



**CITY OF PORTLAND
MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4)
QUALITY ASSURANCE MONITORING PLAN**

July 31, 2015

Prepared by:

**CITY OF PORTLAND
BUREAU OF ENVIRONMENTAL SERVICES**

TABLE OF CONTENTS

SECTION 1	INTRODUCTION	1-1
1.1	Purpose	1-1
1.2	Organization	1-1
1.3	Permit Requirements and Monitoring Objectives	1-1
1.4	Modifications.....	1-2
1.5	Long-Term Monitoring Strategy	1-3
SECTION 2	DRY AND WET SEASON INSTREAM MONITORING.....	2-1
2.1	Project Task/Organization	2-1
2.2	Background.....	2-1
2.3	Monitoring Objectives	2-1
2.4	Monitoring Locations	2-1
2.4.1	Monitoring Frequency	2-2
2.4.2	Sample Collection Methodology.....	2-2
2.5	Connection to Long-Term Monitoring Strategy	2-3
SECTION 3	CONTINUOUS INSTREAM MONITORING	3-1
3.1	Project Task/Organization	3-1
3.2	Background.....	3-1
3.3	Monitoring Objectives	3-1
3.4	Monitoring Locations	3-1
3.4.1	Monitoring Frequency and Duration	3-1
3.4.2	Sample Collection Methodology.....	3-1
3.5	Special Data Quality Objectives and Criteria	3-2
3.6	Connection to Long-Term Monitoring Strategy	3-2
SECTION 4	STORMWATER MONITORING	4-1
4.1	Project Task/Organization	4-1
4.2	Background.....	4-1
4.3	Monitoring Objectives	4-1
4.4	Monitoring Locations	4-2
4.4.1	Target Population	4-2
4.4.2	Description of Sample Design.....	4-2
4.4.3	Monitoring Locations	4-3
4.4.4	Monitoring Frequency and Duration	4-3
4.4.5	Sample Collection Methodology.....	4-4
4.5	Connection to Long-Term Monitoring Strategy	4-5
SECTION 5	MACROINVERTEBRATE MONITORING	5-1
5.1	Project Task/Organization	5-1
5.2	Background.....	5-1

5.3	Monitoring Objectives	5-1
5.4	Study Design and Monitoring Process	5-2
5.4.1	Monitoring Locations	5-2
5.4.2	Monitoring Frequency and Duration	5-2
5.4.3	Sample Collection Methodology	5-2
5.5	Special Data Quality Objectives and Criteria	5-3
5.5.1	Measurement Quality Objectives	5-3
5.5.2	Sample Handling and Custody	5-3
5.6	Quality Control	5-3
5.6.1	Field Quality Control.....	5-3
5.6.2	Laboratory Quality Control	5-4
5.7	Connection to Long-Term Monitoring Strategy	5-4
SECTION 6 STORM EVENT TARGETING		6-1
6.1	Sampling Considerations	6-1
6.2	Storm Criteria	6-1
6.3	Weather Forecasting	6-2
SECTION 7 SAMPLING STAFF		7-1
7.1	Storm Monitoring Coordinator	7-1
7.2	Field Sampling Teams	7-1
SECTION 8 FIELD SAMPLING PROCEDURES		8-1
SECTION 9 QUALITY CONTROL/QUALITY ASSURANCE		9-1
SECTION 10 REFERENCES		10-1

TABLES

Table 1.1	Monitoring Objectives Matrix	1-5
Table 2.1	Surface Water Monitoring Locations – Fixed Locations	2-2
Table 3.1	Current USGS Gauge Locations	3-2
Table 4.1	Stormwater Monitoring Locations	4-3
Table 4.2	Stormwater Sample Laboratory Analytes, Containers, Volumes, Methods Preservation, and Holding Times	4-5
Table 5.1	Biological Communities Field Quality Control	5-3
Table 5.2	Macroinvertebrate Laboratory Quality Control	5-4

FIGURE

5.1	Wadeable Site Reach Features with Macroinvertebrate L, C, R Sampling Points	5-2
-----	---	-----

SECTION 1

INTRODUCTION

1.1 PURPOSE

This Quality Assurance Monitoring Plan (QAMP) describes the quality assurance/quality control (QA/QC) and sampling and analysis procedures for the collection of stormwater and surface water samples by the City of Portland (City) Bureau of Environmental Services. Stormwater and surface water quality data will be collected and reported annually from representative monitoring locations for compliance with the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit (Permit No. 101314) issued to the City by the Oregon Department of Environmental Quality. The MS4 permit requires the City to monitor stormwater and surface water during each 5-year permit term.

This QAMP will guide (or provide reference to appropriate documents) all sampling, analyses, data assessment, data management, and other monitoring-related activities conducted under the permit and will ensure that quality control and consistency are maintained.

1.2 ORGANIZATION

Section 1.0 provides a summary of the NPDES MS4 permit requirements related to monitoring, procedures for making modifications to this plan, and a summary of the overall long-term monitoring strategy. In the following sections, this QAMP covers the main elements of the NPDES MS4 environmental monitoring program including instream monitoring (Section 2.0), continuous instream monitoring (Section 3.0), stormwater monitoring (Section 4.0), and macroinvertebrate monitoring (Section 5.0). Section 6.0 provides a description of storm event targeting, Section 7.0 provides a description of sampling staff, and Section 8.0 provides a description of field sampling procedures. Section 9.0 provides information related to quality control procedures. The last section of this document (Section 10) lists the references cited in this QAMP.

The City conducts significant monitoring of stormwater in the underground injection control (UIC) system for compliance with its Water Pollution Control Facility (WPCF) permit. The UIC stormwater monitoring program is documented in the WPCF Permit Sampling and Analysis Plan (WPCF-SAP) and the WPCF Permit Quality Assurance Project Plan (WPCF-QAPP). Where methods and QA/QC procedures overlap, this document references those sections of the WPCF-SAP and WPCF-QAPP in order to minimize duplication and simplify the process for any potential future modifications.

1.3 PERMIT REQUIREMENTS AND MONITORING OBJECTIVES

Schedule of B.1.a of the City's MS4 permit provides the minimum monitoring and reporting requirements. It lists the following six objectives that the monitoring program must incorporate:

- i. *Evaluate the source(s) of the 2004/2006 303(d) listed pollutants applicable to the co-permittees' permit area;*
- ii. *Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;*
- iii. *Characterize stormwater based on land use type, seasonality, geography or other catchment characteristics;*
- iv. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;*
- v. *Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters; and,*
- vi. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

Table 1.1 (at the end of Section 1.0) shows how the monitoring program presented in this plan addresses each of these six objectives.

Schedule B.2.a-d requires the City to develop a monitoring plan that:

- a. *Identifies how each monitoring objective identified in Schedule B.1.a is addressed and the sources of information used. The co-permittee may use Stormwater Management Plan measurable goals, environmental monitoring activities, historical monitoring data, stormwater modeling, national stormwater monitoring data, stormwater research or other applicable information to address the monitoring objectives.*
- b. *Describes the role of the monitoring program in the adaptive management of the stormwater program.*
- c. *Describes the relationship between environmental monitoring and a long-term monitoring program strategy.*
- d. *Describes the following information for each environmental monitoring project/task:*
 - i. *Project/task organization*
 - ii. *Monitoring objectives, including:*
 - a) *Monitoring question and background;*
 - b) *Data analysis methodology and quality criteria; and,*
 - c) *Assumptions and rationale;*
 - iii. *Documentation and record-keeping procedures;*
 - iv. *Monitoring process/study design, including monitoring location, description of sampling event or storm selection criteria, monitoring frequency and duration, and responsible sampling coordinator;*
 - v. *Sample collection methods and handling/custody procedures;*
 - vi. *Analytical methods for each water quality parameter to be analyzed;*
 - vii. *Quality control procedures, including quality assurance, the testing, inspection, maintenance, calibration of instrumentation and equipment; and,*
 - viii. *Data management, review, validation, and verification.*

This QAMP document addresses these monitoring plan requirements.

