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

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FINAL REPORT

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The following is a list of common acronyms used throughout the text:

BMP(s)	Best Management Practice(s)
C	Celsius
CBP or CBPO	Chesapeake Bay Program Office
CBWM	Chesapeake Bay Watershed Model
DO	Dissolved Oxygen
DW	Dry Weight
EMC	Event Mean Concentration
FTW	Floating Treatment Wetlands
HUC	Hydrologic Unit Code
IA	Impervious Acreage
i-FTW	First Order Reaction Coefficient Model
MAP	Managed Aquatic Plants
MS4	Municipal Separate Storm Sewer System
NEIEN	National Environmental Information Exchange Network
NPDES	National Pollutant Discharge Elimination System
ORP	Oxidation Reduction Potential
R	Rooting Depth Ratio
RE	Removal Efficiency
RR	Runoff Reduction
RS	Runoff Storage
Rv	Runoff Coefficient
SA	Surface Area
SOP	Standard Operating Procedure
ST	Stormwater Treatment
STAC	Scientific and Technical Advisory Committee
TMDL	Total Maximum Daily Load
TN or N	Total Nitrogen
TOC	Total Organic Carbon
TP or P	Total Phosphorus
TSS	Total Suspended Solids
USWG	Urban Stormwater Work Group
WIP	Watershed Implementation Plan
WQGIT	Water Quality Goal Implementation Team
WQv	Water Quality Volume

Summary of Panel Recommendations

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. In general, the three research areas were generally consistent and reinforced each other. Key findings included:

- FTWs have a modest capability to incrementally improve the sediment and nutrient removal performance of existing stormwater wet ponds.

- Much of the improved performance was due to improved settling conditions in the pond after the FTW retrofit, especially by the underwater root network. Some denitrification was also observed within the rafts. Nutrient uptake by the plants themselves, however, was found to be a significant pollutant removal mechanism. Pond removal rates also increased when more raft coverage was added.

- The panel developed a series of curves to estimate pollutant removal as a function of FTW raft coverage, based on an engineering model developed by one of the panelists. The recommended removal rates are shown in the table below:

Incremental Pollutant Removal Rates for FTW Pond Retrofits					
Pollutant	Raft Coverage in Pond				
	10%	20%	30%	40%	50%
TN	0.8%	1.7%	2.5%	3.3%	4.1%
TP	1.6%	3.3%	4.9%	6.5%	8.0%
TSS	2.3%	4.7%	7.0%	9.2%	11.5%

- Frequent operation and maintenance are critical to ensure FTW performance, and the panel outlined some important tasks to maintain their function. Consequently, FTWs have a shorter longevity compared to other retrofits. The panel recommended a three year credit duration (with an approved maintenance plan), which is renewable if a field inspection confirms that the retrofit is still meeting its FTW performance criteria.

- The panel outlined the units needed to report the practice to the state, which are consistent with the prior retrofit report. The panel also recommended several priority research projects, and made several suggestions on how this type of retrofit could be delivered on a more widespread basis.

Section 1. Charge and Membership of Expert Panel

EXPERT BMP REVIEW PANEL: Floating Treatment Wetlands	
Panelist	***Affiliation***
Sarah Lane (*Panel chair*)	Maryland Department of Natural Resources
David Sample	Virginia Polytechnic Institute
Andy Lazur	University of Maryland
Ryan Winston	Ohio State University
Chris Streb	Biohabitats, Inc.
Drew Ferrier	Hood College
Lewis Linker	U.S. EPA, Chesapeake Bay Program Office
Kevin Brittingham	Baltimore County Department of Environmental Protection & Sustainability
Tom Schueler Cecilia Lane (*Panel co-facilitators*)	Chesapeake Stormwater Network
Non-panelists that contributed to the panel's discussions: Peter May, Biohabitats, Inc.; Sarah White, Clemson University; Randy Chambers, College of William & Mary; Karen Duhring, Virginia Institute of Marine Science; Chih-yu Wang, Virginia Polytechnic Institute. Special thanks to David Wood (CRC) for his contributions to finalizing the panel report.	

Floating Treatment Wetlands (FTW) have been implemented in open-water systems, stormwater ponds, farm ponds CAFO lagoons and aquatic nursery operations. In keeping with its established policy, an expert panel was formed in 2013 to evaluate all of the available science on the nutrient and sediment removal performance associated with FTW design applications. The panel was encouraged to evaluate performance research on proprietary FTW designs, but was not asked to endorse or recommend any specific proprietary design.

In doing so, the Urban Stormwater Working Group (USWG) specifically requested that the Panel investigate the following variables that may influence the performance of FTWs:

- A clear and operational definition of the various classes and applications of FTW technology that explicitly references general design and performance specifications

- Determine the primary modes of nutrient removal by FTW (e.g., plant uptake, denitrification or other mechanisms), and whether unit rate(s) can be assigned based on the FTW dimensions or design factors

- Investigate whether the overall rates are permanent, seasonal, or temporary, and how maintenance, harvesting and/or vegetation disposal influence long-term FTW performance

- Check whether the choice of different aquatic plant species can influence FTW removal modes or rates

- Assess possible environmental risks (e.g., invasive species, benthic shading, DO depletion) and benefits (fish habitat, etc.) of FTW, and provide general permitting guidance to the regulatory community on how to maximize benefits and minimize risk

- Look at long-term maintenance, replacement frequency, life-cycle costs and potential applicability for offset/trading

- Define the qualifying conditions under which a locality can receive a nutrient and/or sediment reduction credit

- Recommend appropriate procedures and units for reporting, tracking, and verification of the FTW practice

Beyond this specific charge, the panel was asked to:

- Take an adaptive management approach to refine the accuracy of its removal rate protocol, including any recommendations for further monitoring research that would fill critical management gaps

- Critically analyze any unintended consequences associated with the nutrient management credit and any potential for double or over-counting of the credit

While conducting its review, the panel followed the procedures outlined in the BMP review protocol, as amended (WQGIT, 2014). The process begins with BMP expert panels that evaluate existing research and make initial recommendations on removal rates. These, in turn, are reviewed by the Urban Stormwater Workgroup, and other Chesapeake Bay Program (CBP) committees, to ensure they are accurate and consistent with the Chesapeake Bay Watershed Model (CBWM) and the Scenario Builder tool.

Appendix C describes this report's conformity with the BMP review protocol (WQGIT, 2014). Minutes from the Panel's conference calls are provided as Appendix E.

Section 2. Key Definitions and Qualifying Conditions

2.1 Definition of the Practice

The panel classified floating treatment wetlands (FTW) as a variant of the BMP enhancement retrofit category, as defined by the stormwater retrofit expert panel (SR EPR, 2013). A more specific definition of the practice is provided below.

Wet Pond (aka stormwater retention pond, wet extended detention pond): an existing stormwater retention pond with a permanent pool of water that has an average depth of 3.5 to 8 feet and meets performance criteria for an effective FTW retrofit application.

Floating Treatment Wetlands: A proprietary or non-proprietary floating island design that incorporates the following general elements:

- A buoyant artificial raft that floats on the surface
- Constructed from non-toxic materials such as, but not limited to, HDPE plastic, marine grade polystyrene foam and PVC pipe
- Containing growing media planted with aquatic macrophytes whose roots extend well below the water surface.

The FTW design must also meet or exceed the following general performance criteria, derived from Headley and Tanner (2012), Borne et al (2015) and Wanielista (2012).

The FTW application within an existing pond must:

- Achieve a minimum pond surface coverage of 10% and a maximum cover of no more than 50%
- Have an initial planting density of 2 plugs per square foot and attain a 80% plant coverage on the raft by the end of the growing season
- The raft should be placed perpendicular to the stormwater flow path and be at least 3.5 feet above the bottom of the pond
- Be adequately anchored or tethered in the pond to protect its flood control function during major storms and enable retrieval for periodic maintenance, yet anchoring should not be too taut to inundate the surface and flood the raft
- Not be infested with invasive plants and should be initially protected with netting from geese and turtles during plant establishment
- Use native wetland plant species that meet the five criteria laid out in Wang and Sample (2014) which are appropriate for the ecoregion (Section 3.5)

2.2 Additional Qualifying Condition and Practice Limitations

The upper limit for wet pond drainage area should be no more than 400 acres for this retrofit, as there is no operational experience with FTW applications on lakes, larger reservoirs or flood control facilities (dam safety issues are also a concern).

The expert panel does not recommend deploying FTWs in open water systems as a water quality improvement mechanism. In an open water deployment the FTW does not have the ability to intercept a high proportion of water volume and thus is not providing a measurable water quality benefit. Also, FTW systems become appealing habitat to wildlife that then populate the FTW providing a direct source of fecal coliform and nutrients, potentially negating the benefits of the FTW.

2.3 Potential Benefits of the Retrofit Practice

The deployment of FTWs within existing stormwater wet ponds has several potential benefits to potentially provide cost effective nutrient reduction for Chesapeake Bay communities. These include:

- Retrofits occur with existing private or public stormwater infrastructure, which means there are no land acquisition costs, and the FTWs require no major excavation or re-plumbing of the facility. The FTW rises and falls in response to pulses of stormwater runoff that change the pool elevations of the wet pond.

- The retrofit may enhance the wetland habitat and aesthetic qualities of existing stormwater wet ponds which may attract birds and waterfowl. Being located in the middle of the pool, the FTW raft provides a habitat refuge away from the pond shoreline or aquatic benches.

- At this point in time, there are no known environmental permitting requirements restricting the application of this retrofit (although it is recommended that state stormwater and wetland permitting agencies establish their own guidelines if FTWs are deployed on a more widespread basis).

- Potential third party private sector FTW operators can deploy and sustain FTWs over time. Several researchers are looking to see whether FTWs are an effective technique to grow wetland plant species used for "pond-scaping" efforts or plantings for freshwater wetland establishment.

2.4 Potential Scope of FTW Retrofits in Bay Watershed

According to CBPO staff, approximately 346,000 acres are currently treated by wet ponds in the Chesapeake Bay watershed (or roughly 540 square miles). On average, wet pond surface area comprises about 3% of their contributing drainage area (Schueler, 1987), so that a maximum of about 10,000 surface acres of wet pond could potentially be retrofit in the watershed. Other state-wide BMP databases suggest that this a conservative estimate of wet pond surface acreage in the Chesapeake Bay watershed (Lazur, pers. comm, 2016).

Section 3. Review of the Available Science

3.1 Summary of Available Research

More than 100 papers and reports were discovered on floating treatment wetlands, although the panel only found about 25 that directly pertained to pond retrofit applications. Many papers were excluded from the research review because they were not peer reviewed or involved non-stormwater FTW applications (e.g., wastewater treatment, discharges from animal feeding operations or acid mine drainage mitigation). A list of the full research citations evaluated by the panel can be found in Appendix A.

The panel would like to acknowledge an important climatic/geographic limitation to its research review. Nearly all the pond FTW retrofit studies were conducted in humid or sub-tropical climates, and only a few studies evaluated the capability of FTWs to "over-winter" within a pond (i.e., for either the raft or the plants to effectively withstand thick pond icing conditions which are commonly experienced in the northern portion of the Bay watershed). The implications of this limitation on FTW maintenance operations and overall longevity are further discussed in Section 5.

Lastly, the panel notes that some FTW technologies are proprietary and others are not. The panel could not find enough peer-reviewed research studies to effectively compare FTW technologies. Consequently, it does not endorse any particular FTW technology over another, as long as they meet the general performance criteria for FTW pond retrofits outlined in Section 2.1 of this report.

3.2 Summary of Monitoring Data from FTW Pond Retrofits

The Panel placed a strong emphasis on field studies that monitored how pond pollutant removal changed in response to the FTW deployment. The five key monitoring studies reviewed by the panel are profiled below.

North Carolina Piedmont

Winston et al (2013) monitored two retention ponds that were retrofit with FTWs that covered 9% and 18% of their respective surface area. The study utilized a before and after study design to evaluate the impact of the FTW retrofits, with at least 16 storm events sampled during each phase of the study. The FTW rafts were proprietary, and were planted with five wetland species (*Juncus effusus, Carex stricta, Spartina pectinata, Hibiscus moscheutos* and *Pontederia cordata*).

The first wet pond was known as the Highway pond which drained about 32.3 acres of roadway (88% impervious cover) and had a permanent pool surface area of 0.74 acres (9% of which was covered by FTW). The second wet pond was known as the Museum pond which drained about 5.9 acres of buildings and parking lots (54% impervious cover) and had a permanent pool surface area of 0.12 acres (18% of which was covered by FTW). An overhead photo of both ponds with their FTWs deployed is shown in Figure 1.

Figure 1. Overhead Shot of FTWs Deployed in Two North Carolina Wet Ponds
(Winston et al, 2013)

Both wet ponds were found to be effective at removing most forms of nitrogen and phosphorus prior to the FTW retrofit, but their performance improved further after the FTW retrofit on a mass load basis (See Table 1).

Table 1. Pollutant Removal Performance for NC Pond FTW Retrofits [1]			
	TN	TP	TSS
Highway Pond, Pre-Retrofit	36%	36%	92%
Highway Pond, FTW Retrofit[2]	48%	39%	78%
Museum Pond, Pre Retrofit	59%	57%	89%
Museum Pond, FTW Retrofit [3]	88%	88%	95%
[1] Winston et al, 2013 [2] 9% FTW coverage in Pond [3] 18% FTW coverage in Pond			

Winston also analyzed the median nutrient and sediment EMCs in pond effluent after the FTW retrofit, and reported modest reductions for most nutrient forms, as shown in Table 2.

Table 2. Change in Median EMC in Pond Effluent Following FTW Retrofits (mg/l) [1]						
Monitoring Site	Nitrogen			Phosphorus		Sediment
	TKN	NO3-N	TN	OP	TP	TSS
Highway Pond	0.05	0	0.05	0.03	0	8
Museum Pond	-0.05	0	-0.05	0.05	0.07	8
[1] Winston et al, 2013. Positive values represent a decrease in pollutant concentration						

Most of the increased pond pollutant removal was attributed to improved settling of particulate nutrients, especially near the underwater root network below the FTW. In a follow-up study, Borne et al (2015) measured dissolved oxygen levels at various locations within the Museum Pond in August (Figure 2). The roots below the FTW rafts were found to depress oxygen levels below the FTWs, and produce hypoxia in the underlying water column. The FTW rafts also appeared to slightly depress pH levels in the pond water column. At the end of the study, FTWs were harvested to measure nutrient uptake in the plant biomass. Based on the results, Winston et al (2013) concluded that plant nutrient uptake contributed very little to overall nutrient removal rates.

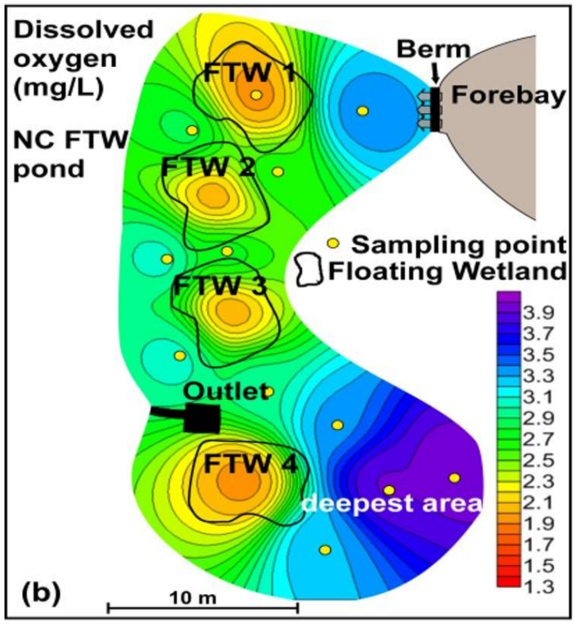

Figure 2. Summer DO Plot for Museum Pond in NC (Borne et al, 2015).

New Zealand

Karine Borne and her colleagues reported on the nutrient removal performance of an experimental FTW pond retrofit near Auckland, New Zealand (Borne et al, 2013 and Borne, 2014). The pond served a 4.2 acre drainage area that was 75% impervious. The study utilized a side by side study design. After runoff entered into a common forebay, flows were split between two equal wet pond cells. One cell served as a control and was not planted, while the second was retrofit with a FTW that covered 50% of the cell's surface area. Seventeen paired storm events were sampled in the experimental pond over about a year. Some of the key results are shown in Table 3.

Table 3. Median EMCs for Pond Influent and Effluent Following FTW Retrofit[1]

Monitoring Location	TN	TP	TSS
	mg/l		
Pond Inlet	0.99	0.09	32
Pond Outlet -Control	0.82	0.07	25
Pond Outlet -FTW Retrofit [2]	0.71	0.04	18

[1] Sources: Borne et al, 2013 and Borne, 2014.
[2] The FTW retrofit covered 50% of pond surface area

Borne et al (2013) summarized the nitrogen removal associated with the FTW retrofit. The FTW retrofit was found to have a mean mass reduction rate for TN that was 12% greater than the no-FTW control. Borne et al (2013) observed that most of the TN removal was associated with the organic nitrogen fraction, which was attributed to enhanced settling characteristics associated with the FTW. The highest nitrogen removal rate was reported during the peak of the growing season. FTW root biofilms were observed to increase the N mineralization rate. Indirect evidence suggested that the high nitrate removal was due to denitrification within the FTW. Borne et al (2013) observed DO depletion and frequent anoxia underneath the FTW cell. As with other studies, Borne found that plant uptake of nitrate did not play a major role in the overall nitrogen removal achieved by the FTW pond retrofit.

Borne et al (2014) reported on phosphorus removal achieved by the FTW retrofit. The FTW retrofit was observed to have a mean mass TP reduction rate that was 27% greater than the no-FTW control. Once again, the bulk of the removal was due to soluble phosphorus sorbing to the FTW root network and subsequent particulate settling. Plant uptake of total phosphorus was not considered an important removal mechanism in the study.

Figure 3. Below Mat Root Biomass Accumulated on a FTW on MD's Eastern Shore
(Photo Credit: Sarah Lane, MD DNR).

Central Florida

Wanielista et al (2012) and Chang et al (2012) reported on the nutrient removal achieved by FTW retrofits at two wet ponds located near the campus of the University of Central Florida. The first pond, known as pond 4M, had a 13 acre drainage area and a 0.6 acre surface area, was not aerated and had about 5% FTW cover. The second pond, termed pond 5, had a 1.64 acre drainage area, 0.09 acre surface area, a fountain for aeration and an estimated 9% FTW cover.

