
A‘ohe hana nui ke alu ‘ia
No task is too big when done together by all

Global Population will Reach 9.6 Billion by 2050

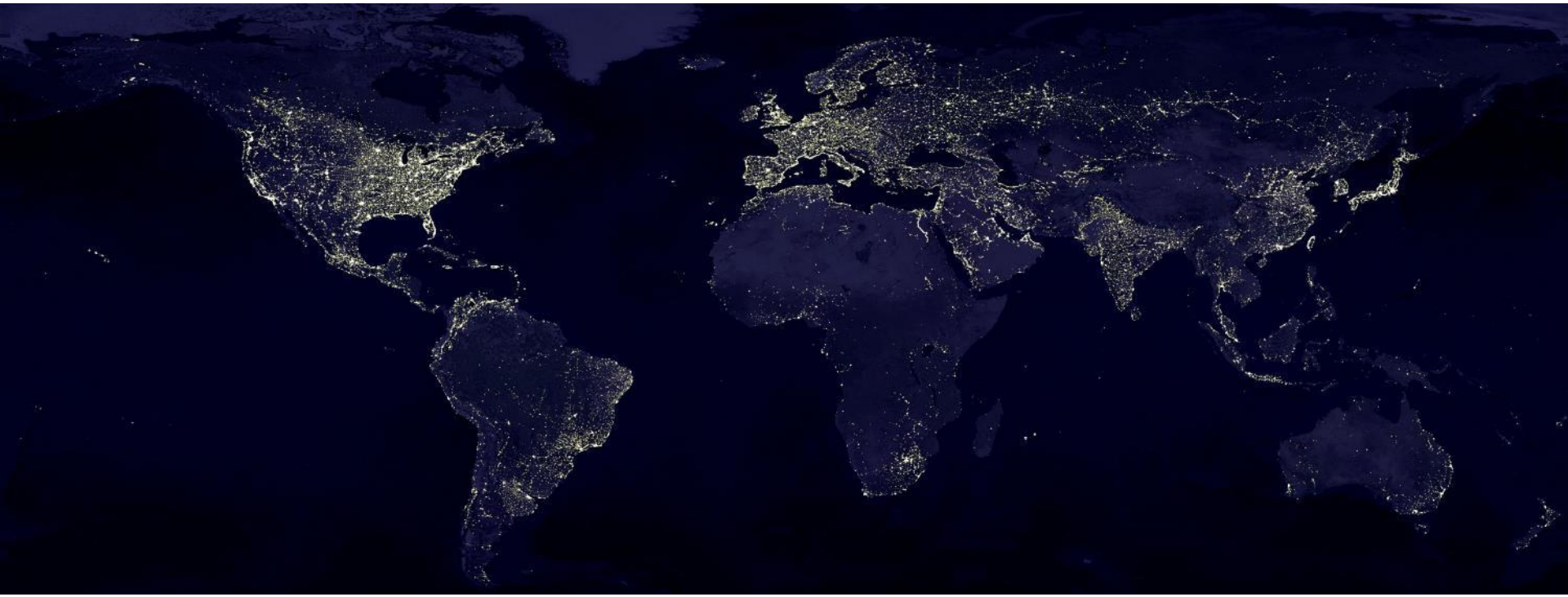


Image source: www.nasa.gov
Source: U.N. Report (2013)

Urbanization Impacts
Local Hydrology and Water Quality

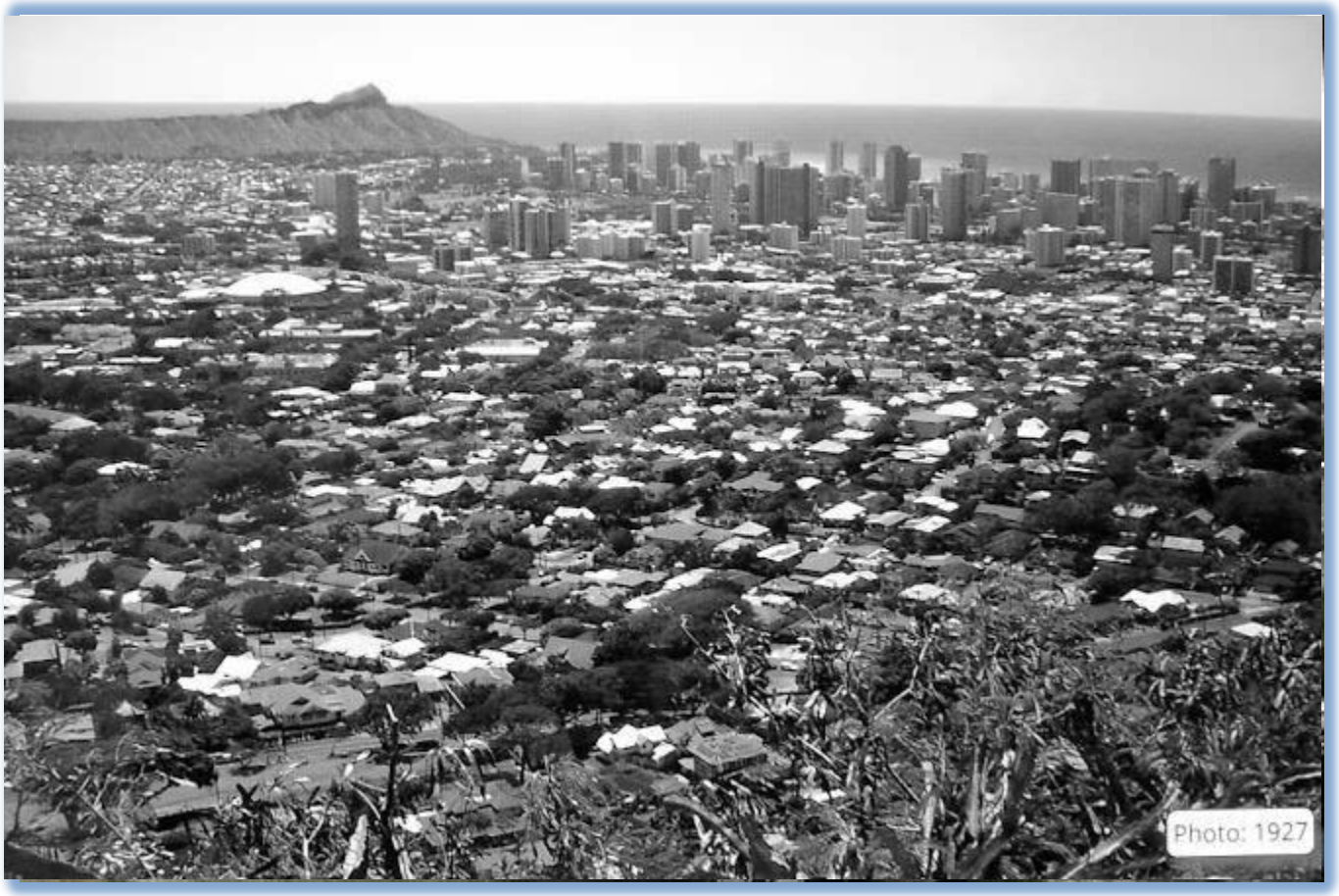
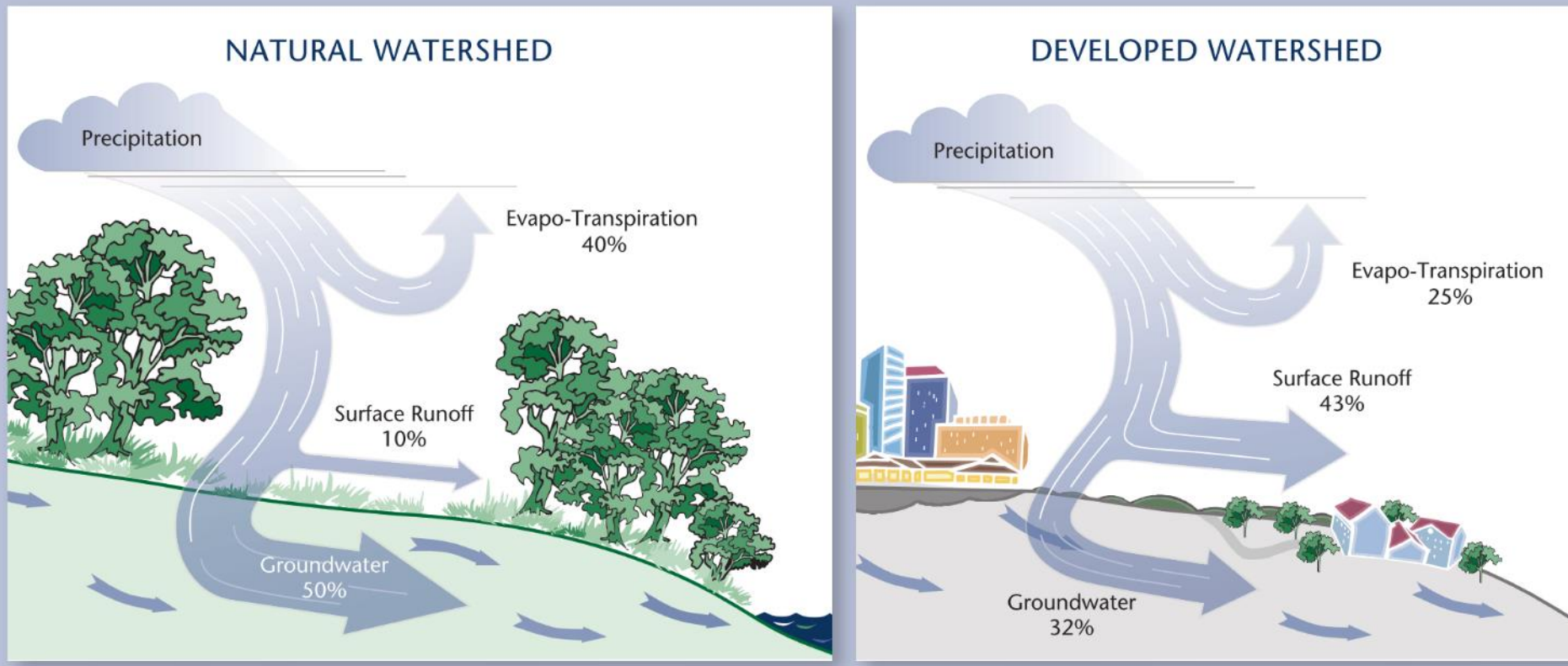
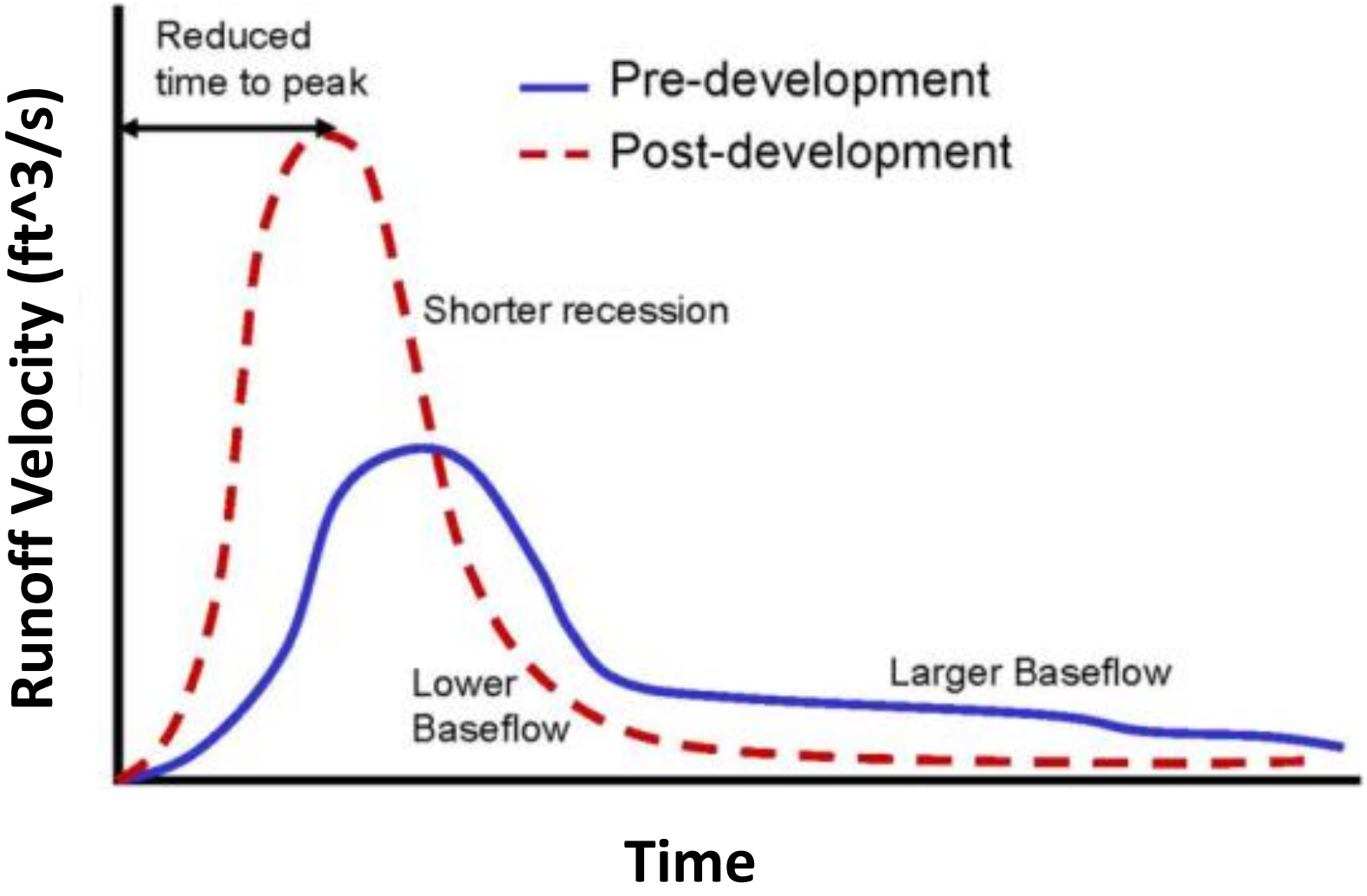


Photo Credit: Bernice Pauahi Bishop Museum



Hydrologic Alterations of Development

Hydrologic Impacts of Development

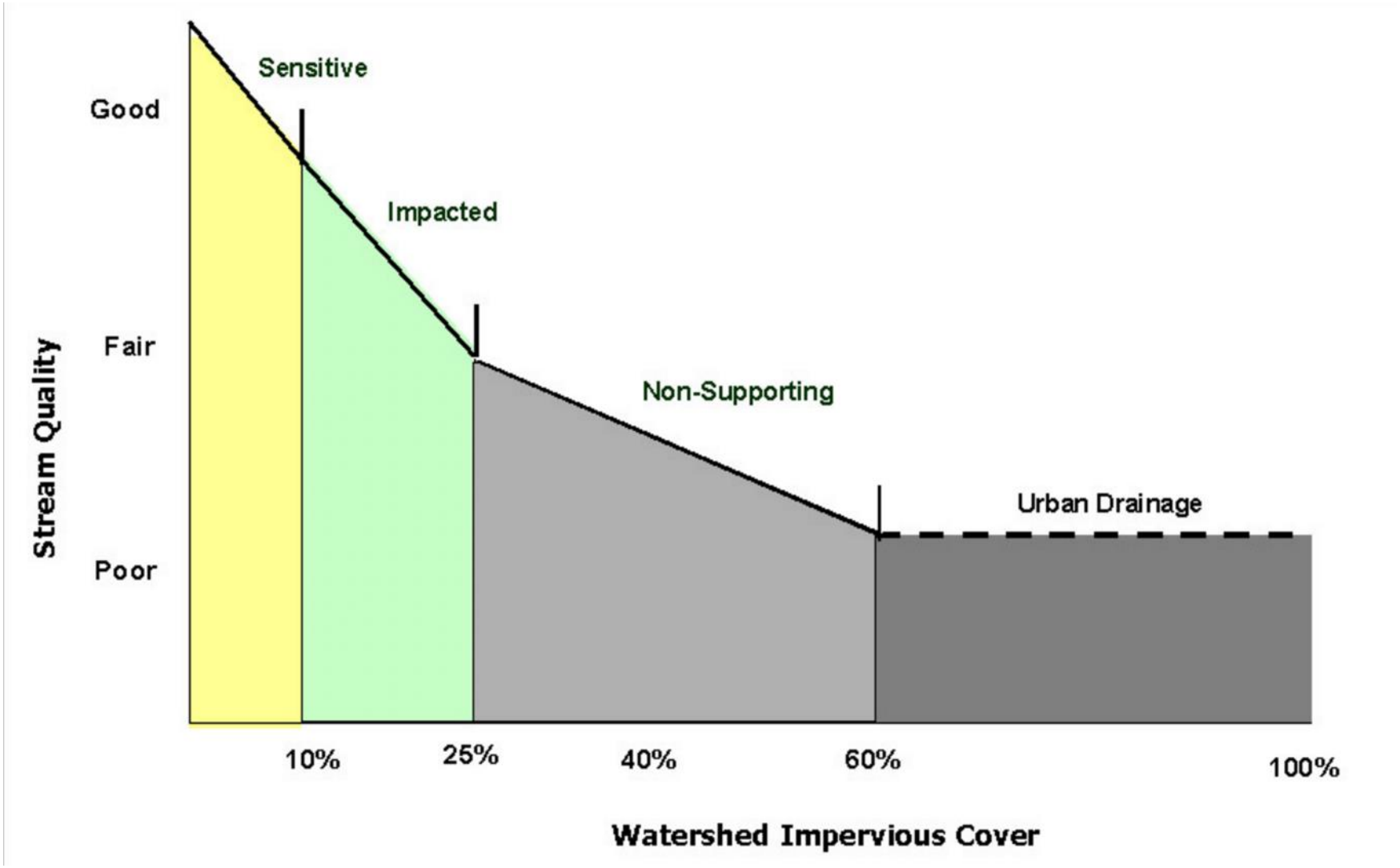


Hydrologic Impacts of Development

Stormwater Outlet Pipe:
Cromwell's Beach

Photo Credit: Amanda Cording

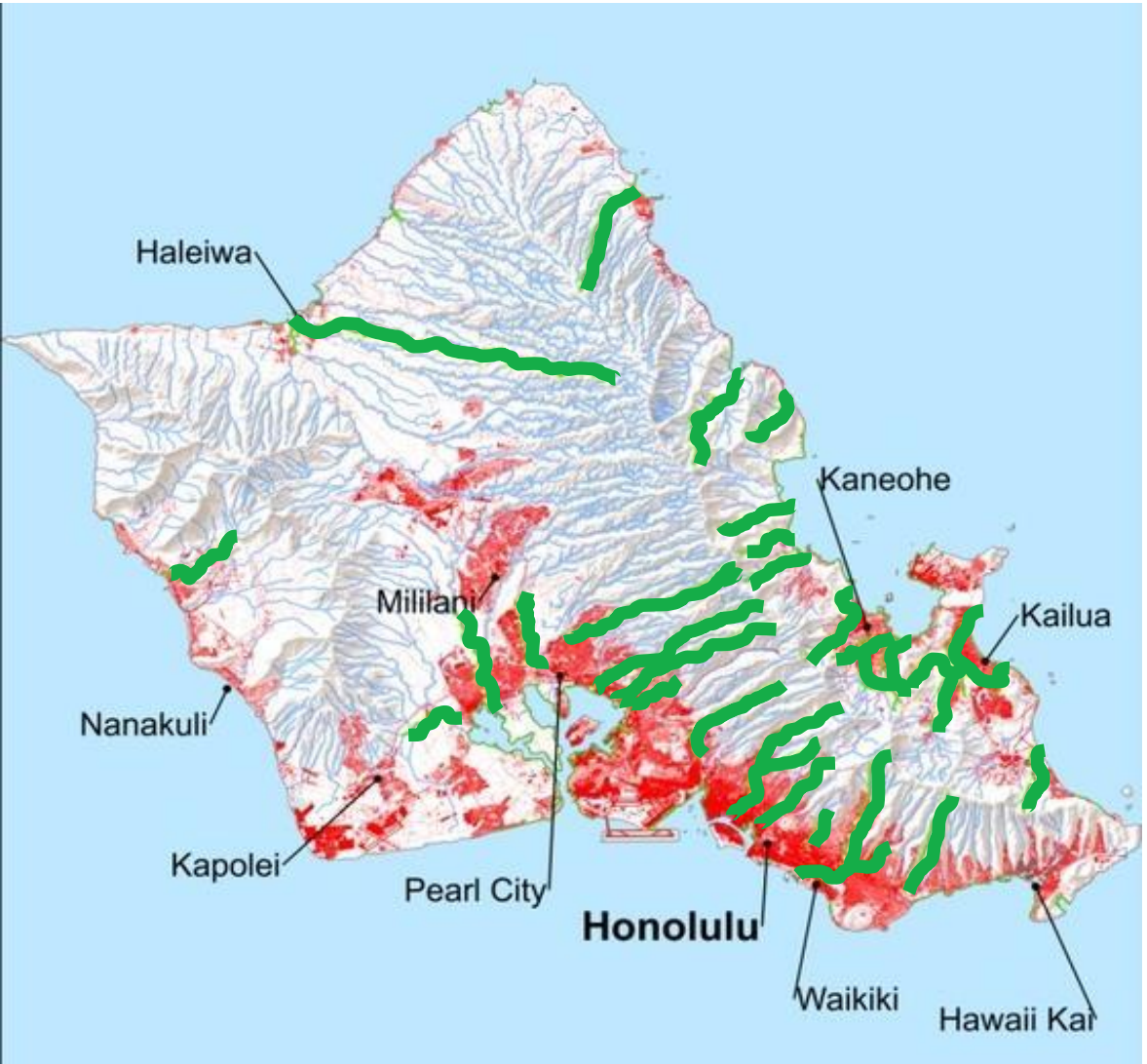
Impervious Surface Impacts Water Quality



Pollutants Found in Stormwater:

bacteria
pathogens
cadmium
chromium
copper
lead
mercury
zinc
phosphorus
nitrogen
oil and grease
total suspended solids

Water Quality Impacts of Development



Definition 303(d): waters that are too polluted or otherwise degraded to meet water quality standards.

