FINAL Feasibility Investigation
Summary Report

Hilo Harbor Navigation Improvements

Hilo, Hawaii - Honolulu District, Pacific Ocean Division

June 2016
Status: FINAL

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Final Feasibility Investigation Summary Report

Navigation Improvements
Hilo Harbor, Hawaii

Prepared by
U.S. Army Corps of Engineers
Honolulu District

June 2016

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Executive Summary

Hilo Harbor is located on the northeast coast of the island of Hawaii (the “Big Island”); the state’s eastern and southernmost island. Hilo Harbor is one of the two main commercial ports for the Island of Hawaii (Kawaihae Harbor serves the west side of the island). Hilo Harbor is the primary location of commercial waterborne traffic for the eastern side of Hawaii Island. It averages more than 2 million tons of waterborne commerce each year, provides a wide range of maritime facilities and services, and is the major distribution center for the Big Island, Hawaii. It also has the sole pier large enough to accommodate cruise ships.

General Navigation Features at Hilo Harbor include a 10,080-foot-long breakwater protecting a 35-ft deep entrance channel as well as a 1,400-ft wide by 2,300-ft long, 35-ft deep basin. Hilo Harbor has three existing piers and a fourth (Pier 4) to be constructed by 2016. Pier 1 is 1,265 feet long and is used by interisland container barges, cargo ships, and large cruise ships. Pier 2 is 703 feet long and is used by cement barges and has a roll-on/roll-off interisland barge facility. Pier 3 is 763 feet long and is primarily used by fuel barges. The proposed Pier 4 will be 602 feet long and used to support interisland cargo operations. The non-federal sponsor for the Hilo Harbor Modification Study is the State of Hawaii, Department of Transportation, Harbors Division. A Feasibility Cost Sharing Agreement (FCSA) was executed September 30, 2013 by the U.S. Army Corps of Engineers (USACE), Honolulu District (POH) and the non-federal sponsor to complete a Feasibility Study investigating potential harbor modifications.

The study was conducted at the request of the non-federal sponsor, which is concerned that turning basin dimensions are inadequate for the existing and future fleet calling at Hilo Harbor. Currently, harbor pilots take unwarranted risks and operate under less than ideal conditions while turning large cruise ships of lengths ranging from 700 to 950 ft. A number of vessels are presently unable to use the harbor due to current federally authorized turning basin dimensions. The limited turning basin dimensions also impede port operations, as delays are associated with maneuvering and docking time. During high wave conditions frequently occurring in the winter months, waves and long-period wave energy impact navigation in the entrance channel and turning basin, resulting in vessel delays. Long-period wave energy in the harbor also impacts operations. During periods of large waves, increased time is required for loading/offloading and mooring of passenger, cargo and commodities vessels. In addition, the existing Federal channel limit is approximately 600 feet from the face of Pier 1, which is not consistent with non-federal berthing area dimensions on a national basis. This space between the edge of the Federal turning basin and the Pier 1 berthing area requires vessels to execute turning maneuvers for arrival and departures well outside the limits of the Federal turning basin.

The non-Federal sponsor, by letter dated 27 July 2015, has requested that the Honolulu District evaluate the accuracy of the Federal project limits in proximity to Pier 1 as authorized by federal law. The non-federal sponsor is responsible for maintaining the depth of the berthing areas.

The alternatives that were developed by the project team were aimed at addressing the goals and objectives of the study, which were developed based on the previously identified existing conditions and problems at the harbor, as well as areas that are within USACE authority. The project goals are, improve navigation and operational efficiency of the harbor, increase allowable vessel sizes calling at Hilo Harbor, and improve safe use of Hilo Harbor.

Since no single measure is able to address both the need for a larger turning basin and the wave impacts to navigation/operations, it is anticipated that breakwater modification(s) and turning basin modifications (by dredging) could be used either in combination to improve all issues identified, or independently to deal with some (but not all) of the problems being experienced. It was concluded from the ship simulations that a turning basin widener provides time savings to be accounted for in the economic justification of the proposed modifications. The measure also provides improved safety for maneuvering of vessels with length overall greater than accommodated by the existing project design. In addition, the expansion of the Federal turning basin toward Pier 1 was determined to improve safety, since simulations showed that turning maneuvers are occurring within this area. The results of wave modeling the existing harbor configuration indicated that the largest waves in the harbor were caused by waves incident from slightly oblique waves between N and NNE directions. Modeling results indicate a spur at the end of the existing breakwater is the most effective alternative because it reduces waves almost everywhere in the harbor, the turning basin and Pier #1 and Pier #2 areas. The reason the breakwater spur achieved such a dramatic reduction in waves was its ability to control waves coming through the entrance.

A breakwater spur was designed to reduce wave energy within Hilo Harbor. For this alternative, a 1,000-foot long spur would be constructed at the head of the existing breakwater in the alignment. The spur would consist of 20 concrete caisson units. A turning basin widener has been designed to facilitate efficient and safe transit of cruise ships into Pier #1 at Hilo Harbor. Dredging to a depth of 35 feet would require removal and disposal of 210,000 cy of material.

Total project costs (in 2014 dollars and not including contingency and escalation) are $67 million for widening of the turning basin, and $145 million for construction of the breakwater spur. Combination of both alternatives results in a total project cost of $189 million. Therefore, a reasonable estimate of the average annual cost of the 35-foot deep turning basin expansion over the 50 year period of analysis would be about $3.2 million. Average annual costs for the breakwater spur over the 50 year period of analysis would be over $6 million.

The crucial benefit category that most of the positive economic impacts of this kind of harbor improvement study will need to justify the project’s costs is increasing the harbor’s economic efficiency. The reduction in transportation costs, due to time savings as calculated within HarborSym, was the primary National Economic Development (NED) benefit of the project. The average annual benefits are about $787,000. With average annual benefits of about $787,000, and average annual costs of about $3.2 million for the 35-foot turning basin widener, this benefit cost ratio came to about 0.25.

It is clear in the case of Hilo Harbor that there are documented issues with both the ability of the turning basin to accommodate existing and future vessels, as well as the impacts of waves and surge during certain storm events. The engineering analysis completed for this study better defined the problems being experienced, and indicates that there are solutions that may significantly improve these issues. The difficulty arises both in the high costs of navigation construction, and the quantification of economic benefits to these improvements, since the problems occur relatively infrequently or are being managed adequately under current conditions. In addition, the intangible benefits of improved safety and potential avoidance of environmental disasters are difficult to measure.

For these reasons, the study team concluded that there is no Federal interest in the Hilo Harbor Modification Study, and recommended that the study be terminated with no further usage of Federal or non-Federal sponsor study funding. The non-Federal sponsor, State of Hawaii, Department of Transportation, Harbors Division, by communication dated 21 October 2015, agreed with the USACE recommendation, and requested that a summary report be produced and the feasibility study subsequently terminated.

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List of Acronyms, Abbreviations, and Symbols

θ	Wave direction (from True North)
ADCP	Acoustic Doppler Current Profiler
B2D	BOUSS-2D
BBL	Barrel
BCR	Benefit to Cost Ratio
BW	Breakwater
C	Celsius
CAA	Clean Air Act
CAD	Computer Aided Design
CAP	Continuing Authorities Program
CAR	Coordination Act Report
CEDEP	Corps of Engineers Dredging Estimating Program
CDIP	Coastal Data Information Program
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and
CFEC	Commercial Fisheries Entry Commission
CFR	Code of Federal Regulations
CHL	Coastal and Hydraulics Lab
COL	Colonel
Corps	U.S. Army Corps of Engineers
cm	Centimeter
CM	Construction Management
CMS	Coastal Modeling System
CWA	Clean Water Act
CWBS	Civil Works Breakdown Structure
CY	Cubic Yards
DAR	Division of Aquatic Resource
DDNPCX	Deep Draft Navigation Planning Center of Expertise
deg	Degrees
DEM	Digital Elevation Model
DOT	Department of Transportation
DOT-H	Department of Transportation Harbors
E	East
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPL	Effective Price Level

ER	Engineer Regulations
ERDC	Engineering Research and Development Center
ESA	Endangered Species Act
ESE	East Southeast
etc.	Et Cetera
F	Fahrenheit
FC	Full Compliance
FCSA	Feasibility Cost Sharing Agreement
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FR/EA	Feasibility Report and Environmental Assessment
FRM	Flood Risk Management
FS	Feasibility Study
ft	Feet
FWCA	Fish and Wildlife Coordination Act
GDM	General Design Memorandum
GMT	Greenwich Mean Time
GNF	General Navigation Feature
GPS	Global Positioning System
HDOT	Hawaii Department of Transportation
HHUG	Hawaii Harbor Users Group
HPA	Hawaii Pilot's Association
H_s	Significant Wave Height
hr	Hour
Hz	Hertz
IG	Infragravity
kg	Kilograms
lbs	Pounds
LERR	Lands, Easements, Real Estate, and Rights-Of-Way
LERRD	Lands, Easements, Real Estate, Rights-Of-Way, and Disposals
LOA	Length Overall
LPG	Liquefied Petroleum Gas
LPP	Locally Preferred Plan
LSF	Local Service Facilities
m	Meter
mg	Milligrams
MBTA	Migratory Bird Treaty Act
MCASES	Micro-Computer Aided Cost Estimating System
MCX	Mandatory Center of Expertise
MHHW	Mean Higher High Water
MHW	Mean High Water

MLLW	Mean Lower Low Water
MLW	Mean Low Water
MMPA	Marine Mammal Protection Act
MSL	Mean Sea Level
MTL	Mean Tide Level
N	North
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NDBC	National Data Buoy Center
NE	Northeast
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
nm	Nautical Miles
NMFS	National Marine Fisheries Service
NNE	North Northeast
NNW	North Northwest
NOAA	National Oceanic and Atmospheric Administration
NW	Northwest
O&M	Operation and Maintenance
OCT	Opportunity Cost of Time
ODMDS	Ocean Dredged Material Disposal Site
OMB	Office of Management and Budget
OMRRR	Operation, Maintenance, Repair, Replacement, and Rehabilitation
PAL	Planning Aid Letter
PC	Partial Compliance
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
POH	US Army Corps of Engineers, Honolulu District
PORTS	Physical Oceanographic Real-Time System
Ro-Ro	Roll-on/Roll Off
S or sec	seconds
S&A	Supervision and Administration
SE	Southeast
sec	Seconds
SHPO	State Historic Preservation Officer
SSE	South Southeast
STS	Ship/Tow Simulator
TEU	Twenty Foot Equivalent Unit
TMK	Tax Map Key
T_p	Peak spectral wave period

TPCS	Total Project Cost Summary Sheet
UHH	University of Hawaii at Hilo
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USS	United States Survey
VOC	Vessel Operating Costs
WIS	Wave Information Studies
WL	Water Level
WRDA	Water Resources Development Act

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1. INTRODUCTION

1.1. Background and Project Area Description

Hilo Harbor is located on the northeast coast of the island of Hawaii (the “Big Island”); the state’s eastern and southernmost island (Figure 1). Hilo Harbor is one of the two main commercial ports for the Island of Hawaii (Kawaihae Harbor serves the west side of the island).

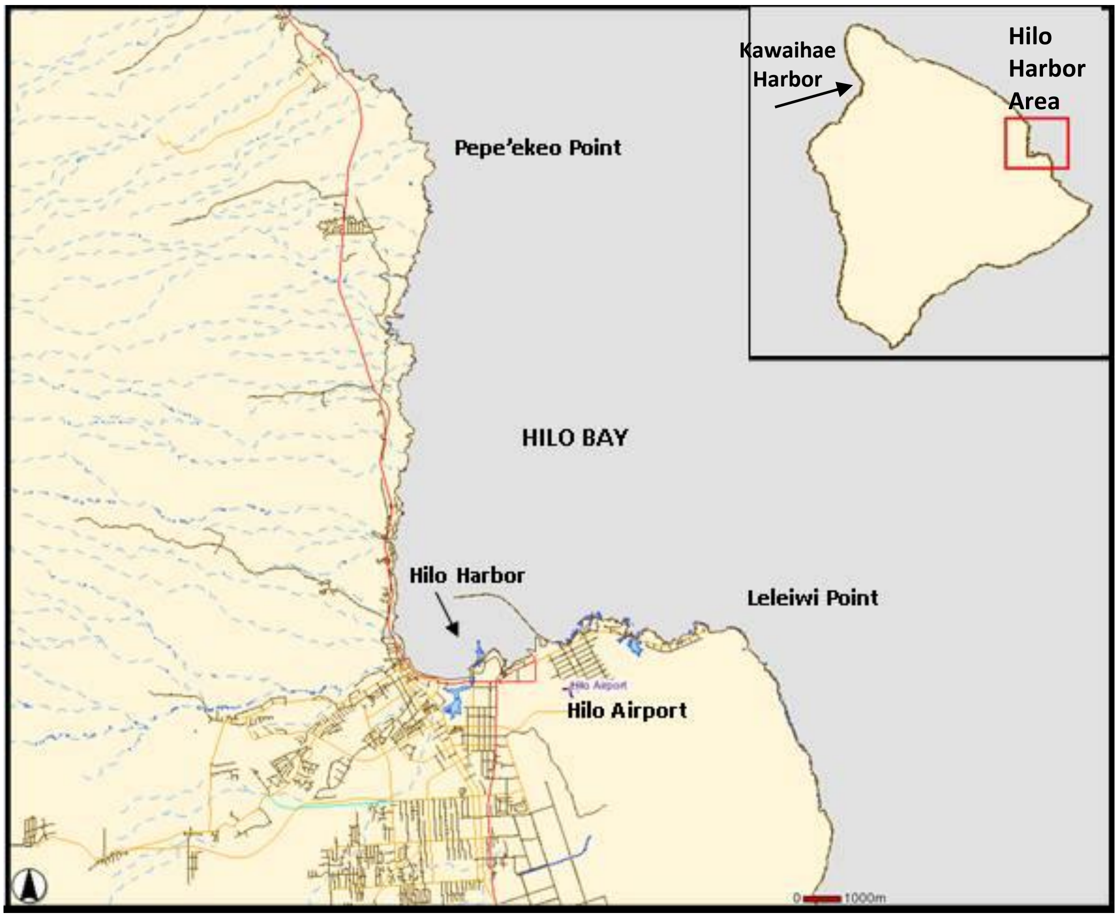

Figure 1. Vicinity Map of Hilo Bay and Hilo Harbor

The harbor, located within Kuhio Bay which is encompassed by the larger Hilo Bay, is approximately two miles from the business district of Hilo (the island’s principal city and county seat, and in close proximity to Hilo’s industrial and commercial centers), shown in Figure 1.

Hilo Harbor is the primary location of commercial waterborne traffic for the eastern side of Hawaii Island. It averages more than 2 million tons of waterborne commerce each year, provides a wide range of maritime facilities and services, and is the major distribution center for the Big Island, Hawaii. It also has the sole pier large enough to accommodate cruise ships (see Figure 2). Hilo Harbor averages three cruise ship calls per week or about 160 per year. In the busiest months for tourism, Hilo gets up to 20 cruise ships calls. In 2007, more than 500,000 tourists came through the Port of Hilo on cruise ships. The most important commodities moving through Hilo Harbor are liquid bulk cargo, including all of the Big Island's petroleum products, and large numbers of vehicles brought in to serve the car rental businesses and the resident population. There is also a small boat harbor, Radio Bay, at the easternmost end of the Hilo Deep Draft Harbor near the root of the breakwater and behind Pier 1. It is used primarily by recreational and transient vessels, a U.S. Coast Guard vessel, and two small University of Hawaii at Hilo research vessels.

Hilo Bay is located at the mouth of two rivers - the Wailuku River and the smaller Wailoa River system. The eastward-flowing Wailuku River is located in the northern half of the Hilo watershed, within the older Mauna Kea geology, and contains stormwater runoff through the entrenched channel of Wailuku River to Hilo Bay. The Wailoa River system occupies the southern half of the Hilo watershed. The Wailoa River system includes three significantly altered streams that flow through the southeastern part of Hilo: Alenaio, Waiakea, and Palai. The main source of flow is a large basal compound spring, Waiakea Spring, which provides the single largest source of groundwater into Hilo Bay.

The land surrounding the Hilo Harbor area was reclaimed from the bay by the placement of fill over the lagoonal deposits and/or coralline detritus. The project site is generally underlain by lagoonal deposits and deposits of calcareous sediments (also known as coralline detritus). Alluvial deposits associated with the Wailuku River underlie the lagoonal deposits and calcareous sediments. Basalt formation from the recent Mauna Loa lava flows may be encountered at greater depths below the alluvial deposits.

Hilo Bay is directly exposed to waves approaching from the sector north through east. Both tradewind waves and North Pacific swells may approach from this direction. Tradewind waves may approach from the sector north through east, with the predominant direction from the northeast. These waves are present 80 to 90 percent of the time during the summer; the frequency decreases to 60 to 70 percent during the winter. Tradewind waves have typical heights of 4 to 12 feet and periods of 7 to 10 seconds. Although Hilo Bay is exposed to tradewind wave approach, the breakwater shelters Hilo Harbor from direct approach of all but the most northerly swell and tradewind waves (Sea Engineering, 1981).

North Pacific swell is generated by winter storms in the North Pacific and may approach from the sector west through northeast. The most common approach direction is from the northwest. This wave type is most frequent from October through April. The average wave period is 14 seconds and deep water heights range up to 15 feet. Hilo Harbor is directly exposed to only the North Pacific swell approaching from the north and northeast. Total frequency of occurrence of all North Pacific swell is 75 percent; however, it approaches from the north and northeast only 12 percent of the time. Because of its large size and long period, though, even swells approaching from more westerly directions may refract and have some influence on the wave climate in the harbor (Sea Engineering, 1981).

The tides in Hilo Harbor are semi-diurnal (two high and two low tides per 25-hour period) with a pronounced diurnal inequality. The mean tidal range, or difference between Mean Low Water (average of all low water heights of each tidal day) and Mean High Water (average of all high water heights of each tidal day), 1.67 feet (ft) for the most recent tidal epoch (1983-2001).

1.2. Federal Project Description

Work started on the original Hilo Harbor project in May 1908 and provided for a rubblemound breakwater 10,170 feet long on Blonde Reef (Figure 2). Subsequently, the River and Harbor Act of 1911 called for a resurvey of Hilo Harbor, with the expectation that larger vessels and greater traffic would require additional commercial facilities. The 1911 survey report for Hilo Harbor recommended extending the breakwater as far as possible within the original cost limits while dredging the entrance to Kuhio Bay to a depth of 35 feet, at an additional estimated cost of $76,000. The recommendations of the survey were adopted by the River and Harbor Act of 25 July 1912, and construction of the breakwater extension and dredging of the harbor commenced under the revised project authorization.

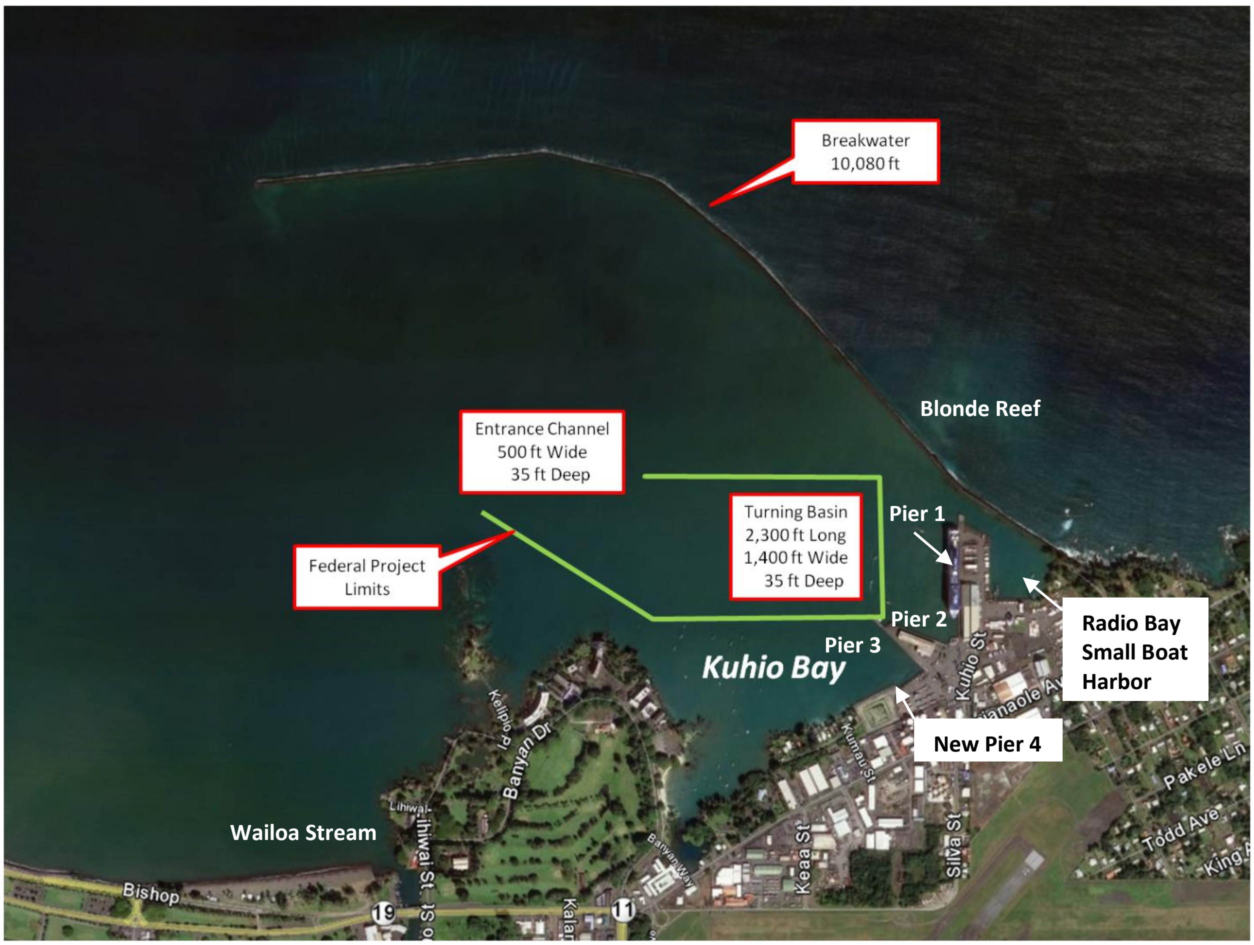

Figure 2. General Navigation Features at Hilo Harbor and Landside Infrastructure

By July 1918, breakwater construction provided significant improvement in harbor conditions during good weather and allowed large vessels to moor at the wharf. In 1924, the Honolulu District Commander recommended extending the breakwater to the originally authorized length of 10,080 feet, and dredging of the harbor basin to a depth of 35 feet. These project modifications were authorized by the River and Harbor Act of 1925. The project was completed in 1930, at a total cost of $3.4 million. General Navigation Features at Hilo Harbor have since remained unchanged, with a 10,080-foot-long breakwater protecting a 35-ft deep entrance channel as well as a 1,400-ft wide by 2,300-ft long, 35-ft deep basin (Figure 2).

The Honolulu District completed a Feasibility Study in February 1982 recommending deepening Hilo Harbor's entrance channel to 39 feet and turning basin to 38 feet at an estimated cost of $3.7 million, resulting in a Chief's Report in 1984 and project authorization in the Water Resources Development Act of 1986. No subsequent work was performed on the authorized project due to lack of non-federal support, resulting in the Assistant Secretary of the Army (Civil Works) submitting the project to Congress in October 1999 for deauthorization. The project was deauthorized in April 2002.

Hilo Harbor has three existing piers and a fourth (Pier 4) to be constructed by 2017 (Figure 2). Pier 1 is 1,265 feet long and is used by interisland container barges, cargo ships, and large cruise ships. Pier 2 is 703 feet long and is used by cement barges and has a roll-on/roll-off interisland barge facility. Pier 3 is 763 feet long and is primarily used by fuel barges. The proposed Pier 4 will be 602 feet long and used to support interisland cargo operations (separating these operations from cruise ship loading and offloading at Pier 1).

Hilo Harbor serves as a port of call for the cruise ship industry which contributes significantly to the local economy. Over the past few years, an average about 100 cruise ships greater than 900 feet long have called at Hilo Harbor. Attempts to maneuver these and other large vessels within the harbor are done at significant risk to both the vessels and harbor facilities particularly during times of adverse wave conditions due to the limited size of the harbor turning basin.

The study area lies within the 2nd Congressional District of Hawaii.

1.3. Study Authority

The Hilo Harbor project was initially authorized under the River and Harbor Act of 1907, subsequent work was authorized under the River and Harbor Act of 1912 and 1925. The Hilo Harbor Modification Study was authorized by Section 209 of the Flood Control Act of 1962, which reads as follows:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Provided, that after the regular or formal reports made on any survey are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law, except that the Secretary of the Army may cause a review of any examination or survey to be made and a report thereon submitted to Congress, if such review is required by the national defense or by changed physical or economic conditions: Provided further, that the Government shall not be deemed to have entered upon any project for the improvement of any waterway or harbor mentioned in this title until the project for the proposed work shall have been adopted by law: ... Harbors and rivers in Hawaii, with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power development, water supply, and other beneficial water uses, and related land resources .... "

1.4. Non-Federal Sponsor

The non-federal sponsor for the Hilo Harbor Modification Study is the State of Hawaii, Department of Transportation, Harbors Division. A Feasibility Cost Sharing Agreement (FCSA) was executed September 30, 2013 by the U.S. Army Corps of Engineers, Honolulu District (POH) and the non-federal sponsor.

1.5. Prior Reports and Existing Studies

1.5.1. Prior Reports

Because of the importance of the study area to the County of Hawaii's residents and the State of Hawaii, there has been a considerable amount of research on Hilo Bay and the surrounding area. The following is a list of the relevant reports that have been completed in the project area.

a) ***Hilo Bay Watershed-Based Restoration Plan.*** *University of Hawaii and Hilo Bay Watershed Advisory Group. 2005.*
The restoration plan focuses on: 1) locally adapted non-structural best management practices (BMP) and associated demonstration projects on a small scale that will serve to reduce nutrient and sediment inputs from a variety of sources; 2) formal and informal education BMPs; 3) gathering of baseline data to spatially locate sources of pollution and to understand the bay ecosystem, followed by dissemination and discussion of research results; and 4) support of county efforts to manage flood water and wastewater. Implementation of the applicable recommendations could enhance Hilo Harbor's ecosystem.

b) ***Hilo Bay Water Circulation and Water Quality Study.*** *USACE Honolulu District. 2009.*
This study was completed under the Planning Assistance to States Program, and investigated the feasibility of modifying the Hilo Harbor breakwater to increase water circulation within Hilo Harbor. Increased circulation could potentially provide corresponding improvements in water quality within the bay, thereby providing a more suitable environment for recreation and a greater aesthetic enjoyment of the area. The resulting changes to wave energy within the harbor were also investigated to quantify the relative effects that the breakwater modification may have on navigation. Model results, estimated costs, and predictions of relative water circulation improvement for five alternative plans are documented in this technical report.

c) ***Water Quality in Hilo Bay, Hawaii USA, Under Baseflow and Storm Conditions, Final Project Report.*** *University of Hawaii at Hilo. 2009.*
The University of Hawaii at Hilo (UHH) Marine Science Department collaborated with the County of Hawaii in conjunction with USACE, to collect essential water quality data that would: 1) allow for a better understanding of the relationship between water quality and circulation within Hilo Bay, and 2) be used in a USACE computer model to

accurately assess whether potential modifications to the Hilo Bay breakwater would improve water quality. UHH collected baseline data on suspended sediment and nutrient inputs to Hilo Bay to assess its response to these inputs under baseflow and storm conditions. This information along with USACE circulation data will allow the County of Hawaii to identify the best and most cost-effective remediation actions to improve Hilo Bay's water quality and may be used in ship simulation models.

d) *Hawaii Island Commercial Harbors 2035 Master Plan Update.* *Hawaii Department of Transportation, Harbors Division. 2011.*
The master plan is a long-range framework for the development of the Hawaii Island commercial harbors to accommodate the future needs of these facilities. There have been two previous Hawaii Island commercial harbors master plans. The planning effort for the *Hawai'i Island Commercial Harbors 2035 Master Plan Update* (2035 Master Plan) was started in 2008. The 2035 Master Plan supersedes the *Hawai'i Commercial Harbors 2020 Master Plan* (2020 Master Plan) that was completed in 1998. The Master Plan serves as a long range guide towards fulfilling future harbor needs to account for changing economic, social, land use, development and other forces that shape the harbors' operations and form the basis for a Capital Improvements Program (CIP).

1.5.2. Existing Water Projects and USACE Studies

The following USACE authorized studies are currently underway in the project study area:

a) *Waiakea-Palai Stream Flood Damage Reduction Project*
The Waiakea-Palai Streams Flood Risk Management (FRM) Project is in the feasibility phase. This project combines the effort of the Waiakea Stream Continuing Authorities Program (CAP) project with the Palai Stream CAP project into a single project under the Specifically Authorized Program. The Feasibility Cost Sharing Agreement (FCSA) for the Waiakea Stream CAP project was signed in March 2004. The FCSA for the Palai Stream CAP project was signed in July 2002. Amendment No. 1 to the Waiakea Stream FCSA, which expanded the Waiakea Stream feasibility study to systematically address the flood risk along both the Waiakea and Palai Streams, was signed in March 2012.

The following are USACE authorized projects constructed and/or further studied in the project area:

b) Wailoa Stream Flood Control Project
The Wailoa Stream Flood Control Project was authorized by the Flood Control Act of 1954. The project protects structures at the University of Hawaii from flooding by Waiakea Stream and its smaller tributary, Kawili Stream. The existing project provides for a 355-feet long channel and an 88-feet long levee to divert the Kawili Stream flows into Waiakea Stream; a 333-feet long channel and 350-feet long levee to divert the combined flows of Waiakea and Kawili Streams into a long and narrow swale area; an 1,100-feet long channel and 800-feet long levee to protect the University of Hawaii Hilo Campus Dormitory; two small diversion levees, one 75 feet long and the other 190 feet long, to divert the flows from the swale area to a new 4,680 feet long channel; and

earth levee totaling 6,510 feet along the channel. The project was completed in August 1965. The non-Federal sponsor is the County of Hawaii, Department of Public Works, which owns and maintains the project. The project was damaged by flooding in August 1994 and repaired under' the authority of Public Law 84-99 in 1995. The project was damaged by an earthquake in 2006 and flooding in 2008 and was repaired under the authority of Public Law 84-99 between 2010 and 2011.

c) Alenaio Stream Flood Control Project
The Alenaio Stream Flood Control Project, which runs through portions of downtown Hilo, was authorized under Section 101 of the Water Resources Development Act (WRDA) of 1986, and with the completion of the General Design Memorandum (GDM) in March 1990, it was reauthorized in WRDA of 1990. The County of Hawaii, Department of Public Works is the local sponsor. The project is in the operations and maintenance phase. The project consists of an 830 feet earthen levee; a 1,790-feet long rectangular concrete-lined channel; a 200-feet long wedge-shaped concrete-lined entrance transition; three floodwall structures consisting of 640 feet of concrete floodwall and 545 feet of concrete rubble masonry floodwall; four bridge replacements; utility relocations; access roads for channel construction and maintenance; removal of several structures and incorporation of floodplain management regulations in undeveloped areas; and an earthen channel at the mouth, connecting the concrete channel to the existing floodplain. The project was physically completed in November 1997. Minor project repairs necessitated by a November 2000 flood event were completed in October 2003 under Public Law 84-99. The flooding partially exposed hazardous material in the left embankment near the mouth. Required disposal actions were completed in August 2004. Alenaio Stream empties into Wailoa Stream (Pond).

The following are USACE studies associated with constructed projects in the project study area:

- USACE, Honolulu District. 1996. General Design Memorandum, Wailoa Stream and Its Tributaries, Hilo, Hawaii.
- USACE, Honolulu District. 1980. Reconnaissance Report for Flood Damage Reduction, Alenaio Stream, Island of Hawaii.
- USACE, Honolulu District. 1982. Final Survey Report and Environmental Impact Statement: Alenaio Stream, Island of Hawaii, Harbors and Rivers in Hawaii.
- USACE, Pacific Ocean Division. 1988. General Design Memorandum No.1 Hydrology, Alenaio Stream, Hawaii.
- USACE, Honolulu District. 1983. Survey Report and Final Environmental Impact Statement: Hilo Harbor.
- USACE, Honolulu District. 1981. Hilo Area Comprehensive Study, Navigation Report.
- USACE, Honolulu District. 2010. Flood Damage Reduction System Summary Inspection Report, Alenaio Stream Flood Control Project.
- USACE, Honolulu District. 2011. Hilo Deep Draft Harbor O&M Inspection.

2. EXISTING AND FUTURE PROJECTED CONDITIONS

2.1. Existing Problems at Hilo Harbor

2.1.1. Turning Basin Size Inadequate

The turning basin dimensions (width and length) are inadequate for the existing and future fleet calling at Hilo Harbor. The existing turning basin design was based on a vessel of 700 ft-length, 92 ft-beam, and 29 ft-draft. Currently, harbor pilots take unwarranted risks and operate under less than ideal conditions while turning large cruise ships of lengths ranging from 700 to 950 ft. Next generation cruise ships are longer than 1,050 ft and have expressed an interest in making Hilo Harbor a regular port of call. A number of vessels are presently unable to use harbor due to current federally authorized turning basin dimensions. Due to the limited turning area for these larger vessels calling at Hilo Harbor, there is currently a high risk of vessel groundings. This in turn leads to a high risk of environmental contamination from potential groundings (oil, petroleum product releases, etc.).

The limited turning basin dimensions also impede port operations, as delays are associated with maneuvering and docking time. Limited clearance exists between Pier 1, Pier 2 and the shallow area adjacent to the breakwater, requiring extra time for turning and berthing of vessels.

The wave energy within the harbor experienced at certain times of the year (discussed below) further amplify the difficulties experienced in turning and maneuvering in the undersized basin.

2.1.2. Wave Impacts to Navigation

During high wave conditions frequently occurring in the winter months, waves and long-period wave energy impact navigation in the entrance channel and turning basin, resulting in vessel delays. This also presents a safety issue as there is no "Plan B" contingency at the harbor for cruise ships that encounter hazardous navigation conditions while entering or exiting the harbor. The problem is more pronounced for deeper draft vessels, and over the years, has been blamed for several groundings.

2.1.3. Wave Impacts to Operations

Long-period wave energy in the harbor also impacts operations. [1] During periods of large waves in the winter, increased time is required for loading/offloading and mooring of passenger, cargo and commodities vessels. The piers have experienced damage in the form of damaged bollards, damaged pier faces and bulkheads, and broken mooring lines due to vessel movement while docked. Damage to the vessels themselves has also been experienced.

2.1.4. Distance from Federal Project Line to Pier 1

The existing Federal channel limit is approximately 600 feet from the face of Pier 1 (see Figure 2). This space between the edge of the Federal turning basin and the Pier 1 berthing area requires vessels to execute turning maneuvers for arrival and departures well outside the limits of the Federal turning basin. This area is currently maintained to approximately 35 ft MLLW by

[1] This is sometimes referred to as wave "surge" because of vessel movements observed at piers. Technically, wave "surge" or "seiche" experienced in harbors is a standing wave oscillation caused by infragravity wave energy (wave periods of 30 seconds or greater). For this report "waves" or "wave energy" refers to normal swell waves (wave period less than 30 seconds) and "surge" refers to infragravity wave oscillations where appropriate.

DOT Harbors (DOT-H).

2.2. Present Navigation Uses and Economic Environment

2.2.1. Existing Harbor Fleet

An average of about 100 cruise ships greater than 900 feet in length call at Hilo Harbor each year. In addition to these large cruise ships, several smaller ones also call occasionally. Cruise ships comprise about 12 to 15 percent of the annual ship calls. Hilo Harbor's primary customer is barge traffic. Barges and their tugs generally make up about 75 percent of Hilo Harbor's traffic. Between 322 and 375 feet long, these barges make the trip from Honolulu to Hilo several times a week carrying most of the fuel, food products and other supplies consumed by the resident and tourist population of the Big Island. Since 2011, there are approximately 200 barge transits (i.e., a round trip) usually originating and ending in Honolulu, at Hilo Harbor each year. Cargo ships in and out of Hilo each year average about 35 transits over these past 3 years. More than 70 percent of these, or 25 transits per year, are the comings and goings of the car carrier from the mainland, the 579-foot long Jean Anne. The rest are primarily tankers in the 400 to 550-foot long class. The future fleet mixes for both with- and without- project conditions, based on waterborne commence trends at Hilo Harbor.

2.2.2. Existing Operating Practices

The existing harbor depth of 35 feet has not become an issue and is not likely to present problems in the near future. The deepest draft vessel expected to call regularly (beginning in late 2015) at Hilo Harbor drafts 31 feet, while the largest of the cruise ships expected to call draft several feet less. However, under existing and future without project conditions, vessel operations are constrained by the current size of the turning basin. Harbor pilots maneuvering large cruise ships (900 to 1100 feet long, well in excess of the 700-ft original design vessel) have difficulty berthing and disembarking at Pier 1 due to the shallow depths just outside the northern edge of the existing Federal channel, adjacent to the breakwater. Intense coordination is required between the pilot, assist tugs and spotters (stationed at the bow and stern) to navigate large cruise ships in and out of Pier 1. If there is a barge or cruise ship moored at Pier 2, the room to maneuver vessels is further decreased. In many cases the pilot is not able to see navigation hazards if standing on bridge, so the pilot must rely on spotters, which is not always a safe practice. This causes delays for both the cruise ships, as well as smaller vessels waiting for them to vacate the congested area. In addition, larger cruise ships that call at Honolulu Harbor are not able to call at Hilo Harbor due to the limited turning basin size. There is additional demand to call at Hilo due to the unique opportunity to visit the active volcanoes on the Big Island of Hawaii. Only 30 miles from Hilo, Volcanoes National Park averages 1.4 million visitors each year, many of whom use Hilo Harbor as their stepping-off point.

In addition, the existing configuration of Hilo Harbor allows excessive long-period wave energy to enter the Federal channel, turning basin, and berthing areas during periods of large wave energy from the north, typically in winter months. The winter is the primary season for cruise-ship tourism, due to the more temperate weather in Hawaii. Inter-Hawaiian Island cruise business remains strong throughout the entire year, but many of the larger cruise ships head to Alaskan waters for the summer months. Large waves are also an issue for barges delivering inter-island cargo and fuel to the Big Island, a critical service that occurs year-round. All vessels entering and exiting the harbor during these high wave conditions experience delays during navigation due to the extra caution required to transit the channel and turning basin safely.

2.2.3. Cancelled Vessel Calls

Large waves within the harbor have also caused ship call cancellations and discouraged new customers from calling at Hilo. In some cases, vessels have foregone calls to the harbor because wave conditions within the harbor (in combination with the limited turning basin size) have been determined too dangerous to maintain safety. In the case of inter-island barges, this missed call results in delayed delivery of cargo/fuel and additional cargo transportation costs. For cruise ships, a missed call to Hilo results in an extra day at sea in lieu of the Hilo visit, causing a loss of tourism revenue in the Hilo area, and disappointed cruise ship passengers who have missed the opportunity to visit the Volcanoes National Park, and may possibly request compensation from the cruise line.

2.2.4. Damage to Harbor Infrastructure and Passenger Safety

Long-period wave energy also affects the vessels that are moored at Piers 1 and 2 under existing conditions. Operations such as tying up, loading/offloading, and refueling are impeded and delayed by the vessel motion that is experienced by moored vessels during high wave conditions. Damages to vessels, pier infrastructure (bulkheads, bollards, etc.), and associated equipment (mooring lines) has also been experienced regularly during these conditions. For instance, Division of Harbor officials reported that while holding a large cruise ship at the dock during one large wave event, several bollards were damaged to the point they had to be replaced. That cost was about $15,000. Damage to the vessels themselves has also been experienced, yet documentation is sparse. While cruise ships are moored at Pier 1, they often are required to use their thrusters to remain in place when high wave energy is being experienced, thereby utilizing additional fuel and manpower to ensure the safety of embarking/disembarking passengers and the vessel.

2.3. Future Projected Economic Conditions

Future economic conditions without harbor improvements will likely include all of the issues noted above, with added difficulty due to continued growth of the economy and tourism demand on the Big Island of Hawaii. The resident population of the Big Island has sustained the fastest growth rate in the State over recent decades, more than tripling since 1980. It is projected to maintain a population increase rate of two (2) times the State of Hawaii's average through the year 2040. Obviously, this population growth will require increased demand for inter-island cargo and fuel to the island. The location of the other deep-draft harbor on the island, Kawaihae Harbor, on the leeward side, precludes it from supporting demand to the entire island. Kawaihae Harbor currently has two piers which service primarily cement barges (Pier 1), and interisland cargo and fuel barge operations (Pier 2). There is no infrastructure to support berthing of cruise vessels. The costs to truck goods from the leeward to windward side over or around the high volcanic and mountainous terrain in between would increase significantly if Hilo Harbor were not able to support demand to the windward side. In addition, Kawaihae Harbor currently does not have the infrastructure or space to accommodate additional cargo and/or fuel. The growth of the economy and demand for barge-shipped cargo will result in increased vessel traffic at Hilo (both number of vessels and frequency of visits). This eventuality will cause an increase in the existing operational inefficiencies and transportation costs, and increased risk of vessel groundings which may have serious safety and environmental implications.

In addition, future demand for tourism to the Big Island, along with the general trend in the cruise line business to build bigger ships, will increase pressure to bring in larger cruise ships, and on a more frequent basis. The limited size of the turning basin (without improvement) will prevent the ability to accommodate larger cruise ships. Those cruise ships that do enter will be subject to difficult and possibly dangerous navigation limitations in the turning basin that may also be amplified under high wave conditions. Future sea level rise in the islands (which is most pronounced in Hilo due to land subsidence) will increase water depth at the harbor, which could increase the wave impacts in both the Federal channel/turning basin and at the berthing areas. This effect would increase the noted effects of large waves that exist now, including vessel motion and associated damages to vessels and harbor infrastructure.

2.4. Environmental Conditions

2.4.1. Coral Present Inside Harbor

In August 2014, biologists from the U.S. Fish and Wildlife Service (USFWS) and State of Hawaii Division of Aquatic Resource (DAR) evaluated an area of approximately 98.23 acres of marine habitat during a Benthic Habitat Mapping Survey (Phase I) of Hilo Harbor, and data from this field work were reported to the USACE in a February 2015 Planning Aid Report. In March 2015, USFWS and DAR biologists conducted quantitative benthic surveys in support of the draft Coordination Act Report or CAR (Phase II) of the 10 acre area and preliminary data from this survey was transmitted to the USACE in May 2015.

USFWS found that the coral reef at the Hilo Harbor project site (Figures 3 & 4) is the habitat of major concern. Coral reef habitat, including sub-habitats such as sea urchin bore holes, crevices, ledges, overhangs, and depressions in the reef, comprise the biological community within the proposed project site and represents the major habitat of concern. The institutional significance of U.S. coral reefs has been established through their designation as Special Aquatic Sites under the Clean Water Act (40 CFR Part 230 §230.44/FR v.45n.249) (CWA) and as a Federal Trust Resource (Executive Order [E.O.] 13089 on Coral Reef Protection). These areas possess special ecological characteristics of diversity, productivity, habitat, wildlife protection, easily disrupted biological integrity, and contribute to the general overall environmental health or vitality of an entire ecosystem of a region.

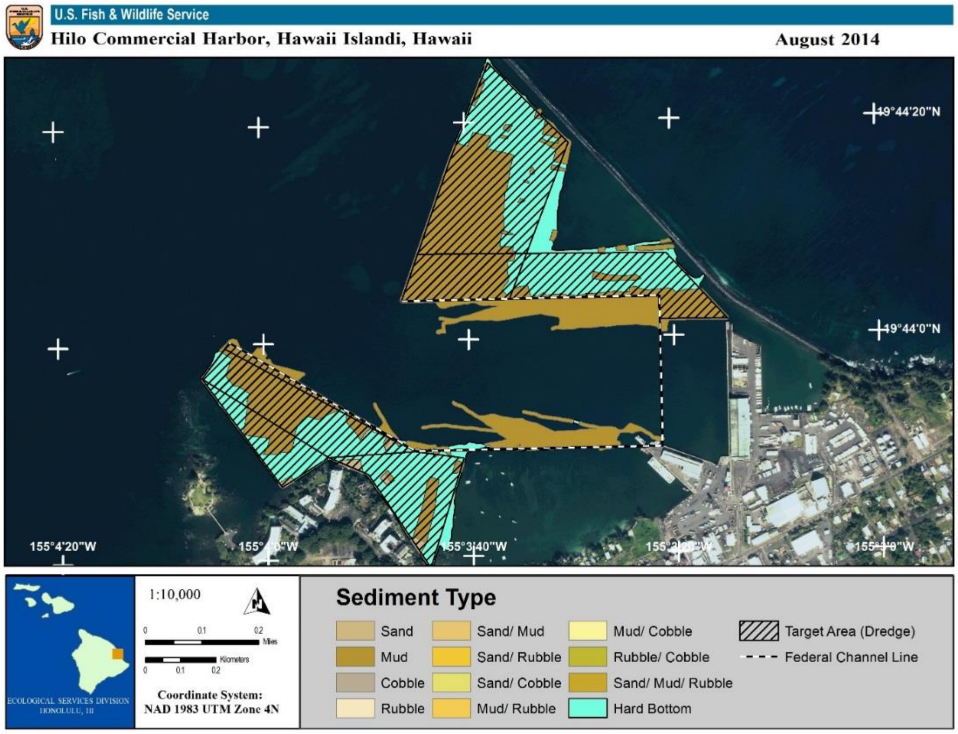

Figure 3. Sediment Types at Hilo Harbor, USFWS Phase 1 Survey (August 2014)

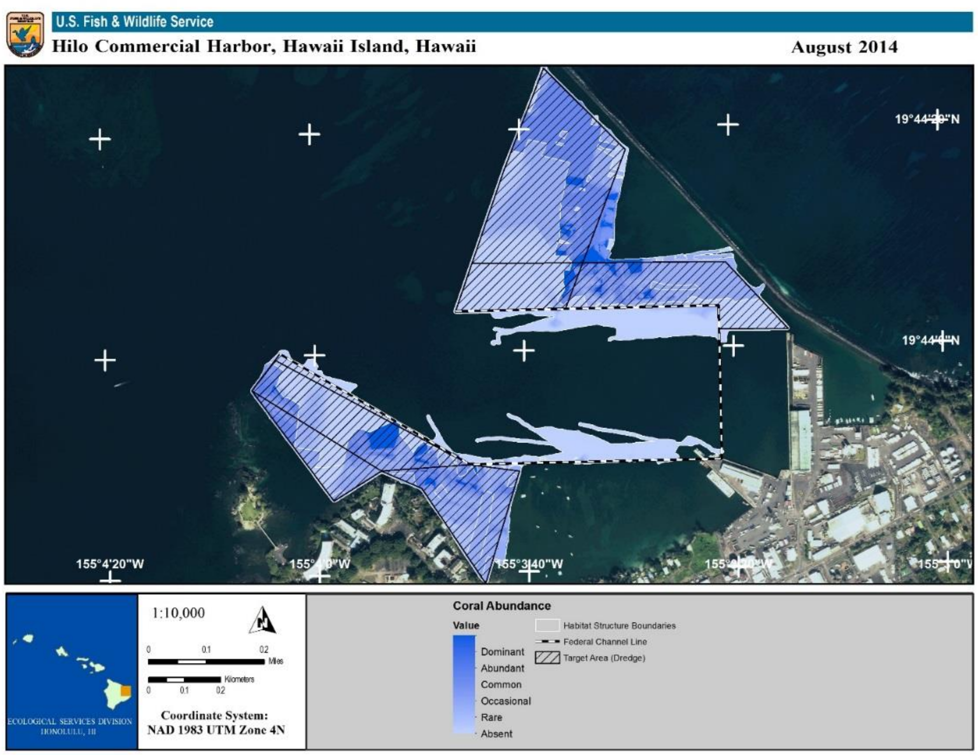

Figure 4. Coral Abundance at Hilo Harbor, USFWS Phase 1 Survey August 2014

As per the USFWS Mitigation Policy (Service, 1981)the coral reef at the proposed project site is considered Resource Category 2 habitat, or Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

2.4.2. Harbor Water Quality

As noted in several of the references listed in section 1.5.1 above, water quality within Hilo Harbor has been a longstanding issue since construction of the breakwater. As noted in Wiegner and Mead, 2009, Hilo Bay waters have been known to exceed state water quality standards since the late 1970s and were formally included on the United States Environmental Protection Agency's (USEPA) 303(d) list of impaired water bodies in 1998. Parameters exceeding standards include nutrients, turbidity, and fecal bacterial indicators. This University of Hawaii at Hilo (UHH) study found that under storm conditions, the largest surface water source of nitrates/nitrites to Hilo Bay was from the Wailoa River and the highest nitrate/nitrite concentrations in the Bay were measured within the Wailoa River plume. The data collected for the study indicated that nutrient concentrations are much greater in the Wailoa than the Wailuku River, likely from the land use in this watershed (e.g. – agriculture and high use of cesspools/septic tanks). The effect of these nutrient inputs to Hilo Bay has not yet been assessed.

According to the study, the largest surface water source of turbidity to Hilo Bay during storms was the Wailuku River and the highest turbidity levels were measured within the Wailuku River plume. These high levels of turbidity most likely stem from the watershed's high relief and its greater percentage of barren land compared to the Wailoa River's watershed. Additionally, the study found that higher turbidity inside the breakwater suggests that the breakwater acts as a partial barrier that prevents particles from being rapidly flushed outside of the Bay. However, within three days following peak storm discharge from the Wailuku River, turbidity levels inside Hilo Bay dropped below Hawaii Department of Health's embayment standards, suggesting that suspended sediments were rapidly exported out of the Bay and/or settled to the sea floor. The USACE (2009) study evaluated several modifications to the breakwater, intended to increase flushing and decrease tracer residence time within the harbor. All modifications showed improvement compared with existing conditions. No additional study or proposals regarding water quality improvements at Hilo Harbor have been conducted by USACE since that time, and evaluation of water quality impacts were not evaluated as part of this study.

3. ALTERNATIVES DEVELOPMENT

3.1. Study Goals and Objectives

The alternatives that were developed by the project team were aimed at addressing the goals and objectives of the study, which were developed based on the previously identified existing conditions and problems at the harbor, as well as areas that are within USACE authority. The goals and objectives are as follows:

The project goals are:

- Improve navigation and operational efficiency of the harbor
- Increase allowable vessel sizes calling at Hilo Harbor
- Improve safe use of Hilo Harbor

The alternative plans are intended to address the following objectives:

- Improve overall operational efficiency and conditions for berthing and departure operations, by reducing delays and thereby decreasing cargo transportation costs.
- Reduce damages to moored vessels, pier infrastructure, and associated mooring equipment.
- Increase visitor expenditure by enabling larger cruise ships to call.
- Enable current and future vessels to safely utilize Hilo Harbor, reducing the risk of vessel groundings and in turn life safety hazards and environmental damage.

3.2. Structural and Non-Structural Measures Considered

A list of measures (defined as an action that can later be combined with other measures to form a complete study alternative) that could be implemented to address the identified objectives were developed early in the study. The intention of this broad listing of potential measures was to make sure that any/all options (both structural and non-structural) to address objectives were considered and evaluated. Table 1 lists the non-structural measures that were evaluated, and which objectives each is intended to address. Table 2 lists the same information for structural measures identified.

3.3. Screening Criteria and Final Measures

The following criteria were developed in order to screen the initial list of non-structural and structural measures:

- **Cost/Net Benefits** – based on judgment of study team members, would the cost of implementing the measure be so excessive that it would most likely exceed the anticipated benefits to be gained? (Yes/No)
- **Practicality** – Given the constraints of the study area and realistic expectations of what is appropriate and reasonable, is this measure practical? (Yes/No)
- **Technically Feasible** – Can this measure be implemented, taking into consideration the requirements of harbor users and accepted operating procedures? (Yes/No)
- **Environmental** - Is this measure environmentally feasible, based on existing knowledge of what impacts may be? (Yes/No)
- **Does it adequately address the problem?** - Will this measure address at least one of the objectives and/or solve (or at least improve) a problem identified? (Yes/No)
- **Social Effects** – Based on existing knowledge of the area, will the measure be acceptable to the public? (Yes/No)
- **Safety** – Is the measure safe? (Yes/No)

Table 1: Non-structural Management Measures Considered

<u>Non-Structural Measures</u>	**Objective(s) to be addressed by this measure**			
	Improve navigation & operational efficiency	Reduce damages	Enable larger cruise ships to call	Increase safety/reduce risk of groundings
Moor vessels offshore and lighter passengers		✔		✔
Use smaller vessels, more frequent trips	✔			✔
Limit operations to daylight hours				✔
Change limits of Federally authorized project to extend turning basin closer to				✔
Facilitate better surge forecasting	✔			✔
Relocate cruise ships to another port	✔	✔		✔
Relocate some functions to Kawaihae	✔	✔		
Repurpose existing piers	✔			
Switch operations for Pier 1 and Pier 4	✔			
Relocate/modify aids to navigation				✔
Facilitate better navigational technologies (side looking sonar, etc.)	✔			✔
Close port at times of high surge		✔		✔
Use more tug assistance	✔			✔
Add more accurate GPS technology in the harbor and lobby NOAA to install PORTS	✔			✔
Moor vessels either offshore or deeper areas of the harbor during high wave		✔		✔
Use counterweights on vessels to dampen surge while moored		✔		

Tables 3 and 4 show the results of the non-structural and structural measure screening that was completed, based on the above criteria. The far right column of each table indicates whether the measure was kept (✔) or removed (✘) from further consideration. It was determined that each of the screening criteria was an important factor in determining feasibility of a measure. Therefore, if any measure failed to meet all criteria, it was eliminated from further consideration.

Table 2: Structural Measures Considered

Structural Measures	Objective to be addressed by this measure			
	Improve navigation & operational efficiency	Reduce damages	Enable larger cruise ships to call	Increase safety/reduce risk of groundings
Relocate harbor	✔	✔	✔	✔
Add bollards		✔		
Reinforce bollards		✔		
Build Pier 5 in HDOT 2035 Master Plan	✔		✔	
Reconstruction of entire harbor	✔	✔	✔	✔
Extend length of existing breakwater and/or add breakwater to other side of entrance	✔	✔		✔
Build mooring dolphins		✔		
Realign breakwater	✔	✔		✔
Deepen basin/channel				✔
Decrease permeability of breakwater	✔	✔		✔
Surge Reduction structures (wave attenuator, new BW, baffles, etc.)	✔	✔		✔
Expand turning basin by dredging	✔		✔	✔
Raise breakwater crest elevation	✔	✔		✔

The majority of non-structural measures removed from consideration were eliminated (entirely or in part) because they would not substantially improve the problems occurring in the harbor. For example, measures such as mooring vessels offshore and lightering passengers, and limiting operations to daylight hours may reduce the risk of groundings, but would not effectively address the problems experienced by wave energy entering the harbor during winter months. Small vessels would experience the same (if not more) navigational difficulties during large wave conditions, and vessels operating only during daylight hours would also still experience difficulty and reduced operational efficiency. Adding aids such as better wave and surge forecasting, modification of navigation aids, and using more tug assistance may improve safety to some degree; however, they would not reduce infrastructure damages or enable large vessels to call the port in the future.

The final list of non-structural measures following the screening are listed below. It should be noted that only the first measure listed (Change limits of the federally-authorized project) is within existing USACE authority. All other non-structural measures would be recommendations from the USACE for other agencies or private entities, and would be implemented at their discretion. For this reason, no further engineering analyses were performed on non-structural measures 2 through 5.

Table 3: Screening of Non-structural measures (X indicates measure does not meet criteria)

<u>**Non-Structural Measures**</u>	**Criteria Used to Screen Management Measures**							
	Cost/Net Benefits	Practicality	Technically Feasible	Environ-mental	Does it address the problem?	Social Effects	Safety	Keep ✔ Remove ✘
Moor vessels offshore and lighter passengers		X	X		X		X	✘
Use smaller vessels, more frequent trips	X				X			✘
Limit operations to daylight hours	X	X			X		X	✘
Change limits of Federally authorized project to extend turning basin closer to Pier 1								✔
Facilitate better surge forecasting					X			✘
Relocate cruise ships to another port		X			X			✘
Relocate some functions to Kawaihae	X	X			X			✘
Repurpose existing piers					X			✘
Switch operations for Pier 1 and Pier 4					X			✘
Relocate/modify aids to navigation					X			✘
Facilitate better navigational technologies (side looking sonar, etc.)								✔
Close port at times of high surge								✔
Use more tug assistance					X			✘
Add more accurate GPS technology in the harbor and lobby NOAA to install PORTS								✔
Moor vessels either offshore or deeper areas of the harbor during high wave								✔
Use counterweights on vessels to dampen surge while moored	X	X			X		X	✘

1. **Change limits of the federally-authorized project** – This measure would change the existing limits of the authorized turning basin to include the area currently located between the limit of the turning basin and Pier 1. A non-Federal berthing area would remain directly adjacent to Pier 1, its width to be determined by the beam of the current design vessel. Since this area is currently maintained to a depth of 35 feet MLLW (same as Federal Project), no new dredging would be required. The Federal government would assume maintenance dredging responsibilities of this area. This measure is intended to improve safety and reduce risk of grounding by allowing vessels to complete turning maneuvers entirely within the Federal turning basin, instead of partially within the non-Federally maintained berthing area, as is the case now.
2. **Facilitate better navigational technologies (side-looking sonar, etc.)** – This measure would encourage Pier 1 users (primarily cruise ships) to adopt newer navigation technologies such as side-looking sonar in order to better determine the vessel's location in reference to the edge of the turning basin. This measure is intended to improve safety and reduce risk of grounding, as well as possibly improve navigation efficiency during berthing operations.
3. **Close the port at times of high waves** – This measure would encourage the Hawaii Department of Transportation (HDOT) to close the ports during periods of anticipated

and/or ongoing high waves. This would require forecasting/measuring of waves and surge on a real-time basis for Hilo Harbor. The University of Hawaii has installed instrumentation and created computer software to predict surge conditions at other harbors in Hawaii, though this is still in the early stages. This measure is intended to improve safety, and reduce damages to moored vessels, pier infrastructure, and associated mooring equipment.

4. **Add more accurate GPS technology in the harbor and lobby NOAA to install PORTS system** – This measure would encourage the HDOT to add additional GPS technology (e.g. – GPS repeaters) to the harbor, in order to improve the accuracy of positioning by cruise ships at Pier 1. In addition, USACE would encourage NOAA to install the PORTS® system at Hilo Harbor. PORTS® is a decision support tool that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, and meteorological parameters (e.g., winds, atmospheric pressure, air and water temperatures) that mariners need to navigate safely (http://tidesandcurrents.noaa.gov/ports.html). This measure is intended to improve safety and reduce the risk of groundings, as well as improving operational efficiencies of the harbor.
5. **Moor vessels either offshore or in deeper areas of the harbor during high waves** – This measure would encourage HDOT to require that, during periods of high waves and potential harbor surge, vessels moor offshore or in deeper areas of the harbor until the wave event subsides. This would likely require the installation of new mooring infrastructure either inside or outside of the harbor. This measure is intended to improve safety, and reduce damages to moored vessels, pier infrastructure, and associated mooring equipment.

Table 4: Screening of structural measures (X indicates measure does not meet criteria)

Structural Measures	Criteria Used to Screen Management Measures							
	Cost/Net Benefits	Practicality	Technically Feasible	Environ-mental	Does it address the problem?	Social Effects	Safety	Keep ✔ Remove ✘
Relocate harbor	X	X		X		X		✘
Add bollards					X			✘
Reinforce bollards					X			✘
Build Pier 5 in HDOT 2035 Master Plan	X	X		X				✘
Reconstruction of entire harbor	X	X		X				✘
Extend length of existing breakwater and/or add breakwater to other side of entrance	X	X		X		X		✘
Build mooring dolphins			X				X	✘
Realign breakwater	X	X		X	X			✘
Deepen basin/channel					X			✘
Decrease permeability of breakwater								✔
Surge Reduction structures (wave attenuator, new BW, baffles, etc.)								✔
Expand turning basin by dredging								✔
Raise breakwater crest elevation								✔

Alternatively, structural measures were eliminated from considerations for various reasons. Several measures (relocate harbor, build Pier 5, harbor reconstruction, extend or add breakwater to entrance, realign breakwater), though they could potentially make substantial improvements to the problems experienced, were removed because they were anticipated to be both prohibitively costly and impractical based on current usage of the harbor and environmental impacts. Adding or reinforcing bollards would not significantly address the safety and navigation problems, and mooring dolphins could present technical and safety challenges. Deepening of the basin/channel was considered for completeness, but would not address any of the objectives, since vessel draft is not currently a limitation.

The final list of structural measures following the screening are listed below.

1. **Decrease permeability of the breakwater** – This measure would involve decreasing the permeability of the breakwater by filling voids in the interior of the structure, in order to reduce transmitted wave energy through the breakwater and into the berthing areas. This could be done through a variety of methods: using concrete-filled grout bags, tremie concrete, or removing armor stones and adding underlayer material in certain areas. This measure is intended to improve safety, improve operational efficiency, and reduce damages to moored vessels, pier infrastructure, and associated mooring equipment by reducing wave energy within the berthing areas.
2. **Wave reduction structures** – This measure would involve building structures intended to reduce the transmission and/or reflection of wave energy through the harbor entrance and into the channel, turning basin, and berthing areas. Depending on where the high wave problem is most pronounced (as shown by numerical models and wave data), the structures may include: rubblemound interior breakwaters (detached or attached to fast land), wave attenuation structures along existing harbor shoreline, or other technologies as appropriate. This measure is intended to improve safety, improve operational efficiency, and reduce damages to moored vessels, pier infrastructure, and associated mooring equipment by reducing wave energy within the berthing areas.
3. **Expand turning basin by dredging** – This measure would involve dredging an area north of the existing turning basin (estimated to be approximately 1.25 acres), currently between 10 to 20 feet depth MLLW, to a depth of 35 feet below MLLW in order to expand the width of the turning basin. Dredged material would be disposed of in an approved deep water site if possible. If not feasible, opportunities for beneficial use and/or other methods of upland disposal would be pursued. This measure is intended to improve safety, improve operational efficiency, and allow larger vessels to call at Hilo Harbor by increasing maneuvering area within the turning basin.
4. **Raise breakwater crest elevation** – This measure would involve raising the crest elevation of the breakwater, which is currently 11 feet above MLLW in most places and 15 feet above MLLW from Stations 11+00 to 20+00, where a repair section using concrete armor units and a concrete rib cap exists. The purpose of this measure is to reduce wave energy entering the berthing areas from overtopping of the breakwater. This could be accomplished by one or several of the following methods: additional armor stone layers, a parapet wall, a concrete monolith, etc. This measure is intended

to improve safety, improve operational efficiency, and reduce damages to moored vessels, pier infrastructure, and associated mooring equipment by reducing wave energy within the berthing areas.

3.4. Conceptual Development of Alternatives

Since no single measure is able to address both the need for a larger turning basin and the wave impacts to navigation/operations, it is anticipated that breakwater modification(s) and turning basin modifications (by dredging) could be used either in combination to improve all issues identified, or independently to deal with some (but not all) of the problems being experienced. The non-structural measure involving changing the limits of the federally-authorized project could be implemented on its own, or in combination with either/both of the breakwater and turning basin modifications. Since the proposed measures for the breakwater and the turning basin function relatively independently of each other, from this point forward each variation of a measure developed will be referred to as an alternative.

3.4.1. Breakwater Modifications

As noted previously, the primary breakwater modifications that would potentially reduce or eliminate the wave energy affecting navigation and operations within the harbor are decreasing permeability of the breakwater, additional wave reduction structures, and raising the breakwater crest elevation. Decreasing breakwater permeability and raising the breakwater crest elevation are modifications that were introduced in order to investigate assertions by some harbor users that wave energy at the inner turning basin and piers was coming over (via wave overtopping) or through (via wave transmission) the existing breakwater trunk. The measure to raise the breakwater crest elevation assume that waves run up and overtop the 11 to 15 ft breakwater crest, with enough energy to create a wave on the interior of the structure. The measure intended to decrease permeability of the breakwater assumes wave transmission occurs through a porous layer of structure below the MSL (i.e., submerged height of structure). In addition, wave transmission would also occur through the above water part of the structure. These measures were evaluated through use of numerical model parameters and were conducted along a limited length of the breakwater (2000 ft) adjacent to Pier 1, where the effects of wave energy are most noticeable. Additional details are available in Section 4.2.3 and Appendix A. Additional wave reduction structures were proposed to address the effects of wave energy propagating through the harbor entrance, and are described below.

Figure 5 shows existing features of Hilo Harbor including the small harbor located landward of Pier 1, and other coastal and land features present in Hilo Bay. The figure shows the features represented in the numerical model BOUSS-2D (B2D) grid, including bathymetric variation outside and inside the harbor with reefs, the breakwater, and two piers. Sketches of modifications investigated are also displayed with bathymetric details.

