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Memorandum

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CC	Kaitlin Sylvester		
Subject	Wet Weather Monitoring		
From	Aaron Hopkins		
Date	08/19/2013		

DCR Wet Weather Monitoring

In an effort to generate baseline data on phosphorus and bacterial inputs from stormwater runoff to the Lower Charles River, the Department of Conservation and Recreation (DCR) and AECOM developed and implemented a wet weather monitoring program. This pilot program was intended to test the proposed protocol and collect loading data for a few selected catchments.

AECOM conducted wet weather monitoring at and around the Elliot and Longfellow Bridges in Boston and Cambridge on June 7th, 2013 according to DCR's wet weather protocol (Appendix A). These catchments were selected due to interest in potential stormwater inputs to the Charles River from local bridges. The last rain event in the area was on June 3rd, approximately 72 hours before monitoring. The targeted storm resulted in 3.6 inches of rain in the 24 hour period that began with the sampling event.

METHODS

Less than 0.05 inches of rain fell in the overnight hours (1:00 AM – 2:00 AM) and AECOM technicians were onsite to capture the first measurable flush of the storm at 7:50 AM (Figure 1).

Grab samples were first collected from the sheet flow running from the Elliot Bridge crown towards the east, this location captured runoff from the bridge deck and eastern approach of the two inbound lanes (Figure 2). The field team then setup on the Longfellow Bridge and collected grab samples from two separate locations on the bridge. Runoff on the Longfellow Bridge deck is captured by regularly spaced scuppers along the curb, the Cambridge sampling location captured sheet flow between two scuppers on the western approach of the two inbound lanes, and the Boston sampling location captured sheet flow between two scuppers on the eastern approach of the two inbound lanes (Figure 3). A nearby stormwater outfall to the Charles River was also sampled (Figure 3). The team then returned to the Elliot Bridge and collected another sheet flow grab sample from the first location approximately two hours after the initial sample to gage changes in stormwater concentrations after the first flush of the storm.

Each grab sample was divided into bottles for nutrient and bacteria analysis and placed on ice. The samples were transported to the Alpha Analytical Laboratory in Westborough, Massachusetts and analyzed for Fecal coliform, *E. coli*, and Total Phosphorus (TP).

RESULTS

The sampling protocol for the pilot program was practical, safe, and efficient for collecting wet weather flow samples. Rapid field mobilization and continual forecast updates were critical for capturing first flush samples. The locations for the pilot study were specifically chosen to minimize traffic safety issues, future locations with accessibility or traffic issues should be addressed individually to ensure safe and efficient sampling of targeted precipitation events.

Bacteria levels, as *E. coli*, in all first flush samples exceeded the Massachusetts Department of Public Health standard from 105 CMR 445.010 of 235 colonies per 100 ml (Table 1). These levels would limit primary contact recreation in the receiving water and indicate bacterial contamination in the catchment. Likely sources of bacteria in the drainage areas of these bridges include dogs and wildlife; it is unlikely that sewer or illicit discharges contribute to the stormwater runoff from either the Elliot or Longfellow Bridges although they are possible in the outfall drainage system.

Table 1. *E. coli* Levels from the June 7-8 Storm

Location	E. coli (MPN/100 ml)	Sample Type
ELLIOT	20,000	First Flush
LONGFELLOW-CAM	1,700	First Flush
LONGFELLOW-BOS	2,500	First Flush
OUTFALL	5,200	First Flush
ELLIOT - 2	5,200	Two Hours into Storm

The second sample collected from the Elliot Bridge, two hours into the storm, showed a substantial decrease in *E. coli* levels, suggesting that the first flush sample may be a worst case scenario and that bacterial input to the receiving waters likely decreases over the course of a rain event.

Total Phosphorus concentrations in the first flush samples were also expected to be elevated over the event mean concentration (EMC). The first flush phenomenon is exaggerated in smaller watersheds with a high percentage of impervious surface (Pitt et al 2004). The drainage areas for the Elliot Bridge and the two Longfellow Bridge samples were very small (700 m^2 and 150 m^2 respectively; Figures 2 and 3) and 100% impervious. The potential for the first flush phenomenon within these catchments is highlighted by the 77% drop in TP concentration at the Elliot Bridge from 0.843 mg/l at first flush to 0.197 mg/l two hours into the storm (Table 2).

