WATER YEAR 2008 DATA REPORT

High Point Phase I Block-Scale Monitoring

Prepared for

Seattle Public Utilities

April 2009

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WATER YEAR 2008 DATA REPORT

High Point Phase I Block-Scale Monitoring

Prepared for

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Introduction

Seattle Public Utilities (SPU) is implementing a large-scale natural drainage system (NDS) project in conjunction with the redevelopment project for the High Point neighborhood in West Seattle (Figure 1). NDS swales are part of what is termed a low impact development (LID) approach to managing stormwater runoff. The goal of the LID approach is to minimize the effect that changes in land use associated with urbanization can have on the natural hydrology within a given catchment. As opposed to conventional stormwater systems that route runoff directly to storm drains, the NDS swales first route runoff through a vegetated/compost-amended swale, slowing runoff and allowing for infiltration into the groundwater. Excess runoff is then routed to a conventional stormwater conveyance system. The end result is improved stormwater quality and decreased erosion in downstream receiving waters. The High Point NDS swales, unlike previous NDS swales constructed by SPU, have been constructed to provide shallow surface ponding (3 to 10 inches), with 3 to 4 feet of bioretention soil and an underdrain collection system.

Herrera Environmental Consultants, Inc. (Herrera) is currently working with SPU to implement a block-scale monitoring program of NDS swales that have been installed at the High Point project site. The project is being funded by SPU, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (U.S. EPA). The goal of the project is to quantify the performance of the NDS swales in terms of water quality treatment and flow retention. The results of the evaluation of NDS performance will be used for the following purposes:

- Establishment of a basis for potential design refinements
- Improvements in NDS performance
- Reduction in installation costs.

To achieve the project goal, the following monitoring activities have been performed in association with a representative NDS test swale in the High Point neighborhood:

- Continuous measurements of ponding depth on the swale's surface
- Continuous measurements of discharge within the swale's underdrain system
- Collection of water quality samples before and after treatment within the swale
- Implementation of controlled infiltration tests on the swale's surface
- Continuous measurements of precipitation in the immediate vicinity of the swale.

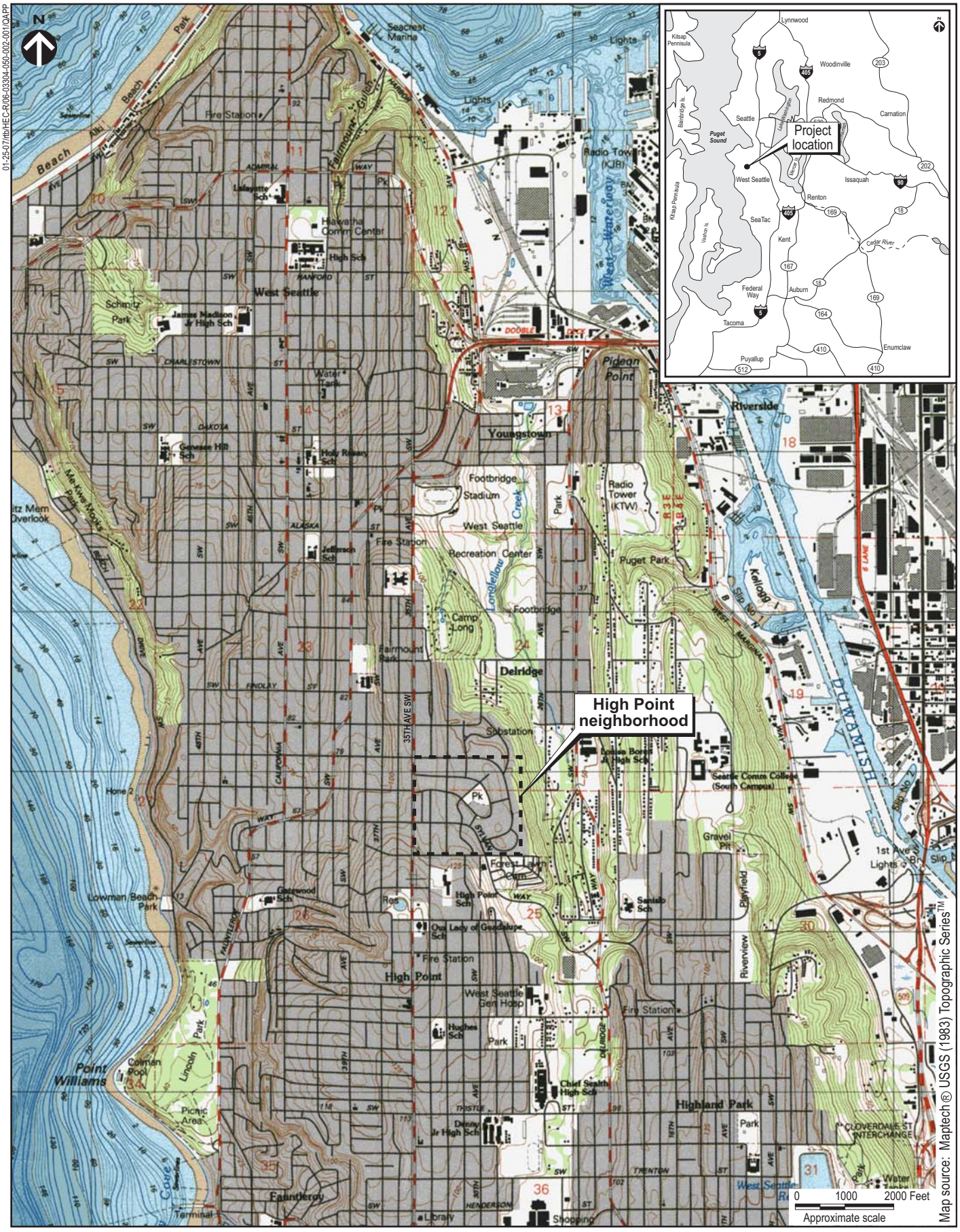


Figure 1. Vicinity map for the High Point redevelopment project site in Seattle, Washington.

The specific monitoring procedures that are being implemented in connection with these activities were documented previously in the quality assurance project plan (QAPP) for the monitoring program (Herrera 2007a). As described in the QAPP, the monitoring for this project was planned to occur over a 3-year period beginning in December 2006 and ending in September 2009, with annual data reports to be prepared at the end of each water year. (A water year begins on October 1 and ends on September 30 of the subsequent calendar year.)

However, during a large storm event in December 2007, the NDS test swale for this monitoring project received substantial quantities of untreated runoff from a nearby construction site. Field observations made after this event indicated severe damage to the NDS test swale by sediment deposits from this runoff. Consequently, SPU suspended monitoring of this NDS test swale at the end of water year 2008 and identified two new NDS test swales for monitoring in water year 2009. The specific monitoring procedures that will be used in connection with these new swales are detailed in a separate QAPP (SPU 2008) that was prepared to meet the project monitoring goal and the monitoring requirements identified in the Seattle's Phase I Municipal Stormwater Permit (Phase I Permit). Monitoring of these new swales will continue through water year 2011, with annual data reports to be prepared at the end of each water year.

This report summarizes the data collected during water year 2008 from the original NDS test swale that was selected for monitoring in connection with this project. Data that were collected in water year 2007 were summarized in a previous report (Herrera 2008). The remainder of this report is organized into the following sections:

- Experimental Design
- Methods
- Results and Discussion
- Conclusions
- References.

Experimental Design

The NDS swales in the High Point neighborhood have five primary components (Figure 2):

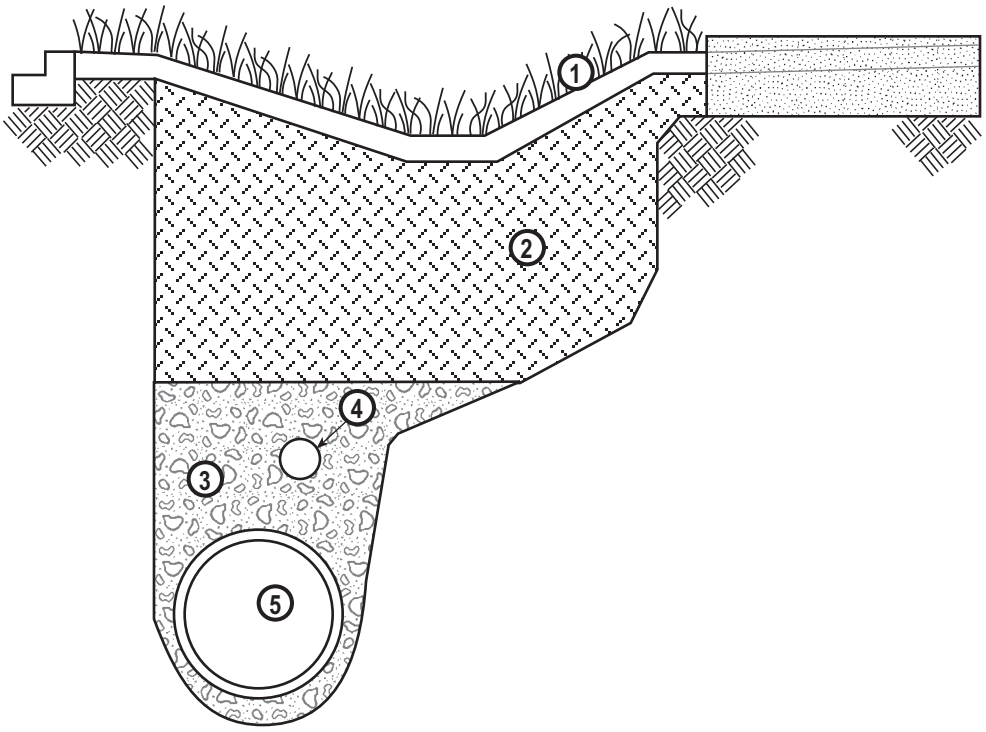
- Grass or vegetated planting strip
- Engineered soil layer
- Gravel drain layer
- Perforated underdrain pipe
- Solid-walled conveyance pipe.

During operation, stormwater runoff from the surrounding drainage basin enters the planting strip via sheet flow where it is retained for a sufficient period of time to allow infiltration to the underlying engineered soil layer. Absorption and filtration processes within the engineered soil layer then provide water quality treatment. Storage within the engineered soil layer also serves to attenuate the flow rate and volume of stormwater runoff. Under conditions of saturation, stormwater will infiltrate the engineered soil layer down to the gravel drain layer. The gravel drain layer provides additional storage for attenuating the flow rate and volume of stormwater runoff. Overflow from the gravel drain layer is collected in the 8-inch-diameter perforated underdrain pipe and then discharged (via a public storm drain maintenance hole [PSDMH]) into a solid-wall pipe through which it is conveyed out of the NDS swale.

As noted in the previous section, the goal of this study is to obtain data for evaluating the water quality treatment and flow control benefits of NDS swales in the High Point neighborhood. These data will then provide a basis for design refinements that might be considered to improve swale performance, reduce installation costs, or both. To achieve this goal, monitoring was conducted in a NDS test swale that was constructed in 2004 and 2005 as part of Phase I of the High Point neighborhood redevelopment project (Figure 3). In conjunction with this study, continuous hydrologic monitoring was to be performed in association with the NDS test swale over a 3-year monitoring period, extending from December 2006 through September 2009. In addition, infiltration rates on the surface of the NDS test swale were to be measured through controlled testing procedures on three occasions. Finally, water quality samples were to be collected in an effort to characterize the pollutants present in stormwater before and after treatment in the NDS test swale. Because monitoring at the NDS test swale was suspended at the end of water year 2008, some of the planned monitoring was not completed. Specifically, continuous hydrologic monitoring was performed for only a 2-year period (i.e., water years 2007 and 2008), and surface infiltration rates were measured on only two occasions (i.e., March 7 and April 11, 2007); the results are provided in two previous data reports (Herrera 2007b, 2007c).

The QAPP (Herrera 2007a) provides detailed information on the experimental design for the four primary components of this monitoring project:

- Hydrologic Simulation Program—Fortran (HSPF) model calibration monitoring



KEY

1. Grass or vegetated planting strip
2. Engineered soil layer
3. Gravel drain layer
4. 8” perforated underdrain pipe
5. Solid-wall conveyance pipe

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Figure 2. Schematic cross-section of a typical natural drainage system swale.

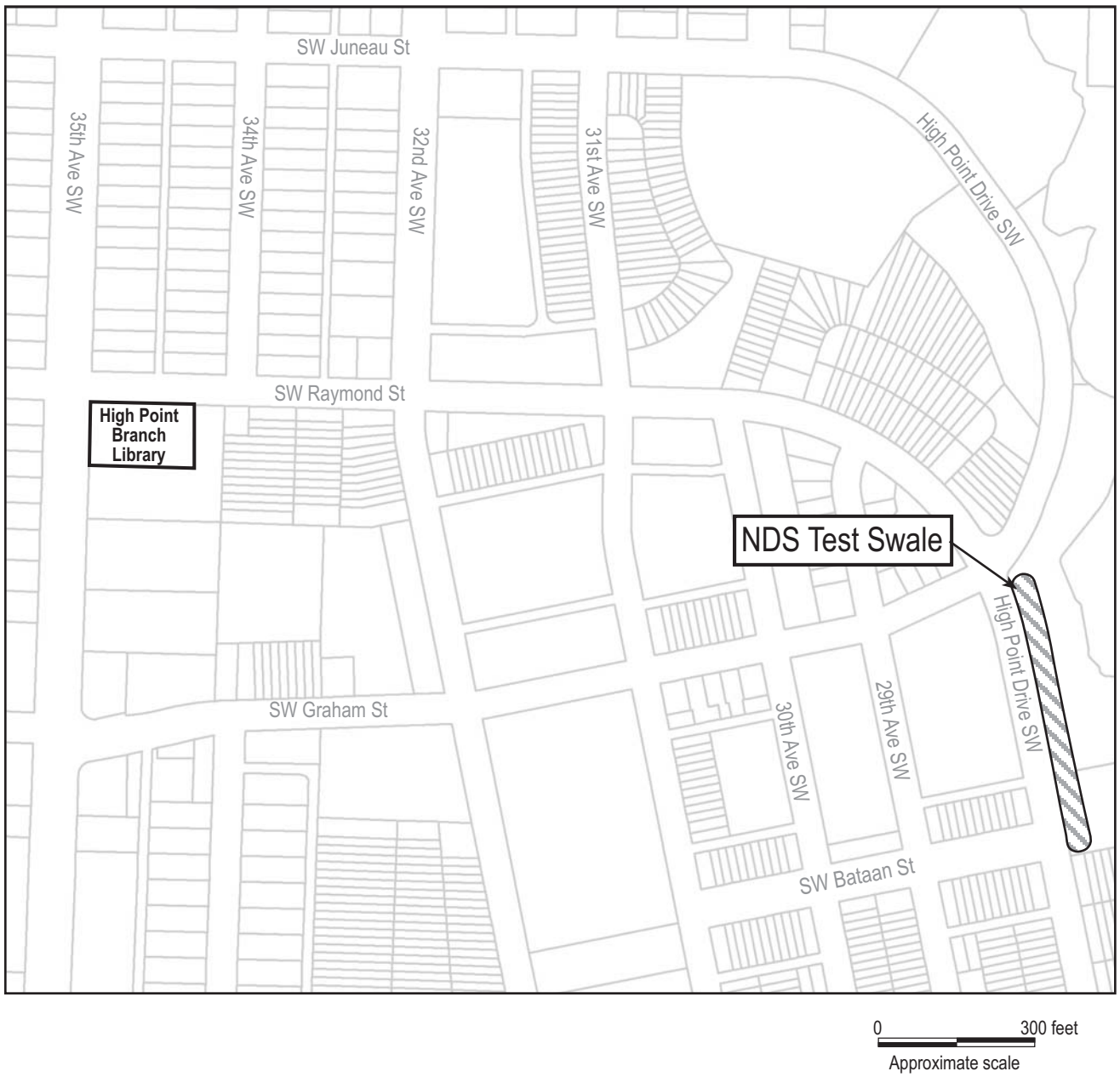

Figure 3. Site map for the High Point redevelopment project site, showing the location of the natural drainage system test swale.

