MARTIN ecosystems

BioHaven Floating Technology

***Stormwater Research Compilation***

# Journal Articles

## 37. Assessment of Floating Treatment Wetlands for Remediation of Eutrophic Lake Waters-Maero Stream

**Type:** NIWA Client Report
**Author:** Sukias, J.P.S., Yates, C.R., and Tanner, C.
**Publication: NIWA Project Environment BOP**
**Date:** 2010

***Abstract:***
*Floating treatment wetlands (FTWs) have been identified as a potential alternative to conventional land-based wetlands. Because FTWs are buoyant, they have the advantage that they can be deployed in deeper water such as lakes, and are not affected by changes in water level. Although they incorporate similar nutrient attenuation mechanisms to those found in conventional natural and construct wetlands, little quantitate data exits regarding available on their treatment performance. A mesocosm trial was therefore under naked to provide information on the efficacy of FTWs to reduce nutrients from stream inflows to Lake Rotoehu. Mean total nitrogen (TN) removal rates of 157 and 239 mg m-2 d-1 (77% and 45% removal) were recorded in the low and high inflow FTW tanks respectively. Mean total phosphorus (TP) removal rates of 2.3 and 5.4 mg m-2 d-1 were recorded in the low and high inflow FTW tanks, corresponding to 35% and 32% removal. These data indicate their performance appears to be similar or greater than what would be expected for conventional surface-flow systems receiving similar loading rates.*

---

## 36. Treating Runoff in the construction and Operational Phases of a Greenfield Development using Floating Wetland Treatment Systems

**Type:** Conference Article
**Author:**Walker, C., Lucke, T. , Boogaard, F. , Schwammberger, P.
**Publication: Novatech 2016**
**Date:** 2016

***Abstract:***
*Floating wetland treatment systems (FWTS) are an innovative stormwater treatment technology currently being trialed on a larger scale in Australia. FWTS provide support for selected plant species to remove pollutants from stormwater discharged into a water body. The plant roots provide large surface areas for biofilm growth, which serves to trap suspended particles and enable the biological uptake of nutrients by the plants. As FWTS can be installed at the start of the construction phase, they can start treating construction runoff almost immediately. FWTS therefore have the potential to provide the full range of stormwater treatment (e.g. sediment and nutrient removal) from the construction phase onwards. A 2,100m2 FWTS has been installed within a greenfield development site on the Sunshine Coast, Queensland. A four-year research study is currently underway which will target the following three objectives; (1) characterise the water quality of runoff from a greenfield development in the construction and operational*

*phases; (2) verify the stormwater pollution removal performance of a FWTS during the construction and operational phases of a greenfield development; and (3) characterise the ability of FWTS to manage urban lake health. This extended abstract presents the proposed research methodology and anticipated outcomes of the study.*

## 35. Treating Runoff in the construction and Operational Phases of a Greenfield Development using Floating Wetland Treatment Systems

**Type:** Conference Article
**Author:**Walker, C., Lucke, T. , Boogaard, F. , Schwammberger, P.
**Publication: Novatech 2016**
**Date:** 2016

***Abstract:***
*Floating wetland treatment systems (FWTS) are an innovative stormwater treatment technology currently being trialed on a larger scale in Australia. FWTS provide support for selected plant species to remove pollutants from stormwater discharged into a water body. The plant roots provide large surface areas for biofilm growth, which serves to trap suspended particles and enable the biological uptake of nutrients by the plants. As FWTS can be installed at the start of the construction phase, they can start treating construction runoff almost immediately. FWTS therefore have the potential to provide the full range of stormwater treatment (e.g. sediment and nutrient removal) from the construction phase onwards. A 2,100m2 FWTS has been installed within a greenfield development site on the Sunshine Coast, Queensland. A four-year research study is currently underway which will target the following three objectives; (1) characterise the water quality of runoff from a greenfield development in the construction and operational phases; (2) verify the stormwater pollution removal performance of a FWTS during the construction and operational phases of a greenfield development; and (3) characterise the ability of FWTS to manage urban lake health. This extended abstract presents the proposed research methodology and anticipated outcomes of the study.*

## 34. Floating Vegetated Island Retrofit to Treat Stormwater Runoff

**Type:** Journal Article
**Author:**Borne, K. And Fassman, E.
**Publication:** Water New Zealnad 7th South Pacific Stormwater Conference
**Date:** 2011

**Notes:**
This peer−reviewed article covers a study of BioHaven® Floating Treatment Wetlands treatment of urban stormwater.

***Abstract:***
*A novel approach to improve retention basin water quality performance is retrofit with a floating vegetated island (FVI) to introduce wetland-like vegetation. Limited studies have identified the capability of pollutant removal of FVI but none have dealt with treatment efficiency at a full scale specifically for stormwater.*

*This paper presents the expected different pollutant removal pathways induced by a FVI as well as the monitoring methodology used to assess the overall efficiency of a retention pond with a FVI compared to an unvegetated one. Sampling and analysis methodologies to quantify the magnitude of each pollutant removal pathway are explained and a preliminary analysis of plant roots from a well established FVI is presented. The results show that the roots hanging in the water below the FVI can host microorganisms. Furthermore they become covered by deposits (clay and iron plaques) which have sorption capacity for elements like sulphur and zinc. Preliminary analysis confirms that roots surfaces below the FVI can act as a sink for pollutants.*

---

## 33. Performance Evaluation of a Floating Treatment Wetland in an Urban Catchment

**Type:** Journal Article
**Author:**Nichols P, Lucke T, Drapper D, Walker C
**Publication:** Water
**Volume:** 8
**Pages:** 244
**Date:** 2016

**Notes:**
This peer−reviewed article covers a study of BioHaven® Floating Treatment Wetlands treatment of urban stormwater.

