent future beach erosion, it will balance the sediment budget within the beach sector, which will help to maintain a more linear beach planform.
9.1 Socioeconomic Setting	The proposed action is anticipated to have a positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed action will restore an existing public beach in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed action may temporarily disrupt commercial activities (e.g., beach concessions) during construction; however, every effort will be made to minimize adverse economic impacts, particularly during the prime daytime beach use hours.
9.3 Scenic and Aesthetic Resources	The proposed action is anticipated to have a positive impact on view planes in the Royal Hawaiian beach sector. The beach at the east end of the sector is severely eroded and the old foundation wall of the Waikīkī Tavern is frequently exposed by erosion. Beach narrowing along the remainder of Royal Hawaiian Beach reduces dry beach area and degrades the aesthetics of the area. Increasing dry beach area will improve view planes along the shoreline.
9.4 Recreation	The proposed action is anticipated to have a positive impact on recreation. Royal Hawaiian Beach is the most popular beach in Waikīkī. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī. Beach use and ocean recreation may be temporarily disrupted during sand recovery and placement operations; however, every effort will be made to limit disruptions, particularly during the prime daytime beach use hours.
9.5 Shoreline Access	The proposed action is anticipated to have a positive impact on shoreline access. Severe erosion at the east end of the sector has resulted in beach narrowing, which limits lateral shoreline access in this area. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users in Waikīkī. Shoreline access will be temporarily disrupted during construction; however, every effort will be made to maintain shoreline access, particularly during the prime daytime beach use hours.
9.6 Air Quality	The proposed action is anticipated to have a short-term impact on air quality. Because most of the work will take place on the sandy shoreline, the proposed action will involve little or no soil disturbance that could result in particulate emissions. During construction, sand recovery and placement operations may result in a temporary degradation in air quality in the immediate vicinity of the project area. This negative impact to air quality will be limited to typical work hours and will end once the sand is in place. Short-term degradation of air quality may occur due to emissions from construction equipment. However, emissions from internal combustion engines are far too small to have a significant or lasting effect on air quality.
9.7 Noise	The proposed action is anticipated to have a short-term impact on noise. The equipment used during sand recovery and placement operations along the shoreline will be audible and may exceed current background noise levels. It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing

Resource	Secondary Impact
	background noise levels or is inaudible to beach users, hotel guests, etc. Appropriate measures will be taken to minimize noise levels to the extent practicable.
9.8 Public Services	The proposed action is anticipated to have a moderate but acceptable negligible impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which may increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this may also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, Ocean Safety and Lifeguard Services Division, and Emergency Medical Services will be informed of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed action does not involve any activities that would permanently alter the need for, or ability to provide, emergency services.
9.9 Public Infrastructure	The proposed action is anticipated to have a negligible impact on public infrastructure. The proposed action will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are no anticipated effects to stormwater runoff that would affect the City and County of Honolulu stormwater drainage system. During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of equipment and materials will involve some heavy vehicle traffic through Waikīkī. Equipment and materials will be transported through Waikīkī and along the shoreline, which will require secure trucking lanes. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable.

11.4 Kūhiō Beach Sector – ʻEwa (west) Basin

The proposed action in the Kūhiō beach sector ʻEwa (west) basin is beach improvements consisting of beach nourishment with modified groins and a segmented breakwater. The proposed action will involve removing portions of the existing structures, modification of the groins, construction of a new groin and segmented breakwater, and placement of sand fill to increase beach width. The anticipated secondary impacts of the proposed action in the Kūhiō beach sector ʻEwa (west) basin are summarized in Table 11-4.

Table 11-4 Anticipated secondary impacts - Kūhiō beach sector ʻEwa (west) basin

Resource	Secondary Impact
8.4 Coastal Hazards	The proposed action is intended to increase dry beach width and volume and create a stable beach that will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed action is anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.
8.5 Coastal Processes	The proposed action is anticipated to alter or affect existing sediment transport and shoreline processes, and wave-driven currents. The proposed groins and segmented breakwater are designed to alter existing wave patterns within the basin to maintain a more stable beach profile. Existing current velocities within the basin are relatively weak, therefore the proposed action is not anticipated to significantly alter wave-driven currents and circulation patterns in the basin. The groins and segmented breakwater will not alter the bathymetry or wave formation characteristics of the seafloor outside of the basin.
8.6 Bathymetry	In-water construction impacts will be limited to the immediate areas of groins and segmented breakwater. The new structural footprints will be carefully delineated, and no construction activities or in-water material storage will be permitted outside of these areas. Construction of the proposed groins and segmented breakwater will not significantly alter the bathymetry of the areas they cover. Short-term changes in nearshore bathymetry and coastal processes are anticipated as the beach equilibrates after sand placement. Dredging of offshore sand deposits involves removing sand from the deposits, resulting in a lowering of the bottom elevation or changing the bathymetry. Dredging could occur at the *Ala Moana, Canoes/Queens* or *Hilton* offshore sand deposits. Detailed wave modeling was conducted to evaluate the potential impacts to bathymetry and wave formation at the offshore sand recovery areas (see Section 8.2.2 and Section 9.4.6). Based on the results of the wave modeling and dredge analysis, no significant impacts to bathymetry are anticipated. The groins and segmented breakwater will not alter the bathymetry of the seafloor outside of the basin.
8.7 Water Quality	The proposed action is anticipated to have a temporary impact on water quality. Sand recovered from the ocean, though highly compatible with the existing dry beach sand, would still have some naturally occurring fine carbonate content that would be

Resource	Secondary Impact
	winnowed from the beach system and moved offshore during the initial equilibration process and beach erosion events. Dredging, transport, and placement of carbonate sand can also increase the percent of fines through mechanical abrasion of the friable grains. Turbidity, or a reduction in water transparency, occurs when fine sediment particles are suspended in the water column. Turbidity can occur at the offshore sand dredging site or along the beach where sand is placed. Industry-standard Best Management Practices (BMPs) will be utilized to minimize the potential for turbidity during sand recovery and placement operations. Water quality monitoring will also be conducted before, during, and after construction.
8.8 Shoreline Change	The proposed action is anticipated to have a positive impact on shoreline change. The project action produce a stable beach in an area that has historically been narrow with no natural source of sand. The groins and segmented breakwater will stabilize the sand so long-term erosion rates will decrease when compared to historical rates. Beach profile monitoring will be conducted before and after construction.
8.10 Marine Biota	The proposed action is not anticipated to result in any significant long-term degradation of the environment or loss of marine habitat. Construction of the groins and segmented breakwater will improve the shoreline conditions and increase potential biological habitat in a relatively barren reef flat area. Ecological services of reef flat habitat will be lost under the project footprints but are anticipated to recover over time as the benthic community re-establishes. Most adult fish in the project vicinity are mobile and will actively avoid direct impacts from project activities. There is potential for demersal fish eggs to be buried; however, new hard substrata created by the groins and segmented breakwater will provide greater surface area for these species to lay eggs in the future. Some impairment of ability of EFH managed species to find prey items could occur, but this effect should be temporary and spatially limited to the immediate vicinity of construction activities. The groins and segmented breakwater will provide bare, stable surfaces for recruitment of corals, algae, and other invertebrates. The structures will be porous, permeable, with approximately 37 percent interstitial void space between stones. Obligate reef dwellers are often limited by the availability of suitable shelter, especially juveniles. Reef fish prefer reef holes and crevices commensurate with the size of the fish. The interstitial spaces between stones will also provide habitat for benthic (crabs, shrimps, worms, etc.) and sessile organisms (sponges and tunicates) which would provide additional foraging resources for fishes. The boulders will also provide a hard, stable surface for coral colonization, and elevates them above the shifting sand and rubble bottom. Turbidity containment barriers will effectively isolate the construction activities from the adjacent seafloor and water column; thus, impacts to marine biota will be limited to the immediate construction area. A marine biological and water quality monitoring program will be implemented to enhance control over construction impacts.
9.1 Socioeconomic Setting	The proposed action is anticipated to have a positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed action will restore an existing public beach in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī.

Resource	Secondary Impact
9.3 Scenic and Aesthetic Resources	The proposed action is anticipated to have short-term negative impacts and positive long-term impacts on scenic and aesthetic resources. Due to its low elevation and profile, the proposed action is not anticipated to adversely affect existing viewplanes. Construction equipment, material stockpiles, and construction activities will be present within the project area during construction. Additionally, the dredging equipment will be visible from the shoreline during sand recovery options. These impacts are temporary in nature and will not be present once the construction phase of the project is completed. The proposed action is anticipated to have a long-term positive impact on scenic and aesthetic resources. While the offshore sand is slightly greyer than the existing beach sand, the color difference is anticipated to be negligible after a season of mixing and fading due to UV exposure. The groins and segmented breakwater will create a wide, stable beach, which will improve view planes along the shoreline. The structures will have a low profile, and substantial portions of these structures will be below the waterline or covered with sand. Viewplanes toward the ocean and along the shoreline will be uninterrupted and similar to what exists today.
9.4 Recreation	The proposed action is anticipated to have a positive impact on recreation. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī.
9.5 Shoreline Access	The proposed action is anticipated to have short-term negative impacts and positive long-term impacts on shoreline access. Shoreline access will be temporarily disrupted during construction. Increasing dry beach area will improve lateral shoreline access and provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī.
9.6 Air Quality	The proposed action is anticipated to have a short-term impact on air quality. Because most of the work will take place on the sandy shoreline, the proposed action will involve little or no soil disturbance that could result in particulate emissions. During construction, sand recovery and placement operations may result in a temporary degradation in air quality in the immediate vicinity of the project area. This negative impact to air quality will be limited to typical work hours and will end once the sand is in place. Short-term degradation of air quality may occur due to emissions from construction equipment. However, emissions from internal combustion engines are far too small to have a significant or lasting effect on air quality.
9.7 Noise	The proposed action is anticipated to have a short-term impact on noise. The equipment used during sand recovery and placement operations along the shoreline will be audible and may exceed current background noise levels. It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing background noise levels or is inaudible to beach users, hotel guests, etc. Appropriate measures will be taken to minimize noise levels to the extent practicable.
9.8 Public Services	The proposed action is anticipated to have a moderate but acceptable ~~negligible~~ impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which may increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this may also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, Ocean Safety and Lifeguard Services Division, and Emergency Medical Services will be informed

Resource	Secondary Impact
	of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed action does not involve any activities that would permanently alter the need for, or ability to provide, emergency services.
9.9 Public Infrastructure	The proposed action is anticipated to have a negligible impact on public infrastructure. The proposed action will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are no anticipated effects to stormwater runoff that would affect the City and County of Honolulu stormwater drainage system. During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of equipment and materials will involve some heavy vehicle traffic through Waikīkī. Equipment and materials will be transported through Waikīkī and along the shoreline, which will require secure trucking lanes. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable. Because of the large number of vehicle-trips involved, construction worker and equipment/material delivery trips will have the potential to affect traffic volumes and/or the level of service on area roadways.

11.5 Kūhiō Beach Sector – Diamond Head (east) Basin

The proposed action in the Kūhiō beach sector Diamond Head (east) basin is beach maintenance consisting of sand pumping with no additional improvements or modifications to existing structures. In collaboration with the WBCAC, the project proponents determined that the Diamond Head (east) basin should remain a safe, calm, and protected area. While the low wave energy produces the calm environment that is enjoyed by many, the wave energy is too low to produce a stable beach profile. Over time, the beach face has migrated (slumped) into the water, with no natural means to return sand to the beach face. This seaward migration of sand has flattened the beach profile and decreased water depths in the basin. To increase dry beach width, the sand will need to be manually recovered and placed back onto the beach. The anticipated secondary impacts of the proposed action in the Kūhiō beach sector Diamond Head (east) basin are summarized in Table 11-5.

Table 11-5 Anticipated secondary impacts - Kūhiō beach sector Diamond Head (east) basin

Resource	Secondary Impact
8.5 Coastal Processes	The proposed action is not anticipated to significantly alter or affect presently ongoing sediment transport and shoreline processes, wave-driven currents, circulation patterns, or offshore wave breaking. The proposed action is intended to increase dry beach width and produce a more linear beach planform. Sediment (sand) will be subject to the same coastal processes that exist under the current conditions.
8.7 Water Quality	The proposed action is anticipated to have a temporary impact on water quality. Sand recovered from the ocean, though highly compatible with the existing dry beach sand, would still have some naturally occurring fine carbonate content that would be winnowed from the beach system and moved offshore during the initial equilibration process and beach erosion events. Dredging and placement of carbonate sand can also increase the percent of fines through mechanical abrasion of the friable grains. Turbidity, or a reduction in water transparency, occurs when fine sediment particles are suspended in the water column. Turbidity can occur at the offshore sand dredging site or along the beach where sand is placed. Industry-standard Best Management Practices (BMPs) will be utilized to minimize the potential for turbidity during sand recovery and placement operations. Water quality monitoring will also be conducted before, during, and after construction.
8.8 Shoreline Change	The proposed action is anticipated to have a positive impact on shoreline change. Conducting periodic beach maintenance will improve lateral shoreline access. While beach maintenance will not prevent future beach erosion, it will balance the sediment budget within the beach sector, which will help to maintain a more linear beach planform.
9.1 Socioeconomic Setting	The proposed action is anticipated to have a positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu. The proposed action will restore an existing public beach in Waikīkī. The economic value of the beaches to the commercial success of Waikīkī is extremely significant. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational and economic uses in Waikīkī. The proposed action may temporarily disrupt commercial activities (e.g., beach concessions) during construction; however, every effort will be made to minimize adverse economic impacts, particularly during the prime daytime beach use hours.

Resource	Secondary Impact
9.3 Scenic and Aesthetic Resources	The proposed action is anticipated to have a positive impact on view planes in the Kūhiō beach sector. Erosion and beach narrowing has degraded the aesthetics of the area. Increasing dry beach width will improve view planes along the shoreline.
9.4 Recreation	The proposed action is anticipated to have a positive impact on recreation. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users and support ongoing recreational uses in Waikīkī. Shoreline access may be temporarily disrupted during construction; however, the duration of construction is very short (estimated 10 days) and every effort will be made to maintain shoreline access, particularly during the prime daytime beach use hours.
9.5 Shoreline Access	The proposed action is anticipated to have a positive impact on shoreline access. Erosion has resulted in beach narrowing, which limits lateral shoreline access in this area. Increasing dry beach area will provide additional space to accommodate the ever-growing number of beach users in Waikīkī. Shoreline access may be temporarily disrupted during construction; however, the duration of construction is very short (estimated 10 days), and every effort will be made to maintain shoreline access, particularly during the prime daytime beach use hours.
9.6 Air Quality	The proposed action is anticipated to have a short-term impact on air quality. Because most of the work will take place on the sandy shoreline, the proposed action will involve little or no soil disturbance that could result in particulate emissions. During construction, sand recovery and placement operations may result in a temporary degradation in air quality in the immediate vicinity of the project area. This negative impact to air quality will be limited to typical work hours and will end once the sand is in place. Short-term degradation of air quality may occur due to emissions from construction equipment. However, emissions from internal combustion engines are far too small to have a significant or lasting effect on air quality.
9.7 Noise	The proposed action is anticipated to have a short-term impact on noise. The equipment used during sand recovery and placement operations along the shoreline will be audible and may exceed current background noise levels. It is not feasible to mitigate construction noise to the extent that it does not at times exceed existing background noise levels or is inaudible to beach users, hotel guests, etc. Appropriate measures will be taken to minimize noise levels to the extent practicable.
9.8 Public Services	The proposed action is anticipated to have a moderate but acceptable ~~negligible~~ impact on public services. Increasing dry beach area could potentially increase the number of beach users in Waikīkī, which may increase the volume of trash and require more frequent solid waste collection and disposal. If the number of beach users in Waikīkī were to increase, this may also result in an increased number of incidents that would require police, fire, and medical services. Prior to commencement of construction activities, the Honolulu Police Department, Honolulu Fire Department, Ocean Safety and Lifeguard Services Division, and Emergency Medical Services will be informed of the project construction schedule and apprised of the emergency vehicle access routes to be used during construction. The contractor will be required to provide ample clearance for emergency vehicles at all times. The proposed action does not involve any activities that would permanently alter the need for, or ability to provide, emergency services.
9.9 Public Infrastructure	The proposed action is anticipated to have a negligible impact on public infrastructure. The proposed action will not require water or electrical power and will not generate a need for additional sanitary wastewater collection and treatment facilities. There are

Resource	Secondary Impact
	no anticipated effects to stormwater runoff that would affect the City and County of Honolulu stormwater drainage system. During construction, workers can park either in a construction staging area or existing public parking facilities. Mobilization and demobilization of equipment and materials will involve some heavy vehicle traffic through Waikīkī; however, this would be of limited duration. Equipment will be escorted to ensure public health and safety, and the delivery of materials and equipment will be timed to minimize impacts to beach users to the maximum extent practicable. Because of the small number of vehicle-trips involved, construction worker and equipment/material delivery trips do not have the potential to substantially affect traffic volumes and/or the level of service on area roadways.

12. MONITORING AND ASSESSMENT PLANS

Monitoring programs are proposed for beach conditions, water quality, and marine biology. These proposed monitoring programs are presented below. Details for each of these monitoring efforts will be expanded upon and may be modified during the permit process, as directed by the regulatory and resource agencies at the Federal and State levels.

12.1 Beach Profile Monitoring

Beach profiles and topographic features will be measured and mapped during the final design and permitting processes. Beach monitoring has previously been conducted for the 2012 Waikīkī Beach Maintenance I project and is currently being conducted for the recently completed 2021 Waikīkī Beach Maintenance II project. These monitoring efforts include detailed and frequent topographic mapping of the beach to monitor shoreline change before and after beach nourishment. The cumulative volume of elevation data for the beach provides a strong foundation for future, pre- and post-construction monitoring efforts.

Beach profiles will be collected prior to construction to establish a baseline for monitoring beach width and volume after placement. These measurements are vital for both ensuring correct placement of sand on the beach and documenting pre-construction beach conditions.

Post-construction monitoring of the beach will also be conducted to evaluate project performance. Post-construction project performance and beach stability will be monitored by periodically surveying beach profiles and documenting the characteristics of the shoreline with photographs. Beach profiles are a common measurement technique used to investigate coastal processes and shoreline change. The profiles will be performed by measuring the beach along a transect perpendicular to the shoreline and will extend as far mauka (landward) or makai (seaward) as necessary to capture specific beach features (e.g., toe, berm, crest).

