Planning & Design of Resilient Water Management Systems

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INCREASED URBANIZATION + CLIMATE CHANGE

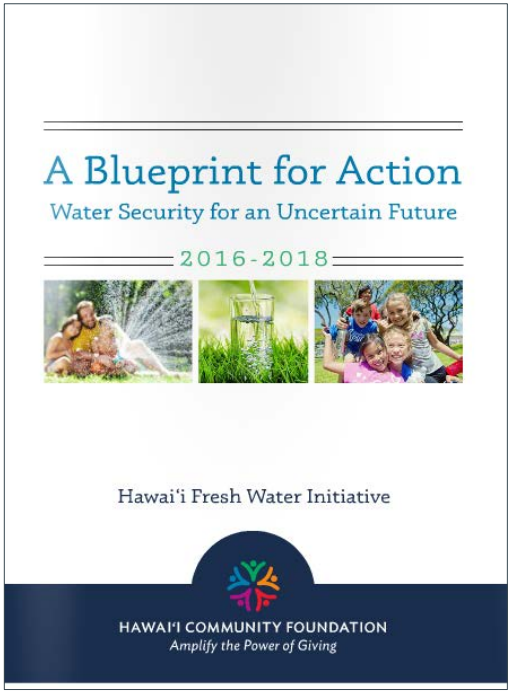
FLOODING |POLLUTION| ⬇ WATER SUPPLY

Hawai`i Fresh Water Initiative:
Create an additional 100 MGD of water by 2030

Conservation – Increase Water Efficiency (40 million gallons per day)

Reuse – Double the volume of reuse

Recharge – Stormwater back into the ground (30 million gallons per day)



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Onsite Reuse

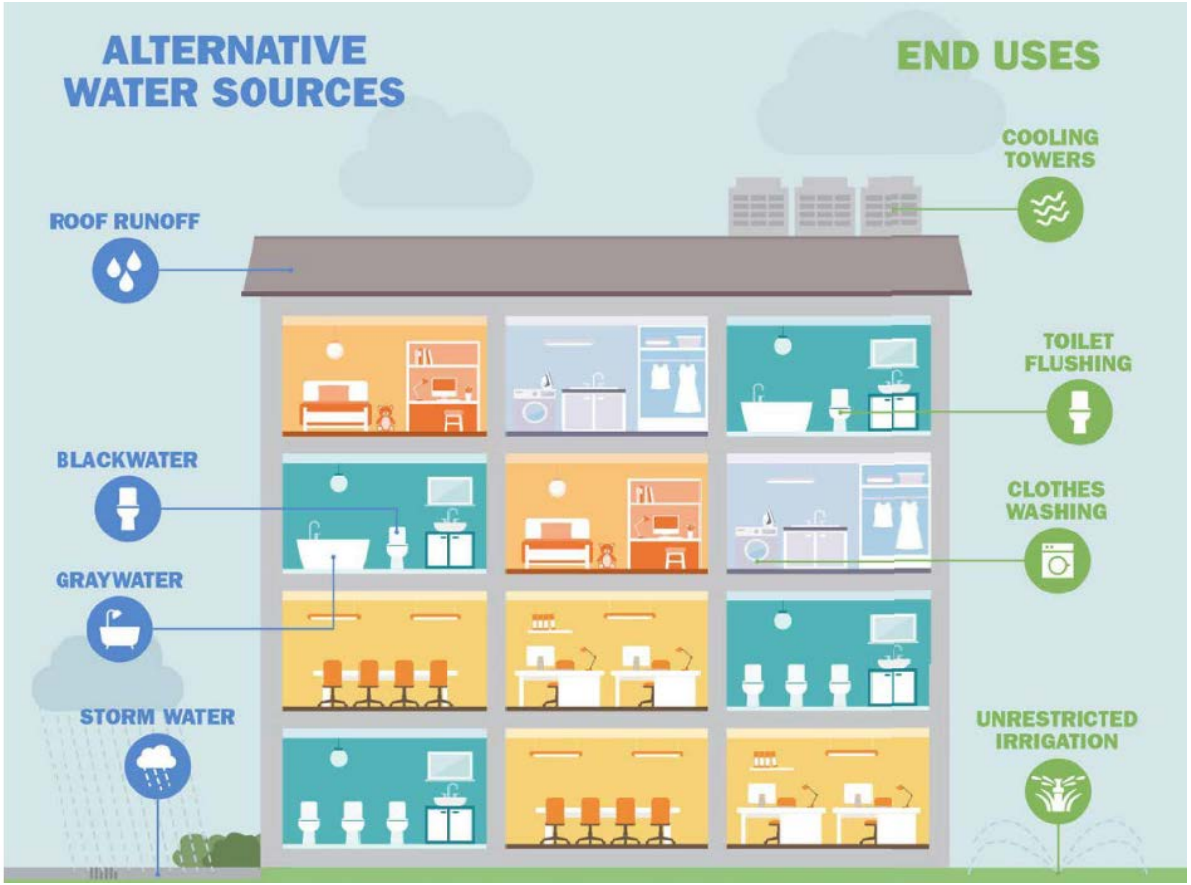

Image source: Nation Blue Ribbon Commission for Onsite Nonpotable Water Systems

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Strategic Water Planning & Resiliency Design

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United States Environmental Protection Agency