- Continuous hydrologic monitoring
- Controlled infiltration tests
- Water quality monitoring.

During the monitoring period covered by this report (i.e., water year 2008), only continuous hydrologic monitoring was performed in accordance with SPU guidance and the schedule outlined in the QAPP. The monitoring stations used for continuous hydrologic monitoring are described in Table 1, and their locations are shown in Figure 4.

Table 1. Location, purpose, and sampling frequency for monitoring stations established for the High Point Phase I Block-Scale Monitoring project.

Station	Station Type	Station Location	Station Purpose	Sampling Frequency
D2	Discharge	PSDMH 5.60 located on High Point Drive SW, approximately midblock between SW Bataan Street and SW Graham Street	Continuous monitoring of stormwater outputs from the NDS test swale	Continuous monitoring was initiated in January 2007 and concluded in June 2008
D3	Discharge	PSDMH 5.50 located near the intersection of High Point Drive SW and SW Graham Street	Continuous monitoring of stormwater outputs from the NDS test swale	Continuous monitoring was initiated in December 2006 and concluded in August 2008
WL1	Water level	NDS test swale overflow drain located on High Point Drive SW, approximately midblock between SW Bataan Street and SW Graham Street	Continuous monitoring of ponding depth at the surface of the NDS test swale and recording of overflow events	Continuous monitoring was initiated in January 2007 and concluded in September 2008
RG1	Precipitation	Seattle Public Library, High Point Branch, at 3411 SW Raymond Street	Continuous monitoring of precipitation depth	Continuous monitoring was initiated in January 2007 and concluded in September 2008

NDS = natural drainage system.
PSDMH = public storm drain maintenance hole.

Continuous hydrologic monitoring was performed to track the outputs of stormwater from the perforated underdrain pipe of the NDS test swale over a 2-year monitoring period. In addition, automated instrumentation was installed on the surface of the NDS test swale to continuously measure the ponding depth near the overflow drain. This instrumentation was also used to record the occurrence (i.e., presence or absence) and duration of overflow events. Precipitation was also monitored continuously to provide data for interpreting the other monitoring results. In order to facilitate this monitoring, the following stations were installed in December 2006 and January 2007 in association with the NDS test swale:

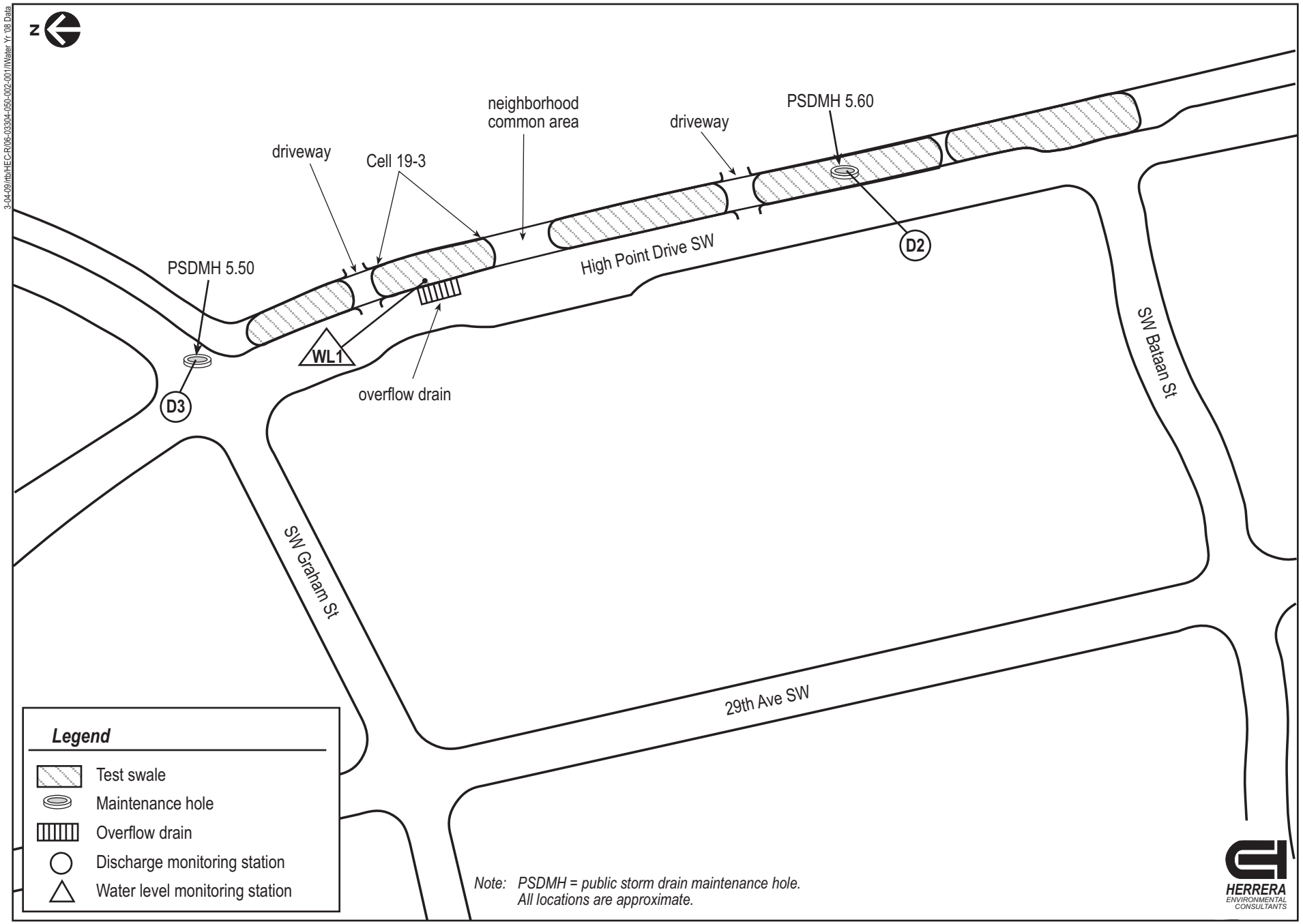

Figure 4. Plan view of the natural drainage system test swale and monitoring station locations for the High Point Phase I Block-Scale Monitoring project.

- A precipitation monitoring station (RG1) was established on the roof of the Seattle Public Library, High Point Branch, at 3411 SW Raymond Street (Figure 3). A rain gauge and data logger were installed at this station to continuously monitor precipitation over the duration of the project.

- Flow monitoring stations were established in two separate PSDMHs that collect water from sections of perforated underdrain pipe within the gravel layer of the NDS test swale. (Water discharged from the underdrain pipes is routed to the solid-wall conveyance pipe shown in Figure 2 within these same PSDMHs.) One station (D2) was established in PSDMH 5.60, located at approximately the midpoint of the NDS test swale (Figure 4). This station receives flow from a section of perforated underdrain pipe that extends approximately 250 feet from PSDMH 5.60 south to the intersection of SW Bataan Street and High Point Drive SW. The other station (D3) was established in PSDMH 5.50 near the intersection of SW Graham Street and High Point Drive SW (Figure 4). This station receives flow from a section of perforated underdrain pipe that extends from PSDMH 5.50 approximately 250 feet south to PSDMH 5.60. Automated flow monitoring equipment was installed in association with each of these stations to continuously monitor stormwater outputs from the NDS test swale.

- One water level monitoring station (WL1) was established on the surface of the NDS test swale near the overflow drain (Figure 4). Automated equipment was installed at this station to continuously record ponding depth and the occurrence and duration of overflow events.

Data from these instruments were used to track stormwater outputs from the NDS test swale. This information was then used to evaluate whether the NDS swales are meeting the requirements for flow attenuation and water quality treatment that were established for Phase I of the High Point neighborhood redevelopment project (Herrera and R.W. Beck 2004). In accordance with these requirements, the stormwater treatment systems on the project site must attenuate the 2-year, 24-hour storm to conditions that existed before the pasture was developed. Similarly, the NDS swales must provide water quality treatment for the 6-month, 24-hour storm. These treatment requirements are to be applied to the entire project site, taking into account all of the associated stormwater systems. Therefore, it is not possible to assess these treatment goals directly using only the monitoring data obtained from the NDS test swale. However, if it can be shown that the NDS test swale is meeting these goals, it may be inferred that other NDS swales on the project site are performing similarly and these treatment goals are likely being met on a system-wide basis.

Methods

This section provides an overview of the sampling, data management, and data analysis procedures that are being used for the continuous hydrologic monitoring component of this project. A more detail description of these procedures is provided in the QAPP (Herrera 2007a).

Sampling Procedures

Continuous hydrologic monitoring for this study involved the collection of precipitation, discharge, and water level data at the stations described previously in the Experimental Design section and shown in Figure 4. The specific procedures that are used to collect each type of data are described in the following subsections.

Precipitation Data

Monitoring station RG1 at the Seattle Public Library, High Point Branch (Figure 3) was used to continuously measure precipitation amounts over the duration of the project. To facilitate this monitoring, a Hydrologic Services TB3 tipping bucket rain gauge was affixed to the library roof on a 10-foot pole and leveled in accordance with the manufacturer's specifications. The rain gauge was interfaced with a Campbell Scientific CR200 data logger that was programmed to record precipitation depths with a 15-minute logging interval. The data logger was housed in a locked, vandal-resistant enclosure that was hidden from public view.

Field personnel performed monthly site visits to upload data from the data logger, check and replace the battery pack as necessary, and visually inspect all system components. Any operational problems identified during these site visits were addressed immediately. Field personnel recorded detailed notes to describe any equipment maintenance or repairs that were required during these site visits.

Discharge Data

Stations D2 and D3 (Figure 4) were used to measure discharge from the perforated underdrain pipe sections for the NDS test swale. In order to facilitate this monitoring, DataGator flow metering systems manufactured by Renaissance Instruments were installed in the perforated underdrain pipe sections at their point of discharge into PSDMH 5.50 and PSDMH 5.60.

Each DataGator flow metering system has two components: a modified Venturi flow tube with three strategically positioned pressure transducers to measure flow and a data logger that allows the continuous recording of flow measurements. In accordance with the manufacturer's instructions, the flow tubes were securely fastened to each 8-inch perforated underdrain pipe with a stainless steel mounting base and leveled with threaded leveling rods. The data loggers

were attached to a ladder rung at the top of each PSDMH by means of short sections of cable and then interfaced with the pressure transducers in the flow tubes using manufacturer supplied communication cables. Finally, the data loggers were programmed to continuously record discharge measurements from the flow tubes at 15-minute logging intervals.

Field personnel performed monthly site visits to upload data from the DataGator flow metering systems, check and replace batteries as necessary, and visually inspect all system components from the top of the PSDMH. Any operational problems that were identified during these site visits were addressed immediately. During all site visits, field personnel recorded detailed notes to describe any equipment maintenance or repairs that were required.

Water Level Data

Monitoring station WL1 (Figure 4) was established to continuously monitor water levels on the surface of the NDS test swale near the overflow drain. To facilitate this monitoring, a Campbell Scientific CS445-L submersible pressure transducer was installed at a low point within the NDS test swale. The pressure transducer was integrated with a Campbell Scientific CR200 data logger that was programmed to continuously record water levels in the swale at 15-minute logging intervals. Both the pressure transducer and data logger were housed in vandal-resistant enclosures that were hidden from public view.

Field personnel performed monthly site visits to upload data from the data logger, check and replace the battery pack as necessary, and visually inspect all system components. Any operational problems that were identified during these site visits were addressed immediately. During all site visits, field personnel recorded detailed notes to describe any equipment maintenance or repairs that were required.

In conjunction with the water level monitoring equipment described above, a staff gauge was also installed in the NDS test swale near the overflow drain. Survey equipment was then used to reference the elevation of both the pressure transducer and overflow drain to the datum on the staff gauge. Using this relationship, the data from the automated monitoring equipment were used to track the occurrence and duration of overflow events at the surface of the NDS test swale.

Data Management Procedures

Data from the automated instruments at each station were uploaded at monthly intervals using a laptop computer in the field. If appropriate, manual measurements were made on site for equipment calibration purposes in accordance with the schedule identified in the QAPP (Herrera 2007a). On the day after each site visit, uploaded data from each monitoring station were transferred to Microsoft Excel spreadsheets to facilitate all subsequent data management, analysis, and archiving activities. At that time, the data were also audited for quality assurance purposes. Any operational problems identified through the audit were addressed immediately.