Recoverable benchmarks will be established at each profile location to ensure that all profiles are measured at the same location, azimuth, and with the same elevation controls. These profiles will be collocated with the profile locations established during the final design and permitting process. The profiles will be measured using standard survey equipment and techniques. The profiles will be plotted, and a summary and discussion of the results will be prepared following each survey event. The schedule for beach monitoring profiles will be as follows.

1. Immediately (within 72 hours) after placement of the sand fill to the design beach shape at each profile location.
2. A complete set of profiles at all locations will be accomplished 30 days, 6 months and 12 months post-construction.
3. After the first year, post-construction profiles will be measured quarterly for 3 years, and may be collected, annually or quarterly, for up to 10 years.

Additional profile locations or measurement times may be added as deemed warranted by the project engineer in order to fully evaluate the performance of the project (e.g., should an atypical or unusual shoreline formation or change occur or should changes occur more rapidly than anticipated). The beach monitoring program will provide information to determine the performance and impacts of the project and establish a timeframe for potential future beach improvement or maintenance actions.

12.2 Water Quality Monitoring

Water quality monitoring will be conducted before, during, and after construction. The monitoring methodology and frequency will be reviewed and approved by the Hawai‘i Department of Health, Clean Water Branch (DOH-CWB), pursuant to the Clean Water Act, Section 401 Water Quality Certification (WQC) process. The WQC defines the Applicable Monitoring and Assessment Plan (AMAP) and Data Quality Objectives (DQO) for the monitoring program. The AMAP will define the water quality sample sites, parameters, frequency, and thresholds for evaluation of test results.

The intent of the AMAP is to conduct water quality sampling and analysis to effectively monitor potential impacts caused by in-water work, including sand recovery, transport, and placement. The AMAP will include baseline (pre-construction), during construction, and post-construction monitoring. Data collected as part of the AMAP will be used to assess the adequacy of Best Management Practices (BMPs) utilized during construction and quantify the impacts of the proposed actions on water quality. If shown to be necessary by the monitoring data, the BMPs will be modified during construction to better protect water quality. The water quality monitoring program will largely follow the *General Monitoring Guidelines for Section 401 Water Quality Certification Projects* (HDOH, 2000). Water quality parameters to be tested as part of the AMAP are pH, turbidity, dissolved oxygen (DO), salinity, and temperature.

During Construction Monitoring

- The Contractor shall follow the accepted Water Quality Monitoring Plan and Applicable Monitoring and Assessment Plan.
- Monitoring will be conducted before, during and after construction.
- Monitoring locations move through the project area as placement activities progress along the shoreline.
- The Contractor shall incorporate all erosion control measures shown in the drawings and the Best Management Practices Plan (BMPP). The BMPP may be modified as necessary to adjust to conditions that develop during construction. Any changes to the BMPP must be submitted immediately to the DOH-CWB for review. The project may only proceed after the DOH-CWB issues a written acceptance of the modified BMPP.
- Turbidity outside the active project site shall not exceed the baseline turbidity geometric value, as defined in the AMAP. The Contractor shall cease all work if unusual turbidity is observed and take the necessary remedial action to correct the problem.
- The monitoring will be conducted by trained professionals with advanced degrees in the marine sciences. Monitoring and sample testing shall comply with the DOH-CWB *General Monitoring Guideline for Section 401 Water Quality Certification Projects* (HDOH, 2000).

Post-Construction Monitoring

Long-term water quality monitoring efforts will be tied to the beach monitoring program schedule and will sample the parameters identified in the AMAP.

12.3 Marine Biological Monitoring

A comprehensive marine environmental assessment will be completed for the final design of the proposed actions. The assessment will provide the basis for evaluating marine biological monitoring results for the project areas and control areas.

During Construction Monitoring

- Monitoring will be conducted before, during and after construction.
- Monitoring stations will be established at selected sites to allow for a comprehensive assessment of pre- and post-construction conditions.
- Monitoring will consist of mapping the seafloor at the monitoring sites with photomosaics of the seafloor.
- Visual comparison and analysis of the photomosaics will be conducted to identify any changes or impacts associated with the projects.

Post-Construction Monitoring

Long-term monitoring for the project area will be completed, using the methodology presented above, at the following intervals:

- Photomosaics will be collected and analyzed at 6 months and 12 months post-construction.
- After the first year, post-construction marine biological monitoring will be conducted annually for 3 years and may be collected for up to 10 years.

12.4 During Construction Mitigation and Monitoring

12.4.1 Protection of Endangered Species (NOAA-NFMS)

The following endangered species BMPs, as recommended by the National Marine Fisheries Service, shall be adhered to during construction of the Proposed Action:

- Project footprints shall be limited to the minimum area necessary to complete the authorized work.
- The project area shall be flagged to identify sensitive resource areas, such as seagrass beds, ESA-listed terrestrial plants, and turtle nests.
- The authorized work shall be timed to minimize effects on ESA-listed species and their habitats.
- The authorized work shall cease under unusual conditions, such as large tidal events and high surf conditions, except for efforts to avoid or minimize damage to aquatic resources.
- Constant vigilance shall be kept for the presence of ESA-listed species during all phases of the authorized work.

- A responsible party, i.e., permittee/site manager/project supervisor, shall designate a competent observer to survey work sites and the areas adjacent to the authorized work area for ESA-listed species.
- The contractor shall establish a safety zone around the project area whereby observers shall visually monitor for marine protected species 30 minutes prior to, during, and 30 minutes post daily project activity. Record information on the species, numbers, behavior, time of observation, location, start and end times of project activity, sex or age class (when possible), and any other disturbances (visual or acoustic).
- If a marine protected species is in the area, either hauled out onshore or in the nearshore waters, a 150-foot buffer must be observed with no humans approaching it. If a monk seal/pup pair is seen, a minimum 300-foot buffer must be observed.
- In the event that a marine protected species enters the safety zone and the project activity cannot be halted, conduct observations and immediately contact NMFS staff in Honolulu to facilitate agency assessment of collected data. For monk seals contact the Marine Mammal Response Coordinator, at (808) 944-2269, as well as the monk seal hotline at (808) 220-7802. For turtles, contact the turtle hotline at (808) 983-5730.
- No one shall attempt to feed, touch, ride, or otherwise intentionally interact with any ESA-listed species.
- For on-site project personnel that may interact with a listed species potentially present in the action area, provide education on the status of any listed species and the protections afforded to those species under Federal laws. NMFS may be contacted for scheduling educational briefings to convey information on marine mammal behavior and explain why and when to call NMFS and other resource agencies.
- A pollution and erosion control plan for the authorized work site and adjacent areas shall be prepared and carried out. At a minimum, this plan shall include and require:
    - Proper installation and maintenance of silt fences, sausages, equipment diapers, and/or drip pans;
    - A contingency plan to control and clean spilled petroleum products and other toxic materials;
    - Appropriate materials to contain and clean potential spills will be stored at the work site, and be readily available;
    - All project-related materials and equipment placed in the water will be free of pollutants;
    - Daily pre-work inspections of heavy equipment for cleanliness and leaks, with all heavy equipment operations postponed or halted until leaks are repaired and equipment is cleaned;
    - Fueling of project-related vehicles and equipment will take place at least 50 feet away from the water, preferably over an impervious surface;
    - A plan to prevent trash and debris from entering the marine environment during the project; and
    - All construction discharge water (e.g., vehicle wash water) must be treated before discharge.
    - Any necessary and appropriate erosion controls shall be properly installed before undertaking the authorized work.

- Temporary access roads and drilling pads shall avoid steep slopes, where grade, soil types, or other features suggest a likelihood of excessive erosion or failure; existing access routes shall be utilized or improved whenever possible, in lieu of construction of new access routes.
- All disturbed areas must be immediately stabilized following cessation of activities for any break in work longer than 4 days.
- The authorized work shall comply with all applicable NWP General and Regional Conditions.
- With the exception of the actual dredging apparatus (e.g. clamshell buckets, or the scoop and articulated arm of a backhoe, etc.), heavy equipment will be operated from above and out of the water.
- The portions of the equipment that enter the water will be clean and free of pollutants.
- Any form of blasting is not authorized.

12.4.2 Protection of Endangered Species (USFWS)

The following endangered and threatened species BMPs, as recommended by the US Fish and Wildlife Service, shall be adhered to during construction of the Proposed Action:

Hawaiian Hoary Bat

- Do not disturb, remove, or trim woody plants greater than 15 feet tall during the bat birthing and pup rearing season (June 1 through September 15).
- Do not use barbed wire for fencing.

Hawaiian Goose

- Do not approach, feed, or disturb Hawaiian geese.
- If Hawaiian geese are observed loafing or foraging within the project area during the breeding season (September through April), have a biologist familiar with the nesting behavior of Nene survey for nests in and around the project area prior to the resumption of any work. Repeat surveys after any subsequent delay of work of 3 or more days (during which the birds may attempt to nest).
- Cease all work immediately and contact the Service for further guidance if a nest is discovered within a radius of 150 feet of proposed work, or a previously undiscovered nest is found within said radius after work begins.
- In areas where Hawaiian geese are known to be present, post and implement reduced speed limits, and inform project personnel and contractors about the presence of endangered species on-site.

Green and Hawksbill Sea Turtles

- Consultation with the Service will take place prior to project commencement to obtain the latest information on sea turtle activity in the area. Should there be any sea turtle activity occurring in the area, recommendations for a monitoring timeline and plan as discussed with the Service will be implemented.
- Incorporate applicable Best Management Practices regarding Work in Aquatic Environments into the project design.

- Have a project team member familiar with sea turtles conduct a visual survey of the project site to ensure no basking sea turtles are present.
    - If a basking sea turtle is found within the project area, cease all mechanical or construction activities within 100 feet until the animal voluntarily leaves the area.
    - Cease all activities between the basking turtle and the ocean.
- Remove any project-related debris, trash, or equipment from the beach if not actively being used.
- Do not stockpile project-related materials in the intertidal zone, reef flats, or stream channels.
- Create a designated staging area for land equipment off of the sand/beach at the end of each work day.
- Minimize the use of lighting and shield all project-related lights so the light is not visible from any beach.
    - If lights can't be fully shielded or if headlights must be used, fully enclose the light source with light filtering tape or filters.
- Incorporate design measures into the construction or operation of buildings adjacent to the beach to reduce ambient outdoor lighting such as:
    - Tinting or using automatic window shades for exterior windows that face the beach;
    - Reducing the height of exterior lighting to below 3 feet and pointed downward or away from the beach; and
    - Minimize light intensity to the lowest level feasible and, when possible, include timers and motion sensors.

<u>Wedge-Tailed Shearwater</u>

- Conduct surveys throughout the project area during the species' breeding season (March through November) to determine the presence and location of nesting areas.
- If wedge-tailed shearwaters nest within the proposed project area and ground disturbance is expected to occur, time project construction outside of the breeding season.
- Install automatic motion sensor switches and controls on all outdoor lights or turn off lights when human activity is not occurring in the lighted area.

<u>Hawaiian Petrel, Newell's Shearwater, and Band-Rumped Storm Petrel</u>

- Fully shield all outdoor lights so the bulb can only be seen from below bulb height and only use when necessary.
- Install automatic motion sensor switches and controls on all outdoor lights or turn off lights when human activity is not occurring in the lighted area.

<u>Hawaiian Yellow-Faced Bee</u>

- If an action will occur in or adjacent to known occupied habitat, a buffer area around the habitat may be required and can be worked out on a site-specific basis through consultation with the Service.
- For coastal species, protect all coastal strand habitat from human disturbance, including:
    - No fires or wood collecting
    - Leave woody debris in place

- Post educational signs to inform people of the presence of sensitive species.

12.4.3 Monitoring of Dredged Sand for Impurities

Operational controls will include monitoring dredge sand for impurities and grains larger than 1 inch in diameter. Monitoring will be conducted during all phases of the operation (sand recovery, transport, stockpiling, and placement) to identify any impurities or excessive content of larger grains at the earliest possible opportunity. If impurities or excessive content of larger grains are observed, then the sand recovery operation will be relocated to a new site. The recovery area where the material was dredged will be marked and will not be utilized again for the remainder of the project.

13. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF HUMANITY'S ENVIRONMENT AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This section discusses the relationship between the short-term uses of humanity's environment and how those uses may compromise or enhance the long-term productivity of that environment.

13.1 Trade-Offs Among Short-Term and Long-Term Gains and Losses

Short-term losses resulting from the proposed actions are primarily associated with construction operations. Sand recovery, sand transport, sand placement, and construction of groins, a sand retaining wall, and a segmented breakwater construction havehas the potential to impact benthic habit and water quality. Best Management Practices (BMPs) will be utilized to minimize or mitigate potential impacts to the maximum extent practicable. Construction activities may also temporarily disrupt beach use, shoreline access, commercial activities, and ocean recreation activities. Construction activities may also temporarily impact noise, air quality, and view planes.

These short-term losses are anticipated to be minor and will only occur during construction and are significantly outweighed by the economic, social, recreational and aesthetic benefits of increasing recreational dry beach width and improving lateral shoreline access. The proposed actions will also decrease vulnerability to coastal hazards, increase resilience to sea level rise, and have a substantial positive impact on the economies of the State of Hawai'i and City and County of Honolulu. These long-term benefits far outweigh the short-term losses associated with construction.

13.2 Extent to Which Proposed Action Forecloses Future Options

Selection of the proposed beach improvement and maintenance actions was a primarily stakeholder-driven process. The project proponents relied heavily on feedback and direction from the WBCAC to identify issues, needs, priorities, and design criteria for each beach sector. The proposed actions will be located almost entirely on submerged lands makai (seaward) of the shoreline in the State Conservation District. With the exception of the Halekūlani beach sector, the proposed actions are consistent with the existing environment and surrounding uses in Waikīkī and will not fundamentally alter the existing conditions along the shoreline. Increasing recreational dry beach area will not inhibit or prevent implementation of other potential alternative solutions in the future.

13.3 Narrows the Range of Beneficial Uses

The proposed actions are consistent with the existing environment and surrounding uses and will not fundamentally alter the character of Waikīkī. Increasing recreational dry beach area will not narrow the range of beneficial uses in the area. Improving and maintaining the beaches of Waikīkī will support existing uses and preserve the recreational, social, cultural, environmental, and aesthetic value of Waikīkī for future generations.

13.4 Long-term Risks to Public Health and Safety

The proposed beach improvement and maintenance actions are intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore flooding to marine flooding. The proposed actions will decrease vulnerability to coastal hazards, increase resilience to sea level rise, and have a substantial positive impact on the economies of the State of Hawaiʻi and City and County of Honolulu.

14. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

An irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed. "Irreversible" refers to the loss of future options and applies primarily to the impacts of use of nonrenewable resources, such as minerals or cultural resources. "Irretrievable" refers to the loss of a resource that is not renewable and cannot be recovered for future use. This section discusses the use of non-renewable resources, potential for irreversible curtailment of the range of beneficial environmental uses, and the possibility of environmental accidents.

14.1 Use of Non-Renewable Resources

The proposed actions will involve the use of non-renewable resources. Construction equipment will include barges, dredging equipment, cranes, excavators, dump trucks, and bulldozers. This equipment will require the use of carbon-based fossil fuels. The proposed actions will also require sand, stone, and concrete. Estimated quantities of The non-renewable resources required for the proposed actions are summarized in Table 14-1.

Table 14-1 Estimated quantities of nonNon-renewable resources required for the proposed actions

Beach Sector	Non-renewable Resources
Fort DeRussy	1,5003,000 cy of beach fill sand.
Halekūlani	60,000 cy of offshore sand fill. 5,000 cy of stone for groin construction. 810 cy of concrete for crown wall construction. 600 cy of concrete for sand retaining wall construction.
Royal Hawaiian	25,000 cy of offshore sand fill.
Kūhiō	28,000 cy of offshore sand fill (ʻEwa (west) basin). 4,500 cy of offshore sand fill (Diamond Head (east) basin). 4,000 cy of stone for groin and breakwater construction. 250 cy of concrete for groin and breakwater construction.

14.2 Irreversible Curtailment of the Range of Beneficial Uses of the Environment

The Waikīkī shoreline is primarily used for recreational and commercial purposes. The proposed actions will increase recreational dry beach width and improve lateral shoreline access, which will support the continuation of existing uses and expand opportunities for recreational enjoyment in Waikīkī. The proposed groins and segmented breakwater in the Kūhiō beach sector ʻEwa (west) basin are largely within the footprint of the existing structures and will not fundamentally alter the character or environment within and adjacent to the existing basin. The proposed groins, sand retaining wall, and beach fill in the Halekūlani beach sector will fundamentally alter the environment in this area but is not anticipated to result in any significant long-term degradation of the environment or loss of habitat. Rather, construction of the proposed groins will improve the shoreline conditions, restore the beach, and increase potential biological habitat in a relatively barren reef flat area. Ecological services of reef flat habitat will be lost under the project footprints (sand and groins) but are anticipated to recover over time as the benthic community re-establishes.

The Iroquois Point Beach Nourishment and Stabilization project, which was completed in 2013, involved the construction of nine rock rubblemound groins very similar in size and construction to the proposed groins, sand retaining wall, and beach fill in the Halekūlani beach sector. Extensive marine ecosystem monitoring is being accomplished for that project (AECOS, 2014). The 1-year post-construction marine ecosystem monitoring shows that the project has resulted in a significant increase in marine species diversity and density. In the vicinity of the groins there has been a 25-fold increase in fish abundance, not counting small baitfish, and a tripling of species richness (number of species). Fish biomass is more than six times greater than prior to construction. Prior to construction of the groins, fish biomass at Iroquois Point was considered low compared to island averages around the state, roughly on par with the shallow reef flats off Waikīkī (AECOS, 2009b, 2011, 2014). After construction, the biomass at the groins is on par with maximum values observed around the state (AECOS, 2014). Other changes in the vicinity of the groins includes an increase in crustose coralline algae cover from 1% to 60%, coral cover increase from 0 to 0.6% and macroinvertebrate cover from 1.4% to 6.3%. Coral abundance in the groin vicinity increased from 0 to 16 colonies per 10 m^2, with the most common coral species being *Pocillopora damicornis*. These changes are attributable to the creation of hard, stable habitat for colonization.

