

Kuualii Fishpond Tsunami Damage Restoration

Anaehoomalu Bay, Waikoloa, South Kohala, Hawaii

Revision 1

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1. INTRODUCTION

1.1 Location and General Description

Anaehoomalu Bay is located on the west coast of the island of Hawaii, approximately 20 miles north of the Kona International Airport and the town of Kailua-Kona, and 10 miles south of Kawaihae Harbor. Location and vicinity maps are shown on Figure 1-1. Kuualii Fishpond and vicinity are TMK (3) 6-9-007:011, Anaehoomalu, Waikoloa, South Kohala, Hawaii, and the boundary of Lot 11 is shown on Figure 1-2. The sand beach inner bay shoreline is flanked by rocky lava basalt shorpelines on both sides with an arc length of just under 1,100 feet between the old masonry channel at the north end and the first, low, basalt outcrop to the south. The beach fronts two fishponds, Kuualii, the larger of the two ponds, and Kahapapa pond next to it to the north. Because of their relationship with the adjacent beach and dune, these fishponds are classified as a loko puuone, or sand dune ponds. The pond area was described by Kikuchi and Belshe (1971) as “a very long, high sand dune fronts the pond, while the inland sides are bounded by an ancient pahoehoe flow”. Kuualii and Kahapapa ponds are connected by a channel, and a channel through the shore at the north end of Kahapapa Pond connects both ponds to the sea and allows for some circulation and flushing of the pond waters. As Kuualii does not have a direct connection to the ocean, its only seawater circulation and exchange mechanism is through its connection with Kahapapa. However, there is a significant groundwater flow into the pond which aids in water exchange and pond flushing.

Many archaeological studies, surveys, and excavations have been conducted over the years in the vicinity of Kuualii and Kahapapa ponds (Corbin, 2011). The studies indicate a high concentration of archaeological sites, including C-shapes, burial caves, platforms, cairns, hearths, petroglyphs, walls, and other habitation features (Barrera, 1971). It is believed that settlement around Kuualii pond began about 800-900 A.D., and the pond was used for aquaculture (Barrera, 1971). However other investigators have concluded initial occupation in the 15th century, and continuing until the 17th century (Jenson, 1990). By the 1800s the area appears to have been abandoned and the pond had fallen into disuse and was poorly maintained.

A brief summary of the recent history of Anaehoomalu Bay and Waikoloa has been written by Chuck Dewitt, who became involved with maintenance of the pond and beach beginning in 1973. This document is unpublished; however copies are available at the resort. In the late 1800s Parker Ranch heirs acquired the lands of Anaehoomalu and Waikoloa Nui (the lands mauka of the bay). In 1968 Boise-Cascade Properties, Inc. bought Waikoloa/Anaehoomalu from Parker Ranch, a total of approximately 31,000 acres. Shortly thereafter development of a destination resort was initiated, and Queen Kaahumanu Highway from Kailua-Kona to Kawaihae was completed by the state in 1974. The Marriott, located directly behind Kuualii fishpond, opened in 1981, though it was the Sheraton at that time. In 1988 the Hyatt (now Hilton) hotel opened at the north end of the property. The present Waikoloa Beach Resort features are shown on Figure 1-3. The project site, Lot 11, is currently owned by Waikoloa Development Company (WDC). It is leased to the Waikoloa Beach Association (WBA), an organization comprised of the hotel owners and other resort elements, which are responsible for maintaining the pond and beach in a neat and attractive condition, and for maintaining/replacing common infrastructure on the property.

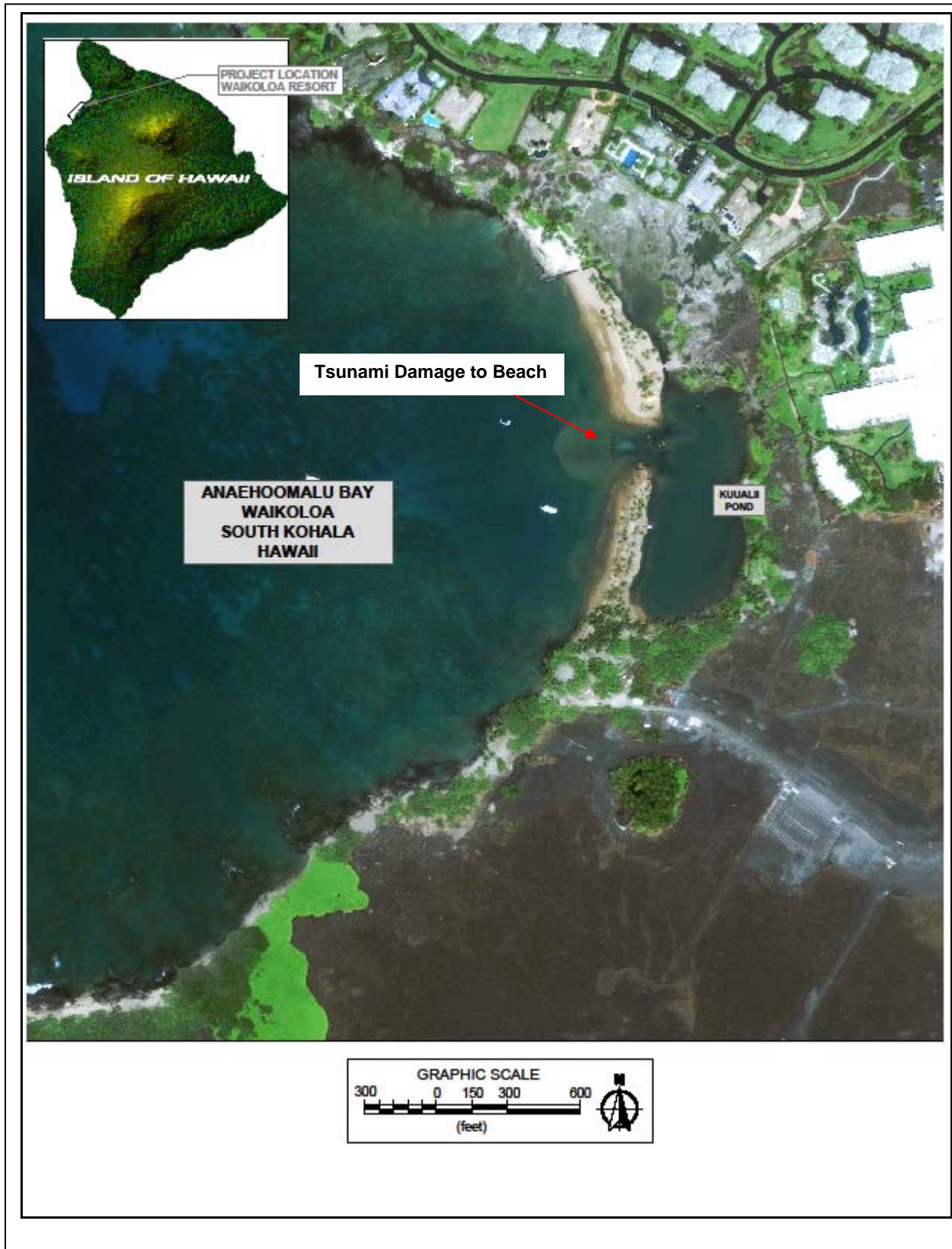


Figure 1-1 Project Location and Vicinity



Figure 1-3 Waikoloa Beach Resort

Kuualii pond is approximately 4 acres in size, about 600 feet long north to south and 250 feet wide. The water depth is typically 3 feet to 4 feet. The pond bottom is composed of fine sediment, typically about 2 feet thick, over firm substrate. The pond and vicinity has been altered and modified over the years. At some point the beach was fortified by extensive planting of coconut trees, and a rock wall was constructed along the makai (ocean) side of the pond. The rock wall is reported to have been constructed in the 1980's during resort development. A 1972 Department of the Army (DA) permit issued by the USACE, Honolulu District (PODCO-O 981-D), authorized improvements to the beach and ponds at Anaehoomalu Bay, as did a State Conservation District Use Permit issued in 1972 (HA-5/5/72-315). The permitted work consisted of removing a rock ledge from the beach area, and clearing/dredging of the ponds and construction of a channel (auwai) through the beach to connect the ponds to the sea in order to improve pond circulation. This channel is the existing one connecting Kahapapa pond to the ocean. The connection between the two ponds was also improved. The DA permit included the condition "That the permittee will maintain the work authorized herein in good condition in accordance with the approved plans", and the CDUP stated that "Boise Cascade shall be responsible for the maintenance of the pond and beach areas." [Note: auwai is the Hawaiian term for a channel with water flowing in it, such as would connect a loko puuone pond to the ocean, and makaha is the term for a fence or gate in the auwai which controls fish entering or leaving the pond.]

Historically, there have been previous coastal natural hazards that have impacted the fishponds. Reportedly, they were damaged by tsunamis in 1946 and 1960, when Parker Ranch conducted repairs, and again damaged by Hurricane Iniki in 1992, when resort personnel conducted the repairs (Chuck Dewitt, unpublished).

1.2 Tsunami Damage and Emergency Beach Repair

On March 11, 2011, a tsunami generated by a massive earthquake in Japan struck the Hawaiian Islands. The tsunami resulted in significant damage to coastal areas, including major damage on the Kona (west) coast of the island of Hawaii. At Anaehoomalu Bay the tsunami severely eroded the beach fronting Kuualii pond, tearing a 100-foot wide gap through the beach and into the pond, extending 2 to 4 feet below water level, and destroying about 220 linear feet of the rock fishpond wall. The beach condition prior to and post tsunami is shown on Figure 1-4 and Figure 1-5. Both figures were obtained from DigitalGlobe, Inc., and are geo-referenced and ortho-rectified satellite imagery, referenced to the Hawaii State Plane, NAD83 coordinate system. The breach can clearly be seen on Figure 1-5, and in a ground level photograph as shown on Figure 1-6. Sand was pushed into the pond on both sides of the gap, as well as carried offshore fronting the gap. Based on the estimated pre-tsunami beach configuration and a topographic survey immediately following the tsunami, roughly 3,000 cubic yards (cy) of sand was estimated to have been eroded in the gap's location, and approximately 9,000 cy was lost from the beach in total.



Figure 1-4 Satellite Image of Waikoloa Beach, 10 November, 2010



Figure 1-5 Satellite Image of Waikoloa Beach, 11 March, 2011



Figure 1-6 The Tsunami Breach at Waikoloa Beach, as Photographed 17 March, 2011



Figure 1-7 Temporary Repairs in the Tsunami Breach at Waikoloa Beach, as Photographed 20 September, 2011

The gap in the beach resulted in continuing sand infill into the pond by wave action. Various permits issued by the County, State and U.S. Army Corps of Engineers (USACE) during development of the resort require the maintenance and preservation of the pond, and thus a request for emergency repair of the beach was made by the WBA to the County Planning Department, the State Department of Land and Natural Resources (DLNR), and the USACE on March 28. After the final necessary approval was granted on July 7, repair work was initiated on July 25, and completed on August 3. The temporary emergency repair plan consisted of installing sand filled geotextile tubes to close the gap in the beach. The completed emergency repair work is shown on Figure 1-7. Plan and section views of the repair plan are shown on Figure 1-8. During the three month period required to obtain all the necessary approvals for the emergency repair work, wave action continued to enlarge the breach in the beach, scour sand from the remaining beach on both sides of the breach, and move sand into the fishpond. Consequently, when emergency repair work was finally able to start, the damage to the beach was considerably greater than it had been immediately after the tsunami. This resulted in the need for geotextile tubes with a total length of 240 feet to completely close the gap.

