PMRF/KEKAHA SHORELINE SURVEY, KAUAI
Project Summary – Feb. 5, 2013

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General Statement: In early November 2012 a shoreline survey was initiated to investigate changes in beaches along the Mana Coastal Plain of west Kauai. It is the intention of the core group of this study to continue surveys through 2013, at a minimum, and possibly over the next two to three years in order to gain a more thorough understanding of the dynamics of the beaches present along the coastal plain, especially the segment including the beaches present along the Pacific Missile Range Facility (PMRF) and the community of Kekaha. This report is provided as a summary of the project to date.

Impetus: The dynamic beaches of Mana have long been the subject of great interest in terms of their character, origin and considerable variability; however, the present investigation was set in motion as the result of two things – 1) severe erosion of the beach fronting the community of Kekaha, beginning especially in 2011, and 2) considerable widening of beaches riming the PMRF portion of the coastal plain.

In recent years, beginning 2010-11, the very popular carbonate sand beach along State Hwy 50 fronting Kekaha began to disappear. Since late 2011 the beach has been essentially nonexistent. At present only the substantial lava rock revetment along the highway has prevented waves from damaging and even removing major portions of the asphalt roadway. In September 2011, I met with Hawaii State Representative Dee Morikawa (House District 16) to discuss the situation, informing her of the general nature of the beaches along the Waimea and Kekaha portions of the coastal plain, especially the 1.5-mile section extending along Kekaha from Oomano Point to MacArthur Park. It was pointed out to her that the only two options for resolution were either 1) the very expensive removal of the revetment and movement of the state highway inland in order to save the beach by allowing it to migrate naturally landward, or 2) a much less expensive upgrading of the revetment in order to maintain the highway, at the same time creating a situa-

tion in which it would be very difficult for the beach to rebuild. Apparently the second option was chosen. A project to extend the revetment by placing pilings along the portion of the highway toward MacArthur Park is now near completion. Today, south shore waves crash into and reflect off the revetment creating a turbulent nearshore setting. Such a high-energy setting makes the redeposition of beach sediment improbable.

In September, 2011, Dennis Rowley, Range Complex Sustainment Coordinator, with PMRF contacted me with a somewhat unusual request. He and co-coordinator John Burger were "concerned" about the unusual abundance of sand along the beaches rimming PMRF. Their beaches were wider than ever, plus beaches were forming along the shore in places before which they had not been observed, at least over the last 10-15 years or so. You have to admit, it's a bit unusual for anyone to be concerned about having too much sand on their beaches.

Based on a bit of discussion concerning the combination of the disappearance of Kekaha Beach and enlargement of PMRF beaches, we initiated a plan to systematically investigate the situation by conducting a long-term survey, minimum duration of one year, involving the construction of a series of beach profiles, on a monthly basis, at selected localities on the missile range facility. Dennis was particularly helpful in facilitating access to the security sensitive facility. He also provided the opportunity for others to be involved in the investigation, which resulted in the incorporation into the study of Kauai Community College (KCC) instructor Steve Taylor and several of his Marine Option students, including at present Tara Bradley, Keli Kleidosty, Teri Jin-Wah Lau and Jana Rothenberg. In addition, based on a reference from Representative Morikawa, in early December 2012 the Principal of St Theresa school in Kekaha, Mary Jean Buza-Sims, contacted me about their concern with the erosion of Kekaha Beach. That contact led eventually to the incorporation into the study of a group of their middle school students, under the guidance of their teacher, Archie Achuara. Dr. Taylor and his four KCC students are now involved mainly in the survey of PMRF beaches whereas Mr. Achuara's eight St Theresa students are involved in the survey of several Kekaha Beach localities. Since early November 2012, beach profiles have been made at six localities, three each at PMRF and Kekaha. Supplementing the monthly construction of beach profiles, wave heights predicted for each of the four sides of Kauai have been monitored, the significance of which is discussed somewhere below.