1.4 MODIFICATIONS

Modifications to the QAMP may be recommended by field sampling staff or laboratory staff, during review and evaluation of the field and/or analytical data, or as part of changes to the monitoring approach. Modifications will be addressed by either revising the QAMP or preparing addenda to the QAMP. The revised QAMP or addenda will describe both the need for the modifications and how the planned changes will be implemented (e.g., sampling and analyses, QA/QC). Modifications may include, but are not be limited to:

- Modifications to the data management system
- Selection of monitoring locations
- Changes in field procedures or analytical methods
- Changes in monitoring protocols
- Change in contract laboratory
- Change in stormwater data evaluation reporting (e.g., graphs, calculations, correlations) and trend analyses reporting (e.g., graphs, statistical methods)

Modifications to the QAMP will be made in accordance with Schedule B.2.e of the permit:

- *Modifications may be made without prior DEQ approval if the following conditions are met:*
 - i. *The co-permittee is unable to collect or analyze any sample, pollutant parameter, or information due to circumstances beyond the co-permittee's control. These circumstances may include, but are not limited to, abnormal climatic conditions, unsafe or impracticable sampling conditions, equipment vandalism or equipment failures that occur despite proper operations and maintenance; or,*
 - ii. *The modification does not reduce the minimum number of data points, which are a product of monitoring location, frequency, and length of permit term, or eliminate pollutant parameters identified in Table B-1 (of the permit).*
- *For other modifications, the City will submit the proposed modification to DEQ for approval 30 days in advance of implementation.*

Per Schedule B.2.f of the permit, the City will include a summary and rationale of any modifications in the subsequent MS4 annual compliance report.

1.5 LONG-TERM MONITORING STRATEGY

The City's long-term strategy for environmental monitoring is focused on evaluating the quality of both stormwater discharges and receiving waters. The purpose of the environmental monitoring is to meet the objectives listed above and to inform the City's decisions related to stormwater management priorities and adaptive management. For both of these monitoring elements (stormwater and receiving water), different types of sampling are conducted in an attempt to answer various questions that will address this purpose. More detail regarding these types of monitoring and how they address the City's long-term strategy is as follows:

Stormwater Monitoring: With respect to stormwater discharges, the strategy is to conduct two types of monitoring. The first is referred to as probabilistic monitoring (also known as generalized random tessellation stratified design) using methods developed by Stevens and Olsen (2004). This probabilistic monitoring includes the collection of grab samples from a relatively large number of representative sites (approximately 75 over the permit term) with small drainage areas. This probabilistic method is used by the City to try to build a robust data set of stormwater quality and to tease out more information regarding pollutant sources that could be related to specific drainage area qualities (e.g., traffic, land use, soils).

The second type of stormwater monitoring is the continued collection of flow-weighted stormwater quality samples from historic fixed land use sites. Data from these sites will be used to evaluate whether detectable trends can be observed in stormwater runoff quality over time and as upstream management measures have been implemented.

Both types of monitoring include the analysis of a comprehensive list of pollutant parameters.

Receiving Water Monitoring: With respect to receiving waters, the strategy is to conduct four types of instream monitoring: continuous monitoring, dry weather ambient monitoring, storm event monitoring, and macroinvertebrate monitoring. Continuous instream monitoring is conducted for select parameters (typically temperature and flow) and is used to evaluate fluctuations in water quality on a diurnal basis and when storm events occur.

The dry weather ambient monitoring will be used to evaluate instream trends over time and to assess compliance with water quality standards and Total Maximum Daily Load (TMDL) goals. Comparing this dry weather instream data with instream storm event data will also provide insights into whether stormwater discharges are contributing to and/or exacerbating water quality issues or trends.

Results from macroinvertebrate sampling may provide further insight into stream quality. As macroinvertebrates are present in the stream year-round, they show the effects of degraded water quality and habitat. Some macroinvertebrates are more sensitive to pollution than others. Therefore, if a receiving stream is inhabited by macroinvertebrates that are more tolerant than others, a pollution problem could exist. Comparing information on the presence of various macroinvertebrate communities to water quality data from the same site will provide indications regarding the potential problems (e.g., low dissolved oxygen, high temperatures, sedimentation).

Results from all of the monitoring described above will be used to inform and adaptively manage the City's stormwater management program over time.

Table 1.1 Monitoring Objectives Matrix

Monitoring objective	Environmental Monitoring Elements				
	Dry and Wet Season Instream Monitoring (Section 2.0)	Continuous Instream Monitoring (Section 3.0)	Probabilistic Stormwater Monitoring (Section 4.0)	Stormwater Monitoring at Historic Land Use Sites (Section 4.0)	Macroinvertebrate Monitoring (Section 5.0)
i. Evaluate the source of the 2004/2006 303(d) listed pollutants applicable to the co-permittees permit area	Analysis of instream samples includes TMDL and some 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Evaluating instream pollutant concentrations in dry weather versus wet weather conditions will assist in identifying the role that stormwater plays as a contributing source of these pollutants.	Evaluating flow and temperature data (and sometimes turbidity) on a continuous basis can be used in comparison with instream water quality data to identify the relationship between these parameters and pollutant concentrations.	Analysis of stormwater samples includes most TMDL and some 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Comparison of stormwater monitoring results with instream results may provide information to evaluate the role that stormwater plays as a potential source.	Analysis of stormwater samples includes TMDL and some 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Comparison of stormwater monitoring results with instream results may provide information to evaluate the role that stormwater plays as a potential source.	Macroinvertebrate sampling, when combined with instream pollutant concentration results, provides information to support the identification of pollutants of concern.
ii. Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities	In combination with results from stormwater monitoring, instream data can be used to evaluate instream trends and the overall effectiveness of stormwater management program/BMP implementation.	If a relationship is identified between flow/turbidity data and pollutant concentrations, that information may be used to select and refine BMPs to enhance effectiveness.	Stormwater monitoring will provide information to support the evaluation of overall BMP effectiveness in reducing pollutants in the monitored catchment.	Stormwater monitoring will provide information to support the evaluation of overall BMP effectiveness in reducing pollutants in the monitored catchment.	Macroinvertebrate monitoring may be used to assess overall program improvements.
iii. Characterize stormwater based on land use type, seasonality, or geography	N/A	N/A	Probabilistic monitoring may potentially answer more specific questions regarding sources of stormwater pollutant concentrations.	Returning to fixed land use stations for monitoring will be used to answer questions related to whether trends have been observed as a result of upstream management measures, and whether trends vary by land use.	Indirectly provides information to support the characterization of MS4 runoff discharges based on seasonality and/or geography.
iv. Evaluate long-term trends in receiving waters associated with MS4 stormwater discharges	Instream data can be used to assess trends. Both dry weather and wet season data will be collected to evaluate ambient trends reflective of stormwater management program implementation.	N/A	Stormwater monitoring will assist in the interpretation of instream trends analyses.	Stormwater monitoring will assist in the interpretation of instream trends analyses.	Macroinvertebrate sampling will provide information to support the evaluation of trends in receiving waters and may be used for trending as an independent measure.
v. Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters	Instream monitoring will provide information to assess the chemical and physical effects of MS4 runoff on receiving waters.	Continuous instream monitoring will provide information to assess select physical effects of MS4 runoff on receiving waters.	Stormwater monitoring will assist in the interpretation of instream water quality concerns and will be used to evaluate potential impacts.	Stormwater monitoring will assist in the interpretation of instream water quality concerns and will be used to evaluate potential impacts.	Macroinvertebrate monitoring will provide information to assess the biological effects of MS4 runoff on receiving waters.
vi. Assess progress toward meeting TMDL pollutant load reduction benchmarks	Instream monitoring will provide information regarding progress toward meeting TMDL waste load allocations (used to establish pollutant load reduction benchmarks).	N/A	Stormwater monitoring may provide information (i.e., improved land use concentrations) for use in the pollutant loads modeling to assess progress toward meeting pollutant load reduction benchmarks.	Stormwater monitoring may provide information (i.e., improved land use concentrations) for use in the pollutant loads modeling to assess progress toward meeting pollutant load reduction benchmarks.	N/A

NA = not applicable.