2,324 Miles of Rivers and Streams are Impaired In Hawai‘i

Date: January 2012

Source:
ESRI Online Basemap;
State of Hawaii, DLNR, Division of Aquatic Resrources;
NOAA 2005 CCAP Data; EPA

2,324 Miles of Rivers and Streams are Impaired In Hawai‘i

Causes of Impairment
Hawaii Rivers and Streams 2010

Description of this table

Cause of Impairment	Cause of Impairment Group	Miles Threatened or Impaired
Turbidity	Turbidity	1,993.9
Nitrate/Nitrite (Nitrite + Nitrate as N	Nutrients	1,275.8
Nitrogen, Total	Nutrients	1,049.9
Phosphorus, Total	Nutrients	944.9
Enterococcus Bacteria	Pathogens	184.7
Trash	Trash	183.2
Total Suspended Solids (TSS)	Turbidity	121.2
Dieldrin	Pesticides	36.8
Chlordane	Pesticides	33.0
Nitrate/Nitrite	Nutrients	31.0
Metals	Metals (other than Mercury)	1.9
Lead	Metals (other than Mercury)	1.9
Phosphate	Nutrients	1.1

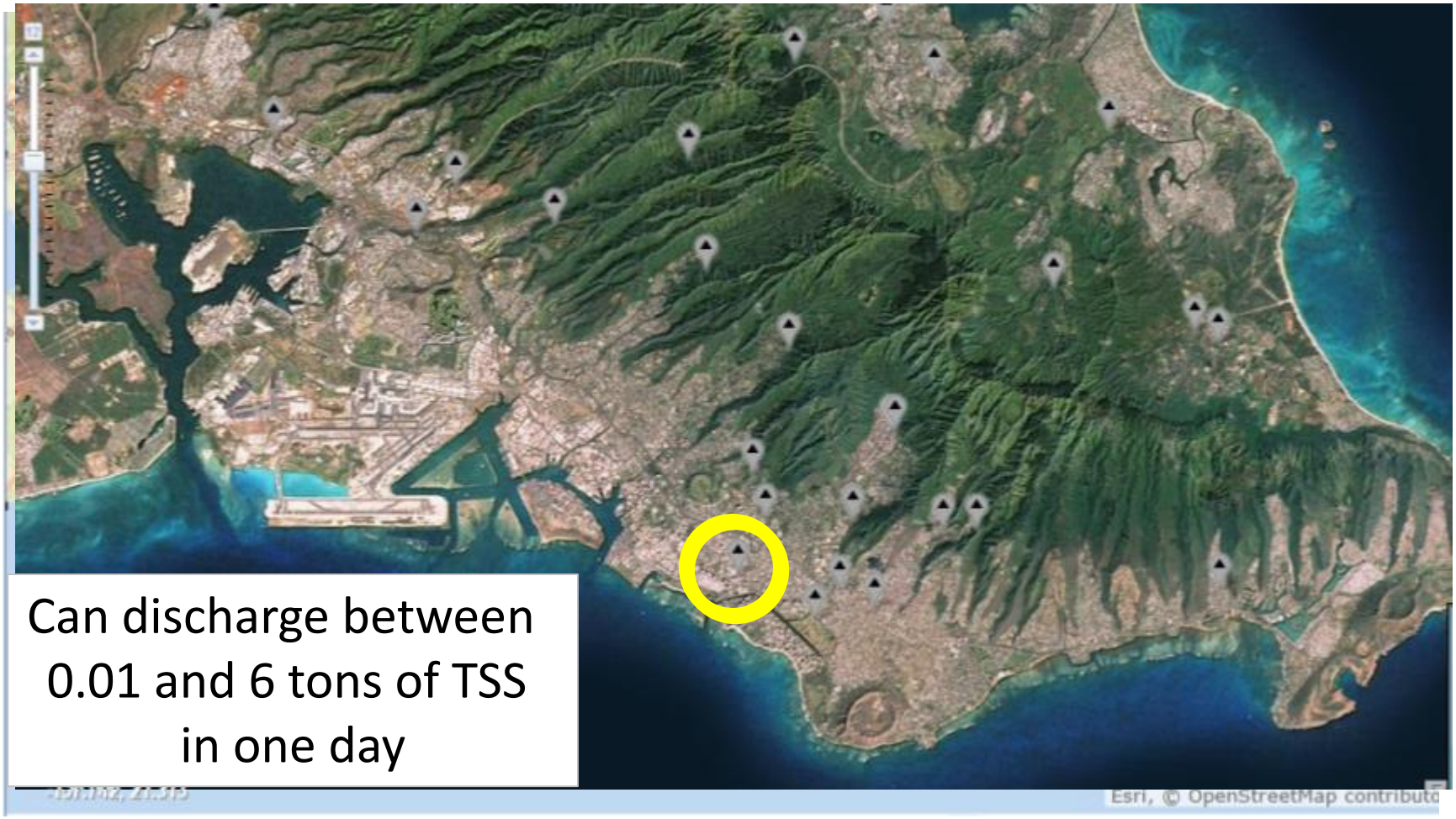
Source: EPA (2010) Hawaii Water Quality Assessment Report

Nine Impaired Streams in Maui

NOTE: Click on the underlined "Waterbody Name" to view a Waterbody report.

Waterbody Name	Waterbody ID	Location	Waterbody Type	Size	Units	State TMDL Development Status
Honokowai	HI6-1-07	Maui	Stream	16.910698	miles	TMDL needed
Honokowai	HI6-1-07	Maui	Stream	16.910698	miles	TMDL needed
Iao	HI6-2-09	Maui	Stream	11.296194	miles	TMDL needed
Iao	HI6-2-09	Maui	Stream	11.296194	miles	TMDL needed
Kahana	HI6-1-08	Maui	Stream	17.250879	miles	TMDL needed
Kahana	HI6-1-08	Maui	Stream	17.250879	miles	TMDL needed
Kahoma	HI6-1-05	Maui	Stream	15.789657	miles	TMDL needed
Kahoma	HI6-1-05	Maui	Stream	15.789657	miles	TMDL needed
Makamakaole	HI6-2-06	Maui	Stream	3.625059	miles	TMDL needed
Makamakaole	HI6-2-06	Maui	Stream	3.625059	miles	TMDL needed
Maliko	HI6-3-01	Maui	Stream	43.825989	miles	TMDL needed
Maliko	HI6-3-01	Maui	Stream	43.825989	miles	TMDL needed
Ukumehame	HI6-1-01	Kauai	Stream	12.225315	miles	TMDL needed
Ukumehame	HI6-1-01	Kauai	Stream	12.225315	miles	TMDL needed
Waihee	HI6-2-07	Maui	Stream	16.384853	miles	TMDL needed
Waihee	HI6-2-07	Maui	Stream	16.384853	miles	TMDL needed
Waipio	HI6-3-10	Maui	Stream	2.806819	miles	TMDL needed
Waipio	HI6-3-10	Maui	Stream	2.806819	miles	TMDL needed

Makiki Stream at King St. Bridge: Oahu, HI



USGS National Water Information System Mapper (2011 – 2013)

Sedimentation Impacts Reef Health

Pu‘ukoholā Heiau National Historic Site and

Kawaihae Harbor, Hawai‘i

Image Source: USGS Pacific Coastal and Marine Science Center

Reference: Anthony, K. R. N., & Connolly, S. R. (2004).

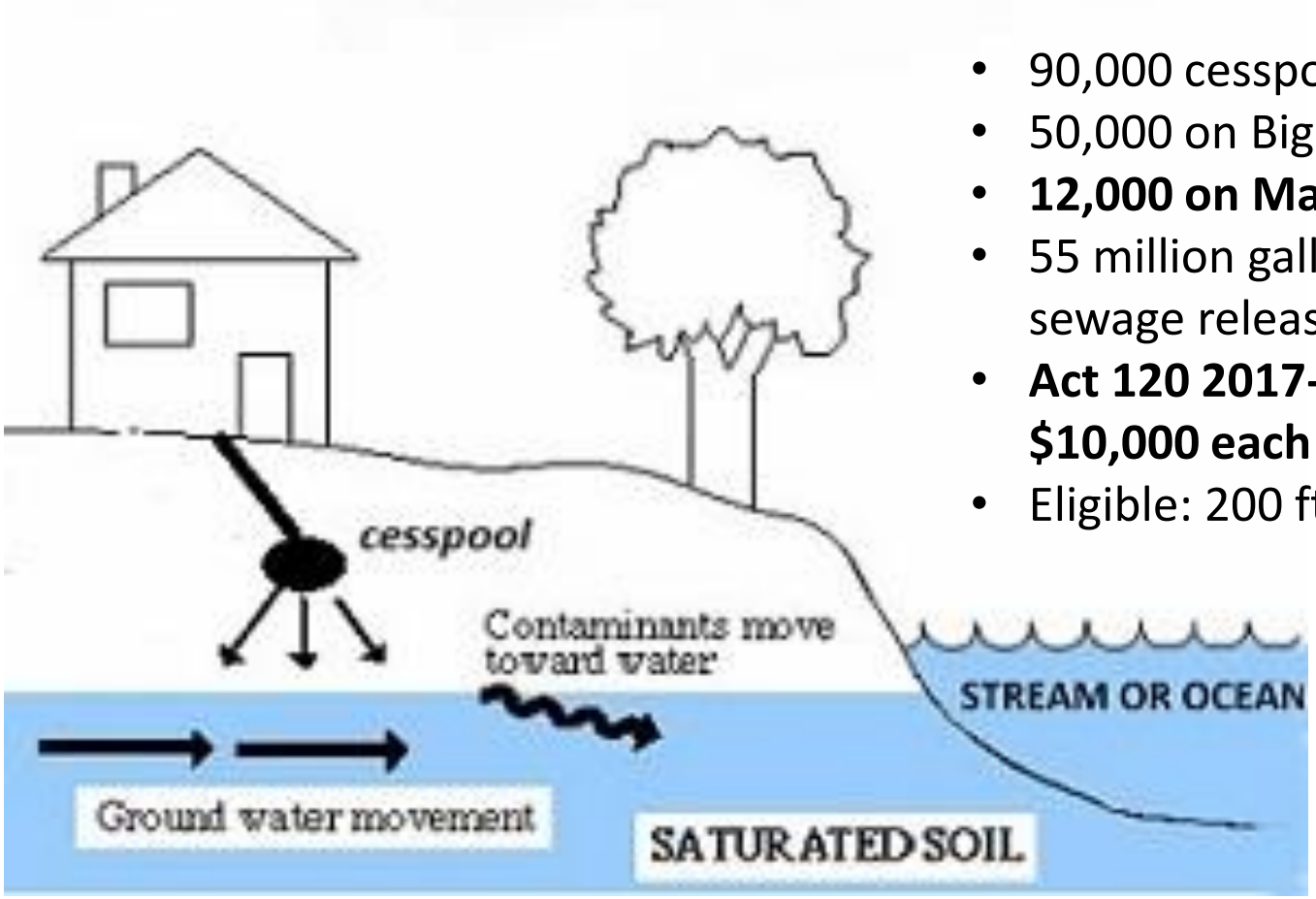
Water Quality Notices

- Launiupoko, Maui March 7th 2017
- Roal Moana Beach, Oahu February 14, 2017
- Honolua Bay, Maui January 29th 2017
- Hanaka'o, Maui December 1, 2016

"The public is advised to stay out of flood waters and storm water runoff due to possible overflowing cesspools, sewer manholes, pesticides, animal fecal matter, dead animals, pathogens, chemicals, and associated flood debris"

- *State Dept. of Health*

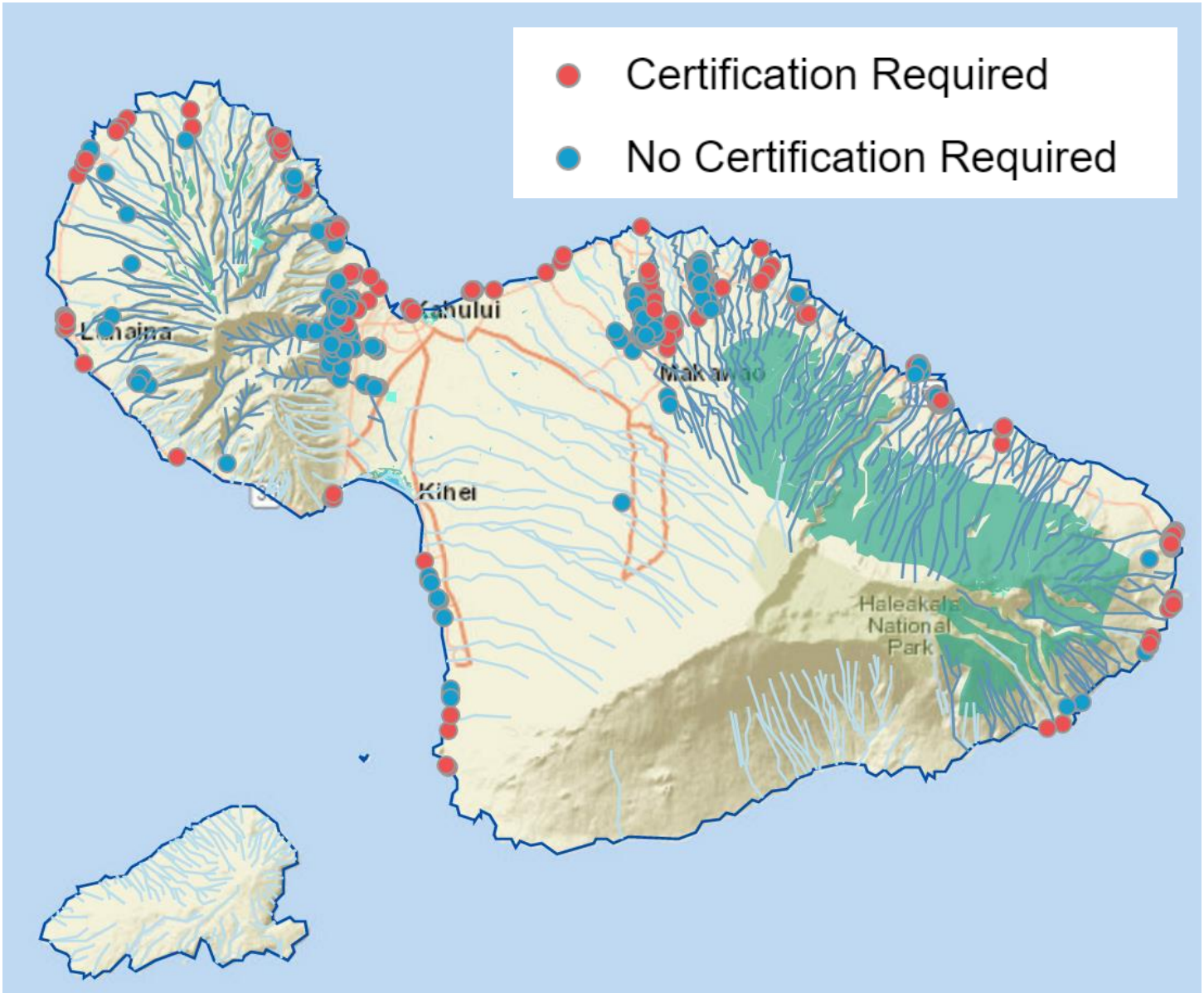
Cesspools Contaminate our Oceans, Streams and Groundwater



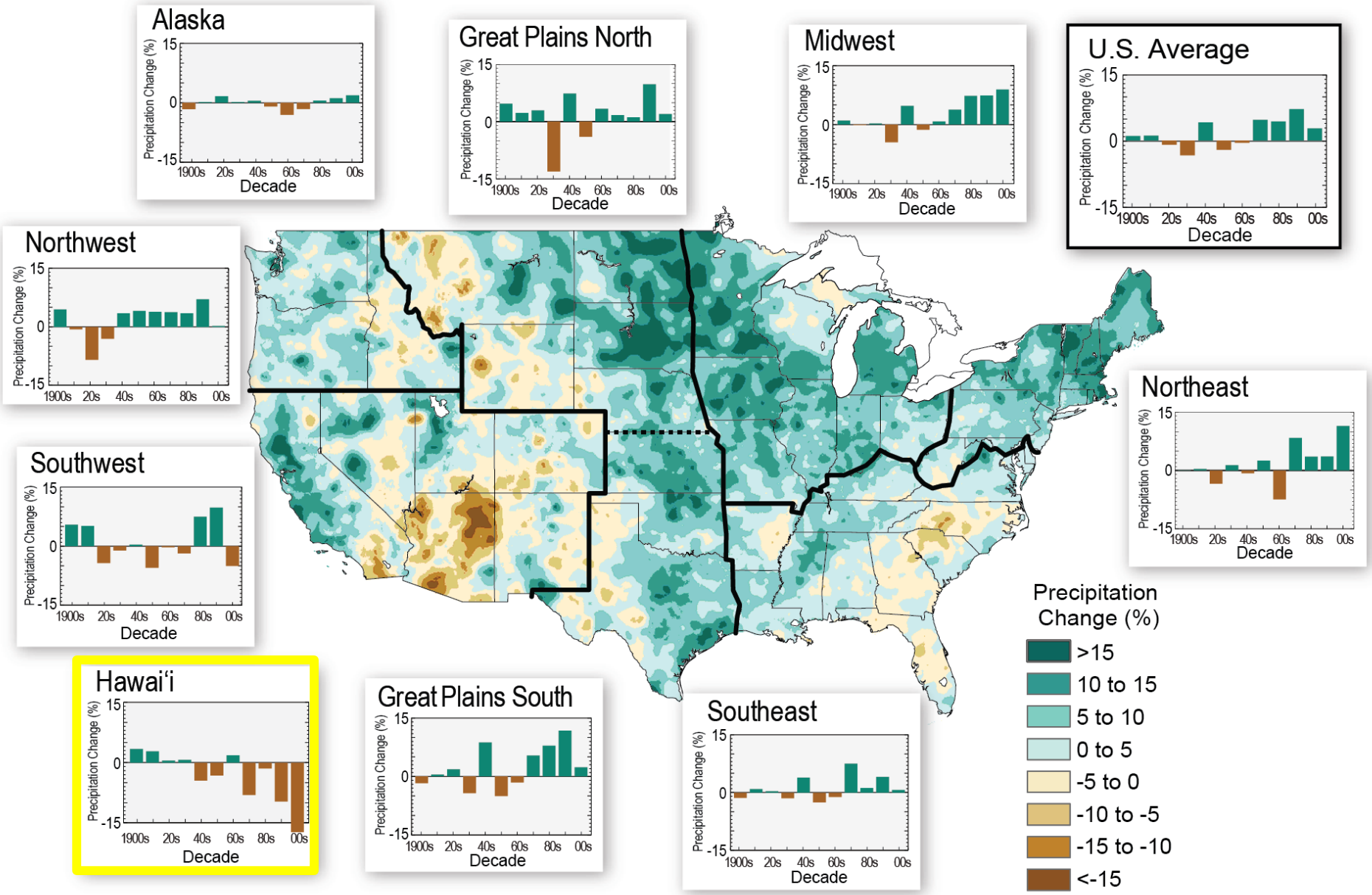
- 90,000 cesspools in HI
- 50,000 on Big Island
- **12,000 on Maui**
- 55 million gallons of untreated sewage released each day
- **Act 120 2017-2020 Tax Credit: $10,000 each**
- Eligible: 200 ft from waterbody

