Maunalua Bay Stream Retrofitting Report

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Introduction

Situated on the southeast shores of O'ahu between Black Point (Kuikipiki'o) and Kawaihoa Point, Maunalua Bay stretches for approximately 28 miles. In its current state, the Bay consists of shallow reefs that extend for 1,000 yards offshore. Of the ten major streams that feed into Maunalua Bay, Wailupe Stream is the only non-hardened (concrete-lined) stream (Mālama Maunalua, 2009). However, there is some community support to harden it based on recent flooding events (SRGII, 2010). Over the years, the area surrounding the Bay has seen a dramatic shift towards urbanization and as a result, the anthropogenic effects have negatively impacted the waters and the reefs of the Bay. One of the main causes of degradation is the increased sediment loads from the Wai'alae watershed to Kuli'ou'ou watershed (Atkinson, 2007). This is a direct result of the channelization and hardening of the streams within the ten watersheds which has increased the discharge into the Bay. In addition to the higher sediment loads, groundwater springs that once fed the Bay, have either been diverted or contaminated by Black Point cesspools (Richardson, Dulai, Whitter, 2017). The purpose of this report is to examine pathways to reduce sediment load by examining upstream solutions and instream retrofitting options for the ten streams that feed into Maunalua Bay.

History of Study Site

Maunalua Bay has always been an important place for Native Hawaiians and their culture. Prior to European contact, the area had an abundant marine life and loko i'a's, or fishponds, that supported the native population and provided fish year-round. Between the 1880s-1950s, management of Maunalua Bay changed. Native vegetation was cleared for cattle and sugar plantations, often resulting in the introduction of non-native flora and fauna that expanded into the upper reaches of the Ko'olau watersheds above the Bay. Urbanization ramped up in the 1950s and much of the land was converted into housing developments. As a result of land development, ponds and wetlands were covered up and filled with sediment thereby increasing the concentration of salt water into these once freshwater, estuarine areas. Additionally, as part of the urban development, most of the streams and tributaries in the watershed were channelized or diverted to make way for housing and reduce flood risk.

Problem

The population across Hawai'i has more than doubled since 1960 (U.S. Census Bureau, 2011). Urbanization and population expansion often lead to control of waterways to minimize flood risk (Allen & Leceh, 1997). The number of impervious surfaces within communities, such as roofs, roads, sidewalks, and channelized streams in combination with high-intensity rainfall experienced in tropical climates has led to significant increases in runoff. Increased runoff results in higher concentrations of surface sediments that flow into drainage systems and end up in the ocean. To mitigate flood risk to adjacent communities, the City and County of Honolulu along with the U.S. Army Corps of Engineers has ‘channelized’ and ‘hardened’ nine out of the ten major drainage streams that feed into Maunalua Bay. Channelizing streams consists of straightening meandering streams to discharge water into the Bay more quickly. Furthermore, the ‘hardening’ of drainage streams consists of lining the drainage with concrete to further expedite the discharge of water to prevent flooding (Mālama Maunalua, 2009). Due to all of these impervious surfaces, much of the Maunalua region has lost its natural hydraulic function (Personal communication).

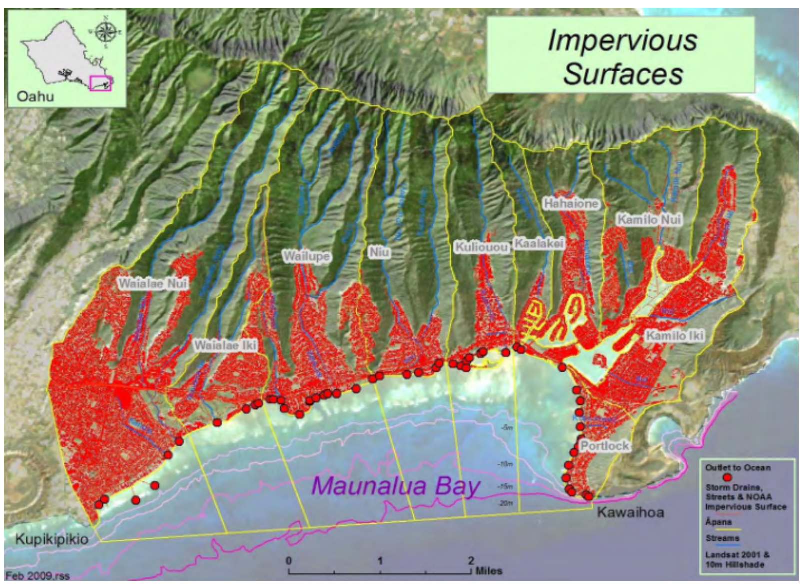

Figure 1: A map of Maunalua Bay and the 10 watersheds that feed into the Bay. This map also depicts all storm drains and outlets that feed into the ocean (Landsat 2001, Mālama Maunalua, 2009)