***Abstract:***
*Floating Treatment Wetlands (FTW) were tested for a 12-month period to study the pollution removal performance in a 7.46ha urban residential stormwater runoff catchment. Overall pollution removal performance was calculated to be 80% for Total Suspended Solids (TSS), 53% for Total Phosphorous (TP) and 17% for Total Nitrogen (TN) for a FTW footprint of 0.14% of the contributing catchment. TSS and TP concentrations were found to be significantly reduced after FTW treatment. The minimum FTW footprint to catchment size ratio required to achieve regulated nutrient removal rate was calculated to be 0.37%. Sum of loads calculations based on flow resulted in pollution load reductions of TSS 76%, TP 55%, and TN 17%. Pollution treatment performance (particularly for TN) was found to be affected by low influent concentrations, and highly-variable inflow concentrations. The study demonstrated that FTWs are an effective treatment solution for the removal of pollution from urban stormwater runoff.*

---

## 32. Floating Wetland Islands as a Method of Nitrogen Mass Reduction: Results of a 1 year Test

**Type:** Journal Article
**Author:** Vazquex-Burney R, Bays J, Messer R, Harris J

**Publication:** Water Science Technology
**Volume:** 72(5)
**Pages:** 704-710
**Date:** 2015

**Notes:**
This peer−reviewed article covers a study of BioHaven® Floating Treatment Wetlands Nitrogen reduction is a reclaimed water storage reservoir.

***Abstract:***
*Floating wetland islands (FWIs) were tested in Pasco County, Florida, as a method of reducing total nitrogen (TN) in reclaimed water during reservoir storage. The Pasco County Master Reuse System (PCMRS) is a regional reclaimed-water transmission and distribution system providing wastewater effluent disposal for the county. Total daily mass loading from reclaimed water is limited by nitrogen content in the PCMRS watershed. To test TN reduction efficacy, 20 FWIs were constructed, installed, and monitored in a lined pond receiving PCMRS reclaimed water. In total, 149 m2 of FWIs were installed, distributed as a connected network covering 1,122 m2, or 7% of pond area. Pond hydraulic residence time averaged 15.7 days. Treatment performance was assessed during three consecutive periods: establishment (first 6 months of grow-in), performance (8 months immediately following grow-in), and control (3 months after the FWIs were removed from the pond). The FWIs enhanced pond nitrogen removal capacity by 32%. The primary effect of the FWIs was to decrease organic nitrogen in the pond outflow. By evaluating the difference between the performance and control periods, an incremental TN removal rate for the FWIs was calculated to be 4.2 kg N/m2 FWI per year.*

---

## 31. Exploring Hydrobiogeochemical Processes of Floating Treatment Wetlands in a Subtropical Stormwater Wet Detention Pond

**Type:** Journal Article
**Author:** Chang, N.B, Z. Xuan. Z Marimon, K. Islam, P. Wanielista
**Publication:** Ecological Engineering
**Volume:** 54
**Pages:** 66−76
**Date:** 2013

**Notes:**
This peer−reviewed article covers a study of BioHaven® Floating Islands and Beemat products that was reported in a previous University of Central Florida report.

***Abstract:***
*Floating treatment wetland (FTW) is one of the emerging best management practices (BMPs) for stormwater treatment where macrophytes provide a suitable root zone environment for*

*microorganisms that allow the plants to remove nutrients through direct uptake into their tissue. In this study, four floating mats with native Florida aquatic macrophytes were deployed in a 340 m2 subtropical stormwater wet detention pond. A fountain in the pond and peat moss used to hold the substrate for plant species on the floating mats are both assumed to add nutrients to the water column. The aim of this study was to evaluate the performance of nutrient removal through the four floating mats and explore associated effects of simultaneous hydrological and biological controls related to various hydrobiogeochemical processes for nutrient removal in a multimedia pond environment. Nutrient concentrations in both inlet and outlet were monitored continuously over 13 months, with episodic (storm events) and routine (non-storm events) sampling plans carried out in parallel to justify the efficacy of the FTWs. Nutrient values within the water column and the sediment were compared before (Phase I) and after (Phase II) the deployment of the FTWs to prove the proposed hypotheses. An additional phase (Phase III) after the removal of the FTWs was added to enhance the understanding of ecosystem response. For non storm events, phosphorus removal was substantial because of the increase in the initial concentrations, presumably due to resuspension of nutrients into the water column from the fountain operation; about 47.7% total phosphorus (TP) and 79.0% orthophosphate (OP) were removed. The removal rates of total nitrogen (TN), nitrite– and nitrate–nitrogen (NOx–N =NO− 2–N + NO− 3–N), and ammonia–nitrogen (NH3–N) were also calculated as 15.7, 20.6, and 51.1%, respectively. Without the uptake by plants, the nutrient removal decreased to different degrees when comparing those in non storm events during Phase II. Considering plant species, nutrient uptake and assimilation by soft rush (Juncus effusus) was much higher than that by pickerelweed (Pontederia cordata) through both leaves and roots in this case. For soft rush, uptake rate in spring is much higher than that in fall. About 77.0 g N and 8.8 g P were removed from pond water via uptake and assimilation during the second phase. Despite organic nitrogen accumulation due to the pickerelweed leaf debris sedimentation, the organic nitrogen concentration in pond water was still kept at a low level, which implies that the ecosystem is capable of efficiently managing the withered plants and circulating nutrients.*

---

## 30. Floating Treatment Wetland Retrofit to Improve Stormwater Pond Performance for Suspended Solids, Copper and Zinc

**Type:** Journal Article
**Author:** Borne, Karine E., E.A. Fassman, C.C. Tanner
**Publication:** Ecological Engineering
**Volume:** 54
**Pages:** 173−182
**Date:** 2013

**Notes:**
This peer−reviewed article summarizes a sophisticated stormwater study that utilized automatic samplers, remote flow measurement sensors, complex math analyses, etc. The study shows that, when plant roots are long enough to reach near the bottom of a pond and water is flowing

through the pond, results are good. There was a plant die−off observed at the end of summer, which produced toxic conditions beneath the mat. This was attributed to severe deoxygenation, which would have affected biofilm performance as well. FTW coverage of the pond was 50%. This was a controlled study with two parallel ponds. The pond with FTW had 41% better removal for TSS than the control pond, 40% for particulate ZN, and 39% for particulate copper.

