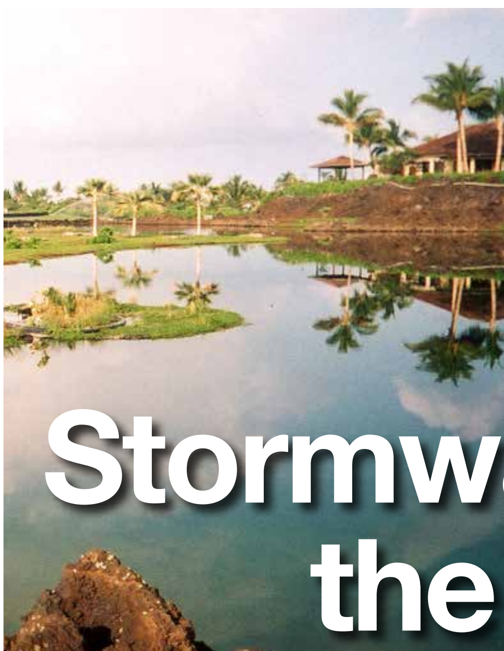

Stormwater Management the Natural Way:

Low Impact Design & Development

An Overview for the Accommodations Industry in Hawai'i

CORAL REEF ALLIANCE

Table of Contents

This photo by Jim Petruzzi

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CORAL REEF ALLIANCE

About this Overview

Low Impact Design (LID) and Development is an environmentally-friendly approach to managing stormwater and protecting Hawai'i's unique coral reefs. Hotels, condominiums, and resorts that use LID principles can significantly lower infrastructure costs, solve flooding, pooling, or runoff problems, increase marketability, add aesthetic value, and protect valuable marine ecosystems found in Hawai'i. This overview is intended to provide a practical introduction to LID principles and describe their specific relevance and uses within hotel and resort properties in Hawai'i. Topics covered in this overview include:

- LID effects on watershed health
- Economic, social, and environmental benefits of LID
- LID projects that hotels can implement
- Case studies of LID projects in Hawai'i
- Getting started with LID (permitting, site planning, etc.)
- Negetive effects of stormwater runoff on coral reef health

Who is it For?

This guide was developed for the hotel and accommodations industry in Hawai'i including, but not limited to:

- property managers
- maintenance and facilities personnel
- guests
- hotel and condominium owners

It is also useful for project planners, investors, business owners, and the extended property management and development community at large. The overview describes LID use within existing hotels and resorts and provides background to help guide new development and redevelopment projects, retrofits and renovations.

The online version of this document can be found at www.coral.org/LID. Feedback or comments can be sent to info@coral.org.

What is a Coral Reef?

Coral reefs are ecosystems that rival tropical rainforests in diversity. They grow over thousands of years, as individual animals—coral polyps—slowly deposit layers of calcium carbonate to form a skeleton. The polyps live in colonies, and obtain the energy they need to build reefs by consuming small floating organisms and photosynthesizing. Over time, they create an elaborate three-dimensional habitat that is key to the functioning of the whole ecosystem. Corals provide food and shelter for hundreds of species of fish and invertebrates along Hawai'i's coastline, enabling amazing biodiversity and astounding scenery. The beneficial products and processes that coral reefs provide, known as their "ecosystem services," are numerous: fishing grounds, gathering areas, habitat for important species, coastline protection, potential medicinal compounds, and, of course, tourism opportunities.

Although coral reefs are ancient, extensive, and vibrant, they are fragile ecosystems that can only exist under very specific conditions. Corals require crystal clear water that transmits sunlight so the algae housed within their tissues can photosynthesize and feed the colony. If the water contains suspended sediment, making it cloudy enough to block the sunlight, the corals will not be able to produce enough energy to build their skeletons. When reef building stops, burrowing invertebrates, coral-eating fish, and storm damage can then erode the reef. When corals cannot regrow the material lost to these forces, they are eventually destroyed, and reefs break down into lifeless rubble.

A healthy reef off Hawai'i's coast.

The Economic Value of Coral Reefs

Hawai'i's tourism is absolutely dependent on the state of Hawai'i's natural environment, yet while beaches can be seen visibly eroding, the degradation of our coral reefs and coastal water quality is not always as apparent. Healthy reefs and clean water are arguably as much of a draw for visitors to Hawai'i as expansive sandy beaches. Coral reefs are extremely valuable to Hawai'i: they are significant culturally, ecologically, and socially, providing food, shoreline protection, and major economic benefits from recreation and tourism. An economic study estimated the value of Hawai'i's coral reefs at $10 billion, with direct economic benefits of $360 million per year (Cesar and van Beukering, 2004).

However, reefs worldwide and in Hawai'i face a suite of threats that includes impacts from global climate change, unsustainable and destructive fishing, invasive species, coastal development, land- and marine-based pollution, and other direct human impacts.

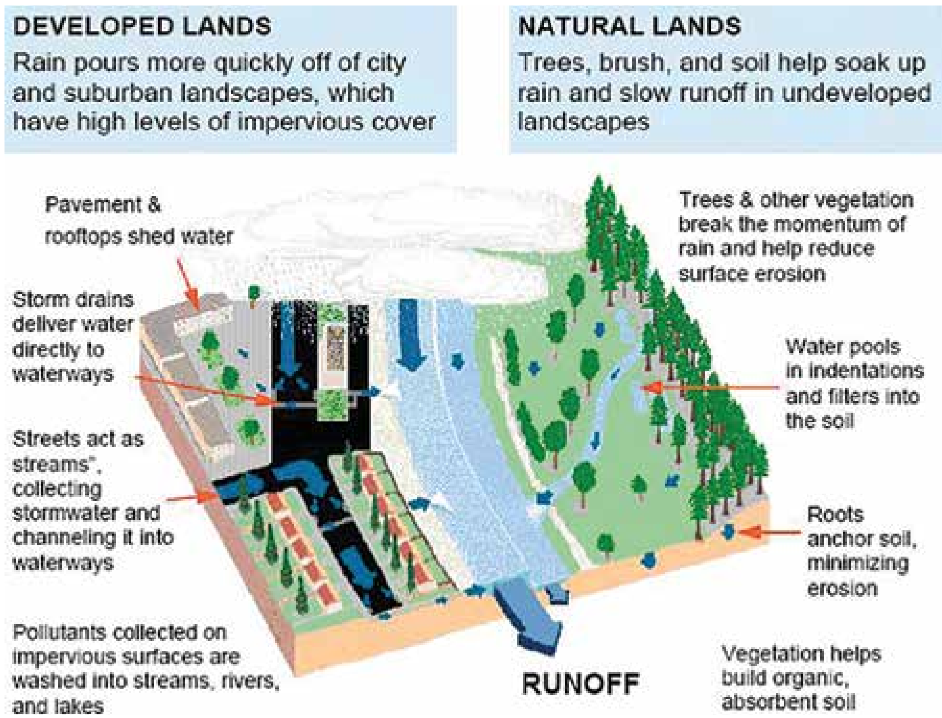
A recent publication by the World Resources Institute, *Reefs at Risk Revisited*, presented the results of a global analysis of reef threats, which found that the majority (60 percent) of the world's reefs are threatened by human activities. Coastal development and watershed-based pollution like stormwater runoff threaten a quarter of all reefs (Burke at al., 2011).

