APPENDIX B

REPORTS

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A-1 ARCHAEOLOGICAL CONDITION REPORT

SCS Project Number 426-1

ARCHAEOLOGICAL CONDITION REPORT FOR AHUKINI-LYDGATE SEGMENT OF THE KAUA`I PATHWAYS PROJECT KAUA`I ISLAND, HAWAI`I

Prepared by:
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and
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September 2005

Prepared for:
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Elizabeth, Colorado 80107

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INTRODUCTION

This interim report discusses the various archaeological and historic preservation issues related to construction and maintenance of the Kaua`i Pathway project and focuses on the segment stretching from Ahukini Point to Lydgate Park. The report lists the known archaeological sites having been documented along this segment, the estimated significance of these sites, and potential mitigation of these sites and sensitive areas during construction of the pathway. As a quasi sensitivity zone report, predictive models are forwarded which detail any possible historic preservation challenges that could impact construction or location of the pathway.

PART I KNOWN ARCHAEOLOGICAL SITES: A SUMMARY

A. Ahukini Point to the Raddison Hotel Area:

Based on a literature review of the proposed pathway alignments, there have been at least 15 archaeological projects conducted in this area from Thrum (1907) to Scientific Consultant Services, Inc. (SCS) in 2004. In 1906 Thrum compiled an inventory of *heiau* throughout the islands. Within the currently discussed segment from Ahukini to Lydgate, he “recorded” two *heiau*: Ahukini and Kalauokamanu. These *heiau* were not marked on maps but were simply described. Both *heiau* had been destroyed supposedly as of 1855. During Bennett’s island-wide survey in 1928-1929, the two *heiau*, now known as Site 101 and Site 102 were also noted. Ahukini Heiau supposedly was built near Ahukini Point on a bluff overlooking the sea while the location of Kalauokamanu was never identified. Bennett (1931) did also note that both *heiau* were previously destroyed. Bennett makes first mention of Site 103, a burial ground in this area: “in the sand dunes that run along the shore half way between Hanama’ulu and Wailua River are many burials.”

From Hanama’ulu Bay to the west, toward Lihue, multiple Land Commission Awards are present. In general, the LCA’s primarily denote *lo`i* lands (taro fields). Here, dryland taro cultivation was probably practiced while coconut, sweet potato, and breadfruit were also likely grown. The Mahele records of the Hanama’ulu area tell of native tenants living in the valleys and by the shoreline. House sites, taro pond fields, irrigation systems, dryland agricultural parcels, fishponds, pastures, and other features were constructed across the prehistoric-traditional landscape. Many of these lands were cleared during Plantation days, thus masking or erasing much evidence for these sites.

At least eleven known archaeological sites are present in the Hanama'ulu area toward the Wailua Golf Course. As one moves from south to north, or Ahukini Point toward Wailua, several sites are present of both a historic and prehistoric nature. First, Ahukini landing itself, a probable late 19th construction, is present inside the breakwall of the bay. Plantation housing for sugar cane workers has been noted just to the south of the point. Foundations still exist in remnant state. Moving inland to the west, several more sites are present:
Site 1845 is the historic Hanama'ulu Railroad Bridge. This bridge is being preserved and represents the plantation era.

Site 2066 consists of multiple features: an upright (burial?), historic road, and historic house foundation;

Site 2067 consists of a historic cemetery perhaps dating to the 1880s. The cemetery is present on the *mauka* side of the highway on the edge of former sugar cane lands.

Site 1843: prior to construction of Ahukini Landing, an old wharf was present on the northern flank of the bay. This is Site 1843 and consists of a concrete wall, foundation, and sugar cane road. This is the location of the old wharf.

Site 1841 occurs just to the north and also represents the historic period: a road and trail running along the coast. It is possible this trail has some time depth from prehistoric times but it has not yet been dated.

As one rounds the point to the north, three archaeological sites are present above the rocky coastline. Site 2068 consists of a looted, historic-period trash dump dating between 1880 and 1910. Datable artifacts include glass and ceramic fragments that were recovered from the bluff, at the edge of plantation lands. Site 1840, nearby, consists of a historic-period retaining wall related to sugar cane or military transport; Site 1839, occurring about 25 m to the east of the trash dump represents the first fully known prehistoric site in this coastal area. This site is a prehistoric complex occurring on the flats and composed of a wall and terrace suspected to be related to temporary habitation. No carbon dates are available for this site.

Proceeding to the north, around the point and onto the flat coastal plains toward Wailua, both historic and prehistoric sites are present. Site 1838 consists of a prehistoric cultural deposit partially eroding out of modified sand dunes. The layers contained charcoal, shells, and coral fragments, this expected so near the coastline. The site had been disturbed during military training exercises in the 1940s. The cultural deposit, now a small remnant, was dated to AD 1170-1400, and represents temporary habitation of the area. This pattern of remnant cultural deposits and temporary activities near the coast holds through the Kealia area and beyond, and is one concern for the present work. The final historic site in this area is Site 1846, two historic railroad bridges used for hauling sugar cane from the fields to Lihue. This site is present more inland and south of the Radisson Hotel.

Site 885, also occurring just to the south of the Raddison hotel, represents a possible traditional Native Hawaiian burial ground. Multiple burials have been documented in this sandy location, from the Raddison through Wailea Golf Course and Lydgate Park.

Overall, this first section contains abundant evidence for historic networks related to plantation-era days and prehistoric sites related to burial and temporary habitation loci. While none of the sites beyond Ahukini landing remain in spectacular form, they do allude to land tenure in the area during the late 1880s onwards. The two prehistoric sites identified near the rocky coastline provide foreshadowing for the immense number of sites occurring to the north along the sandy coastal flats. Site 885 and beyond provide our first glimpses at this pattern.

B. Wailua Golf Course to Wailua River

The most well-known site in this area, due to the influx of CRM research related to golf course activities and development of Lydgate Park, is Site 103, originally recorded by Bennett during island-wide survey in 1928-1929. At this writing, over 66 burials have been identified throughout the golf course alone, with most of these having been re-interred in a burial crypt and preserve area at the golf course itself. This discussion focuses on the area from the south end of the golf course and west to the Correctional Facility to the Wailua River. In this location, we enter one of the most sacred and site-rich areas of the island, an area that will be crucial for pathway development.

The *ahupua`a* of Wailua is situated in the old district of Puna but today is located in two separate judicial districts: south of Wailua River is Lihue District or *moku* and north of the river is Kawaihau District. Wailua Ahupua`a is the largest *ahupua`a* in both districts and extends from the shoreline to Mt. Wai`ale`ale. In this segment, we stop at the southern bank of the Wailua River, the largest navigable stream in the Hawaiian Islands. The southern extent of this area is relatively minor compared with the near-river areas. In this tract, very few LCA's were issued. The flatlands between the dunes and Kalepa Ridge contain swampy areas fed by springs at the base of the ridge that allowed for limited taro cultivation on the margins of the marsh. The coastal dunes between the marshland and the sea were primarily used for human interment (Site 103) while the direct coastline would contain evidence for temporary or seasonal fishing camps and other marine acquisition.

The first site we visit in this artificial corridor is Site 1980, which occurs on the golf course to the east of the correction facility. This site consists of eight traditional-period burials identified in sandy contexts between coastline and marshy areas to the west. It is likely this site could be included as a portion of Bennett's Site 103. As we move north into golf course lands, several more sites are present, particularly Site 103 and its 66+ known burials. Forty-four burials were identified during trenching by SCS in 2000. Also recovered were prehistoric implements (two adzes, sinkers, hammerstone) and historic items (glass and porcelain). Sites -542 through -546 and Site -819 compose portions of Site 103 burials found during monitoring work in 1977. Site -9357, a burial also part of the Site 103 complex, was identified on the grounds of the County correctional facility. A burial preserve area has also been established at the golf course, across from the first tee box.

Two archaeological sites were identified and documented during monitoring in 2003 by SCS at the Kumalani area of Lydagate, just off the golf course. Additional burials related to Site -103 were identified. A total of three incomplete burial sites and two isolated findspots from previously disturbed burials were identified. All were thought to be from traditional contexts. The second site, Site -356, consisted of a traditional cultural layer located within natural sand dune deposits. The site was assessed as a habitation layer and dated to A.D. 1440–1660, a traditional time period consistent with other archaeological finds in the area. Stone tool implements, charcoal, and shell were found at the site. Scattered stone tools (hammerstone, adze fragment) were identified in the sand dune during construction of the Kumalani playground.

While not directly impacting the pathway in this segment, the following is presented to provide additional context to the archaeology of the area. Staying on the south side of the river, near the coastline, we enter the more sacred Wailua River mouth area. On one side is Lydgate Park and across the highway from the hotel is a heiau complex. Staying near the coast, Site -105 is present within the park, much of the site having been preserved today. This site consists of Hikinaakala Heiau and Pu`uhonua o Hauola (city of refuge). This site was first recorded by Thrum in 1906 and later by Bennett (1931), Kikuchi (1974), and Yent (1989). This site is part of the Wailua Complex of Heiau National Historic Landmark. Yent's work at the site concluded that there were two occupational episodes at this site, one historic-period and one earlier occupation. This occupation may or may not have been associated with the *heiau* itself.

Another significant site is present in the area. In 1949, Mrs. Rebecca Banks recorded 36 petroglyph figures on boulders stretching across the mouth of Wailua River. These boulders became a National Historic Landmark in 1962. This petroglyph field was re-surveyed in 1973 and 1984 by Bill Kakuchi and he noted that there may be more in the river and that some boulders had been damaged during clearing the mouth of the river. Jim Powell of SCS states that you can see the site at times of low tide, etc.

The final area of concern on the southern bank of the Wailua River, prior to actually reaching the river, is Site -104 and Site -104a. The main site is Malae Heiau, part of the Wailua Complex of Heiau National Historic Landmark. The *heiau* is a walled, square enclosure measuring over 2 acres in size. Construction of this site occurred in phases through time, with early episodes from AD 1480-1580 and later construction at 1700-1800 and 1720-1840 respectively. Site -104a was identified by Kikuchi in 1987 and consists of an adze workshop/flake scatter occurring to the north-northeast of the *heiau* and extending to the marina. It is likely that the lithic manufacturing workshop was related to prehistoric occupation and use of the *heiau* and environs.

This summary was meant to provide a brief overview of known archaeological sites within the Ahukini-Lydgate pathway corridor in order to understand potential impacts to the sites and to gauge additional site types (*i.e*., burials) that may be identified during archaeological Monitoring of the area.

