SAFEGUARDING CORAL REEFS

with a Curb-cut Rain Garden

Planning, installation and lessons learned from a Demonstration Project in West Maui:

Creating a Curb-cut Rain Garden in the Kāʻanapali Parkway median to filter irrigation and storm water runoff

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CORAL REEF ALLIANCE

THE CAMPBELL FOUNDATION

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The Coral Reef Alliance (CORAL) is an international nonprofit that unites communities to save coral reefs. In Hawaiʻi, CORAL is working with local partners to improve water quality for reefs and people through its Clean Water for Reefs Initiative.

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Problem

For much of the last century, the prevailing philosophy guiding stormwater management in the United States was to protect homes and businesses from flooding, so storm drains and other infrastructure were designed with the goal of getting stormwater away from human-populated areas as quickly and efficiently as possible. Because of this historical legacy, most storm drains in Hawaiʻi still flow directly or indirectly into the ocean. This means that when it rains, all sort of pollutants – from fertilizers from golf courses to oil on people's driveways to fallen leaves – end up traveling down storm drains and getting dumped into the ocean, often directly on top of the coral reefs.

Solution

Low Impact Design (LID) Practices prevent stormwater pollution from reaching the ocean by seeking to mimic natural processes in undeveloped areas that allow storm water to be slowed down, stored, filtered, or sunk into the ground. The Hawaiʻi Coral Reef Strategy (HCRS)'s West Maui Watershed Management Plan has identified LID systems as an effective means of reducing water pollution.

Rain gardens are an example of an effective, relatively low-cost LID Practice. It is a landscaped depression in the ground designed to collect a predetermined volume of storm water runoff from rooftops and other impervious surfaces. When it rains, rain gardens fill up with a few inches of storm water. Afterwards, this water filters through vegetation and sinks safely into the ground instead of running directly into a storm drain or water body. Not only is a rain garden a beautiful landscape feature, but it also protects streams and the ocean from polluted stormwater runoff. Curb cuts are small dips in the curb, like what you might use to get a stroller on and off the sidewalk. In this context, a curb cut is a section of the curb and gutter that has been reconstructed to divert stormwater away from storm drains and into an LID system like a rain garden.

Demonstration Project

Demonstration Site

The Kāʻanapali Beach Resort in West Maui is owned and managed by the Kāʻanapali Operators Association (KOA). The Kāʻanapali Parkway is the primary road for visitors and local residents to access the area's various amenities, which include a golf course, resorts, and a shopping center. At the point where the Kāʻanapali Parkway intersects with Nohea Kai Drive, there is a large median that we chose as the site for our LID practice. It is about 340 yards from the shoreline and within the Special Management Area (SMA).

Rain Garden Location

Demonstration Project (cont'd)

Prior to installation of the curb-cut rain garden, stormwater from heavy rains and irrigation water used for the golf course and landscaping flowed across the Kāʻanapali Parkway and pooled alongside the median's existing curb or went down storm drains that lead to the ocean. The unattractive puddles of polluted water were removed either manually by KOA staff or would naturally evaporate over time.

Pooling water along Kāʻanapali Parkway median prior to rain garden installation

For many years, KOA has been a champion of promoting Green Infrastructure to reduce pollutants entering the ocean through the installation of several LID practices. Some examples include installing curb inlet baskets used to filter pollutants in drains, constructing a bioswale and equipment washdown area to treat polluted water on-site, replacing herbicides with saltwater for weed control, and transitioning the resort's non-native landscape vegetation to incorporate more native Hawaiian plants. While these practices are effective, LID Practices can potentially raise more awareness about green infrastructure because they are visible to the public eye. We chose this site not only because it was a "hotspot" for unsightly pooling irrigation water, but also because it is highly visible to the public.

Objectives

1. Filter stormwater and irrigation water into the ground, instead of allowing it to flow into storm drains that are only a short distance from the ocean.

2. Provide a practical, attractive, and effective example of LID in a highly visible urban context.

3. Support Maui County in building its capacity to incorporate LID into stormwater management practices.

4. Inspire construction of more LID practices like rain gardens island-wide.

5. Support a local partner (KOA) in finding a sustainable practice to the unsightly pooling water near this medium, and in implementing more Green Infrastructure on their property.