June 2018
www.epa.gov/smartgrowth

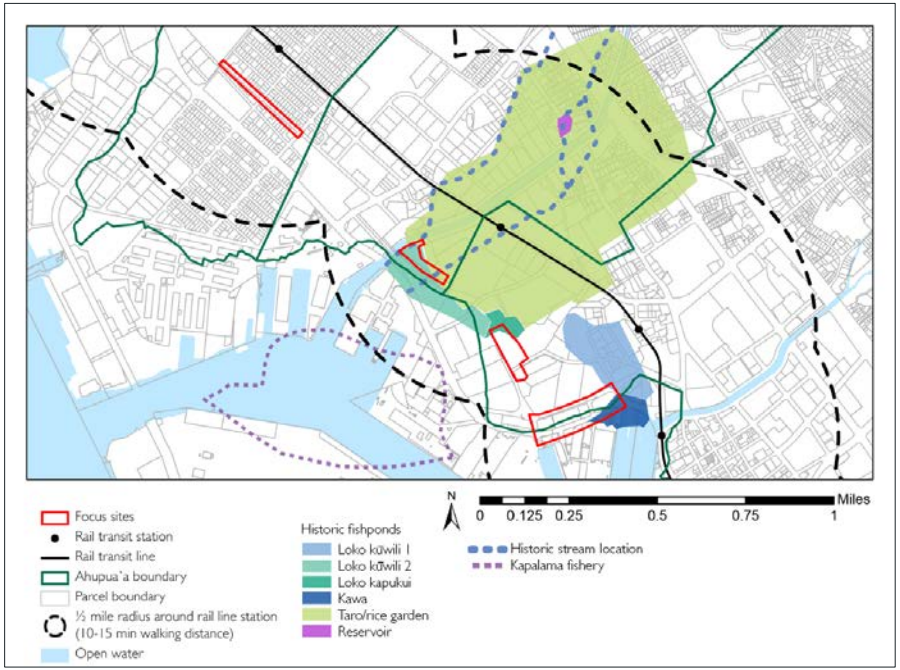
Greening America's Communities

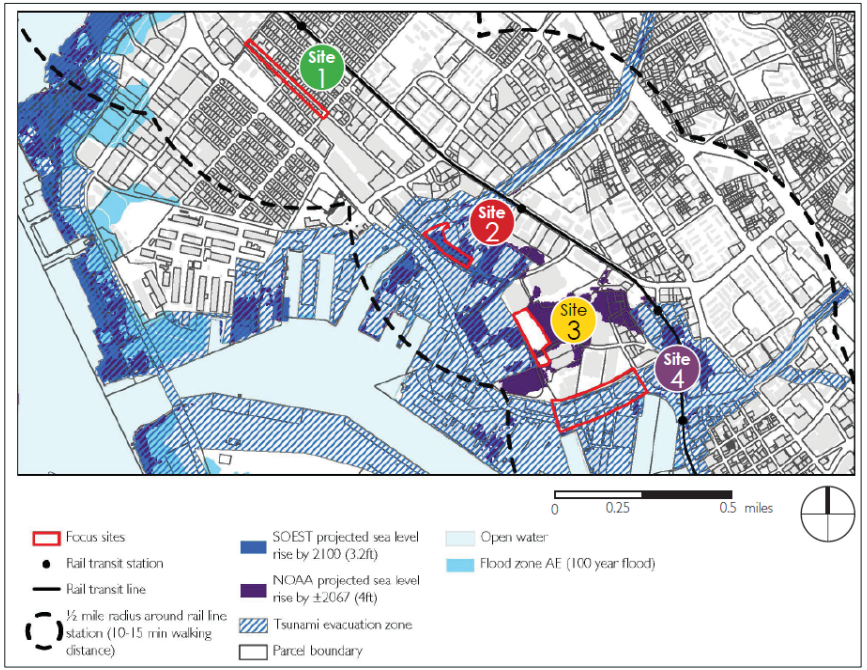
Greening Iwilei and Kapalama

Honolulu, Hawaii

Office of Community Revitalization
Smart Growth Program

EPA Greening America's Communities: Kalihi, Kapalama, & Iwilei





Legend

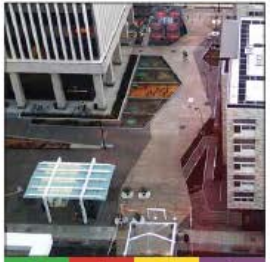
site 1 site 2 site 3 site 4

Greening and Resiliency Tools

3 4

INTEGRATED LANDSCAPE AND BUILDINGS

Green screens, planters, and other elements can provide landscape on building facades, helping to cool buildings and the urban environment and increase biodiversity.



1 2 3 4

ECOBLOCK/ECOBUILDING DEVELOPMENT

Decentralized water and sustainable energy infrastructure build community resiliency and reduces the development's carbon and water footprints.

1 2 3 4

PERMEABLE PAVER

Stormwater runoff percolates through or around pavers to either infiltrate or be collected and directed to storm drain line. Added depth of subbase can retain stormwater.

1 2 3 4

PERMEABLE CONCRETE/POROUS ASPHALT

Stormwater percolates through pavement to either infiltrate or be collected and directed to storm drain line. Added depth of subbase can retain stormwater.

1 2 3 4

BOARDWALK

Allows stormwater to percolate through boards. Enables different look and provides structural support to bridge over green infrastructure or stormwater runoff storage areas.

1 2 3 4

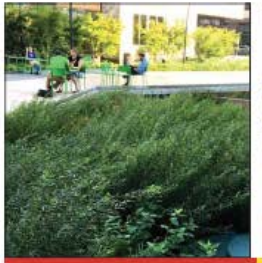
GREEN ROOF

Green roofs can provide stormwater management and treatment, food production, and visual amenity, as well as assist with improving air quality, reduce energy costs, and lower interior building temperatures through insulation and cool roof measures.

1 3 4

DISCONNECTED DOWNSPOUT

Disconnecting rooftop collected water in downspouts from entering the city's drainage infrastructure or gutter allows it to be treated naturally and potentially infiltrate into the soil.



2 3

CONSTRUCTED WETLAND

Constructed wetlands can be engineered to provide for stormwater or wastewater treatment and habitat restoration. They can be internal or exterior to buildings.

1 2 3 4

BIORETENTION/GREEN INFRASTRUCTURE

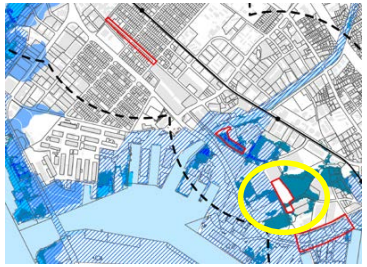
Different types of green infrastructure aid in improving water quality as it captures and treats stormwater runoff with natural processes.