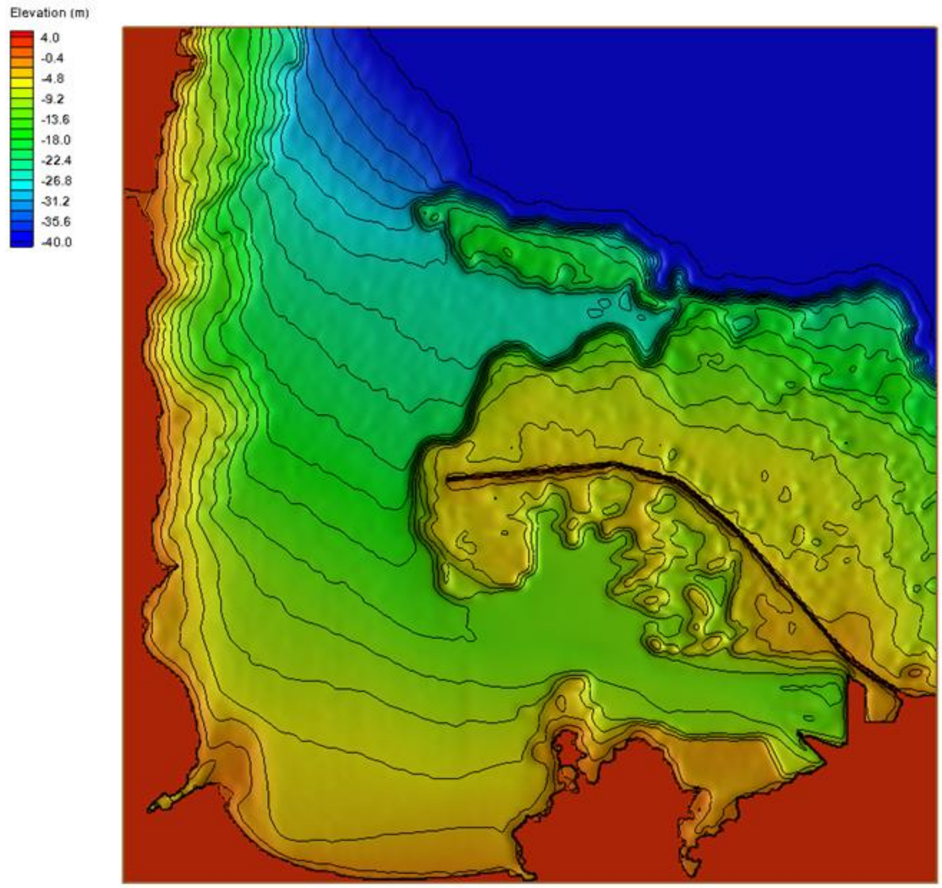

Figure 5. Bathymetric features of existing harbor

The proposed structural modifications include strategic placement of detached breakwaters and breakwater spurs inside the harbor. The first modification (Figure 6) considers a short structure, while longer structures are used in the second and third modifications (Figure 7 and Figure 8). These detached breakwaters and spurs are situated between the federal breakwater and the north edge of the navigation channel, and are intended to intercept and reduce the wave energy that reaches the turning basin and Piers #1 and Pier #2. For safety reasons, these are located at a distance of approximately 200 ft from the north edge of the turning basin. The second and third modifications use medium and long interior breakwaters as shown in Figure 7 and 8. The location, length and orientation of these structures could be adjusted for optimization at the detailed design phase.

The modification shown in Figure 9 involves adding a structure (spur) to the tip of the federal breakwater. As shown previously in Table 4, any extension of the existing breakwater was eliminated from consideration during the initial screening process, due to concerns about cost, practicality, and environmental considerations. This alternative was later reconsidered in order to compare its effectiveness in reducing wave energy with more interior detached breakwaters and spurs. Different attachment points, lengths and angling of the spur were considered to determine desired dimensions of the spur which would produce maximum benefits to the turning basin and Pier #1 & #2 areas.

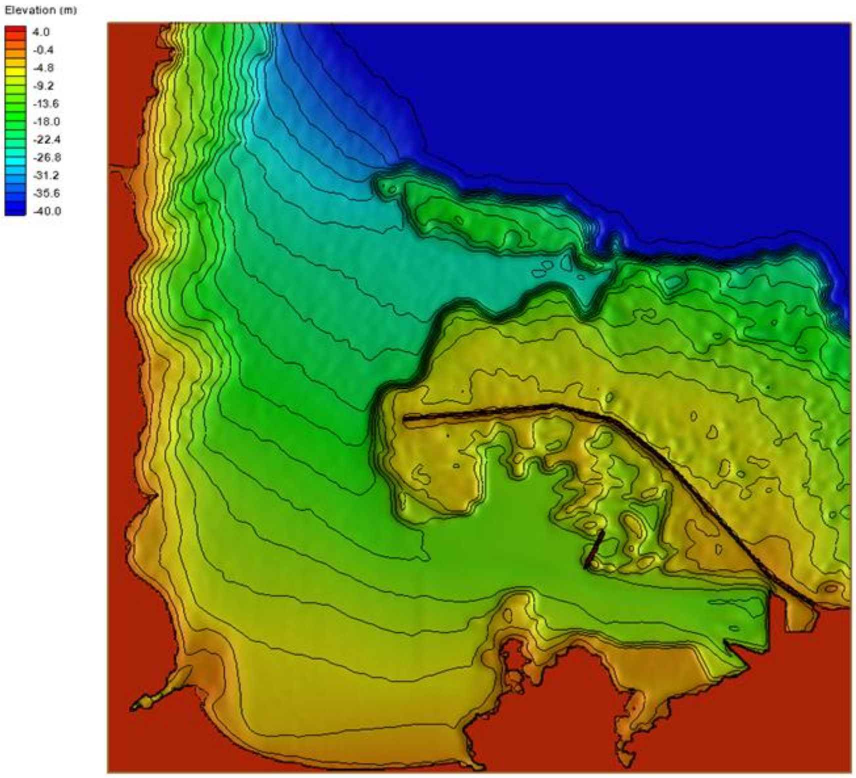

Figure 6. Proposed modification with a short (820 ft) detached breakwater (Alt-1)

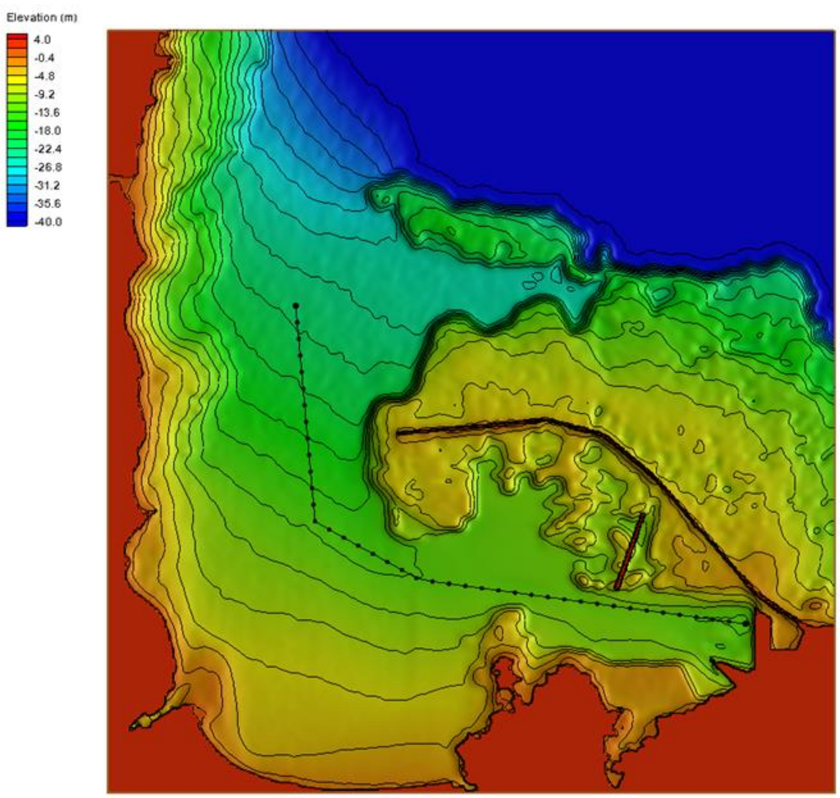

Figure 7. Modification with a medium length (1,580 ft) detached breakwater (Alt-2)

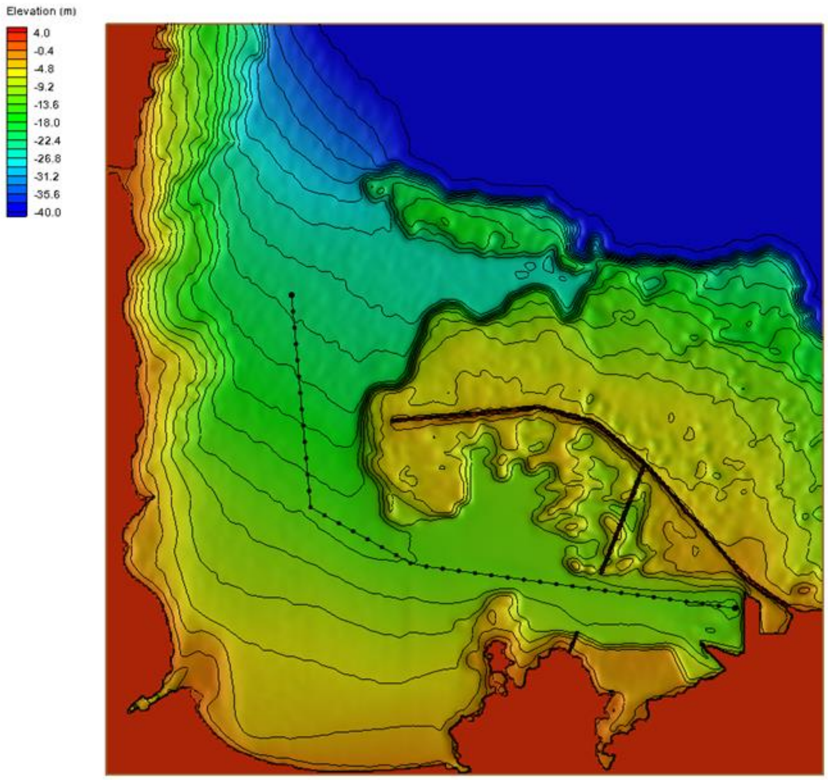

Figure 8. Modification with a long (2,300 ft) attached breakwater and a short (410 ft) structure to the south (Alt-3)

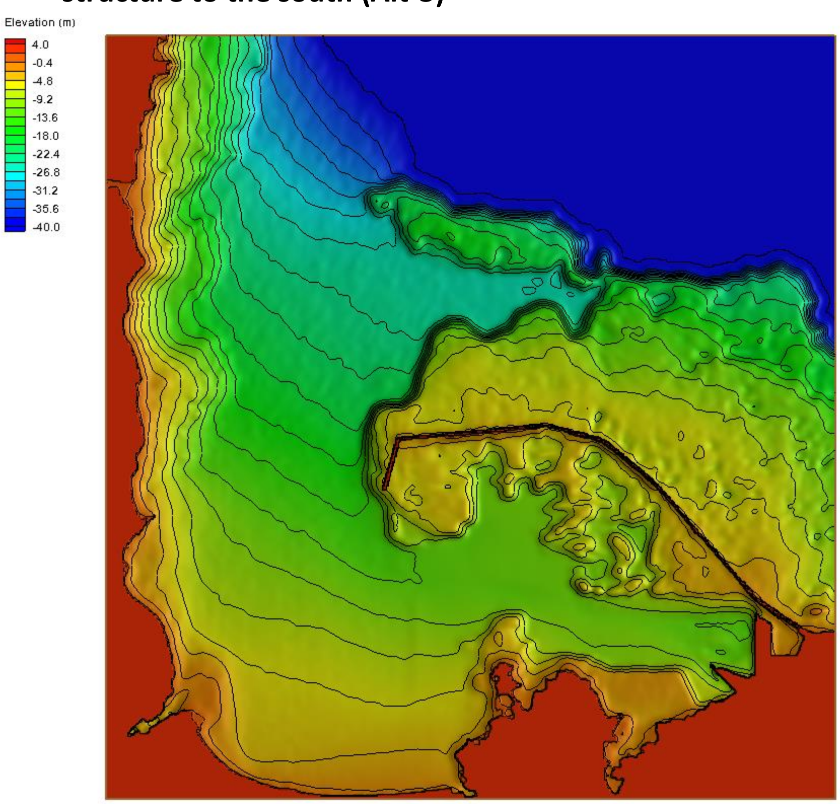

Figure 9. Modification with a spur added to the tip of breakwater (Alt-4)

3.4.2. Turning Basin Modifications

Modification of the turning basin would provide additional area for large vessels (cruise ships) to maneuver when approaching and departing Pier 1. The additional area would increase the "buffer zone" for safety purposes, and potentially increase arrival and departure efficiency. The conceptual design for turning basin widening is shown with bathymetry changes in Figure 11. The turning basin widener is located between the northern end of Pier 1 and the breakwater root. This area was chosen for expansion based on discussions with harbor pilots regarding maneuvering and berthing techniques used while piloting cruise ships. The dimensions of this expansion are approximately 1250 ft length by 250 ft wide. This area would be deepened to 35 ft MLLW (maximum) to be continuous with the rest of the turning basin. The initial dimensions of the widener were developed using a design vessel length of 965 feet (typical cruise ship calling Hilo) and standard engineering guidance recommending a turning basin diameter of approximately 1.5 times vessel length (USACE, 2006), resulting in approximately 1500 ft for total basin width. However, after ship simulation and consultation with harbor pilots, the dimensions were further refined to minimize dredging and resulted in the dimensions and position shown in Figure 10.

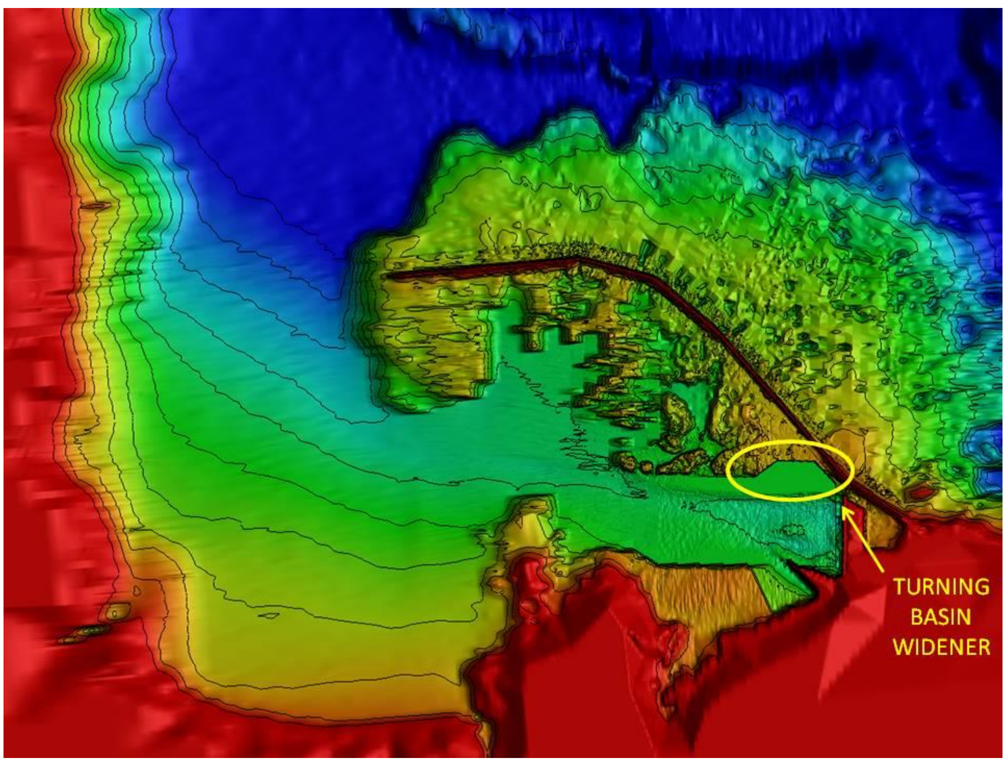

Figure 10. Turning basin widener and existing bathymetric contour lines

3.5. Stakeholders and Sponsor Engagement

Throughout the screening of measures and development of alternatives, the project sponsor and harbor users (including harbor pilots, shipping companies, cruise lines, etc.) were briefed on the status of the study and solicited for input on potential measures and alternatives. The planning charette was an intensive 3-day workshop held in April 2013, intended to collect information on the problems being experienced at the harbor, familiarize the sponsor and stakeholders with the USACE study process, and begin the initial steps of the planning process.

Representatives of USACE attended the Hawaii Harbor Users Group Meeting (HHUG) at DOT-H in Honolulu in July 2014 to brief members on the preliminary alternatives, and to request feedback on economic information. The economic information requested included: costs due to vessel delays/damages, additional tug assistance, and missed port calls experienced due to high waves; potential additional vessel calls in the future; information on groundings or close calls; and information on how operational efficiencies could be improved. Limited feedback or follow up was received; however, some information regarding additional fuel costs borne by cruise ships while berthed during high wave conditions was given.

In December 2014, members of USACE, DOT-H and the Hawaii Pilot's Association (HPA) traveled to the USACE Engineering Research and Development Center, Coastal and Hydraulics Lab (ERDC/CHL) in Vicksburg, Mississippi. Harbor pilots participated in ship simulation (a virtual reality-type simulation of piloting vessels through a navigation channel) to evaluate the feasibility of the turning basin expansion alternative proposed. The results of these simulations are discussed further in Chapter 4. During this trip, harbor pilots and DOT-H representatives also held discussions with ERDC/CHL modelers conducting numerical modeling, in order to provide additional detail on the problems experienced at the harbor, and their observations under various wave conditions.

In April 2015, following evaluation of alternatives using numerical modeling, USACE briefed the HPA on the refinement of conceptual designs and effectiveness of structural modifications, as well as the results of the ship simulations. At this time, harbor pilots were informed that, based on numerical modeling tests, it appears that the wave energy being experienced at Piers 1 and 2 during large swell events are the result of waves refracting/diffracting around the tip of the breakwater and not transmitting through or overtopping the breakwater trunk.

Finally, in August 2015, the HHUG was again briefed on the study progress, including design concepts, numerical modeling and ship simulations completed, estimated costs of alternatives, and preliminary economic benefits. The HHUG (as well as DOT-H) were informed at that time that none of the harbor modifications (to the turning basin or the breakwater) appeared to be economically feasible, and that the study would be terminated.

4. EVALUATION OF ALTERNATIVES AND CONCEPTUAL DESIGNS

Evaluation of the alternatives described in the previous section focused on their improvements to the identified problems (safety, navigational and operational delays due to waves/surge), expected environmental impacts, economic benefits, and estimated costs. Tools used to assist the project team in these evaluations included a ship simulator, numerical models, environmental surveys, economic and cost data. The following sections describe the information developed from these tools, and the assessments made by subject matter experts to evaluate the feasibility of each alternative.

4.1. Improvements to Safety and Efficiency

4.1.1. Ship Simulation

For this study, two different alternatives (in addition to the existing condition) were evaluated with the aid of the Ship/Tow Simulator (STS) at the ERDC/CHL. Turning basin alternative 1 (TB-1) was developed based on a 1500-ft turning area utilizing the existing turning basin area, and an expansion to the north (Figure 11). During simulations, pilot input resulted in development of turning basin alternative 2, TB-2 (Figure 12). This alternative includes a turning basin expansion that is closer to the breakwater and is minimized in area to ensure more effective use of the expanded area (as shown previously in Figure 10). Both alternatives included moving the Federal turning basin limit to a distance approximately 125 ft from Pier 1. The STS simulated these harbor configurations and accurately simulated wind, wave, current, and other environmental conditions. The simulator allowed ship pilots to navigate the harbor under different physical and hydrodynamic scenarios to evaluate navigation changes and safety issues.

Currents for both the existing and proposed turning basin configurations were calculated by ERDC/CHL using the hydrodynamic numerical model CMS-Flow in combination with wave model CMS-Wave (Demirbilek, 2015). Four atmospheric and oceanic conditions were selected and approved by POH for inclusion in the simulator study, intended to represent various wind and wave conditions that harbor pilots may encounter when navigating the harbor. Additional details on these conditions and simulation results are available in Appendix A. Maximum flood and ebb currents, along with the corresponding wave fields were extracted for each of these conditions. The visual scene was developed using the photographs taken during a previous reconnaissance trip to Hilo Harbor (Figure 13).

The design vessels used for this study were the GTS Constellation and the Celebrity Solstice. The GTS Constellation dimensions are 294m (965 ft) length overall (LOA), 32.2m (106 ft) breadth, and 8.04m (26.4 ft) draft. The Celebrity Solstice dimensions are 317.2m (1040 ft) LOA, 38.6m (127 ft) breadth, and 8.5m (28 ft) draft. Both vessels were enabled with azipod thrusters for maneuvering.

Each of the four harbor pilots that participated in the simulations completed approximately 32 simulation runs under various conditions (e.g. – variation in waves, wind, inbound/outbound, vessel, etc.). The majority of simulations were conducted representing daytime conditions, in order to accurately represent typical operations at Hilo Harbor. Alternative configurations were evaluated using pilot questionnaires and composite track plots of vessel position, an example of which is shown in Figure 14. In this study, a transit is labeled unsuccessful if any part of the vessel leaves the confines of the channel or turning basin, impacts a buoy, impacts one of the vessels tied up in the berthing area, impacts pier 2, comes within 30 feet or less of berthed vessels, or runs aground.

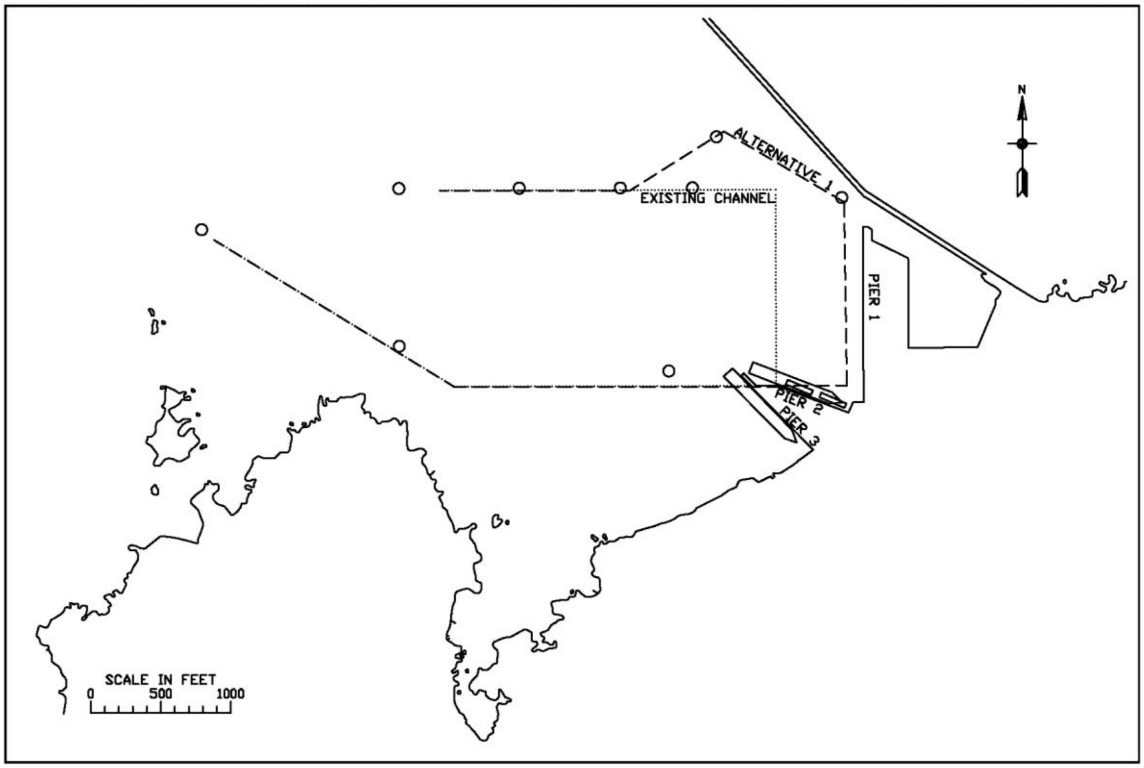

Figure 11. Turning basin widener, TB-1

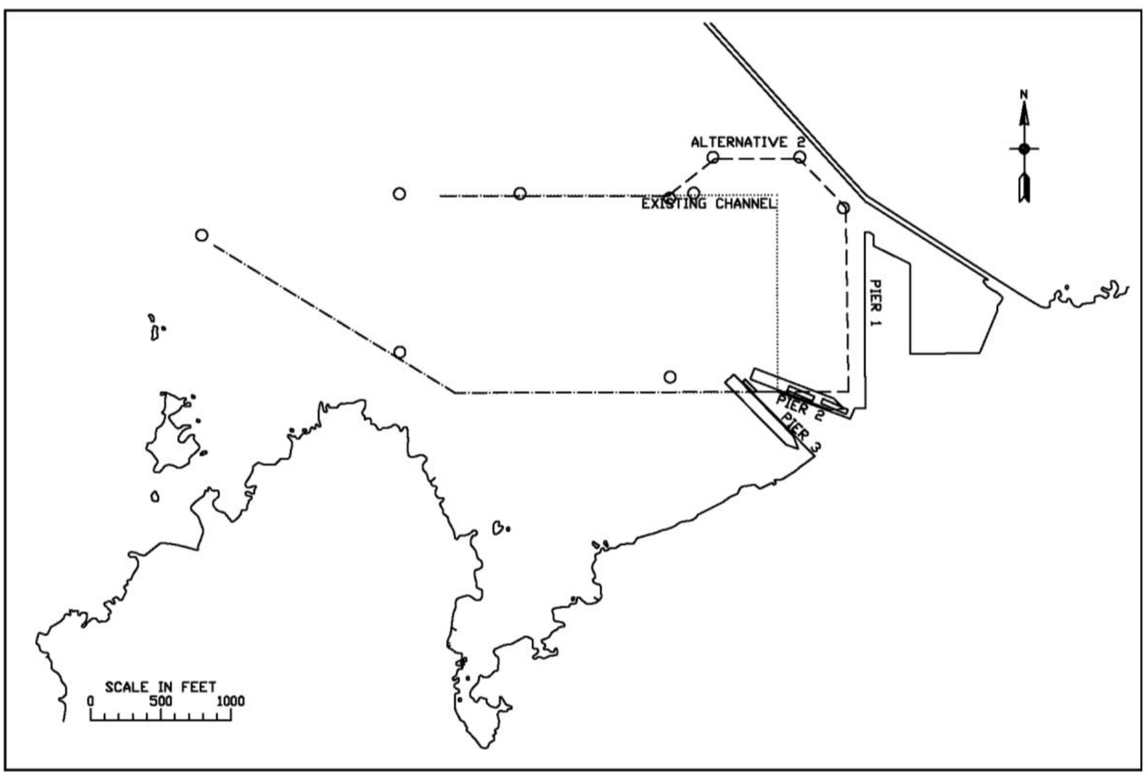

Figure 12. Turning basin widener, TB-2

Figure 13. HarborMaster Jeff Hood and HDOT representative Kim Kido in the ship simulator

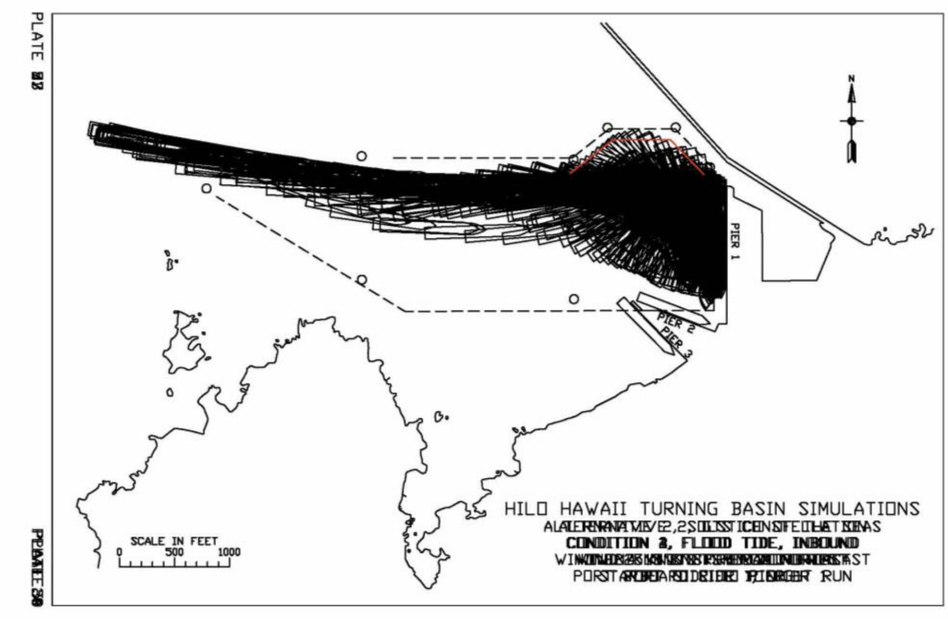

Figure 14. Example composite track plot of ship simulations for TB-2.

It was concluded from the ship simulations that Alternative1 and Alternative 2 provide time savings to be accounted for in the economic justification of the proposed modifications. The two alternatives also provide improved safety for maneuvering of vessels with length overall greater than accommodated by the existing project design. In addition, the expansion of the Federal turning basin toward Pier 1 was determined to improve safety, since simulations showed that turning maneuvers are occurring within this area.

4.2. Improvements to Navigation/Berthing Conditions

4.2.1. Numerical Modeling Studies and Field Data Used

Wave modeling for Hilo Harbor was conducted using two numerical models: namely B2D and CMS-Wave. B2D was used in this study to investigate alternatives representing different proposed structures inside and outside of the harbor. Because B2D is a fully nonlinear time-domain model able to represent linear and nonlinear nearshore wave processes, it is a computationally resource-demanding model. B2D is used in the present study over a small area covering details of the harbor, structures, and the immediate vicinity, including reefs and shorelines.

Because large domain modeling around Hilo Bay was not possible with B2D for the required range of wave conditions, it was necessary to augment B2D modeling with a spectral wave model capable of providing estimates of waves over much larger domains and for a large number of wave conditions. CMS-Wave is part of an integrated Coastal Modeling System (CMS) developed at CHL for coastal inlets and regional modeling project applications. CMS-Wave is a steady-state 2D spectral wave model (Lin and Demirbilek 2012; Lin et al. 2011; Demirbilek and Rosati 2011; Lin et al. 2008; Demirbilek et al. 2008) used for simulating wave processes with ambient currents at navigation channels, coastal inlets, and harbors. In light of the B2D and CMS-Wave complementary features, these models are frequently used in tandem in similar navigation studies.

To determine how winds, waves, and water levels affect navigation at Hilo Harbor, a good understanding of the effects of complex bathymetric features, surrounding coastlines, and protective structures is required. The geometries of the existing breakwater, harbor entrance, navigation channel, turning basin, and piers play a role on navigability. Field data were used in the understanding of the existing navigation difficulties experienced inside and outside the harbor, and for assessing the potential usefulness of alternatives. Wave data for Hilo Harbor were available from five sources: (1) National Data Buoy Center (NDBC) Buoys 51004 and 51100, (2) Coastal Data Information Program (CDIP) Buoy 188, (3) the USACE Wave Information Studies (WIS) Station 82527, (4) a pressure transducer (UH-HB) installed and maintained at Pier #1 by the University of Hawaii collected data from late December 2013 through April 2014, and (5) an Acoustic Doppler Current Profiler (ADCP) installed by ERDC- CHL (CHL H1) in 2007 to collect wave and current data.

CMS-Wave was used to transform offshore wave information provided by deep water coastal buoys to the project site at the seaward boundary of the B2D grid. CMS-Wave was also used to check the reliability of available nearshore wave data for input to the B2D model. Figure 15 shows the CMS-Wave and CMS-Flow model domains and locations of some of the available met-ocean data stations. The CMS-Wave grid domain was greater than CMS-Flow for transforming waves properly from offshore locations into Hilo Bay. The CMS-Flow grid domain was sufficiently large and covered the reef outside Hilo Harbor. The domains and orientation of three B2D grids (N, NNE, and NE grids) are shown in Figure 16.

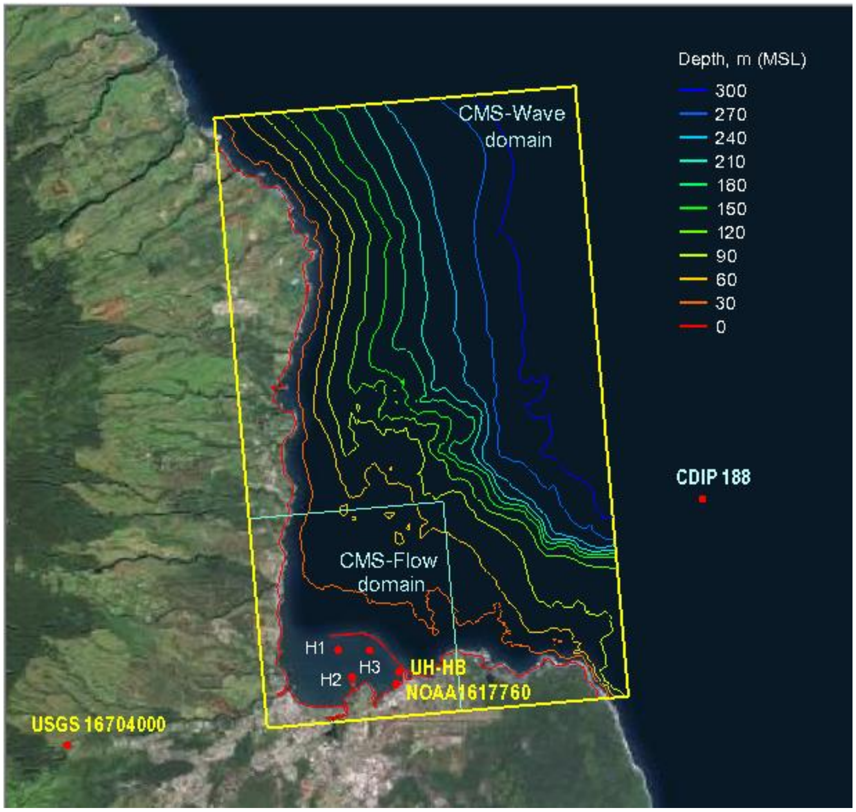

Figure 15. CMS modeling domains and metocean data stations including CDIP 188, UH-HB and CHL H1, H2, H3 gauges

Potential causes of reported problems at Piers 1 and 2 were investigated by evaluating wave processes with and without the proposed modifications. Impacts and effectiveness of the modifications on navigation in the channel and harbor were investigated. The field data collected in 2007, 2013 and 2014 were used in model calibration. Further details on model calibration are available in Appendix A. Numerical model results were utilized to examine the merits of changes and their impacts on different areas of harbor.

Based on analysis of the year 2014 wave climate, a number of severe wave events were reported by NOAA offshore buoys which impacted navigation according to users of Hilo Harbor. Five wave conditions from different directions were selected to investigate the potential harbor surge problem, these included storms and non-storm conditions. Waves generating infragravity (IG) waves inside the harbor could be causing a localized surge at piers if the period of these waves coincides with one of the natural periods of the harbor. The storm events for investigation of surge problem are shown in Table 5.

According to ship captains, pilots, and harbor master familiar with Hilo Harbor, the described surge problem is related to deep water storms occurring outside the harbor. Furthermore, they noted that the surge also occurs during less severe (milder) weather conditions. For this reason, a few typical 2014 wave conditions from different directions in Table 6 were also simulated to investigate the potential surge problem in the harbor.

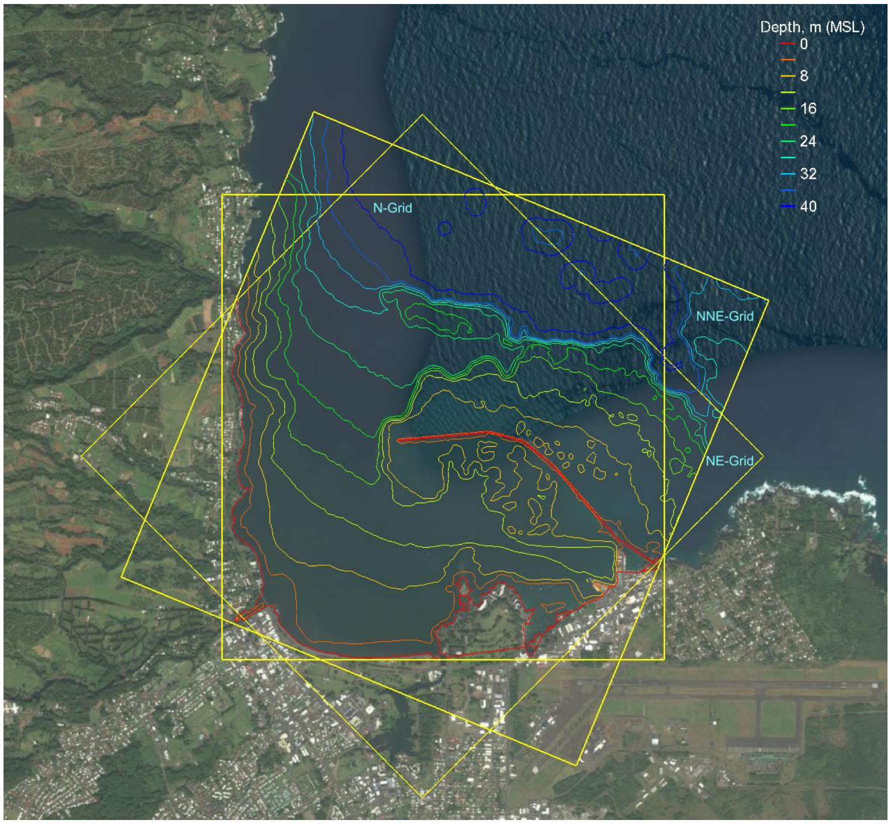

Figure 16. Three B2D model domains (N, NNE, and NE grids)

Table 5: Wave conditions used in B2D simulations.

Event Date & Time	H_s (m)	T_p (sec)	θ (deg)
5 Jan 2014@UTC16	1.5 (4.9)[2]	14.3	5
	2 (6.6)	14.3	5 & 20
	2.1 (7.0)	14.3	0, 18
	2.5, 2.8, 3.4 (8.2, 9.2, 11.2)	14.3	0
23Jan2014@UTC07	5 (16.4)	14.3	0 & 345
27Feb2014@UTC15	2.4 (7.9)	13.3	0
18Mar2014@UTC20	3.3 (10.8)	13.3	0
4Apr2014@UTC05	3 (9.8)	14.3	0 & 345

[2] Equivalent English units (ft) in parenthesis next to metric lengths.

Table 6: Milder wave conditions for study of surge problem.

Test condition	H_s (m)	T_p (sec)	θ (deg)
1	1.3 (4.4)	14.3	40
2	1.5 (4.9)	10	0, 5, 22.5, 45
3	1.5 (4.9)	14.3	8, 15
4	1.8 (5.8)	14.3	28
5	2.0 (6.6)	14.3	20
6	2.6 (8.5)	14.3	8
7	3.4 (11.2)	14.3	350

The storm and non-storm wave conditions in Tables 5 and 6 were used for the IG-generated surge problem, and evaluation of alternatives. These two sets of wave conditions cover a wide range of significant wave height, peak period and directions.

For the assessment of the surge problem, model results at the UH gauge location north of the Pier #1 were analyzed to check for the presence of infragravity waves. These long-period waves are often the primary cause of harbor surging phenomenon, ship moorings, and on/offloading problems in harbors. For incident waves from ±10°of true north, model results showed some wave energy in the low-frequency tail of wave spectra. However, the existence of IG waves with periods close to the natural periods of harbor in the SE corner of harbor is strong indication and cause of great concern for the occurrence of harbor oscillations (surging).

Figure 17 is an example of a typical wave field from B2D for an incident wave from north under the existing breakwater configuration, showing spatial patterns of waves moving over the outside of the fringing reef system, including areas of wave focusing (converging) caused by strong wave refraction, shoaling and breaking, and waves which wrap around the tip of breakwater moving into interior harbor.

Results indicate wave dissipation occurs over the reefs outside the breakwater. There is a significant amount of wave shoaling, refraction, and breaking, which produce a few high and low wave heights zones over the rapidly changing bathymetry on the reef. The figure above shows that after wave energy passes through the entrance and is diffracted at the tip of breakwater, it follows the channel half way into the harbor, and then splits up and refracts toward the channel sides and reefs on both sides of the channel. The height of the outward refracting wave over the reefs and shallower parts of harbor north and south of the channel is small as compared to waves in the channel. The wave heights in the turning basin and at Pier #1 range from 1.6 ft to 2.6 ft and from 0.2 ft to 1.3 ft, respectively. These estimates varied slightly with different model parameters, and the maximum change in wave height was ±20%.

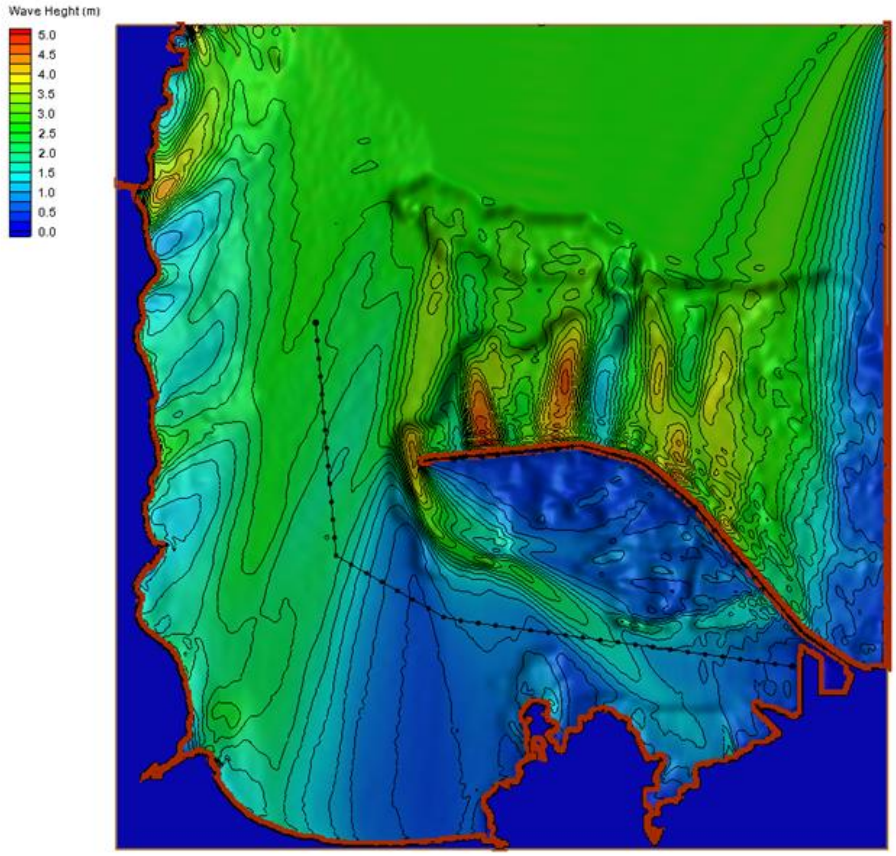

Figure 17. Example of wave height field from a B2D simulation for existing breakwater

4.2.2. Structure Alternatives Evaluation

The results of modeling the existing harbor configuration indicated that the largest waves in the harbor were caused by waves incident from ±10° around the true north (e.g., slightly oblique waves between N and NNE directions). For this reason, the model simulations for evaluation of alternatives considered a severe storm event from nearly north direction. The waves parameters input to the model were Hs = 8.6 ft, Tp =14.3 sec, and θp = 8°. For comparison of alternatives, the focus is on the last 3,280 ft of the navigation channel as it passes through the turning basin. Figures 18 through 21 show the resulting wave fields under this wave condition for each of the alternative configurations presented in Figures 6 through 9, respectively.

The effect of the short (820 ft) detached structure (Alt-1) on waves is localized to the vicinity of the structure, and appears to have diverted waves slightly toward the southeast direction. The comparison of Figure 17 (Existing) and Figure 18 (Alt-1) shows an increase in wave height around Pier #2, Pier #3 and Pier #4 and a reduction in the turning basin and at Pier #1.

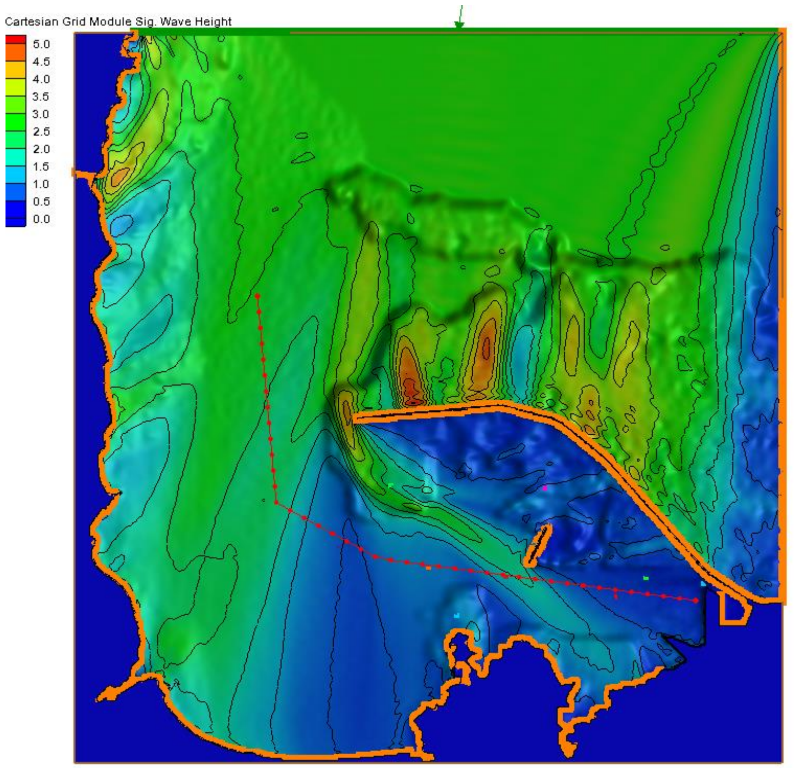

Figure 18. Wave conditions with a short (820 ft) detached breakwater (Alt-1)

Figure 19 provides the results for Alt-2, where a longer structure (1,580 ft length, 40 ft width) than the one in Alt-1 was used initially. In Alt-2, a much longer (2,300 ft long) structure connecting to the breakwater was also tested. Overall, similar results were obtained and there was no significant change in waves in the turning basin and Pier #1 areas. Results provided in Figure 20 look similar to the Alt-2 results in Figure 19, although the addition of a short south structure appears to increase waves in the turning basin and at Pier #1. The 2,300 ft spur shown in Figure 21 (Alt-4) poses the least risk to ships in the channel amongst all structures considered because it is not close to the channel edge. Results in Figure 21 indicate Alt-4 is the most effective alternative because it reduces waves almost everywhere in the harbor, the turning basin and Pier #1 and Pier #2 areas.

Figures 22 and 23 provide a direct comparison of wave heights for each alternative with the existing condition along a transect (indicated by the red line in Figures 18 through 21) through the navigation channel and turning basin, respectively. In summary, the analysis of results indicate Alt-4 is the best alternative for providing the most wave energy reduction in the entire navigation channel, and at the turning basin and Pier #1. Alt-4 outperformed other alternatives with an average wave height reduction of 28% and 89%, respectively in the channel and turning basin. Alt-1, Alt-3 and Alt-2 follow Alt-4 in the ranking of alternatives. The reason Alt-4 achieved such a dramatic reduction in waves was its ability to control waves coming through the entrance. Alt-4 with the spur at the tip of breakwater is able to intercept and re-direct waves toward the southwest side of harbor. The east and southeast sides of the interior harbor (e.g., turning basin, Pier #1 and Pier #2) benefit greatly from this diversion of waves, resulting in greater than 80% wave reduction at Pier #1, Pier #2 and turning basin areas.

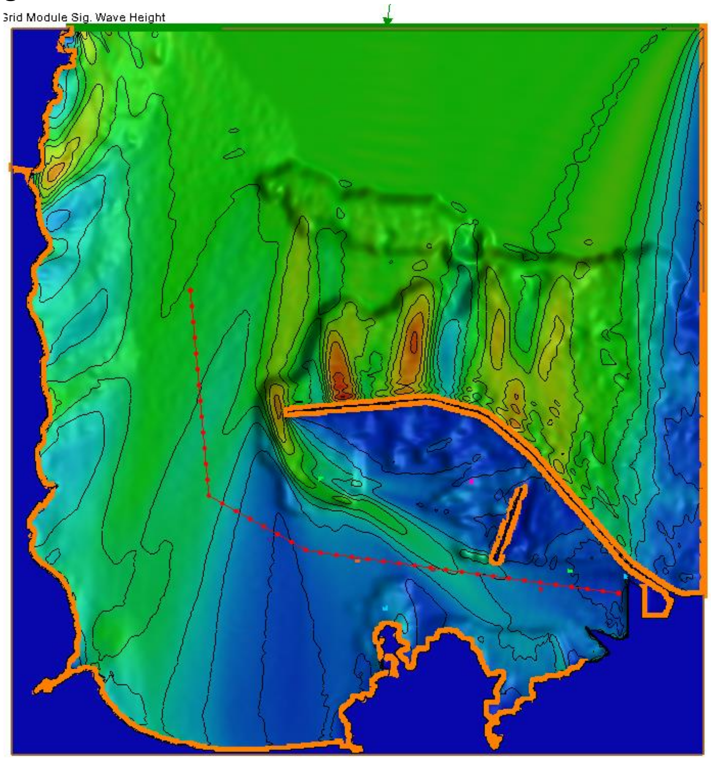

Figure 19. Wave conditions with a medium length (1,580 ft) detached breakwater (Alt-2)

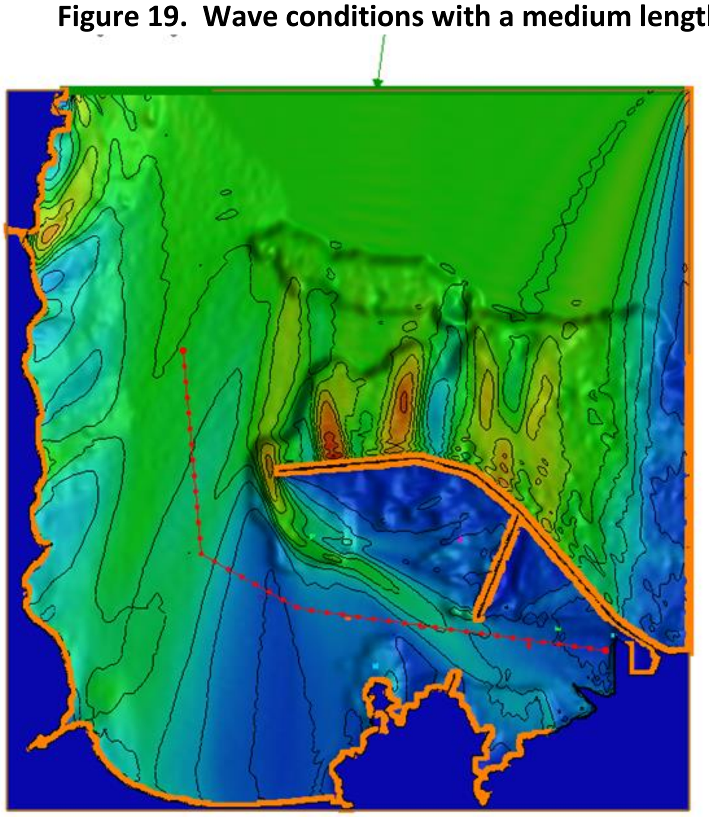

Figure 20. Wave conditions with a longer (2,300 ft) attached breakwater and a short (410 ft) structure to the south (Alt-3)

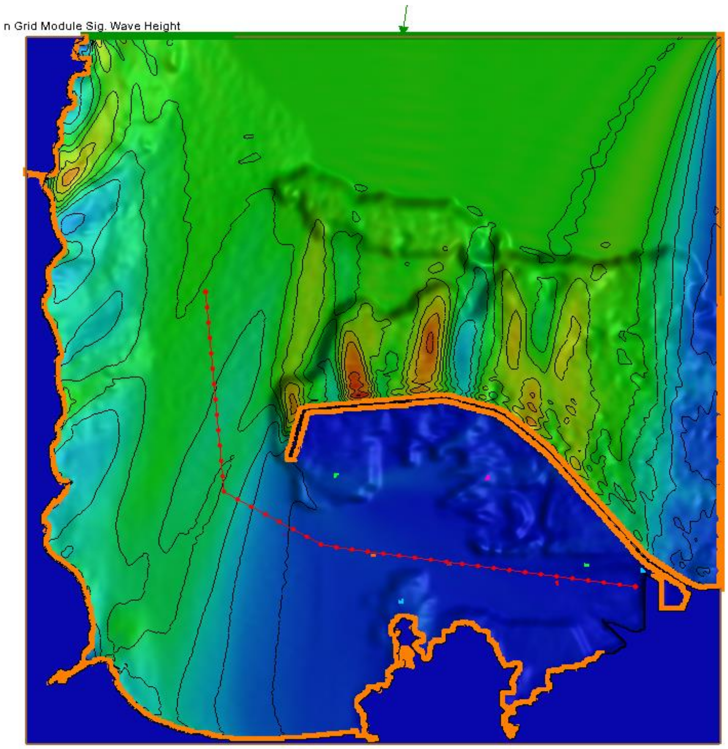

Figure 21. Wave conditions with a spur added to the tip of the breakwater (Alt-4)

4.2.3. Evaluation of Breakwater Permeability and Overtopping

In order to evaluate the potential of breakwater permeability and/or overtopping as the cause of waves at Pier 1, the calculated wave heights on the seaward side of the structure near Pier 1 were compared to those in the lee (harbor side) of the structure. Model results showed waves in the lee of the breakwater remaining essentially constant for three levels of breakwater permeability investigated. Results for three porous layers (3.3 ft, 6.6 ft and 10.0 ft) indicated the transmitted wave height was less than 1.4 ft, or approximately 10% of wave height outside the breakwater. The high crest elevation of the structural segment investigated (~11.5 ft above the MSL) did not permit wave runup/overtopping, ensuring low transmitted wave heights in the lee of breakwater. Model results suggested that wave transmission through the structure was negligible, and that wave runup/overtopping could happen for certain storms conditions (e.g., excessive water piling up on the outer reef that can lead to runup/overtopping of the east side of the breakwater). However, it is not evident that overtopping under these conditions would result in significant wave energy near Pier 1. Further details of this analysis are available in Appendix A.

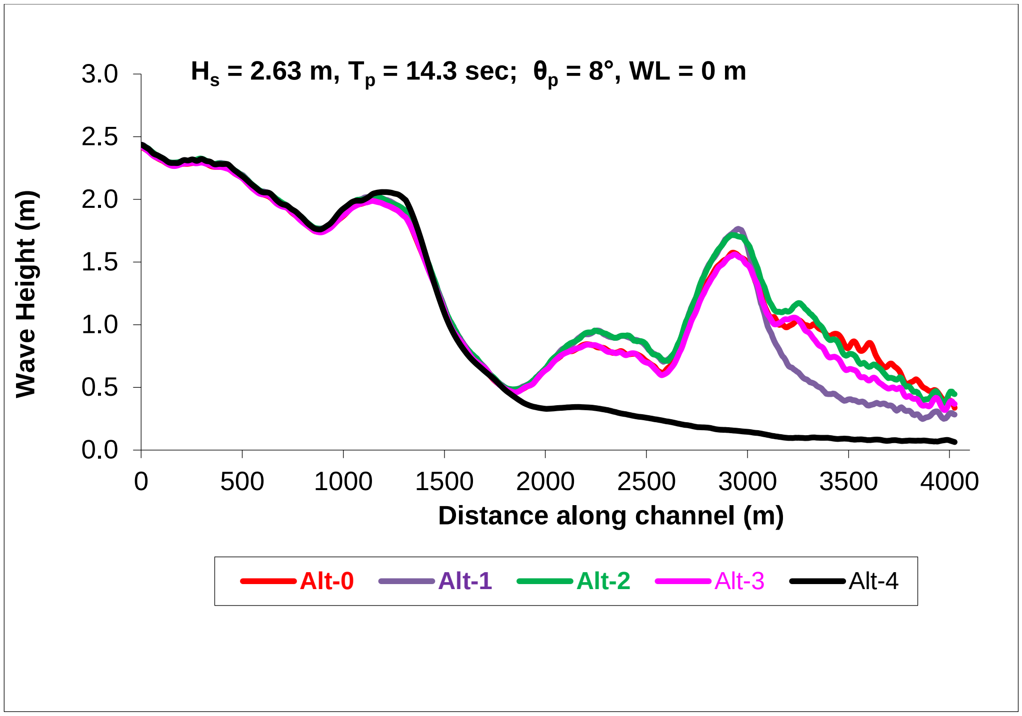

Figure 22. Comparison of wave height variation in the navigation channel for various alternatives with the existing condition (Alt-0).

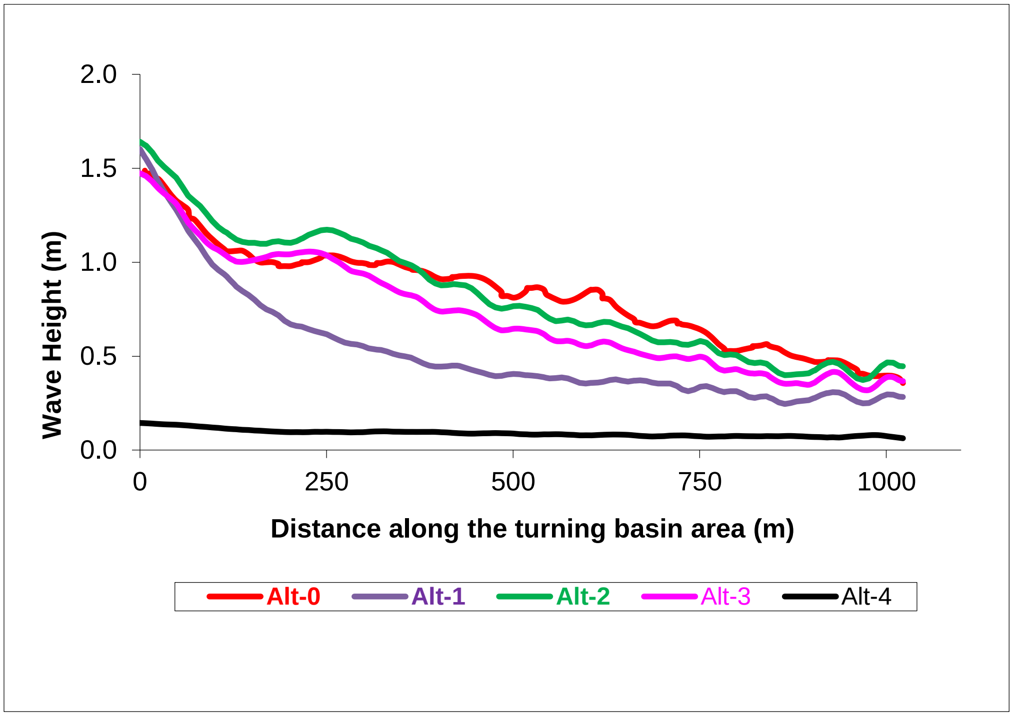

Figure 23. Comparison of wave height variation in the turning basin for various alternatives with the existing condition (Alt-0).

4.3. Conceptual Designs of Alternatives

Based on the evaluation of turning basin expansion and breakwater modifications described above using numerical modeling and ship simulations, the Project Delivery Team (PDT) decided to proceed with a conceptual design of the breakwater modification using a spur at the tip of the breakwater (Alt-4, shown in Figure 9) and turning basin alternative 2 (TB-2, shown in Figure 10). The goal of the turning basin widener is to provide safe navigation access to Pier #1 by the ever increasing sized cruise ships. The breakwater spur is designed to reduce wave energy within the harbor thereby reducing vessel damages as well as improving operational efficiency and navigation safety. The intention was to develop designs to the level of detail required to enable a preliminary cost estimate (defined as more detail than a rough order of magnitude estimate, but not as much detail as would be required to proceed to construction). This includes approximate estimates of material types and quantities, equipment required, approximate footprint, construction duration, etc. The following provides the general details of these conceptual designs.

4.3.1. Breakwater Spur

A breakwater spur was designed to reduce wave energy within Hilo Harbor. For this alternative, a 1,000-foot long spur would be constructed at the head of the existing breakwater in the alignment shown in Figure 24. The spur would consist of 20 concrete caisson units. Each unit would be 50 feet long, 25 feet wide and 25 feet high (Figure 25 and Figure 26). Rebar would be incorporated into the units to provide stiffness. The caissons would not be directly attached to the existing breakwater. All caisson walls would be made of concrete (thickness = 2 feet).

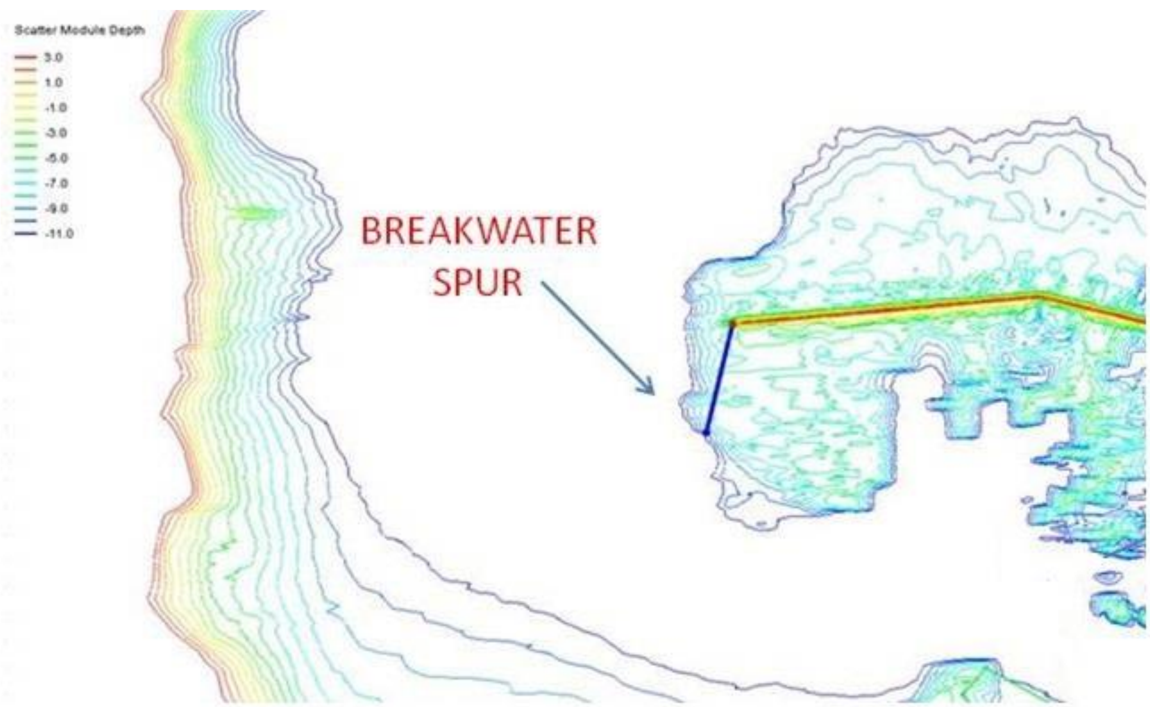

Figure 24. Breakwater spur alignment

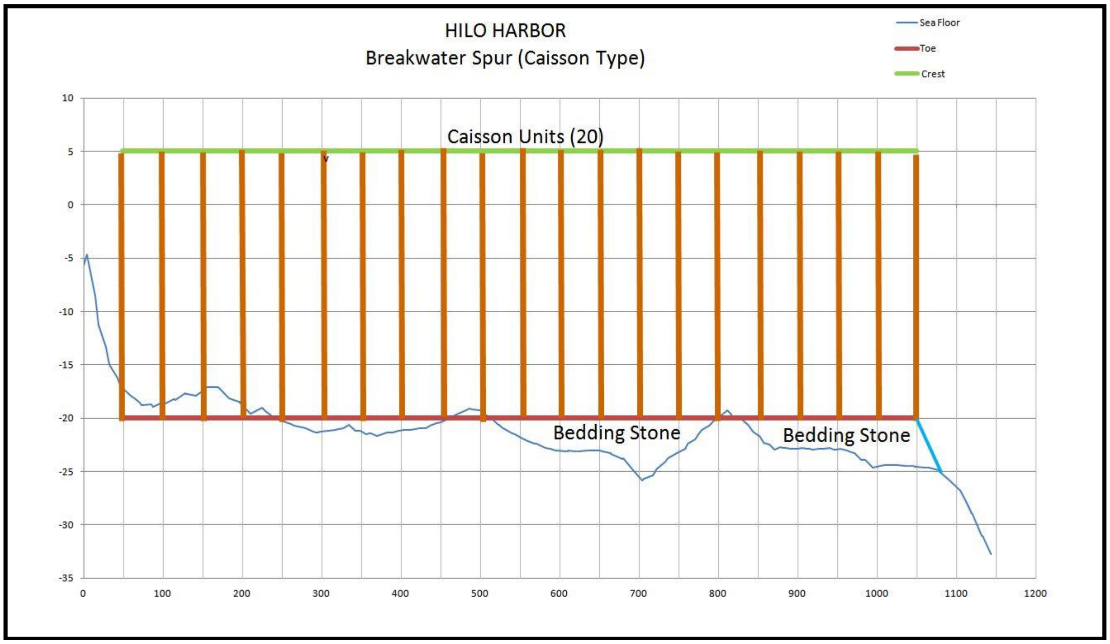

Figure 25. Breakwater spur longitudinal view

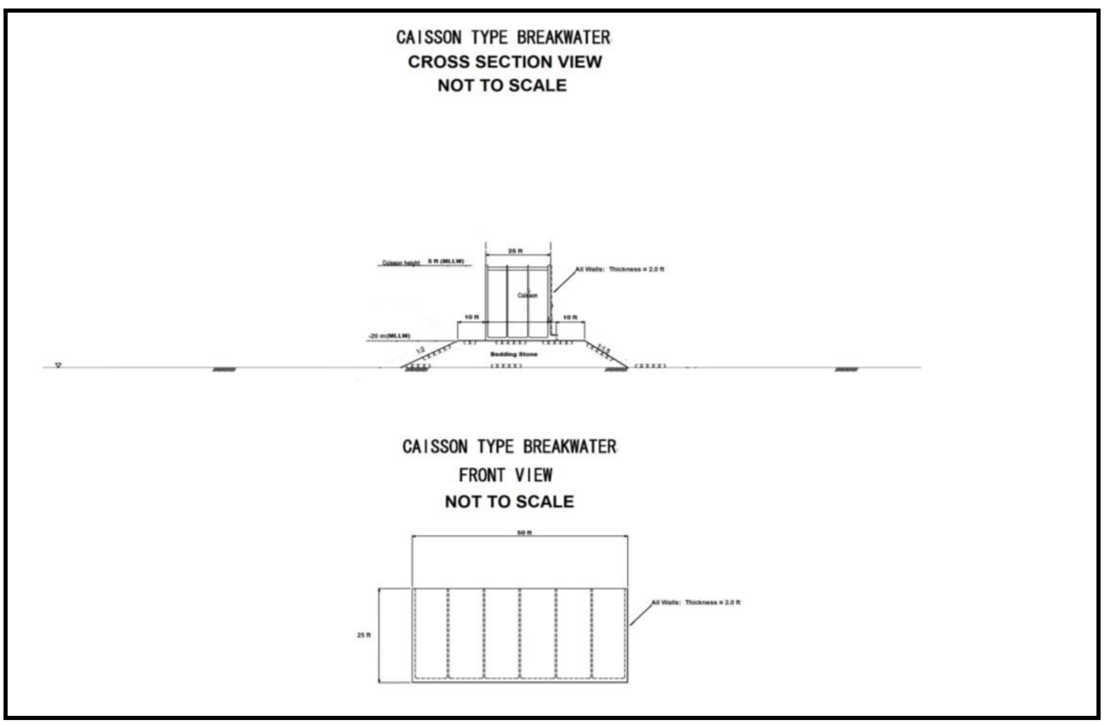

Figure 26. Breakwater spur cross section view

The caisson compartments would be filled with material dredged from the turning basin widener. Construction of the caissons would take place at Kawaihae Deep Draft Harbor located approximately 100 ocean miles from Hilo Harbor. The units would be floated from Kawaihae

Harbor to Hilo Harbor under tug assist. Once at the project site, they would be sunk in place onto a bedding stone foundation.