C. Cultural Resources from Ahukini-Lydgate

As Corbin *et al*. (2002) state, Hanama’ulu translates as “tired (as from walking) bay” and is said to be the birthplace of the hero Kawelo. This area was referred to as Puna District at the time of the Great Mahele of 1848, not Lihue District as it is now known. The Hanama’ulu area is not specifically mentioned in many historical texts. However, Hanama’ulu is noted *Olelo No`eau*, a book of Hawaiian sayings and epithets (Corbin *et al*. 2002:B-1):

*No Hanama`ulu ka ipu puehu* (“The quickly emptied container belongs to Hanama`ulu”)

Pukui (1983:No. 2230) identified another quote about the area:

> “Said of the stingy people of Hanama`ulu, Kaua`i—no hospitality there. At one time, food containers would be hidden away and the people of Hanama`ulu would apologize for having so little to offer their guests.”

From Hanama'ulu Bay to the west, toward Lihue, multiple Land Commission Awards are present. In general, the LCA's primarily denote *lo`i* lands (taro fields). Here, dryland taro cultivation was probably practiced while coconut, sweet potato, and breadfruit were also likely grown. The Mahele records of the Hanama'ulu area tell of native tenants living in the valleys and by the shoreline. House sites, taro pond fields, irrigation systems, dryland agricultural parcels, fishponds, pastures, and other features were across the landscape. Many of these lands were cleared during Plantation days, thus masking or erasing these sites.

The cultural significance of the Wailua Area, further to the North, is well documented. Center of the isle's political and economic universe, Wailua was the chiefly seat of Kaua`i during prehistoric times, as is attested by the numerous *heiau* and other ceremonial sites occurring along the Wailua River basin. The Wailua area is covered in some detail in other sources.

PART II SIGNIFICANCE AND MITIGATION OF THE SITES

The following table denotes significant sites previously identified along this portion of the pathway from Lydgate Park to Ahukini and provides introductory mitigation possibilities for these sites.

Table 1: Lydgate to Ahukini Sites (North to South)

Site #	**Location**	**Mitigation**
# 103 WGC burials Burial Preservation Area	Between driving range & 1st Tee / fairway, along fiber optic cable route. Exact boundaries Unknown.	Reroute path to avoid burials-preserve area.
# 103 WGC Burials	Throughout dunes of WGC.	Monitor all pathway excavations.
# 1838, Habitation site	NE corner of Moody property at shoreline	Monitor all pathway excavations
# 1839, Temporary Habitation site	East side of Moody property	Monitor all pathway excavations
# 1840, possible retaining wall for RR / cane haul road	East side of Moody property	Rehabilitate and include in bike path
# 1841, original RR bed / cane haul road to Kou Wharf	Along SE edge of Moody property	Rehabilitate and include in bike path
# 1843, Kou Wharf, wall and road.	South side of Moody property on Hanama'ulu Bay. Orginal wharf and access for Hanama'ulu Sugar Plantation.	Rehabilitate and include in bike path as rest stop / fishing area. Signage.
# 1845, RR Bridge	Crosses Hanama'ulu Stream, west of beach park.	Rehabilitate and include in bike path. Signage.
# 1846, Two concrete bridges.	RR bridges crossing Kawailoa marsh area.	Rehabilitate and include in bike path.
# 2066 Habitation complex	North west of RR Bridge 3 1845	Avoid Fea. A, (possible burial) Include Fea. B (road), and Test Fea. C. (possible habitation).
# 2068 Historic trash dump	Along eastern edge of Moody property	Monitor as pathway is built through area

The primary form of archaeological mitigation during pathway construction is Monitoring. In certain areas, particularly along the coastline and known burial areas, full-time Monitoring is required due to the likelihood of encountering burials or isolated remains. Other forms of mitigation for this project include rehabilitation of historic features (see above), Data Recovery (in the instance new or significant deposits are identified), Burial Treatment and Preservation, as needed. This mitigation is required and primarily important as there has been a lack of formal Inventory Survey completed along sensitive portions of the pathway, particularly from the plains north of Hanama'ulu Bay to the Wailua Golf Course and south of Hanama'ulu Stream.

SCS will continue to discuss mitigation requirements with the SHPD throughout this process. Again, mitigation requirements are often dependent upon the final course of the pathway and the findings during construction. To aid in preparing for all scenarios, we have employed an ecological model for examining potential site types in the pathway segment area.

PART III SENSITIVE AREAS DURING CONSTRUCTION OF THE PATHWAY

Site sensitivity along this pathway is partially determined by the types of soils encountered. There are five main ecological zones along the pathway, with several being sensitive in terms of archaeological resources. The zones are presented first, followed by a listing of pathway areas that may be sensitive for various cultural resources.

The first zone (Zone I) consists of coastal dunes, which include frontal accretion deposits, backslopes, the crest, and the slip face. Zone I predominantly consists of an area spanning from the high-tide water mark of the ocean to the lower portion of the slip face near the interdune area, or, where the backside of the dune becomes flat and expansive. Zone I sediments are primarily composed of beach sands. These sands are subject to variable sorting when high-energy depositional events such as storm surges or tsunamis typically lead to the deposition of courser sand grains while low energy events can lead to well-sorted, often fine-grained, sedimentary deposition. This is a dynamic zone in terms of landscape morphology as it constantly evolves through wind and tides, particularly if vegetation or modern impediments do not curtail dune migration. It is often in Zone I that archaeological signatures for temporary occupation activities such as fishing camps are identified.

Zone II represents a more stable land surface occurring leeward and inland from the terminus of Zone I. This zone composes the coastal plain or back beach environment. The latter term alludes to the formation of interdune deposits. Both Zone I and Zone II primarily consist of calcareous sand beaches derived from the decomposition of coral and seashells. These sandy deposits and associated coralline basements occur far inland in some areas, a symptom of the Holocene high sea stand occurring between *c.* 5,500 years ago and lasting until about 2,000 years ago (Fletcher and Jones 1996:639). It is frequently within this sandy, back beach area that significant archaeological resources related to permanent habitation and burials are found (e.g., Site 103; see Table 1).

Zone III consists of a landform located at or very near sea level, but removed from the coastal inland of Zone II. This zone is characterized as ‘marsh land,’ or ponded areas that are approximately equal in elevation to sea level yet retain more terrigenous characteristics. Zone III often consists of slightly depressed areas amenable to water and soil catchment. This marsh land does contain some sandy sediment, but alluvial clays dominate soil matrices. It is within Zone III that *lo`i* agriculture was suggested to have been practiced during traditional times (see Creed et al. 1995) and fishponds are often present (e.g., Kawailoa Pond south of the Radisson Hotel). Later, these lands were filled and utilized for rice cultivation and modern occupation. Zone III contrasts brilliantly with Zone II in that it provides a near-coastal alternative for agricultural production normally only afforded at much more inland locations. Permanent residents of the near coastal environment (Zone II in particular) could practice both intensive agriculture while gathering resources from an immediately adjacent ecological zone. It is this situational affordability that allowed for Zone II occupation at the interface of several other significant resource zones.

Zone IV is demarcated by considerable increases in elevation and changes in topography. This zone is common mostly along the southern flank of the pathway route near Hanama’ulu and along the highway, if the pathway is to be placed there. This zone primarily consists of rolling hills and plateaus that lead into more mountainous terrain. Now primarily consisting of grassy plains, subsurface deposits are dominated by the presence of red clays. Some historic and modern uses of this landscape include sugar cane cultivation and pasturing activities. Due to the intensive landscape modifications associated with these historic and modern uses, surface archaeological structures are fairly uncommon, although there are exceptions (Malae Heiau in Wailua). This zone contains red clay soils derived from the decomposition of underlying basalt. The soils are rich in iron and other nutrients amenable to the industrial production of certain crops (*e.g.*, sugar cane). During prehistoric and early historic times, Zone IV could have been used as another transition zone between lowland and upland locales. Trails linking lowland and upland sites and resource procurement zones, small-scale agricultural sites, habitation sites (both permanent and temporary loci), and some *heiau* were constructed in this zone. However, although several site classes may have occurred in Zone IV, the archaeological signatures of these site types may be minimal or non-existent. Zone IV gives way to another zone, the uplands.

The fifth zone (Zone V) consists of the uplands/steep slope lands cut by widely spaced erosional gullies and major drainages consisting of deep ravines. These drainages often create alluvial flats at their terminal points near the coastline (forming Zone III; Hanama'ulu area). Also, plateaus are formed between the valleys and the routes occasionally course along side slopes. Rock outcropping is common is several areas, particularly along the northern flank of Hanama'ulu Bay.

While each of these zones contributed to traditional and historic economies, archaeological signatures for traditional habitation and activity have been most evident in the back beach zone (Zone 2). This zone contained the artifacts produced for on-site use and off-site procurement of resources, midden and faunal remains indicative of food preparation and consumption, subsurface features such as postholes indicative of dwellings, and hearths characteristic of cooking locales, among others. Typically, the greatest quantity of archaeological sites indicating continuous use of the eastern Kaua`i landscape has been recovered from this back beach, accretion zone, the current project area not being an exception. While there is a specific correlation between soil types and the presence/absence of sites along this eastern coast, in this case, the documentation of the greatest proportion of sites being in Zone II does not provide such a simple association. Archaeological inquiry has been primarily conducted in Zone II as infrastructure and housing construction has rapidly expanded. Naturally, the more inquiry into one zone versus other zones skews the results somewhat. It is this caveat that archaeological models defining intensive landscape use through time must address

Ecological Subzones and Archaeological Sites

The back beach, or accretion zone area (Zone II), containing the predominant cultural layers identified in this project area, occurs at the interface of two other ecological zones. Zone I is represented by the immediate coastline, which often includes interdune deposits, crests and slipfaces, and backslope areas. Zone III, a bounding surface for Zone II, consists of an inland marshy area used through history for *lo`i*, fishponds, and wetland resources. This dynamic coastal to slightly inland ecological setting containing three discrete ecological zones, was utilized on a continuous basis along eastern Kaua`i for at least 800 years (see Creed *et al*. 1995).

It has been postulated elsewhere (Dega and Buffum 2001; Dega and Morawski 2002) that Zone II back beach locations were the stable, lowland land surfaces on which primary permanent occupation and associated activities occurred during pre-Contact times. Temporary habitation loci, work areas (e.g., lithic workshops), recreational activity areas, fishing camps, and some burial areas are site types occurring directly along the coastline (Zone I). For the most part, direct coastal areas were transient in that dune movement and erosion were common. Back beach, accretion deposit areas were much more stable and selected for sustained, permanent habitation. Permanent house sites, ceremonial structures, some agricultural features, and such have been documented with more frequency in the Zone II area of eastern Kaua`i. Both burials and subsurface cultural layers often denoted as the paleo A-horizon along eastern Kaua`i have been most often identified in this ecological zone. The present archaeological project may reinforce this hypothesis. The western flank of the back beach zone (Zone III) commingled with depressed, marshy areas extending to the base of hill slopes to the west. These marshy areas, as noted above, were also utilized continuously throughout history, from lo`i and fishpond use to resource gathering areas. During historic times, these marshy areas were often filled and utilized for rice cultivation (see Creed et al. 1995). We continue to explore the possibility that a fishpond also occurred in this back beach area, the Kawailoa Pond south of the Radisson Hotel.