***Abstract:***
*A field trial study with side by side monitoring of two parallel stormwater treatment ponds, one of which contained a floating treatment wetland (FTW), has been carried out to assess the benefit of retrofitting a conventional retention pond with a FTW. Inflow and outflow event mean concentrations (EMCs) were quantified and used to assess the overall pollutant removal efficiency of each system. Findings show that a FTW can significantly improve the runoff water quality and thus reduce the impact on the receiving environment. The present study reveals that a pond retrofit with a FTW would be more efficient than a conventional retention pond, exhibiting a 41% (for total suspended solids – TSS), 40% (for particulate zinc – PZn), 39% (for particulate copper – PCu) and 16% (for dissolved copper – DCu) lower effluent EMC. Physical entrapment of the particulate pollutants into the roots' biofilm seems be a significant removal pathway, which could be impacted by the inflow volume. Due to higher humic content, lower dissolved oxygen and more neutral water column pH induced by the FTW, there was increased potential for adsorption processes and/or precipitation a insoluble copper sulphides, in addition to the direct Cu uptake by the plants. The dissolved zinc (DZn) inlet EMCs, which already met the Australian and New Zealand Environment Conservation Council (ANZECC) water quality guidelines and could correspond to an irreducible concentration of the system, were too low to differentiate the performance of either pond.*

---

## 29. Evaluation of Floating Treatment Wetlands as Retrofits to Existing Stormwater Retention Ponds

**Type:** Journal Article
**Author:** Winston, R.J., W.F. Hunt, S.G. Kennedy, L.S. Merriman, J. Chandler, D. Brown
**Publication:** Ecological Engineering
**Volume:** 54 (2013)
**Pages:** 254−265
**Date:** March 2013

**Notes:**
This peer−reviewed article covers the study previously reported by William Hunt, et al.

***Abstract:***
*Thousands of existing wet retention ponds have been built across the United States, primarily for the mitigation of peak flow and removal of sediment. These systems struggle to mitigate soluble nutrient loads from urban watersheds. A simple retrofit for improvement of pond performance for*

*nitrogen and phosphorus removal could become popular. Floating treatment wetlands (FTWs), one such retrofit, are a hydroponic system that provides a growing medium for hydrophytic vegetation, which obtain nutrients from the stormwater pond. Installation of FTWs does not require earth moving, eliminates the need for additional land to be dedicated to treatment, and does not detract from the required storage volume for wet ponds (because they float). To test whether FTWs reduce nutrients and sediment, two ponds in Durham, NC, were monitored pre and postFTW installation. At least 16 events were collected from each pond during both monitoring periods. The distinguishing characteristic between the two ponds post retrofit was the fraction of pond surface covered by FTWs; the DOT pond and Museum ponds had 9% and 18%, respectively, of their surface area covered by FTWs. A very small fraction of N and P was taken up by wetland plants, with less than 2% and 0.2%, respectively, of plant biomass as N and P. Temperature measurements at three depths below FTWs and at the same depths in open water showed no significant difference in mean daily temperatures, suggesting little shading benefit from FTWs. The two ponds produced effluent temperatures that exceeded trout health thresholds. Both the pre and postFTW retrofit ponds performed well from a pollutant removal perspective. One pond had extremely low total nitrogen (TN) effluent concentrations (0.41 mg/L and 0.43 mg/L) during both pre and postFTW retrofit periods, respectively. Floating treatment wetlands tended to improve pollutant capture within both ponds, but not always significantly. Mean effluent concentrations of TN were reduced at the DOT pond from 1.05 mg/L to 0.61 mg/L from pre to post retrofit. Mean total phosphorus (TP) effluent concentrations were reduced at both wet ponds from pre to post retrofit [0.17 mg/L= to 0.12 mg/L (DOT pond) and 0.11 mg/L to 0.05 mg/L (Museum pond)]. The post retrofit effluent concentrations were similar to those observed for bioretention cells and constructed stormwater wetlands in North Carolina. The DOT pond showed no significant differences between pre and post retrofit effluent concentrations for all nine analytes. The Museum pond had a statistically significant improvement post retrofit (when compared to the pre retrofit period) for both TP and total suspended solids (TSS). Wetland plant root length was measured to be approximately 0.75 m, which had the benefit of stilling water flow, thereby increasing sedimentation. Results suggested that greater percent coverage of FTWs produced improved pollutant removal.*

---

## 28. Assessing Biological and Chemical Signatures related to Nutrient Removal by Floating Islands in Stormwater Mesocosms

**Type:** Journal Article
**Author:** Chang, N.B, Z Marimon, K. Islam, P. Wanielista
**Publication:** Chemosphere
**Volume:** 88
**Pages:** 736-743
**Date:** 2012

**Notes:**

Aquatic floating plants on BioHaven mats were tested for their potential use as a Best Management Practice to be incorporated within existing stormwater detention ponds. Plants were analyzed for their capability to remove nutrient-pollution in parallel with the study of ecological dynamics. Experiments were carried out in cylindrical mesocosms of 5 m diameter and 1.2 m height, above-ground pools with a water volume of 14 m(3). The design parameters tested were for 5% and 10% vegetated floating island coverage of the mesocosm, both with and without shoreline plants called littoral zone. This littoral shelf was 0.5 m thick, graded at a downward slope of 1:5 toward the center using loamy soil with low organic matter content, excavated from below turf grass. Endemic plant species were chosen for the experimental location in central Florida based on a wetland identification manual by the Florida Department of Environmental Protection to ensure the study was not compromised by unique climate requirements of the plants. Nutrient and aquatic chemical conditions such as pH, dissolved oxygen, temperature, turbidity, and chlorophyll a were monitored to understand their relationships to the general wetland ecosystem. Real-time polymerase chain reaction analysis identified the microbial activity near the rhizospheric zone. Logistical placement considerations were made using spatial sampling across the horizontal plane of the mesocosms, beneath and around the root zone, to determine if nutrients tend to aggregate around the floating island. This study concluded that the application of floating islands as a stormwater technology can remove nutrients through plant uptake and biological activity. The most cost-effective size in the outdoor mesocosms was 5% surface area coverage of the mat.

---

## 27. Constructed Wetlands with Floating Emergent Macrophytes: An Innovative Stormwater Treatment Technology

**Type:** Journal Article
**Author:** Headley, T.R. and C.C. Tanner
**Publication:** Critical Reviews in Environmental Science and Technology
**Volume:** 42
**Pages:** 2261−2310
**Date:** 2012

**Notes:**
This peer reviewed article describes various uses for FTWs (stormwater, sewage, acid mine drainage, animal waste, eutrophic lakes, and water supply reservoirs) and focuses on stormwater. Numerous macrophyte species are described. Nutrient removal data for numerous studies and numerous parameters are compiled. This paper provides an excellent summary of research methods and results conducted by major researchers in the field of FTWs.

