Sugar Cove Berm Maintenance Plan

Sugar Cove, Sprecklesville, Maui, Hawaii

October 2014

Prepared for:
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1. INTRODUCTION

The Sugar Cove AOAO (Association) property, located at 320 Paani Place, spans a significant portion of the cove fronting its parcel in Paia, Maui, Hawaii. The Association has solely funded and carried out restoration and maintenance of the beach along approximately 520 feet of shoreline fronting their four-acre property. Beach deflation during the 1980s lead to wide spread turbidity plumes emanating from the native clay bank that was exposed during beach narrowing and loss. By 1989 the entire beach had disappeared against the clay bank. In an effort to combat chronic coastal erosion and beach loss, the Association built the Hayashi Beachwall in 1993 and started their beach restoration efforts in 1995.

Prior to the Association's restoration efforts the beach was completely lost and the nearshore waters of the cove were continuously impacted by the release of fine terrigeneous material from the natural clay bank. During this period of beach loss the nearshore waters, nearshore benthic environment, sandy nearshore ecosystem were heavily impacted and the sand beach ecosystem was completely lost.

The Association's restoration efforts have restored the sand beach and its ecosystem within the cove. The restored beach extends from the coastal armoring structures on the eastern side of the property to the natural, rocky headland on the western side of the cove. This beach restoration program has systematically added sufficient sand volume, over the previous two decades, to re-inflate the entire beach system. As part of these maintenance efforts, the Association routinely adds sand within the County access.

This privately funded, ongoing effort has reestablished the sandy coastline with a County public beach access at the eastern end; improved coastal access along the shoreline; restored the public beach resource; and eliminated the turbidity plume from the native clay bank. More importantly, this ongoing effort has restored the nearshore sandy substrate ecosystem and the sand beach ecosystem, to the benefit of green sea turtles, hawksbill sea turtles, monk seals, native shorebirds, and other fauna that routinely inhabit and utilize sand beaches in Hawaii.

The Association is interested in continuing their efforts through development of a berm restoration program and will submit a Small Scale Beach Nourishment (SSBN) application to the Office of Conservation and Coastal Lands (OCCL) at the Department of Land and Natural Resources.

Without the ongoing restoration and maintenance efforts, history has shown that the natural environment cannot maintain sufficient sediment to support a stable beach system within the cove. Projected sea-level rise coupled with the historic loss of sediment volume indicates that in the absence of the Association's ongoing efforts, there will be no public beach, no sandy coastal access, and no sandy nearshore or beach ecosystems along this section of coastline. Coastal erosion, similar to what is happening at this site, is affecting much of the shoreline along Maui's north shore, compounding the regional impacts.

1.1 Project Location

Sugar Cove is located on the north shore of Maui in the Sprecklesville area, as shown in Figure 1-1. The cove where the Sugar Cove property is located has rocky headlands on the eastern and western sides (Figure 1-2). The property is located on the center and western portions of the cove, with the restored sandy beach along the shoreline. The properties on both the western and eastern portions of cove have armored shorelines or clay and boulder banks. The property, Tax Map Key (TMK) (2) 3-8-002:003, has a Maui County beach access easement on the eastern boundary of the property (Figure 1-3). The County easement appears as a thin blank strip abutting the parcel. This public easement allows unrestricted access to the restored sand beach, and public trust lands, fronting and maintained by the Association.

Figure 1-1 Location map, Island of Maui

Figure 1-2 Location map, Sugar Cove AOAO

Figure 1-3 Location map, Tax Map (Sugar Cove AOAO property has a red outline)

1.2 Coastal Assessment

The coastline between Paia and Kahului meanders along a generally north-northwest facing oriented shoreline. Numerous small embayments are located between rocky or armored headlands along this stretch. Though some areas have sand beaches, chronic shoreline retreat has resulted in beach loss or narrowing along much of this region's shoreline. Decades of sand mining combined with rising global seal level have contributed to the loss or degradation of many of these sandy beaches, as they are increasingly replaced by shoreline armoring, or they disappear against a backdrop of clay banks and boulder beaches. The once sandy headlands that were common to the area are now completely gone, with sparse sand beaches dotting a once golden shoreline.

The sand beach at Sugar Cove is composed primarily of beach quality fill sand placed on the shoreline by the Association. The current beach sits atop and makai of the Hayashi Beachwall, built in 1993. The cuspate beach shape (Figure 1-4) forms a wide curve between the natural western headland and the shoreline armoring headland on the eastern side.

The shallow fringing reef attenuates much of the incident wave energy before it reaches the shoreline. A shallow sand bar has recently formed in the nearshore waters; further minimizing wave energy and helping to stabilize the nearshore sediment connected to the beach system. During site visits, the orientation of the sand bar and wave fronts has been a reflection of the beach shape.

1.2.1 Topography and Profiles (Local Mean Sea Level Datum)

The elevation data presented was collected on March 11, 2014, at the end of the winter season.

The sand beach fronting the parcel extends 60 to 90 feet from the 0-foot contour at local mean sea level (lmsl) to the beachwall's backstop. Beach profiles in the western area (Transect 7), middle area (Transect 5), and eastern area (Transect 3) have active beach face, or foreshore, slopes ranging from 1V:6H to 1V:8H, moving west to east (Figure 1-5). The berm crest in the profiles is around +8 feet in elevation, with a narrow berm sloping upward to the backstop for the beachwall. The nearshore is predominantly a sand field in the middle of the cove.

The restored beach has a stable berm between the active berm crest and the beachwall's backstop (Figure 1-6, Figure 1-7, and Figure 1-8). The County beach access at the east end of the beach (Figure 1-9) has a sand slope leading inland.

The nearshore portions of the beach profiles extend into a ripple covered sand field in the middle of the cove (Figure 1-10). Rocky pavement and boulders extend offshore of the western headland and eastern shoreline armoring units. The nearshore sand field, including the sand bar, has well sorted sands with minimal fine content, similar to the beach sand (Figure 1-11). Smaller and heavier terrigeneous sand sized sediment has accumulating in each ripple's trough.

Currently, enough volume has been restored to the beach to allow the nearshore sand field to store sand in the bar, extending the active beach profile well into the nearshore waters. This is an indication that the current volume of restored sand is supporting a healthy beach system, and should be maintained as part of the Association's ongoing restoration and maintenance program.

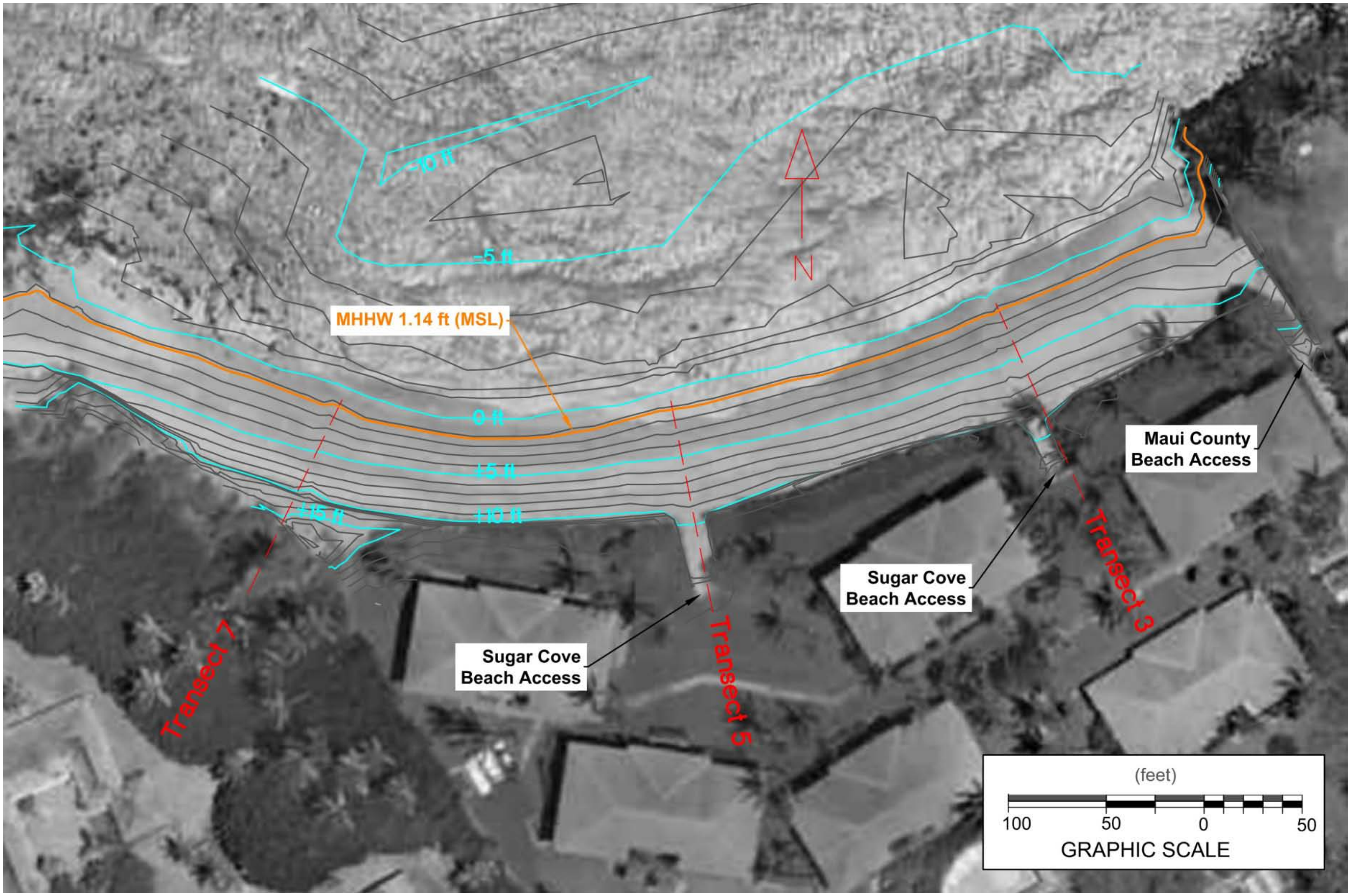


Figure 1-4 Existing topography and bathymetry at the project site, March 11, 2014 (LMSL datum)

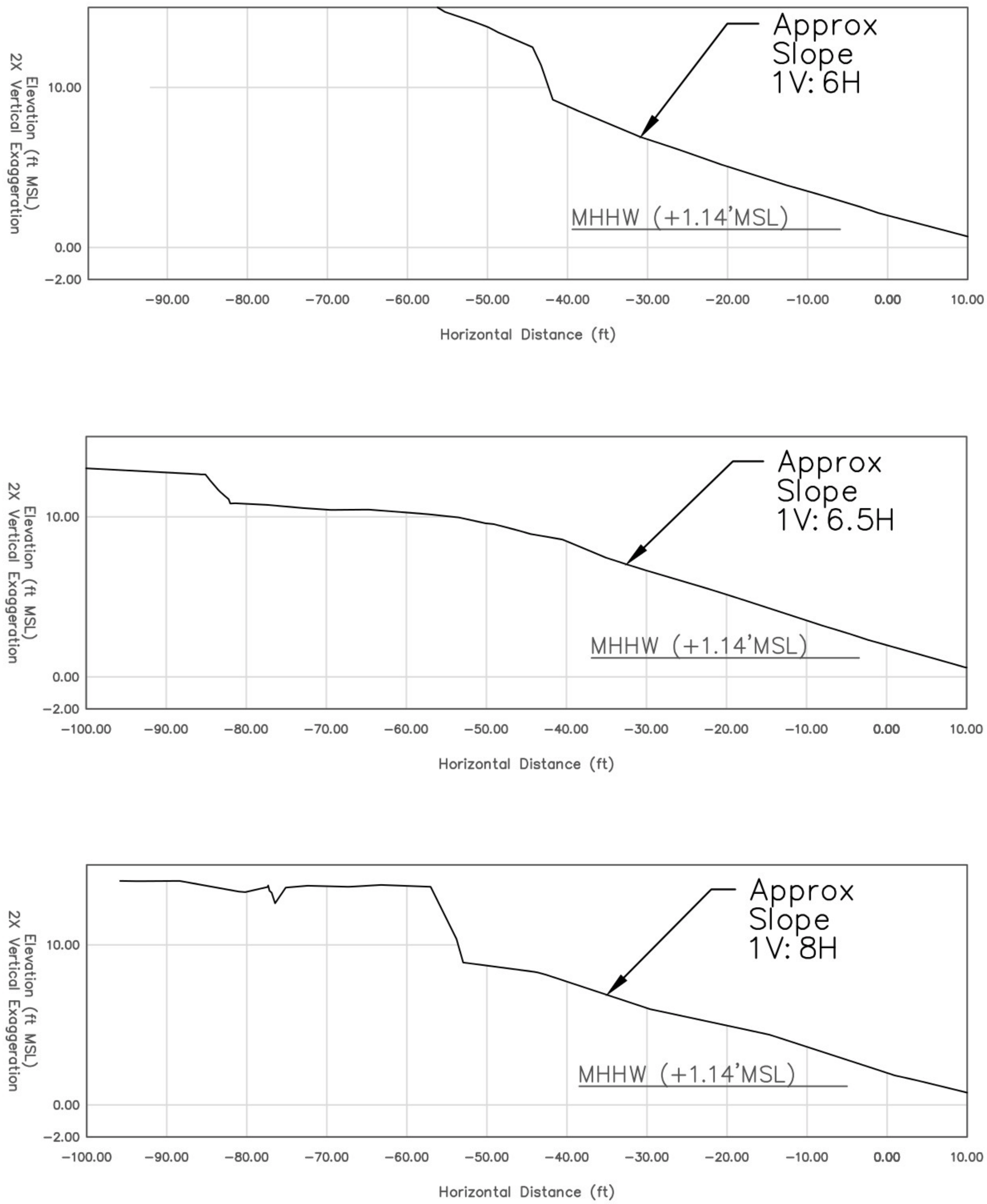


Figure 1-5 Existing profiles at the project site, March 11, 2014 (Transects 7, 5, and 3 at top, middle, and bottom respectively) (LMSL Datum)

Figure 1-6 Looking east along the restored beach, from near the western boundary

Figure 1-7 Looking offshore across the restored beach, from near the middle of the property

Figure 1-8 Looking west along the restored beach, from near the eastern boundary

Figure 1-9 Looking inland along the county beach access abutting the eastern side of the property at the eastern edge of the restored beach

Figure 1-10 Sand ripples forming in the sand field and bar in the nearshore waters of the cove

Figure 1-11 Nearshore sand from the sand bar is beach quality material similar to the restored beach sand

1.2.2 Shoreline History

The shoreline history of Maui's north shore has been dominated by coastal erosion. Both natural and anthropogenic influences have impacted the littoral cells in this region. Doak Cox, in his 1954 report (Appendix I), documented the profound impact that sand mining (Figure 1-12) was having on the north shore's sand beaches. This report is a testament to the fact that in 1954 the community was already witnessing and responding to the chronic shoreline retreat along this coastline. As erosion progressed, areas that had once been covered by sandy nearshore, sand beaches, and sandy coastal plain were exposed to the ocean environment. Moberly, *et al.*, document this history of erosion in their 1964 report on Hawaii's shoreline. They report that, "…lines of beach rock awash at the waterline as much as 800 feet offshore show that the historic record of beach erosion is merely the latest stage in a process operating over the last few hundred years."

By 1986 beach erosion had exposed the clay bank beneath and mauka of the sandy shoreline, resulting in the ongoing presence of turbid waters within the bay (Figure 1-13). These water quality impacts became increasingly persistent and pervasive as the beach and sandy nearshore disappeared. In response, the Association installed a small sandbag structure in 1988; however, high waves during the winter season tore open the bags and left the shoreline unprotected. Wholesale loss of the beach was complete by 1989, resulting in exposure of the clay bank and basalt boulders (Figure 1-14) that stretched along this entire length of the coastline. Though continued erosion into the clay bank resulted in ongoing loss of land and release of fine clay and silt sized particles into the marine waters, it did not result in a sand beach reforming at a more mauka location. The end result was complete loss of the sandy nearshore and sand beach ecosystems, heavily impacted nearshore waters with ongoing turbidity issues resulting from the erosion of the clay bank, and the glaring absence of a sand beach for public access and public recreation.

Figure 1-12 Lime kiln railway debris on Maui's north shore

Figure 1-13 1986 - Nearshore turbidity related to erosion of the clay bank

Figure 1-14 1989 - Wholesale loss of the beach in Sugar Cove

In 1993 the Association had a beachwall designed and built to protect the property and mitigate the ongoing erosion of the clay bank. The Hayashi Beachwall (Figure 1-15) was designed with a low slope, roughly 1V:3.33H, to mimic the natural beach. The structure used 3 ton and larger boulders to hold position during seasonal high surf. The inland termination, or backstop, for the beachwall was a steep revetment, using similar sized boulders and resting against the eroded face of the clay bank.

Two years after construction of the beachwall the Association chose to pursue a beach restoration project. The Association recognized the value of a sand beach in the wake of stabilizing the coastline with a hardened structure. Over nearly two decades of beach replenishment, the continued placement of sand on the coastline has restored a public beach while also holding coastal erosion at bay. This effort has had other positive downstream results, including a marked improvement in water quality, restoration of the sandy nearshore and sand beach ecosystems, and privately funded restoration and maintenance of the public trust beach and beach access.

Modern shoreline variation on the beach is related to seasonal changes in morphology and cyclic volume changes associated with regular beach nourishments.

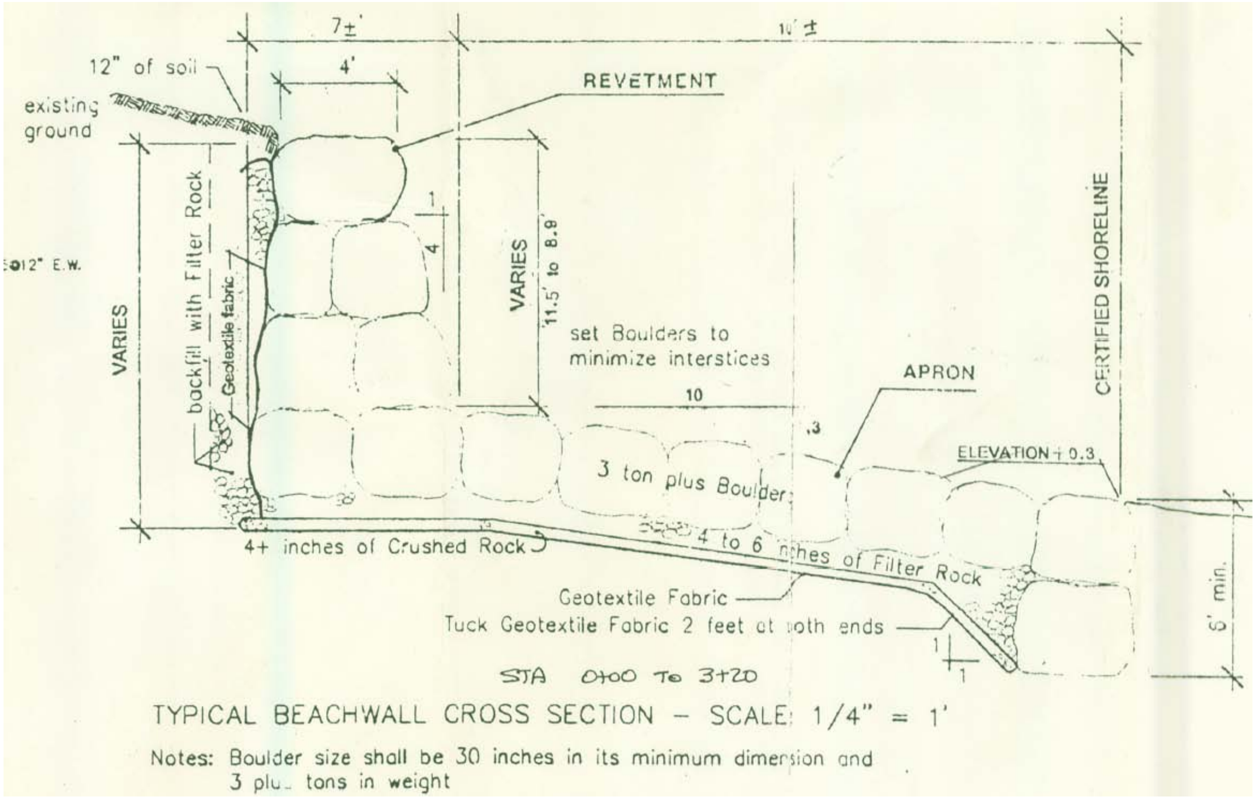


Figure 1-15 1993 – Hayashi Beachwall design

1.2.3 Average Annual Shoreline Erosion Rate

The University of Hawaii Coastal Geology Group has produced erosion rate maps for the sand beaches on the island of Maui. The erosion rate map for Sugar Cove (Figure 1-16) uses data back to the Topographic Sheet mapped in 1912. Even with the inclusion of ongoing beach restoration and maintenance efforts, the beach has calculated erosion rates greater than 2 feet per year over the period from 1912 to 2002. The natural beach had disappeared by 1989, meaning that there was a far greater shoreline recession distance as a result of the natural erosion forces, and the natural erosion occurred within a more compressed time period. As rate is a function of distance and time, the natural rate is much higher than the calculated rate, which includes the restored beach shorelines in 1997 and 2002.

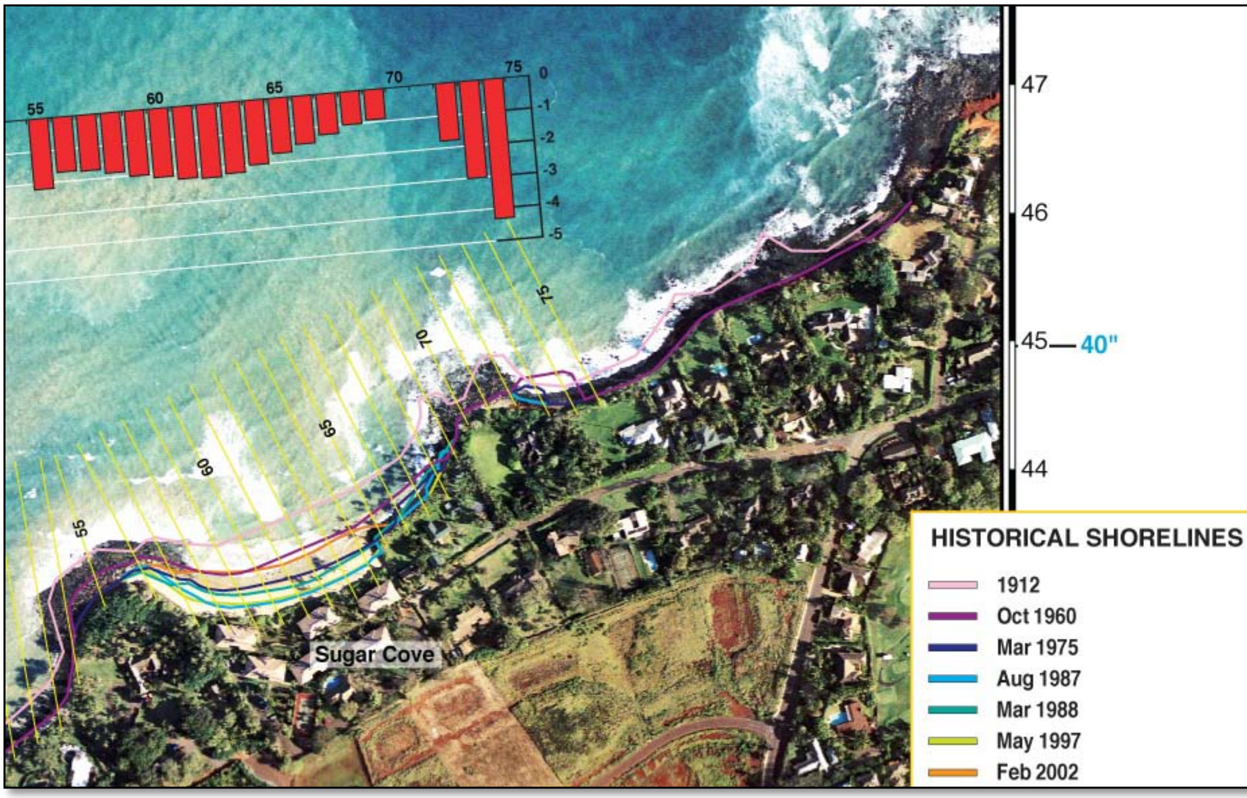


Figure 1-16 Coastal Geology Group shoreline erosion rate map

1.3 Shoreline Neighbors

Shoreline neighbors for the Sugar Cove AOAO are private residences. Many of these private residences have armored coastlines or are situated inland of rocky shorelines or earthen banks. Sugar Cove has restored and actively maintains the only sand beach in the region.

Table 1-1 Shoreline neighbors

Name	TMK	Address
Monroe Cyrus	(2) 3-8-002:004	149 Cane Road, Paia
Douglas Callahan	(2) 3-8-002:072	455 Laulea Place, Paia
Seaview 2004, Inc.	(2) 3-8-002:001	318 Paani Place, Paia
Koolau Properties LLC	(2) 3-8-002:051	316 Paani Place, Paia
Point Triumph LP	(2) 3-8-002:079	314 Paani Place, Paia

2. BERM MAINTENANCE PLAN

2.1 Purpose

Shoreline restoration and ongoing maintenance has been a necessary activity along the coastline fronting Sugar Cove since the loss of the natural beach. The absence of a natural beach since 1989 indicates that the factors controlling beach stability are working in opposition to maintenance efforts. Maintaining the restored berm will require continued placement of sand, high on this erosion prone shoreline, if a sandy coast is desired for the long-term.

The unique setting and conditions at Sugar Cove provide a rare opportunity to merge public and private interests; utilizing private funds to sustain public trust lands. All maintenance activities and costs, borne solely by the Association, have resulted in a publicly accessible and widely used sandy shoreline with a County beach access at the eastern end.

Restoration of the sandy ecosystem has wide spread environmental benefits. The north shore of Maui is rapidly losing sandy shorelines and nearshore substrate. These sandy areas are important to green sea turtles, hawksbill turtles, monk seals, shorebirds, and other coastal fauna.

2.2 Project Scope

The proposed berm maintenance plan incorporates all the previous profile and restoration effort data as well as modern conditions to evaluate the site, quantifying the successful nature of the ongoing coastal restoration and maintenance program. The plan identifies key thresholds for the ongoing maintenance of the berm and target volumes and profiles for placement of beach quality fill material. In addition, the proposed maintenance plan evaluates regulatory jurisdictions and feasibility of implementation. Since berm maintenance is a critical activity for preventing complete beach loss, as has been documented on the site, this plan also concludes that ongoing maintenance should be authorized for periods longer than a single maintenance cycle.

Ongoing maintenance will necessitate development of a monitoring plan that can be used for adaptive management. Visual and photographic assessments will be combined with the ongoing beach profiling effort. In addition, each cycle of maintenance activity will need to be approved by the OCCL for volume, sand quality, and placement design, prior to the maintenance activity.

2.3 Environmental Considerations

Sandy coastlines are inherently dynamic environments. Beach health, as quantified by volume, slope, and position, is controlled by numerous factors, both natural and anthropogenic. The dominant factors are total water level, wave environment, and available sediment volume within the littoral cell, or sand cell. An additional and key factor in this project is the character of the inland substrate.

2.3.1 Water Level

Total water level along the Sugar Cove coastline is affected by numerous factors, which are cyclical, short-term, or long-term in nature. Consistent and predictable cyclic variations are attributable to Hawaii’s normal micro-tidal fluctuations. Seasonal heating and cooling of the ocean waters around Maui also contributes to mild variations in the total water level on an annual cycle.

Short-term variations can include atmospheric pressure variations, oceanic circulation patterns, storm-surge, and wave setup. Atmospheric pressure creates minor variations in water level as it changes. Oceanic circulation patterns, such as the meso-scale eddies originating from the Equatorial Pacific, can create short duration variations of 6 inches or more in local water levels. Storm surges and wave setup are event driven phenomena that can also have profound short-term impacts as winds and waves push additional water into a region.

Long-term variations include large scale ocean currents and sea-level rise. Large scale ocean currents can affect regional water levels. Sea-level rise affects regions differently, but has been measured to average 2.32 mm/year at Kahului Harbor, Maui, which is adjacent to Sugar Cove.

Total water level at Sugar Cove is rising gradually with sea-level rise. The effects of this rise are muted or exacerbated by the other factors. In general terms, beaches will migrate inland with rising water levels if there is insufficient sand volume to support a rise in beach profile elevation at the initial location. A rise in total water level may be a contributing factor to the ongoing erosion pressure on the shoreline.

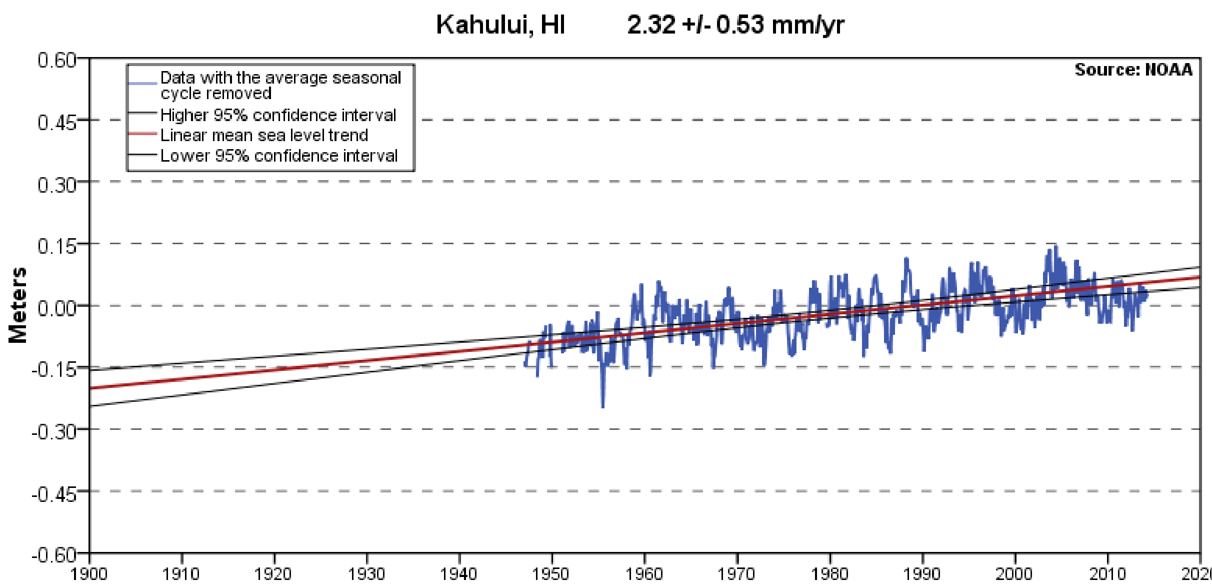


Figure 2-1 Kahului, Maui long-term tide gauge data and trend

2.3.2 Wave Environment

Surrounded by the Pacific Ocean, the Hawaiian Islands are subject to wave approach from all directions. The general Hawaiian wave climate can be described by four primary wave types: 1) trade wind waves generated by the prevailing northeast trade winds; 2) North Pacific swell produced by mid-latitude low pressure systems; 3) southern swell generated by mid-latitude storms of the southern hemisphere; and 4) Kona storm waves generated by local low pressure storm systems. In addition, the islands are occasionally affected by waves generated by tropical storms and hurricanes.

Tradewind waves may be present in Hawaiian waters throughout the year and typically have periods of 6 to 8 seconds and deepwater wave heights of 4 to 8 feet.

Southern swell is generated by southern hemisphere storms and is most prevalent during the months of April through October. These long, low waves typically approach from the south with periods of 12 to 20 seconds and typical deepwater wave heights of 1 to 5 feet.

Kona storm waves are generated by mid-latitude low-pressure system and occur at random intervals throughout the year, especially during the winter months. They approach from the south through west directions. Some winter seasons have several Kona storms; others have none. Kona storm waves typically have periods ranging from 6 to 10 seconds; wave heights are dependent upon the storm intensity, but deepwater heights can exceed 15 feet.

North Pacific swell is produced by severe winter storms in the Aleutian area of the North Pacific, and by other mid-latitude low-pressure systems. North swell may arrive in Hawaiian waters throughout the year, but is largest and most frequent during the winter months of October through March. North swell approaches from the west through north, and occasionally from the north-northeast, with periods of 12 to 20 seconds, and typical deepwater heights of 5 to 10 feet. However, deepwater wave heights of over 20 feet - with breaking wave heights of over 30 feet - are not uncommon.