Historic Preservation Challenges

As discussed further above, several avenues of mitigation are possible for historic properties discovered prior to, or during, construction of the pathway. These include archaeological Monitoring, Data Recovery, Burial Treatment, and site Preservation. The primary impact to construction or location of the pathway appears to be in the form of traditional Native Hawaiian burials. Several known burial areas occur within or near proposed pathway routes. Such is the nature of coastal pathways in Hawaii. The singular challenge will be to more readily define the possible boundaries of the burial areas (and established preserve area such as occur at Wailua Golf Course) and to practice avoidance of the these areas. In working with the SHPD, other site types, such as traditional-period temporary habitation locations or camps and such, may be mitigated through Data Recovery sampling. Rehabilitation and Preservation of sites (see Table 1) will occur as part of the Preservation effort of known sites in the area, none of these occurring in the proposed pathway corridors. The greatest challenge again will be avoidance and protection of known burial preserve areas along the pathway. SCS and the contractors will work with the SHPD and Kaua`i/Ni`ihau Islands Burial Council to assess and mitigate known burials and those that are inadvertently discovered during construction.

Part IV: Interpretive Signs along Ahukini-Lydgate Pathway

This section provides a table (Table 2) listing possible signs and interpretations that may be placed along this portion of the bikepath. This table is open for revision and consultation will occur to refine potential signs in the area.

Table 2: Potential Signage: Ahukini Landing toward Wailua River

#	Location	Sign Site	Size	Description
1	Ahukini Landing	Overlooking Bay and Wharf	L	Description of sugar plantations Lihue to Kapaa. Landing history
2	Ahukini Bluff, South Shore	Beginning of decline into valley	S	Description of RR
3	Hanama'ulu Valley	South end of historic RR Bridge	L	Description of traditional agriculture activities
4	Hanama'ulu Bay	North end of historic RR bridge	L	Description of traditional shoreline activities
5	Kou, Old Landing	At landing north shore of Hanama'ulu Bay	S	Use by Hanama'ulu Sugar Plantation
6	Hanama'ulu / Wailua Ahupua'a	Border between Hanama'ulu & Wailua Ahupua'a	S	Quote Historic descriptions from 19th century travelers and residents
7	Marine Camp	Beach area near Motocross track	S	Historical account
8	Wailua Golf Course/ Hawaiian Burial Area Site -103	Beach south of # 2 green, on trail	S	Description of Hawaiian Burial Area
9	Hanama'ulu Sugar Company	Undetermined	L	Chronology and Sugar Company Information
10	Historic Sites of Hanama'ulu Ahupua`a	Ahukini Point (start of path)	L	Nu`ukoli, Kawailoa, Hanama'ulu Dairy, Wailua Airport, Marine Camp, Luckenback Shipwreck
11	Prehistoric and Historic Sites of Hanama'ulu	Ahukini Point (start of path)	L	Ahukini Heiau, Ahukini Terminal and Railway Company, Ahukini Camp, Ahukini Landing, Railroad Track of Old Bridge, Hanama'ulu Park

CONCLUSIONS

This interim report sought to discuss the various archaeological and historic preservation issues related to construction and maintenance of the Kaua`i Pathway project and focuses on the segment stretching from Ahukini Point to Lydgate Park. The report lists the known archaeological sites having been documented along this segment, the estimated significance of these sites, and potential mitigation of these sites and sensitive areas during construction of the pathway. The historic preservation challenges that may be faced during construction of the coastal pathway are presented, with recommendations for mitigation also being forwarded. SCS will continue to refine this document in consultation with the SHPD and various community organizations. In total, the relationship between known archaeological sites and possible pathway routes presents a dynamic opportunity to further explore the history of the Ahukini-Lydgate area while preserving the rich history of the area.

References available

A-2 PRELIMINARY GEOTECHNICAL REPORTS

October 6, 2005
W.O. 5411-00

Mr. Merle D. Grimes
MDG, Inc.
1042 Broken Arrow Circle
Elizabeth, CO 80107

HANAMA’ULU RIVER BRIDGE
AHUKINI-LYDGATE BIKE/PEDESTRIAN PATH
FEDERAL-AID PROJECT NO. STP-0700(51)
LIHUE, KAUAI, HAWAII

Dear **Mr. Grimes:**

This letter describes the findings from our literature research performed and presents our preliminary geotechnical considerations for the Hanama’ulu River Bridge for the proposed Ahukini-Lydgate Bike/Pedestrian Path project on the Island of Kauai, Hawaii.

We understand that the bike and pedestrian path will be about 10 to 12 feet wide and will consist of a 6-inch thick concrete path. One of the path alignment alternatives travels primarily along the existing shoreline from Ahukini Landing to Lydgate Park. The other path alignment alternative travels further inland along Kapule/Kuhio Highway. One of the path alignment alternatives will traverse one existing major structure, the Hanama’ulu River Bridge. Since the Hanama’ulu River Bridge may be historic, construction of a replacement bridge structure may not be possible. Therefore, the Hanama’ulu River Bridge structure will probably require modifications.

The existing Hanama’ulu River Bridge is a 2-span concrete arch bridge with 53 and 79-foot long spans. The bridge was built in the 1920’s with a bridge deck about 10 feet wide. The bridge piers and abutments are supported on a pile foundation except for the Kapaa-side abutment that is supported on spread footings bearing on rock. The type of pile and other details of the pile foundation were not shown on the available drawings. In addition, subsurface soil information was not provided on the drawings.

Based on geologic maps, the Hanama’ulu River area is underlain by recent alluvial deposits. The recent alluvial deposits are characterized as unconsolidated, non-calcareous soils. These recent alluvial deposits tend to be soft in consistency and compressible. We anticipate that the existing bridge structure is mainly underlain by recent alluvial deposits.

We understand that the existing bridge will be renovated with a new bridge deck on the existing bridge. The bridge deck will consist of precast concrete planks with stainless steel cable railings and concrete railing posts. In addition, new concrete end post structures will be constructed.

The load capacity of the existing bridge foundation will need to be determined for the additional loads of the new bridge deck structure. We understand that bridge scour need not be considered in the bridge design.

We appreciate the opportunity to be of continued service to you on this project. If you have questions or need additional information, please contact our office.

Respectfully submitted,

GEOLABS, INC.

By ______________________
Gerald Y. Seki, P.E.
Senior Geotechnical Engineer

GS:cj

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October 5, 2005
W.O. 5411-00

Mr. Merle D. Grimes
MDG, Inc.
1042 Broken Arrow Circle
Elizabeth, CO 80107

PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
AHUKINI-LYDGATE BIKE/PEDESTRIAN PATH
FEDERAL-AID PROJECT NO. STP-0700(51)
LIHUE, KAUAI, HAWAII

Dear **Mr. Grimes:**

This report describes the findings from our literature research performed and presents our preliminary geotechnical considerations for the proposed Ahukini-Lydgate Bike/Pedestrian Path project between Ahukini Landing and Lydgate Park on the Island of Kauai, Hawaii. This report is intended to provide preliminary geotechnical considerations for planning and for the development of the Environmental Assessment only. Our work was performed in general accordance with the scope of services outlined in our revised fee proposal of June 9, 2005. The general location and vicinity of the project site are shown on the Project Location Map, Plate 1.

SUMMARY OF FINDINGS

Based on our literature research performed for the proposed Ahukini-Lydgate Bike/Pedestrian Path project, we anticipate that the proposed path alignments will traverse beach and dune sand deposits, alluvial soils and volcanic rock. The beach and dune sand deposits generally consist of poorly-graded sands. Portions of the project site are underlain by recent alluvial deposits that are typically soft and compressible. One of the path alignments travels close to an estimated wetland area. In addition, portions of the proposed alignments are underlain by basalt formations. We anticipate that the areas with basalt formations are covered by stiff residual and saprolitic soils, to basalt rock formation.

Several geotechnical considerations that may have a significant impact on project cost and construction time were identified during our literature research. In addition, the geotechnical considerations may have adverse impacts to the project during construction. These geotechnical considerations include settlement due to soft soil deposits, slope raveling, potential rockfall hazards, seepage of groundwater, and flooding associated with high rainfall storms. Special attention should be given to soft ground stabilization, cut slope design, subgrade stabilization, drainage design, and erosion control measures during the design and construction of the bike/pedestrian path project.

We anticipate that the proposed path alignments will traverse soft, loose, and/or unstable ground, such as gullies and stream crossings underlain by recent alluvial soils. Methods to reduce the anticipated path settlements and increase the path stability include removal of the soft and/or loose soil deposits and replacement with compacted fill materials, installation of a working platform or drainage blanket prior to fill placement, and utilizing soil stabilization methods, such as vibro-replacement or jet-grouting to improve the soft and/or loose soil deposits for construction.

In addition, a settlement waiting period likely will be required for embankment construction over the soft ground areas to reduce the potential for shear failure in the soft material and to reduce post construction settlements of the embankment. In addition, a surcharge program with settlement monitoring may be required to reduce the settlement waiting period.

It is proposed to place the new path on the existing Hanama'ulu River Bridge structure. The load capacity of the existing bridge foundation will need to be determined for the additional loads of the new bridge deck structure. New bridge structures will be required for the drainageway crossing near the Radisson Hotel and for the roadway crossing near the Kamalani Bridge. Since poor subsoil conditions may be encountered at the crossing sites, a deep foundation system such as drilled shafts or driven piles may be required to support the new bridge structures. In areas subjected to scour, the new bridge structure should be designed for scour. We understand that the use of viaduct bridge structures is being considered for crossing the soft ground areas. Because of the soft subsoil conditions, we anticipate that a deep foundation system will likely be required to support the viaduct bridge structures.

It should be noted that the findings and preliminary recommendations provided in this report are intended for planning and development of the Environmental Assessment only. The text of this report should be referred to for detailed discussion of our findings and preliminary recommendations.

PROJECT CONSIDERATIONS

The proposed Bike/Pedestrian Path project is located between Ahukini Landing and the existing Lydgate Park on the Island of Kauai, Hawaii. The project involves completion of the planning phase, including obtaining approval of the environmental assessment. The study corridor is located between Ahukini Landing and a point near the existing Lydgate Park, and from the shoreline to the Kapule/Kuhio Highway.

Alternative path alignments were developed during the initial phase of the planning study for the project. These path alignments were reduced to two main alternative path alignments for engineering evaluation to quantify potential costs for grading and major structures. Geotechnical input will be required to identify potential hazards, such as soft ground conditions, rockfall, and other conditions that may have a large impact on project costs and construction time.

We understand that the bike and pedestrian path will be about 10 to 12 feet wide and will consist of a 6-inch thick concrete path. One of the path alignment alternatives travels primarily along the existing shoreline from Ahukini Landing to Lydgate Park. The other path alignment alternative travels further inland along Kapule/Kuhio Highway.