14.3 Possibility of Environmental Accidents

Best Management Practices (BMPs) will be implemented to ensure that adequate protective measures are in place to prevent, if possible, or minimize adverse impacts on the environment and public health, safety, and welfare. The BMP plans will include the following:

- Vehicle, Equipment, and Materials Management
- Waste Management
- Monitoring Procedures and Protocols
- Turbidity Containment
- Erosion and Sediment Control
- Oil and Spill Containment
- Noise Control
- Dust Control
- Air Pollution Control
- Operational Controls
- Structure, Authority, and Responsibilities
- Training
- Health and Safety
- Inspection and Monitoring
- Emergency Procedures, Spill Response Plan, and Contacts
- Contingency Plan

- Suspension of Work
- Record Keeping and Documentation

15. UNRESOLVED ISSUES

Project Phasing (Status: Unresolved)

This ~~DPEIS~~ FPEIS proposed five (5) beach improvement and maintenance actions in four (4) beach sectors of Waikīkī. *Beach maintenance* refers to actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. The proposed beach maintenance actions are intended to be conducted on a periodic basis and may be adapted as sea levels continue to rise. *Beach improvements* refers to actions that involve adding new sand, constructing new structures, and/or modifying existing structures. The proposed beach improvement actions are designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the projects could be effective until about the year 2080, or 50-years post-construction.

Sea level rise projections continue to evolve as new and improved sea level and climate change research becomes available. It is also important to recognize that global sea level rise will not stop within these timeframes but will very likely continue for centuries. As a result, there is uncertainty regarding precisely when and the degree to which the structures will need to be adapted.

While the other beach sectors of Waikīkī – Duke Kahanamoku, Queens, Kapiʻolani, and Kaimana - were not selected for beach improvement and maintenance actions, these areas are clearly important and, as sea levels continue to rise, additional actions may be necessary in these beach sectors in the future.

> Resolution: The Waikīkī Beach Improvement and Maintenance Program consists of five (5) individual actions (projects) that are intended to be implemented in phases. The timing and sequencing for project implementation has yet to be determined and will be dependent on stakeholder feedback and availability of funding. The objective of the Program is to complete all of the proposed actions within approximately one decade and to sequence the projects in a manner that will minimize and isolate disruptions to specific areas for discrete periods of time. This approach will also help to minimize and distribute the cumulative impacts of the proposed actions.

Sand Recovery (Status: Partially Resolved)

The offshore sand deposits that will be used to support the beach improvement actions in the Halekūlani beach sector and Kūhiō beach sector ʻEwa (west) basin have yet to be confirmed. The dredging methods to recovery the offshore sand and transport it to the shoreline for placement have also not been confirmed. Additional quantitative resource surveys may also be required to further evaluate potential impacts to benthic habitat at the offshore sand deposits. These aspects of the projects will be confirmed during the final design and permitting process.

> Resolution: The beach maintenance action in the Fort DeRussy beach sector will involve hydraulic suction dredging to recover approximately 3,000 cy of sand from the *Hilton* offshore sand deposit. The beach maintenance action in the Royal Hawaiian beach sector will involve hydraulic suction dredging to recover approximately 30,000 cy of sand from

the *Canoes/Queens* offshore sand deposit. The proposed beach maintenance action in the Diamond Head (east) basin of the Kūhiō beach sector will involve sand pumping to recover approximately 4,500 cy of submerged sand from within the basin.

Costs and Funding (Status: Unresolved)

The proposed beach improvement and maintenance actions in the DPEIS were presented at a conceptual level. The estimated costs for construction for the proposed actions have yet to be confirmed. Actual construction costs will depend on the final plans and specifications and permit conditions, which will be confirmed during the final design and permitting phase. Initial construction costs will depend on a variety of factors including but not limited to the selected offshore sand deposits, sand recovery and transport methodologies, project timing and sequencing, and monitoring requirements. Recurring construction costs will depend on the frequency of beach maintenance activities and unforeseen maintenance costs. For example, an extreme episodic event (e.g., hurricane or tsunami) could result in unpredicted costs for repair and maintenance. Adaptation costs are similarly difficult to project. As sea levels continue to rise, there is uncertainty regarding precisely when and the degree to which the structures will need to be adapted. The cumulative costs over the life of the Program will continue to be adjusted to account for inflation/deflation.

Monitoring (Status: Unresolved)

The monitoring and assessment plans for the proposed actions include beach profile monitoring, water quality monitoring, and marine biological monitoring (see Chapter 12). At this time, it is unclear if any additional monitoring will be required. Monitoring requirements will be confirmed during the final design and permitting process.

Required Permits and Approvals (Status: Partially Resolved)

Due to recent statutory changes and ongoing policy changes, there is uncertainty in terms of the permits and approvals that will be required for the proposed actions. For example, depending on the location of laydown and staging areas for equipment and materials, and the position of the proposed structures in relation to the shoreline, a Special Management Area (SMA) permit and/or Shoreline Setback Variance (SSV) may be required. The Hawaiʻi Department of Land and Natural Resources is also in the process of finalizing the permitting process for the new Small Scale Beach Restoration (SSBR) Program, which may affect the permits required from the Department of the Army and Hawaiʻi Department of Health.

Resolution: The applicant confirmed that the proposed actions will require a Conservation District Use Permit (CDUP. A current Certified Shoreline will be required as a prerequisite of the CDUP. On March 9, 2023, Mayor Rick Blangiardi enacted Ordinances 23-3 and 23-4, which amended the Revised Ordinances of Honolulu (ROH), Chapter 25 Special Management Area and Chapter 26 Shoreline Setbacks, respectively. At this time, it is unclear if any of the proposed actions will require a Special Management Area Use Permit (SMA) or a Shoreline Setback Variance (SSV). The applicant will consult with the City and County of Honolulu, Department of Planning and Permitting to confirm these requirements during the final design and permitting phase.

Existing Structures (Status: Partially Resolved)

The proposed actions were developed as mandated in Governor David Ige's August 2018 directive to include a sea level rise analysis in Environmental Impact Statements. The proposed actions will be located primarily on submerged lands makai (seaward) of the shoreline in the State Conservation District. However, some aspects of the proposed actions may extend mauka (landward) of the shoreline in the Special Management Area (SMA). The DLNR does not regulate land uses mauka (landward) of the shoreline in Waikīkī. Responsibility for regulation and permitting rests with the City and County of Honolulu.

Most of the existing seawalls that span nearly the entire length of the Waikīkī shoreline are privately-owned structures ~~and are located outside of the Conservation District~~. ~~The DLNR does not have the authority to alter these structures to accommodate the proposed actions.~~ The typical beach crest elevation in the Royal Hawaiian beach sector is +7 ft MSL. The proposed actions have a beach crest elevation of +8.5 ft MSL to account for 1.5 ft of sea level rise. While this can be accomplished in the design and construction of groins and beach fill, it should be noted that the backshore elevations are generally less than +8.5 ft MSL in the Halekūlani and Kūhiō beach sectors. For reference, the seawall fronting the Sheraton Waikiki Hotel has a crest elevation of about +7.4 ft MSL and the seawalls in the Kūhiō beach sector have crest elevations ranging from +7 ft to +10 ft MSL. Nourishing the beach with sand to elevation +8.5 ft MSL would result in sand spilling over these walls and extending into private property. Additionally, sea level rise is projected to rise by 3 ft or more by 2100, which will likely require an additional increase in beach elevation. In these cases, a backstop may be required to support the inshore limit of the beach. The 2013 Iroquois Point Beach Nourishment and Stabilization had a similar challenge. A keystone landscaping wall was constructed along much of the shoreline to support the beach.

During the final design phase, it may be determined that the existing seawalls may need to be modified to accommodate the increased beach elevation. This response to sea level rise may be warranted regardless of the proposed actions, as some shoreline property owners have already begun moving infrastructure to higher floors and renovating the lower floors to be adaptable to coastal flooding. Property owners may find that increasing wall elevations may be a desirable option regardless of the proposed actions.

The proposed actions are intended to provide safe access to and along the shoreline. The proposed action in the Halekūlani beach sector includes an option to incorporate a beach walkway to improve lateral shoreline access between the Royal Hawaiian, Halekūlani, and Fort DeRussy beach sectors. The beach walkway would follow the alignment of the existing walkways that run from Hilton Hawaiian Village past the U.S. Army Hawaiʻi Museum, providing continuous lateral access along approximately 4,500 ft (0.85 mi) of shoreline. The beach walkway would need to be wide enough to be ADA-compliant and could include optional features, such as turnouts, to allow users to stop while not affecting pedestrian traffic. The existing seawalls may need to be modified or replaced to accommodate a beach walkway in the Halekūlani beach sector. Most of the existing seawalls are privately-owned structures and are located outside of the Conservation District. ~~The DLNR does not have the authority to modify or replace these structures to accommodate the proposed actions. At this time, it is unclear~~

~~whether incorporating a beach walkway into the design for the Halekūlani beach sector is feasible.~~

> Resolution: The proposed action in the Halekulani beach sector will require a sand retaining wall to be constructed makai (seaward) of the existing seawalls fronting the Sheraton Waikiki and Halekūlani hotels (Figure 5 10), and at the west end the wall will extend in front of the Outrigger Reef and Castle Waikīkī Shore hotels (Figure 5 11). The top of the sand retaining wall will function as a walkway to improve lateral shoreline access between the Royal Hawaiian, Halekūlani, and Fort DeRussy beach sectors. A flexible beach mat walkway could be installed on the sand beach makai (seaward) of the sand retaining wall to provide lateral access along approximately 1,500 feet of shoreline. The beach mat walkway would need to be wide enough to be ADA-compliant and could include optional features, such as turnouts, to allow beach goers to stop without disrupting pedestrian traffic. Access points could also be constructed to improve perpendicular shoreline access at the public beach right-of-way at Kālia Road and the privately-owned perpendicular access between the Halekūlani Hotel and the Sheraton Waikiki Hotel. The walkway would transition to Royal Hawaiian Beach on the east and Fort DeRussy Beach on the west.

16. RELATIONSHIP TO EXISTING PLANS, POLICIES, AND CONTROLS

Shorelines, beaches, and nearshore waters of Hawaiʻi are considered part of the Public Trust, with access and use available to all people. As a result, Hawaii's shorelines are heavily regulated. The current definition of the "shoreline" in Hawaiʻi is as follows:

> "*Shoreline* means the upper reaches of the wash of the waves, other than storm or seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves (§13-222, HAR)."

Generally, County jurisdiction begins at the shoreline and extends landward. State jurisdiction begins at the shoreline and extends seaward. Federal jurisdiction begins at the mean higher high water (MHHW) line and extends out to the 200 nautical mile limit of the U.S. exclusive economic zone (EEZ); this area is also defined as the "navigable waters of the United States". Figure 16-1 shows relevant permit jurisdiction lines for shoreline construction in Hawaiʻi.

The Federal, State, and County governments all have different objectives and rules regulating what can and cannot be done along the shoreline. Therefore, the definition and location of the "shoreline" is critical for the planning and permitting of any coastal construction. A *certified shoreline* is a line identified by a licensed land surveyor and certified by the State, which reflects the shoreline definition stated above. A certified shoreline is valid for one year and is used to establish jurisdiction and Shoreline Setback boundaries.

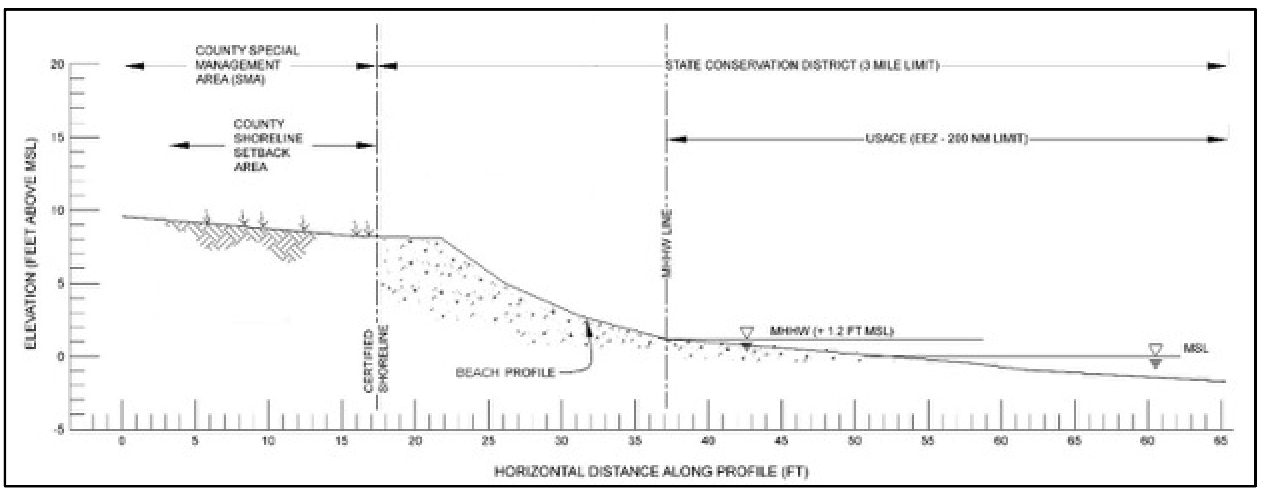


Figure 16-1 Relevant jurisdiction boundaries for shoreline in Hawaiʻi

16.1 Federal

Federal jurisdiction begins at the mean higher high water (MHHW) line and extends out to the boundary of the United States EEZ, 200 nautical miles offshore. This area is defined as the navigable waters of the United States.

16.1.1 Section 10 of the Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act of 1899 (33 USC §403) requires a Department of the Army (DA) permit for any activity that obstructs or alters navigable waters of the U.S., or the course, location, condition, or capacity of any port, harbor, refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water. DA permits are issued by the U.S. Army Corps of Engineers (USACE). As the proposed actions will involve placing sand in the navigable waters of the U.S, a DA permit will be required pursuant to Section 10.

16.1.2 Clean Water Act

The Clean Water Act (CWA) of 1972 (33 USC §1344) is the key legislation governing surface water quality protection in the United States. The Clean Water Act (CWA) of 1977, as amended (33 USC §1251 et seq.), is the major federal legislation concerning the improvement of the nation's water resources. The CWA amended the Federal Water Pollution Control Act and requires federal agency consistency with state nonpoint source pollution abatement plans. Amended again in 1987, the CWA strengthens enforcement mechanisms and regulations for stormwater runoff, providing for the development of industrial and municipal wastewater treatment standard, and a permitting system to control wastewater discharges to surface waters. Sections 401, 402, and 404 of the Act require permits for actions that involve wastewater discharges or discharge of dredged or fill material into waters of the United States.

16.1.2.1 Section 404 and 401

Section 404 of the CWA defines requirements for discharges in navigable waters of the U.S. and sets limits on the discharge of dredged or fill material into navigable waters. Permit approval is through the U.S. Army Corps of Engineers (USACE). Dredging activities and placement of fill trigger the need for a Section 404 permit.

For projects which require a Section 404 permit, a Section 401 Water Quality Certification (WQC) is also required. In Hawaiʻi, the U.S. Environmental Protection Agency has delegated responsibility for implementing Section 401 of the Act to the Hawaiʻi Department of Health, Clean Water Branch (DOH-CWB). See Section 16.2.8 for more information regarding the WQC.

16.1.2.2 Section 402

Discharges of point sources of pollutants into surface waters of the U.S. are controlled under the National Pollutant Discharge Elimination System (NPDES) program, pursuant to Section 402 of the CWA. Pursuant to the CWA and amendments, states may be authorized to administer permit programs. The Hawaiʻi Department of Health (DOH), Clean Water Branch administers the NPDES program in Hawaiʻi. under §11-55, HAR,

16.1.3 Coastal Zone Management Act

The Federal Coastal Zone Management Act of 1972 (16 USC §§1451-1464) was established as a United States National policy to preserve, protect, develop, and where possible, restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations. The Act encourages coastal states to develop and implement coastal zone management plans (CZMPs). The State of Hawaiʻi developed Chapter 205A, HRS (the Hawaiʻi CZM Program) in 1977, which was later approved as a CZMP under the Act in 1978. A CZM Consistency Determination will be coordinated by the Hawaiʻi Office of Planning and Sustainable Development, Coastal Zone Management Program, and is described in Section 16.2.7.

16.1.4 Archaeological and Historic Preservation Acts

The National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.) established a program for the preservation of historic places throughout the United States. The NHPA requires Federal agencies having direct or indirect jurisdiction to take into account effects on any district, site, building, structure, or object that is included or is eligible for inclusion in the National Register of Historic Places (NRHP) prior to the approval of expenditure of any funds or issuance of any license or permit. Consultation with the State Historic Preservation Division (SHPD) will be accomplished to ensure that the proposed actions comply with the provisions of the NHPA. A NHPA Section 106 review will be accomplished during the Department of the Army permit processing for work in the water.

16.1.5 Clean Air Act

The Clean Air Act (CAA) and amendments (42 USC §7401 et seq.) comprise the comprehensive federal law that regulates air emissions from area, stationary and mobile sources. This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Pursuant to the CAA and amendments, State-operated permit programs serve to control emissions. In Hawaiʻi, the State operating permit program is implemented by the DOH, and emissions of regulated air pollutants within the state may be subject to permitting as required under §11-60.1, HAR.

16.1.6 Endangered Species Act

The Federal Endangered Species Act (ESA) of 1973 (16 USC §1531 et seq.) establishes a process for identifying and listing threatened and endangered species. It requires federal agencies to carry out programs for the conservation of federally listed endangered and threatened plants and wildlife and designated critical habitats for such species and prohibits actions by federal agencies that would likely jeopardize the continued existence of those species or result in the destruction or adverse modification of designated critical habitat. Section 7 of the ESA requires consultations with federal wildlife management agencies on actions that may affect listed species or designated critical habitat. Section 9 of the ESA prohibits the “taking” (through harm or harassment) of endangered species without an agency-issued permit. Section 7 consultation is accomplished during the Department of the Army permit processing for work in the water.

16.1.7 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 USC §1801 et seq.), as amended by the Sustainable Fisheries Act, PL 104-297, calls for action to stop or reverse the loss of marine fish habitat. The waters out to 200 nautical miles around the Hawaiian Islands are under the jurisdiction of the Western Pacific Regional Fishery Management Council (WPRFMC). The WPRFMC has approved a Fisheries Management Plans (FMP) for Hawaiʻi that designates all the ocean waters surrounding Oʻahu, from the shore to depths of over 100 ft, including the area that would be affected by the proposed actions as "Essential Fish Habitat" (EFH). The proposed actions are located within waters designated as EFH (including water column and all bottom areas) for coral reef ecosystem, bottomfish, pelagic and crustacean Management Unit Species (MUS).

