ASSESSMENT OF WATER QUALITY BENEFITS FROM STORMWATER TREATMENT TRAIN AND OCEAN OUTFALL FOR THE MAIN STREET DRAINAGE BASIN IN NORTH MYRTLE BEACH, SC

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ABSTRACT. In 2013, the city of North Myrtle Beach began construction of a stormwater treatment train designed to reduce loading of fecal bacteria into recreational waters along beaches. The treated water will discharged about 1200 feet offshore through an ocean outfall pipe whose construction will be completed in 2015. The city of North Myrtle Beach, DDC, Inc., and Coastal Carolina University's Environmental Quality Laboratory are collaboratively assessing the efficacy of this drainage system in reducing loading of fecal coliforms, sediment, nutrients and BOD. The assessment addresses regulatory requirements and features innovative approaches to evaluating pollutant load and concentration reduction in a cost-effective manner.

INTRODUCTION

The city of North Myrtle Beach (NMB) is located along the northern coast of South Carolina. It is part of the Grand Strand, which annually hosts approximately 15 million visitors drawn to its famous beaches. In Spring 2014, the city of NMB began construction of an enhanced drainage system designed to help reduce loading of fecal bacteria into the recreational waters of the surf zone and thereby reduce beach advisories. The system will also improve drainage characteristics and reduce flooding.

From the water quality perspective, this system employs a series of best management practices (BMP's) terminating in an ocean outfall that discharges treated stormwater runoff 1200 feet seaward of the SC DHEC Ocean and Coastal Resource Management's (SCHDEC OCRM) setback line. This stormwater had been previously discharging through multiple pipes directly onto the beachface, which was a relict drainage system designed to carry runoff from state-maintained roads.

The ocean outfall pipe is located at the foot of Main Street. Its upstream BMP system collects water from a 100-acre catchment, aka the Main Street Drainage Basin, whose impervious coverage is on the order of 70% of the surface area of this urban municipality. The BMP's include Snouts® outfitted with Bio-Skirts®, catch basin inserts, and settling and mixing boxes. Nonstructural BMP's include street sweeping, routine cleaning of the Bio-Skirts®, and removal of debris from the other structural BMPs.

The associated construction work required a critical area permit from SC DHEC OCRM. The permit stipulated that an assessment be performed to evaluate localized and cumulative effects on water quality and benthic communities under wet and dry conditions. This assessment work is being conducted by Coastal Carolina University's Environmental Quality Lab in partnership with the city of NMB and its contracted engineering consultant, DDC, Inc. The results will also be used by the city of NMB to help meet some of the requirements of its NPDES Phase II Stormwater permit coverage.

EXPERIMENTAL DESIGN

Regulatory Constraints. The following assessment strategies are being employed to address these multiple regulatory needs: (1) An increased frequency of surf zone sampling for *Enterococcus*, (2) Characterization of chemical and microbiological concentrations in dry and wet weather flows from the Main Street Drainage Basin, (3) Quantification of associated mass transport of chemical and microbial constituents into the ocean under dry and wet weather conditions, and (4) Quantification of the load reductions achieved by the BMP treatment trains. The chemical characterization focuses on issues of eutrophication and hypoxia, including measurement of nutrients (nitrogen and phosphorus), total and volatile suspended sediments, BOD5, and dissolved oxygen concentrations. Microbial measurements include *Enterococcus* to address the recreational impairments and fecal coliforms to address National Shellfish Sanitation Program requirements. The results will be compared to data from SC DHEC's recreational beach and shellfish monitoring programs and to real-time information collected by the Long Bay Hypoxia Monitoring Consortium, to evaluate impacts to local marine waters.