One of the path alignment alternatives will traverse one existing major structure, the Hanama’ulu River Bridge. Since the Hanama’ulu River Bridge is historic, construction of a replacement bridge structure may not be possible. Therefore, the Hanama’ulu River Bridge structure will probably require modifications. In addition, two new bridge structures and a tunnel structure are proposed along the alignments.

Based on the relatively flat site topography along most of the path alignments, we anticipate that the majority of the cuts and fills will be on the order of less than 10 feet. However, major cuts and fills on the order of up to about 20 to 30 feet are anticipated for the construction of the proposed path alignment located between Hanama’ulu Bridge and Ahukini Landing.

PATH ALIGNMENT ALTERNATIVES

We understand that two main path alignment alternatives were developed for the project. These selected path alignment alternatives were studied for this report and are described below. The different paths and segments for the path alignment alternatives are shown on the Site Plans, Plates 2.1 through 2.6.

Alternative No. 1

Path Alternative No. 1 generally runs along the existing shoreline. The path starts from Ahukini Landing, circles around Hanama’ulu Bay, and travels near the shoreline to Lydgate Park. At the back of Hanama’ulu Bay, the path alignment is located away from the shoreline and within a low-lying area. In addition, the path crosses over the existing historic Hanama’ulu Bridge in this area.

An alternative segment that connects the shoreline path up to Kapule/Kuhio Highway is proposed near the Wailua Golf Course driving range. This alternative segment includes a tunnel section that crosses an existing pathway. In addition, new bridge structures are proposed near the Radisson Hotel and the Kamalani Play Bridge at Lydgate Park.

Alternative No. 2

Path Alternative No. 2 connects with Path Alternative No. 1 near the northern portion of Hanama’ulu Bay. This alternative path alignment follows existing cane haul roads and runs along the eastern side of Kapule/Kuhio Highway to Lydgate Park. This path alternative also includes alternative path segments that travels from Kapule/Kuhio Highway down to the shoreline near the Radisson Hotel.

GEOLOGIC CONDITIONS

The Island of Kauai is composed of a single basalt shield volcano built by the extrusion of lava of the Waimea Canyon Volcanic Series during the late Pliocene Epoch (more than 2¼ million years before present). Following the cessation of this main shield building phase, there was renewed volcanic activity with the extrusion of basaltic lava of the post-erosional Koloa Volcanic Series and the concurrent deposition of the alluvial sediments of the Palikea Formation.

The majority of the Island of Kauai is covered by lava of the Waimea Canyon Volcanic Series. These lavas consist of four distinct formations: Napali, Olokele, Haupu, and Makaweli. These formations are comprised of thin-bedded a’a and pahoehoe flows to massive basalt flows that ponded in calderas and graben.

Rocks of the Koloa Volcanic Series cover most of the eastern half of the Island of Kauai. These rocks are generally characterized as thick flows of dense basalt extruded from groups of vents aligned in north-south trends in various locales. Associated with the vents are pyroclastic materials, which usually form low cinder cones at the vent.

During the Pleistocene Epoch (Ice Age), there were many sea level changes as a result of widespread glaciation in the continental areas of the world. As the great continental glaciers accumulated, the level of the ocean fell since there was less water available to fill the oceanic basins. Conversely, as the glaciers receded, or melted, global sea levels rose because more water was available. The land mass of Kauai remained essentially stable during these changes, and the fluctuations were eustatic in nature. These glacio-eustatic fluctuations resulted in stands of the sea that were both higher and lower relative to the present sea level of Kauai.

The basaltic rock built by the extrusion of lavas of the Koloa Volcanic Series are generally characterized by flows of jointed dense vesicular basalt inter-bedded with thin clinker layers. The weathering process has formed a mantle of residual soils which grade to saprolite with depth. In general, saprolite is composed of mainly silty material and is typical of the tropical weathering of volcanic rocks. The saprolite grades to basaltic rock formation with depth.

Erosion of the upper Koloa and Waimea Canyon Volcanic Series has deposited alluvial sediments along streams, drainageways, and low-lying areas. These sediments are generally unconsolidated to moderately consolidated, non-calcareous soil deposits. Agricultural and commercial developments within the last century have brought the project site to its present conditions.

The geology for the proposed path alignments were developed based on geologic references. The site geology for the two path alternatives is described in the following subsections.

Alternative No. 1

The proposed path alignment for Alternative No. 1 is mainly underlain by beach and dune sand deposits. The beach and dune sand deposits are characterized as unconsolidated calcareous deposits. These deposits are poorly graded and uniform in particle size. Recent alluvial deposits may be encountered further inland from the shoreline near the Kawailoa area and within the Hanama’ulu Stream area. The recent alluvial deposits are characterized as unconsolidated, non-calcareous soils. These recent alluvial deposits tend to be soft in consistency and compressible. In addition, basalt rock formation of the Koloa Volcanic Series may be encountered along the southern portion of the path alignment at the sides of Hanama’ulu Bay.

Alternative No. 2

This alternative alignment is mainly underlain by alluvial deposits consisting of recent and older alluvium. Characteristics of the recent alluvium are described above. The older alluvial deposits are more consolidated and stiffer in consistency compared to the recent alluvial deposits. The southern portion of path alignment is underlain by basalt rock formation of the Koloa Volcanic Series. We anticipate the presence of residual and saprolitic soils near the ground surface. These soils are developed from the in-situ weathering of the basalt formation. In addition, the northern portion of the path alignment near Lydgate Park is underlain by a dune sand deposit.

SURFACE TERRAIN

The terrain along the bike/pedestrian path project limits varies significantly from level, low-lying areas to sloping hillside areas. A brief description of the topography along the proposed alignments is presented below. These descriptions are based on United States Geological Survey (USGS) topographic maps.

Alternative No. 1

The initial roadway alignment from Ahukini Landing travels around Hanama'ulu Bay with the ground surface varying from low-lying near the mouth of the bay to sloping hillsides along the sides of the bay with ground surface elevations up to about +80 feet Mean Sea Level (MSL). The remaining portion of the alignment travels along the shoreline with ground surface elevations from about +5 to +20 feet MSL.

Alternative No. 2

Since this alternative path alignment is further inland, the ground elevations along Alternative No. 2 are generally higher compared to Alternative No. 1. The existing ground surface near Hanama'ulu Bay is about Elevation +80 feet MSL and generally slopes downwards as the alignment travels along Kapule/Kuhio Highway to Lydgate Park to about Elevation +5 to +20 feet MSL.

EXISTING/NEW BRIDGE STRUCTURES AND TUNNEL

The proposed path alignments will traverse existing and new bridge structures and a new tunnel structure. Description of the bridge and tunnel structures is provided in the subsequent subsections.

Existing Hanama'ulu River Bridge

The Hanama'ulu River Bridge is a 2-span concrete arch bridge with 53 and 79-foot long spans. The bridge was built in the 1920's with a bridge deck about 10 feet wide. The bridge piers and abutments are supported on a pile foundation except for the Kapaa-side abutment that is supported on spread footings bearing on rock. The type of pile and other details of the pile foundation were not shown on the available drawings. In addition, subsurface soil information was not provided on the drawings. We anticipate that the existing bridge structure is underlain by recent alluvial deposits.

We understand that the existing bridge will be renovated with a new bridge deck on the existing bridge. The bridge deck will consist of precast concrete planks with stainless steel cable railings and concrete railing posts. In addition, new concrete end post structures will be constructed.

The load capacity of the existing bridge foundation will need to be determined for the additional loads of the new bridge deck structure. We understand that bridge scour need not be considered in the bridge design.

New Bridge Near Radisson Hotel

A new one-span bridge structure is proposed to cross an existing drainageway near the Radisson Hotel. The new bridge will be supported at it ends by concrete abutment structures and will be about 90 feet in length. The use of prestressed planks or girders is being considered with stainless steel cable railings. Based on the geologic maps, the new bridge site is generally underlain by recent alluvial and beach sand deposits.

New Tunnel Structure Near Driving Range

A new path tunnel structure is proposed near the Wailua Golf Course Facility. The 160-foot long tunnel will be composed of concrete construction and will be about 12 feet wide by 10 feet high. The tunnel structure is situated on a path connecting the Alternative No. 1 Coastal Path with the Alternative No. 2 Highway Path. Based on the geologic maps, the tunnel site is generally underlain by dune sand deposits.

New Bridge Structure Near Kamalani Bridge

A new three-span bridge structure is proposed near the existing Kamalani Bridge within the Lydgate Park area. The new bridge will be about 140 feet in length with span lengths of 35 and 70 feet. The proposed bridge will consist of wooden deck and railings, concrete pier columns, and concrete abutment structures. The wooden deck will be supported by stainless steel cables. We anticipate that the new bridge site is underlain by a dune sand deposit.

WETLAND AREA

We estimate that the proposed Alternative No. 2 path alignment will travel close to an estimated wetland area. In general, these areas are characterized by swamp or marsh-like environment with possible presence of standing water. Wetland sites may contain various forms of unique wildlife, which may require preservation. The approximate location of the estimated wetland site is shown on Plates 2.4 and 2.5.

From a geotechnical engineering point-of-view, swamps and marshlands often imply the presence of soft soils. It should be noted that areas not designated as a “Wetland Site” may also contain deposits of soft soils. These areas are further discussed in the Geotechnical Considerations section.

GEOTECHNICAL CONSIDERATIONS

Based on our desk-top study of the project site, several types of geotechnical considerations may have the potential for adverse impacts on the stability of the planned structures as well as the future maintenance of the proposed path. The geotechnical considerations may include, but are not limited to, the following:

- Settlement Due to Soft Soils
- Slope Raveling or Failure
- Rockfall Hazard
- Seepage of Groundwater
- Flooding by Rainfall

Settlement Due to Soft Soils

Areas underlain by recent alluvium are susceptible to consolidation and settlement over time as man-made fills are placed over these soft ground areas. Based on our literature research, soft soils are likely to be encountered at stream crossings, drainageways, wetland areas and other localized areas. A thorough field exploration should be performed at these locations where soft soil deposits are suspected in order to determine the lateral extent, thickness, and consolidation characteristics under the proposed fill loading conditions. The soft soil areas should be further evaluated to provide recommendations for design and construction of embankments and/or bridge viaduct structures over these areas. The estimated soft ground areas are shown on the Plates 2.1 through 2.6.

Slope Raveling or Failure

Based on the aerial photographs and available topographic maps of the project site, we anticipate that earthwork for the proposed bike and pedestrian path project will involve cuts at various locations throughout the site. We anticipate that substantial cuts of up to about 20 feet in the saprolite and/or weathered rock may be required. Therefore, some slope raveling and localized slope failures may occur on very steep cut slopes. Most of these slope raveling and failures tend to occur in steeply cut slopes with slope inclinations of about 1H:1V or steeper. Because of these existing conditions, cut slope inclinations for the larger cut slopes will need to be evaluated on a case-by-case basis when the vertical profile of the alignment is established.