SECTION 2

DRY AND WET SEASON INSTREAM MONITORING

This section provides a summary of the instream portion of the monitoring program. This summary includes a description of the project task/organization, background, monitoring objectives, monitoring locations, and connection to the long-term monitoring strategy.

2.1 PROJECT TASK/ORGANIZATION

Instream monitoring refers to the collection of water quality samples from streams that receive MS4 discharges. Samples will be collected at fixed sampling locations to evaluate receiving water quality and ambient trends over time and to evaluate instream quality during storm events. The samples will be collected by City of Portland staff and analyzed by the City of Portland water pollution control laboratory (WPCL) or Test America as described in Section 9.0 of this document. WPCL staff will be responsible for data management, and MS4 staff will perform data assessment and evaluation.

2.2 BACKGROUND

Since the early 1990s, the City has collected samples from a set of fixed instream monitoring locations representing various receiving water bodies throughout the City. In 2010, the City re-evaluated its instream monitoring program based on national watershed monitoring approaches. The City decided to begin work to eventually transition to a new method for continued instream monitoring. The new method is called the generalized random tessellation stratified design. The design has a rigorous statistical foundation, yet is able to adapt to the challenges and complexities of collecting data in the natural environment. This newer instream monitoring program includes panels of rotating sampling locations. As the City transitions to using data from this new instream monitoring protocol, the fixed monitoring sites have been maintained to allow for continued receiving water quality data analysis and evaluation of ongoing trends (as required by the MS4 permit). Results from the fixed sites will also be used for a comparison between the two monitoring approaches. Until more data are collected using the newer instream monitoring protocol, results from 11 fixed instream sites will continue to be used for this NPDES MS4 permit monitoring program for evaluating instream water quality and conducting trends analyses.

2.3 MONITORING OBJECTIVES

Instream monitoring will contribute to monitoring objectives i, ii, iv, v, and vi identified in Schedule B.1 of the MS4 permit (see Table 1.1). Specifically, instream monitoring is critical for evaluating long-term trends in receiving waters with MS4 discharges, as well as for assessing the effects of MS4 discharges on receiving waters by evaluating and comparing data during both dry and wet weather conditions. Instream monitoring will also assist in evaluating progress toward addressing TMDL objectives including benchmarks.

2.4 MONITORING LOCATIONS

Table 2.1 lists the fixed monitoring locations that have been sampled in the past and will be retained for sampling during this permit term. These sites were selected as representative of a variety of the major watersheds in Portland and various land uses and geographies.

Table 2.1 Surface Water Monitoring Locations – Fixed Locations

Site ID	Location	Stream Name	Watershed
AWB	NE Airport Way Bridge B	Columbia Slough	Columbia Slough
SJB	St. John’s Landfill Bridge	Columbia Slough	Columbia Slough
M2	1900 SE Millport Road	Johnson Creek	Johnson Creek
JC-6	SE 158th Ave. Bridge	Johnson Creek	Johnson Creek
FC-8	4916 SW 56th Avenue	Fanno Creek	Fanno Creek
TC-4	10750 SW Boones Ferry Road	Tryon Creek	Tryon Creek
TC-5	SW 26th Way and Barbur Boulevard	Tryon Creek	Tryon Creek
TC-6	9323 SW Lancaster Road	Tryon Creek	Tryon Creek
WR-BM	Morrison Street Bridge – RM 12.7	Willamette River	Willamette River
WR-CM	St. John’s Railroad Bridge – RM 6.8	Willamette River	Willamette River
WR-FM	Waverly Country Club – RM 17.9	Willamette River	Willamette River

2.4.1 Monitoring Frequency

Four samples will be collected per year at each location. Two of the four samples will be collected during storm events unless conditions beyond the City’s reasonable control are encountered that prevent the collection of the storm event samples.

2.4.2 Sample Collection Methodology

As per Schedule B.3 of the permit for instream monitoring:

- A minimum of 50 percent of the water quality sampling events must be collected during the wet season (October 1 to April 30).
- Each unique sample event must occur at a minimum of 14 days apart.

Grab samples will be collected at the listed instream sites. The samples will be collected from the site facing upstream. At wadeable sites, the sample bottle or beaker will be submerged upside down, then slowly turned right side up while bringing it up through the water column. Samples will be collected directly into the analyte-specific bottle if there is sufficient water depth. If water depth is insufficient for direct collection into bottles, samples will be collected into a decontaminated stainless steel beaker and then transferred into the analyte-specific bottles. Prior to use in the field, beakers will be decontaminated according to the protocol described in Section 7.64 of the WPCF-SAP. For deeper, faster-moving stream segments, samples are collected from bridges using a column sampler in accordance with BES Field Operations Standard Operating Procedure (SOP) 2.02d.

Field duplicate samples will be collected by filling bottles simultaneously, one in each hand of the sampler. Duplicate samples that are required to be collected in the column sampler or decontaminated stainless steel beaker will be filled by alternating between sample bottles for the same analysis until bottles are filled.

The required sample containers, sample volume, preservative requirements, and maximum holding times are provided in Table 2.2. A separate cooler will be prepared for each site and provided with a zip-tied cooler tag that can be labeled with the sample point code in the field at the time of sample collection.

Table 2.2 Instream Sample Laboratory Analytes, Containers, Volumes, Methods, Preservation, and Holding Times

Compound/Compound Class ⁽¹⁾	Container type	Sample volume	Method	Preservation requirements	Technical holding time
Total Metals Cu, Pb, Zn	HDPE	500 mL	EPA 200.8	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
Dissolved Metals Cu, Pb, Zn	HDPE	500 mL	EPA 200.8	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	EPA 350.1	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	EPA 300.0	Cool to 4°C +/- 2°C	48 hours
Total Phosphorus	Plastic	1 pint	EPA 365.4	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	EPA 365.1	Cool to 4°C +/- 2°C	48 hours
<i>E. coli</i>	Sterile Plastic	250 mL	Colilert QT	Cool to 4°C +/- 2°C	8 hours
Hardness	Plastic	½ pint	SM2340B	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
BOD ₅ (if TMDL is established for this parameter)	Plastic	1 quart	SM5210B	Cool to 4°C +/- 2°C	48 hours
Total Organic Carbon	Amber Glass	250 mL	SM5310B	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Total Suspended Solids	Plastic	1 quart	SM2540D	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)

¹ Samples will also be analyzed in the field for dissolved oxygen, specific conductivity, pH and temperature. See Section 8.0.

2.5 CONNECTION TO LONG-TERM MONITORING STRATEGY

Instream water quality monitoring is one of the monitoring elements that the City has employed to inform the MS4 permit, as well as TMDL development and implementation. Instream water quality monitoring provides a direct measure of the chemical condition of streams within the City that receive MS4 stormwater discharges. In addition to other chemical, physical, and biological data collected instream, as described in Sections 3 and 5, instream water quality monitoring allows for calculating trends analyses, correlating physical and chemical measurements to biological health of the stream, tracking long-term climatic changes, and evaluating the cumulative effect of implementing the City’s NPDES MS4 Stormwater Management Plan. Therefore, instream water quality monitoring will remain a central element of the City’s monitoring program.

SECTION 3

CONTINUOUS INSTREAM MONITORING

This section provides a summary of the continuous instream monitoring portion of the program. The summary describes project task/organization, background, monitoring objectives, monitoring locations, special data quality objectives/criteria, and connection to the long-term monitoring strategy.