Definitions

Removing concrete from the stream beds and restoring it to a more natural state, also known as *softening*, is one of many options to slow pulse-runoff events feeding into Maunalua Bay. Retrofitting is the process of installing or undertaking additional or alternative stormwater management devices or approaches in an existing developed area (DESRT, 2006). In existing urban areas, there are retrofitting opportunities to achieve multiple objectives, including flood mitigation. Retrofitting a hardened stream can serve the dual function of reducing stormwater volume, allowing water to seep back into groundwater through the hyporheic zone and improving the quality of water that is discharged into Maunalua Bay (Richardson, Dulai, Whitter, 2017). This leads to improved ecosystem health and increased water conservation for the State of Oʻahu (DESRT, 2006).

Systems Map

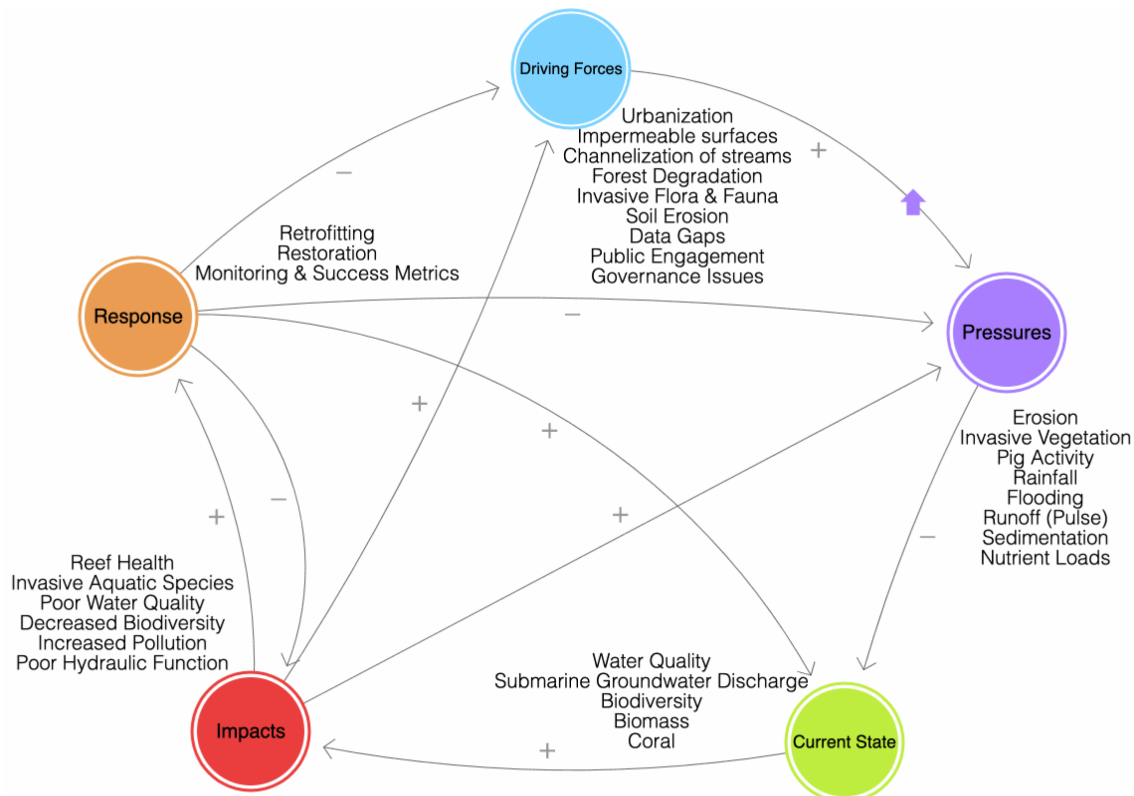

Figure 2: Systems Map utilizing the DPSIR (Driving Forces (D), Pressures (P), Current State (S), Impacts (I), Response (R)) Framework.

Flow Chart

This research is broken down into discrete modules of information highlighting system-wide issues that need to be addressed in order for sedimentation in the Bay to effectively be reduced. The DPSIR Framework views a system through five key leverage points: driving forces, pressures, current state, impacts, and responses. These five points interact with one another in multiple ways forming various feedback loops that form and shape the system of interest. Applying this framework to the Maunalua Bay system with the data available through literature review and expert elicitation, we were able to identify key processes that must be considered when trying to implement retrofitting options. This Report focuses on pathways towards upland and in-stream options with the primary goal of reducing sediment loads that reach the Bay. This flowchart and three stage process guideline illustrates the dynamic decision-making process that precedes any implementation of retrofitting or restoration.