Table 1. Sampling Site Description and Locations

Site #	*Site Name*	*Latitude Longitude*	*Site Description*	*Catch Basin Dimensions (LxWxH)*	*Box Pipe Outlet Diameter*
1	1st Ave South	33°49'5.99"N 78°40'24.25"W	NE corner of 1st Ave S and Ocean Blvd	36.25"x33.5"x35"	18"
2	Main Street	33°49'7.80"N 78°40'21.06"W	SE corner of Main Street and Ocean Blvd	37.5"x34.5"x18"	24"
3	2nd Ave North	33°49'10.38"N 78°40'11.53"W	NW corner of Grand Strand Resort parking lot	22.5"x23"x12"	24"
4	Ocean Outfall	33°49'5.31"N 78°40'19.29"W	East end of Main Street	TBD	72"

Site Description. Sampling sites are located in stormwater catch basins near the intersections of Main Street, 1st Ave S, and 2nd Ave N with Ocean Boulevard (Sites 1, 2, 3 in Table 1). These sites collective receive at least 44% of the catchments total estimated stormwater runoff. They were selected to representatively sample untreated storm water discharges and thereby fulfill assessment strategy 2 above. Sampling will be conducted in two phases; the first to characterize initial conditions and the second to characterize conditions after construction is completed in Spring 2015. Sampling at Sites 1, 2 or 3 will be halted at the end of Phase I, so that an autosampler can be relocated to the Ocean Outfall site (Site 4).

Equipment. Each site is equipped with a Teledyne ISCO autosampling system comprised of a 2150 Area Velocity Flow Module, 674 Rain Gauge, 6712 24-bottle autosampler, YSI 600-OMS water quality sonde and a 2105 Ci Interface module. Power is provided by the city of NMB via 112V outlets. Data are logged by the 2105 Interface module and transmitted via 4G cellular modem service.

The flow sensors are installed on ISCO scissor rings in the reinforced concrete pipes located on the downstream side of each catch basin (**Table 1**). The YSI 600-OMS datasonde and autosampler intake are attached to a rack secured to the bottom of each basin. The rain gauge is mounted on a streetlight pole approximately 25 feet above ground. Data cables run from the catch basin through a conduit into a locked Knaack jobsite box located next to the manhole cover over each catch basin. The cables connect to the 2105 Interface module where data are stored. The ISCO autosampler is also stored within the jobsite box.

Sampling Design. NPDES storm sampling criteria require 72-hr antecedent dry weather with a minimum accumulation of 0.1 inches rainfall (USEPA, 1992). Preliminary hydrographs have been collected since April 2014. An example is shown in **Figure 1** and illustrates that flow starts within minutes of the start of rainfall.

The ISCO autosampler is equipped with 24 1-L sterile ProPak baggies. All tubing used to collect samples will be autoclaved prior to use. The 24 samples will be used to create a composite for characterization of the three main parts of the hydrograph: rising, peak, and falling limbs (**Figure 1**). Flow-weighted compositing will follow USEPA guidelines (Smoley, 1993).

Sample collection will be triggered by a rise in water level over a threshold within a 30-s period. Sampling will then proceed in a time-paced fashion. During the rising and peak portions, sample intervals will be short (on the order of 3 minutes) to accommodate the rapid nature of these sections of the hydrograph. The time intervals during the falling limb will be increased to ensure that the entire hydrograph can be captured within the 24 baggies. The autosampler is outfitted with cables to enable remote alteration of time programming.

Since storm events are typically < 6 hr (**Figure 2**), all samples will be returned to the lab within the 8-hour hold time specified for bacteria analysis according to Table II in 40 CFR Part 136. As US EPA guidelines, hold times are defined as beginning when the last sample in a composite is collected.

Autosampler tubs will be filled with ice prior to deployment and refilled at the time of sample retrieval for transport back to the lab where compositing will be done. A Hobo datalogger will be used to document temperature control. No other preservation will be conducted in the field as per 40 CFR Part 136, Table II, Fn 2 which states other preservation steps can be performed after compositing if a particular analyte's preservative will comprise the integrity of the sample. Note this applies to 24-hr composite samples. The composites will be comprised of approximately 2.5 liters to meet analytical requirements. They will be split into smaller volumes and preserved as required for each analyte.