3.1 PROJECT TASK/ORGANIZATION

Continuous instream monitoring refers to ongoing physical and chemical stream monitoring at fixed locations within streams that receive MS4 runoff. Continuous instream monitoring is typically conducted every 60 minutes, depending on the constituent measured. It typically consists of stream gauge as well as the calculation of stream flow (discharge), based on the cross section of the stream at the monitoring location and the recorded stream gauge height. The U.S. Geological Survey (USGS) operates the monitoring sites at several instream locations in Portland and they provide data management and storage and limited data interpretation. Information from these sites can be found at <http://waterdata.usgs.gov/nwis/rt>.

3.2 BACKGROUND

The USGS operates stream gauges in many Portland streams. Some sites have been monitored since 1940, but more typically, monitoring started in the 1980s. At a minimum, all gauges provide gauge height and calculated discharge. Four gauges also provide temperature monitoring (see Table 3.1). These gauge data can be used to compare chemical monitoring results in terms of their potential relationship with flow. These gauges have also provided valuable information for a variety of permit- and TMDL-related activities, such as the creation of flow duration curves in Johnson Creek that were instrumental in establishing the bacteria TMDL.

3.3 MONITORING OBJECTIVES

Continuous instream monitoring, as available, will contribute to monitoring objectives i, ii, and v identified in Schedule B.1 of the MS4 permit (see Table 1.1).

3.4 MONITORING LOCATIONS

Table 3.1 lists current USGS gauges that are either located within the City limits or provide information about a stream within the City limits.

3.4.1 Monitoring Frequency and Duration

All parameters at all the gauges in Table 3.1 are logged every 15 minutes, except the Willamette River gauge, which creates a data point every 30 minutes. Table 3.1 shows the period of record; monitoring is expected to continue into the foreseeable future at all of these sites.

When data interpretations are available from USGS, the City will provide those in the annual reports.

3.4.2 Sample Collection Methodology

The USGS measures gauge height and discharge according to methods described in Rantz and others (1982) and measures temperature and turbidity according to methods described in Wagner et al. (2006).

Table 3.1 Current USGS Gauge Locations

Location	Parameter	Period of record
Columbia Slough – RM 0.25 Gauge #14211820	Gauge height	10/01/1989 – to date
	Discharge	10/01/1989 – to date
	Stream velocity	
Fanno Creek at 56th Ave. – RM 11.9 Gauge #14206900	Gauge height	10/01/1990 – to date
	Discharge	10/01/1990 – to date
Johnson Creek at Sycamore – RM 10.2 Gauge #14211500	Gauge height	07/01/1940 – to date
	Discharge	10/01/2001 – to date
	Temperature	04/28/1998 – to date
Johnson Creek at Milwaukie – RM 0.7 Gauge #14211550	Gauge height	04/22/1989 – to date
	Discharge	04/22/1989 – to date
	Temperature	05/07/1998 – to date 11/10/2004 – to date
Kelly Creek at 159th Dr. – RM 0.0 Gauge #14211499	Gauge height	03/11/2000 – to date
	Discharge	01/29/2000 – to date
	Temperature	07/27/2010 – to date
Tryon Creek near Lake Oswego – RM 1.0 Gauge #14211315	Gauge height	08/03/2001 – to date
	Discharge	08/02/2001 – to date
Willamette River at Morrison Bridge – RM 12.8 Gauge #14211720	Gauge height	10/11/1987 – to date
	Discharge	10/01/1972 – to date
	Temperature	02/09/1972 – to date
	Turbidity	01/22/2009 – to date
	Specific conductance	
	Stream velocity	
	Dissolved oxygen	
	pH	
	Chlorophyll	
	Sensor depth	
Cyanobacteria		
Nitrate, in situ		

3.5 SPECIAL DATA QUALITY OBJECTIVES AND CRITERIA

The USGS manages all aspects of the installation, maintenance, calibration, reporting, and storage of data from its gauging stations. USGS data are flagged as provisional until they are reviewed and meet USGS data quality standards. Quality assurance procedures for USGS discharge data are described in Rantz (1982) and described in Wagner et al. (2006) for temperature and turbidity data.

3.6 CONNECTION TO LONG-TERM MONITORING STRATEGY

Continuous instream discharge, temperature, and turbidity monitoring provides a direct measure of chemical and physical conditions of streams within the City that receive MS4 discharges. In connection with other chemical, physical, and biological data collected instream (as described in Sections 2 and 5), continuous instream monitoring allows for calculating trends analyses, correlating the biological health of streams to physical and chemical measurements, tracking long-term climatic changes, and evaluating the cumulative effect of implementing the MS4 Stormwater Management Plan (SWMP). Therefore, continuous monitoring, as available from USGS, will remain an element of the City’s monitoring program.

SECTION 4

STORMWATER MONITORING

This section provides a summary of the stormwater monitoring portion of the program. The summary describes project task/organization, background, monitoring objectives, monitoring locations, and connection to the long-term monitoring strategy.

4.1 PROJECT TASK/ORGANIZATION

Stormwater monitoring refers to the monitoring of stormwater discharges from a defined point in the stormwater system during defined storm events. All stormwater monitoring sites are manholes within the storm collection system or the UIC system. City of Portland staff will collect the samples, and the City WPCL and the City's contract laboratories will analyze the samples, as described in Section 9.0 of this QAMP. WPCL staff will be responsible for data management, and MS4 staff will perform data assessment and evaluation.

4.2 BACKGROUND

The City began collecting stormwater samples from 10 land use-based monitoring locations in 1991 to meet NPDES permit requirements to characterize stormwater. Monitoring at the 10 land use stations continued through 1997.

In 1997, a comprehensive stormwater land use characterization report (ACWA, 1997) was developed that compiled stormwater characterization data from all Phase I permittees in Oregon. The study concluded that for most parameters, stormwater pollutant concentrations by land use are similar across all six participating jurisdictions. To date, this is still the most comprehensive stormwater characterization study conducted in Oregon. Based on this report, the DEQ agreed that "a good deal of this characterization has been completed, at least to a point where additional information is not likely to significantly improve our current knowledge of general water quality conditions from different land uses" (DEQ, June 24, 1997). Therefore, beginning in 1997, stormwater monitoring to characterize stormwater runoff according to land uses was gradually reduced and funds were shifted to other aspects of the MS4 program, including best management practice (BMP) effectiveness and instream surface water monitoring. From 1997 until January 2011, when the City's MS4 permit was renewed for the third permit term, three representative land use monitoring locations continued to be monitored. From January 2011 to the present, the City employed a probabilistic stormwater monitoring approach which included monitoring from new sampling locations (see additional description in Section 4.3).

4.3 MONITORING OBJECTIVES

Stormwater monitoring will contribute to monitoring objectives i, ii, iii, iv, v, and vi identified in Schedule B.1 of the MS4 permit (see Table 1.1). More specifically, the City has been interested in gaining a better understanding of the drivers of stormwater pollutant concentrations; this has proven very difficult to date because of the large size of the stormwater catchments sampled. Selecting smaller catchments limits the number of variables that must be considered when trying to determine the factors that influence stormwater quality. Therefore, probabilistic monitoring was initiated during the previous permit term (January 2011 – January 2016) and will continue through this permit term at a modified level.

In addition, given the years that have passed since monitoring of the original land use stations, the City has elected to revisit four of the original land use sites with historic data in order to assess whether there have been significant changes or detectable trends in the quality of stormwater runoff.

4.4 MONITORING LOCATIONS

This section provides information on the selection of monitoring locations for both the probabilistic stormwater sampling and the sampling at fixed land use sites.