***Abstract:***
*The treatment of urban stormwater poses numerous technical and operational challenges, particularly due to the intermittent and highly variable nature of hydrologic and pollutant inputs. Floating emergent macrophyte treatment wetlands (FTWs) are a hybridization of ponds and*

*wetlands that offer potential advantages for treatment of these highly variable flows. FTWs utilize rooted, emergent macrophytes growing on a mat or raft floating on the surface of the water rather than rooted in the sediments. Thus, they can tolerate the widely fluctuating water depths typical of stormwater systems, without the risk of the plants drowning. The roots hang beneath the floating mat and provide a large surface area for biofilm attachment. The authors provide a review of the FTW concept, structure, function, and treatment efficiency reported to date and discuss the potential advantages of this emerging technology for stormwater applications. Although still limited, the available data from mesocosm and pilot studies on removal of key pollutants such as organic matter, suspended solids, nutrients, and metals shows that they can significantly enhance performance of pond systems, and provide similar or better performance than surface flow wetlands for a range of polluted waters. Further studies are needed to verify the apparent potential of FTWs treating stormwater at full scale.*

---

## 26. The Ability of Vegetated Floating Islands to Improve Water Quality in Natural and Constructed Wetlands, A Review

**Type:** Journal Article
**Author:** Masters, B.
**Publication:** Water Practice & Technology
**Volume:** Vol. 7 No. 1
**Pages:** N/A
**Date:** 2012

**Notes:**
This peer−reviewed article provides a detailed overview of the history and various mechanisms of FTWs for water quality improvement, and provides summaries of data obtained by FII in laboratory and field−scale tests. The report also lists suppliers of FTWs worldwide and has a comprehensive reference list of technical articles describing various aspects of FTWs.

***Abstract:***
*Constructed and natural wetlands are widely used to improve many water quality parameters. Vegetated floating islands (VFIs) placed on the surface of these wetlands significantly enhance the efficiency of natural processes that reduce nutrients, suspended solids, heavy metals and other pollutants. Pollutant reduction in VFIs, particularly nutrients such as nitrogen and phosphorous, occurs primarily through the actions of bacterial biofilms growing within the island matrix and on plant roots hanging below the islands. Direct uptake of nutrients by plants is minor, although plants are essential as they provide additional substrate for biofilm development while supplying oxygen and carbon for use by the bacteria. Nitrogen based nutrients are primarily removed from wetlands as nitrogen gas. Phosphorous is mostly deposited as organic rich sediment which accumulates within or beneath the floating islands. This material can become anoxic and return its contained phosphorous to the water column, making it biologically available for algal or bacterial blooms that degrade water quality. Physical removal*

*of this Prich material is an essential wetland management action. VFIs can remove phosphorous at up to 4.6 g/m2/day and ammonia at up to 8.1 g/m2/day with simultaneous denitrification of nitrate to nitrogen gas. VFIs can significantly increase the efficiency of pollutant removal from natural and constructed wetlands.*

---

## 25. The Taxonomy of Treatment Wetlands: A Proposed Classification and Nomenclature System

**Type:** Journal Article
**Author:** Headley, T.R. and N. Fonder
**Publication:** Journal of Environmental Engineering
**Volume:** (in press)
**Pages:** n/a
**Date:** 2011

**Notes:**
This peer−reviewed paper provides good descriptions and pictures of the various types of treatment wetlands.

***Abstract :***
*This paper proposes a structured foundation for classifying and naming different treatment wetland (TW) design alternatives, based on observable physical design traits. A classification hierarchy is organized like a polychotomous key, from general classification criteria to wetland type identification. Three characteristics are typical of all TW: the presence of macrophytic vegetation; the existence of waterlogged or saturated substrate conditions for at least part of the time; and inflow of contaminated water with constituents to be removed. Treatment Wetlands are further classified based on hydrology and vegetation characteristics. Hydrological traits relate to water position, flow direction, degree of saturation and position of influent loading. Based on the predominant position of water in the system, two main groups are identified: those with Surface Flow above a benthic substrate and those with Subsurface Flow through a porous media. The systems with surface flow are divided into three standard types, differentiated by vegetation type: Surface Flow (SF), FreeFloating Macrophyte (FFM), and Floating Emergent Macrophyte (FEM) TWs. Subsurface flow systems always contain sessile emergent macrophytes and are divided into four standard types, based on flow direction: Horizontal SubSurface Flow (HSSF), Vertical Flow (VF), Up Flow (UF) and Fill and Drain (FaD) TWs. Standard types are described with their main applications. Associated variants are identified. An overview of intensified variants, which have elevated energy, chemical or operational inputs in order to increase efficiency or overcome process limitations, is also provided.*

---

## 24. Components of Floating Emergent Macrophyte Wetlands Influencing Removal of Stormwater Pollutants

**Type:** Journal Article
**Author:** Tanner , C.C. and T.R. Headley
**Publication:** Ecological Engineering
**Volume:** 37
**Issue:** 3
**Pages:** 474−486
**Date:** 2011

**Notes:**
This peer−reviewed article describes the findings of tank−scale controlled experiments comparing FTWs planted with and without macrophytes for the removal of metals, phosphorus, and turbidity. The study examines the contribution of each of the major constituents of the FTWs.

***Abstract:***
*Floating treatment wetlands planted with emergent macrophytes (FTWs) provide an innovative option for treating urban storm waters. Emergent plants grow on a mat floating on the water surface, rather than rooted in the bottom sediments. They are therefore able to tolerate the wide fluctuations in water depths that are typical of stormwater ponds. To better understand the treatment capabilities of FTWs, a series of replicated (n = 3) mesocosm experiments (12Å~0.7m3 tanks using 0.36m2 floating mats) were conducted over seven day periods to examine the influence of constituent components of FTWs (floating mat, soil media, and four different emergent macrophyte species) for removal of copper, zinc, phosphorus and fine suspended solids (FSS) from synthetic stormwater. The presence of a planted floating mat significantly (P < 0.05) improved removal of copper (>6fold), fine suspended particles (#3fold reduction in turbidity) and dissolved reactive P (in the presence of FSS) compared to the control. Living plants provided a large submerged root surface area (4.6–9.3m2 of primary roots m− 2 mat) for biofilm development and played a key role in the removal of Cu, P and FSS. Uptake of Cu and P into plant tissues during the trials could only account for a small fraction of the additional removal found in the planted FTWs, and non planted floating mats with artificial roots providing similar surface area generally did not provide equivalent benefits. These responses suggest that release of bioactive compounds from the plant roots, or changes in physicochemical conditions in the water column and/or soils in the planted FTWs indirectly enhanced removal processes by modifying metal speciation (e.g. stimulating complexation or flocculation of dissolved fractions) and/or the sorption characteristics of biofilms. The removal of dissolved zinc was enhanced by the inclusion of a floating mat containing organic soil media, with reduced removal when vegetated with all except one of the test species. The results indicate that planted FTWs are capable of achieving dissolved Cu and Zn mass removal rates in the order of 5.6–7.7 mgm− 2 d− 1 and 25–104 mgm− 2 d− 1, respectively, which compare favorably to removal rates reported for conventional surface flow constructed wetlands treating urban storm waters. Although not directly measured in the present study, the removal of particulate bound metals is also likely to be high given that the FTWs removed approximately 34–42% of the turbidity associated with very fine suspended particulates within three days. This study illustrates the promise of FTWs for*

