I. Project Information

NOAA Grant Number: NA11NOS4820006

Project Title: Sediment Retention at Honokōwai Structure #8, Wahikuli-Honokōwai Priority Site

PI and Staff:

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II. Executive Summary

Land-based source pollutants, including sediments, nutrients and organic matter, are considered one of the primary threats to coral reef ecosystems in West Maui. Land use changes from fallow agricultural lands to housing and development are anticipated in the next 20 years. Sediment retention basins are one of the infrastructure recommendations available to limit sediment to the coast. The West Maui Watershed Management Plan recommended that Honokowai Reservoir #8 could be improved to retain more sediments during storm events.

We evaluated Honokōwai watershed hydrology, original debris basin design parameters, and existing basin characteristics, operations and performance to estimate the effects of different retrofit options on sediment retention capabilities for different interval storm events (2, 5, 10, 25, 50 and 100 year), land use conditions and grain sizes. We used the watershed model GSSHA to estimate discharge and sediment load, and the basin model SWMM to consider the retention capabilities of the dam structure for 16 different design alternatives and five different sediment grain sizes.

Given that for low magnitude and more frequent runoff events (2 year recurrence interval) the target load reduction is 70 percent, we selected several retrofit scenarios for the port openings on Honokowai dam. The recommended modification scenario can be accomplished by installing plates over all eight of the existing 12’ x 24” openings with the upper 6 plates containing 6” diameter openings. Results show that for the 2-yr design storm, this would result in a detention time of 78 and 83 hours for current and future land use scenarios, respectively. The corresponding overall sediment removals would be 84% and 74% (compared to 50% in the existing as-built scenario). The amount of clay sediment passing through the basin during a 2-yr storm will be reduced from 348 tons to 134 tons for current land use and from 513 to 200 tons for future land use (61% improvement). However, all larger storms were estimated to pass over the primary spillway and were not predicted to be highly affected by structural modifications.

III. Purpose

A. Management problem addressed

The Honokowai watershed has been listed as a priority of concern in the NOAA R2R Initiative. Honokōwai Structure #8 consists of a dam and debris basin that impounds and detains the flow of Honokōwai Stream. The existing structure—built in 1991and owned and operated by Maui County, Department of Public Works—delivers fine sediment, coarse debris, and other pollutants to coastal waters and coral reefs via two pathways:

- A concrete outlet structure located near the bottom of the basin that contains eight openings to contain and slowly release low magnitude runoff events (≤ 2 year recurrence interval) and a large primary spillway box that discharges larger runoff events (> 2-yr and < 100-yr), and
- Runoff from extreme storm events (≥ 100-yr) that passes through the unlined erodible channel of an emergency spillway.

The Wahikuli-Honokōwai Watershed Management Plan (Sustainable Resources Group International 2012) established an objective to "[i]ncrease trapping efficiency of fine sediment in the basin by 50 percent thereby decreasing the sediment load discharging . . . to the ocean" (Volume 2, p. 37). More specific goals are 70% sediment capture for low magnitude/more frequent runoff events (≤ 2 year recurrence interval) and 40% capture for discharges between the 2 and 25 year recurrence interval events.

Figure 1 shows the existing dam for Honokowai Reservoir #8. All eight port openings are currently permanently in the open position. This means that for all but the biggest storms, sediment-laden discharge from Honokowai reservoir is able to pass through the dam with minimal time in the reservoir to settle out. To address this problem, this project considered design alternatives that might increase the trapping efficiency of the reservoir through modification of the current dam structure.

Figure 1: Honokawai reservoir drainage port openings. Sixteen design scenarios considered combinations of closing and modifying the openings of the reservoir to alter the drainage times, and the sediment retention, in Honokowai #8 reservoir. Evidence of recent sediment removal in front of the ports is seen in this photo from September 2014.

B. Overarching goal(s) and objective(s) of the project

The objectives of this project were as follows:

1) Reevaluate Honokōwai watershed hydrology, original debris basin design parameters, and existing basin characteristics, operations and performance;
2) Establish a monitoring program to collect field data for evaluation of the hydrological model
3) Analyze potential trapping efficiency and sediment retention for a suite of design alternatives;
4) Analyze potential trapping efficiency and sediment retention for current and future land use; and
5) Evaluate the cost-effectiveness, dam safety ramifications, and hydrologic impacts of various retrofit approaches in reducing basin-delivered sediment loads.

IV. Approach

A. Detailed description of the work that was performed (by objective)

1) Reevaluate Honokowai watershed hydrology

The watershed hydrology was modeled using the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model to make predictions of runoff hydrographs for 2-, 10-, 25-, 50-, and 100-yr recurrence storms using published rainfall data. The predictions of basin performance were modeled for both the as-built condition (from design plans) and for assumed conditions of legacy sediment accumulation.

To calibrate the model for each of the 5 design storms, existing stream peak flow records (1961-2009) were statistically analyzed using a Log-Pearson type III distribution.