Department of Health, Wastewater Branch

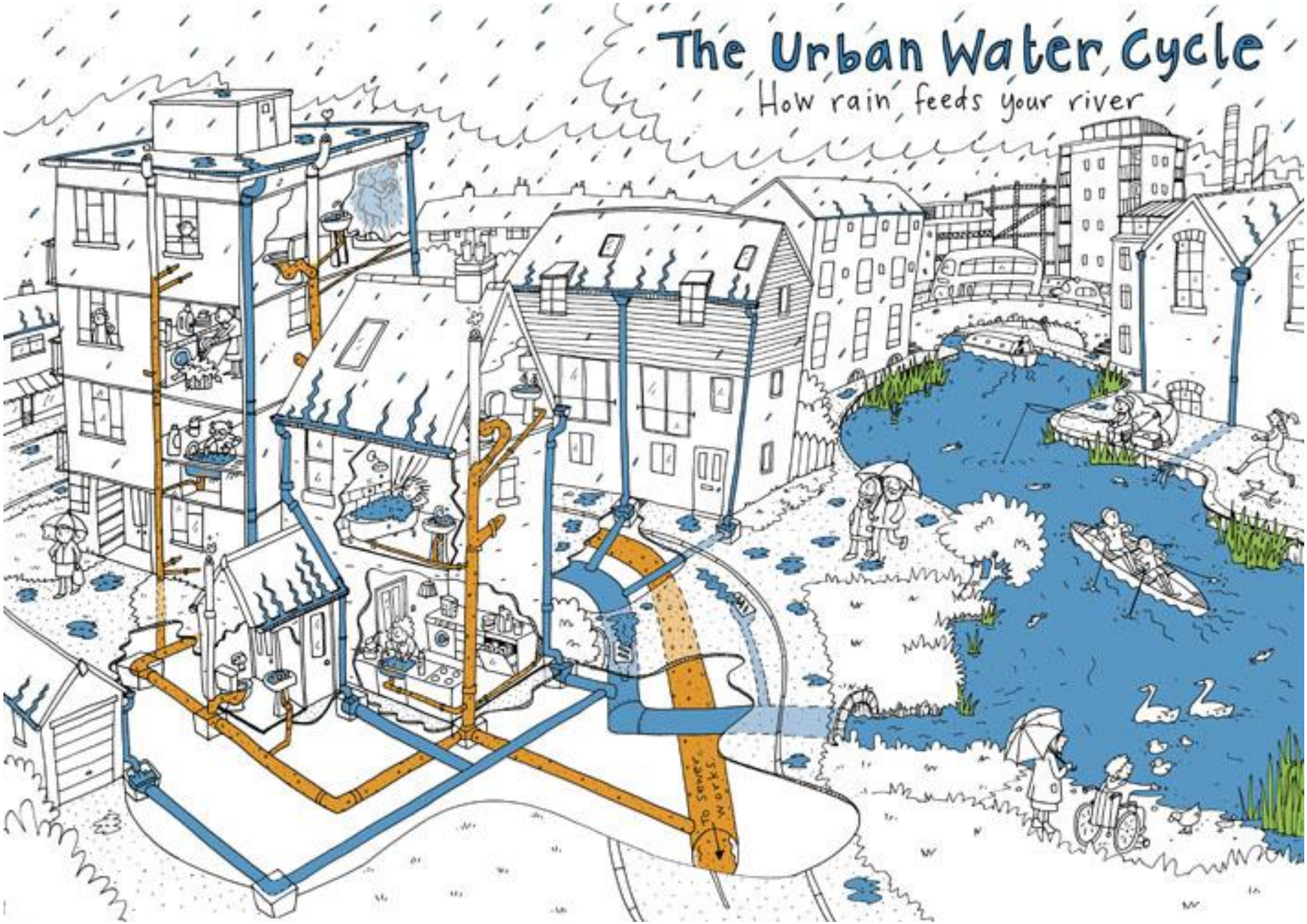
Cesspools Eligible for Tax Rebate

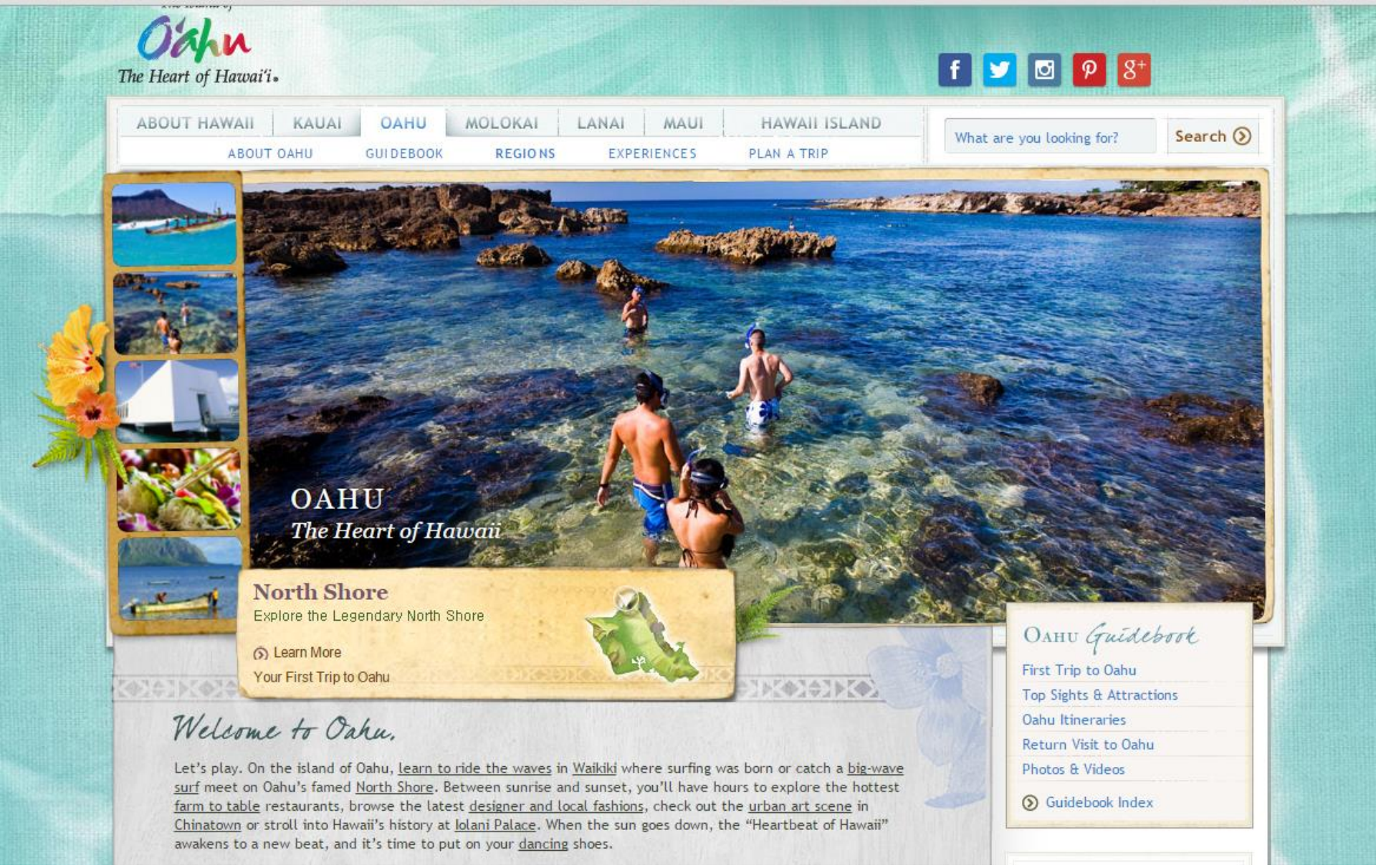


Observed U.S. Precipitation Change



Peterson et al (2013) Monitoring and understanding changes in heat waves, cold waves, floods, and droughts in the United States. Am. Meteorol. Soc.


The Urban Water Cycle
How rain feeds your river
TO SEWAGE WORKS



Tourism is the largest source of private income and jobs in HI

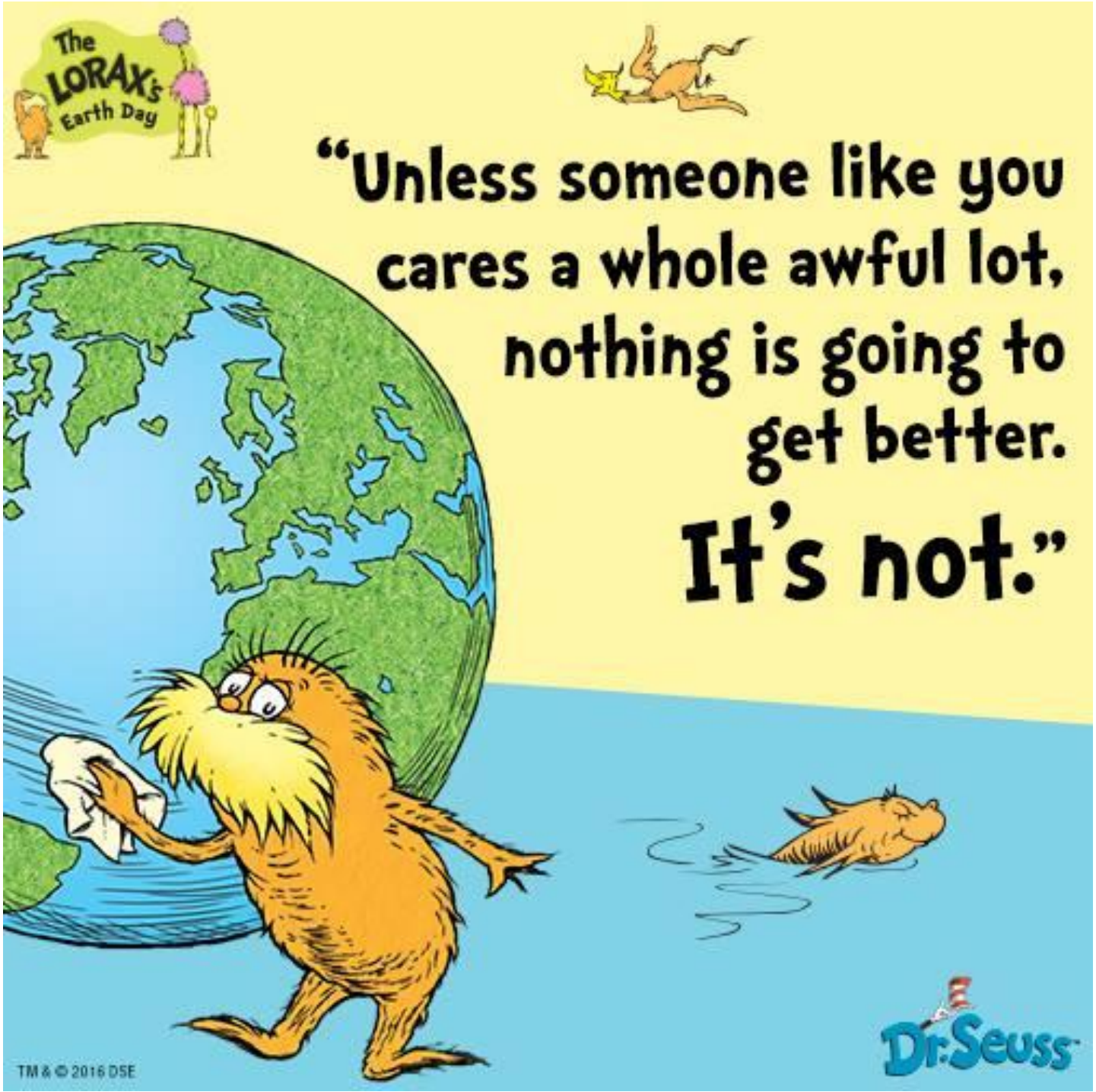
Number of visitors hit new record in 2015, $15.3 Billion in Revenue

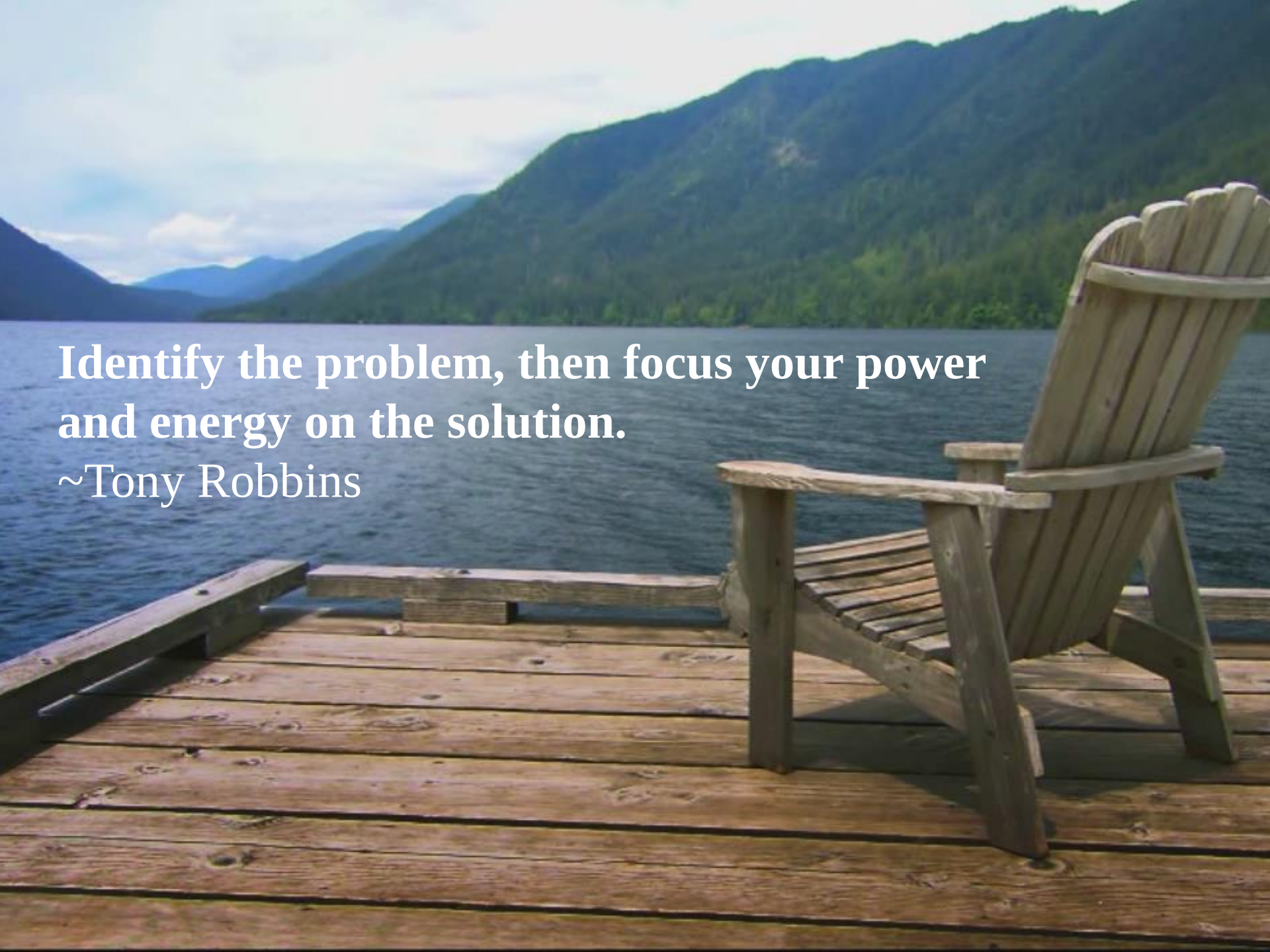


The Importance of Water for our Lifestyle

- Recreation: Snorkeling, scuba diving, surfing, kayaking, canoeing, relaxing, swimming, fishing, habitat, wildlife




The LORAX's Earth Day
"Unless someone like you cares a whole awful lot, nothing is going to get better. It's not."
TM & © 2016 DSE
Dr. Seuss

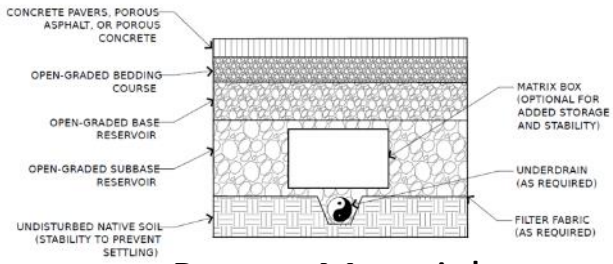

Identify the problem, then focus your power and energy on the solution.
~Tony Robbins


Fossil fuel
Emission

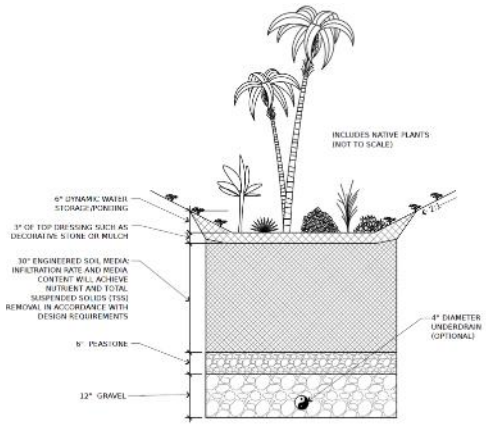
Low Impact Design & Development

LID is an approach to development that aims to mimic pre-development hydrology and uses ecological engineering to remove pollutants in stormwater and wastewater for re-use and/or replenishment of groundwater supplies.

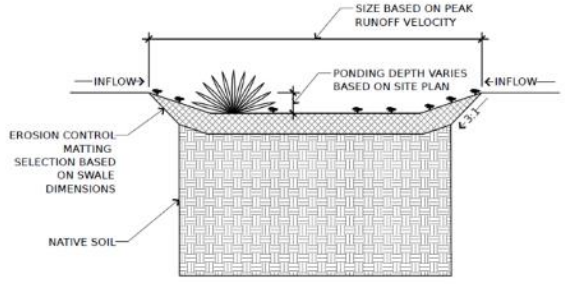


Porous Materials



Bioretention “Green Streets”



Vegetated Swales

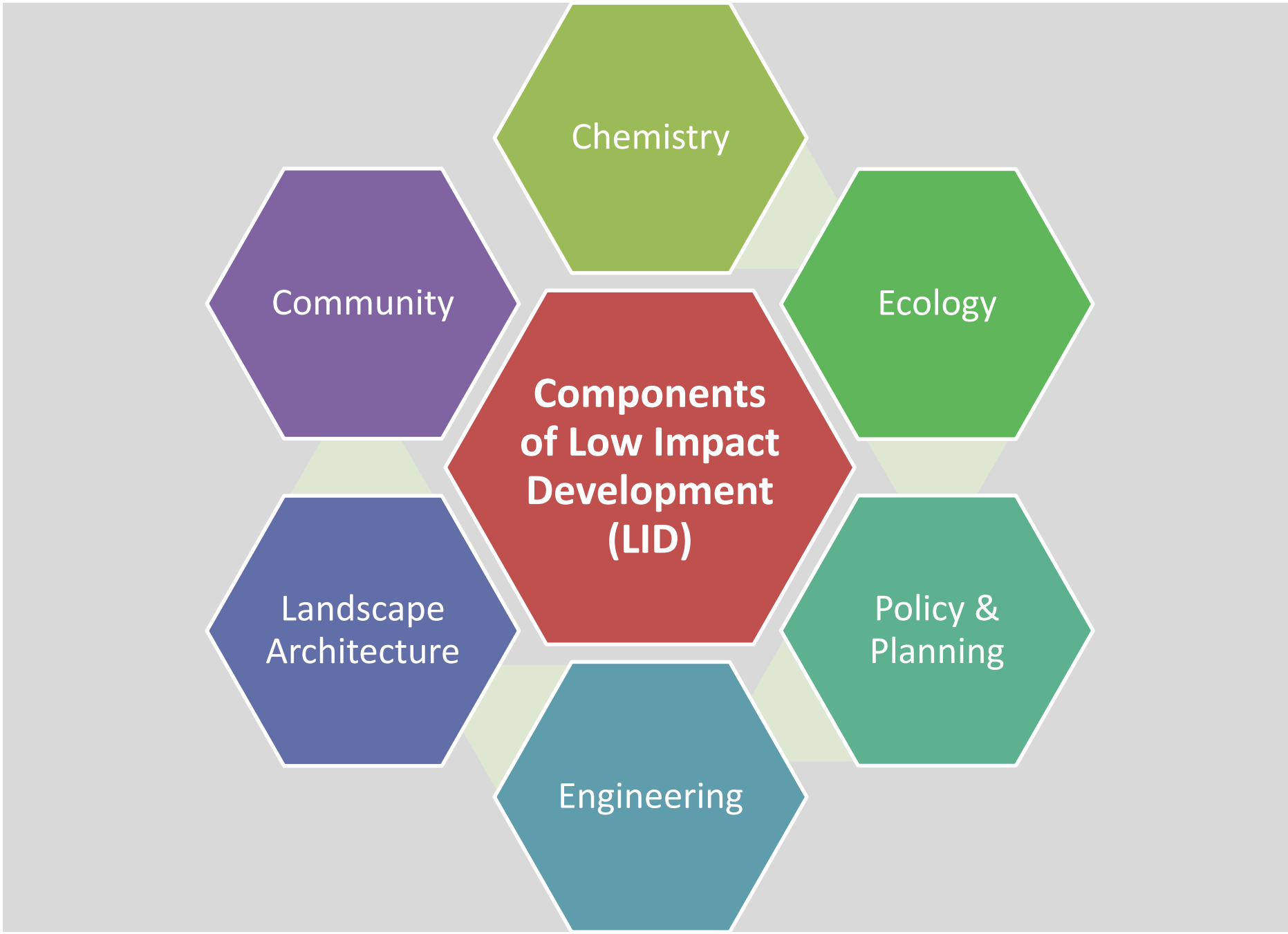
National and Local Proponents of Low Impact Development

AIA Honolulu

CENTER FOR WATERSHED PROTECTION

City and County of Honolulu Requiring Low Impact Development

Presented by Randal Wakumoto, City and County of Honolulu, Stormwater Branch
UH Sea Grant's Green Infrastructure Workshop , October 29, 2015

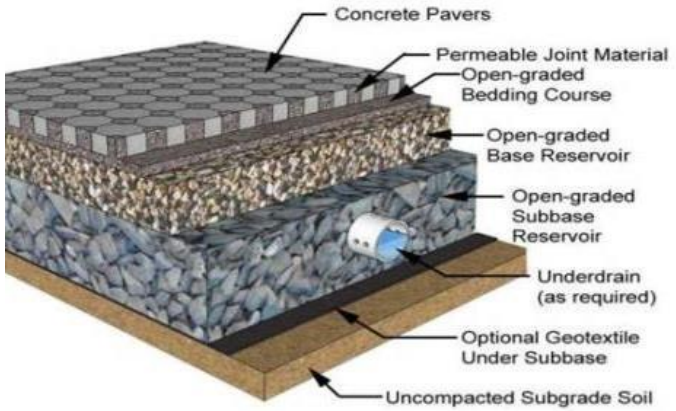

Chemistry
Community
Ecology
Components of Low Impact Development (LID)
Landscape Architecture
Policy & Planning
Engineering