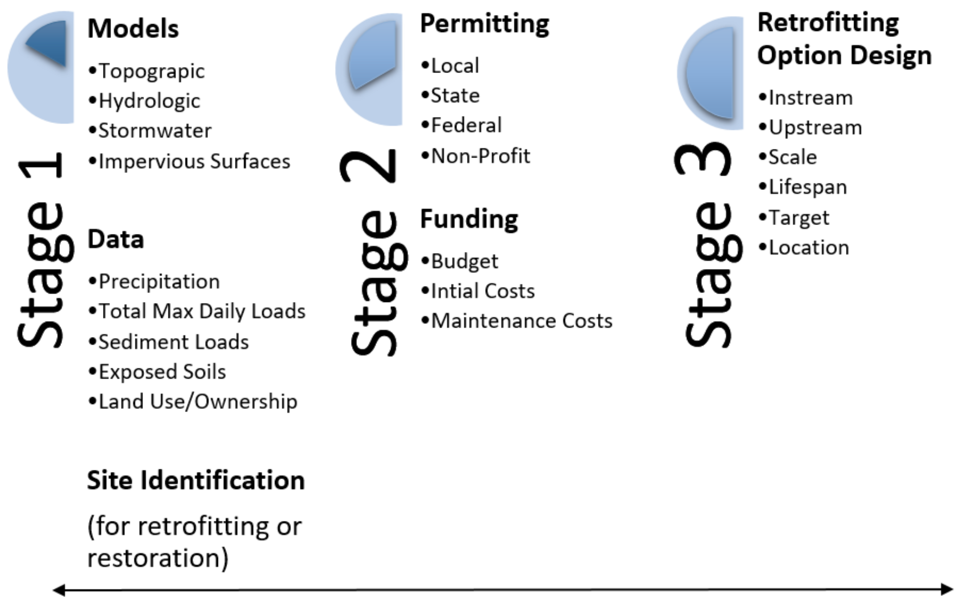

Figure 3: A layout of the three-stage approach that identifies key steps towards the implementation of retrofitting at target sites.

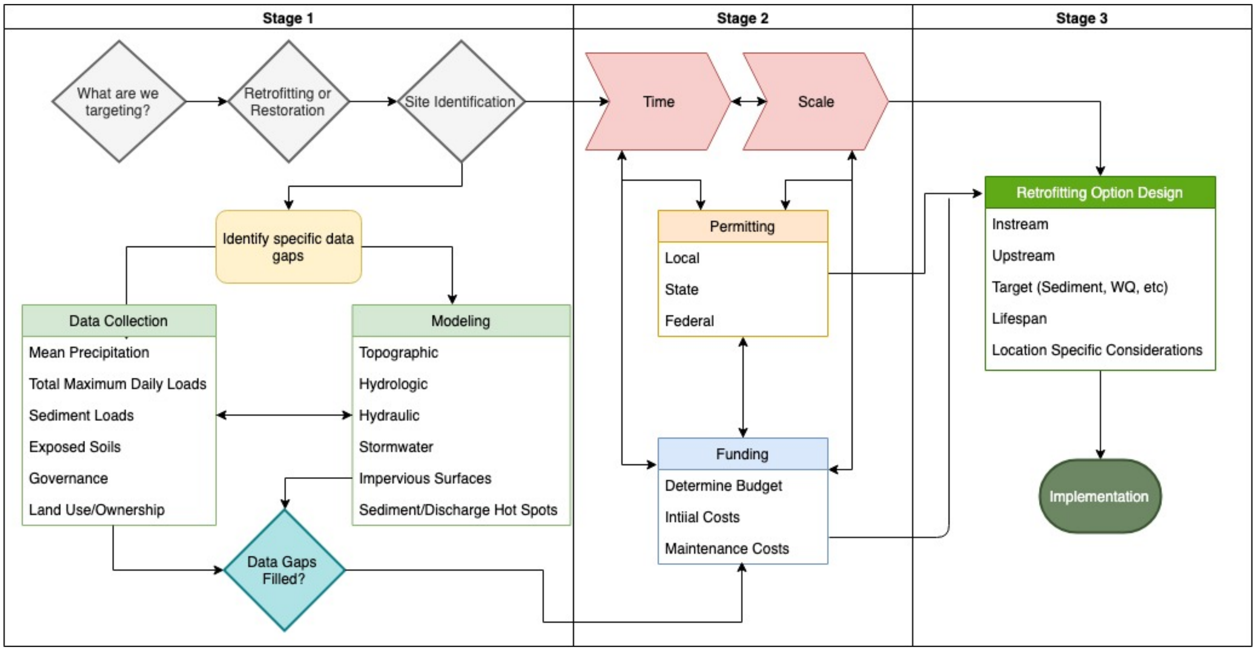

Figure 4: Flowchart that illustrates the three-stage approach towards installing retrofitting solutions and reducing sediment from entering the watershed and into Maunalua Bay.

