Preliminary Evaluation of Flood Control and Treatment of Total Suspended Solids by Dry Detention Basins in Greenville, NC

Camryn Landreth[1], Paige Brown[2], Guy Iverson, Michael O'Driscoll, and Joseph Abuarab
[1] Co-Presenter, Dept. of Health Education and Promotion, East Carolina University: landrethc20@students.ecu.edu
[2] Co-Presenter, Dept. of Biology, East Carolina University: brownpa21@students.ecu.edu


Camryn Landreth


Paige Brown

Abstract

Urban development has increased the total impervious area in human settlements, which has disrupted natural hydrology resulting in increased nuisance flooding and water quality degradation from storms. Over the past several decades, stormwater management has become an integral component of urban planning to mitigate damage through use of stormwater control measures (SCMs). Dry detention basins (DDBs) are a commonly used SCM designed to mitigate peak flow volumes by capturing and storing runoff that is slowly released into the existing stormwater infrastructure. The goal of this study was to characterize functionality and evaluate flood control and treatment of total suspended solids (TSS) by 4 DDBs located in Greenville, NC. Of the 4 DDBs, 2 are within potentially underserved communities according to NC DEQ designation. Onset HOBO pressure transducers were installed in Winter 2023 to measure water levels during storms. Water level data will be used to evaluate storm hydrology to assess flood control by DDBs. Additionally, samples will be collected from the inlet and outlet of DDBs for at least 1 storm to evaluate reduction of TSS concentration. Discharge entering and exiting will also be measured during the storm to estimate mass inputs and exports of TSS. At the time of abstract submission, results are pending data analysis, and this poster will summarize preliminary results for at least 1 storm. Future work will include 2 additional storms to evaluate flood control and TSS treatment (estimated completion: December 2024).

Introduction

What are dry detention basins (DDBs) and why are they important?

- DDBs are stormwater control measures that are used to capture stormwater runoff to improve flood control (e.g., reduced peak flow, downstream flooding). DDBs also treat captured runoff via settling and sedimentation (Campbell, 2022).
- DDBs consist of an inlet (where runoff enters the DDB), a basin (a depressional feature that stores runoff), and an outlet (where water exits the DDB).
- If the DDB is properly designed, constructed, and maintained, then captured runoff will be slowly released over ~2 – 5 days (NC DEQ, 2024a). Inadequate maintenance can result in buildup of trash, limbs, or other objects that hinder DDB functionality (Wissler et al., 2020).

The goal of this poster characterize functionality and evaluate flood control and treatment of total suspended solids (TSS) by 4 DDBs located in Greenville, NC.

Materials & Methods

- 4 DDBs were chosen around Greenville, NC (Fig. 1). Of these 4, 2 are within potentially underserved communities (based on race and income demographics; NC DEQ, 2024b).
- To monitor water levels, 4 Onset HOBO pressure transducers were programmed to record water level every 15 minutes and installed in each DDB outlet in October 2023.
- Precipitation data were retrieved from the NC State Climate Office (2024).
- Water samples were collected from inlets and outlets during a storm on 12 February 2024. A Hanna Instruments 9829 multiprobe meter was used to measure temperature, turbidity, specific conductance, pH, dissolved oxygen, and oxidation-reduction potential.
- Water samples were transported to the Environmental Research Laboratory at ECU to analyze TSS concentrations. Samples were vacuum filtered to separate the solid particles. Filters were dried in an oven at 105 degrees C to evaporate water until a consistent weight was recorded for at least 2 consecutive days.