Foundation preparation would consist of excavation of high spots and placement of bedding stone. Excavation of the high spots shown in Figure 25 would require the removal of 300 cy of hard material. Total volume of bedding stone (100 pound to 300 pound stone) required to fill the cross section shown in Figure 26 would be approximately 3,500 cy.

4.3.2. Turning Basin Widener

The turning basin widener shown in Figure 27 has been designed to facilitate efficient and safe transit of cruise ships into Pier #1 at Hilo Harbor. Dredging of the widener would result in the removal of the in situ volumes shown in Table 7. Volumes are shown for dredging the widener from the existing bottom to 30 feet through 35 feet (in 1-foot increments). Dredging the first increment from existing depth to 30 feet requires excavation and disposal of 145,000 cubic yards (cy) of material. This work would bring the entire area to a depth of 30 feet (there are no deeper areas in the widener). Each additional foot of depth would require dredging a volume of 13,000 cy. Dredging to a depth of 35 feet would require removal and disposal of 210,000 cy of material.

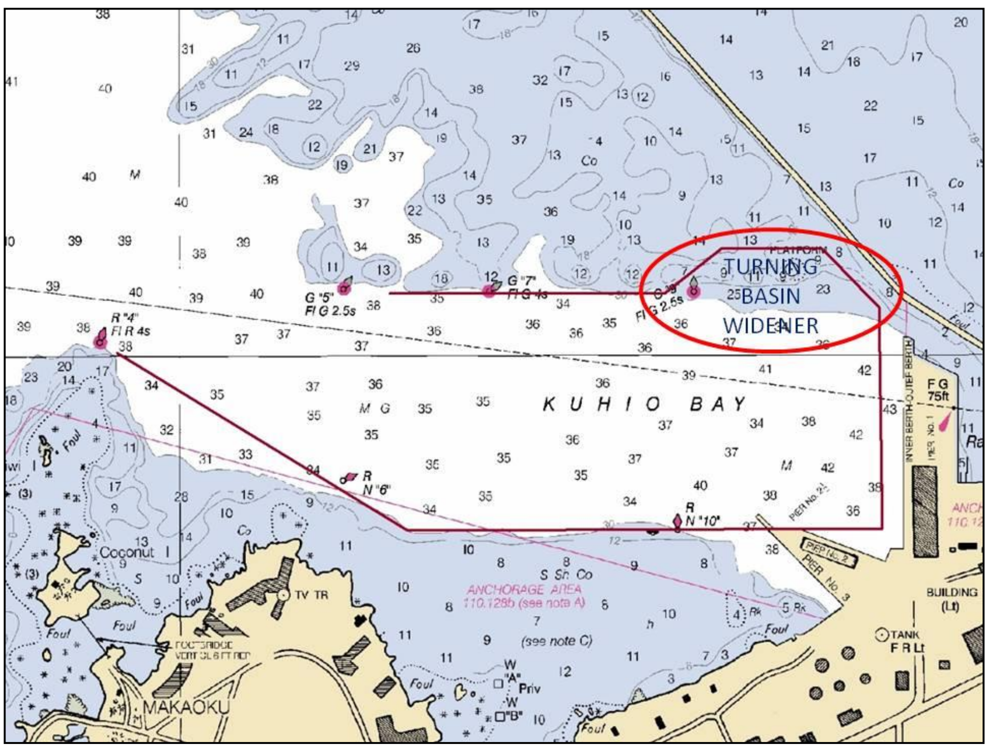

Figure 27: Turning basin widener would be located in the northeast corner of the turning basin

The dredge plant(s) must be capable of removing both "hard" and "loose" material as defined below. The estimated percent "hard" material for each increment of depth is provided in Table 7. Hard material is defined as material requiring the use of special equipment for conventional material removal, and includes boulders or fragments too large to be removed in one piece by the dredge. Loose material is defined as material not qualified as "hard material" above that may be removed in one piece by the dredge. Loose material may include rocks, coral rubble, cobbles, gravels, sand, silt, mud, tree limbs, and branches as well as all metal and other debris.

Table 7: Dredging requirements for the turning basin widener

Dredge Depth (ft, MLLW)	Dredge Volume (cy)	Hard Material (%)
35	210,000	72
34	197,000	67
33	184,000	62
32	171,000	57
31	158,000	52
30	145,000	50

4.4. Expected Environmental Impacts

4.4.1. Fish and Wildlife Resources

As mentioned previously, as part of the requirements of the Fish and Wildlife Coordination Act Section 2(b), the USFWS and State of Hawaii DAR conducted Benthic Habitat Mapping Surveys (Phase I in August 2014, and Phase II in March 2015), based on potential alternative footprint areas within Hilo Harbor identified by USACE. The purpose of the Phase I Marine Habitat Characterization survey was to conduct a qualitative evaluation of potential environmental impacts to approximately 98 acres of area within the harbor, including documentation of the marine habitats and species found in these areas. The results of this survey are documented in a February 2015 Planning Aid Report.

The Phase II survey was a quantitative evaluation of a reduced 10 acre area based on a reduced potential project footprint provided by USACE. This footprint included only the potential dredging area for the turning basin widener. The footprint of the breakwater spur was not included in the survey because this alternative was not being considered at the time of survey coordination. If this breakwater modification were to be pursued into detailed design, a new benthic survey would be required to evaluate environmental impacts. The Phase II survey evaluated potential unavoidable impacts to fish and wildlife resources, and provided results in a Coordination Act Report which describes impacts to algae, corals, macro-invertebrates, reef fishes, and general habitat including marine mammals.

The USFWS concluded that aggregate reef located north of the federal channel and south of the breakwater in Hilo Harbor has been identified as the habitat of major concern for the proposed dredging portion of the project. To various degrees, the reefs within and adjacent to the planned dredging site in Hilo Harbor promote specialized ecological functions, which include species recruitment, foraging, nesting, sheltering from predators, as well as habitat for federally listed green and hawksbill sea turtles.

The final recommendations of the CAR include additional marine biological assessment, post-construction monitoring, and potential compensatory mitigation measures for unavoidable impacts to fish and wildlife resources, if the project were to go to construction. These potential mitigation measures (suggested by DAR) include: a Hilo Bay estuary project, an alien species assessment/inventory in Hilo Bay, a sediment reduction project, a coral fragmentation and transplant project, or additional mooring buoys. Description of these measures is available in Appendix C however, no detailed design or cost estimates were developed as part of the study.

4.4.2. Other Environmental Impacts

Pursuant to 33 CFR 230, POH also initiated the preparation of an Environmental Assessment (EA) to evaluate potential direct, indirect, and cumulative impacts of the proposed project on the human and natural environment. However, due to the preliminary planning level of design completed prior to termination of the Feasibility Study, additional environmental coordination in regards to the following regulations and requirements were not completed:

- Clean Water Act (CWA) Section 401 Water Quality Certification
- CWA Section 404(b)(1) – Discharge of fill into US waters
- Dredge material testing/management for ocean disposal in EPA disposal sites
- Endangered Species Act
- Coastal Zone Management Consistency
- Essential Fish Habitat
- Cultural Resources
- Hazardous, Toxic, and Radiological Waste Assessment
- CWA Section 402 National Pollutant Discharge Elimination System

4.5. Estimated Costs

Following USACE ER 1110-2-1302, Engineering and Design Civil Works Cost Estimating, the cost estimates were prepared at a Class 4 level. Class 4 is for the refinement of the viable array of alternatives, which was based on a concept design. Cost was developed from rough quantity take-offs and supplemented with best professional judgment based on similar projects. Dredging costs were based on the Corps of Engineers Dredging Estimating Program (CEDEP).

4.5.1. General Assumptions for Estimates

The estimates are based on a single contract being awarded to a single Prime Contractor with multiple sub-contractors. The acquisition strategy is assumed as Full and Open Invitation for Bid. The prime contractor would be responsible for oversight of the contract the rest of the work is assumed performed by subcontractors. The estimate for this study assumed that the Prime Contractor will be from Oahu and Dredging Contractor from Oahu. This does not exclude any work effort to contractors from other locations during the bidding process.

The preliminary estimates assume dredge material disposal at the EPA approved Ocean Dredged Material Disposal Site (ODMDS). Upland disposal is at an approved on-island landfill approximately 70 miles away on the West side of the Island of Hawaii.

Reinforced concrete caissons will be cast in the “Bone yard” area next to Hilo Harbor/ Radio Bay/Small Boat Harbor and floated to the new spur location at the end of the breakwater. The caissons will be floated to the site, sunk with sea water and backfilled using excavated dredged material and additional imported fill (rocks).

Project costs are presented in October 2014 (1Q2015) dollars. Further details on cost estimates including procedures, additional assumptions and calculation of contingencies can be found in Appendix D.

4.5.2. Cost Estimate Uncertainties

Unknowns that could affect the project costs and design assumptions prior to the detailed design phase (PED) include the following:

- Weight of caisson limits crane application of caissons.
- Lack of access to roll cast caissons from shore at Hilo Harbor.
- Environmental Mitigation not well defined at this stage. Requires coordination with the USFW.
- Variation in estimated quantities for dredging.
- Changes in Acquisition strategy.
- Changes in the bid schedule.
- Lack of competition for dredging work.
- Encountering hard material during dredging.
- Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Equipment may not be available.
- Possible double handling of hard material for disposal at the ODMDS site.
- Increased permitting regulations affecting designs.
- Entire dredged material may not be allowed for disposal in the ODMDS
- Double handling of material for upland disposal.
- Lack of beneficial use for dredged material.

4.5.3. Total Project Costs for Selected Alternatives

Table 8 is a simplified version of Table D4, found in Appendix D. Total project costs (in 2014 dollars and not including contingency and escalation) are $67 million for widening of the turning basin, and $145 million for construction of the breakwater spur. Combination of both alternatives results in a total project cost of $189 million, as shown in Table D4, Appendix D.

4.5.4. Incremental Analysis

Alternative depths of the turning basin were scaled in one-foot increments between 30 and 35 feet, and a cost estimate was calculated for each depth. This was done so that, in the event that the full authorized depth of 35 feet was not being fully utilized, significant cost savings might be obtained by going only as deep as the existing fleet calling at Hilo Harbor required. Table 9 presents the incremental dredging cost, and is a modified version of Table D5, found in Appendix D.

Table 8. Dredging and Breakwater Spur Alternatives - Total Project Cost and Duration

	Widen Basin by Dredging to 35' MLLW	Construct Breakwater Spur (Caissons)
Item	**Estimated Cost in 2014 Dollars($K)**	**Estimated Cost in 2014 Dollars ($K)**
Real Estate	$62	$62
Construction:		
Mitigation Measures	$3,746	$17,218
Breakwater/Dredging	$43,334	$84,823
Total Construction Cost	**$47,080**	**$102,041**
Planning, Engrg & Design	$11,535	$25,578
Construction Mgt	$8,240	$18,269
Project Cost Total	**$66,917**	**$144,964**
Contingency	89%	110.0%
Fully Funded Cost	**$75,738**	**$166,153**
Estimated Duration	Aug 2020-Nov 2021, 15.2 months	Aug 2020-Feb 2022, 18.2 months

Table 9. Incremental Cost Summary for Dredging Turning Basin

Dredge Depth	30 ft MLLW	31 ft MLLW	32 ft MLLW	33 ft MLLW	34 ft MLLW	35 ft MLLW
Real Estate ($K)	$62	$62	$62	$62	$62	$62
Total Construction Cost ($K)	$33,978	$36,468	$38,960	$41,455	$43,873	$47,080
Planning, Engrg & Design ($K)	$8,325	$8,934	$9,543	$10,154	$10,747	$11,535
Construction Mgt ($K)	$5,946	$6,381	$6,187	$7,254	$7,677	$8,240
Project Cost (2014 $K)	$48,312	$51,844	$55,382	$58,924	$62,358	$66,917

4.5.5. Average Annual Cost

The "class 4 level," cost estimate for the turning basin improvement only at 35 feet was about $67 million (Estimated cost at effective price level October 2014), or approximately $49 million at 30 feet, as noted in Table 9. Operation and maintenance dredging would have to be done on an estimated 10-year cycle, which could add another $350,000 to the annual cost to the 35-foot project, or $250,000 to the 30-foot project. Interest during construction could add an additional $1.3 million to the first cost of the 35-foot project, or $1 million to the 30-foot project. Therefore, a reasonable estimate of the average annual cost of the 35-foot and 30-foot turning basin expansion over the 50 year period of analysis would be about $3.2 million or $2.4 million, respectively.

The only alternative to address the surge problem at Hilo Harbor for which a preliminary cost estimate was made was constructing a spur made of caissons at the end of the existing breakwater. This estimated cost at effective price level October 2014 was about $145 million. Average annual costs over the 50 year period of analysis would be over $6 million, and does not include expanding the turning basin. If constructed together, the estimated cost for both the caisson spur and the improved 35-foot deep turning basin was $188 million, or an average annual cost of more than $8 million.

4.6. Economic Benefits

4.6.1. Improvements to Safety and Vessel Damages

The PDT, including the non-Federal sponsor, discussed a number of problems and opportunities for Hilo Harbor during the early months of this study. USACE staff explained at that time how economic impacts of things like groundings and damages to infrastructure from surge events would have to be evaluated on the basis of the frequency of their occurrence. These potential benefits are difficult to flesh out, and if they occur infrequently, the magnitude of their economic consequence on an annual basis greatly diminishes when assigned a probability of it actually happening. For example, the economic and environmental damages of a vessel grounding can be enormous, but when annualized and the probability of it occurring is taken into account, the monetary value of that annual benefit tends to be small. This is especially true with a harbor like Hilo where groundings are extremely rare. In fact, all safety and life loss prevention related beneficial impacts of the kinds of harbor improvements this study deals with, generally do not equate to large monetary sums unless there is an extensive historic record of vessel groundings, collisions, allisions, near misses, or other mishaps. Safety considerations are an important, on-going problem with pilots and other ship operators taking risks moving large vessels in tight places; they just happen to be very good at what they do.

4.6.2. Improvements to Efficiency

The crucial benefit category that most of the positive economic impacts of this kind of harbor improvement study will need to justify the project's costs is increasing the harbor's economic efficiency. These can be generally related to things like correcting economic inefficiencies due to problems maneuvering ships or handling cargo. Or efficiencies can be improved by reaping the benefits of economies of scale such as attracting larger capacity ships capable of reducing the transportation cost of delivered products. With this latter benefit being more associated with harbor deepening projects, the remaining prevailing benefit to cover the majority of the project's costs at Hilo Harbor will be related to improving the turning basin efficiency. For the proposed improvements to demonstrate that they are economically justified in the case of Hilo Harbor, the benefits resulting from increasing the efficiency of the turning basin alone would have to be nearly sufficient to cover the project's costs. Then, more limited benefits like reducing damages to ships and landside facilities and attracting new, larger ships to call at Hilo could help push the benefit cost ratio above unity.

4.6.3. HarborSym Economic Benefits Model

HarborSym is a computer simulation model that attempts to replicate vessel operations within the channel under various scenarios, including existing and future "without" project conditions as well as "with" project alternatives. Model inputs include information on port structures, such as channel segments, docks, turning basins and anchorages, commodity information, vessel/ fleet information, including estimates of vessel operating costs, tides, port traffic and a set of transit rules.

HarborSym is a data intensive program relying heavily on port-specific inputs. Officials with the Hawaii Department of Transportation, Division of Harbors, provided three years, 2011-2013, of all ships, barges and cargo movements within Hilo Harbor. These data were used to develop several scenarios of existing and future with-and without-project fleet and cargo projections. Further detail on data inputs are provided in Appendix E.

Two with-project growth scenarios were used for HarborSym runs, specifically corresponding to a medium and high growth scenario. With an improved turning basin, the likelihood of the medium and high growth scenarios leading to larger ships increased considerably. The results of the medium and high scenarios were compared to the without-project condition run. Rather than Hilo ship traffic being restricted by general navigation features, such as its turning basin, the limiting restriction becomes demand for shipped goods and services. In other words, Hilo Harbor growth cannot outpace the demand for its commodities and its cruise ship business.

Recognizing that the majority of the National Economic Development (NED) benefits would have to come from increasing the size and efficiency of the turning basin, expanding the turning basin was one structural measure that had to be included. Surge related measures, on the other hand, proved too costly for the limited amount of potential benefits achievable, and were dropped from further economic consideration. Therefore, the HarborSym runs focused on the difference in transportation costs with and without the expanded turning basin. Widening the existing turning basin to 1,650 feet and lengthening it to 2,800 feet was the only with-project condition that was modeled with HarborSym. These dimensions were set given the length and maneuverability characteristics of the design ship, the present configuration of the existing turning basin, revetment, and general layout of the harbor, and input from the harbor pilots.

The pilots of the Hawaii Pilots Association indicated that with the new turning basin in place, turning times will be reduced on anywhere from 10 to 25 minutes depending on the size and maneuverability of the vessel. The ensuing reduction in transportation costs, due to this time savings as calculated within HarborSym, was the primary NED benefit of the project.

4.6.4. Project Benefits

Presenting here only the high growth scenario to test the overall viability of a possible favorable project, the main vessel types that experience cost savings in the "optimistic" scenario are Medium, Large and Largest Passenger/Cruise Ships. When taking the difference in transportation cost in the future without project and future with project, and multiplying that difference by the number of vessels in that vessel class results in the net present value of transportation cost savings for a 50 year period of analysis is $18,880,000. Using the FY15 discount rate of 3.375% the average annual benefits are about $787,000. Additional details on this calculation are available in Appendix E.

4.6.5. Benefit to Cost Ratio (BCR)

As stated earlier, only one alternative, the improved turning basin at 35 feet deep, was fully evaluated. It was evident that if this alternative was not economically justified, other alternatives would only add more costs than benefits and would be even less feasible. As shown in Table 10, with average annual benefits of about $787,000 attributable to the high growth scenario, and average annual costs of about $3.2 million for the 35-foot turning basin widener, this benefit cost ratio came to about 0.25.

Table 10. Dredging Alternative Benefit Cost Ratio

Average Annual Benefits	$787,000
Average Annual Costs	3,200,000
Benefit Cost Ratio	0.25

Regrettably, the fact that under with-project conditions, practically all present and future ship movements within Hilo Harbor would be made safer and with less chance of human, environmental or property harm or damage, has not been factored into this economic analysis. Those unaccounted for safety benefits are not so much overlooked as they are difficult and contentious to include in this type of analysis. However, it is doubtful that these benefits, if measurable, could elevate the benefit cost ratio for this project to a positive conclusion (BCR $\geq$ 1.0).

5. FEASIBILITY INVESTIGATION CONCLUSION

5.1. Justification of Federal Interest

Justification of Federal interest in a water resources project (including navigation) is determined by the Federal objective, which is defined in USACE ER 1105-2-100 Planning Guidance Notebook as "to contribute to national economic development (NED) consistent with protecting the

Nation’s environment, in accordance with national environmental statues, applicable executive orders, and other Federal planning requirements.” In other words, economic benefits to the Nation should exceed costs, and net benefits (benefit – costs) should be maximized, while taking into account applicable environmental regulations, and other laws/requirements.

It is clear in the case of Hilo Harbor that there are documented issues with both the ability of the turning basin to accommodate existing and future vessels, as well as the impacts of waves and surge during certain storm events. The engineering analysis completed for this study better defined the problems being experienced, and indicates that there are solutions that may significantly improve these issues. The difficulty arises both in the high costs of navigation construction, and the quantification of economic benefits to these improvements, since the problems occur relatively infrequently or are being managed adequately under current conditions. In addition, the intangible benefits of improved safety and potential avoidance of environmental disasters are difficult to measure.

For these reasons, the study team concluded that there is no Federal interest in the Hilo Harbor Modification Study, and recommended that the study be terminated with no further usage of Federal or non-Federal sponsor study funding.

5.2. Stakeholder and Sponsor Communication

As noted earlier in this report, the various stakeholders and the non-Federal sponsor were engaged throughout the study process, including the definition of problems, requests for information, and briefings on alternatives and study progress. When it became evident that the project could not be Federally justified even under the most optimistic projections, the sponsor was informed immediately, and agreed that the study should be terminated. This summary report serves as the product for the non-Federal sponsor’s investment, to document the work that was completed, help inform stakeholders, as well as to provide the data collected in the event that it is useful for future harbor planning efforts.

5.3. Future Actions

The termination of this study ends future participation of the project in the USACE planning process at this time. Changes to the economic conditions in the future would be required in order to revisit the feasibility of a Federal investment. The non-Federal sponsor could pursue methods to address the issues identified at Hilo Harbor through non-Federally funded investigation of alternate means such as those suggested as non-structural measures. The non-Federal sponsor has requested that the Honolulu District evaluate the accuracy of the Federal project limits in proximity to Pier 1, as the turning basin cannot currently accommodate many of the vessels calling at the harbor and the vessel berthing area appears to be large in comparison to the size of vessels using the harbor. The non-federal sponsor is responsible for maintaining the depth of the berthing areas. This request is being coordinated with USACE Headquarters by the Honolulu District.

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Hilo Harbor Navigation Improvements
Feasibility Investigation Summary Report
Hilo, Hawaii

APPENDIX A
ENGINEERING

1. INTRODUCTION

1.1. Purpose

Hilo Deep Draft Harbor is located on the northeast coast of the island of Hawaii, the State's southernmost island. The project was initially authorized under the River and Harbor Act of 1907; subsequent work was authorized under the River and Harbor Act of 1912 and 1925. The project was completed in 1930 and consists of a 10,080-foot-long breakwater protecting a 35-foot-deep turning basin. The turning basin is approximately 2,500-ft long and 1,500-ft wide. The non-federal sponsor is the State of Hawaii, Department of Transportation, Harbors Division. Hilo Harbor is one of the two main commercial ports for the Island of Hawaii and is more than 70 miles from Kawaihae Harbor that serves the west side of the island.

This appendix document engineering studies conducted to investigate reported problems and opportunities associated with the federally authorized general navigation features at Hilo Harbor. Engineering investigations described herein were part of a cost-shared feasibility study for improving navigation by evaluation of proposed modifications to the harbor in collaboration with the non-federal sponsor. Modifications to improve navigation to the interior of the harbor have been identified by the Honolulu District and the non-federal sponsor. A small boat harbor maintained by the State of Hawaii is located at the easternmost end of the harbor known as Radio Bay, near the root of the breakwater.

Hilo Bay is located along the east (windward) coast of the island of Hawaii, extending south from Pepe'ekeo Point, and west from Leleiwi Point (Figure A1). The harbor entrance is flanked on the west by a cliffy shoreline and on the east by the breakwater and harbor complex. A tsunami in 1946 damaged nearly 6,000 ft of the breakwater and created a 1,100 ft breach. The breakwater was restored back to its original design in 1948. Combination of storm waves and tsunamis in 1950s, 1960s, and 1970s caused further damage to the structure which was again repaired to the original design. In 1976, Hurricane Kate damaged the breakwater, and continued sporadic damage and transmission through the structure prompted new repairs, including the addition of a concrete rib cap with a single layer tribars placed on a 1V: 1.5H slope on the seaward side of breakwater near Radio Bay. These repairs were completed in 1980s. Figure A2 shows a cross-section of the repaired reach. Figure A3 shows the major features in and around Hilo Bay.

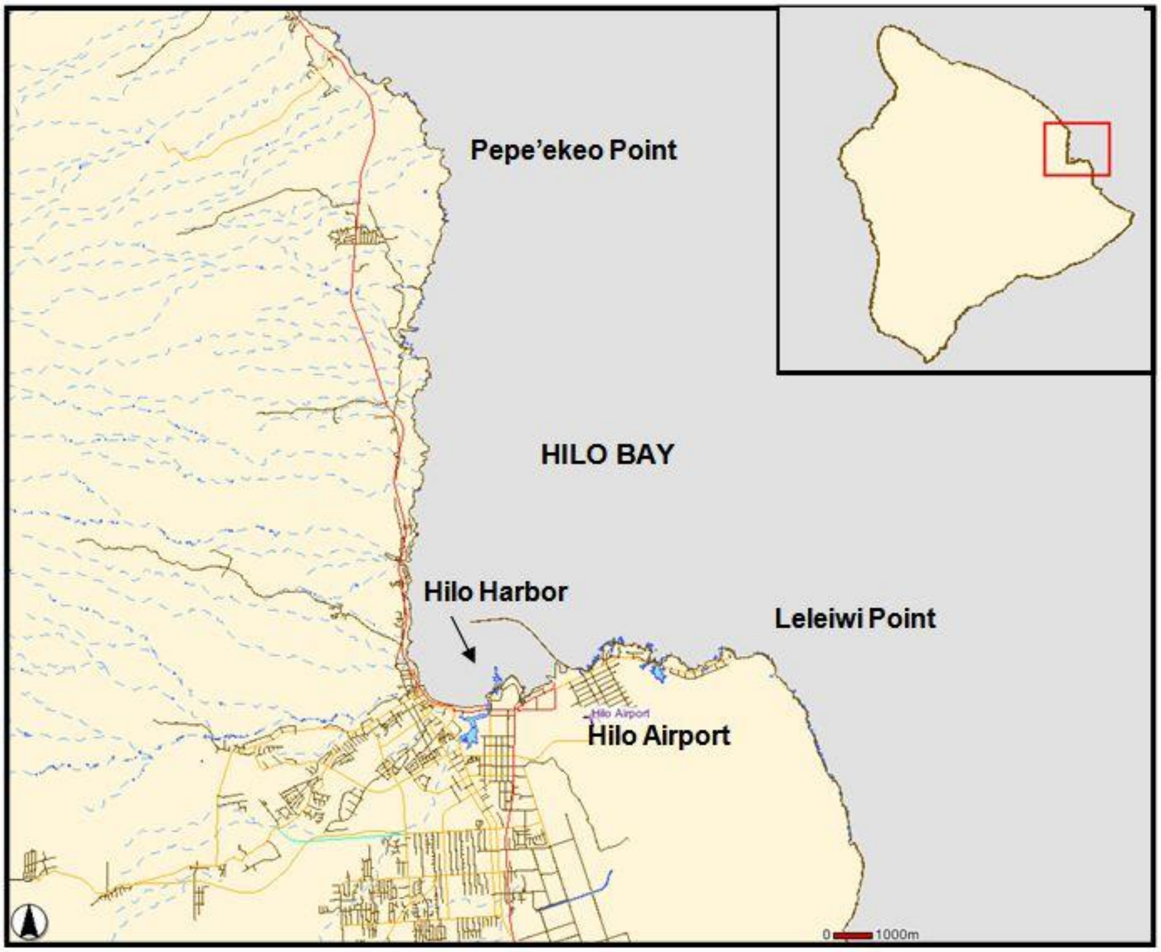

Figure A1. Vicinity and location map for Hilo Bay and Hilo Harbor, HI

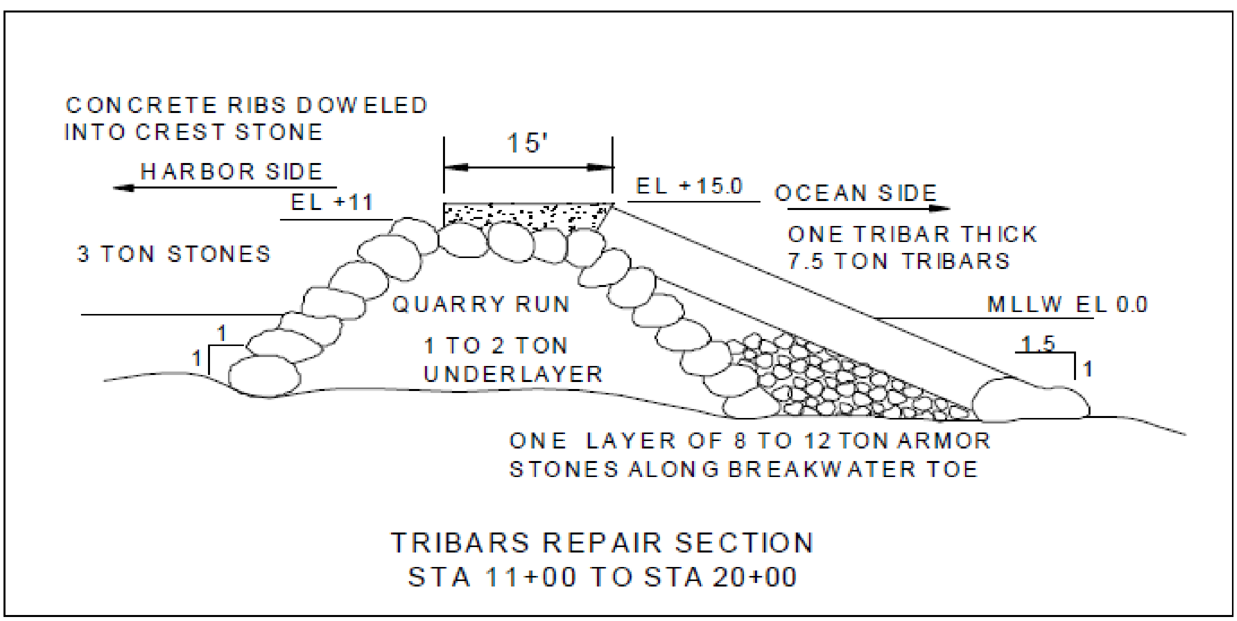

Figure A2. Repair section of the Hilo Harbor breakwater

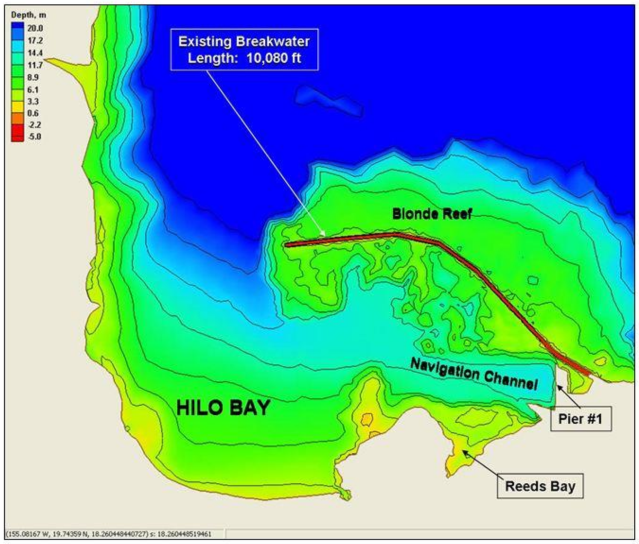

Figure A3. Location of the Hilo Harbor breakwater with respect to Pier #1

The goal of the study was improvement of navigation between the harbor entrance and Pier #1 and Pier #2. Proposed alternatives were evaluated to determine impacts of waves on navigation using Boussinesq and CMS-Wave models. Details of the engineering studies, data requirements, tasks, results, and major findings are provided in this appendix.

1.2. Description of the Study Area

Hilo Harbor is the major commercial and industrial center for the Island of Hawaii and is the primary location of commercial waterborne traffic for the east side of the island. The harbor includes the only cruise ship passenger terminal on the Island of Hawaii, and improvements to the federal channel and turning basin may be warranted to accommodate larger and deeper draft vessels. Accordingly, the current study investigates the federal interest in modifications to Hilo Harbor that may be required by the existing and future fleet. Cruise ships with lengths of over 1,000 ft will need to be accommodated by the harbor.

1.3. Problem Statement

1.3.1. Turning Basin Dimensions

The existing turning basin may be too small to effectively, efficiently and safely accommodate the future fleet at Hilo Harbor. The dimensions of the turning basin may impact the movement of large vessels using the harbor in the future. The majority of the deeper draft calls at the harbor are by vessels with drafts in the 25-30 ft range. Vessels with drafts of 33-35 ft require a high tide and ideal calm conditions to safely navigate within the harbor. Currently, harbor pilots take unwarranted risks and operate under less than ideal conditions while turning large cruise ships of lengths ranging from 700 to 950 ft. Next generation cruise ships are longer than 1,050 ft and have expressed an interest in making Hilo Harbor a regular port of call. A number of vessels are presently unable to use harbor due to current federally authorized turning basin dimensions.

1.3.2. Surge

Another reported issue affecting navigation at Hilo Harbor is the surge problem, which occurs mostly during the winter months. The surge problem is more pronounced for deeper draft vessels, and over the years, has been blamed for several groundings. The reported surge problem is more prominent during high winter swells conditions, and hinders significantly the use of berthing areas. However, the surge problem is not manifested by harmonic oscillations which occur often in harbors. The mariners use the term “surge” for Hilo Harbor to describe a “pulling away of ship” movement from the piers. This type of ship response can also be caused by wind forcing acting on the superstructure of vessels, and it is not necessarily caused by long-period infragravity waves, the well-known cause of classical harbor surge problems. The harbor surge induced by short and long period (infragravity) waves is investigated in the present study as it relates to existing and modified general navigations features at Hilo Harbor.

The surge has also been blamed for vessel groundings and damages to both vessels and piers. Although there have been groundings of large dry bulk carriers in the past in the federal channel, there is no evidence that shows these groundings resulted from surge conditions, or vessels maneuvering in a restricted turning basin. The groundings had occurred when the wind blows out of the north and incident waves come straight down the entrance channel. Because Pier #1 is shared by cargo and cruise operators, there is a lack of space for growing cargo and cruise passenger activities at Hilo Harbor, and concerns for passenger safety when combined with cargo operations.

The potential for ship grounding is perceived by harbor users to be very high adjacent to the root of the breakwater at Pier #1. Turning cruise ships in this area longer than 900 ft presents a problem for the pilots and captains. Larger ships docked alongside Pier #1 have to back out of the berth towards the shallow depths near the breakwater. Some cruise ships use azipods for enhanced control and maneuvering as they navigate dangerously close to the breakwater. Tug boats have to be used to assist with maneuvering the bulkers or tankers by crabbing the bow 90 degrees starboard to help the ship sail straight out through the main channel. The crabbing (or turning) of vessels pushes the stern of the vessel closer to the breakwater, creating a suction force that can pull a vessel further toward the shallow reef and potentially result in grounding.

Expected improvements in port operations as a result of modifications to the federal general navigation features at Hilo Harbor include a) an increase in safety of vessel operations, b) reduced damages to vessels from surge conditions, c) reduced damage to moored vessels and/or harbor infrastructure, d) reduced number of cancellations and delays of services due to high surge conditions, and e) increase in the size and capacity of vessels bringing tourists, goods and services to the harbor. As the busiest port on Hawaii Island and one of the busiest in the State, this harbor will continue to expand as an important port in the State's economic base. The modifications will be significant as they will provide safer vessel operations and allow use of the harbor by larger vessels, thereby increasing cargo volume through the port. The harbor improvements will also increase the opportunities for ports of call by larger passenger vessels in the cruise ship industry.

1.3.3. Proximity of the Turning Basin to Pier #1

The non-federal project sponsor requested that the turning basin dimensions be reassessed in comparison with similar harbors throughout the country. Currently, the landward limit of the turning basin is approximately 600 ft from the Pier #1 bulkhead. This requires the non-federal project sponsor to operate and maintain a much larger than typical berthing area. They request that proximity of the project limit adjacent to Pier #1 be determined by the dimension of the design vessel beam.

1.4. Climatology

1.4.1. Wind Data

In the Hilo area, the tradewind flow is modified by the presence of Mauna Loa and Mauna Kea. During typical east-northeast tradewind conditions, the wind speeds off East Hawaii are relatively lighter than over the open ocean. This area of minimum wind speed is centered at Hilo. The temperature differential between land and sea results in the formation of a land and sea breeze system in the Hilo vicinity, which alternately reinforces and opposes the already weak underlying trade wind flow. During the day the onshore sea breeze reinforces the trade winds. At night, the offshore land breeze dominates, resulting in light southwest winds (Sea Engineering, 1981). The wind rose from USACE Wave Information Studies (WIS) Station 82527 is displayed in Figure A4

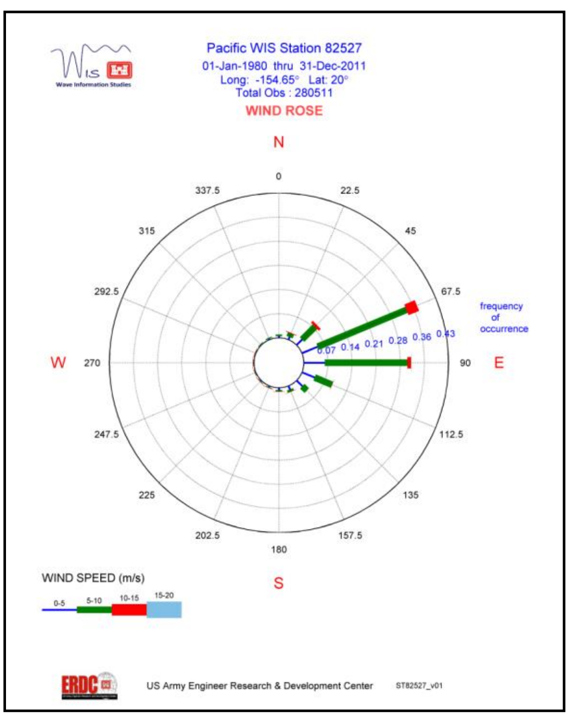

Figure A4. Wind rose for WIS Station 82527 used to hindcast waves for the 32-year wave record

(1980-2011)

1.4.2. Wave Data

Hilo Bay is directly exposed to waves approaching from the sector north through east. Figure A5 shows a wave rose from the area offshore of Hilo Bay between the years 1981 – 2011. Both tradewind waves and North Pacific swells may approach from this direction. Tradewind waves may approach from the sector north through east, with the predominant direction from the northeast. These waves are present 80 to 90 percent of the time during the summer; the frequency decreases to 60 to 70 percent during the winter. Tradewind waves have typical heights of 4 to 12 feet and periods of 7 to 10 seconds. Although Hilo Bay is exposed to tradewind wave approach, the breakwater shelters Hilo Harbor from direct approach of all but the most northerly swell and tradewind waves (Sea Engineering, 1981).

North Pacific swell is generated by winter storms in the North Pacific and may approach from the sector west through northeast. The most common approach direction is from the northwest. This wave type is most frequent from October through April. The average wave period is 14 seconds and deepwater heights range up to 15 feet. Hilo Harbor is directly exposed to only the North Pacific swell approaching from the north and northeast. Total frequency of occurrence of all North Pacific swell is 75 percent; however, it approaches from the north and northeast only 12 percent of the time. Because of its large size and long period, though, even swells approaching from more westerly directions may refract and have some influence on the wave climate in the harbor (Sea Engineering, 1981).

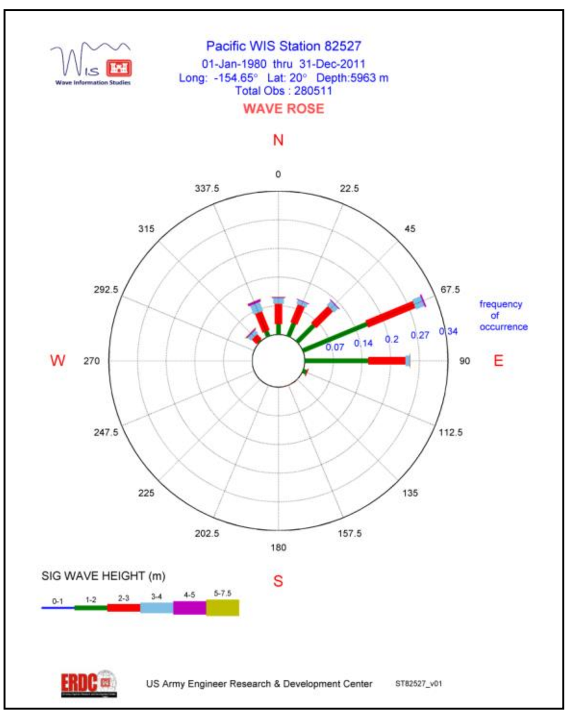

Figure A5. Wave rose for the 32-year wave hindcast (1980-2011) at WIS Station 82527

Wave data for Hilo Harbor were available from five sources: (1) National Data Buoy Center (NDBC) Buoys 51004 and 51100, (2) Coastal Data Information Program (CDIP) Buoy 188, (3) the

USACE Wave Information Studies (WIS) Station 82527, (4) a pressure transducer (UH-HB) installed and maintained at Pier #1 by the University of Hawaii, and (5) an Acoustic Doppler Current Profiler (ADCP) installed by ERDC- CHL (CHL H1) in 2007 to collect wave and current data. Figure A6 and Figure A7 display the areas of interest encompassing Hilo Bay (yellow box area) and locations of available met-ocean data stations.

The NDBC Buoy 51004 is located in deep water 210 nautical miles (nm) southeast of Hilo Harbor, and has collected wave data since November 1984. This buoy started directional wave measurements in September 2009. The NDBC Buoy 51100 is located 240 nautical miles (nm) north-northeast of Hilo Harbor in deep water that has collected directional wave data since April 2009. The CDIP 188, also a deep water buoy, is located 4 nm north of Hilo Harbor, and has collected directional wave data since March 2012. The WIS 82527 is about 20 nm northeast of Hilo Harbor, and has a 32-yr hindcast wave record (1980-2011). The UH-HB gauge was deployed specifically for this Hilo Harbor project needs at the north end of Hilo Harbor Pier #1, and collected data from late December 2013 through April 2014. The CHL's H1 gauge was deployed 0.25 nm SSE of east end of Hilo Bay breakwater, and collected directional wave data during March - June 2007. Table A1 provides the geographical location and nominal depth of various data sources mentioned.

Figure A8 and Figure A9 show examples of wave and wind data collected by two buoys, NDBC 51004 and 51100, in 2011 and 2013, respectively. These plots show measured wave heights are similar at Buoys 51004 and 51100, and smaller wave heights range from 3 ft and 13 ft in summer and fall seasons, and greater wave heights from 7 ft to over 20 ft in winter and spring months. Buoy 51004 detects more southern swell than Buoy 51100 during June to September as Buoy 51100 is sheltered by Hawaiian Islands from southern swell. At this project site, during spring to fall seasons, more waves are from east, which are generated by easterly trade winds.

1.4.3. Tide Data

The tides in Hilo Harbor are semi-diurnal (two high and two low tides per 25-hour period) with a pronounced diurnal inequality. The mean tidal range, or difference between Mean Low Water (average of all low water heights of each tidal day) and Mean High Water (average of all high water heights of each tidal day), 1.67 ft for the most recent tidal epoch (1983-2001). Table A2 provides tidal datum information for NOAA Tide Station 1617760 located within Hilo Harbor (http://tidesandcurrents.noaa.gov/stations.html).

Figure A6. Location of NDBC and CDIP buoys, and WIS, NOAA and USGS Stations

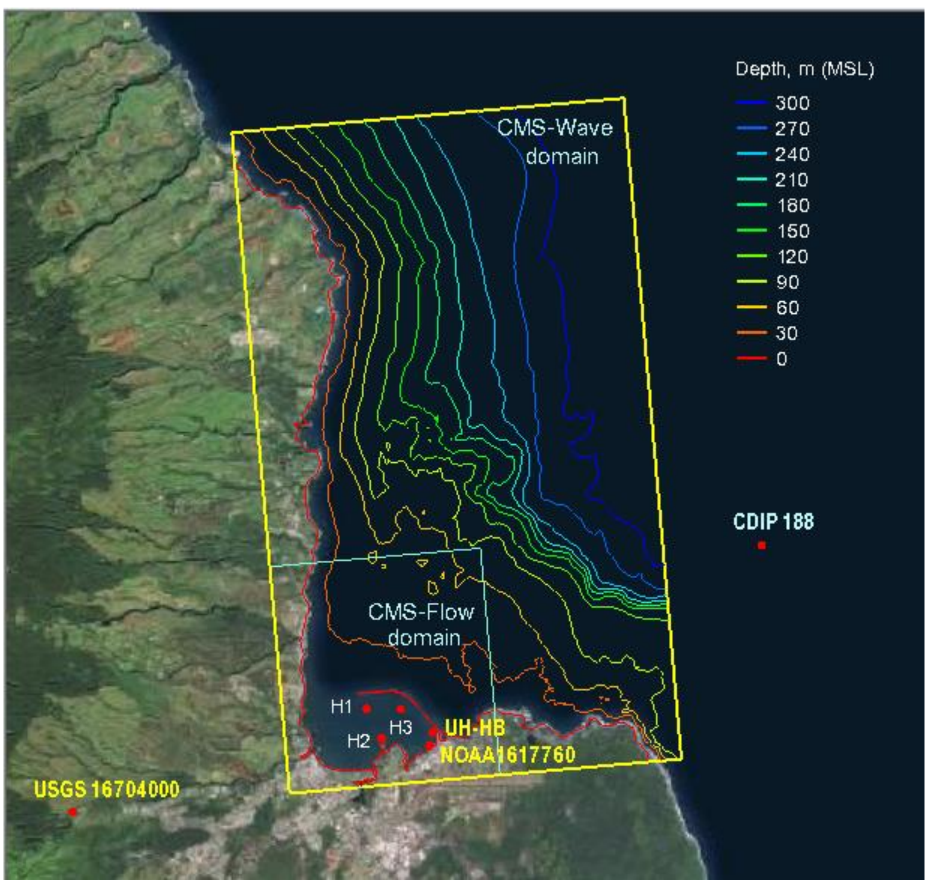

Figure A7. CMS modeling domains with UH-HB and CHL H1, H2, H3 gauges

Table A1. Information on wave data sources

Station	Location	Depth (ft)	Data History
NDBC 51004	17.602 N, 152.395 W	17,150	Nov 1984 - present
NDBC 51100	23.558 N, 153.9 W	15,600	Apr 2009 - present
WIS 82527	20 N, 154.6 W	1,150	1980 - 2011
CDIP 188	19.7814 N, 154.968 W	350	Mar 2012 - present
UH-HB	19.73366 N, 155.054 W	30	Dec 2013 - present
CHL H1	19.7391 N, 155.073 W	20	Mar-Jun 2007

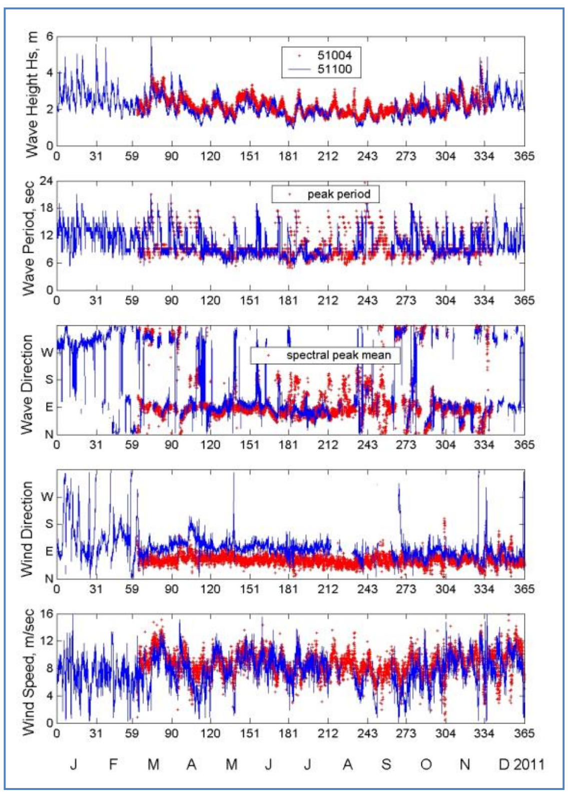

Figure A8. Wind and wave data for 2011 from NOAA Buoys 51004 and 51100

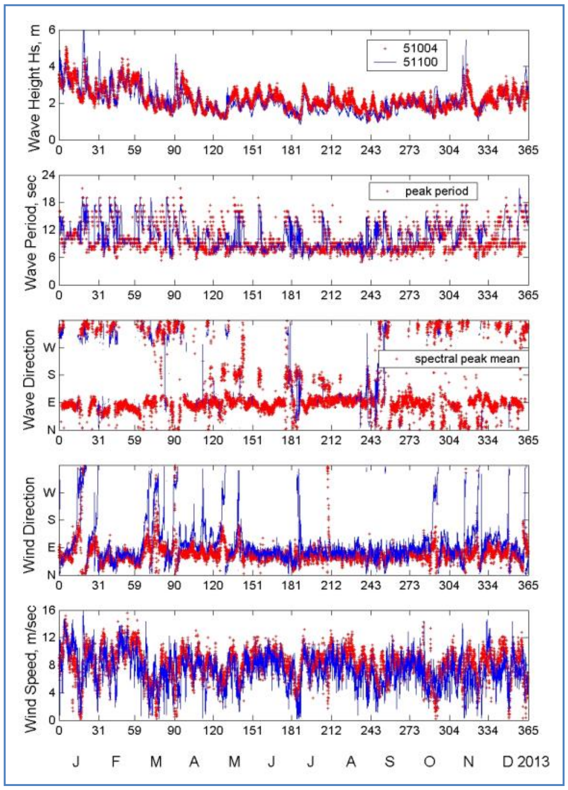

Figure A9. Wind and wave data for 2013 from NOAA Buoys 51004 and 51100

Table A2. Tidal datums (ft) at NOAA 1617760 (Hilo Harbor, HI)

Mean Higher High Water (MHHW)	= 2.40
Mean High Water (MHW)	= 1.97
Mean Sea Level (MSL)	= 1.15
Mean Tide Level (MTL)	= 1.14
Mean Low Water (MLW)	= 0.30
Mean Lower Low Water (MLLW)	= 0.00
Mean Tidal Range (MHW – MLW)	= 1.67

2. NUMERICAL MODEL STUDY

Numerical model tasks included the following: (1) process existing hydrographic survey data of the interior harbor, 2) analyze existing wave and current data from the 2007 field experiments to provide input for numerical models, 3) process and analyze data from a pressure sensor deployed by the University of Hawaii at Pier #2, 4) perform detailed numerical wave modeling inside and outside the harbor to evaluate benefits of the proposed modifications, 5) develop environmental forcing factors (winds, water levels, waves, and currents) for the ship simulation study, and 6) document the results of the numerical model study.

Hydrographic surveys of the harbor interior, entrance, breakwaters, reefs, and nearshore areas within the 40-ft depth contour were used to develop the model grids. Other bathymetry data were obtained from different sources, including digital elevation maps and previous numerical modeling for deep water areas. Available water levels, wave and current data from gauges in the harbor and vicinity were used as model input. Field measurements were used for calibration and validation of the models. Wave conditions were investigated inside and outside of the harbor in evaluation of proposed modifications for improving navigability, usage of harbor, and investigation of the user reported harbor surge problem. A matrix of conditions (water levels, winds, waves, and currents) were also evaluated with CMS-Wave and CMS-Flow to provide inputs to the ship simulation study.

Because waves and currents are the main concerns for harbor users, the goal of each proposed modification was to reduce wave energy at and around the turning basin and inner harbor. The characteristics of waves passing through the harbor entrance are largely controlled by reefs outside the federal breakwater and to a lesser extent by the shoreline west of the harbor entrance. Large waves frequently propagate over the fringing reefs seaward of the breakwater, and along the northwest and west shorelines. The breakwater is very effective in sheltering the harbor from such large wave events. Only waves passing through the entrance between the tip of breakwater and cliffy shoreline to the west can propagate into the interior of harbor. The reefs covering large areas inside and outside the harbor (Figure A10) extend offshore to approximately the 40 ft depth contour. The cross-shore and east-west extent of these reefs varies. The outer reefs extend approximately 2 miles to the east and 0.25 mile to the north of the entrance channel. The inner reefs cover a large part of the harbor interior. When waves break over these reefs, they generate wave-induced currents which can negatively impact navigation in Hilo Harbor. Reefs are also present in the interior harbor except in the navigation channel and Piers #1 & #2, affecting waves inside the harbor complex.

Potential causes of reported problems at Piers #1 were investigated by evaluating wave processes with and without the proposed modifications. Impacts and effectiveness of the modifications on navigation in the channel and harbor were investigated. The field data collected in 2007, 2013 and 2014 were used in model calibration. Numerical model results were utilized to examine the merits of changes and their impacts on different areas of harbor. Alternatives investigated included modifications to the breakwater and turning basin.

2.1. Alternative Harbor Modifications

Figure A10 shows existing features of Hilo Harbor including the small harbor located landward of Pier #1, and other coastal and land features present in Hilo Bay. The figure shows the features represented in the BOUSS-2D (B2D) grid, including bathymetric variation outside and inside the harbor with reefs, the breakwater, and two piers. Sketches of modifications investigated are displayed without bathymetric details. Modifications considered included adding structures to the interior harbor, and enlarging and deepening the turning basin. Each proposed modification is shown in a B2D model grid with schematics or sketches in Figure A11 through Figure A15. Each sketch depicts the type of modification and its location in the harbor. General information about each modification is provided below.

The proposed structural modifications include strategic placement of detached breakwaters and breakwater spurs inside the harbor. The first modification (Figure A11) considers a short structure, while longer structures are used in the second and third modifications (Figure A12 and Figure A13). These detached breakwaters and spurs are situated between the federal breakwater and the north edge of navigation channel, which are expected to intercept and reduce the wave energy that reaches the turning basin and Piers #1 and Pier #2. For safety reasons, these are located at a distance of approximately 200 ft from the north edge of the turning basin. The second and third modifications use medium and long interior breakwaters as shown in Figure A12 and Figure A13. The location, length and orientation of these structures can be adjusted if necessary.

The modification shown in Figure A14 involved adding a structure (spur) to the tip of the federal breakwater. Different attachment points, lengths and angling of the spur were considered to determine desired dimensions of the spur which can produce maximum benefits to turning basin and Pier #1 & #2 areas. Figure A14 shows one of the configurations tested. Dual breakwaters located north and south of the entrance to the turning basin were also evaluated (Figure A15).

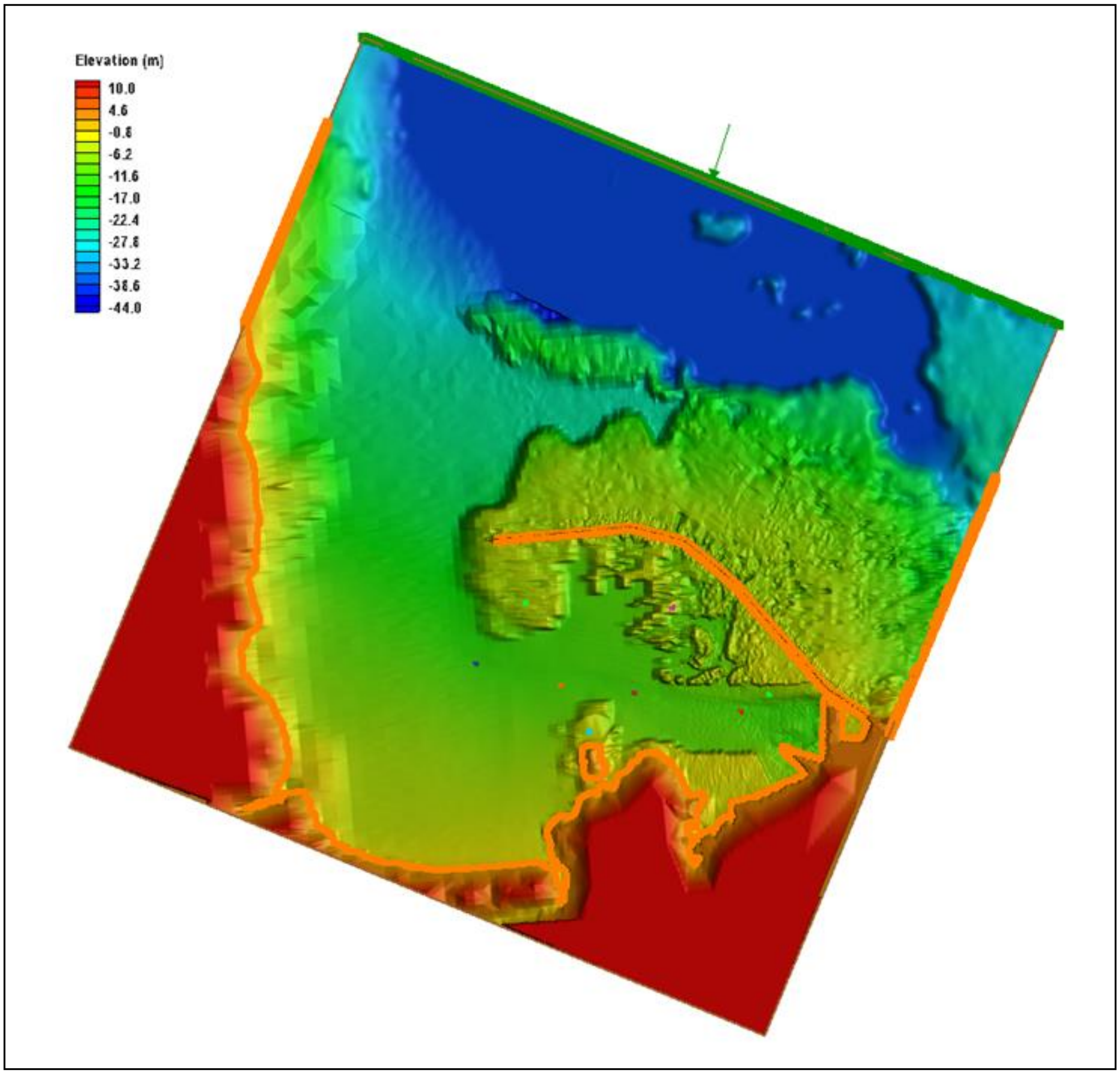

Figure A10. Bathymetric features of existing harbor

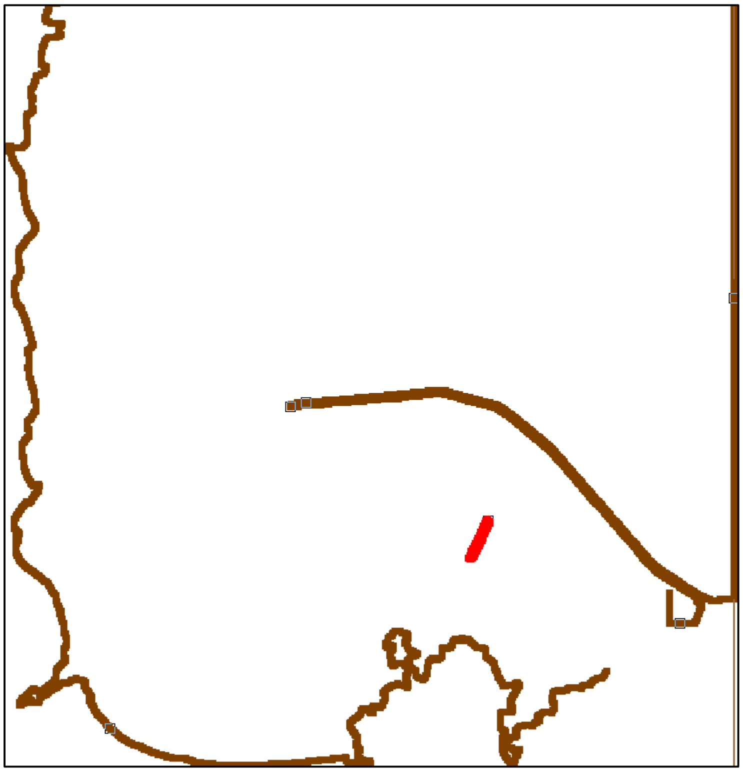

Figure A11. Proposed modification with a short (820 ft) detached breakwater

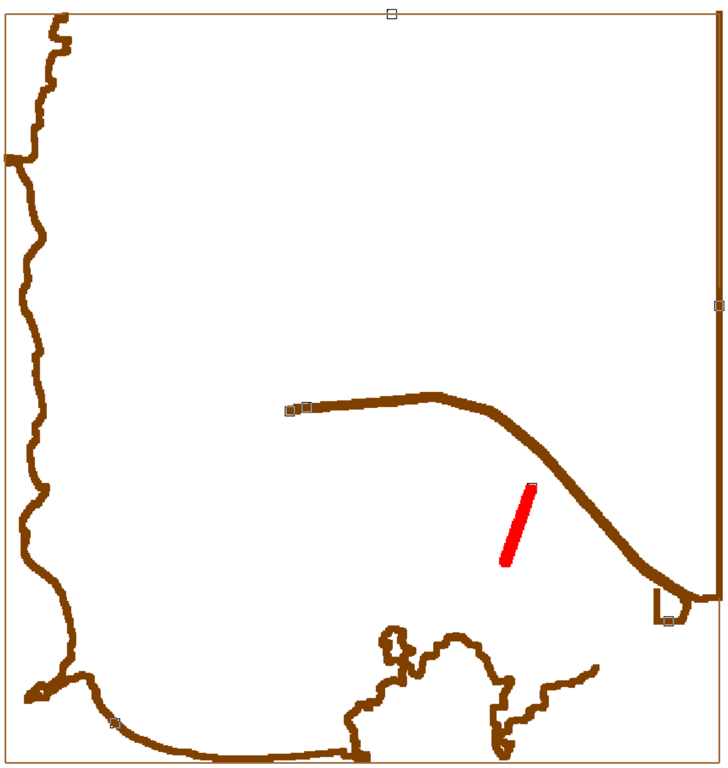

Figure A12. Modification with a medium length (1,580 ft) detached breakwater

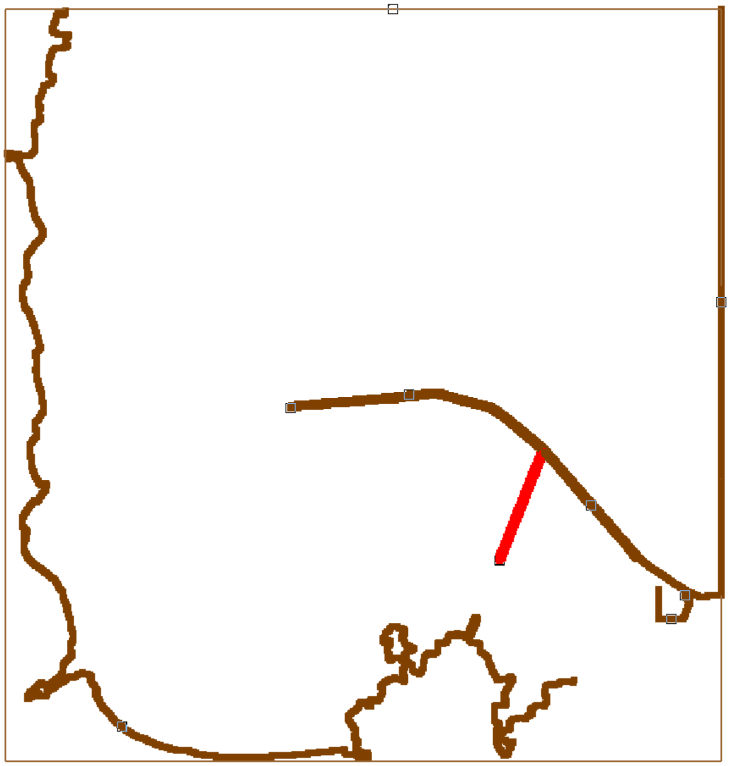

Figure A13. Modification with a longer (2,230 ft) attached breakwater

The turning basin widening is shown with bathymetry changes in Figure A16. The turning basin widener is located between the northern end of Pier #1 and the breakwater root.

