BioHaven® Floating Islands

Natural wetlands have long been recognized for their ability to clean water. More recently, constructed wetlands have become a common best management practice (BMP) for maintaining water quality. BioHaven floating islands are an innovative type of constructed wetland called floating treatment wetlands (FTW), with proven water quality treatment benefits.

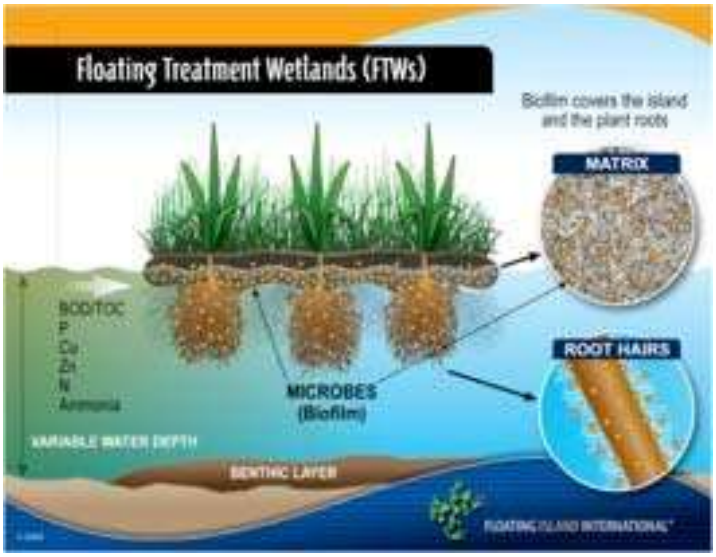
BioHaven Floating Wetlands are constructed with a porous, fibrous material mixed with buoyant foam that serves as a floating platform for plants whose roots grow into the water column and as a high surface area substratum for microbial habitat. In addition to numerous water quality functions, BioHaven islands excel at nitrate removal due to their anoxic zones and self contained organic carbon source.

BioHaven islands provide many benefits:

- Improve water quality and water clarity for wastewater, stormwater, lakes, and ponds, and other waterways
- Enhance fisheries
- Create waterfowl and riparian edge wildlife habitat
- Encourage flourishing native biodiveristy**.**
- Provide aesthetic softscaping for urban areas.
- Wave mitigation for erosion control and shoreline protection
- Multipurposed structural platforms that float

A primary function of BioHavens is to speed up the cycling of nutrients into appropriate biota within target waterways. Secondary uses for FTWs include erosion control, wave dampening and structural platforms, stemming from the product's materials and construction design.

One great advantage of FTWs is that the plants are rooted in a floating mat and not the sediments, which means the plants are not affected by changing water levels that are common in event-driven stormwater retention ponds. BioHavens are easily retrofitted into existing stormwater ponds to increase their efficiency, requiring no pond alterations. Utilizing floating plant treatments in the upfront design stage allows retention ponds to be deeper with a smaller footprint, increasing capacity and retention time without requiring as much land.



Schematic illustration of BioHavens and biofilm

Islands range in size from several square feet to islands larger than football fields. BioHavens can be made in any size, shape or buoyancy. They have withstood numerous freeze/thaw cycles, as well as typhoons, tornadoes, hurricanes and major snowfalls. They are readily customized and can provide multiple benefits. They are modular in that they can be expanded or duplicated to increase their effectiveness. Their small and adjustable size and weight enables them to be deployed rapidly in difficult-to- access settings


A prototype BioHaven, eleven years old

Floating wetlands exist in nature, consisting of a floating organic mat supporting plant growth, with self-buoyancy made possible by the entrapment of gases generated by anaerobic metabolism and the presence of air pockets in the roots of certain plant species. Biomimicking nature, BioHavens provide the "concentrated wetland effect" that transitions nutrients through the food web via biofilms and periphyton. Creating habitat for biofilm-, diatom- and algae-based periphyton, which can readily transition through the food web into fish and higher life forms, can set the stage for improved phosphorus removal from impaired waterways when compared to systems based on free-floating or filamentous algae. Diatoms and green algae are generally acknowledged as the base of the food web.

The buoyancy of BioHaven islands is adjustable. While the island itself can be walked upon (akin to walking on a waterbed), it can be customized to be more walker-friendly by rigidification. For instance, by positioning polymer boards across an island module, the entire module's buoyancy is captured. Individual modules are quickly and easily connected, providing huge buoyancy potential. A large island for Caspian tern nesting in northern California supports many tons of gravel (pictured below).