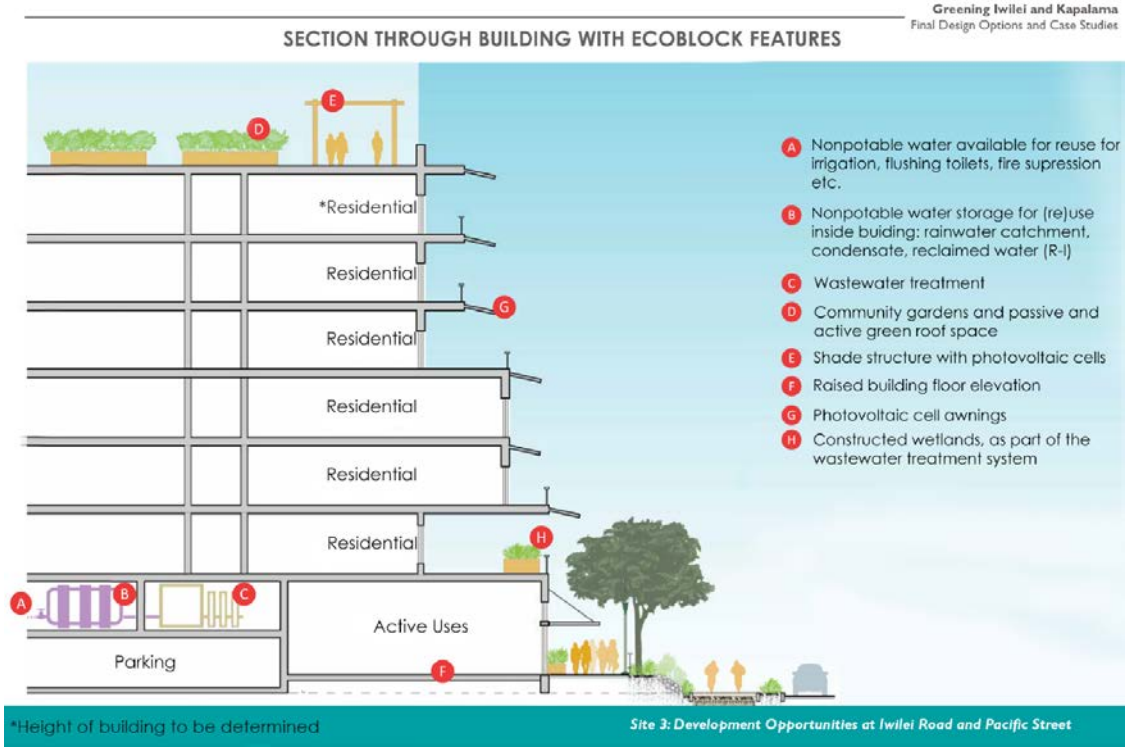
2 3 4

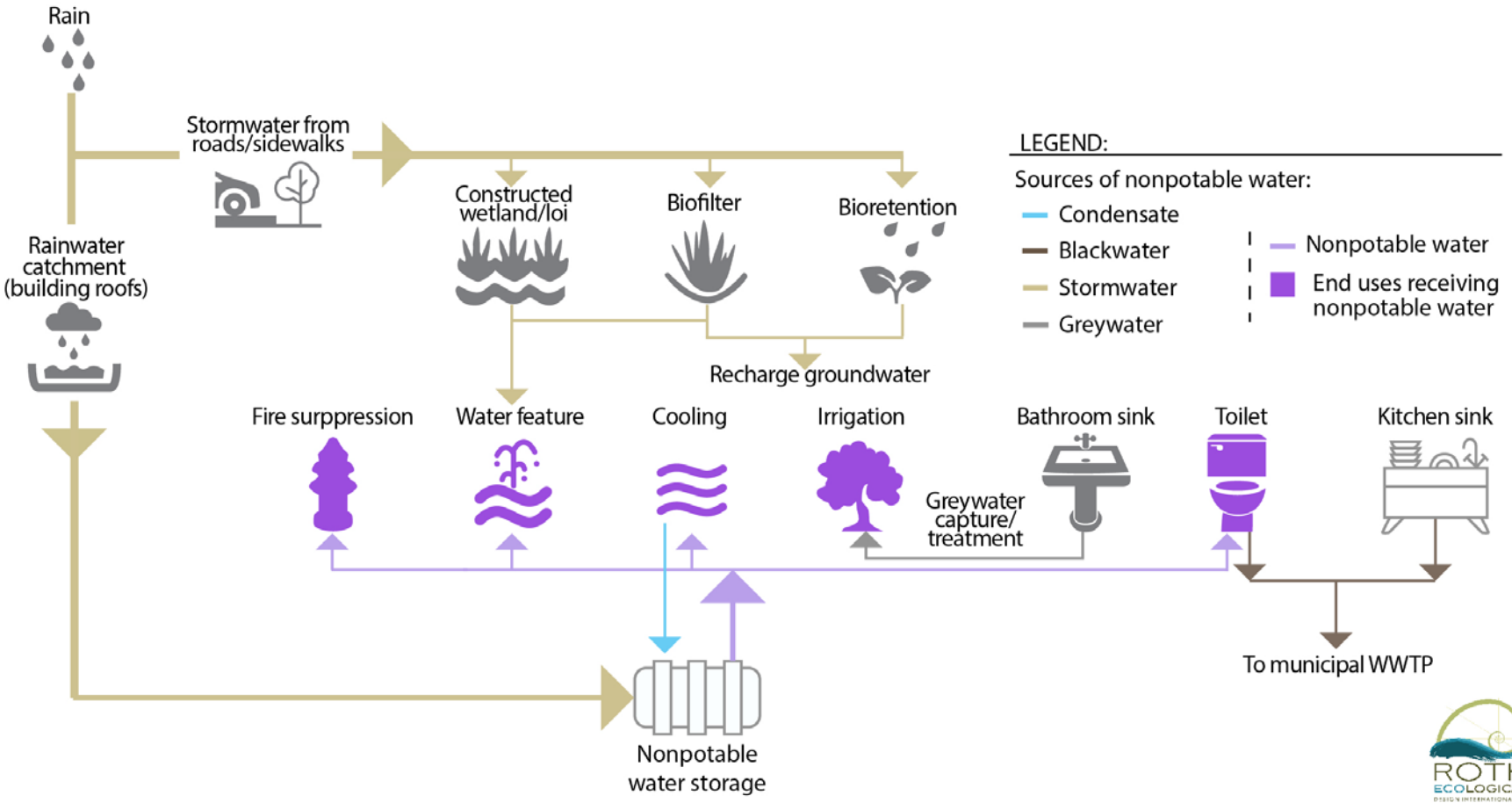
STORMWATER TREE

Planters are designed with curb inlets and recessed soil elevations to capture and treat stormwater runoff with natural processes. Stormwater trees may be "linked" to other trees for increased runoff storage.

EPA Greening America's Communities Iwilei: Redevelopment Concepts






Rain
Stormwater from roads/sidewalks
Rainwater catchment (building roofs)
Constructed wetland/loi
Biofilter
Bioretention
Recharge groundwater
Fire surppression
Water feature
Cooling
Irrigation
Bathroom sink
Toilet
Kitchen sink
Greywater capture/ treatment
To municipal WWTP
Nonpotable water storage
LEGEND:
Sources of nonpotable water:
Condensate
Blackwater
Stormwater
Greywater
Nonpotable water
End uses receiving nonpotable water

Case Study
Hassalo on 8th, Portland OR

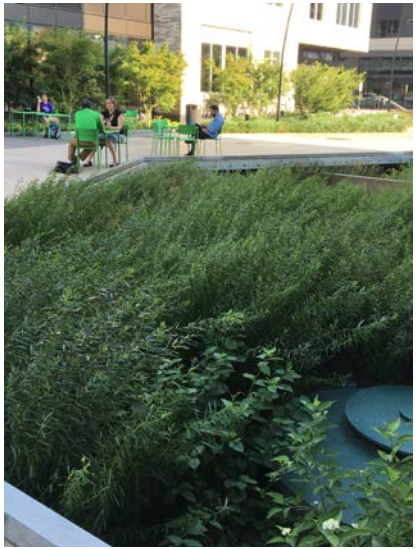
***Hassalo on 8th*[3]**
Portland, Oregon (block development)

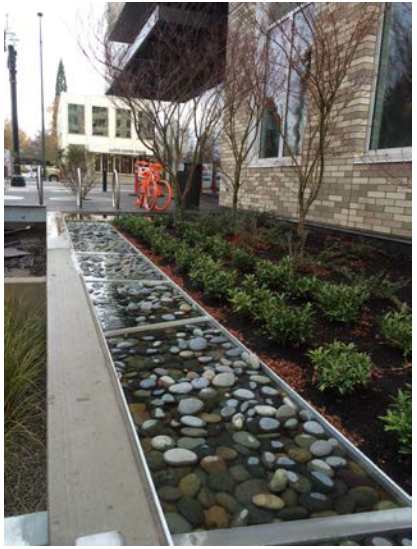
Building facts:

- (3) buildings in a block layout
- 657 residences (with commercial spaces on ground floor)
- 50,000 square feet

Green building features:

- Green roof (Eco-roof garden)
- Onsite wastewater treatment using trickling filters and constructed wetland technologies (45,000 gallons per day). Water is reused for flushing toilets, irrigation for the block's landscape, and feed for cooling tower.
- 60,000 gallon cistern collects rainwater. Collected stormwater used for the block's water feature.
- Over 1,000 bike parking stalls with access to bike valet and repair
- EV charging stations
- Composting
- Located next to Portland's light rail system





