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Potential Regional Sediment Management (RSM) Projects in the Haleiwa Region, Oahu, Hawaii

by Thomas D. Smith

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) provides a summary of Regional Sediment Management (RSM) opportunities in the Haleiwa Region on the island of Oahu, Hawaii. The intent of this CHETN is the identification of potential RSM projects (PRPs) within the Haleiwa Region.

BACKGROUND: Regional Sediment Management (RSM) refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally sensitive and economically efficient manner. RSM changes the focus of engineering activities from the local or project-specific scale to a broader scale that is defined by natural sediment processes. A prime motivator for the implementation of RSM principles and practices is the potential for reducing construction, maintenance, and operation costs of federally authorized projects while increasing benefits. Implementing RSM principles also has the potential to positively impact linking multiple projects in their ability to realize authorized purposes.

RSM was officially implemented at the U.S. Army Corps of Engineer (USACE) Honolulu District (POH), Honolulu, Hawaii, in February 2004. Honolulu District's overall RSM strategy is to investigate RSM opportunities along all regions in Hawaii. To date, Hawaii RSM has been instrumental in quantifying coastal processes and identifying sediment related issues in various regions shown on Figure 1: (a) Island of Oahu (Mokapu Point to Makapuu Point (SEO), and Diamond Head to Pearl Harbor (D2P)); (b) Island of Kauai (Poipu and Kekaha); and (c) Island of Maui (Kahului and Kihei). The Honolulu District's RSM focus in Fiscal Year 2013 (FY13) was the Haleiwa Region on the north shore of Oahu. Figure 2 shows the sub-regions that comprise the region. From left to right in the figure, these sub-regions are (a) Kaiaka Beach, (b) Alii Beach, (c) Haleiwa Small Boat Harbor (HSBH), (d) Haleiwa Beach Park (HBP), and (e) Puaena Point Beach. Other priority RSM regions in Hawaii include Kaanapali in West Maui and Kapaa on Kauai.

Both HSBH and the Haleiwa Beach Restoration Project (fronting HBP) are federally authorized projects constructed in the 1960s. The general navigation features at HSBH consist of (a) an entrance channel (740 feet (ft) long, 100–120 ft wide, 12 ft deep), (b) a revetted mole (1,310 ft long), (c) a stub breakwater (80 ft long), and (d) a wave absorber (140 ft long). The non-federal sponsor for the harbor is the State of Hawaii, Department of Land and Natural Resources, Division of Boating and Ocean Recreation. A total of 11,000 cubic yards (cu yd) of sediment were dredged from the harbor in 1999 and 2009. The Haleiwa Beach Restoration Project consists of (a) a sand beach 1,600 ft long and 140–265 ft wide, (b) an offshore breakwater 160 ft long, and (c) a groin 500 ft long which defines the southern limit of the beach improvements. Construction of the beach restoration project was completed in April 1965 and repaired under the authority of of Public Law 84-99 in 1978. The non-federal sponsor for the beach restoration project is the State of Hawaii, Department of Transportation. Approximately 50,000 cu yd of sand were placed within the project

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limits as part of initial construction and the emergency repair. The project authorization states that the non-federal sponsor is responsible for ongoing maintenance of the project and that USACE may conduct emergency repairs to the project in accordance with Public Law 84-99.