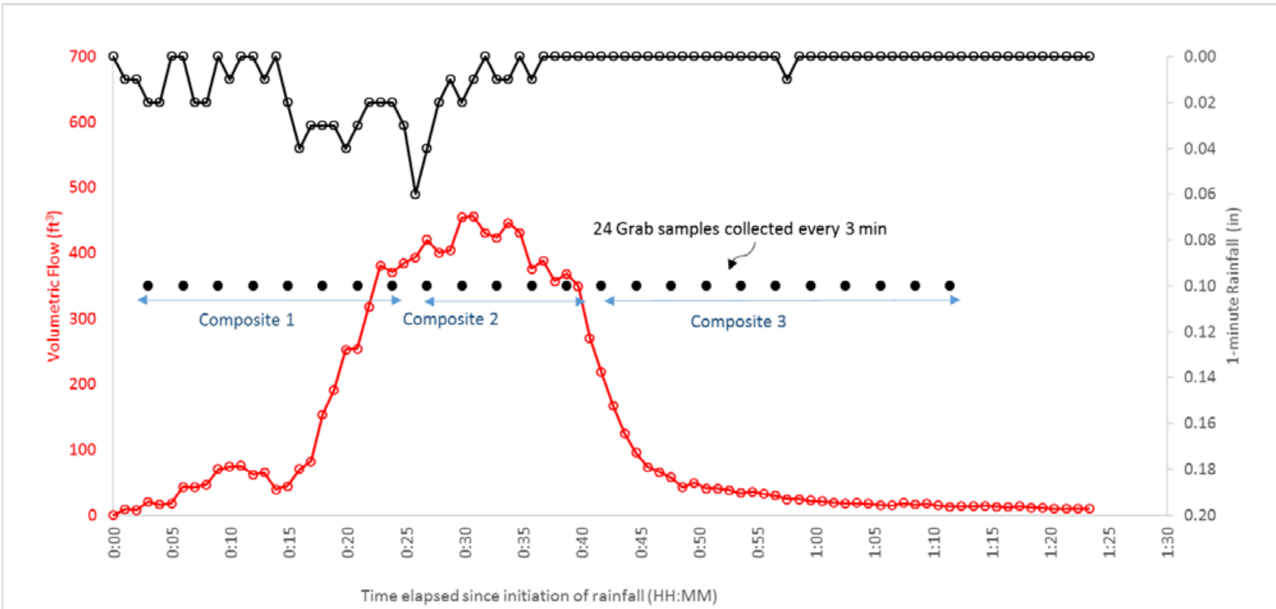

Figure 1. Storm hydrograph collected at 1st Ave S, NMB on 7/10/2014 22:58 to 7/11/2014 0:32 LST. Total rainfall accumulation: 0.63 inches. Total discharge: 11041 cubic feet.

During the storm event, in-situ measurements of specific conductance, dissolved oxygen and temperature will be made once per minutes using the YSI 600-OMS datasonde. The following analytes will be measured in the composited samples, a dry weather sample collected just prior to the storm event, field duplicates, and an equipment blank: BOD5, *Enterococci* and Fecal Coliform bacteria, particulate and unfiltered total phosphorus and total nitrogen, nitrate and nitrite, orthophosphate, ammonia, turbidity, total suspended solids and volatile solids.

PRELIMINARY FINDINGS

Rain fall, water level and discharge have been measured since April 2014 at Sites 1, 2 and 3. A typical hydrograph is shown in **Figure 1**. Statistical summaries of rain and flow duration are shown in **Figure 2**. In-situ measurements of specific conductivity suggest that the Main Street site (pre-construction) is tidal with saltwater backing up into the catch basin.

Storm hydrographs tend to be short, lasting from 1 to 3 hours. Hence an autosampler is critical for collecting samples to characterize rising, peak and declining limb pollutant concentrations. The short nature of the hydrographs reflects the high degree of impervious surface cover and the relatively small surface area in the catchment.

The minimum size rain events that would provide sufficient volume for analysis of all analytes in the three composites is approximately 0.1”. This is close to the minimum US EPA recommendation (US EPA, 1992). It is also near the lower end of the range of typical rain events for NMB as shown in **Figure 2**. US EPA (1992) further recommends that “where feasible, the depth of rain and duration of the rain event should not vary by more than 50% from the average depth and duration. In NMB, stormwater events that meet this criteria range from 0.1” to 0.5”.

SMS4’s are required to begin monitoring in support of their Stormwater Management Programs, particularly where TMDL’s require demonstration of load reduction. In cases where TMDL development is pending, USEPA is now recommending an alternative strategy in which SMS4’s immediately initiate load reduction programs in priority watersheds (US EPA, 2013). Hence there is a growing need to perform stormwater assessment work to demonstrate efficacy of stormwater BMP’s. In the case of bacteria impairments, this is problematic because USEPA does not provide guidance on the use of autosamplers for this purpose, instead suggesting they cannot be used or only at the discretion of the “Director”. Without permitting the use of autosamplers, SMS4 options for stormwater assessment work is going to be prohibitively limited. These limitations are associated with requirements for hold times and preservative steps. Accommodations to address these are discussed below.