6. Provide LID training resources for Maui County developers, engineers, architects, facility managers, and staff.

Demonstration Project (cont'd)

Choosing the most effective LID Practice

There are several types of LID designs that can be chosen based off of land use, treatment objectives, and specific site characteristics. To select an appropriate LID practice for the site we consulted information provided in (a) NOAA's Storm Water Management in Pacific and Caribbean Islands: a Practitioner's Guide to Implementing LID; (b) Hui o Koʻolaupoko's Hawaiʻi Residential Rain Garden Manual; and (c) the Coral Reef Alliance (CORAL) Stormwater Treatment the Natural Way: Low Impact Design & Development Guide (see Additional Resources). The following steps will ensure that you choose the most effective LID practice for your site.

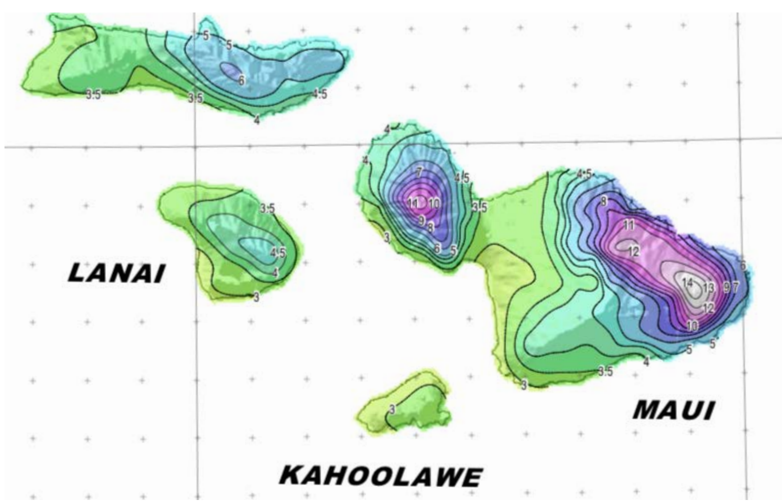
Step 1: Understand the environmental characteristics of your site

(a) Determine the Contributing Drainage Area (CDA)

Contributing drainage area (CDA) refers to the area of impervious surfaces that contribute polluted water and/or stormwater to your project location. LID practices are designed to capture this predetermined volume of water. We measured the CDA using Google Earth and on-site measurements and found it to be about 40,000 square feet.

(b) Determine rainfall data according to performance standards

The performance standards required for your LID practice dictate the type of rainfall data needed. Since we were primarily concerned with water quality treatment and polluted runoff reduction, we needed to know the rainfall depth for the 90th or 95th percentile storm events. A 2012 analysis of the Lāhaina rain gauge by Dr. Neil Berg found that the majority of storm events in the area are relatively small; 90% of all storms rain 1.54 inches or less. This is valuable information to account for when determining the size of your LID practice. For updated site-specific rain gauge data, visit the website for NOAA Atlas 14 Point Precipitation Frequency Estimates.



Cartographic maps of precipitation frequency estimates for Maui County (NOAA, 2014)

(c) Determine the soil drainage characteristics

The rate at which water drains through the soil will determine whether or not your proposed location is a good candidate for LID. For example, compacted clay soils do not allow infiltration and are, therefore, not suitable for LID practices. Soil drainage characteristics will also help determine the overall LID size needed to effectively infiltrate water from your CDA. To test the infiltration rate, KOA staff dug a 12" deep hole in the center of the proposed LID project area. In triplicate, the hole was filled with water and allowed to fully drain. To mimic saturated soil conditions after heavy rains, KOA staff recorded the time it took the water to fully drain after the third filling and divided the distance the water dropped over the time it took to drop/drain. We were looking for a rate of 0.5 inches per hour or more, which is the minimum standard for a good LID location. The infiltration rate at our proposed LID location was 1.5 inches per hour.

Demonstration Project (cont'd)

Step 2: Select the most appropriate LID Practice

We identified a curb-cut rain garden design as the most appropriate LID practice for the following reasons:

1. The CDA, rainfall data, and infiltration rate told us that a rain garden design was sufficient for our treatment needs.