The two ponds utilized different FTW raft technology and planting media, but were planted with the same species --soft-stem bulrush and pickerelweed. Both ponds were heavily influenced by groundwater, which produced significant pond outflows during non-storm periods.

The two ponds were monitored before and after FTWs were deployed, and then the FTW plants were harvested at the end of the experiment. Sampling was limited to 3 storms prior to FTW deployment and 7 storms afterwards (although some non-storm pond outflow samples were also collected). The researchers also noted that nutrient EMCs in the inflows to both ponds were much lower than typical stormwater runoff.

The estimated nutrient removal was slightly lower in Pond 4M, which may reflect its lower FTW surface cover of 5%. Wanielista et al (2012) reported 1 to 4% additional nutrient removal for Pond 4M during storm events, and about 12% during non-storm periods.

Chang et al (2012) reported that Pond 5, with its greater FTW coverage (9%) and fountain, had higher estimated TP and TN removal rates, particularly during non-storm outflows. Chang estimated that TP removal was 48% and TN removal was 16%, but it was not clear how these rates were calculated.

While the Florida study generally reinforces other research that pond FTW retrofits can incrementally remove nutrients, the Panel did not think that its specific removal rates were as relevant to the Chesapeake Bay as other studies. First, the number of storms sampled was limited. Second, the ponds were located in a sub-tropical climate with a year round growing season, which is not representative of conditions in the Chesapeake Bay watershed where the growing season is only 240 days. Third, the ponds were extensively influenced by groundwater, which made it difficult to isolate the FTW effect during storm runoff events. Lastly, the nutrient concentrations measured in the inflow to both ponds were extremely low in comparison to those observed in the Bay watershed.

Maryland Coastal Plain

Two studies investigated nutrient uptake and denitrification rates for FTWs deployed in ponds in the Maryland coastal plain (Lowman, 2013 and Lazur et al, 2013). Both studies confirm that FTWs can grow vigorously in our region and provide strong evidence that FTWs are a hotspot for denitrification, which may help improve their overall nitrogen removal rate.

Lowman (2013) investigated two ponds that had been recently built to control stormwater runoff generated by poultry production facilities on the Maryland eastern shore. Three FTW units were installed in each pond during the year-long study. Sub-sample cores were taken from each FTW unit and sampled for oxidation-reduction potential (ORP) and denitrification potential throughout the growing season. Lowman also sampled the same parameters in the sediment and water column of the ponds, and measured the rate of nutrient uptake that occurred on the rafts. Lowman (2013) observed denitrification potential within the FTW matrix that was 5 to 7 times higher than that measured in pond sediments. The highest denitrification rates were observed at the edge of the FTW rafts as compared to the center of the FTW.

Lowman (2013) concluded that the plant nutrient uptake rates he measured were consistent with other researchers, and that harvesting of plant material, while difficult, could optimize nutrient removal within these rural ponds.

Lazur et al (2013) investigated nutrient uptake rates by six different wetland plant species and two commercially available FTW raft technologies in three ponds located near Easton, MD. 36 FTW units were deployed in the three ponds, and plant material was measured at the beginning and the end of the growing season to determine nutrient uptake rates over time. The FTWs were deployed over the winter, and monitored during the next growing season (one of the only examples of over-wintering reported in the literature).

Lazur et al (2013) concluded that FTWs were an excellent growing medium for most of the plant species, with best results obtained for *Decodon*, *Justica* and *Hibiscus*. *Asclepia* and *Pontederia* appeared to be subject to herbivory by waterfowl and did not grow as well. Measured N uptake rates ranged from 0.2 to 6.7 mg N/sf FTW/day, whereas denitrification rates ranged from 1.28 to 4.06 mg N/sf FTW/day. The highest rates of both N uptake and denitrification were associated with higher pond nitrate concentrations. Denitrification occurred in both the FTW rafts and in pond sediments.

3.3 Summary of FTW Mesocosm Research

The next set of research studies considered by the Panel were FTW mesocosm experiments (Tanner and Headley, 2011, Chang et al, 2012, Van de Moortel et al, 2012, White and Cousins, 2013, Khan et al, 2013, Keizer-Vlek et al, 2014 and Wang and Sample, 2014). Mesocosms provide much greater experimental control and replication and can help isolate key mechanisms involved in nutrient dynamics. The drawback of most mesocosm studies is that they do not realistically portray conditions that are encountered in the field (e.g., variability in rainfall events and inflow concentrations). In particular, it is hard to "scale up" the pond elements such as pool depth and pond sediments in FTW mesocosm studies. As a group, mesocosms are hard to compare, due to inherent differences in their set up and experimental design.

The following summarizes some of the key findings and insights achieved in the mesocosm research studies:

- *FTWs and Pond Hydraulic Performance:* Khan et al (2013) conducted a lab study that evaluated how FTW placement within an experimental pond influenced its hydraulic performance and overall settling conditions. The experimental pond was a 1:10 scale replica with the dimensions of a typical wet pond which allowed testing of a wide range of inflow conditions. FTWs with artificial roots were added to the pond in various configurations. Rhodamine dye was used as a tracer to measure residence time distributions and develop an index of short circuiting. Khan et al (2013) concluded that FTWs improved the hydraulic performance of ponds compared to non-FTW controls. They also noted that one large FTW unit performed better than several smaller units. Short circuiting was reduced when an FTW was placed across the entire width of the experimental pond, and when they were located closer to the inlet than the outlet.

- *FTW Performance as a function of Pond Water Temperature:* Wang and Sample (2014) conducted a six month mesocosm study using natural stormwater obtained from an adjacent wet pond located near Fairfax City, Virginia. Wang and Sample (2014) looked at nutrient uptake under four different treatments: pond water only, unplanted rafts, and rafts planted with pickerelweed (*Pontederia cordata L.*), and softstem bulrush (*Schoenoplectus tabernaemontani)*. TP and TN were reduced by 8.2% and 18.2% in the FTW treatments planted with the pickerelweed and softstem bulrush, respectively. Additionally, the researchers observed a strong relationship between pond water temperature and FTW removal rates, with a decline in efficiency occurring when temperatures were lower than 15 degrees Celsius (e.g., Pickerelweed's removal for both N and P is negligible below 15 degrees Celsius). Peak efficiency occurred when pond temperatures exceeded 25 degrees C. The temperature response was generally greater for P removal than N removal, and differed somewhat among the two plant species tested.

- *FTW and Nutrient Removal:* Tanner and Headley (2011) reported on a New Zealand mesocosm study that investigated nutrient removal associated with FTWs planted with four different species of emergent wetland plants. The short-term experiments used synthetic stormwater runoff to measure FTW nutrient uptake within the tanks.

  Overall, Tanner and Headley (2011) noted that nutrient removal rates were greater for tanks with planted FTWs compared to unplanted control rafts. Plant nutrient uptake was responsible for only a small fraction of the overall TP removal -- most was due to particulate settling. Tanner and Headley (2011) also reported that FTWs reduced DO levels in the tanks, primarily due to root respiration. The authors acknowledged that their experimental design was not intended to measure the pond contribution to overall nutrient removal.

- *Below-Mat Biomass Important to Nutrient Removal*: Several mesocosm experiments observed that the below- mat plant biomass, and in particular, the dense root network that often extends as much as three feet below the mats, appears to be responsible for most of the nutrient reduction.

  For example, Wang and Sample (2013) observed that microbes in the underwater mat and plant roots were the most likely mechanism for nutrient removal in his Virginia mesocosm experiments. Tanner and Headley (2011) also concluded that biofilms on plant roots were a major source of both TSS and TP removal and improved settling conditions within the mesocosms for very fine sediment particles that are often enriched with organic phosphorus. White and Cousins (2013) found that most of the nutrients in their mesocosm experiments were measured in below-mat biomass rather than above-mat biomass, which reinforces the same finding observed in field scale monitoring (Winston et al, 2013).

- *Differential Nutrient Uptake by Different Plant Species:* White and Cousins (2013) reported on mesocosm experiments conducted over two growing seasons in South Carolina. The outdoor trough experiments looked at FTW nutrient uptake and removal for two stormwater nutrient loading rates and two different plant species (*Juncus effusus* and *Canna flaccida*). While White and Cousins (2013) found the FTWs were able to achieve reasonably low N and P concentrations in stormwater effluent, there were significant differences in aerial nutrient uptake rates between the two species -- on average, nutrient uptake by *Juncus* was 60% higher than *Canna*.

  Other mesocosm experiments have yielded the same conclusion. For example, Keizer-Vlek et al (2014) used mesocosms to compare nutrient uptake of two plant species (*Typha augustifolia* and *Iris psuedoacorus*) under two simulated nutrient loading rates. The N and P uptake rates for *Iris* were found to be significantly higher than *Typha* under both nutrient loading rates. Wang and Sample (2014) reported that N and P uptake rates were higher for *Pontederia cordata* than *Schoenoplectus tabernaaemontani*.

  The mesocosm experiments reinforce the findings from larger field-scale monitoring studies profiled in Section 3 (see especially Lazur et al, 2013). Overall, the panel concluded that the number of plant uptake studies were so small that no particular wetland plant species could be recommended for FTWs solely based on nutrient uptake.

- *Plant Senescence and Potential Nutrient Leaching from FTW Detritus*: A few researchers have looked at the potential risk that nutrients might leach from FTW plant detritus at the end of the growing season. Wang and Sample (2014) noted that above mat growth of *Pontederia cordata* stopped in the early Fall as temperatures began to decline. The nutrient uptake rates declined as the plants died back, and Wang and Sample (2014) surmised that some nitrogen and phosphorus may have been released from the FTWs later in the fall. On the other hand, no senescence occurred in the other FTW plant species *Schoenoplectus tabernaaemontani,* during the course of the study. Despite the fact that some nutrients might be released back into the pond when plants die-back and decompose, Wang and Sample (2014) concluded that FTWs "should provide net nutrient removal on an annual basis if harvested at the appropriate time".

  Van de Mortel et al (2012) researched leaching from FTWs in a series of laboratory in-situ litter bag experiments. The FTW detritus was obtained from FTW planted with *Carex* species deployed in the field in a Belgian study. They found that 13% of FTW detritus biomass (dry weight) was lost in 24 hours after immersion in water, and that 23% was lost within 3 days. The relatively rapid loss was primarily attributed to leaching of soluble organic compounds from the detritus. The research team also noted that the decomposition of detritus provided a critical carbon source to promote denitrification within the FTW. The litterbag experiments indicated that about 60% of the mass of FTW detritus was lost within a year under field conditions (i.e., 40% of the mass was still present in the bags immersed in pond water).

3.4 Review of FTW Modeling Studies

Wang and Sample (2013) developed a model for predicting nutrient removal performance of floating treatment wetlands that integrates effects of the raft and associated plants with that of the water body that the FTW raft floats on. This integrated model (the i-FTW model) is based upon first-order reaction kinetics. Parameters of the model include water reaction rate of the water body, and apparent uptake velocity of the FTW; which is a function of the vegetation and the raft materials. Additional parameters in the model include the area of the raft(s) and the volume of the water body.

A literature review was conducted, and 14 FTW studies worldwide were selected that contained information sufficient to fit the i-FTW model. The i-FTW model was found to be more predictive than other engineering models used to estimate removal efficiency (Wang and Sample, 2013). A bootstrap method was used to generate uncertainty and provide robust predictions of performance.

The best estimation of median and expected range (95% confidence interval) of the apparent uptake velocity were 0.048 (0.018–0.059) and 0.027 (0.016–0.040) m/day for TP and TN, respectively. The goodness of fit (r^2) of the i-FTW model on water concentration time series data of the i-FTW experiments was 0.92 ± 0.30 for TP and 0.86 ± 0.38 for TN data (mean ± standard deviation).

The i-FTW model was specifically adapted to predict the effect of FTW raft coverage on nutrient removal rates for pond retrofits in the Chesapeake Bay watershed. The model was applied to a pond in Fairfax, Virginia using a series of engineering models and a ten year rainfall time series. The technical assumptions used in this modeling analysis are described in detail in Appendix B.

3.5 Research on FTW Operational and Maintenance Issues

Most of the field studies involved demonstration projects to test how FTW pond retrofits function under real world conditions. This section summarizes some of the more pertinent FTW operation and maintenance issues. Readers who want more detail on these issues should consult Borne et al (2015).

Annual Harvesting

Most practitioners recommend that a portion of the FTW should be harvested or at least thinned at the end of the growing season or upon plant senescence (Wang and Sample, 2014). The primary purpose of this maintenance task is to prevent the FTW from becoming overgrown but leave enough wetland plant material to propagate during the next growing season. While harvesting removes biomass and nutrients from ponds, the ultimate removal pathway associated with maintenance are pond sediment cleanouts. At the same time, practitioners also acknowledge that harvesting operations are very difficult to perform in the field (Winston et al, 2013, Lowman, 2013). A complete harvest of all biomass within a FTW is not practical given the weight and configuration of the FTW rafts (and the fact most of the biomass is either intertwined within the raft structure or located underwater). Several researchers have looked at where biomass and nutrients are stored within the FTW mats (Beery, 2013, Borne et al, 2015, Winston et al, 2013). In general, about a third of biomass/nutrients are found above the mat, a third are found in the mat itself, and the remaining third are located in the root network below the mat.

The panel recommends that above the mat plant material be thinned at the end of the growing season or upon plant senescence, whichever comes first. The harvested plant material should be composted or land-filled.

Over-Wintering vs. Fall Retrieval

It was noted in Section 1 that the research review found little data that evaluated the capability of FTWs to "over-winter" within a pond in northern climates (i.e., for either the raft or the plants to effectively withstand thick pond icing conditions, or for that matter, exposure to extremely high chloride levels). Over-wintering strategies should be tested in the field to see which ones are practical and cost-effective. For example, one strategy is to deploy the pond FTW over the entire winter season, and making any repairs/plant reinforcement during the following spring.

Downstream Discharges

There have been environmental concerns about the discharges from stormwater retention ponds for many years related to stormwater temperature and hypoxic discharges (Schueler, 1996). For these reasons, most states prohibit or discourage their use in sensitive or high quality streams (e.g., trout waters). The panel investigated whether FTW pond retrofits would mitigate or aggravate these downstream concerns.

Borne et al, 2015 observed that FTWs can further decrease DO levels within stormwater ponds, although the effect appears to be localized in close proximity to the FTW raft. No data was available on whether FTW retrofits modified the DO levels discharged from ponds, but the panel recommends that FTW retrofits be accompanied by a suitable aeration method to minimize the risk of anoxic pond discharges during the summer months.

Winston et al (2013) sampled water temperature profiles in FTW retrofit ponds to determine whether their shading might cool temperatures in the water column and thus reduce downstream thermal discharges. While they found some minor differences in temperature profiles below FTW rafts compared to open water areas, they were not sufficient to reduce thermal discharges from the pond. Given that Borne et al (2015) also came to the same conclusion, the panel was doubtful whether FTW retrofits would be a viable mitigation strategy for stream warming.

FTW Plant Species

To date, a relatively small number of aquatic macrophytes species have been planted within FTWs. Table 4 summarizes the plant species that have been most frequently planted in east coast FTW demonstration projects. Each of the species meet the criteria of Wang and Sample (2014) for FTW plant selection: native to the region and non-invasive, perennial, ability to thrive in a hydroponic environment, and ability to aerate the root network by transporting oxygen from above-water biomass.

Table 4. Plant Species That Have Frequently Been Planted in FTWs [1]

Common Name	Latin Name
Pickerelweed	*Pontederia cordata*
Softstem Bulrush	*Schoenoplectus tabernaemontani*
Blue Flag	*Iris versicolor*
Swamp Rosemallow	*Hibiscus moscheutos*
Soft Rush	*Juncus effusus*
Tussock Sedge	*Carex stricta*
Swamp Milkweed	*Asclepia incarnata*
Swamp Loosestrife	*Decodon verticillatus*
Water Willow	*Justica americana*

[1] North American species planted on east coast FTW demonstration projects

The panel does not recommend any particular plant species but suggests that a qualified wetland scientist be involved in plant selection and that they should be procured from regional wetland nurseries.

FTW Plant Mortality

Several researchers have documented plant mortality in FTW systems for a variety of reasons (e.g., dessication, anoxia, poor post-nursery care, herbivory). While mortality has been observed in individual species, total FTW planting failures are fairly uncommon as long as multiple species are planted on the same raft (i.e., at least a few species will do well enough to ensure adequate FTW plant coverage by the middle of the growing season).

Numerous practitioners have reported that FTWs can be subject to considerable herbivory by geese, waterfowl or turtles, especially during their initial establishment phase (Nemerson et al, 2011, Lazur et al, 2013 and Winston et al, 2013). Borne et al (2015) recommend that plants be protected by plastic netting during this critical phase of plant growth.

Spread of Invasive Species

Several aquatic macrophytes rank among the most aggressive and invasive plant species in the region, so care needs to be taken to select native plant species when planting FTWs. Winston et al (2013) noted the invasive species creeping water primrose (*Ludwigia hexapetala)* was present in one of the NC wet ponds prior to a FTW retrofit. The FTW rafts appeared to provide a foothold for the plants to colonize the better part of the wet pond during the next growing season. Based on this experience, Borne et al (2015) recommends that FTW should not be deployed in ponds that contain invasive plant species or at least invasive species should be eradicated prior to FTW deployment whenever possible.

Tethering and Retrieval

FTWs will rise and fall as pond water levels fluctuate from storm to storm, but they need to be kept in the same general location in the pond to promote settling of solids. In particular, they need to be anchored so they cannot move around the pond during extreme storm events and possibly obstruct risers and spillways. The proposed FTW operations regime requires the ability to safely retrieve a very bulky and heavy raft to perform maintenance. Therefore, the raft needs to be securely anchored within the pond but also easily retrievable from the pond shoreline or a small boat. Furthermore, anchoring should not be so restrictive that the raft is pulled below the surface of the water allowing it to become inundated. If the raft becomes flooded any protective fencing or netting will become obsolete and give wildlife access to the FTW structure.

3.6 Overall Findings on Pollutant Removal

Based on its review of the literature, the panel agreed on the following findings on the pollutant removal capability of FTW retrofits in stormwater ponds:

- While the number of field monitoring and lab mesocosm studies on FTWs was fairly limited, most of the research findings were internally consistent and reinforced one another.

- The incremental effect of FTWs in boosting pond pollutant removal was modest (+5 to 20%), but was consistently positive in the monitoring studies where it was evaluated. In general, TP removal was consistently higher than TN removal in FTW pond retrofits.