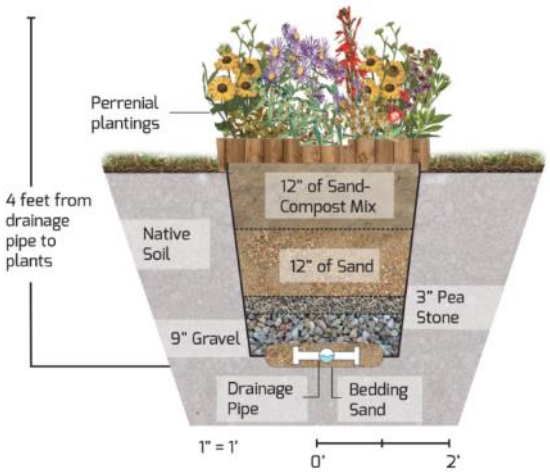
Cost of LID vs Traditional Development

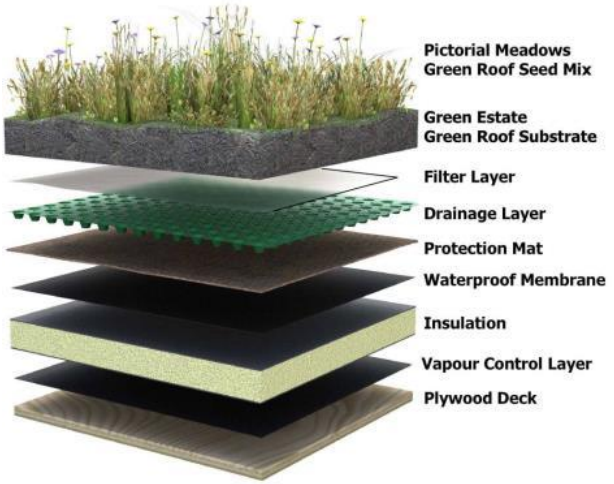
Item	Conventional Option	LID Option	Cost Difference
Mobilization / Demolition	$555,500	$555,500	$0
Site Preparation	$167,000	$167,000	$0
Sediment / Erosion Control	$378,000	$378,000	$0
Earthwork	$2,174,500	$2,103,500	–$71,000
Paving	$1,843,500	$2,727,500	$884,000
Stormwater Management	$2,751,800	$1,008,800	–$1,743,000
Addtl Work-Related Activity (Utilities, Lighting, Water & Sanitary Sewer Service, Fencing, Landscaping, Etc.)	$2,720,000	$2,720,000	$0
Project Total	$10,590,300	$9,660,300	–$930,000

TABLE 3-2 Comparison of Unit Costs for Materials for Greenland Meadows Commercial Development

Green Stormwater Infrastructure (GSI)





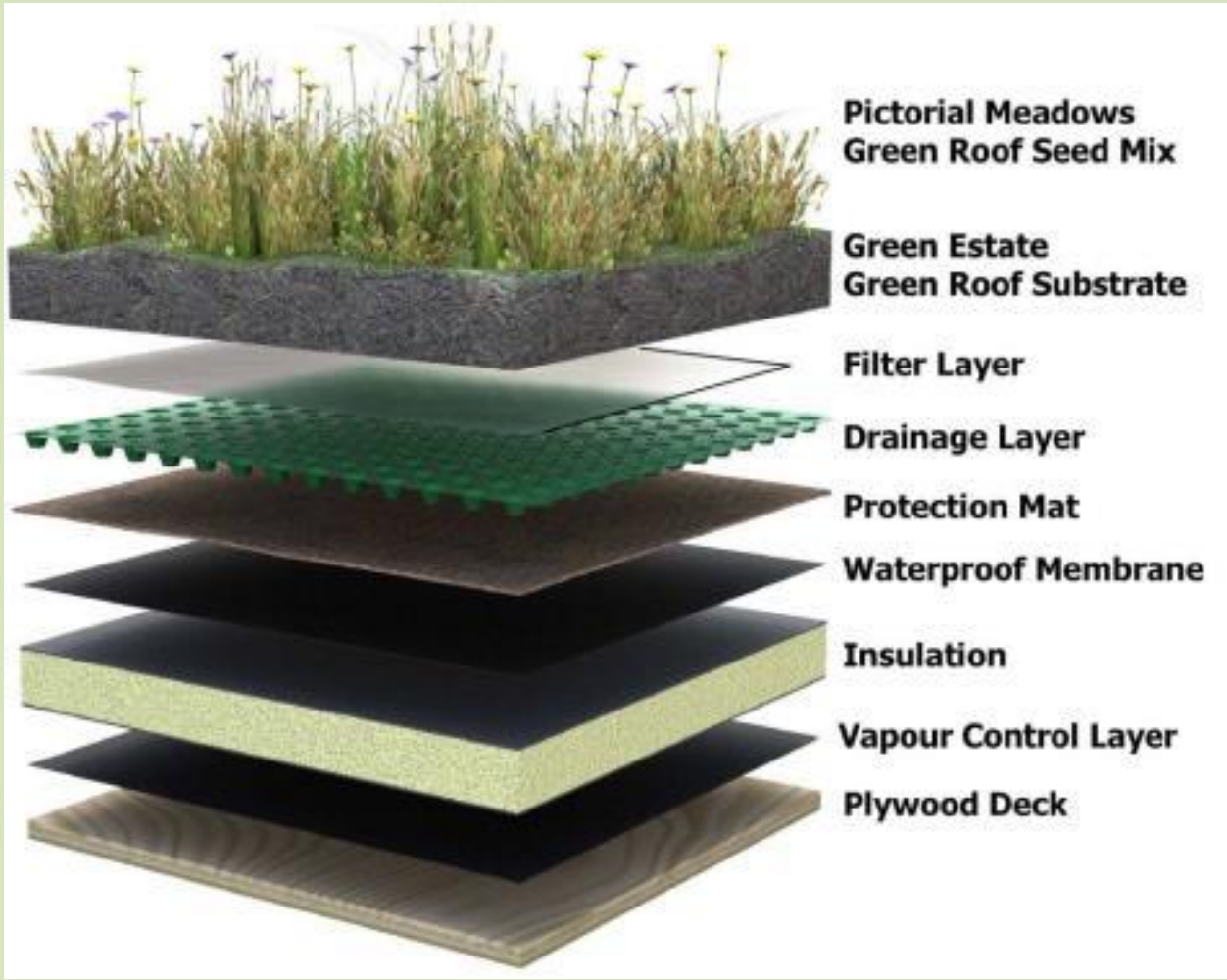


Davis 2008; Dietz and Clausen 2006; Zinger et al. 2013; Collins et al. 2010.

Green Roofs

Design Strengths:
Reduce Volume
Reduce Peak Flows
Remove Pollutants
Reduce Temperature
Heat Island
Provide Habitat
Increase Biodiversity

Design Challenges:
Maintenance
Plant Selection



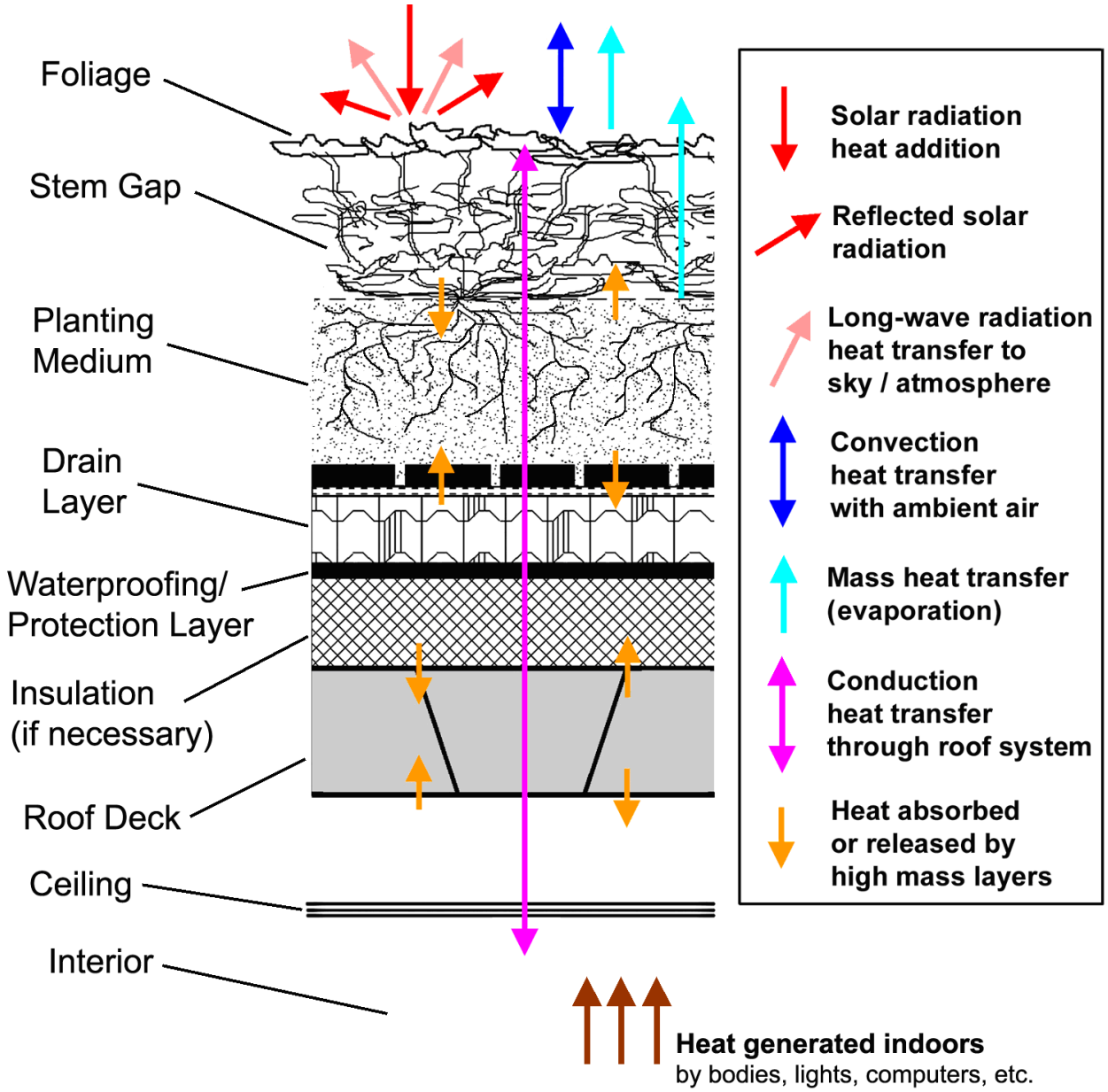
GREEN ROOF SYSTEMS

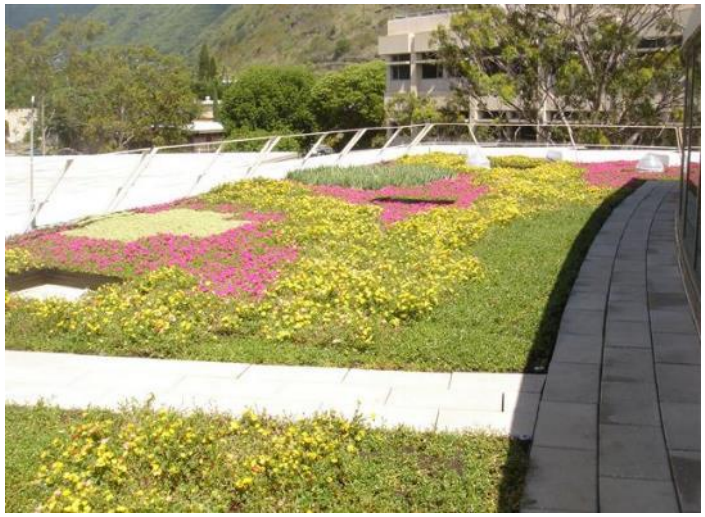
according FLL

	SYSTEMS WITH GRANULAR DRAINAGE				SYSTEMS WITH DRAINAGE PLATES			
								
system designation	G1	G2	G3	G4	P1	P2	P3	P4
typical plants	sedum herbs	sedum herbs perennials	perennials grasses shrubs	grasses shrubs trees	sedum herbs	sedum herbs perennials	perrenials grasses shrubs	grasses shrubs trees
extensive soil mix	2"	4"	-	-	3"	5"	-	-
intensive soil mix	-	-	6"	9"	-	-	8"	12"
separation fabric	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"
granular drainage	2"	2"	4"	6"	-	-	-	-
drainage plate	-	-	-	-	1"	1-1/2"	1-1/2"	2-1/2"
drainage mat	-	-	-	-	-	-	-	-
protection mat	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"
nominal thickness	4"	6"	10"	15"	4"	7"	10"	15"
dry weight	19 lbs/ft²	28 lbs/ft²	45 lbs/ft²	69 lbs/ft²	14 lbs/ft²	23 lbs/ft²	34 lbs/ft²	52 lbs/ft²
saturated weight	26 lbs/ft²	41 lbs/ft²	70 lbs/ft²	105 lbs/ft²	23 lbs/ft²	37 lbs/ft²	57 lbs/ft²	85 lbs/ft²
minimum slope	0:12	0:12	0:12	0:12	1/4:12	1/4:12	1/4:12	1/4:12
maximum slope	1:12	1:12	1:12	1:12	1:12	1:12	1:12	1:12
water retention/Year*	50%	60%	70%	80%	50%	60%	70%	80%
irrigation system	-	-	subsurface	subsurface	-	-	surface	surface

* conservative numbers

Green Roof Insulation and Heat Transfer





University of Hawaii Center for Microbial Oceanography Research & Education

Location: Honolulu, Hawaii

Project Size: 2,768 sq ft

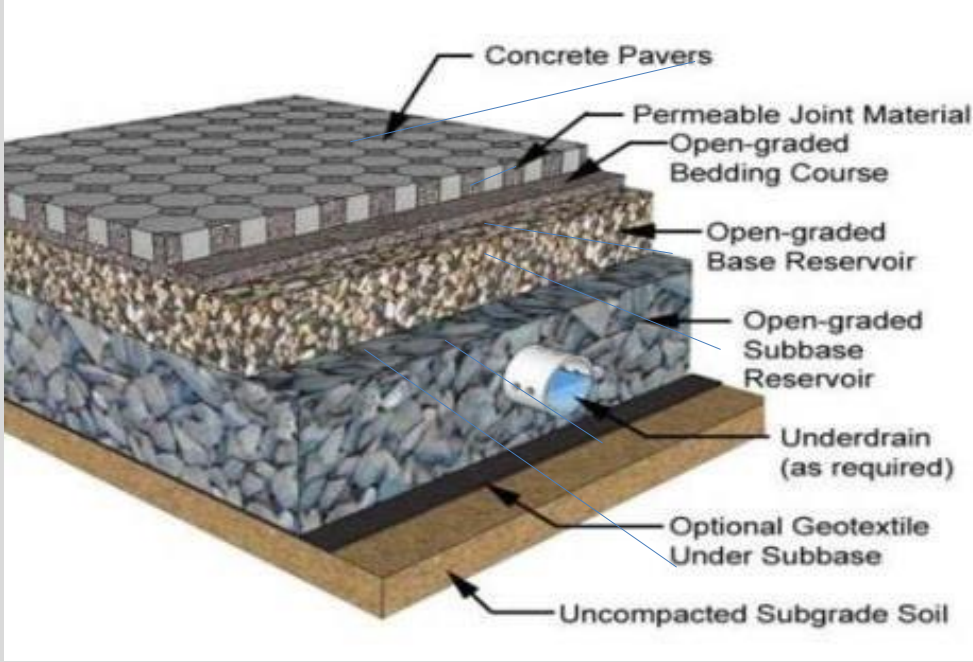
Installation Date: September 23, 2010

Grower: Hawaiian Sunshine Nursery

Turtle Bay Resort

Location: Oahu's North Shore, Hawaii
Project Size: 60,000 sq ft
Partners: Honolulu Roofing Company, Walters, Kimura, Motoda, Hui Ku Maoli Ola

Porous Materials



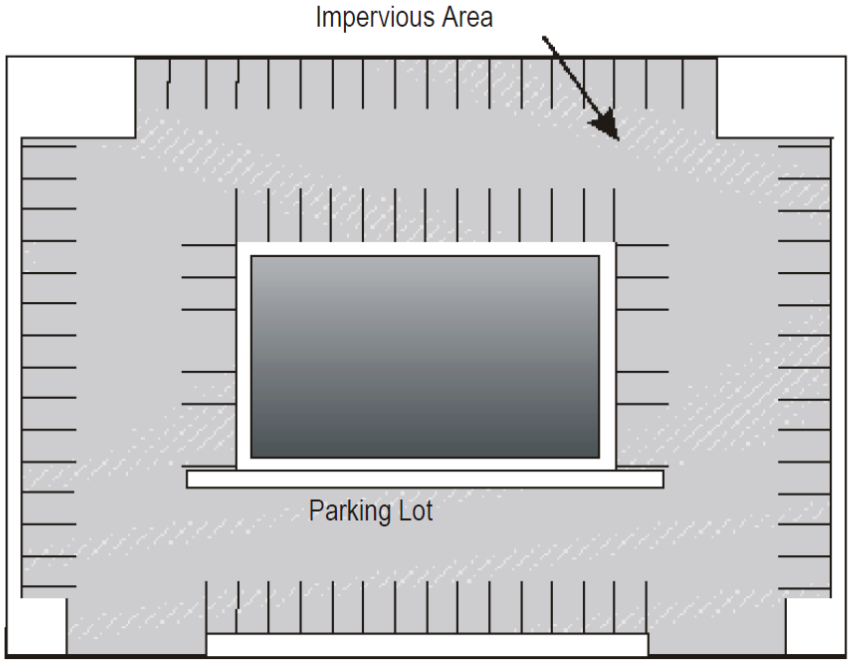
Design Strengths:
Reduces Storm Volume
Reduces Peak Flows
Particulate Pollutant Removal

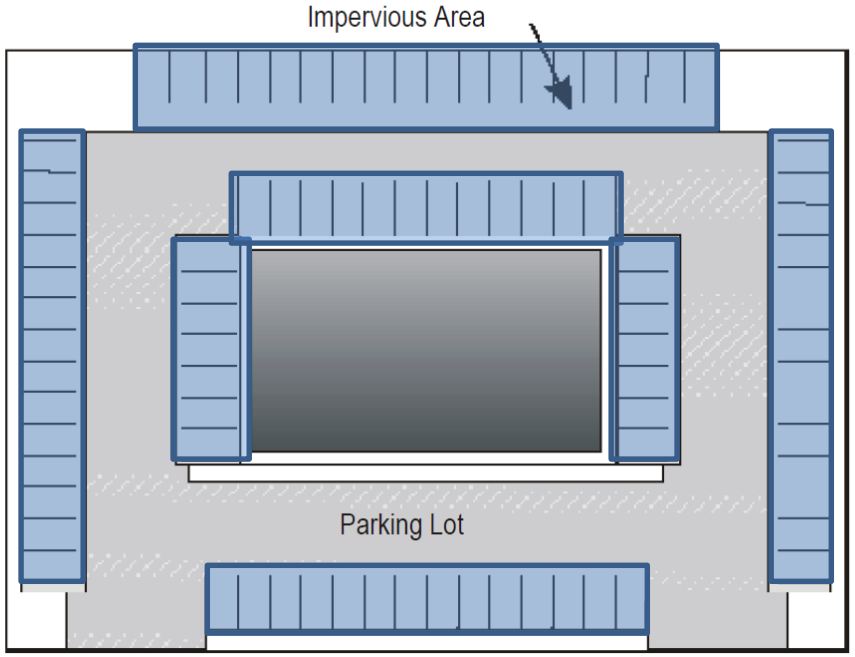
Design Challenges:
Getting both strength and permeability
Protective buffer reduces siltation from offsite flows
Maintenance



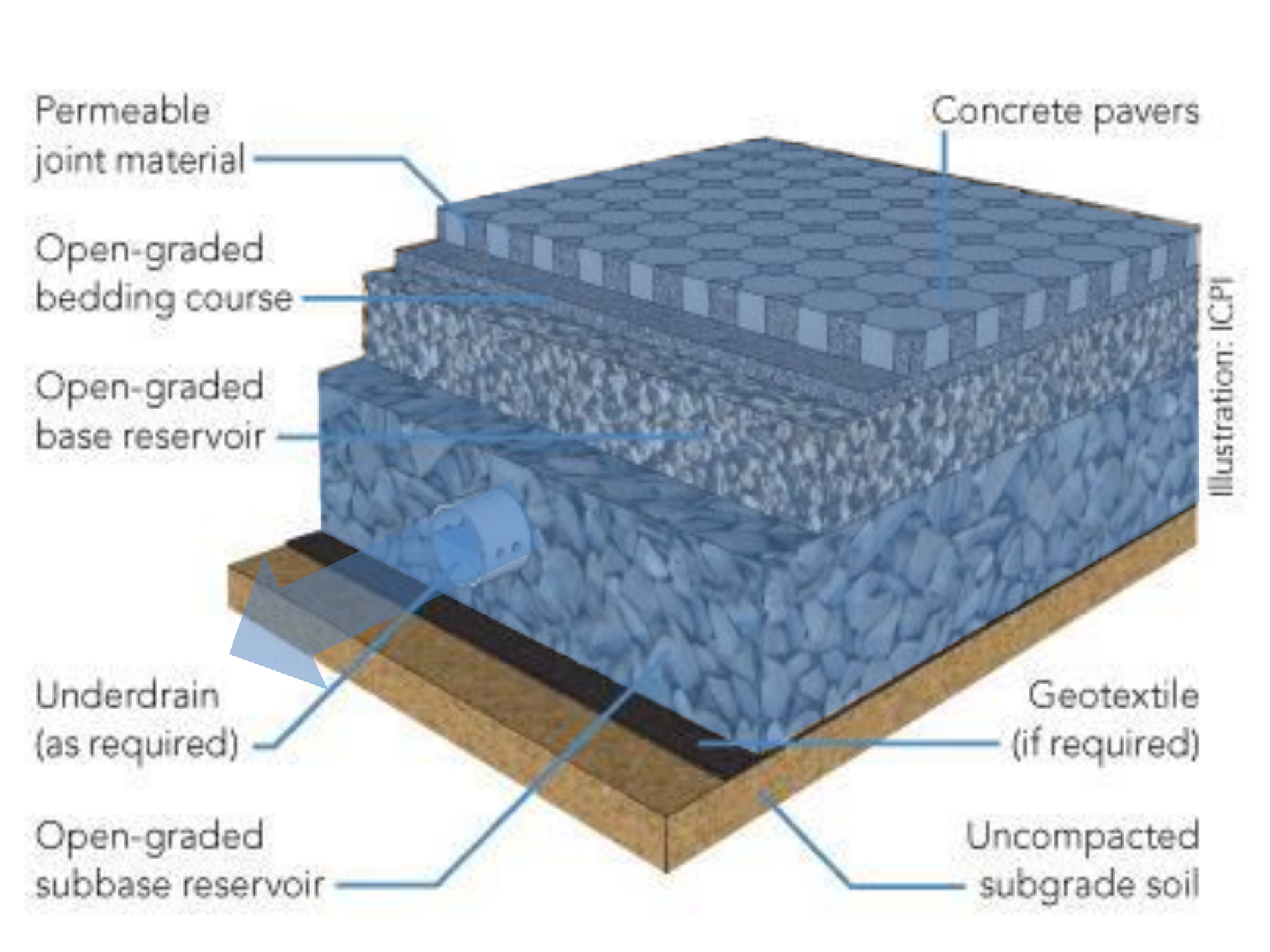

Porous Materials

Figure 2.8: Impervious Parking Lot versus Parking Lot with Some Pervious Surfaces





City and County of Honolulu Department of Environmental Services, 2013. City and County of Honolulu Stormwater Best Management Practice Manual.