Although statistically rare, large waves generated by the close passage of hurricanes can be extremely destructive. Hurricane Iwa (1982) and Hurricane Iniki (1992) each caused serious damage to beaches and property on Kauai, as well as at locations on Oahu and Maui.

The Sugar Cove shoreline is on the northern side of the Maui Nui complex, which consists of the islands of Maui, Lanai, Molokai, and Kahoolawe. These islands shelter the Sugar Cove's coast from direct exposure to southern swell and typical Kona Storms. However, the area is exposed to North Pacific swell and tradewind waves.

Sugar Cove's wave exposure creates a seasonal wave climate dominated by North Pacific swell during the winter months when tradewinds relax and by tradewinds during the summer months when the North Pacific is typically more docile. This seasonal shift in wave conditions generally results in net transport of sand to the east during the winter and west during the summer. Large wave conditions, combined with the restored littoral cell, have also created a sand bar in the nearshore waters.

2.3.3 Sand Volume

During the 1980s the natural beach progressively lost sediment volume as it migrated inland and was pinched against the harder, natural clay bank. The natural beach was eventually lost against the hard clay bank and rocks along the coastline by 1989, when the sand volume was insufficient to form a subaerial beach. Following placement of the beachwall in 1993, the sand beach did not recover. Extensive sand mining of Maui's north shore beaches, as documented by Doak Cox in 1954, combined with natural erosion forces have been significant factors in the long-term depletion of sand volume at Sugar Cove, contributing to shoreline migration and eventual beach loss.

The littoral cell, or sand cell, for this beach extends across the entire cove, from headland to headland, and out into the nearshore waters. The seaward extent, or depth of closure, is the farthest offshore that sand is shared between the marine and terrestrial beach environments.

The natural beach system, prior to its loss in the 1980s, was connected from the landward limits at the clay bank to the offshore limit at the natural depth of closure. The nearshore waters at that time held a significant sand resource, which was the marine portion of the littoral cell. The seafloor within the cove and across both headlands was almost entirely covered by sand in 1912. Though the beach has experienced long-term, chronic erosion, the littoral cell still extended into the middle of the cove and around both headlands as recently as the 1960's.

The beach has slowly been rebuilt over nearly two decades of continued restoration and maintenance efforts. Nearly 30,000 cubic yards of sand has been added to the cove's coastline, prograding a sand beach seaward nearly 80 feet from the beachwall. This volume migrates seasonally to the west and east, in the summer and winter seasons respectively.

Restoration and maintenance activities have also provided enough sediment for a sand bar to form in the nearshore waters, assisting with wave energy dissipation during large wave events. This also signifies that sufficient sand has been added to sustain a modest portion of the beach profile, from the landward limits at the beachwall to the new depth of closure offshore of the sand bar.

Without this anthropogenic contribution of sand volume, there would be no subaerial portion of the littoral cell and the nearshore portion would be severely deflated. The current beach is in a similar position and orientation to the historic 1960 shoreline, as identified by the University of Hawaii Coastal Geology Group, indicating that littoral cell volumes are recovered enough to reoccupy an area where the beach formally resided.

2.3.4 Inland Substrate

The native substrate backing the natural sand beach was progressively exposed during beach regression and loss during the 1980s. This native substrate is an alluvial outwash deposit, consisting of clay and basalt clasts of various sizes. As the beach migrated inland, the harder clay substrate presented an erosion resistant barrier that prevented further beach movement. In addition to contributing to the loss of the beach, exposure of the clay bank had significant negative impacts on water quality as it eroded.

The larger basalt clasts remained on the coastline as a cobble and boulder lag deposit. There is no significant sand source immediately inland of the clay coastline that can provide natural nourishment to the littoral cell.

The beachwall, constructed with 3 ton boulders, is the current anthropogenic substrate between the restored sand beach and the native clay bank. This structure mitigates future shoreline erosion and protects marine waters from release of material from the clay bank.

2.4 Restoration Program

2.4.1 Sand replenishment history

Over nearly two decades the original beach restoration project has grown into a fully developed maintenance program. The ongoing program routinely monitors beach health with profiles and photographic documentation. This routine monitoring has been a key tool for assessing the performance and lifecycle of the restoration activities.

Beach restoration activities began in 1995 with a small influx of under 100 cubic yards, and continued until the last beach restoration effort in the summer of 2011. Beach restoration efforts have included single placement of volumes as high as 6,015 cubic yards, though the average beach fill volume is closer to 1,400 cubic yards.

In total, the 21 previous maintenance activities (Table 2-1) have contributed nearly 30,000 cubic yards of sand to create and maintain a public beach fronting the Association's property.

Table 2-1 Beach Sand Replenishment History

Date	Volume (cy)
Fall 1995	96
Winter 1995	84
Spring 1996	3,248
Summer 1996	2,406
Fall 1997	2,406
Winter 1997	120
Summer 1998	6,015
Spring 1999	1,471
Spring 2000	2,099
Spring 2001	3,070
Fall 2003	729
Spring 2005	2,105
Spring 2006	152
Fall 2006	757
Winter 2006	75
Spring 2007	610
Spring 2008	1,347
Spring 2009	615
Spring 2010	1,088
Spring 2011	414
Summer 2011	824
Total Volume	**29,731**

Sand for the restoration efforts has routinely been provided by a local source, Ameron Hawaii, who acquires the beach quality material from accessible inland dunes. This sand is trucked to the site and spread from shore. Restoration efforts in the past ranged from spot maintenance efforts that added small volumes of sand for beach deflation hotspots, to large scale restoration efforts aimed at providing significant sand volume to the littoral cell.

Post placement, the restoration sand is gradually released, inflating the beach along the full profile within the littoral cell. Continued placement of beach quality sand, combined with years of slow release of the material within the littoral cell, has gradually inflated beach profiles along this stretch of coastline within the cove. Seasonal wave events, combined with natural phenomena have worked to spread the sand to the full extents of the littoral cell.

The current, restored beach is in a similar position and orientation, on the west side of the cove, as the native beach was in 1960. The previous, 1960 beach and littoral cell volume were similar to the current beach system, including the dry sand beach and nearshore sand field.

2.4.2 Results of previous restoration actions

The ongoing collection of beach profiles and photographs of the beach restoration and maintenance program documents the persistent recovery of beach profiles as the littoral cell is gradually inflated with placed, beach quality sand. The profiles indicate long-term, sustained inflation of the cell, with periodic restoration efforts counteracting the natural erosion pressure on the coastline. Profiles from Transect 3 (Figure 2-2), Transect 5 (Figure 2-3), and Transect 7 (Figure 2-4) show the deflated beach profile (30-Jul-96) following the first several restoration efforts. Even after placement of nearly 6,000 cy of sand, the profile was still low. By the 24-Jul-98 profiles more than 14,000 cy of beach quality sand had been added back to the littoral cell. The profiles, at this time, were beginning to show re-inflation of the nearshore portions of the beach system. More recent profiles collected on 30-Nov-12 show persistent inflation of the dry beach and long-term inflation of the nearshore. Continued maintenance has affected a substantial recovery in the littoral system, balancing with the seasonal fluctuations and chronic erosion pressure on the coastline.

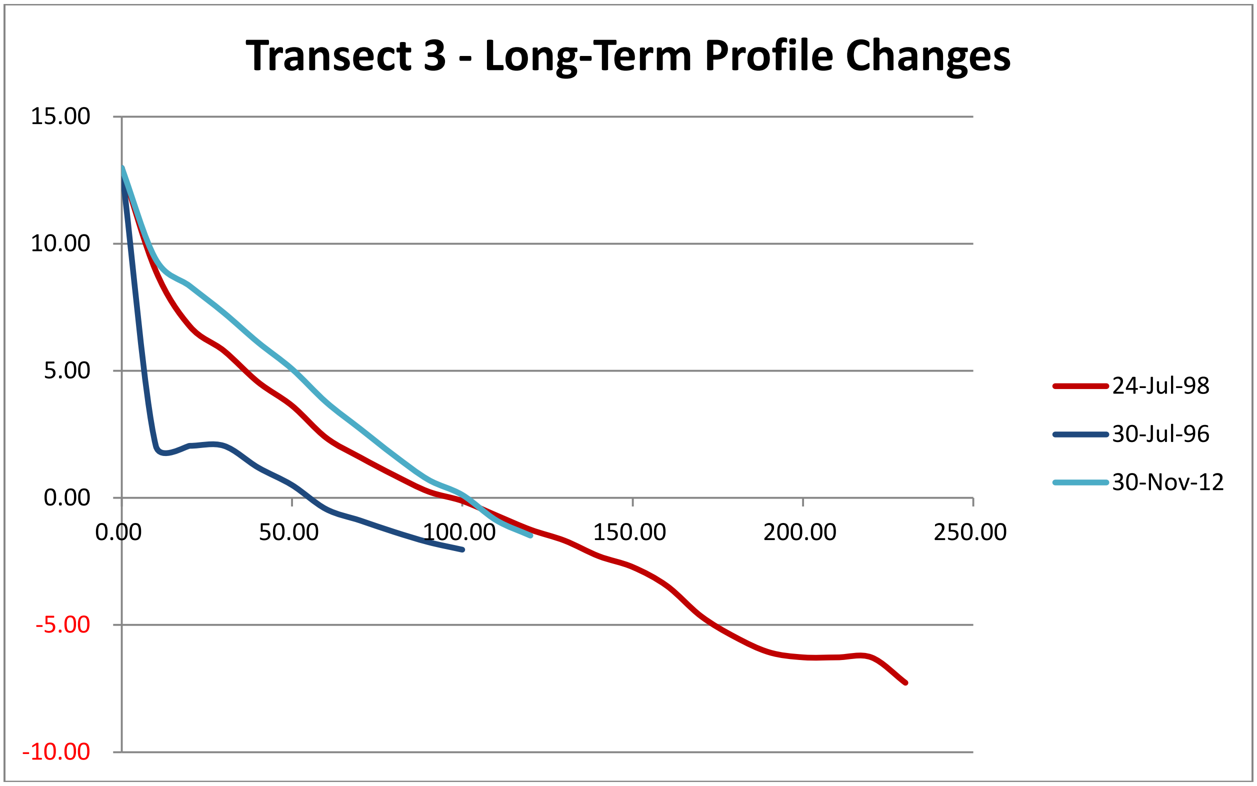


Figure 2-2 Transect 3 beach profile long-term changes

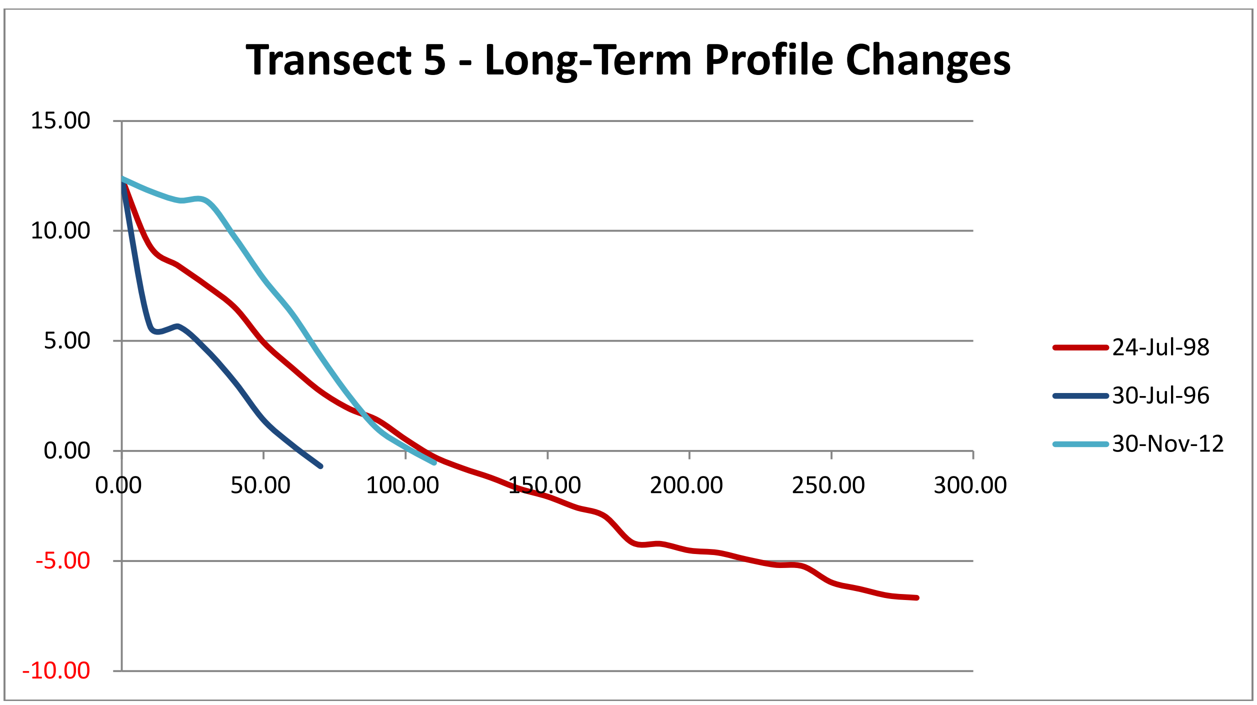


Figure 2-3 Transect 5 beach profile long-term changes

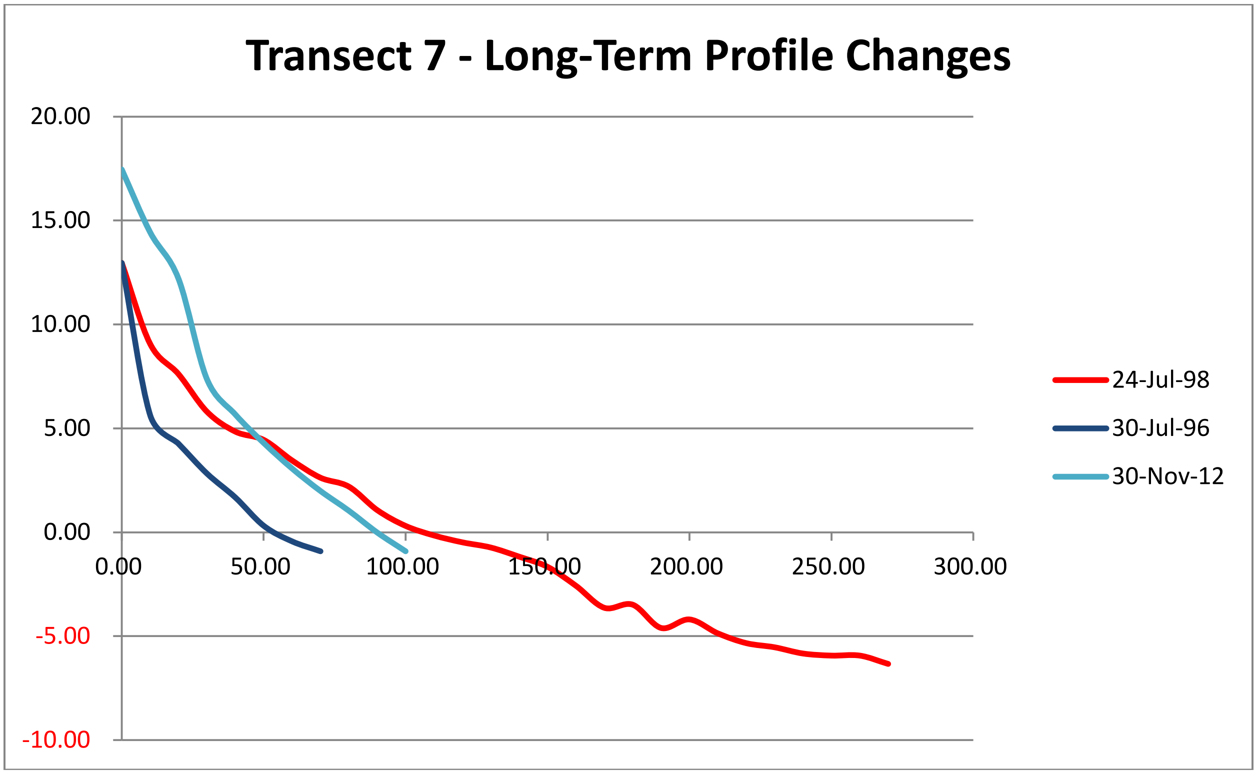


Figure 2-4 Transect 7 beach profile long-term changes

Routine beach profiling conducted by the Association also allows for investigation of the effects of individual restoration efforts. The most representative profiles are surrounding the 1998 summer restoration effort (Figure 2-5, Figure 2-6, and Figure 2-7). This was a larger volume of sand, just over 6,000 cy, which was placed while the littoral cell was still recovering.

All three profiles are deflated on 23-May-98, prior to restoration. Following restoration efforts, all three profiles collected on 24-Jul-98 show significant volume increases in the lower beach face and nearshore portions of the profiles. A large volume of sand was moved offshore quickly to inflate the nearshore portion of the profile, out toward the depth of closure.

The next set of profiles, collected on 31-May-99, was collected after the winter season, and is an excellent example of how the sand migrates during the winter season wave environment. The winter surf had moved sand from the west toward the east, helping to inflate the eastern profiles. Nearly a year after placement, much of the new sand was in the nearshore and in the dry beach at the middle and eastern end. Though the western end supplies sand to the other portions of the littoral cell during the winter months, it recovers during the summer when tradewind waves move sand toward the western headland.

Overall deflation of the profiles indicates that the restoration effort sands likely did not extend all the way to depth of closure, that there is still a chronic erosion pressure along the coastline, and that the cell may either be larger than the area fronting the beach or it may be leaking into adjacent littoral cells.

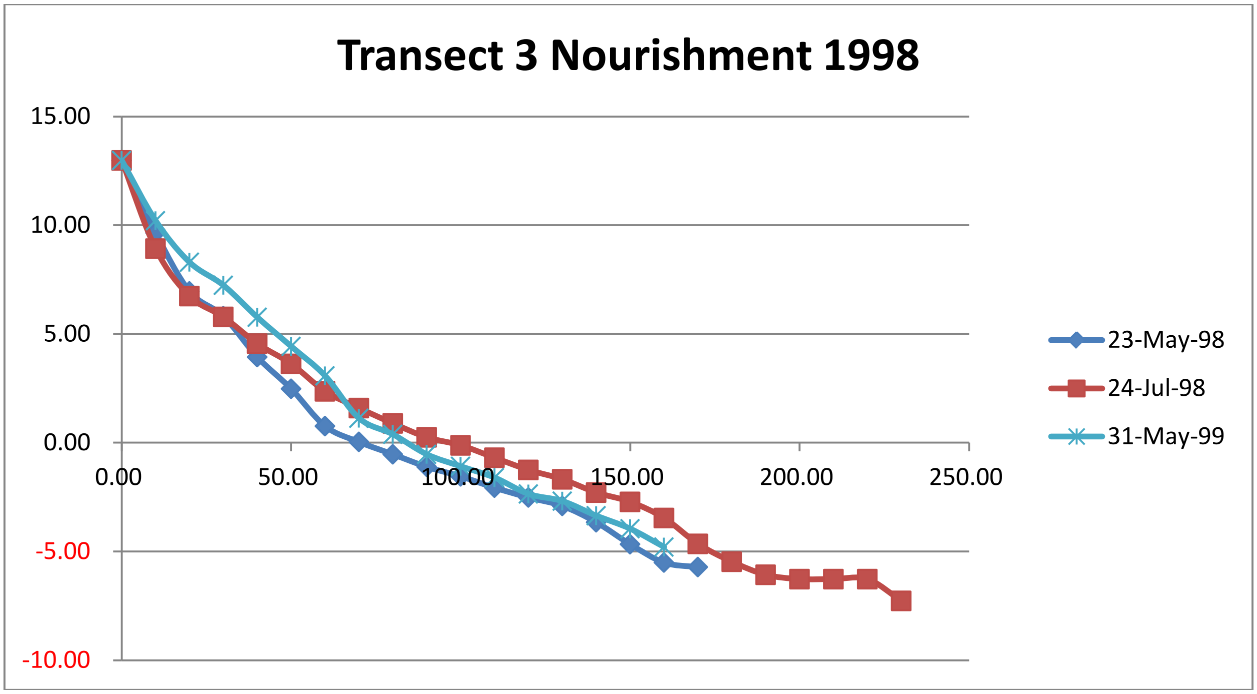


Figure 2-5 Transect 3 beach profile - life-cycle changes (winter accretion)

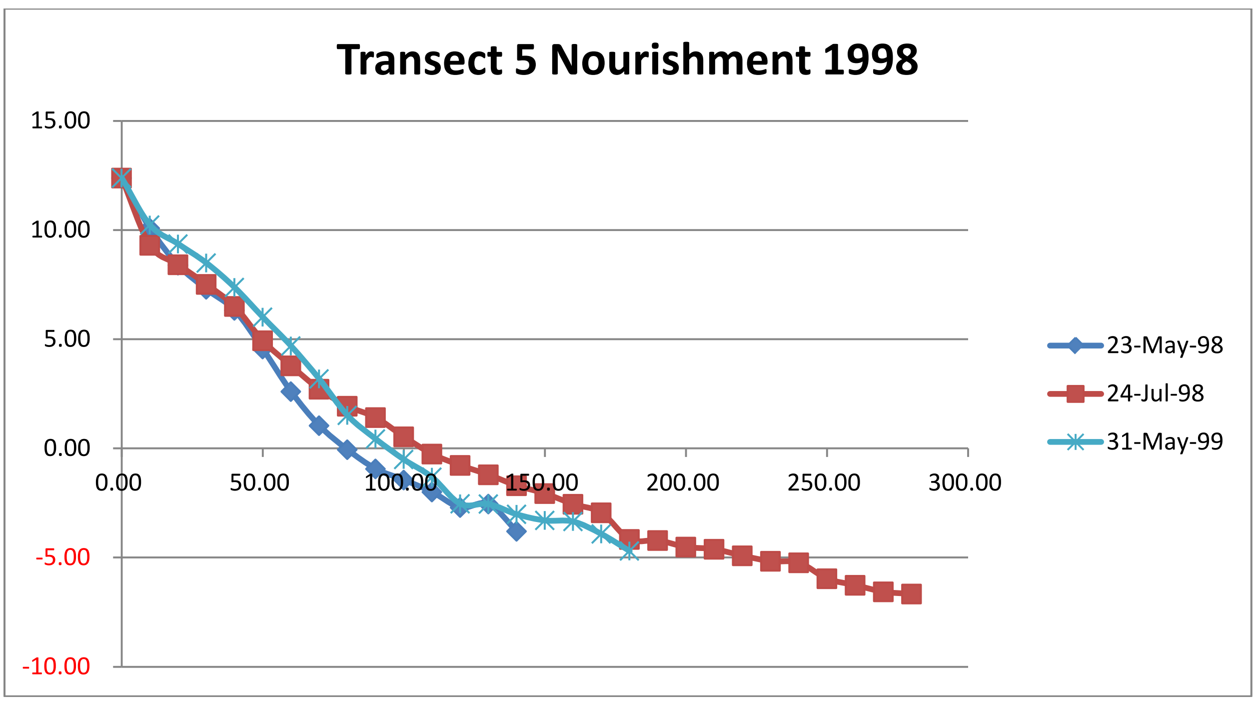


Figure 2-6 Transect 5 beach profile - life-cycle changes (winter stable)

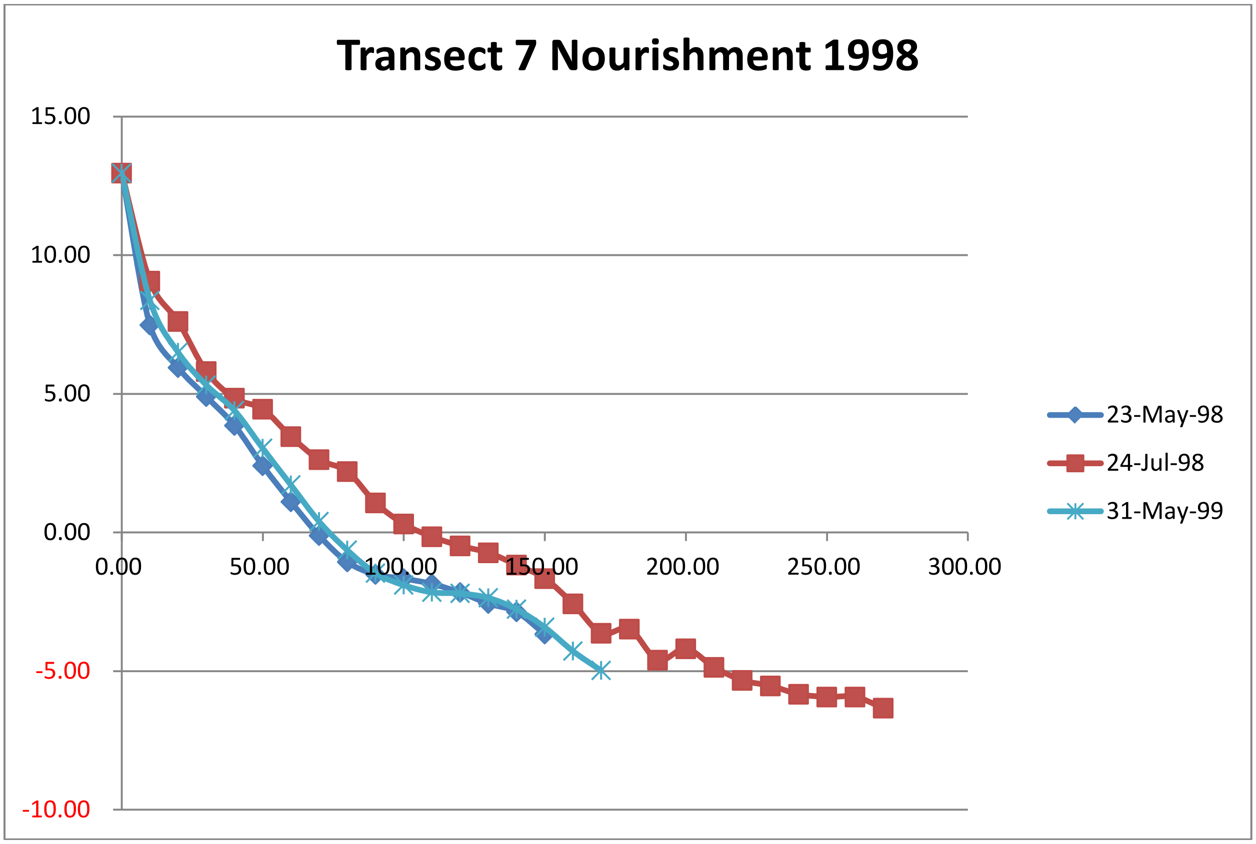


Figure 2-7 Transect 7 beach profile - life-cycle changes (winter erosion)

2.4.3 Life cycle analysis of previous beach restoration actions

Using Transect 5 (Figure 2-8), at the middle of the current beach length, as an indicator for long-term stability of the beach provides useful insights into both the lifecycle of the maintenance efforts and potential maintenance triggers. Transect 5 is the least affected by the seasonal changes in winter and summer, and is the best indicator of long-term changes in the littoral cell. Distances shown in the graph are from a fixed reference point on shore, and do not indicate actual beach berm width. The width is measured from the reference point to the 0-foot contour.

Beach width at Transect 5 routinely returns to 100 feet from the reference point, and is increasing stabile at that width with the gradual, cumulative increase in littoral cell sediment.

Early recovery efforts widened the beach for short periods, but sediment was then spread throughout the cell resulting in overall deflation and recession of the 0-foot contour. Larger efforts, such as the 1998 effort (red point), pushed the 0-foot contour farther offshore, but it returned quickly. This was still early in the recovery effort and the beach quality sand was being spread throughout the entire littoral cell.

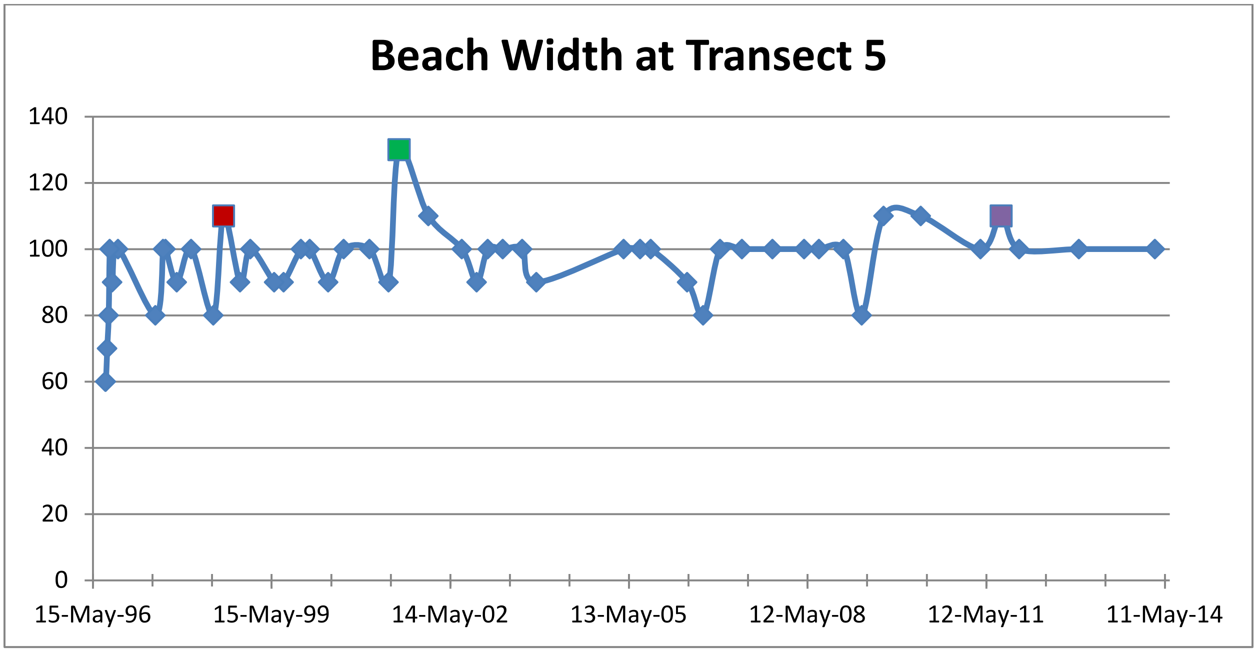


Figure 2-8 Transect 5 beach width changes at 0 feet lmsl

Multiple efforts between 1999 and 2001 added another roughly 6,500 cy of sand (green point). These efforts, however, had a much more pronounced effect on the seaward migration of the 0-foot contour. It is likely that littoral cell was closer to a recovered state following the input of more than 21,000 cy over a six year period. Following this influx of sand the beach system naturally returned to a stable width near approximately 100 feet from the reference point before recessing further as the restoration sediment continued to disperse within the larger littoral cell.

It is unlikely that the littoral cell was fully recovered after 2001. Consequent nourishment efforts continued to return the 0-foot contour to near the 100-foot mark, and were followed by recession events that would draw the 0-foot contour back closer to shore.

By 2011 nourishment efforts had contributed nearly 30,000 cy of sediment to the littoral cell. The last contributions (purple point), placed in 2011 added roughly 1,250 cy of beach quality sediment to the shoreline. These contributions extended beach width beyond the stable 100-foot distance. These recent contributions were relatively small compared to previous volumes required to significantly widen the beach. Following this nourishment effort, the beach returned to a stable 100-foot width. Currently, a sand bar was forming in the nearshore waters, and was identified in the field investigation, profile data, and photographic documentation.

