UIC Stormwater Monitoring Plan for

Central Oregon Highway (US 20)

10th Street to Providence Drive

(M.P. 1.11 to M.P. 2.31)

GeoSyntec Consultants and Oregon State University

Report to:
Oregon Department of Transportation
Project SPR - 335
Water Quality Facility Investigation

Response to Task 4: Stormwater Monitoring Plans

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Introduction and Organization

Section 1

1.1 Introduction

The Oregon Department of Transportation (ODOT) maintains and operates municipal separate storm sewer systems (MS4s) throughout the state of Oregon for conveyance of stormwater from ODOT owned facilities and properties. The Federal Clean Water Act (CWA) requires that the discharge of pollutants to waters of the United States from any point source, including MS4s, be effectively prohibited, unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. As part of ODOT's NPDES MS4 Permit (No. 101822), ODOT is required to implement a policy for conducting a stormwater treatment evaluation as part of the development process for all new, redevelopment and restoration projects.

Furthermore, if an MS4 discharges to a Class V injection system as defined by the Federal Underground Injection Control (UIC) program, such as a sump or drywell, the Permittee is required to conduct water quality monitoring in accordance with the Oregon UIC program regulated by the Oregon Department of Environmental Quality (OAR Chapter 340, Division 44). Under the UIC program, monitoring is required to evaluate the effectiveness of source control and treatment control best management practices (BMPs) in eliminating contamination prior to stormwater injection into the subsurface.

This Stormwater BMP Monitoring Plan proposes an approach for monitoring the effectiveness of stormwater BMPs constructed as part of an improvement project on Highway 20 between 10th Street and Providence Drive in the City of Bend, Deschutes County, Oregon. These stormwater BMPs were specifically designed to treat highway runoff prior to discharging to underground injection controls (UICs).

1.2 Monitoring Plan Organization

This Monitoring Plan includes a statement of the goals and objectives of UIC monitoring for the chosen project site, a description of the site conditions and BMP characteristics including maps and diagrams of recommended sampling locations, guidance information on the type of equipment, monitoring frequency and storm events to target, as well as sample collection methods, and recommended analytical procedures. Also included in this plan is guidance for data analysis and reporting. The monitoring plan is organized as follows:

Section 1	Introduction and Organization
Section 2	Goals and objectives of the Monitoring Effort
Section 3	Site Conditions and BMP Characteristics
Section 4	Sampling Locations and Equipment
Section 5	Monitoring Frequency and Event Targeting

Section 6	Selection of Analytical Parameters
Section 7	The Sampling Team
Section 8	Sample Collection Procedures
Section 9	Quality Assurance and Quality Control
Section 10	Data Management and Reporting

The body of the report includes general descriptions of each of the above sections as well as site specific methods and procedures. Provided in the appendices are some general operating procedures including a field equipment checklist, details of the oil/water separator being used for pretreatment for three of the UIC monitoring locations, and a summary of the contributing areas for each UIC monitoring location including an itemized account of the 50 curb inlets.

Appendix A	Standard Operating Procedures for Stormwater Monitoring
Appendix B	Oil/Water Separator Details
Appendix C	Summary of Curb Inlets

Goals and Objectives of the Monitoring Effort

Section 2

The purpose of this stormwater BMP monitoring plan is to provide guidance on collecting captured sediment and stormwater effluent samples for the assessment of highway runoff water quality after treatment in sedimentation manholes, vegetated swales, and detention basins prior to underground injection via City of Bend Type “B” drywells. This is a base-level effluent monitoring effort with the specific goal of characterizing the quality of runoff entering underground injection controls from ODOT facilities in Bend, Oregon. The data collected in this effort will be useful for estimating the distribution and variability of water quality constituents, which in turn can be used to estimate the minimum number of samples necessary to statistically validate the performance of the stormwater BMPs during a more detailed influent and effluent monitoring effort. Furthermore, this monitoring plan can be used as a working “template” for ODOT staff for the development of monitoring plans at other UIC facilities.

Site Conditions and BMP Characteristics

Section

3

3.1 Study Site Location

The 10th Street to Providence improvement project on US Highway 20 is located in the City of Bend, Oregon between mileposts 1.1 and 2.3. The primary objectives of the project are to improve traffic flow and reduce congestion at 8th Street and 27th Street, as well as construct structural stormwater treatment BMPs (e.g., sedimentation manholes, vegetated swales, and/or detention basins) prior to drywell discharge. Figure 3.1 is a vicinity map that includes the extent of the project.

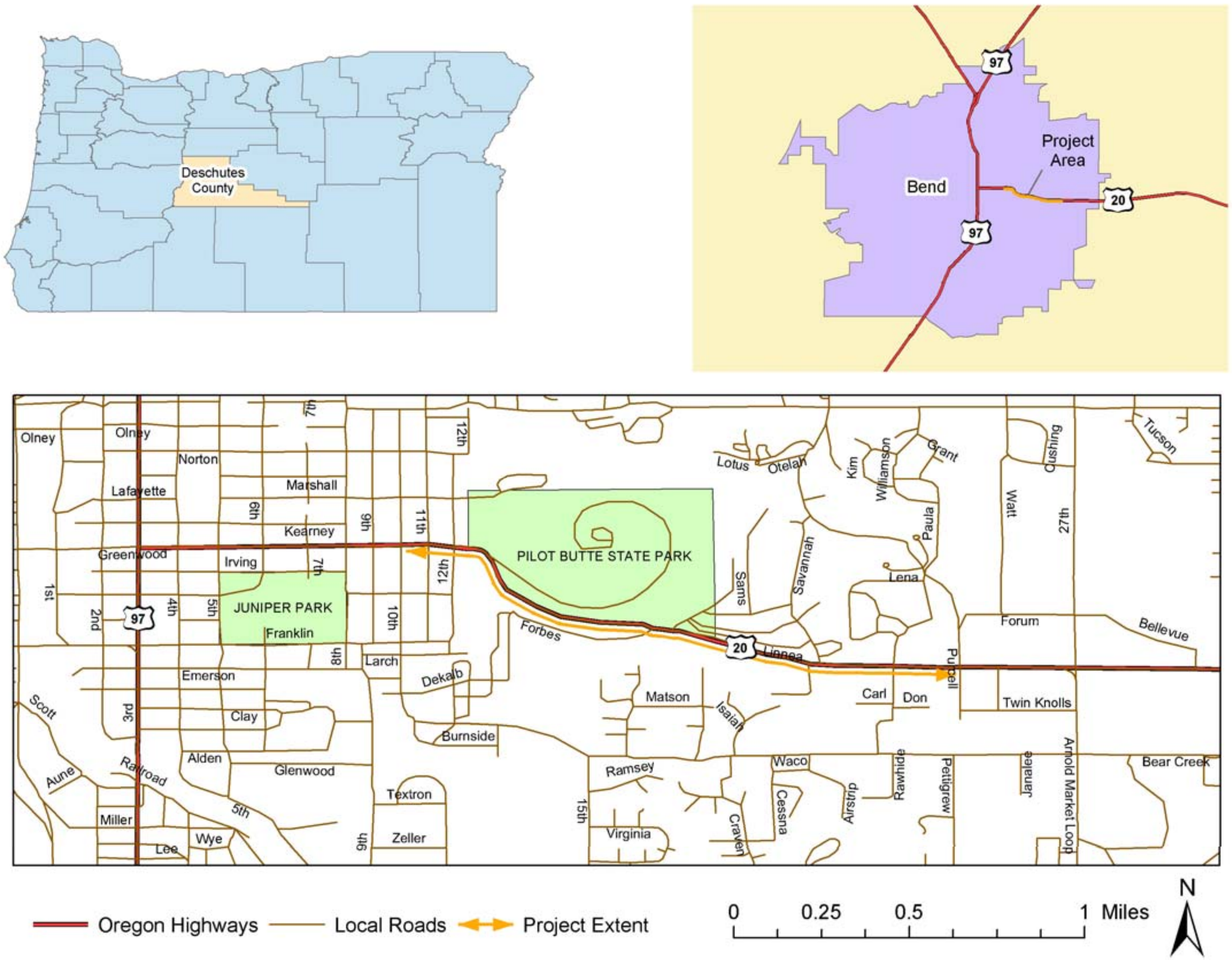

Figure 3.1. Vicinity map of project area and extent of project.

3.2 Hydrology and Hydraulics

The City of Bend is located in Oregon Climate Zone 7, which is characterized by moderate temperatures and an arid climate. Situated east of the Cascades, Bend receives relatively small amounts of rainfall with total annual average rainfall and snowfall depths of 11.75 and 33.1 inches, respectively[1]. Table 3.1 provides a summary of storm event characteristics in Bend, Oregon for rain events greater than 0.1 inch. Events smaller than 0.1 inches generally do not contribute to stormwater runoff. Therefore for the purposes of estimating runoff volumes, these smaller storms were eliminated from the rainfall data set prior to calculating the descriptive statistics in the table below.

Table 3.1. Characteristics of storm events greater than 0.1 inch at Bend, OR.

Bend, OR Rain Gage 0694					
Elevation: 3659.2' above s/l Lat/Lon: 44°03'N / 121°17'W Data Source: National Climatic Data Center Rain Record Used: Oct. 1948 – Sept 2000					
Storm Events	Units	Min	Max	Average	Coef. of Var.
Average Intensity	in/hr	0.004	0.7	0.06	0.97
Depth	in	0.11	6.0	0.4	1.08
Annual No. of Events		9	36	23	0.28
Annual Rainfall Depth	in	3.0	17.1	9.1	0.56

The project includes the construction of 50 curb inlets to convey highway runoff to the storm drain system (see Appendix C for a listing of the curb inlets and their contributing drainage areas). All except two of the inlets have a 3-foot sump for capturing large settleable solids. Once in the storm drain system, stormwater is either conveyed directly to a drywell for subsurface infiltration or is treated in structural stormwater BMPs before entering a drywell. Only during extremely large events would stormwater from the project area of Highway 20 ever reach surface waters, which include small tributary streams and irrigation canals that eventually flow into the Deschutes River.

3.3 Water Quality Issues

In response to water resource contamination concerns associated with stormwater UICs, the DEQ has identified several potential problem pollutants based on their mobility through the unsaturated soil zone above groundwater, their abundance in stormwater, their treatability before discharge, and occurrence in Oregon. The primary pollutant categories of concern include heavy metals, toxic organics, volatile organic compounds (VOCs), nutrients, pesticides, salts, and pathogens.

[1] Western Regional Climate Center, http://www.wrcc.dri.edu/index.html

Stormwater pollutants typically associated with highway runoff include zinc, lead, cadmium, manganese, copper, iron, chromium, nickel, petroleum compounds (e.g., BTEX), polycyclic aromatic hydrocarbons (PAHs), nitrogen, sodium, chloride, calcium, sulfate, and pathogenic microorganisms. The current quality of groundwater resources near the project site is relatively unknown. However, the USGS conducted groundwater monitoring at several locations and depths near the site in 1995 that showed no observed exceedances of primary or secondary drinking water standards of the monitored parameters[2].

3.4 BMP Characteristics

The majority of runoff from Highway 20 will flow through a treatment train of stormwater BMPs including sedimentation sumps, oil/water separators, vegetated swales, detention pipes, and detention basins. The three sedimentation sumps have the dual function of removing sediments and controlling flows to the oil/water separators. The oil/water separators can reduce oil concentrations in runoff to about 10 mg/L within their designed operational flow rate of 0 to 125 gpm (refer to Appendix C for further details).

There are three stormwater detention basins, two of which have two separate bays (Basins 2&2A and 3&3A). Detention Basin 1 is sized for the available space and can hold one-third of the 2-yr, 24-hr storm assuming no infiltration during the event. Overflow will discharge to a drywell and the street. Basin 2 & 2A can hold the entire 10-yr, 6-hr storm volume assuming no infiltration in the ditches or ponds. The overflow goes to two drywells. Additional overflow would threaten nearby homes. Detention Basin 3 & 3A can hold the 25-yr, 24-hr storm assuming no infiltration. This pond will also be receiving overflow water from an irrigation canal. Overflow goes to a drywell and adjacent vacant property. Table 3.2 gives the design capacities and contributing drainage areas for the three detention basins.

Table 3.2. Design capacities and contributing drainage areas of the three detention basins

Detention Basin	Design Capacity (ft^3)	Contributing Drainage Areas (acres)
Basin 1	1,000	0.53
Basin 2&2A	21,034	4.49
Basin 3&3A	27,539	2.95

There are 4 vegetated swales that pre-treat stormwater prior to discharging to Detention Basins 2&2A and 3&3A. All of the swales are designed with 2:1 side slopes and bottom widths of 1-3 feet.