Waimea Beach / Kikiaola Boat Harbor Situation: Of interest concerning the disappearance of Kekaha Beach is the situation regarding Kikiaola Boat Harbor present along Waimea Beach a short distance east of Oomano Point. Waimea beach is composed almost entirely of greenish-gray, olivine-rich volcanic sand that

is transported by south shore-wave-generated longshore currents westward from the mouth of Waimea River to Oomano Point. The substantial lava rock groin structures of the harbor that extend seaward from the beach block the movement of sand westward toward Oomano Point such that the volcanic sand beach between the harbor and Oomano Point is severely diminished (eroded). Many residences of Kekaha have blamed the recently enlarged harbor structure for the erosion of Kekaha Beach. The problem with such a claim is that volcanic sand from Waimea has never contributed to any extent to the sand deposited on Kekaha Beach, even before the harbor structure was emplaced in the 1950s, enlarged in the late 1970s, and again enlarged over the past few years. Kekaha Beach has always been composed principally of yellowish carbonate sand derived from the opposite direction, from the west and north. Such sand is transported southward and southeastward by strong north shore-wave-generated longshore currents moving along the Mana Coastal Plain. Ultimately such sand is derived from as far away as the carbonate reef structures of Haena at the far northeastern end of the Na Pali coast. To summarize this important point, the Kikiaola Boat Harbor structure has had nothing to do with the erosion of Kekaha Beach. This scenario will become clearer as I discuss below the overall model for the beaches of west Kauai.

General Model for Mana Coastal Plain Beaches: The following is a very brief summary of the geological model for the development of the sandy beaches present along the Mana Coastal Plain of west Kauai, emphasizing in particular their sedimentological character and genesis. This model has been developed from ongoing investigations over the past two decades dealing with the geologic history of Kauai's volcanic edifice and its shoreline features. A much more comprehensive, illustrated presentation of this model dealing with the genesis of the Mana Coastal Plain and its beaches will be provided in the coming months.

The Mana Coastal Plain is like a huge, low relief "wing" attached to the western side of the Island of Kauai. It spans an arcuate distance of approximately 17 miles around the wave-eroded westernmost portion of the island, extending from the expansive sandy beach of Polihale to the mouth of Waimea River. More than three miles wide at its widest, the nearly flat, but gently seaward inclined plain is bordered along it's landward margin by the wave-eroded cliffs of the 4 to 5 million year old shield lavas of the Na Pali Member of the Waimea Canyon Basalt. The cliffs of Mana represent merely an extension of the famous precipitous sea cliffs of Na Pali that extend for 14 miles from Kee Beach in Haena southwestward to Polihale and then for another 13 miles inland to Waimea Town. Mana's cliffs were cut, prior to emplacement of the wedge of coastal plain deposits, by North Pacific waves wrapping around the western part of the island. The coastal plain was built up by the westward convergent transport of coastal sediments around the western margin of the island, both from the north and the south. Longshore sedi-

ment transport of predominately carbonate sediments from the north, all along Na Pali to Polihale Beach and beyond, are driven primarily during winter months by North Pacific-wave-generated currents. The westward transport of predominately volcanic sand along the southernmost portion of the coastal plain, from the Waimea River mouth, is driven primarily during the summer months by South Pacific-wave-generated currents. These coastal sediments have accumulated as a seaward thickening wedge across the broad shelf-like Mana submarine platform, a platform created initially by the growth of Kauai's volcanic mountain over a subsided portion of the volcanic edifice of neighboring Niihau. Much of the inland portion of the coastal plain has been infilled with land-derived volcanic sediment shed off the westward sloping apron of the island's dome-like shield. All of this has been occurring over the past several million years as Kauai's volcanic mountain-island has subsided over 3000 feet and sea level has fluctuated episodically every 100-125 thousand years by as much as 400 feet. It's a complex scenario, but one that must be understood in order to adequately comprehend present changes in the beaches of Mana.

Of specific significance regarding the character and origin of the beaches we now see along the Mana Coastal Plain is sediment composition. It provides data critical to an overall understanding of source and distance of longshore transport of the sand that comprises the beaches. Most of the beaches of Mana are composed predominately (commonly much greater than 90%) of carbonate sand grains. Common constituents are calcite ($CaCO_3$) grains of coralline (red) algae and aragonitic (also $CaCO_3$) grains of coral along with minor calcite grains of foraminifera and molluscs. Such sediment is derived primarily from the fragmentation of major reefal buildups in the Haena area (northwestern Kauai shore) and minor reefal buildups along Na Pali. Sediment is transported via north shore-wave-generated longshore currents for 13 miles along Na Pali and then another 13 miles around the coastal plain to Kekaha, terminating at Oomano Point. The most important point here is that much of the carbonate beach sediment that has comprised Kekaha Beach in the past has been transported as much as 25 miles along the coast to the "end of the line" at Kekaha. In addition, as will be reemphasized below, it is important to understand that if north shore waves are relatively weak over a winter season or two, they may not generate currents strong enough to transport the carbonate sand all the way "to the end of the line" at Kekaha. It might become tied up somewhere along the coastal plain, such as along PMRF.