- The majority of the FTW nutrient removal occurs underneath the FTW in the biofilms associated with its dense root network that collectively act as a:

    - Physical filter to decrease flow velocity, enhancing settling of particulate pollutants.

    - Biosorbent for phosphorus and dissolved metals under the neutral pH induced by the FTW.

- Favorable environment for microbial growth which enhances N mineralization, nitrification and denitrification rates.

- Net source of organic matter from the roots that promotes the formation of flocs, increasing settling of particulate pollutants.

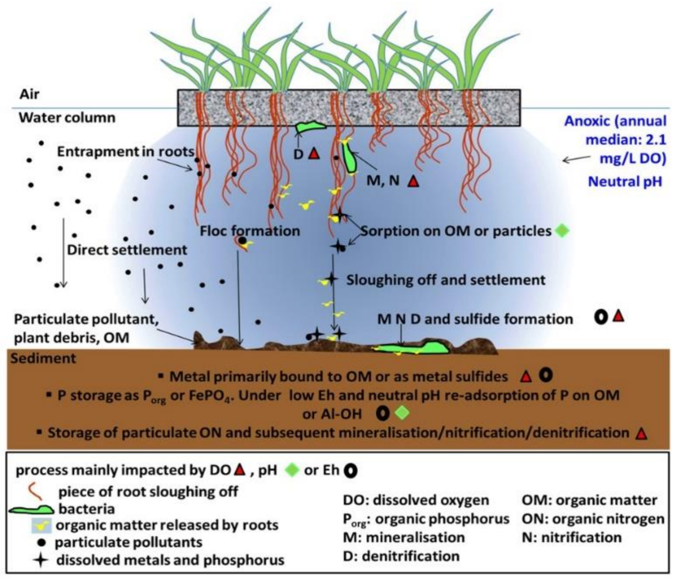

Figure 4. Schematic of FTW root zone treatment pathways (Borne et al 2015)

- Improved settling of particulate nutrients appears to be the dominant removal mechanism in pond FTW retrofit applications. The placement of the FTW acts to improve the hydraulic performance of the pond, reducing flow velocities and improving the overall settling environment. Studies suggest that this effect occurs underneath the FTW and extends all the way to the pond outlet. FTWs should be located closer to the inlet (but outside of the forebay) and be placed perpendicular to the flow path to maximize settling performance.

- FTWs have a strong local influence on dissolved oxygen dynamics within stormwater ponds, and can create hypoxic and/or anoxic conditions below and within FTWs during the growing season. These conditions can promote denitrification within both the FTW mat and the underlying pond sediments.

- Two Maryland research studies confirm that denitrification occurs within the FTW mat, especially near its outer edges where more surface area exists. The contribution of denitrification to overall nitrogen removal appears to be modest.

- Plant uptake of nutrients is not thought to play a major role in the overall nutrient reduction achieved by FTW pond retrofits, although most researchers observe significant differences in uptake rates among different plant species.

- FTWs need to cover at least 10% of a pond's surface area (Borne et al, 2015 and Winston, 2016) to improve their nutrient and sediment removal function. On the other hand, covering more than half of the pond surface area is often impractical due to cost and geometrical concerns. Ratios in excess of 50% may negatively impact pond biologic processes.

- While FTW provide a shading effect, they are not capable of reducing thermal load or average discharge temperature from wet ponds. This shading does not appear to harm existing underwater vegetation since FTWs are deployed at water depths that preclude the growth of any underwater vegetation.

- Given that the monitoring studies and engineering models were in close agreement, the panel elected to use the i-FTW model to predict the effect of raft coverage on nutrient removal rates for FTW pond retrofits. The panel estimated incremental TSS removal rates for FTW retrofits, based on pond sedimentation theory, using relationships between TSS and TP (See Appendix B).

Section 4. Recommended Protocol for FTW Pond Retrofits

4.1 Proposed Nutrient Removal Credits in Other States

Two states have proposed nutrient removal credits for FTW pond retrofits but no credits have been yet officially adopted in either state.

Florida: FDEP (2010) proposed a 20 to 40% incremental removal credit for both nitrogen and phosphorus for "Managed Aquatic Plant Systems" or MAPs that are added to existing wet detention ponds. The draft removal credit was developed to support new stormwater nutrient rules for Florida waters, which were introduced in 2010 but have not been approved to date.

The technical basis for the removal credit appears to be loosely based on the Florida FTW research profiled in Section 3 of this report, although Wanielista (2012) recommended a 12% FTW wet pond retrofit credit for TN and TP in his recommendations. The draft technical criteria presented for FTW retrofits in FDEP (2010) was fairly minimal, but did require a minimum 5% FTW coverage and annual harvesting of plant biomass.

North Carolina: For several years, North Carolina has been drafting new stormwater rules to protect nutrient-sensitive waters of the State such as Jordan Lake and Falls Lake. The rules require pollutant reductions for existing and new development to prevent eutrophication, and they are developing nutrient accounting protocols that are similar to those being crafted in the Chesapeake Bay.

Winston (2016) drafted a recommended protocol for crediting incremental pollutant reduction by FTW pond retrofits in North Carolina, which is summarized in Table 5.

Table 5. Summary of Proposed NC Credit for FTW Pond Retrofits [1]

Pollutant	Range of FTW Coverage [2]	Proposed Pollutant Reduction Credit
TP	Min of 10% SA Cover [3]	Pond effluent concentration reduced by 0.03 mg/l (or about 10% of pond TP inflow EMC)
TN	Min of 10% and Max of 50%	Pond effluent concentration reduced on sliding scale (0.00 mg/l for 10% FTW up to 0.11 mg/l for 50% FTW (or about 5% of typical pond inflow EMC for TN)
TSS	Min of 10% SA Cover [3]	TSS removal rate for wet ponds increased from 85 to 90%

[1] Draft recommendations to NC DEQ that have not been officially approved (Winston, pers. comm.)
[2] All FTWs must achieve 80% plant coverage on the raft and must be placed perpendicular to the primary flow path of the pond
[3] No additional credit beyond 20% FTW cover

4.2 Protocol to Define the Pond Baseline Removal Rate

Table 6 presents the various methods that have been used to define removal rates for wet ponds in the Chesapeake Bay watershed. A conservative estimate for wet pond removal rates was adopted by the Chesapeake Bay Program (CBP) in 2003. The estimates were about 7 to 13% lower than the median removal rates derived from an analysis of 45 wet pond research studies by the Center for Watershed Protection (CWP, 2007). The CBP acknowledges that it discounted the removal rates to reflect concerns about wet pond maintenance over time.

The removal rates for wet ponds and other stormwater treatment practices were revisited by a new CBP expert panel in 2013. By that time, each Bay state had increased their water quality sizing requirements and strengthened their design specifications. The new expert panel produced a series of curves to estimate removal rates for total phosphorus, total nitrogen and total suspended solids based on the degree of runoff storage volume they provided (Figures 5, 6 & 7).

Most states began actively discouraging or even prohibiting the use of wet ponds after 2005 due to stream warming and other environmental permitting concerns. The removal rates for existing wet ponds constructed in earlier eras, however, can be readily estimated from the adjustor curves -- most were designed using a water quality sizing rule of 0.5 or 1.0 inches of pool storage per contributing impervious acre. The corresponding removal rates for wet ponds designed to these sizing criteria are shown in Table 6.

Table 6. Wet Pond Pollutant Removal Rates Over Time

Pollutant	CBP (2003) [1]	CWP (2007)[2]	EPR (2013) [3]	75% NPRD [4]
TSS	60	73	50 - 70	88
TP	45	52	40 - 52	75
TN	20	31	25 - 35	40

[1] First CBP estimate of wet pond removal rates
[2] National Pollutant Removal Database, 3rd edition (CWP, 2007)
[3] Expert Panel Report for Stormwater Treatment Practices, 0.5 to 1.0 inch sizing assumed (SSPS EP, 2013)
[4] 75th percentile removal rate from NPRD (CWP, 2007)

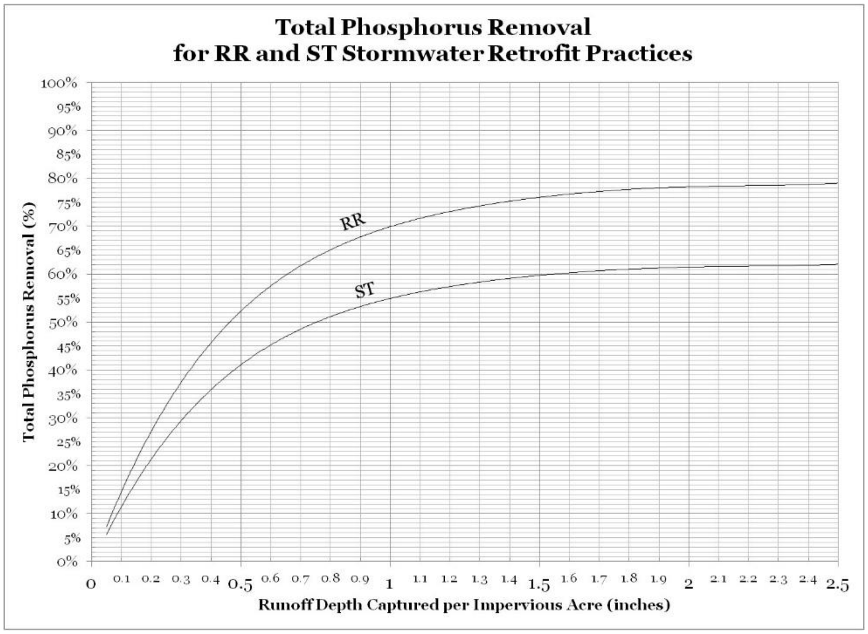

Figure 5. Retrofit Removal Rate Adjustor Curve for Total Phosphorus

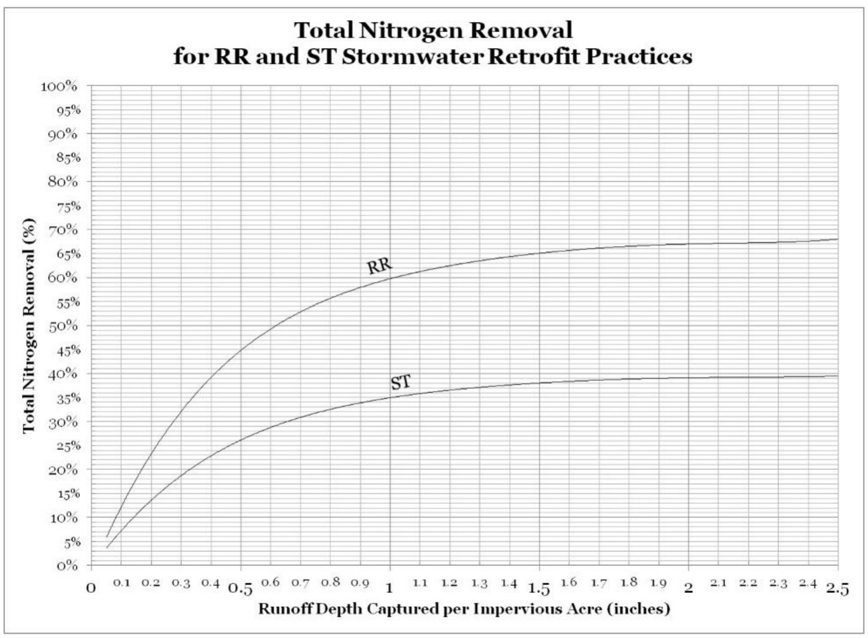

Figure 6. Retrofit Removal Rate Adjustor Curve for Total Nitrogen

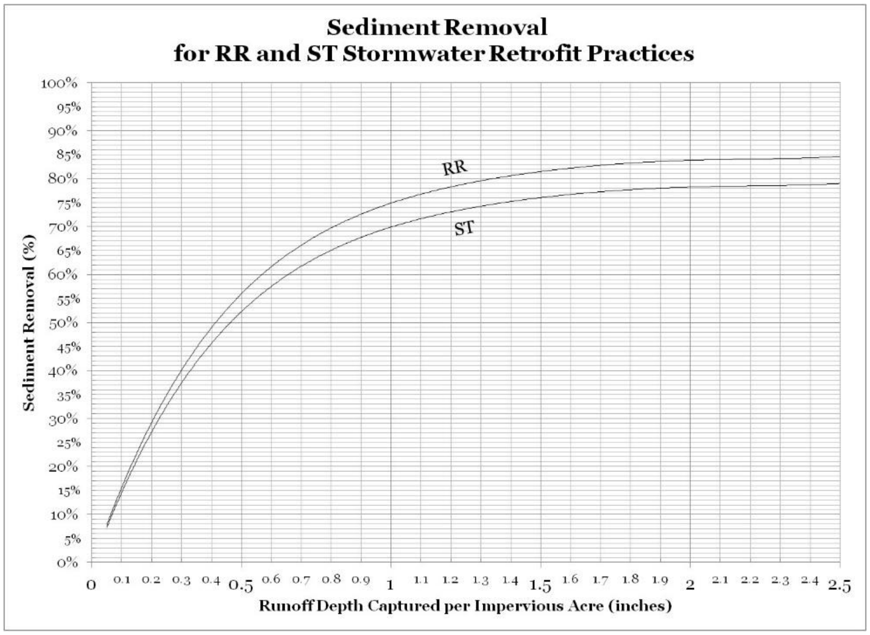

Figure 7. Retrofit Removal Rate Adjustor Curve for Total Suspended Solids

4.3 Protocol to Define FTW Incremental Removal Rate

The Panel developed a simple protocol to compute the incremental removal rate based on the FTW coverage achieved in the wet pond, using the i-FTW model adapted for Chesapeake Bay watershed conditions (Wang and Sample, 2013 and Section 3.4). The incremental removal credit is calculated in three simple steps.

Step 1: Confirm that the wet pond and FTW design conform to the performance criteria for the retrofit installation outlined in Section 2.1.

Step 2: Measure the surface area of the pond and the FTW rafts to determine the percent raft coverage for the pond.

Step 3: Go to Table 7, and find the removal rates that correspond to the percent raft coverage achieved (interpolating if needed).

Table 7. Incremental Pollutant Removal Rates for FTW Pond Retrofits

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

The next section provides a design example to show how both the baseline and incremental removal rates are calculated.

4.4 Pond FTW Retrofit Design Example

A Bay community is looking to retrofit an existing wet pond that was built in 1990 and that serves a 100-acre site developed with a mix of single family homes, apartments and townhouses resulting in a total of 90 impervious acres. The wet pond was designed to provide a water quality volume (WQv) of 1 inch per impervious acre in the contributing drainage area. The community is looking to retrofit the existing wet pond with a Floating Treatment Wetland in order to increase the water quality benefits of the facility.

In order to calculate the increased pollutant reduction, the community must first calculate the amount of pollutant reduction provided by the existing wet pond.

Step 1. Calculate the removal rate of the existing wet pond.

In order to determine the runoff volume treated by a practice, the designer must first estimate the Runoff Storage volume (RS) provided by the existing practice. This, along with the Impervious Area (IA) in acres, is used in the standard retrofit equation to determine the amount of runoff volume in inches treated at the site:

$$= \frac{(RS)(12)}{(IA)}$$

Where:

RS = Runoff Storage Volume (acre-feet)
IA = Impervious Area (acres)

Once the amount of runoff volume in inches treated at the site is determined, the designer references the retrofit removal adjustor curves (Figures 5–7) to determine the pollutant removal rates for the existing wet pond. Wet ponds are classified as a stormwater treatment (ST) practice by the Urban Stormwater Retrofits Expert Panel report (SR EPR, 2013).

The designer finds the amount of runoff depth captured on the x-axis of the retrofit removal rate adjustor curves and goes upward to the ST curve. The designer then moves to the left to find the corresponding removal rate on the y-axis.

In this example, the runoff storage volume (RS) for the wet pond is 7.5 acre-feet and the impervious area (IA) treated by the pond is 90 acres. The local designer inputs that information into the retrofit storage equation above to determine the runoff depth captured per impervious acre to be 1.00".

The designer then finds the 1" runoff depth captured per impervious acre on the x-axis of the retrofit removal rate adjustor curves and determines the removal rates of the existing pond to be as follows:

Removal Rate	TP	TN	TSS
Baseline Pond Removal	55%	35%	70%

Once the designer has calculated the existing removal rates of the wet pond, the next step is to determine the additional removal due to the FTW retrofit.

Step 2. Calculate the incremental removal rate due to the FTW retrofit.

The designer calculates that 30% of the surface area of the pond is going to be covered by the FTW rafts. The designer then consults Table 7 to determine the additional removal benefit from the FTW retrofit. Based on the table, the designer determines that the FTW retrofit gives the pond an additional removal of 2.5% Total Nitrogen, 4.9% Total Phosphorus and 7.0% Total Suspended Solids.

Removal Rate	TP	TN	TSS
Baseline Pond Removal	55%	35%	70%
FTW Incremental Removal Rate	2.5%	4.9%	7.0%
Total Pond and FTW Removal	58%	40%	77%

Section 5. Accountability Mechanisms for the Practice

5.1 General Issues on Practice Reporting and Verification

The panel relied on the general principles for urban BMP verification that were established by the Urban Stormwater Workgroup (USWG, 2014) and approved by the CBP partnership as a whole.

The expert panel concluded that FTW pond retrofits should be subject to all of the accountability procedures established for stormwater retrofit practices, as defined in Section 6 of the stormwater retrofit expert panel report (SR EPR, 2013) including:

- No double counting
- Initial certification of adequate FTW installation
- Retrofit reporting units to state stormwater agency
- Local recordkeeping requirements
- Field verification procedures

Stormwater retrofits are granted a 10 year credit duration which can be renewed for another ten years if a field inspection verifies that the retrofit still exists, is functioning as originally designed and is adequately maintained (SR EPR, 2013). The Panel did note that there are some unique verification issues associated with pond FTW retrofits, most notably their shorter credit duration, as described in the next section.

5.2 Overall Estimate of FTW Longevity

For several reasons, it is anticipated that FTW pond retrofits will have a shorter longevity than other types of stormwater retrofits. First, FTW pond retrofits to date have involved relatively short-term research or demonstration projects -- the panel could find no evidence of any FTW pond retrofits that were operated for longer than three years. Second, FTWs require frequent inspections and maintenance during the growing season to maintain their pollutant removal function (see Section 5.3). Experience has shown that if these maintenance tasks are not regularly performed, the FTW retrofit will ultimately fail. Given these longevity issues, the panel concluded that the duration of the pollutant reduction credit should be substantially shorter than the ten years allowed for standard retrofits.