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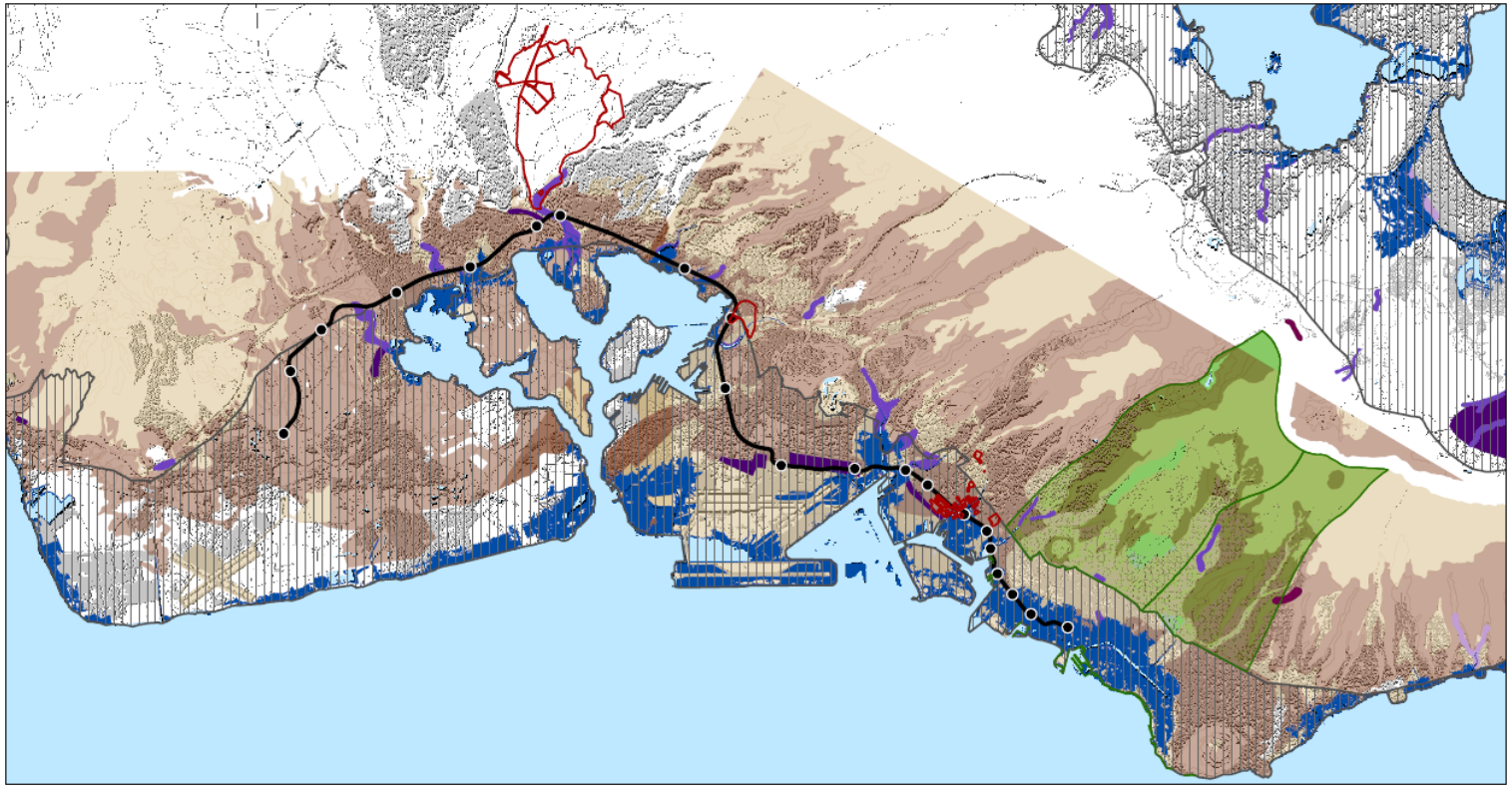
BWS:
Transit Oriented Development
Onsite Water Reuse

Freshwater Initiative Maps (Recharge): Highest Priority Recharge Zones



- Future Development
- Proposed Rail Stations
- Proposed Rail Lines
- Well Draining Soils (Class A and B)
- Low Draining Soils (Class C and D)
- Impervious Surface
- Open Water
- Areas of Flooding (6ft SLR): No Recharge

- Pass Zone

Highest Priority Recharge Zones

- Nuuanu & Palolo Aquifer Systems (above pass zone, where well draining soils occur)

Other Priority Recharge Zones to reduce stormwater runoff only: well-draining soil areas other than flood zones)

Flood Threat Areas (2013)

- Rare Flash Flooding
- Occasional Flash Flooding
- Ponding and Sheetflow
- Landslide

0 1 2 4 Miles

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Kapalama Development

Total Area: **88 acres**

Number of projected residential units: **4400**

Assumed daily water demand: **880K gpd**
(200 gpd per unit)

Average number of residents in PUC = **2.4 people/residential unit**

Projected annual water & sewer bill (no action): >**$2.8M**

Estimate annual stormwater runoff: **~64MG**

Projected annual (future) SWU fee: **~$188K** ($4.82/1000 sf IA)

Image by: City and County of Honolulu TOD

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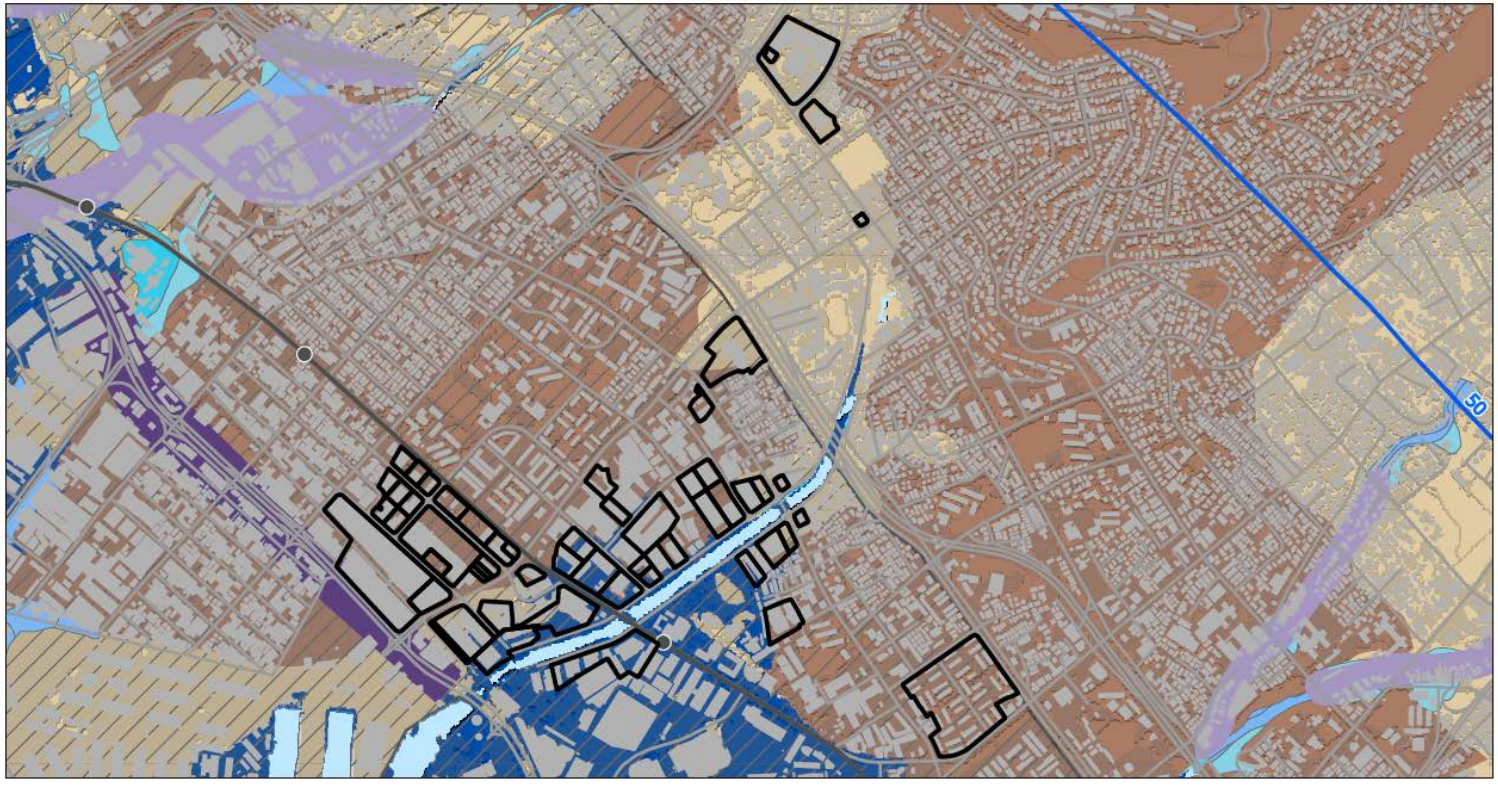