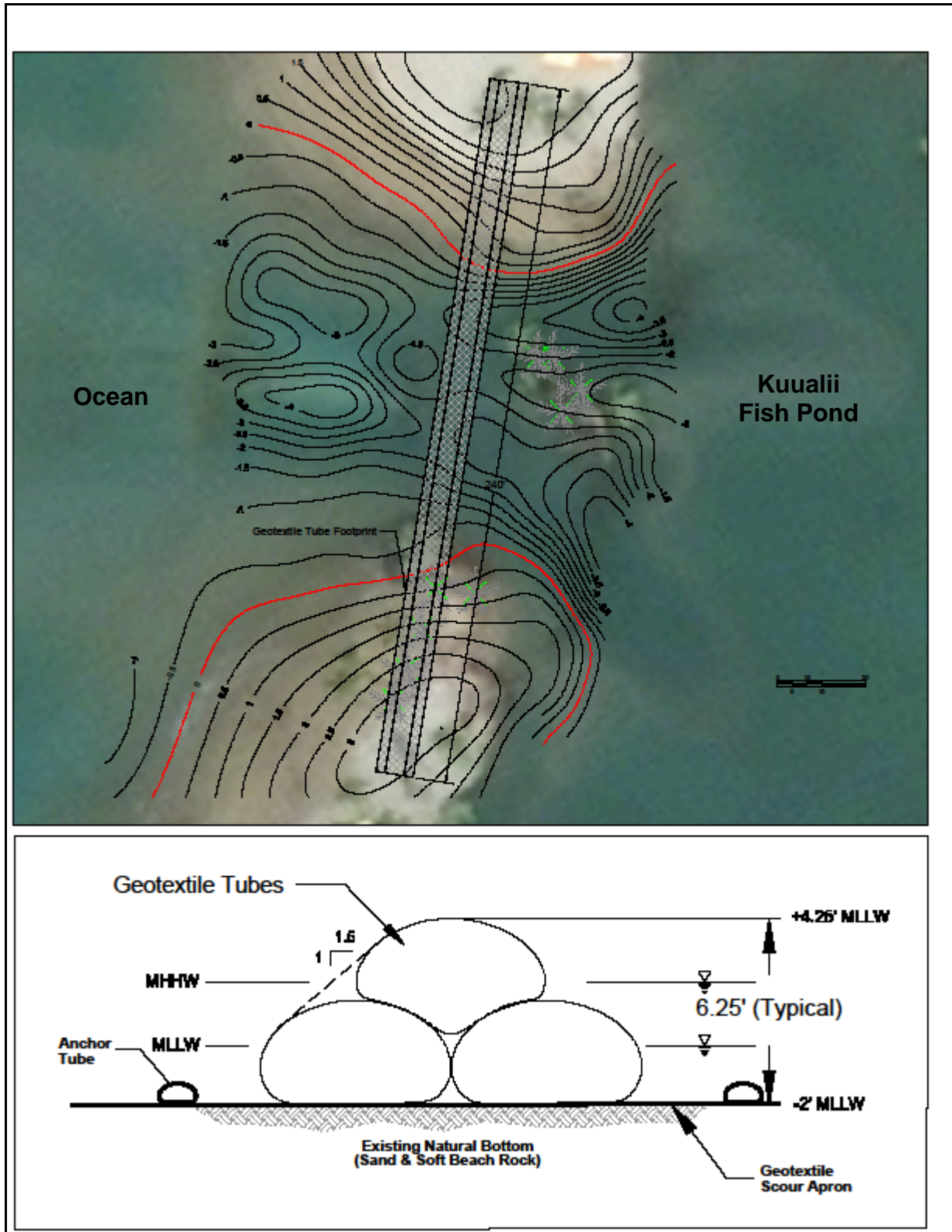


Figure 1-8 Plan View and Cross Section of Emergency Repairs

1.3 Purpose of this Plan

Emergency repair work was accomplished as an intermediate step to protect the fishpond while this long-term, permanent repair/restoration plan for the pond and beach was developed and the necessary permits and approvals are pursued. Permanent repairs include rebuilding the fishpond wall, placement of wall support sand reclaimed from the pond, and berm restoration of the dry beach to its pre-tsunami condition. This report evaluates the repair and restoration needs, and presents a plan for the work. Only repair of tsunami related damage to the pond and beach is proposed at this time. However, due to the rapid recovery of the beach, as seen in Figure 1-9, it is also proposed that the emergency beach repair sand tubes be left in place and covered with sand until such time as they become exposed due to erosion. Since the tubes have been buried beneath the recovered beach, they are no longer impacting littoral processes, and removal would require extensive excavation within the newly recovered beach.



Figure 1-9 Temporary Repairs in the Tsunami Breach at Waikoloa Beach, as Photographed 14 March, 2012

2. EXISTING CONDITIONS

2.1 Shoreline and Beach

As shown on Figure 1-5, the tsunami created a wide breach all the way through the beach and the rock fishpond wall. Sand was both pushed into the pond on both sides of the breach, and moved directly offshore to form a mound immediately seaward of the breach. A survey made on March 21, three weeks after the tsunami, showed the breach to be about 100 feet wide at the mean lower low water (mllw) elevation. A detailed site topographic survey on April 12, 2011 showed the breach to be about 160 feet wide. The post-tsunami beach condition based on the April topographic survey is shown on Figure 2-1. During the three month period required to obtain all the necessary approvals for the emergency repair of the breach, wave action continued to enlarge the breach and scour sand from the remaining beach on both sides and move it into the pond. By the time the emergency repair was accomplished in the first week of August the breach was about 200 feet wide. The damage due to the immediate effects of the tsunami combined with the continuing damage during the permit phase of the emergency breach repair, resulted in the beach being significantly lower in elevation and narrower than it was pre-tsunami. The beach crest is presently about +3 feet mean lower low water (mllw). [Note: all elevations are referenced to the mllw datum.] The beach width above mean higher high water (mhhw) is presently about 50 to 70 feet along the southern half and 80 to 100 feet at the north end.

The pre-tsunami beach size and configuration has been estimated using the November 10, 2010 satellite image (Figure 1-4). Overlaying this on the post-tsunami topographic survey an estimated 9,000 cubic yards (cy) of sand was removed from the beach during creation of the breach and other tsunami damage. The majority of beach sand loss due to the tsunami occurred in the immediate vicinity of the breach; however sand loss lowered the beach crest elevation about 1-foot along virtually the entire length of the beach.

Emergency repairs used sand which had been pushed into the pond on either side of the breach to both fill the tubes and anchor them by creating a minor beach berm on their mauka side. Currently there are six (6) 120 foot long by 15 foot circumference sand filled tubes placed across the breach section to form a 240-foot-long barrier, stacked in a two tubes on the bottom and one on top configuration. Mauka of the tubes is an approximately 25 foot wide sand berm separating them from Kuualii fishpond. The post-emergency repair beach configuration is shown on Figure 2-2.

Following the emergency repair work the beach immediately began to repair itself, with sand accreting on and in front of the geotube barrier. Figure 2-3 and Figure 2-4 show the shoreline fronting the geotubes immediately post-construction (August 4, 2011), and seven months later on March 14, 2012. The bottom tubes are completely buried and only a portion of the top tube is visible, and a natural beach slope extends seaward of the tubes. A topographic survey update on February 25, 2012 shows that approximately 3,400 cy yards of the sand lost during the tsunami has returned to the beach, leaving a current net loss of 5,600 cy from pre-tsunami conditions. The February 25, 2012 survey is shown on Figure 2-5. The nearshore sand mound seaward of where the breach was located has diminished in volume; presumably some of this sand has been moved back on to the beach by wave action.