4.4.1 Target Population

Probabilistic Sampling: Close to 20,000 potential stormwater sampling locations (every accessible manhole) are within the City's stormwater network. Smaller catchments are targeted to better understand the drivers of stormwater pollutant concentrations. MS4 catchments are generally larger, ranging from 0.01 acres to 750 acres with an average 9.7 acres. UIC catchments are smaller, ranging in size from 0.1 acres to 75 acres with an average 2.1 acres. Because UIC catchments are monitored for the UIC program and because of the smaller average size of the UIC catchments, these catchments were selected for MS4 probabilistic stormwater monitoring.

Since the 1991–1996 stormwater monitoring study (ACWA, 1997) and rainfall quality study (Sullivan 2005) indicated that differences in rainfall and stormwater pollutant concentrations are predominantly driven by land use and not geography, the City decided for the previous permit term (2011 to 2016) to use the existing UIC stormwater monitoring network to collect most of their stormwater samples. The advantage of the UIC stormwater network is that it has been sampled since 2005 and a large stormwater pollutant concentration data set is already available that will enable robust statistical analyses. During the last NPDES permit term, three different panels of 15 UIC sampling sites were monitored each year for a total of 45 data points per year. For this permit term, given a shift of resources to evaluate trends in concentrations from historic fixed land use sites, the probabilistic monitoring level has been adjusted to include monitoring of 15 UIC sites per year for the permit term.

Sampling at Fixed Land Use Sites: For this permit term, the City has decided to revisit 4 of the original 10 land use sites in the storm system where significant data have been collected in the past. The purpose of revisiting these sites will be to see whether statistically significant changes have occurred in stormwater pollutant concentrations over time given the implementation of stormwater management BMPs. Sampling will be conducted at each of these 4 sites each year of the permit term.

4.4.2 Description of Sample Design

Probabilistic Sampling: With respect to selected monitoring sites from the UIC system (approximately 9,400 UICs), the Stevens and Olsen (2004) generalized random-tessellation stratified (GRTS) design was selected. The method has been used by the U.S. Environmental Protection Agency and state agencies to successfully monitor water quality, physical habitat, and aquatic life for several years. The design has a rigorous statistical foundation, yet is able to adapt to the challenges and complexities of collecting data in the natural environment.

GRTS survey design is specifically designed to efficiently characterize a large system with many potential sampling locations. It randomly selects sampling locations in a manner that produces a spatially balanced sample.

The GRTS method is designed for large-scale environmental sampling programs such as the one required under the MS4 permit. The GRTS method can also accommodate long-term monitoring programs whose objectives may change over time. With a spatially balanced sample, important subpopulations can be identified throughout the course of the monitoring, and greater sampling efforts can be focused on these subpopulations if supported by a change in the program objectives. In this way, the sampling program can be adaptively managed as it progresses, without losing any statistical power to analyze the collected data.

The City will be applying the GRTS survey design for the subset of UICs located in shallow groundwater that are owned and operated by the City. Selecting UICs from only the subset located in shallow groundwater is being done to meet a monitoring objective of the City's WPCF permit. The GRTS method

will be used to randomly select five sampling panels containing 15 sampling locations each. During each permit year, a given panel with 15 UICs will be sampled.

Sampling at Fixed Land Use Sites: In order to evaluate trends at the fixed land use sites, methods for collecting samples will come as close as possible to methods used in collecting the previous data. This includes the collection of flow-weighted samples during rain events, aiming for the collection of samples from approximately three storms per year at each of the four land use sites. This will produce a total of 12 data points per year.

4.4.3 Monitoring Locations

Probabilistic Sites: See the 2015 WPCF permit list of potential monitoring sites that will be drawn upon for a new panel of 15 sites sampled each year.

Fixed Land Use Sites: A summary of the four fixed land use sites that will be revisited in order to collect data to evaluate trends is provided in Table 4.1.

Table 4.1 Stormwater Monitoring Locations

Site ID	Watershed	Predominant land use	Location	Dates of previous data collection
OF19	Willamette River	Forest Park and Industrial	NW Front and Kittridge Avenues	2000–2011 ^a
M1	Columbia Slough	Mixed	NE 122nd Avenue at the Columbia Slough	1991-2011
R1	Fanno Creek	Residential	Fanno Creek at SW 56th Street	1991-2001
R2	Columbia Slough	Residential	NE 141st Avenue and Sandy Boulevard	1991-1996

^a At the OF19 site, data collection began in 1995. However, data collection methods were inconsistent and not considered comparable prior to 2000.

4.4.4 Monitoring Frequency and Duration

Probabilistic Sampling: The City will collect one stormwater sample from each of 15 designated sampling locations between July 1 and June 30 of each permit year unless conditions beyond the City’s reasonable control are encountered that prevent the collection of samples within a wet season or prevent analyzing any sample or pollutant parameter (Permit Schedule B.2.e).

The City will begin targeting storm events for sampling each fall. The remaining sites will be sampled as appropriate storm events are identified throughout the rest of the monitoring season, as storm events allow.

During each permit year, the City will attempt to sample all 15 selected locations during the same storm event. Since storms often fall short of predicted rainfall amounts and/or durations, there is a possibility that rainfall or runoff may cease prior to the collection of all 15 samples during an event. If not all locations can be sampled during a targeted storm, the remaining locations will be sampled during subsequent storms that meet the criteria required by the permit and referenced in Section 6.0 of this document.

Fixed Land Use Station Sampling: For each of the four fixed land use sites, the City will attempt to collect samples during three storm events per year meeting the criteria required by the permit and referenced in Section 6.0 of this document.

4.4.5 Sample Collection Methodology

Probabilistic Monitoring: The City chose a probabilistic approach to stormwater monitoring, which includes a large number of monitoring locations and annually rotating panels. This approach is only feasible if grab samples are collected because the collection of flow-composite samples is too resource-intensive for such an approach. It is infeasible and cost prohibitive to install flow meters and sampling equipment at 15 different locations every year, as well as to adjust the flow triggers based on weather forecasts that are critical for proper collection of flow-composite samples.

Grab samples will be collected using decontaminated stainless steel beakers connected to telescoping poles by swing samplers. To eliminate the need for field decontamination, a separate decontaminated beaker will be dedicated to each sample location. The sampling team will take care not to place the decontaminated beaker on the ground or hit any part of the manhole or stormwater pipe during sampling activities.

The beaker will be placed into the flow of stormwater and brought to the surface grade to fill sample containers. To the extent practicable, the beaker will be filled and emptied slowly and carefully to avoid degassing the sample. Samples will be placed in pre-cleaned bottles provided by the analytical laboratory and analyzed for the parameters specified in Table 4.2 which shows the required sample containers, sample volume, preservative requirements, and maximum holding times. A separate cooler will be prepared for each site and provided with a zip-tied cooler tag that can be labeled with the sample point code in the field at the time of sample collection.

Fixed Land Use Sites: To be consistent with historic sampling methods, two station designs will be employed in the field depending on whether the site is an instream or manhole location. Automatic sampling and stage recording equipment will be deployed at each site with each station consisting of the following equipment:

- Ultrasonic level sensor and/or Doppler velocity sensor to measure depth of flow and peak velocity in order to estimate flow rate.
- An automatic water quality sampler for collecting a flow-weighted composite sample. Sampling is actuated by flow as calculated by the system microprocessor based on previously collected flow data. The automatic samplers are used to store the stormwater in glass bottles during monitored events.
- A telemetry or remote sensing system to allow the station to be accessed with a personal computer remotely or via telephone lines.

The instrumentation of the stream station is contained in an enclosure mounted on a concrete pad. Manhole stations are completely contained within the existing manhole chambers, such that all equipment is suspended just under the manhole cover.

Automated samplers are programmed to deliver samples throughout the event based on a predicted rainfall volume and hence runoff volume. The intent is to obtain a good representation of the predicted storm with a minimum collection of 3 flow weighted samples that are composited together in the lab.

As with the samples collected from the probabilistic sites, samples from these sites will also be analyzed for the list of parameters specified in Table 4.2.