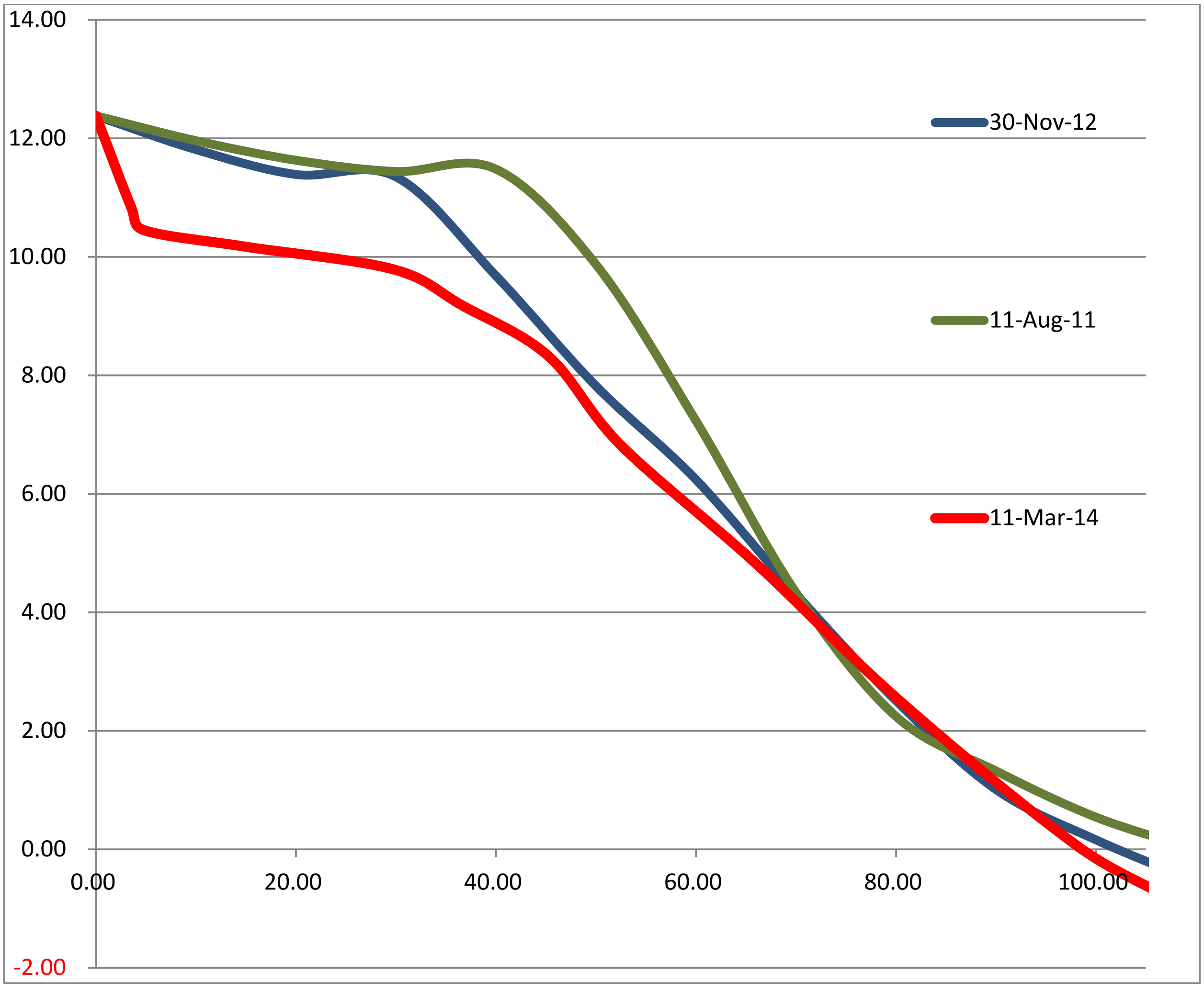


Figure 2-9 Transect 5 beach profiles following the last beach restoration activity

There have been no additional beach restoration activities since 2011, and the beach has maintained a stable width at the 0-foot contour; however, it has also deflated in the upper portions of the beach profile (Figure 2-9). This indicates that there is still erosion pressure along the coastline, which results in volume loss on the berm. This also highlights the natural tendency for oversteepened slopes to slump with time. The current foreshore slope, extending from the beach toe to the berm crest, ranges from 1V:6H to 1V:8H at the three transects, which is within the range of moderate to high energy beaches in Hawaii.

Given the existing condition of the restored beach, the nearshore sand field, the continued presence of the sand bar, and the morphologic changes consequent to the most recent beach maintenance efforts, evidence indicates the current cuspate shape and orientation of the beach is stable when ongoing maintenance balances the natural erosion forces. The overwash berm appears to be the most susceptible to initial erosion impacts and produces the largest volume losses post-restoration. Berm deflation coupled with the foreshore slope returning to slopes between 1V:6H to 1V:8H are the physical triggers that will indicate a need for future maintenance actions.

The overwash berm functions as the storm and erosion buffer for a healthy beach system. The berm maintenance program should focus on routinely inflating this area high on the beach profile. Long-term berm maintenance will be critical for maintaining a healthy littoral cell, a functioning beach, and the sandy coastal hazard mitigation buffer along the coastline.

2.5 Proposed Berm Maintenance Plan

Future berm maintenance efforts are designed to sustain a stable littoral cell volume through programmatic placement of beach quality fill sand. The design placement area and volumes balance the natural erosive forces acting upon the coastline, preventing a drawdown of beach profiles and shoreline recession along the beach face. In the beaches current, restored condition, much of the littoral cell volume loss resulting from the impacts of chronic erosion is in the upper berm area, inland of the berm crest at the top of the foreshore slope.

2.5.1 Maintenance Design

The maintenance program is designed to place beach quality fill sand high on the beach profile, to augment the overwash berm that rests against and atop the Hayashi Beachwall. The 0-foot contour should remain stable if sufficient sand is supplied to protect the dry beach during wave events. This will minimize sand volume lost to offshore currents.

Beach quality fill is designed to be placed from the +5-foot contour to the backstop of the beachwall (Figure 2-10). Fill material will grade upward at a 1V:3H slope from the +5-foot contour to +12 feet, and then extend inland until intersecting the backstop. Profiles (Figure 2-11) illustrate the fill material placement location high on the beach profile.

This placement, high on the beach profile and well above tidal influence, will significantly improve residence time, while also minimizing losses to wave action.

2.5.2 Volume and Frequency

Fill volume estimate is based on the previous restoration efforts in 2011, which placed nearly 1,250 cy of beach quality sand. This effort lasted approximately 3 years before berm deflation began to threaten the stability of the 0-foot contour location. A portion of the fill material was incorporated in the nearshore sand bar and assisted with stabilization of the nearshore sand field.

The goal is to provide enough sediment to allow for maintenance of the berm's elevation, while minimizing loss and maximizing residence time. The proposed volume of roughly 1,300 cy of sand will be sufficient for conducting routine berm maintenance on a roughly 3-year cycle. Extreme wave events or phenomena such as tsunamis, hurricanes, or high elevation meso-scale eddies may result in a truncated schedule due to episodic erosion events.

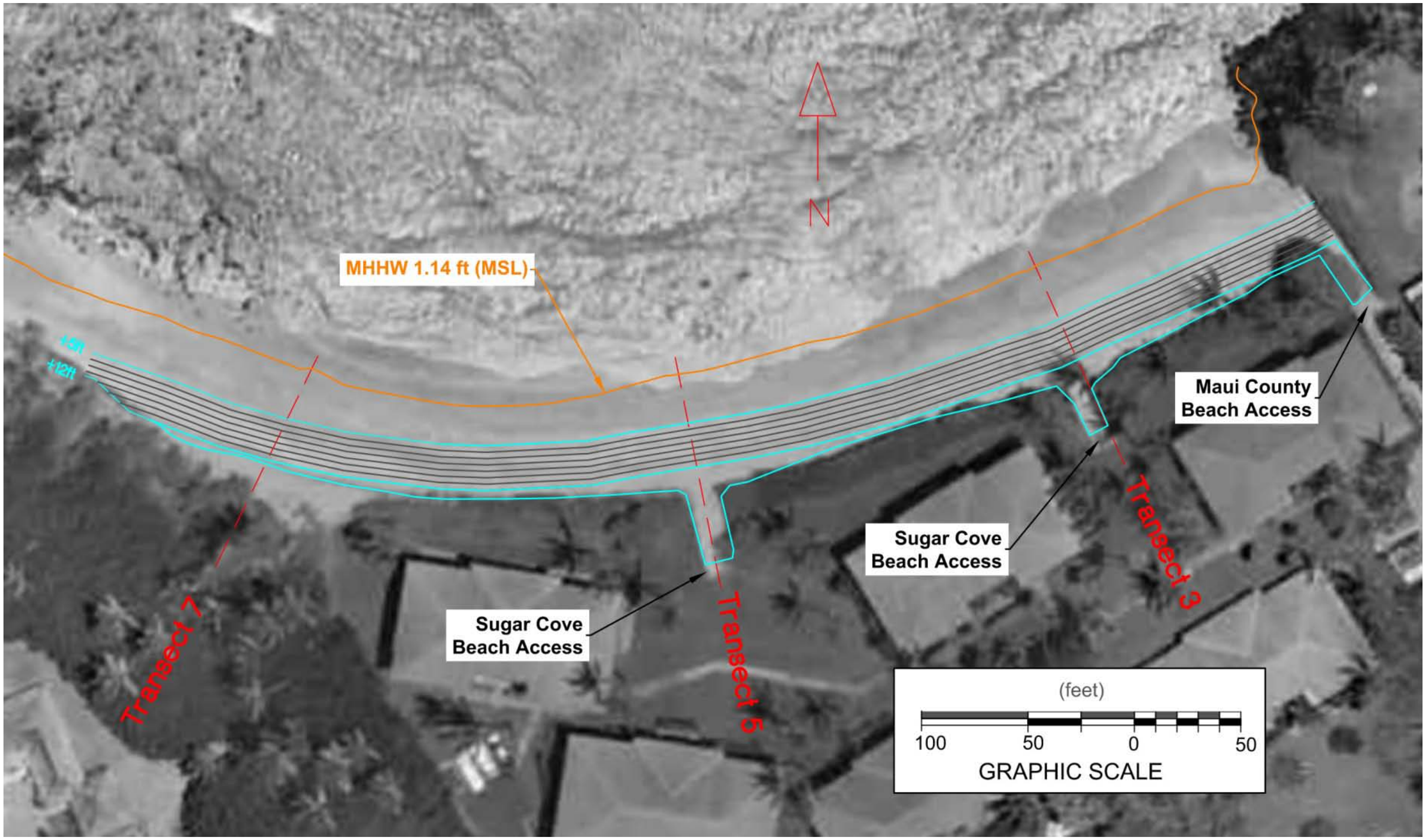


Figure 2-10 Proposed berm maintenance location and contours (LMSL Datum)

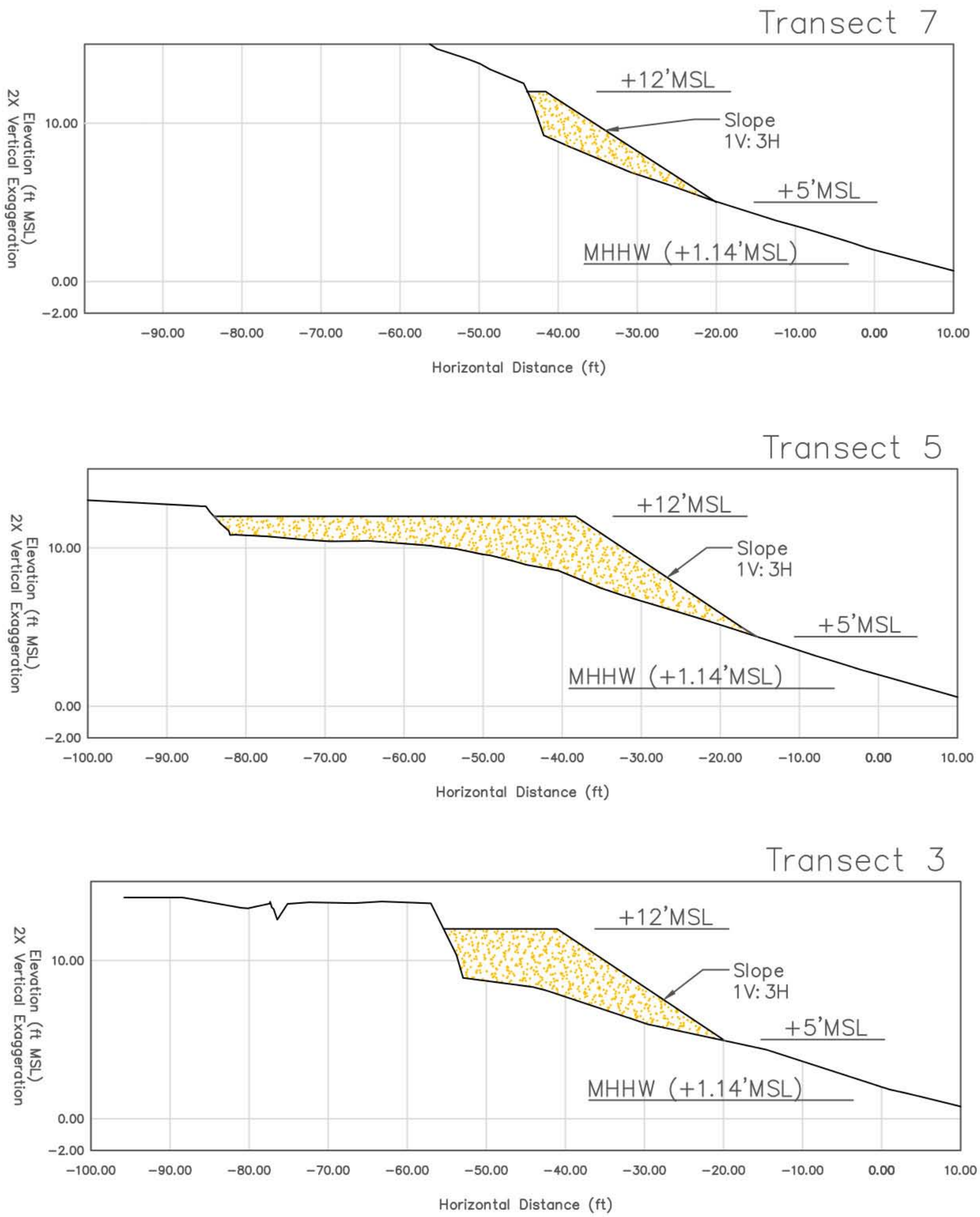


Figure 2-11 Proposed berm maintenance profiles (LMSL Datum)

2.5.3 Physical Triggers

Berm deflation is the primary physical trigger for identifying when to conduct routine volume maintenance efforts. As a general indicator, when the seaward portion of the berm and berm crest are below +10 feet in elevation, the next maintenance effort should be conducted. At that time approximately 1,300 cy of beach quality sand should be added to the upper portion of the profile.

Long-term stability of the beach will be monitored using the relative location of the 0-foot contour to the beachwall. Transect 5, located in the center of the beach and affected the least by seasonal wave climates, is an appropriate location to monitor this beach width indicator. In the event that the 0-foot contour begins to migrate inland, maintenance should be conducted as quickly as possible. An approximate volume of 3,500 cubic yards should be added, extending from the +2.5-foot contour to +12 feet, for rapid stabilization of the beach system.

2.5.4 Equipment List

Level, Total Station, or RTK Survey System – for elevations
Dump truck(s) – for sand delivery
Bulldozer – for sand placement and grading

2.5.5 Description of Work

This work is simple in nature, and consists of delivery and grading of beach quality fill sand on the upper portion of the profile.

- The 5-foot contour will be identified and marked on the foreshore.
- Silt booms will be placed on the makai side of the 5-foot contour.
- Dump trucks will bring the material to the western side of the Association's property, and place the sand next to the berm.
- Ingress and egress of machinery will be along the western side of the property. Equipment staging will be in the parking lot, and material will be transferred to the beach at the western end of the project site.
- A bulldozer, similar in size to a D-5 or D-7, will spread the sand from the west to the east, as the dump trucks are delivering the material.
- Contemporaneous delivery and spreading of the material will minimize the area needed to transfer the material onto the berm.
- The bulldozer will also push sand mauka within the County access and the Association's access paths.
- Some fill material may be delivered to the County access, for distribution at the eastern end of the berm.
- The makai face of the fill material will be graded to a 1V:3H slope.
- The surface of the material will be back bladed to leave the fill material available for immediate use.
- Silt booms and the markings for the 5-foot contour will be removed.

2.6 Sand Analysis

2.6.1 Existing Beach Sand

The existing beach is a product of nearly two decades of maintenance activities conducted by the Association, during which time they have placed almost 30,000 cy of beach quality sand on the coastline. The ongoing efforts have reestablished and stabilized a sandy beach profile seaward and atop the existing erosion mitigation structure. Existing beach sand is a combination of native and fill material that have intermixed along the coastline.

The existing beach sand (Figure 2-12) is reddish yellow in color. Sand sized grains are a mixture of terrigeneous material, including basalt clasts and carbonate grains made of marine organism skeletal and shell fragments, coral and coralline algae fragments, and limestone clasts. The basalt clasts have a range of forms and are generally angular with relatively high surface texture. Carbonate grains also have a range of forms, but are generally rounded and well polished. The larger material at the beach toe and wash line are typically irregular in form and quite angular, with significant surface texture, often containing a significant percentage of fresh marine clasts.

Figure 2-13 is a graph of the sand samples collected within the swash zone, at the wet/dry line, on the upper beach face, and from the berm near the stairwell at the center of the project area's shoreline. The composite sample is a combination of all four of these samples. Also shown on the graph are the +/- 20% thresholds for the composite beach sand sample.

The composite sample of beach sand grains is normally sorted material within the range of coarse (1 mm) to very fine (0.125 mm) sand. The composite sample's median grain size is within the medium sand range, just smaller than 0.4 mm in diameter.

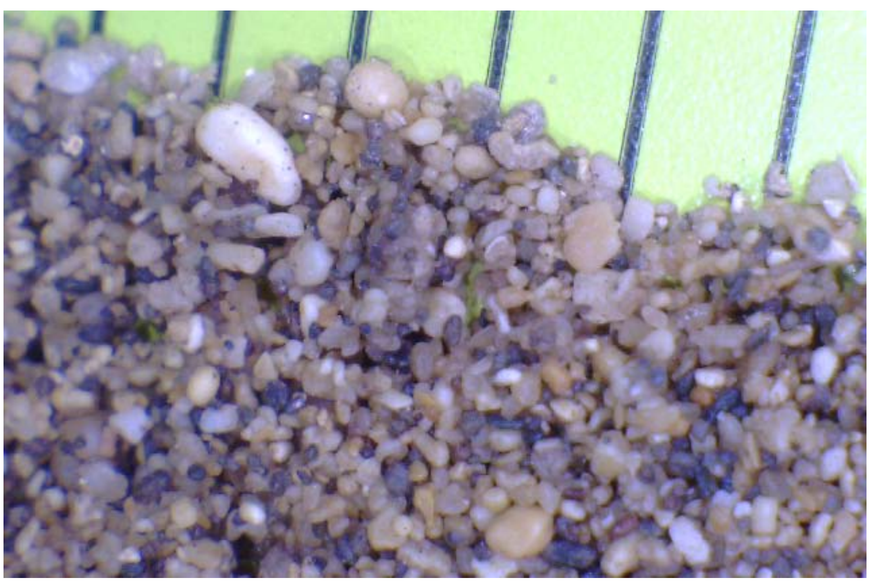


Figure 2-12 Existing beach sand

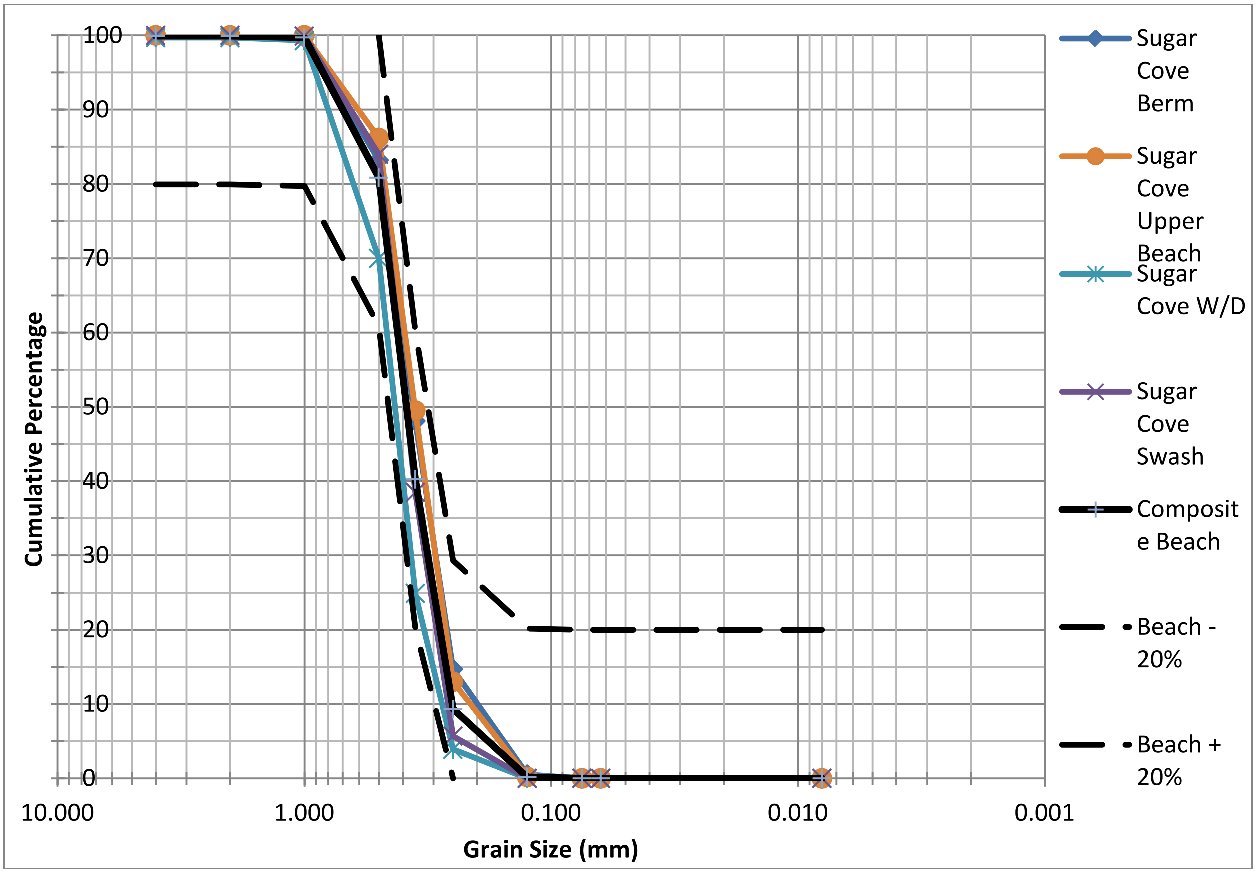


Figure 2-13 Grain size distribution for beach sand samples, composite beach sample, and the +/- 20% thresholds

Table 2-2 shows the grain size distributions for the composite beach sample and the proposed beach quality fill material supplied by Ameron, and discussed in the section below.

Table 2-2 Grain size distributions for Sugar Cove existing beach and proposed beach quality fill sand (Ameron)

size (mm)	4.000	2.000	1.000	0.500	0.420	0.355	0.250	0.149	0.125	0.075	0.063	0.008
Sugar Cove Beach	99.925	99.925	99.725	80.850		40.250	9.325		0.175	0.000	0.000	0.000
Ameron	100.000	97.700			81.10			4.8		2.100		0.000

2.6.2 Proposed Berm Maintenance Sand

Ameron Inland Dune Sand has been a consistent source of beach quality fill material on the island of Maui and was utilized in all the previous beach restoration efforts by the Association. This material has already been excavated, sorted, and stockpiled by Ameron.

This sand is light reddish brown in color and has a median grain size of 0.28 mm. 97.9% of the material is within the range of sand grain size, and 2.1% is silt size. This material is dominantly marine carbonate sediment in origin.

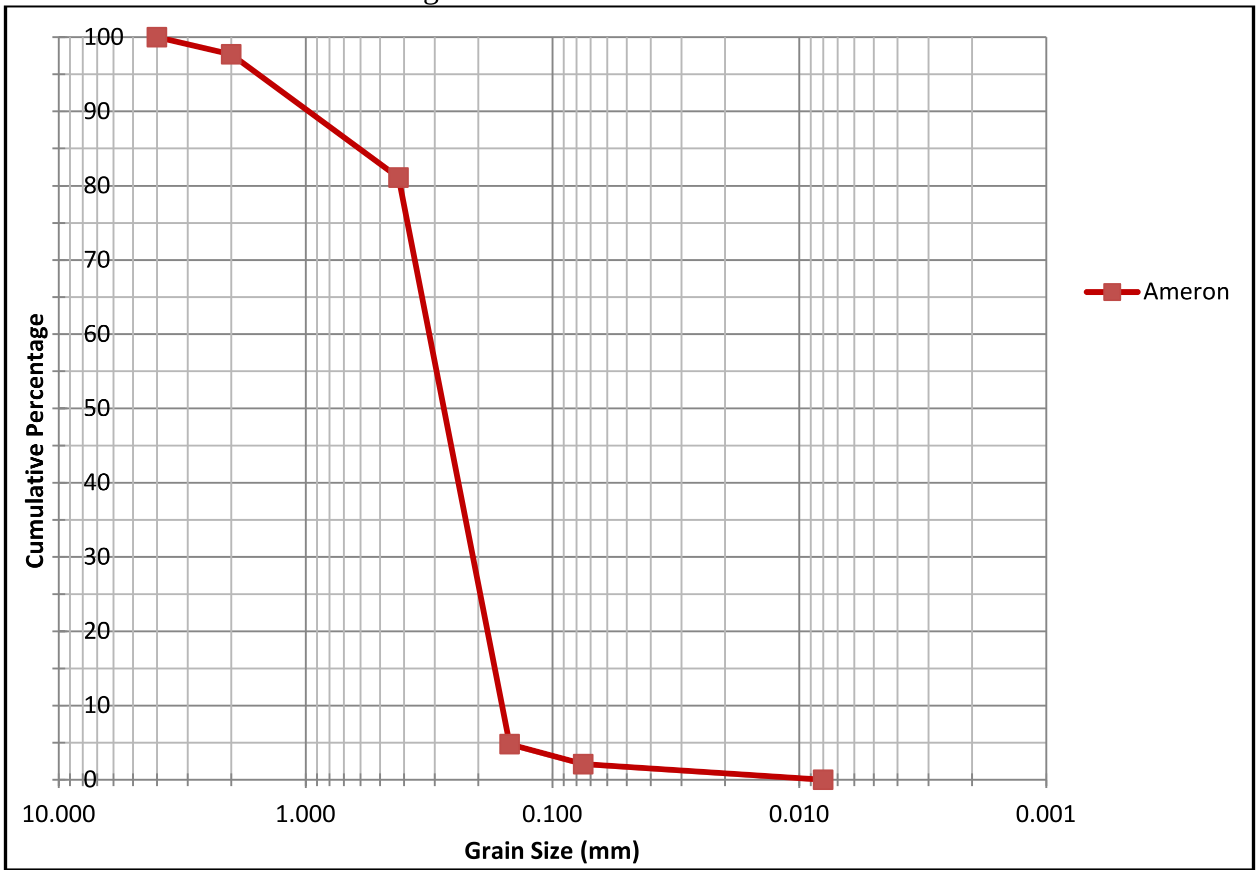


Figure 2-14 Grain size distribution for proposed beach compatible sand sample

2.6.3 Small Scale Beach Nourishment Standards and Sediment Compatibility

Berm fill must be evaluated for compatibility using the standards outlined in the *Guidelines for SSBN Cat II General Application*.

Laboratory grain size analysis results for both the existing beach sand and the proposed berm maintenance sand are presented and discussed above.

The proposed berm fill sand does not exceed 6% fine sediment. Berm fill sand is approximately 2.1% fine sediment, or roughly 1/3 the allowable limit for fine material as identified in the standards.

Analysis shows the proposed berm fill sand has less than 5%, by volume, sediment 0.125 mm or smaller. This is less than one-tenth of the 50%, by volume, threshold identified in the standards.

The proposed berm fill sand has no volume in the size fraction larger than 4.76 mm. The largest grain size in the proposed beach fill sand is between 2.00 to 4.00 mm, and does not exceed the 10%, by volume, limit for grains larger than 4.76 mm.

The proposed berm fill sand does not fit entirely within the +/- 20% brackets around the composite existing beach sand sample (Figure 2-15). This may be a result of variation in the sieve sizes used for analysis of the sand samples. Regardless, the proposed berm fill sample is finer in nature than the existing beach sand.

Due to the finer sediment sizes of the proposed berm fill sand, when compared to the composite beach sand samples, overfill analysis was conducted. This fulfills the requirement in the State's nourishment guidelines. Calculation of the overfill factor (Table 2-3 and Figure 2-16) indicates that maintenance efforts will need to use 126% more sand than the desired volume, due to losses associated with preferential winnowing of fines through normal littoral cell processes. The proposed volume of 1,300 cubic yards of material, after winnowing, leaves roughly 1,032 cy of sand on the berm. This is a similar volume to the previous restoration efforts that successfully restored and maintained the beach using the same sand source.

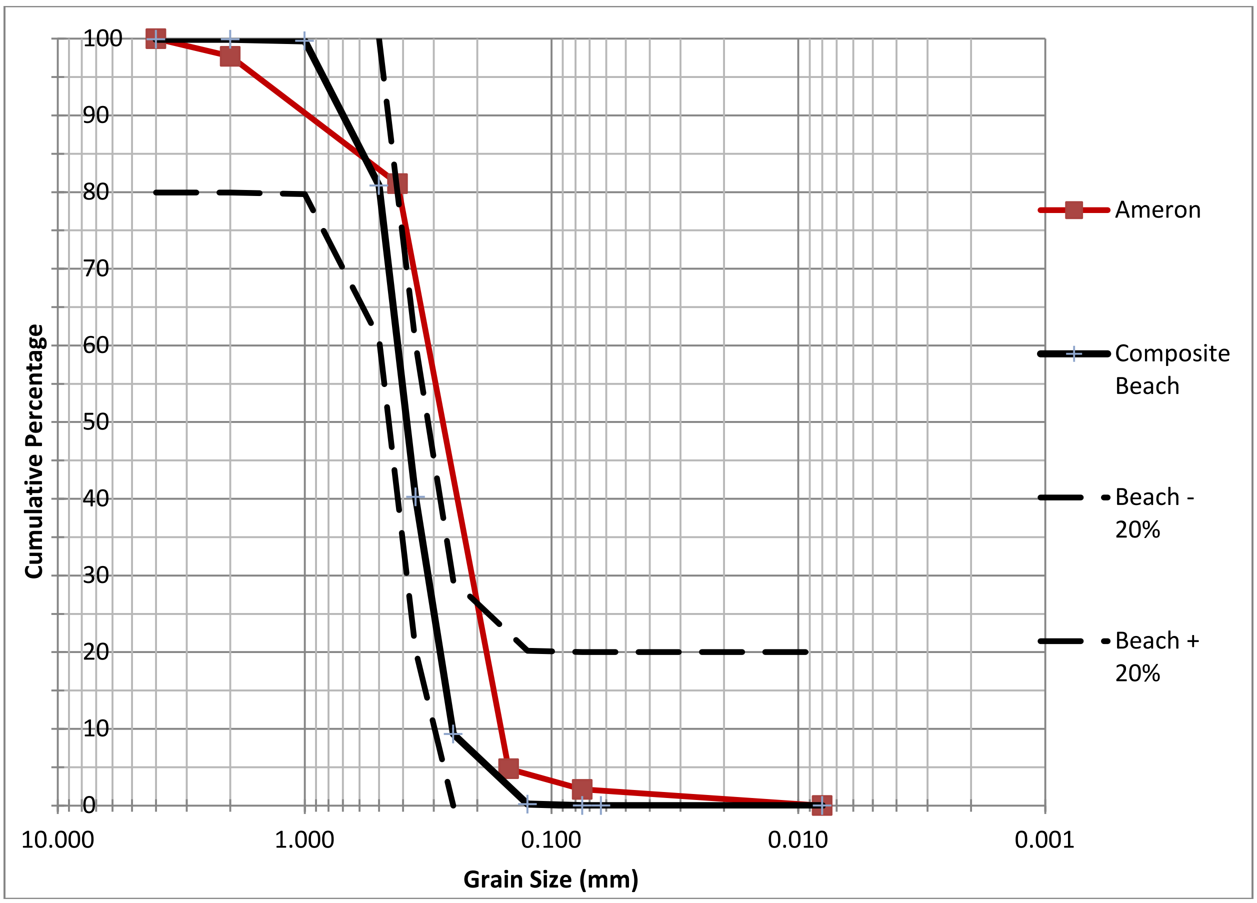


Figure 2-15 Grain size distribution for composite beach sample, the +/- 20% thresholds, and the proposed berm fill sand sample

Table 2-3 Overfill calculations for the proposed berm fill sand

Parameter	Value
Mn	1.34
Mb	1.70
Sigma	0.98
Mb' – Mn'	0.36
Overfill Factor K	1.26

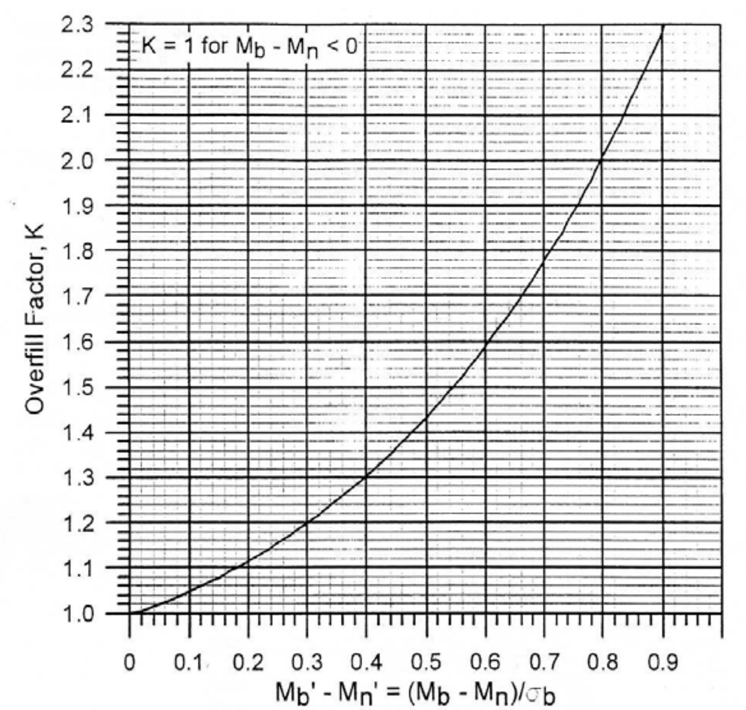


Figure 2-16 Overfill Factor conversion chart

The proposed sediment has been successfully used in all previous restoration efforts at the property. Use of this sediment has restored the beach, and maintained it for nearly two decades, returning it to a condition similar to its documented position and orientation in 1960. Restoration of the sand beach and nearshore sand field has also resulted in restoration of the nearshore and coastal ecosystems. These sand dominated environments have been revitalized with the use of Ameron dune sand. Moreover, the sediment meets all the requirements for a State Category II Small Scale Beach Nourishment application.