For NMB, the short nature of the hydrographs suggests that the entire stormwater event can be sampled well within the 8 hour hold time stipulated by 40CFR Part 136 for bacteria samples. Furthermore, Ghazaleh et al. 2014 have shown that fecal bacteria concentrations are not altered by extended storage in autosamplers without thiosulfate preservative or refrigeration.

Preliminary measurements also indicate that the short nature of the hydrographs also makes maintenance of

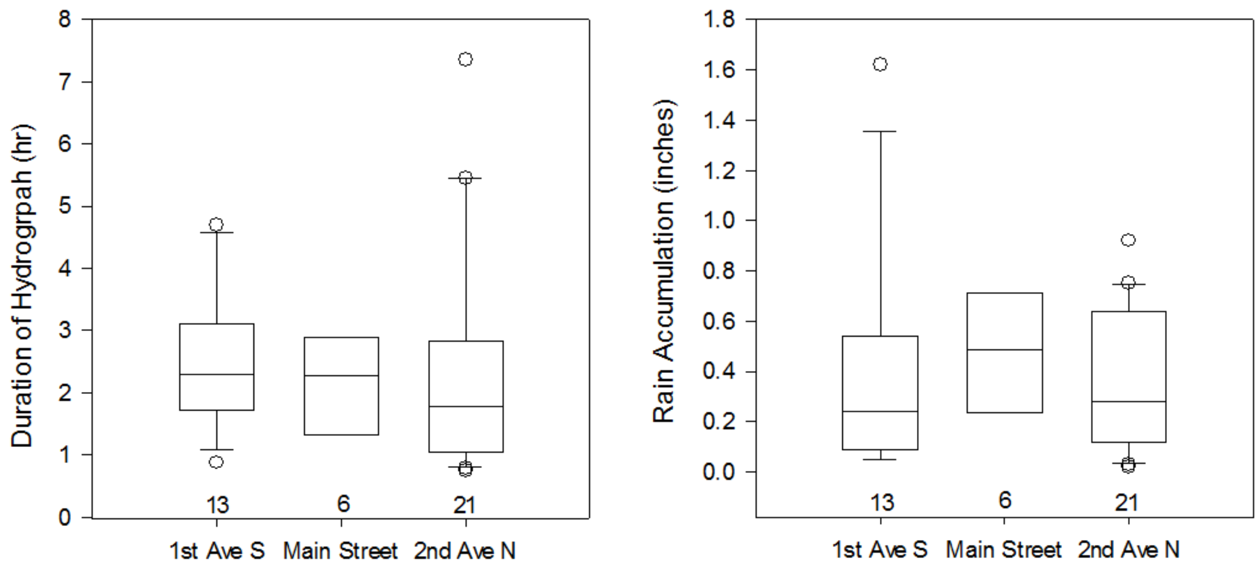

Figure 2. Box plots showing preliminary hydrograph duration (left) and rain accumulation (right) at the three pre-construction sampling sites in NMB, SC

required preservative temperatures (<6°C) feasible, even during the summer, by stocking the autosampler tub with ice and shading the autosampler by storing in a jobsite box.

The short nature of the hydrographs makes design of a time-paced sampling program challenging as the initial samplings need to be closely spaced to generate sufficient volume of water (2.5 L) for analysis of all parameters. To ensure that the entire event can be sampled with 24 bottles, we plan to remotely monitor the progress of the hydrograph and alter the time pacing, most likely by extending the intervals between sampling during the falling limb. Remote alteration of the programming is achieved using HyperTerminal to communicate via modem with the autosampler.

FUTURE PLANS

Phase I sampling will be completed in February 2015 and Phase II in July 2017. The catch basins being studied (**Table 1**) during Phase I represent at least 44% of the total expected flow entering the Ocean Outfall pipe and are representative of the land-use land-cover of the catchment. In the event that significant differences in concentration and loading are observed at the Phase I sampling sites, concentrations in the remaining two catch basins will be characterized using first-flush samplers to better constrain spatial variability.

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