The WPRFMC has also defined "Habitat Areas of Particular Concern" (HAPC). As defined in the 1996 amendments to the Act, these habitats are a subset of EFH that are "rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area". The area that would be affected by the proposed actions is not within a HAPC. A formal EFH consultation will be conducted during the Department of the Army permit processing for work in the water.

16.1.8 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 USC §31), as amended, prohibits (with exceptions) the taking (i.e., harassment, hunting, capture or killing, or attempting to harass, hunt, capture or kill) of marine mammals in waters of the U.S. The implementing regulations at 50 CFR 216 identify definitions, prohibitions, exceptions, permit restrictions, and conditions associated with the MMPA.

16.1.9 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 USC §703 et seq.), establishes protections for migratory birds and prohibitions including those related to activities which "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export…" unless permitted by regulations. The MBTA prohibits the relocation of listed species without a permit from the U.S. Fish and Wildlife Service. In the event a listed migratory bird enters the construction zone, the contractor must stop work in the immediate area so as not to disturb the bird.

16.1.10 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act of 1934, as amended (16 USC §§ 661-666[C] et seq.) mandates that wildlife, including fish, receive equal consideration and be coordinated with other aspects of water resource development. This is accomplished through consultation with NMFS, the U.S. Fish and Wildlife Service (USFWS), and appropriate state agencies whenever any body of water is proposed to be modified in any way and a Federal permit or license is required. These agencies determine the possible harm to fish and wildlife resources, the measures needed to both prevent the damage to and loss of these resources, and the measures needed to develop and improve the resources, in connection with water resource development. NMFS, the USFWS, and state agencies submit comments to Federal licensing and permitting agencies on the potential harm to living marine resources caused by the proposed water development project, and recommendations to prevent harm (NMFS 2004). In all, the FWCA compliance process includes the following four steps: consultation (notice of initiation); reporting (e.g., field surveys and summary reports) and recommendations to protect, mitigate, and restore natural resources; Action agency consideration of recommendations, and Action agency implementation of recommendations.

16.2 State of Hawaiʻi

Beaches and nearshore submerged lands makai (seaward) of the certified shoreline are administered by the DLNR Office of Conservation and Coastal Lands (DLNR-OCCL). Furthermore, permitting and enforcement of some Federal regulations have been delegated to State agencies.

16.2.1 Chapter 343, Hawaiʻi Revised Statutes

Chapter 343, HRS and §11-200.1, HAR establishes the system of environmental review for proposed projects which ensures that environmental concerns are given appropriate consideration in decision making, along with economic and technical considerations. Chapter 343, HRS also establishes various circumstances that would necessitate the preparation of an Environmental Assessment or an Environmental Impact Statement.

Discussion:
State-funded projects and work within the State Conservation District are actions that require preparation and processing of an Environmental Assessment or Environmental Impact Statement (EIS) pursuant to Chapter 343, HRS. The proposed actions involve work within the State Conservation District. Furthermore, the project is receiving State funding through an MOU between the DLNR and WBSIDA. As the proposed actions could potentially have local and vicinity-related impacts along a broad reach of shoreline, an EIS is being prepared. Under Act 172 (12), the DLNR determined that the proposed actions constitute a “program”; therefore, a Programmatic EIS is required.

16.2.2 Shoreline Certification

Projects that occur along the shoreline or on State submerged lands typically require a certified shoreline. The proposed actions will require a Conservation District Use Permit (CDUP) (Section 16.2.3). Pursuant to §13-5-31, HAR, a certified shoreline is required to apply for a CDUP.

~~16.2.2~~16.2.3 State Land Use Districts

Pursuant to Chapter 205, HRS, all lands in the State have been placed into one of four land use districts by the State Land Use Commission. These land use districts have been designated "Urban", "Rural", "Agricultural", and "Conservation". Conservation District lands are further broken down into five (5) subzones that identify land uses that could be applied for. These subzones, from most restrictive to least restrictive, are (1) Protective, (2) Limited, (3) Resource, and (4) General. The Conservation District has an additional subzone – Special, which is unique to each location.

Coastal Lands include beaches, dunes, and rocky coasts that are seaward of the shoreline. The proposed actions are within the Conservation District, Resource Subzone. The DLNR Office of Conservation and Coastal Lands (DLNR-OCCL) is responsible for the regulation of land uses in the Conservation District . The Hawaiʻi Board of Land and Natural Resources (BLNR) approves land uses of the State Conservation District by issuing Conservation District Use Permits (CDUP). Statutes governing administration procedures of the Conservation District are written in Chapter 183C, HRS Conservation District). The administration is further clarified by the §13-5, HAR, Conservation District.

The identified land use for the proposed actions is noted in §13-5-22, HAR, P-16 Beach Restoration(D-1) Sand placement in excess of 10,000 cubic yards including structures necessary to retain sand, extraction of sand from submerged lands, and transportation or transmission of sand from an offshore extraction site to the replenishment site . To allow, modify or deny sand placement in excess of 10,000 cy including structures necessary to retain sand, extraction of sand from submerged lands, and transportation or transmission of sand from an offshore extraction site to the replenishment site would be at the discretion of the Board of Land and Natural Resources.

In evaluating the merits of a proposed land use, the department or board shall apply the following criteria:

The proposed land use is consistent with the purpose of the Conservation District.

Discussion:
The purpose of the Conservation District is "…to regulate land-use in the conservation district for the purpose of conserving, protecting, and preserving 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." (§13-5-1, HAR). The proposed actions are anticipated to protect and improve Waikīkī Beach, which is an important and valuable Public Trust resource. The proposed land uses are an adaptive management strategy to promote the long-term sustainability of beach resources in Waikīkī, while also not materially impacting

public health, safety, and welfare. The proposed actions are anticipated to restore the public beach, improve recreational resources, improve lateral shoreline access, and increase resilience to coastal hazards and sea level rise. These objectives are consistent with the purpose of the State of Hawaiʻi Conservation District.

The proposed actions are consistent with the objectives of the subzone of the land on which the use will occur.

Discussion:
The objective of the Resource subzone is "…to ensure, with proper management, the sustainable use of the natural resources of those areas." (§13-5-13, HAR). The proposed actions are an identified land use within the Resource subzone of the Conservation District, pursuant to §13-5-22, HAR, P-16, BEACH RESTORATION.

As stated above, the proposed actions are an adaptive management strategy to promote the long-term sustainability of beach resources in Waikīkī, while also not materially impacting public health, safety, and welfare. The proposed actions involve the recovery of sand from deposits located offshore of Waikīkī Beach, transporting the sand to shore, and placement of the sand along the shore to achieve the design beach profiles.

In addition, beach improvement actions are proposed in two beach sectors of Waikīkī (Figure 2-3 and Figure 2-4):

- Halekūlani Beach Sector – Beach Nourishment with Stabilizing ~~Groins~~Structures
- Kūhiō Beach Sector: ʻEwa (west) Basin – Beach Nourishment with Modified Groins and ~~a~~ Segmented Breakwater.

The proposed stabilizing ~~groins and modification to the Kūhiō Beach crib wall~~structures (groins, sand retaining wall, and segmented breakwater) will help to ~~manage~~stabilize the placed sand. These actions are anticipated to restore the public beach, improve recreational resources, improve lateral shoreline access, and increase resilience to coastal hazards and sea level rise. This is consistent with the purpose of the Resource (R) subzone.

The proposed actions comply with provisions and guidelines contained in chapter 205A, HRS, entitled "Coastal Zone Management," where applicable;

Discussion:
Detailed discussion of the proposed actions and their relationship to the Hawaiʻi Coastal Zone Management Program is presented in Section 16.2.7 of this ~~DPEIS~~FPEIS.

The proposed actions will not cause substantial adverse impact to existing natural resources within the surrounding area, community, or region;

Discussion:
Improving and maintaining the sandy beaches of Waikīkī will contribute to the preservation and continuation of an important and valuable Public Trust resource. The offshore sand proposed for use in Waikīkī is essentially a sustainable resource in the context of the scope and scale of the

proposed actions. Other than temporary, short-term environmental impacts during construction, the proposed actions are not anticipated to result in impacts which can be expected to degrade the environmental quality in Waikīkī.

The proposed actions, 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:
Waikīkī is a predominantly engineered shoreline. Almost the entire length of Waikīkī is armored by seawalls that were constructed in the early 1900s, many of which are in various states of disrepair. The beaches of Waikīkī are primarily man-made and composed almost entirely of sand that has been imported from various terrestrial sources, other beaches, and dredged from offshore deposits. Beach stability is largely dependent on the presence of numerous groins, breakwaters, and other structures that stabilize the sand along the shoreline. ~~The proposed actions will improve existing public beaches and are intended to preserve an important and valuable Public Trust resource along the coastline.~~ The proposed beach improvement and maintenance actions will use offshore sand that is compatible with the existing physical conditions of the beaches in Waikīkī. The proposed structures (groins and segmented breakwater) will be consistent in size and appearance to structures that already exist in Waikīkī, so existing view planes will not be significantly altered.

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 scenic and aesthetic beauty of the Waikīkī coastline draws millions of tourists to its sights and beaches each year. Due to its low elevation and profile, the proposed actions are not anticipated to significantly affect existing viewplanes. Construction equipment, material stockpiles, and construction activities will be present within the project area during construction. Additionally, the dredging equipment will be visible from the shoreline. All of these impacts are temporary and will not be present once construction is completed.

The proposed actions are anticipated to have a positive long-term impact on the scenic and aesthetic resources of Waikīkī, as they will increase recreational dry beach area and prevent the existing seawalls from becoming exposed by erosion. The color of sand from the offshore sand deposits is slightly grayer than the existing beach sand; however, after a season of mixing and fading in the sun, the color difference is anticipated to be negligible. This will be an improvement of the open space characteristics for the public trust resource along this section of the coast.

Subdivision of land will not be utilized to increase the intensity of land uses in the Conservation District;

Discussion:
The proposed actions do not include the subdivision of land.

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

Discussion:
Beaches and shorelines are inherently dangerous in Hawai'i. Strong waves and currents can cause injuries that range from non-life-threatening scrapes and bruises to life-threatening spinal and brain injuries and drowning. There are currently four lifeguard towers in the project area. The proposed actions are not anticipated to change the hazard from breaking waves along the shoreline.

Heavy equipment including barges, dump trucks, excavators, and boats could pose a hazard to the public during construction. Public safety during construction will be of utmost importance. With the implementation of proper precautions, safety notices, markings, and outreach, no changes to public health hazards along the shoreline are anticipated as a result of the proposed actions.

The proposed actions will have some impact on air, noise, and water quality during construction; however, these impacts will be mitigated to the maximum extent practicable by using Best Management Practices (BMPs) and monitoring protocols. The proposed actions will not result in any post-construction or long-term effects on public health, safety, and welfare.

~~The proposed actions will not alter existing land use patterns makai (seaward) of the beach~~. The improved beaches will likely attract beach users who do not presently use these areas; however, this increase will be consistent with the current recreational use of the Waikīkī area. The proposed actions could result in an increase in the general level of commercial activity in the Waikīkī area~~, and thus will have a long-term benefit~~. The proposed actions are anticipated to have a negligible effect on public infrastructure and a moderate but acceptable impact on public services. Once completed, the~~y~~ improvements will not require water, power, sanitary wastewater collection, or additional emergency services. Additional ocean safety and lifeguard services may be required.

~~16.2.3~~16.2.4 Hawai'i State Plan

The Hawai'i State Plan (HRS Chapter 226) is a long-range comprehensive plan that establishes the overall theme, goals, objectives, policies, and priority guidelines for statewide planning. The Hawai'i State Plan provides a framework for determining priorities, allocating public resources, and improving coordination between State and County plans, policies, programs, projects, and regulatory activities.

The objectives of the proposed beach improvement and maintenance actions are to:

- Restore and improve the beaches of Waikīkī.
- Increase beach stability through improvement and maintenance of shoreline structures.
- Provide safe access to and along the shoreline.
- Increase resilience to coastal hazards and sea level rise.

Review and analysis of HRS Chapter 226 indicates that the proposed actions are consistent with The Hawaiʻi State Plan objectives and policies listed below.

§226-8 Objective and policies for the economy--visitor industry

(b) (1) Support and assist in the promotion of Hawaii's visitor attractions and facilities.

(2) Ensure that visitor industry activities are in keeping with the social, economic, and physical needs and aspirations of Hawaii's people.

(3) Improve the quality of existing visitor destination areas by utilizing Hawaii's strengths in science and technology.

(4) Encourage cooperation and coordination between the government and private sectors in developing and maintaining well-designed, adequately serviced visitor industry and related developments which are sensitive to neighboring communities and activities.

(5) Develop the industry in a manner that will continue to provide new job opportunities and steady employment for Hawaii's people.

Discussion:
The proposed beach improvement and maintenance actions will improve the quality of an existing visitor destination area by restoring the beaches of Waikīkī and preserving the economic value of the beaches as one of the primary drivers of Hawaii's tourism-based economy. The public and private sectors are working together to develop and implement a program that will maintain an environmentally sound, ecologically beneficial, beach resource and the visitor industry that depends on it.

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

(2021) (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:

(1) Exercise an overall conservation ethic in the use of Hawaii's natural resources.

(2) Ensure compatibility between land-based and water-based activities and natural resources and ecological systems.

(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.

(5) Consider multiple uses in watershed areas, provided such uses do not detrimentally affect water quality and recharge functions.

(6) Encourage the protection of rare or endangered plant and animal species and habitats native to Hawaii.

(7) Provide public incentives that encourage private actions to protect significant natural resources from degradation or unnecessary depletion.

(8) Pursue compatible relationships among activities, facilities, and natural resources.

(9) Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes.

Discussion:
The proposed beach improvement and maintenance actions will be conducted with a suite of environmental Best Management Practices (BMPs) that are designed to protect and preserve natural resources while not causing any costly or irreparable damage. Preserving the beach resource increases the accessibility of the shoreline area for public, recreational, educational, and scientific purposes and increases shoreline habitat.

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

(b) (1) Promote the preservation and restoration of significant natural and historic resources.

(3) Promote the preservation of views and vistas to enhance the visual and aesthetic enjoyment of mountains, ocean, scenic landscapes, and other natural features.
(4) Protect those special areas, structures, and elements that are an integral and functional part of Hawaii's ethnic and cultural heritage.

(5) Encourage the design of developments and activities that complement the natural beauty of the islands.

Discussion:
Waikīkī Beach is world famous for its scenic and natural beauty and historic cultural elements. The proposed beach improvement and maintenance actions will increase recreational dry beach area, which will benefit the preservation and enhancement of viewplanes along the Waikīkī shoreline.

§226-13 Objectives and policies for the physical environment--land, air, and water quality

(2) Promote the proper management of Hawaii's land and water resources.

(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.

(6) Encourage design and construction practices that enhance the physical qualities of Hawaii's communities.

(8) Foster recognition of the importance and value of the land, air, and water resources to Hawaii's people, their cultures and visitors.

Discussion:
The proposed beach improvement and maintenance actions will be undertaken by the State of Hawaiʻi Department of Land and Natural Resources (DLNR), which is responsible for overseeing beaches and submerged lands out to the seaward extent of the State's jurisdiction. The proposed actions were developed in collaboration with public and private stakeholders with the shared goal and vision of improving and preserving the beaches of Waikīkī for current and future generations. The proposed actions will enhance the physical quality of the beaches.

The proposed beach improvement and maintenance actions are intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. The project components will increase the wave energy dissipating properties of the beach and decrease the landward extent of wave runup, reducing the vulnerability of the backshore to marine flooding.

The proposed actions are anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area. Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.

16.2.5 Hawaiʻi 2050 Sustainability Plan

The Hawaiʻi 2050 Sustainability Plan serves as the state's sustainability and climate strategic action plan. The plan was originally published in 2008 and updated in June 2021. The plan currently provides recommendations for sustainability and climate change resilience over the coming decade.

The Hawaiʻi 2050 Sustainability Plan identifies eight (8) Focus Areas:

1. Promote a Sustainable Economic Recovery.
2. Reduce Greenhouse Gas Emissions.
3. Improve Climate Resiliency.
4. Advance Sustainable Communities.
5. Advance Equity.
6. Institutionalize Sustainability Throughout Government.
7. Preserve the Natural Environment
8. Perpetuate Traditional Ecological Knowledge and Values

The actions proposed for the Waikīkī Beach Improvement and Maintenance Program support the following recommendations set forth in the Hawaiʻi 2050 Sustainability Plan:

1. Promote a Sustainable Economic Recovery

Strategy 7: Reduce the environmental footprint of the tourism economy.

Recommendation: Develop a framework for a comprehensive sea level adaptation and resilience plan for the Waikīkī Special District.

Discussion: One of the primary objectives of the Waikīkī Beach Improvement and Maintenance Program is to increase resilience to coastal hazards and sea level rise. The proposed beach improvement actions are designed based on the most recent sea level rise predictions by the National Oceanic and Atmospheric Administration (Sweet et al. 2022) and are designed to be implemented in phases, with the initial phase being designed for approximately 1.5 ft of sea level rise, thus in 25 to 30 years following construction it may be necessary to raise the project elevations. If then raised by several feet, the projects could be effective until about the year 2080, or 50-years post-construction.

2. Improve Climate Resilience

Strategy 17: Integrate climate change adaptation and resilience considerations into planning and implementation.

Recommendation: Study the feasibility of and prioritize nature-based solutions (e.g., on Hawaii's high energy shorelines to manage and mitigate erosion).

Discussion: The proposed actions are considered nature-based solutions, which are defined as projects that are produced by a combination of natural processes and human engineering (Bridged et al. 2021).

Strategy 19: Implement actions that improve the state's resilience to climate change.

Recommendation: Identify and select adaptation strategies (e.g., infrastructure investments, policy changes) that increase Hawaii's resilience while upholding the goals of doing so equitably (e.g., using the equity lens framework) and in line with Native Hawaiian Traditional Ecological Knowledge, and local values

Discussion: Waikīkī is directly exposed to natural hazards including tsunami, storm surge and hurricanes. The beaches of Waikīkī are chronically eroding and the backshore (landward of the beach) is frequently flooded, particularly during high tides and high surf events. In recent years, Hawaiʻi has experienced record high tides (referred to as *King Tides*) that have exacerbated erosion and flooding in Waikīkī. These events have highlighted the impacts of sea level rise on the beaches of Waikīkī. As sea levels continue to rise, beach loss will progressively degrade the recreational, social, cultural, environmental, aesthetic, and economic value of Waikīkī.