*stormwater treatment, and supports the need for larger scale, longer term studies to evaluate their sustainable treatment performance.*

---

## 23. Floating Treatment Wetlands for the Removal of Fine Particulates, Copper, and Zinc for Stormwater

**Type:** Conference Article
**Author:** Headley, T.R. and C.C. Tanner
**Publication:** 11th International Conference on Wetland Systems for Water Pollution Control (India)
**Volume:** Nov 1−7
**Pages:** 655-659
**Date:** November 2008

***Abstract:***
*Floating Treatment Wetlands (FTWs) provide an innovative option for treating urban stormwaters. They employ emergent plants growing on a mat flowing on the water surface, rather than rooted in the bottom sediments. Thus, they can tolerate the wide water depth fluctuation typical in stormwater systems, without the risk of the plants becoming inundated and stressed. The plant roots hang beneath the floating mat and provide a large surface area for biofilm growth and entrapment of fine suspended particulates. Because the plants are not rooted in the sediment, they are forced to acquire their nutrition directly form the water column, which may enhance rates of nutrient and element uptake into biomass. A series of batch-loaded mesocosm experiments (12 x0.7 m3 tanks using 0.36 m2 floating mats) wrier conducted to examine the effectiveness of FTWs for removal of copper, zinc and fine particulates from an artificial stormwater. The results indicate that the presence of a planted floating mat can substantially improve the removal of fine suspended particles and copper. The removal of dissolved zinc was also improved by the inclusion of a floating mat, although the effect of plants was less clear. These promising results support the need fro further studies to investigate longer-term treatment performance under field conditions.*

---

## 22. Floating Treatment Wetlands: An Innovative Option for Stormwater Quality Applications

**Type:** Conference Article
**Author:** Headley, T.R. and C.C. Tanner
**Publication:** 11th International Conference on Wetland Systems for Water Pollution Control (India)
**Volume:** Nov 1−7
**Pages:** 1101−1106
**Date:** 2008

**Notes:**

This peer−reviewed article is a short version of the 2012 report by Headley and Tanner (listed below). It describes various types of FTWs with macrophytes.

***Abstract:***
*Floating Treatment Wetlands (FTWs) are an innovative variant of the more traditional constructed wetland and pond technologies that offer great potential for treatment of urban storm waters. FTWs employ rooted, emergent macrophytes (similar to those used in surface and subsurface flow wetlands) growing on a mat floating on the surface of the water rather than rooted in the sediments. Thus, they can tolerate the wide water depth fluctuation typical in stormwater systems, without the risk of the plants becoming inundated and stressed. In many aspects, FTWs are a hybrid between a pond and a wetland; they behave hydraulically similar to a stormwater detention pond, whilst imparting similar treatment processes to that of a wetland. The plant roots hang beneath the floating mat and provide a large surface area for biofilm growth which forms an important part of the treatment reactor. This paper provides a review of the FTW concept, structure and function, and discusses some of the potential advantages of this emerging technology for stormwater applications.*

---

## 21. Evaluating the Effectiveness of two Stormwater Wetlands in North Carolina

**Type:** Journal Article
**Author:** Line, D.E., Jennings, G.D., Shaffer, M.B., Calabria, J., Hunt, W.F.
**Publication:** Transactions of the American Society of Agricultural and Biological Engineers
**Volume:** 51
**Pages:** 21-528
**Date:** 2008

**Notes:**
Two constructed stormwater wetlands in North Carolina were monitored to document their efficiencies at reducing nitrogen, phosphorus, and sediment loads in runoff from urban areas. Inflow to and outflow from the two wetlands were monitored during at least ten storm events, and flow-proportional samples of each were collected and analyzed. The first wetland (CMS), located in the Piedmont region, had a relatively low wetland surface to drainage area ratio of 2.2%, while the second (UNC), located in the mountains region, had less storage and a wetland surface to drainage area ratio of 4.7%. The UNC wetland had a much more diverse and extensive plant community. For the CMS wetland, the median load reduction efficiencies of nitrogen forms ranged from 47% to 54%, while the corresponding reductions for the UNC wetland ranged from 57% to 71%. The median reduction efficiencies for phosphorus forms for the CMS wetland ranged from 59% to 76%, while those for the UNC wetland ranged from -95% to 70%. The median reduction efficiencies for TSS were 72% and 88% for the CMS and UNC wetlands, respectively. The median load reduction efficiencies of nitrogen forms, total phosphorus, and sediment for the UNC wetland were greater than for the CMS wetland and were considerably

greater than corresponding median efficiencies of other completed studies. These results indicate that both of these wetlands were, in general, more efficient at reducing pollutant loading than many others reported in the literature. The greater efficiencies may be the result of a relatively high surface area to drainage area ratio and a diverse plant community in the UNC wetland and a considerable storage capacity of the CMS wetland.

# Published Reports

---

## 20. Recommendations of the Expert Panel to Define Removal Rates for Floating Treatment Wetlands in Existing Wet Ponds

**Type:** Final Report; Technology Review
**Author:** Lane S, Sample D, Lazur A, Winston R, Streb C, Ferrier D, Linker L, & Brittingham K
**Presentation:** Chesapeake Stormwater Network and Chesapeake Research Consortium
**Pages:** 1-91
**Date:** June 6, 2016

**Notes:**
Floating treatment wetlands (FTWs) are rafts of wetland vegetation that are deployed in stormwater ponds with a permanent pool of water. The panel classified them as a variant of the BMP enhancement retrofit category, as defined by the retrofit expert panel. FTW retrofits can be installed on existing wet ponds with a contributing drainage area of 400 acres or less. The panel also defined general performance criteria for FTW retrofits that need to be met to earn credit.
The panel reviewed FTW research which included field monitoring studies, mesocosm studies, and engineering models.