2. A rain garden is typically the most aesthetically-pleasing LID practice. Because this site is so high-profile, aesthetics and the ability to blend-in with the surrounding landscape were high priorities.

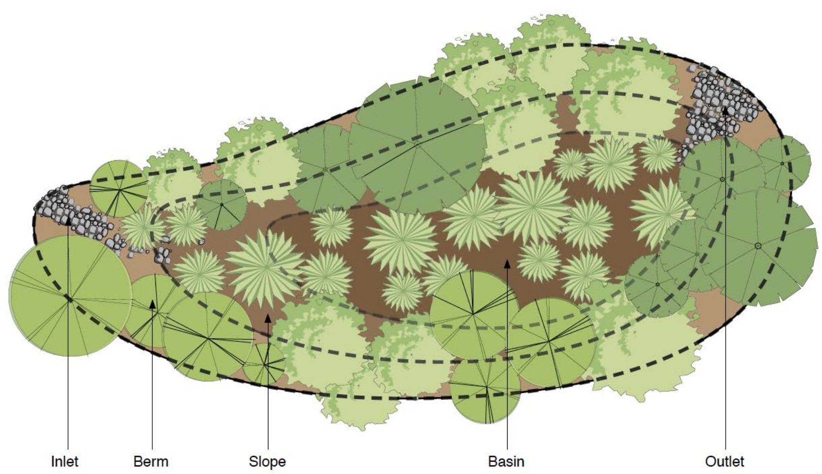
3. The existing curbed median could be easily retrofitted with two curb cuts for pooling water to enter and, during heavy rains, exit the rain garden.

4. The site met certain criteria for successful rain garden implementation, such as low slope and proximity to runoff sources.

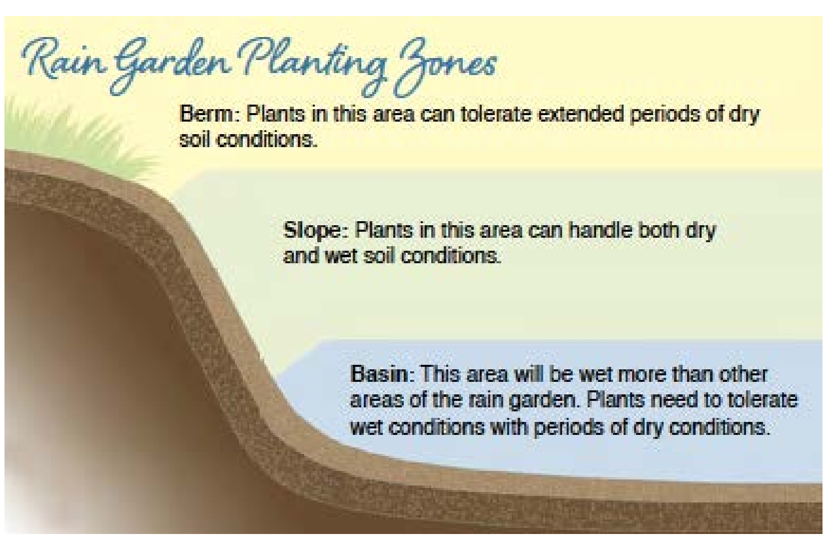
5. All materials could be locally sourced and relatively low-cost.

6. It would be low-maintenance. The site was not shaded by larger trees, so we knew plants within the rain garden would naturally receive sufficient water and sunlight.

7. It could incorporate native Hawaiian plants into the design.



Example of a rain garden layout (Hui o Ko‘olaupoko, 2012)



Rain Garden Planting Zones (Hui o Ko‘olaupoko, 2012)

Construction of the Curb-cut Rain Garden

Step 1: Develop a design and implementation plan in collaboration with partners

CORAL collaborated with KOA staff, as well as their contracted engineer and landscape architect, to develop a curb-cut rain garden design and installation plan for this site.

