Understanding the Mechanics behind a Constructed Stormwater Wetlands with emphasis on the Inlet Sedimentation Forebay

College of ENGINEERING VILLANOVA UNIVERSITY

CEE Day

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Introduction

Stormwater management is a practice currently implemented in the form of rain gardens, green roofs and constructed stormwater wetlands to reduce the amount of nutrients and metals found in stormwater runoff. At Villanova University a Constructed Stormwater Wetland (CSW) has been implemented as a mean to reduce the nutrients and metals concentration in stormwater runoff that is entering the headwaters of Mill Creek. Over the years this stormwater control measure (SCM) has been analyzed as a whole but little is known on the mechanics of each individual section. The main objective of this research is to understand the basic mechanics of the Inlet Sedimentation Forebay with emphasis on Nitrogen and the Nitrogen Cycle.

Site Overview

The retrofitted Constructed Stormwater Wetland (CSW 2.0) located next to the Law School at Villanova University collects and treats the stormwater runoff of both main and west campus with a watershed of approximately 47 acres. Of the 47 total acres treated, 29 of these acres are collected from Villanova University's main campus while 18 acres are collected from Villanova University's west campus as denoted by the red and blue circles, respectively, as seen in Figure 1 below.

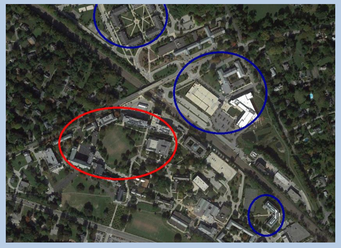

Figure 1: CSW 2.0 Watershed

Figure 2: CSW 2.0 Setup

The water collected from both Villanova University's main and west campus empties out into a sedimentation forebay (IN) before flowing through a series of three meanders, identified as Meander 1 (M1), Meander 2 (M2), and Meander 3 (M3). Each meander consists of narrow strips followed by a deep zone and a sluice-gate weir, used to control the flow within the system. The system then empties into a retention bay before finally reaching the outlet structure (OUT) as seen in Figure 2 above.

Methods

To have an adequate understanding of both the Inlet Sedimentation Forebay and the CSW 2.0 as a whole, samples were collected at different locations as seen in Figure 3 and Figure 4 below. For the sake of this study, samples were collected only under baseflow conditions (after a dry period of at least 48 hours).

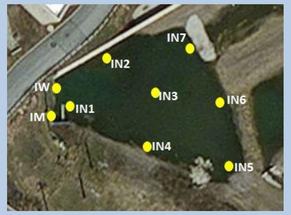

Figure 3: Inlet Sampling Map

Figure 4: CSW 2.0 Sampling Map

Samples were tested with a discrete nutrient analyst photospectrometer for the presence of Nitrate (NO_2), Oxygenized Nitrogen (NO_X), Total Kjeldahl Nitrogen (TKN), and Ammonia (NH_3). After the first sampling of the Inlet, the question arose whether disturbing the settled sediment altered the concentrations of Nitrogen in the samples. Due to this, all other samples were collected taking care to not disturb the sediment at the site. A dye tracer test was also performed to have an understanding of the travel time through the entire CSW 2.0 during baseflow conditions.

Results – Inlet Sedimentation Forebay

To have a more comprehensive understanding of the mechanics of the IN it was necessary to understand the physical changes that have occurred from the year of its retrofit to the present date. Figure 5 presents the data points collected while surveying the IN. Cross sections can be seen in Figure 6 and Figure 7 below.

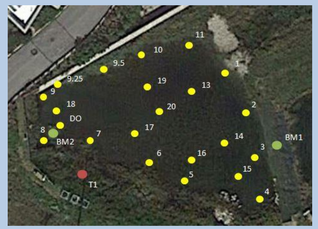

Figure 5: Survey Setup

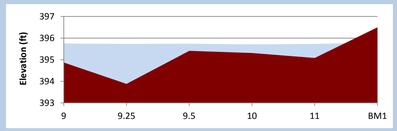

Figure 6: Deep Elevation Profile

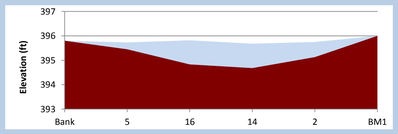

Figure 7: Shallow Elevation Profile

Results – Inlet Sedimentation Forebay

The IN was sampled during two separate occasions; once during the Winter and once during Spring. Both the seasonal historical data and the sampled data can be seen in Figure 8. The samples collected on 2/10 demonstrate a uniformity throughout the IN while the data collected on 3/31 show higher concentrations of NO_2 entering the system.

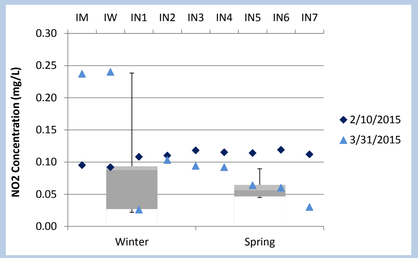

Figure 8: NO_2 Concentrations of the Inlet Sedimentation Forebay

Results – CSW 2.0

The data collected during the Spring sampling of the CSW 2.0 shows a slight removal of NO_2 from the IN to the OUT. This trend is consistent with the historical data collected as seen in Figure 9. A tracer test demonstrated a mean travel time of 29.34 hours from the location where rhodamine dye was dumped to the beginning of M1 and a mean travel time of 76.71 hours to the OUT.

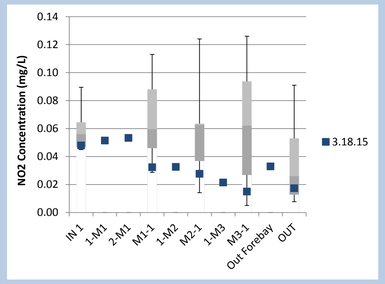

Figure 9: NO_2 Concentrations of the CSW 2.0

Moving Forward

1. Sample the complete CSW 2.0 and compare to the recent samples collected.
2. Determine if the IN is completely mixed.
3. Analyze the presence of the different forms of Nitrogen within the individual sections of the CSW 2.0.

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