Simulated Runoff Testing:
Performance Testing of Green Stormwater Infrastructure in Controlled Conditions

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Abstract

The Philadelphia Water Department has taken steps to reduce combined sewer overflow through the means of Green Stormwater Infrastructure. Stormwater management practices (SMPs), such as rain gardens and underground tree trenches, are designed to capture stormwater, promote infiltration and evapotranspiration, or slowly release stormwater into gray infrastructure after the peak intensity of the storm. In accordance with PWD's Comprehensive Monitoring Plan (CMP), monitoring is being conducted on certain SMPs to validate that their performances meet the design standards. For a SMP on Hewson Street in the Kensington area of Philadelphia, a simulated runoff test (SRT) was conducted to determine the performance of the infiltration stormwater tree trench. Standardized monitoring methods coupled with metered flow into the system allowed for the calculation of the recession rate of water out of the SMP.

Introduction

A Simulated Runoff Test (SRT) imitates a storm of specific intensity over the measured drainage area of the SMP. Monitoring techniques are used to determine the rate of water entering and leaving the system. SRT methods are derived from methods used by Portland Oregon's Bureau of Environmental Services [1] and are intended to be easily applicable to a variety of stormwater management practices.

Figure 1. Photograph of SRT configuration

Methods

Methods used are from PWD's CMP [2]. Using the Sensus WL-1250 portable water meter tester seen in Figure 1, a metered flow of 741 cubic feet (CF)(a volume equivalent to a 1"/hour storm over the drainage area of the system's feeding inlets) was applied to the system. This is half of the SMP's design storage capacity.

In order to measure the changing volume of water stored within the trench, water level sensors set to record on a one-minute time interval were installed in the Observation Well (OW1), Cleanout 1* (CO1), and Green Inlet 2 (GI2)(Fig. 2). Manual measurements using electronic water tape were taken at these locations every 10 minutes to accurately calibrate the water level data. The changing water level within the system was used to determine the associated change in volume of water stored via a stage to storage curve created from design plans.

**For this analysis, the Cleanout refers to the vertical section of the perforated distribution pipe shown in Figure 4.*

Assumptions

Assumptions were made regarding the physical configuration of the system. The assumptions are as follows:

- Sump depth is 10" below the bottom of the trench.
- Porosity of the stone storage is 0.40.
- Lateral movement of water leaving the system, while not an insignificant volume, becomes a small factor in the overall recession rate over time.

Results

Based on recorded data, all water was drained from the storage volume in 9.9 hours (594 minutes)(Fig. 5). Figure 3 shows the water levels recorded by the monitoring devices within the system, adjusted to depict the system's components in reference to the bottom of the sump. A recession rate (sum of all hydrologic processes) of 42 CF/hour was calculated from peak volume observations and assumptions of storage within the system's distribution pipes and inlets.

Using construction records, an effective infiltration footprint was calculated by taking the stone storage footprint and multiplying it by the assumed porosity, 0.4, of the storage media. Emerson and Traver [3] used similar methods to estimate infiltration rates when comparing infiltration-based SMPs, however this analysis assumed the wetted area in the stone storage was simply the stone storage footprint. The effective infiltration footprint was 412 square feet for the SMP. Dividing the recession rate by the effective infiltration footprint gave an estimated infiltration rate, water flux at the stone storage and soil interface, of 1.22 in/hr.