Rockfall Hazard

It should be noted that areas adjacent to relatively steep hillsides are susceptible to rockfall. Rockfall involves the detachment and fall of rock material from the slope face that can present dangerous conditions for bike and pedestrian traffic. Because of these potential issues, cut slope inclinations for the larger cut slopes will need to be evaluated on a case-by-case basis when the vertical profile of the alignment is established.

Seepage of Groundwater

We anticipate that the soils encountered during path construction may have relatively high water contents due to the high rainfall and high groundwater levels. In addition, perched groundwater tables may exist in some areas. Because of the high moisture anticipated in the weathered materials, earthwork cuts may expose permeable layers responsible for transmitting seepage of subsurface groundwater, which in turn may cause potentially unstable cut faces.

Flooding by Rainfall

Based on a review of available topographic maps of the site, the Island of Kauai contains numerous rivers, streams, and drainage paths as a result of the high volume of tropical rainfall. Extended periods of heavy rainfall may swell drainage pathways to their capacity and flood low-lying areas. We wish to emphasize that adequate modeling of scour potential and storm water runoff should be performed for the design of new bridge structures.

CLOSURE

We appreciate the opportunity to provide geotechnical services to you on this project. If you have questions or need additional information, please contact our office.

Respectfully submitted,

GEOLABS, INC.

By

Gerald Y. Seki, P.E.
Senior Geotechnical Engineer

By

Clayton S. Mimura, P.E.
President

CLAYTON S. MIMURA
LICENSED PROFESSIONAL ENGINEER
No. 4176-C
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

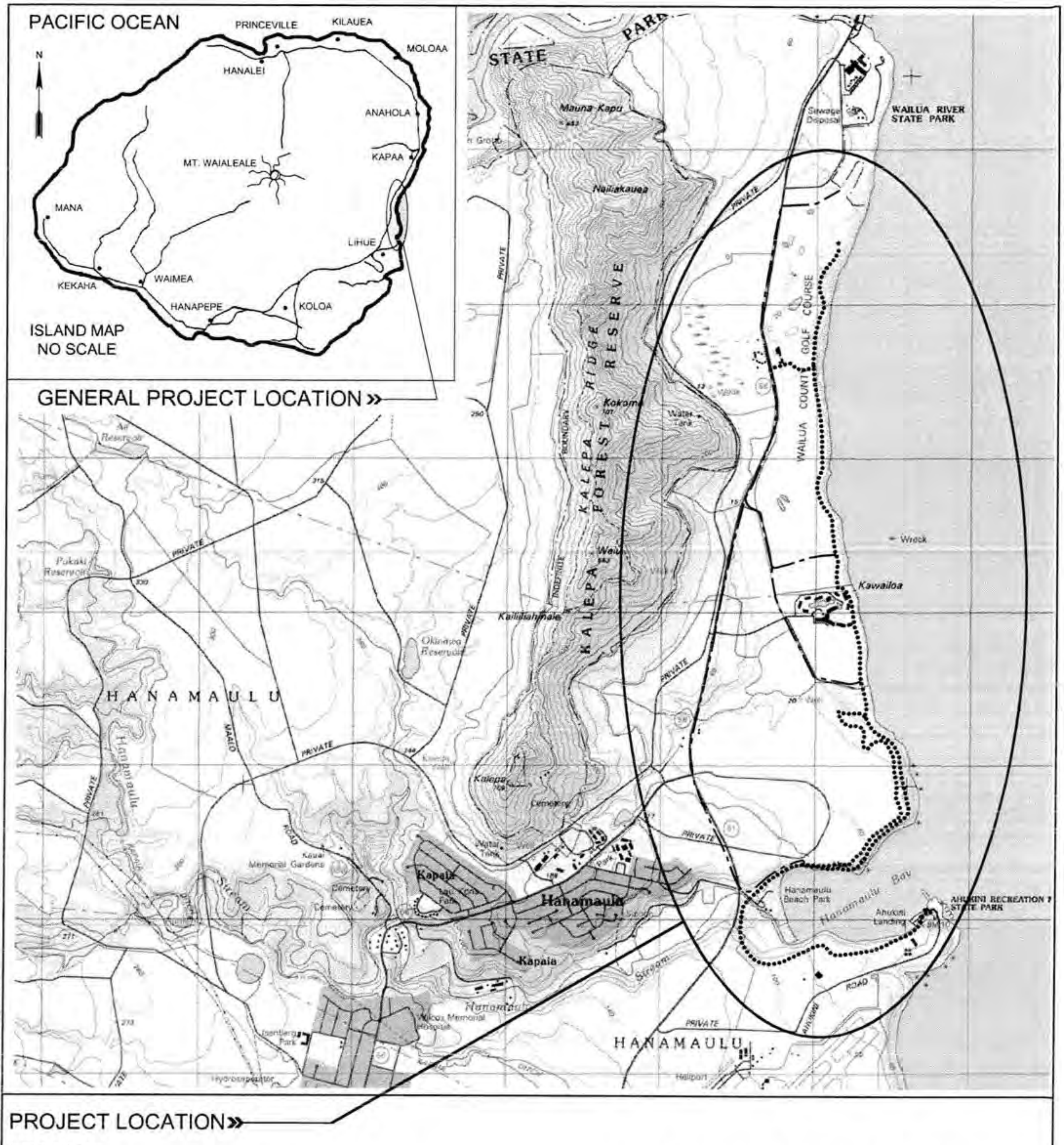
SIGNATURE 4-30-06
EXPIRATION DATE OF THE LICENSE

CSM:GS:as

Attachments: Project Location Map, Plate 1
Site Plans, Plates 2.1 thru 2.6

(4 Copies to Addressee)

(h:\5400Series\5411-00.gs1)



LEGEND:

- ·············· ALTERNATE NO. 1
- —·— ALTERNATE NO. 2

3000 1500 0 3000 FT.

GRAPHIC SCALE

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REFERENCE: MAP CREATED WITH TOPO!® ©2001 NATIONAL GEOGRAPHIC (WWW.NATIONALGEOGRAPHIC.COM/TOPO).

PROJECT LOCATION MAP

AHUKINI-LYDGATE BIKE/PEDESTRIAN PATH
FEDERAL AID PROJECT NO. STP-0700(51)
LIHUE, KAUAI, HAWAII

GEOLABS, INC.

Geotechnical Engineering

DATE	DRAWN BY	PLATE
SEPTEMBER 2005	HYC	
SCALE	W.O.	1
1" = 3,000'	5411-00	

User: KIM File Created: September 30, 2005 File Last Updated: October 04, 2005 11:51:22am
File: T:\Drafting-9904\Working\5411-00Ahukini-LydgateBikePath\5411-00PLM.dwg\PLM

SOIL MAP PLATE 2.1

SOIL MAP PLATE 2.2

SOIL MAP PLATE 2.3

SOIL MAP PLATE 2.4

SOIL MAP PLATE 2.5

SOIL MAP PLATE 2.6

A-3 GEOLOGICAL STATUS OF THE SHORELINE REPORT

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December 28, 2009

Merle D. Grimes, LLC
1042 Broken Arrow Circle
Elizabeth, Colorado 80107
303-571-5787 wk
303-571-5788 fx

Dear Mr. Grimes:

Following is my report on the geologic status of the shoreline at Wailua.

Physical Setting

The shoreline at Wailua on Kauai's east coast experiences persistent trade winds that blow 50 to 80% of the winter months, and 85 to 95% of the summer months[1]. These winds are incident to the shore at Wailua from a northeasterly angle such that they create a southward littoral current capable of transporting suspended sand and other materials in the water column. These winds may accelerate under the influence of the east Kauai vortex that develops due to diurnal heating of the upland. As a result, 25 to 35 knot winds are not uncommon and a moderate alongshore coastal current develops from the north to the south during gusting periods.

The trades cause the formation of a strong and persistent sea state in the waters offshore. Most of the long-period swell energy is dissipated at the seaward crest of the fringing reef, and the shoreline is characterized by 1 to 3 foot wind-waves with short periods (5-10 sec.), but openings and channels in the reef do allow shoreline access to higher energy waves. The primary energy controlling marine sediment transport at Wailua comes from tidal flow, long period surge, local wind-waves and their resulting currents across the reef-flat surface moving predominantly from north to south as well as directed offshore through channels and into depressions in the reef. The result is a shoreline that is not straight. Rather it has evolved pronounced curvatures and protuberances due to sediment accumulation and removal in response to both alongshore sediment transport and channel incision.

The reef-flat at Wailua is dominated by carbonate sediments produced as skeletal debris from various benthic organisms on the adjacent reef (carbonate algae, micromolluscs, coral fragments, and fossil carbonate lithic (rock) fragments). Closer to shore and along the littoral zone and beach, sediments tend to be clean carbonate sands produced by the reefal organisms.

The immediate upland on the northern and central sections is a sandy coastal plain with an origin related to a recent, past higher sea level (ca. 2000 yr ago), dune formation, and alongshore sediment accumulation. The upland along the southern section is basaltic, of volcanic origin.

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[1] Sanderson, M. 1993. Prevailing Trade Winds, University of Hawaii Press, 126 p.

Controls on Shoreline Position

Shorelines maintain equilibrium (their position) under the influence of three environmental controls: sediment supply, waves and currents, and sea-level movements. These three factors compete for control over shoreline position. Sea level has been rising at approximately 1.5 to 2.4 mm/yr for most of the last century or more, and may, more recently, have experienced an acceleration in rate. Waves and currents have likely experienced little change in the last few centuries, although structures intersecting the littoral zone (such as the swimming pond) will influence their local impact. Sediment supply may vary widely due to human influences, seasonal changes in sediment production and delivery, and long-term shifts in sediment availability. A shoreline with sufficient sediment supply can maintain its position even while sea level and wave energy increase.

The shoreline at Wailua can be analyzed for changes in physical position over the last 75 years using a time series of historical aerial photographs and maps.

Methodology

The following map displays results of our historical shoreline analysis. Historical beach positions, color coded by year (see figure), were determined for the Wailua coastline using orthorectified and georeferenced aerial photographs and National Ocean Survey (NOS) topographic survey charts. We use the low water mark as the historical shoreline position (or shoreline change reference feature, SCRF). For locations in which there is coastal armoring or rocky shoreline seaward of any vegetation, the SCRF is delineated along the high water mark. Movement of the SCRF is used to calculate erosion/accretion rates at shore-normal transects spaced every 20 m (66 ft) along the shoreline. The 1987 SCRF is not used in the calculation of the annual erosion hazard rate, however it provides a gauge of seasonal uncertainty.