The panel estimated that the longevity of a FTW pond retrofit system is three years, if a responsible party exists to inspect and maintain the facility (i.e., an enforceable and funded maintenance plan). The credit can be renewed for an additional three years if field inspections demonstrate that the FTW is in operable condition and meets plant coverage requirements. If an enforceable operation and maintenance plan is lacking for the FTW pond retrofit, the panel recommends the credit duration be restricted to a single year.

5.3 Unique FTW Operation and Maintenance Criteria

The panel notes that regular operation and maintenance are essential to maintain the performance of FTW retrofits over time -- communities should not expect that they can simply deploy FTWs and walk away. While the specific maintenance tasks for FTW retrofits depend on the specific pond environment and FTW technology used, the panel generally concurs with the FTW operation and maintenance recommendations established by Borne et al (2015). These activities may entail:

- Quarterly inspections of the FTW retrofit throughout the year
- Shoot trimming in the early summer, if needed (FTW harvesting is extremely difficult and is usually confined to biomass above the surface of the raft)
- Reinforcement plantings if the end of season 80% plant coverage threshold is not achieved over the raft
- Immediate removal of any invasive macrophyte species that colonize the FTW raft
- Repairs to tethering and/or anchoring systems to ensure the FTW is properly placed within the pond
- Other operations, as needed to maintain the function and performance of the FTW pond retrofit
- Implementation of herbivory prevention devices during planting
- Removal of herbivory prevention devices once plants are successfully established

5.4 Reporting, Tracking and Verifying the Practice

Reporting FTW Pond Retrofits

FTW pond retrofits fall within an existing category of stormwater retrofits -- Enhancements to Existing BMPs - so communities should report the following data as outlined by the retrofit expert panel (SR EPR, 2013) or otherwise required by your state stormwater agency:

- Retrofit class (i.e., Enhancement of existing BMP)
- GPS coordinates for the wet pond (lat/long)
- Year of installation (and year credit lapses)
- 12 digit watershed in which it is located
- Total drainage area and impervious cover area treated by the wet pond
- Runoff volume treated by the wet pond
- Percent FTW coverage over pond surface area
- Incremental sediment, nitrogen and phosphorus removal rates, based on FTW pond coverage in Table 7.

Tracking FTW Retrofits Over Time

Given the relatively short credit duration for FTW retrofits, communities should develop a local tracking system to record FTW installation and subsequent operation and maintenance activities over the year. In general, communities have a one-year time frame to bring them back into compliance should they not pass the field verification inspection. This grace period is waived, however, if the FTWs are removed from the pond.

Localities can renew the credit for an additional three years if they can report to the state that the retrofit has passed the field inspection. Otherwise, the credit is automatically terminated by the state when its initial credit duration expires.

Verification for FTW Pond Retrofits

Verification of the FTW pond retrofit is straight forward. Communities conduct a field inspection of the retrofit at the end of its third growing season to assess the structural integrity of the FTW raft and to ensure that it still meets the performance criteria outlined in Section 2.1. These criteria are relatively easy to assess in the field, and include:

- Minimum pond surface coverage by FTW
- 80% plant coverage within the FTW rafts
- Native plant species are maintained
- FTW units are placed perpendicular to flow path, and are adequately tethered/anchored
- Depth from FTW raft to pond bottom is 3.5 feet or greater
- Other criteria, as established by the appropriate state stormwater agency

Section 6. Future Research and Management Needs

6.1 Panel's Confidence in its Recommendations

One of the key elements of the CBP BMP Review Protocol is that each expert panel should express its confidence in the removal rates that they ultimately recommend (WQGIT, 2014). While the available research on FTW retrofit performance was fairly limited, the panel concluded that the studies were internally consistent and tended to reinforce each other. Numerous lines of evidence indicated that FTWs improved pond settling conditions, thereby enhancing overall pollutant removal. Consequently, the panel was reasonably confident that the modest incremental FTW pollutant reductions it recommends are reliable and technically supported.

The panel also concluded that its recommendations should be re-visited within five years if more FTW monitoring research and operational experience become available. This panel should be reconvened sooner if more compelling research is published on FTW applications within tidal waters.

6.2 High Priority Research Recommendations

The panel recommended several priority research studies that would increase understanding about the long term performance of FTW pond retrofits, such as:

- Field testing to determine the best FTW over-wintering strategy

- Denitrification measurements within both the FTW matrix and wet pond sediments underneath the raft, in order to develop a better nitrogen mass balance for the interaction of FTWs and ponds

- Field monitoring studies on the pollutant removal performance of FTW applications in a broader range of aquatic settings, especially for sediment

- Modeling work to develop design tools to optimize nutrient and sediment removal by adjusting FTW surface area and configuration within ponds

- Plant research to identify which FTW plant species maximize coverage, nutrient uptake, habitat value and aesthetics

6.3 Future Implementation Considerations

The panel identified several priorities to improve local capability to employ FTW pond retrofits in their communities to maximize pollutant reduction to local waterways and the Chesapeake Bay.

- More training and outreach to MS4s to determine which legacy wet ponds within their local stormwater BMP inventory are the best candidates for this class of retrofits
- Work with private sector companies who manage and maintain ponds and wetlands to see if there is a broader private sector market to deploy and operate the practice on a more widespread basis.
- Evaluate whether economic incentives and/or public/private partnerships could expand the delivery of FTW retrofits within individual communities, especially for privately-owned ponds that are managed by cash-strapped homeowner associations.

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Appendix B. Calculating FTW Improvement Using the i-FTW Model

A case study wet pond was selected to assess FTW treatment capability using the i-FTW model. Ashby Pond in Fairfax City, VA, which is located in the headwaters of Accotink Creek, a tributary of the Potomac River and Chesapeake Bay. Accotink Creek is listed as impaired due to urban impacts to the benthic invertebrate community as well as E. coli and PCB pollution, as shown in Figure 1. The upstream watershed is approximately 121.8 ac, and is approximately 38% impervious and can be further subdivided into three subwatersheds.

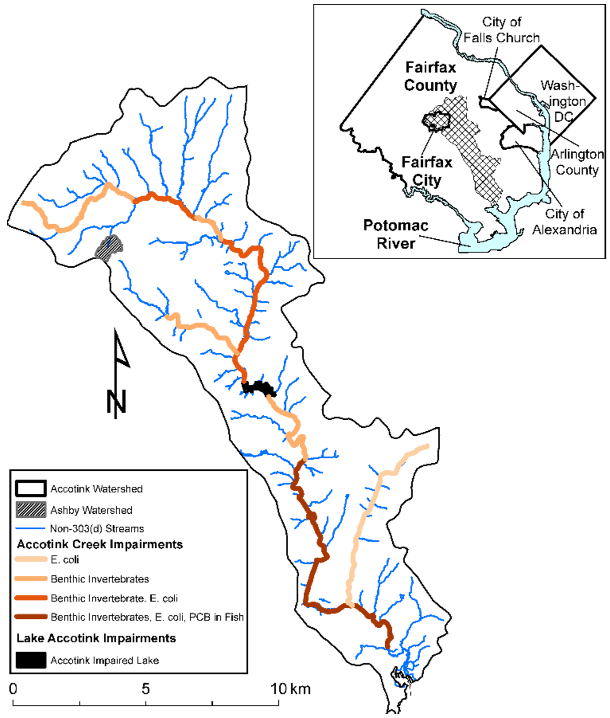

Figure 1. Location of Ashby Pond in the Accotink Creek Watershed, Fairfax City, VA (Schwartz, 2014).

Prior to beginning this study, the pond was extensively retrofitted. Dredging removed accumulated sediment, the bottom was re-graded, and a concrete outflow structure with dual outlets was installed. High flows spill over the top of the outflow through a 12.4 ft-wide broad crested weir and low flows pass through a 0.7 ft perforated PVC pipe wrapped in geotextile fabric. The pipe collects water from below the surface of the permanent pool and releases it at the foot of the weir. All outflows then enter a 10 ft wide by 52ft-long rectangular channel which discharges to Daniels Run.

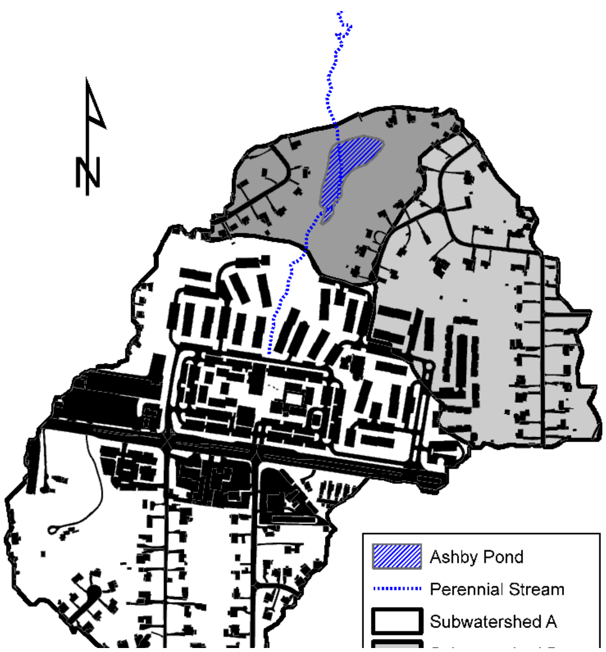

Figure 2. Land use in the subwatersheds draining to Ashby Pond, Fairfax City, VA (Schwartz, 2014).

The goal of the pond retrofit was to retain and treat the 1-inch storm event. This goal was largely met despite the relative small size of the pond (2 AF at normal pool) with respect to the large watershed. Results of a 5-month monitoring program conducted from September 2012 to March 2013 found that, despite the pond's size and a large storm event in the monitoring period (Hurricane Sandy), the pond removed approximately

57% of TN, 41% of TP and 76% of TSS, exceeding state standards for N reduction, but was less than those for P (Schwartz, 2014).

Associated with the in-pond monitoring program a mesocosm study was conducted, summarized in (Wang and Sample, 2014; Wang et al., 2014a) and a field demonstration, summarized in (Wang et al., 2014b). A first-order kinetic model of in-pond and FTW treatment processes was developed, and named the i-FTW model because of its integration of pond and FTW components, conceptually shown in Figure 3 (Wang and Sample, 2013).

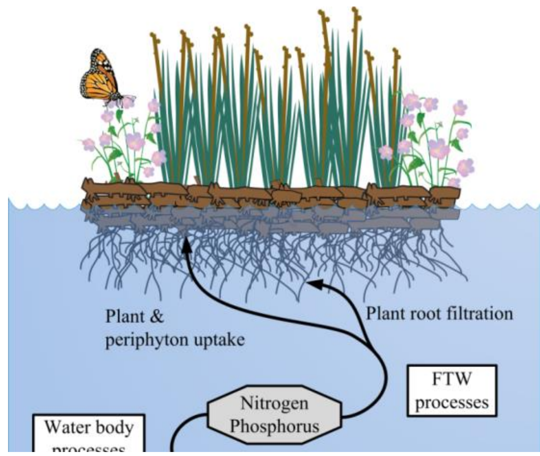

Figure 3. Conceptual diagram of i-FTW model (Wang and Sample, 2013).

The i-FTW model is expressed as:

$$C_t = C_0 e^{-\left(k_p + \frac{v_f A_r}{V}\right)t} \qquad (3)$$

Where:

C_t	=	Concentration in pond outflow, mg/L
C_0	=	Initial concentration in pond, weighted average of inflow and initial pond concentration, mg/L
$V(t)$	=	Volume of pond at time step, t, ft^3
k_p	=	Pond settling rate, 1/day
v_f	=	FTW treatment/removal, 1/d
A_r	=	Total area of FTW rafts, ft^2
T	=	Reaction time, or the sum of interevent time and 50% of the preceding storm duration, days

A hydrologic model was constructed using the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) (Huber et al., 1988; Rossman, 2004). Local geologic information (Drake, 1986)was used to incorporate a groundwater component, allowing the model to be run in a continuous mode. The model was run for the period January 1, 2000 to January 1, 2010; simulated pond depth is shown in Figure 4, and pond outflow in Figure 5.

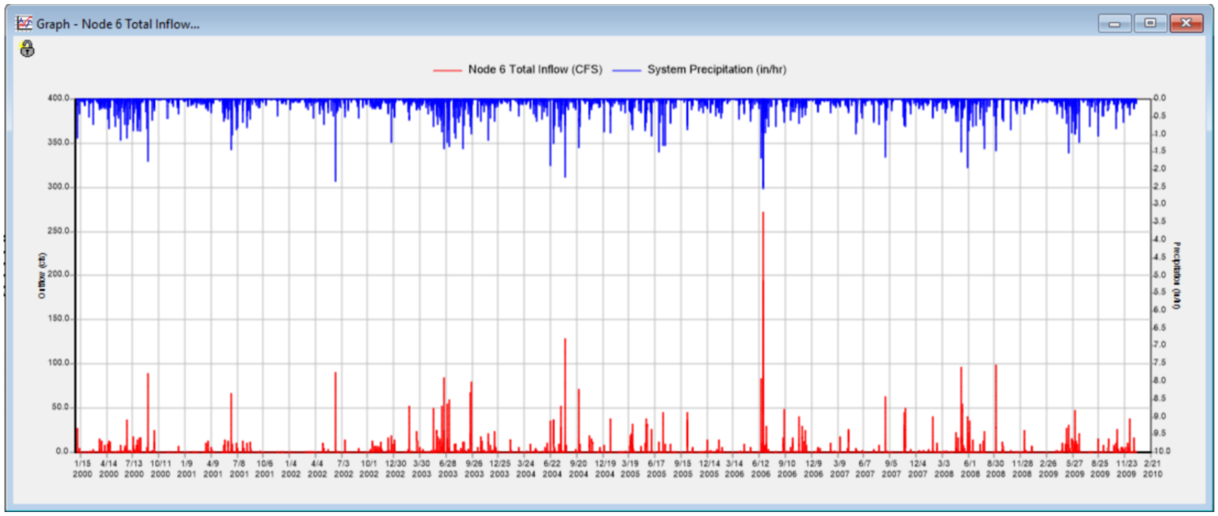

Figure 4. SWMM modeled Ashby Pond volume/, Jan 1, 2000-Jan 1, 2010.

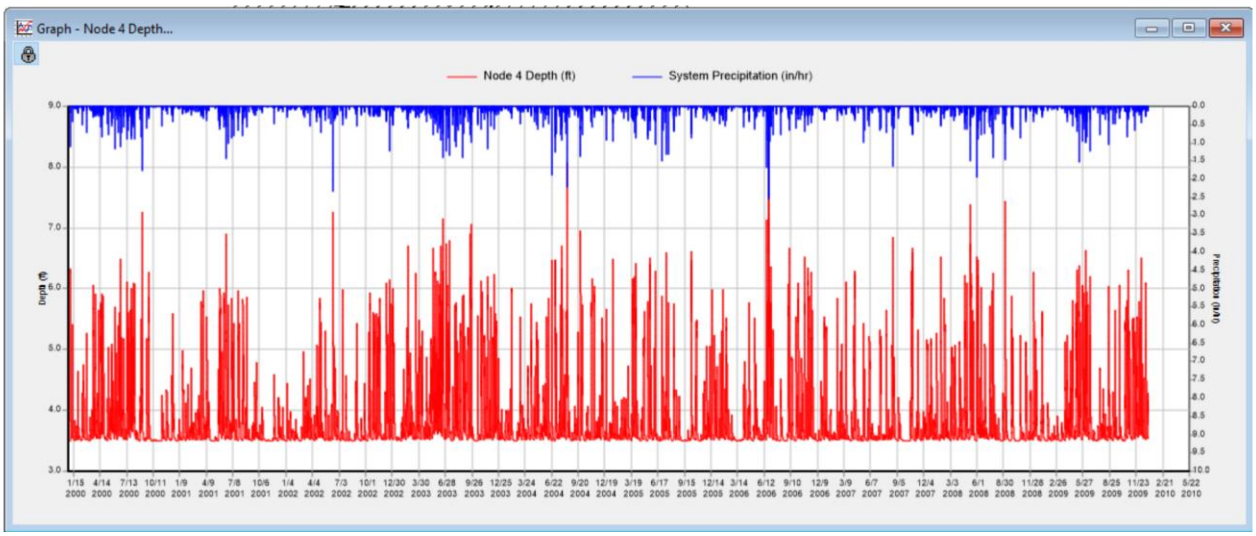

Figure 5. SWMM modeled Ashby Pond outflows, Jan 1, 2000-Jan 1, 2010.

The pond volume and outflow were processed into a series of events using PCSWMM (Computational Hydraulics International) and treatment with and without the FTWs was simulated using the i-FTW model, varying % raft coverage from 5 to 50%, and assuming annual harvesting, a constant removal rate for N and P, and incoming watershed event mean concentration (EMC) of TN=3.0 mg/L N and 0.3 mg/L P, an initial pond concentration of 1.0 mg/L N and 0.1 mg/L P, k_w=0.021 1/d N, k_w=0.026 1/d P (average literature values). Mass removal for N and P was computed as the median of the annual loads for the 10-year series. Three separate curves were produced for TN and TP removal, for v_f values at the 25th, 50th, and 75th percentile for N and P, taken from Wang and Sample, 2013. Results are provided in Figure 6 for TN and Figure 7 for TP. These results suggest that FTWs can make modest improvements in small wet pond performance, 3-7%N, 7-9% P.