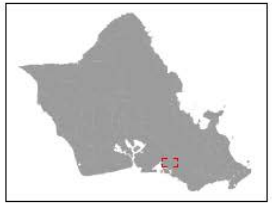

Future Development
Proposed Rail Stations
Proposed Rail Lines
Street Centerlines
Building Footprints
Impervious Surface
Open Water

Pass Zone (Low Priority Recharge)
Annual Rainfall (in)
Areas of Flooding (6ft Sea Level Rise): No Recharge/High Priority Rainwater Harvesting
Well Draining Soils (Class A and B)
Low Draining Soils (Class C and D)

Flood Threat Areas (2013)
Rare Flash Flooding
Occasional Flash Flooding
Ponding and Sheetflow
Landslide

Flood Zone
AE
AO
X

*Priority Recharge Zones: well-draining soil areas other than flood zones)

0 0.1 0.2 0.4 Miles

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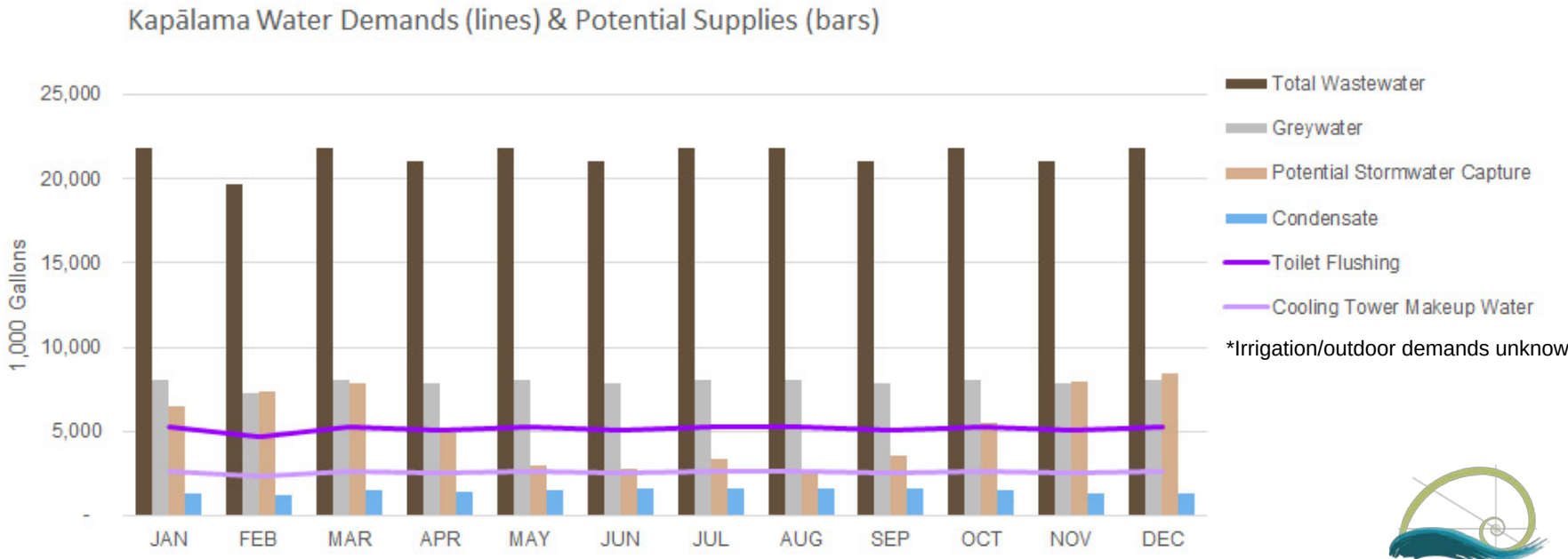
Kapalama Development Water Supplies & Demands (Based on TOD programming estimates)



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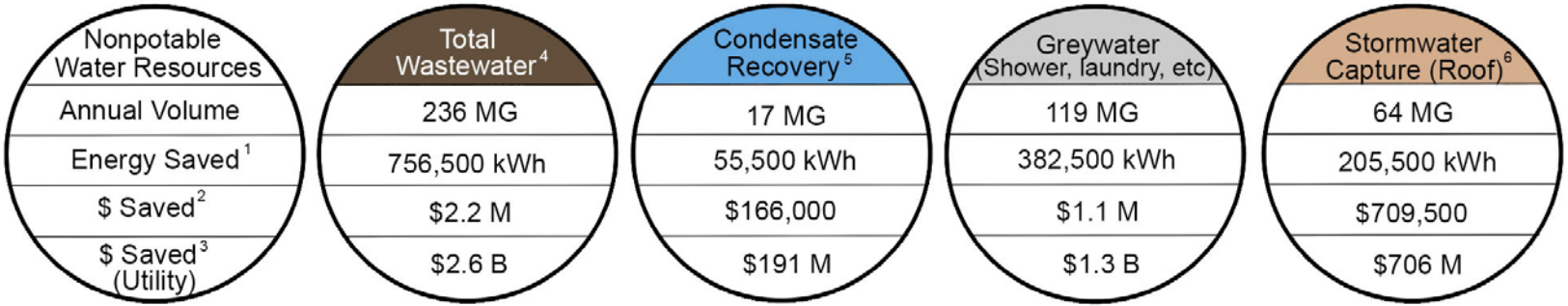
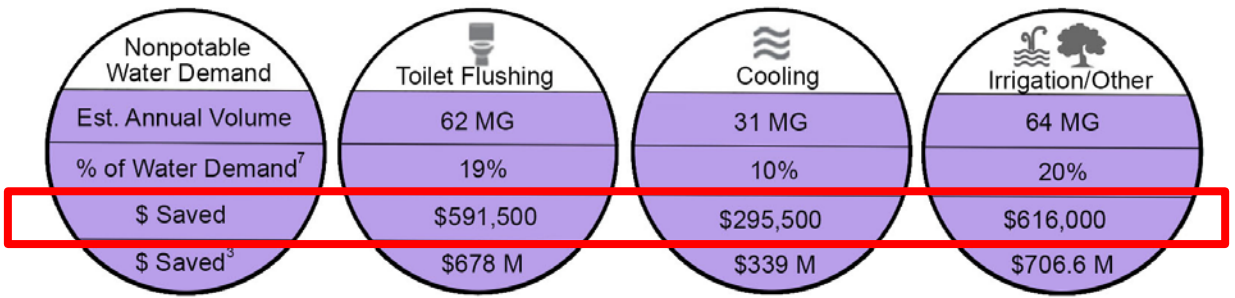
ANNUAL WATER PORTFOLIO (WITH UTILITY SAVINGS)



ANNUAL NONPOTABLE WATER DEMANDS



1. Energy Assumption based on average energy intensity of 3.2 kWh/kgal for Oahu (DLNR, 2016 Hawaii Water Energy Nexus Report)
2. Occupant savings are based on assumption of replacing potable water with nonpotable water (estimated from avoided potable water and sewer costs) and SWU fee of $4.82/1000 sf IA and credit is no more than 50% fee credit w/GI
3. Savings for BWS (offset new source charge) $11/gal
4. Total wastewater includes greywater and blackwater
5. 12 gal/1000sq ft per day (Novak 2014)
6. Assumes water capture from building roofs only
7. EPA Indoor Residential Water Use

