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Commentary on "Mitsch et al., 2015, Protecting the Florida Everglades wetlands with wetlands: Can stormwater phosphorus be reduced to oligotrophic conditions?"

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ABSTRACT

Constructed wetlands have been utilized with varying levels of success in an effort to reduce nutrient concentrations entering waterways. In south Florida, stormwater treatment areas (STAs) have been utilized to remove excessive phosphorus (P) from surface waters for more than two decades with remarkable results. Even though the STAs have been operational for more than two decade, further improvement of P removal performance is necessary to achieve the desired outflow concentrations. This commentary critically reviews a recently published manuscript concerning the ability of alternative vegetative communities' ability to improve STA treatment efficiency. The commentary provides clarification of Everglades STA effluent limit and the total P water quality criterion established for the Everglades Protection Area. The commentary also addresses fundamental issues with the authors' experimental design and interpretability in light of the studies treatment fidelity, controls and scalability.

In their paper titled "Protecting the Florida Everglades wetlands with wetlands: Can stormwater phosphorus be reduced to oligotrophic conditions?" Mitsch et al. (2015) presented results from an approximate three-year mesocosm study comparing the phosphorus (P) uptake characteristics of various plant communities and other short-term P storage dynamics. The overall objective of this study was to assess nutrient removal efficacy of different wetland vegetative communities in an effort to transition waters from eutrophic (30–100 $\mu g\,L^{-1}$ total P (TP); Reddy and DeLaune, 2008) to oligotrophic (< 10 $\mu g\,L^{-1}$ TP; Reddy and DeLaune, 2008) conditions. I appreciate the opportunity to comment on this study, provide clarification on several points related to stormwater treatment area (STA) performance and discharge limits, water quality standards and restoration efforts. Further, this commentary will discuss study limitations that could mislead readers to inappropriately apply results to current STA operations or future STA planning.

1. Everglades total phosphorus water quality standards

Water quality criterion are expressed using three components: magnitude, duration and frequency. Magnitude refers to the concentration of a pollutant (i.e. phosphorus). Duration is the period of time over which aquatic life can be exposed to elevated levels of pollutants without harm. Frequency is the number of times an excursion can occur over time without impairing the aquatic community or other designated use. Therefore water quality criterion are not intended to be an instantaneous value never to be exceeded.

Mitsch et al. (2015), much like others (Surratt and Aumen, 2014; Zapata-Rios et al., 2012), misinterprets the 10 $\mu g\,L^{-1}$ (parts per billion) TP criterion for the Everglades Protection Area (EvPA). The 10 $\mu g\,L^{-1}$ criterion is far more complex than a mere instantaneous concentration and must be interpreted in its entirety. The TP limit is a numeric nutrient criterion (one of the first and lowest for Florida) established by the Florida Department of Environmental Protection (FDEP) that is supported by a data collection effort in conjunction with the South Florida Water Management District (SFWMD) and two Universities (Duke University and University of Florida) to provide the technical backing for the criterion (Payne et al., 2001a,b, 2000). The 10 $\mu g\,L^{-1}$ TP criterion, expressed as a long-term geometric mean (GM) concentration in Everglades marshes, was established under the direction of the Everglades Forever Act (EFA) and other applicable provisions of §373 and §403 Florida Statutes (F.S.) and embodied in rule under 62–302.540 Florida Administrative Code (F.A.C.) (Florida Department of Environmental Protection, 2005). Currently, achievement of the TP rule (i.e., 62–302.540 FAC) is assessed for a network of impacted and unimpacted, spatially explicit monitoring locations in Water Conservation Areas (WCAs). Achievement of the P criterion is different for Everglades National Park than the established TP criterion for the EvPA. As acknowledged by 62–302.530(4)(c) achievement of the TP criterion is assessed according to methods set forth in Appendix A of

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the Settlement Agreement (Hoeveler, 1988) until the Settlement Agreement is amended or terminated.

Achievement of the criterion is assessed by a four-part test for each WCA using two networks of stations; impacted and unimpacted. The parts of the achievement test are:

1 The five-year GM averaged across all stations is less than or equal to 10 $\mu g\,L^{-1}$.
2 The annual GM averaged across all stations is less than or equal to 10 $\mu g\,L^{-1}$ for three of five water years.
3 The annual GM averaged across all stations is less than or equal to 11 $\mu g\,L^{-1}$; and
4 The annual GM at all individual stations is less than or equal to 15 $\mu g\,L^{-1}$.

The TP criterion monitoring network is comprised of 58 monitoring stations. Compliance with the four-part test is assessed by FDEP every year and presented in the South Florida Environmental Report (http://www.sfwmd.gov/sfer/). During Water Year 2014 (WY2014; May 1, 2013–April 30, 2014), 55 of the 58 stations had sufficient data (i.e., greater than six samples between wet and dry season) to be included in the assessment. During the WY2014 assessment, unimpacted portions of each WCA passed all four parts of the compliance assessment, as expected, and are therefore in compliance with the TP criterion. Even though in recent years conditions within the impacted portions have improved, impacted portions of each WCA failed one or more parts of the criterion assessment. As a result, these areas exceed the criterion and remain impacted. If a particular impacted station has recovered sufficiently to achieve an annual GM of 15 $\mu g\,L^{-1}$ or less and a long-term (five-year) GM of 10 $\mu g\,L^{-1}$ or less, they can transition from impacted to unimpacted. As a result of the ongoing restoration efforts during WY2014, six stations transitioned from impacted to unimpacted (Julian, 2015; Julian et al., 2015).