There are seven drywell locations that receive runoff from the project area of Highway 20, all of which have varying degrees of treatment prior to subsurface injection. Table 3.3 lists the contributing drainage areas, the rim elevations, and the type of stormwater treatment associated with each of the drywells.

[2] http://waterdata.usgs.gov/or/nwis/qwdata

Also included in the table are the reference sheet numbers from the project plans and the station and/or location of each drywell.

Table 3.3. Subsurface discharge locations and characteristics.

US 20 UIC ID	Ref. Sheet No. from Plans	Station/Location	Drainage Area (acres)	Rim Elevation (feet)	Number of Curb Inlets and Types of Stormwater Treatment
1	PP 1.0	31+93, 50' RT	0.50	3643.2	2 curb inlets
2	PP 1.0-3.0 SD 1.0	Basin 1 Outfall 12th St. 12+64.2, 26.4' LT	0.53	3651.4	2 curb inlets, all runoff receives detention in Basin 1.
3	PP 2.0 SD 1.0-2.0	Basin 2&2A Outfall (2 drywells in series)	4.49	3648.4 3647.5	21 curb inlets - 2 w/o 3' sump, runoff from 20 areas (including the 2 w/o sump) discharge to swales, all runoff receive detention in Basins 2 & 2A
4	PP 4.0-6.0 SD 3.0	Basin 3&3A Outfall	2.95	3660.5	11 curb inlets – all except 1 discharge to swales, runoff from 4 areas (including the 1 w/o swale treatment) receive detention in both Basins while the runoff from the remaining 7 areas receive detention in Basin 3A only.
5	PP 7.0 SD 4.0	79+20.1, 4' RT 79+60.8, 4' RT (2 drywells in series)	1.11	3654.5 3653.8	4 curb inlets – 3 receive detention in 150'X36" detention pipe. Total runoff enters flow control manhole (Sta. 78+80), which includes a 3' sedimentation sump. Treatment in oil/water separator for low flows.
6	PP 8.0 SD 4.0	86+50, 4' RT 86+90, 4' RT (2 drywells in series)	1.65	3647.4 3647.2	4 curb inlets – 2 receive detention in 500'X24" detention pipe. Total runoff enters flow control manhole (Sta. 86+23.9), which includes a 3' sedimentation sump. Treatment in oil/water separator for low flows.
7	PP 9.0 SD 4.0	93+67.9, 4' RT 94+07.9, 4' RT (2 drywells in series)	1.60	3640.3 3640.0	6 curb inlets – 2 receive detention in 550'X24" detention pipe and 2 receive detention in 178' of the pipe. Total runoff enters flow control manhole (Sta. 93+40), which includes a 3' sedimentation sump. Treatment in oil water separator for low flows

The BMP process flow diagrams (PFDs) associated with each subsurface discharge location are shown in Figure 3.2.

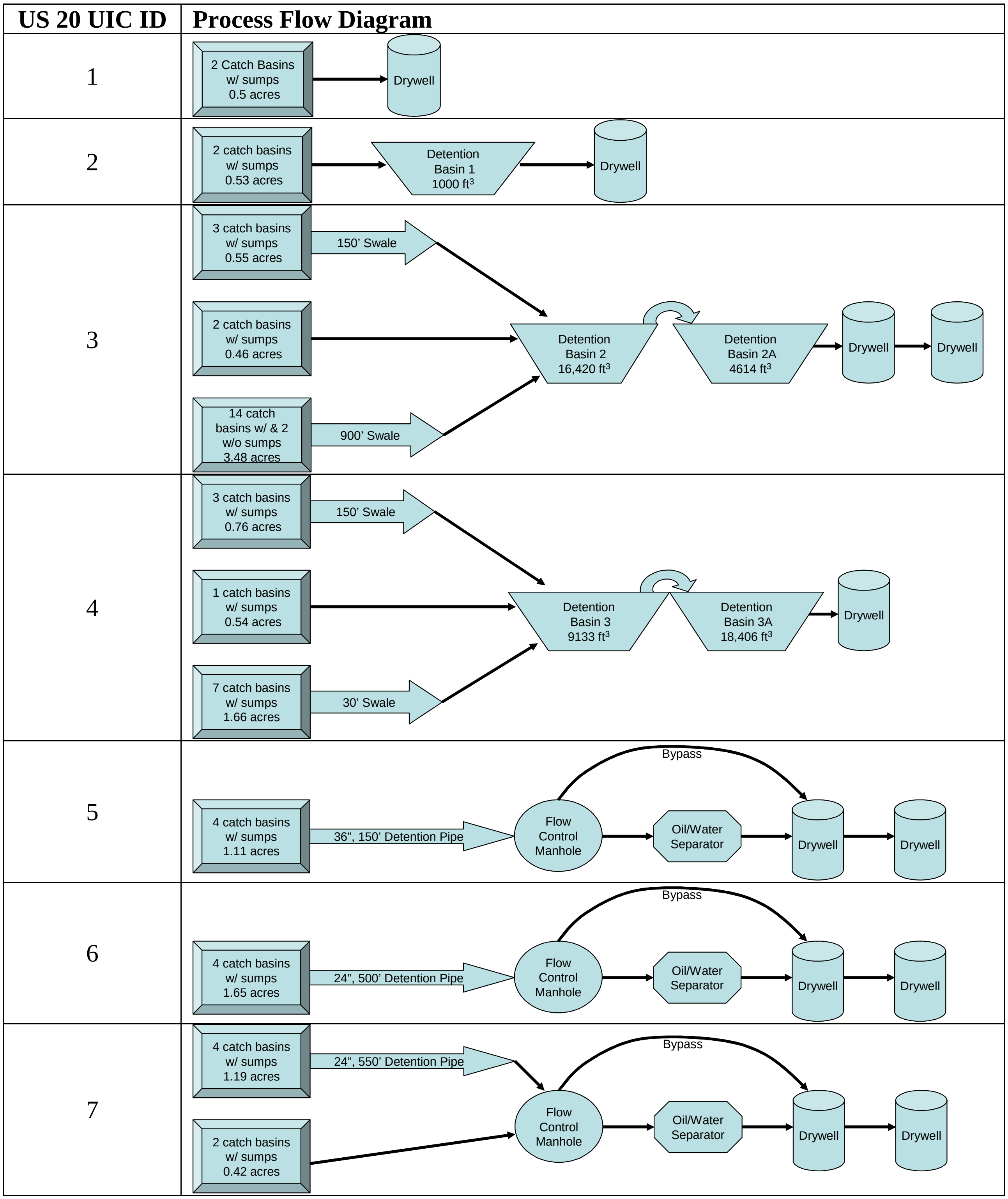

Figure 3.2. BMP Process Flow Diagrams for each subsurface discharge location.

Sampling Locations and Equipment

Section 4

4.1 Sampling Locations

As required by the Oregon UIC Rules, grab samples shall be collected at the last available sampling point prior to storm water injection into the subsurface. Therefore, the sampling locations chosen for this monitoring effort correspond to the seven subsurface discharge locations listed in Table 3.3. Note that all of the sites have varying levels of treatment prior to infiltration, and since it is not expected that the influent runoff quality will vary significantly from site to site, the monitoring of the sites with little to no treatment will provide a good estimate of the influent quality for the sites with higher levels of treatment. Therefore, even though only effluent quality will be monitored, preliminary estimates of the pollutant removal performance of several of the project BMPs can be determined.

In addition to water quality monitoring, sediment captured in the catch basin sumps and the sedimentation manholes will be periodically sampled. Sediment sampling will aid in evaluating the ability of these gross pollutant BMPs at removing sediment-bound contaminants.

Since some of these locations are in the highway median, traffic controls will have to be established prior to the onset of sampling. ODOT standard traffic control practices and the site-specific Health and Safety Plan should be adamantly followed during all sampling events.

Figure 4.1 gives the general location of each sampling site, and Figure 4.2 through Figure 4.7 show the specific location of the UIC to be sampled. Note that for locations 3, 5, 6, and 7 only discharges to the first drywell need be sampled.

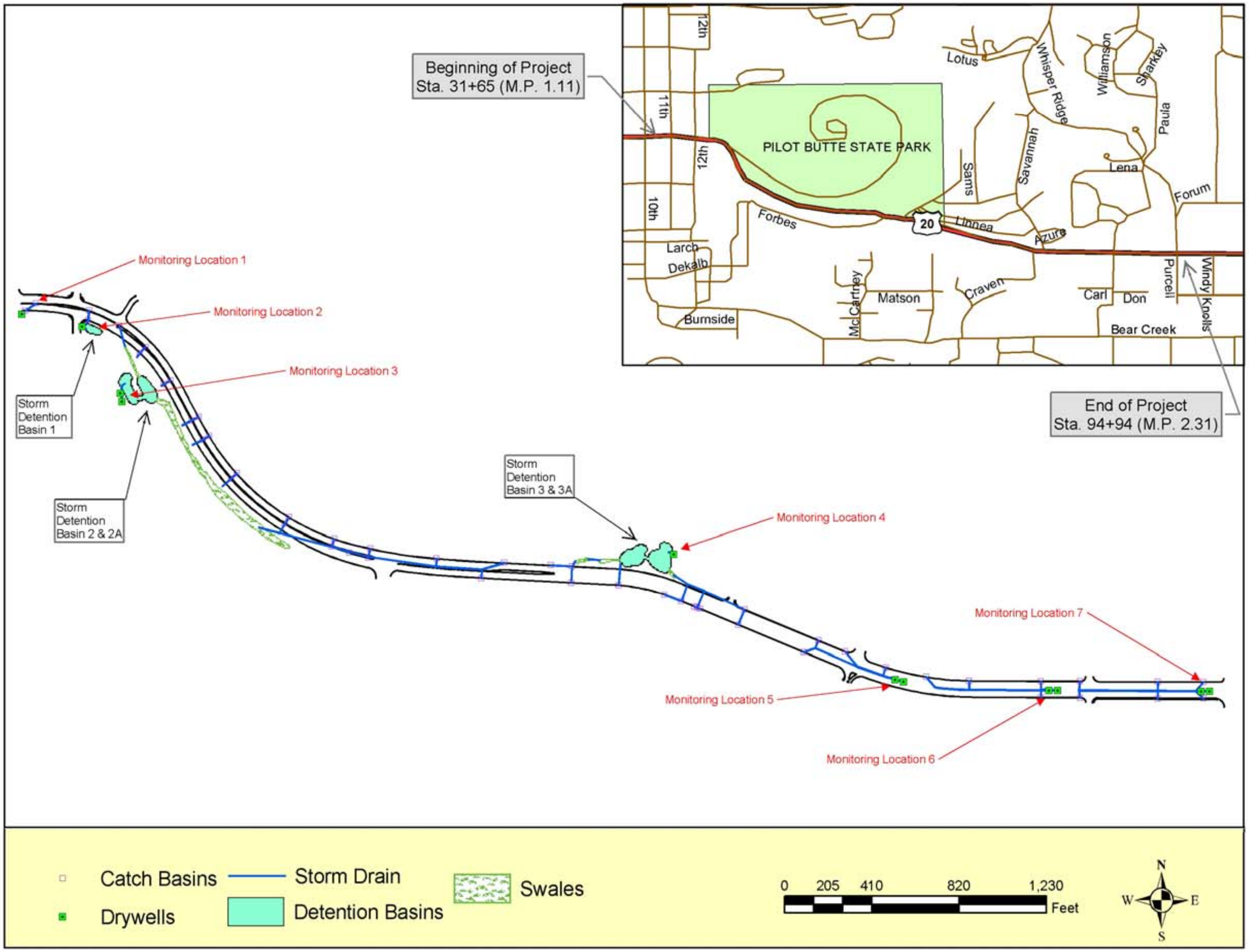

Figure 4.1. Samling site locations for UIC influent monitoring.