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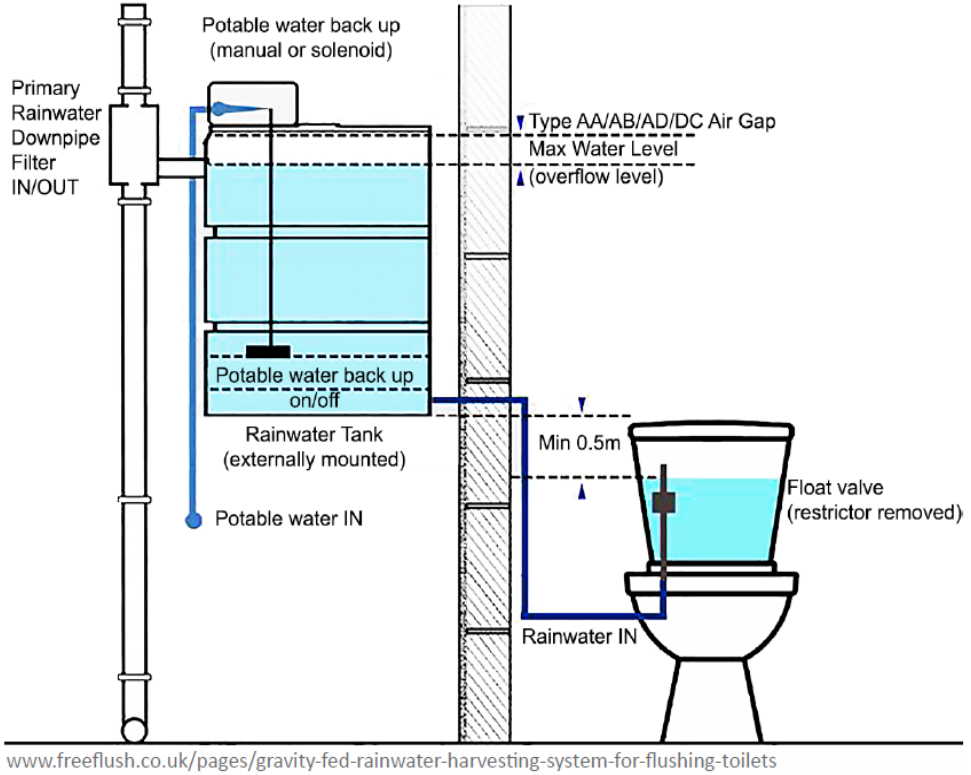
Recommendation: Rainwater Harvesting for Nonpotable Reuse (Individual Parcel)

Rainwater Harvesting (Building roof only)

- 1”-24hr rainfall intensity = 37,000 gallons
- 40,000 gallon (min) catchment tank(s)
- ~ $5 /gallon for tank w/installation.
- Total cost: **$200,000**
- ~Annual cost savings: **$12,700 (w/SWU credit)**
- ROI: **16 years** (without rebate)
- Rainwater cistern may qualify for a
- Water Sense rebate (TBD program to be initiated in 2020)



Onsite Water Reuse/Green Infrastructure

UHWO Administration & Allied Health

Re·gen·er·a·tive

- To give new life or energy to; revitalize;

- To become formed or constructed again.

Goals for UHWOC

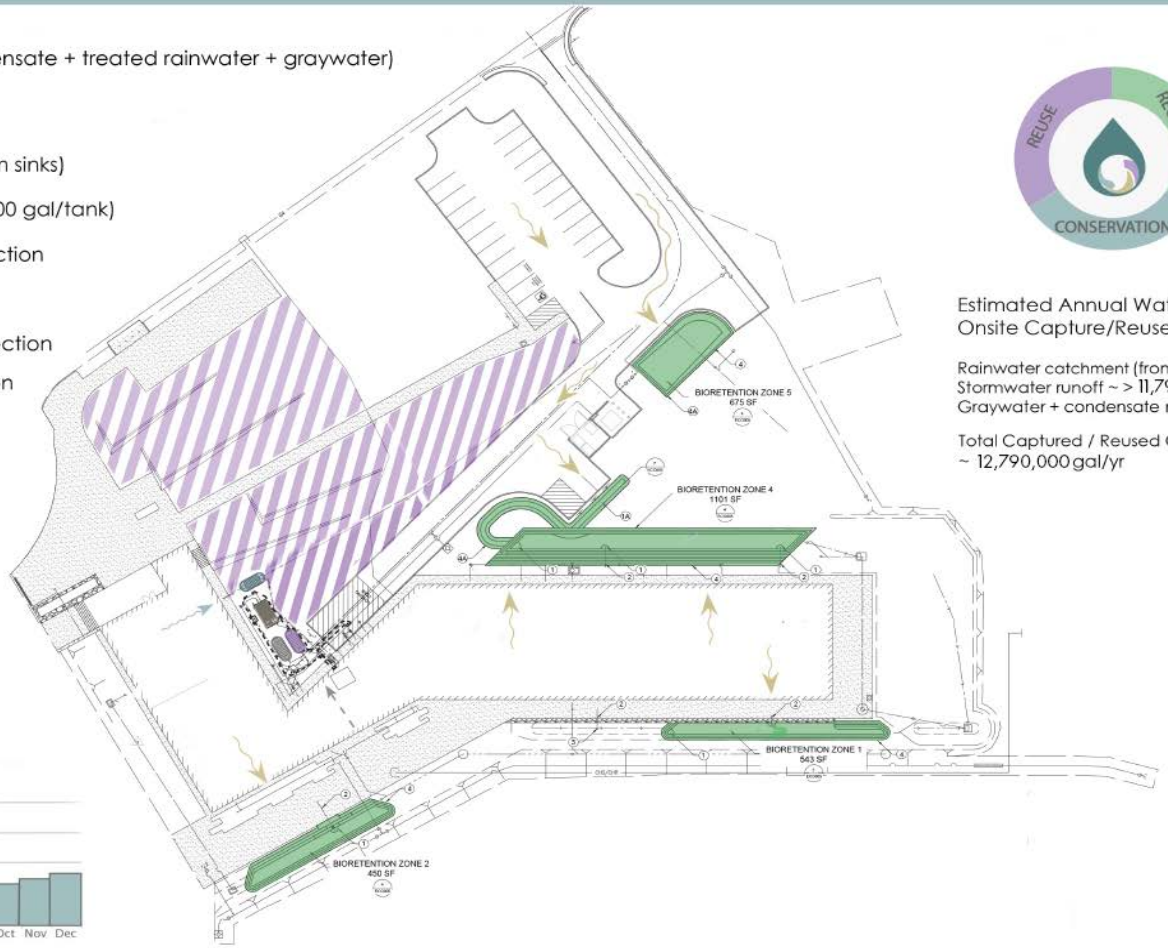
The UHWOC site goals are **restorative** and **healing**: to support the revival of a native landscape ecology while demonstrating 21st C sustainability to learners of all ages, by rebuilding soil lost from plantation style agriculture and managing water and nutrients onsite.

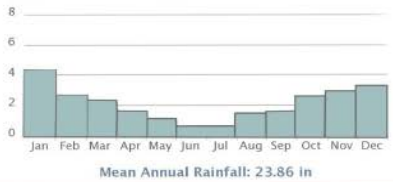
Net-Zero Water:

Net-Zero Water is the concept of balancing a devlopment's annual water demand through efficient use, capture and reuse of water resources. This process is fundamental to acheive the restorative, healing and sustainability goals for the site.