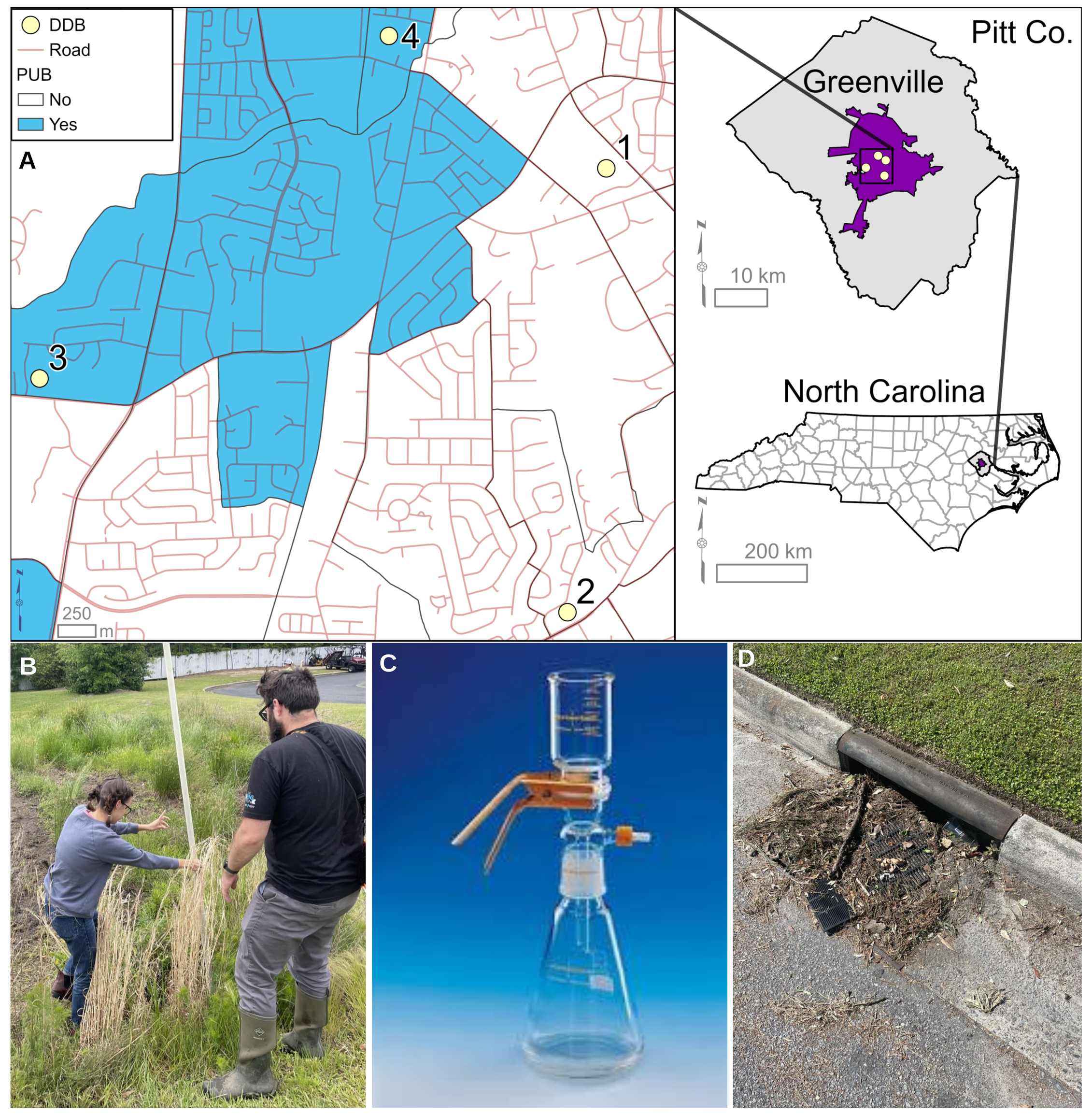

Figure 1. A) Site map showing DDBs in Greenville, NC; PUB= potentially underserved block. B) Camryn and Guy working in a DDB. C) Filtration equipment used when analyzing TSS concentrations. D) Clogged stormwater drain – TSS source?