Low Impact Design & Development

The Role of LID in Watersheds

When it rains, the water that falls on land does so within a watershed. A watershed is an area of land that catches, stores, and conveys rainwater that will ultimately flow into the ocean (EPA, 2014). Within a watershed, stormwater is conveyed above ground in bodies of water like rivers and streams, stored in organic matter like plants or forest leaf litter, or sunk into underground aquifers. Topography, soil type, and the amount and type of vegetation present are all factors that influence how water moves through a watershed.

In an undisturbed forested or natural Hawaiian watershed, some rainwater is captured on the leaves of trees where it later evaporates or gradually flows toward the ground. The water that reaches the ground is drawn up by plant roots and utilized for growth, and organic matter such as leaf litter stores and releases water slowly over time into streams and rivers. These rivers flow down into wetlands or estuaries, where plants and animals take up and filter nutrients and organic materials. Finally, the water enters the ocean where it supports coastal ecosystem processes. Within a natural system, water remains a valuable resource throughout its journey through the watershed. LID principles seek to mimic these hydrologic and natural processes by allowing water to be slowed down, stored, filtered, or sunk into the ground on its way to the ocean so that stormwater remains a resource instead of a liability.



In a developed or altered landscape, water falls onto streets, parking lots, roofs, or other impervious areas and becomes stormwater runoff. This water runs off the land instead of sinking into the ground or being stored in organic material. The more impervious surface there is, the greater the amount of runoff. Stormwater runoff can erode the landscape, washing away topsoil and ground cover and picking up loose materials as it flows across the land. These materials can include oils, fertilizers (nitrogen and phosphorous), pesticides, sediment, paint particles, tire treads, and other pollutants harmful to coral reefs and marine ecosystems. In this case, the stormwater is no longer a valuable resource, but a polluted and potentially damaging liability.

Stormwater Runoff and the Health of Hawai‘i’s Coral Reefs

Degraded reef

Healthy reef

Sediments from stormwater runoff create murky and aesthetically unappealing coastal waters, which hinder marine recreation and negatively affect the visitor experience. Sediment runoff also disrupts photosynthesis by blocking out sunlight, which reduces the corals’ ability to obtain food. Furthermore, sediments can settle on and smother corals, and also contain chemicals and toxins harmful to reef ecosystems, including hydrocarbons, pesticides, and herbicides.

Stormwater also contains nutrients such as nitrogen and phosphorous which can be harmful to coral reefs by encouraging the growth rates of algae (seaweed or limu). Since corals grow slowly, they cannot compete with algae that can more efficiently absorb nutrients and grow rapidly. This can cause algae to overgrow the living coral, and in some cases form periodic “blooms.” Research has indicated that algal blooms play a significant role in chronic, or ongoing, reef degradation (Ross et al. 2012). Algal blooms are also a threat to Hawai‘i’s tourism-based economy when excess algae washes onto beaches creating an unappealing and foul smelling nuisance.

LID has the potential to eliminate much of the stormwater pollution currently flowing into the ocean and onto coral reefs in Hawai‘i. The hotel and accommodations industry has an important role to play in protecting the near-shore environment and ensuring that visitors are able to continue to swim in clean clear water and experience vibrant healthy coral reefs and marine ecosystems. Each square-foot of pavement that is replaced with a pervious alternative, or each flower bed that is replaced with a rain garden or other appropriate LID system, directly results in less pollution reaching the ocean, and more protection of the unique coastal ecosystems in Hawai‘i. LID Principles manage stormwater by slowing it down, sinking it into the ground, and filtering it or storing it as close as possible to its source: that is, as soon after it hits the ground as is feasible.

Algae can outcompete and overgrow the reef, killing coral

Algae blooms in Maui recently resulted in $20 million of annual economic loss from removal expenses and lost tourism revenue (Hunt 2007).

Multicopter Maui

Why LID?

LID is able to serve multiple functions when used on a hotel or resort property, and can therefore provide a variety of economic, social, and environmental benefits.

Conventional stormwater management requires complex and expensive infrastructure. Lower left photo by Lauren Roth Venu.

A Less Expensive Option (Economic)

Conventional stormwater management systems are designed to convey stormwater as quickly as possible off of the property or to the nearest body of water. Accomplishing this requires paved channels, culverts, large diameter piping, and underground storm drains. This infrastructure involves high labor costs for land excavation, clearing, and grubbing. LID, on the other hand, often requires minimal piping, reduced paving, and less hard infrastructure, as well as significantly less excavation and grubbing. A cost comparison study conducted by the EPA examined 17 LID case studies and found that "… in the vast majority of cases, significant savings were realized during the development and construction phases of the projects due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Total capital cost savings ranged from 15 to 80 percent when LID methods were used…" (EPA, 2007 pg. 2)

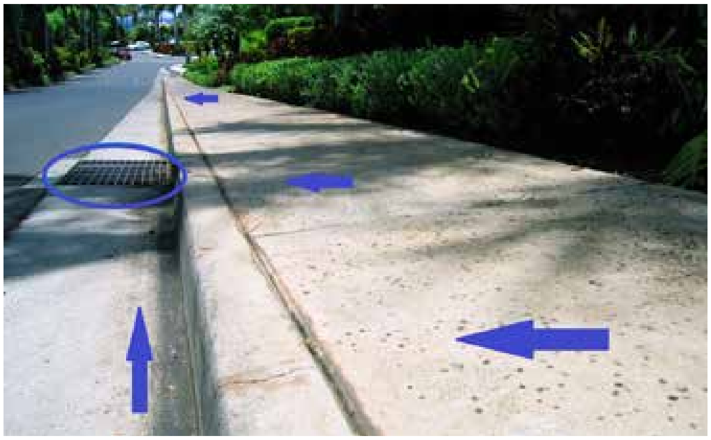
It is also important to note that because LID systems serve multiple functions, they can present significant cost savings over time.