Due to the established TP criterion and the general concern related to existing flows entering the EvPA, a water quality based effluent limitation (WQBEL) was developed for discharges from the Everglades STAs. The WQBEL ensures that the STAs will not cause or contribute to the degradation of water quality in the EvPA as it relates to TP, or cause any negative impacts downstream (South Florida Water Management District, 2013). The objective of the WQBEL is to establish an effluent limit, as measured by an annual flow-weighted mean (FWM) TP concentration for the discharge from an STA to ensure that the TP numeric criterion is not violated in the receiving water body. The use of a FWM concentration versus a GM was deemed more protective since GMs are not as representative of variation in outflow volume and TP concentration during the year. As such a GM to FWM conversion was necessary to ensure that discharges from the STA will achieve a long-term GM of 10 $\mu g\,L^{-1}$. Through a rigorous analysis, the SFWMD determined that the relationship between GM and FWM was not a 1:1 relationship but rather a 1:1.3 relationship (Fig. 1). Therefore, to achieve a long-term GM of 10 $\mu g\,L^{-1}$, the STAs must achieve a long term FWM of 13 $\mu g/L$. Additional information on development of the WQBEL was detailed in South Florida Water Management District (2012) and United States Environmental Protection Agency (2010) Much like the TP rule, the WQBEL is a multipart compliance tool composed of two parts that includes:

1 13 $\mu g\,L^{-1}$ as an annual FWM in more than three out of five years and;
2 19 $\mu g\,L^{-1}$ as an annual FWM.

The STAs are currently in an interim period of operation during which the FDEP will exercise its enforcement discretion to allow the STAs to continue to maintain operations until completion of the State of Florida's Restoration Strategies projects (South Florida Water Management District, 2013). During this interim period, regulatory oversight in the form of milestones and conditions are stipulated in a consent decree, and attached to a National Pollutant Discharge Elimination System (NPDES) permit and an EFA permit (http://www.dep.state.fl.us/everglades/ecp_sta.htm). The Restoration Strategies projects include flow-equalization basins, acquisition and construction of additional STA acreage and structural upgrades of existing water conveyance features (final expected completion date of 2024) (South Florida Water Management District, 2013). This study as well as others are being implemented as part of the Restoration Strategies Science Plan (South Florida Water Management District, 2013). Results from these studies could be used to inform the design and operations of water quality projects, which will ultimately improve capabilities to manage for achievement of the WQBEL.

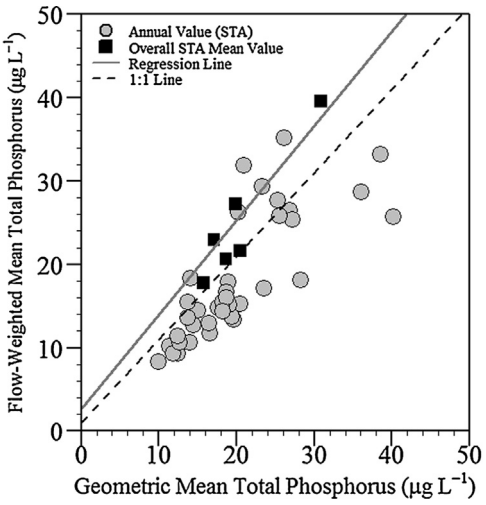

Fig. 1. The relationship between long term (LT) flow-weighted mean (FWM) and geometric mean (GM) total phosphorus (TP) concentrations in micrograms per liter ($\mu g\,L^{-1}$) adapted from South Florida Water Management District (2012). GM concentrations were calculated using grab TP data from all outflow structures at an STA.

2. Experimental design

In their study, Mitsch et al. (2015) used 18 flow-through mesocosms with six macrophyte assemblages and three randomly placed replicates that received inflow water from STA-1W. The use of "pretreated" water is important to both the study design and overall mesocosm dynamics. Over the 21-year history of STA–1 W (previously the Everglades Nutrient Removal (ENR) facility), annual outflow FWM TP concentration ranged from 19 $\mu g\,L^{-1}$ to 119 $\mu g\,L^{-1}$ with an overall annual average outflow FWM TP concentration of $43 \pm 7\ \mu g\,L^{-1}$. During the study, an average annual outflow FWM TP concentration of $31 \pm 4\ \mu g\,L^{-1}$ was observed. Most of the vegetative communities used in this study included submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV), these vegetative communities ideally would be established in a "second treatment cell" within the treatment flow-path of a full-scale STA with predominately Emergent Aquatic Vegetation (EAV) occupying the "first treatment cell". EAV has the capability to reduce the P concentration by increased hydraulic resistance facilitating increased settling of P from the water column and, if present, allow for uptake by periphyton communities. Both processes reduce the water column P to manageable concentrations for other more sensitive vegetative communities (SAV and FAV) to "polish" the final discharge water via direct uptake from the water column. The use of EAV in the mesocosms could be viewed as a