2.2. CMS-Wave Modeling

Wave modeling for Hilo Harbor was conducted using two numerical models: namely B2D and CMS-Wave. B2D was used in this study to investigate alternatives representing different proposed structures inside and outside of the harbor. Because B2D is a fully nonlinear time-domain model able to represent linear and nonlinear nearshore wave processes, it is a computationally resource-demanding model. B2D is used in the present study over a small area covering details of the harbor, structures, and the immediate vicinity, including reefs and shorelines.

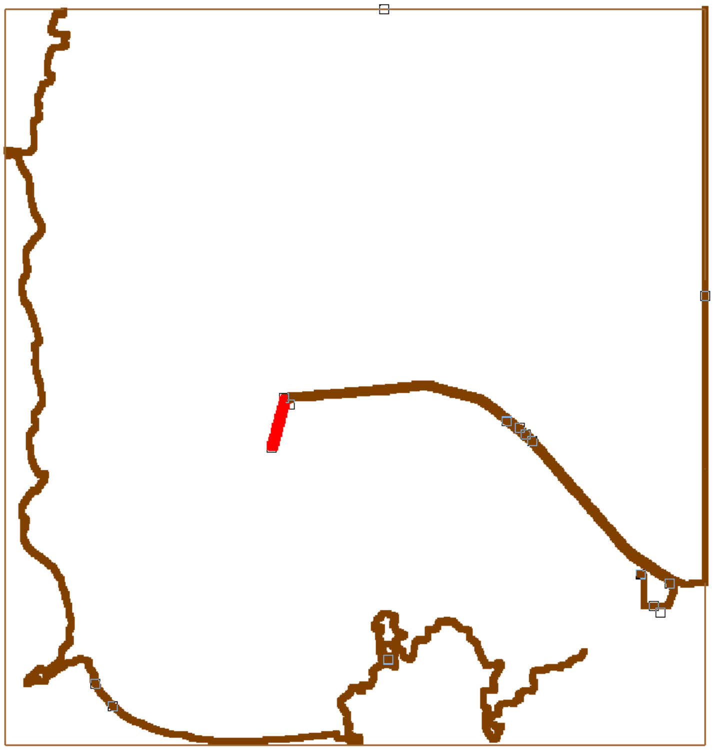

Figure A14. Modification with a spur added to the tip of breakwater

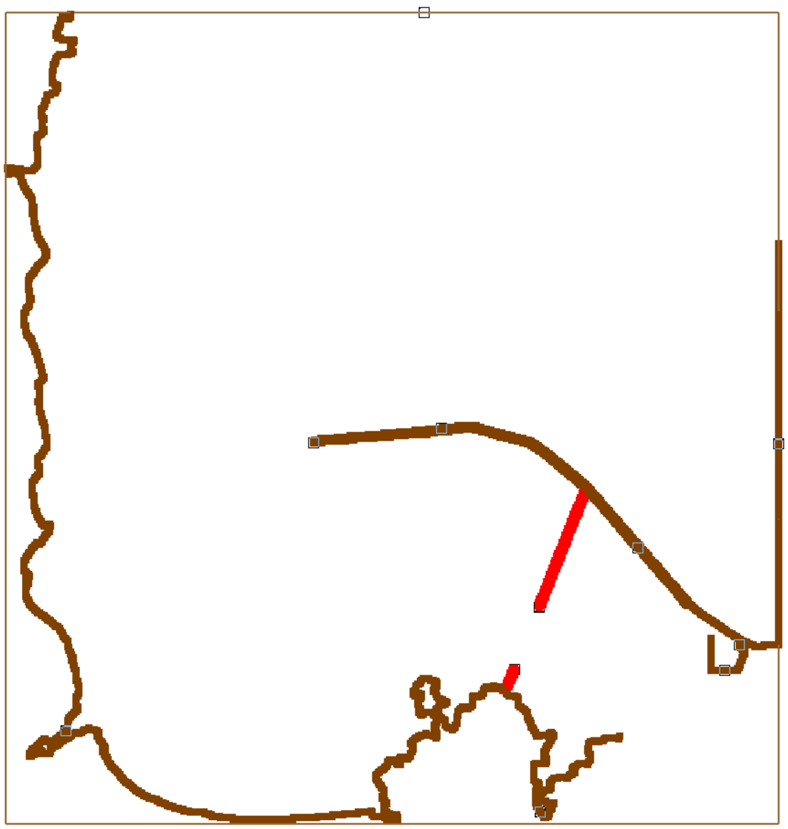

Figure A15. Modification with dual structures north and south of channel

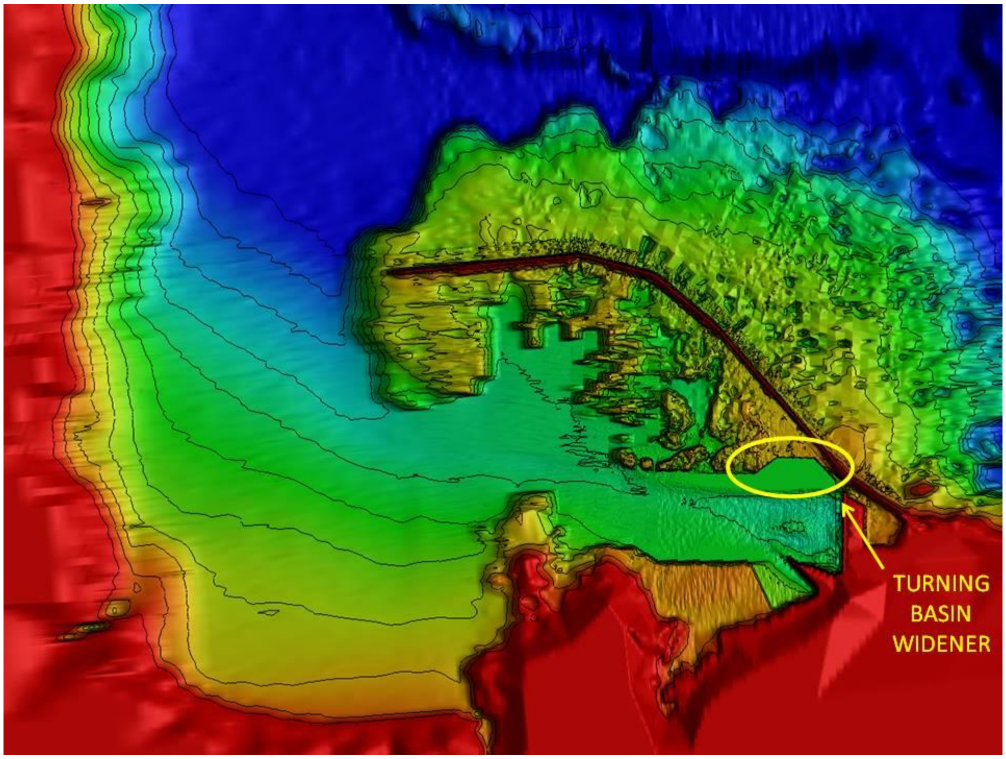

Figure A16. Turning basin widener and existing bathymetric contour lines

Because large domain modeling around Hilo Bay was not possible with B2D for the required range of wave conditions, it was necessary to augment B2D modeling with a spectral wave model capable of providing estimates of waves over much larger domains and for a large number of wave conditions. CMS-Wave is part of an integrated Coastal Modeling System (CMS) developed at CHL for coastal inlets and regional modeling project applications. CMS-Wave is a steady-state 2D spectral wave model (Lin and Demirbilek 2012; Lin et al. 2011; Demirbilek and Rosati 2011; Lin et al. 2008; Demirbilek et al. 2008) used for simulating wave processes with ambient currents at navigation channels, coastal inlets, and harbors. In light of the B2D and CMS-Wave complementary features, these models are frequently used in tandem in similar navigation studies.

To determine how winds, waves, and water levels affect navigation at Hilo Harbor, a good understanding of the effects of complex bathymetric features, surrounding coastlines, and protective structures is required. The geometries of the existing breakwater, harbor entrance, navigation channel, turning basin, and piers play a role on navigability. Field data were used in the understanding of the existing navigation difficulties experienced inside and outside the harbor, and for assessing the potential usefulness of alternatives. CMS-Wave was used to transform offshore wave information provided by deep water coastal buoys to the project site at the seaward boundary of the B2D grid. CMS-Wave was also used to check the reliability of available nearshore wave data for input to the B2D model.

CMS-Wave can be used in half-plane or full-plane mode for wave transformation in deep or shallow water. The half-plane mode is the default because CMS-Wave can run more efficiently in this mode as waves are transformed primarily from the seaward boundary toward shore. The model is based on the wave-action balance equation that includes wind-wave generation and growth, wave propagation, refraction, shoaling, diffraction, reflection, breaking, and dissipation. The computational efficiency of the model and recent improvements to capabilities of the model allow the simulation of large domains and a large number of wave conditions. The nested-grid capability of the model is used here to ensure necessary grid resolution for representing fine details of the harbor geometry.

Two grids were generated, one for CMS-Wave and another for CMS-Flow. Figure A7 shows the CMS-Wave and CMS-Flow model domains. The CMS-Wave grid consisted of 504 x 564 grid cells, with variable cell spacing. The smallest cells were 13 ft in Hilo Bay, with cell size increasing to 650 ft in the offshore. CMS-Wave grid covered a rectangular domain of 11 km x 18.5 km extending eastward and northward to about the 1,100 ft depth contour. The CMS-Flow grid was a sub-domain of CMS-Wave, with 472 x 503 grid cells of variable cell size 13 ft to 540 ft. The flow model grid covered a rectangular area of 6 km x 6.4 km that extended from Hilo Bay to the 260 ft depth contour. The CMS-Wave grid domain was greater than CMS-Flow for transforming waves properly from offshore locations into Hilo Bay. The CMS-Flow grid domain was sufficiently large and covered the reef outside Hilo Harbor. Bathymetric data for both grids were extracted from NGDC database, USGS Digital Elevation Model (DEM), and USACE surveys, which represented the most recent bathymetry of Hilo Bay and harbor complex.

The domains and orientation of three B2D grids (N, NNE, and NE grids) are shown in Figure A17. The north grid in Figure A18 shows details of Hilo Bay bathymetry, the breakwater to the north that protects the harbor, the reefs outside and in the interior harbor, and the two piers. Figure A19 is an example of wave field from B2D for an incident wave from north, showing spatial patterns of waves moving over the outside fringing reef system, including areas of wave focusing (converging) caused by strong wave refraction, shoaling and breaking, and waves which wrap around the tip of breakwater moving into interior harbor. Similar wave height trends were also observed in B2D model results obtained with the other B2D grids.

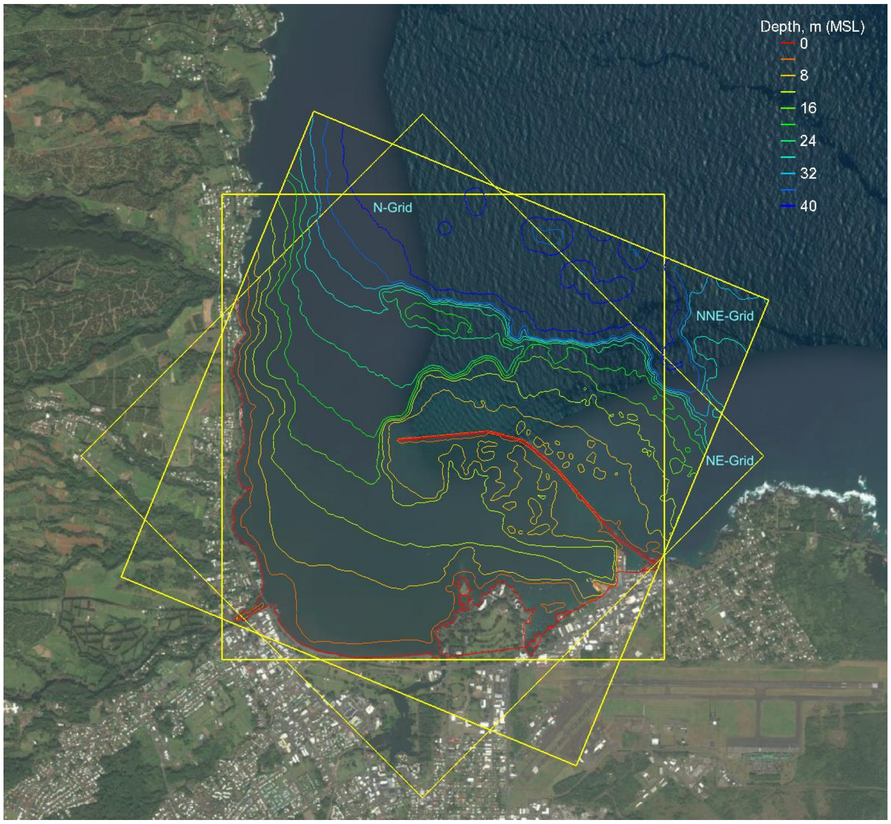

Figure A17. Three B2D model domains (N, NNE, and NE grids)

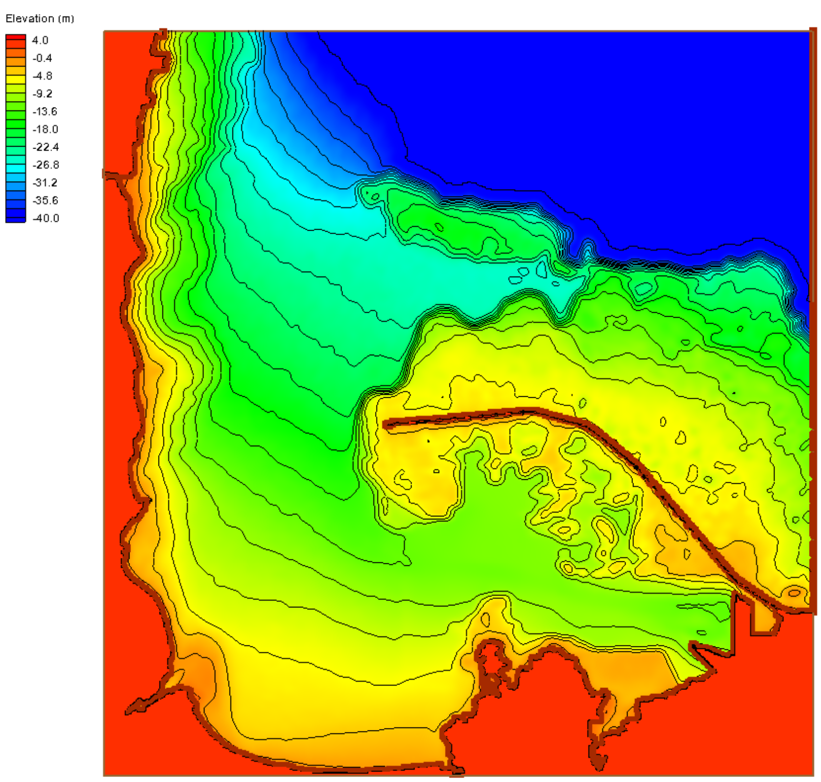

Figure A18. Bathymetric features of Hilo Bay in B2D north grid

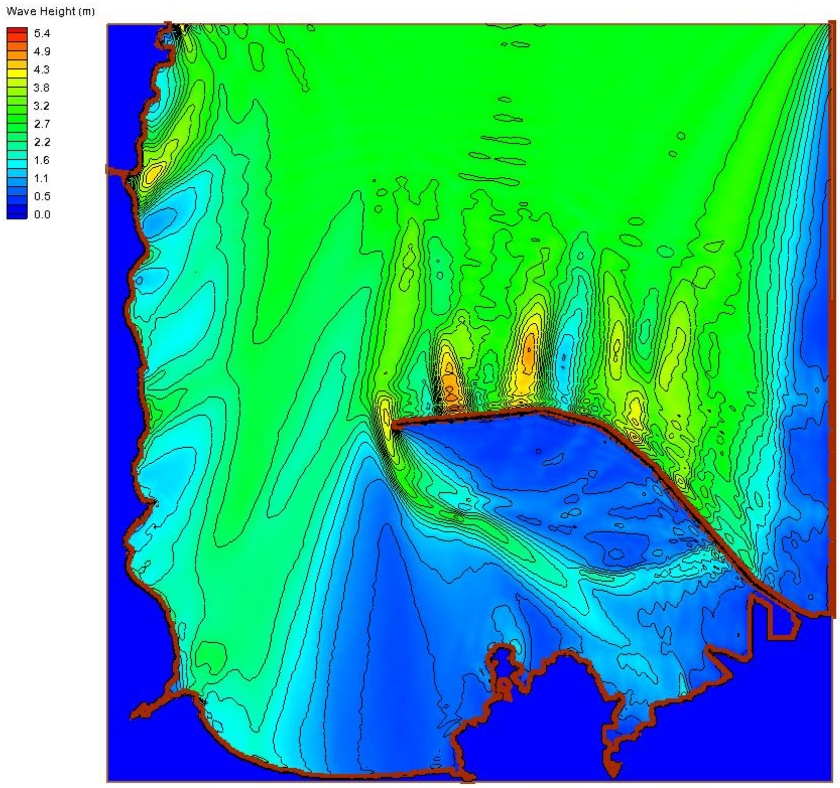

Figure A19. Example of wave height field from a B2D simulation

2.3. Model Verification

The deep water spectral waves were transformed with CMS-Wave using the full-plane mode. These simulations used 35 directional bins with a 5-deg directional resolution, and 42 frequency bins with frequencies ranging from 0.04 to 0.45 Hz in a 0.01-Hz increment. Wave shoaling, refraction, diffraction, reflection, runup processes and wind input were included in the simulations. CMS-Flow was coupled with CMS-Wave to calculate water level variation and current field in the flow model domain.

The CMS-Wave and CMS-Flow models were calibrated for the period of 21-31 March 2007. Incident directional waves were obtained from NDBC Buoy 51001 (23.445 N, 162.279 W), surface winds from WIS 82527, and water levels as boundary condition to the CMS were obtained from NOAA 1617433. CMS-Wave and CMS-Flow were coupled at 3-hr interval. The effect of reef bottom on calculated water level and current estimates was calibrated by tuning Manning's coefficients in CMS-Flow. Figure A20 shows two regions with different Manning's coefficients (0.075 and 0.085) used in the flow model.

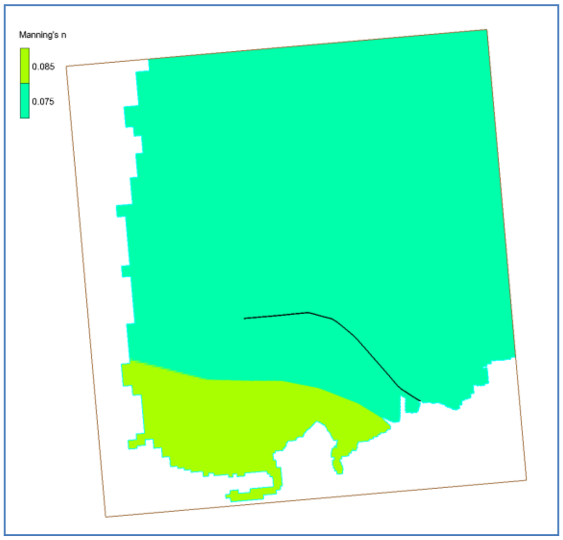

Figure A20. Manning's coefficients applied in CMS-Flow

Figure A21 shows the comparison of calculated and measured waves for 21-31 March 2007 at CHL H1. Figure A22 shows calculated and measured water levels for 21-31 March 2007 at CHL H1 and NOAA 1617760. Figure A23 shows calculated and measured currents for 21-31 March 2007 at CHL H1 and H2. The CMS calculated current magnitude and direction at H1 agree well with data, but current magnitude at H2 is overestimated by model. The model calculated current direction estimates at H2 had a larger bias than those at H1. The overestimated current magnitude at H2 is likely caused by the hindcast coastal wind data used in the model, which are stronger than the winds in the Bay.

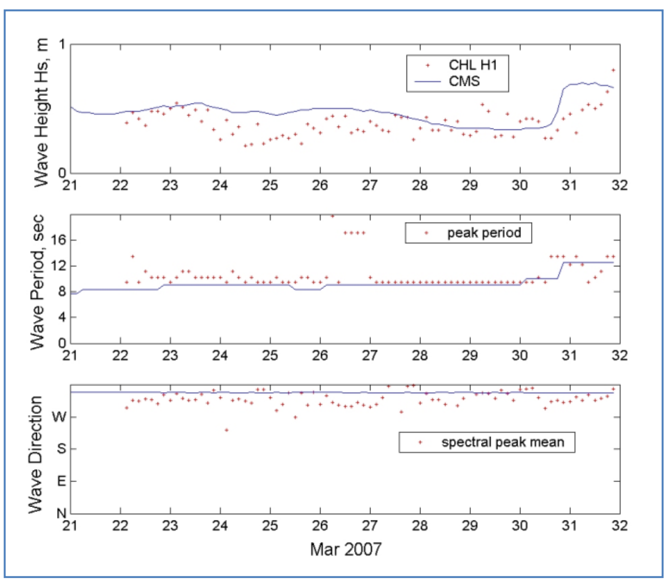

Figure A21. Measured and model waves during 21-31 March 2007 at CHL H1

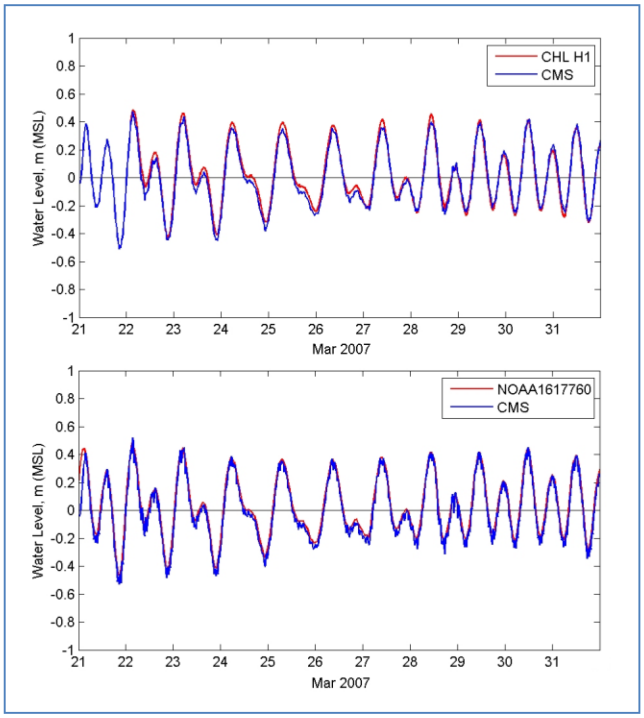

Figure A22. Measured and model water levels for 21-31 March 2007at CHL H1 and NOAA 1617760

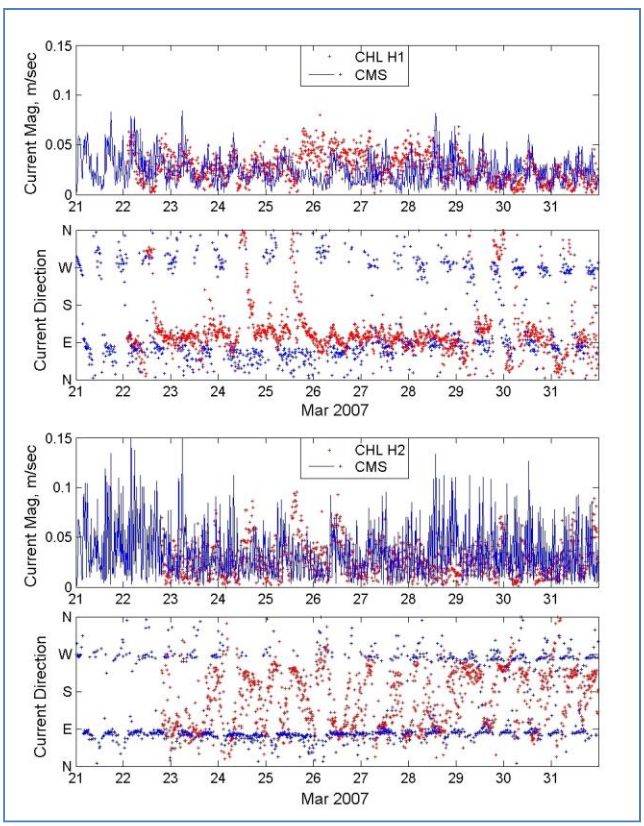

Figure A23. Measured and model currents for 21-31 March 2007at CHL H1 and H2

2.4. Model Runs for Ship Simulator Input

CMS simulations were conducted for the existing harbor and a proposed dredge configuration shown by a polygon in Figure A24. The dredge depth inside the polygon was set to 35 ft MLLW. The conditions used in CMS simulations are listed in Table A3. All simulations were forced by water levels, waves, and winds, except for Condition 3 in which an additional run was conducted with flow discharges for Wailoa River and Wailuku River. The discharge for Wailoa River was estimated based on measured river flow discharge for Wailuku River by using the proportion of drainage areas of two rivers.

Table A3 provides the inputs for each of the simulation condition corresponding to spring tides and storm events. This includes simulation period (start and end dates of simulations), duration of simulation in hours, two harbor configurations considered (e.g., existing harbor [Alt-0] and one area of existing harbor dredged [Alt-1]), runs with river discharges, and two water levels considered (spring tide and average tide or mean range).

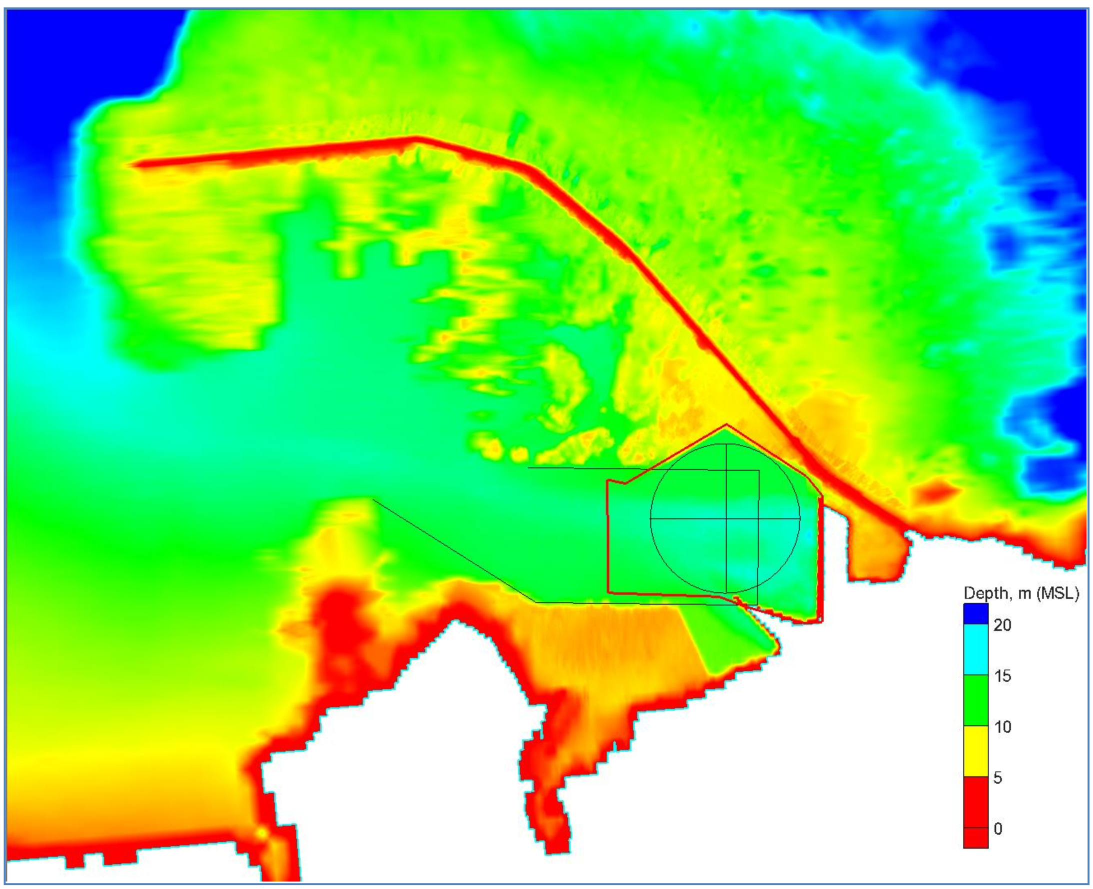

Figure A24: Location of proposed dredge area inside the polygon

Table A3. Input data used in CMS simulations for ship simulator

Simulation Dates	Duration (hr)	Configuration	Water Level
6-7 May 2012	24	Alt-0 Alt-1 (Dredged harbor)	Spring tide
14-15 November, 2012	24	Alt-0 Dredge	Spring tide
24-26 March, 2012	36	Alt-0 (without Rivers)	Spring tide
24-26 March, 2012	36	Alt-0 (with Rivers)	Spring tide
15-16 May, 2011	33	Alt-0, Alt-1	Mean range
27-29 October, 2012	33	Alt-0, Alt-1	Mean range
22-23 December, 2012	33	Alt-0, Alt-1	Mean range

2.5. Model output for ship simulator

CMS results corresponding to maximum currents in the navigation channel were extracted in a sub-rectangular area of CMS-Flow grid domain. Figure A25 shows this sub-rectangular area (Area A) where CMS results were extracted. The time of occurrence of the maximum current field during a simulation was determined for each of flood and ebb cycle. This was done by using two small rectangular areas (Areas B and C) to calculate the spatially-averaged current magnitude corresponding to the maximum flood current (in Area B) and maximum ebb current (in Area C). The maximum current fields were saved for the existing bay configuration and also for a proposed dredge area and in the channel and turning basin. Examples of maximum flood and ebb current fields are provided in Figures A26 and A27. These were extracted from CMS run for 6-7 May 2012, where wave heights were calculated for the existing bay configuration.

In general, the calculated maximum current magnitude in Hilo Bay along the navigation channel was small, less than 20 cm/sec in Area B and less than 15 cm/sec in Area C. Maximum wave height can reach 6 ft to 8 ft in Area B and 3 ft to 5 ft in Area C. Along Piers 1 and 2, the maximum current was less than 10 cm/sec and maximum wave height is less than 1.5 ft.

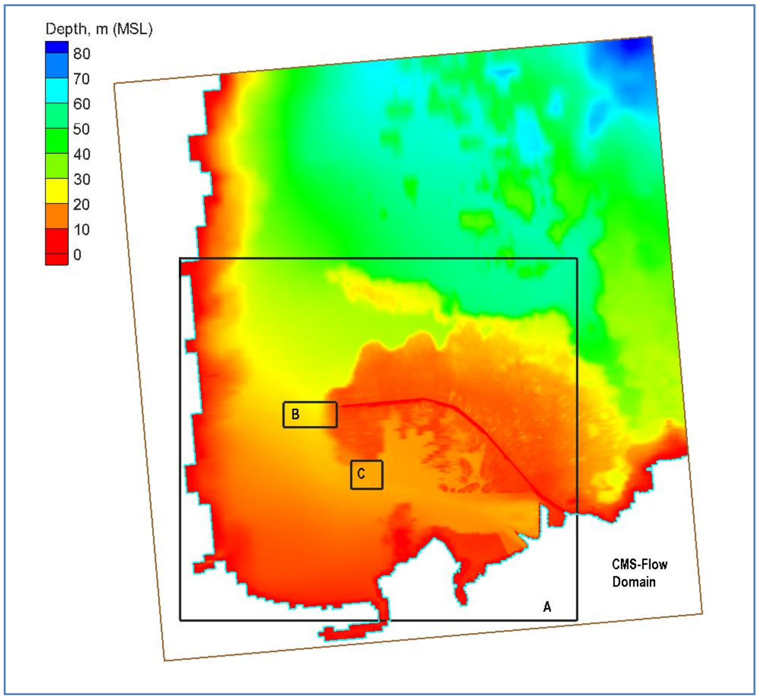

Figure A25: Location map of areas A, B, and C used in extraction of model results

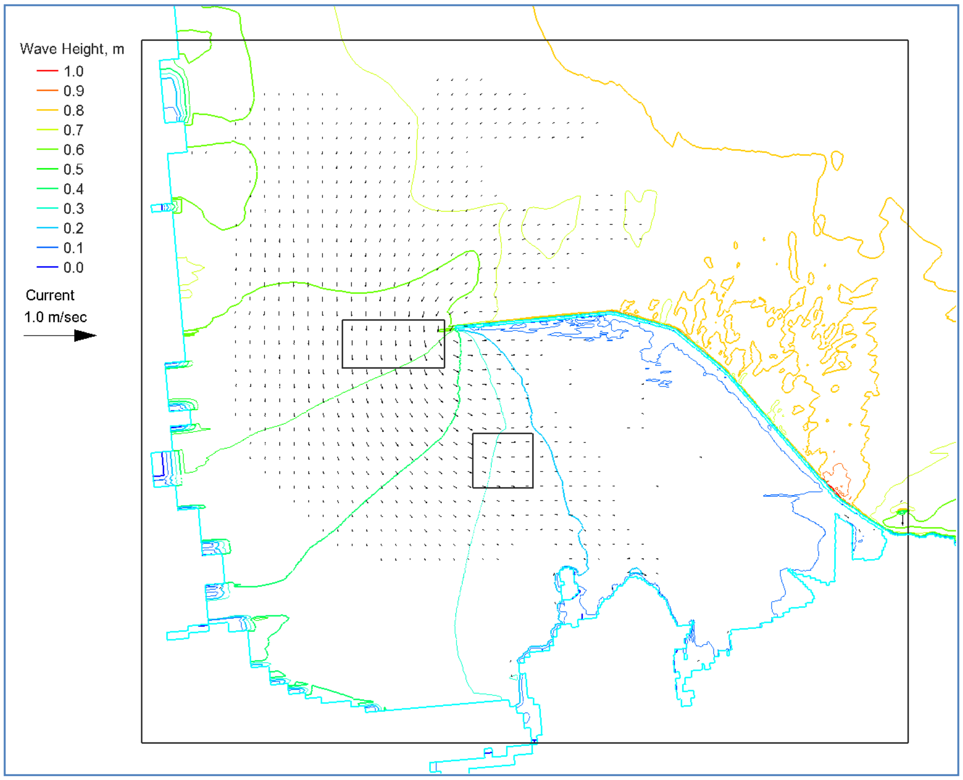

Figure A26: Calculated maximum flood current field at 23:30 GMT on 6 May 2012

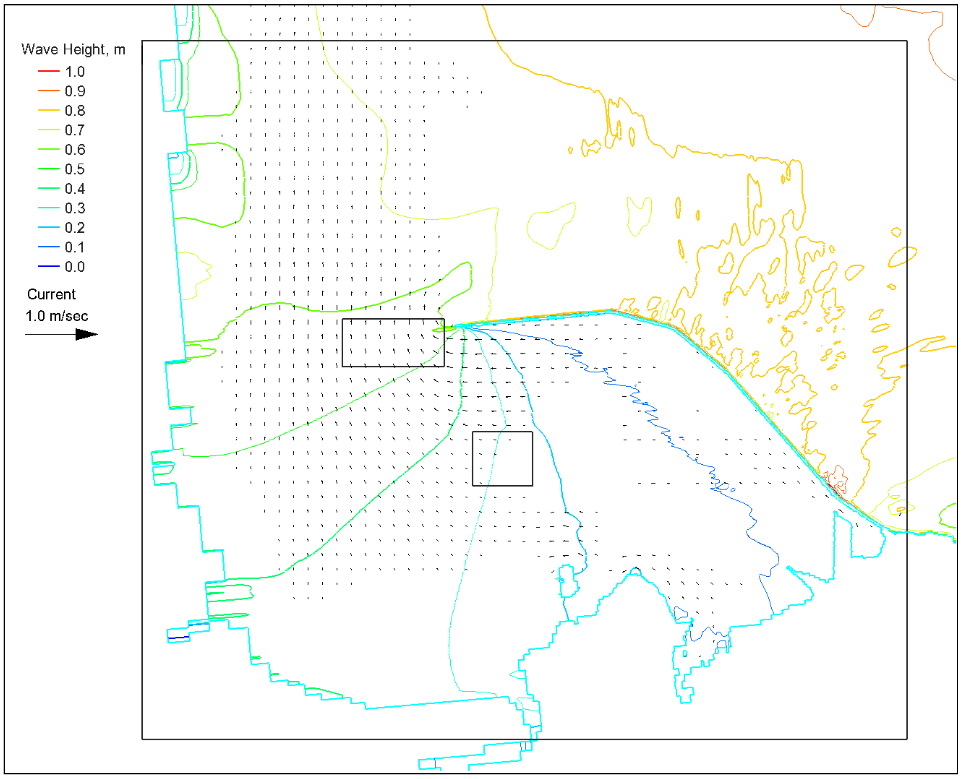

Figure A27: Calculated maximum ebb current field at 06:30 GMT on 7 May 2012

The extracted water level and current results were saved in text files in a format specified by the ship simulator team. Table A4 provides a summary of meteorological conditions simulated for the ship simulator study using CMS-Wave and CMS-Flow. Input conditions were selected in close coordination with the POH project delivery team and with the stakeholders (State agency, pilots, and harbor master).

The summary information in Table A4 includes date of the selected condition simulated, duration of simulation and associated water level, wind forcing, deep water incident wave parameters. Each condition is simulated for two harbor configurations, the Existing harbor (without mooring/turning basin dredged) and with a dredged mooring area. The 24-26 Mar 2012 condition was repeated with/without two river discharges to assess the effect of river flow on waves and currents in the interior harbor. The output desired from these combined CMS-Wave and CMS-Flow simulations were coordinated with the CHL ship simulator team. The results at the time of peak flood/ebb current and corresponding winds were extracted from the CMS solution files. CMS results from these coupled simulations were processed and the output quantities requested included time- and spatially-varying winds, wave parameters, water levels and current components, which were extracted and provided to the ship simulator team in the specified formats in text files.

Table A4. Summary of the extracted output files for ship simulator study

Simulation Dates	Duration (Hr)	Water Level	Wind Forcing	Incident Wave	Config.	Output Timestamp (GMT)	Local Wind Field (m/sec, deg N)
6-7 May 2012	24	Spring tide	~ 8 m/sec ENE	~2 m 9 sec ENE	Exist	Max flood current @ 23:30, 6 May 2012	8 m/sec, 82 deg
					Dredge	Max ebb current @ 06:30, 7 May 2012	8 m/sec, 88 deg
14-15 Nov 2012	24	Spring tide	~ 2 m/sec NE	~2 m 14 sec E	Exist	Max flood current @ 12:00, 14 Nov 2012	2 m/sec, 237 deg
					Dredge	Max ebb current @ 19:00, 14 Nov 2012	3 m/sec, 21 deg
24-26 Mar 2012	36	Spring tide	~ 10 m/sec NE	~3 m 10 sec NE	Exist (No Rivers)	Max flood current @ 23:00, 24 Mar 2012	10 m/sec, 49 deg
						Max ebb current @ 17:30, 25 Mar 2012	11 m/sec, 36 deg
24-26 Mar 2012	36	Spring tide	~ 10 m/sec NE	~3 m 10 sec NE	Exist (With Rivers)	Max flood current @ 23:00, 24 Mar 2012	10 m/sec, 49 deg
						Max ebb current @ 17:30, 25 Mar 2012	11 m/sec, 36 deg
15-16 May 2011	33	Mean range	~ 10 m/sec NE	~3 m 10 sec NE	Exist	Max flood current @ 21:30, 15 May 2011	10 m/sec, 45 deg
					Dredge	Max ebb current @ 03:30, 16 May 2011	15 m/sec, 45 deg
27-29 Oct 2012	33	Mean range	~ 10 m/sec N	~3 m 12 sec N	Exist	Max flood current @ 10:45, 28 Oct 2012	10 m/sec, 0 deg
					Dredge	Max ebb current @ 14:45, 28 Oct 2012	20 m/sec, 0 deg
22-23 Dec 2012	33	Mean range	~ 10 m/sec ENE	~4 m 15 sec ENE	Exist	Max flood current @ 07:00, 23 Dec 2012	11 m/sec, 72 deg
					Dredge	Max ebb current @ 23:30, 22 Dec 2012	11 m/sec, 65 deg

3. BOUSSINESQ 2-DIMENSIONAL (B2D) NUMERICAL MODELING

B2D is used in this study for the nearshore wave modeling between approximately the 130 ft depth contour and land (shorelines). This model is appropriate for smaller domains and a limited number of wave conditions and capable of modeling linear and nonlinear nearshore wave processes. The surge problem in Hilo Harbor is investigated using B2D since this model handles both short- and long-period waves by solving for time-domain shallow-water nonlinear wave processes using Boussinesq type equations.

Both offshore and nearshore areas of Hilo Harbor are included in the B2D wave modeling grids. The extensive fringing reefs outside the harbor beyond the harbor entrance and breakwater and reefs in the interior of harbor are included in the B2D modeling. Model simulations were conducted for two water levels for the existing harbor and four alternatives. Effects of wave diffraction, reflection, refraction, shoaling, breaking, nonlinear wave-wave and wave-current interactions on waves affecting navigation are included in these simulations. The model provides estimates of wave parameters (height, period, and direction), wave-induced currents (circulation), and infragravity (IG) waves which are known to be potential source of harbor surge problems (Demirbilek et al. 2007b, 2007c, 2005a, 2005b; Nwogu and Demirbilek 2004, 2001; Nwogu 2006, 2000, 1996, 1994, 1993a, 1993b).

The same modeling domains were used for the existing harbor and alternatives. Grid setup for the existing harbor was modified as required for each alternative. For consistency of extracting and comparing model results at some selected output points, the same spatial extent and output stations were used for the alternatives.

3.1. Alternatives Investigated

The modeling domains for the existing harbor and alternatives are shown in Figure A28 through Figure A32. The existing harbor is designated as “Alt-0” in Figure A28 since it is the baseline study plan. It includes reefs, breakwater, harbor entrance, interior harbor and shorelines.

The numerical model grids developed for Alt-1, Alt-2, Alt-3 and Alt-4 are provided in Figure A29 through Figure A32. The objective of each proposed modification is to reduce wave energy in the turning basin and at the piers. Different length spurs are used to intercept and redirect waves heading to these areas. A brief description of each alternative and its modeling domain follows. A summary of main features of five alternatives investigated is provided in Table A5.

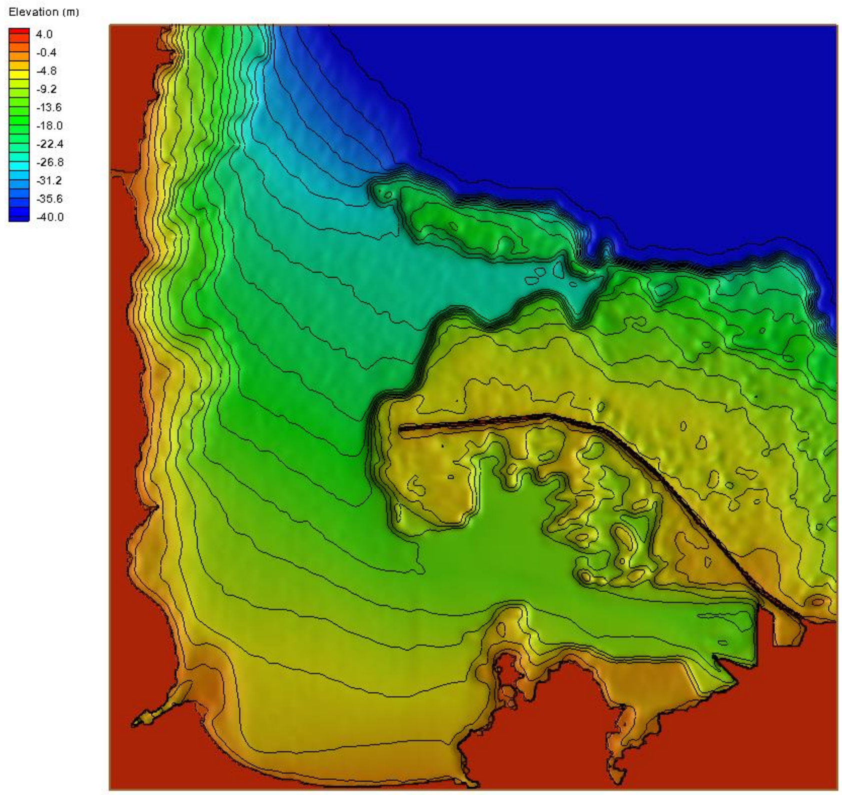

Figure A28. Existing harbor geometry (Alt-0)

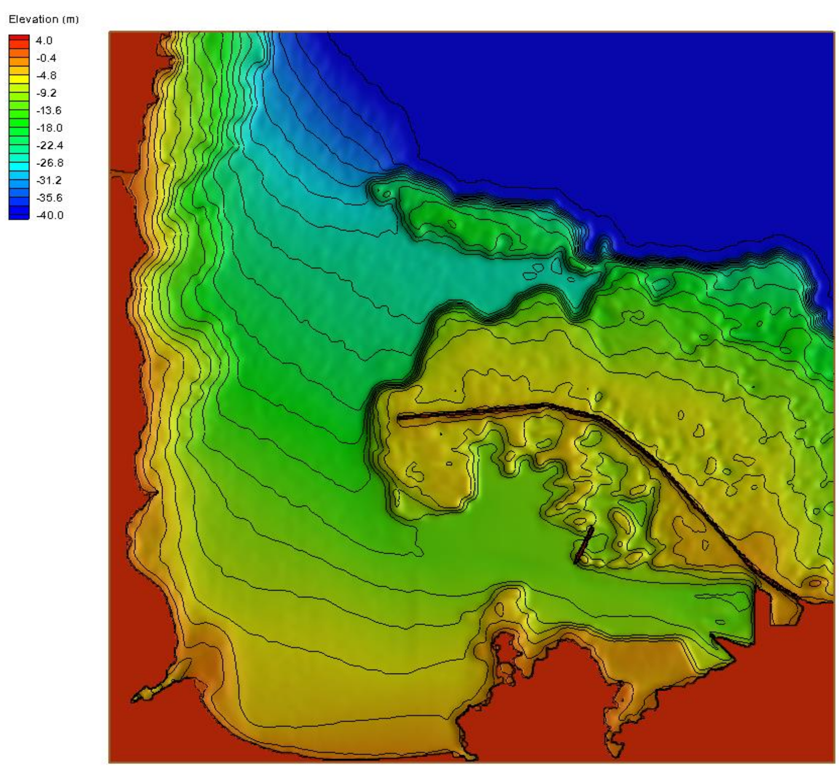

Figure A29. Alt-1 with a short detached structure

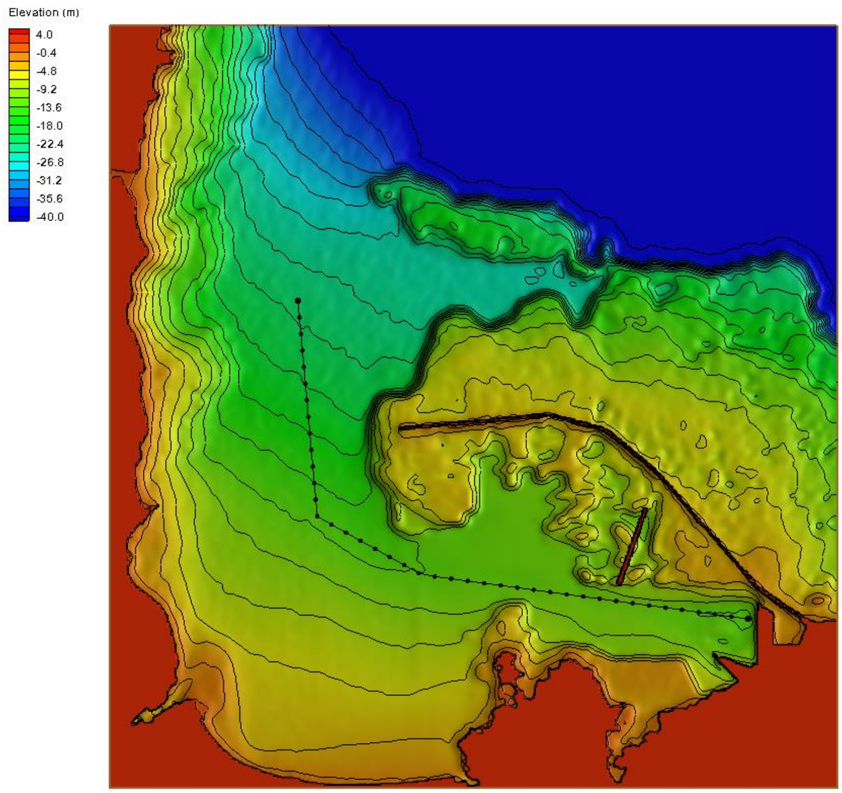

Figure A30. Alt-2 with a medium length detached structure

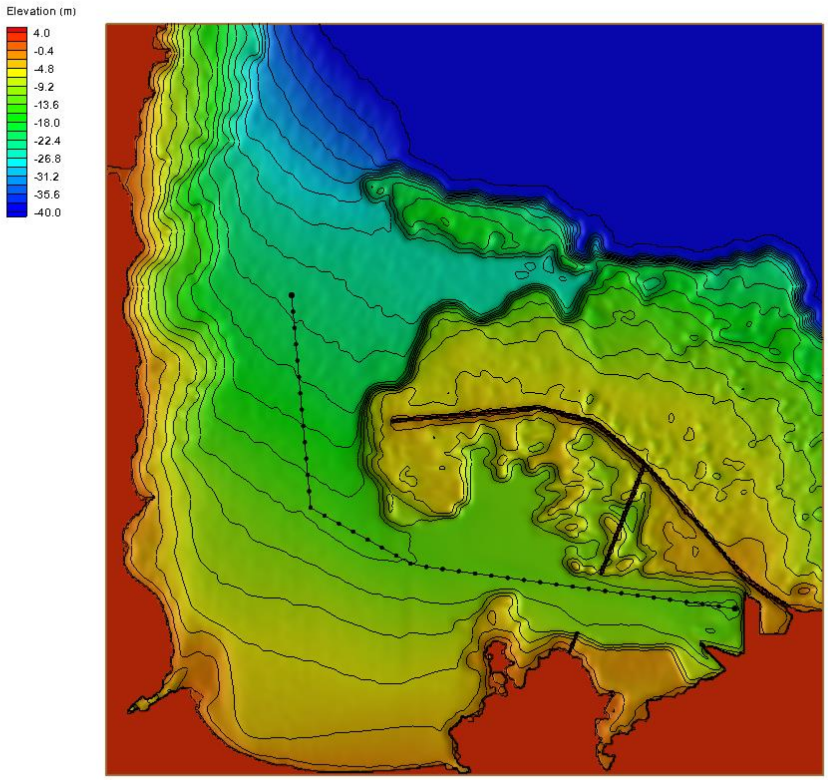

Figure A31. Alt-3 with interior structures (north structure connects to breakwater)

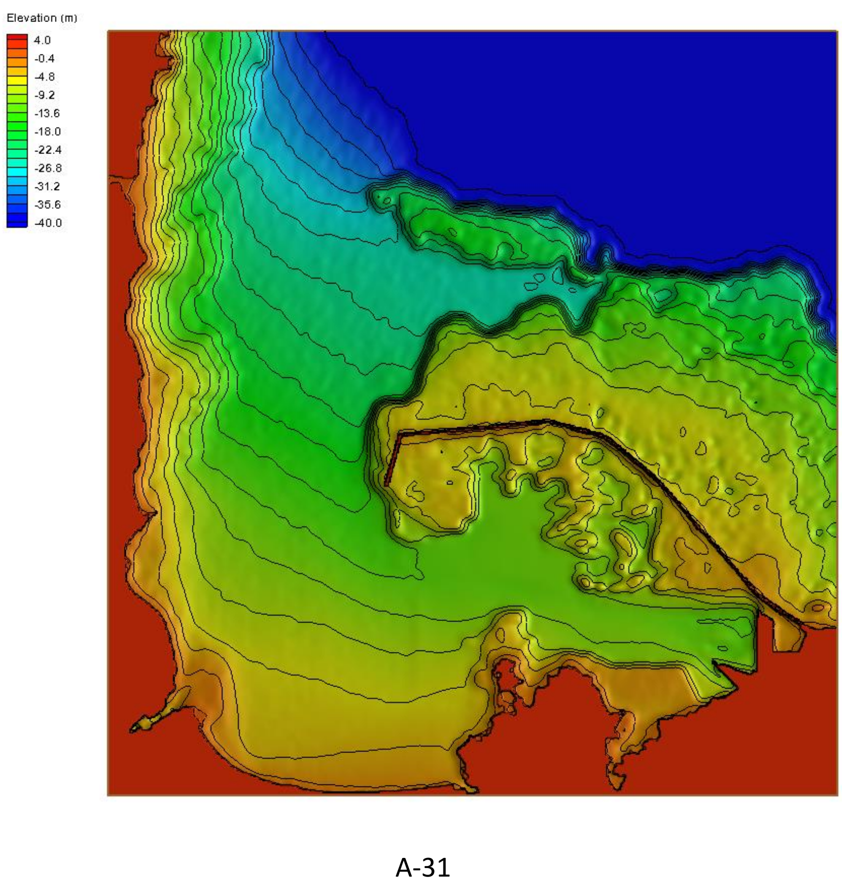

Figure A32. Alt-4 with a spur near the west tip of breakwater

Table A5: Summary of five harbor configurations investigated

ID	Configuration	Features
Alt-0	Existing harbor	Present harbor geometry
Alt-1	Existing harbor with a short interior structure	Positioned west of mooring area, oriented NE, between the north channel edge and Federal breakwater
Alt-2	Existing harbor with a medium length	Similar to Alt-1, has a medium length structure
Alt-3	Existing harbor with a longer interior structure	Similar to Alt-2, has a longer structure that extends and joins to the Federal breakwater
Alt-4	Existing harbor with a medium length spur at the tip of breakwater	Added to near the west tip of Federal breakwater in a southwest orientation

The modification for Alt-2 (Figure A30) includes a medium length structure nearly twice the length of the structure tried in Alt-1. This structure was also positioned north of the navigation channel and aligned in a northeast direction, but was moved eastward closer to the turning basin because the shorter structure in Alt-1 did not reduce wave energy significantly in the turning basin and at the piers. The length and width of structure in Alt-2 are 1,580 ft and 40 ft, respectively.

Alt-2 (Figure A30) and Alt-3 (Figure A31) geometries look similar except that a longer structure is used in Alt-3. The length and width of this structure are 2,300 ft and 40 ft, respectively. It extends and connects to the federal breakwater. Model test simulations indicated no significant gain in protection of the turning basin and at the piers using such a long structure in Alt-3. For this reason, Alt-3 was not further investigated. Note that the channel centerline is depicted by a dotted black line in Figures A-30 and A-31 since it serves as a reference for the locations of interior structures, the turning basin and piers.

The Alt-4 as shown in Figure A32 is different than the three previous alternatives. In this case a spur is used to control the waves coming through harbor entrance. This was done because model simulations indicated waves passing through the entrance turn and propagate eastward into the turning basin and towards the piers in the southeast corner of the inner harbor. To minimize the effects of these waves, a spur was attached to the most western tip of the breakwater. Different length and orientation of the spur were tried. The selected final spur is shown in Figure A32, is 2,300 ft long and 40 ft wide and oriented in a southwest direction.

Based on data from deep water offshore buoys and hindcast estimates, incident waves into Hilo Bay during the months of October-March are generally from the NW to E sector. Therefore, waves can be expected from NNW, N, NNE, NE, and E directions. During the months of May-September, waves are mainly from ESE, E, NE, and N directions. When the deep water waves are transformed to the B2D grid boundaries located in comparatively shallow depths, a significant variation can be expected in the wave height, wave period, and wave direction along the wavemaker boundaries of B2D grids. The range for wave parameters was 3.2 ft < Hs < 16.5 ft, 8 sec < Tp < 16 sec, and 0 < Өp < 20°, respectively.

Based on analysis of year 2014 wave climate, a number of severe wave events were reported by NOAA offshore buoys which impacted navigation according to users of Hilo Harbor. Five wave conditions from different directions were selected to investigate harbor surge problem, these included storms and non-storm conditions. Waves generating infragravity (IG) waves inside the harbor could be causing a localized surge at piers if the period of these waves coincides with one of the natural periods of the harbor. The storm events for investigation of surge problem are shown in Table A6.

Table A6: Wave conditions used in B2D simulations.

Event Date & Time	H_s (m)	T_p (sec)	θ (deg)
5Jan2014@UTC16	1.5	14.3	5
	2	14.3	5 & 20
	2.14	14.3	0, 18
	2.5, 2.8, 3.4	14.3	0
23Jan2014@UTC07	5	14.3	0 & 345
27Feb2014@UTC15	2.4	13.3	0
18Mar2014@UTC20	3.3	13.3	0
4Apr2014@UTC05	3	14.3	0 & 345

According to ship captains, pilots, and harbor master familiar with Hilo Harbor, the surge problem is related to deep water storms occurring outside the harbor. Furthermore, they noted that the surge also occurs during less severe (milder) weather conditions. For this reason, a few typical 2014 wave conditions from different directions in Table A7 were also simulated to investigate surge problem in the harbor.

Table A7: Milder wave conditions for study of surge problem.

Test condition	H_s (m)	T_p (sec)	θ (deg)

1	1.33	14.3	40
2	1.5	10	0, 5, 22.5, 45
3	1.5	14.3	8, 15
4	1.77	14.3	28
5	2	14.3	20
6	2.63	14.3	8
7	3.44	14.3	350

The storm and non-storm wave conditions in Tables A-6 and A-7 were used for the IG-generated surge problem, and evaluation of alternatives. These two sets of wave conditions cover a wide range of significant wave height, peak period and directions. A few simulations were repeated for two water levels (0.0 ft and 1.6 ft, MLLW). Model results showed the water level clearly affected wave patterns on fringing reefs outside, and had less influence on waves at the mooring basin and in the immediate vicinity of two piers.

3.2. Model Calibration and Validation

The two field data sets described above were used to test and validate the model. Two highest wave conditions recorded by ADCP1 in April and May 2007 are shown in Figure A33. These and four events from the 2013-2014 field study were selected for model calibration and validation. The validation for the second set of events with a wide range of input conditions of was performed in time- and frequency-domain. These simulations were used to investigate appropriateness of model parameters (e.g., calibration), including selection of damping layers (width and coefficient), bottom friction, turbulence coefficient, and lengths of model simulation times necessary to adequately model generation and changes in developing IG waves.

Because model results appeared to be sensitive to the incident wave direction, each condition was simulated for three incident wave directions (0° = N and ±10° from N). Considering the 2-Hz sampling rate and short record length of field data and relatively calm seas being simulated, the overall agreement between model and data was considered reasonable. Hence, no attempt was made to fine-tune the numerical model parameters to improve model calculated wave height, period, and direction estimates, and instead it was decided to provide average estimates for three incident wave directions. The calculated wave spectra in Figure A33 and Figure A34 contains wave energy in the IG frequency band (less than 0.05 Hz), indicating low-frequency waves exist in this part of interior harbor away from the piers and mooring basin. Comparison of energy densities in Figure A33 (1Apr2007) and Figure A34 (12May2007) indicates both magnitude and frequencies of emerging IG waves inside the harbor varying with the characteristics of incident waves. More energetic IG waves of larger wave height and longer peak period occurred for 1 April 2007 event as compared to 12 May 2007 event. Analysis of model results the presence of long-period infragravity waves (IG) near the piers and at the ADCP1.

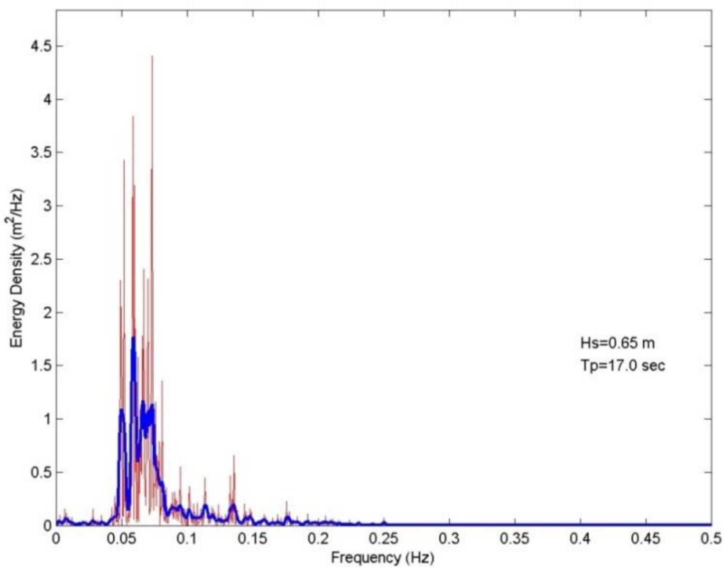

Figure A33: Calculated wave spectra for 1 April 2007 event.

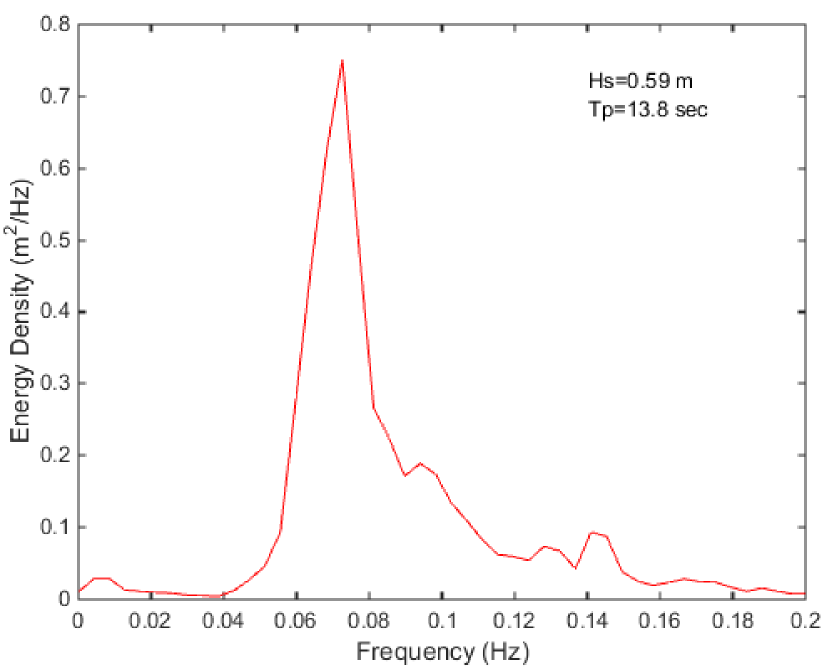

Figure A34: Calculated wave spectra for 12 May 2007 event.

3.2.1. Calibration/validation with 2013-2014 field data

Model validation with 2007 field data showed B2D was capable providing good estimates of design wave parameters (height, period, direction), and model predictions agreed with field data reasonably well. Results also showed the existence of wave energy in low-frequencies near the harbor entrance far from the piers where the surge problem has been observed. Additional validation tests were then conducted for four events selected from the 2013-2014 field study.

The NNE grid was used to simulate the 5 Jan 2014 @UTC1600 condition. The significant wave height field from simulation is shown in Figure A34. Larger significant wave heights exist outside the harbor in Figure A34, and also in the western part of navigation channel at the harbor entrance and near the tip of breakwater. Model results indicate waves over the reefs seaward of the breakwater converging in some areas as denoted by orange to yellowish color bands, designating areas with largest wave heights. Larger waves which break generate wave-induced currents seaward of the breakwater and waves which could reach the structure can runup and overtop the breakwater segments with low elevation.