In accordance with the manufacturer's recommendations, postprocessing of the data from the DataGator flow metering systems at stations D2 and D3 was also performed to eliminate noise from sensor readings that were below the lower threshold for accuracy. Specifically, the DataGator flow metering systems were constructed with three separate pressure transducers that are positioned at the inlet, throat, and outlet of a Venturi flow tube. Data from the inlet and outlet pressure transducers were processed according to the flow chart in Appendix A to remove spurious values in the flow data record that relate to pressure readings less than the manufacturer's recommended threshold for accuracy of 0.005 pounds per square inch.

Water level measurements from station WL1 were also adjusted to reflect the ponding depth relative to the staff gauge at the station and the overflow drain for the NDS test swale. In this manner, the data from station WL1 were used to track the occurrence and duration of overflow events at the surface of the NDS test swale.

At the end of each water year, the hydrologic data from all stations were subjected to a final data quality assurance review before analysis to ensure that they conformed with the specific measurement quality objectives specified in the QAPP (Herrera 2007a). The data quality assurance review procedures and results from the current water year are described in the data quality assurance review memorandum provided in Appendix B.

Data Analysis Methods

Hydrologic data in this study were collected to determine whether the stormwater treatment goals established for Phase I of the High Point redevelopment project are being met. Specifically, the stormwater treatment systems on the site must attenuate the 2-year, 24-hour storm to conditions before the pasture was developed and provide water quality treatment for the 6-month, 24-hour storm. These treatment requirements are to be applied to the entire project site, taking into account all of the associated stormwater systems. If, as noted previously, it can be shown that the NDS test swale is meeting these goals, it may be inferred that other NDS swales on the project site are also performing similarly and these treatment goals are also likely being met on a system-wide basis.

To facilitate the evaluation of the NDS test swale performance relative to these treatment goals, hydrologic data collected in this study were processed to compile the following information for each storm that occurred during the monitoring period:

- Storm precipitation depth at station RG1
- Storm duration at station RG1
- Storm average intensity at station RG1
- Storm peak intensity at station RG1
- Storm antecedent dry period at station RG1
- Peak water level at station WL1
- Peak effluent discharge rate at stations D2 and D3
- Effluent volume at stations D2 and D3.

(Note that storm events are delineated based on a precipitation depth of at least 0.01 inches and a period of at least 12 hours with no precipitation separating each event.)

The characteristics of storm events that produce measurable effluent discharge volumes at stations D2 and D3 were then summarized in order to provide a general assessment of the treatment performance of the NDS test swale relative to design expectations. Similarly, the characteristics of storm events that produce overflow events in the NDS swale, as measured at station WL1, were also characterized and compared to these treatment goals.

Results and Discussion

In general, the monitoring results for the NDS test swale during water year 2008 indicate substantial changes in performance relative to those recorded during water year 2007 (Herrera 2008) following the discharge of untreated runoff to the swale from a nearby construction site during an unusually large storm event that began on December 1, 2007. Photo documentation showing construction runoff entering the NDS test swale during this storm event is provided in Appendix C. Field observations made after this event indicated severe damage to the NDS test swale by sediment deposited during this runoff event. This sediment likely decreased surface infiltration rates and contributed to increased ponding in the NDS test swale during water year 2008 relative to water year 2007.

Additionally, the monitoring results from water year 2008 were likely influenced by an expansion of the drainage basin that contributes runoff to the NDS test swale. This expansion was related to Phase II of the High Point redevelopment project and involved the construction of new roadway and housing over the spring and summer of 2007 in that area immediately south of SW Bataan Street and adjacent to High Point Drive SW (Figure 3). The increase in basin area was approximately 0.25 to 0.50 acres more than the original basin area, which was approximately 1.63 acres. Due to this increase, the rainfall/runoff relationship for the NDS test swale changed from water year 2007 to water year 2008. This change also likely contributed to the increased ponding in the NDS test swale during water year 2008.

The results of the continuous hydrologic monitoring during water year 2008 are discussed below by data type: precipitation data, discharge data, and water level data.

Precipitation Data

The raw precipitation data from station RG1 during water year 2008 are summarized graphically in Figure 5. A detailed summary of the data from individual storm events (including the date and time for the storm beginning and end, storm duration, antecedent dry period, precipitation total, maximum intensity, and average intensity) is provided in Appendix D (Table D-1). More general summary statistics computed from these data are provided in Table 2. The forms that were completed in conjunction with routine quality assurance audits of the data from station RG1 are provided in Appendix E, and the results of the formal verification and validation review of these data are summarized in Appendix B.

A total of 99 storm events occurred duringr water year 2008. (Storm events are defined by a precipitation depth of at least 0.01 inches and a period of at least 12 hours with no precipitation separating each event.) For 18 of these storms, the precipitation totals exceeded 0.50 inches; 23 storms had totals between 0.50 and 0.25 inches, and 58 storms had totals that were less than 0.25 inches. The median precipitation total across all the storms was 0.22 inches. The five highest precipitation totals (8.05, 1.57, 1.36, 1.32 and 1.12 inches) occurred during storm events that began on December 1, 2007, and October 17, November 14, January 1, and August 19,

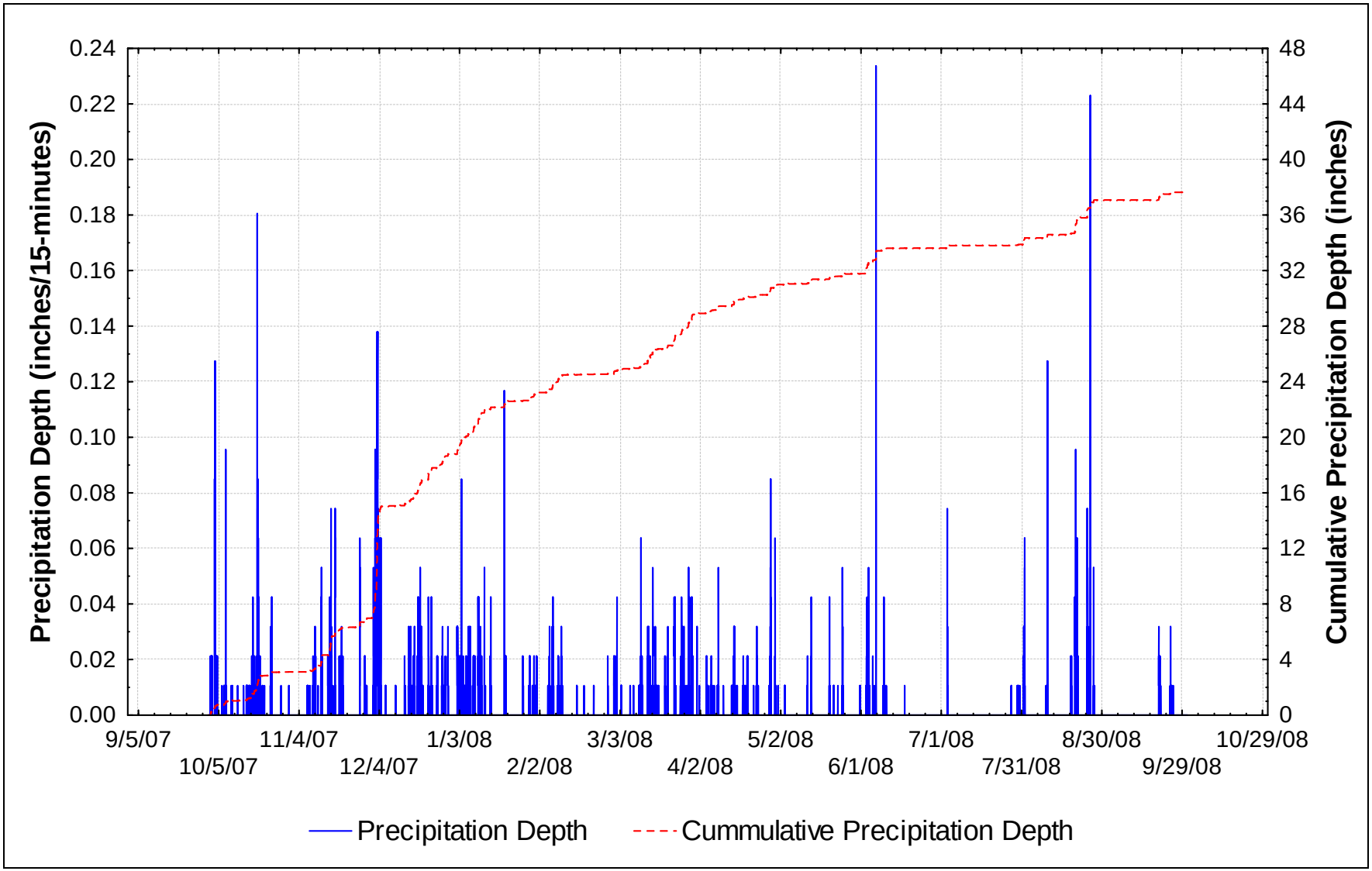

Figure 5. Precipitation depth measured at station RG1 for the High Point Phase I Block-Scale Monitoring project during water year 2008.

2008, respectively. These five storms were the only storms with precipitation totals exceeding the threshold corresponding to the 6-month, 24-hour design storm (1.08 inches). The precipitation total for the storm that began on December 1, 2007, also exceeded the threshold corresponding to the 2-year, 24-hour design storm (1.68 inches). However, the total duration of this storm (74.5 hours) was much longer than 24 hours. The NDS test swale was severely damaged by runoff from a nearby construction site during this storm.

Table 2. Summary statistics for storm events measured during water year 2008.

	Minimum	Median	Maximum
Precipitation total (inches) [a]	0.02	0.22	8.05
Storm duration (hours)	0.75	10	82.75
Antecedent dry period (hours)	12.75	44.75	623.5
Average intensity (inches/hour)	0.002	0.02	0.15
Maximum intensity (inches/15 minutes)	0.02	0.03	0.23

[a] Storm events are defined as precipitation depths of 0.01 inches or greater and a period of 12 hours or greater with no precipitation between each event.

The median storm duration for all storm events was 10 hours, and the range was 0.75 to 82.75 hours. Similarly, the median storm antecedent dry period was 44.75 hours, and the range was 12.75 to 623.5 hours. The storm with the highest average intensity (0.15 inches/hour) began on November 26, 2007, and lasted only 2.5 hours. The storm with the highest maximum intensity (0.23 inches/15 minutes) began on June 6, 2008, and lasted 6 hours.

In general, water year 2008 was slightly drier than normal based on analyses performed by the National Weather Service (2008) using data from Seattle-Tacoma International Airport (Sea-Tac Airport). For example, the precipitation total for water year 2008 from Sea-Tac was 34.05 inches, whereas the historical average is approximately 37.07 inches. The precipitation total for water year 2008 at High Point station RG1 was 37.64 inches.

Discharge Data

Discharge monitoring at stations D2 and D3 was suspended on June 26, and August 2, 2008, respectively. The available raw discharge data that were collected from each station during water year 2008 are provided in Figure 6. (To aid in the interpretation of these data, Figure 6 also presents daily precipitation totals from station RG1.) Data from these two stations for individual storm events (including total flow volume, maximum discharge rate, and flow duration) are summarized in Appendix D (Table D-2). More general summary statistics computed from these data are provided in Table 3. The forms that were completed in conjunction with routine quality assurance audits of these data are provided in Appendix E, and the results from the formal verification and validation review of these data are summarized in Appendix B.

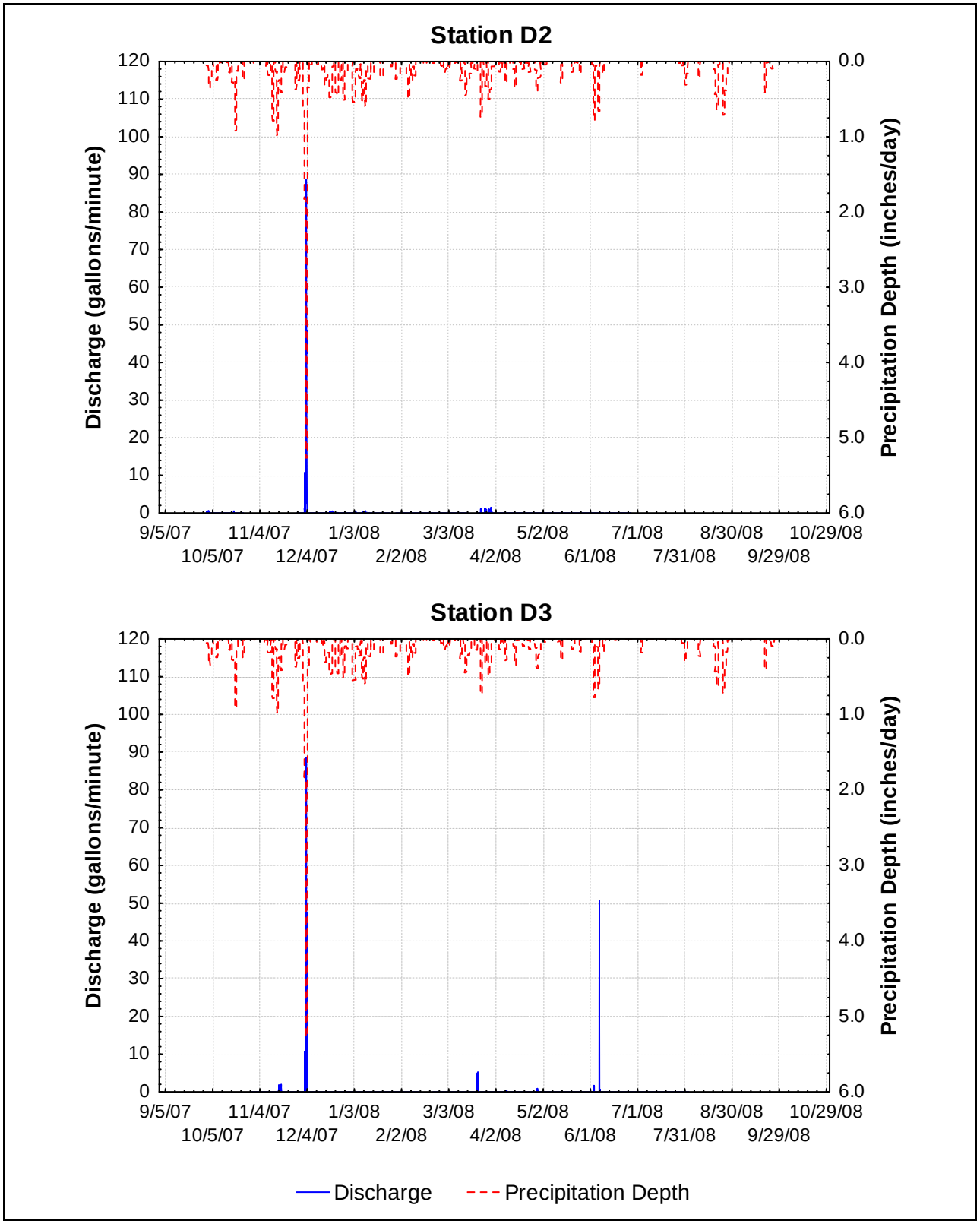

Figure 6. Discharge measured at stations D2 and D3 for the High Point Phase I Block-Scale Monitoring project during water year 2008.