Preliminary Results

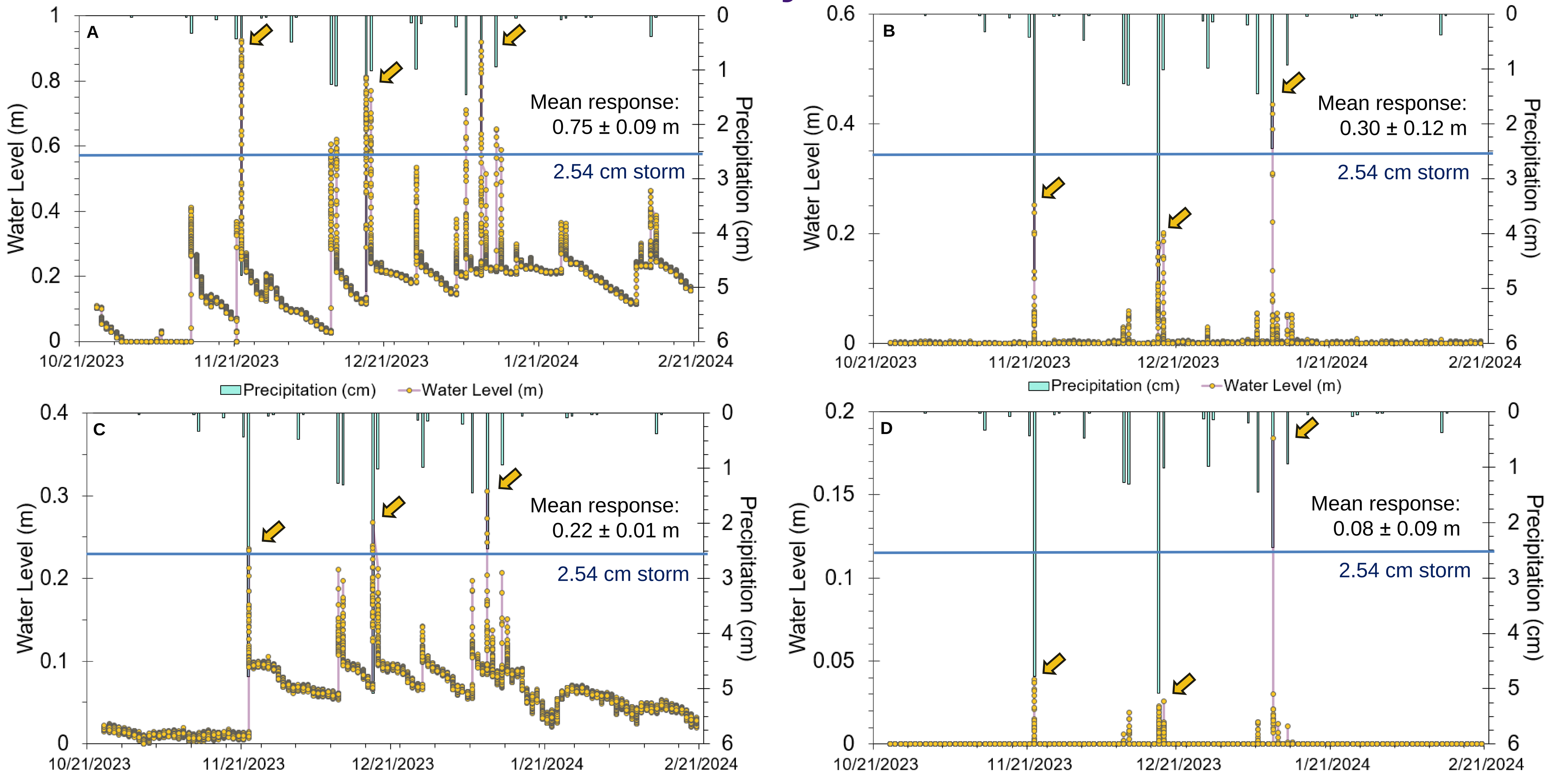

Figure 2. Outlet water level (gold circles) responses to precipitation (teal bars) from Oct 2023 to Feb 2024. Gold arrows show peaks after 1-inch (2.54 cm) storms at sites 1 (A), 2 (B), 3 (C), and 4 (D).


Figure 3. Photos of Camryn and Paige completing water sampling and obtaining physicochemical parameters.