Reduced Maintenance Costs (Economic)

Stormwater often contains fertilizer (primarily nitrogen and phosphorous). Although these nutrients are essential for plant health and growth, when misplaced they wreak havoc on coral reef and other marine ecosystems. Capturing these nutrients within appropriate planted LID systems enables plants to utilize the nutrients and can reduce or eliminate the need for fertilization over time. Additionally, LID systems utilizing appropriate native plants that are well adapted for the soils and climates of Hawai‘i generally require less intensive maintenance and irrigation when compared to exotic landscape plants.

Free Irrigation Water (Economic)

Providing potable (drinkable) water



When it rains on this property, stormwater runs off of the sidewalk, into the street, and down the storm drain with no filtration along the way. Proper planning using LID would reverse this flow, and chanel water into the nearby landscape features. This would allow water to sink into the ground providing valuable irrigation to the plants and natural filtration of the stormwater. Arrows in the photo indicate the direction of stormwater flow.

Along this road, curb cuts and a central bioswale convert a roadway median into a highly effective stormwater control device. Stormwater running off the road enters the bioswale through curb openings. The bioswale then filters and sinks the stormwater into the ground. This particular bioswale, located on a tropical island in Southern China, was able to handle a large volume of water when a typhoon struck the region shortly afer the project was constructed. Photo by Green Earth Operations.

Potentially free irrigation water runs off this parking lot every time it rains; meanwhile, expensive potable water is used to irrigate this bed. Curb cuts and a lower grade could allow stormwater to run into the bed.

to residents and businesses in the Hawaiian Islands is a very expensive and energy intensive process. For example, roughly $10 million annually is spent on the electricity alone that is needed for pumping, purifying, and distributing water to Maui's population

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Guidance From the EPA

"…in the vast majority of cases, significant savings were realized during the development and construction phases of the projects due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Total capital cost savings ranged from 15 to 80 percent when LID methods were used…"

Why LID?

(MCEA, 2009). With energy costs and water rates expected to rise in upcoming years, LID practices that reduce the amount of water purchased from public utilities make strong financial sense. Rainwater harvesting, for example, stores water that can then be used at a later time for irrigation or other non-potable uses.

Help with LEED Certification (Economic)

Leadership in Energy and Environmental Design (LEED) certification is intended to encourage sustainable green building and development. LEED certifies new projects and major renovations, and to qualify, a project must earn a minimum number of ‘points’ based on five categories of environmental standards. For hotel and resort projects—whether new or a retrofit—seeking LEED Certification, LID can significantly contribute points to each of these five categories and greatly assist with reaching LEED targets and goals (SEMCOG, 2008) (see LEED Certification Standards: www.usgbc.org).

Increased Marketability (Economic)

There are increasing trends in consumer support of green, environmentally friendly, and sustainable businesses. This is especially true within the hotel and resort sector (GSTC, 2012). The Global Sustainable Tourism Criteria (GSTC) has set internationally recognized ‘sustainability criteria’ for hotels and resorts and this has led to the development of a number of certification programs for the sector, including Sustainable Travel International, Rainforest Alliance Accommodation Certification, and, in Hawaiʻi, The Hawaiian Green Business Program (see: http://energy.hawaii.gov/green-business-program). Recently released Hawaiʻi travel guide books contain ‘green accommodations’ sections, and trends point to a growing number of discerning tourists who are asking the places they stay to demonstrate environmental and social sustainability. LID is an excellent way to show a property’s commitment to environmental sustainability, and can go a long way toward helping a property meet sustainability certification standards.

Opportunities for Hotel Guests and Community Engagement (Social)

Sharing and explaining the functions of LID elements to guests, through interpretive signs, sustainability tours, and marketing materials, is an excellent way to highlight a property’s commitment to sustainability and increase the market share of this discerning demographic. When

implementing LID, a social component can also be included that highlights the unique aspects of Hawaiian and Polynesian culture and history. For example, a rain garden could be planted as a ‘canoe garden’ that includes culturally significant plants such as kalo (taro), kukui (candlenut), maiʻa (banana), and ʻuala (sweet potato) and interpretive descriptions of each plant’s significance can be provided (White, 1994). Partnering with schools, nonprofits, and residential and neighborhood groups to create and maintain rain gardens

Compare

A conventional flower bed...
• Aesthetic benefits

Vs.

...a rain garden
• Aesthetic benefits
• Stormwater management
• Reduced irrigation and maintenance costs
• Reduced fertilization costs
• Environmental benefits

and other LID elements is also an excellent way to involve the community and showcase a business as a model of community and environmental stewardship.

Protecting Natural Resources (Environmental, Economic)

Tourists come to Hawai‘i to experience the unique natural beauty these islands have to offer. Many of their activities, including snorkeling, swimming, diving, and relaxing on the beach, center around the ocean. When ocean water turns brown from sediment runoff, or blooms of noxious algae—caused by fertilizer runoff—cover a beach, tourists can become dissatisfied and may be less likely to choose Hawai‘i as their vacation destination in the future. Protecting the marine ecosystem is essential for protecting our tourism economy.

LID Worksheet:
Accompanying this overview is the LID Property Assessment Worksheet. The worksheet is a questionnaire and checklist that can be used to assess a particular hotel or resort's potential for installing or incorporating LID systems into the property.

Types and Examples of LID

LID systems can provide a number of uses and benefits to a hotel or resort property, while simultaneously saving money and protecting the environment. While each site has its own unique characteristics, LID can be used everywhere. Some LID principles are designed to store water for later use, others are designed as treatment systems, and some are meant to sink water into the ground. A mixture of LID systems should be spread throughout a property so their collective benefits can overlap and complement one another. The following are examples of LID systems that can be readily adopted by hotels and resorts, and have the potential to make profound positive impacts on the fragile ecosystems found in the state of Hawaiʻi. (Note: this list is not exhaustive. For more information and examples of LID, see the resources section.)

