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Using Floating Wetland Islands to Reduce Nutrient Concentrations in Lake Ecosystems

In lake-front communities, the implementation of beneficial wetland systems can be limited by a lack of space. Floating Wetland Islands offer an innovative solution to space limitations and provide many of the same benefits as traditional wetlands. They are mobile, temporary wetlands that can be strategically placed to maximize their nutrient-reducing and habitat-building capabilities.

By Fred S. Lubnow

Wetlands are extremely valuable water resources. They provide refuge and spawning habitat for a variety of organisms, including many desirable gamefish, serve to filter out pollutants such the nutrients nitrogen and phosphorus that would otherwise enter a lake or pond, stabilize and filter out sediments, recharge aquifers, contribute toward the reduction of large hydrologic loads associated with storm events, and provide a variety of recreational and aesthetic amenities.[1]

Given the high ecological and water quality value associated with wetlands, the use of wetlands for stormwater treatment and management is well-recognized by New Jersey Department of Environmental Protection (NJDEP). In fact, the chapter on the design and installation of standard constructed wetlands in New Jersey's Best Management Practices (BMPs) Manual was recently updated and expanded.[2]

Unfortunately, the amount of land and space available for the design and installation of wetland BMPs is not typically available for lake communities. An alternative to wetland BMPs for eutrophic (highly productive) lakes and ponds with limited watershed space is the installation of Floating Wetland Islands (FWIs). As will be described in detail below, FWIs can serve as an effective means of assimilating nutrients, such as nitrogen and phosphorus, that otherwise would fuel the growth of nuisance algae and certain aquatic plants.

A variety of factors can impact the water quality of a lake or pond. Factors include prevailing climatic conditions, general hydrology and watershed characteristics that dictate pollutant loading, internal loading of nutrients, and the composition of the lake's biological community. For most freshwater ecosystems, the blue-green algae, also known as cyanobacteria, are one of the major issues associated with undesirable water quality conditions. These organisms create nuisance surface scums and blooms; create unpleasant tastes and odors through the production of compounds such as geosmin and 2-methylisoborneol (also known as MIB); are not a preferred source of food for the aquatic food web; and produce cyanotoxins. Thus, these nuisance algae negatively impact both recreational lakes as well as potable sources of drinking water.

Blue-green algae are extremely effective at thriving in freshwater ecosystems. Gas vacuoles regulate their buoyancy so they can take advantage of high nutrient concentrations in deeper waters and move to the surface to out-compete other algae for light.[3] Their large colonial growth and production of cyanotoxins dissuades grazing by herbivorous zooplankton (micro-animals that live in the open waters of lakes and ponds). In addition, some genera can produce their own nitrogen by fixing atmospheric nitrogen through the use of specialized cells called heterocysts, which means they are not dependent on inorganic sources of nitrogen like other algal groups. However, to fix nitrogen requires a large amount of energy, which also requires high phosphorus concentrations in the water. This is why blue-green algae concentrations tend to increase as phosphorus concentrations increase, which also tend to increase with more agriculture and development within a lake's watershed.

Additionally, blue-green algae prefer and thrive in higher water temperatures and water bodies that experience lower flushing rates, resulting in more blue-green algae blooms during the hot, dry summer months. The increase in the frequency and magnitude of such blooms can also be at least partially attributed to climate change. However, of all of the ecosystem factors that contribute toward nuisance algal blooms, the one that we can have the most direct control over is nutrient loading.

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For freshwater ecosystems, phosphorus tends to be the primary limiting nutrient. In fact, one pound of phosphorus has the potential to generate up to 1,100 lbs of wet algal biomass—that "green cotton candy" one sees in lakes and ponds. Reducing the phosphorus load entering into a lake or pond will have a direct improvement in water quality. It can reduce the amount of total algal biomass as well as favor more desirable, non-blue-green algae, such as green algae and diatoms. External watershed-based sources of phosphorus can be controlled through a variety of techniques: stormwater management; agricultural best management practices; shoreline or streambank stabilization; septic management; point source management; and behavioral management techniques (e.g., goose management, picking up pet waste, and the use of non-phosphorus fertilizers).[4]

Many stormwater management techniques incorporate the use of wetland plants or wetland systems for their capacity to assimilate nutrients and filter out particulate material.[5] A large portion of the phosphorus in stormwater and runoff is adsorbed onto sediment particles. Unfortunately, for many lake communities throughout the Mid-Atlantic states there is very little nearshore property available for the installation of large wetland treatment systems. Nearshore property tends to already be occupied by cottages and homes. Additionally, the stormwater infrastructure of such lake-side communities tends to be minimal, so the installation of any stormwater treatment systems to reduce the phosphorus load entering a lake is difficult and expensive. However, one innovative means of addressing watershed-based phosphorus loading is through the installation of FWIs.