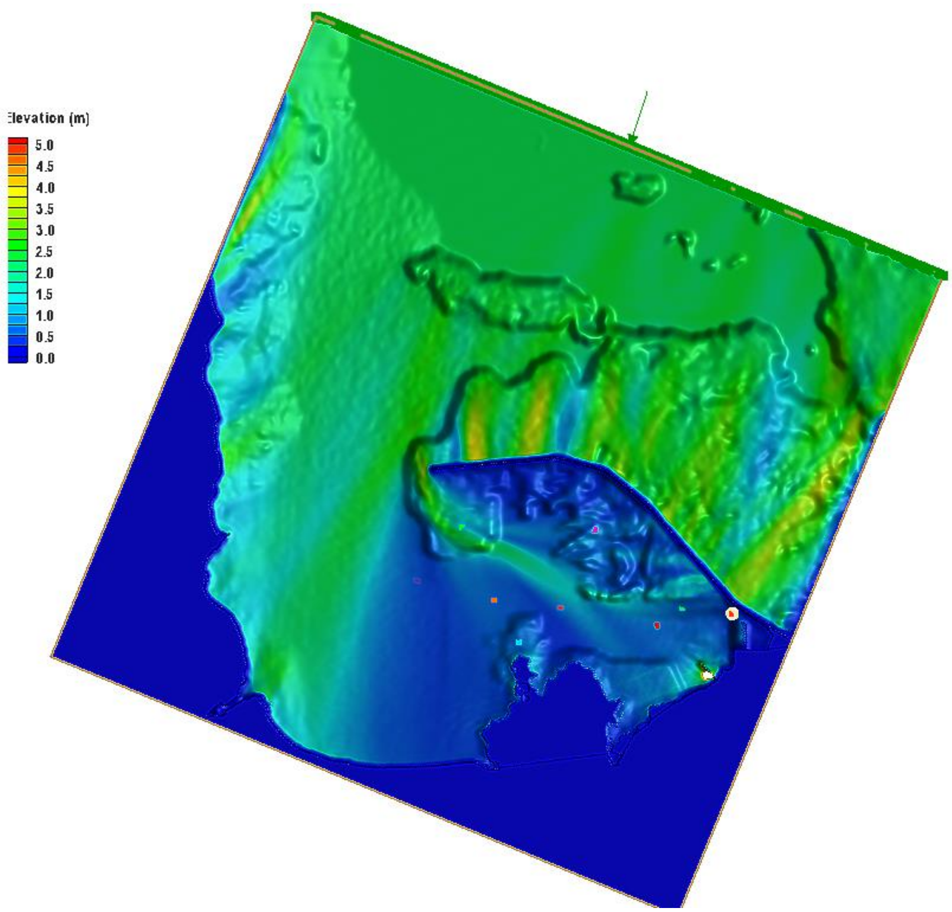

Figure A34: B2D calculated significant wave height field for 5Jan2014@1600 UTC.

Figure A34 shows low and high wave height zones develop over the exterior and interior reefs, in the harbor entrance, and along the navigation channel inside the harbor. Waves wrap around the western tip of breakwater and continue to the east and southeast toward the mooring/turning basin and Pier #1 & Pier #2. Waves which propagate into interior harbor refract outward from the dredged navigation channel toward reefs present north and south of the navigation channel. Waves with smaller heights move through the navigation channel towards the turning basin and Pier #1 & Pier #2. The height of waves at the mooring area and Pier #1 & Pier #2 is generally less than 1.6 ft.

Overall, good comparisons are obtained in the frequency-domain and time-domain. These results demonstrate model is capable of representing the time variation of waves in this part of Hilo Harbor, and that the model captures the characteristics of IG wave energy.

Results indicate wave dissipation occurs over the reefs outside the breakwater. There is a significant amount of wave shoaling, refraction, and breaking, which produce a few high and low wave heights zones over the rapidly changing bathymetry on the reef. The zoomed image shows that after wave energy passes through the entrance and is diffracted at the tip of breakwater, it follows the channel half way into the harbor, and then splits up and refracts toward the channel sides and reefs on both side of the channel. The height of outward refracting wave over the reefs and shallower parts of harbor north and south of channel is smaller as compared to waves in the channel. The wave heights in the turning basin and at Pier #1 range from 1.6 ft to 2.6 ft and from 0.2 ft to 1.3 ft, respectively. These estimates varied slightly with different model parameters, and the maximum change in wave height was ±20%.

This oblique wave was next simulated with the NNE grid. A similar pattern of wave height is obtained outside the breakwater and in the entrance. However, comparatively more wave energy arrives along the west shoreline and greater energy gets to the SW side of harbor. Waves move in and propagate through the channel, and refract outward from channel toward the reefs and shallower areas of harbor north and south of channel. Less wave energy reaches the turning basin because more wave energy is directed SE toward Pier #3 & Pier #4, the new piers under construction. The maximum wave height in the turning basin and Pier #1 is reduced to 2.5 ft and 1.0 ft, respectively. These estimates changed ±15% with model setup and parameters used.

The results provided in the previous section indicated that the largest waves in the harbor were caused by waves incident from ±10° around the true north (e.g., slightly oblique waves between N and NNE directions). For this reason, model simulations for evaluation of alternatives considered a severe storm event from nearly north direction. The waves parameters input to the model were H_s = 8.6 ft, T_p =14.3 sec, and θ_p = 8°, WL =0 ft. For comparison of alternatives, the attention is on the last 3,280 ft distance of navigation channel as it passes through the turning basin.

The short structure in Alt-1 was located west of the turning basin in an attempt to reduce waves affecting vessel maneuvering in the basin. Iterations on positioning of this 40 ft wide and 820 ft long structure indicated that the maximum reduction was obtained with part of structure placed in the channel. Doing so would pose a risk to the ships using the channel and the turning basin, and was not considered. It was necessary to place the structure close to the edge of navigation channel at 38 ft depth and at a relatively safe distance west of the turning basin. The effect of structure on waves is localized to the vicinity of structure, and appears to have diverted waves slightly toward southeast direction. The comparison of Figure A35 (Alt-0) and

Figure A36 (Alt-1) shows an increase in wave height around the Pier #2, Pier #3 and Pier #4 and a reduction in the turning basin and at Pier #1.

Figure A37 provides the results for Alt-2, where a twice longer structure (1,575 ft length, 40 ft width) than the one in Alt-1 was used initially. The structure was placed west of the turning basin near the north edge of channel at 31.2 ft depth. Similar to the results for Alt-1, Figure A37 shows the structure is clearly redirecting waves to southeast direction that helps to reduce waves in the turning basin and Pier #1. In Alt-2, a much longer (2,300 ft long) structure connecting to the breakwater was also tested. Overall, similar results were obtained and there was no significant change in waves in the turning basin and Pier #1 areas.

As shown in Figure A38, two structures were used in Alt-3 to better control waves in the southeast side of Hilo Harbor. The lengths of north and south structures were 2,300 ft and 410 ft, respectively. The tips of north and south structures on the channel side were at 30 ft and 33 ft depth. Results provided in Figure A38 look similar to the Alt-2 results in Figure A37, although the addition of a short south structure appears to increase waves in the turning basin and at Pier #1.

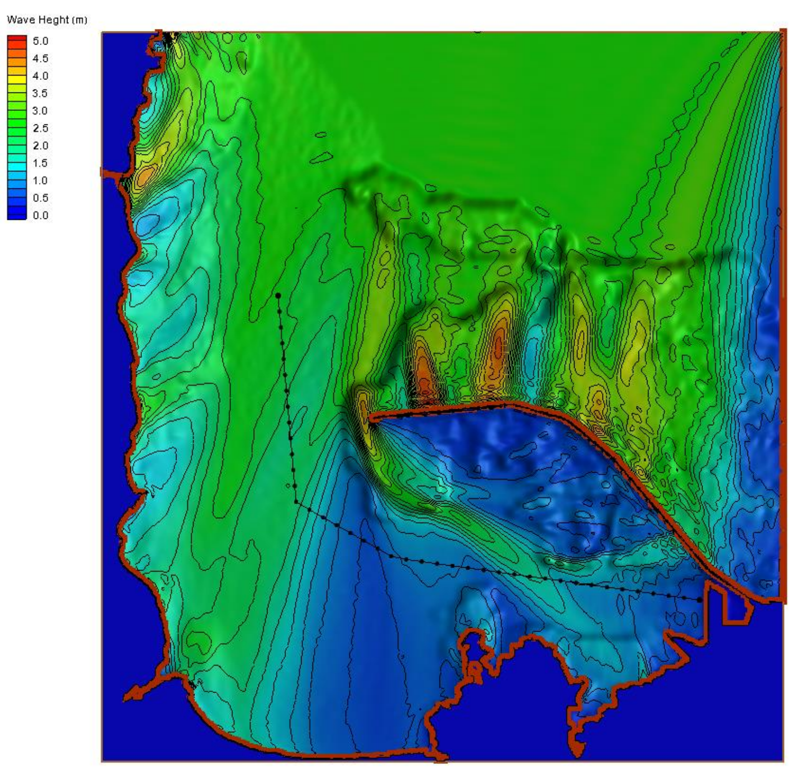

Figure A35: Wave height variation along navigation channel for Alt-0.

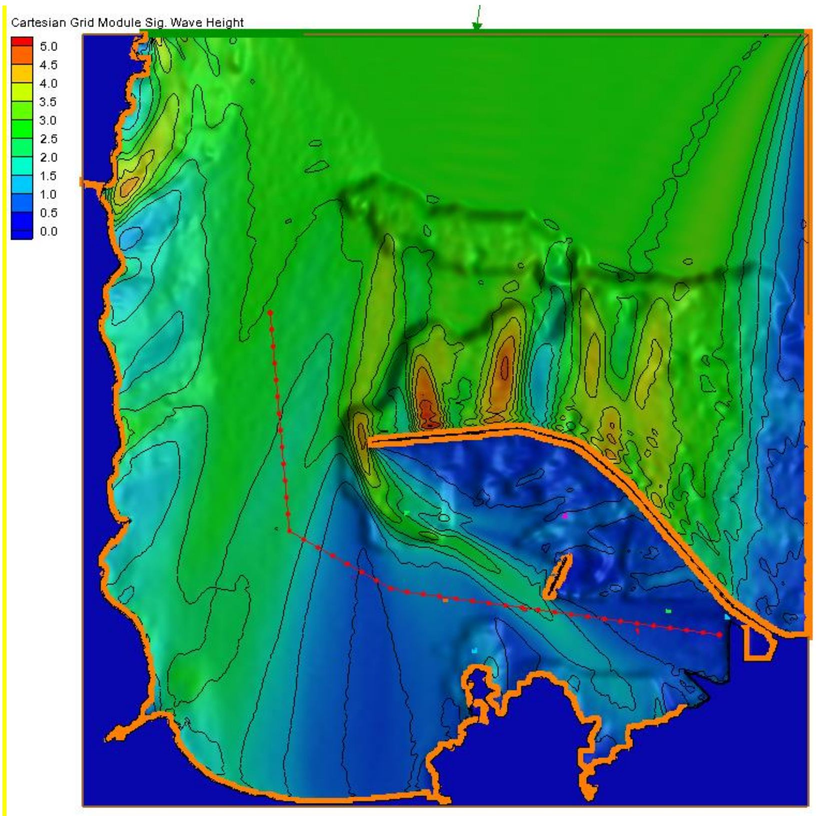

Figure A36: Wave height variation along navigation channel for Alt-1.

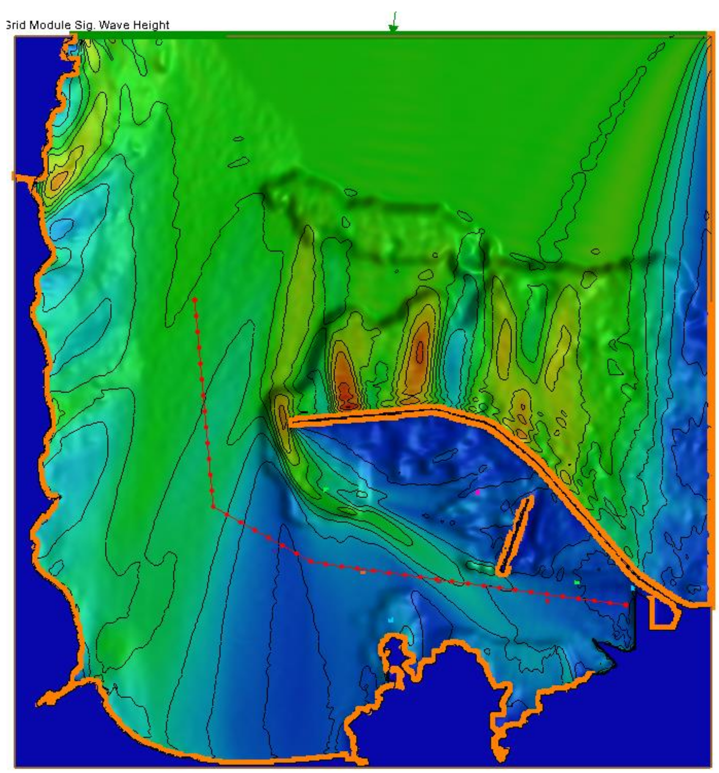

Figure A37: Wave height variation along the navigation channel for Alt-2.

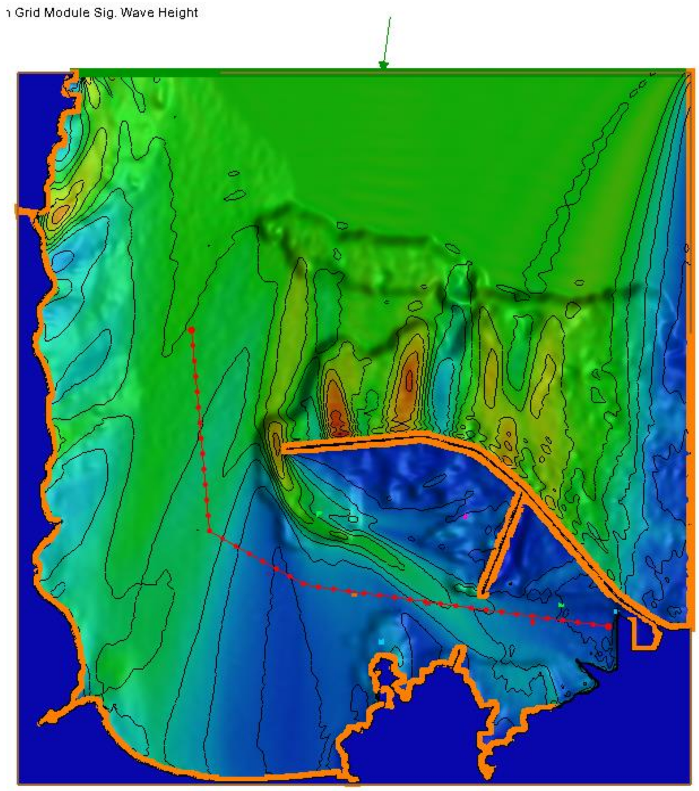

Figure A38: Wave height variation along the navigation channel for Alt-3.

Alt-4 has a 2,300 ft long spur attached to the west end of the breakwater. It is oriented in southwest direction and extends toward the navigation channel, and ends at 23 ft depth. This structure poses no risk to ships in the channel amongst all structures considered because it is not close to the channel edge. Results in Figure A39 indicate Alt-4 is the most effective alternative because it reduces waves almost everywhere in the harbor, the turning basin and Pier #1 and Pier #2 areas included.

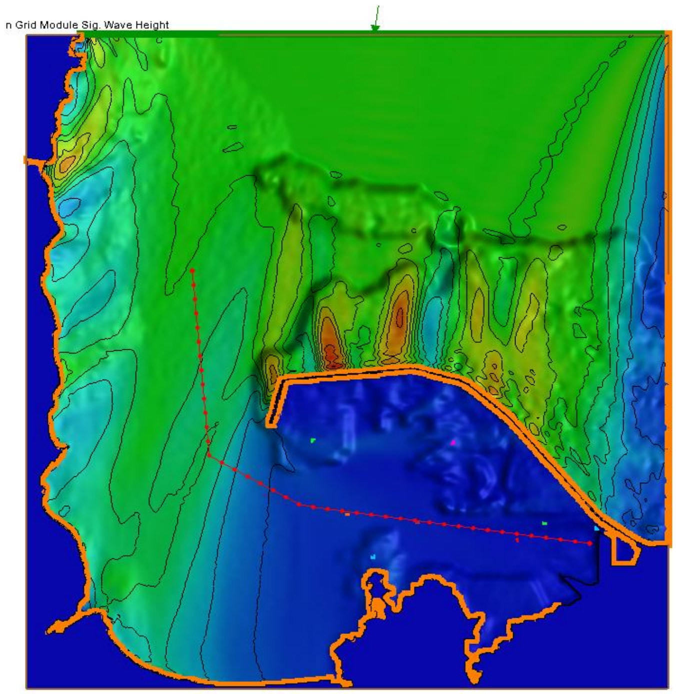

Figure A39: Wave height variation along the navigation channel for Alt-4.

Figure A40 provides a direct comparison of wave heights for each alternative and results of Alt-0 (e.g., existing harbor or no project). Figure A41 shows the percent change in wave height relative Alt-0. Figure A42 shows the wave height difference (bias) between alternatives and Alt-0. The relative percent wave height change is defined as % Change = (alternative – Existing)/Existing *100. This can vary between -100 to 100 depending on the relative values of wave heights for an alternative and Existing (Alt-0). The wave height difference (bias) is defined as Difference = alternative – Existing. The results for the entire channel transect are summarized in Table A8.

In summary, the analysis of results provided in Figures 4-41 through 4-44 indicates Alt-4 is the best alternative for providing the most wave energy reduction in the entire navigation channel, and at the turning basin and Pier #1. Alt-4 outperformed other alternatives with an average wave height reduction of 28% and 89%, respectively in the channel and turning basin. Alt-1, Alt-3 and Alt-2 follow Alt-4 in the ranking of alternatives. The reason Alt-4 achieved such a dramatic reduction in waves was its ability to control waves coming through the entrance. Alt-4 with the spur at the tip of breakwater is able to intercept and re-direct waves toward the southwest side of harbor. The east and southeast sides of interior harbor (e.g., turning basin, Pier #1 and Pier #2) benefit greatly from this diversion of waves, resulting in greater than 80% wave reduction at Pier #1, Pier #2 and turning basin areas.

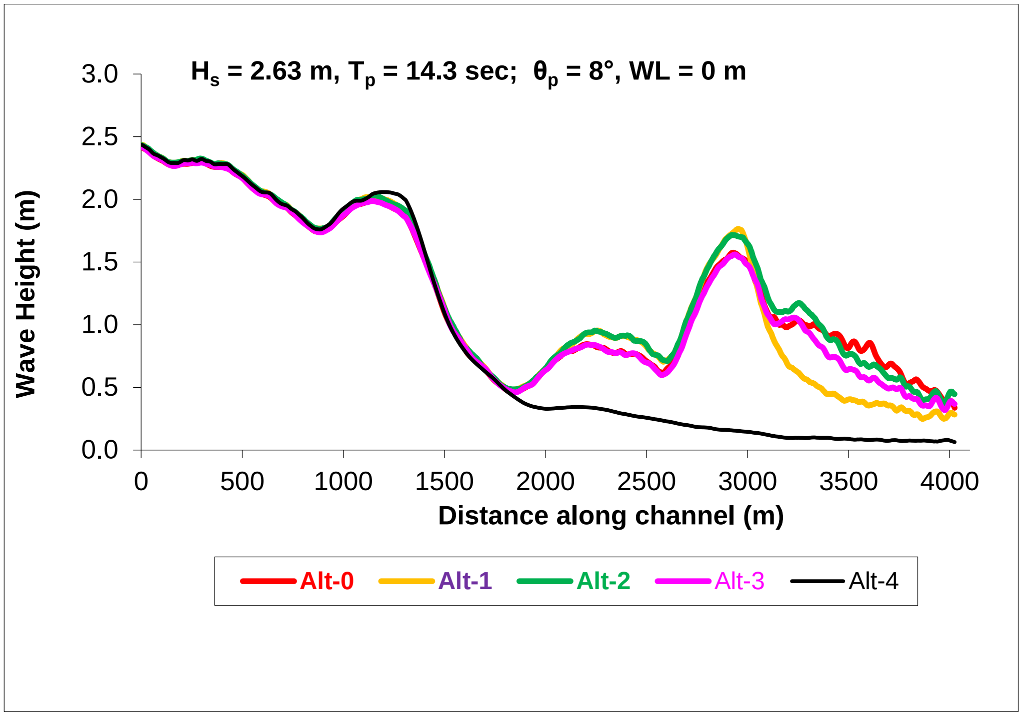

Figure A40: Comparison of wave height variation by alternatives in the navigation channel.

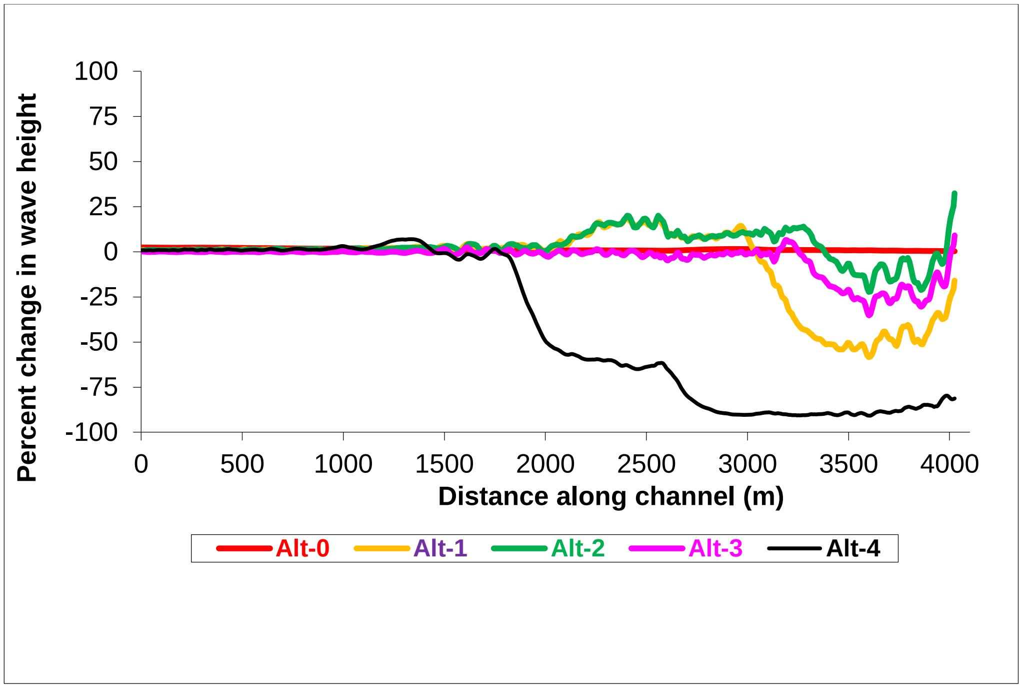

Figure A41: Percent change in wave height along channel centerline.

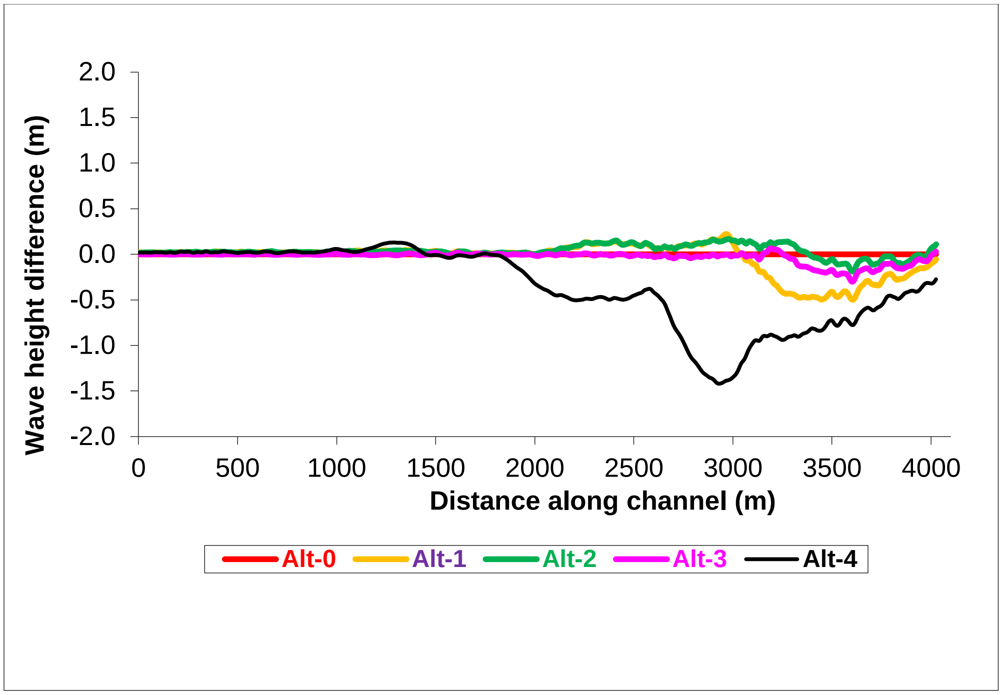

Figure A42: Wave height difference along channel centerline by alternatives.

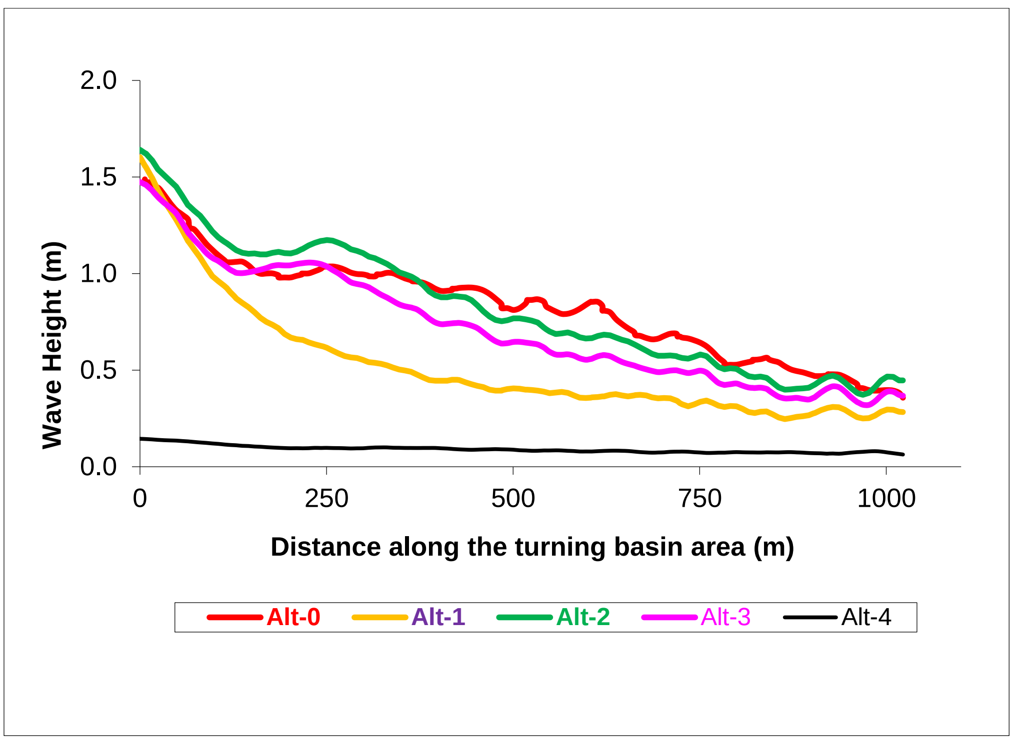

Figure A43: Comparison of alternatives based on calculated wave height in turning basin.

Table A8: Comparison of alternatives based on wave height statistics in turning basin and Pier #1.

Wave Height Stats	Alt-0	Alt-1	Alt-2	Alt-3	Alt-4
Average (m)	0.83	0.53	0.83	0.73	0.90
Maximum (m)	1.49	1.60	1.64	1.47	0.15
Minimum (m)	0.34	0.25	0.37	0.32	0.06
Ave diff (m)	0	-0.30	0.0	-0.11	-0.74
Max diff (m)	0	0.11	0.15	-0.02	-1.34
Min diff (m)	0	-0.09	0.04	-0.02	-0.27

3.3. Permeability of breakwater

No field measurements of water levels, waves, and currents were available to assess the potential transmission of waves, currents, and sediments passing through the breakwater structure. The calculated wave estimates on seaward side of the structure were compared to those in the lee (harbor side) of structure. Figure A44 shows the section of breakwater selected for investigation. Model results were saved along two transects, each approximately 2,000 ft long. The outside transect (T1) and inside transect (T2) were positioned slightly beyond the toe of structure.

Three storms were simulated to examine structure permeability. Figure A45 shows wave height estimates along the two transects, starting from west tip (0 ft) to east end (2,000 ft) of these transects. The wave heights along T2 in the lee of structure remain essentially constant for three levels of breakwater permeability investigated. The permeability of breakwater assumes wave transmission occurs through a porous layer of structure below the MSL (e.g., submerged height of structure). In addition, wave transmission would also occur over the exposed part of structure. Additional transmission would occur due to wave runup/ overtopping over the low crest elevation of structure above MSL. Results for three porous layers (3.3 ft, 6.6 ft and 10 ft) indicate the transmitted wave height varies from 0.7 ft to 1.5 ft. Wave heights inside the breakwater were predicted to be approximately 10% of the wave height outside the breakwater. The high crest elevation of structure (~11.5 ft) above the MSL prevented wave runup/overtopping of the breakwater section investigated. This is the main reason for calculated low transmitted wave heights along T2.

Figure A44: Outer and inner transects for breakwater permeability testing.

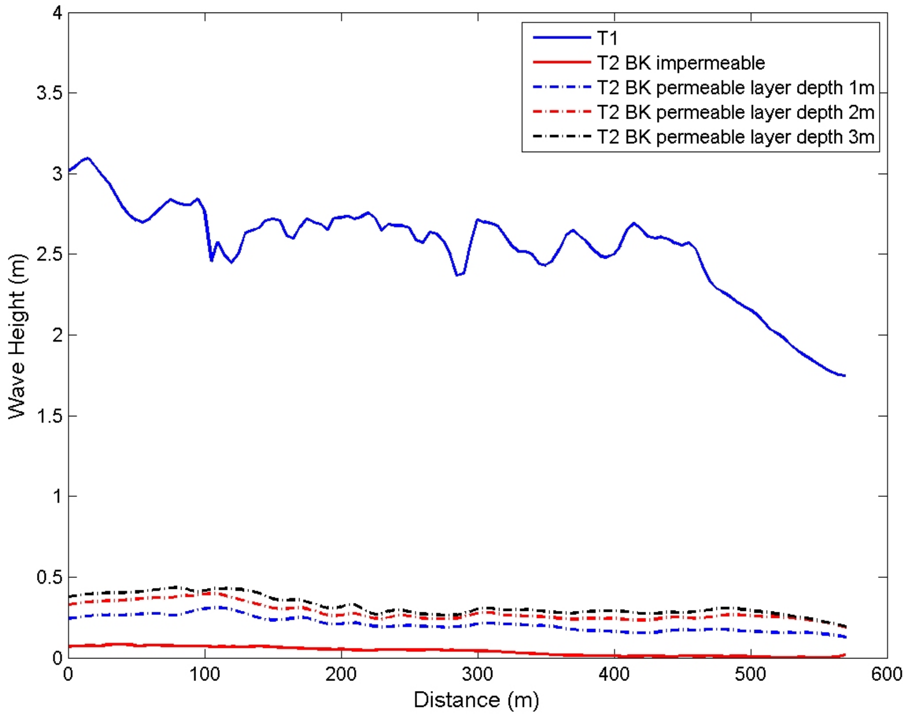

Figure A45: Estimates of wave height for assumed permeability of the breakwater.

A percent reduction in mean wave height inside the harbor on transect T2 can be defined as (T2-T1)/T1*100 using the mean wave heights (m) along T1 and T2. The mean wave heights on T1 and T2 and calculated percent reductions for three incident wave conditions are provided in Table A9. The percent reductions are provided in parentheses. These calculations are provided for impermeable and permeable breakwaters for three porous layer thicknesses. Included are estimates for a breakwater with wave runup/overtopping. The result of the permeability analysis indicates that wave transmission over and through the breakwater is not responsible for the “surge” problems reported by users at Hilo Harbor. Wave heights along transect T2 were not significantly sensitive to modeling the upper limits of the breakwater crest as permeable in one (1) meter increments as evidenced by the values in Table A9. Reducing the breakwater crest elevation in the model by 3.3 ft, 6.6 ft and 10.0 ft only resulted in a 7%, 10% and 11% increase in the wave transmission, respectively.

3.4. Numerical Modeling Summary

For the assessment of the surge problem, model results at the UH gauge location north of the Pier #1 were analyzed to check for the presence of infragravity waves. These long-period waves are often the primary cause of harbor surging phenomenon, ship moorings, and on/offloading problems in harbors. For incident waves from ±10°of true, model results showed some wave energy in the low-frequency tail of wave spectra. However, the existence of IG waves with periods close to natural periods of harbor in the SE corner of harbor is strong indication and cause of great concern for the occurrence of harbor oscillations (surging).

Table A9: Estimates of mean and percent wave reduction in harbor.

Transect	Characteristic of breakwater	Offshore Incident Waves			Mean
		Dir = 0° Hs = 3.4 m Tp = 14.3 sec	Dir = 25° Hs = 3.3 m Tp = 13.3 sec	Dir = 345° Hs = 5.0 m Tp = 14.3 sec	
T1		2.49	2.54	2.72	2.58
T2	Impermeable	0.04 (99%)*	0.04 (99%)	0.04 (98%)	0.04 (99%)
	Permeable layer (1 m)	0.19 (92%)	0.21 (92%)	0.21 (92%)	0.20 (92%)
	Permeable layer (2 m)	0.26 (89%)	0.28 (89%)	0.29 (89%)	0.28 (89%)
	Permeable layer (3 m)	0.30 (88%)	0.32 (87%)	0.34 (88%)	0.32 (88%)
	Wave runup	0.19 (93%)	0.20 (92%)	0.21 (92%)	0.20 (92%)

* Percent reduction of mean wave height on T2 in parentheses.
Wave height estimates on T1 and T2 are in meters.

Model results showed waves in the lee of breakwater remaining essentially constant for three levels of breakwater permeability investigated. Results for three porous layers (3.3 ft, 6.6 ft and 10.0 ft) indicated the transmitted wave height was less than 1.4 ft, or approximately 10% of wave height outside the breakwater. The high crest elevation of structural segment investigated (~11.5) above the MSL did not permit wave runup/overtopping, ensuring low transmitted wave heights in the lee of breakwater. Model results suggested that wave transmission through the structure was negligible, and that wave runup/overtopping could happen under right conditions for certain storms (e.g., excessive water piling up on the outer reef that can lead to runup/overtopping of parts of east side of breakwater).

Alt-4 offered the highest reduction of wave energy in the turning basin and at Pier #1 & Pier #2. It is not only the efficiency of Alt-4 makes it an excellent potential long-term solution to improving the conditions inside the existing harbor, but also Alt-4 achieves this objective by not increasing the risk to navigation.

4. FINAL ARRAY OF ALTERNATIVES

SMART Planning involves expediting the process of screening alternative solutions using existing data, expert elicitation and commonly accepted practices, along with other techniques developed to shorten required investigation time. Once a final array of alternatives is identified, those alternatives are carried into the detailed design portion of the study. The project delivery team (PDT) considers these alternatives further through hydraulic modeling, preliminary design work, costing, benefit evaluation and other similar studies.

The alternatives that the Hilo Harbor Modifications Study PDT formulated were screened based on a set of criteria agreed to by the PDT. One of the most important criterions was the alternatives projected benefit-cost ratio (BCR). Based on this and other criteria dealing with Effectiveness, Efficiency, Completeness and Acceptability, the PDT set out to formulate the best array of structural and nonstructural alternatives practicable.

4.1. Nonstructural Measures

To minimize impacts and costs of construction, and comply with federal regulations requiring equal consideration is given to a nonstructural plan, the PDT formulated the following nonstructural alternatives:

Alternative 1 – Non-structural

- NS1 : Change limits of federally-authorized project
- NS5: Mooring either in harbor or offshore in deeper areas during large waves
  Objectives met: Reduce damages, improve safety

Alternative 2 – Non-structural

- NS 2: Better navigational technologies (Lateral looking view similar to depth sonar)
- NS3: Close port at times of high surge
- NS4: More accurate GPS technology (within a foot) in the harbor and lobby NOAA to install PORTS system
  Objectives met: Improve operational efficiency, reduce damages and improve safety

Most of these nonstructural solutions are geared toward addressing the surge problem within Hilo Harbor. The Hilo Harbor users have already been implementing some of these non-structural measures and practices, such as closing the port on extreme surging days and mooring ships in and around the harbor while they wait for calmer water. Other ideas presented in these non-structural solutions are likely to be pursued in the future, such as altering the federally authorized project limits and installing more sophisticated gages and equipment to better prepare ship operators for surge conditions in and around the piers. In the end, no attempts were made to calculate BCRs for either of these two nonstructural solutions.

4.2. Structural Solutions

Alternative 3 –Structural

- S3: Expand turning basin by dredging
- S2: Surge reduction structures (Wave attenuator, new BW, baffles, etc.)

  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

Alternative 4 –Structural

- S3: Expand turning basin by dredging

- S1: Decrease porosity of breakwater
- S4: Raise Breakwater Crest Elevation

  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

<u>Alternative 5 – Most Assertive</u>

- S3: Expand turning basin by dredging
- S2: Surge reduction structures (Wave attenuator, new BW, baffles, etc.)
- S1: Decrease porosity of breakwater
- S4: Raise Breakwater Crest Elevation
- Non-Structural Measures : Alt-1 or Alt-2

  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

Several of these structural solutions deal with addressing Hilo Harbor's surge problem. Winter wind and swell conditions favorable for these turbulent harbor conditions happen an average of about 10 to 12 times per year. Occasionally, perhaps 2 to 3 times a year on average, surge conditions in the harbor are severe enough to wave off scheduled ship calls or damage moored vessels. Benefits to addressing surge in the harbor might include fuel savings, fewer cancelled ship calls, decreased damages to vessels, bollards, piers, and other harbor infrastructure, life and safety benefits for all concerned, and more interest shown by new shipping lines to call at Hilo; never do port authorities want these problems to add to ships not calling.

The following documents the engineering investigation conducted on the final array of alternatives brought forward into detailed analysis in support of the following goals.

- Improve navigation and operational efficiency of the harbor
- Increase allowable vessel sizes calling at Hilo Harbor
- Improve safe use of Hilo Harbor

Alternatives considered for detailed engineering analysis included provision of a turning basin widener and a breakwater spur. The goal of the turning basin widener is to provide safe navigation access to Pier #1 by the ever increasing sized cruise ships. The breakwater spur is designed to reduce wave energy within the harbor thereby reducing vessel damages as well as improving operational efficiency and navigation safety.

4.3. Turning Basin Widener

The turning basin dimensions (width and length) are inadequate for the existing and future fleet calling at Hilo Harbor. The existing turning basin design was based on a vessel of 700 ft-length, 92 ft-beam, and 29 ft-draft. There are currently several cruise ships calling at Hilo Harbor with lengths of 965 feet, and one (Celebrity 's "Solstice of the Seas") with a length of 1,041 feet, a beam of 121 ft, and a draft of 27 ft, which can call at Hilo during calm conditions. Due to the limited turning area for these larger vessels calling at Hilo Harbor, there is currently a high risk of vessel groundings. This in turn leads to a high risk of environmental contamination from potential groundings (oil, petroleum product releases, etc.).

Enlarging the turning basin would greatly increase safe harbor operations and reduce the likelihood of groundings while maneuvering in the existing channel when high winds and strong surging waves are present. Enlarging the turning basin will also reduce maneuvering time and increase efficiency of many of the larger vessels calling at Hilo Harbor. Enlarging the turning basin could also stimulate the port's business to attract newer, larger and more profitable cruise ships, which is an important and quantifiable benefit. The limited turning basin dimensions also impede port operations, as delays are associated with maneuvering and docking time.

The turning basin widener shown in Figure A46 has been designed to facilitate efficient and safe transit of cruise ships into Pier #1 at Hilo Harbor. Dredging of the widener would result in the removal of the in situ volumes shown in Table 1. Volumes are shown for dredging the widener from existing bottom to 30 feet through 35 feet (in 1-foot increments). Dredging the first increment from existing depth to 30 feet requires excavation and disposal of 145,000 cubic yards (cy) of material. This work would bring the entire area to a depth of 30 feet (there are no deeper areas in the widener). Each additional foot of depth would require dredging a volume of 13,000 cy. Dredging to a depth of 35 feet would require removal and disposal of 210,000 cy of material.

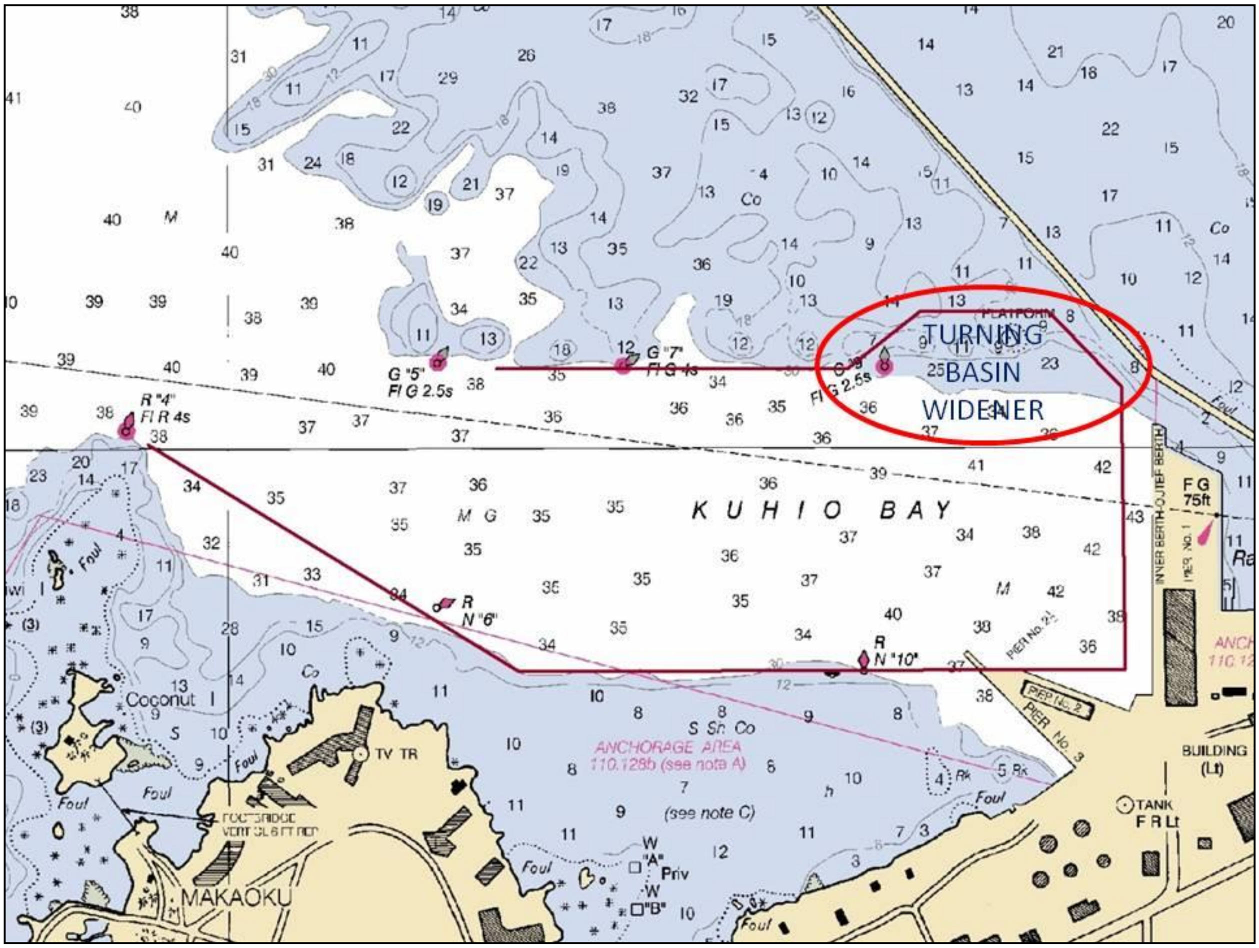

Figure A46: Turning basin widener would be located in the northeast corner of the turning basin

The dredge plant(s) must be capable of removing both “hard” and “loose” material as defined below. The estimated percent “hard” material for each increment of depth is provided in Table A10. A coral mitigation plan was not been developed for this alternative.

> Hard material is defined as material requiring the use of special equipment for conventional material removal, and includes boulders or fragments too large to be removed in one piece by the dredge.
>
> Loose material is defined as material not qualified as "hard material" above that may be removed in one piece by the dredge. Loose material may include rocks, coral rubble, cobbles, gravels, sand, silt, mud, tree limbs, and branches as well as all metal and other debris.

Table A10: Dredging requirements for the turning basin widener

Dredge Depth (ft, MLLW)	Dredge Volume (cy)	Hard Material (%)
35	210,000	72
34	197,000	67
33	184,000	62
32	171,000	57
31	158,000	52
30	145,000	50

4.4. Breakwater Spur

Vessel delays along with damages to ships and portside infrastructure due to wave surge within Hilo Harbor have been reported by harbor users. Surge problems within the harbor have also caused ship call cancellations and discouraged new customers from calling at Hilo Harbor. During high wave conditions, frequently occurring in the winter months, waves and long-period wave surge impact navigation in the entrance channel and turning basin, resulting in vessel delays. This also presents a safety issue as there is no "Plan B" contingency at the harbor for cruise ships that encounter hazardous navigation conditions while entering or exiting the harbor.

Long-period wave surge in the harbor also impacts operations. During periods of large waves from the north, increased time is required for loading/offloading and mooring of passenger, cargo and commodities vessels. The piers have experienced damage in the form of damaged bollards, damaged pier faces and bulkheads, and broken mooring lines due to vessel movement while docked. For instance, the non-federal project sponsor reported that while holding a large cruise ship at the dock during one surge event, several bollards were damaged to the point they had to be replaced.

A breakwater spur was designed to reduce wave energy within Hilo Harbor. For this alternative, a 1,000-foot long spur would be constructed at the head of the existing breakwater in the alignment shown in Figure A47. The spur would consist of 20 concrete caisson units. Each unit would be 50 feet long, 25 feet wide and 25 feet high (Figure A48 and Figure A49). Rebar would be incorporated into the units to provide stiffness. The caissons would not be directly attached to the existing breakwater. All caisson walls would be made of concrete (thickness = 2 feet).

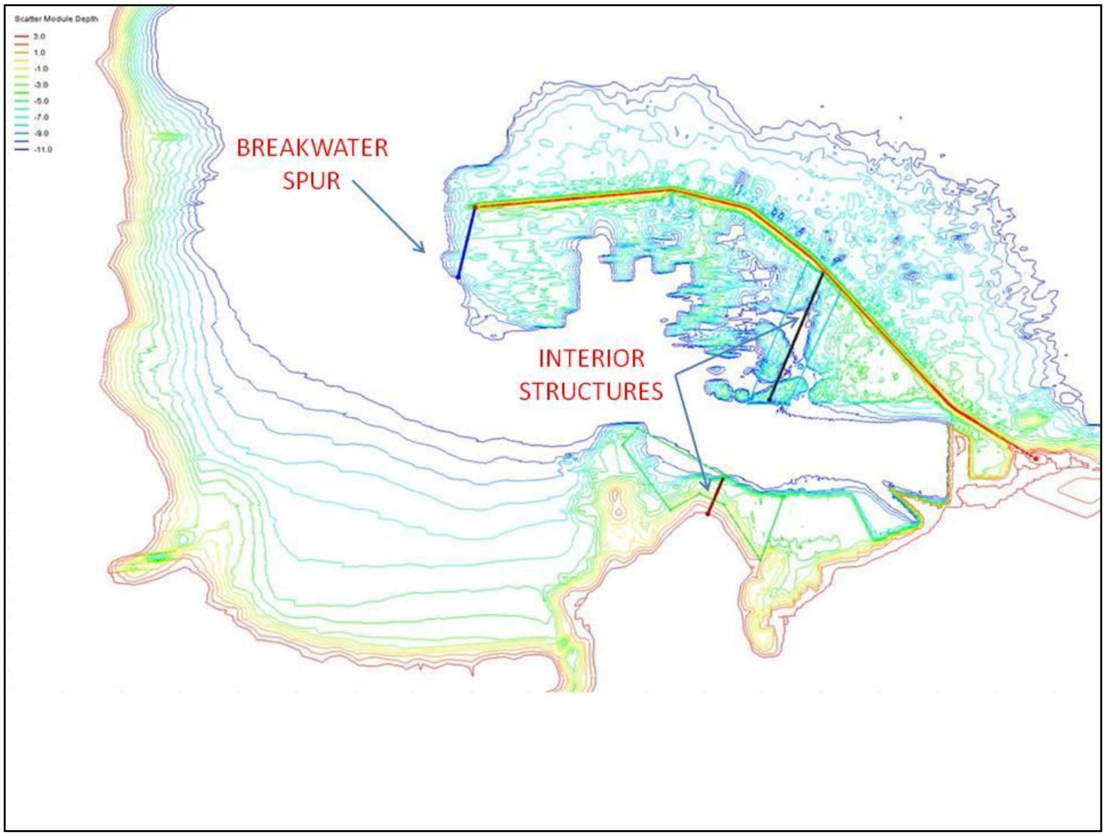

Figure A47: Breakwater spur and interior structure alignment

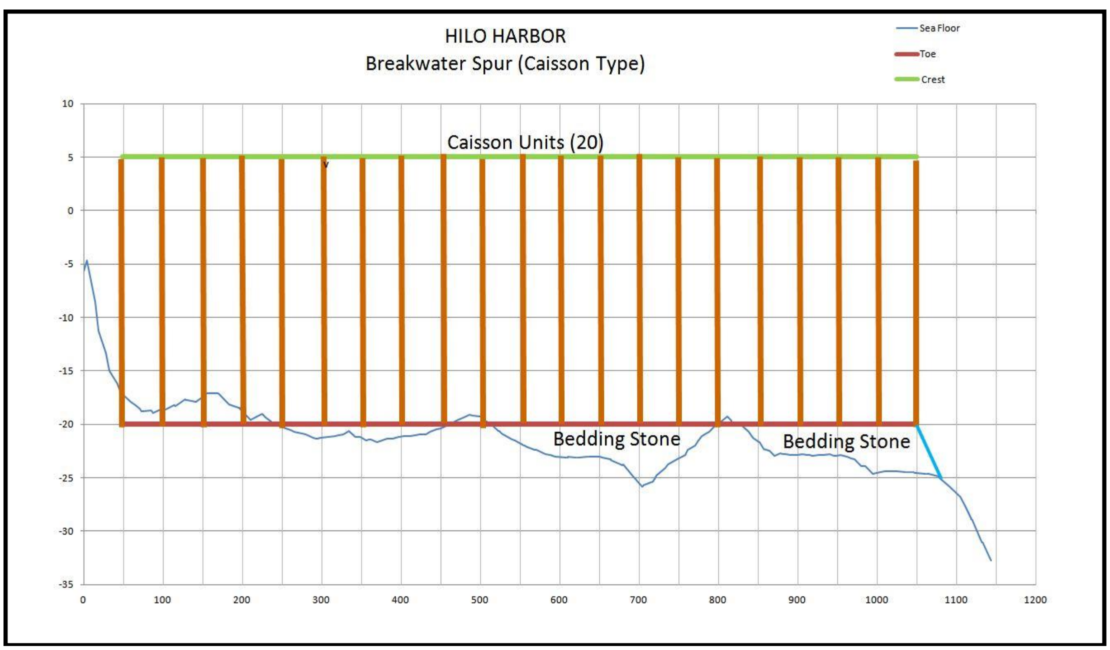

Figure A48: Breakwater spur longitudinal view

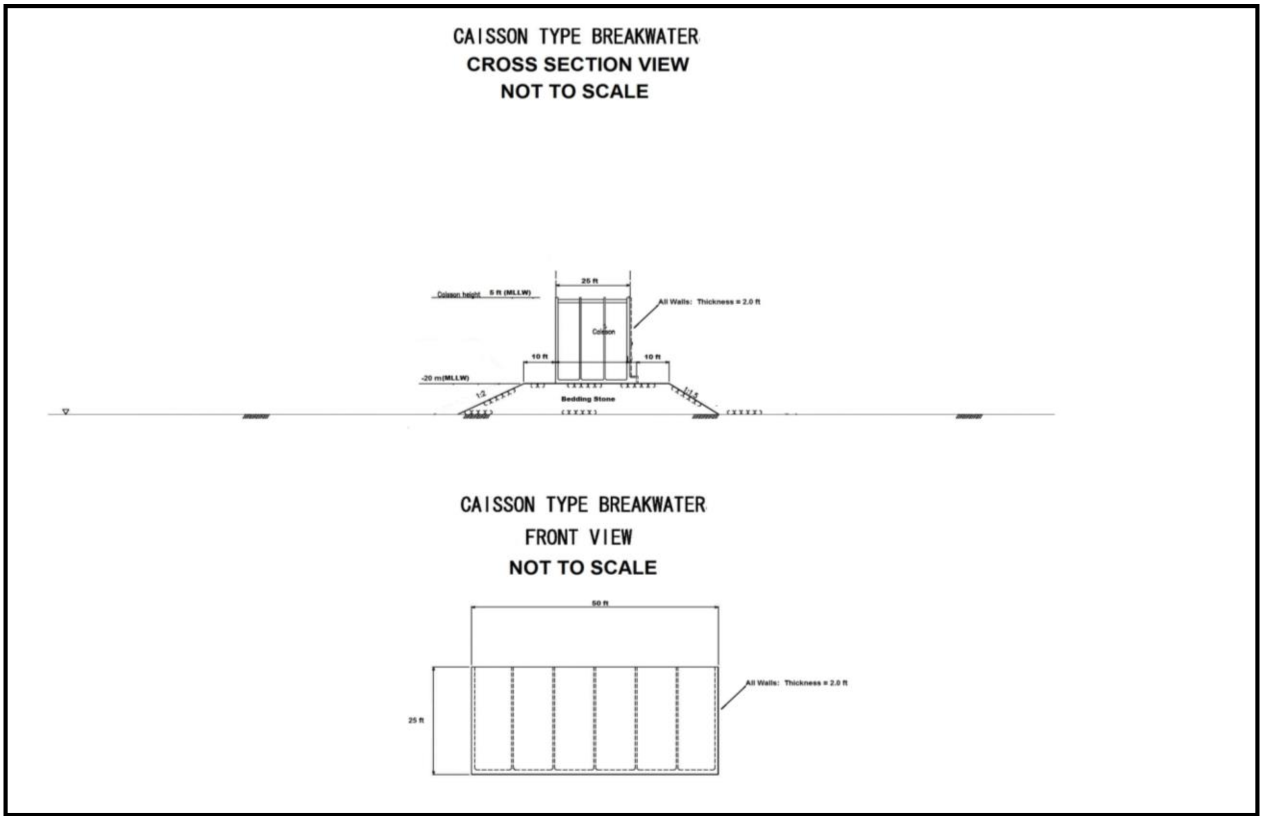

Figure A49: Breakwater spur cross section view

The caisson compartments would be filled with material dredged from the turning basin widener. Construction of the caissons would take place at Kawaihae Deep Draft Harbor located approximately 100 ocean miles from Hilo Harbor. The units would be floated from Kawaihae Harbor to Hilo Harbor under tug assist. Once at the project site, they would be sunk in place onto a bedding stone foundation.

Foundation preparation would consist of excavation of high spots and placement of bedding stone. Excavation of the high spots shown in Figure A48 would require the removal of 300 cy of hard material. Total volume of bedding stone (100 pound to 300 pound stone) required to fill the cross section shown in Figure A49 would be approximately 3,500 cy. A coral mitigation plan was not been developed for this alternative.

5. SHIP SIMULATION STUDY

5.1. Reconnaissance Trip

The Reconnaissance trip for the study was conducted 13 – 16 February, 2012. The purpose of the trip was to meet with representatives of the Hawaiian Pilots Association and the State of Hawaii Department of Transportation. The trip also included a site visit to Hilo Harbor. Mr. Dennis Webb represented the U.S. Army Corps of Engineers (USACE), Engineering and Development Center (ERDC) and Ms. Jessica H. Podoski, P.E. and Mr. Thomas D. Smith, P.E. represented the USACE, Pacific Ocean Division, Honolulu District (POH).

On 13 February 2012, the USACE representatives meet with Captains Tom Heberle and Sinclair Brown of the Hawaii Pilots Association to discuss the Hilo Harbor project. The pilots expressed concerns that the size of the existing turning basin needs to be increased. The pilots indicated that a 1,500 foot-wide basin would be adequate. The reason for the larger basin would be to accommodate larger cruise ships and larger Roll On/Roll Off ships. Presently the one ship calling now is the 580 foot-long Jeanne Ann. A second vessel was to be in operation in 2015, the 692 foot-long Marjorie C. At present, the length over all (LOA) of the most typical cruise ship calling at Hilo is 965 foot-long. Ships longer than 1,000 feet, the 1,041 foot long Celebrity Solstice class, call at Hilo approximately one to two times per year. The Queen Mary II at 1,132 feet LOA is also a future possibility. The pilots also mentioned the possibility that the cruise ship pier may be relocated by the State of Hawaii, Department of Transportation (DOT), Harbors Division.

On 14 February 2012, Mr. Webb and Ms. Podoski traveled to Hilo and met with Messrs. Jeff Hood, Elton Suganuma, and Russell Moore of the State of Hawaii Department of Transportation. At that time, it was mentioned that possible cruise ships of 1045 ft in length would call at the port. Since then, the Celebrity Solstice has made numerous calls.

On 15 February 2012, Mr. Webb and Ms. Podoski boarded the Ocean Princess, a 592 ft long cruise ship, outside the Hilo Harbor breakwater at approximately 0530 hours along with Captain Rich Demuth of the Hawaii Pilots Association and were able to observe the docking maneuver. Mr. Webb took digital photographs of the harbor to develop the visual scene for the ship simulation study.

5.2. Database Development

Currents for both the existing and proposed turning basin configurations were calculated by ERDC using hydrodynamic numerical models (Demirbilek, 2015) at the Coastal and Hydraulics Laboratory (CHL). Four atmospheric and oceanic conditions were selected and approved by POH for inclusion in the simulator study. They were as follows:

Condition 1. Spring tide simulation: selected time period is 5-14 November 2012. Condition 1 includes a maximum offshore incident wave with significant wave height (Hs) = 3.3 m, peak wave period (Tp) = 14 seconds, with peak wave direction from the north northeast (NNE).

Condition 2. Simulation with a strong constant wind from north (N): selected time period is 28-30 October 2012 time period. Condition 2 uses a constant wind speed=20 meters per second (m/sec) (~40 knots) from north (N), and the associated offshore incident waves.

Condition 3. Simulation with a strong constant wind from northeast (NE): selected time period is 15-17 May 2011. Flood & ebb currents along with the corresponding wave fields. Condition 3 uses a constant wind speed = 12.5 m/sec (~ 25 knots) from NE, and the associated offshore incident waves.

Condition 4. Simulation with medium to strong winds and incident waves: selected time period is 19-23 December 2012. Condition 4 includes a max incident wave with Hs = 4.3 m, Tp = 15 sec from NNE, and a max wind from northwest (NW) (~25 knots).

The wind conditions listed above were the winds used to develop the fetch. The pilots do not move ships in Hilo when the winds are greater than 25 knots. The following local wind (i.e. the wind that acts on the ship's superstructure) were used, Condition 1: 4 knots from the southwest, Condition 2, 15 knots from the north, Condition 3: 25 knots from the northeast, and Condition 4: 22 knots from the east northeast.

Maximum flood and ebb currents, along with the corresponding wave fields were extracted for each of these conditions. The currents were then converted into the format required by the ERDC Ship/Tow Simulator (STS).

The visual scene was developed using the photographs taken during the reconnaissance trip.

5.3. Simulation Testing

Validation for Hilo Harbor Turning Basin was conducted December 1 – 14, 2014. Figure A50 shows the simulation of Hilo Harbor. Session 1 was December 1 – 5. Session 1 included validation and testing of the existing condition and Alternative 1. Validation is the process of adjusting the existing condition model until the ship responds correctly. If appropriate, these adjustments are carried forward into the models of Alternative 1. The following personnel participated in Session 1: Ms. Jessica H. Podoski (POH), Kim Kido DOT Harbors (non-federal sponsor), Captain Jeff Hood Hawaii Department of Transportation, Harbors Division (Hilo Harbormaster), Captain Fred Dorflinger Hawaii Pilots Association (December 1 – 4 only) and Todd Nettles SAM Economics Planning Center of Expertise (December 1 - 2 only).

Figure A50. Captain Enos and Sinclair at the helm for ship simulation of Hilo Harbor

Captain Jeff Hood acted as the second pilot for simulation testing. During the Session 1 testing the pilots requested development of a second alternative based upon their experiences with the simulation of Alternative 1 (Figure A51). Alternative 2 is shown in Figure A52.

Session 2 was conducted December 10 – 14, 2014. The following participated in Session 2: Mr. Thomas D. Smith (POH), Captain Ed Enos (Hawaii Pilot Association) and Captain Sinclair Brown (Hawaii Pilots Association).

5.4. Results

The following is an example of the ship simulation runs conducted for the study. Results from the other ship simulation runs are available upon request.

Condition 1, Inbound, Flood Tide. The composite track plot for Solstice of the Seas, for inbound transits in the existing conditions with Condition 1 flood tide and 4 knots of wind from the southwest are shown in Figure 53. All four runs were successful. Track plots of the same condition with the GTS Constellation are shown in Figure 54. The Figure 54 runs were conducted in daylight conditions. All four runs were successful. Two additional runs with the GTS Constellation were conducted as nighttime runs. They were both successful and are shown in Figure 55.