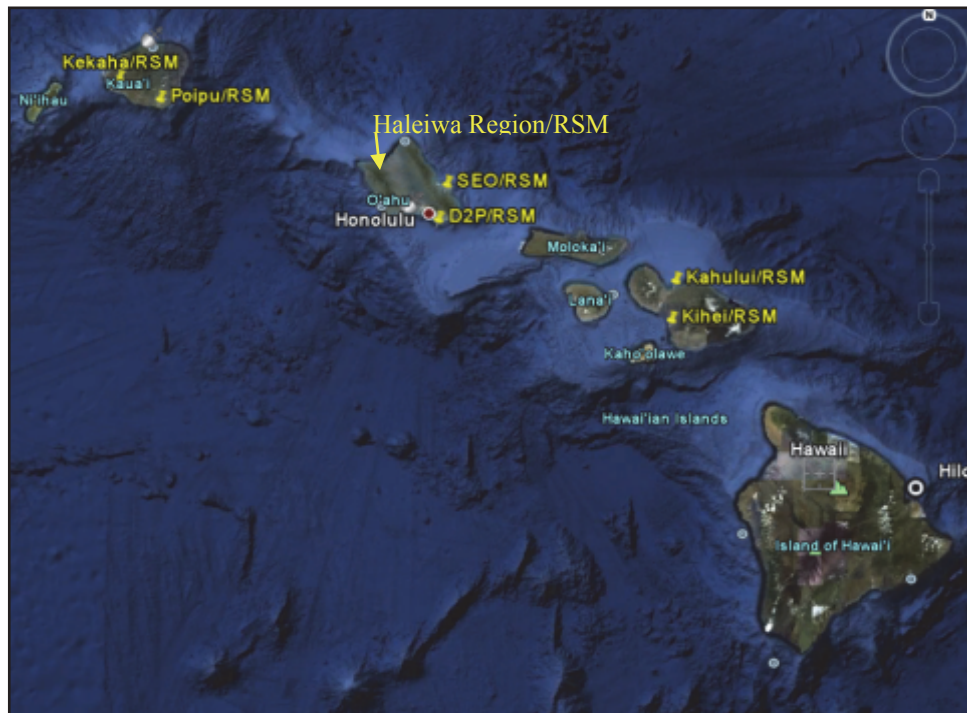


Figure 1. Hawaiian Islands showing existing Hawaii RSM regions, including Haleiwa Region.



Figure 2. Sub-regions within the Haleiwa Region.

APPROACH: Shoreline change for the region was quantified by the U.S. Geological Survey (USGS) in their report titled *National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands* (Fletcher et al. 2012). The USACE Coastal Inlets Research Program (CIRP) Coastal Modeling System (CMS) numerical models CMS-Wave and CMS-Flow (Sanchez et al. 2011) were implemented to simulate wave transformation and water circulation within the region. Prevailing (trade wind) and predominant (northwest swell) wind and wave conditions were simulated in steering mode to capture the interdependence of waves and currents. Additionally, the CIRP and Dredging Operations and Environmental Research (DOER) Program Particle Tracking Model (PTM) (McDonald et al. 2006) was utilized to identify dominant sediment pathways. An RSM workshop was held in June 2013 to engage stakeholder discussion about the issues within the region and to solicit input on PRPs. The workshop attendees met in the region and walked the shoreline to view the coastal morphology and existing structures firsthand. The results of the shoreline change analysis and coastal processes modeling (coupled with the workshop findings) culminated in the identification of six PRPs for the region.

Shoreline Change Analysis. Shoreline change rates were calculated from long-term and short-term shoreline data. All available shorelines were used for long-term rate calculations, and post-World War II shorelines were used for short-term rate calculations. A minimum of three historical shoreline positions were required when calculating a shoreline change rate with the technique employed by the USGS. For the USGS North Oahu Region, the maximum long-term erosion rate (-4.3 ± 2.6 ft/year (yr)) was found at Haleiwa Beach Park along a segment of shoreline landward of the Haleiwa Beach Park breakwater where the beach was completely lost at some time between 1988 and 2006. This beach has undergone substantial modification throughout its history, including construction of a groin, breakwater, seawall, and two beach nourishment projects (Hwang 1981; Sea Engineering, Inc. 1988).

Data utilized in the USGS shoreline change analysis were available in tabular as well as Geographic Information System (GIS) formats. Figure 3 is a graph of the USGS shoreline data for the 18 yr between 1988 and 2006. The figure indicates the long-term stability of the shoreline to the west (left in the figure) of Haleiwa Harbor and the erosive history of the shoreline to the east (right in the figure) of the harbor. Utilizing a conversion factor of 0.4 cu yd/square foot (sq ft) of shoreline change, the volume of material lost and gained in the region was estimated for this same time period (Figure 4). Based on this methodology, it appears that approximately 18,000 cu yd of sand eroded from the HBP shoreline over this time period.

Numerical Modeling. Figure 5 shows the resulting water circulation patterns simulated from a northwest swell condition with peak significant wave height of 26 ft, peak wave period between 16 and 22 seconds (sec), and wave direction of 320° . The general circulation patterns are dictated by the presence of relic stream channels offshore of Kaiaka Beach and Haleiwa Small Boat Harbor. The small black arrows in the figure indicate the direction of flow while current velocities are color coded in accordance with the legend in the top left corner of the figure (ranging from 0 m/sec in blue to 2 m/sec in red). Interpretation of the CMS-Flow results (large black arrows) suggests that flow enters the Kaiaka Beach channel from both the reef and the nearshore waters. Correspondingly, flow enters the channel offshore of HSBH from the reef fronting Alii Beach and also from the Haleiwa Beach Park shoreline.