1. Pervious Pavement

sink

Removing pavement and replacing it with a surface that allows stormwater to pass through will greatly reduce the amount of stormwater runoff a property has to deal with in the first place, and reduce its potential to negatively affect the property and nearby coastal ecosystem. A careful examination of a property's paved areas can often identify 'dead pavement,' or areas that are paved but don't necessarily need to be (see LID Assessment Worksheet). These could be prime locations for pavement removal and replacement with plant beds, bioswale median strips, or another LID component, adding to a property's beauty and keeping water from pooling or flooding.

This "dead pavement" is a prime location for a bioswale or other LID system that could treat runoff from the parking lot.

In areas that must be paved, consider using hardscapes that allow water to pass through. Examples of "pervious pavement" include a wide variety of gravel, bricks, pavers, grass paving cells, or even "pervious concrete." Footpaths are often easy targets, but pervious pavement products or grass paving cells manufactured today can also handle the design and load requirements for heavy truck and car traffic. Pervious concrete can be poured and shaped exactly like standard concrete and can be used in most of the same situations (see: http://www.perviouspavement.org/).

2. Bioswales

slow, filter, sink

Consisting of a shallow planted depression with gently sloping sides, a bioswale acts like a trap to stormwater flowing across the landscape.

This constructed wetland system designed by Roth Ecological Design Int. for the Ernie Els Golf Course at Hoakalei, Oahu is an example of an 'edge' constructed wetland designed to protect water quality within a pond.

Bioswales are positioned in a property to slow and impede the flow of stormwater before it is discharged into a receiving environment. By slowing the stormwater down, sediment and suspended particles can settle out of the water, thereby reducing the impact on nearby marine environments. Plants within the bioswale take up and filter these nutrients and pollutants. Parking lots and other impervious surfaces are prime locations for bioswales, where they can catch and treat water flowing off the pavement. They can also serve as buffer strips around sensitive natural waterways, capturing and filtering stormwater before it flows into a body of water.

3. Rain Gardens

slow, filter, sink

Rain gardens are engineered to capture a predetermined volume of water when it rains, treat that water using plants, and allow it to sink into the ground where it will recharge groundwater. A rain garden is typically shallower in depth than a bioswale, and is often used as a stand-alone garden bed or landscaping element. The depth and size of a rain garden are determined by how much water it can effectively filter and sink into the ground over a 24 hour period. This is calculated by determining the area of impervious surface (roof, pavement, etc.), the average rainfall amount for a particular property, and the 'infiltration rate,' or how fast the water sinks into the soil where the rain garden is to be located (see the LID Assessment Worksheet for a detailed description). Often, engineered soil mixtures of sand and compost replace the native soil to allow for hydrologic consistency within rain gardens. Rain gardens may not be as effective in areas of clayey soils as these soils easily compact and impede drainage.

4. Constructed Wetlands

slow, store, filter, sink

Constructed wetlands (sometimes referred to as "artificial wetlands") are designed to filter and treat larger volumes of stormwater by mimicking a natural swamp or wetland. Constructed wetlands, incorporate aerobic and anaerobic water treatment into their construction. The aerobic section functions like a rain garden, as an intermittently wet region that treats stormwater through the biological uptake of nutrients and pollutants. The anaerobic section uses low oxygen biological processes to further treat stormwater within organic matter or soil layers. A wetland can be designed to retain water, thereby creating extra storage for larger rain events. Constructed wetlands may also be applied as 'edge' landscaping, whereby plants are strategically placed around ponds or other waterways to treat stormwater runoff before it enters the waterway or to treat the waterway itself. This

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Types and Examples of LID

practice maintains good water quality within the water feature. Also, constructed wetlands, like other vegetated stormwater filters, contribute to the aesthetics of a landscape.

Water features on golf courses can provide excellent rainwater-storage systems, and can be coupled with artificial wetlands to maintain good water quality like this example at the Hualālai Resort on Hawaiʻi Island.

5. Rain Catchment

store, use

Capturing stormwater and storing it for non-potable use at a later time is an excellent way to utilize this water resource and reduce the money spent purchasing potable water. Stormwater can be stored in tanks above or below ground, in open ponds, or in other water features such as those on golf courses. A rain catchment storage vessel is sized according to the area of impervious surface that will be feeding it, and should take into account daily water demands of the site, rainfall amounts, and frequency. (See the LID Assessment Worksheet for instructions for calculating the amount of potential water that can be collected from a particular surface area.)

Water flowing from gutters, downspouts, or storm drains can be directed into a storage vessel. A filtration device is used prior to the water entering the storage vessel to keep out leaves or other debris. For new developments, a rain harvesting system can be incorporated during the project planning stage. With retrofits or redevelopment, or where space is a limiting factor for above ground storage, underground tanks can be placed beneath parking lots during a repaving project or when excavation is necessary for another reason. In some cases, existing storage tanks, cisterns, or other unutilized infrastructure can be repurposed to capture and store rainwater. Stored water is most commonly used for irrigation, however upon the State of Hawaiʻi's acceptance of the most recent Uniform Plumbing Code (2012), this water may become available for use in cooling towers, flushing toilets, and fire suppression systems (see local county plumbing codes). It is important to note that large above-ground tanks will require a building permit, and below-ground tanks likely a grading and grabbing permit (see permitting section for details).