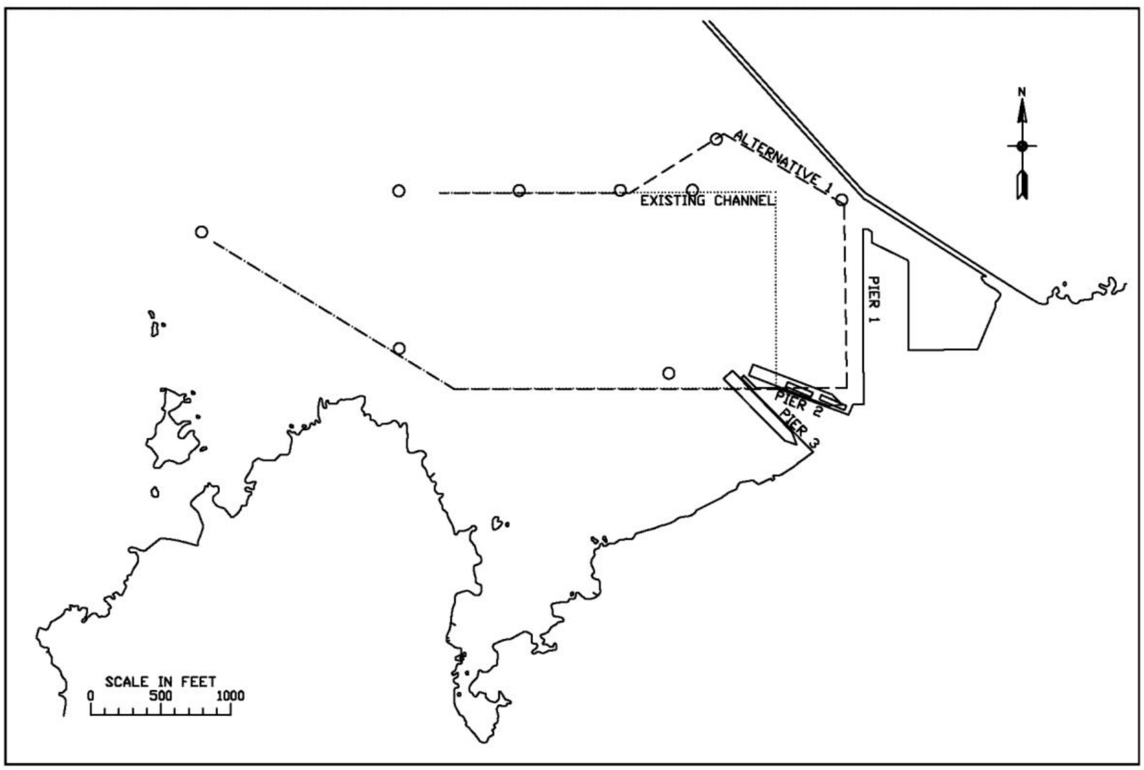

Figure A51: Alternative 1

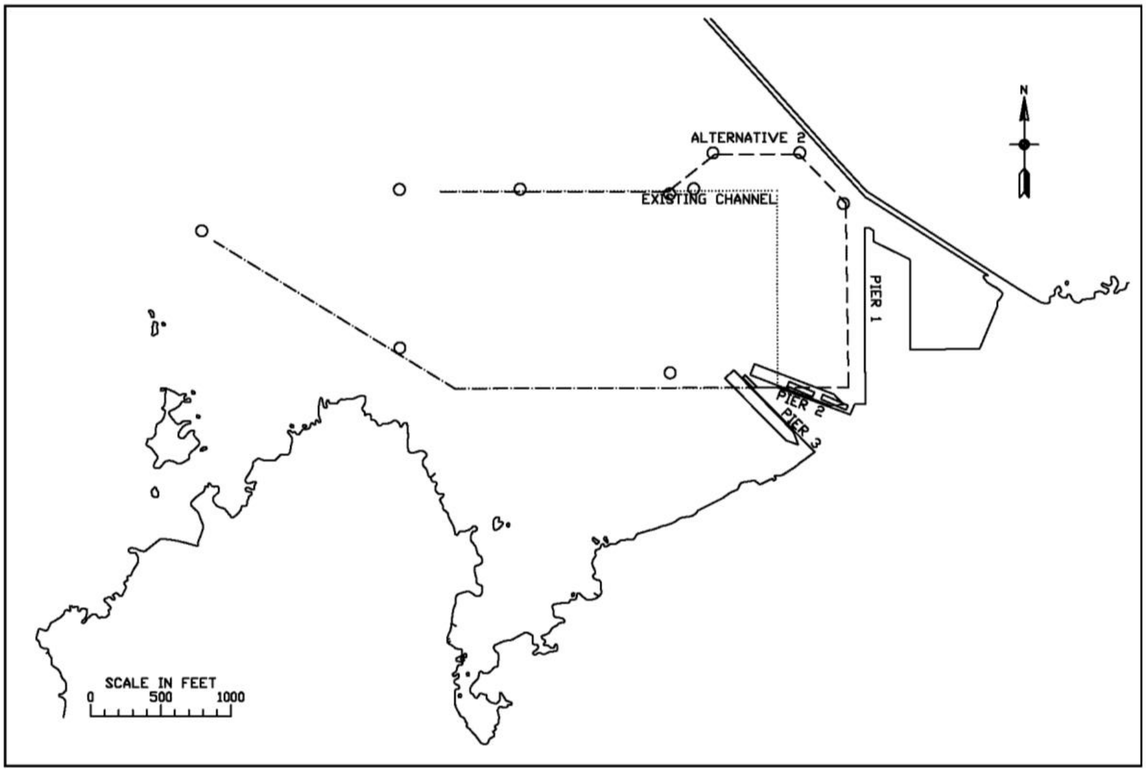

Figure A52: Alternative 2

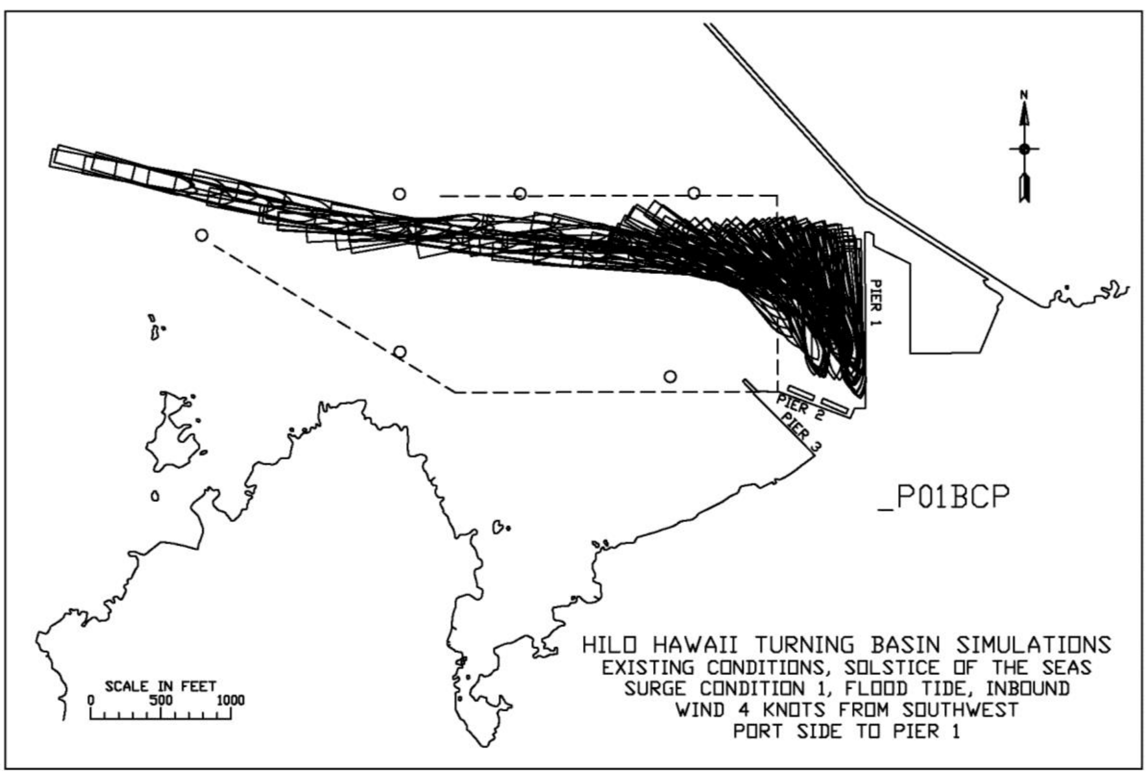

Figure 53: Composite track plot for Solstice of the Seas for Condition 1.

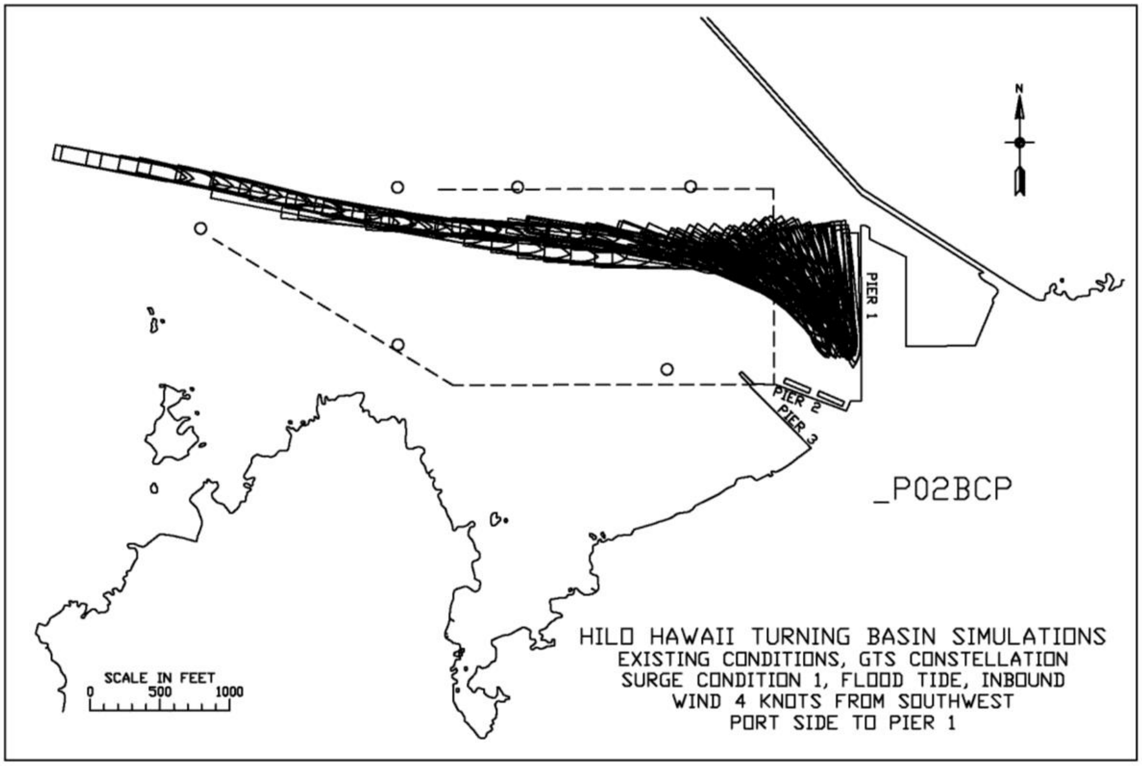

Figure 54: Composite track plot for GTS Constellation for Condition 1.

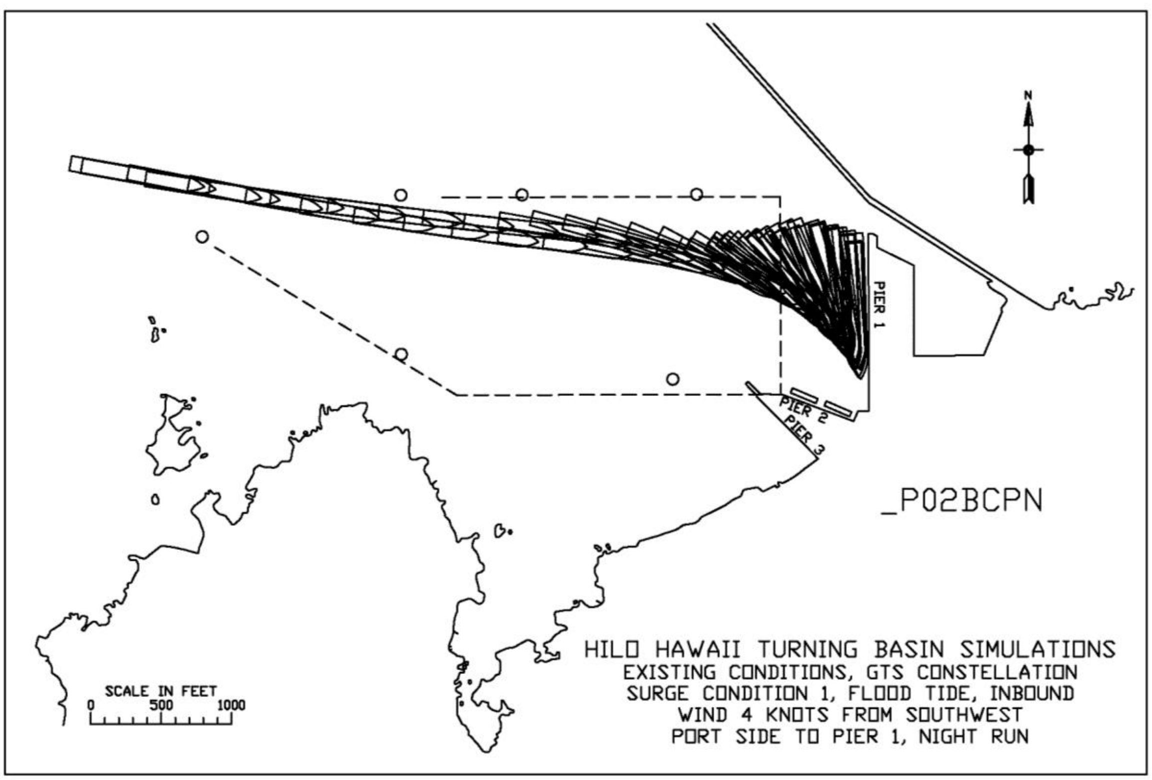

Figure 55: Composite track plot for GTS Constellation for Condition 1 (nighttime).

Table A11 through Table A14 summarize all runs for the various conditions simulated and provide details on the outcome of the runs. For Condition 1, all transits were successful except for the two noted in Table A11. The first unsuccessful run was the Solstice of the Sea for Alternative 1 during the day on an inbound run under flood tidal flow. In this run, the ship crossed the northern limit of the basin and maneuvered into the shallow reef area. The other unsuccessful run was the Solstice of the Sea for Existing Conditions during the day on an outbound run with ebb tidal flow. In this case the vessel hit Buoy N10 but was successful in making the turn without grounding. Table A12 summarizes the results of the simulations for Condition 2. Only one run was unsuccessful for this condition. In this run, the Solstice of the Sea when out of the basin near Pier 1 for Alternative 1 inbound under a flood tide. Table A13 and Table 14 provide summaries of the simulations for Condition 3 and Condition 4, respectively. There were three unsuccessful runs for Condition 3 and two unsuccessful runs for Condition 4. Out of all the runs conducted for the Hilo Harbor modification ship simulation, only eight were unsuccessful. The Solstice of the Sea accounted of seven of the unsuccessful runs while the GTS Constellation went beyond the basin limits for Alternative 1 while outbound under an ebb tide. In this run, the GTS came within 20 feet a docked cruise ship. Overall, the Solstice of the Sea was the only vessel that had significant difficulty transiting existing conditions and alternative simulations.

Table A11. Hilo Harbor Simulation Results - Condition 1 (Outbound, Ebb Tide) - Nov 5 -14, 2012, wind at 4 knots from the southwest

Alternative	Heading	Tide	Ship		Visibility	Successful	Unsuccessful	Notes
Existing	Inbound	Flood	Solstice of the Seas		Day	4	0	
			GTS Constellation			4	0	
					Night	2	0	
Alternative 1			Solstice of the Seas		Day	3	1	One ship crossed northern edge of basin
			GTS Constellation			4	0	
					Night	2	0	One ship used widened area
Alternative 2			Solstice of the Seas		Day	2	0	One ship used widened area
			GTS Constellation			2	0	One ship used widened area
					Night	2	0	
Existing	Outbound	Ebb	Solstice of the Seas		Day	3	1	Hit buoy N "10" but successfully turned
			GTS Constellation			4	0	
					Night	2	0	
Alternative 1			Solstice of the Seas		Day	4	0	Two ships used widened area
			GTS Constellation			4	0	
					Night	2	0	
Alternative 2			Solstice of the Seas		Day	2	0	Both used widened area
			GTS Constellation			2	0	Both used widened area
					Night	2	0	

Table A12. Hilo Harbor Simulation Results - Condition 2 (Outbound, Ebb Tide) - Oct 28-30, 2012, wind at 15 knots from the north

Alternative	Heading	Tide	Ship	Plate	Visibility	Successful	Unsuccessful	Notes
Existing	Inbound	Flood	Solstice of the Seas	19	Day	4		
			GTS Constellation	20		4		
Alternative 1			Solstice of the Seas	21		3	1	Went about 25 ft out of the basin near Pier 1
			GTS Constellation	22		4		
Alternative 2			Solstice of the Seas	23		2		Neither ship used widened area
			GTS Constellation	24		2		Both ships used widened area
Existing	Outbound	Ebb	Solstice of the Seas	25		4		
			GTS Constellation	26		4		
Alternative 1			Solstice of the Seas	27		4		One ship used widened area.
			GTS Constellation	28		4		
Alternative 2			Solstice of the Seas	29		2		
			GTS Constellation	30		2		

Table A13. Hilo Harbor Simulation Results - Condition 3 (Outbound, Ebb Tide)- May 15-17, 2011, wind at 25 knots from the northeast

Alternative	Heading	Tide	Ship	Plate	Visibility	Successful	Unsuccessful	Notes
Existing	Inbound	Flood	Solstice of the Seas	31	Day	3	1	One run hit the south end of Pier 1
			GTS Constellation	32		2		Ships docked port side to Pier 1.
				33		2		Ships docked starboard side to Pier 1.
Alternative 1			Solstice of the Seas	34		3	1	Touched the northern edge of the Alt 1 widener.
			GTS Constellation	35		3		Additional run lost when visuals went down
Alternative 2			Solstice of the Seas	36		2		
			GTS Constellation	37		2		
Existing	Outbound	Ebb	Solstice of the Seas	38		4		Came within 50 feet of the Pier 2 barges
			GTS Constellation	39		4		
Alternative 1			Solstice of the Seas	40		4		Three ships used widened area
			GTS Constellation	41		3	1	One ship hit the vessels at Pier 2
Alternative 2			Solstice of the Seas	42		2		Both ships used widener
			GTS Constellation	43		2		

Table A14. Hilo Harbor Simulation Results - Condition 4 (Inbound, Flood Tide)- December 19-23, 2012, wind at 22 knots from the east northeast

Alternative	Heading	Tide	Ship		Visibility	Successful	Unsuccessful	Notes
Existing	Inbound	Flood	Solstice of the Seas		Day	3		Port side to Pier 1
						1		Starboard side to Pier 1
			GTS Constellation			2		Port side to Pier 1
						2		Starboard side to Pier 1
Alternative 1			Solstice of the Seas			4		Two ships used widener
			GTS Constellation			4		
Alternative 2			Solstice of the Seas			2		
			GTS Constellation			2		
Existing	Outbound	Ebb	Solstice of the Seas			4		Port side to Pier 1
						2		Starboard side to Pier 1
			GTS Constellation			2		Port side to Pier 1
						3		Starboard side to Pier 1
Alternative 1			Solstice of the Seas			3	1	Port side to Pier 1. Came within 10 ft of docked cruise ship
						4		Starboard side to Pier 1
			GTS Constellation			3	1	One ship came within 20 ft of docked cruise ship
Alternative 2			Solstice of the Seas			2		
			GTS Constellation			2		

5.5. Conclusions from Ship Simulation Study

The composite track plots for all ship simulation runs are shown in Figures A55 through A61. Figure 56 and Figure 57 are of the existing condition for inbound and outbound runs, respectively. Figure 58 and Figure 59 are of Alternative 1 for inbound and outbound runs, respectively. Figure 60 and Figure 61 are of Alternative 2 for inbound and outbound runs, respectively.

It was concluded that Alternative1 and Alternative 2 provide time savings to be accounted for in the economic justification of the proposed modifications. The two alternatives also provide improved safety for maneuvering of vessels with length over all greater than accommodated by the existing project design. Federal participation in the implementation of these and/or other alternatives will ultimately be determined by their associated costs and benefits.

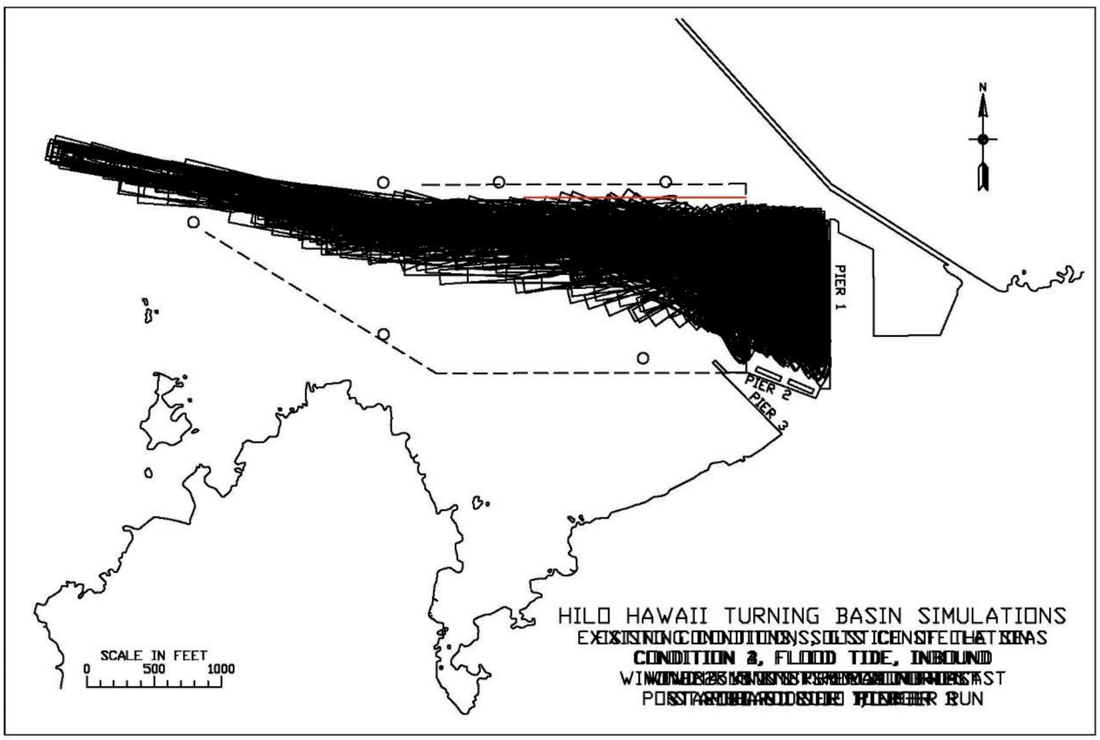

Figure 56: Composite track of all inbound runs for existing conditions.

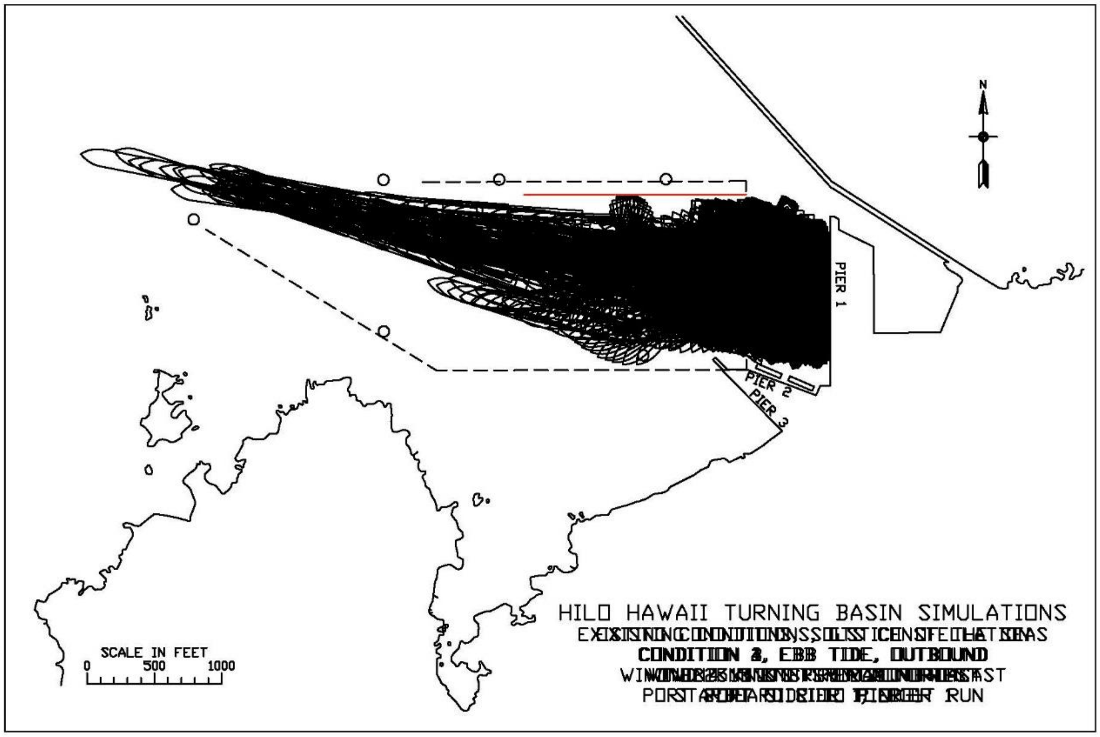

Figure 57: Composite track of all outbound runs for existing conditions.

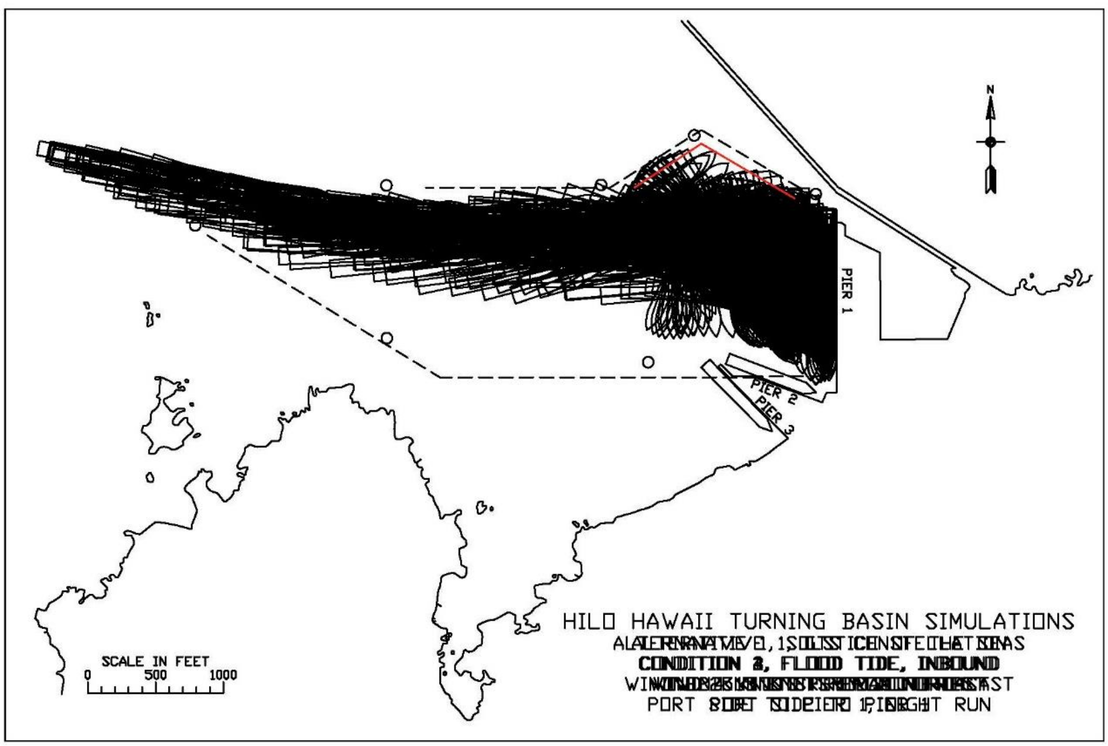

Figure 58: Composite track of all inbound runs for Alternative 1.

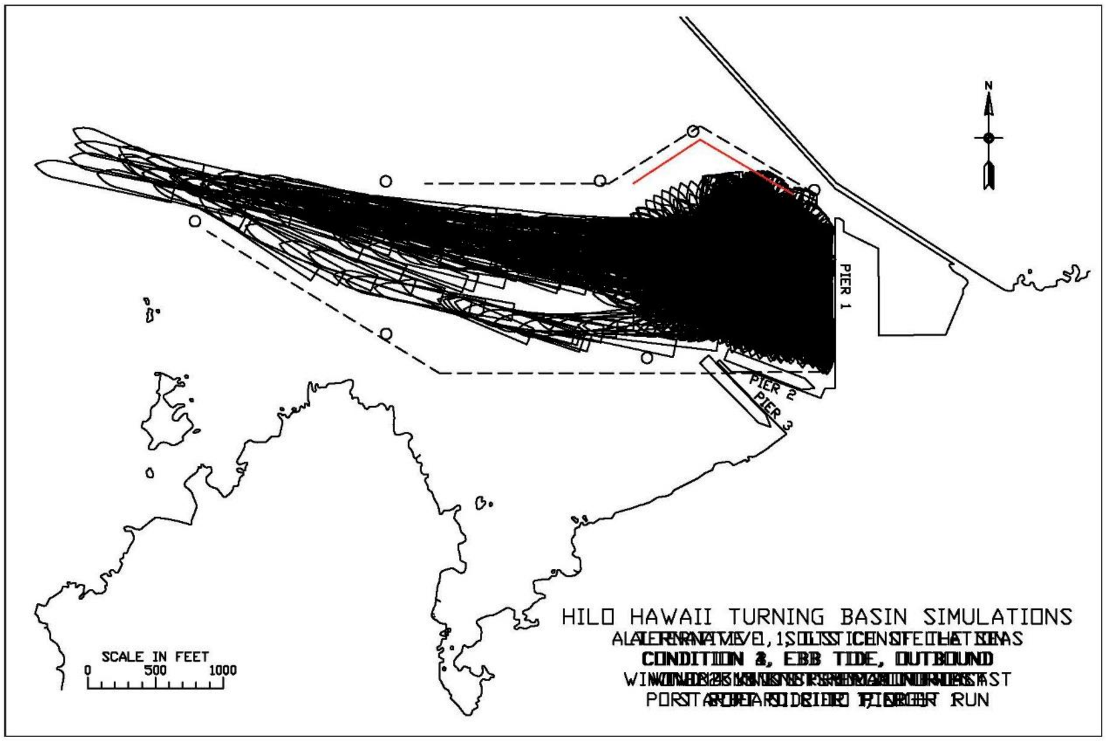

Figure 59: Composite track of all outbound runs for Alternative 1.

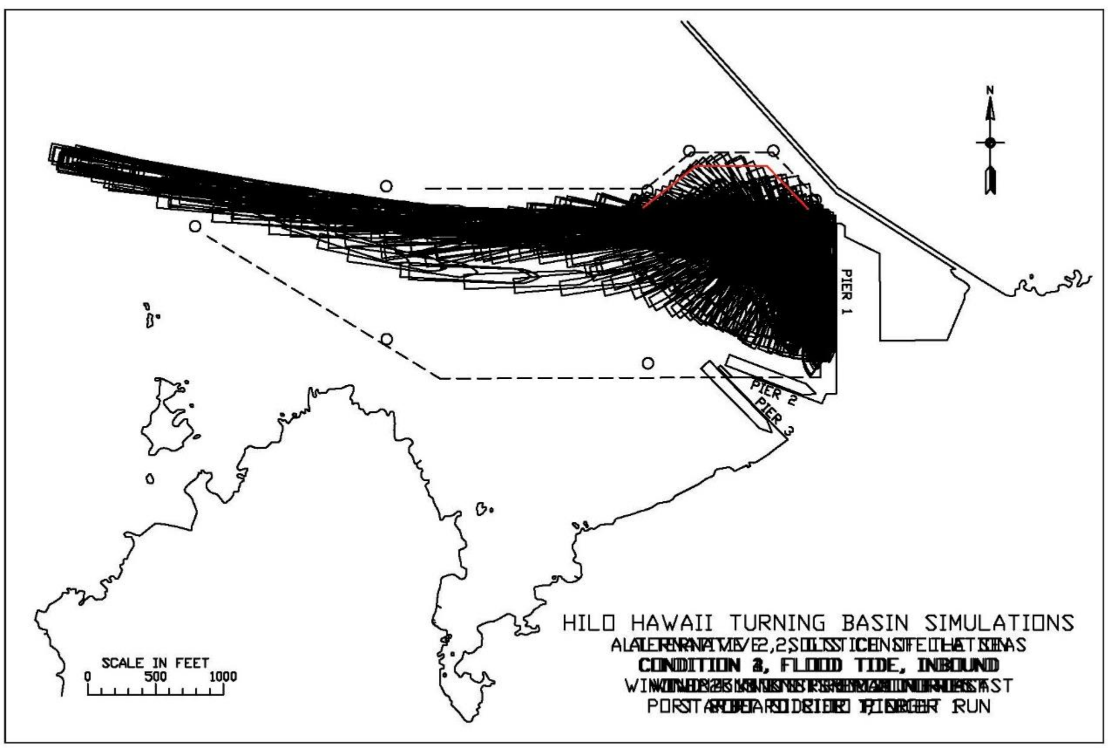

Figure 60: Composite track of all inbound runs for Alternative 2.

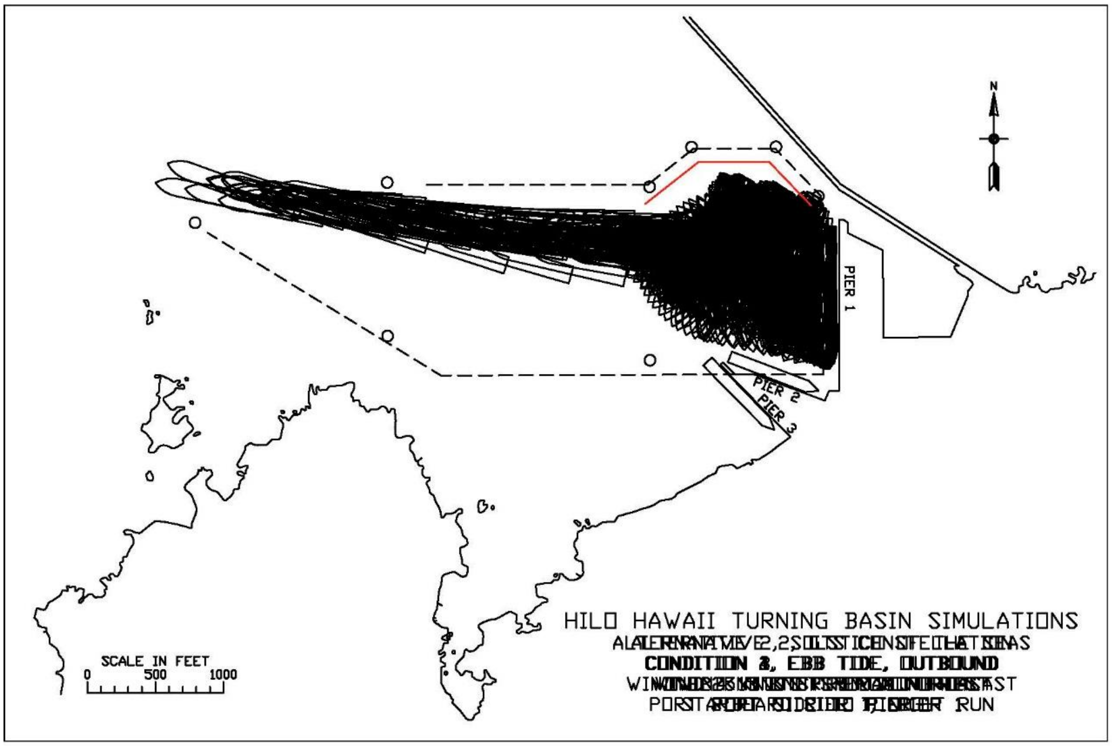

Figure 61: Composite track of all outbound runs for Alternative 2.

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APPENDIX B

GEOTECHNICAL INVESTIGATIONS

1. HILO HARBOR IMPROVEMENTS

1.1. Introduction

This appendix presents the findings of the geotechnical analysis for the selected alternative for the Hilo Harbor Improvements Feasibility Study, Hilo, Hawaii. This alternative involves various measures to reduce surge entering the harbor area and widening and deepening the expanded turning basin. The scope of the geotechnical investigation included a site visit and literature search for existing subsurface information that could be used for this study.

1.2. Location and Description

The project is located in the Hilo Harbor on the eastern side of the island of Hawaii. The Vicinity Map is provided in other sections of this report. Some of the main objectives for this project are to decrease the wave energy impacting the harbor area and provide efficient and safe access for larger passenger ships to the berthing area. The boundaries of the expanded turning basin and the breakwater improvements are shown in other sections of this report. The expanded turning basin will deepen the basin to 35 feet MLLW. The storage site for the dredged material is assumed to be provided by the State. The limits of the dredging will place the deepened basin almost at the toe of the existing breakwater. The improvements to the existing breakwater to resist effects of the wave surge impacts consists of a 1,000 feet concrete caisson spur located at the end of the existing breakwater.

2. LITERATURE REVIEW

Subsurface investigations were not conducted for this project at this feasibility study stage. The following information was extracted from the report produced by Geolabs, Inc. titled "Geotechnical Engineering Exploration, Interisland Cargo Terminal Facility, Phase 1 Dredging, Hilo Harbor, Island of Hawaii" for the State of Hawaii DOT Harbors Division. A map of the project limits is shown on Figure 1 of the main report. This information is assumed to be generally applicable to this project.

2.1. Regional Geology

"The Island of Hawaii is the largest in the Hawaiian Archipelago and covers an area of approximately 4,030 square miles. The island was formed by the activity of the following five shield volcanoes: Kohala (long extinct), Mauna Kea (activity during recent geologic time), Hualalai (last erupted in 1801 - 1803), and Mauna Loa and Kilauea (both still active).

The project site is within the Hilo Harbor area. Hilo Harbor lies at the intersecting slopes of the Mauna Loa and Mauna Kea Volcanoes. The lava flows of the Mauna Loa Volcano are relatively "young" in terms of geologic time and may be on the order of only 750 to 1,500 years old.

Below the basaltic lava flows of the Mauna Loa Volcano, the underlying lava flows of the Mauna Kea Volcano are believed to be Pliocene to Pleistocene in age and belong to the upper member of the Hamakua Volcanic Series."

2.2. Site Conditions

"The land surrounding the Hilo Harbor area was reclaimed from the bay by the placement of fill over the lagoonal deposits and/or coralline detritus. The project site is generally underlain by lagoonal deposits and deposits of calcareous sediments (also known as coralline detritus). Alluvial deposits associated with the Wailuku River underlie the lagoonal deposits and calcareous sediments. Basalt formation from the recent Mauna Loa lava flows may be encountered at greater depths below the alluvial deposits."

2.3. Subsurface Conditions

"The mudline was encountered at about 10 to 13.5 feet below the water level. In general, a thin layer of harbor deposits about 1 to 2.5 feet thick was encountered below the mudline. The harbor deposits consisted of very soft sandy silt and loose silty sand. Lagoonal deposits and coralline detritus, consisting of loose to medium dense silty gravel and sand, were encountered below the harbor deposits extending to the maximum depths explored.

Severely fractured coral ledges were encountered along the top of slope that transitions from the proposed dredge area to the dredged basin adjacent to Pier 3. The coral ledges were about 1 to 5.5 feet thick and were encountered between depths of about 12.5 and 16.5 feet and about 23.5 and 31 feet below the water level. The relative hardness of the coral encountered ranged from soft to medium hard.

A basalt rock ledge was encountered in Boring No. 106 between the depths of about 23 to 25.5 feet below the water level. The basalt rock encountered was generally severely fractured and hard. During the jet probing operations performed by Sea Engineering, Inc., rock was observed in the area near Boring No. 106. In addition, basalt rock was observed along the shoreline."

3. GEOTECHNICAL ENGINEERING ANALYSIS

3.1. Dredging to Expand the Harbor

Based on the proximity of this project to the Pier 4 project cited above, the subsurface conditions (soil/rock stratums) is assumed to be similar and therefore dredged material type that will be encountered is anticipated to be similar. The elevations of the stratum encountered will change due to the different locations.

Conventional dredging methods using clamshell buckets and cutterhead dredge methods may be used for the dredging operations. Excavated material will generally be a mixture of coral detritus and sand and is generally satisfactory fill material that can be used for future projects. Also, it can be assumed that a small percentage of coral ledge rock and basalt rock will be encountered during dredging operations.

The close proximity of the dredging to the existing breakwater toe will require stability analysis to determine how close the dredging should be so as to not impact the breakwater.

3.2. Breakwater Improvement

The geotechnical concern is for the foundation of the caissons. Any silt layers and very loose layers within the depth of foundation influence will have to be accounted for. At least the top soft layers will have to be removed and any deeper soft layers will be accounted for in the bearing/settlement analysis. The depth of soft layer removal will result in a higher caisson height requirement.

3.3. Engineering Recommendations

Assume that the large majority of dredged material will be coral detritus and sand with a small percentage of say 5% – 10% of coral rock and basaltic rock that may require special dredging equipment. This assumption has risks involved but it is anticipated that the cost associated with rock excavation will not change by much, especially moving in the higher direction.

Assume excavating a soft layer below the mudline of 2.5 feet prior to caisson placement. It is assumed that the bearing capacity will be sufficient and that the settlement of the caissons will be small.

This is only a feasibility level study and if this project is funded for full design, an in depth geotechnical investigations must be performed to verify assumptions made for this study. The above information will more than likely change during the design phase when borings with testing will provide more accurate subsurface conditions.

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APPENDIX C

ENVIRONMENTAL

1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Honolulu District (POH), conducted a Feasibility Study (FS) to evaluate alternatives for navigation improvement at Hilo Harbor in Hilo, Hawaiʻi. The purpose of the study was to identify and evaluate engineering solutions to accommodate the increase in navigation activities and address wave energy within the harbor. The proposed alternatives include: 1) expansion of the federal turning basin, and 2) construction of in-water structures to reduce wave (surge) energy at the channel entrance.

Pursuant to 33 CFR 230, POH also initiated the preparation of an Environmental Assessment (EA) to evaluate potential direct, indirect, and cumulative impacts of the proposed project on the human and natural environment. The results of the FS and the EA would be combined into an Integrated Feasibility Report and Environmental Assessment.

2. ENVIRONMENTAL ANALYSIS

Following is a summary of the environmental work completed to date.

During a week-long Planning Charrette, April 24-26, 2013, the Honolulu District invited U.S. Fish and Wildlife Service (USFWS) to participate in the SMART planning process. This initial planning meeting was the beginning of informal consultation with USFWS. The Honolulu District used feedback received from USFWS to inform project alternatives development.

On December 6, 2013, the Honolulu District, requested that the USFWS provide us with a Planning Aid Letter (PAL) in accordance with the Fish and Wildlife Coordination Act of 1934 (FWCA), as amended (16 U.S.C. 661 et. seq.) for the proposed project.

As part of this effort, biologists from USFWS and State of Hawaii Division of Aquatic Resource (DAR) evaluated an area of approximately 98.23 acres of marine habitat during a Benthic Habitat Mapping Survey (Phase I) of Hilo Harbor in August 2014. Data from this field work were reported to the USACE in a February 2015 Planning Aid Report. Based on this report, the USACE reduced the overall scope of the project to an area of approximately 10 acres of marine habitat.

In March 2015, the USFWS and DAR biologists conducted quantitative benthic surveys in support of the draft Coordination Act Report (Phase II) of the 10 acre area Preliminary data from this survey was transmitted to the Honolulu District in May 2015. In May 2015, the Honolulu District provided USFWS with a revised map which further reduced planned dredging from 10 acres to 6.6 acres for the purpose of avoiding construction-related impacts to high value coral resources, identified in the Planning Aid Report (Phase 1 survey). In June 2015, the

Honolulu District reached a determination that there was no further federal interest in this project due to high costs and low benefits.

3. SUMMARY OF PRELIMINARY MITIGATION DISCUSSION AND RECOMMENDATIONS

Throughout the study process, mitigation and their costs were a concern. During alternatives development, it was difficult to know with any type of certainty what the true impacts of modifications to Hilo harbor would have on the natural resources within Hilo Harbor. Mitigation requirements could not be determined. At the time the project was terminated, resource agencies began preliminary discussions for recommended mitigation. This section contains a summary of preliminary mitigation discussion and concerns from the various agencies and is presented as a record of the informal discussion that took place.

The excerpt below was taken from an email chain circulated between US Fish and Wildlife Service; US Environmental Protection Service; National Oceanic and Atmospheric Administration Fisheries, Habitat Conservation Division; and the State of Hawaii Department of Land and Natural Resources, Division of Aquatic Resources on 23-24 June 2015.

> ***Summary of Preliminary Mitigation Recommendations by Various Agencies***
>
> *In the event that the Hilo Harbor Modification Study is reinitiated, USFWS recommended that a marine biological assessment be conducted on the aggregate reef habitat to evaluate the distribution and relative abundance of algae, corals, non-coral macroinvertebrates, and reef fishes within the project area.*
>
> *To aid in the development of appropriate survey methodology, USFWS recommends that USACE provide detailed descriptions of the planned project that includes: (a) planned dredging design, (b) methods and potential schedule for conducting planned dredging, (c) vessel operational plans and schedules, and (d) maintenance dredging plans and schedules.*
>
> *To assist in this discussion, the DAR has submitted a list of mitigation topics that could potentially help stimulate this future conversation. The Service received this list of mitigation topics from the State of Hawaii DAR during a June 22, 2015 multi-agency meeting. See list below:*
>
> *1) Hilo Bay Estuary Project- this project would involve the planting of native grasses in the Hilo Bay estuary to minimize the introduction of sediments from upland areas. It would also include assessment and monitoring the organisms in the estuary to determine any population trends after the grass is planted.*
>
> *2) Alien Species Assessment/Inventory in Hilo Bay- this project would be to inventory all of the alien species that are observed in Hilo Bay by conducting assessments (including underwater) and doing literature searches. An inventory will be collected to assist DAR in future management decisions and potential regulations.*

3) Sediment Reduction Project- the compensatory mitigation funds would be used by the State of Hawaii Division of Forestry and Wildlife to help with projects upslope of Hilo Bay to minimize the sediments that reach the Bay during rain events. These projects may include, but are not limited to: a) fencing of native trees to prevent the introduced species (pigs, goats, cattle, etc.) from destroying the area and making the soil exposed; b) eradication or control the population of these introduced species; and c) the removal and control of the invasive gorse plant from the Hilo watershed.

4) Coral Fragmentation and Transplant Project- DAR would contract a UH-Hilo researcher or a private researcher in the Hilo area to collect some of the coral that will be impacted by the expansion project and attempt to grow the corals so they can be transplanted back into a part of Hilo Bay. This project would expand the capacity for coral fragment planting should the need arise for DAR in the Hilo area.

5) Mooring Buoys- the compensatory mitigation funds would be used by the State of Hawaii Division of Boating and Ocean Recreation for mooring buoys in Hilo Bay. Mooring buoys eliminates the need for boater operator to throw an anchor overboard to secure their vessel in Hilo Bay. Mooring buoys were a mitigation option for a previous project at Hilo Harbor, but the status of those mooring buoys are unknown hence the lowest ranking of preference for DAR.

Throughout the mitigation discussion, the agencies found it very challenging to identify good mitigation. There were requests for quantitative information of the resource impacts in order to decide on the best mitigation project as the scaling affects practicability.

It has been noted that of concern is that compensatory mitigation is subject to the Clean Water Act and to the 2008 Compensatory Mitigation Rule. Any compensatory mitigation project should include a mitigation plan based on the 12 elements in the Mitigation Rule and the mitigation project should be commensurate with the impacts. The amount of mitigation should also take into consideration the temporal loss (time between the impact and when mitigation is fully successful) and likelihood of mitigation success.

A draft table of mitigation options with pros and cons for potential mitigation approaches was developed with input from the Coral Reef Task Force's Coral Injury Mitigation Handbook (still in draft).

Specific comments:

1. Hilo Bay Estuary Project. This approach would be very challenging to relate erosion control and water quality improvements with specific improvements in near shore aquatic resources including coral. Generally, large scale improvements on land are needed to get any measureable results in the ocean.

2. Alien Species Assessment. Studies and research are not acceptable as mitigation projects. However, restoration of a site via control of alien species would potentially be acceptable.

3. Sediment reduction. Similar to the proposed Hilo Bay Estuary Project (number 1), it is hard to relate the work in watershed to a specific amount of coral improvements.

4. Coral fragment out planting. This could work for mitigation if there were a specific area where coral formerly existed that is now degraded (but the stressor is gone now). Out planting to restore a coral site is a potentially good and measureable project.

5. Mooring Buoys. It is unknown if day use moorings are good or bad for corals. Like the proposed Hilo Bay Estuary Project (number 1), and the proposed Sediment Reduction (mitigation 3), it would be hard to predict and measure any benefit to coral.

At the time of project termination, the Honolulu District had not considered or analyzed specific mitigation measures. Should the Hilo Harbor project be reinitiated in the future, it is recommended that environmental conditions be reexamined and impact analysis reevaluated before consideration and implementation of any mitigation measures.

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APPENDIX D
COST

1. PROJECT DESCRIPTION

The project consists of various measures to reduce surge and increase the turning basin area of Hilo Harbor, located on the East side of the Island of Hawaii, State of Hawaii.

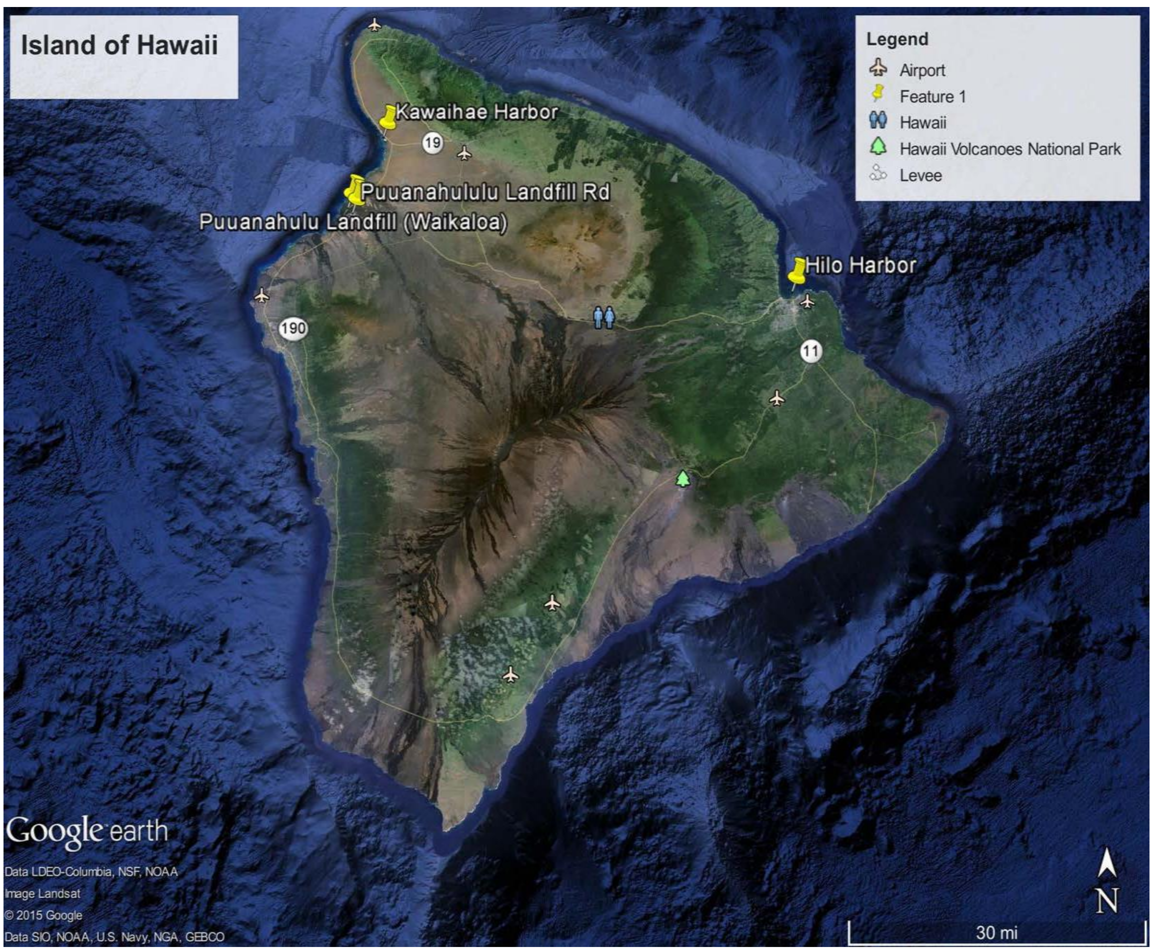

Figure D1. Project Vicinity Map

Figure D2. Hilo Harbor project location map

The following describes the measures included the Viable Alternatives.

Table D1: Measures

Alternatives	Description
1. Widen the turning basin by dredging.	Dredge to 35 ft MLLW
2. Construct a Breakwater Spur	1,000' ft long concrete caissons with equally spaced cells, walls are 2' thick. The base is 2' thick. Cast and float to the end of Hilo Harbor Breakwater. Caissons are 25' wide X 50' Long X 25' High. Caissons will have reinforcing.
3. Construct Break Water Spur and widen the turning basin by dredging.	Combination of Alt 1 & 2.

2. BASIS OF ESTIMATE AND QUANTITY

This initial feasibility cost estimate is based on the Feasibility Report November 2015 (Draft). Input for the estimate was obtained from the Project Delivery Team (PDT). Following ER 1110-2-1302, Engineering and Design Civil Works Cost Estimating, the cost estimates were prepared at a Class 4 level.

- Class 5 for screening of the initial viable array of alternatives which based the costs on historical cost data from other dredging projects in the past.
- Class 4 for the refinement of the viable array of alternatives, which was based on a concept design. Cost was developed from rough quantity take-offs and supplemented with best professional judgment based on similar projects. Dredging costs were based on the Corps of Engineers Dredging Estimating Program (CEDEP).
- Class 3 for inclusion in the preliminary feasibility report which was based on a 35% level of design. Quantities for this level of design were calculated from 10-60% quality of project definition. Quantity calculations were aided by the use of Microstation, Google Earth, and Excel software. Major cost items were obtained from material suppliers. **The Class 3 estimate was not prepared at this report due to negative economic results.**

3. ESTIMATED DESIGN AND CONSTRUCTION SCHEDULE

The estimate was initially based is based on the entire contract awarded to a single contractor with multiple subcontractors. The estimated schedule is shown in the table below:

Table D2: Project Schedule

Phase	Estimated Start	Estimated End	Estimated Midpoint
Real Estate Acquisition	July 2019	July 2019	July 2019
Planning, Engrg & Design	Oct 2017	Sep 2019	Sep 2018
Solict/Award	Jun 2020	June 2020	N/A

The Tentatively Selected Plan construction schedule is presented in this Appendix. The estimated construction time is based on the following:

a. Caissons: Typical construction crew (1 shift) working 8 hr/day and X 5 day weeks.

b. Dredging: Typical construction crew (3 shifts) working 24 hr/day and X 7 day weeks.

c. An overall Production Efficiency Rate of 80% which is based on anticipated project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays. Anticipated weather delays are included in the construction schedule.

Table D3: Construction Duration

Estimated Construction Duration			
	Dredging	Caissons	Dredging + Caissons
Construction Start	Mar 2021	Mar 2021	Mar 2021
Construction End	Dec 2024	June 2024	June 2024
Midpoint	Feb 2023	Oct 2022	Oct 2022

CONSTRUCTION WINDOWS: None

OVERTIME: This estimate contains no overtime to complete the project.

4. ACQUISITION PLAN

The estimate is based on a single contract being awarded to a single Prime Contractor with multiple sub contractors. The acquisition strategy is assumed as Full and Open Invitation for Bid. The prime contractor will be responsible for oversight of the contract the rest of the work is assumed performed by subcontractors.

4.1. Sub-Contracting

At the 10% level of design estimate, the assumption a single contractor. A single subcontractor markup was used for any subcontractor effort. For the Tentatively Selected Plan estimate, the subcontractors are broken out as:

- Dredging
- Hauling
- Material Supplier (concrete, rocks)
- Disposal Cost
- Concrete/Grouting Sub
- Reinforcing Sub

It is assumed that the prime contractor will perform the rest of the work.

5. PROJECT CONSTRUCTION

5.1. Mobilization, Demobilization & Preparatory Work

5.1.1. Mobilization/Demobilization

The estimate for this study assumed that the Prime Contractor will be from Oahu and Dredging Contractor from Oahu. This does not exclude any work effort to contractors from other locations during the bidding process.

5.1.2. Temporary Facilities

The estimate includes the assumption office trailers and temporary utilities for the Prime Contractor and Government. The electricity will be supplemented by diesel generator.

5.1.3. Surveys

Assume pre and post-hydrographic survey, layout.

5.1.4. Disposal

The preliminary estimates assume disposal at the EPA approved Ocean Dredged Material Disposal Site (ODMDS). Upland disposal is at an approved on-island landfill approximately 70 miles away on the West side of the Island of Hawaii.

5.1.5. Features & Discussion

- SITE ACCESS: The sites are located in Hilo Harbor, Island of Hawaii. Land access to the staging area is available. Land access to the Harbor is via the piers.
- BORROW AREAS: The borrow sources is assumed from an on-island commercial source. Borrow areas for bedding and fill is assumed to be from on-island.
- CONSTRUCTION METHODOLOGY: The construction methodology will be industry standard.
- UNUSUAL CONDITIONS (Soil, Water, and Weather): The harbor is subjected to infrequent and unpredictable winter swells (typically November to February) and surges from the North East which could affect dredging operations. Subsurface may contain basalt material.
- UNIQUE TECHNIQUES OF CONSTRUCTION: None
- EQUIPMENT AND LABOR AVAILABILITY: The cost assumes equipment and labor is readily available on the Island of Hawaii or from the other locations.
- ENVIRONMENTAL CONCERNS: None at this stage.
  Standard Best Management Practices such as silt fences, gravel entrances to the contractor's storage area are included in the estimate.

6. COST ESTIMATE ASSUMPTIONS

6.1. Effective Dates for Labor, Equipment, Material Pricing

Effective Price Level: (EPL) Project costs are presented in October 2014(1Q2015) dollars.

The construction cost estimate was developed using MCASES 2nd Generation estimating software in accordance with EF 1110-2-1302, Civil Works Cost Engineering, 15 Sep 2008; UFC 3-740-05, Handbook: Construction Cost Estimating, 8 November 2010, Change 1, June 2011. The construction cost estimate was prepared using MII Version 4.2, and the latest 2012 English Cost Book and 2014 Equipment Library (Region 10).

The labor rates used is from the State of Hawaii Department of Labor & Industrial Wage Rate Schedule Bulletin#482 16 Sep 2014 effective until September 2015 for the State of Hawaii for Building, Heavy (Heavy and Dredging), Highway and Residential Construction Types for all counties in Hawaii Statewide.

Labor and Equipment Productivity: The overtime hours listed above in the Construction Schedule, has been implemented into the MCASES estimate to account for additional labor and equipment adjustments. The estimate includes an overall Production Index of 90% which is based on anticipated project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays.

6.1.1. Escalation

Escalation has been calculated within the estimate. Price levels have been escalated from price levels of the construction cost estimate to the midpoint of construction indicated in the above chart in paragraph 3b.

6.1.2. Functional Costs

Functional costs using the Civil Works Breakdown Structure (CWBS) associated with this work were developed from quantity take-offs using CAD drawings, historical costs and input from PDT members as follows:

1) 01 – Lands and Damages: This account covers costs Lands and Damages for Construction. The initial estimate for real estate costs were derived from the tax map key full replacement. Market cost will be determined at a more detailed design level by an appraiser. Based on real estate's judgment, TMK costs are typically much lower than market costs.
2) 06 – Fish & Wildlife Facilities – This account covers environmental mitigation for the dredging or caisson work...
3) 10 – Break Waters & Seawalls – This account covers the breakwater extension using concrete caissons.
4) 12 – Navigation Ports & Harbors – This account covers dredging.
5) 30 – Planning, Engineering and Design (PED): This account covers construction management during the construction. The initial cost is based on a % of the construction cost.
6) 31 - Construction Management (CM): This account covers supervision and administration costs during construction. The initial cost is based on a % of the construction cost.

6.1.3. Estimate Assumptions

Key assumptions used for estimating the construction cost of the proposed alternative are as follows:

1) Analysis performed on major cost items based on level of design. The viable array conceptual design is at approximately 10% quality of project definition.
2) Reinforced concrete caissons will be cast in the "Bone yard" area next to Hilo Harbor/ Radio Bay/Small Boat Harbor and floated to the new spur location at the end of the breakwater. The caissons are 25' wide X 25' high X 50' long, and a total of 20 each are required for a total spur length of 1,000. The caissons will be floated to the site, sunk with sea water and backfilled using excavated dredged material and additional imported fill (rocks). It is assumed there will be access to the piers to load the fill material onto the contractor's barge.
3) Dredging operations is assumed 24/7.

4) Access to the dredging project area is readily available with the exception of any cruise ship or inter-island barge movement.
5) All dredged material is assumed disposed of at the Ocean Dredged Material Disposal Site (ODMDS) site located approximately 8 miles from Hilo Harbor. EPA data indicates the depth of 1,080-1,110 ft, seafloor radius of 300 ft, and surface disposal zone of 1000 ft. ODMDS still has available capacity for dredged material disposal.
6) Fuel Prices: Marine Fuel ("MGO") $2.50/gal in Honolulu Harbor as of April 2015. All marine fueling for tugs are in Honolulu Harbor. Hilo Harbor does not have the capability to fuel the tugs.
    a. Tug hire is readily available from Hilo Harbor or Honolulu Harbor.
    b. Dredging Company will hire a tug for dredge plant placement/movement. Dredge plant will be docked when not in use.
7) Access to structures will be constructed and used as permanent access roads for O&M maintenance.
8) General % markups will be used for the initial estimate. Markups will be refined for the tentatively selected plan.

6.1.4. Contingencies by Feature or Sub-Feature

Current Headquarters USACE guidance requires a formal analysis on all projects where the projected cost exceeds $40 million. In accordance with ER 1110-2-1302 and ECB 2007-17, 10 Sep 2007, Cost Risk Analysis was used to identify and measure the cost impact of project uncertainties within the estimated total project cost. The risk model used was an Abbreviated Cost Risk Analysis template created by the Cost Mandatory Center of Expertise (MCX) to determine the contingencies by Civil Works Features for the initial viable alternatives, incremental cost and optimized design cost prior to selection of the recommended plan.

1) Oracle Crystal Ball analysis will be used to develop contingencies for the Recommended Plan.
2) Contingencies are added to the cost estimate based on results of risk analysis. Results yielded contingencies added to the construction costs.

3) Table D4 summarizes the contingency amounts.
4) Unknowns that could affect the project costs and design assumptions prior to the detailed design phase (PED) include the following:
   - Weight of caisson limits crane application of caissons.
   - Lack of access to roll cast caissons from shore at Hilo Harbor.
   - Environmental Mitigation not well defined at this stage. Requires coordination with the USFW.
   - Variation in estimated quantities for dredging.
   - Changes in Acquisition strategy.
   - Changes in the bid schedule.
   - Lack of competition for dredging work.
   - Encountering hard material during dredging.
   - Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Equipment may not be available.
   - Possible double handling of hard material for disposal at the ODMDS site.
   - Increased permitting regulations affecting designs.
   - Entire dredged material may not be allowed for disposal in the ODMDS
   - Double handling of material for upland disposal.
   - Lack of beneficial use for dredged material.

Real Estate Contingency was based on judgment by the Real Estate PDT member for the viable array. Tax Map Key (TMK) costs are typically much lower than market costs.

6.1.5. Total Project Cost Summary

The Total Project Cost Summary Sheet (TPCS) includes the construction costs from the MCASES estimate, project markups, as well as costs for Lands and Damages, Planning, Engineering & Design, and Construction Management.

Table D4: Viable Array of Alternatives Total Project Cost

Alternatives Total Project Cost (Fully Funded) Budget Year 2016) based on 10% Level of Design (Class 4 Historical/Parametric) [1, 2, 3, 4, 5, 6, 7, 8]

Total Project Cost (Fully Funded) Budget Year 2016 based on 10% Level of (Class 4 Historical/Parametric)						
	Widen Basin by Dredging to 35' MLLW			Construct Breakwater Spur (Caissons)		
CWBS Acct	Estimated Cost @ EPL 1 Oct 14 Including. Contingency ($K)		Fully Funded Total Project Cost @ FY16 ($K)	Estimated Cost @ EPL 1 Oct 14 Including. Contingency ($K)		Fully Funded Total Project Cost @ FY16 ($K)
01 Real Estate	$62		$66	$62		$66
Construction:						
06 Fish & Wildlife Facilities	$3,746		$4,200	$17,218		$19,126
10 Breakwater	$43,334		$47,895	$84,823		$95,592
Total Construction Cost	$47,080		**$52,095**	$102,041		**$114,718**
30 Planning, Engrg & Design	$11,535		$13,260	$25,578		$28,781
31 Construction Mgt	$8,240		$10,317	$18,269		$22,588
Project Cost Total	$66,917		**$75,738**	$144,964		**$166,153**
Contingency	89%			110.0%		
Fully Funded Cost	**$75,738**			**$166,153**		
Estimated Duration	Aug 2020-Nov 2021, 15.2 months			Aug 2020-Feb 2022, 18.2 months		

Total Project Cost (Fully Funded) Budget Year 2016 based on 10% Level of (Class 4 Historical/Parametric)			
	Construct Break Water Spur + Dredging to 35' MLLW		
	Est Cost @ EPL 1 Oct 14 Including Contingency ($K)		Fully Funded Total Project Cost @ FY16 ($K)
01 Real Estate	$62		$66
Construction:			
06 Fish & Wildlife Facilities	$18,725		$21,102
10 Breakwater	$69,960		$78,842
12 Navigation Ports & Harbors	$44,337		$49,966
Total Construction Cost	$133,022		**$149,909**
30 Planning, Engrg & Design	$32,588		$37,513
31 Construction Mgt	$23,728		$29,443
Project Cost Total	$188,950		**$216,930**
Contingency	103%		
Fully Funded Cost	**$216,930**		
Estimated Duration	Aug 2020-Feb 2022, 18.2 months		

1. Contingency (Cont) determined by Cost Risk Analysis
2. Planning, Engineering & Design (PED)
3. Construction Management (CM)
4. Effective Price Level (EPL) – Fiscal Year of the Estimate, 1 Oct XX
5. Total Project Cost (TPC) – includes contingency & escalation of a fully funded project. The Alternative cost was refined using preliminary designs after screening of the initial viable array of alternatives.
6. Mean Lower Low Water (MLLW)
7. $K = $100,000
8. See he Total Project Cost Summary Sheet for the cost listed in the table.

7. INCREMENTAL COST

Incremental cost was developed to demonstrate whether each dredging depth added additional benefits aside from cost (net benefits). The combination of measures was determined by the hydraulic engineer. The Economist analyzed whether additional measures maximized net benefits (refer the Economics Appendix).