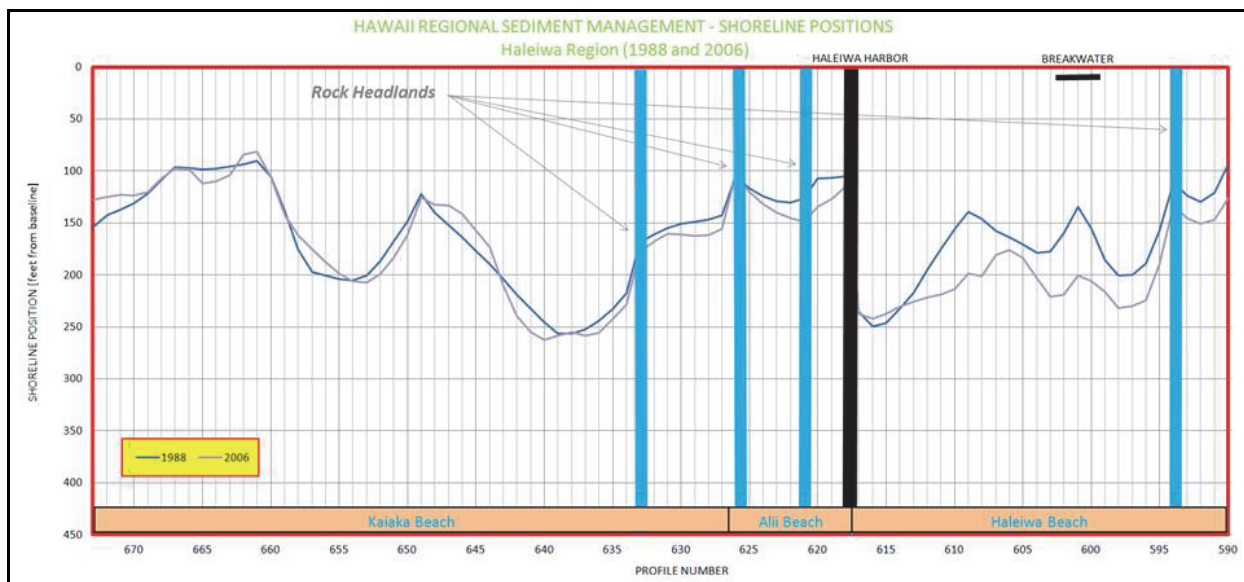


Figure 3. Shoreline changes within the Haleiwa Region from 1988 to 2006, as determined by U.S. Geological Survey (after Fletcher et al. 2012).

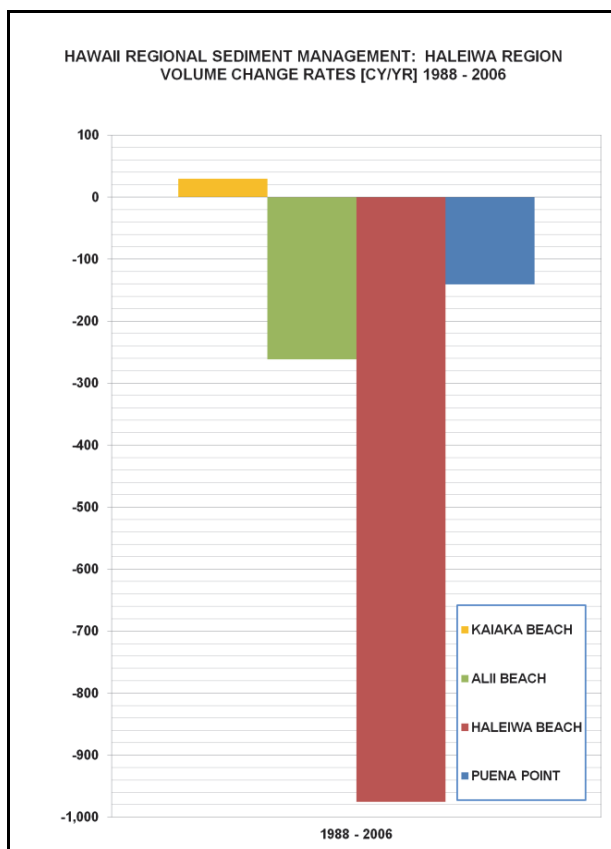


Figure 4. Volume change rates for the Haleiwa Region based on shoreline change measured by USGS (1988-2006), utilizing a conversion factor of 0.4 cu yd/sq ft (after Fletcher et al. 2012).