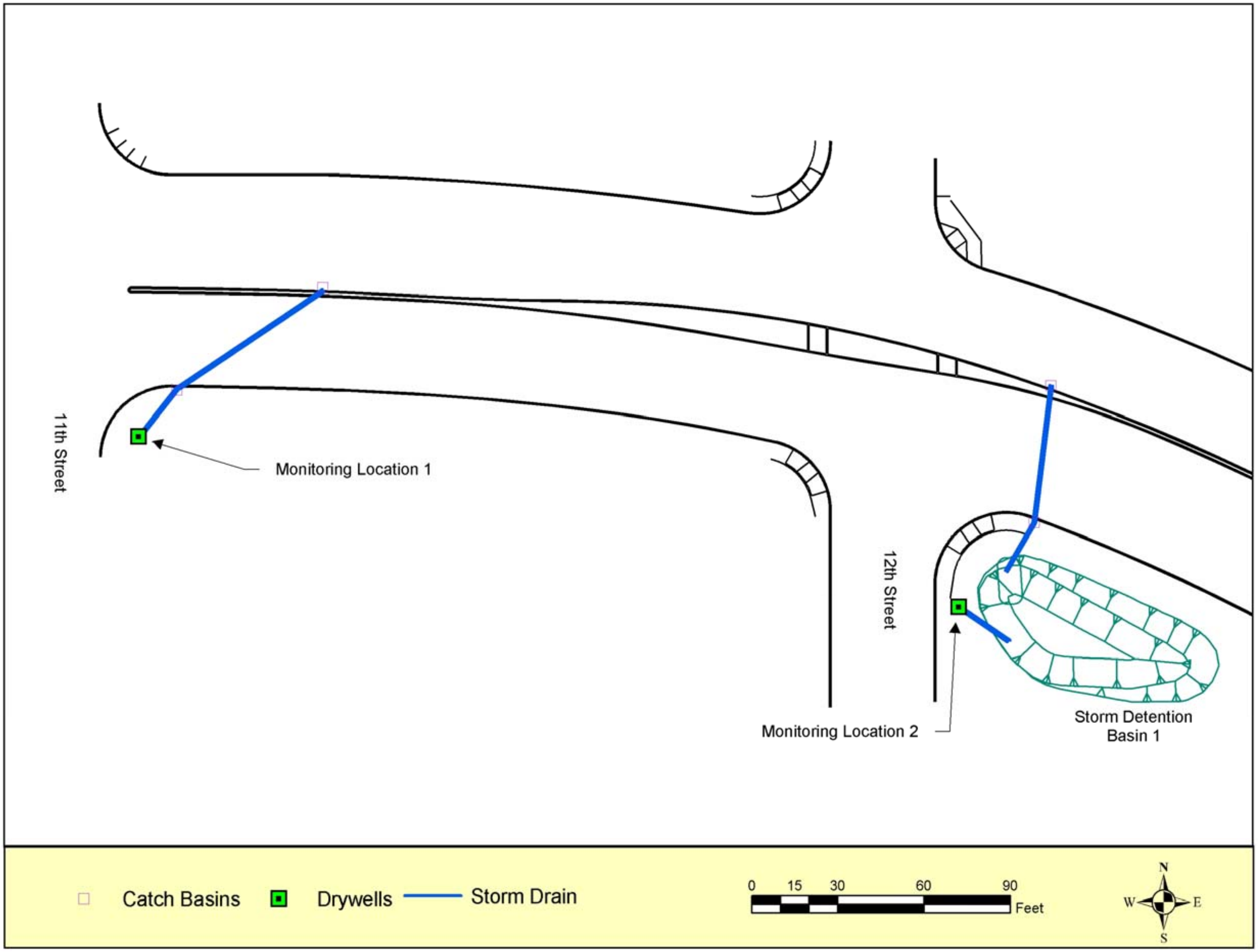

Figure 4.2. Monitoring Locations 1 and 2.

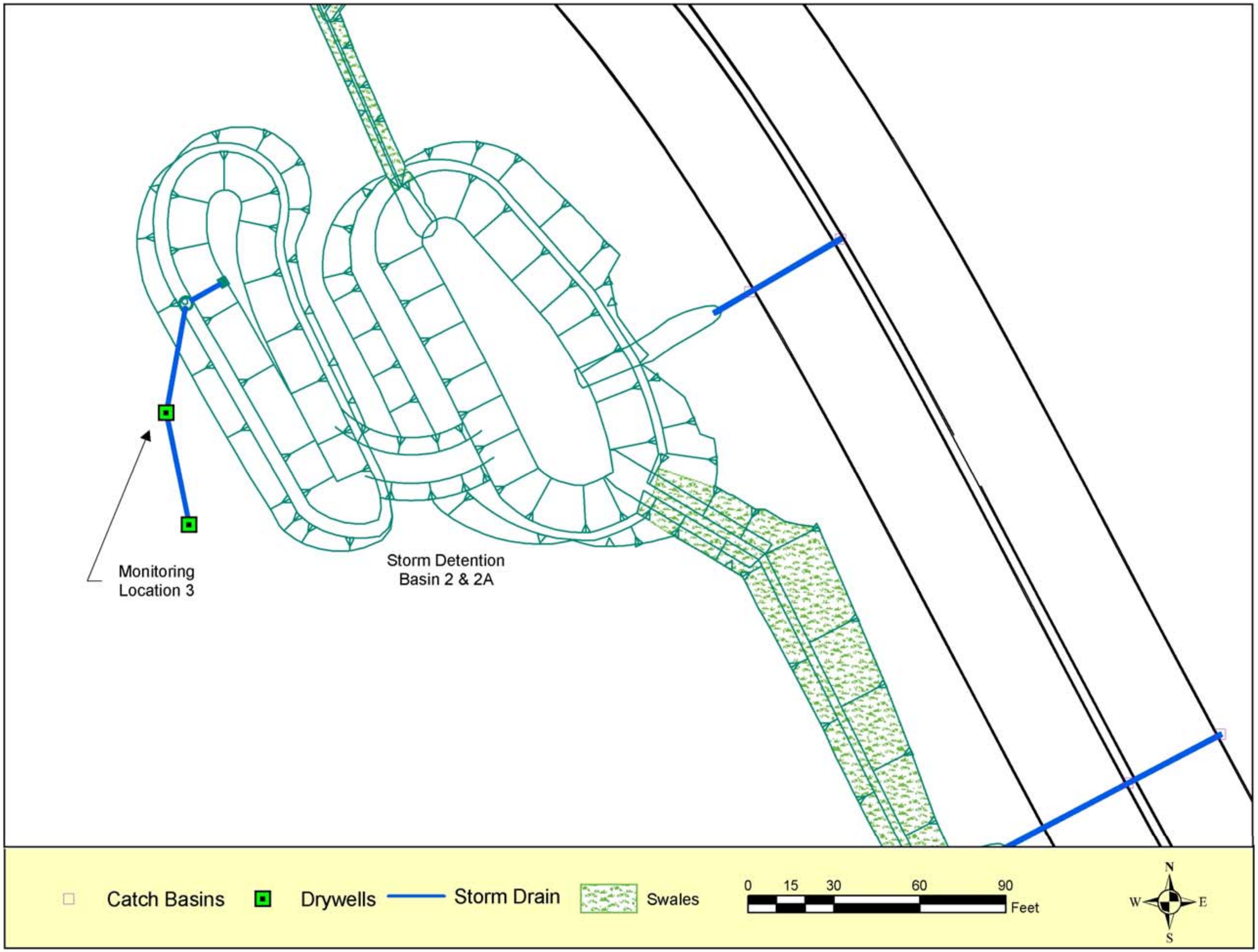

Figure 4.3. Monitoring Location 3.

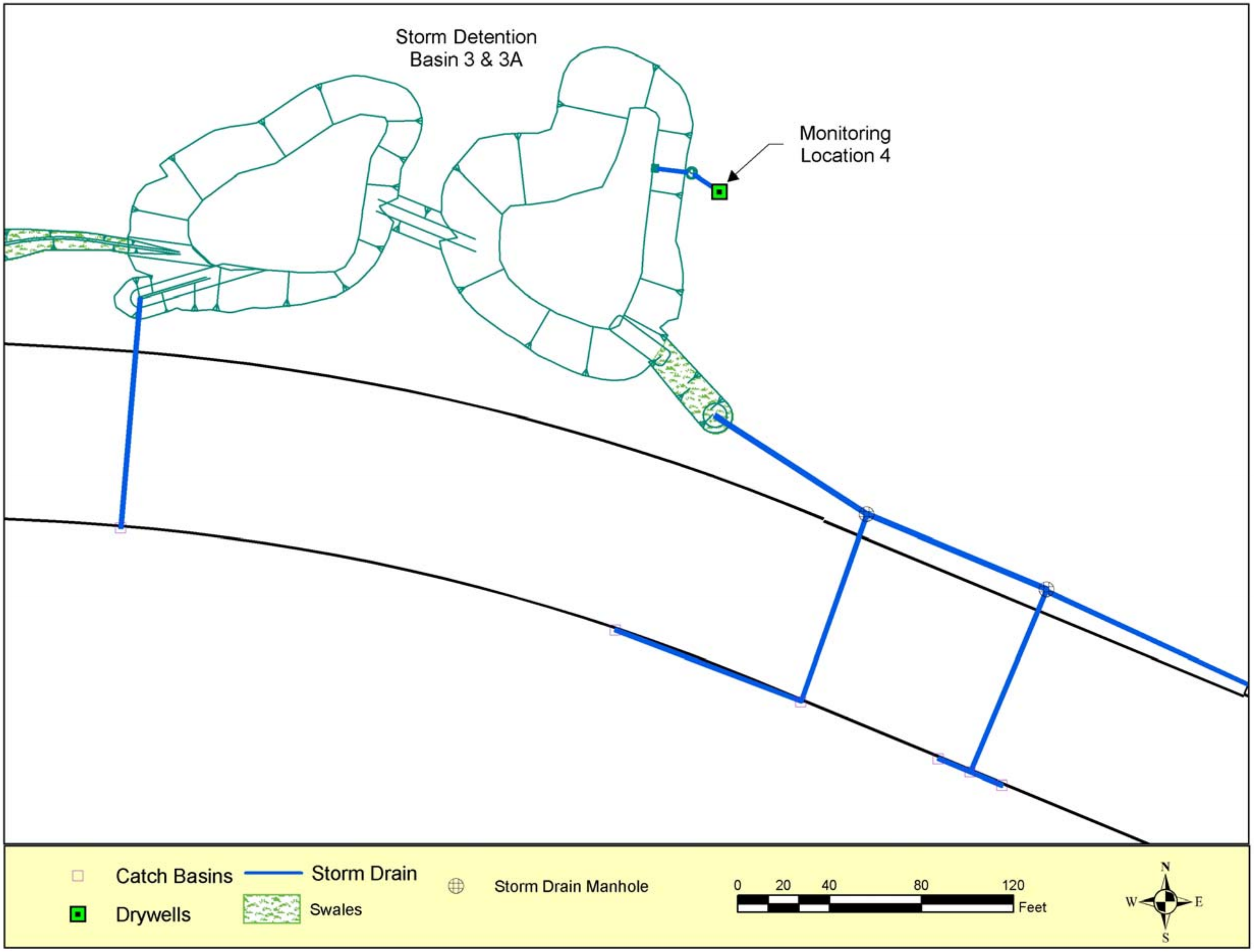

Figure 4.4. Monitoring Location 4.