Table 2. Total Phosphorus Concentrations from the June 7-8 Storm

Location	**TP (mg/l)**	**Sample Type**
ELLIOT	0.843	First Flush
LONGFELLOW-CAM	0.319	First Flush
LONGFELLOW-BOS	0.209	First Flush
OUTFALL	0.196	First Flush
ELLIOT - 2	0.197	Two Hours into Storm

A review of more than 400 paired samples from the National Stormwater Quality Database yielded a ratio to relate first flush concentrations to EMCs for certain compounds (Maestre et al 2004). The ratio calculated for Total Phosphorus concentrations in commercial land use areas (1.44) allowed for the estimation of EMCs from the first flush data collected during this study (Table 3). The estimated EMCs were then used to calculate phosphorus loading from these watersheds for comparison to the Lower Charles River Total Maximum Daily Load (TMDL).

Table 3. Total Phosphorus Concentrations and Estimated Total Phosphorus EMCs from the Sheet Flow Samples Collected During the June 7-8 Storm First Flush

Location	**First Flush (mg/l)**	**Estimated EMC (mg/l)**	**Watershed Area (m^2)**	**Annual Load (kg/year)**
ELLIOT	0.843	0.585	700	0.43
LONGFELLOW-CAM	0.319	0.222	150	0.03
LONGFELLOW-BOS	0.209	0.145	150	0.02

Note: Annual loads were based on annual precipitation from the TMDL (41.5 inches) converted to 41.25 inches of runoff based the impervious area curve number and runoff calculations for small urban watersheds (USDA 1986).

These estimates for annual loading represent substantial exceedances over the TMDL recommendations but are in line with the 1998-2002 water quality data from commercial land use areas that were used to generate the TMDL. The Elliot Bridge sheet flow would require a 90% reduction in TP to attain the TMDL loading rates while the Longfellow Bridge sheet flow would require a 75% reduction on the Cambridge side and a 60% reduction on the Boston side.

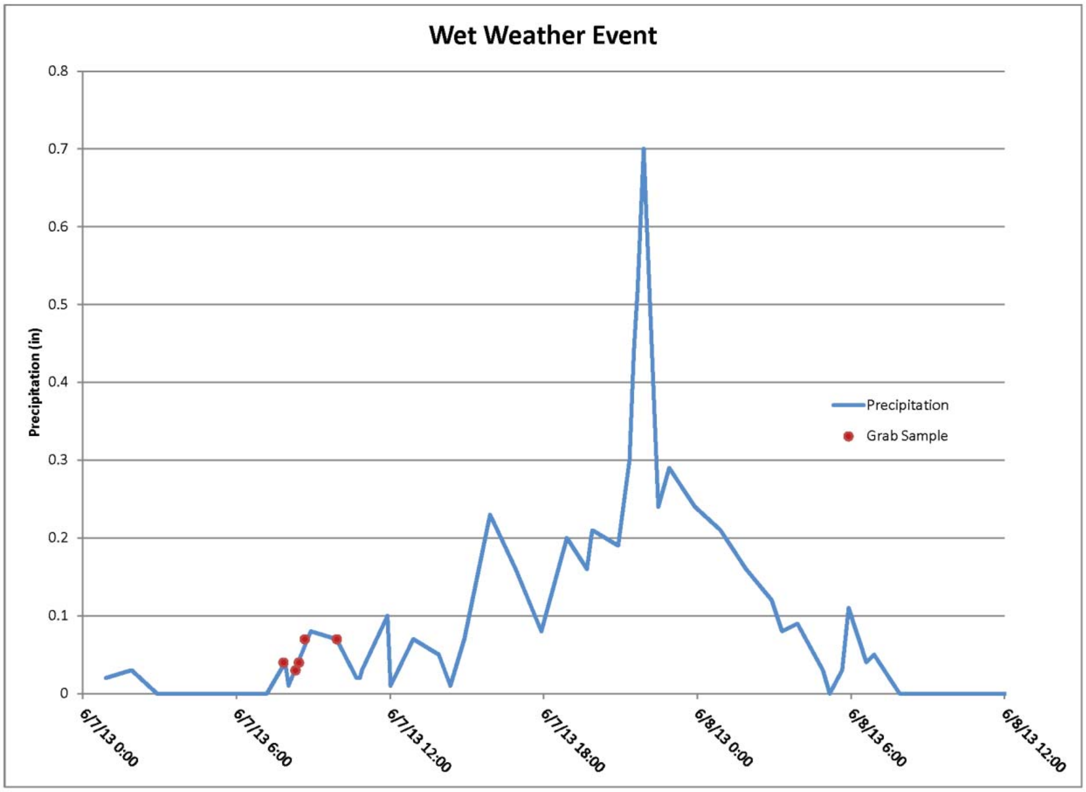
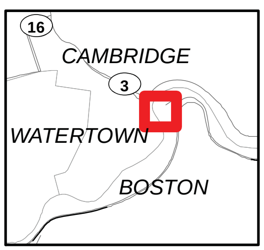