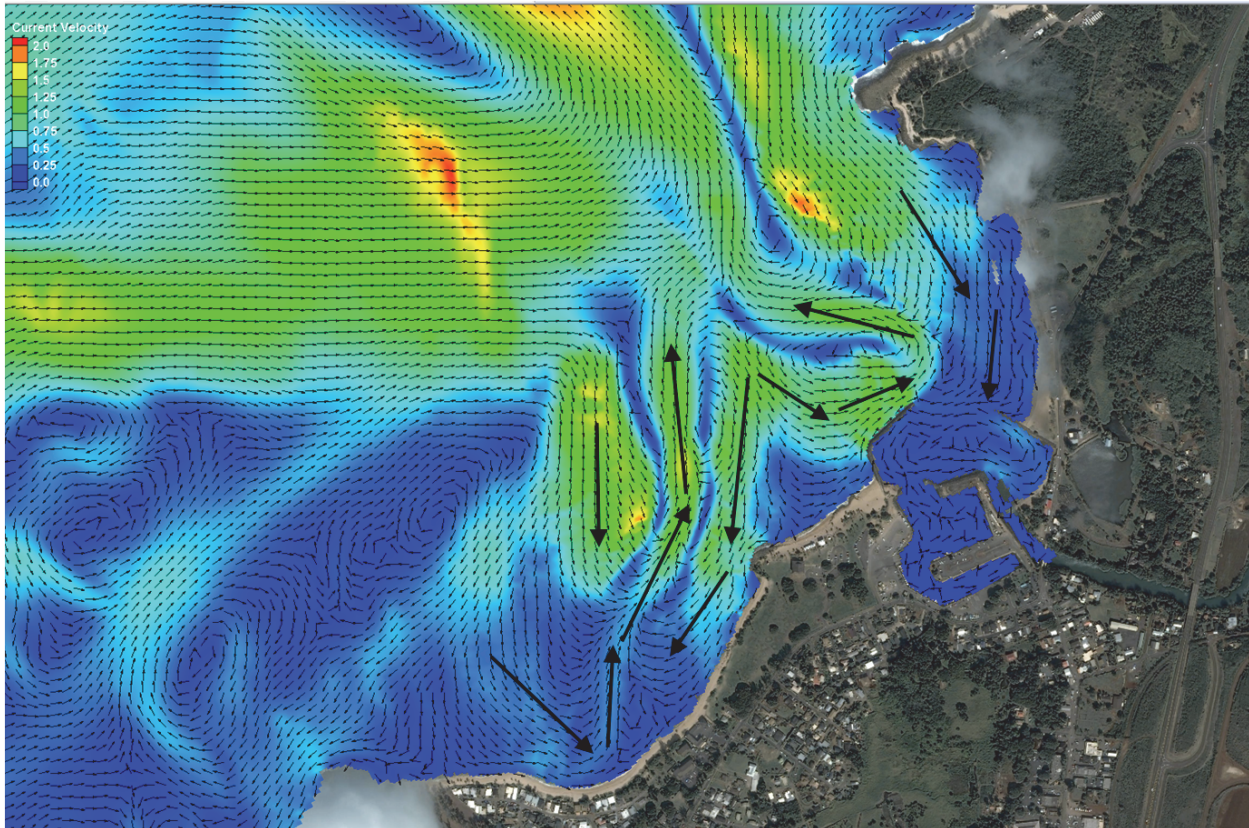


Figure 5. Wave-driven circulation simulated for a northwest swell with mean wave height of 26 ft, peak wave period between 16 and 22 sec, and wave direction of 320° .

The PTM provides powerful visualizations of potential sediment transport utilizing the results from both CMS-Wave and CMS-Flow. Figure 6 shows the PTM solution for the northwest swell scenario following 48 hours (hr) of model runtime. While some of the particles were transported into the HSBH sub-region (between the HBP groin and harbor main breakwater), the majority ended up in the adjacent stream channel (as would be expected from the CMS model results). The numerical models were unable to simulate sediment transport through the HBP groin.

POTENTIAL RSM PROJECTS: The Project Delivery Team developed conceptual plans for PRPs based on a general understanding of the regional shoreline changes and CMS model results along with the insight of regional stakeholders. The RSM workshop, held on 20 June 2013, featured focused breakout sessions on coastal processes, PRPs, and associated environmental considerations for the PRPs. The following PRPs were identified as being implementable, practicable, and environmentally acceptable; (a) reduce sediment transport into HSBH (Figure 7a); (b) facilitate beneficial use of dredged material from HSBH (Figure 7b); (c) develop sand sources (Figure 7c); (d) sand tighten the HBP groin (Figure 7d); (e) restore HBP (Figure 7e); and (f) construct additional shore protection structures at HBP (Figure 7f).