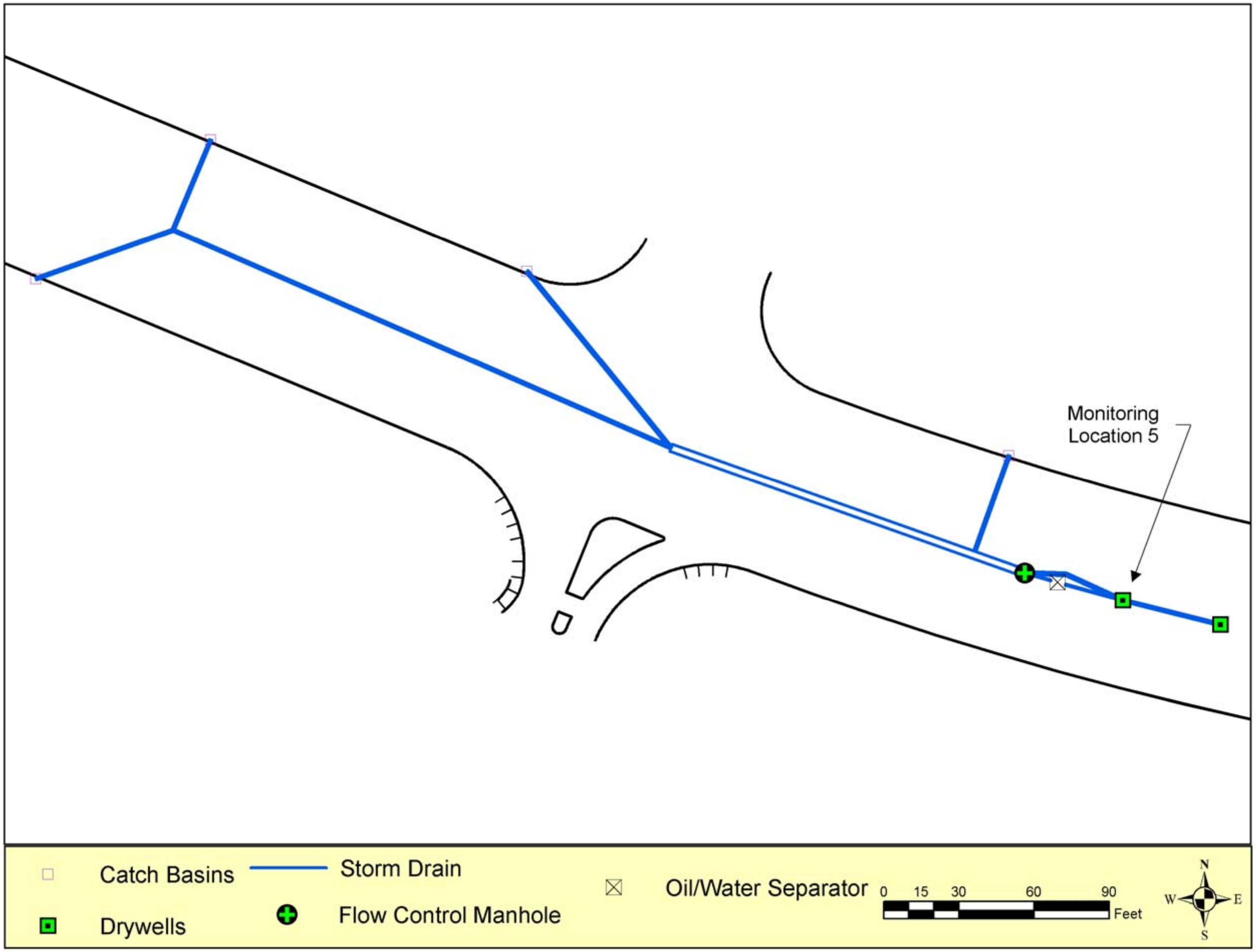

Figure 4.5. Monitoring Location 5.

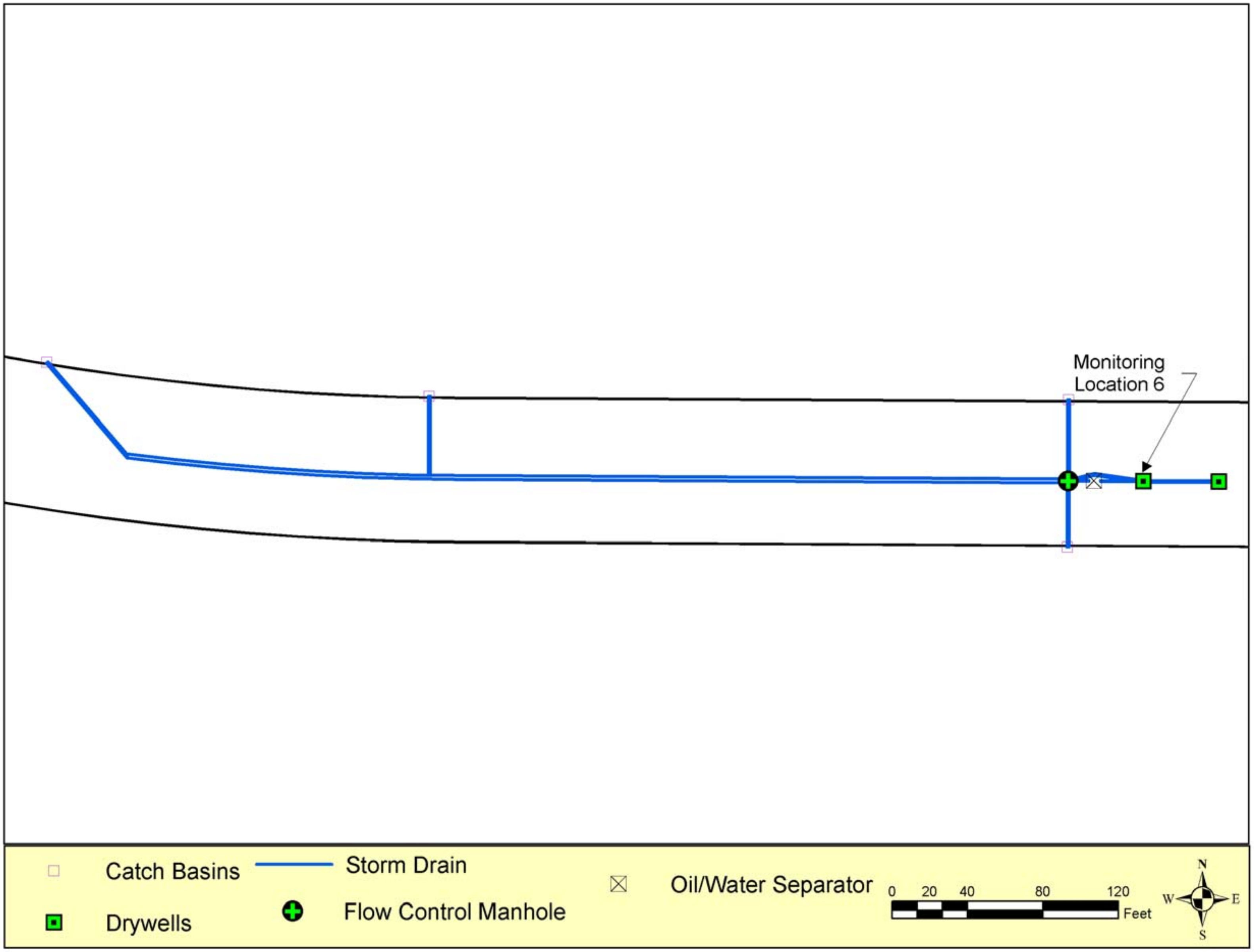

Figure 4.6. Monitoring Location 6.

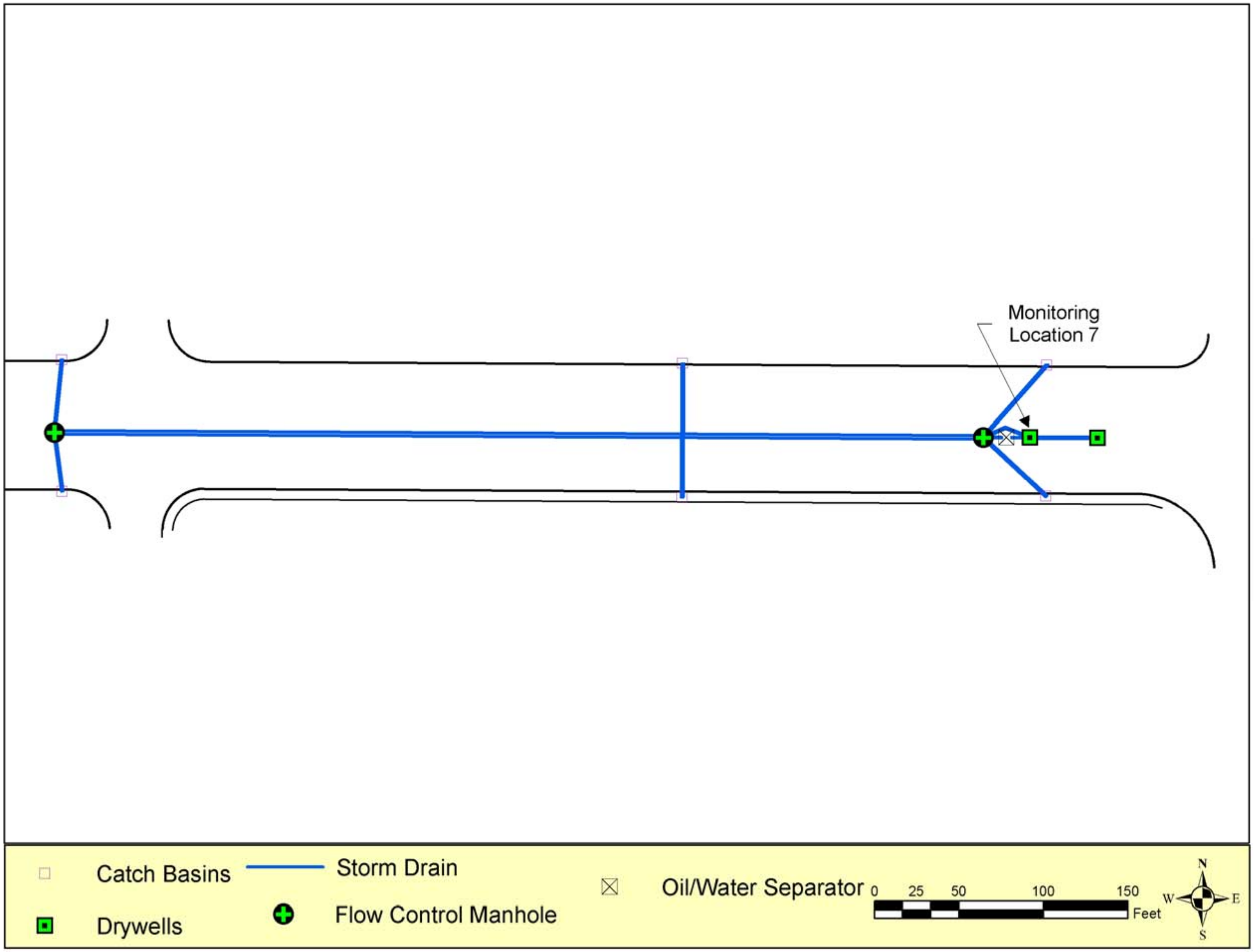

Figure 4.7. Monitoring Location 7.

4.2 Sampling Equipment

During the first year of sampling, water quality will be monitored by taking grab samples at the outfalls into each drywell. For the cases where two drywells are in series, only discharges to the first one will be monitored, as the second dry well would only receive runoff during high flow events or if the first dry well begins to clog. The equipment necessary to take grab samples include:

Water Quality Samples

- Extension pole with sampling vessel grappling arm
- 1000-mL glass beaker for sample collection
- Polyethylene and glass jars (depending on parameter; see Section 6)
- 2 – 1-gallon glass jars (provided by lab)
- 3 – 40-mL VOC vials (provided by lab)
- E. Coli bottle (provided by lab)
- Cooler with ice (4oC)
- Watch or stopwatch
- Distilled water

At the end of the wet season sediment samples should be collected from the catch basin sumps and the sedimentation manholes using a Birge-Ekman grab sampler or similar device capable of collecting and retaining fine particulates. The following equipment is required for sediment sampling:

Sediment Samples

- Birge-Ekman sampler (Teflon-coated)
- 32-ounce wide-mouth glass jars with Teflon-lined lids (one for each sampling location)
- Large plastic bucket for compositing samples
- Large cooler with ice (4^{o}C)
- Distilled water (at least 2 gallons)
- Powderless, disposable nitrile gloves

See SOP A-2 Field Equipment Preparation for a complete list of equipment and documentation that should be taken to the field.

Monitoring Frequency and Event Targeting

Section 5

5.1 Event Targeting

According to the UIC Rules, "[UIC influent] sampling shall be conducted twice within the first 12 months of implementation of the stormwater management plan, followed by annual sampling during a representative storm event at the onset of wet weather conditions." To account for unforeseen circumstances, such as equipment failures, contaminated samples, etc., the target number of events is four (weather and funds permitting) for the first year of monitoring. The quantitative probability forecast information will be examined regularly during the rainy season. A target event should have a 70% probability of producing 0.3 inches of rainfall in a 24 hour period and 80% probability of producing an average intensity of 0.03 inches per hour.

5.2 Weather Forecasting

The storm event coordinator will use four resources to monitor storm activity.

Oregon Climate Service (http://www.ocs.orst.edu/)
National Weather Service (http://www.wrh.noaa.gov/Portland/)
Extended Range Weather Forecasting Company (http://www.erfweather.com)
NW News Channel 8 (http://www.kgw.com/weather)

Weather monitoring should occur throughout the wet season, or until the desired number of events have been sampled. However, since this site is located in an area that receives snowfall in the winter, monitoring will likely occur during the spring and fall seasons when runoff is more likely to occur. Weather monitoring will include both monitoring of precipitation and monitoring of temperature to predict whether runoff will occur at the site.