Table D5: Incremental Cost Summary

Cost Description	30’ MLLW	31’ MLLW	32’ MLLW	33’ MLLW	34’ MLLW	35’ MLLW
01 Real Estate ($K)	$62	$62	$62	$62	$62	$62
Total Construction Cost ($K)	$33,978	$36,468	$38,960	$41,455	$43,873	$47,080
30 Planning, Engrg & Design ($K)	$8,325	$8,934	$9,543	$10,154	$10,747	$11,535
31 Construction Mgt ($K)	$5,946	$6,381	$6,187	$7,254	$7,677	$8,240
Estimated Cost @ EPL 1 Oct 14 Incl. Contingency ($K) *See TPCS Sheet	$48,312	$51,844	$55,382	$58,924	$62,358	$66,917

Cost Appendix Attachments

See following pages

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 30'MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Program Year (Budget EC): 2016
Effective Price Level Date: 1 OCT 15

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***		***K***	***L***	***M***	***N***	***O***
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$15,996	$14,236	89.0%	$30,232	0.0%	$15,996	$14,236	$30,232	$0	$30,232	10.5%	$17,680	$15,735	$33,414
	CONSTRUCTION ESTIMATE TOTALS:	$17,978	$16,000		$33,978	0.2%	$18,007	$16,026	$34,033	$0	$34,033	10.5%	$19,902	$17,713	$37,615
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$4,405	$3,920	89.0%	$8,325	2.3%	$4,506	$4,011	$8,517	$0	$8,517	12.4%	$5,064	$4,507	$9,571
31	CONSTRUCTION MANAGEMENT	$3,146	$2,800	89.0%	$5,946	2.3%	$3,218	$2,864	$6,083	$0	$6,083	22.4%	$3,939	$3,505	$7,444
	PROJECT COST TOTALS:	$25,583	$22,729	88.8%	$48,312		$25,786	$22,909	**$48,696**	$0	**$48,696**	12.3%	$28,962	$25,734	$54,696

______________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

______________________ **PROJECT MANAGER, Derek J. Chow**

______________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

______________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

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______________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

______________________ **CHIEF, CONTRACTING, Marilyn Clark**

______________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

______________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

ESTIMATED FEDERAL COST:	**65%**	**$35,552**
ESTIMATED NON-FEDERAL COST:	**35%**	**$19,144**
ESTIMATED TOTAL PROJECT COST:		**$54,696**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 30'MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District
PREPARED: 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			1-May-15	Program Year (Budget EC):			2016					
		Effective Price Level:			1-Oct-14	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	DREDGING to 30' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$15,996	$14,236	89.0%	$30,232	0.0%	$15,996	$14,236	$30,232	2021Q2	10.5%	$17,680	$15,735	$33,414
	CONSTRUCTION ESTIMATE TOTALS:	$17,978	$16,000	89.0%	**$33,978**		$18,007	$16,026	$34,033			$19,902	$17,713	$37,615
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$449	$400	89.0%	$849	2.3%	$459	$409	$868	2018Q4	11.0%	$510	$454	$963
1.0%	Planning & Environmental Compliance	$180	$160	89.0%	$340	2.3%	$184	$164	$348	2018Q4	11.0%	$204	$182	$386
15.0%	Engineering & Design	$2,697	$2,400	89.0%	$5,097	2.3%	$2,759	$2,456	$5,215	2018Q4	11.0%	$3,062	$2,725	$5,787
1.0%	Reviews, ATRs, IEPRs, VE	$180	$160	89.0%	$340	2.3%	$184	$164	$348	2018Q4	11.0%	$204	$182	$386
1.0%	Life Cycle Updates (cost, schedule, risks)	$180	$160	89.0%	$340	2.3%	$184	$164	$348	2018Q4	11.0%	$204	$182	$386
1.0%	Contracting & Reprographics	$180	$160	89.0%	$340	2.3%	$184	$164	$348	2018Q4	11.0%	$204	$182	$386
3.0%	Engineering During Construction	$539	$480	89.0%	$1,019	2.3%	$551	$491	$1,042	2021Q2	22.4%	$675	$601	$1,275
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$2,697	$2,400	89.0%	$5,097	2.3%	$2,759	$2,456	$5,215	2021Q2	22.4%	$3,377	$3,005	$6,382
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$449	$400	89.0%	$849	2.3%	$459	$409	$868	2021Q2	22.4%	$562	$500	$1,062
	CONTRACT COST TOTALS:	$25,583	$22,729		$48,312		$25,786	$22,909	$48,696			$28,962	$25,734	$54,696

Filename: HiloHarborDredge(30ft)(Hilo)(10Sep15)Non-CAP Example TPCS Mar 2015 r2 (2).xlsx
TPCS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 31'MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Program Year (Budget EC): 2016
Effective Price Level Date: 1 OCT 15

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***		***K***	***L***	***M***	***N***	***O***
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$17,313	$15,409	89.0%	$32,722	0.0%	$17,313	$15,409	$32,722	$0	$32,722	10.5%	$19,135	$17,030	$36,166
	CONSTRUCTION ESTIMATE TOTALS:	$19,295	$17,173		$36,468	0.1%	$19,324	$17,198	$36,522	$0	$36,522	10.5%	$21,358	$19,008	$40,366
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$4,727	$4,207	89.0%	$8,934	2.3%	$4,836	$4,304	$9,140	$0	$9,140	12.4%	$5,434	$4,836	$10,270
31	CONSTRUCTION MANAGEMENT	$3,376	$3,005	89.0%	$6,381	2.3%	$3,454	$3,074	$6,527	$0	$6,527	22.4%	$4,227	$3,762	$7,988
	PROJECT COST TOTALS:	$27,452	$24,392	88.9%	$51,844		$27,668	$24,584	**$52,252**	$0	**$52,252**	12.3%	$31,076	$27,615	$58,691

________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

________________ **PROJECT MANAGER, Derek J. Chow**

________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

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________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

________________ **CHIEF, CONTRACTING, Marilyn Clark**

________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

ESTIMATED FEDERAL COST:	**65%**	**$38,149**
ESTIMATED NON-FEDERAL COST:	**35%**	**$20,542**
ESTIMATED TOTAL PROJECT COST:		**$58,691**

**** CONTRACT COST SUMMARY ****

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 31'MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi
PREPARED: 5/1/2015

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**1-May-15**	Program Year (Budget EC):			2016					
		Effective Price Level:			1-Oct-14	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	DREDGING to 31' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$17,313	$15,409	89.0%	$32,722	0.0%	$17,313	$15,409	$32,722	2021Q2	10.5%	$19,135	$17,030	$36,166
	CONSTRUCTION ESTIMATE TOTALS:	$19,295	$17,173	89.0%	**$36,468**		$19,324	$17,198	$36,522			$21,358	$19,008	$40,366
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$482	$429	89.0%	$911	2.3%	$493	$439	$932	2018Q4	11.0%	$547	$487	$1,034
1.0%	Planning & Environmental Compliance	$193	$172	89.0%	$365	2.3%	$197	$176	$373	2018Q4	11.0%	$219	$195	$414
15.0%	Engineering & Design	$2,894	$2,576	89.0%	$5,470	2.3%	$2,961	$2,635	$5,596	2018Q4	11.0%	$3,285	$2,924	$6,210
1.0%	Reviews, ATRs, IEPRs, VE	$193	$172	89.0%	$365	2.3%	$197	$176	$373	2018Q4	11.0%	$219	$195	$414
1.0%	Life Cycle Updates (cost, schedule, risks)	$193	$172	89.0%	$365	2.3%	$197	$176	$373	2018Q4	11.0%	$219	$195	$414
1.0%	Contracting & Reprographics	$193	$172	89.0%	$365	2.3%	$197	$176	$373	2018Q4	11.0%	$219	$195	$414
3.0%	Engineering During Construction	$579	$515	89.0%	$1,094	2.3%	$592	$527	$1,119	2021Q2	22.4%	$725	$645	$1,370
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$2,894	$2,576	89.0%	$5,470	2.3%	$2,961	$2,635	$5,596	2021Q2	22.4%	$3,623	$3,225	$6,848
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$482	$429	89.0%	$911	2.3%	$493	$439	$932	2021Q2	22.4%	$603	$537	$1,141
	CONTRACT COST TOTALS:	$27,452	$24,392		$51,844		$27,668	$24,584	$52,252			$31,076	$27,615	$58,691

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 32'MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Program Year (Budget EC): 2016
Effective Price Level Date: 1 OCT 15

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$18,632	$16,582	89.0%	$35,214	0.0%	$18,632	$16,582	$35,214	$0	$35,214	10.5%	$20,593	$18,328	$38,921
	CONSTRUCTION ESTIMATE TOTALS:	$20,614	$18,346		$38,960	0.1%	$20,643	$18,372	$39,015	$0	$39,015	10.5%	$22,816	$20,306	$43,121
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$5,049	$4,494	89.0%	$9,543	2.3%	$5,165	$4,597	$9,762	$0	$9,762	12.4%	$5,804	$5,166	$10,970
31	CONSTRUCTION MANAGEMENT	$3,607	$3,210	89.0%	$6,817	2.3%	$3,690	$3,284	$6,974	$0	$6,974	22.4%	$4,516	$4,019	$8,535
	PROJECT COST TOTALS:	$29,324	$26,058	88.9%	$55,382		$29,553	$26,261	**$55,814**	$0	**$55,814**	12.3%	$33,193	$29,499	$62,692

______________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

______________________ **PROJECT MANAGER, Derek J. Chow**

______________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

______________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

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______________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

______________________ **CHIEF, CONTRACTING, Marilyn Clark**

______________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

______________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

ESTIMATED FEDERAL COST:	**65%**	**$40,750**
ESTIMATED NON-FEDERAL COST:	**35%**	**$21,942**
ESTIMATED TOTAL PROJECT COST:		**$62,692**

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 32'MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi
PREPARED: 5/1/2015

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 1-May-15 Effective Price Level: 1-Oct-14				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	DREDGING to 32' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$18,632	$16,582	89.0%	$35,214	0.0%	$18,632	$16,582	$35,214	2021Q2	10.5%	$20,593	$18,328	$38,921
	CONSTRUCTION ESTIMATE TOTALS:	$20,614	$18,346	89.0%	**$38,960**		$20,643	$18,372	$39,015			$22,816	$20,306	$43,121
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$515	$458	89.0%	$973	2.3%	$527	$469	$996	2018Q4	11.0%	$585	$520	$1,105
1.0%	Planning & Environmental Compliance	$206	$183	89.0%	$389	2.3%	$211	$188	$398	2018Q4	11.0%	$234	$208	$442
15.0%	Engineering & Design	$3,092	$2,752	89.0%	$5,844	2.3%	$3,163	$2,815	$5,978	2018Q4	11.0%	$3,510	$3,124	$6,634
1.0%	Reviews, ATRs, IEPRs, VE	$206	$183	89.0%	$389	2.3%	$211	$188	$398	2018Q4	11.0%	$234	$208	$442
1.0%	Life Cycle Updates (cost, schedule, risks)	$206	$183	89.0%	$389	2.3%	$211	$188	$398	2018Q4	11.0%	$234	$208	$442
1.0%	Contracting & Reprographics	$206	$183	89.0%	$389	2.3%	$211	$188	$398	2018Q4	11.0%	$234	$208	$442
3.0%	Engineering During Construction	$618	$550	89.0%	$1,168	2.3%	$632	$563	$1,195	2021Q2	22.4%	$774	$689	$1,462
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$3,092	$2,752	89.0%	$5,844	2.3%	$3,163	$2,815	$5,978	2021Q2	22.4%	$3,871	$3,445	$7,316
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$515	$458	89.0%	$973	2.3%	$527	$469	$996	2021Q2	22.4%	$645	$574	$1,219
	CONTRACT COST TOTALS:	$29,324	$26,058		$55,382		$29,553	$26,261	$55,814			$33,193	$29,499	$62,692

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 33'MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	**TOTAL ($K) J**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$19,952	$17,757	89.0%	$37,709	0.0%	$19,952	$17,757	$37,709	$0	$37,709	10.5%	$22,052	$19,626	$41,678
	CONSTRUCTION ESTIMATE TOTALS:	$21,934	$19,521		$41,455	0.1%	$21,963	$19,547	$41,510	$0	$41,510	10.5%	$24,274	$21,604	$45,879
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$5,372	$4,781	89.0%	$10,153	2.3%	$5,496	$4,891	$10,387	$0	$10,387	12.4%	$6,175	$5,496	$11,672
31	CONSTRUCTION MANAGEMENT	$3,838	$3,416	89.0%	$7,254	2.3%	$3,926	$3,494	$7,421	$0	$7,421	22.4%	$4,805	$4,277	$9,082
	PROJECT COST TOTALS:	$31,198	$27,726	88.9%	$58,924		$31,440	$27,941	**$59,380**	$0	**$59,380**	12.3%	$35,312	$31,386	$66,698

ESTIMATED FEDERAL COST:	**65%**	**$43,354**
ESTIMATED NON-FEDERAL COST:	**35%**	**$23,344**
ESTIMATED TOTAL PROJECT COST:		**$66,698**

____________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

____________________ **PROJECT MANAGER, Derek J. Chow**

____________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

____________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

____________________ **CHIEF, ENGINEERING, Todd C. Barnes**

____________________ **CHIEF, Civil Works Tech Branch, Michael F. Wong**

____________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

____________________ **CHIEF, CONTRACTING, Marilyn Clark**

____________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

____________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 33'MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District PREPARED: 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 1-May-15 Effective Price Level: 1-Oct-14				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	DREDGING to 33' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$19,952	$17,757	89.0%	$37,709	0.0%	$19,952	$17,757	$37,709	2021Q2	10.5%	$22,052	$19,626	$41,678
	CONSTRUCTION ESTIMATE TOTALS:	$21,934	$19,521	89.0%	**$41,455**		$21,963	$19,547	$41,510			$24,274	$21,604	$45,879
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$548	$488	89.0%	$1,036	2.3%	$561	$499	$1,060	2018Q4	11.0%	$622	$554	$1,176
1.0%	Planning & Environmental Compliance	$219	$195	89.0%	$414	2.3%	$224	$199	$423	2018Q4	11.0%	$249	$221	$470
15.0%	Engineering & Design	$3,290	$2,928	89.0%	$6,218	2.3%	$3,366	$2,995	$6,361	2018Q4	11.0%	$3,735	$3,324	$7,059
1.0%	Reviews, ATRs, IEPRs, VE	$219	$195	89.0%	$414	2.3%	$224	$199	$423	2018Q4	11.0%	$249	$221	$470
1.0%	Life Cycle Updates (cost, schedule, risks)	$219	$195	89.0%	$414	2.3%	$224	$199	$423	2018Q4	11.0%	$249	$221	$470
1.0%	Contracting & Reprographics	$219	$195	89.0%	$414	2.3%	$224	$199	$423	2018Q4	11.0%	$249	$221	$470
3.0%	Engineering During Construction	$658	$586	89.0%	$1,244	2.3%	$673	$599	$1,272	2021Q2	22.4%	$824	$733	$1,557
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$3,290	$2,928	89.0%	$6,218	2.3%	$3,366	$2,995	$6,361	2021Q2	22.4%	$4,119	$3,666	$7,785
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$548	$488	89.0%	$1,036	2.3%	$561	$499	$1,060	2021Q2	22.4%	$686	$611	$1,297
	CONTRACT COST TOTALS:	$31,198	$27,726		$58,924		$31,440	$27,941	$59,380			$35,312	$31,386	$66,698

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 34' MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis) Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$21,231	$18,896	89.0%	$40,127	0.0%	$21,231	$18,896	$40,127	$0	$40,127	10.5%	$23,466	$20,884	$44,350
	CONSTRUCTION ESTIMATE TOTALS:	$23,213	$20,660		$43,873	0.1%	$23,242	$20,685	$43,927	$0	$43,927	10.5%	$25,688	$22,862	$48,550
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$5,686	$5,061	89.0%	$10,747	2.3%	$5,817	$5,177	$10,994	$0	$10,994	12.4%	$6,536	$5,817	$12,354
31	CONSTRUCTION MANAGEMENT	$4,062	$3,615	89.0%	$7,677	2.3%	$4,155	$3,698	$7,854	$0	$7,854	22.4%	$5,086	$4,526	$9,612
	PROJECT COST TOTALS:	$33,015	$29,343	88.9%	$62,358		$33,269	$29,569	**$62,838**	$0	**$62,838**	12.3%	$37,367	$33,215	$70,582

ESTIMATED FEDERAL COST:	**65%**	**$45,878**
ESTIMATED NON-FEDERAL COST:	**35%**	**$24,704**
ESTIMATED TOTAL PROJECT COST:		**$70,582**

_____________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

_____________________ **PROJECT MANAGER, Derek J. Chow**

_____________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

_____________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

_____________________ **CHIEF, ENGINEERING, Todd C. Barnes**

_____________________ **CHIEF, Civil Works Tech Branch, Michael F. Wong**

_____________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

_____________________ **CHIEF, CONTRACTING, Marilyn Clark**

_____________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

_____________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 34' MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District PREPARED: 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: **1-May-15** Effective Price Level: 1-Oct-14				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	DREDGING to 34' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$21,231	$18,896	89.0%	$40,127	0.0%	$21,231	$18,896	$40,127	2021Q2	10.5%	$23,466	$20,884	$44,350
	CONSTRUCTION ESTIMATE TOTALS:	$23,213	$20,660	89.0%	**$43,873**		$23,242	$20,685	$43,927			$25,688	$22,862	$48,550
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$580	$516	89.0%	$1,096	2.3%	$593	$528	$1,121	2018Q4	11.0%	$658	$586	$1,244
1.0%	Planning & Environmental Compliance	$232	$206	89.0%	$438	2.3%	$237	$211	$449	2018Q4	11.0%	$263	$234	$498
15.0%	Engineering & Design	$3,482	$3,099	89.0%	$6,581	2.3%	$3,562	$3,170	$6,732	2018Q4	11.0%	$3,953	$3,518	$7,471
1.0%	Reviews, ATRs, IEPRs, VE	$232	$206	89.0%	$438	2.3%	$237	$211	$449	2018Q4	11.0%	$263	$234	$498
1.0%	Life Cycle Updates (cost, schedule, risks)	$232	$206	89.0%	$438	2.3%	$237	$211	$449	2018Q4	11.0%	$263	$234	$498
1.0%	Contracting & Reprographics	$232	$206	89.0%	$438	2.3%	$237	$211	$449	2018Q4	11.0%	$263	$234	$498
3.0%	Engineering During Construction	$696	$619	89.0%	$1,315	2.3%	$712	$634	$1,346	2021Q2	22.4%	$871	$776	$1,647
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$3,482	$3,099	89.0%	$6,581	2.3%	$3,562	$3,170	$6,732	2021Q2	22.4%	$4,359	$3,880	$8,239
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$580	$516	89.0%	$1,096	2.3%	$593	$528	$1,121	2021Q2	22.4%	$726	$646	$1,372
	CONTRACT COST TOTALS:	$33,015	$29,343		$62,358		$33,269	$29,569	$62,838			$37,367	$33,215	$70,582

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **SA-Hilo Harbor Modifications, HI (Dredge Only to 35'MLLW)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: **Honolulu District**
PREPARED: **5/1/2015**
POC: **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***		***K***	***L***	***M***	***N***	***O***
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	$0	$3,800	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$22,928	$20,406	89.0%	$43,334	0.0%	$22,928	$20,406	$43,334	$0	$43,334	10.5%	$25,341	$22,554	$47,895
	CONSTRUCTION ESTIMATE TOTALS:	$24,910	$22,170		$47,080	0.1%	$24,939	$22,196	$47,134	$0	$47,134	10.5%	$27,564	$24,532	$52,095
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$6,103	$5,432	89.0%	$11,535	2.3%	$6,243	$5,557	$11,800	$0	$11,800	12.4%	$7,016	$6,244	$13,260
31	CONSTRUCTION MANAGEMENT	$4,360	$3,880	89.0%	$8,240	2.3%	$4,460	$3,970	$8,430	$0	$8,430	22.4%	$5,459	$4,858	$10,317
	PROJECT COST TOTALS:	$35,427	$31,490	88.9%	$66,917		$35,697	$31,730	**$67,428**	$0	**$67,428**	12.3%	$40,095	$35,643	$75,738

_________________________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

_________________________ **PROJECT MANAGER, Derek J. Chow**

_________________________ **CHIEF, REAL ESTATE, Steven N. Cayetano**

_________________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

_________________________ **CHIEF, ENGINEERING, Todd C. Barnes**

_________________________ **CHIEF, Civil Works Tech Branch, Michael F. Wong**

_________________________ **CHIEF, CONSTRUCTION, Olson T. Okada**

_________________________ **CHIEF, CONTRACTING, Marilyn Clark**

_________________________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

_________________________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

ESTIMATED FEDERAL COST:	**65%**	**$49,230**
ESTIMATED NON-FEDERAL COST:	**35%**	**$26,508**
ESTIMATED TOTAL PROJECT COST:		**$75,738**

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: SA-Hilo Harbor Modifications, HI (Dredge Only to 35'MLLW)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District PREPARED: 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Effective Price Level:			**1-May-15** 1-Oct-14	Program Year (Budget EC): Effective Price Level Date:			2016 1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	DREDGING to 35' MLLW Only													
06	FISH & WILDLIFE FACILITIES	$1,982	$1,764	89.0%	$3,746	1.5%	$2,011	$1,790	$3,800	2021Q2	10.5%	$2,222	$1,978	$4,200
12	NAVIGATION PORTS & HARBORS	$22,928	$20,406	89.0%	$43,334	0.0%	$22,928	$20,406	$43,334	2021Q2	10.5%	$25,341	$22,554	$47,895
	CONSTRUCTION ESTIMATE TOTALS:	$24,910	$22,170	89.0%	**$47,080**		$24,939	$22,196	$47,134			$27,564	$24,532	$52,095
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$623	$554	89.0%	$1,177	2.3%	$637	$567	$1,205	2018Q4	11.0%	$707	$629	$1,337
1.0%	Planning & Environmental Compliance	$249	$222	89.0%	$471	2.3%	$255	$227	$481	2018Q4	11.0%	$283	$252	$534
15.0%	Engineering & Design	$3,737	$3,326	89.0%	$7,063	2.3%	$3,823	$3,402	$7,225	2018Q4	11.0%	$4,243	$3,776	$8,018
1.0%	Reviews, ATRs, IEPRs, VE	$249	$222	89.0%	$471	2.3%	$255	$227	$481	2018Q4	11.0%	$283	$252	$534
1.0%	Life Cycle Updates (cost, schedule, risks)	$249	$222	89.0%	$471	2.3%	$255	$227	$481	2018Q4	11.0%	$283	$252	$534
1.0%	Contracting & Reprographics	$249	$222	89.0%	$471	2.3%	$255	$227	$481	2018Q4	11.0%	$283	$252	$534
3.0%	Engineering During Construction	$747	$665	89.0%	$1,412	2.3%	$764	$680	$1,444	2021Q2	22.4%	$935	$832	$1,768
0.0%	Planning During Construction	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$3,737	$3,326	89.0%	$7,063	2.3%	$3,823	$3,402	$7,225	2021Q2	22.4%	$4,679	$4,164	$8,843
0.0%	Project Operation:	$0	$0	89.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$623	$554	89.0%	$1,177	2.3%	$637	$567	$1,205	2021Q2	22.4%	$780	$694	$1,474
	CONTRACT COST TOTALS:	$35,427	$31,490		$66,917		$35,697	$31,730	$67,428			$40,095	$35,643	$75,738

Hilo Harbor Dredge(30ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**17,978,608.86**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (30' MLLW)	**15,996,343.67**
1202 Harbors (Dredging) @ 30' MLLW	**15,996,343.67**

Hilo Harbor Dredge(31ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**19,295,266.57**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (31' MLLW)	**17,313,001.38**
1202 Harbors (Dredging) @ 31' MLLW	**17,313,001.38**

Hilo Harbor Dredge(32ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**20,614,446.36**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (32' MLLW)	**18,632,181.17**
1202 Harbors (Dredging) @ 32' MLLW	**18,632,181.17**

Hilo Harbor Dredge(33ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**21,934,009.62**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (33' MLLW)	**19,951,744.42**
1202 Harbors (Dredging) @ 33' MLLW	**19,951,744.42**

Hilo Harbor Dredge(34ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**23,213,278.61**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (34' MLLW)	**21,231,013.42**
1202 Harbors (Dredging) @ 34' MLLW	**21,231,013.42**

Hilo Harbor Dredge(33ft)(9Sep15)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	463 Days

Description	ContractCost
Contract Cost Summ (ECC)	**21,934,009.62**
06 Fish and Wildlife Fac (Environmental Mitigation) Dredging	**1,982,265.19**
Envir Mitigation for Dredging	**1,982,265.19**
12 Navigation Ports & Harbors (33' MLLW)	**19,951,744.42**
1202 Harbors (Dredging) @ 33' MLLW	**19,951,744.42**

Abbreviated Risk Analysis

Project Name & Location: **Hilo Harbor, Hilo Harbor, Hilo**
Project Development Stage/Alternative: **Feasibility (Alternatives)**
Risk Category: **Moderate Risk: Typical Project Construction Type**

District: **POH**
Alternative: **Dredge 35'**
Meeting Date: **5/4/2015**

Total Estimated Construction Contract Cost = **$ 24,911,000**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 54,000		15.00%	$ 8,100	$ 62,100
1	06 FISH AND WILDLIFE FACILITIES	Environmental Mitigation	$ 1,982,000		63.67%	$ 1,261,931	$ 3,243,931
2	12 NAVIGATION, PORTS AND HARBORS	Mob, Demob & Prep Work	$ 1,690,500		64.07%	$ 1,083,118	$ 2,773,618
3	12 NAVIGATION, PORTS AND HARBORS	Dredging	$ 21,238,500		131.02%	$ 27,825,735	$ 49,064,235
4			$ -		0.00%	$ -	$ -
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other (less than 10% of construction costs)	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 6,103,000		11.30%	$ 689,889	$ 6,792,889
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 4,360,000		17.61%	$ 767,827	$ 5,127,827
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 54,000	15.00%	$ 8,100	$ 62,100.00
Total Construction Estimate	$ 24,911,000	121.11%	$ 30,170,785	$ 55,081,785
Total Planning, Engineering & Design	$ 6,103,000	11.30%	$ 689,889	$ 6,792,889
Total Construction Management	$ 4,360,000	17.61%	$ 767,827	$ 5,127,827
Total	**$ 35,428,000**	**89%**	**$ 31,636,601**	**$ 67,064,601**

	Base	**50%**	**80%**
Range Estimate ($000's)	$35,428k	$54,410k	$67,065k

* 50% based on base is at 50% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.	

Hilo Harbor, Hilo Harbor, Hilo Dredge 35'

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 4-May-15

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
PS-1	Environmental Mitigation	Consultations with the USFWS has not net determined the extent of mitigation required.	No scope determined at this stage.	Moderate	Possible	2
PS-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging.	Estimate assumes local availability of dredge plant. Assume larger (heavier) rock bucket is shipped in. (see dredging concerns)	Moderate	Likely	3
PS-3	Dredging	Geotechnical information is not available at this stage to determining the type of material for dredging. This will determine the type of dredge plant equipment needed and disposal requirements.	It is possible the dredged material is acceptable for disposal in the ODMDS site. If not acceptable, material will have may have to be double handled, screened, crushed and disposed into the ODMDS or dispose upland adding significant cost to the disposal.	Significant	Possible	3
PS-13	Planning, Engineering, & Design	PED cost could be underestimated when compared to historical PED costs calculated using % of Construction Cost.	The PED cost was estimated based the key level of effort for each discipline and it was provided to the Project Mgr . It is possible that additional requirements necessary to complete the design is omitted. The likelihood of it occurring is marginal.	Marginal	Possible	1
PS-14	Construction Management	Minor Concerns.	N/A.	Negligible	Unlikely	0
AS-1	Environmental Mitigation	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5
AS-2	Mob, Demob & Prep Work	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5

AS-3	Dredging	Larger clamshell dredge with rock bucket for dredging. Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized. Compitition is low. High risk due to required plant to remove hard material. What if the plant will not??	Significant	Very LIKELY	5
AS-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0
AS-14	Construction Management	Small business contractor may need more Government Oversight.	If the construction contract is awarded to a small business contractor unfamiliar with the submittal process, more government oversight may be required. The impact to Construction Management cost would be moderate since more off-island travel would be required to provide Government assistance. This may possibly increase the cost to Construction Management.	Moderate	Possible	2
CON-1	Environmental Mitigation	Minor Concerns	N/A.	Marginal	Possible	1
CON-2	Mob, Demob & Prep Work	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities call for 210,000 cyds at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	It is possible a modification to the contract would be needed if hard material is too hard for excavation with rock bucket. Also, material is assumed to be a limestone material, which may required double handling for disposal at ODMS re-use is unsatisfactory geotechnically. The impact to the cost would be significant since due to increased disposal fee and hauling costs.	Critical	Likely	5
CON-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-14	Construction Management	Minor Concerns	N/A.	Negligible	Unlikely	0
Q-1	Environmental Mitigation	No quantities provided for Enviromental Mitgation.	Cost could increase as further consultations with the USFS is done.	Moderate	Possible	2
Q-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clammshell dredge with rock bucket for dredging.	Based on material type (hard) and depth, A large plant brought from the mainland is possible.	Moderate	Possible	2

Q-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities provided at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	Hard material, requires overdepth to reach pay line. Estimate assumes 1ft on avg depth. This could require additional depending on hardness and bucket size.	Moderate	Likely	3
Q-13	Planning, Engineering, & Design	No quantities for PED.	N/A.	Negligible	Unlikely	0
Q-14	Construction Management	No quantities for CM.	N/A.	Negligible	Unlikely	0
FE-1	Environmental Mitigation	None	N/A.	Marginal	Unlikely	0
FE-2	Mob, Demob & Prep Work	None	N/A.	Negligible	Unlikely	0
FE-3	Dredging	None	N/A.	Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None	N/A.	Negligible	Unlikely	0
FE-14	Construction Management	None	N/A.	Negligible	Unlikely	0
EST-1	Environmental Mitigation	Estimate based on a similar project and the acrage of corals impacted.	Estimate was based on a similar project & area of impacted corals. For Barbers Point, the cost of mitigation that USFWS (and other agencies) requested would have been $2 million dollars. For that project, the acreage of corals that would have been removed is significantly higher than the acreage being proposed for Hilo Harbor assumptions .	Moderate	Possible	2
EST-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clammshell dredge with rock bucket for dredging.	Assumes, main plant is available within Honolulu area with competition. If not then most likely will result in cost increase.	Negligible	Possible	0
EST-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities estimated at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	Assumes, main plant is available within Honolulu area with competition. This also assumes the material could be dredged without drill and blast or splitting. If not then most likely will result in cost increase.	Significant	Likely	4
EST-13	Planning, Engineering, & Design	No concerns. The cost was provided by the Project Manager.	It is assumed major PED items are included. It is possible unanticipated tasks are needed in the PED stage which could marginally increase the PED cost.	Marginal	Possible	1

EST-14	Construction Management	Based upon above, construction contract period could be larger than priced.	Based upon above, construction contract period could be larger than priced. Also, the estimate assumes 24/7 operation. If not possible, the duration & cost will increase.	Moderate	Possible	2
EX-1	Environmental Mitigation	Minor Concerns	N/A.	Marginal	Possible	1
EX-2	Mob, Demob & Prep Work	Minor Concerns	N/A.	Marginal	Possible	1
EX-3	Dredging	Possibility for fuel increase.	Fuel prices have recently decreased in the past months and appear to be currently slowly increasing. It is likely the cost of fuel will escalate when the project is awarded causing significant increase to the cost since the project uses heavy sitework equipment.	Significant	Likely	4
EX-13	Planning, Engineering, & Design	As the project moves to construction, the local government could impose further requirement which delays the project construction.	It is possible the PED cost was underestimated if additional legal requirements are imposed. The rating is negligible since the project is coordinated through legal channels. Time for permits.	Negligible	Possible	0
EX-14	Construction Management	Local protests could delay construction work.	It is possible community protests and disagreements could delay construction work and increase to the CM cost requiring more Government quality assurance. The impact to the CM would be marginal since it is anticipated that through public outreach and notices, the community concerns are addressed.	Marginal	Possible	1

Hilo Harbor, Hilo Harbor, Hilo Dredge 35'
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$54
06 FISH AND WILDLIFE FACILITIES	**Environmental Mitigation**	2	5	1	2	0	2	1	$1,982
12 NAVIGATION, PORTS AND HARBORS	Mob, Demob & Prep Work	3	5	0	2	0	0	1	$1,691
12 NAVIGATION, PORTS AND HARBORS	Dredging	3	5	5	3	0	4	4	$21,239
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
All Other (less than 10% of construction costs)	Remaining Construction Items	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	1	0	0	0	0	1	0	$6,103
31 CONSTRUCTION MANAGEMENT	Construction Management	0	2	0	0	0	2	1	$4,360
									$35,374
Risk		$ 2,915	$ 10,155	$ 8,887	$ 1,403	$ -	$ 4,038	$ 4,230	**$31,629**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 2,915	$ 10,155	$ 8,887	$ 1,403	$ -	$ 4,038	$ 4,230	**$31,629**
								Total	**$67,003**

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **SA-Hilo Harbor Modifications, HI (Caisson only, from Hilo)**
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED: 5/1/2015**
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
10	BREAKWATER & SEAWALLS	$40,392	$44,431	110.0%	$84,823	1.5%	$40,980	$45,078	$86,057	$0	$86,057	11.1%	$45,520	$50,072	$95,592
06	FISH & WILDLIFE FACILITIES	$8,199	$9,019	110.0%	$17,218	0.0%	$8,199	$9,019	$17,218	$0	$17,218	11.1%	$9,107	$10,018	$19,126
	CONSTRUCTION ESTIMATE TOTALS:	$48,591	$53,450		$102,041	1.2%	$49,179	$54,096	$103,275	$0	$103,275	11.1%	$54,627	$60,090	$114,718
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$11,906	$13,097	110.0%	$25,003	2.3%	$12,180	$13,398	$25,578	$0	$25,578	12.5%	$13,705	$15,076	$28,781
31	CONSTRUCTION MANAGEMENT	$8,504	$9,354	110.0%	$17,858	2.3%	$8,700	$9,570	$18,269	$0	$18,269	23.6%	$10,756	$11,832	$22,588
	PROJECT COST TOTALS:	$69,055	$75,909	109.9%	$144,964		$70,113	$77,072	**$147,185**	$0	**$147,185**	12.9%	$79,146	$87,006	$166,153

ESTIMATED FEDERAL COST:	**65%**	**$107,999**
ESTIMATED NON-FEDERAL COST:	**35%**	**$58,153**
ESTIMATED TOTAL PROJECT COST:		**$166,153**

______________ **CHIEF, COST ENGINEERING, Gary F. Yamauchi**

______________ **PROJECT MANAGER, Derek J. Chow**

______________ **CHIEF, REAL ESTATE, Steven N. Ca**

______________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

______________ **CHIEF, ENGINEERING, Todd C. Barnes**

______________ **CHIEF, Civil Works Tech Branch, Michael F. Wong**

______________ **CHIEF, CONSTRUCTION, Olson T. Okada**

______________ **CHIEF, CONTRACTING, Marilyn Clark**

______________ **CHIEF, Programs Mgt Branch, Roxane E. Iseri**

______________ **CHIEF, PROJECT MGT, Anthony J. Paresa**

****** CONTRACT COST SUMMARY ******

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Caisson only, from Hilo)
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District PREPARED: 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			**1-May-15**	Program Year (Budget EC):			2016					
		Effective Price Level:			1-Oct-14	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
10	BREAKWATER & SEAWALLS	$40,392	$44,431	110.0%	$84,823	1.5%	$40,980	$45,078	$86,057	2021Q3	11.1%	$45,520	$50,072	$95,592
06	FISH & WILDLIFE FACILITIES	$8,199	$9,019	110.0%	$17,218	0.0%	$8,199	$9,019	$17,218	2021Q3	11.1%	$9,107	$10,018	$19,126
	CONSTRUCTION ESTIMATE TOTALS:	$48,591	$53,450	110.0%	**$102,041**		$49,179	$54,096	$103,275			$54,627	$60,090	$114,718
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$1,215	$1,337	110.0%	$2,552	2.3%	$1,243	$1,367	$2,610	2018Q4	11.0%	$1,379	$1,517	$2,897
1.0%	Planning & Environmental Compliance	$486	$535	110.0%	$1,021	2.3%	$497	$547	$1,044	2018Q4	11.0%	$552	$607	$1,159
15.0%	Engineering & Design	$7,289	$8,018	110.0%	$15,307	2.3%	$7,457	$8,202	$15,659	2018Q4	11.0%	$8,275	$9,103	$17,378
1.0%	Reviews, ATRs, IEPRs, VE	$486	$535	110.0%	$1,021	2.3%	$497	$547	$1,044	2018Q4	11.0%	$552	$607	$1,159
1.0%	Life Cycle Updates (cost, schedule, risks)	$486	$535	110.0%	$1,021	2.3%	$497	$547	$1,044	2018Q4	11.0%	$552	$607	$1,159
1.0%	Contracting & Reprographics	$486	$535	110.0%	$1,021	2.3%	$497	$547	$1,044	2018Q4	11.0%	$552	$607	$1,159
3.0%	Engineering During Construction	$1,458	$1,604	110.0%	$3,062	2.3%	$1,492	$1,641	$3,132	2021Q3	23.6%	$1,844	$2,029	$3,873
0.0%	Planning During Construction	$0	$0	110.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	110.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$7,289	$8,018	110.0%	$15,307	2.3%	$7,457	$8,202	$15,659	2021Q3	23.6%	$9,219	$10,141	$19,361
0.0%	Project Operation:	$0	$0	110.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$1,215	$1,337	110.0%	$2,552	2.3%	$1,243	$1,367	$2,610	2021Q3	23.6%	$1,537	$1,690	$3,227
	CONTRACT COST TOTALS:	$69,055	$75,909		$144,964		$70,113	$77,072	$147,185			$79,146	$87,006	$166,153

HiloHarbor(5May15-Caisson Only)(10pct)

For this standalone alt, assume import bedding. Reuse-excavated material for fill inside the caisson.

Estimated by	T. Kazunaga, POH-EC-S
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	5/8/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	554 Days

Description	ContractCost
Contract Cost Summ (ECC)	**43,558,416.05**
10 Breakwaters (Cast at Hilo Harbor)	**35,359,899.54**
1000 Breakwaters	**35,359,899.54**
06 Fish and Wildlife Fac (Environmental Mitigation) Caissons	**8,198,516.51**
Envir Mitigation for Caissons	**8,198,516.51**

Abbreviated Risk Analysis

Project Name & Location: **Hilo Harbor, Hilo Harbor, Hilo**
Project Development Stage/Alternative: **Feasibility (Alternatives)**
Risk Category: **Moderate Risk: Typical Project Construction Type**

District: **POH**
Alternative: **#1 - Cast at Hilo Harbor**
Meeting Date: **5/4/2015**

Total Estimated Construction Contract Cost = **$ 48,591,000**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 54,000		14.53%	$ 7,849	$ 61,849
1	10 BREAKWATERS AND SEAWALLS	Caisson	$ 40,392,000		166.13%	$ 67,104,464	$ 107,496,464
2	06 FISH AND WILDLIFE FACILITIES	Enviromental Mitigation	$ 8,199,000		70.94%	$ 5,816,092	$ 14,015,092
3					0.00%	$ -	$ -
4			$ -		0.00%	$ -	$ -
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other (less than 10% of construction costs)	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 11,906,000		11.30%	$ 1,345,866	$ 13,251,866
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 8,504,000		22.75%	$ 1,935,020	$ 10,439,020
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ 54,000	14.53%	$ 7,849	$ 61,848.84
Total Construction Estimate	$ 48,591,000	150.07%	$ 72,920,555	$ 121,511,555
Total Planning, Engineering & Design	$ 11,906,000	11.30%	$ 1,345,866	$ 13,251,866
Total Construction Management	$ 8,504,000	22.75%	$ 1,935,020	$ 10,439,020
Total	**$ 69,055,000**	**110%**	**$ 76,209,290**	**$ 145,264,290**

	Base	50%	80%
Range Estimate ($000's)	$69,055k	$114,780k	$145,264k

* 50% based on base is at 50% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Hilo Harbor, Hilo Harbor, Hilo #1 - Cast at Hilo Harbor

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 4-May-15

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
PS-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x25x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Weight of caisson limits crane application of caissons. No access to roll caissons from shore. Optimum is build in dry and float. This would require additional facilities at Hilo Port.	Critical	Very LIKELY	5
PS-2	Enviromental Mitigation	Scope not well defined. Possible scope growth.	Scope will not be defined until coordination with the USFW is completed. Cost could increase or decrease.	Moderate	Likely	3
PS-13	Planning, Engineering, & Design	PED cost could be underestimated when compared to historical PED costs calculated using % of Construction Cost.	The PED cost was estimated based the key level of effort for each discipline and it was provided to the Project Mgr . It is possible that additional requirements necessary to complete the design is omitted. The likelihood of it occurring is marginal.	Marginal	Possible	1
PS-14	Construction Management	Minor Concerns	Minor Concerns	Marginal	Likely	2
AS-1	Caisson	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5
AS-2	Enviromental Mitigation	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5
AS-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0

AS-14	Construction Management	Small business contractor may need more Government Oversight.	If the construction contract is awarded to a small business contractor unfamiliar with the submittal process, more government oversight may be required. The impact to Construction Management cost would be moderate since more off-island travel would be required to provide Government assistance. This may possibly increase the cost to Construction Management.	Moderate	Possible	2
CON-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Casting of concrete with reinforced steel, could be challenging. Heat, shrinkage and volume changes. Estimate assumes need to have the base slab cast first for reinforcing steel placement, something to lap the wall reinforcement too and to support the interior wall form work from. From there a continuous placement. Need to make sure there are no cold joints, during the placement so depending on the mix design so plenty of trucks and vibrators, high water reducing agents etc., placing in cooler weather, so in some locations night-time helps. Estimate assumes this will nott be your a typical ready mix.	Significant	Likely	4
CON-2	Enviromental Mitigation	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-14	Construction Management	Minor Concerns	N/A.	Negligible	Unlikely	0
Q-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Dredge material used for caisson fill and local fill from bedding and remiander of caisson fill. Depending on sea floor material. It is assume material would remain on barge prior to placement within caisson.	Additional fill may be required, if dredging material is not suitable.	Moderate	Possible	2
Q-2	Enviromental Mitigation	Quantities not provided at this stage.	It is likely the quantity will change based as further information is developed.	Moderate	Likely	3
Q-13	Planning, Engineering, & Design	No quantities for PED.	N/A.	Negligible	Unlikely	0
Q-14	Construction Management	No quantities for CM.	N/A.	Negligible	Unlikely	0

FE-1	Caisson	Option requires dewater or water access facilities to be constructed	Option requires dewater or water access facilities to be constructed	Marginal	Likely	2
FE-2	Enviromental Mitigation	None	N/A.	Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None	N/A.	Negligible	Unlikely	0
FE-14	Construction Management	None	N/A.	Negligible	Unlikely	0
EST-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Estimating approach depends on obtaining access to water from Hilo Port "Boneyard" area. This option requires disruption of existing site. If this is not feasibile, this option is no longer valid.	Critical	Likely	5
EST-2	Enviromental Mitigation	Estimate based on a similar project and the acrage of corals impacted.	Estimate was based on a similar project & area of impacted corals. For Barbers Point, the cost of mitigation that USFWS (and other agencies) requested would have been $2 million dollars. For that project, the acreage of corals that would have been removed is significantly higher than the acreage being proposed for Hilo Harbor. assumptions	Moderate	Possible	2
EST-13	Planning, Engineering, & Design	No concerns. The cost was provided by the Project Manager.	It is assumed major PED items are included. It is possible unanticipated tasks are needed in the PED stage which could marginally increase the PED cost.	Marginal	Possible	1
EST-14	Construction Management	Based upon above, construction contract period could be larger than priced.	Based upon above, construction contract period could be larger than priced.	Moderate	Possible	2
EX-1	Caisson	Community opposition or lack of support. Requires excavation of sea floor for placement.	Requires permit to exacavate in area and placement of permenate structure. It is possible the community opposes the project construction method. The rating is marginal since public meetings and review will be held to minimize lack of support and resolve obstacles.	Negligible	Unlikely	0
EX-2	Enviromental Mitigation	Minor Concerns	N/A.	Marginal	Possible	1
EX-13	Planning, Engineering, & Design	As the project moves to construction, the local government could impose further requirement which delays the project construction.	It is possible the PED cost was underestimated if additional legal requirements are imposed. The rating is negligible since the project is coordinated through legal channels. Time for permits.	Negligible	Possible	0
EX-14	Construction Management	Local protests could delay construction work.	It is possible community protests and disagreements could delay construction work and increase to the CM cost requiring more Government quality assurance. The impact to the CM would be marginal since it is anticipated that through public outreach and notices, the community concerns are addressed.	Marginal	Possible	1

Hilo Harbor, Hilo Harbor, Hilo #1 - Cast at Hilo Harbor
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$54
10 BREAKWATERS AND SEAWALLS	**Caisson**	5	5	4	2	2	5	0	$40,392
06 FISH AND WILDLIFE FACILITIES	Enviromental Mitigation	3	5	0	3	0	2	1	$8,199
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
All Other (less than 10% of construction costs)	Remaining Construction Items	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	1	0	0	0	0	1	0	$11,906
31 CONSTRUCTION MANAGEMENT	Construction Management	2	2	0	0	0	2	1	$8,504
									$69,001
Risk		$ 25,899	$ 19,808	$ 10,968	$ 1,834	$ 2,272	$ 15,072	$ 349	**$76,201**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 25,899	$ 19,808	$ 10,968	$ 1,834	$ 2,272	$ 15,072	$ 349	**$76,201**
								Total	**$145,202**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Caisson & Dredge 35')
PROJECT NO: P2 #145545
LOCATION: Hilo, Island of Hawaii, Hawaii

DISTRICT: Honolulu District **PREPARED:** 5/1/2015
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi

This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
06	FISH & WILDLIFE FACILITIES	$9,224	$9,501	103.0%	$18,725	1.5%	$9,358	$9,639	$18,997	$0	$18,997	11.1%	$10,395	$10,707	$21,102
10	BREAKWATER & SEAWALLS	$34,463	$35,497	103.0%	$69,960	1.5%	$34,964	$36,013	$70,978	$0	$70,978	11.1%	$38,838	$40,003	$78,842
12	NAVIGATION PORTS & HARBORS	$21,841	$22,496	103.0%	$44,337	1.5%	$22,159	$22,823	$44,982	$0	$44,982	11.1%	$24,614	$25,352	$49,966
	CONSTRUCTION ESTIMATE TOTALS:	$65,528	$67,494		$133,022	1.5%	$66,481	$68,475	$134,957	$0	$134,957	11.1%	$73,847	$76,062	$149,909
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	$0	$63	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN	$16,053	$16,535	103.0%	$32,588	2.3%	$16,422	$16,915	$33,338	$0	$33,338	12.5%	$18,479	$19,034	$37,513
31	CONSTRUCTION MANAGEMENT	$11,467	$11,811	103.0%	$23,278	2.3%	$11,731	$12,083	$23,814	$0	$23,814	23.6%	$14,504	$14,939	$29,443
	PROJECT COST TOTALS:	$93,102	$95,848	102.9%	$188,950		$94,689	$97,482	**$192,171**	$0	**$192,171**	12.9%	$106,887	$110,043	$216,930

CHIEF, COST ENGINEERING, Gary F. Yamauchi

PROJECT MANAGER, Derek J. Chow

CHIEF, REAL ESTATE, Steven N. Cayetano

CHIEF, PROJECT MGT, Anthony J. Paresa

CHIEF, ENGINEERING, Todd C. Barnes

CHIEF, Civil Works Tech Branch, Michael F. Wong

CHIEF, CONSTRUCTION, Olson T. Okada

CHIEF, CONTRACTING, Marilyn Clark

CHIEF, Programs Mgt Branch, Roxane E. Iseri

CHIEF, PROJECT MGT, Anthony J. Paresa

ESTIMATED FEDERAL COST:	**65%**	**$141,005**
ESTIMATED NON-FEDERAL COST:	**35%**	**$75,926**
ESTIMATED TOTAL PROJECT COST:		**$216,930**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: SA-Hilo Harbor Modifications, HI (Caisson & Dredge 35')
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Hilo Harbor Feasiility Study

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Gary F. Yamauchi
PREPARED: 5/1/2015

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			**1-May-15**	Program Year (Budget EC):			2016					
		Effective Price Level:			1-Oct-14	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
06	FISH & WILDLIFE FACILITIES	$9,224	$9,501	103.0%	$18,725	1.5%	$9,358	$9,639	$18,997	2021Q3	11.1%	$10,395	$10,707	$21,102
10	BREAKWATER & SEAWALLS	$34,463	$35,497	103.0%	$69,960	1.5%	$34,964	$36,013	$70,978	2021Q3	11.1%	$38,838	$40,003	$78,842
12	NAVIGATION PORTS & HARBORS	$21,841	$22,496	103.0%	$44,337	1.5%	$22,159	$22,823	$44,982	2021Q3	11.1%	$24,614	$25,352	$49,966
	CONSTRUCTION ESTIMATE TOTALS:	$65,528	$67,494	103.0%	**$133,022**		$66,481	$68,475	$134,957			$73,847	$76,062	$149,909
01	LANDS AND DAMAGES	$54	$8	15.0%	$62	1.5%	$55	$8	$63	2018Q3	4.7%	$57	$9	$66
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$1,638	$1,687	103.0%	$3,325	2.3%	$1,676	$1,726	$3,402	2018Q4	11.0%	$1,860	$1,915	$3,775
1.0%	Planning & Environmental Compliance	$655	$675	103.0%	$1,330	2.3%	$670	$690	$1,360	2018Q4	11.0%	$744	$766	$1,510
15.0%	Engineering & Design	$9,829	$10,124	103.0%	$19,953	2.3%	$10,055	$10,357	$20,412	2018Q4	11.0%	$11,159	$11,493	$22,652
1.0%	Reviews, ATRs, IEPRs, VE	$655	$675	103.0%	$1,330	2.3%	$670	$690	$1,360	2018Q4	11.0%	$744	$766	$1,510
1.0%	Life Cycle Updates (cost, schedule, risks)	$655	$675	103.0%	$1,330	2.3%	$670	$690	$1,360	2018Q4	11.0%	$744	$766	$1,510
1.0%	Contracting & Reprographics	$655	$675	103.0%	$1,330	2.3%	$670	$690	$1,360	2018Q4	11.0%	$744	$766	$1,510
3.0%	Engineering During Construction	$1,966	$2,025	103.0%	$3,991	2.3%	$2,011	$2,072	$4,083	2021Q3	23.6%	$2,487	$2,561	$5,048
0.0%	Planning During Construction	$0	$0	103.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	103.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
15.0%	Construction Management	$9,829	$10,124	103.0%	$19,953	2.3%	$10,055	$10,357	$20,412	2021Q3	23.6%	$12,432	$12,805	$25,237
0.0%	Project Operation:	$0	$0	103.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
2.5%	Project Management	$1,638	$1,687	103.0%	$3,325	2.3%	$1,676	$1,726	$3,402	2021Q3	23.6%	$2,072	$2,134	$4,206
	CONTRACT COST TOTALS:	$93,102	$95,848		$188,950		$94,689	$97,482	$192,171			$106,887	$110,043	$216,930

HiloHarbor-CaissonDredge(35)(r9Sep15)

Estimated by	T. Kazunaga, POH-EC-S
Designed by	Tom Smith, POH-EC-T
Prepared by	Tracy Kazunaga
Preparation Date	9/9/2015
Effective Date of Pricing	10/1/2021
Estimated Construction Time	554 Days

Description	ContractCost
Contract Cost Summ (ECC)	**65,528,372.50**
06 Fish and Wildlife Fac (Environmental Mitigation)	**9,223,626.22**
Envir Mitigation for Caissons	**7,378,900.98**
Envir Mitigation for Dredging	**1,844,725.24**
10 Breakwaters (Cast at Hilo Harbor)	**34,463,335.07**
1000 Breakwaters	**34,463,335.07**
12 Navigation Ports & Harbors (35' MLLW)	**21,841,411.21**
1202 Harbors (Dredging) @ 35' MLLW	**21,841,411.21**

Abbreviated Risk Analysis

Project Name & Location: **Hilo Harbor, Hilo Harbor, Hilo**
Project Development Stage/Alternative: **Feasibility (Alternatives)**
Risk Category: **Moderate Risk: Typical Project Construction Type**

District: POH
Alternative: Caisson + 35' Dredge
Meeting Date: 5/4/2015

Total Estimated Construction Contract Cost = **$ 65,528,000**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 54,000		15.00%	$ 8,100	$ 62,100
1	10 BREAKWATERS AND SEAWALLS	Caisson	$ 34,463,000		166.13%	$ 57,254,435	$ 91,717,435
2	12 NAVIGATION, PORTS AND HARBORS	Mob, Demob & Prep Work	$ 1,218,000		64.07%	$ 780,383	$ 1,998,383
3	12 NAVIGATION, PORTS AND HARBORS	Dredging	$ 20,624,000		131.02%	$ 27,020,645	$ 47,644,645
4	06 FISH AND WILDLIFE FACILITIES	Environmental Mitigation	$ 9,223,000		70.94%	$ 6,542,482	$ 15,765,482
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other (less than 10% of construction costs)	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 16,053,000		11.30%	$ 1,814,647	$ 17,867,647
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 11,467,000		22.75%	$ 2,609,227	$ 14,076,227
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 54,000	15.00%	$ 8,100	$ 62,100.00
Total Construction Estimate	$ 65,528,000	139.78%	$ 91,597,945	$ 157,125,945
Total Planning, Engineering & Design	$ 16,053,000	11.30%	$ 1,814,647	$ 17,867,647
Total Construction Management	$ 11,467,000	22.75%	$ 2,609,227	$ 14,076,227
Total	**$ 93,102,000**	**103%**	**$ 96,029,920**	**$ 189,131,920**

	Base	50%	80%
Range Estimate ($000's)	$93,102k	$150,720k	$189,132k

* 50% based on base is at 50% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Hilo Harbor, Hilo Harbor, Hilo Caisson + 35' Dredge

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 4-May-15

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
PS-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x25x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Weight of caisson limits crane application of caissons. No access to roll caissons from shore. Optimum is build in dry and float. This would require additional facilities at Hilo Port.	Critical	Very LIKELY	5
PS-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clammshell dredge with rock bucket for dredging.	Estimate assumes local availability of dredge plant. Assume larger (heavier) rock bucket is shipped in. (see dredging concerns)	Moderate	Likely	3
PS-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities call for 210,000 cyds at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	It is possible the excavated/screened material is not geotechnically suitable for reuse for the berms, fill and riprap. Any import of material will significantly impact the cost by increasing disposal costs.	Significant	Possible	3
PS-4	Environmental Mitigation	Scope not well defined. Possible scope growth.	Scope will not be defined until coordination with the USFW is completed. Cost could increase or decrease.	Moderate	Likely	3
PS-13	Planning, Engineering, & Design	PED cost could be underestimated when compared to historical PED costs calculated using % of Construction Cost.	The PED cost was estimated based the key level of effort for each discipline and it was provided to the Project Mgr . It is possible that additional requirements necessary to complete the design is omitted. The likelihood of it occurring is marginal.	Marginal	Possible	1
PS-14	Construction Management	Subsurface unknowns might be discovered during excavation, causing delay and increase in costs.	It is possible that underground utilities, cultural deposits and burials are found during the construction phase which could result in delays and increased project costs as the design is revised. The likelihood of findings any utilities, cultural deposits and burials is unlikely because preliminary surveys conducted did not find any.	Marginal	Likely	2
AS-1	Caisson	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5

AS-2	Mob, Demob & Prep Work	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5
AS-3	Dredging	Larger clamshell dredge with rock bucket for dredging. Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized. Compitition is low. High risk due to required plant to remove hard material. What if the plant will not??	Significant	Very LIKELY	5
AS-4	Environmental Mitigation	Estimate assumes full and open acqusition plan.	Acqusition method has not been finalized.	Significant	Very LIKELY	5
AS-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0
AS-14	Construction Management	Small business contractor may need more Government Oversight.	If the construction contract is awarded to a small business contractor unfamiliar with the submittal process, more government oversight may be required. The impact to Construction Management cost would be moderate since more off-island travel would be required to provide Government assistance. This may possibly increase the cost to Construction Management.	Moderate	Possible	2
CON-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Casting of concrete with reinforced steel, could be challenging. Heat, shrinkage and volume changes. Estimate assumes need to have the base slab cast first for reinforcing steel placement, something to lap the wall reinforcement too and to support the interior wall form work from. From there a continuous placement. Need to make sure there are no cold joints, during the placement so depending on the mix design so plenty of trucks and vibrators, high water reducing agents etc., placing in cooler weather, so in some locations night-time helps. Estimate assumes this will nott be your a typical ready mix.	Significant	Likely	4
CON-2	Mob, Demob & Prep Work	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities call for 210,000 cyds at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	It is possible a modification to the contract would be needed if hard material is too hard for excavation with rock bucket. Also, material is assumed to be a limestone material, which may required double handling for disposal at ODMS re-use is unsatisfactory geotechnically. The impact to the cost would be significant since due to increased disposal fee and hauling costs.	Critical	Likely	5
CON-4	Environmental Mitigation	Minor Concerns	N/A.	Negligible	Unlikely	0

CON-13	Planning, Engineering, & Design	Minor Concerns	N/A.	Negligible	Unlikely	0
CON-14	Construction Management	Minor Concerns	N/A.	Negligible	Unlikely	0
Q-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Dredge material used for caisson fill and local fill from bedding and remiander of caisson fill. Depending on sea floor material. It is assume material would remain on barge prior to placement within caisson.	Additional fill may be required, if dredging material is not suitable.	Moderate	Possible	2
Q-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clammshell dredge with rock bucket for dredging.	Based on material type (hard) and depth, A large plant brought from the mainland is possible.	Moderate	Possible	2
Q-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities call for 210,000 cyds at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	Hard material, requires overdepth to reach pay line. Estimate assumes 1ft on avg depth. This could require additional depending on hardness and bucket size.	Moderate	Likely	3
Q-4	Environmental Mitigation	Quantities not provided at this stage.	It is likely the quantity will change based as further information is developed.	Moderate	Likely	3
Q-13	Planning, Engineering, & Design	No quantities for PED.	N/A.	Negligible	Unlikely	0
Q-14	Construction Management	No quantities for CM.	N/A.	Negligible	Unlikely	0
FE-1	Caisson	Option requires dewater or water access facilities to be constructed	Option requires dewater or water access facilities to be constructed	Marginal	Likely	2
FE-2	Mob, Demob & Prep Work	None	N/A.	Negligible	Unlikely	0
FE-3	Dredging	None	N/A.	Negligible	Unlikely	0
FE-4	Environmental Mitigation	None	N/A.	Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None	N/A.	Negligible	Unlikely	0

FE-14	Construction Management	None	N/A.	Negligible	Unlikely	0
EST-1	Caisson	Current design calls for breakwater spur constructed as 1000 lf of caisson of 50x21x25 cast, rolled in water and float to jobsite. 20 ea. Current weight of caisson exceed 3Mlbs per each. Casting at Hilo has limited oppurtunity. There is sufficient room at "boneyard" near the port, however access to water is no available. There are exiisting local canoe club which resides on location. Optimum approach would be to build a temp "graveyard" spur, dewater, cast caisson, re-water and float. There is also concern on gap opening between perm pier and breakwater from shore to jobsite. Prep at spur site requires special equipment to prepare sea floor for caisson placement. Dredge material used for caisson fill.	Estimating approach depends on obtaining access to water from Hilo Port "Boneyard" area. This option requires disruption of existing site. If this is not feasibile, this option is no longer valid.	Critical	Likely	5
EST-2	Mob, Demob & Prep Work	Depth of water and material type requires larger clammshell dredge with rock bucket for dredging.	Assumes, main plant is available within Honolulu area with competition. If not then most likely will result in cost increase.	Negligible	Unlikely	0
EST-3	Dredging	Depth of water and material type requires larger clamshell dredge with rock bucket for dredging. Current quantities call for 210,000 cyds at the 35' level. Contractor will be have to excavate beyond the 35' limit to meet pay prisim. Cost Estimate assumes avg if 1ft over dredging area. This is handled as "Non Pay" yardage included within the calculation of the unit price.	Assumes, main plant is available within Honolulu area with competition. This also assumes the material could be dredged without drill and blast or splitting. If not then most likely will result in cost increase.	Significant	Likely	4
EST-4	Environmental Mitigation	Estimate based on a similar project and the acrage of corals impacted.	Estimate was based on a similar project & area of impacted corals. For Barbers Point, the cost of mitigation that USFWS (and other agencies) requested would have been $2 million dollars. For that project, the acreage of corals that would have been removed is significantly higher than the acreage being proposed for Hilo Harbor assumptions.	Moderate	Possible	2
EST-13	Planning, Engineering, & Design	No concerns. The cost was provided by the Project Manager.	It is assumed major PED items are included. It is possible unanticipated tasks are needed in the PED stage which could marginally increase the PED cost.	Marginal	Possible	1
EST-14	Construction Management	Based upon above, construction contract period could be larger than priced.	Based upon above, construction contract period could be larger than priced.	Moderate	Possible	2
EX-1	Caisson	Community opposition or lack of support. Requires excavation of sea floor for placement.	Requires permit to exacavate in area and placement of permenate structure. It is possible the community opposes the project construction method. The rating is marginal since public meetings and review will be held to minimize lack of support and resolve obstacles.	Negligible	Unlikely	0
EX-2	Mob, Demob & Prep Work	Minor Concerns	N/A.	Marginal	Possible	1
EX-3	Dredging	Possibility for fuel increase.	Fuel prices have recently decreased in the past months and appear to be currently slowly increasing. It is likely the cost of fuel will escalate when the project is awarded causing significant increase to the cost since the project uses heavy sitework equipment.	Significant	Likely	4
EX-4	Environmental Mitigation	Minor Concerns	N/A.	Marginal	Possible	1
EX-13	Planning, Engineering, & Design	As the project moves to construction, the local government could impose further requirement which delays the project construction.	It is possible the PED cost was underestimated if additional legal requirements are imposed. The rating is negligible since the project is coordinated through legal channels. Time for permits.	Negligible	Possible	0

EX-14	Construction Management	Local protests could delay construction work.	It is possible community protests and disagreements could delay construction work and increase to the CM cost requiring more Government quality assurance. The impact to the CM would be marginal since it is anticipated that through public outreach and notices, the community concerns are addressed.	Marginal	Possible	**1**

Hilo Harbor, Hilo Harbor, Hilo Caisson + 35' Dredge
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$54
10 BREAKWATERS AND SEAWALLS	**Caisson**	5	5	4	2	2	5	0	$34,463
12 NAVIGATION, PORTS AND HARBORS	Mob, Demob & Prep Work	3	5	0	2	0	0	1	$1,218
12 NAVIGATION, PORTS AND HARBORS	Dredging	3	5	5	3	0	4	4	$20,624
06 FISH AND WILDLIFE FACILITIES	Environmental Mitigation	3	5	0	3	0	2	1	$9,223
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
0	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
All Other (less than 10% of construction costs)	Remaining Construction Items	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	1	0	0	0	0	1	0	$16,053
31 CONSTRUCTION MANAGEMENT	Construction Management	2	2	0	0	0	2	1	$11,467
									$93,048
Risk		$ 25,255	$ 26,713	$ 17,937	$ 2,984	$ 1,938	$ 16,792	$ 4,403	**$96,022**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 25,255	$ 26,713	$ 17,937	$ 2,984	$ 1,938	$ 16,792	$ 4,403	**$96,022**
								Total	**$189,070**

Hilo Harbor Navigation Improvements
Feasibility Investigation Summary Report
Hilo, Hawaii

APPENDIX E
ECONOMIC EVALUATION

1. INTRODUCTION

The scope of this feasibility study was for the Project Development Team (PDT), including the project's non-Federal sponsor, to investigate the existing problems and opportunities at Hilo Harbor, inventory and forecast present and future conditions, formulate and evaluate potential alternatives to address the problem, compare these alternatives and, if an alternative or alternatives could yield a positive benefit cost ratio, determine which plan would generate the most net economic benefits.

Going into the study, the PDT felt there was a reasonable expectation that when these analyses were complete, they would show that the total impact of these NED benefits for at least one alternative would outweigh the cost of the improvements necessary to achieve it. Therefore, it was determined to be in the Federal interest and the USACE's mission to facilitate commercial navigation to pursue these harbor improvements. As it turned out, the costs of the necessary harbor improvements outweighed the achievable level of NED benefits and none of the alternatives were economically feasible.

4. EXISTING GENERAL CONDITIONS OF HILO HARBOR

Hilo is located on the northeast coast of the Island of Hawaii, at the eastern end of Kuhio Bay, an arm of Hilo Bay, approximately two miles east of the business district of Hilo, the principal city of the island. Hilo Harbor is one of the two main commercial ports for the Island of Hawaii (Kawaihae Harbor serves the west side of the island).

The entrance to the port is in deepwater from the north, between a coral reef (Blonde Reef) on the east and the shores of Hilo Bay on the west; thence easterly through the bay and following inside the reef to Kuhio Bay. A 10,080-foot long rubblemound breakwater extends in an arc along the reef from the shore east of Kuhio Bay.

In addition to conventional and containerized general cargo, the principal waterborne commodities handled at the port are molasses, petroleum products, fertilizer and cement.

The completed portion of the existing project, authorized by the River and Harbor Acts of March 2, 1907, July 25, 1912, and March 3, 1925, provided for the following work:

- A rubblemound breakwater 10,080 feet long
- An entrance 35 feet deep
- A harbor basin 1,400 feet wide, 2,300 feet long and 35 feet deep

This portion of the project was completed in July 1930. Last maintenance dredging was accomplished over a decade ago, but another maintenance job is scheduled for Fiscal Year 2016. At the time of survey for the 1998 maintenance dredging, the controlling depths of all projects were considered to be at project depth 35 feet. All depths refer to the plane of mean lower low water. There are no bridges crossing Hilo Harbor.

Hilo Harbor has three existing piers and a fourth (Pier 4) to be constructed by 2016. Pier 1 is 1,265 feet long and is used by interisland container barges, cargo ships, and large cruise ships. Pier 2 is 703 feet long and is used by cement barges and has a roll-on/roll-off interisland barge facility. Pier 3 is 637 feet long and is primarily used by fuel barges. The proposed Pier 4 will be 602 feet long and used to support interisland cargo operations (separating these operations from cruise ship loading and offloading at Pier 1).