As the beaches continue to erode and flooding occurs more frequently and extends further landward, processes that are likely to accelerate as sea levels continue to rise, the shoreline will migrate further landward. As the shoreline approaches the existing shoreline armoring, there will be incremental loss of recreational beach area and shoreline habitat, a process that is referred to as *coastal squeeze* (Lester and Matella, 2016). While it is possible that some sand may remain in front of the existing shoreline armoring, what remains of the beaches will be narrow, submerged, unstable, inaccessible, and unusable. Without beach improvements and maintenance, sea level rise will likely result in substantial beach loss in Waikīkī.

Healthy, stable beaches provide a first line of defense against coastal flooding and inundation by rising sea levels and hurricane storm waves. Beach improvements are necessary to ensure that the beaches and economy of Waikīkī are sustainable and resilient to sea level rise.

Strategy 20: Increase the resilience of vulnerable populations to the impacts of climate change and other shocks and stressors.

Recommendation: Encourage community involvement and resilience by working with community members, matching community partners with funders, and initiating conversations between communities and the government.

Discussion: The actions proposed for implementation in Waikīkī will be undertaken by the State of Hawaiʻi Department of Land and Natural Resources (DLNR), which is responsible for overseeing beaches and submerged lands out to the seaward extent of the State's jurisdiction. The proposed actions were developed in collaboration with public and private stakeholders with the shared goal and vision of improving the beaches of Waikīkī for current and future generations.

Project coordination and implementation is being done in collaboration with the Waikīkī Beach Special Improvement District Association (WBSIDA), which is a private non-profit organization that was created in 2015 by City ordinance to preserve and restore Waikīkī Beach, and to serve as a cost-share partner in a public-private partnership with the DLNR. The WBSIDA is governed by a Board of Directors that consists of representatives of Waikīkī's major resorts, property owners, State and County government designees, and other stakeholders. The WBSIDA provides a mechanism for coordination of the proposed actions with a broad spectrum of Waikīkī stakeholders and securing private funding to support project implementation.

The proposed actions were developed in close collaboration with the Waikīkī Beach Community Advisory Committee (WBCAC), which was formed in 2017 to provide a forum to engage stakeholders and provide guidance and feedback on design criteria and rationale for beach improvement and maintenance projects in Waikīkī. The WBCAC is composed of various stakeholders representing business (29%), government (29%), hotels and resorts (11%), non-profit organizations (14%), and science and engineering (17%). The WBCAC serves as a representative body to communicate the diversity of perspectives and priorities in the broader Waikīkī community, provide guidance and feedback for beach management and planning activities in Waikīkī, and ensure that future beach management projects address the issues and concerns of the Waikīkī community and local stakeholders.

The WBCAC has and continues to serve a vital role in the planning process that led to the selection of the proposed actions. The WBCAC was directly involved in determining the priorities and objectives for each beach sector, establishing planning and design criteria, evaluating conceptual options, and providing feedback on the conceptual designs for the proposed actions. The function of the WBCAC is further enhanced by the role of the University of Hawai'i Sea Grant Program's Waikīkī Beach Management Coordinator, who provides technical support, education and outreach, and project coordination.

~~16.2.4~~16.2.6 State of Hawai'i Functional Plans

Functional plans set forth the policies, statewide guidelines, and priorities within a specific field of activity, when such activity or program is proposed, administered, or funded by any agency of the state. Functional plans are developed by the state agency primarily responsible for a given functional area, which includes agriculture, conservation lands, education, energy, higher education, health, historic preservation, housing, recreation, tourism, and transportation. The Conservation Lands, Recreation, and Tourism State Functional Plans are relevant to the Proposed Action.

~~16.2.4.1~~16.2.6.1 Conservation Lands State Functional Plan (1991)

Objective IIA: Establishment of plans for natural resources and land management.
To achieve that objective, Policy IIA(1) says to formulate and maintain a management plan for resources and lands having significant conservation value. Waikīkī Beach is a resource that has significant conservation value. The proposed actions will support this objective by ensuring sustained use of the natural resource by increasing dry beach width.

Objective IIC: Enhancement of natural resources.
In accordance with Policy IIC(2), the proposed action will expand and enhance outdoor recreation opportunities. By increasing the sand volume, the dry beach will widen, and more space will be available to the public for outdoor recreational activities and the scenic value of the natural resource will be enhanced. Moreover, the restored littoral system will improve the sandy ecosystem value and services.

Objective IID: Appropriate development of natural resources.
Following Policy IID(3), the proposed actions will develop recreational resources on the shoreline and mauka areas. If the shoreline becomes too narrow, the recreational resources along the beach will decrease. By performing the proposed actions, the beach width will increase and the number of recreational opportunities on the natural resource will increase accordingly.

~~16.2.4.2~~16.2.6.2 Recreation State Functional Plan (1991)

Objective II-B of the Recreation State Functional Plan is to meet the special recreation needs of the elderly, the disabled, women, single-parent families, immigrants, and other groups. Policy

II-B(2) says to give higher priority to providing physical access to the disabled. The proposed action will increase dry beach area in Waikīkī and improve lateral shoreline access.

~~16.2.4.3~~16.2.6.3 Hawaiʻi State Tourism Functional Plan (1991)

Objective II.A. of the Hawaiʻi State Tourism Functional Plan is to develop and maintain well-designed visitor facilities and related developments that are sensitive to the environment, sensitive to neighboring communities and activities, and adequately serviced by infrastructure and support services. Policy II.A.8. calls for encouraging the development of hotels and related facilities within designated visitor destination areas with adequate infrastructure and support services before development of other possible visitor destinations. The plan identifies in the Action II.A.8.a, guidelines for tourism development that states effort should be made to minimize loss of public recreational opportunities. While the existing hotels and resorts along Waikīkī Beach are not new tourism development, the Waikīkī Beach Special Improvement District Association (WBSIDA) is making an effort financially and through operations to minimize loss of the public recreational resource by proposing to restore and maintain the beaches of Waikīkī.

~~16.2.5~~16.2.7 Coastal Zone Management Program

Enacted as Chapter 205A, HRS, the Hawaiʻi Coastal Zone Management (CZM) Program was promulgated in 1977 in response to the Federal Coastal Zone Management Act of 1972. The CZM area encompasses all lands throughout the entire state and all marine waters extending seaward from the shoreline to the extent of the state's police power and management authority, including the United States territorial sea. The U.S. territorial sea extends 12 miles from the shoreline. The proposed actions will require an application to be made to the State Office of Planning and Sustainable Development, CZM Program, for a CZM Consistency Determination. The proposed actions will be measured against the objectives and policies of the CZM program listed in 205A-2, HRS. These objectives and policies, and their relationship to the Proposed Action are as follows:

(1) Recreational Resources
(A) Provide coastal recreational opportunities accessible to the public.

Policies:

A. Improve coordination and funding of coastal recreational planning and management; and
B. Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by:
    i. Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas;
    ii. Requiring restoration of coastal resources that have significant recreational and ecosystem value, including but not limited to coral reefs, surfing sites, fishponds, sand beaches, and coastal dunes, when these resources will be unavoidably damaged by development; or requiring monetary compensation to the State for recreation when restoration is not feasible or desirable;

iii. Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational value;
iv. Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation;
v. 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;
vi. Adopting water quality standards and regulating point and nonpoint sources of pollution to protect, and where feasible, restore the recreational value of coastal waters;
vii. Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, and artificial reefs for surfing and fishing; and
viii. 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 that dedication against the requirements of section 46-6;

Discussion:
The proposed beach improvement and maintenance actions will stabilize the recreational beach resource allowing for continued recreational use of the shoreline. Most recreational activities along the Waikīkī shoreline are dependent on the existence of the beach. During and after the proposed actions, all public access will be managed to promote the health, safety, and welfare of the public, as well as to maintain ample public access consistent with the conservation of the natural resource.

To meet water quality standards for the project area, appropriate Best Management Practices (BMPs) will be used to prevent the release of pollutants into the marine environment. The proposed actions will be an improvement of the existing beach recreational opportunities as the restored beaches are entirely for public use. Some impacts will be imposed on vessel and recreational ocean transit during sand recovery, transport, and placement operations. Efforts will be made to notify potentially affected members of the local and visiting community prior to construction.

(2) Historic Resources

(A) 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:

A. Identify and analyze significant archaeological resources;
B. Maximize information retention through preservation of remains and artifacts or salvage operations; and
C. Support state goals for protection, restoration, interpretation, and display of historic resources;

Discussion:

The proposed actions do not include excavation of the dry beach in Waikīkī. The offshore sand deposits are not anticipated to have the potential to contain cultural or archaeological materials. The proposed sand placement areas are on actively mobile beaches. If any cultural or archaeological artifacts are discovered during project operations, work will cease, and the State Historic Preservation Division will be contacted. Public meetings will be held, and the local community will be regularly consulted during project development to solicit community feedback concerning the potential cultural impacts of the proposed beach improvement and maintenance activity.

(3) Scenic and Open Space Resources

(A) Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.

Policies:

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

Discussion:

The Waikīkī shoreline is a globally recognized visitor destination. The wide expanse of water with typically calm conditions, the deep blue colors of the ocean, and an unobstructed view of Diamond Head make the seaward and alongshore views from the shoreline spectacular. Waikīkī Beach itself is a scenic landmark, with millions of tourists each year traveling to see it. At the same time, the tall buildings that have been developed relatively close to the ocean along portions of the shoreline in the project area disrupt view planes along the Waikīkī shoreline.

The appearance of the beach is of significant interest to the Waikīkī resort community, as their guests represent the most numerous and closest viewers. However, it is also of considerable interest to the public and those who own and/or use adjacent areas. Waikīkī Beach, like all sandy shorelines in Hawaiʻi, is available to any member of the public and can be visited and enjoyed at any time. Thus, the project area is also of equal value to members of the public who visit the area. The ongoing erosion within the project area is having deleterious effects on the scenic and aesthetic value of the Waikīkī shoreline.

Impacts to scenic and open space resources will largely be confined to the sand recovery and transportation, and placement phases of the proposed actions. Visible turbidity during operations may impact the deep-blue colors of the ocean offshore of the Waikīkī shoreline. A detailed discussion of turbidity is provided in Section 8.7.

Construction equipment including barges, tugboats, cranes, temporary piers or trestles or pipelines, dump trucks, off-road capable vehicles, loaders, etc., will be present both on the beach and offshore during construction. The dredge barge will be visible from the shoreline for the duration of sand recovery efforts.

The proposed actions, over the long-term, are anticipated to be compatible with the visual environment and will improve the scenic and aesthetic resources of the Waikīkī area. The color of sand from the offshore sand deposits is slightly grayer than the existing beach sand; however, after a season of mixing and fading in the sun, the color difference is anticipated to be negligible.

(4) Coastal Ecosystems

(A) Protect valuable coastal ecosystems, including reefs, beaches, and coastal dunes, from disruption and minimize adverse impacts on all coastal ecosystems.

Policies:

A. Exercise an overall conservation ethic, and practice stewardship in the protection, use, and development of marine and coastal resources;
B. Improve the technical basis for natural resource management;
C. Preserve valuable coastal ecosystems of significant biological or economic importance, including reefs, beaches, and dunes;
D. Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land and water uses, recognizing competing water needs; and
E. 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:
The proposed actions are designed to minimize potential impacts to the marine environment. Turbidity containment barriers will surround the active work areas during sand recovery, transport, and placement operations. Impacts on water quality are anticipated to be minor, temporary, and localized to the immediate vicinity of the work activities. No long-term impacts to water quality are anticipated.

The beach resource and its consequent ecological value has been severely degraded by erosion. The proposed actions will restore the beach resource, supporting all manner of organisms that rely on the coastal sandy substrate, including *honu* (green sea turtles) and Hawaiian monk seals. Best Management Practices (BMPs) as typically recommended by the NOAA National Marine Fisheries Service will be adhered to during construction to avoid impacts to marine biota, protected species, and Essential Fish Habitat (EFH).

(5) Economic Uses

(A) Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policies:

A. Concentrate coastal dependent development in appropriate areas;

B. Ensure that coastal dependent development and coastal related development are located, designed, and constructed to minimize exposure to coastal hazards and adverse social, visual, and environmental impacts in the coastal zone management area; and
C. Direct the location and expansion of coastal development to areas designated and used for that development and permit reasonable long-term growth at those areas, and permit coastal development outside of designated areas when:
   i. Use of designated locations is not feasible;
   ii. Adverse environmental effects and risks from coastal hazards are minimized; and
   iii. The development is important to the State's economy.

Discussion:
Much of Hawaii's economy is based on tourism, following the exodus of island youth during the economic decline of the 1950's. At that time there was a conscious decision to focus on tourism to rebuild the economy and create stable, local jobs. The proposed actions and consequent improvement of beach related tourism is anticipated to have a positive corresponding effect on the City and County of Honolulu and State of Hawaiʻi economies through tax revenue generated by sustained or increased visitor populations. The proposed actions are also anticipated to create temporary construction and construction-related jobs. While the proposed actions will not create any permanent positions, a restored beach does improve the longevity and security of jobs related to beach use and coastal-dependent industries. The infrastructure mauka (landward) of and dependent on the beaches are visitor industry facilities. The proposed beach improvement and maintenance actions will minimize or reverse the existing natural social, visual, and environmental coastal impacts currently hindering these visitor industry facilities. The proposed actions will restore a major economic resource in an area currently zoned as Resort. The proposed actions are anticipated to have no impact on the density of coastal development or result in any proposed new coastal development in Waikīkī.

(6) Coastal Hazards
(A) Reduce hazard to life and property from coastal hazards.

Policies:
A. Develop and communicate adequate information about the risks of coastal hazards;
B. Control development, including planning and zoning control, in areas subject to coastal hazards;
C. Ensure that developments comply with requirements of the National Flood Insurance Program; and
D. Prevent coastal flooding from inland projects;

Discussion:
Flood Insurance Rate Maps indicate that the Waikīkī coastline is exposed to flooding caused by storm waves and tsunami. The proposed actions are intended to mitigate the impacts of wave overtopping and flooding by increasing dry beach width and volume, which will provide a protective buffer between the ocean and the existing backshore infrastructure. This will increase the wave energy dissipating properties of the beaches and decrease the landward extent of wave runup, reducing the vulnerability of the backshore to marine flooding. The proposed actions are anticipated to have a negligible impact on hurricane and tsunami hazards for the Waikīkī area.

Damage from hurricanes and tsunamis depends on the height of the water level rise relative to the backshore elevation, neither of which will be affected by the proposed actions.

(7) Managing Development

(A) Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

Policies:

A. Use, implement, and enforce existing law effectively to the maximum extent possible in managing present and future coastal zone development;
B. Facilitate timely processing of applications for development permits and resolve overlapping or conflicting permit requirements; and
C. 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:
This proposed beach improvement and maintenance actions meet the definition of development pursuant to Chapter 205A, HRS, as defined in 205A-22:

"*Development*" means any of the uses, activities, or operations on land or in or under water within a special management area that are included below:

(A) Placement or erection of any solid material or any gaseous, liquid, solid, or thermal waste;
(B) Grading, removing, dredging, mining, or extraction of any materials;
(C) Change in the density or intensity of use of land, including but not limited to the division or subdivision of land;
(D) Change in the intensity of use of water, ecology related thereto, or of access thereto; and
(E) Construction, reconstruction, or alteration of the size of any structure.

The proposed actions will be reviewed by Federal, State, and County agencies as well as the general and affected public through the environmental review and permitting processes. All required permits will be obtained prior to project implementation. Additional consultation opportunities will be provided during the final design and permitting process. Both potential short-term and potential long-term impacts are presented in this ~~DPEIS~~ FPEIS and will be presented in future permit applications.

(8) Public Participation

(A) Stimulate public awareness, education, and participation in coastal management.

Policies:

A. Promote public involvement in coastal zone management processes;
B. 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; and

C. Organize workshops, policy dialogues, and site-specific mediations to respond to coastal issues and conflicts;

Discussion:
Selection of the proposed actions was a primarily stakeholder-driven process. The proposed actions are the result of consultations that were conducted with the State of Hawaiʻi, Department of Land and Natural Resources, Office of Conservation and Coastal Lands (DLNR-OCCL), the Waikīkī Beach Special Improvement District Association (WBSIDA), and the Waikīkī Beach Community Advisory Committee (WBCAC). The purpose of these consultations was to establish priorities and design criteria for beach improvement and maintenance projects that will achieve State of Hawaiʻi and City and County of Honolulu objectives to improve the resilience and sustainability of Waikīkī's beaches, while minimizing disruption to existing commercial operations. A total of six (6) WBCAC meetings were conducted between November 7, 2017 and January 19, 2021. For additional information about the WBCAC, please see Section 2.4 and Appendix A.

The public was initially informed of the proposed Waikīkī Beach Improvement Maintenance Program during a public meeting that was held at the Waikīkī Community Center on December 5, 2017. The public was formally engaged through the publication of the Environmental Impact Statement Preparation Notice (EISPN), which was published in ~~the OEQC~~ *The Environmental Notice* on December 23, 2020. For additional information about the early consultation process, please see Chapter 19 and Appendix A.

The DLNR also created a project website as a knowledge resource for members of the community who are interested in learning more about the proposed actions and to provide a convenient means for the public to communicate questions to the applicant: https://dlnr.hawaii.gov/occl/waikiki

(9) Beach and coastal dune protection
(A) Protect beaches and coastal dunes for:
(i) Public use and recreation;
(ii) The benefit of coastal ecosystems; and
(iii) Use as a natural buffer against coastal hazards; and
(B) Coordinate and fund beach management and protection.

Policies:
A. 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;
B. Prohibit construction of private shoreline hardening structures, including seawalls and revetments, at sites having sand beaches and at sites where shoreline hardening structures interfere with existing recreational and waterline activities;
C. Minimize the construction of public shoreline hardening structures, including seawalls and revetments, at sites having sand beaches and at sites where shoreline hardening structures interfere with existing recreational and waterline activities;
D. Minimize grading of and damage to coastal dunes;

E. Prohibit private property owners from creating a public nuisance by inducing or cultivating the private property owner's vegetation in a beach transit corridor; and
F. 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; and

Discussion:
The objectives of the proposed beach improvement and maintenance actions are to:

- Restore and improve the beaches of Waikīkī.
- Increase beach stability through improvement and maintenance of shoreline structures.
- Provide safe access to and along the shoreline.
- Increase resilience to coastal hazards and sea level rise.

