SAFEGUARDING CORAL REEFS

Floating Treatment Wetlands to Filter Stormwater Runoff and Reduce Water Pollution

Demonstration Project: Building a "do it yourself" floating treatment wetland in a wet retention basin at Ka'anapali Golf Resort in West Maui

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CORAL REEF ALLIANCE

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

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Problem

Wet retention ponds ("settling ponds" that generally always have water in them) are a common stormwater management practice in Hawaiʻi and throughout the United States. They are ponds designed to temporarily capture and hold the stormwater runoff to allow pollutants to settle out of suspension before water is discharged into natural water bodies like streams, ponds, estuaries and the ocean. However, total suspended solids (TSS) and nutrients like nitrogen are not always treated efficiently by these systems if retention times are not long enough to allow settling, or if conditions in the pond do not allow for denitrification to occur. In these situations, wet retention ponds may continue to leach pollutants into the environment.

Retention pond

Solution

A **floating treatment wetland** (FTW) is a valuable retrofit to improve the pollution treatment effectiveness of a wet retention pond. An FTW consists of a floating raft of buoyant material that is deployed on the surface of the pond, on which aquatic plants are grown hydroponically so that their roots extend down into the water column (Lane, 2016). Constructed wetlands, which involve planting wetland plants along the edge of ponds or other waterways, are a commonly used best management practice to treat stormwater runoff. An FTW provides the same benefits, with several additional advantages:

1. Plant roots take up nutrients to support plant growth. The roots hanging down in the water column provide an ideal habitat for denitrifying bacteria. These bacteria remove nitrogen from the water and convert it into nitrogen gas which bubbles out of the water and is released into the atmosphere (Headly, 2012).
2. Plant roots capture suspended sediment and particulates and encourage the settling out of these fine-grained materials, thereby increasing the settling rates and overall effectiveness within a wet retention pond (McAndrew, 2016).
3. Plants are floating on the water surface and therefore unaffected by water level fluctuations caused by flooding or drought.
4. No additional land (which is often expensive) is required because FTWs are constructed within an existing wet retention pond.
5. No building permits are required.
6. An FTW can easily be moved aside to accommodate standard pond maintenance activities such as removal of accumulated sediment.
7. FTWs are often appreciated by local communities for the wildlife habitat and landscape beauty they provide.

Demonstration Project

Demonstration Site

In the Ka‘anapali Golf Resort in West Maui, there is a series of wet retention ponds (hereafter referred to as ponds) designed to manage stormwater before it enters the ocean near Black Rock. The area which contributes stormwater to this pond system is typical of an urban setting in Hawai‘i, with common features like golf course greens, manicured landscapes for resorts and condominiums, parking lots, roadways and suburban neighborhoods.

In 2016, The Nature Conservancy (TNC) conducted water quality measurements in the Ka‘anapali Golf Resort's pond system to understand the relative pollution loading and determine its potential contribution to pollution of the nearshore environment. Of the five ponds sampled, water quality samples showed that the Ka‘anapali Golf Basin pond (makai of the highway), had the largest TSS concentrations, the second largest nitrogen concentrations and the lowest stormwater flows (Babcock, 2017). Nutrient and TSS levels exceeded state standards. In the nearshore ocean environment, elevated nutrient levels and reef stress associated with excess nutrients were also detected (Vargas-Ángel et al, 2017). While there are many causes of excess nutrients, one potential source is nutrient-rich stormwater runoff entering the pond system and eventually flowing into the ocean. TNC researchers recommended a constructed wetland or other nutrient-absorbing "best management practice" (Falinski, 2016). We chose to use this opportunity to construct an FTW to reduce nutrient loads at this site.

Objectives

1. Demonstrate how a simple "do it yourself" FTW can be constructed with a limited budget.
2. Showcase how a simple FTW can significantly reduce nutrient and TSS pollution.
3. Add to the local aesthetic of the ‘Ka‘anapali Golf Basin' treatment pond.