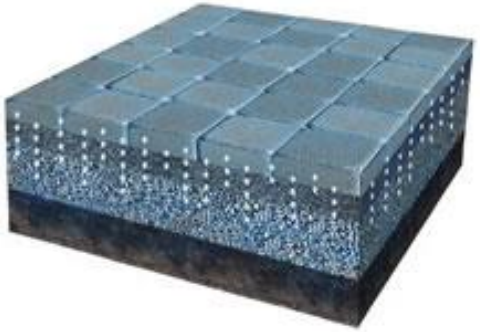

Permeable
joint material
Concrete pavers
Open-graded
bedding course
Open-graded
base reservoir
Underdrain
(as required)
Geotextile
(if required)
Open-graded
subbase reservoir
Uncompacted
subgrade soil
Illustration: ICPI

Porous Materials for Water Infiltration

Permeable Asphalt

Permeable Concrete

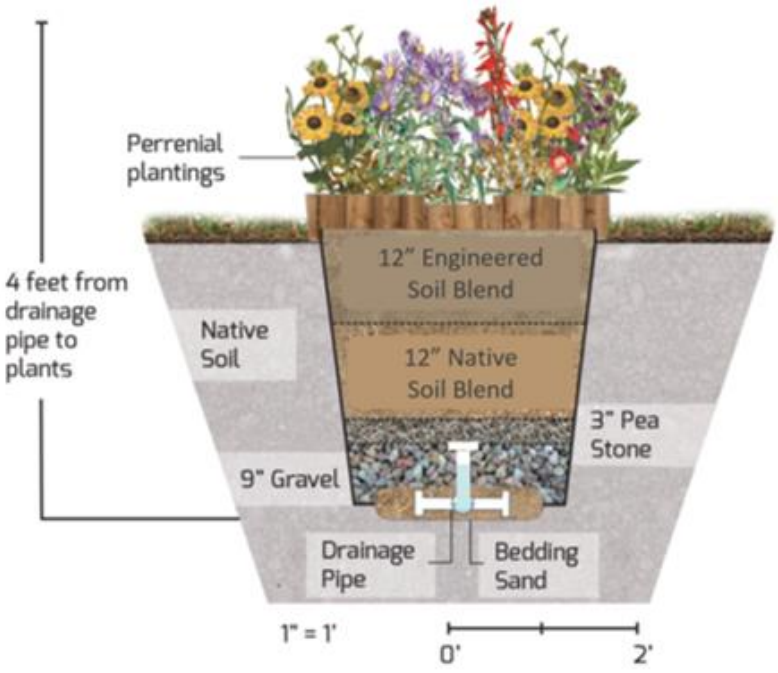
Permeable Pavers



Bioretention & Green Streets

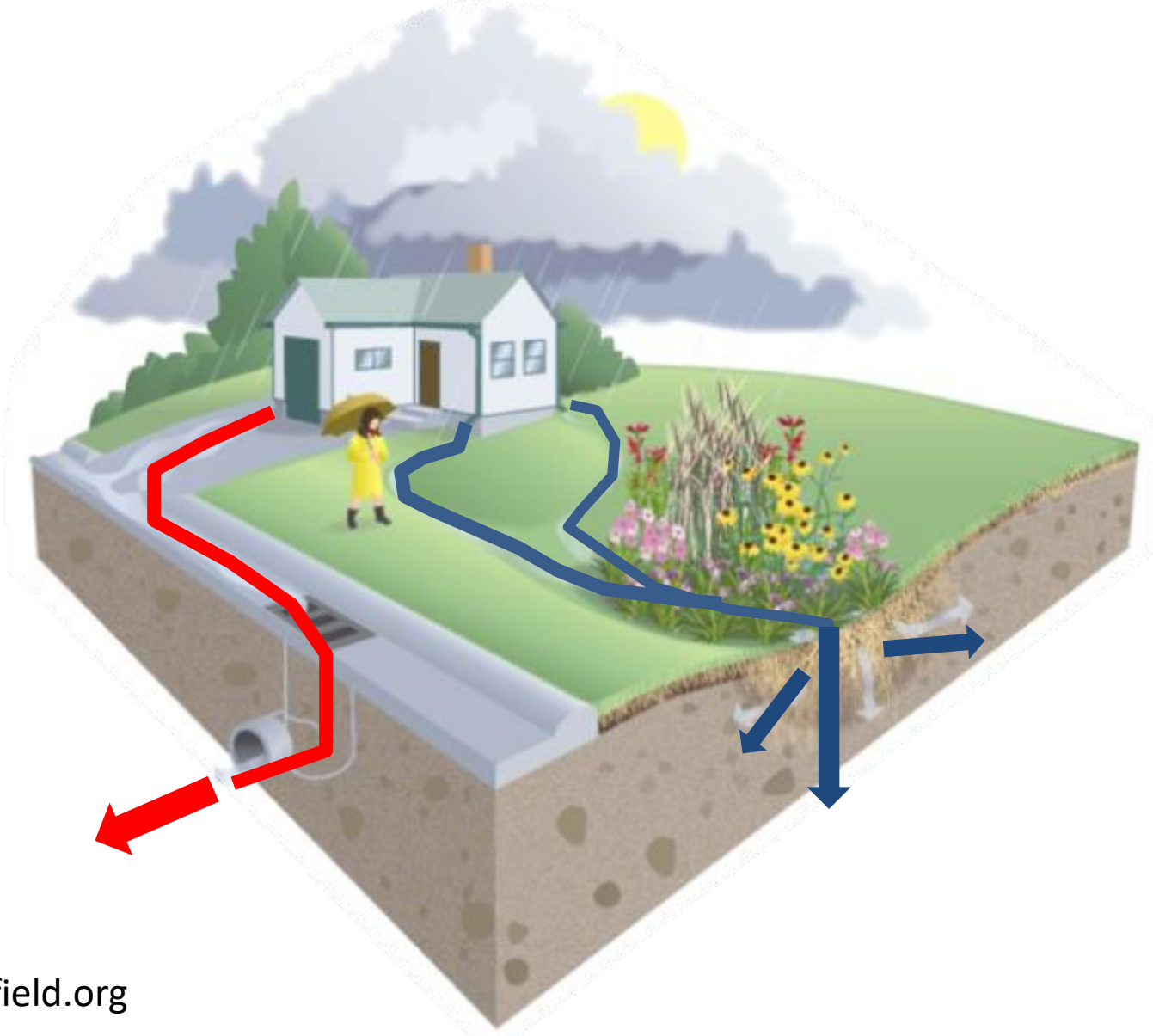
Design Strengths:
Reduces Volume & Peak Flows
Removes Total Suspended Solids
Removes Nutrients
Improved Aesthetics

Design Challenges:
Obtaining proper infiltration
Directing flow into feature
Maintenance






What is a Rain Garden?



Source: northfield.org

Complex

Many Paths

Destination

Residential Bioretention

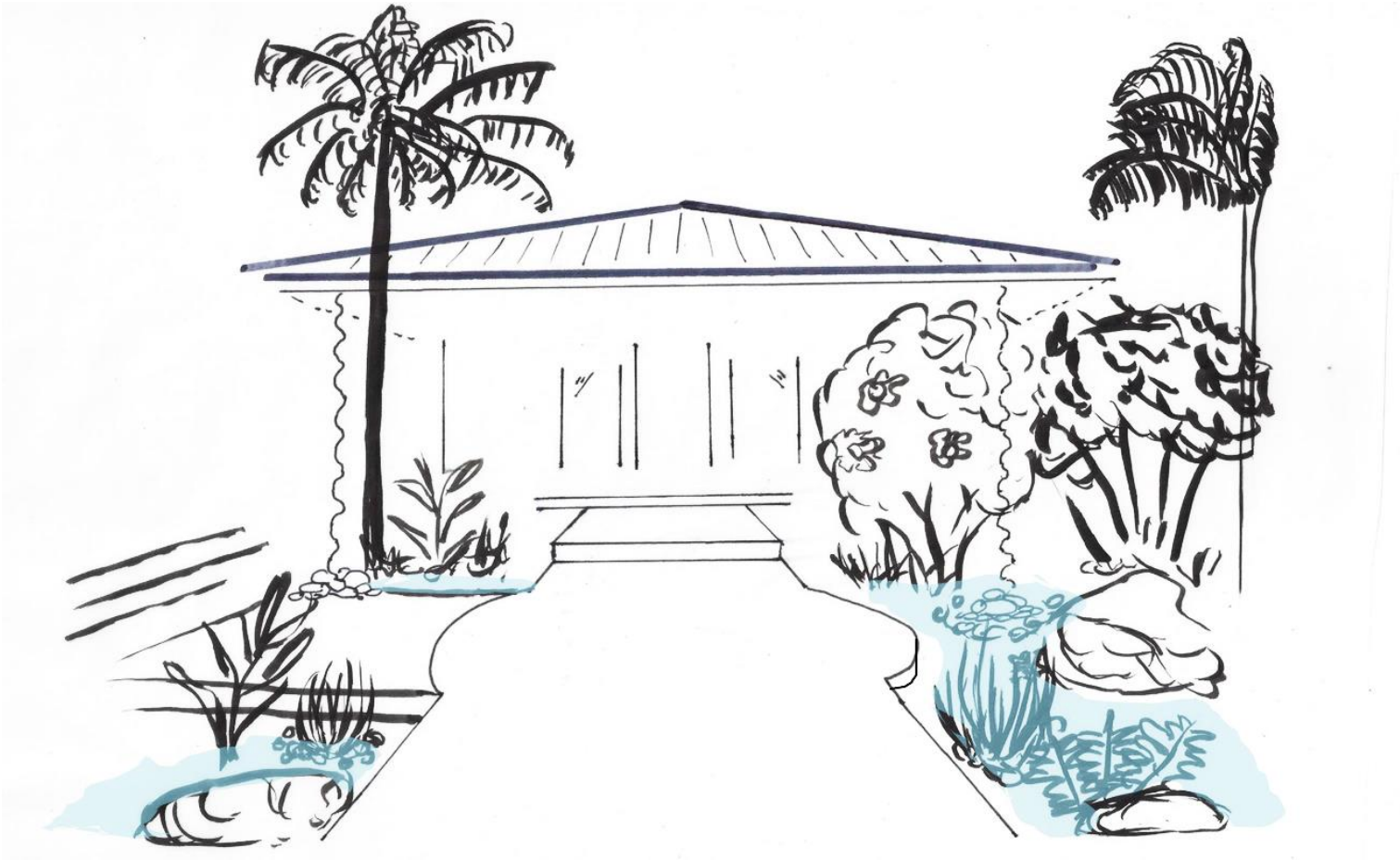


Image Source: Amanda Cording

Simple: Residential

Residential Scale

Neighborhood Scale Bioretention

Image Source: Amanda Cording

Neighborhood Scale

City-Scale Bioretention

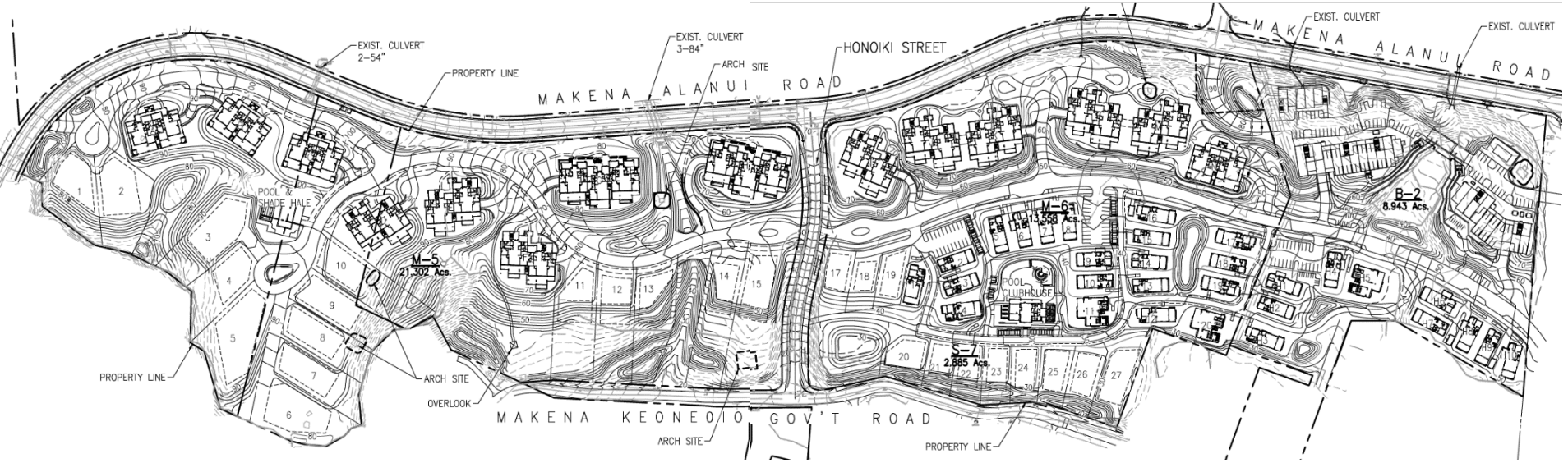
Commercial Scale Bioretention
NOMA District Washington, DC

ECOSOLUTIONS
innovative designs – living systems

Large Scale LID:
Pre-Development Conditions

Proposed M5/M6/S7/B2 Low Impact Development (LID) Site Plan

Traditional Development Basemap



Required to **retain**:

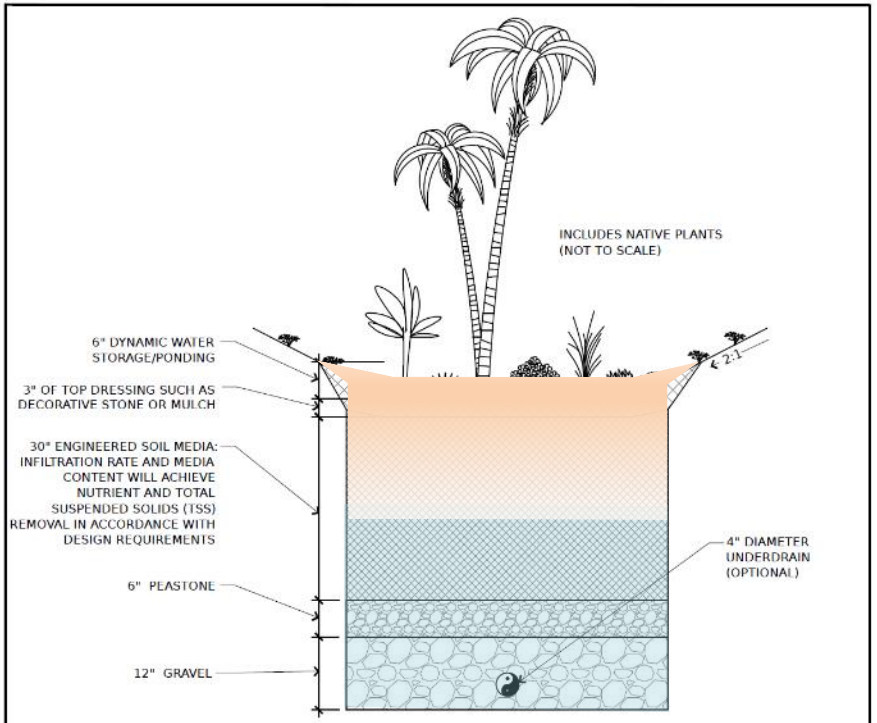
- 100% of the 2.5” (50-yr, 1-hr) storm event

Low Impact Development Basemap

Bioretention & porous materials can **retain + treat**:

- 100% of the 2.5” (50-yr, 1-hr) storm event
- 100% of the 3.0” (100-year, 1-hr) storm event

Bioretention & Porous Materials



NOTES:

1. THE BIORETENTION FACILITY MAY NOT RECEIVE ANY INFLOW UNTIL THE ENTIRE CONTRIBUTING DRAINAGE AREA HAS BEEN STABILIZED. SEDIMENT INFLOW CAN RESULT IN FAILURE OF THE BIORETENTION FACILITY.