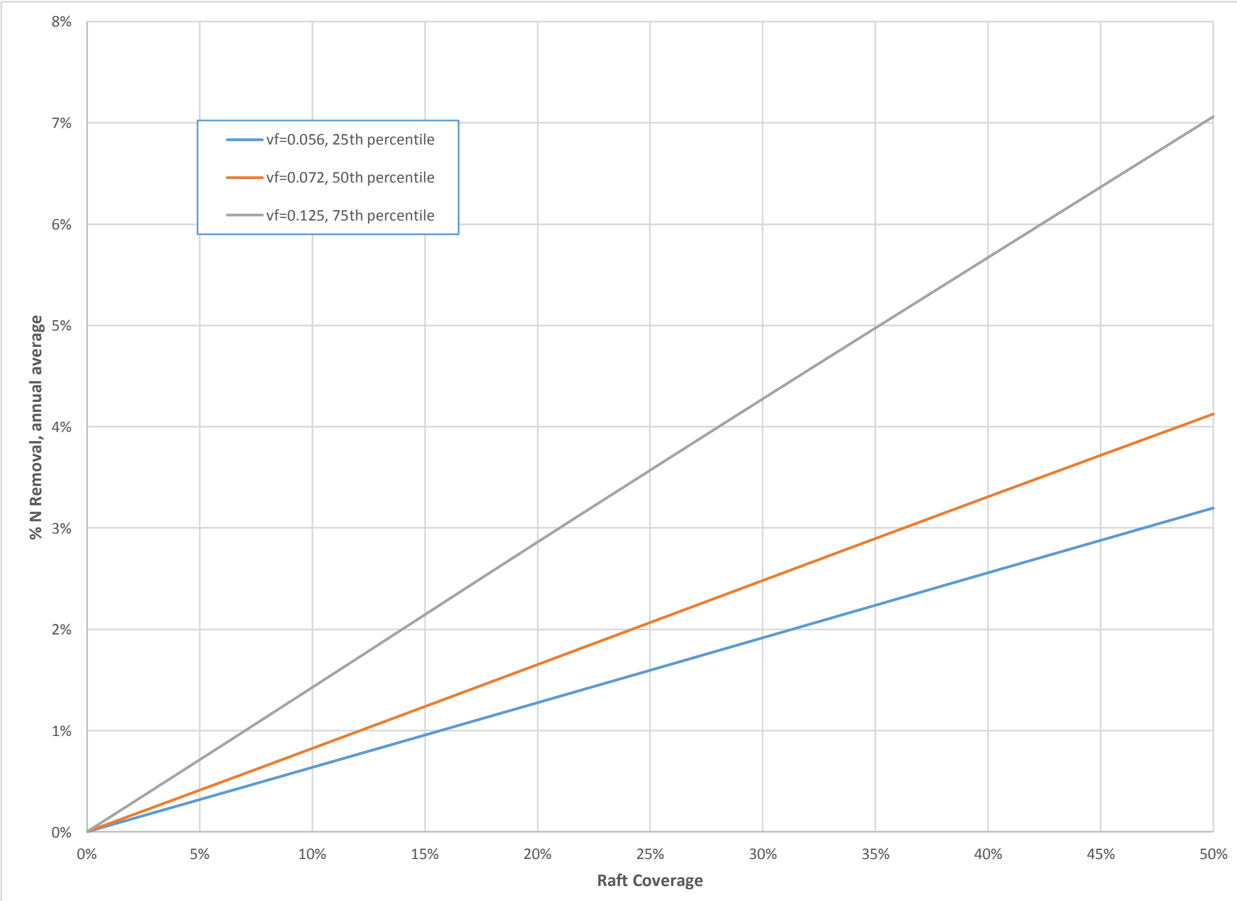

Figure 6. Modeled TN removal from Ashby Pond, Jan 1, 2000-Jan 1, 2010.

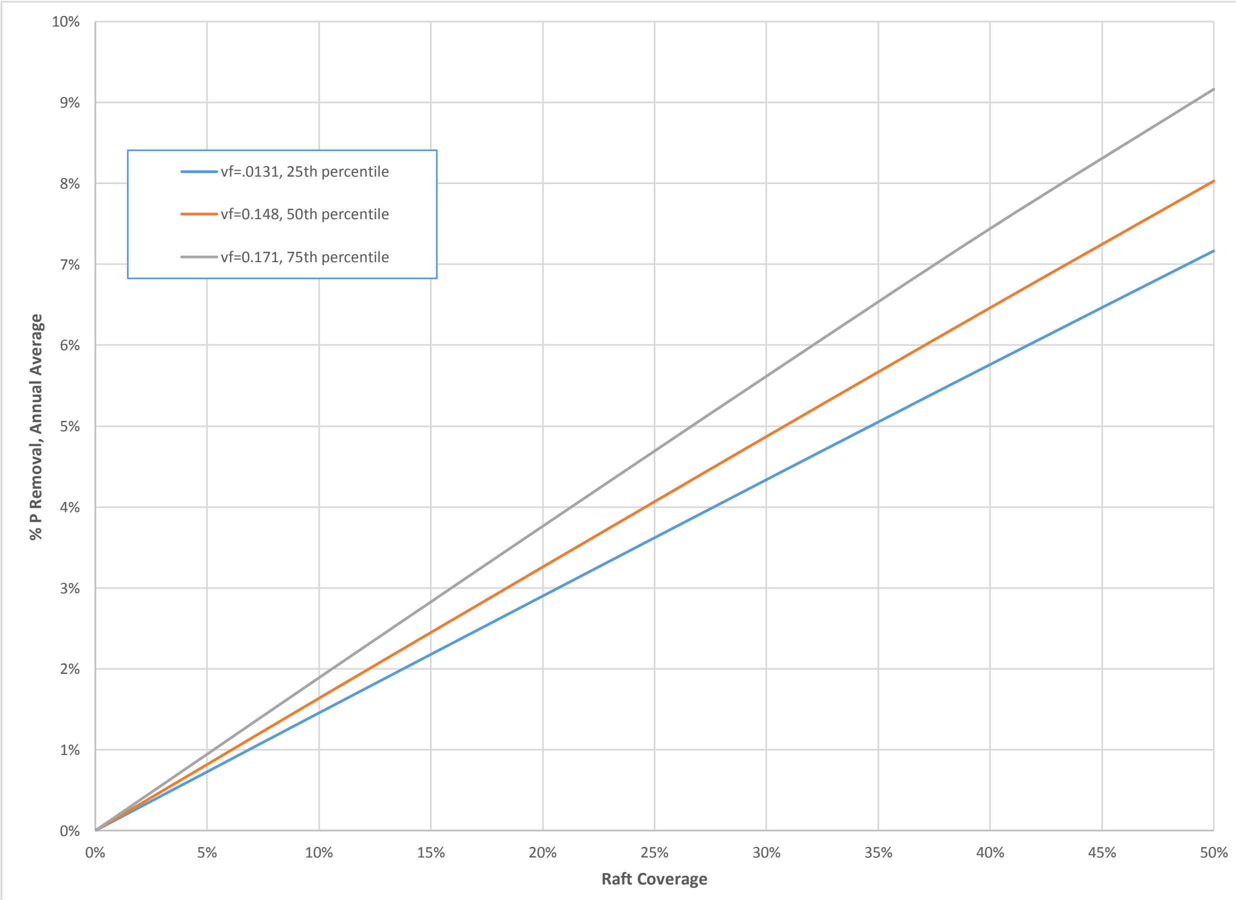

Figure 7. Modeled TP removal from Ashby Pond, Jan 1, 2000-Jan 1, 2010.

Sediment Removal Rates: Since the current version of the i-FTW model does not predict the incremental sediment reduction achieved by FTW retrofits, the expert panel used professional judgment and sedimentation theory to derive TSS removal rates based on percent raft coverage. The basic technical assumption was that TSS removal rate was directly linked to the known TP removal rate calculated from the i-FTW model. Specifically, the TSS Removal Rate is = TP removal rate/0.7. This is based on the fact that TSS is 100% particulate, and TP is only 70% particulate (the remainder being soluble in nature). This assumption is reinforced by three decades of pond research that shows TSS removal consistently exceeding TP removal in pond environment.

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Appendix C. Conformity with BMP Review Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT, 2014) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

1. **Identity and expertise of panel members:** See Table on Page 5

2. **Practice name or title:** Floating treatment wetland (FTW) retrofits of existing wet ponds

3. **Detailed definition of the practice:** Section 2.1, page 7. The practice is considered a variant of the BMP enhancement retrofit category, as defined by a prior expert panel.

4. **Recommended N, P and TSS loading or effectiveness estimates:** An incremental removal rate above the baseline removal rate for wet stormwater ponds, as calculated from the curves presented in Sections 4.2 and 4.3 of the report.

5. **Justification of selected effectiveness estimates:** See Section 3: Review of the Available Science (pages 9-22)

6. **List of references used:** Page 34 for literature cited in the report, and Appendix A for all literature consulted

7. **Detailed discussion on how each reference was considered:** See Section 3: Review of the Available Science (pages 9-22)

8. **Land uses to which BMP is applied**: urban land uses, including impervious and pervious land

9. **Load sources that the BMP will address and potential interactions with other practices**: Urban stormwater runoff generated from the contributing drainage area of existing wet stormwater ponds.

10. **Description of pre-BMP and post-BMP circumstances and individual practice baseline:** Applies to FTW retrofits installed at existing stormwater wet ponds that meet the qualifying conditions outlined in Section 2.2 (p. 7). Each FTW must also meet all the performance criteria outlined in Section 2.1 (p. 7).

11. **Conditions under which the BMP works/not works:** The practice requires regular operation and maintenance to perform properly. Research on operational and maintenance issues is provided in Section 3.5 (p. 17).

Recommended operation and maintenance criteria for FTW retrofits are provided in Section 5.3.

12. **Temporal performance of BMP including lag times between establishment and full functioning:** No lag time in performance for FTW retrofits.

13. **Unit of measure:** percent removal for TSS, TP and TN

14. **Locations in CB watershed where the practice applies:** Anywhere in the Bay watershed where the qualifying conditions are met.

15. **Useful life of the BMP:** Three years, if an enforceable O&M plan exists for the FTW retrofit, one year if it does not.

16. **Cumulative or annual practice:** Cumulative

17. **Description of how BMP will be tracked and reported:** See Section 5 (pages 29-31)

18. **Ancillary benefits, unintended consequences, double counting:** Potential benefits of FTWs are outlined in Section 2.3. No significant unintended consequences or double counting issues associated with FTWs.

19. **Timeline for a re-evaluation of the panel recommendations.** 5 years, see section 6.1 (page 32)

20. **Outstanding issues:** None

Appendix D. Technical Requirements to Entering the Practice in Scenario Builder and the Chesapeake Bay Watershed Model

Background: In accordance with the *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model* (WQGIT, 2015) each BMP expert panel must work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert panel report.

The purpose of this technical appendix is to describe how the Expert Panel's recommendations will be integrated into the Chesapeake Bay Program's modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Part 1: Technical Requirements for Reporting and Crediting the Practice

Q1. How is the BMP defined in the Chesapeake Bay Watershed Model?

A1. Floating treatment wetlands (FTW) are a variant of the BMP enhancement retrofit category. A more specific definition of the practice is provided below.
*Wet Pond: A*n existing stormwater retention pond with a permanent pool of water that has an average depth of 3.5 to 8 feet and meets performance criteria for an effective FTW retrofit application. Wet ponds designed to treat runoff from impervious surfaces associated with the farmstead, covered storage areas and barn rooftops in rural areas are also eligible for the retrofit.
Floating Treatment Wetlands: A proprietary or non-proprietary floating island design that incorporates the following general elements:

- A buoyant artificial raft that floats on the surface
- Constructed from non-toxic materials such as, but not limited to, HDPE plastic, marine grade polystyrene foam and PVC pipe
- Containing growing media planted with aquatic macrophytes whose roots extend well below the water surface.

Q2. What types of qualifying criteria must be met to report the practice for credit in the Phase 6.0 Watershed Model?

A2. The FTW application within an existing pond must:

- Achieve a minimum pond surface coverage of 20% and a maximum cover of no more than 50%
- Have an initial planting density of 2 plugs per square foot and attain a 80% plant coverage on the raft by the end of the growing season
- The raft should be placed perpendicular to the stormwater flow path and be at least 3.5 feet above the bottom of the pond
- Utilize FTW units with a large surface area
- Possess a suitable method for re-aeration to prevent anoxic discharges from the pond during the summer months

- Be adequately anchored or tethered in the pond to protect its flood control function during major storms and enable retrieval for periodic maintenance, yet anchoring should not be too taut to inundate the surface and flooding the raft
- Not be infested with invasive plants and should be initially protected with netting from geese and turtles during plant establishment
- Use native wetland plant species that are appropriate for the ecoregion

Q3. Which land use categories are eligible to receive nutrient and sediment reduction credit the Practice in the Phase 6.0 Watershed Model?

A3. In the Phase 6.0 Watershed Model, nutrient and sediment reduction credits for the practice are applied to all of the land uses within the contributing drainage area of the existing wet stormwater pond that meets the qualifying condition.

Q4. How much nitrogen, phosphorus and sediment reduction credit are associated with the practices?

A4. A series of curve are used to define the incremental TSS, TP and TN removal rate associated with the FTW retrofit, based on amount of FTW coverage over the surface area of the existing wet pond, as described in Section 4.3. A design example is presented in Section 4.4 to show how to properly compute the credit.

Q5. What do jurisdictions need to report to NEIEN in order to receive credit?

A5. FTW pond retrofits fall within an existing category of stormwater retrofits -- Enhancements to Existing BMPs - so jurisdictions will need to report the following to NEIEN:

- Retrofit class (i.e., Enhancement of existing BMP)
- GPS coordinates for the wet pond (lat/long)
- Year of installation (and year credit lapses)
- 12 digit watershed in which it is located
- Total drainage area and impervious cover area treated by the wet pond
- Runoff volume treated by the wet pond
- Percent FTW coverage over pond surface area
- Incremental sediment, nitrogen and phosphorus removal rates, as calculated by the FTW curves

Q9. Are the practices cumulative or annual BMPs?

A9. This class of retrofit is a cumulative practice.

Q10. How does the BMP interact with other BMPs located within the same catchment in the CBP modeling tools?

A10. The FTWs are installed within existing wet ponds and otherwise have no interaction with other BMPs.

References:

Chesapeake Bay Program (CBP). 2014. Strengthening verification of best management practices implemented in the Chesapeake Bay watershed: a basin-wide framework. Report and documentation from the Chesapeake Bay Program Water Quality Goal Implementation Team's BMP Verification Committee. Annapolis, MD.

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Appendix E. Compiled Panel Meeting Minutes

Floating Treatment Wetlands Expert Panel
First Teleconference
Meeting Minutes
Friday, September 6, 2013

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present?**
Sarah White	Clemson University	Yes
David Sample	Virginia Tech	Yes
Andy Lazur	U of MD	Yes
Sarah Lane	MD DNR	Yes
Ryan Winston	NCSU	No
Chris Streb	Biohabitats, Inc.	Yes
Drew Ferrier	Hood College	Yes
Randy Chambers	College of William and Mary	Yes
Karen Duhring	VIMS	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	Yes
Chih-yu Wang	Virginia Tech	Yes
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes Yes

1. **Call to Order and Panelist Introductions**
   Tom Schueler, CSN, called the meeting to order, thanked the panelists for their participation in the Expert Panel and gave a brief overview of the Chesapeake Bay Program's BMP Panel Review Process (Attachment B). **Tom** explained that most of the other Expert Panels have not worked with proprietary technologies and that it is not the job of the panel to endorse one proprietary technology over another and that is essential that whatever recommendations the panel comes up with will need to be defined in a "nonproprietary way". **Tom** then asked the panelists to introduce themselves.

2. **Review of the Charge for the Panel, the BMP Panel Review Process and Panelist Responsibilities**
   Tom reviewed the charge for the Floating Treatment Wetlands practice (Attachment A) and asked the panelists if they had any questions. He then went over the general CBP protocol for developing pollutant removal rates for urban BMPs and the expectations for the panelists (Attachment B).

3. **Summary of 2012 Research Workshop**
   Tom provided an overview of the 2012 research workshop (Attachment C) and asked the panelists who were in attendance at that workshop to identify what they thought the main technical issues associated with FTW would be for panel consideration:
   - **Sarah White** - long-term capability; active vs. passive systems

- **Sarah Lane** – active vs. passive; nutrient removal mechanisms; double-counting.
- **Andy Lazur** – still some data gaps: maintenance may be more anecdotal information based on what researchers encountered when studying the practices; type of FTW used; plant species options; harvesting and disposal

Randy Chambers asked if there is enough scientific research to answer all of the questions identified in the charge. **Tom** noted that this a good point and although we prefer peer-reviewed literature, it is okay for the panel to review unpublished or gray literature and so **please send any relevant research and or reports to CSN to be included in the literature list** (Attachment D). **Sarah Lane** noted
that there may not be enough information in the data pertaining to the issue of long- term maintenance and replacement frequency. **David Sample** noted that the panel may not be able to achieve everything identified in the charge but that should be able to make some good recommendations. It would be good to separate out the performance of FTWs in stormwater ponds from those in use in open water systems. **Tom agreed and said that CSN would try to group the literature into categories. Tom** also informed the panel of the Urban Stormwater Retrofits Expert Panel Recommendations and indicated that the panel would want to take a look the final report to (1) get an idea of the final product of the Urban BMP Review Panels and (2) to evaluate if the panel would opt to use a similar crediting approach for FTWs.

ACTION: Panelists to send all research/reports to CSN to be included into literature list.

ACTION: CSN to send retrofit expert panel report to panelists.

4. **Review Process of Recent Literature on FTW Practices and Discussion of Research Review Workshop Cecilia Lane, CSN**, explained the literature review process. Asked panelists to identify and submit important existing black and grey literature on studies that are not yet included in our reference list (Attachment D). **Cecilia** noted that all of the literature is going to be housed on a dropbox website to which she will be sending around a link and instructions. She will be assigning the literature to the panelists for presentation at the next meeting. **Tom** explained that the next panel meeting will be the "research review workshop" (Attachment E) where panelists will be asked to present on the research they are conducting and/or on the literature they reviewed from the literature list. Each panelist will be asked to review approximately 4 papers from the literature list and prepare 4-5 slides about each paper relevant to the charge. **Cecilia** explained that many documents were submitted by industry representatives and may not have been subjected to the scientific rigor that is required by the CBP Protocol. **Tom** indicated that he would be asking 1-2 panelists to review the promotional documents. The Panel then discussed grouping the literature into the following

categories and **Tom** asked panelists to volunteer for a specific category of papers to review:

- Type of water body used in:
    a. Stormwater ponds,
    b. Open water/tidal
    c. Agricultural/swine lagoons,
    d. Running water
- Mesocosm vs. full application
- Plant species: freshwater (**Sarah White**) vs tidal (**Karen Duhring**)

Tom asked **Lew Linker** to provide a 15 min presentation on how the Chesapeake Bay Watershed Model (CBWM) credits BMPs installed in the watershed at the next panel meeting.

The panel discussed scheduling the next panel meeting and **Tom** asked the panelists to please respond quickly to doodle polls requests to ensure scheduling success.

ACTION: CSN to group literature into categories and assign to panelists.