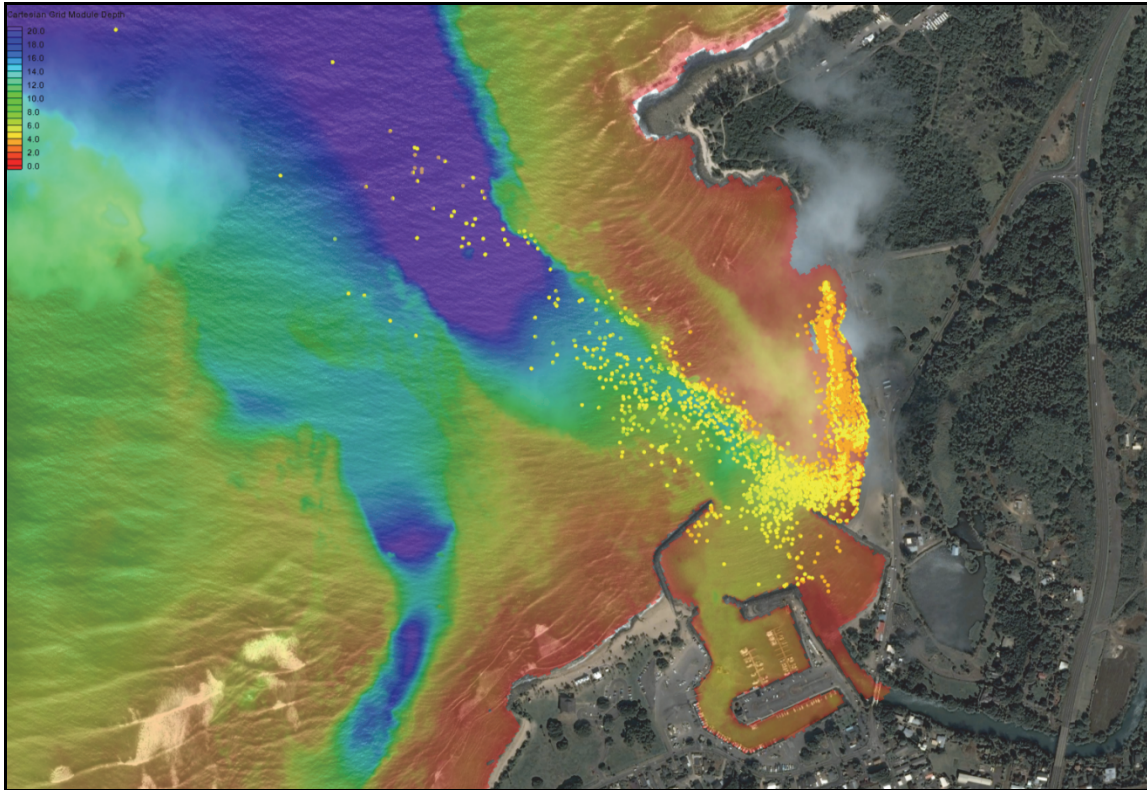


Figure 6. Particle Tracking Model (PTM) results for transport of sand from Haleiwa Beach Park shoreline under the northwest swell simulated by CMS-Wave and CMS-Flow over a 48 hr time period.

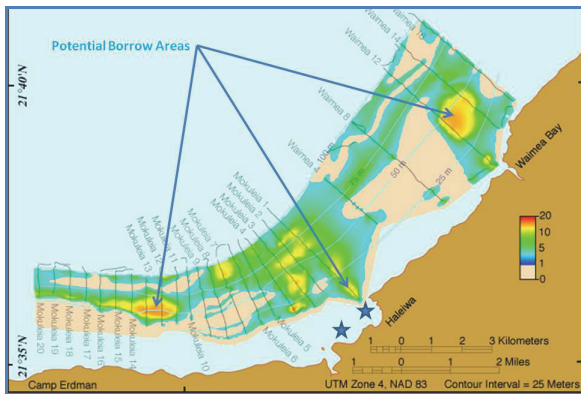
Reduce Sediment Transport into Haleiwa Small Boat Harbor (Figure 7a). Wave inundation overtops the crest of the State-owned main breakwater at HSBH during times of heavy surf (Figure 7a). Sand is deposited into the harbor by this mechanism, resulting in channel shoaling and development of an inner harbor beach. Measures that would decrease the amount of sand lost from Alii Beach and entering the harbor include (a) extending and raising the breakwater root, (b) constructing a wall to serve as a wave inundation backstop, (c) backpassing and/or bypassing sand from the eastern portion of Alii Beach, (d) grading the profile along the oceanside of Alii Beach periodically to reduce overtopping (engage with the City and County of Honolulu Department of Facility Maintenance), and (e) planting native vegetation on the backshore to promote dune growth. Bypassing sand from Alii Beach to the HBP shoreline may not be a viable option since the USGS shoreline change data indicate that Alii Beach is a slightly erosive littoral cell. There does not appear to be a substantial surplus of sand at Alii Beach; therefore, even the sand that has been transported to the harbor side of the breakwater might need to be passed back into the littoral cell. The logistics of excavating the wayward sand and identification of optimal placement location(s) need to be investigated.