39,000-ft^2 island in Sheepy Lake, CA

WATER QUALITY

BioHavens are in use today to address water quality issues across watersheds with stormwater and agricultural runoff, freshwater dead zones, sewage clean up, and acid mining wastewater. As demonstrated in field-scale case studies, waterways containing FTWs remove contaminants such as ammonia, total nitrogen, total phosphorus, total organic carbon (TOC), biochemical/chemical oxygen demand (BOD/COD) and total suspended solids (TSS). Biofilm also has the proven ability to capture and sequester heavy metals and other toxic agents.

For water quality improvement using BioHaven islands, a spreadsheet model constructed from accumulated data is used to estimate either the floating island size(s) required to meet water quality objectives, or the effect on a waterway of a given floating island size.

BioHavens islands are especially well suited for nitrate removal. The islands create an anoxic zone by blocking diffusion of oxygen from the air/water interface and by blocking oxygen generation from algal photosynthesis (Dodkins 2014). Oxygen consumption by microbial metabolism associated with the islands further reduces DO, creating the anoxic environment required for nitrate removal. The other requirement for nitrate removal is a source of organic carbon, which is supplied by the litter form the island plants.

For total nitrogen removal, pairing BioHaven islands with the BioFil Filter creates a complete solution based on optimum efficiencies for both processes. The BioFil's aerobic environment compliments the islands anoxic environment creating a synergistic pairing for highly efficient total nitrogen reduction.

Water quality before and after BioHaven treatment
(McLean's Pit landfill, New Zealand)

PLANTS

Plant based remediation derives much of its effectives from the symbiotic relationship between plants and the microorganisms associated with them. The metabolites produced by microorganisms during degradation of organics, along with N and P, are absorbed by plants as a food source. Microorganisms in turn use the metabolites released through plant roots as a food source. This relationship produces a synergistic effect resulting in increased degradation rates and removal of organic chemicals from the water surrounding the plant root system.

Plants play a number of important roles in both nitrate removal and a multitude of other water quality aspects. With respect to nitrate removal, the major role of plants is to provide a source of organic carbon. In addition to carbon disposition, the plant roots i) intercept and filter particulates, aiding sedimentation, (ii) provide a large surface area for microorganisms and iii) alter the physico-chemical and chemical environment via the release of humic acids and through reducing DO exchange (acidity and lower oxygen increasing denitrification).

Numerous factors contribute to the choice of plant species for use in water quality processes. A primary consideration is to choose native plants that will thrive in the local environment. When the primary function of plants is to support denitrification, plants may be chosen for the quality of its litter. As an example, cattail litter is generally considered a better carbon source than bulrush litter.

Plants have been used effectively for pollution remediation on land for many years. Phytoremediation research has provided volumes of research documenting the ability of specific plant species to remove various chemical pollutants. BioHaven islands provide the platform to utilize this powerful tool in the aquatic environment.

Extensive root system

LIVING SHORELINE

Living shorelines are intended to protect property by preventing erosion and/or reclaiming land frontage, providing habitat, encouraging recreation, enhancing natural beauty and reducing restoration costs. FTWs that are properly shaped and positioned meet all these objectives while avoiding some problems associated with traditional alternatives. Traditional designs using bulkheads and rock require heavy equipment and can cause significant destruction during

installation, while BioHavens are lightweight and can be positioned by hand. Bulkheads serve only as a protection barrier for living shoreline components; BioHavens provide both the desired barrier and wave dampening, while simultaneously providing a soft area for plants and wildlife habitat. Wave energy is readily damped, as waves do not rebound off BioHavens but are absorbed into the "soft" material.

BioHavens being installed at Bayou Sauvage National Wildlife Refuge near New Orleans to protect an eroding shoreline by allowing sediments to accumulate and by providing new vegetation. August 2009

Shoreline islands 20 months after installation

The US State Department recognized BioHaven® Floating Islands as a Top 6 Innovative Water Technology at a March 21, 2014 Washington, DC celebration of World Water Day. The game-changing water technologies, developed by Americans, selected by an independent panel of experts, and presented at the Department of State included pioneering approaches to water treatment, purification, pumping, monitoring, testing, energy and nutrient recovery, and water plant design. Our Floating Island technology was included among the Top Six technology providers.

BioHaven projects have been completed in collaboration with the US Army Corps of Engineers, U.S. Geological Survey, Natural Resources Conservation Service, U.S. Forest Service, Government of Singapore, New Zealand's National Institute of Water and Atmospheric Research, and many others with thousands of
islands launched worldwide.

Islands in New Zealand spell out the name of the city

Islands in China