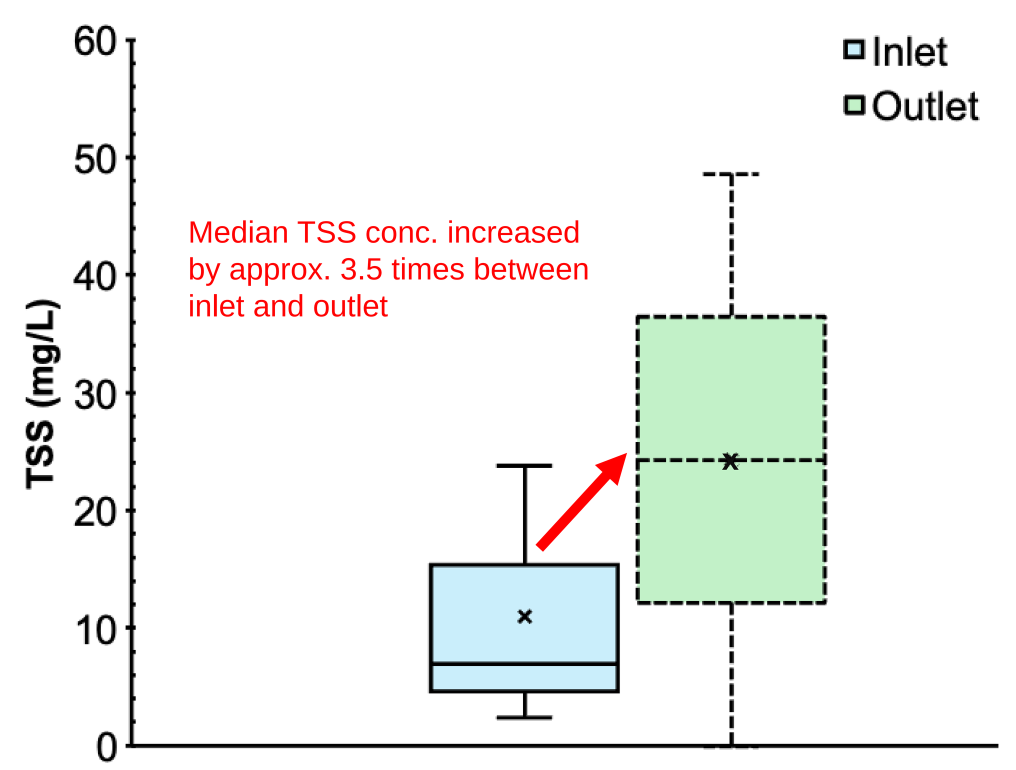

Figure 4. Boxplot of total suspended solids (TSSs) concentrations for pooled inlet and outlet.

Table 1. Median (range) of physicochemical parameters for pooled inlet and outlet.

Parameter	Inlet	Outlet
Temperature (deg. C)	13.55	15.12
SC (μS/cm)	55	64.5
Turbidity (FNU)	33	40
pH	7.05	6.89
ORP (mV)	160.7	143.8
DO (mg/L)	5.86	5.99

Discussion

Water Level Responses to Precipitation (Figures 2A – 2D):

- Water level at Sites 1 (Fig. 2A) and 3 (Fig. 2C) were most responsive to precipitation events. Water level increases were greatest in all DDBs when precipitation exceeded ~2.54 cm (1 in).
- Site 1-3 (2A – 2 C):
  - Mean increase in water level was greatest at Site 1, followed by Sites 2 and 3, respectively. Site 1 has the largest drainage area with at least 5 inlets, whereas all other DDBs have 1 inlet.
  - Water levels in outlets at Sites 1 and 3 were most sensitive to rainfall. There were 14 and 5 peaks that exceeded 0.2 m at Sites 1 and 3, respectively.
  - Site 2 had 3 peaks that exceeded 0.2 m that coincided with the 2.54 cm storms. This site was less responsive to smaller storms, which may be due to differences in drainage area relative to Sites 1 and 3.
- Site 4 (2D):
  - This site had the lowest increase in water level during 2.54 cm storms and was less responsive to rainfall.
  - This could be due to variability in drainage area, spatial patterns in precipitation, and/or maintenance condition. This DDB had the most maintenance issues of all the studied DDBs:
    - The pipe infrastructure draining to the DDB is damaged and eroding, which could be releasing runoff before reaching the basin.
    - Substantial sedimentation around the inlet that is likely impeding water flow into the basin.
    - This DDB is overgrown with substantial forest coverage, thus trees could be absorbing runoff.
- Drawdown at Sites 1 and 3 exceeded 5 days and may take up to several weeks to return to pre-storm levels. While water level at Sites 2 and 4 returned to pre-storm levels within 24 – 48 hours.

Water Quality Treatment by DDBs (Figure 4 & Table 1)

- Mean and median concentration of TSS increased between the DDB inlet and outlet (Fig. 4).
- DDB outlets also contained median values of temperature, turbidity, and specific conductance (SC) that were greater than the median inlet value (Table 1).
- Water quality data have only been collected from 1 storm so far, thus more data is needed.

DDB Performance based on Socioeconomic Status and Maintenance Status

- Sites 3 and 4 (Fig. 2C and 2D) are in potentially underserved blocks based on race and income demographics.
    - Water levels at Site 4 quickly returned to pre-storm levels after storms. However, this site has maintenance concerns (see above).
    - Site 3 also has maintenance issues with substantial sedimentation around the inlet pipe, which is likely impeding water flow and reducing drawdown rates.
- Site 1 also has maintenance issues (overgrown and substantial litter accumulation), but drawdown rates appear to be sufficient to drain to pre-storm levels within 3 – 5 days.
- More water quality data is required to evaluate socioeconomic status and maintenance impacts on performance.

Preliminary Conclusions & Future Work

Preliminary results indicated that:

- Storms that exceeded ~2.54 cm increased water levels in all DDBs.
- Water level responses were affected by drainage area, number of inlets, and/or maintenance condition.
- Maintenance condition at Sites 1 and 3 likely inhibited drawdown rates.
- Water exiting DDBs contained greater TSS and turbidity
- Socioeconomic status may not be a significant predictor of DDB performance

Future work will include at least 2 additional storm sampling events, and continued monitoring of water level and precipitation through approximately October 2024.

Acknowledgments & References

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