Erosion rates are determined at yellow shore normal transects (20 m). Annual erosion rates are displayed in a shore-parallel histogram graph located offshore of the coast on the diagram. Colored bars on the graph correspond to shore-normal transects; approximately every fifth transect and bar are numbered. Where necessary, some transects have been purposely deleted during data processing; as a result, transect numbering is not consecutive everywhere. Where complete beach loss has occurred, erosion rate calculations apply only to the time period when a beach existed.

Results

Our historical shoreline analysis reveals that the Wailua coast experiences intermittent historical variability in the form of some coastal segments that have long-term stability and others that display chronic erosion.

The northern portion of the coast at Lydgate Park suffers from chronic erosion at rates exceeding 2 ft/yr in places. This is due to the negative influence of the rock-wall swimming pond on sediment availability to the adjacent coast immediately to the south. The negative effects of the rock wall taper off at a distance of about 1500 feet to the south and the shoreline achieves greater long-term stability beyond this.

Along the Wailua Golf Course shoreline, the effects of erosion tend to be temporally sporadic and inconsistently spaced. Localized erosion characterizes places where reef channels and depressions intersect with the sandy beach to capture sands and divert them offshore. These are locations where sands might otherwise reside along the beach. The practice range is one such location where erosion rates of 1 to 2 ft/yr characterize the last several decades.

Historical beach positions, color coded by year, are determined using ortho-rectified and georeferenced aerial photographs and National Ocean Survey (NOS) topographic survey charts. The low water mark is used as the historical shoreline, or shoreline change reference feature (SCRF).

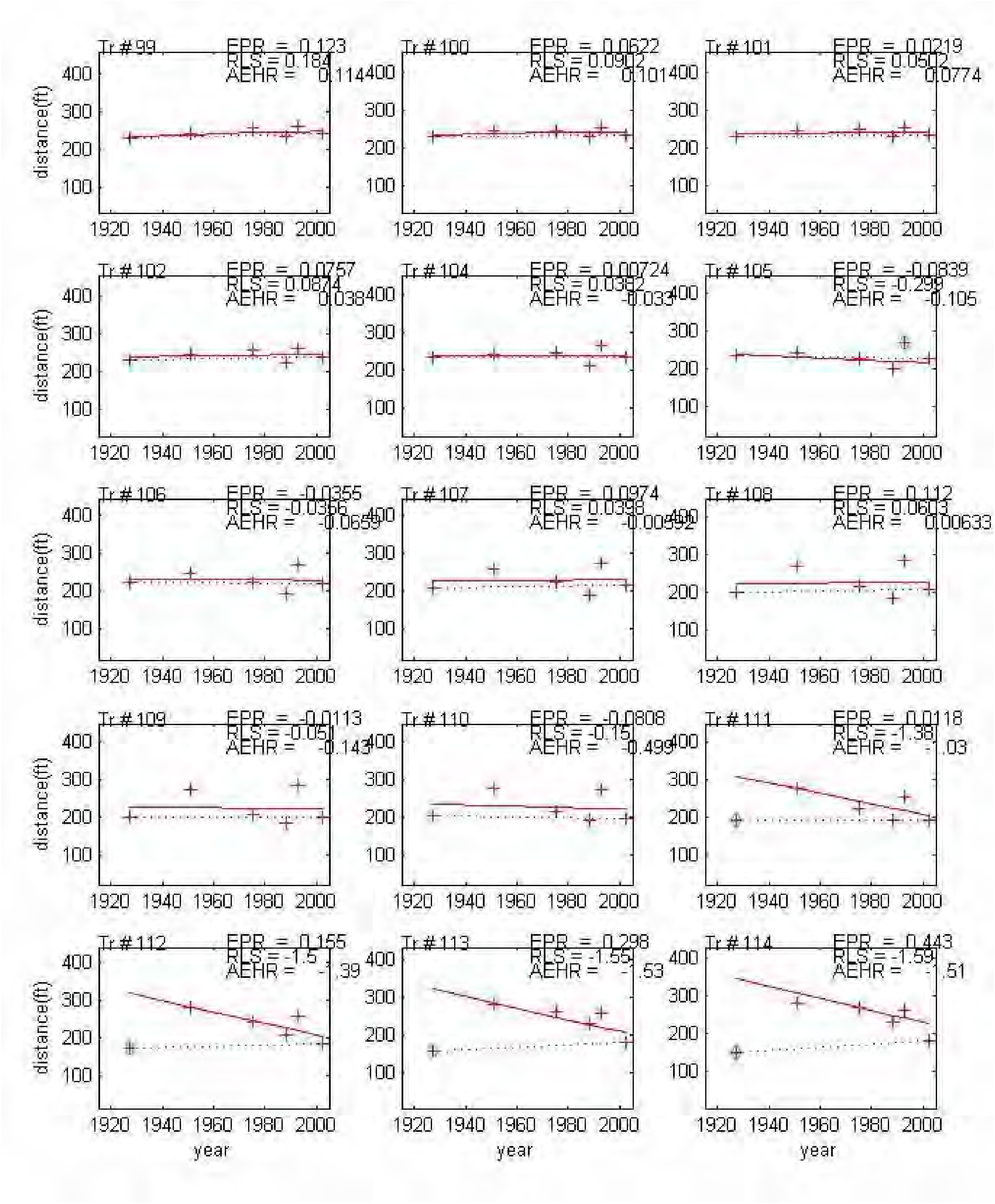
For situations in which there is coastal armoring or rocky shoreline seaward of any vegetation, the vegetation line is drawn along the seaward side of the rock or armoring. If there is no sandy beach in these areas, both the vegetation line and the SCRF are delineated along the mean high water line.

Movement of the SCRF is used to calculate erosion rates along shore-normal transects spaced every 20 m (66 ft) along the shoreline. The 1987 SCRF is not used in the calculation of the AEHR, however it provides a gauge of seasonal uncertainty.

Erosion rates are measured every 20 m along the shoreline. These sites are denoted by yellow shore normal transects. The AEHRs are shown on the shore-parallel histogram graph. Colored bars on the graph correspond to shore-normal transects; approximately every fifth transect and bar are numbered. Where necessary, some transects have been purposely deleted during data processing; as a result, transect numbering is not consecutive everywhere. Where complete beach loss has occurred, erosion rate calculations apply only to the time period when a beach existed.

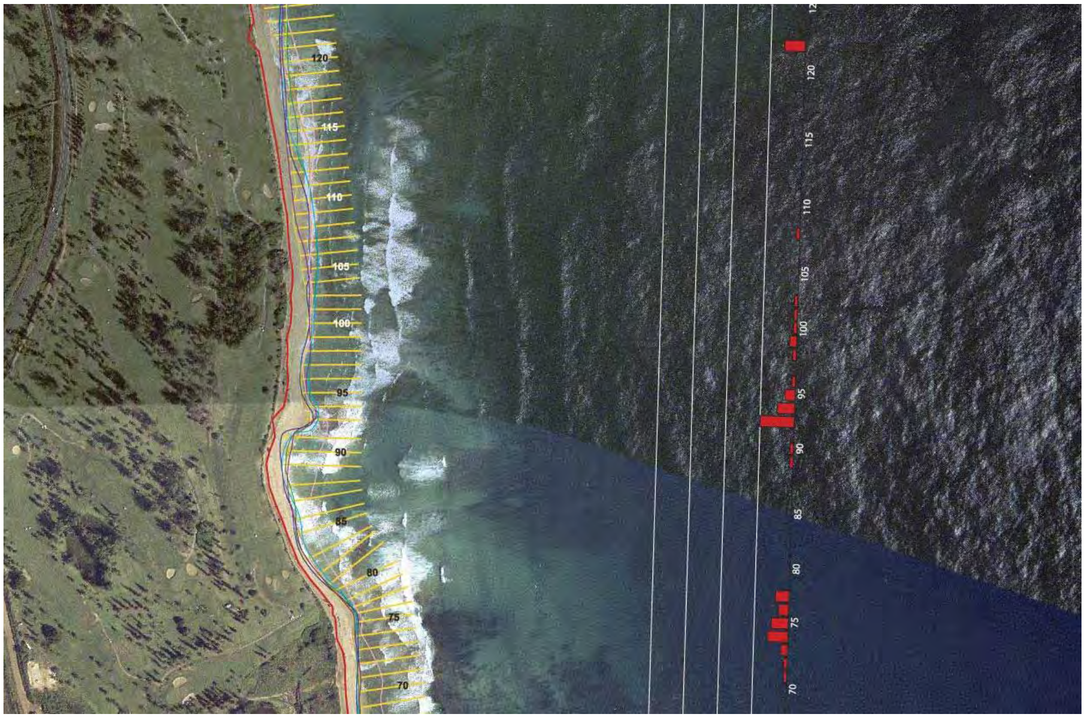
The 50 year erosion hazard line is derived by multiplying the AEHR for each transect by 50 and projecting the calculated distance along each transect from the most recent data point (2002).

The first and second fairways show a history of relative stability when averaged over time. However, direct inspection of the coastline, and interviews with observers, indicate that the coast undergoes periods of retreat during high wave and wind events. The presence of large stone blocks at the location where a natural dune would otherwise exist, confirm a history of attempts to armor the coast to prevent land loss. A closer look at the history of shoreline positions on this section of coast, between transects 125 and 75, reveals the intermittent history. Transects 99-114 (below) illustrate and exemplify this.



The plot of shoreline positions through time, as typically captured in transect (Tr) #108, shows that two episodes of erosion characterize the otherwise stable shoreline. The period 1927-1950 is characterized by a strong erosion trend that apparently recovered over the following decades. Another erosion trend from 1988-1992 also displays strong shoreline displacement that also recovered in the subsequent decade.

The 1927-1950 trend may be due to a storm event, sand-mining from the beach, or reef blasting all of which are known to have occurred periodically over the course of the early to middle 20th century. The fact that the low water mark (the seaward front of the beach) recovered to nearly its original position following each erosion period suggests that a storm event, causing temporary sand removal, was the culprit for displacing the shoreline rather than permanent sand removal associated with blasting or mining. The 1992 erosion trend is the result of high wave energy related to Hurricane Iniki.



Overall, it appears that the position of the low water mark, which we map as the shoreline reference feature, and which is located at the seaward edge of the beach at the base of the sloping foreshore, has essentially maintained its position over the past 75 years. That history has been characterized by erosion events that temporarily displace the toe landward, which subsequently recovers, but permanently cuts-back the edge of the fairway, which does not recover. This has led to placement of stone blocks in a fruitless effort to stop erosion that would cease on its own anyway upon the termination of the storm. Net stability of the beach toe, and chronic retreat of the dune edge, suggest that the beach width has increased over time and that the beach relies on dune sand released by erosion to maintain its position.

Nature of the Erosion Problem

Coastal erosion occurs when a sandy shoreline (with a beach) experiences a deficiency in sand volume preventing it from maintaining a stable position on the edge of the ocean. The sand deficiency may be caused by human actions, a rise in sea level, or a major event such as a storm or tsunami.