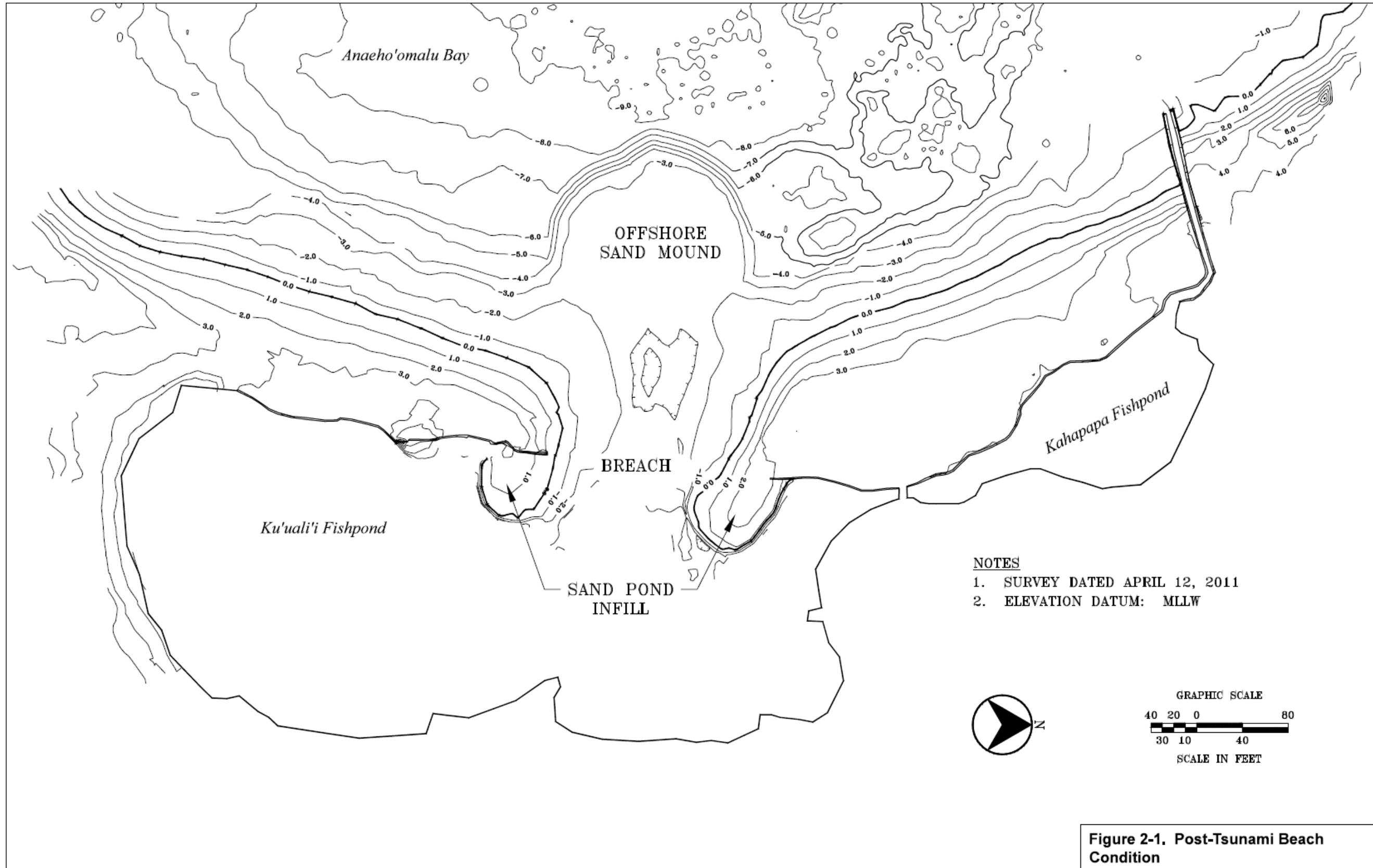


Figure 2-1 Post Tsunami Beach Condition

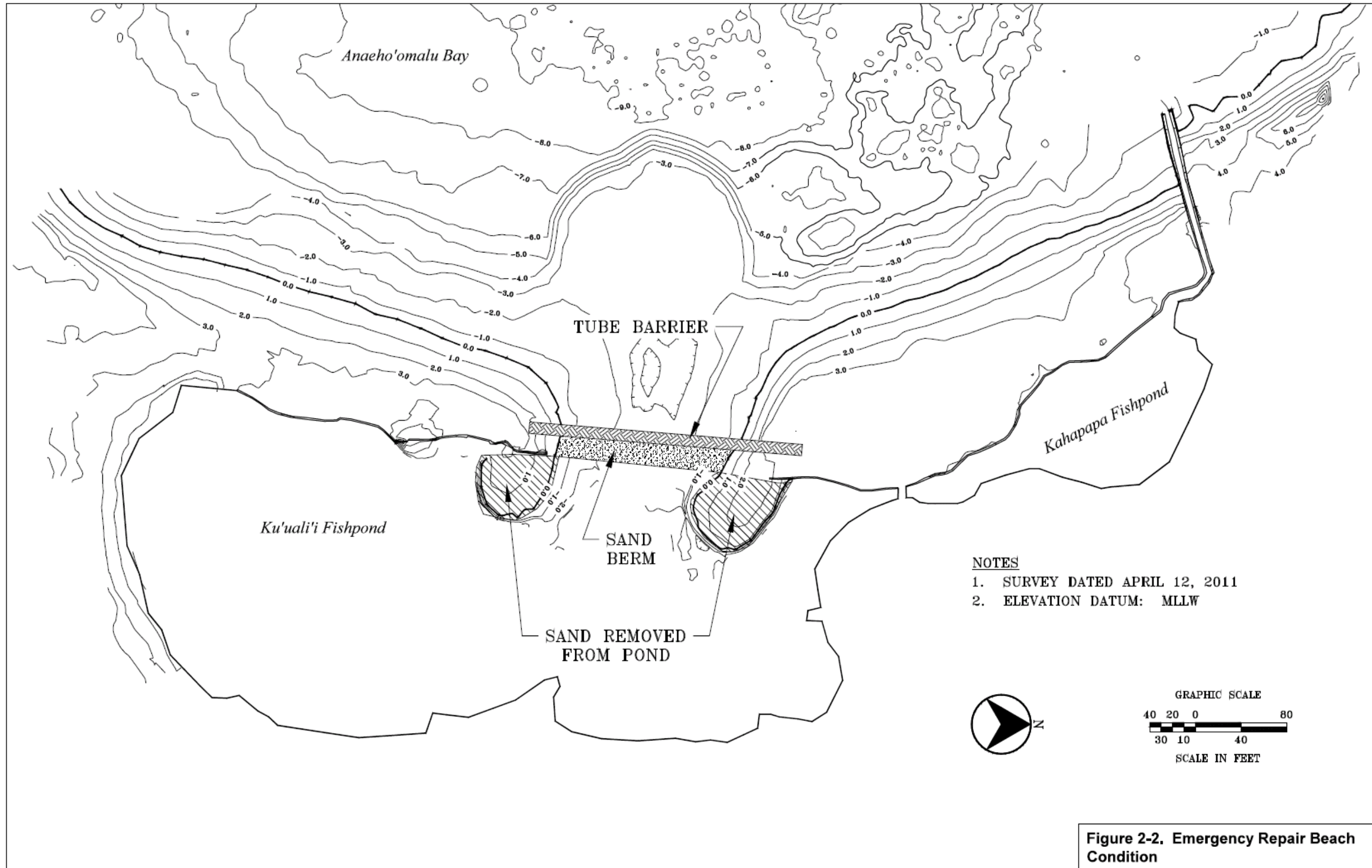


Figure 2-2 Emergency Repair Beach Condition



Figure 2-3 Post Emergency Repair, August 4, 2011



Figure 2-4 March 14, 2012 Shoreline

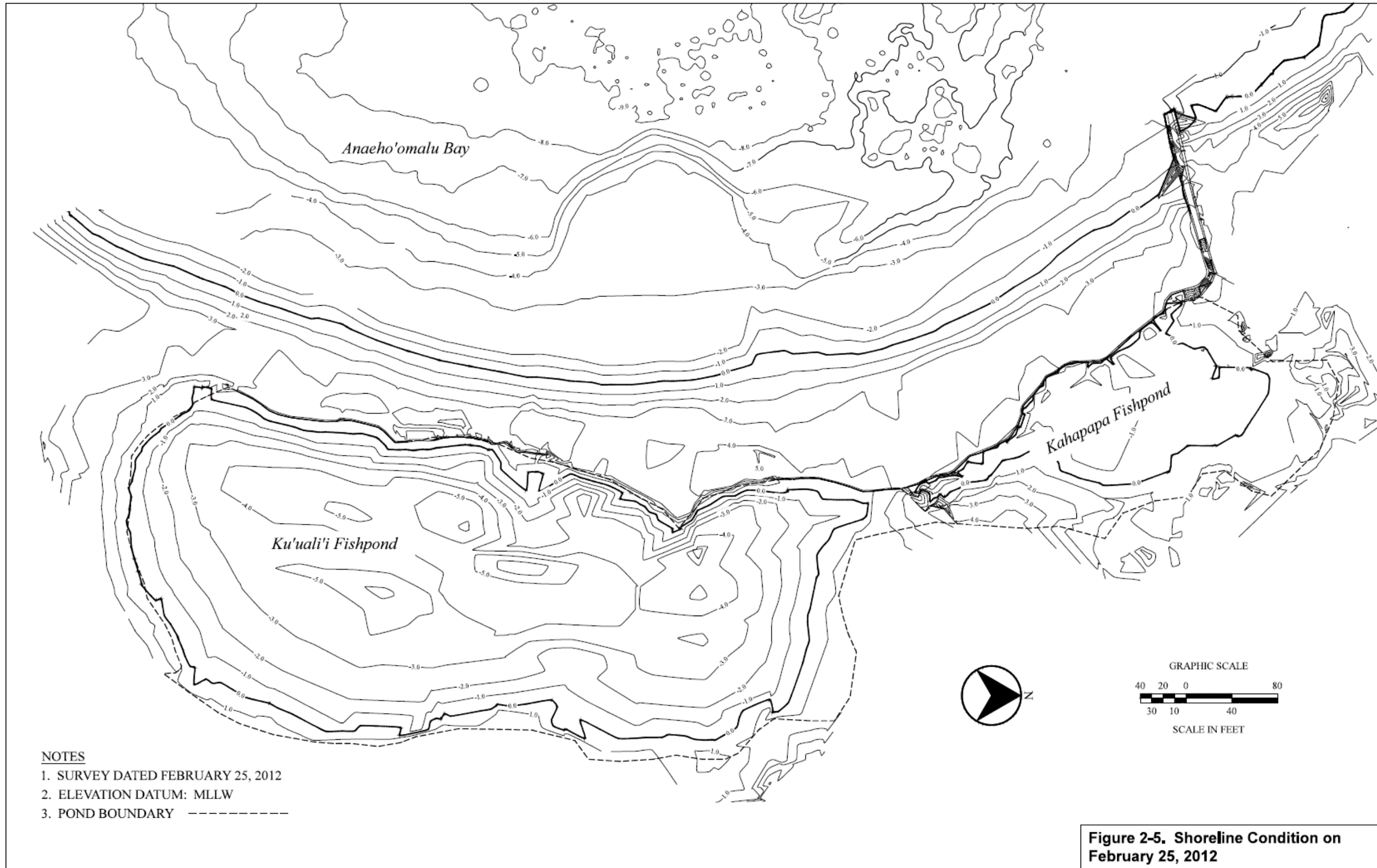


Figure 2-5 Shoreline Condition on February 25, 2012

The emergency repairs removed much of the sand in-fill from the pond in the vicinity of the breach to fill the geotubes, however an estimated 800 cy of sand remains to be removed and could be placed on the beach.

The sand on the beach is a mixture of calcium carbonate (e.g. marine origin shell and reefal fragments) and basalt lava. The sand is relatively coarse, with a median grain size of 0.5 mm. Bottom sediments seaward of the beach toe, in about four feet of water, are typically very fine sand, with a median size less than 0.1 mm. The sand comprising the mound seaward of the beach breach is identical to the sand on the beach, indicating that the mound was created by tsunami eroded beach sand.

The berm area is roughly horizontal with hummocks and depressions. Hummocks have peak elevations near +5 feet mllw, and depressions have minimum elevations around +3 feet mllw. The beach face has a slope that ranges from 9H:1V to 10H:1V. The beach face is denuded, as the coconut trees were removed due to tsunami related volume loss and shoreline recession. There is still a sparse coconut stand on the berm and dune, in the area not breached by the tsunami.

The mauka side of the beach is typified by a steep slope, held in place by the makai boundary wall of Kuualii Pond. The wall is a grouted basalt rock wall, constructed with man-size rocks and a concrete cap.

Beach and berm sand are primarily carbonate, and tan in color. The bulk of the sand volume is in the coarse and medium grain size fractions, with limited fines and very little pebbles. There is a minor component of terrigenous material and very little organic detritus in the beach face, berm, and dune sand.

The nearshore environment is sandy substrate adjacent to the beach face, with a sand apron spreading out from the project area toward the reef crest. There are numerous, discrete coral colonies, in small mounds, between 50 to 150 meters from the project site, sitting within the broader sand apron. The reef structure consolidates to a fringing reef by 200 meters from the project site, and extends to the deep reef crest approximately 600 to 800 meters from the project site.

There is limited wave action along the shoreline, as most wave energy is attenuated by the reef crest and shallow fringing reef offshore of the project site. The project site is sheltered from all tradewind waves and partially sheltered from most North Pacific and South Pacific swell. Winter season Kona low pressure systems passing through the islands can generate waves which directly approach the beach. Limited wave energy and currents at the project site are generally a result of the mid-day sea breeze that develops along the coastline.