We had initially hoped to calibrate the model using 2014 data collected in Honokowai during the 2013-2014 rainy season. The equipment to monitor discharge, turbidity and suspended sediment into Honokowai #8 was specified and purchased for this project. A proposal letter was submitted to the Maui County Department of Public Works (DPW) to install the equipment for the duration of the project period to collect data to calibrate and validate the GSSHA model described above. Unfortunately, we were not able to secure access in time to deploy the equipment. We plan to continue to work with the DPW to guide installation of the monitoring equipment in the coming year, and will adjust the model results as necessary, if we have new data.

2) Analyze potential trapping efficiency for a suite of design alternatives

The routing of runoff through the basin and the retention of sediment in the basin were modeled using EPA's Storm Water Management Model (SWMM). Basin sediment retention performance was modeled for the existing outlet structure and 16 different modifications thereof. The 16 scenarios are described in Table 1.

Table 1: Description of retrofit scenarios modeled with SWMM to estimate effects of trapping efficiency of sediment. Highlighted scenarios were found to meet retention objectives (70% retention) for 2-year storms in the watershed.

Scenario	Description
A	Existing Condition, all eight ports open
B	Ports #1 and #2 Closed; #3, 4, 5, 6, 7, 8 Open
C	Ports #1, 2, 3, 4 Closed; # 5, 6, 7, 8 Open
D	Ports #1, 2, 3, 4, 5 , 6 Closed; #7 ,8 Open
E	All-closed condition, all ports closed
F	Ports #l, 2 , 3, 5, 7 Closed; #4, 6, 8 Open
G	Ports #1, 3, 5, 7 Closed; #2, 4, 6, 8 Open
H	Ports #l, 2 , 3, 5, 6, 7 Closed; #4, 8 Open
I	Ports #1, 2 Closed; #3, 4, 5, 6, 7, 8 Change Port to 1 ft diameter circular port, Open
J	Ports #1, 2, 5, 6 Closed; #3, 4 , 7, 8 Change port to 1 ft diameter circular port, Open
K	Port #1, 2, 5, 6, 7, 8 Closed; #3, 4 Change port to 1 ft diameter circular port, Open
L	Port#1, 2, 5, 6, 7, 8 Closed; #3, 4 Change port to 9 inch diameter circular port, Open

M	Ports #1, 2, 5, 6, 7, 8 Closed; #3, 4 Change port to 6 inch diameter circular port, Open
N	Port #1, 2, 5, 6 Closed; #3, 4 , 7, 8 Change port to 9 inch diameter circular port, Open
O	Ports #1, 2, 5, 6 Closed; #3, 4 , 7, 8 Change port to 6 inch diameter circular opening, Open
P	Ports #1, 2 Closed; #3, 4, 5, 6, 7, 8 Change port to 6 inch diameter circular opening, Open
Q	Ports #1, 2 Closed; #3, 4, Change port to 9 inch diameter circular port, Open; #5, 6, 7, 8 Change port to 6 diameter circular port, Open

3) Analyze potential trapping efficiency for current and future land use

Existing and future land use scenarios were input into GSSHA to predict sediment flows (for 5 different particle sizes) from the watershed into the debris basin for each of the statistical storm events. The current land use map was acquire from the 2010 Landfire dataset. For future scenarios, it was assumed that all land currently classified as fallow/grassland would transition to medium development during the future life of the reservoir. Estimates of changes in both discharge and sediment load were made for the two land use scenarios. These estimates were then used as inputs to the basin retention model.

4) Evaluate the cost-effectiveness, dam safety ramifications, and hydrologic impacts of various retrofit approaches

After the initial results for changes in trapping efficiency were calculated, a reduced number of scenarios were more thoroughly considered. Specifically, scenarios J, K, L, M, N and P were analyzed for feasibility, design considerations, sediment trapping efficiency for current and future land uses, and for all intervals of storms.

B. Project management: List of individuals and/or organizations performing the work.

The project was executed by the Water Resources Research Center at the University of Hawaii at Manoa.

Data was made available by the following organizations:

- DLNR Engineering Division, Dam Safety Program, coordination and permit issuance for dam retrofit under the Hawai‘i Dam and Reservoir Safety Act of 2007.
- U.S. Geological Survey, Pacific Water Sciences Center and estimates of low flow and event discharge in Honokowai stream.

V. Results

A. Accomplishments and findings

Using synthetic rain events, this project was one of the first to estimate event discharge and sediment export in west Maui using a model that estimated both sheet and channel erosion. The GSSHA modeling efforts resulted in peak watershed runoff flows which range from approximately 550 to 4,700 cfs for 2-

and 100-yr statistical storms, respectively. The GSSHA-predicted total sediment flows ranged from approximately 1,000 to 45,000 tons for 2- and 100-yr statistical storms, respectively.