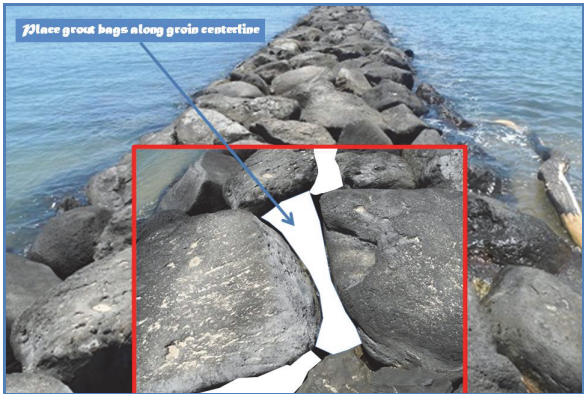
7a. Reduce sediment transport into HSBH.



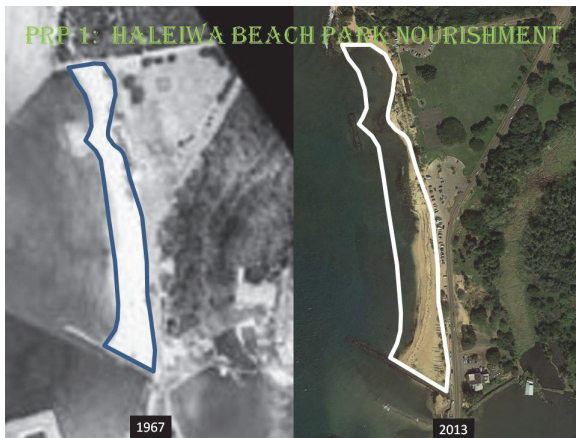
7b. Beneficial use.



7c. Develop sand sources.



7d. Sand tighten HBP groin.



7e. Nourish HBP.



7f. Headland control at HBP.

Figures 7a-f. Potential RSM Projects developed through investigation of historic shoreline changes, coastal processes modeling, and stakeholder input.

Facilitate Beneficial Use of Dredged Material from Haleiwa Small Boat Harbor (Figure 7b). Historically, maintenance material dredged from HSBH has been turned over to contractors who are responsible for disposal in adherence with all applicable local, state, and federal laws and regulations. Most of the material has been relegated to upland disposal sites with occasional beneficial reuse which takes material out of the system (e.g., landfill cover and

road construction). Figure 7b shows a representative sample of the material dredged from the harbor in 2009. Beach quality material was encountered in the entrance channel while finer grained sediment was found in the inner harbor. Actions that need to occur prior to the next maintenance dredging at HSBH include (a) developing a programmatic agreement among federal, state, and local governments as well as environmental resource agencies to place beach quality sand onto adjacent shorelines, (b) acquiring permits and land areas for stockpiling dredged material for eventual placement on the beach, (c) conducting a pilot project to demonstrate the capability to clean marginal quality material, and (d) engaging applicable environmental resource agencies that oversee protection of marine habitat.

Develop Sand Sources (Figure 7c). The volume of material typically dredged from HSBH is not enough to provide long-term sustainability of the region's beaches (even if it were all beach-quality material). Therefore, there is a need to develop viable sand sources and identify enough suitable material to maintain the region's beaches. The sediment pathways identified through CMS modeling indicate locations where sand is being deposited within the region (blue stars shown in Figure 7c). These areas could potentially be used as sustainable sand sources. A USGS study identified sand fields offshore of the region in relatively deep water (between the 100 and 150 ft-depth contours) as pointed out by the arrows in Figure 7c. There is potential that the Kaiaka Beach relic stream channel may also be a viable sand source. Investigations currently being conducted by the City and County of Honolulu are intended to identify additional offshore sand fields. These in-water sources as well as other upland sources (Hawaiian Cement still has material from the 2009 maintenance dredging of HSBH, and Makai Ranch is selling tsunami-deposited sand) need to be inventoried and developed through the permit process for future use within the region.