Demonstration Project (cont'd)

Constructing the Floating Treatment Wetland

The Coral Reef Alliance (CORAL) collaborated with the Ka'anapali Golf Course to construct an FTW at the Ka'anapali Golf Basin pond (indicated on the map). While there are a number of proprietary manufacturers of FTW components, we wanted to demonstrate the effectiveness of a simple affordable 'do it yourself' design using materials readily available at any local hardware store. We constructed the framework for two, four foot by eight foot FTWs using 60 feet of four inch PVC pipe. Plastic lattice panels were then zip-tied to this frame and 400 individual plants in three inch hydroponic pots were inserted into the lattice squares and tied in place using zip-ties.

Characteristics of suitable plants for an FTW are those that

a. can be grown in a hydroponic system where their roots absorb nourishment directly from the water;
b. have an extensive root surface area to allow for maximum bacterial habitat; and
c. are aesthetically pleasing.

Using these criteria, we chose a range of native Hawaiian plants. We augmented the nutrient capture ability of the FTWs by adding sterile vetiver grass that has been approved by the United States Department of Agriculture (USDA) for use in Hawai'i. Vetiver has an extensive root system and its ability to absorb significant amounts of nutrients is well documented (Gupta, 2012). The following plants were used in this project:

Plant Name		Cost	Total Quantity Planted in FTW
Vetiver grass	(*Chrysopogon zizanioides*)	$150 for 100	100
Ahu aha	(*Cyperus trachysanthos*)	$24 for 4	Each of these plants were divided to make additional individual plants
Puu kaa	(*Cyperus trachysanthos*)	$24 for 4	
Pili grass	(*Heteropogon contorta*)	$12 for 6	
Ala ala wai nui	(*Peperomia sp.*)	$13 for 6	
Uki uki	(*Dianella sandwicencis*)	$55 for 10	
'Ae'ae	(*Bacopa monnieri*)	$44 for 98	98
Kalo (taro)	(*Colocasia esculenta*)	$30 for 20	20
Totals		**$352 for 248 plants**	**400**


Completed FTW

Constructing the Floating Treatment Wetland (cont'd)

Step 1: Construct the PVC frame (~1 hour)


Step 1, a

a. Measure and cut the PVC pipe pieces to match the dimensions of the four foot by eight foot panels of plastic lattice (so that the lattice can sit on top of the frame). Be sure to account for the extra length provided by the elbow fittings and Tee fittings. "Measure twice, cut once!"

b. Lay out all the pipe and fitting pieces before gluing to ensure proper sizing.

c. *Optional step*: Fill the PVC pipes with empty plastic water bottles with tight lids. This ensures that the frame will stay buoyant even if there is a leak in a pipe joint or a hole develops in a pipe.


Step 1, b

d. Working as a team (three to four people), glue the frame together on a level surface to ensure pipes line up correctly. Hold all the joints tightly until the glue dries.

Step 2: Affix the plastic lattice panel to the frame (~15 minutes)


Step 1, d

a. Lay the plastic lattice on top of the PVC frame.

b. Use zip-ties around the perimeter and center crosspiece to attach the lattice to the frame.

c. *Optional step*: To enhance aesthetics, paint the lattice and frame with a non-toxic water based paint. For this project, we painted the frame green to camouflage it a little. In retrospect this wasn't necessary as the plants quickly filled in and grew over the frame, hiding it completely from view.

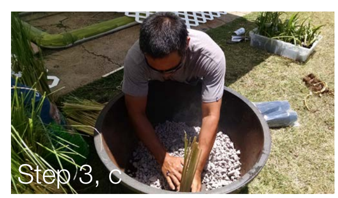
Step 3: Repot the plants into hydroponic pots (3 to 4 hours with a team of three people)


Step 2, c

a. Remove plants from their pots.

b. Divide plants as needed.

c. Repot plants into three inch hydroponic pots using a lightweight hydroponic growing medium, such as coconut choir.