Table 3. Summary statistics for flow events measured at stations D2 and D3 during water year 2008.

		Minimum	Median	Maximum
Station D2	Peak discharge (gallons/min)	0.07	0.54	88.6
	Flow volume (gallons)	6.30	76.7	50,300
	Flow duration (hours)	0.25	3.25	38.5
Station D3	Peak discharge (gallons/min)	0.89	1.94	88.6
	Flow volume (gallons)	42.5	248	42,300
	Flow duration (hours)	1.25	3.75	24.3

Excluding periods when no data were collected due to equipment malfunction or the suspension of monitoring, discharge data were collected over 69 storm events at station D2 (Appendix D, Table D-2). However, stormwater discharges from the underdrain pipe associated with station D2 were observed only during 17 of these events. The largest discharge was measured during the December 1, 2007, storm event. The peak discharge rate measured at station D2 during this event was 88.6 gallons per minute (gal/min), and the total flow volume was 50,300 gallons. Peak discharge rates measured during the other 16 storm events at station D2 were extremely low in comparison, with a median of 0.51 gal/min and a range from 0.07 to 1.48 gal/min. Discharge rates this low are difficult to measure accurately with the equipment used in this study. Total flow volumes during these 16 events were also relatively insignificant (median = 76.4 gallons; range = 6.3 to 239 gallons).

Discharge data were collected over 81 storm events at station D3 (Appendix D, Table D-2). However, stormwater discharges from the underdrain pipe associated with station D3 were only observed during seven of these events. Similar to station D2, the largest discharge was measured during the December 1, 2007, storm event. The peak discharge rate measured at station D3 during this event was 88.6 gal/min, and the total flow volume was 42,300 gallons. A relatively high peak discharges rate (50.7 gal/min) was also measured during a storm event that began on June 6, 2008, and produced 0.66 inches of precipitation in a 9-hour period. The flow volume measured at station D3 during this event was 3,254 gallons. Peak discharge rates measured during the other five storm events at station D3 were near the lower threshold (i.e., 1 gal/min) for accurate measurement using the equipment used in this study. For example, peak discharge rates for these five storm events ranged from 0.89 to 5.16 gal/min, with a median of 0.51 gal/min. Total flow volumes during these five events were also relatively small (median = 231 gallons; range = 42.5 to 4,600 gallons).

In general, these data indicate that relatively insignificant quantities of stormwater were discharged from the NDS test swale's underdrain system during storm events with precipitation totals less than the 6-month, 24-hour, and 2-year, 24-hour design storms for water quality and flow control, respectively. Except for those measured during the December 1, 2007, storm event, flow volumes and peak discharge rates in the underdrain system also remained fairly low even when measured precipitation totals exceeded the corresponding thresholds for these design storms.

After similar observations were made during water year 2007 (Herrera 2008), records from the construction and design phase of the project were examined to determine whether native soil characteristics are influencing the low discharge rates from the underdrain system of the NDS test swale. The results from this review indicated that relatively impermeable soils (i.e., glacial till and silty fine sand/fine sandy silt) underlie much of the High Point neighborhood (SvR Design 2002). However, relatively permeable soils (i.e., gravelly sand/sandy gravel and slightly fine to medium sand) can be found in the immediate vicinity of the NDS test swale. Rapid infiltration of stormwater from the gravel drain layer of the test swale (Figure 2) into these soils likely explains the lack of significant discharge from the underdrain system.

Water Level Data

The raw water level data from station WL1 are summarized graphically in Figure 7 for water year 2008. (To aid in the interpretation of these data, Figure 7 also shows daily precipitation totals from station RG1.) Data from station WL1 for individual storm events (including average water depth, maximum water depth, and ponding duration) are summarized in Appendix D (Table D-3). The forms that were completed in conjunction with routine quality assurance audits of these data are provided in Appendix E, and the results from the formal verification and validation review process are summarized in Appendix B.

Excluding periods when no data were collected due to equipment malfunctions, water level data were collected at station WL1 over 96 storm events (see Appendix D, Table D-3). Ponding occurred during 58 of these events, with substantial ponding (i.e., more than 2 inches) during 29 of these events. This represents a substantial increase in the frequency of ponding within the swale relative to water year 2007. For example, out of the 83 storm events that were monitored during water year 2007 at station WL1, ponding was observed during only 7 events, with substantial ponding during only one of these events (Herrera 2008).

As noted above, two factors likely contributed to this pattern in the data. First, field observations indicated severe damage to the NDS test swale due to construction-related runoff during the December 1, 2007, storm event. Sediment deposited with this runoff likely decreased surface infiltration rates and contributed to increased ponding in the NDS test swale during water year 2008 relative to water year 2007. Second, the drainage basin that contributes to the NDS test swale expanded by 15 to 30 percent over the spring and summer of 2007 due to new roadway and housing construction for Phase II of the High Point redevelopment project. Runoff from these areas subsequently increased the amount of stormwater entering the NDS test swale during any given storm event relative to conditions in water year 2007. This change likely also contributed to the increased ponding observed in the NDS test swale during water year 2008.

Despite the increased frequency of ponding during water year 2008, water levels within the NDS test swale exceeded the depth threshold (13.32 inches) that results in a discharge to the overflow drain on only three occasions. The first occasion was during a storm event that began on November 17, 2007, and produced 0.41 inches of precipitation over a 6-hour period. The second

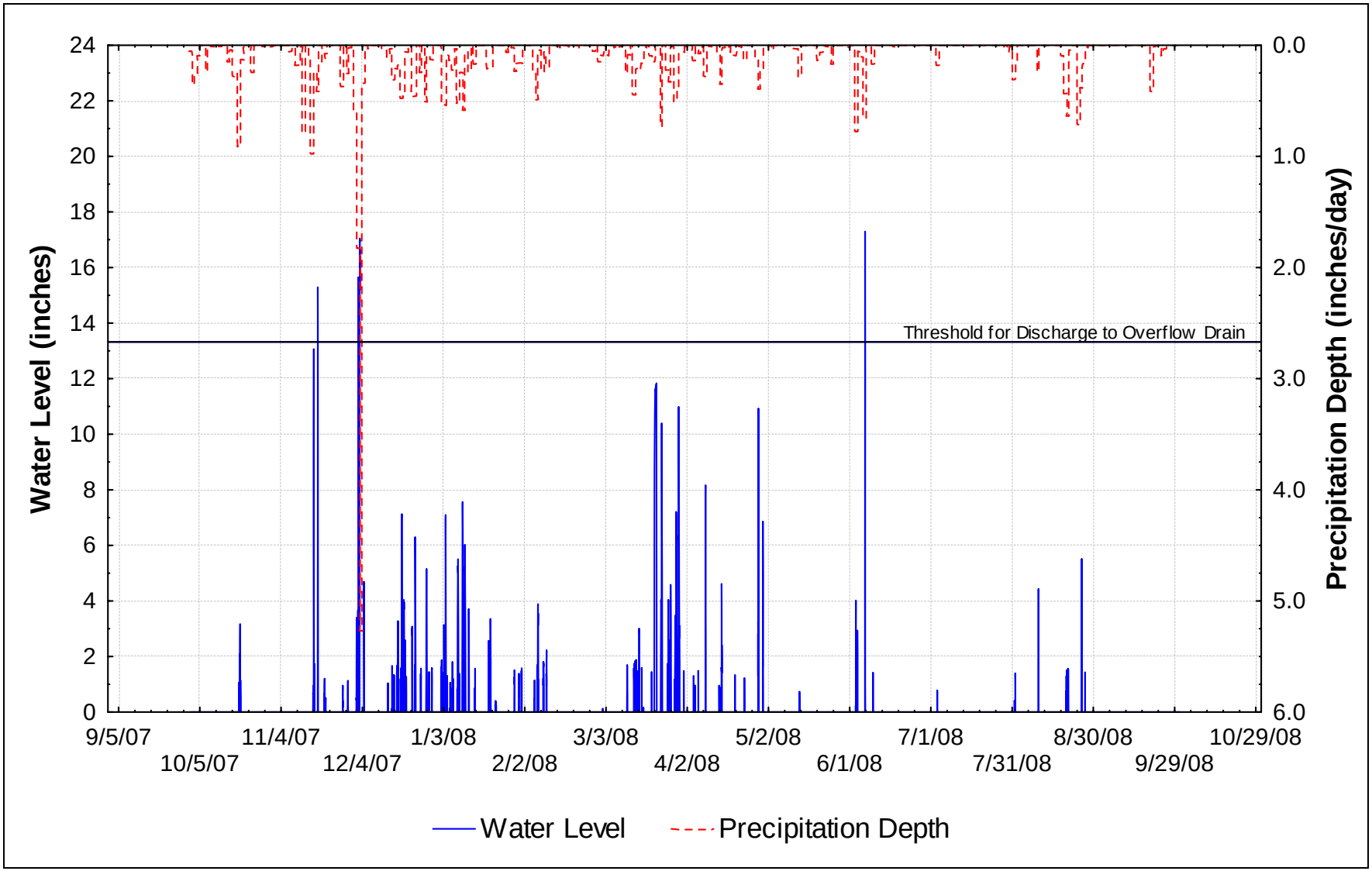

Figure 7. Water level measured at station WL1 for the High Point Phase I Block-Scale Monitoring project during water year 2008.

occasion was during the December 1, 2007, storm event. Due to heavy flooding during this event, the data logger associated with station WL1 was severely damaged; therefore, only a partial record of water levels is available. Based on this incomplete data record, water levels measured at station WL1 reached a depth of at least 17.3 inches during this event. The third occasion of a discharge to the overflow drain occurred was during a storm event that began on June 6, 2008, and produced 0.66 inches of precipitation over a 9-hour period. The highest measured water level at station WL1 during this event was 17.3 inches.

Conclusions

The major conclusions from the monitoring data collected during water year 2008 for the High Point Phase I Block-Scale Monitoring project are summarized below.

- Continuous hydrologic data collected during water year 2008 indicated that precipitation totals for four storm events exceeded the threshold corresponding to the 6-month, 24-hour design storm. The precipitation total for one storm also exceeded the threshold corresponding to the 2-year, 24-hour design storm. However, the total duration of all of these storms was longer than 24 hours.

- In general, the NDS test swale effectively treated all runoff from storm events with precipitation totals less than the 6-month, 24-hour, and 2-year, 24-hour design storms for water quality and flow control, respectively. Except for the December 1, 2007, storm event, flow volumes and peak discharge rates measured in the underdrain system also remained fairly low even when measured precipitation totals exceeded the corresponding thresholds for these design storms. The low discharge rates observed from the underdrain system of the test swale are likely influenced by underlying native soils that are relatively permeable (i.e., gravelly sand/sandy gravel and slightly fine to medium sand).

- The frequency of ponding within the NDS test swale increased markedly in water year 2008 relative to water year 2007 due to a combination of factors. Most importantly, field observations indicated that the NDS test swale was severely damaged by construction-related runoff during the December 1, 2007, storm event. Sediment deposited with this runoff likely decreased surface infiltration rates and contributed to the increased ponding in the NDS test swale during water year 2008. Additionally, the drainage basin contributing to the NDS test swale expanded due to new roadway and housing construction that occurred over the spring and summer of 2007. Because of this increase in contributing basin area, the rainfall/runoff relationship for the NDS test swale changed between water years 2008 and 2007. This change likely also contributed to the increased ponding observed in the NDS test swale during water year 2008.

References

Herrera. 2007a. Quality Assurance Project Plan: High Point Phase I Block Scale Monitoring. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. August 13, 2007.

Herrera. 2007b. Data Report: First Controlled Infiltration Test for the High Point Phase I Block Scale Monitoring Project. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. April 10, 2007.

Herrera. 2007c. Data Report: Second Controlled Infiltration Test for the High Point Phase I Block Scale Monitoring Project. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. May 24, 2007.

Herrera. 2008. Water Year 2007 Data Report: High Point Phase I Block Scale Monitoring Project. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. April 4, 2008.

Herrera and R.W. Beck. 2004. Hydrologic Modeling for High Point Revitalization, Seattle, Washington. Appendix C of High Point Drainage Plan Report prepared by SvR Design Company. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., and R.W. Beck, Seattle, Washington. May 5, 2004.

National Weather Service. 2008. Water Year 2008 Climate Charts for Seattle-Tacoma Airport. Obtained February 2, 2009, from organization website: <http://www.wrh.noaa.gov/climate/yeardisp.php?stn=KSEA&wfo=sew&year=2007&span=Water+Year>.

SPU. 2008. Phase I Municipal Stormwater NPDES Permit, Section S8F, Stormwater Treatment Best Management Practice Evaluation; Quality Assurance Project Plan, Biofiltration Swales. Seattle Public Utilities. Revision: R3D1 (Draft). August 15, 2008.

SvR Design. 2002. Soil map prepared for Phase I of the High Point neighborhood redevelopment project. Prepared for Seattle Public Utilities by SvR Design Company, Seattle, Washington. June 27, 2002.