In response to a sand deficiency, the land abutting the beach may erode. This releases sand from the abutting dunes to feed the beach – in the process the shoreline migrates landward some distance and may stabilize once again if the sand deficiency is restored. Although the beach will migrate landward, it may not experience any narrowing due to erosion if it receives the sand eroded from the dunes. That is, a wide beach can persist even as it migrates landward at the expense of the abutting land. Hence, there is a difference between coastal erosion (land loss) and beach erosion (beach loss). Because of this phenomenon, for the environmental health of the beach (and because the beach is often more valuable than the land) it may be appropriate to let the erosion continue as a means of restoring a sand deficiency.

If a sand deficiency is temporary (such as a seasonal event associated with seasonal wave changes) any erosion will be temporary and repair itself from one year to the next. If a deficiency persists from year to year this signifies an ongoing impact to sand volume. Likely causes may include ongoing sea-level rise, ongoing human impacts, or continuing recovery from a large one-time impact such as a storm or tsunami. In such a case the landward recession is chronic.

In cases where chronic erosion destroys private land and/or threatens built structures, abutting owners have a tendency to develop remedial measure to stop the erosion. The most common measure is to build a seawall. However, this impounds the dune sand that would otherwise nourish the beach, and on a chronically eroding shoreline, seawalls will cause the beach to disappear. This is an undesirable result as the original goal of most coastal land use is to enjoy the economic and environmental benefits of the beach. In Hawaii particularly, the beach is a public resource and it is inappropriate to allow private land use to impact conservation land.

Unfortunately, in Hawaii where chronic erosion is a widespread problem, past practice has been to build seawalls in response to erosion. As a result, the total length of beaches on the island of Oahu has decreased by 25% due to seawall building, over 400 seawalls exist on the Maui shoreline with fewer than half being properly permitted, and public access to the sea is significantly decreased throughout the state because beach loss limits shoreline use.

Ironically, the attempt to armor the Wailua fairway coastline has not prevented landloss, and because the armoring is haphazard and poorly engineered, neither has it significantly interfered with sand movement from the dune to the beach. However, the dune does have a sand deficiency, and were the dune to undergo sand augmentation it would likely experience enhanced stability, ecological restoration, and offer better protection to the recessing fairway.

Appropriate Development - Pathway

Although the most appropriate coastal development emphasizes mitigating coastal hazards such as storm surge, erosion, and tsunami inundation by avoiding the problem through broad setbacks of several hundred feet or more, too many times we are forced to develop in the coastal hazard zone because of logistical, economic, and even philosophical constraints.

The Pathway project is a typical example. Laudably promulgated on the philosophy of “public access forever”, the pathway would be ideally sited on a modular, low-impact surface with minimal solid area facing the sea at a distance of at least 100 feet and most appropriately 200 feet setback from the vegetation line. Unfortunately, at locations where upland improvements force the pathway to a considerably more seaward position, or landward, away from the coast altogether, attempts must be made to accommodate the presence of unexpected traits in the new venue.

Pushed to the seaward edge of the fairway, perched on the edge of an episodically retreating upland surface, the design of the path should attempt to minimize hazard exposure, environmental impact, and negative influences on the function of the golf course. Hence, the following general guidelines are proposed.

The pathway should:

1. Restore the natural sand volume and geometry of the original coastal dune, as well as its critically important function as a coastal environment;
2. Present an absolute minimum surface area toward seaward forces;
3. Withstand strong instantaneous buoyant, shearing, and concussive forces associated with marine inundation and high winds;
4. Withstand temporary erosion events associated with storms;
5. Be amenable to future post-erosional sand placement to restore the dune system.

This results in essentially two structural options.

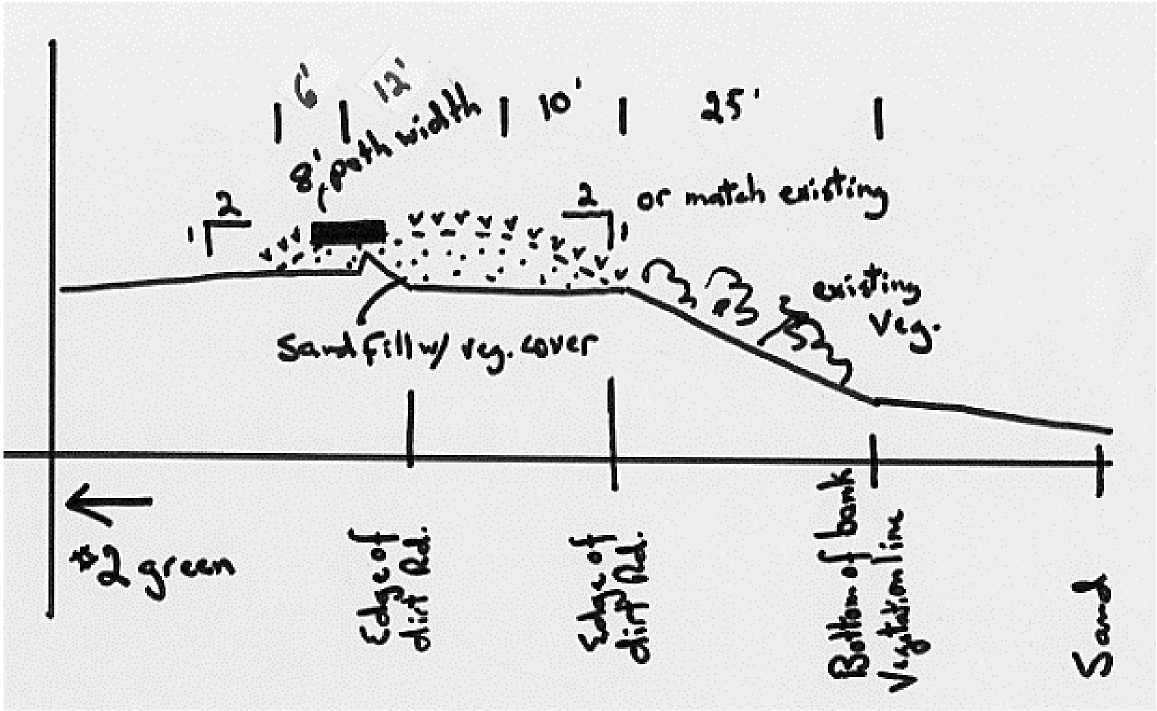
1. Build a lightweight pathway surface consisting of lockable modular sections floating on a sand foundation in connection with dune restoration. Dune construction should be located as far landward as possible, between the seaward-most line of stable vegetation on the beach and the fairway rough. It should emphasize a slope of 2:1 or greater (3:1) and a fill volume of approximately 8-10 yds^3/ft of frontage. Modular path sections should have a tethering system to prevent scattering during flooding. A small retaining wall to prevent sand spillage onto the pathway is acceptable. The dune should be strongly vegetated. A source of sand needs to be identified both for the initial restoration, as well as for replacement of sand eroded in future years.
2. Build a hanging pathway on narrow externally threaded auger piles of sufficient strength to allow broad spacing to avoid interference with wave processes. This version would likely survive marine forces intact and allow sand placement below and between the pathway superstructure. Piles would be augered several feet below grade and allow for marine flooding and erosion without subsequent damage to the path. Following the season of high wave action, sand restoration could ensue.

In both cases the existing topographic grade will simply be buried by the restored dune. This includes burying the stone blocks, dirt road, eroded escarpments, and other topographic features.

Both of these approaches emphasize the application of sand nourishment to the coastline. Although sand nourishment is not a permanent solution to coastal recession, it is the most consistent with natural environmental processes, it is the most permitable approach from a regulatory point of view, it represents a maintenance commitment, and does entail ongoing costs in repairing future erosion damage.

Kauai has three sand sources: Mana, Mahaulepu, and offshore. Offshore sand mining has not been considered here although this option is viable if the County wishes to pursue it further. Mana sand is the best developed resource at this time. However, the sand from Mana has shown a tendency to compact and harden when placed in the intertidal zone. This effect should be mitigated in the present circumstance due to its removal from daily tidal inundation as part of a dune. The most effective approach to improving the sand is to wash it using a wet elevator and airfall system. With this treatment it is unlikely that the dune fill will undergo hardening. A sand improvement system such as this exists at the Mahaulepu quarry.

The following figure provides a generalized restoration section.



Shoreline South of Wailua Golf Course

Data on shoreline change to the south of the golf course indicates that erosion increases in the area of the Kauai Hilton hotel and to its south. Erosion on the south end of the Hilton property reaches a chronic rate of ~0.3 ft/yr and to the south in the area of the dirt road that accesses the shore, erosion reaches ~0.5 ft/yr.

The remainder of the shoreline to Ahukini Point was not analyzed with regard to shoreline change history. The majority of this coastline is rocky and not subject to pronounced erosive forces. Despite this, the placement of the bike path does present a challenging permitting issue as it will be subject to marine inundation during storm and tsunami events and frequent wave forces if it is placed too close to the higher intertidal zone. The bath should be structurally designed to withstand shearing, concussive, and buoyant marine forces.

The location of the path along the rocky shoreline should emphasize keeping the widest possible open space (set-back) between any evidence of marine influence and the seaward edge of the path. Where the path will have to be squeezed between rocky shore and heavy vegetation, it is most advantageous to conduct vegetation cutback, and locate the path in the upland direction.

The photo(s) below illustrates where it would be problematic to permit a pathway on the upper most boulders and seaward of the vegetation – the path will need to be located within the vegetation zone and *well* (~20ft) landward of the uppermost boulder zone. Exact location of the pathway in this section would be best performed with a coastal expert, a chainsaw, and flagging ribbon. In the bottom photo, the location of the old road/railbed does not *exactly* represent the optimal location. The bike path would be best located mauka of the road, or at least on the mauka edge of this feature.

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A-4 STRUCTURAL REPORT

AHUKINI LANDING TO LYDGATE PARK
STRUCTURAL STATUS REPORT

KSF, Inc.

October 5, 2005

The path from Ahukini Landing to Lydgate Park may require the following proposed new structures or retrofit work on existing structures (refer to Map S-1), depending on the final path alignment.