The improved beach will enhance recreational opportunities, improve public access to and use of the shoreline, and provide a natural buffer against coastal hazards. The proposed actions are designed to restore and maintain the beaches in a manner that works with natural coastal processes while also mitigating existing erosion pressure along the Waikīkī coastline. The proposed actions are consistent with the objective of HRS §205A to protect beaches and coastal dunes and coordinate and fund beach management and protection.

(10) Marine and coastal resources

(A) Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

Policies:

A. Ensure that the use and development of marine and coastal resources are ecologically and environmentally sound and economically beneficial;
B. Coordinate the management of marine and coastal resources and activities to improve effectiveness and efficiency;
C. 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;
D. Promote research, study, and understanding of ocean and coastal processes, impacts of climate change and sea level rise, marine life, and other ocean resources to acquire and inventory information necessary to understand how coastal development activities relate to and impact ocean and coastal resources; and
E. Encourage research and development of new, innovative technologies for exploring, using, or protecting marine and coastal resources.

Discussion:
The proposed actions are anticipated to have no significant long-term negative impacts to marine resources. Minor short-term impacts associated with sand recovery, transport, and placement are anticipated. Environmental construction specifications and Best Management Practices (BMPs) will be implemented to protect marine resources, including water quality, benthic flora and fauna, corals, fishes, and protected species. Formal consultations will be conducted with marine resource agencies, including the NOAA National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and the DLNR Division of Aquatic Resources

to ensure that all potential environmental impacts are mitigated to the maximum extent practicable. The proposed actions are anticipated to have a long-term positive impact on the sandy coastal resource and ecology, providing both an environmental and economic benefit.

~~16.2.6~~16.2.8 Water Quality Certification

The Clean Water Act (CWA) of 1972 (33 USC §1344) is the key legislation governing surface water quality protection in the United States. In Hawaiʻi, the U.S. Environmental Protection Agency (EPA) has delegated responsibility for implementing the Section 401 of the Act to the State Department of Health, Clean Water Branch (DOH-CWB). Actions that may constitute fill into Waters of the United States include:

- Placement of mooring blocks around the sand recovery areas.
- Placement of temporary piers and mooring blocks at the sand offloading locations.
- Removal of sand from the sand recovery areas.
- Placement of sand below the MHHW line

Discussion:
The proposed actions are subject to review under the Clean Water Act. The DOH-CWB issues Water Quality Certifications (WQC) for projects that involve fill into the Waters of the United States. The WQC will require submission of an Applicable Monitoring and Assessment Plan (AMAP) and Data Quality Objectives (DQO) to the DOH-CWB. The AMAP and DQO will specify the water quality sampling and testing that will be conducted before, during, and after construction to quantitatively confirm the effectiveness of the Best Management Practices (BMPs) that will be implemented to isolate and minimize potential contamination of coastal waters.

~~16.2.7~~16.2.9 §11-55, HAR – Water Pollution Control

Section 402 of the Clean Water Act requires a National Pollutant Discharge Elimination System (NPDES) authorization any time construction activity (including staging and laydown areas) covers an area one (1) acre in size or greater and is intended to prevent pollutants from reaching coastal waters as a result of storm water runoff. The Hawaiʻi Department of Health, Clean Water Branch (DOH-CWB), under §11-55, HAR, administers the NPDES program in Hawaiʻi.

Discussion:
The proposed actions may require an NPDES. Information required to obtain an NDPES permit include project specific details and construction drawings, storm and non-storm water discharge, a Stormwater Management Plan, a Best Management Practices Plan (BMPP), and Post-Construction Pollutant Control Measures. The NPDES permit application process requires the applicant to demonstrate that the necessary BMPs will be in place during the construction phase, and the BMPs will be sufficient to prevent potential pollution during conditions identified for a 10-year rain event.

16.3 City and County of Honolulu

Coastal lands in Waikīkī mauka (landward) of the shoreline are located in the Special Management Areas (SMA), and City and County of Honolulu rules and regulations apply.

16.3.1 General Plan

The General Plan for the City and County of Honolulu was first adopted in 1977 and has been subsequently amended (most recently in 2002). The Plan is a comprehensive statement of the long-range social, economic, environmental and design objectives for the general welfare and prosperity of the people of Oʻahu, including broad policy statements that facilitate the attainment of the Plan's objectives.

The General Plan is organized into 11 subject areas:

I. Population
II. Economic Activity
III. The Natural Environment
IV. Housing
V. Transportation and Utilities
VI. Energy
VII. Physical Development and Urban Design
VIII. Public Safety
IX. Health and Education
X. Culture and Recreation
XI. Government Operations and Fiscal Management

Discussion:
The proposed beach improvement and maintenance actions are relevant to four key objectives outlined in the General Plan. Each of these objectives and the relevant policies are listed below, followed by a discussion of the program's relationship to each:

II. Economic Activity, Objective B: To maintain the viability of Oahu's visitor industry.

- *Policy 2*: Provide for a high quality and safe environment for visitors and residents in Waikīkī.
- *Policy 3*: Encourage private participation in improvements to facilities in Waikīkī.
- *Policy 8*: Preserve the well-known and widely publicized beauty of Oʻahu for visitors as well as residents.

Discussion:
Waikīkī is recognized as Hawaii's primary visitor destination and is home to more than 30,000 visitor accommodation units including resorts, hotels, and condominiums, which accounts for 90% of all units on Oʻahu and nearly half of all units in the State of Hawaiʻi (HTA, 2018). The beaches of Waikīkī have tremendous historical, cultural, and recreational value and are the primary amenity that supports the tourism-based economies of Waikīkī and the State of Hawaiʻi. Hospitality Advisors LLC (2008) found that more than 90% of visitors considered beach availability in Waikīkī as very important or somewhat important.

The beaches of Waikīkī are chronically eroding, and the backshore is frequently flooded, particularly during high tides and high surf events. The beaches of Waikīkī are critical infrastructure and the primary amenity that has established Waikīkī as a world-class tourism destination. Complete erosion of Waikīkī Beach would result in an annual loss of $2.223 billion in visitor expenditures (Tarui et al. 2018).

The primary objectives of the proposed actions are to:

- Restore and improve the beaches of Waikīkī.
- Increase beach stability through improvement and maintenance of shoreline structures.
- Provide safe access to and along the shoreline.
- Increase resilience to coastal hazards and sea level rise.

The proposed actions are consistent with the objectives set forth in *Policy 2* to "provide for a high quality and safe environment for visitors and residents in Waikīkī", and *Policy 8* to "preserve the well-known and widely publicized beauty of Oʻahu for visitors as well as residents". The proposed actions will improve lateral access along the shoreline for both tourists and residents, thereby improving access to ocean-based recreational activities along the beach. Increasing the viability of Waikīkī Beach, Hawaii's top visitor destination, will directly support the economies of the State of Hawaiʻi and City and County of Honolulu.

In 2019, the Hawaiʻi State Legislature appropriated $8.85 million to support beach improvement and maintenance projects in Waikīkī with up to $3 million of this support provided by the Waikīkī Beach Special Improvement Distract Association (WBSIDA). The funds contributed by the WBSIDA are consistent with the objective set forth in *Policy 3* to "encourage private participation in improvements to facilities in Waikīkī".

III. Natural Environment, Objective A: To protect and preserve the natural environment.

- *Policy 1*: Protect Oahu's natural environment, especially the shoreline, valleys, and ridges, from incompatible development.
- *Policy 2*: Seek the restoration of environmentally damaged areas and natural resources.
- *Policy 3*: Retain the Island's streams as scenic, aquatic, and recreation resources.
- *Policy 4*: Require development projects to give due consideration to natural features such as slope, flood and erosion hazards, water-recharge areas, distinctive land forms, and existing vegetation.
- *Policy 5*: Require sufficient setbacks of improvements in unstable shoreline areas to avoid the future need for protective structures.

III. Natural Environment, Objective B: To preserve and enhance the natural monuments and scenic views of Oʻahu for the benefit of both residents and visitors.

- *Policy 1*: Protect the Island's well-known resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shoreline, fishponds, and bays; and reefs and offshore islands.

Discussion:

The beaches of Waikīkī are chronically eroding, and the backshore is frequently flooded, particularly during high tides and high surf events. The proposed beach improvement and maintenance actions will help to protect and preserve the beaches of Waikīkī, which are a valuable Public Trust resource.

X. Culture and Recreation
Objective D: To provide a wide range of recreational facilities and services that are readily available to all residents of Oahu.

- *Policy 5*: Encourage the State to develop and maintain a system of natural resource-based parks, such as beach, shoreline, and mountain parks.
- *Policy 6*: Provide convenient access to all beaches and inland recreation areas.
- *Policy 8*: Encourage ocean and water-oriented recreation activities that do not adversely impact on the natural environment.
- *Policy 10*: Encourage the private provision of recreation and leisure-time facilities and services.
- *Policy 12*: Provide for safe and secure use of public parks, beaches, and recreation facilities.

Discussion:
The beaches of Waikīkī are chronically eroding and lateral shoreline access is limited in many areas. As sea levels continue to rise and the beaches continue to erode, the shoreline will become increasingly less accessible. The proposed beach improvement and maintenance actions will help to improve lateral shoreline access which will help to support the various beach and ocean-based recreation activities that are currently practiced in Waikīkī.

16.3.2 Primary Urban Center Development Plan

The City and County of Honolulu's Development Plan (DP) program provides a conceptual framework for implementing the objectives and policies of the General Plan on a regional basis. Eight geographical DP and Sustainable Communities Plan (SCP) areas have been established on Oʻahu. Waikīkī is included in the Primary Urban Center Development Plan, which includes the coastal plain that extends along Oʻahu's southern shore from Waiʻalae -Kahala in the east to Pearl City in the west, and from the shoreline to the westerly slopes of the Koʻolau mountain range.

The Primary Urban Center Development Plan reaffirms the region's role in Oʻahu's development pattern through the establishment of policies in the following areas:

- Natural, historic, cultural and scenic resources
- Parks and recreation areas
- Lower- and higher-density residential neighborhoods
- Commercial and visitor industry facilities
- Military installations, transportation centers and industrial areas
- Design of streets and buildings
- Neighborhood planning
- Transportation networks and systems

Discussion:
The proposed beach improvement and maintenance actions comply with the following policies and guidelines in the Primary Urban Center Development Plan:

- Protect scenic beauty and scenic views and provide recreation (Section 3.1.1 Open Space Preservation).
- Promote access to shoreline and mountain areas (Section 3.1.1 Open Space Preservation).
- Modify shoreline setbacks as needed to protect the natural shoreline, lessen the impact to coastal processes, and address sea level rise (Section 3.1.3.2 Shoreline Areas).
- Analyze the possible impact of sea level rise for new public and private projects in shoreline areas and incorporate, where appropriate and feasible, measures to reduce risks and increase resiliency to impacts of sea level rise (Section 3.1.3.2 Shoreline Areas).

The Primary Urban Center Development Plan is currently being revised and was transmitted to the Honolulu Planning Commission for review on October 18, 2023.

16.3.3 Oʻahu Resilience Strategy

The Oʻahu Resilience Strategy is a clear vision for a thriving island community—even in the face of challenge and change. The Strategy includes four pillars, 12 goals, and 44 actions for the City, partners, and our community to implement in order to directly address the challenge of long-term affordability and the impacts of the climate crisis.

The Oʻahu Resilience Strategy, developed by the City and County of Honolulu, Office of Climate Change, Sustainability and Resiliency, was formally adopted by the Honolulu City Council in September 2019 (Resolution 19-233). The Strategy serves as a guiding policy document to improve Oahu's resilience to social, economic and environmental stresses, with an emphasis on preparing for climate change impacts. To inform climate resilient planning while balancing economic and environmental goals for sustainability, the Strategy identifies 44 actions across four focal areas or resilience "pillars":

- *Pillar I*: Remaining Rooted
- *Pillar II*: Bouncing Forward
- *Pillar III*: Climate Security
- *Pillar IV*: Community Cohesion

Discussion:
The proposed beach improvement and maintenance actions are consistent with the following goals and actions items of the Oʻahu Resilience Strategy:

Pillar II. Bouncing Forward

Goal 1: Pre-Disaster Preparation

Action 14. Establish Future Conditions Climate Resilience Design Guidelines

Goal 2: Effective Disaster Response

Action 18. Increase Oahu's Preparedness Utilizing Scenario Modeling and Artificial Intelligence

Pillar III. Climate Security

Goal 3: Climate Resilient Future

Action 28. Chart a Climate Resilient Future by Creating and Implementing a Climate Adaptation Strategy

Action 29. Protect Beaches and Public Safety with Revised Shoreline Management Rules

Action 30. Protect Coastal Property and Beaches Through Innovation and Partnerships

Action 34: Minimize Economic and Property Risk within the Ala Wai Canal Watershed

Waikīkī is directly exposed to natural hazards including tsunami, storm surge and hurricanes. The beaches of Waikīkī are chronically eroding and the backshore (landward of the beach) is frequently flooded, particularly during high tides and high surf events. In recent years, Hawaiʻi has experienced record high tides (referred to as King Tides) that have exacerbated erosion and flooding in Waikīkī. These events have highlighted the impacts of sea level rise on the beaches of Waikīkī. As sea levels continue to rise, beach loss will progressively degrade the recreational, social, cultural, environmental, aesthetic, and economic value of Waikīkī.

As the beaches continue to erode and flooding occurs more frequently and extends further landward, processes that are likely to accelerate as sea levels continue to rise, the shoreline will migrate further landward. As the shoreline approaches the existing shoreline armoring, there will be incremental loss of recreational beach area and shoreline habitat, a process that is referred to as coastal squeeze (Lester and Matella, 2016). While it is possible that some sand may remain in front of the existing shoreline armoring, what remains of the beaches will be narrow, submerged, unstable, inaccessible, and unusable. Without beach improvements and maintenance, sea level rise will likely result in substantial beach loss in Waikīkī.

The Oʻahu Resilience Strategy defines resilience as “the ability to survive, adapt and thrive regardless of what shocks or stresses come our way.” Healthy, stable beaches provide a first line of defense against coastal flooding and inundation by rising sea levels and hurricane storm waves. Beach improvements are necessary to ensure that the beaches and economy of Waikīkī are sustainable and resilient to sea level rise.

16.3.4 Climate Ready Oʻahu

The City and County of Honolulu developed the Climate Ready Oʻahu plan to serve as a comprehensive resilience strategy for the island of Oʻahu. The plan was formally adopted by the Honolulu City Council in February 2024 (Resolution 24-016). The Climate Ready Oʻahu plan consists of 12 strategies with 54 recommended actions to address the projected impacts of climate change, sea level rise, and coastal erosion on the island of Oʻahu.

Discussion:

The proposed beach improvement and maintenance actions are consistent with the following goals and actions items of the Climate Ready Oʻahu plan:

Strategy 5: Strengthen climate resilience of beach and wetland ecosystems through preservation and restoration.

Action 5.4 Collaborate with the community to restore beach and dune systems in City Beach parks.

The proposed actions were developed in close collaboration with the Waikīkī Beach Community Advisory Committee (WBCAC), which was formed in 2017 to provide a forum to engage stakeholders and provide guidance and feedback on design criteria and rationale for beach improvement and maintenance projects in Waikīkī. The WBCAC is composed of various stakeholders representing business (29%), government (29%), hotels and resorts (11%), non-profit organizations (14%), and science and engineering (17%). The WBCAC serves as a representative body to communicate the diversity of perspectives and priorities in the broader Waikīkī community, provide guidance and feedback for beach management and planning activities in Waikīkī, and ensure that future beach management projects address the issues and concerns of the Waikīkī community and local stakeholders.

The WBCAC has and continues to serve a vital role in the planning process that led to the selection of the proposed actions. The WBCAC was directly involved in determining the priorities and objectives for each beach sector, establishing planning and design criteria, evaluating conceptual options, and providing feedback on the conceptual designs for the proposed actions. The function of the WBCAC is further enhanced by the role of the University of Hawaiʻi Sea Grant Program's Waikīkī Beach Management Coordinator, who provides technical support, education and outreach, and project coordination. The WBCAC held six (6)eight (8) formal meetings from 2017 to 20212022. The meeting agendas and outcomes are included as Appendix A. The WBCAC will continue to provide feedback on the proposed actions throughout the environmental review, final design, and permitting processes.

Strategy 9: Safe and Reliable Infrastructure

Action 9.4: Create a toolbox of innovative funding mechanisms for climate adaptation.

The Climate Ready Oʻahu plan recognizes funding as one of the main constraints to effective and proactive climate adaptation and identified Special Improvement Districts (SID) as an innovative mechanism for climate adaptation. The actions proposed for implementation in Waikīkī will be undertaken by the State of Hawaiʻi Department of Land and Natural Resources (DLNR) in collaboration with the Waikīkī Beach Special Improvement District Association (WBSIDA), which is a private non-profit organization that was created in 2015 by City and County of Honolulu ordinance to preserve and restore Waikīkī Beach, and to serve as a cost-share partner in a public-private partnership with the DLNR. The WBSIDA is governed by a Board of Directors that consists of representatives of Waikīkī's major resorts, property owners, State and County government designees, and other stakeholders. The WBSIDA provides a mechanism for coordination of the proposed actions with a broad spectrum of Waikīkī stakeholders and securing private funding to support project implementation.

16.3.5 Special Management Area

The Hawaiʻi Coastal Zone Management (CZM) Program (Chapter 205A, HRS) regulates all types of land uses and activities ("development") in the Special Management Area (SMA). Under Chapter 205A, HRS, this has been delegated to the planning departments of the counties of Kauaʻi, Maui, and Hawaiʻi and the Department of Planning and Permitting of the City and C The City and County of Honolulu has adopted: (1) boundaries which identify the SMA; and (2) rules and regulations which are consistent with Chapter 205A, HRS, that control development within the SMA (Chapter 25, ROH). The proposed actions should, therefore, comply with the objectives and policies contained in Chapter 205A-2, HRS, entitled Coastal Zone Management; objectives and policies, and the review guidelines contained in 205A-26, HRS entitled Special Management Areas.