Table 4.2 Stormwater Sample Laboratory Analytes, Containers, Volumes, Methods Preservation, and Holding Times

Compound/compound class ⁽¹⁾	Container type	Sample volume	Method	Preservation requirements	Technical holding time
Total Metals Cu, Pb, Zn	HDPE	500 mL	200.8	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
Dissolved Metals Cu, Pb, Zn	HDPE	500 mL	200.8	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	350.1	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	300.0	Cool to 4°C +/- 2°C	48 hours
Total Phosphorus	Plastic	1 pint	365.4	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	365.1	Cool to 4°C +/- 2°C	48 hours
<i>E. coli</i> ²	Sterile Plastic	250 mL	Colilert QT	Cool to 4°C +/- 2°C	8 hours
Hardness	Plastic	½ pint	SM2340B	HNO ₃ to pH<2; cool to 4°C +/- 2°C	6 months
Total Organic Carbon	Amber Glass	250 mL	SM5310B	H ₂ SO ₄ to pH<2; cool to 4°C +/- 2°C	28 days
Total Suspended Solids	Plastic	1 quart	SM2540D	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)

¹. Samples will also be analyzed in the field for dissolved oxygen, specific conductivity, pH, and temperature. See Section 8.0..

². For stormwater monitoring described in this section (Section 4.0), *E. coli* will only be analyzed in samples collected from the four fixed land use monitoring sites

4.5 CONNECTION TO LONG-TERM MONITORING STRATEGY

This stormwater monitoring approach has evolved over the years from the stormwater monitoring started in 1991. While the early focus was on characterizing stormwater from various land uses, the focus of the probabilistic monitoring approach is on evaluating other factors that drive stormwater pollutant concentrations. With that, the probabilistic monitoring approach differs from previous land use monitoring as it includes reduced catchment sizes by about two orders of magnitude, and the number of locations and frequency of sampling was increased in order to increase the number of samples collected per year by a factor of almost five. Analysis of this collected data will help to determine how stormwater monitoring will be adaptively managed in future permit terms.

In addition, monitoring four of the historic fixed land use monitoring sites should help to indicate whether detectable trends can be observed. Results will be reviewed to identify whether or not improvements have occurred and for which parameters. This too will help to adaptively manage stormwater BMPs in future permit terms.

SECTION 5

MACROINVERTEBRATE MONITORING

This section provides a summary of the macroinvertebrate monitoring portion of the program. The summary describes project task/organization; background; monitoring objectives; study design and monitoring process; special data quality objectives and criteria; quality control; and connection to the long-term monitoring strategy.

5.1 PROJECT TASK/ORGANIZATION

Macroinvertebrate monitoring refers to the annual monitoring of benthic macroinvertebrates in late summer. During the previous permit term, samples were collected from the same rotating sampling locations where instream monitoring occurred (i.e., at the probabilistic instream monitoring locations). Macroinvertebrate monitoring will continue to be conducted at those sites. For this permit term, samples will be collected from 16 sites per year. City water pollution control lab staff will collect the samples, which will be analyzed by a contract taxonomist.

5.2 BACKGROUND

Macroinvertebrate presence information is useful for evaluating water quality and habitat condition because macroinvertebrates:

- Are present in diverse habitat types
- Represent local conditions because they have limited dispersal ability
- Are an important food source for fish and other wildlife
- Are sensitive to changes in physical habitat and water chemistry.

Macroinvertebrate communities are evaluated through observed/expected (OE) ratio of taxa loss and through indicators of biotic integrity (IBIs). OE ratio of taxa loss is developed using models based on data from reference and/or “least disturbed” sites. Metrics used to develop macroinvertebrate IBIs generally include (EPA, 2004):

- Taxonomic richness, composition, and diversity—i.e., the number of distinct taxa and relative abundance of organisms
- Feeding groups: Diversity in feeding groups—i.e., those that depend on cold water environment vs. those that are algal-feeding, warm-water species
- Habits—e.g., burrowing vs. clinging macroinvertebrates as indicators of sediment transport within a stream
- Pollution tolerance: Presence or absence of sensitive taxa reflects changes in physical habitat and water chemistry.

5.3 MONITORING OBJECTIVES

Macroinvertebrate monitoring will contribute to monitoring objectives ii, iv, v, and vi identified in Schedule B.1 of the City’s MS4 Permit (see Table 1.1). Macroinvertebrate monitoring is intended to track the status and trends of biological communities within water bodies that receive MS4 discharges. Macroinvertebrate monitoring will be timed to coincide with the first instream monitoring of the fiscal year so biological information is collected at the same time summer water quality samples are collected.

5.4 STUDY DESIGN AND MONITORING PROCESS

Special monitoring and sample collection and preservation procedures will be followed, as described below. These procedures follow *National Rivers and Stream Assessment: Field Operations Manuals*.

https://www.nemi.gov/methods/method_summary/12564/

https://www.nemi.gov/methods/method_summary/12563/

5.4.1 Monitoring Locations

Macroinvertebrate samples will be collected at 16 sites per year where instream water quality samples are collected as part of the newer instream monitoring protocols per Section 2.2.

5.4.2 Monitoring Frequency and Duration

Macroinvertebrate samples will be collected once per year, concurrent with the summer dry weather (July 1 through September 30) instream water quality sampling conducted at 16 of the rotating instream sampling sites under the new instream monitoring protocol described in Section 2.2.

5.4.3 Sample Collection Methodology

Benthic macroinvertebrate samples will be collected using the following protocols (adapted from the U.S. Environmental Protection Agency *National Rivers and Streams Assessment, Field Operations Manual*, 2009). A sample is collected from one meter downstream of each of 11 cross-section transects at the assigned sampling locations (Figure 5.1) using a D-frame kicknet. The sample location at Transect A is determined at random, and each following transect is assigned a station based off the pattern right (R), center (C), left (L). At transects where a center sampling point is assigned and the stream width is between one and two net widths wide, the left or right sampling point is picked randomly instead. If the stream width is only one net width wide at a transect, the net is placed across the entire stream width and the sampling point is designated as center. If a sampling point is located in water that is too deep or too swift to safely sample, an alternate sampling point on the transect will be selected at random. The kick area at each transect is approximately one square foot for a total area of approximately 11 square feet for each composite sample.

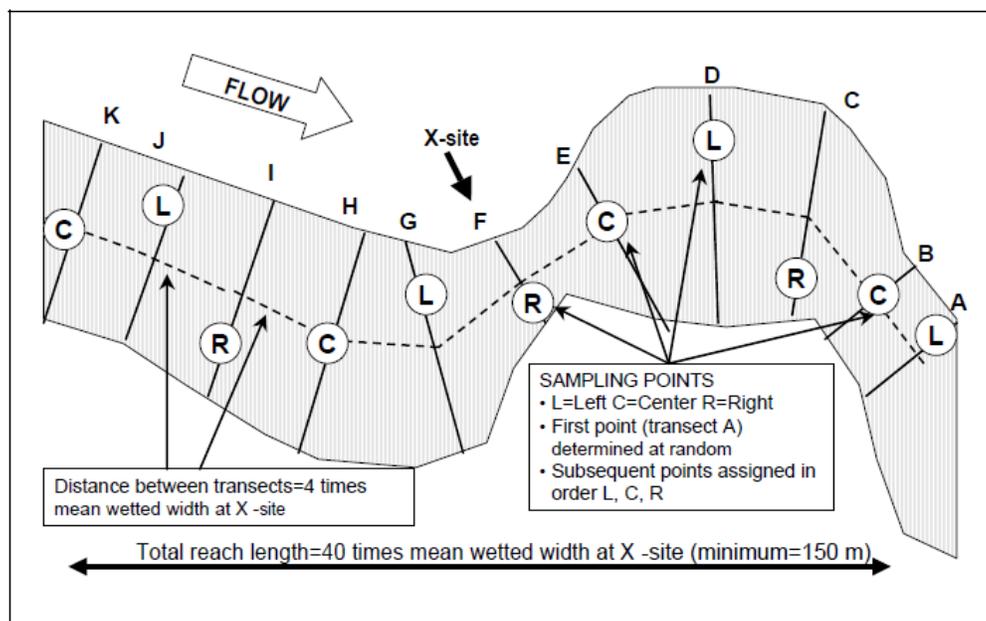


Figure 5.1 Wadeable Site Reach Features with Macroinvertebrate L, C, and R Sampling Points

(from USEPA 2009, p. 45, Figure 4-6)

5.5 SPECIAL DATA QUALITY OBJECTIVES AND CRITERIA

This section includes information on measurement quality objectives and sample handling and custody.