1. Proposed Ramp South of the Existing Hanama'ulu Railroad Bridge
2. Existing Hanama'ulu Railroad Bridge Retrofit
3. Proposed Retaining Wall for Path Access Ramp at the Hanama'ulu Beach Park
4. Proposed Retaining Wall Path on the North Shore of Hanama'ulu Bay
5. Existing Cane Haul Box Culvert Bridge - Radisson Bypass Alternative
6. Proposed Temporary Integrated Boardwalk Plank System
7. Proposed Radisson Hotel Bike/Pedestrian Bridge
8. 4th Fairway – Proposed Bike/Pedestrian Bridge
9. 2nd Fairway – Proposed Helical Pile Boardwalk Path with Dune Restoration
10. 1st. Fairway – Proposed Helical Pile Boardwalk Path with Dune Restoration
11. 17th Green – Proposed Helical Pile Boardwalk Path
12. Proposed Lydgate Park Bike/Pedestrian Bridge

The following is a status report of structural assessment work completed to date:

1. Proposed Ramp South of the Existing Hanama'ulu Railroad Bridge

Three alternatives were prepared for this structure.

a. **Embankment**: Fill and re-grade the entire area to keep slopes within the ADA 5% maximum. This should be a low cost solution but accessibility problems and large height/grade differentials will increase construction difficulty. This solution impacts a wide area. The filled areas are likely to cause drainage problems, as runoff will be accumulated on the uphill side of the fill.

b. **MSE:** Use a mechanically stabilized earth, segmental retaining wall system to define the path. This system utilizes a system comprised of concrete masonry units with geotextile tiebacks to retain and stabilize the backfill. This may be the most cost effective system with the least impact on the area. Drainage concerns will be similar to "a" above as uphill runoff will be accumulated (Refer to Drawing S-2).

c. **Bridge:** Construct an elevated structure. A bridge requires foundation and superstructure work and would be the most costly especially if deep foundations (piles) are required. A major advantage of an elevated structure will be its limited impact on the surrounding area as the topography will be minimally affected and drainage will not be an issue (Refer to Drawing S-3).

Estimate of Probable Construction Costs:

- Embankment Option: Not available at this time. Estimate requires detailed topographic survey
- MSE/Segmental Retaining Wall Option: $1,000,000.00
- Elevated Bridge/Ramp Option: $1,5000,000.00 ($250.00 per s.f. plan area of deck)

2. Existing Hanama'ulu Railroad Bridge Retrofit

The following is a report summarizing our work regarding the Structural Assessment and Recommendations for the Historic Hanama'ulu Railroad Bridge (Refer to Drawing S-4).

a. Observations

The bridge appears to be in very good condition considering its age and ocean front exposure. Several site visits have been conducted. At this time, no exploratory evaluations such as coring and concrete sampling have been performed. Several minor spalled areas are visible from the ground. The top "trough" which formed the original roadway for the railway was filled with dirt and debris. Once cleaned, additional concrete damage can be expected due to constant moisture from the organic material. It is expected that these concrete defects can be readily repaired using conventional chip-and-patch methods. (See Section "E")

Photo of the Hanama'ulu Railroad Bridge


Another view of the Hanama'ulu Railroad Bridge

b. **Structural Assessment**

An original plantation drawing was available indicating dimensions but containing very little other information regarding reinforcing steel or the foundation piles. The bridge was modeled using a STRUDL finite element program neglecting any reinforcing steel. Loading from the proposed, new concrete deck used to widen the path was included. The structure, with smaller secondary arches supported on longer span primary arches, was found to be completely in compression. Concrete compressive stresses were in the 500-psi range. This would partially explain the few observed spalls as the absence of tensile cracks has allowed the concrete to continue to protect the reinforcing steel.

c. **Foundation Assessment**

Geolabs, Inc is assessing the substructure. Initial indications are that the existing foundation will be adequate to support the new path as the new loads will be of the same order of magnitude as originally intended. Field assessments to probe the depth of the top of the pile cap and collection of boring samples have yet to be completed. Unknown will be the size, depth, number and condition of the original piles, assumed to be timber. This information will be extremely difficult to ascertain.

d. **Design and Recommendations**

Various schemes to modify the top deck for an increased width and guardrails have been reviewed. The recommend solution uses pre-cast concrete planks attached to the existing structure with epoxy embedded steel dowels. The planks span across the width of the existing bridge to provide a widened path and will provide a durable, low maintenance pathway. Intermittent concrete posts that support steel cables are used for their minimal visual impact and low cost.

e. **Concrete Repairs**

All concrete repairs shall be done in accordance with recommended practices of the International Association of Concrete Repair Specialists. Properly installed repairs will assure that the life of the structure can be extended with a minimum of additional concrete maintenance. All repairs visible from the ground shall be finished to match the color and texture of the existing concrete. In areas such as the upper trough, where continuous moisture and debris build up can be anticipated, any reinforcing steel exposed for repairs shall be coated with an anti corrosion material. Replacement segments of reinforcing shall be galvanized, stainless steel coated or FRP.

It is recommended that additional drains be installed along the length of the upper trough to remove any accumulated water. Also, the entire trough surface area should be coated with a waterproofing membrane as this area will be in accessible and difficult to maintain once the new roadway decking is installed.

Estimate of Probable Construction Costs:
$300,000.00 to $500,000.00

3 and 4. Proposed Retaining Wall Path – Hanama'ulu Beach Park and on the North Shore of Hanama'ulu Bay

Retaining walls will be required on steep slopes in order to provide a location for the bike/pedestrian path (Refer to Drawing S-5). Typically, the slope of the path shall not exceed a 5 percent grade for accessibility requirements. The path grade can exceed 5 percent, but not greater than 8.33 percent for a length, not to exceed 30 feet before a landing of at least 5 feet long is required that does not exceed a 2 percent grade. Whenever the path grade exceeds 5 percent, hand railing is required.

Estimate of Probable Construction Costs:
$2,700.00 per lineal foot

5. Existing Cane Haul Box Culvert Bridge - Radisson Bypass Alternative

An existing cane haul box culvert structure located upstream and mauka of the Radisson may be used as an alternate route. The concrete appears to be in good condition. Substantial cost savings may be realized with this alternative as only retrofit safety railings and an overlay surfacing material will be required.

Estimate of Probable Construction Costs:
$65,000.00 (railing and concrete path surface)

6. Proposed Temporary Segmental Boardwalk Plank System

The temporary integrated boardwalk plank system is designed to sit directly on top of the existing sand with minimal disturbance to the sand sub-grade and vegetation. The 12 - foot by 12 - foot planks (Refer to Drawing S-6) are prefabricated off-site. They are connected with stainless steel bolts and can easily be removed. Stainless steel anchor/augers that are attached to the planks will be screwed into the sand in order to keep the planks from washing away or becoming projectiles during flood and high wind conditions.

Estimate of Probable Construction Costs:
$90.00 per square foot

7. Proposed Radisson Hotel Bike/Pedestrian Bridge

In order to span the ditch at this location, a 90 - foot span bridge is required. Three single span alternatives are proposed. All alternatives are designed to expedite construction and keep the work out of the water to avoid permitting issues.

a. **Pre-stressed Concrete Plank:** A pre-stressed concrete planks with a cast in place concrete topping (Refer to Drawing S-5). The pre-cast plank has a thin cross section and will have a lesser impact on the stream flow than a concrete girder bridge would have.

b. **Pre-stressed Concrete Girder:** Pre-stressed girders with a concrete deck are considered as an alternate (Refer to Drawing S-6). The advantage of this system is a lighter structure requiring a more economical foundation. The depth of the girders is a disadvantage. Raising the bridge will affect the on-grade portion of the trail on either end of the bridge, as retaining walls may be required. If the girder structure is lowered, stream flow may be adversely affected.

c. **Pre-fabricated Carbon Steel Bridge:**

Pre-fabricated steel bridges have become common, low cost alternatives on the mainland. For marine environments such as the Kauai bike/pedestrian path, the bridge will need to be hot-dipped galvanized and then painted with a marine grade coating of which there are many color options.

The pre-fabricated bridge sits on two abutments and can easily span without a center support pier for distances up to 140 lineal feet. They are typically 10 foot in width and have a concrete deck that is installed after the bridge has been set on its two abutments. The bridge has a 10,000 LBS vehicle load and a lifting weight of 37,543 LBS.

The manufacturer has a limited warranty of 10 years for the bridge. The actual life of the bridge will greatly depend on the maintenance routine that is implemented on the bridge. Steel bridges such as the Golden Gate Bridge are examples of painted steel bridges that can last indefinitely with proper maintenance.

Estimate of Probable Construction Costs:
Pre-stressed Concrete Plank Option: $500,000.00
Pre-stressed Concrete Girder Option: $450,000.00
Pre-fabricated Steel Bridge Option: $250,000.00

8. **4th Fairway – Proposed Bike/Pedestrian Bridge**

A bridge with a span of approximately 80 lineal feet will be required in order to cross over the ditch at this location. The same three bridge design options that were considered for the Proposed Radisson Hotel Bridge in Section Seven are proposed for this bridge and there is no significant difference in cost.

Estimate of Probable Construction Costs:
Pre-stressed Concrete Plank Option: $500,000.00
Pre-stressed Concrete Girder Option: $450,000.00
Pre-fabricated Steel Bridge Option: $200,000.00

9. **2nd Fairway – Proposed Helical Pile Boardwalk Path with Dune Restoration**

A helical pile supported boardwalk system is used along the coastline where there is tidal erosion and limited space (Refer to Drawings S-9 and S-10). Environmental and permitting constraints in the shoreline area prohibit permanent structures. The helical pile is removable; yet stable enough to support the boardwalk even if there is substantial sand erosion. The entire boardwalk system may be dismantled and the helical piles removed thus qualifying the structure as “temporary

Estimate of Probable Construction Costs:
$850.00 per lineal foot, including safety railing and excluding dune restoration

10. **1st. Fairway – Proposed Helical Pile Boardwalk Path with Dune Restoration**

The same Helical Pile Boardwalk Design used for the 2nd fairway will be utilized for the 1st fairway; however, the dune restoration design is slightly different (refer to drawing S-11).

Estimate of Probable Construction Costs:
$850.00 per lineal foot, including safety railing and excluding dune restoration

11. **17th Green – Proposed Helical Pile Boardwalk Path**

The same Helical Pile Boardwalk Design used for the 1st and 2nd fairways will be utilized for the 1st fairway; however, no dune restoration is needed (Refer to Drawing S-9).

Estimate of Probable Construction Costs:
$850.00 per lineal foot, including safety railing and excluding dune restoration

12. Proposed Lydgate Park Bike/Pedestrian Bridge

A bridge over the unpaved sand road is required mauka of the play structure. A 140 - foot span bridge will allow continued vehicular access to the beach via the sand road. Two alternatives were considered:

a. **Suspension Bridge.** In keeping with the aesthetic theme of the Kamalani Play Bridge structure, a suspension bridge is recommended (Refer to Drawing S-12). Reinforced concrete piers and a stainless steel cable will support the bridge span. The decking will be framed of either Trex or wood timber planks.

b. **Concrete Girder Bridge.** As an alternate to the suspension structure, a 3 span concrete girder bridge is proposed (Refer to Drawing S-13). Although more costly, a concrete structure will be more durable and require much less maintenance than the suspension bridge option.

Estimate of Probable Construction Costs:
Suspension Bridge Option: $500,000.00
Concrete Girder Bridge Option: $700,000.00