---

## 19. Floating Wetland Islands as a Method of Nitrogen Mass Reduction: Results of 1-Year Test

**Type:** Conference Presentation
**Author:** Vazquez-Burney, R., Harris, J., Bays, J., Kenty, K., Messer, R.
**Presentation:** 14th IWA International Conference on Wetland Systems for Water Pollution Control; Shanghai, China
**Pages:** 1-10
**Date:** October 12-16, 2014

**Notes:**
This manuscript details the methods, data analysis, and results of a performance assessment of floating wetland islands (FWIs) for nitrogen management of reclaimed waters in total maximum daily load (TMDL) limited watersheds. The purpose of this study was to explore if FWIs could passively provide total nitrogen (TN) reduction while reclaimed water is being stored in reclaimed water reservoirs before it is applied for irrigation in TMDL limited watersheds.

The Pasco County Master Reuse System (PCMRS) is a regional reclaimed water transmission and distribution system providing the sole wastewater effluent disposal mechanism for the Pasco County Utilities Services Branch partially within a TMDL-limited watershed. To approximate the efficacy of FWIs to reduce TN in the PCMRS, FWIs were constructed, operated, and monitored in a lined pond receiving reclaimed water from the PCMRS subject to FWI coverage. A total of 149 m2 of FWIs were installed, distributed as a connected network covering 1,122 m2, or 7 percent of pond area. Reclaimed water was applied at a rate designed to yield a reservoir residence time of approximately 25 days. A tracer study established that the average pond residence time was 15.7 days.

Water quality performance was assessed during three consecutive periods: establishment (first 6 months of grow-in), performance (8 months immediately following grow-in), and control (3 months after the FWIs were removed from the pond). The results indicate that FWIs installed in reclaimed water reservoirs enhanced pond nitrogen removal capacity by 32 percent by decreasing suspended algal growth and increasing denitrification. The primary effect of the FWIs was to decrease organic nitrogen in the pond outflow. By evaluating the difference between the performance and control periods, an incremental TN removal rate for the FWIs was calculated to be 4.2 kg N/m2 FWI per year.

---

## 18. Assessing the Performance of Floating Wetland Islands for Nitrogen Management of Reclaimed Water

**Type:** Abstract
**Author:** Vazquez-Burney, R., Harris, J., Bays, J., Kenty, K., Messer, R.
**Publication:** unpublished
**Pages:** n/a
**Date:** March 2014

**Notes:**
The Pasco County Master Reuse System (PCMRS), located in Florida, USA, is the sole method of wastewater effluent management for Pasco County. The PCMRS is a flexible system serving approximately 12,000 residential reclaimed water customers. As regulations evolve, Pasco County is committed to complete water reuse for beneficial purposes. The County's vision includes growth to over 25,000 residential reclaimed water customers. Consistent with the Total Maximum Daily Load (TMDL) for Tampa Bay, the PCMRS was given an allocation for total nitrogen (TN) to the Hillsborough Bay Drainage Basin (HBDB), which drains directly to Tampa Bay. This value is calculated based on an assumed TN attenuation rate for reclaimed water used for irrigation as it infiltrates through the soil and a representative concentration of TN in the PCMRS. To meet this allocation the County must lower TN concentrations in the reclaimed water applied in the HBDB. One strategy the County is pursuing is to passively use storage facilities to reduce TN. The County currently operates a 100 million gallon (MG) reclaimed

water reservoir and a 500 MG reservoir is currently under construction. As a possible storage system enhancement, floating wetland islands (FWI) were studied. Passive reduction of TN by FWI on reclaimed water reservoirs could allow for the increased use of reclaimed water within the HBDB. To assess the efficacy of FWI to reduce TN in reclaimed water reservoirs, an 18−month controlled study was conducted. The study consisted of the installation of a total of 1,600 square feet of FWI within a four−acre test cell receiving reclaimed water at rates designed to mimic reclaimed water reservoirs. Monitoring was conducted of the hydrology, weather, water quality, and plant tissue content, as well as a tracer study, to assess treatment potential, and sizing criteria. Removal efficiency for TN was measured to be approximately 63 percent during the performance period after the FWI were established. Average TN concentrations were reduced on average from 6.4 mg/L to 2.4 mg/L. The results were compared to a 3−month control period after the FWIs were removed from the test cell. By evaluating the difference between the two periods, the rate at which the FWIs removed TN from the test cell was calculated to be 0.9 pounds per square foot of island per year. The results revealed that during the performance period, TN treatment was consistent with rates measured in treatment wetlands, and that TN treatment was superior with the presence of FWIs. In addition to treatment performance, observations were drawn related to habitat creation, species succession, and nuisance species control. This presentation will summarize monitoring results, evaluated treatment performance, challenges in installation, and additional observations from the study. Information related to estimated removal rates, plant uptake versus microbial reduction and nitrogen species transformations will be presented.

---

## 17. Reducing the Impact of NPS Pollution through the Establishment of Floating Wetlands in Eucha Lake

**Type:** Unpublished Report
**Author:** Oklahoma Water Resource Board
**Publication:** EPA Grant CA# C9-00F313-01-Project 2
**Pages:** 1-81
**Date:** December 10, 2013

**Executive Summary:**
In 2010 the OWRB received special FY11 319(h) funding via the Office of the Secretary of Environment, from Region VI EPA for the project “Reducing the Impact of NPS Pollution through the Establishment of Floating Wetlands in Eucha Lake” with the intent to implement an innovative means to mitigate the impact of non-point source (NPS) pollution on a receiving water. The State of Oklahoma has designated the Oklahoma Conservation Commission (OCC) as the state's technical lead agency for the 319 Program. The City of Tulsa provided the bulk of the requisite 40% cost share while other state environmental agencies; OWRB, GRDA, ODWC and City of Oklahoma City also provided valuable cost share.

All outputs and outcomes for the project were accomplished:

- Output – All floating wetland units, 6,400 ft2, were installed in the upper end of Eucha Lake with the help and assistance of City of Tulsa employees and equipment, the Grand River Dam Authority (GRDA) aquatic plant nursery, and Oklahoma Department of Wildlife Conservation (ODWC) aquatic plant nursery.
- Habitat Outcome – Habitat provided by the floating wetlands were determined using Habitat Evaluation Procedures (HEP) models. Fish species reliant on cover for reproductive success derived the greatest benefit while all modeled species benefitted from additional food and cover. Flathead catfish, river otters, and great blue herons also benefitted.
- Water Quality Outcome 1 – Total phosphorus (TP) was determined to be reduced as a result of the floating wetlands. Removal measured via sedimentation traps and plant biomass was estimated at some 19.6 kg TP per year or 3.1 g TP per ft2 of wetland per year.
- Water Quality Outcome 2 – The estimated removal rate for the floating wetlands did not make a significant difference to water quality. Coverage would need to be increased one hundred times to yield a 4.5% reduction of the annual phosphorus load.