Each step in the flowchart illustrates individual milestones that represent a process or project that needs to be completed before moving on to the next step. Decision points are identified with different shapes and colors that represent information deficits or important processes that must be completed before further progress can take place. The flowchart begins in Stage 1 with the initial question "What are we targeting?". This question sets the tone for the entire decision-making process, as all decisions are geared towards reducing sediment, water volume, velocity, improving water quality or any combination thereof. Each stage shows the sequence in which these steps need to be accomplished. While both charts are broken down into distinct stages, many of the decisions or steps can be completed or undertaken simultaneously. The stages are suggestions from experts to make the process follow a logical sequence.

System-Wide Issue

It is important to note that retrofitting is a singular solution to a system-wide issue in the watersheds that flow into Maunalua Bay. Current urban infrastructure and channelized systems cannot be removed without serious ecological and economic impact, let alone displacing thousands of East Honolulu and Hawaii Kai residents. Channelized streams may mitigate flood risk to residents but effectively serve as an expedited delivery system for sediment traveling from the top of the watershed down to the Bay. However, applying in-stream retrofitting or restoration solutions to the channelized stream systems, to mitigate sedimentation is too narrow in scope. It may reduce the amount of sediment entering the Bay but would only be a temporary and ineffective solution without looking at the system as a whole. The degraded ecosystem health in the Bay is the product of years of development that neglected to consider ecological impacts to the health of the system. To reverse this process, instream retrofitting options need to be part of a suite or chain of actions that address all factors impacting the quality of water entering the Bay.

Apart from in-stream retrofitting solutions, sediment entering the stream network can be prevented from entering the channelized stream system through upland restoration. Invasive plant and animal species, most notably feral ungulates, are the primary culprits behind increased soil erosion in natural areas above the watershed's urban centers. Restoration of the degraded upland stream area is necessary to reduce excessive amounts of sediment from entering the channelized streams and should help Maunalua Bay reef system avoid further degradation.

Targeted in-stream retrofitting options can reduce streamflow velocity, volume, improve water quality, and capture sediment. Many of these options can also be applied to natural stream areas for site restoration. Additionally, stormwater runoff from adjacent urban areas to channelized streams pose a serious threat to water quality, volume, and velocity. Impervious surfaces in urban areas prevent infiltration of surface water into groundwater networks and instead direct runoff into the channelized streams. When combined with the spatial brevity of the watersheds in Hawai'i, a minimal lag time between precipitation and increased streamflow creates violent pulse events.

Modeling and Data Collection

As identified through expert elicitation, Maunalua Bay's watershed has significant data gaps for water resources outside of the Bay itself. To our knowledge, there is little to no data on the hydrological functions of the watersheds in this area. Hydrological or topographical models, stream gauges, or historic datasets are needed. Without this data, it may prove difficult to support or prove that proposed modifications to the streams, stormwater system, or riparian areas are having an impact. Data could also help indicate sources of sediment inputs, such as conservation or urban land-use areas. It should be noted that the USGS provides guidance on how to model or make an assumption for a watershed that does not have data collected (U.S. Department of Interior & USGS, 2017).

Obstacles

Governance and permitting will be a primary obstacle to overcome when trying to modify the streambed or surrounding area. There is no database or map available to the public to determine land ownership or point of contact. Land ownership spans local, part-time residents, the City and County of Honolulu, the State of Hawaii, and federal U.S. government. Each of these actors has different protocols and permits that must be completed before any modifications can take place. In most situations, multiple actors become involved in the process before modifications can occur. Currently, no accessible protocol is in place to guide any interested party through the permitting process. This can hinder or dissuade those interested. It is highly encouraged that future research or projects on retrofitting in the Maunalua Bay area focus on navigating the various governance and permitting issues involved.

Bridging the Gap

The Hawaiian proverb "*E Mālama ʻoe I ka ʻĀina, e Mālama ka ʻĀina ia ʻoe"* translates to 'take care of the land and the land will take care of you'. The common belief is that local residents and businesses want Maunalua Bay restored, but the details of what actions they want to take and the depth of their feelings are unknown. Urbanization and development are key contributing factors to the channelization of the watershed streams and the declining health of the Bay's ecosystem. Contrarily, from interviews conducted the local population have now become essential stakeholders and the perception is that they want the Bay and surrounding natural areas to be restored and flourish (personal communication). If measures are taken to galvanize the populous into action, many of the obstacles mentioned in the preceding text can be overcome. There needs to be an open and transparent dialogue between the various actors on what the expectations for the future of the Bay should be, as well as the steps to make those expectations a reality.

Solutions

See Appendix A

Methodology

See Appendix B