Step 2: Calculate the size and depth of the rain garden

Typically, the depth and size of a rain garden are determined by how much water it can effectively filter and sink into the ground within 30 hours. The right size for a bioretention depends upon three factors: the CDA, the infiltration rate, and the rainfall data plus other sources of water (e.g. excess irrigation water). Using the sizing chart and formula from the Hui o Koʻolaupoko's Hawaiʻi Residential Rain Garden Manual, an infiltration rate of 1.5 inches per hour and a CDA of 17,000 ft^2 equates to a rain garden size of approximately 1,275 ft^2 (141.7 yd^2). However, this calculation assumes a maximum depth of 1 foot. To account for heavier storm events, excess irrigation water, and the growing intensity and frequency of storms due to climate change, we decided to allow for extra retention capacity and decided to build a 1,350ft^3 (50yd^3) rain garden with a maximum depth of two feet, which is the maximum project size and depth without triggering an SMA Use Permit.

Step 3: Design the rain garden and identify the location of the curb cuts

Upon finalizing the size and depth of the rain garden, KOA's civil engineer designed the curb transformation plan and KOA's landscape architect designed the rain garden layout plan that incorporated the locations of the two curb cuts. The rain garden took on a long, meandering shape with two larger basins on the terminal sides, so as to increase retention volume and mimic the organic shape of the neighboring golf course's sand dunes and disperse the flow of water over the shallow system. This rain garden was designed to process typical rain events and excess irrigation. During heavy rain events, the rain garden will act as a closed storm water recycling system; storm water will overflow onto the grassy median and back into the curb system, where it will re-enter the curb cuts into the rain garden. The location of the two curb cuts were chosen because water pooled most excessively in those areas. As a result, storm water and pooling water is now slowed, treated, and infiltrated. Additionally, rather than a nuisance, the water is now a natural irrigation resource for vegetation within the rain garden.

Outline of rain garden

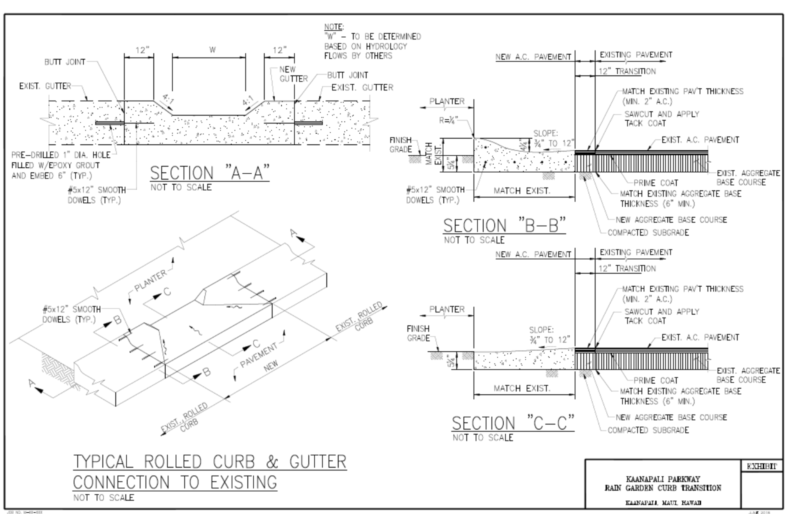
Step 4: Clear and excavate the area

Prior to excavation, the landscape architect spray-painted the outline of the rain garden for the excavation crew. KOA staff removed the sod grass so that they could remove the irrigation lines from the area. KOA staff then excavated the rain garden to design specifications using their excavating machinery. After excavation, the soil was 'fluffed' to decrease compaction and improve its ability to absorb and filter water and the slope was manually refined to ensure water flowed to the larger basin areas.

KOA staff excavating the rain garden area

Step 5: Retrofit the curbs

Curb cuts can be inexpensive and simple by doing the cuts yourself using a concrete saw. However, since aesthetics for this location were a high priority, we decided to contract the job to professionals. After excavation, the existing curbs were cut to design specifications and concrete was re-poured over the cut portion to ensure a clean, quality finish.