Waimea Beach, extending for about 3 miles from the mouth of Waimea River westward to Oomano Point, is a significantly different story. The predominately (95+ percent) volcanic sand (lava rock fragments and olivine mineral grains) derived from the erosion of lava rocks in Waimea Canyon, another complex sedimentological scenario of weathering, erosion, transport and deposition. The can-

yon sediment is dumped at the river mouth and then transported westward by south shore-wave-generated currents to Oomano Point and slightly beyond to Kekaha Beach. A quarter-mile long transition zone exists just west of Oomano Point where the two beaches converge. Most of Waimea's volcanic sand moves offshore just east of Oomano Point and is lost to island. Kekaha's carbonate sand does not make it around Oomano Point in the other (eastward) direction. Again, the very important point here is that the beaches of Waimea and Kekaha are completely different in terms of sand content and origin. Both have problems with respect erosion, but such problems must be analyzed separately.

Mana/Kekaha Beach Study – Primary Hypothesis and Approach: The beaches along the PMRF portion of the Mana Coastal Plain are "fat." Kekaha Beach has essentially disappeared, with minimal prospect for its return in the near future. We would like to better understand the situation in order hopefully provide a favorable solution. The residents of Kekaha would love to have their beach back!

The hypothesis I have put forth for testing is that the carbonate sand that has comprised Kekaha Beach in the past has been derived from the north shore-wave-generated longshore movement of sand along Na Pali and Mana to Kekaha. The disappearance of Kekaha's beach and buildup of PMRF's beaches most likely is due to a couple winter seasons of weak North Pacific swells. Mana's longshore currents have not been strong enough to drive the sand all the way to Kekaha. Additional factors include possible stronger than "normal" summer South Pacific swells, along with trade wind-generated currents, that may have generated south shore-wave-generated longshore currents that would have transported Kekaha beach sediment westward toward Mana. A final significant factor contributing to the disappearance of Kekaha Beach, and making the return of its sand less than probable, is the substantial lava rock revetment present along State Hwy 50 fronting the community of Kekaha.

The test we have designed consists of two main forms of observation 1) periodic, systematic beach profiling and 2) wave height monitoring. Six localities have been selected at which beach profiles are being constructed on a monthly basis. Along the PMRF shoreline, profiles are being made at Kinikini Ditch, Major's Bay and Kokole Point. Along the Kekaha shoreline, profiles are being made at the beach near the Mana Drag Strip, at MacArthur Park and the small beach in from of St Thereas' Church. Each day the predicted heights of waves approaching the island from the four main sides of the island (N, S, E, W) are being downloaded from the Kauai Ocean Report. That data is obtained from the National Weather Service and provided by kauaiexplorer.com on a daily basis.

Preliminary Results To Date: Only three months of data has been obtained to date. Initial beach profiles were constructed in early to mid-November. The profiles of mid-December displayed relatively little change; although, particularly strong trade wind-driven longshore current along the southwest shore did appear to drive sediment westward a bit from Kekaha to PMRF. Our mid-January profiles did display significant changes at several of our beach profile localities. A series of large North Pacific swells were recorded during the intervening month, between the December and January observations. The beach at Majors Bay (PMRF) revealed a decrease in width of more than 70 meters, from greater than 175 meters to less than 105 meters, while the beach at MacArthur Park (Kekaha) displayed an increase in width of 35 meters, from about 45 to 80 meters. Sand was also observed to be accumulating a bit eastward to the park toward Kekaha. However, south shore waves have continued to reflect off the highway revetment creating a high-energy environment, making deposition of sand along the highway difficult. Results to date are encouraging, but of course we have a long way to go with this investigation. Our next beach surveys are planned for the middle of February, weather and surf permitting.