Step 3, c

d. Place re-potted plants into the lattice squares using whatever desired layout or pattern you choose. For this project, we placed the taller grasses and sedges in the center of the frame with the smaller broad-leafed and creeping plants towards the edges so that they could grow out into the water.

e. *Optional step*: Normally, water will quickly saturate the pots and keep them from floating out, and eventually the root mass will hold the pots in place as well. However, if your site experiences excessive wind, or plants are very tall, you might choose to secure the pots to each other underneath the lattice using zip ties. To do this, lay the frame on some chairs and lie underneath it as you tie the pots together. This activity is quite time intensive and will use many zip ties.


Step 3, e


Completed FTW

Constructing the Floating Treatment Wetland (cont'd)

Step 4: Launch the FTW (10 minutes)

a. Secure the FTW to the shore with a rope. With two people, gently and slowly slide the FTW into the water.

b. Anchor the FTW into place. You can either tie anchor lines (rope) from the FTW to stakes or trees on the shore, or use a few small boat anchors to secure the FTW in place; our demonstration site already had stakes in place. Make sure there is enough slack in the anchor lines to allow for the rise and fall of water levels in the pond. This project was constructed in a small pond that occasionally overflows. We therefore crossed the anchor lines like an "X" on both sides to prevent excessive lateral movement, while still allowing for several feet of rise and fall.


Step 4, a

Step 5: Maintain the FTW

Little maintenance is required over time, but generally includes:

- Replacement of dead plants.
- Removal of dead plant material as needed. Do not leave plant biomass in the pond; compost or dispose of it instead.
- Seasonal replacement of annual plants in temperate locations.
- Repairs to the FTW framework as needed; check the structural integrity and buoyancy of FTWs as they age.


Step 4, b


FTW after six weeks of growth

Project Costs

Item	Cost
60 feet of 4" PVC pipe	$140
8, 90 degree elbow fittings	$73
4 Tee fittings	$73
2, 4' x 8' panels of plastic lattice	$48
1 bag (500 ct) large size zip ties	$32
400 gro pro 3" hydroponic net pots	$140
1 bag of coconut choir planting media	$18
1 bag of perlite rocks for planting media	$18
1 quart of green paint and 2 brushes	$22
1 quart PVC pipe cleaner and glue	$30
50 feet of rope	$10
Total Materials Cost	**$594**

Results

We estimated the nutrient uptake using the following information:

a. Lane (2016) created a rating curve to describe the pollution removal rates of FTWs based on the ratio of planted surface area of the FTWs to the overall pond surface area. In our case we achieved a 40 percent coverage.

b. Based on this curve, we expect to reduce nutrient and TSS by approximately 9.2 percent.

c. Because of the warm climate and year-long growing season, these rates could be as high as 20 percent.

Constructing an FTW is an easy and cost effective solution to reduce pollution from nutrients and suspended solids. To quantify the nutrient reduction capability of an FTW in Hawai'i, we recommend constructing FTWs at additional wet retention ponds and measuring nitrogen and TSS levels before and after installation.

Incremental Pollutant Removal Rates for FTW Pond Retrofits

Pollutant	Raft Coverage in Pond				
	10%	20%	30%	40%	50%
Total Nitrogen (TN)	0.8%	1.7%	2.5%	3.3%	4.1%
Total Phosphorus (TP)	1.6%	3.3%	4.9%	6.5%	8.0%
Total Suspended Solids (TSS)	2.3%	4.7%	7.0%	9.2%	11.5%

(Lane, 2016)

THANK YOU!

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- Craig Trenholme, Ka‘anapali Golf Course
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- Wayne Hedani, Ka‘anapali Operators Association
- John Astilla, Sunshine Vetiver Solutions
- Paul Sturm, Ridge to Reefs

Additional Resources

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

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

Sources

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