Sediment samples were collected at three deposition points in west Maui and analyzed for grain size and settling velocity. Significantly, the project found that fine sediments settle very slowly and are only effectively removed if detention times are greater than or equal to 48 hours, because of the slow settling time of fine sediments. For the current land use scenario, the clay sediment fraction represent 35 to 45% of the total mass depending on the storm size. The small silt fraction represents an additional 16 to 19% of the total mass.

The project also made estimations to compare current land use with a future land use scenario where fallow agriculture land was developed. The future land use scenario results significantly increased amounts of very fine sediments that will damage the receiving reefs.

The SWMM simulations found that for the current land use scenario, the as-built overall sediment trapping efficiency of the basin is between 50% and 36% for the 2- and 100-yr storm events, respectively for associated detention times of 13 and 16 hours, respectively. Values for other statistical storm magnitudes fall between these values. The detention times and trapping efficiencies were not substantially altered when the basin stage-volume curve was modified to simulate the presence of accumulated legacy sediments (or sediment that might currently exist within the basin). This leads to the conclusion that it would not make sense to excavate the sediments that have accumulated in the basin over its nearly 20-year life. The SWMM simulations found that only the 2-year storm event is fully contained in the basin below the elevation of the primary spillway and therefore can be effectively and substantially affected by modifications to the outlet structure.

All larger storms were estimated to pass over the primary spillway and were not predicted to be highly affected by structural modifications, effectively making the 2-yr storm the design storm.

Several modification scenarios (called J, K, L, M, N and P) could achieve the pollution reduction goal of 70% sediment capture for the design storm with existing land use conditions, however, many fewer scenarios (L, M and P) could also achieve this goal for the predicted future land use conditions. Scenarios L and M consist of only 2 reduced-size outlet openings compared to the current 8 large openings and may be highly susceptible to outlet clogging (increased maintenance requirements).

The recommended modification scenario is scenario P which can be accomplished by installing plates over all eight of the existing 12’ x 24” openings with the upper 6 plates containing 6” diameter openings. For the 2-yr design storm, this would result in a detention time of 78 and 83 hours for current and future land use scenarios, respectively. The corresponding overall sediment removals would be 84% and 74% (compared to 50% in the existing as-built scenario). The amount of clay sediment passing through the basin during a 2-yr storm will be reduced from 348 tons to 134 tons for current land use and from 513 to 200 tons for future land use (61% improvement). Similarly, the amount of small silt sediment passing through the basin during a 2-yr storm will be reduced from 128 tons to 20 tons for current land use and from 97 to 15 tons for future land use (84% improvement).

VI. Applications

Throughout the retrofit modeling process, an open dialogue was maintained between the project group and Tova Callender, West Maui Watershed Coordinator. At several points, the status of our project was communicated with the Maui County Department of Public Works (DPW). Further, a site visit was conducted in September 2014 to investigate the site, and to continue collaboration efforts with the DPW. Communication was maintained, as well, with the DLNR Dam Safety office to ensure that retrofits would not require additional permits. The DLNR Dam Safety office was able to work with us to acquire the as-built drawings for Honokowai #8, which allowed us to estimate the area-volume capacity curves for the basin.

During the project, five graduate students participated in and were trained in the modeling efforts; two of the students will use this training to complete modeling efforts for the rest of the west Maui priority watersheds. Additionally, an undergraduate level class in watershed hydrology used this project as a final design project in Spring 2014.

The main product of this project was a comprehensive technical report describing in detail the methods and results of our research. A scientific manuscript is in preparation, as well, to be submitted by early 2015. The report will be distributed to the Maui County Department of Public Works and the Army Corps of Engineers to assist in planning efforts. As this is the first report to consider the operational efficiency of retention basins, we believe it will be useful moving forward in the planning process for all five watersheds during the current Army Corps of Engineers process. As Honokowai #8 Reservoir has a similar design to seven other reservoirs in the islands built around the same time for a similar purpose, including Kahana Reservoir in Kahana watershed, these analyses can be replicated for other reservoirs based on the same method.

The project was presented by Dr. Babcock at the West Maui Ridge to Reef Researchers meeting in March 2014.

VII. Evaluation

The project fulfilled the main objective: to evaluate different retrofit options for Honokowai Reservoir #8. We combined watershed modeling with basin retention modeling to consider how much sediment would be exported to the coast for different storm intervals, for current and future land use scenarios, and for different levels of sediment build-up present in the reservoir to evaluate 16 different configurations of openings in the dam.

The project start was delayed due to contracting issues and was completed in seven months instead of twelve. Therefore, planned instrumentation for flow and sediment sampling during one wet season at the basin outflow could not be accomplished. However, the instrumentation was purchased and it is recommended that it be deployed and operated during the 2014-15 wet season in order to obtain a data set for possibly enhanced calibration of the GSSHA watershed model. If the model outputs (water and/or sediment flows) are modified, then the sediment capture can be re-evaluated using SWMM.

Final Report Prepared by: _____ Date submitted: _____

Signature of Point of Contact: _____