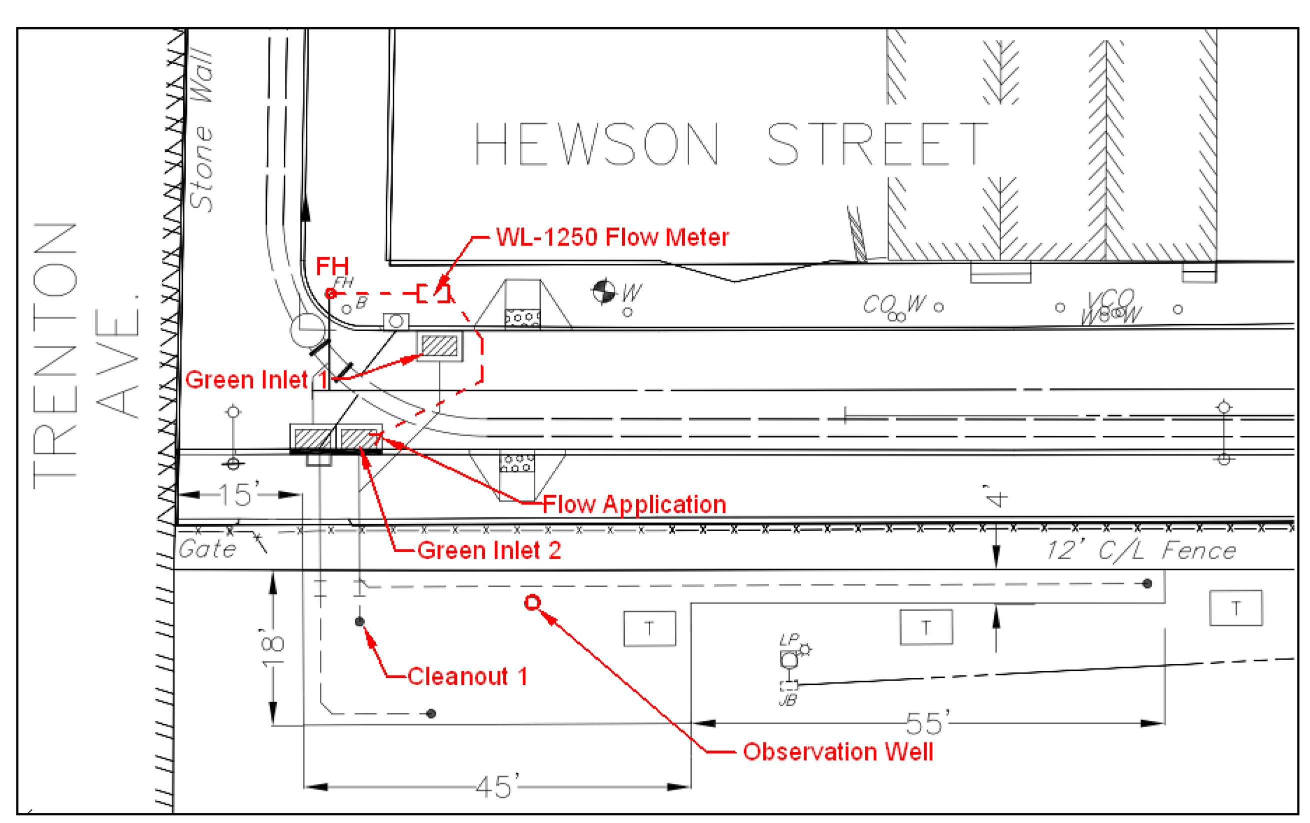

Figure 2. A labeled plan view of the SRT configuration on Hewson Street.