2.7 Regulatory Jurisdictions

2.7.1 Hawaii State Conservation District

This project is located in its entirety within the State of Hawaii Conservation District. Submerged lands, part of the Resource Subzone of the Conservation District, extend across the seafloor from the 3-mile offshore limit to the shoreline, as defined in Hawaii Revised Statute (HRS) §205A and identified by the highest wash of the highest wave, not to include tsunami or hurricane waves. The shoreline location is inferred to be along the mauka wall of the Hayashi beachwall and the top of the access stairs from the subject property. The mauka limit of the maintenance project will be along the face of the shoreline backstop's wall or the erosion scarp from previous efforts, for much of the shoreline. The mauka limit at the beach access and stairways will be at the 12-foot contour, makai of the top-most step. The mauka limit along the western side of the property will be against the erosion scarp in the dune face.

The Small Scale Beach Nourishment application satisfies the Conservation District permit requirement.

2.7.2 Special Management Area and Shoreline Setback Area

The project is located entirely makai of the shoreline, as identified Hawaii Revised Statute Chapter 205A. As such, it is located makai of the Maui County Special Management Area and jurisdiction, and does not require any County permits.

2.7.3 Navigable Waters and Clean Water Act

Mean higher high water at Kahului Harbor, as measured by the NOAA tide station, is +1.14 feet above local mean sea level. This project is designed so that beach quality fill material is placed no lower than +5 feet above lmsl. There is a 3.86 foot vertical offset between mhhw and project activities, which translates to a 23 to 31 foot horizontal offset. As such, the project should be located outside of both Section 10 and Section 404 waters. There will be no discharge associated with this project.

2.7.4 Clean Water Act Section 402 National Pollutant Discharge Elimination System (NPDES)

The beach maintenance area is approximately 16,822 square feet in total, or 0.39 acres in surface area. The stockpile and equipment area will be approximately 5,400 square feet in total, or 0.12 acres in surface area. The entire project area is expected to be less than 0.55 acres.

This project should not require a NPDES permit.

2.7.5 OEQC Public Notice of Proposed Action (Draft Letter)

Project Name: Sugar Cove Berm Maintenance Program

Publication Form
The Environmental Notice
Office of Environmental Quality Control

Instructions: Please submit one hardcopy of the document along with a determination letter from the agency. On a compact disk, put an electronic copy of this publication form in MS Word and a PDF of the EA or EIS. Please make sure that your PDF documents are ADA compliant. Mahalo.

Applicable Law: **Chapter 343, Hawaii Revised Statutes; Title 13, Chapter 5, Hawaii Administrative Rules**

Type of Document: **Small Scale Beach Nourishment Application Category II**
Island: **Hawaii**
District: **Paia**
TMK: **(2) 3-8-002:033**
Permits Required: **Conservation District Use Application – Small Scale Beach Nourishment Programmatic Permit**
Applicant or Proposing Agency: **Sugar Cove AOAO**
Address: 320 Paani Place #6C, Paia, Hawaii 96799
Contact & Phone: Mr. Rich Salem (808) 388-1300

Approving Agency/ Accepting Authority: **State Department of Land and Natural Resources – Office of Conservation and Coastal Lands (OCCL)**
Address: 1151 Punchbowl Street, Room 131 Honolulu, Hawai`i 96813
Contact & Phone: Samuel J. Lemmo, Administrator, OCCL, (808) 587-0377

Consultant: **Sea Engineering, Inc.**
Address: Makai Research Pier
41-305 Kalanianaole Highway
Waimanalo, HI 96795
Contact & Phone: **Chris Conger 259-7966 ext. 26**

3. EXISTING ENVIRONMENT

3.1 Receiving State Water Information

The Department of Health Clean Water Branch has identified the waters seaward of the beach at Sugar Cove as Class A marine waters that are open coastal waters. The seafloor is classified as a Class II Sand Beach in conformance with HAR 11-54-03(d)(2) and 11-54-07(a). There are no Water Quality Limited Segments, as listed by the Hawaii State Department of Health according to section 303(d) of the Federal Clean Water Act, in the area of the Sugar Cove. Sugar Cove is not identified as an embayment within HAR 11-54-03(c)(1) and HAR 11-54-06.

In addition, the project is located well inland and at a significantly higher elevation than the mean higher high water mark, and all work will be conducted with dry beach quality sand that will not generate any return water. There will be no discharge associated with this project.

3.2 Physical and Chemical Environment

The upland area adjacent to Sugar Cove is developed land and private residences. This area is typically landscaped in common residential turf grasses and shrubs that are suitable for coastal environments. The trees in the area are predominantly coconut trees, though numerous other species are distributed throughout the region. The coastal plain is alluvium, with a thick clay matrix and entrained basalt blocks ranging from boulder to sand sized particles. The alluvium sits atop rocks of the Kula series, all of which is within the lower slopes of Haleakala.

The marine environment in the region is a shallow fringing reef with intermixed sand fields and pavement areas. The shoreline is a mixture of natural rocky and clay substrates, coastal armoring units, and sand beaches. Most of the sand beaches around Sugar Cove have been lost to or significantly impacted by erosion during the past 50 years.

3.2.1 Major topographic and bathymetric features

The shallow fringing reef, known as Spartan Reef, has an intermittent reef crest approximately 0.75 miles offshore of Sugar Cove. The fringing reef ranges in depth from 6 to 24 feet (Figure 3-1), and has a mixture of substrate types including beach rock, fossil reef, and sand. Sugar Cove has a natural rocky headland on the east side of the cove; however, the beach is constrained by the seawall abutting its eastern side (Figure 3-2), which act as a headland in terms of beach processes. The western headland is a natural rocky point with clay substrate on the shoreline. Both natural headlands have rocky basalt outcrops and boulder fields extending seaward from their shorelines. Between the headlands, the pavement is a mixture of fossil reef and beach rock slabs. Historically, the center of the bay has been a broad sand field that is also connected to sand channel on the eastern side (Figure 3-3, Figure 3-4, and Figure 3-5). Prior to the late 1960s, the beach extended across the full cove and beyond the natural headlands to both the east and west.

Depressions in the reef have historically been filled with sand in this region. When the beach was deflating during the late 1980s, the entire littoral cell suffered a severe reduction in nearshore and beach sand. Following complete loss of the beach and draw down of nearshore sand volumes, the nearshore sand fields were severely reduced in size and volume. Beach restoration and maintenance activities have restored much of the littoral cell's volume, and in doing so have re-inflated the nearshore component of the beach profile. Modern, restored littoral cell health is evidenced by the formation of a sand bar during higher wave events, and the presence of well sorted, rippled sediment in the nearshore sand fields. Sufficient, appropriately sized sediment in the nearshore allows for the nearshore sand field and dry beach to respond to changes in the wave environment without significantly impacting beach stability.

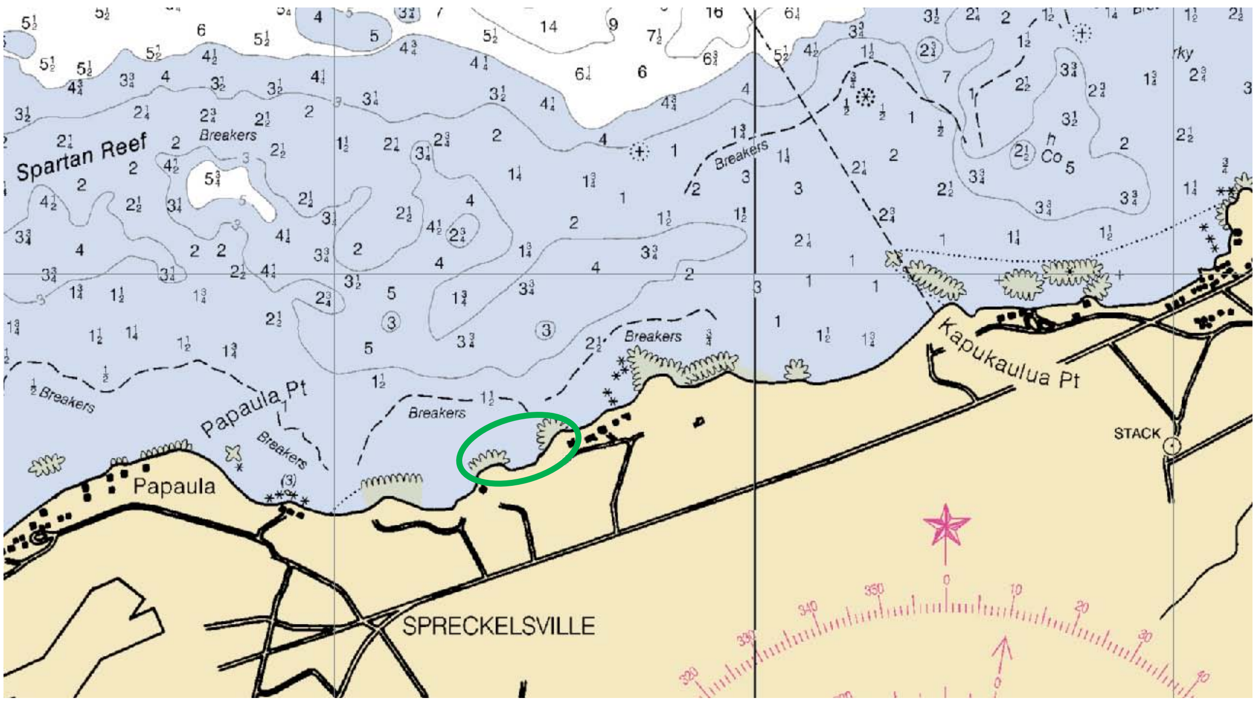


Figure 3-1 Navigation chart for the area, green oval indicates the Sugar Cove region (depths are in fathoms)

Figure 3-2 Seawall at eastern end of Sugar Cove beach

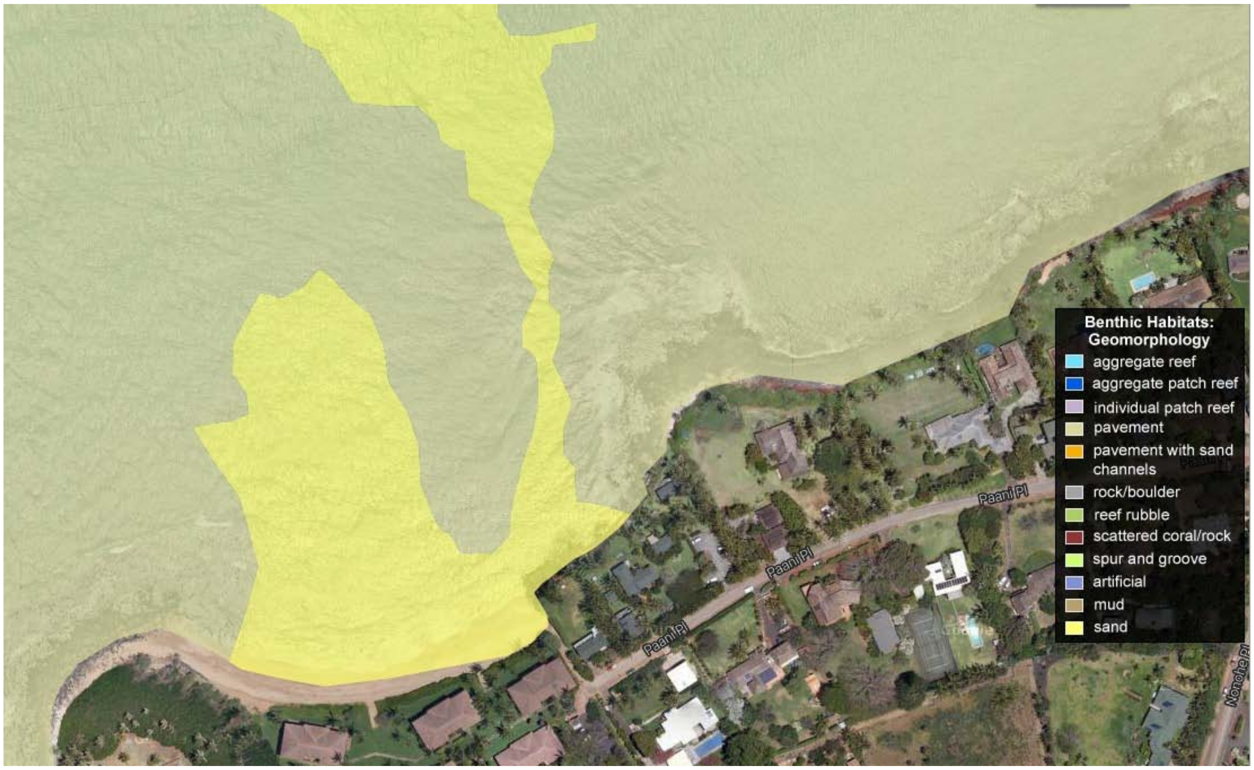


Figure 3-3 NOAA mapped benthic substrates for the area

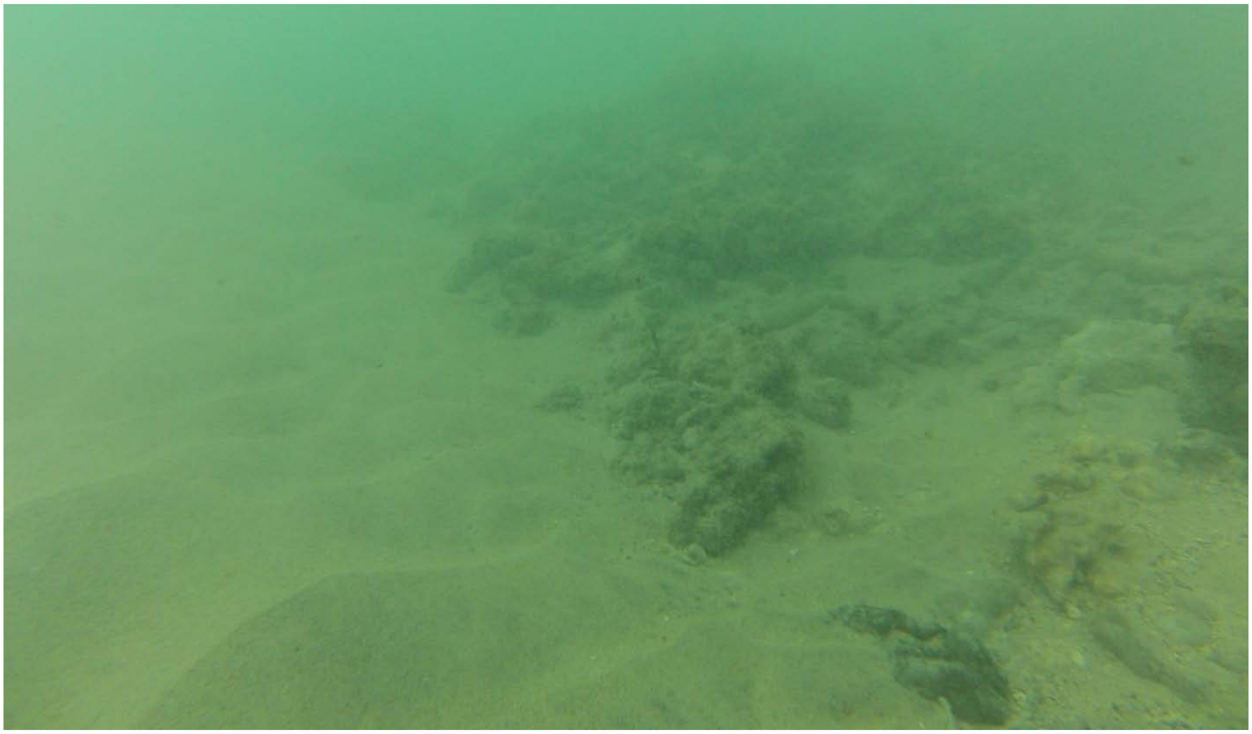


Figure 3-4 Sand and pavement substrates typical of the area

Figure 3-5 Sand substrate typical of the area

3.3 Biological Environment

Modern coastal biology is once again dominated by beach ecosystem organisms. The marine biology has been categorized by NOAA (Figure 3-6) as a mixture of uncolonized areas, in the sand fields, and 50-90% turf algae, in the pavement and basalt headland areas. The turf algae (Figure 3-7, Figure 3-8, and Figure 3-9) was present during site visits, and was pervasive across much of the hard substrate within the cove. Much of the nearshore was naturally covered by beach and nearshore sands as recently as the 1960s. Restoration and maintenance of the littoral cell has restored the sandy ecosystems, also.

No coral colonies were observed in the nearshore waters.

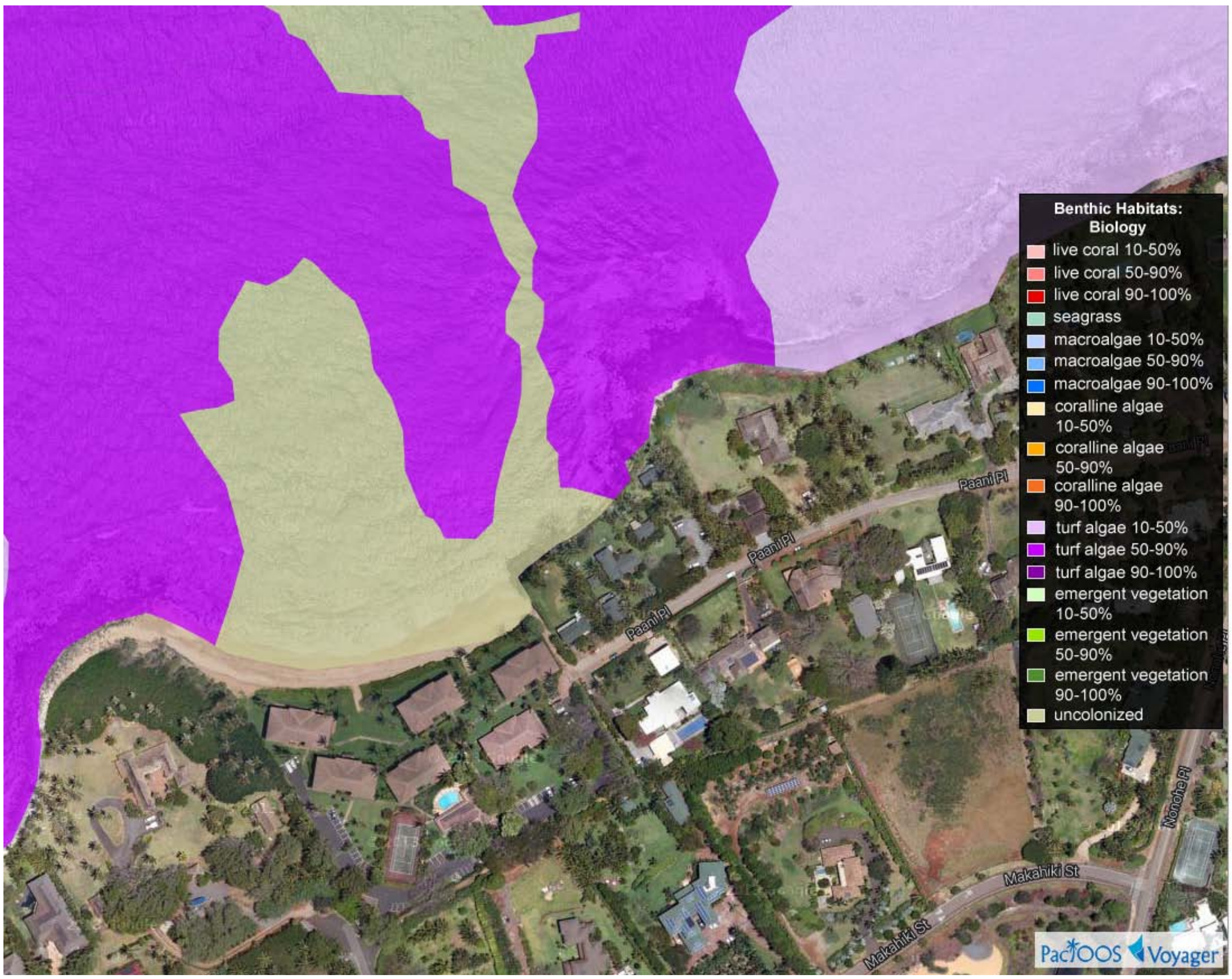


Figure 3-6 NOAA mapped benthic habitats for the area

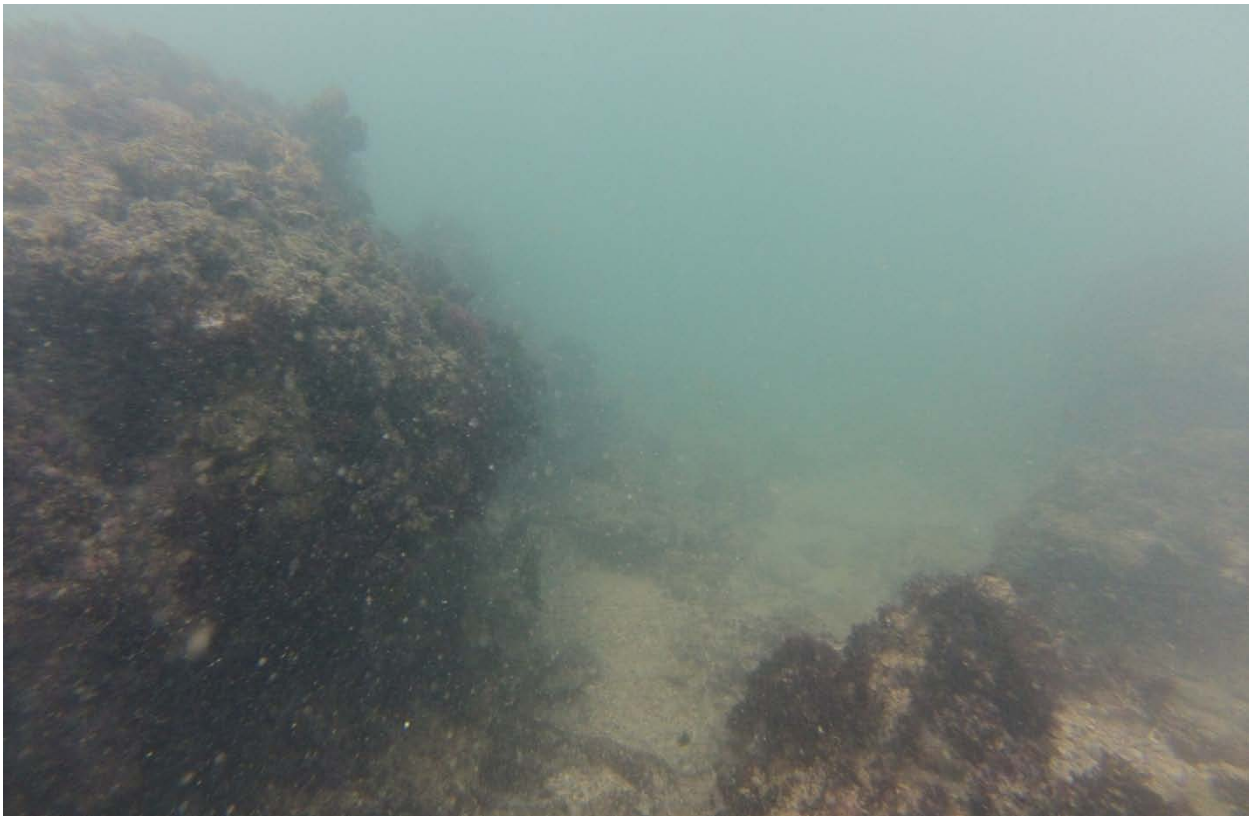


Figure 3-7 Turf algae typical of the area, in the eastern portion of the cove

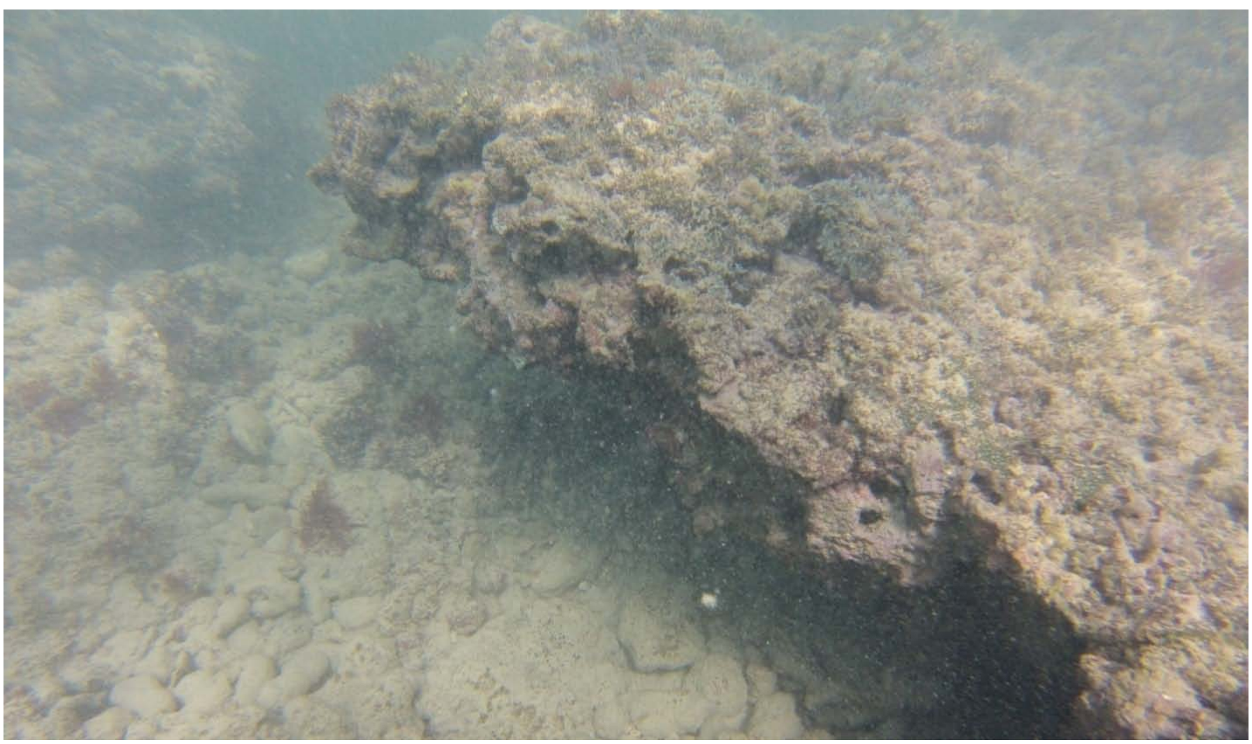


Figure 3-8 Turf algae typical of the area, offshore of the center of the cove

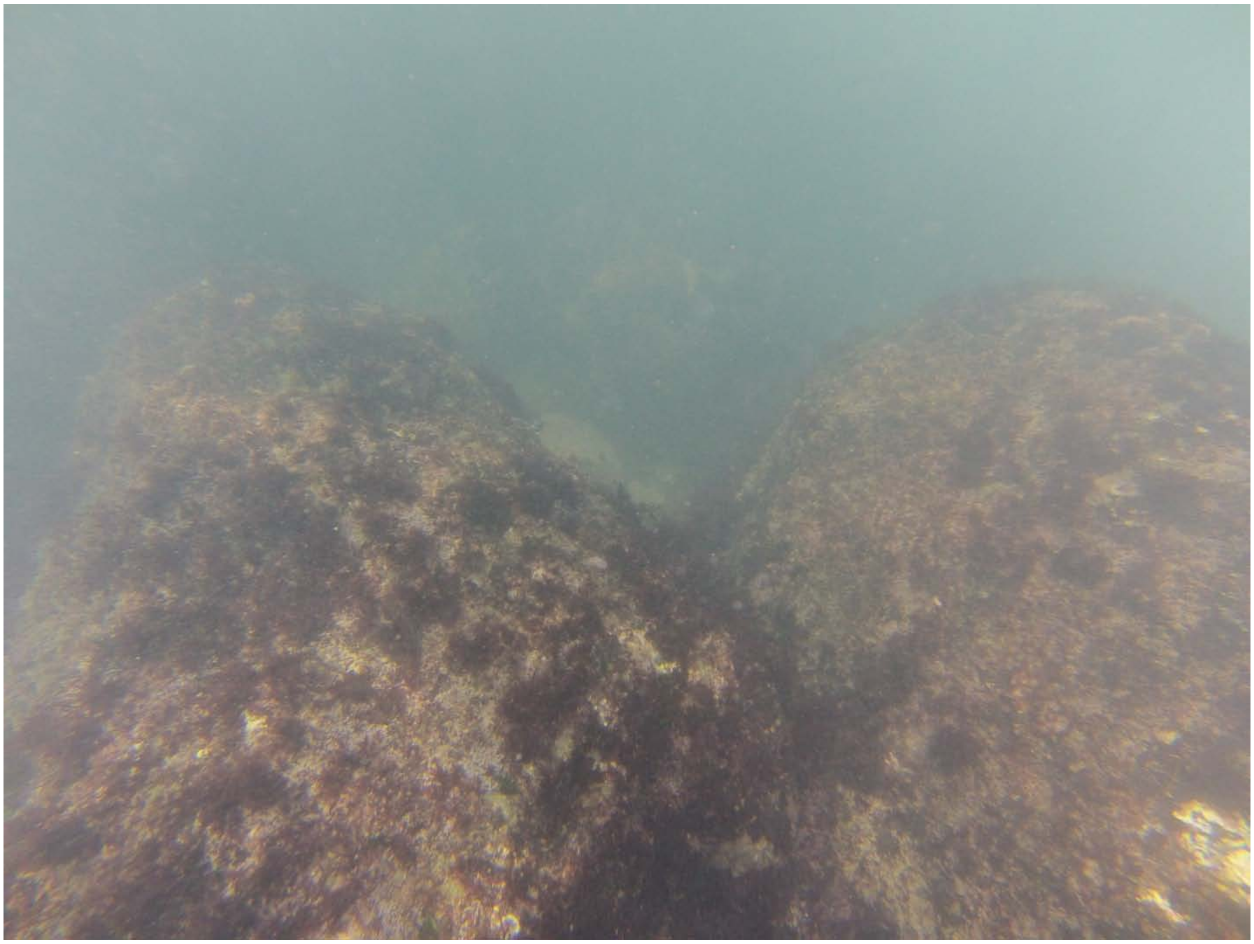


Figure 3-9 Turf algae typical of the area, on the western side of the cove

3.3.1 Endangered Species Habitat

No Green Sea Turtles, Hawksbill Sea Turtles, Humpback Whales, or Hawaiian Monk Seals were observed during any site visits to the property. However, sand beaches are an important element for sea turtle and monk seal habitats.