Sand Tighten the Haleiwa Beach Park Groin (Figure 7d). As indicated in Figure 4, the short-term erosion rate for the HBP shoreline is approximately 1,000 cu yd/yr. Coastal process modeling has shown that the material from the HBP shoreline is moving offshore into a relic stream channel and toward the HSBH to the west. Visual evidence indicates that a significant portion of the material is transported through the HBP groin. The porosity of the groin is estimated to be on the order of 20%–30% due to the large voids between armor stones, and also due to the apparent loss of underlayer stones. Sand tightening of the groin could reduce the erosion being experienced along the HBP shoreline. Sand tightening methods that could be considered include (a) rehabilitation of the structure (restore the underlayer and reset the armor layer), (b) placing a marine mattress on the inner side slope (the marine mattress could be held in place with a cover of larger stone), (c) pumping grout along the centerline (Figure 7d), (d) grouting the inner side slope, and (e) inserting/filling grout bags along the centerline.

Restore Haleiwa Beach Park (Figure 7e). The HBP shoreline has been nourished twice through the authority of the federally authorized Beach Restoration Project. Initial nourishment of the project occurred in 1965 with subsequent emergency repair to the project in 1978 following the impacts of several severe wave events. Approximately 70,000 cu yd of sand have eroded from the HBP shoreline since initial project construction. It appears that the majority of this sand is being directed offshore by the HBP groin (Figure 6).

The project footprint was digitized from the 1967 aerial photograph shown in the left panel on Figure 7e. To illustrate the extent of project restoration currently required, the project footprint

was superimposed onto the 2013 image shown in the right panel in Figure 7e. Evident in the figure, erosion is not uniform throughout the project area. Currently there is no dry beach to the east where erosion threatens to undermine the pavilion seawall. The pavilion itself will be in danger of being lost if the shoreline is not stabilized. In contrast, the western portion of the project is relatively wide due to the impoundment of sediment adjacent to the groin. As a temporary action, sand could be backpassed from the western portion of the beach to the east (placed behind the offshore breakwater). A more permanent solution would be to conduct full-scale restoration of the project, but there is no indication this will happen in the near term. The project was originally formulated for recreation; however, recreation is currently not a primary USACE mission. Also, the project is reaching the end of its 50 yr project life, and the non-federal sponsor (Hawaii Department of Transportation) is not anticipated to fund restoration.

Some stakeholders feel that beach nourishment is only a short-term solution. It was suggested that natural clues can provide insight to potential solutions (investigate Engineering With Nature (EWN) approaches. <http://el.erd.usace.army.mil/ewn> or <http://www.engineeringwithnature.org>). Others expressed the need to identify causes of the erosion and locate the areas where the sand is being transported to recycle it back onto the beach. A sand tracer study would facilitate investigations of the ultimate fate of material being lost from HBP. Moving structures back from the shoreline may also be a reasonable option if the upland area is comprised of beach-quality material. It will take a concerted effort between government agencies and concerned stakeholders to sort through all the available options, develop a sustainable strategy, and implement measures to stabilize the HBP shoreline (in accordance with applicable regulatory requirements).

Construct Additional Shore Protection Structures at Haleiwa Beach Park (Figure 7f). Ultimately, the HBP shoreline may not be stable without the benefit of additional coastal structures. Two conclusions that can be made from the shoreline change analysis presented above are that the HBP shoreline is not stable in the long term and the eastern portion of shoreline erodes faster than the rest of the project area. Existing coastal structures associated with the Haleiwa Beach Restoration Project include an offshore breakwater 160 ft long and a groin 500 ft long which defines the southern limit of the project. Tuned T-head groins are a proven method of increasing the retention time of beach nourishment. Figure 7f is a proposed PRP that would result in the restoration of the beach and the construction of shoreline stabilization structures. The original PRP proposed construction of two T-head groins (shown by dashed lines in the figure), one shore-connected stem that would connect to the existing breakwater, and two T-heads. One T-head would extend from the Puaena Point headland, and one would connect to the existing groin (which would also be sand tightened as part of this plan). In response to stakeholders input, the two T-head groins were deleted from the PRP due to concerns for recreational uses such as canoe paddling. The resulting project configuration would ensure shoreline stability in the eastern littoral cell and reduce (or potentially eliminate) the erosion rate along the remainder of shoreline. Wave transformation and water circulation modeling would be required to validate and fine tune structure design. Ultimately, a phased approach to implementation would be beneficial.