FWI are structures composed of woven, recycled, plastic material (Figure 1). Vegetation is planted directly in the plastic material of the FWI with some peat and mulch (Figure 2), and then launched into a water body (Figure 3). Once in position, the FWI is secured in place with a set of lines and anchors. The vegetation grows on the FWI, with their roots growing through the plastic material, creating excellent habitat for a variety of microorganisms. This is achieved primarily through the creation of a large amount of surface area that harbors a large amount of diverse microbial growth. It is estimated that a 250 ft² FWI has the surface area equal to approximately one acre of natural wetland.[6]

Once installed and in position, the FWI serves as a sink for nutrients, in particular phosphorus. The diverse microbial communities in and underneath the FWI assimilate phosphorus where it is then sequestered into living biomass. Some of this biomass is the vegetation

Figure 1: Construction of a FWI. Photo Credit: Fred S. Lubnow

Figure 2: Completed planting of one of the islands. Photo Credit: Fred S. Lubnow

Figure 3: Deployment of one of the islands. Photo Credit: Fred S. Lubnow

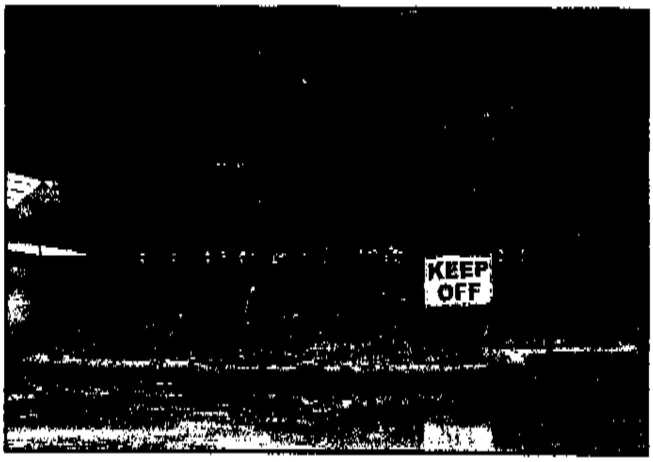

Figure 4: Installed Floating Wetland Island in 2010. Photo Credit: John Gigliotti

Figure 5: Installed Floating Wetland Island in 2012. Photo Credit: Fred S. Lubnow

Figure 6: Installed Floating Wetland Island in 2014. Photo Credit: Fred S. Lubnow

growing on the FWI; some is in other microbial organisms or larger organisms that may exist on the FWI (i.e., macroinvertebrates). A portion of this phosphorus may eventually be incorporated into larger organisms, such as in fish or birds, which can then move away from the FWI.

A number of studies have estimated that the amount of phosphorus removed through the use of one 250 ft^2 FWI is approximately 10 lbs of total phosphorus per year.[7] Since one lb of phosphorus has the potential to generate up to 1,100 lbs of wet algae biomass, this also means that one 250 ft^2 FWI has the potential to prevent the growth of up to 11,000 lbs of wet algae biomass. Essentially, the FWIs divert phosphorus that would otherwise be used to stimulate nuisance algal growth into the more desirable native wetland vegetation on top of the island.

Diverting some of the incoming phosphorus load into the FWI, and associated biomass, also reduces the amount of phosphorus available for nuisance growth, particularly phytoplankton, filamentous mat algae, and free-floating plants such as duckweed. In addition to being a sink for nutrients, FWIs provide excellent refuge habitat for small invertebrates, which in turn attracts desirable organisms such as forage and gamefish. FWIs can be planted with attractive, native vegetation creating an aesthetic amenity for the lake. They also provide habitat for desirable waterfowl and contribute toward shoreline protection. However, while these additional ecosystem functions can certainly be beneficial, nutrient assimilation tends to be the primary value for FWIs.