Figure 1. Precipitation and wet weather sample times for the June 7-8 storm. Precipitation data from weather station KBOS at Logan Airport (www.wunderground.com).

Figure 2
Wet Weather Monitoring
2013
Elliot Bridge

System 1:
Sheet flow collected from the Elliot Bridge during the first flush and rising limb of the storm on June 7, 2013.

Sample Collection Location
Estimated Sheet Flow
CatchBasin
Manhole
Inlet
Outlet
Other
Conveyance (Pipe)
DCR Parkway in Urban Area
DCR Property in Urban Area
Town Boundary



N

0 50 100 200 Feet

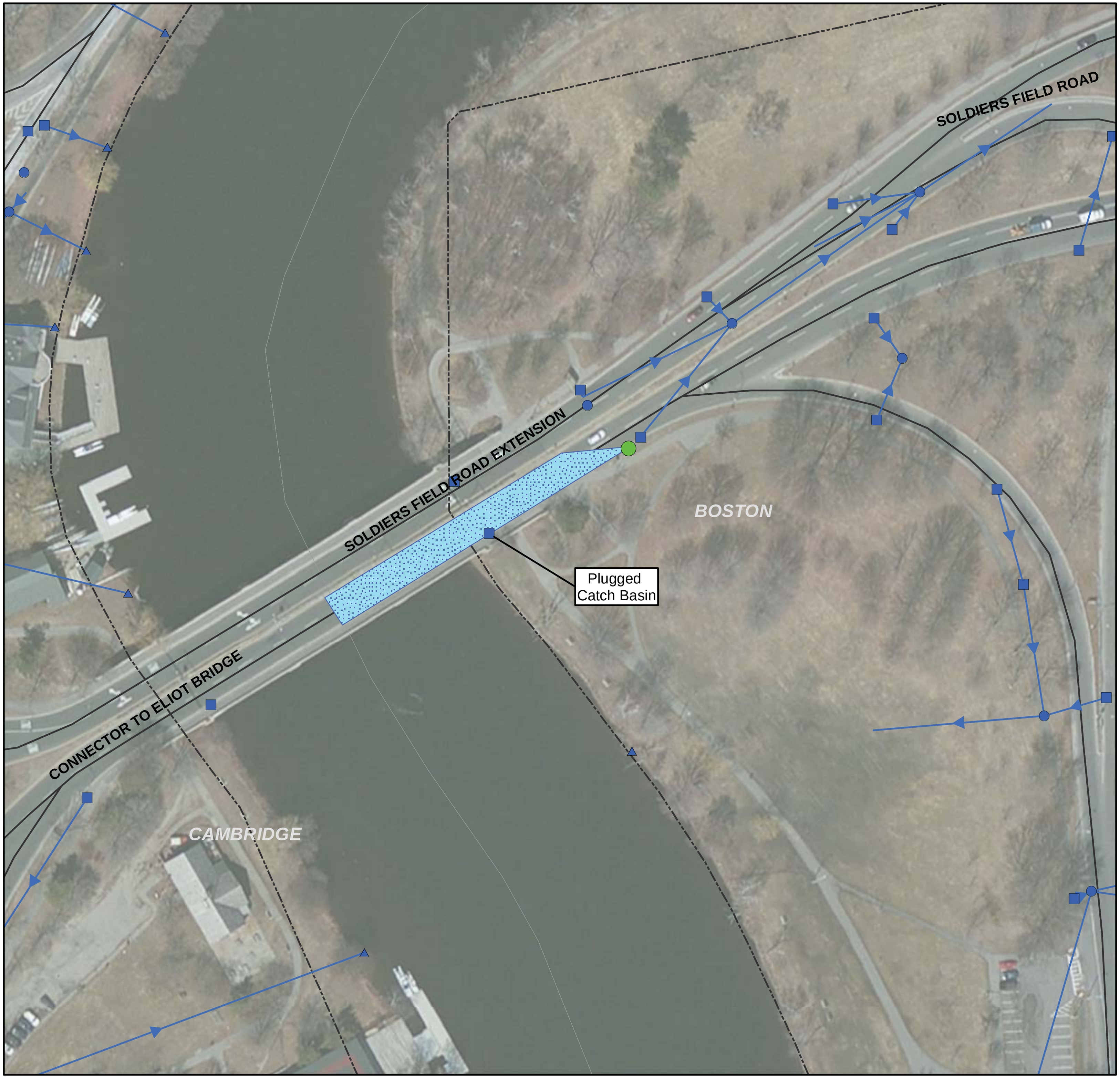
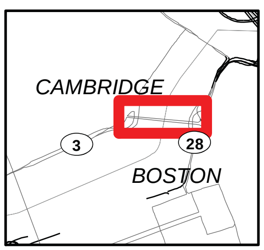