ACTION: All literature and panel documents to be housed in a dropbox account. CSN to send link and instructions to panel dropbox folder to panelists.

ACTION: Lew Linker to provide a presentation on the CBWM at the next panel meeting.

ACTION: CSN to revise the agenda based on panel feedback and send around to panelists.

ACTION: CSN to follow-up with researchers on presentation requirements for the Research Review Workshop.

5. **Scoping of Technical Issues to Address.**

Tom Schueler, CSN, explained that in the past BMPs were assigned a unit removal rate but most of the recent panels have found it difficult to justify these unit removal rates (see Urban Stormwater Retrofits Expert Panel Recommendations Section 4). **Tom** then asked the panel if they had any preliminary ideas about what the crediting protocols would be for FTWs.

- **Sarah White**: difference in input concentrations, temperature, vegetation
- **Tom** also gave an overview of how crediting FTWs was handled in North Carolina and indicated that panelist Ryan Winston could speak more to this at the next panel meeting.
- **Dave Sample**: 5-10% is similar to the numbers he has been seeing

- **Chris Streb**: said the National Aquarium study was able to use the number and density of organisms to project potential reductions; study should be out soon **Chris to send new National Aquarium report to panel when complete**; long-term survival of the systems will need to be considered.
- **Sarah Lane**: advised the panel to look at discount factors for the BMP efficiencies; to consider if local governments will be able to get the same pollutant removal as researchers conducting studies; possibly take a two-tiered approach to address the difference in removal rates associated with actively (harvested) vs. passively managed systems; **Tom** asked Sarah if there were any Algal Turf Scrubber papers relevant to this panel to please send them along for panel review. **Sarah** indicated that she would be able to send the preliminary ATS panel recommendations.

ACTION: Chris Streb to send new National Aquarium report to panel when complete

ACTION: Sarah Lane to send the preliminary ATS panel recommendations.

Tom Schueler thanked the panelists for their service. Indicated that we typically get minutes out within the next week. He encouraged panelists to look at the approved reports
http://www.chesapeakebay.net/groups/group/urban_stormwater_workgroup
(under the "publications" tab).

List of Attachments

- Attachment A – The Proposed Charge for the Panel
- Attachment B – The CBP Protocol
- Attachment C – Findings from research workshop 2012
- Attachment D – Literature List
- Attachment E – Draft Agenda for Second Meeting

Floating Treatment Wetlands Expert Panel
Second Meeting – Research Workshop
Meeting Minutes
Friday, November 1, 2013

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present?**
Sarah White	Clemson University	Yes
David Sample	Virginia Tech	No
Andy Lazur	U of MD	No
Sarah Lane	MD DNR	No
Ryan Winston	NCSU	Yes
Chris Streb	Biohabitats, Inc.	Yes
Drew Ferrier	Hood College	No
Randy Chambers	College of William and Mary	Yes
Karen Duhring	VIMS	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	Yes
Chih-yu Wang	Virginia Tech	No
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes Yes

1. **Call to Order and Panelist Introductions**
   Tom Schueler, CSN, called the meeting to order, thanked the panelists for their participation in the Expert Panel and explained that the goal of the research workshop is to hear from experts on in the field on the research they have conducted on Floating Treatment Wetlands (FTWs) as well as from the panelists on the literature they have reviewed. The Panel is looking for commonalities in the research and answers to the panel's charge.

2. **Literature Update**
   Cecilia Lane, CSN gave an update on the literature review phase of the panel. Several panelists noted that they had trouble accessing their papers. **Cecilia** will follow-up with those panelists after the meeting to make sure they have all of the literature they need. **Lew Linker** asked where the resources from the panels ultimately end up. **Tom** agreed that CBP needs to establish an archival protocol for the panel resources and agreed to bring it up to the USWG.

ACTION: Cecilia to follow-up with panelists individually to help them get the literature they were assigned.

ACTION: Tom to talk to USWG about an archival protocol for expert panel resources.

ACTION: Panelists please submit any additional literature for the review to Cecilia Lane watershedgal@hotmail.com by December 1, 2013.

3. **Overview of Simulating BMPs in the Chesapeake Bay Watershed Model Lew Linker, CBPO** gave an overview of how BMPs are simulated in the Chesapeake Bay Watershed Model. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- A special edition of JAWRA devoted to the Chesapeake Bay, includes several papers on the watershed model; The papers can be found here on the CBP website under the publications tab here: http://www.chesapeakebay.net/groups/group/modeling_team
- **Tom** informed the panel that every expert panel has made recommendations on how to enhance the model and CBPO welcomes the feedback.
- **Tom** noted that many other panelists have asked about the sediment delivery ratio factor of the model and how that relates to reductions. He also noted that there is a discount factor applied to Nitrogen. It is important to note that the unit loads for urban land and BMP reductions you get are not 100% of what gets to the Bay.
- FTWs will probably be modeled as a "management filter" in the CBWM.
    - **Chris Streb** noted that FTWs may be categorized as augmentations of ponds versus the estuarine applications. Surface area coverage and depth will be important for the BMPs, what sort of implication for the model?
    - **Tom** answered that what other panels have done to address this issue is to identify bounding conditions wherever possible based on the application of or the design factors of the BMP (as defined in the research) and in this way the panel can exclude the nonperformers. Also other panels have developed a computational protocol with "qualifying conditions" for a BMP to receive a project specific removal rate.
- **Ryan Winston** asked for clarification on what reductions we are looking to define in this panel. **Tom** clarified that the purpose of the panel is to identify appropriate reduction efficiencies for Floating Treatment Wetlands for all three pollutants TN, TP, TSS. They can either be expressed as a straight load reduction or an enhancement of an existing BMP. Will share some tables with the panel on the average loading coming off of urban pervious and impervious lands and share a copy of the retrofit technical memo with the panelists.

ACTION: CSN to share the loads from urban pervious and impervious lands with the panel. Reminder to panelists to take a look at the retrofit expert panel memo.

4. **Research Presentations**
   Ryan Winston, Josh Lowman, and **Sarah White,** gave presentations on the research they have conducted on Floating Treatment Wetlands. This summary

provides a brief snapshot of the day's presentations, and focuses on the key points and discussion rather than the information presented on the slides. Please consult the presentations for details. All presentations are available on the FTW dropbox folder.

Ryan Winston presented his research on *Floating Treatment Wetlands as Retrofits to Existing Stormwater Wet Retention Ponds in North Carolina*. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- **Ryan** introduced himself to the panel and gave a brief overview of his background in FTWs. **Ryan** is a research scientist at NCSU and works under Bill Hunt studying FTWs among other BMPs. North Carolina has recently approved FTWs for use as a BMP and Ryan was involved in that process.
- **Tom** noted and **Ryan** confirmed that seasonal harvesting was not part of the management regime for the FTWs as part of the study – rather the islands were passively maintained.
- Surface area coverage is a potential way to credit FTWs and that is how it has been approached in North Carolina (NC)
- Ryan noted that it is important to direct water flow through root zone because that is where sedimentation can occur and where nutrient uptake can occur either through adsorption to the roots themselves. Research in Australia looking at restricting flow through root zones. Recommend aligning FTWs perpendicular to the flow to force water through root zones.
- Think most of the nutrient removal is occurring in/underneath the root zone through flow retardants and biological activity in the root zone.
- **Ryan** discussed some of Karine Borne data (University of Auckland) – she looked at 50% surface area coverage (against a no treatment pond). Median effluent concentrations (TN) were lower with the FTW at 50% coverage. Very low for TP.
- NC allows FTWs as a retrofit to existing stormwater ponds. Phosphorus credit requires 20% surface area coverage and require 80% of the FTW to be planted. Required to be placed perpendicular to flow. No additional credit given for TP beyond 20% coverage. Removes requirements for additional pond components (filter strip, shelves etc.)
- **Tom** asked **Ryan** about the plants used in the different studies. **Ryan** explained they looked at seasonality but didn't see much difference in FTW performance. FTWs have been used in Montana. The majority of the treatment occurs in/is due to roots of the plants so cold weather systems would still be able to remove pollutants due physical filtration and allow for some sedimentation.
- **Tom** noted that a lot of the research indicates that the ability of the FTWs to reduce pollutants via denitrification however the research did not include in-situ measurements, do you think denitrification occurred?
    - **Ryan**, they did not do in-situ measurements; Karine Borne research has shown conditions for dissolved oxygen (DO) where denitrification would occur and collected measurements for DO.

Ryan will send her paper to the panel, it is not in peer review yet, asks the panel to keep it internal.

- **Lew Linker** asked what physical processes for TP and TSS removal are occurring with the practices and how can we up the denitrification potential of the FTWs.
  - **Ryan**, the physical filtration and increased sedimentation as a result of the decreased velocity as water flows through the roots. Also very small particulates adsorb to the roots
  - Denitrification potential of FTWs determined by looking at DO underneath the islands

ACTION: Ryan to send Karine Borne paper on DO measurements in stormwater ponds with FTWs.

Josh Lowman from ESIS, Inc., Health, Safety and Environmental gave a presentation on the *Evaluation of Floating Treatment Wetlands in Stormwater Retention Ponds on Poultry Farms to Reduce Nutrient Loading*. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- Nutrient removal was an order of magnitude higher than Ryan Winston's data (sites in piedmont) due to groundwater influence and having dirtier water entering the system
- Plant uptake is a big part of the nutrient reduction value of the system
- Would have liked to look at when the chickens were removed – might have added to the N input to the system
- **Lew Linker** asked where the sampling was conducted; **Josh** clarified they sampled at the center and the edge of the matrix.
- High denitrification potential in the center of the mats
- **Tom** asked what proportion of the surface area the FTWs occupied. **Josh** didn't have the data in front of him but can let us know. **Tom** commented that he is envisioning table with all of the research studies organized by area coverage for the panel to review
- **Sarah White** asked if there would have been a difference in the denitrification potential if they had looked at the root systems versus the mats. **Josh** thinks there would be more potential for denitrification in the mats (versus the roots) because of increased surface area
- **Sarah White** asked if the calculations of surface area for the roots versus the mats have been done by anyone, maybe plant dependent. Both **Josh** and **Ryan** indicated that this had not been done in their research. Unsure if it exists in the literature.
- **Chris Streb**, saw in the Baltimore Inner Harbor work that surface area of the roots also dependent upon the other organisms in the system (for example, roots are grazed by organisms)
- **Tom** asked which plants performed the best in their study. **Josh** noted that Swamp Milkweed and Lake Sedge performed best (followed by swamp mallow, bulrush and cardinal flower) and that was based on visual and plant

biomass analysis *only*. **Josh** also noted that invasive plants were an issue on the edges of the FTWs but once plants were established with a high enough density, it could be easily managed.

- **Chris Streb** commented that he reviewed the **White** and **Lowman** papers and noted that their numbers didn't match. Asked if this was a conversion issue? 26- 126 kg/ha (Lowman) vs. 16 - 28 g/m² (White) – White's study had 95% cover;
    - **Lew Linker** surprised that denitrification is happening within the matrix itself and independent of the plant community. Panel should consider recommending how to construct FTWs for the best possible pollutant removal. **Lew** also asked Josh to define the "edge" of the FTW**Ryan**'s study used peat moss as the media; **Josh's** study used plastic in matrix and added peat moss for plant establishment.
    - **Josh** noted that his ideal FTW (for N removal) would be a donut shaped island for optimal denitrification to occur
- **Chris Streb**, Denitrification potential was rate per mass of material when corrected by area and mass of material, the overall denitrification potential of the FTWs was 3-6% of each pond. Why do you think that was?
- **Josh** offered to do whatever he can to help with the panel.

ACTION: Cecilia to follow-up with Josh Lowman about the studies he cited in his ppt to be added to our literature list.

ACTION: Cecilia to follow-up with Josh Lowman on what amount of the pond surface area was covered with FTWs in his research project.

ACTION: CSN to create a table of the research studies organized by area coverage for the panel to review

ACTION: CSN to put together table on above ground accumulation rates and removal in lbs/sqft

Sarah White, Clemson University, presented on the *Evaluation of Floating Treatment Wetland Plant Nutrient Uptake with Varied Nutrient Loading Rates*. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- **Chris Streb** asked and **Sarah White** clarified that they harvested at the end of the study (8 weeks)
- Very little difference in concentration over time between when tanks are spiked and then drained
- Used in a very rich nutrient scenario where they plants were not nutrient derived, which will probably drive the reduction efficiencies
- 50% had more nutrient removal
- **Chric Streb** asked if there was a higher concentration in the *juncus* experiment. **White**, yes but couldn't fix as much.

- **Tom** commented on the use of edible plants in FTWs would need to be dependent upon application of them (i.e., not used in swine lagoons).
- **Tom** asked about the DO data: asked which system the 50-100% numbers were for. **White** clarified that was from the mesocosm (smaller) system where she actually had bubblers set up. It's important point that if had 50-100% coverage in a stormwater pond and resulted in the release of anoxic waters downstream, that would be a water quality violation. What factors are impacting the DO measurements? **White**, it could be depth. Systems only 30" deep. **White** thinks we should be careful having 50% coverage and the potential for anoxic effluents.
- **Streb**, one of her papers indicated that 90% coverage resulted in 2 degree drop in temperature which would benefit/offset the DO levels. **Streb** noted that the additional coverage will drop the temperature from both shading and ET processes. Seeing a 3-4 deg Celsius reduction in a project he's working on. **Tom** agreed that is something that the panel will need to address as well: although we can't always measure change in volume in a stormwater pond but could use standard ET metrics to be used**. Streb** offered to submit some papers with ET rates to the panel. **Streb** also noted that hydraulic residence time is a key factor for thermal benefits. **Tom** noted the average hydraulic residence time for a stormwater pond is approximately 6-7 days.

ACTION: Chris Streb to submit papers on ET papers for panel review

5. **Research Summaries**
   The remaining panelists gave brief overviews on the literature they reviewed for the panel primarily focusing on information that could be used to address the panels charge. **Chris Streb**, **Randy Chambers**, **Karen Duhring** and **Kevin Brittingham** gave brief overviews of the literature they reviewed for the panel. The main conclusions can be found in the presentations in the dropbox folder. The following are some of the discussion highlights:

- **Streb**, Lowman study has some cost data that may be useful. **Tom** noted that none of the other panels have addressed cost however since FTWs are an innovative technology the users would need cost information.
- **Streb,** maybe could have less surface area coverage with directed flow to prevent short-circuiting. **Winston** agrees, surface area coverage is not the only metric to be considered.
- **Tom** informed the panel that the ESC panel has found that using 3 baffles in a sedimentation basin increased sediment removal. Supports the idea of flow direction as an important factor.
- **Winston** noted that the Florida paper (that Duhring reviewed) was based on grab sampling. **Tom** noted that dry removals have better quality than wet weather.
- **Tom** asked about the incoming concentrations for the aquaculture treatment system (Italian paper). **Brittingham** confirmed that there was data in the

paper and that it was a highly loaded system. **Brittingham** recommended that all panelists read the FTW review paper (Tanner, EST).
    - *T. R. Headley & C. C. Tanner (2012): Constructed Wetlands With Floating Emergent Macrophytes: An Innovative Stormwater Treatment Technology, Critical Reviews in Environmental Science and Technology, 42:21, 2261-2310. Available at: http://dx.doi.org/10.1080/10643389.2011.574108*
- **Tom** reminded panelists that if they review a resource that doesn't meet the CBP requirements for scientific rigor, simply email Cecilia the name of the paper and she will remove it from the literature collection.

ACTION: All panelists to read the paper: FTW review paper (Tanner, EST)

6. **Discussion of Technical Information**
Tom thanked all of the panelists for their presentations and asked everyone to indicate what they had learned during the course of the day and what ideas were reinforced by the data that was presented. He reminded the group that we are looking for the panel to identify areas of concurrence, common threads and also identify areas of missing information.

- **Ryan Winston**, noted that he found it interesting that Josh Lowman's research identified that location of the FTW where the denitrification occurred was very important; reinforced the idea that much of the nutrient removal occurs through suspended particle removal and plant uptake not as much of a factor in nutrient removal as biofilm
- **Sarah White**, surprised by North Carolina recommendation for 20% coverage (Wannalista work had previously said over 10% no additional benefit); interested to know more about the biofilm factor
- **Randy Chambers**, denitrification issues and the impact of the 'edge' effect that Lowman noted; Panel will need to better define how things are working from a nutrient perspective in FTWs. residence time issues (1 year, 24-hr storm for at least 24 hours) think about impact of FTW in the stormwater pond context;
    - **Ryan**, ponds in NC drawdown in 2-5 days (1" wq volume and 10 year storm)
    - **Tom**, ponds do have a permanent pool and concentration goes up and down dependent on storm size.
- **Tom** agreed and said that if FTWs are going to be applied to stormwater ponds will need to consider the residence time of ponds. Tom will give a presentation on ponds and the different designs by state at the beginning of next panel meeting.
- **Lew Linker,** struck by complexity of the nutrient removal processes: the matrix itself having denitrification potential, interception of flow, settling, etc. Implications of these issues in the panel recommendations
- **Karen Duhring**, surprised by Lowman work; the idea of a 'beneficial use' and if panel is going to recommend harvesting – need to know more on how to

harvest and provide that information to local implementers and the idea of beneficial uses of harvested material

  - **Streb**, that might be the biggest different between the beemat (a potted plant) and biohaven versions of FTWs
  - **White,** very heavy and difficult to harvest
  - **Winston**, biohaven mats – not possible to get plants out of matrix, very difficult
  - **Streb**, harvesting in open water was very difficult

- **Chris Streb**, NC methodology is a good way to approach it (at least as a baseline), struck by no tidal attenuation papers. Encouraged by Lowman finding of edge effect (would help with O&M)
  - **Tom,** the Panel can decide later about the wave attenuation/open water type of application
- **Kevin Brittingham**, majority of Baltimore County ponds are ED dry ponds (and usually are drained by County as a result of citizen complaints), not sure how beneficial the FTWs would be, also thoughts about privately owned ponds trying to use FTWs to get utility fee credits. **Tom** noted that final report could contain information on the location of wet ponds in the watershed and where the FTWs could be applied.
- **Tom** great to see the denitrification work so don't have to rely solely on nutrient removal from plant uptake. Reinforced by the design variations didn't result in a huge change in benefits of FTWs.

7. **Identification of Next Steps for the Panel**
   Tom noted that we will have our next panel meeting in December at which he will provide an overview of stormwater ponds and how it is relevant to the FTWs. The Panel will hear from the remaining panelists; **Tom** asked the panel prior to the next meeting to please start thinking through conceptual models on how this might be expressed. **Tom** thanked the panelists for their support.