Results

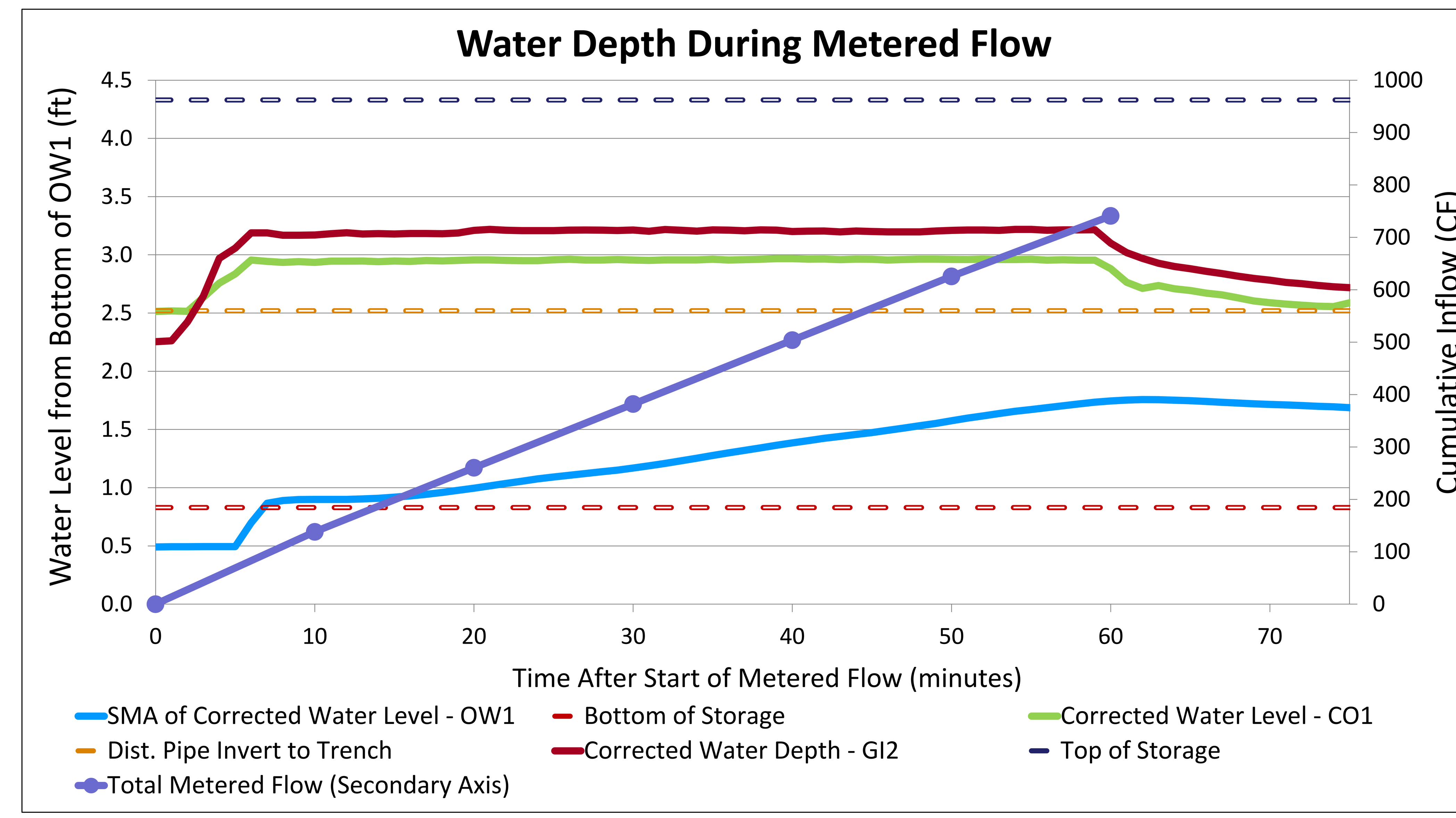

Figure 3. A 5-minute simple moving average of water depth data from OW1 and recorded responses within the system. Data was corrected to show elevation of water in reference to the bottom of the sump.

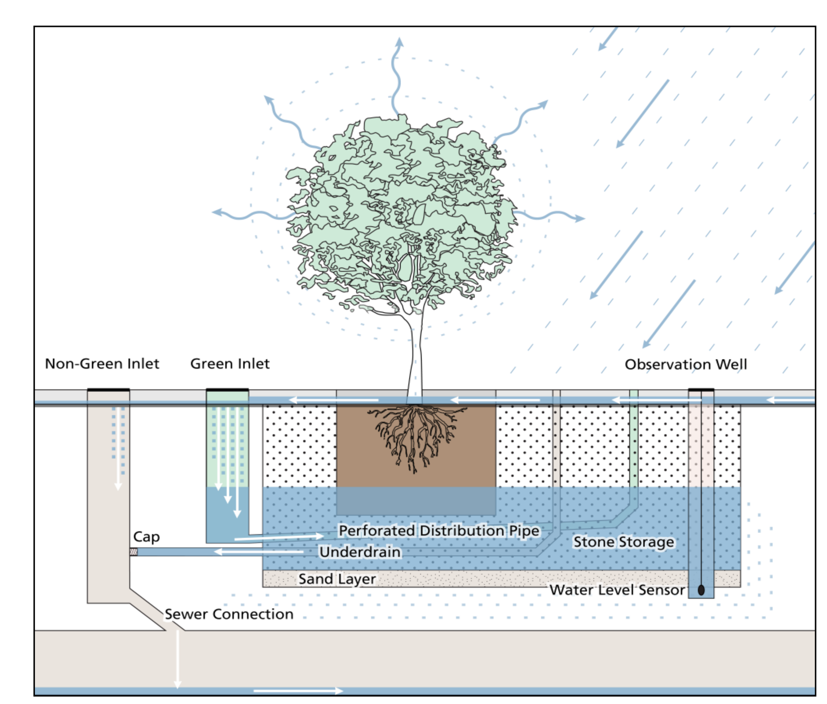

Figure 4. A representative cross section of an infiltration stormwater tree trench [4].