Figure 3
Wet Weather Monitoring
2013
Longfellow Bridge

System 2:
Sheet flow was collected from the Longfellow Bridge on both the Cambridge and Boston approaches. A stormwater outfall that contributes to the Charles River was also sampled on June 7, 2013.

- Sample Collection Location
- Estimated Sheet Flow
- CatchBasin
- Manhole
- Inlet
- Outlet
- Other
- Conveyance (Pipe)
- DCR Parkway in Urban Area
- DCR Property in Urban Area
- Town Boundary



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N

0 50 100 200 Feet

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Pitt, R., Maestre, A., and Morquecho, R. Stormwater Characteristics as Contained in the Nationwide MS4 Stormwater Phase 1 Database. Critical Transitions in Water and Environmental Resources Management: pp. 1-9. 2004.

USDA. Natural Resources Conservation Service, Conservation Engineering Division. Urban Hydrology for Small Urban Watersheds. Technical Release 55. June 1986.

Appendix A

Wet Weather Protocol

DCR 2013

AECOM will perform monitoring of selected stormwater systems during rain events as part of a pilot wet weather monitoring program. The program will focus on discharges to the Lower Charles River in support of the phosphorus TMDL for that reach of the river (see attached maps). Monitoring will include systems that only receive runoff from DCR properties, roadways, or bridges as well as a system that receives runoff from non-DCR sources.

Targeted storm events will include a forecast of at least 0.5 inches of rain in an eight hour period preceded by at least 48 hours of dry weather (less than 0.1 inches of rain) during the Spring (March to June) of 2013.

The stormwater monitoring event will include a single grab sample at the 3 previously identified locations. Sampling will occur during the rising limb of the storm event and, if possible, will capture the first flush (initial 30 minutes of precipitation) of the event.

Specific monitoring procedures are outlined below:

<u>Monitoring Procedure</u>

1. Setup at the pre-selected monitoring location at least 30 minutes before the forecasted beginning of the rain event.
2. Record the time that precipitation begins.
3. Collect one liter of water within 30 minutes of the first steady rainfall (rising limb and/or first flush) and record the time. For discharges from outfalls or within catchbasins and manholes collect samples directly from pipes with a remote sampling device. Use a pole mounted sample cup with squared edges to collect sheet flow from roadways and bridges.
4. Divide the sample into bottles for bacteria and total phosphorus and place the bottles on ice.
5. Photograph the flow and note the major sources of runoff.
6. Deliver all samples to the laboratory for bacteria and total phosphorus analysis.
7. Compare sampling times with hydrograph recorded at a local weather station.

Method adapted from:

NPDES Storm Water Sampling Guidance Document. US Environmental Protection Agency. EPA 833-8-92-001. July 1992.

EPA NH Draft NPDES Permit, http://www.epa.gov/region1/npdes/stormwater/nh/2013/NHMS4-NewDraftPermit-2013.pdf