3.3.2 Essential Fish Habitat

There were no coral colonies observed during the most recent site visit on March 11, 2014. Turf algae was present at the outer most margins of the cove during the most recent site visit, and has been documented as part of the NOAA maps for the area, as provided by PacIOOS Voyager. The cove is dominated by uncolonized sandy substrate or pavement.

3.3.3 Wetland or Estuary

The project area is not located on a designated wetland or estuary.

3.3.4 Marine Life Conservation District

The project area is not located in a State of Hawaii Marine Life Conservation District.

3.4 Human Use Characteristics

The coastline is frequently used by both tourists and local residents alike. The coastal and nearshore areas are most commonly used for sunbathing, coastal lateral access, windsurfing, kite boarding, surfing, paddling, snorkeling, swimming, and fishing.

There is excellent lateral shoreline access along this coastline as a result of the beach restoration and maintenance program at Sugar Cove.

3.5 Backshore and Coastal Development

The inland areas are all developed as private residences. This entire region of coastline is lined with private residences, as single family homes or associations.

3.6 Historic and Cultural Resources

The Hayashi Beachwall, which armors the coastline, was built in 1993. The existing beach is a product of nearly 30,000 cubic yards of beach sand fill that has been added to an armored coastline since 1995. There are no historic or cultural features located on or above the beachwall.

4. PROJECT OUTCOMES

4.1 Beach Condition

Evidence shows the beach was significantly farther offshore as recently as the mid-1900s. The entire north shore of Maui has experienced the impacts of chronic erosion, resulting from both natural and anthropogenic factors for many decades. These erosion forces eventually resulted in the complete loss of the beach at Sugar Cove by 1989. The native clay and boulder substrate was fully exposed at this point, impacting the nearshore environment and highlighting the fact that there are no accessible sandy coastal plain resources available for the beach. Following construction of the Hayashi Beachwall in 1993, which stabilized the shoreline location, no natural beach reformed along the coastline.

Only through the ongoing efforts of the Association has a sand beach been restored along the cove’s coastline. The net outcome of this maintenance program is that a beach is present along a section of coastline where the natural littoral processes could no longer support one.

Immediately following maintenance operations, there will be a short period when the berm is being incorporated into the subaerial beach profile, and the beach shape is adjusting. This will not be a negative effect, merely a morphologic shift along the dry beach profile.

Without this berm maintenance activity the beach will once again narrow and be lost. Erosion forces are still active along this coastline, and will continue to affect littoral cell volume. Maintenance is the only way to combat these forces and maintain a beach environment.

4.2 Marine Substrate and Local Littoral Processes

The restoration process, at its inception, restored sediment to the littoral cell, re-inflating both the nearshore and subaerial portions of the beach profile. Ongoing maintenance of the system will sustain these volumes in an erosion prone environment.

The proposed maintenance program will not alter the existing littoral system or the ecosystems that are reliant on both submerged and subaerial sandy substrate. Sand quality in the nearshore environment, which is a product of nearly two decades of beach restoration efforts, is very good. The nearshore sand field has well sorted material with low fine content. Beach sand samples also document the present of modern, natural marine carbonate sand input.

Results from the ongoing beach maintenance program indicate that it is augmenting the natural processes to restore and sustain and stable littoral cell in the cove.

Moreover, the restored beach orientation and position is in-line with the 1960 beach, as identified in dated ortho-mosaic aerial photographs. The onshore and nearshore sand system, for the western portion of Sugar Cove, sits atop both terrestrial and marine substrate that was previously covered with sand. Previous maps show the beach extended well offshore earlier in the century and was connected to the beaches around both the east and west headlands.

Moberly, *et al.*, in their 1964 report on Hawaii's shorelines, documented beach rock ridges well offshore of the beaches at that time. These beach rock ridges were a clear indication that the reef had previously been covered with sand in the form of nearshore sand fields, sand beaches, and sandy coastal plains. Both natural and anthropogenic influences have resulted in erosion along the north shore's coastline, as documented by Doak Cox in 1954 (Appendix I). This erosion has impacted shoreline location on a local and regional scale. This project is a small effort to help restore the littoral cell and sand beach within Sugar Cove.

4.3 Environmental Effects

As the proposed maintenance program is an extension of the ongoing activities, no changes are expected in the environment.

Sand placement location is situated above mhhw. The shallow fringing reef extends more than ¾ mile outside the cove, significantly reducing incident wave size. In addition, the nearshore sand bar attenuates much of the remaining incident wave energy reaching the cove. Little interaction is expected between the beach quality fill sand and the marine environment.

Berm maintenance sand is from the same source as the 2003 beach restoration project at Kanai A Nalu in Maalaea, Maui, Hawaii. The Kanai A Nalu (KAN) project differed significantly from this one, in that it placed sand directly in the swash zone in an effort to repair a lost beach; however, the KAN project did extensive monitoring of water quality, flora, and fauna conditions before, during, and after the project. The monitoring efforts and their results were documented by Norcross, *et al.*, in their 2003 report on the project and the monitoring efforts (Appendix II). Monitoring results indicate the pre-nourishment conditions, similar to Sugar Cove with an exposed clay bank on the eroded shoreline, had very high background levels of turbidity, especially during high wave events. During construction turbidity levels spiked while the sand was being placed in the water. However, post-nourishment turbidity levels were significantly lower than pre-nourishment levels, as the clay bank was no longer exposed the wash of the waves. This beach restoration effort effectively removed the natural turbidity source.

Sugar Cove, through nearly 20 years of beach restoration and now berm maintenance has also minimized the exposure of the natural clay bank. This clay bank was present beneath the native sand beach, and was exposed as a result of chronic erosion on the coastline. During the late 1980s and early 1990s there is ample evidence documenting the water quality impacts this substrate imparted on the nearshore waters of Sugar Cove and the surrounding areas, Figure 1-13 is just one example of the nearshore water quality impacts during normal trade wind conditions. Sugar Cove's ongoing efforts to restore and maintain the beach have once again covered the natural clay bank, preventing the release of fine, terrigeneous material into the nearshore waters.

The sand proposed for the berm maintenance activities is from the same source the KAN project sand. Though there is some minor component of fines within the material, the sand characteristics are well within the Small Scale Beach Nourishment guidelines and have been documented to stabilize quickly, providing significant and quantifiable improvement for areas that would otherwise have high, natural turbidity levels.

In addition to improvements to water quality, the restored beach also restores a sandy haul out area for sea turtles and monk seals, as well as native habitat for shorebirds and other coastal fauna.

4.4 Recreational Uses

Restoration of the beach and ongoing maintenance has returned the littoral cell to the pre-erosion conditions. The beach and its interconnected nearshore sand field have inflated to the necessary volume to stabilize the coastline. This has improved shoreline access, swimming, sunbathing, and water ingress and egress. Development of the nearshore sand bar has created a body surfing and boogie board surf break, which is used as a learning spot for locals and visitors alike. Tourists and locals both frequent the beach, and it is regularly used as a launching point for snorkeling, surfing, windsurfing, and paddling. These uses will continue under the proposed beach maintenance program.

4.5 Upland Development

The Association's fast land is protected from coastal erosion by the Hayashi Beachwall. No impact from beach restoration or maintenance is expected on the existing upland development at the project site, or at neighboring residential parcels.

4.6 Cultural or Historic Sites

There are no cultural or historic sites that have been identified at the site. As such, there will be no impacts to cultural or historic resources.

5. ADAPTIVE MANAGEMENT PLAN

The intent of this plan is to approach long-term berm maintenance with a programmatic, well planned, managed approach that allows for ongoing monitoring and adaptive management. The 10-year lifespan of the management plan, covering multiple berm maintenance efforts requires ongoing monitoring of beach face and nearshore elevations, review of berm fill sand prior to each placement, review of the placement plan prior to each effort, and monitoring of each effort both during and after placement.

5.1 Adaptive Management Goals

The adaptive management plan is intended to review each previous effort for the following:

- Quality of placed material, after placement
- Observed beach and ocean conditions
- Beach profile adjustments
- Maintenance activity lifecycle

The overarching goal is to use to the data collected to quantify and qualify the effectiveness of material placement during each berm maintenance cycle, and the material's impact, or lack thereof, on the environment.

5.2 Management Team

The management team will consist of the following:

- A Sugar Cove AOAO representative
- A technical consultant
- A representative from the Office of Conservation and Coastal Lands

5.3 Management Tasks

Quality of Placed Material

Six months after placement, a composite sand sample from the berm will be analyzed for grain size distribution. These data will be compared to the pre-placement beach sample and berm maintenance fill sand sample data to document any changes in character to the beach sand.

Observed Beach and Ocean Conditions

Conditions will be documented though photographs of the nearshore waters, nearshore substrate characteristics, location of the shoreline, and general condition of the beach and backshore, from along the each of the three transects. These photographs will be collected just prior to start of each effort, during placement, and one month after placement. Additional photographs will be collected during each beach profile effort.

Beach Profile Adjustments

Beach profiles will be collected before and after each placement, and continuing on with the semi-annual schedule. These beach profile data will be collected at the three previously identified locations. Data will be added to the long-term record for review and analysis.

Maintenance Activity Lifecycle
The project will be reviewed prior to each berm maintenance effort to assess the duration of previous berm maintenance actions, with respect to the beach quality sand augmenting the dry beach volume and profile.

Effectiveness of Material Placement
Each placement will be photographed to document beach conditions prior to placement, during placement, immediately after placement, and semi-annually after placement. Photographs will be taken from each of the transect locations, looking in multiple directions, to capture existing beach conditions.

Review
Data from each of these tasks, combined with the photograph sets, will be reviewed prior to the next berm maintenance effort. Each review will detail potential erosion events, such as extreme waves, storms, or tsunamis, which may have impacted the shoreline. Each review will discuss the volume placed, starting and ending profiles, environmental conditions including both nearshore and beach areas, and berm maintenance material characteristics from previous efforts.

5.4 Management Decisions

The management team will review existing data from the previous berm maintenance effort(s), prior to the next effort. The team will determine if the previous effort(s) were successful in design and implementation. They will review the proposed maintenance effort design and materials, with respect to the previous effort(s).

The management team will determine if the proposed design and materials are within the scope of this management plan and the Small Scale Beach Nourishment program. The management team will then review the proposed design and materials within the scope of the previously collected data sets, including the history of environmental conditions. If the team determines that alteration(s) are needed for the upcoming berm maintenance effort, and these alterations can be supported by the existing data, then the design and materials will be adapted as needed.

6. ALTERNATIVES

6.1 No Action

The no action alternative was attempted prior to 1989. No action resulted in wholesale loss of the sand beach and exposure of the clay bank and boulders that comprise the natural shoreline. Loss of the beach resulted in significant clay and silt input to marine waters, as well as degradation of lateral coastal access.

If 'No Action' is chosen today, the sand beach will deflate and disappear, leaving the Hayashi Beachwall without a surface cover of sand. This will have significantly negative impacts on the littoral cell, the public trust lands, and beach access. This will also eliminate the sand beach environment that is central to Hawaii's coastal ecosystem.

This is not the preferred action.

6.2 Incorporate Beach Stabilization Structures

Recent projects, such as Iroquois Point and the local example at Stables Beach Road have utilized beach stabilization structures to secure littoral sediment within confined portions of their regional littoral cells. Since Sugar Cove has a relatively well constrained littoral cell, it is feasible that groins could be designed to assist in stabilizing the sand within the cove.

Engineered T-Head groins can be designed to both improve stability of the littoral cell and tune the shape of the subaerial beach. Tuned groins could be added to both the eastern and western headlands.

Figure 6-1 Iroquois Point beach restoration project with tuned T-Head groins

Offshore structures, though highly effective, have significant regulatory hurdles. In addition, these structures are located on State submerged land and require long-term easements from the State. The structures fall under DA Section 10 regulations, and will be evaluated for their impacts on Essential Fish Habitat and Endangered Species. They will also need extensive study prior to permitting, often times requiring significant Environmental Assessments or Environmental Impact Statements, depending on the size and location of the structures.

Currently, this is not the preferred action, as efforts under the existing maintenance program have been sufficient to restore and sustain a beach at Sugar Cove. As sea levels rise over the coming decades to century, incorporation of stabilization structures may be needed to offset the effects of drowning of the western headland and an increase in total water level along the length of the beach face.

7. BEST MANAGEMENT PRACTICES PLAN

The purpose of this Best Management Practices Plan (BMPP) is to ensure that adequate protective measures are in place during regular beach maintenance of Sugar Cove, Sprecklesville, Maui, Hawaii. This plan is designed to prevent, if possible, or minimize adverse impacts to the environment. The project specifications will require the Construction Contractor to adhere to environmental protection measures, including, but not limited to, those included in this plan.

7.1 General

This section covers the requirements of environmental and pollution control during construction activities. The Contractor shall be responsible for conformance to Title 11, Chapter 60 of the Public Health Regulations, Department of Health, State of Hawaii.

1. With the exception of those measures set forth elsewhere in this plan, environmental protection shall consist of the prevention of environmental pollution as the result of construction operations under this project. For the purpose of this plan, environmental pollution is defined as the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare, unfavorably alter ecological balances of importance to human life, affect other species of importance to man, or degrade the utilization of the environment for aesthetic and recreational purposes.

2. The work shall include the following:

    A. Make sure that all permits required for this plan are obtained and valid for the construction period.

    B. Provide all facilities, equipment and structural controls for minimizing adverse impacts upon the environment during the construction period.

3. Applicable Regulations: In order to provide for abatement and control of environmental pollution arising from the construction activities of the Contractor and his subcontractors in the performance of the work performed shall comply with the intent of the applicable Federal. State, and local laws and regulations concerning environmental pollution control and abatement, including, but not limited to the following regulations:

    A. State of Hawaii, Department of Health, Administrative Rules. Chapter 55. WATER POLLUTION CONTROL: Chapter 54, WATER QUALITY STANDARDS.

    B. State of Hawaii, Department of Health, Administrative Rules, Chapter 59, AMBIENT AIR QUALITY: Chapter 60, AIR POLLUTION CONTROL LAW.

    C. State of Hawaii, Department of Health, Administrative Rules, Chapter 44A, VEHICULAR NOISE CONTROL.

D. State of Hawaii, Occupational Safety and Health Standards, Title 12, Department of Labor and Industrial Relations, Subtitle 8, Division of Occupational Safety and Health, Subparagraph 12-202-13, ASBESTOS DUST: Environmental Protection Agency, Code of Federal Regulations Title 40, Part 61 Subpart A, NATIONAL EMISSION STANDARDS FOR AIR POLLUTANTS and Subpart B, NATIONAL EMISSION STANDARDS FOR ASBESTOS; and U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Asbestos Regulations, Code of Federal Regulations Title 29, Part 1910.

7.2 Suitable Material

1. All maintenance equipment and material shall be free of contaminants of any kind including: excessive silt, sludge, anoxic or decaying organic matter, clay, dirt, oil, floating debris, grease or foam or any other pollutant that would produce an undesirable condition to the beach or water quality.

2. All berm fill sand shall be free from any objectionable sludge, oil, grease, scum, excessive silt, organic material or other floating material.

7.3 Historic or Cultural Features

1. No adverse impacts to any historical or cultural feature are expected, since the project is located on beach fill material, made of processed and well sorted carbonate sediment, sitting atop the beachwall.

2. Should any unanticipated archaeological site(s), such as walls, platforms, pavements and mounds, or remains such as artifacts, burials, concentrations of charcoal or shells be uncovered by the work activity, all work shall cease in the immediate area and the contractor shall notify the State Historic Preservation Office at 808.692.8015. No work shall resume until the owner/contractor obtains clearance from the Historic Preservation Office.

7.4 Environmental Protection

1. All permits and clearances shall be obtained prior to the start of any maintenance activities. The Contractor and his sub-contractors shall ensure that all construction work complies with all permit conditions and commitments made with environmental agencies.

2. The Contractor shall perform the work in a manner that minimizes environmental pollution and damage as a result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of the maintenance activities.

3. The contractor shall complete daily inspection of equipment for conditions that could cause spills or leaks; clean equipment prior to operation near the water; properly site storage, refueling, and servicing sites; and implement spill response procedures and stormy weather preparation plans.

4. The project shall be completed in accordance with all applicable State and County health and safety regulations.

5. The Contractor shall provide notifications to the National Marine Fisheries Services, 808.944.2200, including the Protected Resources Division, at least 72 hours prior to scheduled start of maintenance activities.

7.5 Solid Waste and Disposal

1. Any maintenance activity related debris that may pose an entanglement hazard to marine protected species must be removed from the project site if not actively being used and/or at the conclusion of the maintenance activity.

2. The Contractor shall not dispose of any concrete, steel, wood, and any other debris into lagoon waters. Any debris that falls into the water shall be removed at the Contractor's own expense.

3. No contamination (trash or debris disposal, alien species introductions, etc.) of marine (reef flats, lagoons, open oceans, etc.) environments adjacent to the project site shall result from project related activities.

4. The Contractor shall remove all floating or submerged materials and/or debris at the end of each day, with the exception of any silt containment devices, as needed.

5. The Contractor shall ensure that an Oil Spill Response Plan is in place which shall detail procedures for managing the accidental release of petroleum products to the aquatic environment during construction. Absorbent pads, containment booms and skimmers will be available to facilitate the cleanup of petroleum spills.

6. Any spills or other contaminations shall be immediately reported to the DOH Clean Water Branch (808-586-4309).

7. In the event that floating hydrocarbon (oil, gas) products are observed, the Contractor or his designated individual will be responsible for directing that in-water work be halted so that appropriate corrective measures are taken in accordance with the Oil Spill Response Plan. The Department of Land and Natural Resources shall be notified as soon as practicable, and the activity causing the plume will be modified by containment. The responsible individual will document the event and the measures taken to correct the issue, and will report the incident (with photographs) to the Office of Conservation and Coastal Lands as soon as is practicable. Work may continue only after the issue is no longer visible.

8. No contamination of the marine environment shall result from the permitted activities. Particular care must be taken to ensure that no petroleum products, trash or other debris enter near-shore and open ocean waters. When such material is found within the project area, the

Contractor, or his designated construction agent, shall collect and dispose of this material at an approved upland disposal site.

9. Waste materials and waste waters directly derived from maintenance activities shall not be allowed to leak, leach or otherwise enter marine waters.

7.6 Waste Waters

Construction operations shall be conducted so as to prevent discharge or accidental spillage of pollutants, solid waste, debris, and other objectionable wastes in surface waters and underground water sources.

7.7 Erosion Control

1. Silt curtains and/or booms will be individually anchored and regularly inspected during sand placement operations, as needed.

2. Silt curtains and/or booms will be left in place each night, as needed. All anchors and booms will be inspected prior to sunset.

3. The Contractor is responsible for the proper handling, storage and/or disposal of all waste generated by maintenance activities.

4. The Contractor shall confine all maintenance activities to areas defined by the drawings and specifications. No materials shall be stockpiled in the marine environment.

5. The Contractor shall keep maintenance activities under surveillance, management and control to avoid pollution of surface or marine waters. Daily visual inspection of the project site and its environs will be conducted by a designated individual, or his representative, to verify that the permitted activities do not result in uncontrolled adverse environmental impacts.

6. Visual inspections will include monitoring of the effectiveness of the silt curtains and/or booms to ensure proper function.

7. Visual inspections will be documented with photographs and written descriptions, if necessary.

8. Sand fill placement shall not be done during storms or periods of high surf.

9. Visual monitoring will include ongoing inspections for turbidity outside of the confines of the silt curtains and/or booms. In the event that turbidity is observed outside of the silt curtains, work shall stop and the silt curtains shall remain in place until the turbidity dissipates. Silt curtains, booms, and anchors shall be inspected after dissipation and prior to returning to sand retrieval operations.

10. Drainage outlets shall be maintained to minimize erosion and pollution of the waterways during construction. Surface runoff shall be controlled in order to minimize silt and other contaminants entering the water. Should excessive siltation or turbidity result from the Contractor's method of operation, the Contractor shall install silt curtains or other silt contaminant devices as required to correct the problem. Such corrective measures shall be at no additional cost to the Owner.

11. Wherever trucks and/or vehicles leave the site and enter surrounding paved streets, the Contractor shall prevent any material from being carried onto the pavement. Waste water shall not be discharged into existing streams, waterways, or drainage systems such as gutters and catch basin unless treated to comply with the State Department of Health water pollution regulations.

12. During interim grading operations, the grade shall be maintained so as to preclude any damage to adjoining property from water and eroding soil.

13. Temporary berms, cut-off ditches and other provisions which may be required because of the Contractor's method of operations shall be installed at no cost to the Owner.

14. Drainage outlets and silting basins shall be constructed and maintained as directed by the Owner to minimize erosion and pollution of waterways during construction.

15. Mean higher high water will be marked along the shoreline prior to conducting operations to ensure that neither equipment nor fill operate or are placed seaward of mhhw.

16. Operational bounds on land will be marked with traffic cones and patrolled by project staff as needed to ensure that members of the public do not enter the project area.

7.8 Noise Control

1. Best management practices shall be utilized to minimize adverse effects to air quality and noise levels, including the use of emission control devices and noise attenuating devices.

2. Noise shall be kept within acceptable levels at all times in conformance with HAR Title 11 § 46 Community Noise Control, State Department of Health, Public Health Regulations. The contractor shall obtain and pay for a community noise permit from the State Department of Health when equipment or other devices emit noise at levels exceeding the allowable limits.

3. Construction equipment shall be equipped with suitable mufflers to maintain noise within levels complying with applicable regulations.

4. Starting of construction equipment meeting allowable noise limits shall not be done prior to 7:00 a.m. without prior approval of the Engineer. Equipment exceeding allowable noise limits shall not be started up prior to 7:30 a.m.

7.9 Dust Control:

1. Dust, which could damage crops, orchards, cultivated fields and dwellings, or cause nuisance to persons, shall be abated and control measures shall be performed. The Contractor shall be held liable for any damage resulting from dust originating from his operations.

2. The Contractor, for the duration of the contract, shall maintain all excavations, embankments, haul roads, permanent access roads, plant sites, waste disposal areas, borrow areas, and all other work areas within or without the project limits free from dust which would cause a hazard to the work, or the operations of other contractors, or to persons or property. Industry accepted methods of stabilization suitable for the area involved, such as sprinkling or similar methods will be permitted. Chemicals or oil treating shall not be used.

3. The Contractor shall prevent dust from becoming airborne at all times including non-working hours, weekends and holidays in conformance with the State Department of Health, Administrative Rules, Title 11, Chapter 60 - Air Pollution Control.

4. The method of dust control and costs shall be the responsibility of the Contractor.

5. The Contractor shall be responsible for all dust damage claims arising from his work.

7.10 Air Pollution Control:

1. Emission: The Contractor shall not be allowed to operate equipment and vehicles that show excessive emissions of exhaust gases until corrective repairs or adjustments are made to the satisfaction of the Owner.

7.11 Protected Marine Species

1. The project manager shall designate a competent observer to survey the marine areas adjacent to the proposed action for ESA-listed marine species, including but not limited to the green sea turtle, hawksbill sea turtle, and Hawaiian monk seal.

2. Visual surveys for ESA-listed marine species shall be made prior to the start of work each day, and prior to resumption of work following any break of more than one half hour, to ensure that no protected species are in the area (typically within 50 yards of the proposed work).

3. Work shall be postponed or halted when ESA-listed marine species are within 50 yards of the proposed work, and shall only begin/resume after the animals have voluntarily departed the area. If ESA-listed marine species are noticed after work has already begun, that work may continue only if there is no way for the activity to adversely affect the animal(s). For example, divers performing surveys or underwater work (excluding the use of toxic chemicals) is likely safe. The use of heavy machinery is not.

4. Do not attempt to feed, touch, ride, or otherwise intentionally interact with any ESA listed marine species.

5. All on-site project personnel must be apprised of the status of any listed species potentially present in the project area and the protections afforded to those species under federal laws. A brochure explaining the laws and guidelines for listed species in Hawaii, American Samoa, and Guam may be downloaded from:
http:www.nmfs.noaa.gov/prot_res/MMWatch/Hawaii.htm

6. The Contractor shall keep a record of all turtle sightings, incidents of disturbance, or injury, and shall provide a report to the State and the National Marine Fisheries Service (NMFS), and will be the contact person for any issues involving green sea turtles during maintenance activities.

7. Upon sighting of a monk seal or turtle within the safety zone during project activity, immediately halt the activity until the animal has left the zone. In the event a marine protected species enters the safety zone and the project activity cannot be halted, conduct observations and immediately contact NMFS staff in Honolulu to facilitate agency assessment of collected data. For monk seals contact the Marine Mammal Response Coordinator, David Schofield, at (808) 944-2269, as well as the monk seal hotline at (888) 256-9840. For turtles, contact the turtle hotline at 983-5730.

8. The Contractor shall immediately report any incidental take of marine mammals. The incident must be reported immediately to NOAA Fisheries' 24-hour hotline at 1-888-256-9840, and the Regulatory Branch of the USACE at 808-438-9258. In Hawaii, any injuries incidents of disturbance or injury to sea turtles must be immediately reported, and must include the name and phone number of a point of contact, location of the incident, and nature of the take and/or injury. The incident should also be reported to the Pacific Island Protected Species Program Manager, Southwest Region (Tel: 808-973-2987, fax: 808-973-2941).

7.12 Operational Controls

1. This Plan will be reviewed with the project field staff prior to the start of work.
2. All activities significantly impacting the environment will not begin until appropriate BMPP's are properly installed.
3. Construction will be immediately stopped, reduced or modified; and/or new or revised BMPP's will be immediately implemented as needed to stop or prevent polluted discharges to receiving waters.

7.13 Structure, Authority, and Responsibility

The Project Manager/Superintendent/Project Engineer will ensure compliance with this plan.

The Project Manager/Superintendent/Project Engineer will appoint and train one (1) additional individual to properly install all BMPP's and to comply with all aspects of this plan.

7.14 Suspension of Work:

1. Violations of any of the above requirements or any other pollution control requirements which may by specified in the Technical Specifications herein shall be cause for suspension of the work creating such violation. No additional compensation shall be due the Contractor for remedial measures to correct the offense. Also, no extension of time will be granted for delays caused by such suspensions.

2. If no corrective action is taken by the Contractor within 72 hours after a suspension is ordered by the Owner, the Owner reserves the right to take whatever action is necessary to correct the situation and to deduct all cost incurred by the Owner in taking such action from monies due to the Contractor.

3. The Owner may also suspend any operations which he feels are creating pollution problems although they may not be in violation of the above-mentioned requirements. In this instance, the work shall be done by force account.

8. CONTINGENCY PLAN

The following plan will be implemented by the General Contractor to prevent/respond to polluted discharges resulting from a severe storm or natural disaster. It is the General Contractors responsibility to abide by the following plan as well as any other binding plan, agreement, regulation, rule, law, or ordinance applicable.

All contactors associated with the following construction project, Sugar Cove Beach Maintenance, will follow this plan when a severe storm is either forecast or anticipated. General contractors must:

a. Regularly monitor local weather reports for forecasted and/or anticipated severe storm events, advisories, watches, warnings or alerts. The contractor shall inspect and document the condition of all erosion control measures on that day prior, during, and after the event. The contractor shall prepare for forecasted and/or anticipated severe weather events to minimize the potential for polluted discharges.

b. Secure the construction site. Securing the site should generally include:
   - i. Removing or securing equipment, machinery, and maintenance materials.
   - ii. Cleaning up all maintenance debris.
   - v. Implementing all Best Management Practices detailed in the Site's SSBMP Plan. This includes BMPs for materials management, spill prevention, and erosion and sediment control.

c. In the event of a severe weather advisory (hurricanes, tropical storms, natural disasters) or when deemed necessary, cease regular construction operations. Work crews must finalize securing the project site, and evacuate until the severe weather condition has passed.

d. Upon return to the Site, all BMPs shall be inspected, repaired and/or re-installed as needed. If repair is necessary, it shall be initiated immediately after the inspection and repairs or replacement will be complete within 48 hours. To facilitate repair or replacement, the contractor will be required to store surplus material on the project site if the site is located where replacement materials will not be readily available.

e. When there either has been a discharge which violates Hawaii Water Pollution rules and regulations OR there is an imminent threat of a discharge which violates Hawaii Water Pollution rules and regulations and/or endangers human and/or environmental health, the permittee shall at a minimum execute the following steps:
   - i. Assess whether construction needs to stop or if additional BMPs are needed to stop or prevent a violation.
   - ii. Take all reasonable measures to protect human and environmental health.
   - iii. Notify responsible parties listed below and immediately notify the DOH of the incident. The notification shall also include the identity of the pollutant sources and the implemented control or mitigation measures.
     - 1. Mr. Rich Salem – (808) 388-1300
     - 3 Operator/ Emergency Contact Number: TBD
     - 4. Department of Health
       Clean Water Branch (During regular working hours): 808-586-4309

Hawaii State Hospital Operator (After hours): 808-247-2191

iv Document corrective actions, take photographs of discharge and receiving waters.

v. Revise Site Specific BMPs Plan to prevent future discharges of a similar nature.

9. EMERGENCY SPILL RESPONSE PLAN

9.1 Pre-Emergency Planning

a. An initial and periodic assessment shall be made of the project site and potential hazardous spills that may be encountered during the normal course of work. This plan is not intended to address issues relating to materials such as PCB, Lead, Asbestos, etc. since these types of materials would have specific work plans already developed. This plan should be revised as necessary to correspond to the assessment.
b. A Hazardous Materials inventory list and MSDS sheets, to include subcontractors' materials, will be filed in a binder and located in the Project Office. The inventory list and MSDS sheets will be updated and maintained by the Project Manager and site safety officer; as new materials are added.
c. Personnel will consult the applicable MSDS sheet prior to its use.
d. Personnel will handle hazardous materials safely and use personnel protective equipment (PPE), recommended/required by the MSDS, when handling hazardous materials.
e. Personnel will receive "Hazard Communication" training within three (3) working days of arrival and "product specific" training prior to the initial use/exposure of a product. This training will be conducted by the Project Manager/Superintendent or site safety officer.
f. All personnel will be trained on the contents of this plan within the first month of maintenance and at least annually thereafter. The training should include a rehearsal of this plan. An attendance sheet will be kept on file at the Project Office.
g. Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids. Approved safety cans or DOT approved containers shall be used the handling and use of flammable liquids in quantities of five (5) gallons or less. For quantities of one (1) gallon or less, only the original container or approved metal safety can shall be used, for storage, use and handling of flammable liquids.
h. Flammable or combustible liquids shall not be stored in areas used for exits, stairways, or normally used for the safe passage of people.

9.2 Personal Protective and Emergency Spill Response Equipment

a. ABC fire extinguishers will be located in the project field office and in each of the company vehicles. There will be at least one fire extinguisher, rated at not less than 10B, within 50 feet of any stockpile of 5 gallons of flammable or combustible liquids or 5 pounds of flammable gas storage.

NOTE: Fire extinguishers should not be located "directly" with hazardous materials, so as to endanger first responders.

b. Spill kits will be located at the project field office and/or within 50 feet of the hazardous material storage area. The spill kit contents shall be determined by the

Project Manager/Superintendent based on the anticipated hazardous materials to be stored and/or used on the project. The spill kits will be inventoried quarterly and appropriate logbook entries made.

c. Emergency response personal protective equipment (PPE) consisting of:
    i. Face shield
    ii. Tyvex coveralls
    iii. Rubber gloves
    iv. Air-purifying respirators with HEPA and organic vapor combination cartridges will be issued to the Emergency Response Team members and maintained in the project office. Separate Respiratory Protection Equipment shall be designated and labeled as such; this equipment will be inspected at least every 30 calendar days and appropriate logbook entries made.

9.3 Personnel Roles, Lines of Authority and Communication

a. Emergency Response Coordinator (ERC)
    i. The Project Superintendent is the designated ERC. If the Project Superintendent is not available, the safety officer is the designated ERC.
    ii. The ERC will be in charge of and will coordinate the appropriate emergency response procedures in this plan.

b. Emergency Response Team (ERT)
    i. The ERT consists of Construction General Foreman, Labor Foreman, and a Laborer designated by the Project Superintendent.
    ii. The ERT will appropriately respond to the emergency in accordance with this plan at direction of the ERC.

9.4 Emergency Alerting and Response Procedures

a. Any person causing or discovering a known hazardous or unknown release or spill will:
    i. Immediately alert nearby personnel who may be exposed to the effects of the release or spill.
    ii. Report the release or spill immediately to the ERC and the ERT. All pertinent information regarding the release should be provided to the ERC, such as the amount and type of material released, location of the release, and other factors, which may affect the response operation.
    iii. If the spill or release if a petroleum product or known non-toxic chemical, the person will take immediate and appropriate measures to stop or limit the rate of release, (i.e. close the spigot to the drum or form oil or curing compound) and or contain or stop the migration of the release (i.e. create a berm of dirt around the release) until the ERC and ERT arrive.
    iv. If the spill release is a toxic, highly flammable, or unknown chemical, the person will first notify the ERC before approaching the spill area

from upwind to determine the source, type, and quantity of the release. The person should monitor the spill until the ERC and ERT arrive.

v. The ERC will assess possible hazards to human health or the environment that may result from the release, fire, or explosion.

vi. If the spill or release is less than 25 gallons of a known petroleum product or non-toxic chemical, the ERC will direct the ERT to contain and cleanup the spill or release.

vii. If the spill or release is toxic or unknown, the ERC will immediately notify the County of Hawaii Fire Department and ask for assistance from the HAZMAT Response Team.

viii. Immediately after the emergency, the ERC will arrange for disposing of the recovered waste, contaminated soil or any other material that results from the release, fire, or explosion at the project site in accordance with the County of Hawaii and State regulations and manufacturer's instructions (if source of spill or release is known).

9.5 Emergency Notification and Reporting Procedures

a. In the event that a release enters the storm or sewer system, the ERC will immediately notify the Nation Response Center (NRC) at 1.800.424.8802, the Hawaii Department of Health, Hazard Evaluation and Emergency Response Office (HEER) at 808.586.4249 and LRPC at 808.935.2785.
b. The ERC will immediately notify appropriate agencies and submit written follow-up notification in accordance with the Hazardous Substance Release Notification Guideline.

9.6 Safe Distance Staging Area

a. A staging area at safe distance up wind and higher than the location of the spill or release and its source will be immediately established.
b. Access to the spill or release location will be cleared for emergency vehicles and equipment to be used to contain and clean up the spill or release.

9.7 Site Security and Control

a. If the spill or release is located on or near the roadway, stop all traffic until the release is cleaned up.
b. If the spill or release is located away from vehicle or pedestrian traffic, install barricades/safety fencing around the affected area.
c. If the spill or release occurs during night operations, provide adequate light and use ground guides to escort emergency vehicles to the affected area.

9.8 Evacuation Routes and Procedures

a. Persons injured during the emergency condition will be evacuated to the staging area where they will be treated and or further evacuated to the nearest medical facility. The appropriate MSDS(s) will be provided to emergency service personnel and are intended to be delivered to the emergency room physicians.

b. Persons working at the affected area and who are not needed in the response effort; will report the staging areas for accountability.

9.9 Decontamination and Disposal Procedures

a. Persons involved in the spill clean-up are required to perform personal hygiene, utilizing soap and fresh water prior to eating, drinking, or smoking.
b. Contaminated PPE shall be appropriately cleaned and disinfected if possible. If this is not possible it shall be disposed per the same requirements of the contaminated substance.
c. Sorbent pads/materials and the spilled substance will be placed in appropriate containers and disposed as specified by the appropriate MSDS.
d. Contaminated soil will be placed in appropriate container(s) or on plastic sheeting. The ERC will arrange with an environmental services company to properly characterize, prepare the manifest, label the containers, transport, and dispose of the contaminated soil. The generator's copy of the manifest will be kept in the project files for a minimum of three (3) years.
e. In the event of a substantial release (25 gallons or more) of a suspected or known toxic chemical, the Fire Department HAZMAT Response Team will be called to control/cleanup the release. They will establish and provide the decontamination operations as required.

9.10 Emergency Medical Treatment and First Aid

a. First aid kits will be maintained at the project field office, all company vehicles, and gang boxes.
b. Injured person(s) will be treated at the staging area by a certified first aid trained individual at the project site until the ambulance arrives or they are evacuated to the nearest medical facility.
c. The appropriate MSDS(s) will be provided to emergency service personnel and are intended to be delivered to the emergency room physicians.

9.11 After the Spill Procedures

a. The ERC will review what happened and implement changes and/or corrections to prevent spill from occurring and to improve the spill response and clean-up procedures. This Plan will be revised to reflect those changes/corrections/improvements implemented.
b. The ERC will prepare a record of the spill response and keep it in the project files for a minimum of three (3) years.
c. The ERC will submit Follow-up Notification to HEER when required.
d. Spill response kits shall be replenished directly after the emergency.

9.12 Emergency Contacts

National Response Center (NRC)		1.800.424.8802
Coast Guard Operations Center, Honolulu	(working hours)	1.808.522.8264
	(after hours)	1.808.927.0830
Hawaii State Department of Health Hawaii Evaluation and Emergency Response (HEER)		1.808.586.4249
County of Maui Fire Department		911
In the event that a release enters the storm or sewer system, the ERC will immediately notify NRC, HEER, and LEPC		1.808.935.2785
(*name*), Project Manager, (*company*)		*Tel. No. - TBD*
(*name*), Project Engineer, (*company*)		*Tel. No. - TBD*
Chris Conger, Design Engineer, Sea Engineering, Inc.		*1.808.259.7966*

APPENDIX I

THE SPRECKELSVILLE BEACH PROBLEM

DOAK C. COX

ADDRESS ALL COMMUNICATIONS TO
EXPERIMENT STATION, H.S.P.A.

EXPERIMENT STATION

OF THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

HONOLULU 14, HAWAII, U. S. A.

CABLE AND WIRELESS ADDRESS
"EXPERIMENT"

THE SPRECKELSVILLE BEACH PROBLEM

by Doak C. Cox, Geologist
Experiment Station, HSPA

August 1954

Contents

Illustrations

12,000 cy x 40 = 480,000 cy!

THE SPRECKELSVILLE BEACH PROBLEM

Introduction:

For many years, probably at least 50, the beaches which make up the shoreline on the north side of Maui between Kahului and Paia and centering on Spreckelsville have in general retrograded. The only exception is on the part of the coast adjacent to the east breakwater of Kahului harbor, where, since the breakwater was built, the beach has been prograding at least until recently. The amounts of loss are large, amounting to many tens of feet of recession, and can probably be measured fairly accurately in some sections and over some periods by reference to old surveys.

Also for many years, but especially since 1949, sand has been removed from various beaches on this coastline for the manufacture of lime, for concrete aggregate, for filters, and most recently for road surfacing. About 3500 cu. yards per year are withdrawn at the lime kiln at Paia, which has been operating about 40 years, and about 170 yards per week (equivalent to nearly 9000 cu. yards per year) have been removed from the same area for road surfacing and concrete products manufacture, principally the former.

The retreat of the beaches has been a matter of concern for years, first from a general regard for conservation and more recently because of increasing property values arising from home construction on this coastline.

The brief study reported here was made because of the desire of Hawaiian Commercial & Sugar Co. to increase the output of the lime kiln, coupled with concerns for both sand reserves and beach values. Its objectives were, if possible, to estimate what quantities of sand could be withdrawn from the beaches in question without affecting them adversely, or, failing that, to recommend studies that might lead to the development of such an estimate.

I spent three days on this problem specifically, inspecting the beaches, examining surveys and maps, and talking to persons familiar with the beaches. On one day I was accompanied by Dr. F. P. Shepard of Scripps Institution of Oceanography and on another by Dr. K. O. Emory of the University of Southern California, both authorities on shoreline geology. This report is based in part on their comments in the field and through subsequent correspondence. Their help is very gratefully acknowledged.

Beach processes and their evaluation in general:

It is generally recognized that no small segment of a beach is a unit by itself. Each segment is in at least approximate equilibrium with other segments on the same beach and even with other beaches and reservoirs of sand on the nearby shallow bottom. Removal of sand from one segment may be very quickly compensated by shifts of sand from the bottom and other segments.

The accompanying diagram indicates in somewhat simplified fashion the normal disposition of sand on any system of beaches interconnected by longshore currents. With seasonal and other changes in ocean conditions, sand may be moved out from the beach to be deposited on the shallow bottom, thus temporarily depleting the beach. With reversal of the conditions, the sand is moved back rebuilding the beach. The resulting fluctuations in beach width are well known to all frequenters of beaches.

Sand is continually being produced or introduced in some part of such a system of beaches, or more generally in several areas. This production is balanced by losses to deep bottom areas from which the sand cannot be raised to the beach zone by wave action, by losses landward by wind transport, and by the destruction of sand by attrition.

On any stable coastline, one with no progressive changes in physical ocean and air forces, the long-term rate of supply of sand, the long-term rate of destruction, and the long-term rate of wind removal are constant. Any artificial removal of sand from beaches on such a coast, whether the sand is taken from the shallow bottom, the lower part of the beaches or the top of the beaches, can be continued over a long term only if the losses by destruction or by transport out of the beach system are equally reduced. Such reduction may be accomplished by retreat of the shoreline to a new position at which the forces of removal or destruction of the sand are sufficiently reduced to permit a new equilibrium.

For any given ratio between artificial sand removal and natural sand transport along a given system of beaches, the change between the original, natural equilibrium beach shape and position and the new equilibrium beach shape and position might be very small or very large, depending on a great many factors including the topography of the coastline, the nature of the oceanographic and meteorological agencies operating on it, and the degree to which the topography would have to be altered to affect the action of the forces.

Natural stability cannot be assumed, however. As in all involved physiographic processes, natural changes in beach processes and, consequently, beach shapes are known to occur. Some of these changes, those involved in the tidal cycles or the annual cycle for example, can be evaluated with short periods of measurement. There are, however, indications of long period changes that cannot be evaluated without long-period study or at least very intensive study for a moderate period.

Even if long-term natural changes could be neglected, the effects of any actual artificial rate of removal of sand from a beach system could not be evaluated unless there were good measurements of the beaches both before and after continued removal. Either these would have to be long enough to span natural short term cyclical changes or they would have to be coupled with a study and evaluation of natural short term changes and their phases at the times of the measurements. With natural long-term changes also in progress, the effects of such an actual artificial removal of sand would further depend on an evaluation of the long term changes and their subtraction from the measured changes. Such evaluation is difficult enough and subject generally to some uncertainty. Extrapolation to estimate the effects of new or larger rates of artificial removal is another major step more difficult and uncertain.

Geology and physiography of the Spreckelsville coast:

The topography and geology of the Spreckelsville beaches and surroundings are shown on an accompanying map. Maui is, of course, predominantly a volcanic island, the product of two volcanoes, Haleakala and West Maui. The coast between Kahului and Paia represents part of the northwest flank of Haleakala modified slightly by erosion and sedimentation. Kahului Harbor, however, was developed at the junction between Haleakala and West Maui, the West Maui slopes being modified still more by sedimentation at that place so that the coast west of Kahului for a couple of miles is composed of alluvium, beach deposits, and dune sands, fringed by a coral reef. East of Paia, the coast is mostly volcanic, lava flow ridges projecting as points with beaches developed only in the bays between. Immediately east, the bays mostly represent swales between the latest flows, but beyond Kuau, a mile east, marine erosion has cut back the shore to make cliffs interrupted generally only by bays resulting from the submergence of erosional valleys.

In the easternmost three miles of the coast in question, from Paia to Papaula occasional lava ridges capped by red soil, probably representing initial flow ridges little modified by erosion, crop out on the shore, generally forming points. Beach deposits form the rest of this shore between the points, and only beach deposits are found on the shore along the three miles of coast westward from Papaula to Kahului.

The whole of the coast in question, and that for several miles to the west, is fringed by a coral reef built undoubtedly on the extension of the lava flow slopes below sea level. The top of the reef ranges from a half a mile to a mile in width and slopes gradually seaward from depths of a few feet at the toe of the beaches to 10 to 30 feet at the outer edge. There is considerable topographic relief on the reef, particularly near its outer margin where channelways of deeper water cut back into it.

The beaches consist largely of calcareous sand, in part fragments of coral and algal limestone from the reef, in part fragments of shells from the reef area, and in part micro-shells especially foraminifera from the top and outer edge of the reef.

There are many outcrops of beach rock along the shore, calcareous sand of the same sort as in the present beaches but consolidated, marking a previous shoreline. This beach rock probably was formed at some time when the sea level was a few feet lower than the present, because it extends below present low tide, and because in places it overlaps red soil residual on the lava flows and apparently little eroded. This previous shoreline differed materially from the present, having been generally farther seaward at least between Papaula and Paia. Several of the present beach points owe their existence to protection of the shore by remnants of the beachrock that formed in bays of the previous shoreline. This condition is shown in an accompanying aerial photograph.

Exclusive of onshore-offshore cyclical movements, the predominant direction of transport of sand is undoubtedly from east to west along the shore. This is expectable from the predominant direction of the trade winds and their waves, and is indicated by the systematic deposition of sand and prograding of the shore just east of the east Kahului breakwater, and by the shape of the shore adjacent to many small groins which have been built in places on the coast.

Loss of sand to deep water may occur either across the reef, especially through deeper channelways suitably oriented, or at Kahului where the reef is narrow or absent. The submarine topography off Kahului suggests a gentle uniform sand slope, down which sand may well be moving. The construction of the east breakwater may have reduced the ease with which sand can be carried into the deeper water there.

Prior to the turn of the century some sand was blown inland to feed the dunes which were then active on the isthmus between East and West Maui. The present rate of growth of dunes does not seem to be large. Either the supply of sand was reduced coincidentally with the introduction of algeroba trees, which anchored the dunes, or it was never very large.

Recent beach changes:

Beach recession has been noted by residents since soon after the turn of the century. Both early positions of the beach and dates are vague at the moment, but some precise data may be obtainable from early surveys and from old photographs, etc. The impression I have received is that the general retreat may average about 100 feet or, say, 30 yards. If a prism of sand with this width, an average depth of say 3 yards, and a length of 9000 yards (from Paia to about 1/2 mile from the east Kahului breakwater has been removed, the sand loss has been over 800,000 cu. yds., or, say, 16,000 cu. yards per year.

I get the impression that in the last 10 years the recession has amounted to about 10 yds., which to the same depth and over the same length as above, amounts to 270,000 cu. yds. or about 27,000 cu. yds. per year.

In the 40 years since the breakwater was built there has been an accumulation of sand along perhaps 800 yds. of shore averaging perhaps 100 yds. wide and to, the same depth as above, representing a gain of 240,000 cu. yds. or 6000 cu. yds. per year. The present beach profile, however, indicates recent and perhaps only temporary recession.

The rate of sand removal for the last 5 years has amounted to about 3500 cu. yds. per year for lime manufacture and about 8500 cu. yds. per year for road surfacing and concrete, or a total of about 12,000 cu. yds. per year. Prior to that the rate was much less, perhaps only 3000 or 4000 cu. yds. per year. It is possible that the increase in rate of removal coincided with the reversal from prograding to retrograding next to the breakwater.

By these figures it would appear that the losses of 16,000 to 27,000 cu. yds. per year are at least of the same order of magnitude as the gains of sand mined plus accretion at Kahului, 10,000 to 12,000 or 18,000 cu. yds. per year, but this cannot be interpreted as meaning that the recession of the beaches in general was the result of the combination of the effects of the artificial withdrawal and the breakwater construction. It seems improbable that the breakwater would have any effects far up-current and certainly impossible that it could promote erosion. The estimated accretion at Kahului suggests that there must have been something on the order of 6000 cu. yds., at least, of sand moving out of the eroding section besides what was lost by mining, and the excess of estimated loss over estimated amount mined suggests that there must have been some natural change coincident with the mining. Whether the amount deposited at Kahului was heightened by the results of the natural change, assuming the change may have been one that led to increased transport of sand down-current, or whether it was diminished, assuming the change may have been one that led to decrease of supply of sand from up-current cannot be determined, and there is no way of estimating at present how much sand is still or was originally moving down-current and out to deep water without appearing in increases or decreases in beach volume. Any reduction in the rate of sand being transported inland must have compensated in part for the artificial and natural losses of sand from most of the beach, and may have added to the influence of the breakwater in causing accretion at Kahului. The present and past rates of inland transport cannot, however, be estimated at present.

Recommendations:

It is not certain to me that there is much hope of producing close estimates of the effects of artificial removal of sand, say to 10% as measured in linear beach recession. However, the sand involved has so great a value both in place in the beach and as an economic mineral deposit, that a considerable amount of research appears justified to produce and evaluate even a relatively crude estimate. Two types of study will be involved; (1) the measurement of quantities of sand removed, and concurrent changes in sand volumes, including the collection of evidence of the magnitude of past withdrawals and beach changes, (2) the study of natural places of storage and modes of transfer of sand, both to permit evaluation of the measurements, and to indicate the kinds and places of measurement that will be of use. These studies may be thought of as on two levels; (1) studies that can be made under the engineering supervision available on the plantation, and (2) studies that will have to be made by or under the close supervision of a specialist in shoreline geology. The processes involved in the maintenance of beaches are so complicated that estimates based on anything less than thorough study by thoroughly qualified persons are likely to be useless or, worse, seriously misleading.

What follows is then a list of recommendations of records that can be compiled and measurements that can be made by personnel on Maui before specialized study, but that will be of reasonably certain use when the specialized study is undertaken, plus a discussion of the possible means for initiating the specialized study and some suggestions as to its content, plus general recommendation concerning handling of the problem until detailed studies can be undertaken.

The following are programs of compilation and measurement recommended to be undertaken now:

(1) Compile all existing surveys and maps showing the shoreline in question on the same scale preferably about 1:2400 (1 in. = 200 ft.), to show past changes adequately. The following sources may be useful: ordinary land surveys, federal topographic surveys, federal hydrographic surveys, harbor surveys, plantation topographic surveys including those made most recently by aerial photography. Such surveys will permit an analysis of shoreline migration. Its significance will depend, among other things, on how well short term changes can be evaluated and how large they are. The migration can be translated into volumes if profiles are known or can be assumed.

(2) Collect any old photographs of the beaches, both for further evidence of previous position of previous shorelines and for evidence on previous beach profiles.

(3) Collect any repeated inshore bathy-metric surveys, as of Kahului Harbor, that might be indicative of shoaling or scouring.

(4) Collect all data available on past artificial sand removal.

(5) Prepare as good an estimate as possible from these data of rates and volumes of sand removed in the past.

(6) Have strips of vertical aerial photographs taken of the coast twice a year, in late February or early March and in late August or early September, and also after any unusual storms, the dates and the flight altitudes to fit in with other plantation aerial photographic work. Photographs suitable for topographic mapping should be specified. Such photographs will provide a record of beach changes including the annual changes, that can be reduced to quantitative estimates whenever desired.

(7) The beach profile should be measured at frequent intervals, say bi-monthly, along about a dozen lines, which may as well be selected for the present for convenience from the standpoint of ease of accessibility, except that at least two lines should be in the area of accretion near Kahului. Such profiles may be measured in a few minutes by two men using a rod, a tape, and the horizon.

(8) Profiles of a few large areas of loose sand under water on the reef should be measured by reference to the tops of lines of stakes driven to known elevations and left partially protruding from the sand.

(9) Wave records of some sort should be kept for correlation with beach-line and profile changes. Preferably the approximate height and period of breakers and the rough offshore wave directions should be recorded daily by someone living on the coastline.

(10) Records should be kept of sand removal by date and place.

(11) The bathymetry of the reef surface, mapped in part on U.S.C.&G.S. Reg. No. 3514 on a scale of 1:20,000, should be completed inshore and checked by aerial photographs taken in clear calm weather.

There is no one now in Hawaii who has the training, time, and physical qualifications required for adequate work on the more specialized phases of the investigation. It seems possible that the University may appoint a shoreline specialist as its next professor of geology a year from now. If so I hope he may be available for consultation on problems of the sort encountered on Maui. The specialized study will probably include:

(1) More precise geologic mapping than is available at present.

(2) A study of the sand on the beaches and on the adjacent sea flow, to identify sources and facilitate tracking.

(3) A biological study of the reef.

(4) A study of wave and longshore current directions on and near the reef combined with a study of reef topography to indicate probable directions of sand movement.

(5) Check and volumetric estimation of sand movement by trapping.

(6) Analysis of the sand volume changes in the light of demonstrated directions of movement and their changes and artificial removal.

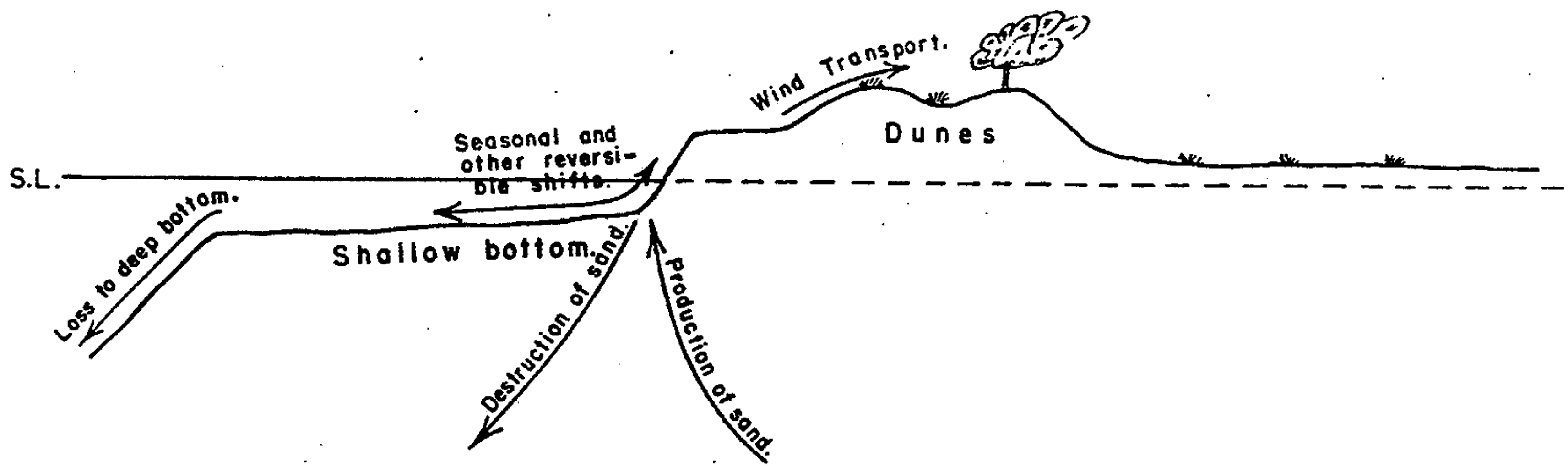
Because the detailed work cannot be done immediately, and because some decisions must be made now whether to modify or not to modify artificial sand withdrawal, the following recommendations are made concerning the mining of sand until an adequate study has produced results sufficiently good to serve as a basis for future recommendations:

(1) Cease taking sand from the beaches for uses that can economically be supplied from other sources. The sand for road surfacing, for example, may be taken from the dunes.

(2) Do not expand the lime production at present.

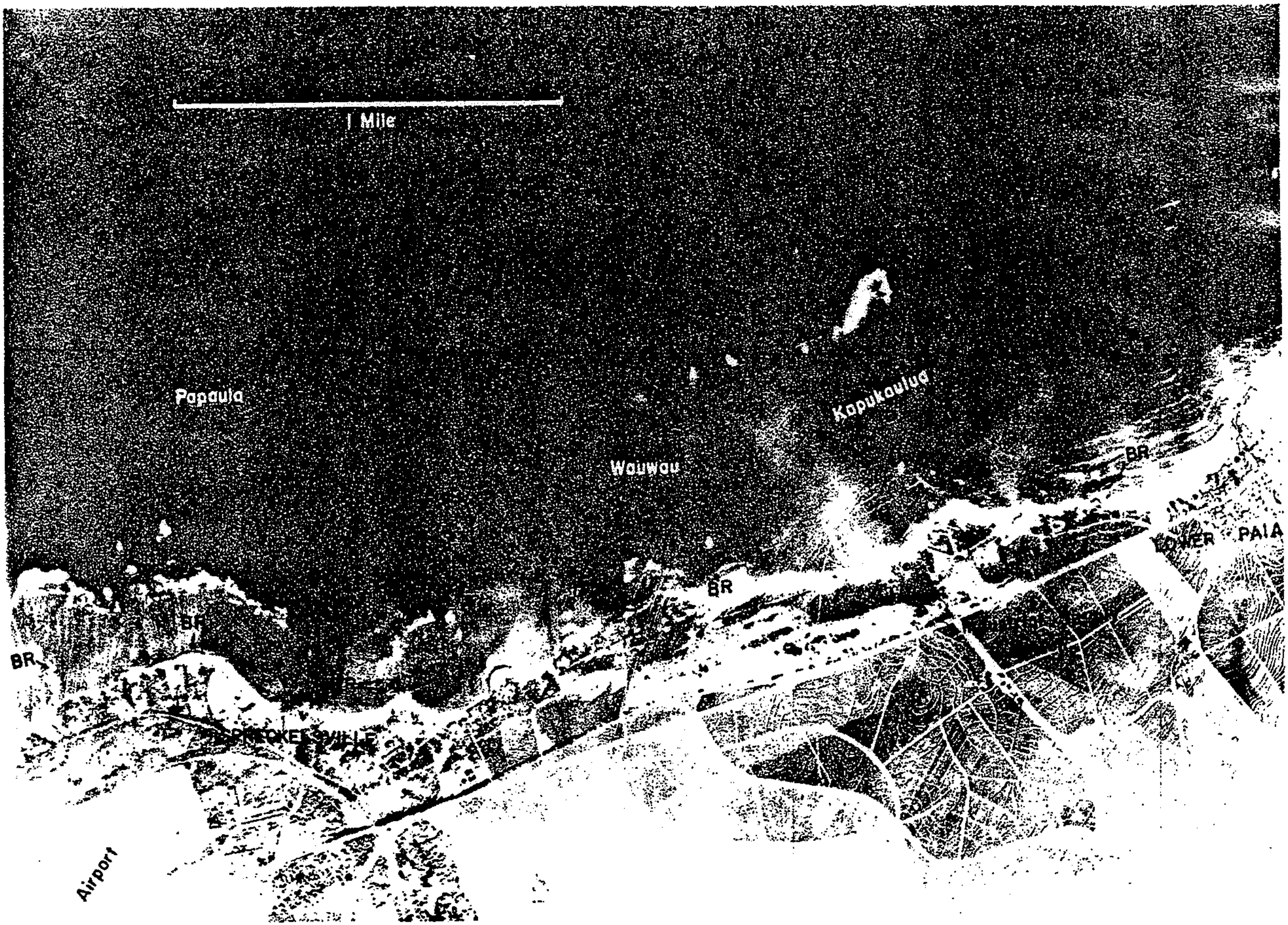
(3) Cease returning the lime-kiln rejects to the ocean. This fine material, in suspension, may be affecting reef growth and thereby the production of beach sand in the vicinity.

sp



DISPOSITION OF SAND ON A SYSTEM OF BEACHES

Plate 1 from report
"The Spreckelsville Beach Problem"
August 1954
by
Doak C. Cox, Geologist,
Hawaiian Sugar Planters Association



Aerial Photograph of beaches near Paia. BR signifies beach-rock.

A. Industrial supply beach, Kapukaulua. Recession of beach has resulted in killing coconut trees. Breakers in left middle ground are on a westward extension of the same beach-rock ridge as shown in Plate 4-A.

B. Beach at Wawau. Outcrop of lava with residual soil cap in foreground. Beach-rock ridge in left middle ground.

APPENDIX II

MARINE MONITORING FOR SMALL-SCALE BEACH REPLENISHMENT MAALEAE, MAUI, HAWAII – PRELIMINARY REPORT

NORCROSS, Z.M.N., BROWN, D., KNOWLTON, C.

MARINE MONITORING FOR SMALL-SCALE BEACH REPLENISHMENT MAALAEA, MAUI, HAWAII – FINAL REPORT

Norcross-Nu'u, Z.[1], Brown, D.[2], Knowlton, C.[2], Colvin, M.[2]

ABSTRACT

Marine and coastal environmental monitoring was carried out on a monthly basis from October 2002 to September 2003 to establish a baseline of physical, chemical and biological conditions from which comparisons could be made during and after beach replenishment to determine the extent of environmental impacts from this activity. The small-scale beach replenishment project consisted of the addition of 3000 cubic yards of inland dune sand with less than 1% fine particles at the #200 sieve. The sand was placed at the Kanai A Nalu condominiums in Maalaea, South Maui, over the period of June 2 to June 6, 2003. Water quality monitoring was conducted on a daily basis during the sand placement, or construction period, and three times within the 5 days following the completion of sand placement. Monthly monitoring resumed one month after the sand placement. Of the water quality parameters monitored, turbidity was the only parameter that appeared to be affected by the sand placement, increasing by up to 21.63 NTU over pre-construction levels. On average, turbidity levels increased by 2.22 NTU, and returned to pre-construction levels within 5 days following the completion of construction. Beach profiles revealed increases in the seaward extent of the beach in the month following construction that did not greatly exceed the seaward extent seven months prior to sand placement. The beach face has experienced an average inflation of zero to approximately half a meter above levels of the previous year, and up to 1 m above pre-nourishment levels. Video analysis revealed that the bottom cover consisted mainly of sand and algae; after nourishment, sand coverage increased and algae coverage decreased. Fish counts revealed an increase in fish following beach nourishment; however this may have been influenced by the improved visibility following the sand placement. Ghost crabs, which had disappeared entirely before the beach replenishment due to the lack of sand, were well established within three months following sand placement. Sediment trap analysis revealed no significant changes is suspended sediment type and composition.

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[2] Maui Community College Marine Option Program, 310 Kaahumanu Ave., Kahului, HI 96732. Tel: (808) 984-3203 Email: Donnabro@hawaii.edu

INTRODUCTION

The Kanai A Nalu Association of Apartment Owners (AOAO) first undertook beach replenishment in 1997 to mitigate beach erosion and the undermining of a retaining wall that had been exposed to wave action. Formerly fronted by a healthy sandy beach, this area has experienced an erosion rate of close to 0.5 ft/yr since the early 1900's (http://www.co.maui.hi.us/departments/Planning/erosion.htm). The erosion was accelerated after 1952, possibly influenced by the construction of Maalaea harbor, approximately 600 m to the south. Sand replenishment of approximately 1500 cubic yards took place 3 times between May of 1997 and May of 1998. By the year 2001, much of this sand was gone. A sandy beach is desirable at this location to offer protection to the buildings from wave and erosion damage, as well as to increase occupancy rates and property values, and to facilitate lateral shoreline access and recreational opportunities. The beach replenishment project is funded privately by the Kanai A Nalu AOAO, and in part by a grant from Maui County.

An unpublished study of the reef in front of Kanai A Nalu was conducted by Robin Neubold in 1998, in an attempt to determine whether there had been any negative impacts to the reef from the previous sand replenishment efforts. Neubold's study concluded that the beach nourishment had caused no adverse effect on the offshore marine ecosystem. A 2001 permit application for further beach replenishment prompted a closer look at the environmental parameters that could be affected by further placement of inland dune sand on the beach. This study examines water quality, including turbidity, dissolved oxygen content, temperature and salinity, as well as beach profiles, suspended sediment characteristics, fish counts, ghost crab hole counts, and video transects analyzed with a random point-count system. A baseline of these parameters was established with monthly monitoring for the 9-month period leading up to the beach replenishment project. This baseline was used to determine the extent of impacts from beach replenishment on the physical, chemical and biological properties of the marine and coastal ecosystem, many of which were monitored daily during the construction period, and again monthly for a period of three months following the completion of construction.

METHODS

Sampling Location and Frequency

Water quality was analyzed along three transects, numbered 1-3 from north to south, with three stations along each transect; one in the swash zone, one at 25 m, and one at 100 m, for a total of nine stations (Figure 1). These measurements included turbidity, salinity, dissolved oxygen content, and temperature. The transects were spaced approximately 100 m apart, with the central transect located at the center of the Kanai A Nalu property, and the northern and southern transects located at approximately the center of the properties adjacent to Kanai A Nalu on the north and south sides. Sampling was conducted monthly from October 9, 2002 to September 11, 2003. An additional set of turbidity samples was collected at the 3 swash stations on October 16th, 2002, as there was heavy rainfall and elevated runoff volumes which led to high turbidity levels. As this heavy rainfall event was associated with a Kona storm, the water was too rough to safely allow sampling at the offshore stations.

During the 5-day construction period (June 2-6, 2003) and the 2 days following the completion of construction, sampling was conducted daily. Samples were also taken on the 5th day following completion of construction. During the construction period, water quality was measured daily at approximately 12 p.m., and was also measured at 7:30 a.m. on the morning that the construction began, prior to any sand being placed near the water.

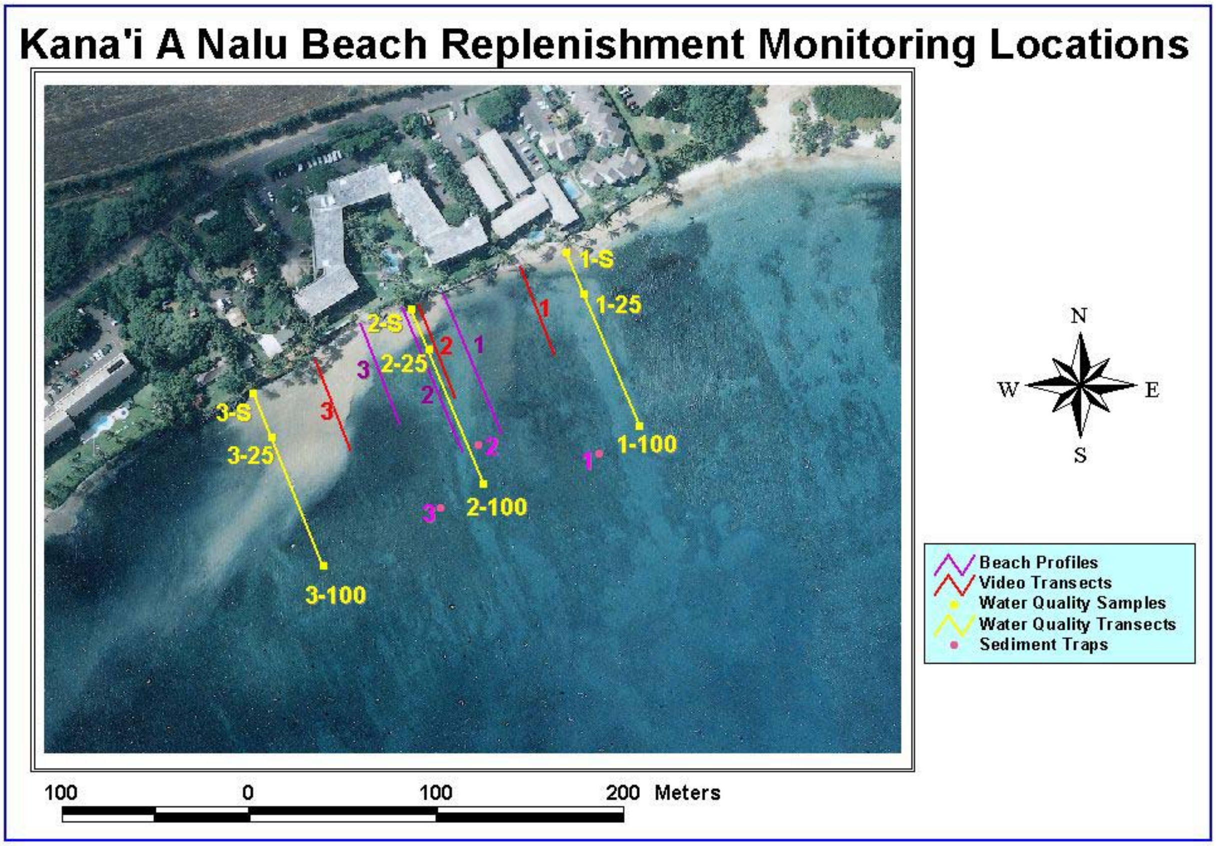


Figure 1. Location and identification of sediment traps, beach profiles, video transects, and water quality monitoring stations.

Beach profiles were conducted at three locations monthly beginning in November 2002, with previous beach profiles conducted in April and September 2002 at the northern and southern profile lines. All three lines are located in front of the Kanai A Nalu property, and are numbered 1-3 from north to south. Profile 1 is located at the northern edge of the landward mouth of a sand channel. The channel is situated approximately offshore of the center of the Kanai A Nalu property. Profile 2 is located at the center of the property and in the center of the sand channel, and profile 3 crosses the reef flat to the south of the sand channel. Reference points for the profile lines are located on the seawall fronting the property.

Three sediment traps were located between 75 and 100 m offshore, in front of Kanai A Nalu. As the traps are difficult to anchor, they were placed based on suitability of the hard-bottom substrate. The hard bottom fronting Kanai A Nalu is relatively shallow out to 100 m. To determine changes in sedimentation occurring as a result of beach replenishment, it was necessary to place the traps within 100 m of the shoreline. As a result, the traps experienced frequent damage whenever the surf heights rose above 3 feet. Further, poor visibility often made locating the traps difficult or impossible, despite the use of GPS waypoints for trap location. While the sediment trap data set is not as regular or complete as the water quality data set, we were able to obtain a basic representation of fluctuations in suspended sediment type and composition.

Monitoring Equipment

A Yellow Springs International (YSI) 85 meter was used to measure temperature (ºC), dissolved oxygen concentration (mg/L), and salinity (ppt). For the period of November to May, salinity was measured with a refractometer as the salinity function was not working on the YSI. The YSI was transported to the sampling stations in a plastic container on a rescue surfboard. Water samples were collected in bottles at all nine stations, and taken to shore for immediate analysis of turbidity levels using a LaMotte 2020 Turbidimeter.

Beach profiles were conducted using a surveyor's level, a 7m extendable stadia rod, and a measuring tape. Swimmers carried the rod offshore, taking measurements regularly until beyond the seaward extend of the sand.

Ghost crab holes were counted on the beach at each monthly visit. A 1-m square was randomly placed on the beach, and the number of crab holes in the square meter area was counted. Four samples were taken per visit.

Sediment traps were constructed using 6" sections of 2" diameter PVC pipe capped on one end and secured vertically through the holes in garden trays (Figure 2). Three pipe sections were used in each of three traps. The trays were held down with bricks, and zap-strapped to the hard bottom. Sediment suspended in the water column falls out and is collected in the pipes. The pipe sections were changed every month, providing that they were located, and sediment was dried and analyzed for mass, grain size, and carbonate fractionation.

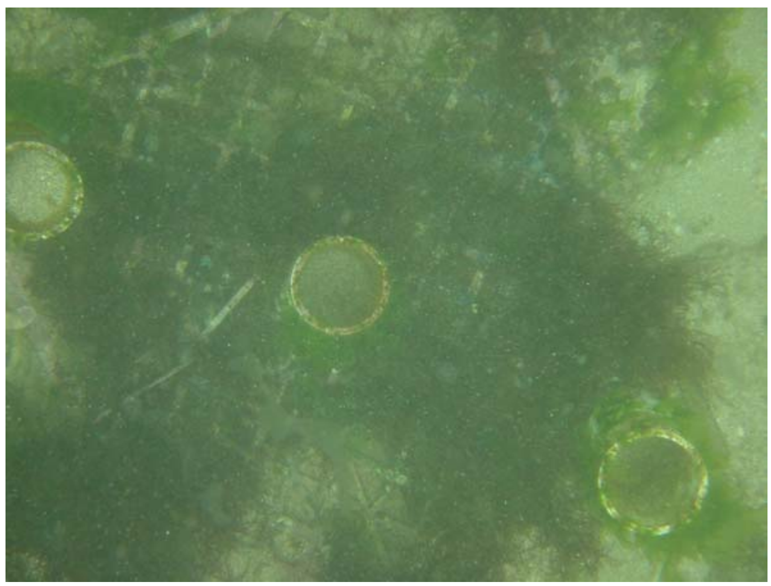


Figure 2: Sediment trap consisting of three 6" PVC pipe sections, capped on the bottom, supported by a garden tray.

Video transects were conducted on the morning of the first day of the construction period, prior to sand being placed on the beach (June 2, 2003). Three video transects were filmed close to the same transects used for water quality monitoring, and extended 100 m offshore. The videos were analyzed using a random point-count system. Fish counts were conducted simultaneously with the video surveys, along the three transects. In February 2004, a second video transect survey and fish counts were conducted to determine whether any negative impacts had resulted from the sand placement.

RESULTS

Turbidity

Turbidity levels at all stations fell mainly within the 0-12 nephalometric turbidity unit (NTU) range between October 2002 and June 2003, with the exceptions of an excursion into the 40 NTU range during the previously mentioned October Kona storm, and another excursion to 23

NTU in April 2003 during a high surf event (Figure 3). Typically, turbidity levels decreased with increasing distance offshore; average swash turbidity was 8.87 NTU, average 25 m turbidity was 3.61 NTU, and average 100 m turbidity was 1.85 NTU.

During the construction period, there was a visible increase in turbidity. Swash zone turbidity averages increased by 2.33 NTU over pre-construction averages to 11.20 NTU, while average turbidity at 25 m increased by 2.86 NTU to an average of 6.47 NTU and 100 m turbidity averages increased by 1.47 NTU over pre-construction levels to 3.32 NTU.

By June 11, five days after construction had ceased, turbidity levels had returned to within 1 NTU of pre-construction levels at 7 of the 9 sampling stations, and within 3 NTUs of pre-construction levels at the remaining 2 stations (3-25 and 3-100).

The highest actual increase in turbidity from pre-construction levels was 21.63 NTUs, occurring at station 3-25, which reached a level of 24.37 NTUs compared with 2.74 NTUs before construction. The pre-construction average between October and May at this location was 3.67 NTUs.

The highest percent increase in turbidity occurred at station 1-100, which reached a maximum of 18.4 NTUs, almost 14 times higher than the pre-construction level of 1.34 NTUs. The pre-construction average between October and May at this location was 2.60 NTUs.

The samples collected on July 8, 2003, revealed turbidity levels notably lower than the averages from between October and May, at all nine stations. Turbidity levels remained low at all stations through September 2003.

Temperature

Pre-construction ocean surface temperatures between October and June at Kanai A Nalu ranged from a minimum of 24.8 ºC to a maximum of 27.6 ºC, with an average of 25.9 ºC (Figure 4). Typically, water temperatures decreased the further offshore they were measured, with differences between the swash zone and 100 m stations of up to 1 ºC on a given day.

During the construction period, surface temperatures were noticeably high relative to pre-construction levels, averaging 27.5 ºC. This may be attributable to a period of warm southerly winds that coincided with the construction period. Sea surface temperatures recorded by the Mokapu waverider buoy located off of Kailua Bay, Oahu (http://www.soest.hawaii.edu/~buoy/), reveal an increase in ocean surface temperatures from 26.4 ºC on June 1 to 28.2 ºC on June 4, falling back down to 26.4 ºC by the 14th of June. Data archives from June 2002 at the Kailua buoy indicate that surface temperatures did not exceed 26.5 ºC over the month of June last year. Further, between June 14th and July 24th, 2003, temperatures recorded by the Mokapu buoy did not rise over 26.5 ºC, and did not rise over 27.5 ºC through the remainder of the study period. This suggests that the first two weeks of June 2003 were an unusually warm period.

On the third day of construction an unusual spike in the data indicates a temperature reading of 34.8 degrees. It is likely that this is an instrument reading or recording error. Within five days of the completion of construction, temperatures had returned to below 26.5 ºC, and gradually began to climb through a normal range as the summer months progressed.

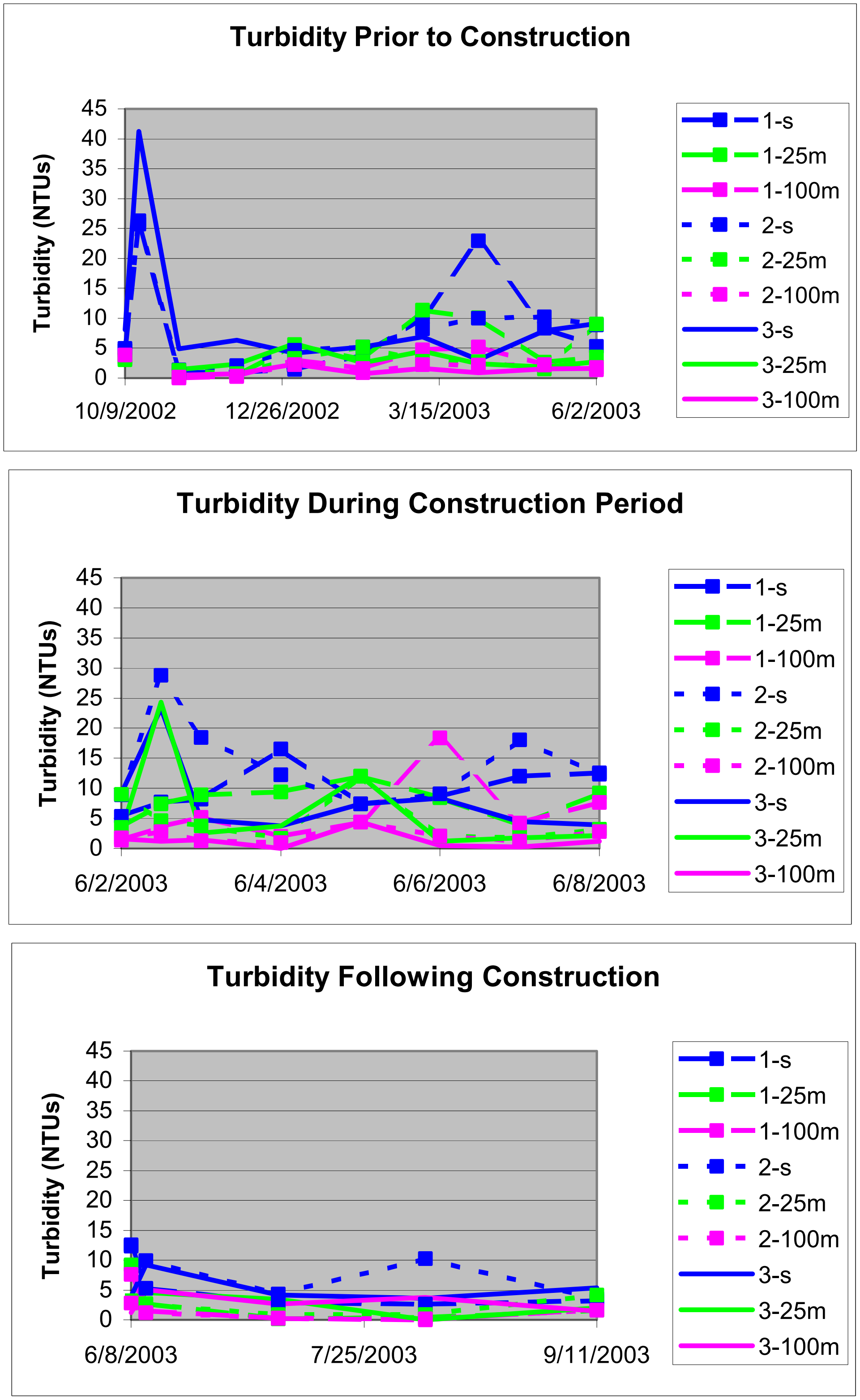
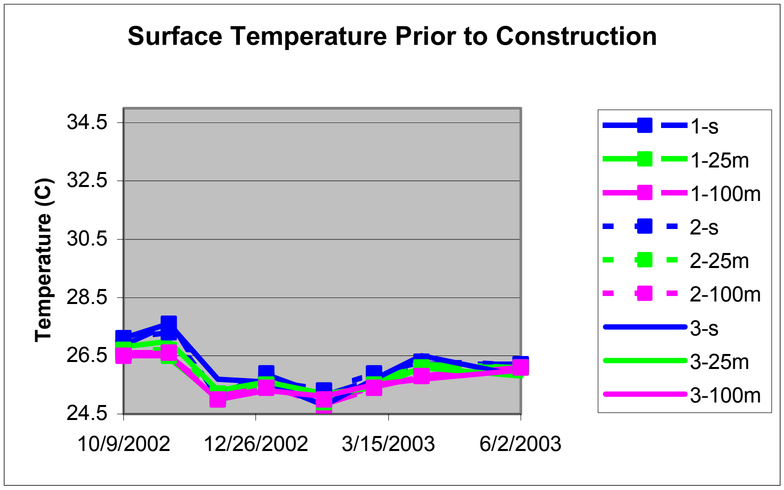
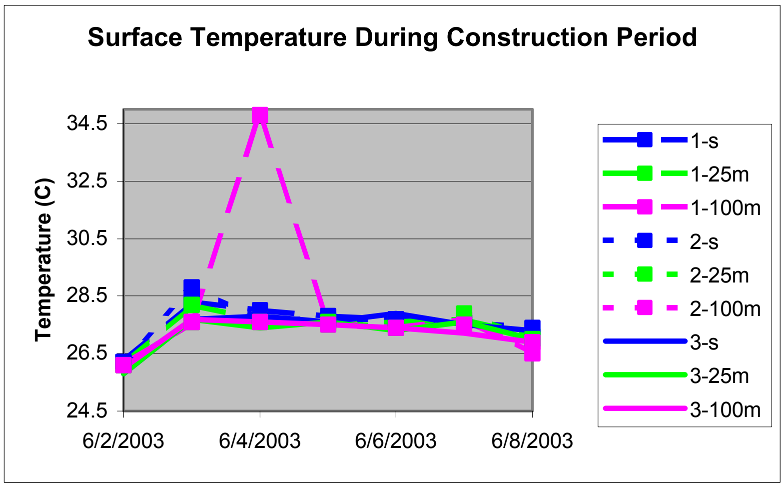


Figure 3: Turbidity levels before, during, and after beach replenishment. Turbidity levels experienced increases at various locations during construction, but returned to normal within 5 days following the completion of construction. In the months following construction, turbidity levels remained, on average, lower than pre-construction levels.





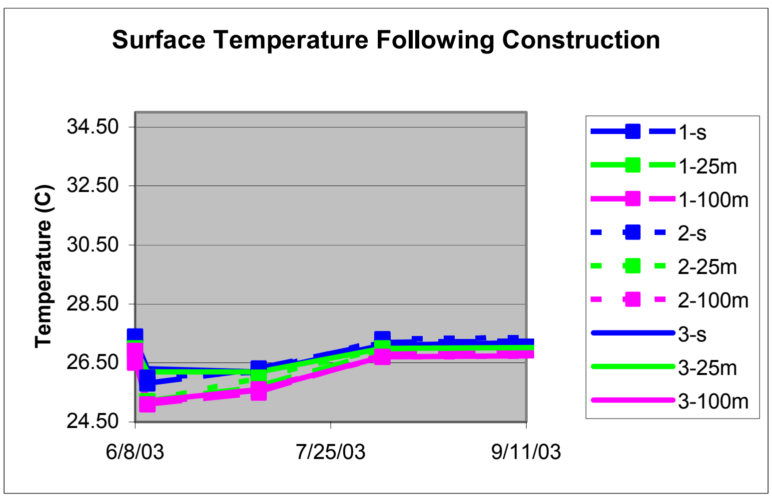


Figure 4: Ocean surface temperatures before, during and after beach replenishment. Southerly winds brought unusually high ocean temperatures to the Hawaiian Islands in the first week of June, 2003. The temperature spike on June 4, 2003 is likely an instrument error. The slight increase in temperature through September 2003 falls within normal ranges for summer conditions.

Salinity

Pre-construction salinity levels varied from 30.0 to 36.2 parts per thousand (ppt) with an average of 34.22 ppt (Figure 5). Salinity generally increased with increasing distance of measurement from shore, with differences of up to 5 ppt between swash and 100 m stations on a given transect for a given day. The lowest salinity was almost always recorded at station 3-100, which may be due to its proximity to a storm water runoff outlet.

During construction, salinity ranged from 32.2 ppt to 36.6 ppt, with an average of 35.07 ppt. Salinity levels at swash, 25 m and 100 m station fell closer together near the high end of the range toward the end of and following the construction period. This may be attributable to the increase in ocean surface and air temperatures leading to increased evaporation during this period, as well as to low summer rainfall levels.

Following construction, salinity levels remained fairly constant and slightly elevated, though within a normal range, particularly given the warm, dry summer conditions.

Dissolved Oxygen Concentration

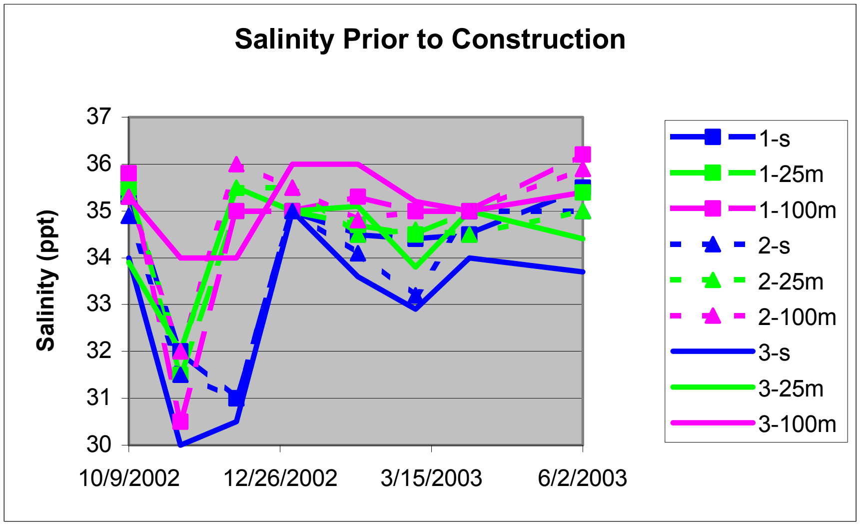
Dissolved oxygen concentrations between October 2002 and June 2003 ranged from a minimum of 5.36 mg/L to a maximum of 15.73 mg/L, with an average of 8.6 mg/L (Figure 6). During data collection, it was noted that where heavy accumulations of algae were present, dissolved oxygen levels tended to be high.

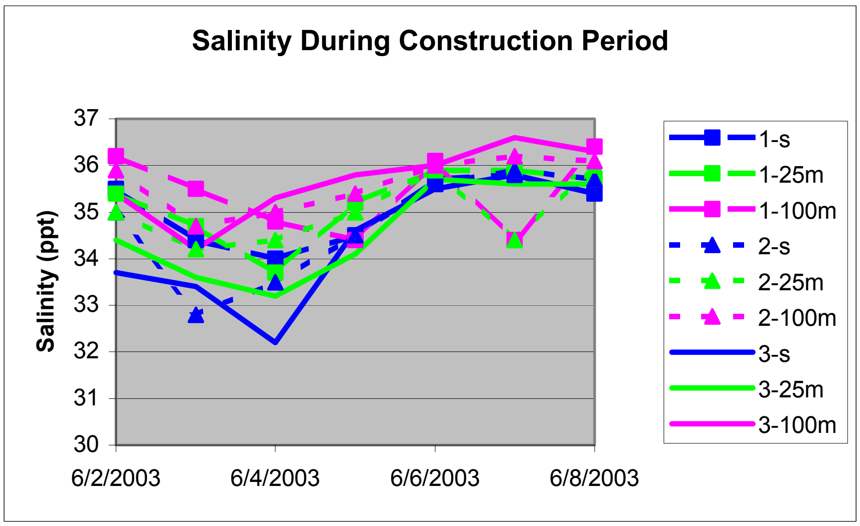
During construction, dissolved oxygen levels stayed within the pre-construction range, varying from 5.73 mg/L to 10.85 mg/L. No unusual levels or fluctuations were observed. Following the construction period, dissolved oxygen levels remained within the average pre-construction range, with no unusual trends noted, through the end of the study period.

Beach Profiles

All three of the beach profiles appeared to be relatively stable until the February 5, 2003 survey, at which time they displayed heavy erosion (Figures 7, 8 and 9). Based on wind records from the National Data Buoy Center (http://www.ndbc.noaa.gov), there were at least 11 days in January 2003 with Kona winds. These southerly winds generate short period waves, which, according to long-time residents at Kanai A Nalu, have historically caused temporary and extensive erosion of the beach at this location. Between February 5 and June 2 2003, there was little recovery of the beach profiles.

Following the beach replenishment in June 2003, beach face volume increases were immediately most dramatic at profile 3, where the majority of the new sand was stockpiled (Figures 10 and 11). However, after three months, the stockpiles had been dissipated and the beach appeared to have almost re-established equilibrium. As of the most recent survey on September 11 2003, no stockpile remained, and the beach face inflation had dropped to a maximum of a 0.8 m increase over pre-construction levels at profile 3, or 0.5 m increase over levels from the previous September. At profile 2, after the small stockpile dissipated, the elevation of the beach at the seawall had increased by a maximum of 1.3 m from pre-construction levels, or 1.0 m from the previous November. Volume increases at profile 1 were the lowest, with 0.5 m of inflation from pre-construction to September 11 2003, or 0.2 m of inflation over levels from September 2002.





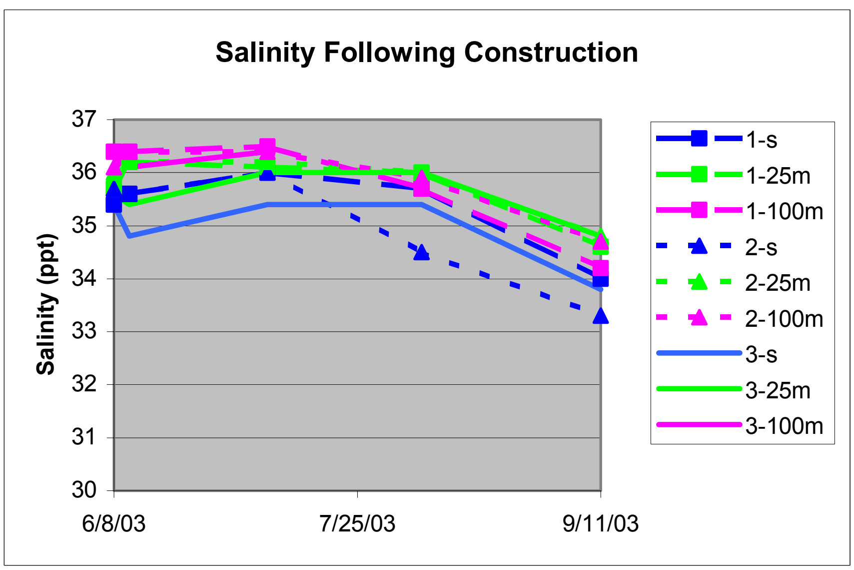
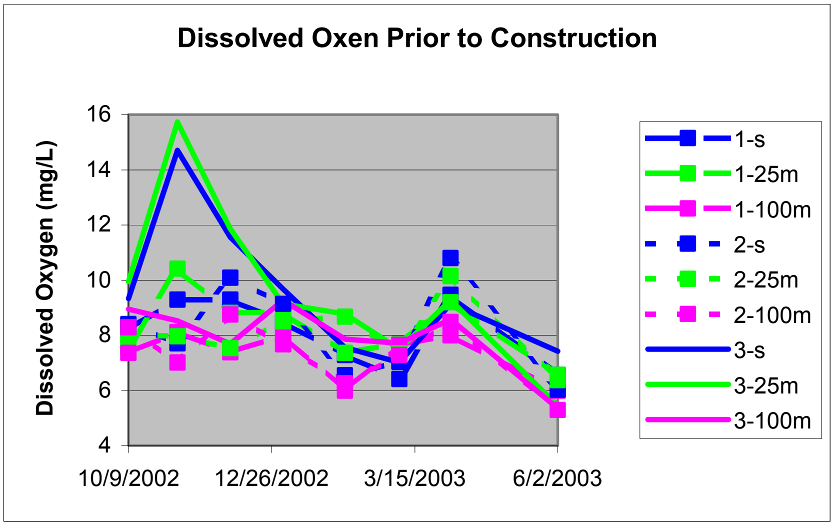
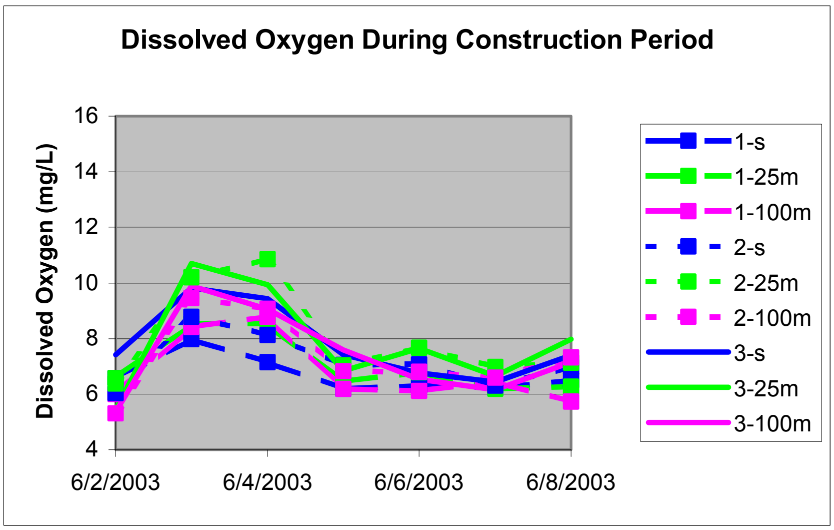


Figure 5: Salinity before, during and after beach replenishment. No unusual fluctuations are noted. Slightly higher salinity during warmer, drier summer months is normal.





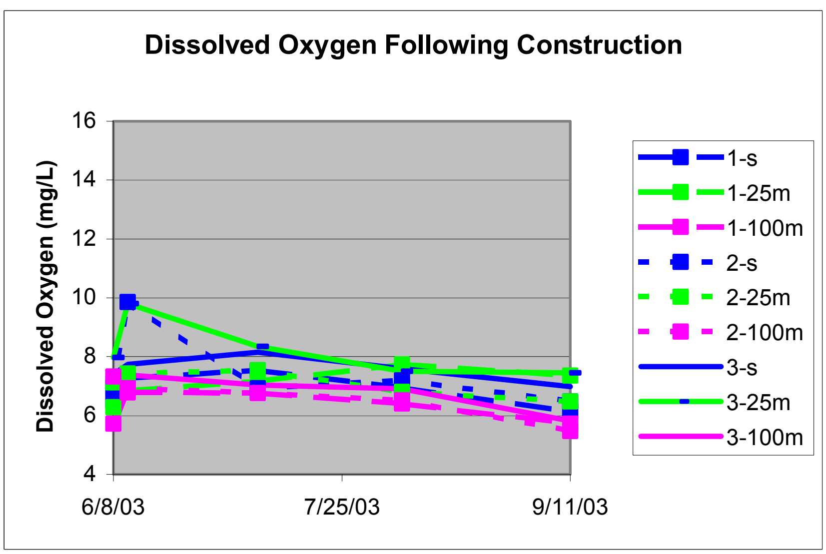


Figure 6: Dissolved oxygen levels before, during and after beach replenishment. No unusual fluctuations are noted.

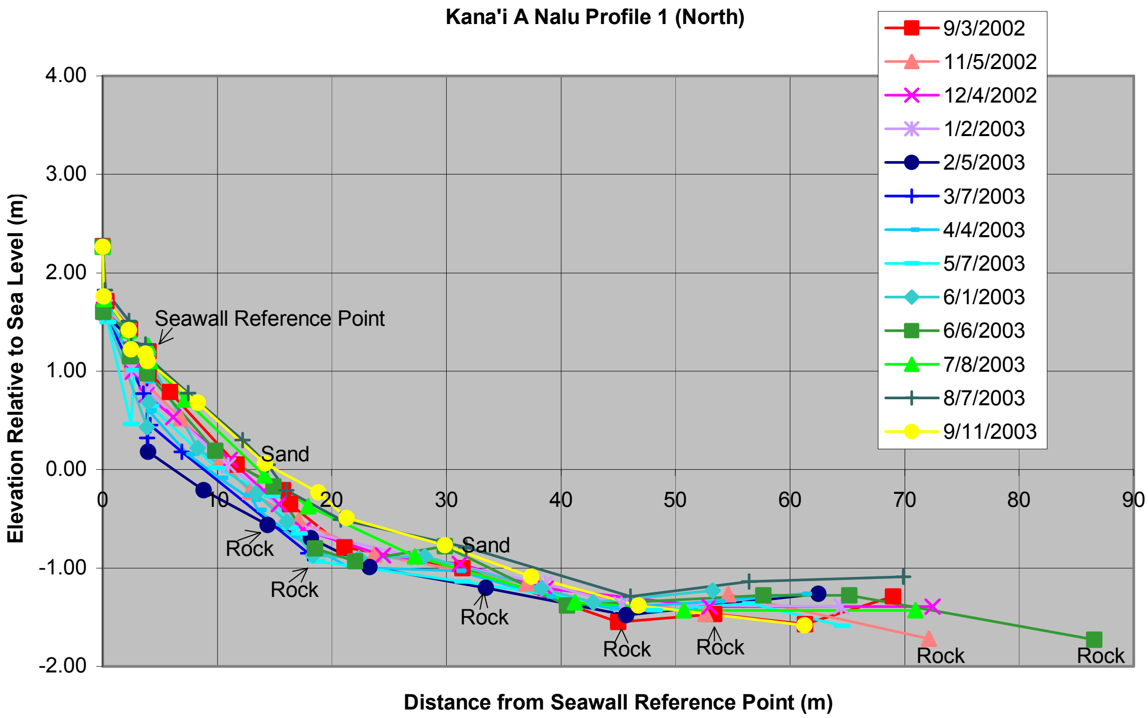


Figure 7: Northernmost beach profile, located at northern edge of sand channel. Note heavy erosion on February 5, 2003. Replenished sand (green, yellow) demonstrates a slight increase in beach face volumes over levels existing in September 2002.

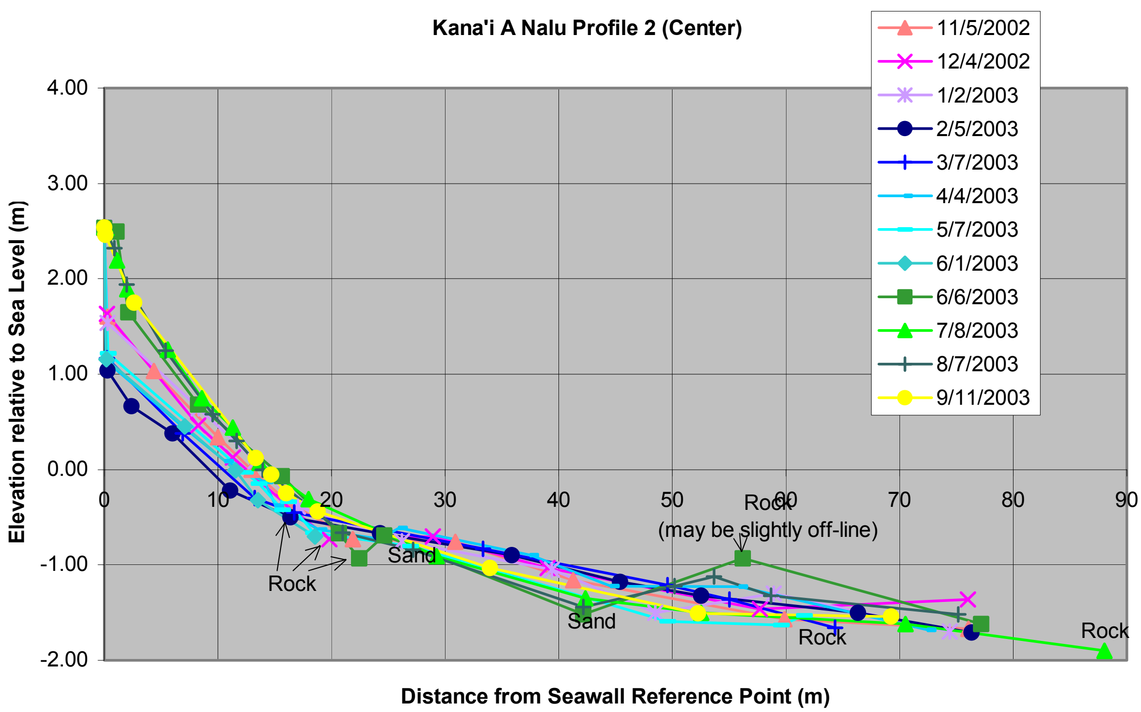


Figure 8: Central beach profile, located in center of sand channel. Note heavy erosion on February 5, 2003. Replenished sand (green, yellow) appears to be located primarily on the beach face, and maintains volume through the September 2004 survey.

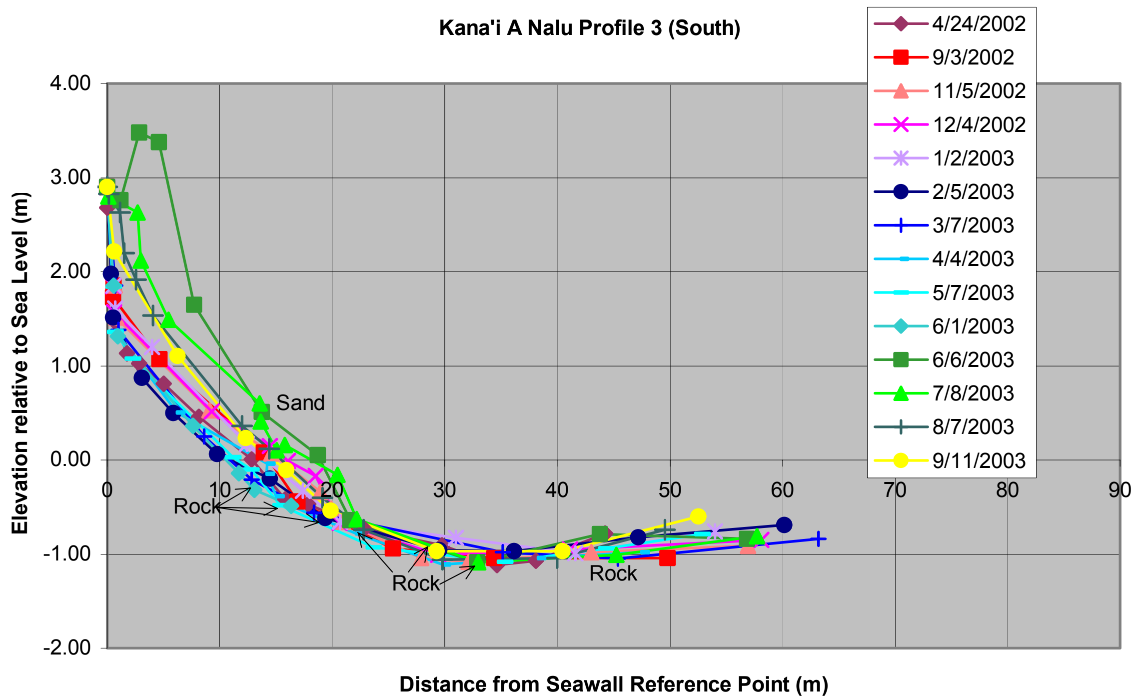


Figure 9: Southern beach profile, located adjacent to fringing reef. Note the sand stockpiles in place following beach replenishment. Sand volume appears to be confined primarily to the beach face. Ocean floor seaward of 22 m is mainly hard bottom throughout the entire study period.

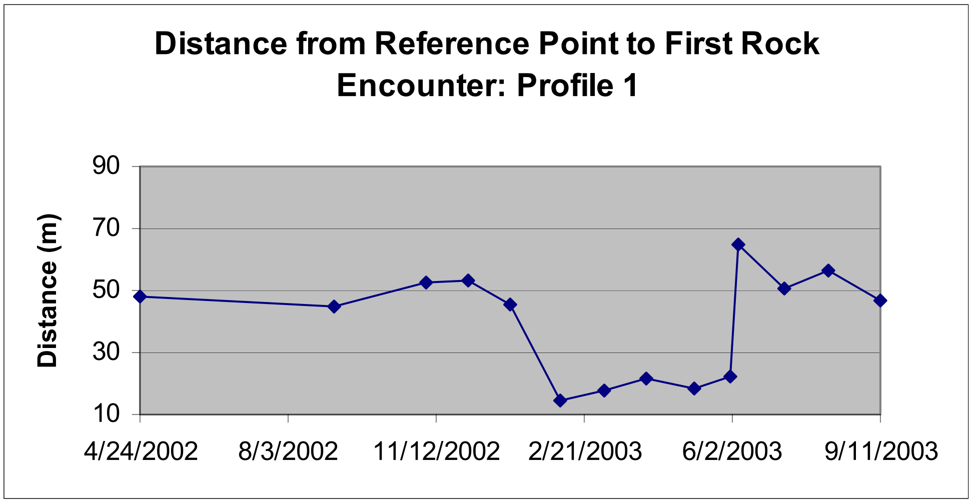
The location of the first encounter of rock seaward of the reference points can be used as an indicator of the extent of hard bottom covered with sand (Figure 12). At profiles 1 and 2 that cross the sand channel, the distance to the first encounter of rock decreased dramatically after January 2, 2003. The retreat at profile 1 was 30.9 m while profile 2 retreated 42.5 m. Six months later, profile 1 had recovered only 8 m, and profile 2 only 6 m from January losses, with minor gains and losses in between.

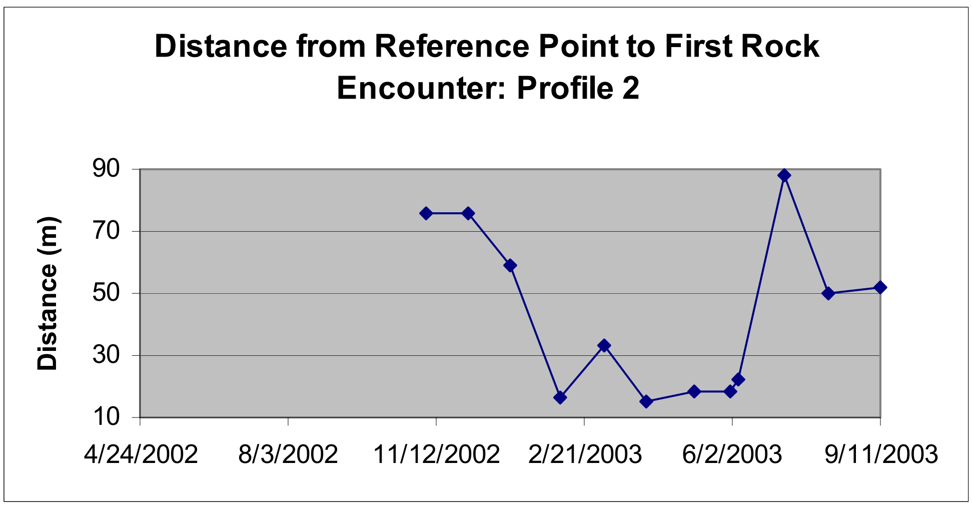
At profile 3, while 16.5 m of retreat occurred after January 2, 2003, in general the location of the first encounter of rocky substrate relative to the reference point changes very little through time. This is likely due to the presence of a shallow fringing reef at this location. As waves break over the reef, longshore currents are generated between the reef and the beach as the water follows the path of least resistance toward the adjacent channel where circulation patterns turn seaward. This longshore current causes sand to migrate predominantly alongshore, or northward at this location, rather than cross-shore, or onto the reef.

From beach profiles conducted on the final day of sand placement, June 6 2003, only profile 1 had experienced a significant seaward shift in sand, shifting by 42.8 m to a distance of 65.2 m offshore, which is 12 m further seaward than in November 2002. This distance dropped back by 15 m to a distance of 50 m offshore one month later, and remained relatively stable through September. On July 8 2003, the seaward extent of sand at profile 2 had shifted seaward by 65 m to a distance of 88 m offshore, which is 12 m further offshore than in November and December 2002. One month later, this distance dropped back to a comfortable mid-range from pre-

Figure 10: Looking southward over beach profiles 1, 2 and 3, before and after beach replenishment. Note the two points of reference.

Figure 11: Looking northward over beach profiles 2 and 1, before and after beach replenishment. Note the point of reference.





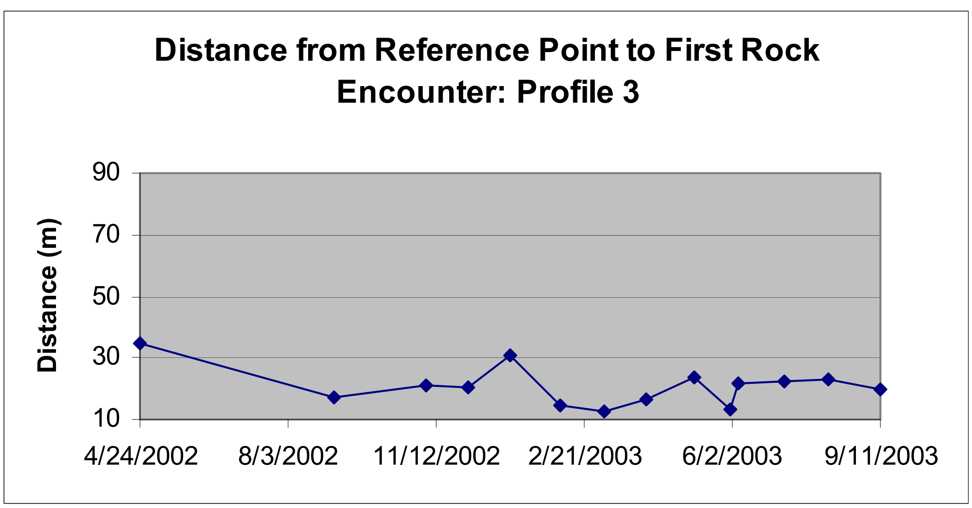


Figure 12: These plots illustrate the seaward extent of hard-bottom covered with sand. A period of sand retreat can be seen, particularly at profiles 1 and 2, after January 2003. Following the June 2003 beach replenishment, the seaward extent of the sand does not significantly exceed distances recorded in the 2002 surveys. Reference points are located on the seawall.

construction levels, and remained relatively stable through September. At profile 3, while there was an increase of 8.5 m in the distance offshore to first encounter of hard bottom when sand placement occurred, the distance to hard bottom measured on July 8, 2003 (22.2 m) was similar to that measured on May 5 2003 (23.7 m), prior to sand placement. This boundary remained stable through the rest of the study period.

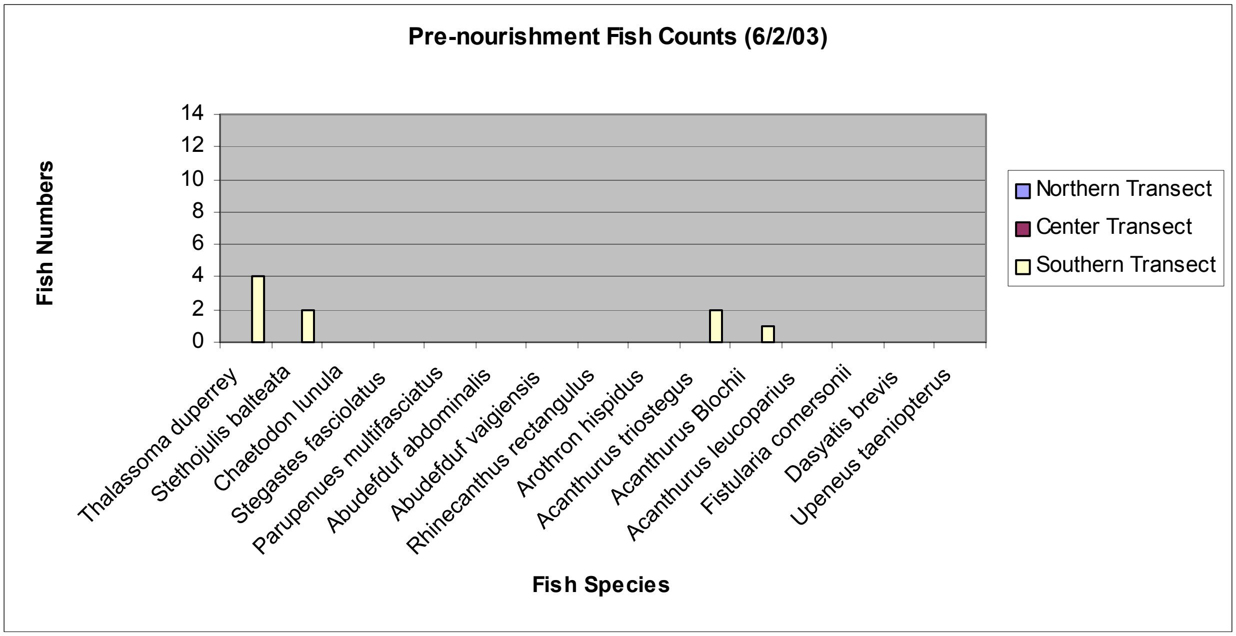
Ghost Crabs
From September 2002 to January 2003, ghost crab holes averaged 2 to 3 per square meter. By February 5 2003, with no dry beach left, no ghost crab holes were found. As the beach remained in an eroded state until the beach replenishment in June, no ghost crab holes were found throughout this period. By July 8 2003, ghost crabs were beginning to return, although there were only approximately 6 holes in total over the 100 m stretch in front of Kanai A Nalu. By September, ghost crab populations were completely recovered, at 2 to 3 per square meter (Figure 13).

Figure 13: Ghost crab holes, 3 months after beach nourishment.

Fish Counts
Fish counts were conducted along three shore-normal 100 m transects immediately before the beach replenishment, and 8 months after the beach replenishment. The number of fish was significantly greater at the later survey, with a total of only 9 fish seen on the southernmost of the three transects prior to the beach nourishment (no fish were seen on the two northernmost transects), and a total of 79 fish counted over the three transects on the post-nourishment survey (Figure 14).

Video Transects – Bottom Composition
Three shore-normal transects 100 m in length were surveyed with video, immediately prior to the beach replenishment, and again 8 months later, to determine any changes in bottom composition. At the two northernmost transects, sand cover increased and algae cover decreased following the beach nourishment, while the opposite is true for the southernmost transect (Figure 15). All three transects were dominated by sand and algae bottom cover, both before and after the sand nourishment.

Suspended Sediment Analysis
To determine whether the addition of sand from inland dune deposits contributed to an increase in terrigenous sediments in the water column, a 31.45 % muriatic acid solution, that dissolves carbonate sediments and leaves terrigenous sediment mass unchanged, was added to samples collected from the sediment traps. In this manner the percentage by mass of carbonate versus terrigenous sediments was calculated. While the data set is small, it can be seen that there was no noteworthy increase in relative terrigenous sediment component in the traps following the beach nourishment (Figure 16). While the southern trap did experience a relative increase in terrigenous sediments, this ratio fell between those of the previous two pre-nourishment ratios for that transect. The ratio of carbonate to terrigenous sediments remained relatively constant at the northern trap, and the terrigenous proportion decreased relative to the carbonate component at the center transect.



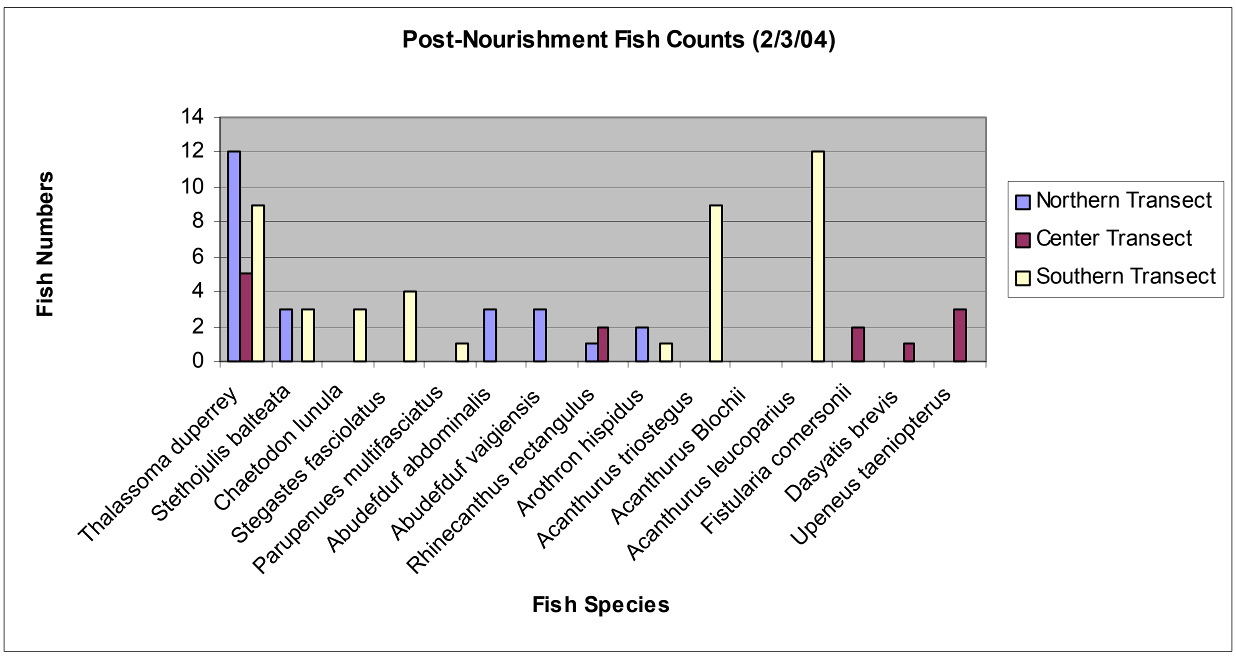


Figure 14. Fish counts increased at all transects following beach replenishment. However, this could have been affected by improved visibility following beach nourishment.

Sediment trap contents were also analyzed for grain size distribution using a wet sieve procedure. As the traps were often full upon collection, the actual mass of sediments collected could not be compared, as we were unable to determine how long the traps had been full. The fraction by mass of fine particles collected were compared with the fraction by mass of coarse particles, to determine if the relative ratio of fine particles to coarse particles suspended in the water column changed over the study period. Ratios of fine to coarse particles following beach nourishment remained within pre-nourishment ranges (Figure 17).

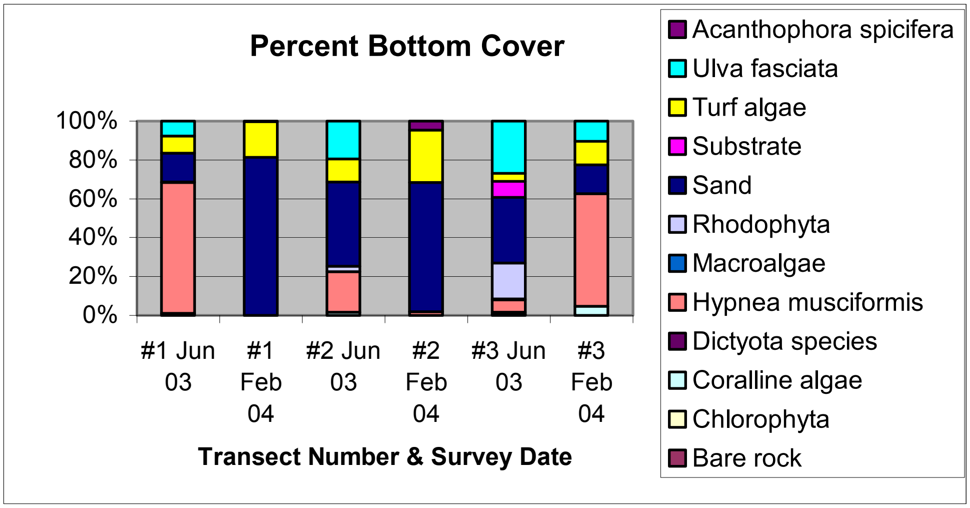


Figure 15. Bottom composition changes consisted mainly of changes in the ratio of sand and algae cover.

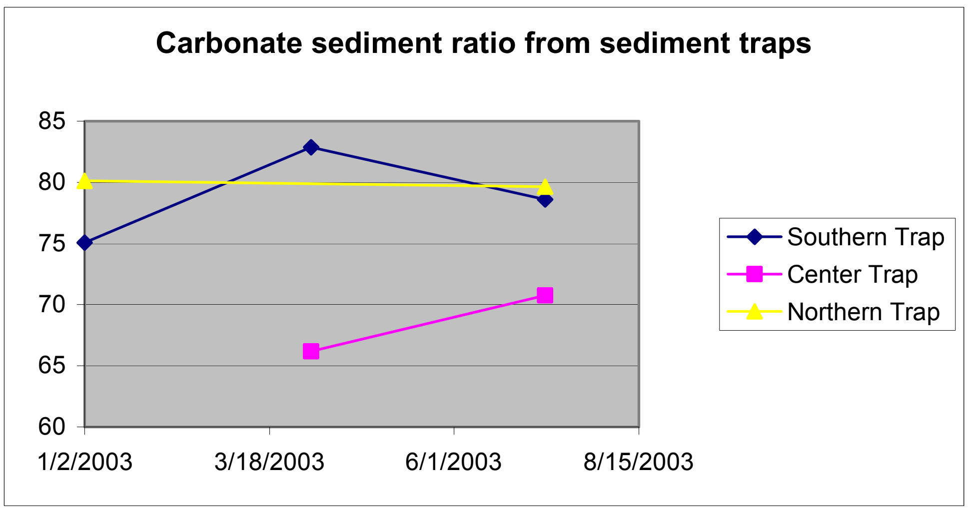


Figure 16. No noteworthy changes to the terrigenous – carbonate sediment ratio occurred following the sand replenishment.

DISCUSSION

Water Quality

Of the water quality parameters monitored (turbidity, temperature, salinity and dissolved oxygen content), the only parameter that appears to have been impacted by the beach replenishment is turbidity. The most apparent issue regarding turbidity is that each day, the location of the sediment plume changed depending on wind direction and strength, surf height, and tides, which all affect surface currents.

Under prevailing trade wind conditions, strong wind-driven surface currents would normally carry a sediment plume from Kanai A Nalu, southward toward Maalaea Harbor. However, during the construction period in June 2003, winds were blowing mainly onshore, or from the southeast. Rather than a southward current, there was a northward current that carried the

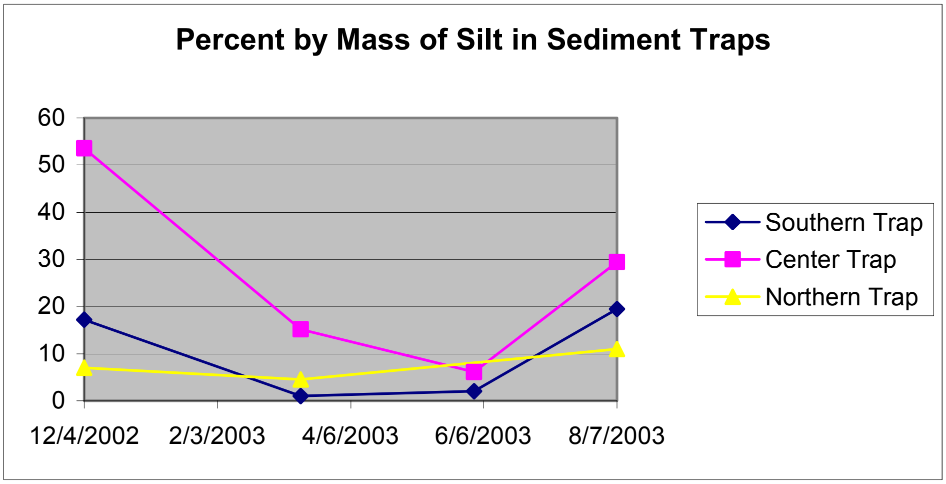


Figure 17. Ratio of silt and clay sized particles suspended it water column, relative to coarser particles. Post-nourishment ratios did not exceed pre-nourishment ratios.

sediment plume toward Haycraft Park. The plumes extended farthest offshore at the locations of the channels through the reef, where seaward currents exist. Where the reefs were closest to shore and the water the shallowest, the plumes were generally confined close to the beach. Each day the conditions would change and the location of the heaviest part of the plume would move, as is evident on the graph of turbidity during the construction phase.

The turbidity levels recorded on July 8 2003 were all below 5 NTU, and are characteristic of the low turbidity levels that existed prior to the erosional event of January 2003. Based on this observation, it is possible that sand acts to suppress background turbidity levels by covering fine sediment layers that are prone to disturbance and suspension. Increases in turbidity resulting from the sand nourishment were temporary, lasting less than two weeks.

Beach Profiles

While the beach face volume at all three profiles has been increased above the highest levels surveyed prior to the beach replenishment, the extent of hard bottom being covered by the sand only minimally exceeded pre-replenishment sand coverage at profiles 1 and 2, and did not exceed pre-replenishment sand coverage at profile 3. This is of particular interest as the bulk of the sand placement occurred in the immediate proximity of profile 3. As explained earlier, profiles 1 and 2 are located within the sand channel, and seaward currents through the channel facilitate the offshore movement of sand. Longshore currents landward of the shallow reef at profile 3 discourage cross-shore sediment transport.

Ghost Crabs

It is interesting to note that the process of beach replenishment essentially restored a habitat that had disappeared completely for the 5 months prior to sand placement. One condominium guest, observing us counting crab holes on the morning of the final survey, suggested that we should come back at 1pm as she had noted large increases in the numbers of crabs on the beach, daily, at this time. There was clearly a healthy crab population reestablished on the beach fronting the Kanai A Nalu condominium within 3 months after the sand replenishment.

Fish Counts
While the number of fish observed increased dramatically from pre-nourishment to post-nourishment surveys, this was probably influenced in part by an improvement in visibility that occurred following the sand placement. No negative impacts to fish abundance from the beach replenishment activity were observed.

Video Transects – Bottom Composition
Due to the fact that sampling took place only twice, it is possible that the results were influenced by seasonal conditions. For instance, a significant storm that took place on January 14th/15th 2004 may have influenced the beach profile, contributing to an increase in offshore sand. However, it is clear that bottom cover both before and after beach nourishment consists predominantly of algae and sand. Further analysis of the video transects was limited by the heavily time-consuming nature of this work. No negative impacts resulting from the beach nourishment activity were discernible based on the video analysis.

Suspended Sediment Analysis
The carbonate fractionation revealed that there was not a notable increase to the ratio of terrigenous material in the water column following the beach replenishment efforts. This was the expected result as the sand used was carbonate dune sand, with less than 1% silt and clay-sized particles.

As the 6" tall sediment traps were often full upon collection, we were unable to compare absolute masses of suspended sediments over the study period, as it was impossible to determine when the traps had stopped collecting sediment. While an analysis of the ratio by mass of fine to coarse particles suspended in the water column was conducted, these results may have been influenced by wave activity, which tends to mobilize larger particles into the water column. As such, these results are the least robust of all the measurements conducted for this study.

General Observations
Underwater visibility at Kanai A Nalu was very good from the initial surveys in September 2002 right up until the January 2, 2003 survey. From the February 5, 2003 survey through to the June 2, 2003 survey, when the beach was in an eroded state, visibility was consistently poor. Underwater visibility in the July 2003 study, conducted one month following the placement of sand, was excellent; by far the most clear the water had been since January 2003, possibly due to a suppression of bottom sedimentation. Water clarity remains good, but from visual observation, it appears that the beach is losing some volume. Further sand replenishment may be necessary to maintain the beach.

One topic this study did not cover was to determine where the sand moves to when it leaves the beach. Based on our general observations, some of the sand appears to move northward driven by incoming swells, and some moves in and out through the sand channel in response to varying wave conditions. It appears that the beach is impacted the most severely by Kona storms, after which the beach becomes bare as the sand is presumably carried out through the sand channel. This sand gradually moves back onto the beach under gentler wave climates, recovering generally within 2 months or less following the Kona storm event. Over time, there appears to be a net loss of sand toward the north, and a possible net loss offshore

CONCLUSIONS
From the studies conducted, it appears that the beach replenishment project at Kanai A Nalu has had no long-term negative impacts on the marine and coastal environment, and that there has been an improvement in water quality and sand crab habitat. The beach face volume has been inflated without an extensive increase to the area of hard-bottom coverage. Turbidity was temporarily increased, but not beyond levels that have occurred naturally during storm water runoff. Turbidity levels returned to a normal range within 5 days of the project's completion. In most cases, measurements revealed either minimal change, or improvements following the beach replenishment.

Acknowledgements
We would like to thank Alethea McMahon, Darrell Conley, Robert Bruck, Megan Colvin, and Julia Hannon for their extensive assistance with data collection, and the Kanai A Nalu AOAO for their enthusiastic support of this study.