2. COMPACTION: IT IS VERY IMPORTANT TO MINIMIZE COMPACTION OF THE BASE OF THE BIORETENTION AREA.

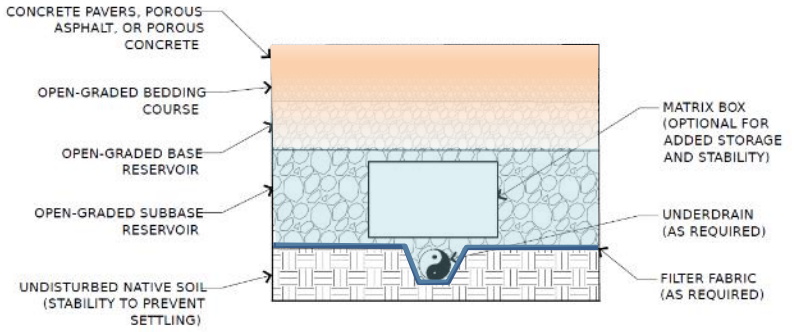
TYPICAL SECTION - BIORETENTION BASIN

ECOSOLUTIONS
www.ecosoldesigns.com
315 Plains Road Westford,VT 05494
t: 802.598.6297 f: 802.598.6297
1440 'Alewa Dr. E1 Honolulu, HI 96817
o: 808.367.1026 c: 808.372.5719

Proposed Makena Resort
M-5/M-6/S-7/B-2 Project

Drawn By: GS | Checked By: DHW
Scale: Not to Scale | Date: July 11, 2016

Sheet: 1 of 4
Job Number: 16-031



TYPICAL SECTION - PERMEABLE PAVEMENT

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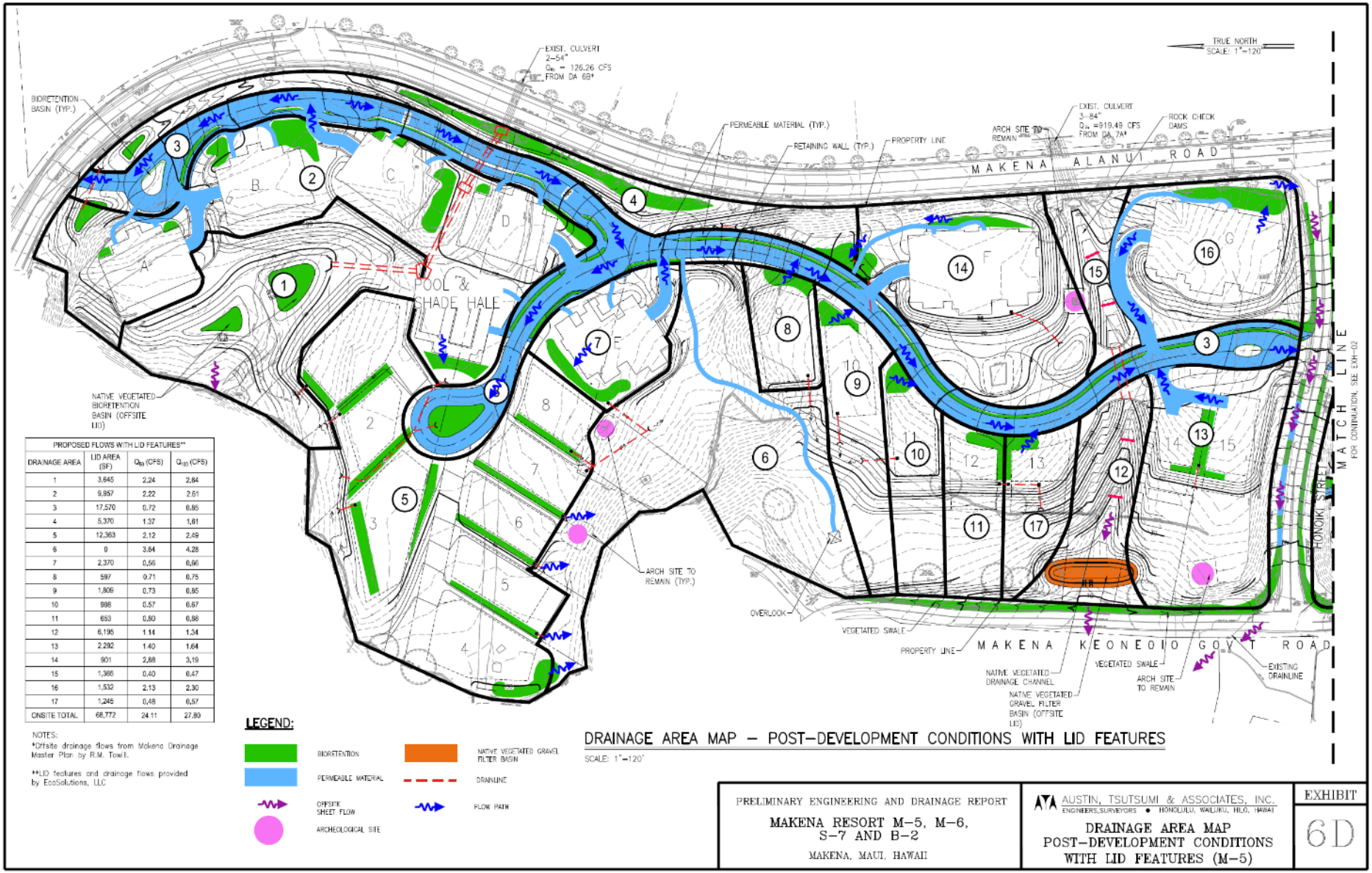
Proposed Makena Resort
M-5/M-6/S-7/B-2 Project
Drawn By: GS | Checked By: DHW
Scale: Not to Scale | Date: July 11, 2016

Sheet: 3 of 4
Job Number: 16-031



PROPOSED FLOWS WITH LID FEATURES**			
DRAINAGE AREA	LID AREA (SF)	Q_{50} (CFS)	Q_{100} (CFS)
1	3,645	2.24	2.84
2	9,957	2.22	2.61
3	17,570	0.72	0.85
4	5,370	1.37	1.61
5	12,363	2.12	2.49
6	0	3.64	4.28
7	2,370	0.56	0.66
8	597	0.71	0.75
9	1,809	0.73	0.85
10	998	0.57	0.67
11	653	0.80	0.88
12	6,195	1.14	1.34
13	2,292	1.40	1.64
14	901	2.68	3.19
15	1,366	0.40	0.47
16	1,532	2.13	2.30
17	1,245	0.48	0.57
ONSITE TOTAL	68,772	24.11	27.80

NOTES:
*Offsite drainage flows from Makena Drainage Master Plan by R.M. Towill.

**LID features and drainage flows provided by EcoSolutions, LLC

LEGEND:

BIORETENTION
PERMEABLE MATERIAL
OFFSITE SHEET FLOW
ARCHEOLOGICAL SITE
NATIVE VEGETATED GRAVEL FILTER BASIN
DRAINLINE
FLOW PATH

DRAINAGE AREA MAP – POST-DEVELOPMENT CONDITIONS WITH LID FEATURES

SCALE: 1"=120'

PRELIMINARY ENGINEERING AND DRAINAGE REPORT
MAKENA RESORT M-5, M-6, S-7 AND B-2
MAKENA, MAUI, HAWAII

AUSTIN, TSUTSUMI & ASSOCIATES, INC.
ENGINEERS, SURVEYORS • HONOLULU, WAILUKU, HILO, HAWAII

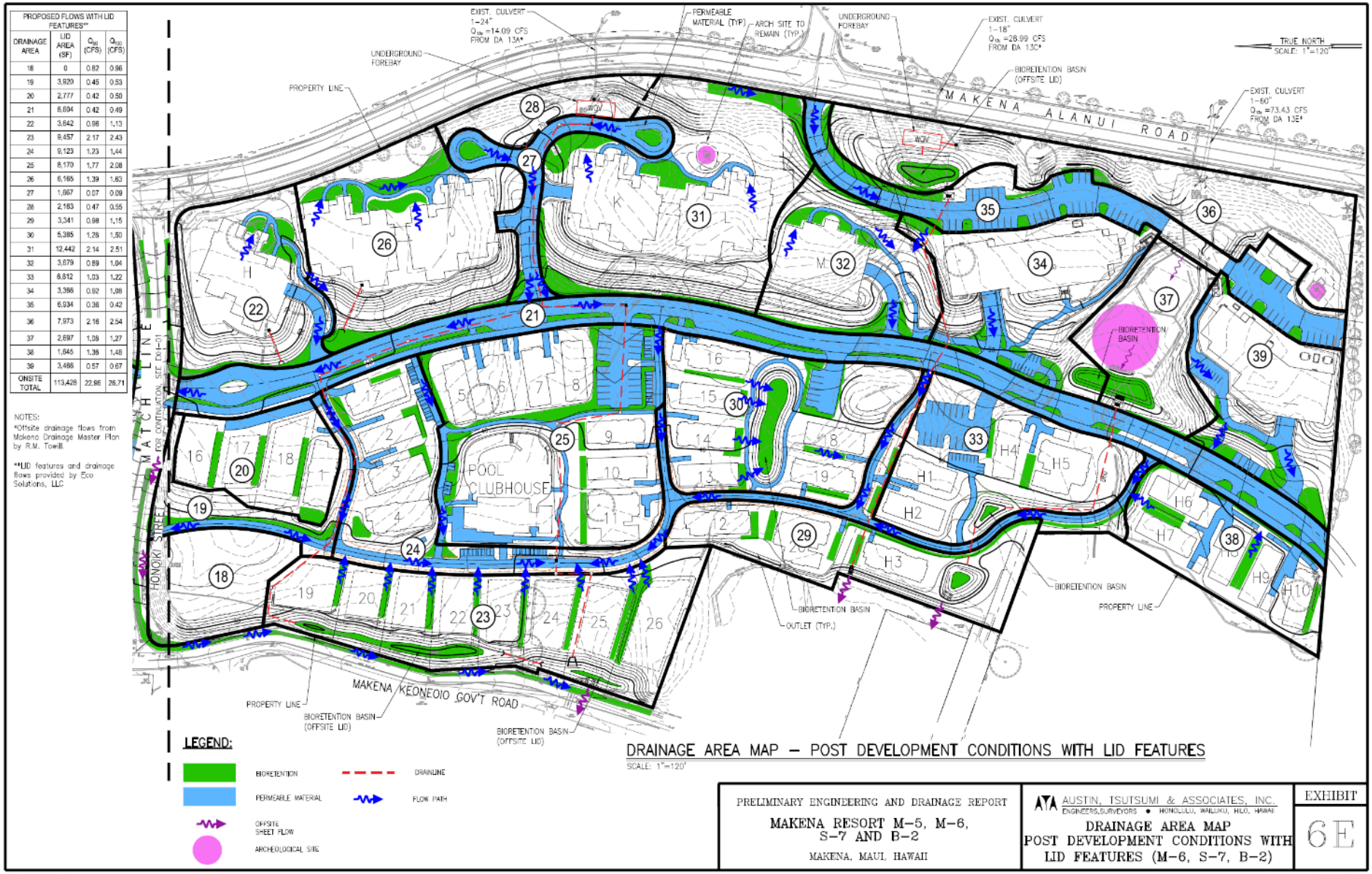
DRAINAGE AREA MAP
POST-DEVELOPMENT CONDITIONS
WITH LID FEATURES (M-5)

EXHIBIT 6D

JOB NO. M-14-544

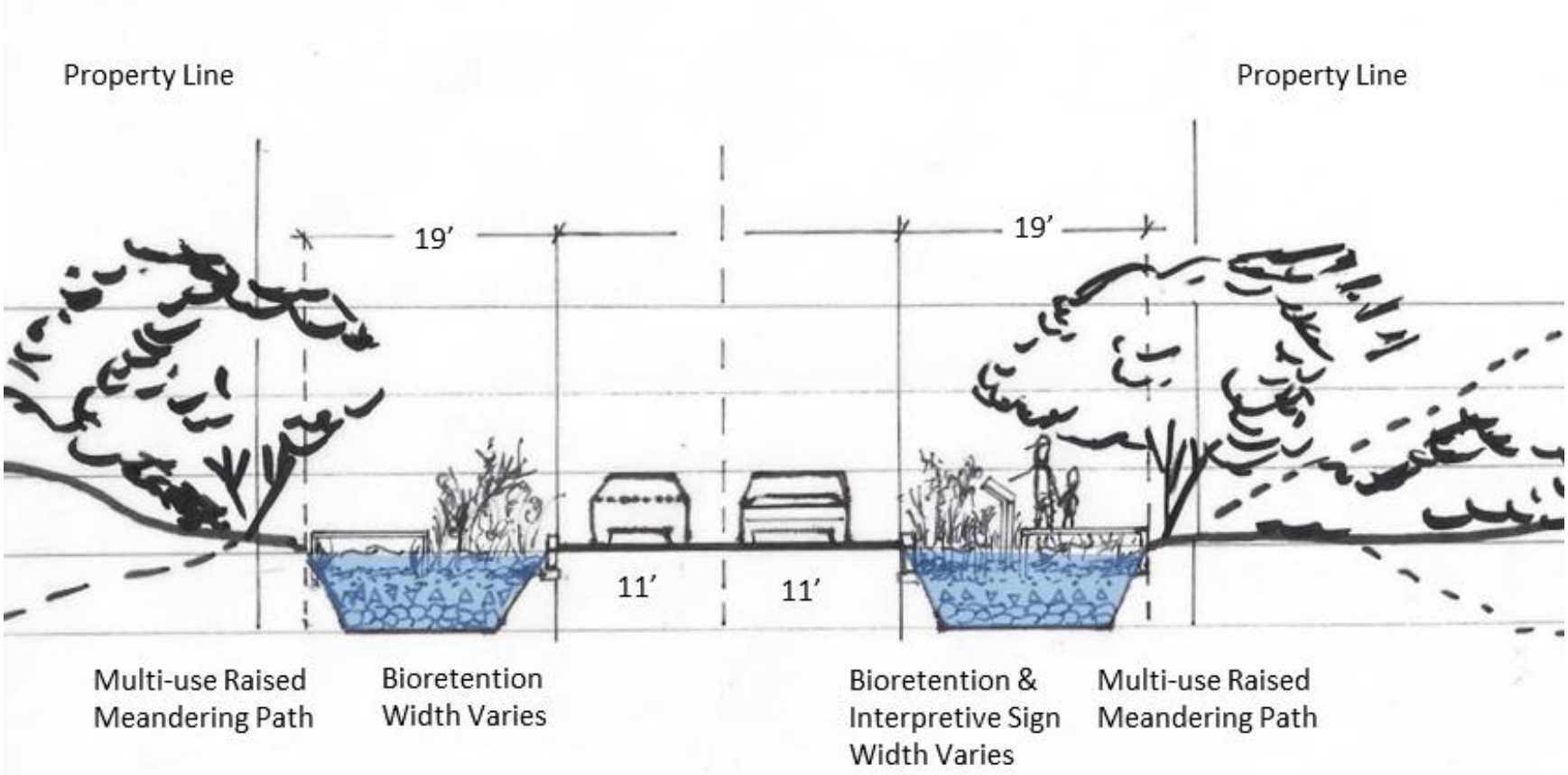
OCTOBER 2015
REV. JULY 2016

Proposed M5/M6/S7/B2 Low Impact Development (LID) Features



Proposed M5/M6/S7/B2 Low Impact Development (LID) Features

Bioretention Green Streets



Summary:
22' pavement
On-street parking
Drainage in bioretention
Adequate space for street trees
Zero "effective" impervious cover

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Bioretention Green Streets

Green Streets Concepts

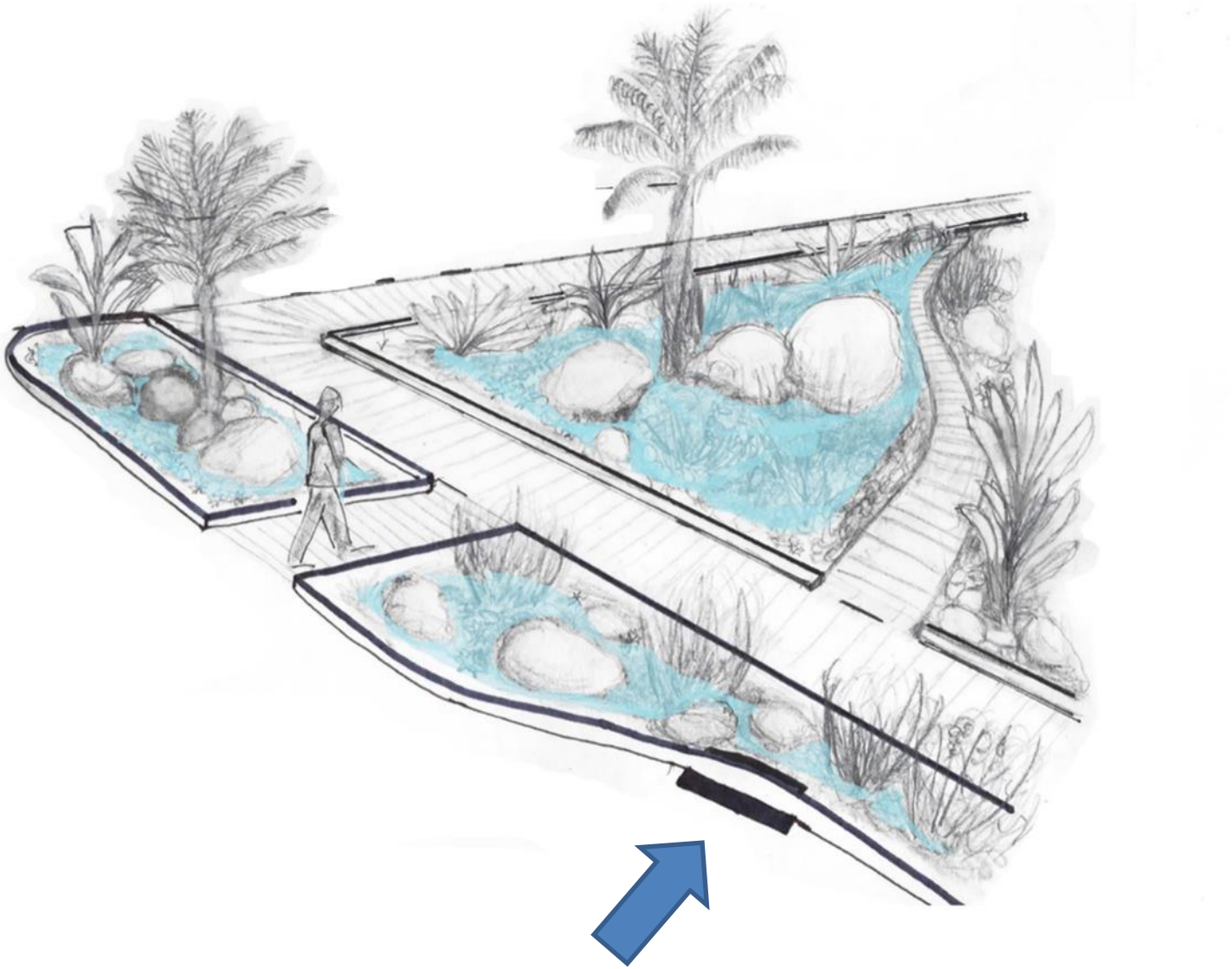


Image Source: Amanda Cording


Rendering Produced by Jeff Brink

Decentralized Wastewater Treatment & Greywater Reuse

Design Strengths:
Soluble Pollutant Removal
Provides Habitat
Increase Biodiversity
Efficient/Low Cost
Low Maintenance
Low Energy Consumption
Aesthetics (Functional Design)

Design Challenges:
Requires Maintenance

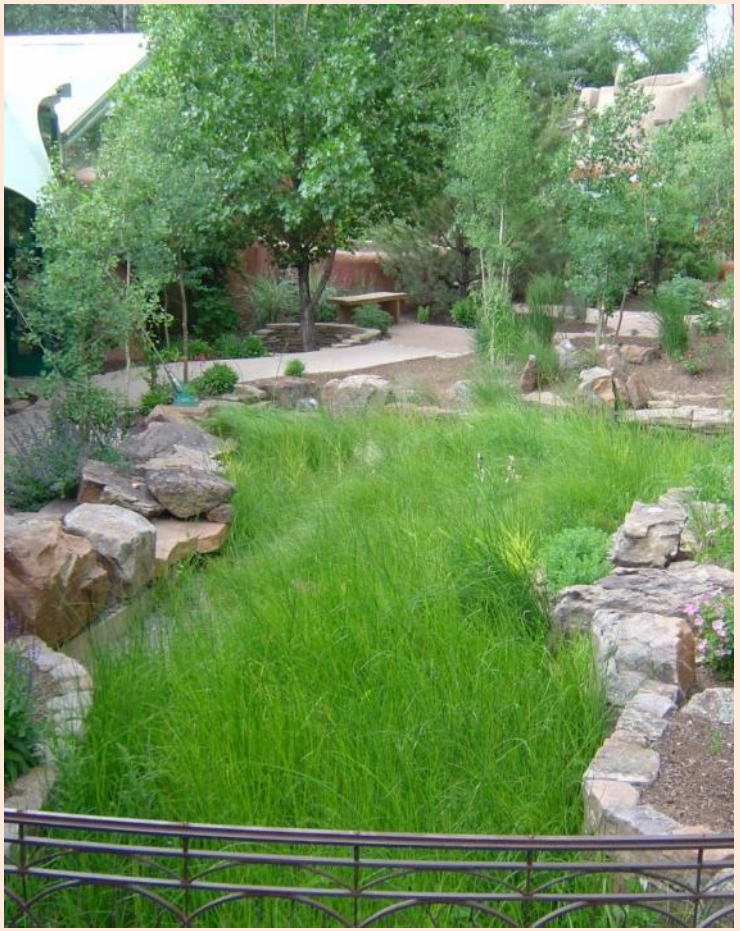
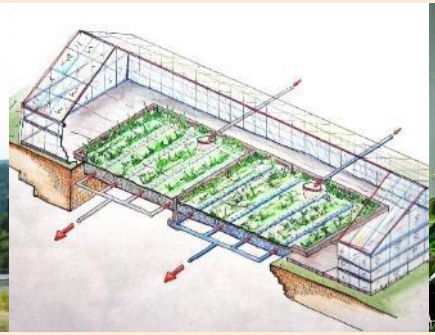
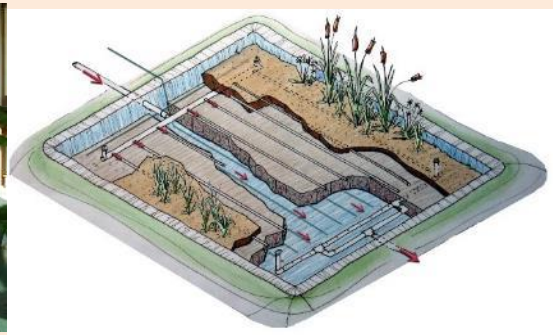


Image: Living Designs Group Inc.





