Section S8.F.7 – Best Management Practice Evaluation
Pervious Pavement Flow Reduction

March 2012

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EXECUTIVE SUMMARY

Purpose. Section S8.F.7 of the 2007 National Pollution Discharge and Elimination System (NPDES) permit requires monitoring of a flow reduction hydraulic Best Management Practice (BMP). This condition requires the City to continuously monitor rainfall and runoff from one flow reduction strategy and to annually report these results. This report summarizes the methods and results of flow monitoring data from the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project).

Site Setup. The Project is located at the Tacoma Landfill and consists of a 36,100 square foot area paved with equal areas of pervious pavers, pervious concrete, pervious asphalt, and standard, impervious asphalt. The Project was constructed over an existing impermeable geomembrane liner that was installed as part of the landfill's environmental controls. Surface runoff and infiltrated flows through the pervious pavement sections were isolated from each other to facilitate flow monitoring.

Flow Comparisons between Pavement Sections. Flow data was collected from March 2007 to June 2010. Periodic data gaps occurred during this time period due to battery failures or other flow meter issues. For this flow reduction study, data collected over a one year period between June 2009 and June 2010 were initially analyzed since that data were believed to be the most complete set of data available for the site. During this one year data analysis period, 102 storm events were targeted for comparison purposes.

Visual observation of the flow data showed that smaller rain events (generally less than 0.15 inches) may not generate an observable flow response from the pervious pavement sections while a response was observed from the standard asphalt section. Visual observation also indicated that peak flows of infiltrated water from pervious pavement sections are generally less than standard asphalt peak flows.

During an approximately 6 month period, a maximum of 155 gallons of surface runoff was collected in each of the surface runoff catch basins associated with each pervious pavement section. This is significantly less than the roughly 121,500 gallons of runoff (predicted based on the 21.6 inches of rainfall that fell during this time period) that would have been collected from standard impervious pavement. This suggests that the pervious pavement sections are still able to effectively infiltrate rainfall after over four years of use.

The statistical comparison identified in the QAPP, however, was not completed since it was determined after reviewing one year of the flow data that the flow information was not accurate enough to allow for a successful comparison between the pavement sections. These inaccuracies appear to be due to errors associated with using level measurements from a bubbler meter and Manning's equation to generate flows; with the very low flows seen at the site, accurate enough data could not be generated even after efforts were made to calibrate Manning's equation based on actual flows. Future flow studies at this site should consider installing a flume to generate more accurate flow data.

1.0 PROJECT OVERVIEW

This report summarizes the methods and results of flow data collected from the Tacoma Landfill Employee Parking Lot and Pervious Pavement Demonstration Project (Project) to fulfill the requirements of Section S8.F.7 of the City's 2007 National Pollution Discharge and Elimination System (NPDES) permit.

The site was monitored between March 2007 and June 2010. Between March 2007 and October 2009, individual storm events were targeted and sampled for water quality parameters. The results of the water quality performance, maintenance, and durability study for data collected between March 2007 and October 2009 are provided in a separate report included as Appendix A.

Continuous flow data was collected between March 2007 and June 2010, but periodic gaps in flow data occurred due to battery failures or other equipment issues. For this flow reduction study, only data collected over a one year period between June 2009 and June 2010 were analyzed since this data period was believed to provide the most complete set of data.

1.1 PROBLEM STATEMENT

Impervious surfaces prevent rainfall from infiltrating the underlying soil. This alters the natural hydrologic cycle resulting in increased stormwater runoff since rainfall does not immediately recharge the underlying groundwater. Pipes and detention ponds are frequently required to collect and convey this water to local water bodies. As the area of impervious surfaces in a watershed increases, the peak runoff rate increases which can lead to urban flooding and scouring of rivers and streams. Pervious pavement, on the other hand, allows the majority of rainwater to pass through the pavement and infiltrate the underlying soils. This reduces the need for surface water collection systems. However, uncertainties in the long-term performance, maintenance requirements, and durability of pervious pavements have inhibited their widespread use. Limited research has been conducted to quantify the reduction in stormwater runoff from pervious pavements.

To assess the flow reduction performance of pervious pavements in relation to standard asphalt, the City conducted a pilot study at the Tacoma Landfill. The test site consists of a 36,100-square-foot paved area, which is used to provide employee parking, constructed with equal size sections of pervious interlocking pavers, pervious concrete, pervious asphalt and standard, impervious asphalt (approximately 9,000 square-feet each). Construction of the Project was completed in April 2006. Continuous flow data was collected between June 2009 and June 2010.

1.2 MONITORING OBJECTIVES

The pervious pavement best management practices (BMPs) are classified as short-term BMPs for hydrologic control. To evaluate hydrologic control efficiencies, the following performance metrics for each pervious pavement section were identified in the Section S8.F – Stormwater Treatment Best Management Practice Evaluation: Quality Assurance Project Plan (QAPP, Appendix B) developed for this project:

- Individual storm reduction in peak flow;
- Individual storm reduction in average flow; and
- Average annual reduction in flow volume.

2.0 PROJECT DESCRIPTION

This section describes the Project site, Project construction, and the Project's stormwater conveyance system.

2.1 PROJECT SITE CHARACTERISTICS

The Project is located at the Tacoma Landfill, which is an approximately 240 acre solid waste facility that is owned and operated by the City of Tacoma Solid Waste Utility (Figure 1). All regions of the landfill are closed and capped, except for a 15 acre area of the landfill that is still actively receiving refuse.

The landfill cap system present at the site prevents water from entering the underlying refuse in order to prevent groundwater contamination. This landfill cap system (Figure 2) consists primarily of six inches of topsoil, eighteen inches of cover material, a drainage net, and two impermeable high density polyethylene (HDPE) liners (a primary and a secondary liner separated by a twelve inch sand layer) over the underlying refuse. The landfill cap also includes a system of drainage ditches (Figure 3) which convey stormwater away from the site and into the City's stormwater system.

2.2 PROJECT DESCRIPTION

The Project consists of a 36,100 square foot paved area constructed in 2006 at the Tacoma Landfill to provide additional employee parking and storage areas. The pervious pavement parking lot is adjacent to an existing employee parking lot, located on the east side of the administration building (Figure 4). The pervious pavement parking lot is located in an area of the landfill that has been closed with a landfill cap as described in Section 2.1.

The Project was constructed in sections (9,028 SF each) with three sections of pervious pavement (pervious pavers, pervious concrete, and pervious asphalt) and one section of standard, impervious asphalt. Cross sections of the standard asphalt and pervious pavements used in this Project are shown in Figure 5.

2.2.1 Pervious Pavers

The pervious paver materials installed at the Project site are UNI-ECOLOC manufactured by UNI-GROUP U.S.A. The pavers are approximately 3 1/8" high with an "L" shaped pattern. The pavers were mechanically installed in the parking lot.

2.2.2 Pervious Concrete

The pervious concrete material installed at the Project site contains the Perco-Bond admixture distributed by Michiels International LLC to create a "PercoCrete" product. PercoCrete differs from most other pervious concrete products in that it provides a smooth finish as well as water retention. After water enters the pavement section, it slowly exfiltrates from the PercoCrete into the underlying soils below.

2.2.3 Pervious Asphalt

The pervious asphalt material installed at the Project site is HMA Cl ½" PG 64-22 with an open graded mix. The gradation requirements for the asphalt are listed below:

US Standard Sieve Size	Percent Passing
½" Square	100
3/8" Square	92-98
No. 4	32-38
No. 8	12-18
No. 16	7-13
No. 30	0-5
No. 200	0-3
Asphalt % of total mixture	5.5% to 6.0%

Compaction of the pervious asphalt mix occurred when the surface was cool enough to resist a 10-ton roller. Minimal passes were allowed (just enough to get a smooth surface) with the roller to ensure the porosity of the pavement would not be significantly reduced.

2.2.4 Standard Asphalt

The standard asphalt material installed at the Project site is HMA Cl ½" PG 58-22. The standard asphalt material met the installation and material requirements listed in the 2004 Standard Plans for Road, Bridge, and Municipal Construction prepared by the Washington State Department of Transportation.

2.2.5 Subgrade Materials

Beneath all the pavement sections, a crushed gravel base was used to provide structural integrity to the pavement and to provide additional water storage for the pervious pavement sections. The crushed gravel base was an open graded, fractured stone conforming to ASTM No. 57 gradation requirements.

The existing topsoil material was removed prior to installation of the crushed gravel base. Approximately twelve to eighteen inches of existing cover material remained under the crushed gravel base over the underlying composite liner.

2.3 FLOW PATH

2.3.1 Infiltrated (Subsurface) Water for Pervious Pavement Sections

Water that infiltrates through the pervious pavement sections moves through the underlying gravel base and then does either of the following:

- Infiltrates through the cover soil until it reaches the drainage net and primary HDPE liner. Water then travels west along the HDPE liner/drainage net until it reaches the perforated pipe located at the west edge of the pavement section.
- Remains in the gravel base layer (due to the lower permeability of the underlying cover soils) and travels west until it reaches the west side of the pavement section. The water then infiltrates the cover soil until it enters the perforated pipe on the west side of the pavement section.

The perforated pipe collects these subsurface flows and discharges the flow into the monitoring manholes located on the west edge of each pervious pavement section (Figure 4).

Subsurface flows between the pavement sections are isolated from each other by a geosynthetic clay liner (GCL) flap (Figure 6). The GCL flap is placed between each pavement section to prevent subsurface flows from one pavement type reaching the monitoring manhole for a different pavement type. A GCL flap and perforated pipe were also installed around the perimeter of the parking lot to prevent subsurface flows from adjacent capped areas reaching the monitoring manholes. The GCL was installed vertically (liner to pavement surface) and connected to the HPDE liner with bentonite.

The monitoring manholes are equipped with a bubbler flow meter connected to an automatic sampler. More information about the specific monitoring equipment used in this Project is provided in Section 3.1.1.

2.3.2 Surface Runoff

2.3.2.a Standard Asphalt

Surface runoff in the standard asphalt pavement area flows to the northwest corner of the site where it flows through a 4" surface drain and discharges to a 48" diameter catch basin. The outlet pipe of the catch basin is equipped with a bubbler flow meter connected to an automatic sampler. More information about the specific monitoring equipment used in this Project is summarized in Section 3.1.1.

2.3.2.b Pervious Pavement Sections

Surface runoff from each of the pervious pavement sections flows west until it reaches a concrete curb and gutter on the west side of the pavement section. Water is collected in the curb and gutter and discharged into a 24" diameter catch basin (one catch basin for every pavement section). The pavement sections are separated by a concrete curb to minimize surface runoff from one pavement section reaching the catch basin for another pavement section. The catch basin is equipped with a gate valve that allows water to be collected in the basin during a storm event and then discharged after the storm. Volume measurements are made as described in Section 3.1.2 in order to monitor surface runoff over time.

Since the concrete curb and gutter is not pervious, it is covered with a metal plate (sloped to drain away from the pavement section) to prevent rainfall from hitting the gutter and being conveyed to the catch basin without having the opportunity to infiltrate through the pervious pavement.

2.4 SITE MAINTENANCE

Since the pervious pavement sections are expected to clog over time, the site was swept with a vacuum sweeper on an as needed basis. Determinations on when the site needed to be swept were made based on visual observation and on the amount of surface runoff from the pervious pavement sections. No sweeping occurred during the flow monitoring project study period (June 2009 to June 2010).

3.0 MONITORING METHODS

This Section provides an overview of the monitoring methods, quality control procedures, and equipment maintenance. A more detailed description of the monitoring methods is provided in the Section S8F – Stormwater Treatment Best Management Practice Evaluation: Quality Assurance Project Plan (QAPP, Appendix B) developed for this Project.

3.1 FLOW MONITORING METHODOLOGY AND EQUIPMENT

3.1.1 Pervious Pavement Infiltrated Water and Standard Asphalt Surface Runoff

Infiltrated flows from the pervious pavement sections and surface runoff from the standard asphalt section were measured continuously for the duration of the study using with an ISCO 730 bubbler flow module. The bubbler flow module measured water depth and this data was converted to flow using Manning's equation. The bubbler flow meters were programmed to record the water level at 5 minute intervals.

3.1.2 Pervious Pavement Surface Runoff

Surface runoff from each pervious pavement section was collected in a catch basin (separate catch basins for each pervious pavement section). Water levels within catch basins were measured periodically and then drained.

3.1.3 Rain Gauge

An ISCO 674 rain gauge, which measures rainfall in 0.01 inch increments, is located at the Project site and was proposed to be used for rainfall monitoring for the project in the QAPP. After review of the data collected during the monitoring period, however, numerous data gaps due to battery failures were identified. Therefore, an alternate rain gauge located approximately 0.2 miles away from the Project site was used instead.

This alternate rain gauge consists of an RMI tipping bucket, which measures rainfall in 0.01 inch increments. This rain gauge is connected via the City's SCADA system to the City's servers, which logs rain data at 5 minute intervals.

3.2 QUALITY CONTROL PROCEDURES & EQUIPMENT MAINTENANCE

Routine flow monitoring maintenance visits were performed every two weeks, during the storm event setup, or as needed for data review. Each maintenance visit included visual inspection and cleaning of the sensors, calibration checks and level calibration if necessary. All maintenance activities were documented on field sheets kept on file in the field notebooks.

At the completion of the project, the parameters used in Manning's equation were verified by running a known flow rate of water through a port installed just upstream of the monitoring manholes. The slope in Manning's equation was adjusted, as needed, until the flow reading matched actual conditions. Flow measurements from the pavement sections were reprocessed with the revised slope to reflect the actual pipe conditions.

Due to the Project's location over buried refuse, there is the potential that slopes in the outlet pipes may have changed over the course of the study due to differential settlement occurring as the underlying refuse decomposes. Given that the buried refuse below the Project is over twenty years old, differential settlement was expected to be minimal.

4.0 DATA VALIDATION, ANALYSIS, AND USABILITY

This Section provides an overview of the data validation and analysis procedures that occurred during and after collection of the field data. The application of these procedures to data collected during this study is provided in Section 5.0.

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Rainfall, water depth, and flow data underwent data review, verification, and validation. This review included a review of the rainfall and flow data for gross errors such as spikes or data gaps to determine the completeness of the data set. Rainfall and flow measurements were verified by comparing the hyetograph and hydrograph for consistency with previously collected data for each pavement section.

Fine sediment was frequently observed in the monitoring manhole that collected runoff from the infiltrated flows from the pervious concrete pavement section. This ongoing issue affected flow monitoring. Field crews would routinely “sweep” the line and remove as much of the debris as they could. The sediment would also build up on the bubbler probe, necessitating frequent cleaning of the probe to prevent clogging. These particles, likely from the pervious concrete material, led to on-going issues with flow measurement at the pervious concrete sampling location. After review of the flow data, all pervious concrete infiltrated flow data were rejected due to the unreliability of the data.

Following review of the pervious pavers’ infiltrated flow data, periodic creep in the flow measurements was identified due to clogging of the meter. Data was corrected, as needed, by adjusting the level measurements so that flows returned to baseline conditions after storm events.

4.2 DATA REVIEW

The following rainfall parameters were tabulated for each monitored storm event:

- Rain Depth (inches);
- Peak Storm Intensity (inches/hours)
- Storm Intensity (inches/hours)
- Duration (hours);and
- Antecedent Dry Period (hours);

The following hydrologic parameters were tabulated from each infiltrated flow collection point for the pervious pavement sections and from the surface runoff from standard asphalt for each monitored storm event:

- Average flow (gpm);
- Peak flow (gpm);
- Duration of flow (hours); and
- Total volume (gallons);

For the catch basins associated with the pervious pavement sections, catch basin depth was recorded periodically in order to measure surface runoff volume.

5.0 RESULTS

This Section summarizes the storm event and flow data collected at the Project site over the course of one year data analysis period. Flows from the pervious pavement sections during each storm event are compared to standard asphalt to determine if there are reductions in peak flow, average flow, or an overall reduction in peak flow volume. This section also describes the maintenance/durability of the site.

5.1 STORM EVENTS

Continuous flow data was collected between March 2007 and June 2010, but periodic gaps in flow data occurred due to battery failures or other equipment issues. For this flow reduction study, only data collected over a one year period between June 2009 and June 2010 were analyzed since this data period was believed to provide the most complete set of data.

During the one year period between June 2009 and June 2010, 102 storms were initially targeted for analysis. Storms were targeted for analysis if rainfall was 0.03 inches or greater and a flow response was seen at any of the sampling locations. If the standard asphalt flow meter was not functioning for an event, data was not tabulated from the other sections because data from the standard asphalt section was needed for the data analysis since it served as the control for the project. Table 1 provides a summary of all the missing flow records during the study period.

Table 2 summarizes the storm characteristics and the flow characteristics from each pavement section for all targeted storms during the monitoring period. Monthly hydrographs and hyetographs are included in Appendix C; the hydrographs and hyetographs for each storm targeted for analysis are included in Appendix D.

Comparisons of individual storm events from the pervious pavement sections versus standard asphalt were complicated by overlapping flow events. This occurred because rainfall must first infiltrate the pervious pavement sections and then be conveyed in the subsurface to the monitoring manhole. This resulted in lower peak flows and longer flow durations for the three pervious pavement sections. It could take many hours for the flow to return to baseline (near zero) at the pervious pavement test sections unlike the standard, impervious asphalt section which returned to baseline flow almost immediately after the rainfall stopped. During this several hour period when the flow was returning to baseline, rain may have started falling again and flow may have started to increase. This made it difficult to determine the start and end of storm events from the pervious pavement sample locations. Standard asphalt flows, on the other hand, showed an immediate response to rainfall making it easy to determine the start and stop of runoff from each storm event.

Fine sediment was frequently observed in the monitoring manhole that collected runoff from the infiltrated flows from the pervious concrete pavement section. As described in Section 4.1, this ongoing issue resulted in all the pervious concrete data being rejected.

The hydrograph and hyetograph were visually inspected to determine which storms should be accepted for analysis. Based on a review of the hydrographs/hyetographs, 12 storms from the pervious pavers section and 4 storms from the pervious asphalt section were excluded from all analyses. The majority of the rejected storms were rejected due to failures of the metering equipment (Table 1) and not due to issues with the hydrographs/hyetographs.

5.2 FLOW DATA

5.2.1 Pervious Pavement Infiltrated Runoff versus Standard Asphalt Surface Runoff

Table 2 shows the peak flow, average flow, flow duration, and total flow recorded from each pavement section[1] for each targeted storm event. Of the 102 storms targeted for analysis, there were 36 storms where the meter at the standard asphalt section recorded flows, but there were no discernible flows (flows identifiable above the background noise of the meter) recorded from both the pervious asphalt and pervious pavers sections.

As shown in Table 2, the total flow recorded from the pavement sections for each event differed significantly from each other. While it is possible that the pervious pavement sections would have lower flows than the standard asphalt section due to the ability of the underlying soil to retain some of the water and due to surface runoff from the pervious sections, flows from the pervious pavement sections should never exceed the flows from the standard asphalt section. However, this situation did occur which suggests that flow measurements may not be accurate.

The predicted maximum flow for each storm was also determined based on the storm event total rainfall (inches) and the size of the runoff area (9,028 SF for each pavement section). As can be seen in Table 2, the predicted maximum flow for each storm also differed significantly from the recorded data. Figure 7 provides a graphical comparison of total flows measured from each pavement section as a percentage of the predicted maximum total flow based on recorded rainfall for the storm event. There were numerous instances where flows from the pavement sections were recorded as being higher than the predicted maximum flow which again suggests issues with the accuracy of the flow data.

Figure 7 shows that when a response was observed from the pervious pavement sections, pervious asphalt total flows were generally greater than standard asphalt total flows and pervious pavers total flows were generally less than standard asphalt total flows.

The observations discussed above suggest that despite the flow calibration done to fine tune the pipe slope in Manning's equation, the variables in Manning's equation still may not be accurate or that the flow metering equipment may not be sensitive enough.

Due to these apparent issues with the flow data, the flow data was determined to not be accurate enough to complete the statistical analysis identified in the QAPP. Therefore, only a qualitative review of the data was performed.

5.2.1.a Average and Peak Flows

Despite the uncertainty in the flow data, Figure 8 suggests that peak flows were greatest for the standard asphalt section compared to the two pervious pavement sections. This result is not unexpected since flows for the pervious pavement sections must travel through the pavement section and underlying soils prior to being measured. This delay likely caused the flow duration for the pervious pavement sites to increase which helped spread out the flow over a longer period of time.

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[1] For the pervious pavement sections, flow measurements were from the infiltrated flows through the pavement sections as described in Section 2.3.1. For standard asphalt, flow measurements were from flows leaving the catch basin as described in Section 2.3.2.a.

Figure 9 shows average flows from the three pavement sections. There is no discernible trend here and given the unreliability of the flow data, no conclusions can be drawn.

5.2.1.b Response to Rainfall

Figure 10 and Table 3 show storm events where a response to rainfall was not observed at one or both of the pervious pavement sections, but a response was observed at the standard asphalt section. Most events with no observed response at one of both of the pervious pavement sections were less than 0.15 inches total and had a maximum 15-minute peak intensity of less than or equal to 0.04 in/hr.

Table 4 shows all the storm events with 0.20 inches or less in rainfall where a response was observed at both pervious pavement sections. There were only five storm events with less than or equal to 0.15 inches of rainfall where a response was observed at both pervious pavement sections. This is in comparison to 33 storm events with less than or equal to 0.15 inches of rain where a response was not observed at one or both of the pervious pavement sections. Based on this information, it appears that pervious pavements do have the ability to retain some water in the pavement section/underlying soil.

5.2.2 Surface Runoff from Pervious Pavements

Table 5 shows the total volume collected from the three pervious pavement catch basin locations between December 21, 2009 and June 2, 2010[2]. No sweeping or other site maintenance activities occurred during the study period that would impact the permeability of the pavement sections. During this approximately 6 month period of data collection, 155 gallons or less was measured in each of the surface runoff catch basins. Since these catch basins are covered with a HPDE lid, evaporation is expected to be minimal. During this same time period, roughly 21.6 inches of rain fell on the site. This equates to roughly 121,500 gallons of predicted maximum runoff from each pavement section. This suggests that the pervious pavements are effective at significantly reducing the amount of surface runoff.

Historical data collected on an individual storm event basis during the water quality study was also reviewed to provide additional information about the surface runoff characteristics of pervious pavement over time. Figure 11 shows the catch basin water depth versus storm rainfall depth over time between February 2007 and June 2009. As can be seen from the figure, catch basin water depth generally increased over time until the site was cleaned with a vacuum sweeper in November 2008. All the pervious pavement test sites had a noticeable decrease in catch basin depth versus rainfall depth immediately after the cleaning. The variability seen in the catch basin depth data is likely impacted significantly by the rainfall intensity during each storm event; high intensity rainfall is more likely to induce runoff from the pervious pavements than low intensity rainfall.

When comparing the pervious pavement sections during the study period, the pervious pavers section appears to have had the least amount of surface runoff, while the pervious concrete section appears to have had the greatest amount of surface runoff.

5.3 DURABILITY

The following general observations about maintenance and durability were noted since construction of the site in 2006:

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[2] The field data book was lost and information recorded between June 2009 and December 2009 was lost.

- The pervious pavers required periodic weeding to keep the joints clean. When not weeded, grasses were growing several feet tall out of the joints. Weed killer was not used on the pavers due to the water quality monitoring being conducted.
- Pervious concrete had some surface cracking and spalling which was repaired by the subcontractor about one year after installation. The cracking may have been caused by an issue with the mix design or site conditions during installation since cracks were only observed in areas that were part of the first concrete pour. The cracks may also have been caused by settlement that occurred at the landfill since the Project site is constructed over landfilled garbage which tends to settle differentially over time.
- During warm weather, the pervious asphalt surface had some surface scuffing and rutting at the wheel turning locations. This is likely due to the fact that unlike standard asphalt, the pervious asphalt was not well compacted (in order to encourage infiltration). When the pavement material got warm during hot weather, the asphalt binders could not contain the aggregate.

6.0 CONCLUSIONS

Visual observation of the flow data showed that smaller rain events (generally less than 0.15 inches) may not generate an observable flow response from the pervious pavement sections while a response was observed from the standard asphalt section. Visual observation also indicated that peak flows of infiltrated water from pervious pavement sections are generally less than standard asphalt peak flows.

During an approximately 6 month period, a maximum of 155 gallons of surface runoff was collected in each of the surface runoff catch basins associated with each pervious pavement section. This is significantly less than the approximately 121,500 gallons of runoff (predicted based on the 21.6 inches of rainfall that fell during this time period) that would have been collected from standard impervious pavement. This suggests that the pervious pavement sections are still able to effectively infiltrate rainfall even after over four years of use.

The statistical comparison identified in the QAPP, however, was not completed since it was determined after reviewing one year of the flow data that the flow information was not accurate enough to allow for a successful comparison between the pavement sections. These inaccuracies appear to be due to errors associated with using level measurements from a bubbler meter and Manning's equation to generate flows; with the very low flows seen at the site, accurate enough data could not be generated even after efforts were made to calibrate Manning's equation based on actual flows. Future flow studies at this site should consider installing a flume to generate more accurate flow data.

TABLES

Table 1
Summary of Missing Flow Records

Pervious Pavers					
BEGIN		END		MISSING RAINFALL (inches)	REASON
Date	Time	Date	Time		
6/9/2009	4:15	6/18/2009	10:30	0.00	Battery failure
7/21/2009	10:30	7/23/2009	10:30	0.00	Battery failure
7/28/2009	17:15	8/10/2009	12:45	0.00	Battery failure
9/1/2009	1:15	9/4/2009	16:30	0.07	Battery failure
9/16/2009	1:45	9/18/2009	17:15	0.03	Battery failure
10/9/2009	16:45	10/12/2009	10:45	0.00	Battery failure
10/21/2009	19:15	10/26/2009	11:15	1.37	Download error
11/1/2009	10:45	12/9/2009	15:30	7.99	Issues with sampler head, had to replace and reprogram head
1/21/2010	16:15	2/2/2010	10:30	0.82	Battery failure
3/2/2010	21:45	3/4/2010	16:30	0.02	Battery failure
4/7/2010	1:30	4/12/2010	14:00	0.18	Battery failure
5/27/2010	22:30	6/2/2010	13:45	1.74	Battery failure
		Total Missing Rainfall ->		**12.22**	

Pervious Asphalt					
BEGIN		END		MISSING RAINFALL (inches)	REASON
Date	Time	Date	Time		
8/16/2009	17:30	9/4/2009	16:30	0.00	Battery failure
12/9/2009	1:00	12/9/2009	15:30	0.00	Battery failure
12/23/2009	9:00	12/24/2009	11:00	0.00	Battery failure
4/6/2010	1:00	4/12/2010	13:45	0.00	Battery failure
5/28/2010	23:45	6/2/2010	14:00	0.00	Battery failure
		Total Missing Rainfall ->		**0.00**	

Standard Asphalt					
BEGIN		END		MISSING RAINFALL (inches)	REASON
Date	Time	Date	Time		
8/4/2009	7:00	8/10/2009	13:00	0.00	Battery failure
8/19/2009	22:30	9/4/2009	16:45	0.00	Battery failure
11/20/2009	12:00	12/9/2009	15:45	2.02	Battery failure
1/18/2010	2:15	1/19/2010	11:45	0.03	Battery failure
2/26/2010	20:30	3/4/2010	16:30	0.27	Battery failure
5/30/2010	21:45	6/2/2010	14:00	0.00	Battery failure
		Total Missing Rainfall ->		**2.32**	

Table 2
Storm Event Characteristics

Storm Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period	**Standard Asphalt** Storm Event				**Pervious Pavers** Storm Event				**Pervious Asphalt** Storm Event				**Predicted Runoff from Each Section** (based on rainfall)	Notes
		Total precip inches	Duration hrs	Intensity in/hr	Pk Intensity in/15 min	hrs	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	gallon	
1	6/19/09	0.15	7.5	0.02	0.04	>432	12.0	1.2	9	505	0	0	0	0	0	0	0	0	844	
2	6/21/09	0.27	1.8	0.15	0.17	6	20.5	7.1	2	741	7.2	1.1	5	308	8.4	3.5	4	635	1520	
3	6/25/09	0.04	1.3	0.03	0.01	76	6.9	1.5	2	153	0.0	0.0	0	0	0.0	0.0	0	0	225	
4	8/11/09	0.21	3.8	0.06	0.02	7	8.0	2.6	6	842	0.0	0.0	0	0	2.3	1.5	6	180	1182	
5	8/12/09	0.18	9.8	0.02	0.02	3	4.4	2.0	6	662	1.2	0.8	12	368	3.3	1.8	6	241	1013	
6	8/13/09	0.07	1.8	0.04	0.02	32	4.4	1.5	3	245	0.0	0.0	0	0	0.0	0.0	0	0	394	
7	9/5/09	0.26	4.3	0.06	0.04	11	10.9	3.3	6	1146	2.7	1.7	8	455	9.1	3.1	7	918	1463	
8	9/6/09	1.21	24.8	0.05	0.11	3	34.2	4.4	28	5180	24.3	3.4	34	6731	27.0	5.2	28	6626	6810	
9	9/16/09	0.03	1.5	0.02	0.01	174	1.9	0.5	4	104	0.0	0.0	0	0	0.0	0.0	0	0	169	
10	9/19/09	0.24	3.8	0.06	0.04	55	7.3	2.7	5	825	1.2	0.8	21	834	8.2	3.6	6	593	1351	
11	10/1/09	0.06	1.8	0.03	0.05	64	1.6	0.8	2	45	0.0	0.0	0	0	0.0	0.0	0	0	338	
12	10/13/09	0.07	0.8	0.09	0.07	243	4.4	1.9	2	227	0.0	0.0	0	0	0.0	0.0	0	0	394	
13	10/13/09	0.10	1.5	0.07	0.03	8	10.2	2.5	3	380	0.0	0.0	0	0	0.0	0.0	0	0	563	
14	10/14/09	0.08	1.5	0.05	0.03	2	8.7	2.2	3	303	1.4	1.0	4	138	1.5	1.3	3	117	450	
15	10/14/09	0.23	3.0	0.08	0.03	4	13.4	5.3	4	955	5.5	2.8	6	914	10.9	6.9	5	1551	1294	
16	10/16/09	0.68	10.3	0.07	0.10	10	21.2	3.2	12	2403	20.3	6.0	12	2695	18.8	5.4	14	4462	3827	
17	10/17/09	0.43	4.3	0.10	0.12	5	28.0	4.5	6	1612	32.0	11.0	2	1646	31.6	6.1	7	2560	2420	
18	10/17/09	0.42	6.3	0.07	0.09	7	33.0	4.1	8	1954	7.6	4.1	7	1666	13.0	6.0	9	3435	2364	
19	10/28/09	0.26	12.5	0.02	0.03	55	8.0	1.0	14	800	2.0	1.2	24	957	3.9	2.2	18	725	1463	
20	10/30/09	0.31	13.5	0.02	0.05	38	15.2	1.5	17	1394	4.5	1.7	16	1206	8.2	1.7	18	1724	1745	
21	11/5/09	2.50	56.8	0.04	0.22	121	77.0	4.8	64	13416					21.4	5.8	75	18034	14070	
22	11/9/09	0.07	3.3	0.02	0.01	23	4.4	1.1	8	397					0.0	0.0	0	0	394	
23	11/9/09	0.30	4.8	0.06	0.07	7	24.5	3.7	9	1482					10.0	4.3	10	2149	1688	
24	11/10/09	0.31	9.8	0.03	0.04	14	14.3	2.0	13	1616					10.9	2.4	14	2096	1745	
25	11/13/09	0.17	3.5	0.05	0.03	31	10.9	2.5	6	858					5.1	1.4	8	540	957	
26	11/15/09	0.44	11.3	0.04	0.04	42	10.2	2.8	12	1940					10.0	4.1	15	2735	2476	
27	11/16/09	1.12	32.5	0.03	0.05	18	19.1	3.1	36	6213					13.0	5.5	37	10025	6303	
28	11/19/09	0.59	9.0	0.07	0.05	23	21.2	4.3	12	2944					14.0	6.0	15	3880	3320	
29	11/20/09	0.24	4.5	0.05	0.03	12	10.2	3.4	7	1283					8.2	4.2	9	1897	1351	
30	12/14/09	0.56	8.8	0.06	0.04	8	10.9	3.3	14	2889	7.0	3.3	15	2101	13.0	5.8	16	3898	3152	
31	12/15/09	0.23	15.8	0.01	0.03	6	6.7	1.4	19	1535	2.7	2.3	15	480	5.1	1.6	18	1768	1294	
32	12/16/09	0.35	18.3	0.02	0.05	6	12.6	1.7	23	2366	7.0	2.5	16	2052	8.2	3.2	23	3670	1970	

Table 2
Storm Event Characteristics

Storm Event No.	Storm Date	Storm Characteristics: Total precip inches	Duration hrs	Intensity in/hr	Pk Intensity in/15 min	Storm Event Antecedent Period hrs	**Standard Asphalt** Storm Event: Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	**Pervious Pavers** Storm Event: Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	**Pervious Asphalt** Storm Event: Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	**Predicted Runoff from Each Section** (based on rainfall) gallon	Notes
33	12/18/09	0.49	29.0	0.02	0.02	46	4.9	1.5	33	3020	3.1	1.9	32	3326	7.4	2.7	30	4134	2758	
34	12/21/09	0.27	9.8	0.03	0.06	5	12.6	1.4	19	1613	17.7	3.8	12	1727	13.0	3.8	15	2961	1520	
35	12/29/09	0.14	12.0	0.01	0.02	54	3.4	0.8	13	573	0.0	0.0	0	0	0.0	0.0	0	0	788	
36	12/30/09	0.03	0.3	0.12	0.02	13	6.1	0.8	4	205	0.0	0.0	0	0	0.0	0.0	0	0	169	
37	12/31/09	0.39	8.3	0.05	0.03	11	8.7	2.9	8	1412	4.5	3.0	12	1740	10.9	3.9	14	3010	2195	
38	1/1/10	0.26	7.3	0.04	0.02	6	6.1	1.1	26	1666	4.5	2.8	20	1665	10.0	3.0	25	3840	1463	
39	1/4/10	1.26	34.5	0.04	0.05	7	10.2	1.9	45	5251	11.8	4.3	35	5531	14.0	4.5	41	10690	7091	
40	1/7/10	1.09	27.0	0.04	0.06	46	14.3	2.1	38	4884	13.4	6.9	28	4579	15.2	4.2	33	7628	6134	
41	1/10/10	0.66	17.3	0.04	0.04	42	10.2	2.4	25	3606	11.4	6.4	18	2762	15.2	6.4	25	5605	3714	
42	1/11/10	0.28	17.8	0.02	0.03	8	8.0	1.8	26	2718	5.1	2.2	22	1500	10.0	3.2	25	4507	1576	
43	1/13/10	0.09	12.0	0.01	0.02	8	6.1	1.4	18	1540	2.2	1.4	9	559	4.5	1.9	14	1524	507	
44	1/14/10	0.13	7.5	0.02	0.02	9	6.1	1.9	12	1448	5.1	2.4	8	322	9.1	3.1	14	1917	732	
45	1/15/10	0.34	5.0	0.07	0.03	3	8.7	3.3	11	2152	10.0	5.5	7	1909	11.9	6.6	12	3953	1913	
46	1/23/10	0.02	0.5	0.04	0.01	128	0.8	0.4	6	97	0.0	0.0	0	0	0.0	0.0	0	0	113	
47	1/24/10	0.47	15.3	0.03	0.04	24	12.6	2.3	21	2856					11.9	2.4	21	2759	2645	
48	1/30/10	0.19	31.5	0.01	0.01	7	4.4	1.2	38	2735					2.8	0.6	31	977	1069	
49	2/1/10	0.12	9.0	0.01	0.01	31	3.0	1.0	20	1165	0.0	0.0	0	0	0.0	0.0	0	0	675	
50	2/3/10	0.27	15.3	0.02	0.04	5	14.3	1.8	19	1276	2.5	1.5	16	317	6.6	2.1	16	1708	1520	
51	2/4/10	0.18	9.0	0.02	0.02	19	9.4	1.6	12	907	1.3	1.0	5	125	3.3	1.4	11	705	1013	
52	2/6/10	0.18	12.8	0.01	0.01	38	1.9	0.8	16	743	1.3	1.1	22	617	1.5	1.0	16	300	1013	
53	2/10/10	0.18	8.5	0.02	0.01	75	3.4	1.4	15	927	1.9	1.5	16	961	2.3	0.9	14	543	1013	
54	2/11/10	0.09	5.0	0.02	0.02	8	8.7	2.2	5	432	2.2	1.9	9	785	2.8	1.9	8	522	507	
55	2/12/10	0.51	14.8	0.03	0.09	6	31.7	3.4	18	2663	21.7	2.9	22	3616	20.0	3.7	23	4330	2870	
56	2/13/10	0.44	19.8	0.02	0.03	12	9.4	2.3	24	2627	4.1	2.4	26	1852	9.1	3.7	28	4665	2476	
57	2/15/10	0.24	10.0	0.02	0.02	28	8.7	1.5	14	1226	2.9	1.7	22	1580	8.2	1.6	16	1449	1351	
58	2/23/10	0.73	50.0	0.01	0.03	174	12.6	1.5	48	3226	2.3	1.4	53	3222	5.1	2.4	53	4123	4108	
59	2/26/10	0.26	5.0	0.05	0.03	10	11.8	2.7	8	1389	2.7	1.8	11	1020	9.1	3.5	11	2129	1463	
60	3/7/10	0.11	17.3	0.01	0.01	89	3.0	0.9	21	323	0.0	0.0	0	0	0.0	0.0	0	0	619	
61	3/9/10	0.08	2.8	0.03	0.01	35	2.6	0.8	5	175	0.0	0.0	0	0	0.0	0.0	0	0	450	
62	3/11/10	1.18	31.5	0.04	0.09	5	15.2	3.2	34	5894	7.0	2.8	34	4740	14.0	4.6	29	7624	6641	
63	3/16/10	0.08	12.0	0.01	0.03	70	17.1	1.7	15	506	0.0	0.0	0	0	0.0	0.0	0	0	450	
64	3/21/10	0.07	9.8	0.01	0.02	107	3.0	0.7	13	104	0.0	0.0	0	0	0.0	0.0	0	0	394	
65	3/25/10	0.13	6.0	0.02	0.02	39	2.6	0.9	8	356	0.0	0.0	0	0	0.0	0.0	0	0	732	
66	3/25/10	0.27	8.0	0.03	0.04	8	13.4	2.2	10	1347	3.1	1.7	13	1062	8.2	2.3	13	1682	1520	
67	3/28/10	0.20	2.8	0.07	0.04	31	11.8	3.1	4	887	1.7	1.4	8	425	9.1	2.1	7	857	1126	
68	3/28/10	1.69	42.5	0.04	0.16	8	69.1	4.6	45	9729	12.9	3.4	46	2877	17.5	5.5	46	13655	9511	

Table 2
Storm Event Characteristics

Storm Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period	**Standard Asphalt** Storm Event				**Pervious Pavers** Storm Event				**Pervious Asphalt** Storm Event				**Predicted Runoff from Each Section** (based on rainfall)	Notes
		Total precip	Duration	Intensity	Pk Intensity		Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume		
		inches	hrs	in/hr	in/15 min	hrs	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gallon	
69	3/30/10	0.19	2.3	0.08	0.06	10	19.1	4.9	3	874	5.9	3.6	9	217	11.9	4.0	6	1269	1069	
70	4/2/10	0.93	26.5	0.04	0.05	9	28.0	3.5	33	5894	9.6	2.8	33	1904	14.0	4.9	33	7803	5234	
71	4/5/10	0.12	4.5	0.03	0.03	15	8.7	2.2	11	628	0.0	0.0	0	0	0.0	0.0	0	0	675	
72	4/6/10	0.03	3.0	0.01	0.01	8	1.9	0.6	5	192	0.0	0.0	0	0					169	
73	4/7/10	0.11	3.0	0.04	0.02	28	5.5	2.0	4	489	0.0	0.0	0	0					619	
74	4/8/10	0.07	0.8	0.09	0.02	7	8.7	2.4	2	325	0.0	0.0	0	0					394	
75	4/12/10	0.08	5.0	0.02	0.01	128	3.0	0.7	6	251	0.0	0.0	0	0	0.0	0.0	0	0	450	
76	4/15/10	0.03	0.3	0.12	0.02	48	3.0	0.8	2	97	0.0	0.0	0	0	0.0	0.0	0	0	169	
77	4/17/10	0.18	1.3	0.14	0.05	6	18.1	5.1	3	845	1.5	1.3	2	156	2.8	1.5	2	161	1013	
78	4/17/10	0.03	0.5	0.06	0.02	5	4.9	1.2	2	129	0.0	0.0	0	0	0.0	0.0	0	0	169	
79	4/19/10	0.10	2.5	0.04	0.02	48	6.7	1.5	5	440	0.0	0.0	0	0	0.0	0.0	0	0	563	
80	4/20/10	0.52	19.5	0.03	0.03	15	10.2	2.0	20	2443	3.1	2.3	20	1753	8.2	2.5	20	2866	2926	
81	4/24/10	0.14	8.8	0.02	0.03	9	12.6	0.8	11	520	1.7	1.3	11	415					788	pervious asphalt data didn't show event; too little flow or data issue?
82	4/26/10	0.25	13.0	0.02	0.05	48	10.2	1.4	14	1204	2.4	2.1	14	371	6.6	1.1	14	787	1407	
83	4/27/10	0.33	7.5	0.04	0.06	7	17.1	2.5	11	1774	9.0	3.1	8	1411	13.0	3.4	8	1708	1857	
84	5/2/10	0.40	9.3	0.04	0.04	35	13.4	3.3	11	2189	3.1	2.4	12	1128	11.9	3.1	13	2283	2251	
85	5/4/10	0.03	0.3	0.12	0.02	32	2.2	1.5	1	66	0.0	0.0	0	0	0.0	0.0	0	0	169	
86	5/4/10	0.16	5.0	0.03	0.08	8	8.7	1.5	9	712	0.0	0.0	0	0	0.0	0.0	0	0	900	
87	5/10/10	0.37	8.8	0.04	0.04	116	12.6	3.4	11	2235	2.4	1.9	10	810	8.2	2.2	9	1186	2082	
88	5/18/10	0.05	2.5	0.02	0.01	>93	3.0	1.2	4	229	0.0	0.0	0	0	0.0	0.0	0	0	281	
89	5/18/10	0.14	1.8	0.08	0.06	4	24.5	6.0	3	725	0.0	0.0	0	0	0.0	0.0	0	0	788	
90	5/19/10	0.27	5.5	0.05	0.040	22	22.3	4.1	6	1491	2.7	2.0	9	935	9.1	3.7	6	1277	1520	
91	5/20/10	0.05	0.8	0.07	0.020	4	4.9	2.1	2	161	0.0	0.0	0	0	0.0	0.0	0	0	281	
92	5/20/10	0.46	16.3	0.03	0.130	4	36.9	2.0	17	1864	12.6	4.0	16	1067	13.0	2.1	19	2150	2589	long drawn out storm; could potentially be split into two
93	5/22/10	0.04	0.3	0.16	0.020	11	7.3	2.4	1	147	0.0	0.0	0	0	0.0	0.0	0	0	225	
94	5/23/10	0.06	4.3	0.01	0.010	11	1.3	0.4	5	111	0.0	0.0	0	0	0.0	0.0	0	0	338	
95	5/25/10	0.2	16.5	0.01	0.020	50	8.7	1.6	17	833	0.0	0.0	0	0	0.0	0.0	0	0	1126	
96	5/26/10	0.29	4.3	0.07	0.060	8	38.2	6.7	6	2108	4.9	2.8	7	952	11.9	3.4	10	1961	1632	
97	5/28/10	0.45	13.8	0.03	0.020	6	10.2	3.8	15	3459					10.0	3.3	17	3246	2533	
98	6/3/10	0.29	10.0	0.03	0.020	22	8.7	2.6	12	1789	2.4	1.5	19	1196	6.6	1.9	13	1287	1632	
99	6/6/10	0.33	11.5	0.03	0.040	45	17.1	4.0	14	2223	2.4	1.6	14	707	10.0	2.9	14	1140	1857	

Table 2
Storm Event Characteristics

Storm Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period	**Standard Asphalt** Storm Event				**Pervious Pavers** Storm Event				**Pervious Asphalt** Storm Event				**Predicted Runoff from Each Section** (based on rainfall)	Notes
		Total precip	Duration	Intensity	Pk Intensity		Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume		
		inches	hrs	in/hr	in/15 min	hrs	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gallon	
100	6/8/10	1.06	22.0	0.05	0.460	48	86.4	3.0	23	3865	118.3	4.9	24	5051	67.2	3.4	27	4931	5965	long storm; could be broken into smaller storms.
101	6/11/10	0.05	3.0	0.02	0.010	10	4.4	1.5	3	299	0.0	0.0	0	0	0.0	0.0	0	0	281	
102	6/11/10	0.12	4.3	0.03	0.020	110	8.0	1.1	10	484	0.0	0.0	0	0	0.0	0.0	0	0	675	

Color Key

Grey	Sampling event was excluded after review of the hydrograph and hyetograph.
Yellow	No response seen in meter for event. Meter appears to be functional.

Table 3
Storm Events with No Response at Pervious Pavement Sections

Sample Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period	**Standard Asphalt** Storm Event				**Pervious Pavers** Storm Event				**Pervious Asphalt** Storm Event				**Predicted Runoff from Each Section** (based on rainfall)
		Total precip inches	Duration hrs	Intensity in/hr	Pk Intensity in/15 min	hrs	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	Peak Flow gpm	Average Flow gpm	Flow Duration hrs	Volume gallon	gallon
1	6/19/09	0.15	7.5	0.02	0.04	>432	12.0	1.2	9	505	0	0	0	0	0	0	0	0	844
3	6/25/09	0.04	1.3	0.03	0.01	76	6.9	1.5	2	153	0.0	0.0	0	0	0.0	0.0	0	0	225
4	8/11/09	0.21	3.8	0.06	0.02	7	8.0	2.6	6	842	0.0	0.0	0	0	2.3	1.5	6	180	1182
6	8/13/09	0.07	1.8	0.04	0.02	32	4.4	1.5	3	245	0.0	0.0	0	0	0.0	0.0	0	0	394
9	9/16/09	0.03	1.5	0.02	0.01	174	1.9	0.5	4	104	0.0	0.0	0	0	0.0	0.0	0	0	169
11	10/1/09	0.06	1.8	0.03	0.05	64	1.6	0.8	2	45	0.0	0.0	0	0	0.0	0.0	0	0	338
12	10/13/09	0.07	0.8	0.09	0.07	243	4.4	1.9	2	227	0.0	0.0	0	0	0.0	0.0	0	0	394
13	10/13/09	0.10	1.5	0.07	0.03	8	10.2	2.5	3	380	0.0	0.0	0	0	0.0	0.0	0	0	563
22	11/9/09	0.07	3.3	0.02	0.01	23	4.4	1.1	8	397					0.0	0.0	0	0	394
35	12/29/09	0.14	12.0	0.01	0.02	54	3.4	0.8	13	573	0.0	0.0	0	0	0.0	0.0	0	0	788
36		0.03	0.3	0.12	0.02	13	6.1	0.8	4	205	0.0	0.0	0	0	0.0	0.0	0	0	169
46	1/23/10	0.02	0.5	0.04	0.01	128	0.8	0.4	6	97	0.0	0.0	0	0	0.0	0.0	0	0	113
49	2/1/10	0.12	9.0	0.01	0.01	31	3.0	1.0	20	1165	0.0	0.0	0	0	0.0	0.0	0	0	675
60	3/7/10	0.11	17.3	0.01	0.01	89	3.0	0.9	21	323	0.0	0.0	0	0	0.0	0.0	0	0	619
61	3/9/10	0.08	2.8	0.03	0.01	35	2.6	0.8	5	175	0.0	0.0	0	0	0.0	0.0	0	0	450
63	3/16/10	0.08	12.0	0.01	0.03	70	17.1	1.7	15	506	0.0	0.0	0	0	0.0	0.0	0	0	450
64	3/21/10	0.07	9.8	0.01	0.02	107	3.0	0.7	13	104	0.0	0.0	0	0	0.0	0.0	0	0	394
65	3/25/10	0.13	6.0	0.02	0.02	39	2.6	0.9	8	356	0.0	0.0	0	0	0.0	0.0	0	0	732
71	4/5/10	0.12	4.5	0.03	0.03	15	8.7	2.2	11	628	0.0	0.0	0	0	0.0	0.0	0	0	675
72	4/6/10	0.03	3.0	0.01	0.01	8	1.9	0.6	5	192	0.0	0.0	0	0					169
73	4/7/10	0.11	3.0	0.04	0.02	28	5.5	2.0	4	489	0.0	0.0	0	0					619
74	4/8/10	0.07	0.8	0.09	0.02	7	8.7	2.4	2	325	0.0	0.0	0	0					394
75	4/12/10	0.08	5.0	0.02	0.01	128	3.0	0.7	6	251	0.0	0.0	0	0	0.0	0.0	0	0	450
76	4/15/10	0.03	0.3	0.12	0.02	48	3.0	0.8	2	97	0.0	0.0	0	0	0.0	0.0	0	0	169
78	4/17/10	0.03	0.5	0.06	0.02	5	4.9	1.2	2	129	0.0	0.0	0	0	0.0	0.0	0	0	169
79	4/19/10	0.10	2.5	0.04	0.02	48	6.7	1.5	5	440	0.0	0.0	0	0	0.0	0.0	0	0	563
85	5/4/10	0.03	0.3	0.12	0.02	32	2.2	1.5	1	66	0.0	0.0	0	0	0.0	0.0	0	0	169
86	5/4/10	0.16	5.0	0.03	0.08	8	8.7	1.5	9	712	0.0	0.0	0	0	0.0	0.0	0	0	900
88	5/18/10	0.05	2.5	0.02	0.01	>93	3.0	1.2	4	229	0.0	0.0	0	0	0.0	0.0	0	0	281
89	5/18/10	0.14	1.8	0.08	0.06	4	24.5	6.0	3	725	0.0	0.0	0	0	0.0	0.0	0	0	788
91	5/20/10	0.05	0.8	0.07	0.020	4	4.9	2.1	2	161	0.0	0.0	0	0	0.0	0.0	0	0	281
93	5/22/10	0.04	0.3	0.16	0.020	11	7.3	2.4	1	147	0.0	0.0	0	0	0.0	0.0	0	0	225

Table 3
Storm Events with No Response at Pervious Pavement Sections

Sample Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period	**Standard Asphalt** Storm Event				**Pervious Pavers** Storm Event				**Pervious Asphalt** Storm Event				**Predicted Runoff from Each Section** (based on rainfall)
		Total precip	Duration	Intensity	Pk Intensity		Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume	Peak Flow	Average Flow	Flow Duration	Volume	
		inches	hrs	in/hr	in/15 min	hrs	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gpm	gpm	hrs	gallon	gallon
94	5/23/10	0.06	4.3	0.01	0.010	11	1.3	0.4	5	111	0.0	0.0	0	0	0.0	0.0	0	0	338
95	5/25/10	0.2	16.5	0.01	0.020	50	8.7	1.6	17	833	0.0	0.0	0	0	0.0	0.0	0	0	1126
101	6/11/10	0.05	3.0	0.02	0.010	10	4.4	1.5	3	299	0.0	0.0	0	0	0.0	0.0	0	0	281
102	6/11/10	0.12	4.3	0.03	0.020	110	8.0	1.1	10	484	0.0	0.0	0	0	0.0	0.0	0	0	675

Color Key

Sampling event was excluded after review of the hydrograph and hyetograph. (grey)

No response seen in meter for event. Meter appears to be functional. (yellow)

Table 4
Storm Events (≤ 0.2 inches) with Response at Both Pervious Pavement Sections

Storm Event No.	Storm Date	Storm Characteristics				Storm Event Antecedent Period
		Total precip inches	Duration hrs	Intensity in/hr	Pk Intensity in/15 min	hrs
14	10/14/09	0.08	1.5	0.05	0.03	2
43	1/13/10	0.09	12.0	0.01	0.02	8
54	2/11/10	0.09	5.0	0.02	0.02	8
44	1/14/10	0.13	7.5	0.02	0.02	12
81	4/24/10	0.14	8.8	0.02	0.03	9
25	11/13/09	0.17	3.5	0.05	0.03	31
5	8/12/09	0.18	9.8	0.02	0.02	3
51	2/4/10	0.18	9.0	0.02	0.02	19
52	2/6/10	0.18	12.8	0.01	0.01	38
53	2/10/10	0.18	8.5	0.02	0.01	75
77	4/17/10	0.18	1.3	0.14	0.05	6
48	1/30/10	0.19	31.5	0.01	0.01	7
69	3/30/10	0.19	2.3	0.08	0.06	10
67	3/28/10	0.20	2.8	0.07	0.04	31

Table 5
Catch Basin Water Depth Measurements

Measurement Date & Time	Pervious Pavers			Pervious Concrete			Pervious Asphalt		
	Water Depth (in)	Volume (gal)	CB emptied? (Y/N)	Water Depth (in)	Volume (gal)	CB emptied? (Y/N)	Water Depth (in)	Volume (gal)	CB emptied? (Y/N)
12/21/09 13:20 (Pre)	3			3			4		
01/11/10 15:10 (Post)	17.5	28.4	Y	19	31.3	Y	4.5	1.0	Y
01/11/10 15:10 (Pre)	3			3			4		
02/02/10 09:49 (Post)	7.5	8.8	Y	9	11.8	Y	4.5	1.0	Y
02/02/10 09:49 (Pre)	3			3			4		
02/26/10 14:10 (Post)	11.5	16.6	Y	23.25	39.7	Y	7	5.9	Y
02/26/10 14:10 (Pre)	3			3			4		
04/12/10 13:00 (Post)	21	35.3	Y	22	37.2	Y	7.5	6.9	Y
04/12/10 13:00 (Pre)	3			3			4		
06/02/10 13:10 (Post)	23	39.2	Y	21	35.3	Y	23.5	38.2	Y
Total Gallons for Collected Events ->		**128.3**			**155.2**			**52.9**	

FIGURES

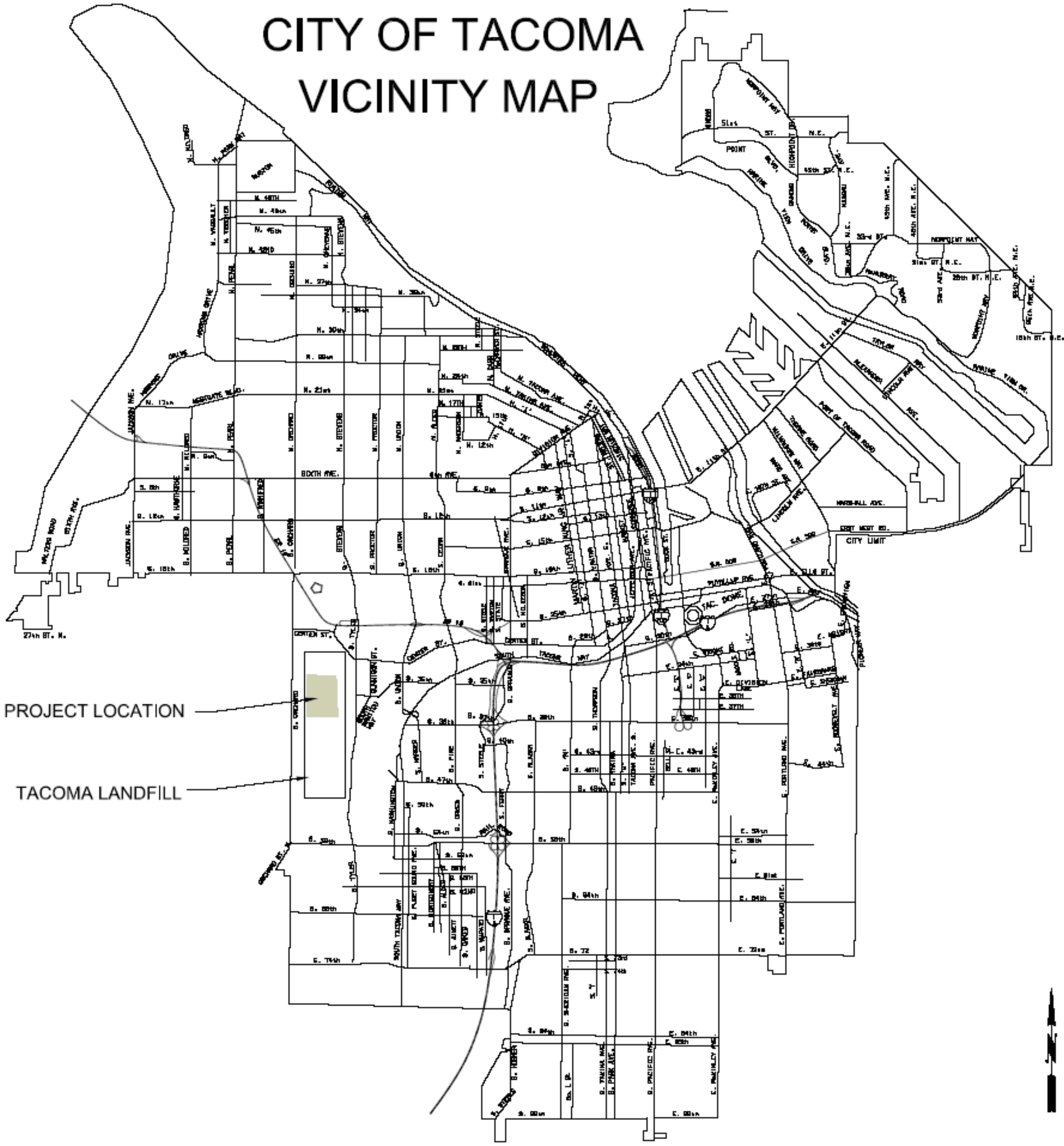

Figure 1. City of Tacoma Vicinity Map

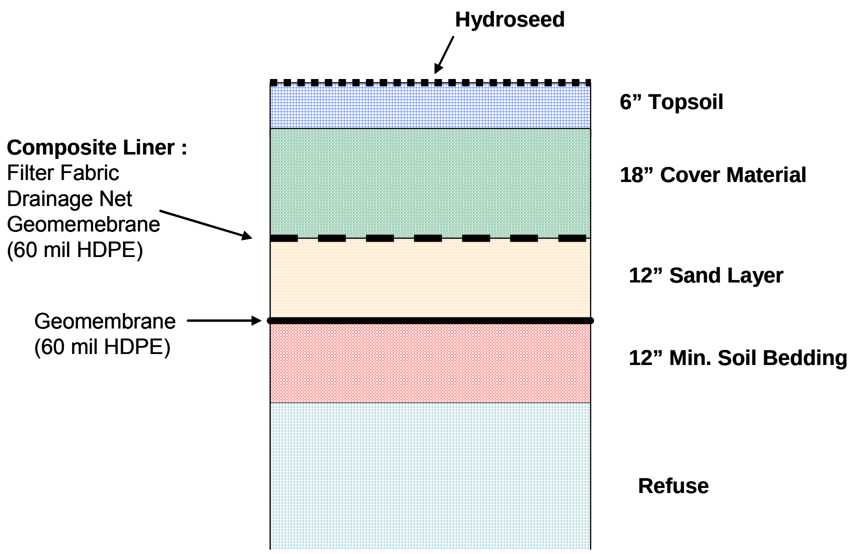

Figure 2. Landfill Cap Cross-Section

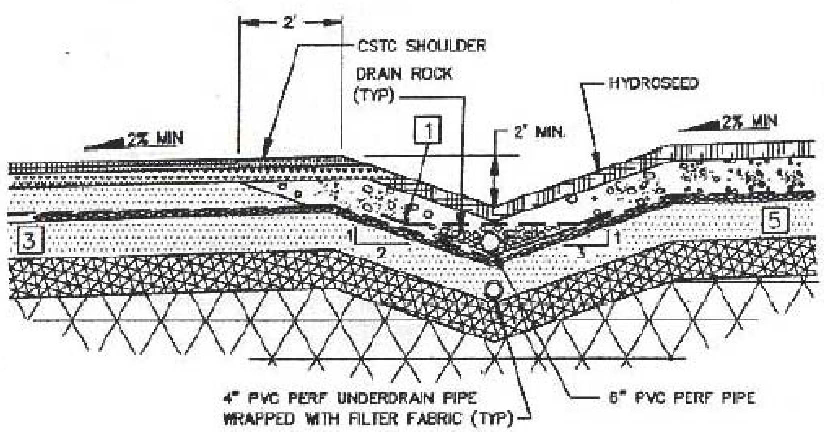

Figure 3. Landfill Cap Drainage System

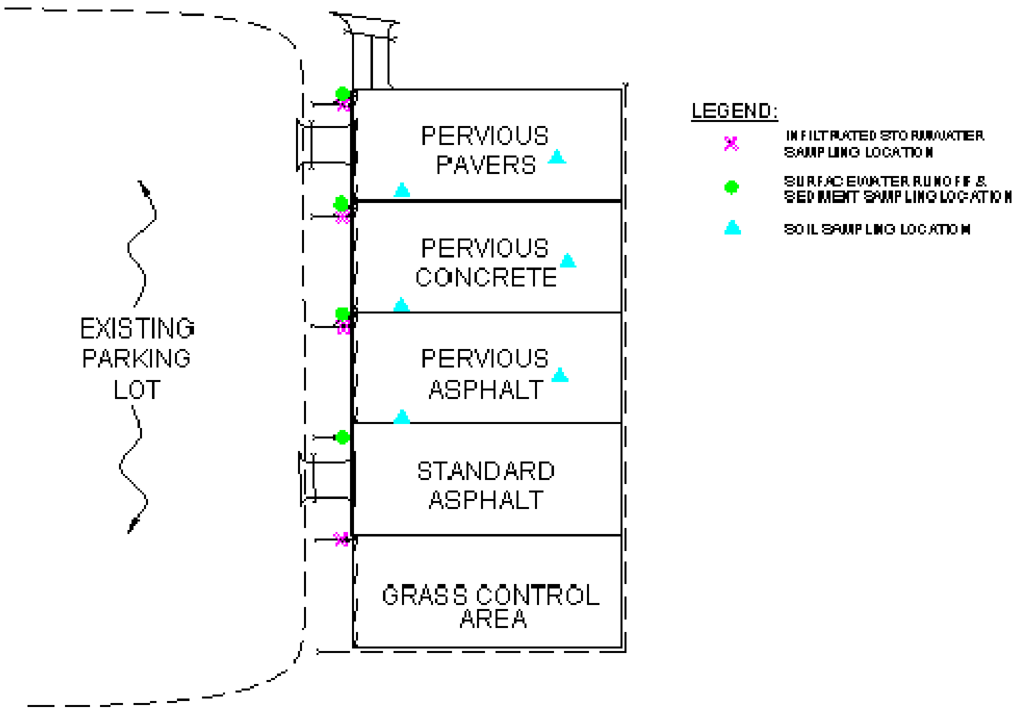

Figure 4. Project Site Layout

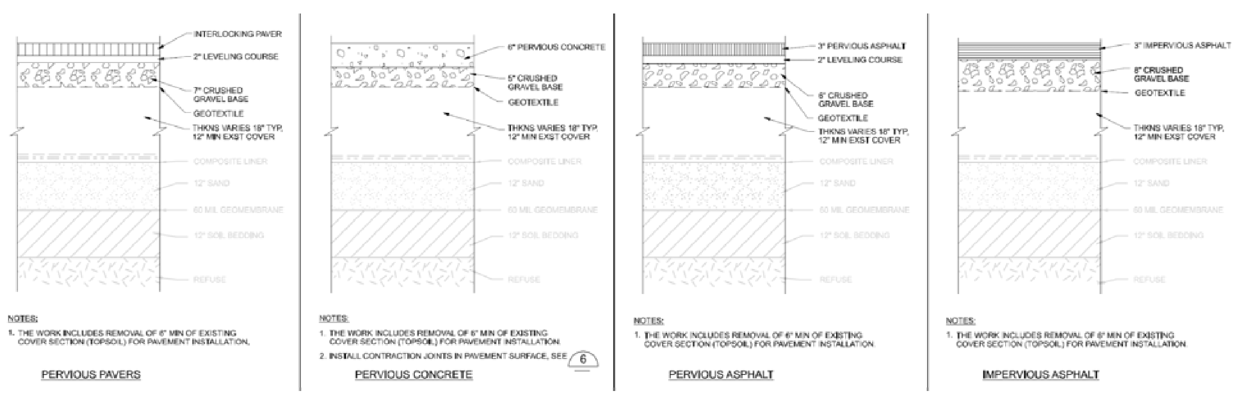

Figure 5. Pavement Cross Sections

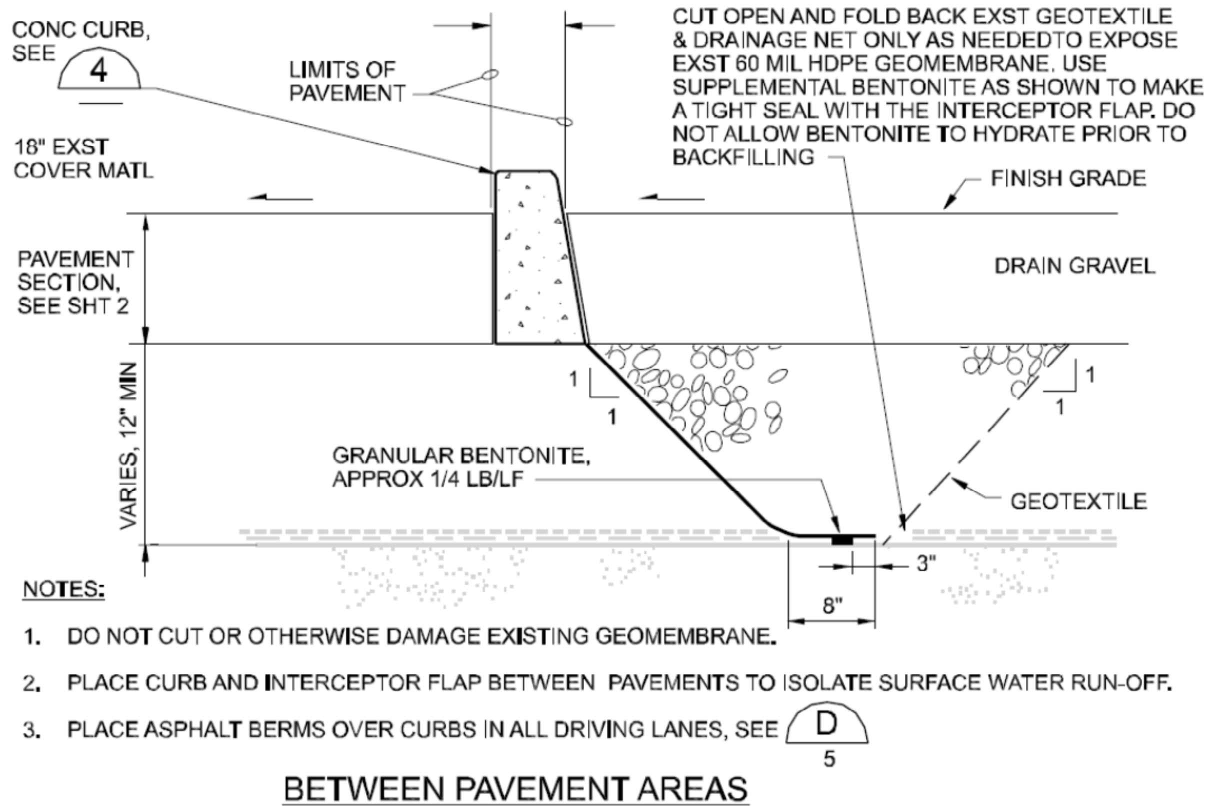

Figure 6. GCL Interceptor Flap

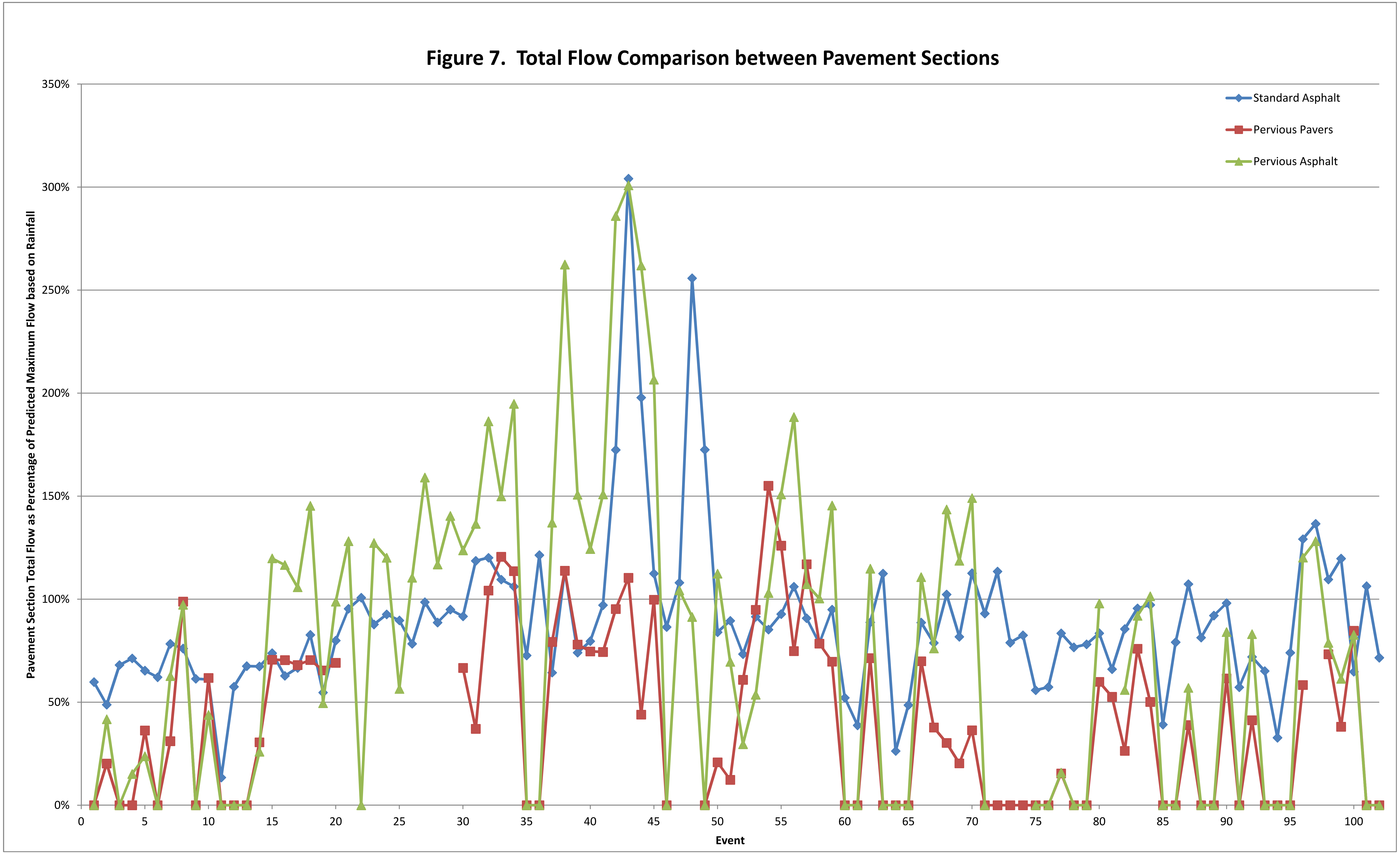

Figure 7. Total Flow Comparison between Pavement Sections
Pavement Section Total Flow as Percentage of Predicted Maximum Flow based on Rainfall
350%
300%
250%
200%
150%
100%
50%
0%
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Event
Standard Asphalt
Pervious Pavers
Pervious Asphalt

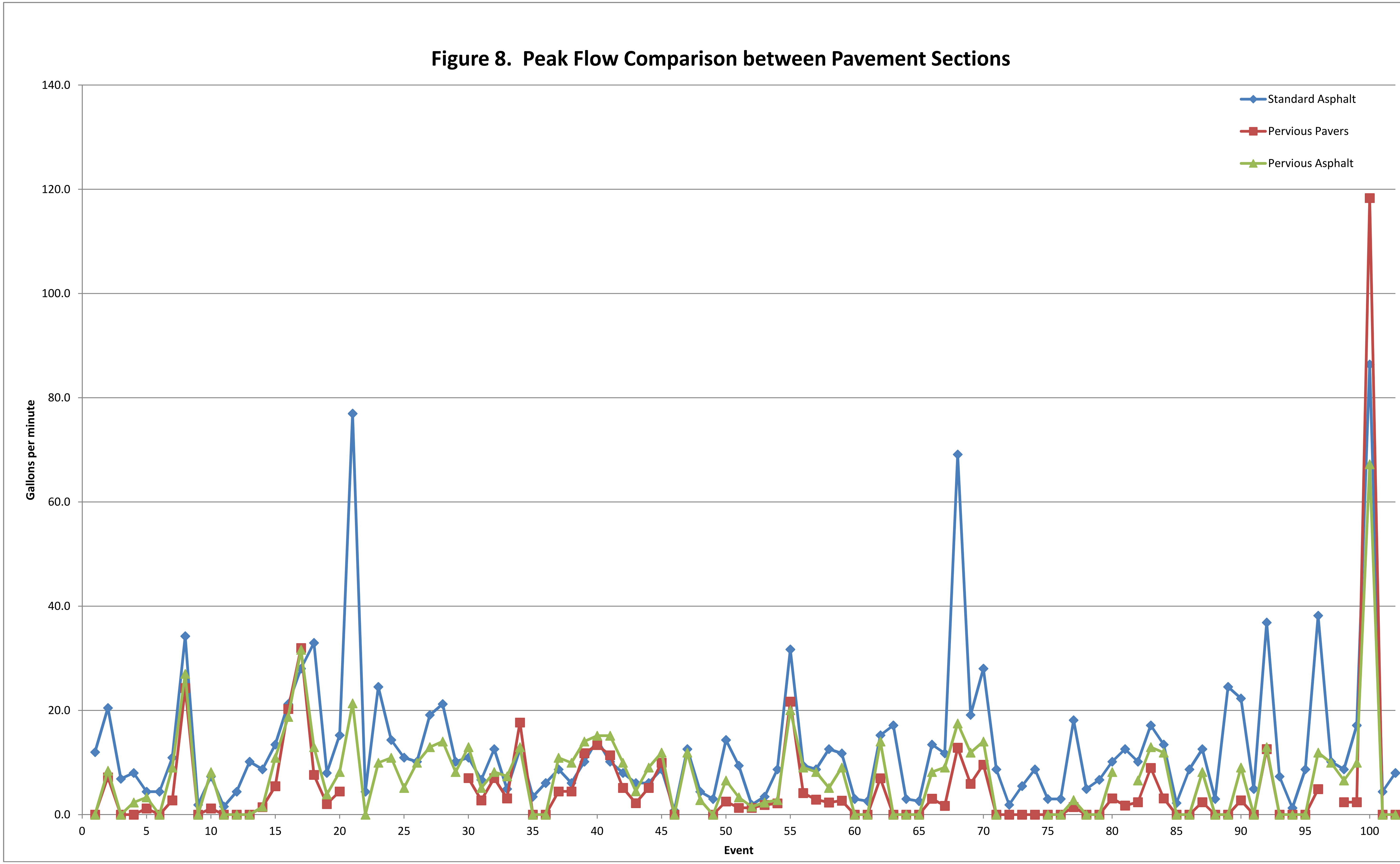

Figure 8. Peak Flow Comparison between Pavement Sections
Gallons per minute
Event
Standard Asphalt
Pervious Pavers
Pervious Asphalt
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

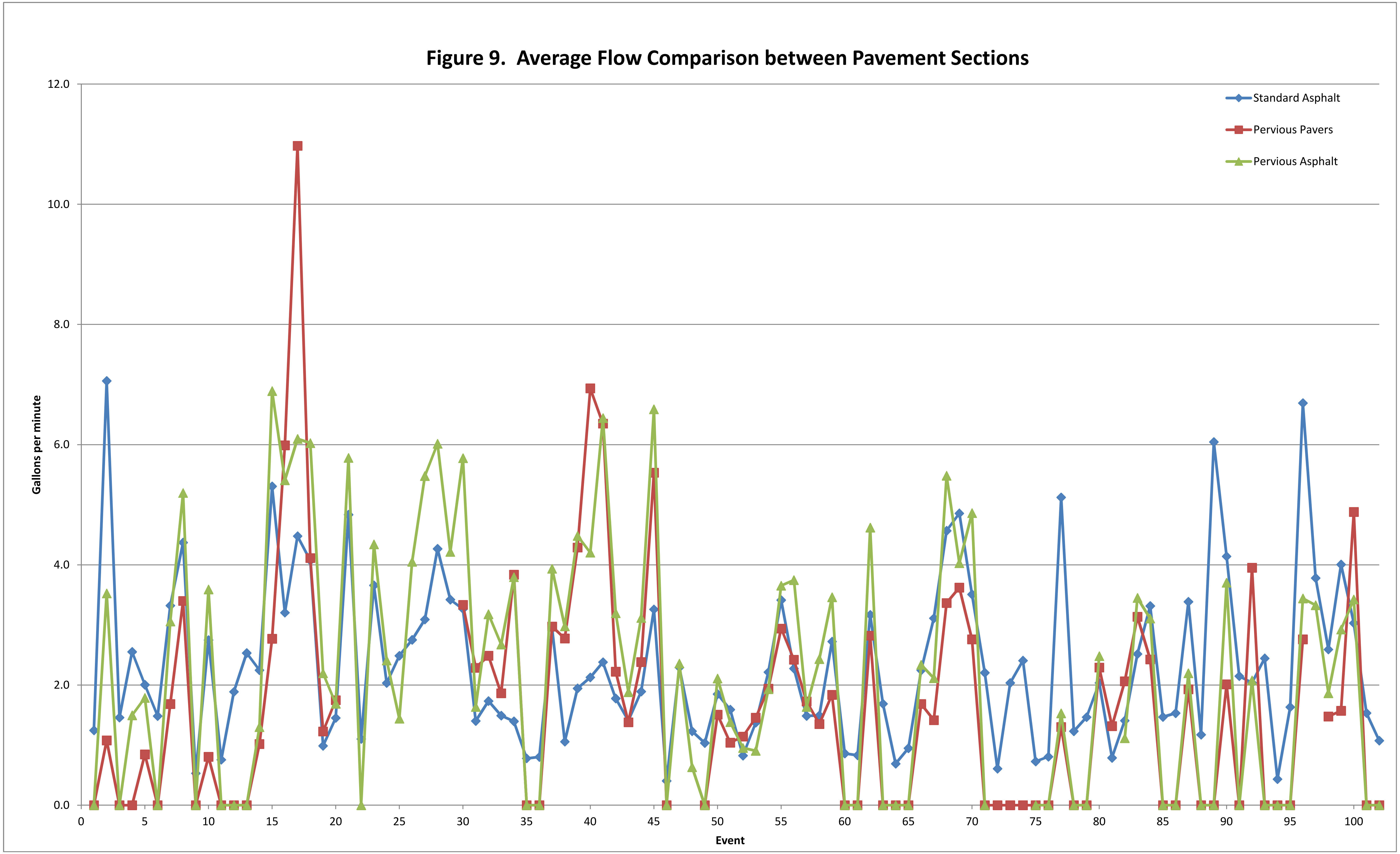

Figure 9. Average Flow Comparison between Pavement Sections
Standard Asphalt
Pervious Pavers
Pervious Asphalt
Gallons per minute
Event
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

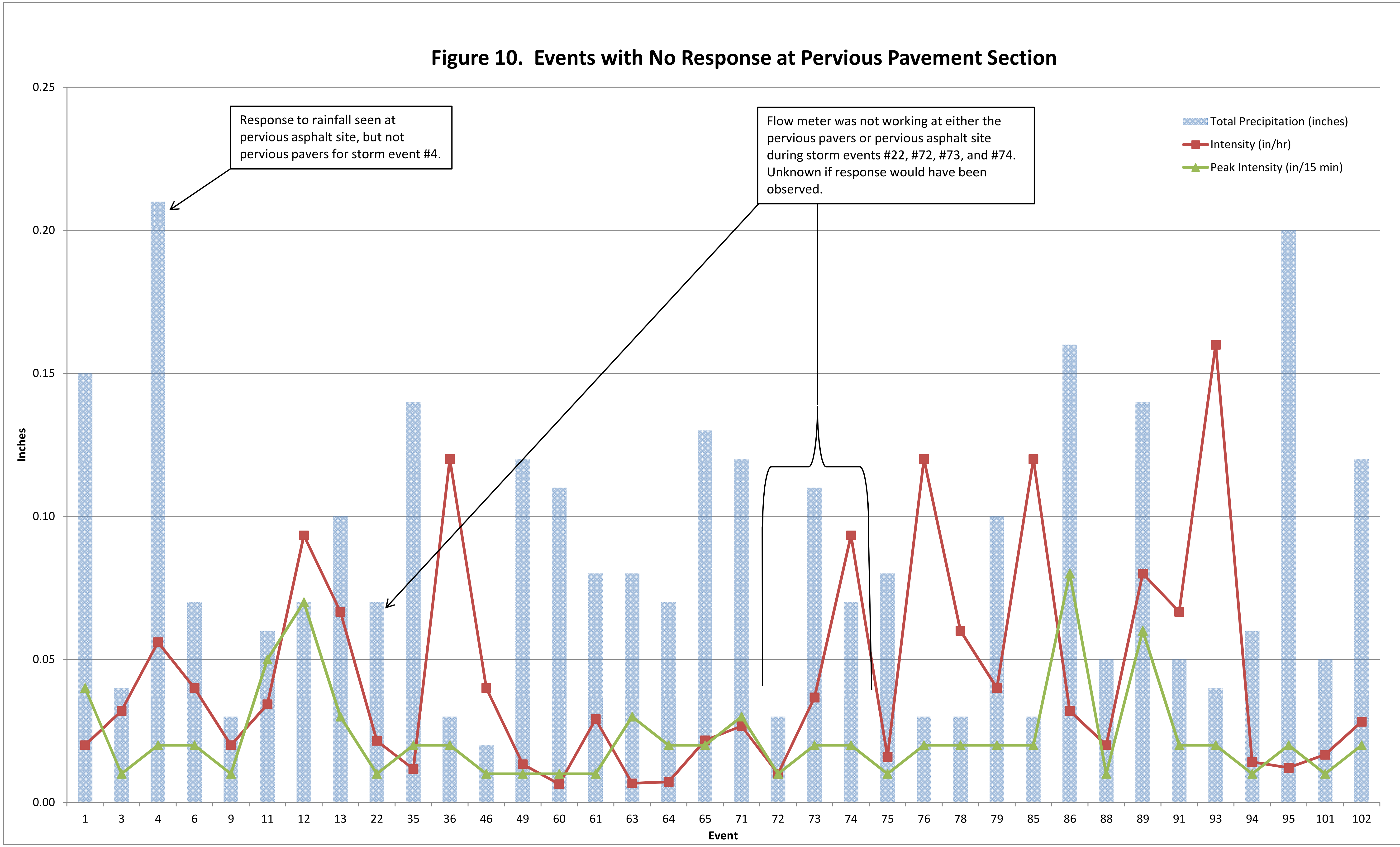
Figure 10. Events with No Response at Pervious Pavement Section
Response to rainfall seen at pervious asphalt site, but not pervious pavers for storm event #4.
Flow meter was not working at either the pervious pavers or pervious asphalt site during storm events #22, #72, #73, and #74. Unknown if response would have been observed.
Total Precipitation (inches)
Intensity (in/hr)
Peak Intensity (in/15 min)
Inches
0.25
0.20
0.15
0.10
0.05
0.00
Event
1 3 4 6 9 11 12 13 22 35 36 46 49 60 61 63 64 65 71 72 73 74 75 76 78 79 85 86 88 89 91 93 94 95 101 102

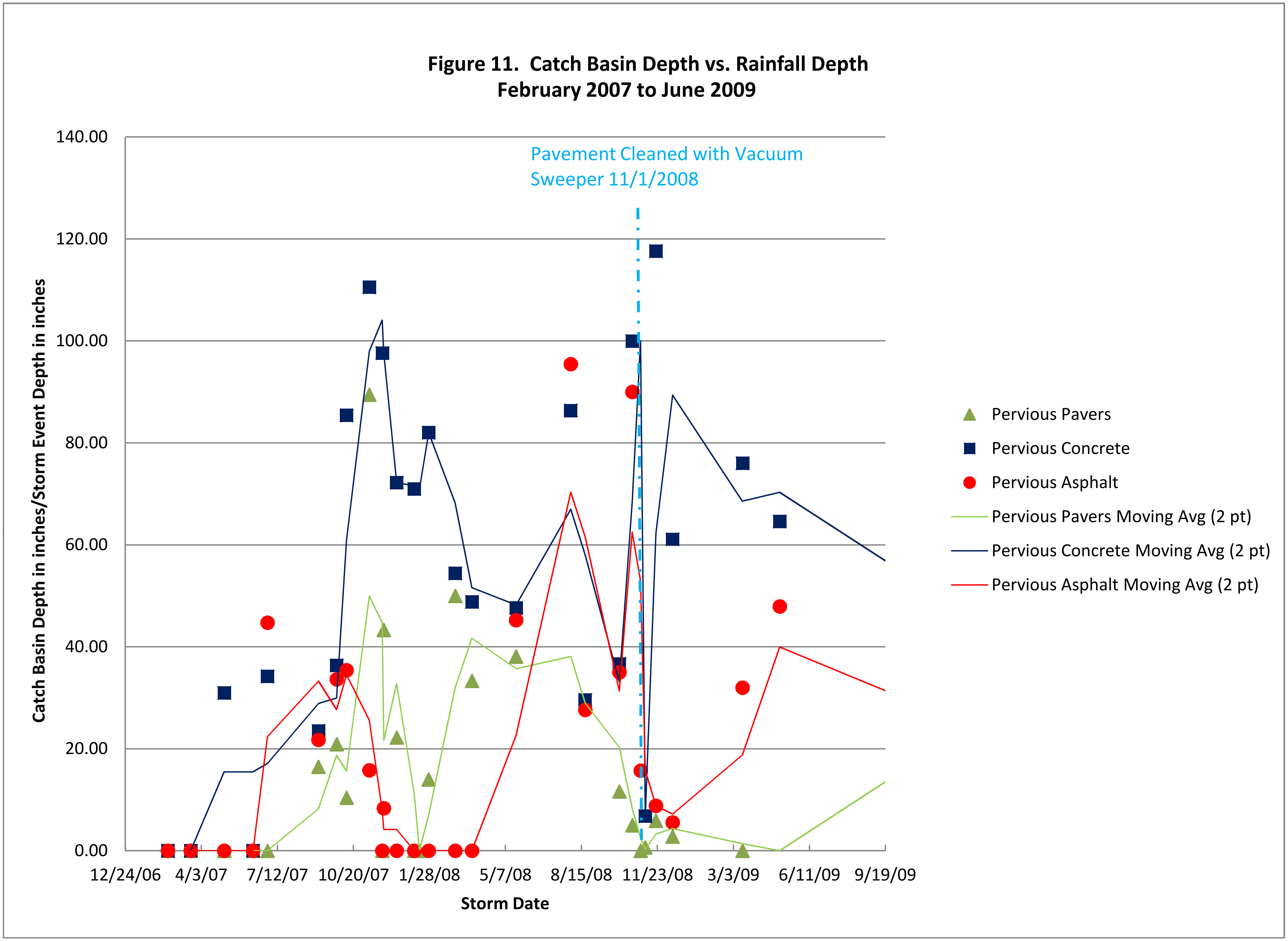
Figure 11. Catch Basin Depth vs. Rainfall Depth
February 2007 to June 2009
Pavement Cleaned with Vacuum Sweeper 11/1/2008
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
12/24/06
4/3/07
7/12/07
10/20/07
1/28/08
5/7/08
8/15/08
11/23/08
3/3/09
6/11/09
9/19/09
Storm Date
Catch Basin Depth in inches/Storm Event Depth in inches
Pervious Pavers
Pervious Concrete
Pervious Asphalt
Pervious Pavers Moving Avg (2 pt)
Pervious Concrete Moving Avg (2 pt)
Pervious Asphalt Moving Avg (2 pt)

APPENDICES

APPENDIX A. TACOMA LANDFILL PERVIOUS PAVEMENT DEMONSTRATION PROJECT – WATER QUALITY REPORT

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

October 21, 2011

Prepared By
City of Tacoma

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EXECUTIVE SUMMARY

Project Overview. This report summarizes the methods and results of data collected from the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The Project is located at the Tacoma Landfill and consists of a 36,100 square foot area paved with equal areas of pervious pavers, pervious concrete, pervious asphalt, and standard, impervious asphalt. The City of Tacoma (City) conducted the study to evaluate how each pavement type performed with respect to flow control, water quality, maintenance, and durability.

Site Setup. The Project was constructed over an existing impermeable geomembrane liner that was installed as part of the landfill's environmental controls. Surface runoff and infiltrated flows through the pervious pavement sections were isolated from each other to facilitate flow and water quality monitoring.

Sampling Approach. Rainfall, flow, and water quality data were collected for 37 separate storm events from March 2007 through October 2009, resulting in the collection of 111 stormwater samples (80 flow composite samples, 31 grab samples). Automatic flow-composite sampling in accordance with the Washington State Department of Ecology's Technology Assessment Protocol was performed on the infiltrated flows from the pervious pavers, pervious concrete, and pervious asphalt test locations and from the surface runoff from the standard asphalt section. Grab samples were collected from the catch basins that collected surface runoff from the three pervious pavement sections. Of the 80 flow composite samples collected, 64 were accepted for analysis because they either completely satisfied the Quality Assurance Project Plan criteria or only had minor deviations from the criteria.

General Comparisons between Pavement Sections. Statistically significant differences ($p < 0.05$) were observed between sample locations for 19 of the 34 analytes. The number of analytes with statistically significant differences in the post-hoc tests (Dunn's or Tukey's) between the various sampling locations is shown below:

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow							
	Catch Basin	2						
Pervious Concrete	Infiltrated Flow	14						
	Catch Basin		0	16				
Pervious Asphalt	Infiltrated Flow	14		18				
	Catch Basin		1		3	1		
Standard Asphalt	Catch Basin	2	2	9	2	10	14	

General Comparison by Analyte Type. Pollutant concentrations were compared between the sample locations and results and generally indicate:

- pH: The pH for the infiltrated flow for pervious concrete had a maximum value of 12.4 which was significantly higher than all the other sites. The pH value remained high (all values greater than 10.5) over the duration of the study.
- Total Suspended Solids and Hardness: The hardness and total suspended solids concentrations for the infiltrated flow for pervious concrete was significantly different than most of the other sample locations. Several other statistically significant differences were noticed between the sample locations for total suspended solids and hardness.

- Petroleum Hydrocarbons: Statistically significant differences were observed between the sampling locations for both NWTPH-Diesel and NWTPH-Heavy Oil. Based on a visual analysis of the box plots, NWTPH-Heavy Oil concentrations appear to be lower in all the infiltrated flow sample locations than in the respective catch basin sample locations.
- Metals: Both total lead and total zinc had statistically significant differences between several of the sampling locations. The box plot for total zinc showed the most notable differences in concentrations with the infiltrated flow samples appearing to be less than the respective catch basin samples for all pavement types.
- PAHs: Seven of the PAHs showed statistically significant differences between sample locations. For several of the PAHs, the box plots showed lower concentrations at the infiltrated flow sample locations compared to the respective catch basin locations. Many of the PAHs had numerous results that were less than the analytical detection limits which impacted the statistical analyses.
- Phthalates: Five of the phthalates showed statistically significant differences between sample locations. Many of the phthalates had numerous results that were less than the analytical detection limits which impacted the statistical analyses.

Costs. The costs per square foot for the four different pavement types when the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project were constructed in 2005 are shown below.

Pavement Section	Cost/SF
Pervious Pavers	$6.44
Pervious Concrete, 6" thick	$11.00
Pervious Asphalt, 3" thick	$2.89
Standard Impervious Asphalt, 3" thick	$1.44

Recommendations. The high pH values observed over the course of the study in the infiltrated flow from the pervious concrete site are cause for concern since they could impact the underlying groundwater and/or receiving water. Other pervious pavement water quality studies have shown similar results, but the pH values in those studies typically dropped to less than pH 9 within one year following pavement installation. Additional study would be needed to determine the exact cause of the sustained high pH values observed in this Project.

The apparent lower concentrations of NWTPH-Heavy Oil, total zinc, numerous PAHs, and numerous phthalates at the infiltrated water sample locations associated with the pervious pavements compared to the surface runoff collected in the catch basins suggests that pervious pavement sections coupled with the underlying soils can cause a noticeable reduction in pollutant concentrations. Additional sampling would be required to determine if all the differences observed by visual comparison are statistically significant.

1.0 PROJECT OVERVIEW

This report summarizes the methods and results of data collected from the Tacoma Landfill Employee Parking Lot and Pervious Pavement Demonstration Project (Project). The 36,100-square-foot paved area, which is used to provide employee parking, was constructed with equal size sections of pervious interlocking pavers, pervious concrete, pervious asphalt and standard, impervious asphalt (approximately 9,000 square-feet each). Construction of the Project was completed in April 2006. Sampling was completed in October 2009.

The purpose of this demonstration Project is to study different types of pervious pavements and how each pavement type performs with respect to flow control, water quality, maintenance and durability. Gathered data was compared to standard asphalt and then used to support low impact development and the City's NPDES program.

1.1 PROBLEM STATEMENT

Impervious surfaces prevent rainfall from infiltrating the underlying soil. This alters the natural hydrologic cycle resulting in increased stormwater runoff since rainfall does not immediately recharge the underlying groundwater. Pipes and detention ponds are frequently required to collect and convey this water to local water bodies. As the quantity of impervious surfaces in a watershed increases, the peak runoff rate increases which can lead to urban flooding and scouring of rivers and streams. As water passes across impervious surfaces, it also picks up pollutants (e.g., oil, metals) which are conveyed to local water bodies through the stormwater system.

Pervious pavement, on the other hand, allows the majority of rainwater to pass through the pavement and infiltrate the underlying soils. This reduces the need for surface water collection systems and may help naturally remove contaminants from the water as it percolates through the pavement and underlying soil layer.

However, uncertainties in the long-term performance, maintenance requirements, and durability of pervious pavements have inhibited their widespread use. Limited research has been conducted to quantify the reduction in stormwater runoff and pollution from pervious pavements.

To assess the performance of pervious pavements in relation to standard asphalt, the City conducted a pilot study at the Tacoma Landfill. The City constructed an employee parking lot using three different types of pervious pavement (pervious pavers, pervious concrete, and pervious asphalt) and standard, impervious asphalt. Each pavement type consisted of approximately 9,000 SF of pavement surface. Data collection was initially targeted for two years, but that was increased to two and a half years to ensure enough data was collected to generate statistically significant results.

1.2 MONITORING OBJECTIVES

The objectives of this study, as outlined in the Quality Assurance Project Plan (QAPP) (Appendix B) were:

- *Flow Control*: To investigate the effectiveness of different pervious pavement types (pervious concrete, pervious asphalt and pervious interlocking pavers) to infiltrate and attenuate storm peak flow rate variations.[1]
- *Water Quality Treatment*: To investigate each pervious pavement's ability to reduce the concentration of selected pollutants in stormwater runoff.
- *Maintenance*: To investigate the maintenance requirements and maintenance frequency for each pavement type.
- *Durability*: To evaluate how the different pavement types hold up over time.

[1] Subsequent to the development of the QAPP, the City decided to implement a secondary more detailed study to monitor the flow control of the different pervious pavement sites in relation to standard, impervious asphalt. This analysis will be discussed in a separate report.

2.0 PROJECT DESCRIPTION

This section describes the Project site, Project construction, and the stormwater conveyance system.

2.1 PROJECT SITE CHARACTERISTICS

The Project is located at the Tacoma Landfill, which is an approximately 240 acre solid waste facility that is owned and operated by the City of Tacoma Solid Waste Utility (Figure 1). All regions of the landfill are closed and capped, except for a 31 acre area of the landfill that is still actively receiving refuse.

The landfill cap system present at the site prevents water from entering the underlying refuse to prevent groundwater contamination. This landfill cap system (Figure 2) consists primarily of six inches of topsoil, eighteen inches of cover material, a drainage net, and two impermeable high density polyethylene (HDPE) liners (a primary and a secondary liner separated by a twelve inch sand layer) over the underlying refuse. The landfill cap also includes a system of drainage ditches (Figure 3) which convey stormwater away from the site and into the City's stormwater system.

Sampling of the soil cover material over the cap was completed in two locations within the Project footprint prior to starting construction. Results (Appendix A) show that the cation exchange capacity ranged from 2.6 to 2.8 meq/100 g at six inches deep and between 1.8 and 1.9 meq/100 g at twelve inches deep. Based on the low cation exchange numbers observed in the existing cover material, it was not expected to be able to provide significant treatment of the infiltrated water.[2]

2.2 PROJECT DESCRIPTION

The Project consists of a 36,100 square foot paved area constructed at the Tacoma Landfill to provide additional employee parking and storage areas. The new paved area is adjacent to an existing employee parking lot, located on the east side of the administration building (Figure 4). The new parking lot is located in an area of the landfill that has been closed with a landfill cap as described in Section 2.1.

The Project was constructed in sections (approximately 9,028 SF each) with three sections of pervious pavement (pervious pavers, pervious concrete, and pervious asphalt) and one section of standard, impervious asphalt. Cross sections of the standard asphalt and pervious pavements used in this Project are shown in Figure 5.

2.2.1 Pervious Pavers

The pervious paver materials installed at the Project site are UNI-ECOLOC manufactured by UNI-GROUP U.S.A. The pavers are approximately 3 1/8" high with an "L" shaped pattern. The pavers were mechanically installed in the parking lot.

---

[2] The City of Tacoma Surface Water Management Manual, Volume 5, Section 3.4.2 requires a minimum two foot deep soil layer with a 5% organic content and a minimum cation exchange capacity of 5 meq/100 g in order to be allowed to serve as a treatment layer beneath a water quality or detention facility.

2.2.2 Pervious Concrete

The pervious concrete material installed at the Project site contains the Perco-Bond admixture distributed by Michiels International LLC to create a "PercoCrete" product. PercoCrete differs from most other pervious concrete products in that it provides a smooth finish as well as water retention. After water enters the pavement section, it slowly exfiltrates from the PercoCrete into the underlying soils below.

2.2.3 Pervious Asphalt

The pervious asphalt material installed at the Project site is HMA Cl ½" PG 64-22 with an open graded mix. The gradation requirements for the asphalt are listed below:

US Standard Sieve Size	Percent Passing
½" Square	100
3/8" Square	92-98
No. 4	32-38
No. 8	12-18
No. 16	7-13
No. 30	0-5
No. 200	0-3
Asphalt % of total mixture	5.5% to 6.0%

Compaction of the pervious asphalt mix occurred when the surface was cool enough to resist a 10-ton roller. Minimal passes were allowed (just enough to get a smooth surface) with the roller to ensure the porosity of the pavement would not be significantly reduced.

2.2.4 Standard Asphalt

The standard asphalt material installed at the Project site is HMA Cl ½" PG 58-22. The standard asphalt material met the installation and material requirements listed in the 2004 Standard Plans for Road, Bridge, and Municipal Construction prepared by the Washington State Department of Transportation.

2.2.5 Subgrade Materials

Beneath all the pavement sections, crushed gravel base was used to provide structural integrity to the pavement and to provide additional water storage for the pervious pavement sections. The crushed gravel base was an open graded, fractured stone conforming to ASTM No. 57 gradation requirements.

The existing topsoil material was removed prior to installation of the crushed gravel base. Approximately twelve to eighteen inches of existing cover material remained under the crushed gravel base over the underlying composite liner. As described in Section 2.1, the cation exchange capacity of the underlying cover soil ranged from 1.8 to 2.8 meq/100 g before construction occurred.

2.2.6 Material Costs

The cost per square foot for the four difference pavement types (2005 costs) are shown below.

Pavement Section	Cost/SF
Pervious Pavers	$6.44
Pervious Concrete, 6" thick	$11.00
Pervious Asphalt, 3" thick	$2.89
Standard Impervious Asphalt, 3" thick	$1.44

2.3 FLOW PATH

2.3.1 Infiltrated (Subsurface) Water for Pervious Pavement Sections

Water that infiltrates through the pervious pavement sections moves through the underlying gravel base and then does either of the following:

- Infiltrates through the cover soil until it reaches the drainage net and primary HDPE liner. Water then travels west along the HDPE liner/drainage net until it reaches the perforated pipe located at the west edge of the pavement section.
- Remains in the gravel base layer (due to the lower permeability of the underlying cover soils) and travels west until it reaches the west side of the pavement section. The water then infiltrates the cover soil until it enters the perforated pipe on the west side of the pavement section.

The perforated pipe collects these subsurface flows and discharges the flow into a monitoring manhole located west of the pervious pavement sections (Figure 4).

Subsurface flows between the pavement sections are isolated from each other by a geosynthetic clay liner (GCL) flap. The GCL flap is placed between each pavement section to prevent subsurface flows from one pavement type reaching the monitoring manhole for a different pavement type. GCL and perforated pipe were also installed around the perimeter of the parking lot to prevent subsurface flows from adjacent capped areas reaching the monitoring manholes. The GCL was installed vertically (liner to pavement surface) and connected to the HPDE liner with bentonite. Figure 6 shows the GCL flap between the pavement sections.

The monitoring manholes are equipped with a bubbler flow meter connected to an automatic sampler. More information about the specific monitoring equipment used in this Project is provided in Section 3.1.1.

2.3.2 Surface Runoff

2.3.2.a Standard Asphalt

Surface runoff in the standard asphalt pavement area flows to the northwest corner of the site where it flows through a 4” surface drain and discharges to a 48” diameter catch basin. After passing through the catch basin, flows proceed into the monitoring manhole which is equipped with a bubbler flow meter connected to an automatic sampler. More information about the specific monitoring equipment used in this Project is summarized in Section 3.1.1.

Samples were not collected directly from the catch basin because of the desire to mimic the level of treatment (sediment deposition) typically seen in runoff from parking lots. Therefore, a monitoring manhole was installed downstream of the catch basin for the standard, impervious asphalt section.

2.3.2.b Pervious Pavements

Surface runoff from the pervious pavement areas flows west until it reaches a concrete curb and gutter on the west side of the pavement section. Water is collected in the curb and gutter and discharged into a 24” diameter catch basin. The catch basin is equipped with a gate valve that allows water to be collected in the basin during a storm event and then discharged after the storm. Volume measurements are made before and after each storm event to determine the amount of surface runoff from each storm event. Sampling of these catch basins is described in Section 3.1.2.

Since the concrete curb and gutter is not pervious, it is covered with a metal plate (sloped to drain away from the pavement section) to prevent rainfall from hitting the gutter and being conveyed to the catch basin without having the opportunity to infiltrate through the pervious pavement.

2.4 SITE MAINTENANCE

Since the pervious pavement sections are expected to clog over time, the site was swept with a vacuum sweeper on an as needed basis. Determinations on when the site needed to be swept were made based on visual observation and on the amount of surface runoff from the pervious pavement sections.

3.0 MONITORING METHODS

This section provides an overview of the monitoring methods, including sampling approach, qualifying events, stormwater quality parameters, sample collection, sample handling, quality control procedures, and equipment maintenance. A more detailed description of the monitoring methods is provided in the QAPP developed for this Project. The monitoring approach for this study was adapted from the Technology Assessment Protocol – Ecology (TAPE) (Washington State Department of Ecology 2008[3]).

3.1 SAMPLING METHODOLOGY AND EQUIPMENT

3.1.1 Pervious Pavement Infiltrated Water and Standard Asphalt Surface Runoff

Samples were collected using automatic flow-weighted composite sampling as defined by the TAPE. Samples were collected from the monitoring manholes during the storm event with a goal of at least 10 aliquots collected over at least 75% of the total storm runoff volume. By collecting aliquots over the majority of the storm runoff volume, samples were representative of the entire storm event.

Samples from both the pervious pavement sections (infiltrated flows) and standard asphalt (surface runoff) were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer through Teflon tubing. The bubbler flow module measured water depth and this data was converted to flow using Manning's equation. Sample collection was flow paced by the flow monitoring equipment to collect flows over the storm event; pacing was determined by field crews based on the expected size of the storm event.

In accordance with TAPE protocols, all organics samples were collected through Teflon® intake lines into 1-gallon glass jars with Teflon®-lined lids. This approach was used because these materials are known to be the most inert in terms of adsorption and desorption of organic compounds (CDOT 2000). Sample bottles were cleaned by the analytical laboratory using a dilute sulfuric acid rinse followed by a deionized (DI) water rinse.

This sampling method, however, did not allow for the collection of manual grab samples for NWTPH samples. NWTPH samples were instead collected using the automatic samplers, which may have resulted in some additional error in these measurements because some TPH may have adhered to the sampling equipment. This could have resulted in analytical results that were lower than would otherwise be measured and could have complicated comparisons of results between pavement sections.

3.1.2 Pervious Pavement Surface Runoff

Surface runoff from the pervious pavement sections was collected in catch basins associated with each pervious pavement section. Catch basins were drained prior to each storm event and the gate valve closed prior to the storm event. Volume measurements were taken by field staff before and after the storm event to determine the amount of runoff that occurred during the

[3] The QAPP was developed based on the 2004 version of the TAPE. Minimal changes have occurred in the sampling design in the 2008 version of the TAPE.

event. Grab samples were collected directly from the catch basin if enough water was collected during that storm event. After sample collection, water was released to the drainage system. Samples were collected using a stainless steel bucket and distributed into the correct sample container type depending on the type of analysis to be performed.

3.2 Qualifying Events

3.2.1 Qualifying Storm Event

A qualifying storm event was defined for the Project as having a minimum of 0.2 inches of rain and an antecedent dry period of less than 0.02 inches of rain in the preceding 24 hours. Antecedent rain data was collected from an ISCO 674 rain gauge located on the Project site. The rain gauge was connected to an ISCO 6712 sampler which was used to record rain data. Rainfall was recorded in 0.01 inch increments and logged every 15 minutes.

3.2.2 Qualifying Sampling Period

The goal for a qualifying sampling event was to collect at least 10 aliquots over at least 75% of the storm's total runoff volume. This goal was based on the recommendations defined in TAPE.

3.3 Whole-Water and Sediment Parameters

Analytical parameters evaluated as part of this study were selected for several reasons. Typical stormwater runoff parameters (e.g., TSS, zinc, lead, and copper) were included in the study due to their common occurrence in urban runoff and their potential for impact to receiving waters. Additional metal and organic parameters (e.g., PAHs, phthalates) were included in this study because of the challenges the City faces in its urban drainage basins with these parameters. Water quality parameters selected for evaluation are listed in Table 1.

Sediment samples were collected from all the catch basins at study completion. The parameters for sediment analysis are listed in Table 2.

3.4 Sample Handling

Proper sample collection, handling, preservation, transport, and custody procedures were followed as described in the QAPP. Sample containers were appropriately labeled and logged on the chain-of-custody forms. Samples were iced during sample collection (by adding ice to the sampler base). No sample preservation was done prior to delivery to the laboratory. Samples were collected from the field and delivered to the laboratory within 24 hours of the onset of rainfall.

3.5 Quality Control Procedures

Quality control samples were collected for field and laboratory activities and analyzed to estimate bias and precision. The quality control procedures were conducted to determine if any of the sample containers, preservation methods, handling procedures, or sampling equipment contributed constituents to the sample. This section provides a brief description of the field and laboratory quality control samples and their associated frequency, acceptance criteria, and corrective actions.

3.5.1 Field Quality Control

One equipment rinse blank was collected over the course of the study from the standard asphalt test section. The standard asphalt test section was used for this quality control test because it was expected to see the highest pollutant concentrations. The sample was collected midway through the sampling timeline. Only one rinsate blank was collected for this Project because other studies by the City have shown that their methods and procedures adequately clean the sample tubing between sampling events.

The equipment rinsate blank collected had a few exceedences of quality control parameters[4] (Table 3). The three exceedances were all phthalates and they were reported as estimated values (J flag) at exactly two times the MDL; these minor exceedances are not believed to have impacted data quality.

The same quality control parameters were implemented for blank sample collection as were in place for all other sample collections. The sample line was rinsed with DI water by running the sampler pump in reverse with a volume of DI water equal to at least three times the suction line volume. After cleaning the sample line, the field blank was collected by drawing DI water through the cleaned sample intake line.

3.5.2 Laboratory Quality Control

Samples were submitted to the City of Tacoma Environmental Services Laboratory, a laboratory accredited by the Washington State Department of Ecology, for analysis. Laboratory procedures followed those developed and currently implemented as described in the Environmental Services Laboratory Quality Assurance Manual (City of Tacoma 2010[5]) for sample analysis and reporting. Analyses (e.g., grain size, cation exchange capacity) that could not be performed at the City of Tacoma Environmental Services Laboratory were sent to laboratories accredited by the Washington State Department of Ecology for the specific analyses that was being performed.

Laboratory quality control checks included method blanks, laboratory replicates, laboratory control samples, and matrix spikes. Quality control results for laboratory activities were reviewed by the Laboratory Quality Assurance Officer and summarized in a case narrative. Laboratory reports included the case narrative which identified any discrepancies with analysis or QC samples, a laboratory QC results summary, and laboratory results for both storm and QC samples. Data were deemed acceptable for use.

3.6 EQUIPMENT MAINTENANCE

The flow monitoring and water quality sampling equipment were inspected prior to each sampling period to make sure they were operational. Inspections and preventative maintenance

[4] The QAPP did not define the quality control parameters for the equipment rinsate blank. The acceptance criteria used were less than two times the method detection limit (MDL) or less than 10% of the lowest sample reported.

[5] The Quality Assurance manual was updated several times during the sampling of the Project. The QA/QC for the Project followed the most recent version of the manual at the time of sample analysis.

activities on the automated samplers and bubblers occurred as part of the pre-storm setup activities and during monthly site visits for routine data downloads. Maintenance records and calibration activities were documented on field sheets kept on file in the field notebooks.

4.0 DATA VALIDATION, ANALYSIS, AND USABILITY

This section provides an overview of the data validation and analysis procedures that occurred during and after collection of the field data. The application of these procedures to data collected during this study is provided in Section 5.0.

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Rainfall, water depth, flow, and water quality data underwent data review, verification, and validation as described below.

4.1.1 Data Review

Rainfall and flow data were reviewed for gross errors such as spikes or data gaps to determine the completeness of the data set. Rainfall and flow measurements were verified by comparing the hyetograph and hydrograph for consistency with previously collected data for each pavement section.

4.1.2 Data Verification

The Laboratory Quality Assurance Officer verified that all laboratory Quality Control results were in compliance with acceptable criteria. The Project Manager verified that field water quality QC results were in compliance with acceptance criteria. The Project Manager validated Project data by determining whether procedures in the QAPP were followed during data collection.

4.1.3 Data Validation

The Project Manager reviewed all laboratory data to ensure that results were appropriately qualified. All results were suitable for use as qualified.

4.2 DATA ANALYSIS

This section describes the data analysis conducted on the storm events and on the whole-water, soil, and sediment data.

4.2.1 Storm Event Data

Hydrologic data from sampled storms were analyzed for the following information:

- Storm Event Antecedent Conditions (measured rainfall, duration);
- Storm Event Conditions (total precipitation, duration); and
- Sampling Event Conditions (flow rate, volume, sample collection timing and duration).

This information was then compared to the storm and sampling event criteria identified in Section 3.2 to determine what sampling periods should be accepted. Whole-water data from accepted sampling periods were analyzed using the methods discussed in Section 4.2.2.

4.2.2 Whole-Water Comparisons

Concentration data from each pavement section were analyzed using an ANOVA analysis to determine if a statistically significant difference in concentration exists between pavement types. The following statistical tests were used based on the distribution of the concentrations:

- Normal Distribution (Shapiro-Wilks p-value ≥ 0.10): Parametric ANOVA with a Tukey post-hoc test; and
- Non-Normal Distribution (Shapiro-Wilks p-value < 0.10): Non-parametric ANOVA (Krustal-Wallis) with a Dunn post-hoc test.

If a statistically significant difference was found using an ANOVA analysis, a post-hoc test on the mean concentration values was used to determine which pavement types were significantly different from each other. The Dunn test was performed using Excel using the equations in Zar (1999). The ANOVA tests and the Tukey test were performed using SYSTAT.

Results (discussed in Sections 5.0 and 6.0) are also presented in the form of "box and whisker" plots to provide a visual analysis. The bottom of the lower "whisker" represents the smallest non-outlier observations of the ranked concentration values, the lower end of the box represents the 25th percentile, the heavy horizontal line in the middle of the box is the median of the values, the upper end of the box is the 75th percentile, and the top of the upper "whisker" is the largest non-outlier observation. Outliers were defined as anything greater than 1.5 times the interquartile range (75th percentile value minus the 25th percentile value) away from either the 25th percentile or the 75th percentile value. Outliers were not shown on the box plots. This format presents the range of values in a convenient manner.

4.2.3 Sediment Data

Sediment samples were collected from all catch basins at the end of the Project in March 2011. The catch basins were not cleaned during the study. The samples were analyzed to determine pollutant concentrations on a dry weight basis.

4.2.4 Maintenance Data

Maintenance inspections were conducted prior to each sampling event. Maintenance notes are included in the field sheets kept on file in the field notebooks.

5.0 RESULTS

This section summarizes the data collected at the Project site. Results presented include storm event characteristics, water quality data, sediment data, and maintenance data. Section 6.0 provides a more detailed discussion of the data collected for each type of analyte (i.e., PAHs, phthalates).

5.1 STORM EVENTS

Thirty-seven storms were sampled over a two and a half-year period from March 2007 to October 2009, resulting in the collection of 111 stormwater samples. Table 4 summarizes the storm and sampling period characteristics and identifies whether or not each sampling period met the criteria outlined in the QAPP. Detailed storm event summaries are provided in Appendix C.

5.1.1 Flow

TAPE guidelines recommend that automatic flow-weighted composite sampling be conducted such that at least 10 aliquots are composited and that the aliquots cover at least 75% of each storm's total runoff volume. The greater the number of aliquots collected and the greater the storm coverage, the greater the confidence that the data represent the event mean concentration for the entire storm.

Table 4 shows that several sampling periods did not meet the 75% criterion identified in the QAPP. This is largely due to issues associated with the predicted storm size versus the actual storm size. If a storm event was much smaller than what was predicted, the flow pacing setup would have collected too few aliquots over the storm duration. If the storm event was much larger than what was expected, the flow pacing setup would have collected all of the aliquots (48 maximum) before the storm event was over and the 75% of the total storm runoff volume goal may not have been attained.

Meeting the flow criteria in the TAPE and QAPP was further complicated by the flow characteristics of the pervious pavement sites since the water must first infiltrate the pavement section and then be conveyed in the subsurface to the monitoring manhole. This resulted in much lower peak flows and longer flow durations for the three pervious pavement sites. It may take many hours for the flow to return to baseline (near zero) at the pervious pavement test sites unlike the standard, impervious asphalt section which returns to baseline flow almost immediately after the rainfall stops. During this several hour period when the flow was returning to baseline, rain may have started falling again and flow may have started to increase. This made it difficult to determine the start and end of storm events from the pervious pavement sample locations.

Fine sediment was frequently observed in the monitoring manhole that collected runoff from the infiltrated flows from the pervious concrete pavement section. This ongoing issue also affected flow monitoring. Field crews would routinely "sweep" the line and pump out as much of the debris as they could. The sediment would also build up on the bubbler probe, necessitating frequent cleaning of the probe to prevent clogging. These particles, likely from the pervious concrete material, led to on-going issues with flow measurement at the pervious concrete sampling location.

The hydrograph and hyetograph were visually inspected to determine which storms should be accepted for analysis. For very large storm events, partial storms were accepted for analysis. In some cases during the very long events, the 24 hour sampling limit was met prior to the storm event being completed; these storms were accepted as partial storms. Due to the complicating factors mentioned above, storms that were collected over more than 50% of the total storm runoff volume and which were collected over a good initial portion of the storm (when the pollutant concentrations are expected to be highest) were accepted for analysis. Sixteen sampling events were excluded for analysis due to the sampling period flow characteristics.

5.1.2 Storm Depth and Duration

The QAPP defines a qualifying storm event as having a minimum depth of 0.20 inches. The TAPE guidelines, however, recommend that total rainfall during the sampling period have a minimum depth of 0.15 inches with a duration greater than 1 hour. TAPE also recommends that the average rainfall intensity should exceed 0.03 inches per hour for at least half of the sampled storm.

The QAPP developed for this Project set stricter guidelines to be consistent with other sampling being conducted by the City. For data analysis, all storms that met the TAPE guidelines (minimum of 0.15 inches with a minimum 1-hour storm duration) were accepted for analysis. No storms were excluded based on storm depth or duration.

5.1.3 Antecedent Rainfall

The QAPP defines the antecedent rainfall criteria as having an antecedent dry period with less than 0.02 inches in the 24 hours prior to the event. The TAPE guidelines, however, recommend that less than 0.04 inches fall in the 6 hours prior to the event. The TAPE guidelines were used instead of the QAPP guidelines since the TAPE guidelines were deemed stringent enough to ensure that pollutants were not mobilized prior to the event. No storms were excluded based on antecedent rainfall conditions.

5.2 WATER QUALITY DATA

5.2.1 Pollutant Concentrations

Table 5 provides the summary statistics for accepted storms for each water quality parameter. Results are presented for all infiltrated flow locations collectively, for all catch basin locations collectively, and for individual sample locations.

Pollutant concentrations observed from the standard, impervious asphalt were compared to Thea Foss basins 237A and 243 (Table 6) because these basins collect significant runoff from highways and other high traffic roadways. Pollutant concentrations in the standard asphalt section appear to generally be less than those seen in the Thea Foss basins, especially for TSS, lead, zinc, and several PAHs. Phthalate concentrations were generally similar between the two locations. The lower concentrations seen in the standard asphalt test section compared to the Thea Foss basins is likely due to the difference of use in the drainage basins; the standard asphalt test section is used for employee parking and sees infrequent vehicular traffic. Thea Foss basins 237A and 243, on the other hand, collect flows from highly urbanized areas with frequent vehicular traffic.

5.2.2 Comparisons between Pavement Sections

Analysis of variance (ANOVA) was performed on the analyte concentrations (see Section 4.2.2) to determine whether or not statistically significant differences exist between the sample locations. Concentrations reported as less than the detection limit were included in the analysis by using one half of the detection limit as the concentration. ANOVA results are presented in Table 7. Statistically significant differences between sample locations were observed for 19 of the analytes.

Post-hoc tests (Tukey or Dunn as described in Section 4.2.2) were then conducted on these analytes to determine the differences between the sample locations (Table 8 and Table 9).[6] Table 10 provides a summary of the total number of statistically significant differences between the pavement sites. In general, when looking at all analytes together the following general differences (Table 10) were observed:

- Infiltrated flow for pervious pavers – Statistically significant differences were primarily noted for the infiltrated flow for pervious concrete (14 differences) and infiltrated flow for pervious asphalt (14 differences).
- Catch basin for pervious pavers – Two or fewer statistically significant differences were noted between the catch basin for pervious pavers and all other sampling locations. The limited number of statistically significant differences was likely influenced by the fact that only eleven samples were collected from this sample location; all other sample locations had more samples collected.
- Infiltrated flow for pervious concrete – Statistically significant differences were primarily noted for the infiltrated flow for pervious pavers (14 differences), catch basin for pervious concrete (16 differences), infiltrated flow for pervious asphalt (18 differences), and the standard asphalt catch basin (9 differences).
- Catch basin for pervious concrete – Statistically significant differences were primarily noted for the infiltrated flow for pervious concrete (16 differences).
- Infiltrated flow for pervious asphalt – Statistically significant differences were primarily noted for the infiltrated flow for pervious pavers (14 differences), infiltrated flow for pervious concrete (18 differences), and the standard asphalt catch basin (10 differences).
- Catch basin for pervious asphalt – Statistically significant differences were primarily noted for the standard asphalt catch basin (14 differences).
- Catch basin for standard asphalt – Statistically significant differences were primarily noted for the infiltrated flow for pervious concrete (9 differences), infiltrated flow for pervious asphalt (10 differences), and the pervious asphalt catch basin (14 differences).

[6] Post-hoc comparisons were not performed between infiltrated flow samples from one pervious pavement type and pervious pavement catch basin samples from another pavement type. Comparisons were not performed because it was believed that no logical conclusions could be drawn from these types of comparisons.

5.3 SEDIMENT DATA

Table 11 provides a summary of the sediment data collected from the catch basins at the end of the Project. Since only one sample was collected during the Project, results should be interpreted with caution.

Total organic carbon and metal concentrations generally appear to be higher in the pervious pavers and pervious asphalt samples compared to the pervious concrete and standard asphalt samples. For PAHs, the pervious asphalt samples appeared to generally have the highest results followed by pervious pavers. DEHP was also notably higher in the pervious pavers and pervious asphalt samples compared to pervious concrete and standard asphalt. In general, pervious concrete samples appear to have the lowest levels of contamination. Grain size results from the catch basins are provided in Appendix D.

When the samples were collected in March 2011, none of the catch basins had sediment in the middle of the basin. This suggests that flow through the catch basins was pushing the sediment out of the basins. The pervious pavers and pervious asphalt catch basins had about 1.0” of sediment at the perimeter of the basin, the pervious concrete catch basin had about 3.0” at the perimeter of the basin, and the standard asphalt catch basin about 3.5” at the perimeter of the basin. Since sediment was being pushed out of the basins, the sampled sediment may not be representative of all the sediment that passed through the basins over the duration of the Project (i.e., smaller or larger particles may have been preferentially trapped in the basin). The differing amount of sediment in the basins may have also been impacted by the amount of surface runoff (i.e., pervious pavements have less surface runoff, therefore less sediment ends up being conveyed to the catch basins) or by the ability of the pervious pavement sections to trap sediment in the pervious surface.

5.4 MAINTENANCE/DURABILITY

The following general observations were noted during the Project:

- The pervious pavers required periodic weeding to keep the joints clean. When not weeded, grasses were growing several feet tall out of the joints. Weed killer was not used on the pavers due to the water quality monitoring being conducted.
- Pervious concrete had some surface cracking and spalling which was repaired by the subcontractor about one year after installation. The cracking may have been caused by an issue with the mix design or site conditions during installation since cracks were only observed in areas that were part of the first concrete pour. The cracks may also have been caused by settlement that occurred at the landfill since the Project site is constructed over landfilled garbage which tends to settle differentially over time.
- During warm weather, the pervious asphalt surface had some surface scuffing and rutting at the wheel turning locations. This is likely due to the fact that unlike standard asphalt, the pervious asphalt was not well compacted (in order to encourage infiltration). When the pavement material got warm during hot weather, the asphalt binders could not contain the aggregate.

Due to observations of decreasing infiltration in the pervious pavement sections, the parking lot was swept with a vacuum sweeper on November 1, 2008. Figure 7 shows the catch basin water depth versus storm rainfall depth over time. As can be seen from the figure, catch basin water depth generally increased over time until the site was cleaned with a vacuum sweeper in November 2008. All the pervious pavement test sites had a noticeable decrease in catch basin depth versus rainfall depth immediately after the cleaning. The variability seen in the catch basin depth data is likely impacted significantly by the rainfall intensity during each storm event; high intensity rainfall is more likely to induce runoff from the pervious pavements than low intensity rainfall.

In general, the pervious pavers section appears to have had the least amount of surface runoff. The pervious concrete section appears to have had the greatest amount of surface runoff during the study (Figure 7).

6.0 TREATMENT ANALYSIS

This section provides a more detailed discussion of the differences between each sample location for each type of analyte. The data is generally presented in the form of a “box and whiskers” plot format as described in Section 4.2.2.

On the box plots, “IF” identifies the infiltrated flow sample location and the “CB” identifies the catch basin sample location for each pavement type (e.g., pervious pavers, pervious concrete, pervious asphalt, and standard asphalt). The “catch basin” sample for the standard asphalt section was actually taken from the monitoring manhole downstream of the standard asphalt catch basin. See Section 2.3 for a more detailed description of the sample locations.

6.1 CONVENTIONAL PARAMETERS

6.1.1 Hardness and Total Suspended Solids

Figures 8 and 9 show box plots for hardness and total suspended solids. Two figures are presented because the hardness results for infiltrated flows from pervious concrete (Figure 8) were substantially different than those seen at the other sampling locations; the scale of the graph was changed for Figure 9 to better show the differences between the other sampling locations.

As can be seen from the figures, the infiltrated flow from pervious concrete differs substantially from other sampling locations for both hardness and total suspended solids. This is confirmed with the post-hoc tests (Table 8) which show several statistically significant differences between the pervious concrete and the other sample locations. The characteristics of concrete itself (i.e., it contains a significant amount of calcium which results in high hardness values) are the likely reason for the differences observed between it and the other sampling locations for both hardness and TSS.

Figure 9 also shows noticeable differences between most sampling locations for hardness which is supported by the post-hoc tests in Table 8. Based on the box plots, the catch basin samples from each pavement type appear to have lower hardness values than those observed in the infiltrated flow samples. This result is not unexpected since rainwater itself has very low hardness values; rainwater that infiltrates through pavement sections likely picks up cations as it passes through the pervious pavement materials resulting in higher hardness numbers for the infiltrated flows.

Interestingly some differences were observed in TSS between the sampling sites (Figures 8 and 9, Table 8), but the TSS values for catch basin samples were not consistently greater than the infiltrated flow samples. This suggests that particles are migrating through the underlying geotextile and subgrade and are being collected in the infiltrated flows. Particle size distribution testing would be needed to determine if the size distribution of the particles seen in the infiltrated samples was significantly different from that seen in the catch basin samples. With the relatively low TSS concentrations seen at this site (median 16.5 mg/L for standard asphalt), pervious pavements do not appear to be effective at significantly reducing TSS from stormwater.

TSS at the site ranged from 0.9 mg/L to 167 mg/L with a median concentration in infiltrated samples of 10.1 mg/L and in catch basin samples of 10.0 mg/L(Table 5). For the standard asphalt catch basin, the values ranged from 5.5 mg/L to 165 mg/L with a median value of 16.5 mg/L.

In comparison to the Thea Foss basins 237A and 243 which receive significant highway runoff (Table 6), the TSS values at the standard asphalt sampling location are substantially less. This is likely due to the very small runoff area (~9000 SF) and low vehicular use for the standard asphalt test area.

6.1.2 pH

Figure 10 shows the box plots for pH. As can be seen in the figure, the pH for the infiltrated flow for pervious concrete was significantly higher than all the other sites; its maximum value was 12.4 Standard Units which is just below the threshold of pH 12.5 to be considered a dangerous waste. Again, the characteristics of concrete itself (i.e., the presence of calcium hydroxides resulting from the reaction of portland cement and water) are the likely cause of the high pH values observed. This is discussed in more detail in relation to other studies in Section 7.1.3.

Table 9 shows several statistically significant differences between sample locations for pH. Based on the box plots (Figure 10), it appears that the pH for catch basin and infiltrated flow samples for both the pervious concrete and pervious pavers (which are made of standard, impervious concrete) appear to be higher than the pervious and standard asphalt samples. This is not unexpected due to the properties of concrete; additional sampling would be required to determine if all these observed differences are statistically significant.

Overall, the pervious pavements appear to have slightly higher pH values than standard asphalt, but the values, with the exception of pervious concrete, are all within the neutral range of pH ~7.

6.2 PETROLEUM HYDROCARBONS

Figure 11 shows box plots for NWTPH-Diesel and NWTPH-Heavy Oil. These samples were not collected as grab samples as suggested by TAPE since it would have required sampling crews be on-site during the storm event which was not practical in many instances. The samples were collected as composites throughout the storm in glass bottles along with the other organic parameters. This deviation from TAPE recommendations may have resulted in some additional error in these measurements because some TPH may have adhered to the sampling equipment. If TPH did adhere to the sampling equipment, the analytical results would have been lower than would otherwise be measured and would have affected the comparisons between the sampling sites.

Several statistically significant differences were observed for both NWTPH-Diesel and NWTPH-Heavy Oil using the Dunn post-hoc test (Table 8). Although the post-hoc tests don't show this, the NWTPH-Heavy Oil on the box plots (Figure 11) suggest that the results for the infiltrated flow samples from all pavement sites were less than the catch basin samples; additional sampling would be required to determine if a statistically significant difference actually exists. The lack of statistically significant results for NWTPH-Diesel and NWTPH-Heavy Oil was likely affected by the number of samples with results that were below the analytical detection limits.

Overall, pervious pavements appear to be effective in reducing NWTPH-Heavy Oil in infiltrated flow samples. Surface runoff from the pervious pavement sections and standard asphalt sections appear to be similar. These results suggest that the oil is either being treated or trapped in the pervious pavement or underlying subgrade or is being trapped on the surface where it is conveyed to the catch basin.

6.3 METALS

Figures 12 and 13 show box plots for the metal analytes (copper, lead, mercury, and zinc). Box plots were not prepared for dissolved metals because only two samples were run for dissolved metals (Table 5). ANOVA and post-hoc tests suggest statistically significant differences in pollutant concentrations between sampling sites for total lead and total zinc (Table 7). The lack of statistically significant results was likely affected by the number of samples that were below analytical detection limits at several of the sampling locations (Table 5).

A summary of the differences follows:

- Total Copper – ANOVA testing did not show any statistically significant differences between the sampling locations (Table 7). The box plots (Figure 12) show a wide range in pollutant concentrations at each sampling location. This suggests that copper is not affected by infiltration through pervious pavements.
- Total Lead – Pervious concrete infiltrated flows were significantly different than the pervious concrete catch basin and the pervious asphalt infiltrated flows (Table 8). A couple of other statistically significant differences were observed for total lead (Table 8). Only 55 of the 111 samples had results greater than the detection limit which impacted the statistical analysis.
- Total Mercury – ANOVA testing did not show any statistically significant differences between the sampling locations (Table 7). Only three samples were above the detection limit for total mercury, so differences between the sampling locations were not expected.
- Total Zinc – Seven statistically significant differences between sampling locations were observed for total zinc (Table 8). Based on the box plots (Figure 13), the catch basin samples had higher zinc concentrations than the infiltrated flows for all pavement types. This observed difference is only partially supported with the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration through pervious surfaces appears to be effective in removing zinc.

6.4 PAHS

Figures 14 through 21 show box plots for low and high molecular weight PAHs (LPAHs and HPAHs). ANOVA and post-hoc tests suggest statistically significant differences in pollutant concentrations between sampling sites for phenanthrene, benzo(a)anthracene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, fluoranthene, and pyrene (Table 7).

The lack of statistically significant results for many of the PAHs was likely a result of the number of collected samples with results below the analytical detection limit. Of the 111 samples collected, only phenanthrene, benzofluoranthenes, fluoranthene, and pyrene had more than 50 samples with results above the detection limit (Table 5). Overall, pervious pavements appear to be effective at removing HPAHs. No conclusions can be drawn for LPAHs due to the number of samples collected that were below detection limits.

Influent concentrations at the standard asphalt catch basin site are generally less than the concentrations seen in Thea Foss basins 237A and 243 (Table 6). This is likely due to the significant differences in the size and use of the runoff areas.

A summary of the notable differences is provided below:

- Phenanthrene – Five statistically significant differences were observed for phenanthrene (Table 8). Based on the box plots (Figure 17), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples. This observed difference is only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration appears to remove phenanthrene from pervious pavers and pervious asphalt and slightly reduce concentrations in pervious concrete.
- Benzo(a)anthracene – The infiltrated flow for pervious concrete had statistically significant differences from all other sampling locations. A few other statistically significant differences were noted for this analyte (Table 8). Overall, infiltration appears to remove benzo(a)anthracene from pervious pavers and pervious concrete (Figure 17).
- Benzo(g,h,i)perylene – The infiltrated flow for pervious concrete had statistically significant differences from all other sampling locations. A few other statistically significant differences were noted for this analyte (Table 8). The box plots (Figure 18) also appear to show that catch basin concentrations were, in general, higher than infiltrated flow samples. Overall, infiltration appears to remove benzo(g,h,i)perylene from all three types of pervious surfaces.
- Benzofluoranthenes – Six statistically significant differences were observed for benzofluoranthenes (Table 8). Based on the box plots (Figure 19), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples. This observed difference is only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration appears to remove benzofluoranthenes from all three types of pervious surfaces.
- Chrysene – Six statistically significant differences were observed for chrysene (Table 8). Based on the box plots (Figure 19), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples. This observed difference is only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration appears to remove chyrsene from all three types of pervious surfaces.
- Fluoranthene – Six statistically significant differences were observed for fluoranthene (Table 8). Based on the box plots (Figure 20), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples. This observed difference is only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration appears to remove fluoranthene from all three types of pervious surfaces.
- Pyrene – Six statistically significant differences were observed for pyrene (Table 8). Based on the box plots (Figure 21), it appears that the catch basin samples had higher concentrations than the infiltrated flows. This observed difference is only partially supported by the statistics data; additional sampling would be needed to

confirm whether these differences are statistically significant. Overall, infiltration appears to remove pyrene from all three types of pervious surfaces.

6.5 PHTHALATES

Figures 22 through 24 show the box plots for phthalates. ANOVA and post-hoc tests suggest statistically significant differences in pollutant concentrations between sampling sites for all phthalates with the exception of dimethyl phthalate (Table 7). Of the 111 samples collected, only bis(2-ethylhexyl)phthalate (DEHP) and diethyl phthalate had more than 50 samples with results above the detection limit; this likely hindered the statistical analyses and it made the visual comparisons between box plots more difficult.

Influent concentrations at the standard asphalt catch basin site are generally similar to the concentrations seen in Thea Foss basins 237A and 243 (Table 6).

A summary of the differences for DEHP and diethyl phthalate are provided below. Other parameters were not discussed because they were significantly impacted by the amount of data that was below the detection limit.

- DEHP – Five statistically significant differences were observed for DEHP (Table 8). Based on the box plots (Figure 22), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples. This observed difference is only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant. Overall, infiltration appears to remove DEHP from all three types of pervious surfaces.
- Diethyl phthalate – Three statistically significant differences were observed for diethyl phthalate (Table 8). Based on the box plots (Figure 23), it appears that the catch basin samples had higher concentrations than the infiltrated flow samples with the exception of the results from the pervious asphalt pavement. These observed differences are only partially supported by the statistics data; additional sampling would be needed to confirm whether these differences are statistically significant.

7.0 COMPARISON WITH OTHER PERVIOUS PAVEMENT STUDIES

This section provides a brief discussion of some of the other pervious pavement studies and how this Project compares to the results observed from the other studies. Since no other studies were found that analyzed PAHs and phthalates at pervious pavement sites, these parameters are not discussed.

7.1 CONVENTIONAL PARAMETERS

7.1.1 Hardness

In a study of a small parking lot in Renton, WA, Brattebo and Booth (2003) found significantly ($p < 0.01$) higher concentrations of hardness and conductivity in infiltrated flow samples than samples collected from surface runoff from standard asphalt. Among the pervious pavements tested during this Project, hardness was highest among the concrete-based pervious pavements (Turfstone® and UNI Eco-Stone®) compared to the plastic based pervious pavements (Grasspave2® and Gravelpave2®). These results from the Renton project are consistent with the results from this Project which saw higher hardness values for both the pervious pavers and pervious concrete samples in comparison to the other sampling locations (Figure 9).

7.1.2 Total Suspended Solids

Briggs (2006) compared the TSS of infiltrated runoff between pervious asphalt and standard asphalt in a parking lot project in Durham, New Hampshire. A statistically significant ($p = 0.002$) difference was observed between the pervious and standard asphalt samples. Median TSS was 37 and 0.2 for standard asphalt surface runoff and pervious asphalt infiltrated flows, respectively. Briggs suggested that the low levels of TSS observed in the infiltrated flow samples from pervious asphalt were likely the fine subgrade materials (e.g., clays) that were passing through the geotextile filter fabric.

For this Project, a statistically significant difference was not observed between the catch basin sample for standard asphalt and infiltrated flows from pervious asphalt (Table 8). Median values for TSS for this Project were 16.5 and 8.4, respectively (Table 5).

7.1.3 pH

7.1.3.a Pervious Concrete

Collins (2007) studied four different types of pervious pavements (pervious concrete, ConPave™ Octabrick concrete pavers, SF-Kooperation™ Rima concrete stone pavers, and concrete grid pavers[7]) and standard asphalt in a 20-stall parking lot in North Carolina. pH results from all the pervious pavement sections were statistically ($p < 0.01$) higher than standard asphalt runoff. pH results from pervious concrete varied over the course of the study with a maximum value of 11.3 and a minimum value of 8.3. Although sampling results were highly variable, the pH for pervious

[7] The ConPave™ Octabrick concrete pavers and SF-Kooperation™ Rima concrete stone pavers are permeable interlocking concrete pavers with 12.9% and 8.5% void spaces respectively. The concrete grid pavers were filled with sand fill while the Octabrick and Rima pavers were filled with pea gravel.

concrete slowly trended downward over the course of the study and had a pH of 9.1 ± 1.1 within a year after placement of the pavement.

Thomle (2010) provides a detailed discussion of the pH mechanisms in play with concrete and summarizes the results from four previous pervious pavement studies involving pervious concrete, including Collins's (2007) study in North Carolina. Thomle's analysis of pervious concrete core samples and other studies shows that pervious concrete pH values typically decline to less than ~9 within the first year.

As concrete ages, the pH generally drops as the calcium hydroxides in the pavement are replaced with calcium carbonate. This replacement process, referred to as "carbonation", occurs when carbon dioxide is absorbed from the air or from other carbonate sources (Thomle 2010). This process also occurs on the surface of standard concrete. The rate of pH decline is strongly related to the level of contact with ambient air. Thomle showed that concrete samples with increased exposure to outside air see a faster rate of pH decline.

The decrease in pH to below ~9 within the first year of installation was not observed at this Project (Figure 25). Since pH decreases are believed to occur due to the concrete's exposure to ambient air, the type of pervious concrete (PercoCrete) used in the Project may have affected the pH results. The PercoCrete product has a smooth finish, unlike other pervious concrete products which typically have a very rough aggregate looking appearance; this difference may have reduced the amount of ambient air contact within the concrete and significantly slowed down the carbonation process. The fact that the PercoCrete product also retains water and allows it to slowly exfiltrate from the pavement could further reduce the amount of contact with outside air and slow the rate of pH reduction.

7.1.3.b Pervious Asphalt

Briggs (2006) compared the pH of infiltrated runoff between pervious asphalt and standard asphalt in a parking lot project in Durham, New Hampshire. Briggs found a statistically significant ($p < 0.0001$) difference between the pervious and standard asphalt samples. The median pH was 6.1 and 7.1 for standard asphalt surface runoff and pervious asphalt infiltrated flows, respectively.

For this Project, a statistically significant difference ($p = 0.001$) was also observed between the catch basin sample for standard asphalt and infiltrated flows from pervious asphalt with median pH values of 6.4 and 6.9, respectively.

7.2 PETROLEUM HYDROCARBONS

Pervious concrete block pavers (CeePy blocks) bedded with pea gravel were exposed to mineral oil over a 62 day laboratory study in a study conducted by Newman et al. (2001). Results showed that the pervious pavers could successfully trap and then biodegrade the oil.

This is consistent with the results seen in this Project where NWTPH-Heavy Oil samples were notably higher in catch basin samples than in infiltrated flow samples (Figure 11). This suggests that pervious pavements coupled with their underlying soils are able to either trap or treat oils that are accidentally released onto the pavement surface.

7.3 METALS

Studies of four different permeable pavers by Dierkes et al (2002) showed that all the permeable pavers retained cadmium, copper, lead, and zinc in a laboratory study using synthetic rainwater. Pervious pavers constructed with pervious concrete pavers and constructed with grass material in the joints performed better than pervious pavers with large joints filled with sand. Dierkes et al (2002) also showed that the majority of the pollutants are trapped within the first 2 cm of the pavement with higher concentrations of metals in the subgrade up to 20 cm in depth after simulating 50 years in operation.

Briggs (2006) found statistically significant ($p = 0.005$) differences between pervious asphalt infiltrated flows and surface runoff from standard asphalt for zinc[8] in the parking lot study in New Hampshire. Median concentrations were 0.043 mg/L and 0.002 mg/L for standard asphalt and pervious asphalt, respectively. This Project also noted statistically significant differences between infiltrated flows from pervious asphalt and catch basin samples from standard asphalt (Table 8, Figure 13). Median concentrations for zinc from the Tacoma Landfill site were 4.3 mg/L and 58.8 mg/L for infiltrated flows from pervious asphalt and catch basin samples from standard asphalt, respectively (Table 5).

Brattebo and Booth (2003) found that concentrations of zinc and copper were significantly ($p < 0.01$) lower in the infiltrated flow samples from pervious pavements (Turfstone®, UNI Eco-Stone®, Grasspave2®, and Gravelpave2®) than in the surface runoff from standard asphalt in their parking lot study. The total zinc results from this Project also showed lower concentrations in the infiltrated flow samples from pervious pavements compared to the catch basin sample from standard asphalt (Figure 13). This Project did not, however, show a significant difference between the copper concentrations in the infiltrated flow samples from the pervious pavements and the standard asphalt catch basin samples (Figure 12).

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[8] Zinc was the only metal analyte evaluated by Briggs (2006).

8.0 CONCLUSIONS

This section discusses the overall results of the Project, including a discussion on removal efficiencies and maintenance requirements.

8.1 DIFFERENCES BETWEEN SAMPLING LOCATIONS

Comparison of the three pervious pavements (pavers, concrete, and asphalt) with standard, impervious asphalt shows that, in general, significant differences do exist in the pollutant concentrations between the infiltrated flows collected from the pervious pavements and overland runoff collected in the catch basins from all four pavement types.

The small size of the pavement sections (~9,000 SF) and the use of the pavement (employee parking lot only) likely led to the generally low contamination levels seen in both the infiltrated flow and catch basin samples. This hindered the statistical comparison of the different sites due to the number of samples that were censored (below the detection limit). Additional sampling, especially at lower detection limits, would be needed to determine if the differences identified are statistically significant.

8.2 SEDIMENT DATA

Sediment samples were collected from the catch basins at the end of the study. For the pervious pavement sections, the pervious asphalt and pervious pavers pavement sections generally had the highest pollutant concentrations, while pervious concrete had the lowest concentrations. Additional sampling would be needed to determine if statistically significant differences actually exist.

8.3 MAINTENANCE

The Project site required periodic maintenance during the study to maintain the performance. The site was vacuum swept once in November 2008 and the pervious paver site required periodic weeding to keep weeds from growing out of the gaps in the pavers. Following vacuum sweeping, the infiltration rates at the pervious pavement sites did improve for a short time period.

8.4 FUTURE USE OF PERVIOUS PAVEMENT

The high pH values observed over the course of the study at the pervious concrete site are cause for concern since they could impact the underlying groundwater and/or receiving water. Additional study is needed to determine if this is solely a characteristic of the specific ad-mixture (PercoCrete) used on this Project or if it is a problem common to all pervious concrete sites.

The apparent reduction in NWTPH-Heavy Oil, Total Zinc, numerous HPAHs, and numerous phthalates between the infiltrated water at the pervious pavement locations and the surface runoff collected in the catch basins suggests that pavement sections coupled with the underlying soils can cause a noticeable reduction in pollutant concentrations. Additional sampling would be required to determine whether the differences observed by visual comparison of the box plots are statistically significant.

If surface runoff from pervious pavements is collected and conveyed to the stormwater system, treatment of the water may still be necessary to remove pollutants. Since the amount of surface runoff from pervious pavements is much less than runoff from standard impervious pavements, the size of the required treatment system would be greatly reduced. Local codes should be consulted to determine treatment requirements.

9.0 REFERENCES

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TABLES

Table 1. Water Quality Parameters

Conventionals	Petroleum Hydrocarbons	Metals	PAHS		Phthalates
			LPAHs	HPAHs	
Hardness	NWTPH-Dx	Total Copper	2-Methylnaphthalene	Benzo(a)anthracene	bis(2-Ethylhexyl)phthalate
pH	NWTPH-HO	Total Lead	Acenaphthene	Benzo(a)pyrene	Butylbenzylphthalate
Total Suspended Solids (TSS)		Total Mercury	Acenaphthylene	Benzo(g,h,i)perylene	Diethyl phthalate
		Total Zinc	Anthracene	Benzofluoranthenes	Dimethyl phthalate
		Lead, dissolved	Fluorene	Chrysene	Di-n-butylphthalate
		Mercury, Dissolved	Naphthalene	Dibenz(a,h)anthracene	Di-n-Octyl phthalate
		Zinc. Dissolved	Phenanthrene	Fluoranthene	
				Indeno(1,2,3-cd)pyrene	
				Pyrene	

Table 2. Sediment Quality Parameters

Conventionals	Petroleum Hydrocarbons	Metals	PAHS		Phthalates
			LPAHs	HPAHs	
Total Solids (TS)	NWTPH-Dx	Total Copper	2-Methylnaphthalene	Benzo(a)anthracene	bis(2-Ethylhexyl)phthalate
Volatile Solids (VS)	NWTPH-HO	Total Lead	Acenaphthene	Benzo(a)pyrene	Butylbenzylphthalate
Grain Size		Total Mercury	Acenaphthylene	Benzo(g,h,i)perylene	Diethyl phthalate
Total Organic Carbon (TOC)		Total Zinc	Anthracene	Benzofluoranthenes	Dimethyl phthalate
			Fluorene	Chrysene	Di-n-butylphthalate
			Naphthalene	Dibenz(a,h)anthracene	Di-n-Octyl phthalate
			Phenanthrene	Fluoranthene	
				Indeno(1,2,3-cd)pyrene	
				Pyrene	

Table 3. Equipment Rinsate Blank QC Exceedances

Date	TestName	SampleID	Result	Units	Flag	Qualifier	MDL	2 x MDL	OK	Lowest Sample	10% of lowest samp reported	Meet QC Protocols?
7/24/2008	Butyl benzyl phthalate	Standard Asphalt	0.18	ug/L	J		0.09	0.18	N	0.045	0.0045	N
7/24/2008	Diethylphthalate	Standard Asphalt	0.2	ug/L	J		0.1	0.2	N	0.036	0.0036	N
7/24/2008	Di-n-butylphthalate	Standard Asphalt	0.2	ug/L	J		0.1	0.2	N	0.025	0.0025	N

Table 4. Storm Event Characteristics

Sample Event No.	Sample Date	Sample Location	Storm Characteristics (Criteria: precip >= 0.2 inches) Total precip inches	Duration hrs	Intensity in/hr	Meet Criteria	Storm Event Antecedent Conditions Ante Period hrs	24 hr inches	Meet Criteria	Storm Event Peak Flow gpm	Flow Duration hrs	Volume gallon	Predicted Volume gallon	Sampling Event # Sample Aliquots count	Sample Duration hrs	Volume gpm	% of Storm Volume over which Samples Collected	Notes
1	3/19/07 - 3/20/07	Perv Concrete	0.44	18	0.02	Y	31	0.00	Y	262.2	NA	NA	2,476	48	8	1,038,258	NA	Level measurement remained elevated after storm event. Flow exceeds pipe capacity. Data no good.
1	3/19/07 - 3/20/07	Perv Asphalt	0.44	18	0.02	Y	31	0.00	Y	13.5	20	4,710	2,476	48	14	4,143	88.0%	
2	5/2/07 - 5/3/07	Standard Asphalt	0.42	22	0.02	Y	20	0.03	N	16.0	24	6,454	2,363	48	16	4,498	69.7%	One sample aliquot was collected prior the beginning of the storm. This was excluded from the sampling event volume and duration calculations. Storm accepted. Large event with good sampling during initial portion of storm.
3	6/9/07	Perv Pavers	0.38	8	0.05	Y	107	0.00	Y	4.9	18	1,715	2,138	10	0.5	140	8.2%	Two sample aliquots were collected after the storm event. These were excluded from the sampling event volume and duration calculations.
3	6/9/07	Perv Asphalt	0.38	8	0.05	Y	107	0.00	Y	12.5	8	1,977	2,138	43	8.0	1,972	99.7%	
3	6/9/07	Standard Asphalt	0.38	8	0.05	Y	107	0.00	Y	10.5	9	3,530	2,138	28	8.0	3,308	93.7%	
4	6/28/07 - 6/29/07	Perv Pavers	0.38	21.0	0.02	Y	86	0.00	Y	35.9	12	2,208	2,138	23	0.5	380	17.2%	
4	6/28/07 - 6/29/07	Perv Asphalt	0.38	21.0	0.02	Y	86	0.00	Y	33.0	5.5	1,678	2,138	38	5.0	1,170	69.7%	Storm accepted. Large event with good sampling during initial portion of storm.
5	9/4/07	Perv Pavers	0.85	8.0	0.11	Y	>192	0.00	Y	100.1	10.8	4,199	4,783	29	6.1	3,926	93.5%	
5	9/4/07	Perv Asphalt	0.37	7.0	0.05	Y	>192	0.00	Y	15.8	6.5	1,774	2,082	48	6.0	1,638	92.3%	Used partial storm since storm was very larget and samples collected for good portion of intial part of storm. 3 sample aliquots were collected after partial storm - not included in caclulations. Whole event was 5,144 gallons (32.4% of sample collection).
6	9/16/08	Standard Asphalt	0.27	21.3	0.01	Y	295	0.00	Y	9.5	26	5,460	1,519	47	6.8	1,411	25.8%	
7	9/28/07	Perv Pavers	0.55	10.25	0.05	Y	203	0.00	Y	34.8	13	3,001	3,095	48	3.0	2,277	75.9%	
7	9/28/07	Perv Concrete	0.55	10.25	0.05	Y	203	0.00	Y	15.5	13.3	3,466	3,095	48	6.0	1,251	36.1%	Five aliquots were taken prior to the start of the rain event.
7	9/28/07	Perv Asphalt	0.55	10.25	0.05	Y	203	0.00	Y	26.4	9.25	2,581	3,095	48	6.0	2,366	91.7%	
7	9/28/07	Standard Asphalt	0.55	10.25	0.05	Y	203	0.00	Y	10.2	11.5	4,227	3,095	42	11.0	4,221	99.9%	
8	10/10/07	Perv Pavers	0.23	17.8	0.01	Y	59	0.01	Y	10.2	23.3	1,454	1,294	19	19.0	1,360	93.5%	

Table 4. Storm Event Characteristics

Sample Event No.	Sample Date	Sample Location	Storm Characteristics (Criteria: precip >= 0.2 inches) Total precip inches	Duration hrs	Intensity in/hr	Meet Criteria	Storm Event Antecedent Conditions Ante Period hrs	24 hr inches	Meet Criteria	Storm Event Peak Flow gpm	Flow Duration hrs	Volume gallon	Predicted Volume gallon	Sampling Event # Sample Aliquots count	Sample Duration hrs	Volume gpm	% of Storm Volume over which Samples Collected	Notes
9	11/10/07	CBs Only	0.19	6.3	0.03	N	13	0.03	N	NA	NA	NA	1,069	NA	NA	NA	NA	Only CBs were analyzed for this event.
10	11/27/07	CBs Only	0.21	4	0.05	Y	51	0.00	Y	NA	NA	NA	1,182	NA	NA	NA	NA	Only CBs were analyzed for this event.
11	11/29/07	Perv Pavers	0.30	15	0.02	Y	42	0.00	Y	2.2	19	1,719	1,688	20	16.8	1,028	59.8%	Samples collected over good portion of initial portion of storm event.
11	11/29/07	Perv Concrete	0.30	15	0.02	Y	42	0.00	Y	8.6	20.5	1,522	1,688	26	16.0	1,349	88.6%	Four sample aliquots were collected before the storm event. These were excluded from the sampling event volume and duration calculations.
12	12/15/07 - 12/16/07	Perv Pavers	0.27	20	0.01	Y	29	0.00	Y	4.2	38	2,099	1,519	26	32.9	1,872	89.2%	
12	12/15/07 - 12/16/07	Perv Asphalt	0.27	20	0.01	Y	29	0.00	Y	8.9	16	2,384	1,519	37	15.1	2,327	97.6%	
12	12/15/07 - 12/16/07	Standard Asphalt	0.27	20	0.01	Y	29	0.00	Y	9.9	22	4,325	1,519	43	19.9	4,140	95.7%	
13	1/8/08	Perv Concrete	0.31	9	0.03	Y	22	0.02	N	2.6	11	638	1,744	15	9.8	598	93.7%	Two sample aliquots were collected before the storm event. These were excluded from the sampling event volume and duration calculations.
13	1/8/08	Perv Asphalt	0.31	9	0.03	Y	22	0.02	N	12.7	11	3,676	1,744	48	3.5	2,365	64.3%	
13	1/8/08	Standard Asphalt	0.31	9	0.03	Y	22	0.02	N	10.6	13	2,669	1,744	41	11.3	2,491	93.3%	
14	1/14/08	Perv Pavers	0.15	3	0.05	N	33	0.00	Y	2.9	21	587	844	29	6.9	450	76.7%	
15	1/27/08	Perv Asphalt	0.24	10	0.03	Y	148	0.00	Y	7.4	29	2,137	1,351	30	15.5	2,073	97.0%	
15	1/27/08	Standard Asphalt	0.24	10	0.03	Y	148	0.00	Y	12.0	13	2,733	1,351	39	11.7	2,671	97.7%	
16	3/1/08	Perv Asphalt	0.34	15	0.02	Y	53	0.00	Y	11.9	17	2,750	1,913	39	15.8	2,669	97.1%	
16	3/1/08	Standard Asphalt	0.34	15	0.02	Y	53	0.00	Y	11.4	17.3	3,219	1,913	47	16.9	3,114	96.7%	
17	3/23/08	Perv Pavers	0.42	15	0.03	Y	36	0.00	Y	3.3	0.8	69	2,363	4	0.2	16	23.2%	Flow data doesn't look good. Flow duration too short. Bubbler meter was impacted by debris.
17	3/23/08	Perv Concrete	0.42	15	0.03	Y	36	0.00	Y	3.7	22.0	1,428	2,363	46	8.8	927	64.9%	Two sample aliquots were collected before the storm event. These were excluded from the sampling event volume and duration calculations. Large event. Samples collected over good portion of initial portion of storm. Samples accepted.

Table 4. Storm Event Characteristics

Sample Event No.	Sample Date	Sample Location	Storm Characteristics (Criteria: precip >= 0.2 inches)				Storm Event Antecedent Conditions			Storm Event				Sampling Event				Notes
			Total precip inches	Duration hrs	Intensity in/hr	Meet Criteria	Ante Period hrs	24 hr inches	Meet Criteria	Peak Flow gpm	Flow Duration hrs	Volume gallon	Predicted Volume gallon	# Sample Aliquots count	Sample Duration hrs	Volume gpm	% of Storm Volume over which Samples Collected	
17	3/23/08	Perv Asphalt	0.42	15	0.03	Y	36	0.00	Y	21.0	16.3	4,871	2,363	48	8.4	3,397	69.7%	Large event. Samples collected over good portion of initial portion of storm. Samples accepted.
17	3/23/08	Standard Asphalt	0.42	15	0.03	Y	36	0.00	Y	11.7	16.8	5,130	2,363	48	7.2	3,153	61.5%	Large event. Samples collected over good portion of initial portion of storm. Samples accepted.
18	5/20/08	Perv Concrete	0.41	14	0.03	Y	155	0.00	Y	2.9	14.0	551	2,307	25	6.0	461	83.7%	
18	5/20/08	Perv Asphalt	0.41	14	0.03	Y	155	0.00	Y	11.6	8.8	2,653	2,307	37	7.3	2,568	96.8%	
18	5/20/08	Standard Asphalt	0.41	14	0.03	Y	155	0.00	Y	12.5	14.3	4,068	2,307	48	8.8	3,308	81.3%	
19	8/1/08	Perv Concrete	0.22	13	0.02	Y	46	0.00	Y	13.4	21	2,242	1,238	46	13.4	1,564	69.8%	One sample aliquot was collected before the storm event. This was excluded from the sampling event volume and duration calculations.
19	8/1/08	Perv Asphalt	0.22	13	0.02	Y	46	0.00	Y	13.2	13	2,216	1,238	17	11.1	1,882	84.9%	
20	8/20/08	Perv Pavers	0.76	22	0.03	Y	240	0.00	Y	36.5	N/A	N/A	4,277	47	9.4	1,559	N/A	flow never returned to zero. Bubbler clogged?
20	8/20/08	Perv Concrete	0.76	22	0.03	Y	240	0.00	Y	12.9	23.5	3,064	4,277	48	17.0	2,131	69.5%	greater than 6 hour gaps between rain, but flow did not completely return to zero between rainfall. Large event. Samples collected over good portion of initial portion of storm. Samples accepted.
20	8/20/08	Perv Asphalt	0.76	22	0.03	Y	240	0.00	Y	27.4	23.5	6,300	4,277	42	19.7	5,636	89.5%	greater than 6 hour gaps between rain - flow returned to zero between rainfall. Multiple events. Storm rejected
20	8/20/08	Standard Asphalt	0.76	22	0.03	Y	240	0.00	Y	13.6	23.75	5,145	4,277	35	21.3	4,741	92.1%	greater than 6 hour gaps between rain - flow returned to zero between rainfall. Multiple events. Storm rejected
21	10/3/08	Perv Concrete	0.64	34	0.02	Y	18	0.06	N	4.9	27	1,407	3,601	35	23.0	1,389	98.7%	
21	10/3/08	Perv Pavers	0.64	34	0.02	Y	18	0.06	N	24	23	3,553	3,601	48	4.2	1,837	51.7%	Large event. Samples collected over good portion of initial portion of storm. Flow didn't return to zero after event. Samples accepted.
21	10/3/08	Perv Asphalt	0.64	34	0.02	Y	18	0.06	N	17	23	4,736	3,601	34	23.0	4,650	98.2%	
21	10/3/08	Standard Asphalt	0.64	34	0.02	Y	18	0.06	N	15	37	11,726	3,601	48	29.0	8,840	75.4%	Flow did not return to zero. Pipe clogged?
22	10/20/08	Perv Concrete	0.20	10	0.02	Y	56	0.00	Y	2.7	16	228	1,125	10	10.8	164	71.9%	

Table 4. Storm Event Characteristics

Sample Event No.	Sample Date	Sample Location	Storm Characteristics (Criteria: precip >= 0.2 inches) Total precip inches	Duration hrs	Intensity in/hr	Meet Criteria	Storm Event Antecedent Conditions Ante Period hrs	24 hr inches	Meet Criteria	Storm Event Peak Flow gpm	Flow Duration hrs	Volume gallon	Predicted Volume gallon	Sampling Event # Sample Aliquots count	Sample Duration hrs	Volume gpm	% of Storm Volume over which Samples Collected	Notes
23	10/31/08	Perv Pavers	0.35	13	0.03	Y	198	0.00	Y	5.6	11	1,519	1,970	47	4.7	888	58.5%	1 aliquot before sampling event Samples collected over good portion of initial portion of storm event. Samples accepted. Flow didn't competely return to zero after event
23	10/31/08	Perv Asphalt	0.35	13	0.03	Y	198	0.00	Y	12.9	8	1,883	1,970	27	7.1	1,689	89.7%	
24	11/6/08	Perv Concrete	3.09	31	0.10	Y	130	0.00	Y	37.4	27	7,416	17,388	48	18.0	4,446	60.0%	storm event exceeded 24 hours Very large storm. Samples collected over good portion of intial portion of storm.
25	11/20/08	Standard Asphalt	0.17	9	0.02	N	179	0.00	Y	19.7	10	2,162	957	27	8.7	1,959	90.6%	
26	12/13/08	Standard Asphalt	0.36	23	0.02	Y	46	0.00	Y	19.2	28	6,110	2,026	34	23.0	5,684	93.0%	storm event exceeded 24 hours
27	3/14/09	Perv Pavers	0.35	22.87	0.015	Y	139	0.00	Y	7.9	13	2,792	1,970	48	10.0	2,099	75.2%	Partial storm used.
27	3/14/09	Perv Concrete	0.29	14	0.021	Y	139	0.00	Y	12.1	17	7,555	1,632	48	7.8	3288	43.5%	
27	3/14/09	Perv Asphalt	0.35	22.87	0.015	Y	139	0.00	Y	13.0	22	2,817	1,970	23	20.2	2,661	94.5%	Partial storm used.
27	3/14/09	Standard Asphalt	0.90	30.76	0.029	Y	139	0.00	Y	45.4	33	11,514	5,064	50	26.6	8,409	73.0%	Storm exceeded 24 hours. Samples collected over good distribution of early portion of storm event.
28	3/28/09	Perv Pavers	0.29	7	0.043	Y	66	0.00	Y	5.4	7	1,445	1,632	48	4.4	1,033	71.5%	Partial storm used. Very large event and samples collected over good portion of intial event.
28	3/28/09	Perv Asphalt	0.64	13	0.050	Y	66	0.00	Y	16.7	12	5,970	3,601	48	7.0	3,461	58.0%	Partial storm used. Very large event and samples collected over good portion of intial event.
28	3/28/09	Standard Asphalt	0.27	6	0.045	Y	66	0.00	Y	27.0	7	3,973	1,519	48	6.0	3,500	88.1%	Partial storm used. Very large event and samples collected over good portion of intial event.
29	4/1/09	Perv Concrete	0.17	5.5	0.031	N	24	0.00	Y	18.3	11	7,800	957	48	2.1	1,599	20.5%	
30	4/17/09	Perv Concrete	0.29	13	0.023	Y	69	0.00	Y	18.3	20	16,498	1,632	41	14.6	2,327	14.1%	7 samples before storm event
30	4/17/09	Perv Asphalt	0.29	13	0.023	Y	69	0.00	Y	8.8	6	1,330	1,632	17	4.2	1,145	86.1%	
30	4/17/09	Standard Asphalt	0.29	13	0.023	Y	69	0.00	Y	9.8	12	1,578	1,632	15	10.2	1,413	89.5%	
31	4/28/09	Perv Pavers	0.61	6	0.111	Y	86	0.00	Y	24.5	5	3,024	3,433	48	2.5	1,219	40.3%	Partial storm used. Very large event and samples collected over good portion of intial event.

Table 4. Storm Event Characteristics

Sample Event No.	Sample Date	Sample Location	Storm Characteristics (Criteria: precip >= 0.2 inches)				Storm Event Antecedent Conditions			Storm Event				Sampling Event				Notes
			Total precip inches	Duration hrs	Intensity in/hr	Meet Criteria	Ante Period hrs	24 hr inches	Meet Criteria	Peak Flow gpm	Flow Duration hrs	Volume gallon	Predicted Volume gallon	# Sample Aliquots count	Sample Duration hrs	Volume gpm	% of Storm Volume over which Samples Collected	
32	5/2/09	Perv Concrete	0.24	12	0.020	Y	72	0.00	Y	37.4	5	2,607	1,351	11	0.2	117	4.5%	
32	5/2/09	Perv Asphalt	0.24	12	0.020	Y	72	0.00	Y	18.1	7	2,761	1,351	36	5.6	2,207	79.9%	
32	5/2/09	Standard Asphalt	0.24	12	0.020	Y	72	0.00	Y	85.2	11	2,573	1,351	25	7.6	2,363	91.8%	
33	5/4/09	Perv Pavers	0.39	9	0.045	Y	25	0.00	Y	18.5	7	2,314	2,195	48	4.0	1,888	81.6%	Partial storm used. Very large event and samples collected over good portion of intial event.
34	9/5/09	Perv Pavers	0.25	5	0.053	Y	545	0.00	Y	5.6	9	1,504	1,407	23	8.2	1,318	87.6%	3 sample aliquots after storm
34	9/5/09	Perv Concrete	0.25	5	0.053	Y	545	0.00	Y	21.9	12	6,184	1,407	48	3.5	3,283	53.1%	Flow did not return to zero after storm event. Estimated end of runoff.
34	9/5/09	Standard Asphalt	0.25	5	0.053	Y	545	0.00	Y	19.0	6	1,985	1,407	14	4.9	1,589	80.1%	2 sample aliquots after storm
35	9/19/09	Standard Asphalt	0.21	4	0.060	Y	73	0.00	Y	12.7	5	1,427	1,182	16	3.6	1,266	88.7%	
36	10/16/09	Perv Pavers	0.68	10.5	0.065	Y	32	0.02	N	41.8	14	6,924	3,827	48	8.8	3,592	51.9%	Storm exceeded 24 hours. Very large storm. Samples collected over
36	10/16/09	Perv Concrete	0.25	5.5	0.045	Y	32	0.02	N	23.4	7.25	8,446	1,407	48	6.0	6927	82.0%	Partial storm used. Very large event and samples collected over good portion of intial event.
36	10/16/09	Perv Asphalt	0.68	10.5	0.065	Y	32	0.02	N	21.9	14	5,203	3,827	34	12.1	4,850	93.2%	14 aliquots were collected after storm. Storm rejected.
36	10/16/09	Standard Asphalt	0.68	10.5	0.065	Y	32	0.02	N	37.0	12	4,139	3,827	24	11.2	3,715	89.8%	19 aliquots were collected before/after storm. Storm rejected.
37	10/31/09	Perv Pavers	0.24	13.25	0.018	Y	38	0.00	Y	9.0	30	4,276	1,351	48	9.3	2,199	51.4%	Samples collected over good portion of initial portion of storm event.
37	10/31/09	Perv Concrete	0.24	13.25	0.018	Y	38	0.00	Y	31.6	20.25	24,276	1,351	44	17.5	21,219	87.4%	
37	10/31/09	Perv Asphalt	0.24	13.25	0.018	Y	38	0.00	Y	9.5	13	1,981	1,351	26	11.9	1,829	92.3%	
37	10/31/09	Standard Asphalt	0.24	13.25	0.018	Y	38	0.00	Y	26.5	16	2,370	1,351	23	13.1	2,079	87.7%	

Color Key

Blue	Did not meet the criteria specified in the QAPP. Sampling event was included in analysis since deviation from QAPP was condidered minor.
Red	Did not meet the criteria specified in the QAPP. Sampling event was excluded from analysis since deviation from QAPP was condidered significant.
	Sampling event was excluded since one or more of the sampling criteria were not met (significant variation)

Table 5. Storm Event Influent Summary Statistics

		All Sites												Pervious Pavers					
		Infiltrated Flows						Catch Basin						Infiltrated Flows					
Test Name	Units	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median
Conventionals																			
Hardness	mg/L	46	46	12.3	973	151.8	40.6	65	65	3.58	52.8	21.0	20.8	15	15	17.1	82.4	47.7	47.7
pH	Std. Units	46	46	6	12.4	8.2	7.3	65	65	5.2	7.8	6.8	6.8	15	15	6.6	7.7	7.25	7.3
TSS	mg/L	38	37	0.9	167	28.14	10.1	63	62	*2.2*	165	15.7	10	13	12	2.0	52.7	13.6	6.6
Petroleum Hydrocarbons																			
NWTPH-Diesel	mg/L	46	25	*0.04*	0.71	0.18	0.2	65	41	0.05	1.3	0.27	0.2	15	6	*0.04*	0.2	0.12	0.1
NWTPH-Heavy Oil	mg/L	46	23	0.09	0.92	0.32	0.4	65	56	0.1	8.49	0.98	0.6	15	8	0.09	0.4	0.23	0.15
Metals																			
Copper	ug/L	46	34	1.79	46.6	11.7	9.05	65	44	2.03	43.7	11.4	8.66	15	12	*2.33*	30.4	12.0	5.8
Lead	ug/L	46	21	0.12	57.9	4.48	3.3	65	34	0.27	15.6	4.1	3.3	15	8	0.17	57.9	5.74	3.3
Mercury	ug/L	46	1	*0.05*	0.073	*0.05*	*0.05*	65	2	*0.05*	0.10	*0.05*	*0.05*	15	0	*0.05*	*0.05*	*0.05*	*0.05*
Zinc	ug/L	46	37	1.27	162	9.85	5.45	65	65	12	181	48.9	42.3	15	13	*1.7*	162	17.4	7.3
Lead, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	2	0	*1.3*	*1.3*	*1.3*	*1.3*	NT	NT	NT	NT	NT	NT
Mercury, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	2	0	*0.05*	*0.05*	*0.05*	*0.05*	NT	NT	NT	NT	NT	NT
Zinc, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	2	2	16.6	37.3	27.0	27.0	NT	NT	NT	NT	NT	NT
LPAHs																			
2-Methylnaphthalene	ug/L	46	13	*0.003*	0.029	0.008	0.005	65	29	*0.002*	0.033	0.009	0.010	15	4	0.003	0.025	0.008	0.005
Acenaphthene	ug/L	46	4	*0.002*	0.023	0.006	0.004	65	1	*0.003*	0.01	0.007	0.010	15	1	*0.003*	0.01	0.006	0.003
Acenaphthylene	ug/L	46	3	*0.002*	0.06	0.008	0.003	65	13	*0.002*	0.056	0.009	0.010	15	1	*0.003*	0.01	0.006	0.003
Anthracene	ug/L	46	4	*0.002*	0.018	0.007	0.004	65	7	*0.003*	0.113	0.010	0.010	15	1	*0.004*	0.018	0.007	0.004
Fluorene	ug/L	46	7	*0.002*	0.015	0.007	0.006	65	12	*0.002*	0.028	0.008	0.010	15	1	*0.003*	0.01	0.006	0.003
Naphthalene	ug/L	46	14	0.003	0.073	0.012	0.01	65	33	*0.004*	3.190	0.066	0.010	15	5	0.003	0.073	0.014	0.01
Phenanthrene	ug/L	46	17	*0.003*	0.057	0.009	0.010	65	60	0.006	0.348	0.031	0.017	15	3	*0.003*	0.013	0.007	0.005
HPAHs																			
Benzo(a)anthracene	ug/L	46	4	*0.001*	0.029	0.006	0.004	65	22	*0.002*	0.233	0.013	0.010	15	1	*0.002*	0.029	0.007	0.002
Benzo(a)pyrene	ug/L	46	4	*0.002*	0.039	0.009	0.006	65	20	*0.002*	0.297	0.016	0.010	15	3	*0.004*	0.036	0.010	0.009
Benzo(g,h,i)perylene	ug/L	46	4	0.004	0.031	0.009	0.008	65	30	*0.003*	0.475	0.023	0.010	15	1	*0.008*	0.023	0.010	0.008
Benzofluoranthenes	ug/L	46	8	*0.003*	0.055	0.008	0.008	65	47	*0.003*	0.960	0.039	0.014	15	4	*0.003*	0.055	0.010	0.008
Chrysene	ug/L	46	5	*0.002*	0.025	0.007	0.005	65	41	*0.003*	0.554	0.026	0.011	15	2	*0.003*	0.025	0.007	0.004
Dibenz(a,h)anthracene	ug/L	46	2	*0.004*	0.027	0.009	0.007	65	0	*0.003*	0.014	0.008	0.010	15	1	0.007	0.021	0.009	0.007
Fluoranthene	ug/L	46	10	*0.004*	0.069	0.009	0.009	65	57	*0.004*	1.05	0.049	0.022	15	4	0.005	0.023	0.009	0.009
Indeno(1,2,3-cd)pyrene	ug/L	46	4	*0.004*	0.035	0.009	0.007	65	21	*0.003*	0.352	0.016	0.010	15	2	*0.007*	0.035	0.011	0.007
Pyrene	ug/L	46	13	*0.003*	0.028	0.008	0.008	65	59	*0.003*	0.725	0.038	0.018	15	6	0.004	0.028	0.008	0.006
Phthalates																			
bis(2-Ethylhexyl)phthalate	ug/L	46	15	*0.16*	1.8	0.79	1.0	65	53	*0.16*	8.9	2.2	1.5	15	7	0.18	1.8	0.84	1.0
Butylbenzylphthalate	ug/L	46	6	*0.09*	1.0	0.52	0.21	65	23	0.116	1.3	0.67	1.0	15	2	*0.17*	1	0.52	0.2
Diethyl phthalate	ug/L	46	27	0.055	2.8	1.04	1.0	65	24	*0.072*	1.5	0.65	1.0	15	9	*0.072*	2.8	1.04	0.388
Dimethyl phthalate	ug/L	46	5	*0.016*	1.0	0.44	0.06	65	17	*0.03*	1.0	0.56	1.0	15	1	*0.031*	1.0	0.42	*0.031*
Di-n-butylphthalate	ug/L	46	9	*0.05*	1.0	0.58	0.56	65	17	*0.1*	1.0	0.64	1.0	15	5	0.11	1.0	0.65	1.0
Di-n-Octyl phthalate	ug/L	46	2	0.076	1.0	0.48	0.20	65	19	*0.084*	2.9	0.73	1.0	15	1	*0.084*	1.0	0.45	0.088

Italic = Below detection limit
n = number of samples
# detects = number of samples greater than the detection limit
NT- not tested

Table 5. Storm Event Influent Summary Statistics

		Pervious Pavers						Pervious Concrete											
		Catch Basin						Infiltrated Flows						Catch Basin					
Test Name	Units	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median
Conventionals																			
Hardness	mg/L	11	11	17.7	33.5	26.3	26.7	12	12	138	973	492	495	21	21	24.4	52.8	33.8	32.4
pH	Std. Units	11	11	6.3	7.8	7.13	7.2	12	12	10.6	12.4	11.7	11.6	21	21	6.4	7.7	7.20	7.20
TSS	mg/L	11	11	3.5	29.8	9.98	6	11	11	4.9	167	65.7	65.2	21	21	3.6	59.2	14.12	9.40
Petroleum Hydrocarbons																			
NWTPH-Diesel	mg/L	11	4	0.05	0.34	0.19	0.2	12	8	0.06	0.45	0.19	0.20	21	12	0.06	0.64	0.20	0.20
NWTPH-Heavy Oil	mg/L	11	10	*0.4*	1.9	0.96	1	12	6	0.1	0.6	0.30	0.31	21	16	0.2	8.49	1.30	0.60
Metals																			
Copper	ug/L	11	4	*5.3*	15	7.83	6.2	12	9	3.31	46.6	15.1	10.5	21	14	*5.3*	32.1	11.23	8.96
Lead	ug/L	11	2	*3.3*	7.4	3.76	3.3	12	6	0.12	24.7	6.32	3.3	21	11	1.04	6.7	3.61	3.30
Mercury	ug/L	11	0	*0.05*	*0.05*	*0.05*	*0.05*	12	1	*0.05*	0.073	*0.05*	*0.05*	21	0	*0.05*	*0.05*	*0.05*	*0.05*
Zinc	ug/L	11	11	26.8	83.5	51.5	50.7	12	8	1.27	17.2	6.90	5.35	21	21	18.2	67.6	33.75	29
Lead, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	0	*1.3*	1.3	*1.3*	*1.3*
Mercury, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	0	*0.05*	*0.05*	*0.05*	*0.05*
Zinc, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	1	16.6	16.6	16.60	16.6
LPAHs																			
2-Methylnaphthalene	ug/L	11	3	0.004	0.029	0.010	0.010	12	8	0.003	0.029	0.009	0.004	21	11	0.003	0.031	0.010	0.010
Acenaphthene	ug/L	11	0	*0.003*	0.01	0.008	0.010	12	1	*0.002*	0.01	0.005	0.003	21	1	*0.003*	0.01	0.007	0.010
Acenaphthylene	ug/L	11	3	*0.003*	0.056	0.013	0.010	12	2	*0.002*	0.06	0.013	0.003	21	5	*0.003*	0.035	0.009	0.010
Anthracene	ug/L	11	0	*0.003*	0.01	0.008	0.010	12	2	*0.002*	0.01	0.005	0.004	21	3	*0.003*	0.019	0.008	0.010
Fluorene	ug/L	11	3	*0.003*	0.016	0.009	0.010	12	4	*0.002*	0.013	0.006	0.0045	21	4	*0.003*	0.018	0.008	0.010
Naphthalene	ug/L	11	6	0.006	0.06	0.016	0.010	12	5	*0.004*	0.038	0.015	0.010	21	9	*0.004*	0.047	0.014	0.010
Phenanthrene	ug/L	11	11	0.008	0.1	0.031	0.019	12	12	0.003	0.057	0.014	0.0085	21	18	0.007	0.078	0.024	0.014
HPAHs																			
Benzo(a)anthracene	ug/L	11	5	0.004	0.035	0.013	0.010	12	2	*0.001*	0.01	0.005	0.004	21	7	*0.002*	0.036	0.009	0.010
Benzo(a)pyrene	ug/L	11	3	*0.004*	0.072	0.016	0.010	12	1	*0.002*	0.039	0.008	0.004	21	6	*0.004*	0.048	0.012	0.010
Benzo(g,h,i)perylene	ug/L	11	5	*0.005*	0.056	0.017	0.010	12	2	0.004	0.01	0.008	0.008	21	9	*0.005*	0.069	0.015	0.010
Benzofluoranthenes	ug/L	11	8	*0.007*	0.107	0.027	0.015	12	3	*0.003*	0.012	0.006	0.005	21	14	*0.003*	0.048	0.017	0.014
Chrysene	ug/L	11	6	*0.003*	0.07	0.020	0.013	12	1	*0.002*	0.01	0.005	0.003	21	12	*0.003*	0.054	0.014	0.010
Dibenz(a,h)anthracene	ug/L	11	0	0.006	0.01	0.009	0.010	12	0	0.004	0.01	0.007	0.007	21	0	0.006	0.01	0.009	0.010
Fluoranthene	ug/L	11	10	0.008	0.166	0.037	0.021	12	5	0.005	0.069	0.012	0.005	21	17	0.004	0.114	0.027	0.019
Indeno(1,2,3-cd)pyrene	ug/L	11	3	*0.005*	0.041	0.013	0.010	12	1	*0.004*	0.01	0.007	0.007	21	5	0.005	0.018	0.010	0.010
Pyrene	ug/L	11	11	0.008	0.093	0.029	0.022	12	6	0.004	0.015	0.007	0.0065	21	18	0.003	0.073	0.024	0.016
Phthalates																			
bis(2-Ethylhexyl)phthalate	ug/L	11	9	*1.0*	8.7	2.74	1.8	12	4	*0.16*	1.0	0.59	0.67	21	17	0.59	8.9	2.16	1.7
Butylbenzylphthalate	ug/L	11	2	*0.17*	1.0	0.805	1.0	12	1	*0.09*	1.0	0.36	0.17	21	8	0.116	1.3	0.69	1.0
Diethyl phthalate	ug/L	11	1	*0.072*	1.0	0.761	1.0	12	2	0.055	1.0	0.32	0.10	21	6	*0.072*	1.0	0.64	1.0
Dimethyl phthalate	ug/L	11	1	0.031	1.0	0.744	1.0	12	0	*0.016*	*1.0*	0.28	0.041	21	2	*0.031*	1.0	0.59	1.0
Di-n-butylphthalate	ug/L	11	1	*0.1*	1.0	0.765	1.0	12	0	*0.05*	*1.0*	0.32	0.10	21	4	*0.1*	1.0	0.64	1.0
Di-n-Octyl phthalate	ug/L	11	4	0.409	2.9	1.192	1.0	12	1	0.076	1.0	0.36	0.15	21	5	*0.084*	1.1	0.73	1.0

Italic = Below detection limit
n = number of samples
# detects = number of samples greater than the detection limit
NT- not tested

Table 5. Storm Event Influent Summary Statistics

		Pervious Asphalt												Standard Asphalt					
		Infiltrated Flows						Catch Basin						Catch Basin					
Test Name	Units	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median	n	# detects	Minimum	Maximum	Arithmetic Mean	Median
Conventionals																			
Hardness	mg/L	19	19	12.3	28.2	19.2	17.7	15	15	3.79	34	14.3	14.3	18	18	3.58	20.8	8.37	8.04
pH	Std. Units	19	19	6	7.6	6.87	6.9	15	15	5.8	7	6.53	6.5	18	18	5.2	7.7	6.23	6.4
TSS	mg/L	14	14	0.9	56.7	12.15	8.41	15	14	*2.2*	20.8	9.75	7.6	16	16	5.5	165	27.18	16.5
Petroleum Hydrocarbons																			
NWTPH-Diesel	mg/L	19	11	0.07	0.71	0.22	0.2	15	13	0.05	1.3	0.33	0.2	18	12	0.08	1.2	0.34	0.265
NWTPH-Heavy Oil	mg/L	19	9	0.11	0.92	0.40	0.4	15	14	0.1	3.6	0.81	0.56	18	16	0.22	2.2	0.77	0.61
Metals																			
Copper	ug/L	19	13	1.79	32.3	9.45	6.7	15	12	2.03	31.1	10.9	8.3	18	14	5.24	43.7	14.26	9.73
Lead	ug/L	19	7	0.12	3.3	2.33	3.3	15	8	0.27	6.6	3.69	3.3	18	13	1.4	15.6	5.17	3.3
Mercury	ug/L	19	0	*0.05*	*0.05*	*0.05*	*0.05*	15	0	*0.05*	*0.05*	*0.05*	*0.05*	18	2	*0.05*	0.102	*0.05*	*0.05*
Zinc	ug/L	19	16	*1.7*	19.2	5.76	4.3	15	15	12	98.3	48.8	42.3	18	18	24.1	181	64.97	58.8
Lead, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	0	*1.3*	*1.3*	*1.3*	*1.3*
Mercury, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	0	*0.05*	*0.05*	*0.05*	*0.05*
Zinc, Dissolved	ug/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1	1	37.3	37.3	37.30	37.3
LPAHs																			
2-Methylnaphthalene	ug/L	19	1	*0.003*	0.01	0.007	0.010	15	4	*0.003*	0.01	0.006	0.005	18	11	*0.002*	0.033	0.009	0.008
Acenaphthene	ug/L	19	2	*0.003*	0.023	0.008	0.010	15	0	*0.003*	0.01	0.006	0.003	18	0	*0.003*	0.010	0.006	0.0045
Acenaphthylene	ug/L	19	0	*0.003*	0.01	0.007	0.010	15	3	*0.003*	0.056	0.010	0.01	18	2	*0.002*	0.015	0.007	0.008
Anthracene	ug/L	19	1	*0.003*	0.01	0.007	0.010	15	2	*0.003*	0.113	0.014	0.006	18	2	*0.003*	0.038	0.009	0.009
Fluorene	ug/L	19	2	*0.003*	0.015	0.008	0.010	15	2	*0.003*	0.028	0.008	0.006	18	3	*0.002*	0.019	0.008	0.008
Naphthalene	ug/L	19	4	0.003	0.011	0.008	0.010	15	6	*0.004*	*3.19*	*0.236*	*0.01*	*18*	*12*	*0.004*	0.05	0.015	0.011
Phenanthrene	ug/L	19	2	*0.003*	0.011	0.007	0.010	15	14	0.006	0.061	0.018	0.015	18	17	*0.01*	0.348	0.050	0.024
HPAHs																			
Benzo(a)anthracene	ug/L	19	1	*0.002*	0.01	0.007	0.010	15	3	*0.002*	0.032	0.008	0.006	18	7	*0.002*	0.233	0.022	0.009
Benzo(a)pyrene	ug/L	19	0	*0.004*	0.01	0.007	0.010	15	5	*0.004*	0.041	0.012	0.01	18	6	*0.002*	0.297	0.025	0.01
Benzo(g,h,i)perylene	ug/L	19	1	*0.005*	0.031	0.010	0.010	15	6	*0.005*	0.094	0.017	0.01	18	10	*0.003*	0.475	0.041	0.014
Benzofluoranthenes	ug/L	19	1	*0.003*	0.01	0.007	0.010	15	11	0.003	0.07	0.020	0.013	18	14	*0.003*	0.96	0.087	0.023
Chrysene	ug/L	19	2	*0.003*	0.011	0.007	0.010	15	10	*0.003*	0.026	0.013	0.014	18	13	*0.003*	0.554	0.055	0.014
Dibenz(a,h)anthracene	ug/L	19	1	0.006	0.027	0.010	0.010	15	0	0.006	0.01	0.008	0.007	18	0	0.003	0.014	0.008	0.009
Fluoranthene	ug/L	19	1	0.004	0.01	0.008	0.010	15	13	0.008	0.084	0.027	0.017	18	17	0.008	1.05	0.100	0.027
Indeno(1,2,3-cd)pyrene	ug/L	19	1	0.005	0.027	0.010	0.010	15	5	0.005	0.032	0.011	0.009	18	8	*0.003*	0.352	0.030	0.010
Pyrene	ug/L	19	1	0.003	0.01	0.007	0.010	15	13	0.006	0.07	0.021	0.013	18	17	0.004	0.725	0.074	0.021
Phthalates																			
bis(2-Ethylhexyl)phthalate	ug/L	19	4	0.26	1.0	0.88	1.0	15	11	*0.16*	4.3	1.37	1.1	18	16	0.71	6.4	2.52	2.04
Butylbenzylphthalate	ug/L	19	3	*0.09*	1.0	0.63	1.0	15	4	*0.17*	1.0	0.547	0.34	18	9	*0.17*	1.00	0.66	0.63
Diethyl phthalate	ug/L	19	16	0.712	2.18	1.50	1.5	15	6	*0.072*	1.0	0.536	0.2	18	11	0.249	1.5	0.70	0.75
Dimethyl phthalate	ug/L	19	4	*0.031*	1.0	0.56	1.0	15	5	*0.031*	1.0	0.444	0.116	18	9	*0.030*	1.00	0.50	0.128
Di-n-butylphthalate	ug/L	19	4	*0.1*	1.0	0.69	1.0	15	4	*0.1*	1.0	0.517	0.34	18	8	0.20	1.00	0.66	0.795
Di-n-Octyl phthalate	ug/L	19	0	*0.084*	1.0	0.58	1.0	15	2	*0.084*	1.0	0.532	0.511	18	8	*0.084*	1.4	0.61	0.525

Italic = Below detection limit
n = number of samples
\# detects = number of samples
greater than the detection limit
NT- not tested

Table 6. Comparison between Standard Asphalt and Thea Foss Concentrations

Test Name	Units	Standard Impervious Asphalt				Thea Foss Outfall 237A				Thea Foss Outfall 243			
		Minimum	Maximum	Arithmetic Mean	Median	Minimum	Maximum	Arithmetic Mean	Median	Minimum	Maximum	Arithmetic Mean	Median
Conventionals													
Hardness	mg/L	3.58	20.8	8.37	8.04	14.7	66.6		30.8	59.3	3150.0		389.0
pH	Std. Units	5.2	7.7	6.23	6.4	5.7	7.9		6.7	6.2	7.4		7.0
TSS	mg/L	5.5	165	27.18	16.5	6.10	187.00	48.41	40.0	4.40	300.00	77.54	58.00
Petroleum Hydrocarbons													
NWTPH-Diesel	mg/L	0.08	1.2	0.34	0.265	NT	NT	NT	NT	NT	NT	NT	NT
NWTPH-Heavy Oil	mg/L	0.22	2.2	0.77	0.61	NT	NT	NT	NT	NT	NT	NT	NT
Metals													
Copper	ug/L	5.24	43.7	14.26	9.73	NT	NT	NT	NT	NT	NT	NT	NT
Lead	ug/L	1.4	15.6	5.17	3.3	0.60	44.80	13.25	11.2	1.36	379.00	49.47	26.80
Mercury	ug/L	*0.05*	0.102	0.05	0.05	NT	NT	NT	NT	NT	NT	NT	NT
Zinc	ug/L	24.1	181	64.97	58.8	36.10	361.00	108.54	99.35	19.6	1170.00	124.61	94.80
Lead, Dissolved	ug/L	*1.3*	1.3	1.30	1.3	*0.18*	4.11	0.88	0.7	*0.01*	145.00	5.89	2.00
Mercury, Dissolved	ug/L	*0.05*	0.05	0.05	0.05	NT	NT	NT	NT	NT	NT	NT	NT
Zinc, Dissolved	ug/L	37.3	37.3	37.30	37.3	14.10	282.00	64.39	58.0	8.37	910.00	51.37	31.50
LPAHs													
2-Methylnaphthalene	ug/L	*0.002*	0.033	0.009	0.008	*0.001*	0.101	0.019	0.015	*0.002*	0.136	0.017	0.012
Acenaphthene	ug/L	*0.003*	0.010	0.006	0.0045	*0.002*	0.532	0.016	*0.005*	*0.002*	0.045	0.018	0.018
Acenaphthylene	ug/L	*0.002*	0.015	0.007	0.008	*0.001*	0.056	0.006	*0.005*	*0.002*	0.064	0.010	*0.005*
Anthracene	ug/L	*0.003*	0.038	0.009	0.009	*0.002*	0.086	0.014	0.013	*0.002*	0.079	0.025	0.020
Fluorene	ug/L	*0.002*	0.019	0.008	0.008	*0.001*	0.110	0.015	0.012	*0.002*	0.098	0.019	0.014
Naphthalene	ug/L	*0.004*	0.05	0.015	0.011	*0.002*	0.150	0.031	0.024	*0.005*	0.135	0.027	0.021
Phenanthrene	ug/L	*0.01*	0.348	0.050	0.024	*0.002*	0.893	0.122	0.092	*0.005*	0.221	0.074	0.058
HPAHs													
Benzo(a)anthracene	ug/L	*0.002*	0.233	0.022	0.009	*0.001*	0.737	0.093	0.062	*0.001*	0.335	0.050	0.030
Benzo(a)pyrene	ug/L	*0.002*	0.297	0.025	0.01	*0.001*	0.865	0.106	0.080	*0.002*	0.182	0.047	0.028
Benzo(g,h,i)perylene	ug/L	*0.003*	0.475	0.041	0.014	*0.002*	0.764	0.116	0.085	*0.004*	0.189	0.053	0.034
Benzofluoranthenes	ug/L	*0.003*	0.96	0.087	0.023	*0.005*	2.150	0.320	0.226	0.005	0.554	0.132	0.086
Chrysene	ug/L	*0.003*	0.554	0.055	0.014	*0.005*	1.340	0.211	0.152	0.002	0.516	0.101	0.069
Dibenz(a,h)anthracene	ug/L	0.003	0.014	0.008	0.009	*0.002*	0.177	0.026	0.018	*0.003*	0.044	0.011	0.005
Fluoranthene	ug/L	0.008	1.05	0.100	0.027	0.015	2.500	0.345	0.237	0.014	0.444	0.140	0.111
Indeno(1,2,3-cd)pyrene	ug/L	*0.003*	0.352	0.030	0.010	*0.002*	0.669	0.095	0.069	*0.004*	0.137	0.037	0.024
Pyrene	ug/L	0.004	0.725	0.074	0.021	0.012	2.190	0.310	0.218	0.012	0.620	0.146	0.106
Phthalates													
bis(2-Ethylhexyl)phthalate	ug/L	0.71	6.4	2.52	2.04	*0.3*	19.0	3.2	2.8	*0.2*	41.0	3.1	1.9
Butylbenzylphthalate	ug/L	*0.17*	1.00	0.66	0.63	0.100	2.2	0.5	*0.5*	0.085	9.2	1.6	0.5
Diethyl phthalate	ug/L	0.249	1.5	0.70	0.75	0.1	230.0	3.8	*0.5*	*0.1*	7.6	0.7	*0.5*
Dimethyl phthalate	ug/L	*0.030*	1.00	0.50	0.128	0.000	*0.5*	*0.4*	*0.5*	*0.000*	1.0	*0.4*	*0.5*
Di-n-butylphthalate	ug/L	0.20	1.00	0.66	0.795	0.0	4.8	0.5	*0.5*	0.05	1.1	*0.5*	*0.5*
Di-n-Octyl phthalate	ug/L	*0.084*	1.4	0.61	0.525	0.04	2.5	0.5	*0.5*	*0.04*	1.0	*0.4*	*0.5*

NT = Not Tested

Italic = Below detection limit

Table 7. ANOVA Comparison between Pavement Sections

Test Name	Units	ANOVA Type	ANOVA p-value
Conventionals			
Hardness	mg/L	N	**0.000**
pH	Std. Units	P	**0.000**
TSS	mg/L	N	**0.000**
Petroleum Hydrocarbons			
NWTPH-Diesel	mg/L	N	**0.000**
NWTPH-Heavy Oil	mg/L	N	**0.000**
Metals			
Copper	ug/L	N	0.150
Lead	ug/L	N	**0.001**
Mercury	ug/L	N	0.206
Zinc	ug/L	N	**0.000**
Lead, Dissolved	ug/L	N	1.000
Mercury, Dissolved	ug/L	N	1.000
Zinc, Dissolved	ug/L	N	0.317
LPAHs			
2-Methylnaphthalene	ug/L	N	0.315
Acenaphthene	ug/L	N	0.291
Acenaphthylene	ug/L	N	0.154
Anthracene	ug/L	N	0.735
Fluorene	ug/L	N	0.743
Naphthalene	ug/L	N	0.059
Phenanthrene	ug/L	N	**0.000**
HPAHs			
Benzo(a)anthracene	ug/L	N	**0.032**
Benzo(a)pyrene	ug/L	N	0.138
Benzo(g,h,i)perylene	ug/L	N	**0.034**
Benzofluoranthenes	ug/L	N	**0.000**
Chrysene	ug/L	N	**0.000**
Dibenz(a,h)anthracene	ug/L	N	0.261
Fluoranthene	ug/L	N	**0.000**
Indeno(1,2,3-cd)pyrene	ug/L	N	0.140
Pyrene	ug/L	N	**0.000**
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/L	N	**0.000**
Butylbenzylphthalate	ug/L	N	**0.009**
Diethyl phthalate	ug/L	N	**0.000**
Dimethyl phthalate	ug/L	N	0.070
Di-n-butylphthalate	ug/L	N	**0.020**
Di-n-Octyl phthalate	ug/L	N	**0.002**

P = Parametric test (ANOVA). Normality was assumed for Sharpio-Wilks p-value greater than 0.10
N = Non-parametric test (Kruskal-Wallis)
Bold = Greater than 95% probability that there is a difference between any of the sample locations

Table 8. Dunn Post-Hoc Test
Results by Sample Location

Hardness

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x>0.2		1				
	Catch Basin		x>0.2	0.1<x<0.2	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x<0.05	x>0.2	1	
Standard Asphalt	Catch Basin	x<0.05	x<0.05	x<0.05	x<0.05	0.1<x<0.2	x>0.2	1

Total Suspended Solids

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x<0.05	1					
Pervious Concrete	Infiltrated Flow	x>0.2		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x<0.05	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	x<0.05	1

NWTPH-Diesel

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x<0.05	1					
Pervious Concrete	Infiltrated Flow	x>0.2		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	0.05<x<0.1		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	0.1<x<0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

NWTPH-Heavy Oil

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	0.05<x<0.1	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	0.1<x<0.2	x>0.2	0.05<x<0.1	x<0.05	1

Total Lead

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x>0.2		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Total Zinc

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x<0.05	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Table 8. Dunn Post-Hoc Test
Results by Sample Location

Phenanthrene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	0.1<x<0.2		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Benzo(a)anthracene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	x<0.05	1

Benzo(g,h,i)perylene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	x<0.05	1

Benzofluoranthenes

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Chrysene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Fluoranthene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	0.1<x<0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Table 8. Dunn Post-Hoc Test Results by Sample Location

Pyrene

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

bis(2-Ethylhexyl)phthalate

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	0.1<x<0.2	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x>0.2	x>0.2	x<0.05	x<0.05	1

Butylbenzylphthalate

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	0.05<x<0.1		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	x<0.05	1

Diethyl phthalate

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	0.1<x<0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x>0.2		x>0.2		1		
	Catch Basin		x>0.2		0.1<x<0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	x>0.2	1

Di-n-butylphthalate

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x>0.2		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	0.05<x<0.1	1

Di-n-Octyl phthalate

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1						
	Catch Basin	x>0.2	1					
Pervious Concrete	Infiltrated Flow	x<0.05		1				
	Catch Basin		x>0.2	x<0.05	1			
Pervious Asphalt	Infiltrated Flow	x<0.05		x<0.05		1		
	Catch Basin		x>0.2		x>0.2	x>0.2	1	
Standard Asphalt	Catch Basin	x>0.2	x>0.2	x<0.05	x>0.2	x>0.2	0.05<x<0.1	1

(gray)	Comparison test not performed
(red)	Test is signifcant at greater than 0.05 level.
(yellow)	Test is signifcant between 0.05 and 0.1 level
(green)	Test is significant between 0.1 and 0.2 level

Table 9. Tukey Post-Hoc Test
Results by Sample Location

pH

Probabilities

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow	1.000						
	Catch Basin	0.992	1.000					
Pervious Concrete	Infiltrated Flow	0.000		1.000				
	Catch Basin		0.999	0.000	1.000			
Pervious Asphalt	Infiltrated Flow	0.177		0.000		1.000		
	Catch Basin		0.020		0.001	0.326	1.000	
Standard Asphalt	Catch Basin	0.000	0.000	0.000	0.000	0.001	0.455	1.000

Grey	Comparison test not performed
Red	Test is signifcant at greater than 0.05 level.
Yellow	Test is signifcant between 0.05 and 0.1 level
Green	Test is significant between 0.1 and 0.2 level

Table 10. Post-Hoc Test Summary - Greater than 0.05 Probablity of Differences

		Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt
		Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Infiltrated Flow	Catch Basin	Catch Basin
Pervious Pavers	Infiltrated Flow							
	Catch Basin	2						
Pervious Concrete	Infiltrated Flow	14						
	Catch Basin		0	16				
Pervious Asphalt	Infiltrated Flow	14		18				
	Catch Basin		1		3	1		
Standard Asphalt	Catch Basin	2	2	9	2	10	14	

Numbers shown reflect the number of analytes that were significant at the 0.05 level.

Table 11. Sediment Data Summary Statistics

Test Name	Units	Pervious Pavers		Pervious Concrete		Pervious Asphalt		Standard Asphalt	
		Result	Flag	Result	Flag	Result	Flag	Result	Flag
Conventionals									
Total Solids	%	28.6		67.4		41.9		69.6	
Total Volatile Solids	%	16.6		3.5		11.1		5.7	
Nutrients									
Total Organic Carbon	mg/Kg	156,000		23,100		143,000		40,500	
Petroleum Hydrocarbons									
NWTPH-Diesel	mg/Kg	80	J	13	J	52	J	33	J
NWTPH-Heavy Oil	mg/Kg	7,500		520		2,900		1,500	
Metals									
Copper	mg/Kg	174		48.4		116		49.9	
Lead	mg/Kg	105		19		105		31	
Mercury	mg/Kg	0.172		<0.0337		0.159		0.0605	
Zinc	mg/Kg	1,970		241		728		189	
PAHs									
LPAHs									
2-Methylnaphthalene	ug/Kg	<30		<29		<30		<29	
Acenaphthene	ug/Kg	<16		<16		<16		<15	
Acenaphthylene	ug/Kg	<23		<23		<23		<23	
Anthracene	ug/Kg	<51		<49		<50		140	
Fluorene	ug/Kg	<19		<19		160		<19	
Naphthalene	ug/Kg	<40		<40		<40		<39	
Phenanthrene	ug/Kg	330		<52		1,300		140	
HPAHs									
Benzo(a)anthracene	ug/Kg	280		<72		590		110	J
Benzo(a)pyrene	ug/Kg	340	J	<100		290	J	110	J
Benzo(g,h,i)perylene	ug/Kg	490	J	<78	J	440	J	150	J
Benzo(b,k)fluoranthenes	ug/Kg	1,200	J	180	J	2,000	J	650	J
Chrysene	ug/Kg	610		<62		620		110	J
Dibenz(a,h)anthracene	ug/Kg	<130	J	<130	J	<130	J	<130	J
Fluoranthene	ug/Kg	480	J	140	J	1,100	J	270	J
Indeno(1,2,3-c,d)pyrene	ug/Kg	300	J	<120		390	J	130	J
Pyrene	ug/Kg	1,300		180		2,100		380	
Phthalates									
bis(2-Ethylhexyl)phthalate	ug/Kg	18,000		1,600		16,000		4,300	
Butyl benzyl phthalate	ug/Kg	1200		210		2,100		860	
Diethylphthalate	ug/Kg	<74		<72		<73		<71	
Dimethyl phthalate	ug/Kg	290		<48		130		<48	
Di-n-butylphthalate	ug/Kg	400		<73		120		<72	
Di-n-Octyl phthalate	ug/Kg	3,500	J	130		<74	J	<73	J

Italic = Below detection limit
n = number of samples
# detects = number of samples greater than the detection limit

FIGURES

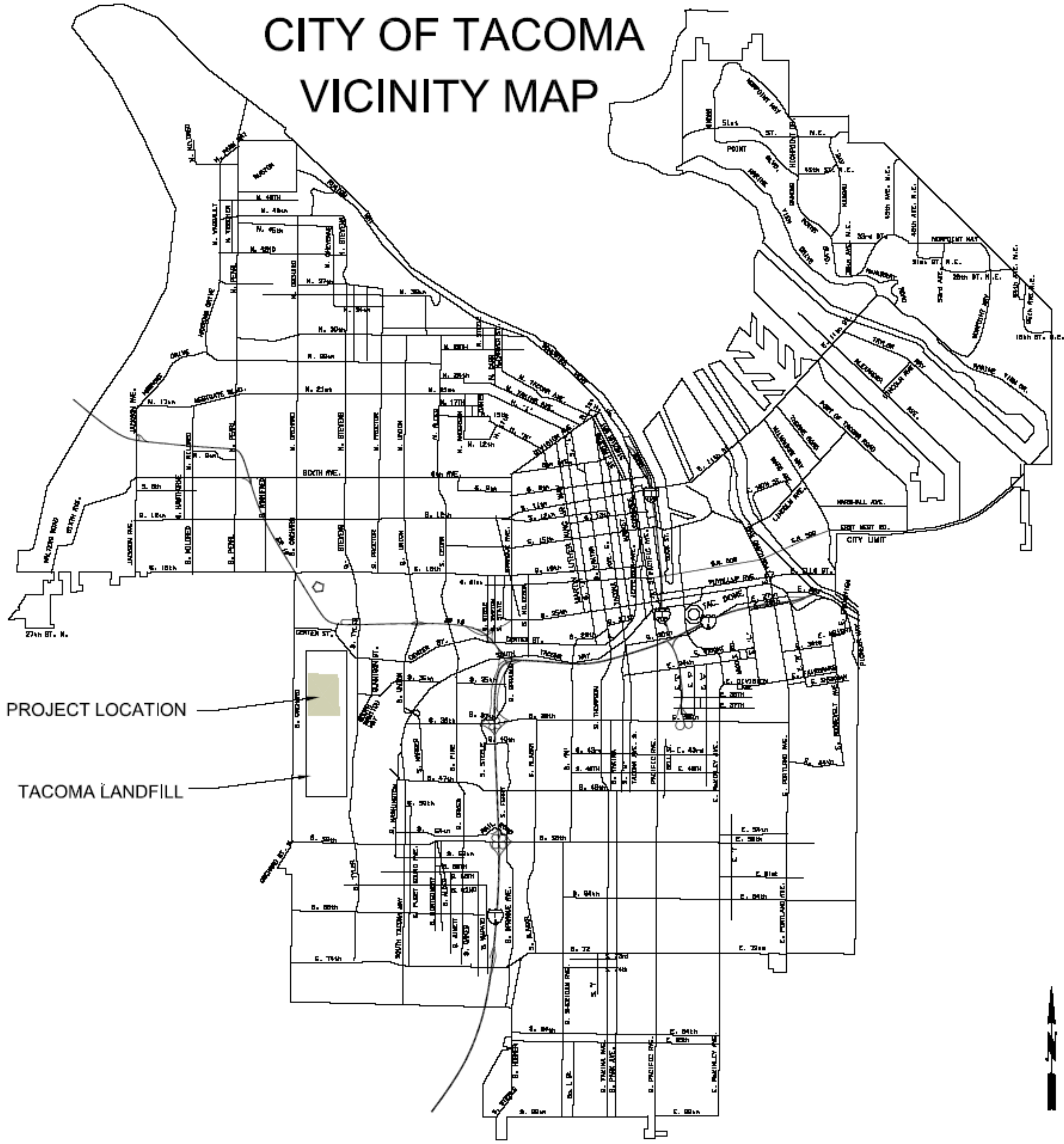


Figure 1. City of Tacoma Vicinity Map

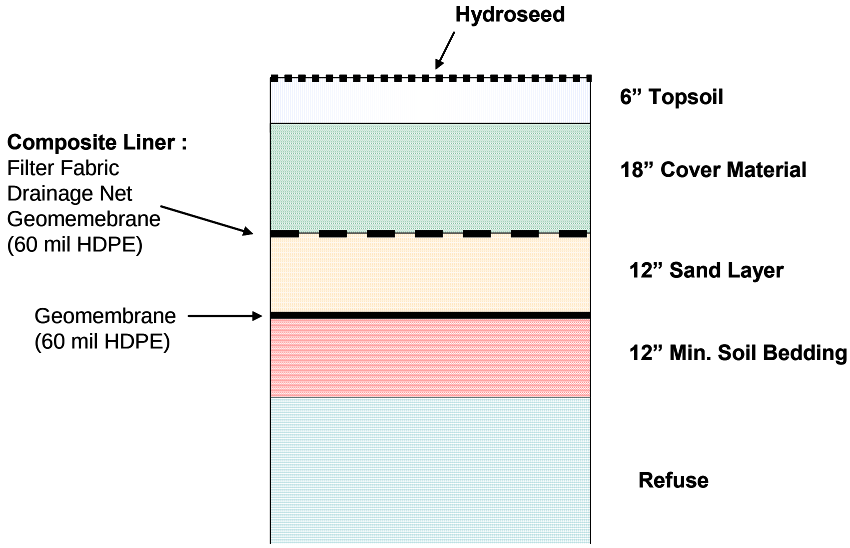


Figure 2. Landfill Cap Cross-Section

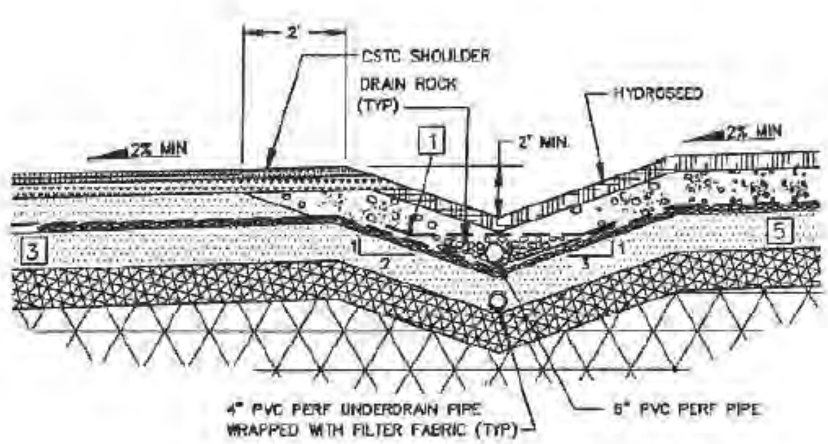


Figure 3. Landfill Cap Drainage System

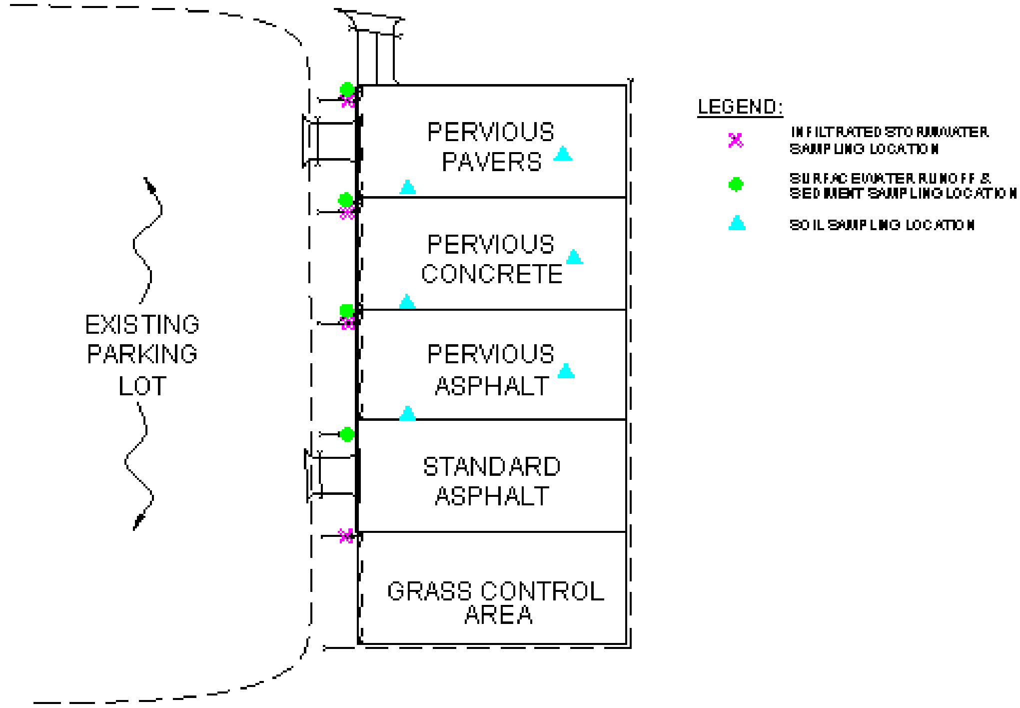


Figure 4. Project Site Layout

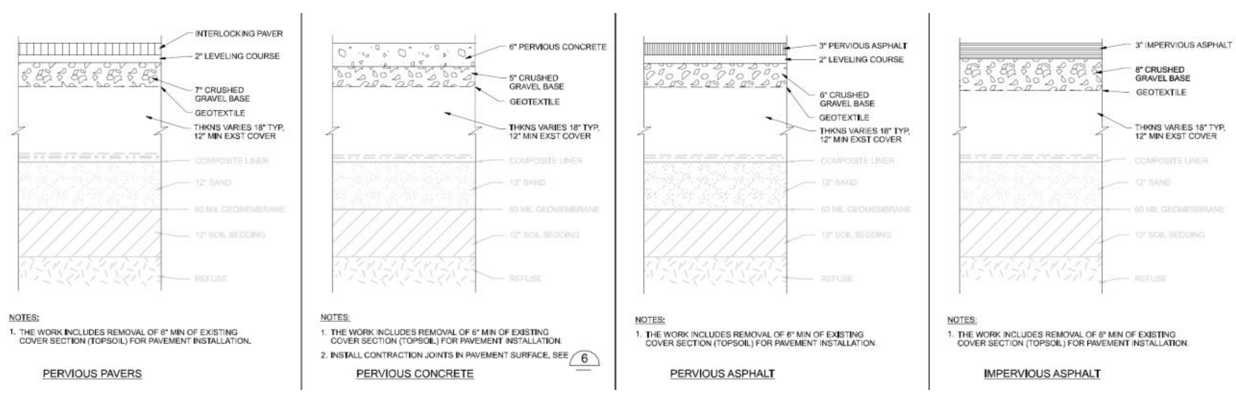


Figure 5. Pavement Cross Sections

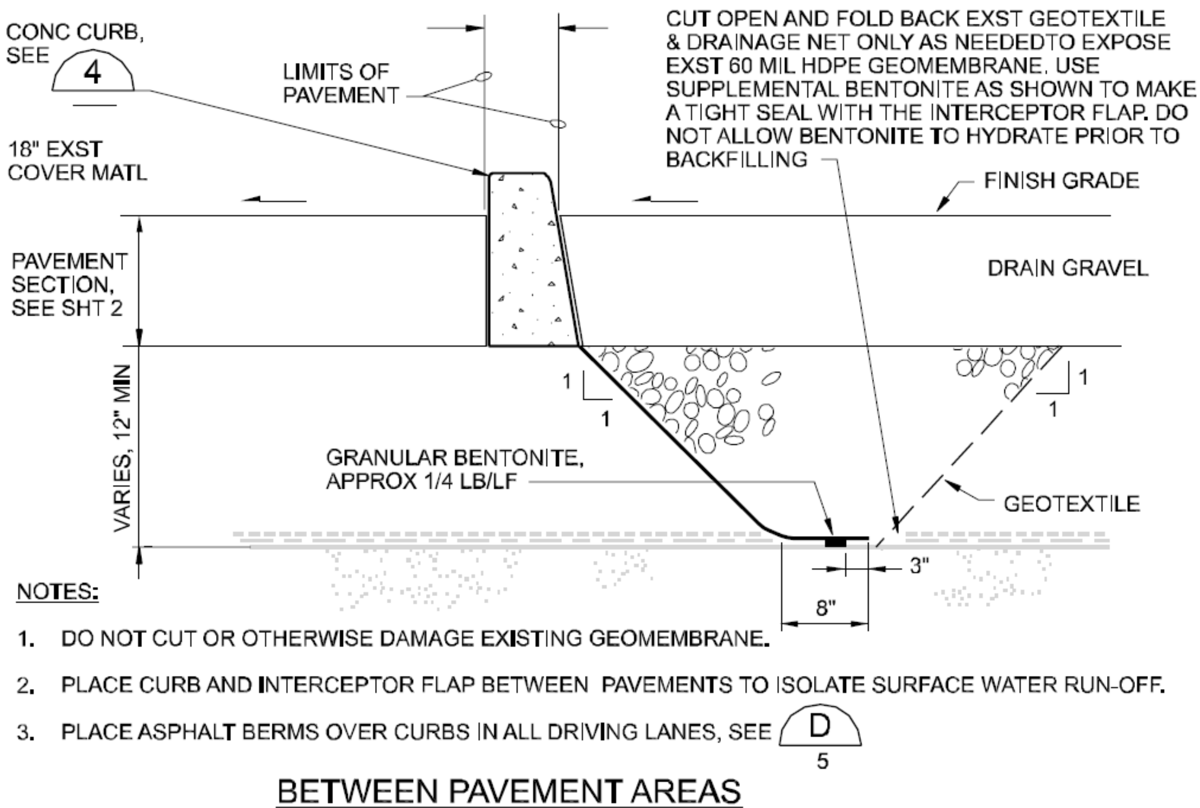


Figure 6. GCL Interceptor Flap

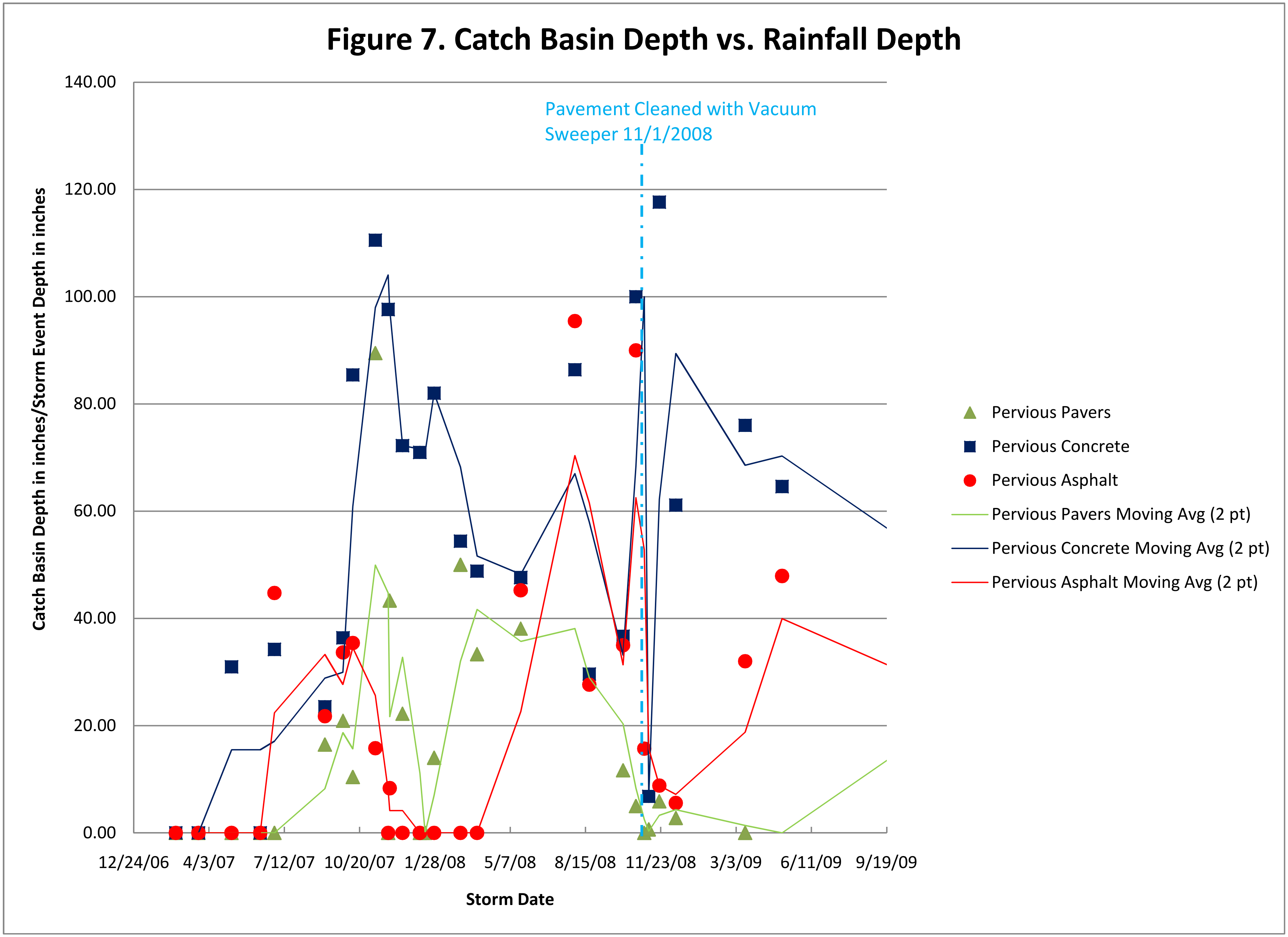


Figure 7. Catch Basin Depth vs. Rainfall Depth
Pavement Cleaned with Vacuum Sweeper 11/1/2008
Catch Basin Depth in inches/Storm Event Depth in inches
Storm Date
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
12/24/06
4/3/07
7/12/07
10/20/07
1/28/08
5/7/08
8/15/08
11/23/08
3/3/09
6/11/09
9/19/09
Pervious Pavers
Pervious Concrete
Pervious Asphalt
Pervious Pavers Moving Avg (2 pt)
Pervious Concrete Moving Avg (2 pt)
Pervious Asphalt Moving Avg (2 pt)

Figure 8. Conventionals Box Plot

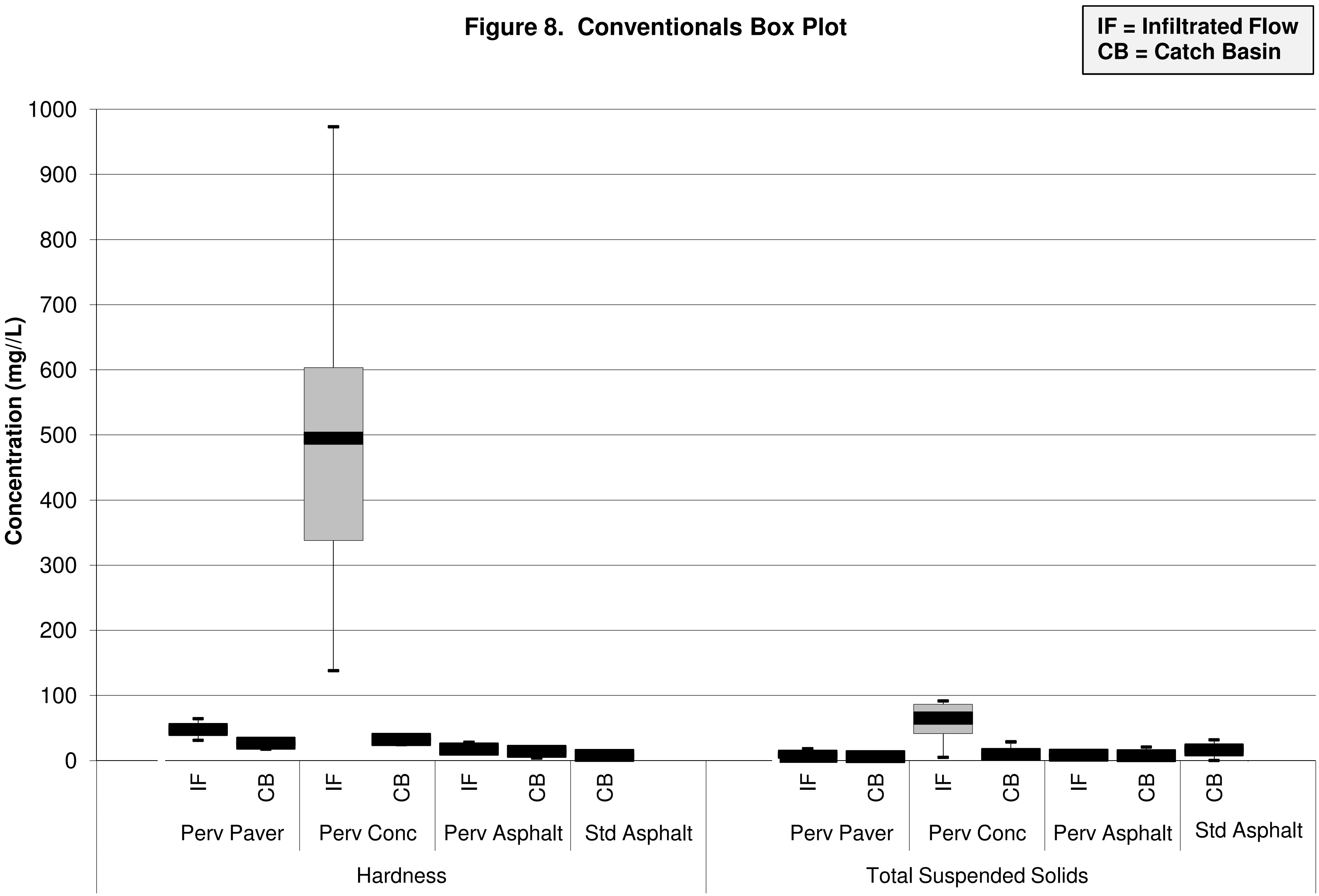


Figure 9. Conventionals Box Plot (No Pervious Concrete IF)

IF = Infiltrated Flow
CB = Catch Basin

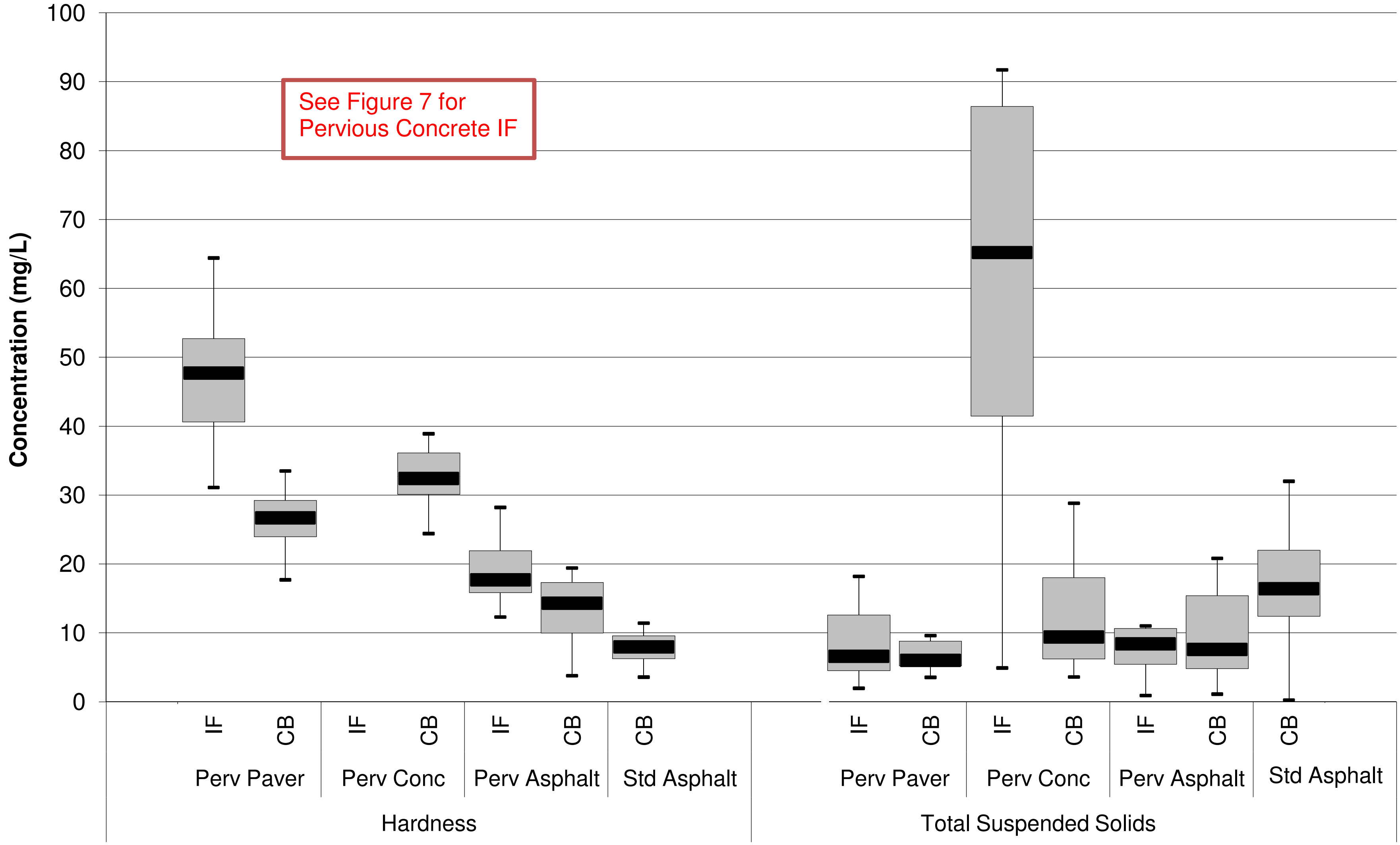


Figure 10. pH Box Plot

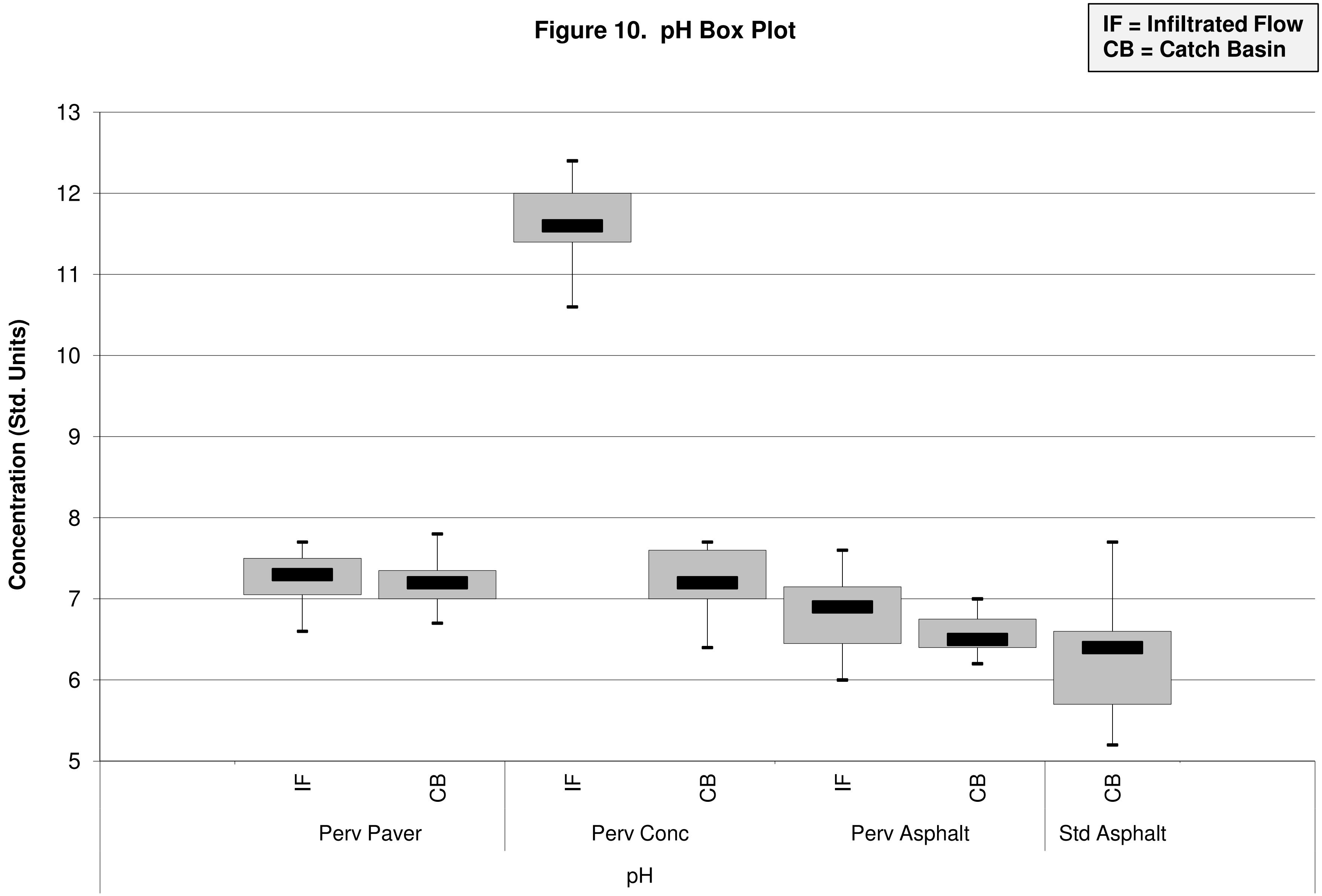


Figure 11. Total Petroleum Hydrocarbons Box Plot

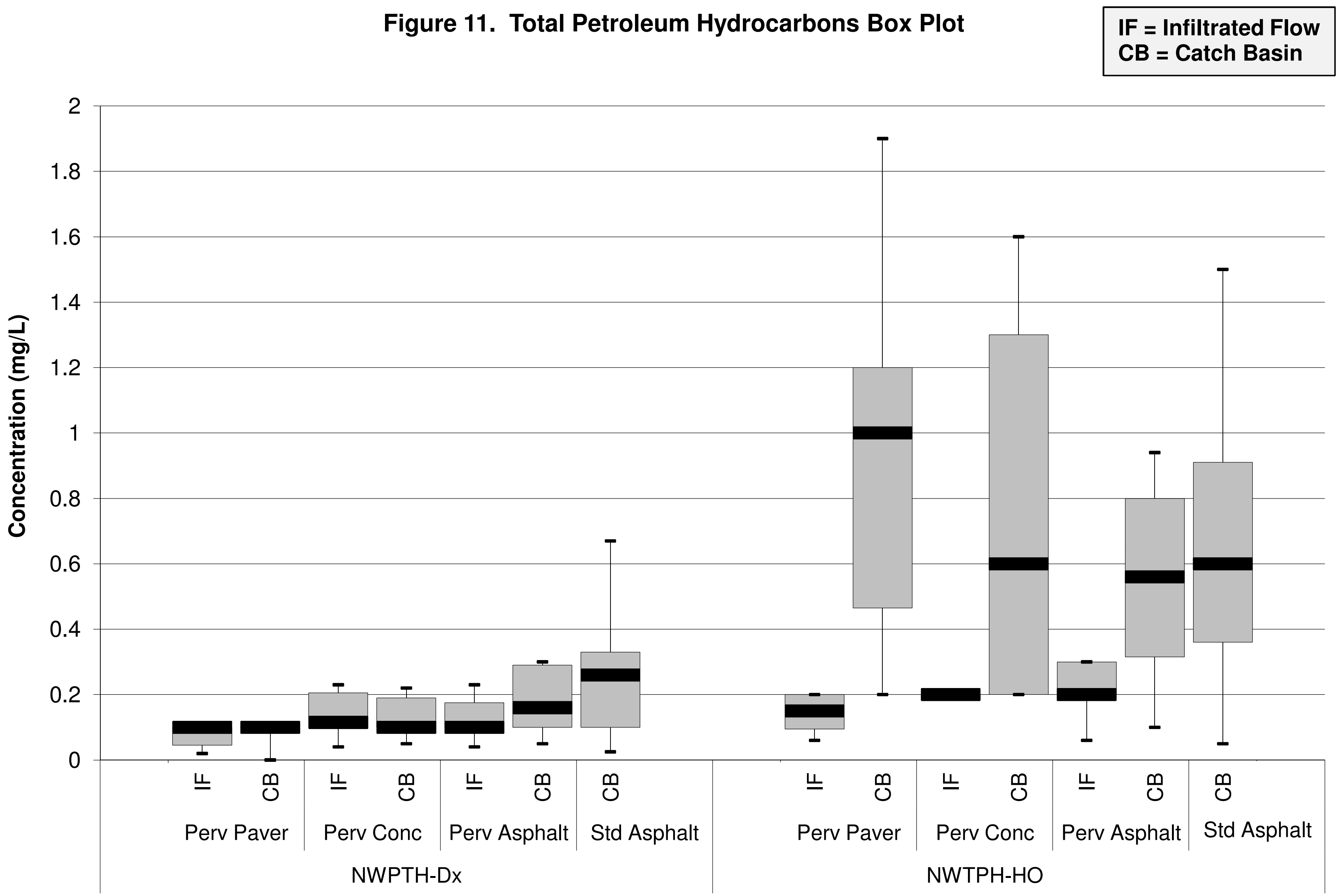


Figure 12. Copper and Lead Box Plot

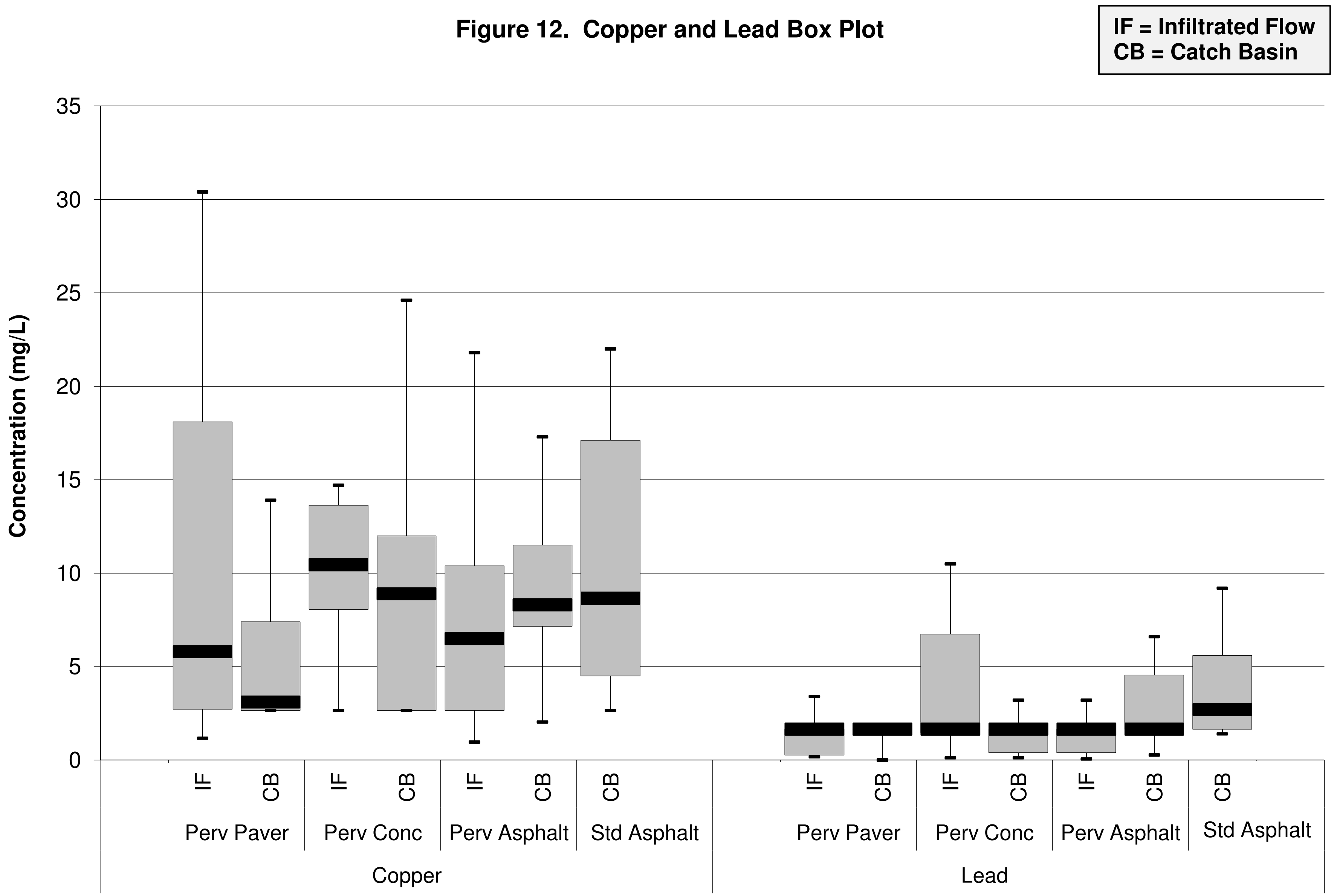


Figure 13. Mercury and Zinc Box Plot

IF = Infiltrated Flow
CB = Catch Basin

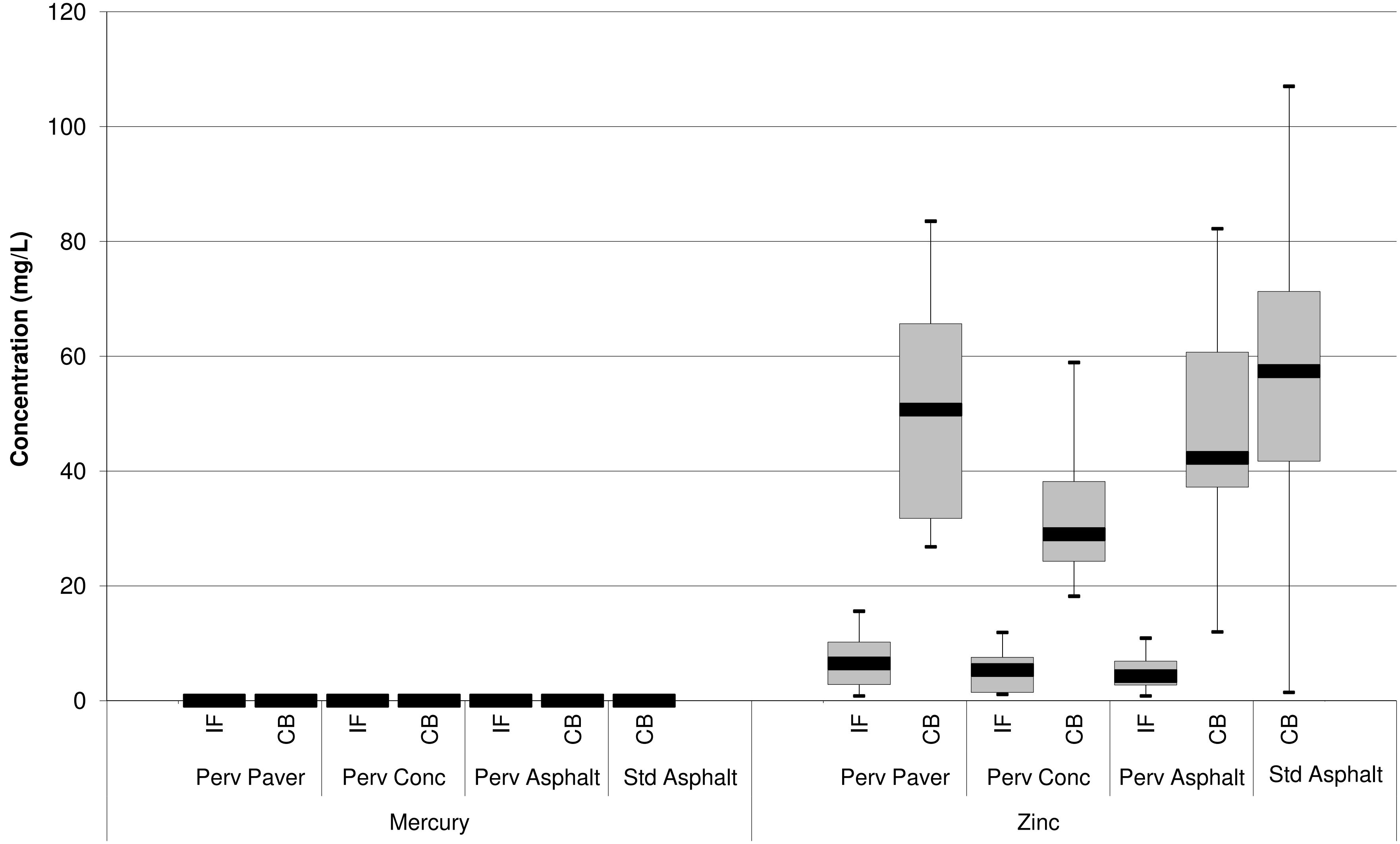


Figure 14. 2-Methylnaphthalene and Acenaphthene Box Plot

IF = Infiltrated Flow
CB = Catch Basin

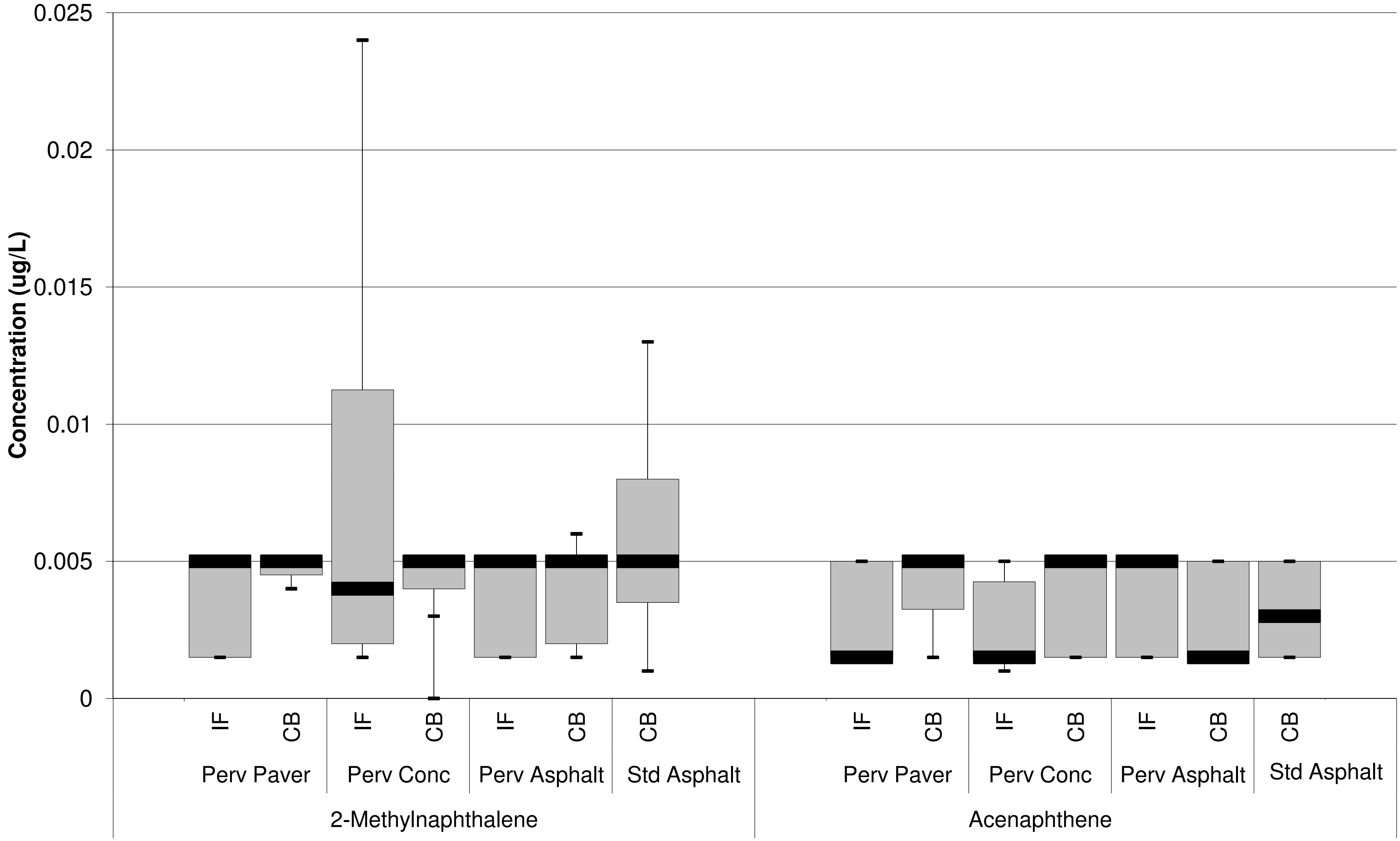


Figure 15. Acenaphthylene and Anthracene Box Plot

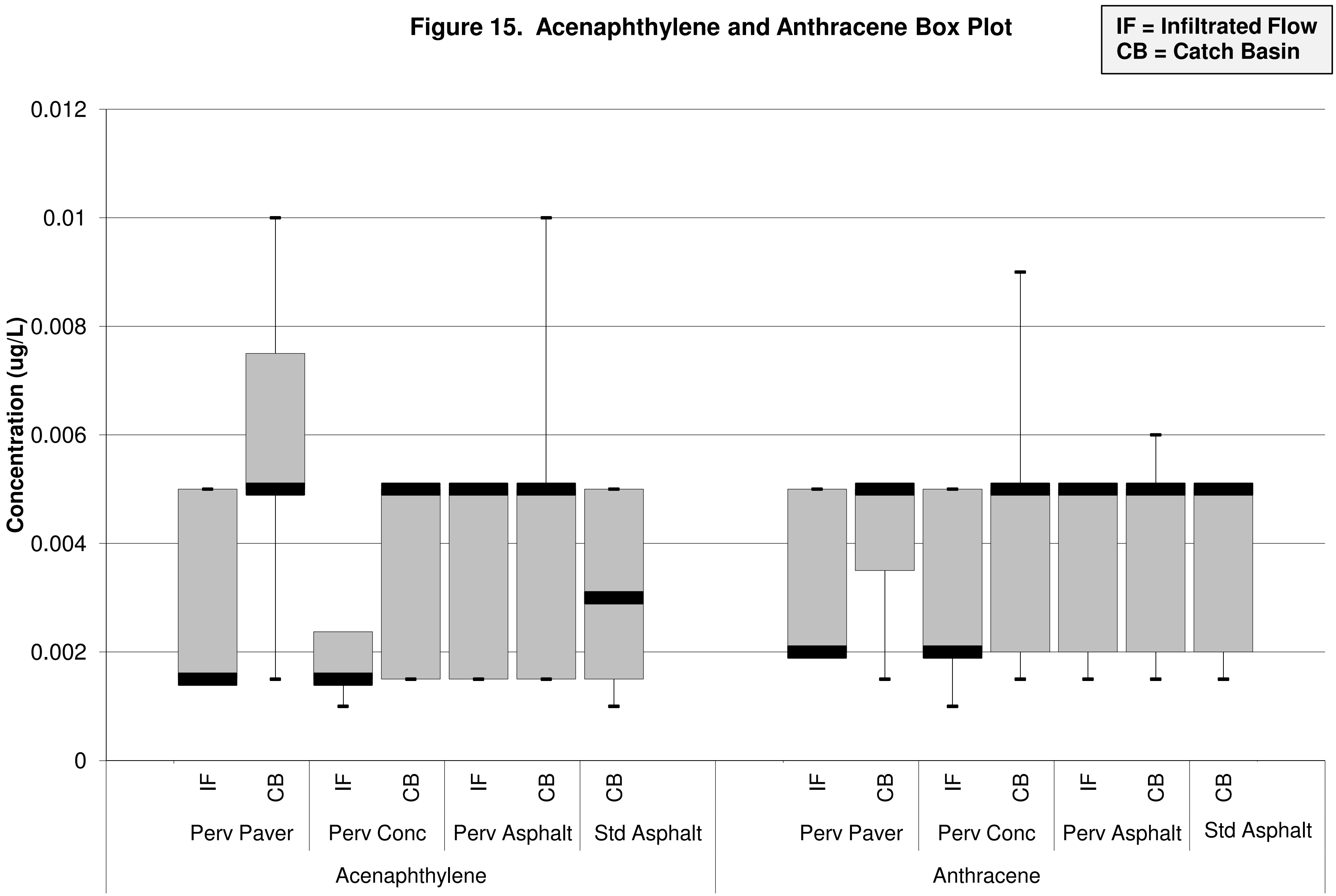


Figure 16. Fluorene and Naphthalene Box Plot

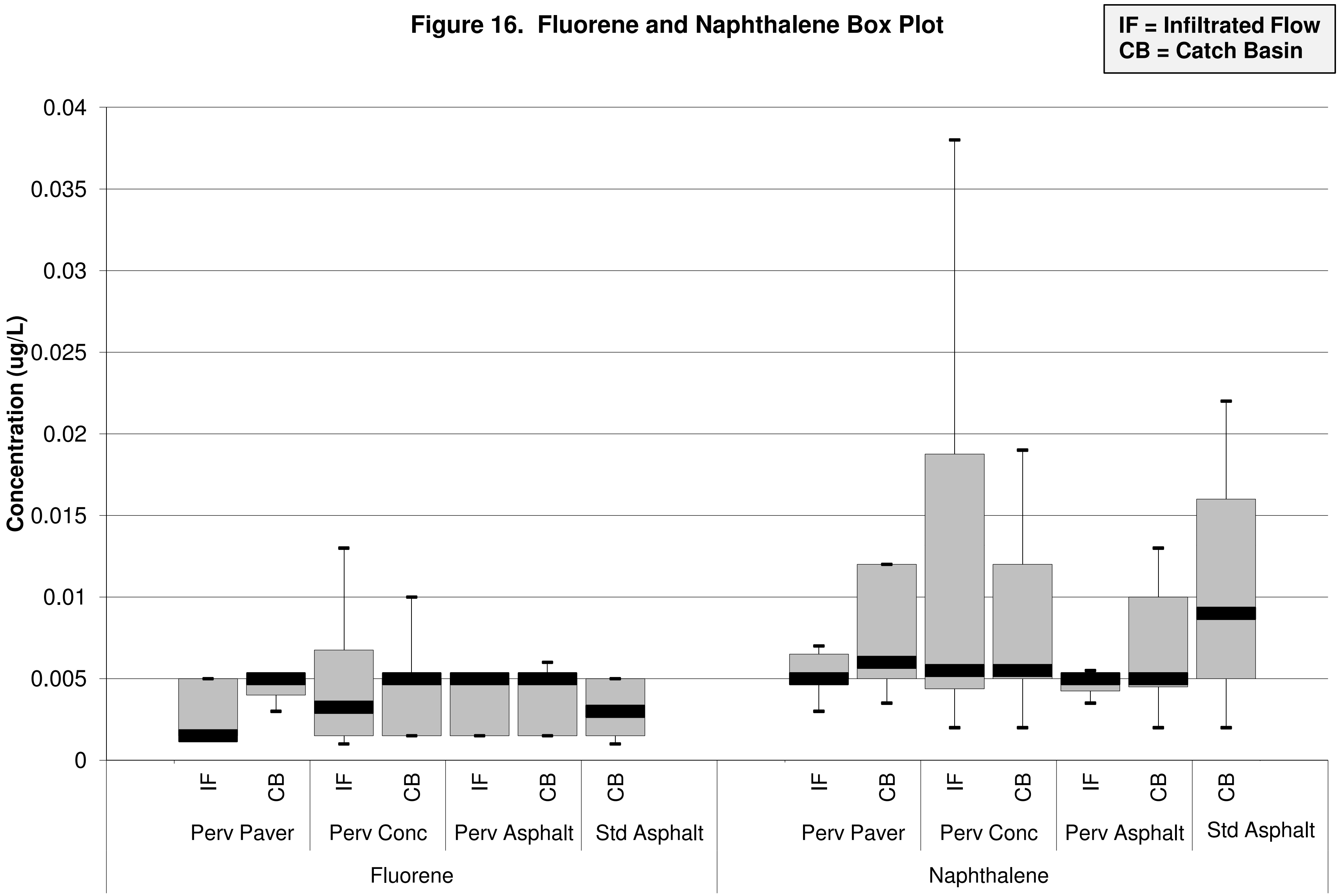
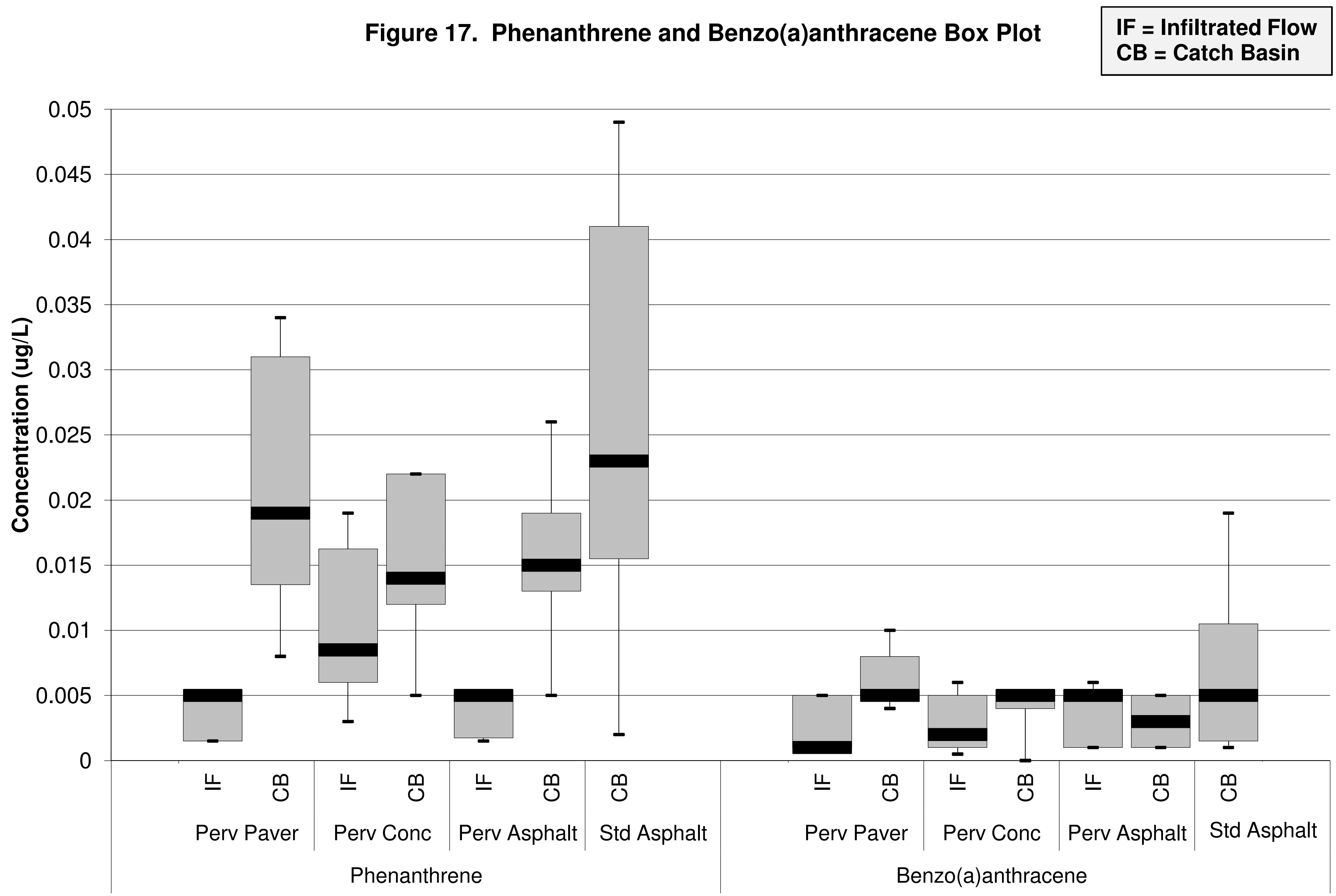


Figure 17. Phenanthrene and Benzo(a)anthracene Box Plot



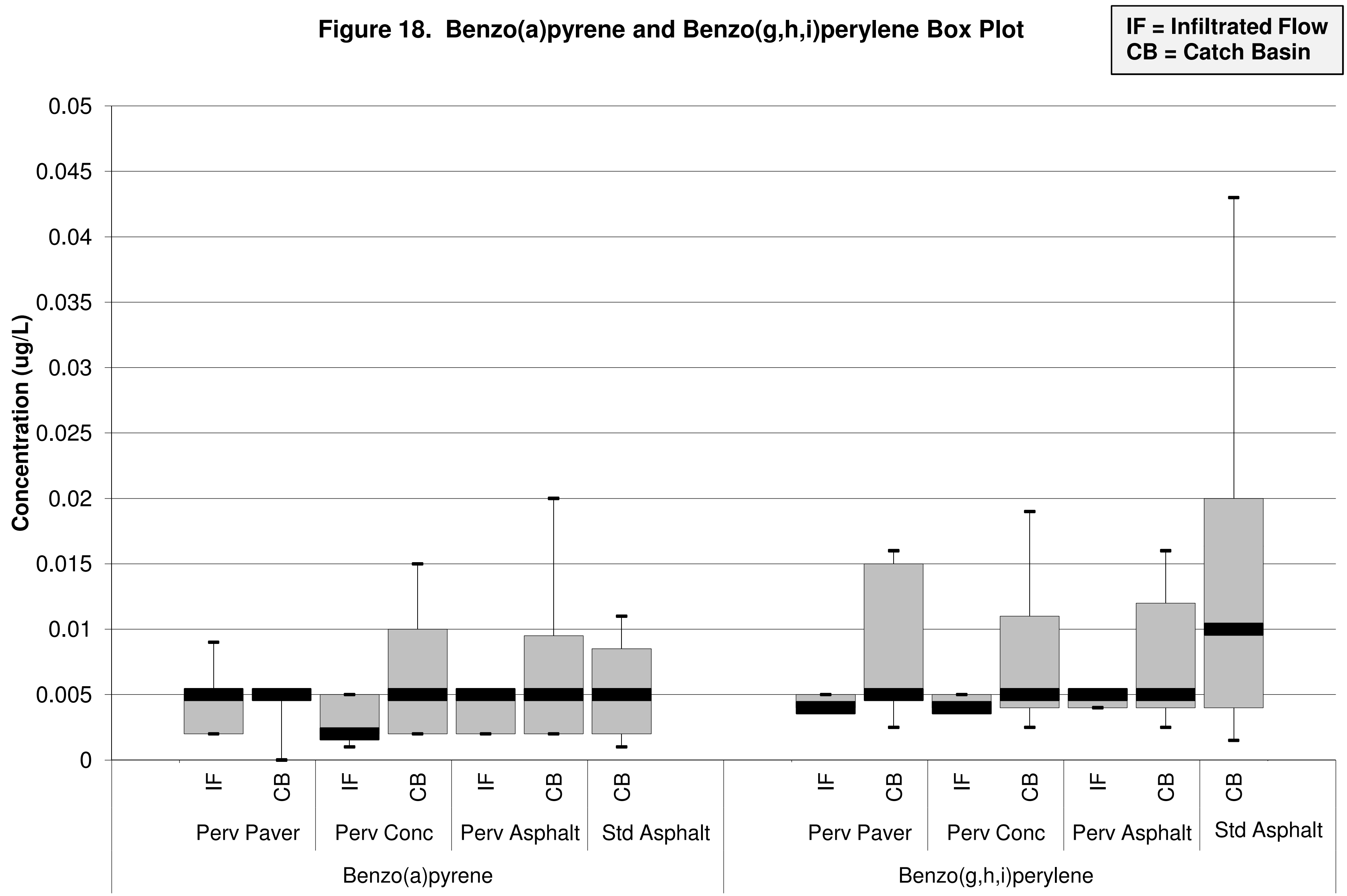


Figure 18. Benzo(a)pyrene and Benzo(g,h,i)perylene Box Plot
IF = Infiltrated Flow
CB = Catch Basin
Concentration (ug/L)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
IF
CB
IF
CB
IF
CB
CB
Perv Paver
Perv Conc
Perv Asphalt
Std Asphalt
Benzo(a)pyrene
IF
CB
IF
CB
IF
CB
CB
Perv Paver
Perv Conc
Perv Asphalt
Std Asphalt
Benzo(g,h,i)perylene

Figure 19. Benzo(b,k)fluoranthenes and Chrysene Box Plot

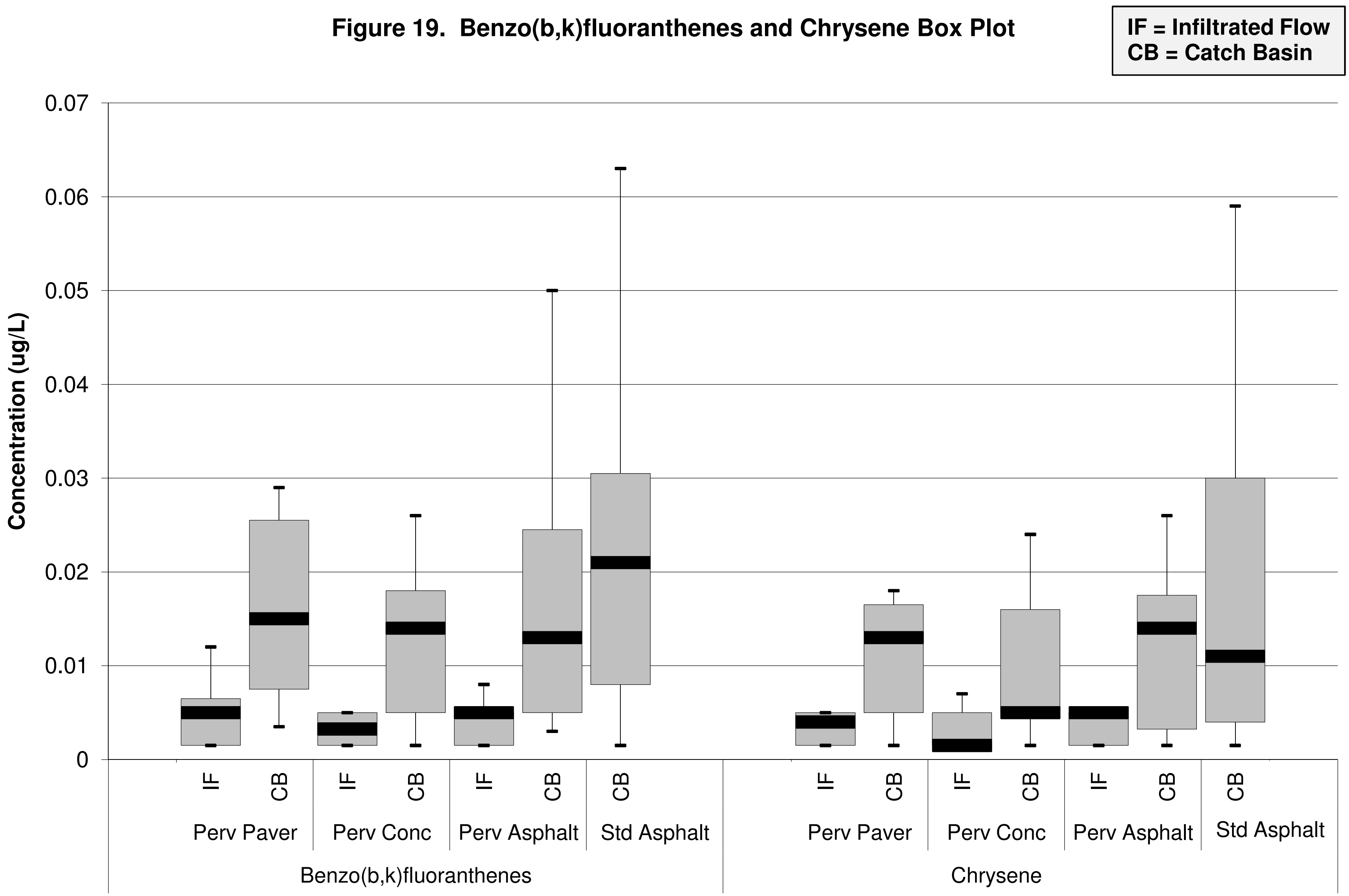


Figure 20. Dibenz(a,h)anthracene and Fluoranthene Box Plot

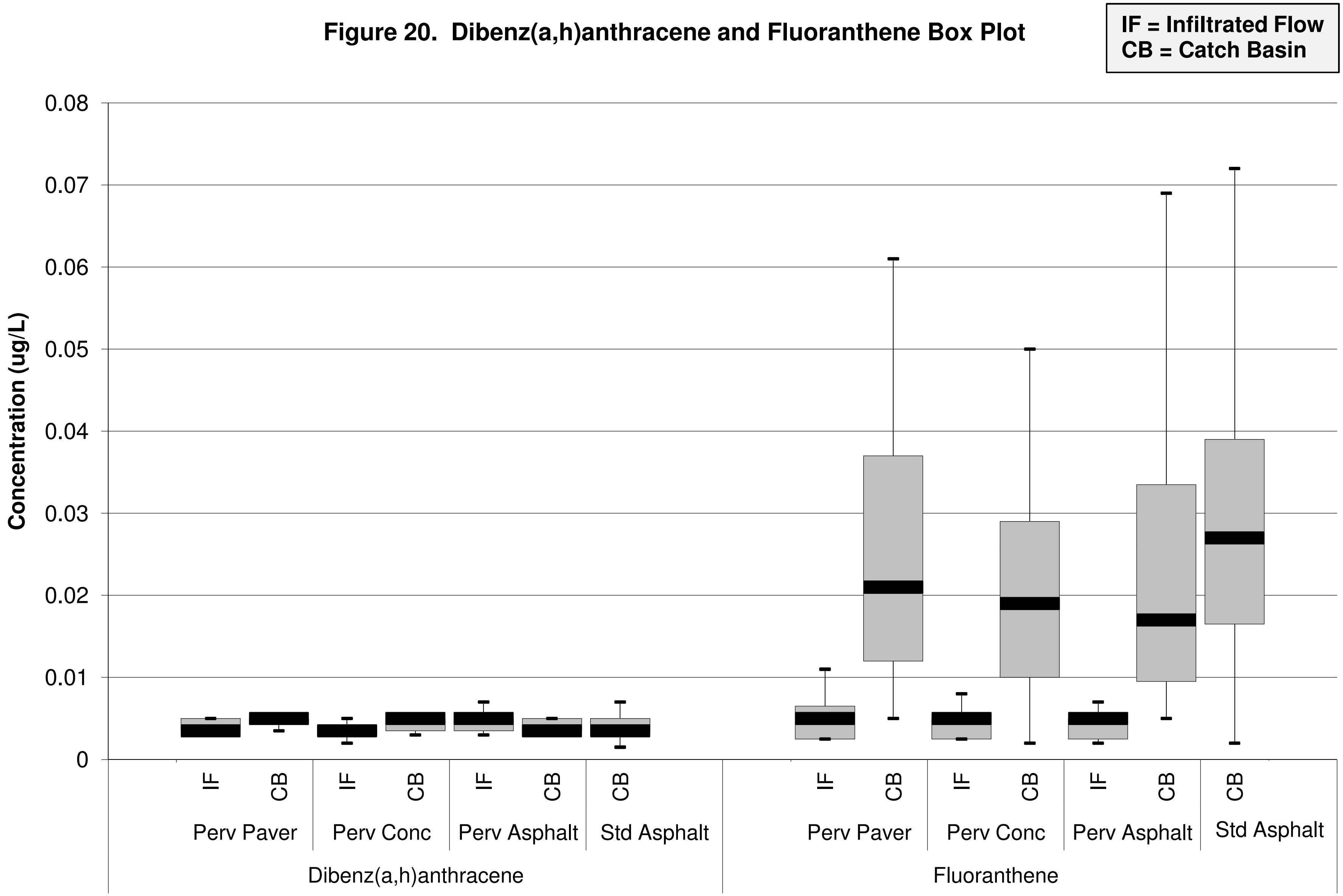


Figure 21. Indeno(1,2,3-cd)pyrene and Pyrene Box Plot

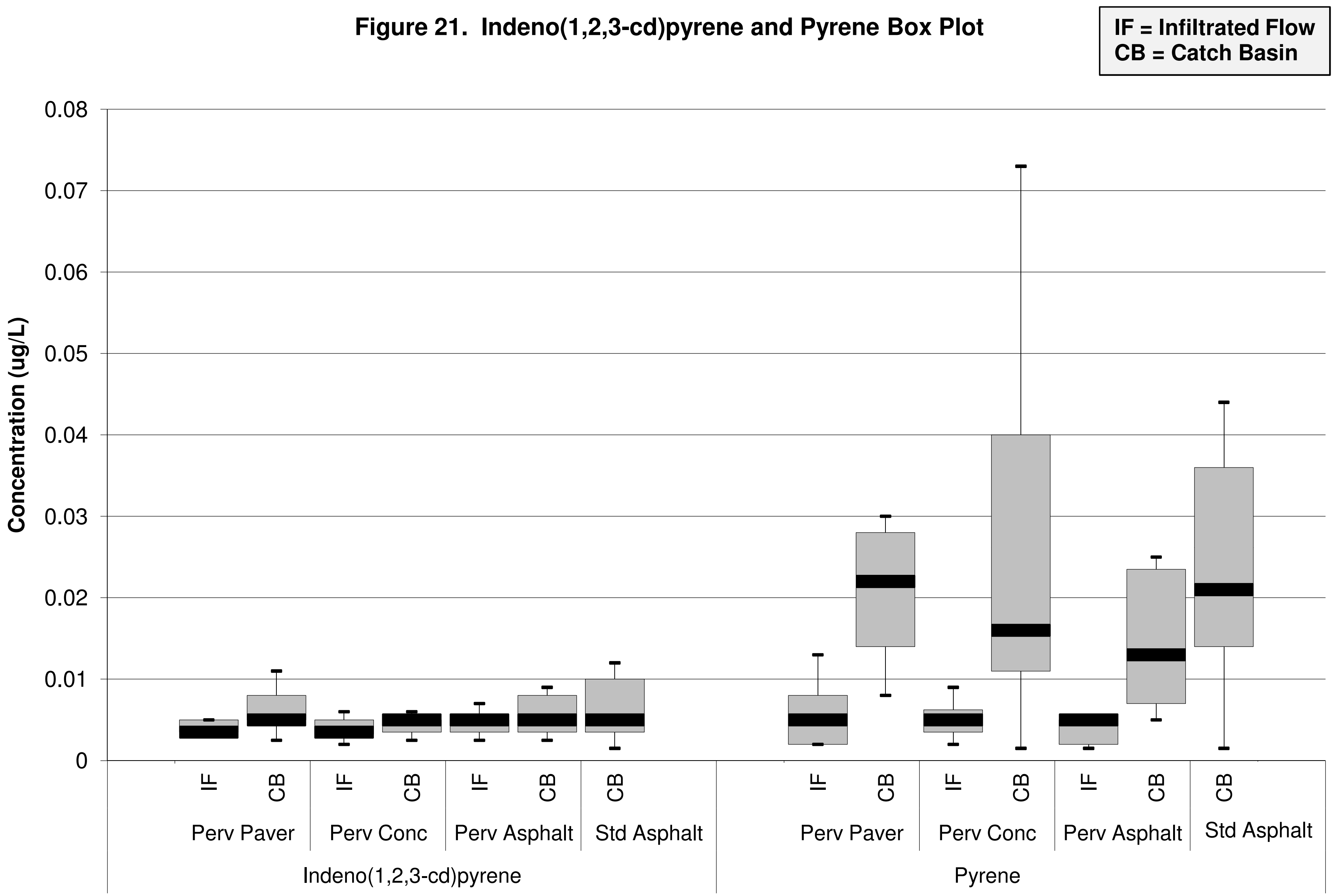


Figure 22. DEHP and Butylbenzylphthalate Box Plot

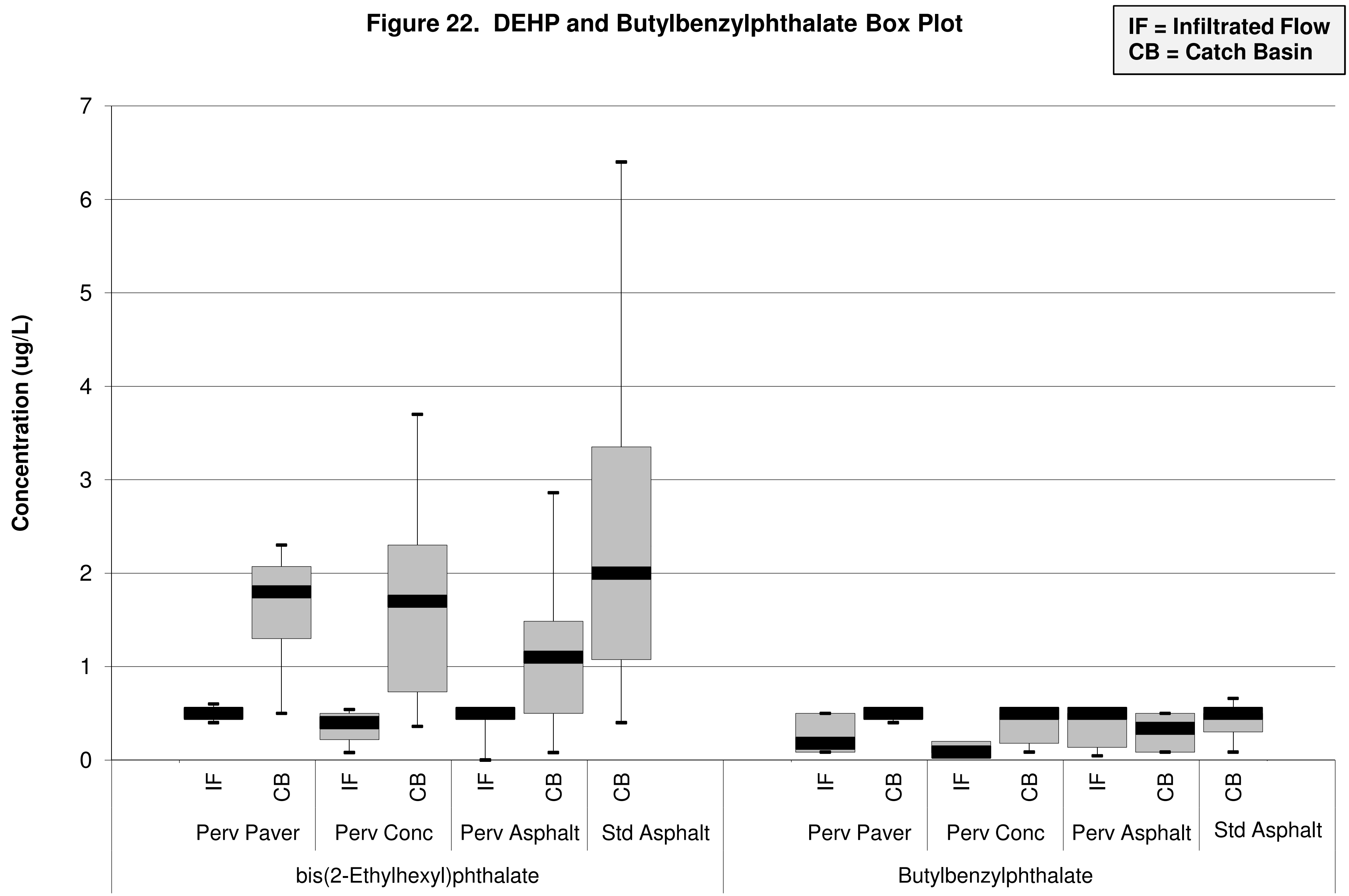


Figure 23. Diethylphthalate and Dimethylphthalate Box Plot

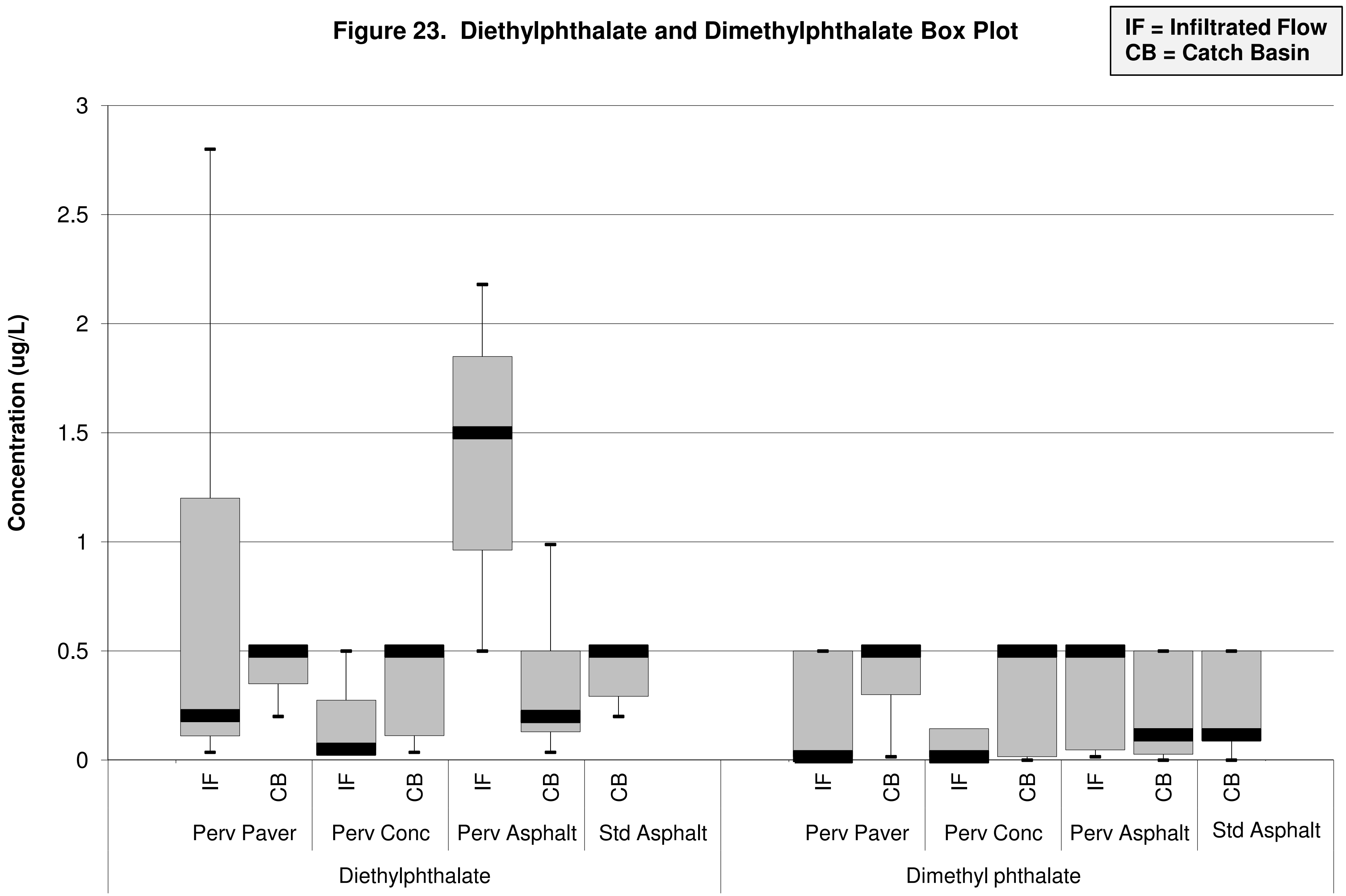
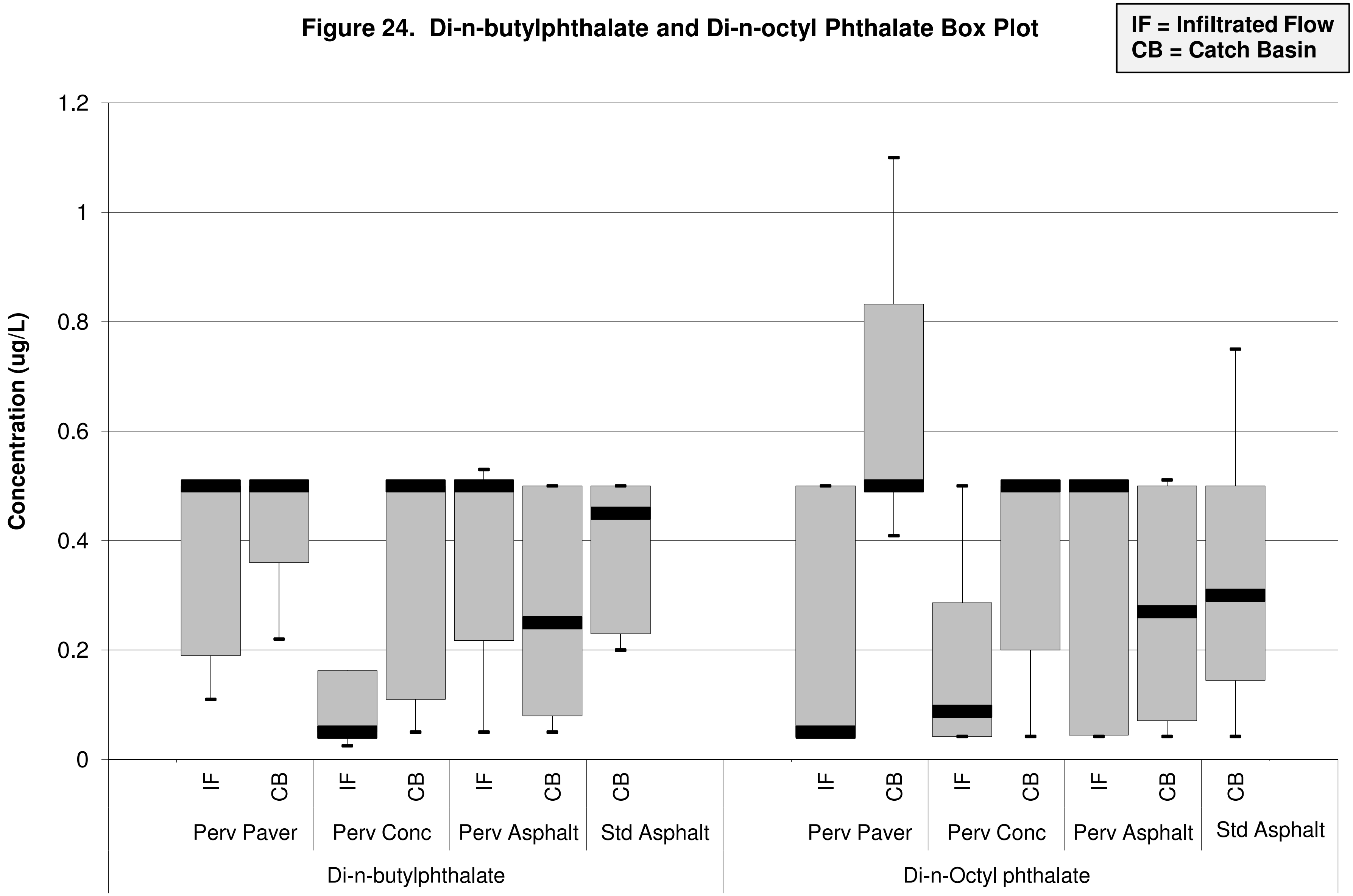


Figure 24. Di-n-butylphthalate and Di-n-octyl Phthalate Box Plot



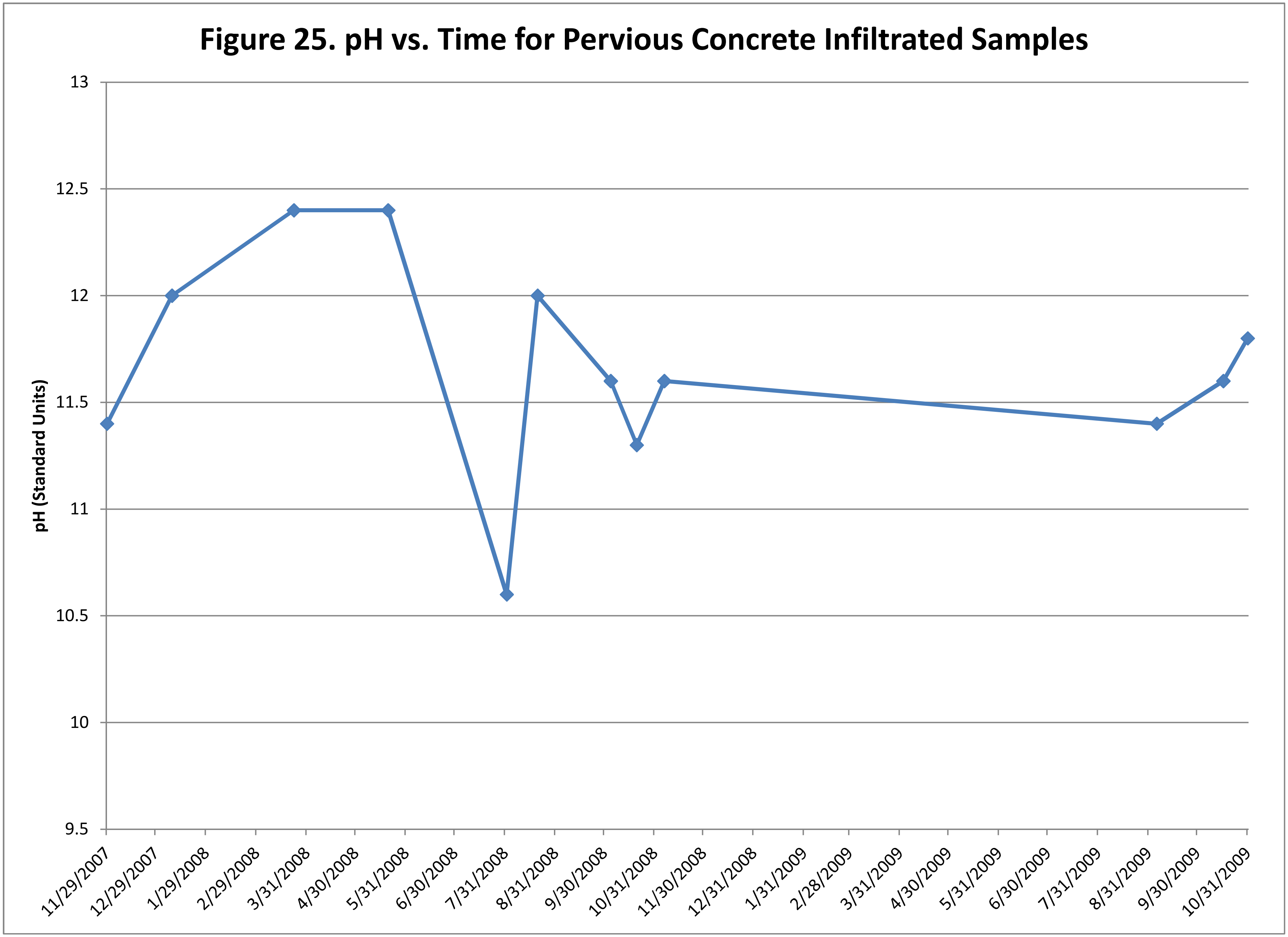


Figure 25. pH vs. Time for Pervious Concrete Infiltrated Samples
pH (Standard Units)
13
12.5
12
11.5
11
10.5
10
9.5
11/29/2007
12/29/2007
1/29/2008
2/29/2008
3/31/2008
4/30/2008
5/31/2008
6/30/2008
7/31/2008
8/31/2008
9/30/2008
10/31/2008
11/30/2008
12/31/2008
1/31/2009
2/28/2009
3/31/2009
4/30/2009
5/31/2009
6/30/2009
7/31/2009
8/31/2009
9/30/2009
10/31/2009

APPENDICES

APPENDIX A. COVER MATERIAL SAMPLING RESULTS

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Tacoma

City of Tacoma
Environmental Services
Science and Engineering Division

Memorandum

TO: Karen Bartlett, Engineering Trainee

FROM: Christopher L. Getchell, Sr. Environmental Specialist

SUBJECT: Landfill Pervious Pavement SAP CC 521400

DATE: June 1, 2005

Attached are the analysis results for the Pervious Pavement soil samples collected April 26, 2005.

Aquatic Research Incorporated analyzed the samples.

If you have any questions concerning these results, call me at (253) 502-2130.

Christopher L. Getchell
Sr. Environmental Specialist
Science and Engineering Division

CLG:LAZ

C:\QCWork\Sharedwd\2005\cvrlttr\50426224.doc

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: TAC001-11 **PAGE 1**
REPORT DATE: 05/25/05
DATE SAMPLED: 04/26/05 **DATE RECEIVED:** 04/27/05
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM CITY OF TACOMA

CASE NARRATIVE

Four water samples were received by the laboratory in good condition. The samples were analyzed according to the chain-of-custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	CATION EXCHANGE CAPACITY (meq/100g)
TP1-6"	2.8
TP1-12"	1.8
TP2-6"	2.6
TP2-12"	1.9

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PHONE: (206) 632-2715 FAX: (206) 632-2417

ASTM D422 PARTICLE SIZE

ANALYSIS DATE: 4/27/2005

LAB SAMPLE ID: TAC001-11A1

ANALYST: S. NIELSON

CLIENT SAMPLE ID: TP1-6"

TOTAL WET WEIGHT (g) 107.24
TOTAL DRY WEIGHT (g) 99.64

PERCENT SOLIDS @ 105C 92.81%

SIEVE FRACTION - SAND GRAVEL

BEAKER # 1

SIEVE FRACTION
BEAKER TARE: 113.0600
TOTAL DRY WT (g) 205.3400
SAMPLE WT (g) 92.2800

SIEVE SIZE	(mm)	(g)	(%)	% FINER	COMMENTS
0.375	9.50	12.6186	12.66%	87.34%	
0.25	6.30	1.1828	1.19%	86.15%	
4	4.75	1.2440	1.25%	84.90%	
10	2.00	5.4453	5.47%	79.43%	plants,rocks
20	0.850	5.5233	5.54%	73.89%	plants,rocks
40	0.425	11.5475	11.59%	62.30%	sand,plants
60	0.250	20.1958	20.27%	42.03%	sand,plants
140	0.106	22.8019	22.89%	19.15%	sand,plants
200	0.075	5.0313	5.05%	14.10%	sand,plants
<200	<0.075	6.9402			sand,plants

TOTAL WT 92.5307
RECOVERY (%) 100.27%

HYDROMETER FRACTION - SILT CLAY

SAMPLE TIME (20C)

BLANK 1.0

TIME MIN	HYDROMETER	TEMP C	K	DIAM (mm)	Δ wt (g)	(%)	% FINER
2	9.0	21.0	0.0137	0.0372	8.0000	8.03%	8.03%
5	7.0		0.0137	0.0238	6.0000	2.01%	6.02%
15	5.0		0.0137	0.0139	4.0000	2.01%	4.01%
30	4.0		0.0137	0.0099	3.0000	1.00%	3.01%
60	4.0		0.0137	0.0070	3.0000	0.00%	3.01%
250	2.5	21.0	0.0137	0.0034	1.5000	1.51%	1.51%
1440	2.0	21.0	0.0137	0.0014	1.0000	0.50%	1.00%

PHYSICAL PROPERTIES

DISTRIBUTION % GRAVEL 20.57% % SAND 65.34% % CLAY/SILT 14.10% MEAN (mm) 1.6255

% SOLIDS 92.91% % WATER 7.09%

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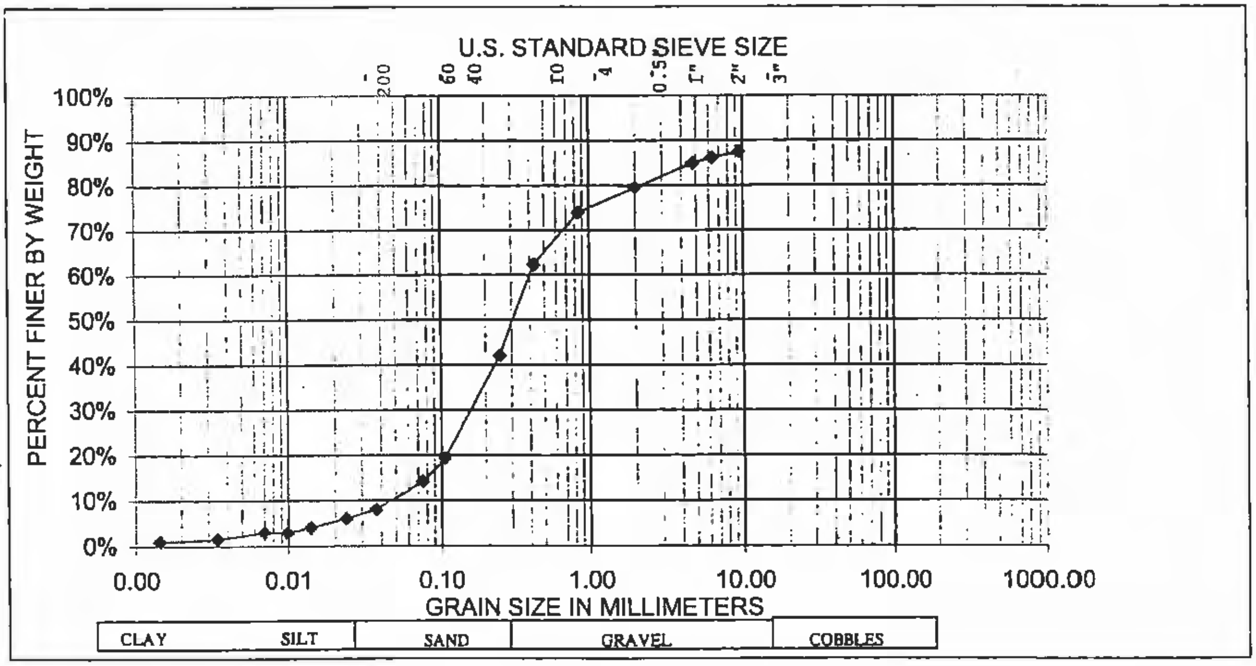
PHONE: (206) 632-2715   FAX: (206) 632-2417

CLIENT SAMPLE ID: TP1-6"



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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

ASTM D422 PARTICLE SIZE

ANALYSIS DATE: 4/27/2005　　LAB SAMPLE ID: TAC001-11A2

ANALYST: S. NIELSON　　CLIENT SAMPLE ID: TP1-12"

TOTAL WET WEIGHT (g) 113.10
TOTAL DRY WEIGHT (g) 105.05

PERCENT SOLIDS @ 105C 92.88%

SIEVE FRACTION
BEAKER TARE: 112.8500
TOTAL DRY WT (g) 207.9300
SAMPLE WT (g) 95.0800

SIEVE FRACTION - SAND GRAVEL　　BEAKER # 2

SIEVE SIZE	(mm)	(g)	(%)	% FINER	COMMENTS
0.375	9.50	17.6073	16.76%	83.24%	
0.25	6.30	5.6717	5.40%	77.84%	
4	4.75	3.2060	3.05%	74.79%	
10	2.00	5.6768	5.40%	69.38%	plants,rocks
20	0.850	4.6867	4.46%	64.92%	plants,sand
40	0.425	8.0198	7.63%	57.29%	
60	0.250	16.4691	15.68%	41.61%	
140	0.106	21.8557	20.81%	20.80%	
200	0.075	5.2256	4.97%	15.83%	
<200	<0.075	6.5064			

TOTAL WT 94.9251
RECOVERY (%) 99.84%

HYDROMETER FRACTION - SILT CLAY
SAMPLE TIME (20C)　　BLANK 1.0

TIME MIN	HYDROMETER	TEMP C	K	DIAM (mm)	Δ wt (g)	(%)	% FINER
2	10.0	21.0	0.0137	0.0370	9.0000	8.57%	8.57%
5	8.0		0.0137	0.0236	7.0000	1.90%	6.66%
15	6.0		0.0137	0.0138	5.0000	1.90%	4.76%
30	4.0		0.0137	0.0099	3.0000	1.90%	2.86%
60	4.0		0.0137	0.0070	3.0000	0.00%	2.86%
250	2.5	21.0	0.0137	0.0034	1.5000	1.43%	1.43%
1440	2.0	21.0	0.0137	0.0014	1.0000	0.48%	0.95%

PHYSICAL PROPERTIES

DISTRIBUTION　% GRAVEL 30.62%　% SAND 53.55%　% CLAY/SILT 15.83%　MEAN (mm) 2.3250

% SOLIDS 92.88%　% WATER 7.12%

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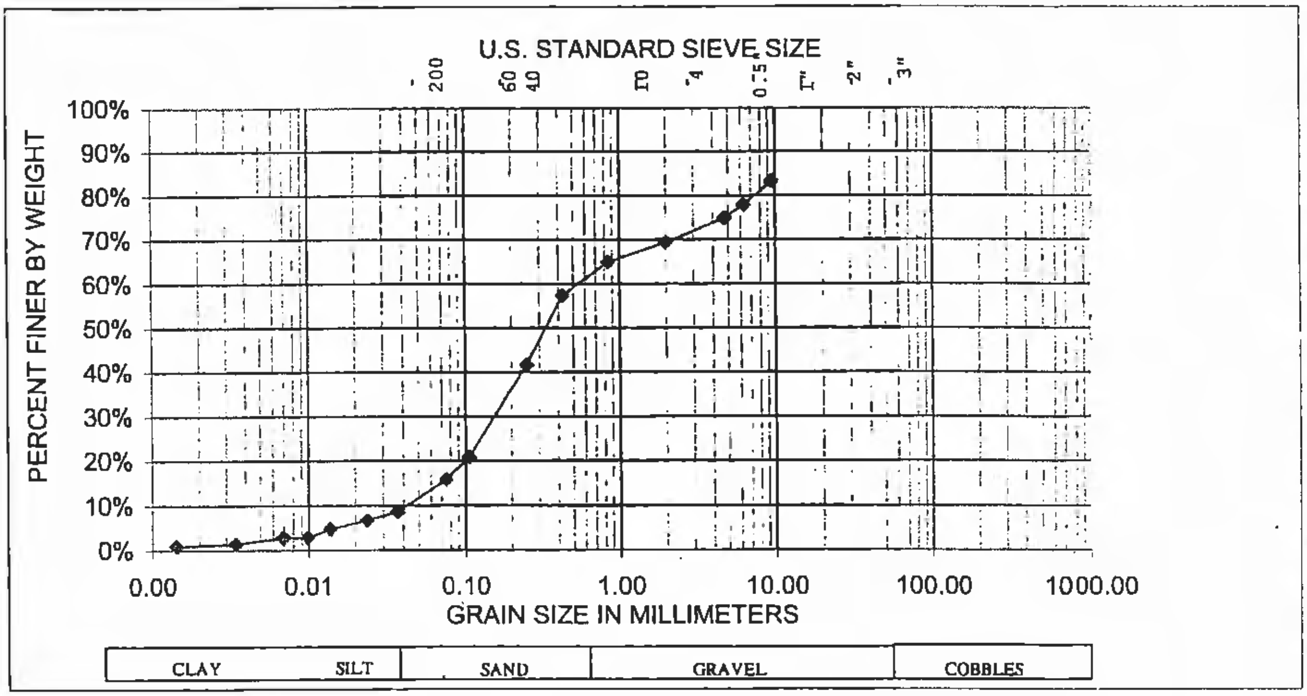
PHONE: (206) 632-2715 FAX: (206) 632-2417

CLIENT SAMPLE ID: TP1-12"



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LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

ASTM D422 PARTICLE SIZE

ANALYSIS DATE: 4/27/2005

LAB SAMPLE ID: TAC001-11A3

ANALYST: S. NIELSON

CLIENT SAMPLE ID: TP2-6"

TOTAL WET WEIGHT (g) 106.67
TOTAL DRY WEIGHT (g) 96.57

PERCENT SOLIDS @ 105C 90.53%

SIEVE FRACTION - SAND GRAVEL

BEAKER # 3

SIEVE FRACTION
BEAKER TARE: 111.7600
TOTAL DRY WT (g) 201.0700
SAMPLE WT (g) 89.3100

SIEVE SIZE	(mm)	(g)	(%)	% FINER	COMMENTS
0.375	9.50	9.3130	9.64%	90.36%	
0.25	6.30	5.0937	5.27%	85.08%	
4	4.75	2.1639	2.24%	82.84%	
10	2.00	5.0135	5.19%	77.65%	plants,rocks
20	0.850	4.5734	4.74%	72.91%	sand,plants
40	0.425	10.8260	11.21%	61.70%	sand,plants
60	0.250	19.3388	20.03%	41.68%	sand,plants
140	0.106	22.5600	23.36%	18.31%	sand,plants
200	0.075	4.5585	4.72%	13.59%	sand,plants
<200	<0.075	5.5866			sand,plants

TOTAL WT 89.0274
RECOVERY (%) 99.68%

HYDROMETER FRACTION - SILT CLAY

SAMPLE TIME (20C) BLANK 1.0

TIME MIN	HYDROMETER	TEMP C	K	DIAM (mm)	Δ wt (g)	(%)	% FINER
2	7.0	21.0	0.0137	0.0376	6.0000	6.21%	6.21%
5	6.0		0.0137	0.0239	5.0000	1.04%	5.18%
15	5.0		0.0137	0.0139	4.0000	1.04%	4.14%
30	4.0		0.0137	0.0099	3.0000	1.04%	3.11%
60	3.0		0.0137	0.0070	2.0000	1.04%	2.07%
250	2.0	21.0	0.0137	0.0035	1.0000	1.04%	1.04%
1440	2.0	21.0	0.0137	0.0014	1.0000	0.00%	1.04%

PHYSICAL PROPERTIES

DISTRIBUTION % GRAVEL 22.35% % SAND 64.05% % CLAY/SILT 13.59% MEAN (mm) 1.6280

% SOLIDS 90.53% % WATER 9.47%

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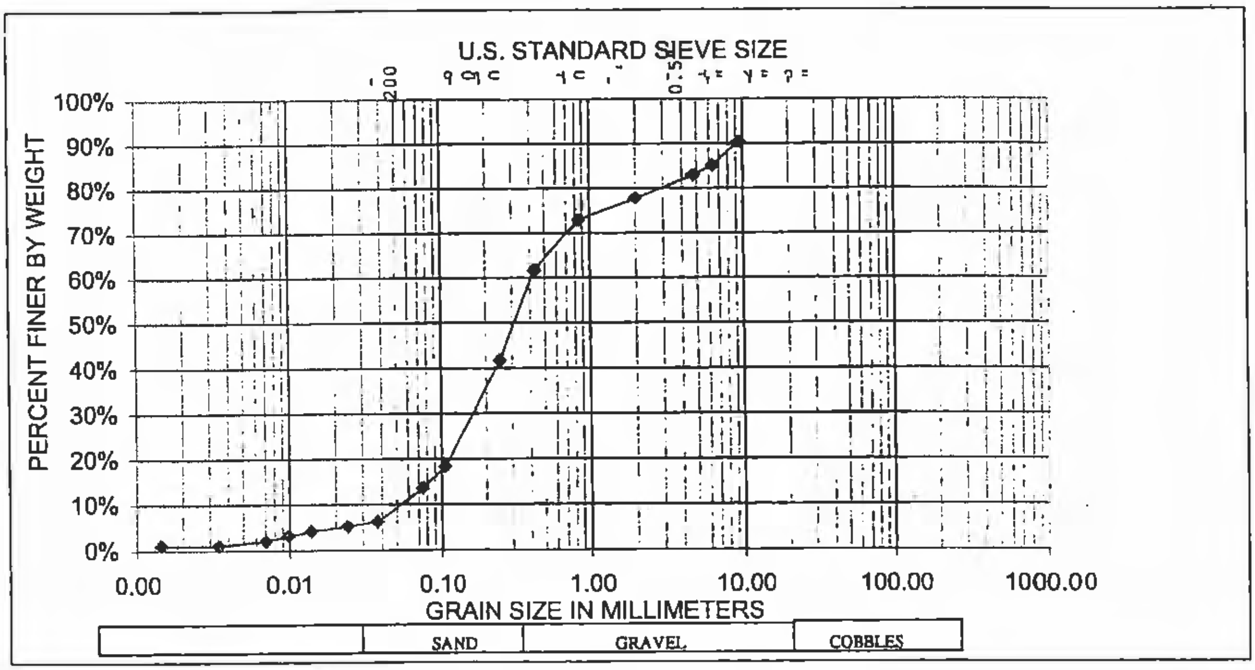
CLIENT SAMPLE ID: TP2-6"



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LABORATORY & CONSULTING SERVICES
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PHONE: (206) 632-2715 FAX: (206) 632-2417

ASTM D422 PARTICLE SIZE

ANALYSIS DATE: 4/27/2005
LAB SAMPLE ID: TAC001-11A4
ANALYST: S. NIELSON
CLIENT SAMPLE ID: TP2-12"

TOTAL WET WEIGHT (g): 112.57
TOTAL DRY WEIGHT (g): 105.26
PERCENT SOLIDS @ 105C: 93.51%

SIEVE FRACTION - SAND GRAVEL
BEAKER #: 4

SIEVE FRACTION
BEAKER TARE: 114.7500
TOTAL DRY WT (g): 206.0900
SAMPLE WT (g): 91.3400

SIEVE SIZE	(mm)	(g)	(%)	% FINER
0.375	9.50	11.0024	10.45%	89.55%
0.25	6.30	2.4888	2.36%	87.18%
4	4.75	2.2364	2.12%	85.06%
10	2.00	5.5276	5.25%	79.81%
20	0.850	5.8478	5.56%	74.25%
40	0.425	10.1766	9.67%	64.58%
60	0.250	18.9764	18.03%	46.56%
140	0.106	23.2416	22.08%	24.48%
200	0.075	5.3445	5.08%	19.40%
<200	<0.075	6.2038		

COMMENTS

TOTAL WT: 91.0459
RECOVERY (%): 99.68%

HYDROMETER FRACTION - SILT CLAY
SAMPLE TIME (20C)
BLANK: 1.0

TIME MIN	HYDROMETER	TEMP C	K	DIAM (mm)	Δ wt (g)	(%)	% FINER
2	11.0	21.0	0.0137	0.0367	10.0000	9.50%	9.50%
5	9.0		0.0137	0.0235	8.0000	1.90%	7.60%
15	7.0		0.0137	0.0137	6.0000	1.90%	5.70%
30	6.0		0.0137	0.0098	5.0000	0.95%	4.75%
60	4.0		0.0137	0.0070	3.0000	1.90%	2.85%
250	3.0	21.0	0.0137	0.0034	2.0000	0.95%	1.90%
1440	2.0	21.0	0.0137	0.0014	1.0000	0.95%	0.95%

PHYSICAL PROPERTIES

DISTRIBUTION % GRAVEL 20.19% % SAND 60.41% % CLAY/SILT 19.40% MEAN (mm) 1.5129

% SOLIDS 93.51% % WATER 6.49%

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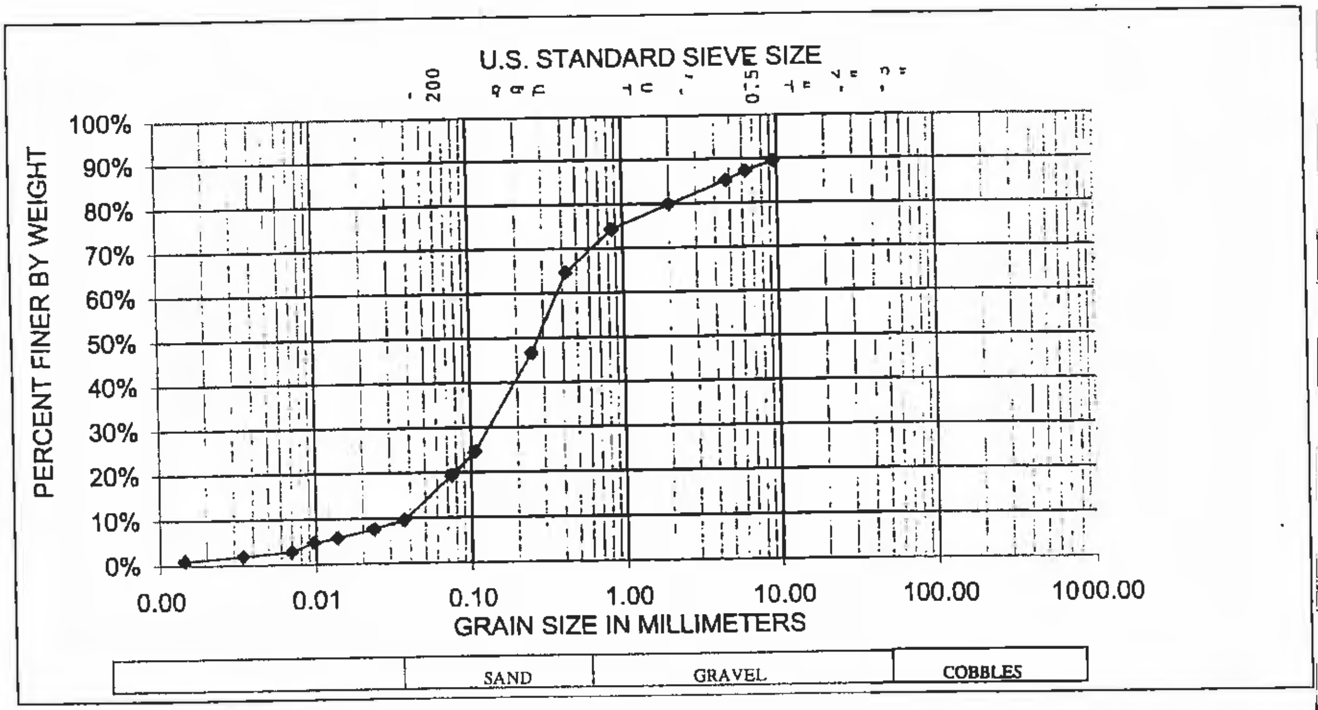
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CLIENT SAMPLE ID: TP2-12"



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LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

ASTM D422 PARTICLE SIZE

ANALYSIS DATE: 4/27/2005
LAB SAMPLE ID: TAC001-11A4-DUP

ANALYST: S. NIELSON
CLIENT SAMPLE ID: TP2-12" - DUP

TOTAL WET WEIGHT (g) 118.49
TOTAL DRY WEIGHT (g) 110.68
PERCENT SOLIDS @ 105C 93.41%

SIEVE FRACTION - SAND GRAVEL

BEAKER # 5

SIEVE FRACTION
BEAKER TARE: 112.8000
TOTAL DRY WT (g) 209.9800
SAMPLE WT (g) 97.1800

SIEVE SIZE	(mm)	(g)	(%)	% FINER
0.375	9.50	9.2113	8.32%	91.68%
0.25	6.30	6.3341	5.72%	85.95%
4	4.75	3.9621	3.58%	82.38%
10	2.00	5.5274	4.99%	77.38%
20	0.850	5.5242	4.99%	72.39%
40	0.425	10.3000	9.31%	63.08%
60	0.250	18.8650	17.04%	46.04%
140	0.106	23.6366	21.36%	24.68%
200	0.075	5.7021	5.15%	19.53%
<200	<0.075	7.7040		

COMMENTS

TOTAL WT 96.7668
RECOVERY (%) 99.57%

HYDROMETER FRACTION - SILT CLAY

SAMPLE TIME (20C)

BLANK 1.0

TIME MIN	HYDROMETER	TEMP C	K	DIAM (mm)	Δ wt (g)	(%)	% FINER
2	11.0	21.0	0.0137	0.0367	10.0000	9.03%	9.03%
5	9.0		0.0137	0.0235	8.0000	1.81%	7.23%
15	7.5		0.0137	0.0137	6.5000	1.36%	5.87%
30	6.0		0.0137	0.0098	5.0000	1.36%	4.52%
60	4.5		0.0137	0.0070	3.5000	1.36%	3.16%
250	3.0	21.0	0.0137	0.0034	2.0000	1.36%	1.81%
1440	2.0	21.0	0.0137	0.0014	1.0000	0.90%	0.90%

PHYSICAL PROPERTIES

DISTRIBUTION % GRAVEL 22.62% % SAND 57.85% % CLAY/SILT 19.53% MEAN (mm) 1.5764

% SOLIDS 93.41% % WATER 6.59%

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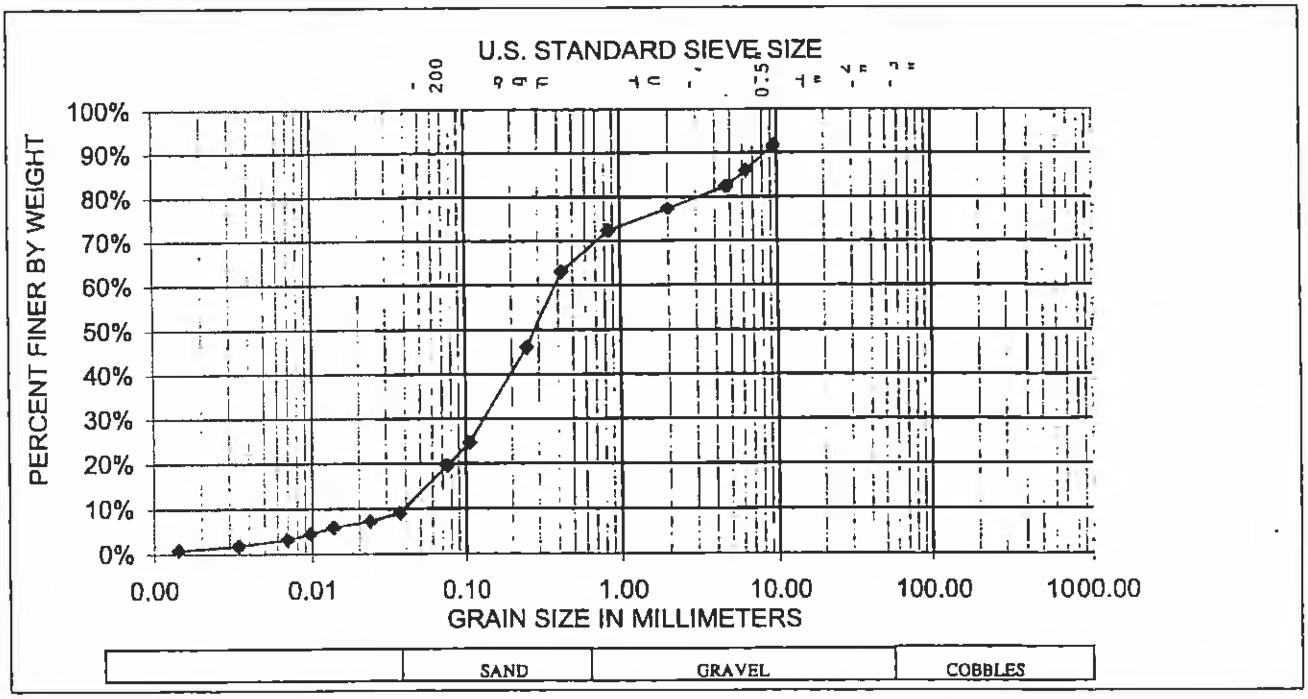
LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CLIENT SAMPLE ID: TP2-12" - DUP



City of Tacoma
Public Works - Environmental Services
Science and Engineering Division

Send Results & Invoice to:
Science and Engineering Division ATTN: Lab
2201 Portland Ave
Tacoma, WA 98421
(253) 502-2130
PO#:

Page 1 of 1 CC# S140.50

Chain of Custody Record

Work Order/Task:
Project Name: Tacoma Landfill Pervious Pavement Project
Samplers (Print): Karen Bartlett

Samples Sent to: Aquatic Research Inc, 3927 Aurora Ave
PO#

Analysis/# of Containers

#	EPA ID	Date	Time	Matrix	Grab	Composite	Sample ID	Total Containers	Particle Size Distribution	Cation Exchange Capacity					Sampler's Initials	Remarks
1		4/26	1:30 PM	soil	X		TP1 - 6" : Landfill Perv. Pavement	1	X	X					KB	Lab# 200504 26224
2		4/26	1:30 PM	↓	X		TP1 - 12" : Landfill Perv. Pavement	1	X	X					KB	225
3		4/26	1:30 PM	↓	X		TP2 - 6" : Landfill Perv. Pavement	1	X	X					KB	226
4		4/26	1:30 PM	↓	X		TP2 - 12" : Landfill Perv. Pavement	1	X	X					KB	227
5																
6																
7																
8																
9																Request ASTM D422
10																for particle size.
11																
12																
13																
14																
15																
16																

Reliquished By (Signature):	Date/Time	Received By (Signature):	Reliquished by (Signature):	Date/Time	Received for Laboratory by (Signature):
Karen Bartlett	4/26/05 15:15			4-26-05 15:15	Bill Eramein

Reliquished By (Signature):	Date/Time	Received for Analysis By (Signature):	Date/Time	Remarks
Bill Eramein	4-27-05 1325	[signature]	4/27/05 1325	

Distribution WHITE - Laboratory CANARY - Other PINK - Inorganics GOLDENROD - Organics

PWK 5235 0068 (05/03)h

APPENDIX B. QUALITY ASSURANCE PROJECT PLAN (QAPP)

TACOMA LANDFILL PERVIOUS PAVEMENT RUNOFF MONITORING

QUALITY ASSURANCE PROJECT PLAN

Prepared By:
CITY OF TACOMA
June 2006

APPROVALS:

Karen Bartlett **Date** Project Manager City of Tacoma	**John O'Loughlin** **Date** Assistant Division Manager City of Tacoma
Christopher Getchell **Date** Laboratory Supervisor City of Tacoma	**Dana de Leon** **Date** QA Manager City of Tacoma

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DISTRIBUTION LIST

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Tacoma, WA 98421
(253)502-2108

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City of Tacoma
Environmental Services Engineering
2201 Portland Avenue
Tacoma, WA 98421
(253)502-2130

Dana de Leon, P.E.
City of Tacoma
Environmental Services Engineering
2201 Portland Avenue
Tacoma, WA 98421
(253)502-2109

Lewis Griffith, P.E.
City of Tacoma
Environmental Services Engineering
2201 Portland Avenue
Tacoma, WA 98421
(253)573-2420

Karen Bartlett
City of Tacoma
Environmental Services
2201 Portland Avenue
Tacoma, WA 98421
(253)502-2257

DEFINITIONS

Equipment Rinsate Blank – A blank sample consisting of reagent grade (analyte free) water that is run through the sampling equipment following the decontamination procedure and prior to sampling. The water that is run or "rinsed" through the equipment is then analyzed for parameters listed in Table 1. Will be labeled with "Equipment Rinsate Blank" and the sampler ID.

Field Duplicate – A second independent (individual) sample collected at the same location and analyzed as an independent sample. Will be labeled with the location name followed by "DUP"

Laboratory Duplicate – An intralaboratory split sample which is used to document the precision of a method in a given sample matrix. Laboratory Duplicates will be labeled with the sample's laboratory number followed with a "D".

Laboratory Splits – An identical aliquot of a single sample. One sample is homogenized and two aliquots are removed and analyzed separately. One sample is analyzed in-house as the sample. The other sample is analyzed by an outside laboratory as a split. Laboratory Splits will be labeled with the sample's identifier followed with "SPLIT". It will have its own laboratory number.

Matrix Spike – An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike sample is used to document the bias of the method in a given sample matrix. Matrix spike samples will be labeled with the sample's laboratory number followed by "S".

Matrix Spike Duplicates – Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike sample is used to document the precision and bias of the method in a given sample matrix. Matrix spike samples will be labeled with the sample's laboratory number followed by "M".

Method Blank – A blank sample consisting of reagent grade (analyte free) water that is analyzed with each sample analysis batch. Metals and Conventionals Method Blanks will be labeled with the first sample in the batch's lab number followed by "PBW" for water analyses and "PBS" for soil analyses. Organics Method Blanks will be labeled with the date of extraction followed by "QC*BW" for water analyses and "WC*BS" for soil analysis. * is replaced by P or PCB for the Pesticides or PCB analysis, and left out for Semi-Volatile Organics.

Reporting Limit – The lowest value at which data will be reported.

Reporting Limit for Sediment – $\frac{(A)(B)}{(C)(D)}$

A = Low Calibration Std in ug/L
B = Extract Volume or Digestate Volume in L
C = Sample Weight extracted in g
D = Decimal Value of the %Solids

Serial Dilution Sample – An aliquot of digested metals sample, diluted by a factor of 5, and analyzed for the target analyte(s). The Serial Dilution sample is used to document the possible interfering elements for ICP analysis. Serial Dilution samples will be labeled with the sample's laboratory number followed by "L".

Surrogate – An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical procedures, but which is not normally found in environmental samples. Surrogate samples will be labeled with the sample's laboratory number followed by "R".

1.0 PROJECT ORGANIZATION

Successful completion of the sampling and analysis requires coordination and adherence to the Quality Assurance Project Plan (QAPP). Staffing and responsibilities are outlined below.

1.1 PROJECT PLANNING AND COORDINATION

Project coordination is the responsibility of Karen Bartlett, Pubic Works Department, Environmental Services Science and Engineering Division. Ms. Bartlett is the primary project contact.

1.2 FIELD SAMPLE COLLECTION

Christopher L. Getchell, Public Works Department, Environmental Services, Science and Engineering Division, is the Supervisor of the City's Laboratory, and will be responsible for monitoring weather forecasts, programming samplers, and overseeing the collection of samples. The field team will consist of City laboratory personnel and, as necessary, other City staff. City staff will collect the samples and record the necessary data on those samples. Mr. Getchell will provide oversight of the field team, ensuring strict adherence to the procedures defined in this QAPP. Mr. Getchell will also oversee the production of the Field Reports. Ms. Bartlett will work closely with Mr. Getchell to ensure consistency with this plan.

The City lab staff has worked with Isco sampling equipment for many years and therefore the theory of flow weighted composite sampling is not new. The manufacturer's representative has provided City staff with training on the use of this specific sampling equipment. The training covered installation, operation, maintenance, use of software and programming of the samplers.

Mr. Getchell will initially be responsible for programming the automatic samplers and for monitoring weather forecasts. Once the project is up and running, Mr. Getchell will be responsible for training additional staff to back him up.

1.3 CHEMICAL ANALYSES

All samples will be submitted to the City of Tacoma's laboratory. The City lab will perform the analysis of selected semi-volatiles, selected metals, hardness, pH, Total Suspended Solids (TSS), Total Solids (TS), Total Volatile Solids (TVS), and Northwest Total Petroleum Hydrocarbon – Diesel extended (NWTPH-Dx). Grain size will be contractor out and analyzed by a private laboratory under contract with the City lab.

The City laboratory is accredited by the Washington State Department of Ecology (Ecology) for the listed analyses. Laboratory Standard Operating Procedures (SOPs) are available at the Public Works Department Environmental Services/ Science & Engineering Division Laboratory. Mr. Getchell will provide oversight of the analytical laboratories, ensuring strict adherence to the procedures defined in this QAPP. The data will be assembled into tabular format and included as part of the final report. A list of parameters, analytical methods, and target reporting limits are included in this QAPP in Table 1.

1.4 LABORATORY QA/QC MANAGEMENT

Lori Zboralski, the QC Officer for the City's laboratory, will perform the QA/QC review of the data, and produce the Quality Assurance Data Summary Package. Mr. Getchell will provide final review of the Quality Assurance Data Summary Package, and will serve as the overall Quality Assurance Manager for the project.

1.5 DATA MANAGEMENT AND ANALYSIS

Dana de Leon, P.E., Public Works Department, Environmental Services, Science & Engineering Division, will supervise data management and statistical analysis of hydrologic, stormwater, and sediment data.

1.6 FINAL REPORT

Karen Bartlett will be responsible for assembling the Final Report describing sample locations; sampling, handling, and analytical methods; data reports including QA/QC chemistry and data validation, database management, statistical evaluations, and an evaluation of data results.

2.0 PROJECT DEFINITION/DESCRIPTION

2.1 BACKGROUND

2.1.1 Tacoma Landfill

The Tacoma Landfill is a solid waste facility that is owned and operated by the City of Tacoma Solid Waste Utility. The site covers approximately 240 acres located on the west side of the City and is bounded approximately by South 31st Street on the north, Tyler Street on the east, South 48th Street on the south, and Orchard Street on the west (Figure 1). The Tacoma Landfill began operation in 1960.

In 1983, an investigation by the Environmental Protection Agency (EPA) resulted in the Tacoma Landfill being placed on the National Priorities List (NPL) of hazardous waste sites as part of the South Tacoma Channel Superfund Site. On March 31, 1988, EPA issued a Record of Decision (ROD) for the Tacoma Landfill, which presented the selected remedial action for the landfill. The selected remedial action included landfill capping and constraints for site operations; installation of a groundwater extraction/treatment system; elimination of offsite landfill gas migration through a gas extraction/flare system; environmental monitoring, including groundwater, surface water, and air emissions; and provision of an alterative water supply to the City of Fircrest and any Tacoma resident deprived of their domestic water supply through contamination emanating from the landfill or as a result of the operation of the extraction system. The City, under a Consent Decree negotiated with EPA and Ecology, has implemented the remedial actions specified in the ROD.

All regions of the landfill are capped, except for a 31 acre region known as the Central Area, which is a permitted, lined and operating cell. The goal of the cap system is to prevent water from entering the buried refuse, since water flowing through the refuse layer could cause additional groundwater contamination if pollutants leach from the refuse. The landfill cap system (Figure 2) consists primarily of cover material, a drainage net, and two impermeable liners that cover refuse material. The cap system also contains a primary and secondary drainage system to convey water away from capped areas (Figure 3). The primary drainage system is located above the first impermeable membrane. Water is collected primarily in surface ditches containing a perforated PVC pipe. The secondary drainage system is located between the two impermeable liners and consists of a filter wrapped PVC underdrain pipe. Water collected in the cap drainage system is conveyed to the Storm Sewer.

2.1.2 New Parking Lot – Pavement Options

An additional 36,100 square foot paved area has been constructed to provide additional employee parking and storage areas for the Tacoma Landfill. The new paved area is adjacent to the current Solid Waste employee parking lot, located on the east side of the administration building (Figure 4). An existing storm sewer system exists in the vicinity of the parking lot, which discharges parking lot runoff through the City Storm Sewer System.

The parking lot site is located on the existing landfill cap. Options for paving the site included the use of impervious and pervious pavements. Impervious pavement would have required removing sections of the cap system and excavating garbage to provide adequate depth to install a stormwater collection system and stormwater quality treatment and flow control devices.[1] On the other hand, pervious pavements allow rainwater to infiltrate through the pavement and into the landfill cover layer, prior to entering the landfill cap primary drainage system. Infiltration through the pervious pavement and cover material provides basic water quality treatment and reduces flow control requirements. The existing cap drainage system conveys the parking lot drainage to the City Storm Sewer system; no additional stormwater water quality treatment is required.

To provide a comparison between pervious and impervious pavement, the new parking area was paved in sections. Each section (9,028 square feet) was constructed with a different product. Pervious concrete, pervious interlocking concrete pavers, pervious asphalt, and a control area paved with a standard asphalt each contribute 9,028 square feet to the new paved area. Cross sections of the standard asphalt and pervious pavement are shown in Figure 5. Additionally, a grass area (9,028 square feet) adjacent to the site will be used as a control and tested for water quality and flow control. Test results will be compared to both impervious and pervious pavement areas and be used for future stormwater modeling of the landfill cap.

2.1.3 Downstream Stormwater Flow Path and Flow Control

The new parking lot is located on the east side of the Landfill. Surface water is collected in the Landfill primary drainage system prior to entering the Landfill storm sewer system, where it is conveyed to a detention pond located on the eastern border of the Landfill property. Following detention, the stormwater enters the public storm system which conveys storm water through the Flett Creek holding basins prior to discharging to Flett Creek, a tributary of Chambers Creek, located in the Chambers-Clover Creek Watershed. Finally, collected stormwater discharges to Puget Sound through Chambers Bay.

The 27,084 square feet of pervious pavement drains to the same cap drainage system where the current unpaved surface area drains. The landfill cover layers provide water quality treatment for all pervious pavement sections. Water quality treatment for the 9,028 square feet of standard asphalt will be provided by discharging runoff to an existing grass lined drainage channel. Flow control for the 36,102 square feet of new

[1] City of Tacoma's Surface Water Management Manual require stormwater treatment for all projects over 5,000 square feet of new or replaced, pollution generating, impervious surfaces and flow control for all projects over 10,000 square feet new or replaced impervious surfaces.

effective impervious surface (pervious pavement and standard asphalt) associated with the parking lot is provided by the existing stormwater detention pond.

2.1.4 Stormwater Quality Regulatory Information

In addition to regulatory requirements under the Clean Water Act to maintain water quality standards in the region, discharges from the Tacoma Landfill are also subject to requirements set forth in an Industrial Stormwater Permit through Ecology and the National Pollution Discharge Elimination System (NPDES). Currently, all stormwater leaving the Tacoma Landfill is periodically sampled for the contaminants listed in Table 2[2]. Exceedances of these Action Levels trigger additional evaluations and/or treatment by the Landfill. Thus, the ability of pervious pavements to help treat stormwater runoff through infiltration into the cap may demonstrate its usefulness in future Tacoma Landfill projects.

In addition to helping the Tacoma Landfill improve its stormwater quality, reductions in stormwater contamination will help support the general City-wide stormwater program. Sampling results will provide information on the effectiveness of pervious pavements for flow control and water quality treatment and will be used to support the City of Tacoma Surface Water Management Manual.

2.2 SCOPE OF SAMPLING AND ANALYSIS EFFORT

Monitoring to be performed under this QAPP will include whole-water, sediment, and soil sampling.

Whole-water samples will be analyzed for target analytes, including selected semi-volatiles (PAHs and phthalates), metals (copper, lead, mercury, and zinc), hardness, pH, TSS, and NWTPH-Dx. Autosamplers will be used to collect stormwater runoff from the standard asphalt section and from subsurface flow from the three pervious pavement sections and the grassy control region. Surface runoff from the three pervious pavement sections will be collected in a sump; manual grab samples will be taken from the sump. When an autosampler is used, samples will be obtained using automated flow composite sampling.

Sediment samples will be collected from a catch basin associated with the standard, impervious asphalt section. Sediment samples will be analyzed for target analytes, including selected semi-volatiles (PAHs and phthalates), metals (copper, lead, mercury, and zinc), NWTPH-Dx, Total Volatile Solids, Total Solids, and grain size.

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[2] The Industrial Stormwater Permit conditions do not apply to employee parking areas. However, runoff from existing employee parking areas is not separated from other "industrial" runoff. Downstream stormwater sampling, required to meet the limits set forth in the Industrial Stormwater Permit, currently measures all runoff from the Tacoma Landfill.

Soil samples will be collected at study inception (as a "background") and completion from the subsurface of the pavement sections. Soil samples will be analyzed for target analytes, including selected semi-volatiles (PAHs and phthalates), metals (copper, lead, mercury, and zinc), NWTPH-Dx, and Total Solids.

A complete listing of analytical methods and reporting limits are provided in Section 10.0 and Table 1.

2.3 SAMPLING DURATION

The project site will be monitored for a minimum two year period. Stormwater samples will be collected during storm conditions as described in Section 5.2.1. Soil samples will be collected prior to and after the two year monitoring period as described in Section 6.0. Sediment samples will be collected at the end of the two year monitoring period and at interim periods as necessary. Details are provided in Section 7.0.

The project site will be revisited after five years to determine the durability of pervious pavements and the maintenance requirements. Storm flow peak rate variations and water quality treatment will be analyzed. Data quality objective and sampling protocols will be developed based on the results of the initial two year monitoring period.

2.4 OBJECTIVES

The objectives of this Quality Assurance Project Plan (QAPP) are:

- Flow Control: To investigate the effectiveness of different pervious pavement types (concrete, asphalt, and interlocking pavers) to infiltrate and attenuate storm flow peak rate variations. Results will be analyzed using correlations and parametric/nonparametric statistical tests.
- Water Quality Treatment: To investigate each pervious pavement's ability to reduce the concentration of selected pollutants in stormwater runoff and to provide a preliminary determination of the treatment level (basic versus enhanced). This will be achieved by a comparison with runoff from standard asphalt pavement and with infiltrated stormwater from the grassy control area. Results will be analyzed using correlations and parametric/nonparametric statistical tests. Soil samples from below the pervious pavement sections will be collected at study inception and completion to determine accumulation of selected pollutants in the subsurface.
- Maintenance: To investigate the maintenance requirements and frequency for each pavement type. This will be achieved by comparing the amount of surface runoff from each pervious pavement over time and by visual inspection.
- Durability: To evaluate the different pavement types for their suitability for storage and parking at the Landfill. This will be achieved by visual inspection of pavement durability over time.

These objectives will be accomplished through performance of the following:

- Develop a QAPP that is consistent with listed analytical protocols.
- Submit the stormwater samples (both infiltrated and runoff) to the City laboratory for analysis of selected semi-volatiles (PAHs and phthalates), selected metals (copper, lead, mercury, and zinc), hardness, pH, NWTPH-Dx, and TSS.
- Submit stormwater sediment samples to the City laboratory for analysis of selected semi-volatiles (PAHs and phthalates), selected metals (copper, lead, mercury, and zinc), total solids, total volatile solids, grain size, and NWTPH-Dx.
- Submit subsurface soil samples to the City laboratory for analysis of selected semi-volatiles (PAHs and phthalates), selected metals (lead, mercury, and zinc), and NWTPH-Dx.
- Produce a Field Report for each sampling event, comparing specific sample collection parameters with the goals and criteria outlined in this QAPP.
- Review the analytical data to assure data quality.
- Perform the statistical analyses
- Produce a Quality Assurance Data Summary Package for each sampling event.

Figure 6 provides a project schedule for completion of these objectives.

3.0 DATA QUALITY OBJECTIVES AND CRITERIA

The City of Tacoma will adhere to their Standard Operating Procedures (SOPs) and accepted analytical methods for collection, preservation, transportation, storage, and analysis of samples in an effort to limit sources of bias. The City's SOPs are available at the Public Works Department Environmental Services/ Science & Engineering Division Laboratory. An overview of the procedures for sample collection and processing are presented in Sections 5.0, 6.0, and 7.0. The analytical methods to be used are presented in Table 1. Every attempt will be made to achieve the reporting limit goals identified in Table 1.

3.1 PRECISION

Precision is a measure of scatter in the data due to random error from sampling and analytical procedures. Precision will be measured using relative percent difference (RPD) on laboratory duplicates.

RPD is calculated by:

$$\text{RPD} = 100 \times \left(\frac{\text{Sample Concentration} - \text{Duplicate Concentration}}{\text{Average Concentration}} \right) \qquad (1)$$

Acceptable limits of laboratory duplicates and Matrix Spike Duplicates (MSD) are listed in Table 3. The frequency of laboratory duplicates and Matrix Spike Duplicates is listed in Table 4. These tests will allow the City to estimate the precision of the data set. Specific details regarding field and laboratory quality control samples are discussed in Section 11.0, including number of control and duplicate samples, which will be performed on each batch.

3.2 BIAS

Bias is a measure of the difference between the parameter result and the true value due to systematic errors. Possible sources of systematic errors are collection, sample instability (physical/chemical), interferences, calibration, contamination, etc.

Bias associated with sample matrix will be measured using the percent recovery (%R) on laboratory control samples and matrix spikes recoveries. Matrix spikes may provide an indication of bias due to interference from the sample matrix. The acceptable recoveries for Laboratory Control Samples (LCS) and Matrix Spikes for the parameters to be analyzed are listed in Table 3. The frequency of LCS and matrix spike samples is listed in Table 3.

Percent Recovery is calculated by:

$$\%\text{R} = 100 \times \left(\frac{\text{Measured Concentration}}{\text{True Concentration}} \right) \qquad (2)$$

Matrix Spike Recovery is calculated by:

$$\%R = 100 \times \left(\frac{\text{Spiked Sample Result} - \text{Sample Result}}{\text{Spike Added}} \right) \quad (3)$$

Surrogate Recovery is calculated by:

$$\%R = 100 \times \left(\frac{\text{Measured Concentration}}{\text{Amount Added}} \right) \quad (4)$$

Bias associated with contamination will be assessed by analysis of equipment rinsate blanks and laboratory method blanks. The equipment rinsate blank is a measure of field concentration whereas the method blank is a measure of laboratory contamination. When a contaminant is found in the blank, the sample concentration must be at least 5 times the concentration of the blank in order to be considered a valid number. Blanks that show contamination result in data being qualified (estimated) up to 10 or 5 times the blank value.[3]

The frequency of method blank samples is listed in. The frequency and location of the equipment rinsate blank samples are described in Section 11.2. One field replicate for field measurements will be collected once per day. Three blind duplicate samples will be collected during the course of this sampling program. The duplicate samples will be analyzed together to provide an estimate of overall variability in the data.

3.3 REPRESENTATIVENESS

3.3.1 Whole-Water

This project will measure stormwater flow variations and stormwater quality of both the surface water runoff and the stormwater that infiltrates the pervious pavements and the grassy area. With regard to stormwater, representativeness is achieved by selecting sampling locations, methods and times so that the data describes the characteristics of stormwater runoff from the site, the varying hydrologic conditions within an individual storm event (i.e. rising and falling portions of the hydrograph), and a representative cross-section of storm types. Additional details regarding representativeness of sample locations, collection of storm flows, and the criteria used for sampling are presented in Sections 5.2, 6.0, and 7.0.

Representativeness of Individual Storm Events. Stormwater samples will be flow-weighted composite samples representing the range of discharge conditions during the

[3] Blank contamination is qualified at specified levels based on the recommendations found in the CLP Functional Guidelines for Organic Data Review (February 1994).

sampling event, including where possible the rising and falling portions of the runoff hydrograph.

Representativeness of Storm Types. Storm events are variable in nature by runoff volume, flow rate, antecedent rainfall, and season. This variability will be evaluated by comparing the magnitude and intensity of the runoff hydrographs, where samples were collected on the hydrographs, time between storm events, and time of year the samples were collected to determine whether a representative range of storm types was included in the monitoring program.

3.3.2 Soil Samples

Subsurface soil samples will be collected for each pervious pavement type at the beginning and end of the two year study. A composite sample will be created using subsamples collected from each pavement section. This will be a useful tool to determine the accumulation of pollutants in the pavement subgrade. Refer to Section 6.0 for additional details.

3.3.3 Sediment Samples

Material captured by the catch basin sump is representative of settleable solids which are transported by stormwater. The sump will be inspected periodically throughout the sampling period to determine the depth of accumulated sediment. In the event that the sump needs to be cleaned out prior to the end of the sampling period, the City will determine the appropriate course of action. The actual sample will be collected from several locations in the catch basin and mixed well to form a composite sample.

3.4 COMPLETENESS AND COMPARABILITY

The completeness and usability of the data will be maximized by using proven sampling techniques, packaging samples for transport to avoid breakage, and timely processing at the laboratory. The analytical requirements in sample volumes to achieve analysis goals will be met to assure acceptable data. Where possible, excess sample will be archived until the laboratory results can be reviewed by the project manager. The goal for generation of useable data will be 100%.

For comparability, the analytical chemistry methods were selected to be appropriate for comparison with other stormwater data sets.

4.0 SAMPLING LOCATIONS

4.1 WHOLE-WATER SAMPLING LOCATIONS

For each pervious pavement area and the grassy control area, stormwater infiltrated through the area will be sampled for flow and water quality by collecting whole-water, flow weighted composite samples. Subsurface lateral flow between pavement areas and the grass control area is prevented using an impermeable clay barrier. Additionally, an underdrain and impermeable barrier are located immediately upgradient of the project area to prevent subsurface flow from entering the project site.

For the standard (impervious) asphalt area, surface runoff will be sampled for flow and water quality by collecting whole-water, flow weighted composite samples. Surface water runoff in the standard asphalt section is isolated from surrounding areas by concrete curbs and asphalt berms.

Surface water runoff generated from pervious pavement areas will be collected in small sumps and sampled manually. Runoff volume collected in the small sumps will be measured manually by measuring the depth of water in the basin. The sump is equipped with a shear gate to prevent unwanted discharge of the stormwater samples. The shear gate will remain closed during sampling events. Surface water runoff in the test sections are isolated from surrounding areas by concrete curbs and asphalt berms.

Sampling locations for whole-water samples are identified in Figure 7.

4.2 SOIL SAMPLING LOCATIONS

The City plans to collect soil samples from a minimum of two locations for each pavement type at the end of the study period. If sample results are dissimilar, additional samples may be collected. In addition, a ‘background’ sample will be collected prior to study commencement after project construction is complete. Sampling locations for soil samples are identified in Figure 7.

4.3 SEDIMENT SAMPLING LOCATIONS

The City plans to collect sediment samples from the catch basin sumps for the standard asphalt and pervious pavement sections. The sump locations are shown on Figure 7.

5.0 WHOLE-WATER SAMPLE COLLECTION AND PROCESSING

5.1 SAMPLING EQUIPMENT

For this project, the City will use five Isco 6700 samplers with flow monitoring modules and five sampling bases along with support equipment (battery charges, data modules, sampler tubs, strainers, glass jars, etc.) to collect stormwater runoff from the standard asphalt section and infiltrated stormwater from the pervious pavement sections and grassy control region. The samplers are composite samplers with sequential sampling capabilities. Each sampler base contains one 12-liter discrete sample containers. For the purpose of this project, the samplers will be programmed to collect both flow proportional discrete samples and grab samples (see Section 5.1.2).

Teflon suction tubing, silicon pump tubing, and glass bottles will be used in all locations. Sampler probes will be attached to the bottom of a mounting ring that is installed into the inlet side of the manhole. The sampler will be located at the ground surface adjacent to the sampling manhole.

Manual sampling will be required to test surface water runoff from the pervious pavement sections. Following a storm event, runoff collected from each pervious pavement section will be measured and recorded. The samples will be collected manually from the catch basin by dipping the sample container directly into the water. If insufficient volume exists in the catch basin to dip the entire container, a clean stainless steel container will be used to dip the sample out of the catch basin and fill the sample containers. After sampling, water remaining in the sump will be discharged from the catch basin. Care shall be taken not to collect or disturb sediment in the bottom of the basin. Catch basin sediment will be sampled as described in Section 7.

5.1.1 Sampler Decontamination Procedures

All sampling equipment and containers will be prepared prior to the sampling event. Decontamination procedures are included in the lab's SOPs, which are available from the Public Works Department Environmental Services/ Science & Engineering Division Laboratory. For this project, auto sampling equipment will be decontaminated in accordance with the existing SOP entitled Glassware Cleaning Following EPA Protocols with the addition of the 5% Nitric acid rinse. After decontamination, the Teflon suction tubing, strainers and silicone tubing will be wrapped in aluminum foil until placed in the field. The ends of the tubing will also be capped with aluminum foil.

Prior to installation, all automatic sampling equipment (ISCO sampler head, Teflon suction tubing, strainers, silicone tubing and all other sampling equipment except glass sampling jars), will be decontaminated according to the steps listed below. After the equipment has been installed and used, the ISCO sampler head (silicon tubing only) and ISCO base will be decontaminated at the lab using the same steps, but the Teflon tubing will be left in place at the sample station and rinsed with 1 gallon of global reagent grade water between each sample event or during routine maintenance.

The sampler will be run on continuous pumping for two minutes with each of the following solutions in the order listed:

- Hot soapy water (2 minutes) with nonphosphate detergent
- Cold tap water (2 minutes)
- Deionized (reagent grade) water (2 minutes)
- 5% nitric acid (2 minutes)
- Deionized (reagent grade) water (2 minutes)
- Methanol (2 minutes)
- Deionized (reagent grade) water (2 minutes)
- Wrap or cap with aluminum foil where appropriate

While deployed in the field, the Teflon sampler/suction hose field rinsing will include pumping (or pouring) one gallon of reagent grade water through the Teflon sampling hose after each sampling event or during weekly maintenance. After each sampling event, the sampler silicon pump tubing will either be replaced with a new silicon hose or a laboratory decontaminated silicone hose. In addition, after sampling the base of the sampler will be replaced with a different base containing sampling jars that have undergone decontamination according to the laboratory's SOP stated above.

Equipment rinsate blanks will be performed by running enough DI (reagent grade) water through a decontaminated Teflon sampler hose, strainer and silicone pump tube installed in the sampler, into a pre-cleaned sampler containers until sufficient volume is collected to run the analytes of interest (see Section 11.2).

The City laboratory will provide glass containers for collecting samples. Glass containers and jars (ISCO 1000 ml glass containers) will be pre-cleaned according to laboratory SOP and is listed below:

- Wash glassware in automatic dishwasher
- Rinse with 1:1 nitric acid
- Rinse three times with DI (reagent grade) water
- Rinsed with Acetone, oven dry or air dry to remove water
- Rinse with Methylene chloride
- Air dry or oven dry bottles, caps and liners to remove remaining Methylene Chloride
- Cap or cover each piece of glassware with aluminum foil and label each piece of glassware with a lot number
- Submit one container from each lot to the metals section and to the organics section for certification

Certification information is kept in the glassware certification file and is available for review at any time. The same procedures are used for cleaning sampling equipment and containers for SIM analysis. The containers will be certified to the detection limits of the project.

5.1.2 Sampler Activation and Programming Protocols

The samplers and their programs will be activated using one or several activation protocols including time or flow rate. The activation protocols are dictated by the site conditions and previous sampling results.

Once the sampler is activated, the sampler will be programmed to collect discrete/sequential flow proportional samples. Samples are taken flow proportionally based on the flow proportional sampling criteria set (every 25 gallons, 50 gallons, or what ever is set by the user). Each time the sampler samples, an approximately 200 to 250 ml sample is taken. Samples are composited in the sample container. A complete sampling sequence could potentially include 48 samples filling one 12-liter containers. Specific sample collection sequences will be determined for each autosampler location depending on initial test results. A minimum volume of 3 to 6 liters (12 to 24 aliquots, depending on the QC that is being performed) is required to perform the selected analyses.

The frequency of the flow proportional sampling is of course dependent on the magnitude of the storm and the flow in the through the pavement system. Flow proportional sampling criteria may be at times adjusted based on the magnitude of the storm that is being predicted. At times, a small storm may not achieve the necessary volumes to trigger enough sampling to meet the minimum volume criteria to perform the necessary analysis. At other times, if the flow proportioning is set to low, and a large storm is encountered, the sampling containers may all be filled in a very short period of time and only a small portion (the beginning) of the storm will be sampled. For all sampling conditions, the samplers will be programmed to perform one pre-flush prior to taking a sample.

The samplers will be programmed to sample anytime conditions indicate that runoff is occurring. Flow proportional discrete samples will be collected as long as the programmed flow rate is met or until all containers are full. A complete sampling event would result in all the sample bottles being filled over the first 24 hours of the storm or 75% to 100% of the storm hydrograph.

Flow rate (GPM) is a condition that can be programmed into the sampler. Once a specified flow rate in gallons per minute is achieved or surpassed, the sampler will activate a flow proportional sampling program. As long as the pre-set flow condition continues to be met, the sampler program will continue. If the flow should drop below the pre-set value, the program will pause the flow proportional sampling program until the flow increases to, or above the setting.

5.1.3 Sampler Maintenance

The samplers will be deployed when a sample is needed and the appropriate sampling conditions are approaching. Other times, the samplers will be removed and returned to the laboratory. While at the laboratory, the samplers will be cleaned and decontaminated as described above, and stored until needed for sampling. If a sampler develops mechanical problems, a replacement sampler will be programmed for that specific location. Samplers will be maintained (download data, change battery, rinse sampling hose, etc.) at least once a week.

5.2 STORMWATER SAMPLE COLLECTION AND PROCESSING

5.2.1 Stormwater Event Criteria and Frequency

For each of the sampling regions (standard asphalt, three pervious pavements, and grassy area), stormwater samples will be collected during storm flow conditions. Sampling frequency for storm flows will be one sample per month with a minimum of two weeks between sampling events, provided sampling opportunities present themselves. Generally, the City will sample whenever conditions present themselves in an attempt to get one to two storm sample(s) per month. Once one or two acceptable stormwater samples have been collected for the month, no additional samples will be collected until the next month. If a sample is not collected in that month, the City will collect two samples in the next month with a minimum of two weeks between sampling events. Sampling will be conducted for two years with a minimum of ten storms sampled per year.

It is anticipated that a greater number of samples will be collected during the winter months with fewer samples in the spring and fall and fewer yet samples in the summer. By sampling once a month, the storms that are sampled will be collected throughout the year and representative of winter, spring, summer and fall storms. Seasonal first flush is the first significant precipitation event that occurs following a dry summer period.

An acceptable precipitation event is defined as follows:

- Total precipitation of at least 0.2 inches.
- Less than 0.02 inches of precipitation in the previous 24 hours (an antecedent period of 24 hours).

  Note: Measured rainfall amounts that are greater than six hours apart are considered separate storm events and samples from these events will not generally be composited as a single storm event. Precipitation measurements are recorded daily at the Tacoma Landfill and will be used to determine the storm or dry weather conditions.

The above criteria should be considered goals. Each event sampled will be evaluated in meeting these goals, but circumstances may at times arise where all of these goals cannot be met. The justification for accepting samples that deviate from these criteria will be provided in the Field Report.

The flow composited sample will represent no less than 75 percent of the total volume of the storm or the first 24 hours of the storm, which ever is less, and contain a minimum of

10 aliquots for compositing. The flow composite sample must be collected for a total duration of at least 2 times the time of concentration for that drainage area.

5.2.2 Stormwater Sampling Protocols

Samples will be collected at a frequency of no closer together than every two weeks. Once it is determined that a sample is needed, the lab will monitor the rain gauge at the Tacoma Landfill located at 3510 South Mullen, Tacoma, WA 98409. Once the required amount of dry weather is achieved, the lab will go on "Storm Watch". When weather forecasts indicate that a storm is coming that may meet the required minimum precipitation, samplers will be deployed ahead of the predicted storm. The samplers will be programmed to stay in the manhole for up to 7 days monitoring water height and flow velocity, and then activate and sample for up to a 24 hour period from the time sampling conditions are satisfied and the first sample is taken. The bottle kit will be filled with ice upon deployment and replenished on a daily basis (every 24 hours) until a storm is captured or the sampler is otherwise retrieved.

The samplers will be programmed to sample anytime storm drain conditions indicate that runoff is occurring. Once the sampler detects the appropriate flow rate to indicate stormwater runoff, a flow based sampling sequence will be activated (see Section 5.1.2). Flow paced discrete samples will be collected as long as the programmed flow velocity and height conditions are met. A full sample would result in all sample bottles being filled over the storm hydrograph.

The samplers would be recovered 20 to 24 hours after it had begun raining or sooner if the rain stopped and no additional rainfall was predicted within the sampling window from the beginning of the rainfall. When the samplers are removed, the end of the Teflon suction line which remains in the manhole will be capped with aluminum foil until it is reattached to the sampler. After sampler retrieval, samples will be capped with screw closures and kept cool during transport from the field to the laboratory by replenishing ice if necessary. The samples will be cooled with ice/blue ice that is enclosed in a second plastic bag to prevent contact and possible contamination from the ice (tap water).

5.2.3 Stormwater Sample Processing

Once back at the laboratory, the storm data will be downloaded from the samplers. Data will be downloaded electronically from the samplers and transferred to a desktop computer for data analysis using the manufacturer supplied software. The data will be reviewed to determine the flow hydrograph and where on that hydrograph samples were taken. The storm data will be compared to the storm criteria to determine if the samples are representative of the storm. The Quality Assurance Manager (Mr. Getchell) or his designee will determine whether the samples meet the sampling criteria, and which of the discrete samples will be composited for analysis. The following criteria will be used to determine the acceptability of storm flow water samples:

1. <u>Sufficient Sample for Analysis</u>. The samples will be checked to determine if there are adequate sample aliquots and volume for analysis.

2. Review Rainfall Data and Criteria. The total rainfall and antecedent dry weather period will be determined to see if the minimum sampling criteria were met using data from the City rainfall gauge located at the wastewater treatment plant.

3. Review Flow Hydrograph, Sample collection (time and number), and Storm Criteria. The City will determine which of the discrete samples should be composited by reviewing the flow hydrograph and the discrete sampling times.

The storm hydrograph will be evaluated to determine the number of aliquots collected (i.e., minimum of 10 aliquots for compositing) and which of the discrete samples will be composited to best represent the storm criteria (i.e., minimum of 75% of the hydrograph volume). The time and number of discrete samples to be composited will be compared to the storm criteria to determine if the composite is representative of the storm runoff.

All samples will be kept cool and preserved within 30 hours from the start of sampling. For this project no preservatives will be added in the field. All preservatives will be added in the laboratory once the discrete samples are combined to form the flow weighted composite sample to represent the portion of the storm of interest. The samples will then be split out for the different analytical parameters. Preservatives will then be added appropriate for the analysis parameter to be performed (i.e. metals: nitric acid, etc.) according to the laboratory's SOP.

Once in the laboratory, the laboratory's SOP for sample handling and storage will be followed. Sample container and storage requirements are presented in Table 1. After analysis, remaining sample will be archived according to the laboratory's SOP. The remaining sample is kept cool (4°C) and retained for 6 months beyond issue of the laboratory report.

Each sample container after compositing will be clearly labeled with the project name, sample identification, date and time of first aliquot collected that is used in the composite, initials of person(s) preparing the sample, analysis specifications, and any pertinent comments such as preservatives present in the sample. A Chain of Custody form with the date and time of the first aliquot collected that is used in the composite will be generated indicating holding time constraints per the laboratory's SOP sample login and tracking. The Chain of Custody form is used by the analyst. A copy of the form is shown in Figure 8.

6.0 SOIL SAMPLE COLLECTION AND PROCESSING

Subsurface soil samples will be collected at study inception and completion. Study inception results will be used to create a "background" sample for comparison with future results. Soil cores will be collected from soil sample locations (Figure 7) and processed according to the laboratory's SOPs.

Once in the laboratory, the laboratory's SOP for sample handling and storage will be followed. Sample container and storage requirements are presented in Table 1. After analysis, the remaining sample will be archived according to the laboratory's SOP. The remaining sample is kept cool (4°C) and retained for 6 months beyond issue of the laboratory report.

Each sample container will be clearly labeled with the project name, sample identification, date and time collected, initials of person(s) preparing the sample, analysis specifications, or any other pertinent comments. A Chain of Custody form with the date and time collected will be generated indicating holding time constraints per the laboratory's SOP sample login and tracking. The Chain of Custody form is used by the analyst. A copy of the form is shown in Figure 8.

7.0 SEDIMENT SAMPLE COLLECTION AND PROCESSING

Representative sediment samples will be collected at study completion. A measurement of accumulated sediment will be obtained and recorded prior to cleaning of the sumps. Sediment will be collected from each catch basin using a stainless steel spoon secured to the end of an extension pole. Four (4) separate aliquots will be collected from the entire depth of sediment and combined in a large stainless steel bowl. Single aliquots will be taken at independent points within the catch basin. Using a stainless steel spoon, the combined aliquots will be thoroughly mixed in the stainless steel bowl and placed in the appropriate sample container provided by the City laboratory (

Table 3). The sample will be stored in a cooler on ice for transport to the City laboratory. Standard chain-of-custody procedures will be followed in accordance with Section 8.2 of the QAPP. Any deviations from the intended collection procedures will be documented.

Prior to each study inception, sump sediments will be cleaned out to ensure that the sampling will represent the discrete and current sampling period and will include no residuals from past discharges. Periodically during the sampling period, the sump will be inspected to determine the depth of sediment accumulation in the sump.

Specific information will be recorded pertaining to the catch basin sample. This information will include visual observations, obstacles encountered, and any deviations from the specified sampling procedures. The information will be recorded on a “CB” Field Log (Figure 9).

Once in the laboratory, the laboratory’s SOP for sample handling and storage will be followed. Sample container and storage requirements are presented in Table 1. After analysis, remaining sample will be archived according to the laboratory’s SOP. The remaining sample is kept cool (4°C) and retained for 6 months beyond issue of the laboratory report.

Each sample container will be clearly labeled with the project name, sample identification, date and time collected, initials of person(s) preparing the sample, analysis specifications, or any other pertinent comments. A Chain of Custody form (Figure 8) with the date and time collected will be generated indicating holding time constraints per the laboratory’s SOP sample login and tracking will be used by the analyst.

8.0 DOCUMENTATION AND RECORDS

8.1 FIELD MEASUREMENTS AND MISCELLANEOUS DATA

In addition to physical collection of the samples, specific field information will be recorded. A field data log will be used to note the date, time, and location of sampling stations. All field data log entries must include the following information:

- Name of the project and location
- Identity of field personnel
- Sequence of events
- Changes to the plan
- Site and atmospheric conditions
- Number of samples collected
- Date, time, location, identification, and description for each sample
- Field measurement results
- Unusual circumstances which could affect the interpretation of the data

For all sediment and soil samples, all field data log entries shall also include:

- Sample location/depth
- Catch basin depth/volume (sediment only)
- Additional Observations
    - Color
    - Gradation
    - Odor

8.2 SAMPLE TRANSPORT AND CHAIN-OF-CUSTODY PROCEDURES

Standard chain-of-custody forms (Figure 8) will be used for lab samples. All sample containers will be cooled with ice and transported in an upright position to the City laboratory directly after collection. The chain-of-custody form will contain the information from which the sample holding times will be determined. The "time of the first aliquot composited", once determined after sample processing, will be entered on this form.

9.0 LABORATORY PROCEDURES

Analytical methods, reporting limit goals, and storage and preservation requirements for water and soil/sediment samples are provided in Table 1. Table 3 and Table 4 list the percent recovery/percent RPD and the QC sample frequency respectively for the analytes. Unless indicated otherwise, all analyses will be performed by the City laboratory. The City will only use another lab if time constraints for analyses are an issue.

9.1 WHOLE-WATER ANALYSES

All whole-water samples will be analyzed for the following target parameters (Table 1):

- Selected Semi-Volatiles (PAHs and phthalates)
- Selected Metals (Copper, Lead, Zinc, and Mercury)
- Total Suspended Solids
- Hardness
- pH
- NWTPH-Dx

In order to achieve ultra low level reporting limits on PAHs and phthalates in water, the selected ion monitoring (SIM) GC/MS technique will be performed. Reporting limits are presented in Table 1.

9.2 SOIL ANALYSES

Soil samples will be analyzed for the following list of target parameters (Table 1). Soil samples will be cleaned up after extraction and prior to analysis using appropriate methods for the analyte of concern.

- Selected Semi-Volatiles (PAHs and phthalates)
- Selected Metals (Copper, Lead, Zinc, and Mercury)
- NWTPH-Dx
- Total Solids

9.3 SEDIMENT ANALYSES

Sediment samples will be analyzed for the following list of target parameters (Table 1). Sediment samples will be cleaned up after extraction and prior to analysis using appropriate methods for the analyte of concern.

- Selected Semi-Volatiles (PAHs and phthalates)
- Selected Metals (Copper, Lead, Zinc, and Mercury)
- Total Solids
- Total Volatile Solids
- NWTPH-Dx
- Grain Size

10.0 ANALYTICAL METHODS

10.1 FIELD REPORT

10.1.1 Water Samples

For each water sampling event, a written field report will be prepared by the City documenting the sample processing including collection and handling of samples. At a minimum, the following will be included in the field report:

- Description of each sampling event including date, time, antecedent and rainfall data, storm duration.
- Comparison to rainfall event goals (see Section 5.2.1).
- Description of sample collection and compositing at each location: plot of flow hydrograph and aliquot number subsample collection time, identify total number and which subsamples were composited (water samples only), ISCO Sampler Program Settings/Sampling Results reports.
- Comparison to sampling criteria (see Section 5.2.1, e.g., 75% of hydrograph, subsamples representative of event, a minimum of 10 subsamples composited).
- Field observations
- Deviation of Field Procedures
- Explanation of any deviations from the quality assurance plan protocols.

The Field Report will be submitted with the Quality Assurance Data Summary Package.

10.1.2 Soil/Sediment Samples

For each soil or sediment sampling event, a written field report will be prepared by the City documenting the sample processing including collection and handling of samples. At a minimum, the following will be included in the field report:

- Description of each sampling event including date and time.
- Description of sample collection and compositing at each location.
- Field observations (color, depth, volume, gradation, odor)
- Deviation of Field Procedures
- Explanation of any deviations from the quality assurance plan protocols.

The Field Report will be submitted with the Quality Assurance Data Summary Package.

10.2 QUALITY ASSUARANCE DATA SUMMARY PACKAGE

For each sampling event, a written laboratory report will be prepared by the City laboratory documenting all the activities associated with the sample analyses. At a minimum, the following will be included in the report:

- Results of the laboratory analyses

- Case Narrative which will include the following:
  - Key associating sample names with lab numbers.
  - Explanation of any deviation from sampling plan protocols or standard lab protocols.
  - Description of sample processing (e.g., whether samples were split)
  - Analytical Methods (including cleanups)
  - Sample name, and which analyses were performed for each one.
  - Identification of which samples were run at contract laboratories
  - Holding times met, dates for sampling, preparation, and analysis
  - Discussion of Quality Control sample results including: if QC sample results were within acceptable limits, what actions were taken if they were not (e.g. – data qualifiers, dilutions, run sample again).
  - Discussion of dilutions and interferences and why reporting limits were exceeded
  - Definitions for all data qualifiers
  - Location and availability of data
  - Provide Narrative of Corrective Actions (see Section 15.0)
  - Explanation of any deviation from chain-of-custody procedures, storage or preservation requirements identified in this plan;

10.3 FINAL REPORT

A Final Report shall be prepared annually by the City. This report will document all activities associated with performance of the sampling activities identified in this plan. The following will be included in the Final Report:

- Type of sampling equipment used.
- Protocols used during sampling and testing, and an explanation of any deviations from the sampling plan protocols.
- Summary of hydrologic data (antecedent dry period, rainfall and runoff) and field parameters, discussion of representativeness of storm samples and storm types, discussion of representativeness of sediment/soil samples, and explanation of any deviations from sampling criteria.
- Locations where the samples were collected. Locations will be shown on a map.
- Tabular presentation of validated analytical results.
- Chain-of-custody procedures used and explanation of any deviations from the sampling plan procedures.
- Summary of the data quality assurance results from all sampling events completed during the year (i.e., were data quality objectives met and, if not, why not).
- Statistical analysis of sampling results and discussion.

11.0 QUALITY CONTROL PROCEDURES

11.1 LABORATORY QUALITY CONTROL

Standard Quality Control procedures used by the City of Tacoma Laboratory will be used for this project as documented in the laboratory's Standard Operating Procedures. At a minimum, laboratory quality control samples will include analysis of surrogates, duplicates, laboratory control samples, method blanks, matrix spike and matrix spikes duplicates in each batch of samples where appropriate. Specific recommendations for QC samples and control limits are listed in Table 3 and Table 4 and in the City laboratory's QA manual or the method being used.

11.2 EQUIPMENT RINSATE BLANKS

The purpose of collecting equipment rinsate blanks is to simulate field conditions and proposed decontamination protocols, and to evaluate if leaving the strainer and Teflon suction tubing in place between sampling events will affect the samples. The method to be used for collecting the equipment rinsate blank is discussed below.

1. Fully decontaminated automatic samplers, strainers, silicon pump tubing and Teflon suction tubing will be installed at the proposed sampling locations (see 5.1.1 as modified from lab's SOP Glassware Cleaning Following EPA Protocols).

2. Samplers will be programmed to collect samples anytime sampling conditions indicate that it is raining and street runoff is occurring.

3. Collection will involve taking a 9-liter sample anytime stormwater runoff conditions are being met. The 9-liter sample will be taken with a pre-purge and pre-rinse and then discharged into the sampler base. A 9-liter container will be placed in the sampler base to confirm that the sample was taken.

   The objective is to pump 9 liters of stormwater through the samplers during three different storms, a total of 27 liters of stormwater, before the equipment rinsate blank sample is taken. The volume of stormwater that passes through the sampler line will be documented by reviewing the sampler tables that keep track of every sample that is taken.

4. After the Teflon suction tubing has been "exposed" to the minimum quantity of stormwater, the equipment rinsate blank will be collected. The equipment rinsate blank will be collected by removing the Teflon tubing from the sampler that has been in the field and flushing it with one gallon of DI (reagent grade) water as described in Section 5.1.1. The sampler hose will then be reconnected to a clean sampler. A crew member will detach the sampler strainer from the mounting plate in the storm line. A capped clean glass 9-liter container of DI (reagent grade) water will be placed in the underdrain pipe. The crew member will place the strainer into the glass container containing the 9 liters of laboratory pure

water. The pump on the clean sampler will be activated and 9 liters of DI (reagent grade) water will be pumped through the strainer and Teflon sampler hose into another clean glass container. This will represent the equipment rinsate blank that is submitted to the laboratory for analysis.

If equipment rinsate blank contamination is detected, the sampling procedures will be revised to reduce the possibility of contamination of the field strainer and Teflon suction line. If equipment rinsate blank contamination is not detected, the dedicated field strainer and Teflon suction line may remain in place for the remainder of the project.

Dedicated field Teflon suction tubing will be replaced whenever City staff finds site conditions that could affect or alter sampling results. These conditions may include, but are not limited to bacterial slime, bent tubing or oil/petroleum products in the storm samples.

Silicon tubing will be replaced whenever City staff finds conditions that could affect or alter sampling results, or the ISCO sampler log indicates it is time for replacement.

12.0 PERFORMANCE AND SYSTEMS AUDITS

The City of Tacoma Laboratory is accredited by Ecology for the parameters being tested for this project with the exception of grain size. The City will subcontract grain size testing to an accredited lab. The City laboratory routinely participates in performance and system audits of their routine procedures. Results of these audits can be obtained from the laboratory. Performance evaluation (PE) samples are also a part of the accreditation process. The results of PE samples are available from the City laboratory or Ecology's accreditation section.

13.0 PREVENTIVE MAINTENANCE

Preventive maintenance procedures related to specific field equipment and analytical laboratory equipment are outlined in the applicable laboratory SOP. Additional information regarding preventive maintenance can be found in the manufacturers' operations manuals for the equipment being used.

14.0 DATA ASSESSMENT PROCEDURES

Once samples have been analyzed, the data generated will by reviewed by the analyst that performed the analysis, the section supervisor, and the Laboratory QC Officer. The Laboratory QC Officer will generate a Quality Control report. This review and report will cover all aspects of the analysis including instrument performance, blank analysis, laboratory duplicate analysis and other QC sample analysis. The report will also discuss the assignment of qualifier flags, how qualifiers affected the data, and which performance parameters resulted in the assignment of flags (why qualifiers were assigned).

Field duplicate samples will be analyzed and precision will be calculated. Holding times, method blanks, equipment rinsate blanks, dilutions, interferences, surrogate recovery, MS/MSD, duplicates and other QC data will be discussed in respect to its affect, if any, on the data.

Equipment rinsate blanks will be analyzed to determine if the sampling equipment is sufficiently decontaminated and whether there is contamination associated with equipment sitting in the field between sampling events. Ecology and EPA allow that positive results from equipment rinsate blanks may be qualified. However, actual (stormwater) sample results may not be qualified because equipment rinsate blanks were positive, and reporting limits may not be raised based on positive equipment rinsate blanks.

In addition, a Teflon suction tubing equipment rinsate blank will be performed as per Section 11.2 to determine if sampler Teflon suction tubing left in place will contaminate future samples. If the analyses on equipment rinsate blanks show contamination, decontamination and sampling procedures will be modified to prevent contamination of future samples.

15.0 CORRECTIVE ACTION

The City laboratory has corrective action forms that are prepared when corrective actions are required. These corrective actions are generally associated with analytical problems. The forms require a statement of the problem that initiated the corrective action and the corrective action that was taken. The form is then reviewed and signed by the supervisor over that section, the QC officer, and the Senior Environmental Specialist who oversees the laboratory in its entirety. These corrective procedures are outlined in the laboratory's QA manual. Corrective action forms are filed with data packages and are available for review at any time. Corrective action forms and/or the corrective action taken will be discussed in the narrative when appropriate. No corrective action forms will be included in standard data packages.

16.0 QUALITY ASSURANCE REPORTS

See Section 14.0 Data Assessment Procedures.

TABLES

Table 1. Summary of Analytes, Methods, Detection Limits, Containers, Preservatives, and Holding Times

Parameters	Methods	Reporting Limit Goal	Container Type	Extraction Holding Time	Analysis Holding Time	Preservative
		WATER				
Metals	Dig + Analysis					
Copper	3015/3051 + 6010B	5 ug/L	P/G,AW	NA	180 days	HNO_3<pH 2
Lead	3015/3051 + 6010B	5 ug/L	P/G,AW	NA	180 days	HNO_3<pH 2
Mercury	7470A	0.2 ug/L	P/G,AW	NA	28 days	HNO_3<pH 2
Zinc	3015/3051 + 6010B	5 ug/L	P/G,AW	NA	180 days	HNO_3<pH 2
Hardness	3015/3051 + 6010B	50 ug/L	P/G,AW	NA	180 days	HNO_3<pH 2
Conventionals Analytes						
pH	EPA 150.1	0.1 Std Units	P/G		immediately	
TSS	EPA 160.2	1 mg/L	P/G		7 days	Cool - 4 deg C
		SIM METHOD				
Semi-Volatiles Analytes	SW-846 8270*		G	7 days	40 days	Cool - 4 deg C
2-Methylnapthalene		0.01 ug/L				
Acenapthene		0.01 ug/L				
Acenapthylene		0.01 ug/L				
Anthracene		0.01 ug/L				
Benzo(a)anthracene		0.01 ug/L				
Benzo(a)pyrene		0.01 ug/L				
Benzo(g,h,i)perylene		0.01 ug/L				
Benzofluoranthenes (b,k)		0.01 ug/L				
Chrysene		0.01 ug/L				
Dibenz(a,h)anthracene		0.01 ug/L				
Fluoranthene		0.01 ug/L				
Fluorene		0.01 ug/L				
Indenol(1,2,3-c,d)pyrene		0.01 ug/L				
Naphthalene		0.01 ug/L				
Phenanthrene		0.01 ug/L				
Pyrene		0.01 ug/L				
bis(2-ethylhexyl) phthalate		1.0 ug/L				
Butyl Benzyl Phthalate		1.0 ug/L				
Di-n-butyl Phthalate		1.0 ug/L				
Di-n-octyl Phthalate		1.0 ug/L				
Diethyl Phthalate		1.0 ug/L				
Dimethyl Phthalate		1.0 ug/L				
		SCAN METHOD				
Semi-Volatiles Analytes	SW-846 8270		G	7 days	40 days	Cool - 4 deg C
2-Methylnapthalene		1.0 ug/L				
Acenapthene		1.0 ug/L				
Acenapthylene		1.0 ug/L				
Anthracene		1.0 ug/L				
Benzo(a)anthracene		1.0 ug/L				
Benzo(a)pyrene		1.0 ug/L				
Benzo(g,h,i)perylene		1.0 ug/L				
Benzofluoranthenes (b,k)		1.0 ug/L				
Chrysene		1.0 ug/L				
Dibenz(a,h)anthracene		1.0 ug/L				
Fluoranthene		1.0 ug/L				
Fluorene		1.0 ug/L				
Indenol(1,2,3-c,d)pyrene		1.0 ug/L				
Naphthalene		1.0 ug/L				
Phenanthrene		1.0 ug/L				
Pyrene		1.0 ug/L				
bis(2-ethylhexyl) phthalate		1.0 ug/L				
Butyl Benzyl Phthalate		1.0 ug/L				
Di-n-butyl Phthalate		1.0 ug/L				
Di-n-octyl Phthalate		1.0 ug/L				
Diethyl Phthalate		1.0 ug/L				
Dimethyl Phthalate		1.0 ug/L				
Total Petroleum Hydrocarbons			G	7 days	40 days	Cool - 4 deg C
Diesel	NWTPH-Dx	0.2 mg/L				
Heavy Oil	NWTPH-Dx	0.4 mg/L				

* Modified to use Selected Ion Monitoring (SIM) to achieve lower detection limits
Container: P=plastic (PET or equiv.), G = glass, AW = acid washed
All parameters analyzed by the City of Tacoma Laboratory

Table 1 Continued. Summary of Analytes, Methods, Detection Limits, Containers, Preservatives, and Holding Times

Parameters	Methods	Reporting Limit Goal	Container Type	Extraction Holding Time	Analysis Holding Time	Preservative
		SOIL/SEDIMENT				
Metals	Dig + Analysis					
Copper	3015/3051 + 6010B	0.5 mg/Kg	P/G,AW	NA	180 days	Cool - 4 deg C
Lead	3015/3051 + 6010B	0.5 mg/Kg	P/G,AW	NA	180 days	Cool - 4 deg C
Mercury	7470A	0.02 mg/Kg	P/G,AW	NA	28 days	Cool - 4 deg C
Zinc	3015/3051 + 6010B	0.5 mg/Kg	P/G,AW	NA	180 days	Cool - 4 deg C
Conventionals Analytes						
Total Solids	EPA 160.3 Modified for soil	1%	P/G		7 days	Cool - 4 deg C
Total Volatile Soilds	EPA 160.4 Modified for soil	1%	P/G		7 days	Cool - 4 deg C
Semi-Volatiles Analytes						
PAH Compounds	SW-846 8270		G	14 days	40 days	Cool - 4 deg C
2-Methylnapthalene		100 ug/Kg dry				
Acenapthene		100 ug/Kg dry				
Acenapthylene		100 ug/Kg dry				
Anthracene		100 ug/Kg dry				
Benzo(a)anthracene		100 ug/Kg dry				
Benzo(a)pyrene		100 ug/Kg dry				
Benzo(g,h,i)perylene		100 ug/Kg dry				
Benzofluoranthenes (b,k)		100 ug/Kg dry				
Chrysene		100 ug/Kg dry				
Dibenz(a,h)anthracene		100 ug/Kg dry				
Fluoranthene		100 ug/Kg dry				
Fluorene		100 ug/Kg dry				
Indenol(1,2,3-c,d)pyrene		100 ug/Kg dry				
Naphthalene		100 ug/Kg dry				
Phenanthrene		100 ug/Kg dry				
Pyrene		100 ug/Kg dry				
Phthalate Compounds	SW-846 8270		G	14 days	40 days	Cool - 4 deg C
bis(2-ethylhexyl) phthalate		100 ug/Kg dry				
Butyl Benzyl Phthalate		101 ug/Kg dry				
Di-n-butyl Phthalate		102 ug/Kg dry				
Di-n-octyl Phthalate		103 ug/Kg dry				
Diethyl Phthalate		104 ug/Kg dry				
Dimethyl Phthalate		105 ug/Kg dry				
Total Petroleum Hydrocarbons						
Diesel	NWTPH-Dx	25 mg/Kg dry	G	14 days	40 days	Cool - 4 deg C
Heavy Oil	NWTPH-Dx	50 mg/Kg dry	G	14 days	40 days	Cool - 4 deg C

Container: P=plastic (PET or equiv.), G = glass, AW = acid washed
All parameters analyzed by the City of Tacoma Laboratory

Table 2. Action Levels for the Industrial Stormwater Permit

Parameter	Action Level
Total Copper	149 µg/L
Total Lead	159 µg/L
Total Zinc	372 µg/L
pH	Outside the range of 5-10 units
Cover sheet parameters for 303(d) listed waterbody segments not listed above	Twice the benchmark level

Adopted from State of Washington (2004, December). *The Industrial General Stormwater Permit.* Retrieved February 11, 2005, from http://www.ecy.wa.gov/programs/wq/stormwater/industrial/final%20ISWGP%20Permit%20modification%20after%20comment.pdf
For samples collected after December 31, 2004. If any two out of the four previous quarterly sampling results for a parameter are above the action levels identified below, the permittee shall proceed with a level two response. If any four quarterly samples for a particular parameter are above the action levels shown above, the permittee shall proceed with a level three response.

Table 3. Percent Recovery and Percent RPD

Parameters	LCS Acceptance Criteria (% Recovery)*	Spike Acceptance Criteria (% Recovery)*	Duplicate Acceptance Criteria (RPD)*	MSD Acceptance Criteria (RPD)*	Surrogate Acceptance Criteria (% Recovery)*
		WATER			
Metals					
Copper	80-120	75-125	20		
Lead	80-120	75-125	20		
Mercury	80-120	75-125	20		
Zinc	80-120	75-125	20		
Hardness	80-120	75-125	20		
Conventionals Analytes					
pH	NA	NA	20		
TSS	85-115	85-115	20		
		SIM METHOD			
Semi-Volatiles Analytes					
Naphthalene	45-113**	39-78**		26	
2-Methylnapthalene	50-106**	27-98**		22	
DiMethylPhthalate	73-96**	57-96**		10	
Acenapthylene	67-95**	46-91**		15	
Acenapthene	55-104**	43-88**		16	
Diethylphthalate		48-119**		24	
Fluorene	62-104**	58-91**		9	
Phenanthrene	65-103**	65-102**		9	
Anthracene	67-104**	58-96**		14	
Di-n-butyl Phthalate	81-106**	60-117**		9	
Fluoranthene	77-108**	60-110**		11	
Pyrene	68-110**	57-112**		20	
Butyl Benzyl Phthalate	85-108**	59-138**		11	
bis(2-ethylhexyl) phthalate	39-128**	12-129**		60	
Benzo(a)anthracene	77-110**	55-112**		11	
Chrysene	76-108**	62-81**		11.2	
Di-n-octyl phthalate		13-137**		20	
Benzo(a)pyrene	77-100**	39-109**		10	
Benzo(b&k)fluoranthenes	77-101**	48-110**		12	
Indeno(1,2,3-c,d)pyrene	50-120**	28-99**		14	
Dibenz(a,h)anthracene	43-117**	28-98**		14	
Benzo(g,h,i)perylene	58-108**	21-98**		15	
2-Fluorobiphenyl (Surrogate)					62-98**
Pyrene-d10 (Surrogate)					56-140**
Terphenyl-d14 (Surrogate)					71-122**
		SCAN METHOD			
Semi-Volatiles Analytes					
Naphthalene	37-87**	37-87**		x	
2-Methylnapthalene	41-90**	41-90**		x	
DiMethylPhthalate	44-137**	44-137**		x	
Acenapthylene	54-91**	54-91**		x	
Acenapthene	52-91**	52-91**		x	
Diethylphthalate	38-144**	38-144**		x	
Fluorene	52-106**	52-106**		x	
Phenanthrene	60-113**	60-113**		x	
Anthracene	59-106**	59-106**		x	
Di-n-butyl Phthalate	46-147**	46-147**		x	
Fluoranthene	58-114**	58-114**		x	
Pyrene	38-136**	38-136**		x	
Butyl Benzyl Phthalate	46-151**	46-151**		x	
bis(2-ethylhexyl) phthalate	42-160**	42-160**		x	
Benzo(a)anthracene	61-107**	61-107**		x	
Chrysene	62-116**	62-116**		x	
Di-n-octyl phthalate	32-183**	32-183**		x	
Benzo(a)pyrene	62-108**	62-108**		x	
Benzo(b&k)fluoranthenes	10-185**	10-185**		x	
Indeno(1,2,3-c,d)pyrene	54-122**	54-122**		x	
Dibenz(a,h)anthracene	52-124**	52-124**		x	
Benzo(g,h,i)perylene	48-123**	48-123**		x	
2-Fluorobiphenyl (Surrogate)					33-99**
Pyrene-d10 (Surrogate)					38-182**
Terphenyl-d14 (Surrogate)					46-142**
Total Petroleum Hydrocarbons					

Table 3 continued. Percent Recovery and Percent RPD

Parameters	LCS Acceptance Criteria (% Recovery)*	Spike Acceptance Criteria (% Recovery)*	Duplicate Acceptance Criteria (RPD)*	MSD Acceptance Criteria (RPD)*	Surrogate Acceptance Criteria (% Recovery)*
		SOIL/SEDIMENT			
Metals					
Copper	80-120	75-125	20		
Lead	80-120	75-125	20		
Mercury	80-120	75-125	20		
Zinc	80-120	75-125	20		
Conventionals Analytes					
Total Solids	NA	NA	20		
Total Volatile Soilds	NA	NA	20		
Semi-Volatiles Analytes					
Naphthalene	38-95**	38-95**		x	
2-Methylnapthalene	40-98**	40-98**		x	
Dimethyl phthalate	56-121**	56-121**		x	
Acenapthylene	47-106**	47-106**		x	
Acenapthene	48-106**	48-106**		x	
Diethyl phthalate	54-122**	54-122**		x	
Fluorene	56-109**	56-109**		x	
Phenanthrene	63-112**	63-112**		x	
Anthracene	62-110**	62-110**		x	
Di-n-butyl Phthalate	65-122**	65-122**		x	
Fluoranthene	62-114**	62-114**		x	
Pyrene	34-126**	34-126**		x	
Butyl Benzyl Phthalate	47-138**	47-138**		x	
bis(2-ethylhexyl) phthalate	49-140**	49-140**		x	
Benzo(a)anthracene	58-112**	58-112**		x	
Chrysene	61-109**	61-109**		x	
Di-n-octyl phthalate	43-150**	43-150**		x	
Benzo(a)pyrene	53-120**	53-120**		x	
Benzo(b&k)fluoranthenes	60-119**	60-119**		x	
Indeno(1,2,3-c,d)pyrene	41-149**	41-149**		x	
Dibenz(a,h)anthracene	42-150**	42-150**		x	
Benzo(g,h,i)perylene	51-133**	51-133**		x	
2-Fluorobiphenyl (Surrogate)					42-106
Pyrene-d10 (Surrogate)					38-127
Terphenyl-d14 (Surrogate)					54-115
Total Petroleum Hydrocarbons					
Diesel	50-150	50-150	x		
Heavy Oil	50-150	50-150	x		
2-Fluorobiphenyl (Surrogate)					50-150
Terphenyl-d14 (Surrogate)					50-150

**Control Chart Limits are updated every 30 entries.
x not established

Table 4. QC Sample Frequency

Parameters	Method Blanks	Lab Duplicates	Laboratory Control Sample	Matrix Spike	Matrix Spike Duplicate	Surrogates	Serial Dilutions
			WATER				
Metals	*1 per 20 samples or 14 days or digestion batch	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days or digestion batch	*1 per 20 samples or 14 days	NA	NA	*1 per 20 samples or 14 days
Conventionals Analytes							
pH	NA	*1 per 20 samples or 14 days or analytical batch	NA	NA	NA	NA	NA
TSS	*1 per 20 samples or 14 days or analytical batch	*1 per 20 samples or 14 days or analytical batch	*1 per 20 samples or 14 days or analytical batch	NA	NA	NA	NA
Semi-Volatiles Analytes							
PAH & Phthalate Compounds	*1 per 20 samples or daily	NA	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days	All Samples	NA
Total Petroleum Hydrocarbons							
Diesel	*1 per 20 samples or daily	*1 per 10 samples or 14 days	*1 per 20 samples or 14 days	NA	NA	All Samples	NA
Heavy Oil	*1 per 20 samples or daily	*1 per 10 samples or 14 days	*1 per 20 samples or 14 days	NA	NA	All Samples	NA
			SOIL/SEDIMENT				
Metals	*1 per 20 samples or 14 days or digestion batch	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days or digestion batch	*1 per 20 samples or 14 days	NA	NA	*1 per 20 samples or 14 days
Conventionals Analytes							
Total Solids	*1 per 20 samples or daily	*1 per 20 samples or 14 days	NA	NA	NA	NA	NA
Total Volatile Soilds	*1 per 20 samples or daily	*1 per 20 samples or 14 days	NA	NA	NA	NA	NA
Semi-Volatiles Analytes							
PAH & Phthalate Compounds	*1 per 20 samples or daily	NA	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days	*1 per 20 samples or 14 days	All Samples	NA
Total Petroleum Hydrocarbons							
Diesel	*1 per 20 samples or daily	*1 per 10 samples or 14 days	*1 per 20 samples or 14 days	NA	NA	All Samples	NA
Heavy Oil	*1 per 20 samples or daily	*1 per 10 samples or 14 days	*1 per 20 samples or 14 days	NA	NA	All Samples	NA

* whichever is more frequent
NA = Not applicable

FIGURES

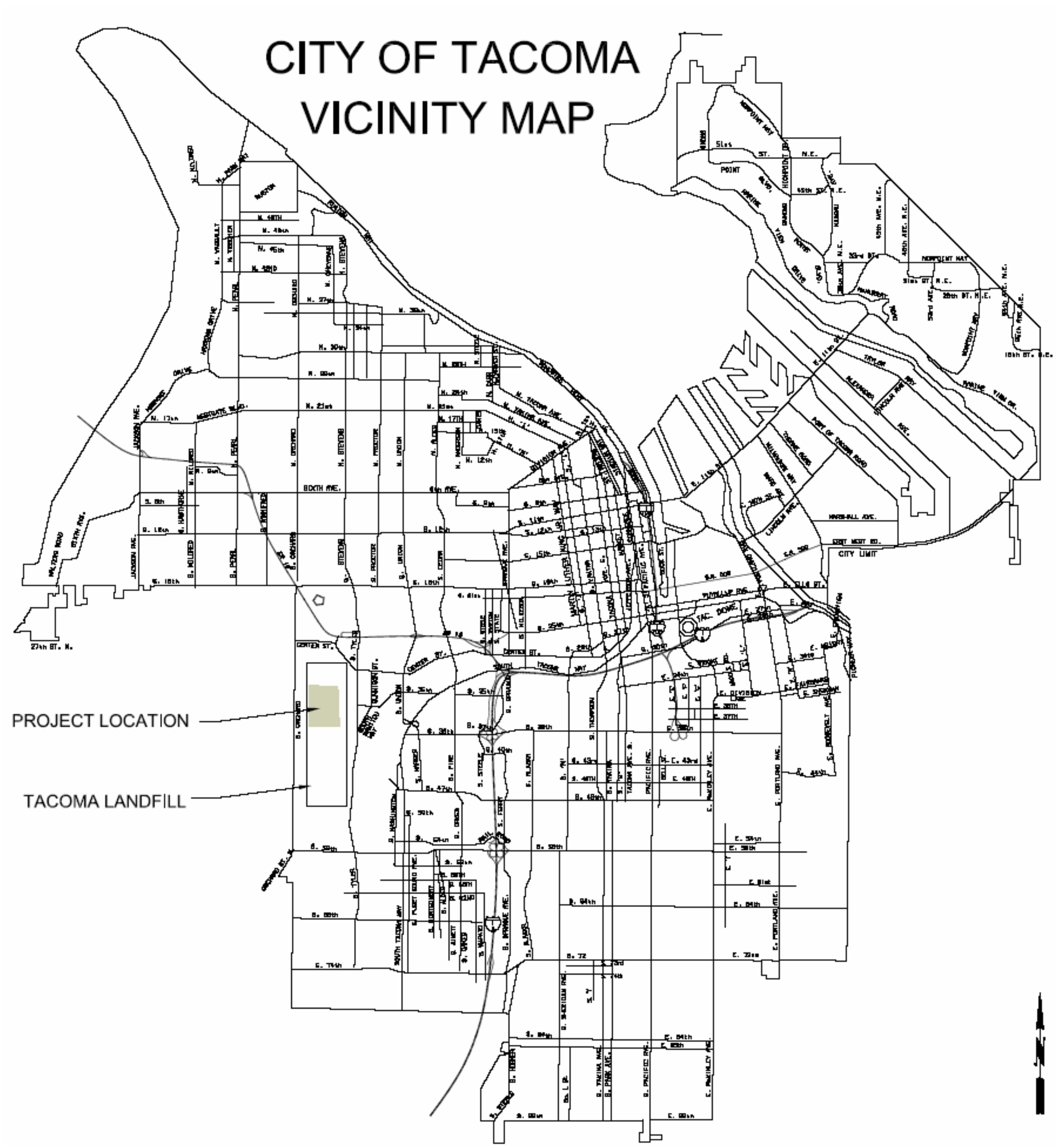


Figure 1. City of Tacoma Vicinity Map

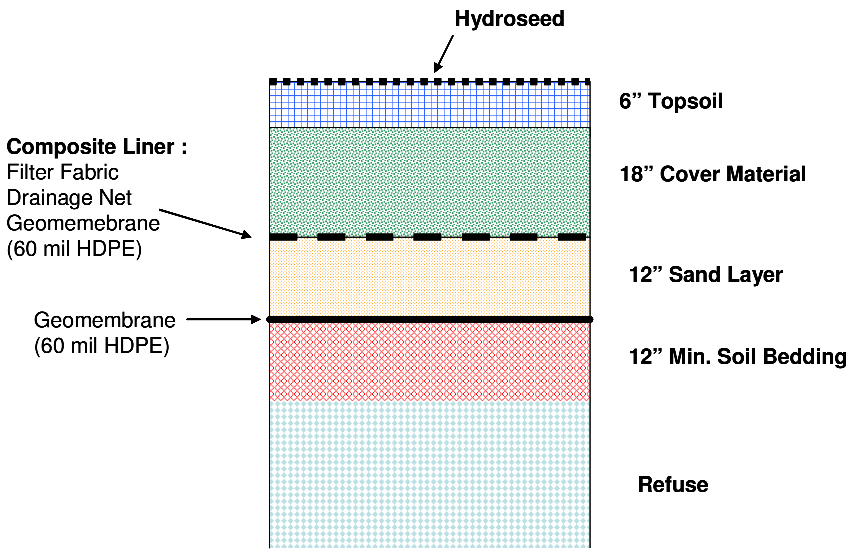


Figure 2. Landfill Cap Cross-Section

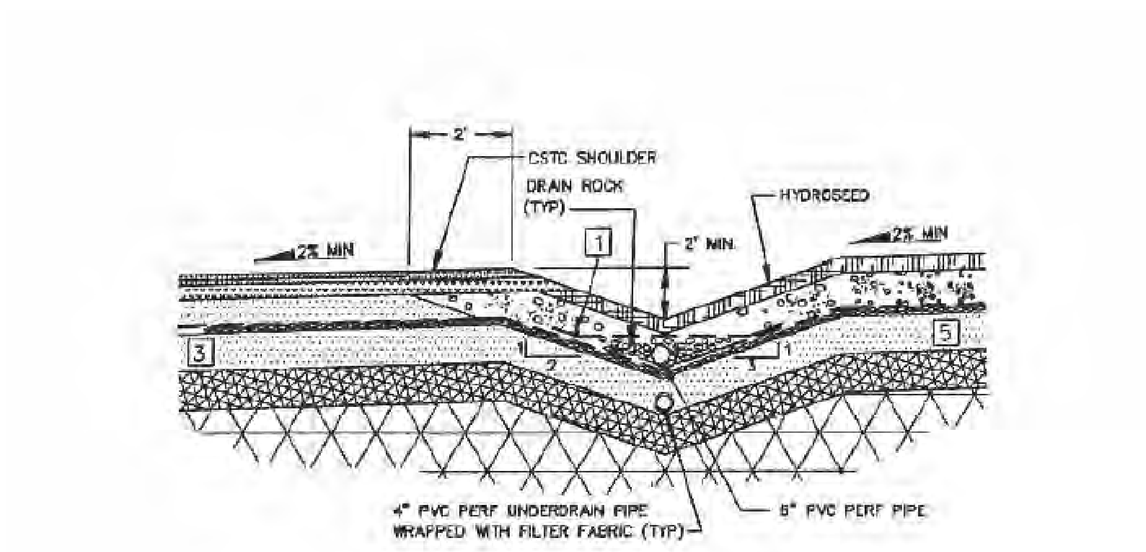
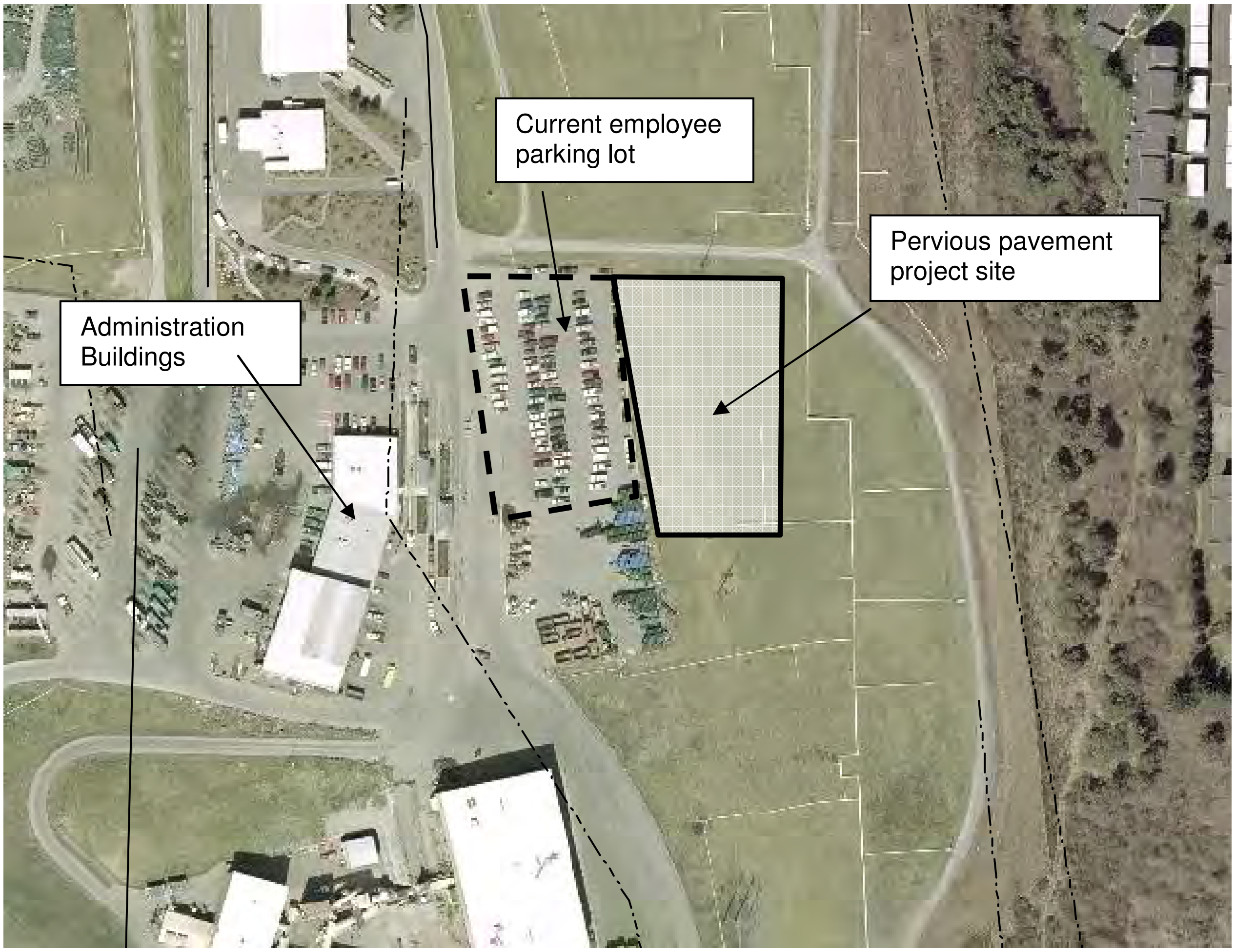


Figure 3. Landfill Cap Drainage System



Approximate Scale 1" = 200'

Figure 4. Location of Proposed Pervious Pavement Site

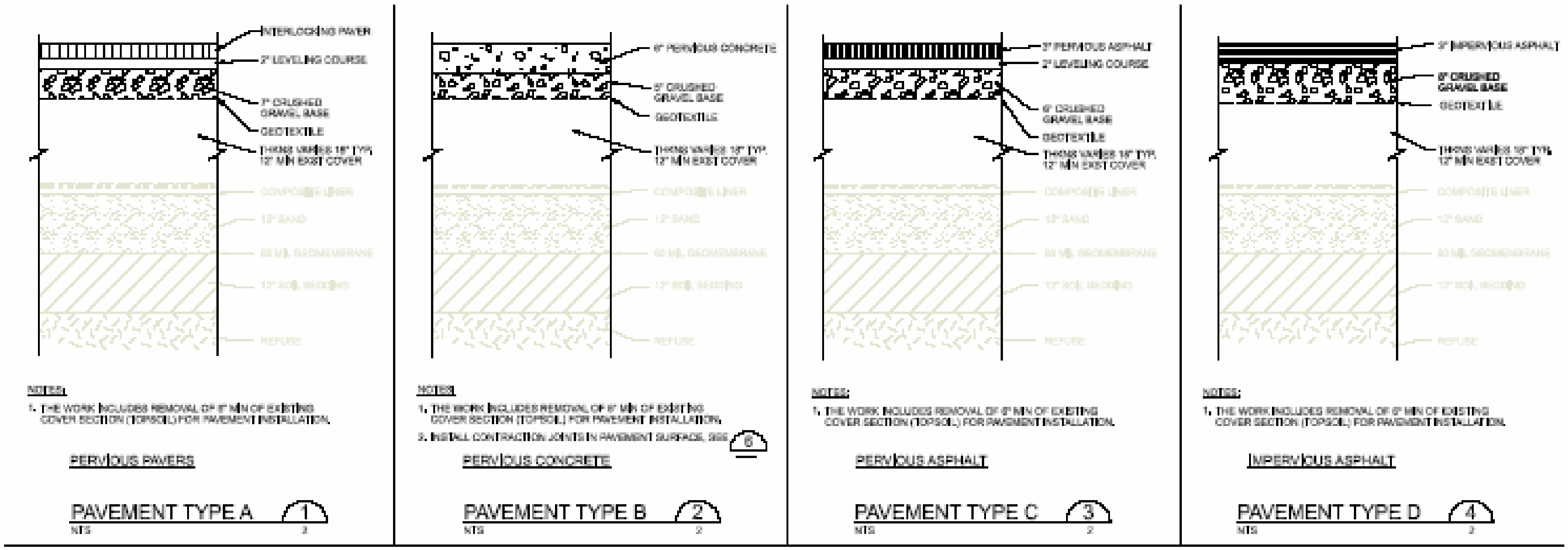


Figure 5. Typical Cross Section for Standard Asphalt and Pervious Pavements

ID		Task Name	Duration	Predec	Start	Finish
1		**Pervious Pavement Project Schedule**	**771 days**		**Mon 4/4/05**	**Mon 3/17/08**
2		**Sign Task Authorization**	5 days		Mon 4/4/05	Fri 4/8/05
3		**Pervious Pavement Design by CH2MHill**	**76 days**		**Mon 4/11/05**	**Mon 7/25/05**
4		60% Design	6 wks	2	Mon 4/11/05	Fri 5/20/05
5		Constructability Review	2.4 wks	4	Mon 5/23/05	Tue 6/7/05
6		90% Design	13 days	5	Wed 6/15/05	Fri 7/1/05
7		City review of 90%	7 days	6	Tue 7/5/05	Wed 7/13/05
8		Final Design	8 days	7	Thu 7/14/05	Mon 7/25/05
9		Design Complete	0 days	8	Mon 7/25/05	Mon 7/25/05
10		**Permits**	**80 days**		**Mon 6/20/05**	**Fri 10/7/05**
11		SEPA review	2 wks		Mon 6/20/05	Fri 7/1/05
12		Grading permit	8 wks	11	Mon 8/15/05	Fri 10/7/05
13		**Advertise & Award**	**50 days**		**Tue 7/26/05**	**Mon 10/3/05**
14		Advertise Process	3 wks	9	Tue 7/26/05	Mon 8/15/05
15		Award Process	7 wks	14	Tue 8/16/05	Mon 10/3/05
16		**Notice to Proceed**	10 days	15	Tue 10/4/05	Mon 10/17/05
17		**Pervious Pavement Construction**	6.5 mons	16,12	Tue 10/18/05	Mon 4/17/06
18		**Pervious Pavement Construction Complete**	0 days	17	Mon 4/17/06	Mon 4/17/06
19		**Pervious Pavement Testing**	24 mons	18FS+	Tue 5/16/06	Mon 3/17/08

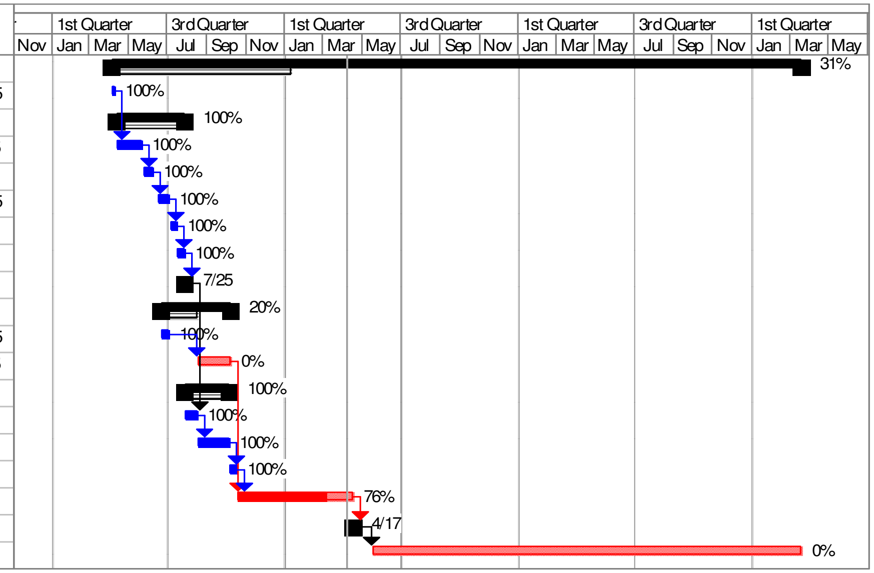


Figure 6. Proposed Project Schedule

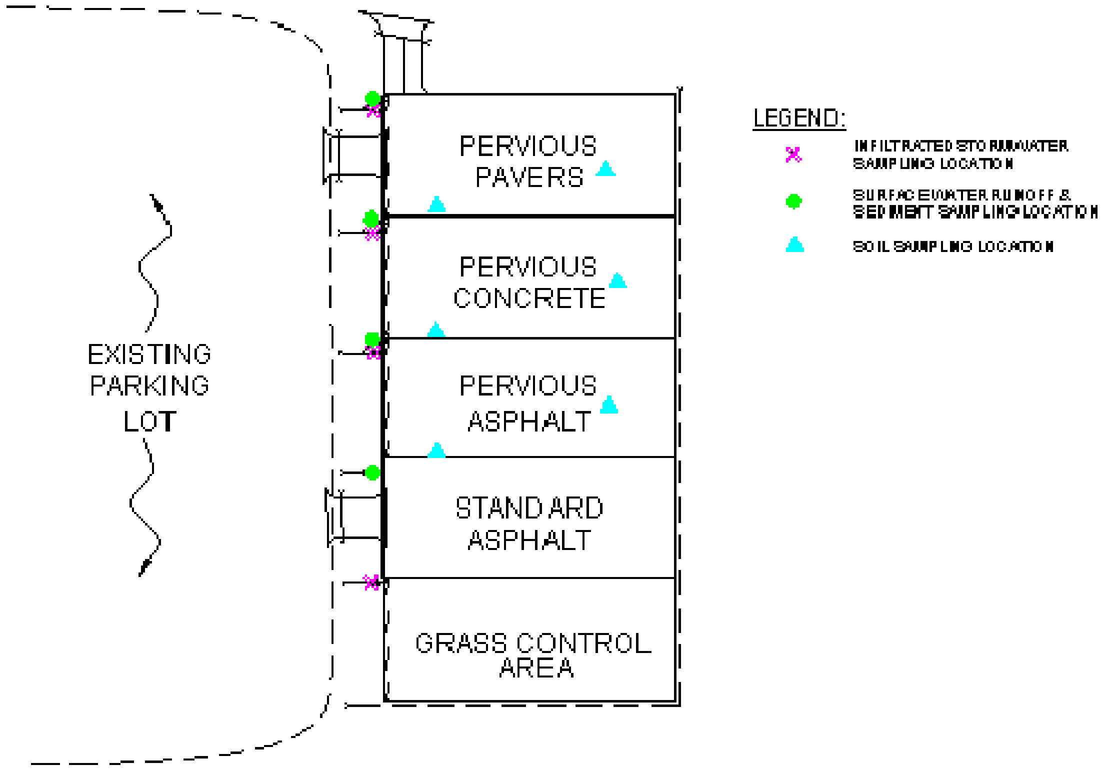


Figure 7. Sampling Locations for Water, Soil, and Sediment

Landfill Pervious Pavement Runoff
Chain of Custody

Outfall: ____________________ Date/Time sampler installed: ____________________

Sampling Crew: ____________________ Log in Crew: __________ Field Coordinator: __________

Weather conditions: ____________________ Date/Time sampler pickup: ____________________

Observed activities in area: ____

Observations during sampler collection: ____

Color, Odors, sheens: ____

Type of Sample: ☐ Stormwater ☐ Baseflow ☐ Rinse Blank

Rain event: ☐ >0.2 inches rain ☐ <0.02 inches of rain previous 24 hours

Samplers:
- ☐ DTU collected
- ☐ Ice Present at pick-up
- ☐ Caps on containers
- ☐ Sample bottles marked
- ☐ Tubing Decon 1000mL Di water
- ☐ Foil over tubing
- ☐ Ice added to base

Containers in sampler:

	Volume?	Added to Comp	Conductivity
1		☐	
2		☐	
3		☐	
4		☐	
5		☐	
6		☐	
7		☐	
8		☐	
9		☐	
10		☐	
11		☐	
12		☐	

Other

Date:

Initial:

pH:

COND:

Lab #

Deviations : ____________________ Time of 1st aliquot composite (Collect time) : ____________________

Relinquished by: ____________________ Received by: ____________________

Date/Time: ____________________ Date/Time: ____________________

Figure 8. Sample Chain-of-Custody Form

Catch Basin Field Log

Project Name: Pervious Pavement Demonstration Project
Project Location: Tacoma Landfill ____________________
Field Personnel: ________________________________

Pre-Storm Conditions
Date:___________________________ Time:______________

Location	Water Depth (in)	Notes (sediment, color, gradation, odor)
Pervious Pavers		
Pervious Concrete		
Pervious Asphalt		
Standard Asphalt		

Post-Storm Conditions
Date:___________________________ Time:______________
Storm Rainfall (in):______________

Location	Water Depth (in)	Notes (sediment, color, gradation, odor)
Pervious Pavers		
Pervious Concrete		
Pervious Asphalt		
Standard Asphalt		

Additional notes or deviations from QAPP:___________________________________
____
____
____
____
____
____
____

Figure 9. CB Field Log

APPENDIX C. STORM EVENT SUMMARIES

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #1
March 19 and 20, 2007

Introduction

This report summarizes the storm event sampled on 03/19/07 and 03/20/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #1.

Table 1. Storm Characteristics

Storm Date		03/19/07 – 03/20/07
Time Storm Began		03/19/07 10:15 am
Total Precipitation (in)		0.44
Duration (hrs)		18
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		31
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #1. As shown above, no rain fell in the 24 hours prior to the sampling event, so this event did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetograph for pervious asphalt and pervious concrete respectively for the storm event. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Fourty-eight sample aliquots were collected for pervious asphalt and pervious concrete during the sampling period. These aliquots were collected over 88.0% of the total storm runoff volume for pervious asphalt. The level data for pervious concrete appears inaccurate since the level exceeds the pipe diameter and since the level did not return to zero after the storm event.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	269.2[a]	13.5	NS
Duration of Flow (hrs)	NS	[a]	20	NS
Total Volume (gallons) during Storm Event	NS	[a]	4710	NS
Total Volume (gallons) during Sampling Event	NS	103,858[a]	4143	NS
Duration of Sampling Event (hrs)	NS	8.0	14.0	NS
Number of Sample Aliquots Collected	NS	48	48	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	NA	88.0%	NS
Volume of Surface Runoff Collected in Vault (in)	0 in	0 in	0 in	

Key: NS = Not Sampled
NM = Not Measured
NA = Not Applicable
[a] = Level measurement remained elevated during and after the sampling event. This indicates an error with the level measurement. Total volume and flow duration could not be determined. Level data exceeds the pipe diameter and is inaccurate.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious asphalt
- Pervious concrete

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted no special observations during the sampling event. Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

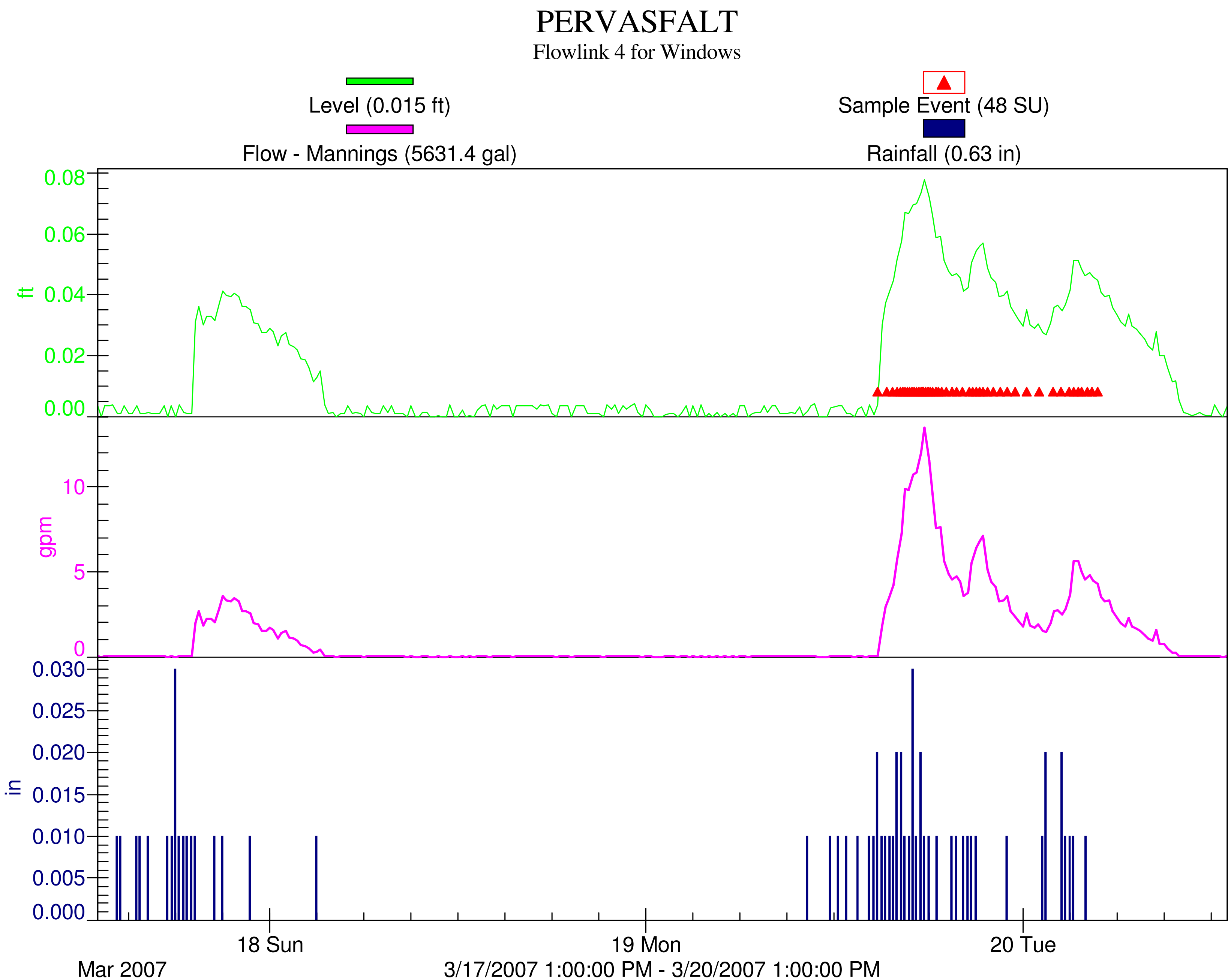
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	19-Mar-07	2-Methylnaphthalene	0.011	ug/L		
Pervious Concrete	19-Mar-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Anthracene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Chrysene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Copper	3	ug/L	U	
Pervious Concrete	19-Mar-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Concrete	19-Mar-07	Fluoranthene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Fluorene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Hardness, Calculated	961	mg/L		
Pervious Concrete	19-Mar-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Lead	14.7	ug/L		
Pervious Concrete	19-Mar-07	Mercury	0.05	ug/L	U	
Pervious Concrete	19-Mar-07	Naphthalene	0.016	ug/L		
Pervious Concrete	19-Mar-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete	19-Mar-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete	19-Mar-07	pH	12.1	Std. Units		
Pervious Concrete	19-Mar-07	Phenanthrene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	Pyrene	0.01	ug/L	U	
Pervious Concrete	19-Mar-07	TSS	230	mg/L		
Pervious Concrete	19-Mar-07	Zinc	8.4	ug/L		
Pervious Asphalt	20-Mar-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Benzo(g,h,i)perylene	0.031	ug/L		
Pervious Asphalt	20-Mar-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	20-Mar-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt	20-Mar-07	Chrysene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Copper	4	ug/L	B	
Pervious Asphalt	20-Mar-07	Dibenz(a,h)anthracene	0.027	ug/L		
Pervious Asphalt	20-Mar-07	Diethylphthalate	1.4	ug/L		
Pervious Asphalt	20-Mar-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	20-Mar-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	20-Mar-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt	20-Mar-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Hardness, Calculated	20	mg/L		
Pervious Asphalt	20-Mar-07	Indeno(1,2,3-cd)pyrene	0.027	ug/L		
Pervious Asphalt	20-Mar-07	Lead	1.1	ug/L	U	
Pervious Asphalt	20-Mar-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	20-Mar-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	20-Mar-07	NWTPH-Heavy Oil	0.4	mg/L	U	

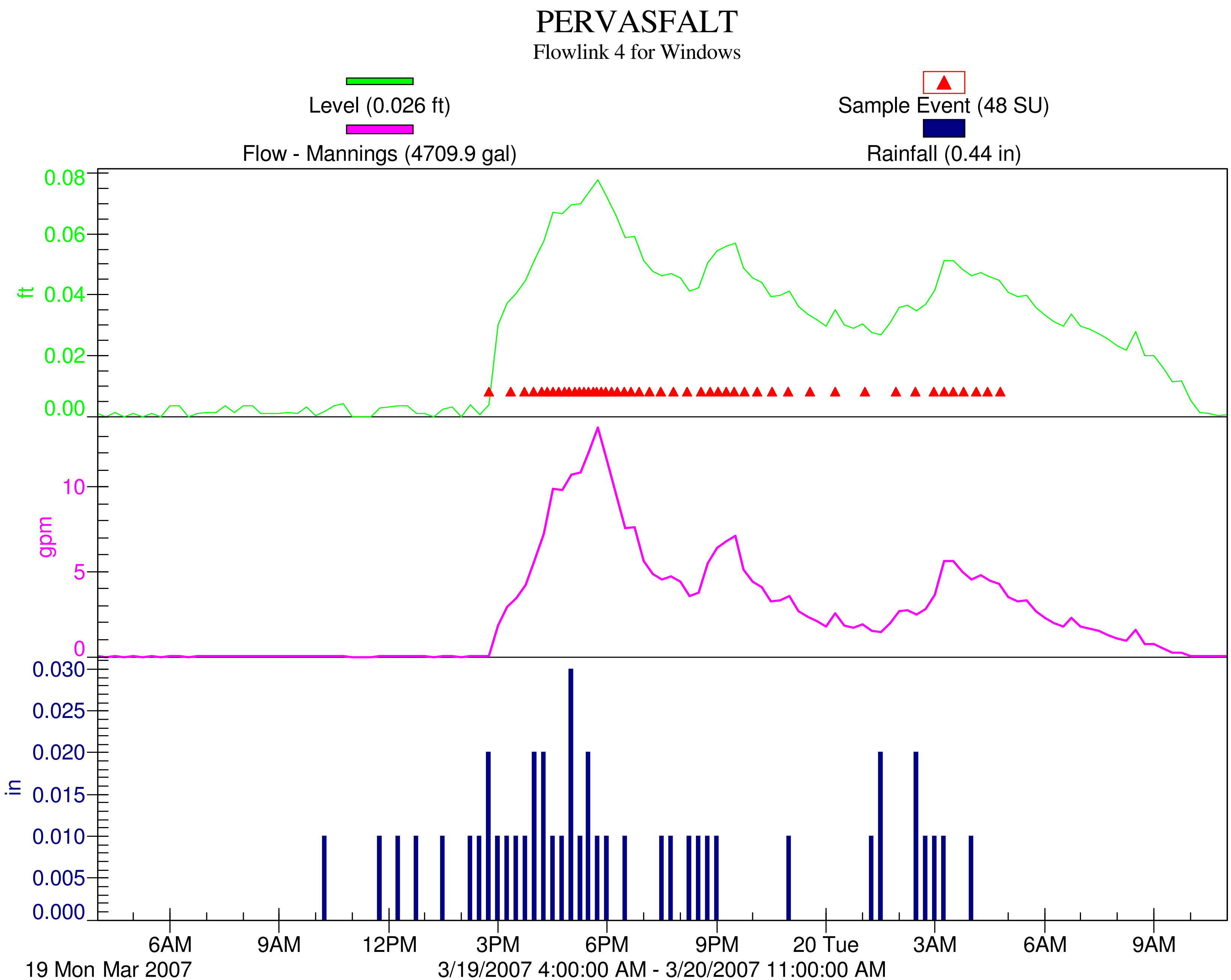
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	20-Mar-07	pH	6	Std. Units		
Pervious Asphalt	20-Mar-07	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt	20-Mar-07	TSS	5.9	mg/L		
Pervious Asphalt	20-Mar-07	Zinc	5.3	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVASFALT
Flowlink 4 for Windows
Level (0.015 ft)
Sample Event (48 SU)
Flow - Mannings (5631.4 gal)
Rainfall (0.63 in)
0.08
0.06
0.04
0.02
0.00
ft
10
5
0
gpm
0.030
0.025
0.020
0.015
0.010
0.005
0.000
in
18 Sun
19 Mon
20 Tue
Mar 2007
3/17/2007 1:00:00 PM - 3/20/2007 1:00:00 PM



PERVASFALT
Flowlink 4 for Windows
Level (0.026 ft)
Sample Event (48 SU)
Flow - Mannings (4709.9 gal)
Rainfall (0.44 in)
ft
0.08
0.06
0.04
0.02
0.00
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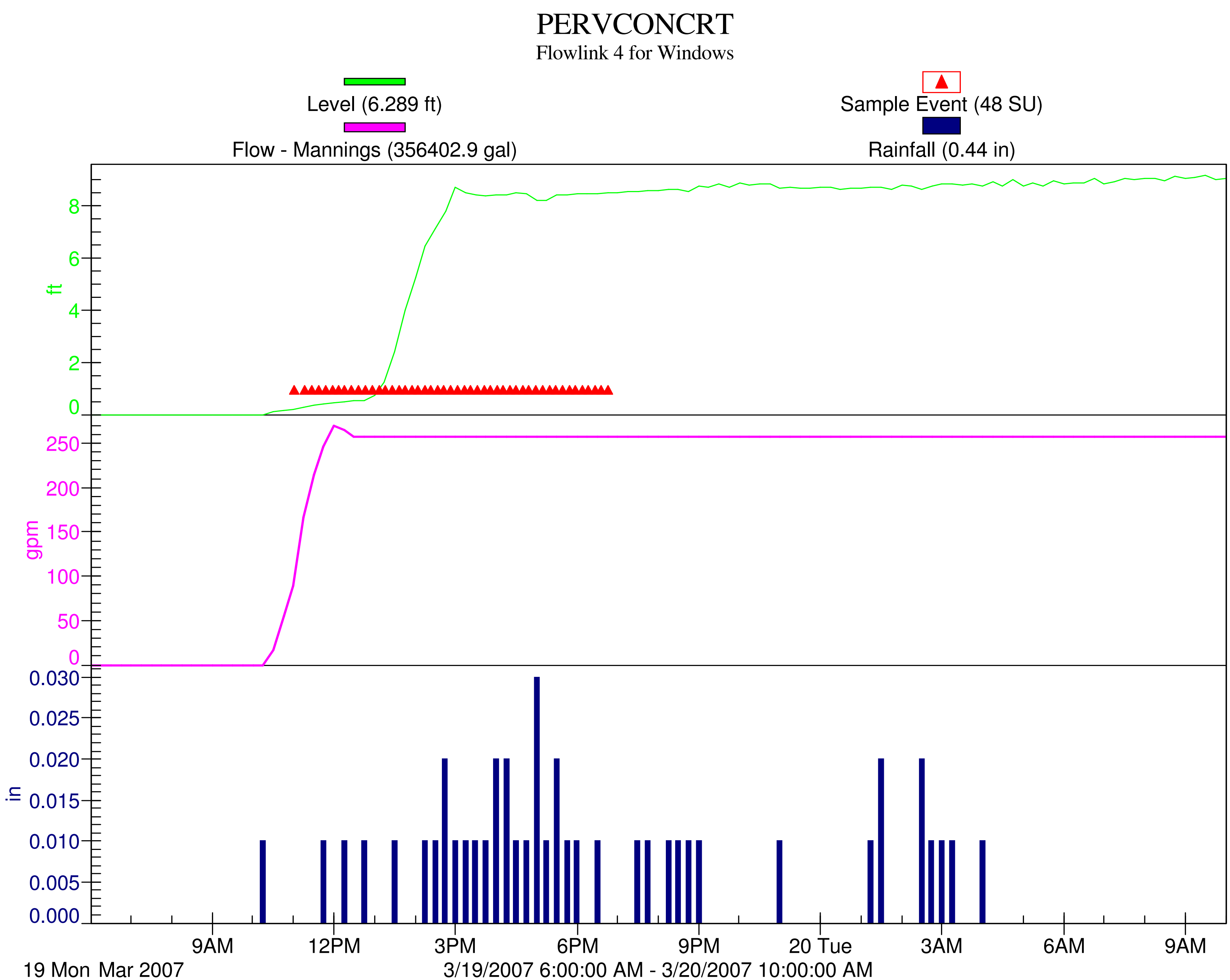
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Rainfall (0.44 in)
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STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #2
May 2 and May 3, 2007

Introduction

This report summarizes the storm event sampled on 05/02/07 and 05/03/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #2.

Table 1. Storm Characteristics

Storm Date		05/02/07 – 05/03/07
Time Storm Began		05/01/07 11:00 pm
Total Precipitation (in)		0.42
Duration (hrs)		22
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		20
Precipitation in 24-hr Antecedent Dry Period (in)		0.03
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	N

This event met the sampling criteria of a minimum 0.2 inches, but did not meet the sampling criteria of less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #2. As shown above, 0.03 inches of rain fell in the 24 hours prior to the sampling event, which exceeded the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Forty-nine sample aliquots were collected during the storm event, but only 48 of the sample aliquots were collected during the sampling period (one aliquot was collected prior to the storm event. These 48 aliquots were collected over 69.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	16.0
Duration of Flow (hrs)	NS	NS	NS	24[a]
Total Volume (gallons) during Storm Event	NS	NS	NS	6,454[a]
Total Volume (gallons) during Sampling Event	NS	NS	NS	4,498[b]
Duration of Sampling Event (hrs)	NS	NS	NS	16[b]
Number of Sample Aliquots Collected	NS	NS	NS	48[b]
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	69.7%
Volume of Surface Runoff Collected in Vault (in)	0 in	13 in	0 in	

Key: NS = Not Sampled

a = Flow duration excluded the extended period of higher than baseline flows that occurred after the rainfall ended. This decision was based on reviewing rainfall response data from other storm events for standard asphalt.

b = One sample aliquot collected prior to the start of the storm event was excluded from the sampling event. This will result in minimal error to the overall sample data for this storm event.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard asphalt
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted no special observations during the sampling event. Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	02-May-07	2-Methylnaphthalene	0.015	ug/L		
Standard Asphalt	02-May-07	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Anthracene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Benzo(a)anthracene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Benzo(a)pyrene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Benzo(g,h,i)perylene	0.013	ug/L		
Standard Asphalt	02-May-07	Benzofluoranthenes	0.021	ug/L		
Standard Asphalt	02-May-07	bis(2-Ethylhexyl)phthalate	1.7	ug/L		
Standard Asphalt	02-May-07	Butylbenzylphthalate	1	ug/L	U	
Standard Asphalt	02-May-07	Chrysene	0.017	ug/L		
Standard Asphalt	02-May-07	Copper	8.5	ug/L		
Standard Asphalt	02-May-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Diethylphthalate	1	ug/L	U	
Standard Asphalt	02-May-07	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	02-May-07	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	02-May-07	Di-n-Octyl phthalate	1	ug/L	U	
Standard Asphalt	02-May-07	Fluoranthene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Fluorene	0.011	ug/L		
Standard Asphalt	02-May-07	Hardness, Calculated	8.19	mg/L		
Standard Asphalt	02-May-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L		
Standard Asphalt	02-May-07	Lead	2.7	ug/L	B	
Standard Asphalt	02-May-07	Lead, Dissolved	1.3	ug/L	U	
Standard Asphalt	02-May-07	Mercury	0.05	ug/L	U	
Standard Asphalt	02-May-07	Mercury, dissolved	0.05	ug/L	U	
Standard Asphalt	02-May-07	Naphthalene	0.012	ug/L		
Standard Asphalt	02-May-07	NWTPH-Diesel	0.34	mg/L		
Standard Asphalt	02-May-07	NWTPH-Heavy Oil	0.98	mg/L		
Standard Asphalt	02-May-07	pH	5.7	Std. Units		
Standard Asphalt	02-May-07	Phenanthrene	0.01	ug/L	U	
Standard Asphalt	02-May-07	Pyrene	0.015	ug/L		
Standard Asphalt	02-May-07	TSS	15.3	mg/L		
Standard Asphalt	02-May-07	Zinc	48	ug/L		
Standard Asphalt	02-May-07	Zinc, Dissolved	37.3	ug/L		
Pervious Concrete CB	03-May-07	2-Methylnaphthalene	0.01	ug/L		
Pervious Concrete CB	03-May-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Acenaphthylene	0.035	ug/L		
Pervious Concrete CB	03-May-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Benzo(g,h,i)perylene	0.01	ug/L		
Pervious Concrete CB	03-May-07	Benzofluoranthenes	0.014	ug/L		
Pervious Concrete CB	03-May-07	bis(2-Ethylhexyl)phthalate	1.9	ug/L		
Pervious Concrete CB	03-May-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Concrete CB	03-May-07	Chrysene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Copper	24.6	ug/L		
Pervious Concrete CB	03-May-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	03-May-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	03-May-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	03-May-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Concrete CB	03-May-07	Fluoranthene	0.01	ug/L		
Pervious Concrete CB	03-May-07	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Hardness, Calculated	36.2	mg/L		
Pervious Concrete CB	03-May-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Lead	5.9	ug/L		
Pervious Concrete CB	03-May-07	Lead, Dissolved	1.3	ug/L	U	
Pervious Concrete CB	03-May-07	Mercury	0.05	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

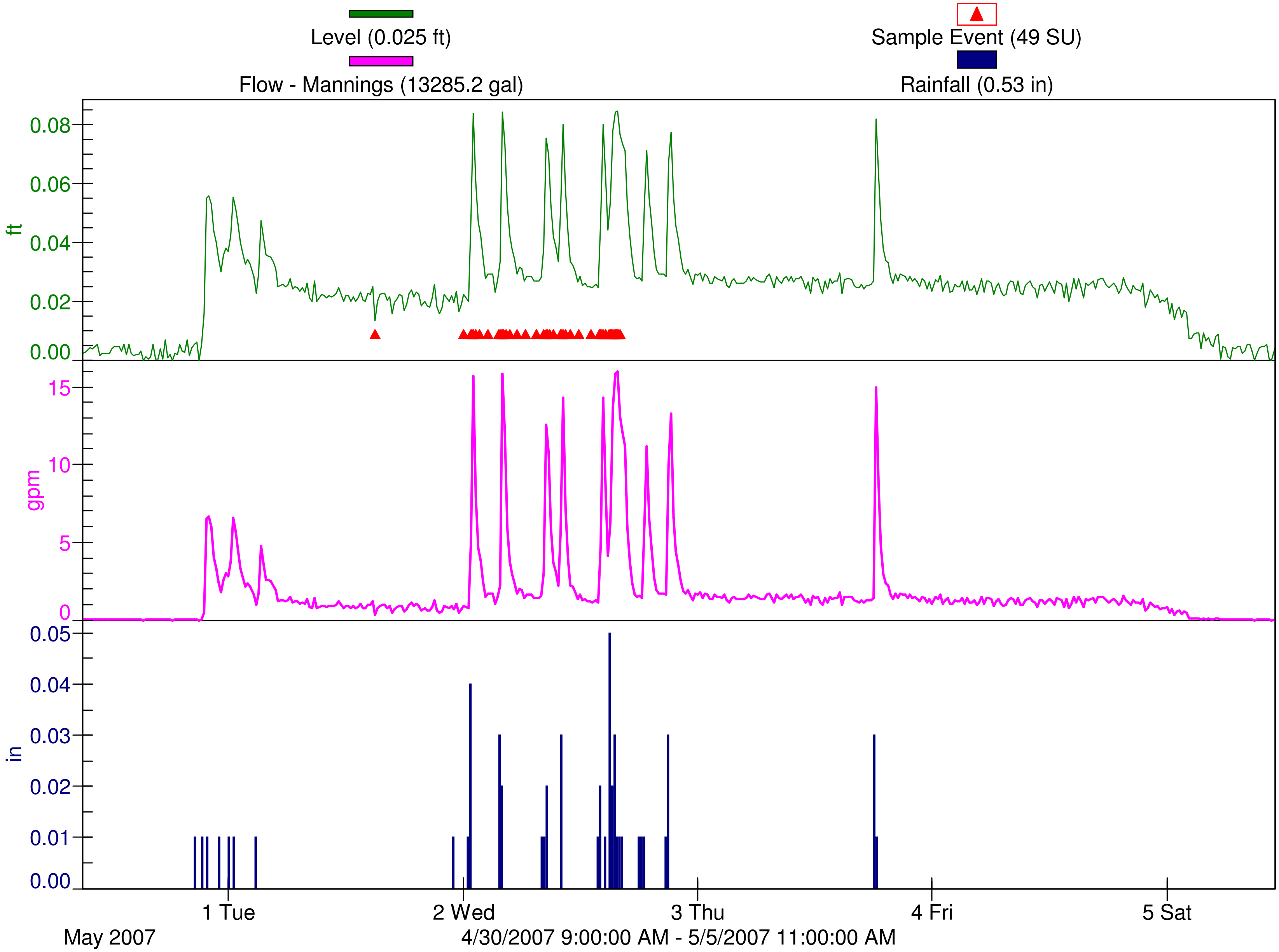
Table 3. Water Quality Data

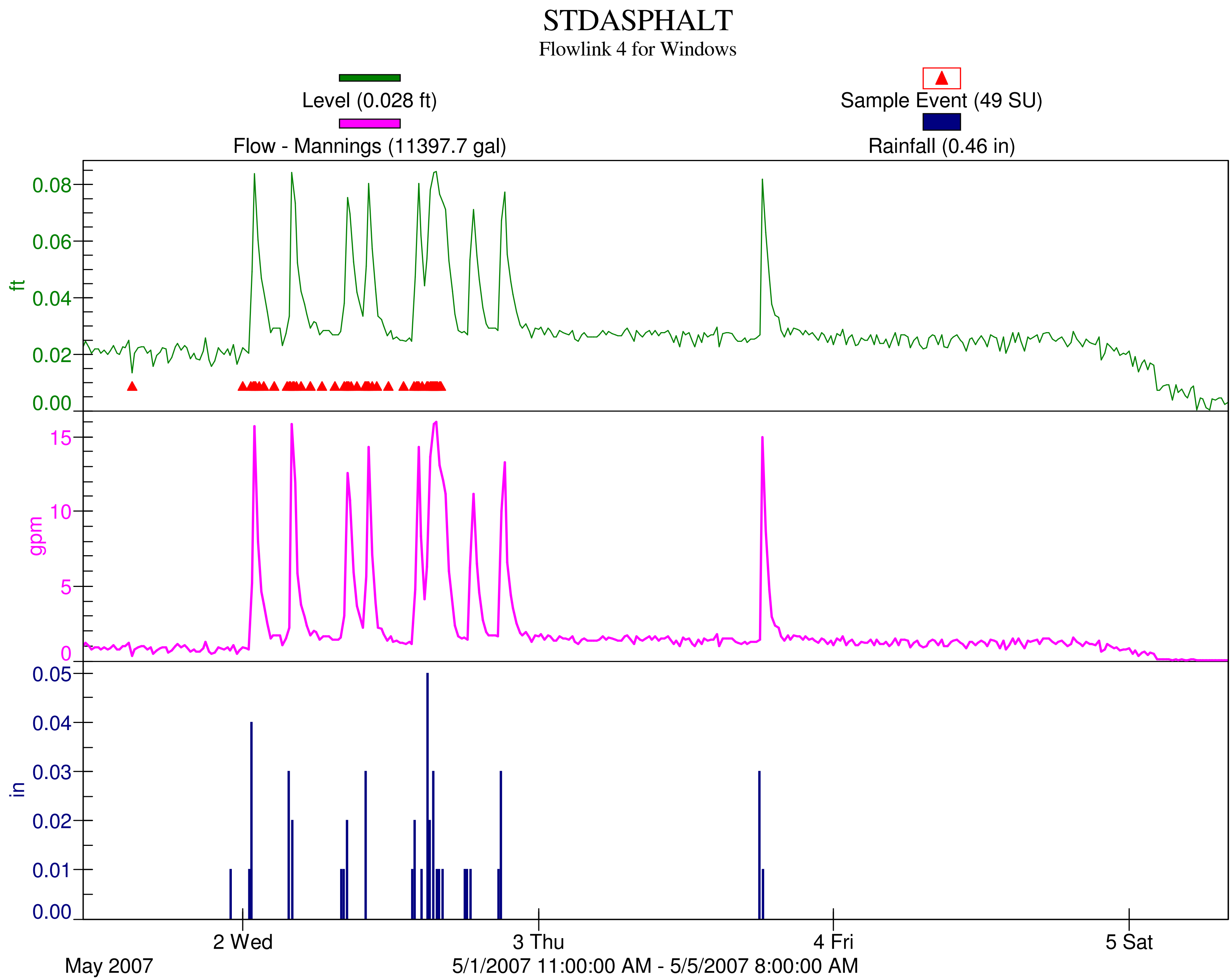
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	03-May-07	Mercury, dissolved	0.05	ug/L	U	
Pervious Concrete CB	03-May-07	Naphthalene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	03-May-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete CB	03-May-07	pH	7.1	Std. Units		
Pervious Concrete CB	03-May-07	Phenanthrene	0.01	ug/L	U	
Pervious Concrete CB	03-May-07	Pyrene	0.011	ug/L		
Pervious Concrete CB	03-May-07	TSS	25.4	mg/L		
Pervious Concrete CB	03-May-07	Zinc	58.5	ug/L		
Pervious Concrete CB	03-May-07	Zinc, Dissolved	16.6	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

STDASPHALT

Flowlink 4 for Windows

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Sample Event (49 SU)
Rainfall (0.46 in)
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STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #3
June 9, 2007

Introduction

This report summarizes the storm event sampled on 06/09/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #3.

Table 1. Storm Characteristics

Storm Date		06/09/07
Time Storm Began		06/09/07 10:00 am
Total Precipitation (in)		0.38
Duration (hrs)		8
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		107
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #3. As shown above, no rain fell in the 24 hours prior to the sampling event, so this met the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, Figure 3, and Figure 4 provide the hydrographs and hyetographs for the storm event for pervious pavers, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious pavers, 12 sample aliquots were collected during the storm event, but only 10 of the sample aliquots were collected during the during the storm event. These 10 aliquots were collected over 8.2% of the total storm runoff volume. For pervious asphalt, 43 sample aliquots were collected during the storm event. These aliquots were collected over 99.7% of the total storm runoff volume. For standard asphalt, 28 samples aliquots were collected over 93.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	4.92	NS	12.5	10.5
Duration of Flow (hrs)	18	NS	8	9
Total Volume (gallons) during Storm Event	1715	NS	1977	3530
Total Volume (gallons) during Sampling Event	140[a,b]	NS	1972	3308
Duration of Sampling Event (hrs)	0.5[b]	NS	8	8
Number of Sample Aliquots Collected	10[b]	NS	43	28
Percentage of Storm's Total Volume over which Samples were Collected	8.2%	NS	99.7%	93.7%
Volume of Surface Runoff Collected in Vault (in)	0 in	0 in	0 in	

Key: NS = Not Sampled
a = Approximate flow volume during sampling event. Sample event duration was too short to get an accurate measurement.
b = Two sample aliquots were collected after the end of the storm event. These aliquots were not included in the above values.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious asphalt
- Standard asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious concrete – no sample.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

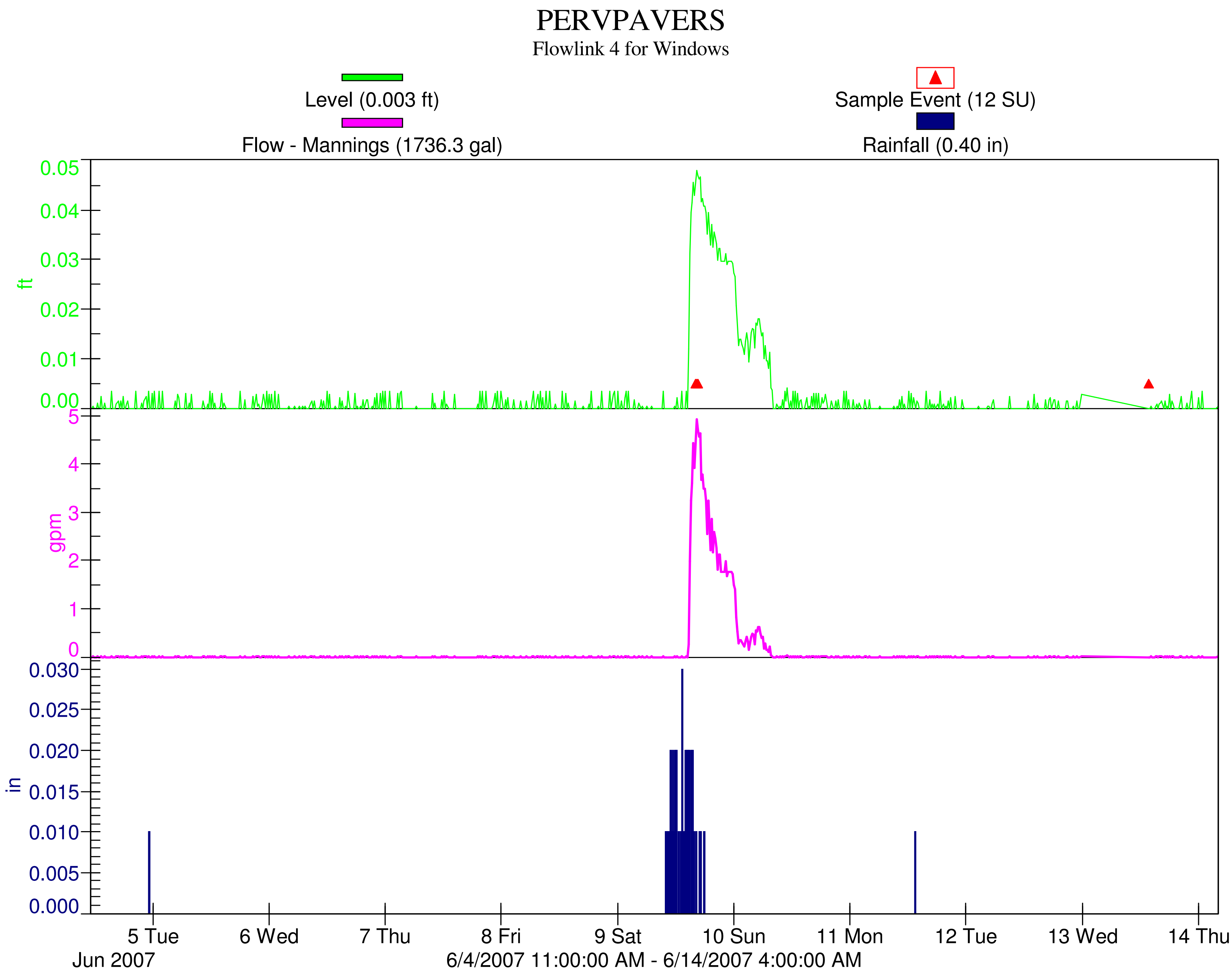
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	09-Jun-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	09-Jun-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt	09-Jun-07	Chrysene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Copper	21.8	ug/L		
Pervious Asphalt	09-Jun-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Diethylphthalate	1.9	ug/L		
Pervious Asphalt	09-Jun-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	09-Jun-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	09-Jun-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt	09-Jun-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Hardness, Calculated	28.2	mg/L		
Pervious Asphalt	09-Jun-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Lead	3.2	ug/L	B	
Pervious Asphalt	09-Jun-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	09-Jun-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	NWTPH-Diesel	0.56	mg/L		
Pervious Asphalt	09-Jun-07	NWTPH-Heavy Oil	0.92	mg/L		
Pervious Asphalt	09-Jun-07	pH	6.4	Std. Units		
Pervious Asphalt	09-Jun-07	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt	09-Jun-07	TSS	11	mg/L		
Pervious Asphalt	09-Jun-07	Zinc	5.6	ug/L		
Pervious Pavers	09-Jun-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Anthracene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Chrysene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Copper	26.8	ug/L		
Pervious Pavers	09-Jun-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Diethylphthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Pavers	09-Jun-07	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Fluorene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Hardness, Calculated	49.4	mg/L		
Pervious Pavers	09-Jun-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Lead	4.4	ug/L	B	
Pervious Pavers	09-Jun-07	Mercury	0.05	ug/L	U	
Pervious Pavers	09-Jun-07	Naphthalene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	NWTPH-Diesel	0.25	mg/L	U	
Pervious Pavers	09-Jun-07	NWTPH-Heavy Oil	0.5	mg/L	U	
Pervious Pavers	09-Jun-07	pH	6.9	Std. Units		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	09-Jun-07	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	Pyrene	0.01	ug/L	U	
Pervious Pavers	09-Jun-07	TSS	9.6	mg/L		
Pervious Pavers	09-Jun-07	Zinc	10.4	ug/L		
Standard Asphalt	09-Jun-07	2-Methylnaphthalene	0.013	ug/L		
Standard Asphalt	09-Jun-07	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	09-Jun-07	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	09-Jun-07	Anthracene	0.01	ug/L	U	
Standard Asphalt	09-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Standard Asphalt	09-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



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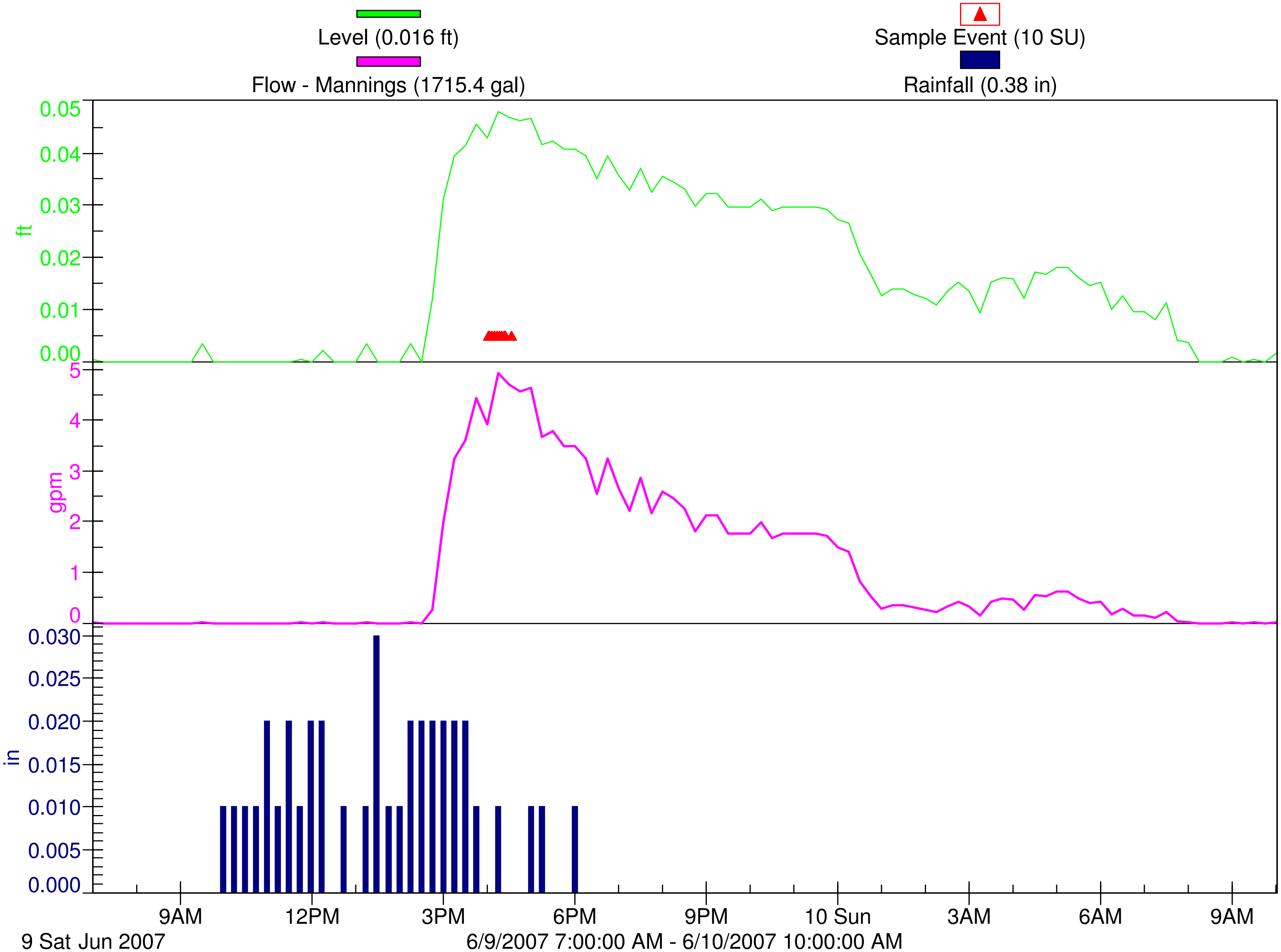
PERVPAVERS

Flowlink 4 for Windows



PERVASFALT

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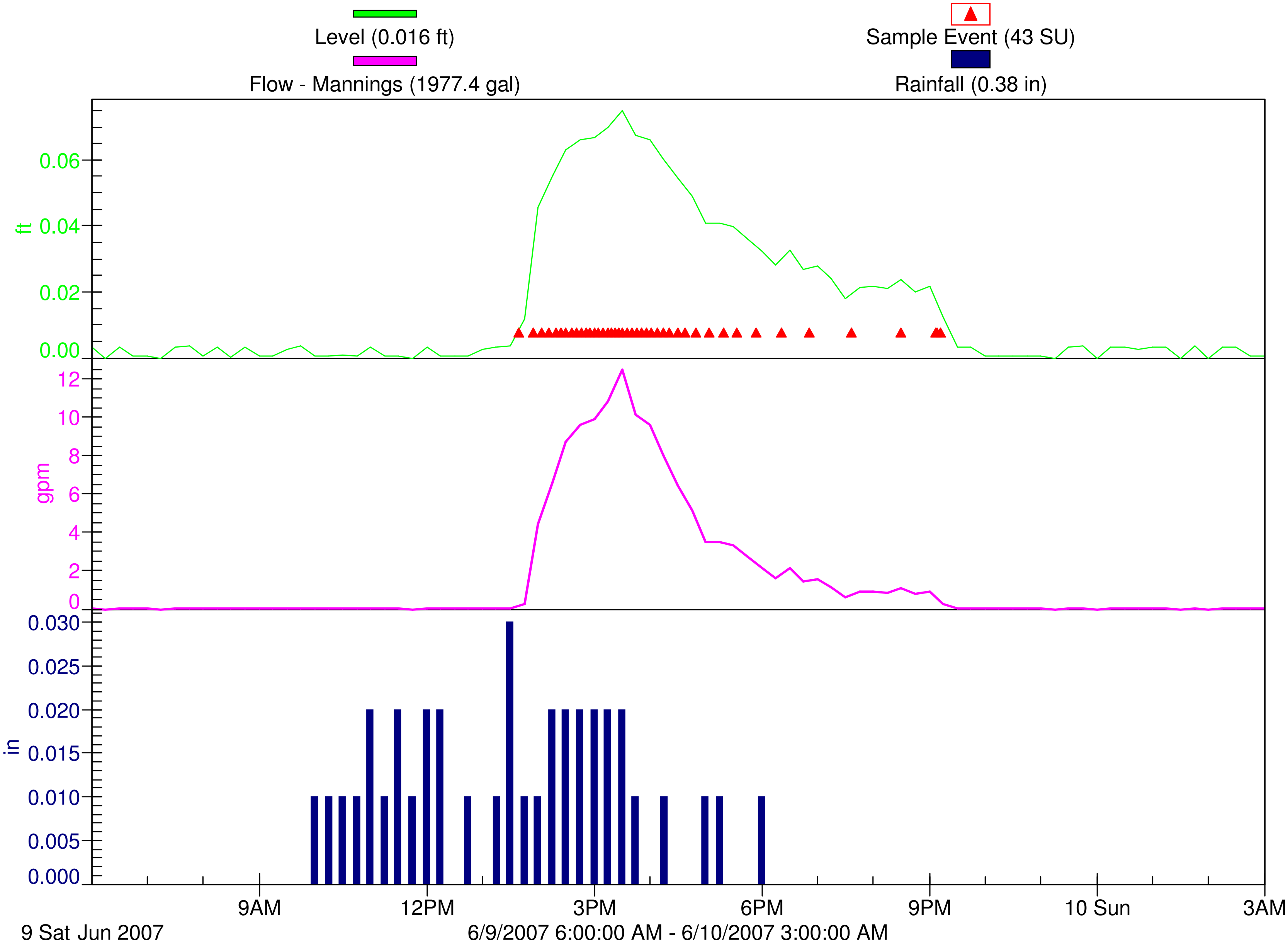
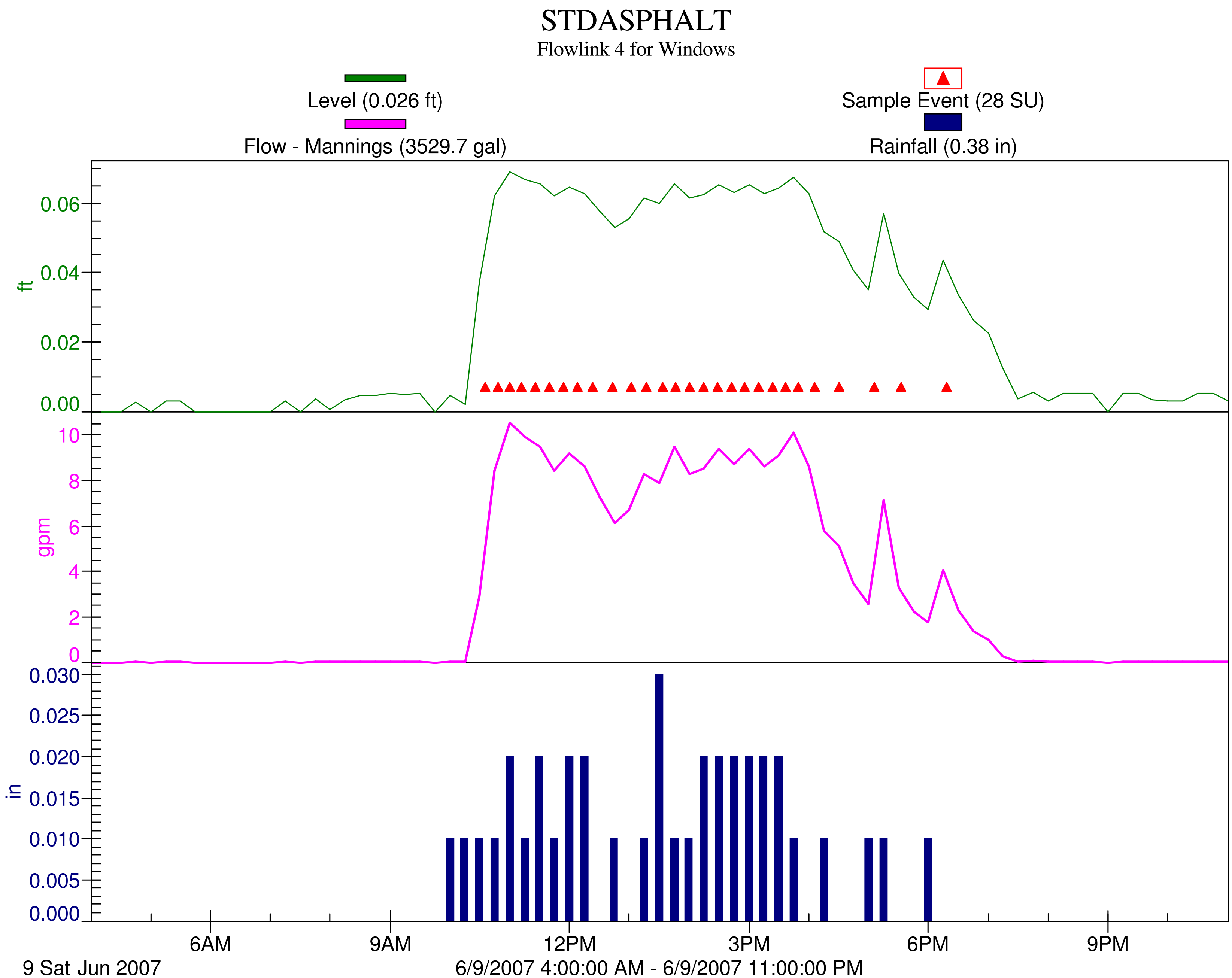




STDASPHALT
Flowlink 4 for Windows
Level (0.026 ft)
Sample Event (28 SU)
Flow - Mannings (3529.7 gal)
Rainfall (0.38 in)
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.030
0.025
0.020
0.015
0.010
0.005
0.000
6AM
9AM
12PM
3PM
6PM
9PM
9 Sat Jun 2007
6/9/2007 4:00:00 AM - 6/9/2007 11:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #4
June 28 and June 29, 2007

Introduction

This report summarizes the storm event sampled on 06/28/07 and 06/29/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #4.

Table 1. Storm Characteristics

Storm Date		06/28/07 – 06/29/07
Time Storm Began		06/28/07 8:45 am
Total Precipitation (in)		0.38
Duration (hrs)		21
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		86
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #4. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event, so this met the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and Figure 3 provide the hydrograph and hyetograph for the storm event for pervious pavers and pervious asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious pavers, 23 sample aliquots were collected during the sampling period. These aliquots were collected over 17.2% of the total storm runoff volume. For pervious asphalt, 38 sample aliquots were collected over 69.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	35.9	NS	33.0	NS
Duration of Flow (hrs)	12	NS	5.5	NS
Total Volume (gallons) during Storm Event	2208	NS	1678	NS
Total Volume (gallons) during Sampling Event	380[a]	NS	1170	NS
Duration of Sampling Event (hrs)	0.5	NS	5.0	NS
Number of Sample Aliquots Collected	23	NS	38	NS
Percentage of Storm's Total Volume over which Samples were Collected	17.2%	NS	69.7%	NS
Volume of Surface Runoff Collected in Vault (in)	0 in	13 in	17 in	

Key: NS = Not Sampled
a = Approximate flow volume during sampling event. Sample event duration was too short to get an accurate measurement.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious asphalt
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted no special observations during the sampling event. Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

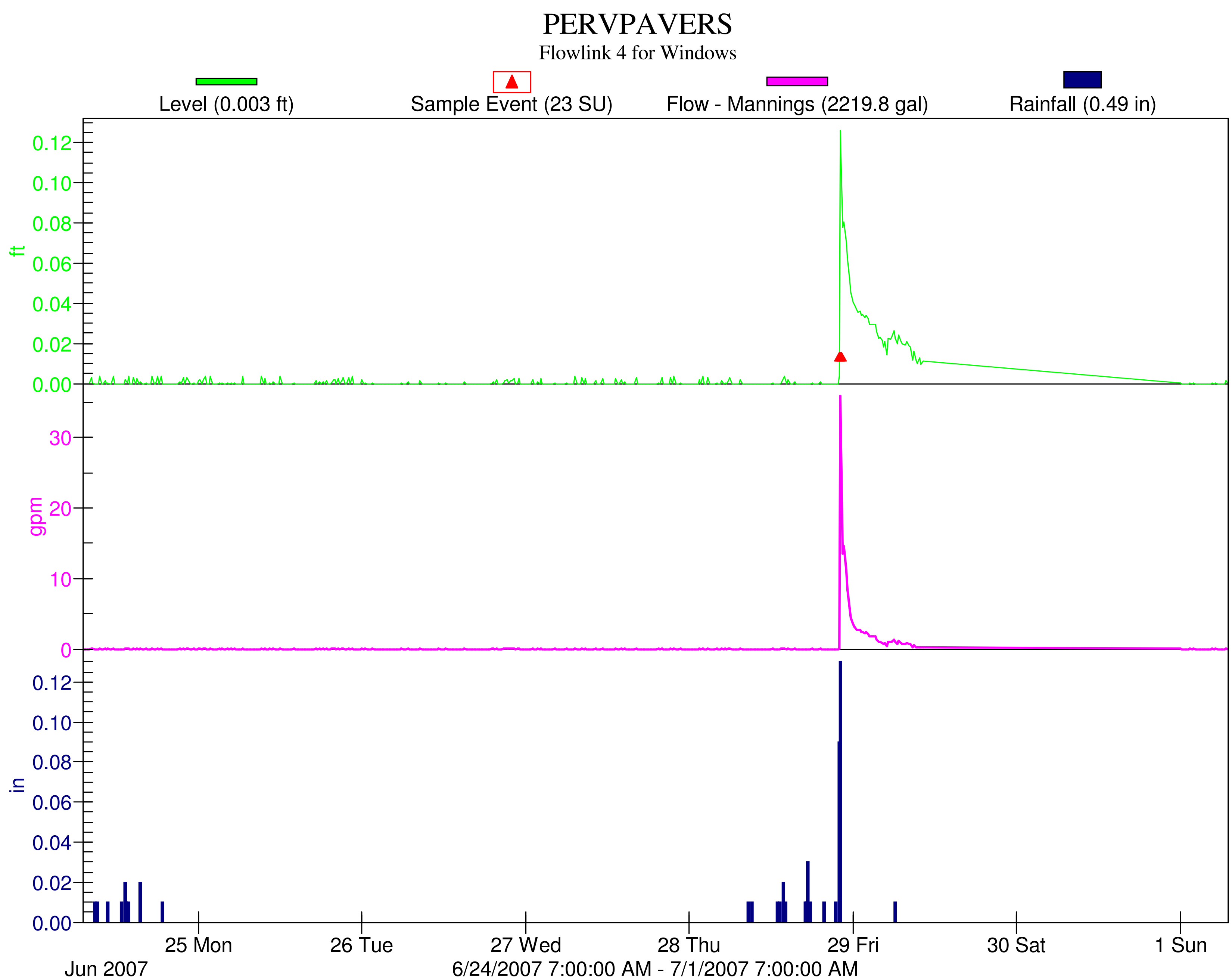
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	29-Jun-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	29-Jun-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt	29-Jun-07	Chrysene	0.011	ug/L		
Pervious Asphalt	29-Jun-07	Copper	10.1	ug/L		
Pervious Asphalt	29-Jun-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Diethylphthalate	2.1	ug/L		
Pervious Asphalt	29-Jun-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	29-Jun-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	29-Jun-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt	29-Jun-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Hardness, Calculated	27.7	mg/L		
Pervious Asphalt	29-Jun-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Lead	2.9	ug/L	B	
Pervious Asphalt	29-Jun-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	29-Jun-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	NWTPH-Diesel	0.23	mg/L		
Pervious Asphalt	29-Jun-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	29-Jun-07	pH	6.3	Std. Units		
Pervious Asphalt	29-Jun-07	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt	29-Jun-07	TSS	56.7	mg/L		
Pervious Asphalt	29-Jun-07	Zinc	10.9	ug/L		
Pervious Asphalt CB	29-Jun-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Chrysene	0.015	ug/L		
Pervious Asphalt CB	29-Jun-07	Copper	7.5	ug/L		
Pervious Asphalt CB	29-Jun-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Diethylphthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Fluoranthene	0.01	ug/L		
Pervious Asphalt CB	29-Jun-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Hardness, Calculated	14.3	mg/L		
Pervious Asphalt CB	29-Jun-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Lead	3.7	ug/L	B	
Pervious Asphalt CB	29-Jun-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	29-Jun-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt CB	29-Jun-07	NWTPH-Diesel	0.3	mg/L		
Pervious Asphalt CB	29-Jun-07	NWTPH-Heavy Oil	0.56	mg/L		
Pervious Asphalt CB	29-Jun-07	pH	6.4	Std. Units		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	29-Jun-07	Phenanthrene	0.018	ug/L		
Pervious Asphalt CB	29-Jun-07	Pyrene	0.013	ug/L		
Pervious Asphalt CB	29-Jun-07	TSS	2.2	mg/L	U	
Pervious Asphalt CB	29-Jun-07	Zinc	37.3	ug/L		
Pervious Concrete CB	29-Jun-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	29-Jun-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	29-Jun-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	29-Jun-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	29-Jun-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	29-Jun-07	Benzo(a)pyrene	0.01	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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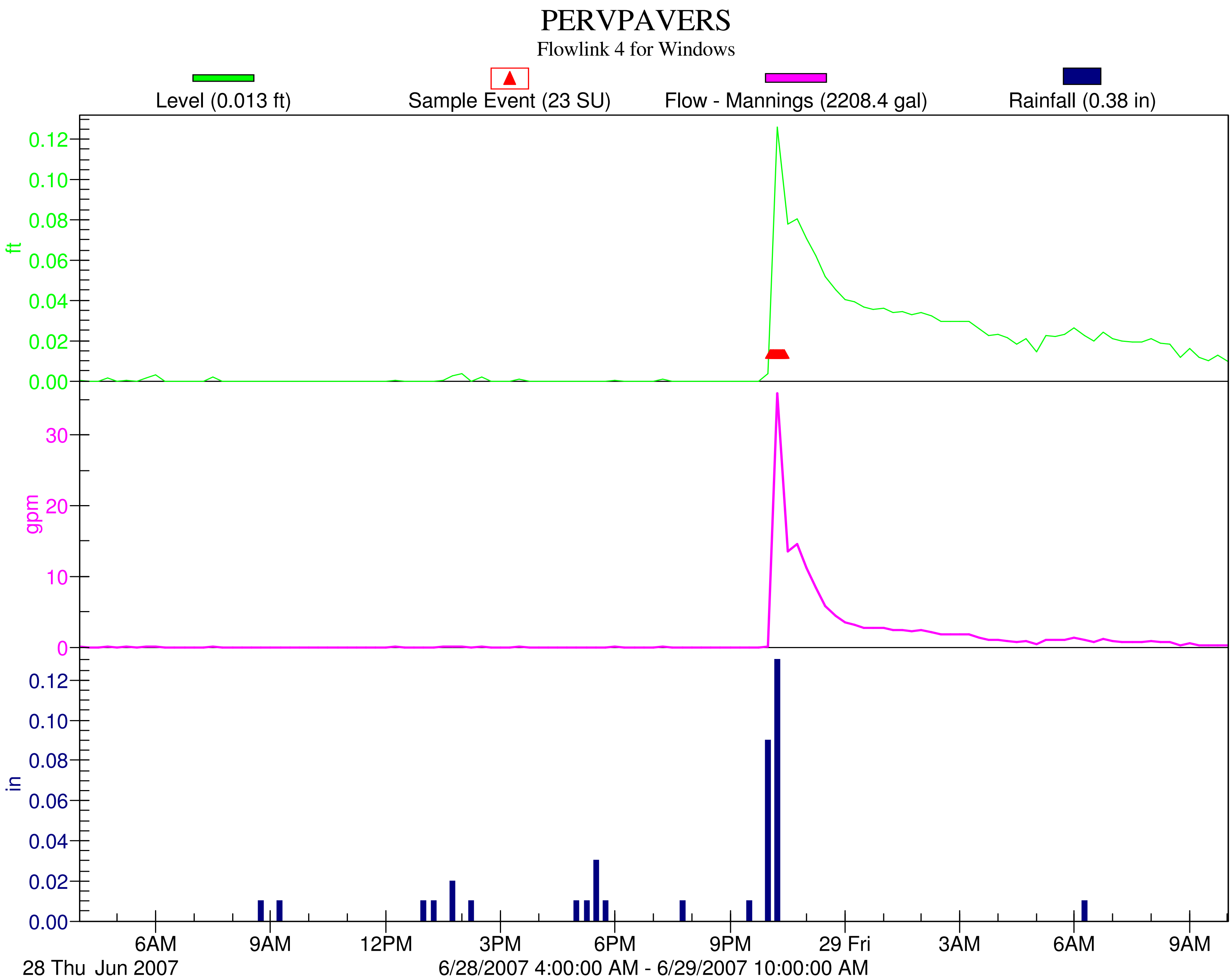
Sample Event (23 SU)
Flow - Mannings (2219.8 gal)
Rainfall (0.49 in)
ft
0.12
0.10
0.08
0.06
0.04
0.02
0.00
gpm
30
20
10
0
in
0.12
0.10
0.08
0.06
0.04
0.02
0.00
25 Mon
26 Tue
27 Wed
28 Thu
29 Fri
30 Sat
1 Sun
Jun 2007
6/24/2007 7:00:00 AM - 7/1/2007 7:00:00 AM


PERVPAVERS
Flowlink 4 for Windows
Level (0.013 ft)
Sample Event (23 SU)
Flow - Mannings (2208.4 gal)
Rainfall (0.38 in)
ft
0.12
0.10
0.08
0.06
0.04
0.02
0.00
gpm
30
20
10
0
in
0.12
0.10
0.08
0.06
0.04
0.02
0.00
6AM
9AM
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29 Fri
3AM
6AM
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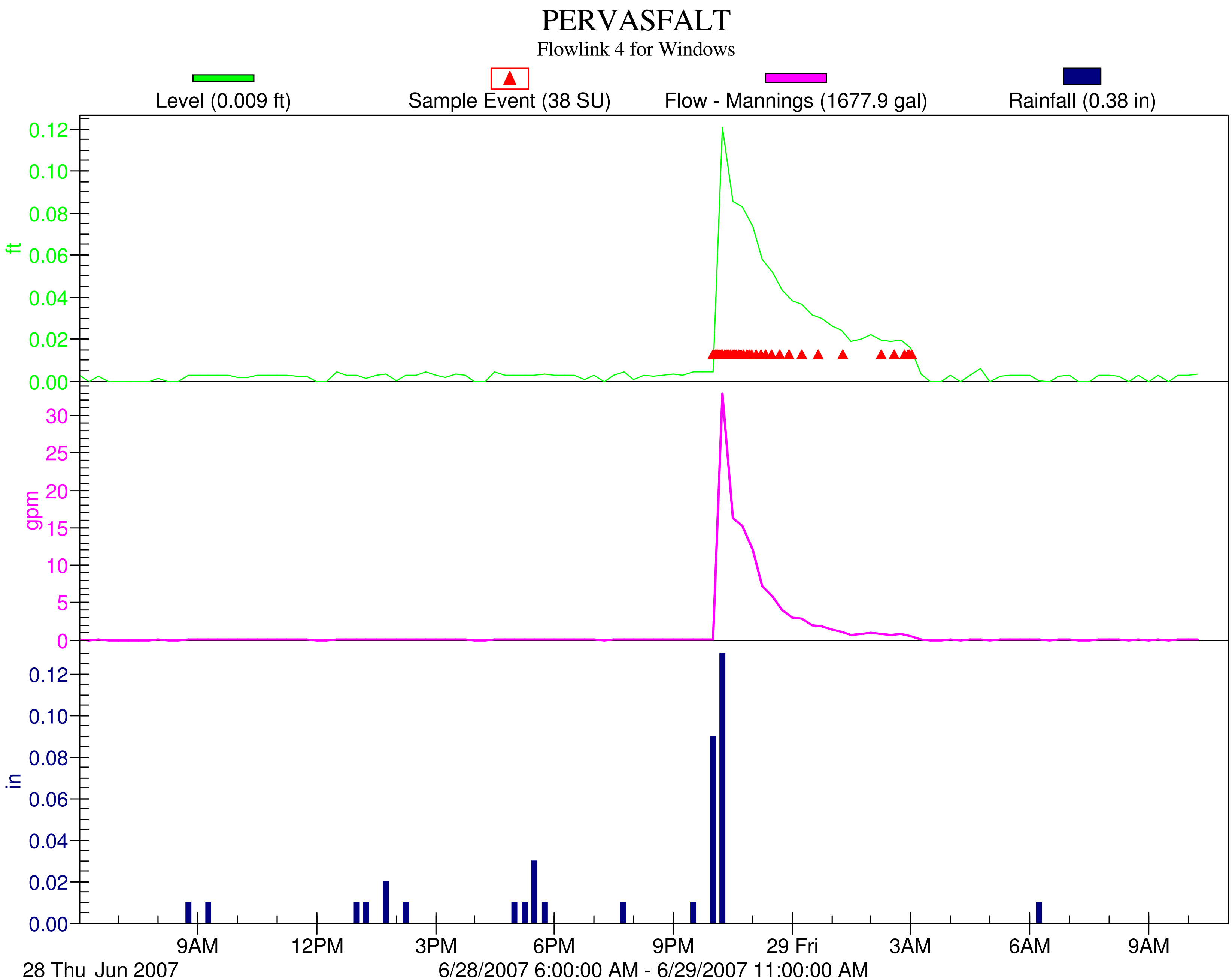
28 Thu Jun 2007
6/28/2007 4:00:00 AM - 6/29/2007 10:00:00 AM



PERVASFALT
Flowlink 4 for Windows
Level (0.009 ft)
Sample Event (38 SU)
Flow - Mannings (1677.9 gal)
Rainfall (0.38 in)
ft
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0.10
0.08
0.06
0.04
0.02
0.00
gpm
30
25
20
15
10
5
0
in
0.12
0.10
0.08
0.06
0.04
0.02
0.00
9AM
12PM
3PM
6PM
9PM
29 Fri
3AM
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9AM
28 Thu Jun 2007
6/28/2007 6:00:00 AM - 6/29/2007 11:00:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #5
September 4, 2007

Introduction

This report summarizes the storm event sampled on 09/04/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #5.

Table 1. Storm Characteristics

Storm Date		09/04/07
Time Storm Began		09/03/07 10:45 pm
Total Precipitation (in)		0.85
Duration (hrs)		8.0
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		>192
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

*Note: A partial storm event was used for pervious asphalt. See storm summary sheet.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #5. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event, so this event did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and Figure 3 provide the hydrograph and hyetograph for the storm event for pervious pavers and pervious asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	100.1	NS	15.8	NS
Duration of Flow (hrs)	10.75	NS	6.5	NS
Total Volume (gallons) during Storm Event	4199	NS	1678*	NS
Total Volume (gallons) during Sampling Event	3926	NS	1774	NS
Duration of Sampling Event (hrs)	6.07	NS	6.0	NS
Number of Sample Aliquots Collected	29	NS	45*	NS
Percentage of Storm's Total Volume over which Samples were Collected	93.5%	NS	92.3%	NS
Volume of Surface Runoff Collected in Vault (inches)	14 in	20 in	18.5 in	

Key: NS = Not Sampled

*Partial storm event was used for pervious asphalt. 3 aliquots were collected after sampling event; these were not included in the above calculations.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pacing was off for pervious concrete. Will adjust pacing on subsequent sampling.
- Standard asphalt autosampler detected no liquid. Hose may have jumped out of the sample bottle during the storm causing no sample to be collected.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

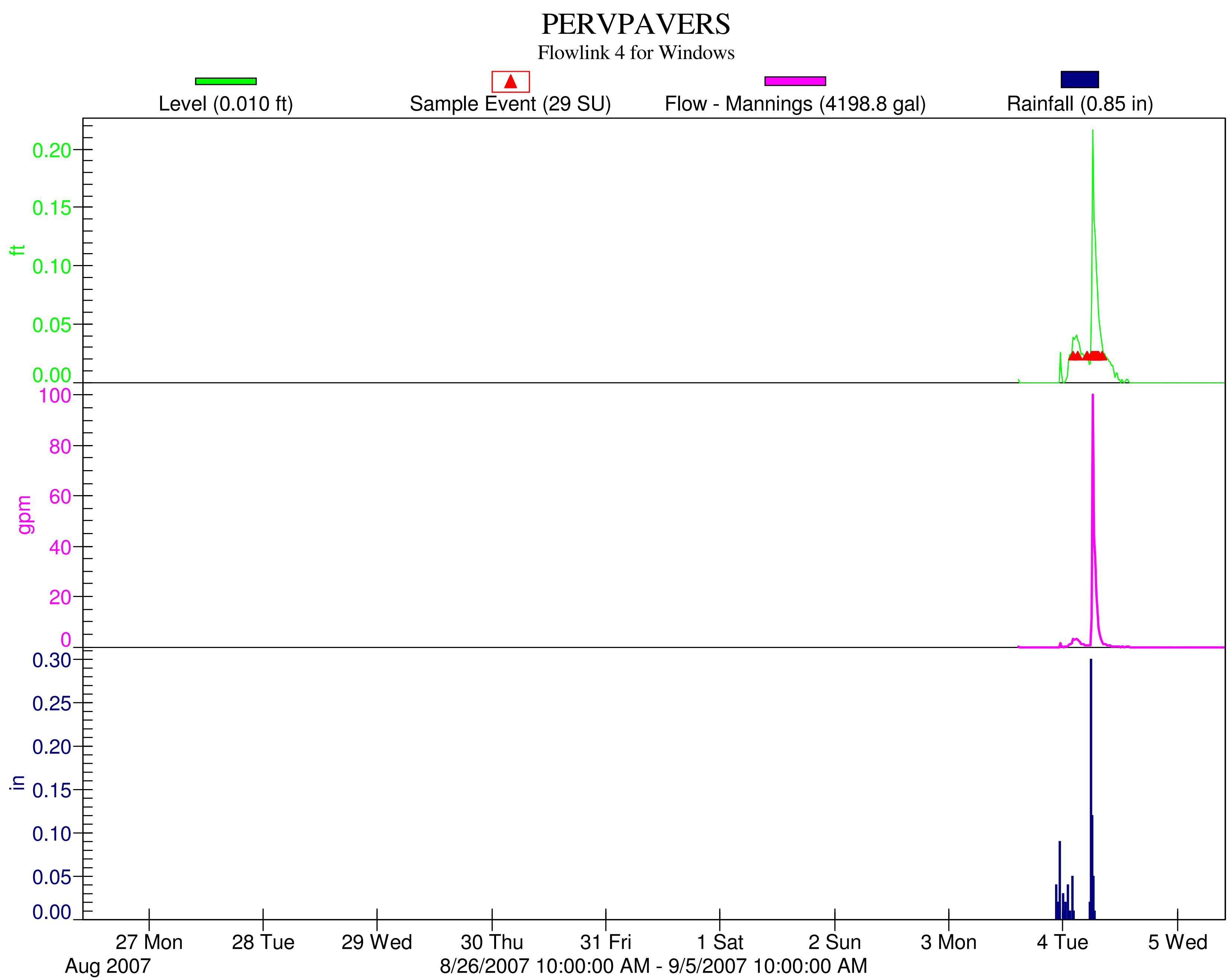
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	04-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Acenaphthene	0.023	ug/L		
Pervious Asphalt	04-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	04-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt	04-Sep-07	Chrysene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Copper	10.7	ug/L		
Pervious Asphalt	04-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Diethylphthalate	1.8	ug/L		
Pervious Asphalt	04-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	04-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	04-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt	04-Sep-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Hardness, Calculated	28.1	mg/L		
Pervious Asphalt	04-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Lead	3.3	ug/L	U	
Pervious Asphalt	04-Sep-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	04-Sep-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	NWTPH-Diesel	0.71	mg/L		
Pervious Asphalt	04-Sep-07	NWTPH-Heavy Oil	0.71	mg/L		
Pervious Asphalt	04-Sep-07	pH	6.4	Std. Units		
Pervious Asphalt	04-Sep-07	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt	04-Sep-07	TSS	19.5	mg/L		
Pervious Asphalt	04-Sep-07	Zinc	9.2	ug/L		
Pervious Asphalt CB	04-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Benzofluoranthenes	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	bis(2-Ethylhexyl)phthalate	1.4	ug/L		
Pervious Asphalt CB	04-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Chrysene	0.014	ug/L		
Pervious Asphalt CB	04-Sep-07	Copper	14.4	ug/L		
Pervious Asphalt CB	04-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Diethylphthalate	1	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Hardness, Calculated	19.4	mg/L		
Pervious Asphalt CB	04-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Lead	3.3	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	04-Sep-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	NWTPH-Diesel	1.3	mg/L		
Pervious Asphalt CB	04-Sep-07	NWTPH-Heavy Oil	2	mg/L		
Pervious Asphalt CB	04-Sep-07	pH	5.8	Std. Units		

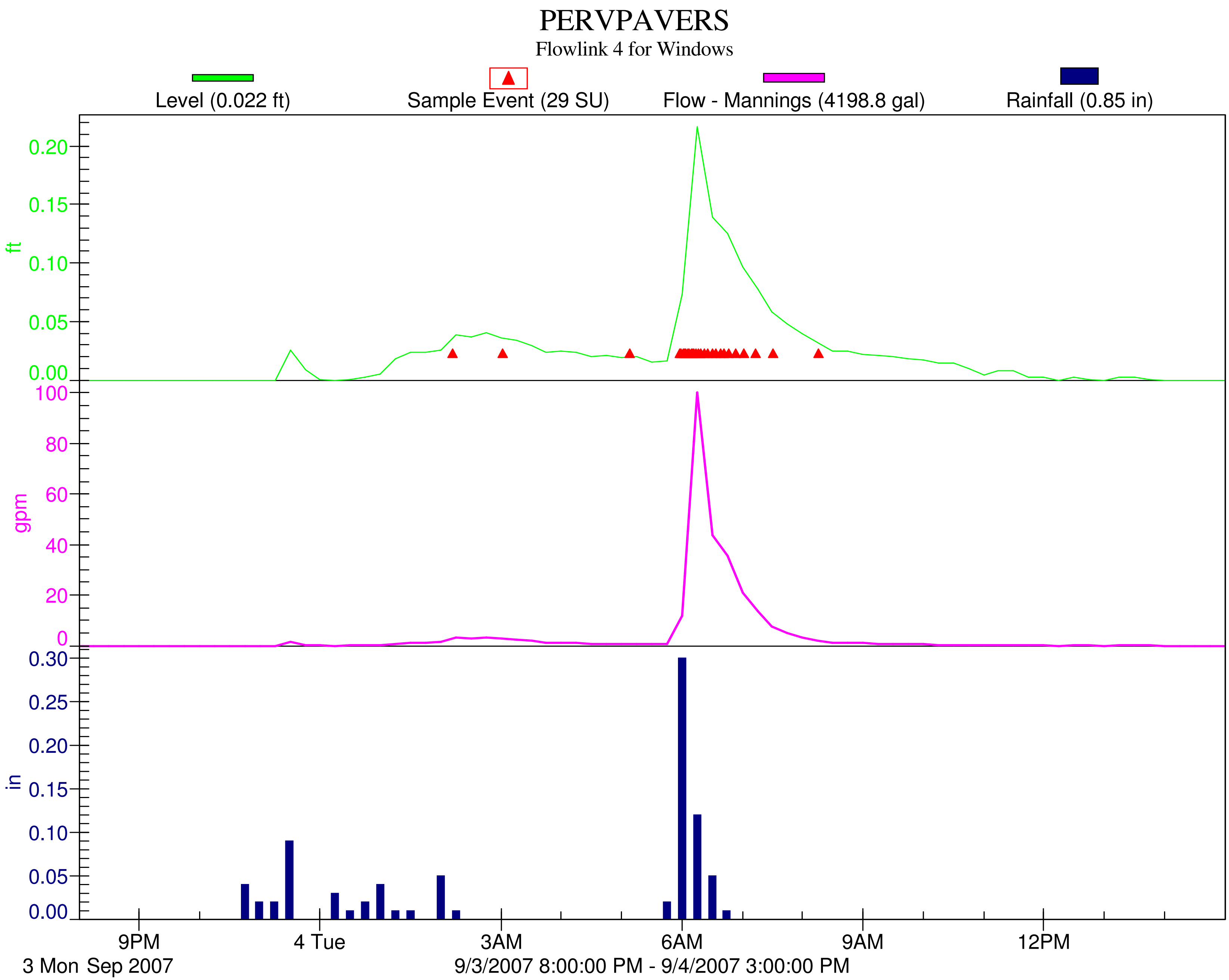
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

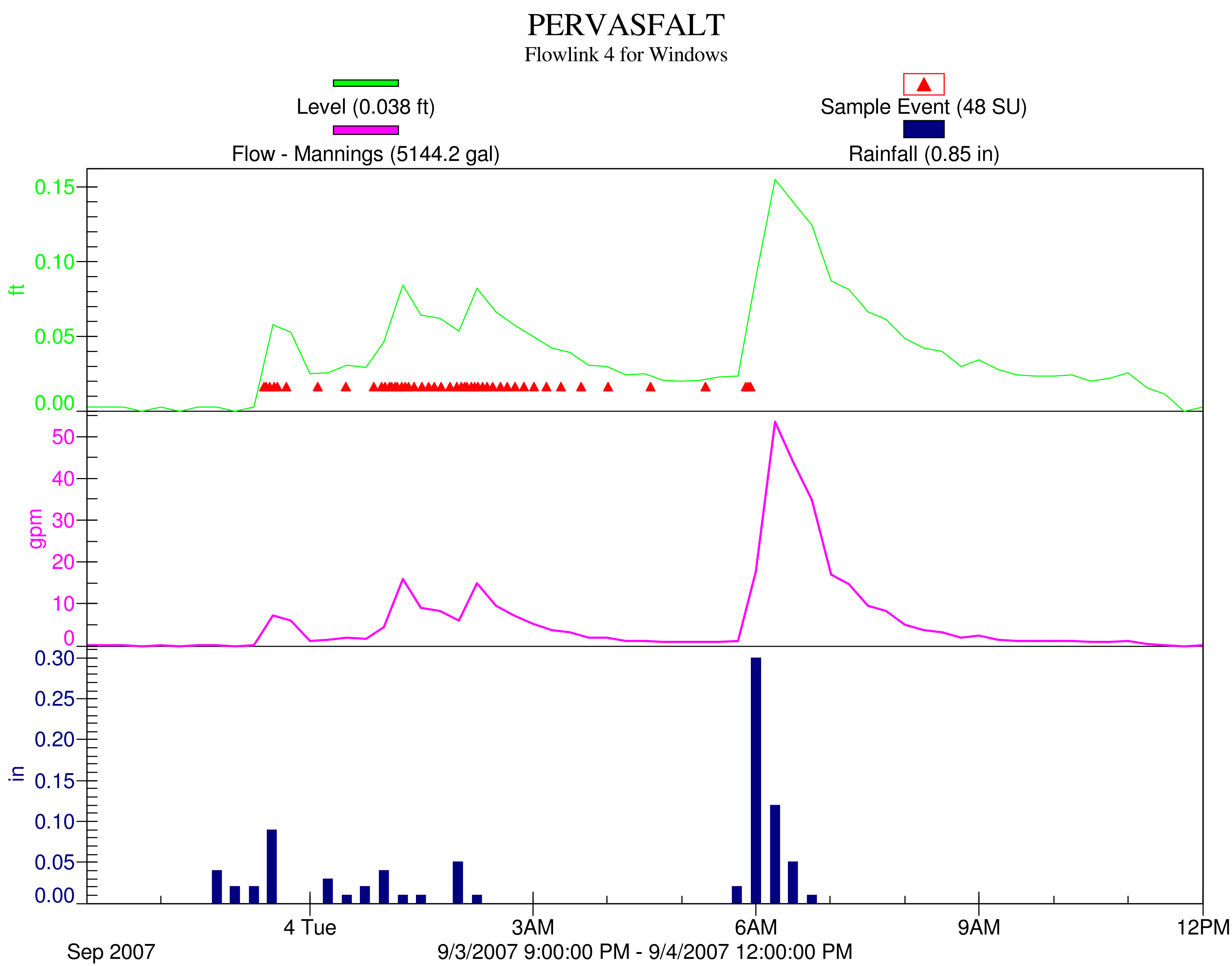
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	04-Sep-07	Phenanthrene	0.017	ug/L		
Pervious Asphalt CB	04-Sep-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt CB	04-Sep-07	TSS	13.4	mg/L		
Pervious Asphalt CB	04-Sep-07	Zinc	82.2	ug/L		
Pervious Concrete CB	04-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	04-Sep-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	04-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	04-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	04-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	04-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	

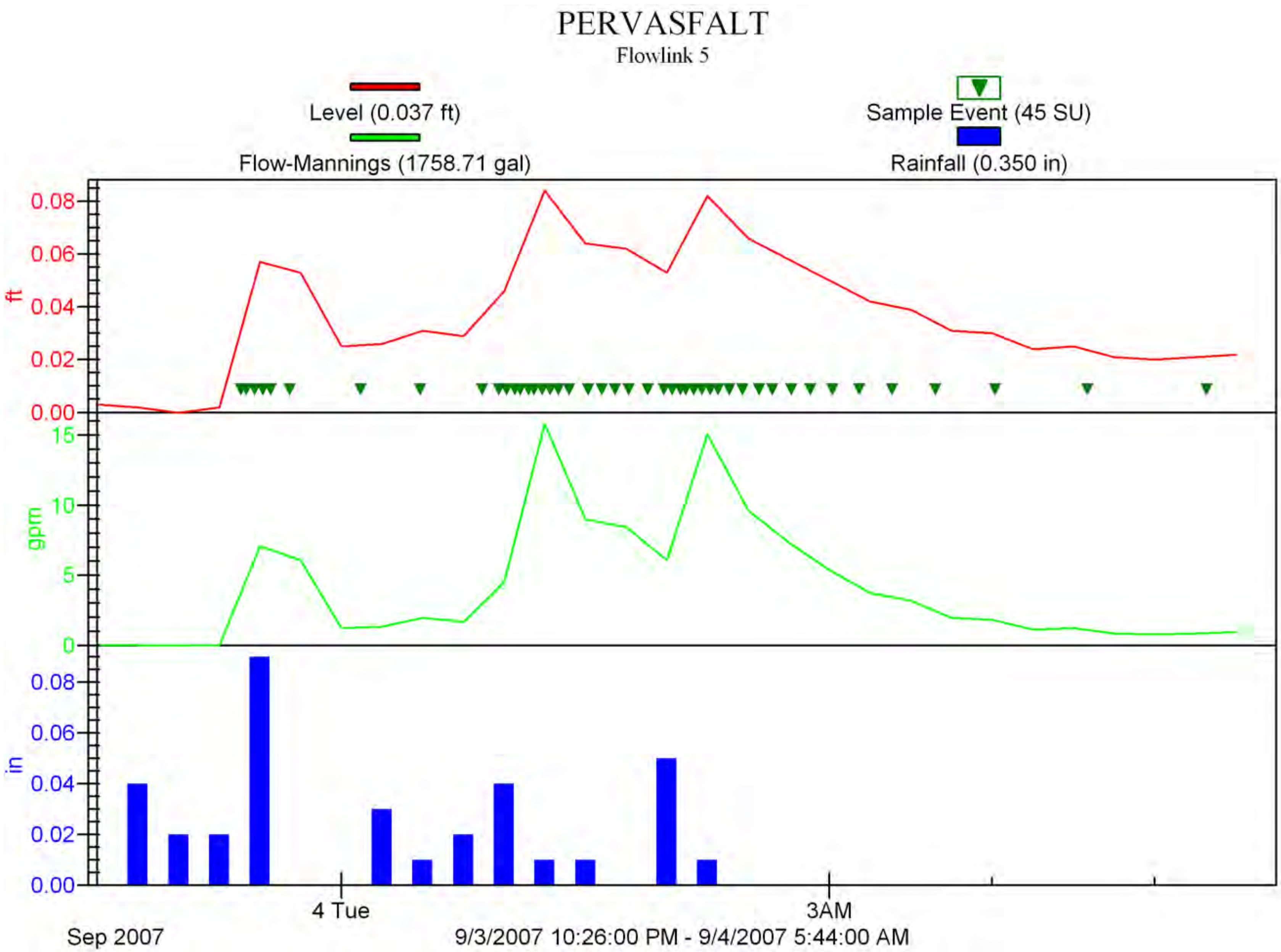
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVPAVERS
Flowlink 4 for Windows
Level (0.010 ft)
Sample Event (29 SU)
Flow - Mannings (4198.8 gal)
Rainfall (0.85 in)
ft
0.20
0.15
0.10
0.05
0.00
gpm
100
80
60
40
20
0
in
0.30
0.25
0.20
0.15
0.10
0.05
0.00
27 Mon
28 Tue
29 Wed
30 Thu
31 Fri
1 Sat
2 Sun
3 Mon
4 Tue
5 Wed
Aug 2007
8/26/2007 10:00:00 AM - 9/5/2007 10:00:00 AM



PERVPAVERS
Flowlink 4 for Windows
Level (0.022 ft)
Sample Event (29 SU)
Flow - Mannings (4198.8 gal)
Rainfall (0.85 in)
ft
0.20
0.15
0.10
0.05
0.00
gpm
100
80
60
40
20
0
in
0.30
0.25
0.20
0.15
0.10
0.05
0.00
9PM
4 Tue
3AM
6AM
9AM
12PM
3 Mon Sep 2007
9/3/2007 8:00:00 PM - 9/4/2007 3:00:00 PM


PERVASFALT
Flowlink 4 for Windows
Level (0.038 ft)
Sample Event (48 SU)
Flow - Mannings (5144.2 gal)
Rainfall (0.85 in)
ft
0.15
0.10
0.05
0.00
gpm
50
40
30
20
10
0
in
0.30
0.25
0.20
0.15
0.10
0.05
0.00
4 Tue
3AM
6AM
9AM
12PM
Sep 2007
9/3/2007 9:00:00 PM - 9/4/2007 12:00:00 PM


PERVASFALT
Flowlink 5
Level (0.037 ft)
Sample Event (45 SU)
Flow-Mannings (1758.71 gal)
Rainfall (0.350 in)
ft
0.08
0.06
0.04
0.02
0.00
gpm
15
10
5
0
in
0.08
0.06
0.04
0.02
0.00
4 Tue
3AM
Sep 2007
9/3/2007 10:26:00 PM - 9/4/2007 5:44:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #6
September 16, 2007

Introduction

This report summarizes the storm event sampled on 09/16/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #6.

Table 1. Storm Characteristics

Storm Date		09/16/07
Time Storm Began		09/16/07 1:30 pm
Total Precipitation (in)		0.27
Duration (hrs)		21.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		295
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #6. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event, so this event did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Fourty-seven sample aliquots were collected during the sampling period. These aliquots were collected over 25.8% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	9.5
Duration of Flow (hrs)	NS	NS	NS	26.0
Total Volume (gallons) during Storm Event	NS	NS	NS	5460
Total Volume (gallons) during Sampling Event	NS	NS	NS	1411
Duration of Sampling Event (hrs)	NS	NS	NS	6.75
Number of Sample Aliquots Collected	NS	NS	NS	47
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	25.8%
Volume of Surface Runoff Collected in Vault (inches)	NM	NM	NM	

Key: NS = Not Sampled

NM = Not measured

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Deployed for all sample locations. No sample was collected from the other sampling locations during this storm event.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

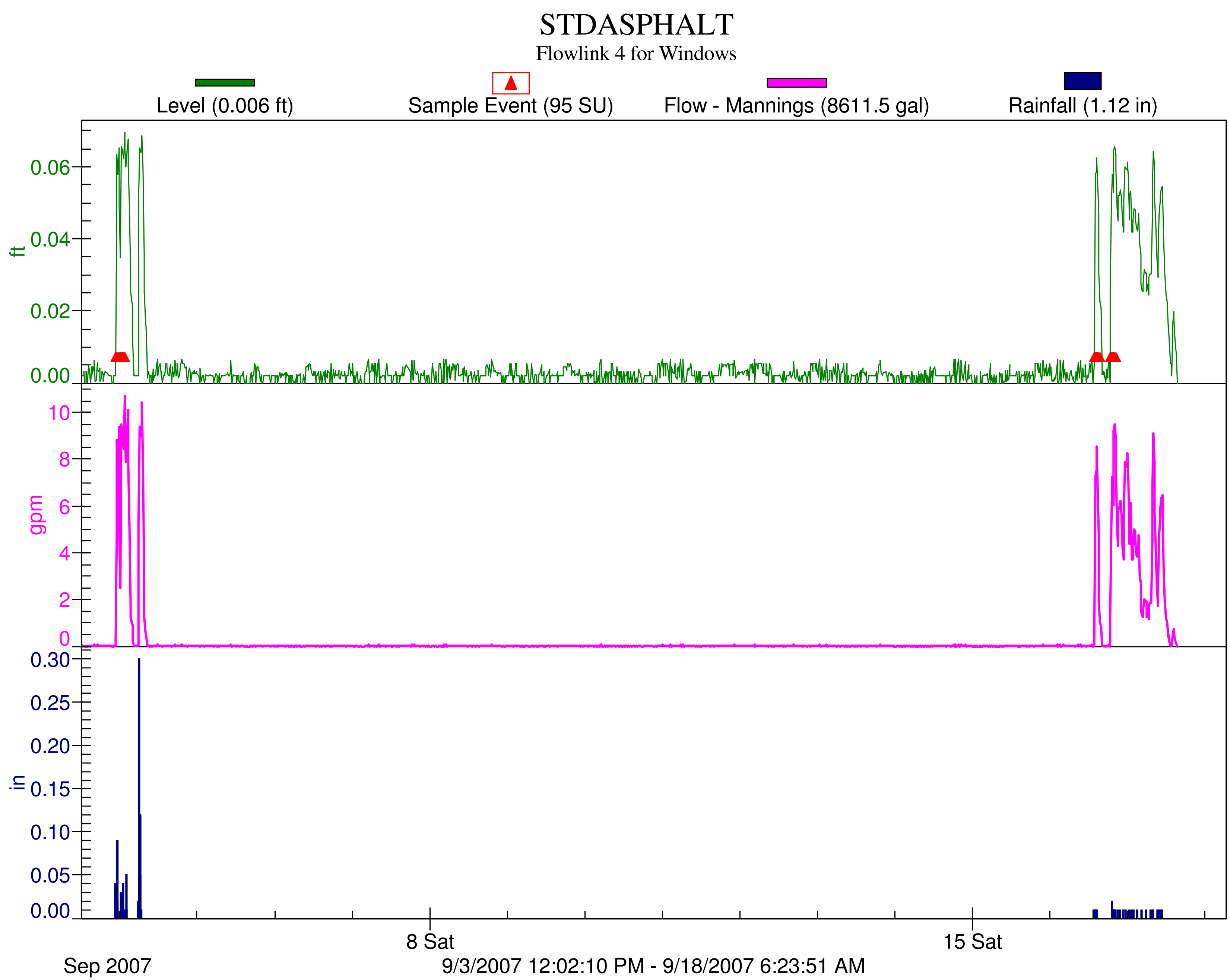
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	16-Sep-07	2-Methylnaphthalene	0.022	ug/L		
Standard Asphalt	16-Sep-07	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Anthracene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Benzo(b,k)fluoranthenes	0.014	ug/L		
Standard Asphalt	16-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	bis(2-Ethylhexyl)phthalate	3	ug/L		
Standard Asphalt	16-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Standard Asphalt	16-Sep-07	Chrysene	0.021	ug/L		
Standard Asphalt	16-Sep-07	Copper	44.9	ug/L		
Standard Asphalt	16-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Diethylphthalate	1.6	ug/L		
Standard Asphalt	16-Sep-07	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	16-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	16-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Standard Asphalt	16-Sep-07	Fluoranthene	0.014	ug/L		
Standard Asphalt	16-Sep-07	Fluorene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Hardness, Calculated	33.8	mg/L		
Standard Asphalt	16-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Lead	5	ug/L	U	
Standard Asphalt	16-Sep-07	Mercury	0.05	ug/L	U	
Standard Asphalt	16-Sep-07	Naphthalene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	NWTPH-Diesel	1.8	mg/L		
Standard Asphalt	16-Sep-07	NWTPH-Heavy Oil	2.5	mg/L		
Standard Asphalt	16-Sep-07	pH	5.5	Std. Units		
Standard Asphalt	16-Sep-07	Phenanthrene	0.01	ug/L	U	
Standard Asphalt	16-Sep-07	Pyrene	0.015	ug/L		
Standard Asphalt	16-Sep-07	TSS	11.2	mg/L		
Standard Asphalt	16-Sep-07	Zinc	230	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

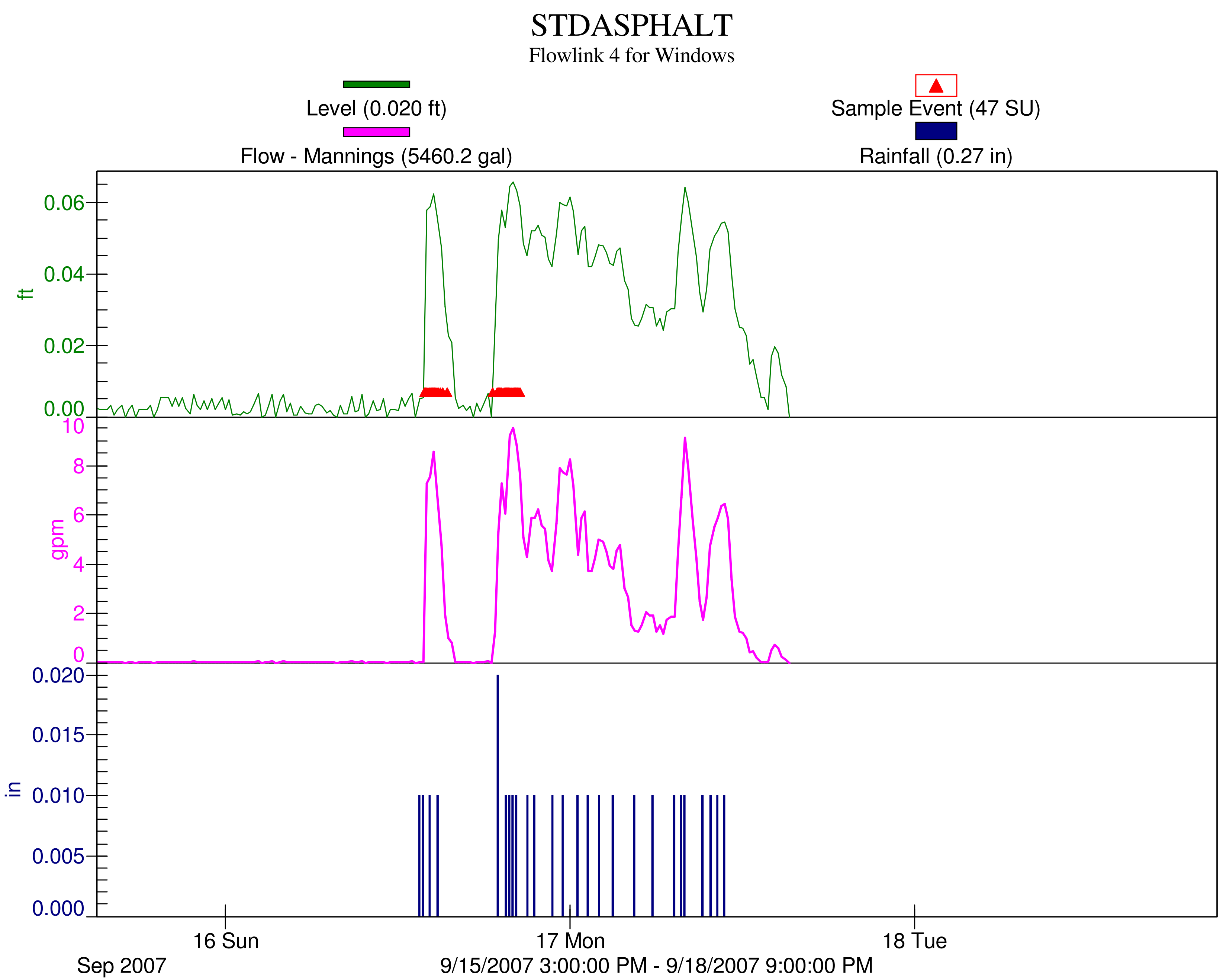
Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



STDASPHALT
Flowlink 4 for Windows
Level (0.006 ft)
Sample Event (95 SU)
Flow - Mannings (8611.5 gal)
Rainfall (1.12 in)
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.30
0.25
0.20
0.15
0.10
0.05
0.00
8 Sat
15 Sat
Sep 2007
9/3/2007 12:02:10 PM - 9/18/2007 6:23:51 AM



STDASPHALT
Flowlink 4 for Windows
Level (0.020 ft)
Sample Event (47 SU)
Flow - Mannings (5460.2 gal)
Rainfall (0.27 in)
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.020
0.015
0.010
0.005
0.000
16 Sun
17 Mon
18 Tue
Sep 2007
9/15/2007 3:00:00 PM - 9/18/2007 9:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #7
September 28, 2007

Introduction

This report summarizes the storm event sampled on 09/28/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #7.

Table 1. Storm Characteristics

Storm Date		09/28/07
Time Storm Began		9/27/07, 8:45 PM
Total Precipitation (in)		0.55
Duration (hrs)		10.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		203
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #7. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, 4, and 5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	34.8	15.6	26.4	10.3
Duration of Flow (hrs)	13	13.3	9.25	11.5
Total Volume (gallons) during Storm Event	3001	3446	2581	4227
Total Volume (gallons) during Sampling Event	2277	1251	2366	4221
Duration of Sampling Event (hrs)	3.0	6.0	6.0	11.0
Number of Sample Aliquots Collected	48	48	48	42
Percentage of Storm's Total Volume over which Samples were Collected	75.9%	36.1%	91.7%	99.9%
Volume of Surface Runoff Collected in Vault (inches)	11.5 in	20 in	18.5 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious concrete
- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted no special observations during the sampling event. Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	28-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Acenaphthene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Acenaphthylene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Anthracene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	J
Pervious Asphalt	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	J
Pervious Asphalt	28-Sep-07	Chrysene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Copper	7.7	ug/L		J
Pervious Asphalt	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Diethylphthalate	1.9	ug/L		J
Pervious Asphalt	28-Sep-07	Dimethyl phthalate	1	ug/L	U	J
Pervious Asphalt	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	J
Pervious Asphalt	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	J
Pervious Asphalt	28-Sep-07	Fluoranthene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Fluorene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Hardness, Calculated	24.1	mg/L		
Pervious Asphalt	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Lead	3.3	ug/L	U	
Pervious Asphalt	28-Sep-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	28-Sep-07	Naphthalene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	28-Sep-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	28-Sep-07	pH	6.4	Std. Units		
Pervious Asphalt	28-Sep-07	Phenanthrene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	Pyrene	0.01	ug/L	U	J
Pervious Asphalt	28-Sep-07	TSS	23.5	mg/L		
Pervious Asphalt	28-Sep-07	Zinc	6.8	ug/L		
Pervious Asphalt CB	28-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Acenaphthene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Acenaphthylene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Anthracene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Chrysene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Copper	5.3	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Diethylphthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Dimethyl phthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Fluoranthene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Fluorene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Hardness, Calculated	12.7	mg/L		
Pervious Asphalt CB	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Lead	3.3	ug/L	U	
Pervious Asphalt CB	28-Sep-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	28-Sep-07	Naphthalene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	NWTPH-Diesel	0.25	mg/L		
Pervious Asphalt CB	28-Sep-07	NWTPH-Heavy Oil	0.43	mg/L		
Pervious Asphalt CB	28-Sep-07	pH	6.3	Std. Units		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	28-Sep-07	Phenanthrene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	Pyrene	0.01	ug/L	U	J
Pervious Asphalt CB	28-Sep-07	TSS	7.6	mg/L		
Pervious Asphalt CB	28-Sep-07	Zinc	36.6	ug/L		
Pervious Concrete	28-Sep-07	2-Methylnaphthalene	0.029	ug/L		
Pervious Concrete	28-Sep-07	Acenaphthene	0.02	ug/L		
Pervious Concrete	28-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Chrysene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Copper	8	ug/L		J
Pervious Concrete	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Concrete	28-Sep-07	Fluoranthene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Fluorene	0.033	ug/L		
Pervious Concrete	28-Sep-07	Hardness, Calculated	370	mg/L		
Pervious Concrete	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Concrete	28-Sep-07	Lead	6.3	ug/L		
Pervious Concrete	28-Sep-07	Mercury	0.05	ug/L	U	
Pervious Concrete	28-Sep-07	Naphthalene	0.016	ug/L		
Pervious Concrete	28-Sep-07	NWTPH-Diesel	0.41	mg/L		
Pervious Concrete	28-Sep-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete	28-Sep-07	pH	11.8	Std. Units		
Pervious Concrete	28-Sep-07	Phenanthrene	0.041	ug/L		
Pervious Concrete	28-Sep-07	Pyrene	0.019	ug/L		
Pervious Concrete	28-Sep-07	TSS	71.6	mg/L		
Pervious Concrete	28-Sep-07	Zinc	6.3	ug/L		
Pervious Concrete CB	28-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Chrysene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Copper	5.3	ug/L	U	J
Pervious Concrete CB	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Concrete CB	28-Sep-07	Fluoranthene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Hardness, Calculated	30.1	mg/L		
Pervious Concrete CB	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	Lead	3.4	ug/L	B	
Pervious Concrete CB	28-Sep-07	Mercury	0.05	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	28-Sep-07	Naphthalene	0.01	ug/L	U	
Pervious Concrete CB	28-Sep-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	28-Sep-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete CB	28-Sep-07	pH	7.2	Std. Units		
Pervious Concrete CB	28-Sep-07	Phenanthrene	0.012	ug/L		
Pervious Concrete CB	28-Sep-07	Pyrene	0.012	ug/L		
Pervious Concrete CB	28-Sep-07	TSS	6.2	mg/L		
Pervious Concrete CB	28-Sep-07	Zinc	18.4	ug/L		
Pervious Pavers	28-Sep-07	2-Methylnaphthalene	0.025	ug/L		
Pervious Pavers	28-Sep-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Pavers	28-Sep-07	Chrysene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Copper	30.4	ug/L		J
Pervious Pavers	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Diethylphthalate	2.8	ug/L		
Pervious Pavers	28-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Pavers	28-Sep-07	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Fluorene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Hardness, Calculated	40.4	mg/L		
Pervious Pavers	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Lead	3.4	ug/L	B	
Pervious Pavers	28-Sep-07	Mercury	0.05	ug/L	U	
Pervious Pavers	28-Sep-07	Naphthalene	0.073	ug/L		
Pervious Pavers	28-Sep-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers	28-Sep-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Pavers	28-Sep-07	pH	7.4	Std. Units		
Pervious Pavers	28-Sep-07	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	Pyrene	0.01	ug/L	U	
Pervious Pavers	28-Sep-07	TSS	40	mg/L		
Pervious Pavers	28-Sep-07	Zinc	14.3	ug/L		
Pervious Pavers CB	28-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Benzo(b,k)fluoranthenes	0.01	ug/L		
Pervious Pavers CB	28-Sep-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Chrysene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Copper	5.3	ug/L	U	J
Pervious Pavers CB	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Diethylphthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Pavers CB	28-Sep-07	Fluoranthene	0.011	ug/L		
Pervious Pavers CB	28-Sep-07	Fluorene	0.01	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers CB	28-Sep-07	Hardness, Calculated	27.4	mg/L		
Pervious Pavers CB	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	Lead	4.3	ug/L	B	
Pervious Pavers CB	28-Sep-07	Mercury	0.05	ug/L	U	
Pervious Pavers CB	28-Sep-07	Naphthalene	0.01	ug/L	U	
Pervious Pavers CB	28-Sep-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers CB	28-Sep-07	NWTPH-Heavy Oil	0.43	mg/L		
Pervious Pavers CB	28-Sep-07	pH	7	Std. Units		
Pervious Pavers CB	28-Sep-07	Phenanthrene	0.013	ug/L		
Pervious Pavers CB	28-Sep-07	Pyrene	0.015	ug/L		
Pervious Pavers CB	28-Sep-07	TSS	6	mg/L		
Pervious Pavers CB	28-Sep-07	Zinc	28.2	ug/L		
Standard Asphalt	28-Sep-07	2-Methylnaphthalene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Anthracene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Benzo(a)anthracene	0.026	ug/L		
Standard Asphalt	28-Sep-07	Benzo(a)pyrene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Benzo(b,k)fluoranthenes	0.028	ug/L		
Standard Asphalt	28-Sep-07	Benzo(g,h,i)perylene	0.023	ug/L		
Standard Asphalt	28-Sep-07	bis(2-Ethylhexyl)phthalate	2.9	ug/L		
Standard Asphalt	28-Sep-07	Butylbenzylphthalate	1	ug/L	U	
Standard Asphalt	28-Sep-07	Chrysene	0.011	ug/L		
Standard Asphalt	28-Sep-07	Copper	10.8	ug/L		J
Standard Asphalt	28-Sep-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Diethylphthalate	1.5	ug/L		
Standard Asphalt	28-Sep-07	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	28-Sep-07	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	28-Sep-07	Di-n-Octyl phthalate	1	ug/L	U	
Standard Asphalt	28-Sep-07	Fluoranthene	0.022	ug/L		
Standard Asphalt	28-Sep-07	Fluorene	0.01	ug/L	U	
Standard Asphalt	28-Sep-07	Hardness, Calculated	8.74	mg/L		
Standard Asphalt	28-Sep-07	Indeno(1,2,3-cd)pyrene	0.012	ug/L		
Standard Asphalt	28-Sep-07	Lead	3.4	ug/L	B	
Standard Asphalt	28-Sep-07	Mercury	0.05	ug/L	U	
Standard Asphalt	28-Sep-07	Naphthalene	0.012	ug/L		
Standard Asphalt	28-Sep-07	NWTPH-Diesel	0.54	mg/L		
Standard Asphalt	28-Sep-07	NWTPH-Heavy Oil	0.84	mg/L		
Standard Asphalt	28-Sep-07	pH	5.2	Std. Units		
Standard Asphalt	28-Sep-07	Phenanthrene	0.021	ug/L		
Standard Asphalt	28-Sep-07	Pyrene	0.021	ug/L		
Standard Asphalt	28-Sep-07	TSS	16.4	mg/L		
Standard Asphalt	28-Sep-07	Zinc	68.8	ug/L		

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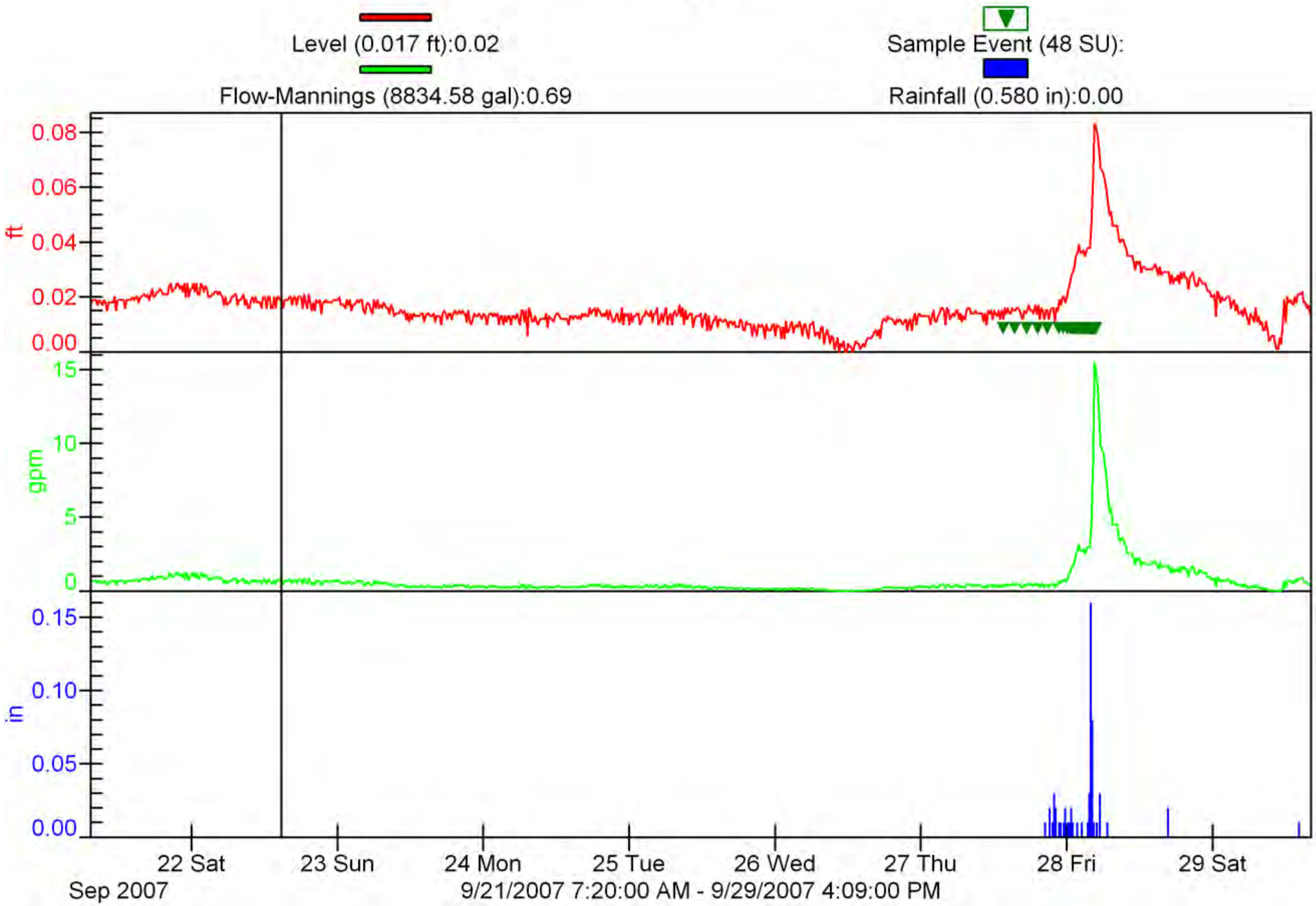
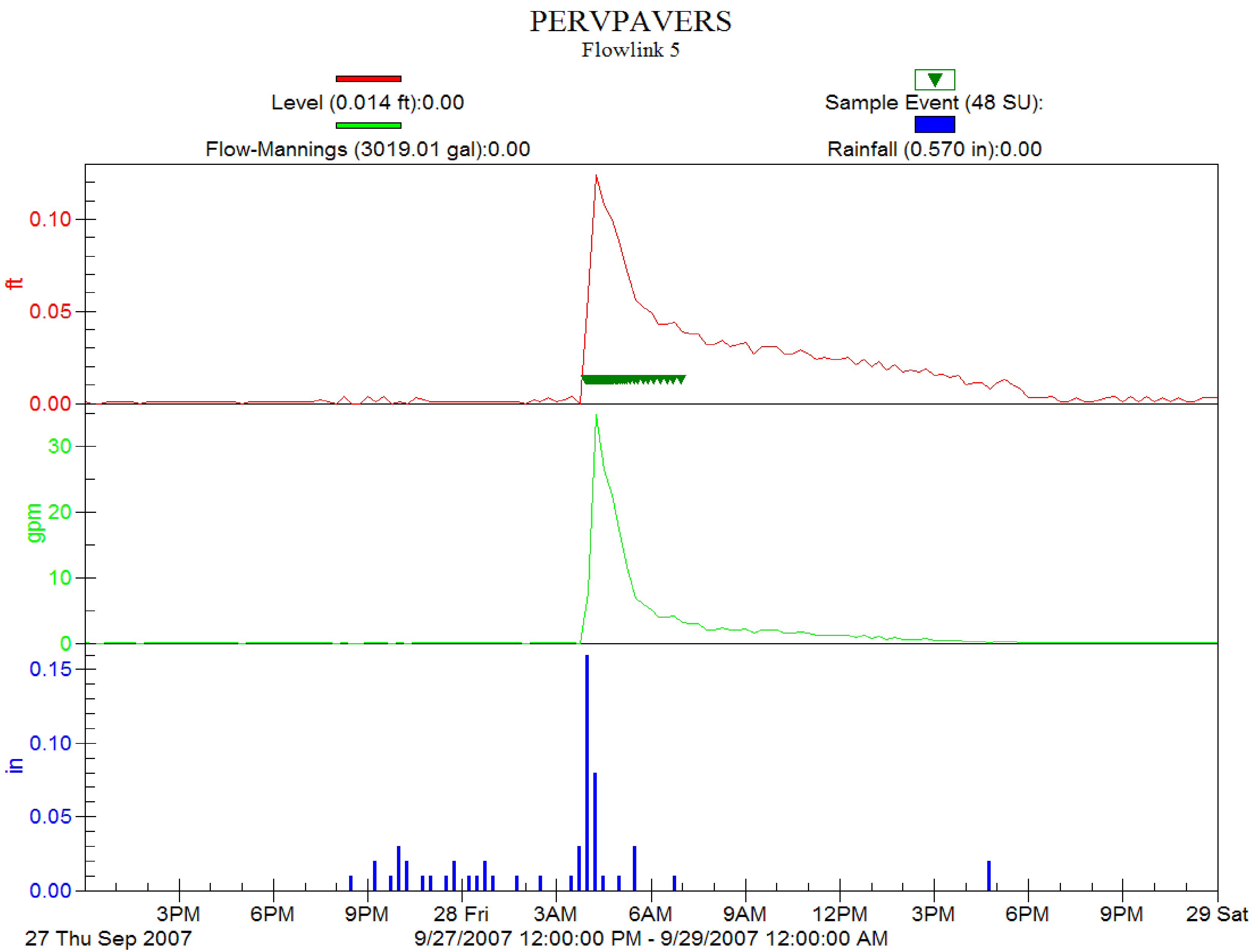
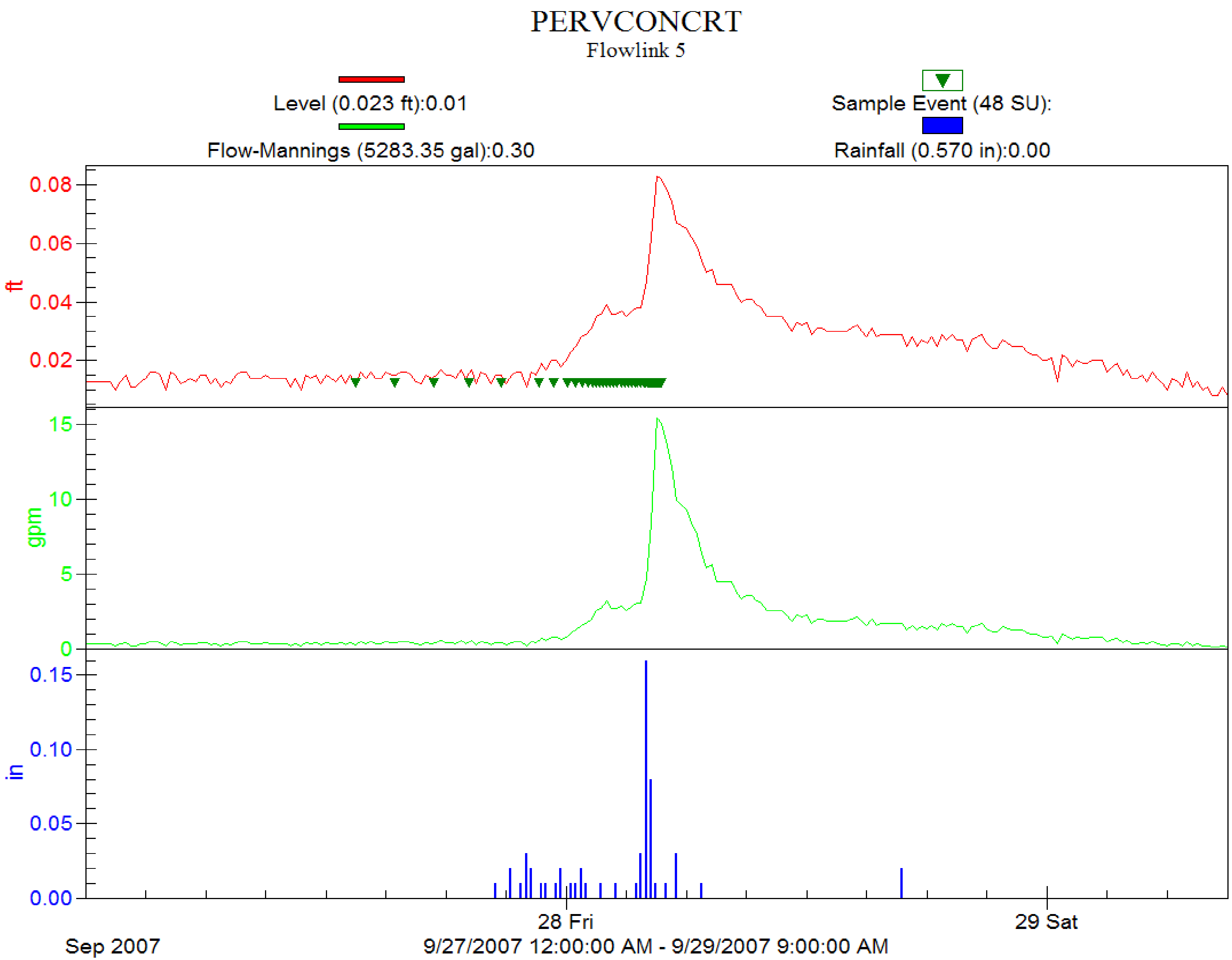
PERVCONCRT

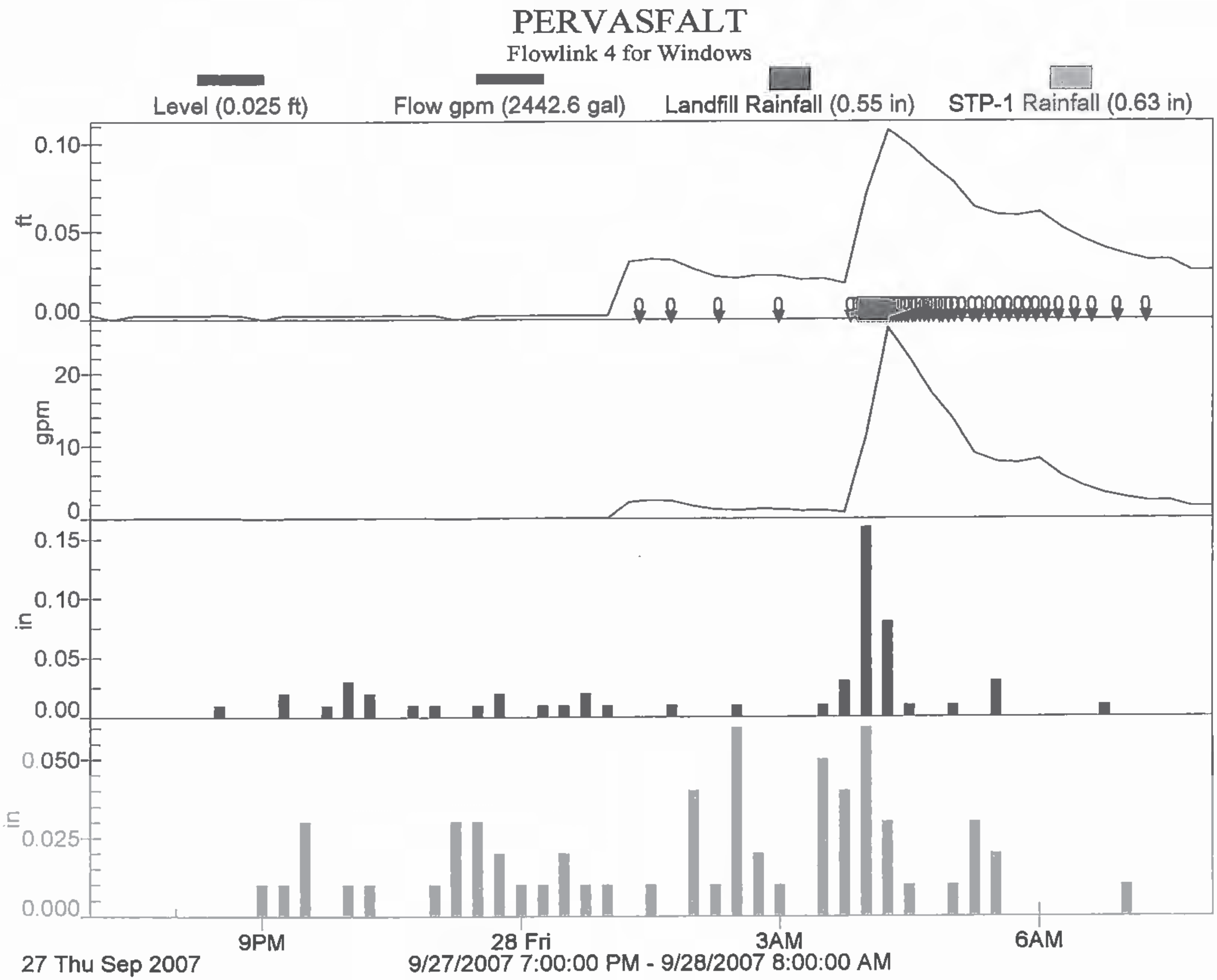
Flowlink 5



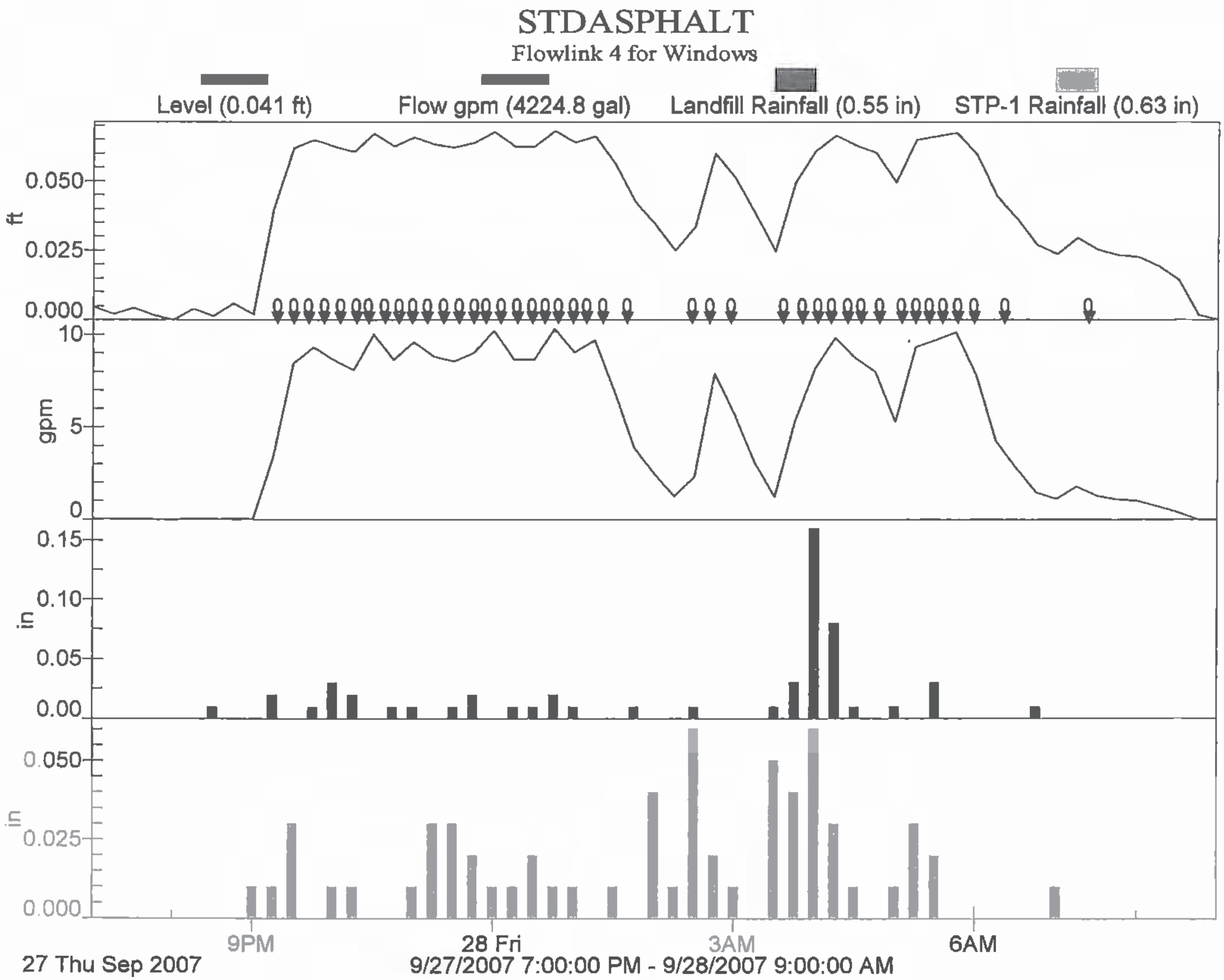

PERVPAVERS
Flowlink 5
Level (0.014 ft):0.00
Flow-Mannings (3019.01 gal):0.00
Sample Event (48 SU):
Rainfall (0.570 in):0.00
ft
0.10
0.05
0.00
gpm
30
20
10
0
in
0.15
0.10
0.05
0.00
3PM
6PM
9PM
28 Fri
3AM
6AM
9AM
12PM
3PM
6PM
9PM
29 Sat
27 Thu Sep 2007
9/27/2007 12:00:00 PM - 9/29/2007 12:00:00 AM



PERVCONCRT
Flowlink 5
Level (0.023 ft):0.01
Flow-Mannings (5283.35 gal):0.30
Sample Event (48 SU):
Rainfall (0.570 in):0.00
ft
0.08
0.06
0.04
0.02
gpm
15
10
5
0
in
0.15
0.10
0.05
0.00
28 Fri
29 Sat
Sep 2007
9/27/2007 12:00:00 AM - 9/29/2007 9:00:00 AM



PERVASFALT
Flowlink 4 for Windows
Level (0.025 ft)
Flow gpm (2442.6 gal)
Landfill Rainfall (0.55 in)
STP-1 Rainfall (0.63 in)
ft
0.10
0.05
0.00
gpm
20
10
0
in
0.15
0.10
0.05
0.00
in
0.050
0.025
0.000
9PM
28 Fri
3AM
6AM
27 Thu Sep 2007
9/27/2007 7:00:00 PM - 9/28/2007 8:00:00 AM



STDASPHALT
Flowlink 4 for Windows
Level (0.041 ft)
Flow gpm (4224.8 gal)
Landfill Rainfall (0.55 in)
STP-1 Rainfall (0.63 in)
ft
0.050
0.025
0.000
gpm
10
5
0
in
0.15
0.10
0.05
0.00
in
0.050
0.025
0.000
9PM
28 Fri
3AM
6AM
27 Thu Sep 2007
9/27/2007 7:00:00 PM - 9/28/2007 9:00:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #8
October 10, 2007

Introduction

This report summarizes the storm event sampled on 10/10/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #8.

Table 1. Storm Characteristics

Storm Date		10/10/07
Time Storm Began		10/10/07 3:00 AM
Total Precipitation (in)		0.23
Duration (hrs)		17.8
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		59
Precipitation in 24-hr Antecedent Dry Period (in)		0.01
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #8. As shown above, 0.01 inches of rain fell in the 24 hours prior to the sampling event, but this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious pavers. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Nineteen sample aliquots were collected during the sampling period. These aliquots were collected over 93.5% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	10.2	NS	NS	NS
Duration of Flow (hrs)	23.3	NS	NS	NS
Total Volume (gallons) during Storm Event	1454	NS	NS	NS
Total Volume (gallons) during Sampling Event	1360	NS	NS	NS
Duration of Sampling Event (hrs)	19.0	NS	NS	NS
Number of Sample Aliquots Collected	19	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	93.5%	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	2.5 in	20.5 in	8.5 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious concrete – No sample. Build-up in line affected the level reading and sampler started sampling nothing. Cleaned out line.

- Pervious asphalt – No sample. Small rain event and pacing too high – changed.
- Standard asphalt – No sample. Sampler tried to sample – recalibrated sample volume.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

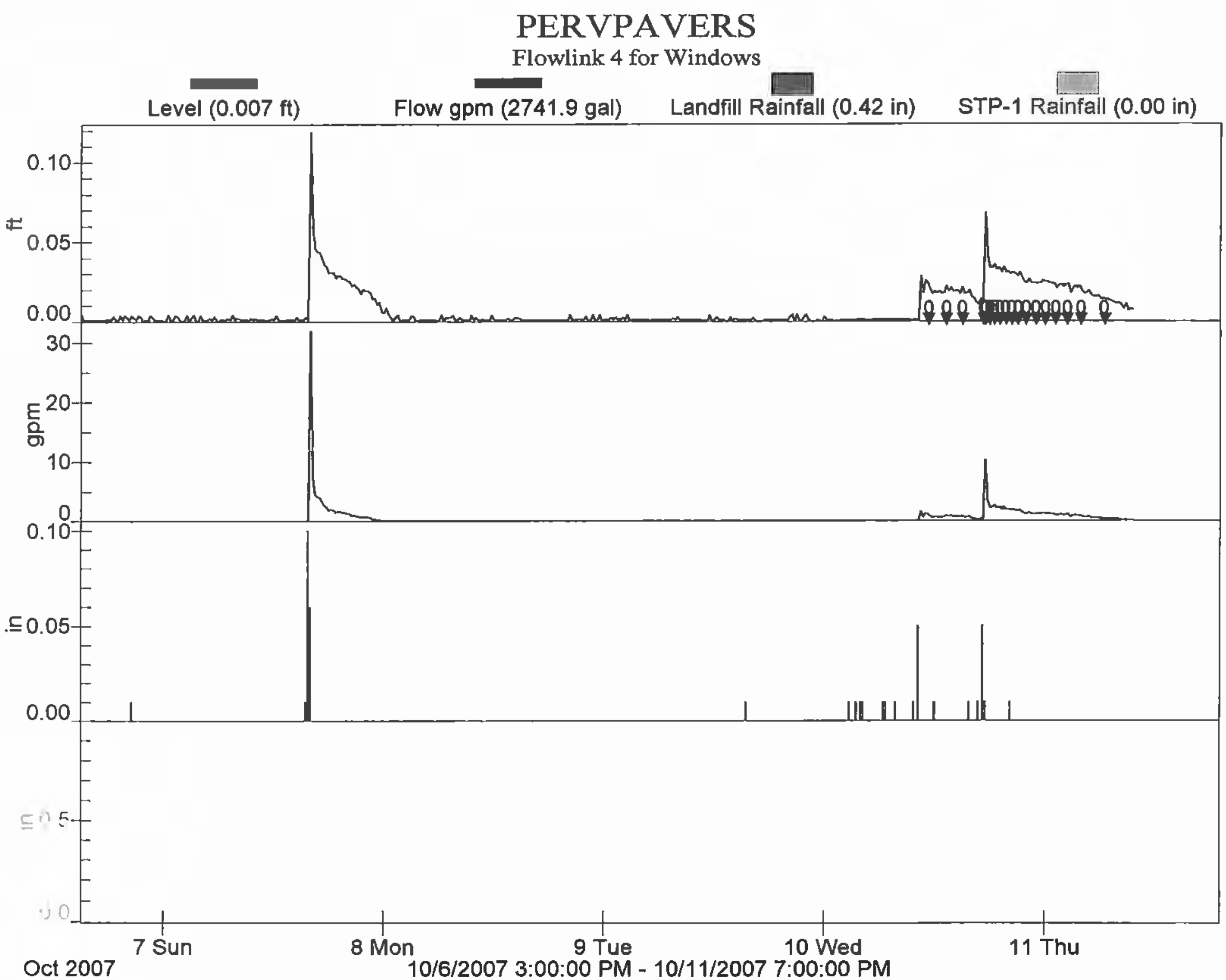
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	11-Oct-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Benzo(a)anthracene	0.032	ug/L		
Pervious Asphalt CB	11-Oct-07	Benzo(a)pyrene	0.02	ug/L		
Pervious Asphalt CB	11-Oct-07	Benzo(b,k)fluoranthenes	0.05	ug/L		
Pervious Asphalt CB	11-Oct-07	Benzo(g,h,i)perylene	0.045	ug/L		
Pervious Asphalt CB	11-Oct-07	bis(2-Ethylhexyl)phthalate	4.3	ug/L		
Pervious Asphalt CB	11-Oct-07	Butylbenzylphthalate	1	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Chrysene	0.017	ug/L		
Pervious Asphalt CB	11-Oct-07	Copper	11.5	ug/L		
Pervious Asphalt CB	11-Oct-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Diethylphthalate	1	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Fluoranthene	0.048	ug/L		
Pervious Asphalt CB	11-Oct-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Hardness, Calculated	15.2	mg/L		
Pervious Asphalt CB	11-Oct-07	Indeno(1,2,3-cd)pyrene	0.032	ug/L		
Pervious Asphalt CB	11-Oct-07	Lead	5.4	ug/L		
Pervious Asphalt CB	11-Oct-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	11-Oct-07	Naphthalene	3.19	ug/L		
Pervious Asphalt CB	11-Oct-07	NWTPH-Diesel	0.21	mg/L		
Pervious Asphalt CB	11-Oct-07	NWTPH-Heavy Oil	0.94	mg/L		
Pervious Asphalt CB	11-Oct-07	pH	6.4	Std. Units		
Pervious Asphalt CB	11-Oct-07	Phenanthrene	0.013	ug/L		
Pervious Asphalt CB	11-Oct-07	Pyrene	0.07	ug/L		
Pervious Asphalt CB	11-Oct-07	TSS	20.8	mg/L		
Pervious Asphalt CB	11-Oct-07	Zinc	62.2	ug/L		
Pervious Concrete CB	11-Oct-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Benzo(b,k)fluoranthenes	0.011	ug/L		
Pervious Concrete CB	11-Oct-07	Benzo(g,h,i)perylene	0.01	ug/L		
Pervious Concrete CB	11-Oct-07	bis(2-Ethylhexyl)phthalate	1.5	ug/L		
Pervious Concrete CB	11-Oct-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete CB	11-Oct-07	Chrysene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Copper	7.5	ug/L		
Pervious Concrete CB	11-Oct-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Diethyl phthalate	1	ug/L	U	
Pervious Concrete CB	11-Oct-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	11-Oct-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	11-Oct-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete CB	11-Oct-07	Fluoranthene	0.013	ug/L		
Pervious Concrete CB	11-Oct-07	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Hardness, Calculated	29.9	mg/L		
Pervious Concrete CB	11-Oct-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	Lead	4.1	ug/L	B	
Pervious Concrete CB	11-Oct-07	Mercury	0.05	ug/L	U	
Pervious Concrete CB	11-Oct-07	Naphthalene	0.01	ug/L	U	
Pervious Concrete CB	11-Oct-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	11-Oct-07	NWTPH-Heavy Oil	0.6	mg/L		
Pervious Concrete CB	11-Oct-07	pH	7.4	Std. Units		

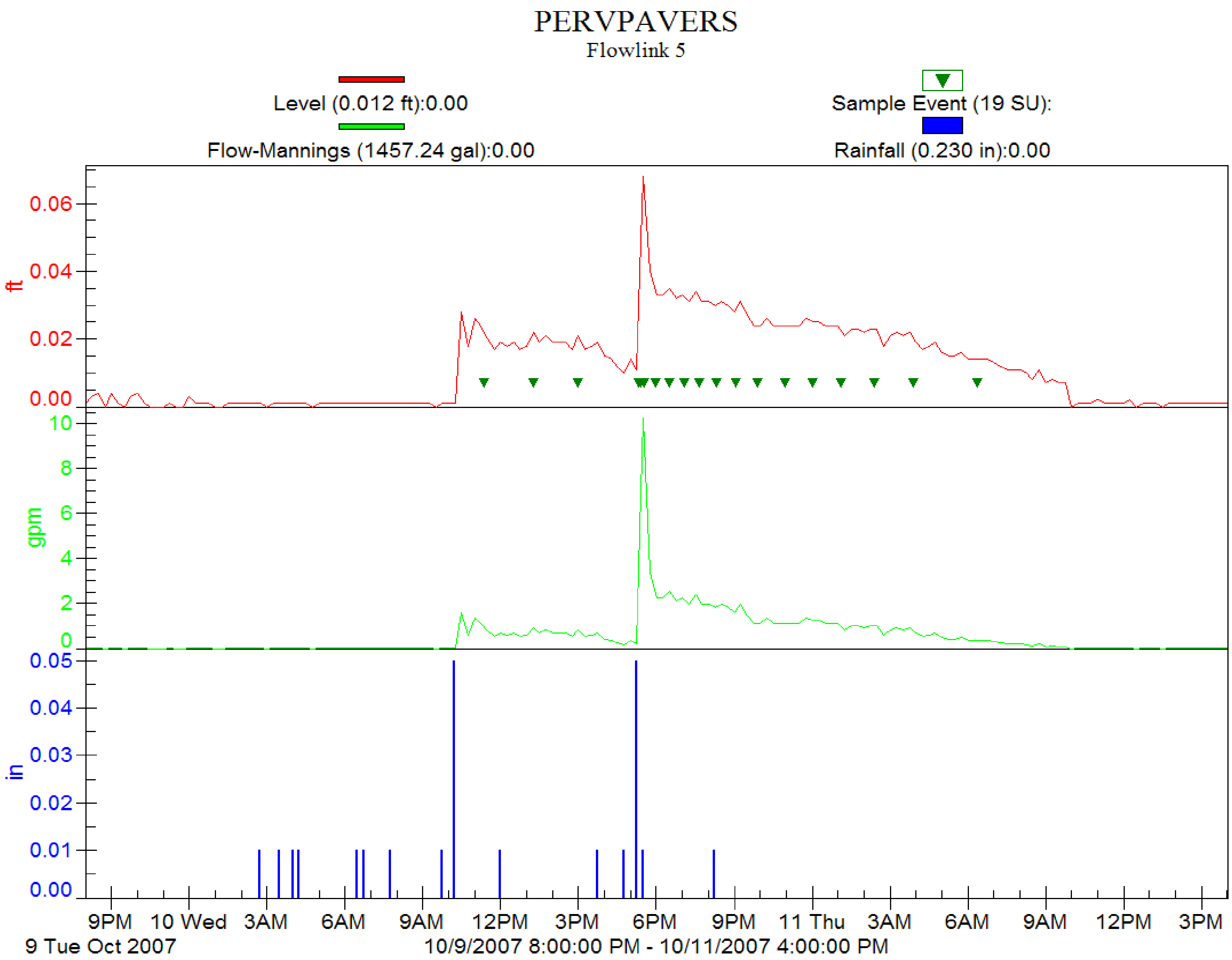
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	11-Oct-07	Phenanthrene	0.013	ug/L		
Pervious Concrete CB	11-Oct-07	Pyrene	0.018	ug/L		
Pervious Concrete CB	11-Oct-07	TSS	7.6	mg/L		
Pervious Concrete CB	11-Oct-07	Zinc	24.3	ug/L		
Pervious Pavers	11-Oct-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Anthracene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers	11-Oct-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers	11-Oct-07	Chrysene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Copper	22.6	ug/L		
Pervious Pavers	11-Oct-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Diethyl phthalate	2.8	ug/L		
Pervious Pavers	11-Oct-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	11-Oct-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers	11-Oct-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers	11-Oct-07	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Fluorene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Hardness, Calculated	39.8	mg/L		
Pervious Pavers	11-Oct-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Lead	3.3	ug/L	U	
Pervious Pavers	11-Oct-07	Mercury	0.05	ug/L	U	
Pervious Pavers	11-Oct-07	Naphthalene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers	11-Oct-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Pavers	11-Oct-07	pH	7.5	Std. Units		
Pervious Pavers	11-Oct-07	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	11-Oct-07	Pyrene	0.01	ug/L		
Pervious Pavers	11-Oct-07	TSS	18.2	mg/L		
Pervious Pavers	11-Oct-07	Zinc	12.1	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVPAVERS
Flowlink 4 for Windows
Level (0.007 ft)
Flow gpm (2741.9 gal)
Landfill Rainfall (0.42 in)
STP-1 Rainfall (0.00 in)
ft
0.10
0.05
0.00
gpm
30
20
10
0
in
0.10
0.05
0.00
7 Sun
8 Mon
9 Tue
10 Wed
11 Thu
Oct 2007
10/6/2007 3:00:00 PM - 10/11/2007 7:00:00 PM



PERVPAVERS
Flowlink 5
Level (0.012 ft):0.00
Flow-Mannings (1457.24 gal):0.00
Sample Event (19 SU):
Rainfall (0.230 in):0.00
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.05
0.04
0.03
0.02
0.01
0.00
9PM
10 Wed
3AM
6AM
9AM
12PM
3PM
6PM
9PM
11 Thu
3AM
6AM
9AM
12PM
3PM
9 Tue Oct 2007
10/9/2007 8:00:00 PM - 10/11/2007 4:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #9
November 10, 2007

Introduction

This report summarizes the storm event sampled on 11/10/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #9.

Table 1. Storm Characteristics

Storm Date		11/10/07
Time Storm Began		11/09/07 10:45 PM
Total Precipitation (in)		0.19
Duration (hrs)		6.3
Met Precipitation Criteria?	Precipitation ≥0.2"	N
Antecedent Period (hrs)		13.0
Precipitation in 24-hr Antecedent Dry Period (in)		0.03
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	N

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #9. As shown above, 0.03 inches of rain fell in the 24 hours prior to the sampling event; this did exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Samples were only collected from catch basins during this sample event.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	NS
Duration of Flow (hrs)	NS	NS	NS	NS
Total Volume (gallons) during Storm Event	NS	NS	NS	NS
Total Volume (gallons) during Sampling Event	NS	NS	NS	NS
Duration of Sampling Event (hrs)	NS	NS	NS	NS
Number of Sample Aliquots Collected	NS	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	17 in	21 in	3 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers catch basin
- Pervious asphalt catch basin
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- No sample was present in any of the automatic samplers.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	10-Nov-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Benzo(a)anthracene	0.018	ug/L		
Pervious Asphalt CB	10-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Benzo(b,k)fluoranthenes	0.013	ug/L		
Pervious Asphalt CB	10-Nov-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	bis(2-Ethylhexyl)phthalate	1.3	ug/L		
Pervious Asphalt CB	10-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Chrysene	0.017	ug/L		
Pervious Asphalt CB	10-Nov-07	Copper	6.8	ug/L		
Pervious Asphalt CB	10-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Fluoranthene	0.013	ug/L		
Pervious Asphalt CB	10-Nov-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Hardness, Calculated	18.3	mg/L		
Pervious Asphalt CB	10-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Lead	6	ug/L		
Pervious Asphalt CB	10-Nov-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	10-Nov-07	Naphthalene	0.226	ug/L		
Pervious Asphalt CB	10-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt CB	10-Nov-07	NWTPH-Heavy Oil	0.5	mg/L		
Pervious Asphalt CB	10-Nov-07	pH	6.2	Std. Units		
Pervious Asphalt CB	10-Nov-07	Phenanthrene	0.013	ug/L		
Pervious Asphalt CB	10-Nov-07	Pyrene	0.012	ug/L		
Pervious Asphalt CB	10-Nov-07	TSS	17.4	mg/L		
Pervious Asphalt CB	10-Nov-07	Zinc	60.1	ug/L		
Pervious Concrete CB	10-Nov-07	2-Methylnaphthalene	0.021	ug/L		
Pervious Concrete CB	10-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	10-Nov-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	10-Nov-07	Anthracene	0.017	ug/L		
Pervious Concrete CB	10-Nov-07	Benzo(a)anthracene	0.036	ug/L		
Pervious Concrete CB	10-Nov-07	Benzo(a)pyrene	0.032	ug/L		
Pervious Concrete CB	10-Nov-07	Benzo(b,k)fluoranthenes	0.048	ug/L		
Pervious Concrete CB	10-Nov-07	Benzo(g,h,i)perylene	0.041	ug/L		
Pervious Concrete CB	10-Nov-07	bis(2-Ethylhexyl)phthalate	8.9	ug/L		
Pervious Concrete CB	10-Nov-07	Butyl benzyl phthalate	1.3	ug/L		
Pervious Concrete CB	10-Nov-07	Chrysene	0.054	ug/L		
Pervious Concrete CB	10-Nov-07	Copper	10.2	ug/L		
Pervious Concrete CB	10-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	10-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	10-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	10-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	10-Nov-07	Di-n-octyl phthalate	1.1	ug/L		
Pervious Concrete CB	10-Nov-07	Fluoranthene	0.077	ug/L		
Pervious Concrete CB	10-Nov-07	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	10-Nov-07	Hardness, Calculated	34.7	mg/L		
Pervious Concrete CB	10-Nov-07	Indeno(1,2,3-c,d)pyrene	0.018	ug/L		
Pervious Concrete CB	10-Nov-07	Lead	5.9	ug/L		
Pervious Concrete CB	10-Nov-07	Mercury	0.05	ug/L	U	
Pervious Concrete CB	10-Nov-07	Naphthalene	0.024	ug/L		
Pervious Concrete CB	10-Nov-07	NWTPH-Diesel	0.36	mg/L		
Pervious Concrete CB	10-Nov-07	NWTPH-Heavy Oil	8.49	mg/L		
Pervious Concrete CB	10-Nov-07	pH	6.6	Std. Units		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	10-Nov-07	Phenanthrene	0.063	ug/L		
Pervious Concrete CB	10-Nov-07	Pyrene	0.073	ug/L		
Pervious Concrete CB	10-Nov-07	TSS	59.2	mg/L		
Pervious Concrete CB	10-Nov-07	Zinc	26.8	ug/L		
Pervious Pavers CB	10-Nov-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Benzo(b,k)fluoranthenes	0.012	ug/L		
Pervious Pavers CB	10-Nov-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	bis(2-Ethylhexyl)phthalate	1.4	ug/L		
Pervious Pavers CB	10-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers CB	10-Nov-07	Chrysene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Copper	7.1	ug/L		
Pervious Pavers CB	10-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Pavers CB	10-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	10-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers CB	10-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers CB	10-Nov-07	Fluoranthene	0.017	ug/L		
Pervious Pavers CB	10-Nov-07	Fluorene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Hardness, Calculated	28.2	mg/L		
Pervious Pavers CB	10-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	Lead	3.3	ug/L	U	
Pervious Pavers CB	10-Nov-07	Mercury	0.05	ug/L	U	
Pervious Pavers CB	10-Nov-07	Naphthalene	0.01	ug/L	U	
Pervious Pavers CB	10-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers CB	10-Nov-07	NWTPH-Heavy Oil	0.78	mg/L		
Pervious Pavers CB	10-Nov-07	pH	6.7	Std. Units		
Pervious Pavers CB	10-Nov-07	Phenanthrene	0.019	ug/L		
Pervious Pavers CB	10-Nov-07	Pyrene	0.017	ug/L		
Pervious Pavers CB	10-Nov-07	TSS	6.5	mg/L		
Pervious Pavers CB	10-Nov-07	Zinc	35.3	ug/L		

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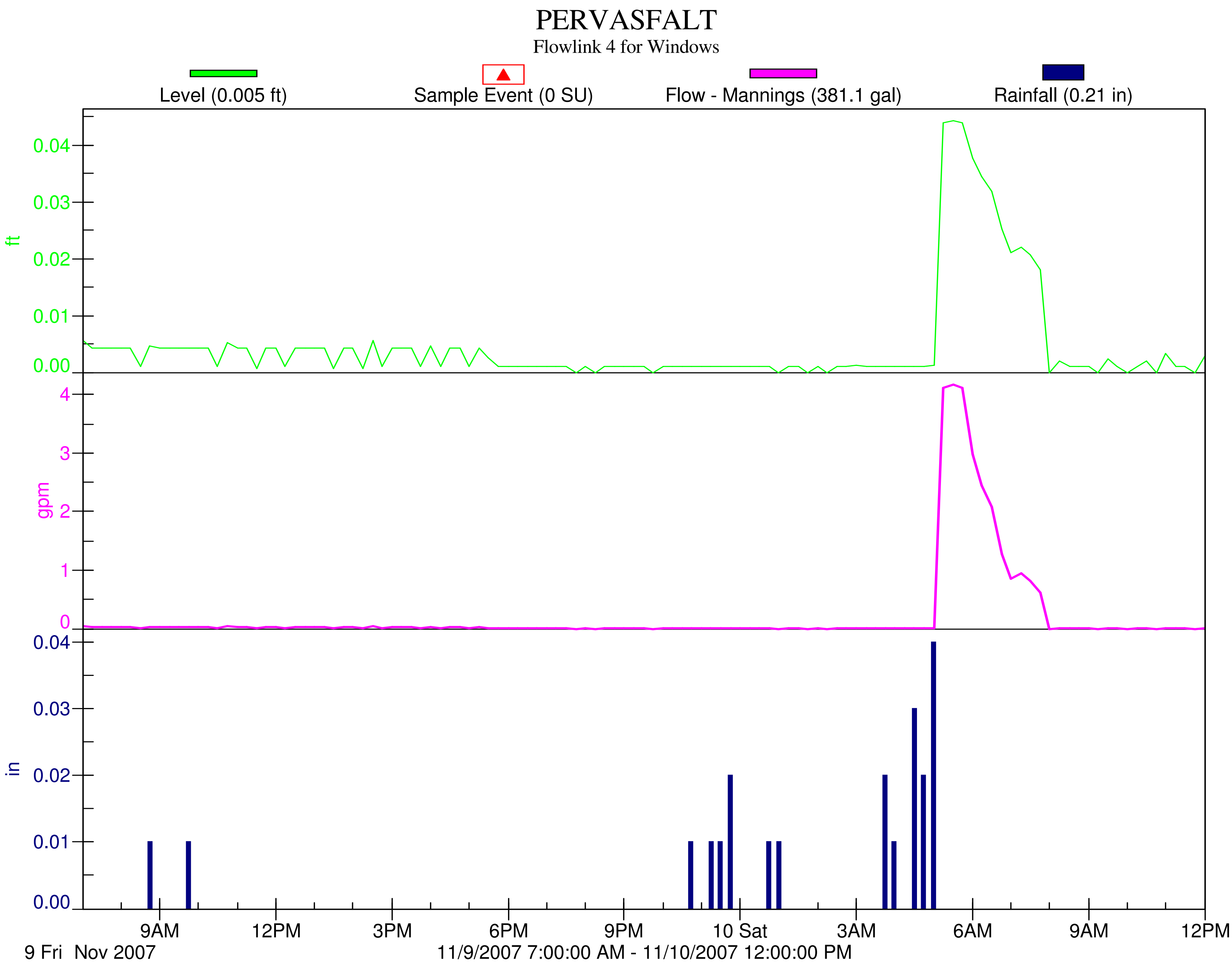
B = value is less than the reporting limit, but greater than the detection limit



PERVASFALT
Flowlink 4 for Windows
Level (0.005 ft)
Sample Event (0 SU)
Flow - Mannings (381.1 gal)
Rainfall (0.21 in)
ft
0.04
0.03
0.02
0.01
0.00
gpm
4
3
2
1
0
in
0.04
0.03
0.02
0.01
0.00
9AM
12PM
3PM
6PM
9PM
10 Sat
3AM
6AM
9AM
12PM
9 Fri Nov 2007
11/9/2007 7:00:00 AM - 11/10/2007 12:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #10
November 27 2007

Introduction

This report summarizes the storm event sampled on 11/27/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #10.

Table 1. Storm Characteristics

Storm Date		11/27/07
Time Storm Began		11/26/07 4:15 PM
Total Precipitation (in)		0.21
Duration (hrs)		4.0
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		51
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #10. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	NS
Duration of Flow (hrs)	NS	NS	NS	NS
Total Volume (gallons) during Storm Event	NS	NS	NS	NS
Total Volume (gallons) during Sampling Event	NS	NS	NS	NS
Duration of Sampling Event (hrs)	NS	NS	NS	NS
Number of Sample Aliquots Collected	NS	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	0 in	20.5 in	0 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

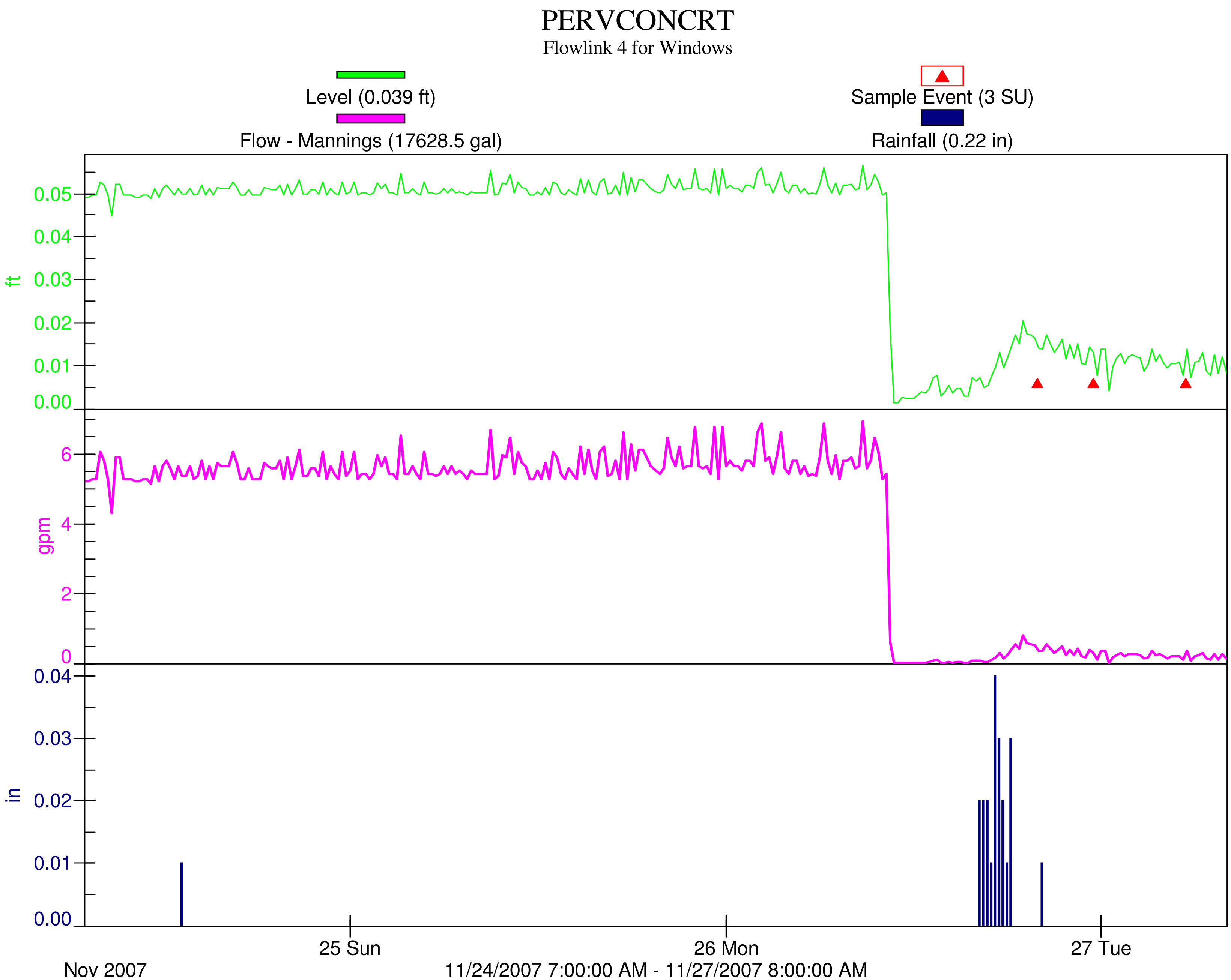
Sampling Observations

The lab noted no special observations during the sampling event. Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	27-Nov-07	2-Methylnaphthalene	0.031	ug/L		
Pervious Concrete CB	27-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Acenaphthylene	0.012	ug/L		
Pervious Concrete CB	27-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Benzo(b,k)fluoranthenes	0.014	ug/L		
Pervious Concrete CB	27-Nov-07	Benzo(g,h,i)perylene	0.011	ug/L		
Pervious Concrete CB	27-Nov-07	bis(2-Ethylhexyl)phthalate	3.7	ug/L		
Pervious Concrete CB	27-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Nov-07	Chrysene	0.016	ug/L		
Pervious Concrete CB	27-Nov-07	Copper	32.1	ug/L		
Pervious Concrete CB	27-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	27-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	27-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Nov-07	Fluoranthene	0.032	ug/L		
Pervious Concrete CB	27-Nov-07	Fluorene	0.012	ug/L		
Pervious Concrete CB	27-Nov-07	Hardness, Calculated	26.2	mg/L		
Pervious Concrete CB	27-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete CB	27-Nov-07	Lead	3.3	ug/L	U	
Pervious Concrete CB	27-Nov-07	Mercury	0.05	ug/L	U	
Pervious Concrete CB	27-Nov-07	Naphthalene	0.047	ug/L		
Pervious Concrete CB	27-Nov-07	NWTPH-Diesel	0.2	mg/L	B	
Pervious Concrete CB	27-Nov-07	NWTPH-Heavy Oil	1.6	mg/L		
Pervious Concrete CB	27-Nov-07	pH	6.8	Std. Units		
Pervious Concrete CB	27-Nov-07	Phenanthrene	0.044	ug/L		
Pervious Concrete CB	27-Nov-07	Pyrene	0.046	ug/L		
Pervious Concrete CB	27-Nov-07	TSS	8.2	mg/L		
Pervious Concrete CB	27-Nov-07	Zinc	30.7	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVCONCRT
Flowlink 4 for Windows
Level (0.039 ft)
Sample Event (3 SU)
Flow - Mannings (17628.5 gal)
Rainfall (0.22 in)
ft
0.05
0.04
0.03
0.02
0.01
0.00
gpm
6
4
2
0
in
0.04
0.03
0.02
0.01
0.00
25 Sun
26 Mon
27 Tue
Nov 2007
11/24/2007 7:00:00 AM - 11/27/2007 8:00:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #11
November 29, 2007

Introduction

This report summarizes the storm event sampled on 11/29/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #11.

Table 1. Storm Characteristics

Storm Date		11/29/07
Time Storm Began		11/28/07 2:15 PM
Total Precipitation (in)		0.30
Duration (hrs)		14.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		42
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #11. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetograph for the storm event for pervious pavers and pervious concrete respectively. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	2.2	8.64	NS	NS
Duration of Flow (hrs)	19	20.5	NS	NS
Total Volume (gallons) during Storm Event	1,719	1522	NS	NS
Total Volume (gallons) during Sampling Event	1,028	1349[a]	NS	NS
Duration of Sampling Event (hrs)	16.8	16.0[a]	NS	NS
Number of Sample Aliquots Collected	20	26[a]	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	59.8%	88.6%[a]	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	13 in	NM	2.5 in	

Key: NS = Not Sampled

NM = Not Measured

a = Four sample aliquots were collected before the storm event. These aliquots were not included in the above values.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious concrete
- Pervious pavers catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious asphalt and standard asphalt – Not enough rain for a good flow.
- Pervious pavers and pervious concrete – Good sample.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	29-Nov-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Benzo(b,k)fluoranthenes	0.019	ug/L		
Pervious Asphalt CB	29-Nov-07	Benzo(g,h,i)perylene	0.016	ug/L		
Pervious Asphalt CB	29-Nov-07	bis(2-Ethylhexyl)phthalate	1.8	ug/L		
Pervious Asphalt CB	29-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Chrysene	0.02	ug/L		
Pervious Asphalt CB	29-Nov-07	Copper	11.5	ug/L		
Pervious Asphalt CB	29-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Fluoranthene	0.018	ug/L		
Pervious Asphalt CB	29-Nov-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Hardness, Calculated	16.5	mg/L		
Pervious Asphalt CB	29-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Lead	3.3	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Mercury	0.05	ug/L	U	
Pervious Asphalt CB	29-Nov-07	Naphthalene	0.013	ug/L		
Pervious Asphalt CB	29-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt CB	29-Nov-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt CB	29-Nov-07	pH	6.7	Std. Units		
Pervious Asphalt CB	29-Nov-07	Phenanthrene	0.015	ug/L		
Pervious Asphalt CB	29-Nov-07	Pyrene	0.025	ug/L		
Pervious Asphalt CB	29-Nov-07	TSS	3.6	mg/L		
Pervious Asphalt CB	29-Nov-07	Zinc	61.3	ug/L		
Pervious Concrete	29-Nov-07	2-Methylnaphthalene	0.015	ug/L		
Pervious Concrete	29-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Acenaphthylene	0.06	ug/L		
Pervious Concrete	29-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Chrysene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Copper	9.2	ug/L		
Pervious Concrete	29-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete	29-Nov-07	Fluoranthene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Fluorene	0.013	ug/L		
Pervious Concrete	29-Nov-07	Hardness, Calculated	560	mg/L		
Pervious Concrete	29-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	Lead	6.2	ug/L		
Pervious Concrete	29-Nov-07	Mercury	0.05	ug/L	U	
Pervious Concrete	29-Nov-07	Naphthalene	0.027	ug/L		
Pervious Concrete	29-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete	29-Nov-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete	29-Nov-07	pH	11.4	Std. Units		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

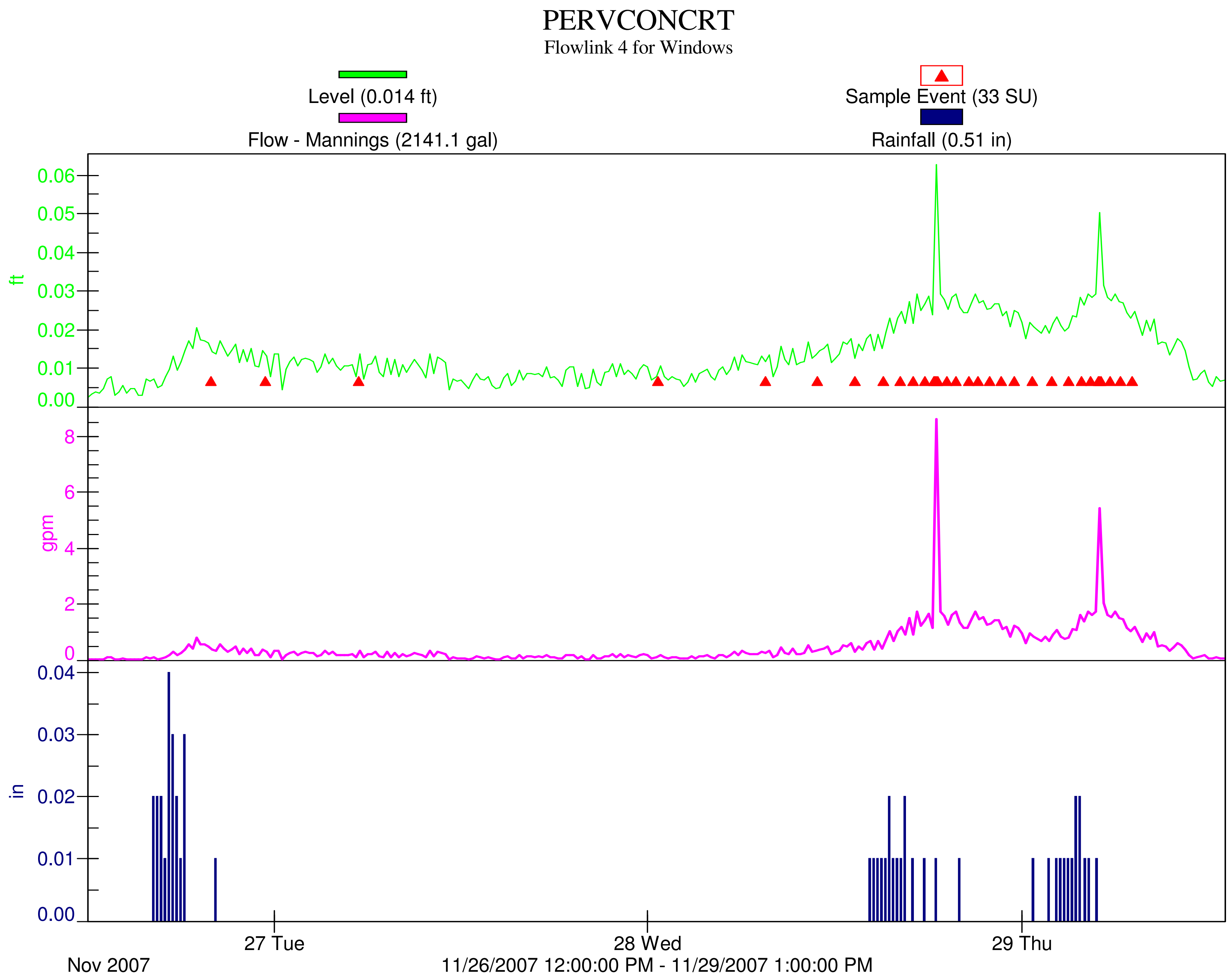
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	29-Nov-07	Phenanthrene	0.016	ug/L		
Pervious Concrete	29-Nov-07	Pyrene	0.01	ug/L	U	
Pervious Concrete	29-Nov-07	TSS	167	mg/L		
Pervious Concrete	29-Nov-07	Zinc	8.6	ug/L		
Pervious Pavers	29-Nov-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers	29-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers	29-Nov-07	Chrysene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Copper	9.8	ug/L		
Pervious Pavers	29-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Diethylphthalate	2.1	ug/L		UJ
Pervious Pavers	29-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	29-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers	29-Nov-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers	29-Nov-07	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Fluorene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Hardness, Calculated	53.1	mg/L		
Pervious Pavers	29-Nov-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Lead	3.3	ug/L	U	
Pervious Pavers	29-Nov-07	Mercury	0.05	ug/L	U	
Pervious Pavers	29-Nov-07	Naphthalene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers	29-Nov-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Pavers	29-Nov-07	pH	6.9	Std. Units		
Pervious Pavers	29-Nov-07	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	Pyrene	0.01	ug/L	U	
Pervious Pavers	29-Nov-07	TSS	3.9	mg/L	U	
Pervious Pavers	29-Nov-07	Zinc	6.5	ug/L		
Pervious Pavers CB	29-Nov-07	2-Methylnaphthalene	0.029	ug/L		
Pervious Pavers CB	29-Nov-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	29-Nov-07	Acenaphthylene	0.012	ug/L		
Pervious Pavers CB	29-Nov-07	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	29-Nov-07	Benzo(a)anthracene	0.025	ug/L		
Pervious Pavers CB	29-Nov-07	Benzo(a)pyrene	0.03	ug/L		
Pervious Pavers CB	29-Nov-07	Benzo(b,k)fluoranthenes	0.056	ug/L		
Pervious Pavers CB	29-Nov-07	Benzo(g,h,i)perylene	0.04	ug/L		
Pervious Pavers CB	29-Nov-07	bis(2-Ethylhexyl)phthalate	8.7	ug/L		
Pervious Pavers CB	29-Nov-07	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers CB	29-Nov-07	Chrysene	0.045	ug/L		
Pervious Pavers CB	29-Nov-07	Copper	13.9	ug/L		
Pervious Pavers CB	29-Nov-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	29-Nov-07	Diethylphthalate	1	ug/L	U	
Pervious Pavers CB	29-Nov-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	29-Nov-07	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers CB	29-Nov-07	Di-n-octyl phthalate	2.9	ug/L		
Pervious Pavers CB	29-Nov-07	Fluoranthene	0.061	ug/L		
Pervious Pavers CB	29-Nov-07	Fluorene	0.016	ug/L		
Pervious Pavers CB	29-Nov-07	Hardness, Calculated	30.6	mg/L		
Pervious Pavers CB	29-Nov-07	Indeno(1,2,3-c,d)pyrene	0.022	ug/L		
Pervious Pavers CB	29-Nov-07	Lead	3.3	ug/L	U	
Pervious Pavers CB	29-Nov-07	Mercury	0.05	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers CB	29-Nov-07	Naphthalene	0.06	ug/L		
Pervious Pavers CB	29-Nov-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers CB	29-Nov-07	NWTPH-Heavy Oil	1.9	mg/L		
Pervious Pavers CB	29-Nov-07	pH	7.2	Std. Units		
Pervious Pavers CB	29-Nov-07	Phenanthrene	0.07	ug/L		
Pervious Pavers CB	29-Nov-07	Pyrene	0.063	ug/L		
Pervious Pavers CB	29-Nov-07	TSS	6	mg/L		
Pervious Pavers CB	29-Nov-07	Zinc	57.5	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



PERVCONCRT
Flowlink 4 for Windows
Level (0.014 ft)
Sample Event (33 SU)
Flow - Mannings (2141.1 gal)
Rainfall (0.51 in)
ft
0.06
0.05
0.04
0.03
0.02
0.01
0.00
gpm
8
6
4
2
0
in
0.04
0.03
0.02
0.01
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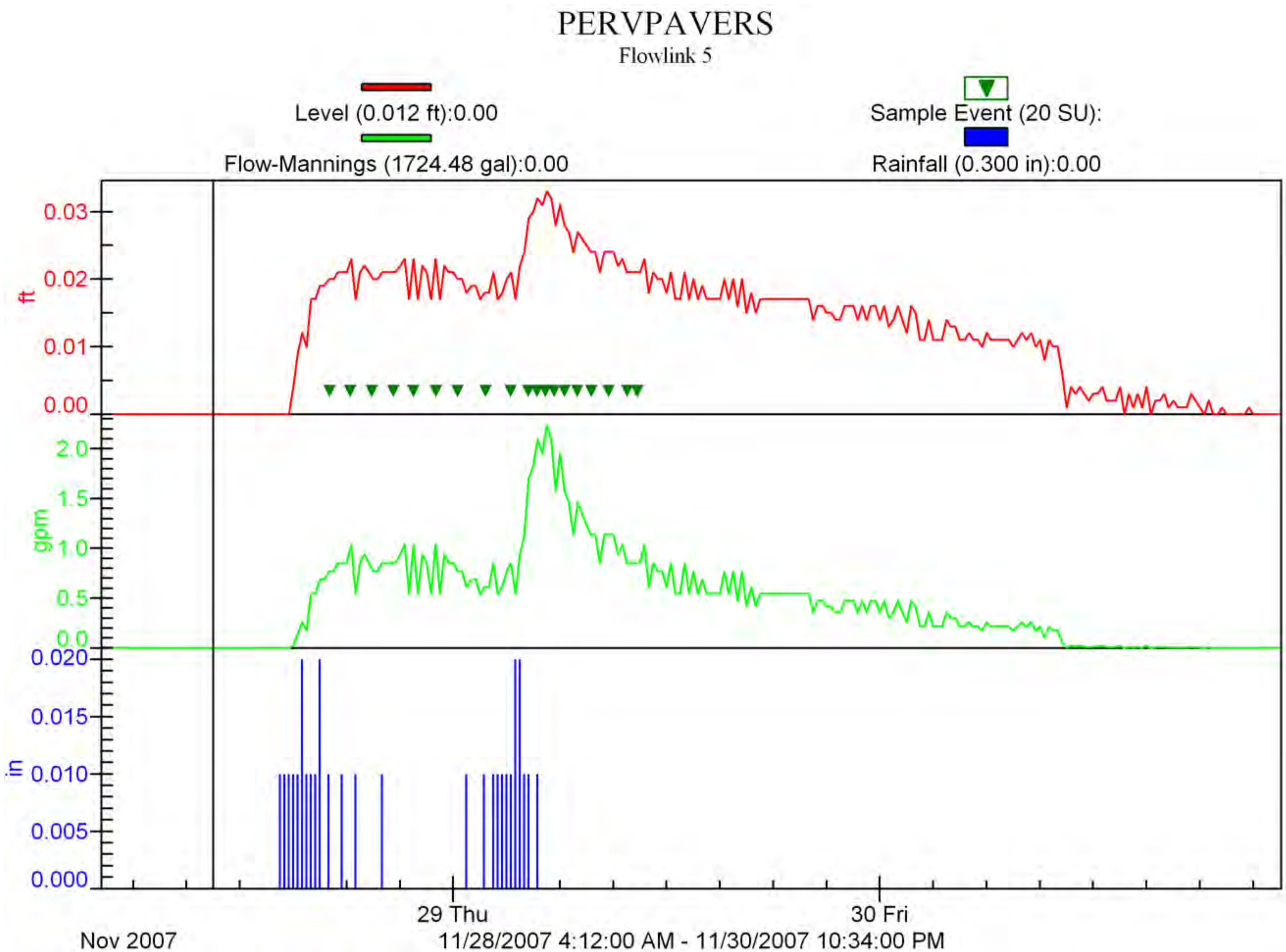
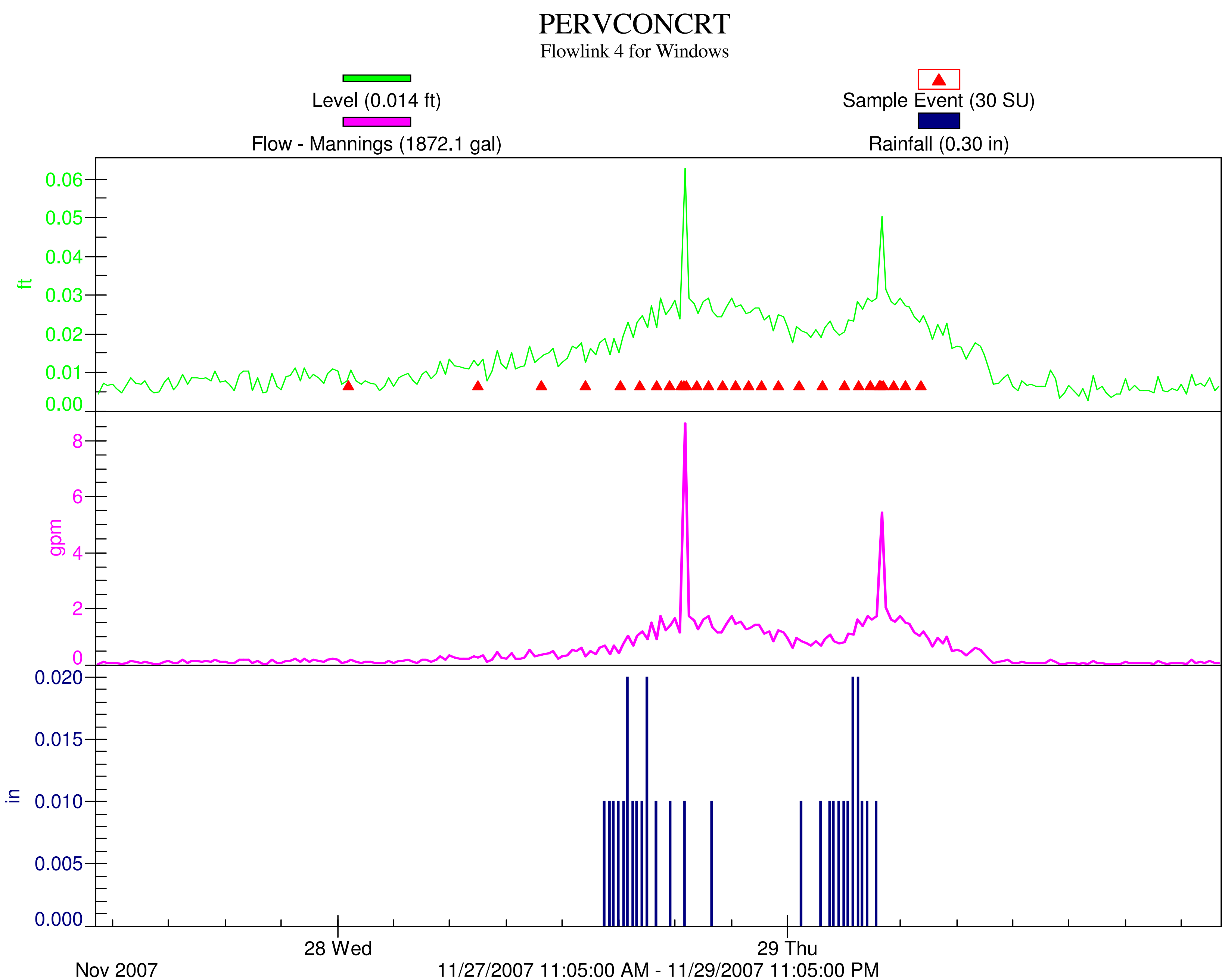
27 Tue
28 Wed
29 Thu
Nov 2007
11/26/2007 12:00:00 PM - 11/29/2007 1:00:00 PM



PERVPAVERS
Flowlink 5
Level (0.012 ft):0.00
Sample Event (20 SU):
Flow-Mannings (1724.48 gal):0.00
Rainfall (0.300 in):0.00
ft
0.03
0.02
0.01
0.00
gpm
2.0
1.5
1.0
0.5
0.0
in
0.020
0.015
0.010
0.005
0.000
29 Thu
30 Fri
Nov 2007
11/28/2007 4:12:00 AM - 11/30/2007 10:34:00 PM



PERVCONCRT
Flowlink 4 for Windows
Level (0.014 ft)
Flow - Mannings (1872.1 gal)
Sample Event (30 SU)
Rainfall (0.30 in)
ft
0.06
0.05
0.04
0.03
0.02
0.01
0.00
gpm
8
6
4
2
0
in
0.020
0.015
0.010
0.005
0.000
28 Wed
29 Thu
Nov 2007
11/27/2007 11:05:00 AM - 11/29/2007 11:05:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #12
December 15 and 16, 2007

Introduction

This report summarizes the storm event sampled on 12/15/07 and 12/16/07 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #12.

Table 1. Storm Characteristics

Storm Date		12/15/07
Time Storm Began		12/14/07 7:45 pm
Total Precipitation (in)		0.27
Duration (hrs)		19.75
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		29.25
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #11. As shown above, 0.00 rain fell in the 24 hours prior to the sampling event, so this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, and 4 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious pavers, 26 sample aliquots were collected during the sampling period. These aliquots were collected over 89.2% of the total storm runoff volume. For pervious asphalt, 37 sample aliquots were collected during the sampling period. These aliquots were collected over 97.6% of the total storm runoff volume. For standard asphalt, 43 sample aliquots were collected during the sampling period. These aliquots were collected over 95.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	4.24	NS	8.92	9.90
Duration of Flow (hrs)	38.3	NS	15.8	22.3
Total Volume (gallons) during Storm Event	2099	NS	2384	4325
Total Volume (gallons) during Sampling Event	1872	NS	2327	4140
Duration of Sampling Event (hrs)	32.9	NS	15.1	19.9
Number of Sample Aliquots Collected	26	NS	37	43
Percentage of Storm's Total Volume over which Samples were Collected	89.2%	NS	97.6%	95.7%
Volume of Surface Runoff Collected in Vault (in)	6 in	19.5 in	0 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious concrete – Sampler did not enable long enough. Check enable and pacing.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	15-Dec-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Anthracene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	15-Dec-07	Butyl benzyl phthalate	1	ug/L	U	UJ
Pervious Asphalt	15-Dec-07	Chrysene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Copper	5.3	ug/L	U	
Pervious Asphalt	15-Dec-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Diethylphthalate	1	ug/L	U	UJ
Pervious Asphalt	15-Dec-07	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	15-Dec-07	Di-n-butylphthalate	1	ug/L	U	UJ
Pervious Asphalt	15-Dec-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Asphalt	15-Dec-07	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Fluorene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Hardness, Calculated	18.2	mg/L		
Pervious Asphalt	15-Dec-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Lead	3.3	ug/L	U	
Pervious Asphalt	15-Dec-07	Mercury	0.05	ug/L	U	
Pervious Asphalt	15-Dec-07	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	15-Dec-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	15-Dec-07	pH	7	Std. Units		
Pervious Asphalt	15-Dec-07	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Pyrene	0.01	ug/L	U	
Pervious Asphalt	15-Dec-07	Zinc	4.3	ug/L	B	
Pervious Concrete CB	16-Dec-07	2-Methylnaphthalene	0.02	ug/L		
Pervious Concrete CB	16-Dec-07	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Benzo(a)anthracene	0.014	ug/L		
Pervious Concrete CB	16-Dec-07	Benzo(a)pyrene	0.011	ug/L		
Pervious Concrete CB	16-Dec-07	Benzo(b,k)fluoranthenes	0.018	ug/L		
Pervious Concrete CB	16-Dec-07	Benzo(g,h,i)perylene	0.017	ug/L		
Pervious Concrete CB	16-Dec-07	bis(2-Ethylhexyl)phthalate	2.8	ug/L		
Pervious Concrete CB	16-Dec-07	Butyl benzyl phthalate	1	ug/L	U	UJ
Pervious Concrete CB	16-Dec-07	Chrysene	0.019	ug/L		
Pervious Concrete CB	16-Dec-07	Copper	5.3	ug/L	U	
Pervious Concrete CB	16-Dec-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Diethylphthalate	1	ug/L	U	UJ
Pervious Concrete CB	16-Dec-07	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	16-Dec-07	Di-n-butylphthalate	1	ug/L	U	UJ
Pervious Concrete CB	16-Dec-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete CB	16-Dec-07	Fluoranthene	0.037	ug/L		
Pervious Concrete CB	16-Dec-07	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Hardness, Calculated	36.1	mg/L		
Pervious Concrete CB	16-Dec-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete CB	16-Dec-07	Lead	3.3	ug/L	U	
Pervious Concrete CB	16-Dec-07	Mercury	0.05	ug/L	U	
Pervious Concrete CB	16-Dec-07	Naphthalene	0.019	ug/L		
Pervious Concrete CB	16-Dec-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	16-Dec-07	NWTPH-Heavy Oil	3.4	mg/L		
Pervious Concrete CB	16-Dec-07	pH	7.3	Std. Units		
Pervious Concrete CB	16-Dec-07	Phenanthrene	0.045	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	16-Dec-07	Pyrene	0.052	ug/L		
Pervious Concrete CB	16-Dec-07	TSS	5.6	mg/L		
Pervious Concrete CB	16-Dec-07	Zinc	29.5	ug/L		
Pervious Pavers	16-Dec-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Anthracene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	bis(2-Ethylhexyl)phthalate	1.8	ug/L		
Pervious Pavers	16-Dec-07	Butyl benzyl phthalate	1	ug/L	U	UJ
Pervious Pavers	16-Dec-07	Chrysene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Copper	5.3	ug/L	U	
Pervious Pavers	16-Dec-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Diethylphthalate	2.7	ug/L		UJ
Pervious Pavers	16-Dec-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	16-Dec-07	Di-n-butylphthalate	1	ug/L	U	UJ
Pervious Pavers	16-Dec-07	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers	16-Dec-07	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Fluorene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Hardness, Calculated	52.3	mg/L		
Pervious Pavers	16-Dec-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Lead	3.3	ug/L	U	
Pervious Pavers	16-Dec-07	Mercury	0.05	ug/L	U	
Pervious Pavers	16-Dec-07	Naphthalene	0.02	ug/L		
Pervious Pavers	16-Dec-07	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers	16-Dec-07	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Pavers	16-Dec-07	pH	7.6	Std. Units		
Pervious Pavers	16-Dec-07	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Pyrene	0.01	ug/L	U	
Pervious Pavers	16-Dec-07	Zinc	7.5	ug/L		
Pervious Pavers CB	16-Dec-07	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Benzo(b,k)fluoranthenes	0.017	ug/L		
Pervious Pavers CB	16-Dec-07	Benzo(g,h,i)perylene	0.014	ug/L		
Pervious Pavers CB	16-Dec-07	bis(2-Ethylhexyl)phthalate	2.3	ug/L		
Pervious Pavers CB	16-Dec-07	Butyl benzyl phthalate	1	ug/L	U	UJ
Pervious Pavers CB	16-Dec-07	Chrysene	0.015	ug/L		
Pervious Pavers CB	16-Dec-07	Copper	5.3	ug/L	U	
Pervious Pavers CB	16-Dec-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Diethylphthalate	1	ug/L	U	UJ
Pervious Pavers CB	16-Dec-07	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	16-Dec-07	Di-n-butylphthalate	1	ug/L	U	UJ
Pervious Pavers CB	16-Dec-07	Di-n-octyl phthalate	1.1	ug/L		
Pervious Pavers CB	16-Dec-07	Fluoranthene	0.024	ug/L		
Pervious Pavers CB	16-Dec-07	Fluorene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Hardness, Calculated	33.5	mg/L		
Pervious Pavers CB	16-Dec-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers CB	16-Dec-07	Lead	3.3	ug/L	U	
Pervious Pavers CB	16-Dec-07	Mercury	0.05	ug/L	U	
Pervious Pavers CB	16-Dec-07	Naphthalene	0.012	ug/L		
Pervious Pavers CB	16-Dec-07	NWTPH-Diesel	0.2	mg/L	U	

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J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers CB	16-Dec-07	NWTPH-Heavy Oil	1.8	mg/L		
Pervious Pavers CB	16-Dec-07	pH	7.2	Std. Units		
Pervious Pavers CB	16-Dec-07	Phenanthrene	0.023	ug/L		
Pervious Pavers CB	16-Dec-07	Pyrene	0.024	ug/L		
Pervious Pavers CB	16-Dec-07	TSS	8	mg/L		
Pervious Pavers CB	16-Dec-07	Zinc	61.6	ug/L		
Standard Asphalt	15-Dec-07	2-Methylnaphthalene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Anthracene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Benzo(a)anthracene	0.014	ug/L		
Standard Asphalt	15-Dec-07	Benzo(a)pyrene	0.011	ug/L		
Standard Asphalt	15-Dec-07	Benzo(b,k)fluoranthenes	0.033	ug/L		
Standard Asphalt	15-Dec-07	Benzo(g,h,i)perylene	0.023	ug/L		
Standard Asphalt	15-Dec-07	bis(2-Ethylhexyl)phthalate	3.8	ug/L		
Standard Asphalt	15-Dec-07	Butyl benzyl phthalate	1	ug/L	U	UJ
Standard Asphalt	15-Dec-07	Chrysene	0.029	ug/L		
Standard Asphalt	15-Dec-07	Copper	5.3	ug/L	U	
Standard Asphalt	15-Dec-07	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Diethylphthalate	1	ug/L	U	UJ
Standard Asphalt	15-Dec-07	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	15-Dec-07	Di-n-butylphthalate	1	ug/L	U	UJ
Standard Asphalt	15-Dec-07	Di-n-octyl phthalate	1	ug/L	U	
Standard Asphalt	15-Dec-07	Fluoranthene	0.04	ug/L		
Standard Asphalt	15-Dec-07	Fluorene	0.01	ug/L	U	
Standard Asphalt	15-Dec-07	Hardness, Calculated	6.76	mg/L		
Standard Asphalt	15-Dec-07	Indeno(1,2,3-c,d)pyrene	0.01	ug/L		
Standard Asphalt	15-Dec-07	Lead	3.3	ug/L	U	
Standard Asphalt	15-Dec-07	Mercury	0.05	ug/L	U	
Standard Asphalt	15-Dec-07	Naphthalene	0.019	ug/L		
Standard Asphalt	15-Dec-07	NWTPH-Diesel	0.2	mg/L	U	
Standard Asphalt	15-Dec-07	NWTPH-Heavy Oil	0.4	mg/L		
Standard Asphalt	15-Dec-07	pH	6.4	Std. Units		
Standard Asphalt	15-Dec-07	Phenanthrene	0.034	ug/L		
Standard Asphalt	15-Dec-07	Pyrene	0.044	ug/L		
Standard Asphalt	15-Dec-07	TSS	12.4	mg/L		
Standard Asphalt	15-Dec-07	Zinc	42	ug/L		

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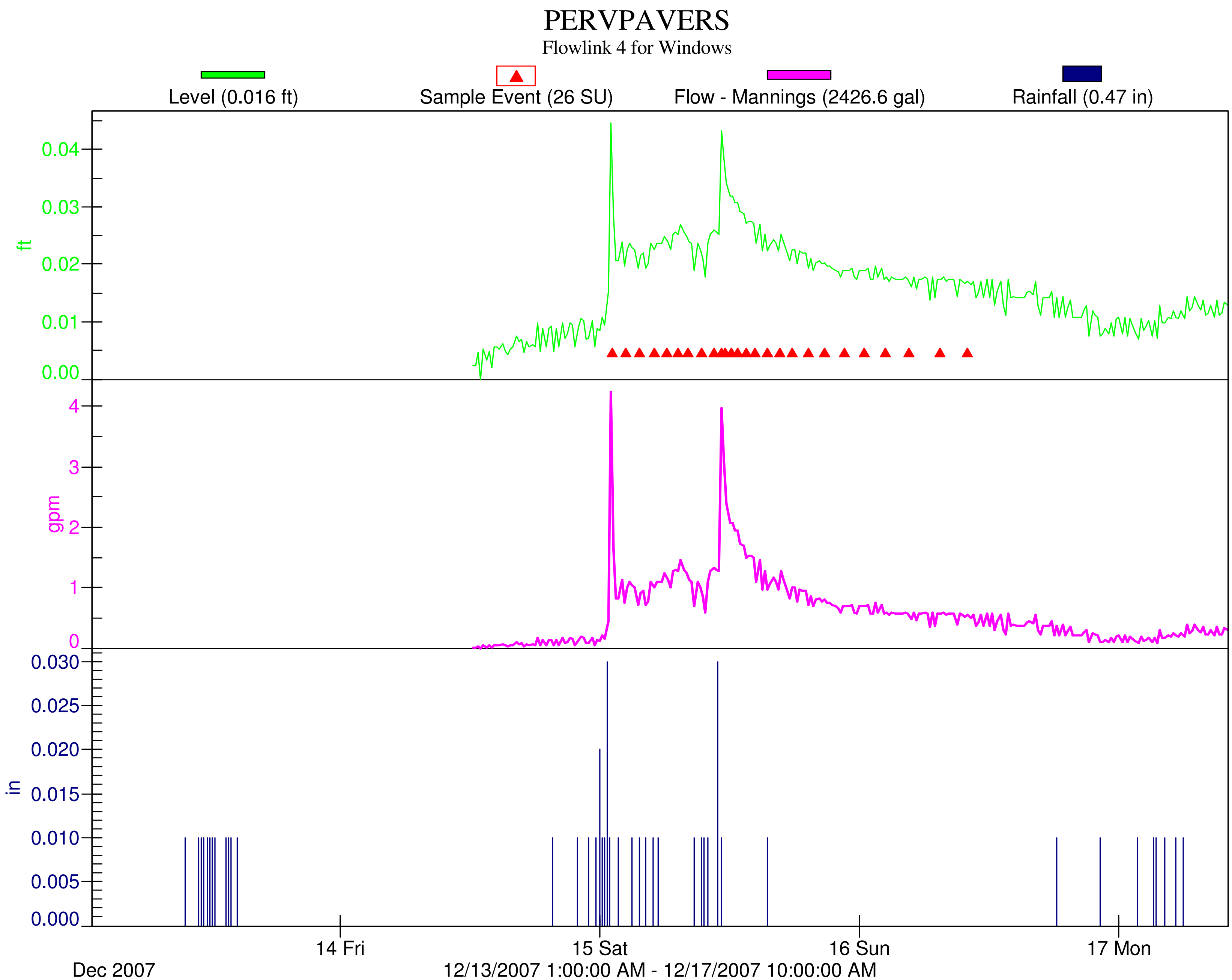

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Flow - Mannings (2426.6 gal)
Rainfall (0.47 in)
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0.02
0.01
0.00
gpm
4
3
2
1
0
in
0.030
0.025
0.020
0.015
0.010
0.005
0.000
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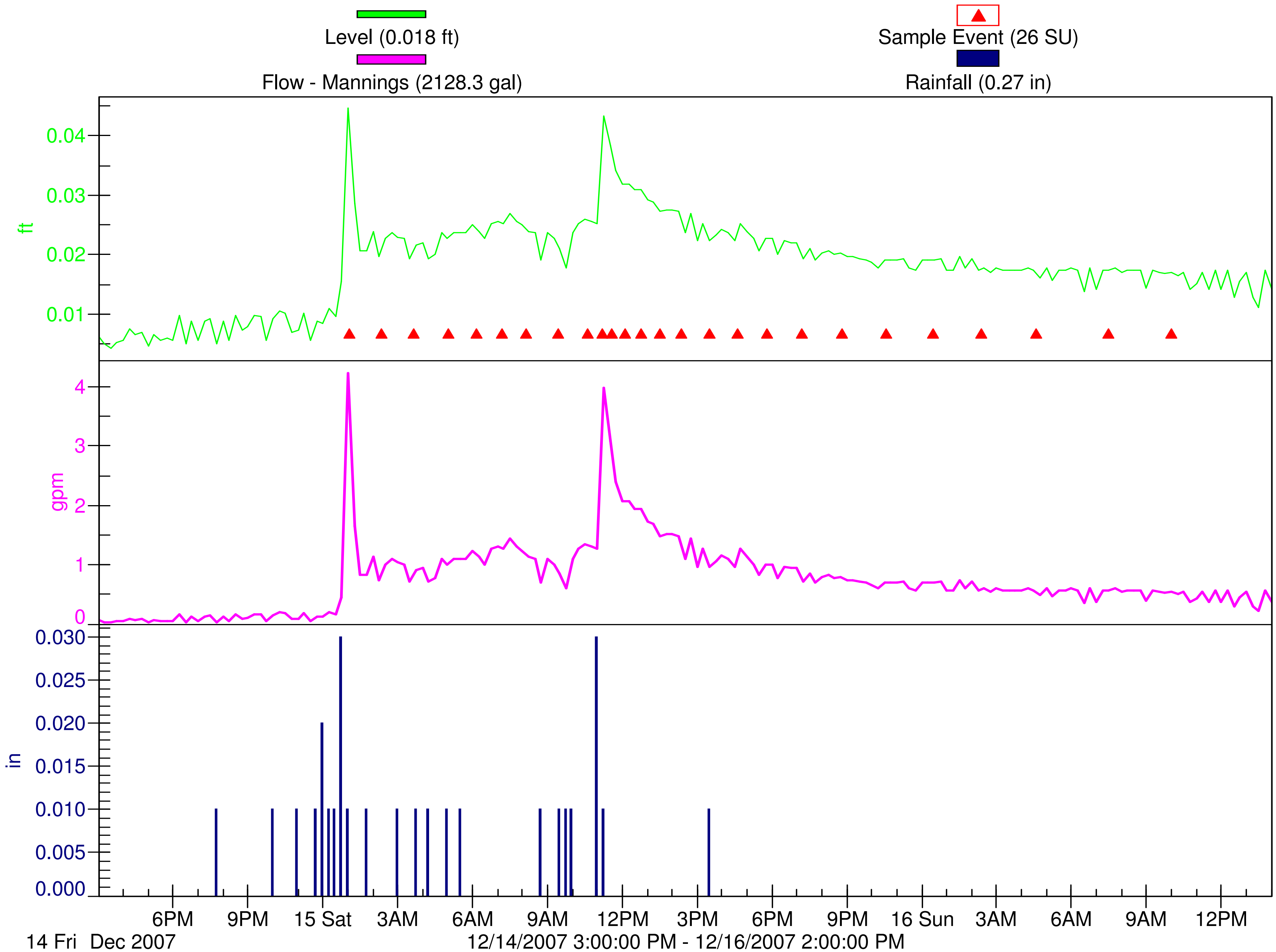
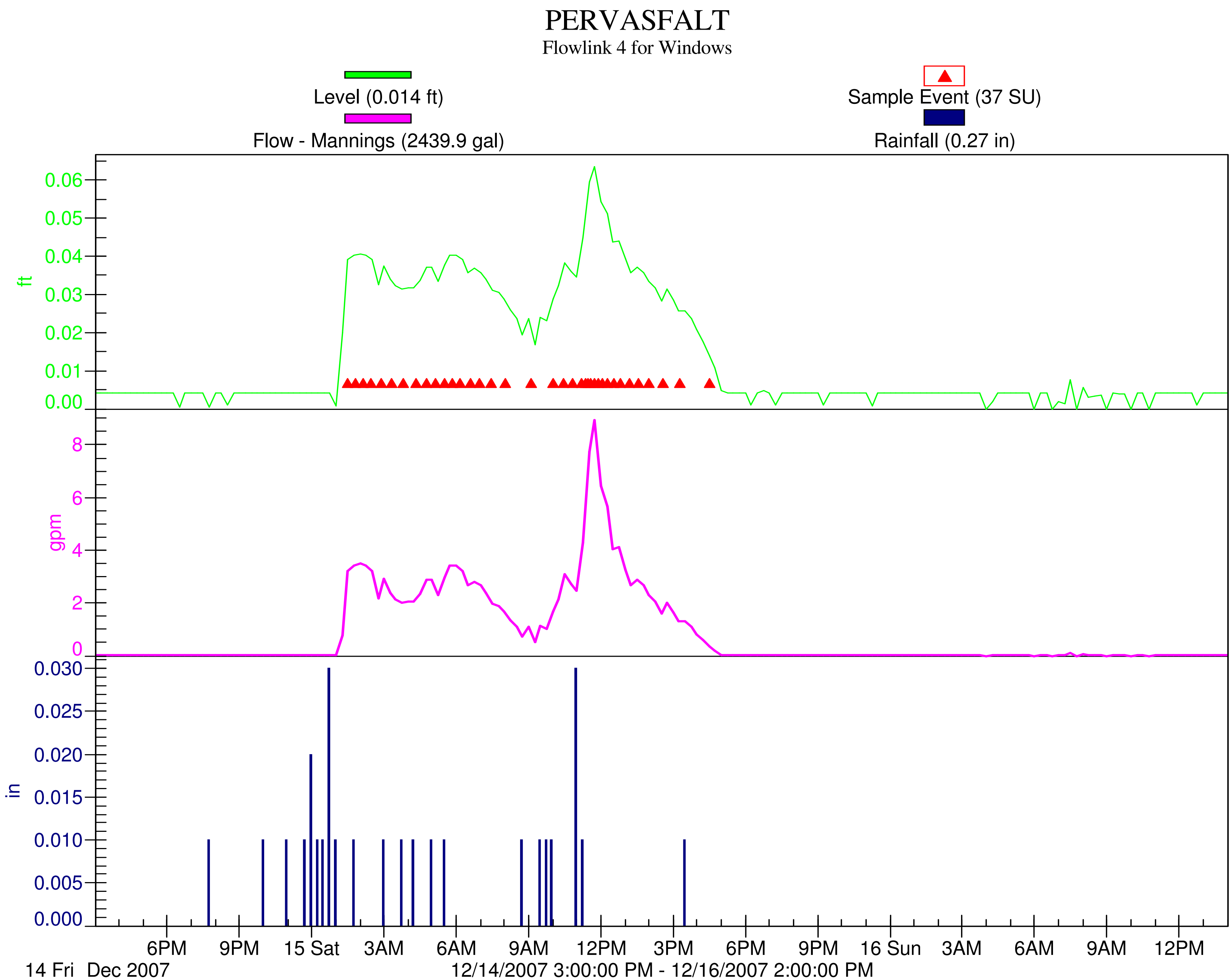
16 Sun
17 Mon
Dec 2007
12/13/2007 1:00:00 AM - 12/17/2007 10:00:00 AM

PERVPAVERS

Flowlink 4 for Windows

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0.05
0.04
0.03
0.02
0.01
0.00
gpm
8
6
4
2
0
in
0.030
0.025
0.020
0.015
0.010
0.005
0.000
6PM
9PM
15 Sat
3AM
6AM
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12PM
3PM
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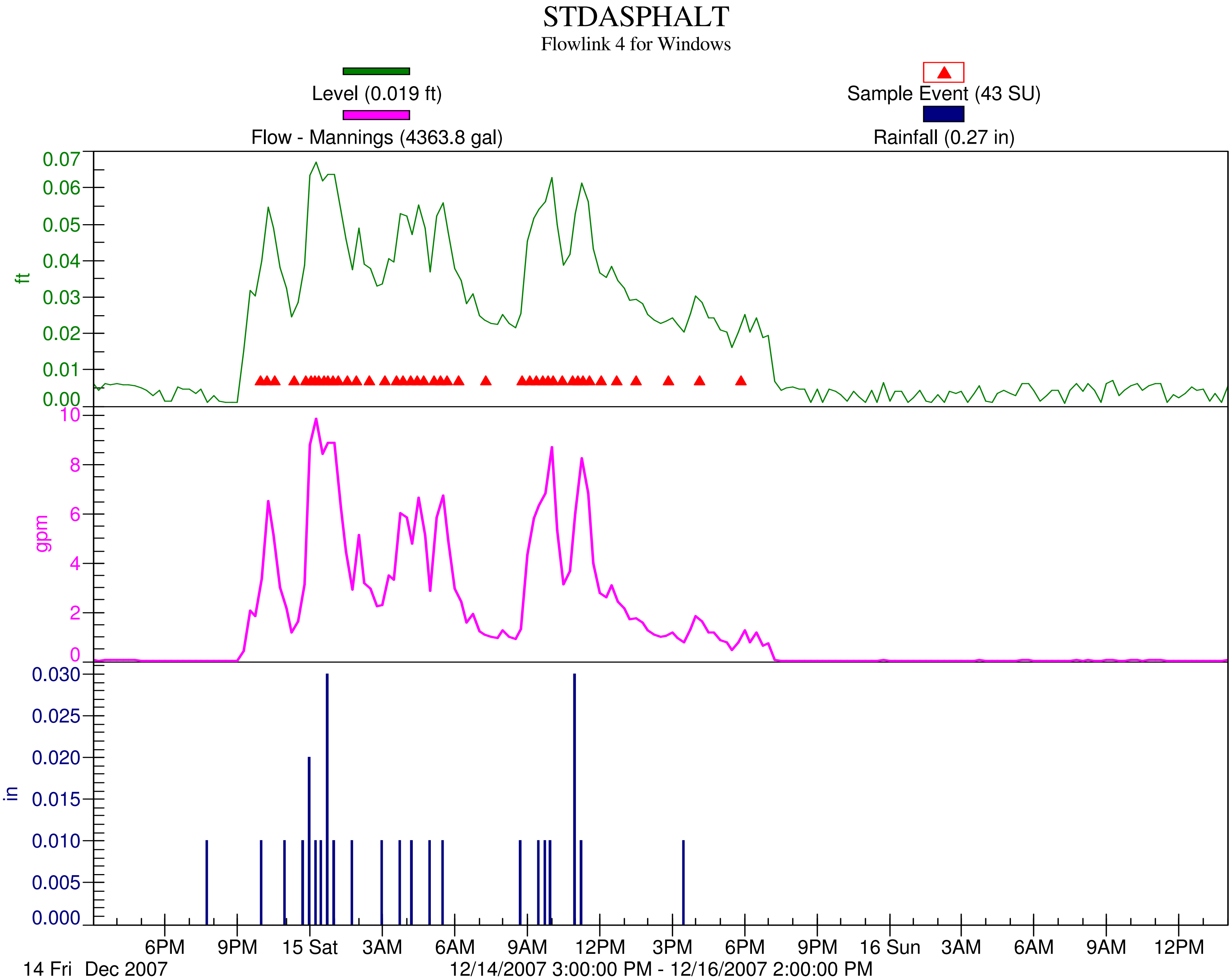
Dec 2007
12/14/2007 3:00:00 PM - 12/16/2007 2:00:00 PM


STDASPHALT
Flowlink 4 for Windows
Level (0.019 ft)
Flow - Mannings (4363.8 gal)
Sample Event (43 SU)
Rainfall (0.27 in)
ft
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0.05
0.04
0.03
0.02
0.01
0.00
gpm
10
8
6
4
2
0
in
0.030
0.025
0.020
0.015
0.010
0.005
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6PM
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14 Fri Dec 2007
12/14/2007 3:00:00 PM - 12/16/2007 2:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #13
January 8, 2008

Introduction

This report summarizes the storm event sampled on 01/08/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #13.

Table 1. Storm Characteristics

Storm Date		01/08/08
Time Storm Began		01/08/08 1:00 am
Total Precipitation (in)		0.31
Duration (hrs)		9.0
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		22.3
Precipitation in 24-hr Antecedent Dry Period (in)		0.02
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	N

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP) since 0.02 inches of rain fell in the antecedent period.

Figure 1 shows the antecedent period for Storm #12. As shown above, 0.02 inches of rain fell in the 24 hours prior to the sampling event, so this exceeded the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, Figure 3, and Figure 4 provide the hydrograph and hyetograph for the storm event for pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious concrete, 17 sample aliquots were collected during the sampling period, but only 15 of these were collected during the during the storm event. These 15 aliquots were collected over 93.7% of the total storm runoff volume. This is not expected to have a significant impact on the data validity for this sampling event.

For pervious asphalt, 48 sample aliquots were collected during the sampling period. These aliquots were collected over 64.3% of the total storm runoff volume. For standard asphalt, 41 sample aliquots were collected during the sampling period. These aliquots were collected over 93.3% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	**Pervious Concrete**	**Pervious Asphalt**	**Standard Asphalt**
Peak Flow Rate (gpm)	NS	2.60	12.70	10.62
Duration of Flow (hrs)	NS	11.3	10.8	12.5
Total Volume (gallons) during Storm Event	NS	638	3676	2669
Total Volume (gallons) during Sampling Event	NS	598[a]	2365	2491
Duration of Sampling Event (hrs)	NS	9.8[a]	3.5	11.3
Number of Sample Aliquots Collected	NS	15[a]	48	41
Percentage of Storm's Total Volume over which Samples were Collected	NS	93.7%[a]	64.3%	93.3%
Volume of Surface Runoff Collected in Vault (inches)	0 in	22 in	0 in	

Key: NS = Not Sampled

a = Two sample aliquots were collected before the storm event. These aliquots were not included in the above values.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious concrete
- Pervious asphalt
- Standard asphalt
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted no special observation during the sampling event.

Field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	08-Jan-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Chrysene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Copper	32.3	ug/L		J
Pervious Asphalt	08-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Diethylphthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Asphalt	08-Jan-08	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Fluorene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Hardness, Calculated	12.7	mg/L		
Pervious Asphalt	08-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Lead	3.3	ug/L	U	
Pervious Asphalt	08-Jan-08	Mercury	0.05	ug/L	U	
Pervious Asphalt	08-Jan-08	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	08-Jan-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	08-Jan-08	pH	6.9	Std. Units		
Pervious Asphalt	08-Jan-08	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	Pyrene	0.01	ug/L	U	
Pervious Asphalt	08-Jan-08	TSS	1.9	mg/L		
Pervious Asphalt	08-Jan-08	Zinc	7	ug/L		
Pervious Concrete	08-Jan-08	2-Methylnaphthalene	0.024	ug/L		
Pervious Concrete	08-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Chrysene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Copper	46.6	ug/L		J
Pervious Concrete	08-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Diethylphthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete	08-Jan-08	Fluoranthene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Fluorene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Hardness, Calculated	805	mg/L		
Pervious Concrete	08-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Lead	24.7	ug/L		
Pervious Concrete	08-Jan-08	Mercury	0.05	ug/L	U	
Pervious Concrete	08-Jan-08	Naphthalene	0.033	ug/L		
Pervious Concrete	08-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete	08-Jan-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete	08-Jan-08	pH	12	Std. Units		

U = value is less than the detection limit
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J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

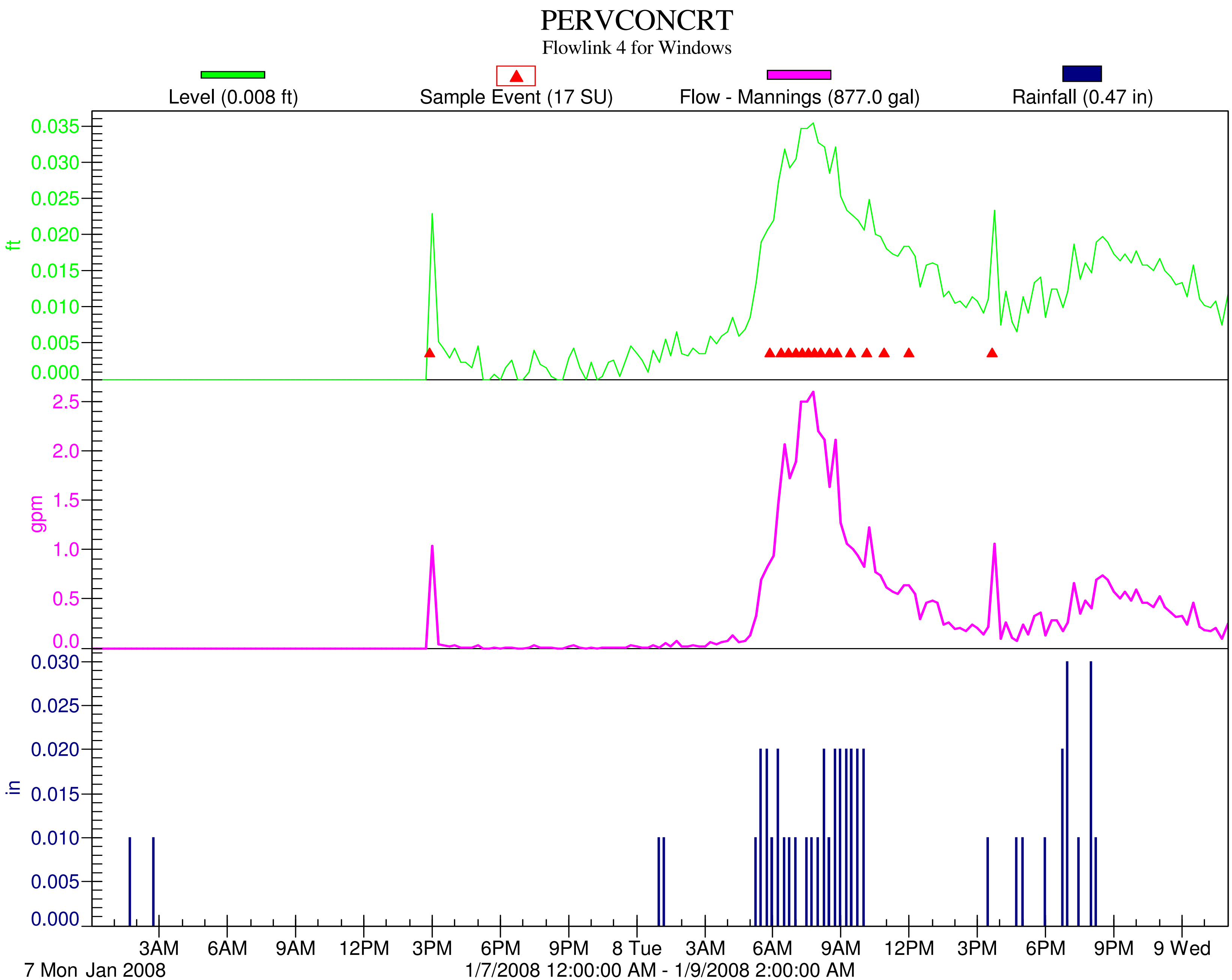
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	08-Jan-08	Phenanthrene	0.013	ug/L		
Pervious Concrete	08-Jan-08	Pyrene	0.01	ug/L	U	
Pervious Concrete	08-Jan-08	Zinc	17.2	ug/L		
Pervious Concrete CB	08-Jan-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Benzo(b,k)fluoranthenes	0.014	ug/L		
Pervious Concrete CB	08-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	bis(2-Ethylhexyl)phthalate	2.2	ug/L		
Pervious Concrete CB	08-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete CB	08-Jan-08	Chrysene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Copper	12.1	ug/L		J
Pervious Concrete CB	08-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	08-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	08-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	08-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete CB	08-Jan-08	Fluoranthene	0.021	ug/L		
Pervious Concrete CB	08-Jan-08	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Hardness, Calculated	30.8	mg/L		
Pervious Concrete CB	08-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete CB	08-Jan-08	Lead	3.3	ug/L	U	
Pervious Concrete CB	08-Jan-08	Mercury	0.05	ug/L	U	
Pervious Concrete CB	08-Jan-08	Naphthalene	0.012	ug/L		
Pervious Concrete CB	08-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	08-Jan-08	NWTPH-Heavy Oil	1.1	mg/L		
Pervious Concrete CB	08-Jan-08	pH	7.7	Std. Units		
Pervious Concrete CB	08-Jan-08	Phenanthrene	0.022	ug/L		
Pervious Concrete CB	08-Jan-08	Pyrene	0.022	ug/L		
Pervious Concrete CB	08-Jan-08	TSS	6.1	mg/L		
Pervious Concrete CB	08-Jan-08	Zinc	20.2	ug/L		
Standard Asphalt	08-Jan-08	2-Methylnaphthalene	0.011	ug/L		
Standard Asphalt	08-Jan-08	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Anthracene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	bis(2-Ethylhexyl)phthalate	1.4	ug/L		
Standard Asphalt	08-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Standard Asphalt	08-Jan-08	Chrysene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Copper	12	ug/L		J
Standard Asphalt	08-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Diethylphthalate	1	ug/L	U	
Standard Asphalt	08-Jan-08	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	08-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	08-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Standard Asphalt	08-Jan-08	Fluoranthene	0.011	ug/L		
Standard Asphalt	08-Jan-08	Fluorene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Hardness, Calculated	3.58	mg/L		
Standard Asphalt	08-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Standard Asphalt	08-Jan-08	Lead	3.3	ug/L	U	
Standard Asphalt	08-Jan-08	Mercury	0.05	ug/L	U	
Standard Asphalt	08-Jan-08	Naphthalene	0.022	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	08-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Standard Asphalt	08-Jan-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Standard Asphalt	08-Jan-08	pH	6.1	Std. Units		
Standard Asphalt	08-Jan-08	Phenanthrene	0.016	ug/L		
Standard Asphalt	08-Jan-08	Pyrene	0.013	ug/L		
Standard Asphalt	08-Jan-08	TSS	5.5	mg/L		
Standard Asphalt	08-Jan-08	Zinc	24.1	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



PERVCONCRT
Flowlink 4 for Windows
Level (0.008 ft)
Sample Event (17 SU)
Flow - Mannings (877.0 gal)
Rainfall (0.47 in)
ft
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
gpm
2.5
2.0
1.5
1.0
0.5
0.0
in
0.030
0.025
0.020
0.015
0.010
0.005
0.000
3AM
6AM
9AM
12PM
3PM
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9PM
8 Tue
3AM
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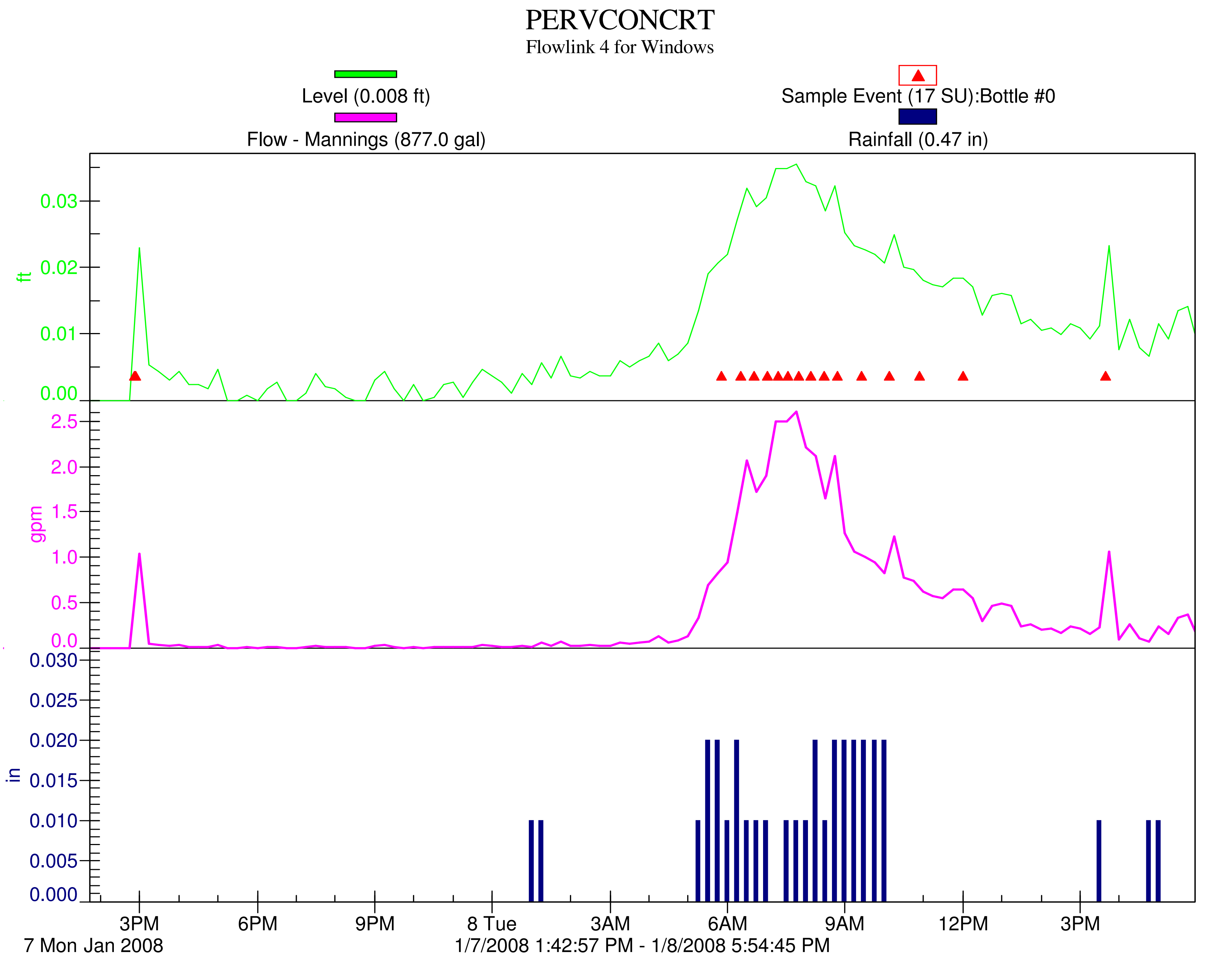
9 Wed
7 Mon Jan 2008
1/7/2008 12:00:00 AM - 1/9/2008 2:00:00 AM



PERVCONCRT
Flowlink 4 for Windows
Level (0.008 ft)
Sample Event (17 SU):Bottle #0
Flow - Mannings (877.0 gal)
Rainfall (0.47 in)
ft
0.03
0.02
0.01
0.00
gpm
2.5
2.0
1.5
1.0
0.5
0.0
in
0.030
0.025
0.020
0.015
0.010
0.005
0.000
3PM
6PM
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3AM
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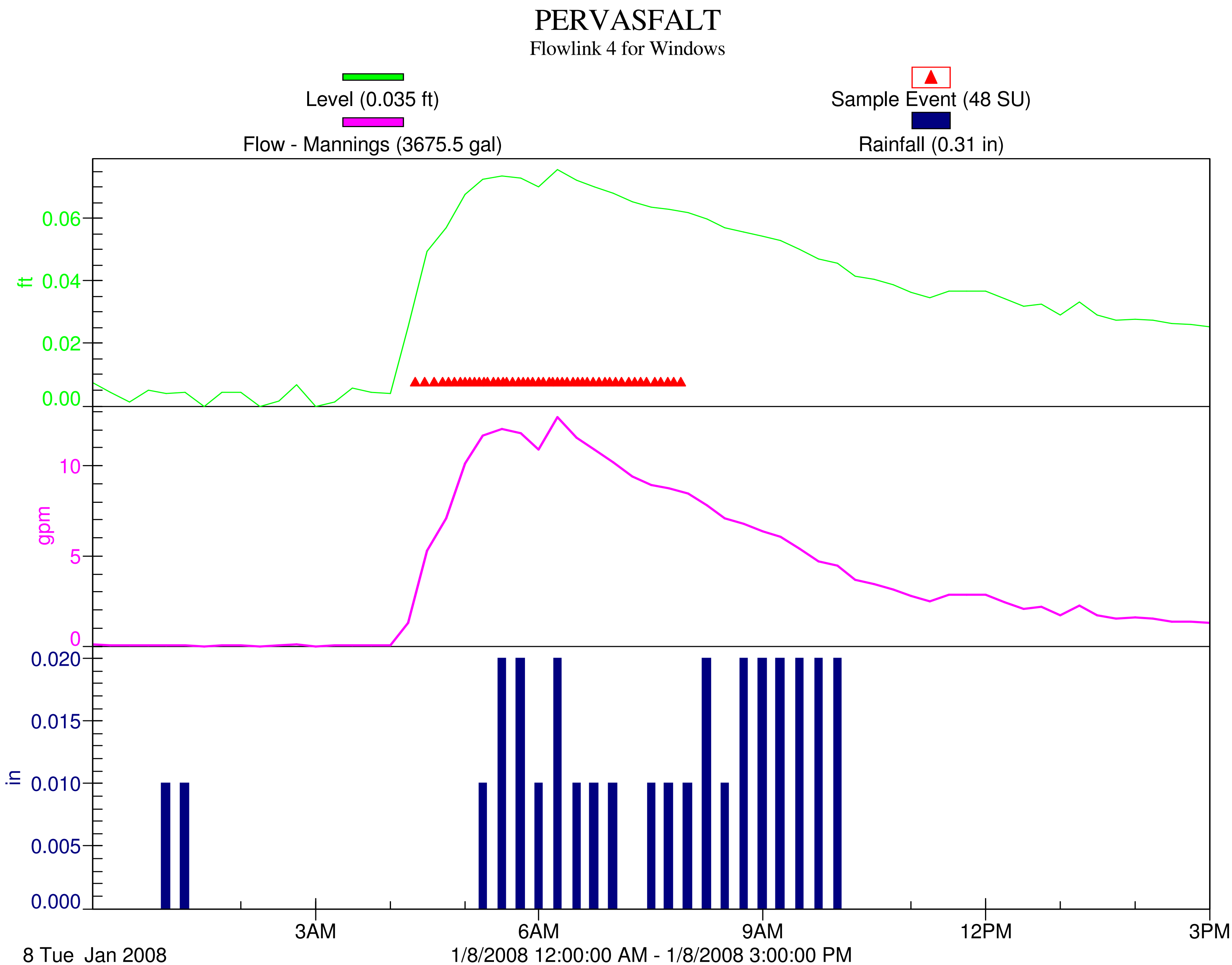
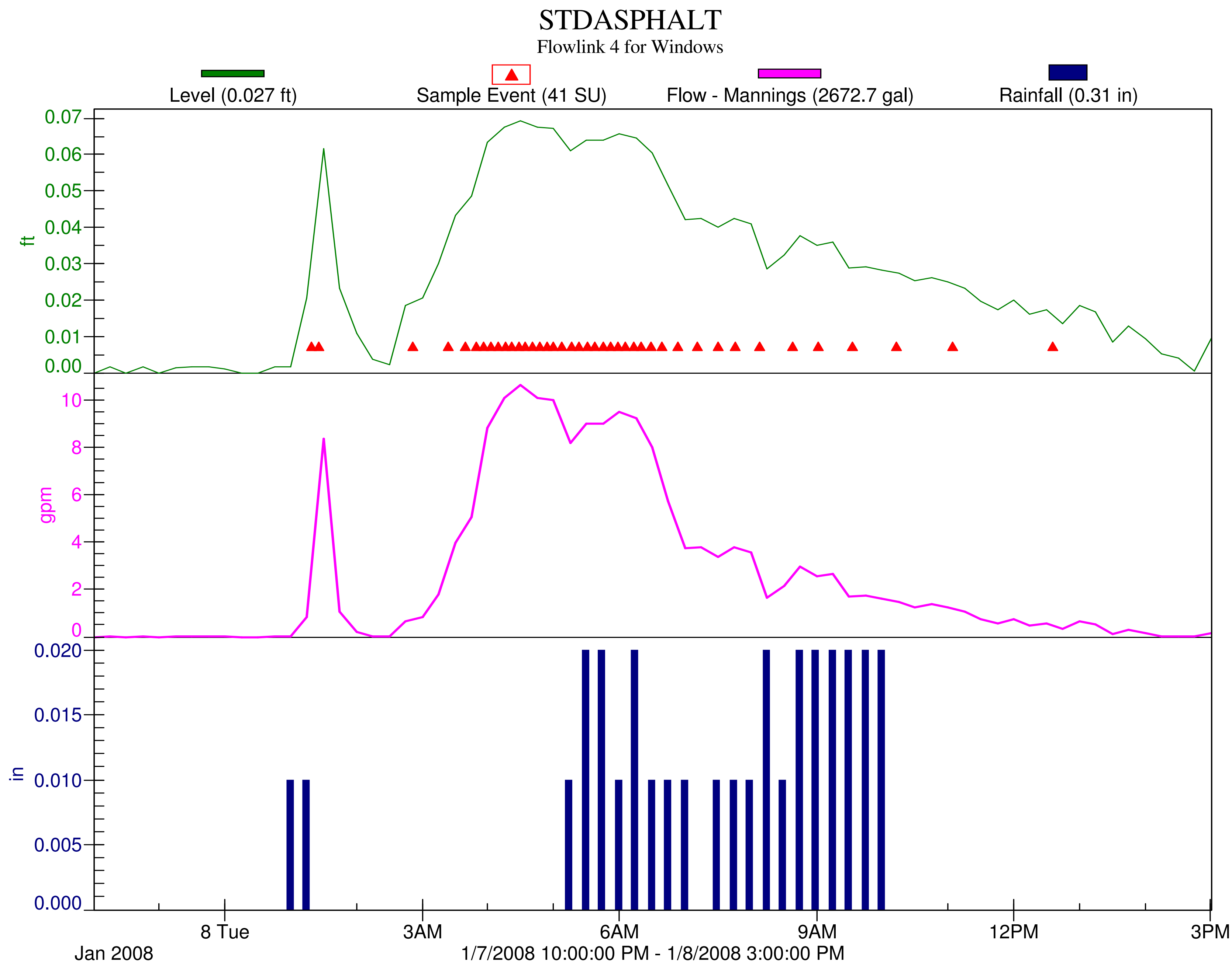


PERVASFALT
Flowlink 4 for Windows
Level (0.035 ft)
Flow - Mannings (3675.5 gal)
Sample Event (48 SU)
Rainfall (0.31 in)
ft
0.06
0.04
0.02
0.00
gpm
10
5
0
in
0.020
0.015
0.010
0.005
0.000
3AM
6AM
9AM
12PM
3PM
8 Tue Jan 2008
1/8/2008 12:00:00 AM - 1/8/2008 3:00:00 PM



STDASPHALT
Flowlink 4 for Windows
Level (0.027 ft)
Sample Event (41 SU)
Flow - Mannings (2672.7 gal)
Rainfall (0.31 in)
ft
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
gpm
10
8
6
4
2
0
in
0.020
0.015
0.010
0.005
0.000
8 Tue
3AM
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12PM
3PM
Jan 2008
1/7/2008 10:00:00 PM - 1/8/2008 3:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #14
January 14, 2008

Introduction

This report summarizes the storm event sampled on 01/14/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #14.

Table 1. Storm Characteristics

Storm Date		01/14/08
Time Storm Began		01/14/08 12:00 PM
Total Precipitation (in)		0.15
Duration (hrs)		3.3
Met Precipitation Criteria?	Precipitation ≥0.2"	N
Antecedent Period (hrs)		32.8
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #13. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Twenty-nine sample aliquots were collected during the sampling period. These aliquots were collected over 76.6% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	2.92	NS	NS	NS
Duration of Flow (hrs)	20.5	NS	NS	NS
Total Volume (gallons) during Storm Event	587	NS	NS	NS
Total Volume (gallons) during Sampling Event	450	NS	NS	NS
Duration of Sampling Event (hrs)	6.9	NS	NS	NS
Number of Sample Aliquots Collected	29	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	76.6%	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	0 in	NM	NM	

Key: NS = Not Sampled
NM = Not Measured

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

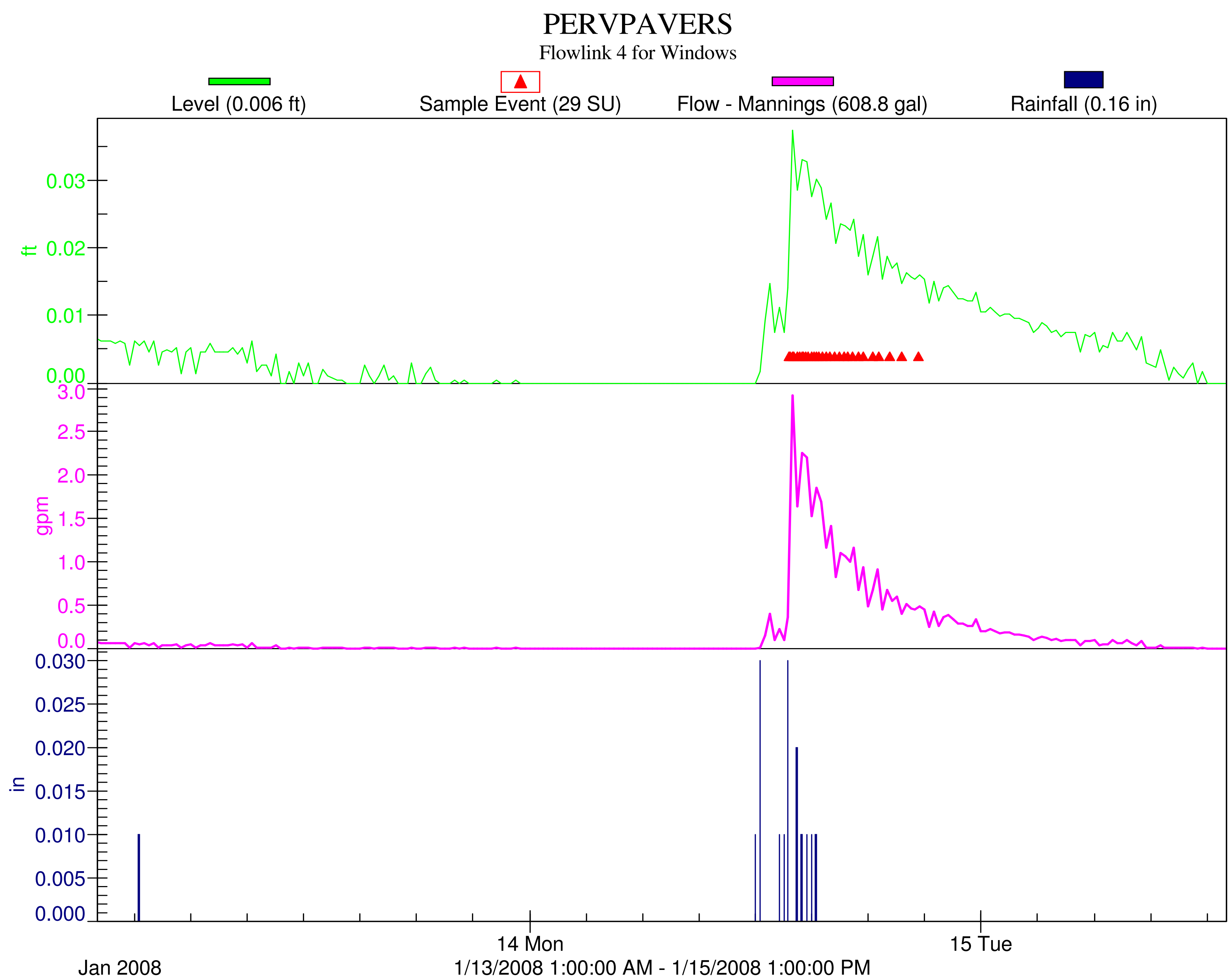
- Pervious concrete, pervious asphalt, and standard asphalt were not deployed. Within 2 week sampling interval.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	14-Jan-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Pavers	14-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers	14-Jan-08	Chrysene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Copper	13.8	ug/L		
Pervious Pavers	14-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Diethylphthalate	2	ug/L		
Pervious Pavers	14-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers	14-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers	14-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers	14-Jan-08	Fluoranthene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Fluorene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Hardness, Calculated	40.8	mg/L		
Pervious Pavers	14-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Lead	3.3	ug/L	U	
Pervious Pavers	14-Jan-08	Mercury	0.05	ug/L	U	
Pervious Pavers	14-Jan-08	Naphthalene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers	14-Jan-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Pavers	14-Jan-08	pH	6.8	Std. Units		
Pervious Pavers	14-Jan-08	Phenanthrene	0.01	ug/L	U	
Pervious Pavers	14-Jan-08	Pyrene	0.01	ug/L		
Pervious Pavers	14-Jan-08	TSS	5.7	mg/L		
Pervious Pavers	14-Jan-08	Zinc	10	ug/L		UJ

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVPAVERS
Flowlink 4 for Windows
Level (0.006 ft)
Sample Event (29 SU)
Flow - Mannings (608.8 gal)
Rainfall (0.16 in)
ft
0.03
0.02
0.01
0.00
gpm
3.0
2.5
2.0
1.5
1.0
0.5
0.0
in
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0.025
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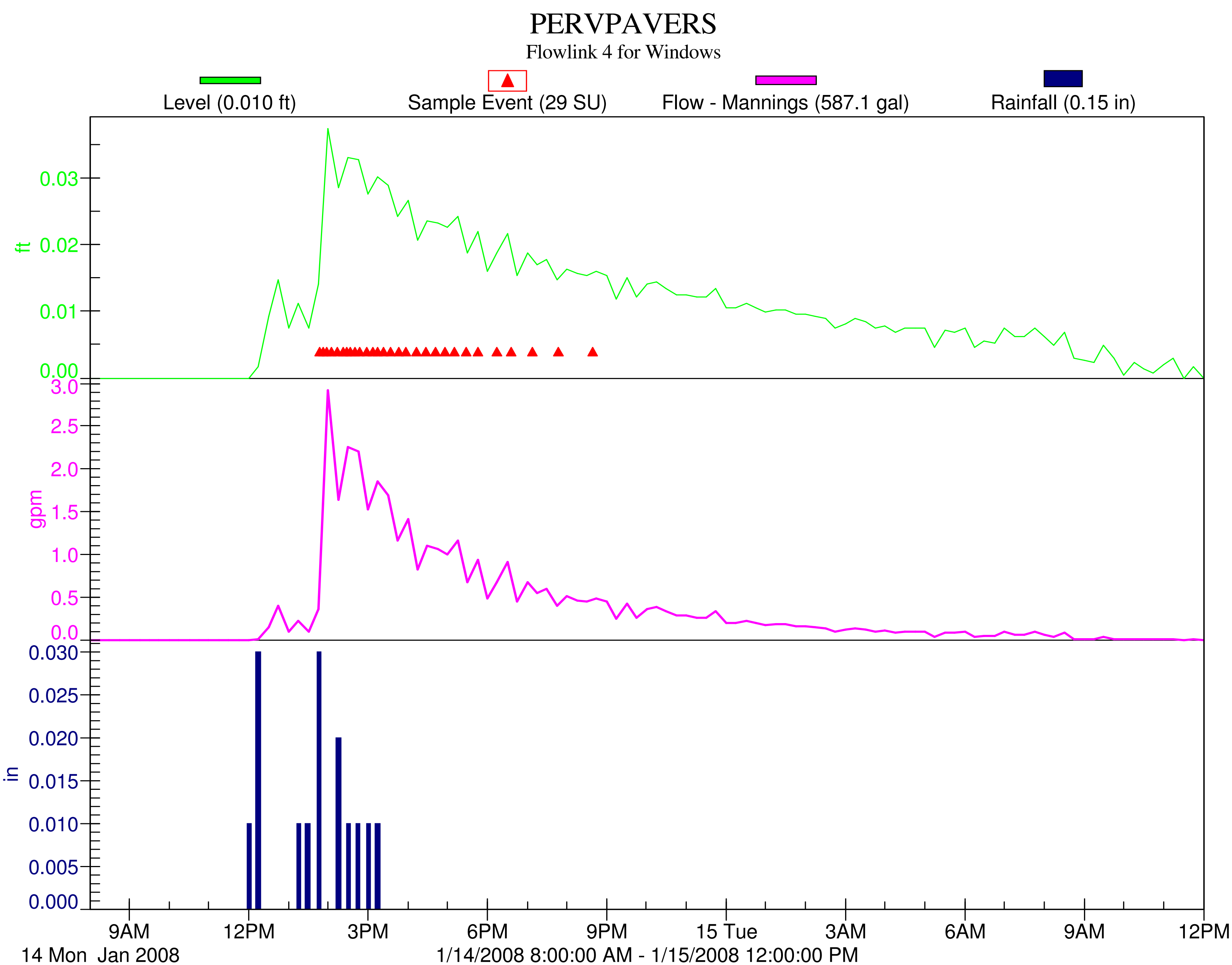
Jan 2008
1/13/2008 1:00:00 AM - 1/15/2008 1:00:00 PM



PERVPAVERS
Flowlink 4 for Windows
Level (0.010 ft)
Sample Event (29 SU)
Flow - Mannings (587.1 gal)
Rainfall (0.15 in)
ft
0.03
0.02
0.01
0.00
gpm
3.0
2.5
2.0
1.5
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9AM
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3AM
6AM
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12PM
14 Mon Jan 2008
1/14/2008 8:00:00 AM - 1/15/2008 12:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #15
January 27, 2008

Introduction

This report summarizes the storm event sampled on 01/27/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #15.

Table 1. Storm Characteristics

Storm Date		01/27/08
Time Storm Began		01/26/08 1:45 PM
Total Precipitation (in)		0.24
Duration (hrs)		9.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		148
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #14. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetographs for the storm event for pervious asphalt and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious asphalt, 30 sample aliquots were collected during the sampling period. These aliquots were collected over 97.0% of the total storm runoff volume. For standard asphalt, 39 sample aliquots were collected during the sampling period. These aliquots were collected over 97.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	7.37	12.02
Duration of Flow (hrs)	NS	NS	29.0	13.0
Total Volume (gallons) during Storm Event	NS	NS	2137	2733
Total Volume (gallons) during Sampling Event	NS	NS	2073	2671
Duration of Sampling Event (hrs)	NS	NS	15.5	11.7
Number of Sample Aliquots Collected	NS	NS	30	39
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	97.0%	97.7%
Volume of Surface Runoff Collected in Vault (inches)	3.5 in	20.5 in	0 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious pavers - Height errors. Checked and calibrated bubbler probe.
- Pervious concrete - Height errors. Cleaned and calibrated bubbler probe.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	27-Jan-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	27-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Asphalt	27-Jan-08	Chrysene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Copper	16.3	ug/L		UJ
Pervious Asphalt	27-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Diethylphthalate	1.5	ug/L		
Pervious Asphalt	27-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	27-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	27-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Asphalt	27-Jan-08	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Fluorene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Hardness, Calculated	21.3	mg/L		
Pervious Asphalt	27-Jan-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Lead	3.3	ug/L	U	
Pervious Asphalt	27-Jan-08	Mercury	0.05	ug/L	U	
Pervious Asphalt	27-Jan-08	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	27-Jan-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	27-Jan-08	pH	6.9	Std. Units		
Pervious Asphalt	27-Jan-08	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Pyrene	0.01	ug/L	U	
Pervious Asphalt	27-Jan-08	Zinc	4.3	ug/L	B	
Pervious Concrete CB	27-Jan-08	2-Methylnaphthalene	0.025	ug/L		
Pervious Concrete CB	27-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	27-Jan-08	Acenaphthylene	0.015	ug/L		
Pervious Concrete CB	27-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	27-Jan-08	Benzo(a)anthracene	0.019	ug/L		
Pervious Concrete CB	27-Jan-08	Benzo(a)pyrene	0.015	ug/L		
Pervious Concrete CB	27-Jan-08	Benzo(b,k)fluoranthenes	0.045	ug/L		
Pervious Concrete CB	27-Jan-08	Benzo(g,h,i)perylene	0.025	ug/L		
Pervious Concrete CB	27-Jan-08	bis(2-Ethylhexyl)phthalate	5.4	ug/L		
Pervious Concrete CB	27-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Jan-08	Chrysene	0.034	ug/L		
Pervious Concrete CB	27-Jan-08	Copper	5.3	ug/L	U	J
Pervious Concrete CB	27-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	27-Jan-08	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	27-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	27-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Concrete CB	27-Jan-08	Fluoranthene	0.05	ug/L		
Pervious Concrete CB	27-Jan-08	Fluorene	0.018	ug/L		
Pervious Concrete CB	27-Jan-08	Hardness, Calculated	27.5	mg/L		
Pervious Concrete CB	27-Jan-08	Indeno(1,2,3-c,d)pyrene	0.016	ug/L		
Pervious Concrete CB	27-Jan-08	Lead	3.3	ug/L	U	
Pervious Concrete CB	27-Jan-08	Mercury	0.05	ug/L	U	
Pervious Concrete CB	27-Jan-08	Naphthalene	0.043	ug/L		
Pervious Concrete CB	27-Jan-08	NWTPH-Diesel	0.35	mg/L		
Pervious Concrete CB	27-Jan-08	NWTPH-Heavy Oil	3	mg/L		
Pervious Concrete CB	27-Jan-08	pH	7.7	Std. Units		
Pervious Concrete CB	27-Jan-08	Phenanthrene	0.063	ug/L		

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B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	27-Jan-08	Pyrene	0.056	ug/L		
Pervious Concrete CB	27-Jan-08	TSS	9.4	mg/L		
Pervious Concrete CB	27-Jan-08	Zinc	22.6	ug/L		
Pervious Pavers CB	27-Jan-08	2-Methylnaphthalene	0.014	ug/L		
Pervious Pavers CB	27-Jan-08	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	27-Jan-08	Acenaphthylene	0.01	ug/L		
Pervious Pavers CB	27-Jan-08	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	27-Jan-08	Benzo(a)anthracene	0.01	ug/L		
Pervious Pavers CB	27-Jan-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers CB	27-Jan-08	Benzo(b,k)fluoranthenes	0.029	ug/L		
Pervious Pavers CB	27-Jan-08	Benzo(g,h,i)perylene	0.016	ug/L		
Pervious Pavers CB	27-Jan-08	bis(2-Ethylhexyl)phthalate	1.3	ug/L		
Pervious Pavers CB	27-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers CB	27-Jan-08	Chrysene	0.018	ug/L		
Pervious Pavers CB	27-Jan-08	Copper	6.2	ug/L		UJ
Pervious Pavers CB	27-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	27-Jan-08	Diethylphthalate	1	ug/L	U	
Pervious Pavers CB	27-Jan-08	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	27-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers CB	27-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Pervious Pavers CB	27-Jan-08	Fluoranthene	0.024	ug/L		
Pervious Pavers CB	27-Jan-08	Fluorene	0.01	ug/L		
Pervious Pavers CB	27-Jan-08	Hardness, Calculated	24.8	mg/L		
Pervious Pavers CB	27-Jan-08	Indeno(1,2,3-c,d)pyrene	0.011	ug/L		
Pervious Pavers CB	27-Jan-08	Lead	3.3	ug/L	U	
Pervious Pavers CB	27-Jan-08	Mercury	0.05	ug/L	U	
Pervious Pavers CB	27-Jan-08	Naphthalene	0.029	ug/L		
Pervious Pavers CB	27-Jan-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers CB	27-Jan-08	NWTPH-Heavy Oil	1	mg/L		
Pervious Pavers CB	27-Jan-08	pH	7.4	Std. Units		
Pervious Pavers CB	27-Jan-08	Phenanthrene	0.034	ug/L		
Pervious Pavers CB	27-Jan-08	Pyrene	0.026	ug/L		
Pervious Pavers CB	27-Jan-08	TSS	29.8	mg/L		
Pervious Pavers CB	27-Jan-08	Zinc	69.7	ug/L		
Standard Asphalt	27-Jan-08	2-Methylnaphthalene	0.033	ug/L		
Standard Asphalt	27-Jan-08	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	27-Jan-08	Acenaphthylene	0.015	ug/L		
Standard Asphalt	27-Jan-08	Anthracene	0.01	ug/L	U	
Standard Asphalt	27-Jan-08	Benzo(a)anthracene	0.025	ug/L		
Standard Asphalt	27-Jan-08	Benzo(a)pyrene	0.023	ug/L		
Standard Asphalt	27-Jan-08	Benzo(b,k)fluoranthenes	0.078	ug/L		
Standard Asphalt	27-Jan-08	Benzo(g,h,i)perylene	0.041	ug/L		
Standard Asphalt	27-Jan-08	bis(2-Ethylhexyl)phthalate	4.6	ug/L		
Standard Asphalt	27-Jan-08	Butyl benzyl phthalate	1	ug/L	U	
Standard Asphalt	27-Jan-08	Chrysene	0.059	ug/L		
Standard Asphalt	27-Jan-08	Copper	7.5	ug/L		UJ
Standard Asphalt	27-Jan-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	27-Jan-08	Diethylphthalate	1	ug/L	U	
Standard Asphalt	27-Jan-08	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	27-Jan-08	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	27-Jan-08	Di-n-octyl phthalate	1	ug/L	U	
Standard Asphalt	27-Jan-08	Fluoranthene	0.072	ug/L		
Standard Asphalt	27-Jan-08	Fluorene	0.019	ug/L		
Standard Asphalt	27-Jan-08	Hardness, Calculated	9.9	mg/L		
Standard Asphalt	27-Jan-08	Indeno(1,2,3-c,d)pyrene	0.027	ug/L		
Standard Asphalt	27-Jan-08	Lead	3.3	ug/L	U	
Standard Asphalt	27-Jan-08	Mercury	0.05	ug/L	U	
Standard Asphalt	27-Jan-08	Naphthalene	0.05	ug/L		

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J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	27-Jan-08	NWTPH-Diesel	0.67	mg/L		
Standard Asphalt	27-Jan-08	NWTPH-Heavy Oil	1.5	mg/L		
Standard Asphalt	27-Jan-08	pH	6.5	Std. Units		
Standard Asphalt	27-Jan-08	Phenanthrene	0.08	ug/L		
Standard Asphalt	27-Jan-08	Pyrene	0.082	ug/L		
Standard Asphalt	27-Jan-08	TSS	19.2	mg/L		
Standard Asphalt	27-Jan-08	Zinc	62.8	ug/L		

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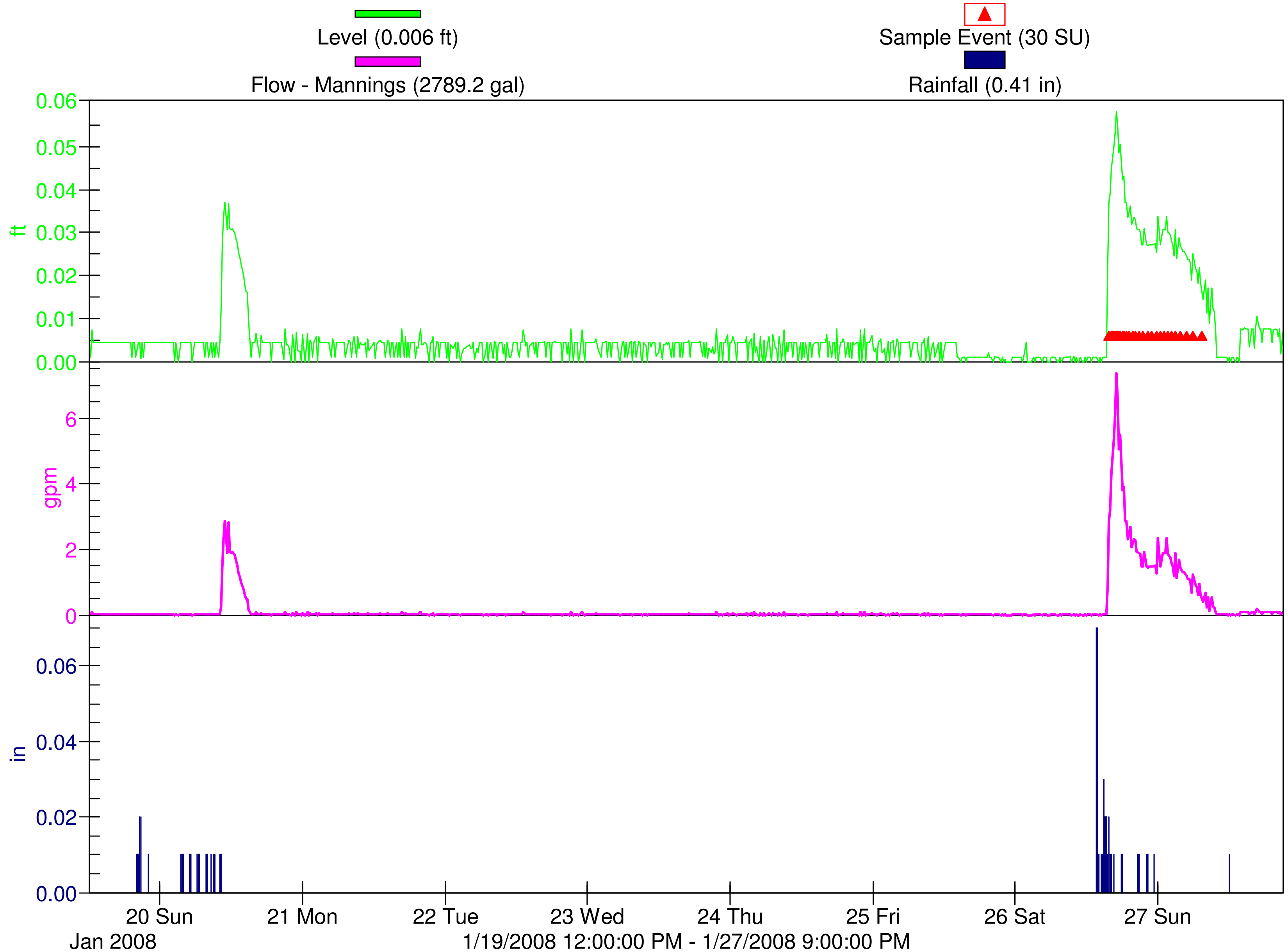
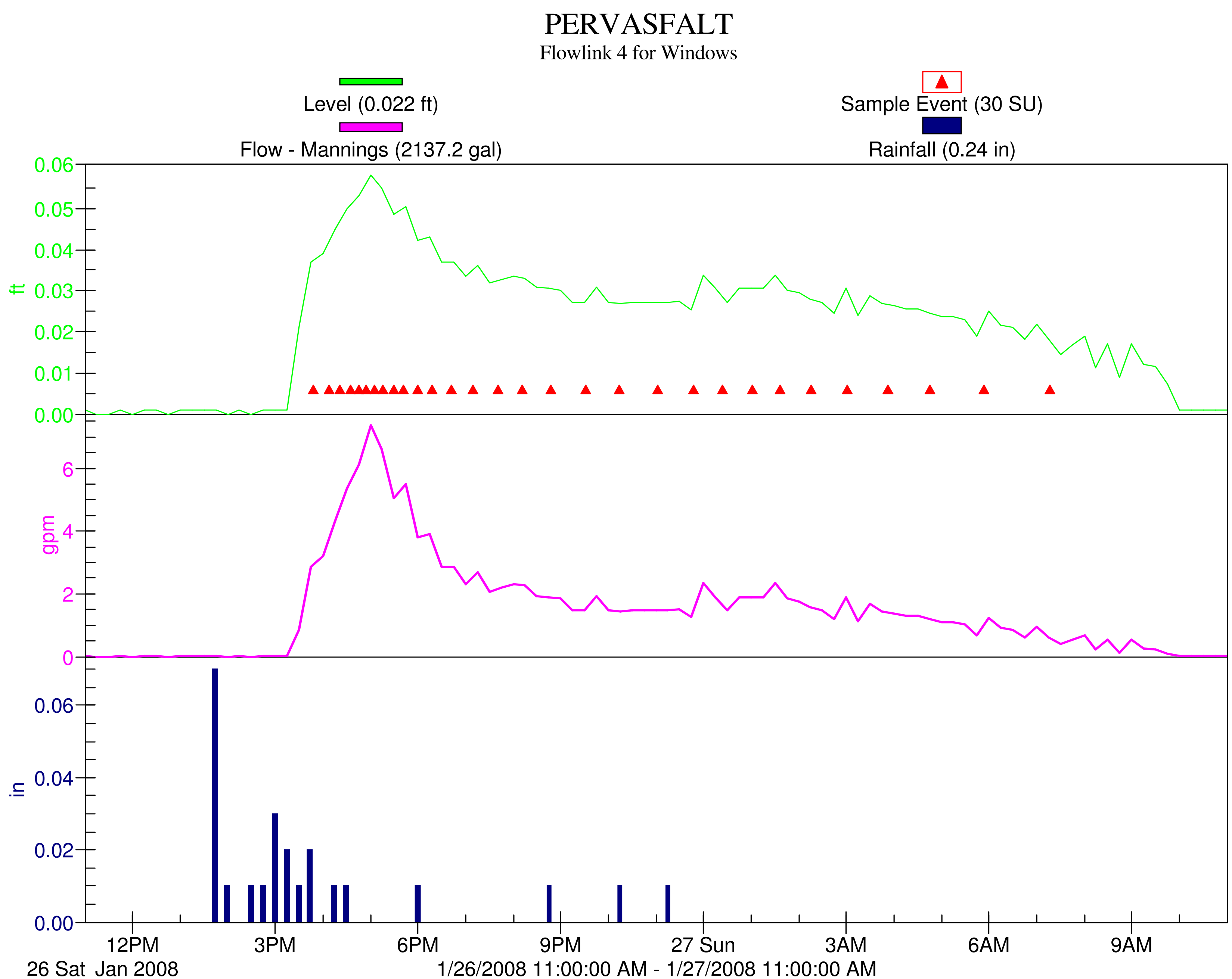
B = value is less than the reporting limit, but greater than the detection limit

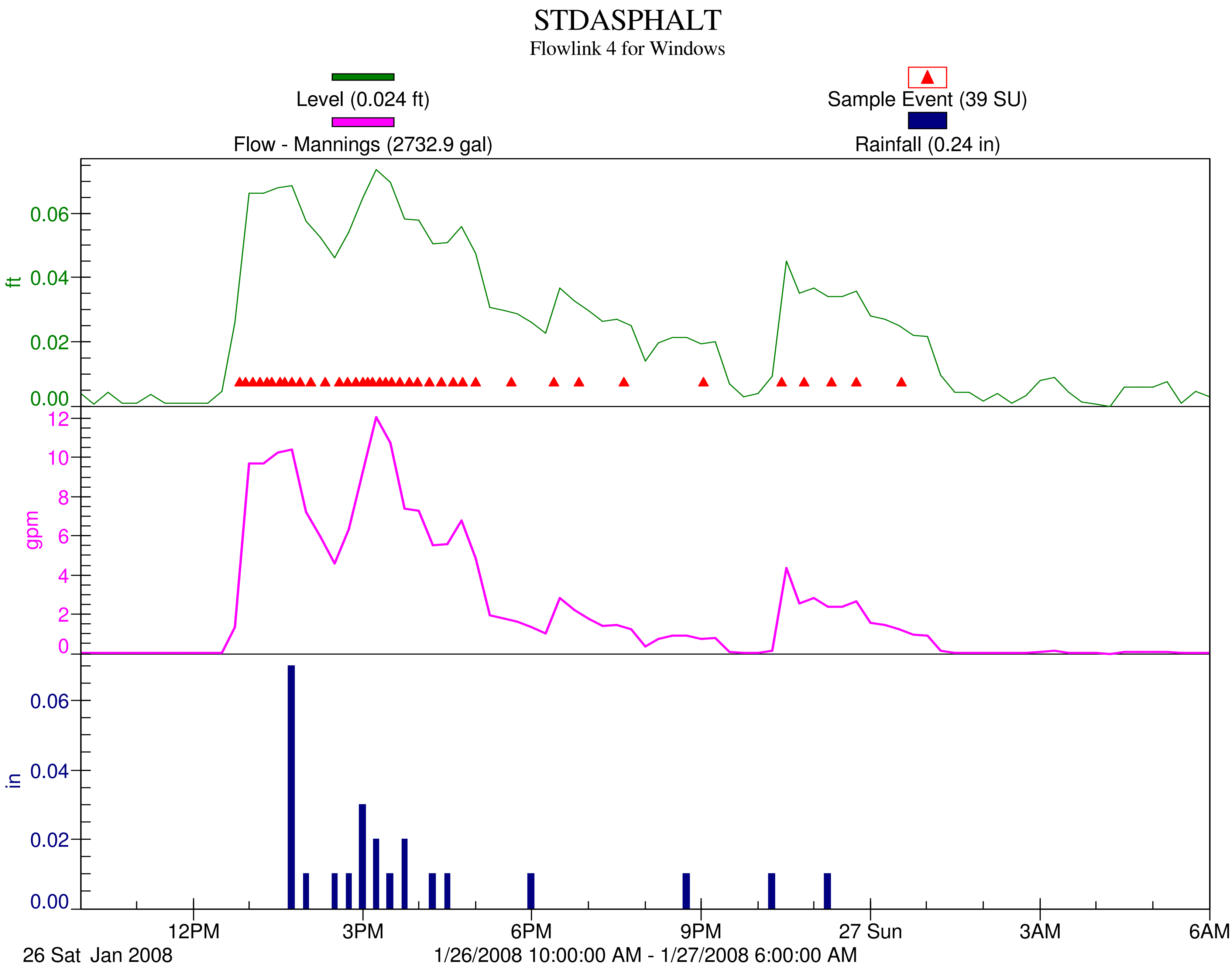
PERVASFALT

Flowlink 4 for Windows





PERVASFALT
Flowlink 4 for Windows
Level (0.022 ft)
Flow - Mannings (2137.2 gal)
Sample Event (30 SU)
Rainfall (0.24 in)
ft
0.06
0.05
0.04
0.03
0.02
0.01
0.00
gpm
6
4
2
0
in
0.06
0.04
0.02
0.00
12PM
3PM
6PM
9PM
27 Sun
3AM
6AM
9AM
26 Sat Jan 2008
1/26/2008 11:00:00 AM - 1/27/2008 11:00:00 AM



STDASPHALT
Flowlink 4 for Windows
Level (0.024 ft)
Flow - Mannings (2732.9 gal)
Sample Event (39 SU)
Rainfall (0.24 in)
ft
0.06
0.04
0.02
0.00
gpm
12
10
8
6
4
2
0
in
0.06
0.04
0.02
0.00
12PM
3PM
6PM
9PM
27 Sun
3AM
6AM
26 Sat Jan 2008
1/26/2008 10:00:00 AM - 1/27/2008 6:00:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #16
March 1, 2008

Introduction

This report summarizes the storm event sampled on 03/01/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #16.

Table 1. Storm Characteristics

Storm Date		03/01/08
Time Storm Began		02/29/08 2:45 PM
Total Precipitation (in)		0.34
Duration (hrs)		14.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		52.75
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #15. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetograph for the storm events for pervious asphalt and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious asphalt, 39 sample aliquots were collected during the sampling period. These aliquots were collected over 97.1% of the total storm runoff volume. For standard asphalt, 47 sample aliquots were collected during the sampling period. These aliquots were collected over 96.7% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	11.91	11.37
Duration of Flow (hrs)	NS	NS	17.0	17.3
Total Volume (gallons) during Storm Event	NS	NS	2750	3219
Total Volume (gallons) during Sampling Event	NS	NS	2669	3114
Duration of Sampling Event (hrs)	NS	NS	15.8	16.9
Number of Sample Aliquots Collected	NS	NS	39	47
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	97.1%	96.7%
Volume of Surface Runoff Collected in Vault (inches)	17 in	18.5 in	0 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pervious pavers – Sample not accepted (2 liters). Program only showed one sample taken, yet 2 liters were present at pick-up. Height errors – checked and recalibrated bubbler probe.
- Pervious concrete – Height errors – cleaned and recalibrated bubbler probe.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	01-Mar-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Acenaphthene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Acenaphthylene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Anthracene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	bis(2-Ethylhexyl)phthalate	1	ug/L	U	
Pervious Asphalt	01-Mar-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Asphalt	01-Mar-08	Chrysene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Copper	15.1	ug/L		
Pervious Asphalt	01-Mar-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Diethylphthalate	1.7	ug/L		
Pervious Asphalt	01-Mar-08	Dimethyl phthalate	1	ug/L	U	
Pervious Asphalt	01-Mar-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Asphalt	01-Mar-08	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Asphalt	01-Mar-08	Fluoranthene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Fluorene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Hardness, Calculated	17.7	mg/L		
Pervious Asphalt	01-Mar-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Lead	3.3	ug/L	U	
Pervious Asphalt	01-Mar-08	Mercury	0.05	ug/L	U	
Pervious Asphalt	01-Mar-08	Naphthalene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Asphalt	01-Mar-08	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Asphalt	01-Mar-08	pH	6.5	Std. Units		
Pervious Asphalt	01-Mar-08	Phenanthrene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	Pyrene	0.01	ug/L	U	
Pervious Asphalt	01-Mar-08	TSS	8.8	mg/L		
Pervious Asphalt	01-Mar-08	Zinc	4.5	ug/L	B	
Pervious Concrete CB	02-Mar-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Acenaphthene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Acenaphthylene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Anthracene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Benzo(b,k)fluoranthenes	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Benzo(g,h,i)perylene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	bis(2-Ethylhexyl)phthalate	2	ug/L		
Pervious Concrete CB	02-Mar-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Concrete CB	02-Mar-08	Chrysene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Copper	5.3	ug/L	U	
Pervious Concrete CB	02-Mar-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Diethylphthalate	1	ug/L	U	
Pervious Concrete CB	02-Mar-08	Dimethyl phthalate	1	ug/L	U	
Pervious Concrete CB	02-Mar-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Concrete CB	02-Mar-08	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Concrete CB	02-Mar-08	Fluoranthene	0.016	ug/L		
Pervious Concrete CB	02-Mar-08	Fluorene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Hardness, Calculated	32.3	mg/L		
Pervious Concrete CB	02-Mar-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	Lead	4.4	ug/L	B	
Pervious Concrete CB	02-Mar-08	Mercury	0.05	ug/L	U	
Pervious Concrete CB	02-Mar-08	Naphthalene	0.01	ug/L	U	
Pervious Concrete CB	02-Mar-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Concrete CB	02-Mar-08	NWTPH-Heavy Oil	1.3	mg/L		
Pervious Concrete CB	02-Mar-08	pH	7.1	Std. Units		

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	02-Mar-08	Phenanthrene	0.012	ug/L		
Pervious Concrete CB	02-Mar-08	Pyrene	0.016	ug/L		
Pervious Concrete CB	02-Mar-08	TSS	3.6	mg/L		
Pervious Concrete CB	02-Mar-08	Zinc	29	ug/L		
Pervious Pavers CB	02-Mar-08	2-Methylnaphthalene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Acenaphthene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Acenaphthylene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Anthracene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Benzo(a)anthracene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Benzo(a)pyrene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Benzo(b,k)fluoranthenes	0.015	ug/L		
Pervious Pavers CB	02-Mar-08	Benzo(g,h,i)perylene	0.012	ug/L		
Pervious Pavers CB	02-Mar-08	bis(2-Ethylhexyl)phthalate	1.8	ug/L		
Pervious Pavers CB	02-Mar-08	Butyl benzyl phthalate	1	ug/L	U	
Pervious Pavers CB	02-Mar-08	Chrysene	0.013	ug/L		
Pervious Pavers CB	02-Mar-08	Copper	5.3	ug/L	U	
Pervious Pavers CB	02-Mar-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Diethylphthalate	1	ug/L	U	
Pervious Pavers CB	02-Mar-08	Dimethyl phthalate	1	ug/L	U	
Pervious Pavers CB	02-Mar-08	Di-n-butylphthalate	1	ug/L	U	
Pervious Pavers CB	02-Mar-08	Di-n-Octyl phthalate	1	ug/L	U	
Pervious Pavers CB	02-Mar-08	Fluoranthene	0.021	ug/L		
Pervious Pavers CB	02-Mar-08	Fluorene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Hardness, Calculated	23.5	mg/L		
Pervious Pavers CB	02-Mar-08	Indeno(1,2,3-c,d)pyrene	0.01	ug/L	U	
Pervious Pavers CB	02-Mar-08	Lead	3.3	ug/L	U	
Pervious Pavers CB	02-Mar-08	Mercury	0.05	ug/L	U	
Pervious Pavers CB	02-Mar-08	Naphthalene	0.011	ug/L		
Pervious Pavers CB	02-Mar-08	NWTPH-Diesel	0.2	mg/L	U	
Pervious Pavers CB	02-Mar-08	NWTPH-Heavy Oil	1.4	mg/L		
Pervious Pavers CB	02-Mar-08	pH	7.1	Std. Units		
Pervious Pavers CB	02-Mar-08	Phenanthrene	0.018	ug/L		
Pervious Pavers CB	02-Mar-08	Pyrene	0.022	ug/L		
Pervious Pavers CB	02-Mar-08	TSS	5.4	mg/L		
Pervious Pavers CB	02-Mar-08	Zinc	76.9	ug/L		
Standard Asphalt	01-Mar-08	2-Methylnaphthalene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Acenaphthene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Acenaphthylene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Anthracene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Benzo(a)anthracene	0.019	ug/L		
Standard Asphalt	01-Mar-08	Benzo(a)pyrene	0.021	ug/L		
Standard Asphalt	01-Mar-08	Benzo(b,k)fluoranthenes	0.063	ug/L		
Standard Asphalt	01-Mar-08	Benzo(g,h,i)perylene	0.043	ug/L		
Standard Asphalt	01-Mar-08	bis(2-Ethylhexyl)phthalate	6.4	ug/L		
Standard Asphalt	01-Mar-08	Butyl benzyl phthalate	1	ug/L	U	
Standard Asphalt	01-Mar-08	Chrysene	0.059	ug/L		
Standard Asphalt	01-Mar-08	Copper	7.7	ug/L		
Standard Asphalt	01-Mar-08	Dibenz(a,h)anthracene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Diethylphthalate	1	ug/L	U	
Standard Asphalt	01-Mar-08	Dimethyl phthalate	1	ug/L	U	
Standard Asphalt	01-Mar-08	Di-n-butylphthalate	1	ug/L	U	
Standard Asphalt	01-Mar-08	Di-n-Octyl phthalate	1.4	ug/L		
Standard Asphalt	01-Mar-08	Fluoranthene	0.067	ug/L		
Standard Asphalt	01-Mar-08	Fluorene	0.01	ug/L	U	
Standard Asphalt	01-Mar-08	Hardness, Calculated	7.12	mg/L		
Standard Asphalt	01-Mar-08	Indeno(1,2,3-c,d)pyrene	0.022	ug/L		
Standard Asphalt	01-Mar-08	Lead	7.2	ug/L		
Standard Asphalt	01-Mar-08	Mercury	0.102	ug/L	B	

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	01-Mar-08	Naphthalene	0.021	ug/L		
Standard Asphalt	01-Mar-08	NWTPH-Diesel	0.28	mg/L		
Standard Asphalt	01-Mar-08	NWTPH-Heavy Oil	1.3	mg/L		
Standard Asphalt	01-Mar-08	pH	6.4	Std. Units		
Standard Asphalt	01-Mar-08	Phenanthrene	0.049	ug/L		
Standard Asphalt	01-Mar-08	Pyrene	0.075	ug/L		
Standard Asphalt	01-Mar-08	TSS	32	mg/L		
Standard Asphalt	01-Mar-08	Zinc	57.4	ug/L		

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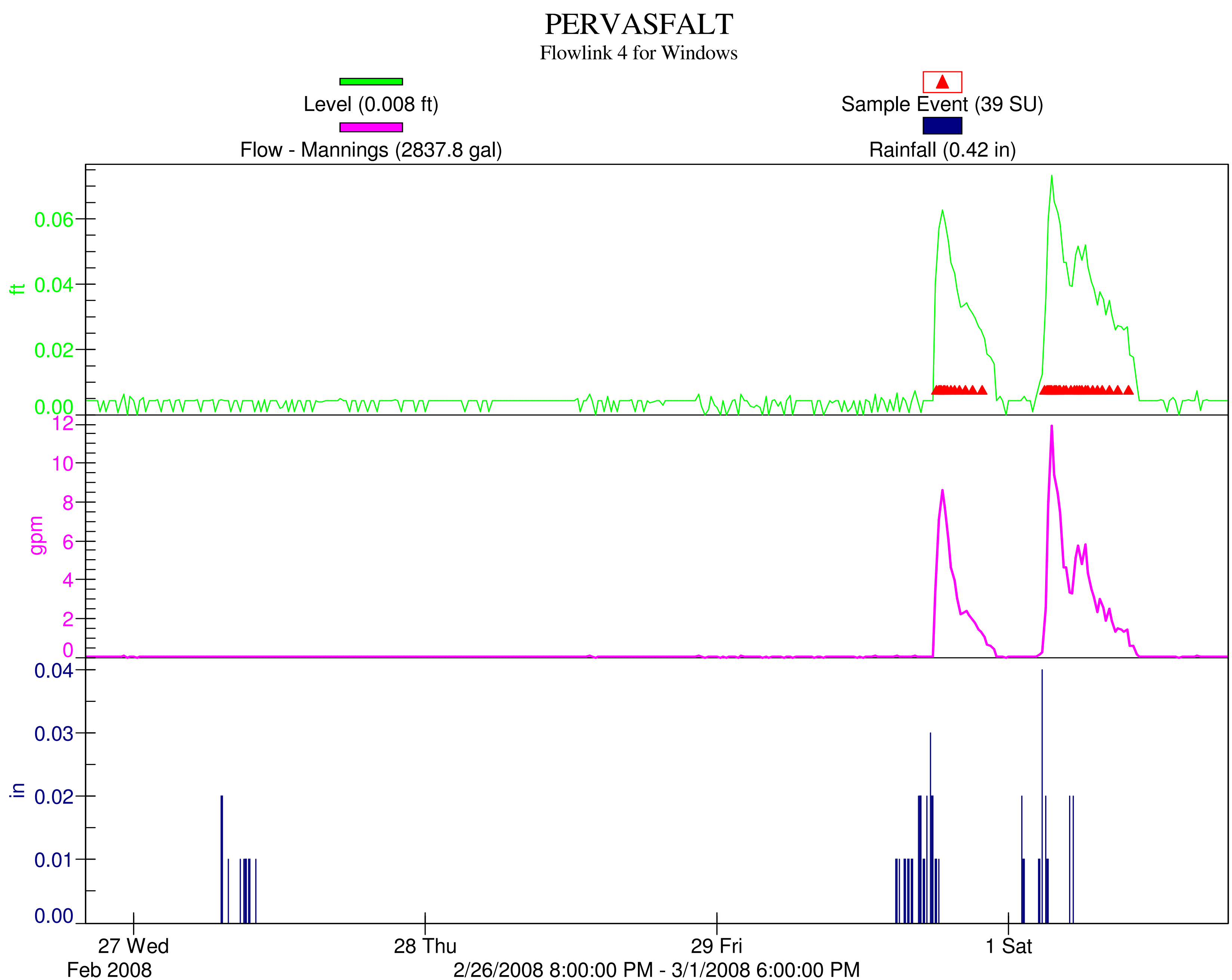
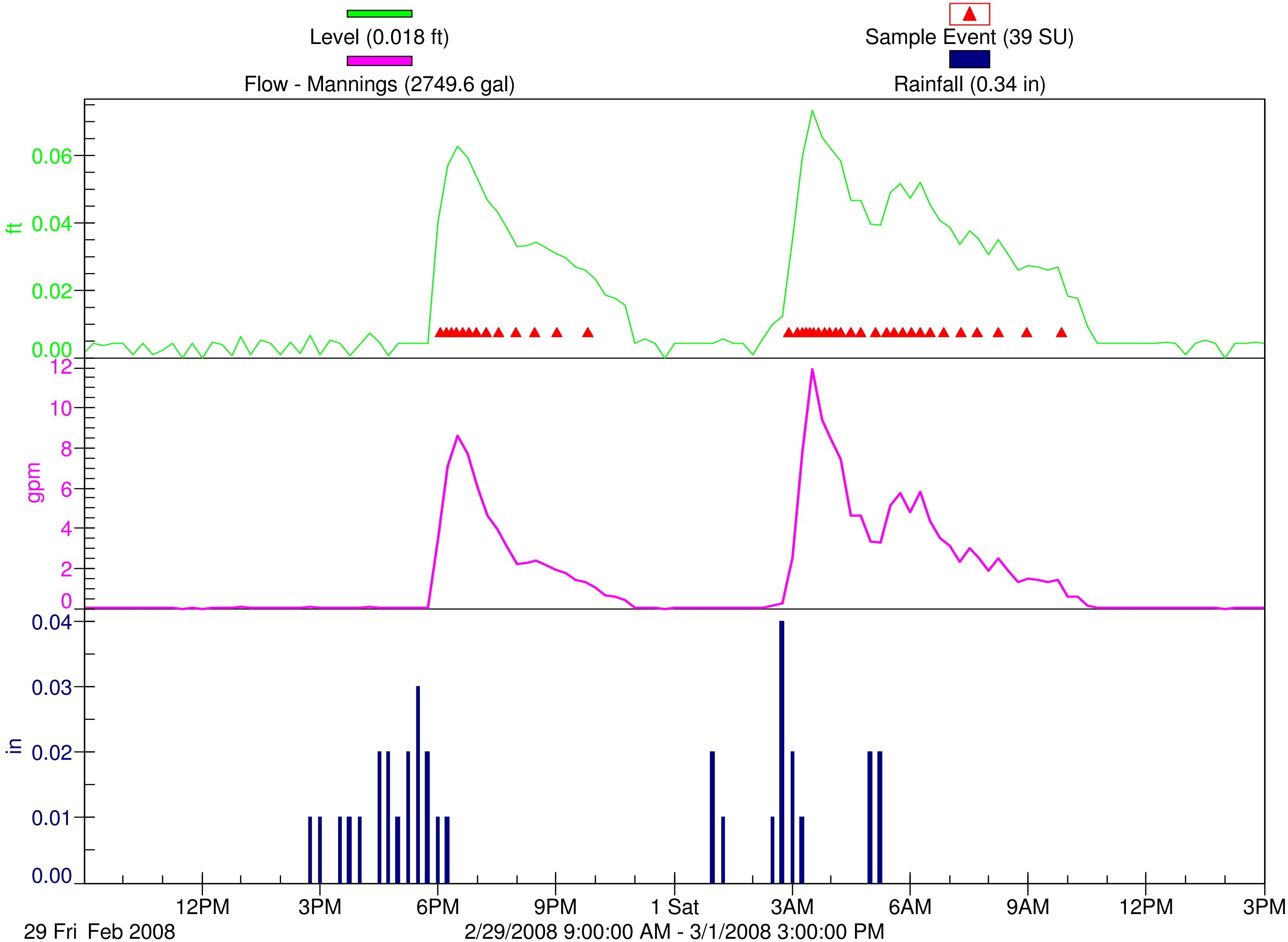
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

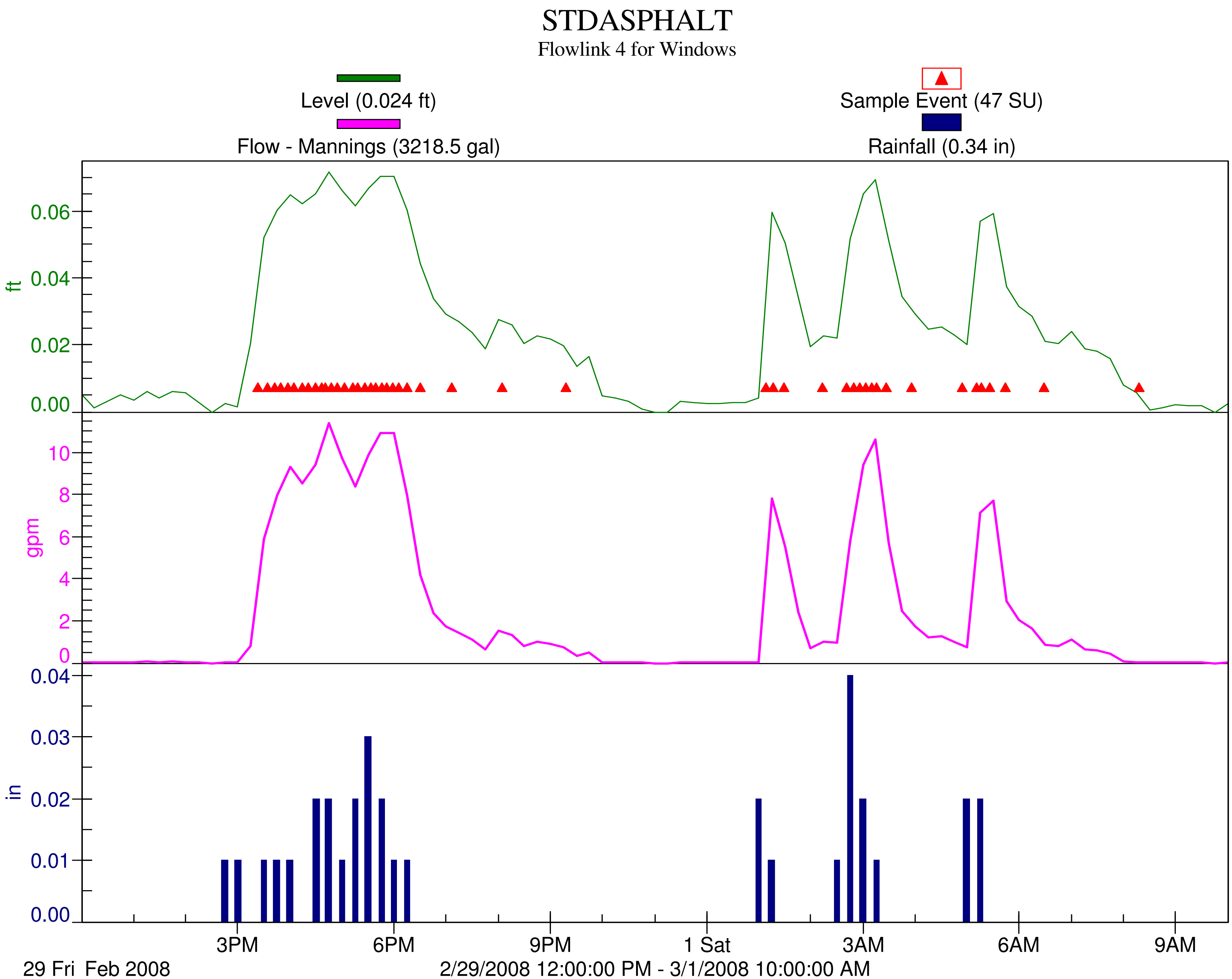


PERVASFALT
Flowlink 4 for Windows
Level (0.008 ft)
Flow - Mannings (2837.8 gal)
Sample Event (39 SU)
Rainfall (0.42 in)
ft
0.06
0.04
0.02
0.00
gpm
12
10
8
6
4
2
0
in
0.04
0.03
0.02
0.01
0.00
27 Wed
28 Thu
29 Fri
1 Sat
Feb 2008
2/26/2008 8:00:00 PM - 3/1/2008 6:00:00 PM

PERVASFALT

Flowlink 4 for Windows





STDASPHALT
Flowlink 4 for Windows
Level (0.024 ft)
Flow - Mannings (3218.5 gal)
Sample Event (47 SU)
Rainfall (0.34 in)
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.04
0.03
0.02
0.01
0.00
3PM
6PM
9PM
1 Sat
3AM
6AM
9AM
29 Fri Feb 2008
2/29/2008 12:00:00 PM - 3/1/2008 10:00:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #17
March 23, 2008

Introduction

This report summarizes the storm event sampled on 03/23/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #17.

Table 1. Storm Characteristics

Storm Date		03/23/08
Time Storm Began		03/23/08 4:30 AM
Total Precipitation (in)		0.42
Duration (hrs)		14.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		36
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #16. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, 4, and 5 provide the hydrographs and hyetographs for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious pavers, 4 sample aliquots were collected during the sampling period. These aliquots were collected over less than 23.2% of the total storm runoff volume. Flow was difficult to measure for this sampling event, since samples were only collected over 0.2 hr.

For pervious concrete, 48 sample aliquots were collected during the storm event with two of these aliquots collected prior to the start of the storm. The 46 aliquots that were collected during the storm event were collected over 64.9% of the total storm runoff volume. Since only 2 of the 48 aliquots were collected prior to the storm start, this is not expected to have a significant negative impact on the data quality.

For pervious asphalt, 48 sample aliquots were collected during the sampling period. These aliquots were collected over 69.7% of the total storm runoff volume. For standard asphalt, 48 sample aliquots were collected during the sampling period. These aliquots were collected over 61.5% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	3.25	3.67	20.99	11.69
Duration of Flow (hrs)	0.8	22	16.3	16.8
Total Volume (gallons) during Storm Event	69	1428	4871	5130
Total Volume (gallons) during Sampling Event	<16[a]	927[b]	3397	3153
Duration of Sampling Event (hrs)	0.2	8.8[b]	8.4	7.2
Number of Sample Aliquots Collected	4	46[b]	48	48
Percentage of Storm's Total Volume over which Samples were Collected	<23.2%[a]	64.9%[b]	69.7%	61.5%
Volume of Surface Runoff Collected in Vault (inches)	14 in	20.5 in	0 in	

Key: NS = Not Sampled

a = Approximate flow volume during sampling event. Sample event duration was too short to get an accurate measurement.

b = Two sample aliquots were collected prior to the storm event. These aliquots were not included in the above values.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious pavers
- Pervious concrete
- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)

- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

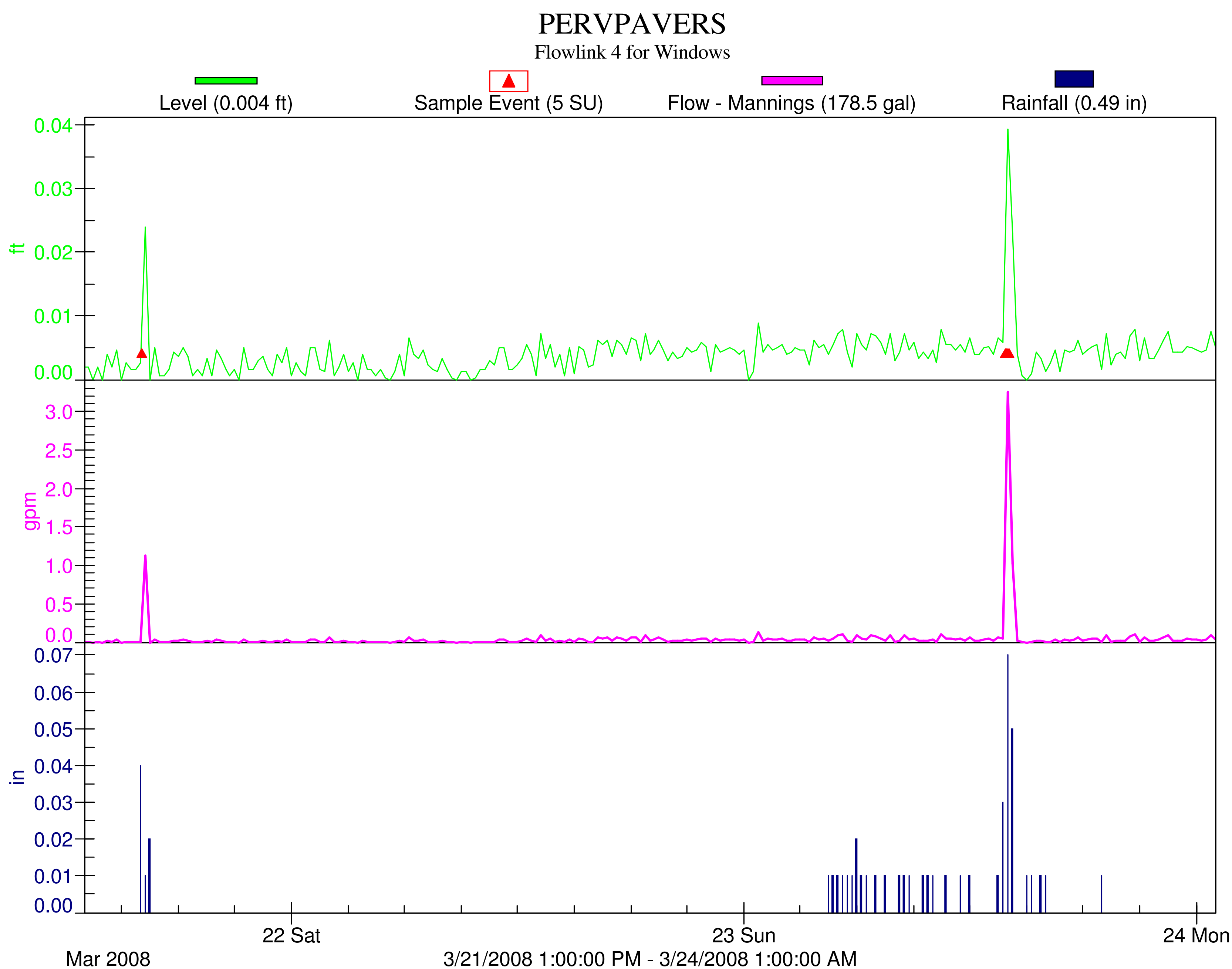
Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The lab noted the following observations during the sampling event:

- Pacings were set for a 0.2" to 0.3" storm. Actual event 0.42".
- Pervious pavers – found a thin piece of concrete in pipe blocking strainer/bubbler. Pump count errors occurred. Only took four samples but ended up with 1.5 L of sample.
- Standard asphalt – Pump count errors occurred. Cleaned pump tubing and recalibrated volume on 4/3/08.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.


PERVPAVERS
Flowlink 4 for Windows
Level (0.004 ft)
Sample Event (5 SU)
Flow - Mannings (178.5 gal)
Rainfall (0.49 in)
ft
0.04
0.03
0.02
0.01
0.00
gpm
3.0
2.5
2.0
1.5
1.0
0.5
0.0
in
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
22 Sat
23 Sun
24 Mon
Mar 2008
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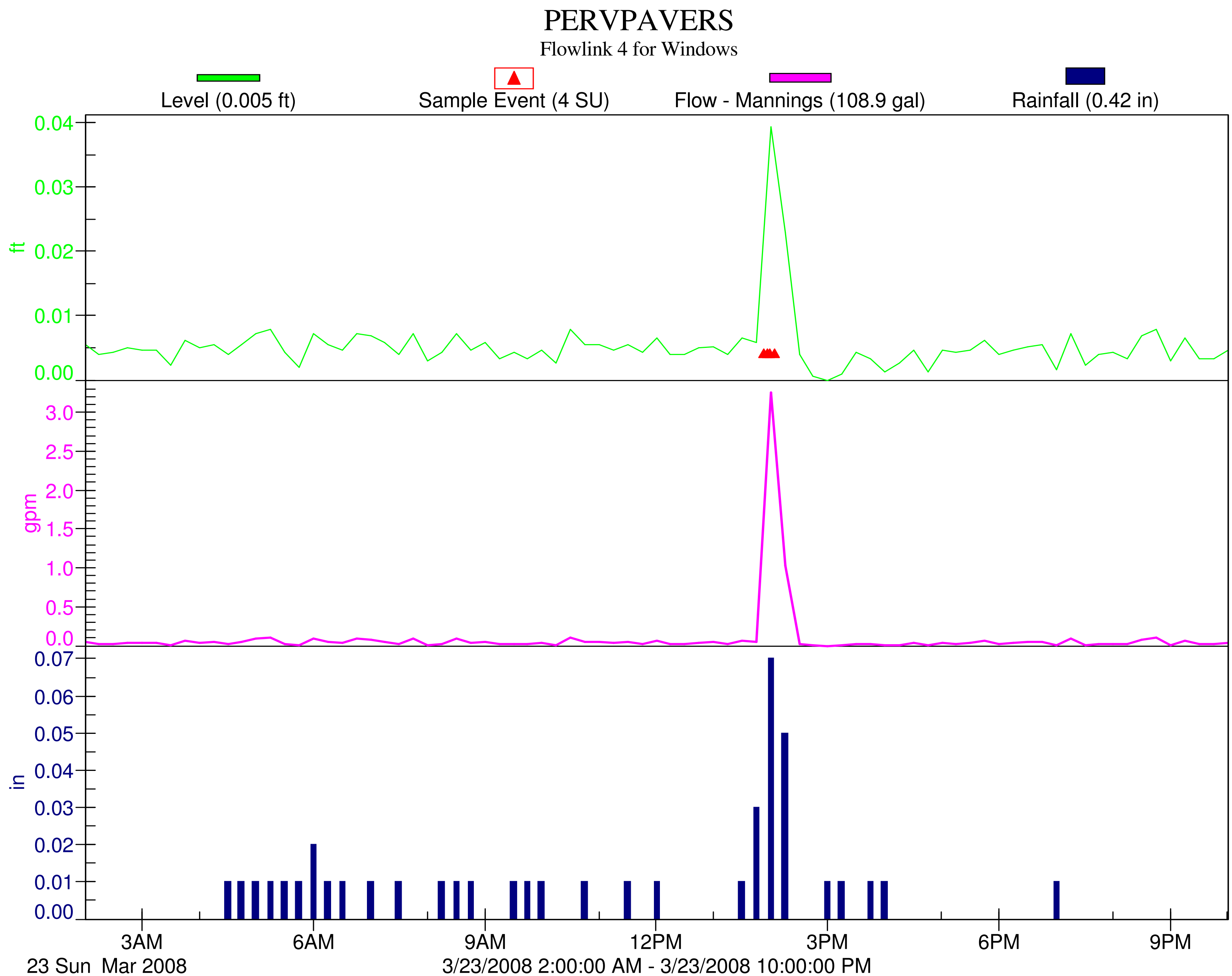
PERVPAVERS
Flowlink 4 for Windows
Level (0.005 ft)
Sample Event (4 SU)
Flow - Mannings (108.9 gal)
Rainfall (0.42 in)
ft
0.04
0.03
0.02
0.01
0.00
gpm
3.0
2.5
2.0
1.5
1.0
0.5
0.0
in
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
3AM
6AM
9AM
12PM
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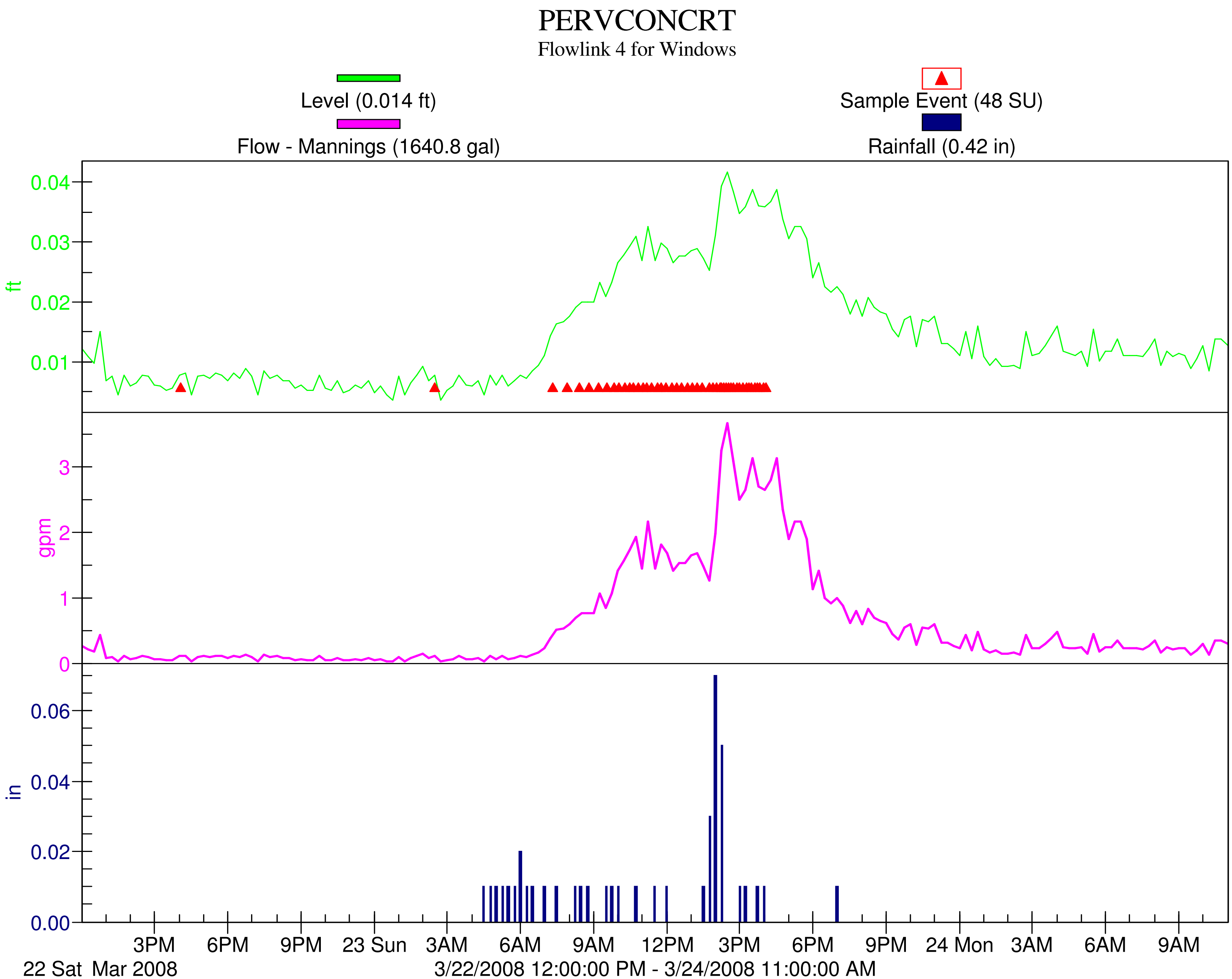
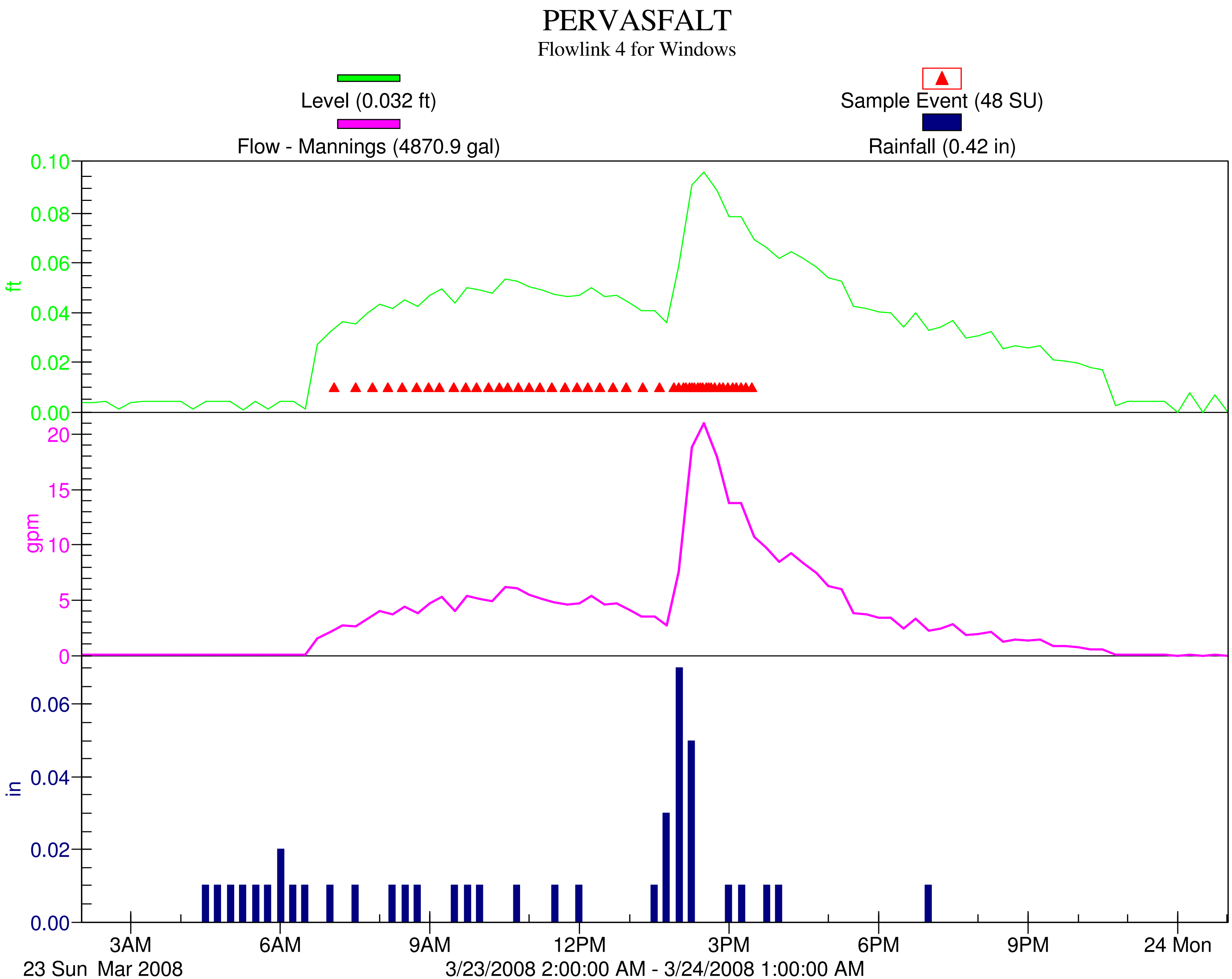
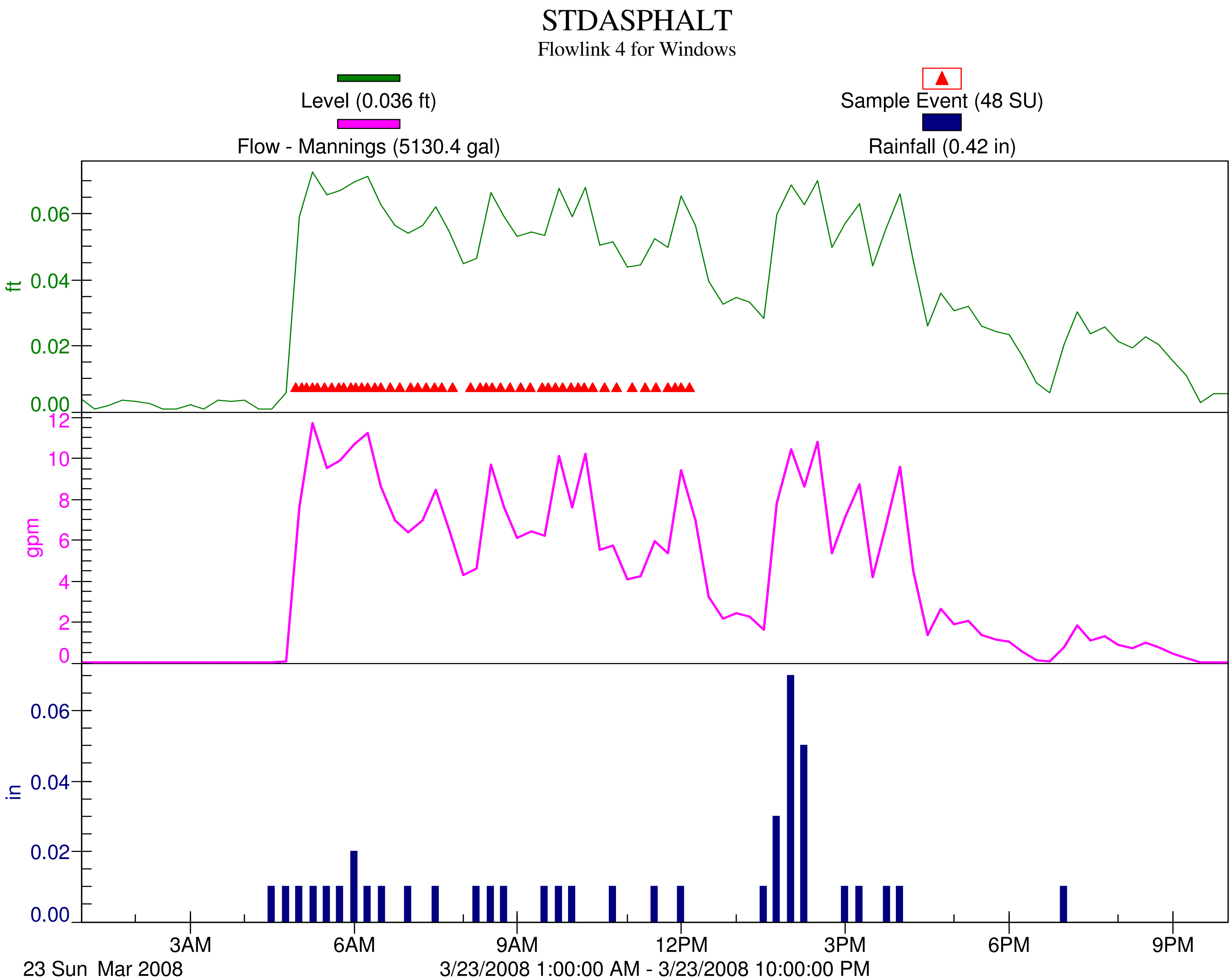


PERVCONCRT
Flowlink 4 for Windows
Level (0.014 ft)
Sample Event (48 SU)
Flow - Mannings (1640.8 gal)
Rainfall (0.42 in)
ft
0.04
0.03
0.02
0.01
gpm
3
2
1
0
in
0.06
0.04
0.02
0.00
3PM
6PM
9PM
23 Sun
3AM
6AM
9AM
12PM
3PM
6PM
9PM
24 Mon
3AM
6AM
9AM
22 Sat Mar 2008
3/22/2008 12:00:00 PM - 3/24/2008 11:00:00 AM


PERVASFALT
Flowlink 4 for Windows
Level (0.032 ft)
Flow - Mannings (4870.9 gal)
Sample Event (48 SU)
Rainfall (0.42 in)
ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
20
15
10
5
0
in
0.06
0.04
0.02
0.00
3AM
6AM
9AM
12PM
3PM
6PM
9PM
24 Mon
23 Sun Mar 2008
3/23/2008 2:00:00 AM - 3/24/2008 1:00:00 AM


STDASPHALT
Flowlink 4 for Windows
Level (0.036 ft)
Flow - Mannings (5130.4 gal)
Sample Event (48 SU)
Rainfall (0.42 in)
ft
0.06
0.04
0.02
0.00
gpm
12
10
8
6
4
2
0
in
0.06
0.04
0.02
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3AM
6AM
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12PM
3PM
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9PM
23 Sun Mar 2008
3/23/2008 1:00:00 AM - 3/23/2008 10:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #18
May 20, 2008

Introduction

This report summarizes the storm event sampled on 05/20/08 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #18.

Table 1. Storm Characteristics

Storm Date		05/20/08
Time Storm Began		05/19/08 1:00 PM
Total Precipitation (in)		0.41
Duration (hrs)		14.0
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		154.75
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #17. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, and 4 provide the hydrograph and hyetograph for the storm event for pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	2.86	11.58	12.47
Duration of Flow (hrs)	NS	14.0	8.8	14.3
Total Volume (gallons) during Storm Event	NS	551	2653	4068
Total Volume (gallons) during Sampling Event	NS	461	2568	3308
Duration of Sampling Event (hrs)	NS	6.0	7.3	8.8
Number of Sample Aliquots Collected	NS	25	37	48
Percentage of Storm's Total Volume over which Samples were Collected	NS	83.7%	96.8%	81.3%
Volume of Surface Runoff Collected in Vault (inches)	16 in	20 in	19 in	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious concrete
- Pervious asphalt
- Standard asphalt
- Pervious pavers catch basin
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

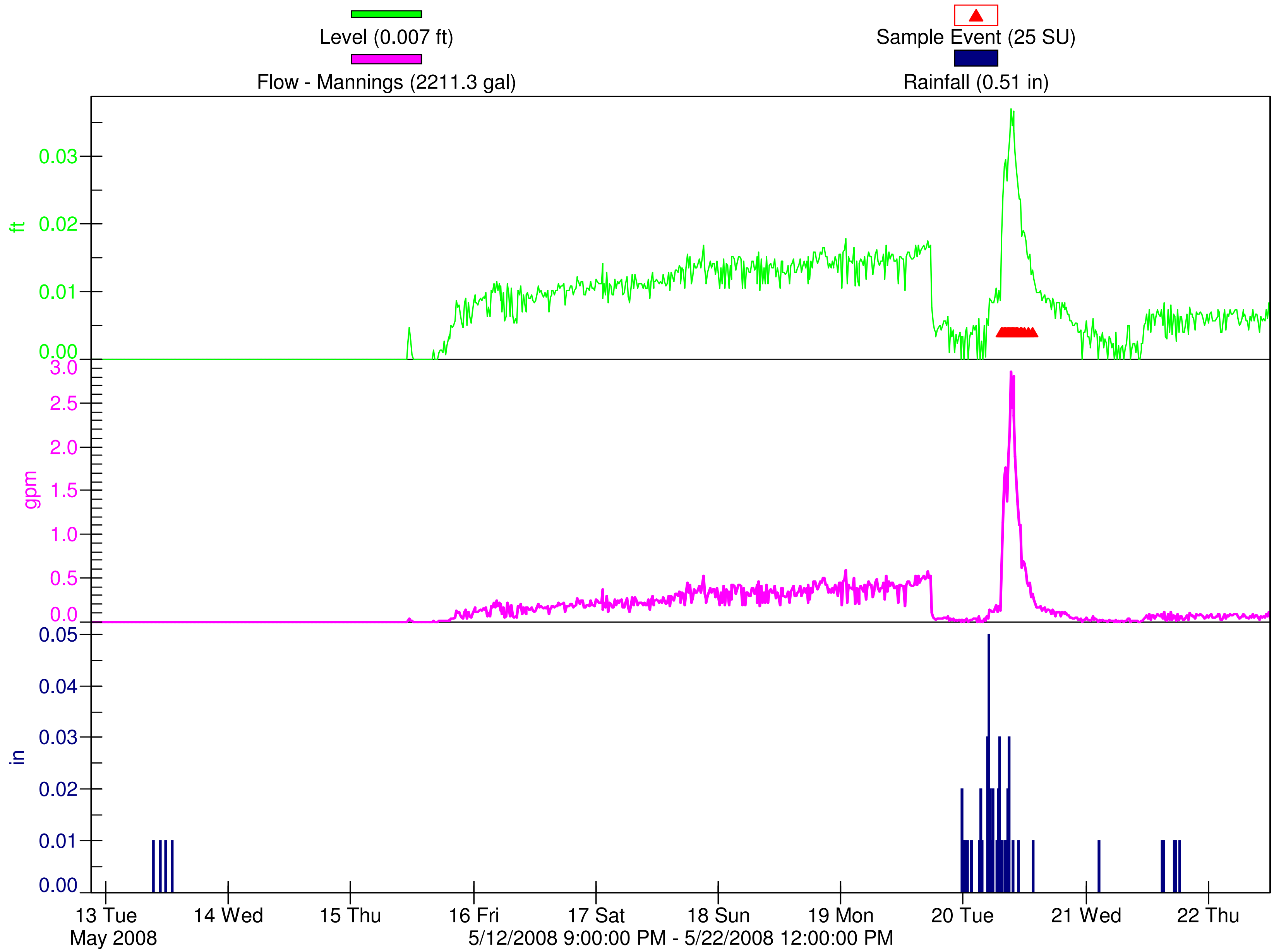
The lab noted the following observations during the sampling event:

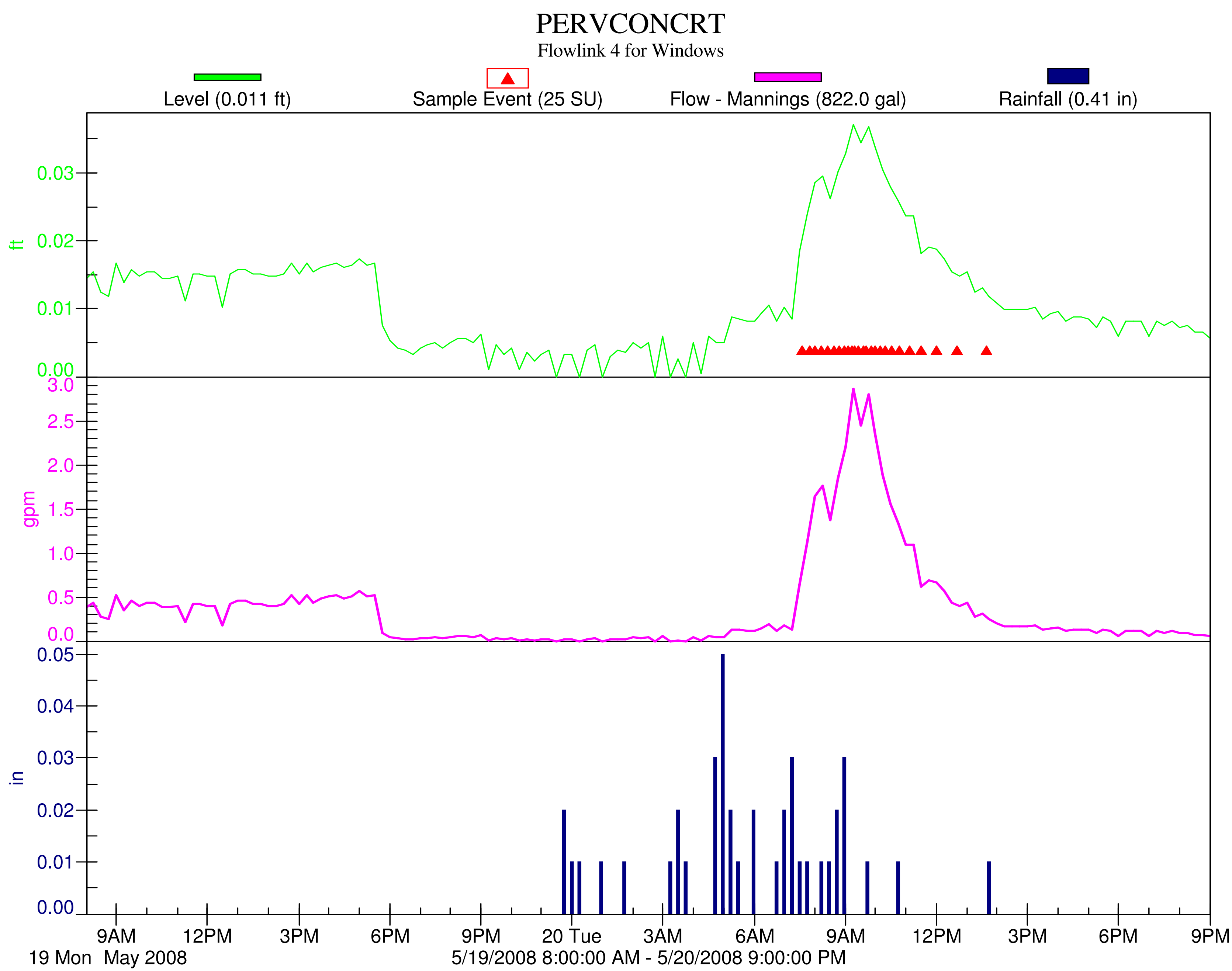
- Pacings were set for a 0.2-0.3" storm. Actual storm event was 0.41".
- Pervious pavers – No sample. Height/flow errors – need to replace bubbler module.
- Pervious concrete – Sample accepted. May need to lower enable slightly.

Additional field notes and the sampling setup report are provided in the Lab's data summary package.

PERVCONCRT

Flowlink 4 for Windows

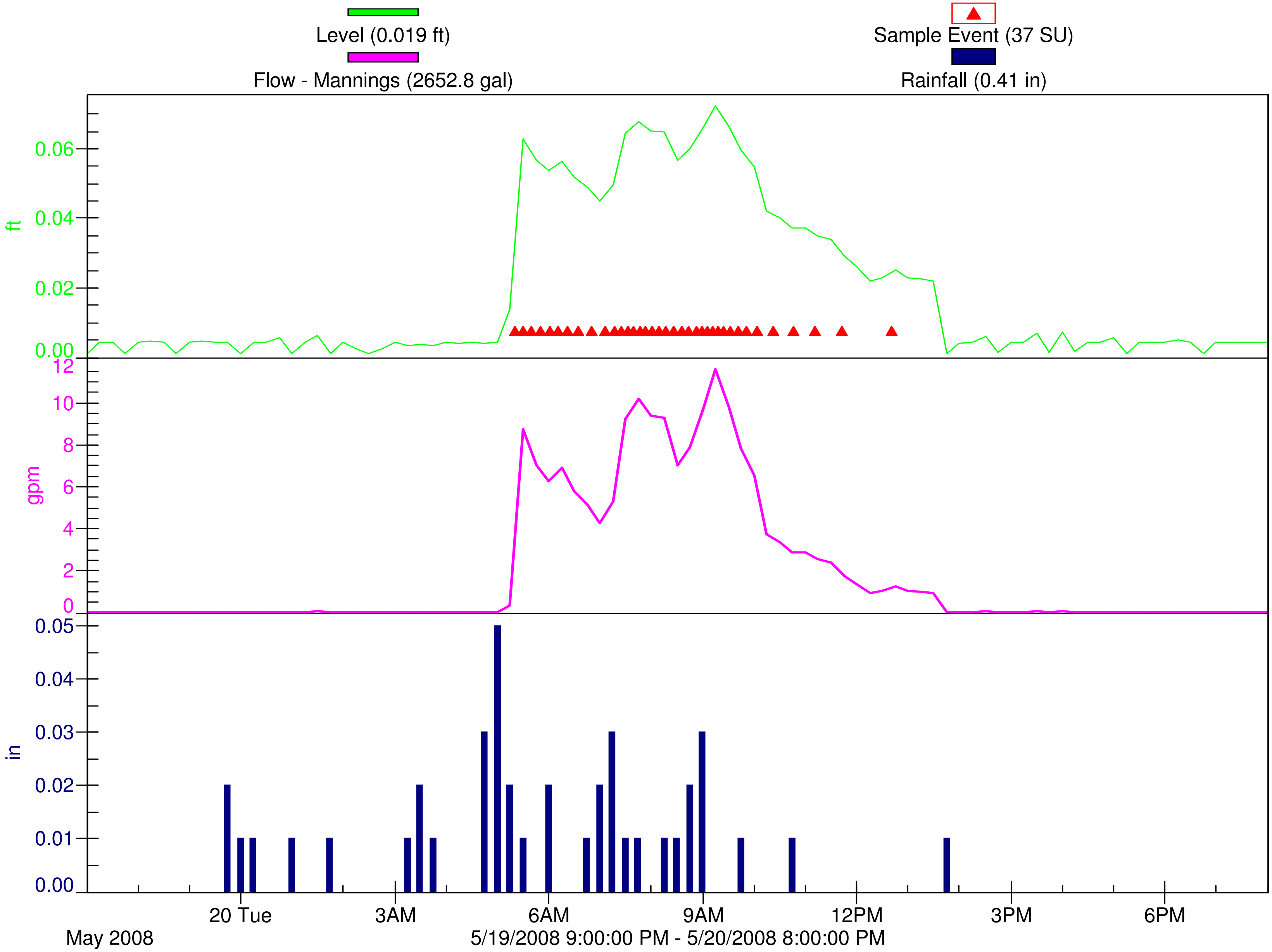


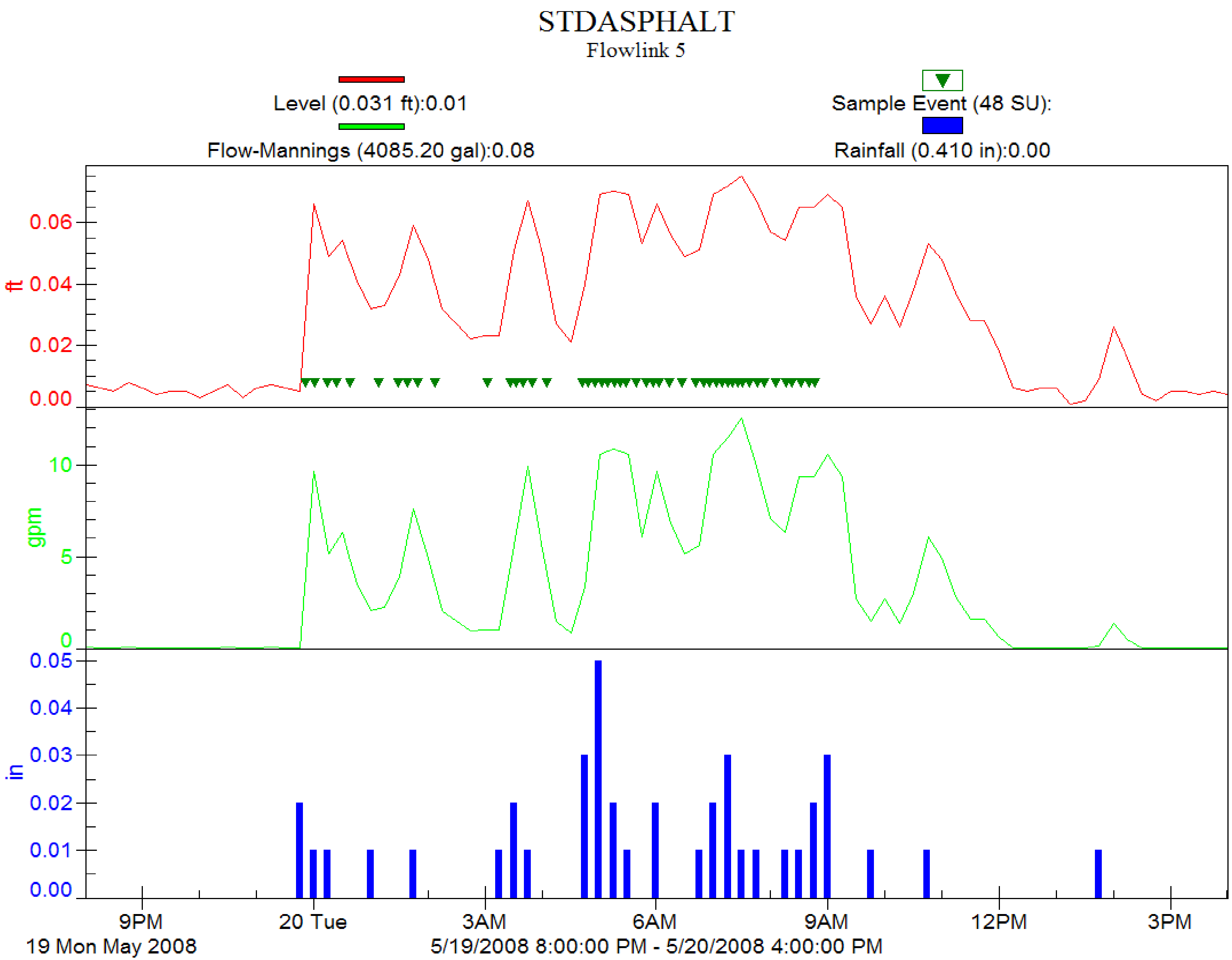


PERVCONCRT
Flowlink 4 for Windows
Level (0.011 ft)
Sample Event (25 SU)
Flow - Mannings (822.0 gal)
Rainfall (0.41 in)
ft
0.03
0.02
0.01
0.00
gpm
3.0
2.5
2.0
1.5
1.0
0.5
0.0
in
0.05
0.04
0.03
0.02
0.01
0.00
9AM
12PM
3PM
6PM
9PM
20 Tue
3AM
6AM
9AM
12PM
3PM
6PM
9PM
19 Mon May 2008
5/19/2008 8:00:00 AM - 5/20/2008 9:00:00 PM

PERVASFALT

Flowlink 4 for Windows





STDASPHALT
Flowlink 5
Level (0.031 ft):0.01
Flow-Mannings (4085.20 gal):0.08
Sample Event (48 SU):
Rainfall (0.410 in):0.00
ft
0.06
0.04
0.02
0.00
gpm
10
5
0
in
0.05
0.04
0.03
0.02
0.01
0.00
9PM
19 Mon May 2008
20 Tue
3AM
6AM
9AM
12PM
3PM
5/19/2008 8:00:00 PM - 5/20/2008 4:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #19
August 1, 2008

Introduction

This report summarizes the storm event sampled on 08/01/2008 by the City of Tacoma Public Works Environmental Services Laboratory (Lab) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #19.

Table 1. Storm Characteristics

Storm Date		08/01/08
Time Storm Began		07/31/08 6:30 PM
Total Precipitation (in)		0.22
Duration (hrs)		12.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Y
Antecedent Period (hrs)		45.5
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Y

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #18. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetograph for the storm event for pervious concrete and pervious asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. For pervious concrete, 47 sample aliquots were collected during the sampling period, but only 46 of these aliquots were collected during the storm event. The 46 aliquots were collected over 69.8% of the total storm runoff volume. This is not expected to have a significant impact on the data validity for this sampling event. The level in the pipe did not return to near zero after the storm event; the end of the runoff period is estimated.

For pervious asphalt, 17 sample aliquots were collected over the total storm runoff volume; these aliquots were collected over 84.9% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	13.39	13.16	NS
Duration of Flow (hrs)	NS	21.0	13.0	NS
Total Volume (gallons) during Storm Event	NS	2242	2216	NS
Total Volume (gallons) during Sampling Event	NS	1564[a]	1882	NS
Duration of Sampling Event (hrs)	NS	13.4[a]	11.1	NS
Number of Sample Aliquots Collected	NS	46[a]	17	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	69.8%[a]	84.9%	NS
Volume of Surface Runoff Collected in Vault (inches)	NM	19 in	21 in	

Key: NS = Not Sampled

NM = Not measured

a = One sample aliquot was collected before the storm event. This aliquot was not included in the above values.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious concrete
- Pervious asphalt
- Pervious concrete catch basin
- Pervious asphalt catch basin

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

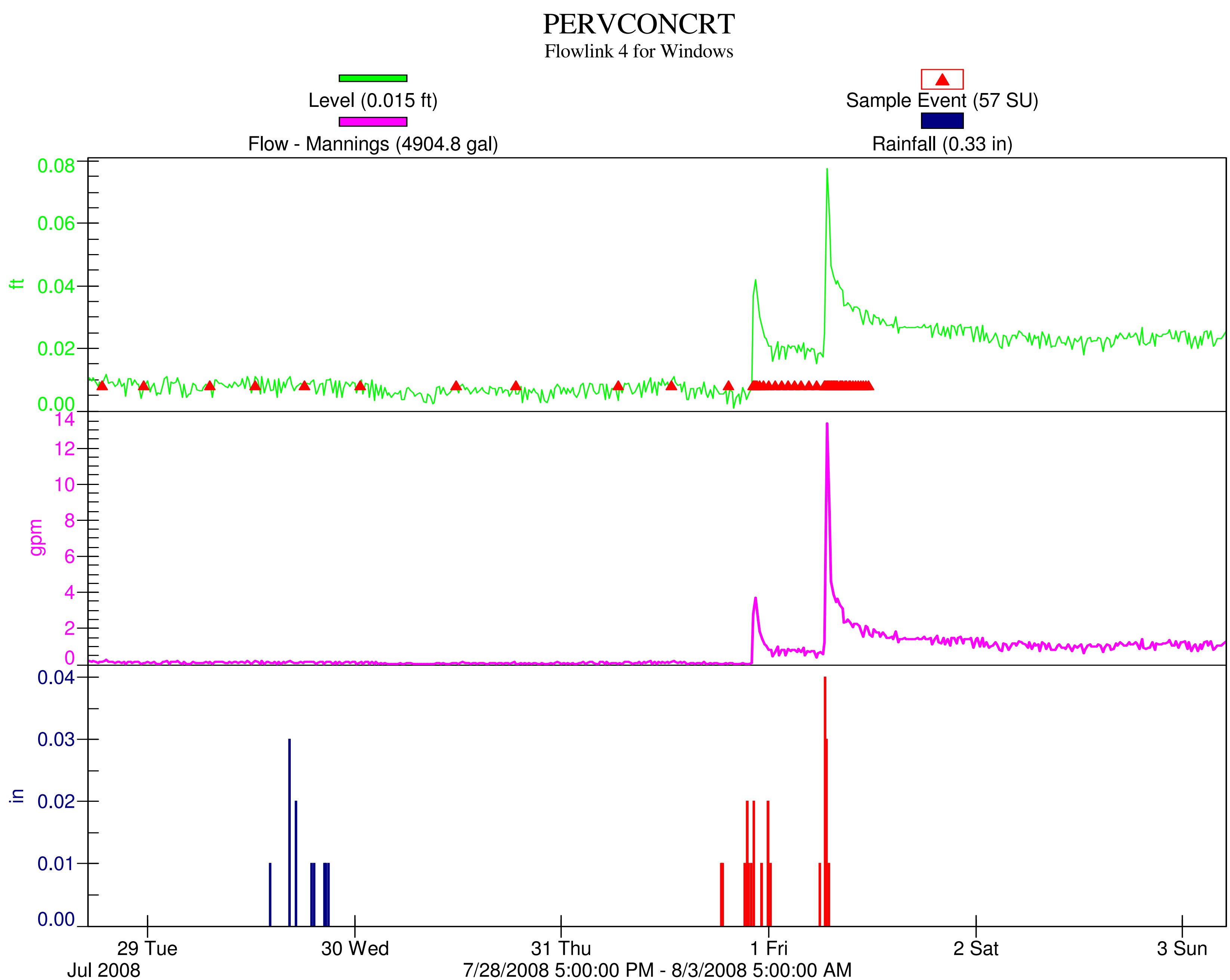
Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

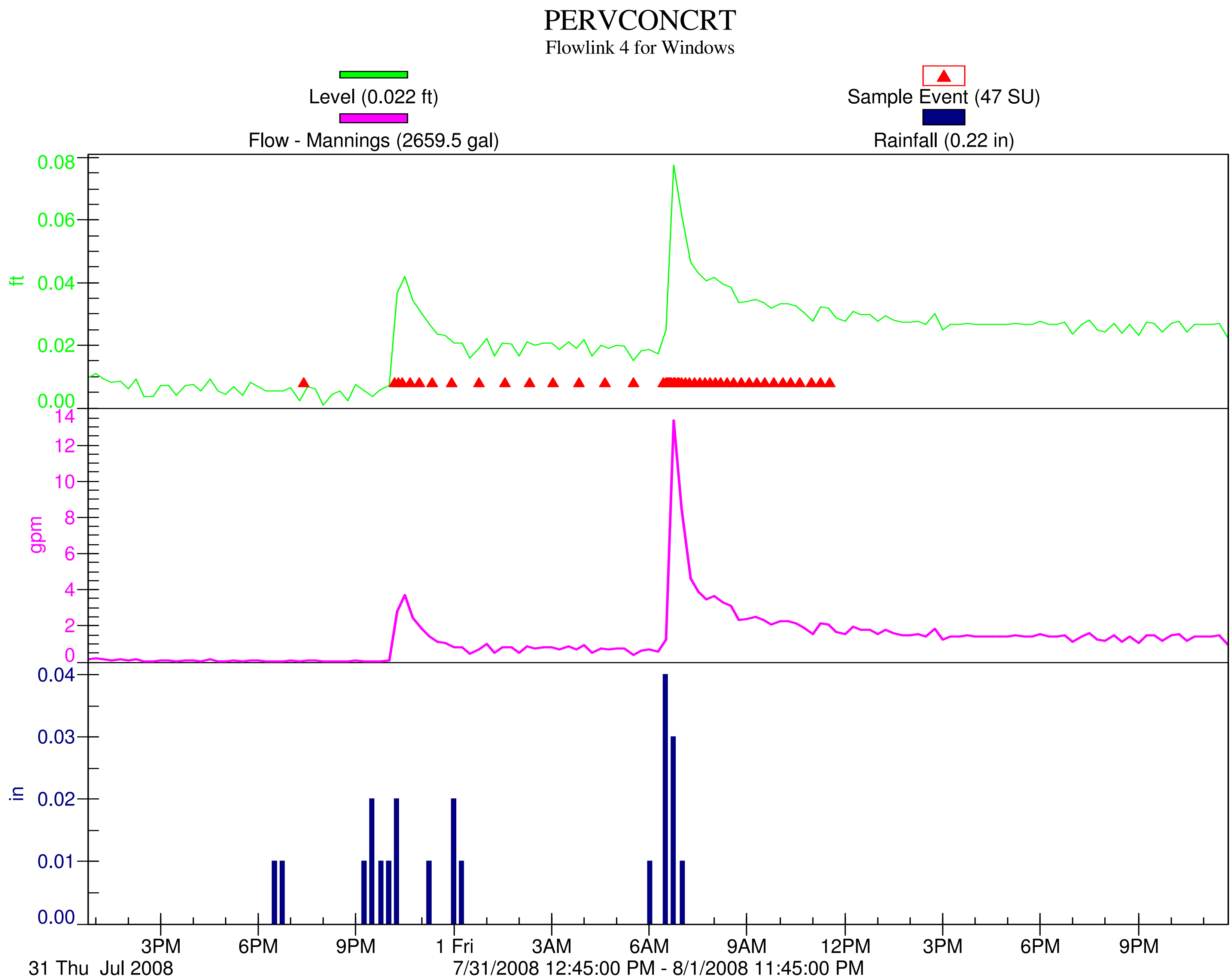
Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

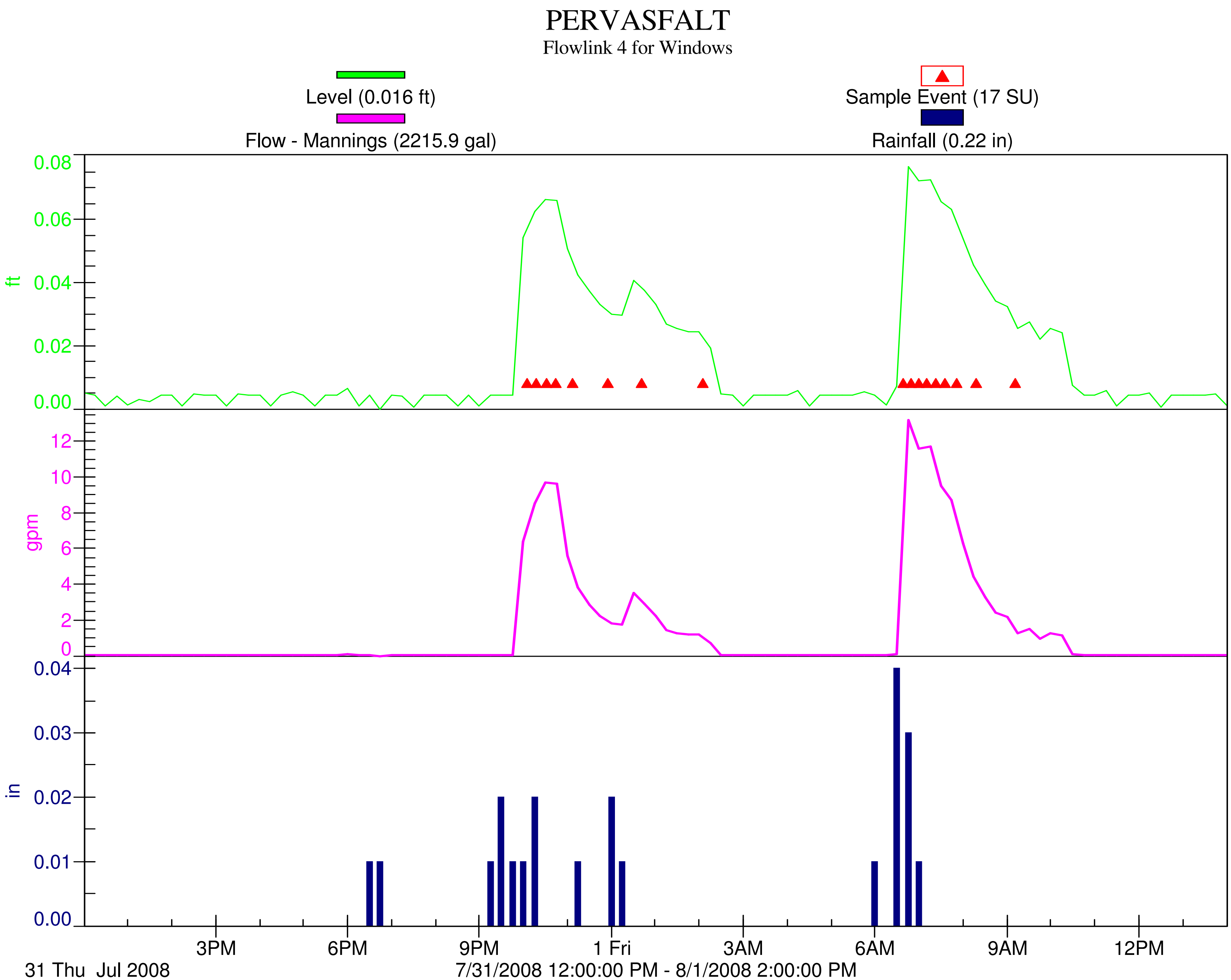
Sampling Observations

Additional field notes and the sampling setup report are provided in the Lab’s data summary package.



PERVCONCRT
Flowlink 4 for Windows
Level (0.015 ft)
Flow - Mannings (4904.8 gal)
Sample Event (57 SU)
Rainfall (0.33 in)
ft
0.08
0.06
0.04
0.02
0.00
gpm
14
12
10
8
6
4
2
0
in
0.04
0.03
0.02
0.01
0.00
29 Tue
30 Wed
31 Thu
1 Fri
2 Sat
3 Sun
Jul 2008
7/28/2008 5:00:00 PM - 8/3/2008 5:00:00 AM


PERVCONCRT
Flowlink 4 for Windows
Level (0.022 ft)
Flow - Mannings (2659.5 gal)
Sample Event (47 SU)
Rainfall (0.22 in)
ft
gpm
in
3PM
6PM
9PM
1 Fri
3AM
6AM
9AM
12PM
3PM
6PM
9PM
31 Thu Jul 2008
7/31/2008 12:45:00 PM - 8/1/2008 11:45:00 PM



PERVASFALT
Flowlink 4 for Windows
Level (0.016 ft)
Sample Event (17 SU)
Flow - Mannings (2215.9 gal)
Rainfall (0.22 in)
ft
0.08
0.06
0.04
0.02
0.00
gpm
12
10
8
6
4
2
0
in
0.04
0.03
0.02
0.01
0.00
3PM
6PM
9PM
1 Fri
3AM
6AM
9AM
12PM
31 Thu Jul 2008
7/31/2008 12:00:00 PM - 8/1/2008 2:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #20
Date: August 20, 2008

Introduction

This report summarizes the storm event sampled on August 20, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #20.

Table 1. Storm Characteristics

Storm Date		8/19/08-8/20/08
Time Storm Began		1945
Total Precipitation (in)		0.76
Duration (hrs)		22
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		240
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #20. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2-5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	36.5	12.9	27.4	13.6
Duration of Flow (hrs)	*	23.5	23.5	23.75
Total Volume (gallons) during Storm Event	*	3064**	6300**	5145**
Total Volume (gallons) during Sampling Event	1559	2131	5636	4741
Duration of Sampling Event (hrs)	9.4	17	19.7	21.3
Number of Sample Aliquots Collected	47	48	42	35
Percentage of Storm's Total Volume over which Samples were Collected	*	69.5%**	89.5%**	92.1%**
Volume of Surface Runoff Collected in Vault (inches)	22+	22.5+	21+	

Key: NS = Not Sampled

* Flow data no good. Bubbler appears clogged.

** Used partial storm event. Very large storm and samples collected over good portion of initial storm.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers
- Pervious Concrete
- Pervious Asphalt
- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	8/20/2008	Hardness, Calculated	18.5	mg/L		
Pervious Asphalt	8/20/2008	pH	7.1	Std. Units		
Pervious Asphalt	8/20/2008	TSS	12.9	mg/L		
Pervious Asphalt	8/20/2008	NWTPH-Diesel	0.14	mg/L	B	
Pervious Asphalt	8/20/2008	NWTPH-Heavy Oil	0.3	mg/L	B	
Pervious Asphalt	8/20/2008	Copper	5.3	ug/L	U	
Pervious Asphalt	8/20/2008	Lead	3.3	ug/L	U	
Pervious Asphalt	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt	8/20/2008	Zinc	5.0	ug/L	J	
Pervious Asphalt	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Asphalt	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	Naphthalene	0.004	ug/L	U	
Pervious Asphalt	8/20/2008	Phenanthrene	0.045	ug/L		
Pervious Asphalt	8/20/2008	Benzo(a)anthracene	0.004	ug/L	U	
Pervious Asphalt	8/20/2008	Benzo(a)pyrene	0.038	ug/L		
Pervious Asphalt	8/20/2008	Benzo(g,h,i)perylene	0.005	ug/L	U	
Pervious Asphalt	8/20/2008	Benzo(b,k)fluoranthenes	0.007	ug/L	U	
Pervious Asphalt	8/20/2008	Chrysene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Asphalt	8/20/2008	Fluoranthene	0.064	ug/L		
Pervious Asphalt	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.005	ug/L	U	
Pervious Asphalt	8/20/2008	Pyrene	0.003	ug/L	U	
Pervious Asphalt	8/20/2008	bis(2-Ethylhexyl)phthalate	0.8	ug/L	U	
Pervious Asphalt	8/20/2008	Butyl benzyl phthalate	0.1	ug/L	J	
Pervious Asphalt	8/20/2008	Diethylphthalate	2.2	ug/L		
Pervious Asphalt	8/20/2008	Dimethyl phthalate	0.1	ug/L	J	
Pervious Asphalt	8/20/2008	Di-n-butylphthalate	0.1	ug/L	J	
Pervious Asphalt	8/20/2008	Di-n-Octyl phthalate	0.41	ug/L	U	
Pervious Asphalt CB	8/20/2008	Hardness, Calculated	12.9	mg/L		
Pervious Asphalt CB	8/20/2008	pH	6.6	Std. Units		
Pervious Asphalt CB	8/20/2008	TSS	5.5	mg/L		
Pervious Asphalt CB	8/20/2008	NWTPH-Diesel	0.28	mg/L		
Pervious Asphalt CB	8/20/2008	NWTPH-Heavy Oil	0.9	mg/L		
Pervious Asphalt CB	8/20/2008	Copper	8.3	ug/L	J	
Pervious Asphalt CB	8/20/2008	Lead	3.3	ug/L	U	
Pervious Asphalt CB	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	8/20/2008	Zinc	42.3	ug/L		
Pervious Asphalt CB	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Asphalt CB	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	8/20/2008	Acenaphthylene	0.056	ug/L		
Pervious Asphalt CB	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Asphalt CB	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	8/20/2008	Naphthalene	0.004	ug/L	U	
Pervious Asphalt CB	8/20/2008	Phenanthrene	0.061	ug/L		
Pervious Asphalt CB	8/20/2008	Benzo(a)anthracene	0.012	ug/L		
Pervious Asphalt CB	8/20/2008	Benzo(a)pyrene	0.041	ug/L		
Pervious Asphalt CB	8/20/2008	Benzo(g,h,i)perylene	0.005	ug/L	U	
Pervious Asphalt CB	8/20/2008	Benzo(b,k)fluoranthenes	0.018	ug/L	J	
Pervious Asphalt CB	8/20/2008	Chrysene	0.003	ug/L	U	
Pervious Asphalt CB	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Asphalt CB	8/20/2008	Fluoranthene	0.084	ug/L		
Pervious Asphalt CB	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.005	ug/L	U	
Pervious Asphalt CB	8/20/2008	Pyrene	0.025	ug/L		
Pervious Asphalt CB	8/20/2008	bis(2-Ethylhexyl)phthalate	1.1	ug/L	J	
Pervious Asphalt CB	8/20/2008	Butyl benzyl phthalate	0.3	ug/L	J	

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UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	8/20/2008	Diethylphthalate	0.2	ug/L	J	
Pervious Asphalt CB	8/20/2008	Dimethyl phthalate	0.0	ug/L	U	
Pervious Asphalt CB	8/20/2008	Di-n-butylphthalate	0.2	ug/L	J	
Pervious Asphalt CB	8/20/2008	Di-n-Octyl phthalate	0.54	ug/L	U	
Pervious Concrete	8/20/2008	Hardness, Calculated	311	mg/L		
Pervious Concrete	8/20/2008	pH	12.0	Std. Units		
Pervious Concrete	8/20/2008	TSS	75.7	mg/L		
Pervious Concrete	8/20/2008	NWTPH-Diesel	0.22	mg/L		
Pervious Concrete	8/20/2008	NWTPH-Heavy Oil	0.2	mg/L	B	
Pervious Concrete	8/20/2008	Copper	8.9	ug/L	J	
Pervious Concrete	8/20/2008	Lead	3.3	ug/L	U	
Pervious Concrete	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Concrete	8/20/2008	Zinc	5.1	ug/L	J	
Pervious Concrete	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Concrete	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	8/20/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Concrete	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete	8/20/2008	Naphthalene	0.004	ug/L	U	
Pervious Concrete	8/20/2008	Phenanthrene	0.057	ug/L		
Pervious Concrete	8/20/2008	Benzo(a)anthracene	0.004	ug/L	U	
Pervious Concrete	8/20/2008	Benzo(a)pyrene	0.039	ug/L		
Pervious Concrete	8/20/2008	Benzo(g,h,i)perylene	0.005	ug/L	U	
Pervious Concrete	8/20/2008	Benzo(b,k)fluoranthenes	0.007	ug/L	U	
Pervious Concrete	8/20/2008	Chrysene	0.003	ug/L	U	
Pervious Concrete	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Concrete	8/20/2008	Fluoranthene	0.069	ug/L		
Pervious Concrete	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.005	ug/L	U	
Pervious Concrete	8/20/2008	Pyrene	0.015	ug/L		
Pervious Concrete	8/20/2008	bis(2-Ethylhexyl)phthalate	0.8	ug/L	U	
Pervious Concrete	8/20/2008	Butyl benzyl phthalate	0.1	ug/L	J	
Pervious Concrete	8/20/2008	Diethylphthalate	0.1	ug/L	U	
Pervious Concrete	8/20/2008	Dimethyl phthalate	0.0	ug/L	U	
Pervious Concrete	8/20/2008	Di-n-butylphthalate	0.1	ug/L	U	
Pervious Concrete	8/20/2008	Di-n-Octyl phthalate	0.43	ug/L	U	
Pervious Concrete CB	8/20/2008	Hardness, Calculated	30.5	mg/L		
Pervious Concrete CB	8/20/2008	pH	7.3	Std. Units		
Pervious Concrete CB	8/20/2008	TSS	11.1	mg/L		
Pervious Concrete CB	8/20/2008	NWTPH-Diesel	0.13	mg/L	B	
Pervious Concrete CB	8/20/2008	NWTPH-Heavy Oil	0.6	mg/L		
Pervious Concrete CB	8/20/2008	Copper	6.6	ug/L	J	
Pervious Concrete CB	8/20/2008	Lead	3.3	ug/L	U	
Pervious Concrete CB	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Concrete CB	8/20/2008	Zinc	28.1	ug/L		
Pervious Concrete CB	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Concrete CB	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	8/20/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete CB	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Concrete CB	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete CB	8/20/2008	Naphthalene	0.004	ug/L	U	
Pervious Concrete CB	8/20/2008	Phenanthrene	0.078	ug/L		
Pervious Concrete CB	8/20/2008	Benzo(a)anthracene	0.011	ug/L		
Pervious Concrete CB	8/20/2008	Benzo(a)pyrene	0.048	ug/L		
Pervious Concrete CB	8/20/2008	Benzo(g,h,i)perylene	0.019	ug/L		
Pervious Concrete CB	8/20/2008	Benzo(b,k)fluoranthenes	0.040	ug/L		
Pervious Concrete CB	8/20/2008	Chrysene	0.024	ug/L		
Pervious Concrete CB	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Concrete CB	8/20/2008	Fluoranthene	0.114	ug/L		

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.015	ug/L		
Pervious Concrete CB	8/20/2008	Pyrene	0.045	ug/L		
Pervious Concrete CB	8/20/2008	bis(2-Ethylhexyl)phthalate	2.3	ug/L	J	
Pervious Concrete CB	8/20/2008	Butyl benzyl phthalate	0.5	ug/L	B	
Pervious Concrete CB	8/20/2008	Diethylphthalate	0.2	ug/L	J	
Pervious Concrete CB	8/20/2008	Dimethyl phthalate	0.0	ug/L	U	
Pervious Concrete CB	8/20/2008	Di-n-butylphthalate	0.2	ug/L	J	
Pervious Concrete CB	8/20/2008	Di-n-Octyl phthalate	1.00	ug/L	U	
Pervious Pavers	8/20/2008	Hardness, Calculated	37.2	mg/L		
Pervious Pavers	8/20/2008	pH	7.0	Std. Units		
Pervious Pavers	8/20/2008	TSS	15.0	mg/L		
Pervious Pavers	8/20/2008	NWTPH-Diesel	0.1	mg/L	B	
Pervious Pavers	8/20/2008	NWTPH-Heavy Oil	0.1	mg/L	B	
Pervious Pavers	8/20/2008	Copper	9.1	ug/L	J	
Pervious Pavers	8/20/2008	Lead	3.3	ug/L	U	
Pervious Pavers	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Pavers	8/20/2008	Zinc	12.9	ug/L		
Pervious Pavers	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Pavers	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	8/20/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Pavers	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Pavers	8/20/2008	Naphthalene	0.004	ug/L	U	
Pervious Pavers	8/20/2008	Phenanthrene	0.049	ug/L		
Pervious Pavers	8/20/2008	Benzo(a)anthracene	0.004	ug/L	U	
Pervious Pavers	8/20/2008	Benzo(a)pyrene	0.040	ug/L		
Pervious Pavers	8/20/2008	Benzo(g,h,i)perylene	0.005	ug/L	U	
Pervious Pavers	8/20/2008	Benzo(b,k)fluoranthenes	0.007	ug/L	U	
Pervious Pavers	8/20/2008	Chrysene	0.003	ug/L	U	
Pervious Pavers	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Pavers	8/20/2008	Fluoranthene	0.072	ug/L		
Pervious Pavers	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.005	ug/L	U	
Pervious Pavers	8/20/2008	Pyrene	0.012	ug/L		
Pervious Pavers	8/20/2008	bis(2-Ethylhexyl)phthalate	0.8	ug/L	U	
Pervious Pavers	8/20/2008	Butyl benzyl phthalate	0.2	ug/L	J	
Pervious Pavers	8/20/2008	Diethylphthalate	0.3	ug/L	J	
Pervious Pavers	8/20/2008	Dimethyl phthalate	0.0	ug/L	U	
Pervious Pavers	8/20/2008	Di-n-butylphthalate	0.1	ug/L	J	
Pervious Pavers	8/20/2008	Di-n-Octyl phthalate	0.45	ug/L	U	
Pervious Pavers CB	8/20/2008	Hardness, Calculated	17.7	mg/L		
Pervious Pavers CB	8/20/2008	pH	7.3	Std. Units		
Pervious Pavers CB	8/20/2008	TSS	25.9	mg/L		
Pervious Pavers CB	8/20/2008	NWTPH-Diesel	0.16	mg/L	B	
Pervious Pavers CB	8/20/2008	NWTPH-Heavy Oil	1.0	mg/L		
Pervious Pavers CB	8/20/2008	Copper	10.1	ug/L	J	
Pervious Pavers CB	8/20/2008	Lead	7.4	ug/L	J	
Pervious Pavers CB	8/20/2008	Mercury	0.050	ug/L	U	
Pervious Pavers CB	8/20/2008	Zinc	83.5	ug/L		
Pervious Pavers CB	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Pervious Pavers CB	8/20/2008	Acenaphthene	0.003	ug/L	U	
Pervious Pavers CB	8/20/2008	Acenaphthylene	0.056	ug/L		
Pervious Pavers CB	8/20/2008	Anthracene	0.003	ug/L	U	
Pervious Pavers CB	8/20/2008	Fluorene	0.003	ug/L	U	
Pervious Pavers CB	8/20/2008	Naphthalene	0.012	ug/L		
Pervious Pavers CB	8/20/2008	Phenanthrene	0.100	ug/L		
Pervious Pavers CB	8/20/2008	Benzo(a)anthracene	0.035	ug/L		
Pervious Pavers CB	8/20/2008	Benzo(a)pyrene	0.072	ug/L		
Pervious Pavers CB	8/20/2008	Benzo(g,h,i)perylene	0.056	ug/L		

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers CB	8/20/2008	Benzo(b,k)fluoranthenes	0.107	ug/L		
Pervious Pavers CB	8/20/2008	Chrysene	0.070	ug/L		
Pervious Pavers CB	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Pervious Pavers CB	8/20/2008	Fluoranthene	0.166	ug/L		
Pervious Pavers CB	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.041	ug/L		
Pervious Pavers CB	8/20/2008	Pyrene	0.093	ug/L		
Pervious Pavers CB	8/20/2008	bis(2-Ethylhexyl)phthalate	7.7	ug/L		
Pervious Pavers CB	8/20/2008	Butyl benzyl phthalate	0.4	ug/L	J	
Pervious Pavers CB	8/20/2008	Diethylphthalate	0.2	ug/L	J	
Pervious Pavers CB	8/20/2008	Dimethyl phthalate	0.1	ug/L	J	
Pervious Pavers CB	8/20/2008	Di-n-butylphthalate	0.1	ug/L	U	
Pervious Pavers CB	8/20/2008	Di-n-Octyl phthalate	2.07	ug/L	U	
Standard Asphalt	8/20/2008	Hardness, Calculated	5.39	mg/L		
Standard Asphalt	8/20/2008	pH	6.4	Std. Units		
Standard Asphalt	8/20/2008	TSS	18.0	mg/L		
Standard Asphalt	8/20/2008	NWTPH-Diesel	0.28	mg/L		
Standard Asphalt	8/20/2008	NWTPH-Heavy Oil	0.8	mg/L		
Standard Asphalt	8/20/2008	Copper	8.0	ug/L	J	
Standard Asphalt	8/20/2008	Lead	3.3	ug/L	U	
Standard Asphalt	8/20/2008	Mercury	0.050	ug/L	U	
Standard Asphalt	8/20/2008	Zinc	44.2	ug/L		
Standard Asphalt	8/20/2008	2-Methylnaphthalene	0.004	ug/L	U	
Standard Asphalt	8/20/2008	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	8/20/2008	Acenaphthylene	0.056	ug/L		
Standard Asphalt	8/20/2008	Anthracene	0.003	ug/L	U	
Standard Asphalt	8/20/2008	Fluorene	0.003	ug/L	U	
Standard Asphalt	8/20/2008	Naphthalene	0.004	ug/L	U	
Standard Asphalt	8/20/2008	Phenanthrene	0.098	ug/L		
Standard Asphalt	8/20/2008	Benzo(a)anthracene	0.015	ug/L		
Standard Asphalt	8/20/2008	Benzo(a)pyrene	0.049	ug/L		
Standard Asphalt	8/20/2008	Benzo(g,h,i)perylene	0.027	ug/L		
Standard Asphalt	8/20/2008	Benzo(b,k)fluoranthenes	0.062	ug/L		
Standard Asphalt	8/20/2008	Chrysene	0.050	ug/L		
Standard Asphalt	8/20/2008	Dibenz(a,h)anthracene	0.006	ug/L	U	
Standard Asphalt	8/20/2008	Fluoranthene	0.130	ug/L		
Standard Asphalt	8/20/2008	Indeno(1,2,3-c,d)pyrene	0.020	ug/L		
Standard Asphalt	8/20/2008	Pyrene	0.062	ug/L		
Standard Asphalt	8/20/2008	bis(2-Ethylhexyl)phthalate	1.9	ug/L	J	
Standard Asphalt	8/20/2008	Butyl benzyl phthalate	0.5	ug/L	B	
Standard Asphalt	8/20/2008	Diethylphthalate	1.1	ug/L		
Standard Asphalt	8/20/2008	Dimethyl phthalate	0.2	ug/L	B	
Standard Asphalt	8/20/2008	Di-n-butylphthalate	0.4	ug/L	J	
Standard Asphalt	8/20/2008	Di-n-Octyl phthalate	0.75	ug/L	U	

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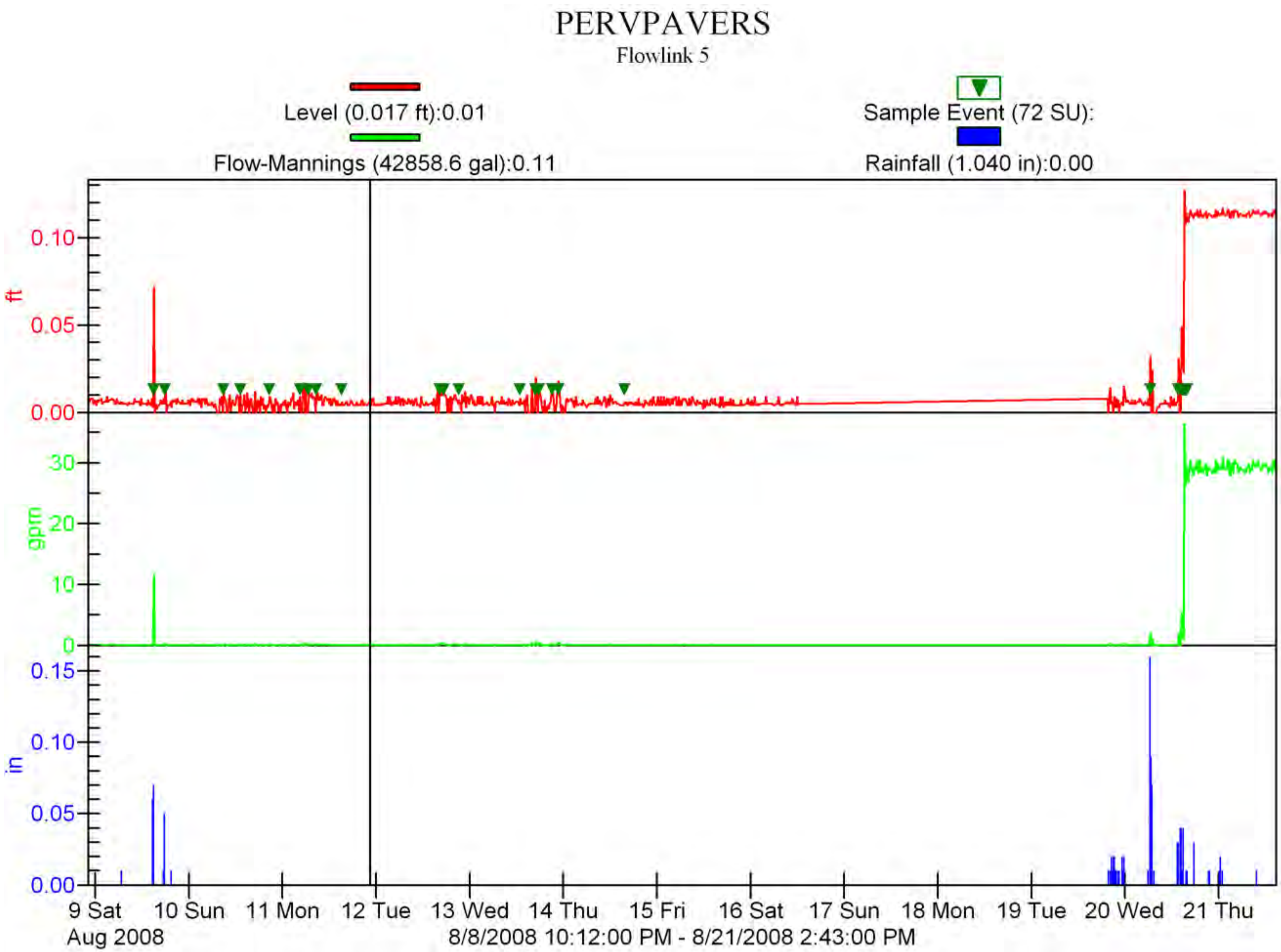
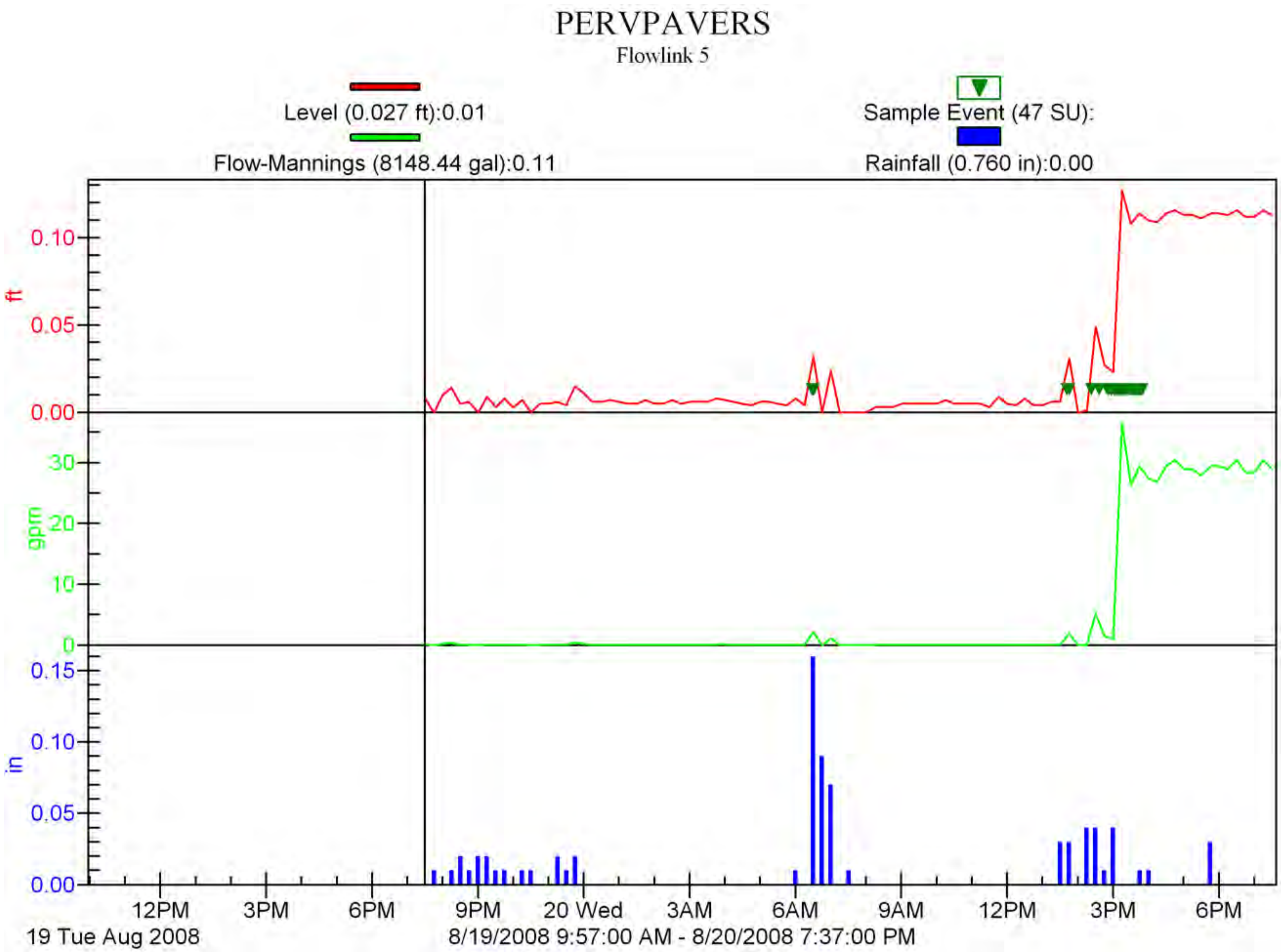


PERVPAVERS
Flowlink 5
Level (0.017 ft):0.01
Flow-Mannings (42858.6 gal):0.11
Sample Event (72 SU):
Rainfall (1.040 in):0.00
ft
0.10
0.05
0.00
gpm
30
20
10
0
in
0.15
0.10
0.05
0.00
9 Sat
10 Sun
11 Mon
12 Tue
13 Wed
14 Thu
15 Fri
16 Sat
17 Sun
18 Mon
19 Tue
20 Wed
21 Thu
Aug 2008
8/8/2008 10:12:00 PM - 8/21/2008 2:43:00 PM



PERVPAVERS
Flowlink 5
Level (0.027 ft):0.01
Flow-Mannings (8148.44 gal):0.11
Sample Event (47 SU):
Rainfall (0.760 in):0.00
ft
0.10
0.05
0.00
gpm
30
20
10
0
in
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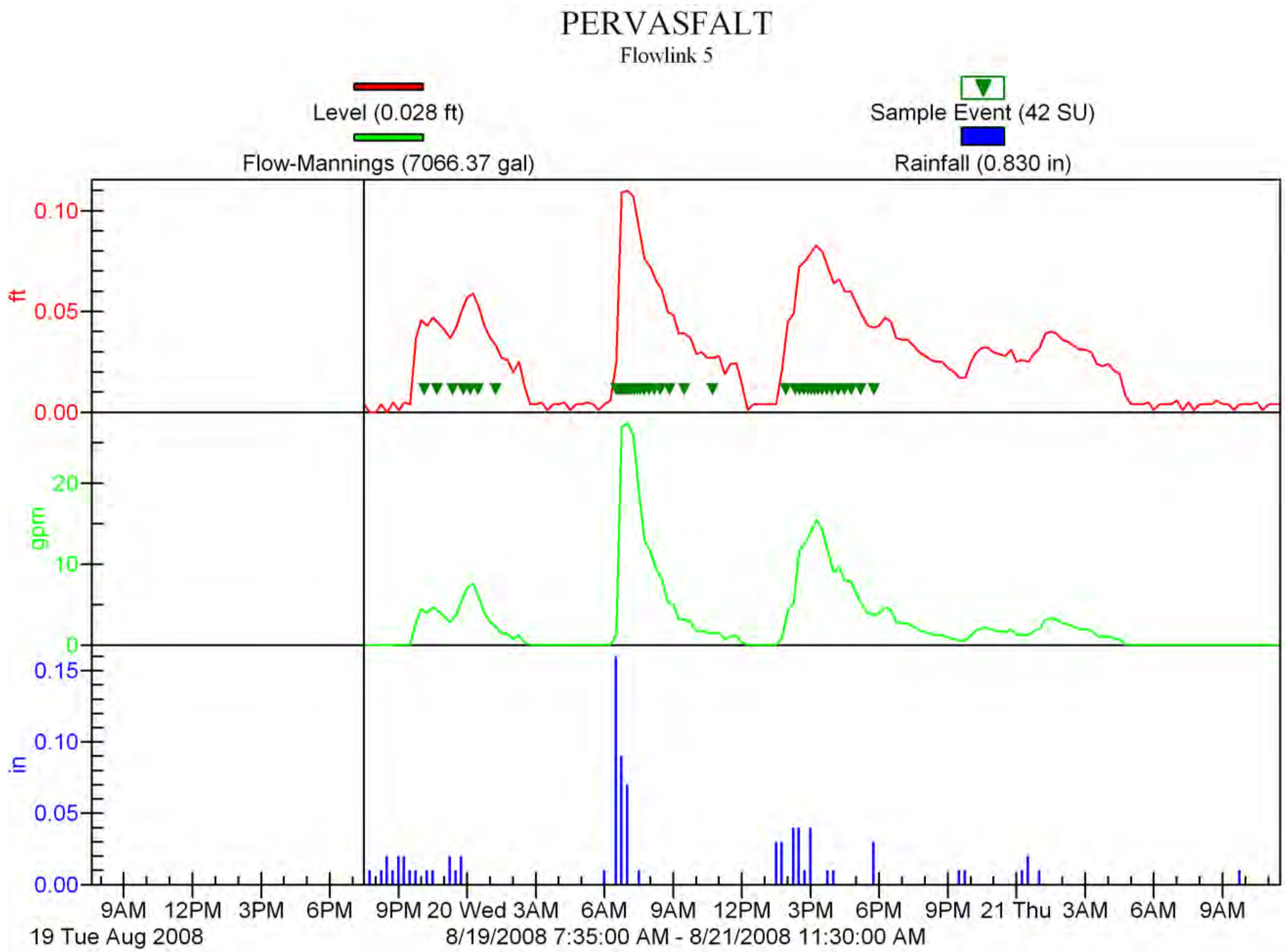
19 Tue Aug 2008
8/19/2008 9:57:00 AM - 8/20/2008 7:37:00 PM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Level (0.028 ft)
Flow-Mannings (7066.37 gal)
Sample Event (42 SU)
Rainfall (0.830 in)
ft
0.10
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19 Tue Aug 2008
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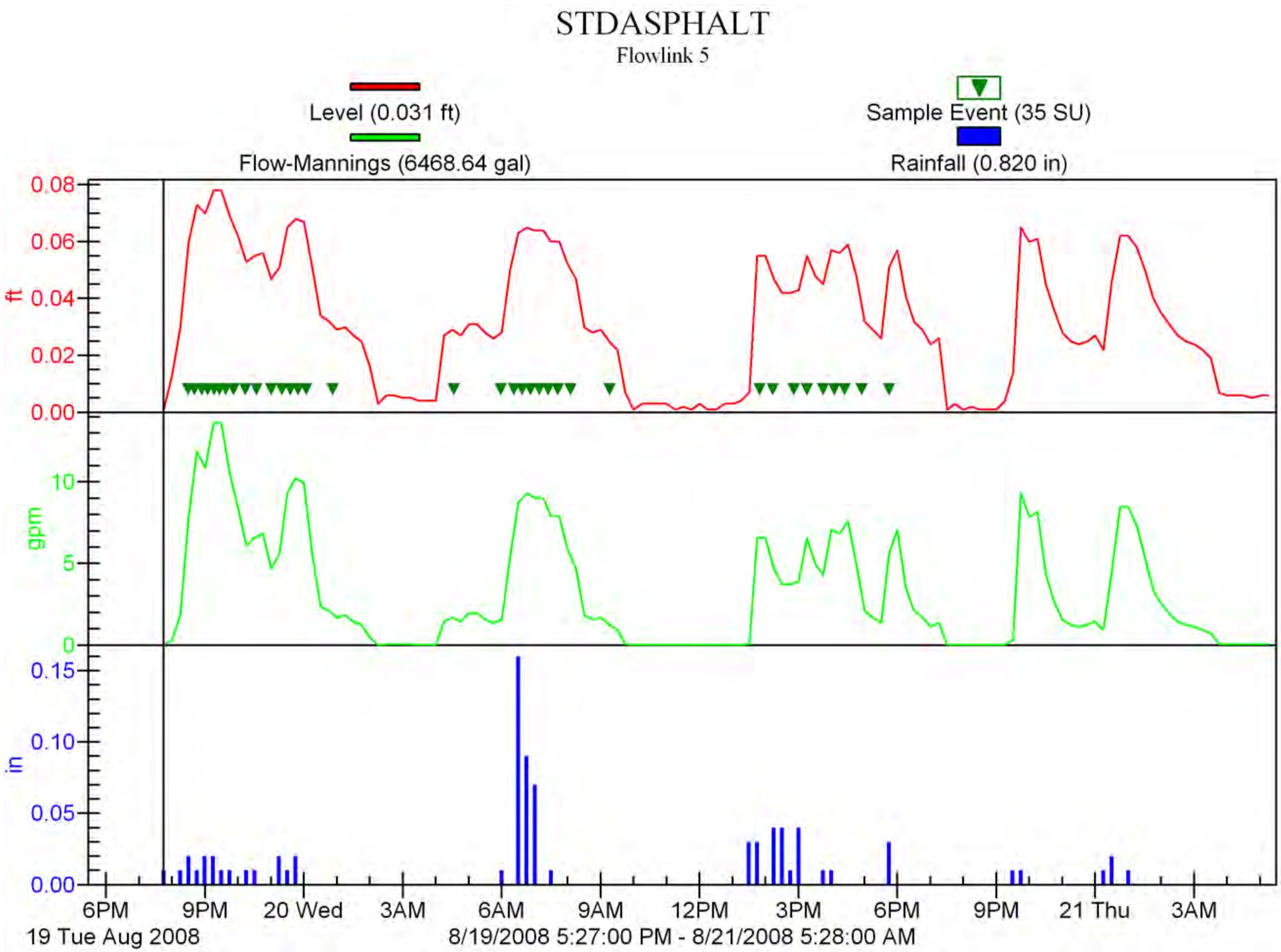
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Flowlink 5
Level (0.031 ft)
Sample Event (35 SU)
Flow-Mannings (6468.64 gal)
Rainfall (0.820 in)
ft
0.08
0.06
0.04
0.02
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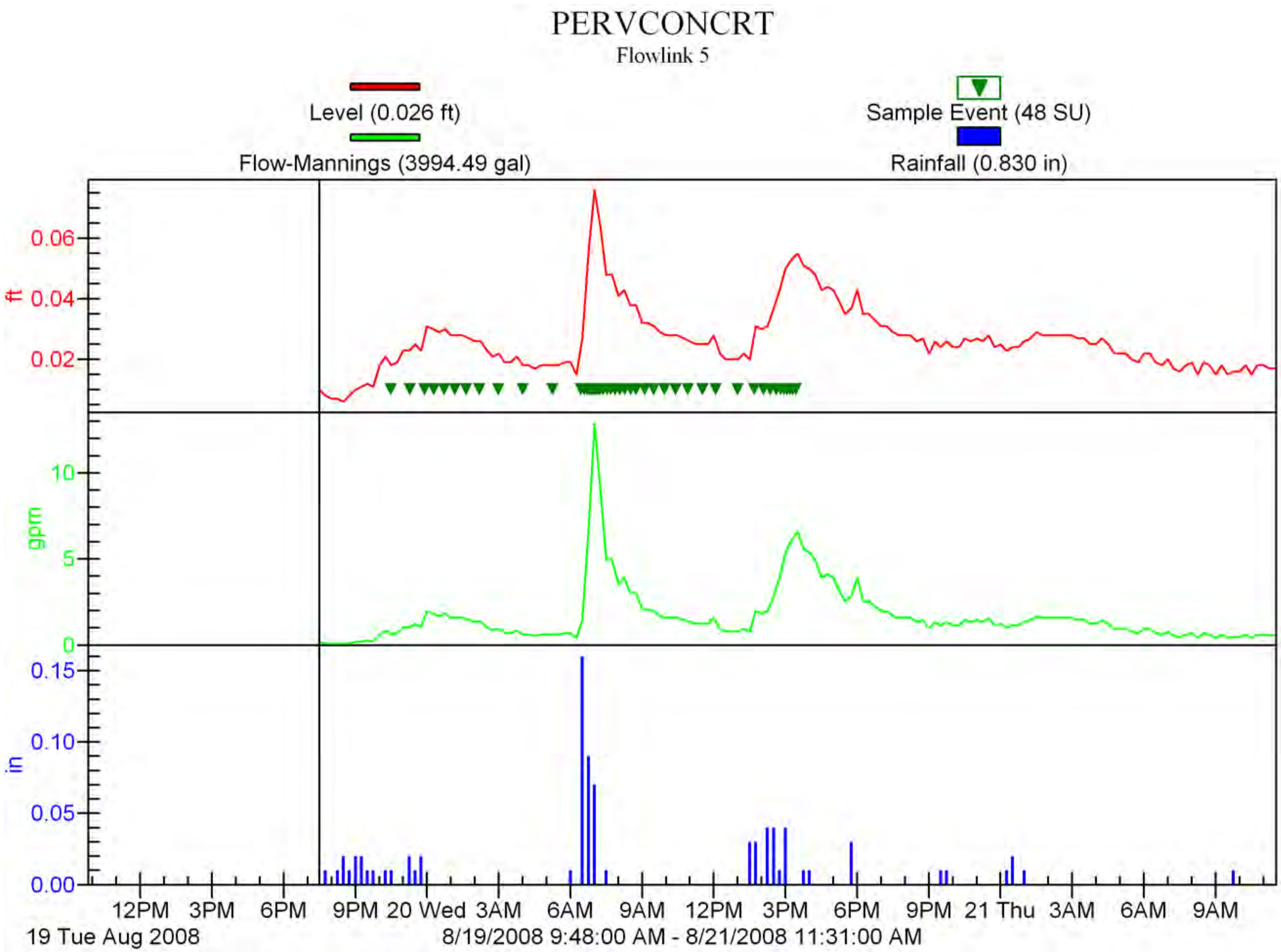

PERVCONCRT
Flowlink 5
Level (0.026 ft)
Flow-Mannings (3994.49 gal)
Sample Event (48 SU)
Rainfall (0.830 in)
ft
0.06
0.04
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12PM 3PM 6PM 9PM 20 Wed 3AM 6AM 9AM 12PM 3PM 6PM 9PM 21 Thu 3AM 6AM 9AM
19 Tue Aug 2008
8/19/2008 9:48:00 AM - 8/21/2008 11:31:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #21
Date: October 3-4, 2008

Introduction

This report summarizes the storm event sampled on October 3-4, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #21.

Table 1. Storm Characteristics

Storm Date		10/3 – 10/4/2008
Time Storm Began		5:00
Total Precipitation (in)		0.64
Duration (hrs)		34
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		166.4
Precipitation in 24-hr Antecedent Dry Period (in)		0.06
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	No

* Storm exceeded 24 hrs. Actual time was 33.75 hrs.

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #21. As shown above, 0.06 inches of rain fell in the 24 hours prior to the sampling event; this exceeded the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2-5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	23	4.92	17.52	15.45
Duration of Flow (hrs)	23	27	23	37
Total Volume (gallons) during Storm Event	3842*	1407	4736	11726
Total Volume (gallons) during Sampling Event	1837	1389	4650	8840
Duration of Sampling Event (hrs)	4.2	23	23.0	29
Number of Sample Aliquots Collected	48	35	34	48
Percentage of Storm's Total Volume over which Samples were Collected	47.8%	98.7%	98.2%	75.4%
Volume of Surface Runoff Collected in Vault (inches)	7	22+	21+	

Key: NS = Not Sampled

*Runoff did not completely return to zero. Used best guess on when storm was complete.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers
- Pervious Concrete
- Pervious Asphalt
- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- The sampler head at the standard asphalt site was switched out with a unit from the grassfield.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	10/4/2008	Hardness, Calculated	17.5	mg/L		
Pervious Asphalt	10/4/2008	pH	7.3	Std. Units		
Pervious Asphalt	10/4/2008	TSS	0.90	mg/L	J	
Pervious Asphalt	10/4/2008	NWTPH-Diesel	0.12	mg/L	B	
Pervious Asphalt	10/4/2008	NWTPH-Heavy Oil	0.3	mg/L	J	
Pervious Asphalt	10/4/2008	Copper	13	ug/L	U	
Pervious Asphalt	10/4/2008	Lead	3.3	ug/L	U	
Pervious Asphalt	10/4/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt	10/4/2008	Zinc	2.9	ug/L	U	
Pervious Asphalt	10/4/2008	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Anthracene	0.004	ug/L	U	
Pervious Asphalt	10/4/2008	Fluorene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Naphthalene	0.004	ug/L	U	
Pervious Asphalt	10/4/2008	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	10/4/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	10/4/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	10/4/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Chrysene	0.003	ug/L	U	
Pervious Asphalt	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	10/4/2008	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	10/4/2008	Pyrene	0.004	ug/L	U	
Pervious Asphalt	10/4/2008	bis(2-Ethylhexyl)phthalate	0.82	ug/L	B	
Pervious Asphalt	10/4/2008	Butyl benzyl phthalate	0.22	ug/L	J	
Pervious Asphalt	10/4/2008	Diethylphthalate	1.766	ug/L		
Pervious Asphalt	10/4/2008	Dimethyl phthalate	0.064	ug/L	J	
Pervious Asphalt	10/4/2008	Di-n-butylphthalate	0.27	ug/L	J	
Pervious Asphalt	10/4/2008	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Asphalt CB	10/4/2008	Hardness, Calculated	15.8	mg/L		
Pervious Asphalt CB	10/4/2008	pH	7.0	Std. Units		
Pervious Asphalt CB	10/4/2008	TSS	10.0	mg/L		
Pervious Asphalt CB	10/4/2008	NWTPH-Diesel	0.14	mg/L	B	
Pervious Asphalt CB	10/4/2008	NWTPH-Heavy Oil	0.6	mg/L		
Pervious Asphalt CB	10/4/2008	Copper	17	ug/L	U	
Pervious Asphalt CB	10/4/2008	Lead	3.3	ug/L	U	
Pervious Asphalt CB	10/4/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	10/4/2008	Zinc	38.0	ug/L		
Pervious Asphalt CB	10/4/2008	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Asphalt CB	10/4/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	10/4/2008	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	10/4/2008	Fluorene	0.006	ug/L	J	
Pervious Asphalt CB	10/4/2008	Naphthalene	0.009	ug/L	U	
Pervious Asphalt CB	10/4/2008	Phenanthrene	0.013	ug/L		
Pervious Asphalt CB	10/4/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt CB	10/4/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt CB	10/4/2008	Benzo(g,h,i)perylene	0.010	ug/L		
Pervious Asphalt CB	10/4/2008	Benzo(b,k)fluoranthenes	0.025	ug/L		
Pervious Asphalt CB	10/4/2008	Chrysene	0.012	ug/L		
Pervious Asphalt CB	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	10/4/2008	Fluoranthene	0.032	ug/L		
Pervious Asphalt CB	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.008	ug/L	J	
Pervious Asphalt CB	10/4/2008	Pyrene	0.022	ug/L		
Pervious Asphalt CB	10/4/2008	bis(2-Ethylhexyl)phthalate	2.86	ug/L		
Pervious Asphalt CB	10/4/2008	Butyl benzyl phthalate	0.17	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	10/4/2008	Diethylphthalate	0.083	ug/L	U	
Pervious Asphalt CB	10/4/2008	Dimethyl phthalate	0.038	ug/L	J	
Pervious Asphalt CB	10/4/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Asphalt CB	10/4/2008	Di-n-Octyl phthalate	0.194	ug/L	J	
Pervious Concrete	10/4/2008	Hardness, Calculated	477	mg/L		
Pervious Concrete	10/4/2008	pH	11.6	Std. Units		
Pervious Concrete	10/4/2008	TSS	51.7	mg/L		
Pervious Concrete	10/4/2008	NWTPH-Diesel	0.19	mg/L	B	
Pervious Concrete	10/4/2008	NWTPH-Heavy Oil	0.2	mg/L	J	
Pervious Concrete	10/4/2008	Copper	29	ug/L		U
Pervious Concrete	10/4/2008	Lead	3.3	ug/L	U	
Pervious Concrete	10/4/2008	Mercury	0.050	ug/L	U	
Pervious Concrete	10/4/2008	Zinc	5.0	ug/L	J	
Pervious Concrete	10/4/2008	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Concrete	10/4/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	10/4/2008	Anthracene	0.004	ug/L	U	
Pervious Concrete	10/4/2008	Fluorene	0.009	ug/L	J	
Pervious Concrete	10/4/2008	Naphthalene	0.009	ug/L	U	
Pervious Concrete	10/4/2008	Phenanthrene	0.009	ug/L	J	
Pervious Concrete	10/4/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	10/4/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	10/4/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	10/4/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	10/4/2008	Chrysene	0.003	ug/L	U	
Pervious Concrete	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	10/4/2008	Fluoranthene	0.005	ug/L	J	
Pervious Concrete	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	10/4/2008	Pyrene	0.004	ug/L	J	
Pervious Concrete	10/4/2008	bis(2-Ethylhexyl)phthalate	0.54	ug/L	B	
Pervious Concrete	10/4/2008	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	10/4/2008	Diethylphthalate	0.072	ug/L	U	
Pervious Concrete	10/4/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	10/4/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete	10/4/2008	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete CB	10/4/2008	Hardness, Calculated	32.4	mg/L		
Pervious Concrete CB	10/4/2008	pH	7.6	Std. Units		
Pervious Concrete CB	10/4/2008	TSS	10.1	mg/L		
Pervious Concrete CB	10/4/2008	NWTPH-Diesel	0.06	mg/L	B	
Pervious Concrete CB	10/4/2008	NWTPH-Heavy Oil	0.5	mg/L		
Pervious Concrete CB	10/4/2008	Copper	15	ug/L	U	
Pervious Concrete CB	10/4/2008	Lead	3.3	ug/L	U	
Pervious Concrete CB	10/4/2008	Mercury	0.050	ug/L	U	
Pervious Concrete CB	10/4/2008	Zinc	30.6	ug/L		
Pervious Concrete CB	10/4/2008	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Concrete CB	10/4/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete CB	10/4/2008	Anthracene	0.004	ug/L	U	
Pervious Concrete CB	10/4/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete CB	10/4/2008	Naphthalene	0.008	ug/L	U	
Pervious Concrete CB	10/4/2008	Phenanthrene	0.014	ug/L		
Pervious Concrete CB	10/4/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete CB	10/4/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete CB	10/4/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete CB	10/4/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete CB	10/4/2008	Chrysene	0.007	ug/L	J	
Pervious Concrete CB	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete CB	10/4/2008	Fluoranthene	0.023	ug/L		

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete CB	10/4/2008	Pyrene	0.017	ug/L		
Pervious Concrete CB	10/4/2008	bis(2-Ethylhexyl)phthalate	2.66	ug/L		
Pervious Concrete CB	10/4/2008	Butyl benzyl phthalate	0.18	ug/L	J	
Pervious Concrete CB	10/4/2008	Diethylphthalate	0.088	ug/L	U	
Pervious Concrete CB	10/4/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete CB	10/4/2008	Di-n-butylphthalate	0.11	ug/L	J	
Pervious Concrete CB	10/4/2008	Di-n-Octyl phthalate	0.974	ug/L	J	
Pervious Pavers	10/3/2008	Hardness, Calculated	46.8	mg/L		
Pervious Pavers	10/3/2008	pH	7.5	Std. Units		
Pervious Pavers	10/3/2008	TSS	9.60	mg/L		
Pervious Pavers	10/3/2008	NWTPH-Diesel	0.05	mg/L	U	
Pervious Pavers	10/3/2008	NWTPH-Heavy Oil	0.1	mg/L	J	
Pervious Pavers	10/3/2008	Copper	23	ug/L		U
Pervious Pavers	10/3/2008	Lead	3.3	ug/L	U	
Pervious Pavers	10/3/2008	Mercury	0.050	ug/L	U	
Pervious Pavers	10/3/2008	Zinc	7.3	ug/L	J	
Pervious Pavers	10/3/2008	2-Methylnaphthalene	0.013	ug/L		
Pervious Pavers	10/3/2008	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	10/3/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	10/3/2008	Anthracene	0.004	ug/L	U	
Pervious Pavers	10/3/2008	Fluorene	0.003	ug/L	U	
Pervious Pavers	10/3/2008	Naphthalene	0.024	ug/L		U
Pervious Pavers	10/3/2008	Phenanthrene	0.005	ug/L	J	
Pervious Pavers	10/3/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	10/3/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	10/3/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	10/3/2008	Benzo(b,k)fluoranthenes	0.008	ug/L	J	
Pervious Pavers	10/3/2008	Chrysene	0.004	ug/L	J	
Pervious Pavers	10/3/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	10/3/2008	Fluoranthene	0.009	ug/L	J	
Pervious Pavers	10/3/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	10/3/2008	Pyrene	0.006	ug/L	J	
Pervious Pavers	10/3/2008	bis(2-Ethylhexyl)phthalate	0.78	ug/L	B	
Pervious Pavers	10/3/2008	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers	10/3/2008	Diethylphthalate	0.388	ug/L	U	
Pervious Pavers	10/3/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	10/3/2008	Di-n-butylphthalate	0.18	ug/L	J	
Pervious Pavers	10/3/2008	Di-n-Octyl phthalate	0.088	ug/L	J	
Pervious Pavers CB	10/4/2008	Hardness, Calculated	26.7	mg/L		
Pervious Pavers CB	10/4/2008	pH	7.8	Std. Units		
Pervious Pavers CB	10/4/2008	TSS	4.00	mg/L		
Pervious Pavers CB	10/4/2008	NWTPH-Diesel	0.05	mg/L	B	
Pervious Pavers CB	10/4/2008	NWTPH-Heavy Oil	0.4	mg/L	J	
Pervious Pavers CB	10/4/2008	Copper	15	ug/L	U	
Pervious Pavers CB	10/4/2008	Lead	3.3	ug/L	U	
Pervious Pavers CB	10/4/2008	Mercury	0.050	ug/L	U	
Pervious Pavers CB	10/4/2008	Zinc	27.7	ug/L		
Pervious Pavers CB	10/4/2008	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Pavers CB	10/4/2008	Acenaphthene	0.003	ug/L	U	
Pervious Pavers CB	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers CB	10/4/2008	Anthracene	0.004	ug/L	U	
Pervious Pavers CB	10/4/2008	Fluorene	0.003	ug/L	J	
Pervious Pavers CB	10/4/2008	Naphthalene	0.007	ug/L	U	
Pervious Pavers CB	10/4/2008	Phenanthrene	0.028	ug/L		
Pervious Pavers CB	10/4/2008	Benzo(a)anthracene	0.006	ug/L	J	
Pervious Pavers CB	10/4/2008	Benzo(a)pyrene	0.004	ug/L	J	
Pervious Pavers CB	10/4/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	

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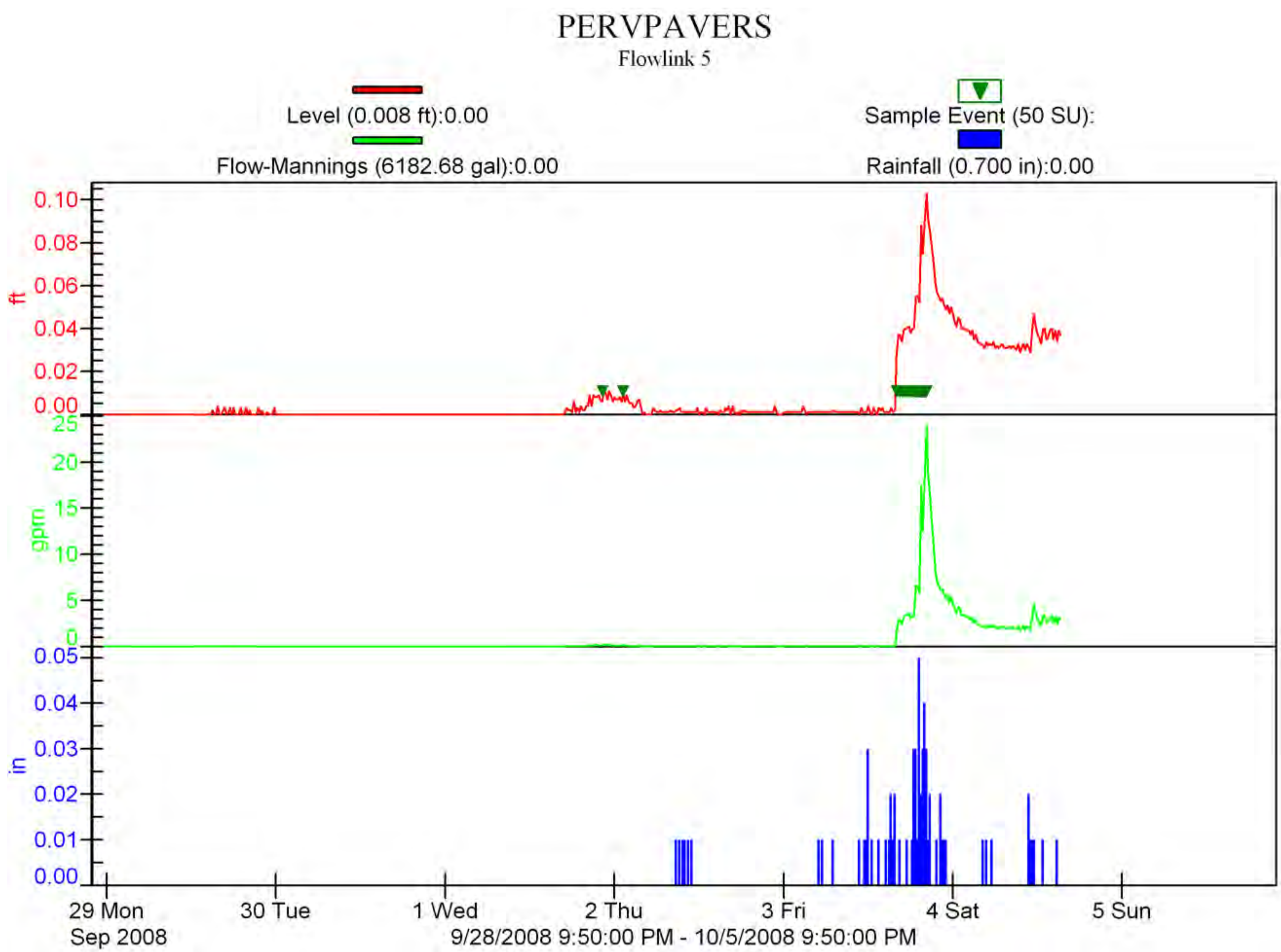
Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers CB	10/4/2008	Benzo(b,k)fluoranthenes	0.022	ug/L		
Pervious Pavers CB	10/4/2008	Chrysene	0.013	ug/L		
Pervious Pavers CB	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers CB	10/4/2008	Fluoranthene	0.050	ug/L		
Pervious Pavers CB	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers CB	10/4/2008	Pyrene	0.030	ug/L		
Pervious Pavers CB	10/4/2008	bis(2-Ethylhexyl)phthalate	1.84	ug/L		
Pervious Pavers CB	10/4/2008	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers CB	10/4/2008	Diethylphthalate	0.072	ug/L	U	
Pervious Pavers CB	10/4/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers CB	10/4/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Pavers CB	10/4/2008	Di-n-Octyl phthalate	0.409	ug/L	J	
Standard Asphalt	10/4/2008	Hardness, Calculated	7.63	mg/L		
Standard Asphalt	10/4/2008	pH	7.0	Std. Units		
Standard Asphalt	10/4/2008	TSS	29.8	mg/L		
Standard Asphalt	10/4/2008	NWTPH-Diesel	0.23	mg/L		
Standard Asphalt	10/4/2008	NWTPH-Heavy Oil	1.2	mg/L		
Standard Asphalt	10/4/2008	Copper	26	ug/L	U	
Standard Asphalt	10/4/2008	Lead	3.5	ug/L	J	
Standard Asphalt	10/4/2008	Mercury	0.050	ug/L	U	
Standard Asphalt	10/4/2008	Zinc	54.1	ug/L		
Standard Asphalt	10/4/2008	2-Methylnaphthalene	0.010	ug/L		
Standard Asphalt	10/4/2008	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	10/4/2008	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	10/4/2008	Anthracene	0.004	ug/L	U	
Standard Asphalt	10/4/2008	Fluorene	0.003	ug/L	U	
Standard Asphalt	10/4/2008	Naphthalene	0.019	ug/L		U
Standard Asphalt	10/4/2008	Phenanthrene	0.061	ug/L		
Standard Asphalt	10/4/2008	Benzo(a)anthracene	0.024	ug/L		
Standard Asphalt	10/4/2008	Benzo(a)pyrene	0.033	ug/L		
Standard Asphalt	10/4/2008	Benzo(g,h,i)perylene	0.065	ug/L		
Standard Asphalt	10/4/2008	Benzo(b,k)fluoranthenes	0.154	ug/L		
Standard Asphalt	10/4/2008	Chrysene	0.070	ug/L		
Standard Asphalt	10/4/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	10/4/2008	Fluoranthene	0.157	ug/L		
Standard Asphalt	10/4/2008	Indeno(1,2,3-c,d)pyrene	0.046	ug/L		
Standard Asphalt	10/4/2008	Pyrene	0.108	ug/L		
Standard Asphalt	10/4/2008	bis(2-Ethylhexyl)phthalate	6.15	ug/L		
Standard Asphalt	10/4/2008	Butyl benzyl phthalate	0.83	ug/L	B	
Standard Asphalt	10/4/2008	Diethylphthalate	0.888	ug/L	U	
Standard Asphalt	10/4/2008	Dimethyl phthalate	0.137	ug/L	J	
Standard Asphalt	10/4/2008	Di-n-butylphthalate	0.28	ug/L	J	
Standard Asphalt	10/4/2008	Di-n-Octyl phthalate	1.389	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
25
20
15
10
5
0
in
0.05
0.04
0.03
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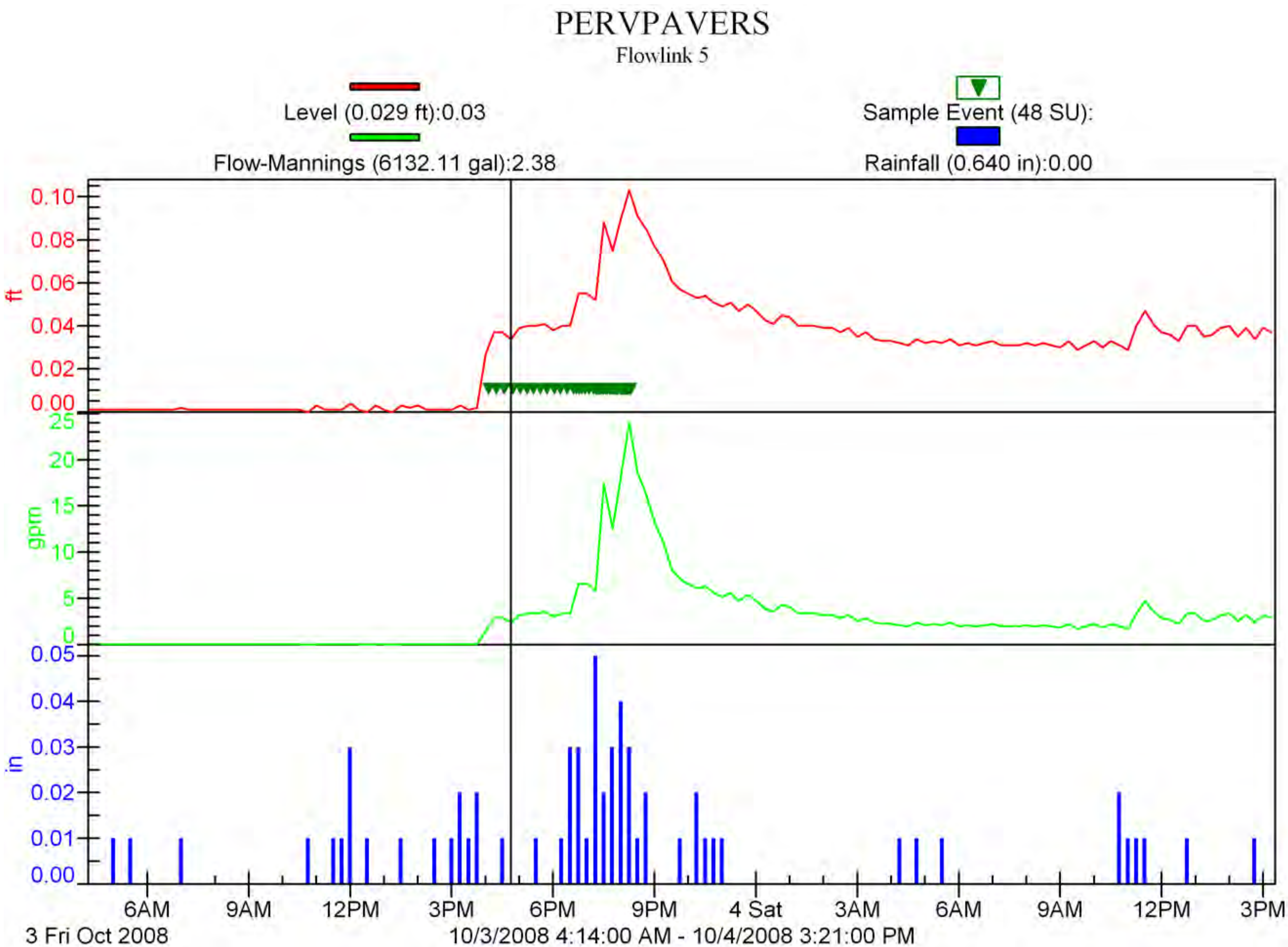
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ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
25
20
15
10
5
0
in
0.05
0.04
0.03
0.02
0.01
0.00
6AM
9AM
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9PM
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12PM
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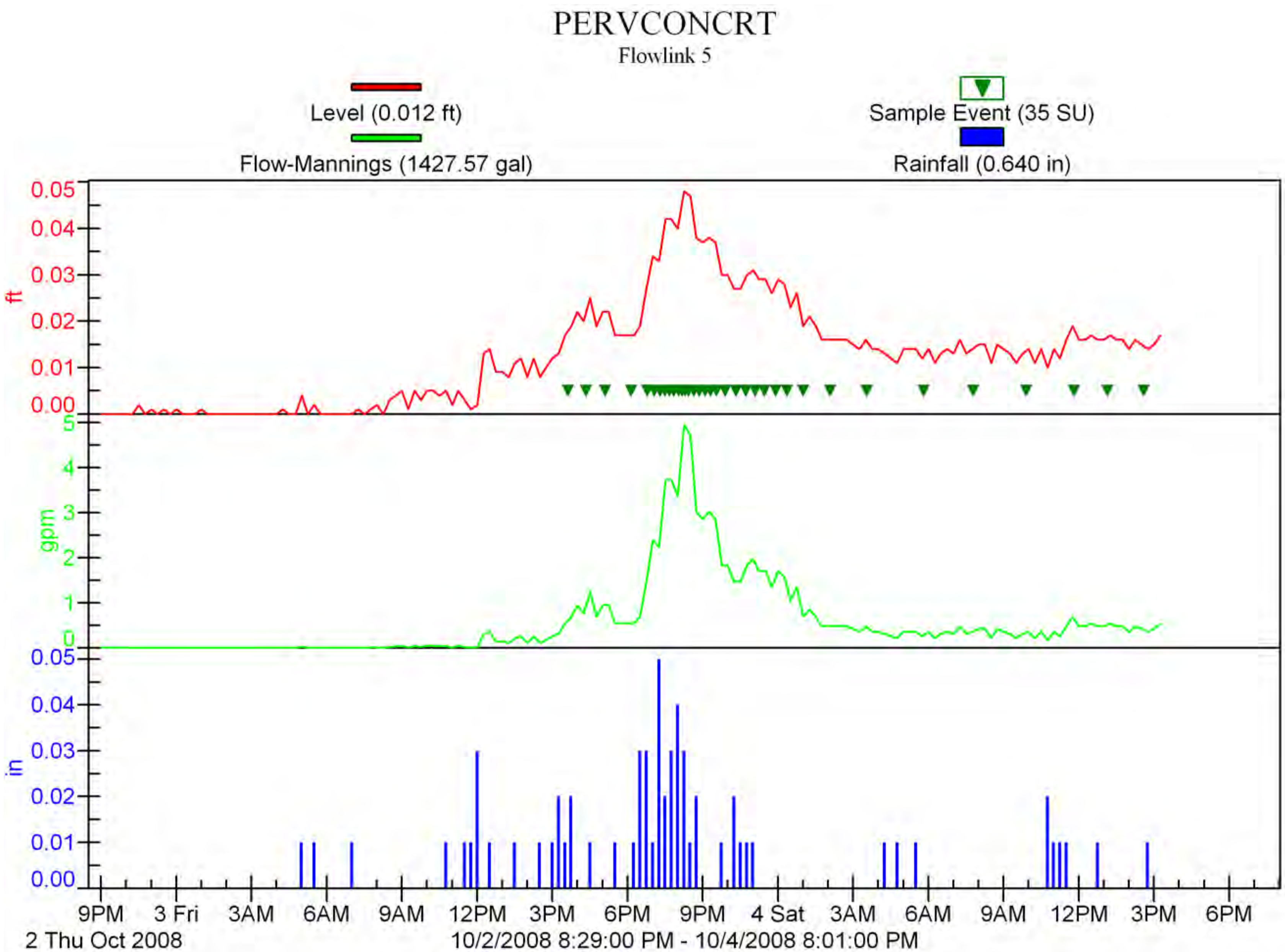
10/3/2008 4:14:00 AM - 10/4/2008 3:21:00 PM



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Flow-Mannings (1427.57 gal)
Sample Event (35 SU)
Rainfall (0.640 in)
ft
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0.04
0.03
0.02
0.01
0.00
gpm
5
4
3
2
1
0
in
0.05
0.04
0.03
0.02
0.01
0.00
9PM
3 Fri
3AM
6AM
9AM
12PM
3PM
6PM
9PM
4 Sat
3AM
6AM
9AM
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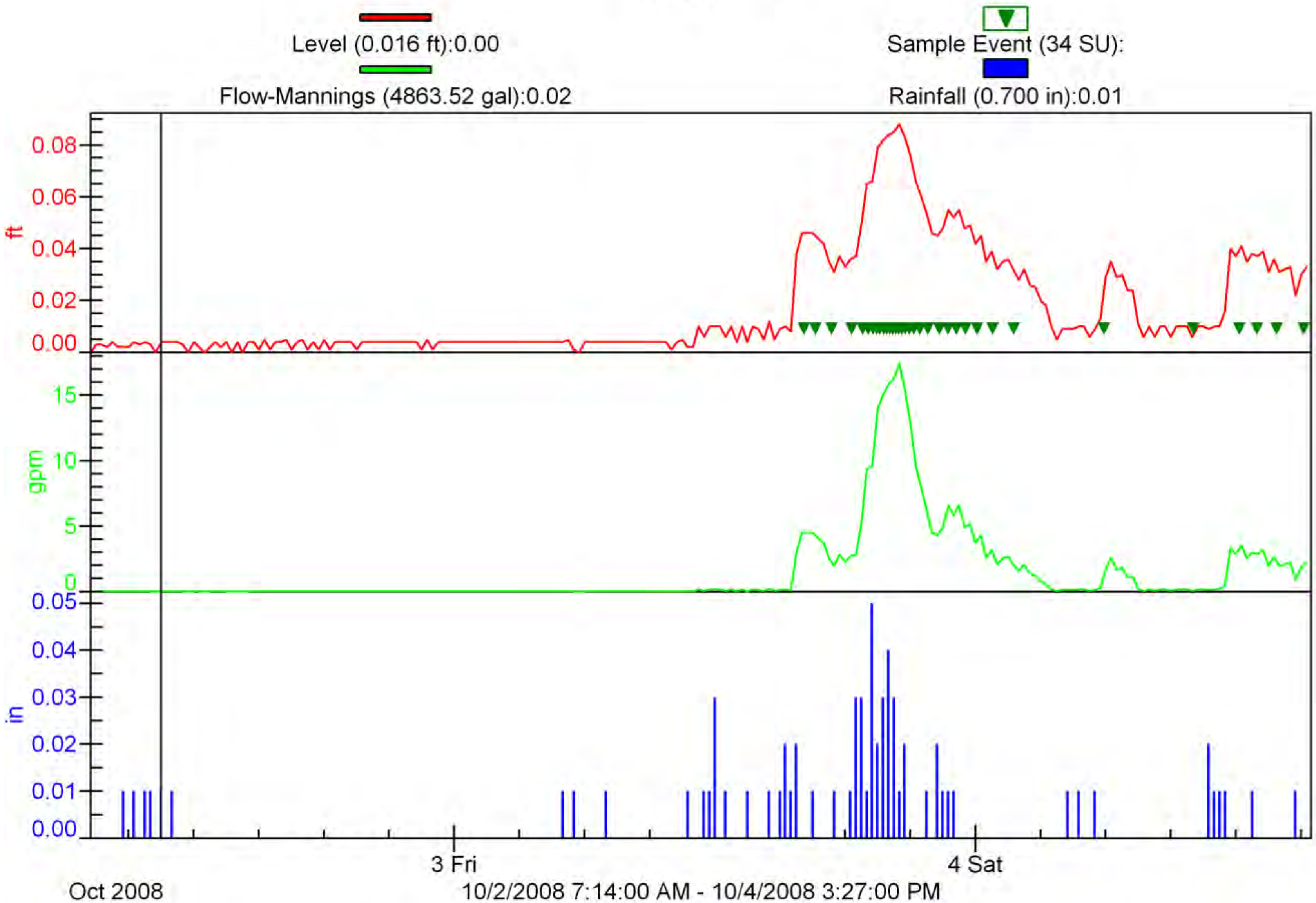
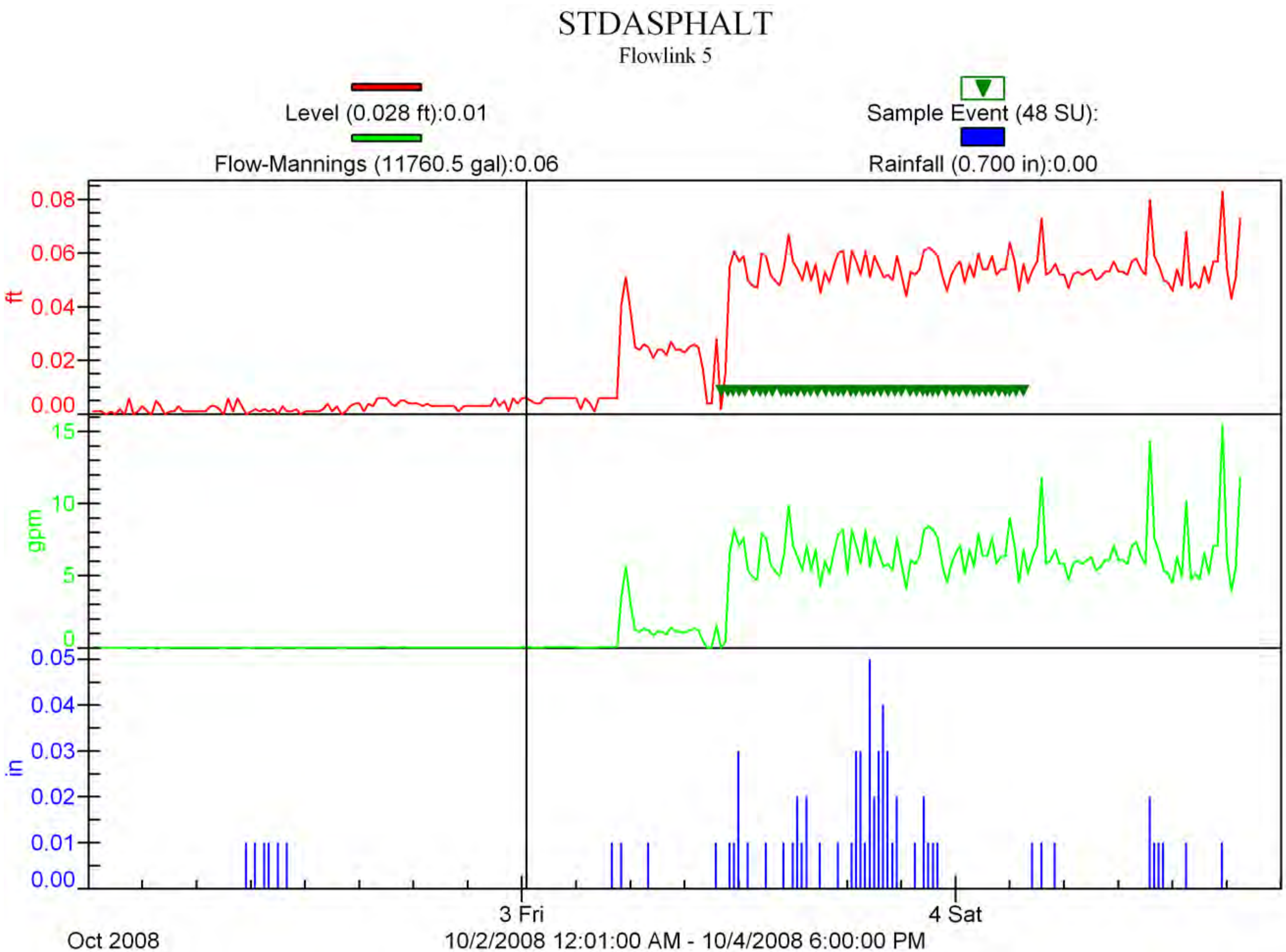
3PM
6PM
2 Thu Oct 2008
10/2/2008 8:29:00 PM - 10/4/2008 8:01:00 PM

PERVASFALT

Flowlink 5





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Flowlink 5
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Flow-Mannings (11760.5 gal):0.06
Sample Event (48 SU):
Rainfall (0.700 in):0.00
ft
0.08
0.06
0.04
0.02
0.00
gpm
15
10
5
0
in
0.05
0.04
0.03
0.02
0.01
0.00
3 Fri
4 Sat
Oct 2008
10/2/2008 12:01:00 AM - 10/4/2008 6:00:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #22
Date: October 20, 2008

Introduction

This report summarizes the storm event sampled on October 20, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #22.

Table 1. Storm Characteristics

Storm Date		10/20/2008
Time Storm Began		07:30
Total Precipitation (in)		0.20
Duration (hrs)		8.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		55.75
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #22. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious concrete. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	2.65	NS	NS
Duration of Flow (hrs)	NS	15.5	NS	NS
Total Volume (gallons) during Storm Event	NS	228	NS	NS
Total Volume (gallons) during Sampling Event	NS	164	NS	NS
Duration of Sampling Event (hrs)	NS	10.8	NS	NS
Number of Sample Aliquots Collected	NS	10	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	71.9%	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	NS	20	18	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Concrete

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Pervious pavers – Sample not accepted (1.5L – insufficient)
- Pervious asphalt and standard asphalt – No sample. Low flow.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

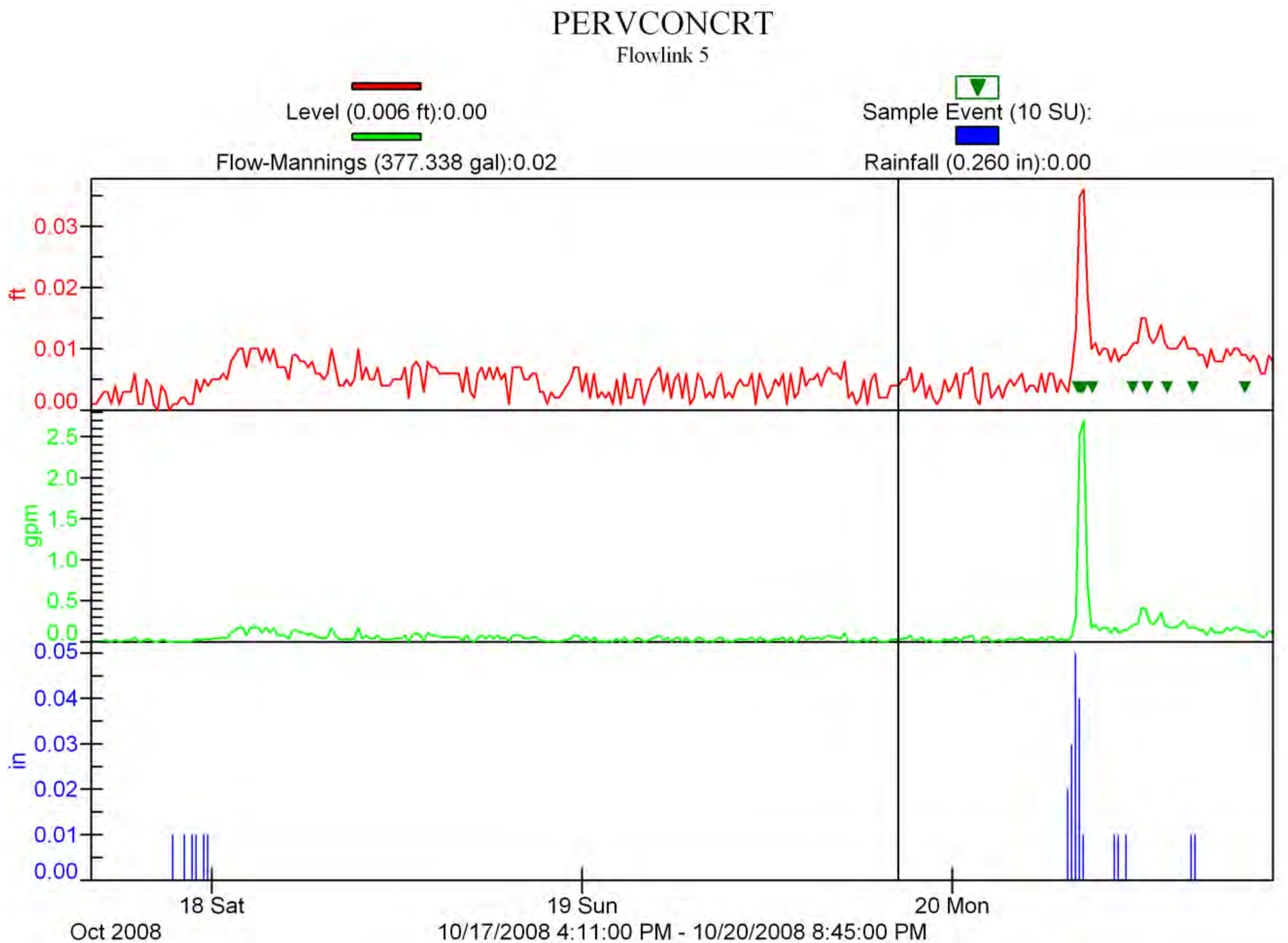
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	10/21/2008	Hardness, Calculated	11.1	mg/L		
Pervious Asphalt CB	10/21/2008	pH	6.4	Std. Units		
Pervious Asphalt CB	10/21/2008	TSS	7.6	mg/L		
Pervious Asphalt CB	10/21/2008	NWTPH-Diesel	0.1	mg/L	B	
Pervious Asphalt CB	10/21/2008	NWTPH-Heavy Oil	0.6	mg/L		
Pervious Asphalt CB	10/21/2008	Copper	17.3	ug/L	J	
Pervious Asphalt CB	10/21/2008	Lead	6.1	ug/L		
Pervious Asphalt CB	10/21/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	10/21/2008	Zinc	50.0	ug/L		
Pervious Asphalt CB	10/21/2008	2-Methylnaphthalene	0.006	ug/L	J	
Pervious Asphalt CB	10/21/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	10/21/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	10/21/2008	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	10/21/2008	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	10/21/2008	Naphthalene	0.014	ug/L	U	
Pervious Asphalt CB	10/21/2008	Phenanthrene	0.026	ug/L		
Pervious Asphalt CB	10/21/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt CB	10/21/2008	Benzo(a)pyrene	0.034	ug/L		
Pervious Asphalt CB	10/21/2008	Benzo(g,h,i)perylene	0.094	ug/L		
Pervious Asphalt CB	10/21/2008	Benzo(b,k)fluoranthenes	0.070	ug/L		
Pervious Asphalt CB	10/21/2008	Chrysene	0.026	ug/L		
Pervious Asphalt CB	10/21/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	10/21/2008	Fluoranthene	0.069	ug/L		
Pervious Asphalt CB	10/21/2008	Indeno(1,2,3-c,d)pyrene	0.032	ug/L		
Pervious Asphalt CB	10/21/2008	Pyrene	0.063	ug/L		
Pervious Asphalt CB	10/21/2008	bis(2-Ethylhexyl)phthalate	1.57	ug/L		
Pervious Asphalt CB	10/21/2008	Butyl benzyl phthalate	0.34	ug/L	J	
Pervious Asphalt CB	10/21/2008	Diethylphthalate	0.988	ug/L	B	
Pervious Asphalt CB	10/21/2008	Dimethyl phthalate	0.046	ug/L	J	
Pervious Asphalt CB	10/21/2008	Di-n-butylphthalate	0.11	ug/L	J	
Pervious Asphalt CB	10/21/2008	Di-n-Octyl phthalate	0.511	ug/L	J	
Pervious Concrete	10/20/2008	Hardness, Calculated	149	mg/L		
Pervious Concrete	10/20/2008	pH	11.3	Std. Units		
Pervious Concrete	10/20/2008	TSS	42.8	mg/L		
Pervious Concrete	10/20/2008	NWTPH-Diesel	0.1	mg/L	B	
Pervious Concrete	10/20/2008	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete	10/20/2008	Copper	11.0	ug/L	J	
Pervious Concrete	10/20/2008	Lead	3.3	ug/L	U	
Pervious Concrete	10/20/2008	Mercury	0.050	ug/L	U	
Pervious Concrete	10/20/2008	Zinc	2.9	ug/L	U	
Pervious Concrete	10/20/2008	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Concrete	10/20/2008	Acenaphthene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Acenaphthylene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Anthracene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Fluorene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Naphthalene	0.010	ug/L	U	
Pervious Concrete	10/20/2008	Phenanthrene	0.006	ug/L	B	
Pervious Concrete	10/20/2008	Benzo(a)anthracene	0.001	ug/L	U	
Pervious Concrete	10/20/2008	Benzo(a)pyrene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Benzo(g,h,i)perylene	0.004	ug/L	J	
Pervious Concrete	10/20/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	J	
Pervious Concrete	10/20/2008	Chrysene	0.002	ug/L	U	
Pervious Concrete	10/20/2008	Dibenz(a,h)anthracene	0.004	ug/L	U	
Pervious Concrete	10/20/2008	Fluoranthene	0.005	ug/L	B	
Pervious Concrete	10/20/2008	Indeno(1,2,3-c,d)pyrene	0.004	ug/L	U	
Pervious Concrete	10/20/2008	Pyrene	0.006	ug/L	B	
Pervious Concrete	10/20/2008	bis(2-Ethylhexyl)phthalate	0.21	ug/L	J	
Pervious Concrete	10/20/2008	Butyl benzyl phthalate	0.09	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	10/20/2008	Diethylphthalate	0.055	ug/L	J	
Pervious Concrete	10/20/2008	Dimethyl phthalate	0.016	ug/L	U	
Pervious Concrete	10/20/2008	Di-n-butylphthalate	0.05	ug/L	U	
Pervious Concrete	10/20/2008	Di-n-Octyl phthalate	0.076	ug/L	J	
Pervious Concrete CB	10/21/2008	Hardness, Calculated	31.1	mg/L		
Pervious Concrete CB	10/21/2008	pH	7.2	Std. Units		
Pervious Concrete CB	10/21/2008	TSS	5.5	mg/L		
Pervious Concrete CB	10/21/2008	NWTPH-Diesel	0.1	mg/L	U	
Pervious Concrete CB	10/21/2008	NWTPH-Heavy Oil	0.4	mg/L	U	
Pervious Concrete CB	10/21/2008	Copper	9.9	ug/L	J	
Pervious Concrete CB	10/21/2008	Lead	3.7	ug/L	B	
Pervious Concrete CB	10/21/2008	Mercury	0.050	ug/L	U	
Pervious Concrete CB	10/21/2008	Zinc	18.2	ug/L		
Pervious Concrete CB	10/21/2008	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Concrete CB	10/21/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	10/21/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete CB	10/21/2008	Anthracene	0.004	ug/L	U	
Pervious Concrete CB	10/21/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete CB	10/21/2008	Naphthalene	0.011	ug/L	U	
Pervious Concrete CB	10/21/2008	Phenanthrene	0.014	ug/L		
Pervious Concrete CB	10/21/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete CB	10/21/2008	Benzo(a)pyrene	0.012	ug/L		
Pervious Concrete CB	10/21/2008	Benzo(g,h,i)perylene	0.069	ug/L		
Pervious Concrete CB	10/21/2008	Benzo(b,k)fluoranthenes	0.026	ug/L		
Pervious Concrete CB	10/21/2008	Chrysene	0.009	ug/L	J	
Pervious Concrete CB	10/21/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete CB	10/21/2008	Fluoranthene	0.029	ug/L		
Pervious Concrete CB	10/21/2008	Indeno(1,2,3-c,d)pyrene	0.017	ug/L		
Pervious Concrete CB	10/21/2008	Pyrene	0.040	ug/L		
Pervious Concrete CB	10/21/2008	bis(2-Ethylhexyl)phthalate	1.42	ug/L		
Pervious Concrete CB	10/21/2008	Butyl benzyl phthalate	0.18	ug/L	J	
Pervious Concrete CB	10/21/2008	Diethylphthalate	0.095	ug/L	J	
Pervious Concrete CB	10/21/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete CB	10/21/2008	Di-n-butylphthalate	0.11	ug/L	J	
Pervious Concrete CB	10/21/2008	Di-n-Octyl phthalate	0.498	ug/L	J	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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gpm
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in
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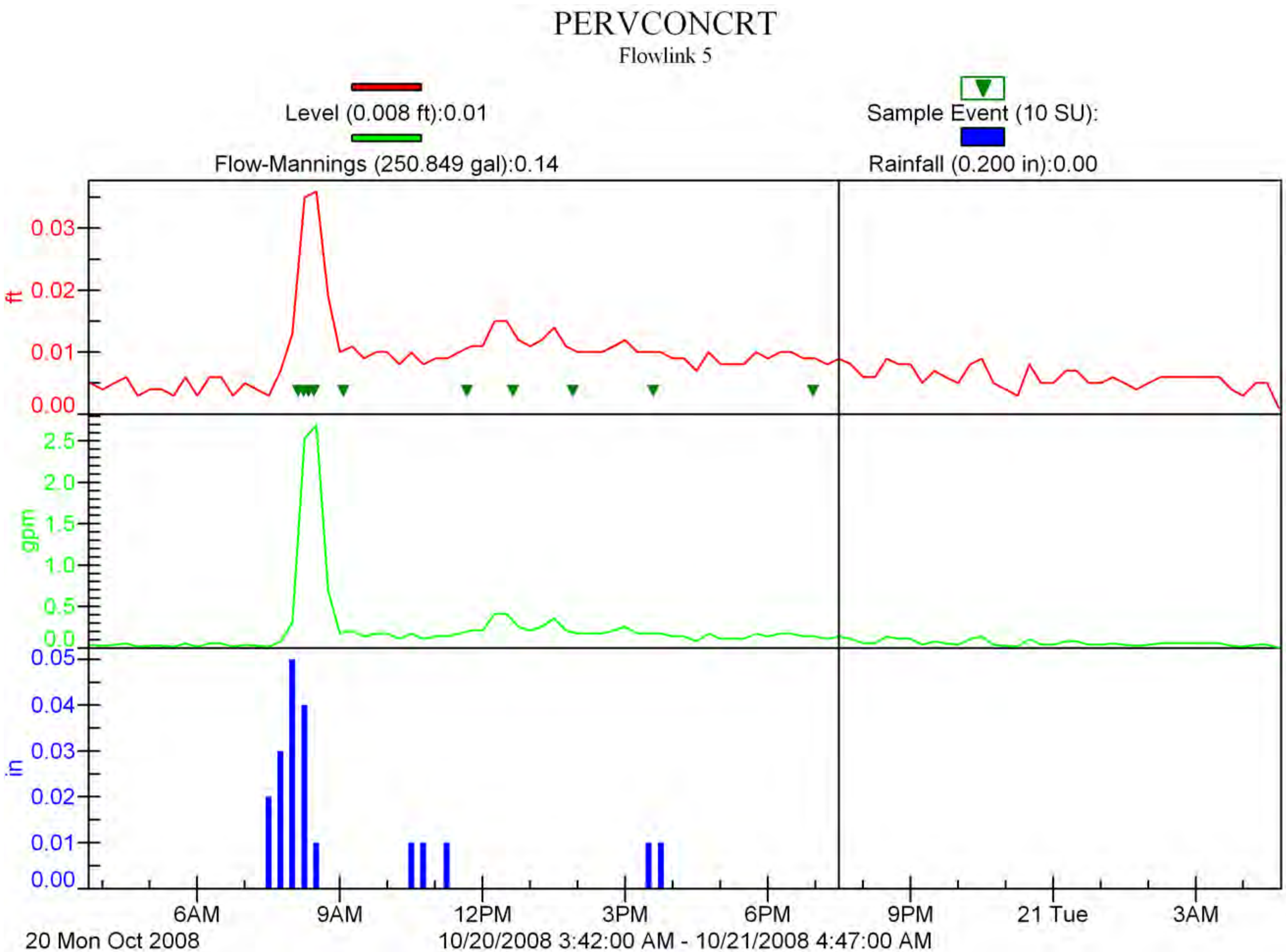
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0.02
0.03
gpm
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0.5
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1.5
2.0
2.5
in
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STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #23
Date: October 30 - November 1, 2008

Introduction

This report summarizes the storm event sampled on October 30 – November 1, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #23.

Table 1. Storm Characteristics

Storm Date		10/30-11/1/2008
Time Storm Began		12:45 AM
Total Precipitation (in)		0.35
Duration (hrs)		12.75
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		198.25
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #23. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 and 3 provide the hydrograph and hyetograph for the storm event for pervious pavers and pervious asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	5.58	NS	12.93	NS
Duration of Flow (hrs)	11	NS	8	NS
Total Volume (gallons) during Storm Event	1519**	NS	1883	NS
Total Volume (gallons) during Sampling Event	888*	NS	1761	NS
Duration of Sampling Event (hrs)	4.7	NS	7.1	NS
Number of Sample Aliquots Collected	47*	NS	27	NS
Percentage of Storm's Total Volume over which Samples were Collected	58.5%**	NS	89.7%	NS
Volume of Surface Runoff Collected in Vault (inches)	0	NS	5.5	

Key: NS = Not Sampled

* One sample was taken prior to the start of the event. It was not included in these calculations.
**Flow didn't completely return to zero after storm. Estimated end of flow.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers
- Pervious Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Standard Asphalt had height errors.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

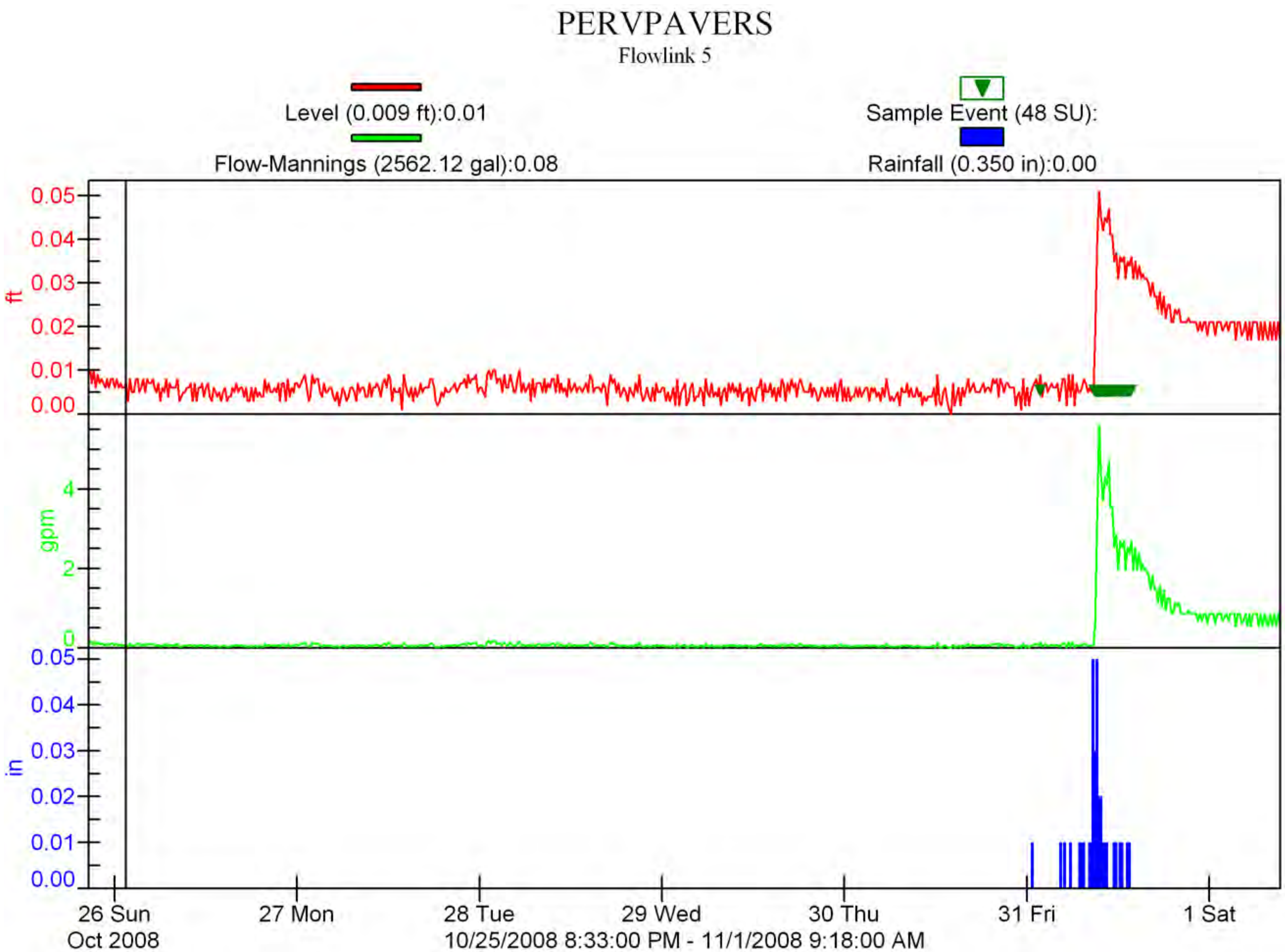
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	10/31/2008	Hardness, Calculated	17.7	mg/L		
Pervious Asphalt	10/31/2008	pH	7.0	Std. Units		
Pervious Asphalt	10/31/2008	TSS	8.80	mg/L		
Pervious Asphalt	10/31/2008	NWTPH-Diesel	0.1	mg/L	B	
Pervious Asphalt	10/31/2008	NWTPH-Heavy Oil	0.3	mg/L	J	
Pervious Asphalt	10/31/2008	Copper	5.3	ug/L	U	
Pervious Asphalt	10/31/2008	Lead	3.3	ug/L	U	
Pervious Asphalt	10/31/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt	10/31/2008	Zinc	3.9	ug/L	J	
Pervious Asphalt	10/31/2008	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	10/31/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	10/31/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	10/31/2008	Anthracene	0.004	ug/L	U	
Pervious Asphalt	10/31/2008	Fluorene	0.015	ug/L		
Pervious Asphalt	10/31/2008	Naphthalene	0.011	ug/L	U	
Pervious Asphalt	10/31/2008	Phenanthrene	0.003	ug/L	J	
Pervious Asphalt	10/31/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	10/31/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	10/31/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	10/31/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	10/31/2008	Chrysene	0.003	ug/L	U	
Pervious Asphalt	10/31/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	10/31/2008	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	10/31/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	10/31/2008	Pyrene	0.004	ug/L	U	
Pervious Asphalt	10/31/2008	bis(2-Ethylhexyl)phthalate	1.0	ug/L	U	
Pervious Asphalt	10/31/2008	Butyl benzyl phthalate	0.19	ug/L	J	
Pervious Asphalt	10/31/2008	Diethylphthalate	1.66	ug/L		
Pervious Asphalt	10/31/2008	Dimethyl phthalate	0.076	ug/L	B	
Pervious Asphalt	10/31/2008	Di-n-butylphthalate	0.16	ug/L	J	
Pervious Asphalt	10/31/2008	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Pavers	10/31/2008	Hardness, Calculated	41.8	mg/L		
Pervious Pavers	10/31/2008	pH	7.2	Std. Units		
Pervious Pavers	10/31/2008	TSS	11.9	mg/L		
Pervious Pavers	10/31/2008	NWTPH-Diesel	0.07	mg/L	B	
Pervious Pavers	10/31/2008	NWTPH-Heavy Oil	0.16	mg/L	J	
Pervious Pavers	10/31/2008	Copper	5.8	ug/L	J	
Pervious Pavers	10/31/2008	Lead	3.3	ug/L	U	
Pervious Pavers	10/31/2008	Mercury	0.050	ug/L	U	
Pervious Pavers	10/31/2008	Zinc	8.3	ug/L	J	
Pervious Pavers	10/31/2008	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Pavers	10/31/2008	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	10/31/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	10/31/2008	Anthracene	0.004	ug/L	U	
Pervious Pavers	10/31/2008	Fluorene	0.003	ug/L	U	
Pervious Pavers	10/31/2008	Naphthalene	0.012	ug/L	U	
Pervious Pavers	10/31/2008	Phenanthrene	0.005	ug/L	J	
Pervious Pavers	10/31/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	10/31/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	10/31/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	10/31/2008	Benzo(b,k)fluoranthenes	0.008	ug/L	J	
Pervious Pavers	10/31/2008	Chrysene	0.003	ug/L	U	
Pervious Pavers	10/31/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	10/31/2008	Fluoranthene	0.008	ug/L	J	
Pervious Pavers	10/31/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	10/31/2008	Pyrene	0.006	ug/L	J	
Pervious Pavers	10/31/2008	bis(2-Ethylhexyl)phthalate	1.0	ug/L	U	
Pervious Pavers	10/31/2008	Butyl benzyl phthalate	0.17	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	10/31/2008	Diethylphthalate	1.0	ug/L	U	
Pervious Pavers	10/31/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	10/31/2008	Di-n-butylphthalate	0.11	ug/L	J	
Pervious Pavers	10/31/2008	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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Flow-Mannings (2562.12 gal):0.08
Sample Event (48 SU):
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0.04
0.03
0.02
0.01
0.00
gpm
4
2
0
in
0.05
0.04
0.03
0.02
0.01
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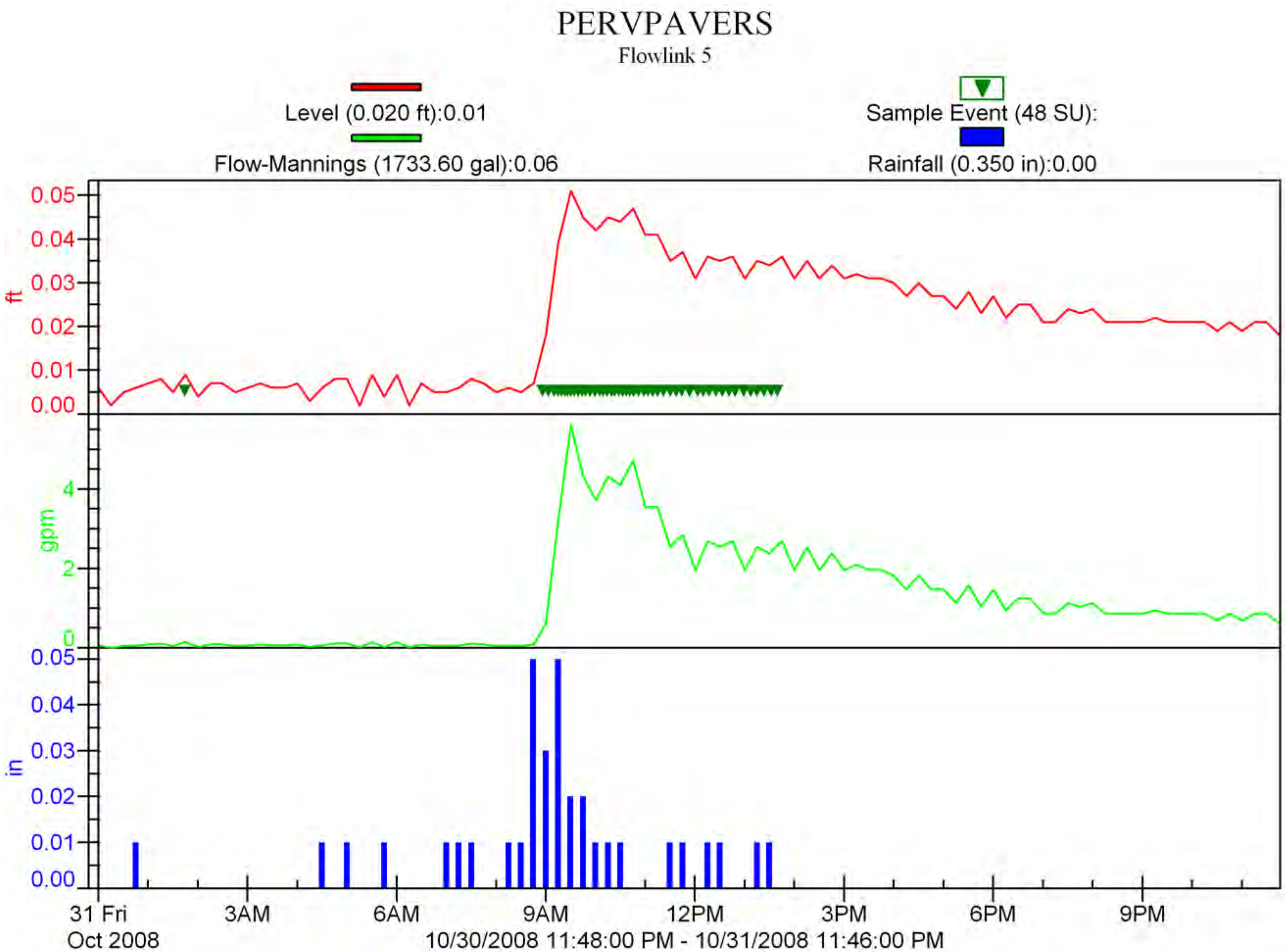
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Flow-Mannings (1733.60 gal):0.06
Sample Event (48 SU):
Rainfall (0.350 in):0.00
ft
0.05
0.04
0.03
0.02
0.01
0.00
gpm
4
2
0
in
0.05
0.04
0.03
0.02
0.01
0.00
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Oct 2008
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6AM
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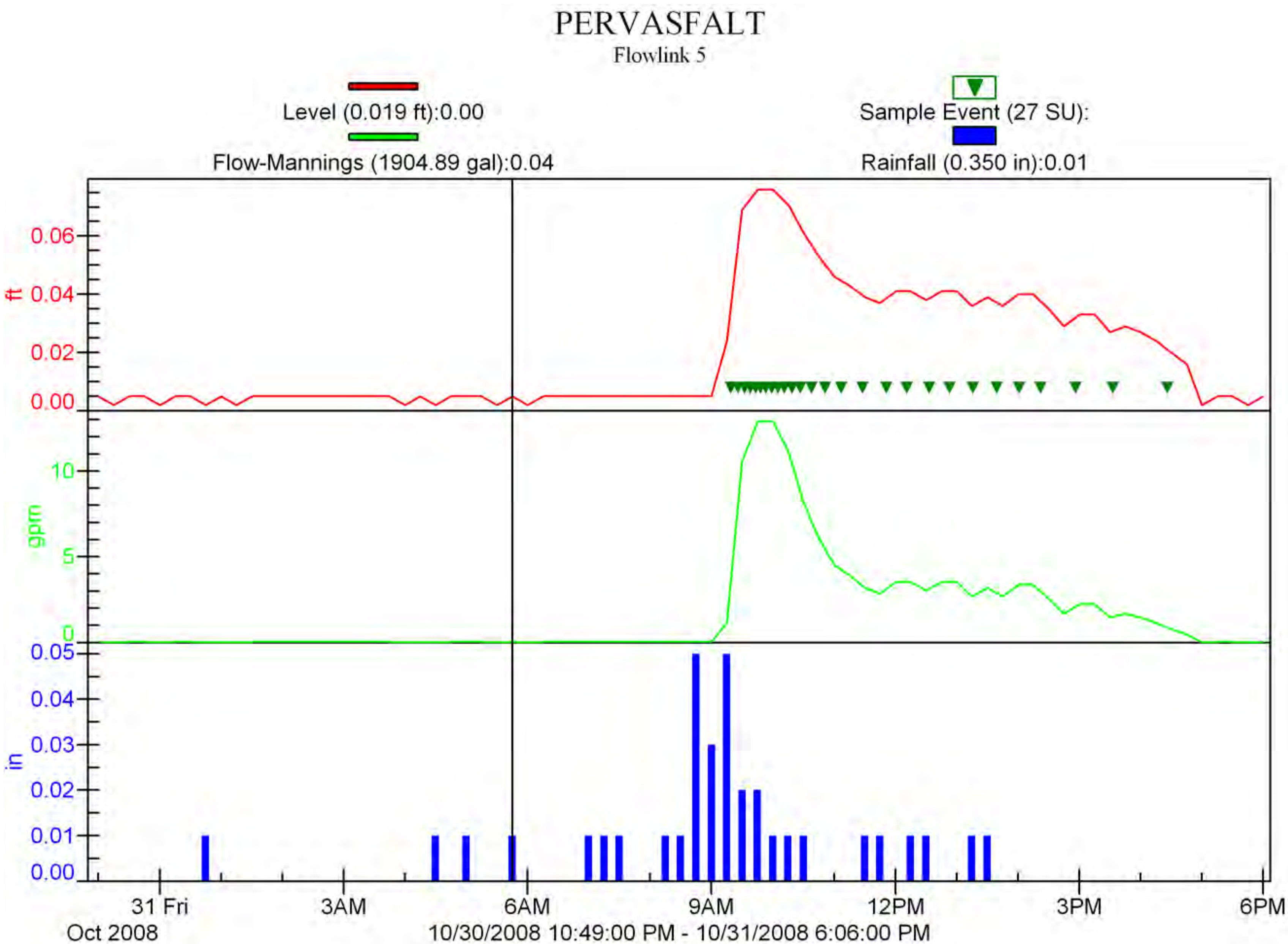
9PM
10/30/2008 11:48:00 PM - 10/31/2008 11:46:00 PM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Flowlink 5
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Flow-Mannings (1904.89 gal):0.04
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Rainfall (0.350 in):0.01
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0.04
0.02
0.00
gpm
10
5
0
in
0.05
0.04
0.03
0.02
0.01
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3AM
6AM
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12PM
3PM
6PM
Oct 2008
10/30/2008 10:49:00 PM - 10/31/2008 6:06:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #24
Date: November 5-6, 2008

Introduction

This report summarizes the storm event sampled on November 5-6, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #24.

Table 1. Storm Characteristics

Storm Date		11/5 - 11/6/2008
Time Storm Began		23:00
Total Precipitation (in)		3.09
Duration (hrs)		31*
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		129.5
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

* Rainfall exceeded 24 hours.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #24. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious concrete. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	37.38	NS	NS
Duration of Flow (hrs)	NS	27*	NS	NS
Total Volume (gallons) during Storm Event	NS	7416	NS	NS
Total Volume (gallons) during Sampling Event	NS	4446	NS	NS
Duration of Sampling Event (hrs)	NS	18	NS	NS
Number of Sample Aliquots Collected	NS	48	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	60.0%	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	NS	21	20+	

Key: NS = Not Sampled

* Flow exceeded 24 hours.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Concrete

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Standard Asphalt had height errors. Module was replaced.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

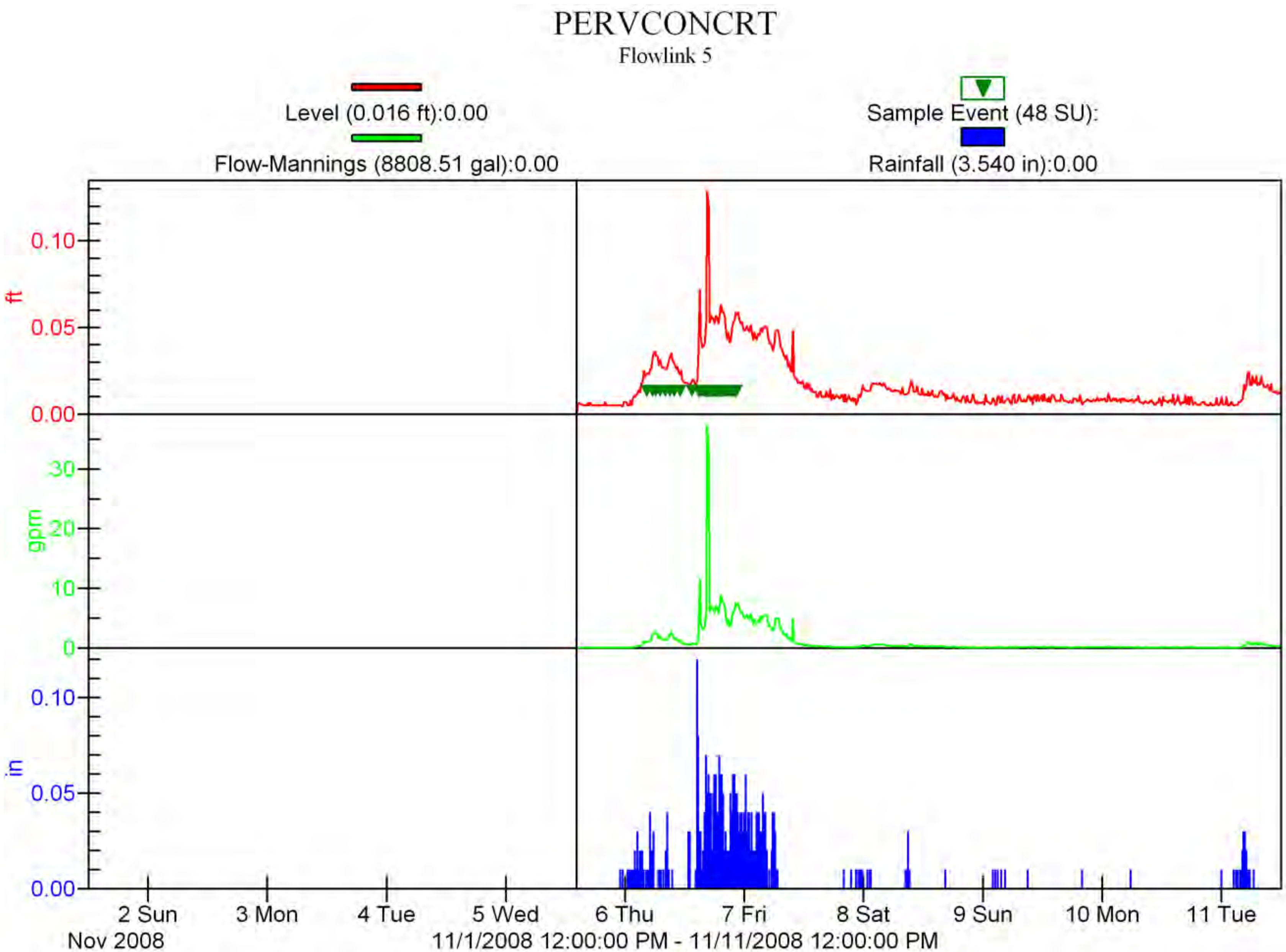
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	11/7/2008	Hardness, Calculated	6.93	mg/L		
Pervious Asphalt CB	11/7/2008	pH	7.0	Std. Units		
Pervious Asphalt CB	11/7/2008	TSS	4.09	mg/L		
Pervious Asphalt CB	11/7/2008	NWTPH-Diesel	0.05	mg/L	J	
Pervious Asphalt CB	11/7/2008	NWTPH-Heavy Oil	0.2	mg/L	J	
Pervious Asphalt CB	11/7/2008	Copper	5.3	ug/L	U	
Pervious Asphalt CB	11/7/2008	Lead	6.6	ug/L	J	
Pervious Asphalt CB	11/7/2008	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	11/7/2008	Zinc	24.5	ug/L		
Pervious Asphalt CB	11/7/2008	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Asphalt CB	11/7/2008	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	11/7/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	11/7/2008	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	11/7/2008	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	11/7/2008	Naphthalene	0.009	ug/L	U	
Pervious Asphalt CB	11/7/2008	Phenanthrene	0.018	ug/L		
Pervious Asphalt CB	11/7/2008	Benzo(a)anthracene	0.006	ug/L	U	
Pervious Asphalt CB	11/7/2008	Benzo(a)pyrene	0.006	ug/L	J	
Pervious Asphalt CB	11/7/2008	Benzo(g,h,i)perylene	0.012	ug/L		
Pervious Asphalt CB	11/7/2008	Benzo(b,k)fluoranthenes	0.024	ug/L		
Pervious Asphalt CB	11/7/2008	Chrysene	0.018	ug/L		
Pervious Asphalt CB	11/7/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	11/7/2008	Fluoranthene	0.033	ug/L		
Pervious Asphalt CB	11/7/2008	Indeno(1,2,3-c,d)pyrene	0.009	ug/L	J	
Pervious Asphalt CB	11/7/2008	Pyrene	0.022	ug/L		
Pervious Asphalt CB	11/7/2008	bis(2-Ethylhexyl)phthalate	1.16	ug/L		
Pervious Asphalt CB	11/7/2008	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt CB	11/7/2008	Diethylphthalate	0.072	ug/L	U	
Pervious Asphalt CB	11/7/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt CB	11/7/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Asphalt CB	11/7/2008	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete	11/6/2008	Hardness, Calculated	513	mg/L		
Pervious Concrete	11/6/2008	pH	11.6	Std. Units		
Pervious Concrete	11/6/2008	TSS	40.1	mg/L		
Pervious Concrete	11/6/2008	NWTPH-Diesel	0.06	mg/L	B	
Pervious Concrete	11/6/2008	NWTPH-Heavy Oil	0.1	mg/L	J	
Pervious Concrete	11/6/2008	Copper	10.4	ug/L	J	
Pervious Concrete	11/6/2008	Lead	3.3	ug/L	U	
Pervious Concrete	11/6/2008	Mercury	0.050	ug/L	U	
Pervious Concrete	11/6/2008	Zinc	2.9	ug/L	U	
Pervious Concrete	11/6/2008	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Concrete	11/6/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	11/6/2008	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	11/6/2008	Anthracene	0.004	ug/L	U	
Pervious Concrete	11/6/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete	11/6/2008	Naphthalene	0.008	ug/L	U	
Pervious Concrete	11/6/2008	Phenanthrene	0.007	ug/L	J	
Pervious Concrete	11/6/2008	Benzo(a)anthracene	0.004	ug/L	U	
Pervious Concrete	11/6/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	11/6/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	11/6/2008	Benzo(b,k)fluoranthenes	0.003	ug/L	J	
Pervious Concrete	11/6/2008	Chrysene	0.003	ug/L	U	
Pervious Concrete	11/6/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	11/6/2008	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	11/6/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	11/6/2008	Pyrene	0.005	ug/L	J	
Pervious Concrete	11/6/2008	bis(2-Ethylhexyl)phthalate	0.22	ug/L	J	
Pervious Concrete	11/6/2008	Butyl benzyl phthalate	0.17	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	11/6/2008	Diethylphthalate	0.200	ug/L	J	
Pervious Concrete	11/6/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	11/6/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete	11/6/2008	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete CB	11/7/2008	Hardness, Calculated	34.5	mg/L		
Pervious Concrete CB	11/7/2008	pH	7.6	Std. Units		
Pervious Concrete CB	11/7/2008	TSS	5.26	mg/L		
Pervious Concrete CB	11/7/2008	NWTPH-Diesel	0.12	mg/L	B	
Pervious Concrete CB	11/7/2008	NWTPH-Heavy Oil	0.7	mg/L		
Pervious Concrete CB	11/7/2008	Copper	5.3	ug/L	U	
Pervious Concrete CB	11/7/2008	Lead	3.3	ug/L	U	
Pervious Concrete CB	11/7/2008	Mercury	0.050	ug/L	U	
Pervious Concrete CB	11/7/2008	Zinc	38.2	ug/L		
Pervious Concrete CB	11/7/2008	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Concrete CB	11/7/2008	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	11/7/2008	Acenaphthylene	0.003	ug/L	J	
Pervious Concrete CB	11/7/2008	Anthracene	0.004	ug/L	U	
Pervious Concrete CB	11/7/2008	Fluorene	0.003	ug/L	U	
Pervious Concrete CB	11/7/2008	Naphthalene	0.017	ug/L		
Pervious Concrete CB	11/7/2008	Phenanthrene	0.015	ug/L		
Pervious Concrete CB	11/7/2008	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete CB	11/7/2008	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete CB	11/7/2008	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete CB	11/7/2008	Benzo(b,k)fluoranthenes	0.016	ug/L	J	
Pervious Concrete CB	11/7/2008	Chrysene	0.010	ug/L		
Pervious Concrete CB	11/7/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete CB	11/7/2008	Fluoranthene	0.022	ug/L		
Pervious Concrete CB	11/7/2008	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete CB	11/7/2008	Pyrene	0.020	ug/L		
Pervious Concrete CB	11/7/2008	bis(2-Ethylhexyl)phthalate	1.89	ug/L		
Pervious Concrete CB	11/7/2008	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete CB	11/7/2008	Diethylphthalate	0.112	ug/L	J	
Pervious Concrete CB	11/7/2008	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete CB	11/7/2008	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete CB	11/7/2008	Di-n-Octyl phthalate	0.193	ug/L	J	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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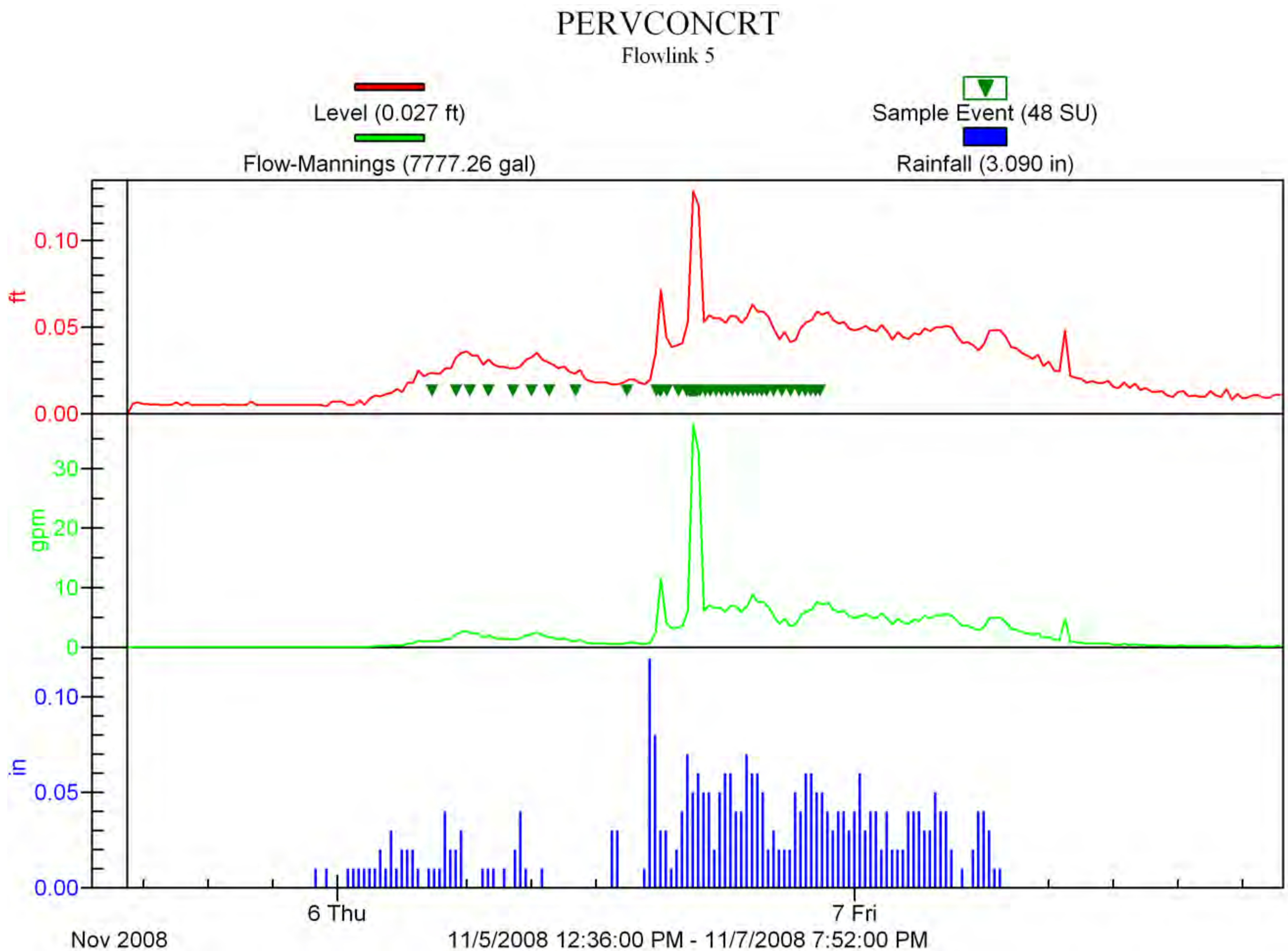
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STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #25
Date: November 20, 2008

Introduction

This report summarizes the storm event sampled on November 20, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #25.

Table 1. Storm Characteristics

Storm Date		11/20/2008
Time Storm Began		0800
Total Precipitation (in)		0.17
Duration (hrs)		8.5
Met Precipitation Criteria?	Precipitation ≥0.2"	No
Antecedent Period (hrs)		178.75
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #25. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for standard asphalt. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection. Twenty-seven sample aliquots were collected during the sampling period. These aliquots were collected over 91% of the total storm runoff volume.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	19.7
Duration of Flow (hrs)	NS	NS	NS	10
Total Volume (gallons) during Storm Event	NS	NS	NS	2162
Total Volume (gallons) during Sampling Event	NS	NS	NS	1959
Duration of Sampling Event (hrs)	NS	NS	NS	8.7
Number of Sample Aliquots Collected	NS	NS	NS	27
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	90.6%
Volume of Surface Runoff Collected in Vault (inches)	0	0	0	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Rain event was smaller than predicted. Most pacings were set too lean.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

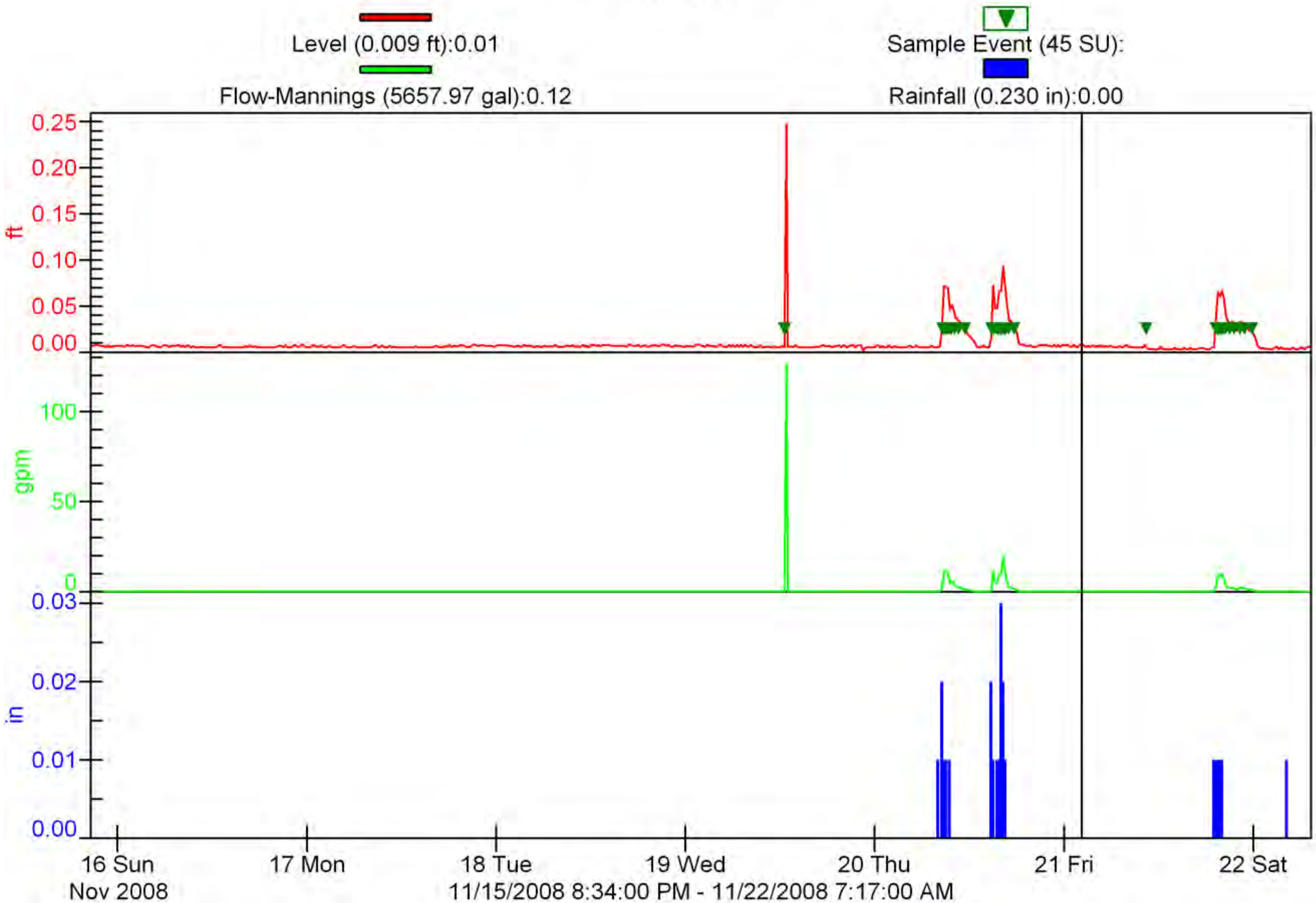
Table 3. Water Quality Data

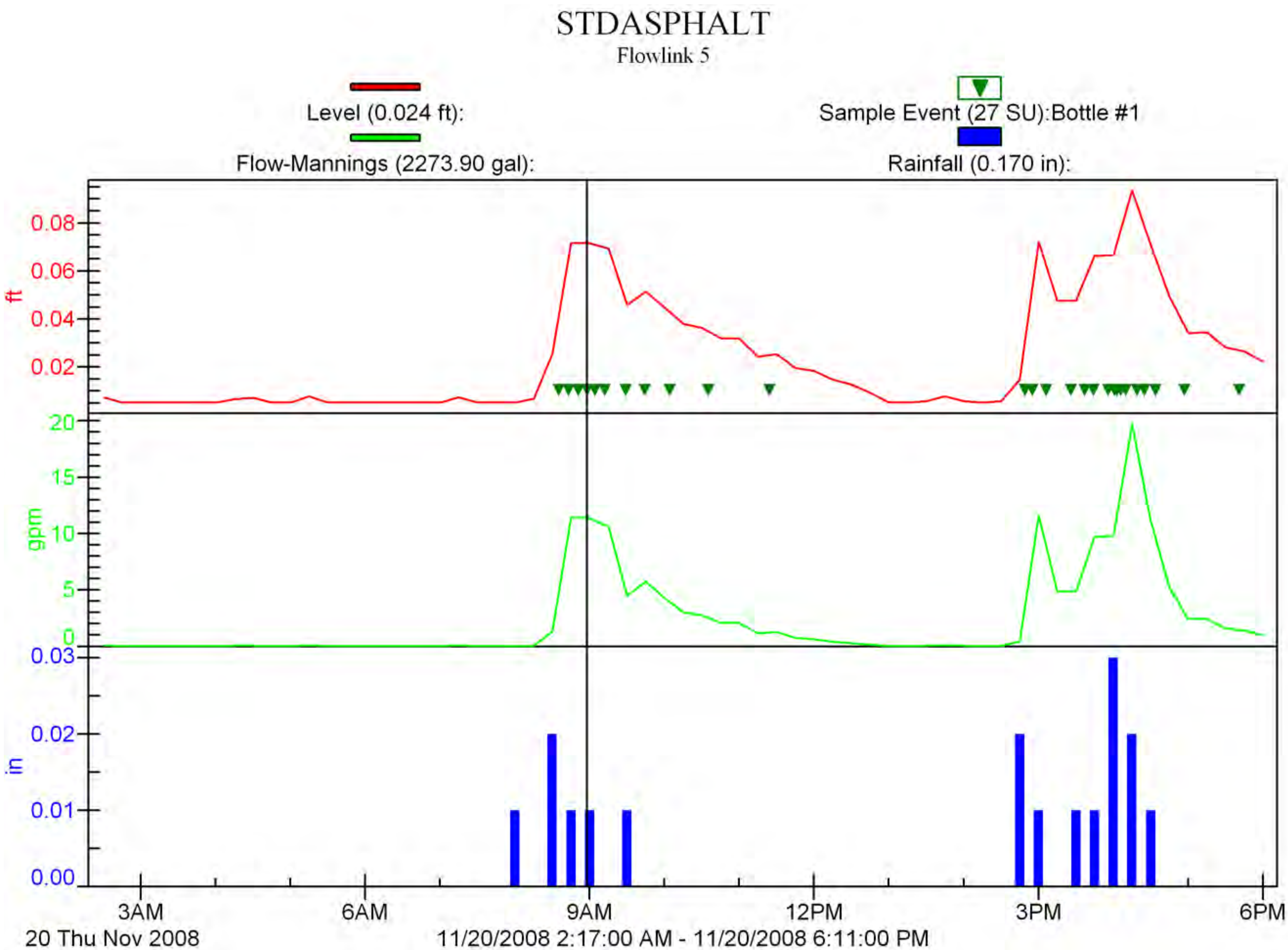
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	11/20/2008	Hardness, Calculated	11.4	mg/L		
Standard Asphalt	11/20/2008	pH	5.7	Std. Units		
Standard Asphalt	11/20/2008	TSS	43.5	mg/L		
Standard Asphalt	11/20/2008	NWTPH-Diesel	0.32	mg/L		
Standard Asphalt	11/20/2008	NWTPH-Heavy Oil	1.34	mg/L		
Standard Asphalt	11/20/2008	Copper	18.1	ug/L	J	
Standard Asphalt	11/20/2008	Lead	15.0	ug/L		
Standard Asphalt	11/20/2008	Mercury	0.050	ug/L	U	
Standard Asphalt	11/20/2008	Zinc	107	ug/L		
Standard Asphalt	11/20/2008	2-Methylnaphthalene	0.016	ug/L		
Standard Asphalt	11/20/2008	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	11/20/2008	Acenaphthylene	0.011	ug/L		
Standard Asphalt	11/20/2008	Anthracene	0.038	ug/L		
Standard Asphalt	11/20/2008	Fluorene	0.019	ug/L		
Standard Asphalt	11/20/2008	Naphthalene	0.034	ug/L		
Standard Asphalt	11/20/2008	Phenanthrene	0.348	ug/L		
Standard Asphalt	11/20/2008	Benzo(a)anthracene	0.233	ug/L		
Standard Asphalt	11/20/2008	Benzo(a)pyrene	0.297	ug/L		
Standard Asphalt	11/20/2008	Benzo(g,h,i)perylene	0.475	ug/L		
Standard Asphalt	11/20/2008	Benzo(b,k)fluoranthenes	0.960	ug/L		
Standard Asphalt	11/20/2008	Chrysene	0.554	ug/L		
Standard Asphalt	11/20/2008	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	11/20/2008	Fluoranthene	1.05	ug/L		
Standard Asphalt	11/20/2008	Indeno(1,2,3-c,d)pyrene	0.352	ug/L		
Standard Asphalt	11/20/2008	Pyrene	0.725	ug/L		
Standard Asphalt	11/20/2008	bis(2-Ethylhexyl)phthalate	4.84	ug/L		
Standard Asphalt	11/20/2008	Butyl benzyl phthalate	0.66	ug/L	J	
Standard Asphalt	11/20/2008	Diethylphthalate	0.325	ug/L	J	
Standard Asphalt	11/20/2008	Dimethyl phthalate	0.096	ug/L	J	
Standard Asphalt	11/20/2008	Di-n-butylphthalate	0.22	ug/L	J	
Standard Asphalt	11/20/2008	Di-n-Octyl phthalate	0.750	ug/L	J	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

STDASPHALT

Flowlink 5

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Sample Event (27 SU):Bottle #1
Flow-Mannings (2273.90 gal):
Rainfall (0.170 in):
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0.06
0.04
0.02
gpm
20
15
10
5
0
in
0.03
0.02
0.01
0.00
3AM
6AM
9AM
12PM
3PM
6PM
20 Thu Nov 2008
11/20/2008 2:17:00 AM - 11/20/2008 6:11:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #26
Date: December 12-13, 2008

Introduction

This report summarizes the storm event sampled on December 12-13, 2008 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #26.

Table 1. Storm Characteristics

Storm Date		12/12-12/13-2008
Time Storm Began		0915
Total Precipitation (in)		0.36
Duration (hrs)		22.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		46
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #26. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for standard asphalt. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	19.15
Duration of Flow (hrs)	NS	NS	NS	27.5*
Total Volume (gallons) during Storm Event	NS	NS	NS	6110
Total Volume (gallons) during Sampling Event	NS	NS	NS	5684
Duration of Sampling Event (hrs)	NS	NS	NS	23
Number of Sample Aliquots Collected	NS	NS	NS	34
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	93.0%
Volume of Surface Runoff Collected in Vault (inches)	1	22+	2	

Key: NS = Not Sampled

*Flow exceeded 24 hrs.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

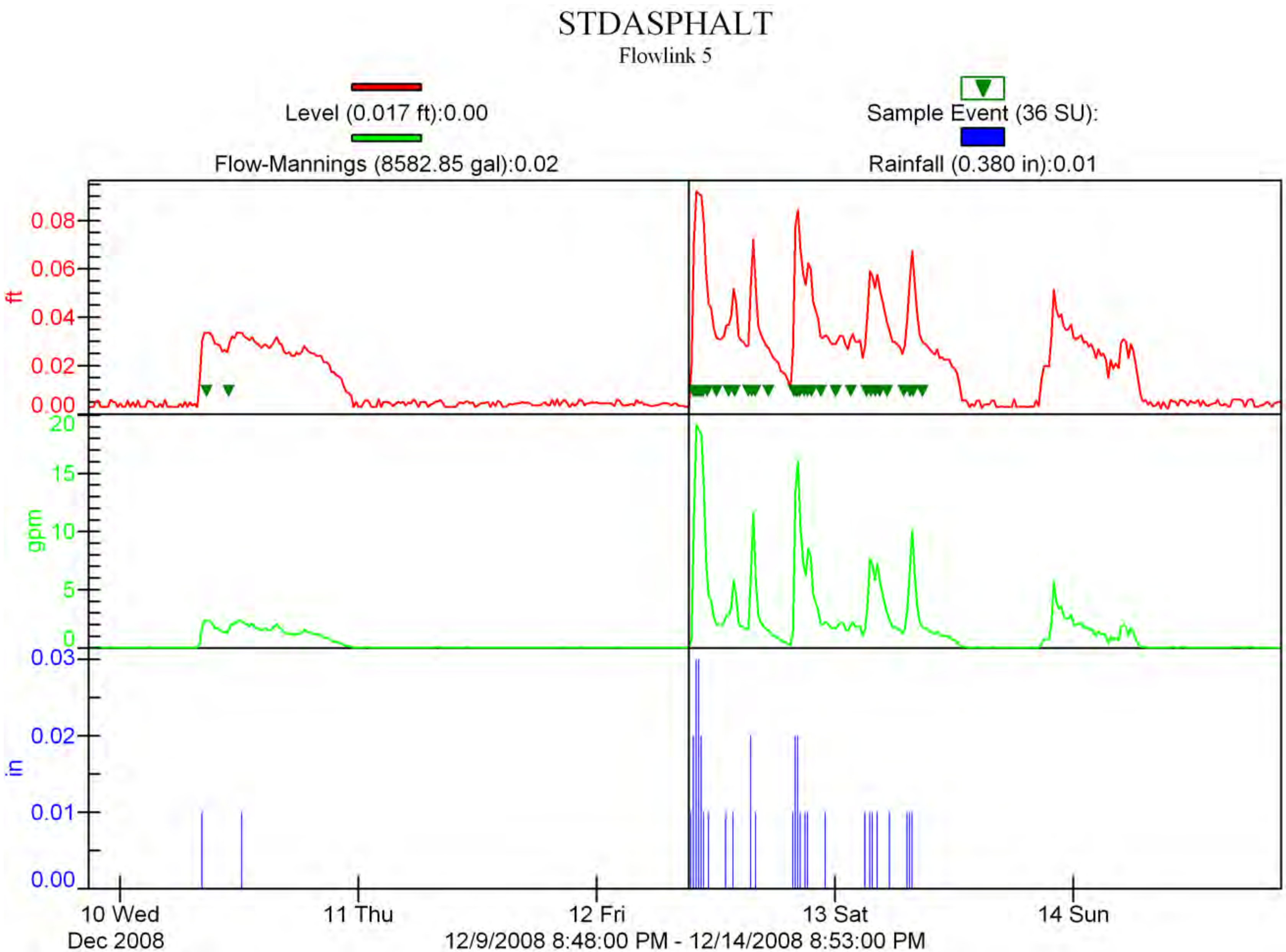
- Rain event was smaller than predicted. Most pacings were set too lean.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	12/13/2008	Hardness, Calculated	8.12	mg/L		
Standard Asphalt	12/13/2008	pH	5.7	Std. Units		
Standard Asphalt	12/13/2008	TSS	22.2	mg/L		
Standard Asphalt	12/13/2008	NWTPH-Diesel	0.16	mg/L	B	
Standard Asphalt	12/13/2008	NWTPH-Heavy Oil	0.54	mg/L		
Standard Asphalt	12/13/2008	Copper	5.3	ug/L	U	
Standard Asphalt	12/13/2008	Lead	6.8	ug/L	J	
Standard Asphalt	12/13/2008	Mercury	0.050	ug/L	U	
Standard Asphalt	12/13/2008	Zinc	43.7	ug/L		
Standard Asphalt	12/13/2008	2-Methylnaphthalene	0.002	ug/L	U	
Standard Asphalt	12/13/2008	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	12/13/2008	Acenaphthylene	0.002	ug/L	U	
Standard Asphalt	12/13/2008	Anthracene	0.003	ug/L	U	
Standard Asphalt	12/13/2008	Fluorene	0.002	ug/L	U	
Standard Asphalt	12/13/2008	Naphthalene	0.004	ug/L	U	
Standard Asphalt	12/13/2008	Phenanthrene	0.102	ug/L		
Standard Asphalt	12/13/2008	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	12/13/2008	Benzo(a)pyrene	0.002	ug/L	U	
Standard Asphalt	12/13/2008	Benzo(g,h,i)perylene	0.003	ug/L	U	
Standard Asphalt	12/13/2008	Benzo(b,k)fluoranthenes	0.235	ug/L		
Standard Asphalt	12/13/2008	Chrysene	0.140	ug/L		
Standard Asphalt	12/13/2008	Dibenz(a,h)anthracene	0.003	ug/L	U	
Standard Asphalt	12/13/2008	Fluoranthene	0.270	ug/L		
Standard Asphalt	12/13/2008	Indeno(1,2,3-c,d)pyrene	0.003	ug/L	U	
Standard Asphalt	12/13/2008	Pyrene	0.179	ug/L		
Standard Asphalt	12/13/2008	bis(2-Ethylhexyl)phthalate	2.7	ug/L		
Standard Asphalt	12/13/2008	Butyl benzyl phthalate	0.6	ug/L	B	
Standard Asphalt	12/13/2008	Diethylphthalate	0.3	ug/L	J	
Standard Asphalt	12/13/2008	Dimethyl phthalate	0.0	ug/L	U	
Standard Asphalt	12/13/2008	Di-n-butylphthalate	0.2	ug/L	J	
Standard Asphalt	12/13/2008	Di-n-Octyl phthalate	0.3	ug/L	B	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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0.04
0.02
0.00
gpm
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5
0
in
0.03
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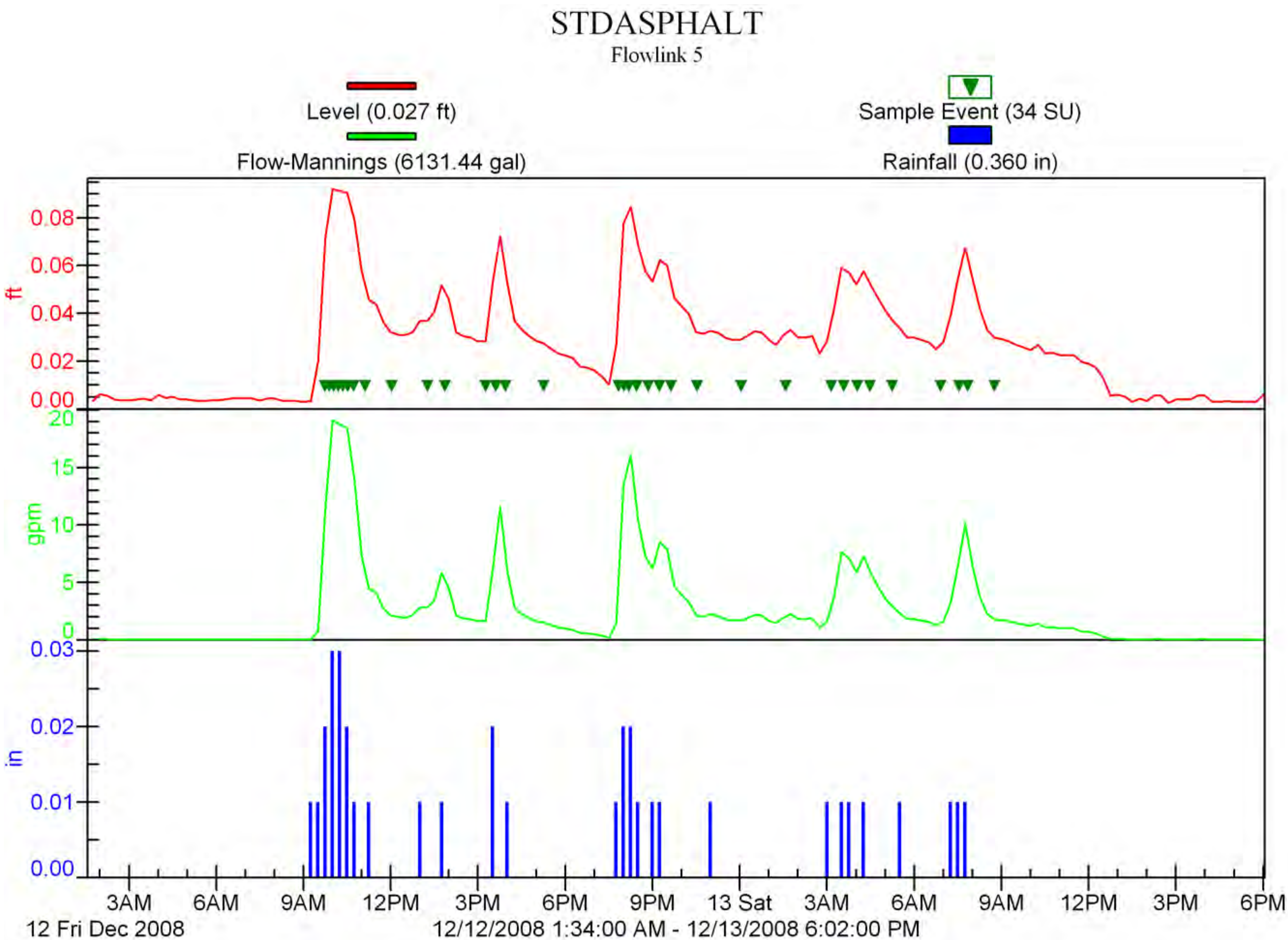
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12 Fri Dec 2008
12/12/2008 1:34:00 AM - 12/13/2008 6:02:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #27
Date: March 14, 2009

Introduction

This report summarizes the storm event sampled on March 14, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #27.

Table 1. Storm Characteristics

Storm Date		3/14/2009
Time Storm Began		0730
Total Precipitation (in)		>0.20*
Duration (hrs)		>14 *
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		138.5
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

* Storm duration was long and fairly drawn out. Sampling events varied by pavement type. All storm durations exceeded 0.20 inches.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #27. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figures 2, 3, 4, and 5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	7.90	12.13	13.04	45.4
Duration of Flow (hrs)	13.25	17	22	32.8
Total Volume (gallons) during Storm Event	2792	7555	2817	11,514
Total Volume (gallons) during Sampling Event	2099	3288	2661	8409
Duration of Sampling Event (hrs)	10	7.8	20.8	26.6
Number of Sample Aliquots Collected	48	48	23	50
Percentage of Storm's Total Volume over which Samples were Collected	75.2%	43.5%	94.5%	73%
Volume of Surface Runoff Collected in Vault (inches)	NM	22+	12	NS

Key: NM = Not Measured

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt
- Pervious Pavers
- Pervious Concrete
- Pervious Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Rain event was larger than predicted. Most pacings were set too aggressive.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	3/15/2009	Hardness, calculated	16.0	mg/L		
Pervious Asphalt	3/15/2009	pH	7.0	Std. Units		
Pervious Asphalt	3/15/2009	NWTPH-Diesel	0.1	mg/L	B	
Pervious Asphalt	3/15/2009	NWTPH-Heavy Oil	0.3	mg/L	J	
Pervious Asphalt	3/15/2009	Copper	2.57	ug/L	B	
Pervious Asphalt	3/15/2009	Lead	0.140	ug/L	J	
Pervious Asphalt	3/15/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	3/15/2009	Zinc	3.08	ug/L	B	
Pervious Asphalt	3/15/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt	3/15/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Naphthalene	0.011	ug/L	U	
Pervious Asphalt	3/15/2009	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	3/15/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	3/15/2009	Benzo(g,h,i)perylene	0.009	ug/L	U	
Pervious Asphalt	3/15/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt	3/15/2009	Dibenz(a,h)anthracene	0.008	ug/L	U	
Pervious Asphalt	3/15/2009	Fluoranthene	0.006	ug/L	U	
Pervious Asphalt	3/15/2009	Indeno(1,2,3-c,d)pyrene	0.008	ug/L	U	
Pervious Asphalt	3/15/2009	Pyrene	0.004	ug/L	U	
Pervious Asphalt	3/15/2009	bis(2-Ethylhexyl)phthalate	0.45	ug/L	U	
Pervious Asphalt	3/15/2009	Butyl benzyl phthalate	0.19	ug/L	U	
Pervious Asphalt	3/15/2009	Diethylphthalate	1.07	ug/L		
Pervious Asphalt	3/15/2009	Dimethyl phthalate	0.034	ug/L	U	
Pervious Asphalt	3/15/2009	Di-n-butylphthalate	0.59	ug/L	U	
Pervious Asphalt	3/15/2009	Di-n-Octyl phthalate	0.093	ug/L	U	
Pervious Asphalt CB	3/15/2009	Hardness, calculated	3.79	mg/L		
Pervious Asphalt CB	3/15/2009	pH	6.9	Std. Units		
Pervious Asphalt CB	3/15/2009	TSS	2.30	mg/L		
Pervious Asphalt CB	3/15/2009	NWTPH-Diesel	0.1	mg/L	B	
Pervious Asphalt CB	3/15/2009	NWTPH-Heavy Oil	0.1	mg/L	J	
Pervious Asphalt CB	3/15/2009	Copper	2.03	ug/L	B	
Pervious Asphalt CB	3/15/2009	Lead	0.270	ug/L	J	
Pervious Asphalt CB	3/15/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	3/15/2009	Zinc	12.0	ug/L		
Pervious Asphalt CB	3/15/2009	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Asphalt CB	3/15/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	3/15/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	3/15/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	3/15/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	3/15/2009	Naphthalene	0.013	ug/L	U	
Pervious Asphalt CB	3/15/2009	Phenanthrene	0.013	ug/L		
Pervious Asphalt CB	3/15/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt CB	3/15/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt CB	3/15/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt CB	3/15/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	J	
Pervious Asphalt CB	3/15/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt CB	3/15/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	3/15/2009	Fluoranthene	0.013	ug/L		
Pervious Asphalt CB	3/15/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt CB	3/15/2009	Pyrene	0.007	ug/L	J	
Pervious Asphalt CB	3/15/2009	bis(2-Ethylhexyl)phthalate	0.16	ug/L	U	
Pervious Asphalt CB	3/15/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt CB	3/15/2009	Diethylphthalate	0.136	ug/L	J	

U = value is less than the detection limit

UJ - value is less than the detection limit and is considered estimated

J = value is considered estimated

B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	3/15/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt CB	3/15/2009	Di-n-butylphthalate	0.50	ug/L	U	
Pervious Asphalt CB	3/15/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete	3/14/2009	Hardness, calculated	831	mg/L		
Pervious Concrete	3/14/2009	pH	11.8	Std. Units		
Pervious Concrete	3/14/2009	TSS	37.3	mg/L		
Pervious Concrete	3/14/2009	NWTPH-Diesel	0.2	mg/L	B	
Pervious Concrete	3/14/2009	NWTPH-Heavy Oil	0.1	mg/L	J	
Pervious Concrete	3/14/2009	Copper	5.82	ug/L		
Pervious Concrete	3/14/2009	Lead	0.090	ug/L	J	
Pervious Concrete	3/14/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	3/14/2009	Zinc	1.28	ug/L	B	
Pervious Concrete	3/14/2009	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Concrete	3/14/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	3/14/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	3/14/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	3/14/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	3/14/2009	Naphthalene	0.010	ug/L	U	
Pervious Concrete	3/14/2009	Phenanthrene	0.004	ug/L	J	
Pervious Concrete	3/14/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	3/14/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	3/14/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	3/14/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	3/14/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	3/14/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	3/14/2009	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	3/14/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	3/14/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete	3/14/2009	bis(2-Ethylhexyl)phthalate	0.16	ug/L	U	
Pervious Concrete	3/14/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	3/14/2009	Diethylphthalate	0.086	ug/L	J	
Pervious Concrete	3/14/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	3/14/2009	Di-n-butylphthalate	0.50	ug/L	U	
Pervious Concrete	3/14/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete CB	3/15/2009	Hardness, calculated	38.9	mg/L		
Pervious Concrete CB	3/15/2009	pH	7.6	Std. Units		
Pervious Concrete CB	3/15/2009	TSS	28.8	mg/L		
Pervious Concrete CB	3/15/2009	NWTPH-Diesel	0.1	mg/L	B	
Pervious Concrete CB	3/15/2009	NWTPH-Heavy Oil	0.2	mg/L	J	
Pervious Concrete CB	3/15/2009	Copper	8.96	ug/L		
Pervious Concrete CB	3/15/2009	Lead	1.98	ug/L	B	
Pervious Concrete CB	3/15/2009	Mercury	0.050	ug/L	U	
Pervious Concrete CB	3/15/2009	Zinc	43.8	ug/L		
Pervious Concrete CB	3/15/2009	2-Methylnaphthalene	0.003	ug/L	U	J
Pervious Concrete CB	3/15/2009	Acenaphthene	0.003	ug/L	U	J
Pervious Concrete CB	3/15/2009	Acenaphthylene	0.003	ug/L	U	J
Pervious Concrete CB	3/15/2009	Anthracene	0.004	ug/L	U	J
Pervious Concrete CB	3/15/2009	Fluorene	0.003	ug/L	U	J
Pervious Concrete CB	3/15/2009	Naphthalene	0.010	ug/L	U	J
Pervious Concrete CB	3/15/2009	Phenanthrene	0.017	ug/L		J
Pervious Concrete CB	3/15/2009	Benzo(a)anthracene	0.004	ug/L	J	
Pervious Concrete CB	3/15/2009	Benzo(a)pyrene	0.004	ug/L	U	J
Pervious Concrete CB	3/15/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	J
Pervious Concrete CB	3/15/2009	Benzo(b,k)fluoranthenes	0.014	ug/L	J	
Pervious Concrete CB	3/15/2009	Chrysene	0.005	ug/L	J	
Pervious Concrete CB	3/15/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	J
Pervious Concrete CB	3/15/2009	Fluoranthene	0.024	ug/L		J
Pervious Concrete CB	3/15/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	J

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	3/15/2009	Pyrene	0.016	ug/L		J
Pervious Concrete CB	3/15/2009	bis(2-Ethylhexyl)phthalate	0.72	ug/L	U	J
Pervious Concrete CB	3/15/2009	Butyl benzyl phthalate	0.18	ug/L	J	
Pervious Concrete CB	3/15/2009	Diethylphthalate	0.097	ug/L	J	
Pervious Concrete CB	3/15/2009	Dimethyl phthalate	0.031	ug/L	U	J
Pervious Concrete CB	3/15/2009	Di-n-butylphthalate	0.50	ug/L	U	J
Pervious Concrete CB	3/15/2009	Di-n-Octyl phthalate	0.084	ug/L	U	J
Pervious Pavers	3/15/2009	Hardness, calculated	64.4	mg/L		
Pervious Pavers	3/15/2009	pH	7.3	Std. Units		
Pervious Pavers	3/15/2009	TSS	4.50	mg/L		
Pervious Pavers	3/15/2009	NWTPH-Diesel	0.1	mg/L	B	
Pervious Pavers	3/15/2009	NWTPH-Heavy Oil	0.1	mg/L	J	
Pervious Pavers	3/15/2009	Copper	2.79	ug/L	B	
Pervious Pavers	3/15/2009	Lead	0.250	ug/L	J	
Pervious Pavers	3/15/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	3/15/2009	Zinc	3.28	ug/L	B	
Pervious Pavers	3/15/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	3/15/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Naphthalene	0.010	ug/L	U	
Pervious Pavers	3/15/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	3/15/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	3/15/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	3/15/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	3/15/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	3/15/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	3/15/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	3/15/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	3/15/2009	bis(2-Ethylhexyl)phthalate	0.50	ug/L	U	
Pervious Pavers	3/15/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers	3/15/2009	Diethylphthalate	0.098	ug/L	J	
Pervious Pavers	3/15/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	3/15/2009	Di-n-butylphthalate	0.50	ug/L	U	
Pervious Pavers	3/15/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	3/15/2009	Hardness, calculated	10.8	mg/L		
Standard Asphalt	3/15/2009	pH	6.6	Std. Units		
Standard Asphalt	3/15/2009	TSS	12.4	mg/L		
Standard Asphalt	3/15/2009	NWTPH-Diesel	0.3	mg/L		
Standard Asphalt	3/15/2009	NWTPH-Heavy Oil	0.4	mg/L		
Standard Asphalt	3/15/2009	Copper	22.0	ug/L		
Standard Asphalt	3/15/2009	Lead	2.86	ug/L	B	
Standard Asphalt	3/15/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	3/15/2009	Zinc	60.2	ug/L		
Standard Asphalt	3/15/2009	2-Methylnaphthalene	0.004	ug/L	J	
Standard Asphalt	3/15/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	3/15/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	3/15/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	3/15/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	3/15/2009	Naphthalene	0.010	ug/L	U	
Standard Asphalt	3/15/2009	Phenanthrene	0.030	ug/L		
Standard Asphalt	3/15/2009	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	3/15/2009	Benzo(a)pyrene	0.004	ug/L	U	
Standard Asphalt	3/15/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Standard Asphalt	3/15/2009	Benzo(b,k)fluoranthenes	0.012	ug/L	J	

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	3/15/2009	Chrysene	0.007	ug/L	J	
Standard Asphalt	3/15/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	3/15/2009	Fluoranthene	0.036	ug/L		
Standard Asphalt	3/15/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Standard Asphalt	3/15/2009	Pyrene	0.016	ug/L		
Standard Asphalt	3/15/2009	bis(2-Ethylhexyl)phthalate	1.16	ug/L	U	
Standard Asphalt	3/15/2009	Butyl benzyl phthalate	0.35	ug/L	J	
Standard Asphalt	3/15/2009	Diethylphthalate	0.282	ug/L	J	
Standard Asphalt	3/15/2009	Dimethyl phthalate	0.067	ug/L	J	
Standard Asphalt	3/15/2009	Di-n-butylphthalate	0.59	ug/L	U	
Standard Asphalt	3/15/2009	Di-n-Octyl phthalate	0.216	ug/L	J	

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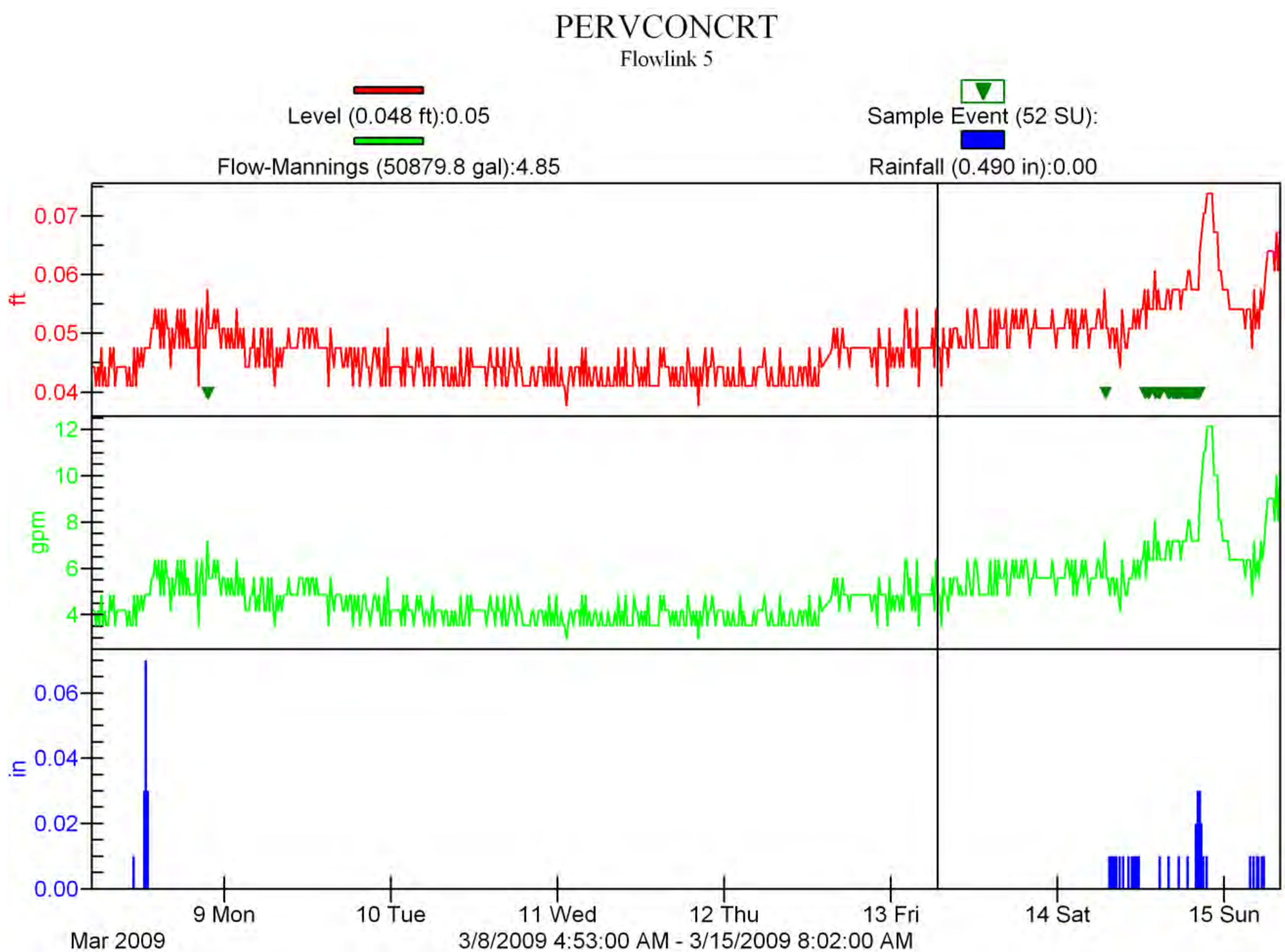

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Flow-Mannings (50879.8 gal):4.85
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ft
0.07
0.06
0.05
0.04
gpm
12
10
8
6
4
in
0.06
0.04
0.02
0.00
9 Mon
10 Tue
11 Wed
12 Thu
13 Fri
14 Sat
15 Sun
Mar 2009
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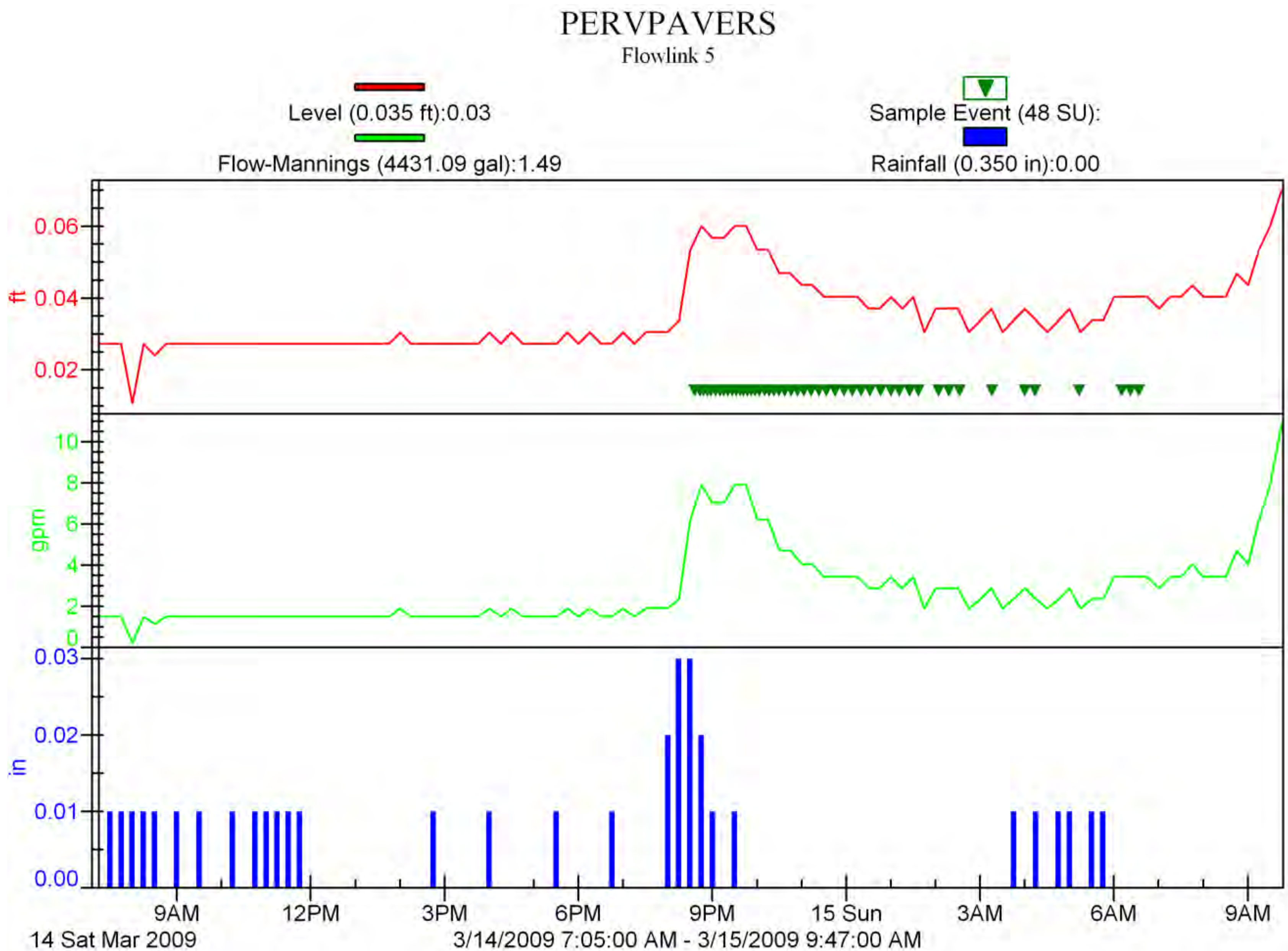
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Flow-Mannings (4431.09 gal):1.49
Sample Event (48 SU):
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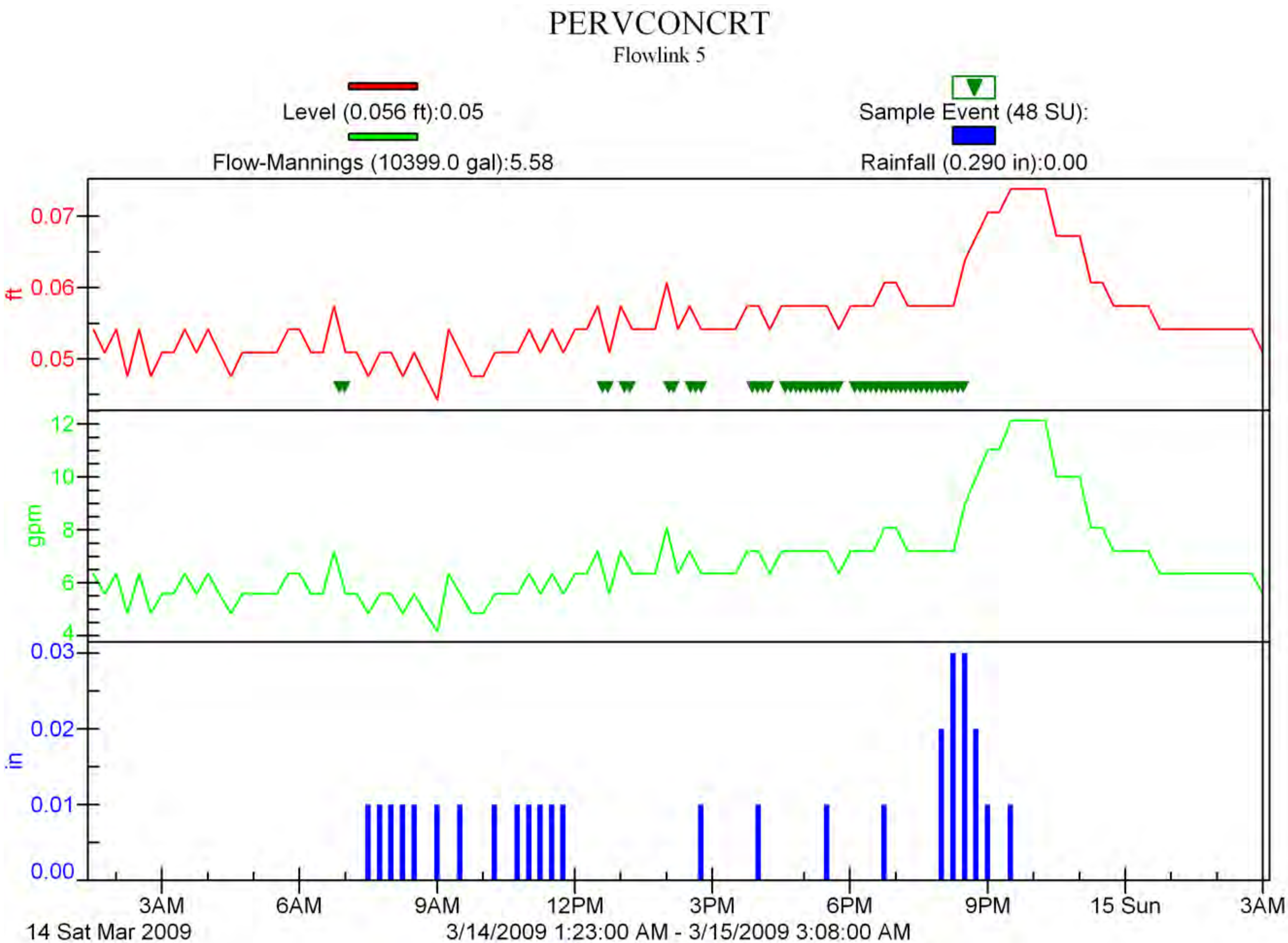
ft
0.06
0.04
0.02
gpm
10
8
6
4
2
0
in
0.03
0.02
0.01
0.00
9AM
12PM
3PM
6PM
9PM
15 Sun
3AM
6AM
9AM
14 Sat Mar 2009
3/14/2009 7:05:00 AM - 3/15/2009 9:47:00 AM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Flow-Mannings (10399.0 gal):5.58
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ft
0.07
0.06
0.05
gpm
12
10
8
6
4
in
0.03
0.02
0.01
0.00
3AM
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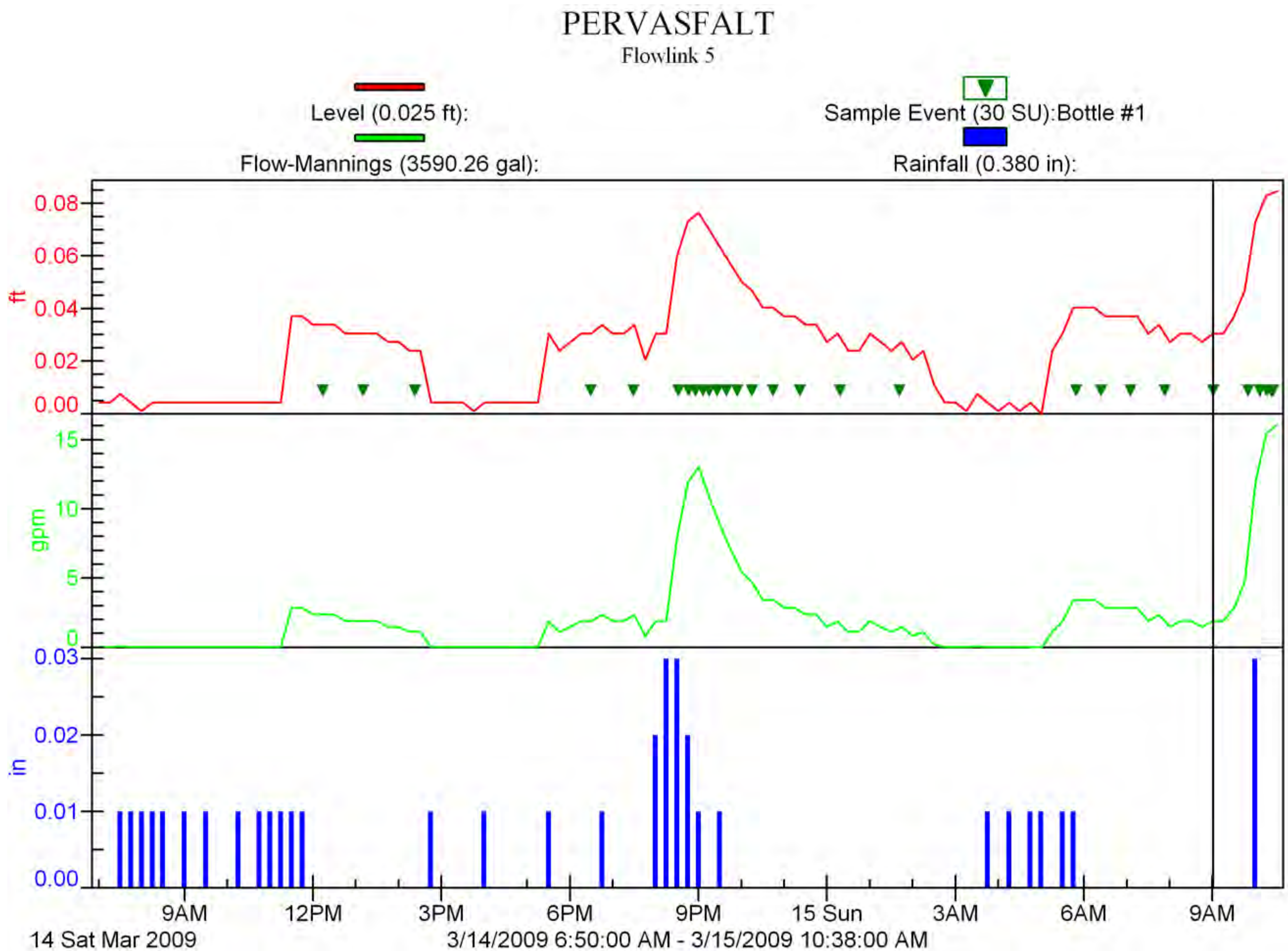
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Flow-Mannings (3590.26 gal):
Sample Event (30 SU):Bottle #1
Rainfall (0.380 in):
ft
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0.06
0.04
0.02
0.00
gpm
15
10
5
0
in
0.03
0.02
0.01
0.00
9AM
12PM
3PM
6PM
9PM
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9AM
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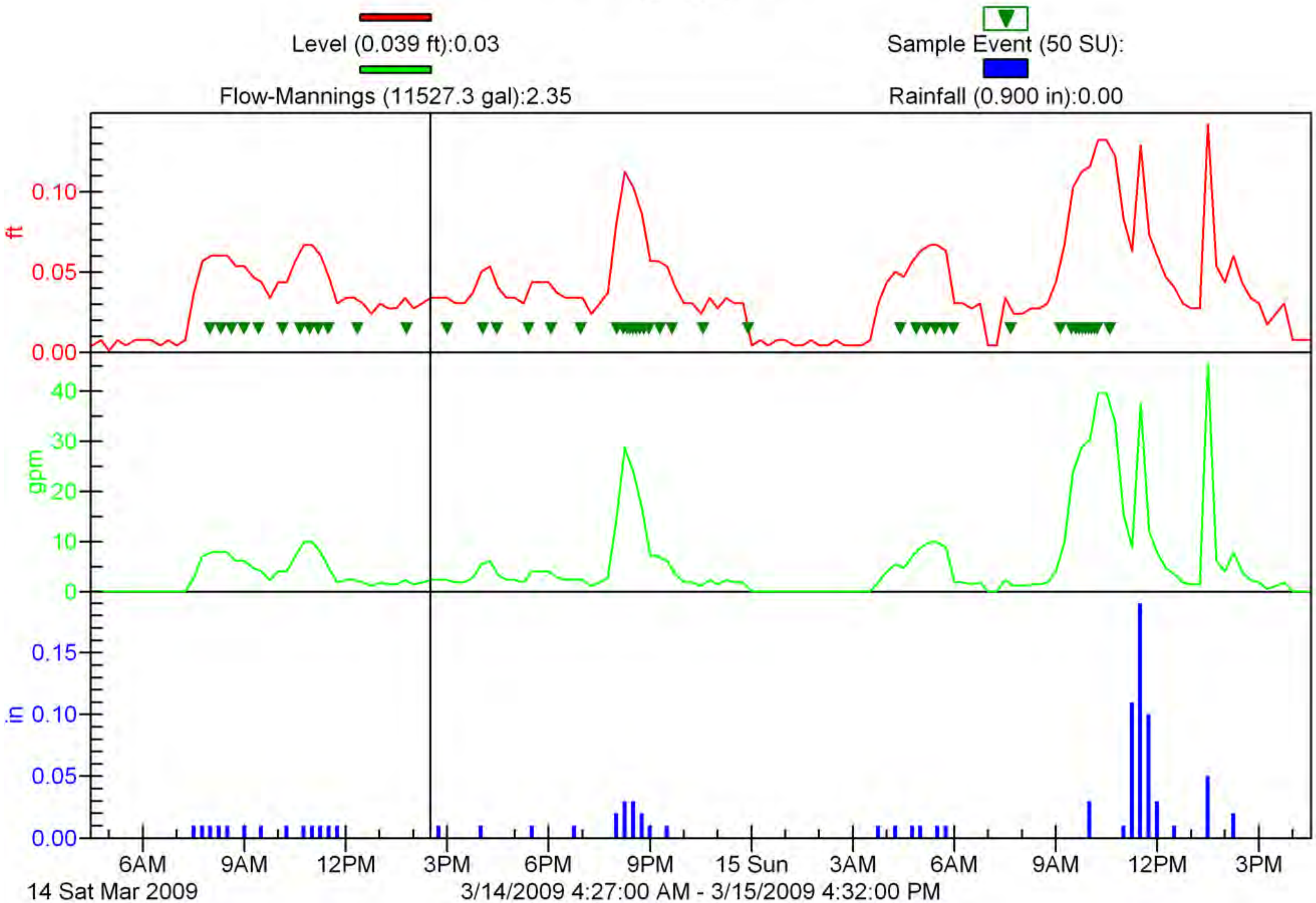
3/14/2009 6:50:00 AM - 3/15/2009 10:38:00 AM

STDASPHALT

Flowlink 5



STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #28
Date: March 28, 2009

Introduction

This report summarizes the storm event sampled on March 28, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #28.

Table 1. Storm Characteristics

Storm Date		3/26-3/29/2009
Time Storm Began		0745
Total Precipitation (in)		0.92*
Duration (hrs)		19.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		66
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

* Partial storm events used for many of the sampling events due to the size of the storm. Refer to the storm summary data sheet for each sampling site.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #28. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 2, and 4 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	5.4	NS	16.73	27.0
Duration of Flow (hrs)	7	NS	12	7
Total Volume (gallons) during Storm Event	1445*	NS	5970*	3973*
Total Volume (gallons) during Sampling Event	1084	NS	3,461	3,500
Duration of Sampling Event (hrs)	4.4	NS	7	6
Number of Sample Aliquots Collected	48	NS	48	48
Percentage of Storm's Total Volume over which Samples were Collected	71.5%*	NS	58.0%*	88.1%*
Volume of Surface Runoff Collected in Vault (inches)	0	NM	0	NS

Key: NS = Not Sampled

NM = Not Measured

* Partial storm event used.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt
- Pervious Asphalt
- Pervious Pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- Rain event was larger than predicted. Most pacings were set too aggressive.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	3/28/2009	Hardness, calculated	12.3	mg/L		
Pervious Asphalt	3/28/2009	pH	7.0	Std. Units		
Pervious Asphalt	3/28/2009	TSS	2.80	mg/L		
Pervious Asphalt	3/28/2009	NWTPH-Diesel	0.07	mg/L	B	
Pervious Asphalt	3/28/2009	NWTPH-Heavy Oil	0.13	mg/L	J	
Pervious Asphalt	3/28/2009	Copper	1.92	ug/L		
Pervious Asphalt	3/28/2009	Lead	0.170	ug/L	J	
Pervious Asphalt	3/28/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	3/28/2009	Zinc	2.38	ug/L		
Pervious Asphalt	3/28/2009	2-Methylnaphthalene	0.003	ug/L	U	J
Pervious Asphalt	3/28/2009	Acenaphthene	0.003	ug/L	U	J
Pervious Asphalt	3/28/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	3/28/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt	3/28/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt	3/28/2009	Naphthalene	0.003	ug/L	J	
Pervious Asphalt	3/28/2009	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	3/28/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	3/28/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	3/28/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	3/28/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	3/28/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt	3/28/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	3/28/2009	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	3/28/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	3/28/2009	Pyrene	0.004	ug/L	U	
Pervious Asphalt	3/28/2009	bis(2-Ethylhexyl)phthalate	0.26	ug/L	J	
Pervious Asphalt	3/28/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt	3/28/2009	Diethylphthalate	0.855	ug/L	J	
Pervious Asphalt	3/28/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt	3/28/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Asphalt	3/28/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Pavers	3/28/2009	Hardness, calculated	55.2	mg/L		
Pervious Pavers	3/28/2009	pH	7.7	Std. Units		
Pervious Pavers	3/28/2009	NWTPH-Diesel	0.04	mg/L	J	
Pervious Pavers	3/28/2009	NWTPH-Heavy Oil	0.09	mg/L	J	
Pervious Pavers	3/28/2009	Copper	2.60	ug/L		
Pervious Pavers	3/28/2009	Lead	0.270	ug/L	J	
Pervious Pavers	3/28/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	3/28/2009	Zinc	2.15	ug/L		
Pervious Pavers	3/28/2009	2-Methylnaphthalene	0.003	ug/L	U	J
Pervious Pavers	3/28/2009	Acenaphthene	0.003	ug/L	U	J
Pervious Pavers	3/28/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	3/28/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	3/28/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	3/28/2009	Naphthalene	0.007	ug/L	J	
Pervious Pavers	3/28/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	3/28/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	3/28/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	3/28/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	3/28/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	3/28/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	3/28/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	3/28/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	3/28/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	3/28/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	3/28/2009	bis(2-Ethylhexyl)phthalate	0.99	ug/L	J	
Pervious Pavers	3/28/2009	Butyl benzyl phthalate	0.35	ug/L	J	
Pervious Pavers	3/28/2009	Diethylphthalate	0.204	ug/L	J	

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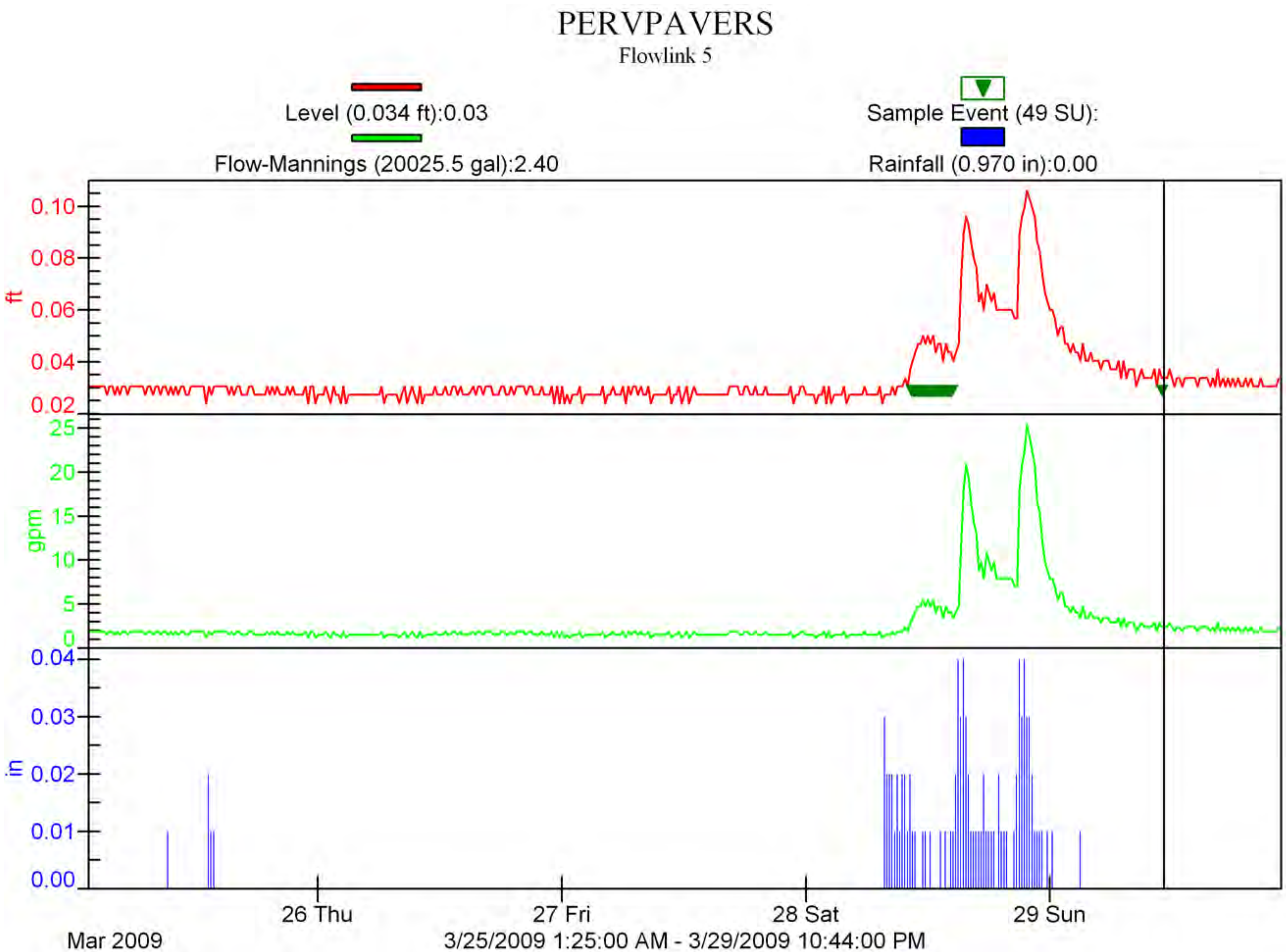
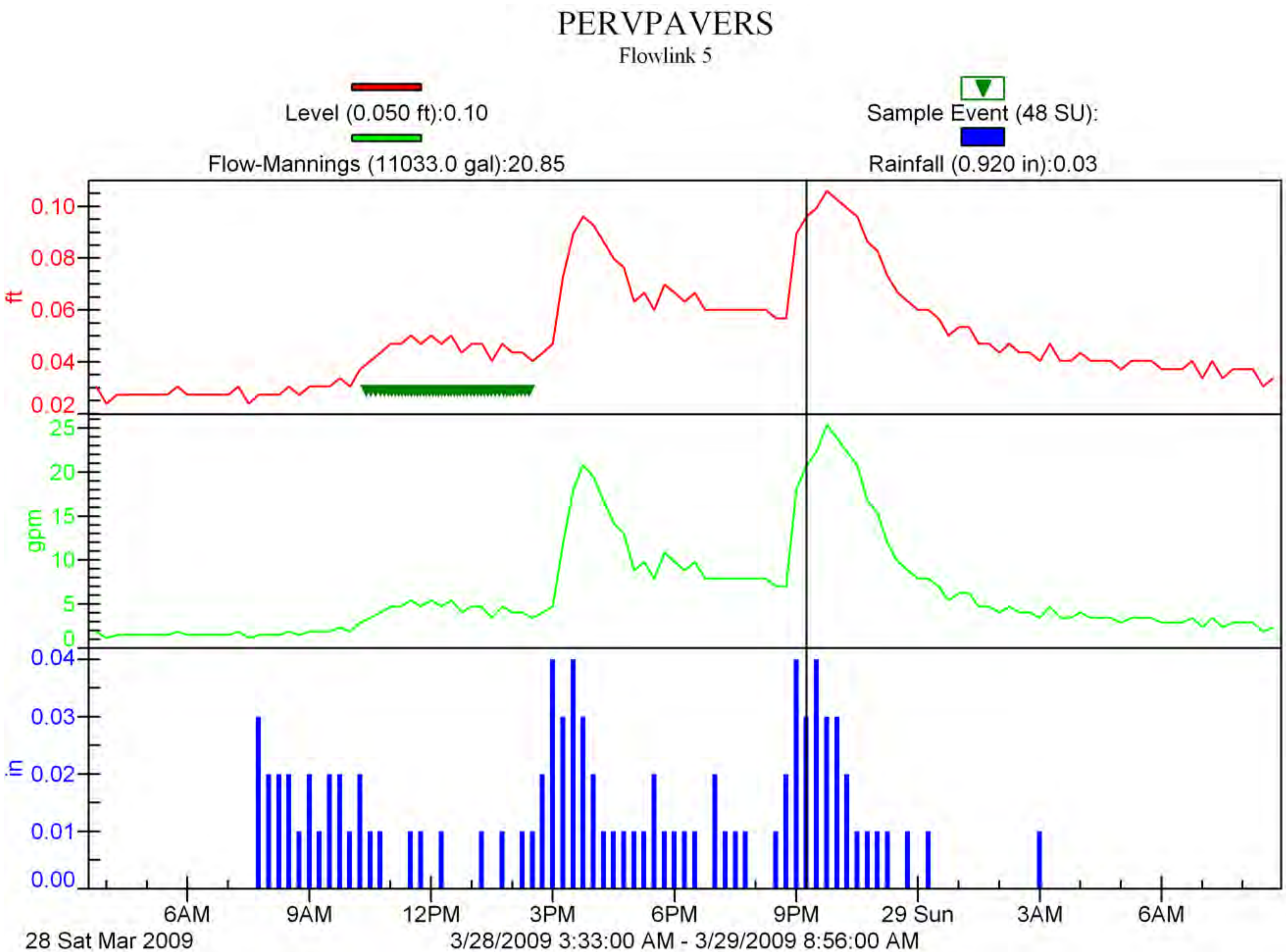
Table 3. Water Quality Data

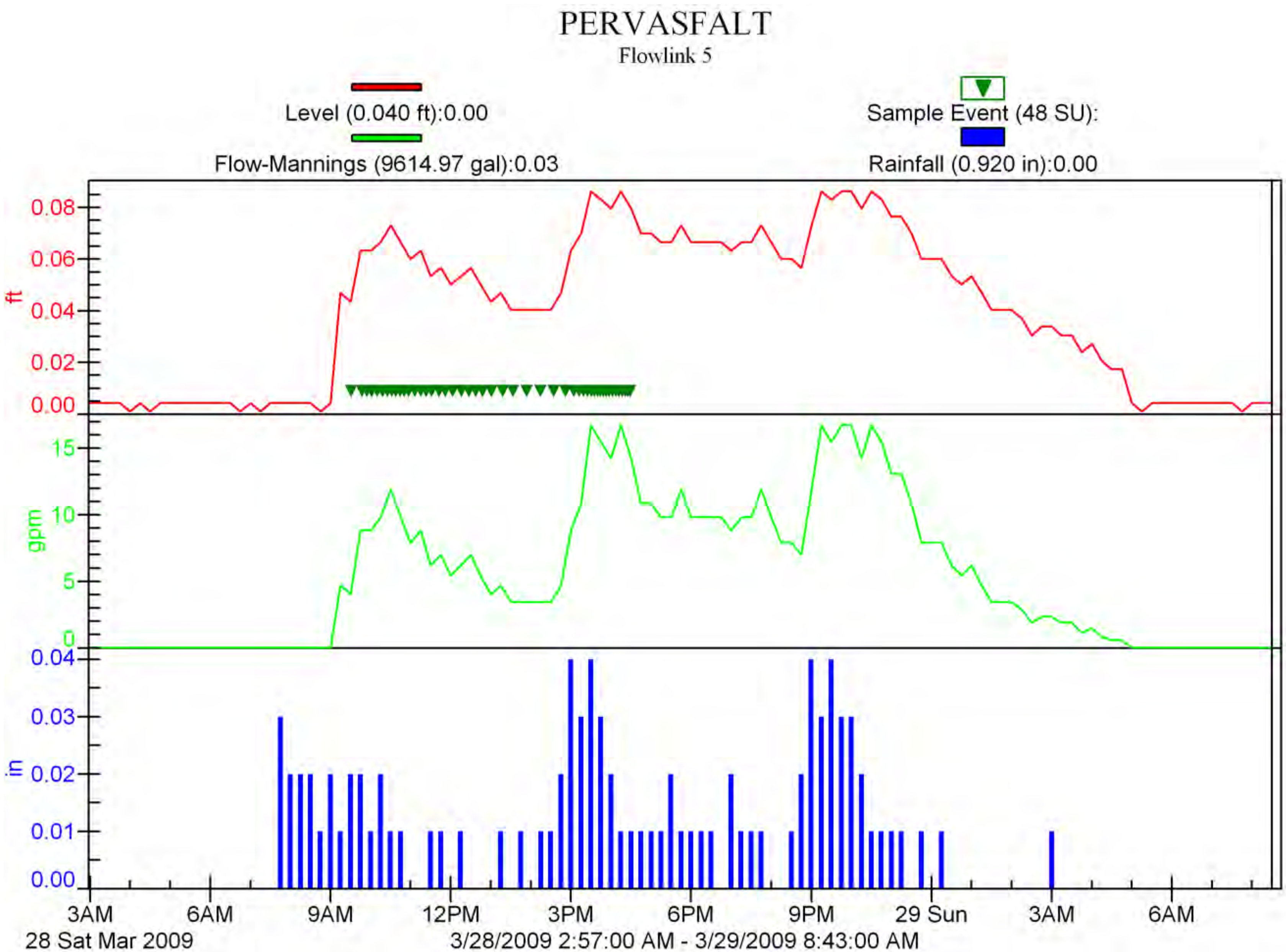
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	3/28/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	3/28/2009	Di-n-butylphthalate	0.38	ug/L	J	
Pervious Pavers	3/28/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	3/28/2009	Hardness, calculated	9.21	mg/L		
Standard Asphalt	3/28/2009	pH	6.6	Std. Units		
Standard Asphalt	3/28/2009	TSS	10.4	mg/L		
Standard Asphalt	3/28/2009	NWTPH-Diesel	0.16	mg/L	B	
Standard Asphalt	3/28/2009	NWTPH-Heavy Oil	0.32	mg/L	J	
Standard Asphalt	3/28/2009	Copper	8.66	ug/L		
Standard Asphalt	3/28/2009	Lead	1.70	ug/L		
Standard Asphalt	3/28/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	3/28/2009	Zinc	47.8	ug/L		
Standard Asphalt	3/28/2009	2-Methylnaphthalene	0.003	ug/L	J	
Standard Asphalt	3/28/2009	Acenaphthene	0.003	ug/L	U	J
Standard Asphalt	3/28/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	3/28/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	3/28/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	3/28/2009	Naphthalene	0.008	ug/L	J	
Standard Asphalt	3/28/2009	Phenanthrene	0.032	ug/L		
Standard Asphalt	3/28/2009	Benzo(a)anthracene	0.007	ug/L	J	
Standard Asphalt	3/28/2009	Benzo(a)pyrene	0.004	ug/L	U	
Standard Asphalt	3/28/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Standard Asphalt	3/28/2009	Benzo(b,k)fluoranthenes	0.011	ug/L	J	
Standard Asphalt	3/28/2009	Chrysene	0.007	ug/L	J	
Standard Asphalt	3/28/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	3/28/2009	Fluoranthene	0.038	ug/L		
Standard Asphalt	3/28/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Standard Asphalt	3/28/2009	Pyrene	0.021	ug/L		
Standard Asphalt	3/28/2009	bis(2-Ethylhexyl)phthalate	1.14	ug/L		
Standard Asphalt	3/28/2009	Butyl benzyl phthalate	0.29	ug/L	J	
Standard Asphalt	3/28/2009	Diethylphthalate	0.285	ug/L	J	
Standard Asphalt	3/28/2009	Dimethyl phthalate	0.087	ug/L	J	
Standard Asphalt	3/28/2009	Di-n-butylphthalate	0.23	ug/L	J	
Standard Asphalt	3/28/2009	Di-n-Octyl phthalate	0.184	ug/L	J	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



PERVPAVERS
Flowlink 5
Level (0.034 ft):0.03
Flow-Mannings (20025.5 gal):2.40
Sample Event (49 SU):
Rainfall (0.970 in):0.00
ft
0.10
0.08
0.06
0.04
0.02
gpm
25
20
15
10
5
0
in
0.04
0.03
0.02
0.01
0.00
26 Thu
27 Fri
28 Sat
29 Sun
Mar 2009
3/25/2009 1:25:00 AM - 3/29/2009 10:44:00 PM


PERVPAVERS
Flowlink 5
Level (0.050 ft):0.10
Sample Event (48 SU):
Flow-Mannings (11033.0 gal):20.85
Rainfall (0.920 in):0.03
ft
0.10
0.08
0.06
0.04
0.02
gpm
25
20
15
10
5
0
in
0.04
0.03
0.02
0.01
0.00
6AM
9AM
12PM
3PM
6PM
9PM
29 Sun
3AM
6AM
28 Sat Mar 2009
3/28/2009 3:33:00 AM - 3/29/2009 8:56:00 AM



PERVASFALT
Flowlink 5
Level (0.040 ft):0.00
Flow-Mannings (9614.97 gal):0.03
Sample Event (48 SU):
Rainfall (0.920 in):0.00
ft
0.08
0.06
0.04
0.02
0.00
gpm
15
10
5
0
in
0.04
0.03
0.02
0.01
0.00
3AM
6AM
9AM
12PM
3PM
6PM
9PM
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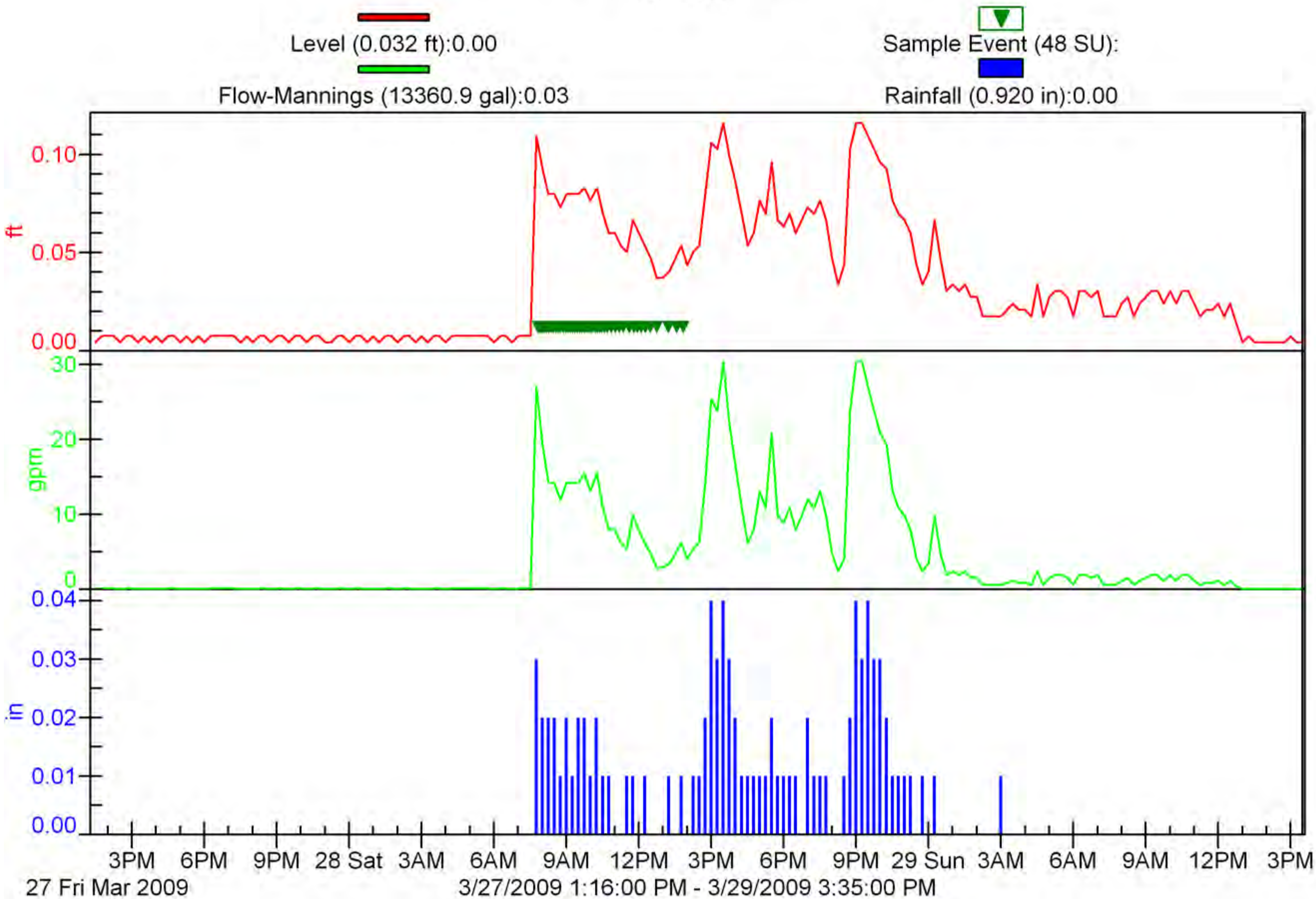
3AM
6AM
28 Sat Mar 2009
3/28/2009 2:57:00 AM - 3/29/2009 8:43:00 AM

STDASPHALT

Flowlink 5



STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #29
Date: April 1, 2009

Introduction

This report summarizes the storm event sampled on April 1, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #29.

Table 1. Storm Characteristics

Storm Date		4/1/2009
Time Storm Began		0700
Total Precipitation (in)		0.17
Duration (hrs)		5.5
Met Precipitation Criteria?	Precipitation ≥0.2"	No
Antecedent Period (hrs)		24
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #29. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious concrete. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	18.32	NS	NS
Duration of Flow (hrs)	NS	11	NS	NS
Total Volume (gallons) during Storm Event	NS	7,800	NS	NS
Total Volume (gallons) during Sampling Event	NS	1599	NS	NS
Duration of Sampling Event (hrs)	NS	2.1	NS	NS
Number of Sample Aliquots Collected	NS	48	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	NS	20.5%	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	NS	0.5	NS	NS

Key: NS = Not Sampled

NM = Not Measured

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Concrete

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

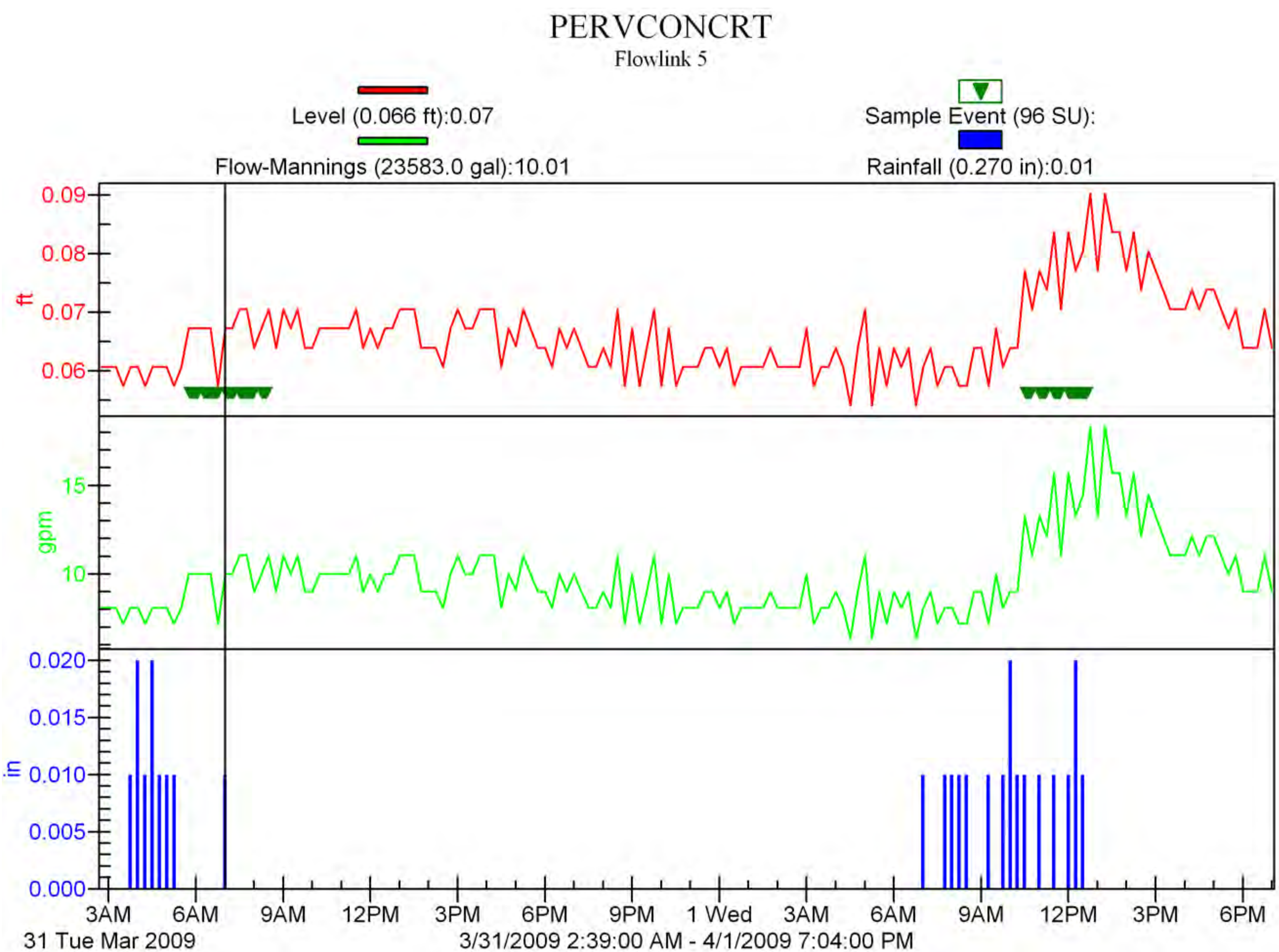
Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS’s data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	4/1/2009	Hardness, calculated	1.09	mg/L		
Pervious Concrete	4/1/2009	pH	11.8	Std. Units		
Pervious Concrete	4/1/2009	TSS	13.4	mg/L		
Pervious Concrete	4/1/2009	NWTPH-Diesel	0.06	mg/L	B	
Pervious Concrete	4/1/2009	NWTPH-Heavy Oil	0.09	mg/L	J	
Pervious Concrete	4/1/2009	Copper	6.50	ug/L	J	
Pervious Concrete	4/1/2009	Lead	0.360	ug/L	J	
Pervious Concrete	4/1/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	4/1/2009	Zinc	13.2	ug/L		
Pervious Concrete	4/1/2009	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Concrete	4/1/2009	Acenaphthene	0.005	ug/L	J	
Pervious Concrete	4/1/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	4/1/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	4/1/2009	Fluorene	0.004	ug/L	J	
Pervious Concrete	4/1/2009	Naphthalene	0.012	ug/L		UJ
Pervious Concrete	4/1/2009	Phenanthrene	0.008	ug/L	J	
Pervious Concrete	4/1/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	4/1/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	4/1/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	4/1/2009	Benzo(b,k)fluoranthenes	0.004	ug/L	J	
Pervious Concrete	4/1/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	4/1/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	4/1/2009	Fluoranthene	0.013	ug/L		
Pervious Concrete	4/1/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	4/1/2009	Pyrene	0.024	ug/L		
Pervious Concrete	4/1/2009	bis(2-Ethylhexyl)phthalate	1.19	ug/L		
Pervious Concrete	4/1/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	4/1/2009	Diethylphthalate	0.534	ug/L	B	
Pervious Concrete	4/1/2009	Dimethyl phthalate	0.206	ug/L	B	
Pervious Concrete	4/1/2009	Di-n-butylphthalate	0.27	ug/L	J	
Pervious Concrete	4/1/2009	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit



PERVCONCRT
Flowlink 5
Level (0.066 ft):0.07
Flow-Mannings (23583.0 gal):10.01
Sample Event (96 SU):
Rainfall (0.270 in):0.01
ft
0.09
0.08
0.07
0.06
gpm
15
10
in
0.020
0.015
0.010
0.005
0.000
3AM
6AM
9AM
12PM
3PM
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3AM
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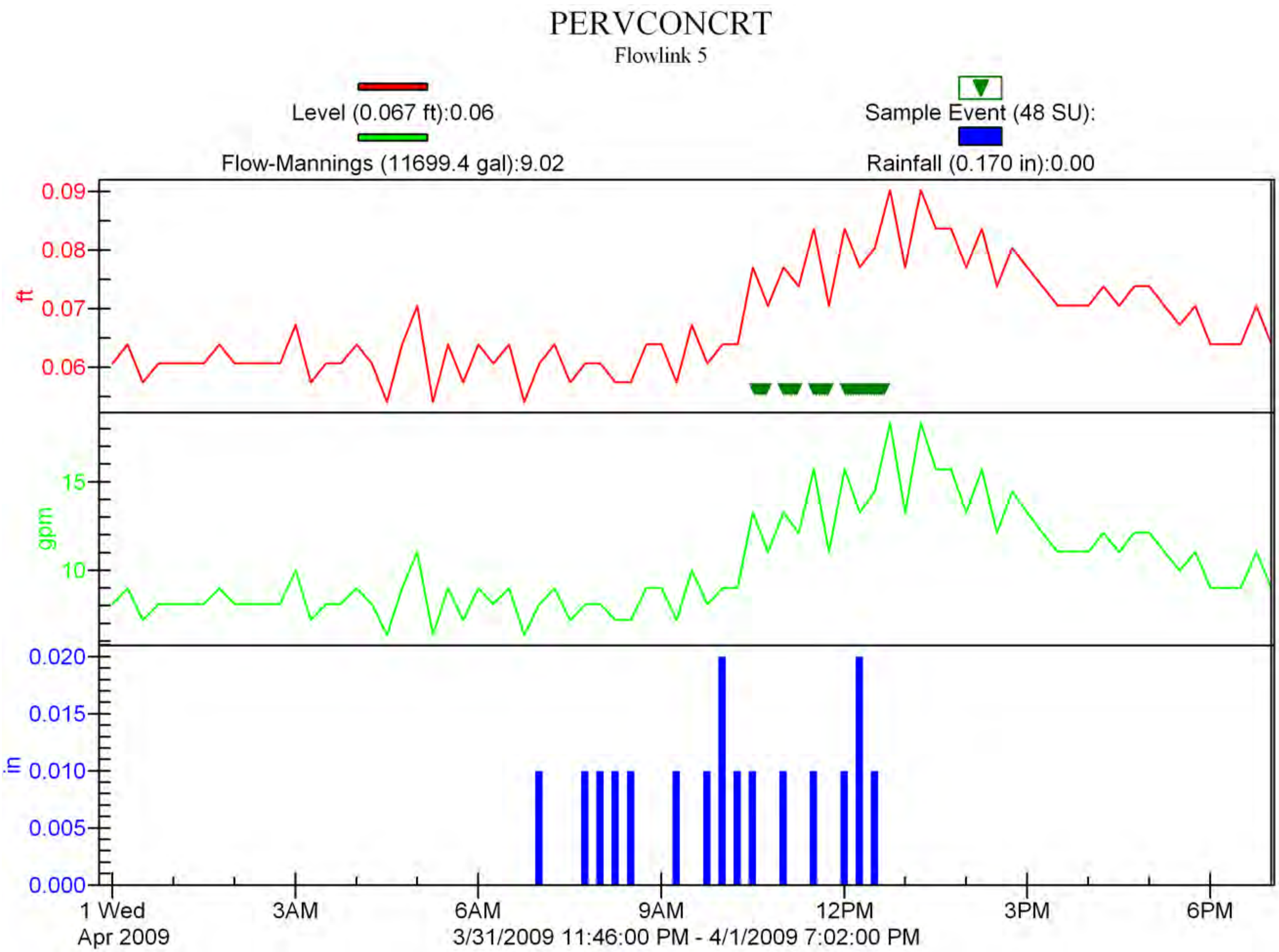


PERVCONCRT
Flowlink 5
Level (0.067 ft):0.06
Flow-Mannings (11699.4 gal):9.02
Sample Event (48 SU):
Rainfall (0.170 in):0.00
0.09
0.08
ft
0.07
0.06
15
gpm
10
0.020
0.015
in
0.010
0.005
0.000
1 Wed
Apr 2009
3AM
6AM
9AM
12PM
3PM
6PM
3/31/2009 11:46:00 PM - 4/1/2009 7:02:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #30
Date: April 17, 2009

Introduction

This report summarizes the storm event sampled on April 17, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #30.

Table 1. Storm Characteristics

Storm Date		4/17/2009
Time Storm Began		12:15 am
Total Precipitation (in)		0.29
Duration (hrs)		12.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		69
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #30. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, and 4 provide the hydrograph and hyetograph for the storm event for pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	18.32	8.83	9.80
Duration of Flow (hrs)	NS	21	6	12
Total Volume (gallons) during Storm Event	NS	16498	1330	1578
Total Volume (gallons) during Sampling Event	NS	2327	1145	1413
Duration of Sampling Event (hrs)	NS	14.6	4.2	10.2
Number of Sample Aliquots Collected	NS	41	17	15
Percentage of Storm's Total Volume over which Samples were Collected	NS	14.1%	86.1%	89.5%
Volume of Surface Runoff Collected in Vault (inches)	NS	NS	NS	NS

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Concrete
- Pervious Asphalt
- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- The storm was larger than predicted. The pacings were set too aggressive.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

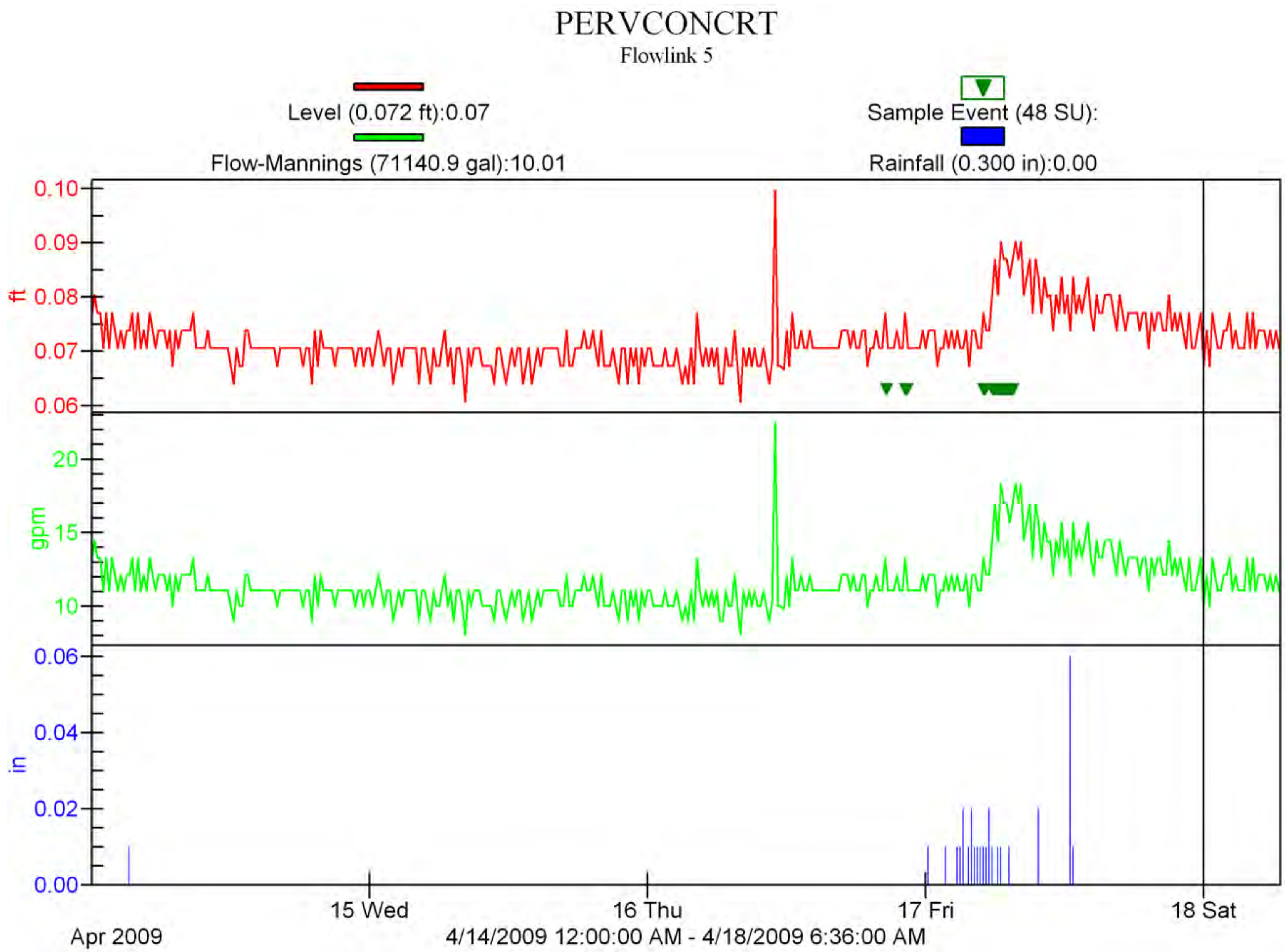
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	4/17/2009	Hardness, calculated	15.7	mg/L		
Pervious Asphalt	4/17/2009	pH	7.4	Std. Units		
Pervious Asphalt	4/17/2009	NWTPH-Diesel	0.07	mg/L	B	
Pervious Asphalt	4/17/2009	NWTPH-Heavy Oil	0.11	mg/L	J	
Pervious Asphalt	4/17/2009	Copper	1.79	ug/L		
Pervious Asphalt	4/17/2009	Lead	0.120	ug/L	J	
Pervious Asphalt	4/17/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	4/17/2009	Zinc	2.29	ug/L		
Pervious Asphalt	4/17/2009	2-Methylnaphthalene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Acenaphthene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Acenaphthylene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Anthracene	0.008	ug/L	U	
Pervious Asphalt	4/17/2009	Fluorene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Naphthalene	0.007	ug/L	J	
Pervious Asphalt	4/17/2009	Phenanthrene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Benzo(a)anthracene	0.004	ug/L	U	
Pervious Asphalt	4/17/2009	Benzo(a)pyrene	0.008	ug/L	U	
Pervious Asphalt	4/17/2009	Benzo(g,h,i)perylene	0.016	ug/L	U	
Pervious Asphalt	4/17/2009	Benzo(b,k)fluoranthenes	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Chrysene	0.006	ug/L	U	
Pervious Asphalt	4/17/2009	Dibenz(a,h)anthracene	0.014	ug/L	U	
Pervious Asphalt	4/17/2009	Fluoranthene	0.010	ug/L	U	
Pervious Asphalt	4/17/2009	Indeno(1,2,3-c,d)pyrene	0.014	ug/L	U	
Pervious Asphalt	4/17/2009	Pyrene	0.008	ug/L	U	
Pervious Asphalt	4/17/2009	bis(2-Ethylhexyl)phthalate	0.90	ug/L	J	
Pervious Asphalt	4/17/2009	Butyl benzyl phthalate	0.35	ug/L	U	
Pervious Asphalt	4/17/2009	Diethylphthalate	1.50	ug/L	J	
Pervious Asphalt	4/17/2009	Dimethyl phthalate	0.062	ug/L	U	
Pervious Asphalt	4/17/2009	Di-n-butylphthalate	0.53	ug/L	J	
Pervious Asphalt	4/17/2009	Di-n-Octyl phthalate	0.17	ug/L	U	
Pervious Concrete	4/17/2009	Hardness, calculated	749	mg/L		
Pervious Concrete	4/17/2009	pH	11.7	Std. Units		
Pervious Concrete	4/17/2009	TSS	3.20	mg/L		
Pervious Concrete	4/17/2009	NWTPH-Diesel	0.06	mg/L	B	
Pervious Concrete	4/17/2009	NWTPH-Heavy Oil	0.06	mg/L	U	
Pervious Concrete	4/17/2009	Copper	5.06	ug/L		
Pervious Concrete	4/17/2009	Lead	0.090	ug/L	J	
Pervious Concrete	4/17/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	4/17/2009	Zinc	1.0	ug/L	U	
Pervious Concrete	4/17/2009	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Concrete	4/17/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	4/17/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	4/17/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	4/17/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	4/17/2009	Naphthalene	0.006	ug/L	J	
Pervious Concrete	4/17/2009	Phenanthrene	0.004	ug/L	J	
Pervious Concrete	4/17/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	4/17/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	4/17/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	4/17/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	4/17/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	4/17/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	4/17/2009	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	4/17/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	4/17/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete	4/17/2009	bis(2-Ethylhexyl)phthalate	0.16	ug/L	U	
Pervious Concrete	4/17/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	4/17/2009	Diethylphthalate	0.076	ug/L	J	

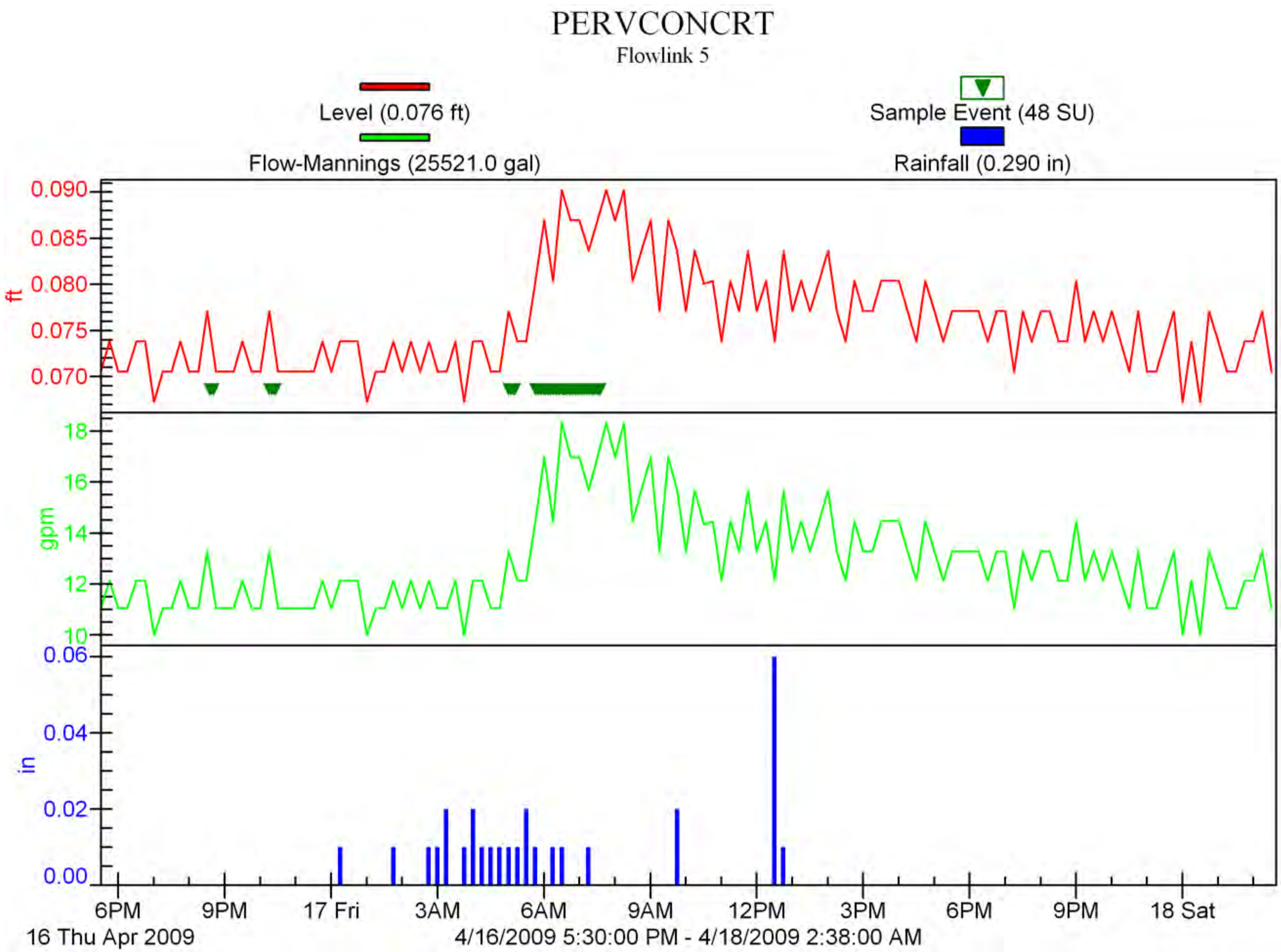
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	4/17/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	4/17/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete	4/17/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	4/17/2009	Hardness, calculated	5.72	mg/L		
Standard Asphalt	4/17/2009	pH	6.5	Std. Units		
Standard Asphalt	4/17/2009	TSS	7.50	mg/L		
Standard Asphalt	4/17/2009	NWTPH-Diesel	0.27	mg/L		
Standard Asphalt	4/17/2009	NWTPH-Heavy Oil	0.48	mg/L		
Standard Asphalt	4/17/2009	Copper	7.91	ug/L		
Standard Asphalt	4/17/2009	Lead	1.40	ug/L		
Standard Asphalt	4/17/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	4/17/2009	Zinc	41.4	ug/L		
Standard Asphalt	4/17/2009	2-Methylnaphthalene	0.006	ug/L	U	
Standard Asphalt	4/17/2009	Acenaphthene	0.006	ug/L	U	
Standard Asphalt	4/17/2009	Acenaphthylene	0.006	ug/L	U	
Standard Asphalt	4/17/2009	Anthracene	0.008	ug/L	U	
Standard Asphalt	4/17/2009	Fluorene	0.006	ug/L	U	
Standard Asphalt	4/17/2009	Naphthalene	0.013	ug/L	J	
Standard Asphalt	4/17/2009	Phenanthrene	0.019	ug/L	J	
Standard Asphalt	4/17/2009	Benzo(a)anthracene	0.004	ug/L	U	
Standard Asphalt	4/17/2009	Benzo(a)pyrene	0.008	ug/L	U	
Standard Asphalt	4/17/2009	Benzo(g,h,i)perylene	0.016	ug/L	U	
Standard Asphalt	4/17/2009	Benzo(b,k)fluoranthenes	0.014	ug/L	J	
Standard Asphalt	4/17/2009	Chrysene	0.006	ug/L	U	
Standard Asphalt	4/17/2009	Dibenz(a,h)anthracene	0.014	ug/L	U	
Standard Asphalt	4/17/2009	Fluoranthene	0.025	ug/L		
Standard Asphalt	4/17/2009	Indeno(1,2,3-c,d)pyrene	0.014	ug/L	U	
Standard Asphalt	4/17/2009	Pyrene	0.012	ug/L	J	
Standard Asphalt	4/17/2009	bis(2-Ethylhexyl)phthalate	2.07	ug/L		
Standard Asphalt	4/17/2009	Butyl benzyl phthalate	0.50	ug/L	J	
Standard Asphalt	4/17/2009	Diethylphthalate	0.34	ug/L	J	
Standard Asphalt	4/17/2009	Dimethyl phthalate	0.100	ug/L	J	
Standard Asphalt	4/17/2009	Di-n-butylphthalate	0.38	ug/L	J	
Standard Asphalt	4/17/2009	Di-n-Octyl phthalate	0.28	ug/L	J	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVCONCRT
Flowlink 5
Level (0.072 ft):0.07
Flow-Mannings (71140.9 gal):10.01
Sample Event (48 SU):
Rainfall (0.300 in):0.00
ft
0.10
0.09
0.08
0.07
0.06
gpm
20
15
10
in
0.06
0.04
0.02
0.00
15 Wed
16 Thu
17 Fri
18 Sat
Apr 2009
4/14/2009 12:00:00 AM - 4/18/2009 6:36:00 AM


PERVCONCRT
Flowlink 5
Level (0.076 ft)
Flow-Mannings (25521.0 gal)
Sample Event (48 SU)
Rainfall (0.290 in)
ft
0.090
0.085
0.080
0.075
0.070
gpm
18
16
14
12
10
in
0.06
0.04
0.02
0.00
6PM
9PM
17 Fri
3AM
6AM
9AM
12PM
3PM
6PM
9PM
18 Sat
16 Thu Apr 2009
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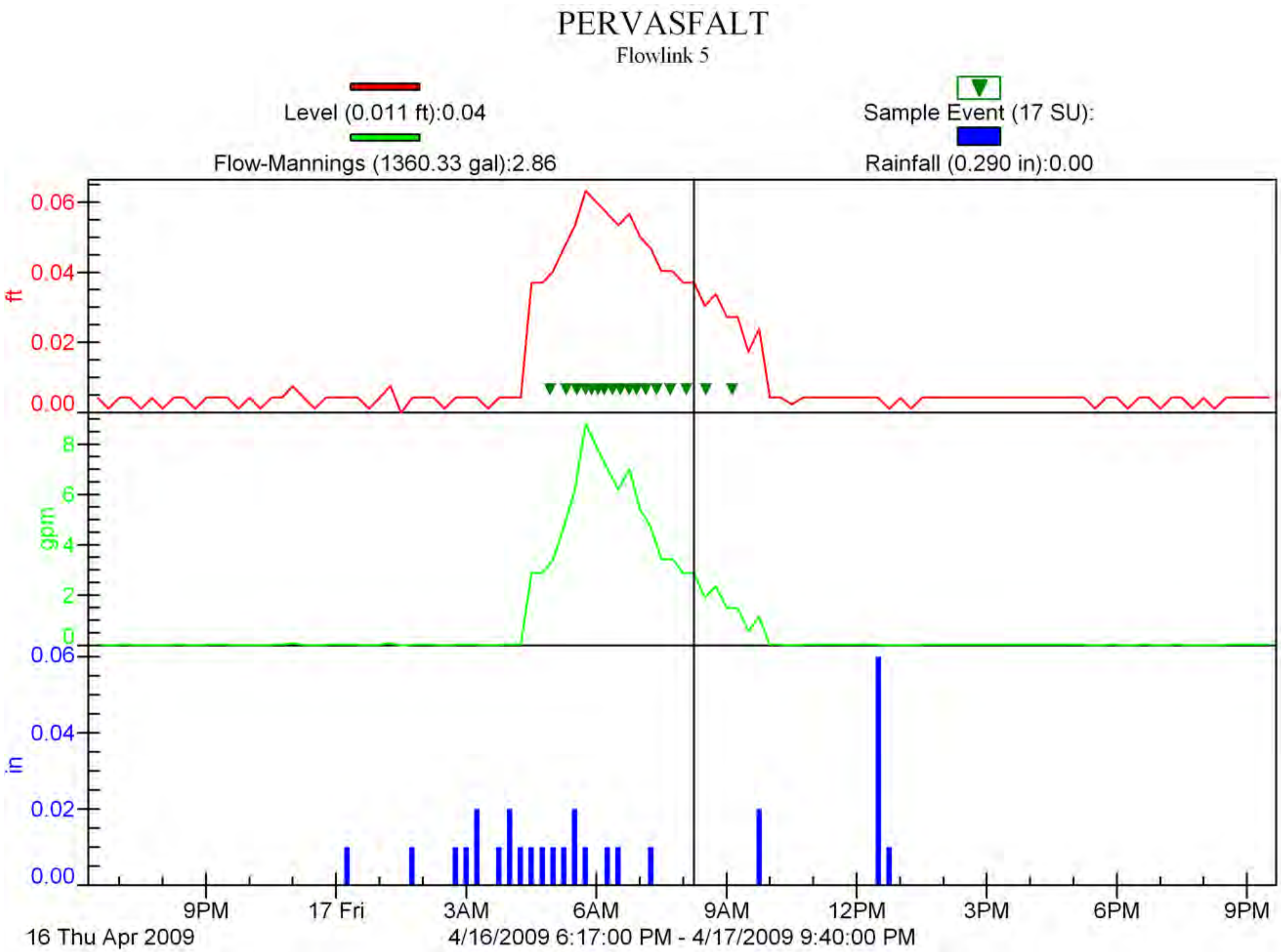
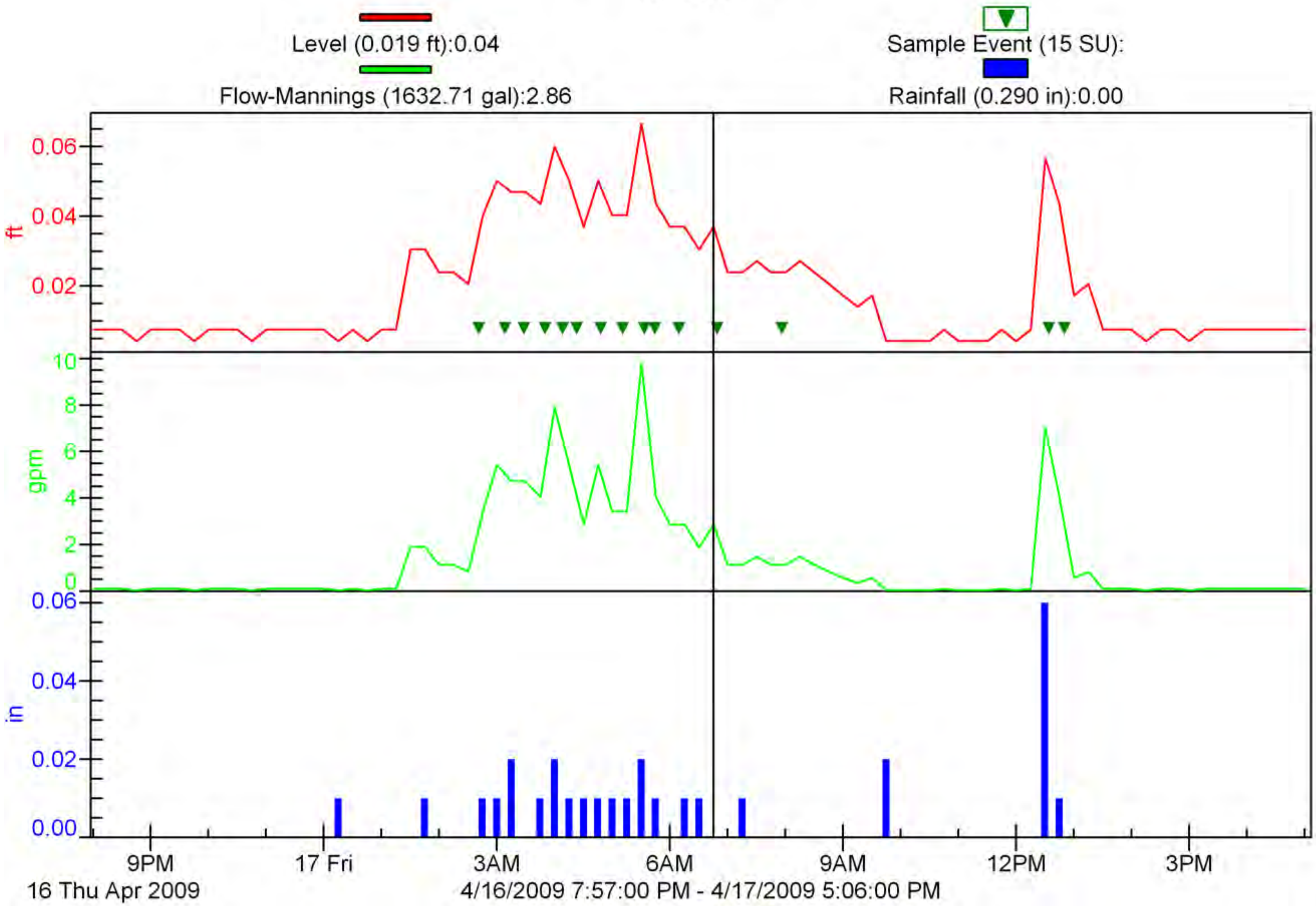


PERVASFALT
Flowlink 5
Level (0.011 ft):0.04
Flow-Mannings (1360.33 gal):2.86
Sample Event (17 SU):
Rainfall (0.290 in):0.00
0.06
0.04
ft
0.02
0.00
8
6
gpm
4
2
0
0.06
0.04
in
0.02
0.00
9PM
17 Fri
3AM
6AM
9AM
12PM
3PM
6PM
9PM
16 Thu Apr 2009
4/16/2009 6:17:00 PM - 4/17/2009 9:40:00 PM

STDASPHALT

Flowlink 5



STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #31
Date: April 28, 2009

Introduction

This report summarizes the storm event sampled on April 28, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #31.

Table 1. Storm Characteristics

Storm Date		4/28/2009
Time Storm Began		0130
Total Precipitation (in)		0.77*
Duration (hrs)		9
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		86
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

* Partial storm event used. See storm summary data sheet.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #31. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious pavers. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	24.45	NS	NS	NS
Duration of Flow (hrs)	5	NS	NS	NS
Total Volume (gallons) during Storm Event	3024*	NS	NS	NS
Total Volume (gallons) during Sampling Event	1219	NS	NS	NS
Duration of Sampling Event (hrs)	2.5	NS	NS	NS
Number of Sample Aliquots Collected	48	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	40.3%*	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	NS	NS	NS	NS

Key: NS = Not Sampled

* Partial storm event used due to size of storm.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

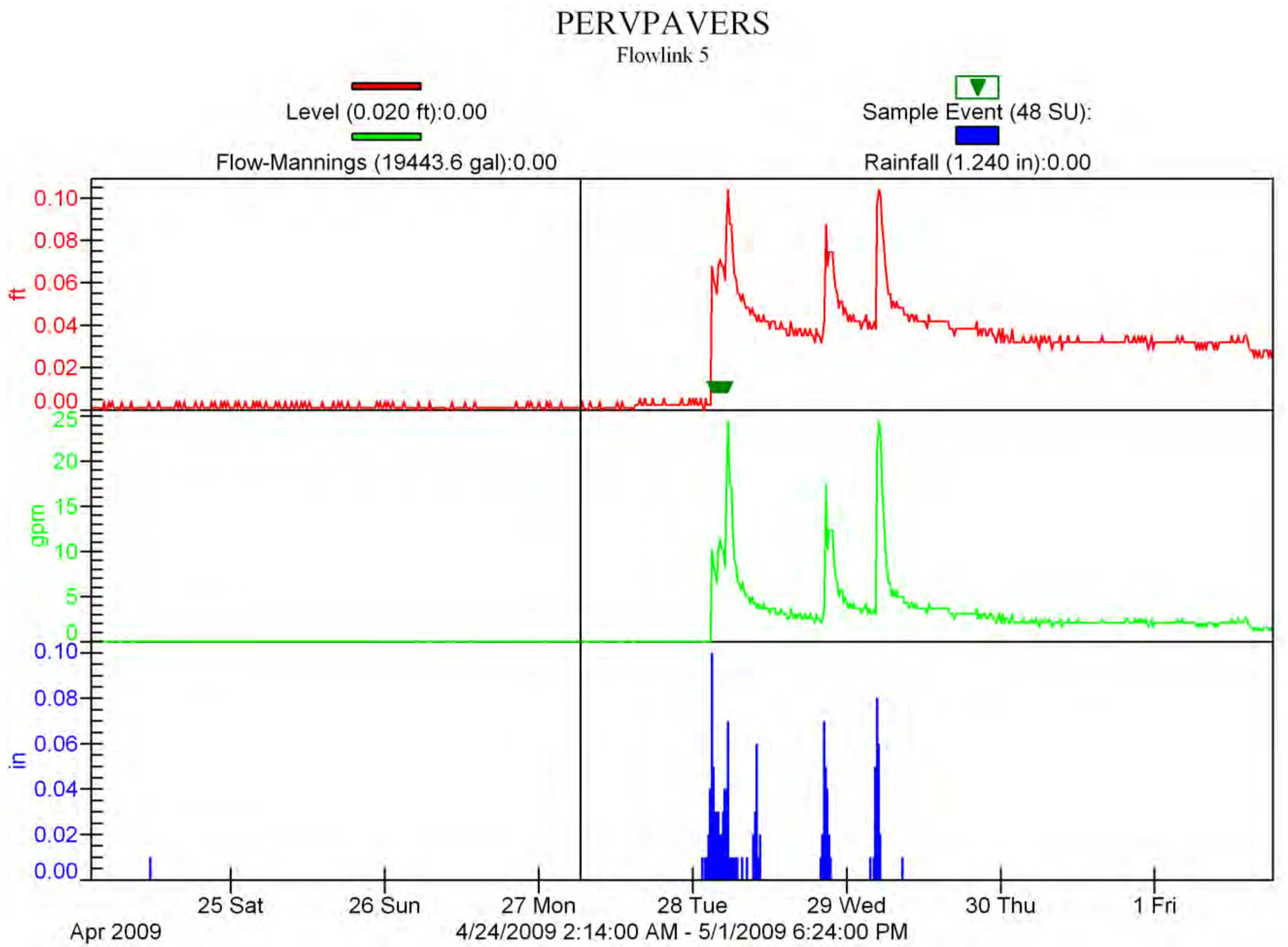
- The storm was larger than predicted. The pacings were set too aggressive.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	4/28/2009	Hardness, calculated	17.1	mg/L		
Pervious Pavers	4/28/2009	pH	7.0	Std. Units		
Pervious Pavers	4/28/2009	TSS	12.6	mg/L		
Pervious Pavers	4/28/2009	NWTPH-Diesel	0.10	mg/L	B	
Pervious Pavers	4/28/2009	NWTPH-Heavy Oil	0.09	mg/L	J	
Pervious Pavers	4/28/2009	Copper	26.3	ug/L		
Pervious Pavers	4/28/2009	Lead	57.9	ug/L		
Pervious Pavers	4/28/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	4/28/2009	Zinc	162	ug/L		
Pervious Pavers	4/28/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	4/28/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Naphthalene	0.003	ug/L	J	
Pervious Pavers	4/28/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	4/28/2009	Benzo(a)pyrene	0.009	ug/L	J	
Pervious Pavers	4/28/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	4/28/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	4/28/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	4/28/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	4/28/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	4/28/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	4/28/2009	bis(2-Ethylhexyl)phthalate	1.0	ug/L	U	
Pervious Pavers	4/28/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers	4/28/2009	Diethylphthalate	0.123	ug/L	J	
Pervious Pavers	4/28/2009	Dimethyl phthalate	0.032	ug/L	J	
Pervious Pavers	4/28/2009	Di-n-butylphthalate	1.0	ug/L	U	
Pervious Pavers	4/28/2009	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit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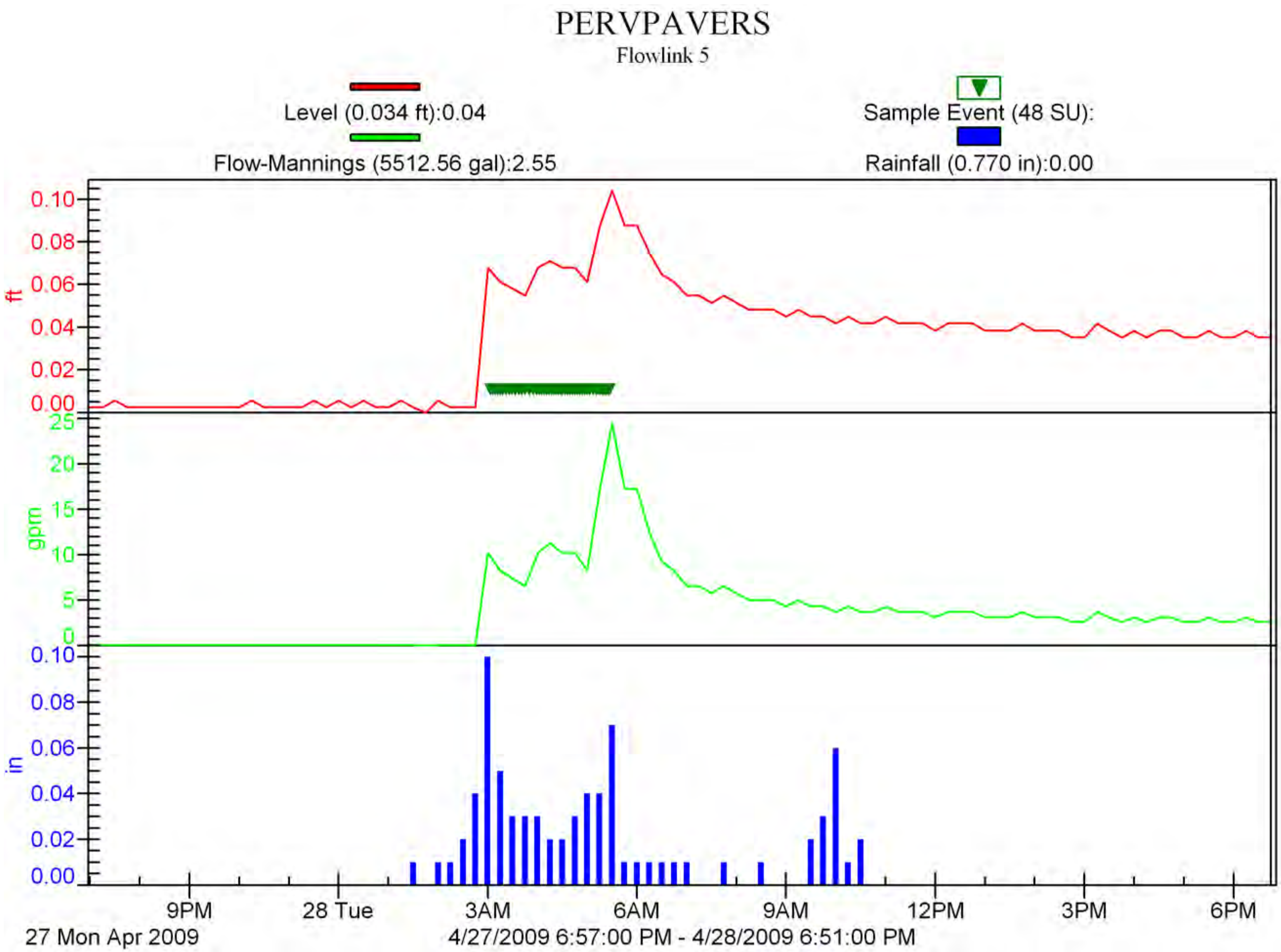
Flowlink 5
Level (0.020 ft):0.00
Flow-Mannings (19443.6 gal):0.00
Sample Event (48 SU):
Rainfall (1.240 in):0.00
ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
25
20
15
10
5
0
in
0.10
0.08
0.06
0.04
0.02
0.00
25 Sat
26 Sun
27 Mon
28 Tue
29 Wed
30 Thu
1 Fri
Apr 2009
4/24/2009 2:14:00 AM - 5/1/2009 6:24:00 PM


PERVPAVERS
Flowlink 5
Level (0.034 ft):0.04
Flow-Mannings (5512.56 gal):2.55
Sample Event (48 SU):
Rainfall (0.770 in):0.00
ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
25
20
15
10
5
0
in
0.10
0.08
0.06
0.04
0.02
0.00
9PM
28 Tue
3AM
6AM
9AM
12PM
3PM
6PM
27 Mon Apr 2009
4/27/2009 6:57:00 PM - 4/28/2009 6:51:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #32
Date: May 2, 2009

Introduction

This report summarizes the storm event sampled on May 2, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #32.

Table 1. Storm Characteristics

Storm Date		5/2/2009
Time Storm Began		0845
Total Precipitation (in)		0.24
Duration (hrs)		12
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		72
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #32. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, and 4 provide the hydrograph and hyetograph for the storm event for pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	37.4	18.1	85.2
Duration of Flow (hrs)	NS	4.5	6.75	11
Total Volume (gallons) during Storm Event	NS	2607	2761	2573
Total Volume (gallons) during Sampling Event	NS	117	2207	2363
Duration of Sampling Event (hrs)	NS	0.2	5.6	7.6
Number of Sample Aliquots Collected	NS	11	36	25
Percentage of Storm's Total Volume over which Samples were Collected	NS	4.5%	79.9%	91.8%
Volume of Surface Runoff Collected in Vault (inches)	0	18.5	15.5	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Concrete
- Pervious Asphalt
- Standard Asphalt
- Pervious Pavers
- Pervious Concrete CB
- Pervious Asphalt CB

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

The ECFSS noted the following observations during the sampling event:

- The storm was larger than predicted. The pacings were set too aggressive.

Additional field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	5/2/2009	Hardness, calculated	14.1	mg/L		
Pervious Asphalt	5/2/2009	pH	6.7	Std. Units		
Pervious Asphalt	5/2/2009	TSS	7.40	mg/L		
Pervious Asphalt	5/2/2009	NWTPH-Diesel	0.15	mg/L	B	
Pervious Asphalt	5/2/2009	NWTPH-Heavy Oil	0.22	mg/L	J	
Pervious Asphalt	5/2/2009	Copper	3.32	ug/L		
Pervious Asphalt	5/2/2009	Lead	0.230	ug/L	J	
Pervious Asphalt	5/2/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	5/2/2009	Zinc	2.81	ug/L		
Pervious Asphalt	5/2/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt	5/2/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Naphthalene	0.003	ug/L	J	
Pervious Asphalt	5/2/2009	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	5/2/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	5/2/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	5/2/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt	5/2/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	5/2/2009	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	5/2/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	5/2/2009	Pyrene	0.004	ug/L	U	
Pervious Asphalt	5/2/2009	bis(2-Ethylhexyl)phthalate	1.0	ug/L	U	
Pervious Asphalt	5/2/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt	5/2/2009	Diethylphthalate	1.50	ug/L		
Pervious Asphalt	5/2/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt	5/2/2009	Di-n-butylphthalate	1.0	ug/L	U	
Pervious Asphalt	5/2/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Asphalt CB	5/3/2009	Hardness, calculated	7.37	mg/L		
Pervious Asphalt CB	5/3/2009	pH	6.5	Std. Units		
Pervious Asphalt CB	5/3/2009	TSS	5.50	mg/L		
Pervious Asphalt CB	5/3/2009	NWTPH-Diesel	0.16	mg/L	B	
Pervious Asphalt CB	5/3/2009	NWTPH-Heavy Oil	0.33	mg/L	J	
Pervious Asphalt CB	5/3/2009	Copper	8.27	ug/L		
Pervious Asphalt CB	5/3/2009	Lead	1.61	ug/L		
Pervious Asphalt CB	5/3/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	5/3/2009	Zinc	37.1	ug/L		
Pervious Asphalt CB	5/3/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt CB	5/3/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	5/3/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	5/3/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	5/3/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	5/3/2009	Naphthalene	0.006	ug/L	J	
Pervious Asphalt CB	5/3/2009	Phenanthrene	0.020	ug/L		
Pervious Asphalt CB	5/3/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt CB	5/3/2009	Benzo(a)pyrene	0.013	ug/L		
Pervious Asphalt CB	5/3/2009	Benzo(g,h,i)perylene	0.012	ug/L		
Pervious Asphalt CB	5/3/2009	Benzo(b,k)fluoranthenes	0.026	ug/L		
Pervious Asphalt CB	5/3/2009	Chrysene	0.020	ug/L		
Pervious Asphalt CB	5/3/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	5/3/2009	Fluoranthene	0.034	ug/L		
Pervious Asphalt CB	5/3/2009	Indeno(1,2,3-c,d)pyrene	0.008	ug/L	J	
Pervious Asphalt CB	5/3/2009	Pyrene	0.020	ug/L		
Pervious Asphalt CB	5/3/2009	bis(2-Ethylhexyl)phthalate	0.81	ug/L	J	
Pervious Asphalt CB	5/3/2009	Butyl benzyl phthalate	0.17	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

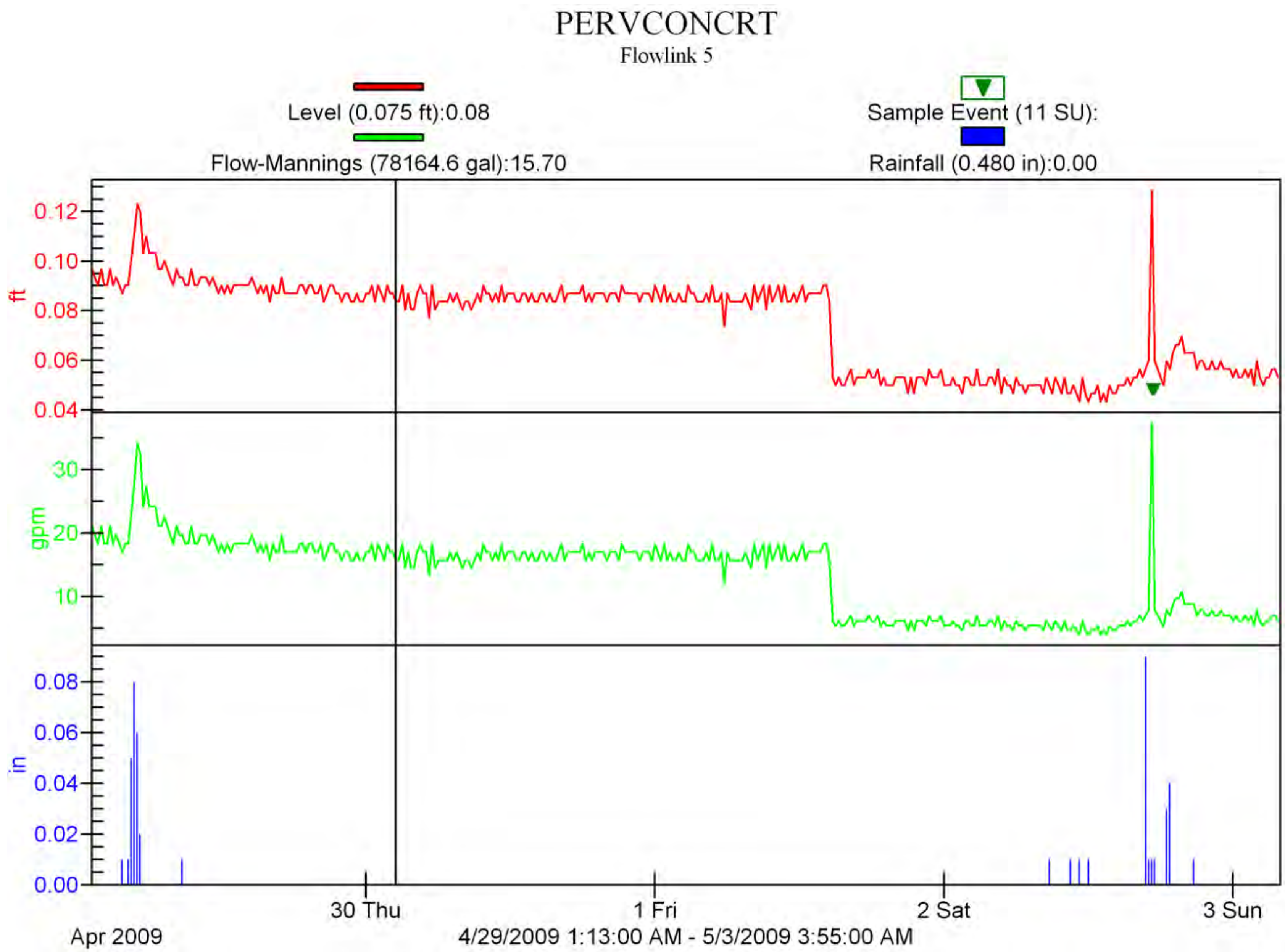
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	5/3/2009	Diethylphthalate	0.123	ug/L	J	
Pervious Asphalt CB	5/3/2009	Dimethyl phthalate	0.104	ug/L	J	
Pervious Asphalt CB	5/3/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Asphalt CB	5/3/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete	5/2/2009	Hardness, calculated	191	mg/L		
Pervious Concrete	5/2/2009	pH	11.2	Std. Units		
Pervious Concrete	5/2/2009	NWTPH-Diesel	0.14	mg/L	B	
Pervious Concrete	5/2/2009	NWTPH-Heavy Oil	0.18	mg/L	J	
Pervious Concrete	5/2/2009	Copper	7.56	ug/L		
Pervious Concrete	5/2/2009	Lead	0.320	ug/L	J	
Pervious Concrete	5/2/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	5/2/2009	Zinc	3.17	ug/L		
Pervious Concrete	5/2/2009	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Concrete	5/2/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	5/2/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	5/2/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	5/2/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	5/2/2009	Naphthalene	0.006	ug/L	J	
Pervious Concrete	5/2/2009	Phenanthrene	0.008	ug/L	J	
Pervious Concrete	5/2/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	5/2/2009	Benzo(a)pyrene	0.010	ug/L	J	
Pervious Concrete	5/2/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	5/2/2009	Benzo(b,k)fluoranthenes	0.006	ug/L	J	
Pervious Concrete	5/2/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	5/2/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	5/2/2009	Fluoranthene	0.007	ug/L	J	
Pervious Concrete	5/2/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	5/2/2009	Pyrene	0.008	ug/L	J	
Pervious Concrete	5/2/2009	bis(2-Ethylhexyl)phthalate	1.0	ug/L	U	
Pervious Concrete	5/2/2009	Butyl benzyl phthalate	0.31	ug/L	J	
Pervious Concrete	5/2/2009	Diethylphthalate	0.379	ug/L	J	
Pervious Concrete	5/2/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	5/2/2009	Di-n-butylphthalate	1.0	ug/L	U	
Pervious Concrete	5/2/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete CB	5/3/2009	Hardness, calculated	37.0	mg/L		
Pervious Concrete CB	5/3/2009	pH	6.9	Std. Units		
Pervious Concrete CB	5/3/2009	TSS	6.40	mg/L		
Pervious Concrete CB	5/3/2009	NWTPH-Diesel	0.19	mg/L	B	
Pervious Concrete CB	5/3/2009	NWTPH-Heavy Oil	0.51	mg/L		
Pervious Concrete CB	5/3/2009	Copper	14.7	ug/L		
Pervious Concrete CB	5/3/2009	Lead	1.04	ug/L		
Pervious Concrete CB	5/3/2009	Mercury	0.050	ug/L	U	
Pervious Concrete CB	5/3/2009	Zinc	25.5	ug/L		
Pervious Concrete CB	5/3/2009	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Concrete CB	5/3/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	5/3/2009	Acenaphthylene	0.003	ug/L	J	
Pervious Concrete CB	5/3/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete CB	5/3/2009	Fluorene	0.004	ug/L	J	
Pervious Concrete CB	5/3/2009	Naphthalene	0.009	ug/L	J	
Pervious Concrete CB	5/3/2009	Phenanthrene	0.012	ug/L		
Pervious Concrete CB	5/3/2009	Benzo(a)anthracene	0.004	ug/L	J	
Pervious Concrete CB	5/3/2009	Benzo(a)pyrene	0.010	ug/L	J	
Pervious Concrete CB	5/3/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete CB	5/3/2009	Benzo(b,k)fluoranthenes	0.007	ug/L	J	
Pervious Concrete CB	5/3/2009	Chrysene	0.004	ug/L	J	
Pervious Concrete CB	5/3/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete CB	5/3/2009	Fluoranthene	0.012	ug/L		
Pervious Concrete CB	5/3/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	

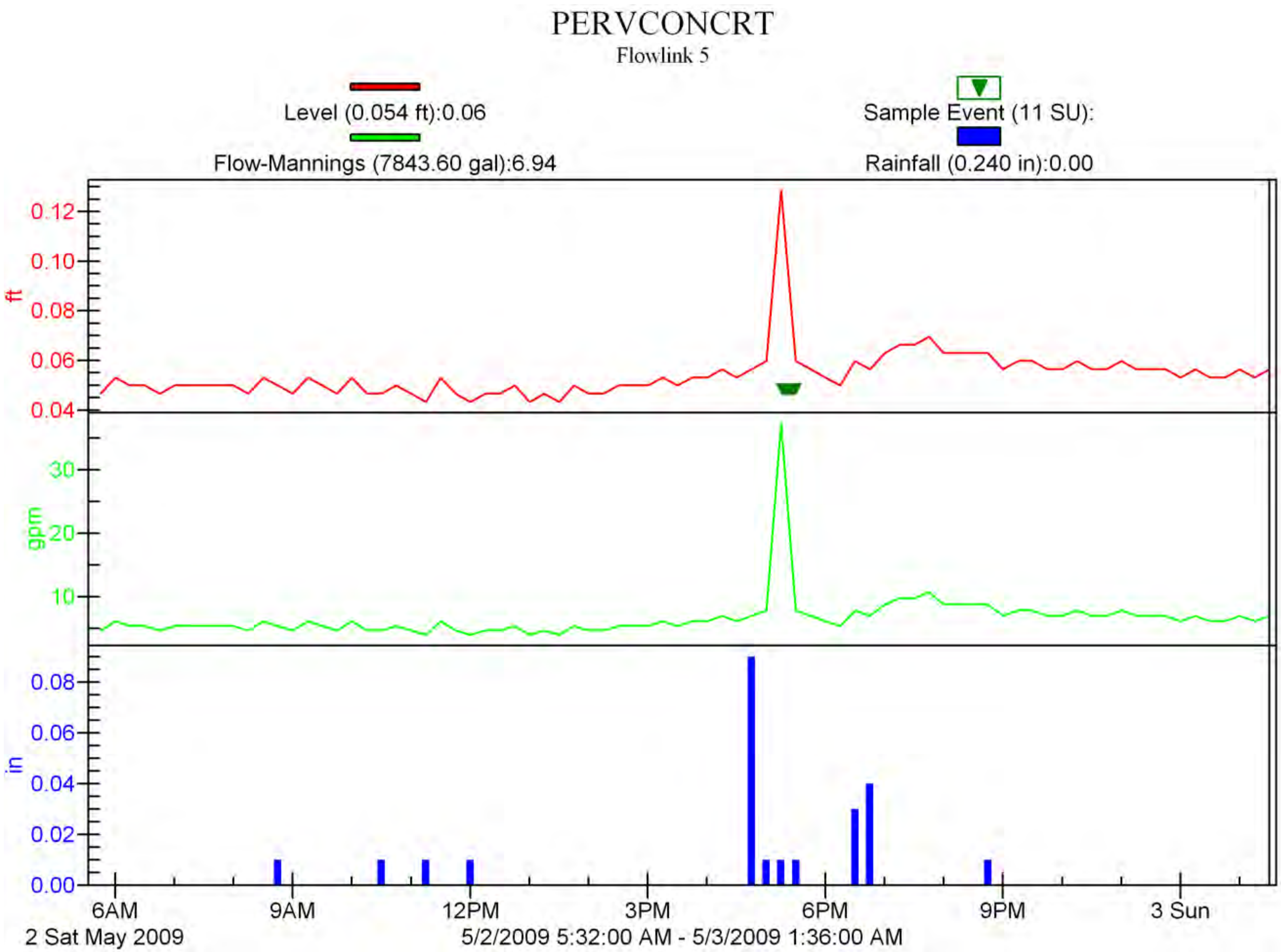
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

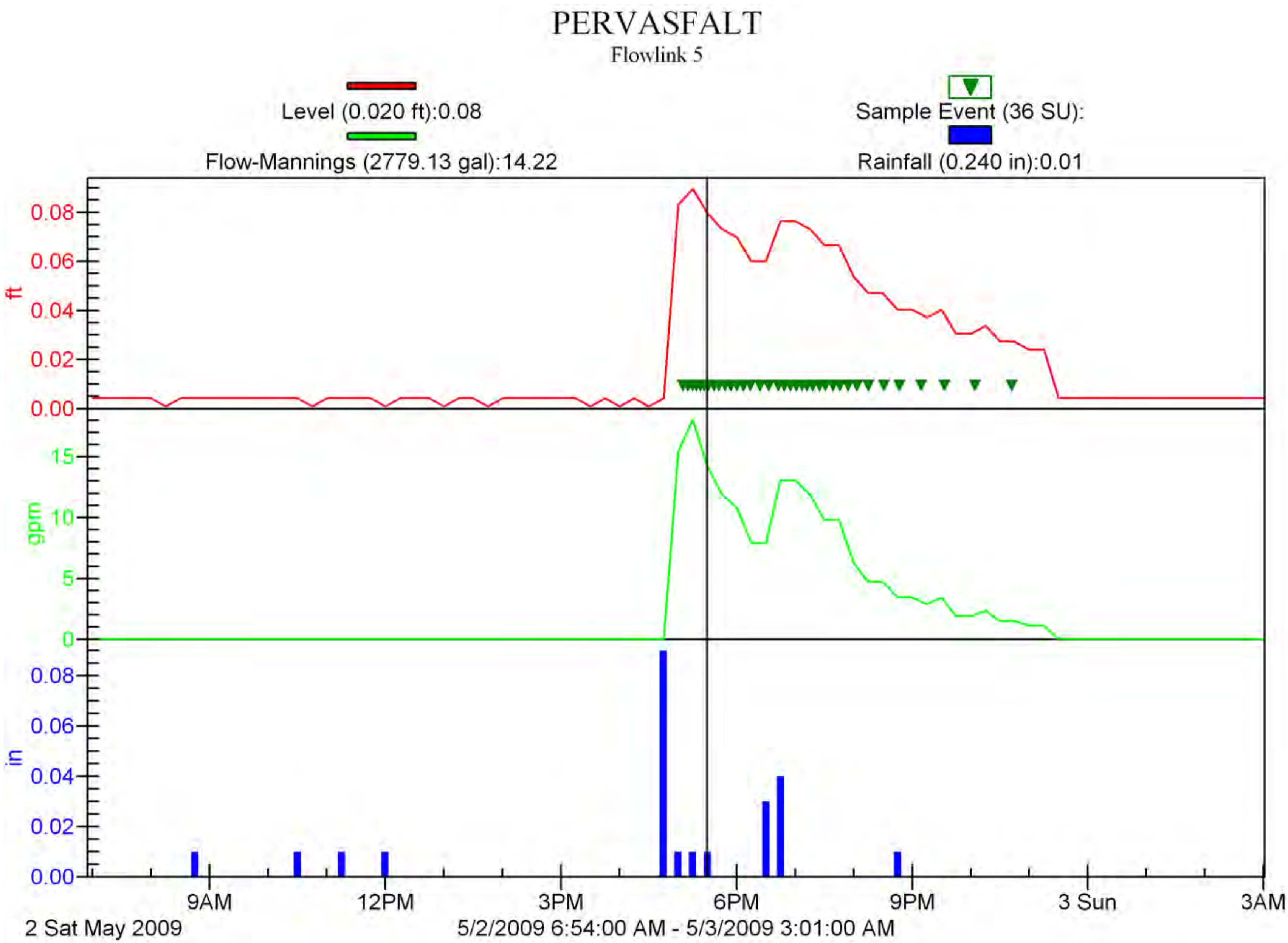
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	5/3/2009	Pyrene	0.006	ug/L	J	
Pervious Concrete CB	5/3/2009	bis(2-Ethylhexyl)phthalate	0.73	ug/L	J	
Pervious Concrete CB	5/3/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete CB	5/3/2009	Diethylphthalate	0.484	ug/L	J	
Pervious Concrete CB	5/3/2009	Dimethyl phthalate	0.032	ug/L	J	
Pervious Concrete CB	5/3/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete CB	5/3/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	5/2/2009	Hardness, calculated	7.96	mg/L		
Standard Asphalt	5/2/2009	pH	5.3	Std. Units		
Standard Asphalt	5/2/2009	TSS	165	mg/L		
Standard Asphalt	5/2/2009	NWTPH-Diesel	0.20	mg/L	U	
Standard Asphalt	5/2/2009	NWTPH-Heavy Oil	0.75	mg/L	J	
Standard Asphalt	5/2/2009	Copper	43.7	ug/L		
Standard Asphalt	5/2/2009	Lead	15.6	ug/L		
Standard Asphalt	5/2/2009	Mercury	0.052	ug/L	B	
Standard Asphalt	5/2/2009	Zinc	99.9	ug/L		
Standard Asphalt	5/2/2009	2-Methylnaphthalene	0.004	ug/L	J	
Standard Asphalt	5/2/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	5/2/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	5/2/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	5/2/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	5/2/2009	Naphthalene	0.007	ug/L	J	
Standard Asphalt	5/2/2009	Phenanthrene	0.023	ug/L		
Standard Asphalt	5/2/2009	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	5/2/2009	Benzo(a)pyrene	0.011	ug/L		
Standard Asphalt	5/2/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Standard Asphalt	5/2/2009	Benzo(b,k)fluoranthenes	0.014	ug/L	J	
Standard Asphalt	5/2/2009	Chrysene	0.003	ug/L	U	
Standard Asphalt	5/2/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	5/2/2009	Fluoranthene	0.026	ug/L		
Standard Asphalt	5/2/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Standard Asphalt	5/2/2009	Pyrene	0.017	ug/L		
Standard Asphalt	5/2/2009	bis(2-Ethylhexyl)phthalate	1.3	ug/L	U	
Standard Asphalt	5/2/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Standard Asphalt	5/2/2009	Diethylphthalate	0.249	ug/L	J	
Standard Asphalt	5/2/2009	Dimethyl phthalate	0.078	ug/L	J	
Standard Asphalt	5/2/2009	Di-n-butylphthalate	1.0	ug/L	U	
Standard Asphalt	5/2/2009	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

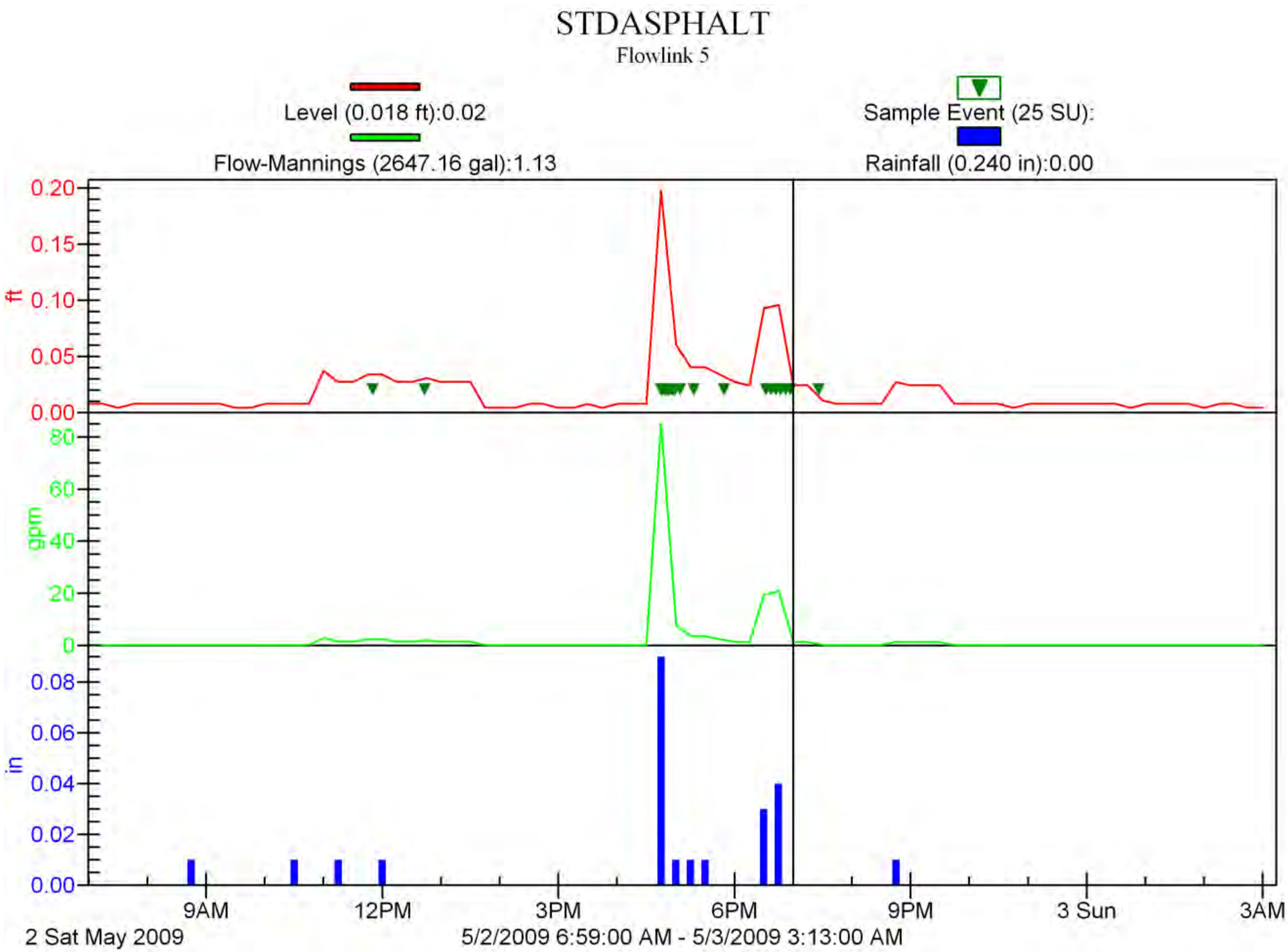

PERVCONCRT
Flowlink 5
Level (0.075 ft):0.08
Flow-Mannings (78164.6 gal):15.70
Sample Event (11 SU):
Rainfall (0.480 in):0.00
ft
0.12
0.10
0.08
0.06
0.04
gpm
30
20
10
in
0.08
0.06
0.04
0.02
0.00
30 Thu
1 Fri
2 Sat
3 Sun
Apr 2009
4/29/2009 1:13:00 AM - 5/3/2009 3:55:00 AM



PERVCONCRT
Flowlink 5
Level (0.054 ft):0.06
Flow-Mannings (7843.60 gal):6.94
Sample Event (11 SU):
Rainfall (0.240 in):0.00
ft
0.12
0.10
0.08
0.06
0.04
gpm
30
20
10
in
0.08
0.06
0.04
0.02
0.00
6AM
9AM
12PM
3PM
6PM
9PM
3 Sun
2 Sat May 2009
5/2/2009 5:32:00 AM - 5/3/2009 1:36:00 AM



PERVASFALT
Flowlink 5
Level (0.020 ft):0.08
Flow-Mannings (2779.13 gal):14.22
Sample Event (36 SU):
Rainfall (0.240 in):0.01
ft
0.08
0.06
0.04
0.02
0.00
gpm
15
10
5
0
in
0.08
0.06
0.04
0.02
0.00
9AM
12PM
3PM
6PM
9PM
3 Sun
3AM
2 Sat May 2009
5/2/2009 6:54:00 AM - 5/3/2009 3:01:00 AM



STDASPHALT
Flowlink 5
Level (0.018 ft):0.02
Flow-Mannings (2647.16 gal):1.13
Sample Event (25 SU):
Rainfall (0.240 in):0.00
ft
0.20
0.15
0.10
0.05
0.00
gpm
80
60
40
20
0
in
0.08
0.06
0.04
0.02
0.00
9AM
12PM
3PM
6PM
9PM
3 Sun
3AM
2 Sat May 2009
5/2/2009 6:59:00 AM - 5/3/2009 3:13:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #33
Date: May 4, 2009

Introduction

This report summarizes the storm event sampled on May 4, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #33.

Table 1. Storm Characteristics

Storm Date		5/4/2009
Time Storm Began		1500
Total Precipitation (in)		0.57*
Duration (hrs)		22.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		25.25
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

* Partial storm event used. See storm summary sheet.

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #33. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for pervious pavers. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	18.46	NS	NS	NS
Duration of Flow (hrs)	7	NS	NS	NS
Total Volume (gallons) during Storm Event	2314*	NS	NS	NS
Total Volume (gallons) during Sampling Event	1888	NS	NS	NS
Duration of Sampling Event (hrs)	4	NS	NS	NS
Number of Sample Aliquots Collected	48	NS	NS	NS
Percentage of Storm's Total Volume over which Samples were Collected	81.6%*	NS	NS	NS
Volume of Surface Runoff Collected in Vault (inches)	NS	NS	NS	NS

Key: NS = Not Sampled

* Partial storm event used due to size of storm.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

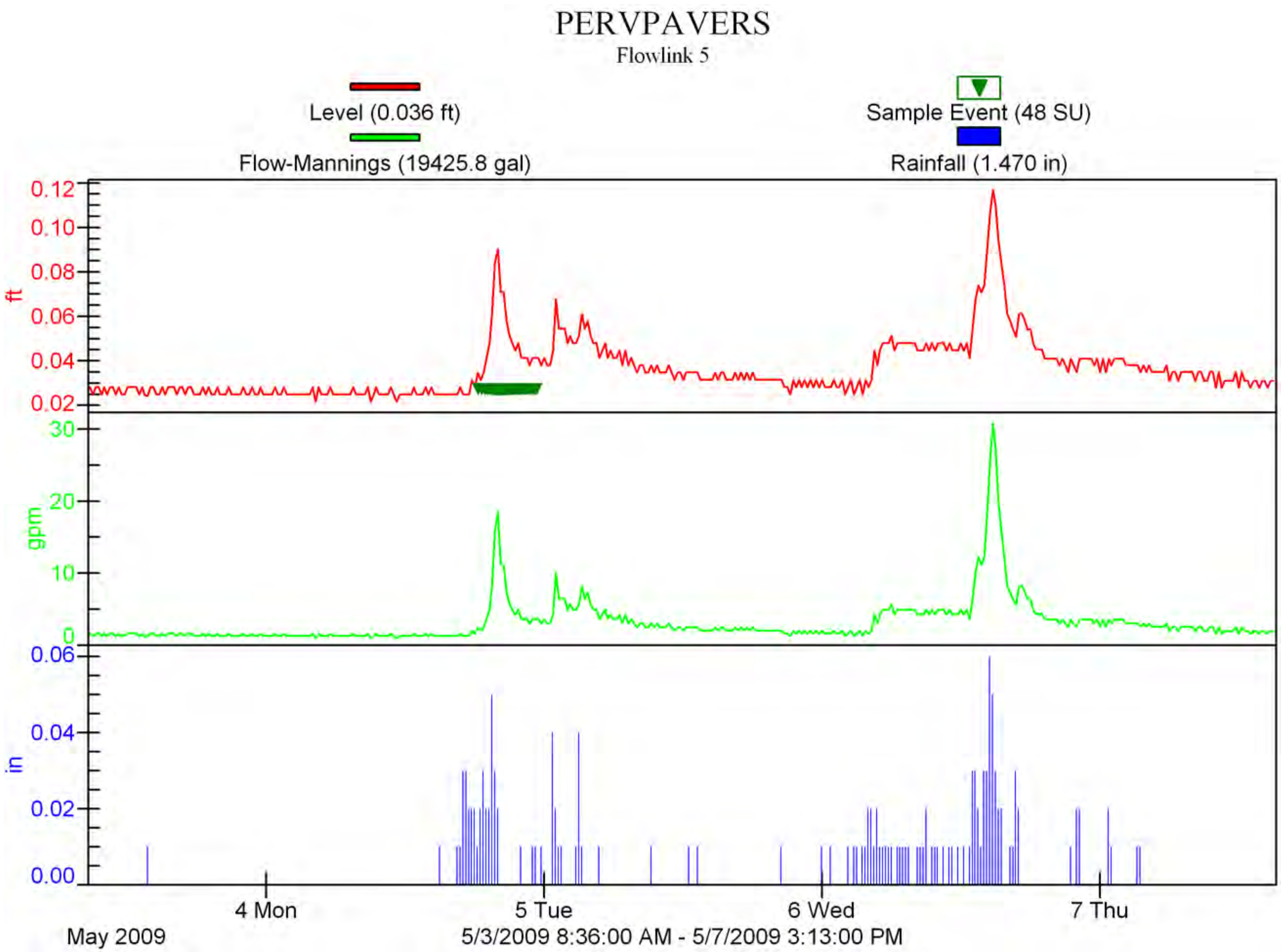
Sampling Observations

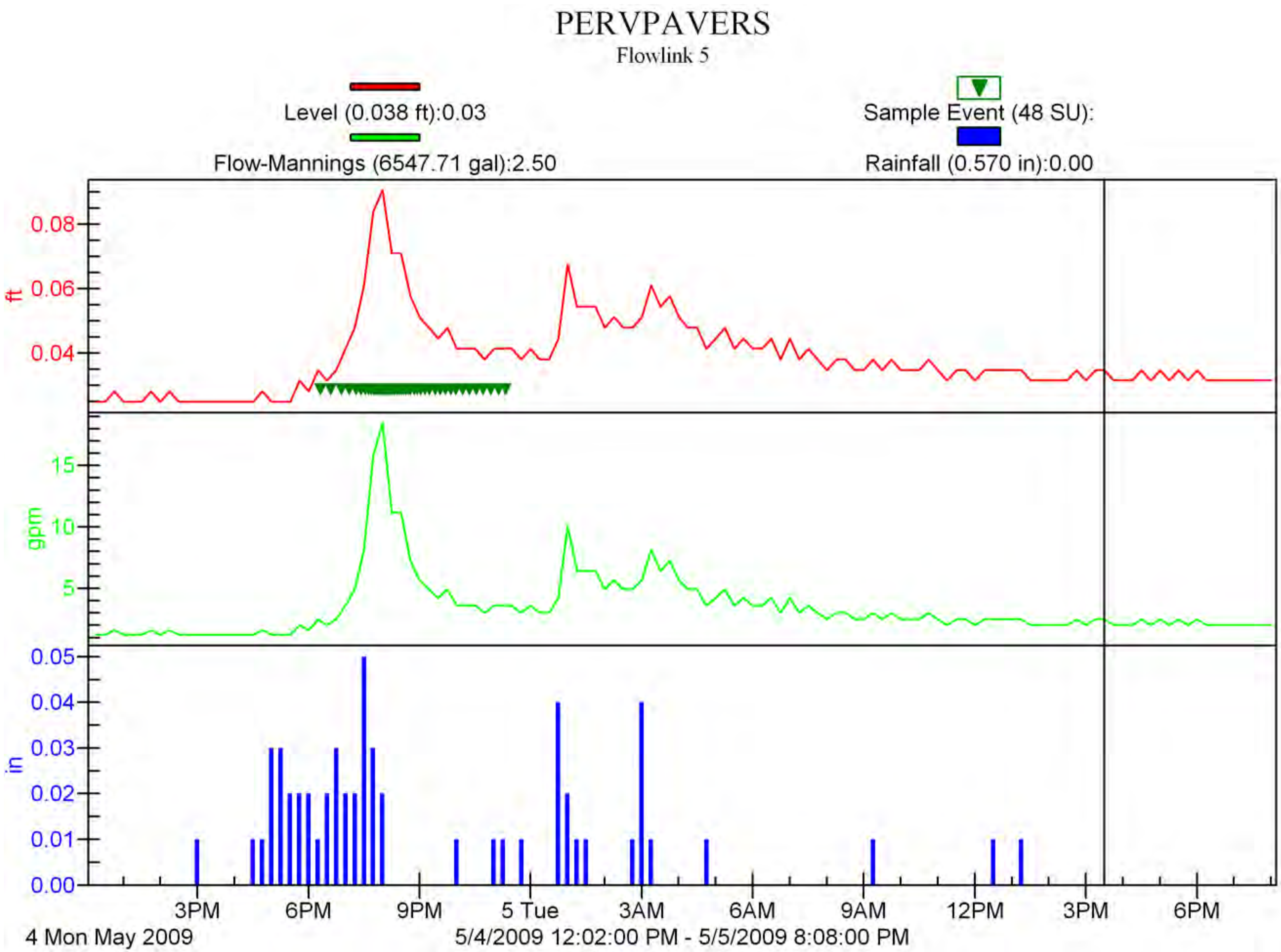
Field notes and the sampling setup report are provided in the ECFSS’s data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	5/4/2009	Hardness, calculated	47.7	mg/L		
Pervious Pavers	5/4/2009	pH	7.2	Std. Units		
Pervious Pavers	5/4/2009	TSS	4.80	mg/L		
Pervious Pavers	5/4/2009	NWTPH-Diesel	0.04	mg/L	U	
Pervious Pavers	5/4/2009	NWTPH-Heavy Oil	0.09	mg/L	J	
Pervious Pavers	5/4/2009	Copper	2.62	ug/L		
Pervious Pavers	5/4/2009	Lead	0.190	ug/L	J	
Pervious Pavers	5/4/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	5/4/2009	Zinc	2.36	ug/L		
Pervious Pavers	5/4/2009	2-Methylnaphthalene	0.005	ug/L	J	
Pervious Pavers	5/4/2009	Acenaphthene	0.005	ug/L	J	
Pervious Pavers	5/4/2009	Acenaphthylene	0.004	ug/L	J	
Pervious Pavers	5/4/2009	Anthracene	0.018	ug/L		
Pervious Pavers	5/4/2009	Fluorene	0.005	ug/L	J	
Pervious Pavers	5/4/2009	Naphthalene	0.006	ug/L	J	
Pervious Pavers	5/4/2009	Phenanthrene	0.013	ug/L		
Pervious Pavers	5/4/2009	Benzo(a)anthracene	0.029	ug/L		
Pervious Pavers	5/4/2009	Benzo(a)pyrene	0.032	ug/L		
Pervious Pavers	5/4/2009	Benzo(g,h,i)perylene	0.023	ug/L		
Pervious Pavers	5/4/2009	Benzo(b,k)fluoranthenes	0.055	ug/L		
Pervious Pavers	5/4/2009	Chrysene	0.025	ug/L		
Pervious Pavers	5/4/2009	Dibenz(a,h)anthracene	0.021	ug/L		
Pervious Pavers	5/4/2009	Fluoranthene	0.023	ug/L		
Pervious Pavers	5/4/2009	Indeno(1,2,3-c,d)pyrene	0.023	ug/L		
Pervious Pavers	5/4/2009	Pyrene	0.028	ug/L		
Pervious Pavers	5/4/2009	bis(2-Ethylhexyl)phthalate	0.28	ug/L	J	
Pervious Pavers	5/4/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers	5/4/2009	Diethylphthalate	0.176	ug/L	J	
Pervious Pavers	5/4/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	5/4/2009	Di-n-butylphthalate	1.0	ug/L	U	
Pervious Pavers	5/4/2009	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVPAVERS
Flowlink 5
Level (0.036 ft)
Flow-Mannings (19425.8 gal)
Sample Event (48 SU)
Rainfall (1.470 in)
ft
0.12
0.10
0.08
0.06
0.04
0.02
gpm
30
20
10
0
in
0.06
0.04
0.02
0.00
4 Mon
5 Tue
6 Wed
7 Thu
May 2009
5/3/2009 8:36:00 AM - 5/7/2009 3:13:00 PM



PERVPAVERS
Flowlink 5
Level (0.038 ft):0.03
Sample Event (48 SU):
Flow-Mannings (6547.71 gal):2.50
Rainfall (0.570 in):0.00
ft
0.08
0.06
0.04
gpm
15
10
5
in
0.05
0.04
0.03
0.02
0.01
0.00
3PM
6PM
9PM
5 Tue
3AM
6AM
9AM
12PM
3PM
6PM
4 Mon May 2009
5/4/2009 12:02:00 PM - 5/5/2009 8:08:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #34
Date: September 5, 2009

Introduction

This report summarizes the storm event sampled on September 5, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #34.

Table 1. Storm Characteristics

Storm Date		9/5/2009
Time Storm Began		0300
Total Precipitation (in)		0.25
Duration (hrs)		4.75
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		545.25
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #34. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, and 4 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	5.58	21.87	NS	19.00
Duration of Flow (hrs)	9.25	12	NS	5.75
Total Volume (gallons) during Storm Event	1504	6184***	NS	1985
Total Volume (gallons) during Sampling Event	1318	3283	NS	1589
Duration of Sampling Event (hrs)	8.17	3.5	NS	4.9
Number of Sample Aliquots Collected	23*	48	NS	14**
Percentage of Storm's Total Volume over which Samples were Collected	87.6%	53.1%	NS	80.1%
Volume of Surface Runoff Collected in Vault (inches)	NS	NS	NS	NS

Key: NS = Not Sampled

* Three sample aliquots were collected after the storm event.

** Two sample aliquots were collected after the storm event.

*** Flow did not return to zero after event. Estimated end of flow.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Pervious Pavers
- Standard Asphalt
- Pervious Concrete

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

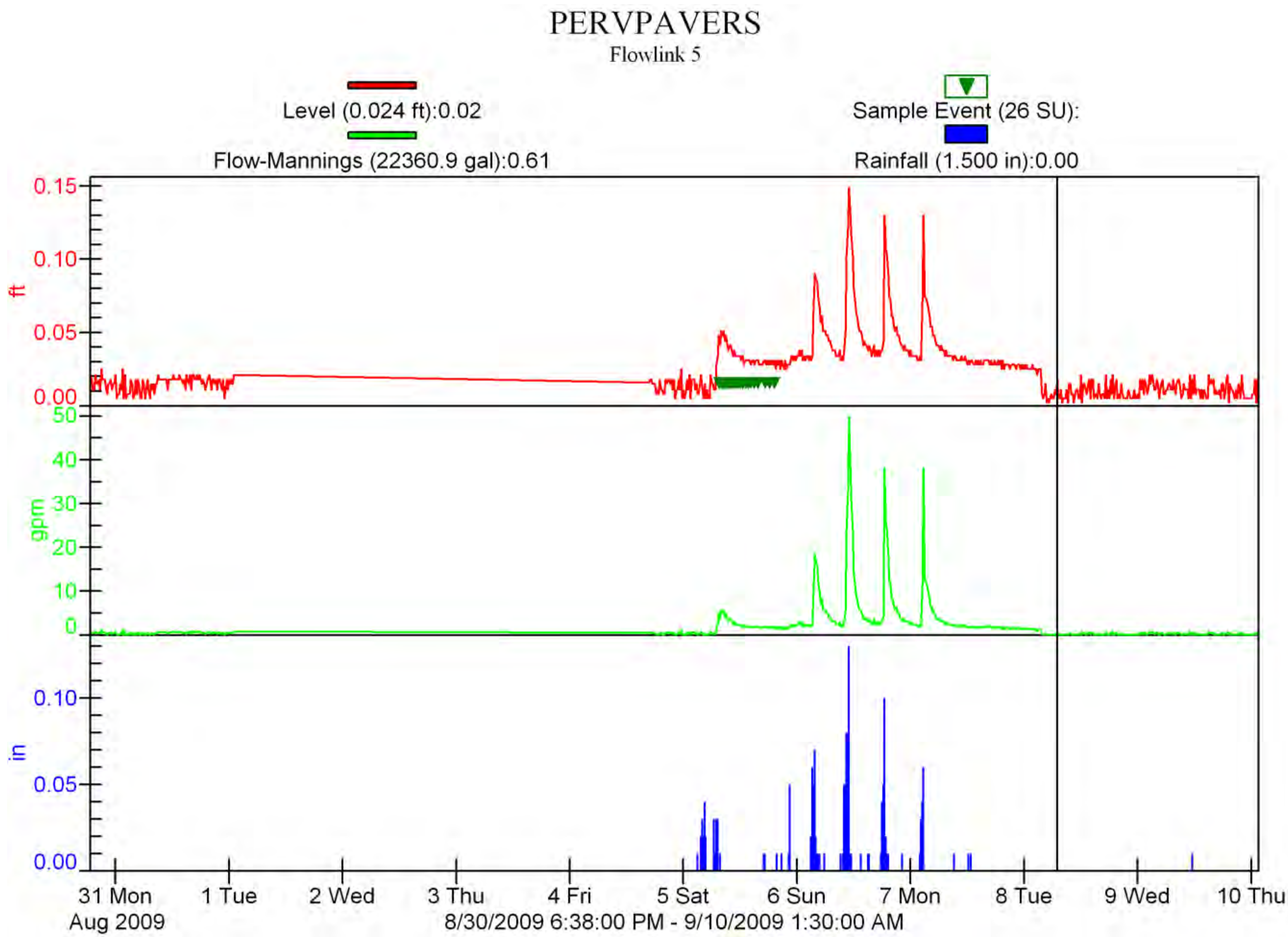
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	9/5/2009	Hardness, calculated	349	mg/L		
Pervious Concrete	9/5/2009	pH	11.4	Std. Units		
Pervious Concrete	9/5/2009	TSS	4.90	mg/L		
Pervious Concrete	9/5/2009	NWTPH-Diesel	0.23	mg/L		
Pervious Concrete	9/5/2009	NWTPH-Heavy Oil	0.21	mg/L		
Pervious Concrete	9/5/2009	Copper	10.5	ug/L		
Pervious Concrete	9/5/2009	Lead	0.90	ug/L	J	
Pervious Concrete	9/5/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	9/5/2009	Zinc	5.6	ug/L		
Pervious Concrete	9/5/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	9/5/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Naphthalene	0.010	ug/L	U	
Pervious Concrete	9/5/2009	Phenanthrene	0.004	ug/L	J	
Pervious Concrete	9/5/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	9/5/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	9/5/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	9/5/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	9/5/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	9/5/2009	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	9/5/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	9/5/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete	9/5/2009	bis(2-Ethylhexyl)phthalate	0.2	ug/L	U	
Pervious Concrete	9/5/2009	Butyl benzyl phthalate	0.2	ug/L	U	
Pervious Concrete	9/5/2009	Diethylphthalate	0.1	ug/L	U	
Pervious Concrete	9/5/2009	Dimethyl phthalate	0.0	ug/L	U	
Pervious Concrete	9/5/2009	Di-n-butylphthalate	0.1	ug/L	U	
Pervious Concrete	9/5/2009	Di-n-Octyl phthalate	0.1	ug/L	U	
Pervious Pavers	9/5/2009	Hardness, calculated	82.4	mg/L		
Pervious Pavers	9/5/2009	pH	7.5	Std. Units		
Pervious Pavers	9/5/2009	TSS	4.20	mg/L		
Pervious Pavers	9/5/2009	NWTPH-Diesel	0.05	mg/L		
Pervious Pavers	9/5/2009	NWTPH-Heavy Oil	0.15	mg/L		
Pervious Pavers	9/5/2009	Copper	5.28	ug/L		
Pervious Pavers	9/5/2009	Lead	0.220	ug/L	J	
Pervious Pavers	9/5/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	9/5/2009	Zinc	2.05	ug/L		
Pervious Pavers	9/5/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	9/5/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Naphthalene	0.010	ug/L	U	
Pervious Pavers	9/5/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	9/5/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	9/5/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	9/5/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	9/5/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	9/5/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	9/5/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	9/5/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	9/5/2009	bis(2-Ethylhexyl)phthalate	0.4	ug/L	J	
Pervious Pavers	9/5/2009	Butyl benzyl phthalate	0.2	ug/L	U	

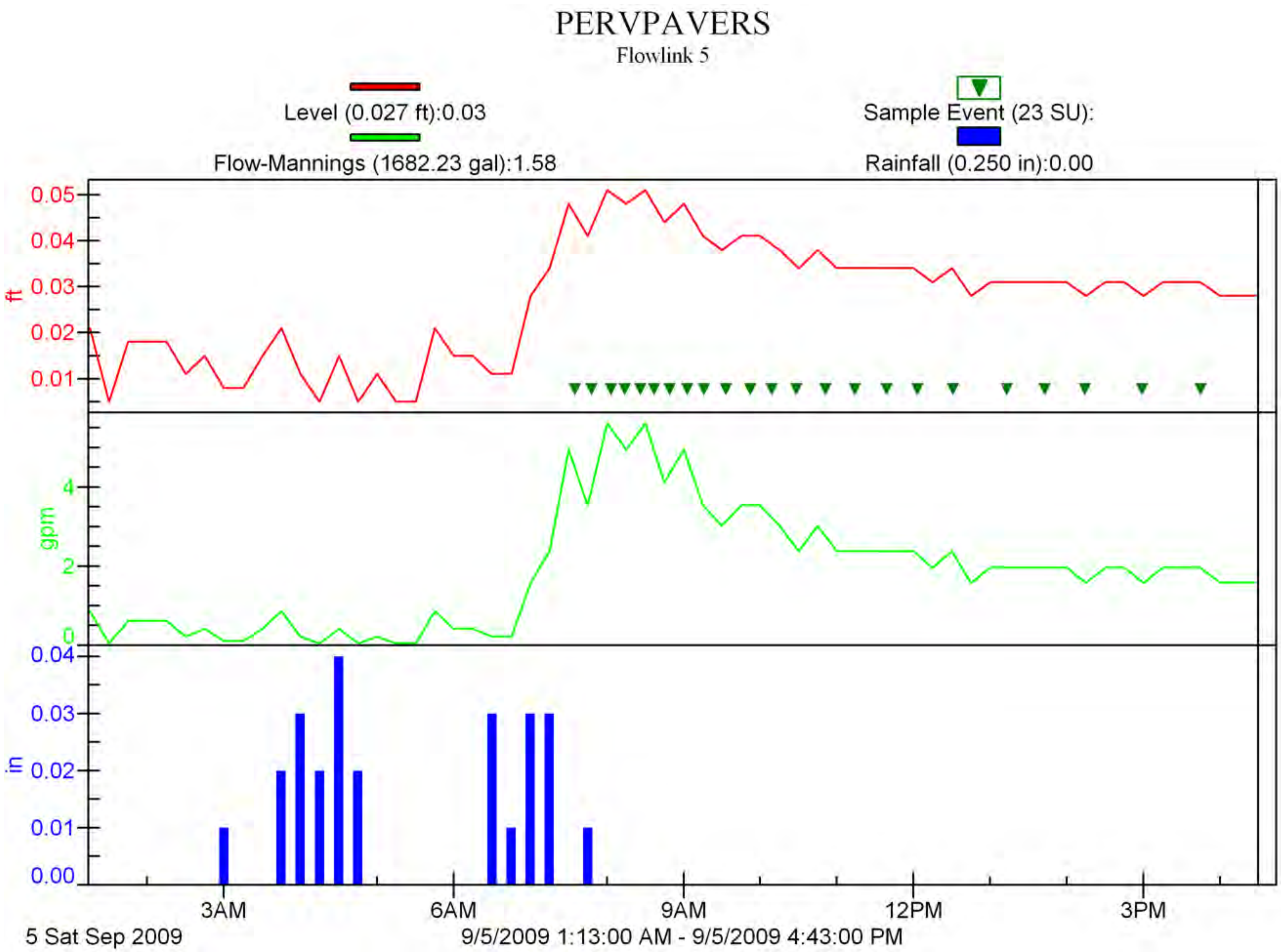
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

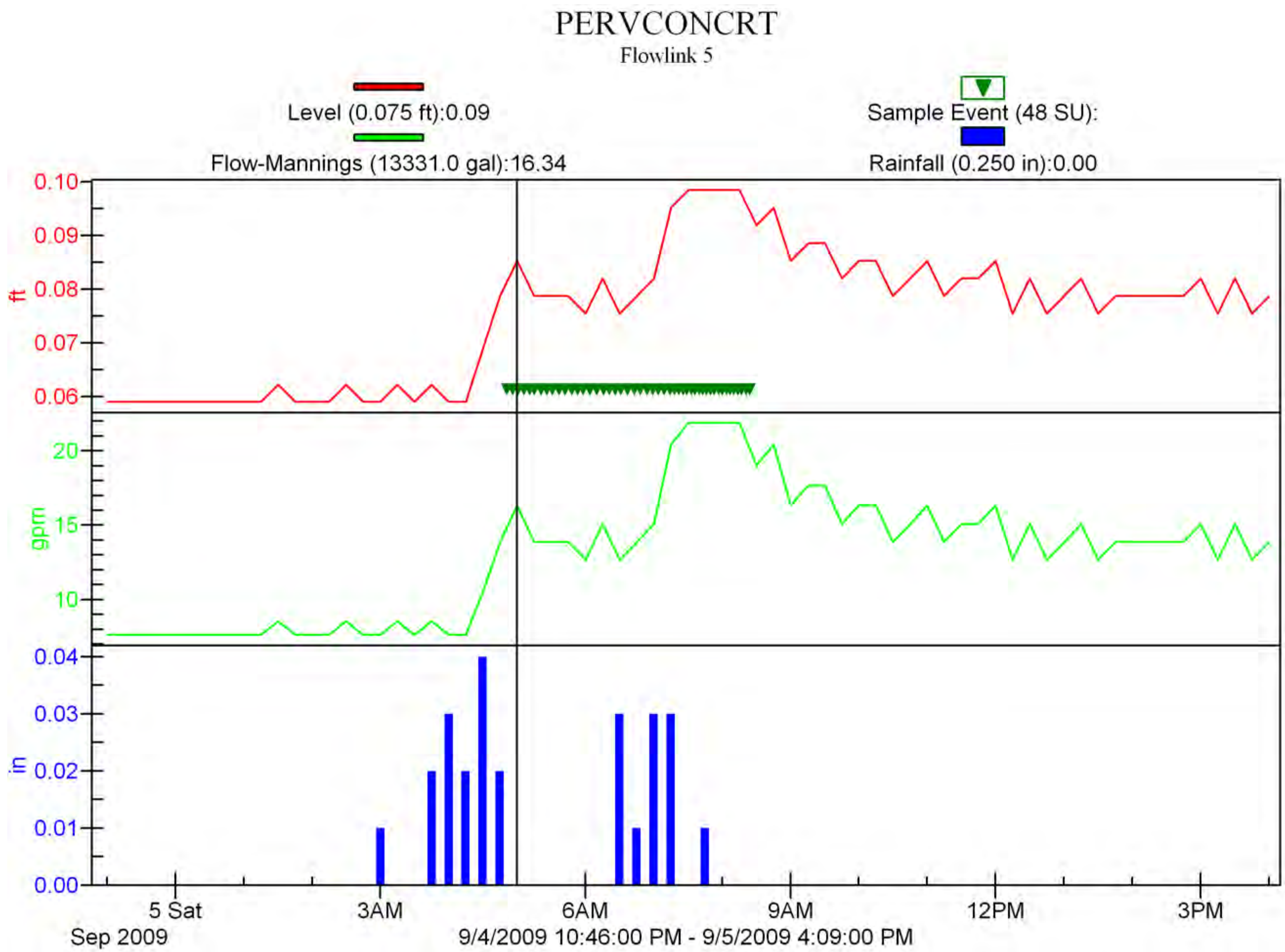
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Pavers	9/5/2009	Diethylphthalate	0.1	ug/L	J	
Pervious Pavers	9/5/2009	Dimethyl phthalate	0.0	ug/L	U	
Pervious Pavers	9/5/2009	Di-n-butylphthalate	0.2	ug/L	J	
Pervious Pavers	9/5/2009	Di-n-Octyl phthalate	0.1	ug/L	U	
Standard Asphalt	9/5/2009	Hardness, calculated	7.02	mg/L		
Standard Asphalt	9/5/2009	pH	6.8	Std. Units		
Standard Asphalt	9/5/2009	TSS	21.9	mg/L		
Standard Asphalt	9/5/2009	NWTPH-Diesel	0.26	mg/L		
Standard Asphalt	9/5/2009	NWTPH-Heavy Oil	0.67	mg/L		
Standard Asphalt	9/5/2009	Copper	16.1	ug/L		
Standard Asphalt	9/5/2009	Lead	9.19	ug/L		
Standard Asphalt	9/5/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	9/5/2009	Zinc	73.7	ug/L		
Standard Asphalt	9/5/2009	2-Methylnaphthalene	0.005	ug/L	J	
Standard Asphalt	9/5/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	9/5/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	9/5/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	9/5/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	9/5/2009	Naphthalene	0.011	ug/L		U
Standard Asphalt	9/5/2009	Phenanthrene	0.019	ug/L		
Standard Asphalt	9/5/2009	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	9/5/2009	Benzo(a)pyrene	0.004	ug/L	U	
Standard Asphalt	9/5/2009	Benzo(g,h,i)perylene	0.017	ug/L		
Standard Asphalt	9/5/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Standard Asphalt	9/5/2009	Chrysene	0.003	ug/L	U	
Standard Asphalt	9/5/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	9/5/2009	Fluoranthene	0.027	ug/L		
Standard Asphalt	9/5/2009	Indeno(1,2,3-c,d)pyrene	0.010	ug/L	J	
Standard Asphalt	9/5/2009	Pyrene	0.024	ug/L		
Standard Asphalt	9/5/2009	bis(2-Ethylhexyl)phthalate	2.0	ug/L		
Standard Asphalt	9/5/2009	Butyl benzyl phthalate	0.4	ug/L	J	
Standard Asphalt	9/5/2009	Diethylphthalate	0.3	ug/L	J	
Standard Asphalt	9/5/2009	Dimethyl phthalate	0.1	ug/L	J	
Standard Asphalt	9/5/2009	Di-n-butylphthalate	0.2	ug/L	J	
Standard Asphalt	9/5/2009	Di-n-Octyl phthalate	0.1	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit


PERVPAVERS
Flowlink 5
Level (0.024 ft):0.02
Flow-Mannings (22360.9 gal):0.61
Sample Event (26 SU):
Rainfall (1.500 in):0.00
ft
0.15
0.10
0.05
0.00
gpm
50
40
30
20
10
0
in
0.10
0.05
0.00
31 Mon
Aug 2009
1 Tue
2 Wed
3 Thu
4 Fri
5 Sat
6 Sun
7 Mon
8 Tue
9 Wed
10 Thu
8/30/2009 6:38:00 PM - 9/10/2009 1:30:00 AM



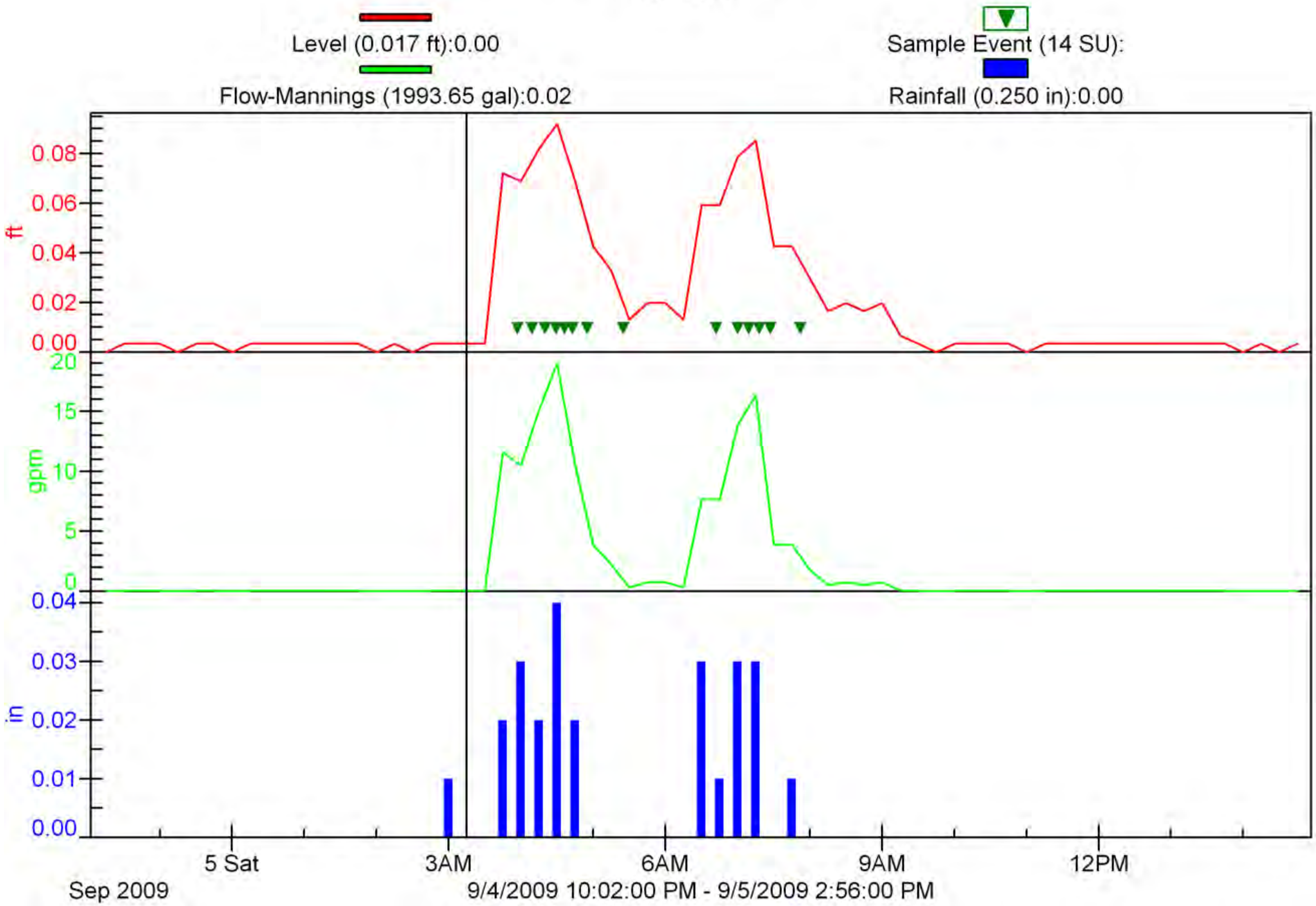
PERVPAVERS
Flowlink 5
Level (0.027 ft):0.03
Sample Event (23 SU):
Flow-Mannings (1682.23 gal):1.58
Rainfall (0.250 in):0.00
ft
0.05
0.04
0.03
0.02
0.01
gpm
4
2
0
in
0.04
0.03
0.02
0.01
0.00
3AM
6AM
9AM
12PM
3PM
5 Sat Sep 2009
9/5/2009 1:13:00 AM - 9/5/2009 4:43:00 PM



PERVCONCRT
Flowlink 5
Level (0.075 ft):0.09
Flow-Mannings (13331.0 gal):16.34
Sample Event (48 SU):
Rainfall (0.250 in):0.00
ft
0.10
0.09
0.08
0.07
0.06
gpm
20
15
10
in
0.04
0.03
0.02
0.01
0.00
5 Sat
Sep 2009
3AM
6AM
9AM
12PM
3PM
9/4/2009 10:46:00 PM - 9/5/2009 4:09:00 PM

STDASPHALT

Flowlink 5



STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #35
Date: September 19, 2009

Introduction

This report summarizes the storm event sampled on September 19, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #35.

Table 1. Storm Characteristics

Storm Date		9/19/2009
Time Storm Began		330
Total Precipitation (in)		0.21
Duration (hrs)		3.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		73
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #19. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2 provides the hydrograph and hyetograph for the storm event for standard asphalt. Sample collection markers are also identified on the storm hydrograph.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	NS	NS	NS	12.70
Duration of Flow (hrs)	NS	NS	NS	5
Total Volume (gallons) during Storm Event	NS	NS	NS	1427
Total Volume (gallons) during Sampling Event	NS	NS	NS	1266
Duration of Sampling Event (hrs)	NS	NS	NS	3.6
Number of Sample Aliquots Collected	NS	NS	NS	16
Percentage of Storm's Total Volume over which Samples were Collected	NS	NS	NS	88.7%
Volume of Surface Runoff Collected in Vault (inches)	NS	NS	NS	NS

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS’s data summary package.

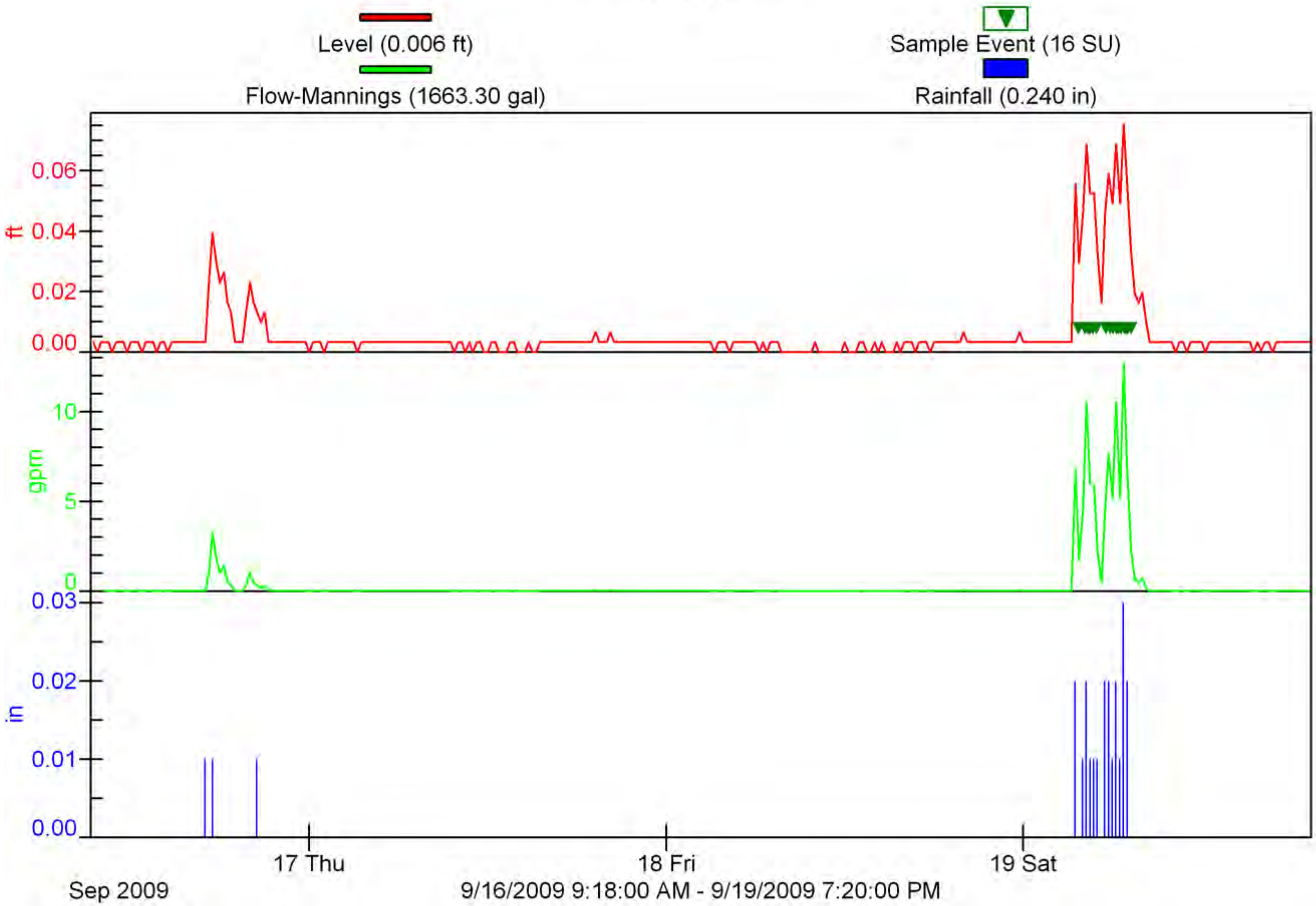
Table 3. Water Quality Data

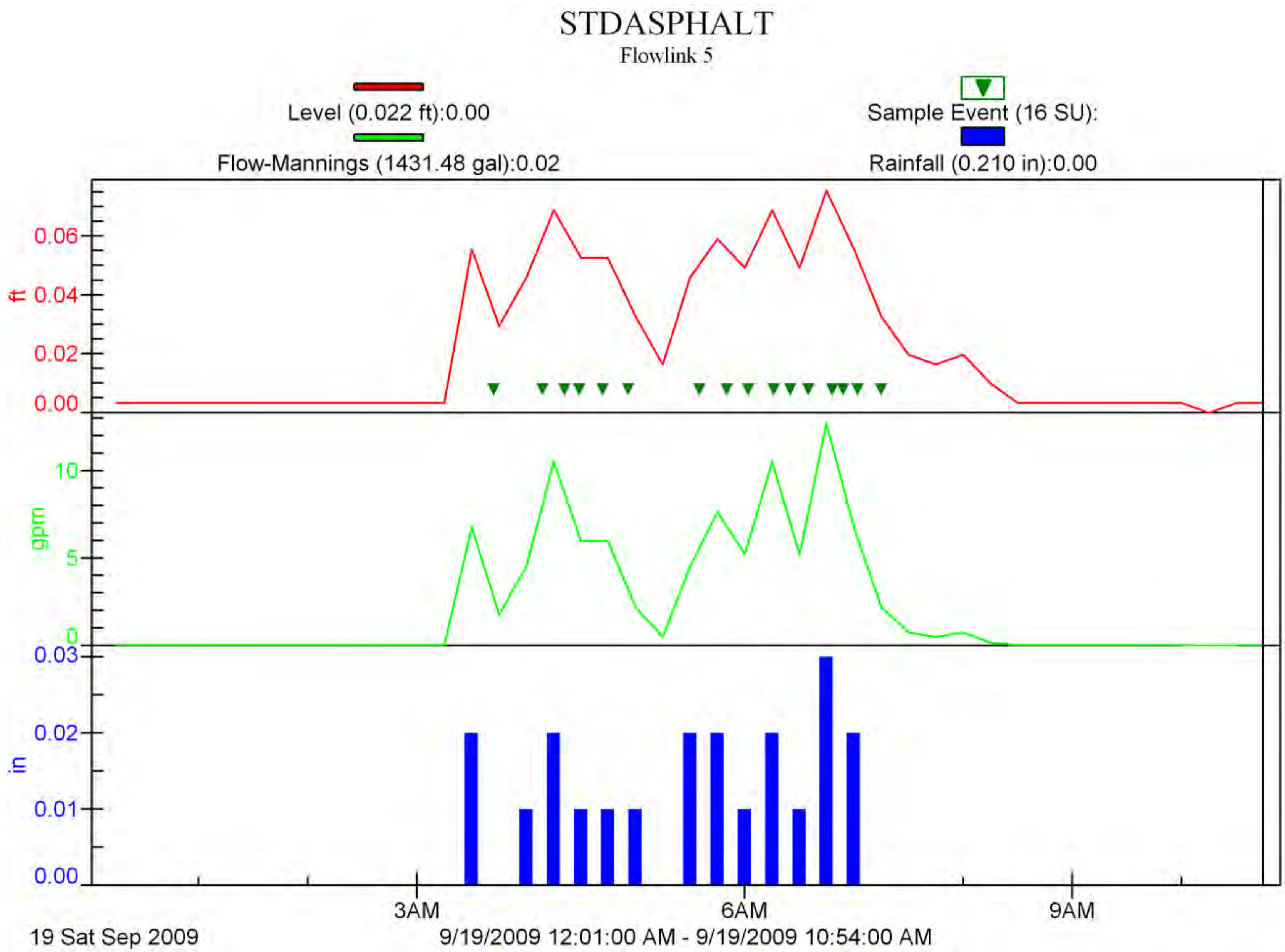
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	9/19/2009	Hardness, calculated	7.50	mg/L		
Standard Asphalt	9/19/2009	pH	6.7	Std. Units		
Standard Asphalt	9/19/2009	NWTPH-Diesel	0.2	mg/L	U	
Standard Asphalt	9/19/2009	NWTPH-Heavy Oil	0.30	mg/L	U	
Standard Asphalt	9/19/2009	Copper	15.3	ug/L		
Standard Asphalt	9/19/2009	Lead	4.11	ug/L		
Standard Asphalt	9/19/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	9/19/2009	Zinc	60.4	ug/L		
Standard Asphalt	9/19/2009	2-Methylnaphthalene	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	9/19/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Naphthalene	0.010	ug/L	U	
Standard Asphalt	9/19/2009	Phenanthrene	0.011	ug/L		
Standard Asphalt	9/19/2009	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	9/19/2009	Benzo(a)pyrene	0.004	ug/L	U	
Standard Asphalt	9/19/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Standard Asphalt	9/19/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Chrysene	0.003	ug/L	U	
Standard Asphalt	9/19/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	9/19/2009	Fluoranthene	0.010	ug/L		
Standard Asphalt	9/19/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Standard Asphalt	9/19/2009	Pyrene	0.004	ug/L	U	
Standard Asphalt	9/19/2009	bis(2-Ethylhexyl)phthalate	0.71	ug/L	J	
Standard Asphalt	9/19/2009	Butyl benzyl phthalate	0.31	ug/L	J	
Standard Asphalt	9/19/2009	Diethylphthalate	1.0	ug/L	U	
Standard Asphalt	9/19/2009	Dimethyl phthalate	0.116	ug/L	J	
Standard Asphalt	9/19/2009	Di-n-butylphthalate	0.45	ug/L	J	
Standard Asphalt	9/19/2009	Di-n-Octyl phthalate	0.084	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

STDASPHALT

Flowlink 5





STDASPHALT
Flowlink 5
Level (0.022 ft):0.00
Flow-Mannings (1431.48 gal):0.02
Sample Event (16 SU):
Rainfall (0.210 in):0.00
ft
0.06
0.04
0.02
0.00
gpm
10
5
0
in
0.03
0.02
0.01
0.00
3AM
6AM
9AM
19 Sat Sep 2009
9/19/2009 12:01:00 AM - 9/19/2009 10:54:00 AM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #36
Date: October 16, 2009

Introduction

This report summarizes the storm event sampled on October 16, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #36.

Table 1. Storm Characteristics

Storm Date		10/16-10/17/2009
Time Storm Began		1000
Total Precipitation (in)		0.68*
Duration (hrs)		10.5
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		32
Precipitation in 24-hr Antecedent Dry Period (in)		0.02
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	No

* Partial storm used for some sites. See storm summary sheet.

This event did not meet the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #36. As shown above, 0.02 inches of rain fell in the 24 hours prior to the sampling event; this exceeded the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, 4, and 5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	41.82	23.4	21.9	37.0
Duration of Flow (hrs)	14	7.25	14	12*
Total Volume (gallons) during Storm Event	6924	8446***	5203	4139
Total Volume (gallons) during Sampling Event	3592	6927	4850	3715
Duration of Sampling Event (hrs)	8.8	6.0	12.1	11.2
Number of Sample Aliquots Collected	48	48	34*	24**
Percentage of Storm's Total Volume over which Samples were Collected	51.9%	82.0%***	93.2%	89.8%
Volume of Surface Runoff Collected in Vault (inches)	NS	21	18.5	

Key: NS = Not Sampled

* 14 aliquots collected outside storm event. These are not included in the above numbers.
** 19 aliquots collected outside storm event. These are not included in the above numbers.
*** Partial storm event used due to size of storm event.

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt
- Pervious Asphalt
- Pervious Concrete
- Pervious Pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8” low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	10/17/2009	Hardness, calculated	16.7	mg/L		
Pervious Asphalt	10/17/2009	pH	7.0	Std. Units		
Pervious Asphalt	10/17/2009	TSS	9.70	mg/L		
Pervious Asphalt	10/17/2009	NWTPH-Diesel	0.09	mg/L		
Pervious Asphalt	10/17/2009	NWTPH-Heavy Oil	0.13	mg/L		
Pervious Asphalt	10/17/2009	Copper	2.76	ug/L		
Pervious Asphalt	10/17/2009	Lead	0.150	ug/L	J	
Pervious Asphalt	10/17/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	10/17/2009	Zinc	1.79	ug/L		
Pervious Asphalt	10/17/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt	10/17/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Naphthalene	0.007	ug/L	U	
Pervious Asphalt	10/17/2009	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	10/17/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	10/17/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	10/17/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt	10/17/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	10/17/2009	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	10/17/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	10/17/2009	Pyrene	0.004	ug/L	U	
Pervious Asphalt	10/17/2009	bis(2-Ethylhexyl)phthalate	0.33	ug/L	J	
Pervious Asphalt	10/17/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt	10/17/2009	Diethylphthalate	0.870	ug/L	J	
Pervious Asphalt	10/17/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt	10/17/2009	Di-n-butylphthalate	0.20	ug/L	J	
Pervious Asphalt	10/17/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Asphalt CB	10/17/2009	Hardness, calculated	8.85	mg/L		
Pervious Asphalt CB	10/17/2009	pH	6.8	Std. Units		
Pervious Asphalt CB	10/17/2009	TSS	19.2	mg/L		
Pervious Asphalt CB	10/17/2009	NWTPH-Diesel	0.13	mg/L		
Pervious Asphalt CB	10/17/2009	NWTPH-Heavy Oil	0.30	mg/L		
Pervious Asphalt CB	10/17/2009	Copper	8.02	ug/L		
Pervious Asphalt CB	10/17/2009	Lead	2.56	ug/L		
Pervious Asphalt CB	10/17/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt CB	10/17/2009	Zinc	37.4	ug/L		
Pervious Asphalt CB	10/17/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt CB	10/17/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt CB	10/17/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt CB	10/17/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt CB	10/17/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt CB	10/17/2009	Naphthalene	0.008	ug/L	U	
Pervious Asphalt CB	10/17/2009	Phenanthrene	0.006	ug/L	J	
Pervious Asphalt CB	10/17/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt CB	10/17/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt CB	10/17/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt CB	10/17/2009	Benzo(b,k)fluoranthenes	0.006	ug/L	J	
Pervious Asphalt CB	10/17/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt CB	10/17/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt CB	10/17/2009	Fluoranthene	0.008	ug/L	J	
Pervious Asphalt CB	10/17/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt CB	10/17/2009	Pyrene	0.007	ug/L	J	
Pervious Asphalt CB	10/17/2009	bis(2-Ethylhexyl)phthalate	0.30	ug/L	J	
Pervious Asphalt CB	10/17/2009	Butyl benzyl phthalate	0.17	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt CB	10/17/2009	Diethylphthalate	0.072	ug/L	U	
Pervious Asphalt CB	10/17/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt CB	10/17/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Asphalt CB	10/17/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete	10/16/2009	Hardness, calculated	347	mg/L		
Pervious Concrete	10/16/2009	pH	11.6	Std. Units		
Pervious Concrete	10/16/2009	TSS	10.6	mg/L		
Pervious Concrete	10/16/2009	NWTPH-Diesel	0.13	mg/L		
Pervious Concrete	10/16/2009	NWTPH-Heavy Oil	0.14	mg/L		
Pervious Concrete	10/16/2009	Copper	5.52	ug/L		
Pervious Concrete	10/16/2009	Lead	0.120	ug/L	J	
Pervious Concrete	10/16/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	10/16/2009	Zinc	1.27	ug/L		
Pervious Concrete	10/16/2009	2-Methylnaphthalene	0.004	ug/L	J	
Pervious Concrete	10/16/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	10/16/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	10/16/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	10/16/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	10/16/2009	Naphthalene	0.012	ug/L		U
Pervious Concrete	10/16/2009	Phenanthrene	0.006	ug/L	J	
Pervious Concrete	10/16/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	10/16/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	10/16/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	10/16/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	10/16/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	10/16/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	10/16/2009	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	10/16/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	10/16/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete	10/16/2009	bis(2-Ethylhexyl)phthalate	0.38	ug/L	J	
Pervious Concrete	10/16/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	10/16/2009	Diethylphthalate	0.072	ug/L	U	
Pervious Concrete	10/16/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	10/16/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete	10/16/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete CB	10/17/2009	Hardness, calculated	32.4	mg/L		
Pervious Concrete CB	10/17/2009	pH	7.3	Std. Units		
Pervious Concrete CB	10/17/2009	TSS	25.9	mg/L		
Pervious Concrete CB	10/17/2009	NWTPH-Diesel	0.07	mg/L		
Pervious Concrete CB	10/17/2009	NWTPH-Heavy Oil	0.28	mg/L		
Pervious Concrete CB	10/17/2009	Copper	8.90	ug/L		
Pervious Concrete CB	10/17/2009	Lead	2.23	ug/L		
Pervious Concrete CB	10/17/2009	Mercury	0.050	ug/L	U	
Pervious Concrete CB	10/17/2009	Zinc	35.7	ug/L		
Pervious Concrete CB	10/17/2009	2-Methylnaphthalene	0.003	ug/L	J	
Pervious Concrete CB	10/17/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete CB	10/17/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete CB	10/17/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete CB	10/17/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete CB	10/17/2009	Naphthalene	0.011	ug/L		U
Pervious Concrete CB	10/17/2009	Phenanthrene	0.009	ug/L	J	
Pervious Concrete CB	10/17/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete CB	10/17/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete CB	10/17/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete CB	10/17/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete CB	10/17/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete CB	10/17/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete CB	10/17/2009	Fluoranthene	0.010	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete CB	10/17/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete CB	10/17/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete CB	10/17/2009	bis(2-Ethylhexyl)phthalate	0.59	ug/L	J	
Pervious Concrete CB	10/17/2009	Butyl benzyl phthalate	0.27	ug/L	J	
Pervious Concrete CB	10/17/2009	Diethylphthalate	0.072	ug/L	U	
Pervious Concrete CB	10/17/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete CB	10/17/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete CB	10/17/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Pavers	10/16/2009	Hardness, calculated	50.8	mg/L		
Pervious Pavers	10/16/2009	pH	7.5	Std. Units		
Pervious Pavers	10/16/2009	TSS	6.60	mg/L		
Pervious Pavers	10/16/2009	NWTPH-Diesel	0.06	mg/L		
Pervious Pavers	10/16/2009	NWTPH-Heavy Oil	0.10	mg/L	J	
Pervious Pavers	10/16/2009	Copper	4.58	ug/L		
Pervious Pavers	10/16/2009	Lead	0.570	ug/L		
Pervious Pavers	10/16/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	10/16/2009	Zinc	5.91	ug/L		
Pervious Pavers	10/16/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	10/16/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Naphthalene	0.006	ug/L	U	
Pervious Pavers	10/16/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	10/16/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	10/16/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	10/16/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	10/16/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	10/16/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	10/16/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	10/16/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	10/16/2009	bis(2-Ethylhexyl)phthalate	0.18	ug/L	J	
Pervious Pavers	10/16/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Pavers	10/16/2009	Diethylphthalate	0.072	ug/L	U	
Pervious Pavers	10/16/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	10/16/2009	Di-n-butylphthalate	0.11	ug/L	J	
Pervious Pavers	10/16/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	10/17/2009	Hardness, calculated	4.40	mg/L		
Standard Asphalt	10/17/2009	pH	6.4	Std. Units		
Standard Asphalt	10/17/2009	TSS	66.7	mg/L		
Standard Asphalt	10/17/2009	NWTPH-Diesel	0.10	mg/L		
Standard Asphalt	10/17/2009	NWTPH-Heavy Oil	0.23	mg/L		
Standard Asphalt	10/17/2009	Copper	11.9	ug/L		
Standard Asphalt	10/17/2009	Lead	11.6	ug/L		
Standard Asphalt	10/17/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	10/17/2009	Zinc	56.3	ug/L		
Standard Asphalt	10/17/2009	2-Methylnaphthalene	0.005	ug/L	J	
Standard Asphalt	10/17/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	10/17/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	10/17/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	10/17/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	10/17/2009	Naphthalene	0.015	ug/L		U
Standard Asphalt	10/17/2009	Phenanthrene	0.011	ug/L		
Standard Asphalt	10/17/2009	Benzo(a)anthracene	0.002	ug/L	U	
Standard Asphalt	10/17/2009	Benzo(a)pyrene	0.004	ug/L	U	
Standard Asphalt	10/17/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	

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Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	10/17/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Standard Asphalt	10/17/2009	Chrysene	0.003	ug/L	U	
Standard Asphalt	10/17/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	10/17/2009	Fluoranthene	0.008	ug/L	J	
Standard Asphalt	10/17/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Standard Asphalt	10/17/2009	Pyrene	0.005	ug/L	J	
Standard Asphalt	10/17/2009	bis(2-Ethylhexyl)phthalate	0.76	ug/L	J	
Standard Asphalt	10/17/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Standard Asphalt	10/17/2009	Diethylphthalate	0.222	ug/L	J	
Standard Asphalt	10/17/2009	Dimethyl phthalate	0.104	ug/L	J	
Standard Asphalt	10/17/2009	Di-n-butylphthalate	0.20	ug/L	J	
Standard Asphalt	10/17/2009	Di-n-Octyl phthalate	0.166	ug/L	J	

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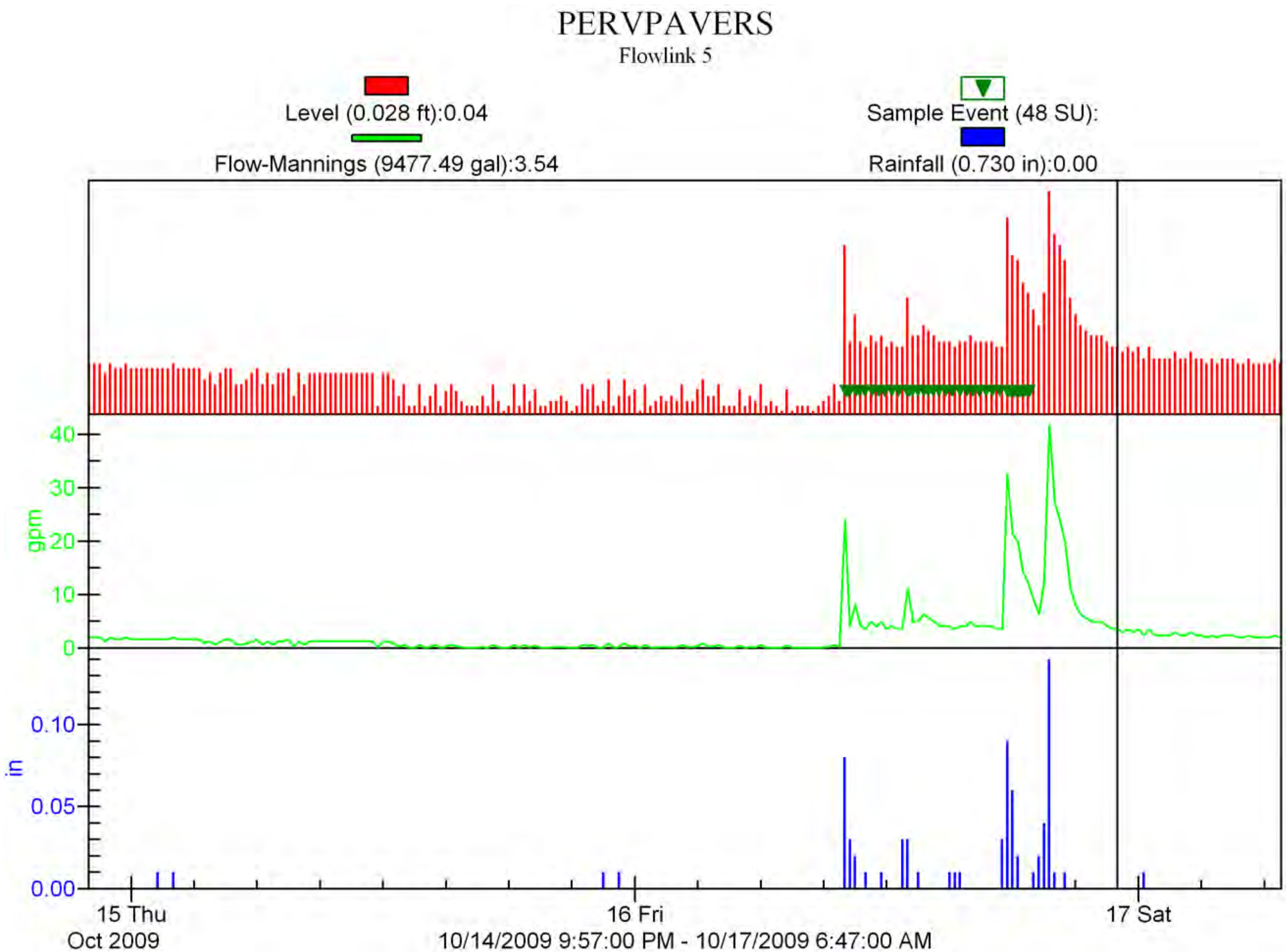
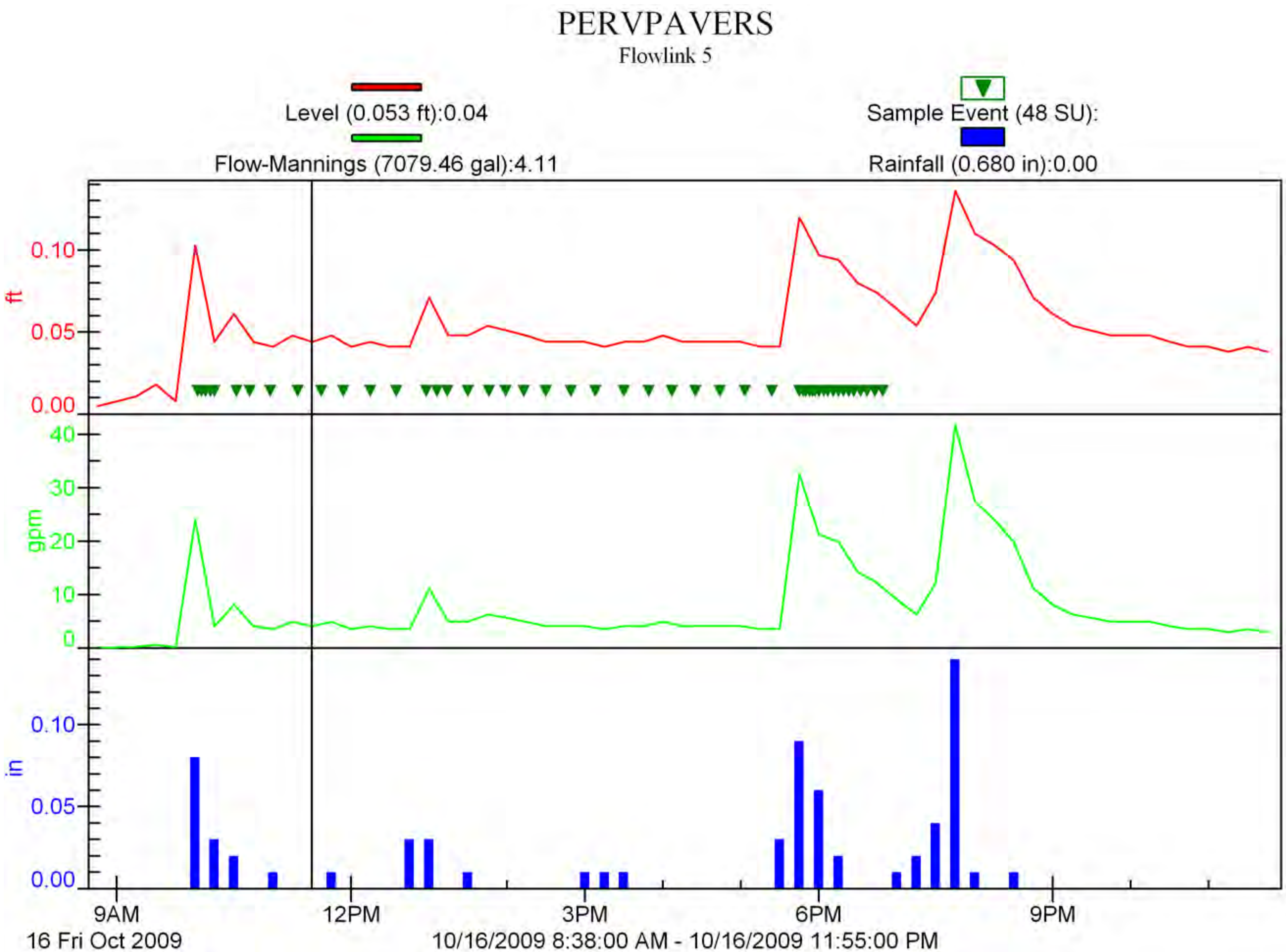
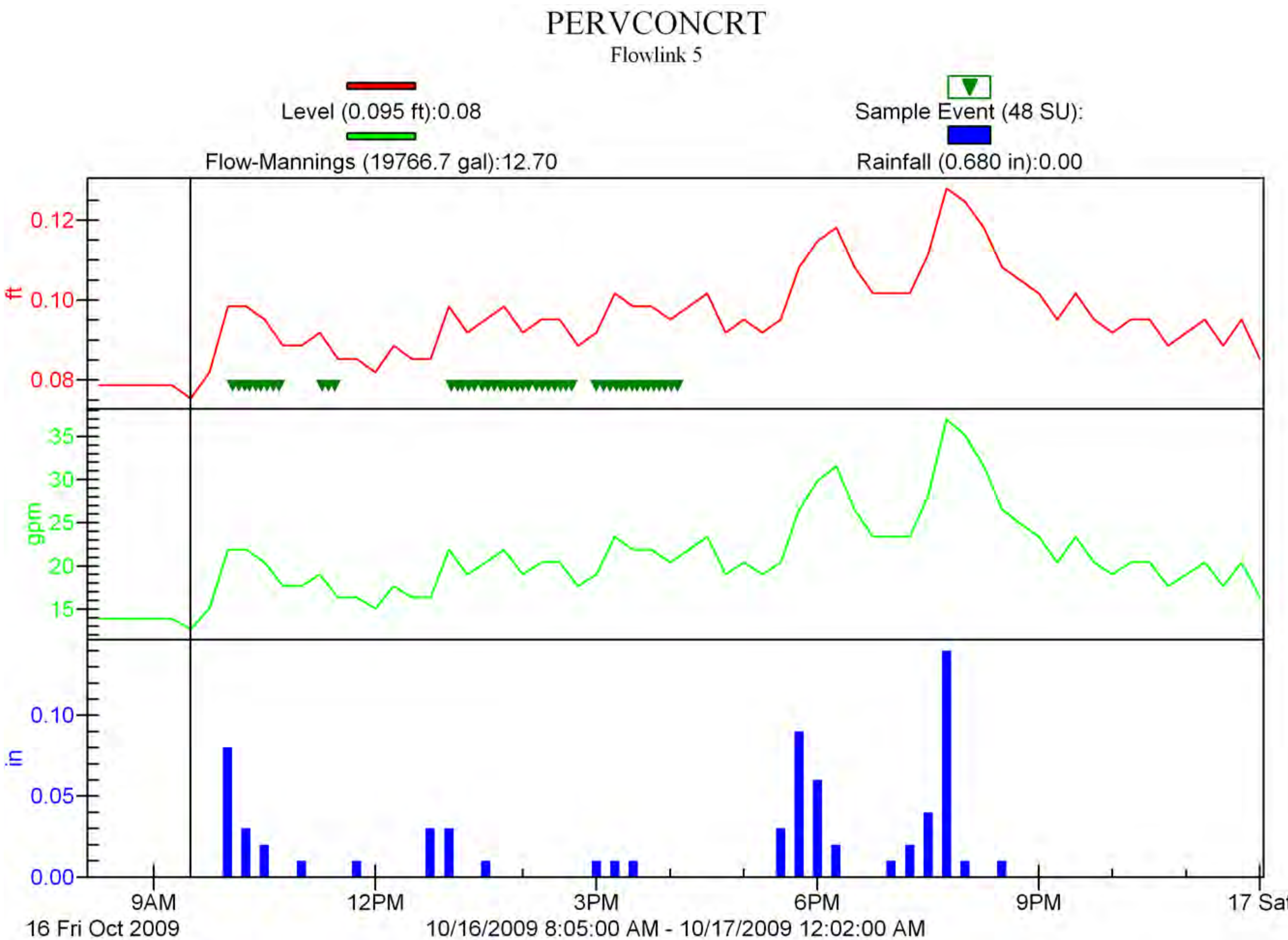
B = value is less than the reporting limit, but greater than the detection limit

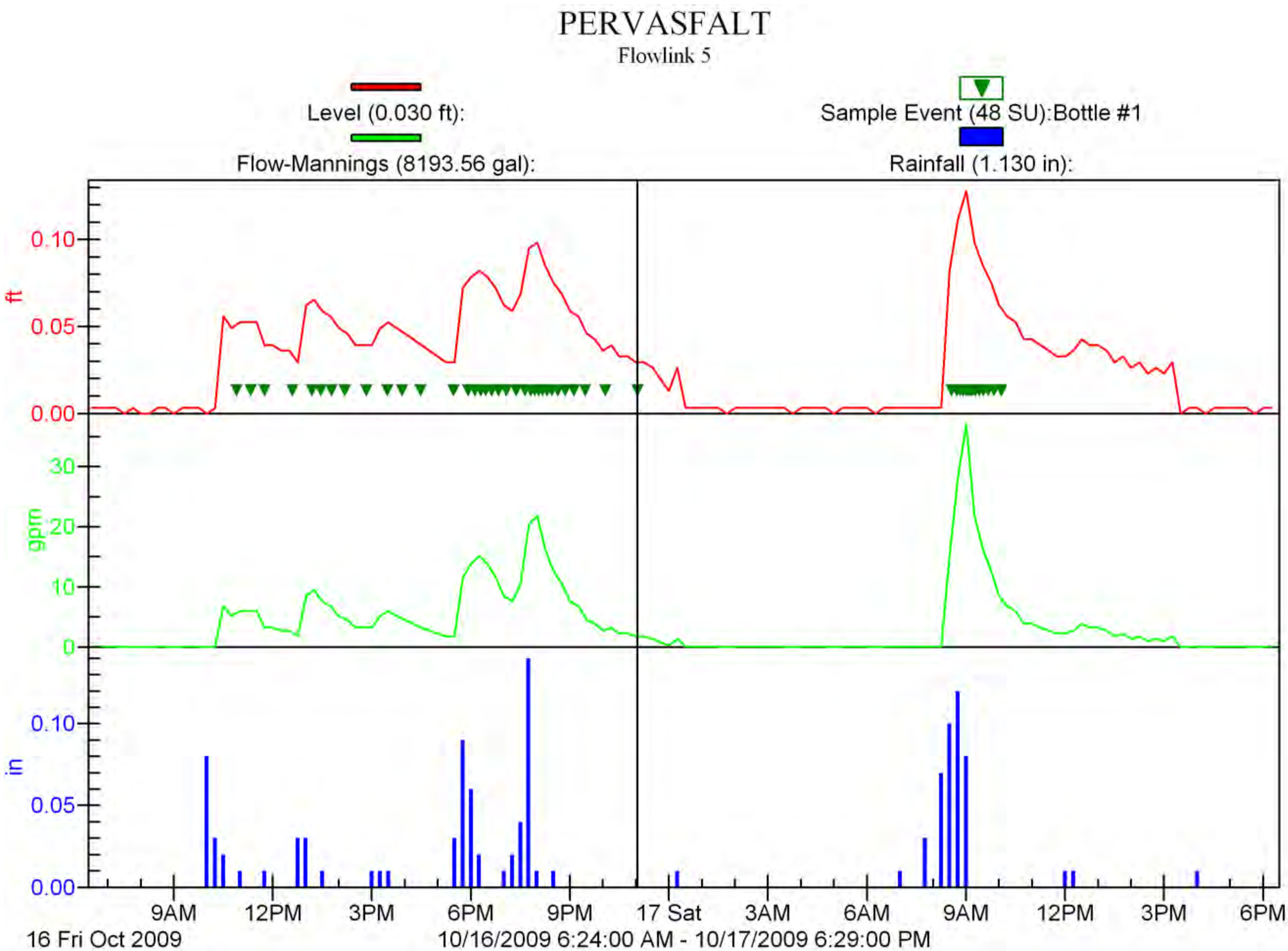


PERVPAVERS
Flowlink 5
Level (0.028 ft):0.04
Flow-Mannings (9477.49 gal):3.54
Sample Event (48 SU):
Rainfall (0.730 in):0.00
gpm
40
30
20
10
0
in
0.10
0.05
0.00
15 Thu
Oct 2009
16 Fri
17 Sat
10/14/2009 9:57:00 PM - 10/17/2009 6:47:00 AM

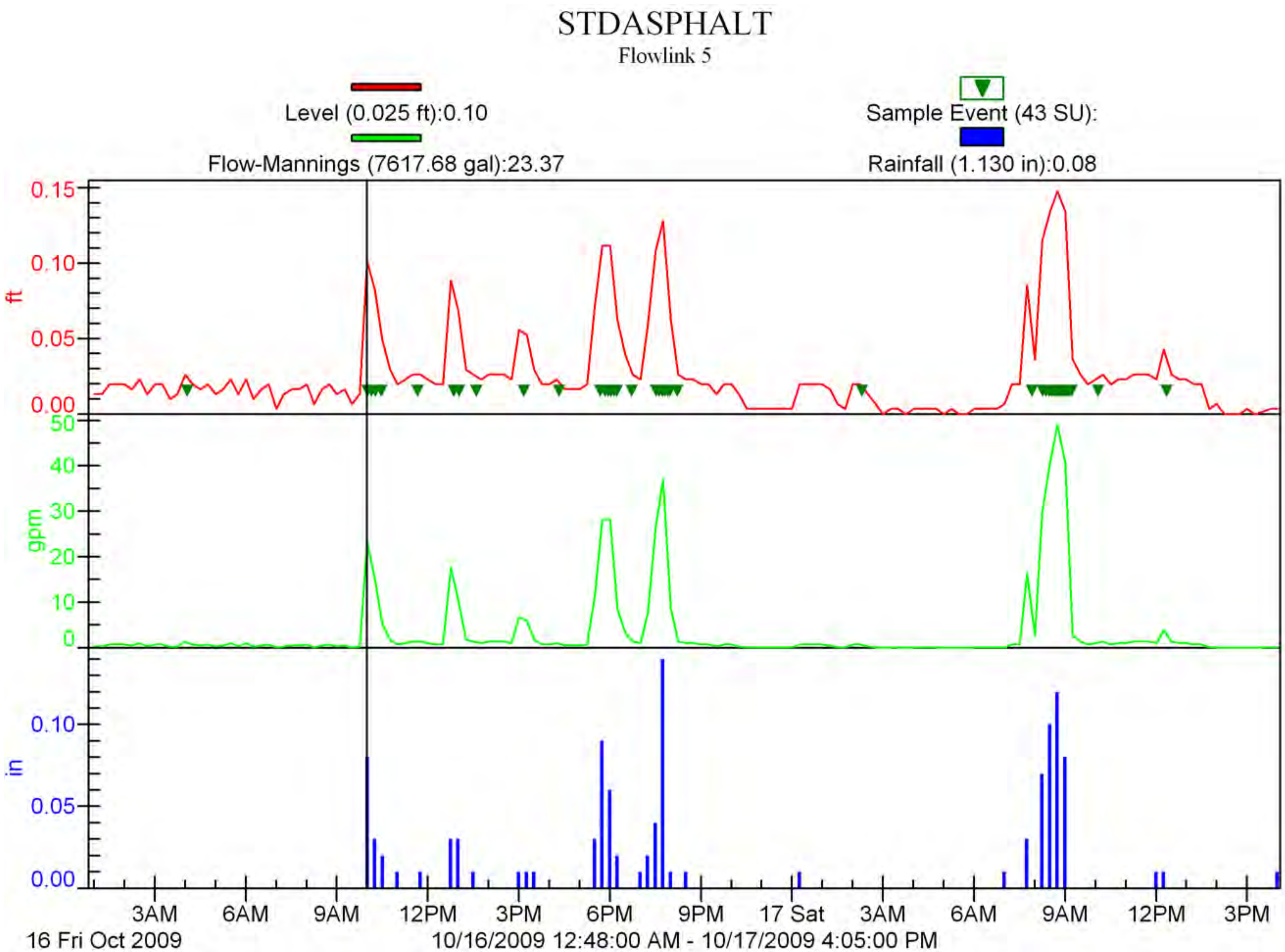

PERVPAVERS
Flowlink 5
Level (0.053 ft):0.04
Flow-Mannings (7079.46 gal):4.11
Sample Event (48 SU):
Rainfall (0.680 in):0.00
ft
0.10
0.05
0.00
gpm
40
30
20
10
0
in
0.10
0.05
0.00
9AM
12PM
3PM
6PM
9PM
16 Fri Oct 2009
10/16/2009 8:38:00 AM - 10/16/2009 11:55:00 PM



PERVCONCRT
Flowlink 5
Level (0.095 ft):0.08
Flow-Mannings (19766.7 gal):12.70
Sample Event (48 SU):
Rainfall (0.680 in):0.00
ft
0.12
0.10
0.08
gpm
35
30
25
20
15
in
0.10
0.05
0.00
9AM
12PM
3PM
6PM
9PM
17 Sat
16 Fri Oct 2009
10/16/2009 8:05:00 AM - 10/17/2009 12:02:00 AM



PERVASFALT
Flowlink 5
Level (0.030 ft):
Sample Event (48 SU):Bottle #1
Flow-Mannings (8193.56 gal):
Rainfall (1.130 in):
ft
0.10
0.05
0.00
gpm
30
20
10
0
in
0.10
0.05
0.00
9AM
12PM
3PM
6PM
9PM
17 Sat
3AM
6AM
9AM
12PM
3PM
6PM
16 Fri Oct 2009
10/16/2009 6:24:00 AM - 10/17/2009 6:29:00 PM



STDASPHALT
Flowlink 5
Level (0.025 ft):0.10
Flow-Mannings (7617.68 gal):23.37
Sample Event (43 SU):
Rainfall (1.130 in):0.08
ft
0.15
0.10
0.05
0.00
gpm
50
40
30
20
10
0
in
0.10
0.05
0.00
3AM
6AM
9AM
12PM
3PM
6PM
9PM
17 Sat
3AM
6AM
9AM
12PM
3PM
16 Fri Oct 2009
10/16/2009 12:48:00 AM - 10/17/2009 4:05:00 PM

STORM REPORT SUMMARY

Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project

Storm #37
Date: October 31, 2009

Introduction

This report summarizes the storm event sampled on October 31, 2009 by the City of Tacoma Public Works Environmental Services Environmental Compliance Field and Support Staff (ECFSS) as part of the evaluation of the Tacoma Landfill Employee Parking Lot Expansion and Pervious Pavement Demonstration Project (Project). The report includes a summary of the:

- Storm characteristics;
- Sampling period flow characteristics;
- Water quality data, including lab quality control information;
- Equipment information; and
- Observations taken by field staff during the sampling event

Storm Characteristics

Table 1 summarizes the storm characteristics for Storm #37.

Table 1. Storm Characteristics

Storm Date		10/30-10/31/2009
Time Storm Began		2145
Total Precipitation (in)		0.24
Duration (hrs)		13.25
Met Precipitation Criteria?	Precipitation ≥0.2"	Yes
Antecedent Period (hrs)		38
Precipitation in 24-hr Antecedent Dry Period (in)		0.00
Meet Antecedent Criteria?	Precipitation <0.02" in 24hrs prior	Yes

This event met the sampling criteria of a minimum 0.2 inches and less than 0.02 inches in the antecedent dry period of 24 hours as specified in the quality assurance project plan (QAPP).

Figure 1 shows the antecedent period for Storm #36. As shown above, 0.00 inches of rain fell in the 24 hours prior to the sampling event; this did not exceed the QAPP criteria of less than 0.02 inches during 24 hours prior to the event. Figure 2, 3, 4, and 5 provide the hydrograph and hyetograph for the storm event for pervious pavers, pervious concrete, pervious asphalt, and standard asphalt respectively. Sample collection markers are also identified on the storm hydrographs.

Sampling Period Flow Characteristics

Table 2 summarizes the sampling period flow characteristics and sample collection.

Table 2. Sampling Event Characteristics

	Pervious Pavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt
Peak Flow Rate (gpm)	9.0	31.6	9.5	26.5
Duration of Flow (hrs)	30	20.25	13	16
Total Volume (gallons) during Storm Event	4276	24,276	1981	2370
Total Volume (gallons) during Sampling Event	2199	21,219	1829	2079
Duration of Sampling Event (hrs)	9.3	17.5	11.9	13.1
Number of Sample Aliquots Collected	48	44	26	23
Percentage of Storm's Total Volume over which Samples were Collected	51.4%	87.4%	92.3%	87.7%
Volume of Surface Runoff Collected in Vault (inches)	NS	21	18.5	

Key: NS = Not Sampled

Water Quality Data

Samples were collected from the following locations during this sampling event:

- Standard Asphalt
- Pervious Asphalt
- Pervious Concrete
- Pervious Pavers

Samples collected were analyzed for the following target parameters:

- Selected semi-volatiles (PAHs and phthalates)
- Selected metals (copper, lead, zinc, and mercury)
- Total suspended solids (TSS)
- Hardness
- pH
- NWTPH-Dx

Table 3 summarizes the water quality results for this storm event. The data includes the analyte concentration and data flags/qualifiers for each sample collection location.

No field duplicate or equipment rinsate blank was collected during this sampling event.

Equipment Information

Samples were collected using an ISCO 6712 portable autosampler equipped with an ISCO 730 bubbler flow module. Samples were collected through a 3/8" low flow strainer.

Rain data was collected using an ISCO 674 rain gauge that is located at the project site. The rain gauge measures every 0.01 inches of rainfall. The rain gauge is connected to an ISCO 6712 sampler, which logs the rain data during the storm event.

Sampling Observations

Field notes and the sampling setup report are provided in the ECFSS's data summary package.

Table 3. Water Quality Data

SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Asphalt	10/31/2009	Hardness, calculated	17.4	mg/L		
Pervious Asphalt	10/31/2009	pH	7.6	Std. Units		
Pervious Asphalt	10/31/2009	NWTPH-Diesel	0.08	mg/L	U	
Pervious Asphalt	10/31/2009	NWTPH-Heavy Oil	0.12	mg/L	U	
Pervious Asphalt	10/31/2009	Copper	1.93	ug/L		U
Pervious Asphalt	10/31/2009	Lead	0.150	ug/L	J	
Pervious Asphalt	10/31/2009	Mercury	0.050	ug/L	U	
Pervious Asphalt	10/31/2009	Zinc	1.70	ug/L		U
Pervious Asphalt	10/31/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Acenaphthene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Anthracene	0.004	ug/L	U	
Pervious Asphalt	10/31/2009	Fluorene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Naphthalene	0.007	ug/L	U	
Pervious Asphalt	10/31/2009	Phenanthrene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Asphalt	10/31/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Asphalt	10/31/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Asphalt	10/31/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Chrysene	0.003	ug/L	U	
Pervious Asphalt	10/31/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Asphalt	10/31/2009	Fluoranthene	0.005	ug/L	U	
Pervious Asphalt	10/31/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Asphalt	10/31/2009	Pyrene	0.004	ug/L	U	
Pervious Asphalt	10/31/2009	bis(2-Ethylhexyl)phthalate	0.68	ug/L	J	
Pervious Asphalt	10/31/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Asphalt	10/31/2009	Diethylphthalate	0.712	ug/L	J	
Pervious Asphalt	10/31/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Asphalt	10/31/2009	Di-n-butylphthalate	0.33	ug/L	U	
Pervious Asphalt	10/31/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Concrete	10/31/2009	Hardness, calculated	548	mg/L		
Pervious Concrete	10/31/2009	pH	11.8	Std. Units		
Pervious Concrete	10/31/2009	TSS	89.8	mg/L		
Pervious Concrete	10/31/2009	NWTPH-Diesel	0.08	mg/L	U	
Pervious Concrete	10/31/2009	NWTPH-Heavy Oil	0.12	mg/L	U	
Pervious Concrete	10/31/2009	Copper	3.31	ug/L		
Pervious Concrete	10/31/2009	Lead	0.260	ug/L	J	
Pervious Concrete	10/31/2009	Mercury	0.050	ug/L	U	
Pervious Concrete	10/31/2009	Zinc	2.27	ug/L		U
Pervious Concrete	10/31/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Acenaphthene	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Anthracene	0.004	ug/L	U	
Pervious Concrete	10/31/2009	Fluorene	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Naphthalene	0.005	ug/L	U	
Pervious Concrete	10/31/2009	Phenanthrene	0.003	ug/L	J	
Pervious Concrete	10/31/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Concrete	10/31/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Concrete	10/31/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Concrete	10/31/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Chrysene	0.003	ug/L	U	
Pervious Concrete	10/31/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Concrete	10/31/2009	Fluoranthene	0.005	ug/L	U	
Pervious Concrete	10/31/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Concrete	10/31/2009	Pyrene	0.004	ug/L	U	
Pervious Concrete	10/31/2009	bis(2-Ethylhexyl)phthalate	0.16	ug/L	U	
Pervious Concrete	10/31/2009	Butyl benzyl phthalate	0.17	ug/L	U	
Pervious Concrete	10/31/2009	Diethylphthalate	0.072	ug/L	U	

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

Table 3. Water Quality Data

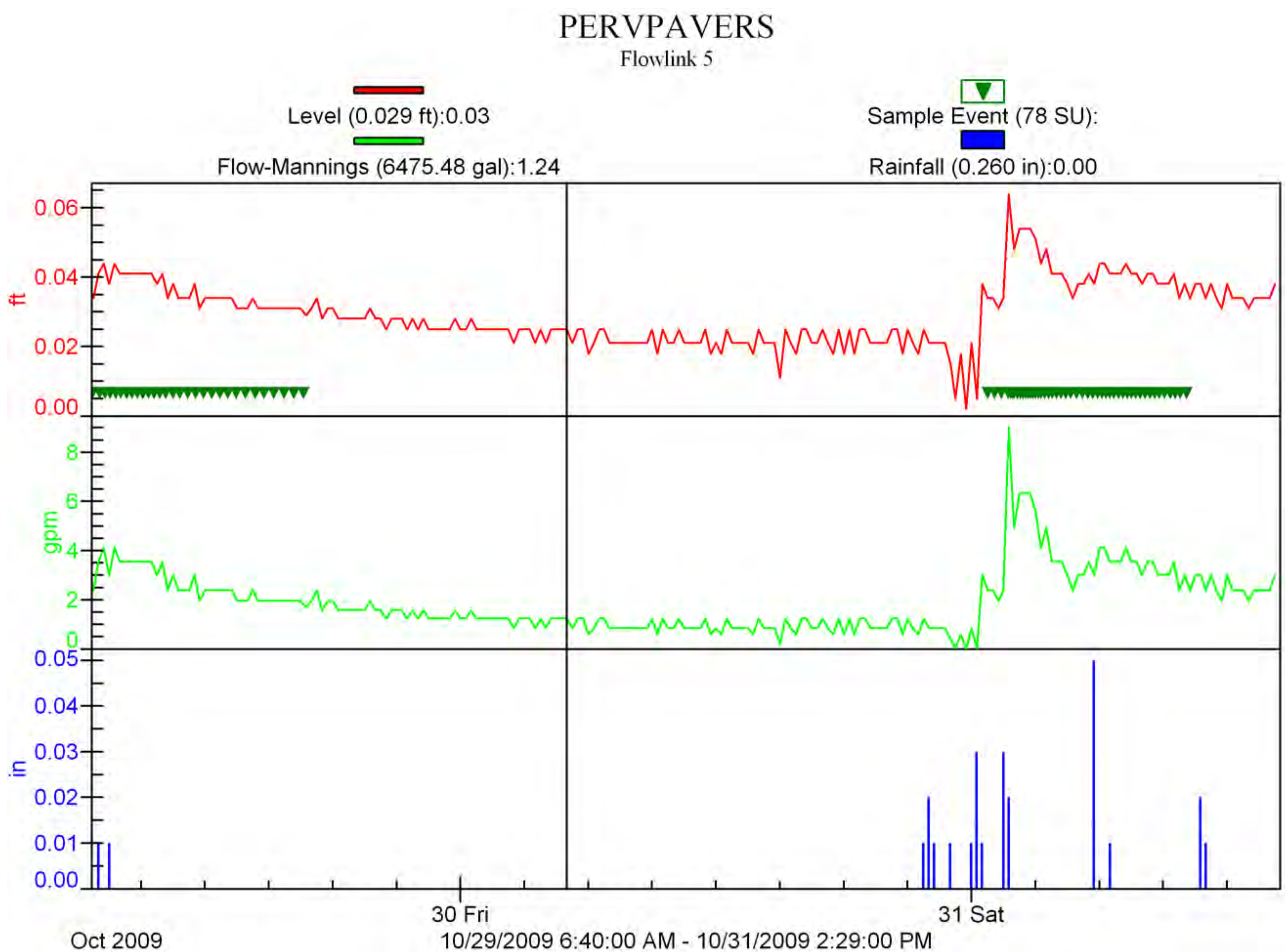
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Pervious Concrete	10/31/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Concrete	10/31/2009	Di-n-butylphthalate	0.10	ug/L	U	
Pervious Concrete	10/31/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Pervious Pavers	10/31/2009	Hardness, calculated	51.6	mg/L		
Pervious Pavers	10/31/2009	pH	7.1	Std. Units		
Pervious Pavers	10/31/2009	TSS	2.00	mg/L		
Pervious Pavers	10/31/2009	NWTPH-Diesel	0.08	mg/L	U	
Pervious Pavers	10/31/2009	NWTPH-Heavy Oil	0.12	mg/L	U	
Pervious Pavers	10/31/2009	Copper	2.33	ug/L		U
Pervious Pavers	10/31/2009	Lead	0.170	ug/L	J	
Pervious Pavers	10/31/2009	Mercury	0.050	ug/L	U	
Pervious Pavers	10/31/2009	Zinc	1.70	ug/L		U
Pervious Pavers	10/31/2009	2-Methylnaphthalene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Acenaphthene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Acenaphthylene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Anthracene	0.004	ug/L	U	
Pervious Pavers	10/31/2009	Fluorene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Naphthalene	0.005	ug/L	U	
Pervious Pavers	10/31/2009	Phenanthrene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Benzo(a)anthracene	0.002	ug/L	U	
Pervious Pavers	10/31/2009	Benzo(a)pyrene	0.004	ug/L	U	
Pervious Pavers	10/31/2009	Benzo(g,h,i)perylene	0.008	ug/L	U	
Pervious Pavers	10/31/2009	Benzo(b,k)fluoranthenes	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Chrysene	0.003	ug/L	U	
Pervious Pavers	10/31/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Pervious Pavers	10/31/2009	Fluoranthene	0.005	ug/L	U	
Pervious Pavers	10/31/2009	Indeno(1,2,3-c,d)pyrene	0.007	ug/L	U	
Pervious Pavers	10/31/2009	Pyrene	0.004	ug/L	U	
Pervious Pavers	10/31/2009	bis(2-Ethylhexyl)phthalate	0.60	ug/L	J	
Pervious Pavers	10/31/2009	Butyl benzyl phthalate	0.18	ug/L	J	
Pervious Pavers	10/31/2009	Diethylphthalate	0.098	ug/L	J	
Pervious Pavers	10/31/2009	Dimethyl phthalate	0.031	ug/L	U	
Pervious Pavers	10/31/2009	Di-n-butylphthalate	0.29	ug/L	U	
Pervious Pavers	10/31/2009	Di-n-Octyl phthalate	0.084	ug/L	U	
Standard Asphalt	10/31/2009	Hardness, calculated	3.94	mg/L		
Standard Asphalt	10/31/2009	pH	6.8	Std. Units		
Standard Asphalt	10/31/2009	NWTPH-Diesel	0.08	mg/L	U	
Standard Asphalt	10/31/2009	NWTPH-Heavy Oil	0.22	mg/L		
Standard Asphalt	10/31/2009	Copper	5.24	ug/L		
Standard Asphalt	10/31/2009	Lead	2.28	ug/L		
Standard Asphalt	10/31/2009	Mercury	0.050	ug/L	U	
Standard Asphalt	10/31/2009	Zinc	30.7	ug/L		
Standard Asphalt	10/31/2009	2-Methylnaphthalene	0.004	ug/L	J	
Standard Asphalt	10/31/2009	Acenaphthene	0.003	ug/L	U	
Standard Asphalt	10/31/2009	Acenaphthylene	0.003	ug/L	U	
Standard Asphalt	10/31/2009	Anthracene	0.004	ug/L	U	
Standard Asphalt	10/31/2009	Fluorene	0.003	ug/L	U	
Standard Asphalt	10/31/2009	Naphthalene	0.009	ug/L	U	
Standard Asphalt	10/31/2009	Phenanthrene	0.015	ug/L		
Standard Asphalt	10/31/2009	Benzo(a)anthracene	0.007	ug/L	J	
Standard Asphalt	10/31/2009	Benzo(a)pyrene	0.006	ug/L	J	
Standard Asphalt	10/31/2009	Benzo(g,h,i)perylene	0.016	ug/L		
Standard Asphalt	10/31/2009	Benzo(b,k)fluoranthenes	0.028	ug/L		
Standard Asphalt	10/31/2009	Chrysene	0.018	ug/L		
Standard Asphalt	10/31/2009	Dibenz(a,h)anthracene	0.007	ug/L	U	
Standard Asphalt	10/31/2009	Fluoranthene	0.025	ug/L		
Standard Asphalt	10/31/2009	Indeno(1,2,3-c,d)pyrene	0.010	ug/L	J	
Standard Asphalt	10/31/2009	Pyrene	0.020	ug/L		

U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

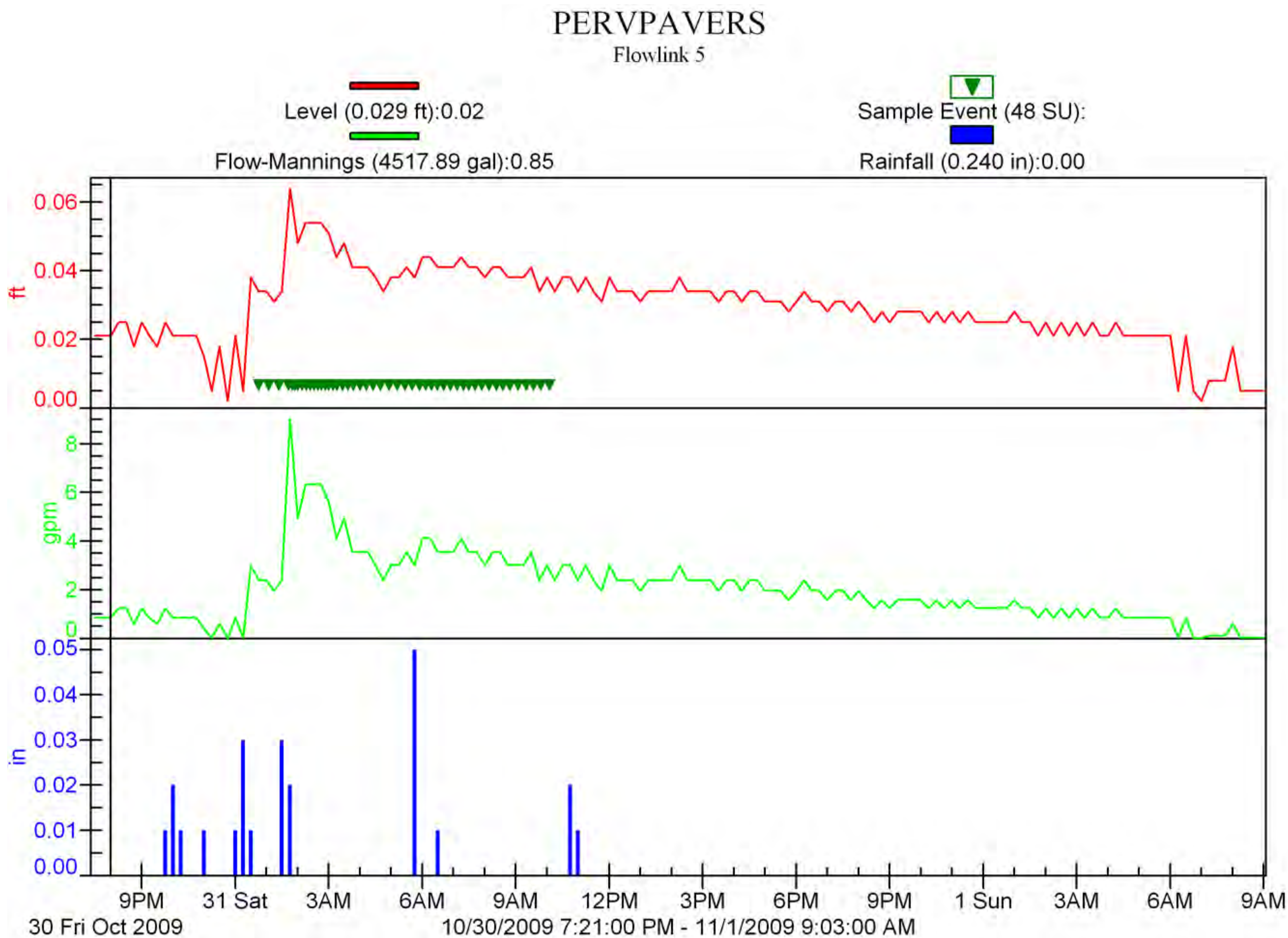
Table 3. Water Quality Data

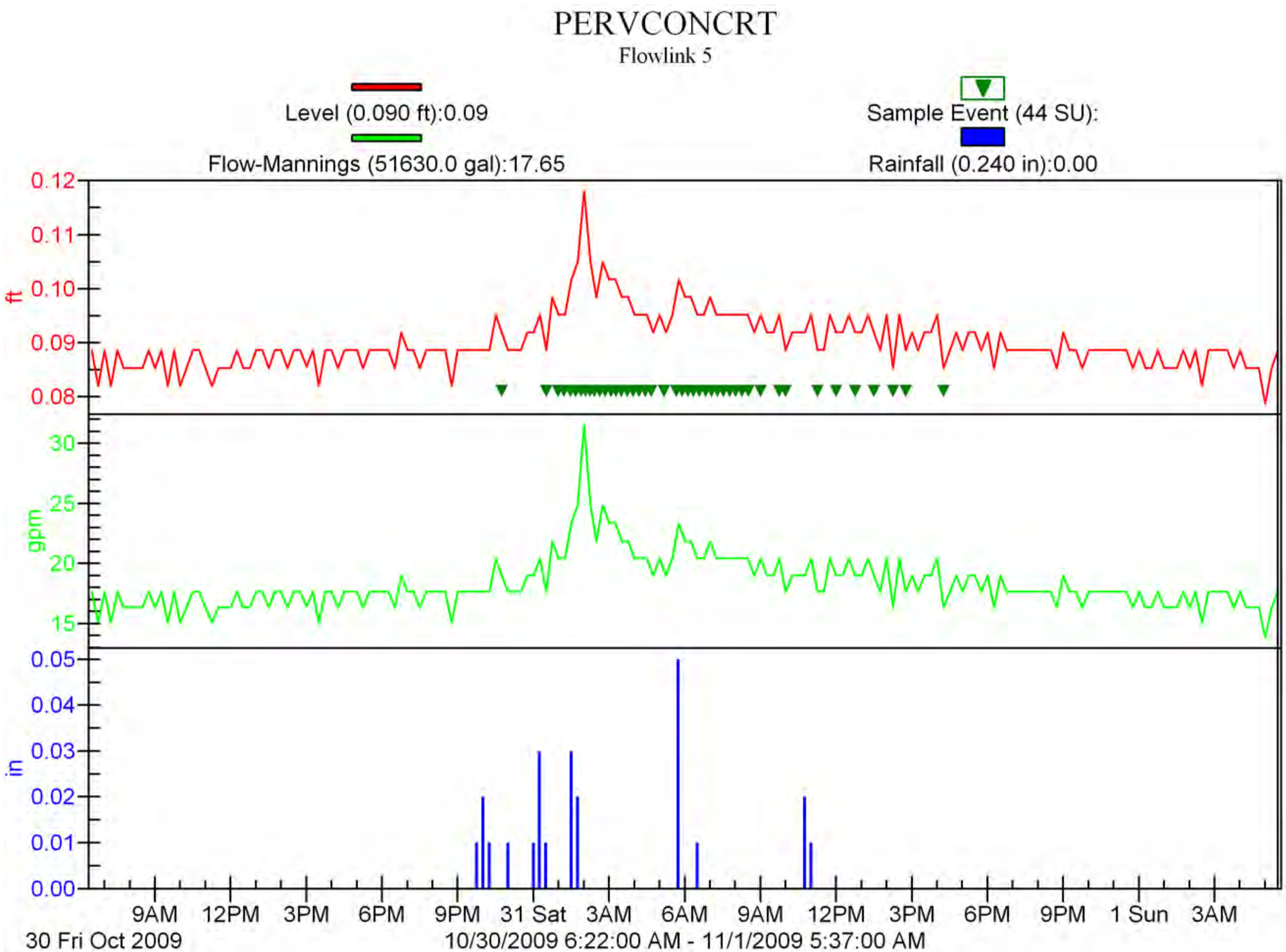
SampleID	Collect_Date	TestName	ReportedResult	Units	Flag	Qualifier
Standard Asphalt	10/31/2009	bis(2-Ethylhexyl)phthalate	1.44	ug/L		
Standard Asphalt	10/31/2009	Butyl benzyl phthalate	0.25	ug/L	J	
Standard Asphalt	10/31/2009	Diethylphthalate	0.273	ug/L	J	
Standard Asphalt	10/31/2009	Dimethyl phthalate	0.099	ug/L	J	
Standard Asphalt	10/31/2009	Di-n-butylphthalate	0.44	ug/L	J	
Standard Asphalt	10/31/2009	Di-n-Octyl phthalate	0.21	ug/L	U	

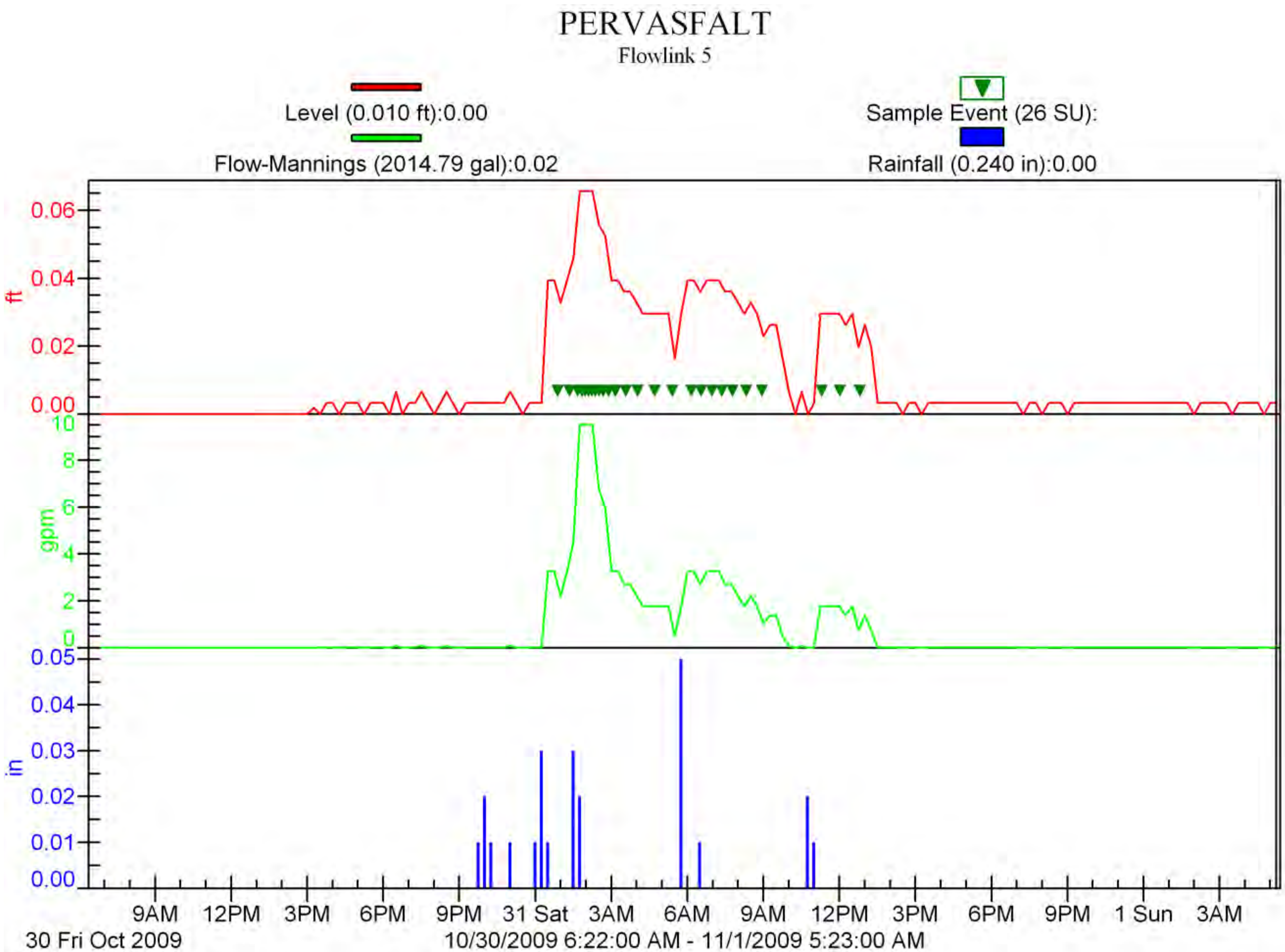
U = value is less than the detection limit
UJ - value is less than the detection limit and is considered estimated
J = value is considered estimated
B = value is less than the reporting limit, but greater than the detection limit

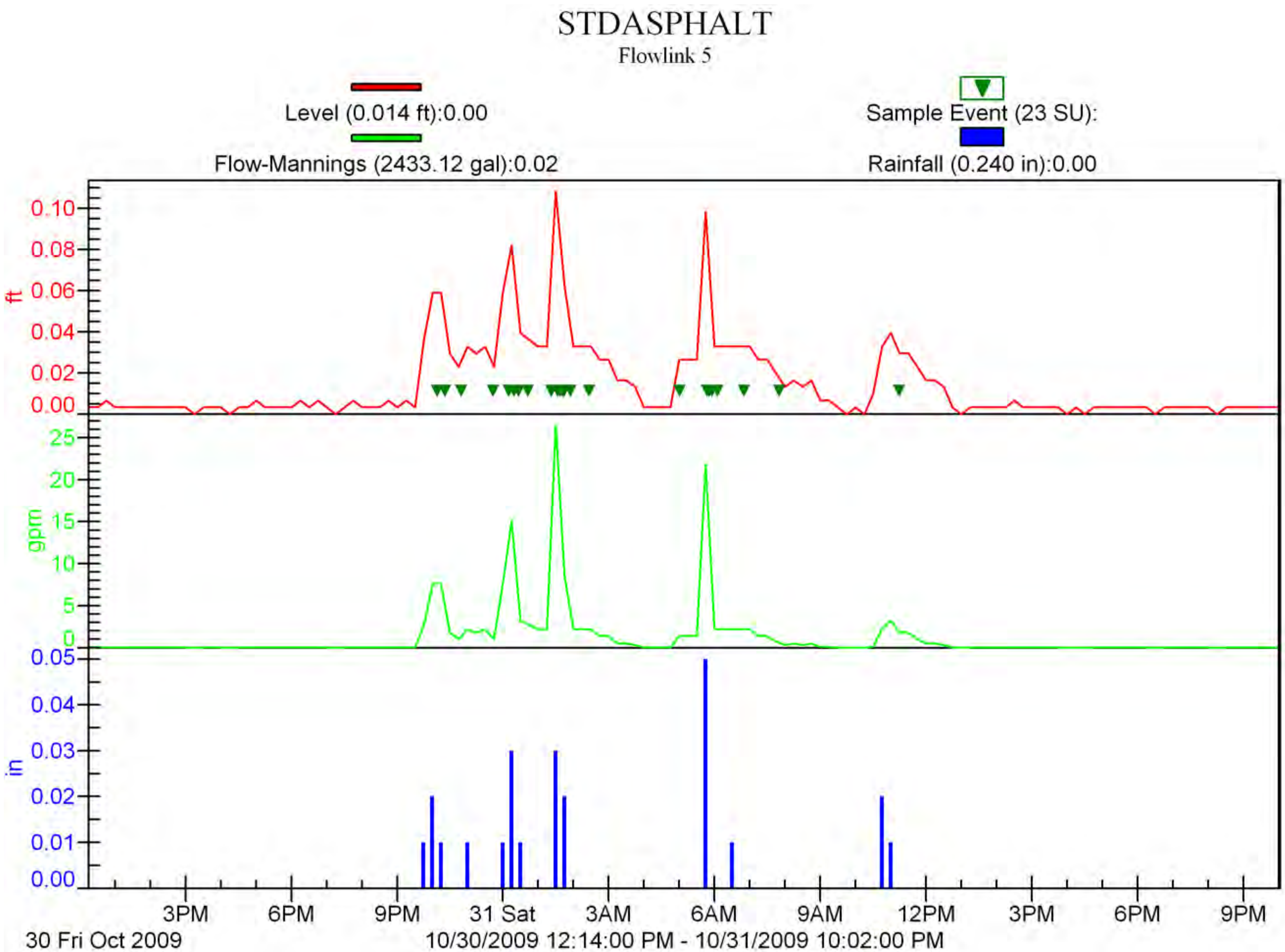


PERVPAVERS
Flowlink 5
Level (0.029 ft):0.03
Flow-Mannings (6475.48 gal):1.24
Sample Event (78 SU):
Rainfall (0.260 in):0.00
0.06
0.04
0.02
0.00
ft
8
6
4
2
0
gpm
0.05
0.04
0.03
0.02
0.01
0.00
in
30 Fri
31 Sat
Oct 2009
10/29/2009 6:40:00 AM - 10/31/2009 2:29:00 PM


PERVPAVERS
Flowlink 5
Level (0.029 ft):0.02
Flow-Mannings (4517.89 gal):0.85
Sample Event (48 SU):
Rainfall (0.240 in):0.00
ft
0.06
0.04
0.02
0.00
gpm
8
6
4
2
0
in
0.05
0.04
0.03
0.02
0.01
0.00
9PM
31 Sat
3AM
6AM
9AM
12PM
3PM
6PM
9PM
1 Sun
3AM
6AM
9AM
30 Fri Oct 2009
10/30/2009 7:21:00 PM - 11/1/2009 9:03:00 AM


PERVCONCRT
Flowlink 5
Level (0.090 ft):0.09
Flow-Mannings (51630.0 gal):17.65
Sample Event (44 SU):
Rainfall (0.240 in):0.00
ft
gpm
in
9AM
12PM
3PM
6PM
9PM
31 Sat
3AM
6AM
9AM
12PM
3PM
6PM
9PM
1 Sun
3AM
30 Fri Oct 2009
10/30/2009 6:22:00 AM - 11/1/2009 5:37:00 AM


PERVASFALT
Flowlink 5
Level (0.010 ft):0.00
Flow-Mannings (2014.79 gal):0.02
Sample Event (26 SU):
Rainfall (0.240 in):0.00
ft
0.06
0.04
0.02
0.00
gpm
10
8
6
4
2
0
in
0.05
0.04
0.03
0.02
0.01
0.00
9AM
12PM
3PM
6PM
9PM
31 Sat
3AM
6AM
9AM
12PM
3PM
6PM
9PM
1 Sun
3AM
30 Fri Oct 2009
10/30/2009 6:22:00 AM - 11/1/2009 5:23:00 AM



STDASPHALT
Flowlink 5
Level (0.014 ft):0.00
Flow-Mannings (2433.12 gal):0.02
Sample Event (23 SU):
Rainfall (0.240 in):0.00
ft
0.10
0.08
0.06
0.04
0.02
0.00
gpm
25
20
15
10
5
0
in
0.05
0.04
0.03
0.02
0.01
0.00
3PM
6PM
9PM
31 Sat
3AM
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri Oct 2009
10/30/2009 12:14:00 PM - 10/31/2009 10:02:00 PM

APPENDIX D. CATCH BASIN SEDIMENT GRAIN SIZE RESULTS

Tacoma

08 June 2011

Karen Bartlett
PW Science and Engineering
326 East D Street
Tacoma, WA 98421

Subject: Pervious Pavement

Enclosed are the analytical results for samples collected 03/23/2011.

A detailed Quality Control Data Review is included with the sample results for your review.

If you have any questions concerning this report, call me at (253)502-2130. Please note that the samples associated with this report will be discarded **3 months** from the date of this report unless notified.

Sincerely,

Christopher L. Getchell
Assistant Division Manager
Environmental Services Laboratory

cc.

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Pervious Pavers	T103175-01	Soil	23-Mar-11 09:55	23-Mar-11 12:30
Pervious Concrete	T103175-02	Soil	23-Mar-11 10:05	23-Mar-11 12:30
Pervious Asphalt	T103175-03	Soil	23-Mar-11 10:15	23-Mar-11 12:30
Standard Asphalt	T103175-04	Soil	23-Mar-11 10:20	23-Mar-11 12:30

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CONTRACT LABS

Soil Classification and Grainsize analysis was performed by Analytical Resources, Incorporated (ARI). The report from ARI is included in this packet.

CHAIN OF CUSTODY

Standard Chain of Custody forms were filled out for these samples.

METHODS

The samples were analyzed according to Standard Methods 2540G for Total and Volatile Solids, EPA SW-846 Methods 6010B for Total Metals, 7471 for Mercury, 8270D for Semi-Volatile Organics, and 9060 Modified for soils for Total Organics Carbon (TOC), and by Washington Department of Ecology Method NWTPH-Ds.

SAMPLE STORAGE, PRESERVATION, & HOLDING TIMES

The samples were extracted within 14 days for Semi-Volatile organics and NWTPH-Dx and analyzed within 7 days for Total and Volatile Solids, 28 days for TOC and Total Mercury, 40 days for Semi-Volatile Organics and NWTPH-Dx, and 180 Days for Total Metals.

METHOD DETECTION LIMITS

All analytes are reported to the Method Detection Limit (MDL). Values greater than the MDL and less than the Practical Quantitation Limit (Reporting Llimit or PQL) are reported for your information. Values may be qualified as estimated (J) as not as precise as values reported greater than the PQL (the low standard or 3 - 5 times the MDL).

METHOD BLANKS

Method blanks were analyzed at the required frequencies of the methods. There was a minimum of one Method Blank for each analytical method. All blank values were less than the Practical Quantitation Limits.

SURROGATES

Surrogate Compounds were added to the samples for Semi-Volatile Organics and NWTPH-Dx. Recoveries were within the laboratory's limits **except for the recoveries of 2-Fluorobiphenyl for NWTPH-Dx in the Pervious Concrete and Standard Asphalt samples wre less than the limit of 50% at 48% and 46%, respectively. The NWTPH-Diesel and NWTPH-Heavy Oil values for these two samples are qualified as estimated**.

LABORATORY CONTROL SAMPLES

Laboratory Control Samples were analyzed with these samples for all parameters. The recoveries were within the laboratory's control limits **except for the following:**

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Analyte	% Recovery	Limits
NWTPH-Diesel	**48**	**50-150**
Fluoranthene	**53**	**60-117**
Benzo(b,k)fluoranthenes	**59**	**60-120**

These analytes are qualifed as estimated (J) for all of the samples.

DUPLICATE SAMPLE ANALYSIS

Duplicate analysis was performed with these samples. The Relative Percent Differences were all within the laboratory's control limits.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE ANALYSIS

Matrix Spike and/or Matrix Spike Duplicate analysis was performed with these samples. The recoveries were within the laboratory's limits except for the following (*):

Samples	Analyte	MS % Recovery	MS % Recovery	Limits
Pervious Concrete	**NWTPH-Diesel**	**48 ***	**48 ***	**50-150**
	Indeno(1,2,3-c,d)pyrene	70	54 *	55-131
	Dibenz(a,h)anthracene	**52 ***	**51 ***	**56-131**
	Benzo(g,h,i)perylene	**47 ***	**44 ***	**51-133**

The NWTPH-Diesel, Dibenz(a,h)anthracene, and Benzo(g,h,i)perylene values are qualifed as estimated (J) for the Pervious Concrete sample based on the low MS and MSD recoveries. Indeno(1,2,3-c,d)pyrene is not qualified on just the MSD recovery outside of limits.

ICP SERIAL DILUTIONS

Indicate samples analyzed at a five-fold dilution for Total Metals. The percent differences of the diluted samples when compared to the undiluted samples were less than 10% for the analytes with concentrations greater than 50 times the method detection limit, except *Discuss Exceptions*.

INTERNAL STANDARDS

Internal Standards were added to these samples for quantitation purposes. The Area counts of these standards must not vary more than a factor of two from the mid-point standard of the calibration curve according to the method. The retention times must not vary by more than 30 seconds. No compounds varied by more than 30 seconds retention time. The internal standard criteria were met for these samples, **except for the following**:

SampleID	Internal Standard	Area Recovery	Associated Compounds
Pervious Pavers	**Perylene-d12**	**26%**	**Di-n-Octyl phthalate Benzo(b,k)fluoranthenes Benzo(a)pyrene Indeno(1,2,3-c,d)pyrene Dibenz(a,h)anthracene Benzo(g,h,i)perylene**
Pervious Asphalt	**Perylene-d12**	**26%**	**Di-n-Octyl phthalate Benzo(b,k)fluoranthenes Benzo(a)pyrene Indeno(1,2,3-c,d)pyrene Dibenz(a,h)anthracene Benzo(g,h,i)perylene**
Standard Asphalt	**Perylene-d12**	**46%**	**Di-n-Octyl phthalate Benzo(b,k)fluoranthenes Benzo(a)pyrene Indeno(1,2,3-c,d)pyrene Dibenz(a,h)anthracene Benzo(g,h,i)perylene**

The Di-n-Octyl phthalate, Benzo(b,k)fluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenz(a,h)anthracene, and Benzo(g,h,i)perylene values for the samples listed above are qualified as estimated (J).

DATA ASSESSMENT

The sample data is acceptable for use. The following qualifiers were added to the sample data:

U to indicate the analyte was not detected at or above the reported value.

UJ to indicate the analyte was not detected at or above the reported estimated value.

J to indicate the value is estimated

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PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Pervious Pavers
T103175-01 (Soil)
23-Mar-11 09:55

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
CONVENTIONAL							
Total Organic Carbon	**156000**	1	0.2	mg/kg	01-Apr-11	04-Apr-11	9060 Mod
Total Solids	**28.6**	5.0	1.0	%	24-Mar-11	25-Mar-11	SM2540G
Solids-Total Volatile	**16.6**	5.00	1.00	%	25-Mar-11	25-Mar-11	SM2540G
Metals							
Copper	**174**	19.4	6.21	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Lead	**105**	19.4	3.49	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Mercury	**0.172**	0.740	0.0740	mg/kg dry	31-Mar-11	01-Apr-11	7471B
Zinc	**1970**	19.4	4.27	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Semi-VOA							
NWTPH-Diesel	**80J**	25	5.4	mg/kg dry wt. dry	31-Mar-11	19-Apr-11	NWTPH-D
NWTPH-Heavy Oil	**7500**	490	84	mg/kg dry wt. dry	31-Mar-11	21-Apr-11	NWTPH-D
Surrogate: 2-Fluorobiphenyl		*57.6 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Surrogate: Terphenyl-d14		*81.5 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Naphthalene	40	120	40	ug/kg dry	31-Mar-11	14-Apr-11	8270D
2-Methylnaphthalene	30	120	30	ug/kg dry	31-Mar-11	14-Apr-11	8270D
2-Chloronaphthalene	30	120	30	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Dimethyl phthalate	**290**	120	49	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Acenaphthylene	23	120	23	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Acenaphthene	16	120	16	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Diethylphthalate	74	120	74	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Fluorene	19	120	19	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Phenanthrene	**330**	120	53	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Anthracene	51	120	51	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Di-n-butylphthalate	**400**	120	74	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Fluoranthene	**480J**	120	63	ug/kg dry	31-Mar-11	14-Apr-11	8270D
bis(2-Ethylhexyl)phthalate	**18000**	1200	970	ug/kg dry	31-Mar-11	18-Apr-11	8270D
Chrysene	**610**	120	64	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Surrogate: Nitrobenzene-d5		*50.1 %*	*32-105*		*31-Mar-11*	*14-Apr-11*	*8270D*
Surrogate: 2-Fluorobiphenyl		*56.9 %*	*39-92*		*31-Mar-11*	*14-Apr-11*	*8270D*
Surrogate: Terphenyl-d14		*74.2 %*	*49-128*		*31-Mar-11*	*18-Apr-11*	*8270D*

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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PW Science and Engineering 326 East D Street Tacoma WA, 98421	Project: **Pervious Pavement** Project Number: ENV-03002-02-02 Project Manager: Karen Bartlett	**Reported:** 08-Jun-11 11:59

Pervious Pavers
T103175-01RE1 (Soil)
23-Mar-11 09:55

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
Semi-VOA							
Butyl benzyl phthalate	**1200**	120	97	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Pyrene	**1300**	120	70	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)anthracene	**280**	120	73	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Chrysene	**670**	120	64	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Di-n-Octyl phthalate	**3500J**	120	76	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(b,k)fluoranthenes	**1200J**	240	160	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)pyrene	**340J**	120	100	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Indeno(1,2,3-c,d)pyrene	**300J**	120	120	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Dibenz(a,h)anthracene	130J	590	130	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(g,h,i)perylene	**490J**	120	80	ug/kg dry	31-Mar-11	20-Apr-11	8270D

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PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Pervious Concrete
T103175-02 (Soil)
23-Mar-11 10:05

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
CONVENTIONAL							
Total Organic Carbon	**23100**	1	0.2	mg/kg	01-Apr-11	04-Apr-11	9060 Mod
Total Solids	**67.4**	5.0	1.0	%	24-Mar-11	25-Mar-11	SM2540G
Solids-Total Volatile	**3.50**	5.00	1.00	%	25-Mar-11	25-Mar-11	SM2540G
Metals							
Copper	**48.4**	8.83	2.83	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Lead	**19.0**	8.83	1.59	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Mercury	0.0337	0.337	0.0337	mg/kg dry	31-Mar-11	01-Apr-11	7471B
Zinc	**241**	8.83	1.94	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Semi-VOA							
NWTPH-Diesel	**13J**	24	5.3	mg/kg dry wt. dry	31-Mar-11	19-Apr-11	NWTPH-D
NWTPH-Heavy Oil	**520**	48	8.2	mg/kg dry wt. dry	31-Mar-11	21-Apr-11	NWTPH-D
Surrogate: 2-Fluorobiphenyl		*48.5 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Surrogate: Terphenyl-d14		*62.8 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Naphthalene	40	120	40	ug/kg dry	31-Mar-11	14-Apr-11	8270D
2-Methylnaphthalene	29	120	29	ug/kg dry	31-Mar-11	14-Apr-11	8270D
2-Chloronaphthalene	29	120	29	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Dimethyl phthalate	48	120	48	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Acenaphthylene	23	120	23	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Acenaphthene	16	120	16	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Diethylphthalate	72	120	72	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Fluorene	19	120	19	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Phenanthrene	52	120	52	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Anthracene	49	120	49	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Di-n-butylphthalate	73	120	73	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Fluoranthene	**140J**	120	62	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Butyl benzyl phthalate	**210**	120	95	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Pyrene	**180**	120	68	ug/kg dry	31-Mar-11	14-Apr-11	8270D
bis(2-Ethylhexyl)phthalate	**1600**	120	95	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Benzo(a)anthracene	72	120	72	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Chrysene	62	120	62	ug/kg dry	31-Mar-11	14-Apr-11	8270D
Surrogate: Nitrobenzene-d5		*36.2 %*	*32-105*		*31-Mar-11*	*14-Apr-11*	*8270D*
Surrogate: 2-Fluorobiphenyl		*45.2 %*	*39-92*		*31-Mar-11*	*14-Apr-11*	*8270D*
Surrogate: Terphenyl-d14		*91.2 %*	*49-128*		*31-Mar-11*	*14-Apr-11*	*8270D*

Lori A. Zboralski

Reviewed By

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Pervious Concrete
T103175-02RE1 (Soil)
23-Mar-11 10:05

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
Semi-VOA							
Di-n-Octyl phthalate	**130**	120	74	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(b,k)fluoranthenes	**180J**	230	160	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)pyrene	100	120	100	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Indeno(1,2,3-c,d)pyrene	120	120	120	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Dibenz(a,h)anthracene	130J	580	130	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(g,h,i)perylene	78J	120	78	ug/kg dry	31-Mar-11	20-Apr-11	8270D

Reviewed By

Pervious Asphalt
T103175-03 (Soil)
23-Mar-11 10:15

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
CONVENTIONAL							
Total Organic Carbon	**143000**	1	0.2	mg/kg	01-Apr-11	05-Apr-11	9060 Mod
Total Solids	**41.9**	5.0	1.0	%	24-Mar-11	25-Mar-11	SM2540G
Solids-Total Volatile	**11.1**	5.00	1.00	%	25-Mar-11	25-Mar-11	SM2540G
Metals							
Copper	**116**	15.3	4.90	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Lead	**105**	15.3	2.75	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Mercury	**0.159**	0.533	0.0533	mg/kg dry	31-Mar-11	01-Apr-11	7471B
Zinc	**728**	15.3	3.37	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Semi-VOA							
NWTPH-Diesel	**52J**	24	5.4	mg/kg dry wt. dry	31-Mar-11	19-Apr-11	NWTPH-D
NWTPH-Heavy Oil	**2900**	240	41	mg/kg dry wt. dry	31-Mar-11	21-Apr-11	NWTPH-D
Surrogate: 2-Fluorobiphenyl		*62.7 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Surrogate: Terphenyl-d14		*69.3 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Naphthalene	40	120	40	ug/kg dry	31-Mar-11	15-Apr-11	8270D
2-Methylnaphthalene	30	120	30	ug/kg dry	31-Mar-11	15-Apr-11	8270D
2-Chloronaphthalene	29	120	29	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Dimethyl phthalate	**130**	120	49	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Acenaphthylene	23	120	23	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Acenaphthene	16	120	16	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Diethylphthalate	73	120	73	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Fluorene	**160**	120	19	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Phenanthrene	**1300**	120	53	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Anthracene	50	120	50	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Di-n-butylphthalate	**120**	120	73	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Fluoranthene	**1100J**	120	62	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Butyl benzyl phthalate	**2100**	120	96	ug/kg dry	31-Mar-11	15-Apr-11	8270D
bis(2-Ethylhexyl)phthalate	**16000**	1200	960	ug/kg dry	31-Mar-11	18-Apr-11	8270D
Chrysene	**620**	120	63	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Surrogate: Nitrobenzene-d5		*57.3 %*	*32-105*		*31-Mar-11*	*15-Apr-11*	*8270D*
Surrogate: 2-Fluorobiphenyl		*56.7 %*	*39-92*		*31-Mar-11*	*15-Apr-11*	*8270D*
Surrogate: Terphenyl-d14		*76.6 %*	*49-128*		*31-Mar-11*	*18-Apr-11*	*8270D*

Pervious Asphalt
T103175-03RE1 (Soil)
23-Mar-11 10:15

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
Semi-VOA							
Butyl benzyl phthalate	**1800**	120	96	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Pyrene	**2100**	120	69	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)anthracene	**590**	120	72	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Chrysene	**1100**	120	63	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Di-n-Octyl phthalate	74J	120	74	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(b,k)fluoranthenes	**2000J**	230	160	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)pyrene	**290J**	120	100	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Indeno(1,2,3-c,d)pyrene	**390J**	120	120	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Dibenz(a,h)anthracene	130J	580	130	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(g,h,i)perylene	**440J**	120	79	ug/kg dry	31-Mar-11	20-Apr-11	8270D

Lori A. Zboralski
Reviewed By

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Standard Asphalt
T103175-04 (Soil)
23-Mar-11 10:20

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
CONVENTIONAL							
Total Organic Carbon	**40500**	1	0.2	mg/kg	01-Apr-11	05-Apr-11	9060 Mod
Total Solids	**69.6**	5.0	1.0	%	24-Mar-11	25-Mar-11	SM2540G
Solids-Total Volatile	**5.70**	5.00	1.00	%	25-Mar-11	25-Mar-11	SM2540G
Metals							
Copper	**49.9**	9.09	2.91	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Lead	**31.0**	9.09	1.64	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Mercury	**0.0605**	0.253	0.0253	mg/kg dry	31-Mar-11	01-Apr-11	7471B
Zinc	**189**	9.09	2.00	mg/kg dry	31-Mar-11	06-Apr-11	6010B
Semi-VOA							
NWTPH-Diesel	**33J**	24	5.3	mg/kg dry wt. dry	31-Mar-11	19-Apr-11	NWTPH-D
NWTPH-Heavy Oil	**1500**	240	41	mg/kg dry wt. dry	31-Mar-11	21-Apr-11	NWTPH-D
Surrogate: 2-Fluorobiphenyl		*46.5 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Surrogate: Terphenyl-d14		*63.0 %*	*50-150*		*31-Mar-11*	*19-Apr-11*	*NWTPH-D*
Naphthalene	39	120	39	ug/kg dry	31-Mar-11	15-Apr-11	8270D
2-Methylnaphthalene	29	120	29	ug/kg dry	31-Mar-11	15-Apr-11	8270D
2-Chloronaphthalene	29	120	29	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Dimethyl phthalate	48	120	48	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Acenaphthylene	23	120	23	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Acenaphthene	15	120	15	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Diethylphthalate	71	120	71	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Fluorene	19	120	19	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Phenanthrene	**140**	120	52	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Anthracene	**140**	120	49	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Di-n-butylphthalate	72	120	72	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Fluoranthene	**270J**	120	61	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Chrysene	**110J**	120	62	ug/kg dry	31-Mar-11	15-Apr-11	8270D
Surrogate: Nitrobenzene-d5		*40.0 %*	*32-105*		*31-Mar-11*	*15-Apr-11*	*8270D*
Surrogate: 2-Fluorobiphenyl		*42.7 %*	*39-92*		*31-Mar-11*	*15-Apr-11*	*8270D*
Surrogate: Terphenyl-d14		*61.6 %*	*49-128*		*31-Mar-11*	*18-Apr-11*	*8270D*

Lori A. Zboralski
Reviewed By

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Standard Asphalt
T103175-04RE1 (Soil)
23-Mar-11 10:20

Analyte	Result	Project Report Limit	MDL	Units	Prepared	Analyzed	Method
Semi-VOA							
Butyl benzyl phthalate	**860**	120	95	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Pyrene	**380**	120	68	ug/kg dry	31-Mar-11	20-Apr-11	8270D
bis(2-Ethylhexyl)phthalate	**4300**	120	94	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)anthracene	**110J**	120	71	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Chrysene	**320**	120	62	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Di-n-Octyl phthalate	73J	120	73	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(b,k)fluoranthenes	**650J**	230	160	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(a)pyrene	**110J**	120	99	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Indeno(1,2,3-c,d)pyrene	**130J**	120	120	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Dibenz(a,h)anthracene	130J	580	130	ug/kg dry	31-Mar-11	20-Apr-11	8270D
Benzo(g,h,i)perylene	**150J**	120	78	ug/kg dry	31-Mar-11	20-Apr-11	8270D

Lori A. Zboralski
Reviewed By

CONVENTIONAL - Quality Control
Environmental Services Laboratory

Sample ID Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1113034 - Conventionals No-Prep										
Blank (1113034-BLK1)				Prepared: 24-Mar-11 Analyzed: 25-Mar-11						
Total Solids	ND	5.0	%							
Duplicate (1113034-DUP1)		**Source: T103175-01**		Prepared: 24-Mar-11 Analyzed: 25-Mar-11						
Total Solids	29.9	5.0	%		28.6			4.51	20	
Batch 1113052 - Conventionals No-Prep										
Blank (1113052-BLK1)				Prepared & Analyzed: 25-Mar-11						
Solids-Total Volatile	ND	5.00	%							
Duplicate (1113052-DUP1)		**Source: T103175-01**		Prepared & Analyzed: 25-Mar-11						
Solids-Total Volatile	15.5	5.00	%		16.6			6.85	20	
Batch 1114052 - Comb./IR										
Blank (1114052-BLK1)				Prepared: 01-Apr-11 Analyzed: 04-Apr-11						
Total Organic Carbon	10	1	mg/kg							
LCS (1114052-BS1)				Prepared: 01-Apr-11 Analyzed: 04-Apr-11						
Total Organic Carbon	417000	1	mg/kg	300000		139	50-150			
Duplicate (1114052-DUP1)		**Source: T103175-02**		Prepared: 01-Apr-11 Analyzed: 05-Apr-11						
Total Organic Carbon	23000	1	mg/kg		23100			0.152	200	

Lori A. Zboralski
Reviewed By

Metals - Quality Control

Environmental Services Laboratory

Sample ID Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1114041 - 3051A										
Blank (1114041-BLK1)				Prepared: 31-Mar-11 Analyzed: 06-Apr-11						
Zinc	ND	2.00	mg/kg wet							
Copper	ND	2.00	mg/kg wet							
Lead	ND	2.00	mg/kg wet							
LCS (1114041-BS1)				Prepared: 30-Mar-11 Analyzed: 06-Apr-11						
Zinc	139	10.0	mg/kg wet	152		91.7	80-120			
Lead	176	10.0	mg/kg wet	207		84.9	80-120			
Copper	290	10.0	mg/kg wet	344		84.4	80-120			
Duplicate (1114041-DUP1)		**Source: T103175-01**		Prepared: 30-Mar-11 Analyzed: 06-Apr-11						
Lead	99.3	19.0	mg/kg dry		105			5.77	35	
Zinc	1900	19.0	mg/kg dry		1970			3.68	35	
Copper	160	19.0	mg/kg dry		174			8.04	35	
Matrix Spike (1114041-MS1)		**Source: T103175-01**		Prepared: 30-Mar-11 Analyzed: 06-Apr-11						
Zinc	2120	18.6	mg/kg dry	186	1970	81.7	75-125			
Copper	249	18.6	mg/kg dry	92.9	174	81.1	75-125			
Lead	258	18.6	mg/kg dry	186	105	82.4	75-125			
Batch 1114044 - Waterbath										
Blank (1114044-BLK1)				Prepared: 31-Mar-11 Analyzed: 01-Apr-11						
Mercury	ND	0.0500	mg/kg wet							
Duplicate (1114044-DUP1)		**Source: T103175-01**		Prepared: 31-Mar-11 Analyzed: 01-Apr-11						
Mercury	0.174	0.693	mg/kg dry		0.172			1.14	35	

Metals - Quality Control

Environmental Services Laboratory

Sample ID / Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1114044 - Waterbath										
Matrix Spike (1114044-MS1)	**Source: T103175-01**			Prepared: 31-Mar-11 Analyzed: 01-Apr-11						
Mercury	3.37	0.728	mg/kg dry	2.91	0.172	110	75-125			
Matrix Spike Dup (1114044-MSD1)	**Source: T103175-01**			Prepared: 31-Mar-11 Analyzed: 01-Apr-11						
Mercury	3.13	0.716	mg/kg dry	2.86	0.172	103	75-125	7.43	200	
Reference (1114044-SRM1)				Prepared: 31-Mar-11 Analyzed: 01-Apr-11						
Mercury	9.55	3.56	mg/kg wet	8.47		113	51.3-148			

Semi-VOA - Quality Control

Environmental Services Laboratory

Sample ID Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1115015 - ASE										
Blank (1115015-BLK1)				Prepared: 31-Mar-11 Analyzed: 19-Apr-11						
NWTPH-Diesel	ND	25	mg/kg dry wt. wet							
NWTPH-Heavy Oil	ND	50	mg/kg dry wt. wet							
Surrogate: 2-Fluorobiphenyl	*1.7*		mg/kg dry wt. wet	*5.00*		*34.8*	*50-150*			
Surrogate: Terphenyl-d14	*2.6*		mg/kg dry wt. wet	*5.00*		*52.9*	*50-150*			
LCS (1115015-BS1)				Prepared: 31-Mar-11 Analyzed: 19-Apr-11						
NWTPH-Diesel	120	25	mg/kg dry wt. wet	250		48.2	50-150			
NWTPH-Heavy Oil	350	50	mg/kg dry wt. wet	500		69.4	50-150			
Surrogate: 2-Fluorobiphenyl	*2.4*		mg/kg dry wt. wet	*5.00*		*47.6*	*50-150*			
Surrogate: Terphenyl-d14	*3.0*		mg/kg dry wt. wet	*5.00*		*60.3*	*50-150*			
Matrix Spike (1115015-MS1)	**Source: T103175-02**			Prepared: 31-Mar-11 Analyzed: 19-Apr-11						
NWTPH-Diesel	130	24	mg/kg dry wt. dry	242	13	48.8	50-150			
NWTPH-Heavy Oil	850	48	mg/kg dry wt. dry	484	520	69.0	50-150			
Surrogate: 2-Fluorobiphenyl	*2.7*		mg/kg dry wt. dry	*4.84*		*56.4*	*50-150*			
Surrogate: Terphenyl-d14	*3.6*		mg/kg dry wt. dry	*4.84*		*73.6*	*50-150*			
Matrix Spike Dup (1115015-MSD1)	**Source: T103175-02**			Prepared: 31-Mar-11 Analyzed: 19-Apr-11						
NWTPH-Diesel	130	24	mg/kg dry wt. dry	244	13	46.8	50-150	3.01	200	
NWTPH-Heavy Oil	990	49	mg/kg dry wt. dry	489	520	97.1	50-150	15.3	200	
Surrogate: 2-Fluorobiphenyl	*2.6*		mg/kg dry wt. dry	*4.89*		*53.8*	*50-150*			
Surrogate: Terphenyl-d14	*3.0*		mg/kg dry wt. dry	*4.89*		*61.8*	*50-150*			
Batch 1115019 - 3545										
Blank (1115019-BLK1)				Prepared: 31-Mar-11 Analyzed: 14-Apr-11						

Semi-VOA - Quality Control
Environmental Services Laboratory

Sample ID / Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1115019 - 3545										
Blank (1115019-BLK1)				Prepared: 31-Mar-11 Analyzed: 14-Apr-11						
Naphthalene	ND	120	ug/kg wet							
2-Methylnaphthalene	ND	120	ug/kg wet							
2-Chloronaphthalene	ND	120	ug/kg wet							
Dimethyl phthalate	ND	120	ug/kg wet							
Acenaphthylene	ND	120	ug/kg wet							
Acenaphthene	ND	120	ug/kg wet							
Diethylphthalate	ND	120	ug/kg wet							
Fluorene	ND	120	ug/kg wet							
Phenanthrene	ND	120	ug/kg wet							
Anthracene	ND	120	ug/kg wet							
Di-n-butylphthalate	ND	120	ug/kg wet							
Fluoranthene	ND	120	ug/kg wet							
Butyl benzyl phthalate	ND	120	ug/kg wet							
Pyrene	ND	120	ug/kg wet							
bis(2-Ethylhexyl)phthalate	ND	120	ug/kg wet							
Benzo(a)anthracene	ND	120	ug/kg wet							
Chrysene	ND	120	ug/kg wet							
Di-n-Octyl phthalate	ND	120	ug/kg wet							
Benzo(b,k)fluoranthenes	ND	240	ug/kg wet							
Benzo(a)pyrene	ND	120	ug/kg wet							
Indeno(1,2,3-c,d)pyrene	ND	120	ug/kg wet							
Dibenz(a,h)anthracene	ND	600	ug/kg wet							
Benzo(g,h,i)perylene	ND	120	ug/kg wet							
Surrogate: Nitrobenzene-d5	*1800*		ug/kg wet	*5000*		*35.6*	*32-105*			
Surrogate: 2-Fluorobiphenyl	*1700*		ug/kg wet	*5000*		*34.5*	*39-92*			
Surrogate: Terphenyl-d14	*2600*		ug/kg wet	*5000*		*51.2*	*49-128*			
LCS (1115019-BS1)				Prepared: 31-Mar-11 Analyzed: 14-Apr-11						
Naphthalene	2600	120	ug/kg wet	5000		51.1	35-100			
Dimethyl phthalate	3000	120	ug/kg wet	5000		59.7	55-119			
Acenaphthylene	2400	120	ug/kg wet	5000		48.2	43-111			
Acenaphthene	2400	120	ug/kg wet	5000		48.9	44-112			
Diethylphthalate	2800	120	ug/kg wet	5000		56.5	51-124			
Fluorene	2600	120	ug/kg wet	5000		52.7	47-102			
Phenanthrene	2900	120	ug/kg wet	5000		57.3	60-116			
Anthracene	2700	120	ug/kg wet	5000		53.0	19-148			
Di-n-butylphthalate	2800	120	ug/kg wet	5000		56.8	62-122			
Fluoranthene	2600	120	ug/kg wet	5000		52.6	60-117			

Lori A. Zboralski
Reviewed By

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Semi-VOA - Quality Control
Environmental Services Laboratory

Sample ID Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1115019 - 3545										
LCS (1115019-BS1)				Prepared: 31-Mar-11 Analyzed: 14-Apr-11						
Butyl benzyl phthalate	3400	120	ug/kg wet	5000		67.6	48-135			
Pyrene	3000	120	ug/kg wet	5000		60.9	32-129			
bis(2-Ethylhexyl)phthalate	3400	120	ug/kg wet	5000		67.0	49-137			
Benzo(a)anthracene	3000	120	ug/kg wet	5000		59.6	55-115			
Chrysene	3000	120	ug/kg wet	5000		59.9	58-113			
Di-n-Octyl phthalate	3500	120	ug/kg wet	5000		69.6	43-147			
Benzo(b,k)fluoranthenes	5900	240	ug/kg wet	10000		59.2	60-120			
Benzo(a)pyrene	2800	120	ug/kg wet	5000		57.0	52-121			
Indeno(1,2,3-c,d)pyrene	3100	120	ug/kg wet	5000		61.9	55-131			
Dibenz(a,h)anthracene	3100	600	ug/kg wet	5000		62.4	56-131			
Benzo(g,h,i)perylene	3100	120	ug/kg wet	5000		62.5	51-133			
Surrogate: Nitrobenzene-d5	*2600*		ug/kg wet	*5000*		*51.3*	*32-105*			
Surrogate: Terphenyl-d14	*3000*		ug/kg wet	*5000*		*60.2*	*49-128*			
Matrix Spike (1115019-MS1)	**Source: T103175-02**			Prepared: 31-Mar-11 Analyzed: 15-Apr-11						
Naphthalene	2900	120	ug/kg dry	4890	ND	60.2	35-100		50	
Dimethyl phthalate	2700	120	ug/kg dry	4890	ND	54.7	55-119		50	
Acenaphthylene	2800	120	ug/kg dry	4890	ND	57.2	43-111		50	
Acenaphthene	3200	120	ug/kg dry	4890	ND	65.1	44-112		50	
Diethylphthalate	3300	120	ug/kg dry	4890	ND	67.9	51-124		50	
Fluorene	3200	120	ug/kg dry	4890	ND	65.0	47-102		50	
Phenanthrene	3600	120	ug/kg dry	4890	ND	72.8	60-116		50	
Anthracene	2800	120	ug/kg dry	4890	ND	58.2	19-148		50	
Di-n-butylphthalate	3900	120	ug/kg dry	4890	ND	79.4	62-122		50	
Fluoranthene	3500	120	ug/kg dry	4890	140	69.1	60-117		50	
Butyl benzyl phthalate	4400	120	ug/kg dry	4890	210	86.6	48-135		50	
Pyrene	4000	120	ug/kg dry	4890	180	77.1	32-129		50	
bis(2-Ethylhexyl)phthalate	6500	120	ug/kg dry	4890	1600	99.8	49-137		50	
Benzo(a)anthracene	3400	120	ug/kg dry	4890	ND	69.0	55-115		50	
Chrysene	3600	120	ug/kg dry	4890	ND	73.3	58-113		50	
Di-n-Octyl phthalate	3800	1200	ug/kg dry	4890	ND	77.2	43-147		50	
Benzo(b,k)fluoranthenes	8100	230	ug/kg dry	9770	ND	82.6	60-120		50	
Benzo(a)pyrene	3000	120	ug/kg dry	4890	ND	61.1	52-121		50	
Indeno(1,2,3-c,d)pyrene	3400	1200	ug/kg dry	4890	ND	70.2	55-131		50	
Dibenz(a,h)anthracene	2500	590	ug/kg dry	4890	ND	52.1	56-131		50	
Benzo(g,h,i)perylene	2300	120	ug/kg dry	4890	ND	46.6	51-133		50	
Surrogate: Nitrobenzene-d5	*2500*		ug/kg dry	*4890*		*52.1*	*32-105*			
Surrogate: Terphenyl-d14	*3200*		ug/kg dry	*4890*		*65.8*	*49-128*			

Lori A Zboralski
Reviewed By

PW Science and Engineering	Project: **Pervious Pavement**	
326 East D Street	Project Number: ENV-03002-02-02	**Reported:**
Tacoma WA, 98421	Project Manager: Karen Bartlett	08-Jun-11 11:59

Semi-VOA - Quality Control

Environmental Services Laboratory

Sample ID Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1115019 - 3545										
Matrix Spike Dup (1115019-MSD1)		**Source: T103175-02**		Prepared: 31-Mar-11 Analyzed: 15-Apr-11						
Naphthalene	2500	120	ug/kg dry	4910	ND	50.5	35-100	17.1	50	
2-Methylnaphthalene	3100	120	ug/kg dry	4910	ND	62.7	35-105		50	
2-Chloronaphthalene	2800	120	ug/kg dry	4910	ND	57.7	40-102		50	
Dimethyl phthalate	3500	120	ug/kg dry	4910	ND	71.7	55-119	27.4	50	
Acenaphthylene	2700	120	ug/kg dry	4910	ND	55.2	43-111	2.98	50	
Acenaphthene	3100	120	ug/kg dry	4910	ND	62.4	44-112	3.72	50	
Diethylphthalate	3300	120	ug/kg dry	4910	ND	66.6	51-124	1.41	50	
Fluorene	3800	120	ug/kg dry	4910	ND	76.5	47-102	16.8	50	
Phenanthrene	3600	120	ug/kg dry	4910	ND	72.6	60-116	0.347	50	
Anthracene	2900	120	ug/kg dry	4910	ND	58.1	19-148	0.353	50	
Di-n-butylphthalate	3900	120	ug/kg dry	4910	ND	80.0	62-122	1.34	50	
Fluoranthene	3600	120	ug/kg dry	4910	140	69.3	60-117	0.837	50	
Butyl benzyl phthalate	5600	120	ug/kg dry	4910	210	110	48-135	23.6	50	
Pyrene	5100	120	ug/kg dry	4910	180	99.4	32-129	24.8	50	
bis(2-Ethylhexyl)phthalate	6300	1200	ug/kg dry	4910	1600	95.8	49-137	2.63	50	
Benzo(a)anthracene	3400	120	ug/kg dry	4910	ND	68.7	55-115	0.102	50	
Chrysene	3600	120	ug/kg dry	4910	ND	73.0	58-113	0.185	50	
Di-n-Octyl phthalate	3800	1200	ug/kg dry	4910	ND	77.2	43-147	0.594	50	
Benzo(b,k)fluoranthenes	8300	240	ug/kg dry	9830	ND	84.8	60-120	3.25	50	
Benzo(a)pyrene	3000	120	ug/kg dry	4910	ND	60.5	52-121	0.524	50	
Indeno(1,2,3-c,d)pyrene	2700	120	ug/kg dry	4910	ND	54.1	55-131	25.4	50	
Dibenz(a,h)anthracene	2500	590	ug/kg dry	4910	ND	51.1	56-131	1.46	50	
Benzo(g,h,i)perylene	2200	120	ug/kg dry	4910	ND	44.0	51-133	5.15	50	
Surrogate: Nitrobenzene-d5	*2100*		ug/kg dry	*4910*		*42.6*	*32-105*			
Surrogate: 2-Fluorobiphenyl	*2600*		ug/kg dry	*4910*		*53.1*	*39-92*			
Surrogate: Terphenyl-d14	*4900*		ug/kg dry	*4910*		*99.6*	*49-128*			

Lori A. Zboralski
Reviewed By

Notes and Definitions

J	The result is an estimated concentration.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

City of Tacoma
Public Works — Environmental Services

Send Results & Invoice to:
Environmental Services Laboratory
326 East D Street
Tacoma, WA 98421
(253) 502-2130
PO#:

Page 1 of 1

Chain of Custody Record

SAP Accounting: ENV-0300 2-02-02
Project Name: Pervious Pavement
Samplers (Print): Ryan Gore, Kevin Brennan, Steve Shortencarrier
Samples Sent to:
PO#

	Lab # T103175	Date	Time	Matrix	Grab	Composite	Sample ID	Total Containers	Grain Size	PAH's/Phthalates	Metals	NWTPH-Dx NWTPH-HO	Total Solids Volatile Solids	TOC	Remarks
1	-01	3/23/11	09:55	Sediment		X	Pervious Pavers	2	X	X	X	X	X	X	Target parameter
2	-02	↓	10:05	↓		↓	Pervious Concrete	2	↓	↓	↓	↓	↓	↓	list is attached
3	-03	↓	10:15	↓		↓	Pervious Asphalt	2	↓	↓	↓	↓	↓	↓	Call Steve S. or
4	-04	↓	10:20	↓		↓	Standard Asphalt	2	↓	↓	↓	↓	↓	↓	Karen B. w/questions
5															
6															
7															
8															
9							SS 3/23/11								
10															
11															
12															
13															
14															
15															
16															

Relinquished By (Signature):	Date/Time	Received By (Signature):	Relinquished By (Signature):	Date/Time	Received for Laboratory By (Signature):
[signature]	3/23/11 11:30	lab cooler	→	3/23/11 12:30	Bill Eismeier
Relinquished By (Signature):	**Date/Time**	**Received for Analysis By (Signature):**		**Date/Time**	**Remarks**

Analytical Resources, Incorporated
Analytical Chemists and Consultants

11 April 2011

City of Tacoma
ATTN: Lori Zboralski
Science and Engineering Division
326 East D Street
Tacoma, WA 98421

RE: Project: Pervious Pavement, ENV-03002-02-02
ARI Job No.: SP11

Dear Lori:

Please find enclosed the original chain of custody record (COC) and the final results for samples from the project referenced above. Analytical Resources, Inc. accepted four sediment samples on March 29, 2011. The samples were analyzed for soil classification as requested.

A copy of these reports will remain on file at ARI. If you have any questions or require further information, please contact me at your convenience.

Sincerely,

ANALYTICAL RESOURCES, INC.

Mark D. Harris
Project Manager
206/695-6210
markh@arilabs.com

Enclosures

cc: file SP11

MDH/esj

4611 South 134th Place, Suite 100 • Tukwila WA 98168 • **206-695-6200** • **206-695-6201** fax

Table of Contents: ARI Job SP11

Client: City of Tacoma

Project: ENV-03002-02-02 Pervious Pavement

Signature

April-11-2011
Date

Chain of Custody Documentation

ARI Job ID: SP11

SP11

CHAIN OF CUSTODY

City of Tacoma Environmental Services
326 East D Street
Tacoma
WA, 98421-1801

(253)502-2130
(253)502-2170

Page 1 of 1

COC Number
Lab Work Order Number T103175

Client Name		Project Name
PW Science and Engineering		Pervious Pavement
Client Contact: Lori Zboralski		Project Number: ENV-03002-02-02
Address: 326 East D Street		Project Description:
City: Tacoma		PO Number:
State/Zip: WA, 98421		Shipped By:
Phone: (253) 502-2133	Fax: (253) 502-2107	Tracking Number:
Sampler: Steve Shortencarrier		Sampler Signature: N/A

Requested Analyses: D2487

Requested Turn Around
Rush requests subject to additional charge. Rush requests subject to lab approval.
Standard (days): 21
Expedited (days):
Due Date: 4/13/2011 0:00

Sample Name or Field ID	Sampled Date	Sampled Time	Sample Type Code	Matrix Code	Container Count	Preservation Code 1	Sample Comments
Pervious Pavers	3/23/11	0955	G	S	1	1	T103175-01
Pervious Concrete	↓	1005	G	S	1	1	-02
Pervious Asphalt	↓	1015	G	S	1	1	-03
Standard Asphalt	↓	1020	G	S	1	1	-04

Relinquished By	Date/Time	Received By	Date/Time
Bill Essmeier	3/29/11 950	Natalie Beatty	3/29/11 9:50
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time

Sample Kit Prepared By — Date/Time

Comments

Cooler Numbers and Temperatures

Matrix Codes: S=Soil

Preserv. Codes: 1=Cool <6°C

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: City of Tacoma

COC No(s): ____________ **NA**

Assigned ARI Job No: SD11

Project Name: Pervious Pavement

Delivered by: Fed-Ex UPS **Courier** Hand Delivered Other: ______

Tracking No: ____________ **NA**

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of to cooler?	YES	**NO**
Were custody papers included with the cooler?	**YES**	NO
Were custody papers properly filled out (ink, signed, etc.)	**YES**	NO

Temperature of Cooler(s) (°C) (recommended 2.0-6.0 °C for chemistry)........ 10.9 ___ ___ ___ ___ ___ ___

If cooler temperature is out of compliance fill out form 00070F   Temp Gun ID#: 90941619

Cooler Accepted by: Natalie Barbry Date: 3/29/2011 Time: 9:50

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	**NO**
Was sufficient ice used (if appropriate)?	**NA**	YES	NO
Were all bottles sealed in individual plastic bags?		YES	**NO**
Did all bottles arrive in good condition (unbroken)?		**YES**	NO
Were all bottle labels complete and legible?		**YES**	NO
Did the number of containers listed on COC match with the number of containers received?		**YES**	NO
Did all bottle labels and tags agree with custody papers?		**YES**	NO
Were all bottles used correct for the requested analyses?		**YES**	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs)...	**NA**	YES	NO
Were all VOC vials free of air bubbles?	**NA**	YES	NO
Was sufficient amount of sample sent in each bottle?		**YES**	NO
Date VOC Trip Blank was made at ARI........	**NA**	______	

What kind of packing material was used? ... Bubble Wrap Wet Ice Gel Packs Baggies Foam Block Paper Other: BOX

Was Sample Split by ARI : **NA** YES Date/Time: ______ Equipment: ______ Split by: ______

Samples Logged by: AV Date: 3/29/11 Time: 1110

*** Notify Project Manager of discrepancies or concerns ***

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Additional Notes, Discrepancies, & Resolutions:

By: Date:

Small Air Bubbles ~2mm	Peabubbles' 2-4 mm	LARGE Air Bubbles > 4 mm	Small → "sm" Peabubbles → "pb" Large → "lg" Headspace → "hs"

Case Narrative, Data Qualifiers, Control Limits

ARI Job ID: SP11

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Client: City of Tacoma	**ARI Project No.:** SP11
Client Project: Pervious Pavement	**Client Project No.:** ENV-03002-02-02

Case Narrative

1. Four samples were received on March 29, 2011, and were in good condition.
2. The samples were submitted for Soil Classification according to ASTM D2487.
3. Grain size distribution was run according to ASTM D422. The samples were prepared according to ASTM D421. An assumed specific gravity of 2.65 was used in the calculations. A standard milkshake mixer type device was used to disperse the samples.
4. Atterberg limits determination was run according to ASTM D4318. The samples were tested for organic classification. One sample, Pervious Pavers, was classified organic.
5. Moisture Content Determination was run according to ASTM D2216.
6. The data is provided in summary tables and plots.
7. There were no further anomalies in the samples or test method.

Approved by: [signature] Date: 4/11/11
Title: *Geotechnical Division Manager*

Sample ID Cross Reference Report

ANALYTICAL RESOURCES INCORPORATED

ARI Job No: SP11
Client: City of Tacoma
Project Event: ENV-03002-02-02
Project Name: Pervious Pavement

	Sample ID	ARI Lab ID	ARI LIMS ID	Matrix	Sample Date/Time	VTSR
1.	Pervious Pavers	SP11A	11-6832	Sediment	03/23/11 09:55	03/29/11 09:50
2.	Pervious Concrete	SP11B	11-6833	Sediment	03/23/11 10:05	03/29/11 09:50
3.	Pervious Asphalt	SP11C	11-6834	Sediment	03/23/11 10:15	03/29/11 09:50
4.	Standard Asphalt	SP11D	11-6835	Sediment	03/23/11 10:20	03/29/11 09:50

Printed 03/29/11

Data Reporting Qualifiers

Effective 2/14/2011

Inorganic Data

U Indicates that the target analyte was not detected at the reported concentration

* Duplicate RPD is not within established control limits

B Reported value is less than the CRDL but ≥ the Reporting Limit

N Matrix Spike recovery not within established control limits

NA Not Applicable, analyte not spiked

H The natural concentration of the spiked element is so much greater than the concentration spiked that an accurate determination of spike recovery is not possible

L Analyte concentration is ≤5 times the Reporting Limit and the replicate control limit defaults to ±1 RL instead of the normal 20% RPD

Organic Data

U Indicates that the target analyte was not detected at the reported concentration

* Flagged value is not within established control limits

B Analyte detected in an associated Method Blank at a concentration greater than one-half of ARI's Reporting Limit or 5% of the regulatory limit or 5% of the analyte concentration in the sample.

J Estimated concentration when the value is less than ARI's established reporting limits

D The spiked compound was not detected due to sample extract dilution

E Estimated concentration calculated for an analyte response above the valid instrument calibration range. A dilution is required to obtain an accurate quantification of the analyte.

Q Indicates a detected analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20%Drift or minimum RRF).

S Indicates an analyte response that has saturated the detector. The calculated concentration is not valid; a dilution is required to obtain valid quantification of the analyte

NA The flagged analyte was not analyzed for

NR Spiked compound recovery is not reported due to chromatographic interference

NS The flagged analyte was not spiked into the sample

M Estimated value for an analyte detected and confirmed by an analyst but with low spectral match parameters. This flag is used only for GC-MS analyses

M2 The sample contains PCB congeners that do not match any standard Aroclor pattern. The PCBs are identified and quantified as the Aroclor whose pattern most closely matches that of the sample. The reported value is an estimate.

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification"

Y The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

EMPC Estimated Maximum Possible Concentration (EMPC) defined in EPA Statement of Work DLM02.2 as a value "calculated for 2,3,7,8-substituted isomers for which the quantitation and /or confirmation ion(s) has signal to noise in excess of 2.5, but does not meet identification criteria" **(Dioxin/Furan analysis only)**

C The analyte was positively identified on only one of two chromatographic columns. Chromatographic interference prevented a positive identification on the second column

P The analyte was detected on both chromatographic columns but the quantified values differ by ≥40% RPD with no obvious chromatographic interference

X Analyte signal includes interference from polychlorinated diphenyl ethers. **(Dioxin/Furan analysis only)**

Z Analyte signal includes interference from the sample matrix or perfluorokerosene ions. **(Dioxin/Furan analysis only)**

Geotechnical Data

A The total of all fines fractions. This flag is used to report total fines when only sieve analysis is requested and balances total grain size with sample weight.

F Samples were frozen prior to particle size determination

SM Sample matrix was not appropriate for the requested analysis. This normally refers to samples contaminated with an organic product that interferes with the sieving process and/or moisture content, porosity and saturation calculations

SS Sample did not contain the proportion of "fines" required to perform the pipette portion of the grain size analysis

W Weight of sample in some pipette aliquots was below the level required for accurate weighting

Geotechnical Analysis
Report and Summary QC Forms

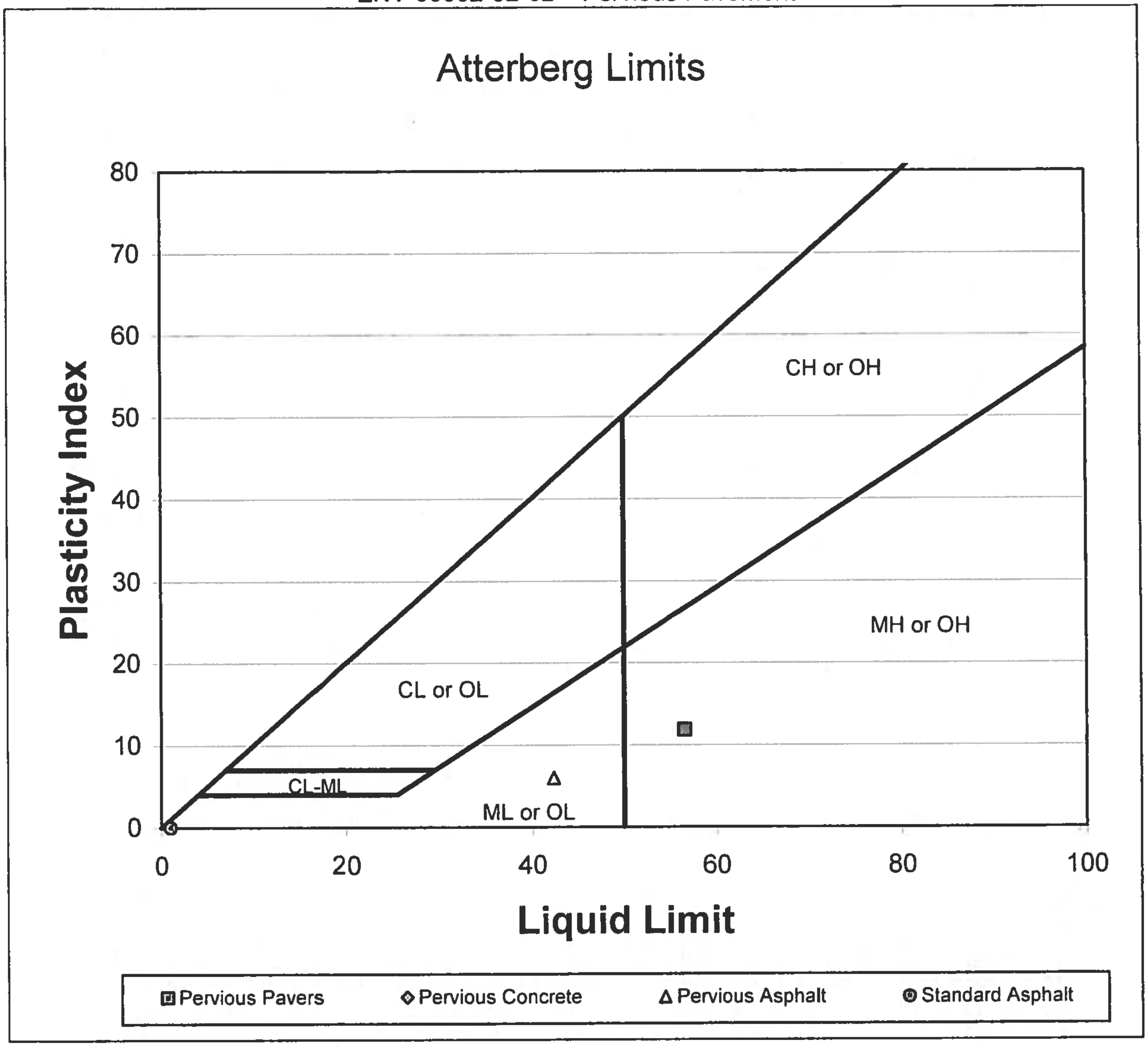
ARI Job ID: SP11

City of Tacoma
Pervious Pavement ENV-03002-02-02

Soil Classification
ASTM D2487

ARI ID	Client ID	Group Symbol	Group Name
A	Pervious Pavers	OH	Sandy Organic Silt
B	Pervious Concrete	SW-SM	Well Graded Sand with Silt
C	Pervious Asphalt	SM	Silty Sand
D	Standard Asphalt	SP-SM	Poorly Graded Sand with Silt

City of Tacoma
ENV-03002-02-02 Pervious Pavement



Sample Identification	As-Received Moisture Content	Plasticity Index	Liquid Limit	Plastic Limit	USCS
Pervious Pavers	222.87	11.8	56.6	44.7	OH
Pervious Concrete	50.15	NA	NA	NA	Non Plastic
Pervious Asphalt	170.82	6.0	42.4	36.4	ML
Standard Asphalt	28.86	NA	NA	NA	Non Plastic

City of Tacoma
Pervious Pavement
ENV-03002-02-02

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
SM14 C	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0	98.5	98.2	97.8	94.4	78.4	67.8	55.5	47.3	34.3	18.8	12.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	98.4	98.1	97.7	93.6	79.5	69.8	55.2	47.9	38.2	19.5	12.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	98.7	98.4	98.0	94.9	79.0	69.2	56.2	47.2	38.3	19.5	12.2
Pervious Pavers	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.5	97.0	89.6	77.3	66.2	59.6	54.1	42.9	35.6	27.4	21.0	13.7	8.2	3.6
Pervious Concrete	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	93.9	71.5	40.0	18.7	12.0	10.1	8.2	6.8	5.9	4.1	3.2	1.8	1.4
Pervious Asphalt	100.0	100.0	100.0	100.0	100.0	99.8	99.8	99.3	97.6	89.9	75.1	58.6	48.0	41.5	33.7	28.8	22.2	17.3	12.3	4.9	2.5
Standard Asphalt	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.9	90.6	75.6	48.8	26.4	14.6	8.6	8.5	6.3	4.9	3.1	2.7	1.3	1.3

Testing performed according to ASTM D421/D422

City of Tacoma
Pervious Pavement
ENV-03002-02-02

Percent Retained in Each Size Fraction

Description	%Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
SM14 C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.3	0.4	3.5	16.0	10.6	12.2	8.2	13.1	15.5	18.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.7	0.3	0.4	4.1	14.0	9.7	14.6	7.3	9.7	18.7	19.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.3	0.4	3.1	15.9	9.8	13.0	9.0	9.0	18.7	19.5
Pervious Pavers	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	7.4	12.3	11.1	6.6	5.5	11.2	7.3	8.2	6.4	7.3	5.5	8.2
Pervious Concrete	0.0	0.0	0.0	0.0	0.0	0.0	0.1	6.0	22.5	31.4	21.3	6.7	1.9	1.9	1.4	0.9	1.8	0.9	1.4	1.8
Pervious Asphalt	0.0	0.0	0.0	0.0	0.2	0.0	0.5	1.7	7.7	14.8	16.5	10.6	6.6	7.7	4.9	6.6	4.9	4.9	7.4	4.9
Standard Asphalt	0.0	0.0	0.0	0.0	0.0	0.0	3.1	6.4	14.9	26.8	22.4	11.8	6.1	0.1	2.2	1.3	1.8	0.4	1.3	1.3

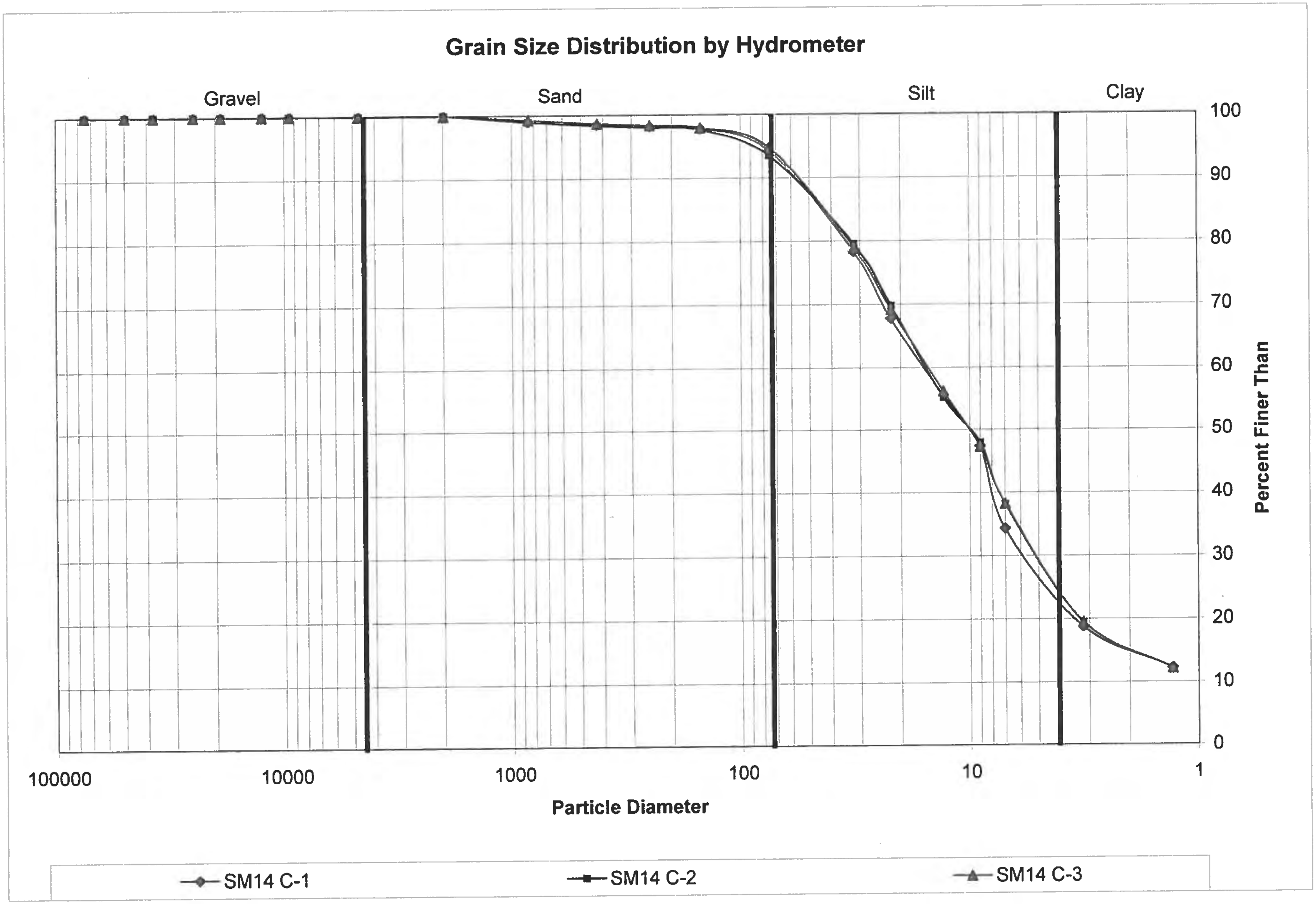
Client:	City of Tacoma	Project No.:	Pervious Pavement
		Project:	ENV-03002-02-02
ARI Triplicate Sample ID:	SM14 C	Batch No.:	SP11-01
		Page:	1 of 1

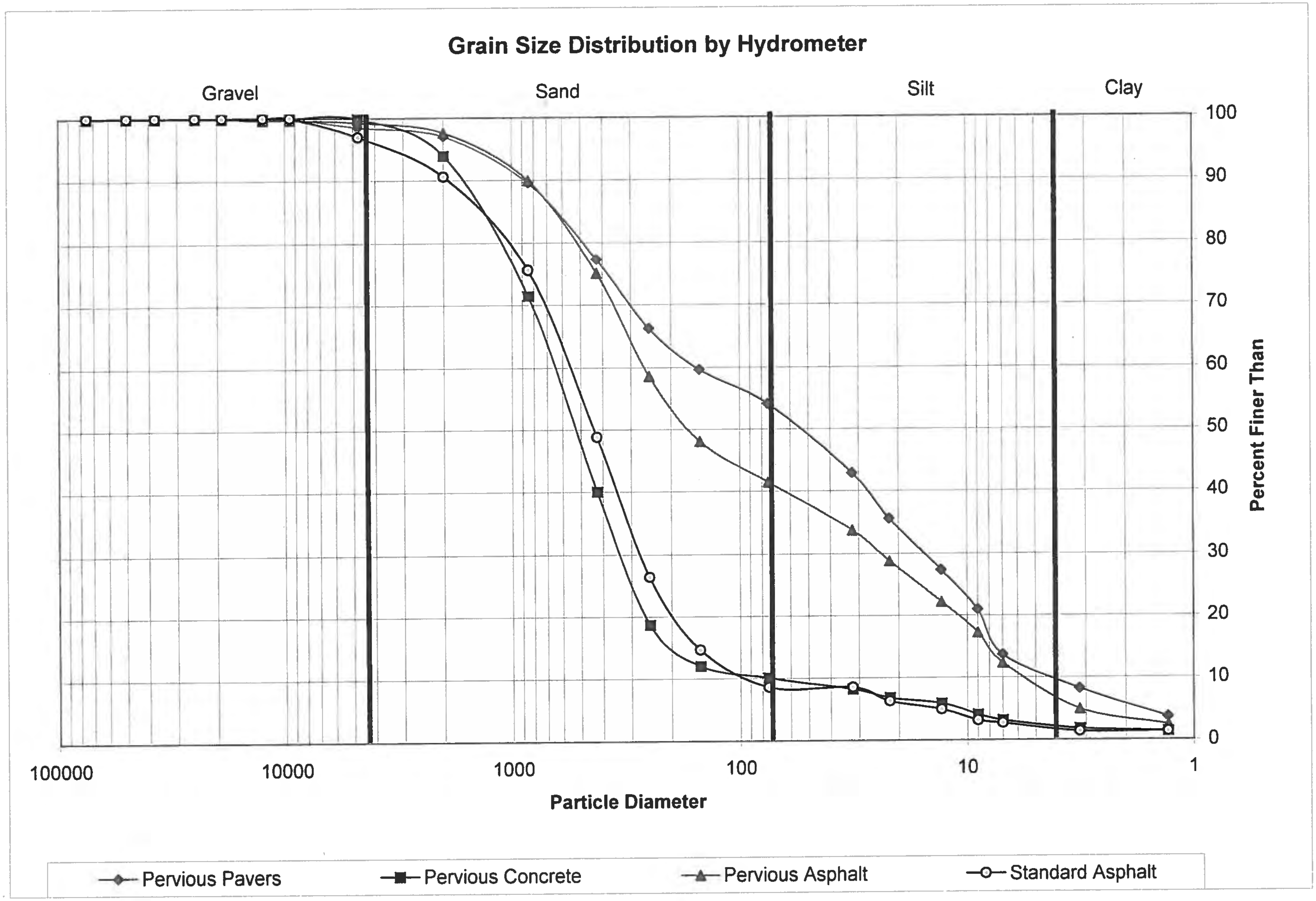
Relative Standard Deviation, By Size

Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
SM14 C-1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0	98.5	98.2	97.8	94.4	78.4	67.8	55.5	47.3	34.3	18.8	12.2
SM14 C-2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	98.4	98.1	97.7	93.6	79.5	69.8	55.2	47.9	38.2	19.5	12.2
SM14 C-3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	98.7	98.4	98.0	94.9	79.0	69.2	56.2	47.2	38.3	19.5	12.2
AVE	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.12	98.53	98.23	97.83	94.28	78.96	68.92	55.63	47.48	36.90	19.26	12.21
STDEV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.17	0.16	0.17	0.65	0.59	1.05	0.50	0.36	2.26	0.42	0.03
%RSD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.17	0.16	0.17	0.69	0.75	1.53	0.90	0.75	6.14	2.21	0.28

This Triplicate applies to the Batch Containing the Following Samples

Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
SM14 C	3/8/2011	3/11/2011	3/16/2011	3/18/2011	
	3/8/2011	3/11/2011	3/16/2011	3/18/2011	
	3/8/2011	3/11/2011	3/16/2011	3/18/2011	
Pervious Pavers	3/23/2011	4/4/2011	4/6/2011	4/8/2011	
Pervious Concrete	3/23/2011	4/4/2011	4/6/2011	4/8/2011	
Pervious Asphalt	3/23/2011	4/4/2011	4/6/2011	4/8/2011	
Standard Asphalt	3/23/2011	4/4/2011	4/6/2011	4/8/2011	


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
100
10
1
Particle Diameter
SM14 C-1
SM14 C-2
SM14 C-3



Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
100
10
1
Particle Diameter
Pervious Pavers
Pervious Concrete
Pervious Asphalt
Standard Asphalt

Geotechnical Raw Data
Analyst Notes and Raw Data

ARI Job ID: SP11

MOISTURE CONTENT DETERMINATION – ASTM D-2216

ARI Job No.: SP11
Set-up Date: 4/4/11

Tested by: gs

ARI Sample ID	Tare #	Wt. Tare (g)	Wt. Wet Soil + Tare (g)	Wt. Dry Soil + Tare (g)	MC %
A	A	1.56	12.57	4.97	
B	B	1.55	65.95	44.44	
C	C	1.56	18.08	7.66	
D	D	1.56	65.36	51.07	

ATTERBERG LIMIT DETERMINATION ASTM D 4318

ARI Job No.: SPI1 Set-Up Date: 4/4/11 Initials: [illegible]

Test Date: 4.7.2011 Initials: [illegible]

	Sample A	Sample B	Sample C	Sample 4	Sample 5
ARI Sample ID:	A	B	C		
Client Sample ID:	PerviousPavers	Pervious Concrete	Pervious Asphalt	Standard Asphalt	
Sample Description:	Sand, organic fines, oily sheen	Sand	Organic Debris & fines	Sand	
Through #40:	(Y)/N	Y/N	(Y)/N	Y/N	Y/N
Crucible #:					

	A	A	A	B	B	B	C	C	C	4	4	4	5	5	5
LIQUID LIMIT															
No. of Blows	24	24	32	NON-PLASTIC			22	23	31	NON-PLASTIC					
Tare #	A.1	A.2	A.3				C.1	C.2	C.3						
Tare Wt.	1.51	1.55	1.55				1.54	1.54	1.51						
Wet Wt. + Tare	5.10	5.28	5.58				6.71	8.77	6.29						
Dry Wt. + Tare	3.79	3.93	4.16				5.15	6.63	4.88						
PLASTIC LIMIT															
Tare #	A.4	A.5					C.4	C.5							
Tare Wt.	1.51	1.55					1.57	1.54							
Wet Wt. + Tare	4.89	4.71					5.25	4.98							
Dry Wt. + Tare	3.88	3.72					4.26	4.07							
ORGANIC LIQUID LIMIT	ORGANIC		Natural Moisture Content			Natural Moisture Content	NON ORGANIC		Natural Moisture Content			Natural Moisture Content			Natural Moisture Content
No. of Blows	25						29								
Tare #	A.0						C.0								
Tare Wt.	1.53						1.55								
Wet Wt. + Tare	4.46						4.77								
Dry Wt. + Tare	3.59						3.98								

Hydrometer Particle-Size Analysis - ASTM D421/422

ARI Job No.: SPIJ ARI Sample ID.: B Setup Date: 4/4/11 Initials: gs
Sample Description: Medium to fine Sand
Method of size reduction: Quartering [X] Sample Splitter [ ] Whole Sample [ ]

Tare Number	B
Tare Weight (g)	10.21
Tare + Air-Dried Sample Weight (g) (before #10 preparation)	200.68
Hydro Test Sample Weight (g) (not including beaker weight)	104.38
Tare + Oven-Dried #10 Washed (g)	22.31
Tare + Oven-Dried #200 Washed (g) (including plus #10 material)	114.01

Hygroscopic Moisture Content	
Tare Number	B
Tare Weight (g)	1.51
Wet Soil + Tare (g)	35.14
Dry Soil + Tare (g)	34.75

Hydro Beaker: 39 Calgon Batch #: 238 Calgon Date: 4/5/11 Technician: gs

Hydrometer Analysis

Hydro #: 193285 Technician: eg

4/6/2011 Time	Δ Time	Test Cylinder	Calgon Blank	Temp (°C)
6:52:00	START			
6:53:00	1	17.5	6.5	19.5
6:54:00	2	15.5	6.5	19.5
6:57:00	5	14	6.5	19.5
7:07:00	15	13	6.5	19.5
7:22:00	30	11	6.5	19.5
7:52:00	60	10	6.5	19.5
11:02:00	250	8.5	6.5	20.5
6:52:00	1440	8	6.5	19.0

Sieve Analysis

Sieve Date: 4/8/2011 Sieve Set #: 4 Technician: DS

Sieve Size	Cumulative Weight (g)
Empty Tare	10.23
2"	
1½"	
1"	
3/4"	
1/2"	
3/8"	
#4	10.44
#10	21.68
#20	46.36
#40	80.87
#60	104.30
#100	111.66
#200	113.79
Pan	114.10

Hydrometer Particle-Size Analysis - ASTM D421/422

ARI Job No.: SP11 ARI Sample ID.: C Setup Date: 4/4/11 Initials: gs

Sample Description: Brown organic fines organic debris

Method of size reduction: Quartering [X] Sample Splitter [ ] Whole Sample [ ]

Tare Number	C
Tare Weight (g)	10.20
Tare + Air-Dried Sample Weight (g) (before #10 preparation)	90.09
Hydro Test Sample Weight (g) (not including beaker weight)	60.55
Tare + Oven-Dried #10 Washed (g)	12.55
Tare + Oven-Dried #200 Washed (g) (including plus #10 material)	46.64

Hygroscopic Moisture Content	
Tare Number	C
Tare Weight (g)	1.52
Wet Soil + Tare (g)	17.89
Dry Soil + Tare (g)	17.57

Hydro Beaker: CJ Calgon Batch #: 238 Calgon Date: 4/5/11 Technician: gs

Hydrometer Analysis

Hydro #: 193285 Technician: eg

4/6/2011 Time	Δ Time	Test Cylinder	Calgon Blank	Temp (°C)
6:59:00	START			
7:00:00	1	30	6.5	19.5
7:01:00	2	27	6.5	19.5
7:04:00	5	24	6.5	19.5
7:14:00	15	20	6.5	19.5
7:29:00	30	17	6.5	19.5
7:59:00	60	14	6.5	19.5
11:09:00	250	9.5	6.5	20.5
6:59:00	1440	8	6.5	19.0

Sieve Analysis

Sieve Date: 4/8/2011 Sieve Set #: 3 Technician: DS

Sieve Size	Cumulative Weight (g)
Empty Tare	10.22
2"	
1½"	
1"	
3/4"	
1/2"	10.41
3/8"	10.41
#4	10.77
#10	12.11
#20	16.77
#40	25.78
#60	35.83
#100	42.26
#200	46.26
Pan	46.76

Hydrometer Particle-Size Analysis - ASTM D421/422

ARI Job No.: SP11 ARI Sample ID.: D Setup Date: 4/4/11 Initials: gs
Sample Description: Sand, Organic Debris & Fines
Method of size reduction: Quartering [X] Sample Splitter [ ] Whole Sample [ ]

Tare Number	D
Tare Weight (g)	9.82
Tare + Air-Dried Sample Weight (g) (before #10 preparation)	212.98
Hydro Test Sample Weight (g) (not including beaker weight)	101.72
Tare + Oven-Dried #10 Washed (g)	29.44
Tare + Oven-Dried #200 Washed (g) (including plus #10 material)	120.99

Hygroscopic Moisture Content	
Tare Number	D
Tare Weight (g)	1.53
Wet Soil + Tare (g)	28.21
Dry Soil + Tare (g)	28.05

Hydro Beaker: DJ Calgon Batch #: 238 Calgon Date: 4/5/11 Technician: gs

Hydrometer Analysis

Hydro #: 193285 Technician: eg

4/6/2011 Time	Δ Time	Test Cylinder	Calgon Blank	Temp (°C)
7:06:00	START			
7:07:00	1	17	6.5	19.5
7:08:00	2	16	6.5	19.5
7:11:00	5	13.5	6.5	19.5
7:21:00	15	12	6.5	19.5
7:36:00	30	10	6.5	19.5
8:06:00	60	9.5	6.5	19.5
11:16:00	250	8	6.5	20.5
7:06:00	1440	8	6.5	19.0

Sieve Analysis

Sieve Date: 4/8/2011 Sieve Set #: 4 Technician: DS

Sieve Size	Cumulative Weight (g)
Empty Tare	9.86
2"	
1½"	
1"	
3/4"	
1/2"	
3/8"	
#4	16.06
#10	28.93
#20	45.61
#40	75.54
#60	100.55
#100	113.70
#200	120.46
Pan	120.91

Hydrometer Particle-Size Analysis - ASTM D421/422

ARI Job No.: SPI1 ARI Sample ID.: A Setup Date: 4/4/11 Initials: gs
Sample Description: Sand, organic fines, oily sheen, organic debris
Method of size reduction: Quartering [X] Sample Splitter [ ] Whole Sample [ ]

Tare Number	A
Tare Weight (g)	10.37
Tare + Air-Dried Sample Weight (g) (before #10 preparation)	71.28
Hydro Test Sample Weight (g) (not including beaker weight)	55.53
Tare + Oven-Dried #10 Washed (g)	12.29
Tare + Oven-Dried #200 Washed (g) (including plus #10 material)	36.09

Hygroscopic Moisture Content	
Tare Number	A
Tare Weight (g)	1.52
Wet Soil + Tare (g)	3.94
Dry Soil + Tare (g)	3.84

Hydro Beaker: DF Calgon Batch #: 238 Calgon Date: 4/5/11 Technician: gs

Hydrometer Analysis

4/6/2011 Hydro #: 193285 Technician: ee

Time	Δ Time	Test Cylinder	Calgon Blank	Temp (°C)
6:45:00	START			
6:46:00	1	32.5	6.5	19.5
6:47:00	2	30	6.5	19.5
6:50:00	5	26	6.5	19.5
7:00:00	15	21.5	6.5	19.5
7:15:00	30	18	6.5	19.5
7:45:00	60	14	6.5	19.5
10:55:00	250	11	6.5	20.5
6:45:00	1440	8.5	6.5	19.0

Sieve Analysis

Sieve Date: 4/8/2011 Sieve Set #: 3 Technician: DS

Sieve Size	Cumulative Weight (g)
Empty Tare	10.42
2"	
1½"	
1"	
3/4"	
1/2"	
3/8"	
#4	11.31
#10	12.18
#20	16.25
#40	22.98
#60	29.08
#100	32.40
#200	35.73
Pan	36.26

1101F-A
Rev. 0

INVOICE

1100147

Invoice To:
Alan Aplin
PW Science and Engineering
326 East D Street
Tacoma, WA 98421

Invoice Number: 1100147-PWSED
Invoiced On: 08-Jun-11
Received: 23-Mar-11

Project: Pervious Pavement
Work Order(s): T103175

PO Number:
Client Contact: Karen Bartlett - PW Science and Engineering
Lab Contact: Christopher L. Getchell - Environmental Services Laboratory

Quantity	Analysis/Description	Matrix	Unit Cost	Extended Cost
Environmental Services Laboratory				
4	Zinc, Total 6010B	Soil	$12.00	$48.00
4	Solids, Total Volatile	Soil	$25.00	$100.00
4	Solids, Total SM2540	Soil	$10.00	$40.00
5	S8270_BNA	Soil	$295.00	$1,475.00
4	S8270_BNA - Reruns	Soil	$0.00	$0.00
4	Organic Carbon, Total 9060 Mod	Soil	$40.00	$160.00
4	NWTPH_DX	Soil	$70.00	$280.00
4	NWTPH_DX - Reruns	Soil	$0.00	$0.00
4	Mercury, Total 7471	Soil	$35.00	$140.00
4	Lead, Total 6010B	Soil	$12.00	$48.00
4	Copper, Total 6010B	Soil	$12.00	$48.00
Additional Items				
1	QA/QC Charge		$240.00	$240.00
			Invoice Total:	**$2,579.00**

APPENDIX B. S8F – STORMWATER TREATMENT BEST MANAGEMENT PRACTICE EVALUATION - QUALITY ASSURANCE PROJECT PLAN

Tacoma City of Tacoma
Public Works Department

November 25, 2009

Julie Lowe
Department of Ecology SWRO/WRU
P.O. Box 47775
Lacey, WA 98504-7775

Re: Phase I Municipal Stormwater NPDES Permit
Permit No.: WAR04-4003

Dear Ms. Lowe:

This letter transmits the City of Tacoma's Final Quality Assurance Project Plan (QAPPS) in accordance with Special Condition S8F of the Phase I Municipal Stormwater Permit including:

- Section S8F – Stormwater Treatment Best Management Practice Evaluation

If you have any questions, feel free to call Dana de Leon at (253) 502-2109. If you have comments or questions regarding analytical laboratory issues, feel free to call Chris Burke at (253) 502-2247.

Sincerely,

Lorna Mauren, P.E.
Assistant P.W. Division Manager

lm:dd:cb:crt

Enclosure: Section S8F - Stormwater Treatment Best Management Practice Evaluation

Cc: Dana de Leon
Chris Burke
Christopher Getchell
Rick Fuller

Tacoma

Section S8F - Stormwater Treatment Best Management Practice Evaluation

Quality Assurance Project Plan

Phase I Municipal Stormwater NPDES Permit

Permit No.: WAR04-4003

Revision: S8F-003 Final

Effective date: 11/30/2009

Prepared by:

City of Tacoma
Tacoma, Washington

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1 TITLE AND APPROVAL SHEET

Quality Assurance Project Plan

Phase I Municipal Stormwater NPDES Permit

Internal Review and Approval

Assistant Division Manager Surface Water (Lorna Mauren, P.E.)	Nov 23, 2009 Approved On:
NPDES Permit Manager (Lorna Mauren, P.E.)	Nov 23, 2009 Approved On:
Program Manager (Dana de Leon, P.E.)	Nov 20, 2009 Approved On:
QA Coordinator (Chris Burke)	Nov 23, 2009 Approved On:

I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Date: 11-30-09

Dan C. Thompson, Ph.D.
Acting Asst. Public Works Director/Environmental Services

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2 Distribution List

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Laboratory QAO	Chris Getchell (Tacoma Laboratory)	253.502.2130 cgetchel@cityoftacoma.org	1
Program Manager	Dana de Leon, P.E. (ESSE SW)	253.502.2109 ddeleon@cityoftacoma.org	1
Field Supervisor	Rick Fuller (ESSE EC)	253.502.2129 rfuller@cityoftacoma.org	1

Acronyms

BMP	Best Management Practice
CAR	Corrective Action Report
COC	Chain of Custody
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPA	Environmental Protection Agency
GIS	Geographic Information System
LID	Low Impact Development
MDL	Method Detection Limit
NCR	Nonconformance Report
NPDES	National Pollutant Discharge Elimination System
QA/QC	Quality Assurance/Quality Control
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
SMMWW	Stormwater Management Manual for Western Washington

2 TABLE OF CONTENTS

QAPP Element: Page No.

List of Tables

List of Figures

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Abstract

This Quality Assurance Project Plan (Plan), prepared by City of Tacoma with assistance from Anchor Environmental LLC, describes management of the *storm water treatment best management practices (BMPs) monitoring study* required under Section S8F of the Phase I Municipal Stormwater Permit, permit number WAR04-4003. The permit requires S8E program effectiveness monitoring which is intended to improve stormwater management efforts by evaluating at least two stormwater management practices that significantly affect the success of or confidence in stormwater controls (Ecology 2007).

This Plan is the fourth of four that will be submitted to the Washington Department of Ecology (Ecology) to meet the permit requirements of Section S8 and covers the *BMP effectiveness monitoring* component of section S8F. This document is a companion to the Section S8 Program QAPP. The City of Tacoma submitted proposals to Ecology on July 12, 2007 and October 5, 2007 to monitoring the following treatment BMP types under S8F:

- Bioinfiltration facilities
- Biofiltration facilities, and
- Pervious pavements (flow reduction strategy).

The primary goal of this Plan is to define procedures that assure the quality and integrity of the collected samples, the representativeness of the results, the precision and accuracy of the analyses, the completeness of the data, and ultimately delivers defensible products and decisions for BMP and flow effectiveness monitoring described in Section S8F.

3 BACKGROUND

3.1 The Problem

Ecology (2006) has defined the problem to be addressed with the Best Management Practice (BMP) effectiveness monitoring as:

- "*Without the feedback loop, we haven't a good basis for altering design criteria in order to improve their performance.*
- *" We are overdue to perform studies to firm up our knowledge of the capabilities and limitations of the "best management practices" that we have been using to reduce the pollutant impacts of our developments."*

3.1.1 Driver

Three basic control strategies exist for stormwater. First, prevent pollutants from coming into contact with stormwater by using source control best management practices (BMPs); second, apply treatment BMPs prior to discharge to surface or ground waters to reduce pollutants in the discharge; and third, control the flow rate of stormwater through flow control BMPs.

The focus of this study is evaluation of treatment BMPs. Treatment BMPs include ponds, swales, filtration, and infiltration devices that are designed to capture runoff and treat it using physical, biological, and/or chemical processes. The effectiveness and feasibility of treatment BMPs is variable, subject to some debate, and much remains to be learned (Ecology 2006).

The permit requires that each Phase I permittee select two treatment types that are standard technologies in their manuals, for detailed performance monitoring.

3.1.2 Decision-making

The results of this study are not intended for use in making specific decisions, but rather to provide a feedback loop to Ecology to improve their knowledge and understanding of the performance of treatment BMPs.

3.2 Study Area

As noted above, each permittee is required to select two treatment types that are standard technologies in their manuals, for detailed performance monitoring. The City of Tacoma has selected the following BMPs for evaluation monitoring (Figure 3-1):

- Two bioinfiltration facilities at the Salishan Hope VI Redevelopment (Salishan),
- Two biofiltration facilities, East 32nd Street and Trolley Court, and
- Three types of pervious pavement at the demonstration project located at the City of Tacoma Landfill (flow reduction strategy only).

These sites were selected based on a review of constructed BMPs within the City and the intent to meet the following criteria (Table 3-1):

- Listed in section S8F2 and S8F7,
- Meets design criteria of current Stormwater Management Manual for Western Washington (SMMWW),
- Meets design criteria of current Puget Sound Low Impact Development (LID) Manual which is referenced in the SMMWW,
- Technically feasible to monitor (access, drainage area, inlet concentration, other),

- Constructed and operable by 2009, and
- There are limited studies of the BMP within our region.

The selected bioinfiltration facilities provide enhanced treatment. The selected biofiltration facilities provide basic treatment. The selected pervious pavements provide a flow reduction strategy.

Table 3-1. BMP effectiveness monitoring projects.

BMP Type	BMP Project	On S8F2 List	Meets Ecology Design Criteria [1]	Meets PS LID Design Criteria [1]	2 of Each
1. Standard bioinfiltration	Salishan	Y'	Y'	Y'	Y
2. Standard biofiltration	East 32nd St. Trolley Court	Y'	Y'	Y'	Y
3. Pervious Pavement – 3 types	Tacoma Landfill	N	Y'	Y'	3 types & control

1 See Ecology (2005) for criteria.

BMP No. 1 – Bioinfiltration Facilities. The Salishan project is a residential redevelopment project consisting of over 1,200 housing units, single and multi-family (see Figure 3-2). During redevelopment, the existing stormwater conveyance system was replaced with new infrastructure including a system of biofiltration and bioinfiltration facilities. These facilities were designed to meet the requirements for basic and enhanced treatment as specified in the Tacoma Surface Water Management Manual (and 2005 Ecology Manual). Two bioinfiltration facilities were selected for this project, East 46th & R Street Swale and East 44th Street Pond. Design criteria for each of these bioinfiltration facilities are provided in Appendix A.

BMP No. 2 – Biofiltration Facilities. The East 32nd Street Improvement required treatment of the improved street runoff (see Figure 3-3). The land use in the area is residential on one side of the street and an office building with parking lot on the opposite side of the street. The East 32nd Street Improvement bioswale consists of two parallel bioswales that receive street runoff from catch basins along East 32nd Street through a pair of 12-inch pipes, one for each bioswale.

The Trolley Court development required treatment of the street, new residences, and one commercial building (see Figure 3-4). The land use in the area is residential and commercial. The Trolley Court bioswale is located at 1712 State St. It receives runoff from surrounding streets and residences through a 12-inch pipe.

These facilities were designed to meet the requirements for basic treatment as specified in the Tacoma Surface Water Management Manual (and 2005 Ecology Manual). Design criteria for each of these biofiltration facilities are provided in Appendix A.

BMP No. 3 – Pervious Pavements. At the Tacoma Landfill, a demonstration project, a 36,100 square foot paved area, was constructed using 3 types of pervious pavement systems and a control, standard asphalt (see Figure 3-5). There are several national studies on the effectiveness of pervious pavement. Tacoma is monitoring the effectiveness of this BMP for both water quality and flow reduction. Tacoma will continue to monitor flow reduction effectiveness at this facility.

The City of Tacoma submitted a proposal to Ecology on July 12, 2007 and follow-up information on October 5, 2007 in regards to monitoring the pervious pavements at the Tacoma Landfill. Additional information regarding Ecology questions on the pervious pavements site are provided in Appendix B.

3.3 Parameters of Concern

The water analytes identified as parameters of concern by Ecology are those that will provide information regarding the effectiveness of basic and enhanced treatment BMPs (Table 3-2).

Table 3-2. Required parameters to be measured in water.

Analyte Group	Parameter
Conventional	Hardness
	pH
	Particle Size Distribution (PSD)
	TSS
Metals (dissolved & total)	Cadmium[1]
	Copper
	Lead[1,2]
	Zinc
	Mercury [2]
Nutrients	Orthophosphate
	Total phosphorus
Organics	PAHs and phthalates [2]

1 These parameters aren't required under NPDES Permit S8F.5.a.
2 These parameters are included as chemicals of concern for Thea Foss Waterway Recontamination Evaluation and are not a required parameter under S8F.

The sediment analytes identified as parameters of concern by Ecology are those that will provide information regarding the effectiveness of basic and enhanced treatment BMPs (Table 3-3).

Table 3-3. Parameters to be measured in sediment.

Analyte Group	Parameter
Conventional	Total solids
	Grain size
	Total Volatile solids
	Total organic carbon [2]
Metals, total recoverable	Cadmium
	Copper
	Lead
	Zinc
	Mercury [2]
Nutrients	Total phosphorus
Total Petroleum Hydrocarbons (TPH)	Diesel Range Organics (DRO)
Organics	PAHs and phthalates [2]
	PCBs [2]

2 These parameters are included as chemicals of concern for Thea Foss Waterway Recontamination Evaluation and are not a required parameter under S8F.

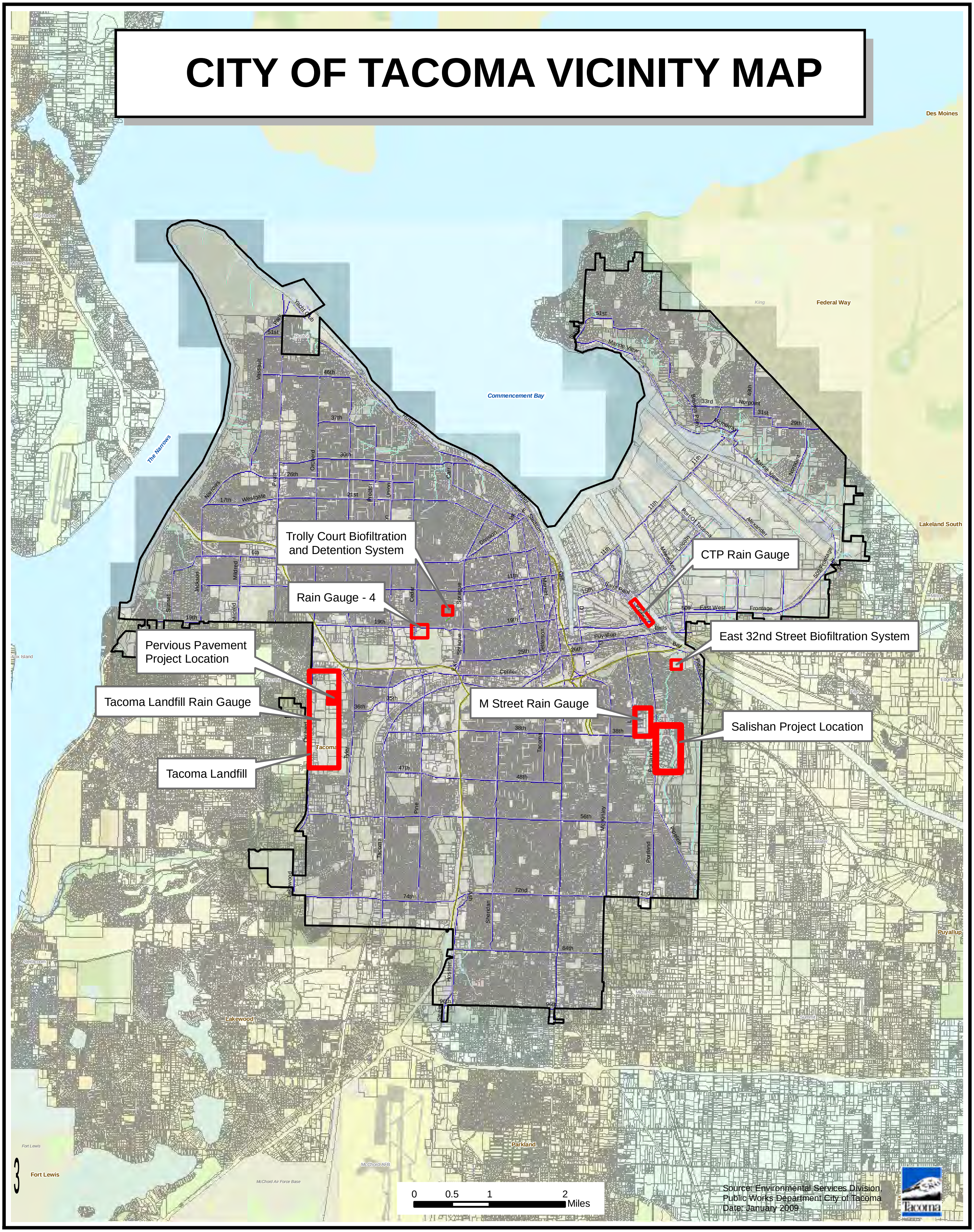


Figure 3-1 City of Tacoma BMP Projects Vicinity Map

Salishan Redevelopment Project

Source: Environmental Services Division,
Public Works Department City of Tacoma
Date: July 2008

Streams and Creeks
City Limits

0 0.125 0.25 0.5 Miles

Figure 3-2
Salishan Project Vicinity

Bioinfiltration Facilities:
East 44th & R St.
East 46th & R St.

Salishan Redevelopment Project

Source: Environmental Services Division,
Public Works Department City of Tacoma
Date: January 2009

Streams and Creeks

City Limits

0 0.125 0.25 0.5 Miles

Figure 3-3
East 32nd Street Project Vicinity

Biofiltration Facilities

Salishan Redevelopment Project

Source: Environmental Services Division,
Public Works Department City of Tacoma
Date: January 2009

Streams and Creeks

City Limits

0 0.125 0.25 0.5 Miles

Figure 3-4
Trolley Court Bioswale Project Vicinity

Biofiltration Facilities:
17th & State St.

Tacoma

Approximate Scale 1" = 125'

Figure 3-5 Location of Pervious Pavement Site, Tacoma Landfill

4 PROJECT DESCRIPTION

This section presents the goals and objectives of the study; describes the boundaries, target populations and practical constraints of the study; and specifies the information and data required to meet the study objectives.

4.1 Study Goals

The study goal is to comply with Section S8F of the permit. Ecology's goal is to provide a performance feedback loop so they can confirm which BMPs perform best for certain pollutants. The Fact Sheet (2006) states:

"*though most of these treatment types have been recommended and in common use for many years, we have only incomplete information about their pollutant removal capabilities. We have some confidence that they are based on sound engineering concepts, but we do not know how well they perform in relation to one another. Without a feedback loop of performance, we cannot confirm which BMP's perform best for certain pollutants.*"

4.2 Study Objectives

Flow and water quality monitoring will be performed within each BMP in order to meet the following objectives:

- Quantify the treatment performance of each BMP for reducing both pollutant concentrations and loads.
- Determine the effectiveness of each BMP at treating the applicable water quality design flow.
- Determine if the treatment performance of each BMP varies in relation to storm event characteristics and/or other operational considerations.

In addition to the flow and water quality monitoring described above, sediment monitoring will be performed within each BMP in order to meet the following objectives:

- Quantify sediment accumulation rates within each component of the BMP for determining maintenance requirements.
- Evaluate the grain size distribution of accumulated sediment within each component of the BMP for use in assessing overall system performance.
- Evaluate pollutant concentrations in accumulated sediment within each component of the BMP.

4.3 Information Requirements

The sampling design for stormwater monitoring under S8F contains three primary activities that will be conducted at each monitoring site:

- Stormwater Sampling
- Sediment Sampling
- Flow Monitoring

General information that will be collected during these activities is described below. In addition, paragraph S8F4 requires “Permittees ... must collect information pertinent to fulfilling the ‘National Stormwater BMP Data Base Requirements’ in section 3.4.3. of that document.” This information includes National Stormwater BMP Database requirements for:

- All BMPs (Table C-1),
- Structural BMPs(Table C-2), and
- Individual structural BMPs (Table C-3).

Influent, effluent and bypass monitoring stations will be established for two Salishan bioinfiltration facilities, two biofiltration facilities, and Landfill’s pervious pavement lot.

Stormwater sampling. Automatic flow-weighted composite sampling methods will be used to collect stormwater samples from qualifying storm events (Section 7.1.3 Representative Sample Criteria). Stormwater samples collected during each storm event will be analyzed for a suite of parameters that are identified in the Phase I Municipal Stormwater Permit for evaluating basic and enhanced treatment performance (Table 3-1).

Hydrologic monitoring will involve measurements of discharge (water level or water level and velocity for estimating discharge using a primary measuring device), as well as precipitation depth. Discharge data will be used to characterize the peak discharge rate, the runoff volume, and the flow duration at each station. Precipitation data will be used to characterize the storm event antecedent dry period, total rainfall distribution during the sampled events, inter-event dry period, and rainfall average and peak intensity during the sampled storm events.

Sediment sampling. Sediment samples collected will be analyzed for a suite of parameters that are identified in the Phase I Municipal Stormwater Permit for evaluating basic and enhanced treatment performance (Table 3-2).

4.4 Study Boundaries

This section describes spatial and temporal boundaries of the problem, the scale of decision-making when appropriate, the characteristics that define the population of interest, and any practical constraints on data collection.

4.4.1 Spatial Boundary

The spatial boundary defines the geographic area within which all decisions will apply and the physical area to be studied and from where the samples will be taken. Ecology may apply any decisions resulting from this study within the Phase I permittees’ jurisdictions.

The five projects are located within Tacoma (Figure 3-1). Tables 4-1 through 4-3 summarize the geographic information for the selected projects. Figures 4-1 through 4-4 and Figure 3-5 show the geographic drainage area for each project.

Table 4-1. Selected BMP effectiveness project – Bioinfiltration Facilities.

	Salishan Bioinfiltration Facilities	
Project	*E. 46th St. & E. R St. Swale (see Figure 4-1)*	*East 44th St. Pond (see Figure 4-2)*
Land use	Residential	Residential
Estimated Project Basin (acres)	2.04	13.9
Treatment Area (acres)	0.611	8.2
Rain gage	CTP - Tacoma No. 1 at 2201 Portland Ave and MST - 3611 E M Street	
Discharge only stations	RSTOUTB	44OUTB
Water quality & discharge stations	RSTIN RSTOUT	44IN 44OUT
Sediment quality stations	RSTSED	44SED

Table 4-2. Selected BMP effectiveness projects – Biofiltration Facilities.

Project	*32nd St. Swale (see Figure 4-3)*	*Trolley Court Swale (see Figure 4-4)*
Land use	3.9 acres Residential 2.6 acres Commercial	Residential
Estimated Project Basin (acres)	6.5	2.27
Treatment Area (acres)	5.23	1
Rain gage	CTP - Tacoma No. 1 at 2201 Portland Ave and MST - 3611 E M Street	RG-4 at S. Cedar St. and Tacoma Landfill
Discharge only stations	32INB1 32INB2 32OUTB	--
Water quality & discharge stations	32IN1 32IN2 32OUT	TCIN TCOUT
Sediment quality stations	32SED1 32SED2	TCSED

Table 4-3. Selected BMP Flow Reduction Strategy – Pervious Pavement.

	Tacoma Landfill Pervious Pavement *(see Figure 3-5)*			
Project	*Pervious concrete*	*Pervious pavers*	*Pervious asphalt*	*Standard Asphalt*
Land use	Commercial - Parking Lot			
Estimated Project Basin	9,028 sq ft	9,028 sq ft	9,028 sq ft	9,028 sq ft
Treatment Area	9,028 sq ft	9,028 sq ft	9,028 sq ft	NA
Rain gage	Tacoma Landfill			
Discharge only stations	Perv. Concrete: Infiltrated stormwater Perv. Concrete CB: Surface water runoff catch basin	Perv. Pavers: Infiltrated stormwater Perv. Pavers CB: Surface water runoff catch basin	Perv. Asphalt: Infiltrated stormwater Perv. Asphalt CB: Surface water runoff catch basin	Std. Asphalt: Surface water runoff

4.4.2 Temporal Boundaries

The temporal boundary defines the timeframe to which the decision applies and when data will be collected. Sample collection and reporting activities may extend beyond the current permit cycle (February 2007 – February 2012) by approximately 15 months, to May 2013.

Each station will be equipped with automated equipment to facilitate continuous monitoring of flows over the 2 year duration of this study (November 2009 – November 2011) and the collection of influent and effluent flow-weighted composite samples during discrete storm events over this period. The collection of flow-weighted composite samples will occur for 8-to-12 storm events in each year of the study to achieve a goal of obtaining up to 35 influent and effluent samples at each BMP by the end of the study period. After 2 complete years of data are collected, the sample numbers, completeness, and statistical power of the data will be reviewed to determine how well sampling objectives were met. If sampling objectives were not met, or statistical power is substantially less than expected, an extension of the monitoring program for a third year may be proposed to Ecology at that time.

4.4.3 Target Population

The characteristics that define the population of interest are: enhanced treatment performance of bioinfiltration facilities from the Salishan project; basic treatment performance of the biofiltration facilities, and flow reduction performance of pervious pavements from the Tacoma Landfill project, within the City of Tacoma.

4.4.4 Practical Constraints

The three primary practical constraints to a successful study are discussed below and include:

1. Sampling design assumptions and requirements;
2. Installation of equipment in time to meet the permit deadline to begin sampling; and
3. Typical logistical challenges associated with the difficult task of monitoring stormwater.

Please refer to S8 Program QAPP, Section 4.1 "*Practical Constraints*" for general information related to stormwater sampling. Site specific constraints are discussed in the following paragraphs.

Sampling design – Both bioinfiltration and biofiltration facilities are located in residential and residential/business areas with an expected TSS concentration in the low end of the acceptable range. At the Landfill Project, the four fully-separated pavement cells (three pervious pavement and one standard pavement) collect runoff from a parking lot surface.

Construction schedule – Salishan's Phase 2 residential housing is currently being constructed. The utilities and streets in Phase 2 were completed in early 2008. The bioinfiltration were constructed and vegetated by July 2008. Most of the housing are rental units and are expected to be fully occupied by November 2009. We anticipate vegetation would be adequately established for monitoring by November 2009.

General maintenance on the biofiltration facilities were completed before August 2009. Unwanted vegetation (trees, shrubs, etc.) in the swales was removed.

The Landfill parking lot was constructed in 2007 and was maintained in October 2008. The parking lot and all sampling locations are currently active.

Fig. 4.1 **East 46th and R-Street Bio-Infiltration Facility Drainage Area**

Created by GPS Crew for City of Tacoma Environmental Services

2005 Ortho-Photo does not reflect current site conditions
Drainage includes street runoff from Salishan Hope VI Redevelopment

Feet 0 50 100 200 300 400

Tacoma

Fig. 4.2

East 44th and T-Street Bio-Infiltration Facility Drainage Area

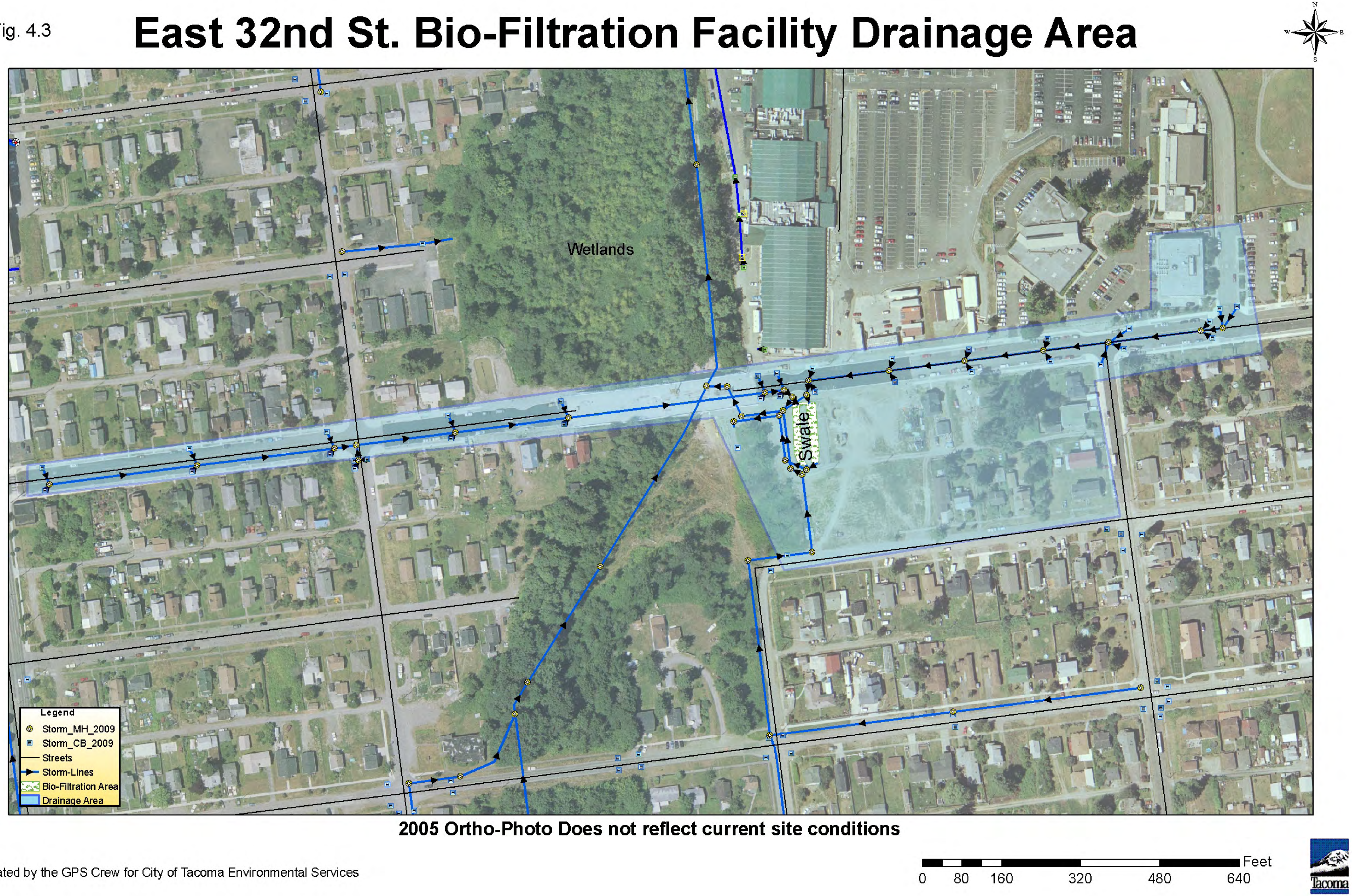
2005 Ortho-Photo Does not reflect current site conditions
Drainage includes street runoff from Salishan Hope IV development

Created by GPS Crew for City of Tacoma Environmental Services

Tacoma

Fig. 4.3

East 32nd St. Bio-Filtration Facility Drainage Area



2005 Ortho-Photo Does not reflect current site conditions

Created by the GPS Crew for City of Tacoma Environmental Services

Fig. 4-4

Trolley Court Bio-Filtration Facility Drainage Area

2005 OrthoPhoto does not reflect current site conditions.
Drainage includes residential lots.

Created by the GPS Crew for City of Tacoma Environmental Services

5 Organization and Schedule

This section describes the roles & responsibilities of the study team, the study timeline and schedule. Please refer to S8 Program QAPP, Section 5.0 "Organization and Schedule" for roles, responsibilities and study timeline/schedule.

The Landfill lot is an active monitoring site. By August 16, 2009, the flow monitoring equipment was set to measure flow continuously. Rainfall at this site is currently monitored continuously.

5.1 Study Deliverables

This section describes the study deliverables. Section 14.2 of this QAPP provides additional details describing the procedure and method for developing the deliverables. Refer to Section 11 of the S8 Program QAPP for documentation and records supporting development of the deliverables and Section 15 of this QAPP for a discussion of the content. Table 5-1 presents the study timeline and schedule as well as study deliverables. It is anticipated that sampling will continue for 2 complete monitoring years. After 2 complete years of data are collected, the sample numbers, completeness, and statistical power of the data will be reviewed to determine how well sampling objectives were met. If sampling objectives were not met, or statistical power is substantially less than expected, an extension of the monitoring program for a third year may be proposed to Ecology at that time.

The study results will be presented in an annual report. Each annual report will include all monitoring data collected during the preceding water year (October 1 – September 30). The first annual monitoring report submitted will include data from a partial water year, November 30, 2009 through September 30, 2010. Each report shall also integrate data from earlier years into the analysis of results, as appropriate. Reports shall be submitted in both paper and electronic form and shall include:

1) A summary including BMP type location, land use, drainage area size, and hydrology for each site.
2) The status of implementing the monitoring program,
3) A comprehensive data and QA/QC report including an explanation and discussion of the results of each monitoring study, and
4) Performance data.

Table 5-1. Study deliverable schedule.

Performance Monitoring Period	Anticipated No. of Events	Anticipated Date of Initiation	Anticipated Date of Annual Completion	Deliverable and Due Date
Water Year 2009	0		09/30/2009	Stormwater Monitoring Status [2] March 31, 2010
Water Year 2010	7-9	10/01/2009	09/30/2010	Stormwater Monitoring Report[2] March 31, 2011
Water Year 2011	8-12	10/01/2010	09/30/2011	Stormwater Monitoring Report[2] March 31, 2012
Water Year 2012	2-5	10/01/2011	09/30/2012	Study Monitoring Report[2] March 31, 2013

1 After 2 complete years of data are collected, the sample numbers, completeness, and statistical power of the data will be reviewed to determine how well sampling objectives were met. If sampling objectives were not met, or statistical power is substantially less than expected, an extension of the monitoring program for a third year may be proposed to Ecology at that time.

2 Submitted with NPDES Annual Report

6 QUALITY OBJECTIVES

This section describes the data quality objectives (DQOs) and measurement quality objectives (MQOs) for the stormwater monitoring program, i.e., the type and quality of data needed to meet the program goals and objectives. DQOs are qualitative and quantitative statements that define the objectives of the project, identify the most appropriate types of data and data collection procedures, and specify acceptable error limits for decision making.

Once established, the DQOs become the basis for the MQOs that are used to assess analytical performance. MQOs are quantitative measures of performance using data quality indicators such as precision, bias, representativeness, completeness, comparability, and sensitivity. Data that meets the QAPP-specified MQOs is considered acceptable for use in project decision making.

6.1 Data Quality Objectives

The DQOs for this project were developed in general accordance with USEPA Guidance for Data Quality Objectives Process, EPA QA/G-4 (USEPA, 2000). The DQO Process for Tacoma's stormwater monitoring program is presented below.

6.1.1 Step 1: State the Problem

The overall objective of the BMP effectiveness monitoring program is to quantify the reductions in flow, contaminant concentrations and loads that result from full-scale field demonstrations of stormwater BMPs. Tacoma is proposing to monitor the following two types of stormwater BMPs:

- Pervious pavement (for hydrologic control)
- Bioinfiltration and biofiltration facilities (for pollutant control)

The objectives of the BMP effectiveness monitoring program are described in more detail in Section 4.2.

6.1.2 Step 2: Identify the Decisions

In accordance with MS4 Permit requirements, Tacoma's BMP effectiveness monitoring program is designed to answer the following questions:

- To what extent does pervious pavement help to improve the quantity (i.e., reduced flow and volume) in stormwater runoff?
- To what extent do bioinfiltration and biofiltration facilities help to improve the quality (i.e., reduced contaminant concentrations) in stormwater runoff?

These questions are developed into the following testable statistical hypotheses:

- *Null Hypothesis S8E-1.* Pervious pavement causes no significant reductions in stormwater flow (peak or average flow) or volume compared to impervious pavement.
- *Alternative Hypothesis S8E-1.* Pervious pavement results in significant reductions in stormwater flow and volume.

- *Null Hypothesis S8E-2.* The contaminant concentrations in stormwater from biofiltration facilities (“effluent”) are not significantly different than concentrations in untreated overland stormwater runoff (“influent”).
- *Alternative Hypothesis S8E-2.* Treatment of stormwater through biofiltration facilities helps to attenuate contaminant concentrations.
- *Null Hypothesis S8E-3.* The contaminant concentrations in infiltrated stormwater beneath bioinfiltration facilities (“effluent”) are not significantly different than concentrations in untreated overland stormwater runoff (“influent”).
- *Alternative Hypothesis S8E-3.* Infiltration of stormwater beneath bioinfiltration facilities helps to attenuate contaminant concentrations.

Sufficient data will be collected in the BMP effectiveness monitoring program to be able to test these hypotheses with an appropriate level of statistical confidence and power.

6.1.3 Step 3: Identify Inputs to the Decision

Tacoma has been monitoring stormwater quality under a Consent Decree with EPA in seven of the largest municipal drainages in the Thea Foss watershed since August 2001. Existing data on stormwater and storm sediment quality is compiled and summarized in Tacoma’s annual stormwater monitoring reports (see Tacoma 2008).

The MS4 Permit requires analysis of the following parameters in the influent and effluent streams for each BMP:

- TSS
- Particle size distribution
- pH
- Total and ortho-phosphorus
- Total and dissolved copper and zinc

Of these parameters, TSS, zinc, and pH have been part of Tacoma’s existing stormwater monitoring program. Summary statistics for TSS, zinc, and other representative analytes in various municipal outfalls are presented in Table 6-1. This table includes the arithmetic mean concentrations and coefficients of variation (CV) over the six-year monitoring period. The CV is a measure of sampling and analytical variability and will be used to evaluate the relationship between sample size and statistical power (see Section 6.1.7 below). The CVs for TSS and zinc range from 0.45 to 0.77. pH will be used as an index field parameter rather than a quantitative performance metric. It is assumed that the quality and statistical variability of the influent stormwater to the BMPs will be similar to these existing stormwater monitoring data, which are derived from a variety of mixed land uses (residential, commercial, and industrial). It is further assumed that the new Permit-required analytical parameters for the BMP effectiveness monitoring program, as listed above, will be characterized by CVs similar to those shown in Table 6-1, but this assumption will need to be confirmed with a few initial rounds of monitoring data.

Table 6-1. Coefficients of Variation in Tacoma Stormwater

Analyte	Outfall 237A		Outfall 237B		Outfall 230		Outfall 235		Outfall 245	
	Arithmetic Mean	Coefficient of Variation (%)	Arithmetic Mean	Coefficient of Variation (%)	Arithmetic Mean	Coefficient of Variation (%)	Arithmetic Mean	Coefficient of Variation (%)	Arithmetic Mean	Coefficient of Variation (%)
Conventionals in mg/L										
TSS	50	0.45	76	0.72	61	0.70	101	0.77	84	0.60
Metals in mg/L										
Lead (Total)	14	0.47	18	0.73	29	0.68	95	0.60	15	0.59
Zinc (Total)	118	0.47	91	0.58	137	0.71	164	0.58	183	0.62
Lead (Diss.)	0.9	0.63	0.8	0.56	1.6	0.87	7.9	0.76	1.0	0.87
Zinc (Diss.)	72	0.59	34	0.66	70	0.65	54	0.68	79	0.75
Organics in µg/L										
DEHP	3.8	0.60	4.2	0.64	5.8	0.71	9.7	1.37 [1]	5.2	1.12 [2]
Phenanthrene	0.16	0.85	0.11	1.08	0.18	0.82	0.18	0.75	0.13	1.74 [3]
Pyrene	0.40	0.76	0.26	0.92	0.37	0.74	0.35	0.68	0.17	1.09

Notes:

Data from City of Tacoma 2008; Annual Stormwater Monitoring Report, 2001-2007, Appendix F

[1] High CV for DEHP in Outfall 235 caused by one extreme outlier in Monitoring Year 2

[2] High CV for DEHP in Outfall 245 caused by two extreme outliers in Monitoring Year 2

[3] High CV for Phenanthrene in Outfall 245 caused by extreme outliers in Monitoring Years 3 and 4

6.1.4 Step 4: Define the Boundaries of the Study

Geographic Boundaries. The geographic boundaries of the BMP monitoring sites include relatively small controlled drainage areas. The pervious pavement study area includes four 0.21-acre plots in an employee parking lot at the Tacoma Landfill. The plots are situated on engineered cover material at a closed cell of the landfill, consisting of clean fill with underdrains on an impervious hydrologic and geochemical barrier. Stormwater runoff flowrates will be measured in sampling ports in the underdrains and in catch basins collecting any resulting surface water runoff. The four experimental plots include standard impervious asphalt, pervious asphalt, pervious concrete, and pervious interlocking blocks.

The bioinfiltration facilities' study areas are 2 acres for the 46th and R Street Swale and 14 acres for the 44th Street Pond. Surface water runoff is collected from surrounding streets of the multi-family Salishan Development and directed into the bioinfiltration facilities. Stormwater "effluent" will be collected from sampling ports in the underdrains of these facilities. The biofiltration facilities' study areas are 6.5 acres for the East 32nd Street Swale and 2.3 acres for the Trolley Court Swale. Surface water runoff is collected from surrounding streets of the residential and commercial areas (residential only for Trolley Court) and directed into the biofiltration facilities. Stormwater "effluent" will be collected from sampling ports in the surface flow discharging from these facilities.

Two water years will be monitored at the BMP sites. The monitoring period will extend from November 30, 2009 through November 30, 2011 (see Table 5-1). After 2 complete years of data are collected, the sample numbers, completeness, and statistical power of the data will be reviewed to determine how well sampling objectives were met. If sampling objectives were not met, or statistical power is substantially less than expected, an extension of the monitoring program for a third year may be proposed to Ecology at that time.

6.1.5 Step 5: Develop Decision Rules

The stormwater monitoring data will be evaluated in accordance with the following decision rules:

1. If it can be shown with statistical significance that Null Hypothesis S8E-1 is false, then a difference in stormwater flow (average and/or peak flow) or volume will have been demonstrated in the pervious pavement areas relative to standard asphalt. By understanding the characteristics of the response hydrograph on these relatively small engineered plots, the results may be scaled up to larger drainage areas.

2. If it can be shown with statistical significance that Null Hypothesis S8E-2 is false, then the biofiltration facilities are able to filter and attenuate contaminant concentrations during stormwater flow through the grass-lined swale channel.

3. If it can be shown with statistical significance that Null Hypothesis S8E-3 is false, then the bioinfiltration facilities are able to filter and attenuate contaminant concentrations during stormwater infiltration and percolation through subsurface soils.

6.1.6 Step 6: Specify Limits on Decision Errors

The BMP effectiveness monitoring program is designed to meet the following levels of statistical sensitivity, confidence, and power:

Minimum Detectable Relative Difference (MDRD). A MDRD between mean influent and effluent concentrations is specified at 50 percent. The monitoring program should be able to detect with statistical significance a 50 percent reduction in stormwater concentrations representing treatment by the BMP. A MDRD of 50 percent is consistent with the minimum level of pollutant reduction that is considered acceptable in Ecology's TAPE guidance (Ecology 2008).

Statistical Confidence and Power. The MS4 Permit specifies goals of 90 to 95 percent statistical confidence and 75 to 80 percent statistical power for BMP effectiveness monitoring (S8F4). The associated alpha levels (0.05 to 0.10) and beta levels (0.20 to 0.25) are the complements of statistical confidence and power, respectively.

6.1.7 Step 7: Optimize the Design

This section provides an estimate of the number of pairs of influent-effluent samples that should be collected to achieve the data quality objectives specified for the BMP effectiveness monitoring program. The number of samples required may be estimated based on the desired MDRD, the acceptable levels of statistical confidence and power (see Section 6.1.6), and an estimate of the variability of the data as measured by the coefficient of variation, or CV (see Section 6.1.3 and Table 6-1).

The sample size analysis follows EPA (1998, section 9.3.3):

$$N = (Z_{\alpha} + Z_{2\beta})^2 (CV/MDRD)^2$$

where [N] = number of samples, [Z_{α} and $Z_{2\beta}$] are Z statistics at the specified alpha and beta levels, [CV] is the coefficient of variation of stormwater data, and [MDRD] is defined in Section 6.1.6.

The estimated sample size to detect a 50 percent reduction between influent and effluent stormwater concentrations as a function of CV is provided in Table 6-2. A range of acceptable confidence levels (alpha = 0.05 to 0.10) and power levels (beta = 0.20 to 0.25) is presented. Depending on the particular analyte and its CV, no more than 20 pairs of samples would be needed to reach 90 percent confidence and 80 percent power, even for the more erratic constituents. At a sampling rate of 10 samples per year, these control limits would be achieved within one to two monitoring years.

It should be noted that the sample sizes estimated in Table 6-2 are based on an assumption of normal distributions, whereas much Tacoma's stormwater data are better described by lognormal distributions (Tacoma 2008). The statistical power may be reduced if the data are log-transformed. The statistical power will be verified at the end of the two-year monitoring period, and if the data provide less power and confidence than was expected, the City will consult with Ecology to determine whether to extend the monitoring program for a third year.

6.2 Measurement Quality Objectives

Please Refer to Section 6.2 of the S8 Program QAPP.

6.2.1 Representativeness

The representativeness of the data is dependent on 1) the sampling locations, 2) the flow regime during sample collection 3) the number of years sampling is performed, and 4) the sampling procedures. Site selection and sampling of pertinent media (i.e., water) and use of only approved analytical methods will assure that the measurement data represents the population being studied at the site.

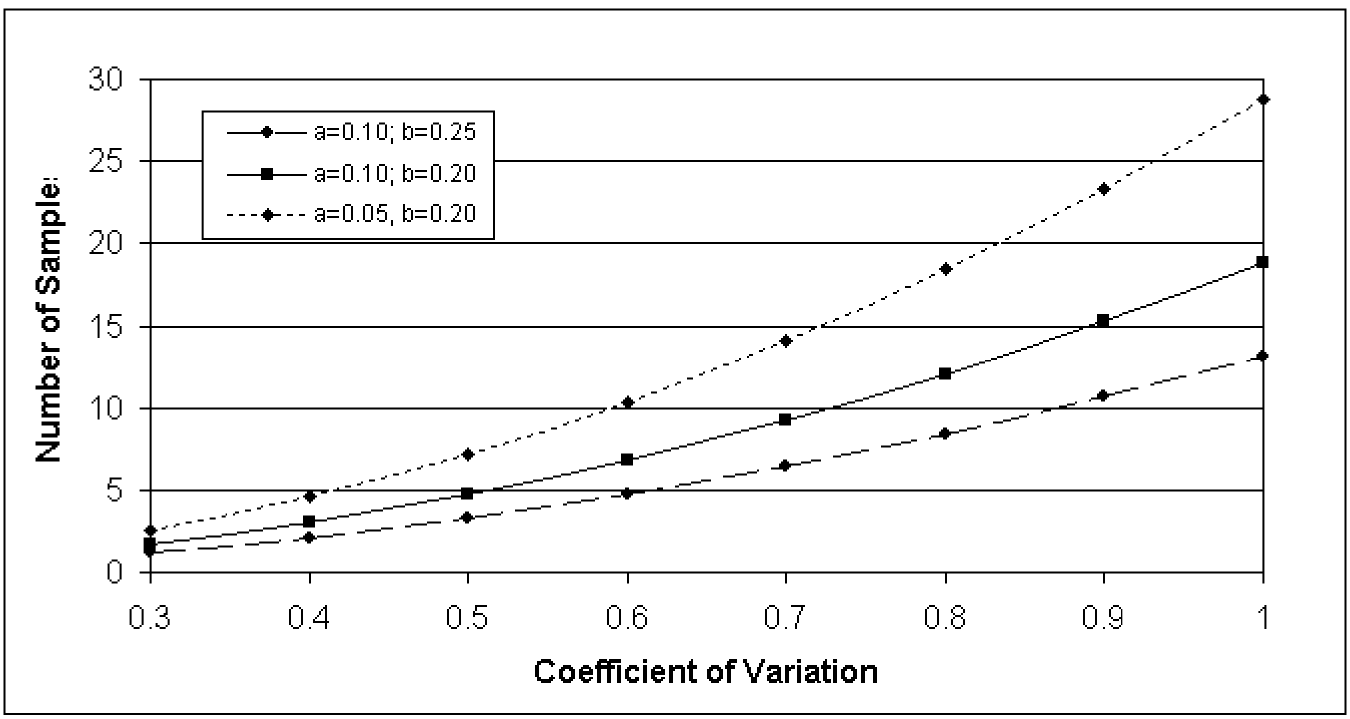
The representativeness of the water quality data to be collected through this study will be ensured by targeting representative storms for sampling based on the criteria (Table 7-1 and Table 7-2*)*: that were derived from the Phase I Municipal Stormwater Permit (Ecology 2007) and recommended procedures from Ecology (2008) in *Guidance for Evaluating Emerging Storm water Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE).*

The representativeness of the sediment and soil quality data to be collected through this study will be ensured by employing consistent and standard sampling procedures. In addition, the representativeness of these data will be ensured by selecting sampling locations that take into account the physical processes that 1) influence location and rate of sediment accumulation within stormwater treatment BMPs (bioinfiltration and biofiltration facilities).

Table 6-2. Estimated Sample Size for BMP Effectiveness Monitoring.

Minimum Detectable Difference: 50%

Confidence (alpha)	Power (beta)	Stormwater Coefficient of Variation							
		0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.10	0.25	1	2	3	5	6	8	11	13
0.10	0.20	2	3	5	7	9	12	15	19
0.05	0.20	3	5	7	10	14	18	23	29



LEGEND:

[Yellow] Sample sizes achieved after 1 monitoring year (10 samples/year)

[Green] Sample sizes achieved after 2 monitoring years (10 samples/year)

The representativeness of the hydrologic data will be ensured by the proper selection and installation of all associated monitoring equipment. Rainfall patterns, stormwater conveyance features, and surrounding land uses were also considered in the identification of monitoring locations and sampling frequencies to ensure that representative data will be obtained for this study. Finally, monitoring will be conducted over a sufficient length of time (2 years) to ensure that data are collected during representative climatic conditions for the region.

7 Sampling Process Design (Experimental Design)

The sampling process design to be used for monitoring is described herein. The sampling process design was developed based on monitoring requirements identified in the Phase I Municipal Stormwater Permit (Ecology 2007) and recommended procedures from Ecology (2008) in *Guidance for Evaluating Emerging Storm water Treatment Technologies: Technology Assessment Protocol Ecology (TAPE).*

The sampling process design to be used for monitoring the pervious pavements lot for the Tacoma Landfill project, is herein. That is, continuous flow monitoring for a period of one year in order to evaluate pervious pavement systems as a flow control strategy.

As described previously, the specific objectives of this monitoring study are as follows:

- Quantify the treatment performance of each bioinfiltration and biofiltration BMP for reducing both pollutant concentrations and loads.
- Determine the bioinfiltration and biofiltration effectiveness of each BMP at treating the applicable water quality design flow.
- Determine if the treatment performance of each bioinfiltration and biofiltration BMP varies in relation to storm event characteristics and/or other operational considerations.
- Quantify the flow reduction performance of each pervious pavement section in comparison to standard asphalt.

In addition to the flow and water quality monitoring described above, sediment monitoring will be performed within each bioinfiltration and biofiltration BMP in order to meet the following objectives:

- Quantify sediment accumulation rates within each component of the BMP for determining maintenance requirements.
- Evaluate the grain size distribution of accumulated sediment within each component of the BMP for use in assessing overall system performance.
- Evaluate pollutant concentrations in accumulated sediment within each component of the BMP.

A short discussion of the monitoring strategy is followed by the detailed sampling design for each project along with the flow and water quality monitoring equipment selection.

7.1 Monitoring Strategy Overview

A discussion of the stormwater monitoring strategy developed to meet the requirements of Section S8F and the recommended procedures from Ecology (2008) in *Guidance for Evaluating Emerging Storm water Treatment Technologies: Technology Assessment Protocol Ecology (TAPE)* is presented below and includes:

- Selection of parameters and analytical methods,
- Selection of sampling techniques and types; and
- Selection of sampling frequency and criteria to ensure representative samples.

7.1.1 Parameters and Analytical Methods

Monitoring parameters were selected by Ecology as those expected to meet basic and enhanced treatment goals and their known presence in stormwater, their potential for adverse impacts, or their value in providing necessary supporting information (see Section 3.3 for additional information). Tables 6-5 and 6-6, in the S8 Program QAPP, present the analytical methods and minimum reporting limits.

7.1.2 Sampling Techniques and Types

Sampling techniques and types to be used include automatic flow-weighted composite sampling of stormwater and manual grab collection of sediment samples. Samples collected in water will be collected using automatic flow-weighted composite sampling. Sediment and soil samples will be collected using manual grab procedures.

7.1.3. Representative Sample Criteria

The TAPE protocol (Ecology 2008) defines "representative" storms that must be monitored when ascertaining performance of treatment BMPs. Storm event criteria are established to: (1) ensure that adequate flow will be discharged; (2) allow some build-up of pollutants during the dry weather intervals; and (3) ensure that the storm will be "representative," (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria ensures that the resulting data will accurately portray the most common conditions for each site. Ensuring a representative sample requires two considerations: (1) the storm event must be representative, and (2) the sample collected must represent the storm event. Table 7-1 lists the qualifying storm event criteria to ensure the storm event sampled is representative. It is anticipated that sampling will continue for 2 complete monitoring years. After 2 complete years of data are collected, the sample numbers, completeness, and statistical power of the data will be reviewed to determine how well sampling objectives were met (see Section 6.1.7 for additional details). If sampling objectives were not met, or statistical power is substantially less than expected, an extension of the monitoring program for a third year may be proposed to Ecology at that time. The maximum number of samples needed to be representative is estimated to be 35.

Table 7-1. Representative storm event criteria.

Criteria	Requirements
Target storm depth	A minimum of 0.15 inches of precipitation over a 24-hour period
Rainfall duration	Target storms must have a duration of at least one hour
Antecedent dry period	A period of at least 6 hours preceding the event with less than 0.04 inches of precipitation.
End of storm	A continuous 6-hour period with less than 0.04 inches of precipitation.

Table 7-2 describes the criteria to ensure the composite sample collected is representative of the storm event sampled.

Table 7-2. Representative sampler collection criteria.

Storm Storm event event duration	<24 hours	>24 hours
Minimum storm volume to sample	75 percent of the storm event hydrograph	75 percent of the hydrograph of the first 24 hours of the storm
No. of Aliquots	At least 10 flow-weighted sub-samples (or aliquots) must be collected during the duration of the event. If fewer than 10, but seven or more aliquots are collected, than the sample will be considered valid only if all other sampling criteria have been met.	
Maximum time period for sample collection (hours)	36	36

7.2 Site-specific Sampling Design

The following subsections provide a more detailed description of the sampling process design that will be used for the Salishan bioinfiltration facilities, East 46th & R Street Swale and East 44th Street Pond, and the biofiltration swales, East 32nd St and Trolley Court. The actual sampling procedures to be implemented in connection with this sampling process design are described in Section 8. A detailed description of the flow monitoring process design that will be used for the pervious pavements at the Landfill is also provided.

7.2.1 Salishan Bioinfiltration Facilities

The East 46th & R Street Swale is approximately 80 feet long and runs west to east at the intersection of East 46th Street & R Street (see Figures 4-1 and 7-1a). The second bioinfiltration facility, the East 44th Pond, is approximately 155.5 feet long and runs south of East 44th Street parallel to T-Street Gulch (see Figures 4-2 and 7-2a). The bioinfiltration facilities have four primary components: a vegetated planting strip, an engineered soil layer, a gravel drain layer, and a perforated under-drain pipe (see Appendix A for details).

During operation, stormwater runoff from the surrounding drainage basin enters the planting strip via the inlet pipe where it is retained for a sufficient period of time to allow infiltration to the underlying engineered soil layer (see Figures 7-1a, 7-1b, 7-2a and 7-2b). Absorption, filtration, retention and evapotranspiration processes within the engineered soil layer then provide water quality treatment and serve to attenuate stormwater runoff rates and volumes. Under saturated conditions, stormwater infiltrates from the engineered soil layer down to the gravel drain layer. The gravel drain layer provides additional storage for attenuating stormwater runoff flow rates and volumes. Overflow from the gravel drain layer is first collected in the perforated under-drain pipe which subsequently discharges to the first bypass structure (see Figures 7-1c and 7-2c). A solid-walled pipe within the outlet structures then conveys the overflow water to the primary stormwater conveyance system for the Salishan neighborhood.

During larger storm events when the infiltration capacity is exceeded, the water depth in the swale/pond will rise until stormwater begins to overflow (or bypass) the swale/pond via two beehive structures (see Figures 7-1c and 7-2c). The elevations of the two overflow (or bypass) beehive structures' are staggered, one lower and one higher. This overflow (or bypass) also connects to the primary stormwater conveyance systems for the Salishan neighborhood.

During larger storm events when the water quality treatment design flowrate is exceeded for the East 44th Street Pond, the upstream flow bypasses the East 44th Street Pond via the flow splitter (see Structure A in Figure 7-2b). The bypassed flow continues to discharge downstream in the primary stormwater conveyance system for the Salishan neighborhood (see Figure 7-2a).

Two monitoring stations will be established in connection with each bioinfiltration facility to measure the quantity and quality of influent (IN) and effluent (OUT) stormwater. Figures 7-1a and 7-2a shows the inlet and outlets of each bioinfiltration facility, East 46th & R Street Swale and East 44th Pond. As noted on Figures 7-1b, 7-1c, 7-2b and 7-2c, the equipment will be secured and/or housed in an enclosure or manhole.

The influent stations are located in the inlet pipe to each of the bioinfiltration facilities (see Figures 7-1b and 7-2b). Similarly, the effluent station is located in the outlet pipe from each of the bioinfiltration facilities (see Figures 7-1c and 7-2c). The treatment performance of the bioinfiltration facilities will be evaluated based on comparisons of loads and concentrations measured at the IN and OUT stations, respectively, for each bioinfiltration facility. To facilitate interpretation of trends in the data from each of these stations, a rain gauge will continuously monitor precipitation near the study site.

The specific monitoring stations established in association with the bioinfiltration facilities will be use to measure:

- Influent quality as measured in the inlet outfall pipe
- Influent flow at the point of discharge to the swale/pond
- Bypassed flow
- Effluent quality as measured in the under-drain pipe
- Effluent flow at the point of discharge for the under-drain pipe

Influent flow to the swale/pond will be continuously monitored at the inlet stations. These stations are designated RSTIN in Figure 7-1a and 44IN in Figure 7-2a and described in Section 7.3.1). When the water quality treatment design flowrate is exceeded for the East 44th Street Pond, the upstream flow bypasses the East 44th Street Pond via the flow splitter. When the infiltration capacity of the swale/pond is exceeded, the water depth in the swale/pond will rise until stormwater begins to overflow (or bypass) the swale/pond via beehive structures. As described above, the bypassed stormwater is then discharged into a nearby storm drain (see Figures 7-1a and 7-2a). Therefore, stations 44INB, 44OUTB and RSTOUTB will also be used to continuously monitor the flow of bypassed stormwater (see detail in Figures 7-1c and 7-2c) and described in Section 7.3.1).

Flow monitoring stations (designated 44OUT and RSTOUT in Figures 7-1c and 7-2c) will also be established at the point of discharge for the under-drain pipes associated with the swale/pond. Both of these under-drain pipes discharge to the first overflow structure for each BMP. These stations will be used to continuously monitor flow rates of effluent stormwater that overflows from the gravel drain layer via these pipes. A schematic diagram showing equipment configuration for these stations is provide in Figures 7-1c and 7-2c and discussed in more detail below under Section 7.3.1.

The flow monitoring equipment at 44IN, 44OUT, RSTIN and RSTOUT will also be used to pace an automated sampler to facilitate the collection of flow-weighted composite samples for characterizing influent and effluent quality to and from the swale/pond. A new rain gauge is installed at a Tacoma Water secured site, 3611 E M Street (designated MST) and will be used to continuously monitor precipitation for the project site. This rain gauge is approximately 0.8 miles from the Salishan swale/pond. As a backup location, an existing rain gauge (designated CTP in Figure 1) will also be used to continuously monitor precipitation for the project site. This rain gauge is approximately 2 miles from the Salishan swale/pond.

Hydraulic Residence Time and Treatment Efficiency. The bioinfiltration facilities may be classified as having an intermediate residence time. In smaller storms, it is expected that the water exiting the BMP in the underdrains will be residual pore waters generated during a previous storm or storms. For example, during a minimum rain event (0.2 inches), the total runoff volume is only about one-quarter to one-third of the detention volume in the void spaces of the soils beneath the facilities, as shown in the table below. During a moderate rain event, the total runoff volume is about the same magnitude as the void spaces. During the six-month storm (~1.4 inches), the total runoff volume is about 8 times the detention volume in the void spaces. Therefore, the bioinfiltration facilities are effectively short-term devices only during large storms (i.e., 6 month return period or greater) which have the ability to flush through several soil pore volumes.

Rain Depth (in)	Runoff Vol. (ft3)	Void Vol (ft3)	Runoff/Void Ratio
East 46th and R Street Facility			
0.2	240	870	0.28
0.5	1,210	870	1.4
1.4 (6 mo.)	6,640	870	7.6
East 44th Street Facility			
0.2	2,180	6,270	0.35
0.5	10,870	6,270	1.7
1.4 (6 mo.)	50,310	6,270	8.0

For small storms, the effluent sample is not expected to be derived from the same storm as the influent sample. As a result, the treatment efficiency for this device will not be analyzed using event-based data pairs, but instead the data will be pooled over many storms for general characterization purposes. Tacoma does not propose to monitor these facilities using a random sampling approach, as described in Ecology's draft TAPE for *Evaluating Stormwater Treatment Technologies with Long Detention Times*, because (1) storm-generated standing water in the swales sets up a hydraulic gradient in the subsurface soils that drives pore waters into the underdrain system, i.e., the hydraulic driving force for effluent flow occurs during storms, although the effluent hydrograph may be lagged and prolonged, and (2) the effluent flow is expected to be ephemeral, with prolonged dry periods between storms, and therefore not practical for random sampling due to the low probability of a successful sampling event. Therefore, Tacoma will monitor these facilities using a sampling approach that targets storm events.

The infiltration rate assumed for the bioinfiltration facilities is approximately 2.4 inches/hour, based on the characteristics of the amended soils. Considering the underdrains are installed to a depth of 3.5 to 4 feet below grade, and assuming a soil porosity of 0.25 to 0.33, the travel time of stormwater through the soil profile to the underdrains is estimated at 4 to 7 hours. Thus, there is likely to be a delay of several hours between the peaks of the influent and effluent hydrographs. Continuous flow data from a few test storms will be used to estimate the delay and pacing of the effluent samples, relative to the influent, and the shape and duration of the effluent tail-out.

Treatment efficiency for the bioinfiltration facilities will be evaluated by pooling influent and effluent concentrations across many storms, respectively. As described above, influent concentrations for both bioinfiltration facilities will be derived from flow-weighted composite samples that are obtained during discrete storm events. Effluent concentrations will be derived from flow-weighted samples that are obtained from the under-drain pipe of each bioinfiltration facility (i.e., 44OUT and RSTOUT). However, influent and effluent data will not be paired on an event-specific basis.

Treatment efficiency will also be assessed for Salishan swale and pond based on comparisons of annual pollutant loads measured in influent, effluent, and bypassed water for each swale. The specific procedures used to calculate these pollutant load estimates are as follows:

- **Influent Loads**: Annual influent flow volumes to the Salishan swale and pond will be obtained from continuously monitored stations 44IN and RSTIN and rainfall data obtained from stations MST and CTP for the year of interest. These volumes will then be multiplied by a flow-weighted average concentration derived from the influent water quality samples that were obtained from the 44IN and RSTIN stations.
- **Effluent Loads**: Annual effluent flow volumes for the Salishan swale and pond will be determined from data collected from continuously monitored stations 44OUT and RSTOUT, respectively, in the under-drains of each bioinfiltration facility. These volumes will then be multiplied by average effluent concentrations that were derived from flow-weighted samples collected in the under drain monitoring stations for each of the respective bioinfiltration facilities.
- **Bypass Loads**: Annual bypass flow volumes to the Salishan swale and pond will be determined from data collected from continuously monitored stations 44INB, 44OUTB and RSTOUTB, respectively, in each bioinfiltration facility. These volumes will then be multiplied by a flow-weighted average concentration derived from the influent water quality samples that were obtained from stations 44IN and RSTIN.

Additional details of treatment efficiency calculations are provided in Sections 14.2.7 and 14.2.8.

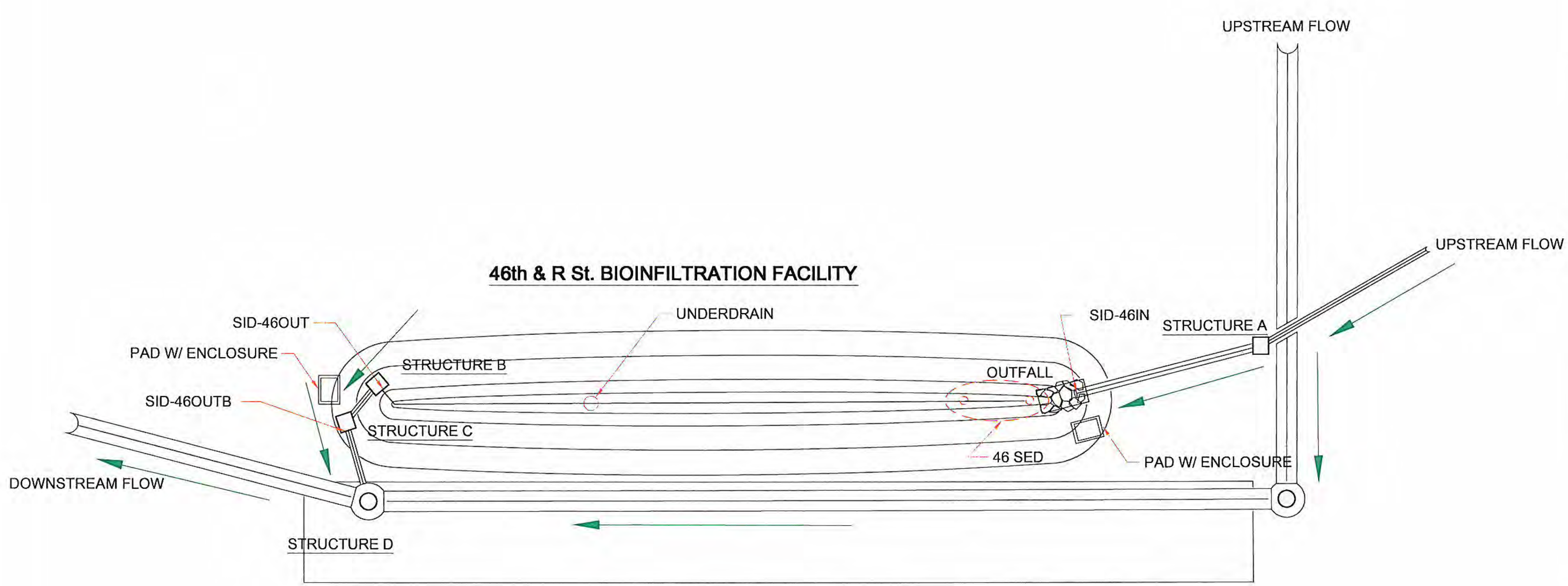
The flow control performance of the Salishan swale and pond will be assessed based on analysis of the timing and frequency bypass events to determine if the swale and pond are effective at treating storm events up to the WWHM3 water quality BMP design flowrate. Additional statistical analyses will also be performed to quantify the performance of each swale with regard to reducing runoff volumes, peak discharge rates, and flow durations.

In addition to stormwater quantity and quality monitoring, sediment sampling will be conducted in the Salishan swale and pond on an annual basis. Figures 7-1a and 7-2a show the locations of sediment monitoring stations to be established in connection with the Salishan swale and pond.

A total of two monitoring stations (designated 44SED and RSTSED in Figures 7-1a and 7-2a) will be established, one in each bioinfiltration facility. Each station will consist of two sampling locations situated at the inlet pipe that allow stormwater to enter the facility and at the bottom of the swale/pond near the inlet pipe. The two samples from each BMP will be composited in the field resulting in one sample from each sediment monitoring station.

Soils in the Salishan swale and pond will be characterized to confirm the soil mixture installed at each site. Parameters to report include soil gradation, cation exchange capacity, organic content and depth.

Finally, controlled infiltration tests will be conducted on three occasions to measure surface infiltration rates in the Salishan swale and the pond. The first set of tests will be performed in November 2009 and follow-up tests will be performed in Fall 2010 and Fall 2011. In general, water will be introduced to maintain a constant water level in the swale (full-scale) or infiltrometer. After the flow rate has remained stable for 60 minutes, the water is turned off and the rate of infiltration (in inches per hour) is recorded until empty.



General Notes

1. FOR STRUCTURE A DETAIL REFER TO FIGURE 7-S.
2. FOR STRUCTURES B & C DETAILS REFER TO FIGURE 7-T.
3. FOR STRUCTURE D DETAIL REFER TO FIGURE 7-U.
4. FOR ALL INLET SAMPLING & MONITORING LOCATIONS DETAILS REFER TO FIGURE 7-S AND 7-U.
5. FOR ALL OUTLET SAMPLING & MONITORING LOCATIONS DETAILS REFER TO FIGURE 7-T.
6. FOR PAD AND ENCLOSURE DETAILS REFER TO FIGURE 7-S AND 7-T.
7. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
8. SID - SAMPLE IDENTIFICATION NUMBER.

No.	Revision/Issue	Date

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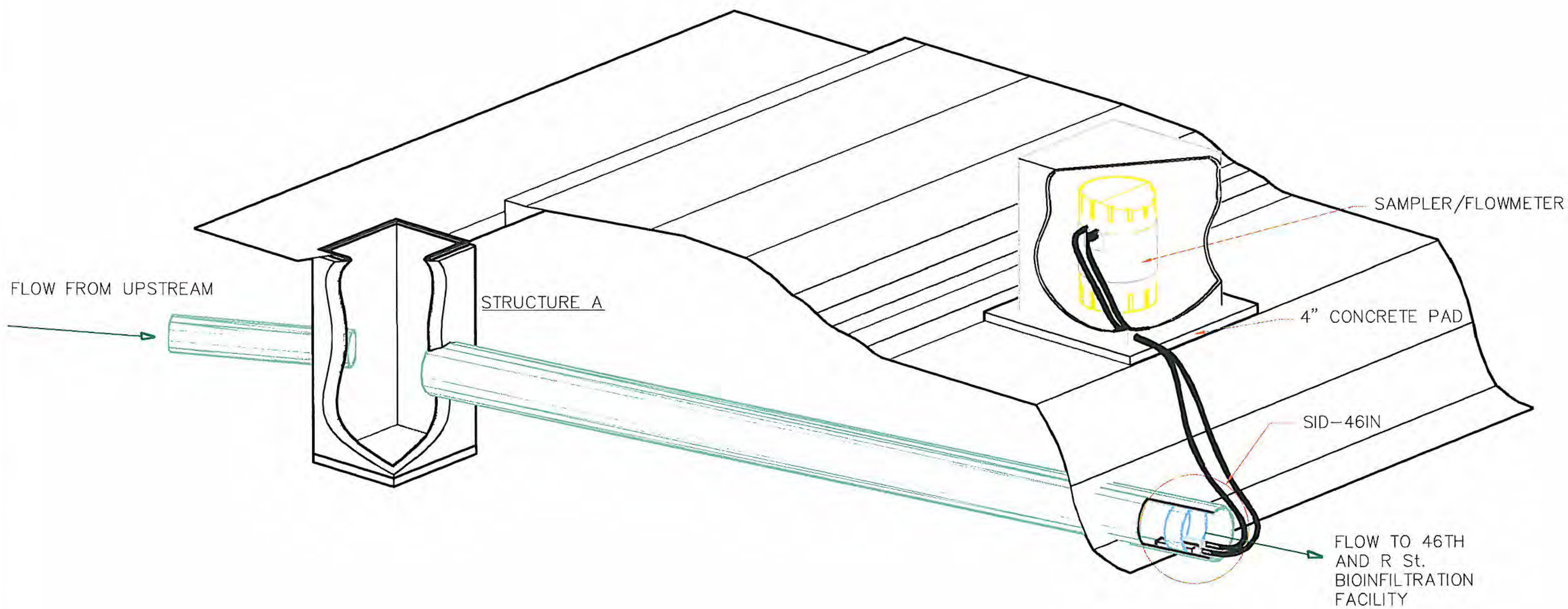
FIGURE 7-1A
46th & R St. BIOINFILTRATION FACILITY MONITORING LOCATIONS

Project	N/A	Sheet: 1 OF 3
Date	JAN 9, 2009	
Scale	NTS	



General Notes

1. FOR STRUCTURE A LOCATION REFER TO FIGURE 7-R.
2. FOR ALL INLET SAMPLE LOCATIONS & MONITORING LOCATIONS REFER TO FIGURE 7-R.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

No.	Revision/Issue	Date

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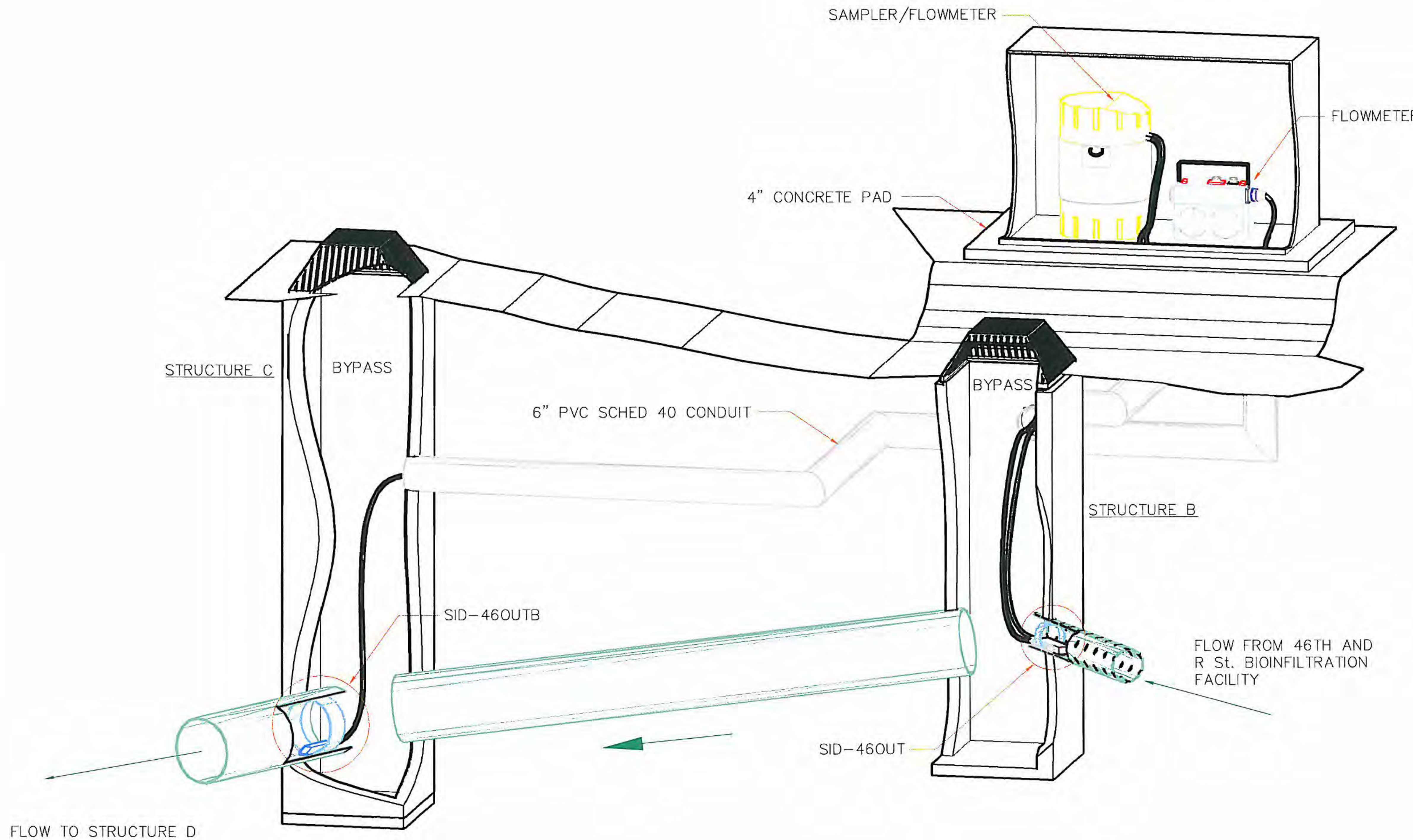
FIGURE 7-1B

INLET STATION FOR 46TH AND R St. BIOINFILTRATION FACILITY

Project N/A	Sheet
Date JAN 9, 2009	2 OF 3
Scale NTS	



General Notes

1. FOR STRUCTURES B & C LOCATIONS REFER TO FIGURE 7-R.
2. FOR ALL OUTLET SAMPLING & MONITORING LOCATIONS REFER TO FIGURE 7-R.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
4. CONDUIT TO BE BURIED OR SURFACE MOUNTED DEPENDING ON CONDITIONS.

No.	Revision/Issue	Date

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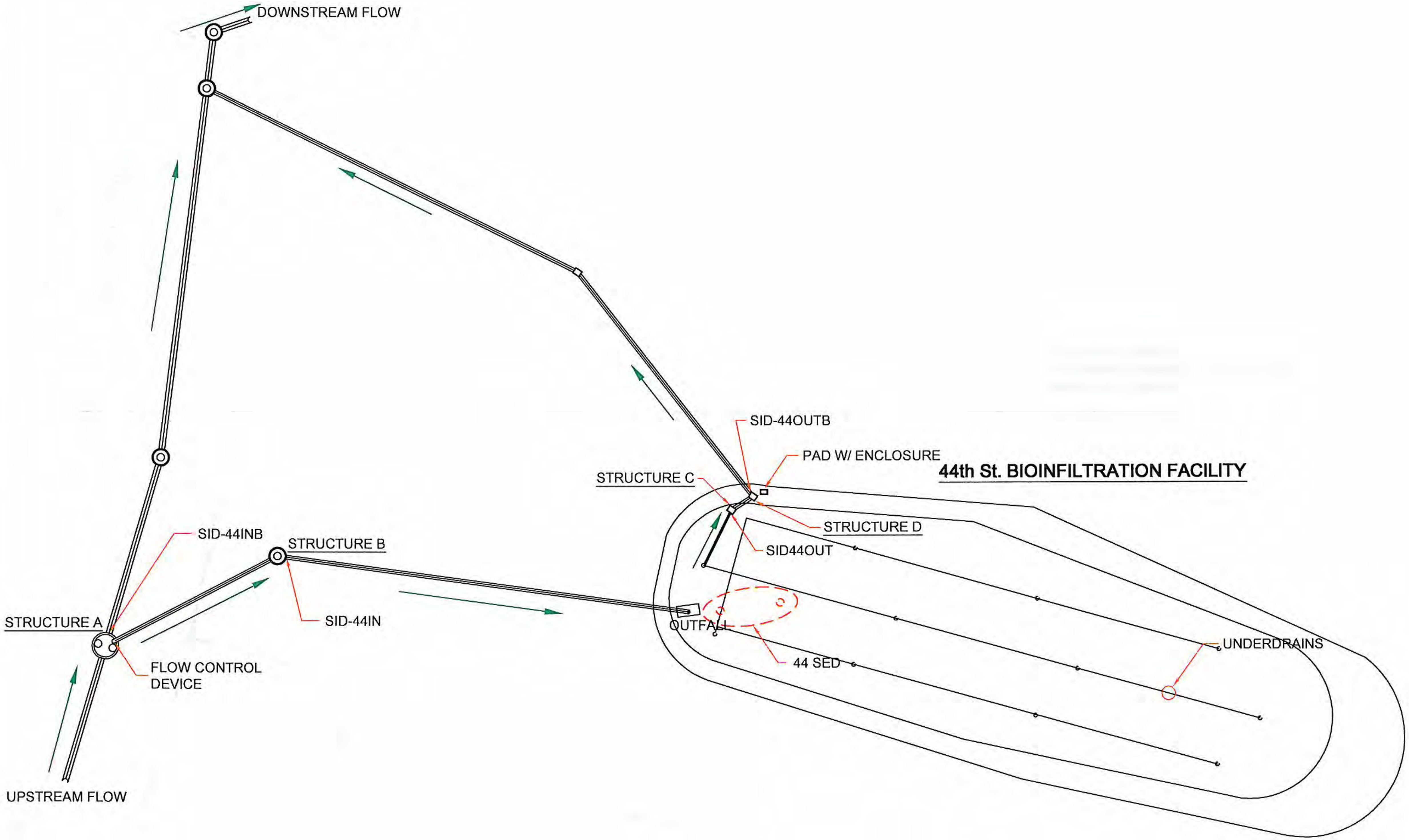
FIGURE 7-1C
OUTLET STATIONS FOR 46TH AND R St. BIOINFILTRATION FACILITY

Project N/A	Sheet
Date JAN 9, 2009	3 OF 3
Scale NTS	



General Notes

1. FOR STRUCTURES A & B DETAILS REFER TO FIGURE 7-B.
2. FOR STRUCTURES C & D DETAILS REFER TO FIGURE 7-C.
3. FOR ALL INLET SAMPLE LOCATIONS & MONITORING LOCATIONS DETAILS REFER TO FIGURE 7-B.
3. FOR ALL OUTLET SAMPLE LOCATIONS & MONITORING LOCATIONS DETAILS REFER TO FIGURE 7-C.
4. FOR PAD AND ENCLOSURE DETAILS REFER TO FIGURE 7-C.
5. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
6. SID - SAMPLE IDENTIFICATION NUMBER.

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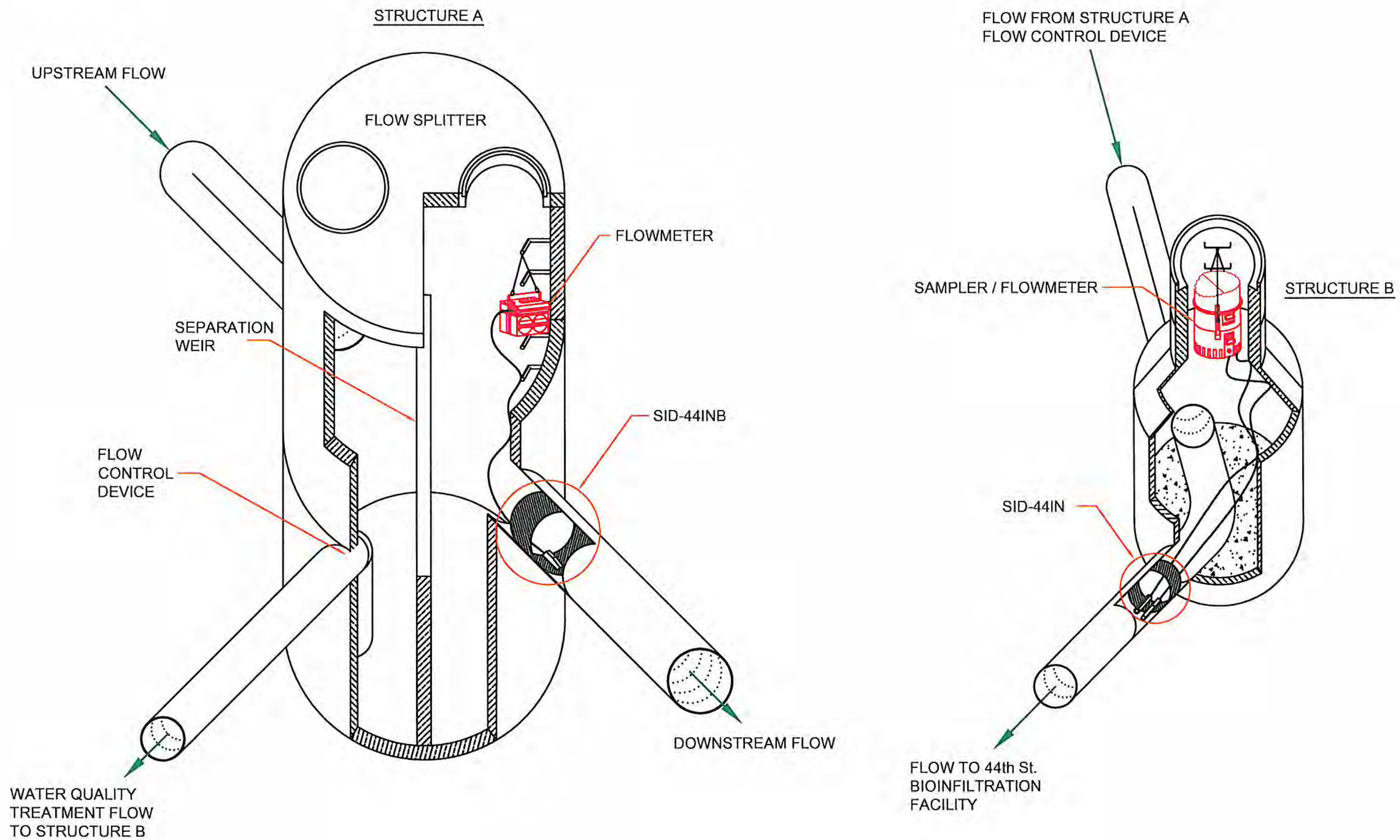
FIGURE 7-2A

44th St. BIOINFILTRATION FACILITY MONITORING LOCATIONS

Project	N/A	Sheet
Date	JAN 9, 2009	1 OF 3
Scale	NTS	



General Notes

1. FOR STRUCTURES A & B LOCATIONS REFER TO FIGURE 7-A.
2. FOR ALL INLET SAMPLE LOCATIONS & MONITORING LOCATIONS REFER TO FIGURE 7-A.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

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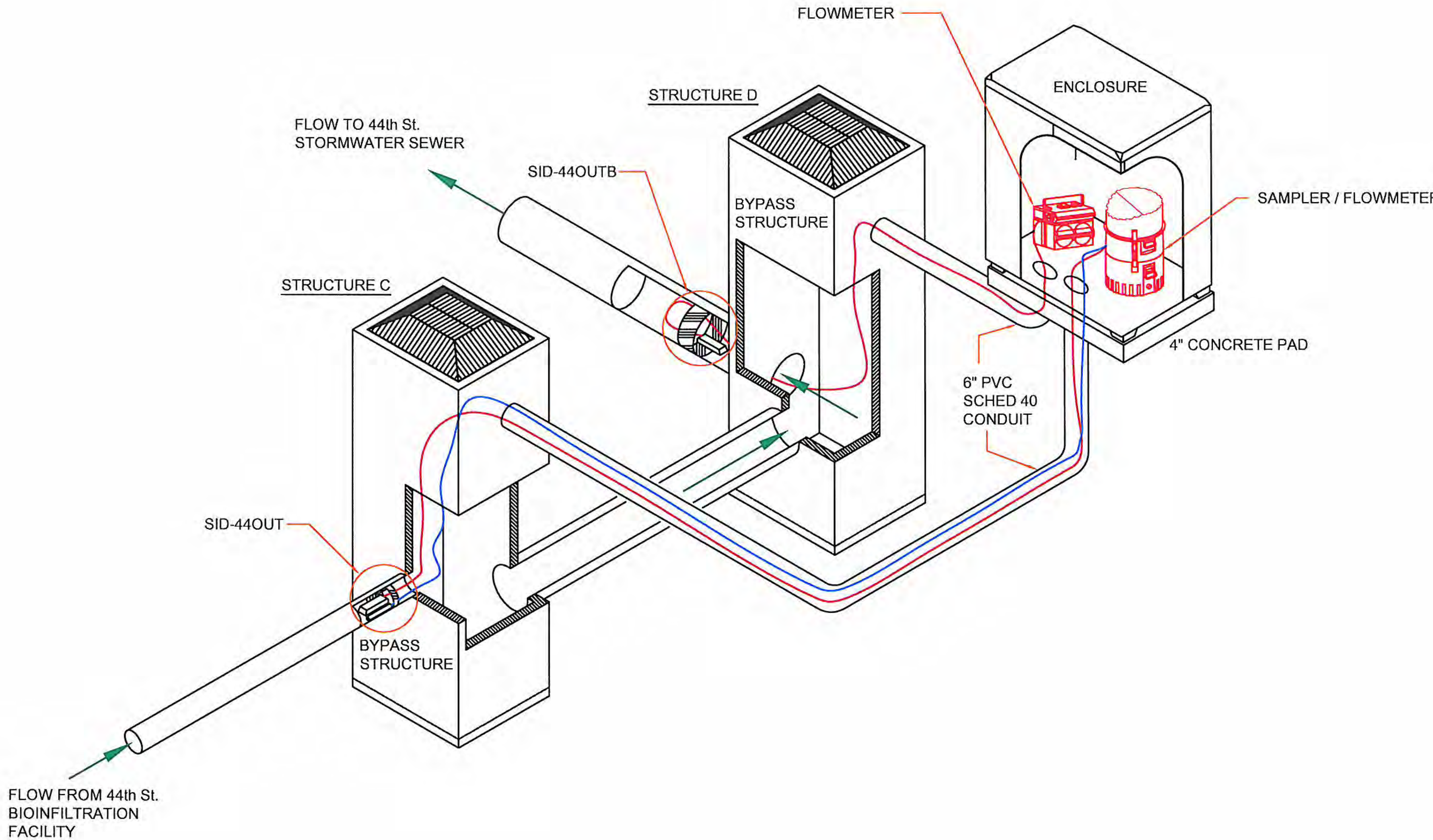
FIGURE 7-2B

INLET STATIONS FOR 44th St. BIOINFILTRATION FACILITY

Project	N/A	Sheet
Date	JAN 9, 2009	2 OF 3
Scale	NTS	



General Notes

1. FOR STRUCTURES C & D LOCATIONS INCLUDING MONITORING EQUIPMENT ENCLOSURE LOCATIONS REFER TO FIGURE 7-A.
2. FOR ALL OUTLET SAMPLING & MONITORING LOCATIONS REFER TO FIGURE 7-A.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
4. CONDUIT MAY BE EITHER BURIED OR SURFACE MOUNTED DEPENDING UPON GROUND CONDITIONS.

No.	Revision/Issue	Date

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FIGURE 7-2C

OUTLET STATIONS FOR 44th St. BIOINFILTRATION FACILITY

Project N/A		Sheet
Date JAN 9, 2009		3 OF 3
Scale NTS		

7.2.2 Biofiltration Facilities

The East 32nd Street Facility has two parallel swales that are approximately 120 feet long and run south of East 32nd Street parallel to T-Street Gulch (see Figures 4-3 and 7-3a). The second biofiltration facility, Trolley Court Swale, is approximately 186 feet long and is south of 17th at the intersection of State Street (see Figures 4-4 and 7-4a). The biofiltration facilities comprise of an inlet pipe, grass-lined channel, and an outlet structure (see Appendix A for details, Table A-3: Trolley Court and Table A-6: East 32 nd Street Facility). During operation, stormwater runoff from the surrounding drainage basin enters a grass-lined channel via an inlet pipe where it disperses across the width of the channel and flows down the length of the channel to allow filtration via the grasses.

The East 32 nd Street Swale consists of two parallel inlets, grass lined channels, and outlets (see Figure 7-3a). The two outlet pipes convey water to a single manhole structure and then to a downstream dispersion facility that disperses the treated water to a downstream wetland in T Street Gulch. During larger storm events, design inlet flows greater than the 100 % 6 month 24 hour flowrate bypasses the biofiltration facility to the primary stormwater conveyance system. In addition, outlet flows greater than 6-month, 24-hour flowrate (see Appendix A, Table A-6) bypasses the dispersion facility to the primary stormwater conveyance system.

Two monitoring stations will be established in connection with each inlet to measure the total quantity and quality of influent (IN) stormwater. Figures 7-3a and 7-3b shows the inlets to East 32 nd Street Swale. As noted on Figure 7-3b, the equipment will be secured and housed in an enclosure. One monitoring station will be established downstream of the single manhole structure to measure the quantity and quality of effluent (OUT) stormwater. Figures 7-3c shows the single manhole structure. The equipment will be secured and housed in a manhole.

The Trolley Court Swale has a single inlet, grass lined channel, and a beehive outlet (see Figure 7-4a). The outlet pipe conveys water to a manhole structure and then to a detention facility that discharges to the primary stormwater conveyance system. Two monitoring stations will be established in the Trolley Court Swale to measure the quantity and quality of influent (IN) and effluent (OUT) stormwater. Figures 7-4a shows the inlet(s) and outlet(s) of this biofiltration facility. As noted on Figures 7-4b and 7-4c, the equipment will be secured and/or housed in an enclosure (OUT) or manhole (IN). The influent station is located in the inlet pipe to the biofiltration facility (see Figure 7-4b). Similarly, the effluent station is located in the outlet pipe from the biofiltration facility (see Figure 7-4c).

The treatment performance of the biofiltration facilities will be evaluated based on comparisons of loads and concentrations measured at the IN and OUT stations, respectively, for each biofiltration facility. To facilitate interpretation of trends in the data from each of these stations, a rain gauge will continuously monitor precipitation near the study site.

The specific monitoring stations established in association with the biofiltration facilities will be use to measure:

- Influent quality as measured in the inlet outfall pipes
- Influent flow at the point of discharge to the swales
- Bypassed flow (East 32nd Street Swale only),
- Effluent quality as measured in the outlet pipes
- Effluent flow at the point of discharge from the swales

Influent flow to the swales will be continuously monitored at the IN stations. These stations are designated 32IN1 and 32IN2 in Figure 7-3a and TCIN in Figure 7-4a and described in Section

7.3.2). When the treatment flow of the East 32nd Street swale is exceeded, the excess stormwater volumes begin to overflow (or bypass) the swale inlets via the inlet manhole structures. As described above, this stormwater is then discharged into a nearby storm drain (see Figures 7-3a and 7-3b). Therefore, stations 32INB1 and 32INB2 will also be used to continuously monitor the flow of bypassed stormwater and described in Section 7.3.2).

Flow monitoring stations (designated 32OUT and TCOUT in Figures 7-3c and 7-4c) will also be established at the point of discharge for the outlet pipes associated with the swales. These stations will be used to continuously monitor flow rates of effluent stormwater that flows from the channel to the outlet structures. A schematic diagram showing equipment configuration for these stations is provide in Figures 7-3c and 7-4c and discussed in more detail below under Section 7.3.2.

The effluent stormwater of the East 32nd Street swale flow discharges to a downstream dispersion facility to a wetland. To protect the dispersion facility and wetland, excess stormwater volumes begin to overflow (or bypass) the swale outlet manhole structure. As described above, this stormwater is then discharged into a nearby storm drain (see Figures 7-3a and 7-3c). Therefore, station 32OUTB will also be used to continuously monitor the flow of bypassed stormwater and description in Section 7.3.2).

The flow monitoring equipment at 32IN1, 32IN2, 32OUT, TCIN, and TCOUT will also be used to pace an automated sampler to facilitate the collection of flow-weighted composite samples for characterizing influent and effluent quality to and from the swales. An existing rain gauge (designated CTP in Figure 3-3) will be used to continuously monitor precipitation for the project site. This rain gauge is approximately 0.8 mile from the East 32nd Street swale. As a backup location, a new rain gauge may be installed at a Tacoma Water secured site, 3611 E M Street (designated MST) and will also be used to continuously monitor precipitation for the project site. This rain gauge is approximately 0.8 mile from the East 32nd Street swale.

An existing rain gauge (designated RG-4 in Figure 3-4) will be used to continuously monitor precipitation for the Trolley Court swale. This rain gauge is approximately 0.5 mile from the Trolley Court swale. As a backup location, existing rain gauge at the Tacoma Landfill will also be used to continuously monitor precipitation for the project site. This rain gauge is approximately 2 miles from the Trolley Court swale.

Hydraulic Residence Time and Treatment Efficiency. The biofiltration facilities are flow-through BMPs with hydraulic residence times estimated at 10 to 20 minutes. As a result, these may be classified as short-term stormwater treatment facilities, and the effluent flow is reasonably assumed to be derived from the same storm as the influent. Treatment efficiency for the biofiltration facilities may therefore be evaluated based on statistical comparisons of paired influent and effluent concentrations during individual storm events. As described above, influent concentrations for both biofiltration facilities will be derived from flow-weighted composite samples that are obtained during discrete storm events. Effluent concentrations will be derived from flow-weighted samples that are obtained from the outlet pipes of each biofiltration facility (i.e., 32OUT and TCOUT).

Treatment efficiency will also be assessed for the swales based on comparisons of the combined annual pollutant loads measured in influent, effluent, and bypassed water for each swale. The specific procedures used to calculate these pollutant load estimates are as follows:

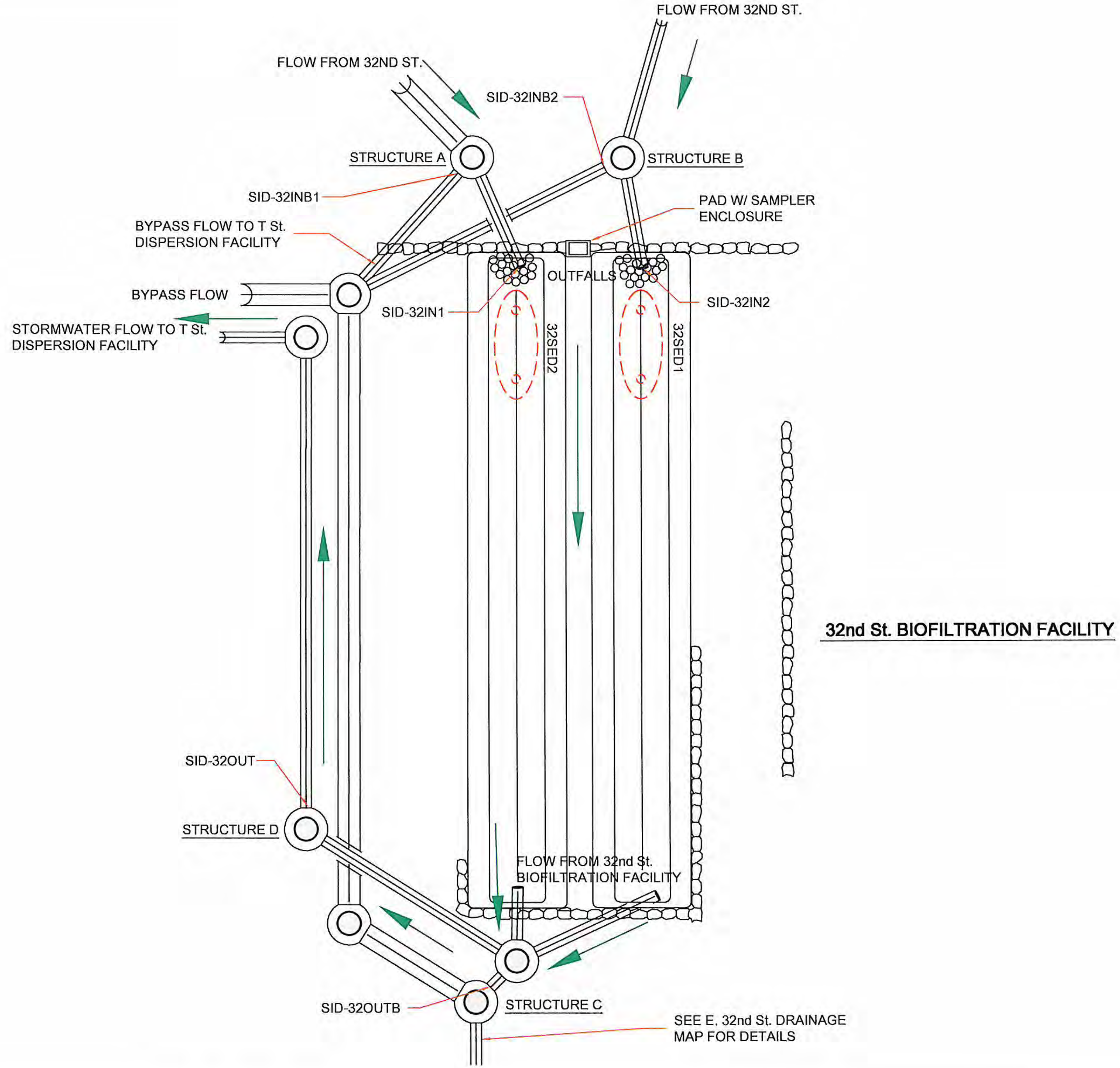
- **Influent Loads**: Annual influent flow volumes to the swales will be obtained from inlet stations 32IN1, 32IN2, and TCIN and rainfall data obtained from the respective stations (MST, CTP, RG-4 and Tacoma Landfill) for the year of interest. These volumes will then be multiplied by a flow-weighted average concentration derived from the influent water quality samples that were obtained from the 32IN1, 32IN2, and TCIN stations, respectively.
- **Effluent Loads**: Annual effluent flow volumes for the swales will be determined from data collected from monitoring stations 32OUT and TCOUT, respectively, in the outlets of each biofiltration facility. These volumes will then be multiplied by average effluent concentrations that were derived from flow-weighted samples collected in the outlet monitoring stations for each of the respective bioinfiltration facilities.
- **Bypass Loads**: Annual bypass flow volumes to the swales will be determined from data collected from monitoring stations 32INB1, 32INB2, and 32OUTB, respectively, in 32nd Street swale. These volumes will then be multiplied by a flow-weighted average concentration derived from the influent and water quality samples that were obtained from stations 32IN1, 32IN2 and 32OUT.

Additional details of treatment efficiency calculations are provided in Section 14.2.7.

The flow control performance of the swales will be assessed based on analysis of the timing and frequency bypass events to determine if the swale and pond are effective at treating storm events up to the 6-month, 24-hour design storm for the East 32nd St Swale and up to the WWHM2 water quality BMP design flowrate for Trolley Court Swale. Additional statistical analyses will also be performed to quantify the performance of each swale with regard to reducing runoff volumes, peak discharge rates, and flow durations.

In addition to stormwater quantity and quality monitoring, sediment sampling will be conducted in the swales on an annual basis. Figures 7-3a and 7-4a show the locations of sediment monitoring stations to be established in connection with the swales. A total of three monitoring stations (designated 32SED1, 32SED2 and TCSED in Figures 7-3a and 7-4a) will be established, one with each inlet to the biofiltration facility. Each station will consist of two sampling locations situated at the inlet pipe that allow stormwater to enter the facility and at the bottom of the swale mid channel near the inlet pipe. The two samples from each swale will be composited in the field resulting in one sample from each sediment monitoring station.

Finally, a detailed description of the vegetation cover in both swales will be completed including the species types growing in the swale bottom and side slopes, as well as an estimate of the percentage of the swale covered in vegetation.



General Notes

1. FOR STRUCTURES A & B DETAILS REFER TO FIGURE 7-Y.
2. FOR STUCTURES C & D DETAILS REFER TO FIGURE 7-Z.
3. FOR INLET SAMPLING AND METERING DETAILS REFER TO FIGURE 7-Y.
4. FOR OUTLET SAMPLING AND BYPASS METERING REFER TO FIGURE 7-Z.
5. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
6. SID-SAMPLE IDENTIFICATION NUMBER.

No.	Revision/Issue	Date

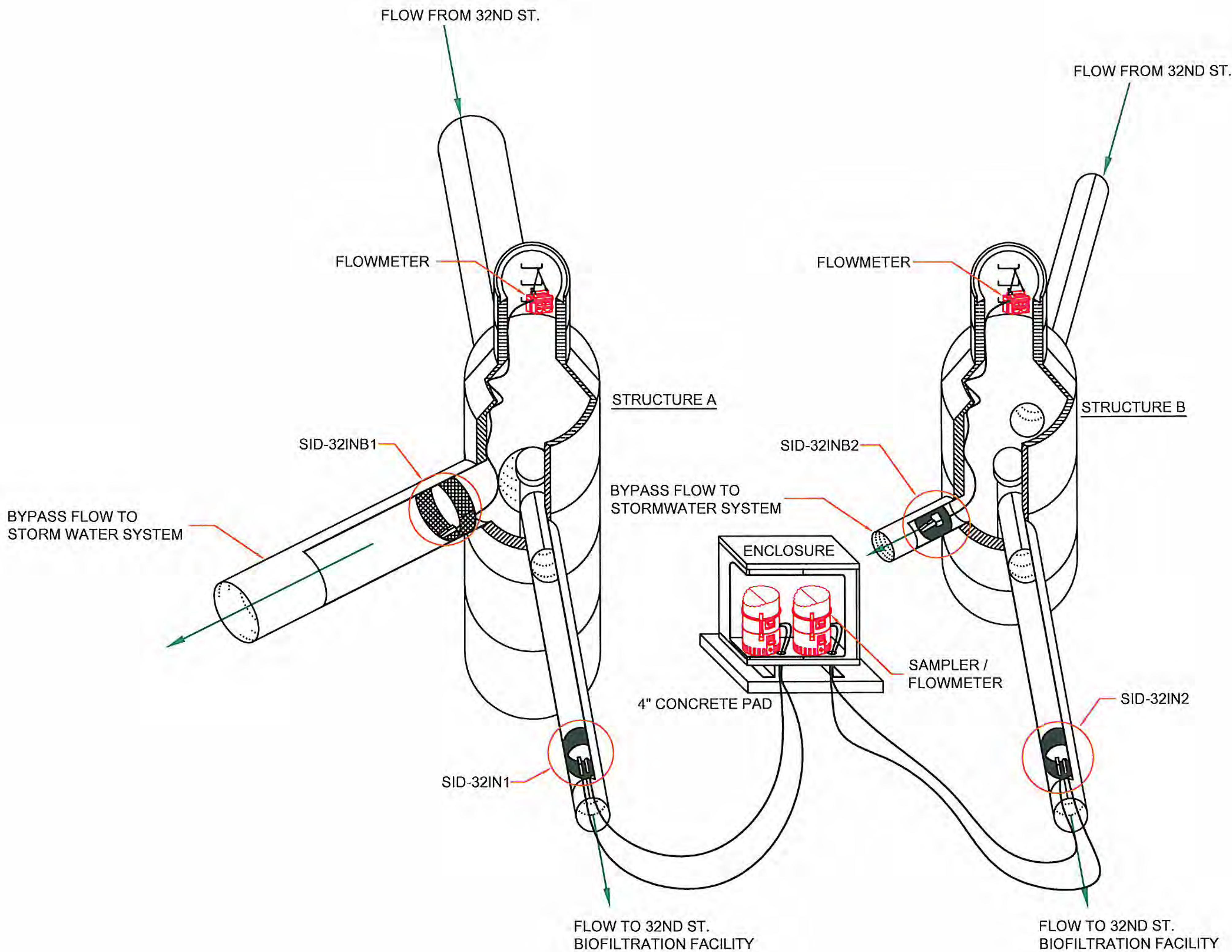
Firm Name and Address

CITY OF TACOMA
SCIENCE AND ENGINEERING
ENVIRONMENTAL COMPLIANCE

Project Name and Address

FIGURE 7-3A
32nd St. BIOFILTRATION FACILITY MONITORING LOCATIONS

Project	N/A	Sheet
Date	JAN 9, 2009	1 OF 3
Scale	NTS	



General Notes

1. FOR STRUCTURES A & B, ALL SAMPLE LOCATIONS & MONITORING LOCATIONS INCLUDING ENCLOSURE LOCATIONS REFER TO FIGURE 7-X.
2. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

No.	Revision/Issue	Date

Firm Name and Address

CITY OF TACOMA

SCIENCE AND ENGINEERING

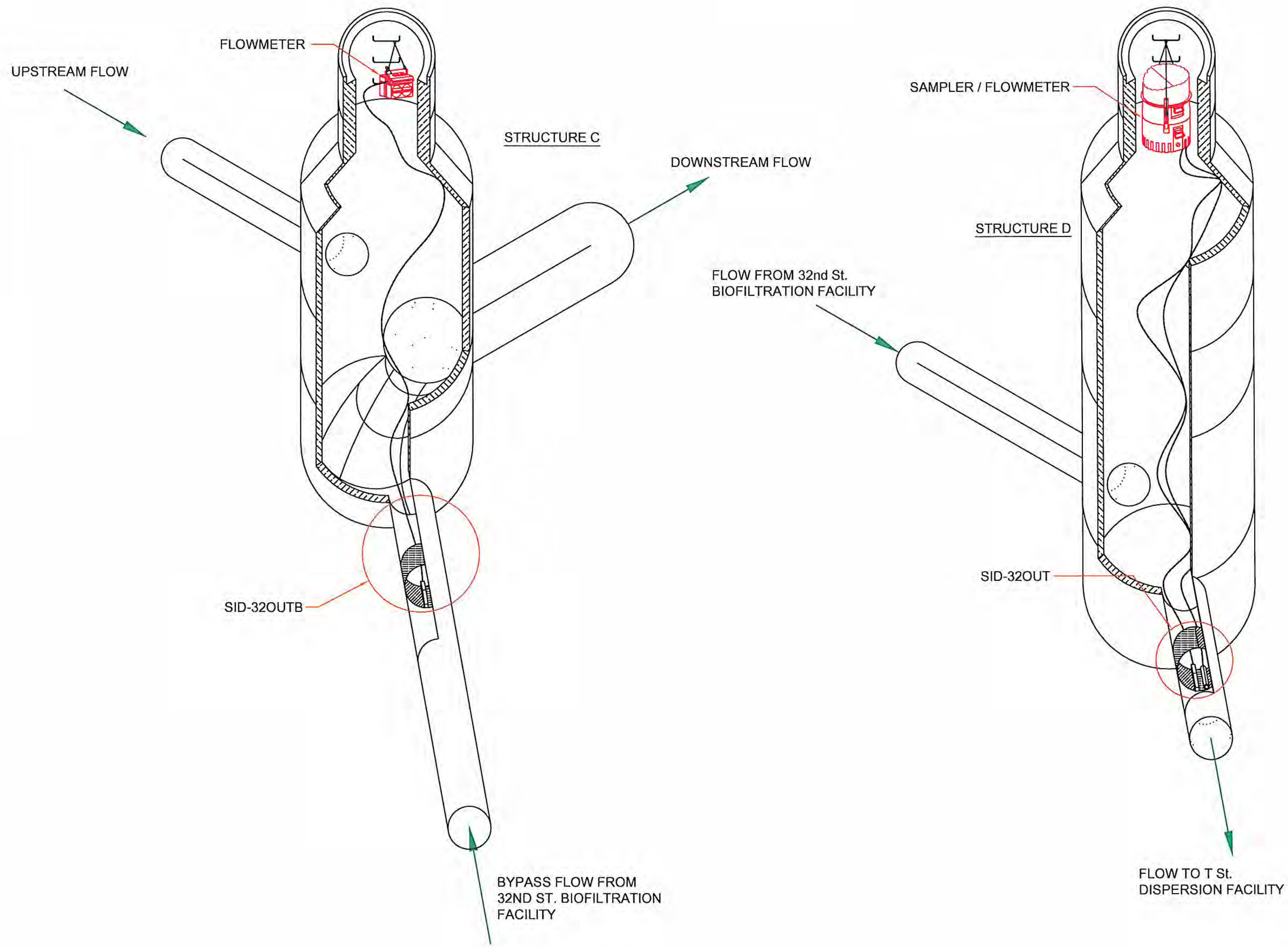
ENVIRONMENTAL COMPLIANCE

Project Name and Address

FIGURE 7-3B

INLET STATIONS FOR 32nd St. BIOFILTRATION FACILITY

Project	N/A	Sheet
Date	JAN 9, 2009	2 OF 3
Scale	NTS	



General Notes

1. FOR STRUCTURES C & D AND ALL SAMPLE AND METERING LOCATIONS REFER TO FIGURE 7-X.
2. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

No.	Revision/Issue	Date

Firm Name and Address

CITY OF TACOMA

SCIENCE AND ENGINEERING

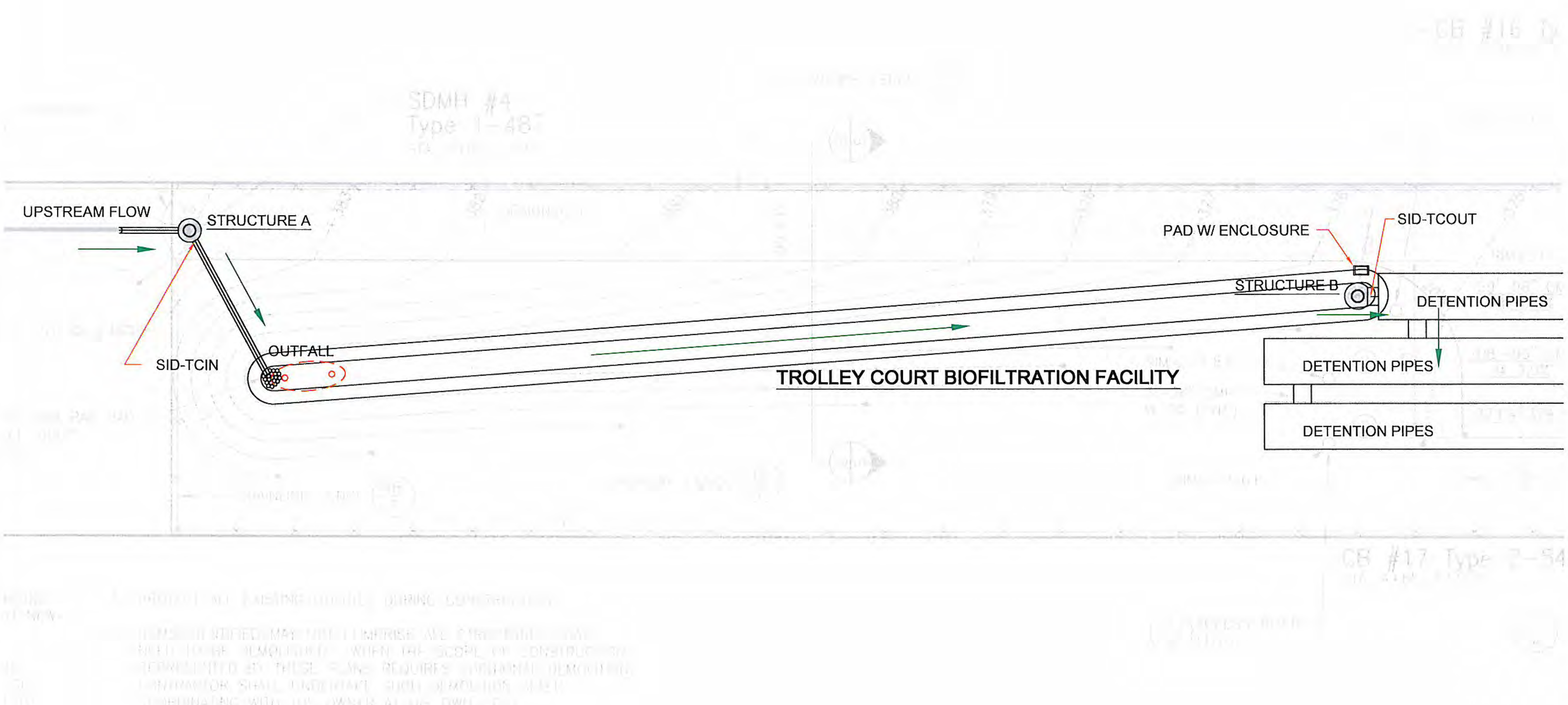
ENVIRONMENTAL COMPLIANCE

Project Name and Address

FIGURE 7-3C

OUTLET STATIONS FOR 32nd St. BIOFILTRATION FACILITY

Project	N/A	Sheet 3 OF 3
Date	JAN 9, 2009	
Scale	NTS	



General Notes

1. FOR STRUCTURE A DETAIL REFER TO FIGURE 7-P.
2. FOR STRUCTURE B DETAIL REFER TO FIGURE 7-Q.
3. FOR INLET SAMPLING & MONITORING LOCATION DETAILS REFER TO FIGURE 7-P.
3. FOR OUTLET SAMPLING & MONITORING LOCATION DETAILS REFER TO FIGURE 7-P.
4. FOR PAD AND ENCLOSURE DETAILS REFER TO FIGURE 7-P.
5. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.
6. SID - SAMPLE IDENTIFICATION NUMBER.

No.	Revision/Issue	Date

Firm Name and Address

CITY OF TACOMA
SCIENCE AND ENGINEERING
ENVIRONMENTAL COMPLIANCE

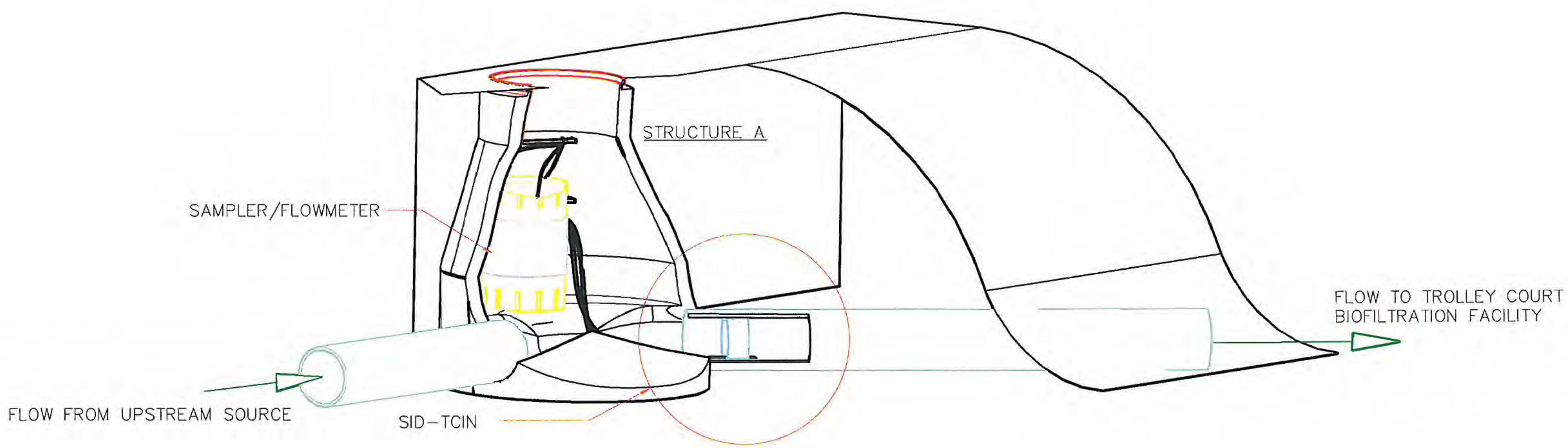
Tacoma

Project Name and Address

FIGURE 7-4A

TROLLEY COURT. BIOFILTRATION FACILITY MONITORING LOCATIONS

Project: N/A	Sheet: 1 OF 3
Date: JAN 9, 2009	
Scale: NTS	



General Notes

1. FOR STRUCTURE A LOCATION REFER TO FIGURE 7-0.
2. FOR INLET SAMPLING AND MONITORING LOCATION, REFER TO FIGURE 7-0.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

No.	Revision/Issue	Date

Firm Name and Address

CITY OF TACOMA

SCIENCE AND ENGINEERING

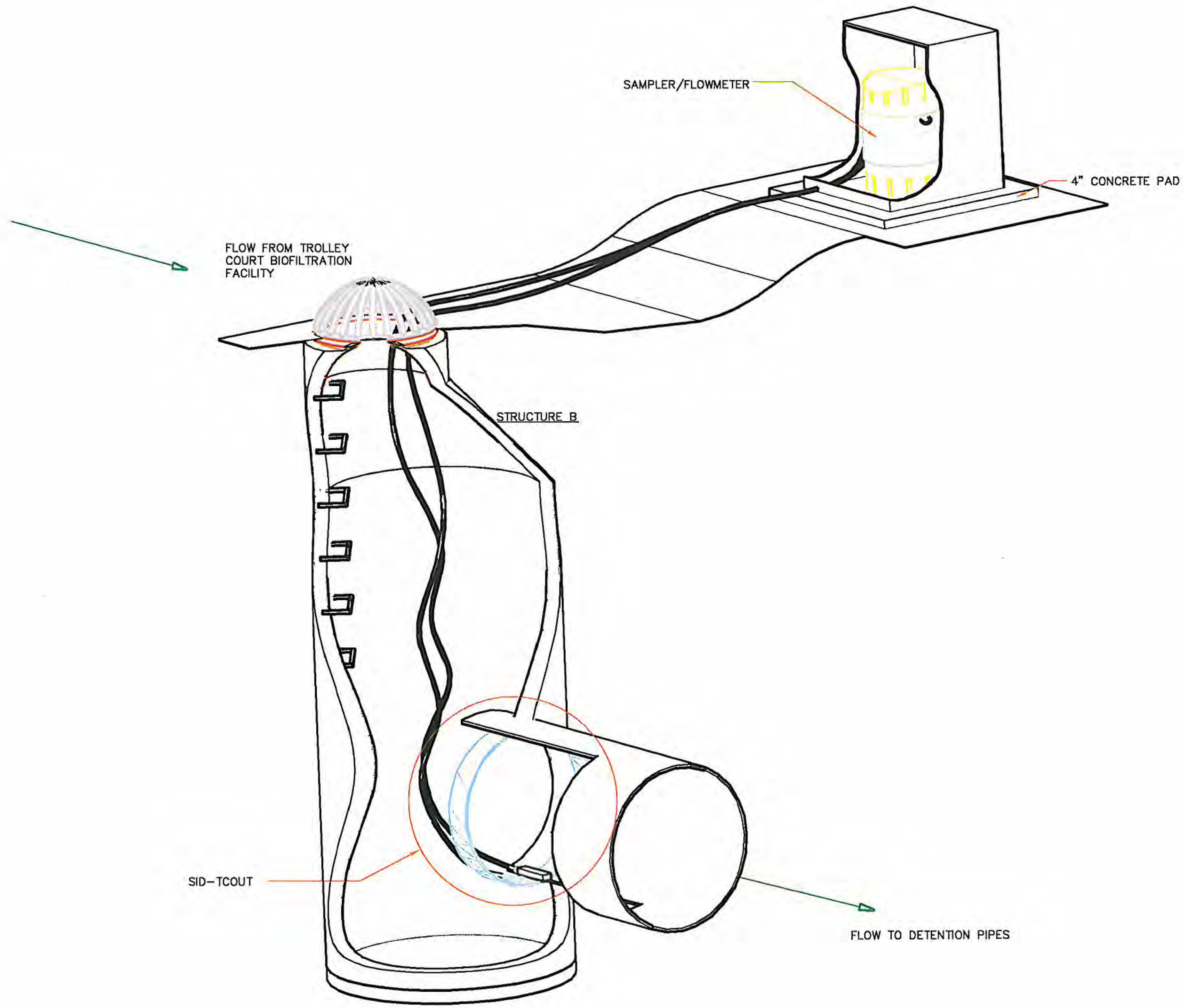
ENVIRONMENTAL COMPLIANCE

Project Name and Address

FIGURE 7-4B

INLET STATION FOR TROLLEY COURT BIOFILTRATION FACILITY

Project N/A	Sheet 2 OF 3
Date JAN 9, 2009	
Scale NTS	



General Notes

1. FOR STRUCTURE B, AND ENCLOSURE LOCATION REFER TO FIGURE 7-O.
2. FOR ALL OUTLET SAMPLING AND MONITORING LOCATIONS, REFER TO FIGURE 7-O.
3. GREEN ARROWS DESIGNATE UPSTREAM TO DOWNSTREAM DIRECTION OF FLOW.

No.	Revision/Issue	Date

Firm Name and Address

CITY OF TACOMA

SCIENCE AND ENGINEERING

ENVIRONMENTAL COMPLIANCE

Project Name and Address

FIGURE 7-4C

OUTLET STATION FOR TROLLEY COURT BIOFILTRATION FACILITY

Project N/A	Sheet
Date JAN 9, 2009	3 OF 3
Scale NTS	

7.2.3 Pervious Pavements – Landfill

Completed in April 2006, the project was constructed in sections (9,028 SF each) with three sections of pervious pavement (pervious pavers, pervious concrete, and pervious asphalt) and one section of standard, impervious asphalt (see Figure 7-5a). Cross sections of the standard asphalt and pervious pavements used in this project are shown in Appendix B, Figure B-1.

Surface runoff with the standard asphalt section flows to the northwest corner of the site where it proceeds through a 4" surface drain and discharges to a 48" diameter catch basin. Flows from the catch basin proceed into the monitoring manhole and then to the primary stormwater system.

Water that infiltrates through the pervious pavement sections moves through the underlying gravel base and cover soil until it reaches the top HDPE liner. Water then travels along the HDPE liner west until it reaches a perforated pipe which collects these flows. The pipe discharges into the monitoring manhole immediately west of each of the sections (Figure 7-5a and b).

Subsurface flows are isolated from each other by a geosynthetic clay liner (GCL) placed between each pavement section and surrounding the perimeter of the site. The GCL was installed vertically (liner to pavement surface) and connected at the base to the HPDE liner with bentonite. See Appendix B, Figure B-2. for a detail of the GCL installation locations.

Surface runoff with the from the pervious pavement sections flows west until it reaches the west side of the section where it is conveyed in a concrete curb and gutter to a 24" diameter catch basin. Since the concrete curb and gutter is not pervious, it is covered with a metal plate to prevent rainfall from hitting the gutter and being conveyed to the catch basin without having the opportunity to infiltrate through the pervious pavement sections (see Figure 7-5b). The catch basin is equipped with a gate valve that allows water to be collected in the basin during a storm event and then manually discharged after the storm.

A total of two monitoring stations will be established in connection with each pervious pavement section to measure the quantity of infiltrated stormwater flow and surface water runoff. In addition, one monitoring station will be established in connection with the standard asphalt (impervious) section to measure the quantity of surface water runoff. Figure 7-5a shows infiltrated stormwater flow and surface water runoff sampling locations. A picture of the flow monitoring manholes are shown in Figure 7-5b. The equipment is secured and housed in an enclosure located immediately west of each section.

The flow reduction performance of each pervious pavement area will be evaluated based on comparisons of flows measured at the infiltrated stormwater flow and surface water runoff stations, for each pervious pavement area to the impervious area flow. To facilitate interpretation of trends in the data from each of these stations, a rain gauge will continuously monitor precipitation at the study site.

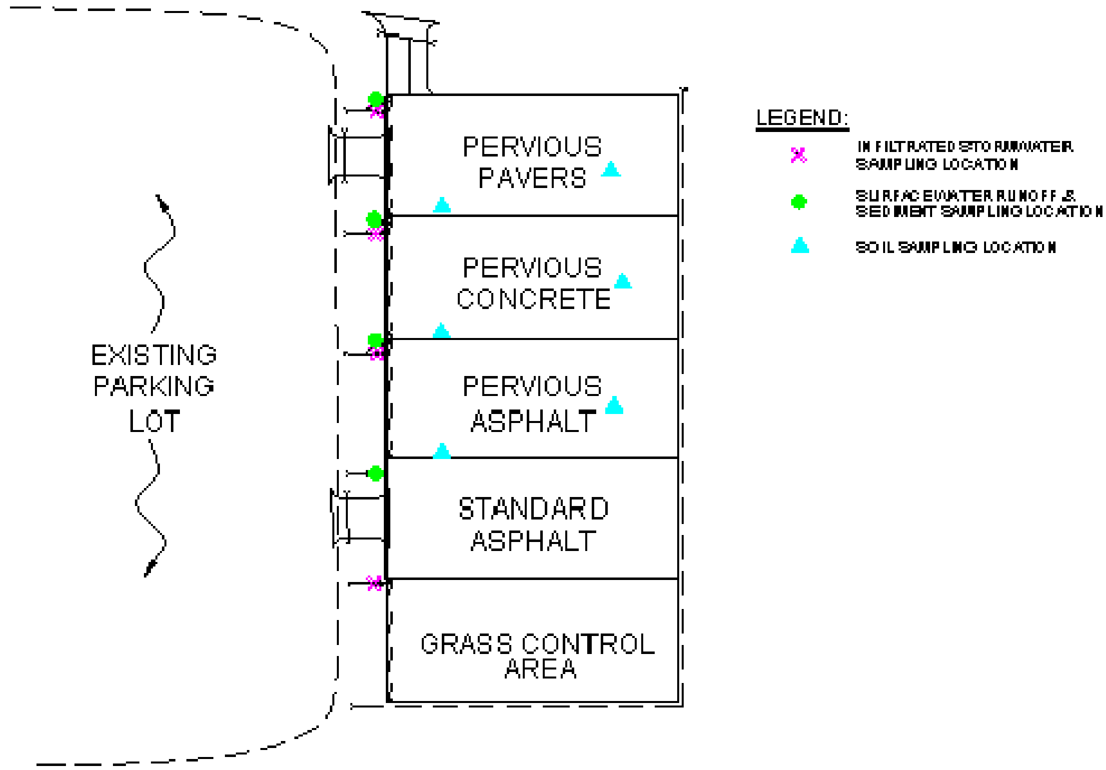


Figure 7-5a Sampling Locations for Each Pavement Section – Tacoma Landfill

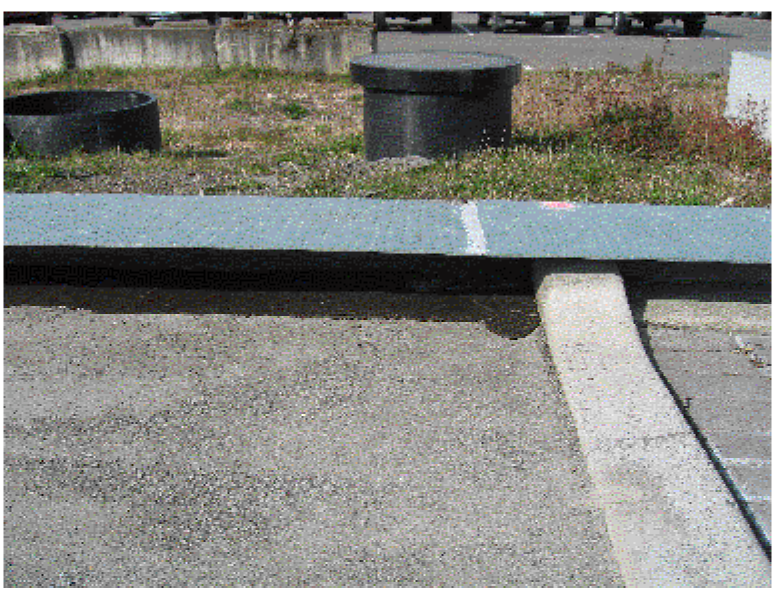


Figure 7-5b –Sampling Manholes and Curbing

The specific monitoring stations established in association with each pervious/impervious pavement section will be use to measure:

- Infiltrated stormwater flow as measured at the point of discharge from each pervious pavement section
- Surface water runoff flow as measured at the point of discharge from each pervious/impervious section

The infiltrated stormwater flows will be continuously monitored at the pervious and impervious pavement stations (monitoring manholes). These stations are designated Perv. Pavers, Perv. Concrete, Perv. Asphalt (see Figure 7-5a). The surface water flows will be continuously monitored at the impervious pavement station (monitoring manholes). This station is designated Std. Asphalt. Asphalt (see Figure 7-5a). The surface water flows will be continuously monitored as a depth of water collected in small sumps for each of the pervious pavement stations. Once measured the sumps is emptied by opening a shear gate. Once emptied the shear gate is closed to continue to collect water from the surface water runoff. These stations are designated Perv. Pavers CB, Perv. Concrete CB, Perv. Asphalt CB (see Figure 7-5a). As described above, all stormwater is then discharged into a nearby storm drain. An existing rain gauge (designated Landfill) will be used to continuously monitor precipitation for the project site.

The flow control performance of the pervious sections will be assessed based on statistical analyses performed to quantify the performance of each section with regard to reducing runoff volumes, peak discharge rates, and flow durations in comparison with the standard asphalt section.

7.3 Flow Monitoring Equipment Strategy

The equipment configurations for any particular station will depend on site-specific hydraulic and access considerations. The following subsections provide a more detailed summary of the equipment that will be used in association with each of the facilities (bioinfiltration, biofiltration and pervious pavements) that will be monitored through this study.

7.3.1 Salishan Bioinfiltration Facilities

Continuous flow monitoring will be performed at the following seven stations associated with the bioinfiltration facilities, East 46th & R Street Swale and East 44th Street Pond: RSTIN, RSTOUT, RSTOUTB, 44IN, 44INB, 44OUT and 44OUTB. Finally, continuous precipitation monitoring will occur at stations CTP and MTS. The specific monitoring equipment that will be used in connection with these stations is described in the following subsections.

RSTIN, RSTOUT, 44IN and 44OUT Stations. Automated monitoring equipment will be installed to facilitate the continuous monitoring of discharge. More specifically, an ISCO 6712 Full-size Portable Sampler with an attached ISCO 750 Area/Velocity Flow Module (see detailed description in Appendix D) will be installed. The area/velocity probe will be fitted to the bottom of the concrete pipe to measure the depth of water and velocity in the pipe. The portable sampler will be programmed to record water level/velocity measurements from the flow module at 5-minute intervals.

Data will be downloaded and processed using ISCO supported software. Flows will be estimated using standard hydraulic equations for circular concrete pipe based on the water level and velocity measurements. All the equipment described above will be powered with an ISCO rechargeable battery that is fully charged prior to each sampling event.

For Stations RSTIN, RSTOUTand 44OUT, the portable sampler will be housed in an enclosure. The area/velocity probe cable from the flow module will be discretely routed out of the enclosure and to the concrete pipe so as to avoid incidents of tampering or vandalism (such as above ground or buried PVC conduit). For Station 44IN, the portable sampler will be housed in a manhole structure. The area/velocity probe cable from the flow module will be routed within the manhole and along the pipe to monitoring location.

RSTINB, RSTOUTB and 44OUTB Stations. Automated monitoring equipment will be installed to facilitate the continuous monitoring of discharge. More specifically, an ISCO 2150 750 Area/Velocity Flow Module (see detailed description in Appendix D) will be installed. If the flow conditions are too shallow for the ISCO probe, a Renaissance Instruments Data Gator (pressure transducer) or American Sigma 920 Area/Velocity flow meter will be used. The flow meter probe will be fitted to the bottom of the concrete pipe to measure the depth of water and velocity (or depth of water only) in the pipe. The portable flow module will be programmed to record water level/velocity measurements from the flow module at 5-minute intervals.

Data will be downloaded and processed using manufacturer's supported software. Flows will be estimated using standard hydraulic equations for circular concrete pipe based on the either water level and velocity measurements or water level only. All the equipment described above will be powered with the manufacturer's rechargeable batteries that are fully charged prior to each sampling event.

For Station 44INB, the portable flowmeter will be housed in a manhole structure. The cable from the flow module will be routed within the manhole and along the pipe to monitoring location. For Stations RSTOUTB and 44OUTB, the portable flowmeter will be housed in an enclosure. The cable from the flow module will be discretely routed out of the enclosure and to the concrete pipe so as to avoid incidents of tampering or vandalism (such as above ground or buried PVC conduit).

MTS and CTP Stations. The MTS station will be an ISCO 676 logging system with a tipping bucket rain gauge placed in a secured area owned by Tacoma Water. It will be installed in accordance with the manufacture's specifications. The MTS rain gauge will interface with ISCO's FloLink software . It will be programmed to record the precipitation depth measurements at 5-minute intervals.

The CTP station currently consists of an ISCO 675 tipping bucket rain gauge that is affixed to the roof of the STP Digester at Tacoma's Central Treatment Plant (Figure 3-1) in accordance with the manufacture's specifications. This rain gauge has an AC power source. The CTP rain gauge is interfaced with ISCO's FloLink software . It is programmed to record the precipitation depth measurements at 5-minute intervals.

7.3.2 Biofiltration Facilities

Continuous flow monitoring will be performed at the following eight stations associated with the biofiltration facilities, East 32nd Street Swale and Trolley Court Swale: 32IN1, 32IN2, 32IN1B, 32IN2B, 32OUT, 32OUTB, TCIN and TCOUT. Finally, continuous precipitation monitoring will occur at stations CTP, RG-4 and MTS. The specific monitoring equipment that will be used in connection with these stations is described in the following subsections.

32IN1, 32IN2, 32OUT, TCIN and TCOUT Stations. Automated monitoring equipment will be installed to facilitate the continuous monitoring of discharge. More specifically, an ISCO 6712 Full-size Portable Sampler with an attached ISCO 750 Area/Velocity Flow Module (see detailed description in Appendix D) will be installed. The area/velocity probe will be fitted to the bottom of the concrete pipe to measure the depth of water and velocity in the pipe. The portable sampler will be programmed to record water level/velocity measurements from the flow module at 5-minute intervals.

Data will be downloaded and processed using ISCO supported software. Flows will be estimated using standard hydraulic equations for circular concrete pipe based on the water level and velocity measurements. All the equipment described above will be powered with an ISCO rechargeable battery that is fully charged prior to each sampling event.

For Stations 32IN1, 32IN2, and TCOUT, the portable sampler will be housed in an enclosure. The area/velocity probe cable from the flow module will be discretely routed out of the enclosure and to the concrete pipe so as to avoid incidents of tampering or vandalism (such as above ground or buried PVC conduit). For Stations 32OUT and TCIN, the portable sampler will be housed in a manhole structure. The area/velocity probe cable from the flow module will be routed within the manhole and along the pipe to monitoring location.

32INB1, 32INB2, and 32OUTB Stations. Automated monitoring equipment will be installed to facilitate the continuous monitoring of discharge. More specifically, an ISCO 2150 750 Area/Velocity Flow Module (see detailed description in Appendix D) will be installed. If the flow conditions are too shallow for the ISCO probe, a Renaissance Instruments Data Gator (pressure transducer) or American Sigma 920 Area/Velocity flow meter will be used. The flow meter probe will be fitted to the bottom of the concrete pipe to measure the depth of water and velocity (or depth of water only) in the pipe. The portable flow module will be programmed to record water level/velocity measurements from the flow module at 5-minute intervals.

Data will be downloaded and processed using manufacturer's supported software. Flows will be estimated using standard hydraulic equations for circular concrete pipe based on the either water level and velocity measurements or water level only. All the equipment described above will be powered with the manufacturer's rechargeable batteries that are fully charged prior to each sampling event.

For Stations 32INB1, 32INB2, and 32OUTB, the portable flowmeter will be housed in a manhole structure. The cable from the flow module will be routed within the manhole and along the pipe to monitoring location.

MTS, CTP and RG-4 Stations. For the East 32nd Street Swale, the MTS station will be an ISCO 676 logging system with a tipping bucket rain gauge placed in a secured area owned by Tacoma Water. It will be installed in accordance with the manufacture's specifications. The MTS rain gauge will interfaced with ISCO's FloLink software. It will be programmed to record the precipitation depth measurements at 5-minute intervals.

For the East 32nd Street Swale, the CTP station currently consists of an ISCO 675 tipping bucket rain gauge that is affixed to the roof of the STP Digester at Tacoma's Central Treatment Plant (Figure 3-1) in accordance with the manufacture's specifications. This rain gauge has an AC power source. The CTP rain gauge is interfaced with ISCO's FloLink software. It is programmed to record the precipitation depth measurements at 5-minute intervals.

For the Trolley Court Swale, the RG-4 station currently consists of an ISCO 676 tipping bucket rain gauge and logging system that is affixed to the roof of the Allenmore Hospital (Figure 3-1) in accordance with the manufacture's specifications. The Landfill station, is located at Tacoma's Landfill and is a SCADA system logger, ST-AB8203. Both of these rain gauges have an AC power source and are programmed to record the precipitation depth measurements at 5-minute intervals. The RG-4 rain gauge will be interfaced with ISCO's FloLink software

7.3.3 Pervious Pavements – Landfill

Continuous flow monitoring will be performed at the following seven stations associated with the Landfill project: Perv. Pavers, Perv. Concrete, Perv. Asphalt, Std. Asphalt, Perv. Pavers CB, Perv. Concrete CB, and Perv. Asphalt CB. Continuous precipitation monitoring may also be performed in association with these stations.

Water levels from both the pervious pavement sections (infiltrated flows designated as Perv. Pavers, Perv. Concrete, and Perv. Asphalt) and standard asphalt (surface runoff designated as Std. Asphalt) are measured using a portable ISCO 730 bubbler flow module (see Figure 7-5c). The bubbler flow module measures water depth and this data is converted to flow using Manning's equation (see Figure 7-5c).

Surface runoff from the pervious pavement sections is collected in catch basins associated with each pervious pavement section (designated as Perv. Pavers CB, Perv. Concrete CB, and Perv. Asphalt CB). Volume measurements are taken by field staff after the storm event. After the measurement is taken, water is released from the catch basin and then collected during the next storm event (see Figure 7-5d).

An ISCO 674 rain gauge, which measures rainfall in 0.01 inch increments, is located at the project site. The rain gauge is connected to an ISCO flowmeter, which is responsible for logging the rain data.

The ISCO flow meters and rain gauges are programmed to record at 5 minute intervals. Data will be downloaded and processed using ISCO supported software. All the equipment described above will be powered with ISCO rechargeable batteries.

Figure 7-5c Flow Monitoring setup for Pervious Pavement and Standard Asphalt Sites

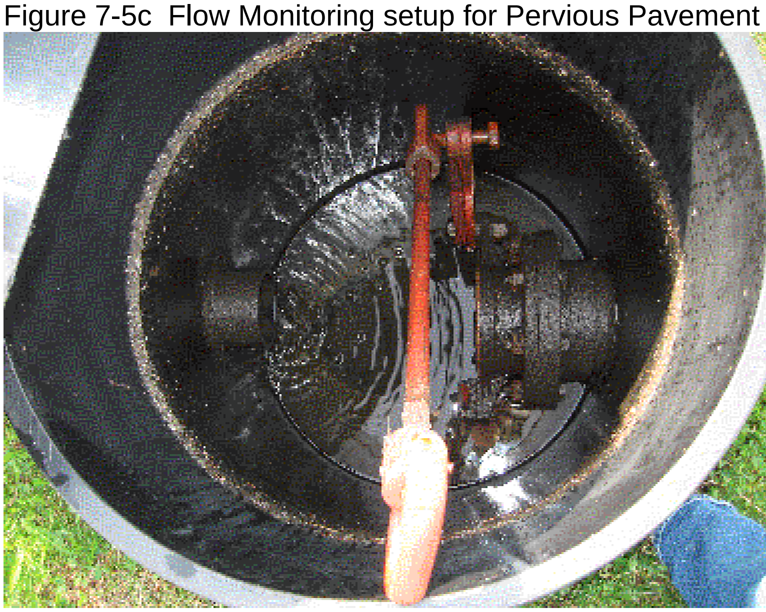


Figure 7-5d Flow Monitoring setup for Surface Water Runoff from Pervious Pavement Sites

7.4 Water Quality Equipment Monitoring Strategy

The configuration of water quality sampling equipment at any particular station will depend on site-specific considerations. The following subsections provide a more detailed summary of the water quality sampling equipment that will be used in association with each of the bioinfiltration and biofiltration facilities that will be monitored through this study.

7.4.1 Salishan Bioinfiltration Facilities - Stations RSTIN, RSTOUT, 44IN and 44OUT

As described above in Section 7.3.1.1, Stations RSTIN, RSTOUTand 44OUT, will be equipped with an ISCO 6712 Full-size Portable Sampler with an attached ISCO 750 Area/Velocity Flow Module (see detailed description in Appendix D) to facilitate flow monitoring at the stations. The same equipment will also be used to facilitate the collection of flow-weighted composite samples. The intake strainer for the portable sampler will be positioned on the bottom of the concrete pipe to intercept water in the pipe.

For Stations RSTIN, RSTOUTand 44OUT, the portable sampler will be housed in an enclosure. The suction line from the portable sampler will be discretely routed out of the enclosure and to the concrete pipe so as to avoid incidents of tampering or vandalism (such as above ground or buried PVC conduit) (see Section 7.3.1.1). For Station 44IN, the portable sampler will be housed in a manhole structure. The suction line from the portable sampler will be routed within the manhole and along the pipe to monitoring location. The suction line from the portable sampler will also be installed with a continuous slope so that all the water will drain out of the line between successive samples to prevent cross contamination.

7.4.2 Biofiltration Facilities - Stations 32IN1, 32IN2, 32OUT, TCIN and TCOUT

As described above in Section 7.3.1.1, Stations 32IN1, 32IN2, 32OUT, TCIN and TCOUT, will be equipped with an ISCO 6712 Full-size Portable Sampler with an attached ISCO 750 Area/Velocity Flow Module (see detailed description in Appendix D) to facilitate flow monitoring at the stations. The same equipment will also be used to facilitate the collection of flow-weighted composite samples. The intake strainer for the portable sampler will be positioned on the bottom of the concrete pipe to intercept water in the pipe.

For Stations 32IN1, 32IN2, and TCOUT, the portable sampler will be housed in an enclosure. The suction line from the portable sampler will be discretely routed out of the enclosure and to the concrete pipe so as to avoid incidents of tampering or vandalism (such as above ground or buried PVC conduit) (see Section 7.3.1.1). For Stations 32OUT and TCIN, the portable sampler will be housed in a manhole structure. The suction line from the portable sampler will be routed within the manhole and along the pipe to monitoring location. The suction line from the portable sampler will also be installed with a continuous slope so that all the water will drain out of the line between successive samples to prevent cross contamination.

8 Sampling Procedures

The quality of data collected in an environmental study is critically dependent upon the quality and thoroughness of field sampling activities. Please refer to S8 Program QAPP, Section 8 Sampling (Field) Procedures for general information related to stormwater sampling which also includes decontamination procedures (S8 Program QAPP, Section 8.1.1). Specific details will be provided in the SOPs. The SOPs will include requirements for training and documentation of activities, collection of field quality control samples, and description of "Clean Handling Techniques" where appropriate.

General procedures for the following activities are described below:

- Flow monitoring,
- Water quality sampling,
- Sediment sampling,
- Soil characterization; and
- Controlled infiltration tests

Specific details of equipment selection and installation are described above in Section 7.

8.1 Sample Identification

All samples will be clearly labeled in the field with indelible ink. Each sample will be uniquely identified by its sample location identifier combined with the sample method (type and technique, i.e. manual grab, automatic flow-weighted composite), the event date and time stamp, and the sample matrix. For composite samples, the date and time stamp will reflect the last aliquot collected.

8.2 Flow Monitoring

As described above in Section 7, continuous monitoring of flows will be performed at influent and effluent monitoring stations associated with bioinfiltration and biofiltration facilities over the 2 year duration of this study (August 2009 – August 2011). In addition, precipitation depths will also be monitored continuously, either using rain gauges at Tacoma's CTP, or at stations established in conjunction with the site. This section begins with a general overview of the sampling procedures that will be used for hydrologic monitoring related to this study. Specific details regarding the monitoring equipment that will be installed in connection with each BMP are presented in Sections 7.3 and 7.4.

To facilitate flow monitoring, sensors for measuring water depth only or water velocity and depth (i.e., ISCO bubbler line or area/velocity probe, respectively) will be installed in stormwater conveyance pipes associated with the monitoring stations. In all cases, the sensors will be installed in accordance with manufacture's specifications and SOPs. To facilitate precipitation monitoring, a rain gauge (ISCO tipping bucket rain gauge) is installed according to manufacturer's specifications in a location where buildings and/or trees in the vicinity will not interfere with its operation.

The sensors for flow and precipitation monitoring will be interfaced with the ISCO or other data loggers capabilities that are programmed to record sensor readings with a 5-minute logging interval. Each data logger will be downloaded manually. A few of the rain gauges are downloaded via Tacoma's SCADA system. Power to most of the data loggers and sensors will be provided by an ISCO rechargeable battery. Some of the rain gauges have AC power. The equipment may be housed in manhole or locking, vandal resistant enclosures that are hidden from public view to the extent possible.

One week after the equipment is installed at a particular station, field personnel will visit the station to confirm that the equipment was installed correctly and is functioning as designed. After this initial check, field personnel will perform biweekly to monthly site visits to upload data, check and replace batteries as necessary, visually inspect all system components, and perform calibration checks as necessary. Any operational problems that are identified during these site visits will be addressed immediately. Field personnel will document maintenance, calibration, and troubleshooting activities in the field notebook.

Data from each station will be uploaded on a biweekly basis and after major storm events manually. The data will then be exported to ISCO Flolink database for all subsequent data management tasks (see Section 11 of the S8 Program QAPP). At this time, the data will also undergo a quality assurance audit (see Section 12 of the S8 Program QAPP). Any operational problems that are identified through this audit will be addressed immediately.

8.3 Water Quality Sampling

As described above in Section 7, water quality sampling will be performed at influent and effluent monitoring stations associated with bioinfiltration and biofiltration facilities over the 2 year duration of this study (November 2009 – November 2011). The goal of this sampling is to collect flow-weighted composite samples during 8 to12 storm events in each year to obtain up to 35 influent and effluent samples at each BMP by the end of this period. This section describes in detail the sampling procedures that will be used to meet this goal.

To facilitate water quality sampling associated with this study, ISCO 6712 full size automated samplers will be installed in association with the influent and effluent monitoring stations for each BMP. Teflon sampler suction tubing will be routed from each automated sampler to the point of sample collection. The suction tubing will be installed with a continuous positive slope from the point of sample collection to the pump head of the associated automated sampler. This will ensure proper draining of the suction tube during automated sampler purging cycles. A strainer will be installed at the terminus of the sampler suction tubing at the point of sample collection to prevent debris from clogging the tubing. The sampler intakes will be carefully positioned to ensure the homogeneity and representativeness of the samples. Specifically, sampler intakes will be installed to ensure that an adequate depth will be available for sampling and to avoid the capture of litter, debris, bed load, and other gross solids that may be present. The automated samplers will be programmed to perform one rinse cycle prior to actual sample collection in order to reduce the likelihood of cross contamination between successive aliquots.

Antecedent conditions and storm predictions will be monitored via the Internet and review of rain gauge data, and a determination will be made as to whether to target an approaching storm for sampling. The volume used to pace the automated samplers will be determined in advance of the storm event based on rainfall versus runoff relationships that are developed using precipitation and runoff volume data that were collected during previous storm events. Using these relationships, runoff volume for each station will be estimated based on the forecasted rainfall total for the targeted storm event. The estimated runoff volume (cubic feet) will then be divided by the desired number of aliquots (i.e., 100-250 ml aliquots) to estimate the sample pacing (cubic feet) volume necessary to collect the required composite sample volume. The rainfall versus runoff relationships will be continually updated throughout the duration of the study to reflect changing hydrologic conditions.

Once a decision has been made to target a storm event for sampling, field personnel will conduct site visits to deploy clean sample bottles in the automated samplers at each monitoring station, calibrate equipment as necessary, clear any obstructions from the sampler intakes, inspect the rain gauges for blockages, and check the operational status of the flow monitoring equipment. Field personnel will then fill the automatic samplers with ice and initiate the sampler program. Ice is estimated to keep the interior of the samplers cool for 48 hours; consequently, ice will not be added to the samplers more than 24 hours before a targeted storm event. The speed and intensity of incoming storm events will then be tracked using Internet-accessible images from publicly available Doppler radar. Actual rainfall totals during sampled storm events will be monitored from the CTP and City's SCADA rain gauges.

After the storm event, storm event criteria identified in Section 7.1.3 for storm event (Table 7-1) and sample representativeness (Table 7-2) will be assessed prior to sample retrieval by analyzing hydrologic and sampling recorded for each station. If the storm event criteria have not been met, the samples will be discarded and the associated bottles sent to the laboratory for cleaning in preparation for the next storm event. If the criteria have been met, field personnel will remove the chilled sample bottles and place them in coolers. Ice will then be added to the coolers to keep the sample temperatures within the sample bottles below 6 degrees Celsius. The sample bottles will then be transported to the laboratory within the allowable limits for sample holding times (see S8 Program QAPP Table 8-1).

In general, the laboratory will be notified at the onset of each sampling event to ensure that adequate laboratory staff will be available to process the incoming samples. Once in the laboratory, water from the containers will be used to fill pre-cleaned, preserved (where appropriate) sample bottles for the required analyses. All samples will be analyzed for the following parameters:

- Total suspended solids,
- Particle size distribution,
- pH,
- Total phosphorus,
- Ortho-phosphate,
- Hardness,
- Cadmium, total and dissolved
- Copper, total and dissolved
- Lead, total and dissolved,
- Zinc, total and dissolved,
- Mercury, total and dissolved[2],
- Orthophosphate
- Total phosphorus, and
- PAHs and phthalates[2].

[2] These parameters are included as chemicals of concern for Thea Foss Waterway Recontamination Evaluation and are not a required parameter under S8F.

Sample bottles used for water quality sampling will be cleaned by laboratory personnel prior to each sampling event using EPA QA/QC specifications Glassware Cleaning Following EPA Protocols (EPA 1990) (see S8 Program QAPP, Section 8.1.1).

8.4 Sediment Sampling

As described above in Section 7, sediment sampling will be performed at monitoring stations associated with the bioinfiltration and biofiltration facilities annually over the 2 year duration of this study (November 2009 – November 2011). Sample locations will be selected close to the inlet(s) where sedimentation is obvious. The first sample will be collected near the inlet and the second sample will be collected mid-channel in close proximity to the inlet. Both of the samples will be composited into a single sediment sample for the BMP site.

Sediment sampling procedures will generally follow Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound (PSEP 1997). In general, the following procedures will be used to sample sediment at any given station.
.

1. Any standing water present at the station will be removed using a bucket or pump. Care will be taken during this process to avoid disturbing the sediments in the area to be sampled.

2. The sediment sample will be obtained from the station using a stainless steel trowel or scoop on a pole and emptied into separate, large stainless steel bowl. Nitrile gloves will be worn at all times while collecting the sample. Field observations (including oil sheens and potential contributing activities) and sample characteristics (odor, amount and type of particles being removed, size description, color, etc.) will also be recorded during sample collection.

3. The contents in the bowl will then be homogenized with a stainless steel spoon. Freestanding liquid will be decanted from the bowl prior to homogenization.

4. Any particles greater than approximately 2 centimeter (cm) in size will be removed from the sample, placed in a separate container, and weighed to determine the proportion this material represents relative to the smaller sediment that remains in the bowl. Leaves will not be removed from the samples.

5. A pint jar will then be filled with the homogenized material from the bowl, labeled, placed on ice, and transported to the laboratory within the allowable limits for sample holding times (see S8 Program QAPP Table 8-1).

Once in the laboratory, the sediment samples will be analyzed for the following parameters:

- Grain size,
- Percent total solids,
- Total volatile solids,
- Total organic carbon [2],
- Total phosphorus,
- Total recoverable metals (cadmium, copper, mercury[2] , lead, and zinc),
- Total petroleum hydrocarbons (diesel fraction and oil fraction),
- PAHs and phthalates [2]; and
- PCBs [2].

[2] These parameters are included as chemicals of concern for Thea Foss Waterway Recontamination Evaluation and are not a required parameter under S8F.

All sediment sampling equipment, including the stainless steel trowels, scoops, buckets, and bowls, will be cleaned and decontaminated prior to each sampling event. Sample bottles used for water quality sampling will be cleaned by laboratory personnel prior to each sampling event using EPA QA/QC specifications Glassware Cleaning Following EPA Protocols (EPA 1990) (see S8 Program QAPP, Section 8.1.1).

8.4.1 Sediment Accumulation Monitoring

As described in Section 7, sediment accumulation rates are to be assessed at strategically located stations associated with the bioinfiltration and biofiltration facilities annually over the 2 year duration of this study (November 2009 – November 2011). Sediment accumulation rates will be measured at the sediment monitoring stations established in connection with the rain gardens. At each of these stations, field personnel will survey the cross sectional profile of the swale using a leveling instrument and surveyors rod. These measurements will be summarized graphically for use in quantifying sediment accumulation rates over time.

8.5 Soil Characterization

In the two bio-infiltration facilities, specifications called for installation of gravelly sand and compost. According to the construction manager, verification tests were performed to confirm the import material met the specifications. However, there are no documents that verify this was completed.

To verify the soil mixture in the Salishan swale and pond, three samples from each facility along the length of the facility (i.e., at upgradient, middle, and downgradient locations) will be collected and analyzed. Each sample will be vertically averaged over the depth of the infiltration layer (approximately three feet). The samples will be analyzed for:

- Grain size (including analysis of fines by hydrometer or pipette)
- Total organic carbon
- Cation exchange capacity

In addition, the depth of the infiltration layer will be measured at each sample location by digging or augering a test hole to the gravel underdrain layer. Sampling will be completed in the summer of 2010 when sampling activities won't disrupt stormwater sampling. A technical memo will be prepared summarizing the field methods, observations, and analytical results.

8.6 Controlled Infiltration Tests

8.6.1 Full-Scale Field Testing at East 46th and R Street Bioinfiltration Swale

1. Water from a nearby fire hydrant will be discharged to the stormwater inlet immediately upstream of the swale using a fire hose. A rotameter will be attached to the hose to measure the discharge rate from the hydrant.

2. The discharge rate from the hose will be varied to maintain a water depth of approximately 1.0 feet in the swale. Every 15 to 30 minutes, the discharge rate of water entering the swale and the water depth in the swale will be manually recorded. Optionally, a pressure transducer and data logger will installed and programmed to automatically and continuously record water depths during the test with a 1-minute logging interval.

3. After the discharge rate required for maintaining the target water depth (1.0 feet) in the swale stabilizes and remains constant for 60 minutes, water flow to the swale will be turned off. The time required for water remaining in the swale to infiltrate the soil will then be measured until there is no longer any standing water.

4. The infiltration rate for each swale is then computed using the following formula:

   $IR = \Delta L / \Delta T$

   Where: IR = Infiltration rate (inches/hour)
   ΔL = Change in water depth (in inches) from the time when water inputs are turned off to the time when no standing water is present
   ΔT = Change in time (in hours) from the time when water inputs are turned off to the time when no standing water is present.

5. If the full-scale field test cannot be performed at the East R Street facility due to unanticipated field constraints or logistical problems, the measurements will be performed using infiltrometers, as described in the next section.

8.6.2 Infiltrometer Measurements at East 44th Street Bioinfiltration Pond

1. Three sites within the pond will be selected to set up the double-ring infiltrometers. The sites will be systematically located along the flow path to provide representative coverage of the upper, middle, and lower third of the pond.

2. Vegetation will be cleared in approximately 10 foot by 10 foot area with a lawn mower or weed-whacker to prepare a clear working area. Care will be taken not compact the soil where the double-ring infiltrometers will be placed.

3. The inner ring will be placed with the cutting edge facing down on the ground. Small obstacles such as stones or twigs will be removed. Using a block of wood to spread the load, the infiltration ring will be hammered about 2 inches vertically into the soil. Care will be taken to minimize disturbance of the soil beneath the infiltrometers.

4. The outer ring will be placed around the inner ring and installed as described above for the inner ring.

5. The outer ring will be filled with water, then the inner ring, to a depth of approximately 4 inches. The water levels within the infiltration rings will be kept as low as possible to encourage only vertical infiltration (i.e., to minimize mounding and lateral loss). The rings will not be allowed to go dry.

6. Water from a nearby fire hydrant will be transferred to a tote tank located on the pond access road. Water will be transferred to a set of Mariotte tubes (constant head device) at each infiltrometer with a garden hose or bucket. Flow rate will be controlled by a valve or by adjusting the head, depending on the infiltration rate.

7. After the discharge rate required for maintaining the target water depth (4.0 inches) in the rings stabilizes and remains constant for 60 minutes, water flow will be turned off. The time required for water remaining in each inner ring to infiltrate the soil will then be measured until there is no longer any standing water.

8. The infiltration rate for each infiltrometer set will then computed using the following formula:

   $IR = \Delta L / \Delta T$

   Where: IR = Infiltration rate (inches/hour)

   ΔL = Change in water depth (in inches) from the time when water inputs are turned off to the time when no standing water is present

   ΔT = Change in time (in hours) from the time when water inputs are turned off to the time when no standing water is present.

9 Measurement Procedures

Please refer to S8 Program QAPP, Section 9 Measurement Procedures for Water and Sediment Quality Analysis.

10 Quality Control

Please refer to S8 Program QAPP, Section 10 Measurement Procedures.

11 Data Management Procedures

Please refer to S8 Program QAPP, Section 11 Data Management & Documentation Procedures.

12 Audits and Reports

Please refer to S8 Program QAPP, Section 12 Audits and Reports.

13 Data Verification and Validation

Please refer to S8 Program QAPP, Section 13 Data Verification and Validation.

14 Data Quality (Usability) Assessment

This section describes the process for assessing data usability, specifically, whether data of the right type, quality, and quantity have been collected to meet project objectives. The proposed methods for qualitative and quantitative data analysis are also described.

Please refer to S8 Program QAPP, Section 14 Data Quality (Usability) Assessment.

14.1 Data Quality Assessment Metrics

The data quality assessment process determines whether the sampling and analytical program has fulfilled the project objectives, including the DQOs established in Section 6.1, and whether the data can be used to support project management decisions with the desired level of confidence.

Data quality assessment is a professional judgment based on several lines of evidence:

- **Laboratory Data Validation Results**. This metric evaluates laboratory data quality, i.e., the extent to which MQOs for accuracy, precision, sensitivity, and bias have been met during laboratory analysis, as determined by the data validation process (see Section 13).

- **Field and Laboratory Completeness**. This metric evaluates data quantity, i.e., the extent to which the QAPP-specified numbers of valid field and laboratory measurements have been obtained and whether field and laboratory completeness goals have been achieved.

- **Sample Representativeness**. The degree to which the monitoring program provides a representative sample of the physical and chemical characteristics of influent stormwater will be evaluated. We will assess whether the flow-weighted composite samplers have successfully captured the time-varying characteristics of individual storm events (i.e., representative sampling of the runoff hydrograph); whether a representative range of storm sizes, intensities, and seasons have been sampled; and how the rainfall and runoff observed during the monitored year(s) compares to an average or “normal” year.

- **Statistical Power**. The statistical variability of the monitoring data (specifically, the coefficient of variation) will be evaluated using the statistical power table (Table 6-1) to determine whether the assumptions used to develop the sampling design are valid, and whether the sample sizes obtained are sufficient to meet the desired levels of statistical confidence and power.

14.2 Data Analysis Methods

14.2.1 Summary Statistics

For each detected chemical, the following summary statistics will be calculated for influent and effluent stormwater data sets:

- Number of samples analyzed
- Number and percentage of samples with detected concentrations
- Arithmetic mean concentration
- Arithmetic standard deviation
- Coefficient of variation
- Minimum and maximum concentrations
- Median concentration (50^{th} percentile)
- 10^{th} and 90^{th} percentile concentrations

Summary statistics will be calculated for each monitoring year and for the combined two-year (or longer) duration of the monitoring program.

The following rainfall parameters will be tabulated for each sampled storm event:

- Rain depth (inches)
- Peak storm intensity (inches/hour)
- Antecedent dry period (hours)

The following hydrologic parameters will be tabulated for each influent and effluent events:

- Average flow (cfs)
- Peak flow (cfs)
- Total discharge volume (acre-feet)

14.2.2 Treatment Efficiency Calculations

Treatment efficiency calculations are dependent on the hydraulic residence time of the BMP, as described below.

Biofiltration BMPs. The biofiltration BMPs are short-term facilities with hydraulic residence times on the order of 10 to 20 minutes. Treatment efficiency calculations will therefore be performed in accordance with Appendix A of Ecology's TAPE guidance, and primary emphasis will be placed on event mean comparisons. The following performance metrics will be calculated for each biofiltration site:

- Individual storm reduction in pollutant concentration
- Individual storm reduction in pollutant loading
- Average annual reduction in pollutant concentration
- Average annual reduction in pollutant loading

Bioinfiltration BMPs. Bioinfiltration BMPs are intermediate-term facilities with estimated lag times of 4 to 7 hours between influent and effluent peaks, based on subsurface infiltration rates and travel times. For smaller storms (i.e., less than about 0.5 inches), it is expected that the water exiting the BMPs will be residual pore water generated during a previous storm or storms. As a result, the influent and effluent data will not be analyzed as event-based data pairs, but instead the data will be pooled over many storms (i.e., over an entire year, or over the duration of the entire monitoring program) for general characterization and comparison purposes. By continuously monitoring the influent/effluent flows at these facilities, the following performance metrics will be calculated for each bioinfiltration site:

- Average annual reduction in pollutant concentration
- Average annual reduction in pollutant loading

Pervious Pavement BMPs. The pervious pavement plots are classified as short-term BMPs for hydrologic control. To evaluate hydrologic control efficiencies, the following performance metrics will be calculated for each of the pervious pavement plots:

- Individual storm reduction in peak flow
- Individual storm reduction in average flow
- Average annual reduction in flow volume

14.2.3 Graphical Data Presentation

Box-and-Whisker Plots. Box-and-whisker plots will be prepared to provide a qualitative comparison of differences between influent and effluent composition. Paired box-and-whisker plots will be prepared for key chemical parameters, including the following:

- Total suspended solids (TSS)
- Copper and zinc (total and dissolved)
- Phosphorus (total and ortho-)
- Particle size (median and 90th percentile)

To evaluate the effectiveness of the hydrologic control BMP at the pervious pavement site, box-and-whisker plots will be prepared for each test site for the following hydrologic parameters:

- Average flow (cfs)
- Peak flow (cfs)
- Total runoff volume (acre-feet)

Box-and-whisker plots will be generated using *Data Analysis for Microsoft Excel* (Berk & Carey 2000) or a suitable substitute. These plots will display the following characteristics of the data distributions:

- Interquartile range, or IQR (data between the 25th and 75th percentile)
- Median and arithmetic mean
- Moderate outliers (more than 1.5 x IQR above the 75th percentile, or below the 25th percentile)
- Extreme outliers (more than 3 x IQR above the 75th percentile, or below the 25th percentile)

Time-Series Graphs. Time-series graphs will be prepared for key chemical and hydrologic parameters. The influent and effluent concentrations will be displayed on the same graph. These graphs will be inspected to determine whether any changes in the effectiveness of the BMP are discernible over time, e.g. whether there is any improvement or deterioration in the performance of the BMP as the BMP surfaces mature (e.g., compaction of pavement surfaces, growth of vegetative cover, bio/geo/chemical changes in subsurface soil properties, etc.). Pollutant reductions (in percent) for key constituents will also be graphed over time (see Section 14.2.2).

14.2.4 Treatment of Non-Detected Values

The analytical laboratory will be required to report estimated values for any detections between the Method Detection Limit (MDL) and the reporting limit (RL), with appropriate data qualifiers (e.g. J-flags). For general summary statistics, undetected values will be substituted at one-half the MDL.

For higher-level statistical analyses, other treatment methods are available for evaluating constituents with a high percentage of undetected values (i.e., >15 percent non-detects). The primary methods for evaluating data sets with a high percentage of non-detects (i.e., "censored" data sets) include: (1) use of nonparametric statistical methods, and (2) extrapolation of data distributions into the undetected region through the use of probability plot regressions (see Ecology 1993).

14.2.5 Identification of Outliers

Outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. It should be noted, however, that lognormal data distributions can tolerate relatively extreme high values, and nonparametric tests are relatively insensitive to the magnitude of outlier concentrations. Thus it may be possible to select statistical tests that minimize the impacts from outliers.

Moderate outliers (deviations greater than 1.5 times the IQR) and extreme outliers (deviations greater than 3 times the IQR) will initially be identified in the box plots described in Section 14.2.2. Other types of outlier tests may be selected based on the recommended methods in Section 4.4 of the EPA document "Guidance for Data Quality Assessment" (EPA/600/R-96/084).

Outliers will not be removed from any data set unless there is supporting information to indicate the outlier was caused by an unusual and unrepresentative event. This type of information would be discussed with Ecology before any decisions are made to exclude any outlier data points.

14.2.6 Statistical Distribution Testing

To verify the appropriateness of using parametric statistical tests, such as pair comparison tests of influent versus effluent concentrations (see Section 14.2.7), conformance of stormwater data with standard statistical distributions (e.g., normal or lognormal distributions) should be demonstrated. Statistical distribution testing will generally follow *Statistical Guidance for Ecology Site Managers* (Ecology 1992, 1993) using the *MTCAStat* program.

For constituents containing mostly detected concentrations (<15% nondetects), numerical distribution tests may be used (Shapiro and Wilk 1965; Gilbert 1987). It is expected that the majority of the monitoring parameters for BMP effectiveness will meet this criterion. For data with a higher percentage of nondetects, probability plot regression methods will be used to help estimate the characteristics of the data distribution below the detection limit (Ecology 1993).

Lognormal test results for Tacoma's stormwater monitoring data from 2001 through 2007 showed excellent conformance to lognormal distributions (Tacoma 2008). These results indicate BMP influent and effluent stormwater concentrations may be similarly lognormal in character, and that parametric statistical tests may be appropriate. However, the assumption of lognormality will be confirmed with the BMP monitoring data.

14.2.7 Pair Comparison Tests (Short-term Biofiltration Facilities and Pervious Pavements)

For treatment facilities with short detention times, including biofiltration and pervious pavement BMPs, treatment efficiencies will be determined using pair comparison tests of influent versus effluent concentrations for individual storm events. Such tests will demonstrate whether significant reductions in chemical concentrations, flow rates or volumes are observed in the effluent stream after treatment.

If the influent and effluent data conform to normal distributions (see Section 14.2.6), then a paired T-test will be performed. If the influent and effluent data conform to lognormal distributions, then a paired T-test will be performed using the logarithms of the data.

If data distributions do not conform to standard normal or lognormal distributions, nonparametric statistical methods will be employed to determine whether influent and effluent concentrations are significantly different. Ecology recommends two types of nonparametric pair comparison tests – the Sign Test and the Mann-Whitney Signed Rank Test. The Mann-Whitney Signed Rank Test has more power than the Sign Test but it requires the data distributions to be symmetrical. As a result, it may be more appropriate to conduct this test using the logarithms of the data to attenuate highly skewed values, which are sometimes observed in stormwater.

While the concentration reduction is the primary effectiveness metric, a mass loading reduction may also be calculated since there will be continual flow monitoring of the BMP devices. In particular, there may be some infiltration beneath the biofiltration BMPs, and thus some reduction in both stormwater volume and concentration. For this calculation, the mean influent and effluent flow-weighted concentrations will be multiplied by the total annual influent and effluent discharge volumes to calculate an annualized mass loading reduction.

14.2.8 Population Comparison Tests (Intermediate-term Bioinfiltration Facilities)

For bioinfiltration facilities with intermediate detention times, event-based pair comparisons are not appropriate. Instead, influent and effluent data will be pooled across many storms to provide general population characteristics for statistical comparisons. Reductions in concentration will be calculated for each complete water year and also for the entire BMP monitoring program. Confidence intervals on the concentration reductions may be calculated using the Monte Carlo method presented in Ecology's Draft TAPE for Long Detention Times, or alternatively, a nonparametric "bootstrapping" method may be used which makes no assumptions about the statistical distributions of the data.

While the concentration reduction is the primary effectiveness metric, a mass loading reduction may also be calculated since there will be continual flow monitoring of the BMP devices. Although the underdrains will likely capture much of the infiltration, there may be lateral losses from the facility or losses to transpiration or other processes, and thus some reduction in both stormwater volume and concentration. For this calculation, the mean influent and effluent flow-weighted concentrations will be multiplied by the total annual influent and effluent discharge volumes to calculate an annualized mass loading reduction.

15 DATA ANALYSIS AND PRESENTATION

This section discusses the content of the Annual Stormwater Monitoring Report, which covers data collected during the previous water year. Each Annual Stormwater Monitoring Report, which is an attachment to the Annual Report under the Phase I Permit, is required to include the following four elements (Permit Section H.1 .a):

1. A summary including the BMP type location, land use, drainage area size, and hydrology for each site,
2. The status of implementing the monitoring program,
3. A comprehensive data and QA/QC report for each part of the monitoring program, with an explanation and discussion of the results of each monitoring study; and
4. Performance data.

These requirements are discussed below in three sections that will likely provide the outline for the report; a site summary, a comprehensive data summary, and a QA/QC summary.

15.1 Site Summary and Status

The site summary and status will include a summary of the study and the current status.

Site Summary The "summary including the BMP type location, land use, drainage area size, and hydrology for each site" is a brief description of the more detailed information presented in this QAPP. Additionally, the following information, if applicable, will be included in this section of the annual Stormwater Monitoring Report:

- Describe any land use changes in the drainage basin that would potentially affect hydrology or pollutant loading.
- Indicate hydrologic information if a monitoring site is subject to base flow from groundwater or is tidally influenced. Describe backwater conditions or other site-specific conditions if they influence sampling.
- Describe any preliminary conclusions regarding BMP effectiveness. Ecology recognizes that it may be too early to draw conclusions depending upon study design.

Status:

- A description of any changes made to the sampling program. Significant changes must be documented in a revised QAPP.
- A narrative description of status as of the end of the reporting period and statement as to when the program will be completed, if appropriate.
- A physical description of the BMP for the reporting period, such as damage, maintenance actions or repairs.
- Based on the monitoring activities up through the reporting period, the status of meeting the statistical goal, including an estimate of the remaining number of samples needed to meet these statistical performance measures.

15.2 Comprehensive Data Summary

The comprehensive data report will include at a minimum:

Stormwater sampling results

- A table or descriptive summary indicating whether the sampled storm events met the requirements listed in Tables 7-1 and 7-2.
- For each storm event at each site, a summary or graph of the following:
  - Time versus precipitation,
  - Time versus flow rate, and
  - Time versus initiation of aliquot collection.
- Tables showing qualified analytical results from each sampling event.
- Tables showing hydrological information for each measured event:
  - Total precipitation (inches),
  - Influent, effluent, and bypass peak flow rate (gpm), and
  - Total influent, effluent, and bypass volume (gallons).
- Tables showing sampling information for each measured event:
  - Number of influent and effluent aliquots,
  - Influent and effluent EMCs for each parameter monitored.

Sediment sample results

- Tables showing qualified sediment quality data.

Performance results

- Tables showing performance data for each event that has usable paired data.

15.3 Quality Assurance/Quality Control Summary

The QA/QC summary will include at a minimum:

1. A data validation memo for each sampling event that includes: (a) a narrative analysis of appropriate *field quality control* procedures *data quality indicator results* and of any associated issues and corrections made and (b) a narrative analysis of appropriate laboratory quality control procedures with measurement quality objectives discussed, any associated issues and corrections made.

2. A summary Quality Assurance Report, which includes:
   - A narrative summarizing the data validation memos that apply to the entire reporting period.
   - An overall assessment of the usability and representativeness of the data.
   - A summary description of any planned changes or deviations from the approved QAPP to address problems encountered during QA/QC.

References

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List of Revisions

The current list of revisions for this QAPP follows.

Revision Number	Effective Date	Revised by	Revision Summary
S8F-001	8/11/2008	Dana de Leon, Lauren McIntire, Chris Burke and Todd Thornburg	Initial draft.
S8F-002	1/30/2009	Dana de Leon, Lauren McIntire, Chris Burke and Todd Thornburg	Redline
S8F-003	11/30/2009	Dana de Leon, Lauren McIntire, Chris Burke and Todd Thornburg	Final

Appendix A
Design Criteria for BMPs

Design Criteria for Salishan Rain Garden

TABLE A-1.	Salishan Bioinfiltration Swale Info Requested /4/2008 for DOE Evaluation
TABLE A-2.	Flow Splitter Orifice Calculations
DOCUMENT A-1.	Design Criteria from DOE BMP T7.30 Bio-infiltration Swale
FIGURE A-1.	Salishan Drawings

Design Criteria for Alternatives

TABLE A-3.	Trolley Court Biofiltration Swale Info Requested 2/4/2008 for DOE Evaluation
TABLE A-4.	Design Criteria from DOE BMP T9.10 Basic Biofiltration Swale
FIGURE A-2.	Trolley Court Drawings
TABLE A-5.	E. 32nd Biofiltration Swale Info Requested 2/4/2008 for DOE Evaluation
TABLE A-6.	Design Criteria from DOE BMP T9.10 Basic Biofiltration Swale
TABLE A-7.	Flow Splitter Orifice Calculations
FIGURE A-2.	E. 32nd Drawings

Note: Design drawings that have been provided on the CD are designated as Exhibits A – L. Design reports that have been provided on the CD are designated as Reports 1 – 3.

TABLE A-1. Salishan Bioinfiltration Info Requested 2/4/2008 for DOE Evaluation

1	**Drainage area details:**			
1a	**Percentage of area in each Land Use category**			
		100% Residential		
1b	**Impervious area total:**			
	East 44th Pond		8.183	acre
	East R Swale 1		0.611	acre
1c	**Type and sizes of impervious areas:**			
	Type:	***residential streets & parking; NOTE:*** *roof impervious bypasses treatment & is tight-lined to the storm water conveyance system.*		
	Sizes:	***See 1b above for impervious areas generating runoff that are infiltrated by the swales***		
1d	**PGIS :**	***NOTE:*** *all impervious considered was PGIS*		
	East 44th Pond		8.183	acre
	East R Swale 1		0.611	acre
1e	**PGPS:**			
	East 44th Pond		5.715	acre
	East R Swale 1		1.432	acre
1f	**Non-PGIS:**			
		0 acres or 0 SF total; NOTE: *all pervious surfaces were assumed to be PGPS*		
1g	**Type of pervious areas:**			
		Till Grass		

TABLE A-1 Cont.

2 Design Documentation:

2a Engineering calculations for sizing the facility:

Appendix D of Report 1 on the CD

2b Comparison to all design criteria and sizing required by the permit/'05 manual:

See Document A-1 of this appendix.

2c Drawings showing location, dimensions, influent and effluent conveyances:

See Figure A-1. Salishan Drawings of this appendix.

2d Verification of the facility as on-line or *off-line*

If off-line, provide design basis and details of bypass or **splitter:**

See Appendix C of Report 1 on the CD for 44th Street Pond flow splitter calcs.

3 Site Soils and Groundwater (soils testing will be done by City of Tacoma in November 2009)

3a High groundwater elevations (especially critical for wetpool designs):

n/a

3b Site soils and pertinent design details

3b1 Liner(s):

No liner. Layers consist of existing subsoil, bio-infiltration soil mix, and shredded bark mulch.

3b2 Estimated infiltration losses from pond/wetland:

Unknown

3b3 Documentation of soil analyses (size gradation, CEC, etc) and compost quality if involved in treatment or design water loss:

Existing soils analyses: ***see Appendix A of Report 1 on the CD.***

3c Description of methods & procedures used to determine the long-term bioinfiltration swale infiltration rates:

Unknown

TABLE A-1 Cont.

4	**Media Description and Specifications (soils testing & plant I.D. will be done by the City of Tacoma; 4a-d will be revised)**
4a	Vegetation species (swales, strips, bioretention, wetlands) and densities:
	native groundcover & shrub plants
4b	Artificial media types, sizes/gradation, depths (or thickness):
	Unknown
	Sand type, gradation, depth (or thickness)
4c	***65-70% gravelly sand***
	Description of any Amendments
4d	***30-35% composted by volume; compost will be 7/16-inch material per WAC 173-350-220 (10) rating.***
5	**Proposed Monitoring Locations**
5a	Percent of drainage area and influent flow tributary to monitoring site; NOTE: not shared drainage area

	Drainage Area (%)	Influent Flow Tributary to Monitor (%)
East 44th Pond	100%	100.0%
East R Swale 1	100%	100.0%

6	**O&M Status**
6a	The condition of the facility as compared to the parameters in the Maintenance Table (Table 4.5 of the '05 manual).
	The East R St. Swale 1 will be maintained by either the Tacoma Housing Authority (THA) or a homeowners association. The East 44th St. pond will be maintained by the City of Tacoma. Amended soils will be tested & maintained, plants will be pruned & replaced when necessary, litter & sediment will be removed, and the hydraulic structures will be repaired when necessary. Appendix G Report 1 on the CD is a draft maintenance checklist.
	This system was recently installed; therefore it is too early to comment on the condition.

TABLE A-2. Flow Splitter Orifice Calculations: Calculation 1 on CD

CITY OF TACOMA'S ASSESSMENT

THEORETICAL

Equation	Orifice Equation		Q =	CA(2gh)^.5
Given	WQ=	0.7016	cfs	NOTE: from WWHM2 using 15-min time steps
	WQ (110%) =	0.77176	cfs	
	C=	0.62	per EIT Book	
	g=	32.2		

Find Dimensions for flow splitter such that:

- A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility.
- The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.

Solve

Diameter, D (in)	Area, A (ft^2)	Head, h (ft)	Orifice Q at 100-yr Flow (cfs)	% of WQ Design Flow
0.5	0.0014			
1	0.0055			
1.5	0.0123			
2	0.0218	50.54968951	0.77176	110.00%
2.5	0.0341	20.70515282	0.77176	110.00%
3	0.0491	9.985123853	0.77176	110.00%
3.5	0.0668	5.389721163	0.77176	110.00%
4	0.0873	3.159355594	0.77176	110.00%
4.5	0.1104	1.972370144	0.77176	110.00%
5	0.1364	***1.294072051***	0.77176	110.00%
5.5	0.1650	0.883868623	0.77176	110.00%
6	0.1964	0.624070241	0.77176	110.00%

TABLE A-2. Cont.

ACTUAL				
Equation	Orifice Equation		WQactual =	CA(2gh)^.5
Given	WQ=	0.7016	cfs	NOTE: from WWHM2 using 15-min time steps
	WQ (110%) =	0.77176	cfs	
	C=	0.62	per EIT Book	
	g=	32.2		
	h=	1.5	ft	
	A=	0.1364	ft^2	
Find	WQactual			
	%ofWQ			
Solve	***WQactual=***	***0.8309***	***cfs***	
	%of WQ=	***15.56***	***%***	Should be no more than 110% of 6-month, 24-hr storm per DOE
	% beyond WQ(110%)=	5.91	%	Approximately 6% more flow going to system than max allowable

TABLE A-2. Cont.

PARAMETRIX'S ASSESSMENT; NOTE: All inputs are the same as in their Appendix C of the report except the 110%-of-WQ value is fixed					
THEORETICAL					
Equation	Orifice Equation		Q =	CA(2gh)^.5	
Given	WQ=	0.6402	cfs	NOTE: from WWHM2 using 15-min time steps	
	WQ (110%) =	0.70422	cfs		
	C=	0.68	Source unknown; back-calculated		
	g=	32.2			
Find	Dimensions for flow splitter such that:				
	*	A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility.			
	*	The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.			
Solve					
	Diameter, D (in)	**Area, A (ft^2)**	**Head, h (ft)**	**Orifice Q at 100-yr Flow (cfs)**	**% of WQ Design Flow**
	0.5	0.0014			
	1	0.0055			
	1.5	0.0123			
	2	0.0218	34.98937821	0.70422	110.00%
	2.5	0.0341	14.33164932	0.70422	110.00%
	3	0.0491	6.911482116	0.70422	110.00%
	3.5	0.0668	3.730645907	0.70422	110.00%
	4	0.0873	2.186836138	0.70422	110.00%
	4.5	0.1104	1.365231035	0.70422	110.00%
	5	0.1364	***0.895728082***	0.70422	110.00%
	5.5	0.1650	0.611794333	0.70422	110.00%
	6	0.1964	0.431967632	0.70422	110.00%

TABLE A-2. Cont.

ACTUAL				
Equation	Orifice Equation		WQactual =	CA(2gh)^.5
Given	WQ=	0.6402	cfs	NOTE: from WWHM2 using 15-min time steps
	WQ (110%) =	0.70422	cfs	
	C=	0.68	per EIT Book	
	g=	32.2		
	h=	1.5	ft	
	A=	0.1364	ft^2	
Find	WQactual			
	%ofWQ			
Solve	***WQactual=***	***0.9113***	***cfs***	
	%of WQ=	***29.75***	***%***	Should be no more than 110% of 6-month, 24-hr storm per DOE
	% beyond WQ(110%)=	20.71	%	Approximately 20% more flow going to system than max allowable

TABLE A-2. Cont.

CONCLUSION
Appendix C of Report 1 on the CD shows that Parametrix found that an orifice diameter of 4-inches should be used. For a diameter of 4-inches, the weir height (head) is approx. 1.97-ft, or 2-ft. However, on sheet C5.3 (Exhibit B) it shows that the orifice diameter proposed to be used changed to 5-inches with a weir height of 2-ft. It was field verified that the installed orifice's diameter is 5-inches with a weir height of 1.5-ft.
In "Parametrix's Assessment" above it can be seen that the WQ = 0.6102 cfs, which is not the WQ shown in the WWHM2 calculations calculations found in Appendix D of Report 1 on the CD. On 12/31/08 Greg Hannan wrote "Please note that the flow splitter calculations were completed before the final tweaking of the basins and modeling & explains why there is a minor difference between the flow rates. This should not have any impact whatsoever to the function of the system." For Parametrix's orifice diameter of 5-inches the calculated weir height (i.e. head) is found to be 0.8-ft whereas the actual installed weir height is 1.5-ft, thus the water quality pond receives more than the 6-month, 24-hr WQ determined by Parametrix. Using the actual installed weir height and Parametrix's other values, the WQactual = 0.9113cfs, or 29.75% of the WQ. Recall that the max allowable WQ rate per DOE is WQ(110%) = 0.70422 cfs, making the WQactual approximately 20.7% beyond that.
"The City of Tacoma's Assessment" above shows the results using a slightly different C value and the correct WQ = 0.7016 cfs. The resultant weir height for an orifice diameter of 5-inches is 1.29-ft. Using the actual installed values determined in the field the WQactual = .0.8309 cfs, or 15.56% of the WQ. Recall that the max allowable WQ rate per DOE is WQ(110%) = 0.77176 cfs, making the WQactual approximately 5.91% beyond that.
Assuming "The City of Tacoma's Assessment" is correct, the weir height is approximately 0.21-ft or 2.5-inches too tall. If this concrete weir were modified to the correct weir height of approximately 1.29-ft, the flow control structure would bypass flows greater than the 6-month, 24-hr storm event.

DOCUMENT A-1. Design Criteria from DOE BMP T7.30 Bio-infiltration Swale
(DOE 2005 Manual Volume V page 7-5)

- **Sizing**
  Use the same design sizing procedures outlined in Chapter 3 of Volume III for infiltration facilities designed as treatment facilities.

  - **2005 DOE Manual Excerpt: Volume III Section 3.3.9**

    (B) For 91% infiltration (water quality treatment volume)

    On-line treatment facilities placed ***upstream or downstream*** of a detention facility must be sized to infiltrate 91% of the runoff file volume directed to it.
    Off-line treatment facilities placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by WWHM (or other approved continuous runoff model), to the treatment facility. Within the WWHM, the flow splitter icon is placed ahead of the pond icon which represents the infiltration basin. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

    See Chapter 4 for flow splitter design details.

    NOTE: The above referenced "Chapter 4" appears to not exist under Volume III. It has been assumed that the reference meant to refer to Volume V Section 4.5.1 and thus the assessment of the flow splitter design was done using Vol. V Sec. 4.5.1. See "….." to see this assessment.

  - **Salishan HOPE VI Redevelopment Stormwater Site Plan – Area 2A (100% Design), hereafter referred to as "Report 1"**

    In Appendix D "Bioinfiltration (Soil Filtration) Facility Sizing Calculations are the WWHM2 calculations for East 44th Pond and East R Swale 1. At the end of the output data is the following information per swale:

    East 44th Pond
    Water Quality BMP Flow and Volume:
    On-line facility volume: *1.0419 acre-feet*
    On-line facility target flow: *1.114 cfs*
    Adjusted for 15 min: *1.1973 cfs*
    Off-line facility target flow: *0.6402 cfs*
    Adjusted for 15 min: *0.688 cfs*

East R Swale

Water Quality BMP Flow and Volume:

On-line facility volume: *0.1121 acre-feet*
On-line facility target flow: *0.0916 cfs*
Adjusted for 15 min: *0.0949 cfs*
Off-line facility target flow: *0.0514 cfs*
Adjusted for 15 min: *0.0533 cfs*

- **Drawdown Time**
  For the water quality design volume: 48 hours max. See Site Suitability Criterion (SSC 4) in Section 3.3.7, Chapter 3, Volume III**.**
  - **Manual Excerpt:** **SSC-4, Volume III Section 3.3.7**

    Drawdown time:
    For infiltration facilities designed strictly for flow control purposes, there isn't a maximum drawdown time. If sizing a treatment facility, document that the 91st percentile, 24-hour runoff volume (indicated by WWHM or MGS Flood) can infiltrate through the infiltration basin surface within 48 hours. This can be calculated using a horizontal projection of the infiltration basin mid-depth dimensions and the estimated long-term infiltration rate.

    This drawdown restriction is intended to meet the following objectives:
    • aerate vegetation and soil to keep the vegetation healthy
    • enhance the biodegradation of pollutants and organics in the soil.
  - **Report 1:**
    2"/hr (per a Parametrix employee affiliated with the project)

- **Swale Bottom:**
  Flat with a longitudinal slope less than 1%
  - **Report 1:**

    Swale 1 = 0%
    Swale 2 = 0%

- **Max Ponded Level:**
  6 inches
  - **Report 1:**
    1' (overflow height)

- **Treatment Soil:** City of Tacoma will test actual soils and report in the annual report.
  To be at least 18 inches thick with a CEC of at least 5 meq/100 gm dry soil, organic content of at least 1%, and sufficient target pollutant loading capacity. The design soil

thickness may be reduced to as low as 6 inches if appropriate performance data demonstrates that the vegetated root zone and the natural soil can be expected to provide adequate removal and loading capacities for the target pollutants. The design professional **should** calculate the pollutant loading capacity of the treatment soil to estimate if there is sufficient treatment soil volume for an acceptable design period. (See Criteria for Assessing the Trace Element Removal Capacity of Biofiltration Systems, Stan Miller, Spokane County, June 2000).

NOTE: Other combinations of treatment soil thickness, CEC, and organic content design factors can be considered if it is demonstrated that the soil and vegetation will provide a target pollutant loading capacity and performance level acceptable to the local jurisdiction.

- **<u>Report 1:</u>**
  - "Each water quality treatment facility will be constructed by excavating and backfilling with a minimum of 18 inches of compost-amended soils to improve water retaining capacity, filtration, and sorption as well as allowing for pollutant uptake by vegetative root zones." (pg 4-5)
  - "The engineered soil mix for the bioretention facilities will nominally be 30 to 35 percent composted material by volume and approximately 65 to 70 percent gravelly sand. These materials will be well-mixed and placed in the facilities to a depth of 2 to 4.5 feet. Compost will be 7/16-inch material meeting the stability rating of very stable, stable, or moderately unstable as defined in WAC 173-350-220 (10)." (pg 4-5)
  - Per site construction manager, contractor submittals and some testing to verify conformance to specifications was completed.

- **Treatment Zone Depth:**
  6 inches or more should contain sufficient organics and texture to ensure good growth of the vegetation. <u>City of Tacoma will test actual soils and report in the annual report</u>.
  - **<u>Report 1:</u>**
    Refer to the response to the above "Treatment Soil" subject

- **Treatment Soil Infiltration Rate:** <u>Facilities will be tested by Tacoma per QAPP</u>
  Should not exceed 1-inch per hour for a treatment zone depth of 6 inches relying on the root zone to enhance pollutant removal. The Site Suitability Criteria in Section 3.3.7 of Chapter 3, Volume III **must** also be applied, if a design soil depth of 18 inches is used then a maximum infiltration rate of 2.4 inches per hour is applicable.
  - **<u>Report 1:</u>**
    Refer to the response to the above "Treatment Soil" subject

    "**Facility infiltration rates:** Based on the expected infiltration rate of the amended soils, an infiltration rate of 2.4 inches per hour was used for swales in Area 2A." (pg 4-7)

- **Grass:**
  Use native or adapted grass should be used.

  - **<u>Report 1:</u>**
    "Swales and ponds will be planted with native groundcover and shrub plants." (Pg 4-5)

  - Per site construction manager, plantings were completed by Berger Partnership. Tacoma will confirm plantings per QAPP

- **Pretreatment:**
  Pretreatment of debris, gross TSS, and oil & grease to prevent the clogging of the treatment soil and/or growth of the vegetation, **where necessary**.

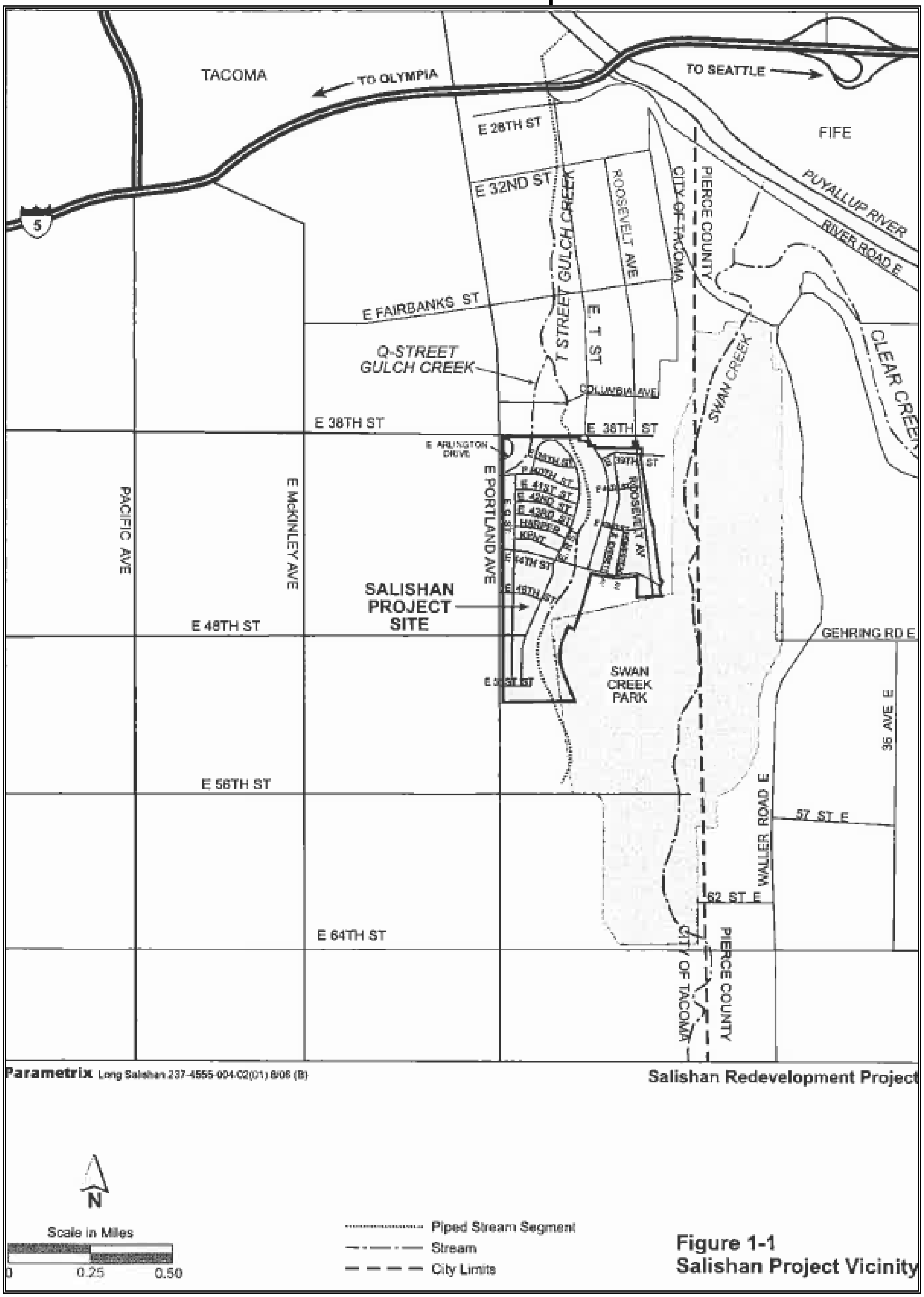
  - **<u>Salishan Site Visit:</u>**
    No pretreatment exists nor is it necessary.

- **Pollutant Identification:**
  Identify pollutants particularly in industrial and commercial area runoff, that could cause a violation of Ecology's ground water quality Standards (Chapter 173-200 WAC). Include appropriate mitigation measures (pretreatment, source control, etc.) for those pollutants.

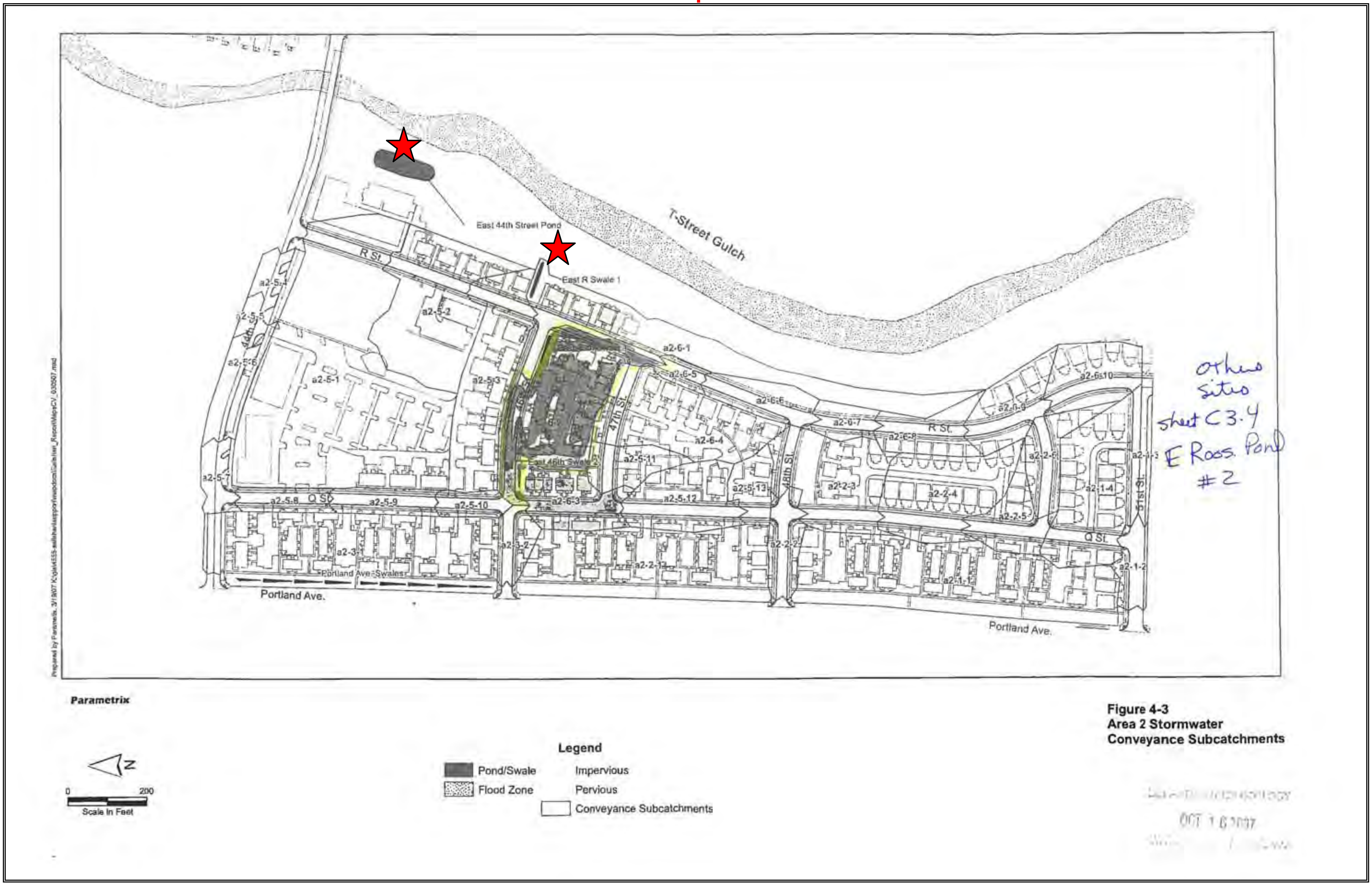
  - **<u>Salishan Site Visit:</u>**
    Pollutants of this type are not of concern in this residential development.

FIGURE A-1. Salishan Drawings

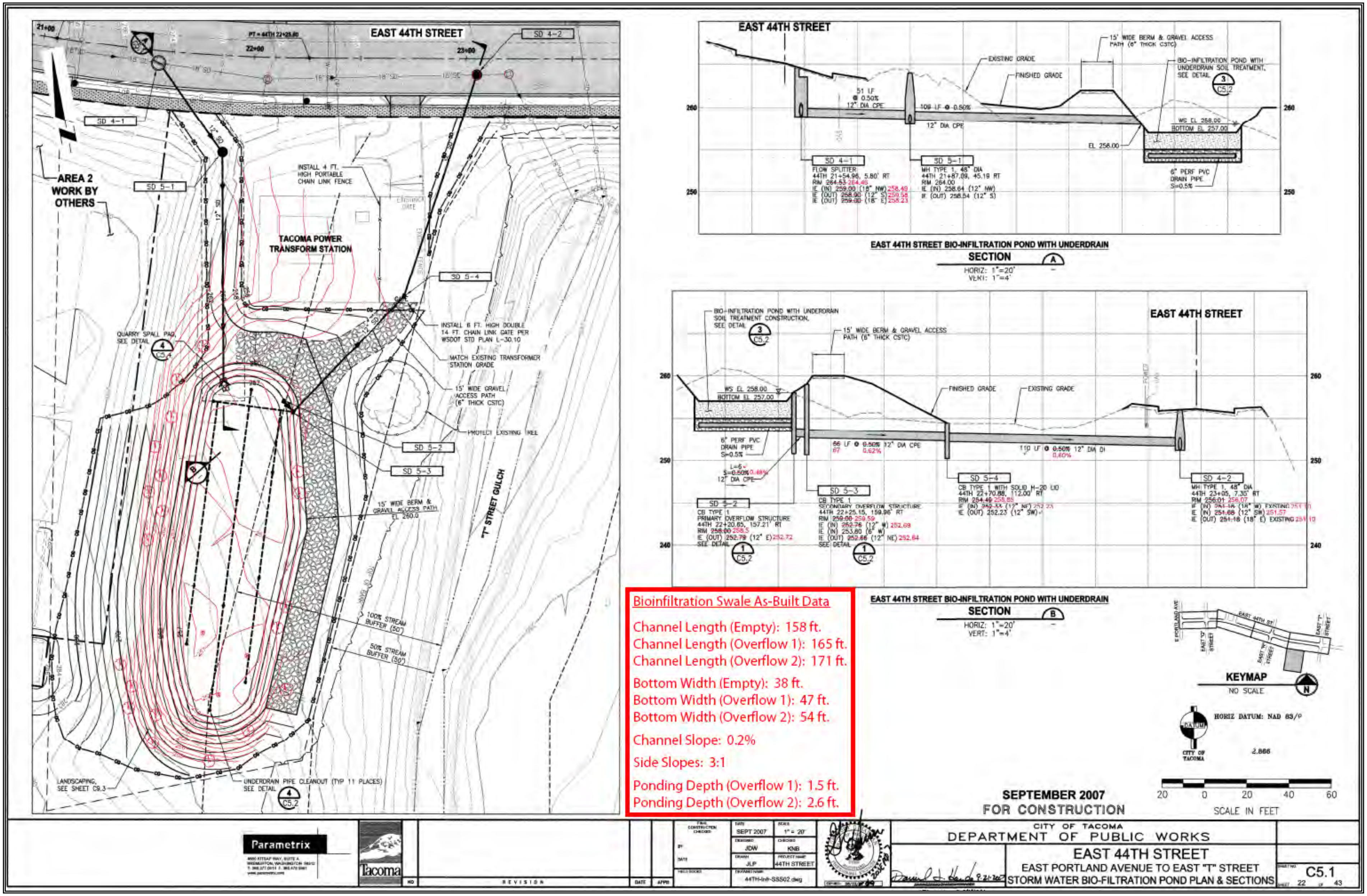
Location Map 1



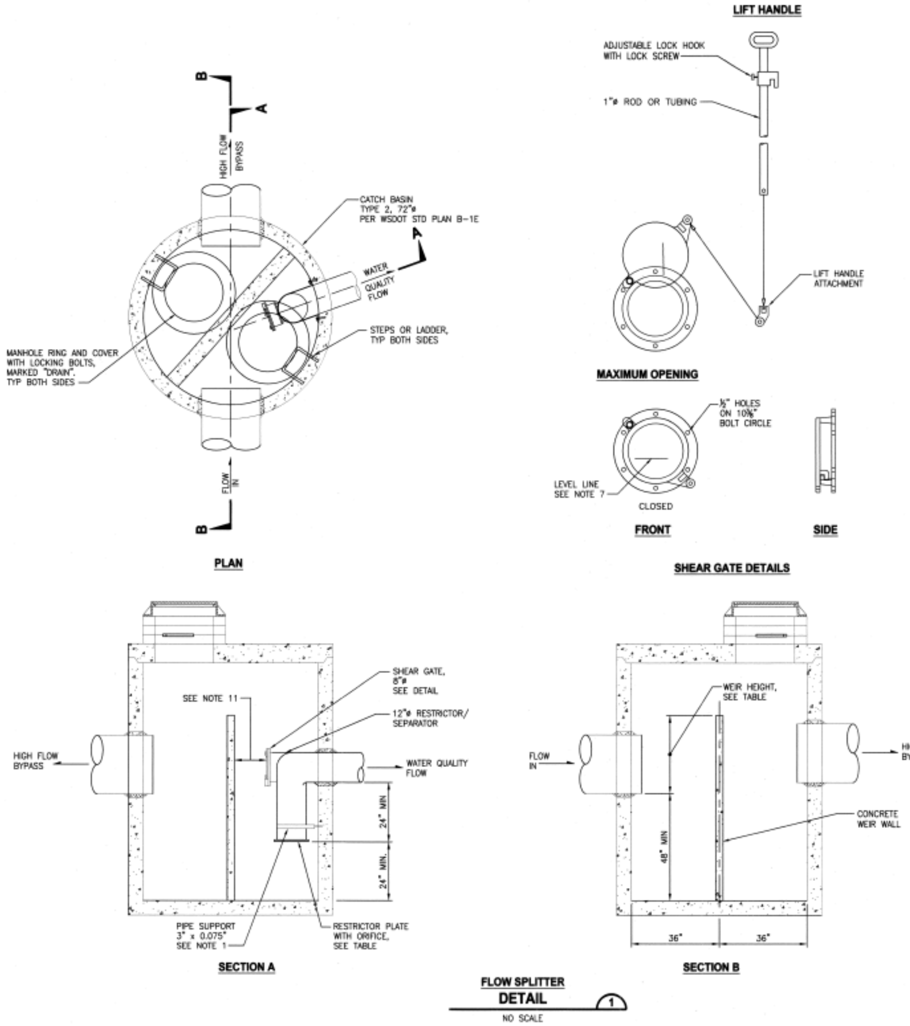
Location Map 2



44th St. Pond: Exhibit A on CD



44th St. Pond Flow Splitter Details: Exhibit B on CD



FLOW SPLITTER NOTES:

1. THE PIPE SUPPORT AND THE RESTRICTOR/SEPARATOR SHALL BE CONSTRUCTED OF THE SAME MATERIAL AND BE ANCHORED AT A MAXIMUN SPACING OF 36". ATTACH THE PIPE SUPPORT TO THE MANHOLE WITH 5/8" STAINLESS STEEL EXPANSION BOLTS OR EMBED THE SUPPORT INTO THE MANHOLE WALL 2".
2. THE FLOW RESTRICTOR/SEPARATOR SHALL BE FABRICATED FROM ONE OF THE FOLLOWING MATERIALS:
   0.060" CORRUGATED ALUMINUM ALLOY DRAIN PIPE
   0.064" CORRUGATED GALVANIZED STEEL DRAIN PIPE WITH TREATMENT 1
   0.064" CORRUGATED ALUMINIZED STEEL DRAIN PIPE
   0.060" ALUMINUM ALLOY FLAT SHEET, IN ACCORDANCE WITH ASTM B 209M, 5052 H32 OR EPS
   HIGH DENSITY POLYETHYLENE STORM SEWER PIPE.
3. THE FRAME AND LADDER OR STEPS ARE TO BE OFFSET SO THAT: THE SHEAR GATE IS VISIBLE FROM THE TOP; THE CLIMB-DOWN SPACE IS CLEAR OF THE RISER AND GATE; THE FRAME IS CLEAR OF THE CURB.
4. ORIFICE IS TO BE CUT ROUND AND SMOOTH.
5. THE SHEAR GATE SHALL BE MADE OF ALUMINUM ALLOY IN ACCORDANCE WITH ASTM B 26M AND ASTM B 275, DESIGNATION ZG32A; OR CAST IRON IN ACCORDANCE WITH ASTM A 48, CLASS 30B. THE LIFT HANDLE SHALL BE MADE OF A SIMILAR METAL TO THE GATE (TO PREVENT GALVANIC CORROSION), IT MAY BE OF SOLID ROD OR HOLLOW TUBING, WITH ADJUSTABLE HOOK AS REQUIRED. A NEOPRENE RUBBER GASKET IS REQUIRED BETWEEN THE RISER MOUNTING FLANGE AND THE GATE FLANGE. INSTALL THE GATE SO THAT THE LEVEL-LINE MARK IS LEVEL WHEN THE GATE IS CLOSED. THE MATING SURFACES OF THE LID AND THE BODY SHALL BE MACHINED FOR PROPER FIT. ALL SHEAR GATE BOLTS SHALL BE STAINLESS STEEL.
6. THE SHEAR GATE MAXIMUM OPENING SHALL BE CONTROLLED BY LIMITED HINGE MOVEMENT, A STOP TAB, OR SOME OTHER DEVICE.
7. ALTERNATE SHEAR GATE DESIGNS ARE ACCEPTABLE, IF MATERIAL SPECIFICATIONS ARE MET AND FLANGE BOLT PATTERN MATCHES.
8. SEE PLANS FOR SIZE AND LOCATION OF ALL PIPES AND ORIFICES.
9. CONCRETE WEIR WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
10. CONCRETE WEIR WALL SHALL BE KEYED AND GROUTED IN PLACE.
11. PROVIDE MAXIMUM CLEARANCE BETWEEN THE WEIR WALL AND THE SHEAR GATE (18 INCHES MINIMUM). THIS MAY BE ACHIEVED BY SKEWING THE OUTLET PIPE AWAY FROM CENTER AS NEEDED.

FLOW SPLITTER TABLE

FLOW SPLITTER #	SWALE/POND	WEIR HEIGHT (FT)	ORIFICE ø IN
SD 4-1	44TH ST POND	~~2.0~~ 1.6	5.0

SEPTEMBER 2007
FOR CONSTRUCTION

Parametrix

Tacoma

NO	REVISION	DATE	APPD

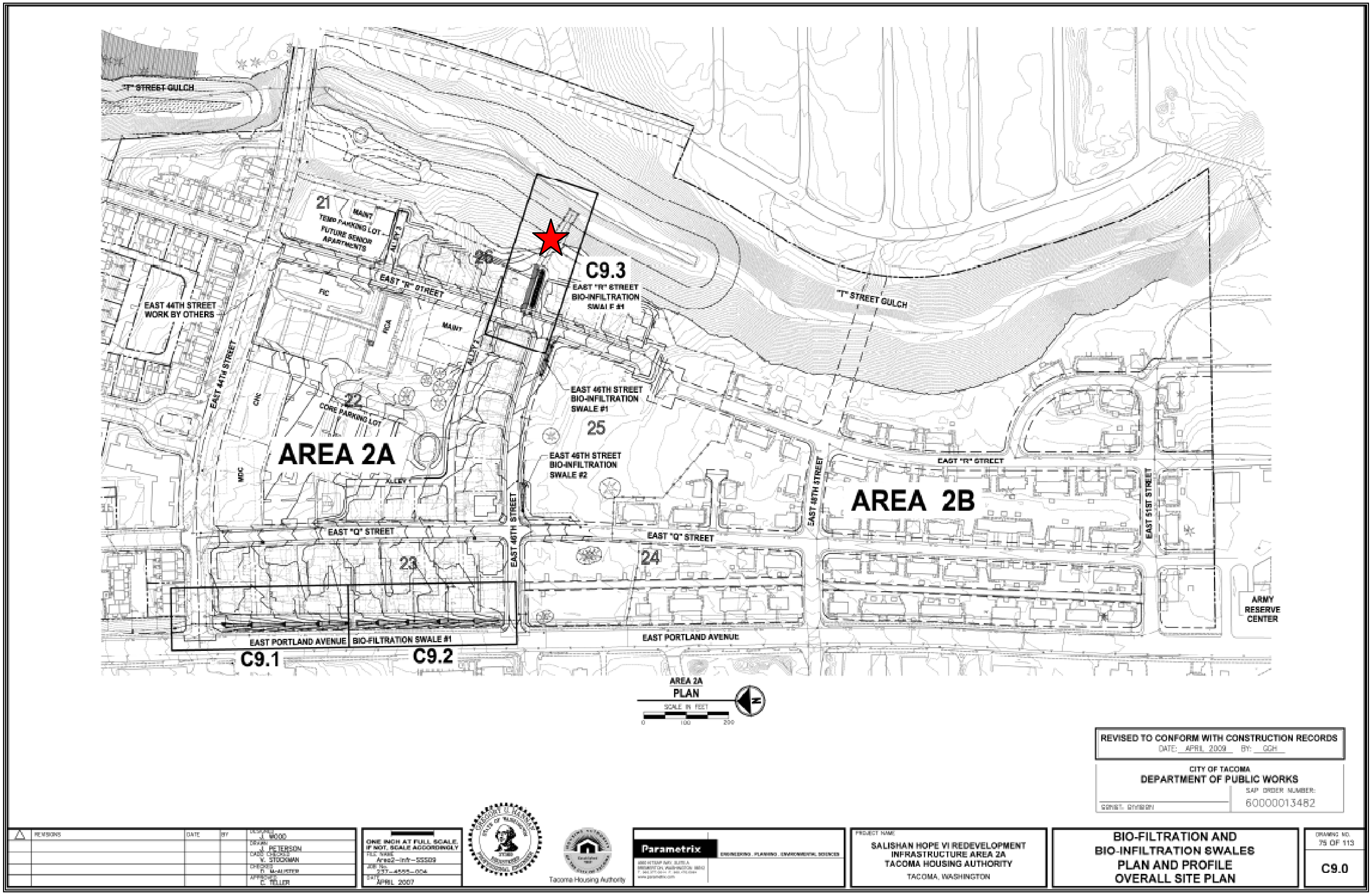
CONSTRUCTION CHECKED	DATE SEPT 2007	SCALE NO SCALE	
BY	DESIGNED JDW	CHECKED KNB	
DATE	DRAWN JLP	PROJECT NAME 44TH STREET	
FIELD BOOKS	DRAWING NAME 44TH-Infr-DET01.dwg		

CITY OF TACOMA
DEPARTMENT OF PUBLIC WORKS

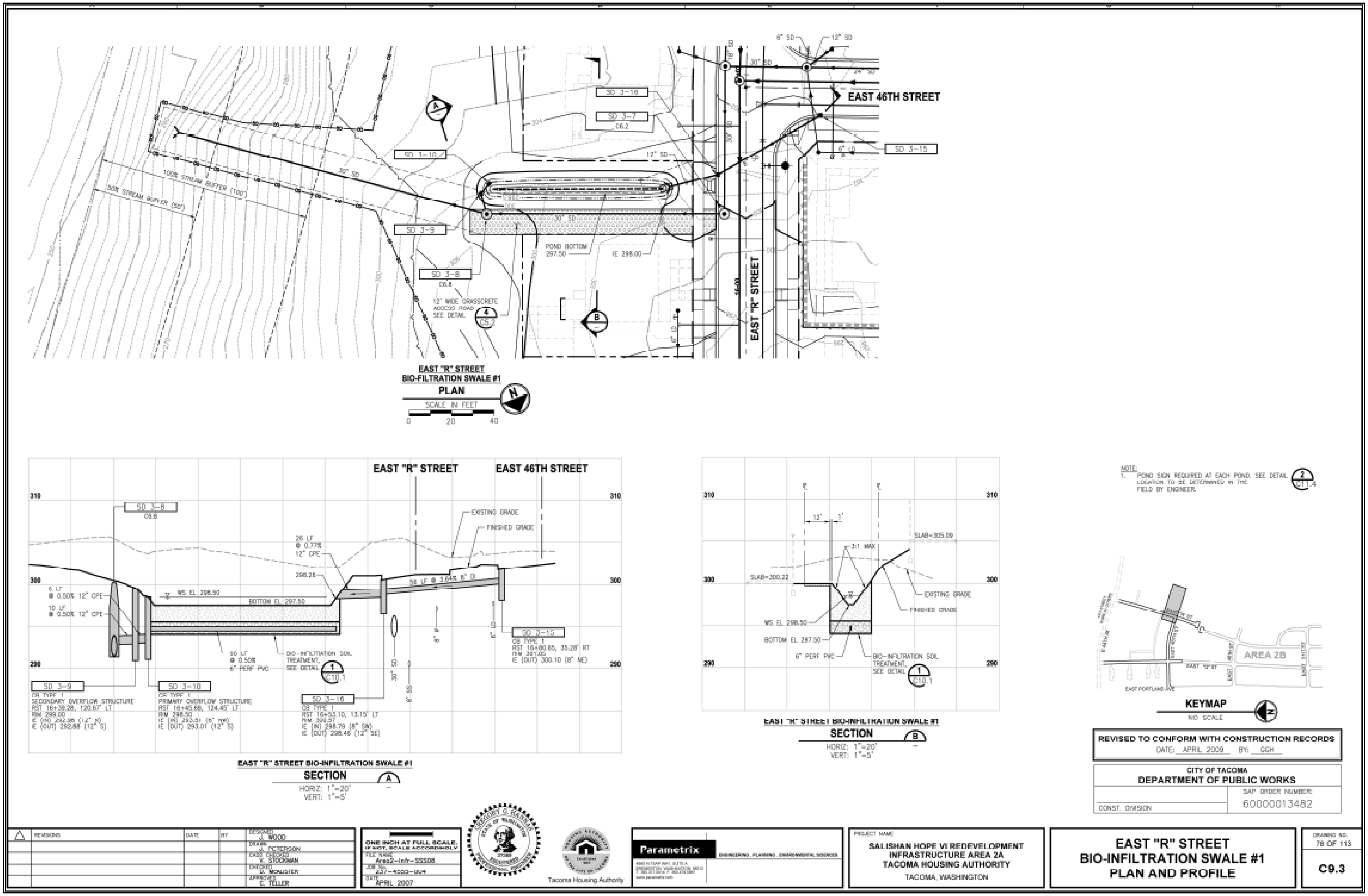
EAST 44TH STREET
EAST PORTLAND AVENUE TO EAST "T" STREET
FLOW SPLITTER DETAIL

SHEET NO. C5.3
SHEET 24 OF 43

R St. Swale Plan: Exhibit C on CD



R St. Swale: Exhibit D on CD



R-Street Bio-infiltration Details: Exhibit E on CD

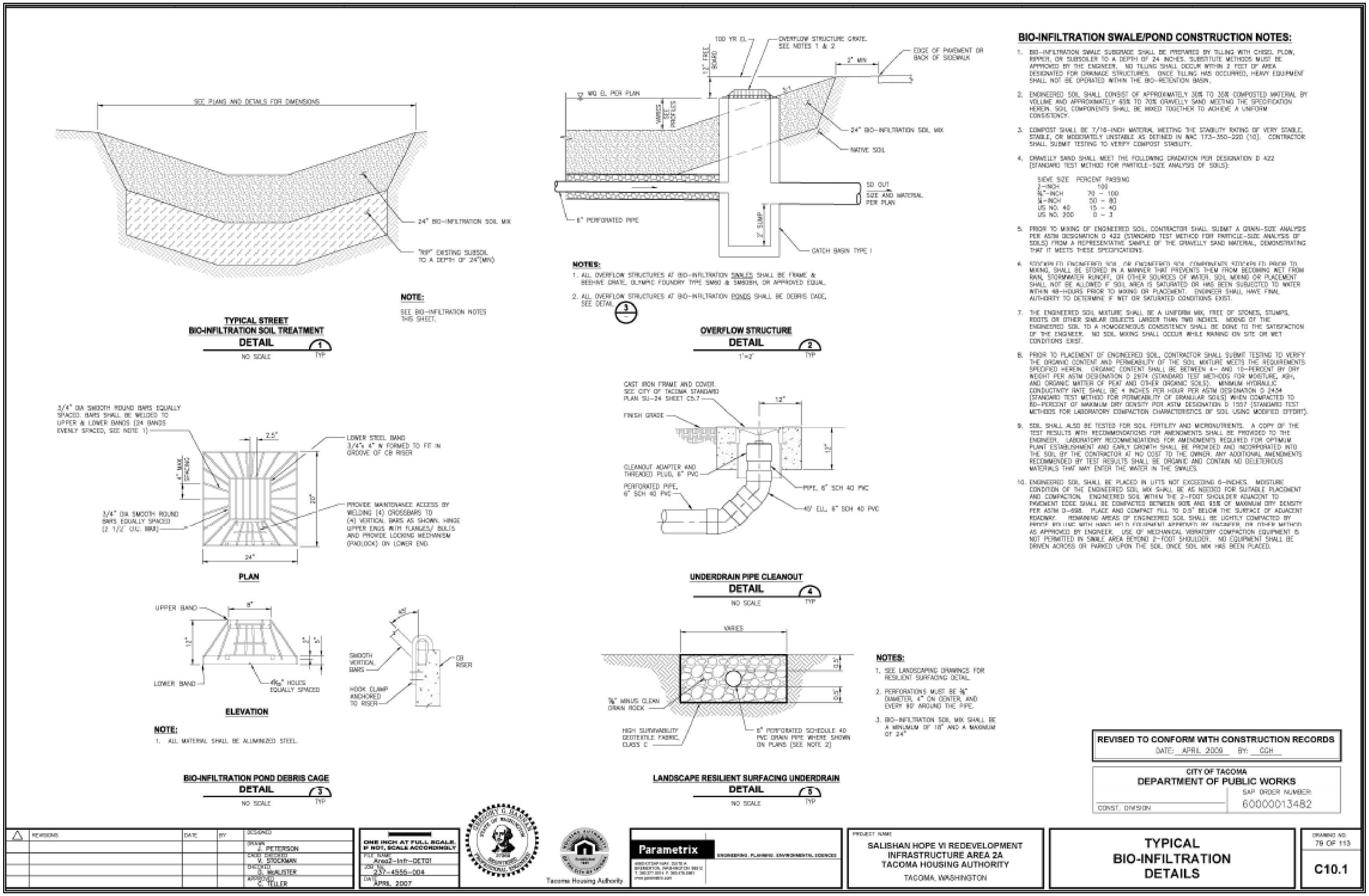


TABLE A-3. Trolley Court Info Requested 2/4/2008 for DOE Evaluation

1	**Drainage area details:**						
1a	**Percentage of area in each Land Use category:**						
		Residential (100%)	2.27	acre	or	***98,881.2***	SF
1b	**Impervious area total:**						
		Roads	0.53	acre	or	23,086.8	SF
		Lots (11)	0.56	acre	or	24,393.6	SF
		Total	***1.09***	***acre***	***or***	***47,480.4***	***SF***
1c	**Type and sizes of impervious areas:**						
		Type	***Public road, access road, private road, and 11 lots @ 2200 SF each.***				
		Sizes	***See 1b above for impervious areas***				
1d	**PGIS :**	***Assuming driveways are 300SF***					
		(11 x 300SF) + 23,086.8 = 26386.8SF or 0.6 acres					
1e	**PGPS:**						
		Landscaping for 11 Lots	0.83	acre	or	36,154.8	
1f	**Non-PGIS:**	***Assuming driveways are 300SF***					
		24,393.6 - (11 x 300SF) = 21093.6SF or 0.48 acres					
1g	**Type of pervious areas:**						
		Grass storm tract & landscaping for 11 lots					

TABLE A-3. Cont.

2 **Design Documentation:**

2a **Engineering calculations for sizing the facility:** ***Appendix C of Report 2***

2b **Comparison to all design criteria & sizing required by DOE 2005 manual:**

See Table A-4 of this appendix and Exhibits F, G, & H on the CD.

2c **Drawings showing location, dimensions, influent and effluent conveyances:**

See Figure A-2 of this appendix. Additional info: 4ft-wide, 186ft-long, & a longitudinal with a slope of 2%.

2d **Verification of the facility as on-line or off-line**

The system is on-line per the drawings and a site visit.

3 **Site Soils and Groundwater (if applicable)**

3a **High groundwater elevations (especially critical for wetpool designs):** *n/a*

3b **Site soils and pertinent design details**

3b1 Liner(s):
No liner.

3b2 Estimated infiltration losses from pond/wetland
N/A

3b3 Documentation of soil analyses (size gradation, CEC, etc.) & compost quality if treatment or design water loss:

<u>**Existing soils analyses:**</u> ***Type C***

3c **Description of methods & procedures used to determine the long-term bioswale infiltration rates:**
Unknown

4 **Media Description and Specifications (if applicable)**

4a Vegetation species (swales, strips, bioretention, wetlands) and densities:
In calcs assumed "grass-legume mixture (it seems, as was in the example calcs in the manual). On November 13th City Environmental Specialists/Biologists performed a preliminary bioswale vegetation identification; see Exhibit L for the technical memorandum. Some grasses can only be identified when growing, thus, the sites will be revisited in the spring (2010).

4b Artificial media types, sizes/gradation, depths (or thickness)
Unknown

4c Sand type, gradation, depth (or thickness)
Unknown

4d Description of any Amendments
A mix of compost and native soil

TABLE A-3. Cont.

5 Proposed Monitoring Locations

5a Percent of drainage area and influent flow tributary to monitoring site

	Drainage Area (%)	Influent Flow Tributary to Monitor (%)
Swale Series	100.0%	100.0%

6 O&M Status

6a The condition of the facility as compared to the parameters in the Maintenance Table (Table 4.5 of the ’05 manual).
"Storm Drainage Maintenance Manual" of the SSP, pg 23-24; Also listed on pg 65 of the City's "Storm Water Detention

& Treatment Facilities: Operation & Maintenance Manual"

Is comparable to that of DOE pg 9-19 http://www.ecy.wa.gov/pubs/0510033.pdf:
Maintenance
Criteria

• Inspect biofilters at least once every 6 months, preferably during storm events, and also after storm events of > 0.5 inch rainfall/ 24 hours. Maintain adequate grass growth and eliminate bare spots.

• Mow grasses, if needed for good growth {typically maintain at 4 – 9 inches and not below design flow level (King County, 1998)}.

• Remove sediment as needed at head of the swale if grass growth is inhibited in greater than 10 percent of the swale, or if the sediment is blocking the distribution and entry of the water (King County, 1998).

• Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.
Prevent scouring and soil erosion in the biofilter. If flow channeling occurs, regrade and reseed the biofilter, as necessary.
Maintain access to biofilter inlet, outlet, and to mowing (Figure 9.8)

• If a swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the drainpipes.

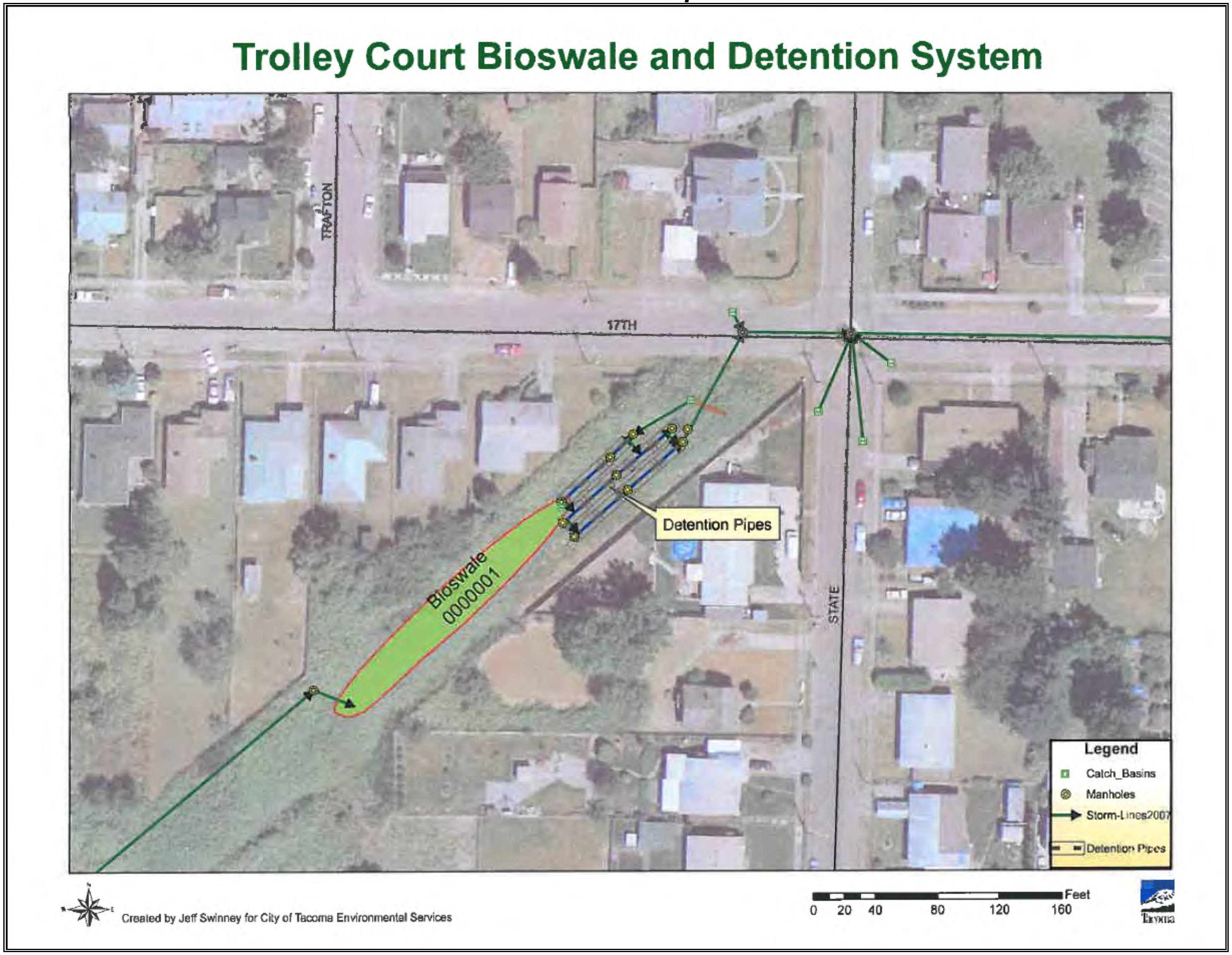
TABLE A-4. Design Criteria from DOE BMP T9.10 Basic Biofiltration Swale

Design Parameter	BMP T 9.10-Biofiltration Swale	Trolley Court Final Design Value
Longitudinal Slope	.015 - .025 ft/ft	0.02 ft/ft
Max. Velocity	1 ft/s @ K multiplied by the WQ design flow rate; for stability, 3 ft/s max	0.306 ft/s where K=1.8 & the WQ design velocity was 0.17 ft/s
Max. Water Depth	2"- if mowed frequently; 4" if mowed infrequently	0.25ft or 3"
Manning Coefficient	(0.2 - 0.3); (0.24 if mowed infrequently)	0.2
Bed Width (bottom)	2-10ft	3.99ft
Freeboard Height	0.5ft	0.5ft
Min. Hydraulic Residence Time at Water Quality Design Flow Rate	9 min (18 min for continuous inflow *See Vol. I, Appdx B	1320s or 22min
Min. Length	100ft	186ft
Max. Sideslope	3H : 1V ; 4H : 1V preferred	3H : 1V

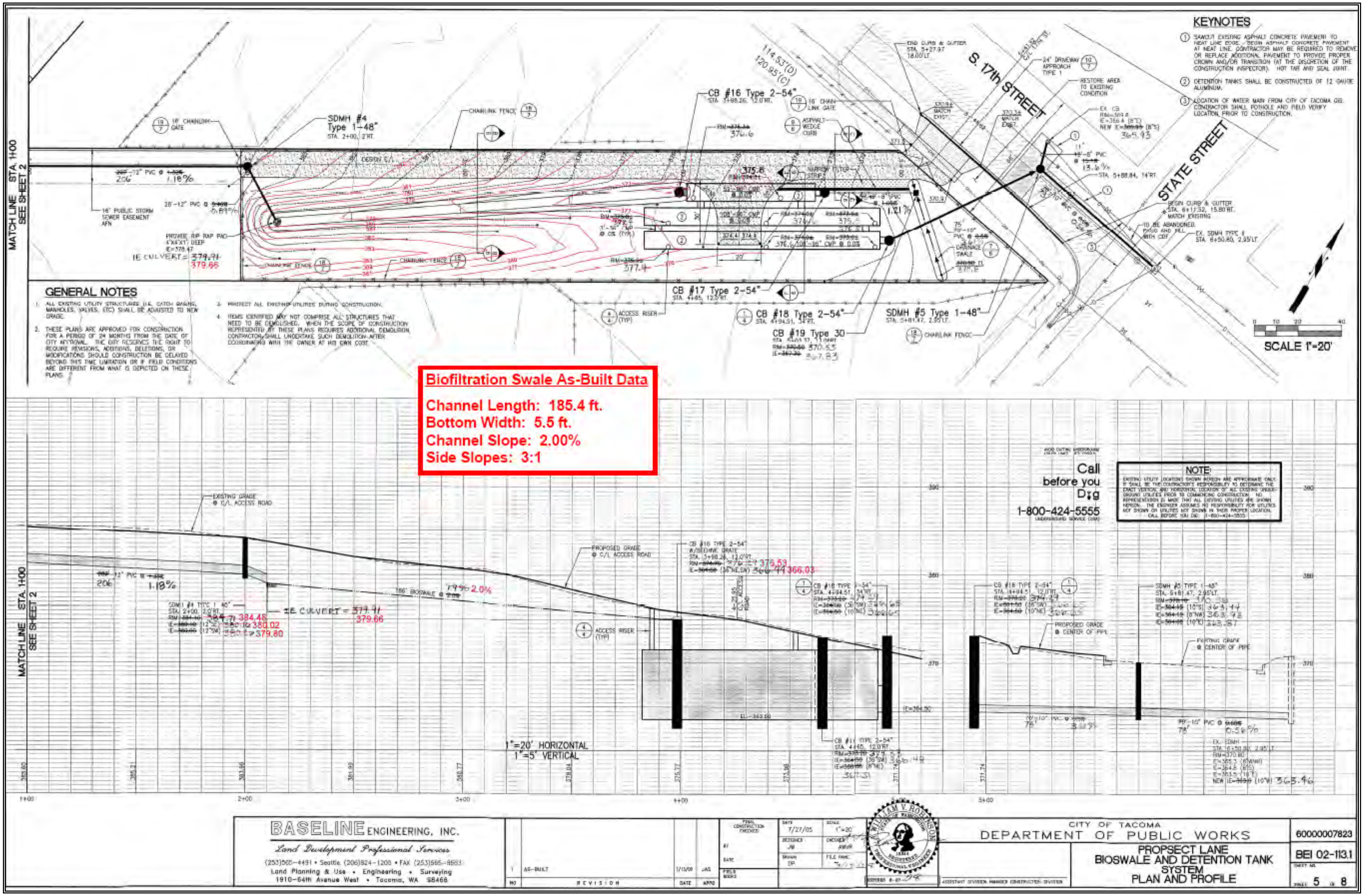
NOTE: The Max. Velocity was determined using WWHM per Appendix C pages 48 & 49 of the SSP.

FIGURE A-2. **Trolley Court Drawings**

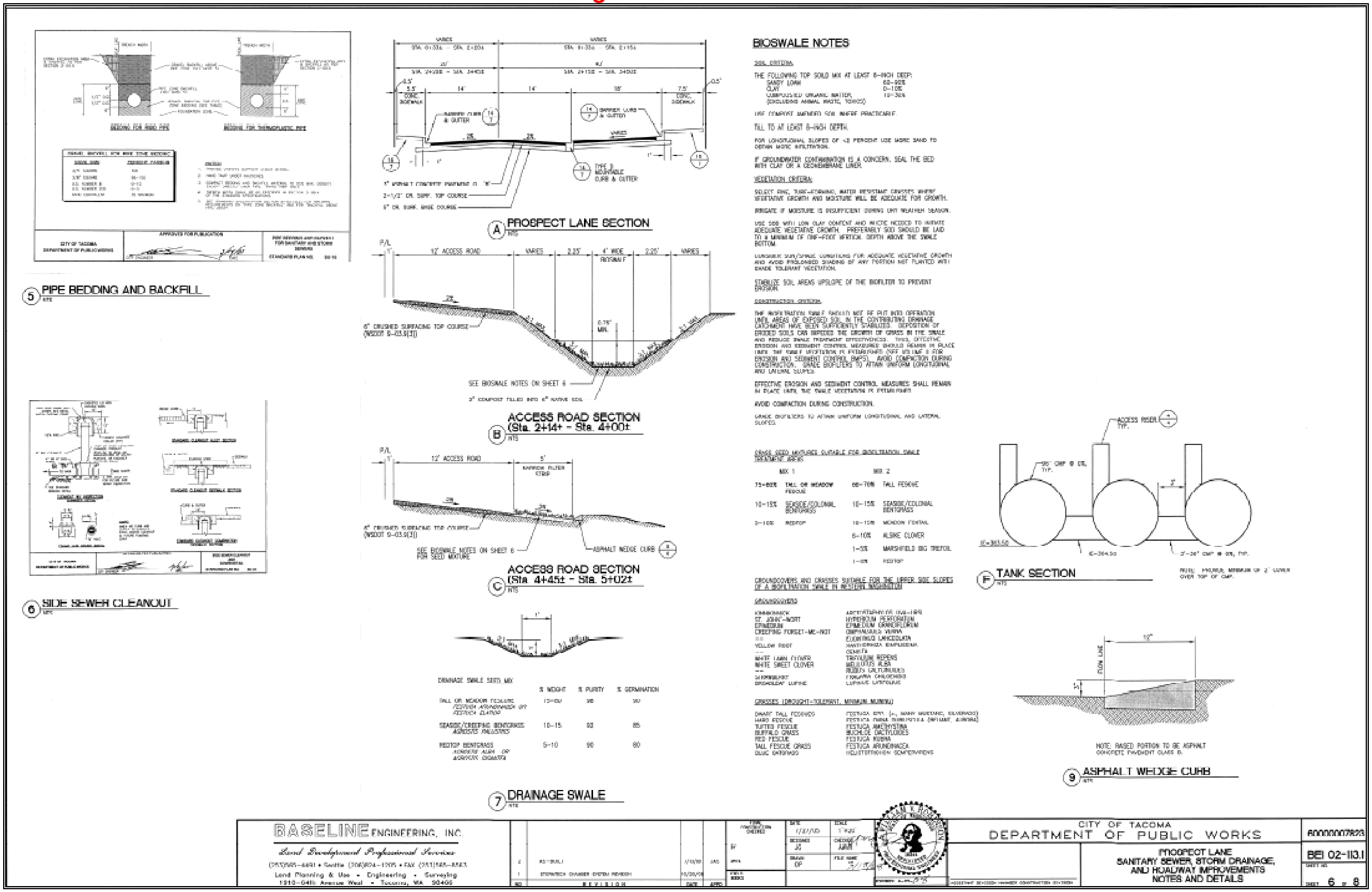
Location Map



Biofiltration Swale & Detention Tank Profile: Exhibit F



Storm Drainage Notes & Details: Exhibit G



Public Flow Restrictor-Oil Pollution Control Device: Exhibit H

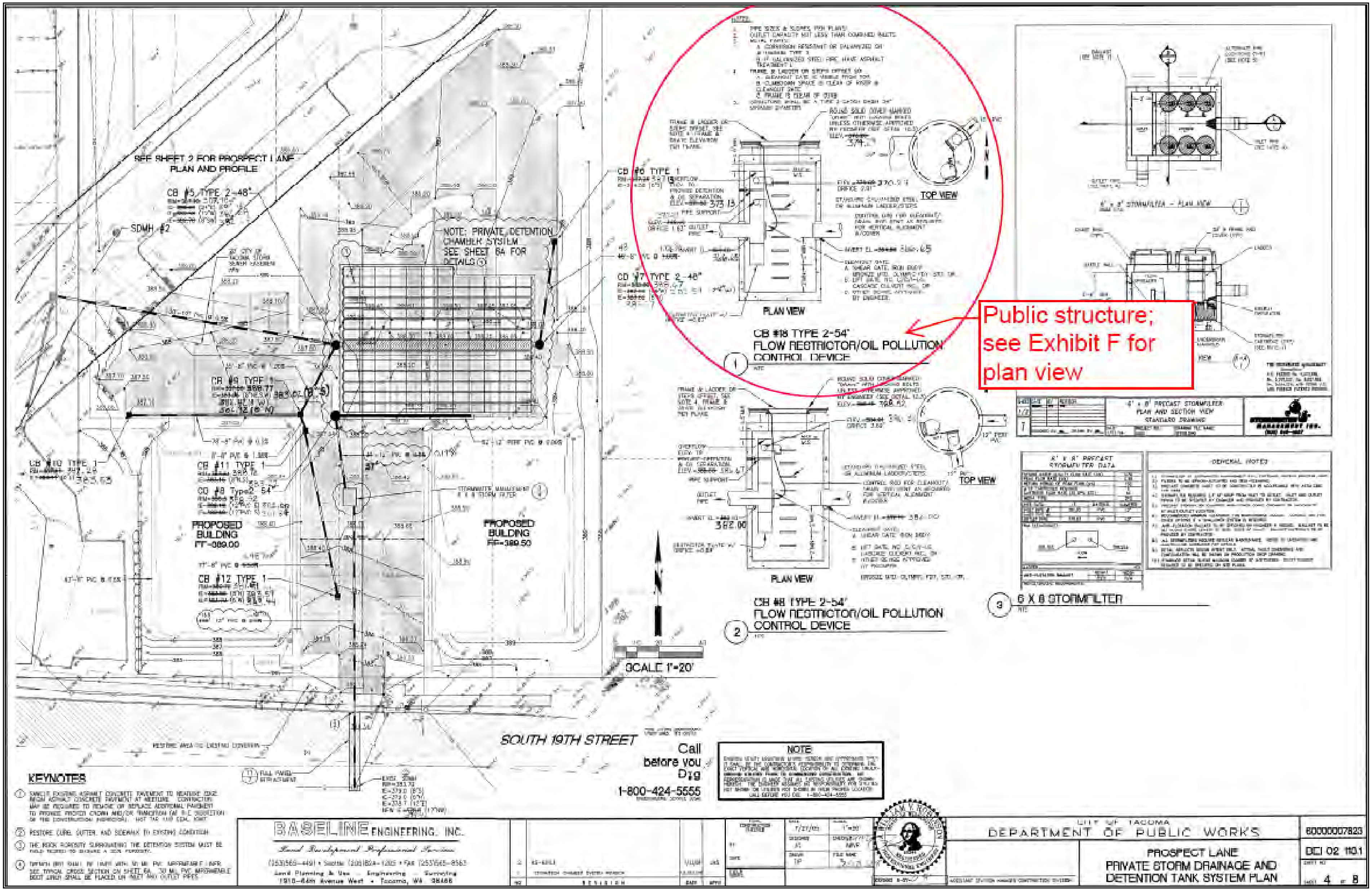


TABLE A-4. E. 32nd Biofiltration Swale Info Requested 2/4/2008 for DOE Evaluation

1	**Drainage area details:**								
1a	**Percentage of area in each Land Use category:**								
		Residential		3.9	acre		***60.00***	***%***	
		Commercial		2.6	acre		***40.00***	***%***	***Not provided; Estimated from visual inspection***
			Total	***6.5***	***acre***				
1b	**Impervious area total:**								
		Residential		N/A	acre	or	N/A	SF	
		Commercial		N/A	acre	or	N/A	SF	
			Total	***5.23***	***acre***	***or***	***227819***	***SF***	
1c	**Type and sizes of impervious areas:**								
		Type		***Residential & commercial pavement & roofs***					
		Sizes		***See 1b above for impervious areas***					
1d	**PGIS :**	***80%***							***Not provided; Estimated from visual inspection***
1e	**Pervious area total:**								
		Residential		N/A	acre	or	N/A	SF	
		Commercial		N/A	acre	or	N/A	SF	
			Total	***1.31***	***acre***	***or***	***57063.6***	***SF***	
1f	**PGPS:**	***N/A***							
1g	**Type of pervious areas:**								
		Open spaces, lawns, parks (>75% grass)							
2	**Design Documentation:**								
2a	**Engineering calculations for sizing the facility:**								
		Appendices of Report 3 on CD.							
2b	**Comparison to all design criteria & sizing required by DOE 2005 manual:**								
		See Table A-5 of this appendix.							
2c	**Drawings showing location, dimensions, influent and effluent conveyances:**								
		See Figure A-3 of this appendix.							
2d	**Verification of the facility as on-line or off-line**								
		If off-line, provide design basis and details of bypass or splitter: ***The bioswales were designed for the 6-month 24-hr event where all excess flow is routed to a bypass manhole. The system is off-line. Additional information not provided.***							

TABLE A-4. Cont.

3 Site Soils and Groundwater (if applicable)

3a High groundwater elevations (especially critical for wetpool designs):

N/A

3b Site soils and pertinent design details

3b1 Liner(s):

No liner.

3b2 Estimated infiltration losses from pond/wetland (?)

N/A

3b3 Documentation of soil analyses (size gradation, CEC, etc) and compost quality if involved in treatment or design water loss:

Existing soils analyses: ***deemed suitable for proposed improvements with geotech's recommendations.***

Soil contains coarse gravel, fine to medium sand with silt, and more. See Report 3 on the CD.

Engineered soils analyses: ***Not provided.***

3c Description of methods & procedures used to determine the long-term bioswale infiltration rates:

Unknown

4 Media Description and Specifications (if applicable)

4a Vegetation species (swales, strips, bioretention, wetlands) and densities:

On November 13th City Environmental Specialists/Biologists performed a preliminary bioswale vegetation identification; see Exhibit L for the technical memorandum. Some grasses can only be identified when growing, thus, the sites will be revisited in the spring (2010).

4b Artificial media types, sizes/gradation, depths (or thickness)

Not provided

4c Sand type, gradation, depth (or thickness)

Not provided

4d Description of any Amendments

Not provided

TABLE A-4. Cont.

5 Proposed Monitoring Locations

5a Percent of drainage area and influent flow tributary to monitoring site

Unknown since it is off-line. Swales receive 6.5 acres of 7.07 acre area (92% to bioswales pre-bypass)

6 O&M Status

6a The condition of the facility as compared to the parameters in the Maintenance Table (Table 4.5 of the '05 manual).

"Operation & Maintenance Manual" Section 6.0 of Report 3 on the CD

Is comparable to that of DOE pg 9-19 http://www.ecy.wa.gov/pubs/0510033.pdf:
Maintenance
Criteria

• Inspect biofilters at least once every 6 months, preferably during storm events, and also after storm events of > 0.5 inch rainfall/ 24 hours.

Maintain adequate grass growth and eliminate bare spots.

• Mow grasses, if needed for good growth {typically maintain at 4 – 9 inches and not below design flow level (King County, 1998)}.

• Remove sediment as needed at head of the swale if grass growth is inhibited in greater than 10 percent of the swale, or if the sediment is blocking the distribution and entry of the water (King County, 1998).

• Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.

Prevent scouring and soil erosion in the biofilter. If flow channeling occurs, regrade and reseed the biofilter, as necessary.

Maintain access to biofilter inlet, outlet, and to mowing (Figure 9.8)

• If a swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the drainpipes.

TABLE A-5. Design Criteria from DOE BMP T9.10 Basic Biofiltration Swale

BIOFILTRATION SWALE CALCULATOR

Water Quality Equations:

b = Kb * Q * n / (1.49 * y^1.67 * s^0.5) - Z * y

T = b + 2 * y * z

A = b * y + Z * y^2

V = K * Q / A

L = V * t * 60

Vd = Ld / 60 / t

Ad = Q / Vd

bd = (Ad - Z * y * y) / y

Water Quality Variables:

y	=	Depth of Flow (in)	y	3.96	Max. 4; or Max. 2 if Mowed Frequently
y	=	Depth of Flow (ft)	y	0.33	
n	=	Manning's Roughness Coefficient for WQ	n	0.30	0.2-0.3, 0.24 if Mowed Infrequently
Z	=	Side Slope of Trapezoid	Z	3	
Kb	=	Adjustment Factor for Calculating b	Kb	1.0	2.5 for WWHM; 1.0 for SBUH
Q	=	Water Quality Design Flow Rate (cfs)	Q	0.82	SBUH*
s	=	Longitudinal Slope (dimensionless)	s	0.01	Maximum 0.025
b	=	Bottom Width of Trapezoid (ft)	b	10.19	2 to 16
T	=	Top Width of Trapezoid (ft)	T	12.17	
A	=	Cross Sectional Area (sf)	A	3.69	
K	=	Ratio of SBUH Peak / WQ Flow - See Figure 9.6	K	N/A	1 for SBUH; 2.5*(?) for WWHM
V	=	Design Flow Velocity (fps)	V	.22	Vmax = 1.0 (or 0.5 for Filter Strip)
t	=	Hydraulic Residence Time (min)	t	9	9 ; Use 18 for Continuous Inflow
L	=	Swale Length (ft)	L	117	Minimum 100

Sizing Criteria

Design Parameter	BMP T 9.10-Biofiltration Swale	E 32nd St. Final Design Value (w/o κ & 2.5)	E 32nd St. Final Design Value (w/κ & 2.5)
Longitudinal Slope	.015 - .025 ft/ft	.01 ft/ft	.01 ft/ft
Max. Velocity	1 ft/s @ K multiplied by the WQ design flow rate; for stability, 3 ft/s max	.22 ft/s; stability N/A since “offline”	.78 ft/s; stability N/A since “offline”
Max. Water Depth	2"- if mowed frequently; 4" if mowed infrequently	3.96”	3.96”
Manning Coefficient	(0.2 - 0.3); (0.24 if mowed infrequently)	.3	.3
Bed Width (bottom)	2-10ft	10.19ft	10.19ft
Freeboard Height	0.5ft	0.0ft	0.0ft
Min. Hydraulic Residence Time at Water Quality Design Flow Rate	9 min (18 min for continuous inflow *See Vol. I, Appendix B	9min	3min
Min. Length	100ft	117ft	117ft
Max. Sideslope	3H : 1V ; 4H : 1V preferred	3H : 1V	3H : 1V

The designer(s) used the 6-month 24-hr flow event from the SBUH model where $Q_{6\ month}$ is 1.64 cfs, the peak flow. Since there are two identical bioswales this value was divided into two yielding a flow of .82cfs/Swale as shown above.

The alteration to Manning’s equation for determining the base width of a trapezoid (the bioswale) in the 2005 DOE manual applies a factor of 2.5 to account for the differential between Water Quality design flow rate and the SBUH design flow. The designer(s) used FlowMaster where the 2.5 factor was not accounted for.

The old DOE and City of Tacoma SWMMs’ step for calculating the maximum velocity for Biofiltration Swales reads:

$$V = \frac{Q}{A}$$

Whereas it should have read as follows:

$$V = \frac{\kappa Q}{A}$$

Due to the above error the designer(s) did not account for “κ”. If it had been accounted for it would have had a value of “3.5”. Without using the “κ” both the hydraulic residence time and the maximum velocity were not “correct” as they are both dependent variables.

TABLE A-6. Flow Splitter Orifice Calcs: Calculation 2 on CD

SDMH #57: CITY OF TACOMA'S ASSESSMENT

THEORETICAL

Equation Orifice Equation Q = CA(2gh)^.5

Given

WQ=	1.64	cfs	NOTE: from SBUH, 6-month 24-hr event
WQper=	0.82	cfs	
WQ (110%) =	1.804	cfs	NOTE: didn't design for 110%, just 100%
C=	0.62	per EIT Book	
g=	32.2		

Find Dimensions for flow splitter such that:

- * A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility.
- * The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.

Solve

Diameter, D (in)	Area, A (ft^2)	Head, h (ft)	WQ (cfs)	% of WQ Design Flow
0.5	0.0014			
1	0.0055			
1.5	0.0123			
2	0.0218	57.06655635	0.82	100.00%
2.5	0.0341	23.37446148	0.82	100.00%
3	0.0491	11.27240619	0.82	100.00%
3.5	0.0668	6.084564109	0.82	100.00%
4	0.0873	3.566659772	0.82	100.00%
4.5	0.1104	2.226648137	0.82	100.00%
5	0.1364	1.460903843	0.82	100.00%
5.5	0.1650	***0.997816981***	0.82	100.00%
6	0.1964	0.704525387	0.82	100.00%

TABLE A-6. Cont.

ACTUAL PER COT ENGINEERING TECHS				
Equation	Orifice Equation		WQactual =	CA(2gh)^.5
Given	WQ=	1.64	cfs	NOTE: from WWHM2 using 15-min time steps
	WQper=	0.82	cfs	
	C=	0.62	per EIT Book	
	g=	32.2		
	h=	0.57	ft	
	A=	0.1650	ft^2	
Find	WQactual & % of WQ			
Solve	**WQactual=**	***0.6198***	***cfs***	
	%of WQ=	***75.58***	***%***	Should be no more than 110% of 6-month, 24-hr storm per DOE
CONCLUSION				

Appendix C of Report 3 on the CD shows that Barghausen found that an orifice diameter of 5.5-inches yields a head in the control structure of approximately 1-foot. These calculations were re-run by the City as shown above under "City of Tacoma's (COT's) Assessment" & the calculations found equivalent results. Using Exhibit K on the CD titled “Water Quality Details,” the City utilized the specified orifice diameter to find the corresponding head in the control structure. It was field verified that the installed orifice's diameter is 5.5-inches with a head in control structure value of 0.51-ft.

As shown above in the COT's Assessment of SDMH #57, it was found that the bypass flow is less than the design proposal, thus the WQactual is only 75.58% of the WQ. Therefore, the western bioswale receives less flow than it is supposed to.

TABLE A-6. Cont.

SDMH# 45: CITY OF TACOMA'S ASSESSMENT

THEORETICAL

Equation Orifice Equation Q = CA(2gh)^.5

Given

WQ=	1.64	cfs	NOTE: from SBUH, 6-month 24-hr event
WQper=	0.82	cfs	
WQ (110%) =	1.804	cfs	NOTE: didn't design for 110%, just 100%
C=	0.62	per EIT Book	
g=	32.2		

Find Dimensions for flow splitter such that:

* A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility.
* The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.

Solve

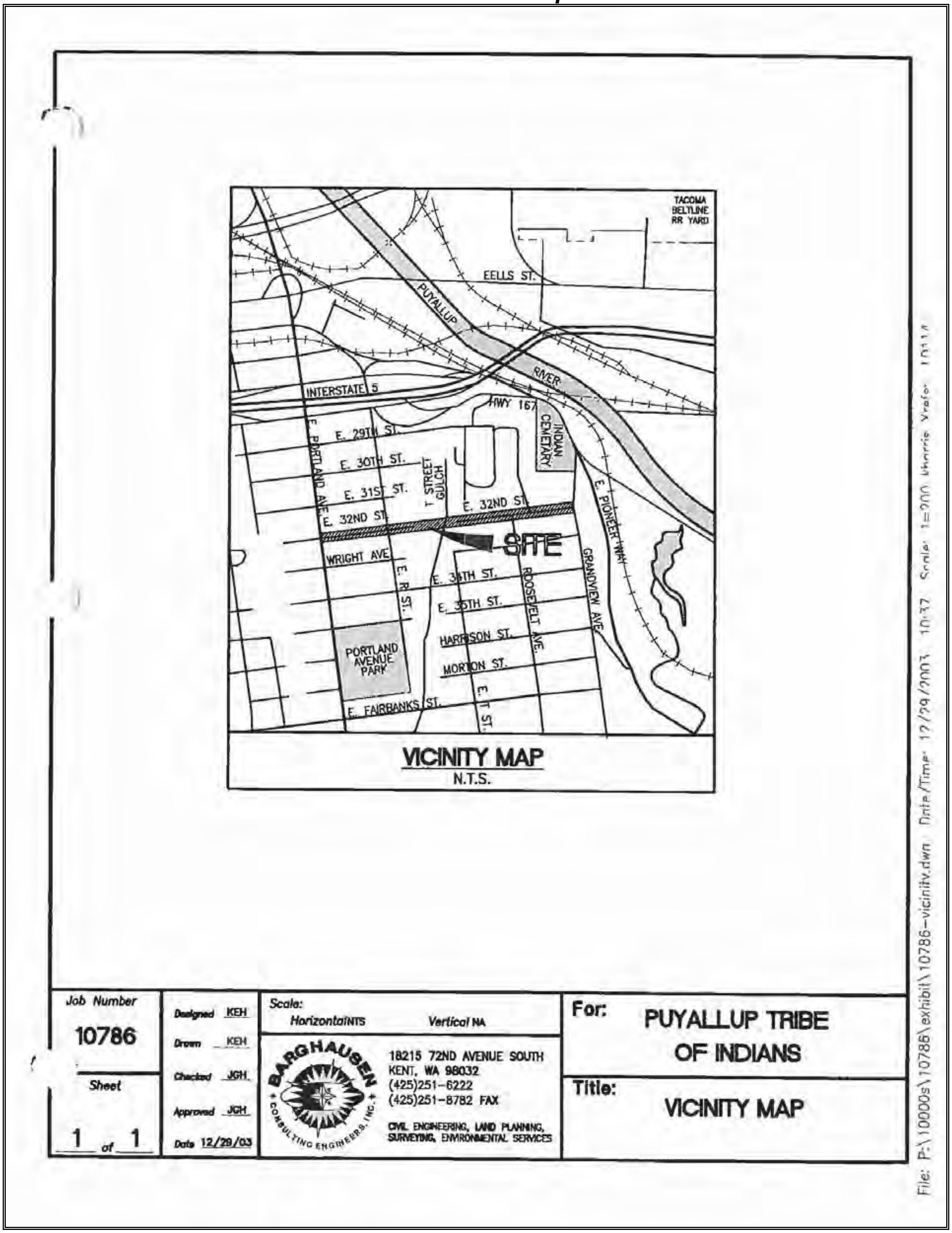
Diameter, D (in)	Area, A (ft^2)	Head, h (ft)	WQ (cfs)	% of WQ Design Flow
0.5	0.0014			
1	0.0055			
1.5	0.0123			
2	0.0218	57.06655635	0.82	100.00%
2.5	0.0341	23.37446148	0.82	100.00%
3	0.0491	11.27240619	0.82	100.00%
3.5	0.0668	6.084564109	0.82	100.00%
4	0.0873	3.566659772	0.82	100.00%
4.5	0.1104	2.226648137	0.82	100.00%
5	0.1364	1.460903843	0.82	100.00%
5.5	0.1650	***0.997816981***	0.82	100.00%
6	0.1964	0.704525387	0.82	100.00%

TABLE A-6. Cont.

ACTUAL PER COT ENGINEERING TECHS				
Equation	Orifice Equation		WQactual =	CA(2gh)^.5
Given	WQ=	1.64	cfs	NOTE: from WWHM2 using 15-min time steps
	WQper=	0.82	cfs	
	C=	0.62	per EIT Book	
	g=	32.2		
	h=	2	ft	
	A=	0.1650	ft^2	
Find	WQactual			
	%ofWQ			
Solve	**WQactual=**	***1.5358***	***cfs***	
	%of WQ=	***187.29***	***%***	Should be no more than 110% of 6-month, 24-hr storm per DOE
CONCLUSION				
	Appendix C of Report 3 on the CD shows that Barghausen found that an orifice diameter of 5.5-inches yields a head in the control structure of approximately 1-foot. These calculations were re-run by the City as shown above under "City of Tacoma's (COT's) Assessment" & the calculations found equivalent results. Using Exhibit K on the CD titled "Water Quality Details," the City utilized the specified orifice diameter to find the corresponding head in the control structure. It was field verified that the installed orifice's diameter is 5.5-inches with a head in control structure value of 2-ft.			
	As shown above in the COT's Assessment of SDMH #45, it was found that the bypass flow is one foot greater than the design proposal, thus the WQactual is greater than 110% of the WQ. Therefore, the eastern bioswale receives more flow than it is supposed to.			

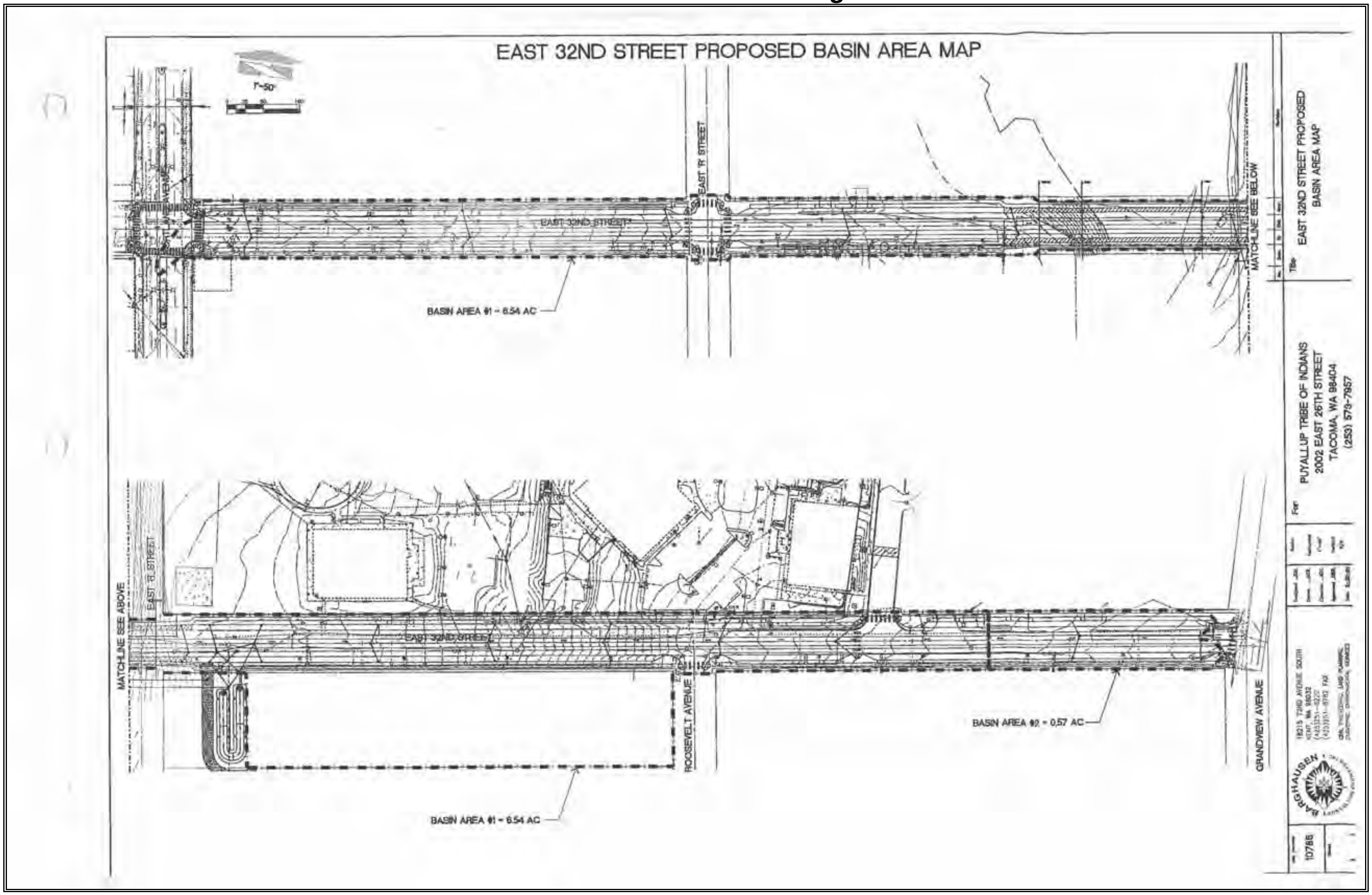
FIGURE A-3. E. 32nd Drawings

Location Map 1

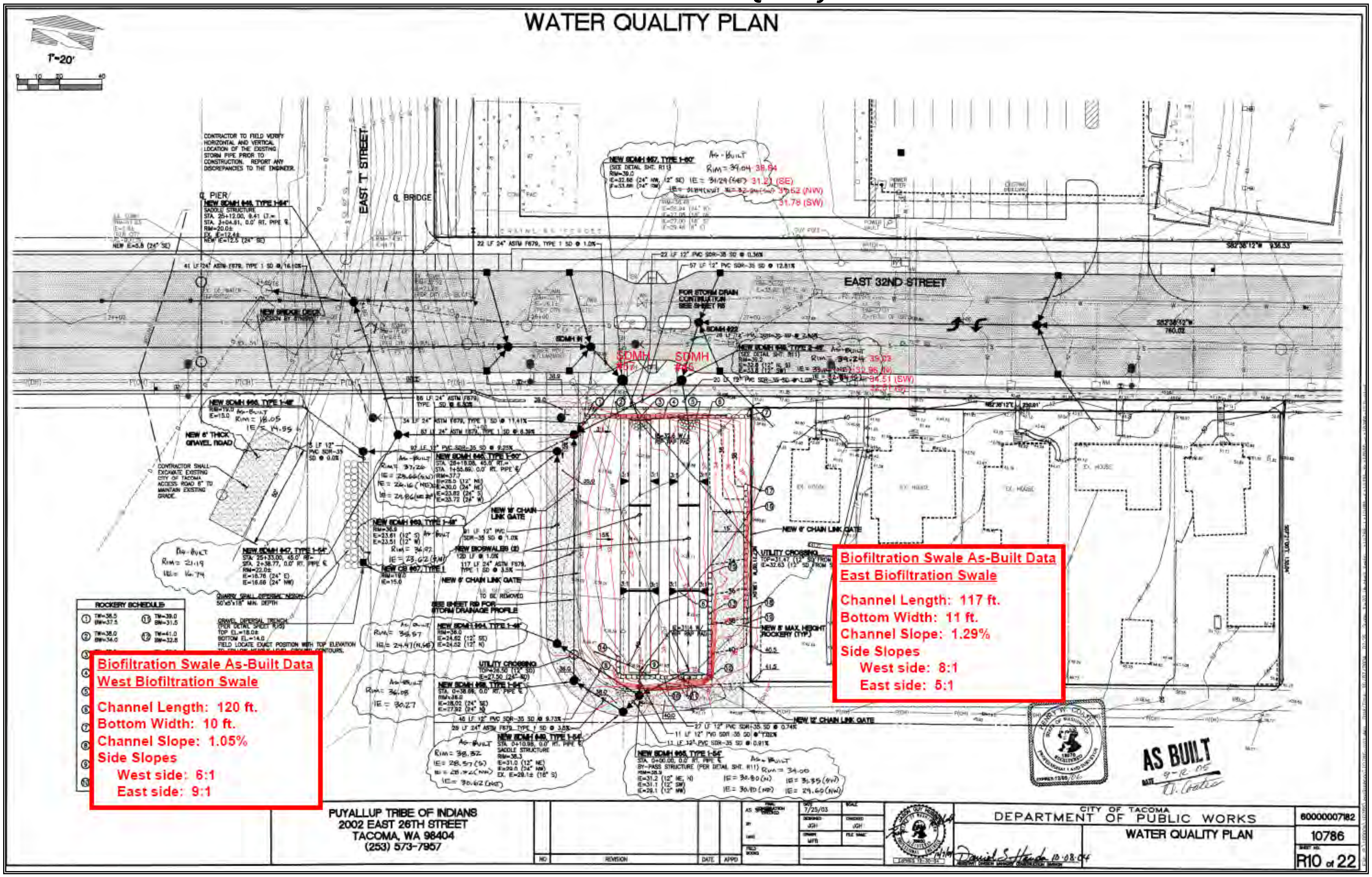


Location Map 2

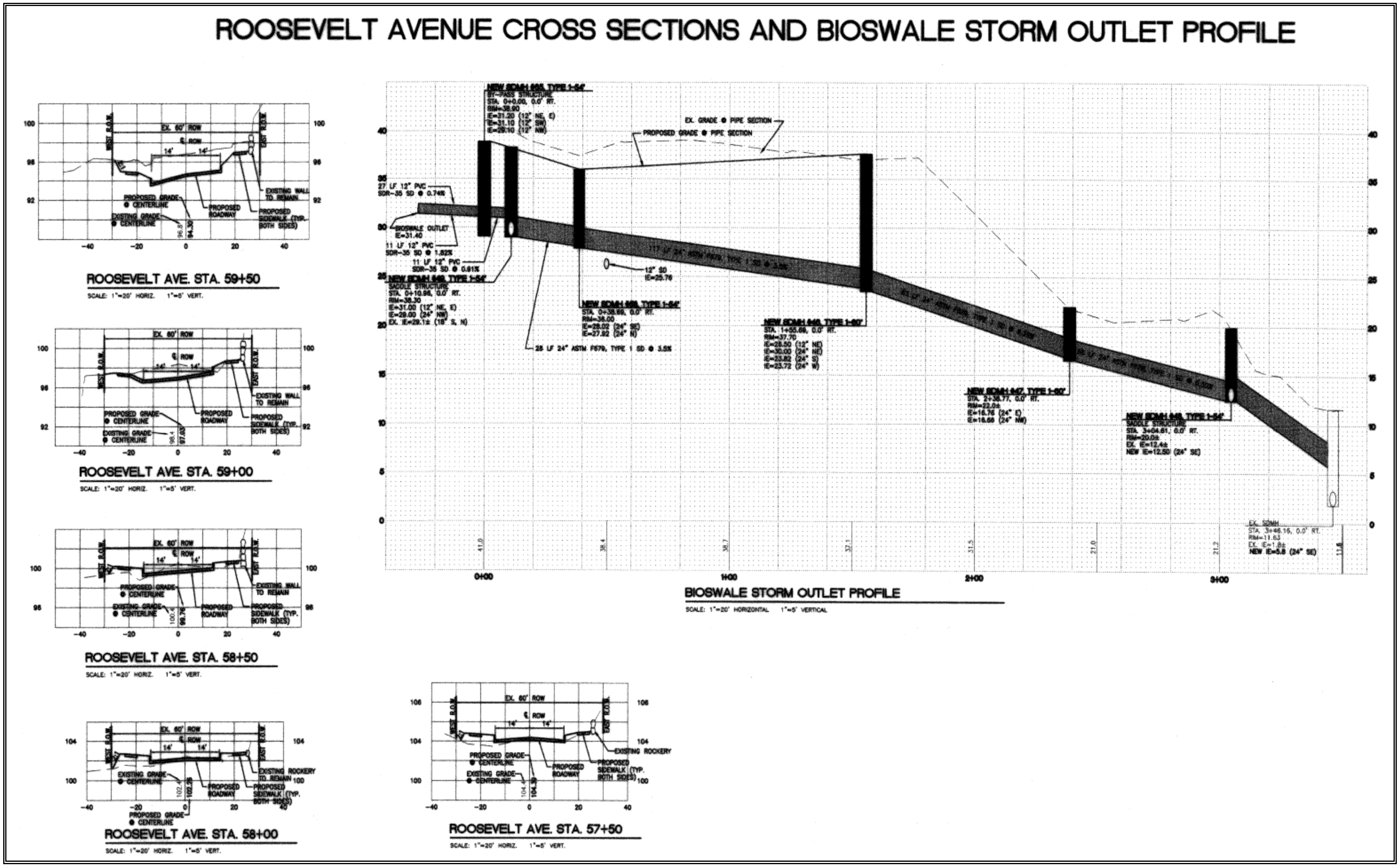
Biofiltration Swales Contributing Basin Area



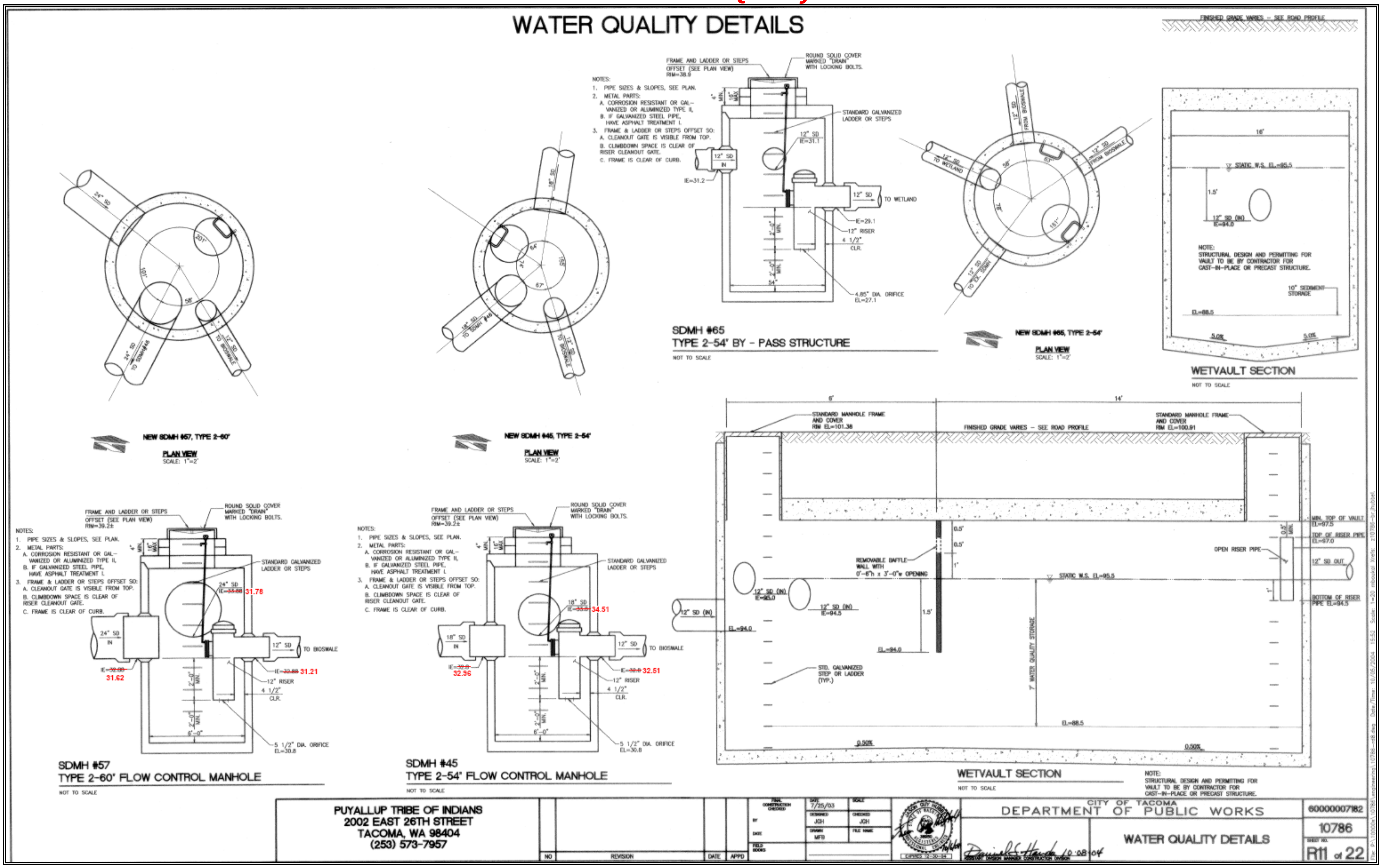
Biofiltration Swale Water Quality Plan: Exhibit I



Biofiltration Swale Outlet Profile: Exhibit J



Biofiltration Swale Water Quality Details: Exhibit K



Department of
Public Works

Technical Memorandum

November 18, 2009

To: Dana B. de Leon, P.E.
From: Karla Kluge, Senior Environmental Specialist

Subject: Bioswale vegetation preliminary identification

Request Description: Detailed description of the vegetation cover in the bioswales located at the 32nd Street Bridge and Trolley court, including specie types growing in the swale bottom and side slopes, as well as an estimate of the percentage of swale covered in vegetation.

I visited the sites with Shannon Stragier, Senior Environmental Specialist, on November 13, 2009.

32nd Street Bridge, Easement 3598 (50003800100, 50003800110, 50003800130)

Sides of Swale:
- White clover (*Trifolium repens*)
- Red clover (*Trifolium wormskjoldii*)
- Cottonwood saplings (*Populus balsamifera*)
- Velvet grass (*Holcus sp.)*
- Vetch*
- Quackgrass (*Agropyron repens*)
- Common western dandelion*
- Queen Anne's lace (*Daucus carota*)
- English plantain (*Plantago lanceolate*)
- Curly dock (*Rumex crispus*)
- Bitter dock (*Rumex obtusifolius*)
- Fireweed (*Epilobium angustifolium*)
- Buckwheat (possibly *Polygonum bistortoides*)
- Unknown Grass*

Bottom of Swale:
- Soft Rush (*Juncus effuses*)
- Willow smartweed (*Polygonium lapathifolicem*)
- Vetch*
- Reed Canary Grass (*Phalaris arundinacea*)
- Common western dandelion*
- Quackgrass (*Agropyron repens*)
- Buttercup (*Ranunculus repens*)
- Red clover (*Trifolium wormskjoldii*)
- White clover (*Trifolium repens*)
- Horsetail*

Ryegrass*
Unknown Grass*

The percentage of vegetation cover in the swale is 90-95%.

In addition to the vegetation noted above, I believe that there is also Tansy Ragwort located in both the bottom and on the sides of the bioswale.

Trolley Court, 1712 State Street (4715014340 and 4715014350)

Sides of Swale:

Vetch*
Broadleaf plantain (*Plantago major*)
English plantain (*Plantago lanceolata*)
Himalayan blackberry (*Rubus procerus*)
Red clover (*Trifolium wormskjoldii*)
Velvet grass (*Holcus sp.)*
Thistle (*Cirsium arvense*)
Scotchbroom (*Cytisus scoparius*)
Mint- Bugleweed-(*Lycopus uniflorus*)
Tufted hairgrass (*Deschampsia cespitosa*)
Fireweed (*Epilobium angustifolium*)
Dandelion*
Unknown grass (poa sp.)

Bottom of Swale:

Quackgrass (*Agropyron repens*)
Red clover (*Trifolium wormskjoldii*)
Buttercup (*Ranunculus repens*)
Dandelion*
Velvet grass (*Holcus sp.)*
Soft Rush (*Juncus effuses*)
Timothy (*Phleum pretense*)
Reed Canary grass (*Phalaris arundinacea)*
Sweet Vernal grass (*Anthoxanthum odoratum*)
Colonial bentgrass (*Agrostis tenius*)

Percentage of vegetation cover in the swale is 98-100%.

*Due to the lack of inflorescence on many plants and the season, some of the plant identifications described above should be considered preliminary until I am able to return to the site and verify them, especially the grasses. Grasses should be identified in the growing/flowering season, and I can not identify the unknown grass species at this time to determine if the grass represents the seed mix used in construction.

I recommend that a follow-up site visit occur in the spring after flowering starts to evaluate and confirm these preliminary plant identifications. Mowing of the bioswale should temporarily cease to allow the grass to flower prior to my next site visit. Please contact me in the spring to conduct a follow-up site visit.

Appendix B
Tacoma Landfill Pervious Pavements Details

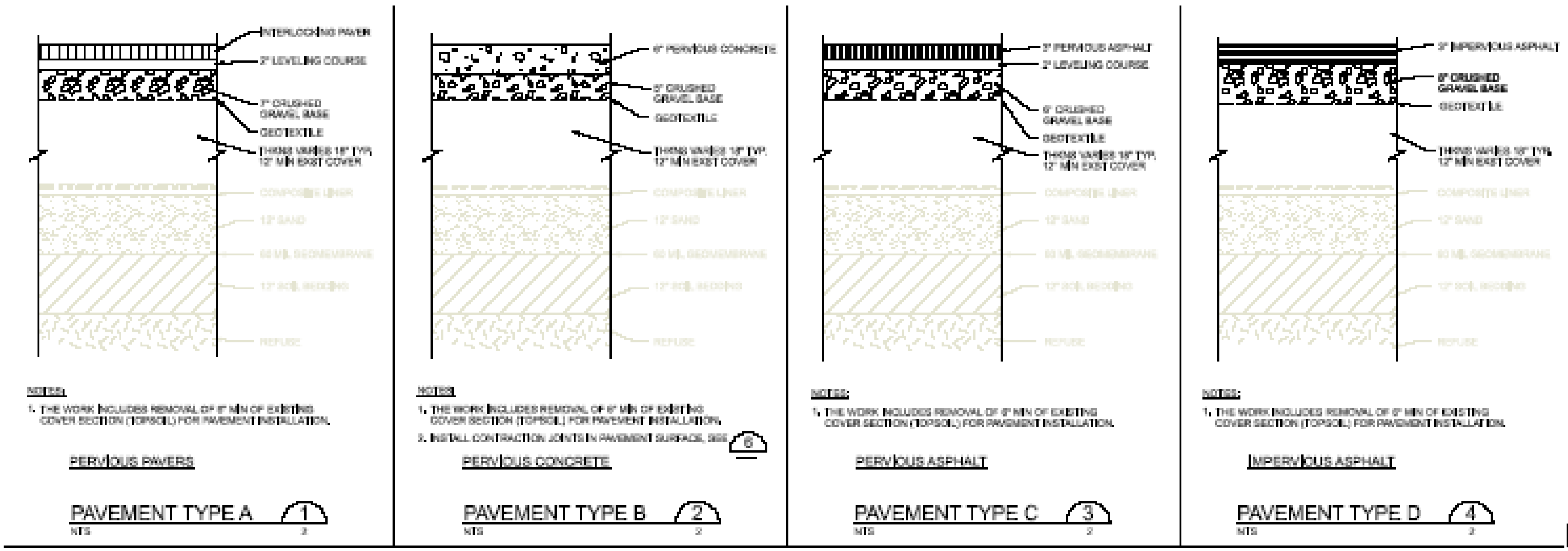
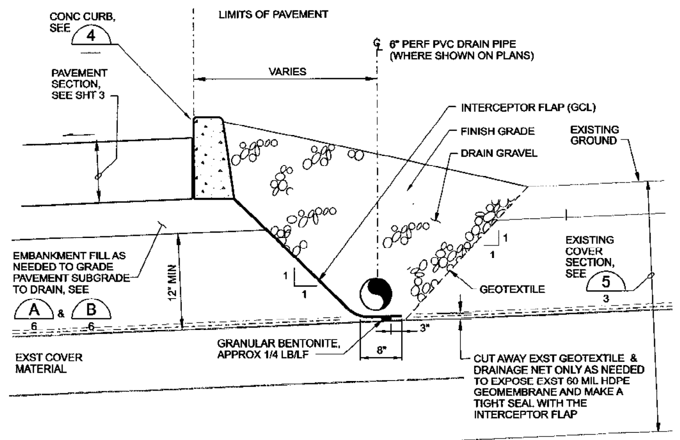


Figure B-1. Typical Cross Section for Standard Asphalt and Pervious Pavements

Hydraulic Separation between the Standard Asphalt & Pervious Pavement Cells

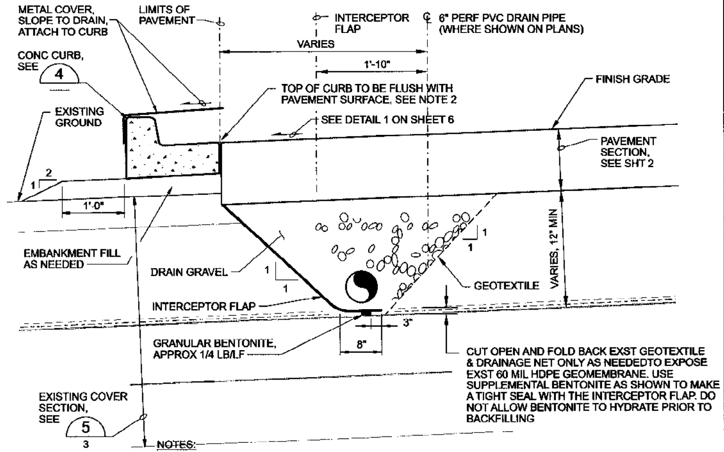
As shown on Details 1, 3, and 6 on Sheet 4 of the Plans (see Figure B-2), the parking lot is isolated from adjacent flows using an interceptor flap. This flap consists of a geosynthetic clay liner (GCL) which is connected to the existing HDPE landfill liner using granular bentonite. When subsurface flows from surrounding areas reach the parking lot area, they are stopped by the GCL and are collected in a 6" perforated PVC pipe. These flows are conveyed around the parking lot and discharged downstream.

Subsurface flows between the pavement test sections are also isolated using a GCL flap as shown in Detail 7 on Sheet 4 of the Plans (see Figure B-2). Surface flows are prevented from moving between pavement sections via a concrete curb.



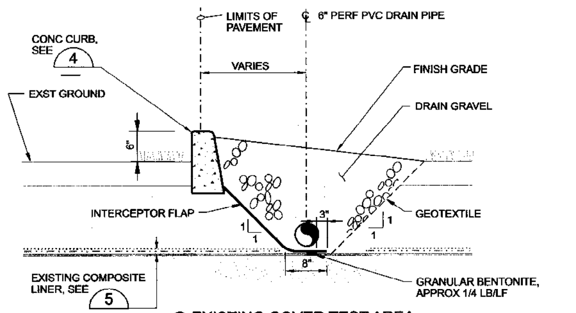
NOTE:
DO NOT CUT OR OTHERWISE DAMAGE EXISTING GEOMEMBRANE. CONTRACTOR SHALL REPAIR ANY DAMAGE AT HIS OWN EXPENSE.

EAST INTERCEPTOR FLAP & DRAIN PIPE (1)
NTS 2, 6



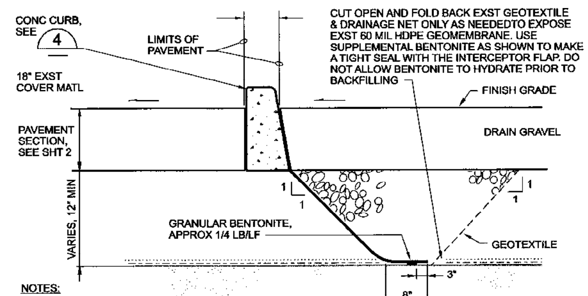
NOTES:
1. DO NOT CUT OR OTHERWISE DAMAGE EXISTING GEOMEMBRANE.
2. PROVIDE RAISED BERM AND CLOSED CHANNEL AT ACCESS ROAD CROSSINGS AS NEEDED TO DIVERT SW RUN-OFF TO THE DRAINAGE CHANNELS, SEE

WEST INTERCEPTOR FLAP & DRAIN PIPE (3)
NTS 2, 4, 6



@ EXISTING COVER TEST AREA

SOUTH INTERCEPTOR FLAP (6)
NTS 2, 5

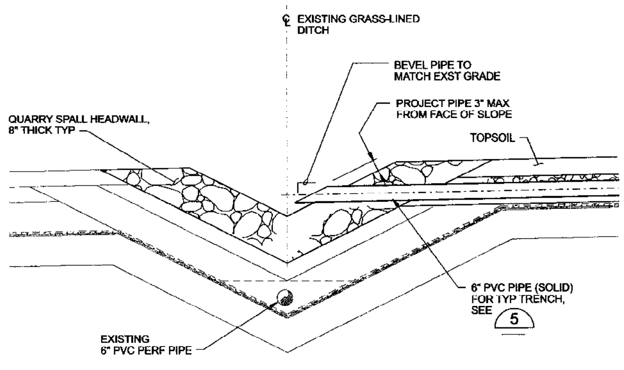


NOTES:
1. DO NOT CUT OR OTHERWISE DAMAGE EXISTING GEOMEMBRANE.
2. PLACE CURB AND INTERCEPTOR FLAP BETWEEN PAVEMENTS TO ISOLATE SURFACE WATER RUN-OFF.
3. PLACE ASPHALT BERMS OVER CURBS IN ALL DRIVING LANES, SEE D 5

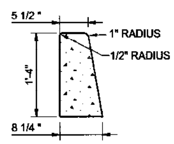
BETWEEN PAVEMENT AREAS

INTERMEDIATE INTERCEPTOR FLAP (7)
NTS 2, 6

NOTE:
1. EXTEND QUARRY SPALLS 5'-0" EACH SIDE OF CULVERT CENTERLINE.

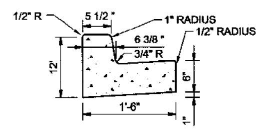


DISCHARGE TO EXISTING GRASS-LINED DITCH (2)
NTS 2



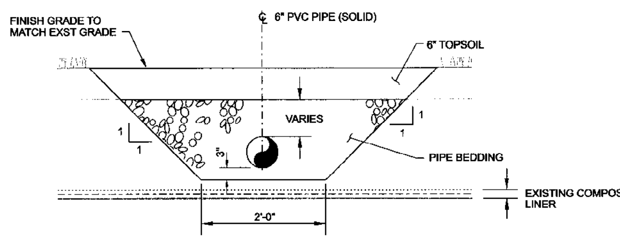
CEMENT CONCRETE TRAFFIC CURB

NOTES:
1. CURBS ARE WSDOT STANDARD PLAN F-1.
2. CONTRACTOR IS RESPONSIBLE FOR SETTING AND SECURING CONCRETE CURBS TO ONE ANOTHER AND TO THE PAVEMENT AREAS SO THAT THE COMBINED AREAS FUNCTION AS A UNIFORMLY SLOPING INTEGRAL SLAB HAVING THE DIMENSIONS, ELEVATIONS AND SURFACE GRADES AS SHOWN IN 1 6

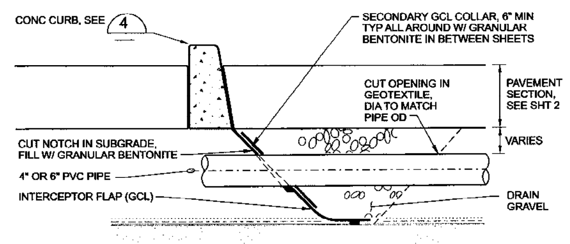


CEMENT CONCRETE TRAFFIC CURB AND GUTTER

PRECAST CONCRETE CURBS (4)
NTS



TYPICAL PIPE TRENCH (5)
NTS 5



PIPE PENETRATION @ INTERCEPTOR FLAP (8)
NTS 5

7-21-05

CH2MHILL | Tacoma

NO	REVISION	DATE	APPD
1	FOR BID	7-20-05	CLE

FINAL CONSTRUCTION CHECKED / BY / DATE / FIELD BOOKS

DATE: MAY 2005 | SCALE: NTS | DESIGNED: CLE | CHECKED: BD | DRAWN | PROJECT NAME: 326982
DRAWING NAME: 326982 details dwg 4.dgn
29-JUN-2005 12:42:50
EXPIRES 3/21/06

ENGINEERING DIVISION MANAGER

CITY OF TACOMA
DEPARTMENT OF PUBLIC WORKS

Tacoma Landfill Employee Parking Lot Expansion & Pervious Pavement Demonstration Project
INTERCEPTOR DETAILS

ENV-00205
SHEET NO. 4
SHEET 4 OF 10

Appendix C
National Stormwater BMP Database Requirements

Table C-1. National Stormwater BMP Database requirements for all BMPs.

Data Element	Description
General Test Site Information	
BMP Test Site Name	Name that site is known by locally.
City	City closest to test site.
State	State where test was performed.
Zip Code	Zip code of the test site.
Country	Country where the test site is located.
Altitude	Altitude to nearest 100 ft or 30 m.
Sponsoring and Monitoring Agencies for Test Site	
Address	Includes monitoring and sponsoring agency name and contact information.
Watershed Information	
Subject Watershed Name	Name that watershed is referred to locally.
Total Watershed Area	Topographically defined area drained by system.
Percent (%) Impervious Area	Total percent of impervious surface in watershed.
Regional Climate Station (US)	Regional climate station in US that is most relevant to test site.
Land Use Information	Description of land uses (only required for non-structural BMPs).
Monitoring Stations	
Station	User-defined name for subject monitoring station.
Identify Upstream BMP	BMP upstream of the monitoring point (if any).
Identify Relationship to Upstream BMP	Identify the relationship of the monitoring station to the upstream BMP (i.e. inflow, outflow or not applicable).
Identify Downstream BMP	BMP downstream of the monitoring point (if any).
Identify Relationship to Downstream BMP	Identify the relationship of the monitoring station to the downstream BMP (i.e. inflow, outflow or not applicable).
Monitoring Instrumentation	
Monitoring Station Name	Select monitoring station where the instrument is located.
Precipitation Data	
Monitoring Station Name	Identify monitoring station where precipitation event was monitored.
Storm Runoff and Base Flow Data	
Monitoring Station Name	Select monitoring station where flow event was monitored.
Type of Flow	Base flow or stormwater runoff.
Flow Start Date	Month, day and 4-digit year (e.g. 01/01/1998).
Total Bypass Volume (if any)	Total runoff volume minus runoff volume influent to BMP.
Total Storm Flow Volume into or from BMP	Total runoff volume minus the bypass volume.
Dry Weather Base Flow Rate	Flow rate during dry-weather conditions.

Table C-1. National Stormwater BMP Database requirements for all BMPs. (continued).

Water Quality Sampling Event	
Monitoring Station Name	Select monitoring station where samples were collected.
Related Flow-Event	Select flow data corresponding to water quality data.
Date Water Quality Sample Collected	Month, day and 4-digit year the water quality sample was collected.
What Medium Does the Instrument Monitor	e.g. Groundwater, surface runoff.
Water Quality Parameters	STORET water quality parameters analyzed.
Value	Value of measured constituent.
Unit	Units of measured constituent.
Qualifier	Select STORET qualifier code.

Table C-2. National Stormwater BMP Database requirements for structural BMPs.

Data Element	Description
Structural BMP Information	
Structural BMP Name	Common name by which BMP is referred to locally.
Structural BMP Type	Select the type of BMP being monitored at the site (drop-down list).
Date Facility Was Put Into Service	Month, day and 4-digit year facility became operational.
Number of Separate Inflows	Number of inflows into the facility.
Describe the Type and Design of Each BMP Outlet	Description of the outlet configuration (i.e. Perforated riser).
Is the BMP Designed to Bypass When Full?	Select "Overflow" or "bypass" characteristics of BMP.
BMP Drawing	Plan view and profile of BMP (in bitmap format for database).

Table C-3. National Stormwater BMP Database requirements for individual structural BMPs.

Data Element	Description
Wetland Channel and Swale Design Data	
Length of Channel/Swale	Length of channel or swale from stormwater inflow to outflow point.
Longitudinal Slope of Channel/Swale	Measured slope between grade control structures in swale.
Bottom Width of Channel /Swale	Average width between side slopes.
Side Slope of Channel Swale	Average slope of swale sides.
2-Year Flow Design Depth in Channel/Swale	Average depth of water in channel/swale during 2-yr flow.
2-Year Peak Design Flow Velocity	Design velocity for 2-yr flow.
Type of Plant Species in Wetland Zone or Swale	List and description of plant species, percent of cover and densities.
Media Filter Design Data	
Permanent Pool Volume, Upstream of Filter Media (if any)	Volume of the permanent pool, if pool is part of filter basin.
Permanent Pool Surface Area	Area of water surface of permanent pool.
Permanent Pool Length	Distance between inflow and outflow (average for multiple inflows).
Surcharge Detention Volume	The design water quality detention volume, including the volume above the filter.
Surcharge Detention Volume Surface Area	The surface area of the design water quality capture volume.
Surcharge Detention Volume's Design Drain Time	The drain time (in hours) of the water quality capture volume.
Surcharge Detention Volume Design Depth	Depth of water quality capture volume.
Media Filter Surface Area	Surface area of the media filter.
Angle of Sloping or Vertical Filter	Inclination of filter in degrees above the horizontal plane.
Number of Media Filter Layers	Number of layers of different filter material in BMP.
Describe Depth and Type of Each Filter Media Layer	Description of the type and depth of media used in the filter.

Appendix D
Sampling Equipment Specifications

Isco 2150 Area Velocity Flow Module

The 2150 Flow Module uses continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave, then measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow.

The 2150's "smart" area velocity probe is built on digital electronics, so the analog level is digitized in the sensor itself to overcome electromagnetic interference. The probe is also factory-calibrated for 10-foot (3 meter) span at different temperatures. This built-in calibration eliminates drift in the level signal, providing long-term level stability that reduces recalibration frequency and completely eliminates span recalibration.

In field use, the 2150 is typically powered either by two alkaline, or Isco Rechargeable Lead-acid batteries, within a 2191 Battery Module. Highly efficient power management extends battery life up to 15 months at 15-minute data storage intervals. Other power options (including solar) are available.

Applications

- Portable and permanent-site AV flow monitoring for inflow and infiltration, capacity assessment, sewer overflow, and other sewer studies.
- Measuring shallow flows in small pipes. Our low-profile area velocity sensor minimizes flow stream obstruction and senses velocity in flows down to 1 inch (25 mm) in depth.

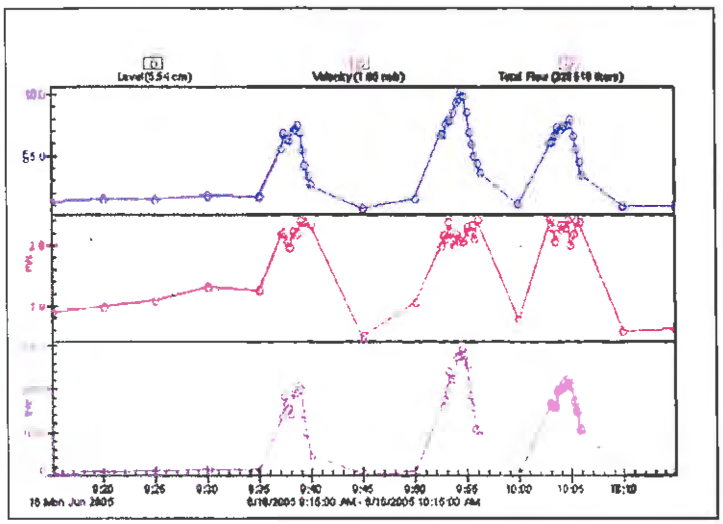
Standard Features

- Rugged, submersible enclosure meets NEMA 4X, 6P (IP68) environmental specs.
- Chemically resistant epoxy-encapsulated sensor withstands abuse, resists oil and grease fouling, and eliminates the need for frequent cleaning.
- Replaceable high-capacity internal desiccant cartridge and hydrophobic filter protect sensor reference from water entry and internal moisture.
- Pressure transducer vent system automatically compensates for atmospheric pressure changes to maintain accuracy.
- The quick-connect sensor can be easily removed and interchanged in the field without requiring recalibration.
- Up to four 2100 Series flow modules can be networked by stacking and/or extension cables.

Above left: Additional modules can be added for redundant or multi-stream measuring (Isco 2110 Ultrasonic Module shown). Right: Optional mounting rings provide quick, secure sensor installation in round pipes from 6 to 80 inches (150 to 2000 mm).

Software Features

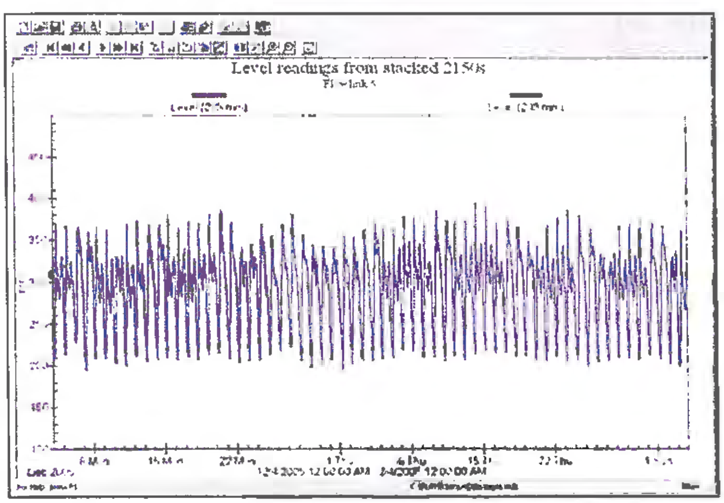
- Secure data storage. All data are continuously stored in flash memory to protect against loss in case of power failure
- Easy to upgrade. New operating software can be downloaded into non-volatile flash memory, without affecting stored program and data.
- Records and stores input voltage and temperature data.
- Variable rate data storage lets you change the data storage interval when programmed conditions occur. This feature assures maximum information about an exceptional event – such as an overflow – while conserving power and data capacity during normal conditions.
- 38,400 bps communication provides speedy setup and data retrieval.



Variable rate data storage

The 2150 flow module has the ability to automatically switch data storage rates based on varying conditions.

In the example at left, the 5-minute data storage rate automatically changed to 30 seconds when the flow rose above a programmed level.



Level stability

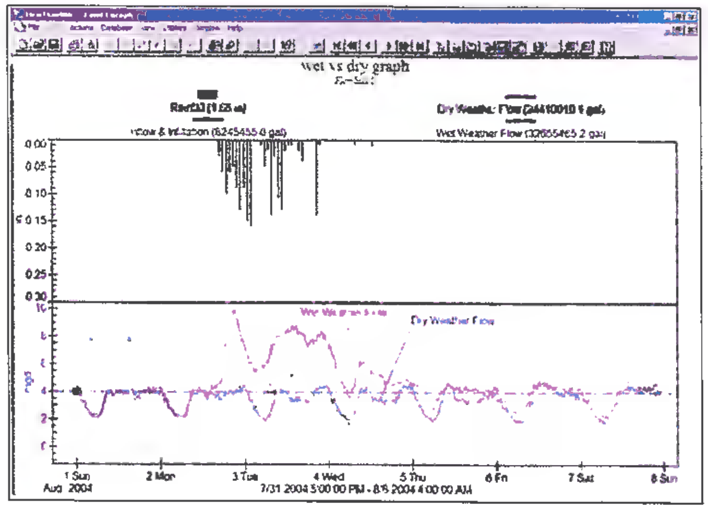
Frequent multipoint level recalibration is a requirement with other area velocity flow meters. Isco's exclusive "smart" sensor design in the area velocity probe yields exceptionally low drift in the level signal.

The 2150's factory-calibrated 3-meter span totally eliminates the need for cumbersome span recalibration in the field.

In the example at left, two area velocity probes were installed at the same site. The level readings from both sensors track closely without any drift, over an 8-week period.

Flowlink® Data Analysis

Isco Flowlink® Software is a powerful tool for analyzing flow and water quality data. It provides site setup, data retrieval, and comprehensive data analysis, as well as advanced reporting and graphing. See separate datasheets for details on Flowlink and Flowlink Pro software.



The Flowlink screen shown above gives a comparison of dry and wet weather flows, plus rainfall typical of an inflow & infiltration study

Information Delivery

Isco 2100 Series Flow Modules offer a wide variety of communication and retrieval options, to minimize the need for expensive on-site visits and confined space entry. These include:

Isco 2103 Land-line Modem Module
Reliable two-way dial-up communication between down-hole 2100 Flow Modules and your desktop computer, equipped with Isco Flowlink Software. A dial-out feature enables the system to transmit a text message alarm to your digital cell phone or pager.

Isco 2103c Cellular Modem Module
All the features of the 2103 Modem with the convenience of cell phone access. And the 2103c can automatically send data via the Internet to a designated server running Flowlink Pro software, using economical 1xRTT packet-switched data transmission.

Isco 2108 Analog Output Module
Provides current outputs for use with Isco 2100 Series Area Velocity and Ultrasonic Flow Modules. It allows easy interface with SCADA/DCS or other secondary instrument systems.

Modbus
2100 Series Flow Modules provide digital RS 232 Modbus output that can be used to interface with external communication modules, SCADA systems, or other devices.

On-site Data Retrieval

Isco Flowlink Software
Download and process data on-site. Enjoy unmatched data management capability, advanced data editing and analysis, powerful reporting and presentation choices, and a variety of downloading and data handling options.

Isco 2101 Field Wizard
A durable, weatherproof module for on-site data retrieval. Don't risk damage to your fragile notebook PC. The 2101 Field Wizard provides on-site display of current readings, information about stored data, diagnostics, and more.

Interrogate all 2100 Series Flow Modules in the stack at one time, and store more than 14 days' data from up to 20 modules!

Isco 2102 Communication Module
Connect with your Isco 2100 Series Flow Modules from the safety and convenience of your vehicle.

Digital spread-spectrum radio signals enable "drive-up" data retrieval, system configuration, and level calibration, with minimum power consumption. "Plug and Play" setup – no interfacing needed.

Specifications

2150 Flow Module

Size (HxWxD):	2.9 x 11.3 x 7.5 in (74 x 287 x 191 mm)
Weight:	2.0 lb (0.9 kg)
Materials of construction:	High-impact polystyrene, stainless steel
Enclosure (self-certified):	NEMA 4X, 6P (IP68)
Temperature Range:	-40° to 140° F (-40° to 60° C) operating and storage
Power Required:	12 VDC nominal (7.0 to 16.6 VDC), 100 mA typical, 1 mA standby
Power Source:	Typically an Isco 2191 Battery Module, containing 2 alkaline or 2 rechargeable lead-acid batteries. (Other power options are available; ask for details.)
Typical Battery Life:	Using 15-minute data storage interval Energizer® Model 529 alkaline - 15 months Isco rechargeable lead-acid - 2.5 months
Program Memory:	Non-volatile programmable flash; can be updated using PC without opening enclosure; retains user program after updating.
Built-in Conversions	
Flow Rate Conversions:	Up to 2 independent level-to-area conversions and/or level-to-flow rate conversions.
Level-to-Area Conversions:	Channel Shapes - round, U-shaped, rectangular, trapezoidal, elliptical, with silt correction; Data Points - Up to 50 level-area points.
Level-to-Flow Conversions:	Most common weirs and flumes; Manning Formula; Data Points (up to 50 level-flow points); 2-term polynomial equation
Total Flow Calculations:	Up to 2 independent, net, positive or negative, based on either flow rate conversion
Data Handling and Communications	
Data Storage:	Non-volatile flash; retains stored data during program updates. Capacity 395,000 bytes (up to 79,000 readings, equal to over 270 days of level and velocity readings at 15-minute intervals, plus total flow and input voltage readings at 24-hour intervals)
Data Types:	Level, velocity, flow rate 1, flow rate 2, total flow 1, total flow 2, input voltage, temperature
Storage Mode:	Rollover; 5 bytes per reading.
Storage Interval:	15 or 30 seconds; 1, 2, 5, 15, or 30 minutes; or 1, 2, 4, 12, or 24 hours Storage rate variable based on level, velocity, flow rate, total flow, or input voltage
Data Retrieval:	Serial connection to PC or optional 2101 Field Wizard module; optional modules for spread spectrum radio; land-line or cellular modem; 1xRTT. Modbus and 4-20 mA analog available.
Software:	Isco Flowlink for setup, data retrieval, editing, analysis, and reporting
Multi-module networking:	Up to four 2100 Series Flow Modules, stacked and/or remotely connected. Max distance between modules 3300 ft (1000 m).
Serial Communication Speed:	38,400 bps

2150 Area Velocity Sensor

Size (HxWxD):	0.75 x 1.3 x 6.0 in (19 x 33 x 152 mm)
Cable (Length x Diameter):	25 ft x 0.37 in (7.6 m x 9 mm) standard. Custom lengths available on request.
Weight (including cable):	2.2 lbs (1 kg)
Materials of construction:	Sensor - Epoxy, chlorinated polyvinyl chloride (CPVC), stainless steel Cable - Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC)
Operating Temperature:	32° to 140° F (0° to 60° C)
Level Measurement:	Method - Submerged pressure transducer mounted in the flow stream Transducer Type - Differential linear integrated circuit pressure transducer Range (standard) 0.033 to 10 ft (0.010 to 3.05 m); (optional) up to 30 ft (9.15 m). Maximum Allowable Level 34 ft (10.5 m) Accuracy ±0.01 ft from 0.033 to 10 ft, (±0.003 m from 0.01 to 3.05 m,) Long-Term Stability ±0.023 ft/yr (±0.007 m/yr) Compensated Range 32° to 122°F (0° to 50°C)
Velocity Measurement:	Method - Doppler ultrasonic, frequency 500 kHz Typical Minimum Depth 0.08 ft (25 mm) Range -5 to +20 ft/s (-1.5 to +6.1 m/s) Accuracy (in water with uniform velocity profile, speed of sound = 4850 ft/s, for indicated velocity range) ±0.1 ft/s from -5 to 5 ft/s (±0.03 m/s from -1.5 to +1.5 m/s) ±2% of reading from 5 to 20 ft/s (1.5 to 6.1 m/s)
Temperature Measurement:	Accuracy ±3.6° F (±2° C)

2191 Battery Module

Size (HxWxD):	6.0 x 9.6 x 7.6 in (152 x 244 x 193 mm)
Weight (without batteries):	3.2 lb (1.4 kg)
Materials of construction:	High-impact polystyrene, stainless steel
Enclosure (self certified):	NEMA 4X, 6P, (IP68)
Batteries:	Two 6-volt Energizer Model 529* alkaline (25 Ahrs capacity) or Isco Rechargeable Lead-acid (5 Ahrs capacity) recommended. *Note – Energizer 529 ER does not give specified life.

2150 Ordering Information

Contact your Teledyne Isco representative for complete ordering details and information on other 2100 Series Modules.

Description	Part No.
2150 with AV sensor, 2191 Battery Module, and Handle	68-2050-002
2150 Module with AV sensor (only)	68-2050-001
Isco Flowlink® 5 Software	68-2540-200
Energizer® Model 529 Alkaline Lantern Battery (2 required)	340-2006-02
Isco Rechargeable Lead-acid Battery (2 required)	60-2004-041
Charger for Lead-acid Batteries (holds 2 batteries)	60-2004-040

Water is life. Protect it.

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Lincoln NE 68504 USA
Tel: (402) 464-0231
USA and Canada: (800) 228-4373
Fax: (402) 465-3022
E-Mail: iscoinfo@teledyne.com
Internet: www.isco.com

Certified ISO 9001

Isco Product Data

Isco 6712 Full-size Portable Sampler

Isco's 6700 Series Portable Samplers have set the industry standard, providing the most comprehensive and durable performance available. With the introduction of our new 6712, Isco takes another step toward the ultimate by including SDI-12 interface capabilities.

This full-size portable lets you take full advantage of the advanced 6712 Controller, with its powerful pump, versatile programming, and optional plug-in modules for integrated flow measurement. Setup is fast and simple, with online help just a key stroke away.

The environmentally-sealed 6712 controller delivers maximum accuracy and easily handles all of your sampling applications, including:

- Flow-paced sampling with or without wastewater effluent
- stormwater monitoring
- CSO monitoring
- permit compliance
- pretreatment compliance

In the Standard Programming Mode, the controller walks you through the sampling sequence step-by-step, allowing you to choose all parameters specific to your application. Selecting the Extended Programming Mode lets you enter more complex programs.

Optional land-line and GSM and CDMA cellular telephone modems allow programming changes and data collection to be performed remotely, from a touch-tone phone. They also provide dial-out alarm.

Bottle options are available for practically any sequential or composite application.

Versatile and Convenient

With eleven bottle choices, Isco's 6712 Sampler lets you quickly adapt for simple or intricate sampling routines. Up to 30 pounds (13.5 kg) of ice fits in the insulated base, preserving samples for extended periods, even in extreme conditions. The 6712 with the "Jumbo Base" option holds bottles up to 5.5 gallon (21 liter).

Tough and Reliable

The 6712 Portable Sampler features a vacuum-formed ABS plastic shell to withstand exposure and abuse. Its tapered design and trim 20-inch (50.8 cm) diameter result in easy manhole installation and removal. Large, comfortable handles make transporting safe and convenient—even when wearing gloves.

Isco's 6712 Portable Sampler carries a NEMA 4X, 6 (IP67) enclosure rating.

Superior capability, rugged construction, and unmatched reliability make the 6712 the ideal choice for portable sampling in just about any application.

Specifications

Isco 6712 Full-size Portable Sampler	
Size (Height x Diameter):	27 x 20 inches (50.7 x 68.6 cm)
Weight:	Dry, less battery - 32 lbs (15 kg)
Bottle configurations:	24 - 1 Liter PP or 350 ml Glass 24 - 1 Liter ProPak Disposable Sample Bags 12 - 1 Liter PE or 950 ml Glass 8 - 2 Liter PE or 1.8 Liter Glass 4 - 3.8 Liter PE or Glass 1 - 9.5 Liter PE or Glass 1 - 5.5 gallon (21 Liter)PE or 5 gallon (19 Liter) Glass, (with optional Jumbo Base)
Power Requirements:	12 V DC (Supplied by battery or AC power converter.)

Pump	
Intake suction tubing: Length Material Inside dimension	 3 to 99 feet (1 to 30 m) Vinyl or Teflon 3/8 inch (1 cm)
Pump tubing life:	Typically 1,000,000 pump counts
Maximum lift:	28 feet (8.5 m)
Typical Repeatability	±5 ml or ±5% of the average volume in a set
Typical line velocity at Head height: of 3 ft. (0.9 m) 10 ft. (3.1 m) 15 ft. (4.6 m)	 3.0 ft./s (0.91 m/s) 2.9 ft./s (0.87 m/s) 2.7 ft./s (0.83 m/s)
Liquid presence detector:	Non-wetted, non-conductive sensor detects when liquid sample reaches the pump to automatically compensate for changes in head heights.

Controller	
Weight:	13 lbs. (5.9 kg)
Size (HxWxD)	10.3 x 12.5 x 10 inches (26 x 31.7 x 25.4 cm)
Operational temperature:	32° to 120°F (0° to 49°C)
Enclosure rating:	NEMA 4X, 6 (IP67)
Program memory:	Non-volatile ROM
Flow meter signal input:	5 to 15 volt DC pulse or 25 millisecond isolated contact closure.
Number of composite samples:	Programmable from 1 to 999 samples
Clock Accuracy:	1 minute per month, typical, for real time clock

Software	
Sample frequency:	1 minute to 99 hours 59 minutes, in 1 minute increments. Non-uniform times in minutes or clock times 1 to 9,999 flow pulses
Sampling modes:	Uniform time, non-uniform time, flow, event. (Flow mode is controlled by external flow meter pulses.)
Programmable sample volumes:	10 to 9,990 ml in 1 ml increments
Sample retries:	If no sample is detected, up to 3 attempts; user selectable
Rinse cycles:	Automatic rinsing of suction line up to 3 rinses for each sample collection
Program storage:	5 sampling programs
Sampling Stop/Resume:	Up to 24 real time/date sample stop/resume commands
Controller diagnostics:	Tests for RAM, ROM, pump, display, and distributor

Ordering Information

Note: Power source, bottle configuration, suction line, and strainer must be ordered separately. Many options and accessories are available for 6712 Samplers; see separate literature for 700 Series Modules and other components to expand your monitoring capabilities. Contact Isco, or your Isco representative for pricing and additional information.

Description	Part Number
6712 Portable Sampler, Full-size Includes controller with 512kB RAM, top cover, center section, base, distributor arm, instruction manual, pocket guide.	68-6710-070
6712 Portable Sampler, with Jumbo Base As described above	68-6710-082

The 6712 Controller is also an SDI-12 data logger, and has many optional capabilities. Please contact Isco or your Isco distributor for more information.

ISCO®
Water is life. Protect it.

Teledyne Isco, Inc.
4700 Superior Street
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USA and Canada: (800) 228-4373
Fax: (402) 465-3022
E-Mail: iscoinfo@teledyne.com
Internet: www.isco.com

Support Products

Rain Gauges

The Isco 674 Rain Gauge connects directly to Isco 6700 Series Samplers, 4200 Flow Meters, and 4100 Flow Loggers to log rainfall along with sampler and flow data.

Our 676 Logging System records rainfall at sites where no sampler or flow meter is deployed.

- Tipping bucket mechanism with jeweled pivot for maximum accuracy

581 Rapid Transfer Device (RTD)

A handy plug-in alternative to using notebook computers in the field.

Retrieve data from these Isco instruments:

- 6700/6712 Samplers and Avalanche
- 4100 Flow Loggers
- 4200 Flow Meters

Isco Power Products

Rugged, reliable batteries and chargers for environmental monitoring applications.

- Built to withstand the harshest environments

Open Channel Flow Measurement Handbook

An essential and extensive resource for professionals who deal with open channel flow.

More than 500 pages of comprehensive information, including standard discharge tables for a wide variety of primary devices.

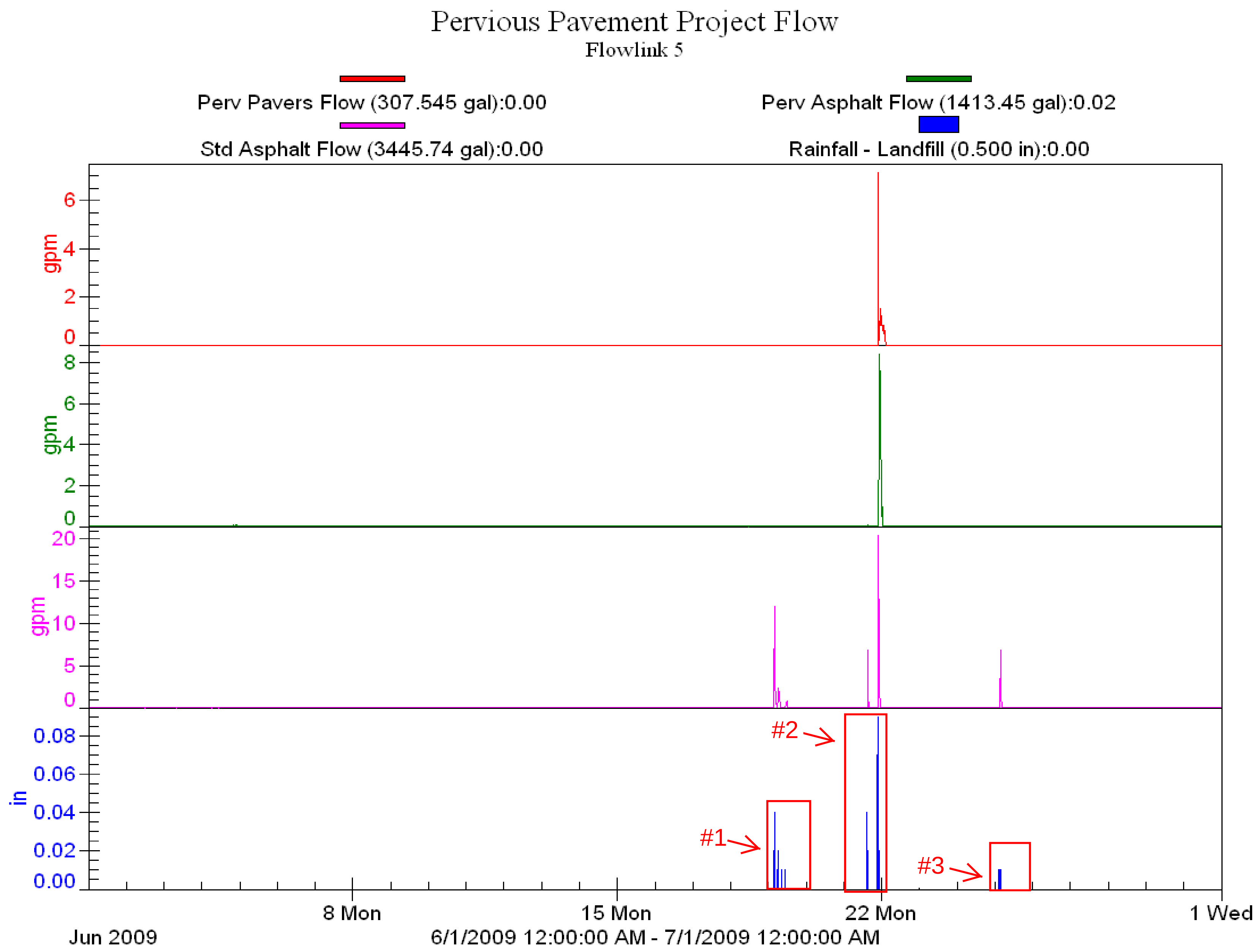
- 6th Edition
- Recently updated and expanded.

Street Level Tools

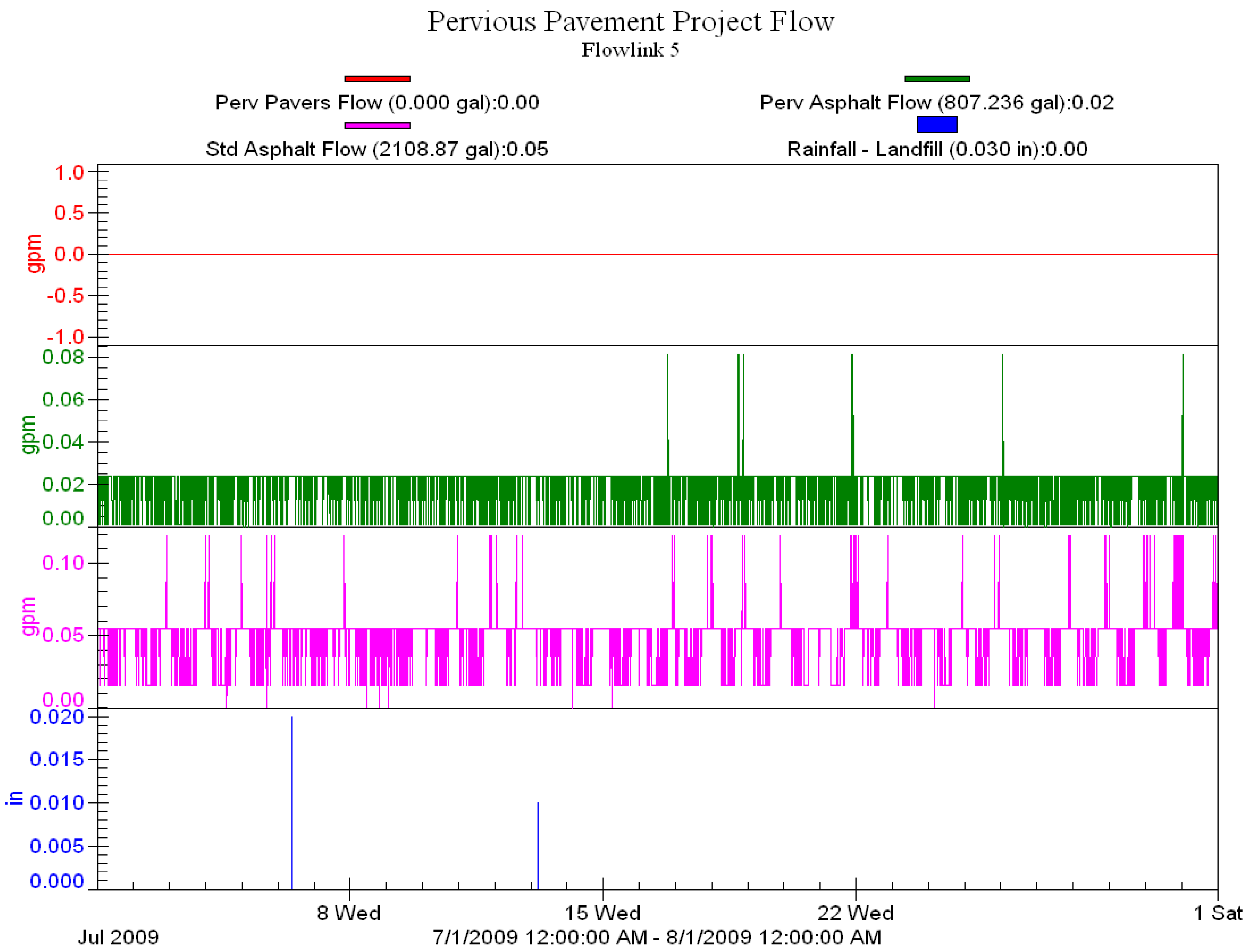
Minimize or eliminate manhole entry.

Versatile accessories that allow a single worker to quickly and safely insert and remove a variety of sensors in manholes as deep as 5 meters.

APPENDIX C. MONTHLY HYDROGRAPHS AND HYETOGRAPHS



Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (307.545 gal):0.00
Perv Asphalt Flow (1413.45 gal):0.02
Std Asphalt Flow (3445.74 gal):0.00
Rainfall - Landfill (0.500 in):0.00
gpm
gpm
gpm
in
#1
#2
#3
8 Mon
15 Mon
22 Mon
1 Wed
Jun 2009
6/1/2009 12:00:00 AM - 7/1/2009 12:00:00 AM



Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (807.236 gal):0.02
Std Asphalt Flow (2108.87 gal):0.05
Rainfall - Landfill (0.030 in):0.00
gpm
1.0
0.5
0.0
-0.5
-1.0
gpm
0.08
0.06
0.04
0.02
0.00
gpm
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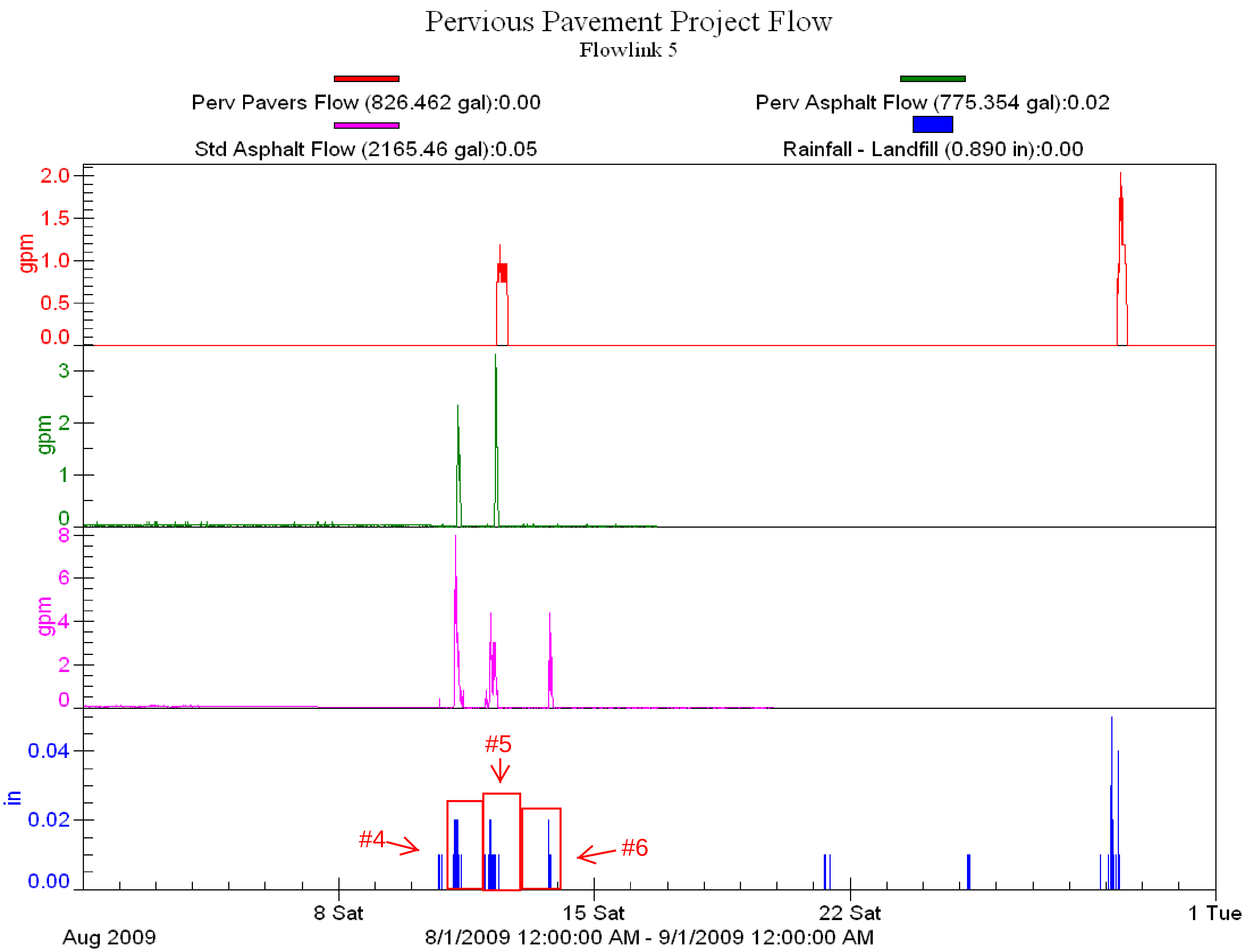

Pervious Pavement Project Flow
Flowlink 5
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Perv Asphalt Flow (775.354 gal):0.02
Std Asphalt Flow (2165.46 gal):0.05
Rainfall - Landfill (0.890 in):0.00
gpm
2.0
1.5
1.0
0.5
0.0
gpm
3
2
1
0
gpm
8
6
4
2
0
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#6
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15 Sat
22 Sat
1 Tue
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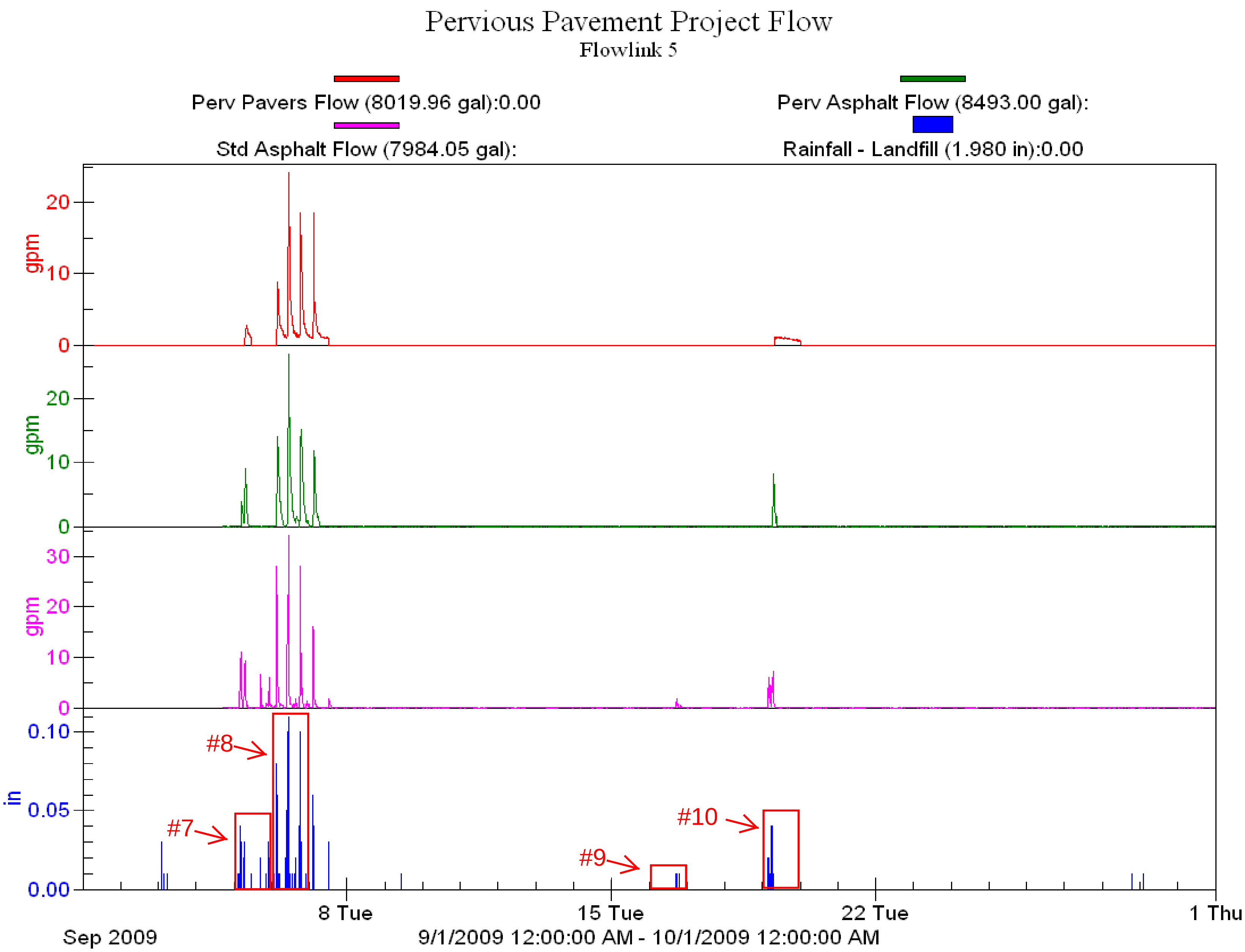
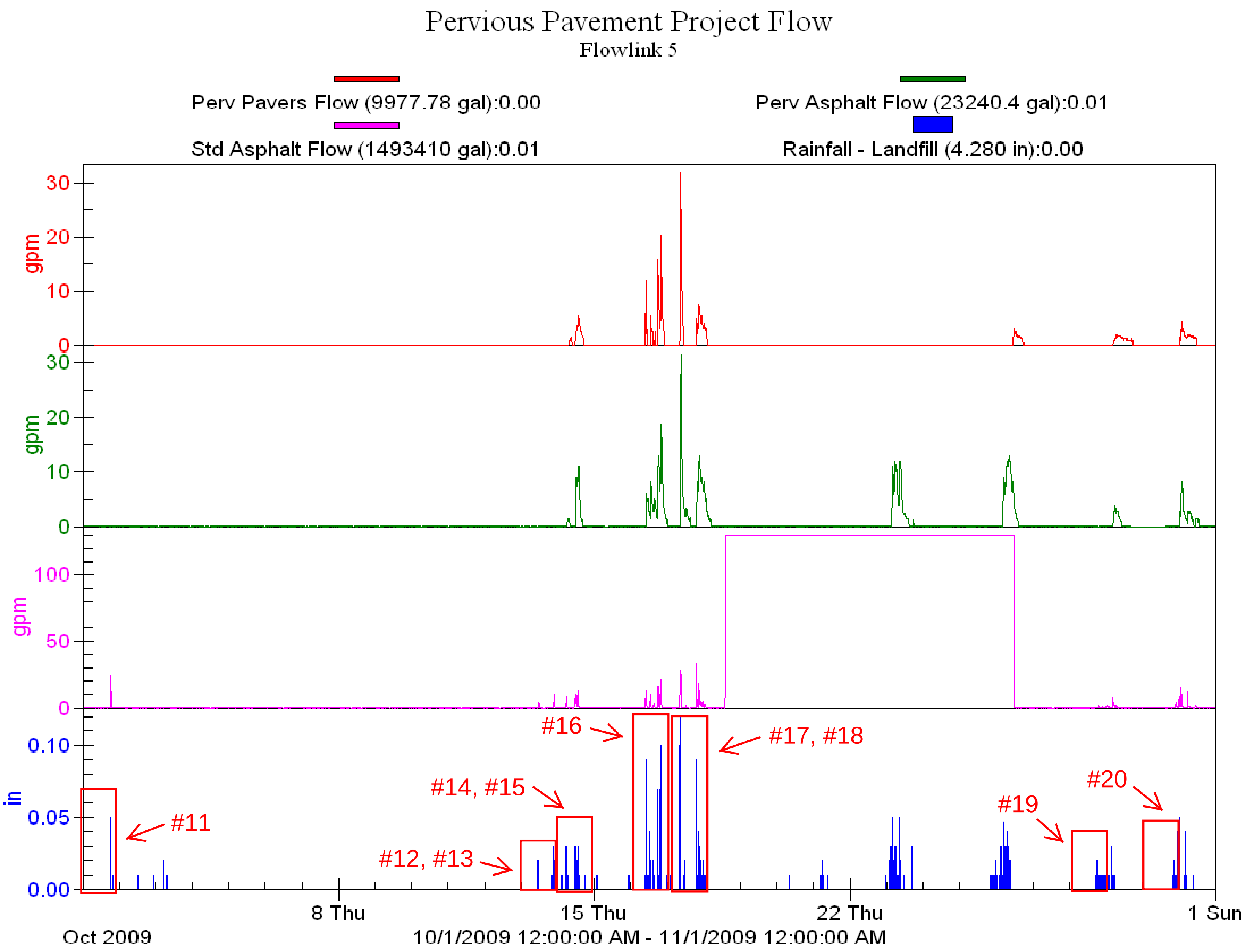
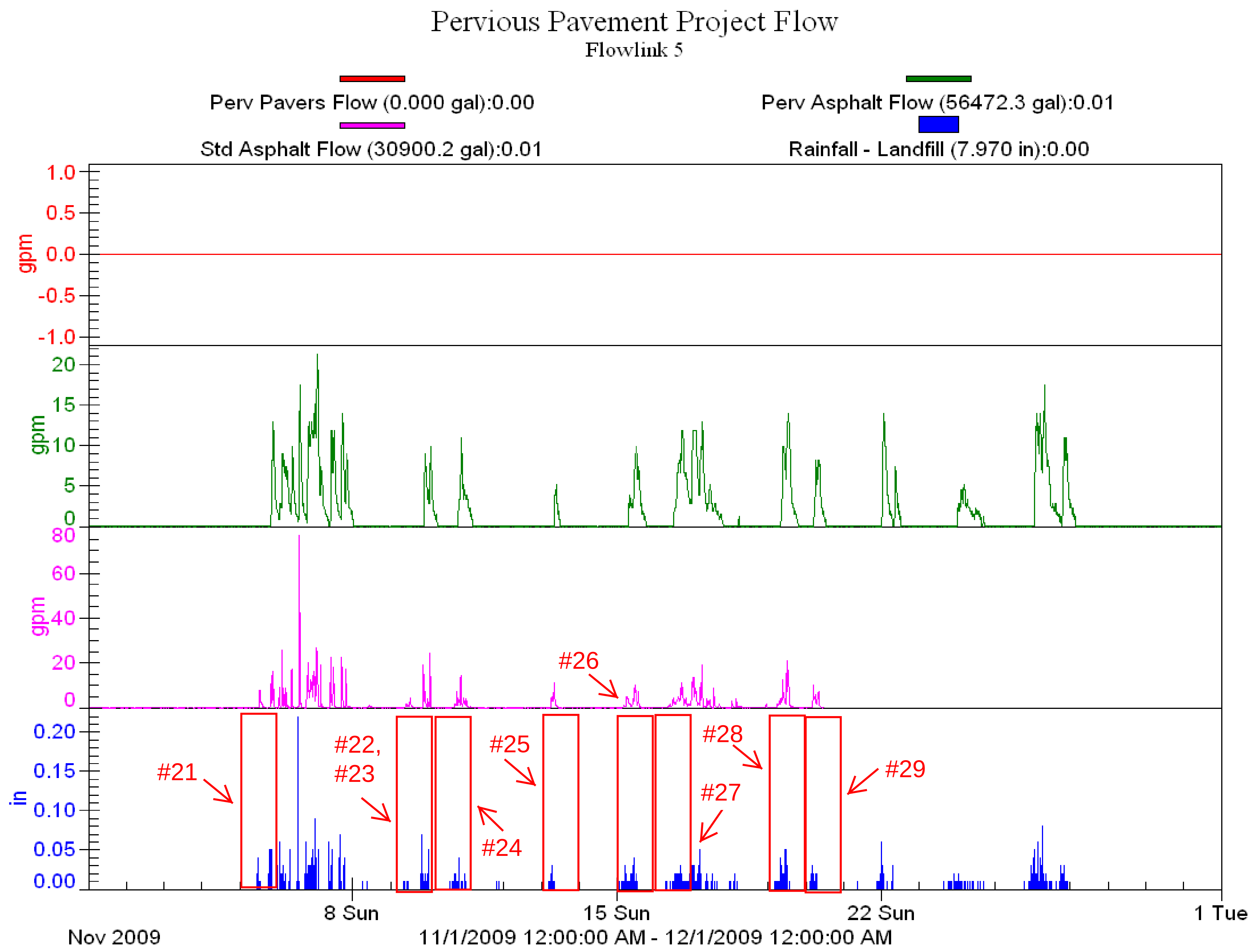
8/1/2009 12:00:00 AM - 9/1/2009 12:00:00 AM



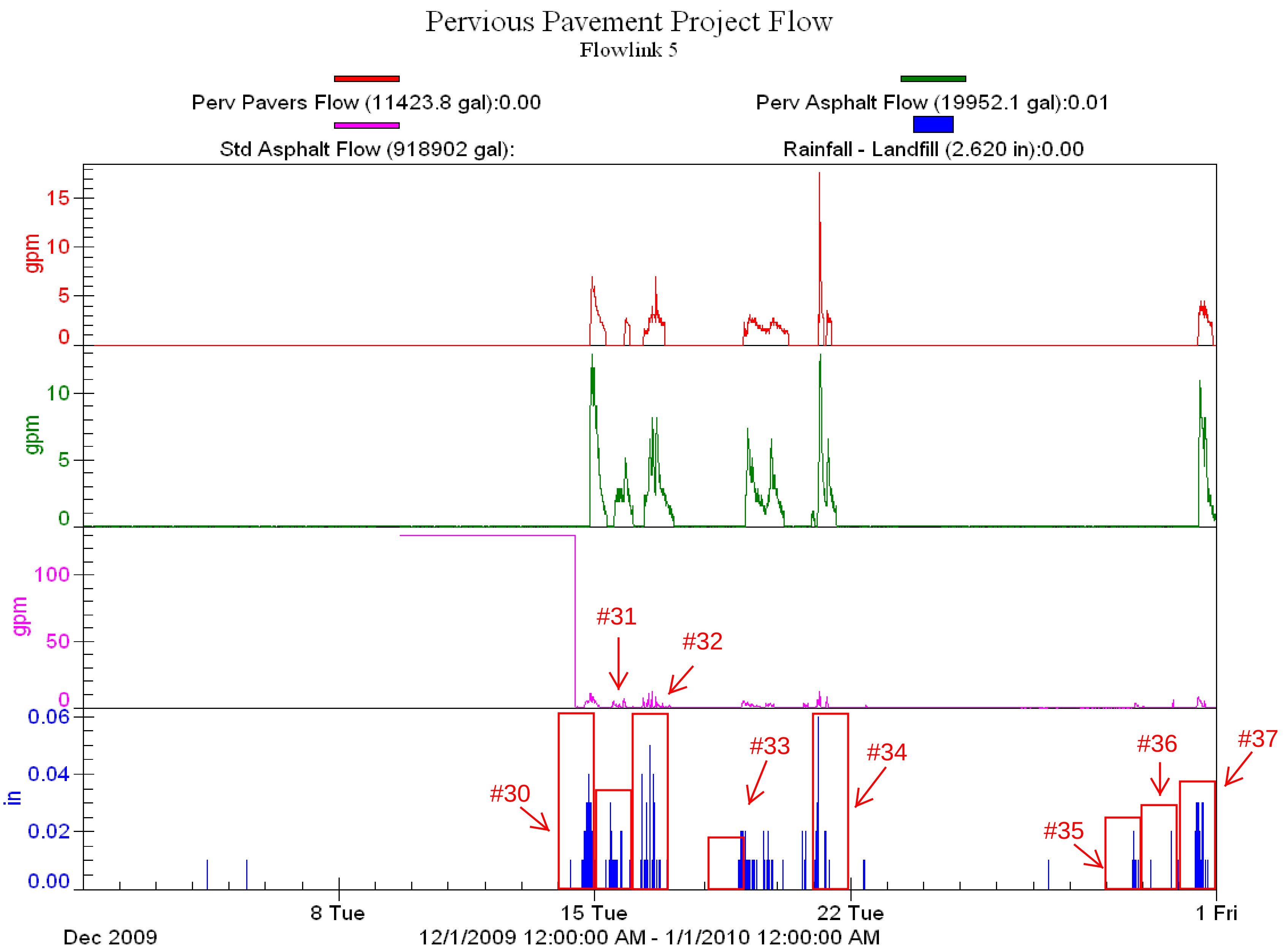
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (8019.96 gal):0.00
Perv Asphalt Flow (8493.00 gal):
Std Asphalt Flow (7984.05 gal):
Rainfall - Landfill (1.980 in):0.00
gpm
gpm
gpm
in
#7
#8
#9
#10
8 Tue
15 Tue
22 Tue
1 Thu
Sep 2009
9/1/2009 12:00:00 AM - 10/1/2009 12:00:00 AM



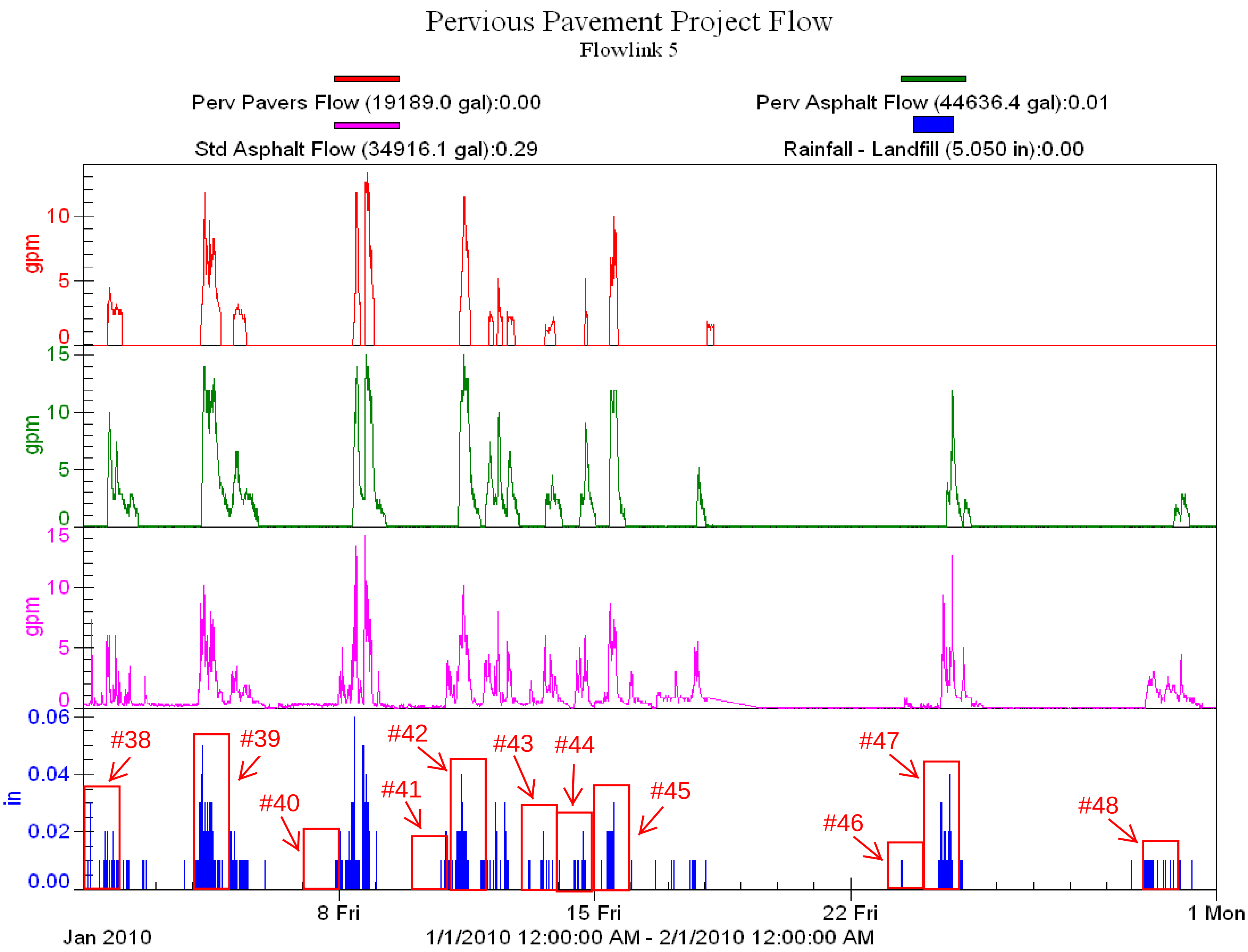
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (9977.78 gal):0.00
Perv Asphalt Flow (23240.4 gal):0.01
Std Asphalt Flow (1493410 gal):0.01
Rainfall - Landfill (4.280 in):0.00
gpm
30
20
10
0
gpm
30
20
10
0
gpm
100
50
0
in
0.10
0.05
0.00
#11
#12, #13
#14, #15
#16
#17, #18
#19
#20
8 Thu
15 Thu
22 Thu
1 Sun
Oct 2009
10/1/2009 12:00:00 AM - 11/1/2009 12:00:00 AM



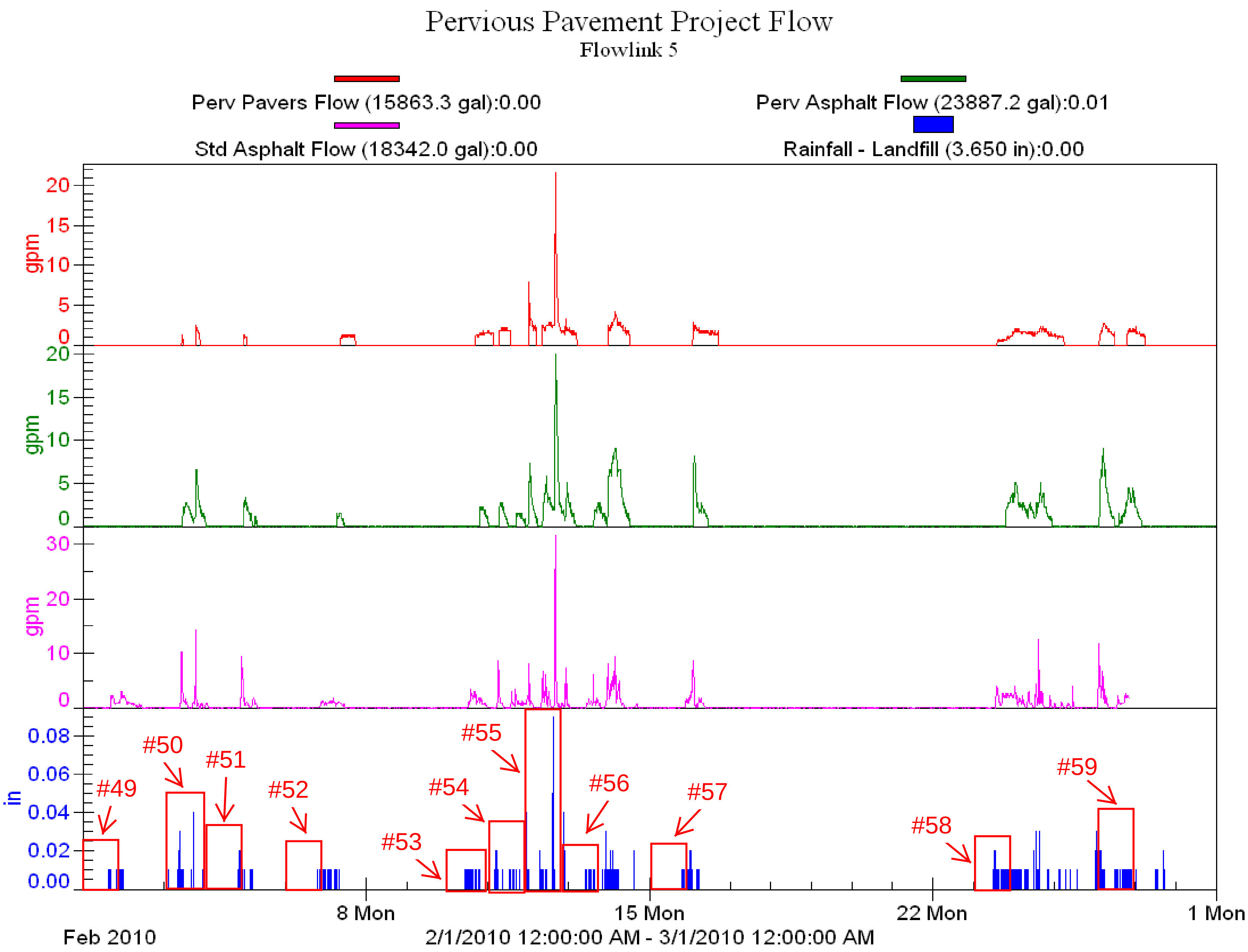
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (56472.3 gal):0.01
Std Asphalt Flow (30900.2 gal):0.01
Rainfall - Landfill (7.970 in):0.00
gpm
1.0
0.5
0.0
-0.5
-1.0
gpm
20
15
10
5
0
gpm
80
60
40
20
0
in
0.20
0.15
0.10
0.05
0.00
#21
#22,
#23
#24
#25
#26
#27
#28
#29
8 Sun
15 Sun
22 Sun
1 Tue
Nov 2009
11/1/2009 12:00:00 AM - 12/1/2009 12:00:00 AM



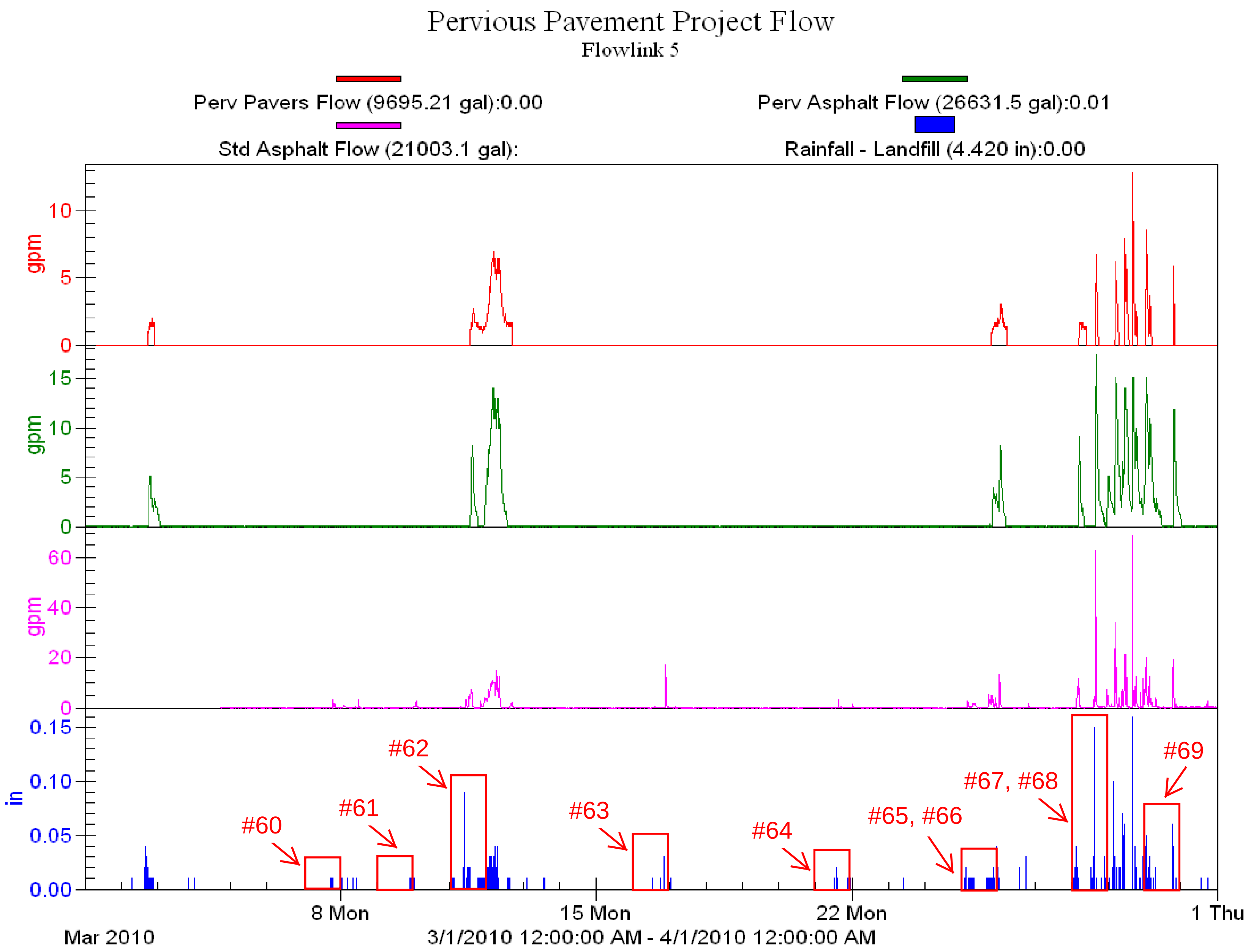
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (11423.8 gal):0.00
Perv Asphalt Flow (19952.1 gal):0.01
Std Asphalt Flow (918902 gal):
Rainfall - Landfill (2.620 in):0.00
gpm
gpm
gpm
in
#30
#31
#32
#33
#34
#35
#36
#37
8 Tue
15 Tue
22 Tue
1 Fri
Dec 2009
12/1/2009 12:00:00 AM - 1/1/2010 12:00:00 AM



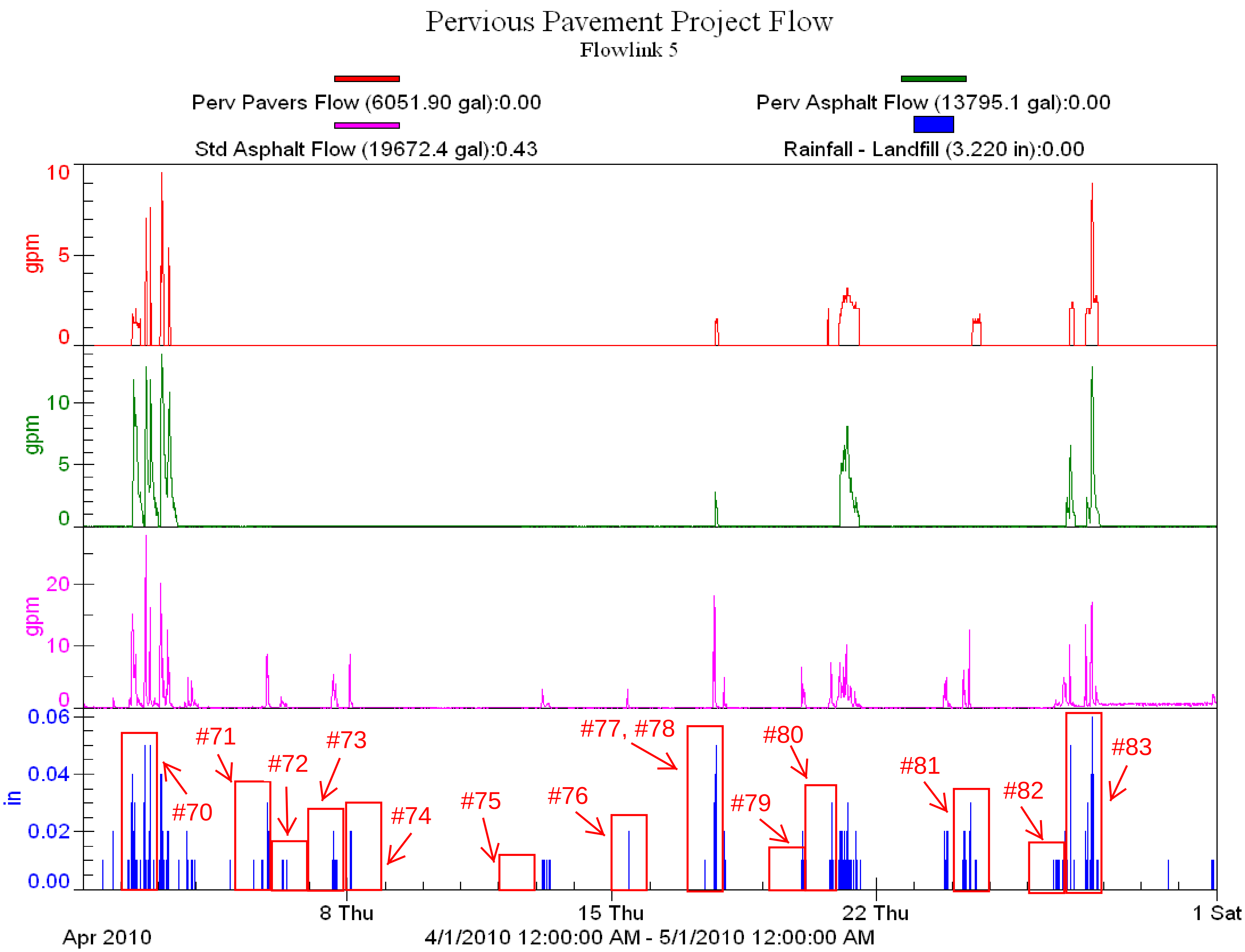
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (19189.0 gal):0.00
Perv Asphalt Flow (44636.4 gal):0.01
Std Asphalt Flow (34916.1 gal):0.29
Rainfall - Landfill (5.050 in):0.00
gpm
gpm
gpm
in
0
5
10
15
0.00
0.02
0.04
0.06
#38
#39
#40
#41
#42
#43
#44
#45
#46
#47
#48
8 Fri
15 Fri
22 Fri
1 Mon
Jan 2010
1/1/2010 12:00:00 AM - 2/1/2010 12:00:00 AM



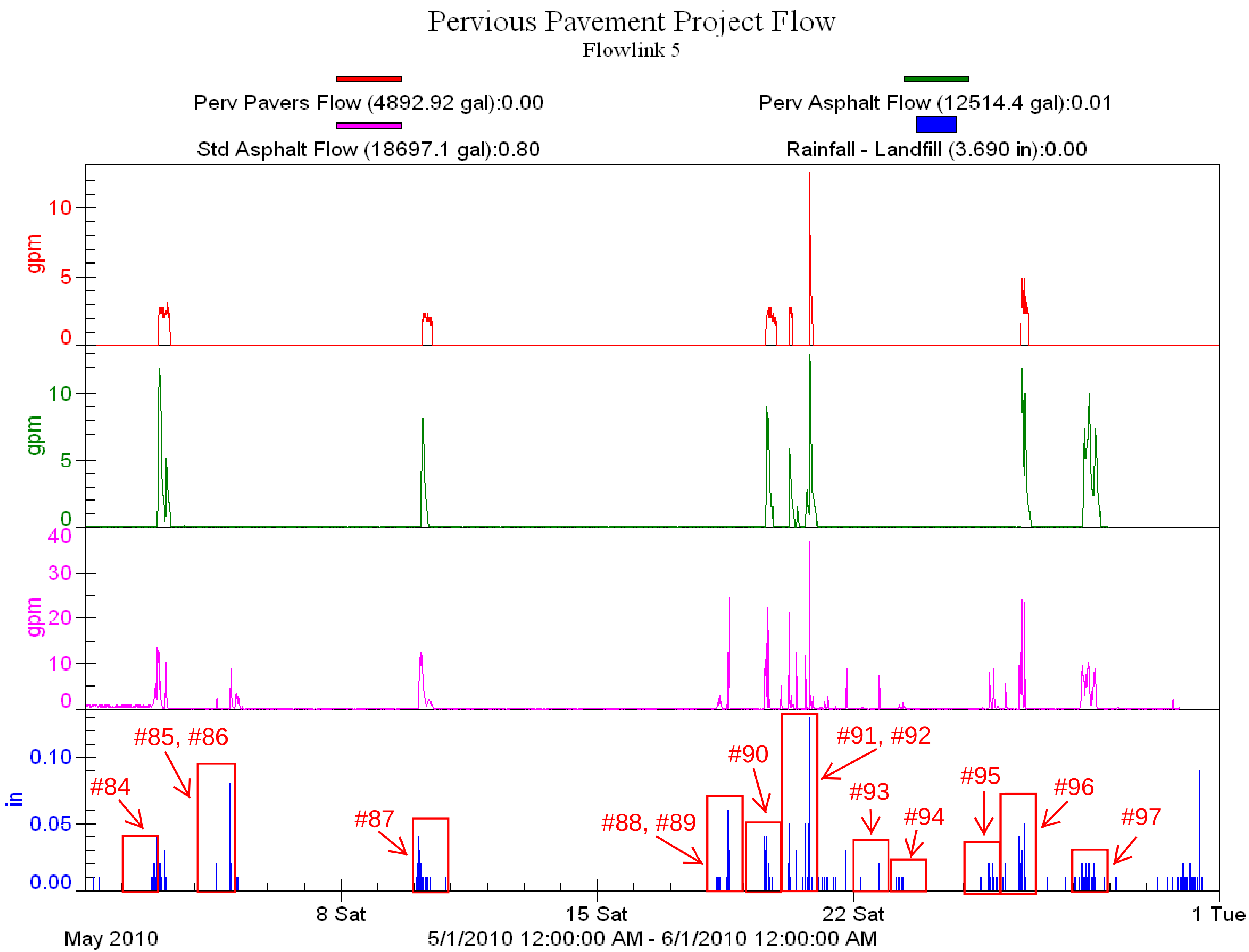
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (15863.3 gal):0.00
Perv Asphalt Flow (23887.2 gal):0.01
Std Asphalt Flow (18342.0 gal):0.00
Rainfall - Landfill (3.650 in):0.00
gpm
gpm
gpm
in
#49
#50
#51
#52
#53
#54
#55
#56
#57
#58
#59
8 Mon
15 Mon
22 Mon
1 Mon
Feb 2010
2/1/2010 12:00:00 AM - 3/1/2010 12:00:00 AM

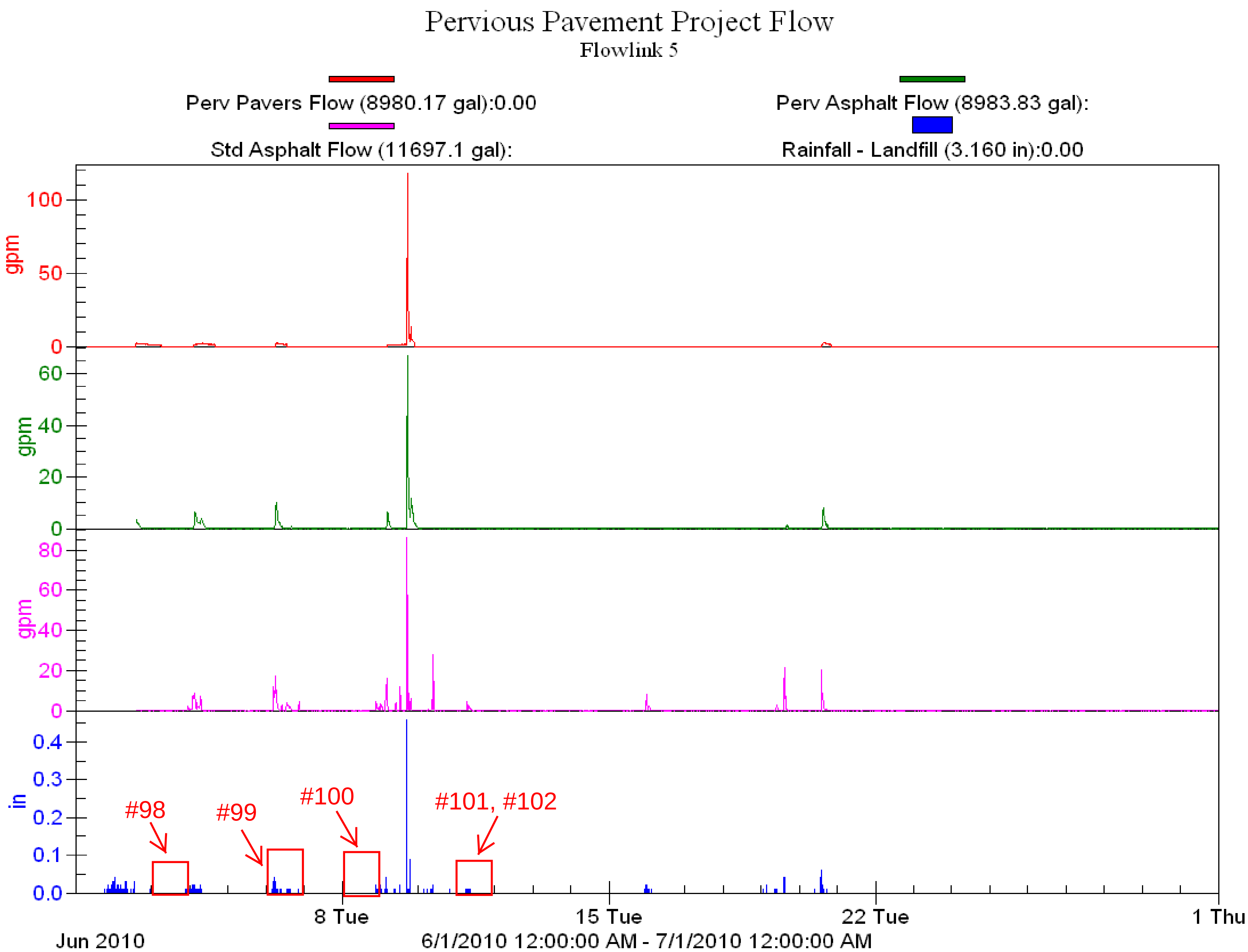


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (9695.21 gal):0.00
Perv Asphalt Flow (26631.5 gal):0.01
Std Asphalt Flow (21003.1 gal):
Rainfall - Landfill (4.420 in):0.00
gpm
gpm
gpm
in
#60
#61
#62
#63
#64
#65, #66
#67, #68
#69
8 Mon
15 Mon
22 Mon
1 Thu
Mar 2010
3/1/2010 12:00:00 AM - 4/1/2010 12:00:00 AM



Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (6051.90 gal):0.00
Std Asphalt Flow (19672.4 gal):0.43
Perv Asphalt Flow (13795.1 gal):0.00
Rainfall - Landfill (3.220 in):0.00
gpm
gpm
gpm
in
#70
#71
#72
#73
#74
#75
#76
#77, #78
#79
#80
#81
#82
#83
8 Thu
15 Thu
22 Thu
1 Sat
Apr 2010
4/1/2010 12:00:00 AM - 5/1/2010 12:00:00 AM


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (4892.92 gal):0.00
Perv Asphalt Flow (12514.4 gal):0.01
Std Asphalt Flow (18697.1 gal):0.80
Rainfall - Landfill (3.690 in):0.00
gpm
in
#84
#85, #86
#87
#88, #89
#90
#91, #92
#93
#94
#95
#96
#97
8 Sat
15 Sat
22 Sat
1 Tue
May 2010
5/1/2010 12:00:00 AM - 6/1/2010 12:00:00 AM



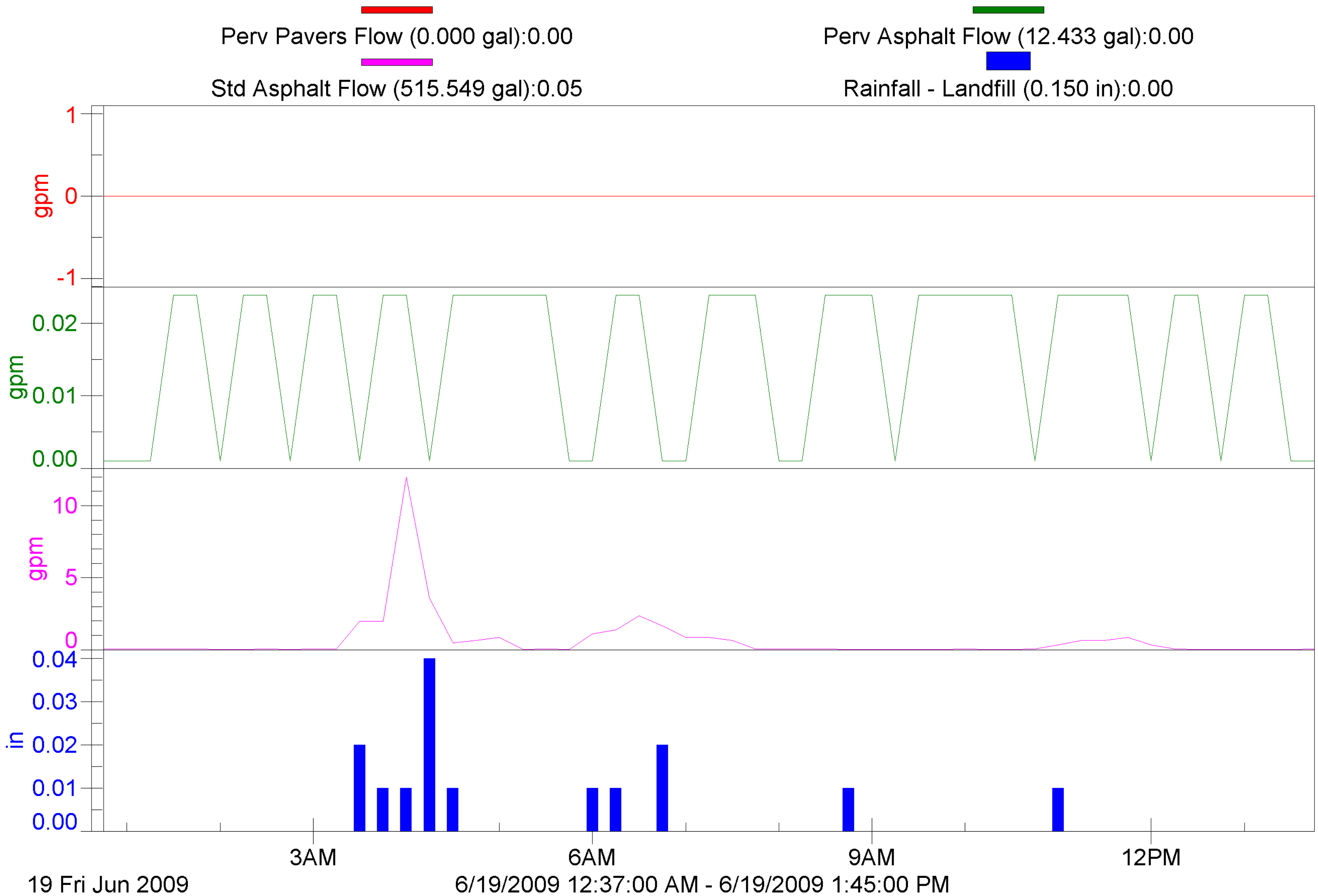
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (8980.17 gal):0.00
Perv Asphalt Flow (8983.83 gal):
Std Asphalt Flow (11697.1 gal):
Rainfall - Landfill (3.160 in):0.00
gpm
100
50
0
60
40
20
0
80
60
40
20
0
in
0.4
0.3
0.2
0.1
0.0
#98
#99
#100
#101, #102
8 Tue
15 Tue
22 Tue
1 Thu
Jun 2010
6/1/2010 12:00:00 AM - 7/1/2010 12:00:00 AM

APPENDIX D. INDIVIDUAL STORM HYDROGRAPHS AND HYETOGRAPHS

Storm #1

Pervious Pavement Project Flow

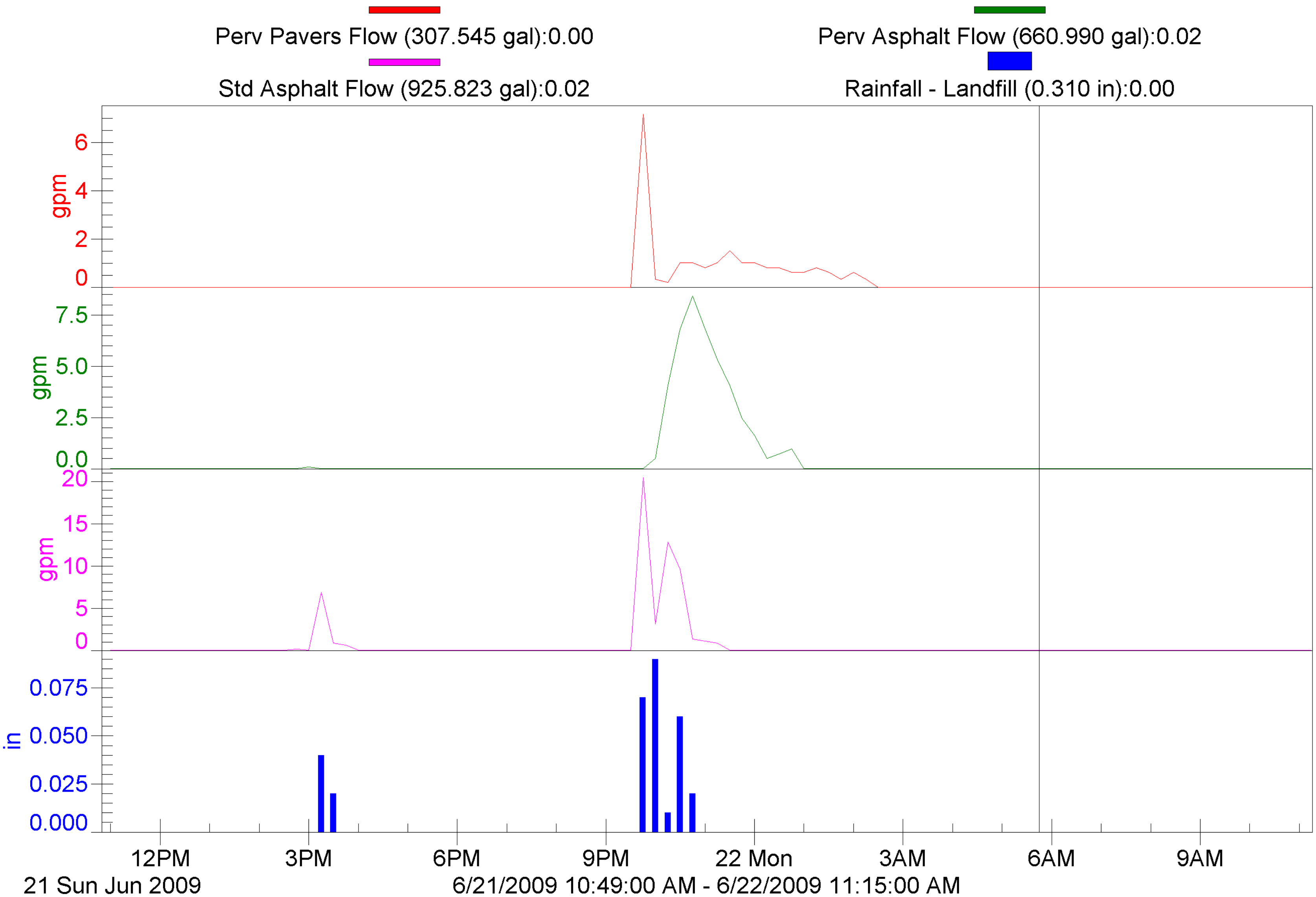
Flowlink 5



Storm #2

Pervious Pavement Project Flow

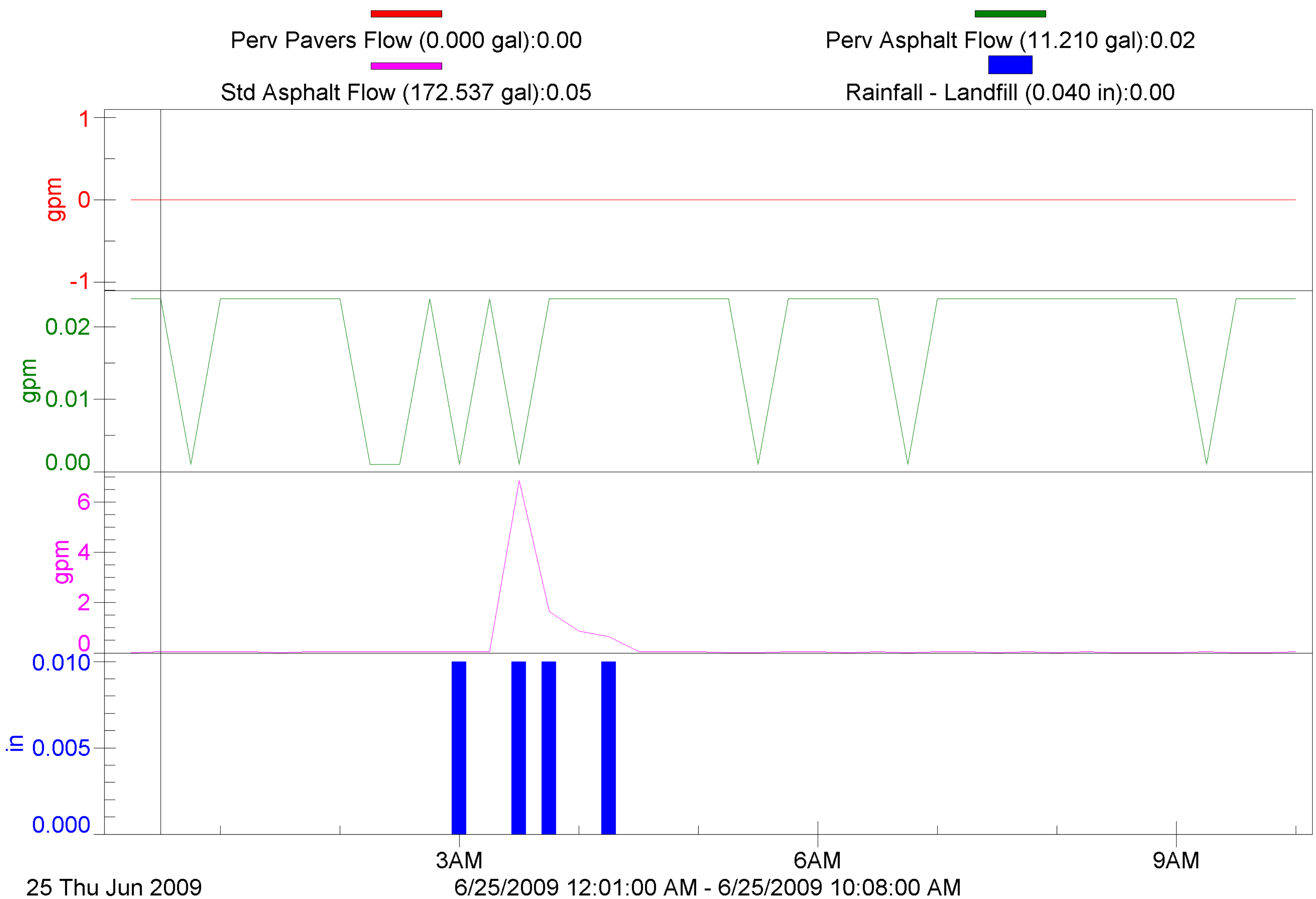
Flowlink 5



Storm #3

Pervious Pavement Project Flow

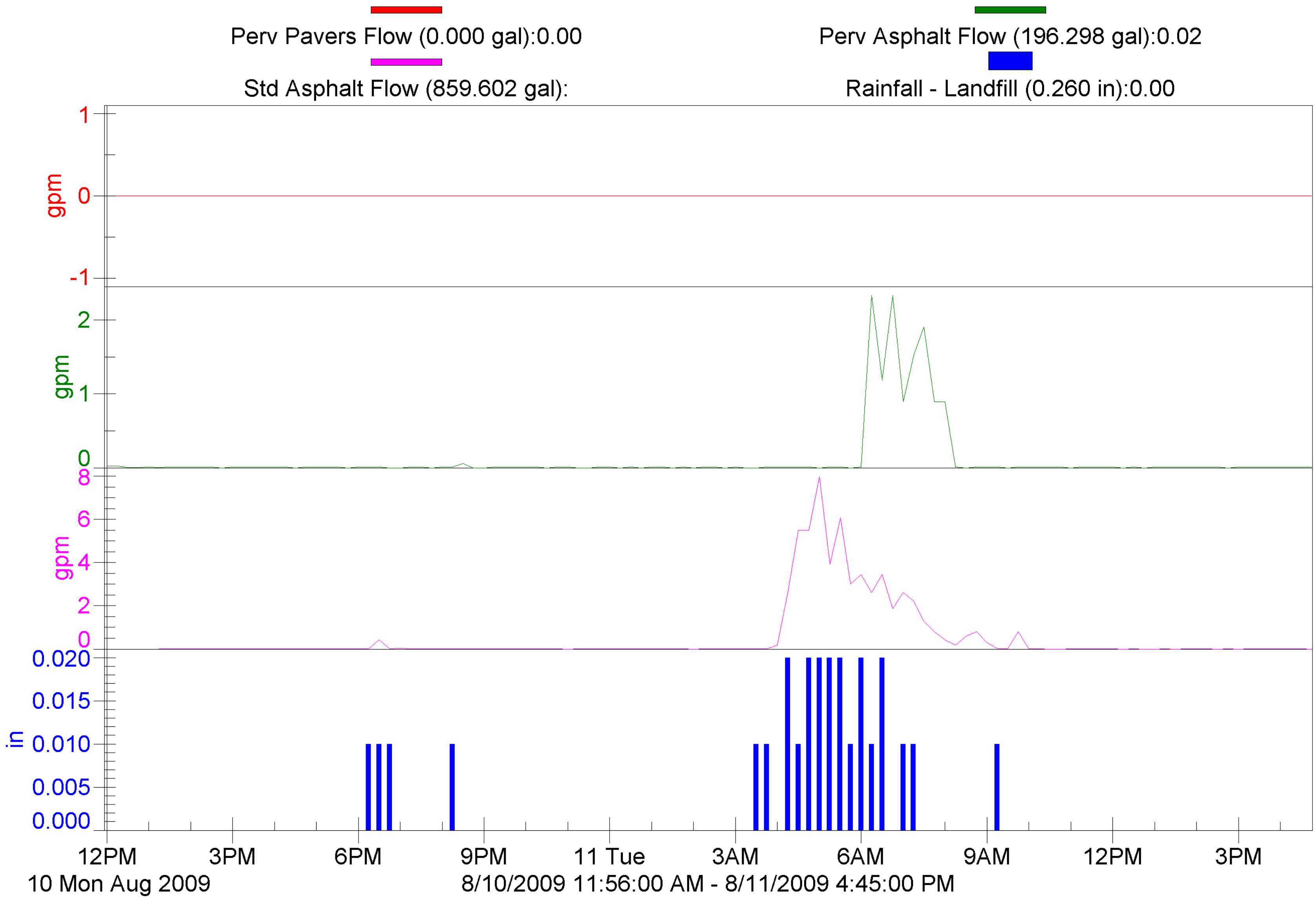
Flowlink 5



Storm #4

Pervious Pavement Project Flow

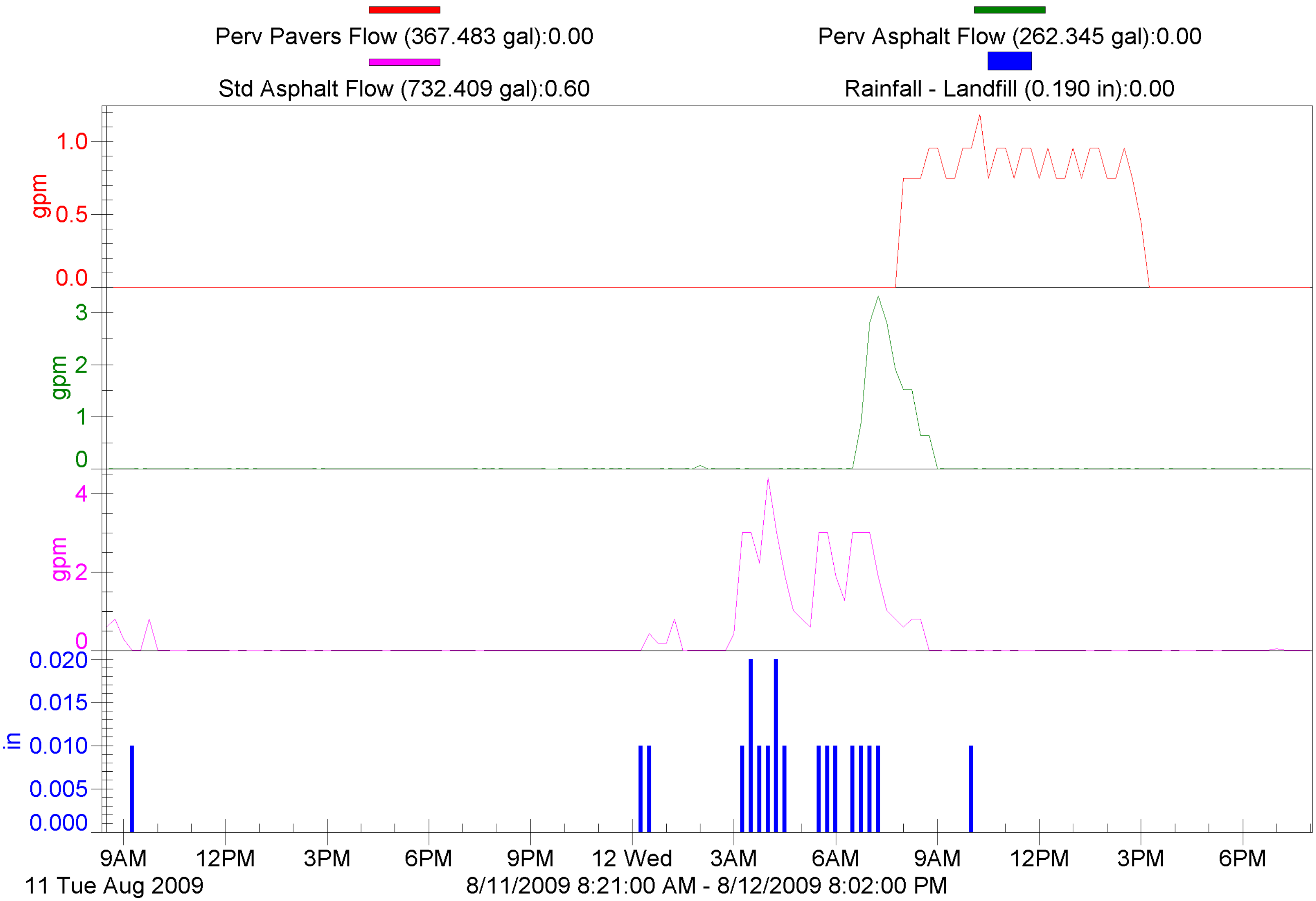
Flowlink 5



Storm #5

Pervious Pavement Project Flow

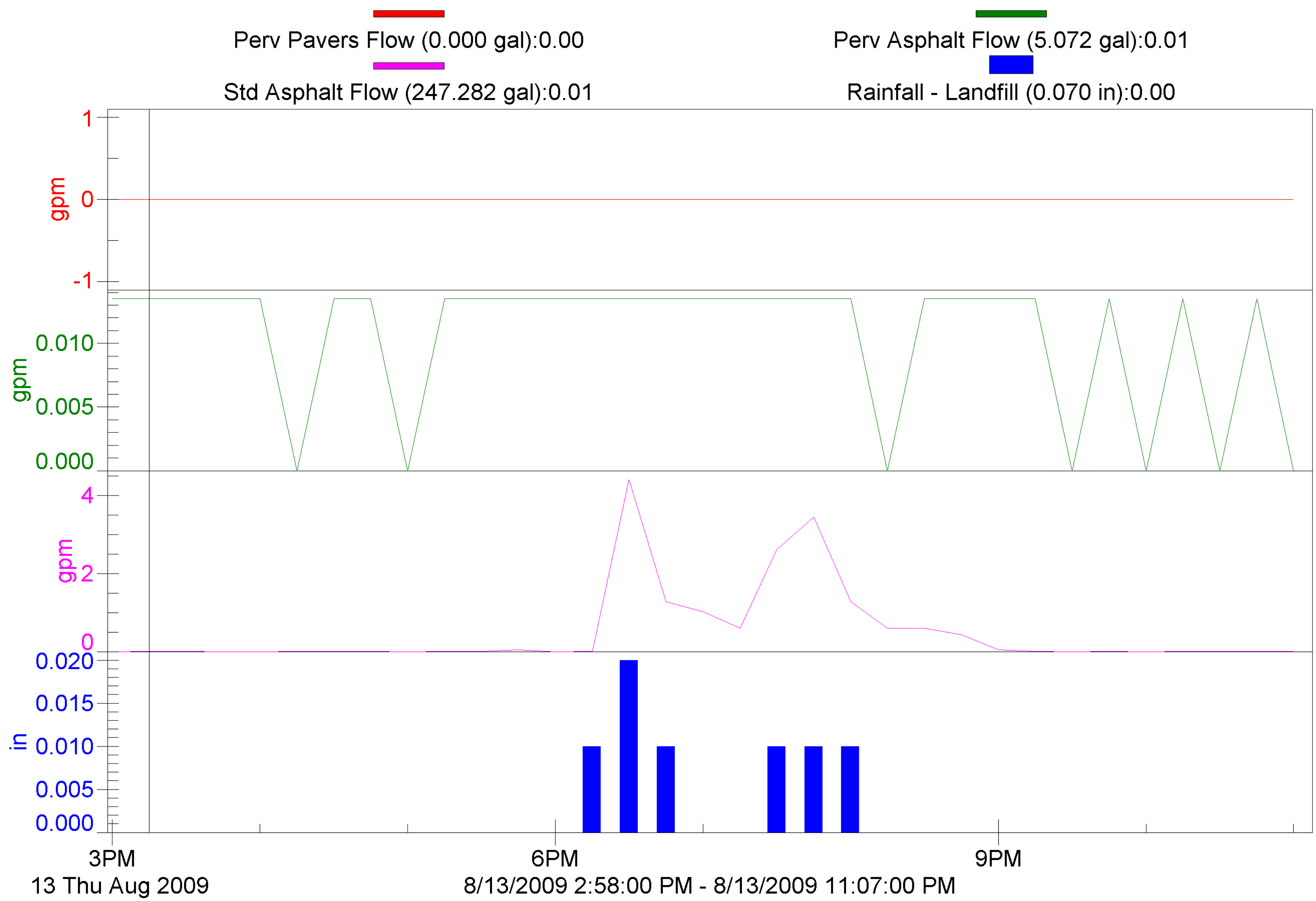
Flowlink 5



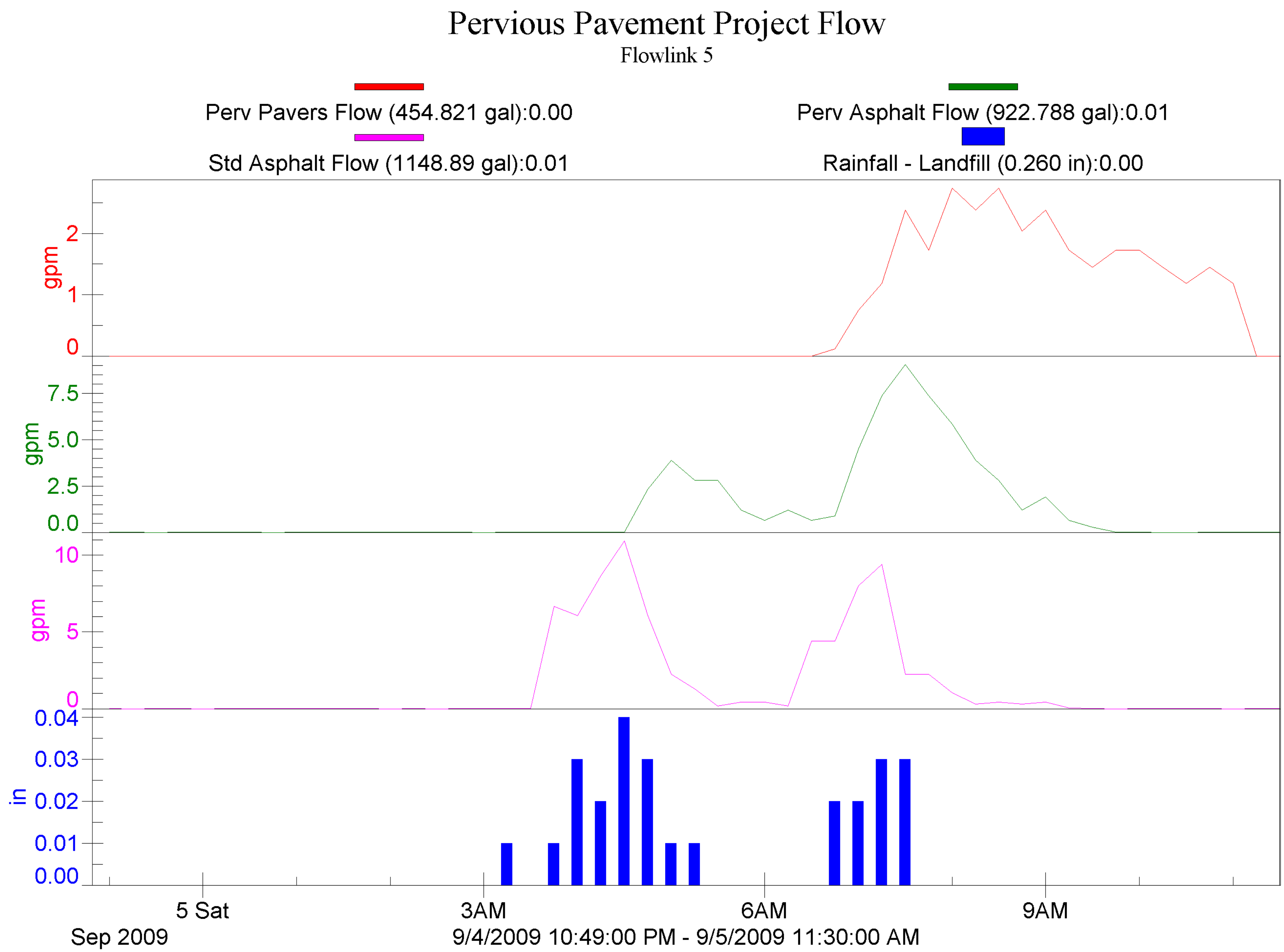
Storm #6

Pervious Pavement Project Flow

Flowlink 5



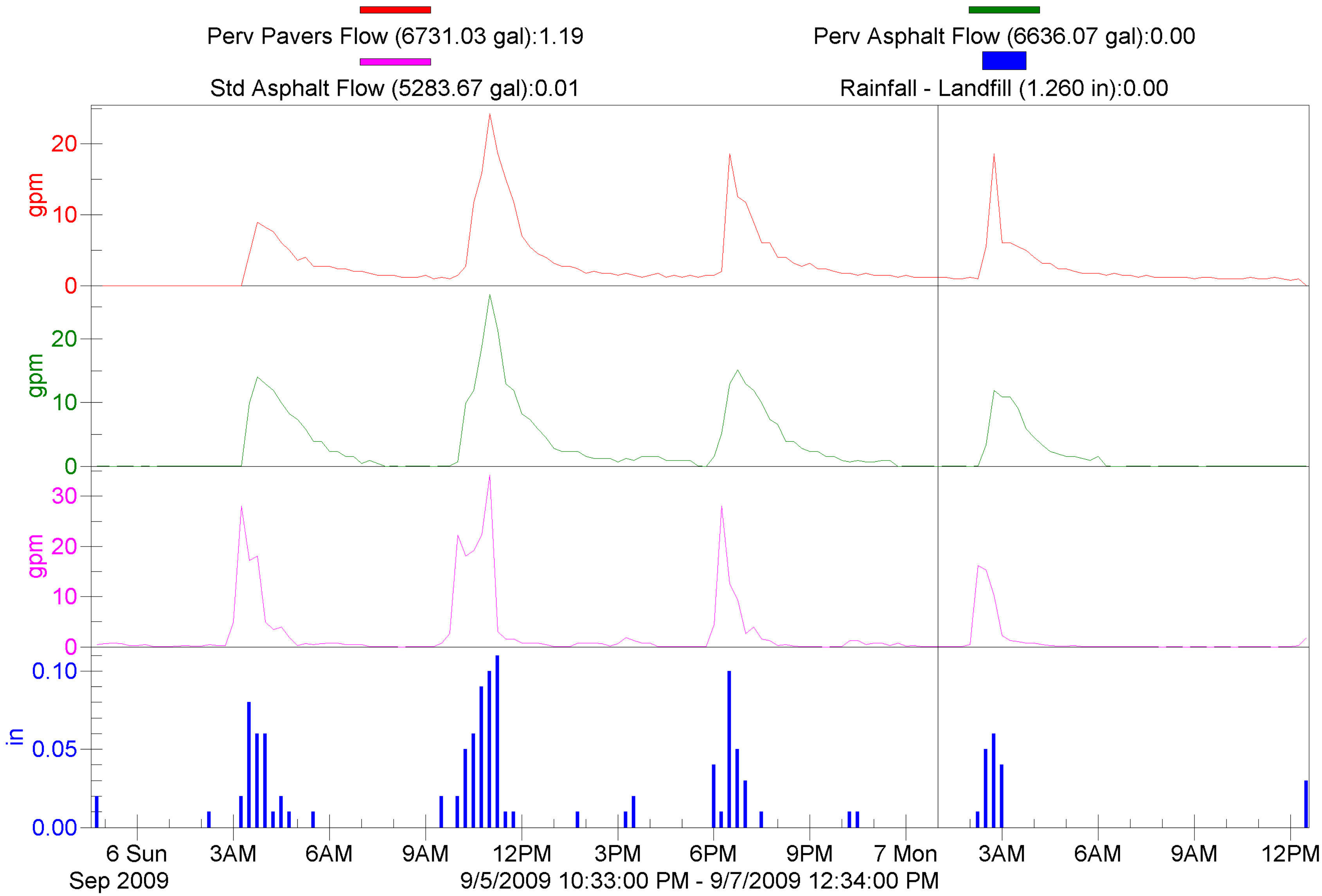
Storm #7


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (454.821 gal):0.00
Perv Asphalt Flow (922.788 gal):0.01
Std Asphalt Flow (1148.89 gal):0.01
Rainfall - Landfill (0.260 in):0.00
gpm
2
1
0
gpm
7.5
5.0
2.5
0.0
gpm
10
5
0
in
0.04
0.03
0.02
0.01
0.00
5 Sat
3AM
6AM
9AM
Sep 2009
9/4/2009 10:49:00 PM - 9/5/2009 11:30:00 AM

Storm #8

Pervious Pavement Project Flow

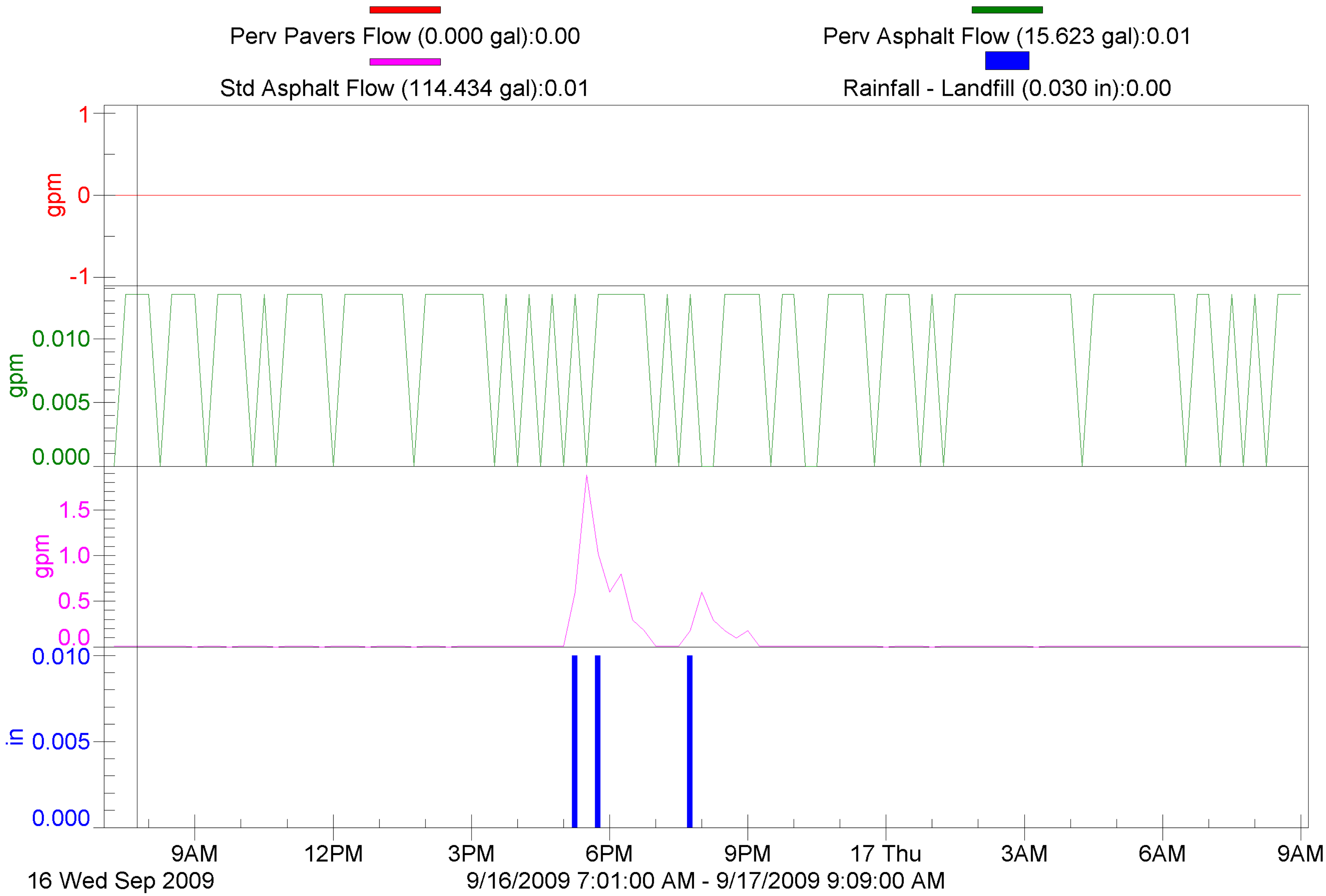
Flowlink 5



Storm #9

Pervious Pavement Project Flow

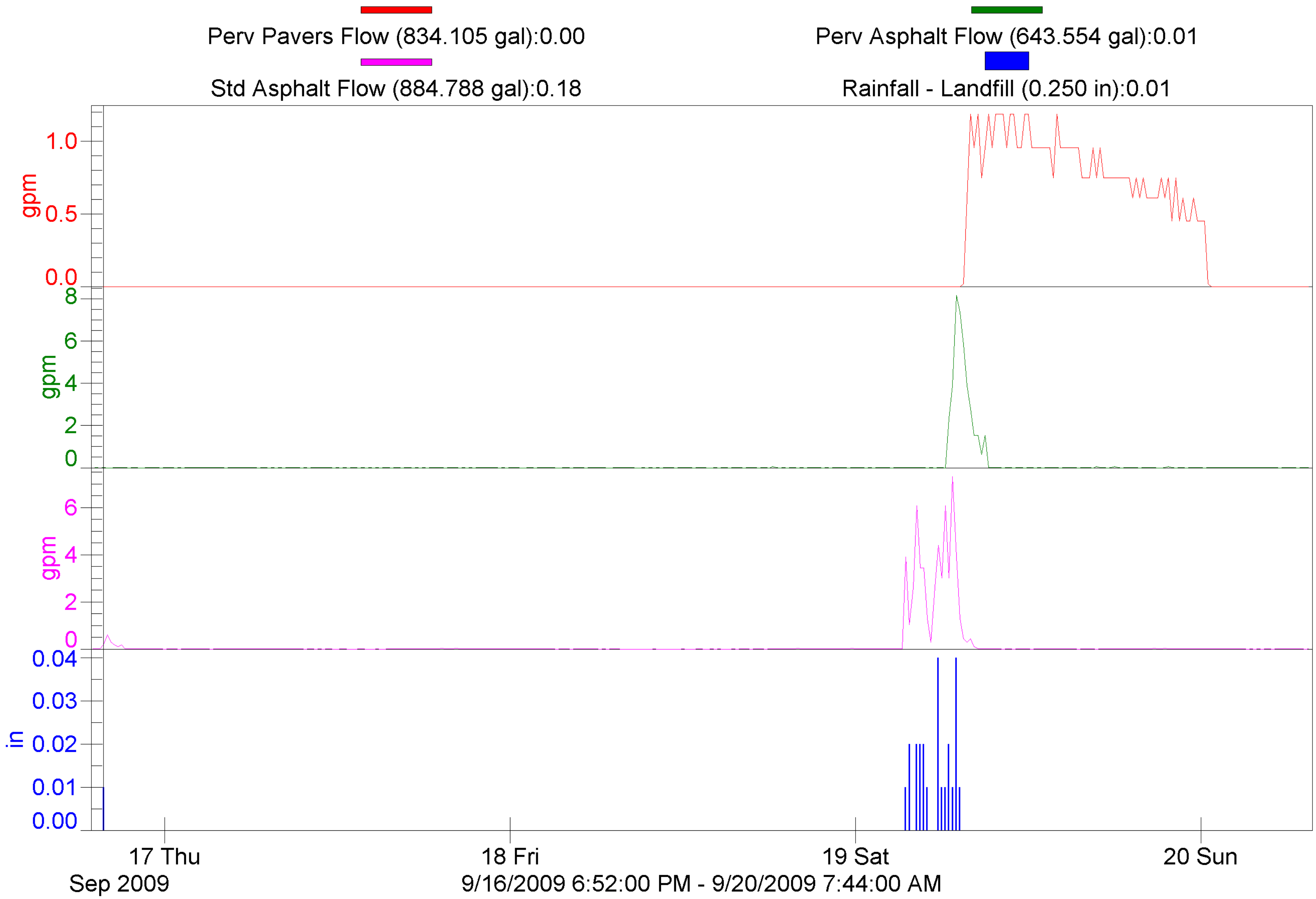
Flowlink 5



Storm #10

Pervious Pavement Project Flow

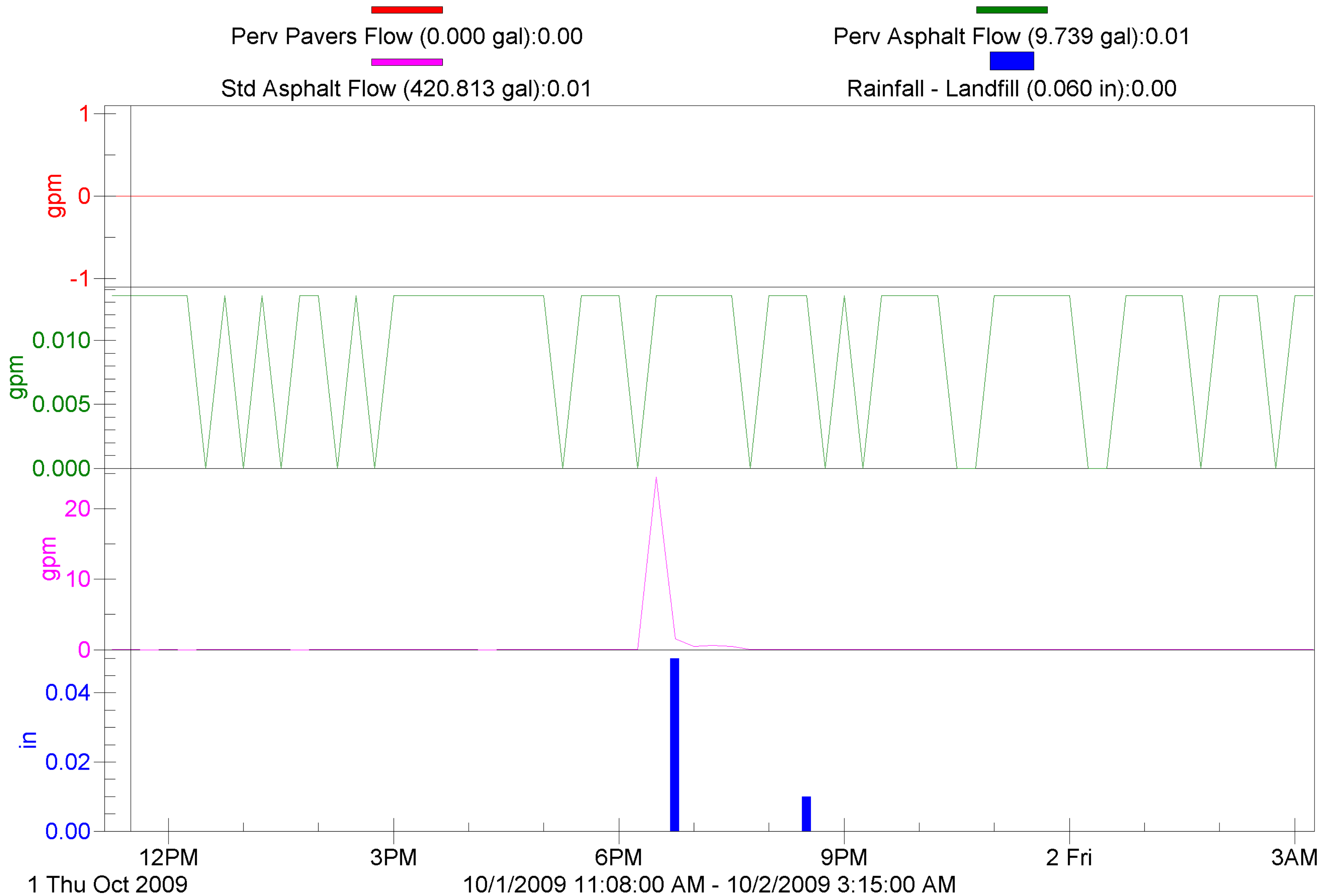
Flowlink 5



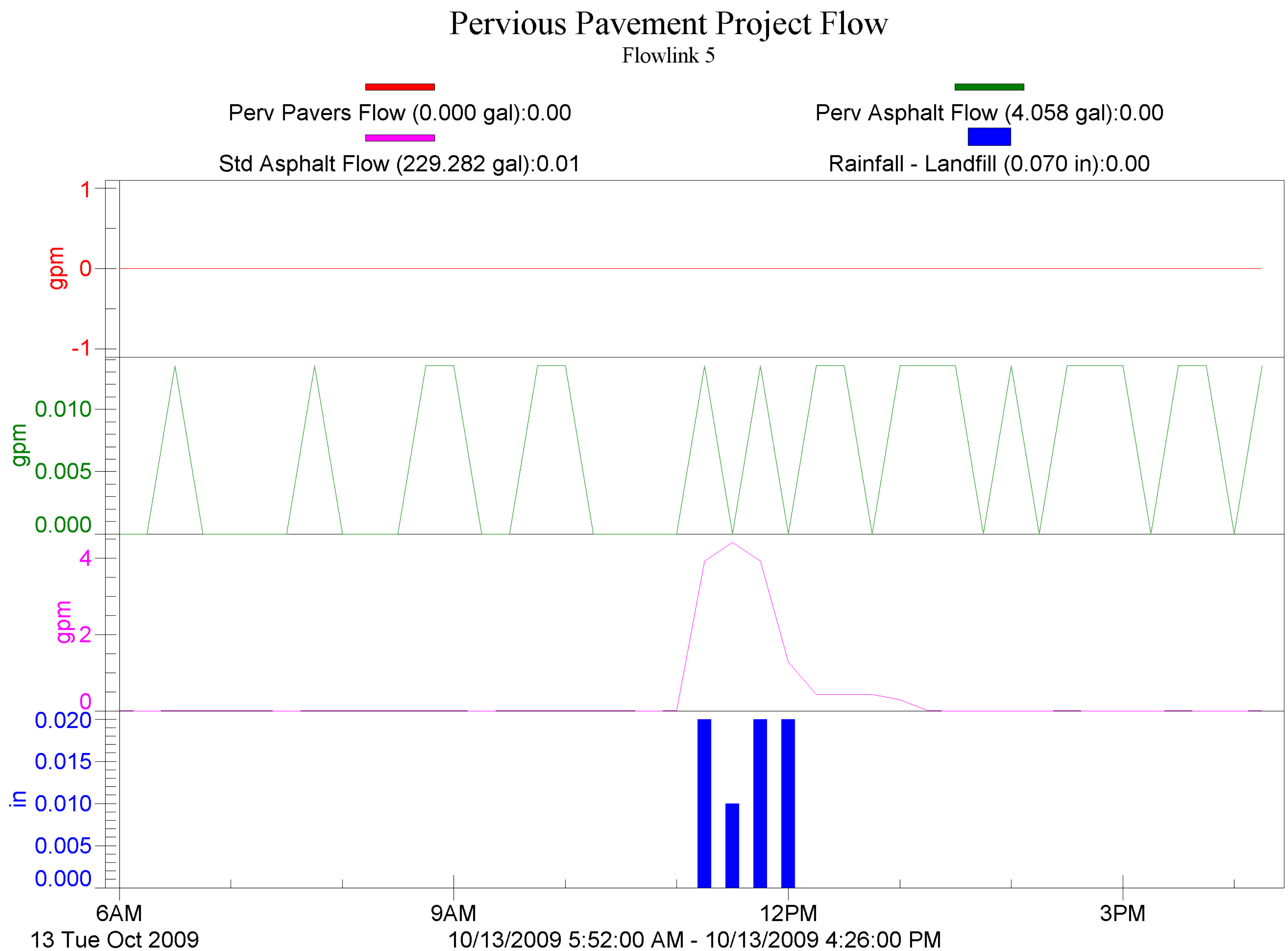
Storm #11

Pervious Pavement Project Flow

Flowlink 5



Storm #12

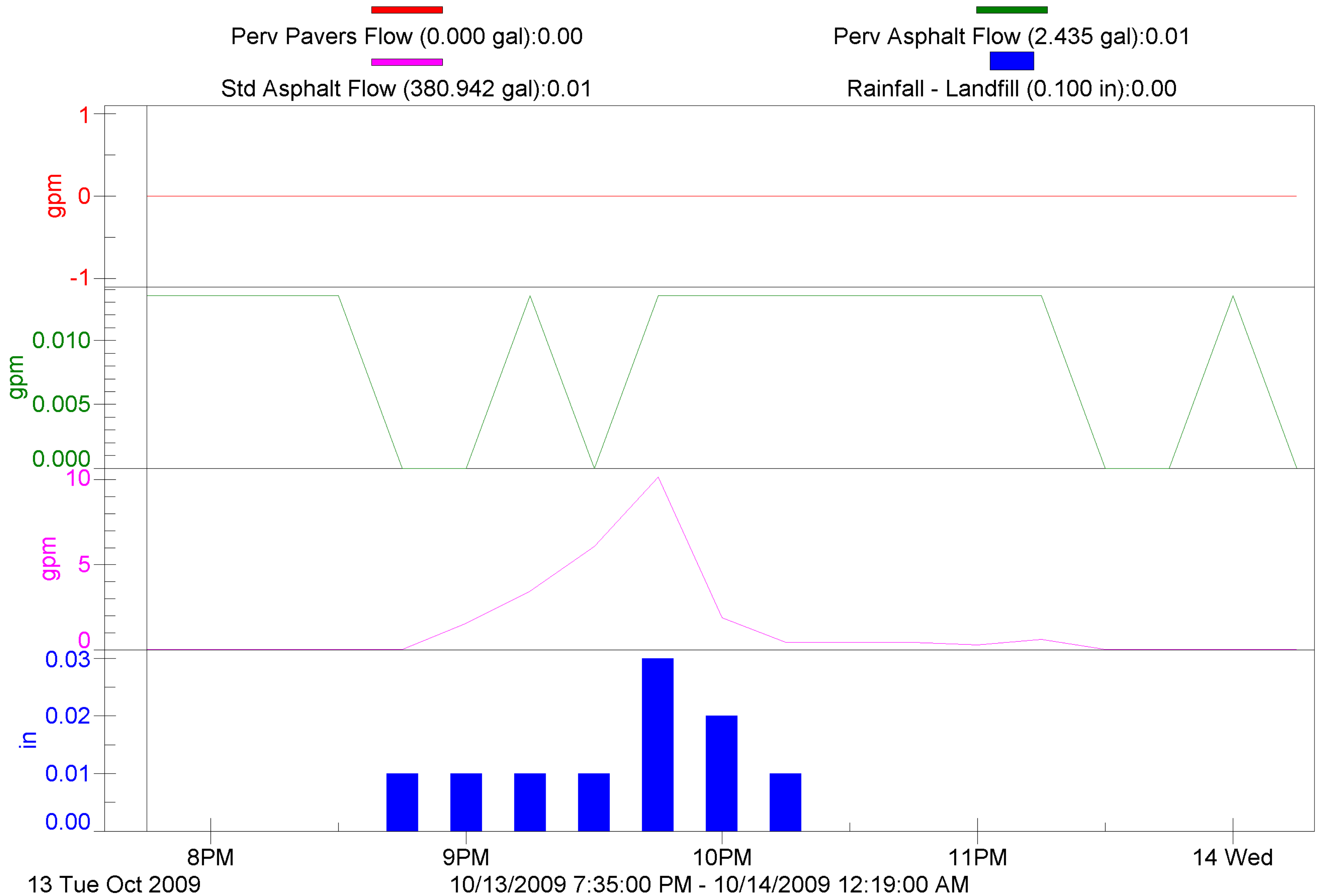


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (4.058 gal):0.00
Std Asphalt Flow (229.282 gal):0.01
Rainfall - Landfill (0.070 in):0.00
gpm
1
0
-1
gpm
0.010
0.005
0.000
gpm
4
2
0
in
0.020
0.015
0.010
0.005
0.000
6AM
9AM
12PM
3PM
13 Tue Oct 2009
10/13/2009 5:52:00 AM - 10/13/2009 4:26:00 PM

Storm #13

Pervious Pavement Project Flow

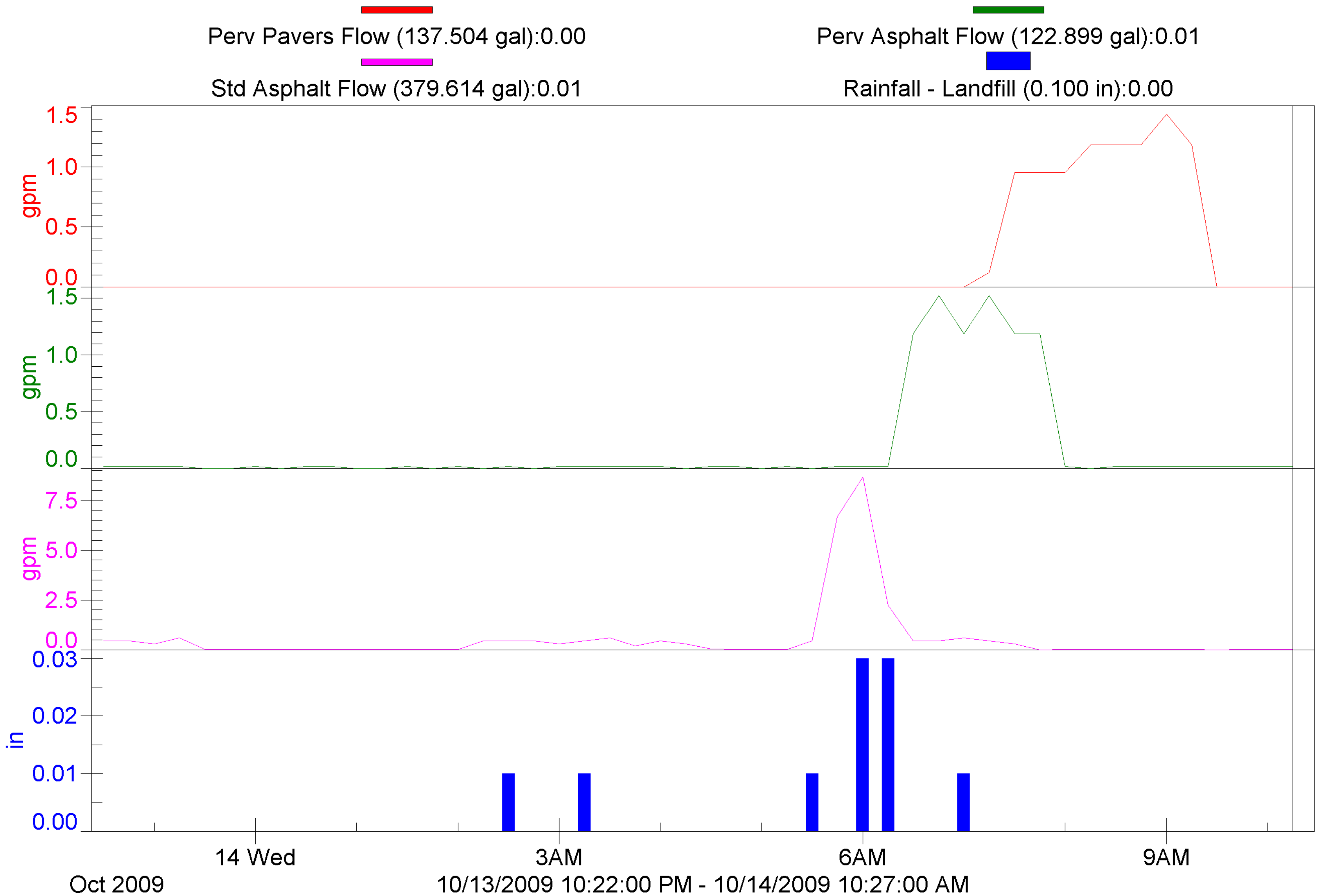
Flowlink 5



Storm #14

Pervious Pavement Project Flow

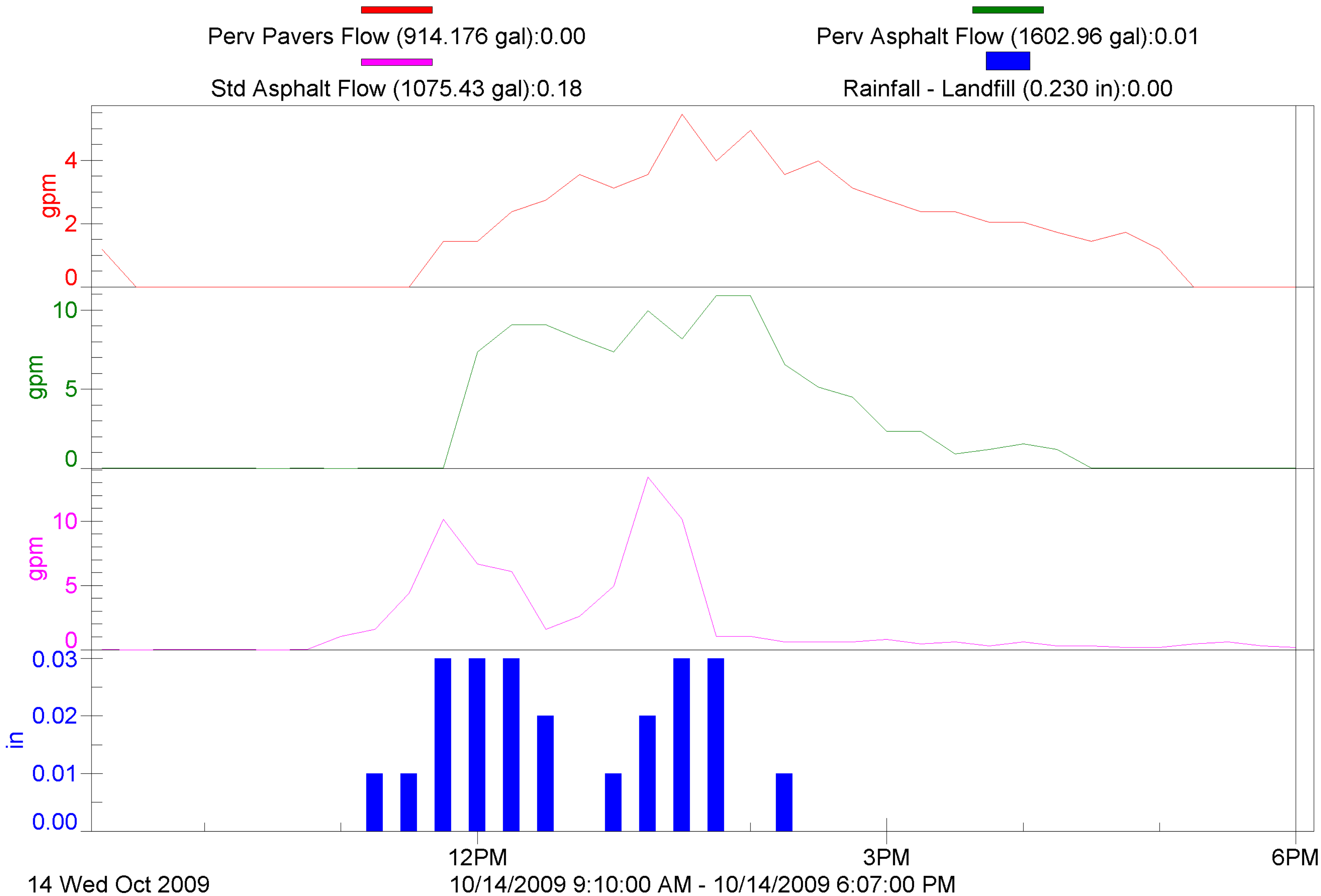
Flowlink 5



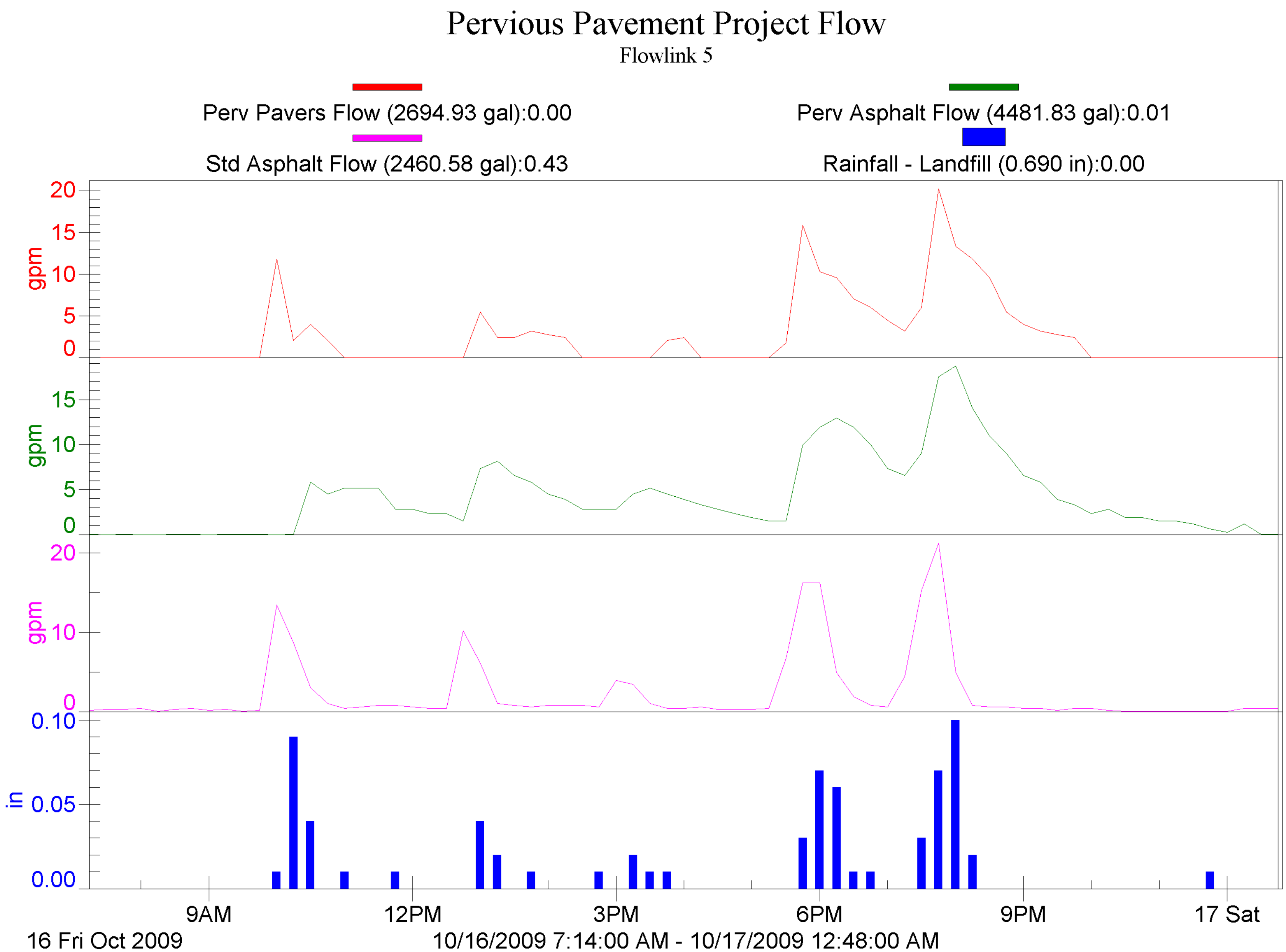
Storm #15

Pervious Pavement Project Flow

Flowlink 5



Storm #16

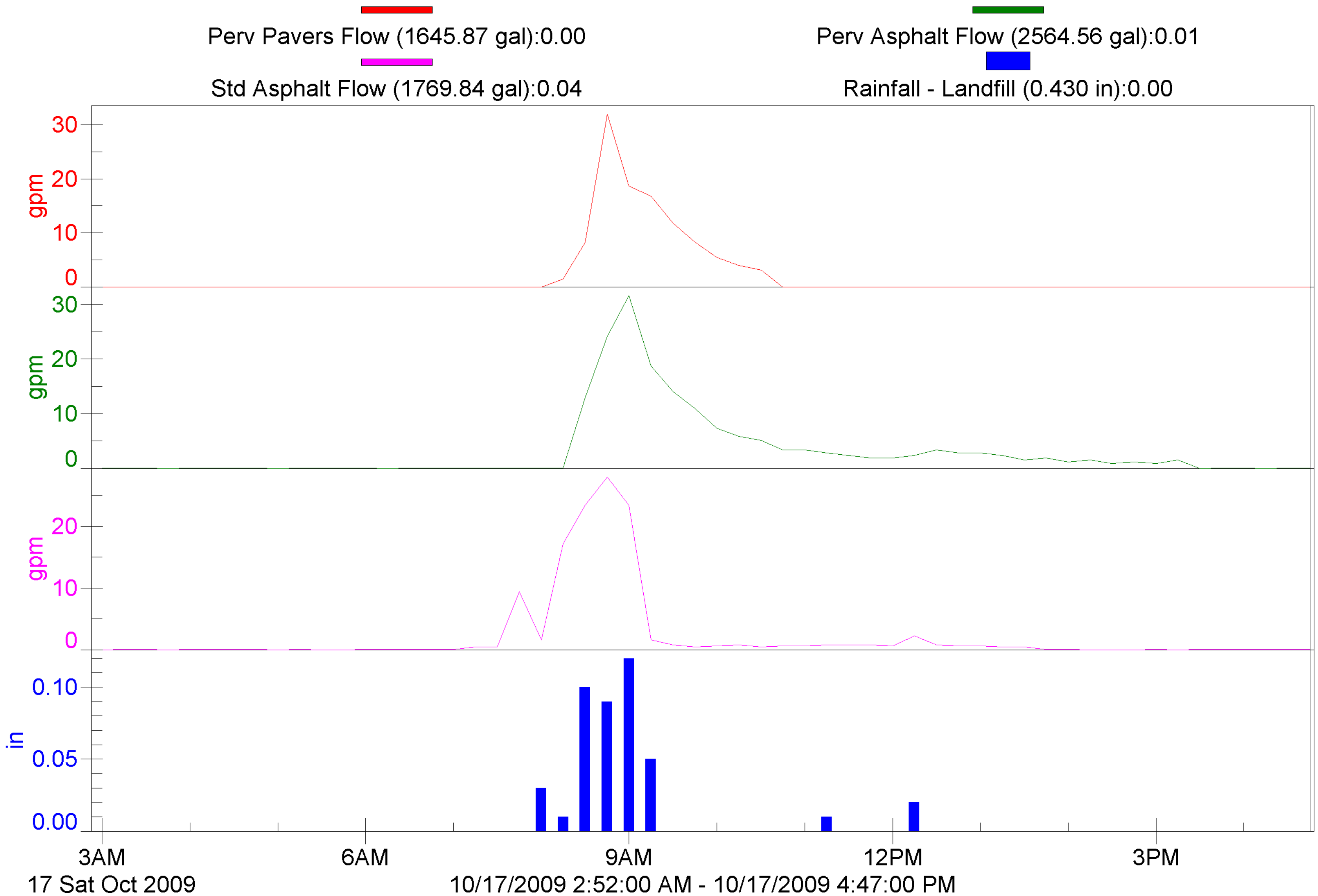


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (2694.93 gal):0.00
Perv Asphalt Flow (4481.83 gal):0.01
Std Asphalt Flow (2460.58 gal):0.43
Rainfall - Landfill (0.690 in):0.00
gpm
20
15
10
5
0
gpm
15
10
5
0
gpm
20
10
0
in
0.10
0.05
0.00
9AM
12PM
3PM
6PM
9PM
17 Sat
16 Fri Oct 2009
10/16/2009 7:14:00 AM - 10/17/2009 12:48:00 AM

Storm #17

Pervious Pavement Project Flow

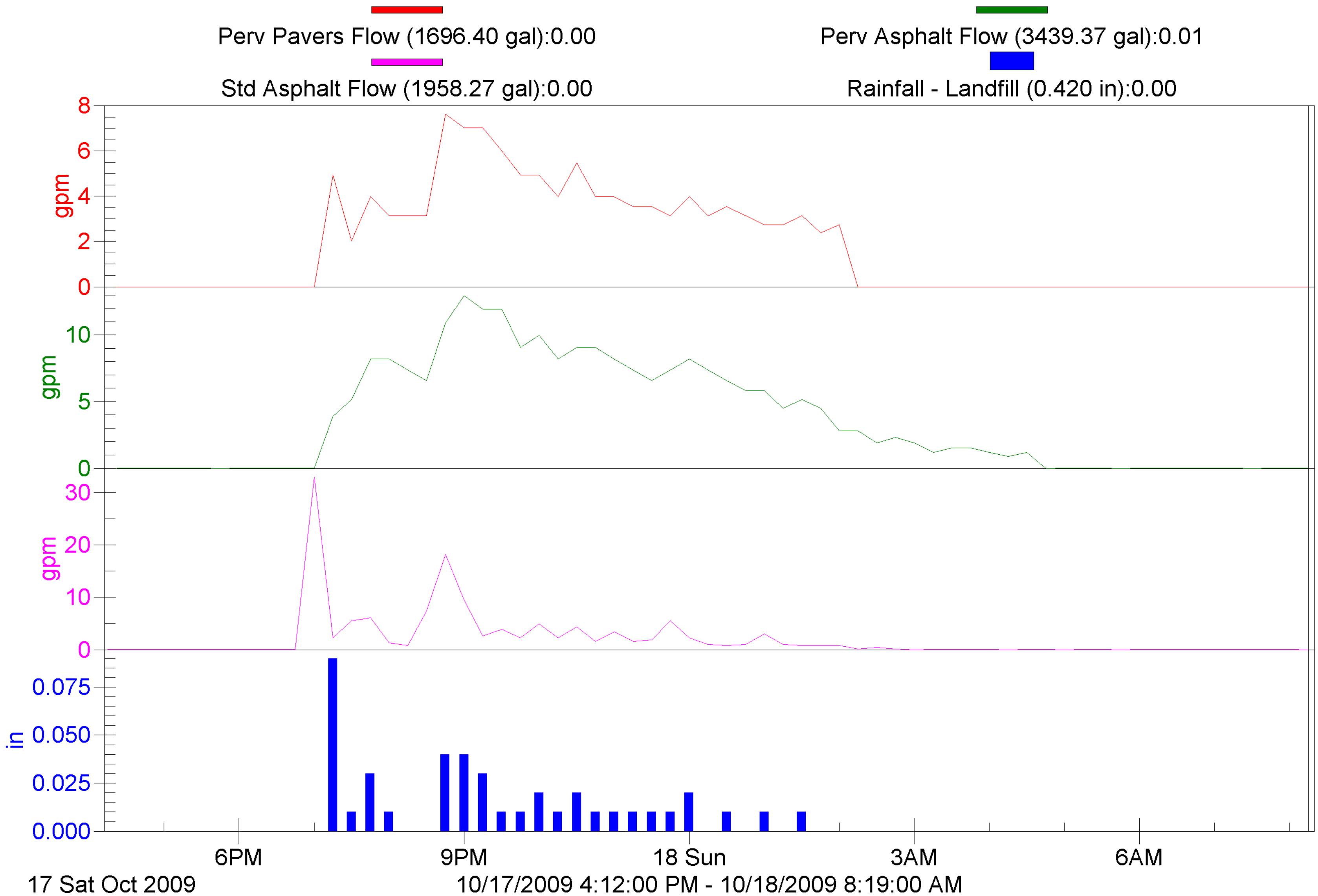
Flowlink 5



Storm #18

Pervious Pavement Project Flow

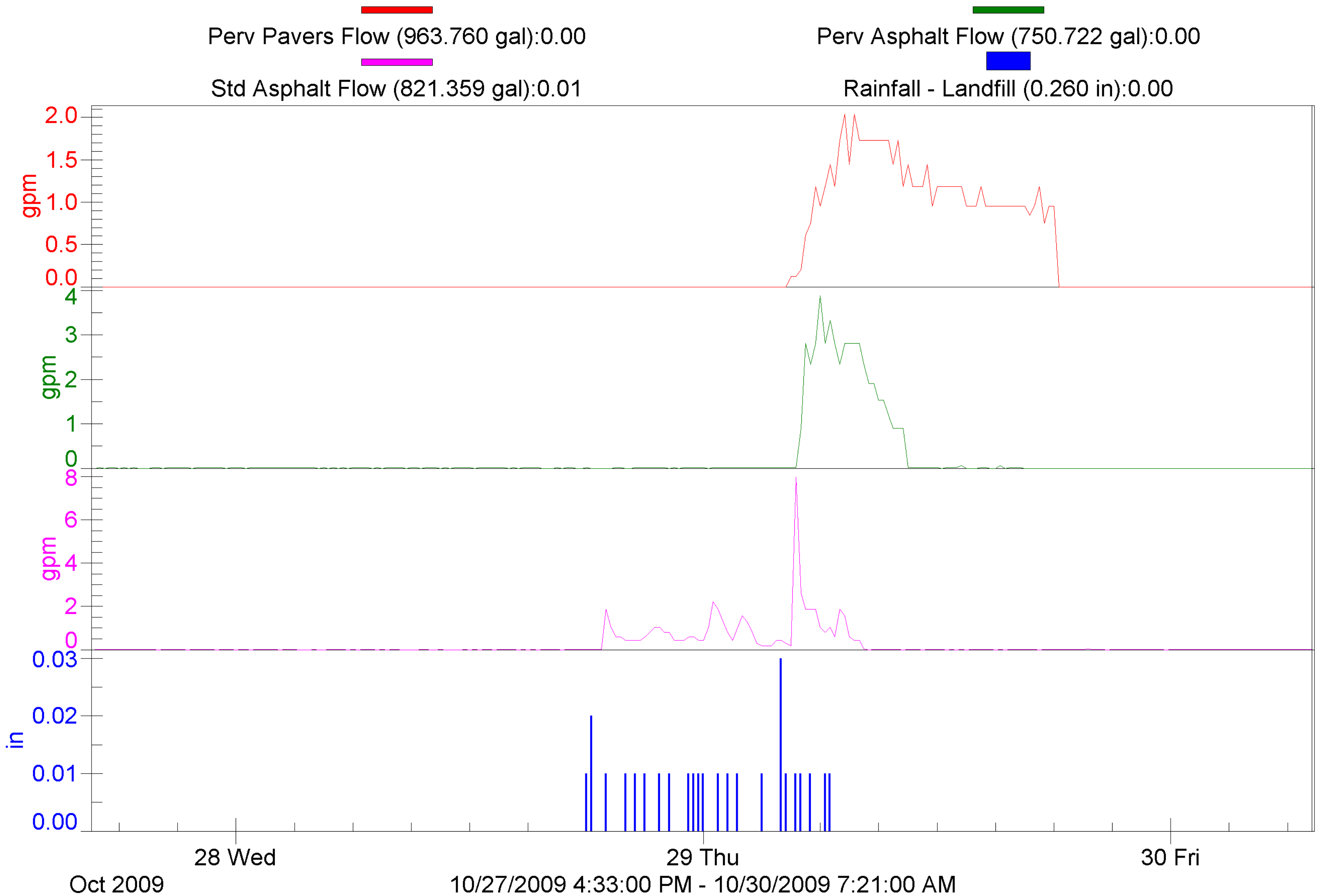
Flowlink 5



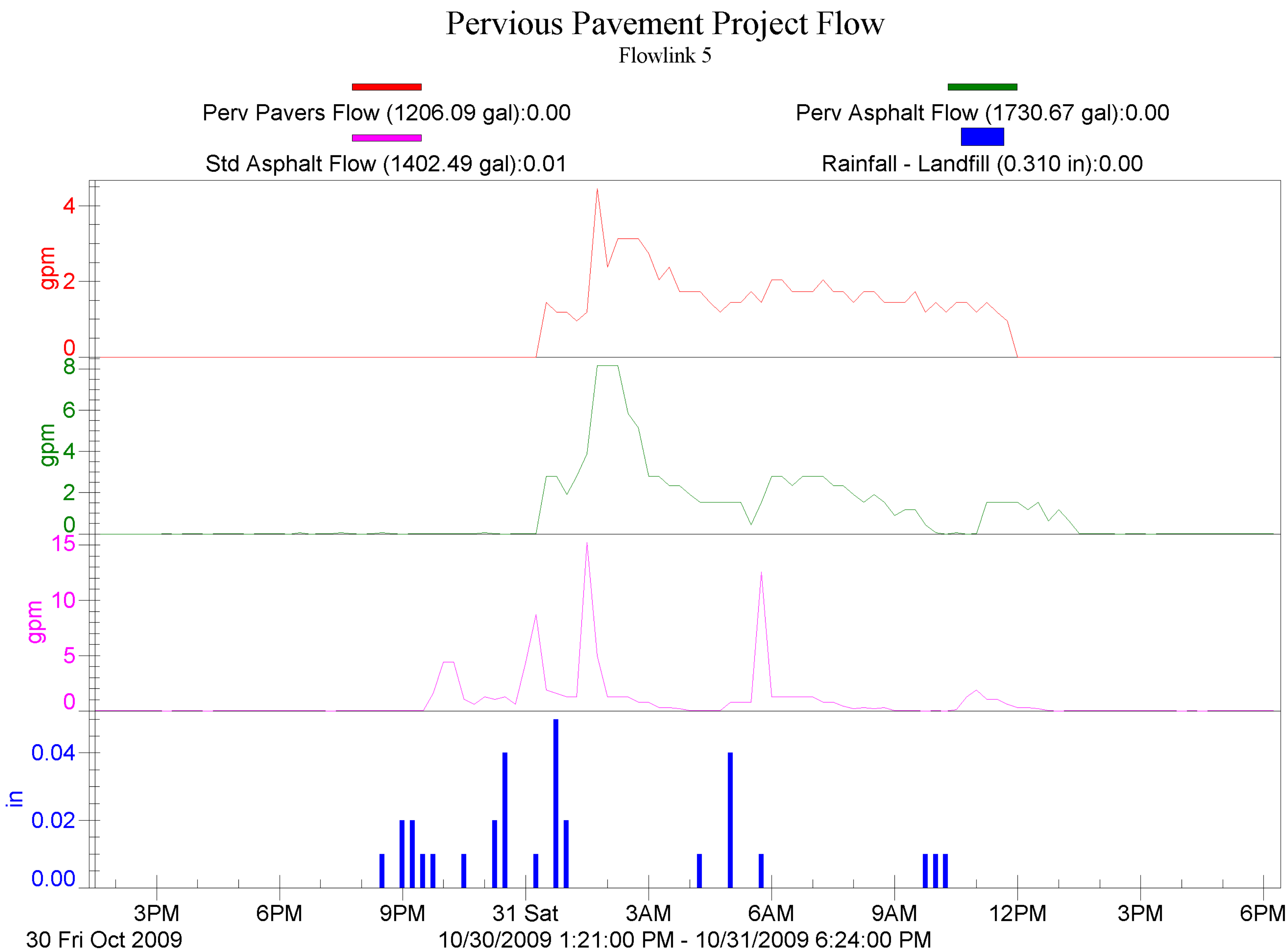
Storm #19

Pervious Pavement Project Flow

Flowlink 5



Storm #20

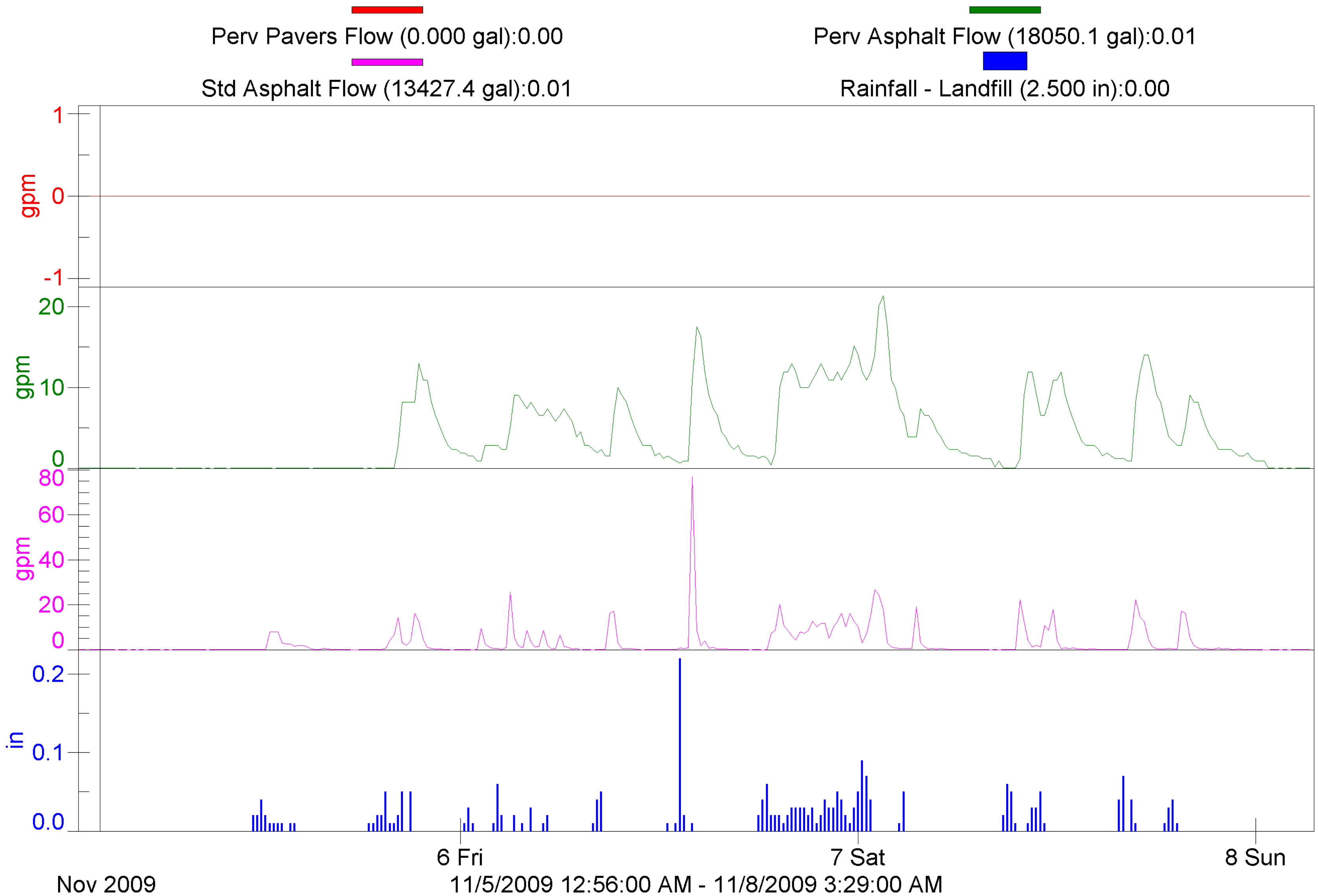


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (1206.09 gal):0.00
Perv Asphalt Flow (1730.67 gal):0.00
Std Asphalt Flow (1402.49 gal):0.01
Rainfall - Landfill (0.310 in):0.00
gpm
4
2
0
8
6
4
2
0
15
10
5
0
in
0.04
0.02
0.00
3PM
6PM
9PM
31 Sat
3AM
6AM
9AM
12PM
3PM
6PM
30 Fri Oct 2009
10/30/2009 1:21:00 PM - 10/31/2009 6:24:00 PM

Storm #21

Pervious Pavement Project Flow

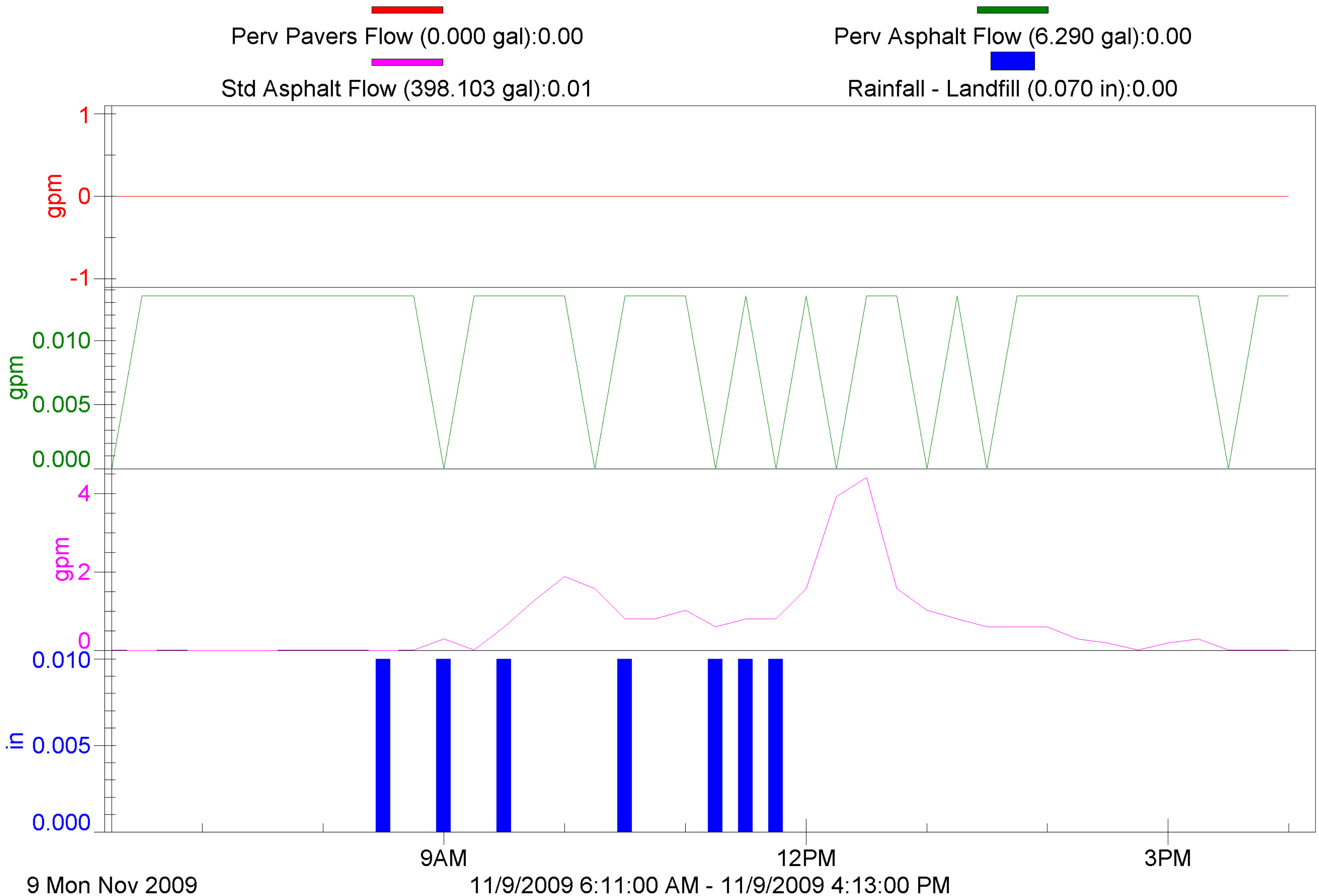
Flowlink 5



Storm #22

Pervious Pavement Project Flow

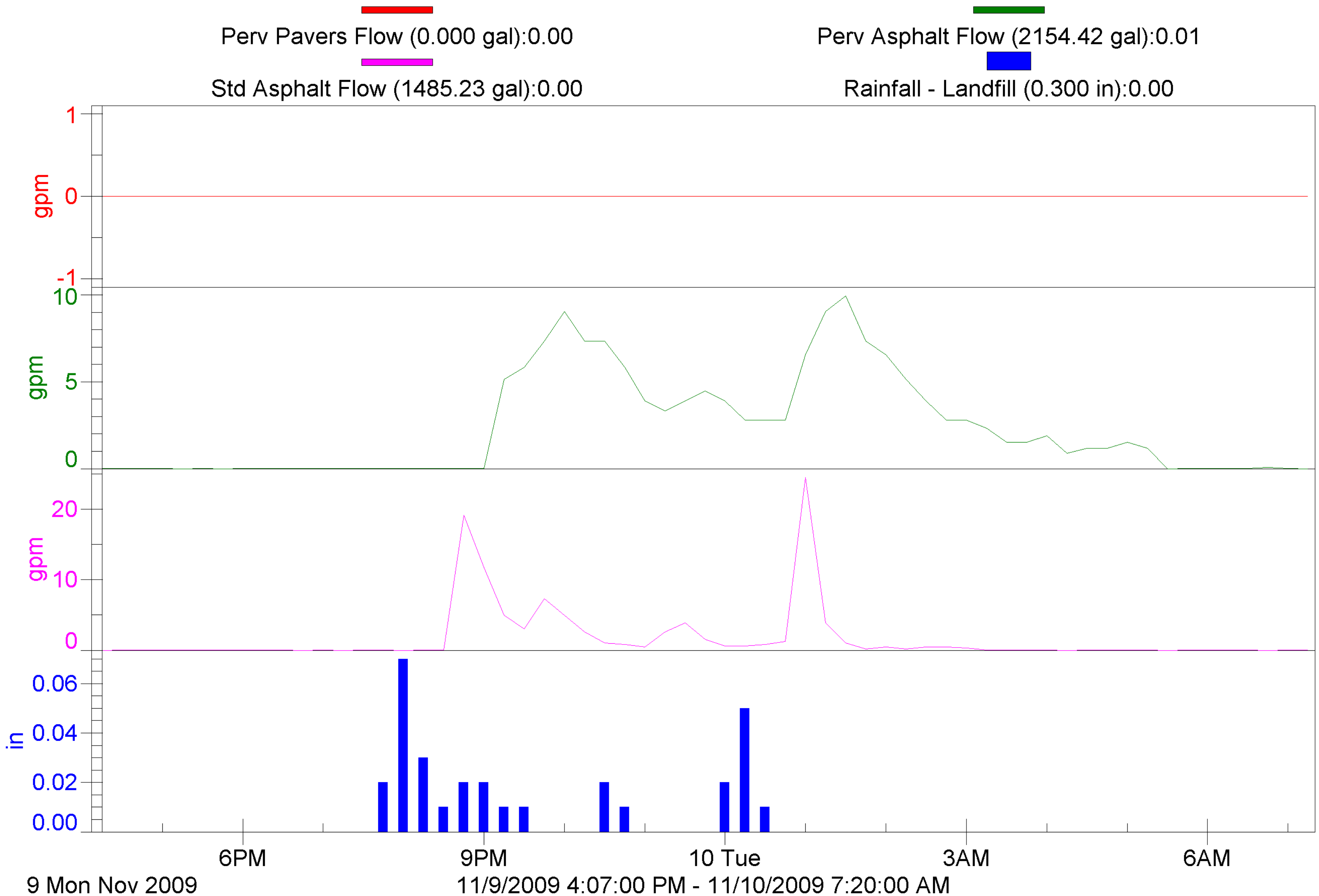
Flowlink 5



Storm #23

Pervious Pavement Project Flow

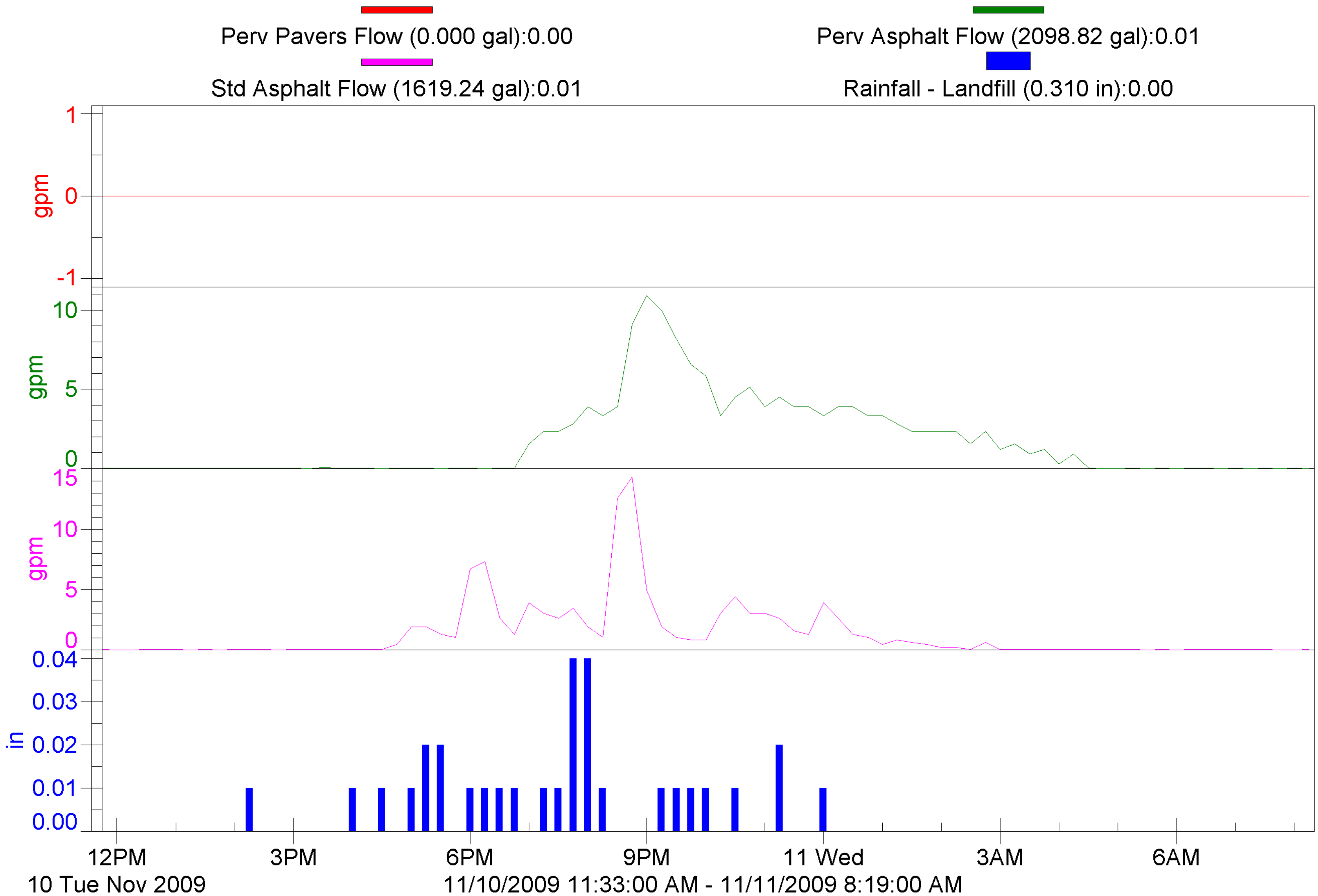
Flowlink 5



Storm #24

Pervious Pavement Project Flow

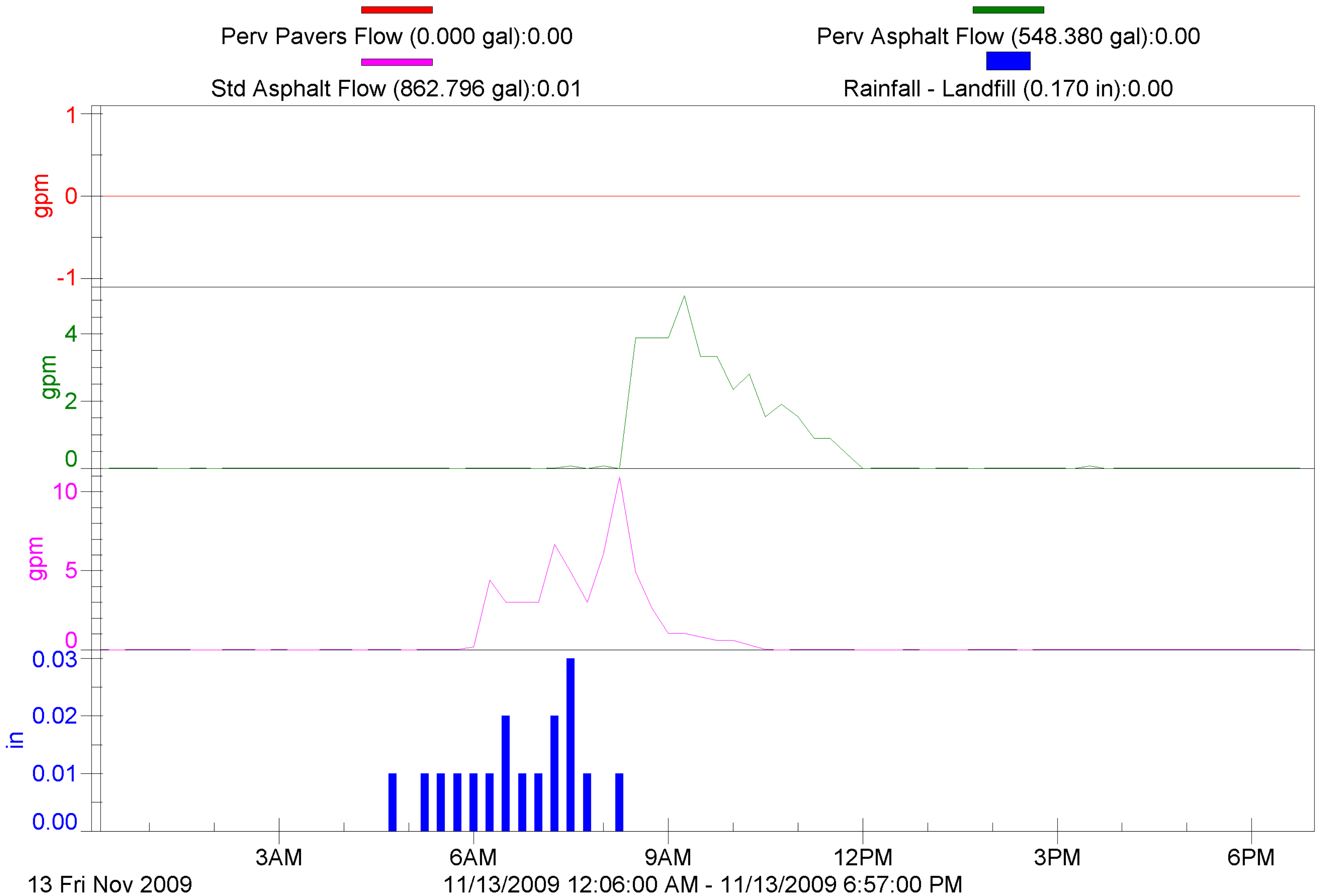
Flowlink 5



Storm #25

Pervious Pavement Project Flow

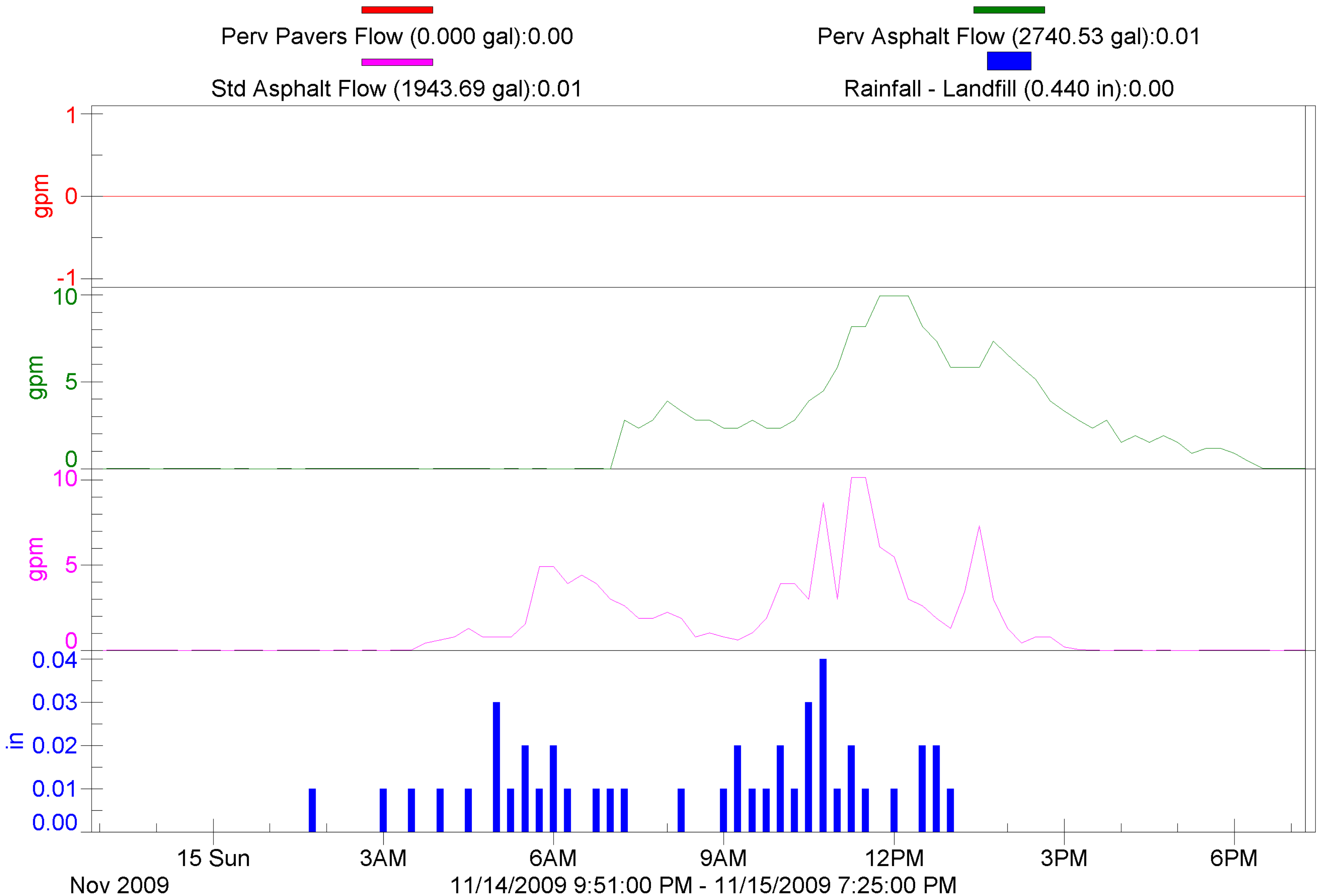
Flowlink 5



Storm #26

Pervious Pavement Project Flow

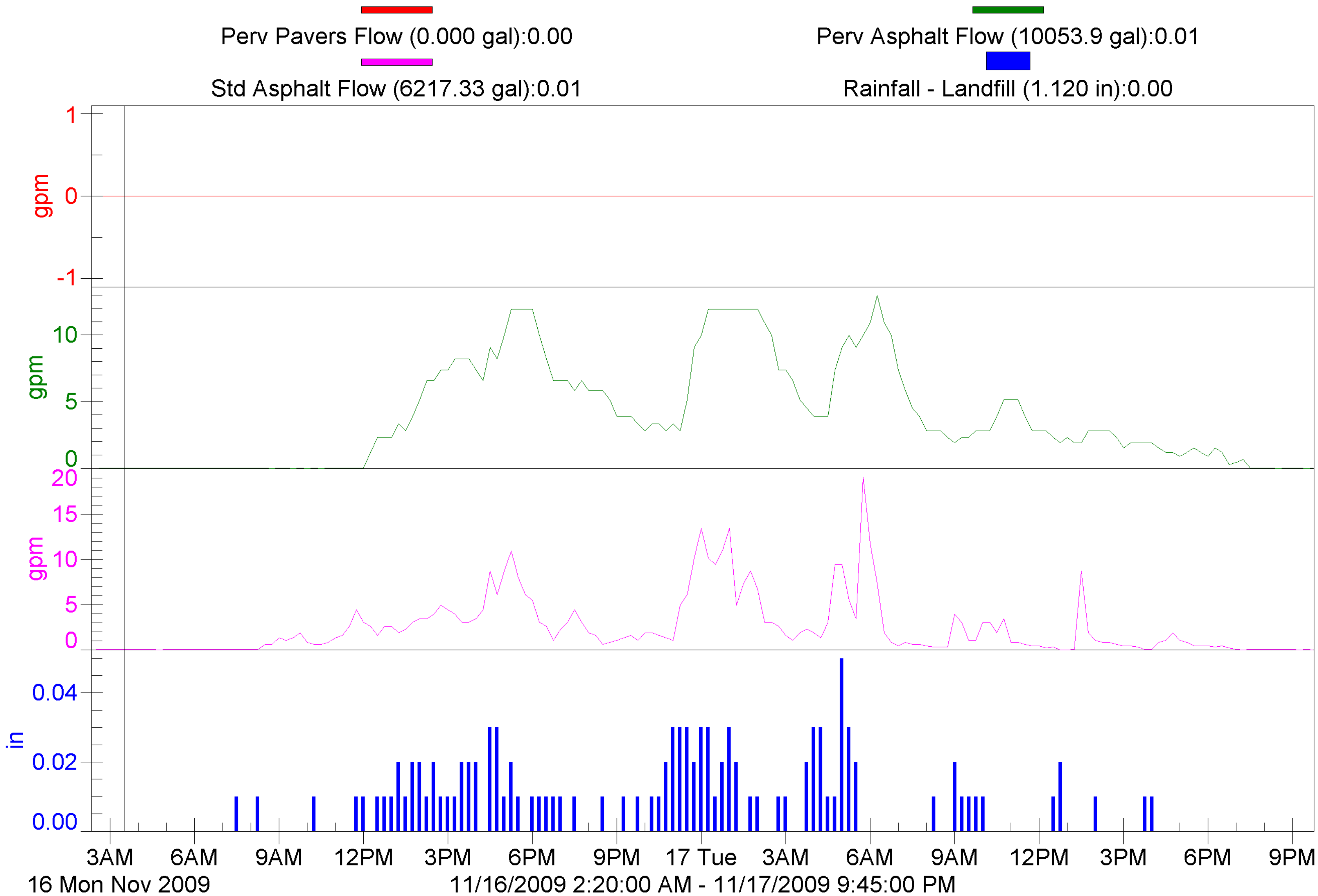
Flowlink 5

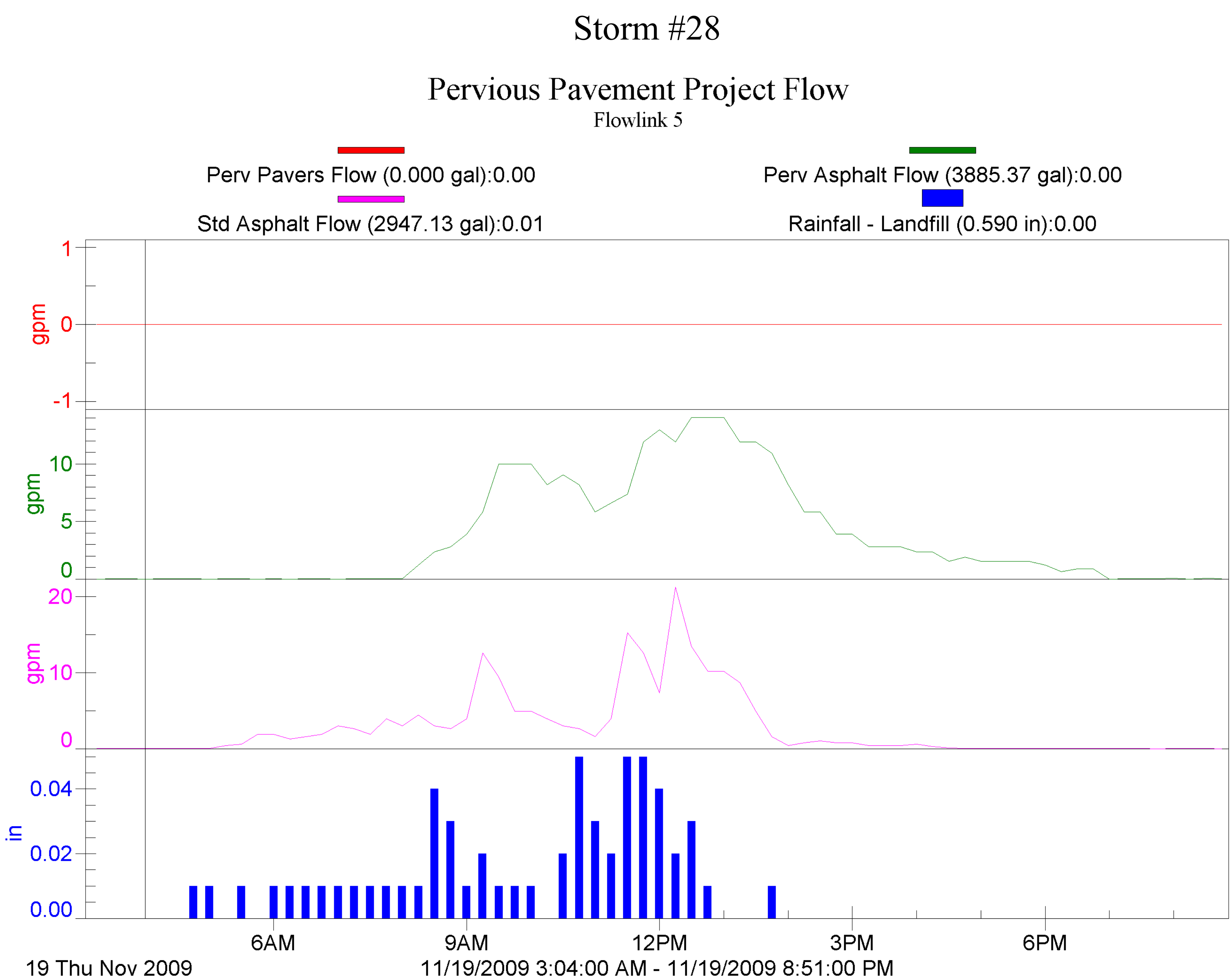


Storm #27

Pervious Pavement Project Flow

Flowlink 5

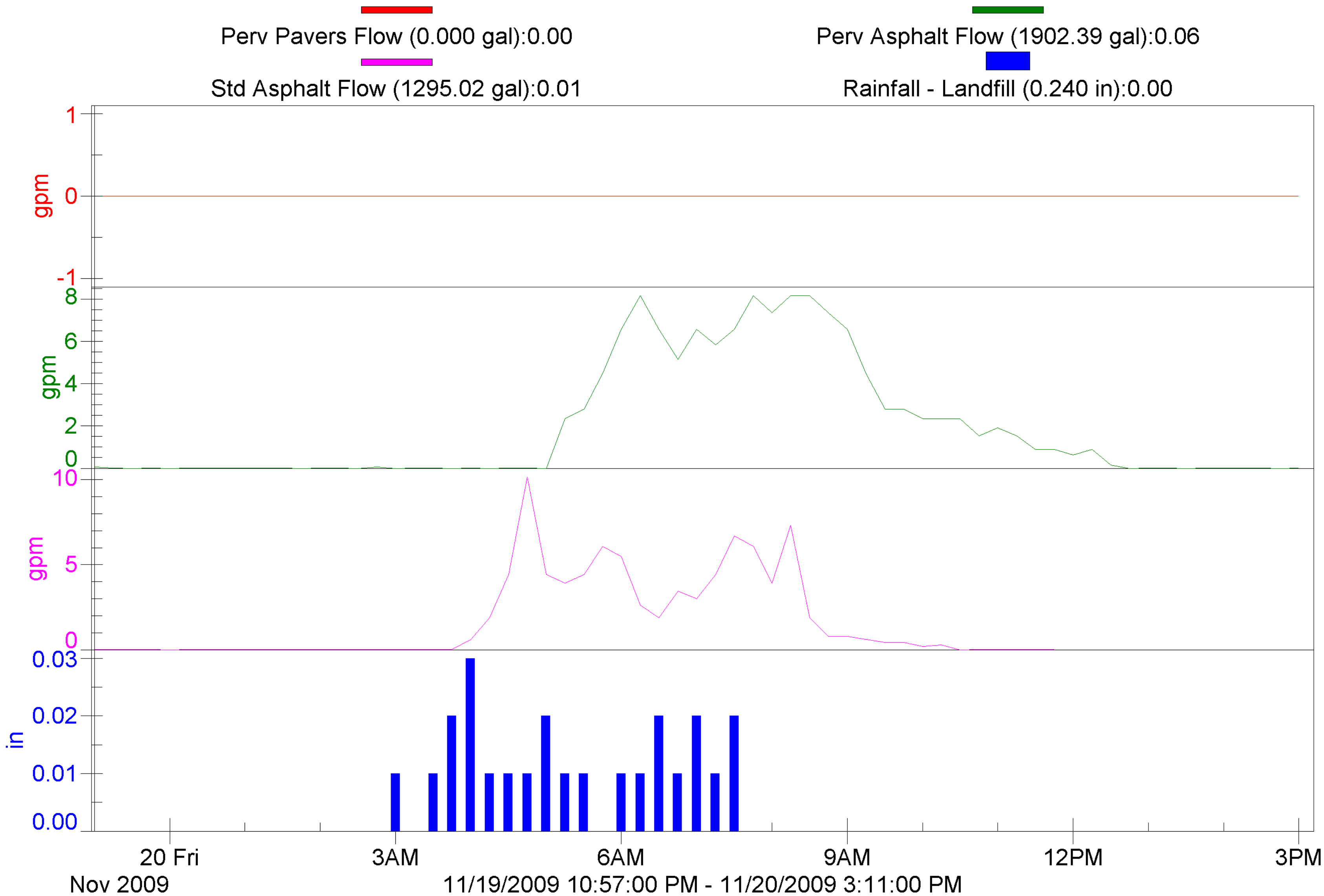



Storm #28
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (3885.37 gal):0.00
Std Asphalt Flow (2947.13 gal):0.01
Rainfall - Landfill (0.590 in):0.00
gpm
1
0
-1
gpm
10
5
0
gpm
20
10
0
in
0.04
0.02
0.00
6AM
9AM
12PM
3PM
6PM
19 Thu Nov 2009
11/19/2009 3:04:00 AM - 11/19/2009 8:51:00 PM

Storm #29

Pervious Pavement Project Flow

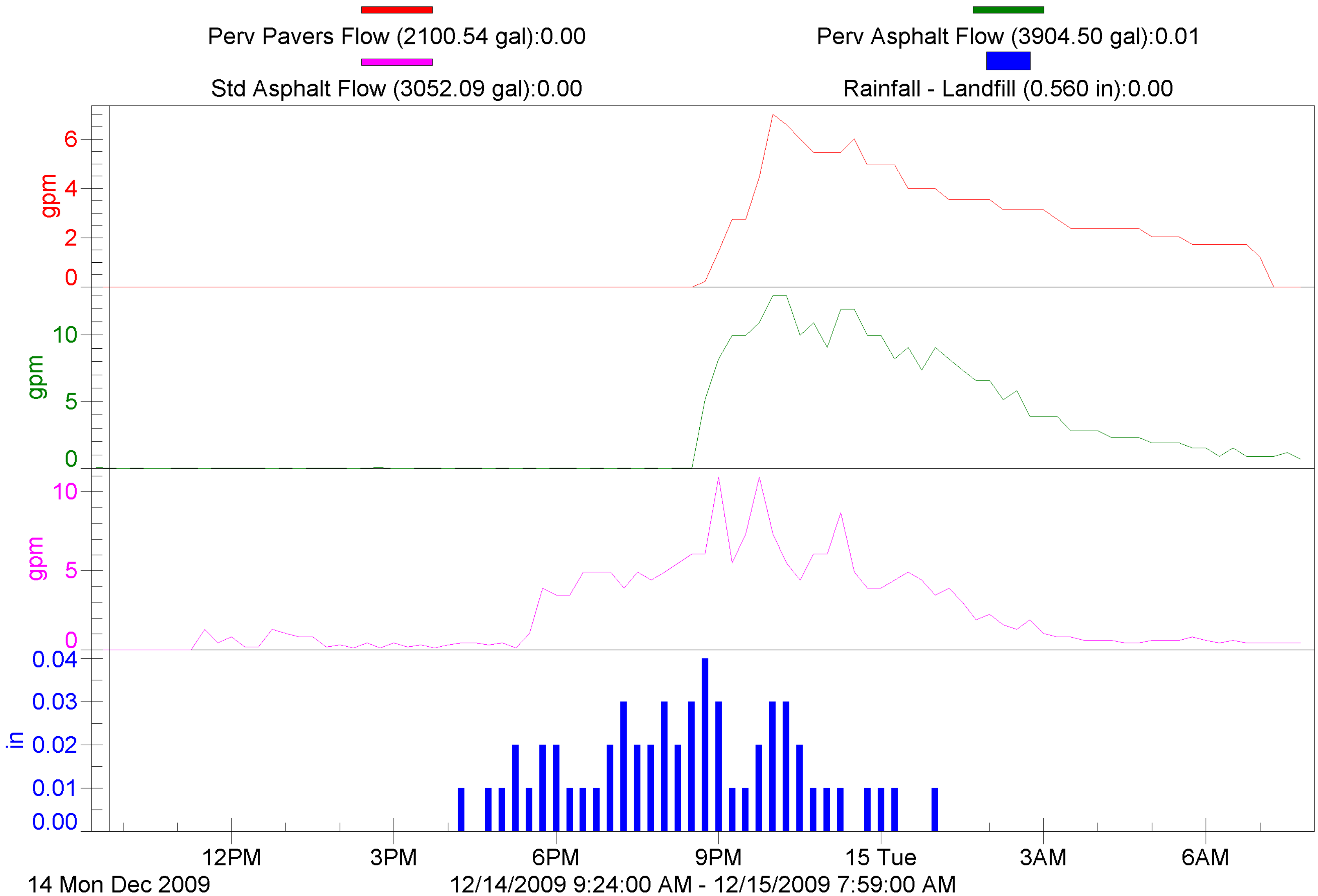
Flowlink 5



Storm #30

Pervious Pavement Project Flow

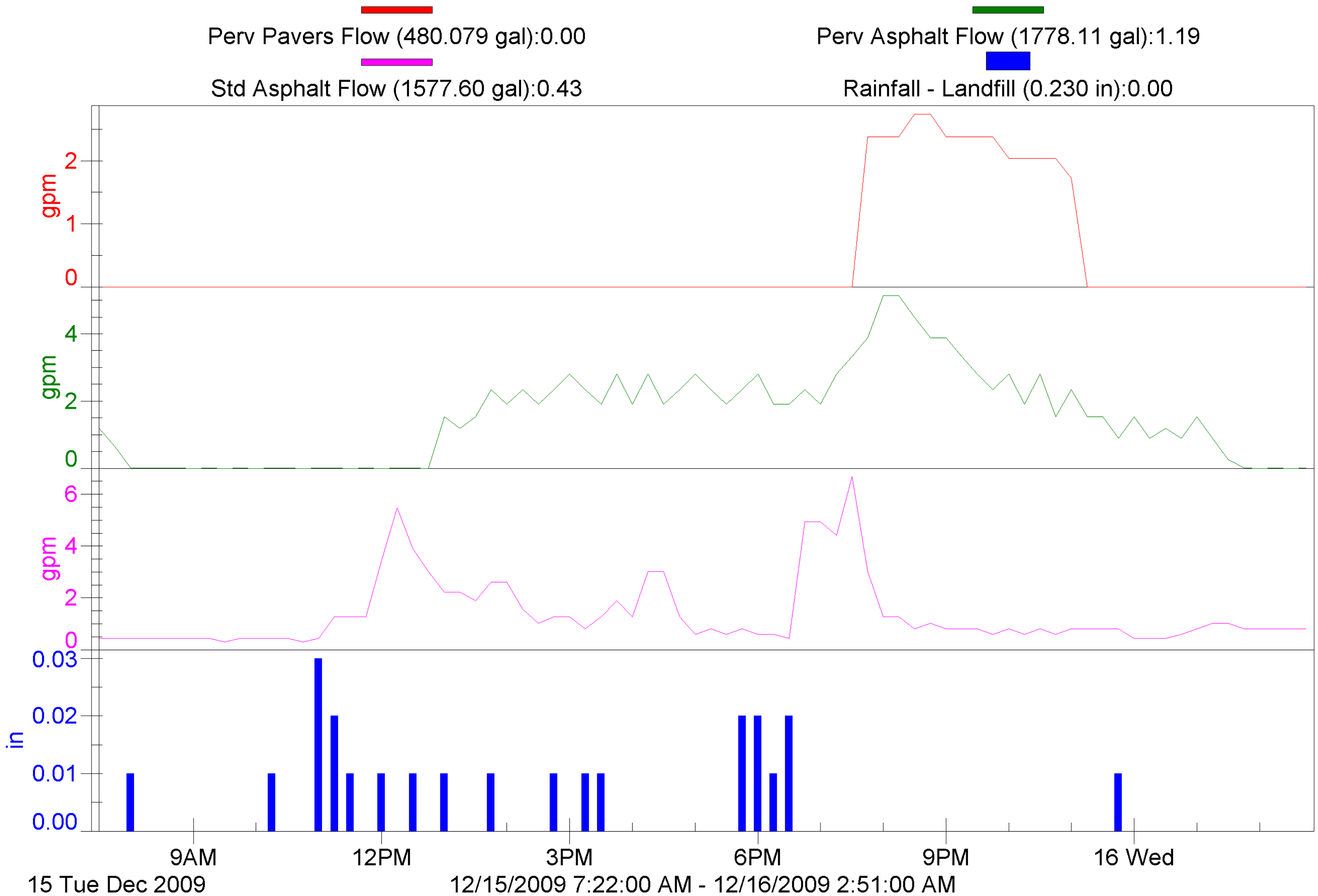
Flowlink 5



Storm #31

Pervious Pavement Project Flow

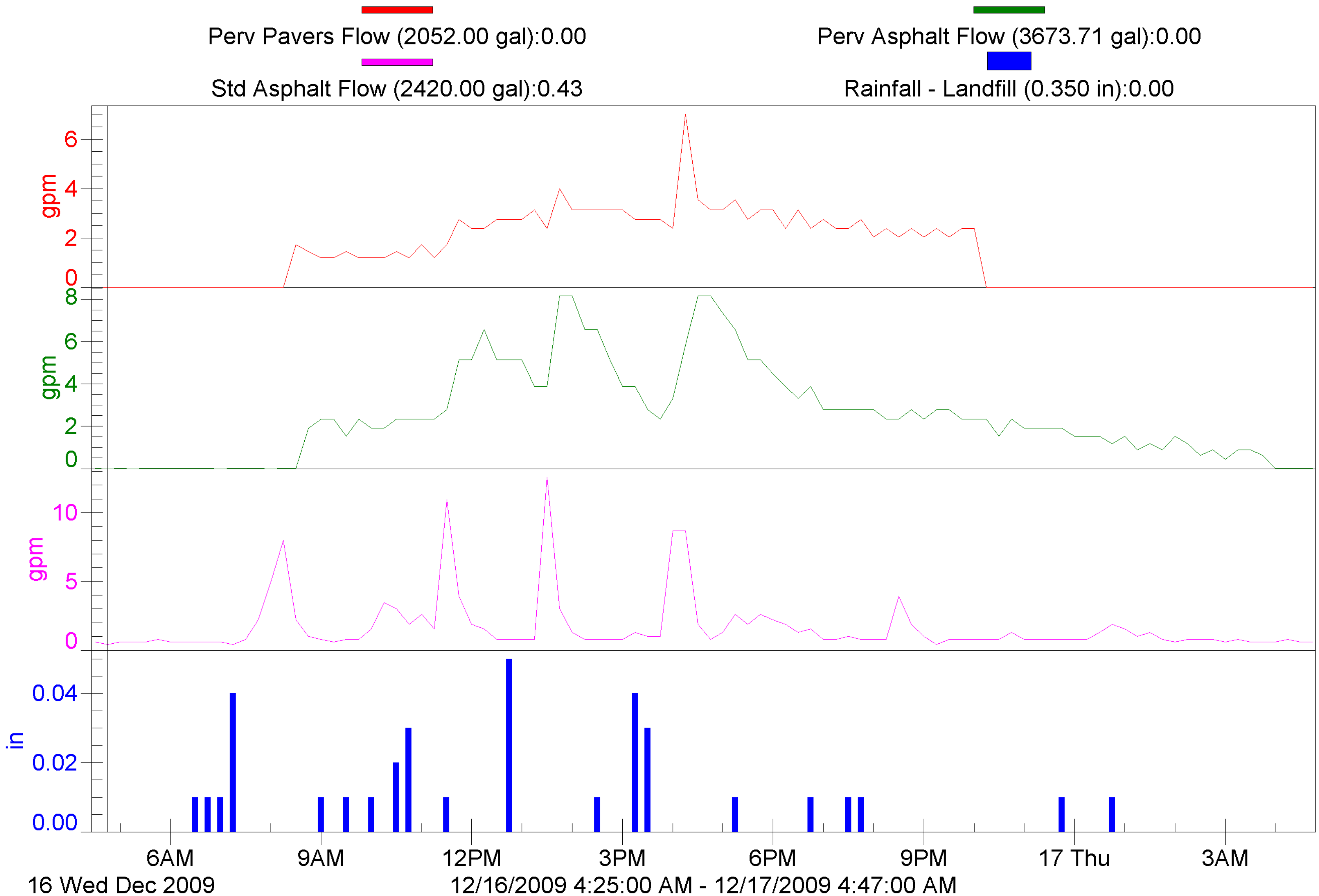
Flowlink 5



Storm #32

Pervious Pavement Project Flow

Flowlink 5



Storm #33

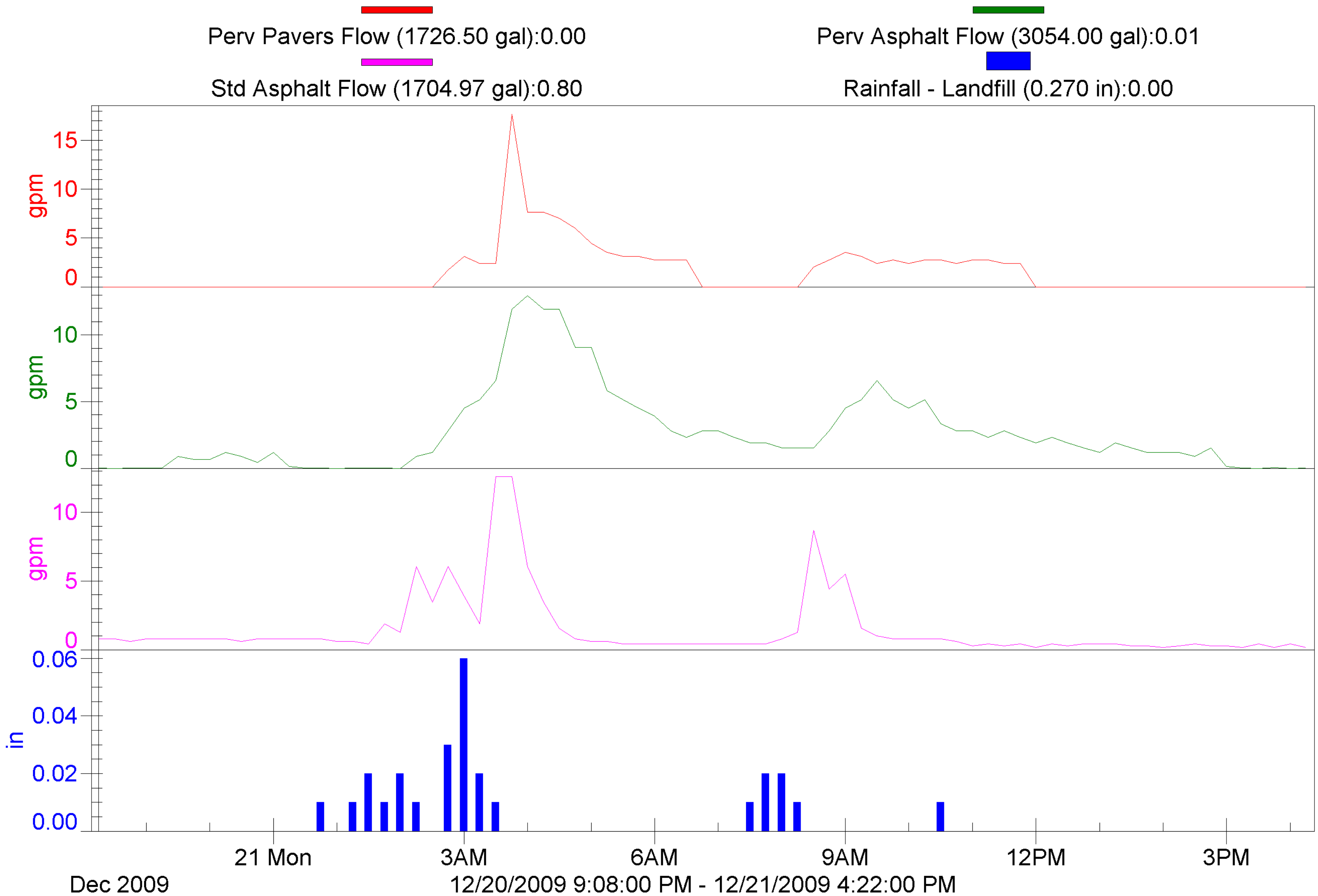
Pervious Pavement Project Flow

Flowlink 5

Storm #34

Pervious Pavement Project Flow

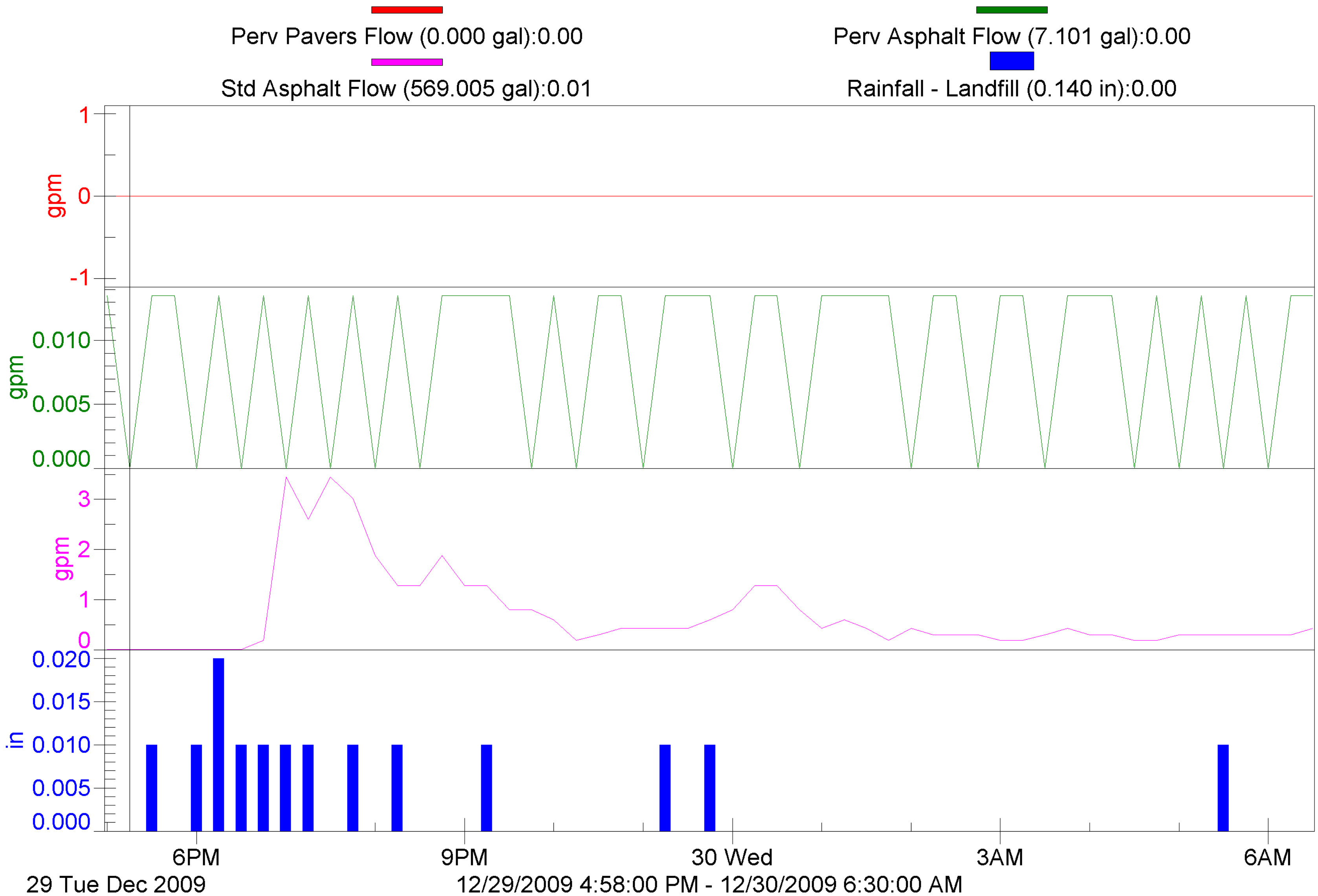
Flowlink 5



Storm #35

Pervious Pavement Project Flow

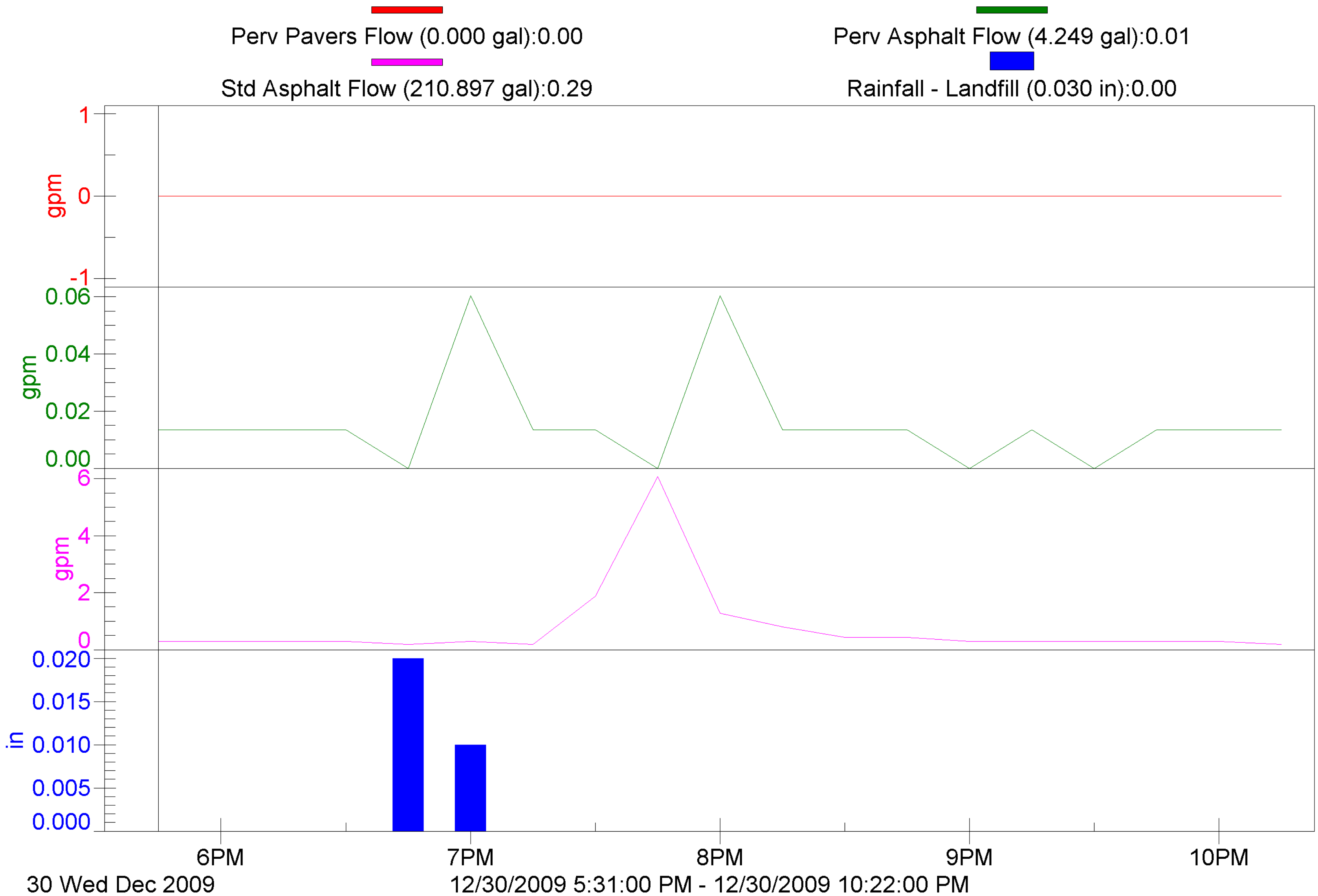
Flowlink 5



Storm #36

Pervious Pavement Project Flow

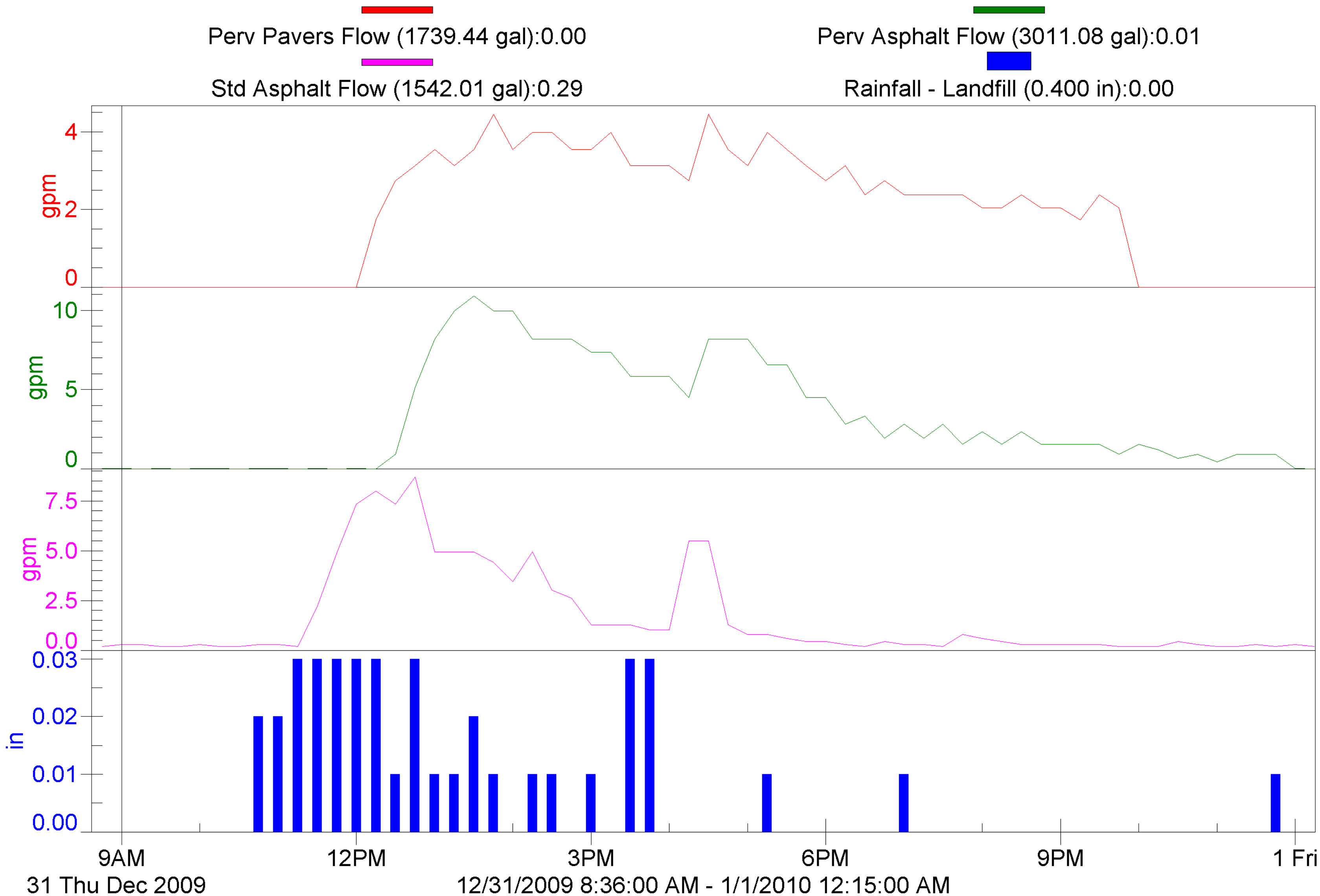
Flowlink 5



Storm #37

Pervious Pavement Project Flow

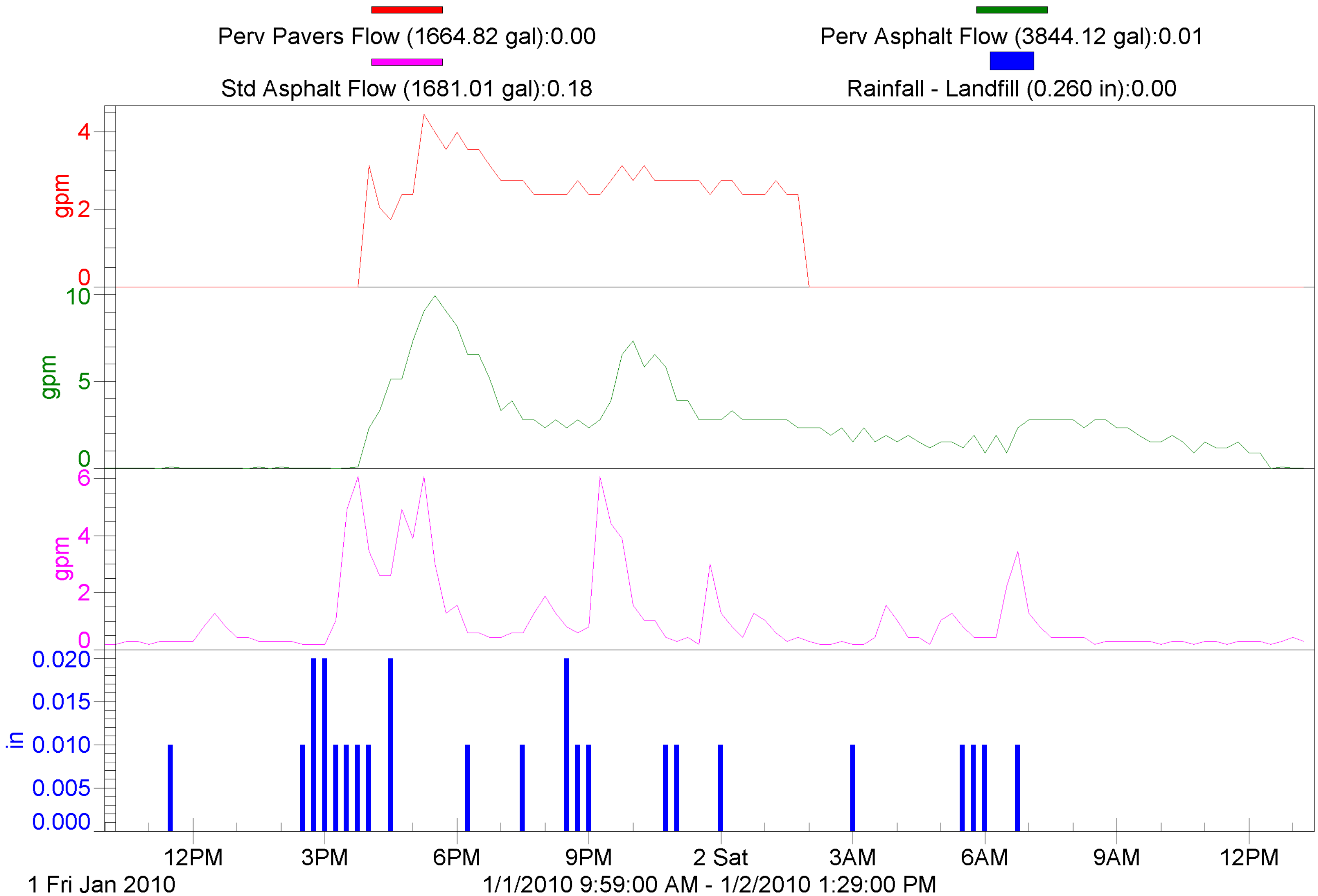
Flowlink 5



Storm #38

Pervious Pavement Project Flow

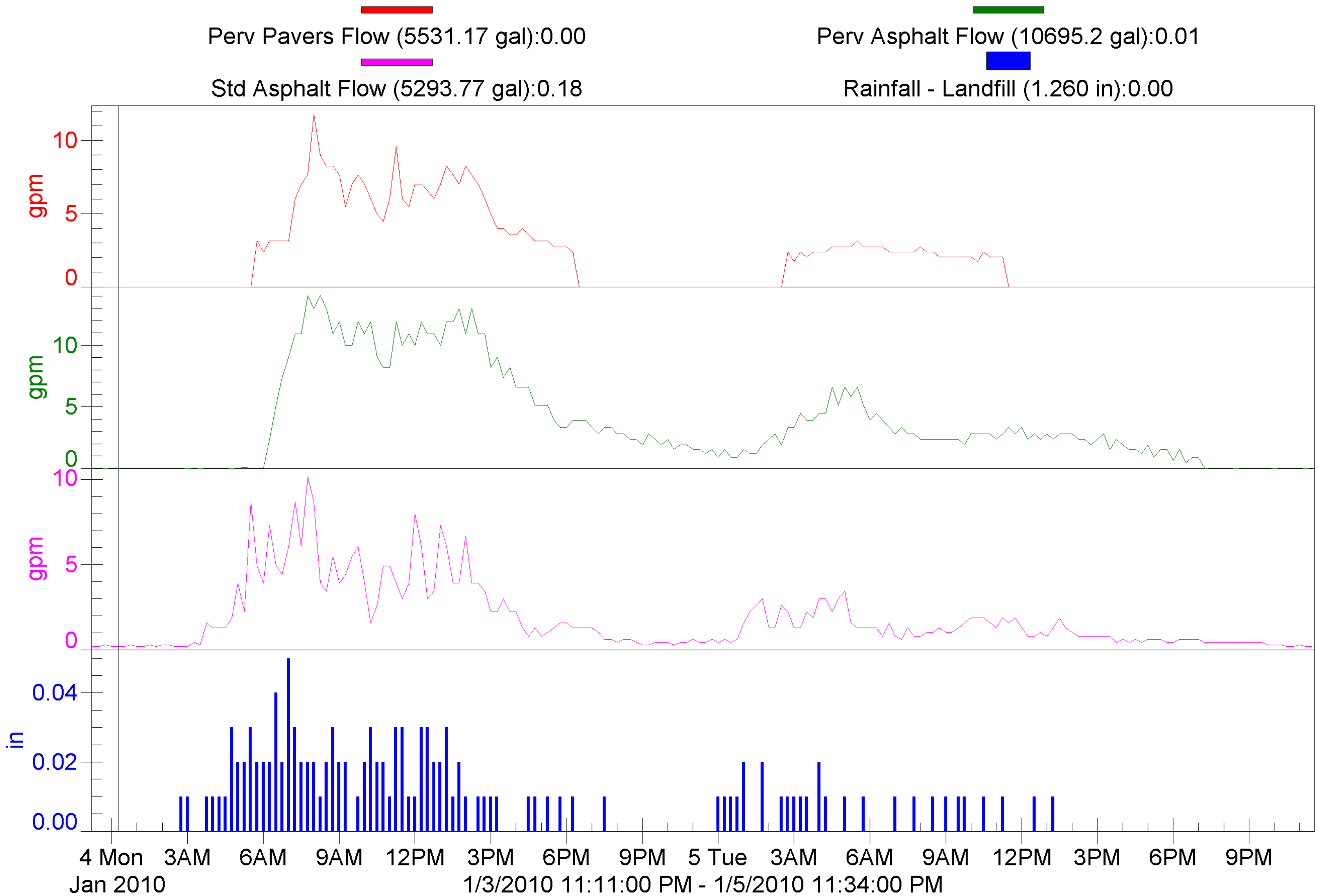
Flowlink 5



Storm #39

Pervious Pavement Project Flow

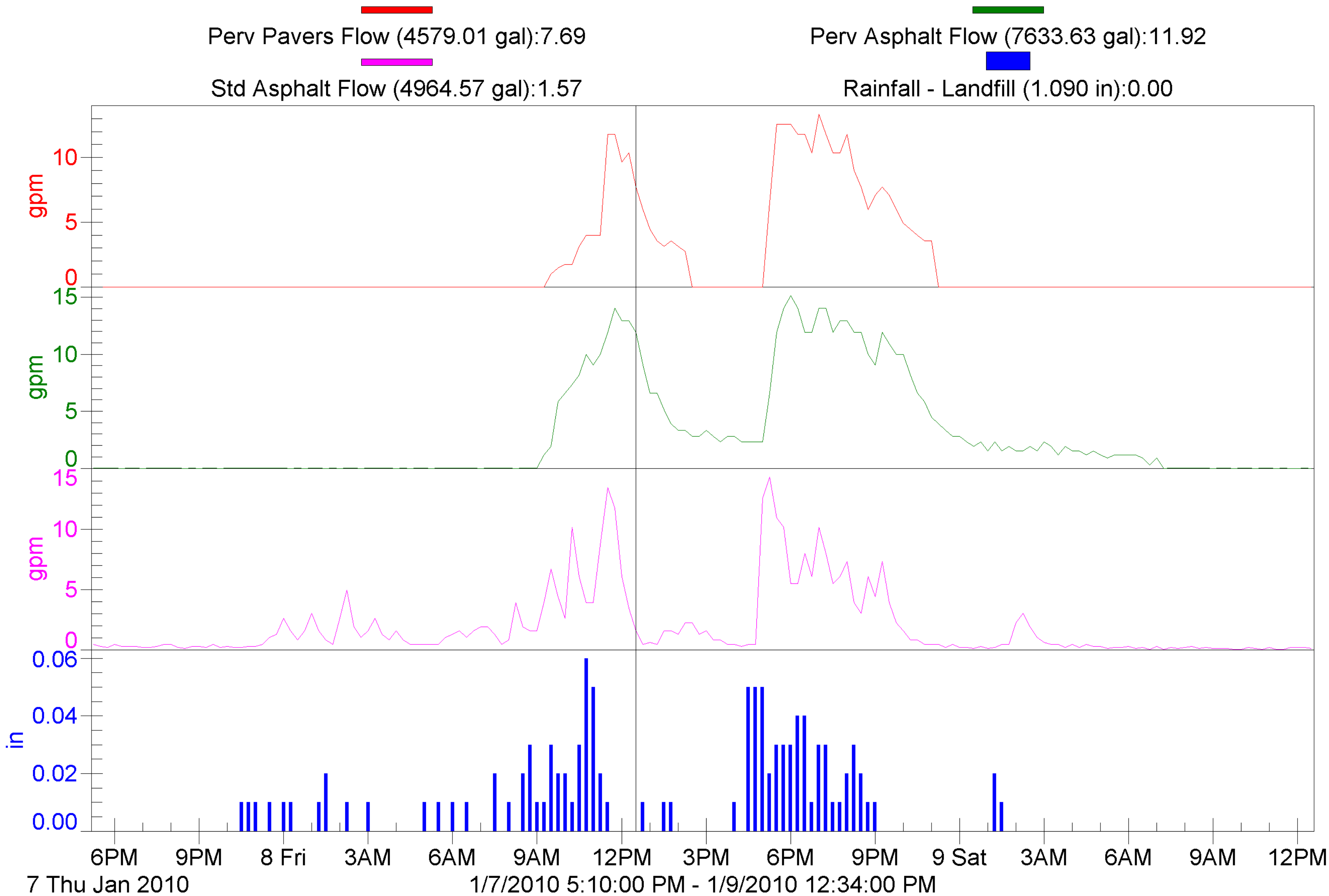
Flowlink 5



Storm #40

Pervious Pavement Project Flow

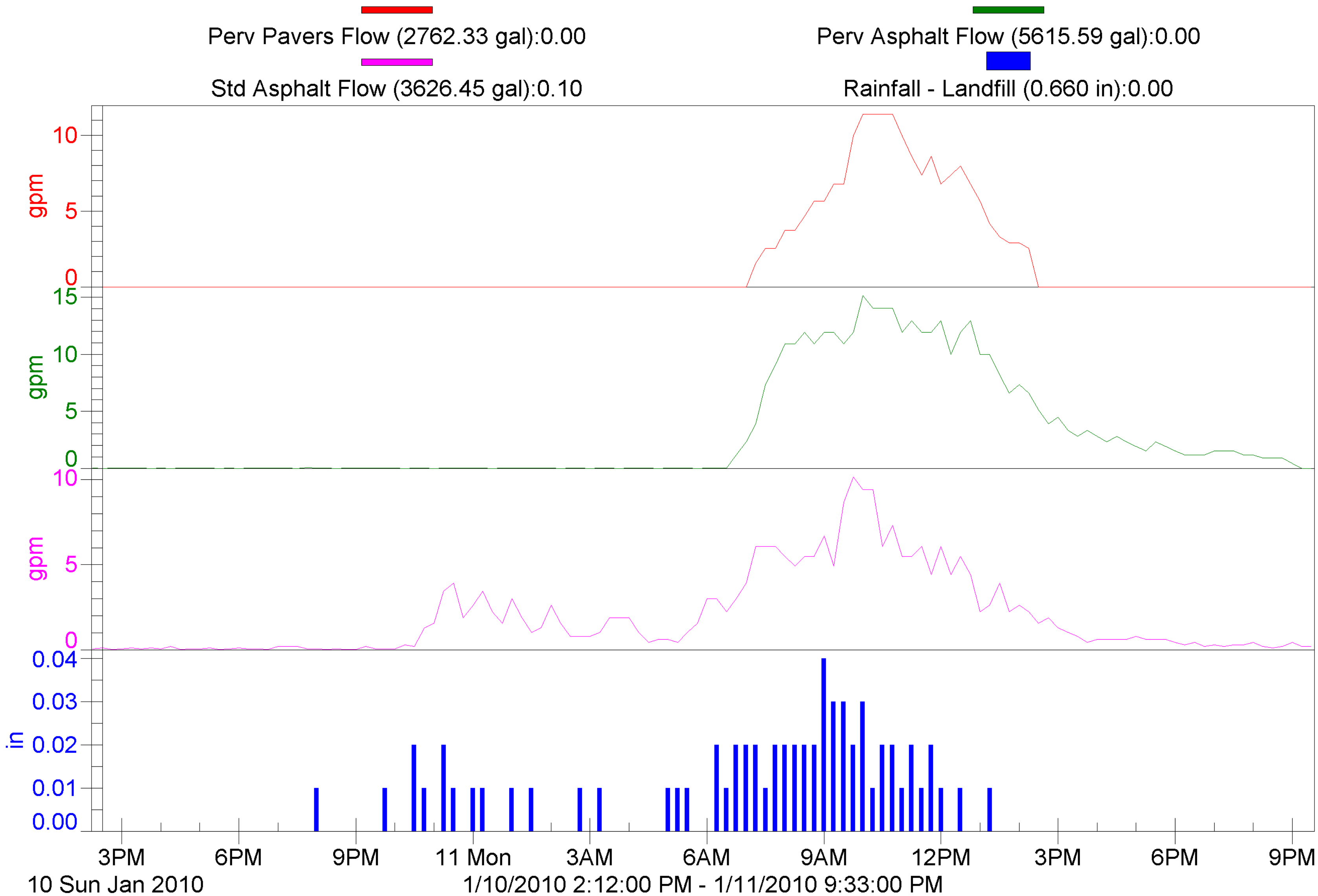
Flowlink 5



Storm #41

Pervious Pavement Project Flow

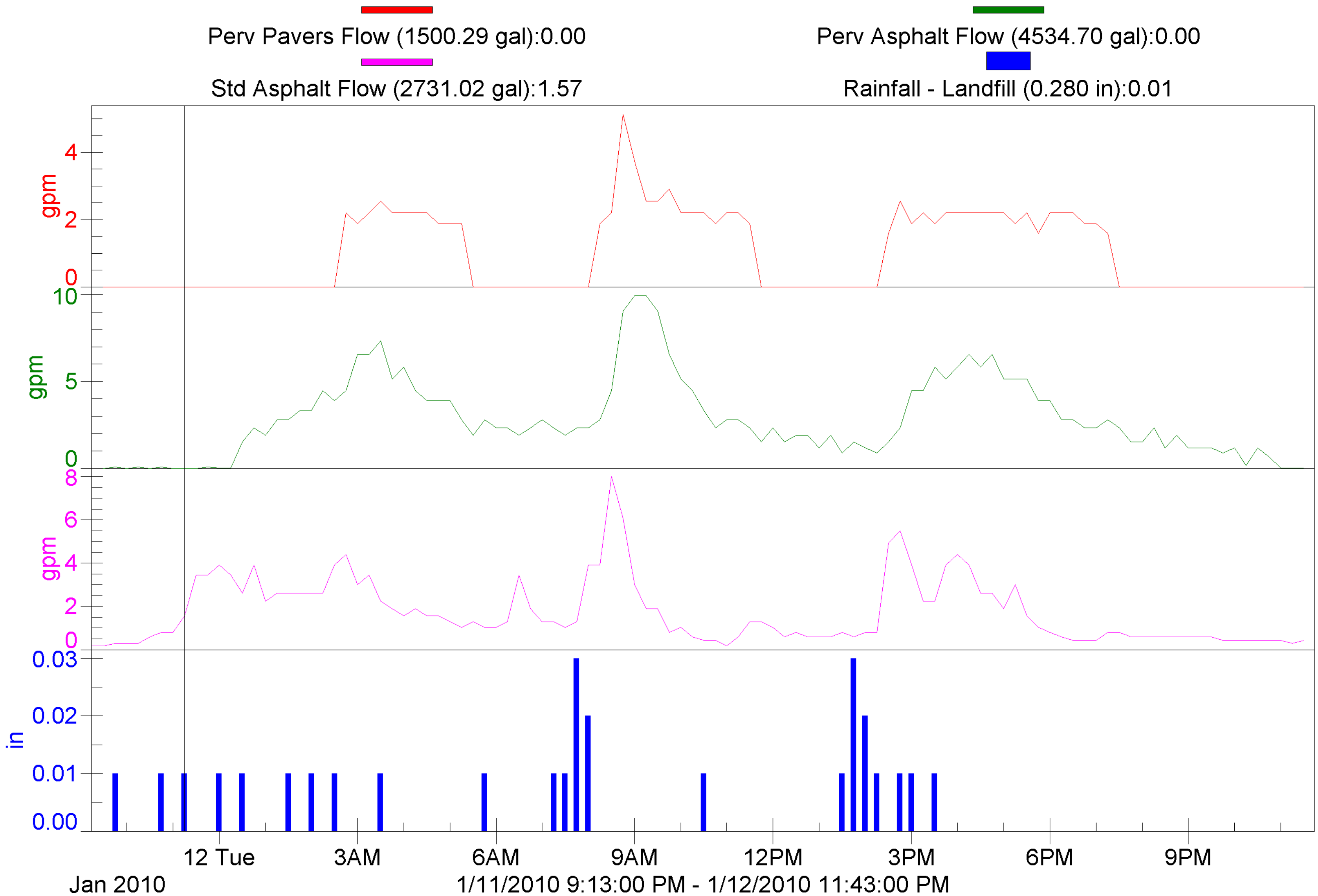
Flowlink 5



Storm #42

Pervious Pavement Project Flow

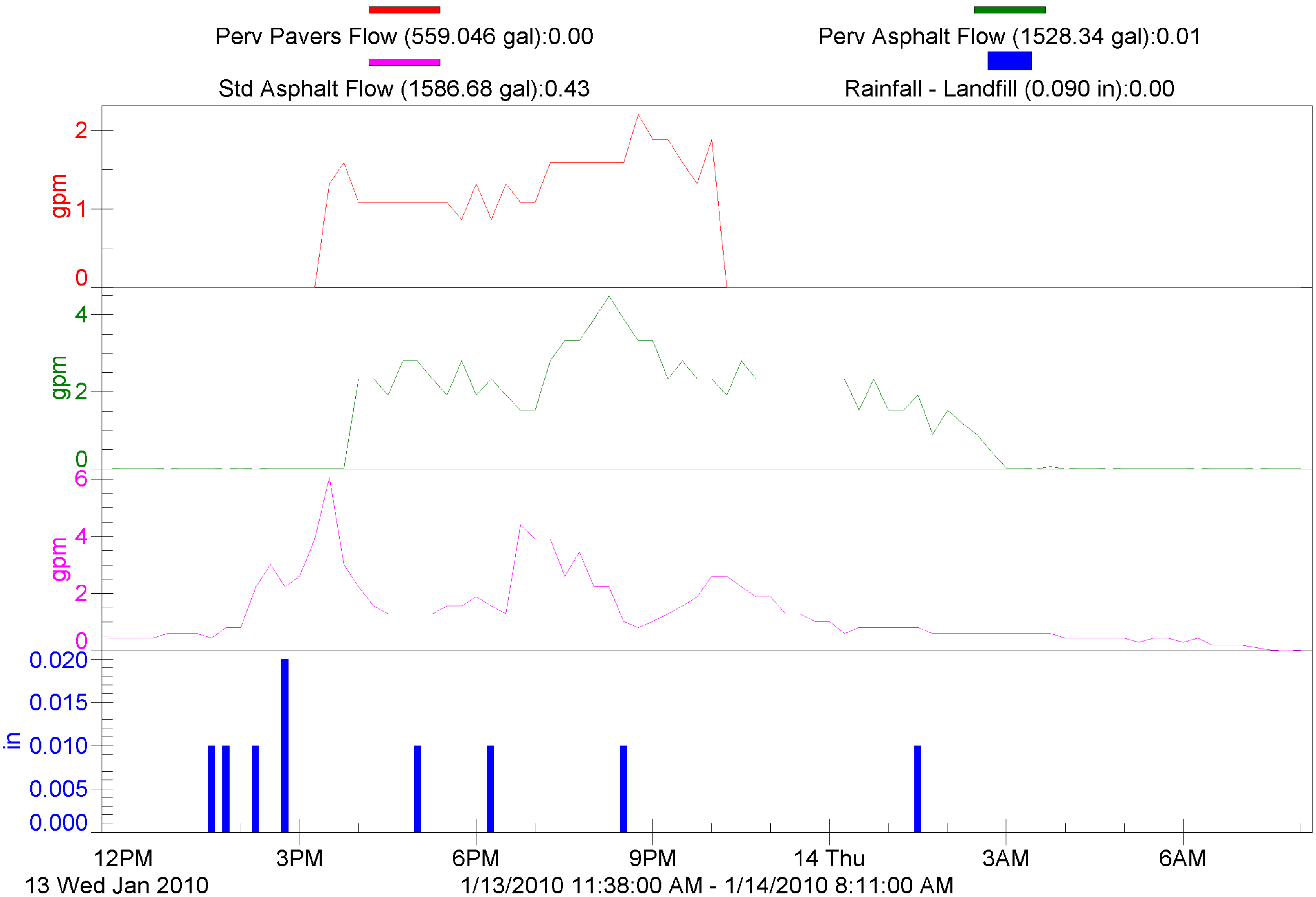
Flowlink 5

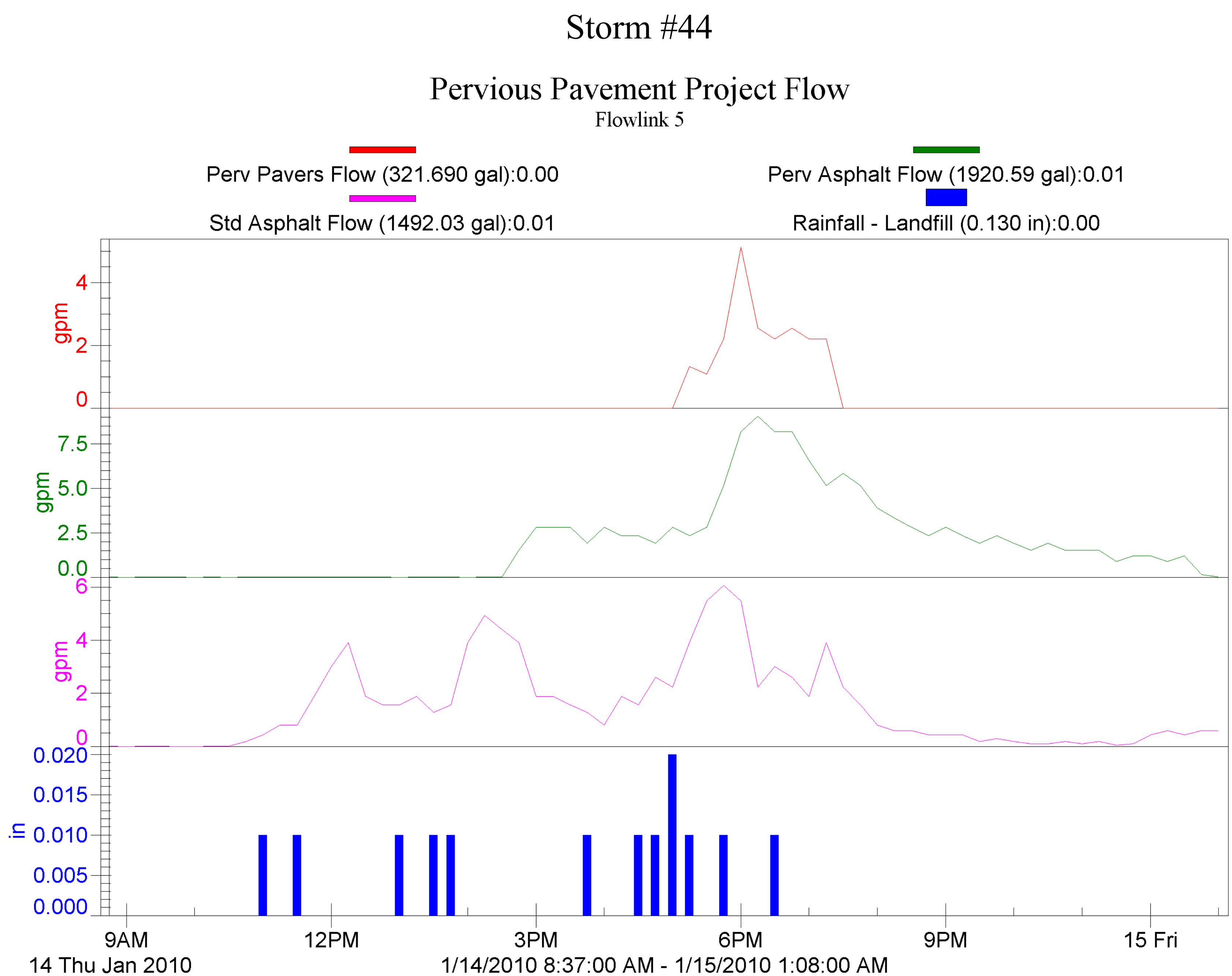


Storm #43

Pervious Pavement Project Flow

Flowlink 5



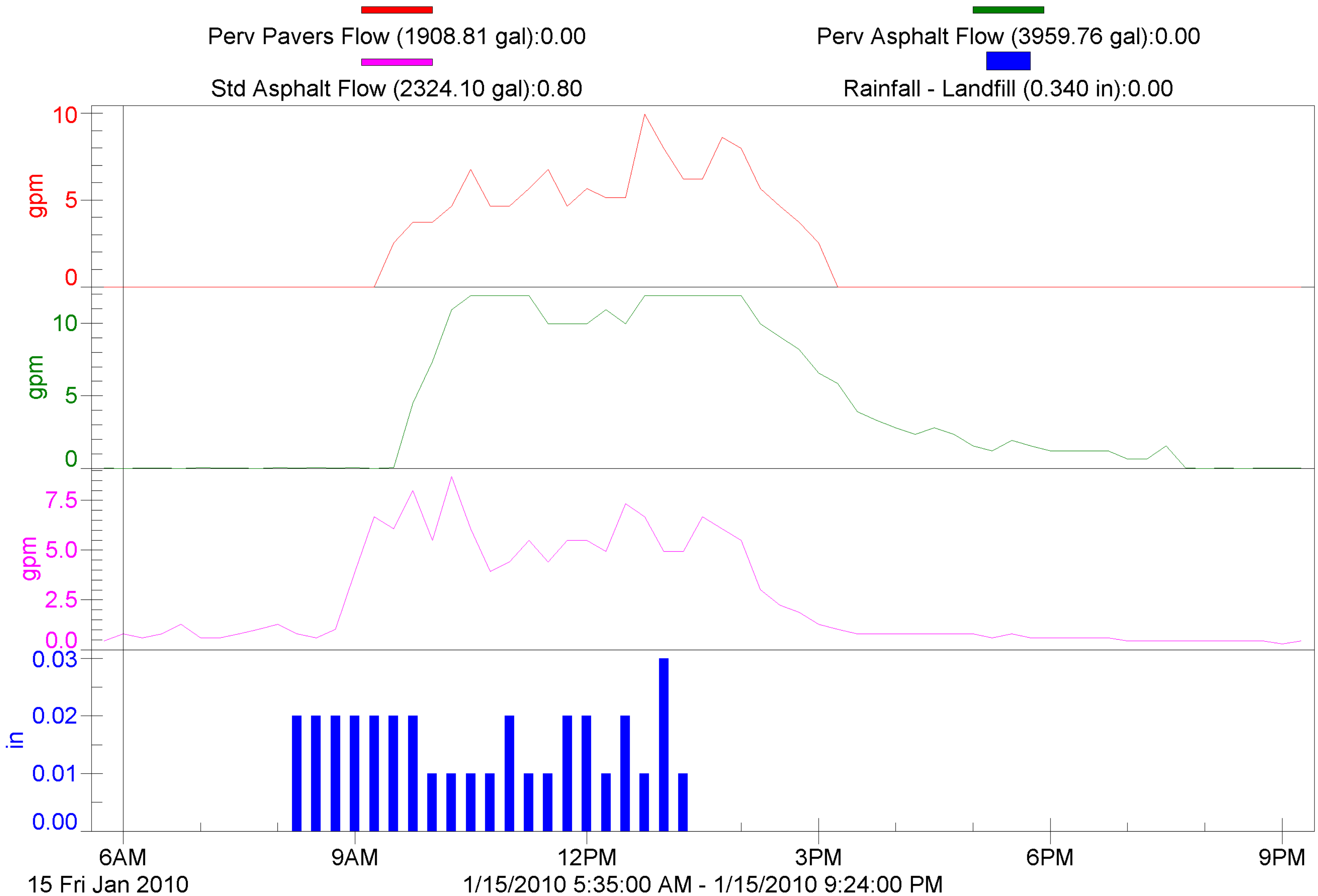


Storm #44
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (321.690 gal):0.00
Perv Asphalt Flow (1920.59 gal):0.01
Std Asphalt Flow (1492.03 gal):0.01
Rainfall - Landfill (0.130 in):0.00
gpm
4
2
0
gpm
7.5
5.0
2.5
0.0
gpm
6
4
2
0
in
0.020
0.015
0.010
0.005
0.000
9AM
12PM
3PM
6PM
9PM
15 Fri
14 Thu Jan 2010
1/14/2010 8:37:00 AM - 1/15/2010 1:08:00 AM

Storm #45

Pervious Pavement Project Flow

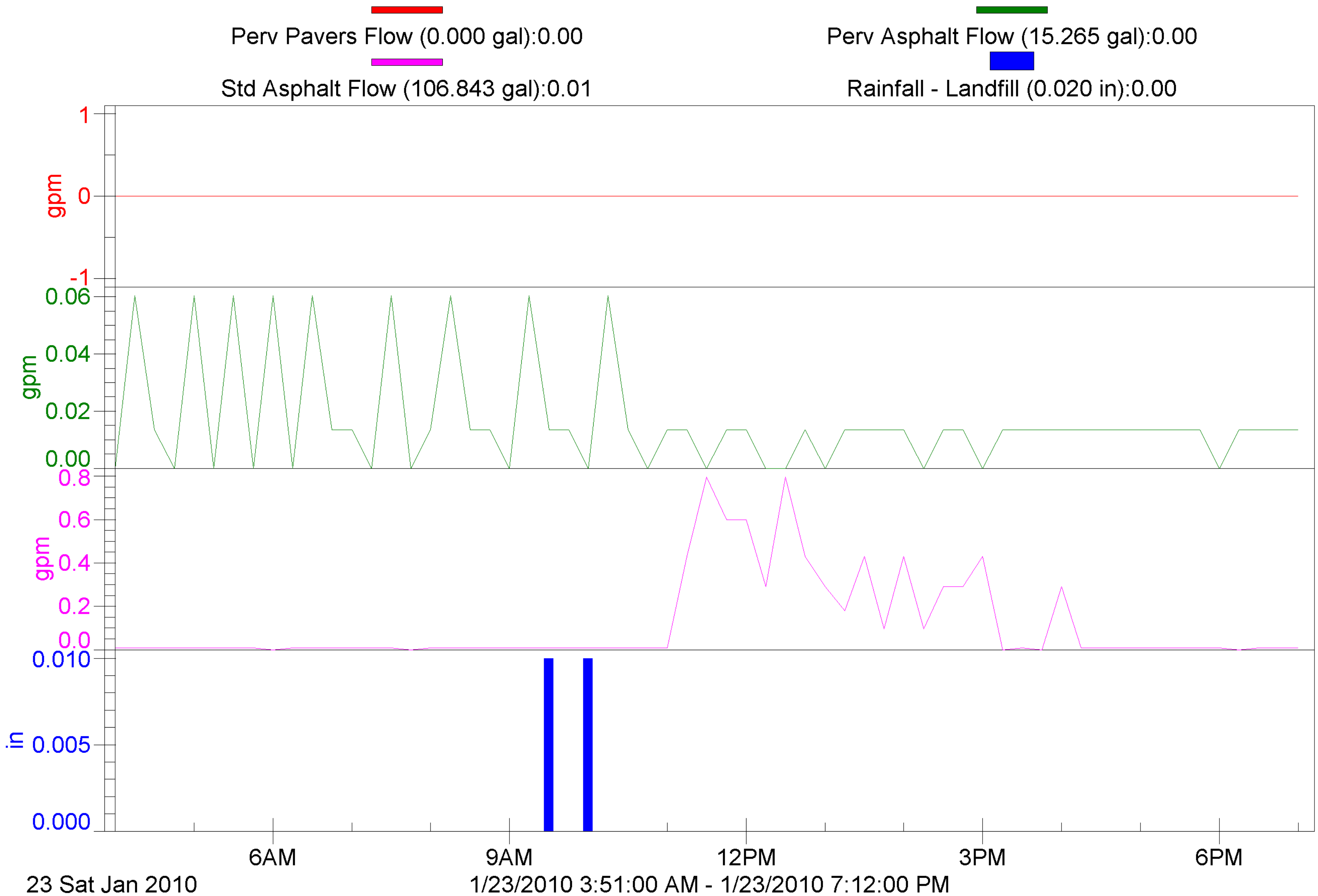
Flowlink 5



Storm #46

Pervious Pavement Project Flow

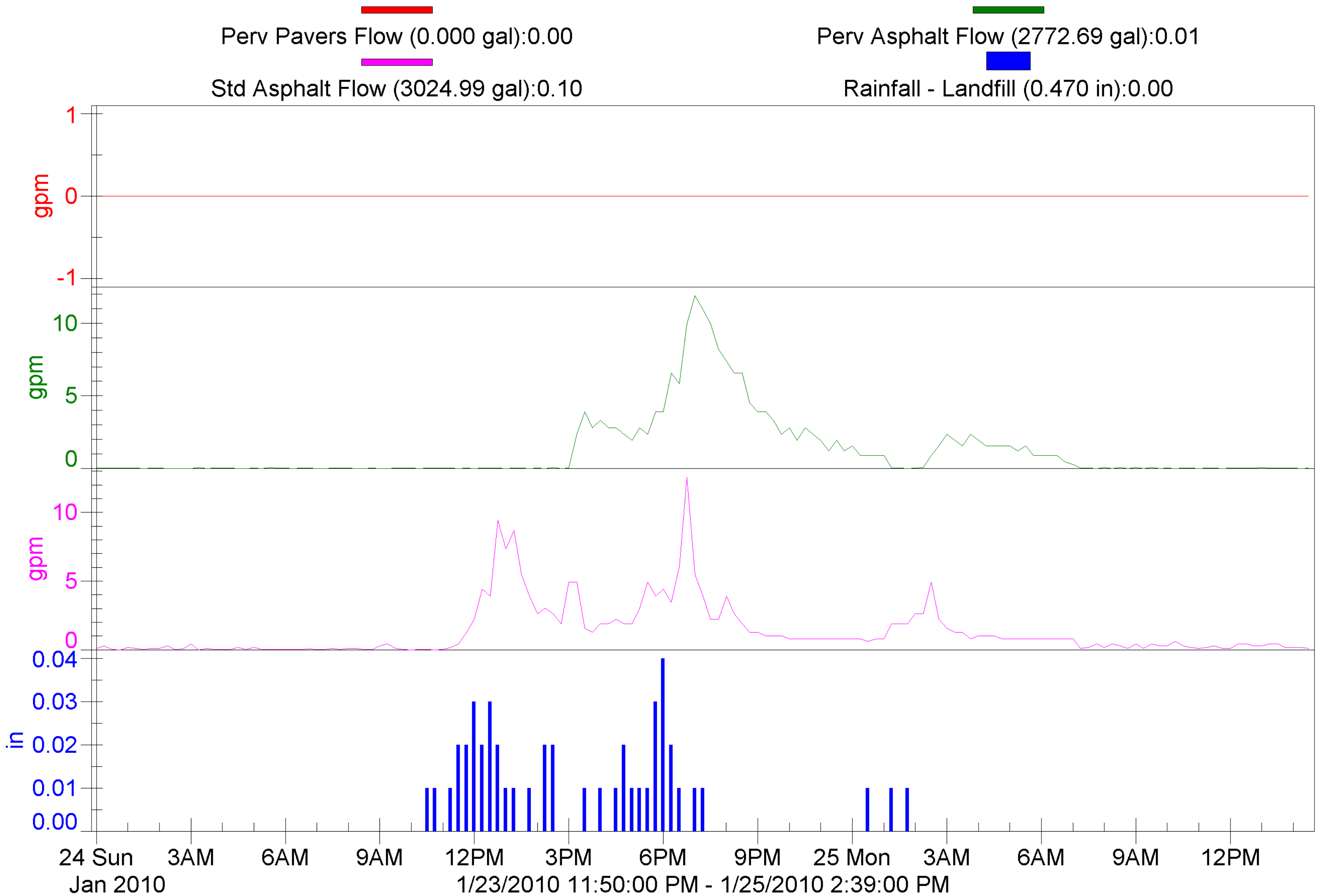
Flowlink 5



Storm #47

Pervious Pavement Project Flow

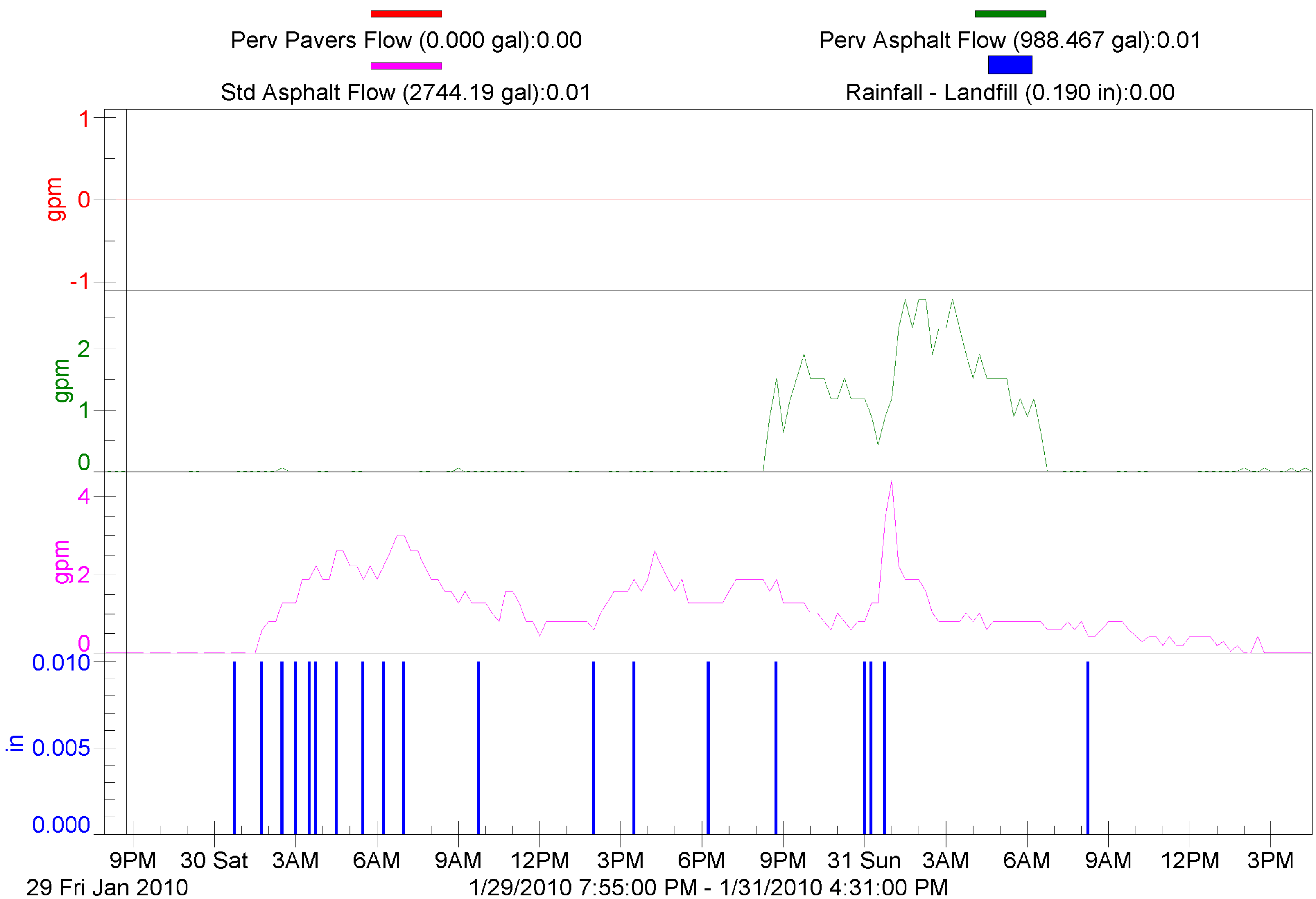
Flowlink 5



Storm #48

Pervious Pavement Project Flow

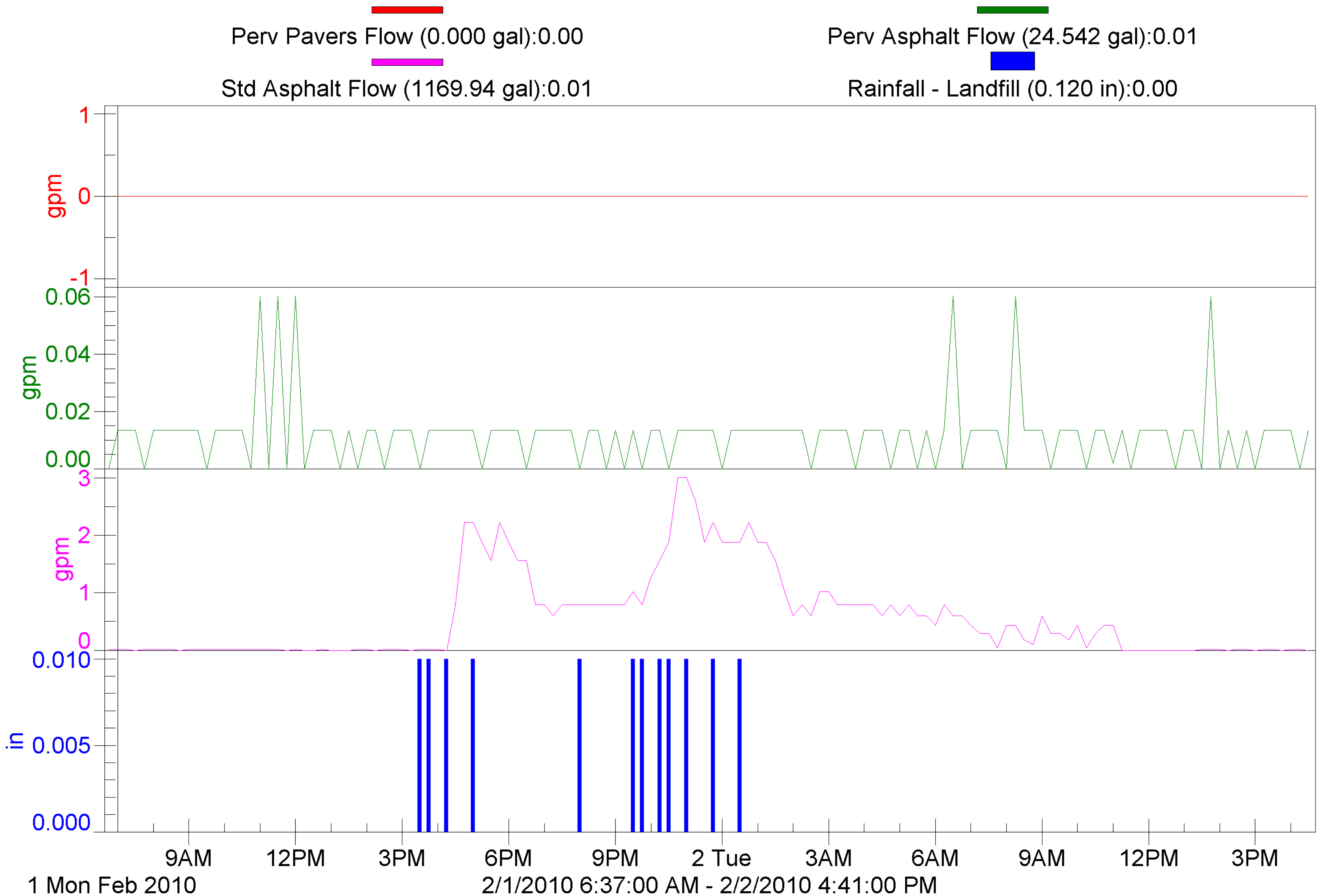
Flowlink 5



Storm #49

Pervious Pavement Project Flow

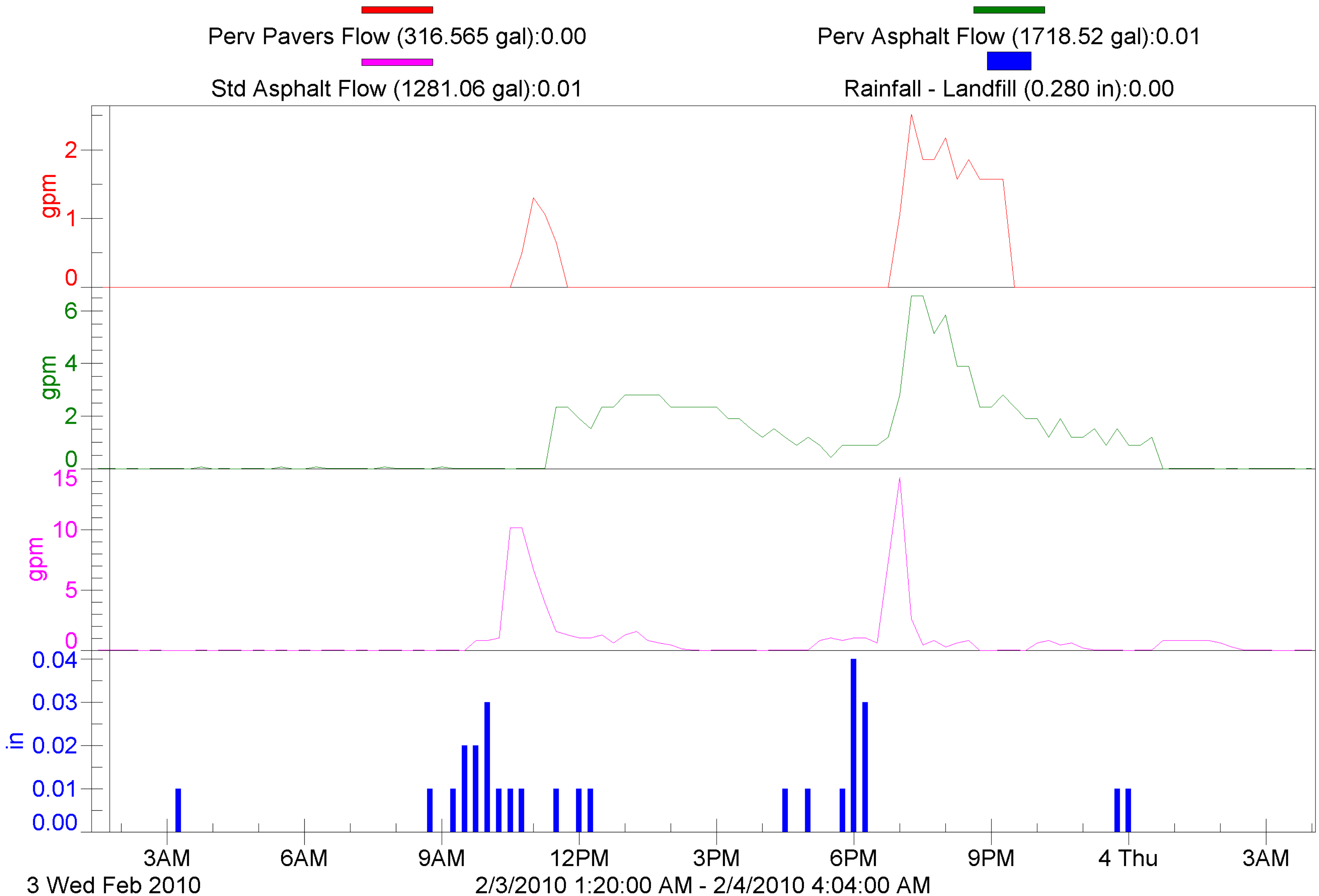
Flowlink 5



Storm #50

Pervious Pavement Project Flow

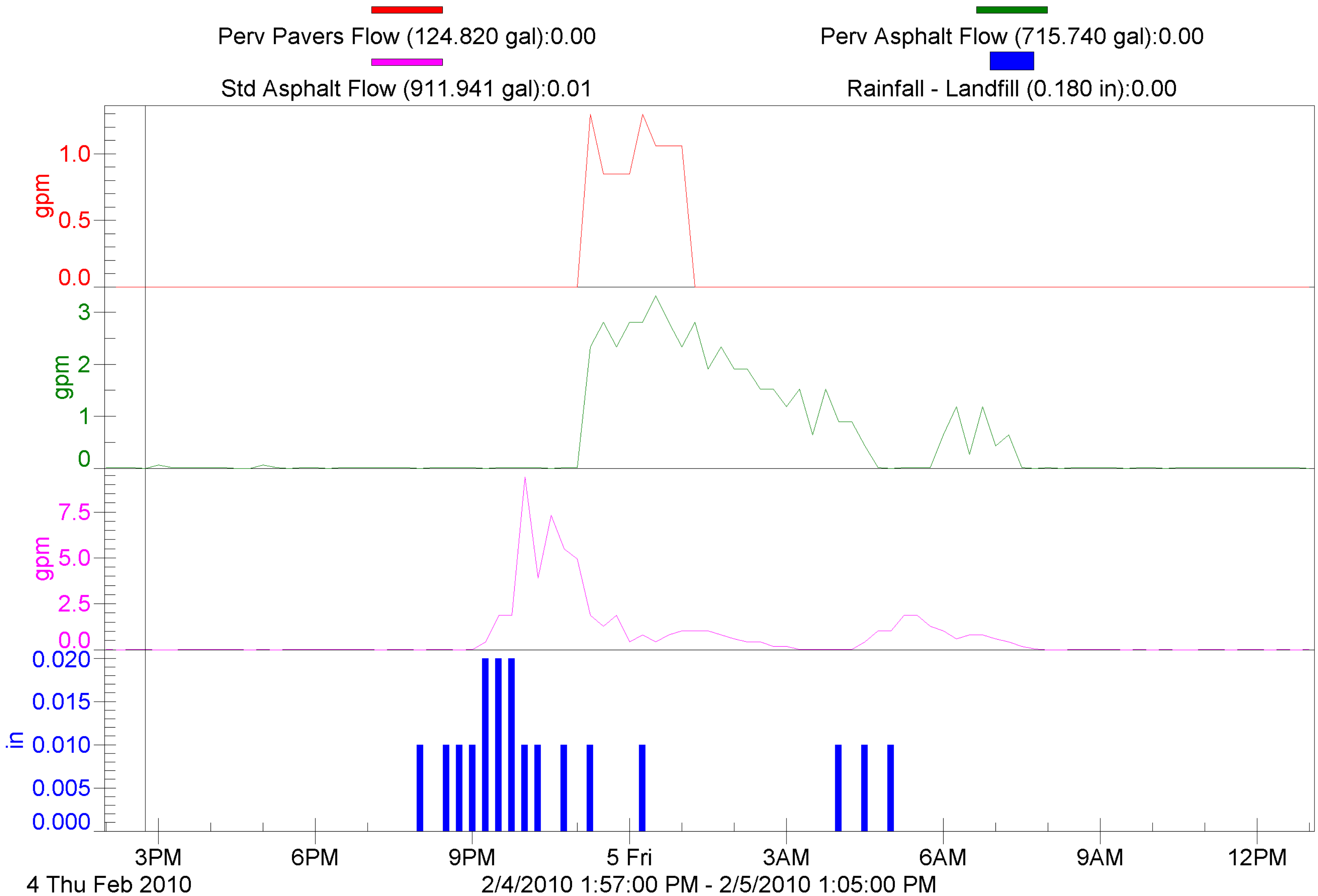
Flowlink 5



Storm #51

Pervious Pavement Project Flow

Flowlink 5



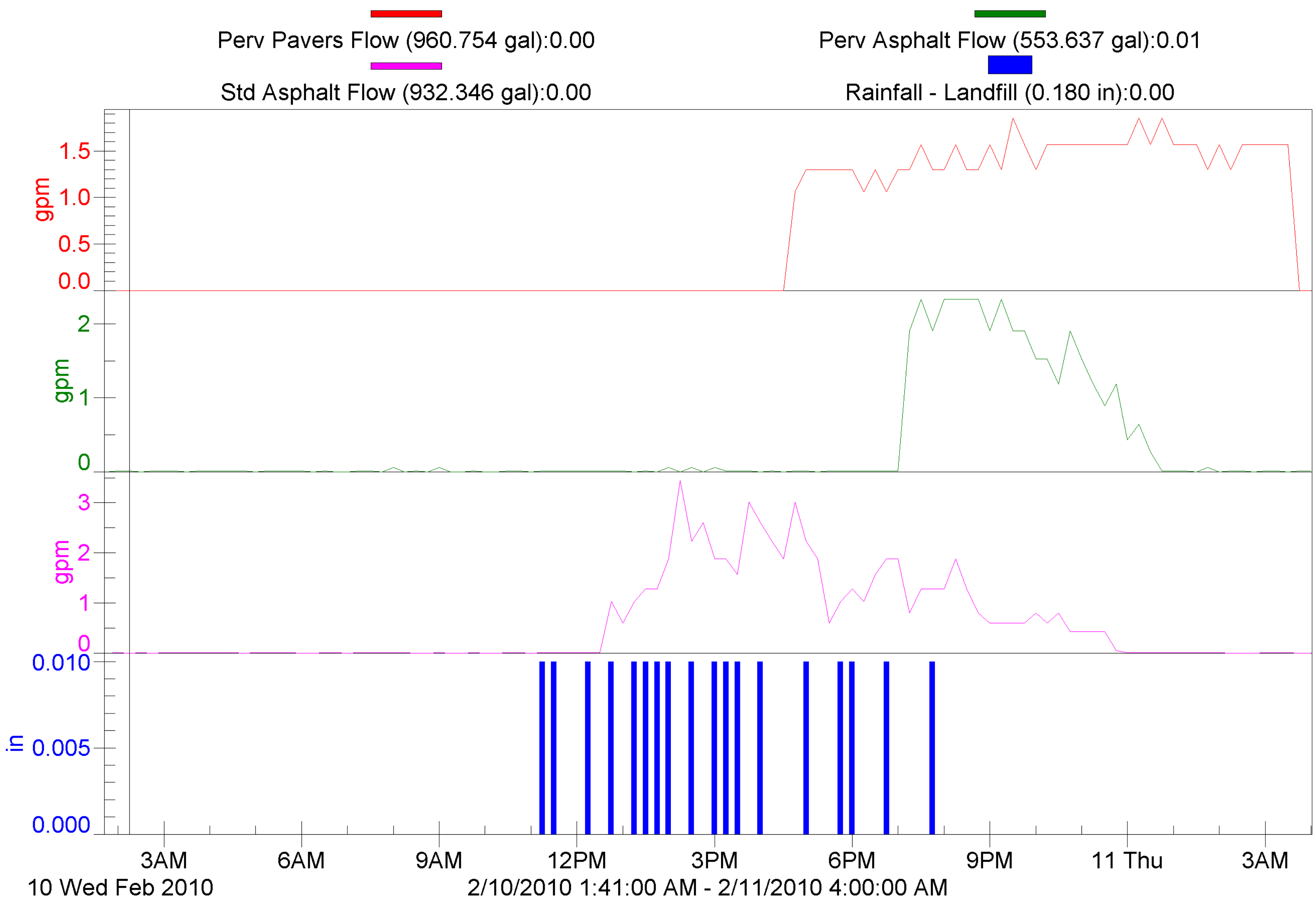
Storm #52

Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (616.707 gal):0.00
Perv Asphalt Flow (323.977 gal):0.01
Std Asphalt Flow (753.171 gal):0.00
Rainfall - Landfill (0.180 in):0.00
gpm
1.0
0.5
0.0
gpm
1.5
1.0
0.5
0.0
gpm
1.5
1.0
0.5
0.0
in
0.010
0.005
0.000
3PM
6PM
9PM
7 Sun
3AM
6AM
9AM
12PM
3PM
6PM
9PM
8 Mon
3AM
6 Sat Feb 2010
2/6/2010 12:11:00 PM - 2/8/2010 5:24:00 AM

Storm #53

Pervious Pavement Project Flow

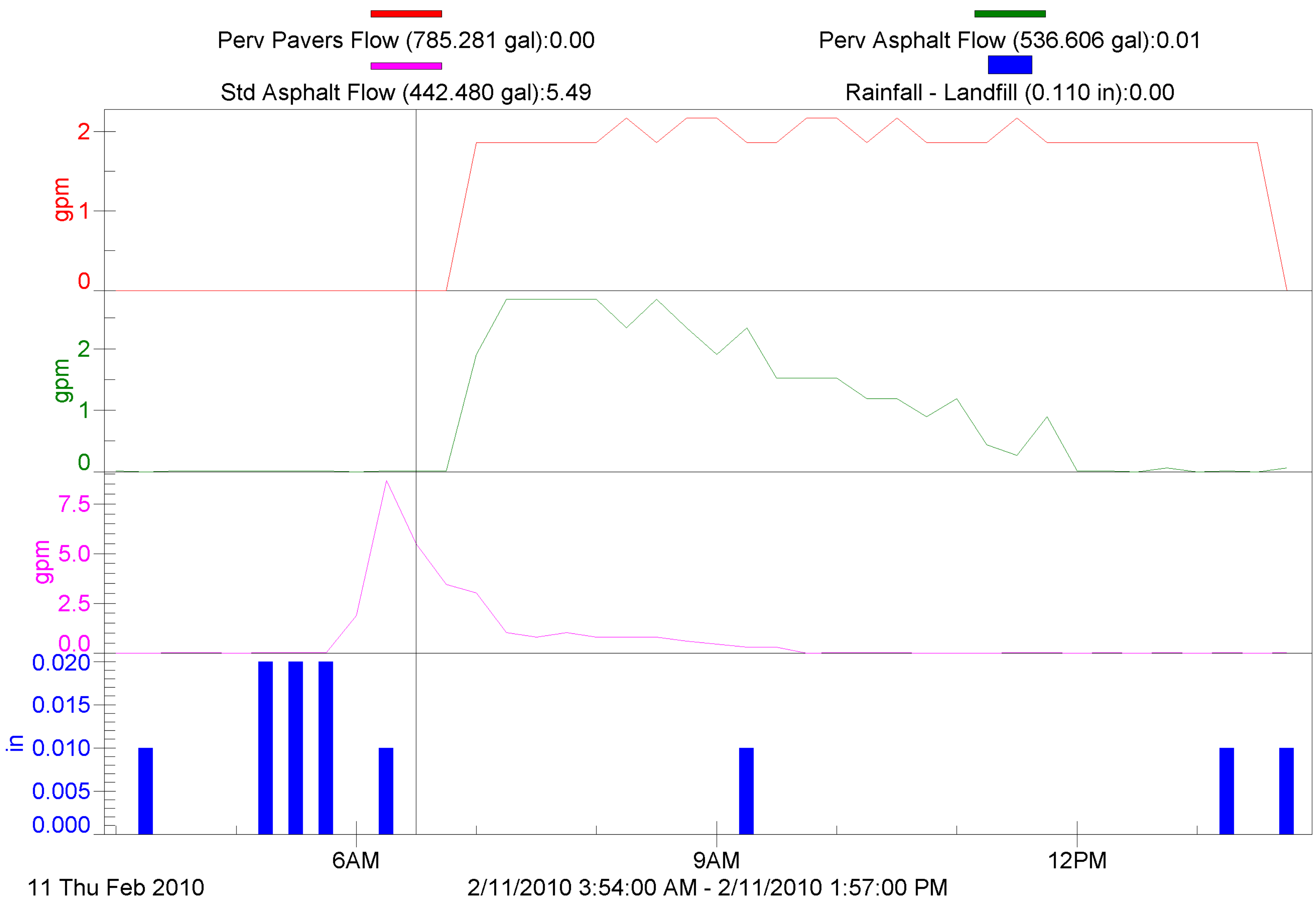
Flowlink 5



Storm #54

Pervious Pavement Project Flow

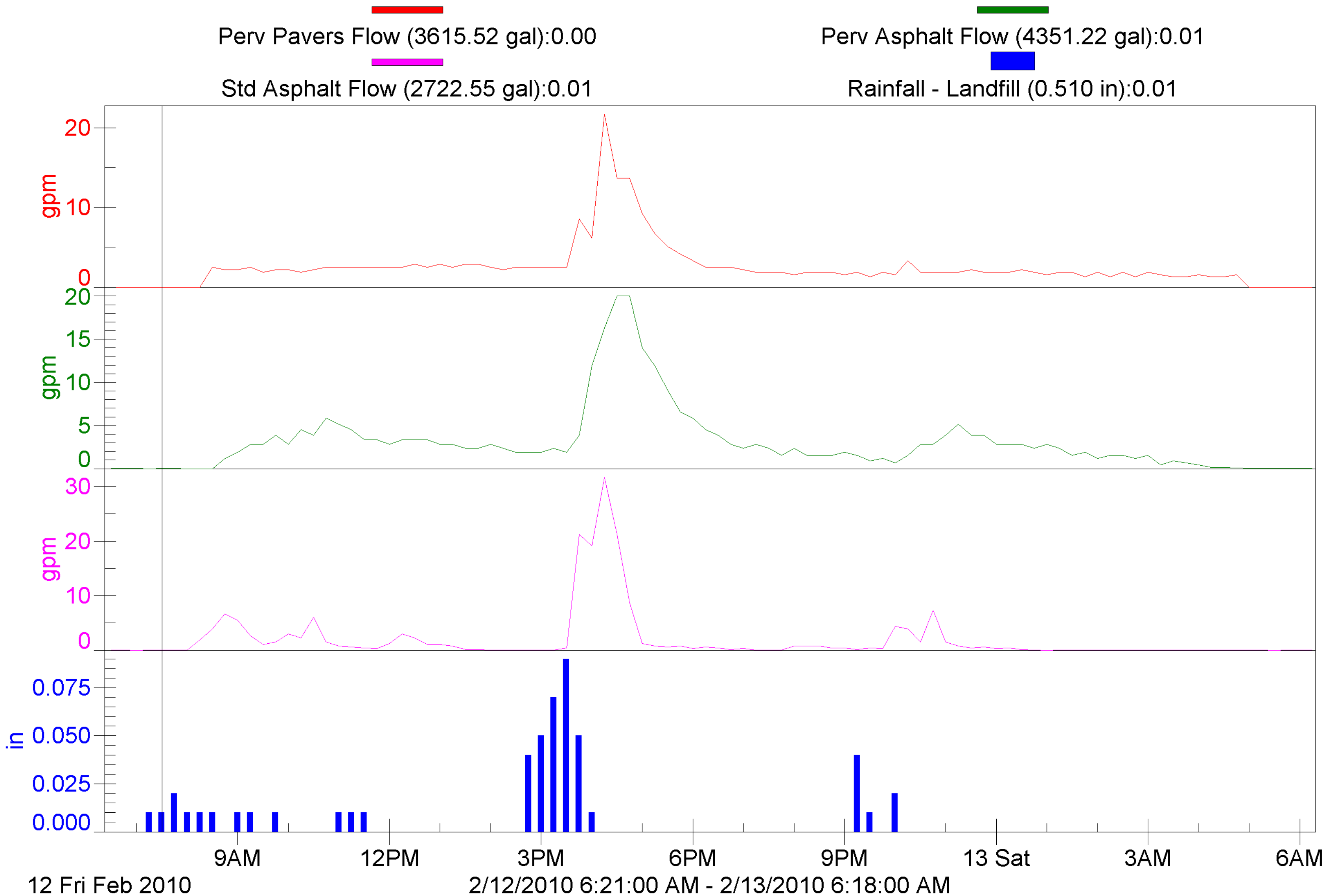
Flowlink 5



Storm #55

Pervious Pavement Project Flow

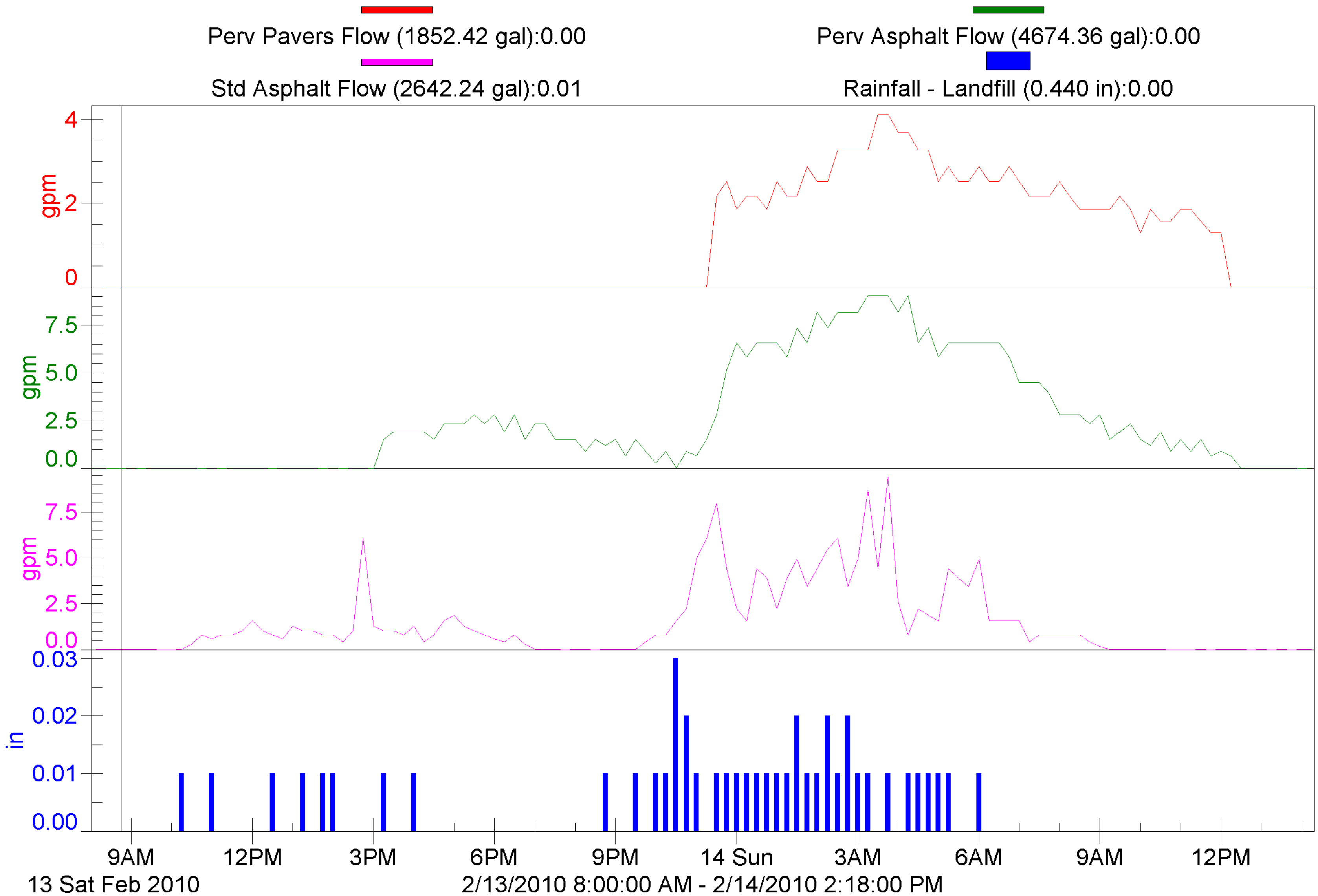
Flowlink 5



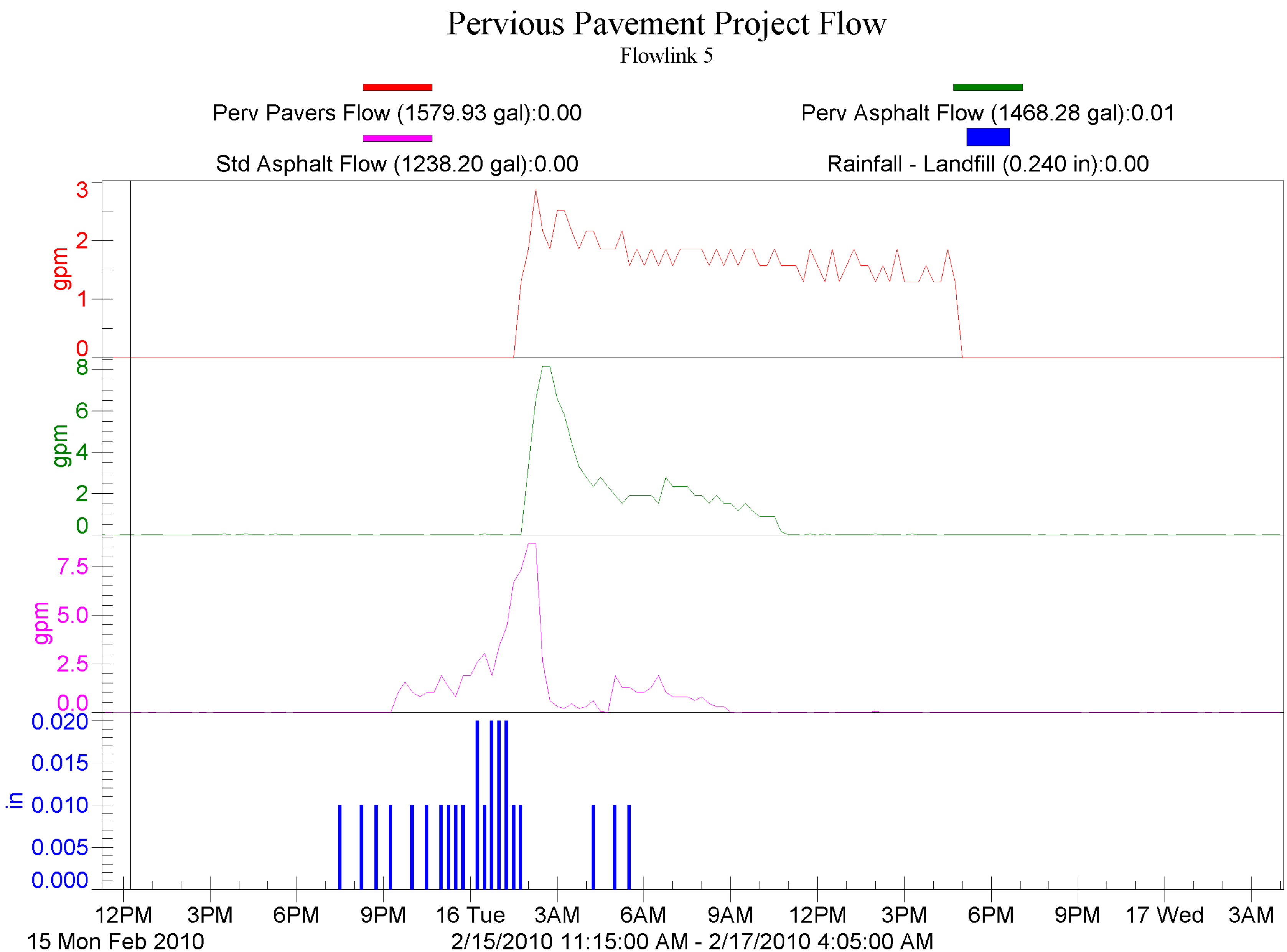
Storm #56

Pervious Pavement Project Flow

Flowlink 5



Storm #57

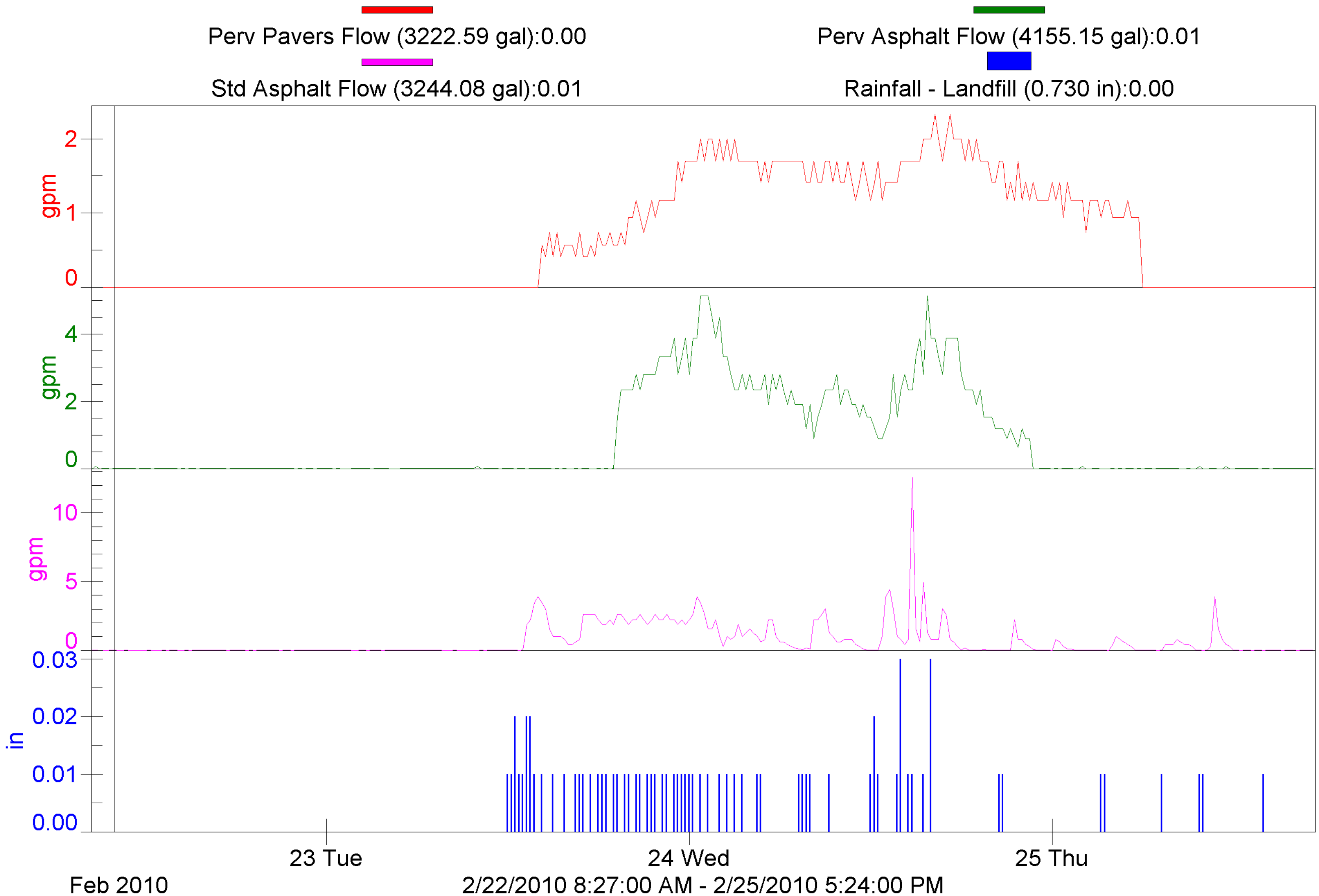


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (1579.93 gal):0.00
Perv Asphalt Flow (1468.28 gal):0.01
Std Asphalt Flow (1238.20 gal):0.00
Rainfall - Landfill (0.240 in):0.00
gpm
3
2
1
0
gpm
8
6
4
2
0
gpm
7.5
5.0
2.5
0.0
in
0.020
0.015
0.010
0.005
0.000
12PM
3PM
6PM
9PM
16 Tue
3AM
6AM
9AM
12PM
3PM
6PM
9PM
17 Wed
3AM
15 Mon Feb 2010
2/15/2010 11:15:00 AM - 2/17/2010 4:05:00 AM

Storm #58

Pervious Pavement Project Flow

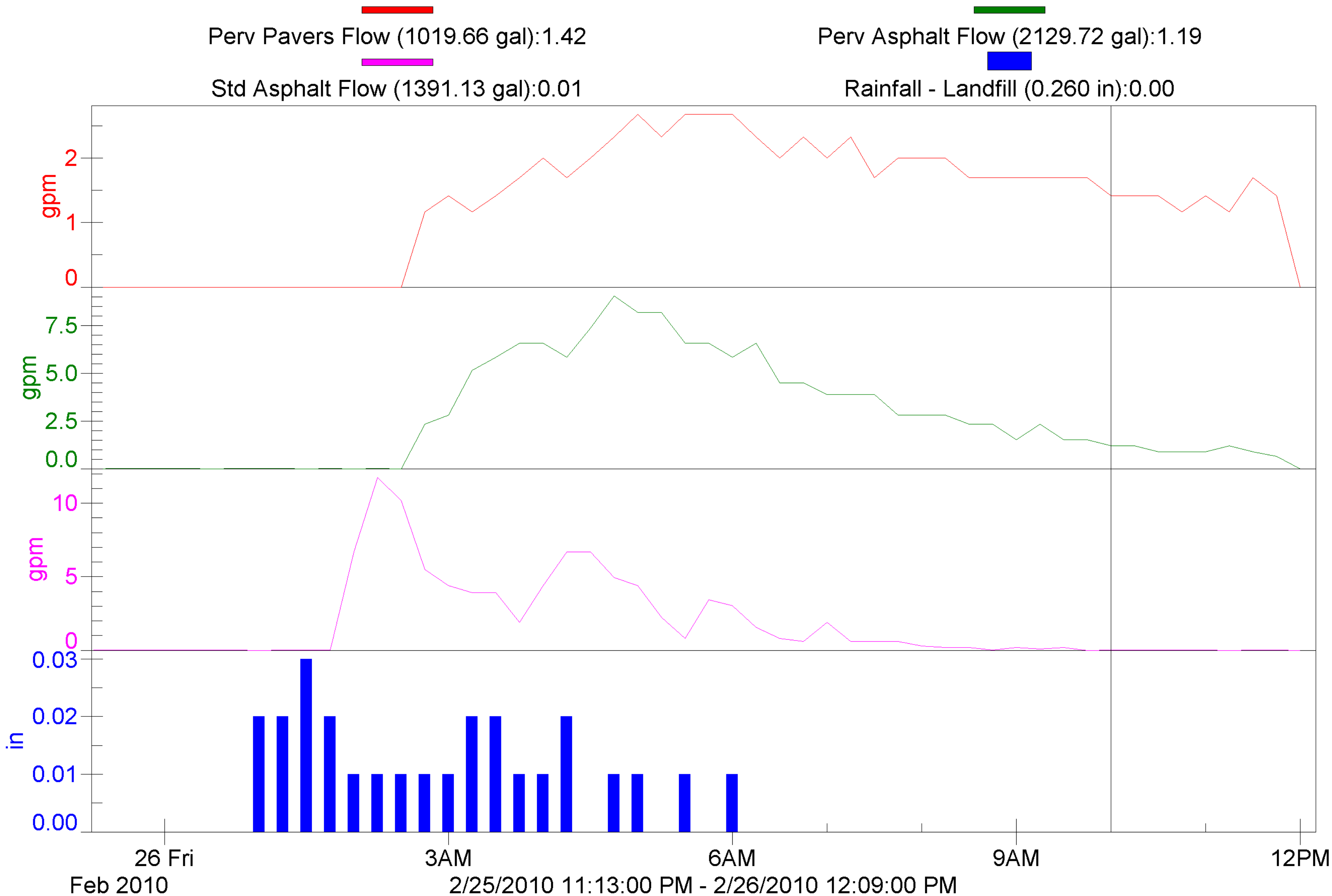
Flowlink 5



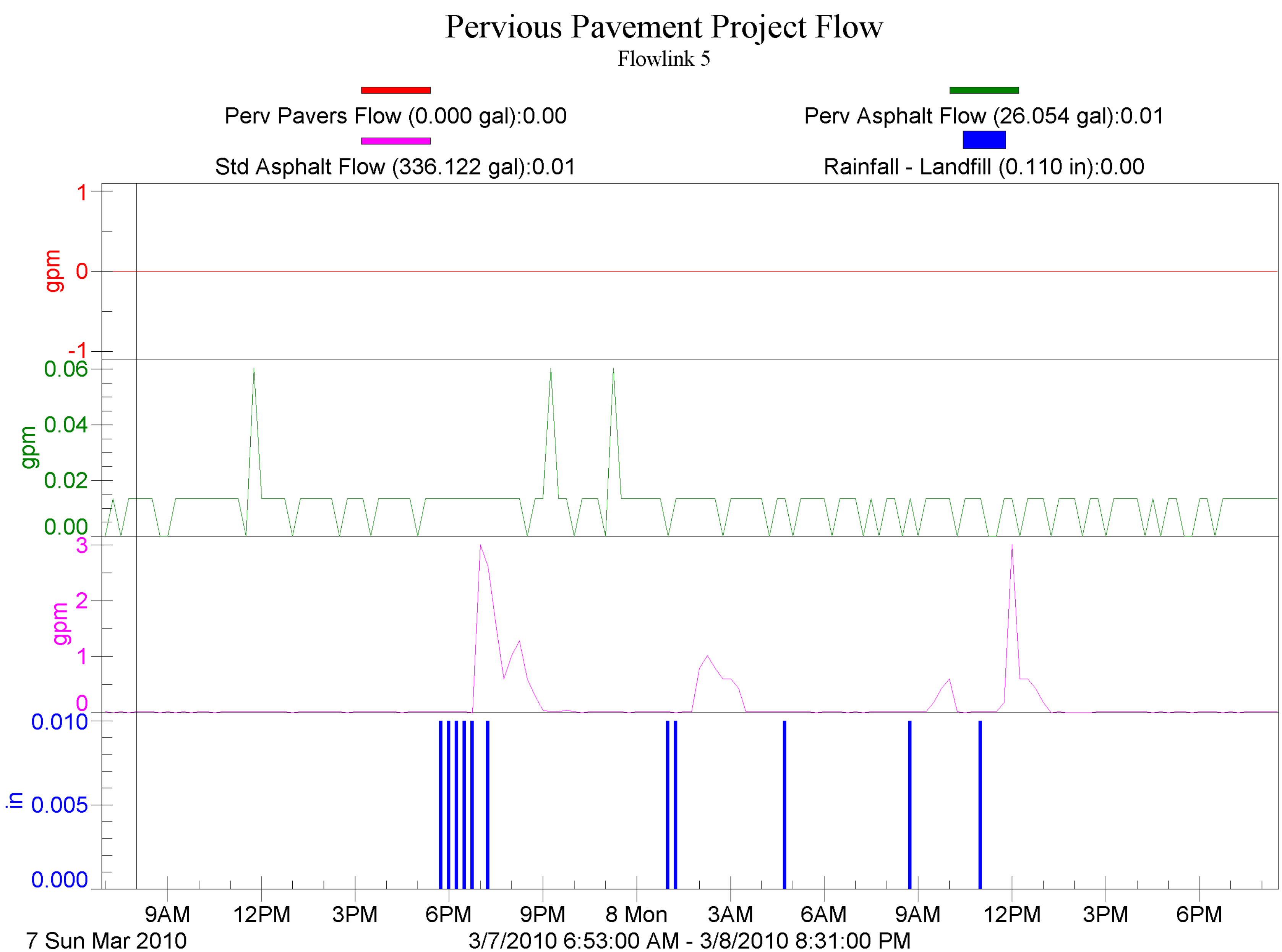
Storm #59

Pervious Pavement Project Flow

Flowlink 5



Storm #60

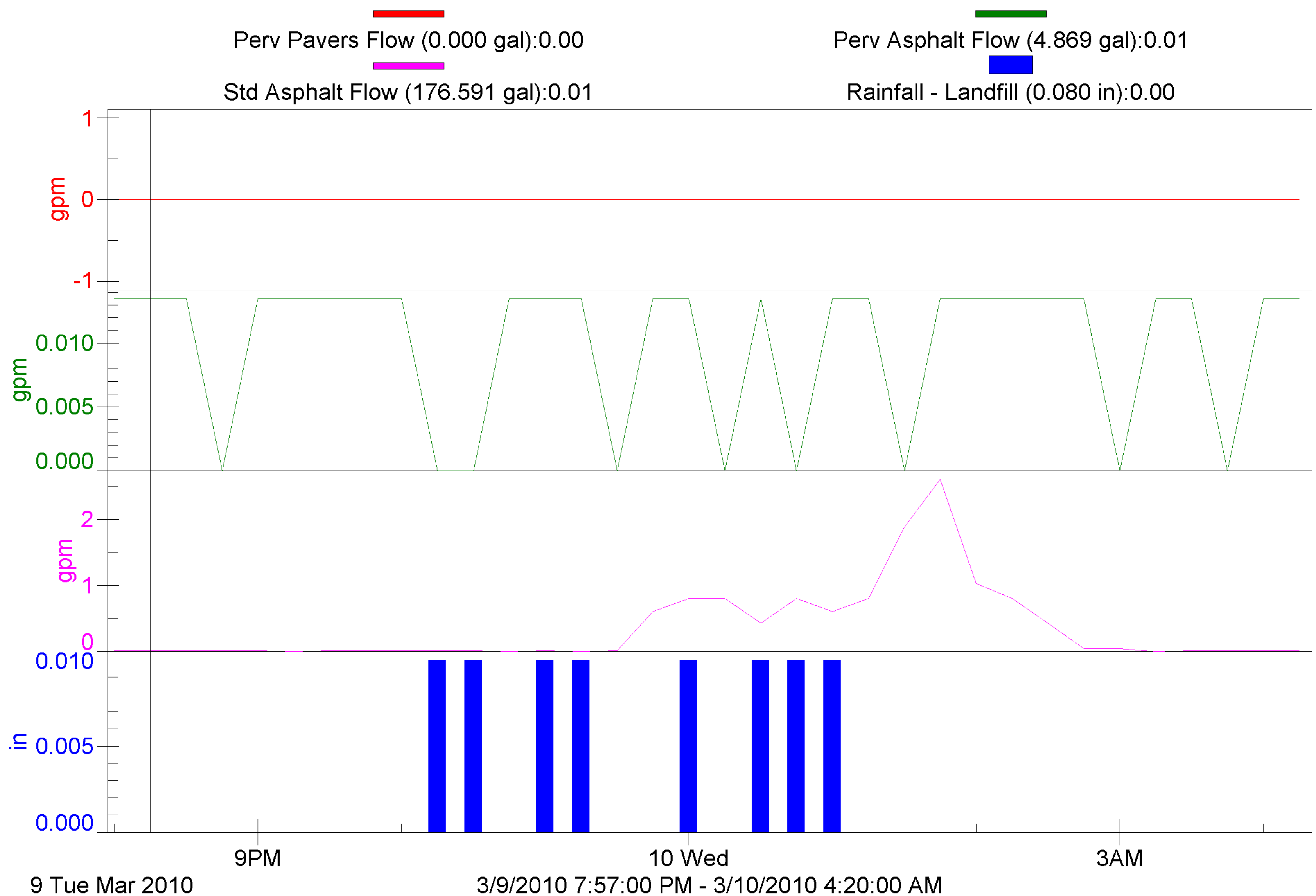


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (26.054 gal):0.01
Std Asphalt Flow (336.122 gal):0.01
Rainfall - Landfill (0.110 in):0.00
gpm
gpm
gpm
in
1
0
-1
0.06
0.04
0.02
0.00
3
2
1
0
0.010
0.005
0.000
9AM
12PM
3PM
6PM
9PM
8 Mon
3AM
6AM
9AM
12PM
3PM
6PM
7 Sun Mar 2010
3/7/2010 6:53:00 AM - 3/8/2010 8:31:00 PM

Storm #61

Pervious Pavement Project Flow

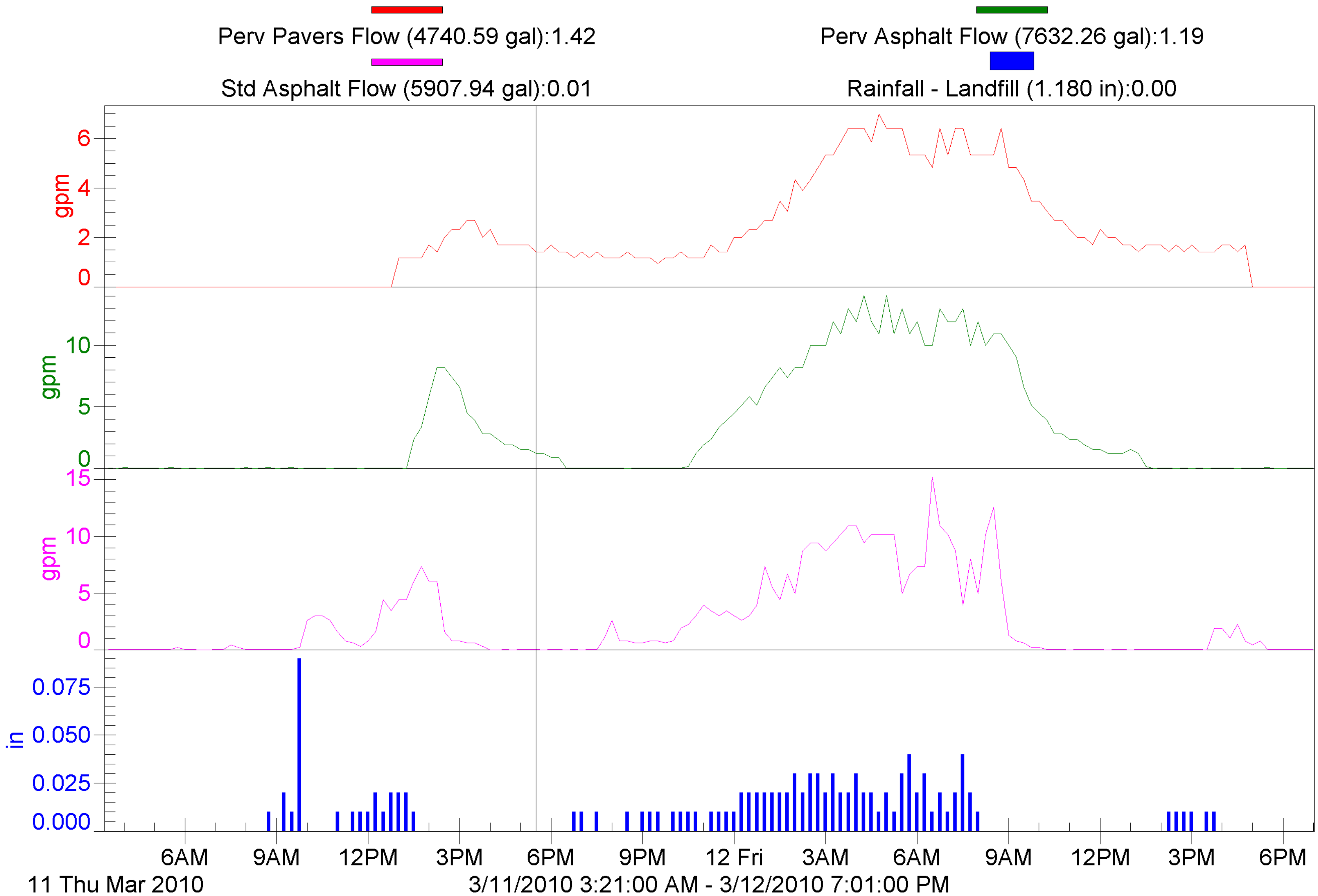
Flowlink 5



Storm #62

Pervious Pavement Project Flow

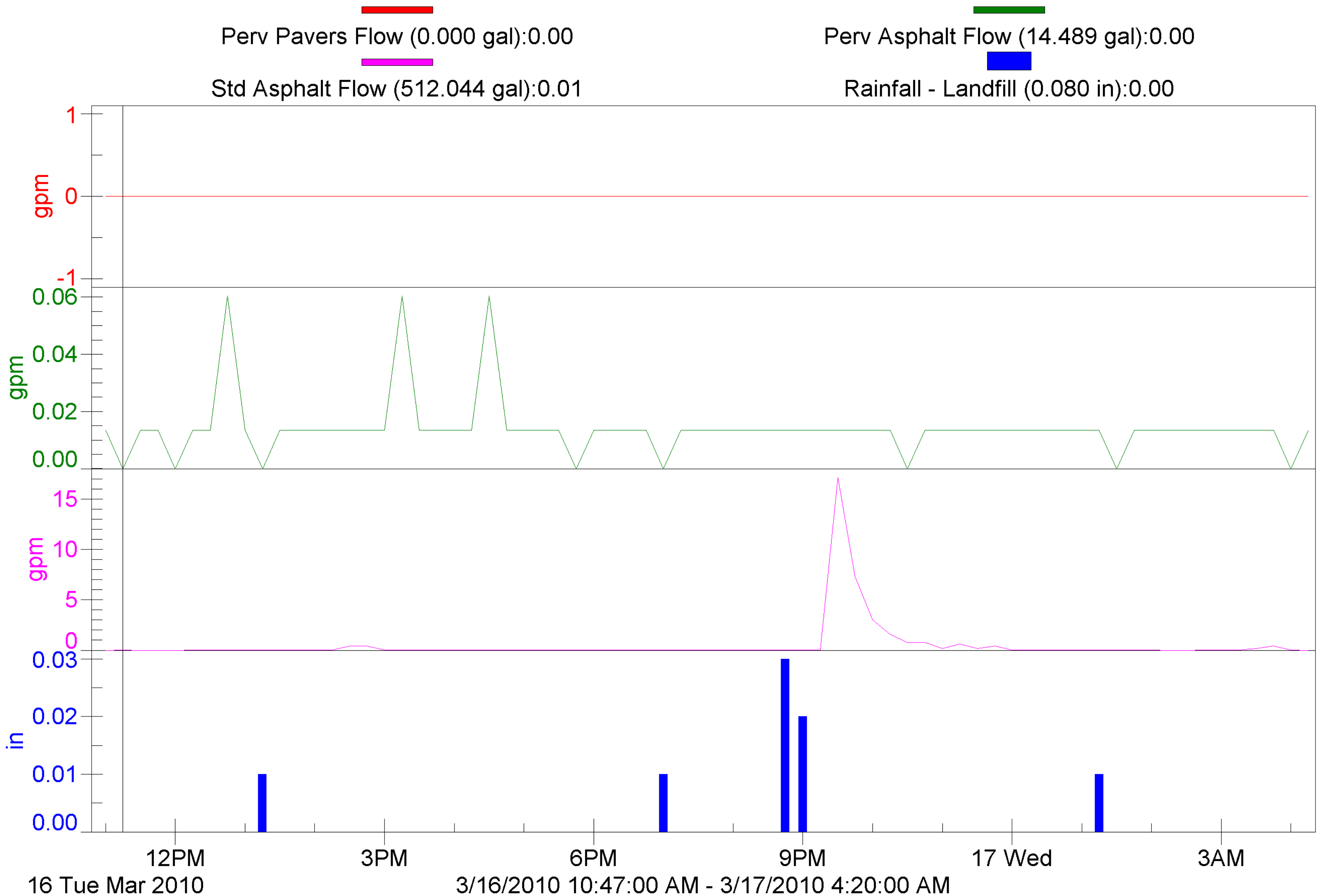
Flowlink 5



Storm #63

Pervious Pavement Project Flow

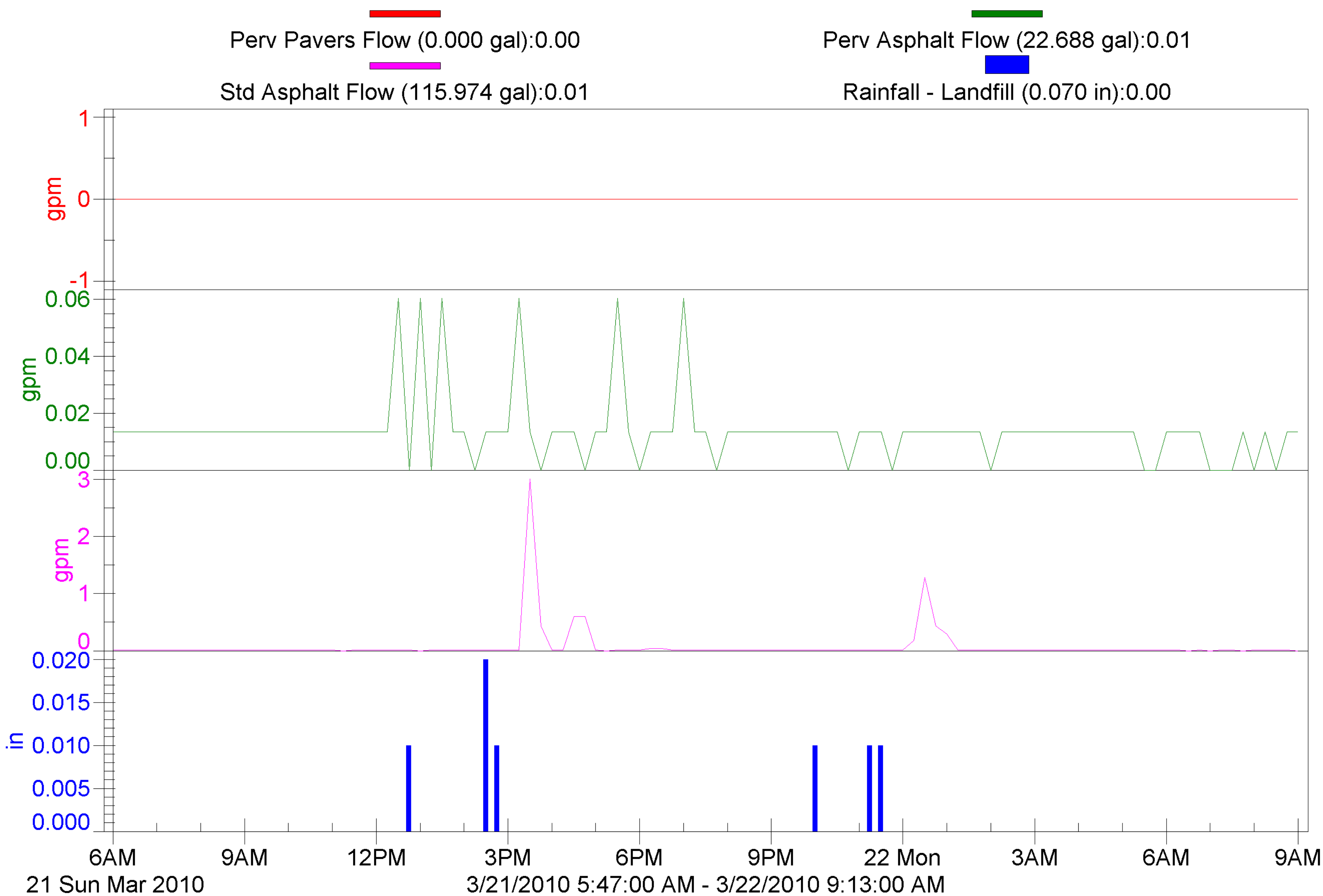
Flowlink 5



Storm #64

Pervious Pavement Project Flow

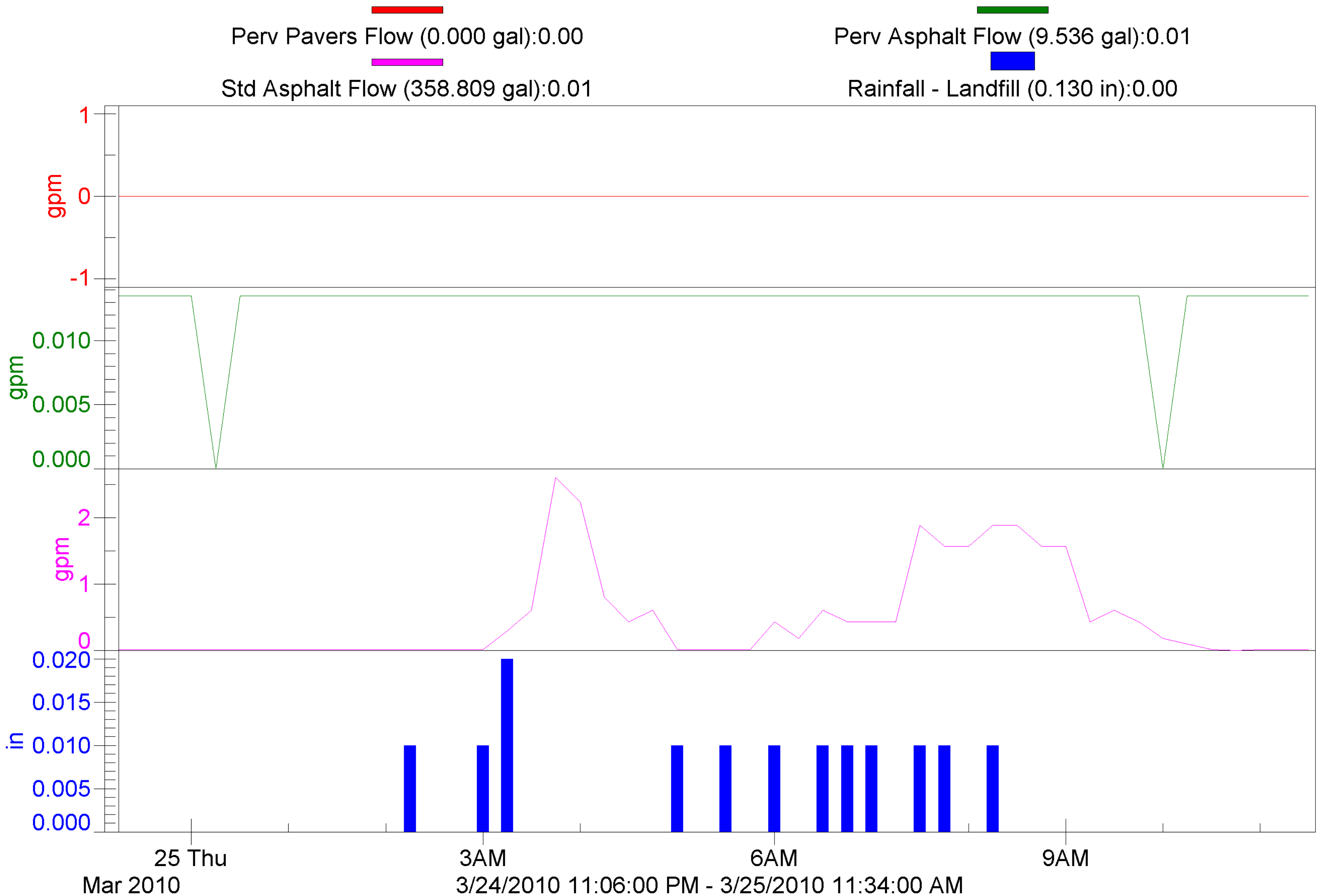
Flowlink 5



Storm #65

Pervious Pavement Project Flow

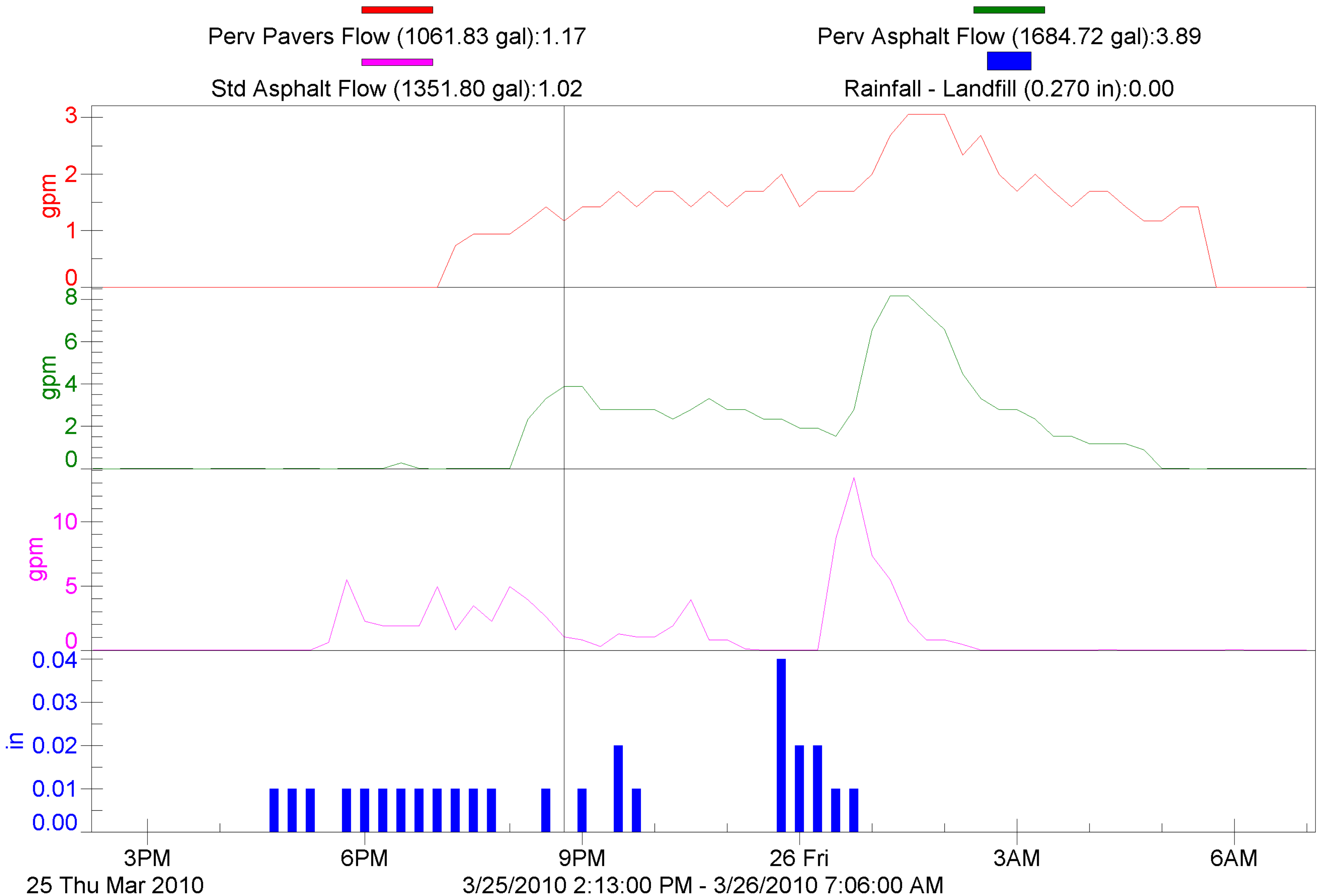
Flowlink 5



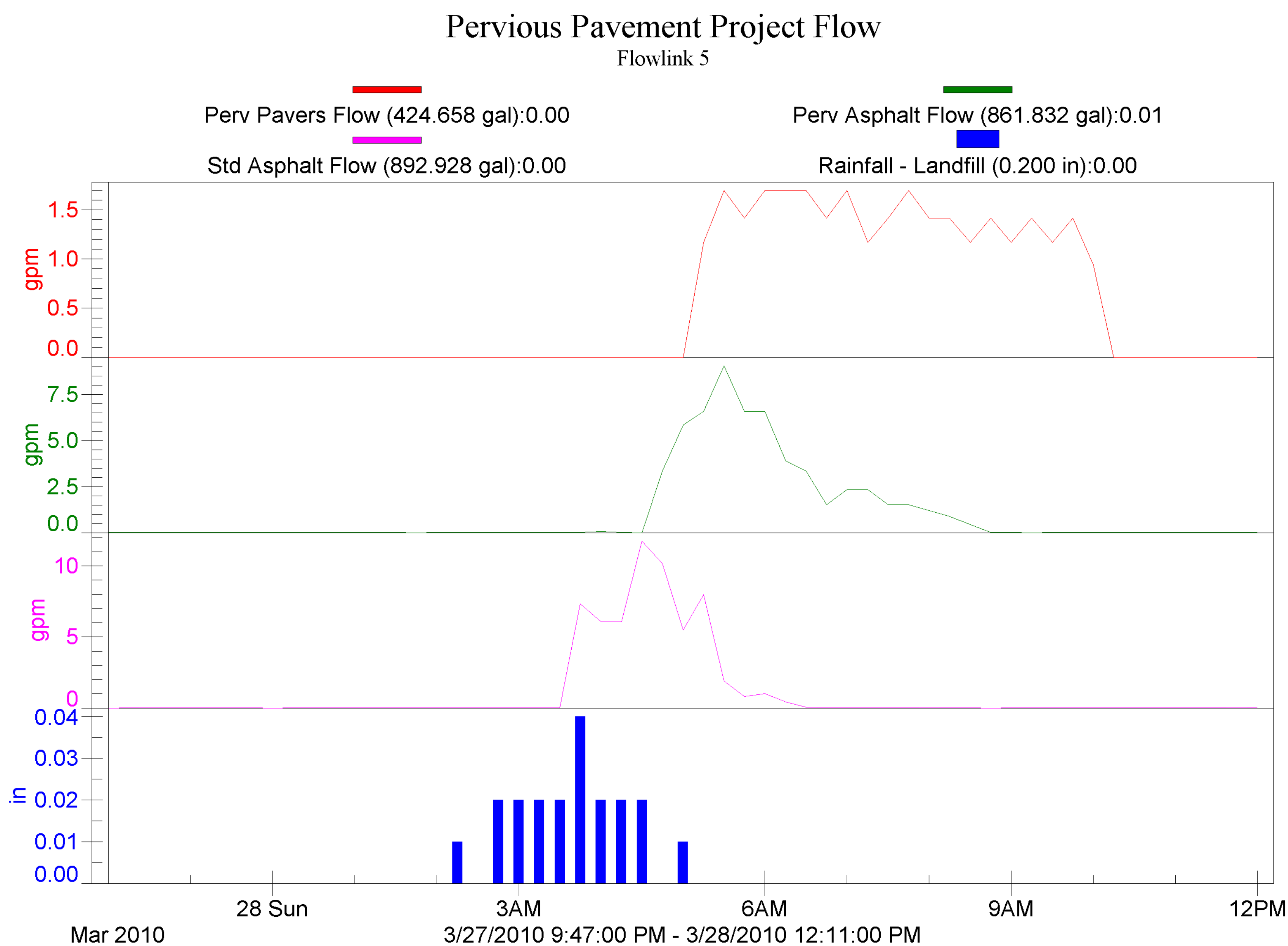
Storm #66

Pervious Pavement Project Flow

Flowlink 5



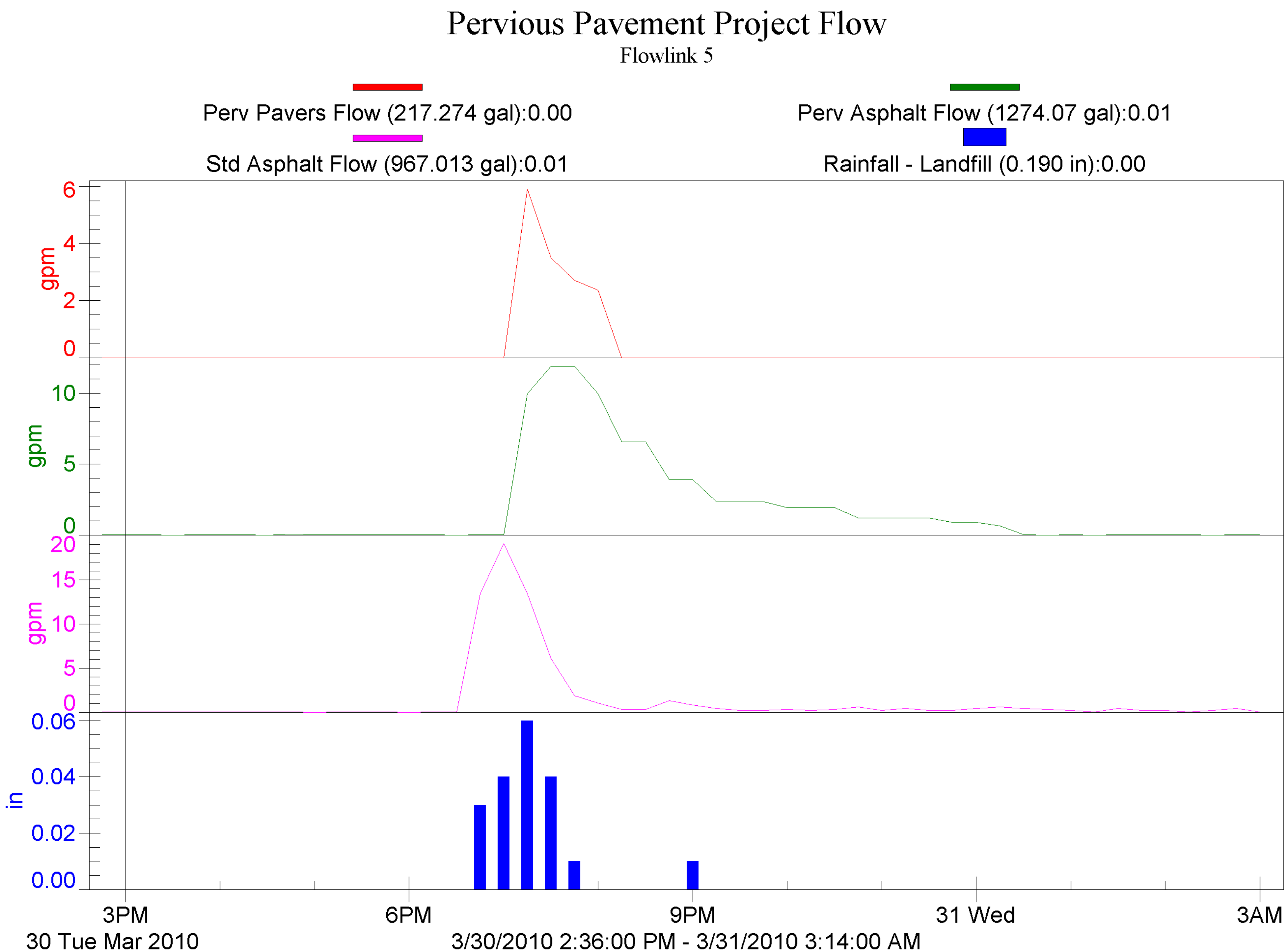
Storm #67


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (424.658 gal):0.00
Perv Asphalt Flow (861.832 gal):0.01
Std Asphalt Flow (892.928 gal):0.00
Rainfall - Landfill (0.200 in):0.00
gpm
1.5
1.0
0.5
0.0
gpm
7.5
5.0
2.5
0.0
gpm
10
5
0
in
0.04
0.03
0.02
0.01
0.00
28 Sun
3AM
6AM
9AM
12PM
Mar 2010
3/27/2010 9:47:00 PM - 3/28/2010 12:11:00 PM

Storm #68

Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (2877.11 gal):0.00
Perv Asphalt Flow (13674.1 gal):0.01
Std Asphalt Flow (9814.26 gal):0.01
Rainfall - Landfill (1.690 in):0.00
gpm
gpm
gpm
in
12PM 3PM 6PM 9PM 29 Mon 3AM 6AM 9AM 12PM 3PM 6PM 9PM 30 Tue 3AM 6AM 9AM 12PM
28 Sun Mar 2010
3/28/2010 10:06:00 AM - 3/30/2010 1:04:00 PM

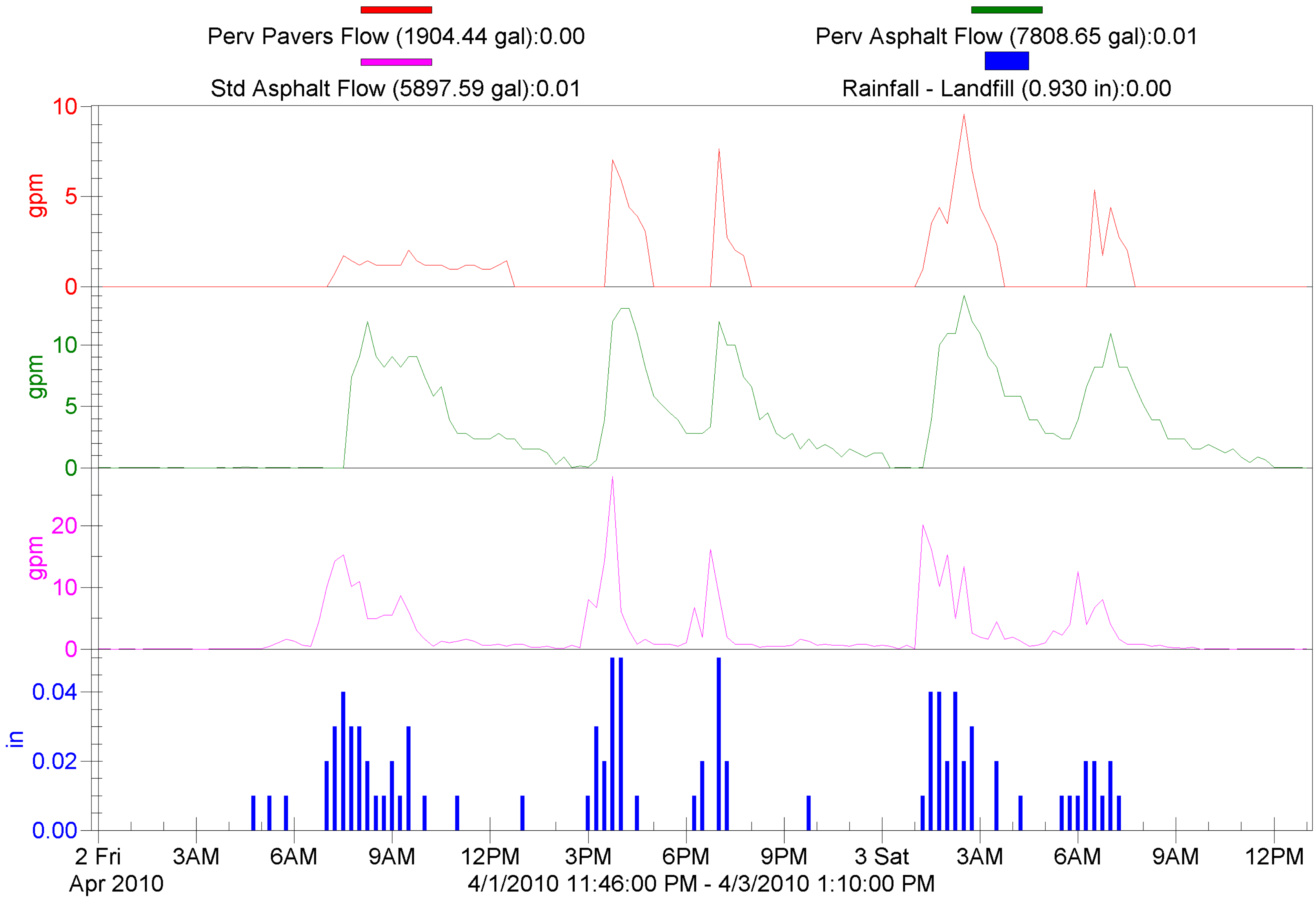
Storm #69


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (217.274 gal):0.00
Perv Asphalt Flow (1274.07 gal):0.01
Std Asphalt Flow (967.013 gal):0.01
Rainfall - Landfill (0.190 in):0.00
gpm
6
4
2
0
gpm
10
5
0
gpm
20
15
10
5
0
in
0.06
0.04
0.02
0.00
3PM
6PM
9PM
31 Wed
3AM
30 Tue Mar 2010
3/30/2010 2:36:00 PM - 3/31/2010 3:14:00 AM

Storm #70

Pervious Pavement Project Flow

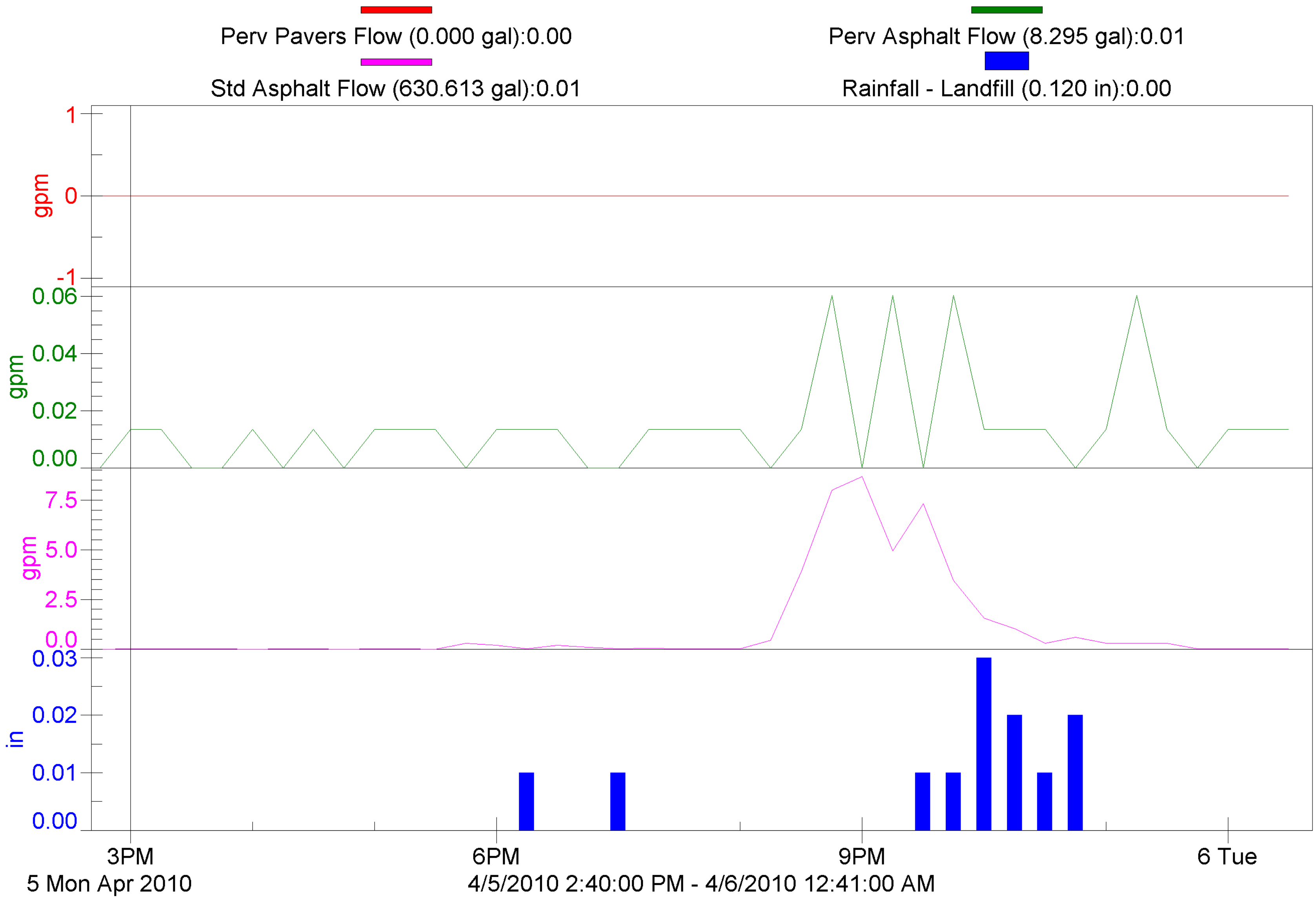
Flowlink 5



Storm #71

Pervious Pavement Project Flow

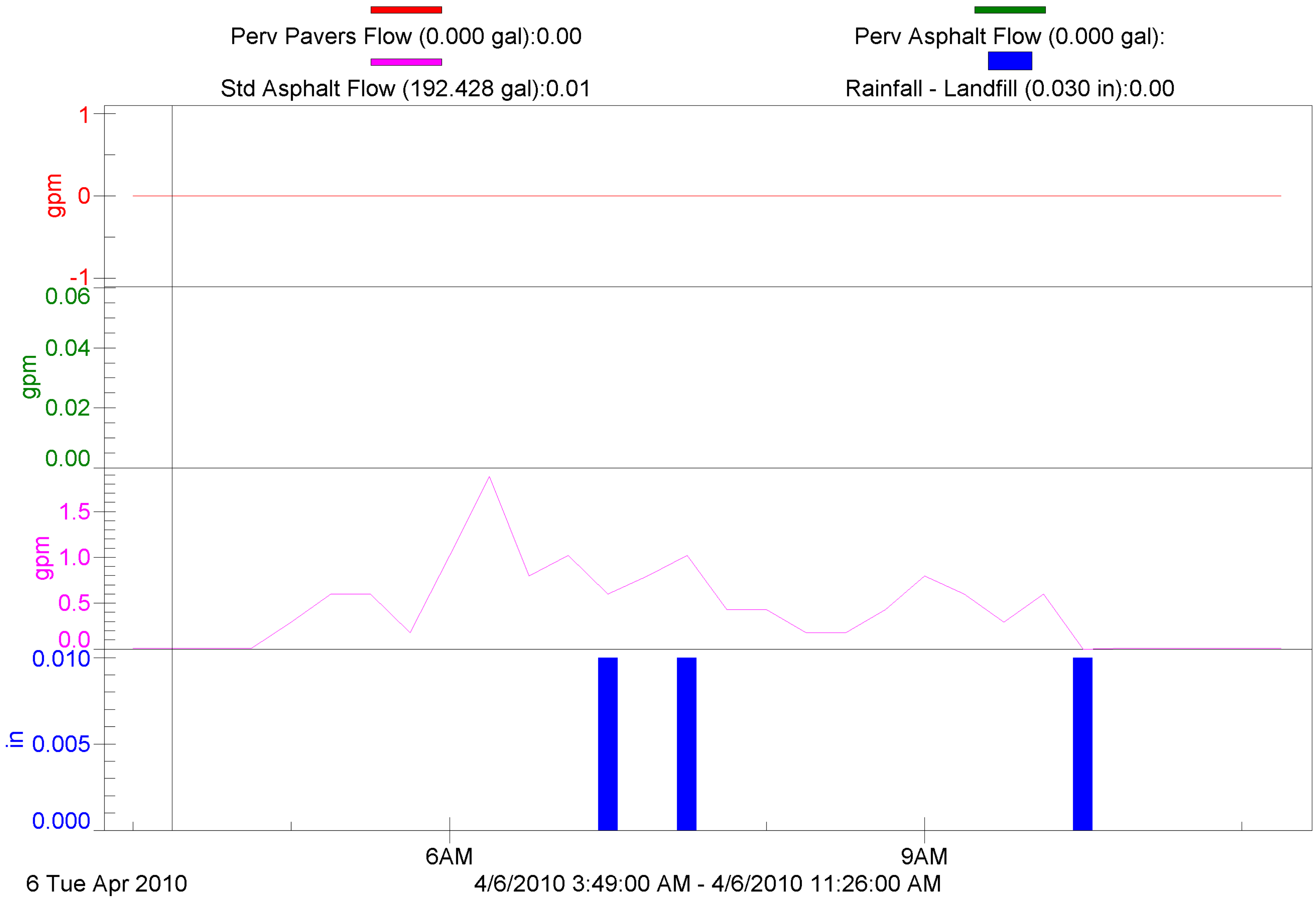
Flowlink 5



Storm #72

Pervious Pavement Project Flow

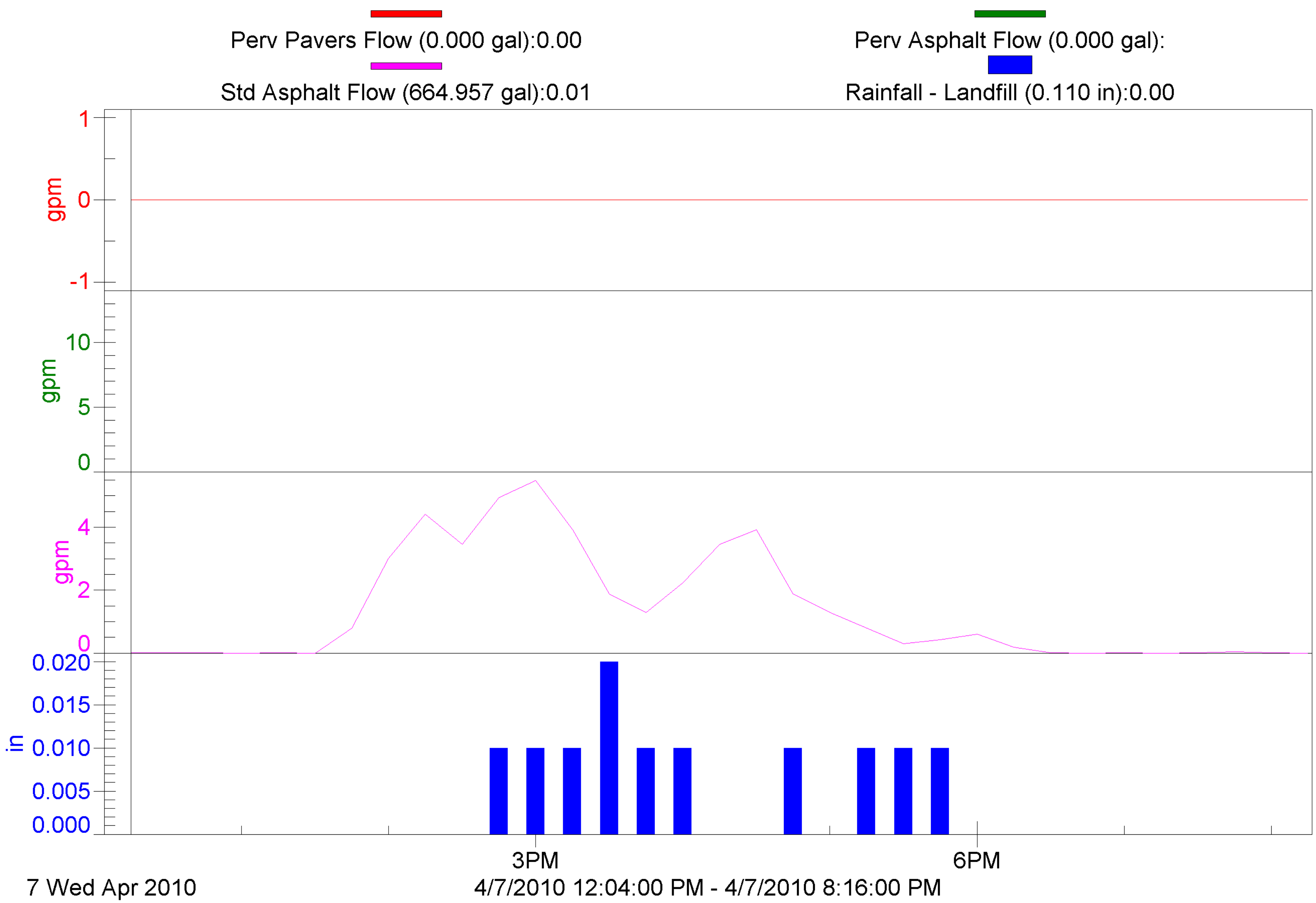
Flowlink 5



Storm #73

Pervious Pavement Project Flow

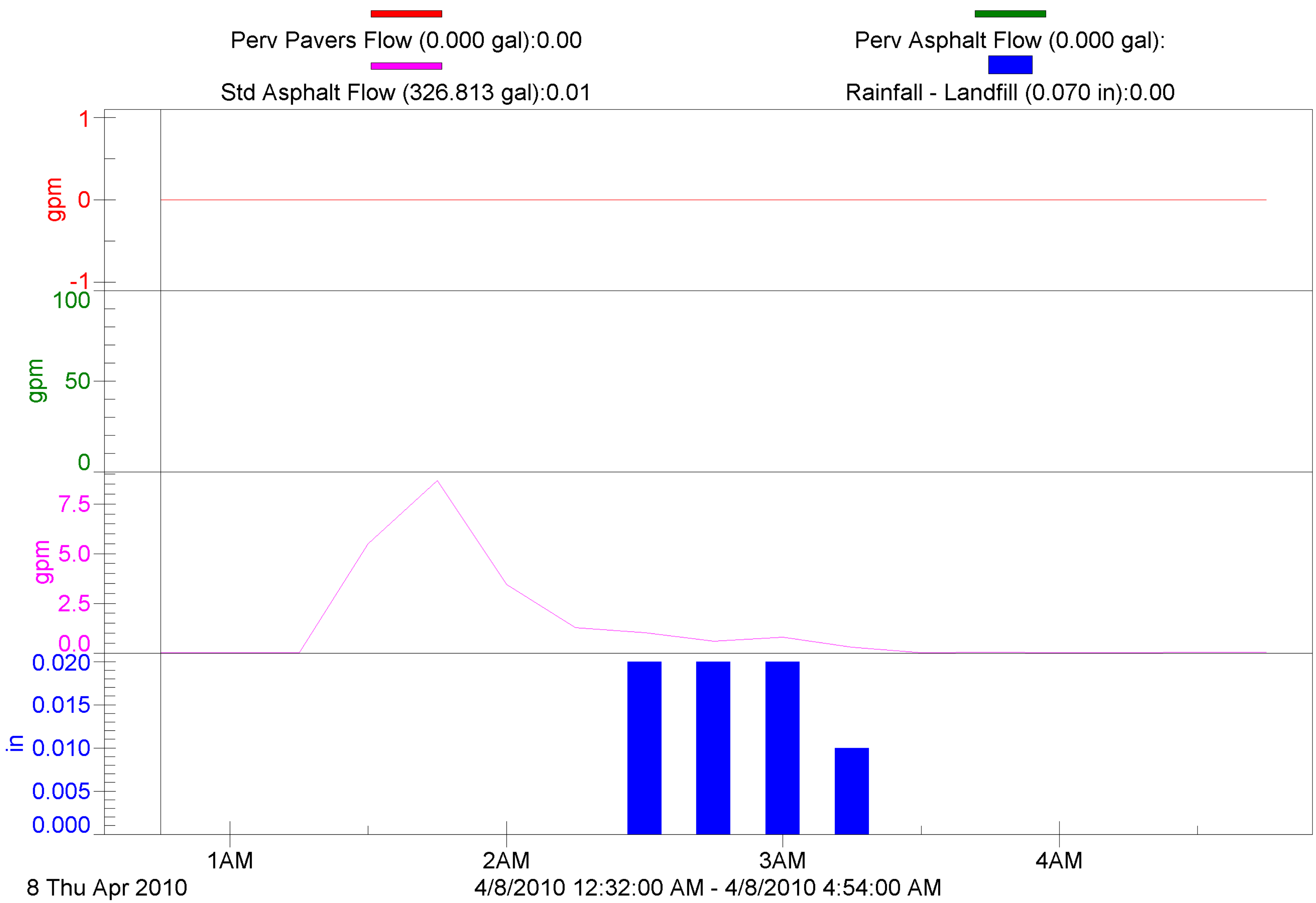
Flowlink 5



Storm #74

Pervious Pavement Project Flow

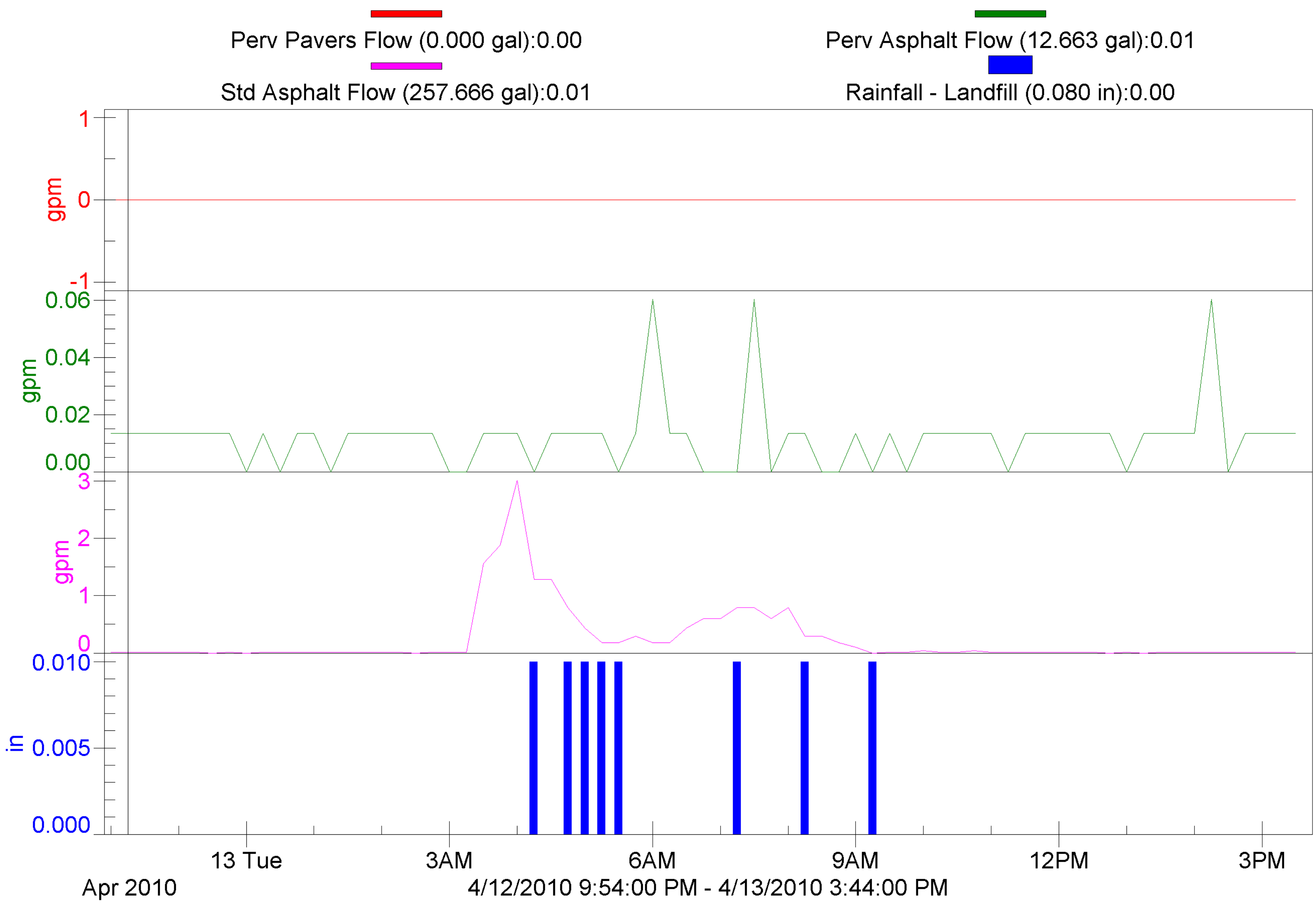
Flowlink 5

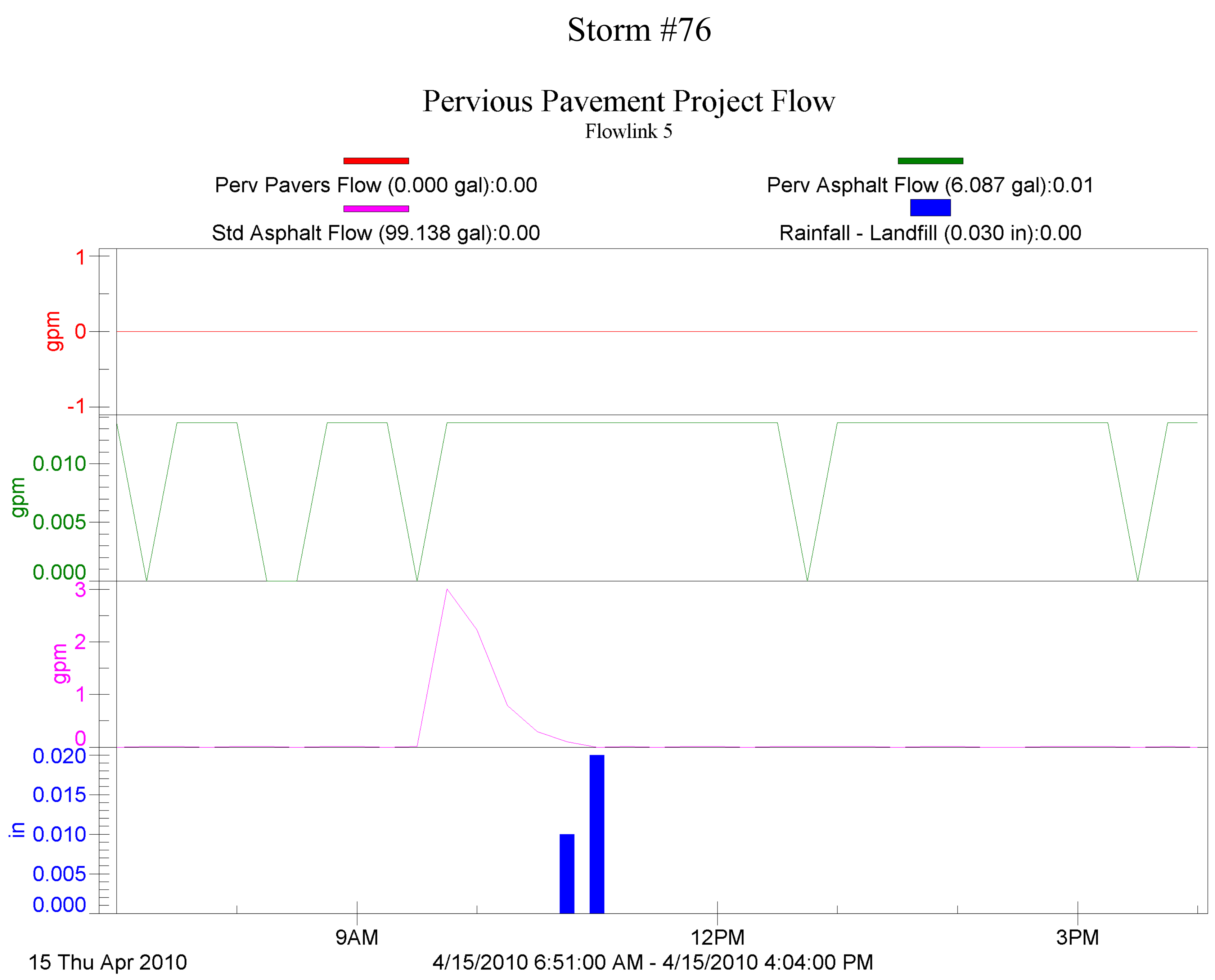


Storm #75

Pervious Pavement Project Flow

Flowlink 5



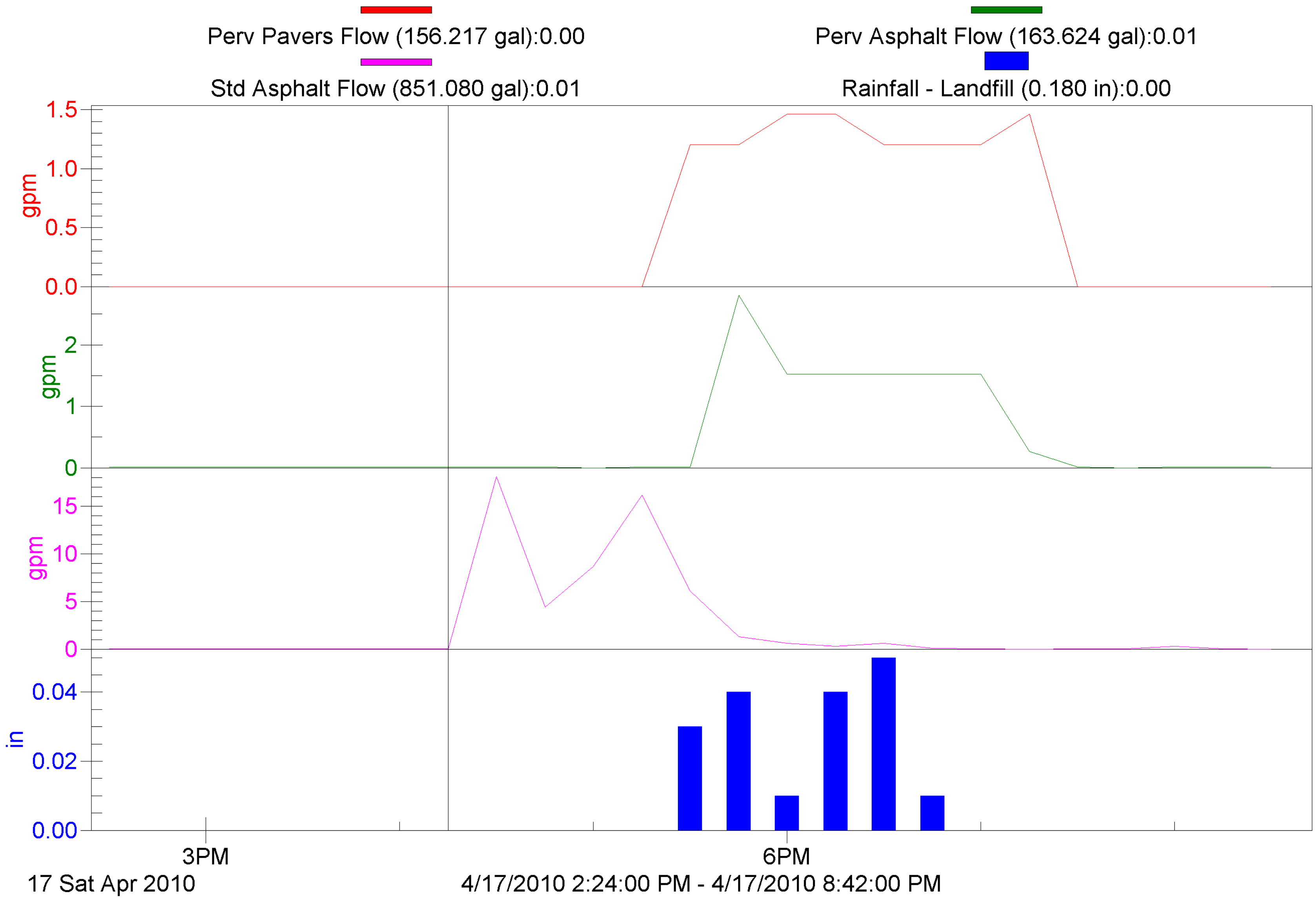


Storm #76
Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (6.087 gal):0.01
Std Asphalt Flow (99.138 gal):0.00
Rainfall - Landfill (0.030 in):0.00
gpm
1
0
-1
gpm
0.010
0.005
0.000
gpm
3
2
1
0
in
0.020
0.015
0.010
0.005
0.000
9AM
12PM
3PM
15 Thu Apr 2010
4/15/2010 6:51:00 AM - 4/15/2010 4:04:00 PM

Storm #77

Pervious Pavement Project Flow

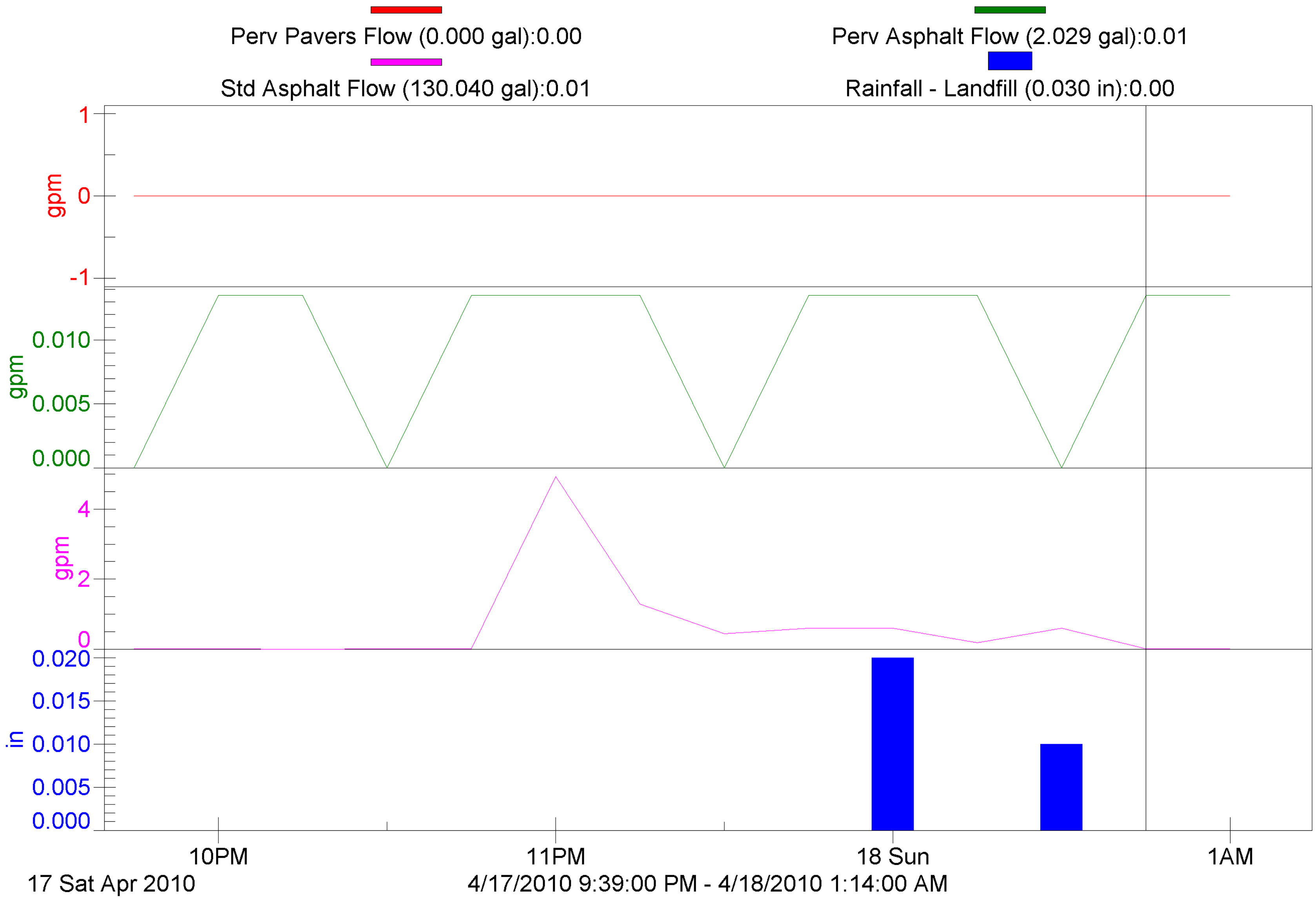
Flowlink 5



Storm #78

Pervious Pavement Project Flow

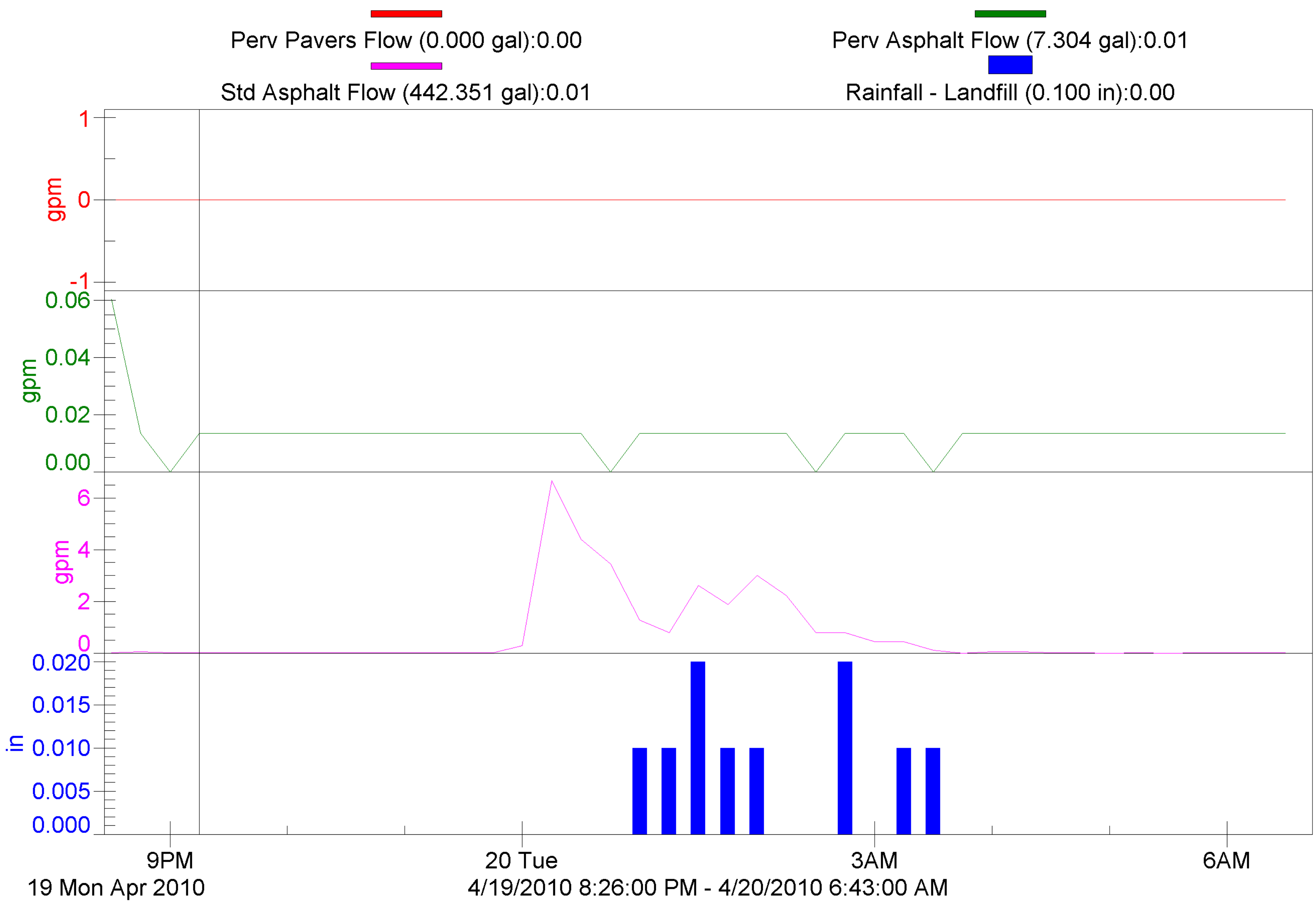
Flowlink 5



Storm #79

Pervious Pavement Project Flow

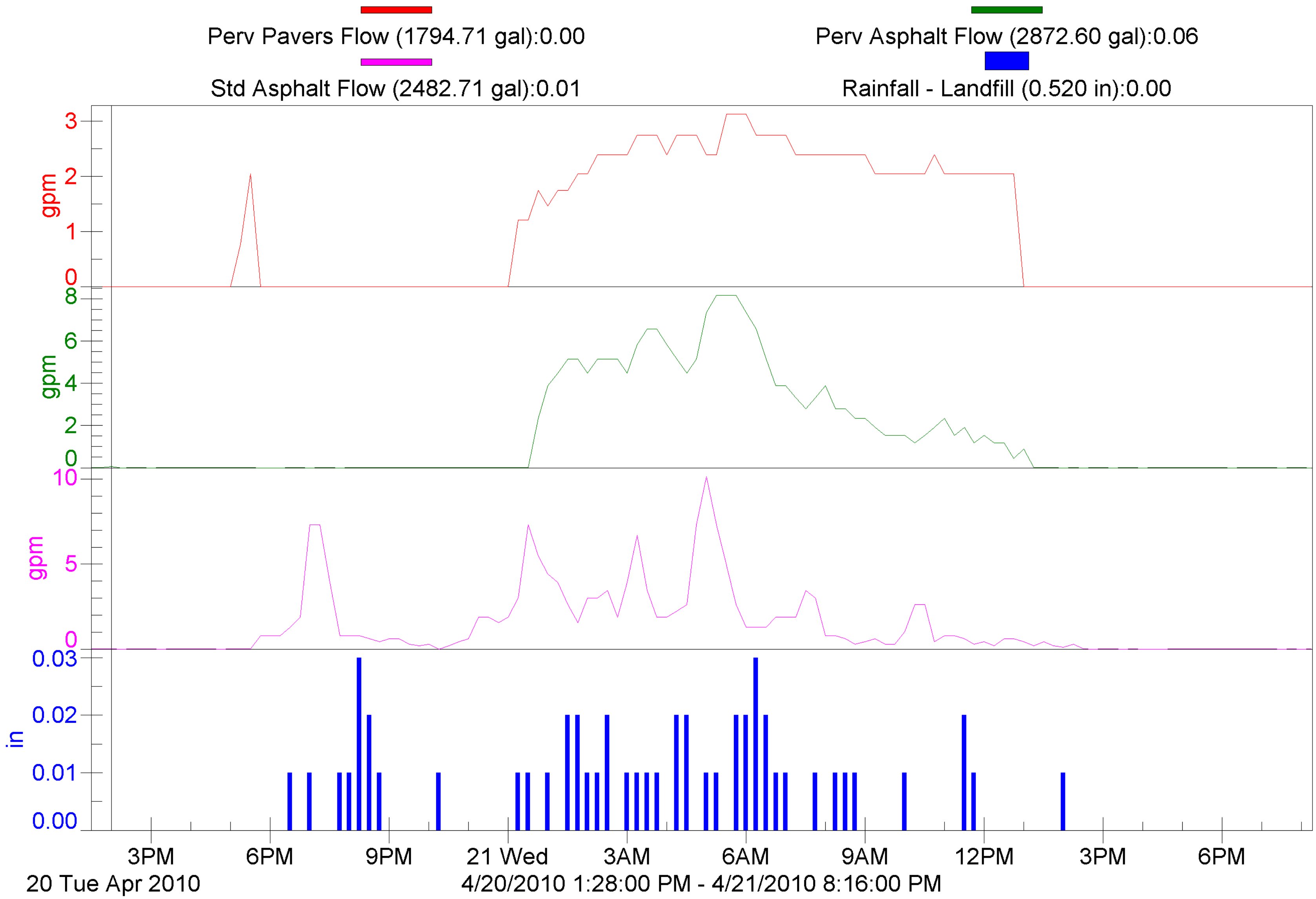
Flowlink 5



Storm #80

Pervious Pavement Project Flow

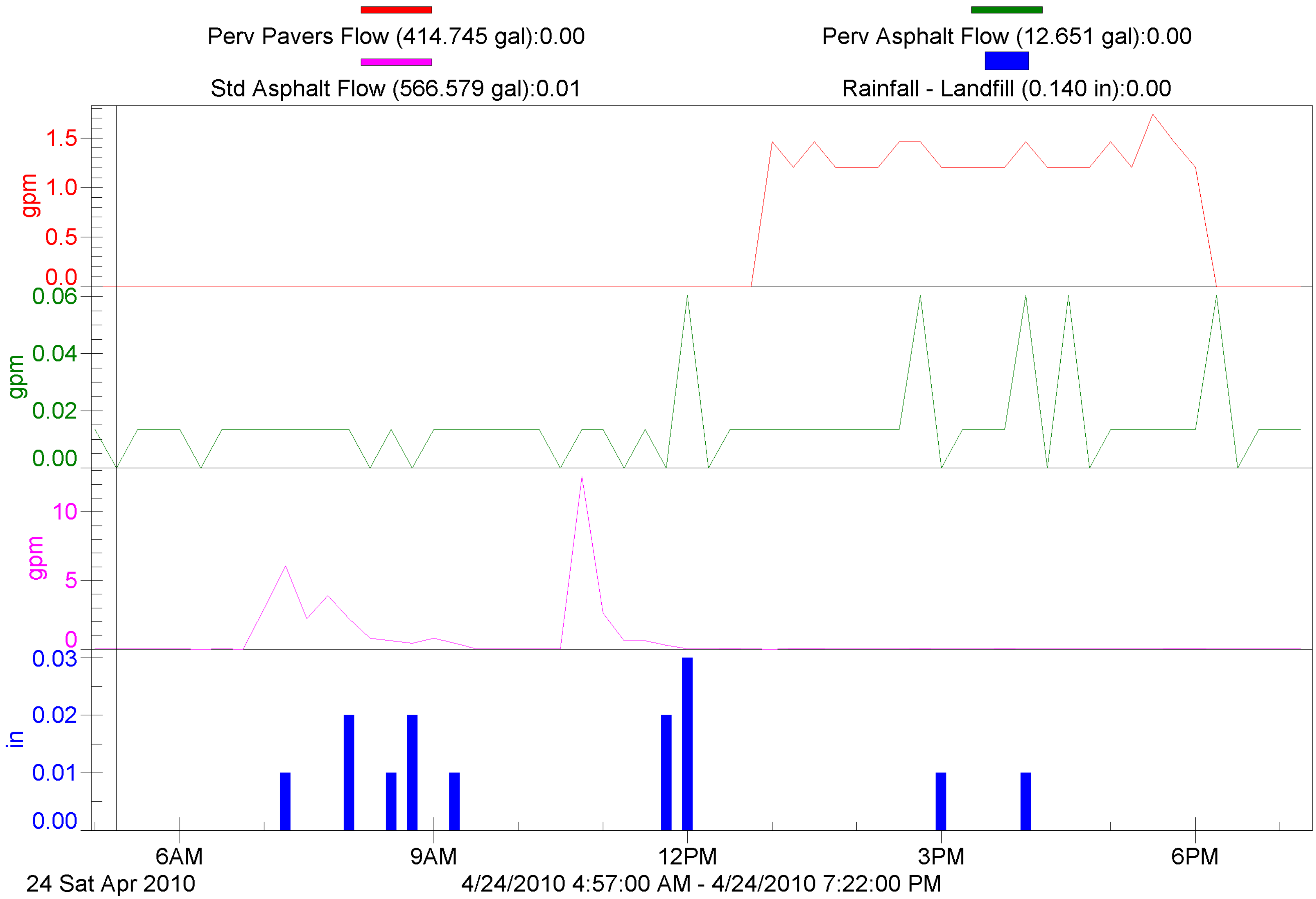
Flowlink 5



Storm #81

Pervious Pavement Project Flow

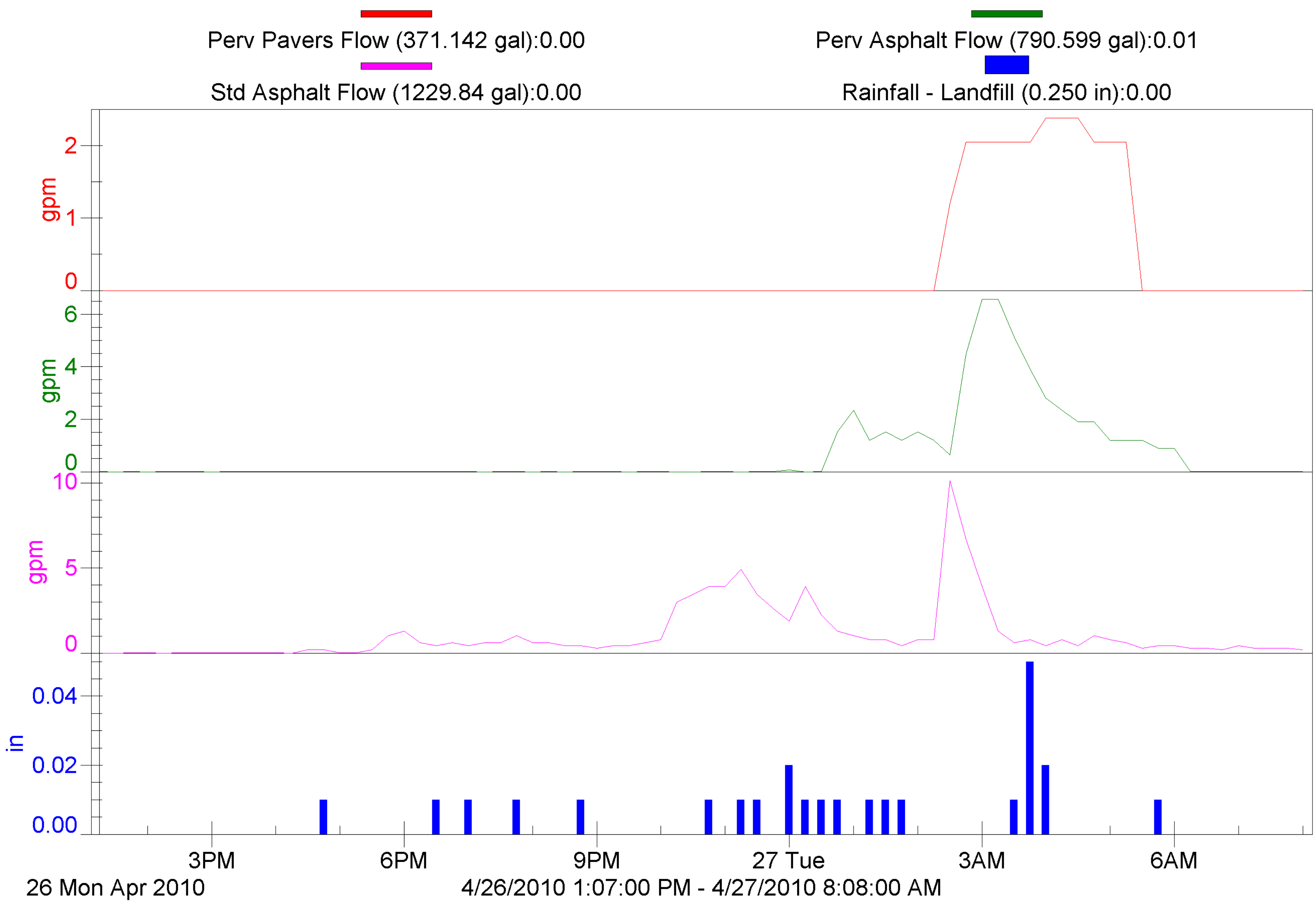
Flowlink 5



Storm #82

Pervious Pavement Project Flow

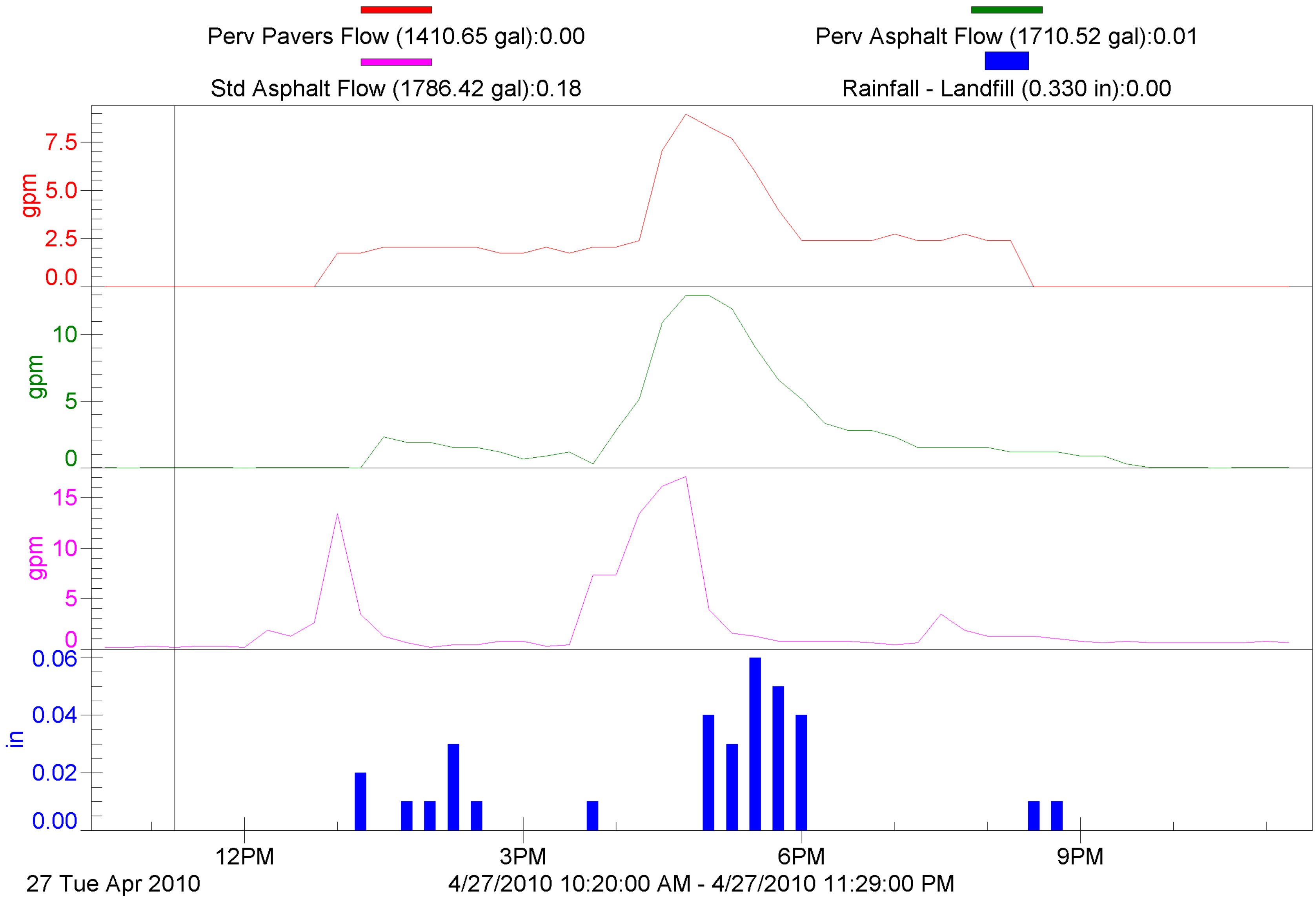
Flowlink 5



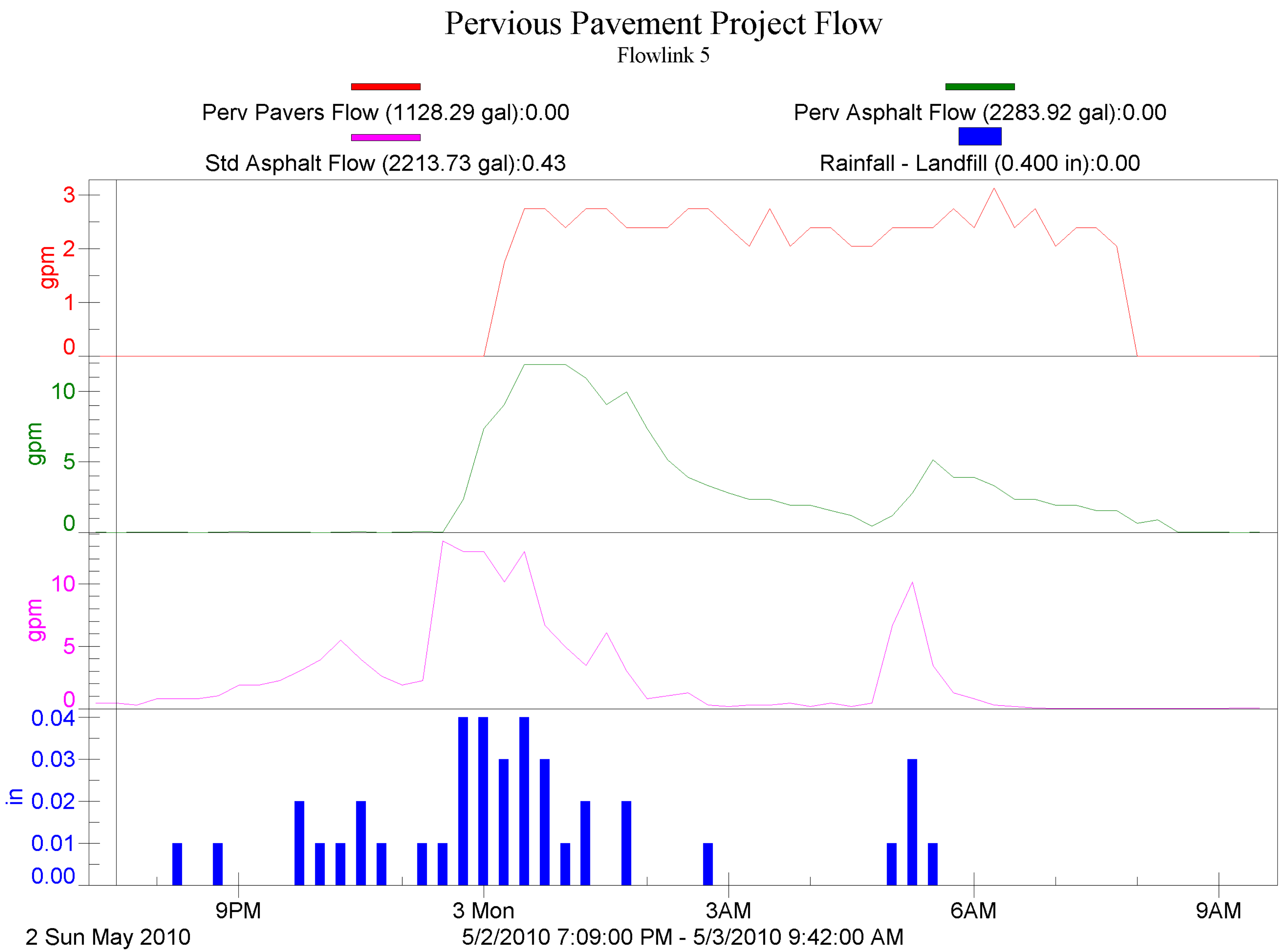
Storm #83

Pervious Pavement Project Flow

Flowlink 5

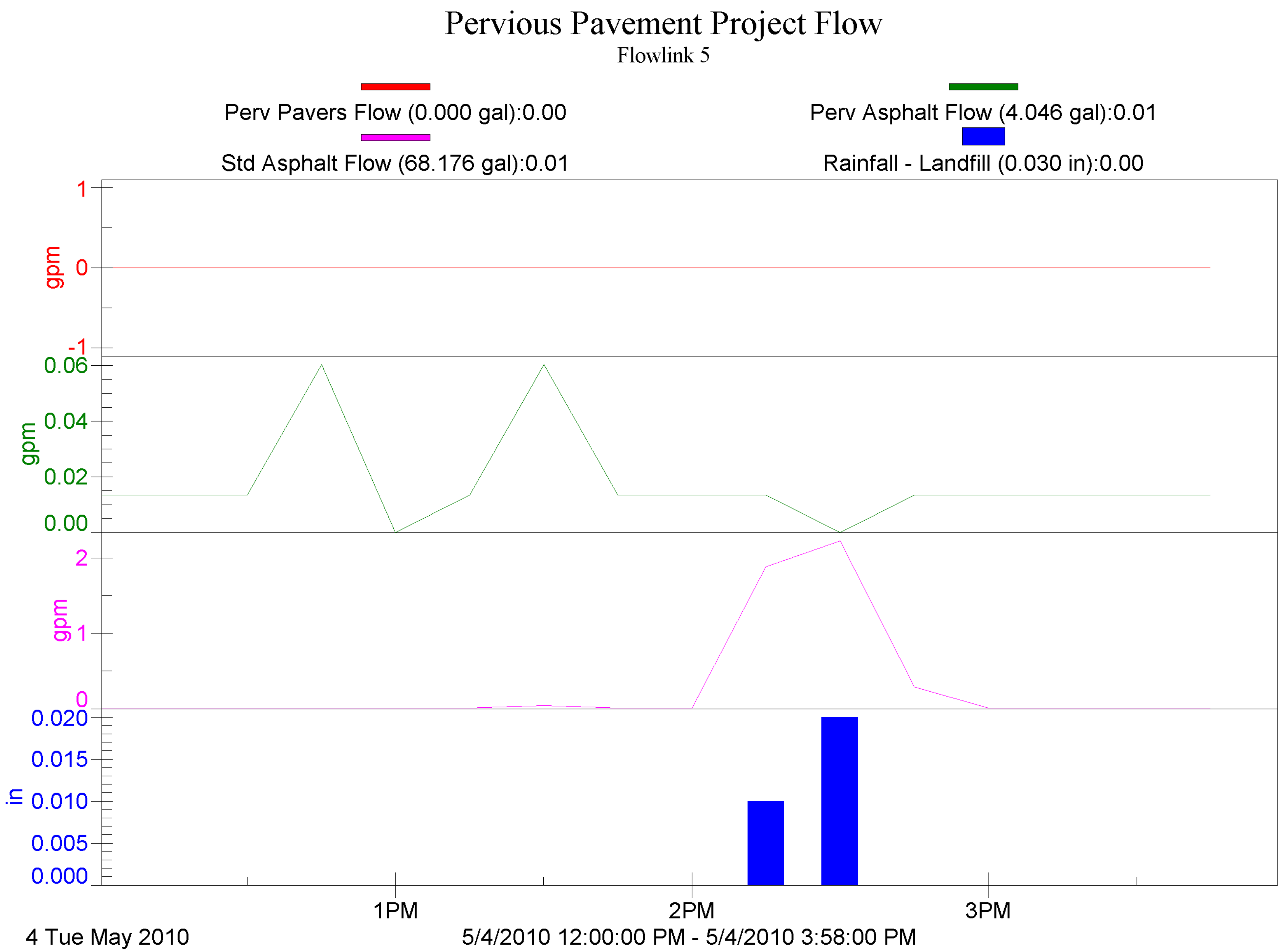


Storm #84



Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (1128.29 gal):0.00
Perv Asphalt Flow (2283.92 gal):0.00
Std Asphalt Flow (2213.73 gal):0.43
Rainfall - Landfill (0.400 in):0.00
gpm
3
2
1
0
gpm
10
5
0
gpm
10
5
0
in
0.04
0.03
0.02
0.01
0.00
9PM
3 Mon
3AM
6AM
9AM
2 Sun May 2010
5/2/2010 7:09:00 PM - 5/3/2010 9:42:00 AM

Storm #85

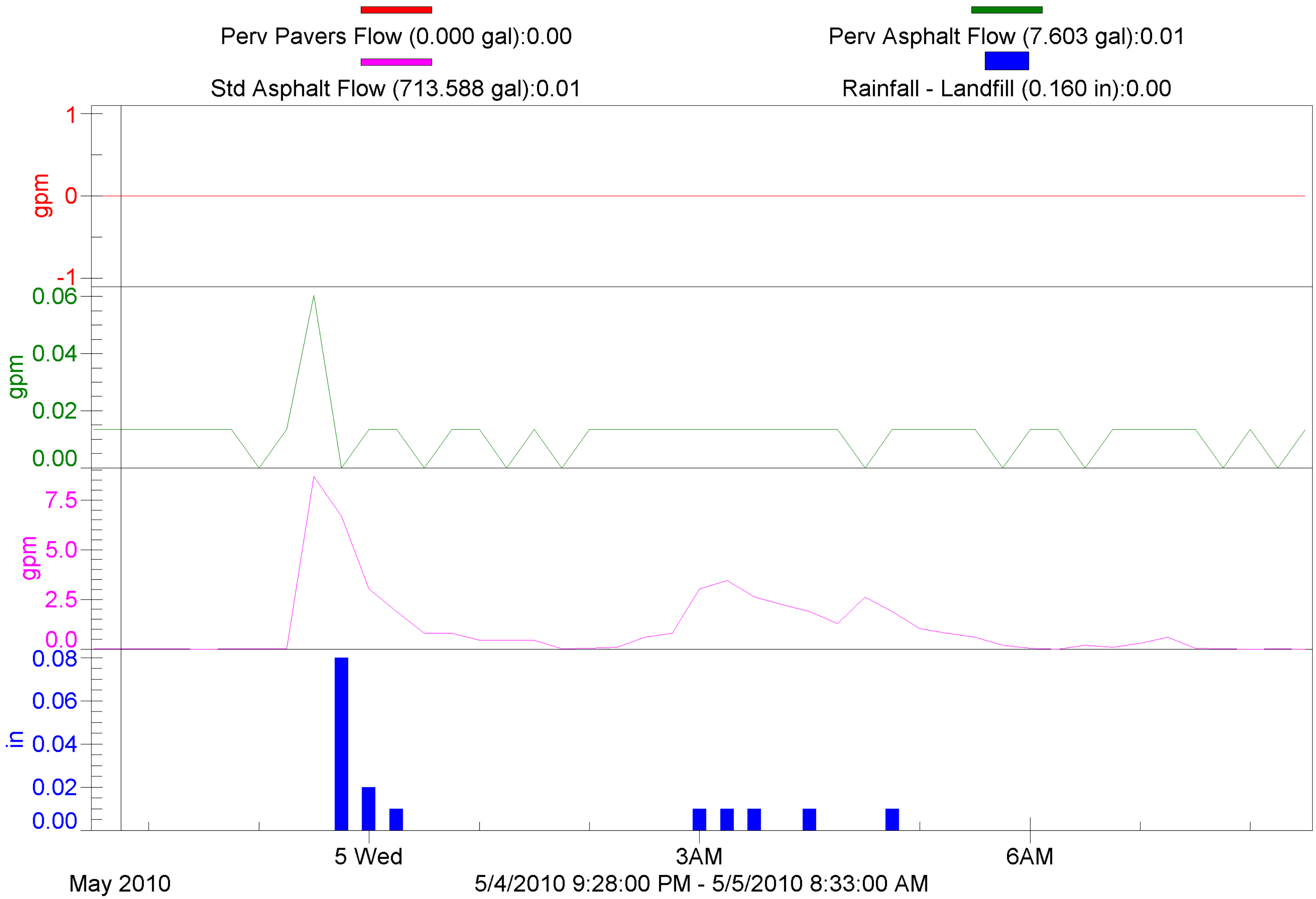


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (4.046 gal):0.01
Std Asphalt Flow (68.176 gal):0.01
Rainfall - Landfill (0.030 in):0.00
gpm
1
0
-1
gpm
0.06
0.04
0.02
0.00
gpm
2
1
0
in
0.020
0.015
0.010
0.005
0.000
1PM
2PM
3PM
4 Tue May 2010
5/4/2010 12:00:00 PM - 5/4/2010 3:58:00 PM

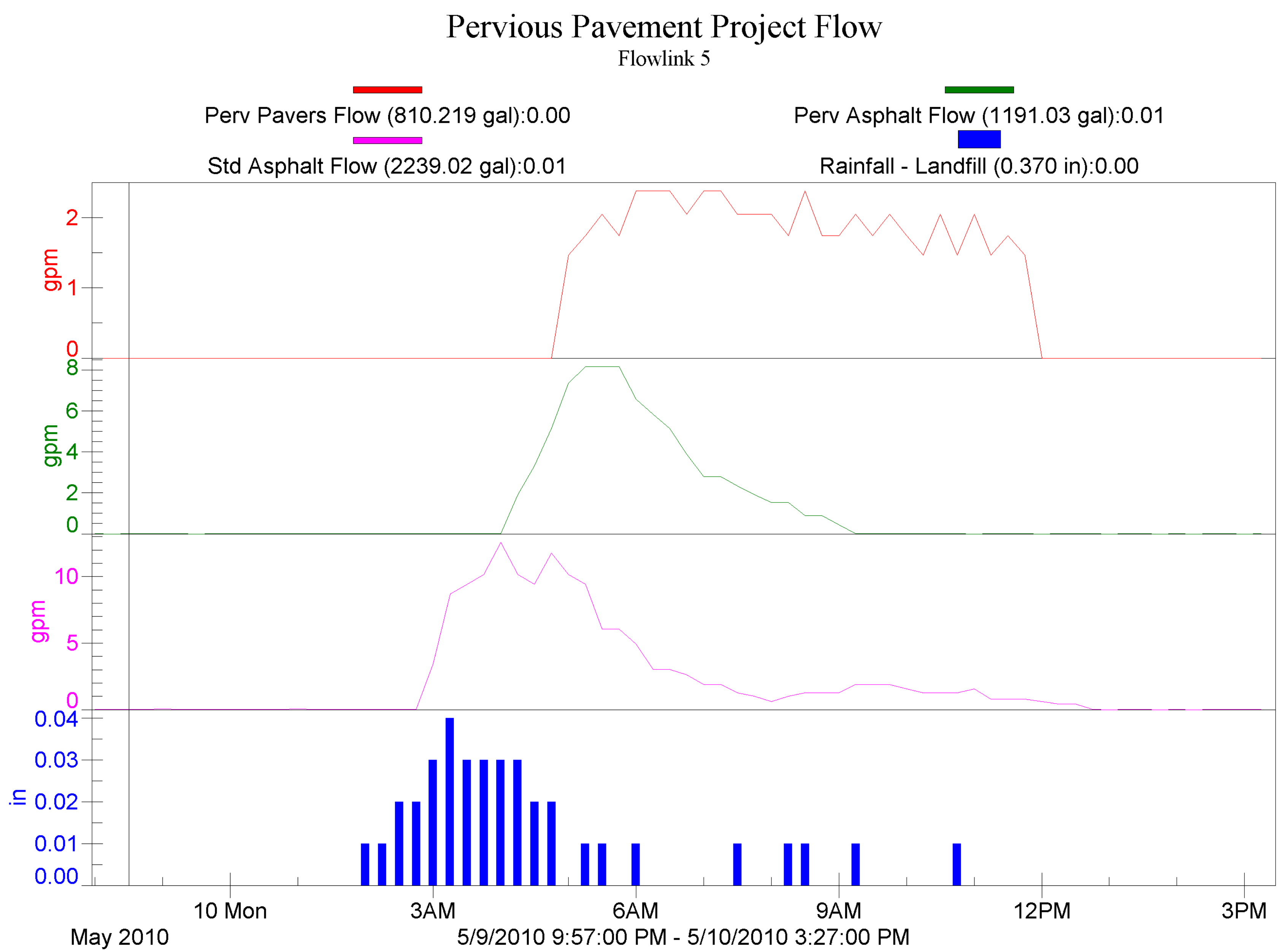
Storm #86

Pervious Pavement Project Flow

Flowlink 5



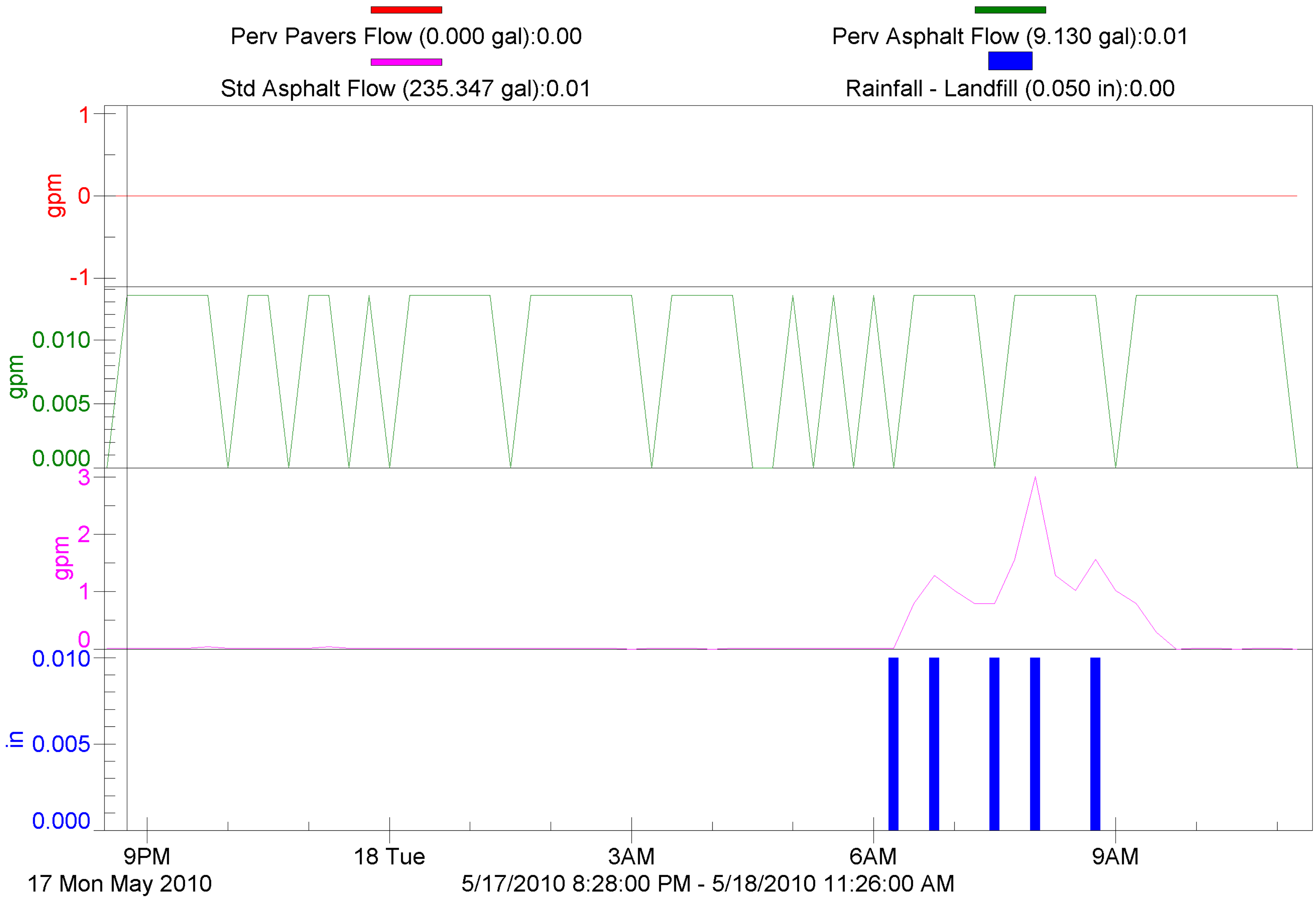
Storm #87


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (810.219 gal):0.00
Perv Asphalt Flow (1191.03 gal):0.01
Std Asphalt Flow (2239.02 gal):0.01
Rainfall - Landfill (0.370 in):0.00
gpm
2
1
0
gpm
8
6
4
2
0
gpm
10
5
0
in
0.04
0.03
0.02
0.01
0.00
10 Mon
3AM
6AM
9AM
12PM
3PM
May 2010
5/9/2010 9:57:00 PM - 5/10/2010 3:27:00 PM

Storm #88

Pervious Pavement Project Flow

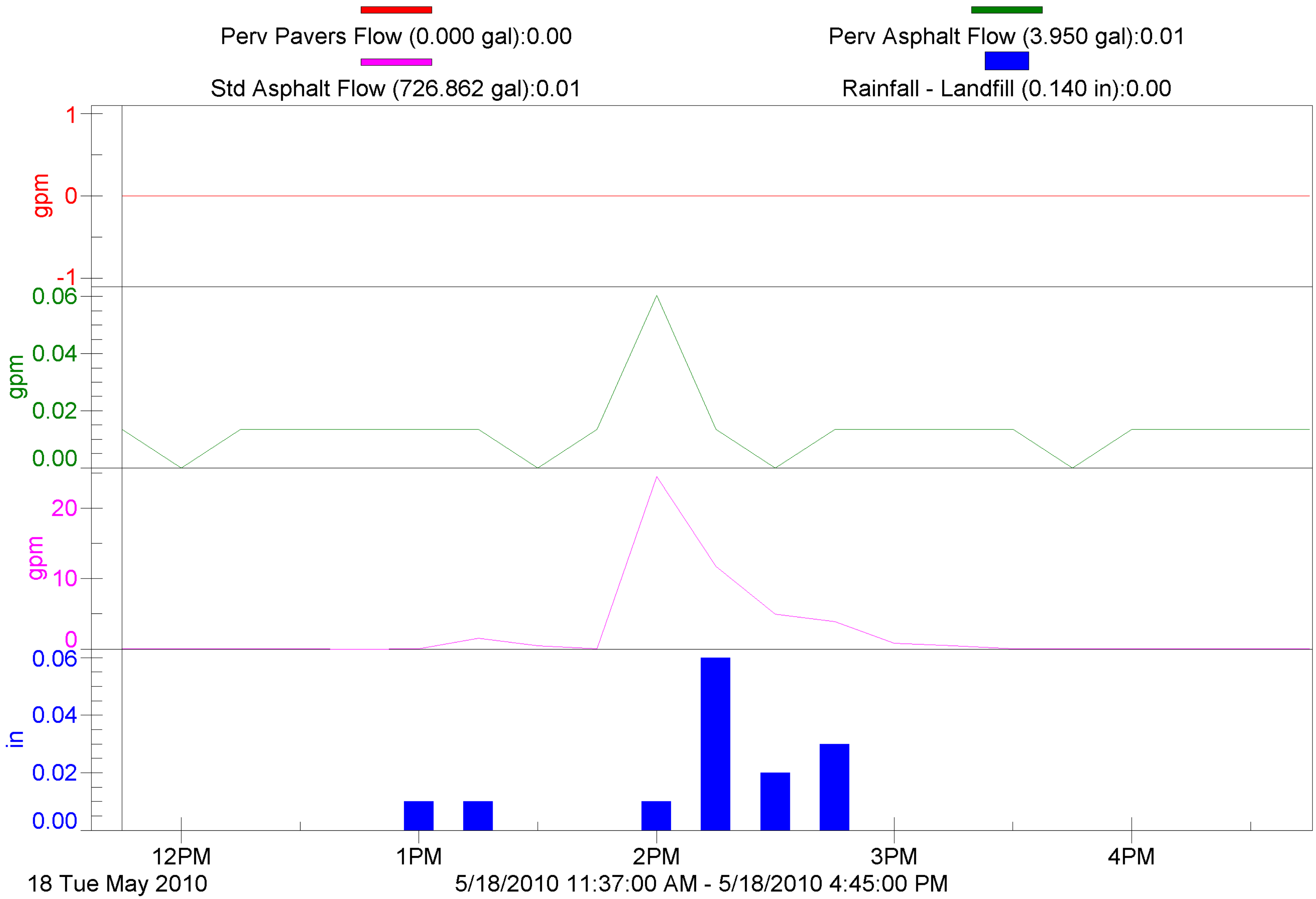
Flowlink 5



Storm #89

Pervious Pavement Project Flow

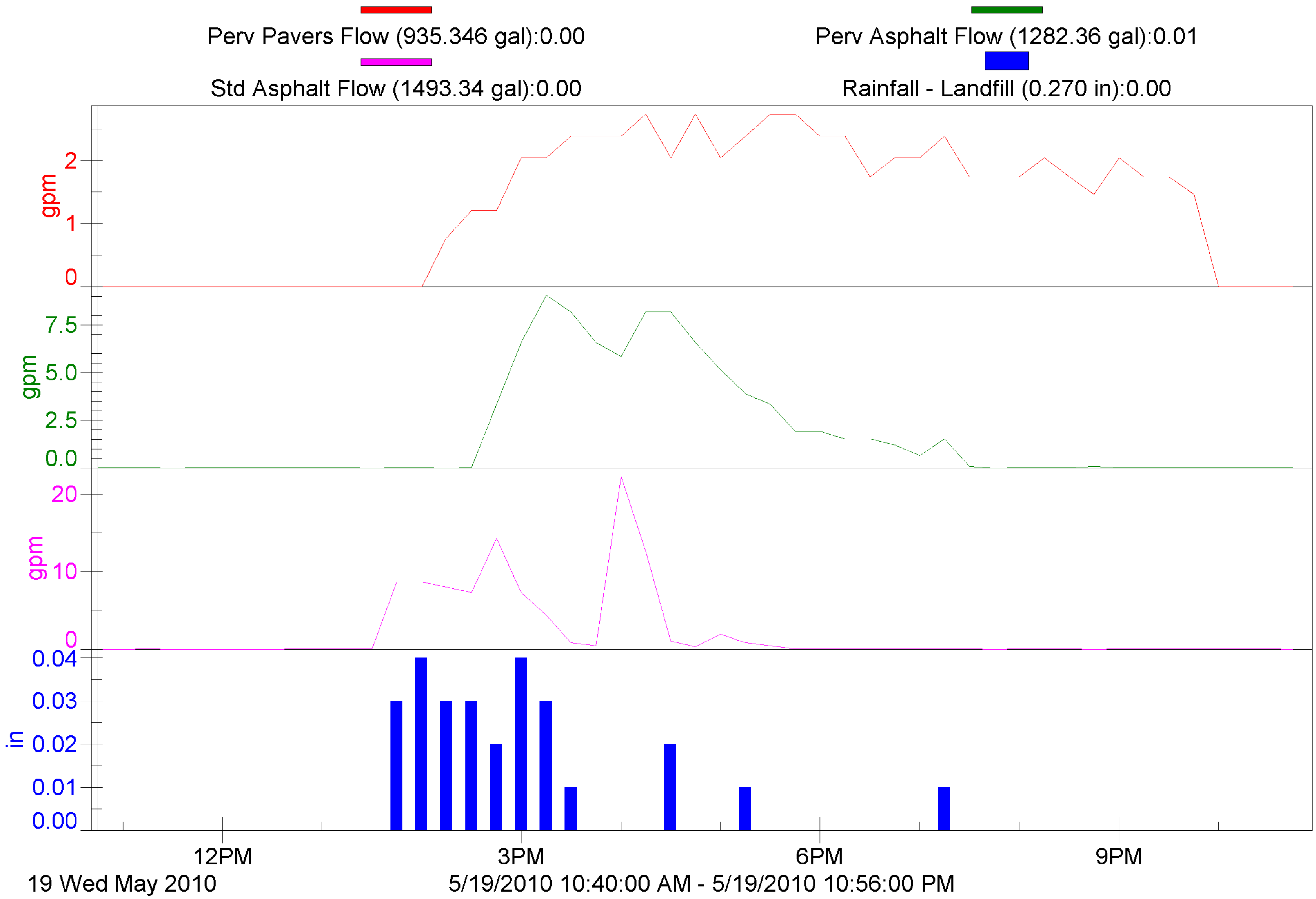
Flowlink 5



Storm #90

Pervious Pavement Project Flow

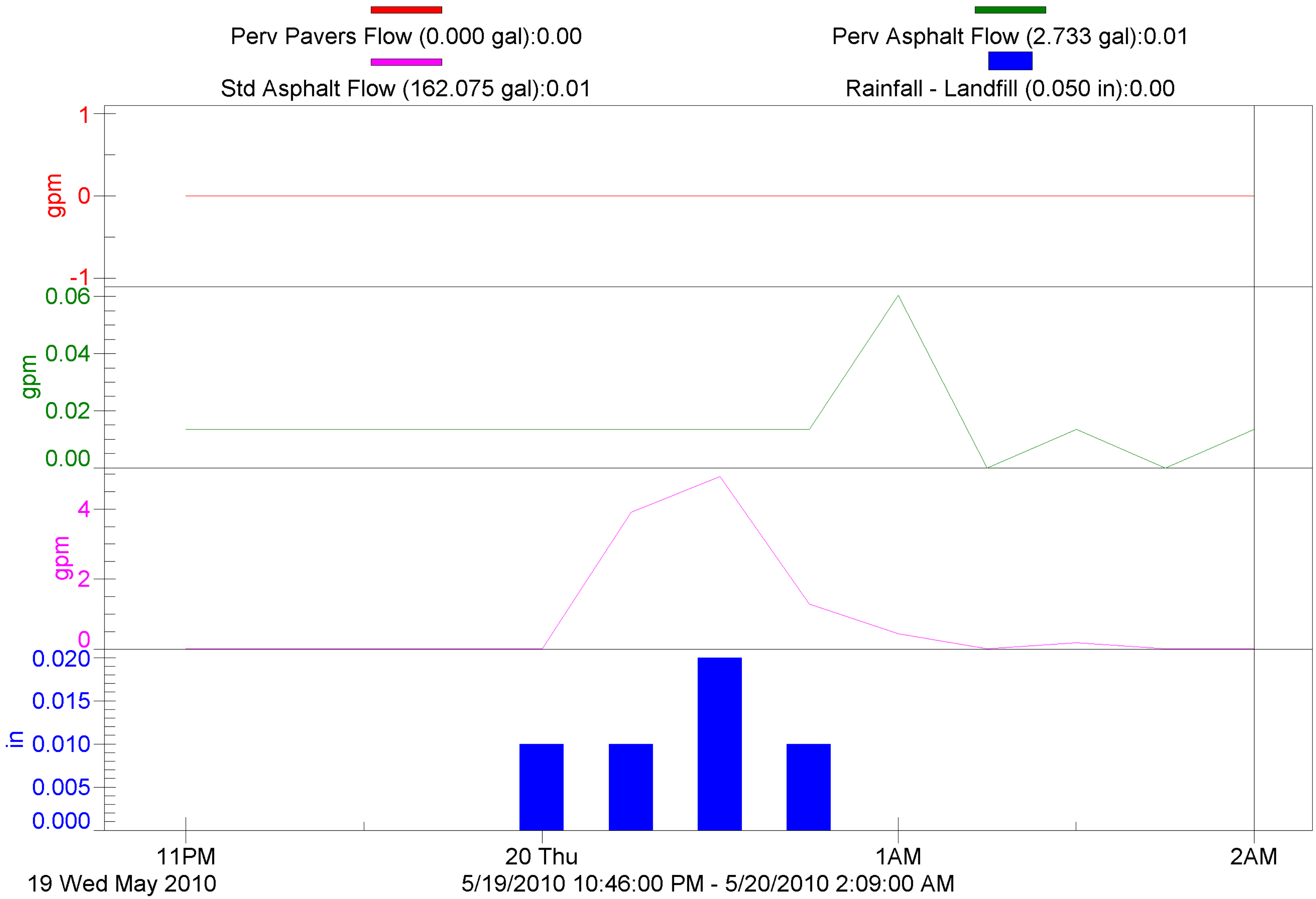
Flowlink 5



Storm #91

Pervious Pavement Project Flow

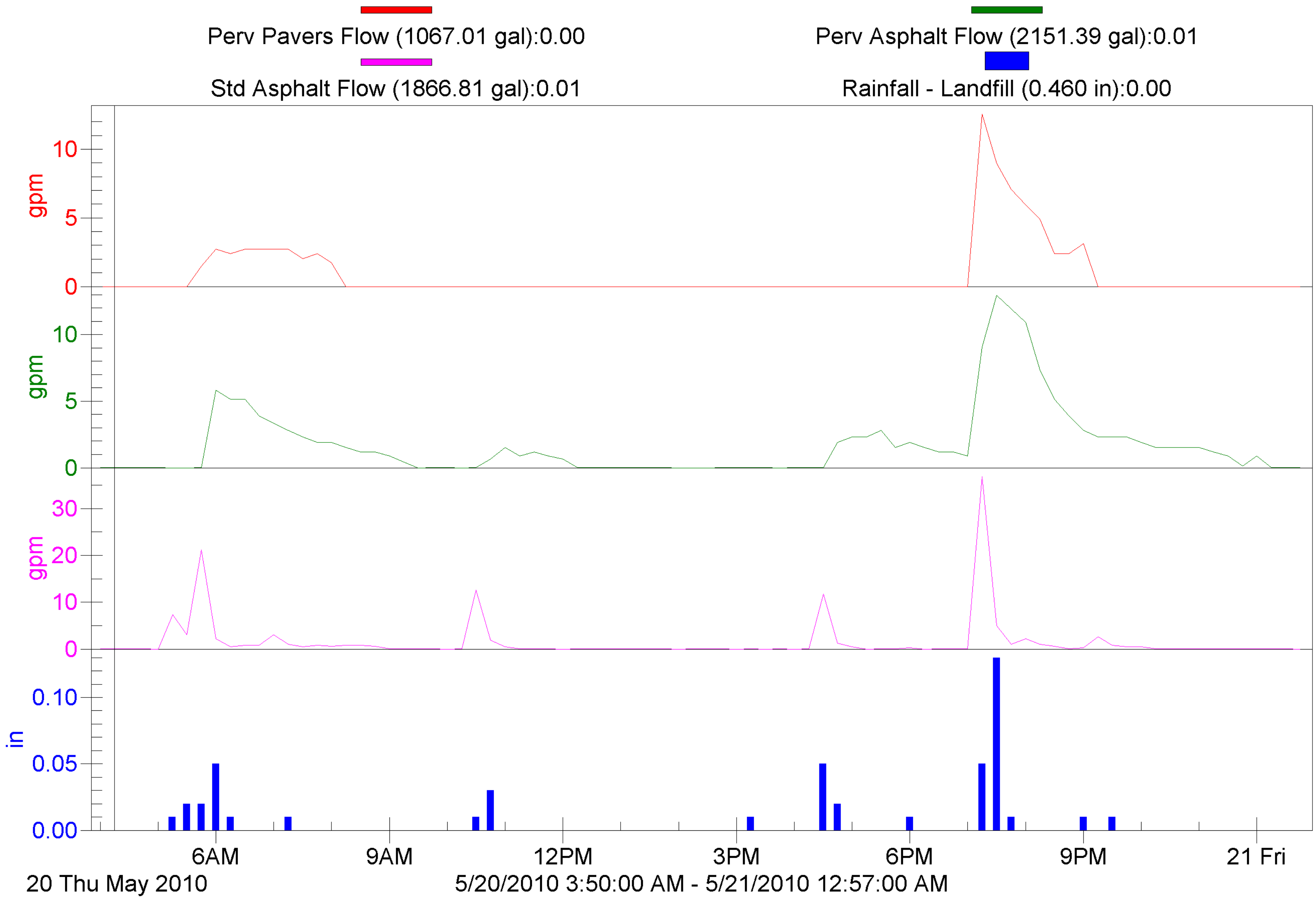
Flowlink 5



Storm #92

Pervious Pavement Project Flow

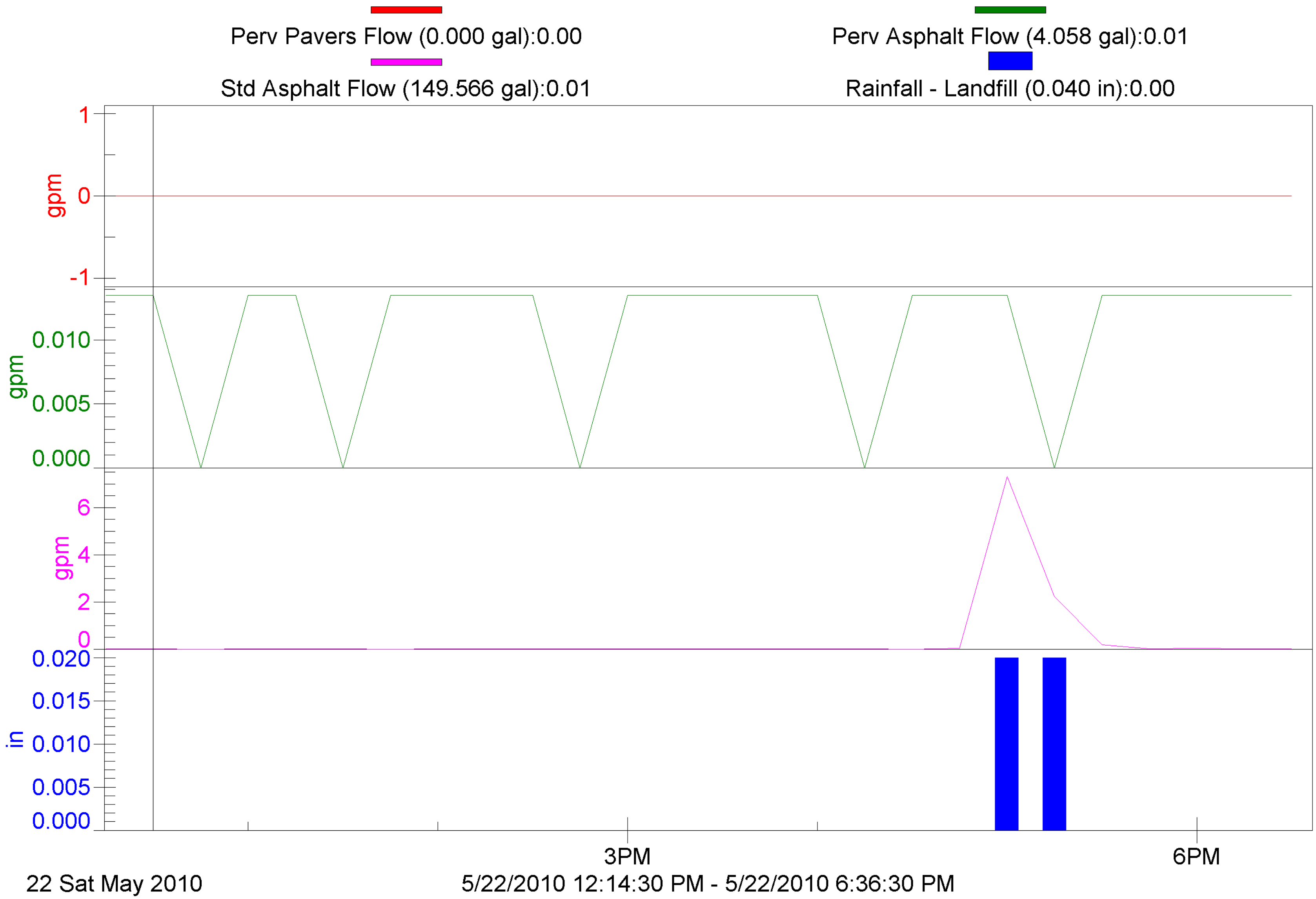
Flowlink 5



Storm #93

Pervious Pavement Project Flow

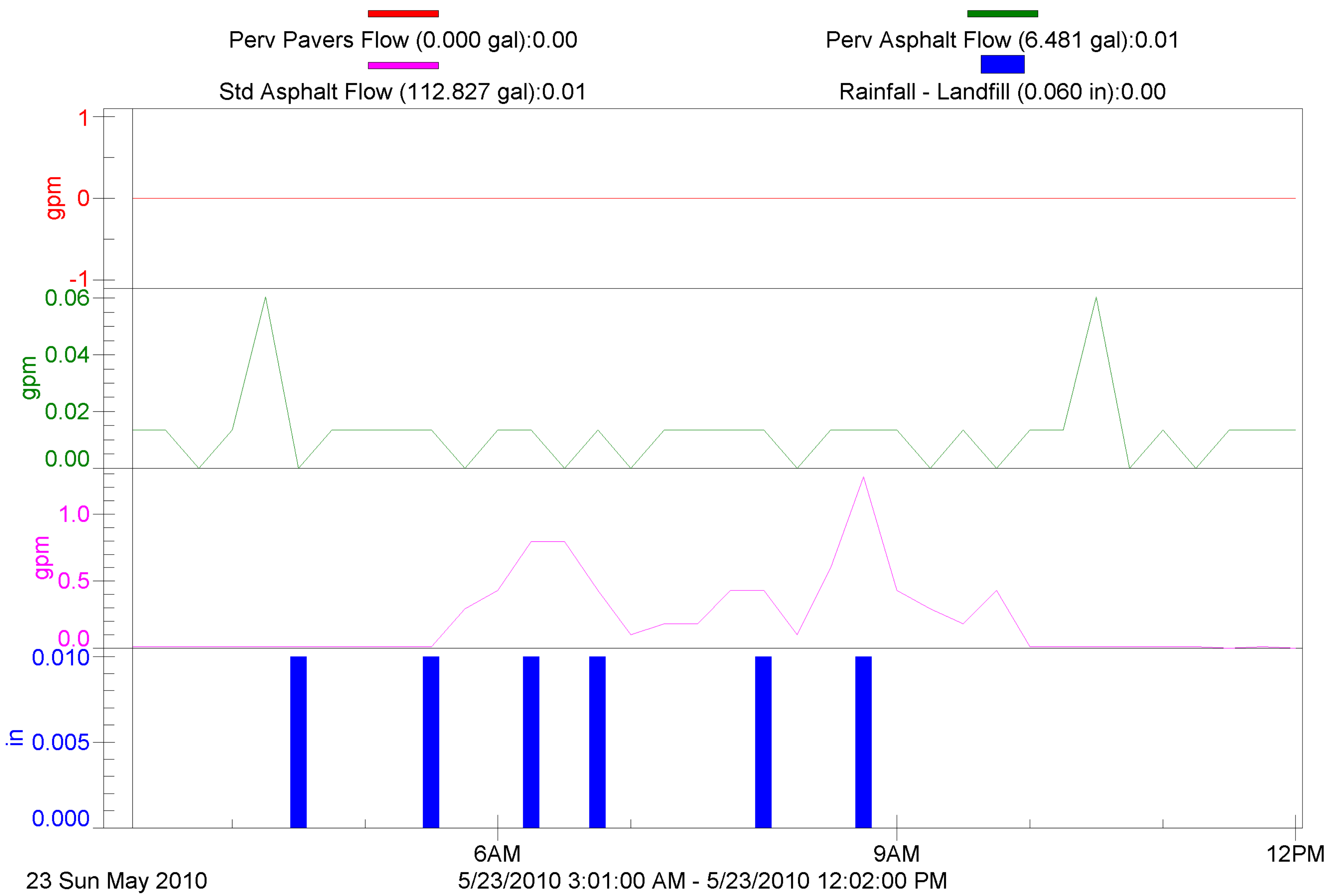
Flowlink 5



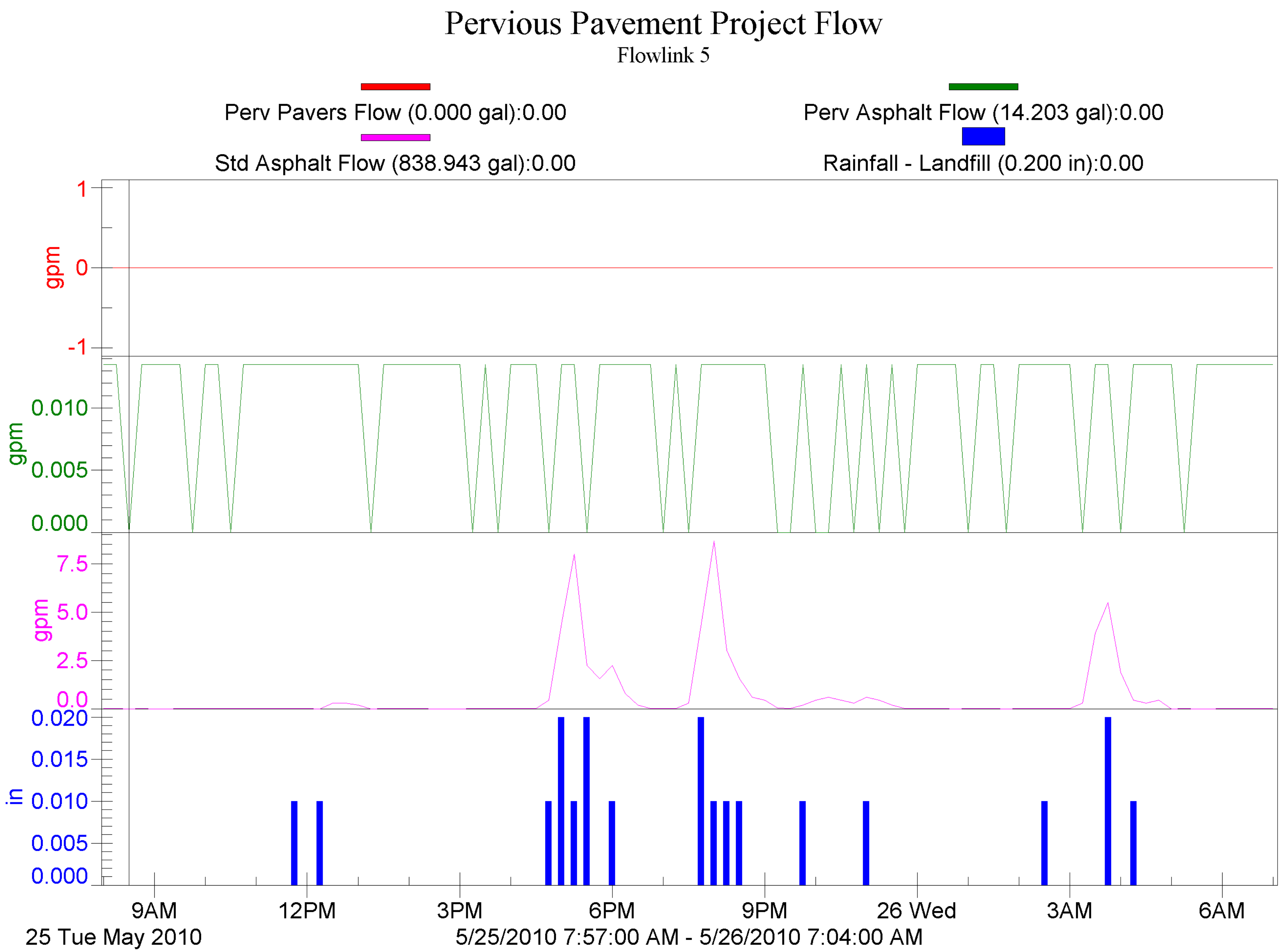
Storm #94

Pervious Pavement Project Flow

Flowlink 5



Storm #95

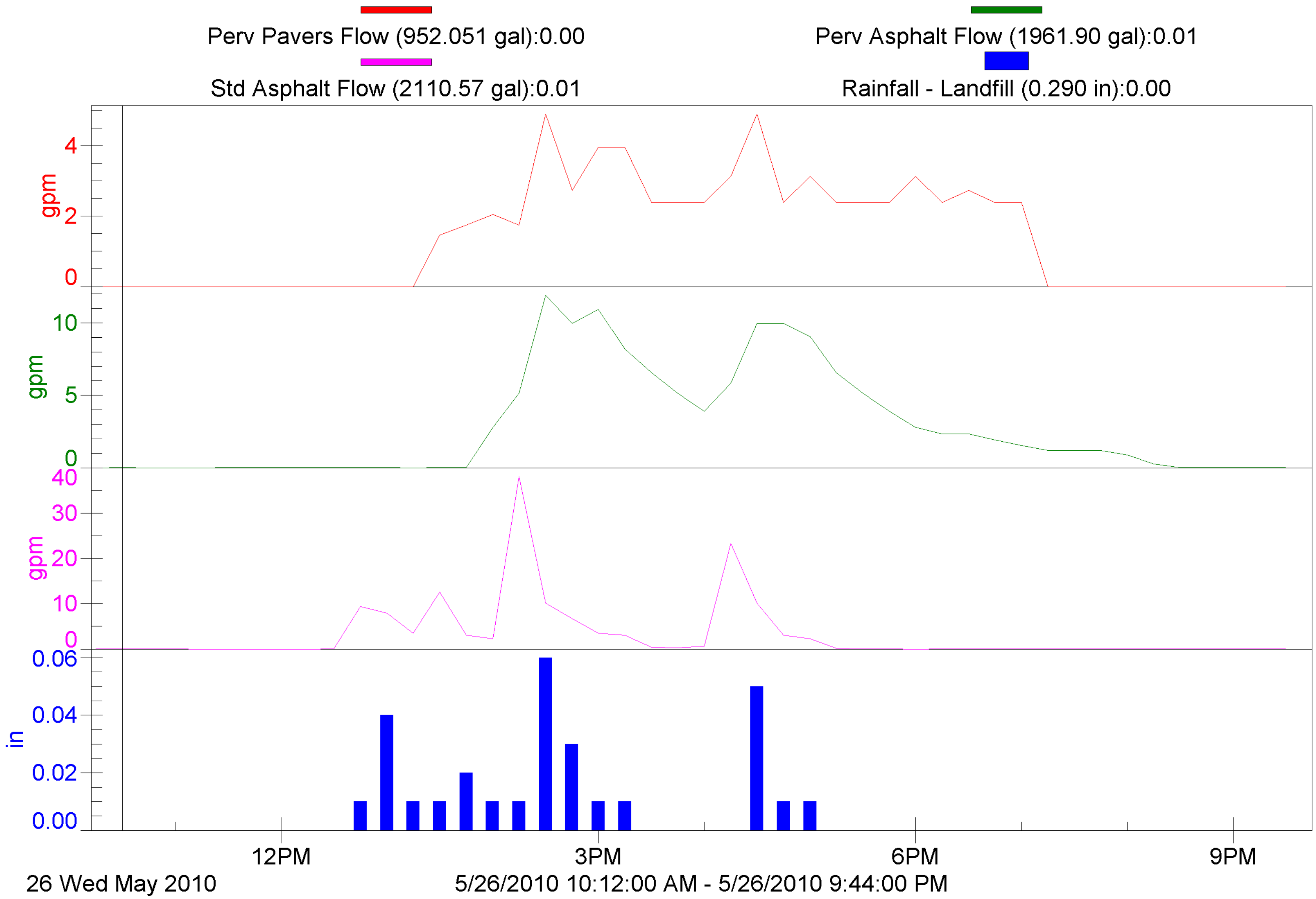


Pervious Pavement Project Flow
Flowlink 5
Perv Pavers Flow (0.000 gal):0.00
Perv Asphalt Flow (14.203 gal):0.00
Std Asphalt Flow (838.943 gal):0.00
Rainfall - Landfill (0.200 in):0.00
gpm
1
0
-1
gpm
0.010
0.005
0.000
gpm
7.5
5.0
2.5
0.0
in
0.020
0.015
0.010
0.005
0.000
9AM
12PM
3PM
6PM
9PM
26 Wed
3AM
6AM
25 Tue May 2010
5/25/2010 7:57:00 AM - 5/26/2010 7:04:00 AM

Storm #96

Pervious Pavement Project Flow

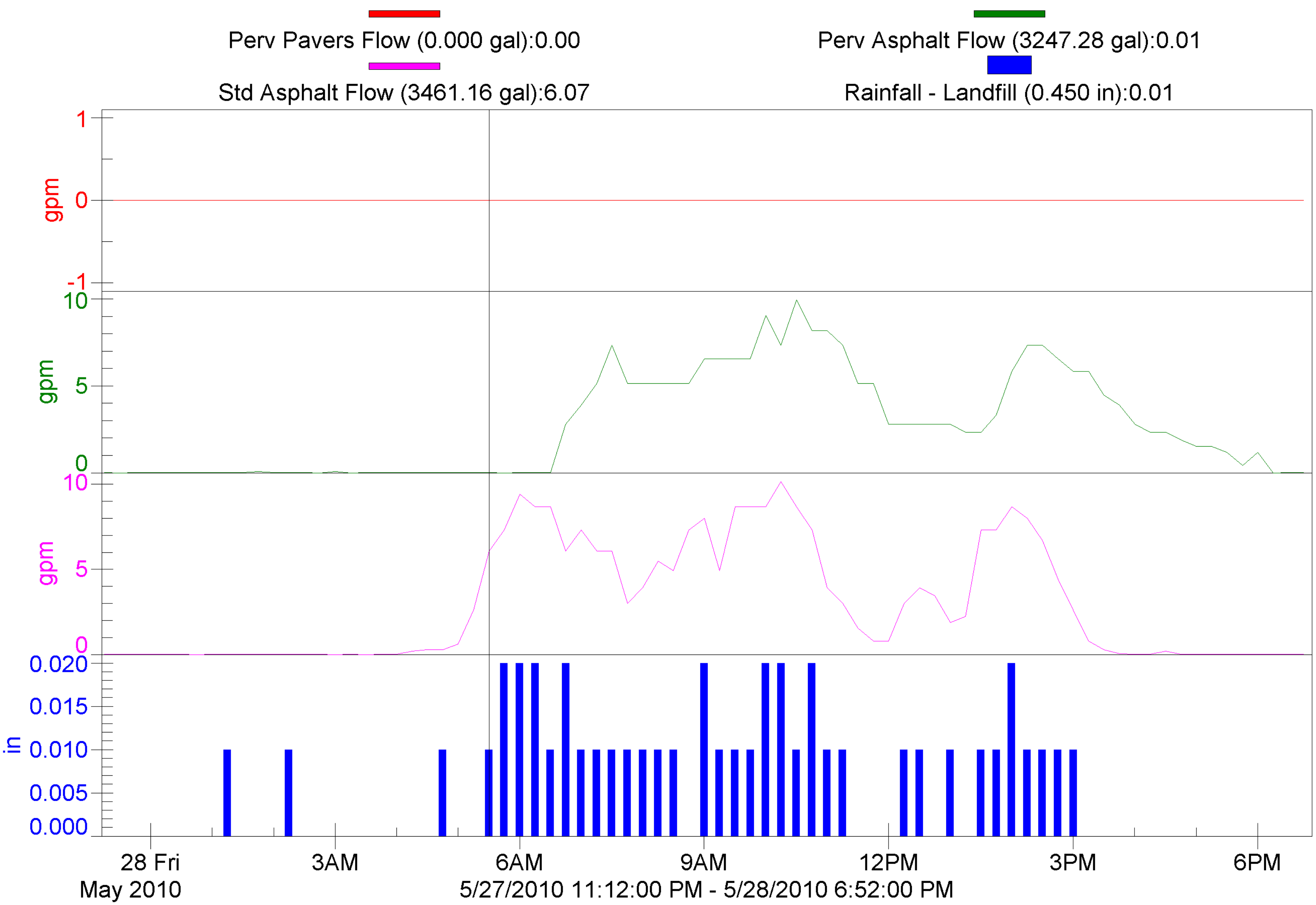
Flowlink 5



Storm #97

Pervious Pavement Project Flow

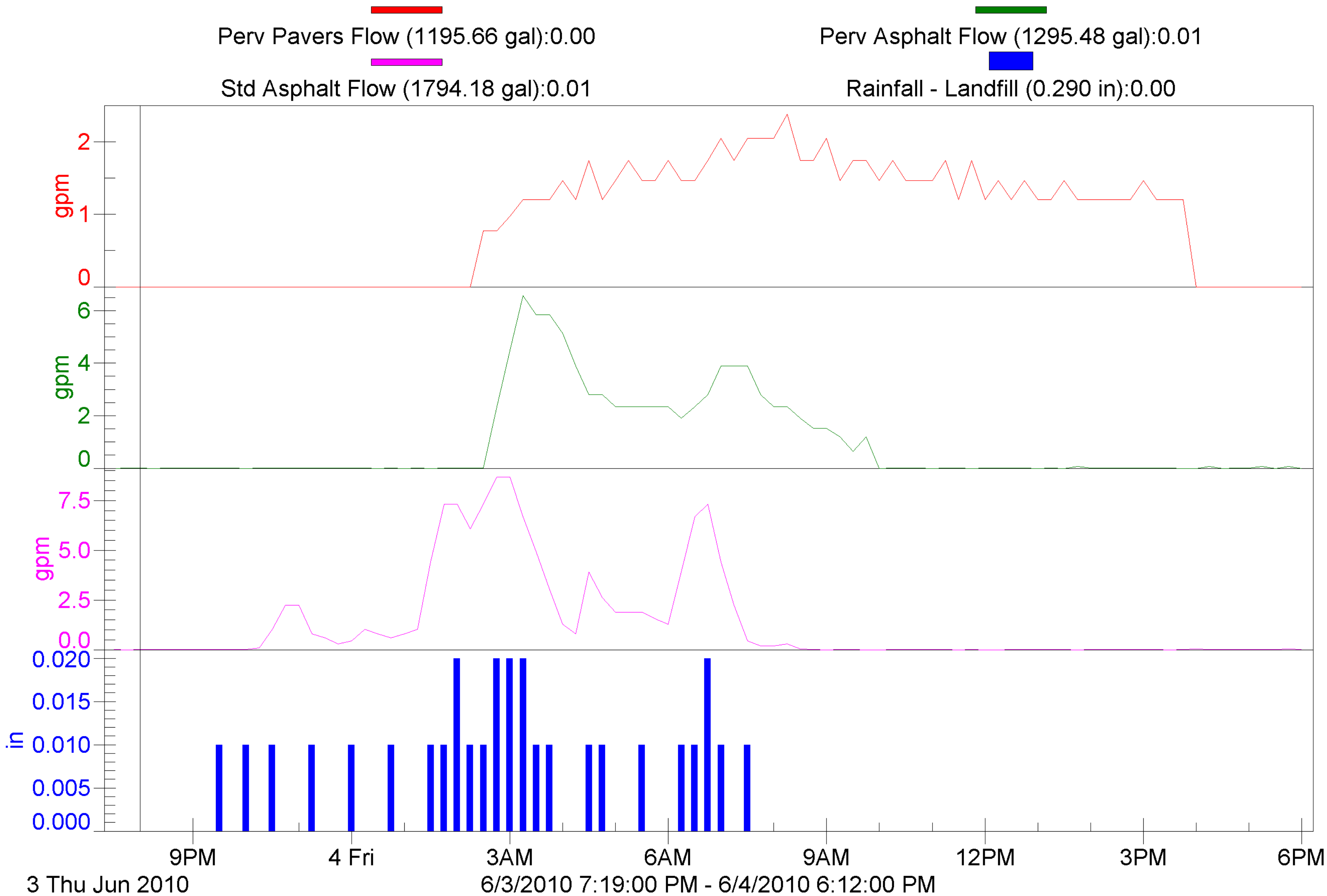
Flowlink 5



Storm #98

Pervious Pavement Project Flow

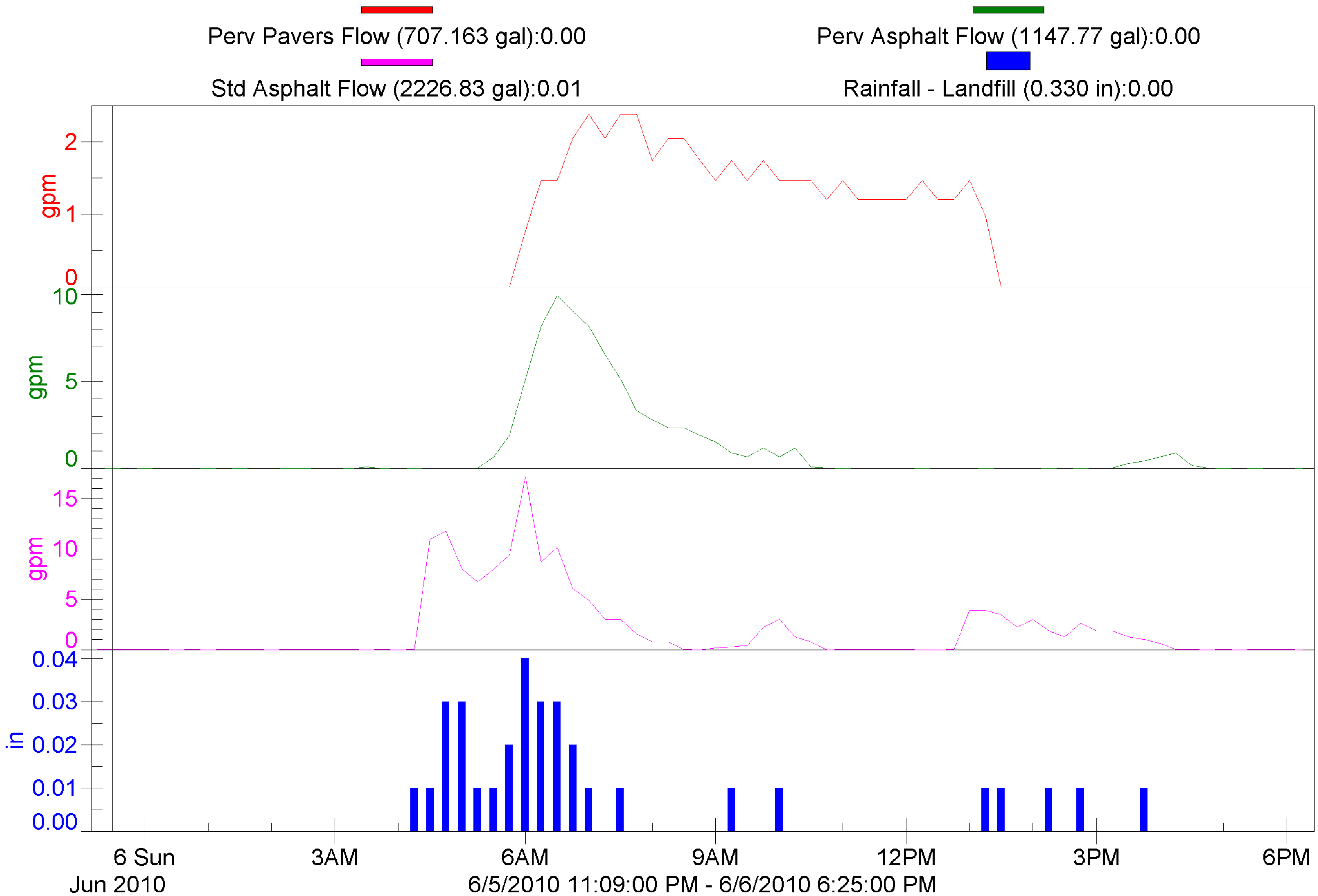
Flowlink 5



Storm #99

Pervious Pavement Project Flow

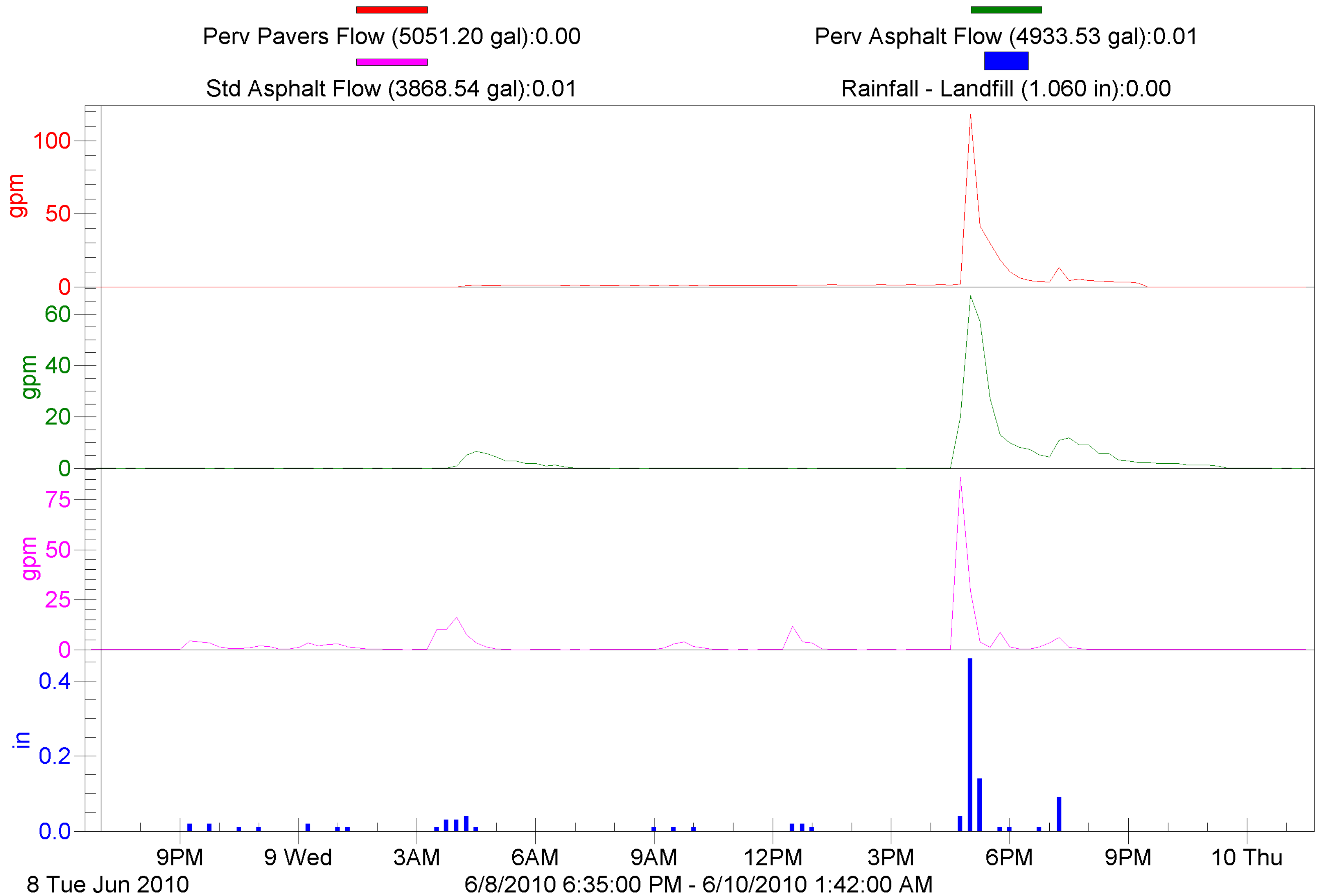
Flowlink 5



Storm #100

Pervious Pavement Project Flow

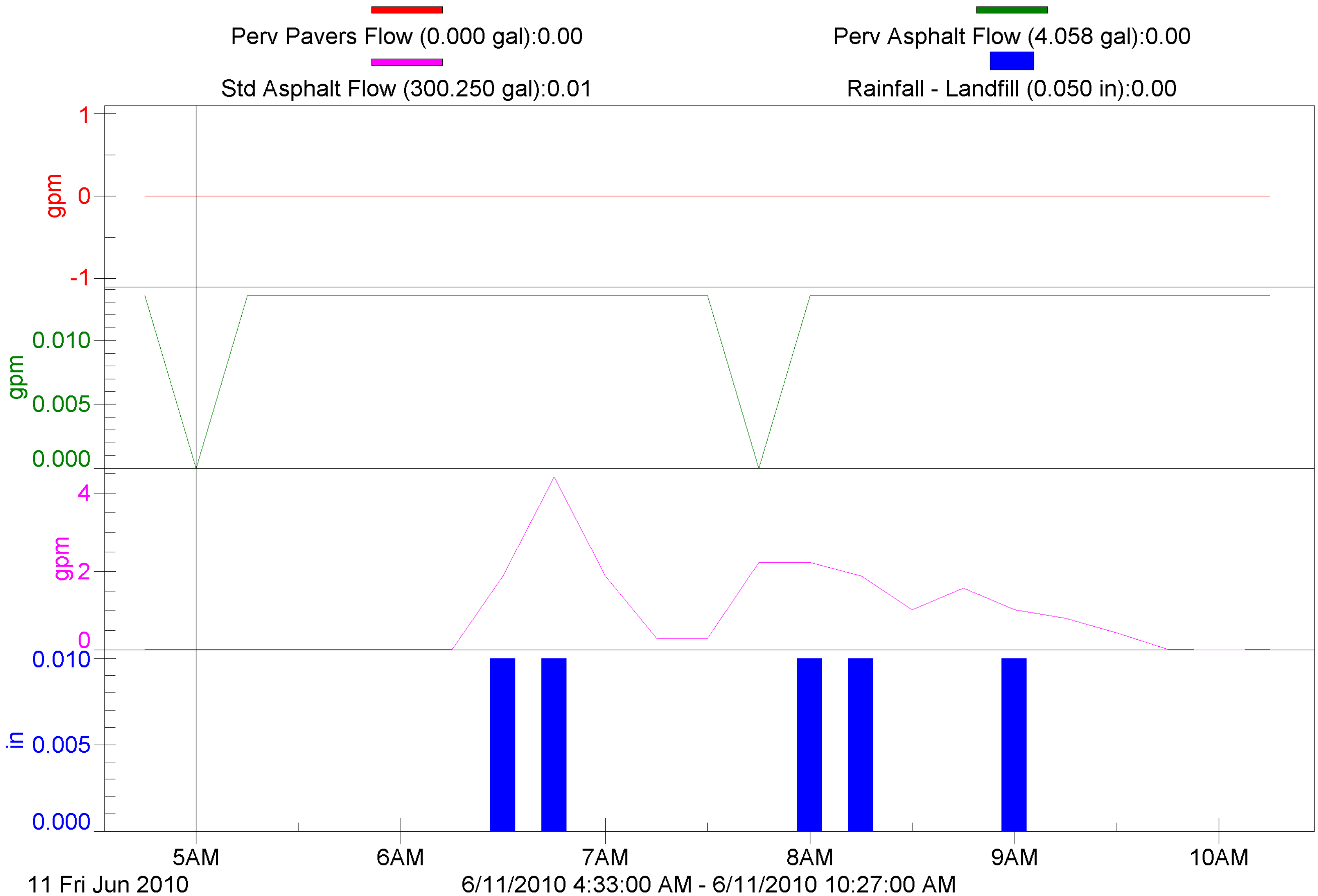
Flowlink 5



Storm #101

Pervious Pavement Project Flow

Flowlink 5



Storm #102

Pervious Pavement Project Flow

Flowlink 5