Discussion:
The proposed beach improvement and maintenance actions will be located primarily makai (seaward) of the shoreline in the Conservation District. However, some aspects of the projects including but not limited to project laydown/staging areas and ingress/egress routes may be located within the SMA. As a result, one or more of the proposed actions may require an SMA permit from the City and County of Honolulu, Department of Planning and Permitting.

16.3.6 Shoreline Setbacks

It is a primary policy of the City and County of Honolulu to protect and preserve the natural shoreline, especially sandy beaches; to protect and preserve public pedestrian access laterally along the shoreline and to the sea; and to protect and preserve open space along the shoreline. It is also a secondary policy of the city to reduce hazards to property from coastal floods (Chapter 26, ROH).

Pursuant to Chapter 205A, HRS, the City and County of Honolulu has established standards and procedures that "generally prohibit within the shoreline area any construction or activity which may adversely affect beach processes, public access along the shoreline, or shoreline open space" (Chapter 26, ROH). The shoreline area regulated by the City and County of Honolulu, Department of Planning and Permitting encompasses the land between the certified shoreline and the shoreline setback line, which is typically 40 feet inland from the certified shoreline with exceptions that allow for adjustments. Structures and activities are expressly prohibited within the shoreline setback area. A Shoreline Setback Variance (SSV) is required for all proposed structures, facilities, construction or any such activities which are prohibited within the shoreline setback area.

Discussion:
The proposed actions will be located primarily makai (seaward) of the shoreline in the Conservation District. However, some construction activities may take place mauka (landward) of the shoreline. As a result, one or more of the proposed actions may require a SSV from the City and County of Honolulu, Department of Planning and Permitting.

17. SUMMARY OF REQUIRED PERMITS AND APPROVALS

17.1 Federal

The following Federal approvals are anticipated to be required for the proposed actions:

- Section 10, Rivers and Harbors Act (U.S. Army Corps of Engineers)
- Section 404, Clean Water Act (U.S. Army Corps of Engineers)

Other Federal laws that may affect the proposed actions include:

- Archaeological and Historic Preservation Act (16 USC § 469a-1)
- National Historic Preservation Act of 1966 (16 USC § 470(f))
- Native American Graves Protection and Repatriation Act of 1990 (25 USC § 3001)
- Clean Air Act (42 USC § 7506(C))
- Coastal Zone Management Act (16 USC § 1456(C) (1))
- Endangered Species Act (16 U.S.C. 1536(A) (2) and (4))
- Fish and Wildlife Coordination Act of 1934, as amended (16 USC §§ 661-666[C] et seq.)
- Magnuson-Stevens Fishery Conservation and Management Act (16 USC § 1801 et seq.)
- Marine Mammal Protection Act of 1972, as amended (16 USC §§ 1361-1421(H) et seq.)
- EO 13089, Coral Reef Protection (63 FR 32701)
- Migratory Bird Treaty Act of 1918, as amended (16 USC §§ 703-712)

17.2 State of Hawaiʻi

The following State of Hawaiʻi approvals are anticipated to be required for the proposed actions:

- Conservation District Use Permit – Hawaiʻi Department of Land and Natural Resources
- ~~Small-scale Beach Nourishment Permit – Hawaiʻi Department of Land and Natural Resources~~
- ~~Small-scale Beach Restoration Permit – Hawaiʻi Department of Land and Natural Resources~~
- Shoreline Certification – Hawaiʻi Department of Land and Natural Resources
- Right of Entry Permit – Hawaiʻi Department of Land and Natural Resources
- Section 401 Water Quality Certification – Hawaiʻi Department of Health
- National Pollutant Discharge Elimination System Permit – Hawaiʻi Department of Health
- Air Pollution Permit – Hawaiʻi Department of Health
- Community Noise Permit – Hawaiʻi Department of Health
- Coastal Zone Management Consistency Review – Hawaiʻi Department of Business, Economic Development, and Tourism, Office of Planning and Sustainable Development

17.3 City and County of Honolulu

The following City and County of Honolulu approvals are anticipated to be required for the proposed actions:

- Special Management Area Use Permit
- Shoreline Setback Variance
- ~~Grubbing,~~ Grading Permit and/or Stockpiling Permit

- Building Permit

A summary of the regulatory approvals that are anticipated to be required for the proposed actions is shown in Table 17-1.

Table 17-1 Summary of Required Regulatory Approvals

	Fort DeRussy Beach Sector	Halekūlani Beach Sector	Royal Hawaiian Beach Sector	Kūhiō Beach Sector: ʻEwa Basin	Kūhiō Beach Sector: Diamond Head Basin
FEDERAL					
Department of the Army Nationwide Permit (NWP)	~~TBD~~N	N	N	N	~~TBD~~R
Department of the Army Individual Permit (IP)	N	R	R	~~TBD~~R	N
STATE OF HAWAIʻI					
~~Small Scale Beach Nourishment Permit (SSBN)~~	~~TBD~~R	~~N~~	~~N~~	~~N~~	~~TBD~~R
~~Small Scale Beach Restoration Permit (SSBR)~~	~~TBD~~	~~N~~	~~TBD~~	~~TBD~~	~~TBD~~
Shoreline Certification	~~N~~R	~~TBD~~R	~~TBD~~R	~~TBD~~R	~~N~~R
Conservation District Use Permit (CDUP)	~~TBD~~R	R	R	R	~~N~~R
Right of Entry Permit (ROE)	R	R	R	R	R
Coastal Zone Management Federal Consistency (CZM)	~~N~~R	R	R	R	~~N~~R
National Pollutant Discharge Elimination System Permit (NPDES)	~~N~~R	R	R	R	N
Section 401 Water Quality Certification (WQC)	~~TBD~~R	R	R	R	~~TBD~~R
Community Noise Permit	R	R	R	R	R
Air Pollution Permit	R	R	R	R	R
CITY AND COUNTY OF HONOLULU					
Shoreline Setback Variance	N	TBD	N	TBD~~N~~	N
Special Management Area Use Permit	TBD~~N~~	TBD	TBD	TBD	N
~~Grubbing,~~ Grading Permit and/or Stockpiling Permit	~~N~~R	R	N	N	N
Building Permit	N	TBD	N	TBD	N

R = REQUIRED
N = NOT REQUIRED
TBD= TO BE DETERMINED

18. EIS DETERMINATION

§11-200.1, HAR, establishes procedures for determining if an action may potentially have a significant effect on the environment and thus require an EIS. An EIS is required if the proposed actions may:

1. Irrevocably commit a natural, cultural, or historic resource;
2. Curtail the range of beneficial uses of the environment;
3. Conflict with the State's environmental policies or long-term environmental goals established by law;
4. Have a substantial adverse effect on the economic welfare, social welfare, or cultural practices of the community or State;
5. Have a substantial adverse effect on public health;
6. Involve adverse secondary impacts, such as population changes or effects on public facilities;
7. Involve a substantial degradation of environmental quality;
8. Be individually limited but cumulatively have substantial adverse effect upon the environment or involves a commitment for larger actions;
9. Have a substantial adverse effect on a rare, threatened, or endangered species, or its habitat;
10. Have a substantial adverse effect on air or water quality or ambient noise levels;
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 water;
12. Have a substantial adverse effect on scenic vistas and viewplanes, during day or night, identified in County or State plans or studies; or
13. Require substantial energy consumption or emit substantial greenhouse gases.

The Hawaiʻi Department of Land and Natural Resources, determined that the proposed actions could have potentially significant impacts that should be evaluated and discussed by preparing an Environmental Impact Statement (EIS) in accordance with Chapter 343, HRS and §11-200.1, HAR. Pursuant to Act 172 (12), the DLNR determined that the proposed actions constitute a "program"; therefore, a "programmatic" EIS is required.

19. EIS CONSULTATIONS

The proposed actions presented in this DPEIS FPEIS are the result of consultations that were conducted with the State of Hawaiʻi, Department of Land and Natural Resources, Office of Conservation and Coastal Lands (DLNR-OCCL), the Waikīkī Beach Special Improvement District Association (WBSIDA), and the Waikīkī Beach Community Advisory Committee (WBCAC). The purpose of these consultations was to establish priorities and design criteria for beach improvement and maintenance projects that will achieve State of Hawaiʻi and City and County of Honolulu objectives to improve the resilience and sustainability of Waikīkī's beaches, while minimizing disruption to existing commercial operations.

19.1 Summary of EIS Consultations

12/16/2016	Waikīkī Beach Special Improvement District Association coordination meeting
11/07/2017	Waikīkī Beach Community Advisory Committee meeting
12/05/2017	Public scoping meeting at Waikīkī Community Center
01/28/2018	Waikīkī Beach Special Improvement District Association coordination meeting
03/20/2018	Waikīkī Beach Community Advisory Committee meeting
07/13/2018	Waikīkī Beach Special Improvement District Association coordination meeting
02/13/2019	Waikīkī Beach Community Advisory Committee meeting
06/19/2019	Waikīkī Beach Special Improvement District Association coordination meeting
07/02/2019	Waikīkī Beach Special Improvement District Association coordination meeting
10/30/2019	Waikīkī Beach Community Advisory Committee meeting
10/30/2019	Waikīkī Beach Special Improvement District Association coordination meeting
12/06/2019	Waikīkī Beach Special Improvement District Association coordination meeting
12/23/2020	EISPN publication in the OEQC *The Environmental Notice*
01/07/2021	EIS public scoping meeting
01/19/2021	Waikīkī Beach Community Advisory Committee meeting
06/08/2021	DPEIS publication in *The Environmental Notice*
01/25/2022	Waikīkī Beach Community Advisory Committee meeting
11/01/2022	Waikīkī Beach Community Advisory Committee meeting
07/14/2023	Hawaiʻi Board of Land and Natural Resource (BLNR) informational briefing

In addition to these early consultations, the Waikīkī Beach Improvement and Maintenance Program has also been widely publicized in various news media formats (Table 19-1).

Table 19-1 Summary of media coverage

Date	Title / Source
12/04/2017	*Public forum to address future of Waikīkī beaches.* Source: Honolulu Star Advertiser
02/26/2017	*State looks through proposed solutions to Waikīkī beach erosion.* Source: KHON2
06/10/2019	*Hawai'i Allocates $13M to keep Waikīkī Beach from disappearing.* Source: Honolulu Star Advertiser
06/11/2019	*Hawai'i invests $13 million to repair state's most visited beach.* Source: Fox news
01/12/2020	*Got any ideas to prevent Waikīkī's beaches from disappearing?* (Source: Honolulu Star Advertiser
12/24/2020	*EISPN Scoping Meeting for the Waikīkī Beach Improvement and Maintenance Program.* Source: DLNR Press Release
12/27/2020	*State Proposed Waikīkī Beach Improvements; public comments welcome.* Source: KITC
01/06/2021	*DLNR: Waikīkī Beach Improvement and Maintenance Program.* Source: KHON2
02/04/2021	*Surfers challenge proposal adding T-head groins to Waikīkī Beach.* Source: Honolulu Star Advertiser
06/16/2021	*Plans for $12 million Waikīkī Beach improvements released.* Source: Honolulu Star Advertiser
06/21/2021	*Public has until July 23 to comment on proposed Waikīkī beach improvement plan.* Source: Honolulu Star Advertiser
06/21/2021	*New beach could come to Waikīkī as part of improvement and maintenance program.* Source: KHON2
06/23/2021	*DLNR May Build More Groins in Waikīkī.* Source: www.jetsetter.com
06/23/2021	*As rising seas invade Waikīkī resorts, state proposes adding more groins.* Source: Honolulu Star Advertiser
07/22/2021	*Column: Hawai'i's ocean users must beware Waikīkī shoreline plan.* Source: Honolulu Star Advertiser (editorial by Keone Downing)
08/09/2021	*Future of Waikīkī Beaches May Rely on $12M Shoreline Stabilization Project.* Source: Hawai'i Public Radio
09/02/2021	*New Royal Hawaiian Groin is first of several planned for Waikīkī.* Source: Honolulu Star Advertiser
10/26/2021	*As sea levels rise, Hawaii is scrambling to save its disappearing beaches.* Source: Hawaii News Now
10/14/2021	*How Will Urban Honolulu Deal With the Rising Ocean* Source: Hawaii Business Magazine
11/12/2021	*Waikiki stakeholders want Gov. David Ige to issue emergency declaration designating Kawehewehe Beach a disaster area.* Source: Honolulu Star Advertiser
01/13/2022	*Hawaii's famed Waikiki Beach could disappear by the end of the century. It's not the only one.*

Date	Title / Source
	Source: SFGATE
01/28/2022	*The Battle to Save Waikiki Beach.* *Source: POLITICO*
08/11/2022	*Two Of Waikiki's Oldest Beach Clubs Are Struggling To Come To Grips With Climate Change.* Source: Honolulu Civil Beat
07/14/2023	*Land Board Receives Briefing on the State of Waikīkī Coastal Lands.* Source: DLNR Press Release
07/30/2023	*Major plans for Waikiki aim to save it from waves, flooding.* Source: Honolulu Star Advertiser
04/02/2024	*Sand replenishment project planned for Waikiki beaches as erosion concerns grow* Source: Hawaii News Now
07/29/2024	*More initiatives for improvements around Waikiki* Source: Honolulu Star Advertiser

19.2 EISPN Publication

Pursuant to Hawaiʻi Administrative Rules (HAR) Chapter §11-200.1-23, HAR, publication of an Environmental Impact Statement Preparation Notice (EISPN) is required prior to filing a Draft Environmental Impact Statement (DEIS). An EISPN for the Waikīkī Beach Improvement and Maintenance Program was published in *The Environmental Notice* on December 23, 2020. The period for public review and submitting written comments on the EISPN was thirty (30) days from the date of publication. A total of 29 comments were received within the 30-day public review period. Responses to all substantive comments received on the EISPN were provided as Appendix G of the Draft Programmatic EIS, which was published in *The Environmental Notice* on June 8, 2021.

19.3 EIS Public Scoping Meeting

Pursuant to §11-200.1-23(d), HAR, a public scoping meeting was held during the EISPN 30-day public comment period. The purpose of the public scoping meeting was to provide agencies, citizen groups, and the public with an opportunity to assist the proposing agency in determining the range of actions, alternatives, impacts, and proposed mitigation measures to be considered in the DPEIS and the significant issues to be analyzed in depth in the DPEIS. The public scoping meeting included a separate portion reserved for oral comments and that portion of the public scoping meeting was audio recorded. A summary of the EIS public scoping meeting, including a general summary of the oral comments made, is provided as Appendix H.

The video recording of the EIS public scoping meeting is available at: https://www.youtube.com/watch?v=1hd0iLCCqp4&t=2348s

The audio recording of the EIS public scoping meeting is available at:

https://seaengineering-my.sharepoint.com/:v:/p/abohlander/Efs7aS6GKbdArXlngT69xooBWCw9fuMokR4kri3IjgywWg?e=P3sXeN

For additional information, please visit the project website at:
https://dlnr.hawaii.gov/occl/waikiki/

19.4 Informational Briefing

On July 14, 2023, an informational briefing was provided to the Hawaiʻi Board of Land and Natural Resource (BLNR). The purpose of the briefing was to update the BLNR and the public on the state of coastal lands in Waikīkī and the status of the EIS for the Waikīkī Beach Improvement and Maintenance Program. Item K-1 was a non-action item and included:

- A "virtual site visit" of Waikīkī presented by the Hawaiʻi Department of Land and Natural Resources (DLNR), Office of Conservation and Coastal Lands (OCCL).
- A history of public-private partnerships in Waikīkī presented by the Waikīkī Beach Special Improvement District (WBSIDA)
- A status report on the Programmatic Environmental Impact Statement for the Waikīkī Beach Improvement and Maintenance Program presented by Sea Engineering, Inc. (SEI).

The agenda for the Informational Briefing (Item K-1) is available at:
https://dlnr.hawaii.gov/meetings/blnr-meetings-2023/land-board-submittals-07-14-23/

The submittal for Item K-1 is available at:
https://dlnr.hawaii.gov/wp-content/uploads/2023/07/K-1.pdf

The presentations for the Informational Briefing are available at:
https://dlnr.hawaii.gov/occl/waikiki/

The video recording of the Informational Briefing is available at:
https://www.youtube.com/watch?v=VOBfoowENC4&t=18639s
(Item K-1 begins at 05:10:15)

The audio recording of the Informational Briefing is available at:
https://files.hawaii.gov/dlnr/meeting/audio/Audio-LNR-230714.m4a
(Item K-1 begins at 05:10:15)

The press release following the BLNR Informational Briefing is available at:
https://dlnr.hawaii.gov/blog/2023/07/17/nr23-116/

20. EIS DISTRIBUTION

The following agencies, organizations, and individuals were directly notified of publication of the Waikīkī Beach Improvement and Maintenance Program Draft Programmatic Environmental Impact Statement (DPEIS), which was published in *The Environmental Notice* on June 8, 2021. The period for public review of the DPEIS was 45 days and concluded on July 23, 2021.

The distribution matrix for the Environmental Impact Statement Preparation Notice (EISPN) and DPEIS is presented in Table 20-1. A total of 29 comments were received on the EISPN. A total of 190 comments were received on the DPEIS (Table 20-2). The representative copy of the consultation letter and written comments and corresponding response letters for the DPEIS are presented in Appendix I.