Since rainfall in the Bend area can be spatially sporadic, it may be desirable (funds permitting) to install a site rain gauge for event monitoring. For guidance on selecting and installing a site rain gauge refer to Section 4.4 and Section 5.1.5, respectively of the "Guidance Manual for Monitoring Highway Runoff Water Quality".[3]

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[3] Strecker, E., L. Mayo, M. Quigley, and J. Howell (2001). "Guidance Manual for Monitoring Highway Runoff Water Quality." *Final report to Federal Highway Administration, Office of Natural Environment* FHWA-EP-01-022.

Selection of Analytical Parameters

Section

6

According to the DEQ UIC Rules (OAR Chapter 340, Division 44), samples shall be analyzed for BTEX (benzene, toluene, ethylbenzene, and xylenes), benzo(a)pyrene, lead (unfiltered), total chromium (unfiltered), cadmium (unfiltered), total nitrogen and fecal coliform bacteria. Note that benzo(a)pyrene is the only polycyclic aromatic hydrocarbon (PAH) required by the DEQ UIC Rules. Table 6.1 is a list of suggested analytical test methods for the water quality parameters of concern. Table 6.2 is a list of the suggested analytical test methods for sediment sampling. All samples, particularly those to be analyzed for BTEX and PAH, should be stored at 4°C. If methods are used that differ from those listed in the table, the analytical laboratory must verify that the reporting limit is below the drinking water quality maximum contaminant level (MCL) for the parameter(s) analyzed with the different method(s).

Table 6.1. Analytical water sampling parameters suggested for monitoring at UIC stormwater BMPs in the City of Bend.

Parameter	Method	Reporting Limit	Minimum Sample Volume/ Bottle/Preservative*	Max Holding Time
BTEX	EPA 8021	Variable	3 40-mL/ VOA	14 days
PAH-SIM	EPA 8270	0.1-0-2 ug/L	2 L/ G A	7/40 days
TPH - Diesel	NW TPH	1 ug/L	2 L/ G A	7/40 days
TPH - Gasoline	NW TPH	1 ug/L	120 mL/ VOA/ HCl	14 days
Nitrate-Nitrogen	EPA 300.0	0.1 mg/L	250 mL/ P	48 hours
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	0.2 mg/L	250 mL/ P	28 days
E. coli	SM 9223B	MPN/100 mL	125 mL/ sterile P	24 hours
Total Suspended Solids	EPA 200.8	1 mg/L	500 mL/ P	6 months
Total and Dissolved Cadmium	EPA 200.8	0.1 ug/L	2 500-mL/ P	6 months if preserved
Total and Dissolved Copper	EPA 200.8	1 ug/L		
Total and Dissolved Chromium	EPA 200.8	0.4 ug/L		
Total and Dissolved Lead	EPA 200.8	0.1 ug/L		
Total and Dissolved Zinc	EPA 200.8	1 ug/L		

* Notes:
G = Glass A = Amber HCl = Hydrochloric Acid
P = Polyethylene VOA = 40 ml glass vial for volatile organic compounds

Table 6.2. Analytical sediment sampling parameters suggested for monitoring at UIC stormwater BMPs in the City of Bend.

Parameter	Method	Reporting Limit	Minimum Sample Volume/ Bottle*	Max Holding Time
Particle Size Analysis	ASTM D422, D1140	NA	400 g/G	NA
Wet Preparation of Sediment Samples	ASTM D2217	NA		
Total Organic Carbon	EPA ESTUARINE	0.2 mg/g	200 g/G	28 days
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	0.1 mg-N/g		
Total Phosphorus	EPA 365.4	0.05 mg-P/g		
Total Copper	EPA 200.8	0.1 µg/g	200 g/G	6 months
Total Lead	EPA 200.8	1 µg/g		
Total Zinc	EPA 200.8	0.5 µg/g		
*NA = Not applicable, G = Glass				

The Sampling Team

Section

7

The Sampling Team refers to all personnel who are involved in logistical support, sample collection, traffic control, and safety during the actual storm event being monitored. There may be backup personnel to cover for employees that have other obligations when a monitoring event is scheduled, but at a minimum the Sampling Team should include:

- Storm Event Coordinator (1 person, can be remote)
- Monitoring Team (2-4 persons)

7.1 Storm Event Coordinator

[INSERT NAME AND TITLE OF STORM EVENT COORDINATOR] will be the Storm Event Coordinator for monitoring. The Storm Event Coordinator (Coordinator) is responsible for observing weather patterns and selecting the events to be monitored. The Coordinator directs monitoring activities from a base station equipped with necessary equipment to track weather conditions, recalculate sampler pacing as conditions change (if applicable), and access dependable two-way communication with weather consultant and field crews (via cell phone or radio). The Coordinator makes the decision of which storms to monitor, when to initiate sampling, and calculates the runoff intervals to be used for automated sampler pacing (if applicable). The Coordinator should notify the Monitoring Team 72 hours in advance of a potential monitoring event.

7.2 Monitoring Team

The Monitoring Team consists of [INSERT NAMES AND TITLES OF TEAM MEMEBERS]. They are responsible for ensuring that all required equipment is ready for field operation. They are also responsible for performing the entire field monitoring activities and most of the monitoring preparation. Any member of the Monitoring Team may recommend canceling monitoring if the predicted conditions do not materialize or if health or safety of the team could be imperiled due to site conditions or extreme weather. The Monitoring Team's other duties include contacting the analytical lab to arrange for delivery of sample bottles and drop-off of the samples at the lab once monitoring is completed.

Sample Collection Procedures

Section

8

Two types of sampling collection procedures and field safety measurement methods are incorporated into this monitoring plan: 1) outfall grab sampling, and 2) captured sediment sampling. There are general procedures for safety, cleanliness, documentation, and transport that apply to all types of stormwater monitoring. Additionally, there are more specific procedures that must be followed for the different types of sampling as well as for individual parameters sampled by similar methods. Stormwater monitoring generally takes place under difficult operating conditions, which can increase safety risks or sample collection problems for the sampling team. There also exists the potential for sample contamination during collection or transport. Adherence to the procedures outlined in this section and the Standard Operating Procedures (SOPs) can help to minimize these risks and problems as well as reduce the likelihood of errors in sampling results. Topics covered in this section include:

- Personal Safety
- Sampling Equipment and Bottles
- Clean Sampling Techniques
- Field Measurement Collection
- Grab Sample Collection
- Automated Sampling and Flow Monitoring
- Transport and Chain of Custody

8.1 Personal Safety

The Health and Safety Plan approved by [INSERT NAME AND TITLE OF ACTIVE HEALTH AND SAFETY OFFICER] should be reviewed by all field personnel before the sampling operations covered in this monitoring plan begin. Personal safety should be of primary concern while conducting all stormwater sampling related activities. All persons involved in the sampling operation should be made aware of the hazards associated with monitoring and should freely voice any concerns if potential hazards become apparent. The Occupational Safety and Health Administration (OSHA) provides regulations and guidance on occupational safety, many of which are directly applicable to the types of activities involved in stormwater monitoring. It is the direct responsibility of each person involved in the monitoring program to read the Health and Safety Plan and adhere to its requirements. The following list provides a few basic health and safety procedures that can help to create a safer sampling environment.

- Do not sample alone, a minimum of two-person field crews will be used for stormwater sampling.

- Do not enter a confined space without proper training, equipment, and surface support.
- Never remove or replace manhole covers with your bare hands or feet.
- Never leave an open manhole unattended.
- Do not start staging or sampling until traffic control has been established.

When sampling near open water it is important to be aware of and avoid drowning hazards. High stormwater flows often carry branches and other debris that can entangle a person or pin them beneath submerged obstacles. Creek banks can be unstable or slippery during wet weather and caution should be observed when walking on wet unstable surfaces.

8.2 Clean Sampling Techniques

Clean sample collection techniques should be followed to minimize the potential for contamination of stormwater runoff samples. Care must be taken during all sampling operations to avoid contamination of the water samples by human, atmospheric, or other potential sources of contamination. The monitoring team should prevent contamination of any of the following items: composite bottles, lids, sample, tubing, and strainers. Whenever possible, samples should be collected upstream, and upwind of sampling personnel to minimize contamination.

8.3 Sampling

Setup a safety zone according to the Health and Safety Plan (HASP) to provide access to the sampling location. Review the Field Data Sheet (FDS) checklist and collect all necessary sampling equipment before visiting site. Record sampling information regarding site condition and sampling notes on the FDS sheet.

Set up a two-person clean sampling team: one “dirty hands” to move equipment and remove manhole lid and one “clean hands” to handle sampling equipment and bottles.

VOC trip blanks will be provided by the lab. Trip blanks should remain in the cooler. Trip blanks are for quality assurance/quality control and will be analyzed by the laboratory only if VOC (BTEX and TPH-gasoline) grab samples test positive.

Field Equipment

See SOP A-2 Field Equipment Preparation

Water quality samples will be collected using a 1000-mL glass beaker attached to an extension rod. The water quality laboratory will decontaminate the sampling vessels prior to the first sampling event and between each subsequent sampling event. A separate glass beaker will be used for each sampling location. All samples will be collected at the effluent discharge point to the UIC.

Sediment samples will be collected using an Ekman or equivalent grab sampler and 1000-mL glass jars with Teflon-lined lids. All sediment samples will be collected in the catch basin sumps and the sedimentation manholes.

Time-Paced Composite Sampling

See SOP A-2 Field Equipment Preparation

Time-paced composite sample will be collected for TPH-Diesel, PAH, total recoverable and dissolved metals (Cd, Cu, Cr, Pb, Zn), nitrate-nitrogen, TKN, and total suspended solids (TSS).

Time-paced composite samples will be collected every 30 to 60 minutes as decided by the team depending on the predicted event conditions. Ideally, 7 to 13 samples should be collected within 6 hours time to fill the two (2) 1-gallon sample jars (7,571 mL total). The expected rainfall intensity and duration, number of team members present and other conditions are factors in determining the sampling interval and volumes. Whichever interval is chosen, it is important to record the sample times and volumes on the field data sheet. The team may decide to increase the volumes per interval or decrease the interval duration if it looks like the rain event will not last 6 hours. Again, this should be recorded on the field data sheet. Additionally, the interval for the bacteria (*E. coli*) grab sample depends on the interval time chosen. The following is a guideline for volumes per interval based on a 6-hour event:

Table 8.1. Volume and time interval guideline for time-weighted composite sample collection.

Interval	**Volume per Interval**	**Rough Volume**	***E. coli* grab**
30 minutes	582 mL:	~ ½ beaker volume	6th interval
45 minutes	841 mL	~ ¾ beaker volume	4th interval
60 minutes	1,082 mL	~ full beaker volume	3rd interval

<u>Time-Paced Composite Sampling Technique</u>

- Decide on the sampling interval and associated volume. Adjust throughout event if conditions dictate.
- Rinse the beaker with source water by filling and emptying three times.
- Fill beaker from the middle of the flow stream.
- Slowly pour the chosen aliquot amount into the first 1-gallon sample jar.
- Replace the lid on the jar and place in the cooler with ice until it is time for the next aliquot.
- Fill out sample collection information on the field data sheet.
- Repeat procedure every chosen interval for 6 hours or until the two (2) 1-gallon sample jars are full.
- Take a photo of sampling site and BMP during one of the composite sample intervals.

Noncomposited Grab Sampling

Separate grab samples will be collected for VOC (BTEX and TPH-Gasoline) and bacteria (*E. coli*) before time-weighted composite sampling begins.

Also, a separate grab sample (approximately 1-liter) should be collected during the first 30 minutes of storm event runoff to characterize the “first flush” prior to taking any other samples. This sample will be analyzed separately for all of the same parameters included in the time-weighted composite sample analysis.

<u>VOC (BTEX and TPH-Gasoline)</u>

- VOCs should be collected from the first grab sample before composite sampling begins.
- Bottles: Three (3) 40-mL glass vials.
- Rinse the beaker with source water by filling and emptying three (3) times just prior to sample collection.
- Fill beaker from the middle of the flow stream.
- Slowly pour sample from glass beaker to vial until there is no headspace and a positive meniscus is visible.
- Secure the lid on the bottle and invert. Look for air bubbles. If air bubbles are present, remove the lid and repeat the process by adding additional sample and re-securing the lid.
- Fill out sample labels and place samples in the cooler with ice.
- Fill out sample collection information on Field Data Sheet.

<u>Bacteria (*E. coli*)</u>

- Bacteria should be collected after two composite samples have been collected and before the third composite sample.
- Bottle: One (1) 100-mL plastic autoclaved bottle.
- Rinse the beaker with source water by filling and emptying three (3) times just prior to sample collection.
- Fill beaker from the middle of the flow stream.
- Slowly pour contents into the autoclaved bottle. Fill the bottle just below the neck.
- Secure the lid on the bottle, fill out the label and place in the cooler with ice.
- Fill out sample collection information on Field Data Sheet.

Sediment Grab Sampling

Sediment sampling will occur at the end of the wet season to assess the grain-size distribution and the quality of captured sediment in the catch basin sumps and the sedimentation manholes. The following general procedures should be followed.

- Clean the sediment sampler with deionized water prior to initiating sampling at each site
- Make sure enough rope is available to lower the sampler to the bottom of the sump.
- With the jaws open lower the sampler to the bottom of the sump and penetrate perpendicular to the sediment.

- Drop a weighted messenger down the rope to activate the jaw closure mechanism.
- Slowly retrieve the sampler and check to make sure if the jaws closed properly. If not, resample.
- Empty contents into the plastic bucket and continue taking samples until three successful samples are collected at each site.
- Using a clean plastic or Teflon-coated spatula, slowly mix sediment. Once thoroughly mixed, transfer a 12-16 ounce subsample to a pre-labeled, 1000-mL glass jar.
- Secure the lid on the jar and place in the cooler with ice.
- Repeat procedure at each sediment sampling site until all sites have been sampled.

8.4 Sample Packing and Shipping

Monitoring personnel will deliver the samples to the laboratory. Sample bottles will be placed in coolers or some other package that is rigid enough to provide protection of the samples and has isolative properties to keep samples cold. During packing, the sample from one monitoring location should not be separated into separate shipping containers unless bottles of one size need to be shipped together because of container size. If samples from a location are separated a copy of the field-sampling sheet pertaining to the bottles will be enclosed in each shipping container. Prior to shipping all sample bottles will be recorded on the packing lists, which will include the shipping date and the method of transporting the samples.

Samples must be delivered to the analytical laboratory within 4 hours of sampling to ensure that the maximum holding time for bacteria of 6 hours is not exceeded.

8.5 Chain of Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain of custody of each sample will be made. This record ensures that samples have not been tampered with or inadvertently compromised in any way, and it also tracks the requested analysis for the analytical laboratory. “Chain of Custody” (COC) refers to the documented account of changes in possession that occur for samples. The Chain of Custody record tracks the sampling path from origin through laboratory analysis. Information necessary in the chain of custody includes:

- Names of the persons collecting the sample(s)
- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples etc.) and any special instructions (e.g., time sensitive analyses)

To ensure that all necessary information is documented, a COC form will accompany each sample or set of samples. COC forms will be printed on multipart carbonless paper so that all personnel handling the samples may obtain a copy.

A COC record should accompany all sample shipments, and the sample originator should retain a copy of the forms. When transferring custody of samples the transferee should sign and record the date and time of each transfer. Each person who takes custody should complete the appropriate portion of the chain of custody documentation.

Quality Assurance and Quality Control

Section

9

The following QA/QC procedures are the recommended procedures for ensuring the collection of representative samples and procurement of reliable analytical results. The choice of adhering to all or part of these procedures depends on budgetary constraints and/or the availability or preference of another field and/or laboratory QC/QA Plan.

9.1 Data Quality Objectives

The quality assurance/quality control (QA/QC) program will be implemented to satisfy the data quality objectives of the monitoring program. The primary data quality objectives are to obtain defensible data of acceptable sensitivity and quality to:

- evaluate the stormwater management program,
- evaluate stormwater quality, and
- evaluate the performance of the BMP

Analytical accuracy and precision are two parameters typically used to evaluate data quality. Accuracy is defined as the closeness of agreement between an observed value and an accepted reference value. Accuracy is expressed as percent recovery:

$$\%R = \frac{X}{T} x100 \tag{9-1}$$

where:

% R	=	Percent recovery
X	=	Observed value of the measurement
T	=	True value of the measurement

The analytical laboratory selected for this study will evaluate the accuracy of its sample extraction and/or analytical procedures using spike samples, which may include matrix spikes (MS), laboratory control samples (LCS) and surrogate spikes. Acceptable spike recoveries must fall within statistically derived laboratory "control limits."

Precision is the agreement among a set a replicate measurements of the same parameter. Precision is quantified by calculating the relative percent difference (RPD) between duplicate measurements:

$$RPD(\%) = \left(\frac{(C_1 - C_2)}{\left[\frac{C_1 + C_2}{2} \right]} \right) x100 \qquad (9\text{-}2)$$

where:

C1 = First sample result

C2 = Second sample result

The analytical laboratory will evaluate precision by performing matrix spike duplicate (MSD), laboratory control sample duplicate (LCSD) and duplicate stormwater sample analyses (typically performed for inorganic parameters only). Acceptable RPDs must meet the precision criteria established by the laboratory.

The data quality objectives also include obtaining data that are comparable and representative of the water quality conditions at each monitoring location. Comparable data will be collected if comparable sampling, analysis, QA/QC and reporting procedures are implemented throughout the monitoring program. Representative samples will be collected by performing sampling activities compliant with the procedures described in this monitoring plan. Duplicate samples will be collected and the results will be used to evaluate representativeness.

Comparability expresses the confidence with which one data set can be compared to another. Data are comparable if collection techniques, measurement procedures, methods, and reporting are equivalent for the samples within a sample set.

9.2 Field Quality Assurance/Quality Control

This section summarizes the QA/QC procedures that will be implemented by field personnel to evaluate sample contamination, sampling precision and matrix interference.

Equipment Blanks

After the intermediate sample container or scoop is cleaned using the procedures described in Appendix A (SOPs), an equipment blank will be collected by pouring reagent-grade water into the apparatus. The water will be transferred into sample bottles and analyzed for the full analytical suite.

Field Duplicate Samples

Field duplicate samples will be collected to evaluate the precision and representativeness of the sample collection procedures as well as sample homogeneity. One duplicate composite sample will be collected for each storm event. The duplicate sample will be collected using the specified manual grab and automated sampling techniques. Twice the volume required for the analytical suite will be collected with each duplicate sample. For grab samples, intermediate sample containers will be used, and the volume collected will be apportioned equally between the intermediate containers. The water in each intermediate container will be poured into a discrete set of sample bottles.

One set of bottles will be labeled with fictitious sample identification and submitted "blind" to the laboratory.

Matrix Spike Samples

Matrix spike (MS) and matrix spike duplicate (MSD) analyses will be performed by the laboratory using project samples. MS/MSDs are described in more detail in the Laboratory QA/QC section. One MS/MSD sample will be analyzed for each storm event for the full analytical suite. Additional sample volume is required to perform MS/MSD analyses. Field crews will submit twice the required sample volume for the sample selected as the matrix spike sample. Field personnel will identify the MS/MSD sample on the chain-of-custody form.

9.3 Laboratory Quality Control

This section summarizes the QC procedures the laboratory must perform and report with the analytical data packages. These procedures are not inclusive of the QA/QC that is required for compliance with the analytical method. The laboratory will be required to implement all procedures required by the analytical methods listed in Section 6, and to implement the Standard Operating Procedures documented in its Quality Assurance Plan. The required frequency for QC procedures and evaluation criteria are summarized in Table 9.1.

Method Blanks

A method blank is prepared using reagent-grade water, and is extracted and analyzed with each sample batch (typically 20 samples extracted and/or analyzed on a given day). Method blank results are used to identify potential sources of sample contamination resulting from laboratory procedures. Target analytes should not be detected in the method blank above the practical quantitative limit.

Bottle Blanks

Bottle blanks are required for trace-level metals analysis to verify the effectiveness of the cleaning procedures. After undergoing the cleaning procedures summarized in Section 9, a representative set of sample bottles will be filled with reagent-grade water acidified to pH <2 and allowed to stand for a minimum of 24 hours. Ideally, the time the bottles are allowed to stand should be as close as possible to the actual time the sample will be in contact with the bottle. After standing, the water should be analyzed for metals. If a metal is detected at or above its practical quantitative limit, the contamination source will be identified, the cleaning procedures corrected or cleaning solutions changed, and all affected bottles recleaned. Bottle blanks will be performed and the results obtained before the bottles are provided to field personnel.

Matrix Spike and Laboratory Control Samples

Matrix spikes (MS), matrix spike duplicates (MSD), laboratory control samples (LCS) and laboratory control sample duplicates (LCSDs) are performed by the laboratory to evaluate the accuracy of the sample extraction and analysis procedures. MS/MSDs are also performed to evaluate matrix interference.

Matrix interference is the effect of the sample matrix on the analysis, which may partially or completely mask the response of the analytical instrumentation to the target analyte(s). Matrix interference may affect the accuracy of the extraction and/or analysis procedures to varying degrees, and may bias the sample results high or low.

The MS/MSD is prepared by adding known quantities of target analytes to a sample. The sample is then extracted and/or analyzed as a typical environmental sample, and the results are reported as percent recovery. The percent recovery for the MS/MSD analysis is expressed as:

$$\%R = \left(\frac{C_{obs} - C_{org}}{C_s} \right) x100 \qquad (9\text{-}3)$$

where:

% R	=	Percent recovery
Cobs	=	Concentration measured in MS analysis
Corg	=	Concentration measured in un-spiked sample analysis
Cs	=	MS concentration

The LCS/LCSD is prepared exactly like a MS/MSD, except a clean control matrix such as reagent-grade water is used. The LCS recoveries are used to evaluate the accuracy of the analytical procedures, independent of matrix effects (see Equation 9-1).

Surrogate Spikes

Surrogate spikes are performed for organic analysis method only. Surrogates are organic compounds that are similar to the target analytes in terms of their chemical structures and response to the analytical instrumentation, but are not usually detected in environmental samples. Surrogates will be added to each environmental sample and laboratory QC sample per the analytical method to monitor the effect of the matrix on the accuracy of the extraction and/or analysis. Surrogate analysis results are reported as percent recovery (Equation 10-1).

Duplicate Analysis

The laboratory will perform duplicate analyses that may include LCSD, MSD and replicate stormwater sample analyses (for inorganic methods only). The laboratory will evaluate the precision of the duplicate analyses by calculating RPDs (Equation 10-2).

9.4 Data Reduction and Validation Requirements and Methods

Laboratory Requirements

Laboratory data reduction and validation requirements will be consistent with the procedures documented in the laboratory Quality Assurance Plan and Standard Operating Procedures (SOPs). Data review will be performed by the project manager and the laboratory QA officer.

Generally, the review will determine whether or not the:

- Sample preparation information is correct and complete.
- Analysis information is correct and complete.
- The appropriate SOPs have been followed.
- Analytical results are correct and complete.
- QC samples are within established control limits.
- Special sample preparation and analytical requirements have been met.
- Documentation is complete.
- Data reduction and validation steps are documented, signed, and dated by the analyst.

Independent Data Review Process

The analytical data received from the laboratory will be independently reviewed by the Project chemist to evaluate if the data are of acceptable quality to satisfy the project data quality objectives. The data quality evaluation will be performed following USEPA guidelines. Guidance is provided in the following documents:

- USEPA Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring (April 1995).
- USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (October 1999).
- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (February 1994).

A summary of the evaluation criteria that will be used for the independent data review process is provided in Table 9.1. The data qualifiers that will be used to flag analytical results associated with QC parameters outside the evaluation criteria are defined below. All qualifiers are defined by USEPA, with the exception of the “H” qualifier.

UJ – The analyte was not detected above the reporting limit. However, the non-detect concentration is considered an estimated value.

U – The analyte was detected, however due to potential sample contamination from laboratory procedures, sampling equipment, sample handling or transportation to the laboratory, the sample reporting limit was raised to the concentration detected in the sample.

J – The analyte was positively identified. However the result should be considered an estimated value.

R – The sample result is rejected due to serious deficiencies in the ability to analyze the sample in compliance with the QC criteria or other laboratory protocols.

H – The reported petroleum hydrocarbon concentration is not representative of the fuel specified for analysis.

Table 9.1. Summary of quality control evaluation criteria and data usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
Method Blank	Organic and Inorganic Methods	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	Detection of Common Laboratory Contaminants in Blank If the sample concentration is less than 10 times the associated method blank concentration, the sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 10 times the method blank concentration, no qualification is necessary. Detection of Other Analytes in Blank: If the sample concentration is less than 5 times the associated method blank concentration, the associated sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 5 times the method blank concentration, no qualification is necessary.	Yes	Qualified results should be reported as non-detect	USEPA 1994, 1995, 1999
Equipment Blank	Organic and Inorganic	One per storm event	Detection of Common Laboratory Contaminants in Blank If the sample concentration is less than 10 times the associated equipment blank concentration, the sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 10 times the equipment blank concentration, no qualification is necessary. Detection of Other Analytes in Blank: If the sample concentration is less than 5 times the associated equipment blank concentration, the associated sample result is qualified by raising the quantitative limit to the concentration detected in the sample. If the sample result is greater than 5 times the equipment blank concentration, no qualification is necessary.	No	Qualified results should be reported as non-detect	USEPA 1994, 1995, 1999
Field Duplicate Samples	Organic and Inorganic	One per storm event	Concentrations at least 5 times the quantitative limit: if the relative percent difference between the original and duplicate sample result exceeds 25 percent, sample results	No	Results qualified as **J** and **UJ** should be considered estimated values, but can	USEPA 1994, 1995

Table 9.1. Summary of quality control evaluation criteria and data usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
			are qualified as **J.** Concentrations less than 5 times the quantitative limit: if the relative percent difference between the original and duplicate sample result is greater than the quantitative limit, detected sample results are qualified as **J.** If one result is below the quantitative limit, the quantitative limit shall be used to calculate the relative percent difference. If the relative percent difference between the original and duplicate sample is greater than the quantitative limit, the non-detect result is qualified as **UJ** and the detected result is qualified as **J.** Exceedingly high relative percent differences (e.g., 100%) will be qualified based on professional judgment. These data may be qualified as **R** (rejected).		be used to fulfill the project data quality objectives Results qualified as **R** can not be used to fulfill the project data quality objectives	
Matrix Spike/ Matrix Spike Duplicate	Organic and Inorganic	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	Organic analyses are not qualified based on matrix spike data alone. Inorganics: Data are qualified only if the original sample concentration does not exceed the matrix spike concentration by greater than 4 times. If MS recovery is above the upper laboratory control limit, detected results are qualified a **J**, and non-detect results are not qualified. If the MS recovery is below the lower laboratory control limit, but is greater than 30%, detected results are qualified as **J**, non-detect results are qualified as **UJ.** If the MS recovery is below 30%, detected results are	No	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** cannot be used to fulfill the project data quality objectives	USEPA 1994, 1995, 1999

Table 9.1. Summary of quality control evaluation criteria and data usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
			qualified as **J** and non-detected results are qualified as **R** (rejected).			
Laboratory Control Sample/ Laboratory Control Sample Duplicate	Organic	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-hour period)	If the LCS recovery is above the upper laboratory control limit, associated detected analytes are qualified as **J**. Non-detect associated analytes are not qualified. If the mass spectral criteria are met but the LCS recovery is below the lower control limit, associated detected analytes are qualified as **J** and associated non-detect analytes are qualified as **R** (rejected). If more than half the compounds in the LCS are not within the laboratory control limits, all associated detected analytes are qualified as **J** and all associated non-detect analytes are qualified as **R** (rejected). *Professional judgment will be used to qualify sample data for the specific compounds that are not included in the LCS solution.*	Yes, to verify recoveries outside laboratory control limits	Results qualified as **J** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** cannot be used to fulfill the project data quality objectives	USEPA 1999
	Inorganic		If the LCS recovery is above the laboratory control limits, detected results are qualified as **J**. Non-detect results are not qualified. If the LCS recovery is below the laboratory control limits but greater than 50%, detected results are qualified as **J** and non-detect results are qualified as **UJ**. If the LCS recovery is below 50%, detected results are qualified as **J** and non-detect results are qualified as **R** (rejected).	Yes, to verify recoveries outside laboratory control limits	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** cannot be used to fulfill the project data quality objectives	USEPA 1994, 1995

Table 9.1. Summary of quality control evaluation criteria and data usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
Surrogates	Organic	Added to every environmental and batch QC sample	Volatile Organic Compounds *If a surrogate recovery is above the upper laboratory control limit, detected sample results are qualified as **J**. Non-detect results are not qualified.* If a surrogate recovery is below the lower laboratory control limit but above 10%, detected results are qualified as **J** and non-detect results are qualified as **UJ**. If a surrogate recovery is less than 10%, detected results are qualified as **J** and non-detect results are qualified as **R** (rejected). Pesticides The guidance above for volatile organic compounds will be used but professional judgment will be used in applying these criteria as surrogate recovery problems may not directly apply to target analytes. Semi-Volatile Organic Compounds The above criteria for volatile organic compounds apply, but sample results are qualified only if two surrogates within each fraction (i.e., acid, base/neutral) are outside control limits.	Yes, to confirm non-compliance is due to sample matrix effects rather than laboratory deficiencies	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives Results qualified as **R** cannot be used to fulfill the project data quality objectives	USEPA 1999
Laboratory Replicate Analysis	Inorganic	One per sample batch (i.e., 20 samples of a similar matrix analyzed within a 12-	<u>Concentrations at least 5 times the quantitative limit</u>: if the relative percent difference between the original and duplicate sample result exceeds the laboratory control limit, sample results are qualified as **J.** <u>Concentrations less than 5 times the quantitative limit:</u> if	Yes	Results qualified as **J** and **UJ** should be considered estimated values, but can be used to fulfill the project data quality objectives	USEPA 1994

Table 9.1. Summary of quality control evaluation criteria and data usability

QC Parameter	Applicable Method	Frequency	Conditions Under Which Data May be Qualified	Reanalysis Required?	Use of Qualified Data	Reference
		hour period)	the relative percent difference between the original and duplicate sample result is greater than the quantitative limit, detected sample results are qualified as **J.** If one result is below the quantitative limit, the quantitative limit shall be used to calculate the relative percent difference. If the relative percent difference between the original and duplicate sample is greater than the quantitative limit, the non-detect result is qualified as **UJ** and the detected result is qualified as **J.** Exceedingly high relative percent differences (e.g., 100%) will be qualified based on professional judgment. These data may be qualified as **R** (rejected).		Results qualified as **R** cannot be used to fulfill the project data quality objectives	
False-Positive Petroleum Hydrocarbon Result	TPH-Gasoline TPH-Diesel	NA	Based on the review of the chromatograms, sample results that do not match the laboratory standard are qualified as **H**. Chromatograms should be reviewed to evaluate if the detection is due to the presence of a different petroleum hydrocarbon, or a volatile organic compound (in the case of TPH-gasoline analysis).	Yes	Use of data qualified as H depends on the information obtained from the review of chromatograms	None. This is not a standard USEPA qualifier.

Data Management and Reporting

Section 10

Results will be reported by the laboratory as hard copy and as electronic files. Hard copy data will be entered into an electronic format, and checked at least once by a different person. Electronic submittal of results will be discussed with the analytical lab in advance of delivery and its format arranged. A separate record will be generated for each sample analysis.

In addition the key information such as; station ID, sample date and time, name of sampler, name of constituent, all results, units, detection limits, EPA methods used, name of the laboratory, and any field notes will be entered into a site water quality database. Additional information, such as compositing of multiple samples, or the use of grab or automatic samples, will also be included.

When reporting the laboratory results for each stormwater sample the following information will be provided:

- Sample site
- Sample date and time
- Sample number (or identification)
- Sampling technician(s)
- Detection Limit and Reliability Limit of analytical procedure(s)
- Sample Results with clearly specified units

At the end of the wet season, after all of the sampling event data have been collected for each sampling site, an exploratory data analysis should be performed. Exploratory data analysis (EDA) consists of calculating summary statistics, such as mean, median, minimum, maximum, standard deviation, interquartile range, skewness, kurtosis, etc., as well as examining the data using graphical tools. Box and whisker plots and normal probability plots should be developed for both the original data sets and log-transformed data, as most stormwater quality data are log-normally distributed. Both of these graphical tools provide a quick look at the distributional shape of the data. By reviewing the data both numerically and graphically, the structure of the data can be evaluated and thereby appropriate approaches and limitations for using the data can be identified. During the EDA, other data anomalies, such as extreme outliers or other obvious data recording/transcribing errors can be readily identified if they exist.

For this monitoring effort, there will only be one season's worth of data (target is 4 events) so the ability to estimate the performance of individual BMPs by comparing the influent quality of the UIC receiving limited pre-treatment (UIC 1) to the influent quality of the other UIC's may not be statistically viable. However, depending on the variability of the storm event data, by constructing side-by-side boxplots or side-by-side probability plots, the data may provide some indication of BMP performance.

Standard Operating Procedures for Stormwater Monitoring (SOPs)

Appendix

A

SOP A-1 Weather Tracking and Monitoring Preparation

The Storm Event Coordinator will review the daily National Weather Service forecasts (www.nws.noaa.gov) and track all potential rainfall events.

If an event being tracked has a 70% or greater probability of generating 0.3 inch of rainfall within a 24 hour period, the Storm Event Coordinator will inform the Monitoring Team 72 hours before its predicted arrival and a the Team will be placed in a "Prepare Mode."

Monitoring Team "Prepare Mode"

- Order bottles from lab and alert lab of possible monitoring activities (may want to keep a supply on hand during monitoring season)
- Assemble field equipment
- Arrange team members schedule for field activities
- Arrange vehicle for monitoring activities
- For 1st event of each season, check and flag all sample locations and assess site conditions, report any potential problems to Storm Event Coordinator

The Storm Event Coordinator will frequently monitor weather patterns and if the forecast still predicts a target magnitude event at 48 hours before its arrival, the Monitoring Team will be placed in a "Stand-By Mode."

Monitoring Team "Stand-By Mode"

- Identify Monitoring Team and arrange schedules for field activities
- Check bottle inventory against station check list
- Initiate chain of custody procedure
- Bench test and calibrate all field equipment
- Confirm team members schedules for field activities
- Arrange for vehicle to conduct monitoring activities

At 24 hours before the event is predicted to arrive, if there is still a 70% probability that the storm will generate 0.3 inch of rainfall within 24 hours, the Storm Event Coordinator will obtain Quantitative Precipitation Forecasts (QPFs) every 6 hours and a monitoring "Alert" will be issued.

Monitoring Team "Alert Mode"

- Label bottles
- Check field boxes for supplies
- Ensure a sufficient amount of ice for sampling and sample transport
- Set up sampling equipment at sites (preferably during daylight hours)

At 12 hours before a target event is scheduled to arrive, a Go/No-Go decision on monitoring will be made by the Storm Event Coordinator. The latest QPF will be obtained and sample frequency calculations will be done for each site and this information will be relayed to the Monitoring Team.

Monitoring Team "Go"

- Mobilize Monitoring Team

Monitoring Team "No-Go"

- Inventory, clean, organize, and prepare sampling equipment for next event.

Once precipitation has begun the Monitoring Team will go into "Sample Mode"

Monitoring Team "Sample Mode"

- Contact Storm Event Coordinator and confirm "Go" decision
- Begin sampling according to sampling procedures in Section 8 and the Standard Operating Procedures (SOPs)

SOP A-2 Field Equipment Preparation

Minimum field equipment should include:

Table A.1: Stormwater monitoring field equipment checklist

Documentation	Safety
Signed Health and Safety Plan	Four gas (0_2, H_2S, CO, CH_4) meter w/ calibration kit
Stormwater Monitoring Plan	Safety line
Monitoring Plan Check Lists and Field Notebooks	Flashing lights for vehicle
Equipment Manuals (if applicable)	Traffic cones
Chain of Custody Forms/Bottle Labels/Permanent markers/pen/pencils	Traffic control signs (may need flaggers)
Sampling Equipment	Cell phone (or two way radios)
Extension pole	Gloves (protective leather and nitrile)
Glass beaker	Hard hat (1 per person)
2 – 1-gallon glass jars w/ lids (provided by lab)	Goggles (1 set per person)
1 – 1-liter glass jar w/ lid (provided by lab)	Safety vest (1 per person)
3 – 40-ml VOC vials (provided by lab)	Raingear
E. Coli bottle (provided by lab)	First Aid kit
1-gallon plastic bags	**Miscellaneous**
Cooler with ice (4^{o}C) (one for each site)	Manhole hook
Watch or stopwatch	Buckets
Distilled water	Ropes
	Duct tape
	Digital camera
	Paper towels

When the Monitoring Team is placed in “Alert Mode” (approximately 24 hrs. prior to sampling) the field equipment checklist should be reviewed to ensure the equipment is available for monitoring.

SOP A-3 Bottle Organization

- Bottles of proper size and material and sufficient quantity should be prepared by the analytical lab and delivered to the Monitoring Team at least 48 hours prior to the sampling event (see sample bottle order form).
- A separate cooler should be prepared and clearly labeled for each set of samples at each monitoring station. The cooler should include the required bottles for sampling at that site as well as bottles for blanks and duplicates as required by the QA/QC plan.
- All sample bottles should be labeled prior to placement in cooler and as much information as possible should be filled out on the labels when bottles are dry. A second label or corresponding Sample ID No. should be place on sample bottle lid.
- One set of clean beakers in Ziploc bags (one 250 mL and one 500 mL) should be placed in coolers with bottles.
- Powder free nitrile gloves should be worn whenever handling clean bottles.

SOP A-4 Clean Sampling Techniques

Sample collection personnel should adhere to the following rules while collecting stormwater samples to reduce potential contamination.

General

- No Smoking
- Do not park vehicles in immediate sample collection area; do not sample near a running vehicle.
- Always wear clean powder-free nitrile gloves when handling composite bottles, lids, sterile grab sample bottles, tubing, or strainers.
- Never touch the inside surface of a sample bottle, lid, or inside of beaker with hands (even if clean or gloved) or any material other than the sample water.
- Never allow any object or material to fall into or contact the collected sample water.
- Avoid allowing rainwater to drip from rain gear or other surfaces into sample bottles.
- Do not eat or drink during sample collection.
- Do not breathe, sneeze, or cough in the direction of an open sample bottle.

Equipment Decontamination Procedures

Non-dedicated sampling equipment will be properly cleaned before sample collection Non-dedicated equipment may include:

- Glass beakers used to collect manual grab samples [note- you cannot use stainless steel for trace metals analysis

Scoops and buckets used to transfer samples into the sample bottles will be cleaned as follows:

- Clean with tap water and phosphate-free laboratory detergent such as Liquinox®
- Rinse thoroughly with tap water
- Rinse thoroughly with analyte-free water (i.e., de-ionized water)
- Air dry

SOP A-5 Grab Sampling

In addition to the sampling procedures described in Section 8.3 these general procedures should also be followed:

- Put on sterile nitrile gloves
- Adhere to clean sampling techniques in SOP-A3
- Remove lid of sample bottle
- Place lid top down on a clean surface out of the rain or hold in hand while taking sample; do not allow inside of lid to contact any objects.
- Fill sample bottle by placing the bottle opening directly under lip of the inflowing stream (do not take samples from pooled areas).
- Replace lid on sample bottle
- Fill out label on sample bottle and place in cooler

Bacteria samples should be taken just prior to completion of monitoring due to the short holding time requirements for their analysis.

SOP A-6 Chain of Custody Records

A chain of custody record (COC) is a legal document designed to track samples and persons who are responsible for them during preparation of the sample container, sample collection, sample delivery, and sample analysis. These form are supplied by the analytical laboratory that perform the sample analysis. The procedures for filling out these forms are as follows:

Prior to sampling

After bottles are labeled placed in coolers, fill out general information on COC form including:

- Company information and Client Code
- Project Name
- Sample Site ID
- Matrix
- Date

- Sample Numbers (unique to each bottle)
- Type of sample

Place COC in a Ziploc bag and tape to the lid of the cooler

After sampling is complete

After sampling has been completed, fill out remainder of the COC including:

- Time sampling was initiated
- Number of containers
- Comments or special instructions
- Disposal requirements

Replace in Ziploc bag and tape to lid of cooler

At laboratory or transfer to another person

Whenever custody of the samples is relinquished:

- Sign and date
- Have new custodian sign and date
- Relay any special instructions
- Take one copy of COC for your records

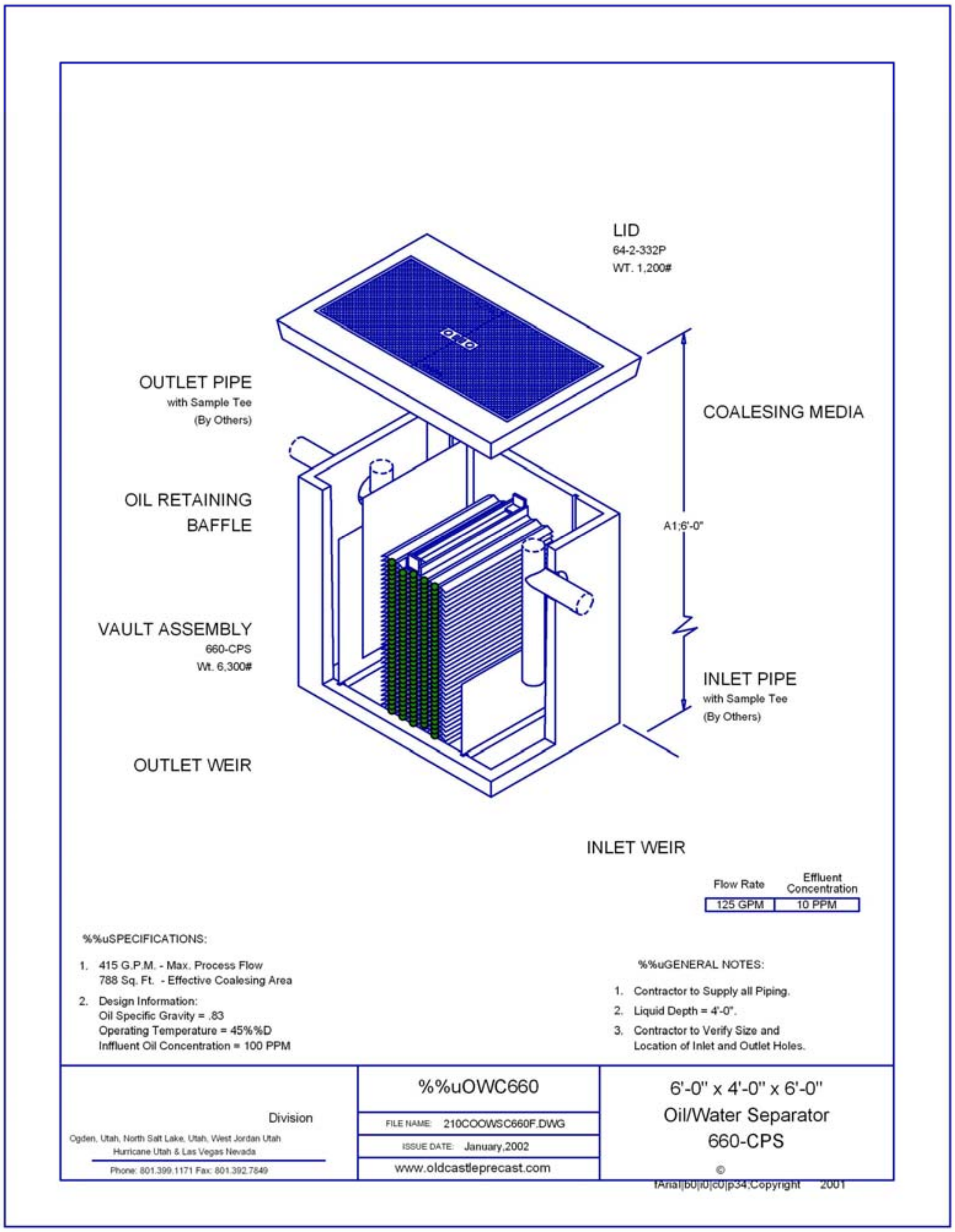
SOP A-7 Transporting, Packaging, and Shipping Samples from the Field to the Laboratory

- Clearly mark the analyses to be performed for each sample.
- Fold the field-sampling sheets and chain of custody record form and place them in plastic bags to protect the sheets during transport. Tape COCs to the lid of the cooler.
- Pack samples well to prevent breakage or leakage (samples should already be labeled) and provide additional protection for glass sample bottles (e.g., foam or bubble wrapping).
- Sample should be packed in ice or an ice substitute to maintain a sample temperature of 4°C during shipping. Ice (or substitute) should be placed in double wrapped watertight bags to prevent leaking during shipping.
- Using duct tape or packing tape, wrap the cooler twice to seal the opening.
- On the sealing tape, write the date and time the sample container was sealed
- Affix destination, identification, and FRAGILE labels to each shipping container.
- Samples must be delivered to the analytical laboratory within 4 hours of sampling to ensure the maximum holding time for bacteria of 6 hours is not exceeded.

Oil / Water Separator Details

Appendix

B



Summary of Curb Inlets

Appendix C

Curb Inlet No.	Station	Reference Sheet No. from Project Plans	Contributing Area (acres)	Contributing Area (ft2)	Final Discharge Location	Total Contributing Drainage Area (acres)
1	32+10 RT	PP 1.0	0.24	10422		
2	32+60 RT	PP 1.0	0.26	11368	Drywell Location 1	**0.50**
3	35+15 LT	PP 1.0	0.19	8394		
4	35+26 RT	PP 1.0	0.34	14703	Detention Basin 1, Drywell Location 2	**0.53**
5	36+74 LT	PP 1.0	0.17	7404		
6	38+33 LT	PP 1.0	0.19	8425		
7	38+33 RT	PP 1.0	0.19	8446		
8	40+30 RT	PP 2.0	0.24	10316		
9	40+30 LT	PP 2.0	0.22	9472		
10	42+45 LT	PP 2.0	0.09	3959		
11	42+45 RT	PP 2.0	0.08	3371		
12	43+50 LT	PP 2.0	0.23	10057		
13	43+50 RT	PP 2.0	0.19	8284		
14	45+77 LT	PP 3.0	0.11	4693		
15	45+77 RT	PP 3.0	0.09	3764		
16	49+10 LT	PP 3.0	0.25	10756		
17	49+10 RT	PP 3.0	0.20	8870		
18	51+55 LT	PP 3.0	0.26	11413		
19	51+55 RT	PP 3.0	0.25	10855		
20	52+43 RT	PP 4.0	0.10	4548		
21	53+35 LT	PP 4.0	0.19	8232		
22	53+35 RT	PP 4.0	0.12	5187		
23	56+58 LT	PP 4.0	0.72	31188		
24	58+75 RT	PP 4.0	0.16	7168		
25	59+80 LT	PP 5.0	0.44	19379	Detention Basin 2&2A, Drywell Location 3	**4.49**
26	62+00 LT	PP 5.0	0.26	11420		
27	63+00 RT	PP 5.0	0.41	17995		
28	63+00 LT	PP 5.0	0.09	4013		
29	65+25 RT	PP 5.0	0.54	23495		
30	67+55 RT	PP 6.0	0.45	19556		
31	68+45 RT	PP 6.0	0.19	8116		
32	69+10 RT	PP 6.0	0.15	6475		

Curb Inlet No.	Station	Reference Sheet No. from Project Plans	Contributing Area (acres)	Contributing Area (ft2)	Final Discharge Location	Total Contributing Drainage Area (acres)
33	69+25	PP 6.0	0.18	7638		
34	69+40	PP 6.0	0.38	16367		
35	71+35 LT	PP 6.0	0.15	6392		
36	71+35 RT	PP 6.0	0.16	6977	Detention Basin 3&3A, Drywell Location 4	**2.95**
37	74+70 RT	PP 7.0	0.16	7122		
38	75+13 LT	PP 7.0	0.17	7510		
39	76+50 LT	PP 7.0	0.27	11931		
40	78+60 LT	PP 7.0	0.50	21871	Flow Control Manhole, Drywell Location 5	**1.11**
41	80+61 LT	PP 8.0	0.47	20332		
42	82+70 LT	PP 8.0	0.43	18840		
43	86+10 LT	PP 8.0	0.65	28306		
44	86+10 RT	PP 8.0	0.10	4215	Flow Control Manhole, Drywell Location 6	
45	87+95 LT	PP 9.0	0.19	8123		
46	87+95 RT	PP 9.0	0.19	8075		
47	91+62 LT	PP 9.0	0.40	17304		
48	91+62 RT	PP 9.0	0.41	17752		
49	93+78 LT	PP 9.0	0.21	9177		
50	93+78 RT	PP 9.0	0.21	9272	Flow Control Manhole, Drywell Location 7	**1.60**