APPENDIX A

Data Processing Procedures for DataGator Flow Metering Systems

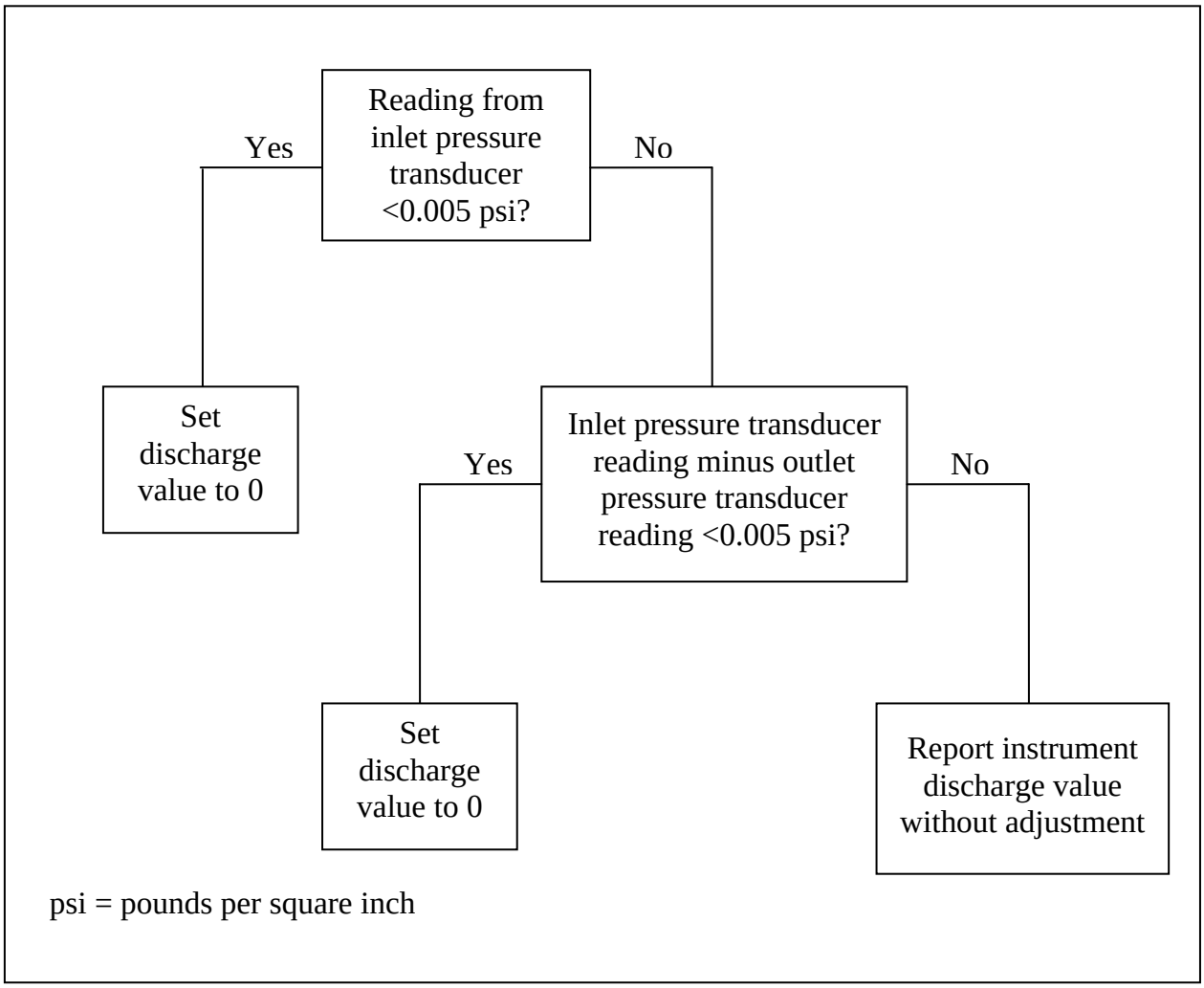

Figure A-1. Data processing procedures for DataGator flow metering systems installed at stations D2 and D3 for the High Point Phase I Block-Scale Monitoring project.

APPENDIX B

Hydrologic Data Validation Review Memorandum

Herrera Environmental Consultants, Inc.

Memorandum

To	Project File 06-03304-050
From	Elizabeth Woodcock and John Lenth, Herrera Environmental Consultants
Date	February 18, 2009
Subject	Water Year 2008 Hydrologic Data Validation Review for the High Point Phase I Block-Scale Monitoring Project

This memorandum presents the results from a quality assurance review of the continuous hydrologic monitoring data that were collected for the High Point Phase I Block-Scale Monitoring project during water year 2008. This review specifically examined water level data from station WL1, precipitation data from station RG1, and discharge data from stations D2 and D3. Detailed descriptions of these stations and their associated monitoring equipment are provided in the quality assurance project plan (QAPP) that was prepared for the project (Herrera 2007).

As outlined in the QAPP, the goal of the data quality assurance review is to ensure that the data collected through this study are scientifically and legally defensible. To meet this goal, the collected hydrologic data were evaluated relative to specific measurement quality objectives (MQOs) that were defined in the QAPP for the following quality assurance measures: bias, representativeness, completeness, and comparability. Separate subsections below describe the MQOs for each quality assurance measure, the methods used to evaluate each MQOs, and the results from each evaluation.

Bias

Bias is the systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected measurement is different from the true value). Bias is assessed based on a comparison of monitoring equipment readings to an independently measured "true" value. As defined in the QAPP, the MQOs for discharge measurements is a difference of no more than 10 percent between the instrument reading and the independently measured value. For water level and precipitation depth measurements, the difference between the instrument reading and the independently measured value will be within 5 percent. For reference, Table B-1 shows the theoretical accuracy of hydrologic monitoring equipment to be used in for this project based on measurements that were made by the manufacturers under controlled conditions.

The specific MQOs for bias are assessed in the following subsections for water level data from station WL1, precipitation data from station RG1, and discharge data from stations D2 and D3.

Station WL1 Water Level Data

As noted above, the MQO for water level measurements at station WL1 is a difference of no more than 5 percent between the instrument's readings and an independently measured value. In order to ensure this objective was met, offset values were derived based on field observations and applied to the raw water level data to account for baseline drift over time. Field observations included documentation of dry conditions in the NDS test swale and independent measurements of stage from the installed staff gauge when water was present. New offset values were derived on at least a monthly basis from these observations. The actual offset values that were used to correct the raw water level data from station WL1 during water year 2008 are summarized in Table B-2 with the corresponding time spans.

Station RG1 Precipitation Data

As noted above, the MQO for precipitation measurements at station RG1 is a difference of no more than 5 percent between the instrument's readings and an independently measured true value. In this case, the true value is the factory specified volume that is required to trip either one of the two tipping buckets that are associated with the rain gauge installed at station RG1. To evaluate the MQO, field personnel made replicate measurements (10 for each tipping bucket, for a total of 20 measurements) of the actual volume required to trip the tipping buckets. Pursuant to the QAPP for the project (Herrera 2007), these measurements are to be made annually through the duration of the project. These replicate measurements were made on October 31, 2008, and the associated results are summarized in Table B-3.

Based on these measurements, the average volume required to trip the tipping buckets was 6.87 milliliters (mL). The percent difference between this value and the factory specified volume for tripping the tipping buckets (6.47 mL) was subsequently calculated based the following equation:

$$\%D = \frac{(M - T) \times 100\%}{T}$$

where:
- %D = percent difference
- M = measured value from instrument
- T = independently measured value

The result from this calculation (6.2 percent different) was just outside the specified MQO for bias. Therefore, raw precipitation data that were collected from station RG1 during water year 2008 were postprocessed to increase the measured precipitation depths by 6.2 percent.

Stations D2 and D3 Discharge Data

As noted above, the MQO for discharge measurements at stations D2 and D3 is a difference of no more than 10 percent between the instrument's readings and an independently measured value. In this case, the independently measured value is derived by making a manual discharge

measurement at each station. More specifically, a calibrated is bucket positioned to capture the discharge from the underdrains associated with each station. A stopwatch is then used to determine the time required to collect a known volume of water in the bucket. Pursuant to the QAPP for the project (Herrera 2007), these measurements are to be made twice annually.

However, field crews were only able to collect one set of measurements in the course of routine monitoring in water year 2008 because water was rarely observed to be discharging from the underdrains associated with stations D2 and D3. Specifically, the MQO was assessed using the method described above at station D2 on January 8, 2008. These data are summarized in Table B-4 and include the discharge rate from the flow monitoring equipment installed at station D2 and the manual measurement of discharge obtained from the calibrated bucket measurements. The percent difference between these values was subsequently calculated based on the equation described above for station RG1. The percent difference between these two measurements exceeded the MQO at 21.2 percent, which is outside the specified MQO for bias. However, it should be noted that flows at station D2 were extremely low when this measurement was made (<0.2 gal/min). According to the manufacturer, discharge rates below approximately 1 gal/min cannot be accurately quantified by the instrument installed at station D2 (Natarajan 2007). Therefore, the results from this calibration check cannot be used to establish the overall usability of the data.

Representativeness

Representativeness is the degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency, and sampling methods. To ensure the representativeness of the hydrologic data collected for this project, a test NDS swale was selected at the onset of the project with typical design features for the High Point project site. Furthermore, 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 for the target conditions of this study were obtained.

Based on comparisons of data collected during water years 2008 and 2007, and anecdotal observations made by field personnel during water year 2008, the test NDS swale selected for this study was severely damaged by construction-related runoff during the December 1, 2007, storm event. Because sediment deposited with this runoff likely decreased surface infiltration rates within the NDS test swale, it is no longer considered to represent the performance of other NDS swales on the High Point project site that were not similarly impacted by the storm. Therefore, SPU suspended monitoring of the NDS test swale at the end of water year 2008 and identified two new NDS test swales for monitoring in water year 2009. The specific monitoring procedures that will be used in connection with these new swales are detailed in a separate QAPP (SPU 2008) that was prepared to meet the monitoring goals identified above for this project and monitoring requirements identified in Seattle's Phase I Municipal Stormwater Permit (Phase I Permit).

Completeness

Completeness is the amount of valid data obtained from the measurement system. Completeness is assessed based on the occurrence of gaps that occurred in the data record for all monitoring equipment. The associated MQO is less than 5 percent of the total data record missing due to equipment malfunctions or other operational problems.

Table B-5 summarizes the percentage of missing data from each monitoring station relative to the anticipated amount that should have been collected during water year 2008 for stations WL1 and RG1. The percentage of missing data from stations D2 and D3 is relative to shortened periods of time due to the suspension of the monitoring at these two stations. Monitoring began at both stations on October 1, 2007, and extended through June 26, 2008, for station D2 and through August 2, 2008, for station D3. The specific flags that were assigned to the missing data are also summarized in Table B-5. (These data flags were derived from a list of codes provided by Seattle Public Utilities for use with the Hydstra database [see Table B-6]).

The data in Table B-5 indicate the goal identified above for completeness was met at all stations except D2 and D3. Stations D2 and D3 exceeded the associated MQO of 5 percent with 16.4 percent and 12.4 percent, respectively. At station D3, a majority of these data were lost over the period from October 1–29, due to an equipment malfunction that corrupted the monitoring data. Despite the removal of the associated data logger from the station for subsequent inspection by the manufacturer, these data could not be salvaged. However, it should be noted that only one storm of significant size (1.57 inches in 79.5 hours) occurred during that time period. At station D3, a significant portion of the lost data was from October 24 through November 27, also due to an equipment malfunction. However, only one storm of considerable size (1.36 inches in 46.0 hours) was missed during this period. Due to these considerations, the gaps in the data record for stations D2 and D3 are not considered to have a significant impact on the overall usability of the data.

Comparability

Comparability is the ability to compare data from the current project to data from other similar projects, regulatory requirements, and historical data. The goal of data comparability was met by using standard units of measurement and reporting conventions in the data report that was prepared for water year 2008. For example, precipitation totals from station RG1 were reported in inches, flow volumes and discharge rates from stations D2 and D3 were reported in gallons and gallons per minute, respectively, and water level data from station WL1 were reported in inches. Summary statistics computed from these data were also presented in standardized tables and figures within the data report to facilitate their comparisons to other data sets with relative ease.

References

Herrera. 2007. Quality Assurance Project Plan: High Point Phase I Block Scale Monitoring. Draft. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Seattle, Washington. September 13, 2007.

Natarajan, Raj. 2007. Personal communication (telephone conversation with John Lenth, Herrera Environmental Consultants, Inc., Seattle, Washington, concerning low level pressure transducer readings and lower threshold for instrument accuracy). Renaissance Instruments, Round Rock, Texas. December 10, 2007.

SPU. 2008. Phase I Municipal Stormwater NPDES Permit, Section S8F, Stormwater Treatment Best Management Practice Evaluation; Quality Assurance Project Plan, Biofiltration Swales. Seattle Public Utilities. Revision: R3D1 (Draft). August 15, 2008.

Table B-1. Hydrologic monitoring equipment accuracy based on manufacturers' specifications.

Monitoring Equipment	Measurement Type	Accuracy
DataGator	Discharge	Open channel: ±3 percent [a] Full pipe: ±3 percent [a] Full pipe below transition: ±10 percent [a] Full pipe below transition: ±5 percent [a]
Campbell Scientific CS445-L submersible pressure transducer	Water level	±0.1% of full span or ±0.01 feet
Hydrologic Services TB3 tipping bucket rain gauge	Precipitation depth	±2% for rainfall intensities ranging from 1 to 28 inches/hour

[a] Accuracy is expressed as a percentage of maximum discharge.

Table B-2. Offset values used to correct raw water level data from station WL1 during water year 2008.

Start Date and Time	End Date and Time	Offset Value (ft)
10/1/07 0:00	10/1/07 9:30	NA - data gaps
10/1/07 9:45	12/3/07 5:00	0.040
12/3/07 5:15	12/4/07 11:45	NA - data gaps
12/4/07 11:56	12/31/2007 23:56	0.095
1/1/2008 0:11	1/14/08 23:56	0.096
1/15/08 0:11	1/20/08 23:41	0.104
1/20/08 23:56	1/22/08 2:26	0.115
1/22/08 2:41	1/22/08 11:41	0.157
1/22/08 11:56	1/23/08 12:56	0.125
1/23/08 13:11	2/1/08 0:11	0.115
2/1/08 0:26	3/20/08 19:59	0.100
3/20/08 20:14	3/21/08 17:14	NA - data gaps
3/21/08 17:29	4/30/08 23:59	0.100
5/1/08 0:14	5/31/08 23:59	0.095
6/1/08 0:14	6/30/08 23:59	0.090
7/1/08 0:14	8/31/08 0:14	0.085
8/31/08 0:29	9/30/08 23:59	0.086

Table B-3. Results from rain gauge calibration measurements made at station RG1 on October 31, 2008.

Replicate	Tipping Bucket No.	Volume to Required to Trip Tipping Bucket (mL)
1	1	6.6
1	2	7.0
2	1	6.8
2	2	6.5
3	1	6.7
3	2	7.2
4	1	7.1
4	2	7.1
5	1	6.8
5	2	6.9
6	1	7.2
6	2	7.0
7	1	6.9
7	2	6.5
8	1	6.7
8	2	6.7
9	1	7.1
9	2	6.9
10	1	7.0
10	2	6.7
Average:		6.9

Table B-4. Comparison of manual and instrument discharge readings from station D2.