Although the phosphorus removal rate was low, these wetlands may provide a cost effective, multi-use solution for systems providing both public water supply and recreational opportunities to a community. Cost comparisons against alternative means of providing benefits highlight this conclusion (Table 1). The cost disparity between nutrient removals indicate preventing nutrient entry into a waterway is best, while floating wetlands in reservoir systems may be relegated to a secondary role. The unique capability of these wetlands to provide habitat for diverse biota under conditions of high water level fluctuation should be particularly appealing for communities strongly influenced by lake recreation.

---

## 16. Waterway Stewardship Through Floating Islands

**Type:** Unpublished Report for Distribution
**Author:** Reinsel, Mark, F. Stewart
**Publication:** Floating Island International, Inc
**Pages:** 1−10
**Date:** June 2012

**Notes:**
This 10−page report provides an overview of floating treatment wetlands (FTWs). The article covers biofilm basics, nutrient removal mechanisms, a comparison of nutrient removal efficacy by FTWs compared to other stormwater BMP methods, and fishery enhancement by FTWs. A bullet list summary of important facts from Azim's periphyton ecology textbook is provided. A short discussion of the Fish Fry Lake case study is also included.

---

## 15. Floating Wetland Systems for Nutrient Removal in Stormwater Ponds – FDOT Project BDK78 98501

**Type:** University Project with Florida DOT Supervision – Final Report
**Project Manager:** Rick Renna, P.E., State Hydraulics Engineer
**Author:** Wanielista, M.P.; NB Chang, M. Chopra, Z. Xuan, K. Islam, Z. Marimon
**Publication:** n/a
**Date:** September 2012

**Notes:**
This 182−page final report describes tank−scale and pond−scale experiments for BioHaven Floating Islands and Beemat products. The pond−scale experiments were affected by nutrient uptake by duckweed and algae in the controls. The study recommends giving a 12% credit for deploying FTWs in stormwater ponds. The report incorporates numerous photographs and numerical data.

---

## 14. Final Report: Evaluation of Floating Wetland Islands (FWIs) as a Retrofit to Existing Stormwater Detention Basins

**Type:** Final Report
**Author:** Hunt, W.F; R.J. Winston, S.G. Kennedy
**Publication:** North Carolina DENR Contract 1653
**Pages:** 1−71
**Date:** March 22, 2012

**Notes:**
This report describes research conducted on real−world stormwater ponds under controlled conditions by the University of North Carolina under a grant funded by the NC DENR. Measured parameters included TN, TP, and TSS. The data were statistically analyzed.

---

## 13. Veterans Park Water Quality Monitoring-Vegetated Island Study

**Type:** Report for Distribution
**Author:** Schoel Consulting Engineers
**Publication:** Not-published
**Date:** December 9, 2011

**Notes:**
The purpose of this study was to evaluate the effects of the vegetated island installed on the large lake in Veterans Park in Hoover, Alabama. A monitoring plan was developed to capture the water quality benefits of the vegetated island. This report presents a summary of the results and conclusions that can be drawn from the data. Although not conclusive, there are certain measurements which show signs of water quality improvements following the installation of the vegetated island. The results indicate that post-island measurements had a constant BOD reading a few days after the storm event when baseline conditions showed an increase in BOD between

Day 3 & Day 8. Additionally, the DO and oxygen saturation readings were increased on Day 8 post-island than in the baseline scenario at the pond outlet.

---

## 12. Floating Treatment Wetlands: A New Tool for Nutrient Management in Lakes and Waterways

**Type:** Report for Distribution
**Author:** Tanner, C., Sukias, J., Park, J., Yates, C., and Headley, T.
**Publication:** NIWA published Report
**Date:** 2011

**Abstract:**
Floating treatment wetlands (FTWs) employing emergent aquatic plants growing on a buoyant mat are an innovative new tool for nutrient management in ponds, lakes and slow flowing waters. Plant roots grow through the floating mat and into the water beneath, providing a large surface area for nutrient assimilation, growth of biofilms and entrapment of fine suspended particulates. By shading the surface and buffering water turbulence FTWs can also promote settling of suspended algae and solids beneath the mats. Microbial nutrient removal processes, such as nitrate conversion to N gases via denitrification, may also be stimulated through creation of localized anoxic zones beneath the mats. The ability of FTWs to be used on deep water bodies and to tolerate wide fluctuations in water depth, means they can be used to retrofit wetland treatment components into existing retention ponds, or used directly as nutrient management tools in ponds, lakes and waterways. Nutrient removal rates recorded in batch and flow-through mesocosm trials are reported. They appear to equal or exceed those reported under comparable conditions for conventional surface-flow wetlands.

---

## 11. A Plant Management Strategy for Maximizing Sustainable Nutrient Removal in Floating Islands

**Type:** Report for Distribution
**Author:** Bateman, M.
**Publication:** Not-published
**Date:** November 2010

**Notes:**
The subject of this white paper is the removal of nutrients via floating treatment wetlands, and in particular, the removal pathways and the fate of removed nutrients. There is a persistent notion that in order for floating treatment wetlands to be effective, the standing crop of biomass must be routinely harvested and removed. This is based in part, on the perception that the primary removal mechanism occurs by plant uptake of nutrients. In 2009, probably the definitive work on treatment wetlands was published by Robert Kadlec. The 30-year study of the Houghton Lake wetland is complete and comprehensive, providing a real-world example of how wetland

treatment systems function over-time. Interestingly, the wetland developed a "floating island" character on its own accord, thus presenting very good information on these types of systems.