2.2 Pond and Nearshore Marine Environment

Waikoloa has one of the most comprehensive environmental monitoring programs on the West Hawaii coast, beginning in 1977 and continuing today. The monitoring focus is primarily on the anchialine ponds located on the north side of Waikoloa Resort, however there are water quality sampling stations in Kahapapa and Kuualii ponds also, as well as nearshore marine sampling stations. Dr. Richard Brock (Environmental Assessment Company) has conducted a quarterly water quality monitoring program for the resort since 1991, reporting on samples from 18 to 24 permanent sampling stations (Brock, 2011). These stations sample a broad cross section of water; from wells inland of the resort, through anchialine ponds, the fishponds, and nearshore coastal waters. The program focuses on measuring water quality parameters identified by the State Department of Health (HAR, Chapter 11-54). There is significant groundwater flow under the resort, and this groundwater is typically nutrient rich, although the nutrient chemistry of West Hawaii groundwater is highly variable both spatially and temporally and concentrations are frequently in excess of biological needs (Brock, 2011). Beginning in 2006 the resort began significantly reducing the application of fertilizers, with the result that nitrogen and phosphorus concentrations in the groundwater, and thus the input of these to the ponds and nearshore waters, has declined. In 2008 the use of treated sewage effluent in the resort's irrigation system was discontinued pending upgrades in treatment to meet Department of Health standards for treated effluent reuse in irrigation water, and this has further contributed to a decrease in nutrient levels. The concentrations of water quality parameters tested typically do not meet the State water quality standards; however they are not particularly high when compared to other undeveloped areas along the West Hawaii coast (Brock, 2011). It is well known that near shore waters on the West Hawaii coast frequently do not meet the standards for nitrate, nitrogen, ammonia nitrogen, total nitrogen and chlorophyll-*a*. The groundwater discharge along the shore also results in slightly lowered nearshore salinity levels. Turbidity also typically exceeds the State standard, and with the standard for West Hawaii of 0.10 NTU most near shore West Hawaii waters are not in compliance (Brock, 2011). West Hawaii coastal waters and Anaehoomalu Bay are designated Class AA (HAR 11-54). "It is the objective of class AA waters that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions" (HAR 11-54).

The Environmental Assessment Co. conducted investigations and made recommendations for improving water clarity in Kuualii and Kahapapa fishponds (Brock, 1991). The ponds fell into disuse in the late 1800's and have not been managed as an aquaculture facility since that time. Presently water exchange in the ponds is low and organic production is high resulting in poor water clarity. The primary sources of water for the ponds are low salinity groundwater, and seawater entering through the Kahapapa connection to the ocean and percolating through the sand beach fronting the pond. The groundwater entering the ponds is high in inorganic nutrients which fuel the growth of algae and phytoplankton, and population densities are much higher than in nearby normal coastal settings, which is the major contributor to the turbid conditions. Brock estimated the residence time of water in Kuualii pond to be 15 to 27 days, far in excess of the growth rate of phytoplankton. One recommendation for improving water clarity was to construct a second auwai, or circulation channel, at the southwest corner of the pond to improve circulation and flushing. Brock contends that such a channel may have existed in prehistoric times, however he acknowledges that no quantitative evidence of this presently exists. The

present channel connecting the two ponds, and the channel connecting Kahapapa pond to the ocean are modern in origin. No additional circulation channels are proposed for the permanent tsunami repair plan.

Planning is underway by the Waikoloa Land and Cattle Company for a new resort residential project to be developed immediately south of the beach and Kuualii fishpond. In support of this project a baseline marine environmental assessment was conducted in 2006 and 2008 by Marine Research Consultants, Inc. (MRC, 2008). The work included water quality sampling and analysis, and assessment of the benthic and fish marine community. Dissolved inorganic and total nutrients showed strong gradients with distance from shore, with the highest values at the shoreline and lowest values furthest from shore. The gradient was very steep to a distance of 50 m from shore, and then flattened out. Salinity concentrations were just the opposite, lowest at the shoreline and increasing with distance seaward. These patterns are indicative of groundwater flow along the shoreline. The central portion of the bay floor, fronting Kuualii pond, is a sand bottom channel. On either side of the channel the bottom consists of hard basalt and limestone substrate covered with reef building corals. The inner portion of the bay is somewhat sheltered from waves, and the coral community structure consists of lobate and branching species of the genera *Porites*. The average coral cover was about 85% of the bottom area, with about half of this being *Porites lobata*. The delicate branching species *Porites compressa* covered about 21% of the bottom, and it showed no indication of breakage or damage by wave action. Besides corals, sea urchins are the other dominant group of macroinvertebrates observed on the reef, the most common being *Echinometra matheai*. Other benthic organisms observed were sea cucumbers (Holothurians), starfish (Asteroidea), and encrusting red calcareous algae. The reef fish community is typical of that found along most of the Kona coast. During the surveys 34 fish species were observed, with herbivores (yellow tang, goldring surgeonfish, and brown surgeonfish) being the most common. Other abundant fishes included wrasses. Observed species of “food fish” (those taken by subsistence and recreational fisherman) included grand-eyed porgeys, squirrelfish, parrotfish, goatfish, and grouper. None of the food fish species were particularly abundant.

The nautical chart for the region is shown in Figure 2-6.

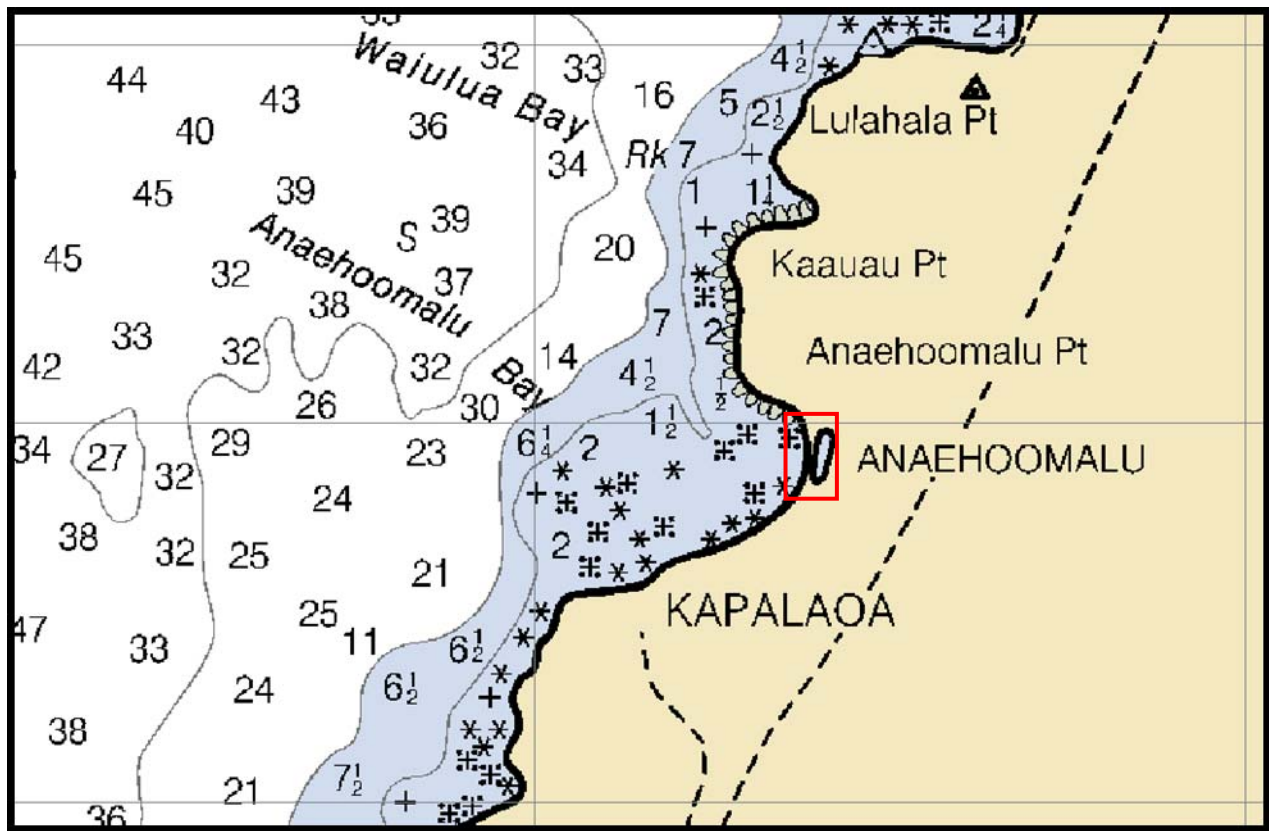


Figure 2-6 Nautical chart for the coastline around Anaehoomalu Bay, including the project vicinity (red box)

2.3 Recreational Uses

Currently, recreation uses include: tourism, sunbathing, beach walking, swimming, snorkeling, kite boarding, outrigger canoe paddling, kayak paddling, surfing, stand up paddling and surfing, and boat charters.

The area is seaward of the Waikoloa resort development. However, the immediate vicinity of the project area is open beach and fishponds. There are a canoe hale, and a public restroom and shower facility south of the project site.

Beach access will be restricted during construction phases of the project, at the project site. Access will be open to both the north and south of the project site, and will be open on the beach face makai of the work area.

2.4 Cultural and Historic Conditions

The project site is the beach berm and dune system that create the makai boundary for Kuualii Pond, a loko puuone fishpond or sand dune pond. Numerous archeological studies, surveys, and excavations of the region have been conducted over the years. The studies indicate a high

concentration of archeological sites in the region. The fishpond was used for aquaculture; however this use was apparently discontinued in the 1800's.

The proposed tsunami restoration project will not impact any of the identified cultural deposits in the region. There will be no excavation of the pre-existing beach area associated with this project, and all beach quality sand will be placed upon the existing surface to design elevations.

See attached Best Management Practices Plan for additional information.

2.5 Beach Sediment

Grain size analysis was conducted by AECOS, Inc. on composite samples of the beach sand. This analysis was completed under AECOS project number 766, log number 28038. Results of the grain size analysis are presented below. Existing sediment has 0.8%, by weight, content that is within the fine size fraction. The existing sand color is tan.

Table 2-1 Grain size distributions for Waikoloa beach and offshore sand deposit samples, Percent Finer by Weight

size (mm)	4.000	2.000	1.000	0.500	0.355	0.250	0.125	0.075	0.063	0.008
Waikoloa Beach	100.00	99.800	98.600	67.200	31.800	13.900	0.500	0.200	0.200	0.000

Grain size analysis for the beach face composite sample show a dominant volume in the coarse to medium size range (approximately 86%). Just over 30% is in the coarse size fraction and slightly more than 50% is in the medium size fraction.