6. Vegetated Roof

filter, store, use, evaporate

Rooftops represent a substantial portion of the impervious surfaces found within a hotel or resort property, and are often viewed as useless or unappealing spaces. Few visitors to hotels or resorts are looking for a "rooftop view" of a tar or gravel covered expanse punctuated by pipes, vents, and AC units. Creating a vegetated roof can turn this unappealing space into a usable and visually pleasing landscape while also providing energy and cost savings for the building below. There are many sizes and types of vegetated roofs, from small rooftop planters and trellises to fully landscaped rooftop courtyards and garden parks. Plants and the planting media that occupy a vegetated roof absorb and evaporate stormwater, and can also help cool a building by providing a reflective and

LID in Practice

Case Studies in Hawai'i

Case Study 1

University of Hawai'i Maui College (UHMC)

Rain Garden

UHMC's Sustainable Living Institute of Maui (SLIM) partnered with the Water Institute for Sustainability Education (WISE) and Tri-Isle Resource Conservation and Development to install a rain garden on campus; the purpose: to treat and infiltrate rainwater from a culvert that collects water from the Kupa'a and Science Buildings, along with some site drainage. It is estimated that the rain garden will treat and recharge up to 270,000 gallons of stormwater annually. The rain garden sits within the SLIM Community Garden which is open for use by the students and community. The goals of the community garden are to increase awareness of food security and to teach the importance of sustainably managing stormwater. The SLIM rain garden team also hosted a workshop for Maui County educators to share details about the project with schools around the island.

Case Study 2

Sheraton Waikiki

Rain Catchment

The Sheraton Waikiki is planning on installing a rain catchment system to harvest rainwater from the roof of the hotel. The collected rainwater will be placed in above ground storage tanks and used for irrigation. Below is an interview with the Eric Au, C.E.M, Area Director of Engineering and Sustainability—Hawai'i for the Starwood Hotels and Resorts Hawai'i.

Q: Why did Starwood choose this particular hotel?
A: Primarily due to the size of our flat roofs (upper and lower roofs) and the ease of tying in the existing roof drains into a central location.

Q: What motivated Starwood to implement a LID catchment system?
A: At Starwood, doing the right thing for the environment and our communities is more important than ever. Our customers and owners are asking for it, our guests expect it, and our associates are passionate about it. Conserving water via rainwater catchment is one of many initiatives we'll be addressing to help preserve our precious resource.

Q: How will the rainwater be used?
A: Irrigation

Q: Does Starwood plan to provide outreach to its guests about the green feature?
A: Yes, most definitely, via in room collateral, TV, and staff.

Case Study 3

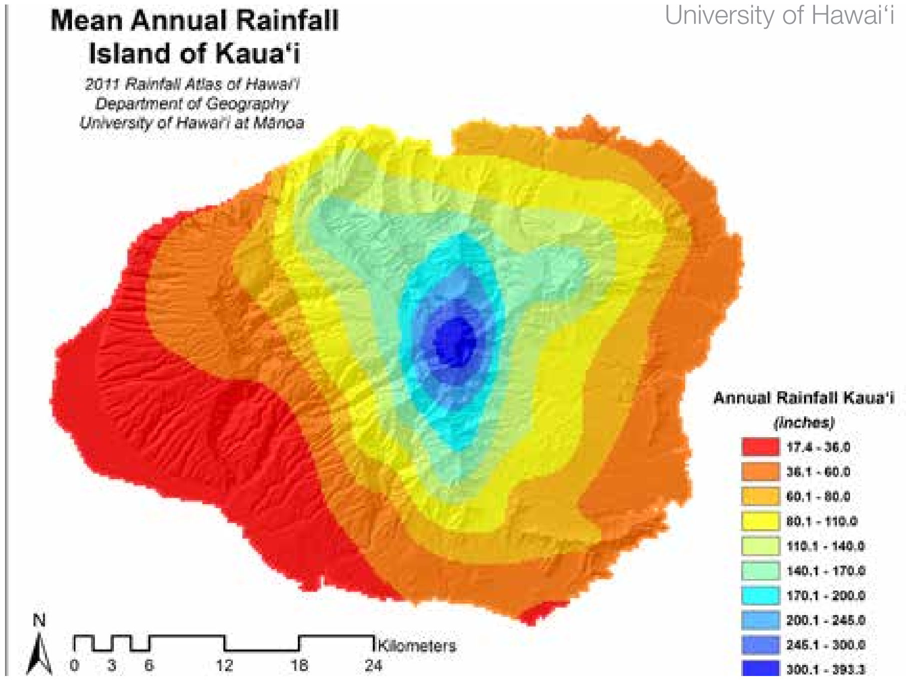
Grand Wailea

Green Roof

The Grand Wailea took a unique approach by designing a vegetated roof atop one of their centrally located buildings. The roof, which consists of flowering shrubs, a grassy lawn, seating areas, and sculptures, was primarily designed to improve the view from many of the rooms at the luxury hotel, and to create a usable space with a striking view for additional guest activities; however, this green roof also helps to reduce stormwater runoff through the plants' uptake of rainwater, and provides cooling benefits to the building below.

Getting Started with LID

LID principles can be incorporated into the site plan of a new development project and utilized effectively with redevelopment or retrofit projects. There are several questions to consider when deciding the best options for using LID elements within a particular property.



1. Is the Site Disturbed or Undisturbed (Brownfield vs. Greenfield)?

Undisturbed sites typically have mature foliage and topsoil that are naturally designed to retain stormwater and recharge it into the ground. Grading the site with heavy equipment will affect this drainage ability by removing vegetation and compacting the underlying soil. The grading process can result in semi- to completely impervious surfaces depending upon the soil type. For this reason, careful site planning is critical. After pervious areas for minimal drainage have been optimized, strategic placement of structures, roads, and parking lots should be considered and, when feasible, placed in areas where disturbance to the natural drainage of the site is minimized.