5.5.1 Measurement Quality Objectives

A subsample of 500 organisms will be sorted and identified as described in Section 5.6. Taxonomic identification of organisms will reach the species level whenever possible or cost-feasible. However, the taxonomic resolution will, at a minimum, be to Standard Taxonomic Effort Level 2 per the following:

<http://www.pnamp.org/project/4210>

5.5.2 Sample Handling and Custody

To adequately track each macroinvertebrate sample, the following parameters are needed: station, site name, site ID (depending on project), collection date, habitat sampled, whether or not the sample was a field duplicate, the number of jars used for the entire macroinvertebrate sample, the collector's initials, and/or the field taxonomist's initials. Labels with all of the information listed above will be placed inside the container and also attached (taped) to the outside.

Macroinvertebrate samples will be placed in plastic sealable bins or a cooler and shipped to the contractor for identification.

5.6 QUALITY CONTROL

Quality control measures for instream and stormwater sampling are described in Section 9 of this QAMP. Because of the special nature of macroinvertebrate sampling and analyses, additional quality control measures are required, as described below.

5.6.1 Field Quality Control

As shown in Table 5.1, quality control measures for field measurements are evaluated primarily through best professional judgment and by ensuring that the work is performed by experienced and/or well-trained field teams.

Table 5.1 Biological Communities Field Quality Control

Item	Frequency	Acceptance criteria	Corrective actions
Inspect kick net	Prior to each use	No holes or tears, no foreign matter on nets	Repair, clean, or replace as necessary
Time collection with stopwatch	20 seconds kicking, 60 seconds picking	Required time +/- 3 seconds to ensure consistency of collection at each site	Add time or repeat sample
Check net	Each collection site	No clinging organisms	Remove any clinging organisms and add to sample
Use widely/commonly accepted taxonomic references	For all identifications	All keys and references used must be based on a bibliography prepared by another laboratory	If other references desired, obtain permission to use from project lead

5.6.2 Laboratory Quality Control

Table 5.2 summarizes biological laboratory quality control measures. The laboratory will archive sample residuals, vials, and slides until the project leader has authorized the disposition of the samples in writing.

Table 5.2 Macroinvertebrate Laboratory Quality Control

Check description	Frequency	Acceptance criteria	Corrective actions
Sample residuals examined by different analyst within lab	10% of all samples completed per analyst	Efficiency of sorting $\geq 95\%$	If $< 95\%$, examine all residuals of samples by that analyst and retrain analyst
Duplicate identification by different taxonomist within lab	5 to 25% of all samples completed per laboratory (see SOP)	Efficiency $\geq 95\%$	Increasing check frequency if acceptance criteria are not met (see SOP)
Independent identification by outside taxonomist	All uncertain taxa	Assigned certainty rating of 1 to 5, reviewed by outside expert if necessary	Reviewed by QC taxonomist, sent to outside expert if "unknown"
Prepare reference collection	Each new taxon per laboratory	Complete reference collection to be maintained by each individual laboratory	Benthic lab manager periodically reviews data and reference collection to ensure reference collection is complete and identifications are accurate

5.7 CONNECTION TO LONG-TERM MONITORING STRATEGY

Since 2010, macroinvertebrate monitoring has been an integral element of the BES's comprehensive instream monitoring program. BES expects to use macroinvertebrates to assess the long-term improvement of the City's watersheds and evaluate the correlation among macroinvertebrates and water quality, hydrology, and physical habitat.

SECTION 6

STORM EVENT TARGETING

This section provides information on sampling considerations, storm criteria, and weather forecasting, all related to the stormwater sampling described in Section 4.

6.1 SAMPLING CONSIDERATIONS

Storms may occur at any time; however, the City will primarily target storms during regular business hours to limit overtime hours that would be required of laboratory staff to meet stringent sample holding time requirements.

Probabilistic Sampling: As described earlier in Section 4, the City will collect stormwater samples one time from 15 designated sampling locations between July 1 and June 30, unless conditions are encountered that are beyond the City's reasonable control (e.g., atypical climatic conditions; see Section 7).

The City will begin tracking and targeting storm events each fall that meet the storm criteria presented in Section 6.2. It may take more than one storm to collect samples from all 15 sampling locations. Whichever locations are not sampled during the first storm will be targeted for sampling during subsequent storm events that meet the storm criteria described in the following Section 6.2.

Fixed Land Use Station Sampling: For the fixed land use sites, an attempt will be made to collect flow weighted composite samples during the same three storm events for each of the four sites. The storm events will be targeted to meet the storm criteria presented in Section 6.2.

6.2 STORM CRITERIA

Adhering to target storm criteria to the extent practicable will help ensure that stormwater runoff will be adequate for sample collection, be representative of stormwater runoff, and be consistent across sampling events (alternate source demonstration [ASD]). Before initiating sampling, the storm forecast will be evaluated against the criteria listed below to assess whether a storm should be targeted for potential compliance sampling. Based on the City's extensive experience with stormwater monitoring in this region, storms meeting these criteria are expected to provide the volume, intensity, and duration of runoff necessary to collect individual samples. Smaller storms, or storms of shorter duration, are considered to have a low probability of producing sufficient runoff to warrant the extensive preparation and mobilization time required for this project.

It is likely that a storm may not meet the criteria below when sampling is completed due to the inherent uncertainty in weather prediction. The following criteria will therefore be used as general guidance to determine when forecasted storms should be targeted for sampling during this project:

- predicted rainfall amount of ≥ 0.1 inch per storm
- predicted rainfall duration ≥ 6 hours
- a goal for the antecedent dry period is 24 hours

Storms meeting these criteria that were unpredicted or were predicted to have less rainfall intensity or duration are not included as potential compliance sampling events.

Hourly and daily rainfall records are available for more than 20 sites on the east side of Portland. These data are maintained in the BES's HYDRA Data Report System and are available at:

http://or.water.usgs.gov/non-usgs/bes/raingage_info/clickmap.html

Storm characteristics for each storm during which samples are collected will be documented and summarized in the annual City UIC Stormwater Discharge Monitoring Report. If not all samples can be collected because of atypical climatic conditions, representative climatic data will be provided to document these conditions.

6.3 WEATHER FORECASTING

The Storm Monitoring Coordinator for this project is the BES Field Operations supervisor or a designated alternate (see Section 7). The Storm Monitoring Coordinator is responsible for tracking storms and reviewing consultant weather forecasts to determine if a predicted storm is likely to meet the criteria for initiating compliance sampling. If the weather forecast predicts that the storm criteria will be met, the Storm Monitoring Coordinator is responsible for mobilizing the BES sampling teams and ultimately making the “go/no go” decision.

Extended Range Forecasting Company, Inc., (ERF) a private Portland weather forecasting service, is the City’s weather consultant. The Storm Monitoring Coordinator receives daily weather forecasts from ERF that have a 10-day forecast including quantity of precipitation forecasts for each day. ERF is available on an as-needed, on-call basis for telephone consultations regarding pending storms. When a candidate storm approaches, the Storm Monitoring Coordinator will communicate frequently with ERF to determine whether to mobilize sampling teams to begin sampling operations.