Floating Treatment Wetlands Expert Panel
Third Teleconference
December 20, 2013
Meeting Minutes

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present?**
Sarah White	Clemson University	Yes
David Sample	Virginia Tech	Yes
Andy Lazur	U of MD	Yes
Sarah Lane	MD DNR	Yes
Ryan Winston	NCSU	No
Chris Streb	Biohabitats, Inc.	Yes
Drew Ferrier	Hood College	Yes
Randy Chambers	College of William and Mary	Yes
Karen Duhring	VIMS	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	Yes
Chih-yu Wang	Virginia Tech	Yes
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes Yes

ACTION ITEMS:

ACTION (*ongoing*): Tom to talk to USWG about an archival protocol for expert panel resources.

ACTION (*ongoing*): CSN to share the loads from urban pervious and impervious lands with the panel. Reminder to panelists to take a look at the retrofit expert panel memo.

ACTION (*ongoing*): CSN to create a table of the research studies organized by area coverage for the panel to review

ACTION (*ongoing*): CSN to put together table on above ground accumulation rates and removal in lbs/sqft
ACTION (*ongoing*): All panelists to read the paper: FTW review paper (Tanner, EST)
ACTION: Andy Lazur to send the CBT final report to CSN for inclusion in the literature.

ACTION: Next meeting date set for Wednesday, January 29th from 10 12.

1. **Call to Order and Panelist Introductions**
   Tom Schueler, CSN, called the meeting to order, thanked the panelists for their participation in the Expert Panel and explained that this meeting was a continuation of ast month's research workshop. He reviewed the minutes and action items from the last meeting.

2. **Overview of Stormwater Ponds**
   Tom Schueler gave a presentation on the performance of wet ponds as this will be the baseline removal of the FTW removal rate. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:
   - Bay State regulations have changed over time to discourage the use of wet ponds: environmental permitting and downstream temperature impacts.
   - Most ponds built for ½" or 1" retention
   - Original removal rates for wet ponds were less than the values found in the literature in order to take a conservative approach
   - Wet ponds have a pretty constant rate of removal (as compared to other LID practices)
   - New expert panels categorized all practices into either Runoff Reduction (RR) or Stormwater Treatment (ST) practices
   - **Tom** noted that the panel could opt to use the curves for the base removal rate of a wet pond and then provide additional incremental rates for ponds with FTWs (as enhancements from retrofit panel recommendations). The additional removal rates would be based on qualifying conditions that the panel has briefly discussed in the past (i.e., minimum coverage, orientation, harvesting, aeration etc.)
   - **Lew** asked why there was a reduced variability of wet pond performance in the 2007 report. **Tom** commented that he believes it's because wet ponds provide a good environment for settling and algal uptake (for pollutant removal) and were less subject to variability because of leaching or larger storm events etc. **Lew** noted that could be significant because FTWs could increase the settling and allow for shading.
   - **Dave Sample** asked how volume of ponds would be determined; **Tom** noted that the panel could cover this in the qualifying conditions i.e., require a bathymetric survey or dredging be done when using the FTW as a retrofit. **Tom** referenced a Bill Hunt paper on loss of capacity of wet ponds over time.
   - **Lew** noted that since algal uptake and settling reduced the variability of the wet pond performance – how much uptake capacity would be lost by the shading impacts of the FTWs. **Tom** noted that there could be impacts from shading and low DO discharges downstream. **Sarah Lane** noted that in the Lowman research they deployed the FTWs in the center of the ponds where there wasn't any existing vegetation; could be required. **Dave** noted that the ponds aren't designed to manage algae, just goes through the outlet structure.

3. **Research Presentations**
   David Sample, Andy Lazur, and **Chih-Yu Wang,** gave presentations on the research they have conducted on Floating Treatment Wetlands. This summary provides a

brief snapshot of the day's presentations, and focuses on the key points and discussion rather than the information presented on the slides. Please consult the presentations for details. All presentations are available on the FTW dropbox folder.

Evaluating Floating Treatment Wetlands for Treating Urban Stormwater, David Sample, Virginia Tech gave an overview of the research he's conducted on floating treatment wetlands. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- No "opportunity costs" as the surfaces of the wet ponds were not currently being used
- Two studies: Fairfax, VA used a non-proprietary version; Virginia Beach study used Biohaven and Beemat systems
- Didn't see the effect of "irreducible concentration" – always able to achieve removal
- Looked at *pickerelweed* and *bulrush* species of plants
- Used a matt without plants and a control – no matt and no plants. The control had no shading, higher temps and more algae growth
- Found mat itself (without plants) had an effect, begs the question are the plants worth it particularly when considering the burden of harvesting
- Most studies lump the FTW and pond performance and most of the treatment comes from the pond itself
- Looked at Phosphorus distribution of biomass which is important for considering where/how to harvest but also need to consider what the plants need in order to survive
- Beemat FTWs were thinner, cheaper, less buoyant and needed filter media/soil for plants
- Biohaven FTWs were thicker, more buoyant, more expensive, lacked soil and more robust in terms of plant growth (therefore more uptake of TN and TP)
- Shading led to cooler temperatures which was good for DO levels and reduced algal growth
- **Tom** asked Dave about the nature and difficulty of harvesting at the end of the growing season. **Wang** noted that they harvested above ground at the end of the growing season but it's probably better to harvest twice a year: once in June and once at the end of the growing season. Concerned if mid-summer harvesting would hurt the plants.
- **Lew** asked about why the 'mat only' provided treatment; **Dave** noted that it is the biofilm that is providing the removal (denitrification and P adsorption) and is the main difference between the types of FTWs – some maximize the surface area coverage which would impact the amount of treatment provided. Removal most likely occurring through denitrification and Phosphorus adsorption.
- **Chris Streb** noted that harvesting is more difficult with a larger raft and that harvesting twice a year might have practical limitations for users; he also noted that they had better success with plant establishment when planting in April resulting in less invasive plants and more overall plant coverage as compared to

planting in early summer (bird predation); noted that the Panel will need to consider the nutrient needs of plants when considering harvesting recommendations (time, frequency). **Dave** commented that if FTWs aren't harvested it would be difficult to control weeds – 1 year after the study had ended (no maintenance), the FTWs were completely overgrown.

- **Sarah White** asked what mass of nutrients were taken up by the weeds as compared to the intended plants. **Dave** and **Wang** noted that they didn't sample the weeds but did harvest them 1 time (late July).
- **Dave** then went through the literature he reviewed for the panel. The complete information can be found in his presentation in the dropbox folder. The following are some of the highlights:
  a. Van de Moortel's paper makes an argument for why *not* to harvest, because it provides a Carbon source for denitrification to occur
     i. Van de Moortel, A. M., Du Laing, G., De Pauw, N., and Tack, F. M.
        1. 2012. The role of the litter compartment in a constructed floating wetland. Ecological Engineering, 39, 71-80
     ii. Based on a theoretical model
  b. Marimon, Z. A., Xuan, Z., and Chang, N. B. 2013. System dynamics modeling with sensitivity analysis for floating treatment wetlands in a stormwater wet pond. Ecological Modelling, 267, 66-79.
     i. Exclusively focused on N removal, used a predictive model to model effect of FTWs, monitoring conducted over winter and plants (*pickerelweed*) wilted
  c. Floating Islands International, 2011. Floating Treatment Wetland
     i. Technology: Total Phosphorus Removal from Wastewater.
     ii. Marketing document is not produced by a 3rd party and it therefore unsuitable for inclusion in the literature review. Removal rate was normalized by pond volume instead of FTW area.
  d. Tanner, C. C., Sukias, J., Park, J., Yates, C., & Headley, T. 2011. Floating Treatment Wetlands: A New Tool for Nutrient Management in Lakes and Waterways. Methods 2008.2011.
     i. Flow-through generally should remove more TN and TP due to continued replenishment of nutrient store.
     ii. Nutrients supplied artificially which is common in most of the literature
  e. Floating Islands International, 2011. Floating Islands Outperform
     i. Constructed Wetlands
     ii. Only provided single numbers and showed no variability
     iii. This marketing document is not produced by a 3rd party and it therefore unsuitable for inclusion in the literature review.
  f. Floating Islands International, Undated. Proving the Concept: Field Test of Floating Treatment Wetland Technology's Ability to Treat Simulated Wastewater
     i. This marketing document is not produced by a 3rd party and it therefore unsuitable for inclusion in the literature review.

Floating Wetlands as Stormwater BMP, Andy Lazur, UMD gave an overview of the research he's conducted on floating treatment wetlands. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- Presenting information from final report just submitted to CBT.
- 2010 a fairly dry year, low input to ponds
- Farm pond had greater ambient nitrate concentration than residential pond
- Looked at denitrification of FTWs and the pond sediment; saw significant differences but need to evaluate further. **Lew** asked what is causing the denitrification in the sediment – from benthic algae.
- Anecdotal evidence from homeowners that pond (with FTW) has less algae
- **Tom** requested that Andy submit a copy of the CBT report to the panel
- **Drew Ferrier** asked where the sediment denitrification rates were assessed (in relation to the FTWs); **Andy** believes it was done under the islands but will follow-up with Jeff directly and let the panel know. **Drew** is curious if greater organic matter beneath the FTWs enhanced the sediment denitrification; **Andy** to look into.
- **Randy Chambers** asked what is the relative ratio when comparing the total amount of Nitrogen removal by denitrification in the sediments versus what is harvested from the plants; **Andy** noted that denitrification is just over 50% of total nutrient removal but more work is needed. **Tom** noted would like to compare with Lowman's denitrification work.

ACTION: Andy Lazur to send the CBT final report to CSN for inclusion in the literature.

Assessing floating treatment wetlands nutrient removal performance through a first order kinetics model and statistical inference, Chih-Yu Wang, Virginia Tech gave an overview of the research he's conducted on floating treatment wetlands. The main conclusions can be found in the presentation in the dropbox folder. The following are some of the discussion highlights:

- **Tom** asked the panel if the first order kinetic model that Chih-yu explained would be a useful way to express the effect of FTWs in the panel's future protocols. **Lew** asked if the model is applied on a catchment wide basis.

4. **Research Summaries**
The remaining panelists gave brief overviews on the literature they reviewed for the panel primarily focusing on information that could be used to address the panels charge. **Sarah Lane**, **Drew Ferrier**, and **Lewis Linker** gave brief overviews of the literature they reviewed for the panel. The main conclusions can be found in their presentations in the dropbox folder.

5. **Identification of Next Steps for the Panel**

Tom noted that we will have our next panel meeting in January at which he will provide a conceptual framework for crediting the FTWs in the CBWM. We will hear from the remaining panelists on the literature they reviewed. The Panel set the date for the next meeting as **Wednesday, January 29th**. **Tom** thanked the panelists for their support.

ACTION: Next meeting date set for Wednesday, January 29th from 10-12.

Floating Treatment Wetlands Expert Panel
Fourth
Teleconference
January 29,
2014
Meeting
Minutes

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present?**
Sarah White	Clemson University	Yes
David Sample	Virginia Tech	Yes
Andy Lazur	U of MD	Yes
Sarah Lane	MD DNR	Yes
Ryan Winston	NCSU	Yes
Chris Streb	Biohabitats, Inc.	Yes
Drew Ferrier	Hood College	Yes
Randy Chambers	College of William and Mary	Yes
Karen Duhring	VIMS	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	Yes
Chih-yu Wang	Virginia Tech	No
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes Yes
Non-panelists: Jeremy Hanson, CRC		

ACTION (*ongoing*): Tom to talk to USWG about an archival protocol for expert panel resources.

ACTION (*ongoing*): CSN to share the loads from urban pervious and impervious lands with the panel. Reminder to panelists to take a look at the retrofit expert panel memo.

ACTION (*ongoing*): CSN to create a table of the research studies organized by area coverage for the panel to review

ACTION (*ongoing*): CSN to put together table on above ground accumulation rates and removal in lbs/sqft

ACTION (*ongoing*): All panelists to read the paper: FTW review paper (Tanner, EST)

ACTION: All panelists to review the new papers submitted by Andy Lazur and Dave Sample (*Evaluation of Floating Treatment Wetlands as a best management practice for stormwater remediation* and *Assessment of the nutrient removal effectiveness of floating treatment wetlands*

***applied to urban retention ponds* respectively) both available on the dropbox folder.**

ACTION: CSN to share the shoreline erosion control expert panel recommendations once complete.

ACTION: Next meeting date tentatively scheduled for end of March, 2014.

1. **Call to Order and Panelist Introductions**
   Tom Schueler, CSN, called the meeting to order, thanked the panelists for their participation in the Expert Panel and explained that this meeting was a continuation of last month's research workshop. He reviewed the minutes and action items from the last meeting.

2. **Continuation of Panelist Book Reports**
   Tom Schueler and **Cecilia Lane** gave brief overviews of the literature they reviewed for the panel. The main conclusions can be found in their presentations in the dropbox folder. Andy Lazur submitted the final report to CBT on a FTW study and Dave Sample indicated a newly published paper by himself and Chih-Yu Wang, and agreed to submit it to the panel for review. With the inclusion of these two final papers the Panel decided to close the research review phase.

   Tom asked **Ryan Winston** what his thoughts were on the transferability of the Wannalista study to the work of the FTW panel. **Winston** noted that in general it corroborates other studies that the panel has reviewed however one caution is that the study used 'grab sampling'. The study also looked at percent coverage of the pond and came to similar conclusions as the DNREC paper despite not communicating with each other. Despite that, **Winston** believes there are other design factors beyond percent coverage to improve performance of the FTWs (e.g., baffles, pumping, direction of flow etc.). **Winston** also noted that the Hawaiian study required re-launch of the FTW after 10 years. **Tom** agreed and noted that the panel may need to identify a relatively short duration for the credit to reflect the degradation of the FTWs over time. **Winston** noted that maintenance of FTWs is a big challenge and are very difficult to move around once established. **Chris Streb** agreed and noted the challenges they faced when moving/maintaining the FTWs as part of the National Aquarium study. **Andy Lazur** offered that the material used in the construction of the islands will impact their durability. **Tom** noted that the panel will need to consider multiple variables when identifying the maintenance regime recommendations (e.g., size, density, mass etc.).

ACTION: Panelists to review the new papers submitted by Andy Lazur and Dave Sample (*Evaluation of Floating Treatment Wetlands as a best management practice for stormwater remediation* and *Assessment of the nutrient removal effectiveness of floating treatment wetlands*

***applied to urban retention ponds* respectively) both available on the dropbox folder.**

3. **Panel Discussion on Conceptual Framework for Removal**
   Tom presented the panel with an annotated outline of the final report and a conceptual framework for crediting FTWs in the Chesapeake Bay watershed. The Panel reviewed the outline and proposed approach and identified areas where they feel they could contribute to the report. Tom asked the Panel to specifically weigh in on the definitions and qualifying conditions section indicating that no other Urban BMP Review Panels have provided design guidance on the BMP:
   - **Lou Linker**: noted that stormwater applications of FTWs is going to be very different from those deployed in tidal water, asked how the panel should address application of FTWs in tidal water. **Tom** agreed and noted that the panel can choose to not recommend a credit for FTWs used in open water applications due to the lack of scientific research to support and instead add it to the section on Future Research and Management Needs
   - **Dave Sample**: feels that harvesting and longevity are linked and so maybe the sections need to be merged (e.g., biohaven systems engineered for the long-term which may not be good for the harvested applications)
   - **Sarah White**: stormwater ponds and agriculture ponds will have different loading rates therefore surface coverage requirements and plant species will differ so may need to differentiate between the two applications (i.e., separate protocols for urban ponds and agriculture ponds)

After a brief overview of the outline **Tom** asked the panel for their general feedback:

- **Ryan Winston**: agrees that will need to have separate protocols for different applications (stormwater vs agricultural applications); should consider focusing on designing a wet pond to include FTWs (for new development) and look at specific design features that would enhance removal by FTWs. Harvesting/maintenance will be a key issue to make sure the FTWs are a viable option. Need to consider the local resources when providing a credit for harvested systems; Anchoring guidance is important for practitioners to prevent ponds from being clogged by adrift FTWs; would like the Panel to delve into the pollutant removal mechanisms for the future panel.
- **Sarah White**: will submit written comments to CSN; important to recommend plants that are specifically adapted to the environment (not just high performers); maintenance requirements may result in private companies that specialize in the maintenance of FTWs; percent cover might need to be increased to 5-20% depending on the size of the pond and nutrient availability.
- **Dave Sample**: the panel will probably find that FTWs are of modest benefit pollutant reduction benefit but will be a starting point for more rigorous

scientific research/monitoring of these systems; **Tom** asked if it would make sense to use the i-FTW model to determine the efficiency. **Sample** said yes as long as we establish a ceiling for the credit although not sure what that number should be.

- **Sarah Lane:** will send written comments to CSN; change the name lagoon so as to not be confused with application in agricultural wastewater settings; agrees it is important to identify appropriate plant species (to environment); dockside deployment should be addressed at least in the definitions section. Comfortable with what she was assigned.
- **Andy Lazur**: sees a need to make general recommendations for design features of the FTWs to summarize what's been seen in the research; reiterates the need for appropriate plant species per the application; change the term 'lagoon' to ag ditches or channels possibly; maintenance can be specific to the design of the system; agrees that maintenance could be done by installers; interested to know how removal rates will be reported (i.e., sq ft etc.). **Tom** asked if the maintenance vendors harvest the plants; **Lazur** said that it can and has but dependent on the contract/need. However if harvested also need to identify proper disposal procedure
- **Karen Duhring**: worth mentioning the tidal/open water applications, however don't think we have the research to support a rate for it, could fall under future research section; maintenance: can we address harvesting vs. not harvesting in terms of performance; plant succession, is it really a problem? Maintenance in terms of plant community evolution should be spelled out for practitioners
- **Randy Chambers**: noted that performance of stormwater ponds varies dramatically by pond and by storm therefore concerned that natural pond variability may mask any treatment attributable to FTWs; design features is also important to identify; should be noted that microbial phenomena not well understood; installation guidance for users is important.
- **Chris Streb**: add to the definitions sections: activated systems, wave attenuation and erosion control (for open water applications); maybe can offer additional credit if can demonstrate reductions in nutrient concentrations, provide justification for the credit possibly through a computational model etc.; longevity (both structural and plants) needs to be addressed, also the fate of the matrix media and what unintended consequences they have on water quality (add to section on potential environmental impacts and benefits); provide guidance for practitioners to make contact with researchers to help build the science behind the FTWs, possibly add to future research needs section.
    - **Tom**: will share the shoreline erosion management panel recommendations with the panel when complete. materials used in the matrix (potential impacts and benefits); guidance for practitioners (regional monitoring consortium) to connect with researchers
    - **Tom**: could have additional protocol that would result in higher credit if conduct monitoring and identify monitoring requirements – to provide incentive for monitoring data

ACTION: CSN to share the shoreline erosion control expert panel recommendations once complete.