Typically only native and robust vegetation is planted on the FWIs; however, whenever possible, species that produce attractive flowers are used. Some of the species that are typically planted on the FWIs, at least in lakes throughout the Mid-Atlantic states, include sweet-scented Joe Pye weed (*Eutrochium purpurem*), swamp rosemallow (*Hibiscus moscheutos*), soft rush (*Juncus effuses*), great blue lobelia (*Lobelia siphilitica*), greenheaded coneflower (*Rudbeckia laciniata*), broadleaf arrowhead (*Sagattaria latifolia*), New England aster (*Symphyotrichum novae-angliae*), New York ironweed (*Vernonia noveboracensis*), common milkweed (*Asclepias syriaca*), and butterfly weed (*Asclepias tuberosa*). Species of milkweed are frequently planted on the FWIs since they produce attractive flowers that attract Monarch butterflies. Additionally, over time, we have seen other desirable species, such as ferns and mosses, inoculate and grow on the FWIs. Occasionally, undesirable species such as reed canary grass will be seen on the FWIs, but if such species are removed as soon as they are observed, they do not pose a major threat of taking over the island.

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In order to demonstrate the development of FWIs over time, a series of figures are provided of FWIs installed in a set of lakes in a private community located in Wayne County, Pa. Figure 4 shows a FWI initially installed in 2010, while Figures 5 and 6 show the FWI in 2012 and 2014. As long as they are properly installed, the FWI can provide an effective means of removing nutrients from the water column. The FWIs can remain in the lake over the winter months since the plastic material insulates the plant roots from freezing.

Once installed, the overall maintenance of the FWIs tends to be relatively low. After the vegetation is planted, it should be allowed to grow with no harvesting of biomass for at least two to three growing seasons. This allows the vegetation to become well-integrated into the island material and to grow high enough to dissuade Canada geese from feeding on the plants and/or using the FWI for nesting. In addition, goose netting should be installed over the vegetation during the first one to two growing seasons to prevent geese from feeding on the plants.[8] Eventually, after a few years, vegetation should be harvested to stimulate additional growth and remove sequestered nutrients; however, harvesting should only focus on plant biomass above the island material. The root complex should remain intact in order to preserve the microbial habitat. Thus, only biomass above the root system should be periodically harvested. Additional goose netting may be required after the vegetation has been harvested to protect the secondary growth.

> "Natural wetlands provide additional valuable ecosystem-based services that FWIs do not, such as mitigation of stormwater volume through evapotranspiration and infiltration and habitat for other more-terrestrial organisms."

There are some limitations associated with FWIs. Currently, the lifespan of an FWI is estimated to be approximately 15 years.[9] However, it should be noted that after long-term monitoring of the original FWIs installed in Montana lakes, this estimation was extended from 10 to 15 years. Also, relative to phosphorus uptake, the islands tend to be most cost-effective for lakes that have water column total phosphorus concentrations at or greater than 0.1 mg/L. In addition, we tend to position them near the shoreline, within the no wake zone to avoid boat traffic. Whenever possible, the FWIs are placed adjacent to or in front of stormwater pipes, swales, or inlets to intercept nutrient-rich stormwater. Finally, it needs to be emphasized the FWIs do not replace the need for wetlands in our watershed. Natural wetlands provide additional valuable ecosystem-based services that FWIs do not, such as mitigation of stormwater volume through evapotranspiration and infiltration and habitat for other more-terrestrial organisms.

In conclusion, FWIs are an effective alternative to large, watershed-based BMPs that may not be feasible due to limitations in space or other environmental factors. FWIs can function as net sinks of nutrients, particularly phosphorus, but tend to be more effective when water column total phosphorus concentrations are greater than 0.1 mg/L. In addition to nutrient uptake, FWIs can also create habitat for desirable organisms such as forage and gamefish, as well as increase both biodiversity and the general aesthetics of a lake ecosystem. ■

Endnotes

1 William J. Mitsch & James G. Gosselink, Wetlands (4th ed. 2007).

2 New Jersey Department of Environmental Protection Division of Watershed Management, New Jersey Stormwater Best Management Practices Manual (revised Sept. 2014), *available at* http://www.nj.gov/dep/stormwater/bmp_manual2.htm.

3 Alexander J. Horne & Charles R. Goldman, Limnology (2d ed. 1994).

4 G. Dennis Cooke et al., Restoration and Management of Lakes and Reservoirs (3d ed. 2005).

5 *Id.* at 2.

6 *Floating Treatment Wetland Technology: Nutrient Removal From Wastewater*, Floating Islands International Inc. (2011), *available at* http://www.floatingislandinternational.com/wp-content/plugins/fii/research/18.pdf.

7 *Id.* at 5.

8 Fred S. Lubnow, *Westtown Lake: Floating Wetland Islands*, 32 Lakeline 31 (2012).

9 *Id.* at 5.