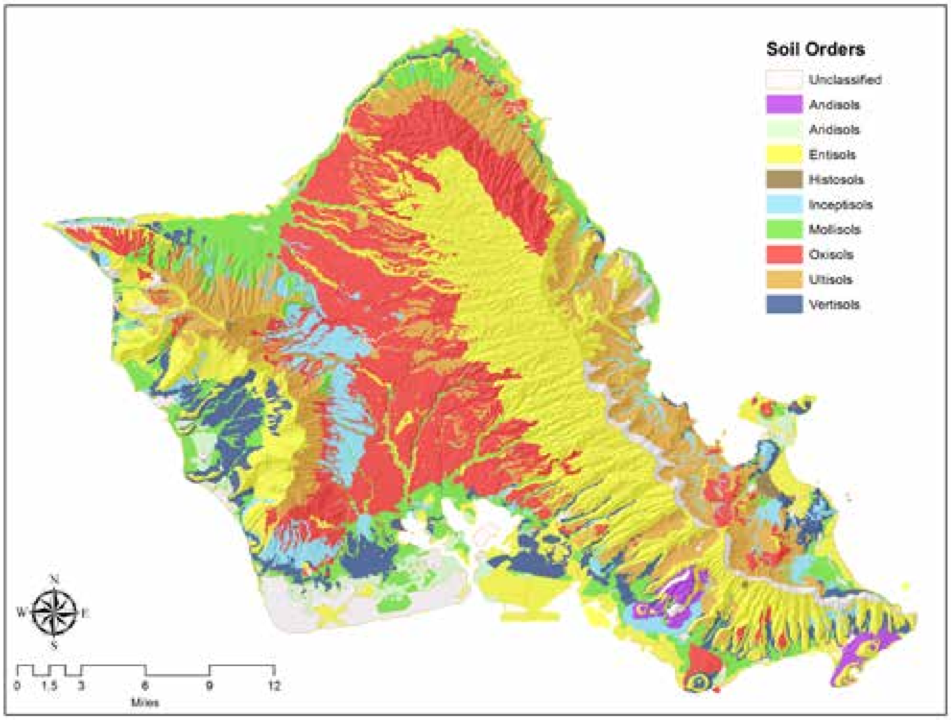
Redevelopments and retrofits typically occur on already disturbed sites; however, a careful examination of the natural environment currently present on a site is still advantageous. Any trees or vegetation will provide stormwater management services, and can conceivably be integrated into the retrofit or remodel plan. It is important to test the drainage ability of the site for permeability before choosing an LID system (see LID Assessment Worksheet). For example, if the soil's ability to sink water has been compromised by soil compaction or the site has inadequate potential to capture rainfall, there may still be opportunities to add underground water storage tanks. For sites with adequate permiability, implementing bioretention systems, such as bioswales or rain gardens, in areas next to impervious surfaces often makes sense. If there are planted landscapes, raised medians, or gardens, these can often be converted into functional planted LID systems. Other retrofit opportunities include above ground storage, permeable pavements, and green roofs.

2. How Much and How Often Does it Rain?

Stormwater management takes into account both water quality and water quantity. Although LID systems can be designed to store water and manage water quantity, they typically are sized to manage and treat the Water Quality Volume (WQV), or the amount of water an LID system must effectively filter or treat in order to remove the majority of pollutants. Most pollutants in stormwater runoff are concentrated in the 'first flush' which occurs at the beginning of a rain storm. LID systems can be designed to capture, filter, and treat the first flush, and then allow excess water to overflow into an additional LID or conventional stormwater system.

The WQV is determined by calculating the 90 percentile rain event, the area of impervious surface, and the total percentage of impervious surface versus pervious surface on the site (runoff coefficient). The 90 percentile rain event is determined by conducting a precipitation frequency analysis to identify the single 24-hour rain event that is bigger than 90 percent of all other rainfall events over a representative period of time. To effectively calculate the WQV requires collecting rainfall data, ideally directly on the site with a rain gauge, and by keeping detailed records. Where rain gauges are not available on the site, the next best option is to identify the closest rain gauge with available data. If rain fall data is unavailable for a representative period of time, models developed by the University of Hawai'i at Manoa Geog-

Major Soil Types of Oahu



University of Hawai‘i

raphy Department and NOAA can help determine monthly and annual averages, as well as rainfall intensity.

Because various counties have different requirements and the 90 percentile rain event varies substantially in different parts of Hawai‘i due to the state's high climate variability, accurately calculating a site's 90 percentile rain event is crucial to maximizing the treatment potential of an LID system (Maui County, 2012). For managing larger, more intense storm events such as the ‘10-year; 2-hour event’ (a measurement often needed for permitting with the various counties) or the even larger ‘100-year event’, LID systems can be coupled with conventional stormwater systems to handle large water volume storm events. For example, overflow devices from an LID system could connect to a municipal storm drain, seepage pit, or detention basin.

When LID systems are designed to have stormwater storage capacity (such as storage tanks, rain catchment systems, or constructed wetlands) these storage volumes can be accounted for and deducted from the overall storage needs of the site. Accounting for the storage capacity of an LID system reduces and minimizes the size requirements needed for a conventional system. This can mean smaller pipes or smaller detention basins can be used, providing significant cost savings.

3. How Much Impervious Surface is There?

The site's total area of impervious surfaces (roofs, roads, parking lots, impacted soils, etc.), together with the rainfall data, will provide an accurate calculation for exactly how much stormwater runoff a particular LID system must be capable of handling.

4. What Kind of Soil is There, and How Well Does it Drain?

The Hawaiian Islands are formed of porous volcanic rock; however, within each island there are a number of soil variations with distinct characteristics and drainage patterns. Maui Island, for example, is generally characterized by dark, iron-rich/quartz-poor rocks, but includes seven distinct types within this one category. Shorelines (at least where hotels and resorts are usually located) are dominated by sandy soils. Sandy soils allow water to sink in quickly, and are generally well-suited for bioswales, rain gardens, and other LID systems designed to sink water. Clayey soils are particularly poor at allowing water to sink, and are thus better suited for catchment and storage.

To determine the type of soil and drainage at the proposed site location, a percolation test should be done. For most commercial projects requiring permitting, this must done by a licensed geotechnical professional. However, for small projects, a simple do-it-yourself test may be adequate; this simple test consists of digging a hole of a specific volume in the area of the proposed LID system, pouring in a measured amount of water, and timing how long it takes for the water to sink into the ground (see LID Assessment Worksheet).

Extensive use of heavy equipment on a site quickly compacts the underlying soil. When soils are compacted, they behave like impervious surfaces and lose their ability to absorb stormwater (City & County of Honolulu, 2011)

Rainfall Resources

University of Hawai'i at Manoa Geography Department Rainfall Atlas:
http://rainfall.geography.hawaii.edu/

NOAA's National Weather Service, Hydrometeorlogical Design Studies Center, Precipitation Frequency Data Server:
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_hi.html

Regulations & Permitting

Most LID system installations will require some form of a permit. For new developments, the plans and permit applications will be submitted with the overall project. For redevelopment or retrofit, it is prudent to time the design and installation of LID systems with additional remodeling or renovation to minimize repetition of surveys and applications. The following section provides an overview of the basic permits and plans that may be required when installing an LID system as a new development or redevelopment/retrofit project in Maui County. Each county in Hawai'i has unique regulations, so it is best to inquire with the local jurisdictions. Consult with a planner or engineer if you are unsure of any aspect of the permitting process.