- **Lew Linker:** supports the addition of the "why" behind the FTWs including a discussion of the different pollutant removal mechanisms; if focus on the process and the 'why' then maybe will address some of the application concerns (e.g., address how FTWs could potentially offer wave attenuation/reduce erosion however cannot quantify based on the literature).
- **Drew Ferrier**: agrees with matching plant species with appropriate nutrient runoff regimes; wonders if there are other factors to match plant species with (e.g., salinity, pH etc.) and do we have the data to support such recommendations; also do we have the data to recommend a mixture of plants that will allow the wetlands to work at the margins of the growing season (early Spring, late Fall etc.); regarding environmental impacts would FTWs draw water fowl that would negatively impact water quality.
- **Kevin Brittingham**: would be good to include in the report: how FTW can be used by regulators to meet TMDL reductions, NPDES/MS4 requirements and how FTW may be used for credits for Stormwater Utility Fees; offer guidance on management and monitoring on FTW when used for meeting these reductions/credits; importance of goose management to insure success of vegetation on FTW

Tom identified some common themes that the panel will need to discuss in more detail at the next meeting and asked the Panel if there are any others to add this list. **Duhring** commented that should add the removal mechanisms via biolfim which could be transferred over to other applications (i.e., open water). **Tom** agreed and indicated will need support from the panel on this topic.

- Agriculture vs. Urban applications
- Does harvesting increase performance or just longevity of the systems
- Active vs. Passive systems
- More robust general recommendations for design and qualifying conditions for consideration of performance
- Develop protocols
- Biofilm/denitrification

4. **Identification of Next Steps for the Panel**
Tom noted that CSN has some writing to do and will be sending draft sections to panelists for review (as indicated in the outline). CSN requests a "rapid review" of the sections with feedback requested within 1 week's time. As a result the panel will most likely not meet again until the end of March, 2014.

ACTION: Next meeting date tentatively scheduled for end of March, 2014.

Floating Treatment Wetlands Expert Panel
Fifth Teleconference
January 27, 2016
Meeting Minutes

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present ?**
Sarah Lane	MD DNR (Panel Chair)	Yes
David Sample	Virginia Tech	Yes
Andy Lazur	U of MD	Yes
Ryan Winston	OSU	Yes
Chris Streb	Biohabitats	No
Drew Ferrier	Hood College	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	No
Chih-yu Wang	Virginia Tech	No
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes
Interested Parties: Peter May, Biohabitats, Inc., David Wood, CRC		

<u>ACTION ITEMS:</u>

ACTION: Panelists are asked to review the update literature list and identify any additional literature by Feb. 3, 2016.

ACTION: CSN to send out a copy of the retrofits expert panel report after the meeting. Panelists are asked to review the retrofit report with specific attention paid to Appendices A&B.
ACTION: CSN to contact a representative from the shoreline management panel to present on their approach at a future panel meeting.

ACTION: Sarah Lane to track down the NRCS std code for ponds that treat stormwater runoff from agricultural lands.

ACTION: CSN to put together a framework document for review by the panel by the end of February. After the framework document is distributed to the panel, CSN will schedule the next panel meeting.

1. **Panel Reintroduction**
   Tom Schueler, CSN, called the meeting to order, thanked the panelists for their participation in the Expert Panel and reviewed the goals and objectives of the review panel, the current roster of panelists, recapped where things left off when they last met and established a game plan for moving forward.

2. **Recent Literature on FTW Practices**
   Cecilia Lane, CSN, presented an updated list of peer reviewed research on the FTWs (Attachment A) and asked the panel to identify any additional literature to be included.

ACTION: Panelists are asked to review the update literature list and identify any additional literature by Feb. 3, 2016.

3. **Wet Pond Removal Rates**
   Tom Schueler, CSN, gave a brief overview on how the baseline removal rates for stormwater ponds are calculated (Attachment B) and led a discussion on how to account for ponds with FTWs added to them. Tom explained that most historic ponds in the Chesapeake Bay watershed were designed to capture 0.5-1" of volume. Tom noted that if the panel should opt to use the baseline rates approach, will also need to identify a max removal rate that can be achieved by adding a floating treatment wetland retrofit.

ACTION: CSN to send out a copy of the retrofits expert panel report after the meeting. Panelists are asked to review the retrofit report with specific attention paid to Appendices A&B.

4. **Implementation and Maintenance of FTWs**
   Ryan Winston, NCSU, discussed the highlights of his research on the Implementation and Maintenance of FTWs (Attachments D & E). The Panel will then discussed some of the key issues of O&M that should be defined as part of their recommendations. The main conclusions can be found in the presentation; the following are some of the discussion highlights:
   - A dense root network is essential for decreasing flow velocity and resulting in pollutant removal
   - Island size does matter in terms of pollutant reduction
   - Root depth to water depth relationship is important
   - Important to use wetland plants that can tolerate anoxic conditions
   - Anchoring is really important: 3-5 lifespan max
   - Sediment accumulation occurs under the islands so location in the pond matters (also for easy cleanout)
   - Shading doesn't have an impact on pond temperature as long as there is less than 50% coverage

5. **i-FTW Model Update and Scenario Spreadsheet**
   Dave Sample, VTech, gave an update on the i-FTW model developed by Virginia Tech and explained how it could be used to extract removal rates for ponds

retrofitted with FTWs. The main conclusions can be found in the presentation; the following are some of the discussion highlights:

- The goal is to develop a spreadsheet or series of curves for that planners can use for pond/FTW design under various scenarios
- I-FTW model separates out the removal by the wetland from the removal by the pond itself
- The plants in the water (the roots) is where the removal is occurring (vs. the shoots)
- Water temperature is an important variable for using the i-FTW model
- Pickerelweed grew faster than soft rush and had deeper roots

6. **Scoping of Technical Issues to Address.**
Tom Schueler, CSN, led the panel in a discussion to scope out the key technical issues needed to be resolved to define nutrient and sediment removal rates and to establish a work plan for future meetings. Tom asked each of the panelists to weigh in on the proposed approach. The following are some of the highlights from the panel discussion:
   - **Lew Linker** asked if the panel would be considering tidal applications. He acknowledged that there isn't a lot of monitoring data and there is some concern about the lifespan of FTWs in tidal waters. Lew noted that the shoreline management panel did consider nutrient reductions from aerial rates of denitrification plant uptake and sedimentation.
   - **Peter May** noted that there is some difficulty with comparing intertidal wetlands with inland systems; challenging to define the parameters (w/ intertidal systems) but could compare harvesting data and equate it to nutrient removal. Also important to consider converse effects of FTWs: contribution of nutrients by waterfowl (in both types of systems).
   - **Sarah Lane** added that the wet pond definition should consider barnyard runoff control (for treating stormwater runoff, <u>not ag</u>) and offered to track down the NRCS std code and crosswalk the proposed credit with ag sector.
   - **Andy Lazur** clarified that panelists would have time to comment on the framework document.

ACTION: CSN to contact a representative from the shoreline management panel to present on their approach at a future panel meeting.

ACTION: Sarah Lane to track down the NRCS std code and crosswalk the proposed credit with the existing FTW ag credit.

ACTION: CSN to put together a framework document for review by the panel by the end of February. After the framework document is distributed to the panel, CSN will schedule the next panel meeting.

Floating Treatment Wetlands Expert Panel
Meeting Minutes
March 17, 2016

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present ?**
Sarah Lane	MD DNR (Panel Chair)	Yes
David Sample	Virginia Tech	No
Andy Lazur	U of MD	Yes
Ryan Winston	OSU	Yes
Chris Streb	Biohabitats	No
Drew Ferrier	Hood College	Yes
Lewis Linker	CBPO	Yes
Kevin Brittingham	Baltimore County	Yes
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes
Non-panelists: Peter May, Biohabitats, Inc., David Wood, CRC		

ACTION ITEMS:

ACTION: Sarah Lane will type up her findings and send it to Alisha Mulkey to get sign off from the AGWG.
ACTION: CSN will work with David Sample to get more information on the i-FTW model and input parameters, to be presented at the next panel meeting.
ACTION: Panel comments on both documents to CSN by 4/8. CSN will then put together a decision draft by 4/15 for approval during a final panel call towards the end of April.
ACTION: Panelists to send photos of FTWs for inclusion in report to CSN by 4/8

1. **Call or Order**: **Tom Schueler, CSN**, called the meeting to order, thanked the panelists for their participation in the Expert Panel.

2. **Review of Action Items and Meeting Minutes from January. Cecilia Lane, CSN** presented the draft meeting minutes from the January Expert Panel meeting and asked panelists if they had any revisions. Sarah Lane reported out on her efforts to crosswalk the proposed BMP with the NRCS standards code.

   ACTION: Sarah Lane will type up her findings and send it to Alisha Mulkey to get sign off from the AGWG.

3. **Review of the Draft Framework Document. Tom Schueler, CSN,** led the panel in a discussion of the Draft Framework for Defining Pollutant Removal Associated with Floating Treatment Wetlands in Existing Wet Stormwater Ponds (Attachment B). Each panelist was asked to provide feedback on the proposed framework.

a. **Definitions and Qualifying Conditions**
    i. Sarah Lane recommended including "homestead structures" as part of the definition for wet ponds in rural areas
    ii. Andy Lazur recommended omitting "precut holes" from the definition for FTWs
    iii. Several panelists agreed that FTWs should not be used in drinking water reservoirs because of their propensity for attracting wildlife
    iv. Ryan Winston is concerned about the R ratio requirement; Tom agreed and offered a minimum permanent pool depth as a replacement condition
    v. Several panelists discussed the planting requirements and came up with an alternate definition

b. **Determining the Baseline Removal Rate of Wet Ponds**
    i. All panelists agreed to the proposed approach for determining the baseline removal of wet ponds

c. **Determining the Incremental Removal Rate of FTWs**
    i. The majority of panelists wanted to see more information on the i-FTW model for determining the incremental removal rate
    ii. There was some discussion on the ability of FTWs to remove pollutants during the dormant season. Ryan Winston noted that removal should not be overly impacted since most of pollutant removal came from settling not plant uptake
    iii. Sarah Lane notes that the AFT panel dealt with the same issue (of seasonality) and addressed it by reducing the efficiency to reflect the number of growing days
    iv. Tom offered that can ask Dave Sample if his spreadsheets would account for the seasonality issue
    v. The Panel agreed that it should be highlighted as a research issue going forward.

d. **Credit Duration**
    i. Panelists decided that the credit duration for a FTW system should be 3 years as long as there is a maintenance plan in place otherwise it would be a 1 year credit.
    ii. The Panel noted that the final recommendation will need to outline any inspection/repair that should occur annually.

ACTION: CSN will work with David Sample to get more information on the i-FTW model and input parameters, to be presented at the next panel meeting.
ACTION: Panel comments on both documents to CSN by 4/8. CSN will then put together a decision draft by 4/15 for approval during a final panel call towards the end of April.
ACTION: Panelists to send photos of FTWs for inclusion in report to CSN by 4/8

4. **Research Review. Tom Schueler, CSN,** walked the panel through a write-up of the major findings from the literature. Panelists were asked to provide comments on the research review by April 8.

a. **Annual Harvesting**
    i. Ryan Winston noted he has concerns about requiring annual harvesting as it will be a burden to folks implementing FTWs. He is okay with recommending annual thinning
    ii. Andy Lazur agreed and said that while it does create a maintenance issue, it is probably important to maximize nutrient reduction by thinning and harvesting the material. The idea of a prewinter harvest to remove the biomass prior to demineralization of vegetative matter. But the practical reality is that it is very labor intensive and it would be tough to require annual harvest.
    iii. Sarah Lane completely agrees and notes whatever option is picked for incremental removal rate, we should crosswalk the inputs to make sure none of these bullets significantly impact the rate calculations.
    iv. Peter May commented that while you don't want to make the requirements onerous, if the intent is to maximize credit removal, the removal, with the exception of denitrification, really comes from harvesting

b. **Plant Species Recommendations**: the panel reviewed the plant species listed in Table 4 of the Research Review Summary. The panel agreed with the plant species recommendations but noted that yellow-flag/yellow-iris is considered a noxious weed and should be replaced with versicolor instead.

5. **Scoping of Technical Issues to Address. Tom Schueler, CSN**, led the panel in a discussion of the key technical issues that need to be resolved to define nutrient and sediment removal rates.

Floating Treatment Wetlands Expert Panel
Meeting Minutes
April 27, 2016

EXPERT BMP REVIEW PANEL		
Panelist	***Affiliation***	**Present ?**
Sarah Lane	MD DNR (Panel Chair)	Yes
David Sample	Virginia Tech	Yes
Andy Lazur	U of MD	No
Ryan Winston	OSU	Yes
Chris Streb	Biohabitats	No
Drew Ferrier	Hood College	No
Lewis Linker	CBPO	No
Kevin Brittingham	Baltimore County	Yes
Tom Schueler Cecilia Lane	CSN (Panel co-facilitators)	Yes
Interested Parties: Peter May, Biohabitats, Inc., David Wood, CRC		

ACTION ITEMS:

ACTION: Sarah Lane will type up her findings and send it to Alisha Mulkey to get sign off from the AGWG.
ACTION: Ryan and Dave to connect offline on possibilities for estimating sediment removal
ACTION: CSN to write-up justification for allowing for less than 20% surface coverage
ACTION: All panelists to provide written comments on the "decision draft" by May 6.

6. **Call or Order**
Tom Schueler, Chesapeake Stormwater Network, called the meeting to order and thanked the panelists for their service.
7. **Review of Action Items and Meeting Minutes from March**
Cecilia Lane, Chesapeake Stormwater Network, reviewed the meeting minutes and action items from the March 17 Expert Panel meeting (Attachment A).
8. **iFTW Model Update and Scenario Spreadsheet**
David Sample, Virginia Tech explained how the iFTW model can be used to extract removal rates for ponds retrofitted with FTWs (Attachment B).
   - **Ryan Winston**, interested to hear if it is possible to separate out what parts of the load removal are plant uptake based vs. of non-plant uptake based with the interest of not having to harvest the plants to credit this annually
   - **Dave Sample** noted that plant uptake not a major component of removal ability of FTWs

9. **Protocol to Define FTW Incremental Removal Rates Discussion**
Tom Schueler thanked Dave Sample for doing the work to put together the curves based on the modeling and asked the panel if they wanted to adopt this method for

defining the FTW incremental removal rate and develop a set of curves that show the removal rate from 20-50% coverage. Tom acknowledged that Dave's work does not have values for TSS removal. Tom asked the panel for feedback on both of these issues.

- **Sarah Lane**, curious how to define the sediment removal rate
- **Dave Sample** asked Ryan Winston if it is necessary to harvest the whole plant in order to remove the sediment attached to the roots
- **Ryan Winston**, noted that while there is some adsorption or capture of sediment by the roots, there is also sedimentation on the bottom of the pond under the FTW and believes there is still a benefit without whole plant removal
- **Ryan Winston**, endorsed the i-FTW model approach for TN and TP removal; do more data analysis for TSS removal (value as a range of raft coverage)
- **David Wood**, concern about developing new set of curves (from CBPO modeling team), prefer an efficiency table could be presented as a table of efficiencies
- **Peter May**, endorses Dave's curves for TN and TP
- The expert panel endorsed the used of Dave Sample's curves for defining TN and TP – put together a table of efficiencies for removal between 20-50% FTW coverage

The Panel then discussed some methods for determining the sediment removal rates for FTWs.

- Tom Schueler noted that there is relatively little data on sediment removal by FTWs (2 studies) and the panel has several options for determining the sediment removal rates:
    - Option 1: assume TSS is roughly proportional to TP
    - Option 2: create new sediment curve based on other data
- **Ryan Winston**, noted that his own data showed a 5% increase in sediment removal post retrofit
- **Dave Sample** mentioned some new papers that could have some data on sediment removal
- Several panelists noted the need to be conservative due to the lack of data

ACTION: Ryan and Dave to connect offline on possibilities for estimating sediment removal

The Panel then discussed the minimum coverage requirements for getting credit for a pond FTW retrofit.

- **Ryan Winston**, indicated that he believes the model is good enough to reduce the coverage minimum to less than 20%
- Tom Schueler agreed but said some sort of minimum should be established to account for times with low pools and possible bypass
- The Panel agreed to reduce the minimum surface coverage required to 10%

ACTION: CSN to write-up justification for allowing for less than 20% surface coverage

10. **Accountability Mechanisms for the Practice**
Tom Schueler led the Panel in a discussion of the remaining issues to be resolved for the FTW credit. These include: reporting, tracking and verification, research recommendations and implementation considerations for floating treatment wetlands (Attachment C).

11. Next Steps.
Tom Schueler informed the Panel of the timeline for review and briefed them on what they can expect in terms of what's next in the expert panel process. Tom also asked each of the panelists on the call to indicate how comfortable they felt about the recommendations to date and to identify any concerns they have about the credit:

- **Sarah Lane**, concerned about the low credit for FTWs and that industry and stormwater managers will find it insufficient to warrant the work of implementing FTWs; she noted that will need to be aware of getting sign-off from habitat GIT and fisheries GIT; and wondered if there any safety issues with having a tethered raft in a stormwater pond; Finally, reminded CSN to invite the Ag workgroup to the July USWG meeting when asking for approval
- **Dave Sample**, industry will not be happy with low credit but industry has not been funding the science
- **Ryan Winston**, agrees with points already made (industry), feels comfortable with recommendations, concerned about anoxic discharges: DO monitoring devices can be expensive for local governments and believes there are plenty of opportunities for entrainment to occur
- **Kevin Brittingham**, pretty satisfied, agrees that there isn't enough credit as a viable BMP in most cases but could be a good opportunity for the right scenario
- **Peter May**, could be good for a local jurisdiction as part of a treatment train, also as a public relations/outreach tool

ACTION: All panelists to provide written comments on the "decision draft" by May 6. CSN to incorporate comments, add in remaining sections and provide final report to panelists by May 13. Final comment deadline will be June 3.