## 10. Control of Microbial Processes for Enhanced Water Treatment Using Floating Island Treatment Systems

**Type:** Grant Final Report
**Author:** Cunningham, A.B., A. Camper, M. Burr and F.M. Stewart
**Publication:** Montana Board of Research and Commercialization Technology
**Date:** 2010

**Notes:**
The final report for the second Montana−based MBRCT grant. The report includes data from controlled laboratory−scale studies at the Center for Biofilm Engineering at Montana State University. The lab experiments compared organic carbon, ammonium and nitrate removal in simulated wastewater for various matrix types including PET and recycled carpet fibers. The experiments also compared various aeration cycling regimes to optimize for combined aerobic and anoxic bacterial removal. DNA analysis was performed on the bacterial biofilms to determine how the nitrifiers and denitrifiers were distributed within the matrix columns. The project also included field−scale components, which comprised a comparison of wind−electric and solar−electric−power for circulating and aerating outdoor islands. In addition, a 1300−sf island was installed in a wastewater lagoon in Billings, MT, and a controlled experiment was started that tracked removal of TN, TP, nitrate, ammonium, phosphate, and COD in an island lagoon and a control lagoon. Removal data are presented in the report. This report is available on the FII website.

## 9. Floating Vegetated Islands for Stormwater Treatment: Removal of Copper, Zinc and Fine Particulates

**Type: Report**
**Author:** Headley, T.R. and C.C. Tanner
**Publication:** NIWA Technical Report No. 030
**Source:** Auckland (NZ) Regional Council
**Pages:** 1−44
**Date:** Nov 2008

**Notes:**
The first part of this report is a study of suitable NZ native plant species suitable for use on FTWs. The second part of this report describes experiments that measured removal rates of copper, zinc, and fine particulates in 1 m3 test tanks run in triplicate. Numerical data of removal rates are presented in the report. The report provides a good description of a well−run experiment and contains photographs of the tanks, FTWs, plant tops and roots.

### 8. Application of Floating Wetlands for Enhanced Stormwater Treatment: A Review

**Type:** Report
**Author:** Headley, T.R. and C.C. Tanner
**Publication:** NIWA Client Report HAM2006−123
**Source:** Auckland (NZ) Regional Council
**Pages:** 1−100
**Date:** Nov 2006

**Notes:**
This report provides descriptions and photographs of a wide range of FTWs that were commercially available in 2006, including the FII products. It does not include experimental results that were obtained after 2006 (see the 2011 and 2012 papers for more recent data).

## Professional & Trade Magazines

### 7. A New Wetlands Technology for Wastewater Treatment

**Type:** Professional Magazine Article
**Author:** Reinsel, Mark
**Publication:** Pollution Engineering
**Pages:** 1-5
**Date:** June 2014

**Notes:**
Floating islands, also known as floating treatment wetlands (FTWs), are a relatively new technology for improving water quality and creating habitat. More than 5,400 floating islands have been installed around the world in the past decade. Island sizes range from small, decorative units to some that are larger than football fields and can be made in any shape or buoyancy. Islands have withstood numerous freeze/thaw cycles, as well as typhoons, tornadoes, hurricanes and major snowfalls.

Primary uses for FTWs include water quality improvement for lake water, wastewater or storm water; fishery enhancement; de-stratification or dissolved oxygen enhancement; and creation of waterfowl and riparian edge wildlife habitat. The typical duty of FTW technology is to rapidly cycle nutrients for 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. Removal rates have been developed in field-scale applications for contaminants such as ammonia, nitrate, phosphorus, metals, total suspended solids (TSS) and

biochemical oxygen demand (BOD). FTWs may have application at industrial sites for such contaminants.

---

## 6. Floating Treatment Wetlands Improve Stormwater Quality

**Type:** Professional Magazine Article
**Author:** Reinsel, Mark
**Publication:** Environmental Science and Engineering
**Volume:** Volume 26, No. 3 May/June 2013
**Pages:** 40–44
**Date:** 2013

**Notes:**
This article provides an overview of case studies in North Carolina and Montana, and provides removal rate and concentration data for eight common pollutants associated with stormwater.

---

## 5. Floating Wetlands Help Boost Nitrogen Removal in Lagoons

**Type:** Trade Magazine Article
**Author:** Reinsel, M.
**Publication:** WaterWorld
**Contract:** June
**Pages:** n/a
**Date:** 2012

**Notes:**
This article gives a short summary of removal of ammonia, nitrate, and some other nutrients at Rehberg Ranch (MT) , Wiconisco (PA) , McLean's Pit (NZ) and the MBRCT test ponds (MT).

http://www.waterworld.com/articles/print/volume-28/issue-6/editorial-features/floating-wetlands-help-boost--nitrogen-removalin-lagoons.html

---

## 4. Wesstown Lake: Floating Wetland Islands

**Type:** Trade Magazine Article
**Author:** Lubnow, F.
**Publication:** Lakeline
**Volume:** Spring
**Pages:** 31–35
**Date:** 2012

Notes:

This five−page article describes the phosphorus uptake mechanisms in FTWs (plants, microbes, filtration of particles, moving up the food chain). In a first pond experiment with FTWs, uptake of P and N were estimated by analyzing plant mass and nutrient concentration in the plants. In a second pond experiment (Mermaid Pool, New Jersey) Pup take was measured for a range of inflow values before and after FTW installation. Graphical results are presented for P uptake at the inlet and outlet of Mermaid Pool during 2011.

---

## 3. Floating Islands for Tertiary Nutrient Removal and Circulators for Primary & Secondary Treatment at an STP

Type: Trade Magazine Article
Author: Ambulkar, A., S. Zeller and D. Klinger
Publication: Everything About Water
Volume: May
Pages: 85−87
Date: 2012

**Notes:**
Photographs and descriptions of BioHaven FTWs at the Wiconisco site, with additional information related to Solar Bee circulators also deployed at the site.

---

## 2. Floating Treatment Wetlands Mitigate Lake Eutrophication

Type: Professional Magazine Article
Author: Reinsel, M.
Publication: Environmental Science & Engineering Magazine
Volume: May/June
Pages: 38−41
Date: 2012

Notes:
This article describes how dissolved oxygen and temperatures were improved for fish habitat at Fish Fry Lake, Shepherd, Montana, using a Leviathan system.

---

## 1. Floating Treatment Wetlands-An Innovative Solution to Enhance Removal of Fine Particulates, Copper and Zinc

Type: Professional Magazine Article
Author: Tanner, C., Headley T.
Publication: The NZWWA Journal/Stormwater

Pages: 27-31
Date: July 2008

Notes:
Reduction of metals, particularly copper and zinc, in urban stormwater has been identified as a priority to protect the health of aquatic ecosystems in the Auckland Region (Auckland Regional Council, 2004). Floating treatment wetlands (FTW), employing emergent plants growing on a mat floating on the water surface, rather than rooted in the bottom sediments, provide an innovative option for treating urban stormwaters.