Date	Time	Discharge from Manual Measurement (gpm)	Discharge from Instrument (gpm)	Difference between Manual and Instrument Readings (%)
1/8/08	10:03	0.17	0.134	21.44

gpm = gallons per minute.

Table B-5. Summary statistics for missing data in water year 2008 for stations RG1, D2, D3, and WL1.

Station RG1	Total missing data: 0.0%
Station D2 [a]	Total missing data: 16.2% No data (Hydstra code 255): 16.2%
Station D3 [b]	Total missing data: 12.4% No data (Hydstra code 255): 12.4%
Station WL1	Total missing data: 0.6% No data (Hydstra code 255): 0.35% Suspect data that requires further analysis (Hydstra code 8): 0.24%

See Table B-6 for a complete list of Hydstra codes.
[a] Total data for this instrument were from 10/1/07 through 6/26/08, or 270 days.
[b] Total data for this instrument were from 10/1/07 through 8/2/08, or 306 days.

Table B-6. Data quality assurance codes for use with Seattle Public Utilities Hydstra database.

Code	Description
1	Good continuous records
2	Good quality edited data
3	Data transposed from a nearby rain gauge
5	Valid data that has undergone screening level review
6	Provisional and subject to change - data not yet reviewed
7	Valid data adjusted for calibration
8	Suspect data that requires further analysis
26	Good daily read records
27	Time corrected
28	Data valid based on reviewer's comment
29	Transposed suspect data
30	Irregular time rate data - weekly/monthly read
31	Transposed missing data
32	Transposed reject data
51	Data interpolated between points 5-minute interval
75	Interpolation
76	Reliable interpolation
77	Correlation with other station - same variable
79	Records partly estimated
80	Accumulated
81	Wet day within accumulated rainfall period
82	Linear interpolation across gap in records
90	Excellent (within 2% of actual discharge)
91	Good (within 5% of actual discharge)
92	Fair (within 8% of actual discharge)
93	Poor (within 10% of actual discharge)
99	Downstream control failed
100	Suspected downstream blockage - level not corrected
101	Velocity data out of bounds - replaced with estimated velocity
102	Level too low for accurate velocity reading
103	Level too low for accurate level reading
104	Records estimated
105	Data transposed from different time period - same gauge
106	Downstream blockage caused level to rise - correct level estimated
107	Sensor not completely anchored
108	Turbulent flow causing significant variation in current meter revolutions

Table B-6 (continued). Data quality assurance codes for use with Seattle Public Utilities Hydstra database.

Code	Description
109	Significant variation between velocities of adjacent flow measurement cells
110	Abnormal velocity distributions
111	Very slow velocities
112	More than 10% of flow in some sections
113	Poor flow measurement cross-section
114	Angular flow through flow measurement cross-section
115	Negative depth at 0 velocity - depth set to 0
116	Velocity negative at depth below sensor limits - velocity set to 0
117	Velocity negative - sensor error - velocity set to 0
118	Velocity estimated based on velocity rating
140	Data not yet checked
141	Data reviewed for QA/QC by consultant
150	Rating table extrapolated due to inadequate gauging information
151	Data missing
152	Data exceeds control limits
160	Bad data - not usable
161	Maximum recordable level exceeded
162	Rating table exceeded
163	Logger adjusted incorrectly - human error
164	Gage unstable immediately after installation
170	Data may be salvageable, but requires further review
201	Data not recorded
202	Power failure
203	Data missing because input sensor damaged or not connected
204	Not enough particles in water for sensor to read velocity or level
248	Reserved
249	Data not measured
250	Data overflow
251	Record gap error
252	Record deleted
253	Point created for comment
254	Power failure or clock altered; no data recorded
255	No data

APPENDIX C

Photographic Documentation

High Point Phase I Block-Scale Monitoring
Flooding Observed during the December 1, 2007, Storm Event
Photographic Log

Photo Number	Photo Description
1	Runoff from construction site adjacent to NDS test swale.
2	Runoff from construction site adjacent to NDS test swale.
3	Runoff from construction site adjacent to NDS test swale.
4	Construction related runoff in NDS test swale.
5	Construction related runoff in NDS test swale.
6	Construction related runoff in NDS test swale.
7	Overflow from the NDS test swale.
8	Runoff from construction site entering the NDS test swale.


1


2


3


4


5


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APPENDIX D

Summary Statistics for Hydrologic Monitoring Data from Individual Storm Events

Table D-1. Summary statistics for precipitation data collected at station RG1 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station RG1 Storm Duration (hours)	Station RG1 Storm Antecedent Dry Period (hours)	Station RG1 Storm Precipitation Depth (inches)	Station RG1 Maximum Precipitation Intensity (inches/15-minutes)	Station RG1 Average Precipitation Intensity (inches/hour)
1	10/1/07 21:15	10/2/07 11:45	14.8	21.3	0.40	0.02	0.03
2	10/3/07 11:15	10/4/07 11:00	24.0	23.5	0.35	0.13	0.01
3	10/7/07 0:00	10/7/07 21:00	21.3	60.8	0.24	0.10	0.01
4	10/9/07 16:30	10/10/07 4:00	11.8	43.8	0.02	0.01	0.00
5	10/15/07 8:45	10/15/07 22:00	13.5	124.5	0.15	0.01	0.01
6	10/16/07 10:30	10/16/07 12:15	2.0	12.8	0.04	0.01	0.02
7	10/17/07 4:30	10/20/07 11:45	79.5	17.3	1.57	0.18	0.02
8	10/21/07 9:00	10/21/07 9:30	0.8	21.5	0.02	0.01	0.03
9	10/24/07 8:30	10/24/07 19:30	11.3	71.3	0.24	0.04	0.02
10	11/7/07 2:30	11/7/07 12:15	10.0	318.8	0.05	0.01	0.01
11	11/9/07 1:30	11/9/07 7:30	6.3	44.8	0.11	0.02	0.02
12	11/9/07 21:00	11/10/07 4:30	7.8	13.8	0.25	0.03	0.03
13	11/12/07 5:15	11/12/07 14:00	9.0	48.5	0.79	0.05	0.09
14	11/14/07 18:45	11/16/07 16:30	46.0	52.8	1.36	0.07	0.03
15	11/17/07 10:30	11/17/07 16:15	6.0	30.0	0.41	0.07	0.07
16	11/19/07 1:00	11/20/07 10:15	33.5	35.8	0.22	0.03	0.01
17	11/26/07 16:45	11/26/07 19:00	2.5	151.5	0.37	0.06	0.15
18	11/28/07 14:30	11/29/07 8:00	17.8	43.5	0.28	0.02	0.02
19	12/1/07 15:00	12/4/07 17:15	74.5	66.3	8.05	0.14	0.11
20	12/6/07 7:30	12/6/07 9:15	2.0	40.8	0.03	0.01	0.02
21	12/10/07 0:45	12/10/07 2:30	2.0	89.0	0.03	0.01	0.02
22	12/13/07 11:00	12/13/07 18:30	7.8	82.0	0.11	0.02	0.01
23	12/14/07 21:45	12/17/07 6:00	56.5	32.5	0.73	0.03	0.01
24	12/18/07 3:00	12/20/07 7:00	52.3	22.0	1.00	0.05	0.02
25	12/22/07 5:00	12/22/07 12:45	8.0	47.5	0.41	0.04	0.05
26	12/23/07 7:45	12/23/07 18:45	11.3	19.5	0.46	0.04	0.04
27	12/25/07 12:45	12/25/07 18:00	5.5	42.5	0.24	0.02	0.04
28	12/27/07 8:30	12/28/07 0:00	15.8	38.8	0.52	0.03	0.03
29	12/28/07 12:30	12/28/07 17:45	5.5	14.5	0.08	0.02	0.02
30	12/29/07 15:30	12/29/07 18:00	2.8	23.0	0.13	0.03	0.05
31	1/2/08 2:30	1/5/08 13:00	82.8	81.8	1.32	0.08	0.02
32	1/6/08 5:30	1/7/08 4:00	22.8	16.5	0.25	0.03	0.01
33	1/8/08 1:15	1/8/08 20:15	19.3	23.8	0.52	0.02	0.03
34	1/9/08 21:30	1/11/08 6:00	32.8	25.5	0.89	0.04	0.03
35	1/12/08 6:30	1/12/08 15:00	8.8	25.5	0.23	0.05	0.03
36	1/14/08 12:30	1/14/08 16:45	4.5	51.0	0.17	0.04	0.04
37	1/19/08 17:30	1/20/08 8:45	15.5	121.3	0.42	0.12	0.03
38	1/26/08 14:00	1/26/08 19:30	5.8	150.0	0.06	0.02	0.01
39	1/28/08 22:30	1/29/08 7:15	9.0	54.8	0.25	0.02	0.03
40	1/30/08 5:30	1/31/08 21:45	40.5	23.0	0.32	0.02	0.01
41	2/5/08 1:00	2/5/08 18:30	17.8	99.8	0.23	0.03	0.01
42	2/6/08 14:15	2/7/08 2:45	12.8	22.8	0.53	0.04	0.04
43	2/8/08 16:15	2/9/08 2:15	10.3	38.8	0.25	0.02	0.02
44	2/9/08 20:15	2/10/08 12:00	16.0	21.0	0.24	0.03	0.02
45	2/15/08 18:30	2/15/08 19:30	1.3	132.3	0.02	0.01	0.02
46	2/22/08 2:45	2/22/08 3:45	1.3	152.0	0.02	0.01	0.02
47	2/27/08 9:00	2/27/08 10:00	1.3	212.3	0.05	0.02	0.04
48	2/29/08 15:45	3/1/08 19:45	28.3	54.3	0.24	0.04	0.01
49	3/3/08 8:15	3/3/08 13:15	5.3	36.3	0.10	0.01	0.02
50	3/6/08 18:15	3/6/08 19:15	1.3	77.8	0.02	0.01	0.02
51	3/10/08 2:15	3/11/08 10:15	32.3	79.8	0.34	0.06	0.01

Table D-1. Summary statistics for precipitation data collected at station RG1 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station RG1 Storm Duration (hours)	Station RG1 Storm Antecedent Dry Period (hours)	Station RG1 Storm Precipitation Depth (inches)	Station RG1 Maximum Precipitation Intensity (inches/15-minutes)	Station RG1 Average Precipitation Intensity (inches/hour)
52	3/13/08 6:00	3/14/08 14:45	33.0	47.5	0.66	0.03	0.02
53	3/15/08 4:15	3/15/08 5:45	1.8	13.8	0.21	0.05	0.12
54	3/15/08 19:15	3/16/08 5:30	10.5	13.8	0.13	0.03	0.01
55	3/16/08 18:00	3/17/08 8:15	14.5	13.3	0.06	0.01	0.00
56	3/19/08 17:30	3/19/08 20:45	3.5	69.8	0.10	0.02	0.03
57	3/20/08 16:15	3/20/08 21:15	5.3	19.5	0.15	0.03	0.03
58	3/23/08 4:30	3/23/08 16:15	12.0	55.0	0.73	0.04	0.06
59	3/25/08 14:00	3/26/08 6:00	16.3	48.0	0.39	0.04	0.02
60	3/26/08 18:45	3/26/08 21:00	2.5	13.0	0.16	0.03	0.06
61	3/28/08 4:15	3/28/08 22:30	18.5	31.5	0.50	0.05	0.03
62	3/29/08 13:45	3/30/08 2:30	13.0	15.3	0.44	0.04	0.03
63	3/31/08 17:00	3/31/08 17:30	0.8	38.5	0.06	0.03	0.08
64	4/4/08 6:15	4/4/08 20:00	14.0	84.8	0.14	0.02	0.01
65	4/5/08 19:00	4/6/08 2:15	7.5	33.0	0.08	0.02	0.01
66	4/6/08 18:30	4/7/08 5:15	11.0	16.5	0.02	0.01	0.00
67	4/8/08 7:15	4/8/08 19:15	12.3	52.8	0.28	0.05	0.02
68	4/13/08 16:15	4/13/08 20:00	4.0	117.3	0.10	0.01	0.02
69	4/14/08 11:15	4/14/08 20:30	9.5	16.3	0.35	0.03	0.04
70	4/15/08 9:15	4/15/08 19:00	10.0	14.3	0.02	0.01	0.00
71	4/17/08 18:45	4/18/08 19:30	25.0	70.0	0.07	0.02	0.00
72	4/19/08 9:45	4/19/08 15:45	6.3	28.5	0.10	0.02	0.02
73	4/22/08 21:45	4/23/08 14:45	17.3	78.0	0.16	0.03	0.01
74	4/27/08 15:45	4/28/08 9:00	17.5	107.5	0.51	0.08	0.03
75	4/29/08 21:15	4/30/08 6:30	9.5	37.8	0.22	0.06	0.02
76	5/3/08 11:30	5/3/08 14:00	2.8	84.5	0.04	0.01	0.02
77	5/11/08 19:45	5/12/08 0:45	5.3	199.5	0.06	0.02	0.01
78	5/13/08 9:00	5/13/08 13:00	4.3	32.3	0.28	0.04	0.06
79	5/20/08 3:15	5/20/08 12:00	9.0	158.5	0.14	0.04	0.02
80	5/21/08 18:30	5/21/08 22:15	4.0	34.5	0.06	0.01	0.02
81	5/25/08 0:45	5/25/08 6:30	6.0	75.5	0.17	0.05	0.03
82	5/31/08 15:30	5/31/08 16:00	0.8	154.5	0.02	0.01	0.03
83	6/2/08 21:30	6/4/08 6:30	33.3	206.8	0.87	0.05	0.03
84	6/5/08 9:30	6/5/08 17:45	8.5	30.8	0.11	0.02	0.01
85	6/6/08 8:00	6/6/08 16:45	9.0	20.5	0.66	0.23	0.07
86	6/9/08 6:45	6/9/08 19:30	13.0	62.3	0.17	0.04	0.01
87	6/10/08 9:00	6/10/08 9:30	0.8	17.8	0.02	0.01	0.03
88	7/3/08 5:00	7/3/08 9:00	4.3	547.8	0.18	0.07	0.04
89	7/27/08 5:00	7/27/08 5:30	0.8	572.5	0.02	0.01	0.03
90	7/29/08 8:45	7/29/08 20:30	12.0	623.5	0.05	0.01	0.00
91	7/31/08 17:00	8/1/08 5:30	12.8	48.3	0.47	0.06	0.04
92	8/9/08 4:45	8/9/08 19:15	14.8	191.8	0.23	0.13	0.02
93	8/18/08 10:00	8/18/08 16:00	6.3	208.3	0.10	0.02	0.02
94	8/19/08 20:30	8/21/08 3:45	31.5	30.0	1.12	0.10	0.04
95	8/24/08 12:15	8/24/08 21:30	9.5	81.0	0.71	0.07	0.07
96	8/25/08 16:15	8/25/08 19:00	3.0	18.8	0.38	0.22	0.13
97	8/26/08 21:30	8/27/08 5:45	8.5	27.8	0.19	0.05	0.02
98	9/20/08 6:30	9/21/08 0:00	17.8	582.8	0.42	0.03	0.02
99	9/24/08 12:30	9/25/08 16:45	28.5	90.5	0.13	0.03	0.00