Aerated Wetland Treatment Systems: Onsite Wastewater Treatment

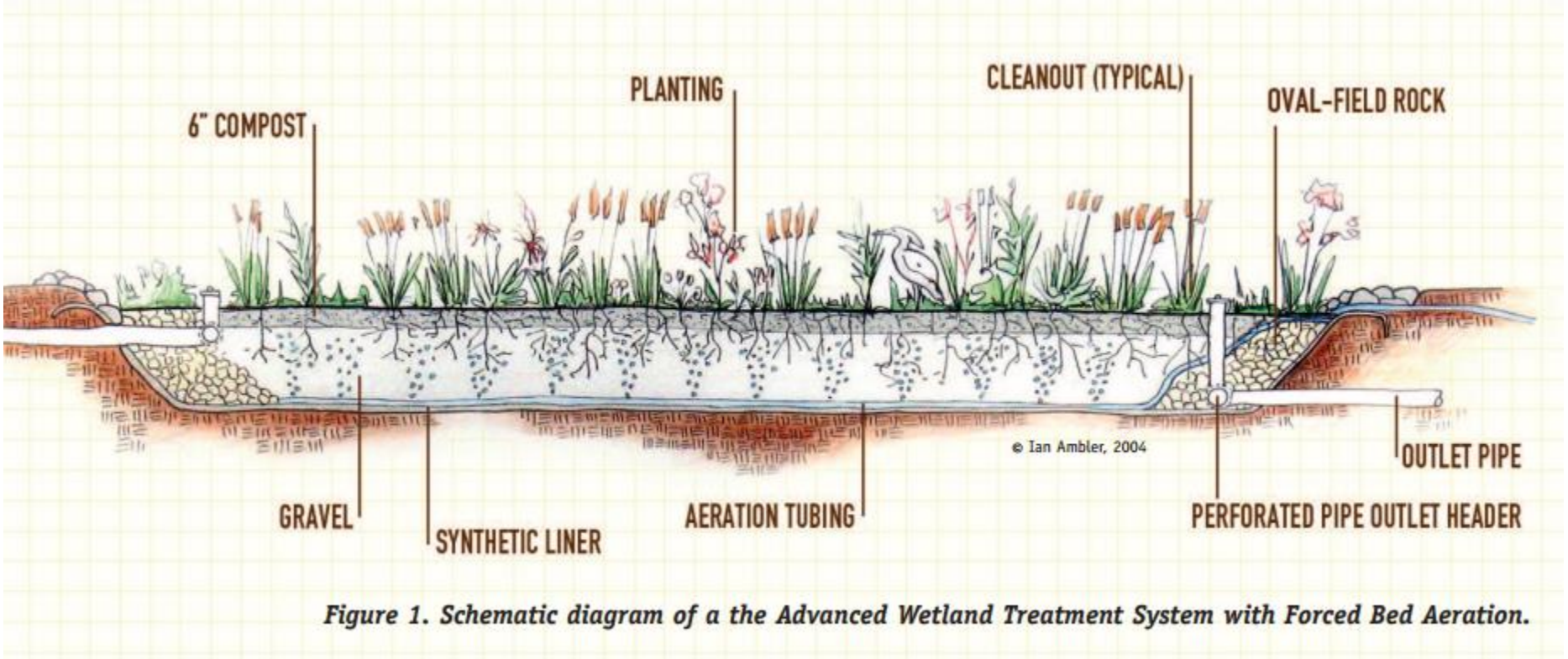
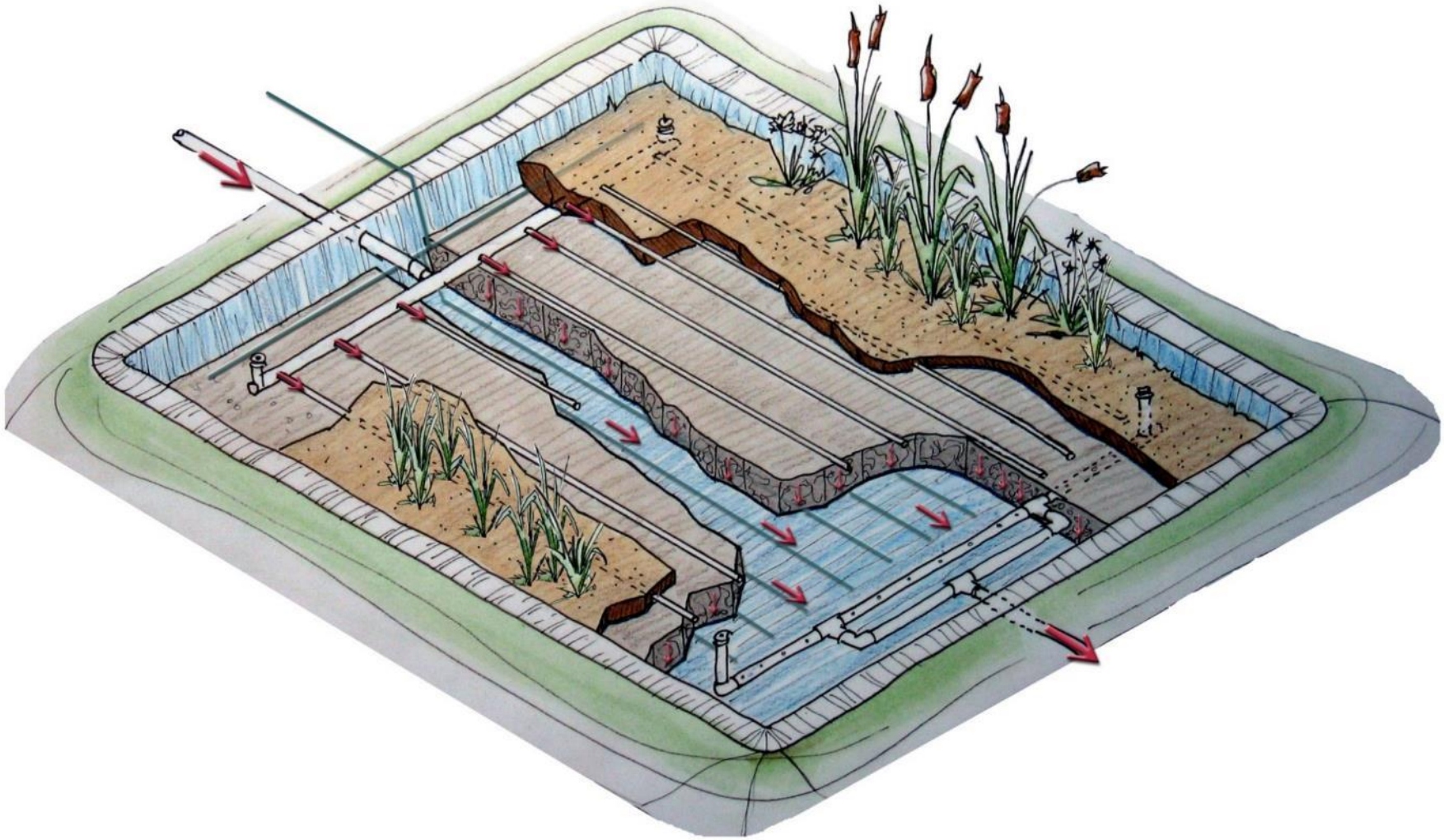
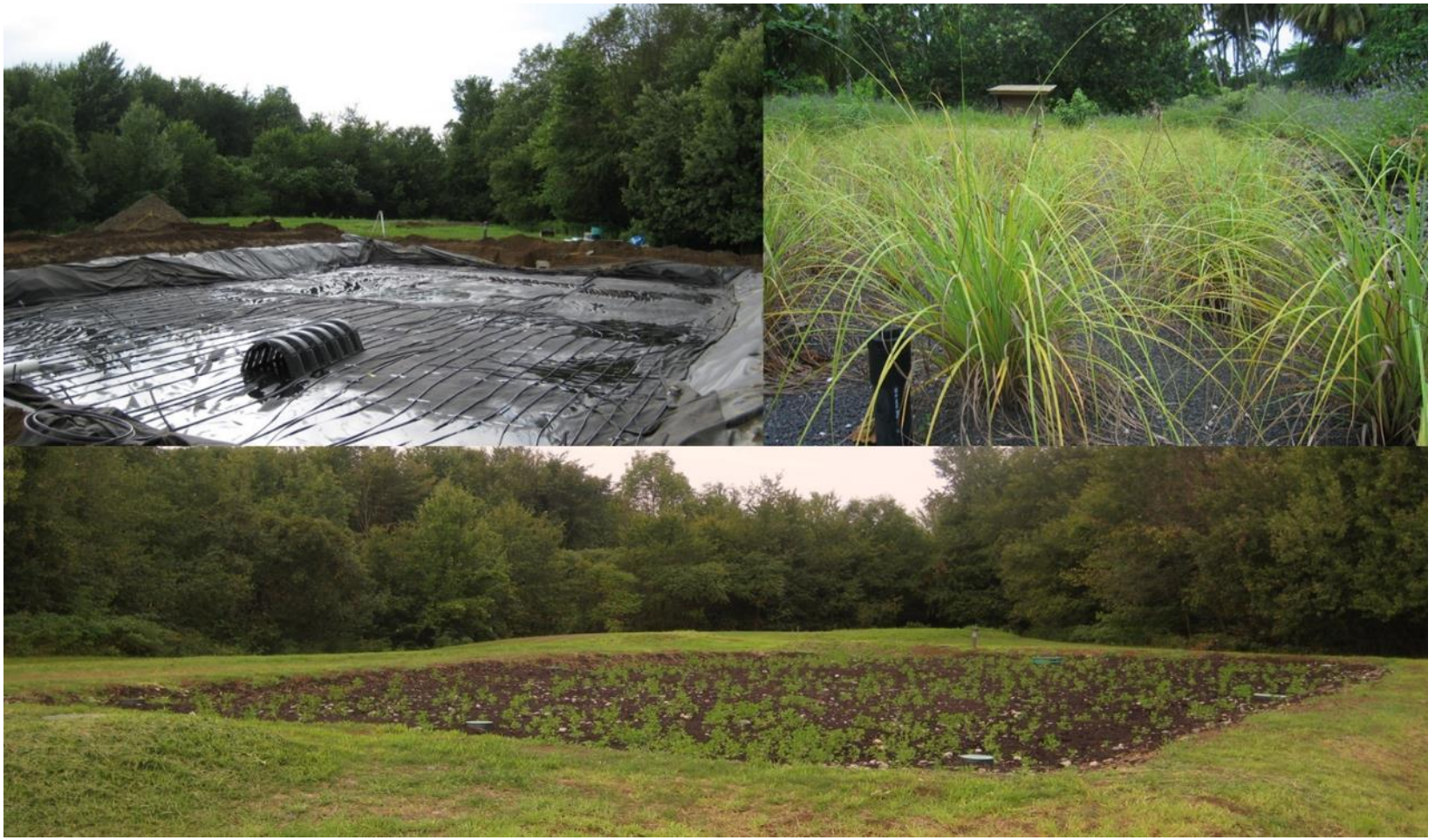


Figure 1. Schematic diagram of a the Advanced Wetland Treatment System with Forced Bed Aeration.

Constructed Wetlands for Wastewater Treatment & Greywater Reuse



Constructed Wetlands for Wastewater Treatment & Greywater Re-Use

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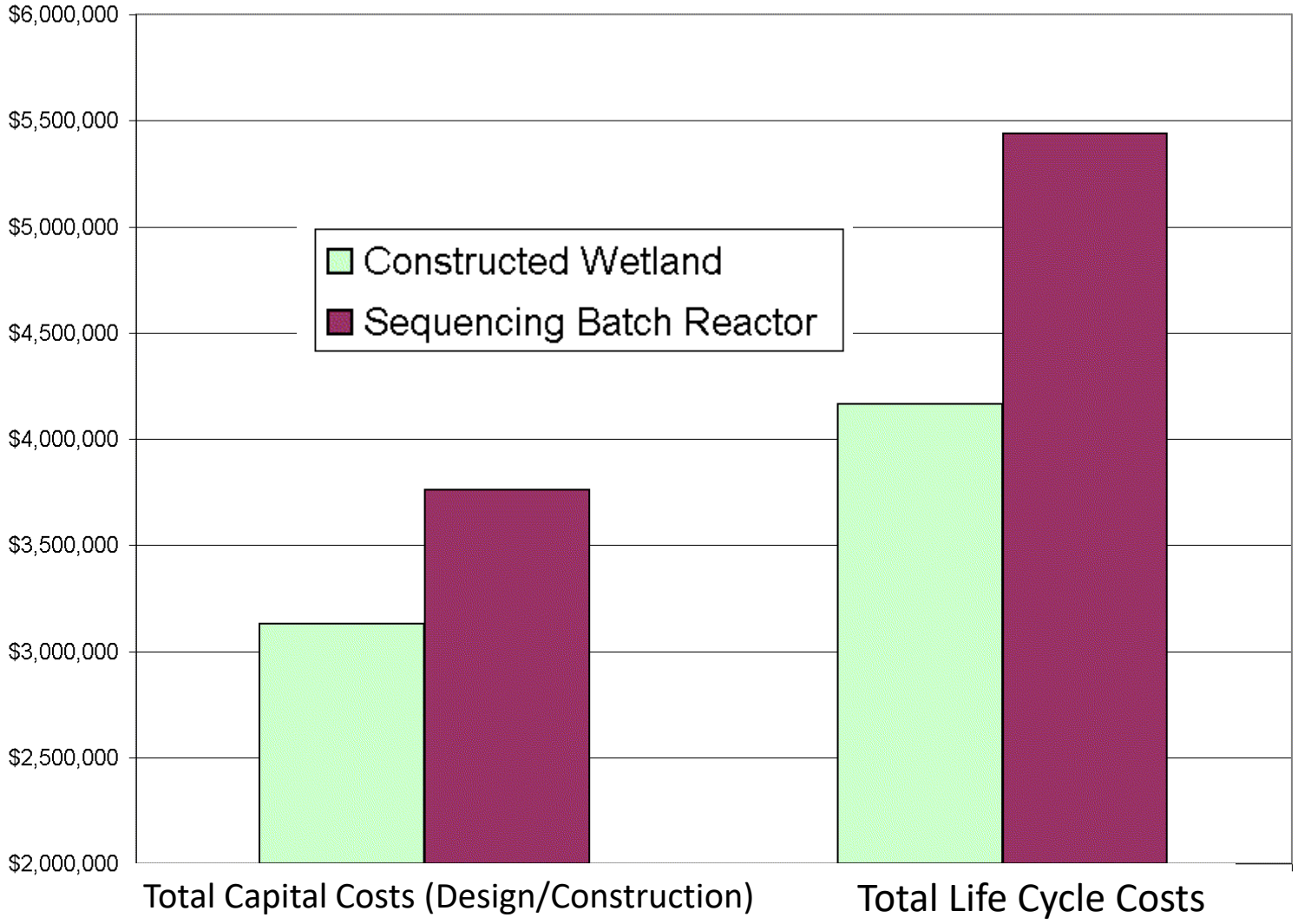
Wastewater Treatment Cost



Condominium Complex at the Smuggler‘s Notch Ski Resort, Vermont

Living Machines / Eco Machines for Wastewater Treatment

A Clarifier Settles Out Solids

Open Aerobic Reactors
Remove Pollutants
such as BOD and Nutrients

Closed Anoxic and
Aerobic Reactors Filter
Odors

Plants and Micro-organisms Utilize Nutrients and Organic Matter:

BOD	< 10 mg/L
TN	< 10 mg/L
TSS	< 10 mg/L

Eco Machine for Wastewater Treatment:
University of Vermont

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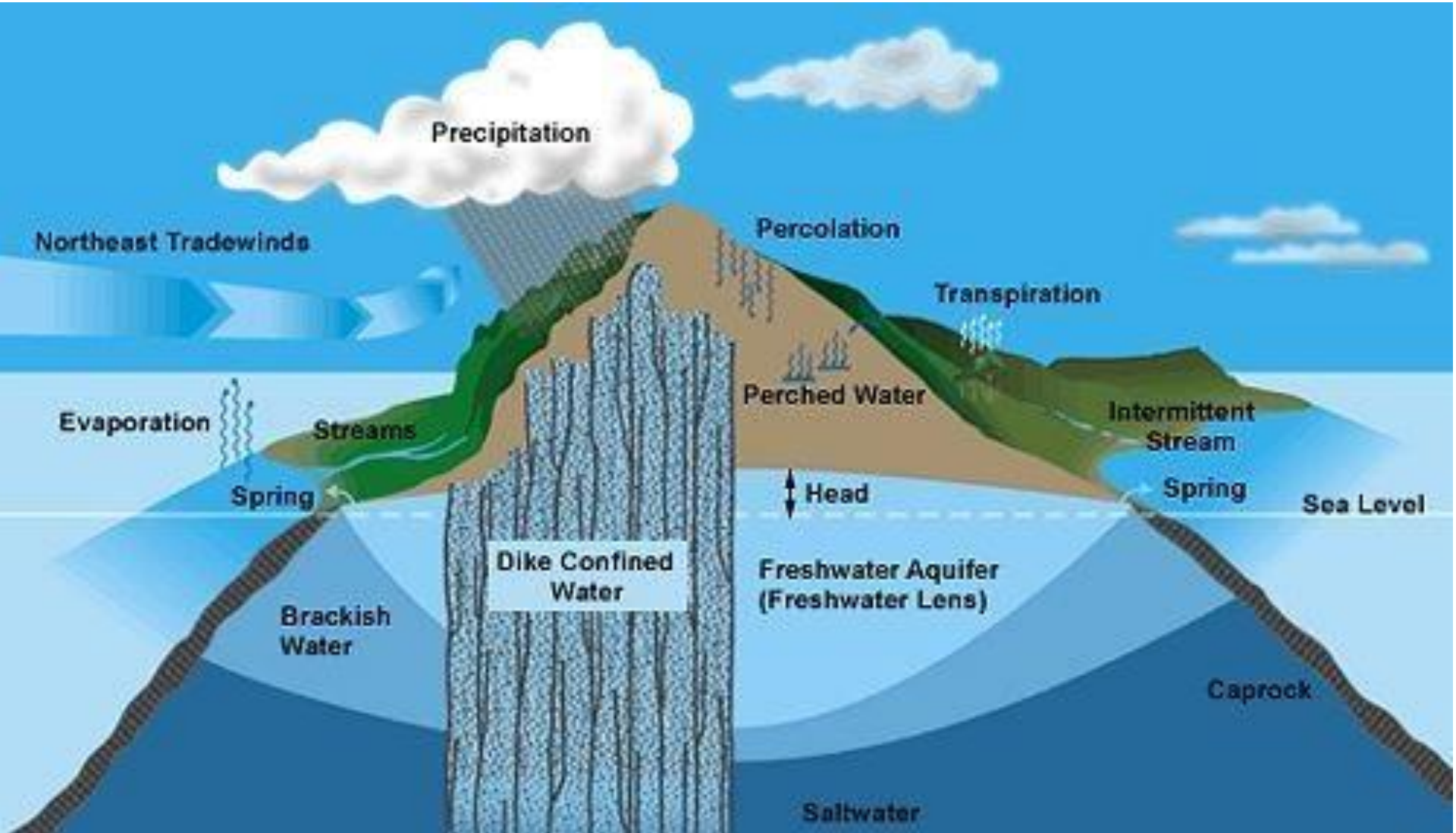
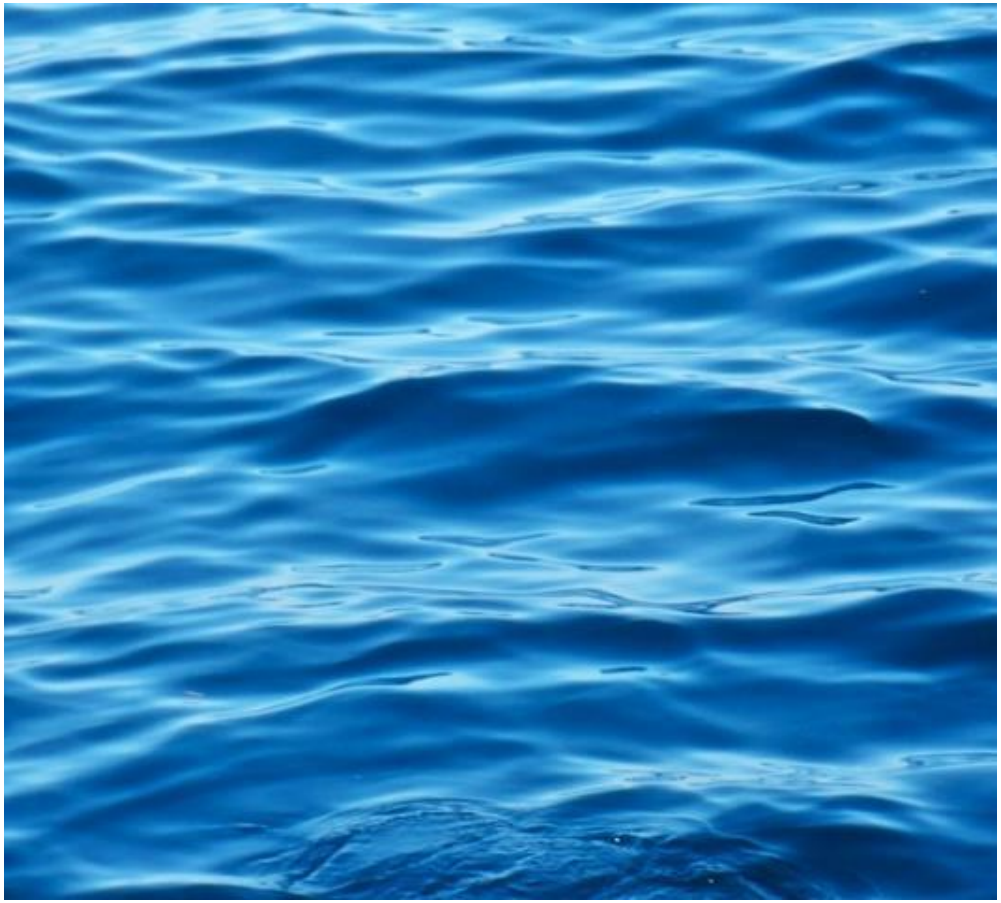
Limited Groundwater Supply in Hawai‘i



Gray Water Reuse



1. Reduce Portable Water Demand for Landscaping
2. Reduces Wastewater Entering Wastewater Treatment
3. Extends Life of Septic Systems
4. Reduces Need for Synthetic Fertilizers
5. Human Health Risk Mitigated by Design
6. Reduces Energy and Costs Needed for WWT

REUSE GUIDELINES

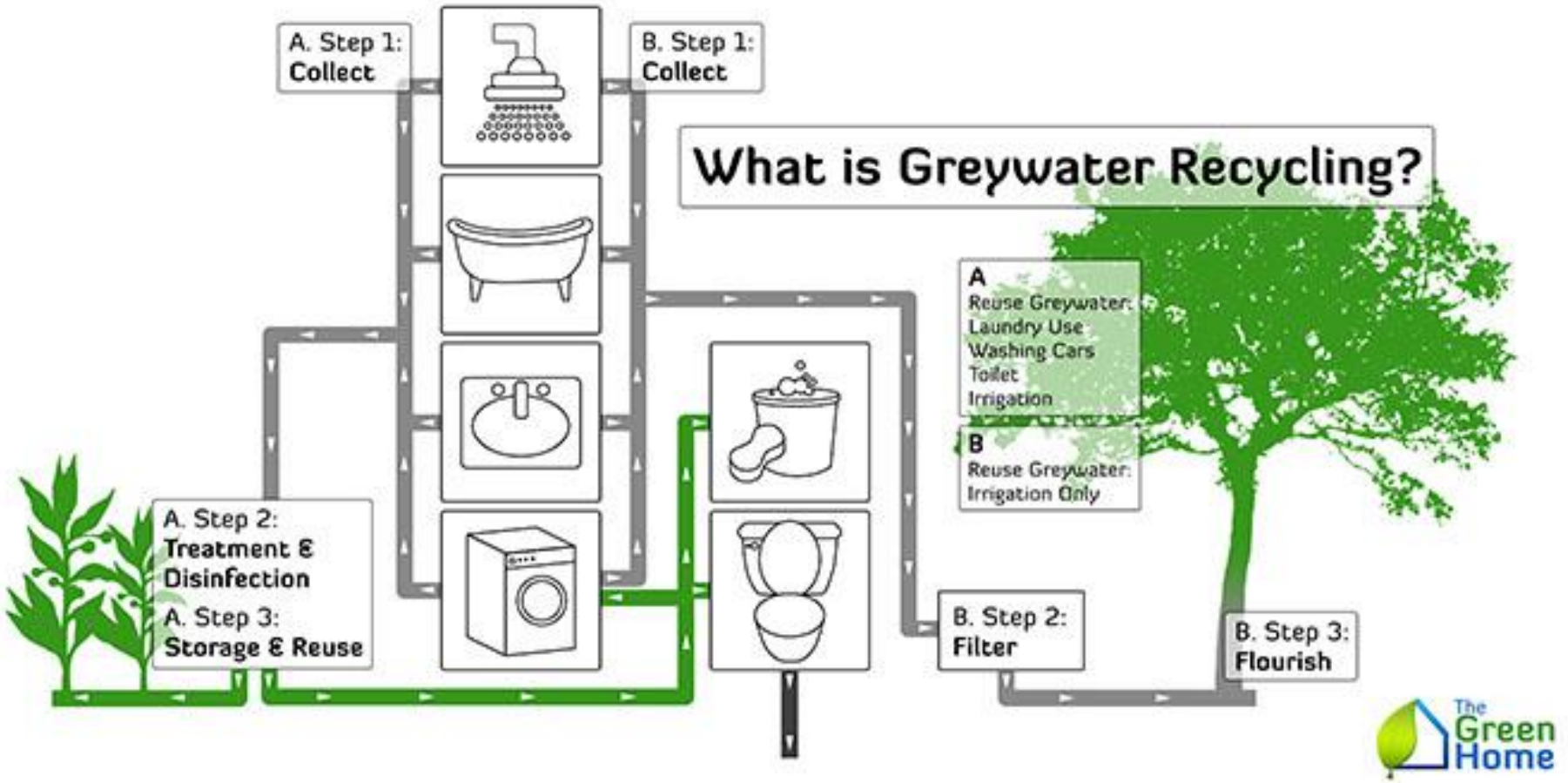
Volume II: Recycled Water Projects

Prepared by
Hawai'i State Department of Health
Wastewater Branch

January 2016
(Replaces May 15, 2002 Version)

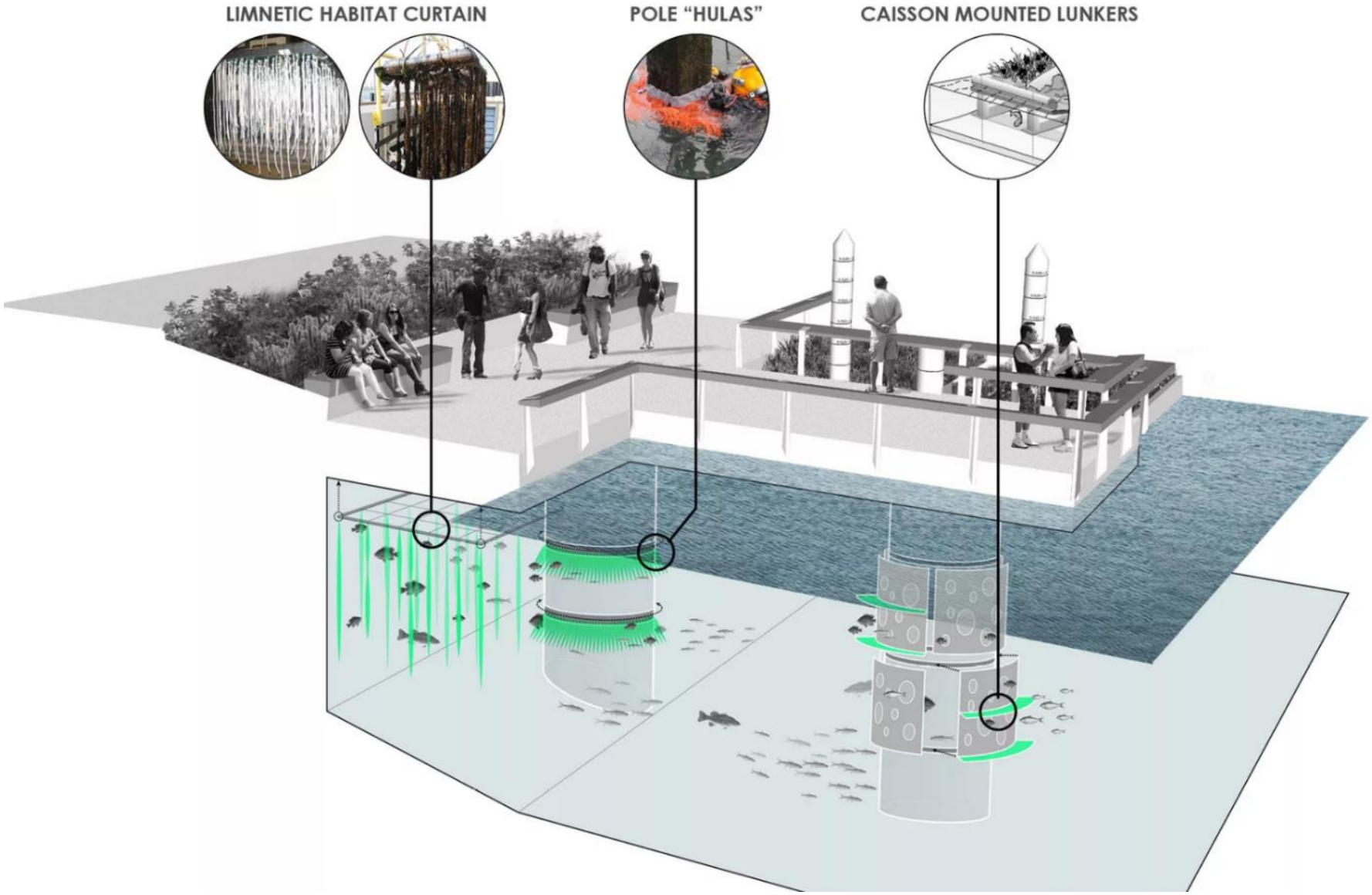
Grey water is defined as wastewater discharged from sources such as showers, bathtubs, sinks, and clothes-washing machines.

Gray Water Reuse



Large-Scale Ecological Restoration & Community Access

The Cove | Christian Philips


LIMNETIC HABITAT CURTAIN
POLE "HULAS"
CAISSON MOUNTED LUNKERS

Floating Treatment Wetlands

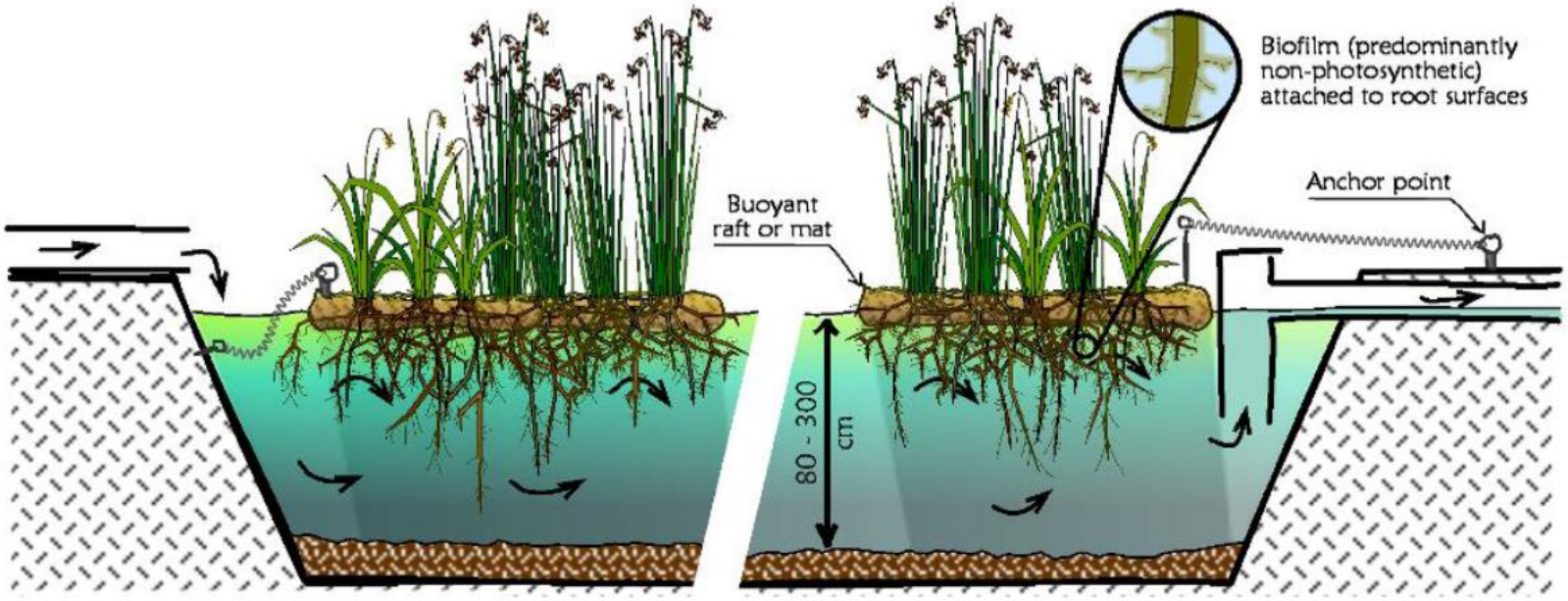
Photo Credit: Floating Islands International

Design Strengths:
Nutrient Removal
Provides Habitat
Increase Biodiversity
Moderates Wave Action
Reduces Shore Erosion

Design Challenges:
Maintenance Logistics

Floating Treatment Wetlands

- Designed for water quality and habitat restoration
- Use emergent aquatic macrophytes
- Grown hydroponically on floating structure



Source: Headley, T. R., and Tanner, C. C. (2012). "Constructed Wetlands With Floating Emergent Macrophytes: An Innovative Stormwater Treatment Technology." *Critical Reviews in Environmental Science and Technology*, 42(21), 2261–2310.

Floating Treatment Wetlands Remove Nutrients

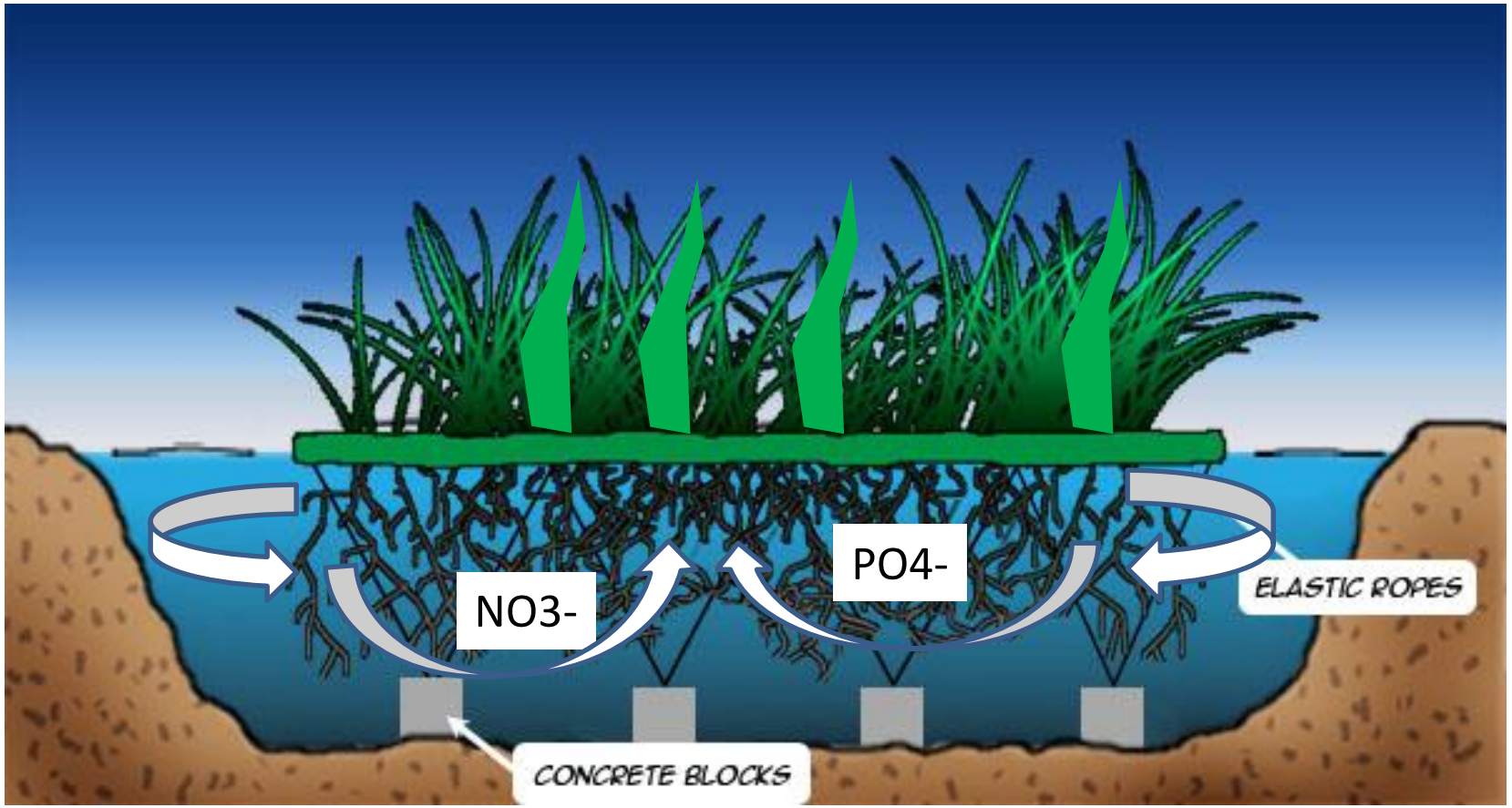
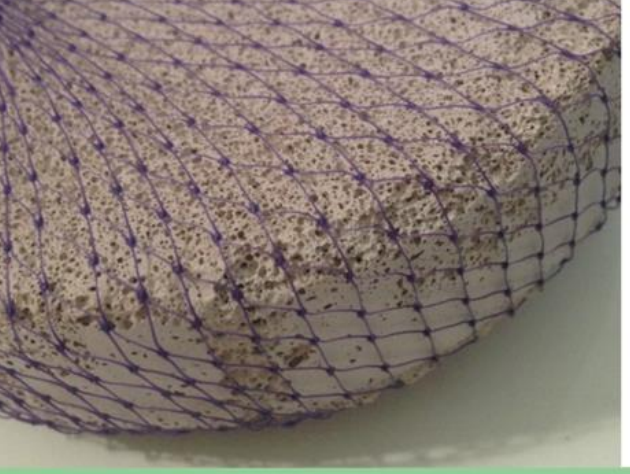
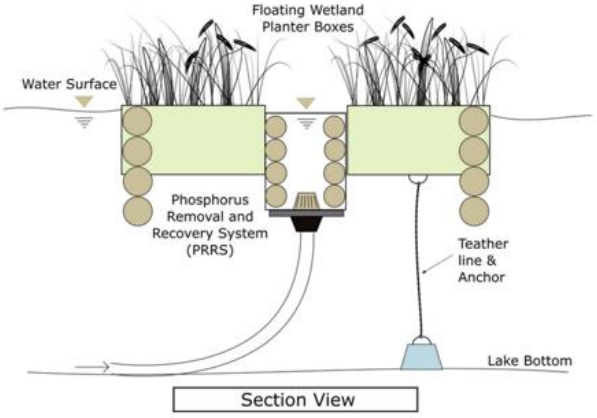


Image Source: http://www.tankonyvtar.hu/





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RESEARCH SITE

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The City of Burlington
is partnering with EcoSolutions, LLC, to
pilot innovative solutions that will help
restore Lake Champlain.

MAIN ST PROJECT SERVICES

ECOSOLUTIONS

Vermont Small Business Accelerators, LLC

Lake Champlain

Restoration Technologies

Lake Champlain is plagued by excess nutrients such as nitrogen and phosphorus. These nutrients contribute to harmful algal blooms. Technologies such as Floating Treatment Wetlands equipped with Phosphorus Removal & Recovery Systems may provide a sustainable solution.

Natural Chemical Free Swimming Pools

Design Strengths:
Decrease Chemical Discharge
Improved Human Health

Design Challenges:
Requires Maintenance


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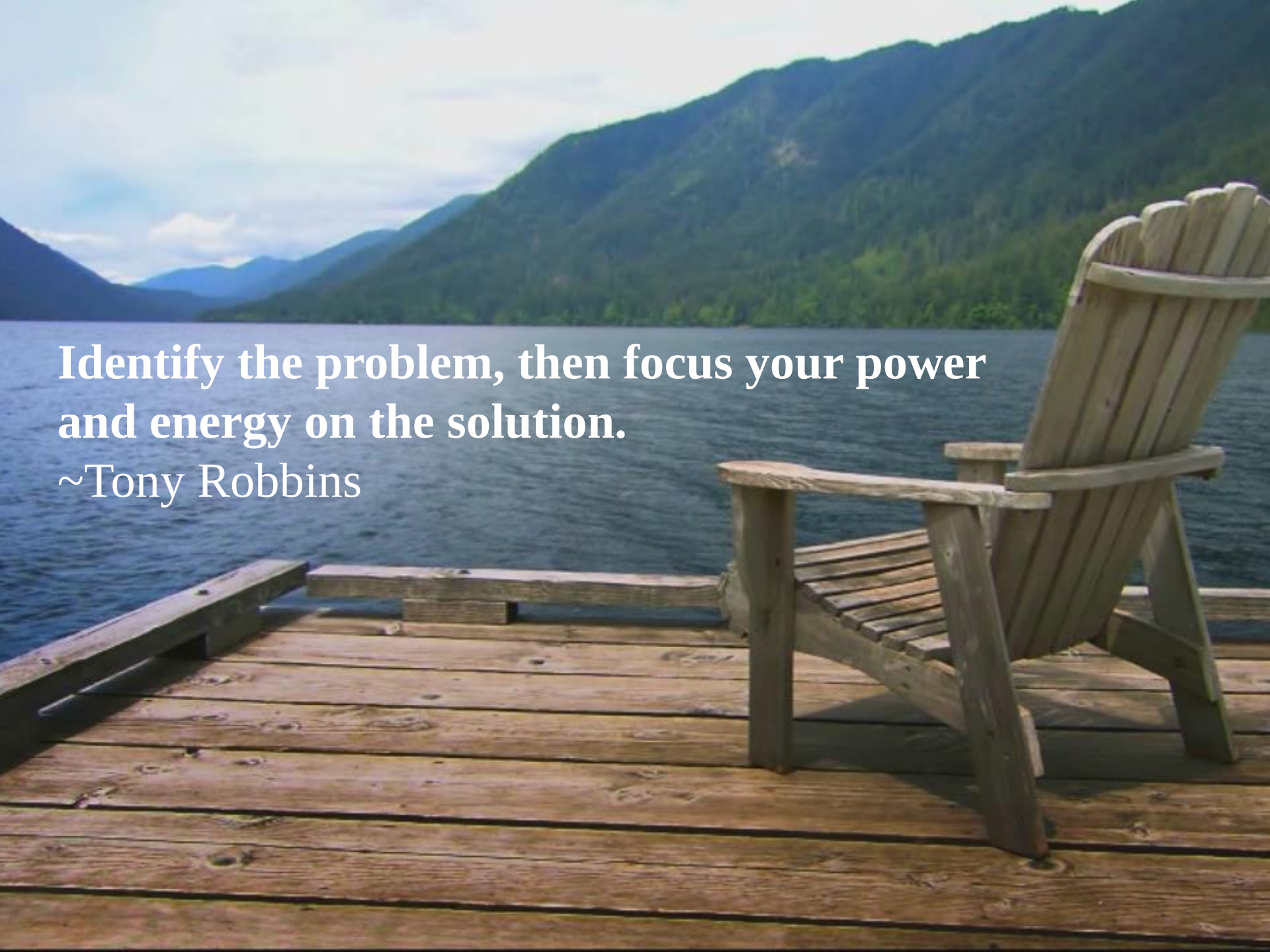
Identify the problem, then focus your power and energy on the solution.
~Tony Robbins

Mahalo Nui!

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(808) 372 - 5719