UHWO Administration + Allied Health Bldg: Comprehensive Water Management

- Nonpotable water (condensate + treated rainwater + graywater) to irragation
- Stormwater bioretantion
- Graywater (from bathroom sinks)
- Rainwater catchment (2000 gal/tank)
- Stormwater drainage direction
- Rainwater direction
- Greywater (from sinks) direction
- Nonpotable water irrigation areas





Mean Annual Rainfall: 23.86 in

Estimated Annual Water Volumes for Onsite Capture/Reuse

Rainwater catchment (from roof) ~390,000 gal/yr
Stormwater runoff ~ > 11,790,000 gal/yr
Graywater + condensate reuse ~ 1,000,000 gal/yr

Total Captured / Reused Onsite
~ 12,790,000 gal/yr

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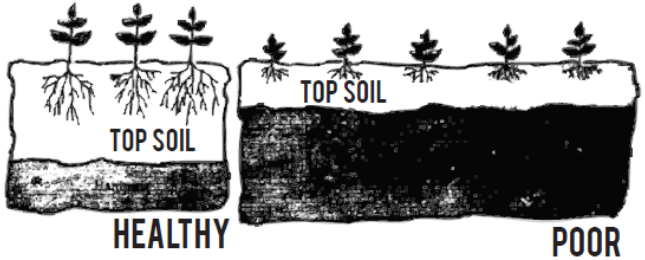
BUILDING & RESTORING SITE ECOLOGY



BUILDING HEALTHY SOIL:

PHYSICAL:
Water-holding capacity*
Soil depth, horizons*
Infiltration rate
Soil texture
Soil bulk density
Aggregate stability
Dispersible clay

CHEMICAL:
Nutrient availability*
Nutrient holding capacity: Cation (CEC) and anion exchange capacity*
Electrical conductivity (salinity), sodium, pH
Toxicities (toxic elements, pesticides, organics)

BIOLOGICAL:
Soil organic matter*
Diversity/Abundance of key soil flora and fauna*
Soil microbial biomass
Labile N
Labile organic C
Vegetation growth and cover
Bioremediation

SELECTING RESTORATIVE-BASED PLANTS:

Nitrogen Fixing
Pollinator attractants
Subsoil mineral miners (tap roots, dynamic accumulators, etc)
Fast carbon pathways (C4 photosynthesis species)
Greywater remediation
Stormwater remediation

HUMAN ECOLOGY:

Engaging students with the landscape
Healthy environment ⟶ Healthy community
Sustainability

University of Hawai'i West O'ahu
Administration & Allied Health Facility

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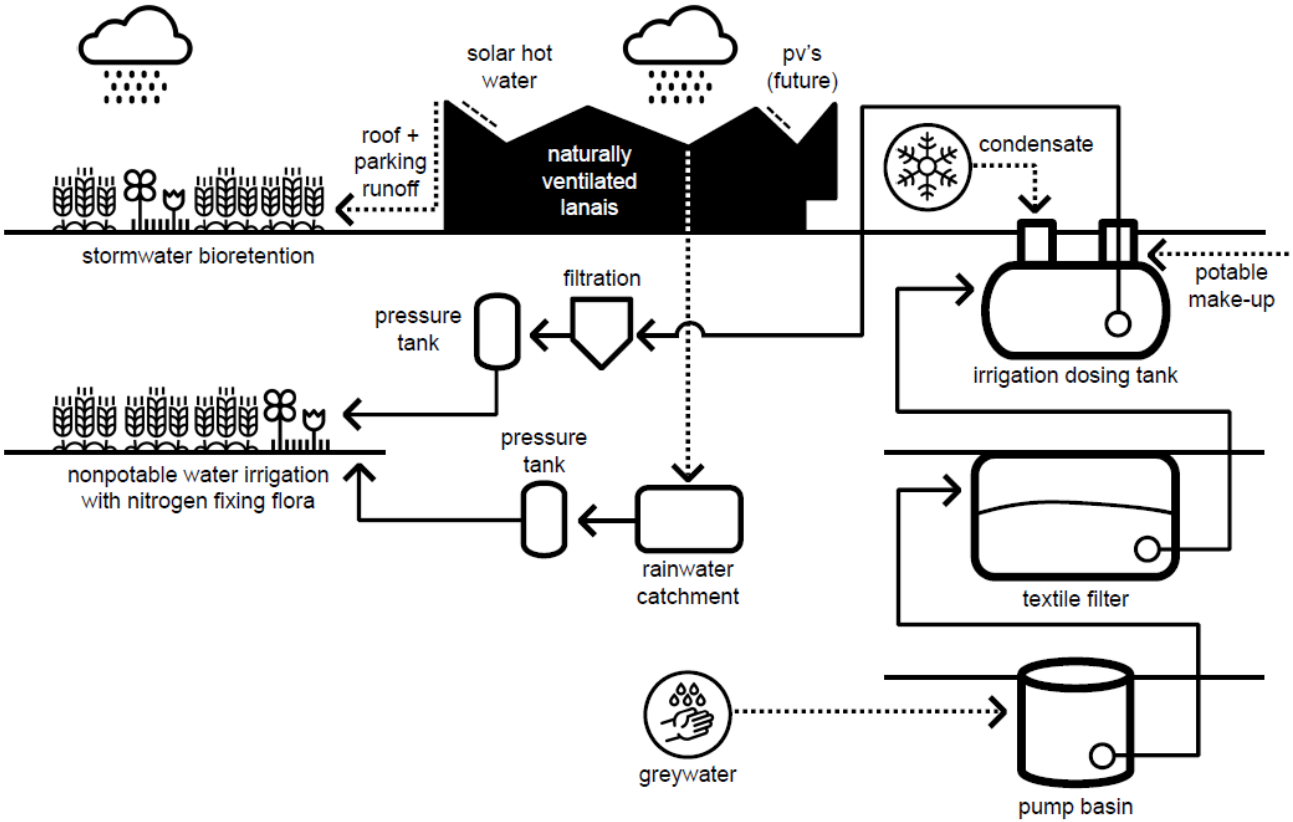

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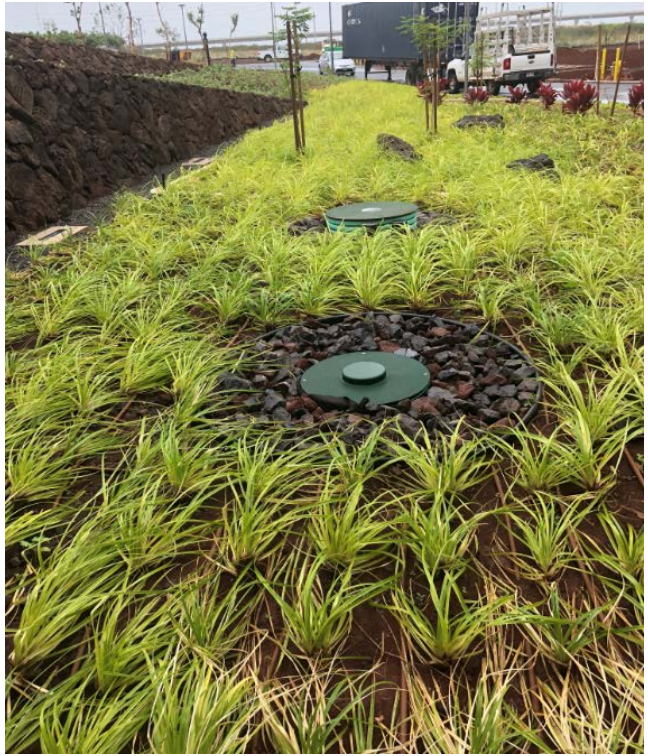

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Constructed Wetlands: Wastewater Treatment

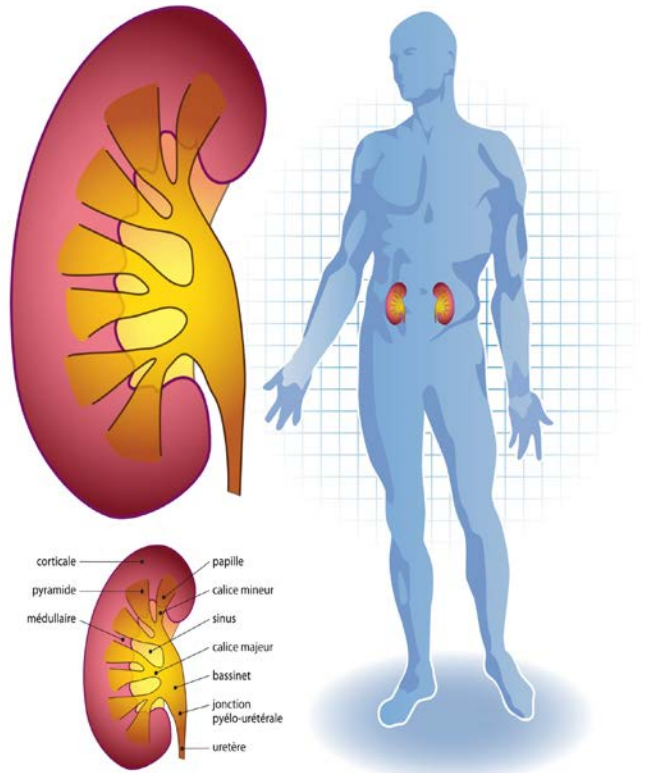
Natural Wetlands: CO2 Sequestration

(1) **“Despite only making up 3% of total land area, wetlands sequester 30% of all soil carbon.** Prairie wetlands alone sequester 7.5 tons of carbon per acre”

AND

(2) **32%** more carbon at higher CO2 levels

1. https://phys.org/news/2018-11-wetland-experts-role-vital-carbon.html
2. Global Change Biology from the Smithsonian Environmental Research Center



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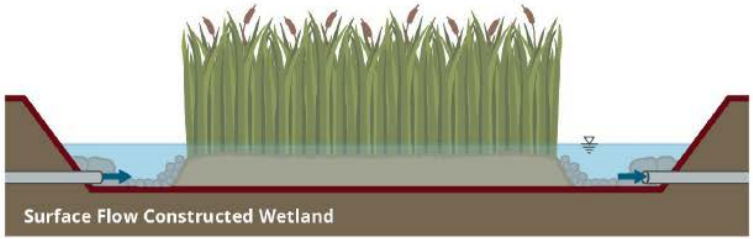
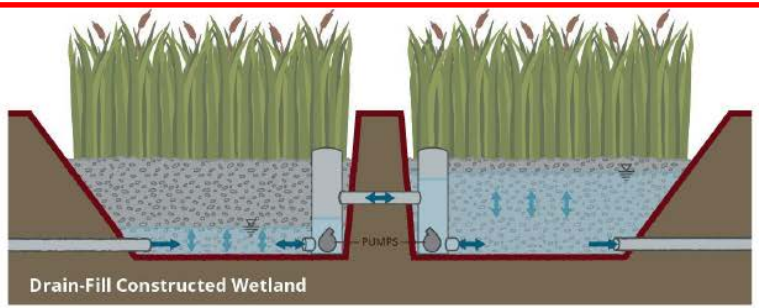
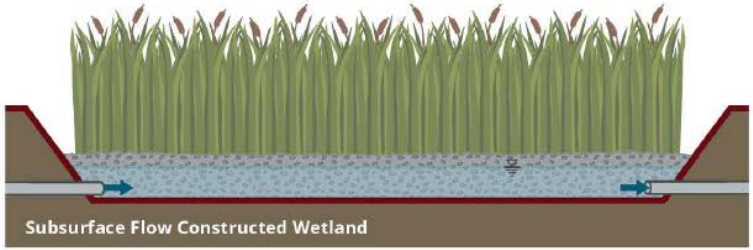
Ecological Services: Water Purification

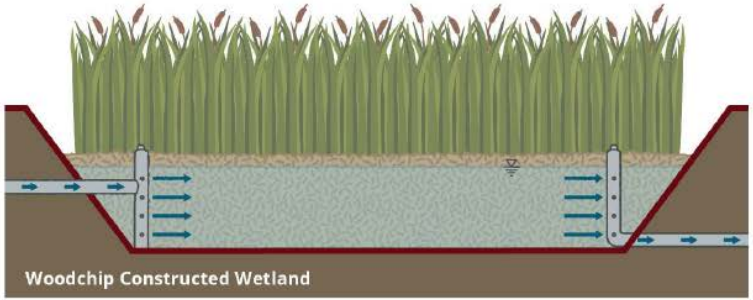
CONSTRUCTED WETLAND TYPES

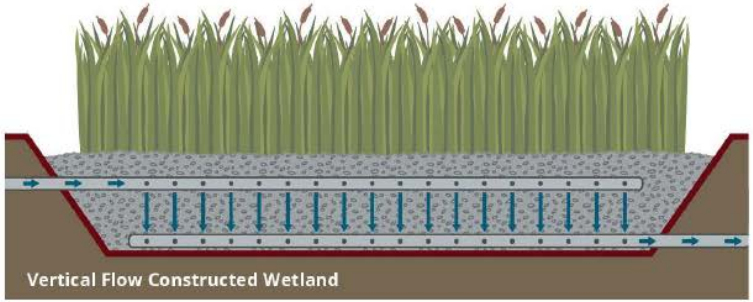
Constructed wetlands for wastewater treatment can be configured to meet a variety of water quailty, footprint, habitat, and aesthetic goals. They range from primarily passive operation to active operation with treatment dosing or cycling. Additionally, treatment media options include gravel, saturated soil, specialty rock, and woodchips.











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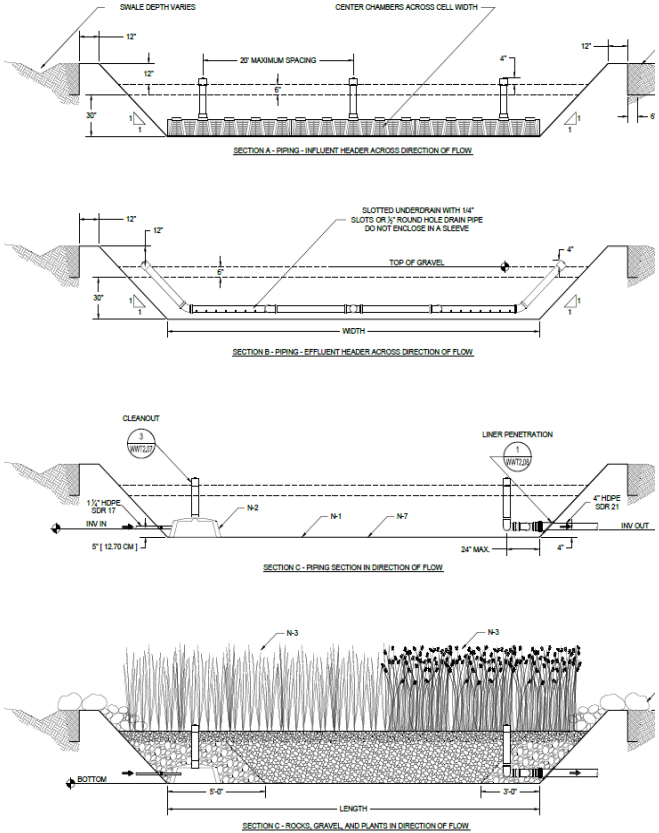
University of West Hawaii Campus, Kailua-Kona (LEED Platinum)



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Green Infrastructure

- ✓ Water Quality
- ✓ Prevents Flooding
- ✓ Supports Water Supply/Security
- ✓ Reduces Heat Island Effect
- ✓ Absorbs CO2
- ✓ Restores Natural Hydrology

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Questions/Discussion

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