Other forecasting resources used include online resources such as National Weather Service predictions, Doppler radar, and smartphone weather applications. Refer to SOP D-1, provided in Appendix B of the WPCF-SAP, for more weather tracking information.

SECTION 7

SAMPLING STAFF

Sampling staff refers to all personnel who are involved in logistical support, sample collection, traffic control, and safety during the actual storm event being monitored. At a minimum, the sampling staff will include:

- A Storm Monitoring Coordinator (one person; can be remote)
- Field sampling teams

These staff are described in more detail in the following sections.

7.1 STORM MONITORING COORDINATOR

The Storm Monitoring Coordinator is responsible for tracking weather patterns and selecting the storms to be monitored. The Storm Monitoring Coordinator will work directly with ERF, to obtain the latest weather forecasts and updates and make the “go/no go” decision.

The Storm Monitoring Coordinator should attempt to notify the sampling teams and the analytical laboratory 72 hours in advance of a potential qualifying storm. The Storm Monitoring Coordinator directs sampling activities by tracking real-time weather conditions and using dependable two-way communication with ERF and sampling teams (via cell phone). The Storm Monitoring Coordinator for this project will be the Field Operations (FO) Supervisor, or a designee.

Instream monitoring events, as opposed to stormwater monitoring events, are typically scheduled in advance, but the Storm Monitoring Coordinator makes the final decision on whether sampling occurs on any given day at which locations.

7.2 FIELD SAMPLING TEAMS

Multiple teams are sometimes used during a single stormwater sampling effort to decrease the length of field time and the number of individual storms needed to collect samples from all stormwater monitoring locations. Sampling teams are comprised of two people, primarily from the City’s FO staff. Generally, multiple sampling teams will be used as the season progresses, particularly if samples have been difficult to collect. Instream monitoring will also be conducted by multiple teams to increase the probability of collecting all samples under very similar weather conditions.

Field staff members are required to read, understand, and follow all procedures documented in this QAMP and the WPCF-SAP and WPCF-QAPP. At a minimum, field sampling personnel will be responsible for the following:

- Inspecting field sampling equipment before use to ensure that it is in proper working order and calibrated
- Ensuring that all field sampling collection forms (e.g., chain of custody forms, field data sheets, daily field report) are properly and completely filled out
- Ensuring that samples are collected, stored, and delivered to the laboratory in accordance with documented procedures

Field staff members also are responsible for performing all the field sampling activities in accordance with the procedures and standards established in the project Health and Safety Plan (see Appendix C of the WPCF-SAP and WPCF-QAPP).

SECTION 8

FIELD SAMPLING PROCEDURES

As described in Sections 1 and 4, storm sampling is also conducted for compliance with the City's WPCF permit. To minimize duplication of documentation, the field sampling procedures for stormwater sampling are not repeated here but can be found in Section 7 of the WPCF-SAP. Section 7 of that document includes a description of the following: personal safety, sample collection location, analytical schedule, sampling equipment preparation, sampling equipment decontamination, sample container preparation, clean sampling techniques, sampling location access procedures, sample collection and handling, field quality control sample collection, sample labeling, sample collection documentation, sample transport and delivery to the laboratory, and change notification.

To supplement Section 7 of the WPCF-SAP, this NPDES MS4 Permit monitoring plan includes instream surface water sampling procedures. Some of the analytical parameters required for the NPDES MS4 permit vary from what is required by the WPCF permit. Therefore, sampling equipment described in the WPCF-SAP should be supplemented by this plan to also include analytical field meters for the analysis of:

- pH
- specific conductance
- dissolved oxygen
- temperature

These field meters will be calibrated at the WPCL prior to initiating stormwater and instream sampling activities using standard field meter calibration procedures. Meters are also checked for drift at WPCL at the end of the field day prior to relinquishing samples. For field parameters that fail drift checks, data is either flagged or rejected as appropriate.

Field parameters will be measured at each sample location immediately after filling the last sample container. Field measurements will be taken from collected stormwater or surface water samples by inserting the analytical field meter probes into the stainless steel beaker or by directly inserting the analytical field meter probes into the flow of surface water.

For surface water monitoring activities, sampling teams will use the following procedures to access each sampling location:

- Set up a staging area close to, but at a safe distance from, the surface water body.
- Observe and document conditions near the sampling location that may affect surface water quality, such as:
 - Physical characteristics (e.g., bank condition, vegetation, shading);
 - Human activities (e.g., homeless camps, trash); and
 - Potential pollutant sources (e.g., pipe discharge, especially during dry conditions).
- Determine if the flow rate in the stream allows for safe access to the stream.

In addition to the personal safety procedures provided in Section 7 of the WPCF-SAP, personal flotation devices should be worn when collecting surface water samples.

SECTION 9

QUALITY CONTROL/QUALITY ASSURANCE

The U.S. Environmental Protection Agency (<http://www.epa.gov/quality/glossary.htm#Q>) defines “quality assurance” (QA) and “quality control” (QC) as follows:

- **QA** is the integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected.
- **QC** is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the established requirements.

The QA/QC procedures that will be followed as part of this management plan are documented in detail in the WPCF-QAPP. The WPCF-QAPP includes the following:

- Project management/data quality objectives
- Sampling handling and custody
- Analytical procedures
- Quality control procedures
- Data management, validation, and reporting
- Data assessment and evaluation
- Inspection and audits
- Deviations, nonconformance, and occurrences
- Monitoring program corrections

Appendices A, B, and C of the WPCF-QAPP provide supporting information, including field sampling and laboratory forms, laboratory method reporting limits, and data qualifiers.

In addition, related to QA/QC, the City has documented standard operating procedures for field measurements of multiple water quality parameters, decontamination of sampling equipment, chain of custody, grab sample collection with bottles, grab sample collection with stainless steel beakers, field filtering of water samples, quality control sample collection, and laboratory analysis.

SECTION 10

REFERENCES

- City of Portland, Bureau of Environmental Services. 2005. WPCL Quality Manual. Revision 6.
- City of Portland, Bureau of Environmental Services. 2006. WPCF Permit Sampling and Analysis Plan. (<http://www.portlandonline.com/bes/index.cfm?c=50442&a=282500>)
- Oregon Association of Clean Water Agencies. 1997. Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990 to 1996. Prepared by Woodward-Clyde Consultants.
- Oregon Department of Environmental Quality, June 24, 1997. Letter to Janet Gillaspie at the Oregon Association of Clean Water Agencies regarding: MS4 Permit Modification. Prepared by Neil Mullane.
- Oregon Department of Environmental Quality. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of Wadeable Oregon streams (November 2005 models). Prepared by Shannon Hubler.
- Oregon Department of Environmental Quality. 2009a. High Level Indicators of Oregon's Forested Streams. Prepared by Shannon Hubler. (<http://www.deq.state.or.us/lab/techrpts/docs/10-lab-003.pdf>)
- Rantz, S.E. and others. 1982. Measurement and computation of streamflow, Volume 1: Measurement of stage and discharge. Volume 2: Computation of discharge. U.S. Geological Survey Water Supply Paper 2175.
- Stevens Jr, D. & Olsen, A. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association, ASA 99, 262-278.
- Sullivan, L. 2005. Preliminary Study Comparing Precipitation Quality Between Nominal Land Uses in Portland, Oregon. Masters of Environmental Management. Environmental Sciences and Resources, Portland State University
- U.S. EPA. 2004. Wadeable Streams Assessment: Field Operations Manual. EPA 841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C
- U.S. EPA. 2009. National Rivers and Streams Assessment, Field Operations Manual. EPA 841-B-07-009.
- Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A. 2006. Guidelines and standard procedures for continuous water-quality monitors: Station operation, record computation, and data reporting. U.S. Geological Survey Techniques and Methods 1-D3.