CONCLUSIONS: Shoreline change analysis for the Haleiwa Region on the north shore of Oahu was instrumental in the development of potential RSM projects. As shown in Figure 3, the Kaiaka Beach and Alii Beach shorelines have been relatively stable in recent years (1988–2006). Conversely, the Puaena Point and HBP shorelines experienced chronic erosion over the same

period. The Puaena Point littoral cell does not contain any threatened infrastructure unlike the HBP cell in which the shoreline has retreated within approximately 30 ft of an historic structure. Coastal processes modeling also informed PRP development by providing insight on general sediment pathways within the region. The modeling demonstrated the dominance of two relic stream channels on wave-induced flow patterns. Wave breaking and energy dissipation over the reefs result in return currents (from nearshore to offshore) that become entrained in the stream channels. Of particular interest was quantification of the impacts created by the construction of the HSBH. Since harbor construction in 1967, sediment has been transported into the littoral cell bounded by the harbor's main breakwater and the HBP groin. Sediment pathways into this cell include the beach face along the eastern portion of Alii Beach where wave inundation overtops the breakwater, through the porous HBP groin, through the gap between the breakwater and the groin, and from Anahulu River discharge. Reducing the amount of sediment entering the HSBH is just one of the potential RSM projects considered as part of the present studies.

Ultimately, shoreline change analysis, coastal processes modeling, and stakeholder engagement have resulted in the identification of six potential RSM projects in the Haleiwa Region. The PRPs presented in this CHETN include the following:

- a. Reduce sediment transport into Haleiwa Small Boat Harbor.
- b. Facilitate beneficial use of dredged material from Haleiwa Small Boat Harbor.
- c. Develop sand sources.
- d. Sand tighten the Haleiwa Beach Park groin.
- e. Restore Haleiwa Beach Park shoreline.
- f. Construct additional shore protection structures at Haleiwa Beach Park.

Below is a list of actions and future studies that need to be conducted in the Haleiwa Region as identified during the June 2013 workshop.

**Necessary studies and actions identified at the June 2013 Haleiwa Region workshop
pertinent to Coastal Processes, Potential RSM Project Implementation, and
Environmental Considerations.**

Coastal Processes

- Incorporate findings of the City and County of Honolulu Haleiwa Beach Park (HBP) study into an RSM Technical Note to include sand source investigations.
- Conduct a shoaling analysis to determine where sediment pathways are depositing sand in the region, and use those areas as sustainable sand sources.
- Investigate natural mineral tracers that may indicate where the sand is going.
- Identify the source of the problem, and look for natural clues that may provide solutions.
- Intercept excess sand before it goes over the breakwater at Alii Beach.
- Consider construction of dunes along portions of the Region's shoreline to reduce wave inundation.
- Provide public outreach on coastal processes and beach nourishment.

Potential RSM Project Implementation

- Sand tighten the HBP groin, nourish the beach, and monitor to determine effectiveness.
- Investigate operation and maintenance requirements for the HBP shore protection project.
- Identify likely sand sources for nourishment of the HBP.
- Conduct a sand tracer study for the HBP prior to construction of new coastal structures to determine where the sand is going.
- Grade the profile along the harborside of Alii Beach periodically to reduce wave overtopping of the breakwater.
- Stockpile material dredged from Haleiwa Small Boat Harbor (HSBH) for subsequent cleaning and eventual placement on the beach. Investigate/coordinate potential stockpile locations.

Environmental Considerations

- Engage applicable environmental agencies (including but not limited to USACE, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Hawaii Department of Lands and Natural Resources, and Hawaii Department of Health (DOH)) that oversee marine habitat.
- Continuously engage with DOH and other environmental agencies regarding benefits of managing sediment on a regional scale.
- Develop and execute a programmatic agreement to place beach-quality sand from harbors (i.e., HSBH) onto adjacent shorelines.
- Coordinate the use of offshore sand sources in the region with environmental agencies.
- Identify species of concern, including corals, sea turtles, monk seals, shorebirds, etc.
- Conduct surveys to quantify the density of marine resources.
- Quantify impacts to organisms within and adjacent to the HSBH breakwater and HBP groin.

POINTS OF CONTACT: This Coastal and Hydraulics Engineering Technical Note (CHETN) was prepared as part of the USACE Regional Sediment Management (RSM) Program and was written by Thomas D. Smith, U.S. Army Corps of Engineers Honolulu District (POH), Honolulu, Hawaii, with input from the Hawaii RSM Product Delivery Team. Smith is the USACE Pacific Ocean Division (POD) RSM Point of Contact (POC). Additional information regarding the Haleiwa Region sediment budgets has been developed by Podoski (2014). Additional information pertaining to Hawaii RSM can be found at <http://gis.poh.usace.army.mil/rsm/index.htm> and at the RSM Program website <http://rsm.usace.army.mil>.

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