FEDERAL AGENCIES
Department of the Interior, U.S. Geological Survey, Pacific Islands Water Science Center
Department of the Interior, U.S. Fish and Wildlife Service
Department of Commerce, National Marine Fisheries Service
Department of the Interior, National Parks Service
Department of Agriculture, National Resources Conservation Service
Department of the Army, U.S. Army Corps of Engineers
Department of Transportation, Federal Aviation Administration
Department of Transportation, Federal Transit Administration
Department of Homeland Security, U.S. Coast Guard 14th District
Environmental Protection Agency, Pacific Islands Office

STATE OF HAWAIʻI
Governor's Office (Accepting Authority)
Department of Agriculture
Department of Accounting and General Services
Department of Business, Economic Development and Tourism
Department of Defense
Department of Education
Department of Hawaiian Homelands
Department of Health, Clean Water Branch
Department of Health, Environmental Health Administration
Department of Land and Natural Resources, Division of Aquatic Resources
Department of Land and Natural Resources, Division of Forestry and Wildlife
Department of Land and Natural Resources, Division of Boating and Ocean Recreation
Department of Land and Natural Resources, Land Division
Department of Land and Natural Resources, Office of Conservation and Coastal Lands
Department of Land and Natural Resources, State Historic Preservation Division
Department of Transportation
Legislative Reference Bureau Library
Office of Planning and Sustainable Development
Office of Hawaiian Affairs
University of Hawaiʻi, Sea Grant Program

University of Hawaiʻi, Water Resources Research Center
University of Hawaiʻi, Thomas H. Hamilton Library
University of Hawaiʻi at Hilo Edwin H. Moʻokini Library
University of Hawaiʻi, Maui College Library
University of Hawaiʻi, Kauaʻi Community College Library

CITY AND COUNTY OF HONOLULU
City and County of Honolulu, Department of Planning and Permitting
City and County of Honolulu, Department of Design and Construction
City and County of Honolulu, Department of Enterprise Services
City and County of Honolulu, Department of Parks and Recreation
City and County of Honolulu, Office of Climate Change, Sustainability and Resilience

STATE LIBRARIES
Department of Education, Hawaiʻi State Library
Department of Education, Kaimuki Regional Library
Department of Education, Waikīkī-Kapahulu Library

MEDIA
Honolulu Star Advertiser
Hawaiʻi Tribune Herald
West Hawaiʻi Today
The Garden Island
Maui News
Molokaʻi Dispatch
Honolulu Civil Beat

OTHER
U.S. Senator Mazie Hirono
U.S. Senator Brian Schatz
U.S. Representative Ed Case
State Senator Sharon Moriwaki
State Representative Adrian Tam
Honolulu County Council Representative Tommy Waters
Hawaiʻi Tourism Authority
Waikīkī Beach Special Improvement District Association
Waikīkī Improvement Association
Waikīkī Neighborhood Board
Diamond Head/Kapahulu/St. Louis Neighborhood Board
Hawaiʻi Shore and Beach Preservation Association
Surfrider Foundation, Oʻahu Chapter
Save Our Surf Hawaiʻi

Table 20-1 EIS Distribution Matrix

EIS Distribution	EISPN Notification	EISPN Comments	EISPN Responses	DPEIS Notification
FEDERAL AGENCIES				
Department of the Interior, U.S. Geological Survey, Pacific Islands Water Science Center	✓			✓
Department of the Interior, U.S. Fish and Wildlife Service	✓			✓
Department of Commerce, National Marine Fisheries Service	✓	✓	✓	✓
Department of the Interior, National Parks Service	✓			✓
Department of Agriculture, National Resources Conservation Service	✓			✓
Department of the Army, U.S. Army Corps of Engineers	✓			✓
Department of Transportation, Federal Aviation Administration	✓			✓
Department of Transportation, Federal Transit Administration	✓			✓
Department of Homeland Security, U.S. Coast Guard 14th District	✓			✓
Environmental Protection Agency, Pacific Islands Office	✓			✓
STATE OF HAWAIʻI				
Governor's Office (Accepting Authority)				✓
Department of Agriculture	✓			✓
Department of Accounting and General Services	✓	✓	✓	✓
Department of Business, Economic Development and Tourism	✓			✓
Department of Business, Economic Development and Tourism, Office of Planning and Sustainable Development, Coastal Zone Management Program	✓	✓	✓	✓
Department of Business, Economic Development and Tourism, Office of Planning and Sustainable Development, Environmental Review Program	✓			✓
Department of Defense	✓			✓
Department of Hawaiian Homelands	✓			✓
Department of Health, Clean Water Branch	✓			✓
Department of Land and Natural Resources, Division of Forestry and Wildlife	✓			✓
Department of Land and Natural Resources, Division of Boating and Ocean Recreation	✓			✓

EIS Distribution	**EISPN Notification**	**EISPN Comments**	**EISPN Responses**	**DPEIS Notification**
Department of Land and Natural Resources, Office of Conservation and Coastal Lands	✓			✓
Department of Land and Natural Resources, Land Division	✓			✓
Department of Land and Natural Resources, State Historic Preservation Division	✓			✓
STATE OF HAWAI'I				
Department of Land and Natural Resources, Division of Aquatic Resources	✓			✓
Department of Transportation	✓			✓
Department of Health, Environmental Health Administration	✓			✓
Legislative Reference Bureau Library	✓			✓
Office of Hawaiian Affairs	✓			✓
University of Hawai'i, Sea Grant Program	✓			✓
University of Hawai'i, Water Resources Research Center	✓			✓
University of Hawai'i, Thomas H. Hamilton Library	✓			✓
University of Hawai'i at Hilo Edwin H. Mo'okini Library	✓			✓
University of Hawai'i, Maui College Library	✓			✓
University of Hawai'i, Kaua'i Community College Library	✓			✓
CITY AND COUNTY OF HONOLULU				
City and County of Honolulu, Department of Planning and Permitting	✓	✓	✓	✓
City and County of Honolulu, Department of Enterprise Services	✓			✓
City and County of Honolulu, Department of Design and Construction	✓	✓	✓	✓
City and County of Honolulu, Department of Parks and Recreation	✓			✓
City and County of Honolulu, Office of Climate Change, Sustainability and Resilience	✓			✓
STATE LIBRARIES				
Department of Education, Hawai'i State Library	✓			✓
Department of Education, Kaimuki Regional Library	✓			✓
Department of Education, Waikīkī-Kapahulu Library	✓			✓

EIS Distribution	EISPN Notification	EISPN Comments	EISPN Responses	DPEIS Notification
MEDIA				
Honolulu Star Advertiser	✓			✓
Hawaiʻi Tribune Herald	✓			✓
West Hawaiʻi Today	✓			✓
The Garden Island	✓			✓
Maui News	✓			✓
Molokaʻi Dispatch	✓			✓
Honolulu Civil Beat	✓			✓
OTHER				
U.S. Senator Mazie Hirono	✓			✓
U.S. Senator Brian Schatz	✓			✓
U.S. Representative Ed Case	✓			✓
State Senator Sharon Moriwaki	✓			✓
State Representative Adrian Tam	✓			✓
Honolulu County Council Representative Tommy Waters	✓			✓
Hawaiʻi Tourism Authority	✓			✓
Waikīkī Beach Special Improvement District Association	✓	✓	✓	✓
Waikīkī Improvement Association	✓			✓
Waikīkī Neighborhood Board	✓	✓	✓	✓
Diamond Head/Kapahulu/St. Louis Neighborhood Board	✓			✓
Hawaiʻi Shore and Beach Preservation Association	✓	✓	✓	✓
Surfrider Foundation, Oʻahu Chapter	✓	✓	✓	✓
Save Our Surf Hawaiʻi	✓	✓	✓	✓

Table 20-2 Public Comments and Responses

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
ABC Stores	✓	✓		
Aqualani Beach & Ocean Recreation	✓	✓		
Dennis Furukawa	✓	✓	✓	✓
Douglas Meller	✓	✓	✓	✓
John Clark	✓	✓		
Joseph Little	✓	✓		
Kyo-ya Hotels and Resorts LP	✓	✓	✓	✓
Maitaʻi and Holokai Catamaran, Inc.	✓	✓	✓	✓
Mandy Blake Bower	✓	✓		
Mark Robinson Trusts and J.L.P. Robinson LLC	✓	✓		
Outrigger Hotels	✓	✓		
Park Hotels & Resorts, Inc. and Hilton Hawaiian Village LLC	✓	✓	✓	✓
Richard Criley	✓	✓		
Robert Fowler	✓	✓		
Russell Leong	✓	✓		
Sidney Sealine	✓	✓		
Queen Emma Land Company	✓	✓		
Waikīkī Beach Services, Ltd.	✓	✓		
Waikīkī Shore AOAO	✓	✓		
Sharon Venegas			✓	✓
Gary Kawakami			✓	✓
John and Rita Shockley			✓	✓
Heidi Better			✓	✓
Susanne Lenz			✓	✓
N. Kau'i Baumhofer Merritt			✓	✓
Nick McGreivy			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
Robert Soberano			✓	✓
Jeff Merz (Waikīkī Neighborhood Board)			✓	✓
Joseph Gawzner			✓	✓
Bucky Goo			✓	✓
Rob Robinson			✓	✓
Alex Kozlov, P.E. (City and County of Honolulu, Department of Design and Construction)			✓	✓
Karen StGermaine			✓	✓
George Parsons (King Parsons Enterprises, Ltd.)			✓	✓
John Kamalei Titchen, J.D.			✓	✓
Richard Hamasaki			✓	✓
Bianca Isaki, Ph.D., Esq.			✓	✓
Paul Sato			✓	✓
Russell Tsuji (Hawai‘i Department of Land and Natural Resources, Land Division)			✓	✓
Cyrus Oda (Kyo-ya Hotels and Resorts)			✓	✓
Morgan Dorr			✓	✓
Alethea Rebman			✓	✓
Art Silver			✓	✓
Spencer Reemelin			✓	✓
Duane Fisher (Park Hotels and Resorts)			✓	✓
Gerry Davis (National Marine Fisheries Service)			✓	✓
Rick Egged (WBSIDA)			✓	✓
Tiare Lawrence			✓	✓
Steve Holmes			✓	✓
Lori Kuai			✓	✓
Marija Čolić, PhD, BCBA, LBA			✓	✓
Unidentified (name not provided)G			✓	✓
Glenn Choy			✓	✓
Henry Bennett			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
S. Sanae Tokumura			✓	✓
Noelle Kauanoe Campbell			✓	✓
Unidentified (name not provided)			✓	✓
Paul Hanada			✓	✓
Unidentified (name not provided)			✓	✓
Malia Kaleopaa			✓	✓
Michelle Becker			✓	✓
Mark Sollberger			✓	✓
Haley Ferguson			✓	✓
Ilima-Lei Macfarlane			✓	✓
Iolana Brewster			✓	✓
Daniel Ikaika Ito			✓	✓
Kaleo N Juraesha Feiteira			✓	✓
Melissa Jasniy			✓	✓
Kelsey Niau			✓	✓
Ronald Whang			✓	✓
Ray Madigan			✓	✓
Bill Plewes			✓	✓
Austin Kino			✓	✓
Carly Byrd			✓	✓
Patrice Choy			✓	✓
John Witeck			✓	✓
Jayla-Riana Sabado			✓	✓
Sarah Steiner			✓	✓
Jazmin Shaffer			✓	✓
Lindsey Dugas			✓	✓
Frankie Aguirre			✓	✓
Sam Garney			✓	✓
Amelia Guertin			✓	✓
Zachary Hitchcock			✓	✓
Hope Tucker			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
Brooke Madrid			✓	✓
Connor Gehris			✓	✓
Kenneth Martens			✓	✓
Allison Candelario			✓	✓
Michaela Rabinov			✓	✓
Alexis Giroux			✓	✓
Eric Nariyoshi			✓	✓
Lucia Gorostiza			✓	✓
Brandee Burgess			✓	✓
Victoria Saldivar			✓	✓
Courtnee Nunokawa			✓	✓
Alicia Alethea			✓	✓
Cassidy Tabata			✓	✓
Robert and Jeanine Goldman			✓	✓
Melissa Gomez			✓	✓
Amber Mira			✓	✓
Savana Ignacio-Torres			✓	✓
Jessee Hoge Kagawa			✓	✓
Danielle Enright			✓	✓
Aubrie Usui			✓	✓
Seaton K. Tilo			✓	✓
Lanning Christophersen Lee, Ph.D.			✓	✓
Dennis Furukawa			✓	✓
Sebastian Kevany			✓	✓
Claire Shearman			✓	✓
Janice Greenwood, MFA			✓	✓
Violet Hahn			✓	✓
Heejung Kang			✓	✓
Damian McPherson			✓	✓
Rhea Nuguid			✓	✓
Tyler Watanabe			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
Amy Rockwell			✓	✓
Gabrielle Garrison			✓	✓
Taryn Holeso-Aki			✓	✓
Delta Dawn Lam			✓	✓
Diane Choy Fujimura			✓	✓
Tabatha Knudson			✓	✓
Annie Fruth			✓	✓
Pua Malia Wong			✓	✓
Stephanie Cram			✓	✓
Ashley Q Wang			✓	✓
Lyla Gonsalves			✓	✓
Henry Mesker			✓	✓
Kayla Gallagher			✓	✓
Travis Edwards			✓	✓
Jason Huang			✓	✓
Mikaela Oshiro			✓	✓
Julia Wolfson			✓	✓
Kayla Cardin			✓	✓
Coral O			✓	✓
John Shigemura			✓	✓
Lei Tocman			✓	✓
Vilma Brice			✓	✓
Xylene Gonzalez			✓	✓
Unidentified (name not provided)			✓	✓
Bridget Mullany			✓	✓
Chelsea Soden			✓	✓
Unidentified (name not provided)			✓	✓
Tim Yee			✓	✓
Jane Chung-Do, PhD			✓	✓
Shannon O'Neill			✓	✓
Sabeth Burad Cuevas			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
Hokulani Nichols			✓	✓
Ava Alders			✓	✓
Kristin Doell			✓	✓
Sandra Kohn			✓	✓
Unidentified (name not provided)			✓	✓
Douglas Meller			✓	✓
Sara Mayko			✓	✓
Kelly Ciurej			✓	✓
Lai Ming Larrea-Tam			✓	✓
Sera Shigeta			✓	✓
Quinton Slade-Matautia			✓	✓
Darcie Morondos			✓	✓
Will Allison			✓	✓
Christina Gobert			✓	✓
Unidentified (name not provided)			✓	✓
Kelis Kaleopaa			✓	✓
Ted Bohlen (Hawai'i Ocean and Reef Coalition)			✓	✓
Tommy Waters (Honolulu City Council)			✓	✓
Allison Yoon			✓	✓
Sara Lara			✓	✓
Kiana Kaempf			✓	✓
Kamakaniokaaina Paikai			✓	✓
Jose Santos			✓	✓
Patricia Thompson			✓	✓
Brittany Walker			✓	✓
Haunani Kāne			✓	✓
Emma Cosford			✓	✓
Yukino Noro			✓	✓
Rachele Mataere			✓	✓
April Mercer			✓	✓
Keala Nazareno			✓	✓

	EISPN Notification	EISPN Comments	DPEIS Comments	DPEIS Responses
Sara Cuhane			✓	✓
Anissa Banda			✓	✓
Kim Estoque			✓	✓
Geodee Clark			✓	✓
Dillyn Lietzke			✓	✓
Kaylani Pula Mauigoa			✓	✓
Kaitlin Banks			✓	✓
Kelia Moniz			✓	✓
Bronson Chinen			✓	✓
Charlene Holani			✓	✓
Melodie Aduja and Alan Burdick (Environmental Caucus of the Democratic Party of Hawaiʻi)			✓	✓
Unidentified (name not provided)			✓	✓
Briahni Atisanoe			✓	✓
Lotte Bok			✓	✓
Kuhio Vellalos			✓	✓
Doorae Shin (Surfrider Foundation, Hawaiʻi Chapter)			✓	✓
Logan Andres			✓	✓
Marilynn Simms			✓	✓
Unidentified (name not provided)			✓	✓
Vincent Burke			✓	✓
Katy Meza			✓	✓
Veronica Ferguson			✓	✓
Maddie Dolleman			✓	✓
Forest Donovan			✓	✓
Dustin Barca			✓	✓
Wendy Snow			✓	✓
Andrew Wycklendt (Hawaiʻi Shore and Beach Preservation Association)			✓	✓
Mary Alice Evans (Office of Planning and Sustainable Development)			✓	✓
Dean Uchida (City and County of Honolulu Department of Planning and Permitting)			✓	✓
Laura Thielen (City and County of Honolulu Department of Parks and Recreation)			✓	✓
Lisa Wallace (State of Hawaiʻi Department of Health, Clean Air Branch)			✓	✓

21. GLOSSARY

Accretion: The gradual addition of new beach to old by the deposition of sediment carried by the ocean.

Beach Berm: A low shelf or narrow terrace on the backshore of a beach, formed of material thrown up and deposited by storm waves or seasonal changes in wave climate.

Beach Face: The section of beach normally exposed to the action of the wave uprush; the foreshore of the beach.

Beach Nourishment: The practice of adding large quantities of sand or sediment to beaches to mitigate erosion and increase beach width.

Beach Profile: The trace of a beach surface on a vertical plane normal to the shoreline. It is commonly concave upward, as the slope is steeper above the water and more gentle seaward.

Beach Improvements: Actions that involve adding new sand, constructing new structures, and/or modifying existing structures. Beach improvement options include beach nourishment with stabilizing groins, segmented breakwaters, and modifications to existing structures.

Beach Maintenance: Actions that involve using existing sand or adding sand with no new structures or modifications to existing structures. Beach maintenance options include beach nourishment, sand backpassing, sand pushing, and sand pumping.

Beach Sector: Discrete coastal units that are semi-contained with limited sediment exchange. Beach sectors are similar to *littoral cells*, which are defined as coastal compartments that contain a complete cycle of sedimentation including sources, transport paths, and sinks (Inman, 2005).

Breakwater: A man-made structure that is designed is to protect the shoreline from waves. Breakwaters are typically parallel to shore and can be attached to shore or detached.

Certified Shoreline: Is a line established by a licensed land surveyor and certified by the State, which reflects the shoreline definition stated in Chapter 13-222 (HAR) and Chapter 205A (HRS).

Depth of Closure*:* The depth of closure is typically the deepest depth at which sediment transport connected to the beach system occurs.

Dredging: In this context - To bring up sand from an area of water.

Erosion: The wearing away of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, wind, and underground water.

Environmental Restoration: Defined in 1987 by John J. Berger as “A process in which a damaged resource is renewed. Biologically. Structurally. Functionally.”

Groin: A man-made structure that is designed to block the longshore transport of sediment. Groins are typically constructed perpendicular to the shoreline.

Littoral Cell: A coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks.

Makai: seaward or toward the sea.

Mauka: landward or toward the mountains.

Rip Current: A relatively strong, narrow current flowing outward from the beach through the surf zone and presenting a hazard to swimmers.

Sea Level Rise: The average long-term global rise of the ocean surface. Regional sea level rise refers to the long-term average sea level rise relative to the local land level, as derived from coastal tide gauges.

Seawall: A man-made structure built along the shoreline that is designed to protect the backshore from waves and erosion. Seawalls are typically steep or vertical and constructed of rock, concrete, or sheet pile.

Turbidity: The quality of being cloudy, opaque, or thick with suspended matter.

22. REFERENCES

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