Curb transition design and finished curb cut

Step 6: Backfill the excavated area

Prior to backfilling, three simple devices for water sampling access were made out of perforated PVC pipe and women's pantyhose (in place of a geotextile sock) and placed at strategic points within the rain garden. This ensures that subterranean water at the base of the rain garden can be easily sampled for nutrient testing in the future. We pre-mixed premium plant-based compost, wood chips, 2% kiawe wood biochar, and soil from the excavation with machinery at the KOA baseyard. This combination of backfill ensures maximum nutrient uptake, water storage, microbial activity to filter pollutants, and minimizes compaction over time. Biochar is charcoal from plant material that has gone through a pyrolysis (burning) process in the absence of Oxygen. Biochar improves soil quality by retaining nutrients such as Carbon, Phosphorous and Nitrogen, and can retain heavy metals and other contaminants. Biochar increases water retention and cation exchange capacity (CEC), with results in soil fertility and microbiota (http://www.ridgetoreefs.org/bioreactors--biochar.html). We backfilled the excavated site with machinery, then spread it manually. KOA also chose to use river rocks at the curb cut inlet channels to help guide water into the larger basin areas and facilitate easy removal of debris buildup.

KOA staff backfilling filter bed media

Step 7: Plant locally-appropriate plants

Plants for a rain garden should be chosen based their moisture tolerance, ability to uptake nutrients, ability to handle contaminants. The site's light availability and soil characteristics should also be considered. Beyond that, plant species can be chosen to match the existing landscape aesthetic. KOA decided to plant native Hawaiian plants. They planted kalo (taro) in the basin of the rain garden because of its high tolerance for both wet and dry conditions, and laua'e in the slope and berm sections because of its ability to tolerate moist to dry conditions.

Demonstration Project (cont’d)

Step 8 (Ongoing): Conduct general maintenance of the curb-cut rain garden

A benefit of installing a rain garden at this site is that KOA staff already regularly maintain the area. In general, maintenance of rain gardens is pretty minimal, but generally includes:

- Weed control
- Replanting kalo, if harvested
- Maintaining irrigation lines, if required

Completed rain garden and curb cuts with young kalo and laua‘e

Demonstration Project (cont'd)

Project Costs

INPUTS	MARKET COSTS
Materials subtotal	**$2450**
Premium Compost	$35-45 /yd^3
Biochar	$500 /yd^3
Wood Chips	$20-35 /yd^3
Soil	$0 (from excavation)
Kalo	~ $2.50/plant
Laua'e	~ $2.50 /small fern
River Rocks	$270 /ton
PVC Water Sampling Devices	~ $20 each
Machinery rental and operations subtotal	**$1,400**
Labor subtotal	**$2270**
Curb transition (contracted cut and concrete re-pour)	$850 * 2 cuts
Other labor costs	$570
TOTAL Project Costs	**$6,120**

Results

- Curb cuts successfully allow irrigation water and storm water to enter the rain garden, preventing it from pooling around the curbs or entering storm drains.

- The rain garden safely absorbs and filters polluted water from irrigation and heavy rains, thereby preventing it from running unfiltered into streams and the ocean.

- The demonstration project has increased public awareness about LID among local residents as well as the Kāʻanapali Beach Resort's approximately 500,000 annual visitors.

- The demonstration project has increased Maui County's goal to incorporate LID into stormwater management practices.

- Increased the application of Green Infrastruture and installation of native Hawaiian plants in Kāʻanapali Beach Resort.

Thank you

Mahalo to those that helped make this project a success, including

- Wayne Hedani, Glenn Gazmen, and staff of Kāʻanapali Operators Association, Inc.

- Russel Y. Gushi, Landscape Architecture, ASLA

- Garrett K. Tokuoka, Austin Tsutsumi & Associates, Inc.

- Tova Callender, West Maui Ridge to Reef Initiative

- Tau Masonry

- Kihei Compost, LLC

THANK YOU!

Additional Resources

Learn more about ways to reduce water pollution in Hawai‘i’s marine environment at coral.org/maui

To visit the demonstration site, or to learn more about this LID practice, contact maui@coral.org

Sources

Coral Reef Alliance (2014). Stormwater Treatment the Natural Way: Low Impact Design & Development

Hui o Ko‘olaupoko (2012). Hawai‘i Residential Rain Garden Manual, Available here: http://www.huihawaii.org/resources.html

NOAA Coral Reef Conservation Program (2014). Storm Water Management in Pacific and Caribbean Islands: a Practitioner’s Guide to Implementing LID. Prepared by: Horsley Witten Group, Inc. and Center for Watershed Protection, Inc.

Photos by CORAL Staff

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