4.1. PIER 1: 1265 Ft Long

General Users of Pier1 are cruise ships, PASHA's car carriers and Matson Navigation Company's barges. Pier 1 can handle overseas containers, cruise ships and Ro/Ro, including most of the automobiles. Platform at inner end is used for stern loading of roll-on/roll-off cargo and also serves Pier 2. An occasional aggregate ship is also worked at Pier 1. Pier 1 handles more than one-half of Hilo's traffic.

Approximately 10 acres of open storage area (up to 3.4 acres in 2004), including 70 refrigerated container positions located at outer end of wharf and at rear of transit shed. A 466-foot-long concrete bulkhead extending east from rear of face (Radio Bay wharf) is used for mooring small craft, including pilot boat in small boat house and USCG vessels at a steel pile, timber-decked pier located adjacent to the boat house. One 33-ton top pick and five yard hustles provide cargo handling equipment at Pier 1 with additional stevedore equipment available as required.

4.2. PIER 2: 703 Ft Long (includes about 170-foot angular portion)

General Users of Pier 2 are Young Brothers, handling mostly inter-island, barged cargo, and Hawaiian Cement Corporation. Pier 2 handles a relatively small amount of Hilo's traffic. The platform at the inner end of Pier 2 is used for stern loading of roll-on/roll-off cargo and also serves Pier 1. It has 2.0 acres of yard area and 37,884 sq ft of shed area (2004).

- Young Brothers has approximately 4 acres of paved open storage are, including 5 refrigerated container positions, are located at rear of Piers 2 and 3.
- Hawaiian Cement Corp has one 10-inch pneumatic pipeline extending from wharf to one 2,000-ton-capacity bulk cement storage tank.

4.3. PIER 3: The Fuel Pier, 637 Ft Long

Pier 3 handles liquid-bulk cargo and pipelines, including fuels, liquefied petroleum gas (LPG) and some chemicals. General Users of Pier 3 are Young Brothers, Chevron Products, Tosco Distribution Corporation, Texaco Refining and Marketing, Tesoro Petroleum Corporation, Shell Oil Company, Citizens Utilities Services and the Gas Company. It has 7.3 acres of yard area. Pier 3 is the second most busy of Hilo Harbor's three piers. It also handles a small amount of inter-island cargo, and Pier 3 is the backup dock for smaller cruise ships on the 6-8 days per year when a 900-foot plus and a 500-700-foot cruise ship call on the same day . To date, the port has never scheduled two 900-foot LOA cruise ships on the same day.

- Total storage capacity of petroleum and gas products: 373,200 barrels in 61 tanks.
- Young Brothers has approximately 4 acres of paved open storage are, including 5 refrigerated container positions, are located at rear of Piers 2 and 3.
- Chevron Products, Company, Inc.: One 10-inch and three 8-inch pipelines extend from wharf to 16 storage tanks at rear, total capacity 118,000 barrels.
- Tosco Distribution Corporation: One 8-inch, three 6-, and one 4-inch pipelines extending from wharf to seven steel storage tanks at rear, total capacity 96,000 barrels, were not in use at time of this survey.
- Texaco Refining and Marketing, Inc.: Three 6-inch pipelines extend from wharf to seven storage tanks at rear, total capacity 45,000 barrels.
- Tesoro Petroleum Corporation: Two 6-inch pipelines extend from wharf to three storage tanks at rear, total capacity 33,900 barrels.
- Shell Oil Company: One 8-inch pipeline extends from wharf to seven steel storage tanks at rear, total capacity 63,000 barrels.
- Citizens Utilities Services, d.b.a. The Gas Company: Bringing in LPG. One 8-inch pipeline extends from wharf to 21 storage tanks at rear total capacity 17,300 barrels.
- Backup dock for 2nd cruise ship and some inter-island cargo

4.4. Pier 4

Pier 4 is under construction and expected to come on-line in 2015. Therefore, it should be included as part of the future without project condition. It basically follows parallel to the shoreline adjacent to Pier 3, and would provide another 602 feet of berthing space. It would only be dredged to 25 feet to accommodate the inter-island barges. Pier 4 would have additional 10 acres of yard storage.

4.5. Pier 5

Pier 5 is much further into the future and is not going to be included in the future without project condition at this point. Long range plans has Pier 5 becoming the main cruise line berth with a length of 830 feet, and the capacity to exceed that length to berth cruise ships over 1,000 feet LOA.

Hilo Harbor serves as a port of call for the cruise ship industry which contributes significantly to the local economy. Over the past few years, an average about 100 cruise ships greater than 900 feet long have called at Hilo Harbor. Attempts to maneuver these and other large vessels within the harbor are done at significant risk to both the vessels and harbor facilities particularly during times of adverse (surge) conditions due to limited size of the harbor turning basin.

Anchorages may be obtained anywhere under the lee of the breakwater where depths are suitable. Good anchorage is available west of Kaulainaiwi Island in depths of 25 to 35 feet over good holding ground. Protected, small-craft anchorages with fair holding ground may be found south of Kuhio Bay, and in the basin east of Pier 1. The Hilo harbormaster usually assigns deep-draft anchorages. There are also 3 anchorages offered in deep ocean water outside the breakwater.

5. RECENT TONNAGE TOTALS FOR HILO HARBOR

According to Waterborne Commerce Statistics of the U.S., as shown in Table 1, about 1 million short tons per year have been moving through Hilo Harbor over recent years. Clearly, imports at Hilo vastly outweigh the port's exports. For whatever reason, annual cargo tonnage totals supplied by the Hawaii Department of Transportation, Harbors Division, differed considerably from those found in Waterborne Commerce Statistics, but this difference was not a factor in the economic analysis that ultimately produced a poor benefit cost ratio.

Table E1: Waterborne Commerce Statistic's Estimate of Imported and Exported Cargoes, 2012-2014, Hilo Harbor, Hawaii

Fiscal year	Imports					
	Foreign		Domestic		Inter-Island	
	Short Tons	TEUs	Short Tons	TEUs	Short Tons	TEUs
2012	11,205		31,117	0	1,022,460	22,055
2013	15,113	0	44,202	126	905,728	22,648
2014	20,711		28,664	231	959,766	26,802

Fiscal year	Exports					
	Foreign		Domestic		Inter-Island	
	Short Tons	TEUs	Short Tons	TEUs	Short Tons	TEUs
2012	0	0	20,309	0	150,117	11,087
2013	0	0	16,437	37	82,328	7,687
2014	0	0	8,703	40	98,835	12,093

6. PROBLEMS AND OPPORTUNITIES AT HILO HARBOR

The purpose of the study is to address concerns expressed by the non-federal sponsor in a letter to the Honolulu District dated October 24, 2003. The letter states that "The Hawaii Pilots Association has expressed difficulties encountered when maneuvering such large vessels within Hilo Harbor's turning basin and has run the risk of groundings. Furthermore, adverse surge conditions at Hilo Harbor, normally occurring during the winter months, preclude Hilo Harbor users in safely mooring and operating from their vessels. Adverse surge conditions also inflict damage(s) to vessels and Hilo Harbor facilities (e.g., pier structure. bollards, etc.) when vessels are pushed into or pulled away from the piers due to high surge conditions. The mitigation of such adverse surge conditions is a widely held interest amongst the Hilo Harbor users."

The PDT, including the non-Federal sponsor, discussed a number of problems and opportunities for Hilo Harbor during the early months of this study. USACE staff explained at that time how economic impacts of things like groundings and damages to infrastructure from surge events would have to be evaluated on the basis of the frequency of their occurrence. These potential benefits are difficult to flesh out, and if they occur infrequently, the magnitude of their economic consequence on an annual basis greatly diminishes when assigned a probability of it actually happening. For example, the economic and environmental damages of a vessel grounding can be enormous, but when annualized and the probability of it occurring is taken into account, the monetary value of that annual benefit tends to be small. This is especially true with a harbor like Hilo where groundings are extremely rare. In fact, all safety and life loss prevention related beneficial impacts of the kinds of harbor improvements this study deals with, generally do not equate to large monetary sums unless there is an extensive historic record of vessel groundings, collisions, allisions, near misses, or other mishaps. Safety considerations are important, on-going problem with pilots and other ship operators taking risks moving large vessels in tight places; they just happen to be very good at what they do.

7. PROJECT GOALS

The project goals are as follows:

- Improve navigation and operational efficiency of the harbor
- Increase allowable vessel sizes calling at Hilo Harbor
- Improve safe use of Hilo Harbor

8. BENEFIT CATEGORIES

The crucial benefit category that most of the positive economic impacts of this kind of harbor improvement study will need to justify the project's costs is increasing the harbor's economic efficiency. These can be generally related to things like correcting economic inefficiencies due to problems maneuvering ships or handling cargo. Or efficiencies can be improved by reaping the benefits of economies of scale such as attracting larger capacity ships capable of reducing the transportation cost of delivered products. With this latter benefit being more associated with harbor deepening projects, the remaining prevailing benefit to cover the majority of the project's costs at Hilo Harbor will be related to improving the turning basin efficiency. For the proposed improvements to demonstrate that they are economically justified in the case of Hilo Harbor, the benefits resulting from increasing the efficiency of the turning basin alone would have to be nearly sufficient to cover the project's costs. Then, more limited benefits like reducing damages to ships and landside facilities and attracting new, larger ships to call at Hilo could help push the benefit cost ratio above unity.

8.1. Inadequate Turning Basin Size

The turning basin dimensions (width and length) are inadequate for the existing and future fleet calling at Hilo Harbor. The existing turning basin design was based on a vessel of 700ft-length, 92 ft-beam, and 29 ft-draft. There are currently several cruise ships calling at Hilo Harbor with lengths of 965 feet, and one (Celebrity 's "Solstice of the Seas") with a length of 1041 feet, a beam of 121 ft, and a draft of 27 ft, which can call at Hilo during calm conditions. Due to the limited turning area for these larger vessels calling at Hilo Harbor, there is currently a high risk of vessel groundings. This in turn leads to a high risk of environmental contamination from potential groundings (oil, petroleum product releases, etc.).

Enlarging the turning basin would greatly increase safe harbor operations and reduce the likelihood of groundings while maneuvering in the existing channel when high winds and strong surging waves are present. Enlarging the turning basin will also reduce maneuvering time and increase efficiency of many of the larger vessels calling at Hilo Harbor. Reducing maneuvering time equates to reducing Vessel Operating Costs (VOC), and reducing VOC is a NED benefit. Enlarging the turning basin could also stimulate the port's business to attract newer, larger and more profitable cruise ships, which is an important and quantifiable benefit.

The limited turning basin dimensions also impede port operations, as delays are associated with maneuvering and docking time. Limited clearance exists between Pier 1, Pier 2 and the shallow area adjacent to the breakwater, requiring extra time for turning and berthing of vessels.

The existing Federal channel limit is approximately 600 feet from the face of Pier 1. This space between the edge of the Federal turning basin and the Pier 1 berthing area requires vessels to execute turning maneuvers for arrival and departures well outside the limits of the Federal turning basin.

The surge problems experienced at certain times of the year (discussed below) further amplify the difficulties experienced in turning and maneuvering in the undersized basin.

8.2. Surge Impacts on Navigation

Reducing delays for vessels and damages to ships and portside infrastructure due to surge problems within Hilo Harbor were also investigated. Surge problems within the harbor have also caused ship call cancellations and discouraged new customers from calling at Hilo. During high wave conditions, frequently occurring in the winter months, waves and long-period wave surge impact navigation in the entrance channel and turning basin, resulting in vessel delays. This also presents a safety issue as there is no “Plan B” contingency at the harbor for cruise ships that encounter hazardous navigation conditions while entering or exiting the harbor. These gains in efficiency and reductions in vessel and facilities damages would be NED benefits if the surge issue could be addressed.

8.3. Surge Impacts on Operations

Long-period wave surge in the harbor also impacts operations. During periods of large waves in the winter, increased time is required for loading/offloading and mooring of passenger, cargo and commodities vessels. The piers have experienced damage in the form of damaged bollards, damaged pier faces and bulkheads, and broken mooring lines due to vessel movement while docked. For instance, Division of Harbor officials reported that while holding a large cruise ship at the dock during one surge event, several bollards were damaged to the point they had to be replaced. That cost was about $15,000. Damage to the vessels themselves has also been experienced, yet documentation is sparse.

8.4. Risk Assessment and Other Safety Considerations

Pilots and other ship, tug and barge operators are known to take more risks than they would in a more ideal harbor setting. Maneuvering large cruise ships and other vessels in tight quarters demands risk taking, skill and courage on the part of the pilots and other operators. To their credit, they are very good at what they do and have had no serious collisions or other consequences. Nonetheless, the PDT searched for monetary benefits to offset the costs of improving the situation within the harbor for these mariners.

9. ESTABLISH EXISTING OPERATING PRACTICES

An average of about 100 cruise ships greater than 900 feet in length call at Hilo Harbor each year. In addition to these large cruise ships, several smaller ones also call occasionally. Cruise ships comprise about 12 to 15 percent of the annual ship calls. Hilo Harbor's primary customer is barge traffic. Barges and their tugs generally make up about 75 percent of Hilo Harbor's traffic. Between 322 and 375 feet long, these barges make the trip from Honolulu to Hilo several times a week carrying most of the fuel, food products and other supplies consumed by the resident and tourist population of the Big Island. Since 2011, there are approximately 200 barge transits (i.e., a round trip) usually originating and ending in Honolulu, at Hilo Harbor each year. Cargo ships in and out of Hilo each year average about 35 transits over these past 3 years. More than 70 percent of these, or 25 transits per year, are the comings and goings of the car carrier from the mainland, the 579-foot long Jean Anne. The rest are primarily tankers in the 400 to 550-foot long class. The future fleet mixes for both with- and without- project conditions, based on waterborne commence trends at Hilo Harbor, were also developed for this study are being still being developed at this point in the study.

The existing harbor depth of 35 feet has not become an issue and is not likely to present problems in the near future. The deepest draft vessel expected to call regularly (beginning in late 2015) at Hilo Harbor drafts 31 feet, while the largest of the cruise ships expected to call draft several feet less. However, under existing and future without project conditions, vessel operations are constrained by the current size of the turning basin. Harbor pilots maneuvering large cruise ships (900 to 1100 feet long, well in excess of the 700-ft original design vessel) have difficulty berthing and disembarking at Pier 1 due to the shallow depths just outside the northern edge of the existing Federal channel, adjacent to the breakwater. Intense coordination is required between the pilot, assist tugs and spotters (stationed at the bow and stern) to navigate large cruise ships in and out of Pier 1. If there is a barge or cruise ship moored at Pier 2, the room to maneuver vessels is further decreased. In many cases the pilot is not able to see navigation hazards if standing on bridge, so the pilot must rely on spotters, which is not always a safe practice. This causes delays for both the cruise ships, as well as smaller vessels waiting for them to vacate the congested area. In addition, larger cruise ships that call at Honolulu Harbor are not able to call at Hilo Harbor due to the limited turning basin size. There is additional demand to call at Hilo due to the unique opportunity to visit the active volcanoes on the Big Island of Hawaii. Only 30 miles from Hilo, Volcanoes National Park averages 1.4 million visitors each year, many of whom use Hilo Harbor as their stepping-off point.

In addition, the existing configuration of Hilo Harbor allows excessive long-period wave surge to enter the Federal channel, turning basin, and berthing areas during periods of large wave energy from the north, typically in winter months. The winter is the primary season for cruise-ship tourism, due to the more temperate weather in Hawaii. Inter-Hawaiian Island cruise business remains strong throughout the entire year, but many of the larger cruise ships head to

Alaskan waters for the summer months. Surge is also an issue for barges delivering inter-island cargo and fuel to the Big Island, a critical service that occurs year-round. All vessels entering and exiting the harbor during these surge conditions experience delays during navigation due to the extra caution required to transit the channel and turning basin safely. In some cases, vessels have foregone calls to the harbor because surge conditions within the harbor (in combination with the limited turning basin size) have been determined too dangerous to maintain safety. In the case of inter-island barges, this missed call results in delayed delivery of cargo/fuel and additional cargo transportation costs. For cruise ships, a missed call to Hilo results in an extra day at sea in lieu of the Hilo visit, causing a loss of tourism revenue in the Hilo area, and disappointed cruise ship passengers who have missed the opportunity to visit the Volcanoes National Park, and may possibly request compensation from the cruise line.

Long-period wave surge also affects the vessels that are moored at Piers 1 and 2 under existing conditions. Operations such as tying up, loading/offloading, and refueling are impeded and delayed by the vessel motion that is experienced by moored vessels during surge conditions. Damages to vessels, pier infrastructure (bulkheads, bollards, etc.), and associated equipment (mooring lines) has also been experienced regularly during these conditions. While cruise ships are moored at Pier 1, they often are required to use their thrusters to remain in place when surge is being experienced, thereby utilizing additional fuel and manpower to ensure the safety of embarking/disembarking passengers and the vessel.

10. FUTURE WITHOUT PROJECT CONDITIONS

Future without project conditions will likely include all of the issues noted above, with added difficulty due to continued growth of the economy and tourism demand on the Big Island of Hawaii. The resident population of the Big Island has sustained the fastest growth rate in the State over recent decades, more than tripling since 1980. It is projected to maintain a population increase rate of two (2) times the State of Hawaii's average through the year 2040. Obviously, this population growth will require increased demand for inter-island cargo and fuel to the island. The location of the other deep-draft harbor on the island, Kawaihae Harbor, on the leeward side, precludes it from supporting demand to the entire island. Kawaihae Harbor currently has two piers which service primarily cement barges (Pier 1), and interisland cargo and fuel barge operations (Pier 2). There is no infrastructure to support berthing of cruise vessels. The costs to truck goods from the leeward to windward side over or around the high volcanic and mountainous terrain in between would increase significantly if Hilo Harbor were not able to support demand to the windward side. In addition, Kawaihae Harbor currently does not have the infrastructure or space to accommodate additional cargo and/or fuel. The growth of the economy and demand for barge-shipped cargo will result in increased vessel traffic at Hilo (both number of vessels and frequency of visits). This eventuality will cause an increase in the existing operational inefficiencies and transportation costs, and increased risk of vessel groundings which may have serious safety and environmental implications.

In addition, future demand for tourism to the Big Island, along with the general trend in the cruise line business to build bigger ships, will increase pressure to bring in larger cruise ships, and on a more frequent basis. The limited size of the turning basin (without improvement) will prevent the ability to accommodate larger cruise ships. Those cruise ships that do enter will be subject to difficult and possibly dangerous navigation limitations in the turning basin that may also be amplified under surge conditions. Future sea level rise in the islands (which is most pronounced in Hilo due to land subsidence) will increase water depth at the harbor, which could increase the surge impacts in both the Federal channel/turning basin and at the berthing areas. This effect would increase the noted effects of surge that exist now, including vessel motion and associated damages to vessels and harbor infrastructure.

For planning purposes the base year is 2020. This date is based on the anticipated completion year of construction. The time horizon for project benefits and costs is 50 years. Thus, the 50-year period of analysis starts at 2020 and ends in 2070. Price levels for project costs and benefits are October 2014 and a discount rate of 3-3/8 percent is assumed in the calculation of all annual equivalent values. Outputs for each of the project features will be measured in terms of their effect on the latest vessel operating costs (VOC) issued through the USACE's Institute of Water Resources. These will reflect efficiency improvements resulting from increased maneuverability and other factors that may save time and/or fuel. These outputs are expected to be significant as they will provide safer vessel operations and stimulate use of the harbor by larger vessels. This is anticipated to translate into increasing cargo and passenger volume with each vessel call, and in the case of cargo ships, possibly eliminate the cost of extra voyages. In addition, any project feature that effectively reduces surge conditions is expected to improve safety within the harbor and reduce potential for damages to vessels and port infrastructure.

11. FINAL ARRAY OF ALTERNATIVES

The SMART Planning paradigm basically involves expediting the process of boiling down alternative solutions to the problems at hand by using existing data and practices, along with logical assumptions, less efficient alternatives can be ruled out if favor of the one alternative that that the PDT agrees is superior. Then, that alternative and only that alternative, goes through the intensive modeling efforts by the PDT, including hydraulic modeling, preliminary design work, costing, and benefit evaluation.

The alternatives that the PDT formulated were screened based on a set of criteria agreed to by the PDT. One of the most important criterions was the alternatives projected cost and net benefits. In other words, how expensive would it be and would it likely have a positive benefit-cost ratio. Based on this and other criteria dealing with Effectiveness, Efficiency, Completeness and Acceptability, the PDT set out to formulate the best array of structural and nonstructural alternatives practicable.

11.1. Nonstructural Solutions

To minimize impacts and costs of construction, and comply with Federal regulations requiring equal consideration be given to a nonstructural plan, the PDT formulated the following nonstructural alternatives:

<u>Alternative 1 – Non Structural</u>

- NS1 : Change limits of federally-authorized project

- NS5: Mooring either in harbor or offshore in deeper areas during large waves
  Objectives met: Reduce damages, improve safety

Alternative 2 – Non Structural

- NS 2: Better navigational technologies (Lateral looking view similar to depth sonar)
- NS3: Close port at times of high surge
- NS4: More accurate GPS technology (within a foot) in the harbor and lobby NOAA to install PORTS system
  Objectives met: Improve operational efficiency, reduce damages and improve safety

Most of these nonstructural solutions are geared toward addressing the surge problem within Hilo Harbor. The Hilo Harbor port authorities have already been implementing some of these nonstructural measures and practices, such as closing the port on extreme surging days and mooring ships in and around the harbor while they wait for calmer water. Other ideas presented in these nonstructural solutions are likely to be pursued in the future, such as altering the federally authorized project limits and installing more sophisticated gages and equipment to better prepare ship operators for surge conditions in and around the docks. In the end, no attempts were made to calculate benefit-cost ratios (BCR) for either of these two nonstructural solutions. More along these lines follows in the Structural Solutions section.

11.2. Structural Solutions

Alternative 3 –Structural

- S3: Expand turning basin by dredging
- S2: Surge reduction structures (Wave attenuator, new BW, baffles, etc.)
  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

Alternative 4 –Structural

- S3: Expand turning basin by dredging
- S1: Decrease porosity of breakwater
- S4: Raise Breakwater Crest Elevation
  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

Alternative 5 – Most Assertive

- S3: Expand turning basin by dredging
- S2: Surge reduction structures (Wave attenuator, new BW, baffles, etc.)
- S1: Decrease porosity of breakwater
- S4: Raise Breakwater Crest Elevation
- Non-Structural Measures : Alt 1 or Alt 2
  Objectives met: Improve operational efficiency, reduce damages, enable larger cruise ships to call, improve safety

Several of these structural solutions deal with addressing Hilo Harbor's surge problem. Winter wind and swell conditions favorable for these turbulent harbor conditions happen an average of about 10 to 12 times per year. Occasionally, perhaps 2 to 3 times a year on average, surge conditions in the harbor are severe enough to wave off scheduled ship calls or damage moored vessels. Benefits to addressing surge in the harbor might include fuel savings, fewer cancelled ship calls, decreased damages to vessels, bollards, piers, and other harbor infrastructure, life and safety benefits for all concerned, and more interest shown by new shipping lines to call at Hilo; never do port authorities want these problems to add to ships not calling.

12. ROLE OF THE DDNPCX

The Deep Draft Navigation Planning Center of Expertise (DDNPCX) is the USACE's regionalized office responsible for all deep draft navigation economic analyses throughout the country. The Honolulu District economist worked closely with the Center to produce this economic appendix.

13. HARBORSYM: USACE'S CERTIFIED, BENEFIT-GENERATING MODEL

The HarborSym computer model, version 1.5.5.0 was used for the Hilo Harbor Modifications Study. The HarborSym model was developed by the U.S. Army Corps of Engineers Institute for Water Resources, located in Ft. Belvoir, Virginia, in cooperation with the Corps National Deep Draft Navigation Planning Center of Expertise, located in the Corps South Atlantic Division office in Atlanta, Georgia.

HarborSym is a computer simulation model that attempts to replicate vessel operations within the channel under various scenarios, including existing and future "without" project conditions as well as "with" project alternatives. Model inputs include information on port structures, such as channel segments, docks, turning basins and anchorages, commodity information, vessel / fleet information, including estimates of vessel operating costs, tides, port traffic and a set of transit rules.

The HarborSym computer model was set up to run the existing conditions at Hilo Harbor based on 2011-2012 data. It is noted that the economic analysis will be based on a comparison of the future "without" and "with" project conditions and that these will be developed based on the 2011-2012 data, plus any changes in commodity shipments and the fleet specifications which have occurred or are expected to occur in the future. Development of the existing condition model required development of the following: (1) a link/node network to represent Hilo Harbor, (2) time and speed assumptions (3) vessel types, (4) route groups, (5) commodity information, (6) port structures, (7) port traffic, (8) tides and currents, and (9) port transit rules. Each of these elements will be discussed in greater detail.

Link/Node Network and Port Structures – The link/node network included 9 nodes. One node represented the channel entrance/exit. Four nodes represented docks including (1) Pier 1 (cruise terminal), (2) Pier 2, (3) Pier 3, and (4) Pier 4. One node represented the turning basin. The remaining 3 nodes were topological and were selected to represent significant changes in the channel features, such as width, depth and/or bearing.

13.1. HarborSym Inputs

HarborSym is a data intensive program relying heavily on port-specific inputs. Officials with the Hawaii Department of Transportation, Division of Harbors, provided three years, 2011-2013, of all ships, barges and cargo movements within Hilo Harbor. These data were used to develop several scenarios of existing and future with-and without-project fleet and cargo projections. Some of the key data inputs are described below.

13.1.1. Time and Speed Assumptions

The Hawaii Pilots Association provided vessel speeds for each reach of the harbor. At the breakwater, the target speed for vessels is 8 knots. Vessels are restricted to 5 knots in the Hilo Harbor area, beginning at the entrance channel. Half way between the entrance channel and Pier 1, the target speed is 3-4 knots. When maneuvering toward berthing at Pier 1, the vessels are restricted to 3 knots or less. Docking, undocking, and turning times were estimated based on total time in the channel, provided by the pilots. Docking and undocking times ranged from 20 minutes to 30 minutes. It was noted that larger vessels turn before docking. Vessel loading and unloading rates were estimated for each dock and were based primarily on pilot data. Gross commodity transfer rates were used; these relate the amount of commodity moved to the amount of time spent at the dock for all purposes.

13.1.2. Reaches

The 9 nodes in the Hilo Harbor link/node network were connected by 8 reaches. These were (1) Channel to Docks, (2) Pier 1, (3) Pier 2, (4) Pier 3, (5) Pier 4, (6) Entrance Channel, (7) Inner Channel, and (8) another Inner Channel reach. The length, width and depth of each channel segment are defined in the model. The reach width is 950 feet and the channel depth is -35 feet, for most of the channel, with the exception of the turning basin, which is 1,400 feet wide with a depth of -35 feet.

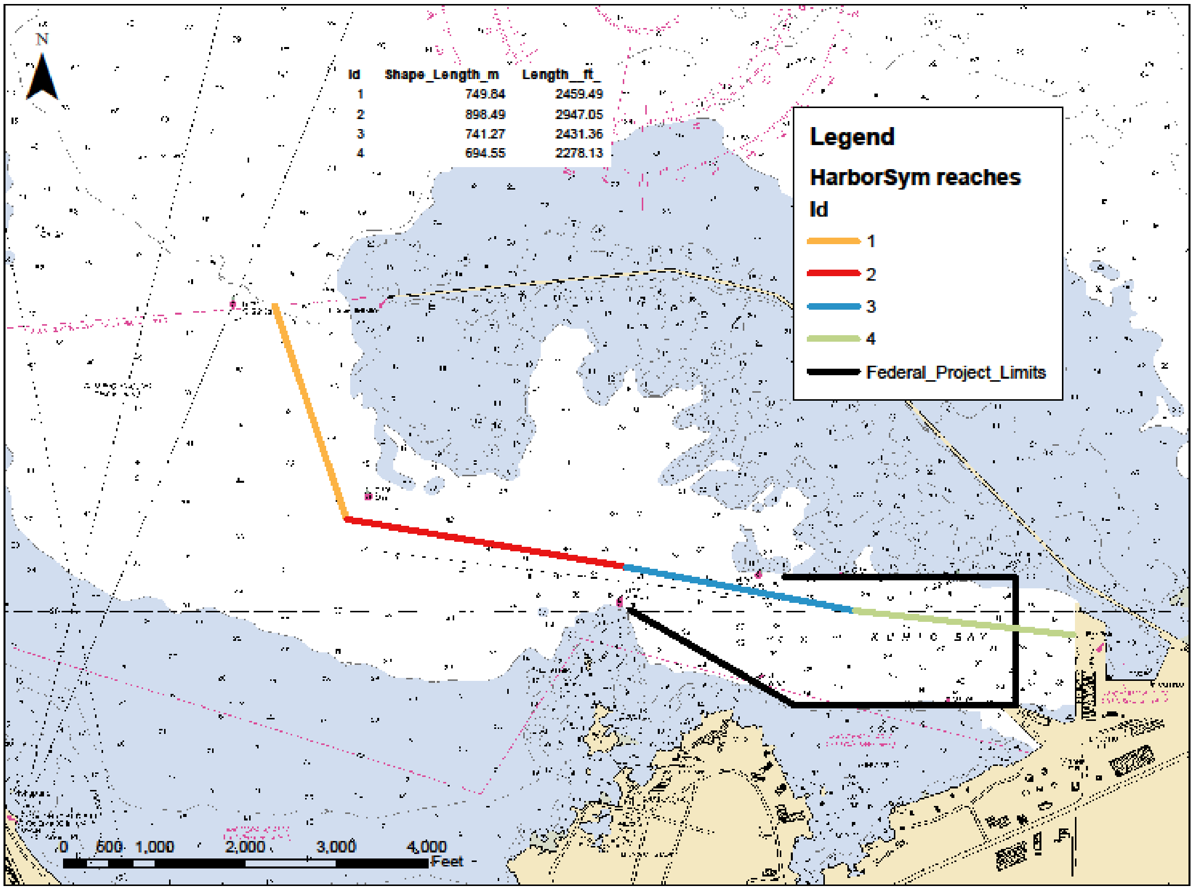

Figure E1. Reaches used in the HarborSym Model

13.1.3. Vessel Types

Four basic vessel types were put into the existing condition model. These included (1) Tug/Barge, (2) Passenger/Cruise Ship, (3) Roll-on/Roll Off (Ro-Ro), and (4) LPG Tanker. Each vessel type was represented by one sub-class, except for the Passenger/Cruise Ship vessel type, which had 4 sub-classes. The Tug/Barge type included one sub-class, the 450-500 feet LOA vessel. The Passenger/Cruise Ship type was represented by four sub-classes of 500-699 feet LOA, 700-899 feet LOA, 900-999 feet LOA, and 1,000-1,100 feet LOA. The Ro-Ro type includes one sub-class of 500-700 feet LOA. The LPG Tanker type included one sub-class of 500-520 feet LOA.

Vessel attributes were defined for each vessel sub-class, including dimensions, speed, and operating costs at sea and in port. Underkeel clearance requirements, vessel immersion factors (stated in tons per inch), and vessel operating costs are provided for each vessel sub-class. Underkeel clearance requirements are based on input provided by the pilots and amount to ten percent of the maximum sailing draft for each vessel sub-class. The vessel operating costs and immersion factors are based on data acquired by the U.S. Army Corps of Engineers Institute for Water Resources. For some inputs, the HarborSym model requires a range of data, including for example, minimum, most likely, and maximum vessel operating costs at sea and in port. The vessel operating cost data are considered proprietary and cannot be disclosed.

13.1.4. Route Groups

Each vessel type was associated with the default route group in HarborSym since no changes in these vessels were expected between the future without and future with project conditions.

13.1.5. Commodities

Commodity information for the existing condition model was obtained primarily from two sources. The Hawaii Pilots Association provided detailed information for the harbor, as well as the U.S. Army Corps of Engineers Waterborne Commerce of the United States data provided by the Navigation Data Center. The model contains specific commodity assignments for each vessel call. The commodity assignments are based on data provided from Waterborne Commerce of the United States and the pilots logs. A couple of the key commodities follow:

- **LPG.** Each year about 10 tankers call carrying Liquid Petroleum Gas (LPG or 4762)). They average LOA of 463 feet and run from 333 ft to 557, say 500 ft LOA. These tankers stay one day or less and average delivery of about 20,000 BBL/trip, for a total of about 168,000 BBL/year. Another 82,000 BBL/year is delivered by either a 230 ft LOA or a 245 ft LOA barge, about 14 barge deliveries per year; one day or less and average about 5,854 BBL per barge. Altogether, LPG averages about 250,000 BBL/year.
- **Vehicles.** Autos and other vehicles are also makeup a significant portion of the barge business at Hilo Harbor. Historically, most of this vehicle traffic comes off the PASHA HAWAII ship, the Jean Anne, a 579 feet LOA, 28-foot draft Ro-Ro car carrier. Hilo is normally the last Hawaiian stop for the Jean Anne before heading home to San Diego. Late in 2015, PASAHA’s new car carrier, the Marjorie C, began calling at Hilo Harbor. At 692 feet LOA and a draft of 31 feet, this commercial ship will be one of the largest calling at Hilo in the near future. In addition to automobiles and other vehicles, these PASHA ships also bring in relatively small deliveries of general merchandize and containers. Automobiles are their main delivery, however, averaging 48,300 short tons of them each year with an average of about 82 trips/year.

13.1.6. Port Traffic

Vessel names, as well as arrival and departure times and drafts were obtained from the Hilo Harbor Pilots Logs, as well as Waterborne Commerce of the United States. Vessel dimensions were obtained from online services such as MarineTraffic.com, imonumber.com (an IMO number database), and VesselFinder.com.

13.1.7. Tides and Currents

Tidal information was obtained from the NOAA tide stations located along Hilo Harbor. One tide station was used in the model. It is noted that no NOAA current stations are available to the model for this area.

13.1.8. Port Transit Rules

Port transit rules were based on input from the Harbor Pilots, who indicated that vessels are currently not allowed to pass each other, and that passenger/cruise vessels have priority in the harbor.

14. ESTABLISHING THE FUTURE WITHOUT- AND WITH-PROJECT CONDITION

The without project condition consists of those future conditions most likely to prevail in the absence of the proposed project. The base year for this project is 2020 when the proposed alternatives will be fully functional and start generating benefits and continues to year 2069.

It is assumed that the commodity flows and the fleet composition is the same in the without project and the with-project condition.

14.1. Developing the Commodity Forecast

An important step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port. Cargo history can offer key insight into a port's long term trade forecast which is the estimated cargo volume upon which future vessel calls are based. In the without and in the future with project conditions, the same volume of cargo is assumed to move through Hilo Harbor; however, channel modifications will allow for more efficient vessel use.

14.2. Developing the Future Fleet Forecast

In addition to a commodity forecast, an accurate forecast of the future fleet is required when evaluating navigation projects. As an economy grows, exports from the port often increase (from the increased output) or demand for imports increase (increased consumer purchasing power). Vessels respond accordingly to satisfy this increased level of trade. To develop projections of the future fleet calling Hilo Harbor, information from the historical vessels and general methodology to forecast total capacity calling Hilo Harbor was determined. By combining information from the commodity forecast with the forecasted fleet capacity, a number of vessel calls for Hilo Harbor's fleet was estimated. The number of transits, particularly those made by larger vessels, is a key variable in calculating the transportation costs. Historically, Hilo Harbor does not have fluctuations in commodities based on seasons; the quantity of commodities remained fairly consistent across all months of the year.

The future fleet forecast used in the HarborSym runs was developed primarily using the actual Hilo Harbor vessel call list from 2013, which was provided by the Hawaii DOT, Harbors Division. Additional information from 2011 and 2012, 2014 and the first half of 2015 also went into developing this fleet forecast, as did some of the future trend visions of key Harbor Division personnel. This led to developing three scenarios, ranging from low (existing), medium (a modest growth in larger ship calls, and high (an optimistic growth in larger ship calls). Under without project conditions, however, the trend to larger ship calls is restricted by Hilo Harbor features like the existing turning basin. Basically, where growth trends were evident in the data, the trends were continued into the future. For example, the larger cruise ships (over 1,000 ft LOA) calling the port were gradually increased over time, as suggested by port officials.

14.3. With-Project Conditions Considered

Two with-project growth scenarios were used for HarborSym runs, specifically corresponding to a medium and high growth scenario. With an improved turning basin, the likelihood of the medium and high growth scenarios leading to larger ships increased considerably. The results of the medium and high scenarios were compared to the without-project condition run. Rather than Hilo ship traffic being restricted by general navigation features, such as its turning basin, the limiting restriction becomes demand for shipped goods and services. In other words, Hilo Harbor growth cannot outpace the demand for its commodities and its cruise ship business.

14.4. Existing Conditions (the Low Scenario) Model Results

The HarborSym model described above was run for a duration of 8,860 hours, or slightly more than one year (2013). There were 498 vessel calls in the call list. The model was run for 20 iterations.

An average of 1,822,387 short tons were moved. Average Vessel Total Cost was $130,267.40, with a standard deviation of $19,688.53. The average time in the system was 15.67 hours. The average gross loading / unloading time was 11.69 hours. Average vessel waiting time was 23.4 minutes with a maximum of 49 minutes and a minimum of zero.

An average of 2.78 deleted vessels were noted (the model occasionally deletes a vessel when it get stuck in the simulation). The maximum number of deleted vessels was six and the minimum number was zero.

The existing condition was used to calibrate the model and will form the basis for the future “without” and “with” project condition models.

15. BENEFITS OF EXPANDED TURNING BASIN

In the spirit of SMART Planning, only one alternative was fully evaluated. Recognizing that the majority of the NED benefits would have to come from increasing the size and efficiency of the turning basin, expanding the turning basin was one structural measure that had to be included. Surge related measures, on the other hand, proved too costly for the limited amount of potential benefits achievable. Therefore, the HarborSym runs focused on the difference in transportation costs with and without the expanded turning basin. Widening the existing turning basin to 1,650 feet and lengthening it to 2,800 feet was the only with-project condition that was modeled with HarborSym. These dimensions were set given the length and maneuverability characteristics of the design ship, the present configuration of the existing turning basin, revetment, and general layout of the harbor, and input from the harbor pilots. Basically, it was the only design for the expanded turning basin that made engineering sense given the existing constraints.

However, alternative depths of the turning basin were scaled in one-foot increments between 30 and 35 feet, and a cost estimate was calculated for each depth. This was done so that, in the event that the full authorized depth of 35 feet was not being fully utilized, significant cost savings might be obtained by going only as deep as the existing fleet calling at Hilo Harbor required. Indications from preliminary HarborSym runs showed that total average annual benefits did decrease with each foot reduction in turning basin depth; however, costs go down as well. If the overall project’s benefit cost ratio (BCR) results had been more favorable, then there would have been an optimization exercise to see at which depth were net benefits maximized. As it turned out, the BCR was so poor (i.e., 0.25) for the more optimistic run that optimizing the depth of the turning basin would a meaningless exercise. The same could be said about varying the width and length dimensions of the with-project turning basin. Incidentally, the pilots of the Hawaii Pilots Association indicated that with the new turning basin in place, turning times will be reduced on anywhere from 10 to 25 minutes depending on the size and maneuverability of the vessel. The ensuing reduction in transportation costs, due to this time savings as calculated within HarborSym, was the primary NED benefit of the project.

As for including surge reduction features in the benefits analysis, PDT Coastal Engineers proposed several measures to mitigate effects of surge within the harbor. These all proved far too costly for the limited benefits they would achieve, and demonstrated no potential for incremental economic justification. Given the limited number of documented cases of lost business to the surge phenomenon and all the assumptions that would have to be made about how many days and to what extent each day would surge impact the harbor under both with and without project conditions, average annual benefits were never estimated for the caisson alternative. In the spirit of SMART Planning, structural alternatives to mitigate the effects of surge on Hilo Harbor were dropped from further consideration.

15.1. Project Costs

The “class 4 level,” MCASES cost estimate for the turning basin improvement only at 35 feet was about $67 million (Estimated cost at effective price level October 2014), or approximately $49 million at 30 feet. Operation and maintenance dredging would have to be done on an estimated 10-year cycle, which could add another $350,000 to the annual cost to the 35-foot project, or $250,000 to the 30-foot project. Interest during construction could add an additional $1.3 million to the first cost of the 35-foot project, or $1 million to the 30-foot project. Therefore, a reasonable estimate of the average annual cost of the 35-foot and 30-foot turning basin expansion would be about $3.2 million or $2.4 million, respectively.

The only alternative to address the surge problem at Hilo Harbor for which a preliminary cost estimate was made was constructing a spur made of caissons at the end of the existing breakwater. This estimated cost at effective price level October 2014 was about $145 million. Average annual costs would be over $6 million, and does not include expanding the turning basin. If constructed together, the estimated cost for both the caisson spur and the improved 35-foot deep turning basin was $188 million, or an average annual cost of more than $8 million.

15.2. Project Benefits

Presenting here only the high growth scenario to test the overall viability of a possible favorable project, the main vessel types that experience cost savings in the “optimistic” scenario are Medium, Large and Largest Passenger/Cruise Ships. When taking the difference in transportation cost in the future without project and future with project, and multiplying that difference by the number of vessels in that vessel class results in the net present value of transportation cost savings for a 50 year period of analysis is $18,880,000. Using the FY15 discount rate of 3.375% the average annual benefits are about $787,000. The cost of expanding the turning basin is $76,764,000. Table 2 shows in 3 steps the derivation of the benefits of lengthening the turning basin and keeping it at a depth of 35 feet using the optimistic future cruise ship forecast or the high growth scenario.

Table E2: Derivation of Average Annual Benefits For the Widened Turning Basin at 35-feet Depth

	Benefits Per Vessel Class		
	2020	2030	2040
Small Pass	$ 7,072.63	$ 5,933.75	$ 4,158.26
Medium Pass	$ 55,501.87	$ 62,357.45	$ 74,066.14
Large Pass	$ 502,573.77	$ 561,763.79	$ 693,546.01
TugBarge	$ 23,750.62	$ 28,854.55	$ 33,959.41
RoRo	$ 44,840.15	$ 51,471.15	$ 65,705.81
LPG Tanker	$ 2,266.26	$ 2,832.80	$ 4,176.96
Largest Pass	$ 17,825.42	$ 39,032.57	$ (11,766.30)
Total Benefits	**$ 653,830.72**	**$ 752,246.06**	**$ 859,688.03**

Total Annual Benefits					
2020	$	653,831	**2045**	$	859,688
2021	$	663,672	**2046**	$	859,688
2022	$	673,514	**2047**	$	859,688
2023	$	683,355	**2048**	$	859,688
2024	$	693,197	**2049**	$	859,688
2025	$	703,038	**2050**	$	859,688
2026	$	712,880	**2051**	$	859,688
2027	$	722,721	**2052**	$	859,688
2028	$	732,563	**2053**	$	859,688
2029	$	742,405	**2054**	$	859,688
2030	$	752,246	**2055**	$	859,688
2031	$	762,990	**2056**	$	859,688
2032	$	773,734	**2057**	$	859,688
2033	$	784,479	**2058**	$	859,688
2034	$	795,223	**2059**	$	859,688
2035	$	805,967	**2060**	$	859,688
2036	$	816,711	**2061**	$	859,688
2037	$	827,455	**2062**	$	859,688
2038	$	838,200	**2063**	$	859,688
2039	$	848,944	**2064**	$	859,688
2040	$	859,688	**2065**	$	859,688
2041	$	859,688	**2066**	$	859,688
2042	$	859,688	**2067**	$	859,688
2043	$	859,688	**2068**	$	859,688
2044	$	859,688	**2069**	$	859,688
2045	$	859,688			

Summary		
$	18,880,027	Net Present Value
	0.03375	Interest Rate
	1.03375	1 + Interest Rate

	50	Period of Analysis
	0.041677258	Capital Recovery Factor
$	786,868	Average Annual Benefits

16. BCR RESULTS AND CONCLUSIONS

As stated earlier, only one alternative, the improved turning basin at 35 feet deep, was fully evaluated. It was evident that if this alternative was not economically justified, other alternatives would only add more costs than benefits and would be even less feasible. As shown in Table E3, with average annual benefits of about $787,000 attributable to the high growth scenario, and average annual costs of about $3.2 million for the 35-foot turning basin widener, this rather optimistic benefit cost ratio came to about 0.25.

Table E3: Turning Basin Widener Benefit Cost Ratio

Average Annual Benefits	$787,000
Average Annual Costs	3,200,000
Benefit Cost Ratio	0.25

The PDT also found that the approach it used to lower costs by decreasing the controlling depth of the turning basin to between 30 and 34 feet would not rescue this poor benefit cost ratio. Even if benefits did not decrease, an unrealistic optimistic assumption, the benefit cost ratio would improve to slightly better than 0.3. More likely scenarios than the optimistic one used here would undoubtedly lead to lower benefits and benefit cost ratios. Potential solutions to the surge problems within the harbor proved to be quite expensive and even more economically infeasible than the turning basin improvement. Plus, the possibility would exist that despite implementing these costly measures, future harbor closures due to this problem would not be entirely eliminated.

Regrettably, the fact that under with-project conditions, practically all present and future ship movements within Hilo Harbor would be made safer and with less chance of human, environmental or property harm or damage, has not been factored into this economic analysis. Those unaccounted for safety benefits are not so much overlooked as they are difficult and contentious to include in this type of analysis. However, it is doubtful that these benefits, if measurable, could elevate the benefit cost ratio for this project to a positive conclusion.

17. DATA SOURCES AND ACKNOWLEDGEMENTS

- Hawaii Department of Transportation, Division of Harbors –
- Arnold Liu, Dean Watase, Kimberly Kido, Jeff Hood, Elton Suganuma, Russell Mora, Verna L. Kong, Dung Vo, Russell Moore, Caroline Sluyter: ship call and cargo records, cruise ship schedules, barge schedules, maintenance issues, damages to ships and piers (bollard replacements), LNG coming to Hawaii, harbor transiting restrictions and rules,
- Hawaii Pilots Association, Tom Heberle, President: Ship operating procedures and turning times, Ship calls, time in port records, problem documentation, tug assistance, safety practices, harbor transiting restrictions and rules, Ship simulation data and findings
- Matson, Russell Chin and Dexter Shimabukuro: Tug and Barge call schedules and conflicts; possibility of ships calling at Hilo directly from the mainland
- Young Brothers, Jeff Lowe: Tug and Barge call schedules and conflicts
- Sause Brothers Tug and Barge usage
- Kirby Marine (formerly Smith Marine) Tug and Barge usage
- Hawaii Cement Company, Nate Lopez-- Tug and Barge usage; no direct ship calls
- Celebrity Line (Celebrity Solstice of the Seas)
- Norwegian Cruise Line, Grant Karamatsu, Captain Chrastina (extra expenses related to surge issues)
- PASHA Hawaii, Mike Caswell and Emily Sinclair: Surge Wave offs and Fuel usage
- Hawaii Gas Company: LPG ship calls, Possibility of LNG coming to Hawaii
- Cruise Lines International Association--North West and Canadian Cruise Ship Corporation, Devon Nikoba, Charles Toguchi and Patrick Shaw
- USACE, Deep Draft Planning Center of Expertise, Todd Nettles and Caitlin Schwall—HarborSym and Vessel Operating Costs
- USACE Waterborne Commerce Statistics Center, New Orleans, LA : Ship traffic and draft data; Commodity data

Hilo Harbor Navigation Improvements
Feasibility Investigation Summary Report
Hilo, Hawaii

APPENDIX F
REAL ESTATE

See following pages

REAL ESTATE PLANNING REPORT
HILO HARBOR MAINTENANCE DREDGE AND BREAKWATER EXPANSION PROJECT, HAWAII

Prepared for
Honolulu District, USACE

Prepared by
Sarah J. Watts, Realty Specialist, Honolulu District
23 June 2015
Updated 24 February 2016

REAL ESTATE PLANNING REPORT
Hilo Harbor Maintenance Dredge and Breakwater Expansion Project, Hawaii

Contents

Hilo Harbor Feasibly Study

REAL ESTATE PLAN

PURPOSE

The Real Estate Plan (REP) will be consolidated into the decision document Feasibility Report for the Hilo Harbor Maintenance Dredging and Breakwater Project. The purpose of the Feasibility Study is to evaluate potential navigation improvements. This Real Estate Plan (REP) identifies and describes the real estate requirements for the lands, easements, rights-of-way, relocations and disposals (LERRD) that will be required.

PROJECT TYPE AND APPLICABILITY

The non-Federal sponsor, the State of Hawaii Department of Transportation Habors Division (DOBOR), requested a feasibility study to address safety and operational inefficiencies at Hilo Harbor attributable to surge within the harbor and turning basin limitations. In response to the request, a 905(b) analysis was initiated in May 2010 resulting in a finding that of continued federal interest in continued feasibility studies. The 905(b) analysis was approved by the Pacific Ocean Division in July 2012. A cost-shared feasibility study addressing modifications to the federally authorized project at Hilo Harbor was initiated on 30 September 2013 with the execution of the Feasibility Cost Sharing Agreement. Non-Federal funds were received on 1 April 2014.

PROJECT SCOPE AND CONTENT

The Hilo Harbor is located on the northeast coast of the island of Hawaii. Hilo Harbor provides a wide range of maritime facilities and services and is the major distribution center for the Island of Hawaii. It is also the island's only cruise ship port, and is an economically vital link to goods and services for the entire Hawaii Island community. Hilo Harbor has been identified by the Non-Federal Sponsor as a priority harbor for growth in which potential significant modifications may be needed to the turning basin and the channel.

The existing harbor was constructed by the U.S. Army Corps of Engineers (USACE) in increments, beginning in 1908 and completed in 1930, and consists of a 10,080-foot long breakwater protecting a 35-foot deep basin. Lands were ceded to the United States of America by the Republic of Hawaii under the Joint Resolution of Annexation approved July 7, 1898 (30 Stat. 750), and fee title was vested in the Federal Government. Additional lands were set aside for military use of the United States by Governor's Executive Order Nos. 176 and 723 of 13 December 1924 and 9 October 1936, respectively. Subsequently, 7.70 acres were conveyed to the State of Hawaii by the United States of America by quit-claim deed dated 11 August 1971; and 2.60 acres were relinquished under a Notice of Cancellation, dated 7 February 1984, given by the

United States of America (Lease No. DACW84-5-74-1), relinquishing and giving up the premises on 12 March 1984.

The five alternative plans being considered are:

Alternative 1, Non-Structural Plan A: Non-structural methods implemented under this alternative would include extending the Federal channel approximately 600 feet from the face of Pier 1 and limits of responsibility and require vessels to moor either in the deeper areas of Hilo Harbor or offshore during periods of high surge.

Alternative 2, Non-structural Plan B: Non-structural methods implemented under this alternative would include encouraging improved berthing technology and data, such as navigational technologies and deployment of the PORTS system by NOAA, and to close the port during times of high surge.

Alternative 3, Turning Basin Expansion and Surge Reduction Structures: Under this Alternative, the areas to the north of the turning basin would be dredged to expand the turning basin, and rubble-mound surge reduction structures would be installed within the existing harbor to address surge reduction. The dredge material will be utilized for the construction of the rubble-mound surge reduction structures.

Alternative 4, Turning Basin Expansion and Breakwater Modifications: Under this Alternative, the areas to the north of the turning basin would be dredged to expand the turning basin; and both the porosity of the existing breakwater would be decreased and the crest elevation of the breakwater would be increased for surge reduction.

Alternative 5, Turning Basin Expansion, Surge Reduction Structures, and Breakwater Modifications: Under this Alternative, the areas to the north of the turning basin would be dredged to expand the turning basin. To reduce surge, rubble-mound surge reduction structures would be installed within the existing harbor, the porosity of the existing breakwater would be decreased, and the crest elevation of the breakwater will be increased. The dredge material will be utilized for the construction of the rubble-mound surge reduction structures. Some or all of the non-structural measures in Alternatives 1 and/or 2 may also be employed in this Alternative.

DESCRIPTION OF LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND DISPOSALS (LERRDs)

The lands required for the deepening of the project are submerged and within the navigable waters of the United States. These lands are available by navigation servitude.

The lands required for rubble-mound surge reduction structures are submerged and within the navigable waters of the United States. These lands are available by navigation servitude.

The lands identified for Turn Basin and Breakwater within Hilo Harbor which are above the High Water Mark owned in Fee by the State of Hawaii. These lands are managed by the Department of Harbors and are available for this project.

The dredge material excavated from the harbor will be transported by barge and placed within the Kawaihae Harbor concrete casting yard. The Kawaihae Harbor is a federally owned and managed project. The staging and construction area identified as the concrete casting yard (Exhibit D) located will temporarily store this material before it is placed within the rubble-mound surge reduction structures. Later, these structures will be transported by barge back to its final resting place on the Hilo Harbor breakwater. The Federal Fee lands will be used temporarily for construction purposes. No acquisition is required for the use of these lands.

Staging and construction work areas for the Turning Basin Expansion is identified on the State of Hawai'i fee owned land. These lands are managed by the Harbors Division and are available for this project. No acquisition is required for the use of these lands.

STANDARD ESTATES

No acquisitions are required for the use of any lands identified for this project.

NON-STANDARD ESTATES

Non-standard estates will not be utilized for the purposes of implementing the proposed project.

FEDERAL LANDS

Federally owned land will not be utilized for the purposes of implementing the proposed project. There is no overlap of LERRD from previous projects in the area.

NEAREST OTHER EXISTING FEDERAL PROJECT

The Kawaihae Harbor will be utilized as a temporary work area for the construction of the concrete casting yard to construct the rubble-mound surge reduction structures.

NAVIGATION SERVITUDE

Lands required for deepening of the project are within the navigable water of the United States and are available by navigation servitude. The proposed placement of for rubble-mound surge reduction structures are also within the navigable waters of the United States and are available by navigation servitude.

INDUCED FLOODING

There will be no induced flooding directly associated with this project.

BASELINE COST ESTIMATE FOR REAL ESTATE

The following cost figures are subject to change prior to construction:

a.	Lands and Damages		$0
b.	Acquisition – Administrative costs		$30,000
	Federal*	$15,000	
	Non-Federal	$15,000	
c.	Public Law 91- 646		$0
d.	Condemnations		$0
e.	Total Estimated Real Estate Cost		$30,000

* Includes Corps Real Estate planning and monitoring costs

UTILITIES & FACILITIES RELOCATIONS

No known utilities or facilities are located in this area and no relocations are required.

RELOCATION ASSISTANCE BENEFITS

There are no P.L. 91-646 businesses or residential relocations assistance benefits required for this project.

HTRW IMPACTS

A phase I environmental assessment was completed for the proposed dredging and disposal activity areas. No areas identified HTRW within these areas. Prior to disposal of dredge material additional testing will occur and contaminated materials will be coordinated with the appropriated environmental agencies and disposed of in accordance with Federal, State, and Local Laws.

MINERAL/TIMBER ACTIVITY

There are no current or anticipated mineral or timber activities within the vicinity of the proposed project that will affect construction, operation, or maintenance of the proposed project. Nor will any subsurface minerals or timber harvesting take place within the project.

VIEWS OF LOCAL RESIDENTS

The DOT and harbor users strongly support the harbor modifications. Further coordination will be ongoing between DOT, USACE, Federal resource agencies, and residents in the area.

ANY OTHER RELEVANT REAL ESTATE ISSUES

There is currently no other real estate issue relevant to planning, designing or implementing the project.

Prepared By:

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Date: 24 February 2016

Reviewed By:

MICHAEL P. BAUMAN
Lead Realty Specialist

Date: 24 FEB 2016

Approved By:

MICHAEL Y. SAKAI
Lead Realty Specialist

Date: 24 FEB2016

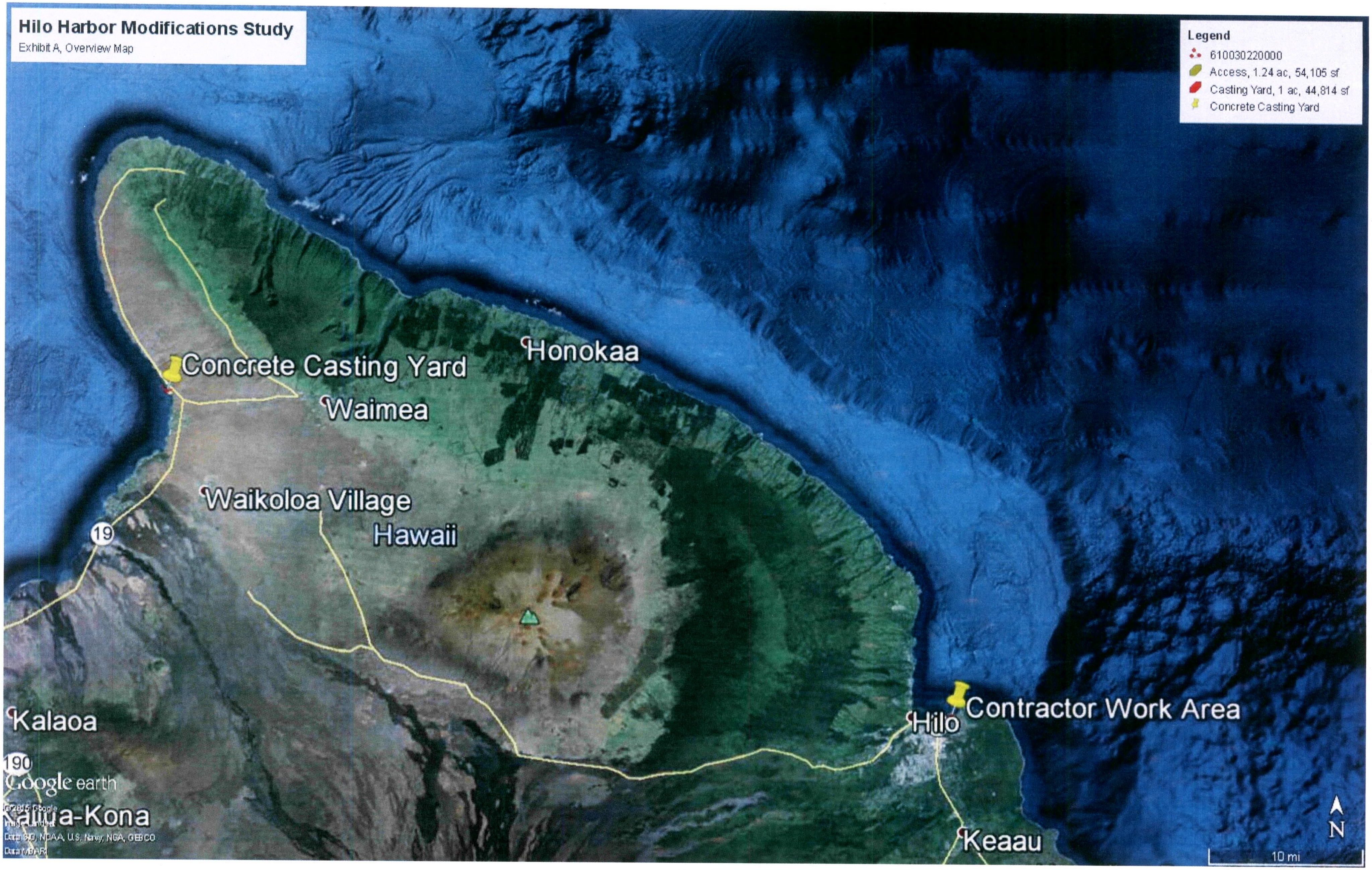
Hilo Harbor Modifications Study
Exhibit A, Overview Map
Legend
610030220000
Access, 1.24 ac, 54,105 sf
Casting Yard, 1 ac, 44,814 sf
Concrete Casting Yard
Concrete Casting Yard
Honokaa
Waimea
Waikoloa Village
Hawaii
19
Kalaoa
190
Google earth
Contractor Work Area
Hilo
Keaau
N
10 mi

EXHIBIT
A

Hilo Harbor Modifications Study
Exhibit B, Hilo Harbor Vicinity Map
Legend
Access, 1.0 ac, 44,718 sf
Contractor Work Area
Perpetual Easement
Potential Contractor Work Area, 2 ac, 88,319 sf
Wainaku
Hilo Bay
Kaula'inaiwi Island
Coconut Island
Kūhiō Bay
Puhi Bay
Reeds Bay
Waihonu Pond
Contractor Work Area
Hilo
Laehala St
Apapane Rd
Lokowa
Nahale-A Ave
Desha Ave
Lauae Yung Ave
Pakele Ln
Todd Ave
King Ave
Baker Ave
Krauss Ave
Ewaliko Ave
Kuhio St
Silva St
Keaa St
Lihiwai St
Kuawa St
Bishop
Wainaku St
Ohai St
Wailuku Dr
Keawe St
Ponahawai St
Haili St
200
19
11
N
4000 ft
Google earth

EXHIBIT B

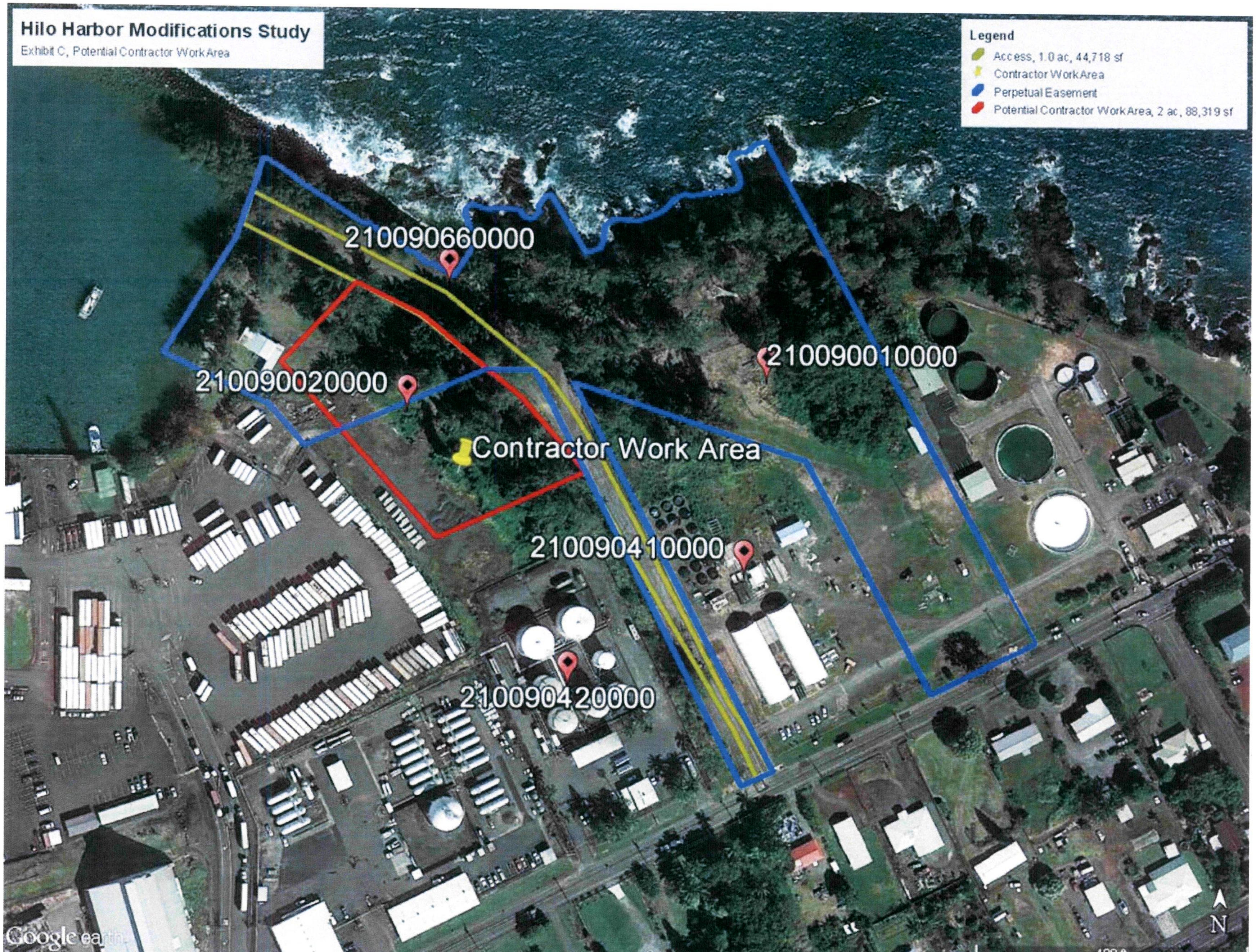
Hilo Harbor Modifications Study
Exhibit C, Potential Contractor Work Area
Legend
Access, 1.0 ac, 44,718 sf
Contractor Work Area
Perpetual Easement
Potential Contractor Work Area, 2 ac, 88,319 sf
210090660000
210090010000
210090020000
Contractor Work Area
210090410000
210090420000
N
400 ft
Google earth

EXHIBIT C

ilo Harbor Modifications Study
xhibit D, Kawaihae Harbor Vicinity Map
Legend
610030220000
Access, 1.24 ac, 54,105 sf
Casting Yard, 1 ac, 44,814 sf
Concrete Casting Yard
Kawaihae Harbor
Kawaihae
270
Concrete Casting Yard
Akoni-Pule
N
1000 ft
oogle earth

EXHIBIT
D


Hilo Harbor Modifications Study
Exhibit E, Potential Concrete Casting Yard
Legend
610030220000
Access, 1.24 ac, 54,105 sf
Casting Yard, 1 ac, 44,814 sf
Concrete Casting Yard
270
Akoni-Pule Hwy
Concrete Casting Yard
Google earth
300 ft
N

EXHIBIT E