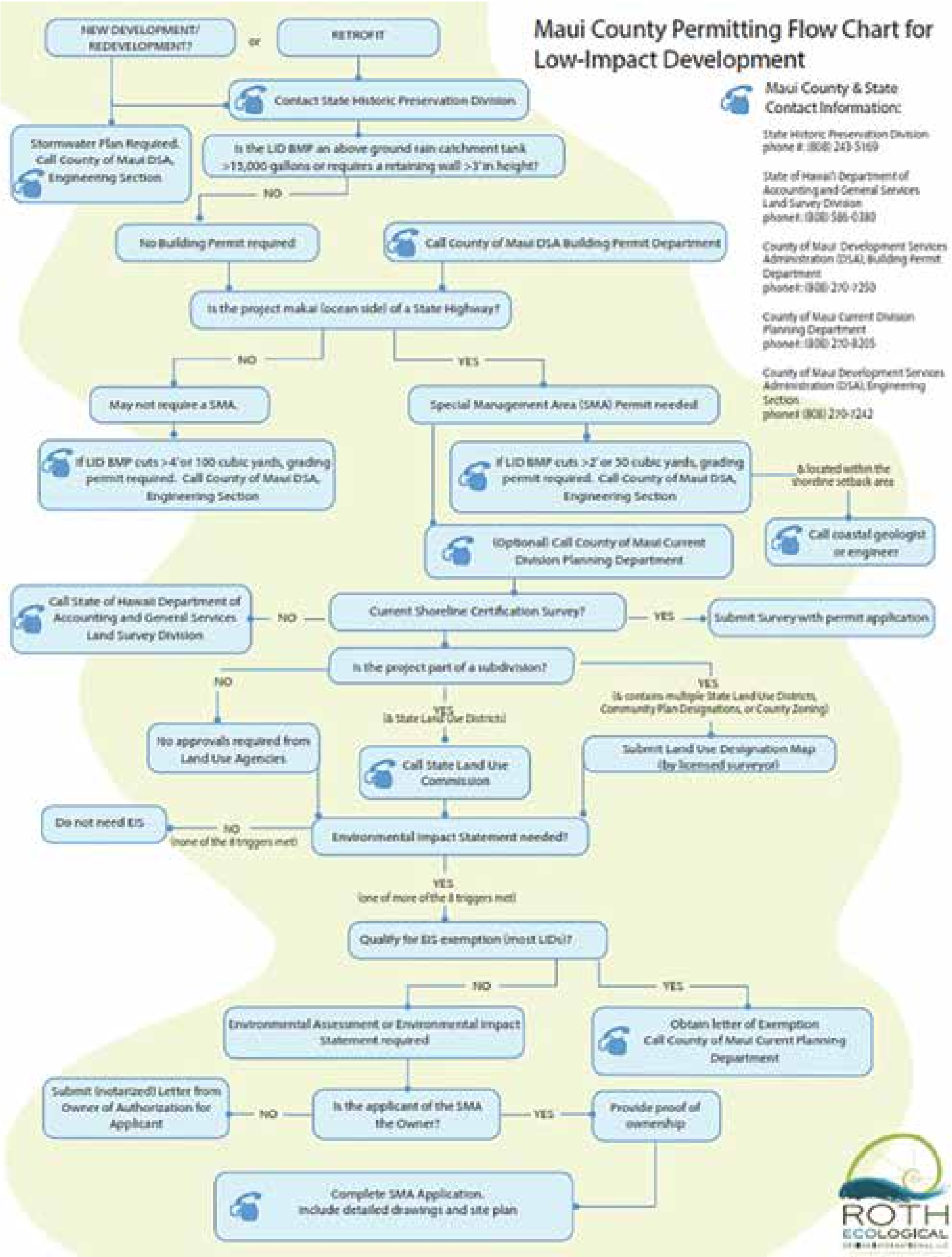
Volunteers install a rain garden at Wahikuli Wayside Park.

Stormwater Plan

For new development projects, the County of Maui Department of Public Works (CMDPW) requires a comprehensive stormwater management plan for development projects disturbing more than one acre or, for those that are less than one acre, a "site-specific Best Management Practice (BMP) plan" for managing stormwater quality. A licensed civil engineer is required to stamp the plan and include a 'maintenance plan' for the BMP(s) selected. Design and engineering details for the plans can be found in Chapter 15-111, *Rules for the Design of Stormwater Treatment Best Management Practices. (*County of Maui Department of Public Works). If a project is not a new development, it is likely that the submission of these plans will not need to be submitted to CMDPW (see County of Maui's Department of Public Works website: www.co.maui.hi.us/index.aspx?nid=124).

State Historic and Preservation Division (SHPD)

Both new developments and retrofits will require contacting the State Historic and Preservation Division (SHPD) to ensure that the project does not impede on historic structures. Projects being developed on previously disturbed land will likely receive a letter of clearance from SHPD and should then be able to proceed. Call (SHPD) with the proposed project's Tax Map Key (TMK) to check if the project site has clearance. This process could take up to three months. The letter of clearance request to SHPD should be from the owner of the property or from a County of Maui Planner. If the project is found to be within a historic site, a site survey may be required by a licensed professional. Additionally, if it is a new development



Special Management Area (SMA) Permit

If the proposed project is located on the ocean side (makai) of the State Highway, it is likely in a Special Management Area (SMA). See the SMA map (http://maps.hawaii.gov/PropertyInSMA/) to determine if your property falls within the SMA zone. Occasionally there are TMKs that fall within SMAs on the mountain (mauka) side of the highway.

Call the local county department of planning office with the project TMKs if you are unsure. For projects that do fall within an SMA, an application to the CMDP is required. This application is available online at: http://www.co.maui.hi.us/documents/17/111/SMAAssessmentApp_7-11_WEB.PDF.

Contact Information:

- County of Hawai'i
  Planning Department
  SMA Permits
  East Hawai'i Office 808.961.8288
  West Hawai'i Office 808.323.4770
- County of Kaua'i
  Planning Department
  SMA Permits 808.241.4063
- County of Maui
  Planning Department
  SMA Permits 808.270.7735
- City and County of Honolulu
  Department of Planning & Permitting
  SMA Permits 808.768.8014

within the shoreline area, an archeological survey may be required.

Building and Grading Permits

Some LID systems will require a building, grading, or grubbing permit. A building permit is a certificate of approval from a local county authority approving the design and construction of typically above ground structures. For example, an above ground rain catchment tank greater than 15,000 gallons or exceeding a 2 to 1 ratio of height to width requires a building permit. Plans for these types of catchment tanks need to be stamped by a Hawai'i licensed structural engineer or architect. Tanks set below grade do not require a building permit, however they may require either a grubbing or a grading permit. Grubbing permits are typically required when any vegetation is removed, and grading permits are required for the excavation of fill, or for the temporary storage of soil or rock-like materials exceeding defined quantities. In Maui County, for example, a grading permit is required if more than 100 cubic yards (4' of cut) of fill is excavated in a non-Special Management Area (SMA) or more than 50 cubic yards (2' of cut) within the SMA. Additionally, if the project is within the shoreline area and is removing greater than 50 cubic yards of material, a coastal geologist or engineer must write a letter that designates the limits of the coastal dune. A grading permit requires two sets of detailed drawings by a State of Hawai'i licensed civil engineer, including a construction BMP plan preventing soil migration offsite. Cost of the grading permit is dependent on the amount of earthworks.

Concluding Remarks

LID is more than a collection of stormwater management systems. It is a design philosophy and a different way of looking at stormwater. It's a way of ensuring that stormwater's value as a vital natural resource is maintained. This overview was intended to provide an introduction to LID, and it is our hope that property owners will use it as a tool and begin to view their properties within the larger context of the watershed.

The next time that it rains on your property, we invite you to grab an umbrella and the LID Assessment Worksheet and take a look around. Observe what is happening to stormwater on your property. Is there pooling or erosion? Does a footpath turn into a stream? Is water pouring off of a roof? Where does that drain lead to? These observations can become the basis for installing LID systems that will slow, sink, filter, or store stormwater, enhance the beauty and functionality of your property, save money, and protect Hawai'i's unique and valuable marine environment that draws so many visitors to our islands each year.

Additional Resources on LID:

water.epa.gov/polwaste/green/
Includes links to several cost benefit studies on LID versus standard stormwater practices and reports addressing perceived barriers to LID use

www.lowimpactdevelopment.org
Includes a number of resources on LID use from the Low Impact Development Center, a non-profit organization dedicated to the advancement of Low Impact Development technology

files.hawaii.gov/dbedt/op/czm/initiative/lid/lid_guide_2006.pdf
Links to "Low Impact Development: A Practitioner's Guide," a "Hawai'i specific" discussion of LID use in the Islands developed following an LID conference held in June 2006

www.honoluludpp.org/Portals/0/SiteDevelopmentDivision/DPP%20Storm%20Water%20BMP%20Guide%20(Dec-2012).pdf
Links to City and County of Honolulu's Department of Planning and Permitting's "Storm Water BMP Guide December 2012," offering detailed descriptions of a number of stormwater best management practices, including technical schematics and drawings

www.usgbc.org
Includes details about Leadership in Energy and Environmental Design (LEED) Certification Standards

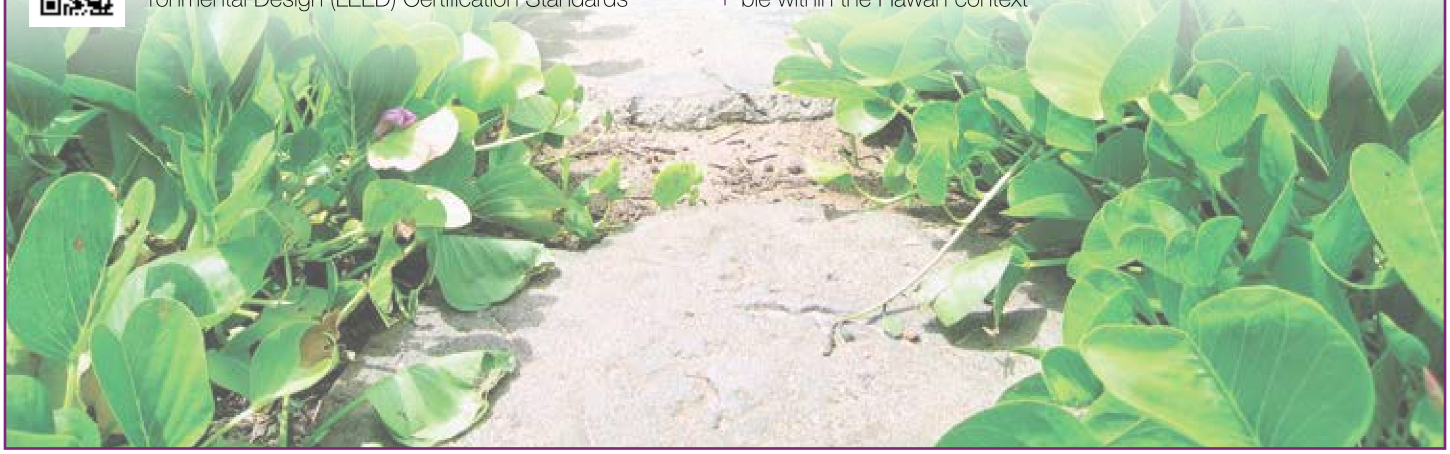
keolamauloa.com/2013/04/our-canoe-garden
Provides a good example of a "canoe garden"

www.perviouspavement.org
Details pervious concrete uses, prices, and applications

www.nrmca.org/certifications/pervious/Search/PERVIOUS/ShowPERVIOUSTablePage.aspx
Links to the National Ready Mixed Concrete Association (NRMCA) database of certified pervious concrete technicians; could be used to locate a pervious concrete specialist or contractor in a particular area

www.westmauir2r.com/uploads/7/5/7/6/7576120/raingardenmanual-web_3-25-13.pdf
Links to the Hawai'i Residential Rain Garden Manual which could be applied on a resort or hotel property as well; published by Hui o Ko'olaupoko in 2013

data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/1906/Feb2014_IslandBMPGuide_wAppendix.pdf
Links to "Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID," documenting "island specific" examples that are very applicable within the Hawai'i context



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CORAL REEF ALLIANCE

www.coral.org