[a] Individual storm event storm events are delineated based on a precipitation depth of 0.01 inches or greater, and a period of 12 hours or greater with no precipitation separating each event.
ND: no data

Table D-2. Summary statistics for discharge data collected at stations D2 and D3 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station D2 Peak Discharge (gallons/min)	Station D2 Storm Volume (gallons)	Station D2 Flow Duration (hours)	Station D3 Peak Discharge (gallons/min)	Station D3 Storm Volume (gallons)	Station D3 Flow Duration (hours)
1	10/1/07 21:15	10/2/07 11:45	0.6	107	3.8	ND	ND	ND
2	10/3/07 11:15	10/4/07 11:00	0.0	0.0	0.0	ND	ND	ND
3	10/7/07 0:00	10/7/07 21:00	0.0	0.0	0.0	ND	ND	ND
4	10/9/07 16:30	10/10/07 4:00	0.0	0.0	0.0	ND	ND	ND
5	10/15/07 8:45	10/15/07 22:00	0.0	0.0	0.0	ND	ND	ND
6	10/16/07 10:30	10/16/07 12:15	0.0	0.0	0.0	ND	ND	ND
7	10/17/07 4:30	10/20/07 11:45	0.5	43.4	1.5	ND	ND	ND
8	10/21/07 9:00	10/21/07 9:30	0.0	0.0	0.0	ND	ND	ND
9	10/24/07 8:30	10/24/07 19:30	ND	ND	ND	ND	ND	ND
10	11/7/07 2:30	11/7/07 12:15	ND	ND	ND	0.0	0.0	0.0
11	11/9/07 1:30	11/9/07 7:30	ND	ND	ND	0.0	0.0	0.0
12	11/9/07 21:00	11/10/07 4:30	ND	ND	ND	0.0	0.0	0.0
13	11/12/07 5:15	11/12/07 14:00	ND	ND	ND	0.0	0.0	0.0
14	11/14/07 18:45	11/16/07 16:30	ND	ND	ND	1.8	264	5.5
15	11/17/07 10:30	11/17/07 16:15	ND	ND	ND	1.9	231	4.0
16	11/19/07 1:00	11/20/07 10:15	ND	ND	ND	0.0	0.0	0.0
17	11/26/07 16:45	11/26/07 19:00	ND	ND	ND	0.0	0.0	0.0
18	11/28/07 14:30	11/29/07 8:00	0.0	0.0	0.0	0.0	0.0	0.0
19	12/1/07 15:00	12/4/07 17:15	88.6	50,302	38.5	88.6	42,303	24.3
20	12/6/07 7:30	12/6/07 9:15	0.0	0.0	0.0	0.0	0.0	0.0
21	12/10/07 0:45	12/10/07 2:30	0.0	0.0	0.0	0.0	0.0	0.0
22	12/13/07 11:00	12/13/07 18:30	0.0	0.0	0.0	0.0	0.0	0.0
23	12/14/07 21:45	12/17/07 6:00	0.0	0.0	0.0	0.0	0.0	0.0
24	12/18/07 3:00	12/20/07 7:00	0.5	76.7	4.5	0.0	0.0	0.0
25	12/22/07 5:00	12/22/07 12:45	0.1	14.7	3.5	0.0	0.0	0.0
26	12/23/07 7:45	12/23/07 18:45	0.1	6.3	1.5	0.0	0.0	0.0
27	12/25/07 12:45	12/25/07 18:00	0.0	0.0	0.0	0.0	0.0	0.0
28	12/27/07 8:30	12/28/07 0:00	0.1	11.6	2.8	0.0	0.0	0.0
29	12/28/07 12:30	12/28/07 17:45	0.0	0.0	0.0	0.0	0.0	0.0
30	12/29/07 15:30	12/29/07 18:00	0.0	0.0	0.0	0.0	0.0	0.0
31	1/2/08 2:30	1/5/08 13:00	0.3	78.2	8.5	0.0	0.0	0.0
32	1/6/08 5:30	1/7/08 4:00	0.0	0.0	0.0	0.0	0.0	0.0
33	1/8/08 1:15	1/8/08 20:15	0.2	44.1	5.3	0.0	0.0	0.0
34	1/9/08 21:30	1/11/08 6:00	0.5	104	11.8	0.0	0.0	0.0
35	1/12/08 6:30	1/12/08 15:00	0.1	11.6	2.8	0.0	0.0	0.0
36	1/14/08 12:30	1/14/08 16:45	0.0	0.0	0.0	0.0	0.0	0.0
37	1/19/08 17:30	1/20/08 8:45	0.0	0.0	0.0	0.0	0.0	0.0
38	1/26/08 14:00	1/26/08 19:30	ND	ND	ND	0.0	0.0	0.0
39	1/28/08 22:30	1/29/08 7:15	ND	ND	ND	0.0	0.0	0.0
40	1/30/08 5:30	1/31/08 21:45	0.0	0.0	0.0	0.0	0.0	0.0
41	2/5/08 1:00	2/5/08 18:30	0.0	0.0	0.0	0.0	0.0	0.0
42	2/6/08 14:15	2/7/08 2:45	0.0	0.0	0.0	0.0	0.0	0.0
43	2/8/08 16:15	2/9/08 2:15	0.0	0.0	0.0	0.0	0.0	0.0
44	2/9/08 20:15	2/10/08 12:00	0.0	0.0	0.0	0.0	0.0	0.0
45	2/15/08 18:30	2/15/08 19:30	0.0	0.0	0.0	ND	ND	ND
46	2/22/08 2:45	2/22/08 3:45	0.0	0.0	0.0	0.0	0.0	0.0
47	2/27/08 9:00	2/27/08 10:00	0.0	0.0	0.0	0.0	0.0	0.0
48	2/29/08 15:45	3/1/08 19:45	0.0	0.0	0.0	0.0	0.0	0.0
49	3/3/08 8:15	3/3/08 13:15	0.0	0.0	0.0	0.0	0.0	0.0
50	3/6/08 18:15	3/6/08 19:15	0.0	0.0	0.0	0.0	0.0	0.0
51	3/10/08 2:15	3/11/08 10:15	0.0	0.0	0.0	0.0	0.0	0.0
52	3/13/08 6:00	3/14/08 14:45	0.0	0.0	0.0	0.0	0.0	0.0

Table D-2. Summary statistics for discharge data collected at stations D2 and D3 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station D2 Peak Discharge (gallons/min)	Station D2 Storm Volume (gallons)	Station D2 Flow Duration (hours)	Station D3 Peak Discharge (gallons/min)	Station D3 Storm Volume (gallons)	Station D3 Flow Duration (hours)
53	3/15/08 4:15	3/15/08 5:45	ND	ND	ND	0.0	0.0	0.0
54	3/15/08 19:15	3/16/08 5:30	ND	ND	ND	0.0	0.0	0.0
55	3/16/08 18:00	3/17/08 8:15	ND	ND	ND	0.0	0.0	0.0
56	3/19/08 17:30	3/19/08 20:45	ND	ND	ND	0.0	0.0	0.0
57	3/20/08 16:15	3/20/08 21:15	ND	ND	ND	ND	ND	ND
58	3/23/08 4:30	3/23/08 16:15	1.2	190	3.3	0.0	0.0	0.0
59	3/25/08 14:00	3/26/08 6:00	1.3	76.2	1.3	0.0	0.0	0.0
60	3/26/08 18:45	3/26/08 21:00	1.0	101	2.0	0.0	0.0	0.0
61	3/28/08 4:15	3/28/08 22:30	1.1	112	2.3	0.0	0.0	0.0
62	3/29/08 13:45	3/30/08 2:30	1.5	239	5.3	0.0	0.0	0.0
63	3/31/08 17:00	3/31/08 17:30	0.0	0.0	0.0	0.0	0.0	0.0
64	4/4/08 6:15	4/4/08 20:00	0.0	0.0	0.0	0.0	0.0	0.0
65	4/5/08 19:00	4/6/08 2:15	0.0	0.0	0.0	0.0	0.0	0.0
66	4/6/08 18:30	4/7/08 5:15	0.0	0.0	0.0	0.0	0.0	0.0
67	4/8/08 7:15	4/8/08 19:15	0.0	0.0	0.0	0.0	0.0	0.0
68	4/13/08 16:15	4/13/08 20:00	0.0	0.0	0.0	0.0	0.0	0.0
69	4/14/08 11:15	4/14/08 20:30	0.0	0.0	0.0	0.0	0.0	0.0
70	4/15/08 9:15	4/15/08 19:00	0.0	0.0	0.0	0.0	0.0	0.0
71	4/17/08 18:45	4/18/08 19:30	0.0	0.0	0.0	0.0	0.0	0.0
72	4/19/08 9:45	4/19/08 15:45	0.0	0.0	0.0	0.0	0.0	0.0
73	4/22/08 21:45	4/23/08 14:45	0.0	0.0	0.0	0.0	0.0	0.0
74	4/27/08 15:45	4/28/08 9:00	0.0	0.0	0.0	0.9	42.5	1.3
75	4/29/08 21:15	4/30/08 6:30	0.0	0.0	0.0	0.0	0.0	0.0
76	5/3/08 11:30	5/3/08 14:00	0.0	0.0	0.0	0.0	0.0	0.0
77	5/11/08 19:45	5/12/08 0:45	0.0	0.0	0.0	0.0	0.0	0.0
78	5/13/08 9:00	5/13/08 13:00	0.0	0.0	0.0	0.0	0.0	0.0
79	5/20/08 3:15	5/20/08 12:00	0.0	0.0	0.0	0.0	0.0	0.0
80	5/21/08 18:30	5/21/08 22:15	0.0	0.0	0.0	0.0	0.0	0.0
81	5/25/08 0:45	5/25/08 6:30	0.0	0.0	0.0	0.0	0.0	0.0
82	5/31/08 15:30	5/31/08 16:00	0.0	0.0	0.0	0.0	0.0	0.0
83	6/2/08 21:30	6/4/08 6:30	0.0	0.0	0.0	1.7	189	2.3
84	6/5/08 9:30	6/5/08 17:45	0.0	0.0	0.0	0.0	0.0	0.0
85	6/6/08 8:00	6/6/08 16:45	0.5	6.8	0.3	50.7	3,254	3.5
86	6/9/08 6:45	6/9/08 19:30	ND	ND	ND	0.0	0.0	0.0
87	6/10/08 9:00	6/10/08 9:30	ND	ND	ND	0.0	0.0	0.0
88	7/3/08 5:00	7/3/08 9:00	ND	ND	ND	0.0	0.0	0.0
89	7/27/08 5:00	7/27/08 5:30	ND	ND	ND	0.0	0.0	0.0
90	7/29/08 8:45	7/29/08 20:30	ND	ND	ND	0.0	0.0	0.0
91	7/31/08 17:00	8/1/08 5:30	ND	ND	ND	0.0	0.0	0.0
92	8/9/08 4:45	8/9/08 19:15	ND	ND	ND	ND	ND	ND
93	8/18/08 10:00	8/18/08 16:00	ND	ND	ND	ND	ND	ND
94	8/19/08 20:30	8/21/08 3:45	ND	ND	ND	ND	ND	ND
95	8/24/08 12:15	8/24/08 21:30	ND	ND	ND	ND	ND	ND
96	8/25/08 16:15	8/25/08 19:00	ND	ND	ND	ND	ND	ND
97	8/26/08 21:30	8/27/08 5:45	ND	ND	ND	ND	ND	ND
98	9/20/08 6:30	9/21/08 0:00	ND	ND	ND	ND	ND	ND
99	9/24/08 12:30	9/25/08 16:45	ND	ND	ND	ND	ND	ND

[a] Individual storm event storm events are delineated based on a precipitation depth of 0.01 inches or greater, and a period of 12 hours or greater with no precipitation separating each event.
ND: no data