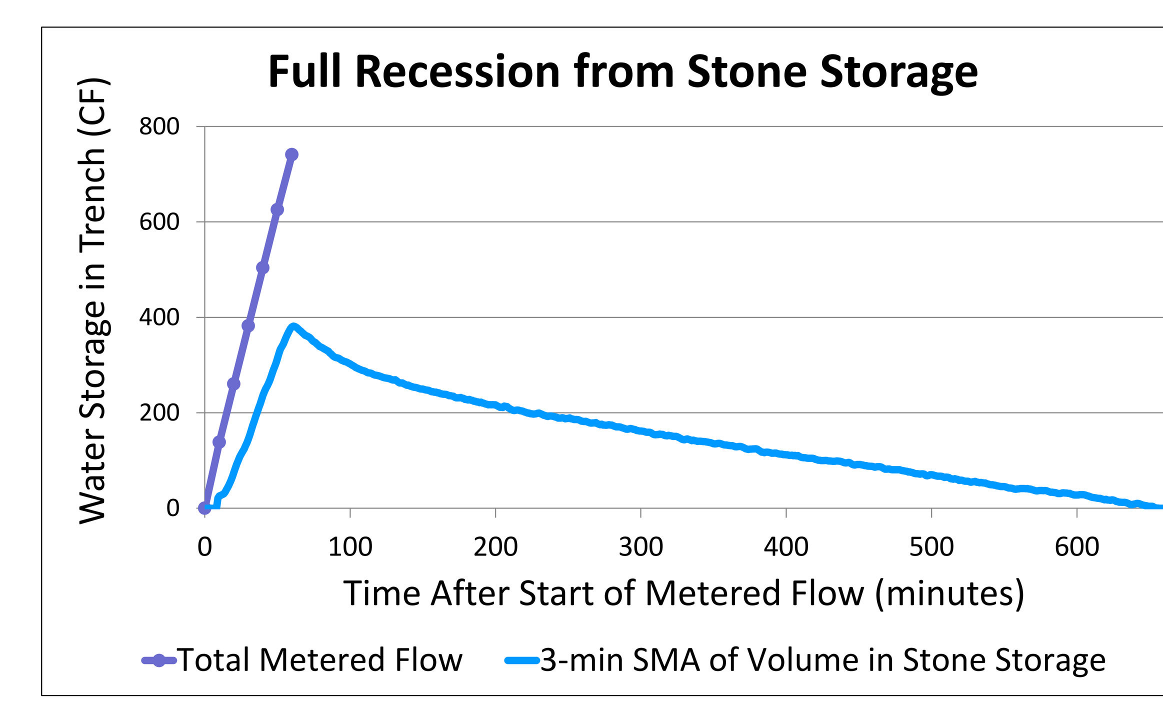

Figure 5. A 3-minute standard moving average showing the recession of water out of the system.

Conclusion

Based on observations from the SRT, the SMP functioned properly. An estimated recession rate of 42 CF/hour was calculated. An estimated rate of infiltration of 1.22 in/hr was calculated based on the recession rate and the effective infiltration footprint. This was very close to the geotechnical investigation infiltration rate of 1.24 in/hr. A time of travel was observed between the application of flow and a recorded response within the system. This travel time (approximately 5 minutes) can be used when validating inflow observations derived from Rain Gauges and other indirect sources.

[1] City of Portland. Bureau of Environmental Services. (2010). *2010 Stormwater Management Facility Monitoring Report*. Retrieved from http://www.portlandoregon.gov/bes/article/417248 [2] Philadelphia Water Department. (2014) *Green City, Clean Waters Comprehensive Monitoring Plan*. Retrieved from http://www.phillywatersheds.org/doc/Revised_CMP_1_10_2014_Finalv2.pdf
[3] Emerson, C.H. and Traver, R.G. (2008) "Multiyear and seasonal variation of infiltration from storm-water best management practices." *Journal of Irrigation and Drainage Engineering*, 134(5), 598-605. [4] [Photograph of infiltration stormwater tree trench]. Retrieved 10 April 2014 from http://www.phillywatersheds.org/what_were_doing/green_infrastructure/gsi_monitoring