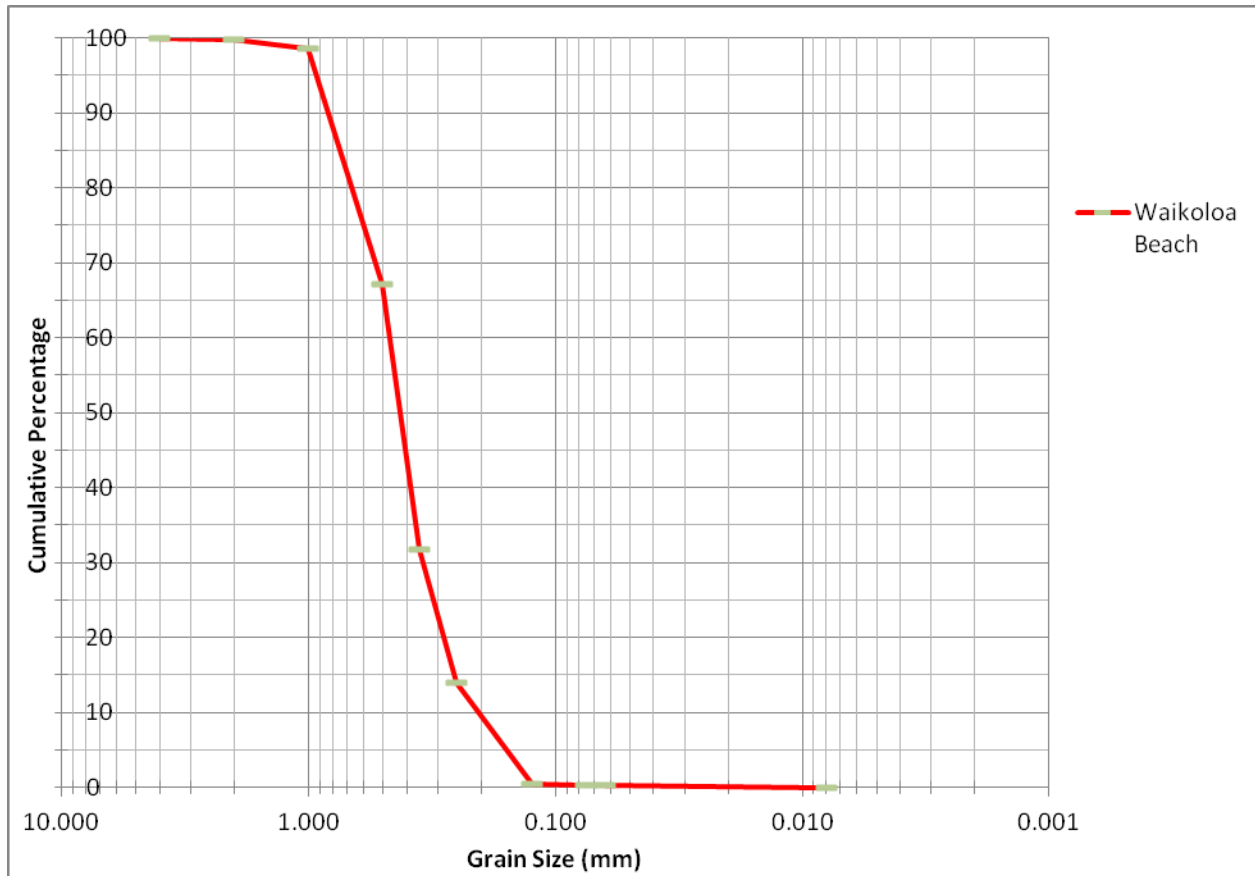


Figure 2-7 Grain size distribution for Waikoloa beach and offshore sand deposit

3. PROPOSED PERMANENT TSUNAMI DAMAGE REPAIR PLAN

Fishpond health for a sand dune pond (loko puuone) is closely tied to the health and location of the adjacent beach system. The beach acts as a natural hazard buffer for the pond by providing a barrier to dissipate incident wave energy and prevent waves from carrying sand and sediment into the pond. Ideally the beach system should be high enough or wide enough to prevent wave overtopping and the resulting carrying of sand into the pond. Prior tsunami (1946 and 1960) and hurricane (Iniki, 1992) events have reportedly resulted in damage to the beach and pond and required repairs to maintain the pond. The existing pond wall was built in the 1980's as a response to winter wave events that were migrating the beach landward into the pond. This wall has been effective at slowing the landward migration of the beach, but has not been sufficient to stop wave overtopping of the beach and washing of sand into the pond. In the past, the resort pushed sand on the beach face up to create a berm at the beach crest to reduce the extent of wave overtopping. However, in 2010 they were ordered by the Army Corps of Engineers to desist from this practice unless a Department of the Army permit for work in waters of the U.S. is obtained. Normally, a healthy frontal dune would provide a natural barrier and protection for a loko puuone pond. However, in its present damaged and degraded condition the beach is not capable of providing an effective barrier for maintenance of the pond. In addition, with potential sea level rise, the beach's natural response will be to elevate and migrate landward. The most important aspect of pond restoration will be to reestablish the wall to provide a fixed barrier to prevent landward beach migration. However, the wall itself is not designed to be stable under direct wave attack, and maintenance of the beach is necessary to protect the wall from wave damage. The wall and beach act together to provide the necessary protection for the pond, the wall provides a fixed barrier for the beach to abut and to stop its landward migration, and the beach provides for wave energy dissipation to protect the wall. Restoration of both the wall and beach is necessary for maintenance and long-term stewardship of the pond resource.

3.1 Wall Repair

The existing pond wall is shown on Figure 3-1. It is not known exactly how the existing wall was constructed. Anecdotal information indicates that large boulders were placed first to form a stable mass, then the cemented stacked rock wall was constructed on top of the boulders. Evidence of this construction technique can be seen at some of the damaged wall locations. Approximately 220 linear feet of wall was completely destroyed by the tsunami, and other sections are now leaning and appear unstable. Given the extensive damage it is recommended that the entire wall be replaced. It is proposed to rebuild the wall in a manner similar to its original construction. The remains of the existing wall will be removed, and sand excavated from around it to expose the boulder foundation. Where boulders are not found, or have settled to a position below the low tide water level, additional boulders will be placed as necessary to create a stable mass. The top of this mass boulder foundation will be at approximately mean lower low water. A cemented stone wall (cement-rubble-masonry or CRM) will then be built on top of the boulder foundation, with a top elevation of +6 feet.



Figure 3-1 Existing Pond Wall

3.1.1 Wall Design

A typical wall section is shown on Figure 3-2. The wall would be of standard gravity wall design, and the first course of wall stone would be carefully placed to key it into the boulder foundation. The total wall length would be approximately 690 linear feet. The wall is designed to replicate the existing feature and tie in to the undamaged portions of the remaining pond walls.

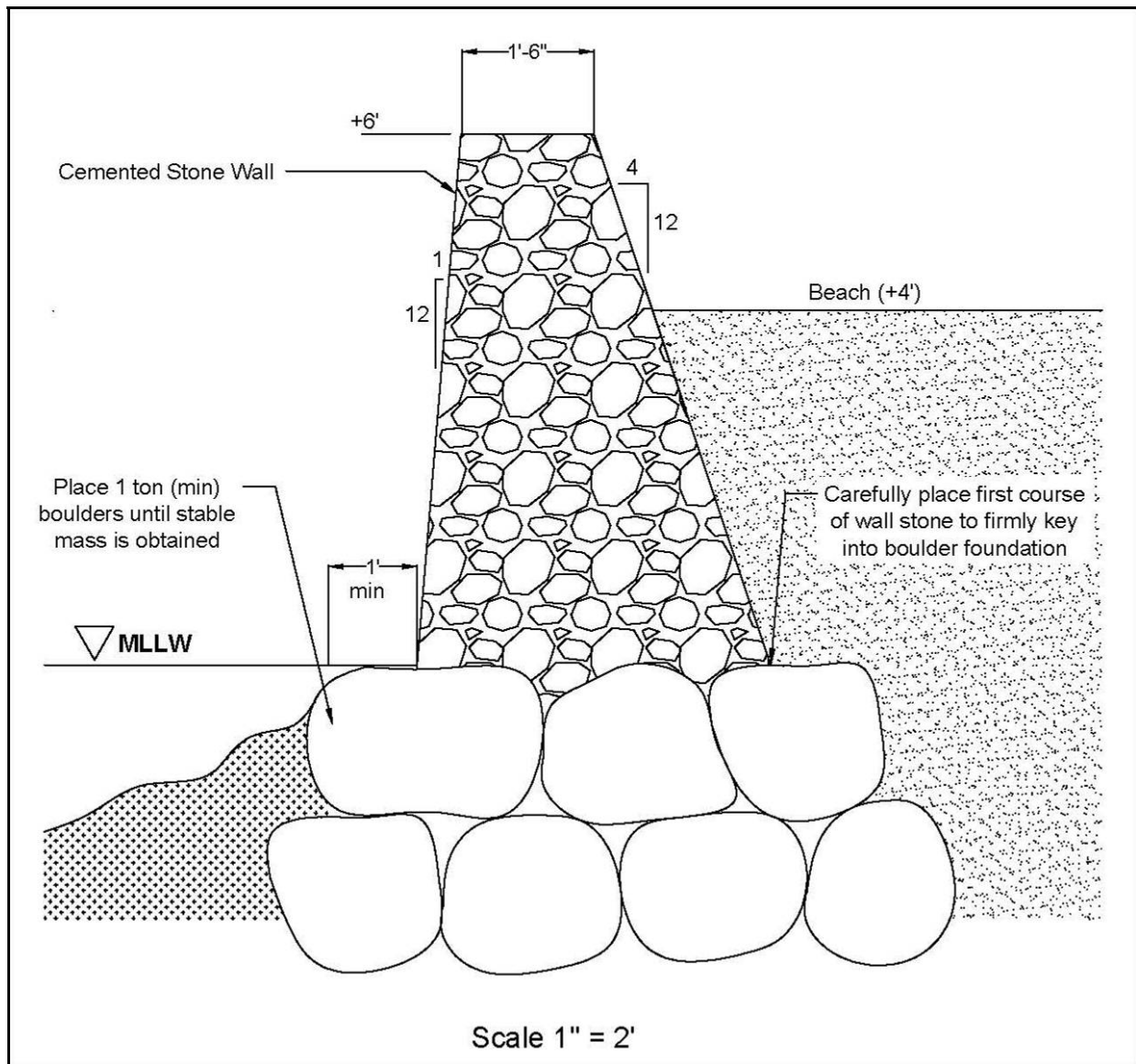


Figure 3-2 Wall Repair Section

3.1.2 Wall Repair Work Plan

Ingress:

Trucks will deliver materials to the site through Kuualii Place, following a short construction road from the end of Kuualii Place to the beach berm. The excavator will be offloaded in the public parking area and driven to the project site. See Figure 3-3.

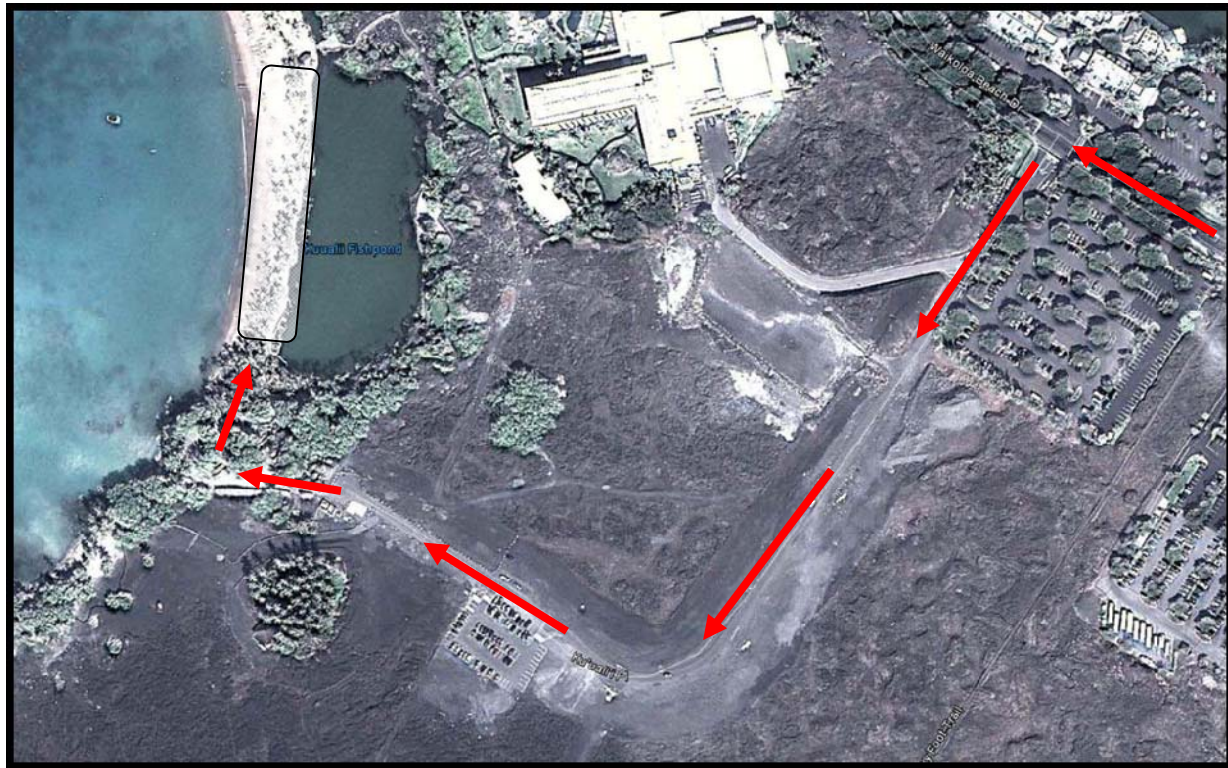


Figure 3-3 Ingress route for each task in the plan. Egress is the same path. General project area is shown within the shaded box.

Mobilization and Staging:

The project site will be demarcated by traffic cones around the perimeter. In addition, project personnel will engage the public as needed to identify the boundaries of the project area.

The primary component of mobilization will be removal of failed sections of wall that cannot be reused in the restored wall and delivery of new wall and foundation material as needed. As the material needs will be identified during the removal and repair process, delivery of foundation and wall materials is expected to be contemporaneous with the wall restoration process. Rather than stockpile the materials on-site, the design is to drive the dump trucks onto the beach, and place the material adjacent to the wall restoration activity.

The excavator will be staged in the project area, as identified in Figure 3-4.



Figure 3-4 Equipment staging area (orange box) will be in the project area, on the beach.

Wall Restoration:

Work will be conducted in 2 sections along the wall, each approximately 300 feet in length. Each section will be environmentally protected, as described in the attached BMPP.

The land based excavator will remove the remaining broken pieces of wall from the pond by using the bucket. Those pieces of damaged wall and foundation material that can be reused will be placed in the work area. Those pieces not appropriate for reuse will be loaded into a truck for hauling to the County disposal site for this type of material. The excavator will then excavate as needed to prepare the new wall foundation, and place foundation boulders. The foundation work will all be from mllw (+0.00 feet mllw at Kawaihae, Station 1617433) to the base of the foundation, at the edge of the beach.

The CRM wall will then be constructed atop the boulder foundation by hand, in a similar fashion as the original wall and other standard CRM retaining walls. The CRM wall construction will be conducted above mllw.

The project area will be marked with orange traffic cones on the beach. Project personnel will engage the public as needed to provide information regarding access limitations due to construction work.

Egress:

Upon successful completion of the task in each section, the project area will be cleaned of all construction related material and debris.

The excavator will remain on site for the following task, which will entail recovery of beach sand from the pond for placement against the makai side of the wall in that section.

3.1.3 Potential Impacts

Minimization and mitigation efforts are described in detail in the attached Best Management Practices Plan.

Temporary adverse impacts to the site will be limited, as the entire project is designed to restore the preexisting pond boundary wall, which was significantly damaged by the 2011 tsunami. Some work will be conducted below mhhw. This work will include removal of the existing, damaged portions of wall, repositioning the existing foundation boulders as needed, and placement of additional foundation boulders as needed.

During the course of construction, there will be limited impacts to noise quality as noise from the construction equipment will exceed typical ambient noise levels. Ambient noise is generally limited to small boat engines, wind, waves, and light vehicles. In addition, there will be an impact to public access at the project site during construction. Access will be unobstructed on both sides of the operation, and the beach face will be open makai of the project area.

Minimal, temporary impacts will be associated with placement of the silt curtains, removal of damaged wall sections, and reestablishing the wall's foundation. None of these minor impacts will last longer than the project duration. No impacts are expected to the nearshore environments, as the project will not be located in the open coastal waters. No impacts are expected to the existing coconut tree stand or the beach environment, as this project will restore the preexisting pond wall.

The damaged wall sections, replacement boulders, and silt curtains are all benign materials. In addition, there is not expected to be any run-off issues, as the work does not include placement of finer sized materials.

3.2 Wall Stabilization and Sand Reclamation

It is proposed to reclaim sand remaining in the pond (800 cy) and place it makai of the restored wall to provide support and protection for the pond wall. The CRM pond wall is designed to act as retaining wall, holding the beach out of the pond area. The CRM wall, a gravity wall, is not designed to withstand the impact of waves washing across the beach face and berm, and required beach sand to both buttress the structure and provide protection from the wash of the waves. All recovered sand would be placed above the mean higher high water (mhhw) elevation (+2.16 feet mllw) on the makai side of the wall.

3.2.1 Wall Stabilization and Sand Reclamation Work Plan

This task will be conducted upon successful completion of the wall restoration task in each work area. There will be no ingress activity for the excavator, as it will already be located on site. Ingress for the front end loader will be along the same path as shown in Figure 3-3.

Sand Reclamation and Placement:

The land based excavator will be positioned on the beach at the edge of the sand recovery sites, above the waterline, and will not enter the pond water. The excavator will reclaim beach sand, washed into the pond, during the 2011 tsunami. The excavator will scoop sand with the bucket and deposit it on the beach berm. The reclaimed sand will be moved along the wall using a front end loader, and deposited against the beach side of the wall, filling the depression between the wall and the beach berm.

All sand placement will be conducted above mhhw and will be separated from the lagoon waters by the CRM retaining wall. Recovered sand will supplement existing beach sand in the area abutting the restored retaining wall. Sand will not be placed higher than the top of the restored wall, at +6 ft mllw.

The project area will be marked with orange traffic cones on the beach. Project personnel will engage the public as needed to provide information regarding access limitations due to construction work.

Egress:

The excavator and front end loader will be loaded onto trailers in the parking lot, and removed from the site.

3.2.2 Potential Impacts

Minimization and mitigation efforts are described in detail in the attached Best Management Practices Plan.

The reclaimed sand and silt curtains are benign materials. In addition, there is not expected to be any run-off issues, as the work is designed to place materials against the restored pond wall.

Temporary adverse impacts to the site will be limited. Only the sand reclamation portion of task will be conducted below mhhw. This portion is in quiescent pond waters and will be segregated from the general waters by a silt curtain.

During the course of construction, there will be limited impacts to noise quality as noise from the construction equipment will exceed typical ambient noise levels. Ambient noise is generally limited to small boat engines, wind, waves, and light vehicles. In addition, there will be an impact to public access at the project site during construction. Access will be unobstructed on both sides of the operation, and the beach face will be open makai of the project area.

Minimal, temporary impacts will be associated with placement of the silt curtains and reclamation of beach sand from the edges of the pond. None of these minor impacts will last longer than the project duration. No impacts are expected to the nearshore environments, as the project will not be located in the open coastal waters. No impacts are expected to the existing coconut tree stand or the beach environment, as this project will restore the beach's pre-existing volume abutting the restored pond wall.

The reclaimed beach sand originally came from the existing beach face and berm, and still comparable material. This sediment is not expected to have any associated run-off issues due to its placement behind, and confinement by, the restored pond wall.

3.3 Berm Restoration

The pre-tsunami beach configuration can be estimated using the November 10, 2010 aerial imagery (Figure 1-4) and LIDAR topographic data for the site. Based on a post-tsunami survey approximately 9,000 cy of sand was removed from the beach during the tsunami, creating what became a 200-foot-wide breach into the pond and reducing much of the beach crest elevation by about a foot. Much of this sand was deposited in the pond, and some was moved offshore immediately seaward of the breach. Instability of the beach due to tsunami damage led to continued changes in the beach configuration and loss of sand into the pond during the interim while waiting for emergency repair approval to close the breach and prevent further damage to the beach and pond. Following completion of emergency repairs the beach began to repair itself, with sand accreting over and seaward of the geotubes, burying the tubes and creating a natural beach slope seaward of them. A February 2012 topographic survey shows that about 3,400 cy of sand has accreted, leaving approximately 5,600 cy still missing from the pre-tsunami beach configuration.

Assuming its availability from a commercial on-land source, up to 4,800 cy of beach quality sand will also be placed on the beach crest above the +2.3 foot mhhw elevation to nourish the beach and help improve its long term stability. Raising the beach crest will also reduce the potential for high waves to overtop the beach and push sand into the fish pond. No sand will be placed below the +2.3 foot elevation or in the water.

Since there is no known, significant average annual erosion rate for the project beach, and placement is intended to focus sand volume storage higher on the beach profile, the project life-

cycle is expected to be on the order of decades, barring future catastrophic events. In addition, reshaping the dune that anecdotally existed on the beach prior to the second half of the last century improves coastal hazard mitigation and limits sand losses into the fishpond from annual wave overwash.

A beach restoration plan view is shown on Figure 3-8.

3.3.1 Sand Source and Delivery

The beach quality sand was recovered as part of the Haleiwa Small Boat Harbor dredge project. This sand is located at Hawaiian Cement's storage yard on Oahu. Currently, Hawaiian Cement has sufficient volume remaining in stockpile to complete the project.

Fill sediment characteristics and laboratory results were provided by the commercial owner of the material, Hawaiian Cement. The beach quality fill material is primarily coarse grain sand (77%). The beach quality fill contains 0.5% content, by weight, which is within the fine size fraction. The sediment is light brown in color.

Results of the individual grain size analyses are presented in the table below for comparison. In addition, both samples are plotted in the figure below, which includes the +/- 20% window for the existing beach face sample.

Table 3-1 Grain size distributions for Waikoloa beach and Haleiwa sand (Hawaiian Cement) deposit samples, Percent Finer by Weight

size (mm)	4.000	2.000	1.000	0.500	0.355	0.250	0.149	0.125	0.075	0.063	0.008
Waikoloa Beach	100.000	99.800	98.600	67.200	31.800	13.900		0.500	0.200	0.200	0.000
Hawaiian Cement	100.000	97.900	82.700	5.700		1.900	1.200		0.500		0.000

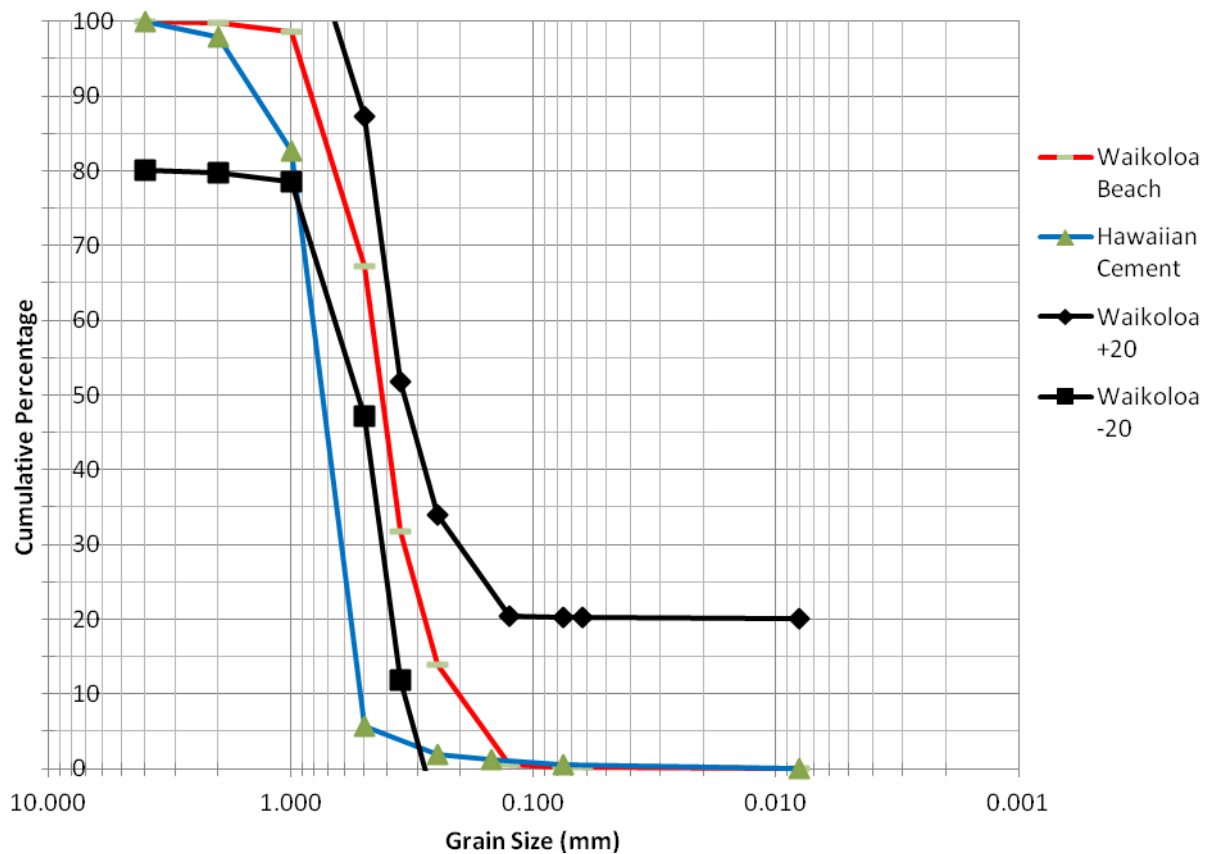


Figure 3-5 Grain size distributions for Waikoloa beach and Haleiwa sand (Hawaiian Cement) samples

The grain size distribution, by weight, comparison shows that the existing beach sand is finer than the proposed beach fill sand. The difference is greater than 20% in the coarse to medium grain sizes. Though this sediment will be placed higher on the beach profile, in the subaerial region, the purpose of the beach restoration project is to stabilize the dune and provide overwash protection to the fishpond. The slightly larger grain size of the fill sand (predominantly coarse grain size), compared to the mostly medium grain sized existing sand, will provide this additional stability without sacrificing either beach performance or aesthetics.

Sand will be transported to the Island of Hawaii via barge, and delivered to the project site by large dump trucks. Trucks will access the site through Kuualii Place, following a short construction road from the end of Kuualii Place to the beach berm, and cross the beach to deposit sand directly at the nourishment area. Bulldozers will grade the beach fill to predetermined lines and grades, as drawn from the finished surface and profiles shown in section 7)g. The project site will be staked with rebar, with finished grade elevations marked, at regular intervals along the beach, including the top of slope on the makai side of the new berm. The +2.3 contour will be staked and marked with a typical, 30" high, construction fence to ensure that neither sand fill nor equipment encroach upon the mhhw limit.

Mobilization and demobilization are expected to take one week, cumulatively. Placement and grading are expected to progress at a rate of 500 cubic yards per day, or faster. Fill and grade activities are expected to take approximately 10 work days, depending on weather. Project duration is expected to be three weeks.

All work will be conducted above mhhw (+2.15 feet mllw at Kawaihae, Station 1617433). As an added buffer, the makai construction limit and fence will be placed at +2.3 feet mllw. No fill will be placed, nor work conducted, below mhhw.

Post-grading surveys will be completed before the end of the project to ensure that placement location and volume are accurate.

Upon successful completion of the project, the beach and berm will be cleaned of all construction related material and debris. The bulldozers will back blade the berm surface upon departure, leaving the beach and berm surfaces relatively smooth and aesthetically pleasing.

3.3.2 *Berm Design*

Beach berm restoration will cover a total area of **37,200** square feet, or **0.85** acres. The entire project area is within TMK (3) 6-9-007:011. Locations of representative beach profiles are shown in Figure 3-6. Representative beach profiles are shown in Figure 3-7.

The current beach berm elevation varies between +3 and +4 feet mllw, in the project area. The proposed berm elevation is approximately +6 feet mllw. The fill's makai face is designed to slope at 1V:3H. The berm will be roughly horizontal, and will extend to the makai face of the pond wall on a level plane.

Centerline length down the berm, in the area of the beach restoration, is **approximately 620 feet**. Average berm width in the restoration **area is 65 feet**.

No work will be conducted, nor fill placed, at or below mhhw.

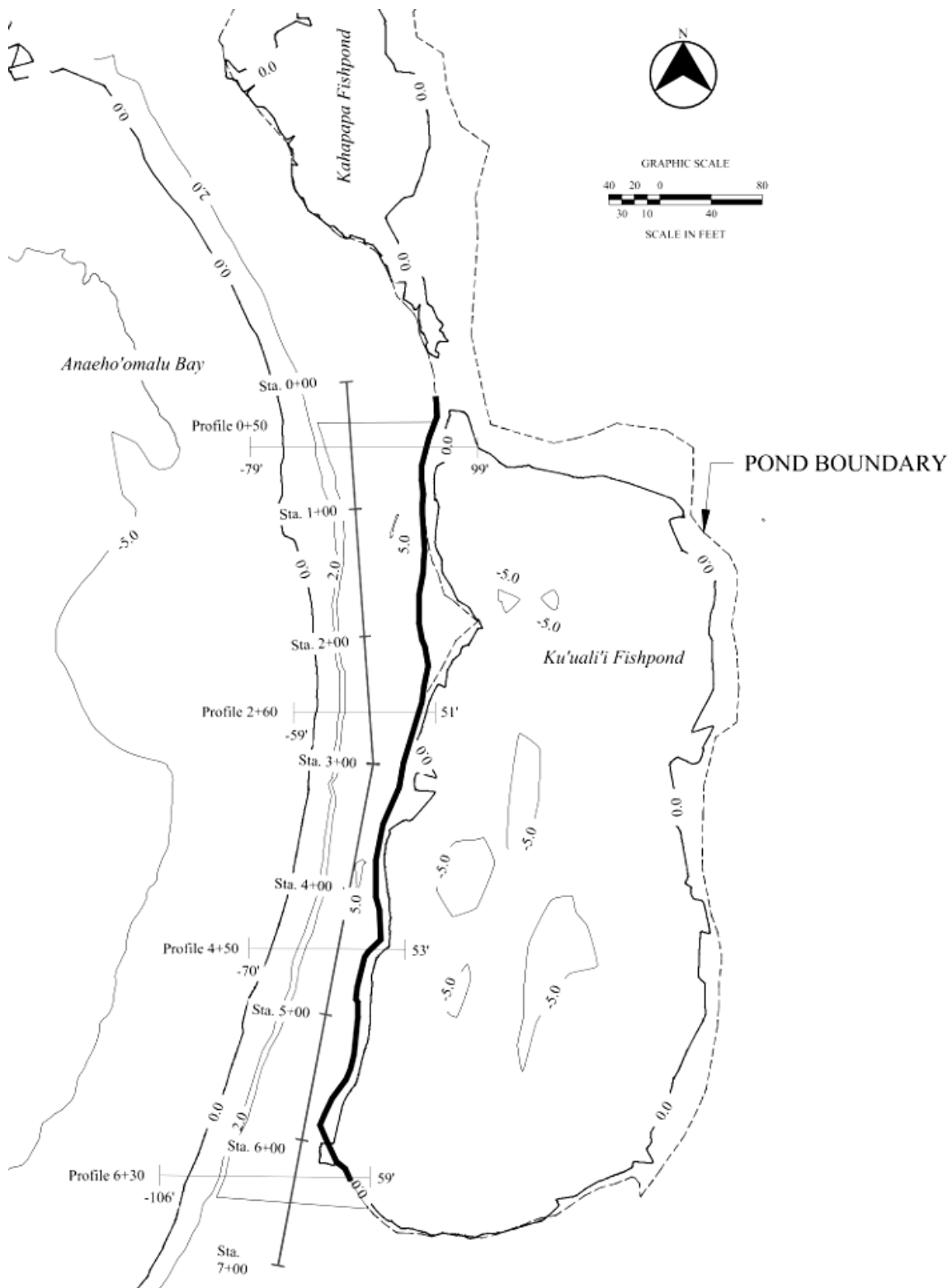


Figure 3-6 Project area map showing profile locations

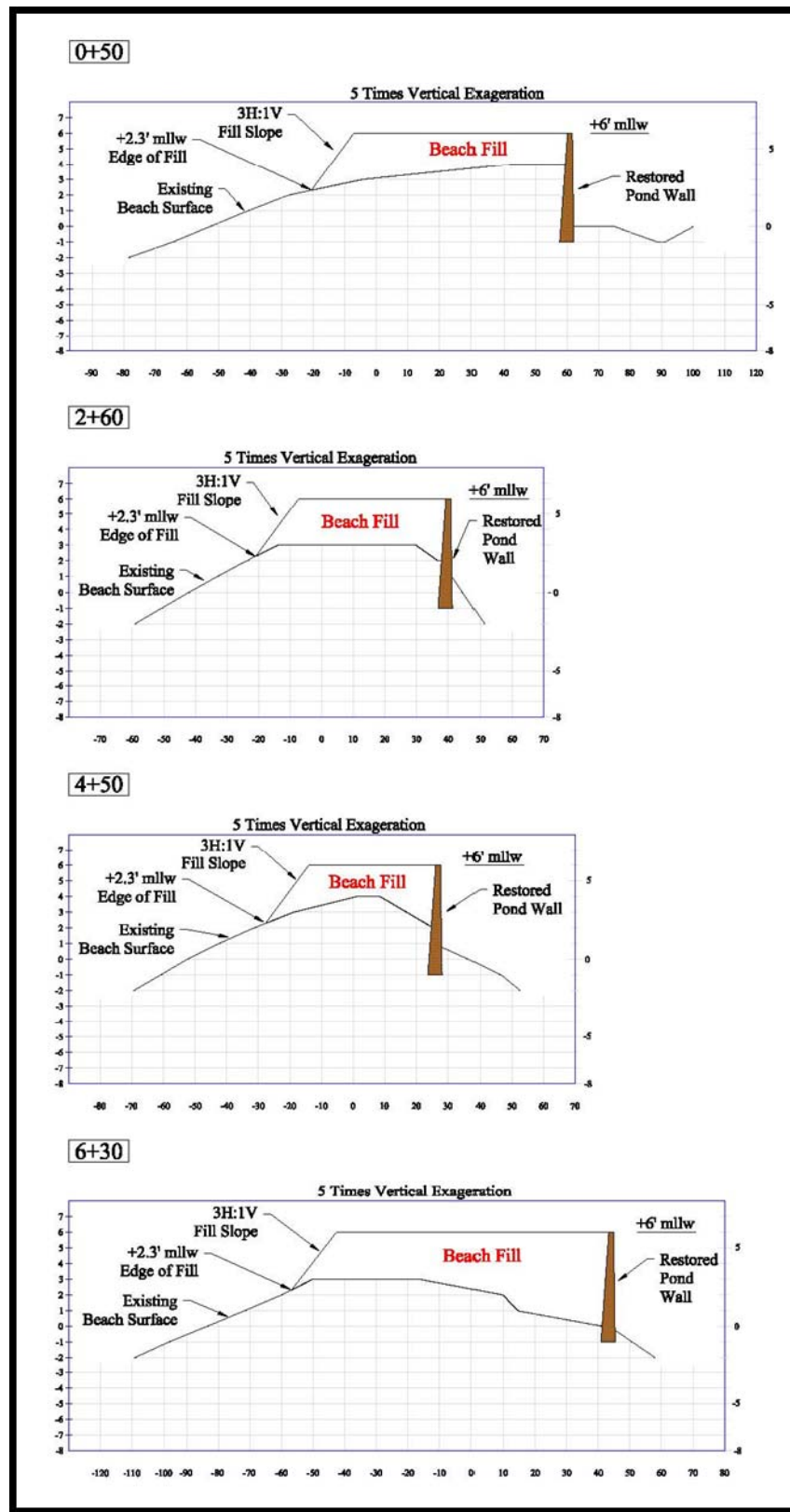


Figure 3-7 Berm restoration profiles showing existing and finished ground elevations

3.3.3 Berm Restoration Work Plan

Ingress:

Trucks will access the site through Kuualii Place, following a short construction road from the end of Kuualii Place to the beach berm, and cross the beach to deposit sand directly at the nourishment area. Bulldozers will also access the site from Kuualii Place, where they will be delivered on trailers. Ingress path will be the same as presented in Figure 3-3.

Mobilization and Staging:

The project site will be demarcated by traffic cones around the perimeter. In addition, project personnel will engage the public as needed to identify the boundaries of the project area.

The primary component of mobilization will be delivery of beach quality sand for nourishing the berm and dune. As the sand will be delivered by barge from Oahu, the project operations are designed to be contemporaneous with offloading of the barge. Rather than stockpile the sand on-site, the design is to drive the dump trucks onto the beach, and place the beach quality sand in the nourishment area for grading. The project site is approximately 11 miles from Kawaihae Harbor.

Bulldozers will be brought to the site by trailer, and will be staged at the project site, on newly placed sand at the south end of the beach, as depicted in Figure 3-4. Dump trucks will be kept offsite.

Fill Placement and Grading:

Bulldozers will grade the beach fill to predetermined lines and grades, as drawn from the finished surface and profiles shown in Figure 3-6 and Figure 3-7. The project site will be staked with rebar, with finished grade elevations marked, at regular intervals along the beach, including the top of slope on the makai side of the new berm. The +2.3 contour will be staked and marked with a typical, 30" high, construction fence to ensure that neither sand fill nor equipment encroach upon the mhhw limit.

All work will be conducted above mhhw (+2.15 feet mllw at Kawaihae, Station 1617433). As an added buffer, the makai construction limit and fence will be placed at +2.3 feet mllw. No fill will be placed, nor work conducted, below mhhw.

The project area will be marked with orange traffic cones on the beach. Project personnel will engage the public as needed to provide information regarding access limitations due to construction work.

Quality Control:

A pre-construction survey, along identified transect lines, will be conducted prior to initiating beach repair activities. The initial survey will be the baseline for calculating placed fill volume. Post-grading surveys, along the same transects, will be completed before the end of the project to ensure that placement location and volume are accurate.

Egress:

Upon successful completion of the project, the beach and berm will be cleaned of all construction related material and debris. The bulldozers will back blade the berm surface upon departure, leaving the beach and berm surfaces relatively smooth and aesthetically pleasing.

Bulldozers will be loaded onto trailers in the parking lot, and removed from the site.

3.3.4 Potential Impacts

Minimization and mitigation efforts are described in detail in the attached Best Management Practices Plan.

Adverse impacts to the site will be limited, as the entire project is designed to remain higher in elevation than mhhw. No work will be conducted, equipment operated, or fill placed below +2.3 feet mllw. The entire project is designed as a beach berm and dune restoration project to return subaerial sediment volume to the degraded littoral system.

During the course of construction, there will be limited impacts to noise quality as noise from the construction equipment will exceed typical ambient noise levels. Ambient noise is generally limited to small boat engines, wind, waves, and light vehicles. In addition, there will be an impact to public access at the project site during construction. Access will be unobstructed on both sides of the operation, and the beach face will be open below +2.3 feet mllw.

No impacts are expected to the existing coconut tree stand or the beach environment, as this project will restore the beach's pre-existing volume. No impacts are expected to either the nearshore or the fishpond environments, as the project will not be located in either water body.

The proposed beach quality fill sand has very low fine content at 0.5% or less. This sediment is not expected to have any associated run-off issues due to its medium to coarse grain size.

3.4 Retention of the Emergency Beach Stabilization Structures

The emergency repair approvals received from the Department of the Army, State DLNR and the County of Hawaii Planning Department, all require that the geotextile tubes used for emergency repairs be removed during implementation of a permanent repair plan and their sand fill be returned to the littoral system. However, given the extensive accretion of sand following the emergency repair, which has buried the tubes, their removal would be very detrimental to the natural beach repair processes which have occurred. Geotube removal would require extensive excavation of the beach to uncover them, which could destabilize the beach and result in additional beach damage. It is thus proposed that the geotubes be left in place. Should, at some future time, they become sufficiently exposed to permit their removal without damage to the beach or natural littoral processes, consideration would be given to removing them.

3.5 Repair Plan Summary

The beach repair plan as shown on Figure 3-8 would consist of the replacement of approximately 690 linear feet of pond wall, recovery of 800 cy of beach sand remaining in the pond, placement

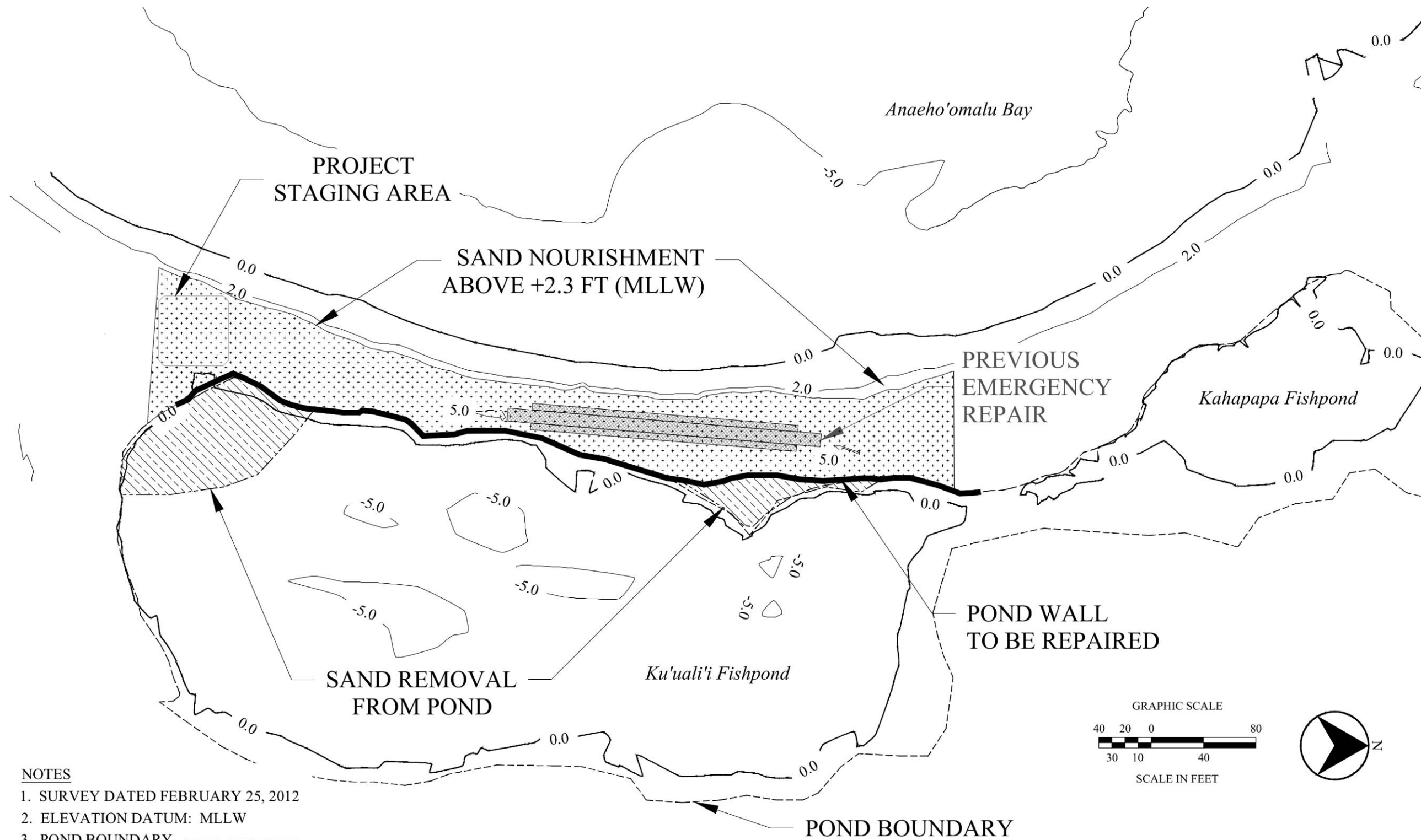
of up to 4,800 cy of sand on the beach crest above the mhhw (+2.16 feet) elevation, at +2.3 feet and higher, and retention of the tsunami damage emergency repair sand tubes. Reconstruction of the wall will require up to 580 cy of stone and approximately 190 cy of CRM to be placed below the mhhw elevation of +2.16 feet.

3.5.1 Equipment List

Specific make and model information for each piece of equipment will be provided by the contractor, and will dependant on available machinery.

- Excavator (Wall Restoration and Sand Reclamation tasks)
- Front End Loader (Sand Reclamation task)
- Bulldozer (Berm Restoration task)
- Dump Truck (Wall Restoration and Berm Restoration tasks)

Figure 3-8 Repair Plan



NOTES

1. SURVEY DATED FEBRUARY 25, 2012
2. ELEVATION DATUM: MLLW
3. POND BOUNDARY - - - - -
4. RECOVERED SAND
5. NOURISHMENT FOOTPRINT

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