Table D-3. Summary statistics for water level data collected at station WL1 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station WL1 Average Water Depth (inches)	Station WL1 Maximum Water Depth (inches)	Station WL1 Ponding Duration (hours)
1	10/1/07 21:15	10/2/07 11:45	0.0	0.0	0.0
2	10/3/07 11:15	10/4/07 11:00	0.0	0.0	0.0
3	10/7/07 0:00	10/7/07 21:00	0.0	0.0	0.0
4	10/9/07 16:30	10/10/07 4:00	0.0	0.0	0.0
5	10/15/07 8:45	10/15/07 22:00	0.0	0.0	0.0
6	10/16/07 10:30	10/16/07 12:15	0.0	0.0	0.0
7	10/17/07 4:30	10/20/07 11:45	ND	ND	ND
8	10/21/07 9:00	10/21/07 9:30	0.0	0.0	0.0
9	10/24/07 8:30	10/24/07 19:30	0.0	0.0	0.0
10	11/7/07 2:30	11/7/07 12:15	0.0	0.0	0.0
11	11/9/07 1:30	11/9/07 7:30	0.0	0.0	0.0
12	11/9/07 21:00	11/10/07 4:30	0.0	0.0	0.0
13	11/12/07 5:15	11/12/07 14:00	0.0	0.0	0.0
14	11/14/07 18:45	11/16/07 16:30	2.4	13.1	10.0
15	11/17/07 10:30	11/17/07 16:15	6.5	15.3	5.0
16	11/19/07 1:00	11/20/07 10:15	0.7	1.2	1.3
17	11/26/07 16:45	11/26/07 19:00	ND	ND	ND
18	11/28/07 14:30	11/29/07 8:00	0.6	1.1	2.0
19	12/1/07 15:00	12/4/07 17:15	ND	ND	ND
20	12/6/07 7:30	12/6/07 9:15	0.0	0.0	0.0
21	12/10/07 0:45	12/10/07 2:30	0.0	0.0	0.0
22	12/13/07 11:00	12/13/07 18:30	0.6	1.0	1.0
23	12/14/07 21:45	12/17/07 6:00	1.3	3.3	12.3
24	12/18/07 3:00	12/20/07 7:00	2.3	7.1	24.3
25	12/22/07 5:00	12/22/07 12:45	2.0	3.1	4.0
26	12/23/07 7:45	12/23/07 18:45	3.2	6.3	10.0
27	12/25/07 12:45	12/25/07 18:00	1.1	1.6	3.0
28	12/27/07 8:30	12/28/07 0:00	3.0	5.2	7.8
29	12/28/07 12:30	12/28/07 17:45	0.7	1.5	1.8
30	12/29/07 15:30	12/29/07 18:00	1.2	1.6	1.8
31	1/2/08 2:30	1/5/08 13:00	1.8	7.1	26.8
32	1/6/08 5:30	1/7/08 4:00	1.0	1.8	3.8
33	1/8/08 1:15	1/8/08 20:15	3.0	5.5	12.0
34	1/9/08 21:30	1/11/08 6:00	3.9	7.6	21.5
35	1/12/08 6:30	1/12/08 15:00	2.7	3.7	3.8
36	1/14/08 12:30	1/14/08 16:45	1.1	1.6	2.0
37	1/19/08 17:30	1/20/08 8:45	2.0	3.4	6.8
38	1/26/08 14:00	1/26/08 19:30	0.0	0.0	0.0
39	1/28/08 22:30	1/29/08 7:15	0.8	1.5	2.3
40	1/30/08 5:30	1/31/08 21:45	0.8	1.6	4.3
41	2/5/08 1:00	2/5/08 18:30	0.6	1.1	0.8
42	2/6/08 14:15	2/7/08 2:45	2.2	3.9	8.3
43	2/8/08 16:15	2/9/08 2:15	1.4	1.8	4.8
44	2/9/08 20:15	2/10/08 12:00	1.4	2.2	3.3
45	2/15/08 18:30	2/15/08 19:30	0.0	0.0	0.0
46	2/22/08 2:45	2/22/08 3:45	0.0	0.0	0.0
47	2/27/08 9:00	2/27/08 10:00	0.0	0.0	0.0
48	2/29/08 15:45	3/1/08 19:45	0.1	0.1	0.3
49	3/3/08 8:15	3/3/08 13:15	0.0	0.0	0.0
50	3/6/08 18:15	3/6/08 19:15	0.0	0.0	0.0
51	3/10/08 2:15	3/11/08 10:15	1.0	1.7	1.0
52	3/13/08 6:00	3/14/08 14:45	1.3	1.9	8.8
53	3/15/08 4:15	3/15/08 5:45	2.1	3.0	2.0
54	3/15/08 19:15	3/16/08 5:30	1.2	1.6	1.3
55	3/16/08 18:00	3/17/08 8:15	0.2	0.2	0.3
56	3/19/08 17:30	3/19/08 20:45	0.0	0.0	0.0

Table D-3. Summary statistics for water level data collected at station WL1 during individual storm events in water year 2008.

Storm ID[a]	Storm Start Date and Time	Storm End Date and Time	Station WL1 Average Water Depth (inches)	Station WL1 Maximum Water Depth (inches)	Station WL1 Ponding Duration (hours)
57	3/20/08 16:15	3/20/08 21:15	10.4	11.8	21.3
58	3/23/08 4:30	3/23/08 16:15	4.1	10.4	13.5
59	3/25/08 14:00	3/26/08 6:00	2.1	4.0	8.8
60	3/26/08 18:45	3/26/08 21:00	2.6	4.6	5.5
61	3/28/08 4:15	3/28/08 22:30	2.9	7.2	15.8
62	3/29/08 13:45	3/30/08 2:30	5.3	11.0	11.8
63	3/31/08 17:00	3/31/08 17:30	1.3	1.5	0.5
64	4/4/08 6:15	4/4/08 20:00	1.0	1.3	0.8
65	4/5/08 19:00	4/6/08 2:15	1.2	1.5	0.8
66	4/6/08 18:30	4/7/08 5:15	0.0	0.0	0.0
67	4/8/08 7:15	4/8/08 19:15	4.0	8.2	2.8
68	4/13/08 16:15	4/13/08 20:00	1.0	1.0	0.3
69	4/14/08 11:15	4/14/08 20:30	1.9	4.6	5.0
70	4/15/08 9:15	4/15/08 19:00	0.0	0.0	0.0
71	4/17/08 18:45	4/18/08 19:30	0.0	0.0	0.0
72	4/19/08 9:45	4/19/08 15:45	1.2	1.3	0.5
73	4/22/08 21:45	4/23/08 14:45	0.8	1.2	1.0
74	4/27/08 15:45	4/28/08 9:00	4.2	10.9	6.3
75	4/29/08 21:15	4/30/08 6:30	3.1	6.9	3.0
76	5/3/08 11:30	5/3/08 14:00	0.0	0.0	0.0
77	5/11/08 19:45	5/12/08 0:45	0.0	0.0	0.0
78	5/13/08 9:00	5/13/08 13:00	0.4	0.7	0.8
79	5/20/08 3:15	5/20/08 12:00	0.0	0.0	0.0
80	5/21/08 18:30	5/21/08 22:15	0.0	0.0	0.0
81	5/25/08 0:45	5/25/08 6:30	0.0	0.0	0.0
82	5/31/08 15:30	5/31/08 16:00	0.0	0.0	0.0
83	6/2/08 21:30	6/4/08 6:30	2.0	4.0	2.5
84	6/5/08 9:30	6/5/08 17:45	0.0	0.0	0.0
85	6/6/08 8:00	6/6/08 16:45	10.4	17.3	2.3
86	6/9/08 6:45	6/9/08 19:30	1.4	1.4	0.3
87	6/10/08 9:00	6/10/08 9:30	0.0	0.0	0.0
88	7/3/08 5:00	7/3/08 9:00	0.8	0.8	0.3
89	7/27/08 5:00	7/27/08 5:30	0.0	0.0	0.0
90	7/29/08 8:45	7/29/08 20:30	0.0	0.0	0.0
91	7/31/08 17:00	8/1/08 5:30	0.7	1.4	1.3
92	8/9/08 4:45	8/9/08 19:15	3.3	4.4	0.5
93	8/18/08 10:00	8/18/08 16:00	0.0	0.0	0.0
94	8/19/08 20:30	8/21/08 3:45	0.8	1.6	4.5
95	8/24/08 12:15	8/24/08 21:30	0.0	0.0	0.0
96	8/25/08 16:15	8/25/08 19:00	2.4	5.5	1.0
97	8/26/08 21:30	8/27/08 5:45	0.9	1.4	1.0
98	9/20/08 6:30	9/21/08 0:00	0.0	0.0	0.0
99	9/24/08 12:30	9/25/08 16:45	0.0	0.0	0.0

[a] Individual storm event storm events are delineated based on a precipitation depth of 0.01 inches or greater, and a period of 12 hours or greater with no precipitation separating each event.
ND: no data

APPENDIX E

Quality Assurance Audit Forms for Hydrologic Monitoring Data

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 10/27/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/26/07	NONE		Multiple time span of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
			Systematic throat pressure drift to unrealistic positive values.	Meeting RI field technician on site on 12/7/07 to replace pressure transducer

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 11/27/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
10/24/07 – 11/27/07	10/24/07 – 11/27/07	Contacted RI, was told to reconfigure data logger unit.		

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 01/02/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 1/2/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
11/27/07–12/20/08	12/07/07 8hr data gap due to repair of throat pressure sensor by Renaissance Instruments	Values flagged and left blank	Multiple time span of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 01/08/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 1-9-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
12/20/08-1/8/08	NONE		Four time spans of negative values 1/8/08: One 4hr- period of unrealistic positive flow values due to error with throat pressure readings. Field observations confirmed flow during this time of 0.17gpm with a 0.4in storm event.	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0) Data sent to manufacturer for recalculation of flow.

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 01/28/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 1-29-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/8/08 – 1/25/08	NONE		5 periods of unrealistic positive flow values due to error with throat pressure readings (2 on 1/8/08, 2 on1/10/08, and 1/14/08). Each period of unrealistic positive flow occurred during rain events of 0.21-0.55inches.	Data sent to manufacturer for recalculation of flow.

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 02/26/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 2-28-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/25/08 - 2/21/08	1/25/08-1/29/08 Data lost due to zeroing of throat pressure transducer coefficients	Values left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 03/25/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 4/22/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
2/21/08 – 03/20/08	03/15/08 – 03/20/08 No data due to battery failure	Values flagged and left blank	2/21/08 – 03/20/08 Negative values for raw data	Will re-zero instrument

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 04/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials 3C

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 4/22/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
03/20/08 – 04/01/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 04/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 4/22/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/01/08 – 04/08/08	4/2/08 7:30-9:00 Data gap due to re-zeroing of instrument	Values flagged and left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 5/1/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SL

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 5-1-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/08/08 – 05/01/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 5/20/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 5/20/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/01/08 – 5/19/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/12/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 6/26/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
5/19/08 – 06/10/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/12/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 6/27/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
06/10/08 – 06/26/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/7/09 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 2-25-09

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
06/26/08 – 07/16/08	06/26/08 – 07/16/08: Unable to connect with equipment – data lost.	Reconfiguration of unit planned for 7/22/08.	None	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/7/09 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EL

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 2-25-09

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
07/16/08 – 8/12/08	07/16/08-7/22/08: Reconfiguration of data on 7/22/08 lost previous data.	Values flagged and left blank	Multiple time span of error flow values	Values set to zero, assigned flag (sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 12/3/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials 3C

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/29/07	9/25/2007 – 10/29/2007 Instrument Failure	Data Logger was sent back to RI to try to recover any data. They were unable to, so values have been flagged and left blank in the data record		

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 12/3/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
10/29/2007 – 12/3/2007	NONE		14 negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/02/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 1/2/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
11/26/07– 12/20/07	12/1/07 Data gap due to calibration of data gator (45min data gap)	Values flagged and left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 01/08/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 1-8-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
12/20/08-1/8/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 01/28/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 1-29-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/8/08 – 1/25/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 2/26/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SL

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 2-28-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/25/08- 02/21/08	2/11/08-2/21/08 No data due to power failure	Values left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 3/25/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
02/21/08 – 03/21/08	NONE		3/20/08 20:00 - 3/21/08 7:15 Instrument indicated flow during period of minimal rainfall.	Data flagged and values set to zero

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 4/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
03/21/08 – 04/01/08	NONE		3/21/08 7:30 – 3/21/08 15:15 Instrument indicated flow during period of minimal rainfall.	Data flagged and values set to zero

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 4/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EL

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/01/08 – 04/08/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 5/1/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 5-1-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/08/08 – 05/01/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 5/20/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 5/20/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/01/08 – 05/19/08	Data gap due to reconfiguring of instrument. 5/1/2008 11:15-13:00	Values flagged and left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/12/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials SC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 6/23/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/19/08 – 06/09/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/17/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials 3C

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 6/27/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
06/09/08 – 06/26/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 7/17/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials EC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 7/18/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
06/26/08 – 7/16/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Date 1/7/09 Page 1 of 1

Checked: initials EC

date 2-25-09

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/16/08 – 8/2/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 10/27/07 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials NL

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/26/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 11/27/07 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials JL

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
10/26/07 – 11/27/07	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/2/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials JC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 1/2/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
11/27/07 – 12/08/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 01/08/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials JL

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 1-8-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
12/08/07– 01/08/08	NONE		Rain gauge calibration on 12/8/08	Calibration data set to zero

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 01/28/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 1-29-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
01/08/08 – 01/23/08	NONE			NONE

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 02/26/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 2-28-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
01/23/08– 02/21/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 03/24/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 3/26/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
02/21/08 – 03/20/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 04/11/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials [illegible]

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
03/20/08 – 04/01/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Date 04/11/08 Page 1 of 1

Checked: initials

date

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/01/08 – 04/08/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Date 05/1/08 Page 1 of 1

Checked: initials EC

date 5-1-08

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/08/08 – 05/01/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 05/1/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EL

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 5/20/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/01/08 – 05/19/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/12/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 6/23/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/19/08 – 6/10/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 6/26/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials TL

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 6/27/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/10/08– 6/26/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Date 7/16/08 Page 1 of 1

Checked: initials SC

date 7/19/08

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/08 – 07/16/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 10/21/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 10/08/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
07/16/08 – 08/07/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 10/21/08 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials EC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 10/08/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
08/07/08 – 10/21/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 10/29/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials 3C

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 12-18-07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/26/07 - 10/26/07	9/29/70- 10/1/07 HSPF Calibration	Values flagged and left blank	NONE	

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 12/3/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 12-6-07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
10/26/07 – 1127/07	NONE		NONE	

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/2/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials 3C

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 1/2/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
11/27/07– 12/20/07	11/26/07 17:00- 12/4/07 11:56 Data logger submerged during 12/3/07 storm event, logged data lost	Values flagged and left blank	NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/10/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials EC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 1/29/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
12/20/07– 01/10/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 1/28/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 1-29-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
01/10/08 – 01/25/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 2/26/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 2-28-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
01/25/08– 02/21/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 03/24/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 3/20/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
02/21/08 – 03/19/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 04/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials JC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
03/19/08 – 04/01/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 04/11/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 4-22-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/01/08 - 04/08/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 05/01/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials SL

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 5-1-08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
04/08/08 – 05/01/08	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 05/20/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials EC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 5/20/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/01/08– 05/19/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 06/12/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials EL

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 6/23/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
05/19/08 – 6/10/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 06/27/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials 3C

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 6/27/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/10/08 – 6/26/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 7/17/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials EC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 7/18/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/08 – 7/16/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date 10/21/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials EC

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 10/30/08

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/16/08 – 8/12/08	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 10/21/08 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials JL

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 2-25-09

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
8/12/08 – 10/21/08	NONE		NONE	

NOTES: