Comprehensive Clackamas County NPDES MS4 Stormwater Monitoring Plan

January 2017

Implementation start: July 1, 2017

Comprehensive Clackamas County NPDES MS4 Stormwater Monitoring Plan

Prepared for

Clackamas County
City of Gladstone, Oregon
City of Milwaukie, Oregon
City of Oregon City, Oregon
City of West Linn, Oregon
City of Wilsonville, Oregon
City of Happy Valley, Oregon
City of Rivergrove, Oregon
Clackamas County Service District #1
Surface Water Management Agency of Clackamas County
Oak Lodge Water Services District

January 2017

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List of Abbreviations

°C	degree(s) Celsius
µg/L	microgram(s) per liter
2004 permit	2004 NPDES MS4 permit
2012 permit	2012 NPDES MS4 permit
ACWA	(Oregon) Association of Clean Water Agencies
BMP	best management practice
BOD	biochemical oxygen demand
$CaCO_3$	calcium carbonate
CCSD #1	Clackamas County Service District #1
CFR	Code of Federal Regulations
cm	centimeter(s)
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorophenyltrichloroethane
DEQ	(Oregon) Department of Environmental Quality
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
JFA	Joint Funding Agreement
mg/L	milligram(s) per liter
mL	milliliter(s)
MPN	most probable number
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
OLWSDD	Oak Lodge Water Services District
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Plan	Comprehensive Clackamas County NPDES MS4 Stormwater Monitoring Plan
QA/QC	quality assurance/quality control
RSAT	Rapid Assessment Technique
SM	Standard Methods
SOP	standard operating procedure
SWMACC	Surface Water Management Agency of Clackamas County
SWMP	stormwater management plan
TCE	trichloroethylene
TMDL	total maximum daily load
UIC	underground injection control
USGS	U.S. Geological Survey
WES	(Clackamas County) Water Environment Services

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Section 1 Introduction

As part of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit requirements, Clackamas County co-permittees are required to develop and implement a stormwater monitoring program. Stormwater monitoring requirements and objectives are outlined in Schedule B of the Clackamas County NPDES MS4 permit (101348), issued March 16, 2012 (2012 permit), and provide the basis for monitoring activities described in this 2017 Comprehensive Clackamas County NPDES MS4 Stormwater Monitoring Plan (Plan).

NPDES stormwater monitoring programs require two components. The first component is ***program monitoring***, which involves the tracking and assessment of programmatic activities, as described in the individual permittees' stormwater management plans (SWMPs). The second component is ***environmental monitoring,*** which includes the actual collection and analysis of samples. The purpose of this 2017 Plan is to address the environmental monitoring component of the requirements.

Clackamas co-permittees initiated implementation of environmental monitoring programs in July 2012 to address requirements of the 2012 permit. Specific monitoring obligations (e.g., data collection requirements, coordinated pesticide monitoring study, mercury monitoring) under the 2012 permit have been completed. This 2017 Plan documents updates to monitoring activities based on outcomes from completed monitoring and includes the following elements referenced in Schedule B.2 of the 2012 permit:

- Identification of how the monitoring objectives are addressed
- Discussion of how the monitoring program is related to adaptive management and a long-term monitoring program strategy
- Documentation and recordkeeping procedures
- Documentation of monitoring sites, parameters, and sample collection frequency and methods
- Identification of the analytical methods
- Protocols for quality assurance and quality control (QA/QC)
- Discussion of data management, review, validation, and verification

Following this introductory Section 1, this 2017 Plan is organized into the following sections:

- Section 2. Objectives- Summarizes objectives of the 2017 Plan, specifically related to the six objectives listed in Schedule B of the 2012 permit
- Section 3. Development and Implementation of the Plan- Provides background information related to the development of the 2017 Plan
- Section 4. Data Gathering Strategies- Outlines various data gathering and data collection strategies and describes how collected data will be used in the adaptive management of the individual stormwater programs and in the development of a long-term monitoring program strategy
- Section 5. Monitoring Activities- Describes environmental monitoring activities including monitoring frequency and locations
- Section 6. Sampling Parameters, Analytical Methods, and Quality Assurance and Control- Provides a summary of sampling parameters, sampling procedures, and analytical methods including applicable QA/QC
- Section 7. Monitoring Data Management and Plan Modifications- Summarizes data analyses, interpretation, and management activities

Section 2 Objectives

Schedule B.1 of the 2012 permit lists six specific monitoring objectives to be addressed with the stormwater monitoring program. The six objectives are listed below:

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

Each of the environmental monitoring activities listed in Section 5 below will be conducted in an attempt to answer specific questions to support the monitoring objectives listed above. These questions are listed for each monitoring activity. Descriptions of the monitoring activities also include a narrative describing how the monitoring objectives will be addressed.

Section 3 Development and Implementation of the Plan

Because of the wide range of variability in stormwater data, collecting and analyzing sufficient data to address environmental monitoring requirements and objectives requires significant resources in order to obtain statistically valid and robust data sets. The Oregon Department of Environmental Quality (DEQ) has acknowledged this issue and provided the following clause in the 2012 permit (Schedule B.4) to allow for a coordinated monitoring approach:

> *Environmental monitoring conducted to meet a permit condition in Table B-1 may be coordinated among co-permittees or conducted on behalf of a co-permittee by a third party. Each co-permittee is responsible for environmental monitoring in accordance with Schedule B requirements. The co-permittee may utilize data collected by another permittee, a third party, or in another co-permittee's jurisdiction to meet a permit condition in Table B-1 provided the co-permittee establishes an agreement prior to conducting coordinated environmental monitoring.*

The original Plan was developed in 2006 by nine Clackamas County co-permittees and was implemented beginning in July 2007. In 2016, coverage was expanded to include two additional co-permittees, Oak Lodge Water Services District (OLWSD), formerly Oak Lodge Sanitary District, and the City of Wilsonville. This 2017 Plan reflects this expansion of coverage.

Development of a coordinated monitoring program stemmed from the need to address the monitoring objectives listed in the 2004 NPDES MS4 permit (2004 permit). Previously, jurisdictions were collecting samples based solely on locations and frequencies outlined in the permit without additional consideration of the new monitoring objectives. Given the limited individual monitoring efforts, smaller jurisdictions with less significant environmental monitoring requirements did not have the resources to address the new monitoring objectives without substantial additional effort beyond the “maximum extent practicable” requirement.

The 2006 Plan was developed by reviewing and compiling each participating co-permittee’s existing monitoring efforts (through annual reports). Information compiled included monitoring locations, sample collection methods, sample collection frequencies, water bodies, TMDL/303(d) list status, and contributing land uses. Jurisdictions participated in a series of workshops to evaluate existing activities combined as a whole. Monitoring activities were then refined to (1) address the identified implementation gaps, (2) minimize duplication of monitoring efforts, and (3) ensure that data collected contained information that was sufficiently comprehensive to address the permit-required monitoring objectives. Key changes and features of the 2006 Plan included the following:

- Additional tracking and targeting of storm events during instream sample collection activities to better evaluate the impacts of stormwater runoff on receiving water quality
- Geographic distribution of instream monitoring locations to avoid “clustering of sites”
- Selection of instream monitoring locations based on “high-priority” tributaries, which were identified as those on the 303(d) list (water quality impaired), and/or those with significant development potential upstream
- Selection of stormwater monitoring locations to ensure representation of varying land use categories
- Changing instream and stormwater sample collection methods from grab sampling to use of a timed-composite sampling method in order to better represent changing runoff conditions throughout a storm event

Since 2006, the Plan has periodically been updated to reflect adjustments in monitoring locations, consistency with revisions to Table B-1 (per the 2012 permit), and inclusion of additional detail related to quality assurance procedures.

As mentioned above, for this 2017 Plan, two additional co-permittees (OLWSD and the City of Wilsonville) joined the coordinated monitoring program. Additionally, in June 2017, the co-permittees’ monitoring obligations under the 2012 permit will be met, prompting this update to the Plan.

This 2017 Plan, to be implemented beginning in July 2017, reflects completion of some select, one-time monitoring obligations under the 2012 permit and refinement of monitoring locations, parameters, and activities based on information collected over the last permit term. Key modifications include the following:

- Inclusion of OLWSD and City of Wilsonville instream, stormwater, and biologic monitoring activities
- Removal of mercury and pesticide monitoring activities, as those obligations have been met
- Removal of biochemical oxygen demand (BOD) and total volatile solids (for co-permittees outside of the Tualatin basin) from the analyte list, because of the limited usefulness of the collected data to date
- Adjustment of analytical methods and reporting limits based on consistency with Code of Federal Regulations (CFR) Title 40 and current laboratory capabilities
- Adjustment of monitoring locations to ensure geographic distribution of data and to continue to inform trends analyses
- Inclusion of routine instream sampling, in addition to targeted dry weather/wet weather instream sampling activities

- Removal of Clackamas County Service District #1's (CCSD #1's) geomorphic monitoring activities from the Plan, as physical conditions are evaluated during biologic (macroinvertebrate) monitoring activities
- Minor editorial updates to improve clarity and consistency with current practices

This 2017 Plan serves as an established agreement to conduct a coordinated monitoring effort. The current participating co-permittees include the cities of Gladstone, Milwaukie, Oregon City, Wilsonville, and West Linn; OLWSD; CCSD #1; and the Surface Water Management Agency of Clackamas County (SWMACC). Monitoring conducted by CCSD #1 and SWMACC is conducted on behalf of Clackamas County and the cities of Happy Valley and Rivergrove, and they are included as participants in this 2017 Plan as well.

Section 4 Data Gathering Strategies

As described in Section 3, development of the original (2006) Plan and subsequent iterations to the Plan have applied adaptive management principles in order to refine individual monitoring activities into a coordinated program and address monitoring objectives. This 2017 Plan reflects the results of these adaptive management efforts.

Three primary strategies are outlined in this 2017 Plan to obtain and review data and information necessary to address the six monitoring objectives of the 2012 permit. These strategies include the following:

1. *Collect water quality data and macroinvertebrate data to address the specified monitoring objectives:* Monitoring locations, frequencies, and parameters were reviewed by the co-permittees as providing beneficial information for the city/jurisdiction in order to address the current monitoring objectives. For some jurisdictions, this exercise resulted in a change (increase or decrease) in data points documented in Table B-1 of the 2012 permit. Selection of the monitoring locations, frequencies, and parameters reflects data that co-permittees have historically collected so that adequate data will be available to assess trends in the future.
2. Conduct literature reviews to track relevant technical information related to stormwater quality that is collected by others, yet representative of co-permittee activities: The scientific community, public agencies, and private organizations interested in stormwater management continue to conduct research related to stormwater characterization and treatment. This costly research is often beyond the means of any one co-permittee to conduct an equivalent type of study. Organizations such as the Oregon Association of Clean Water Agencies (ACWA), Bay Area Stormwater Management Association, Water Environment Research Foundation, state transportation departments, vendors of proprietary stormwater treatment systems, colleges and universities, and others continually conduct this type of research and examine complex stormwater-related issues. By participating in these groups and following current research, co-permittees can realize greater benefits from labor and capital investment than if they were to attempt such studies on their own. As such, the co-permittees plan to rely on information garnered by these organizations to address some of the more complex and costly objectives of the permit, especially with respect to understanding the effectiveness of BMPs.
3. Review and evaluate the monitoring results and other information (literature and stormwater management program tracking measures) collected by the co-permittees to support future decisions related to adaptive management and refinement of both the SWMP and environmental monitoring plan: The compilation of monitoring data during the annual reporting period and the permit renewal period will allow co-permittees to ensure that data are being collected as required and that the data are providing useful information to support adaptive management

goals. In conjunction with the monitoring objectives and adaptive management approach submitted to DEQ by the co-permittees in November 2012, the monitoring data can potentially provide rationale for co-permittees in making decisions related to the allocation of resources among stormwater management activities. Monitoring activities are then revised to better address needs. The intent of the stormwater monitoring program is to provide data to support conclusions related to implementation of the co-permittee's SWMPs (e.g., what are the trends) and NPDES MS4 permit requirements and to ensure that the data continue to provide value as questions are answered or new questions arise.

Section 5 Monitoring Activities

This section describes the coordinated environmental monitoring efforts for the participating Clackamas County co-permittees. This section is organized according to the following monitoring activities:

- Instream monitoring efforts (routine and targeted)
- Stormwater system monitoring efforts
- Biological monitoring efforts
- BMP effectiveness monitoring

The questions to be answered and objectives addressed by each monitoring activity are listed at the beginning of each subsection.

5.1 Instream Monitoring

Instream monitoring throughout the Clackamas MS4 permit area addresses objectives 2, 4 and 5 from Schedule B.1.a of the 2012 permit:

2. *Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;*
4. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges; and*
5. *Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters.*

Instream monitoring activities will attempt to address the following questions:

- What is the ambient water quality status of the water body?
- What are the trends in water quality observed for the water body?
- How is stormwater runoff impacting receiving water quality?
- How does instream water quality change from an upstream location to a downstream location within an urbanized area?

The following sections describe the instream monitoring locations (Section 5.1.1), sample collection methods (Section 5.1.2), and additional instream sample collection efforts (Section 5.1.3).

5.1.1 Description of Instream Monitoring Locations

Instream monitoring efforts conducted by the participating Clackamas County co-permittees as part of this 2017 Plan include a total of 25 sampling locations representing 20 water bodies.

Instream monitoring site selection was conducted to prioritize locations with water quality impairment, meaning they have a TMDL in place or are 303(d)-listed for a specific parameter. Within the

Clackamas County area, the TMDL water bodies and effective and pending 303(d)-listed water bodies are listed in Table 1.

Table 1. Summary of Clackamas County TMDL and 303(d) Listed Streams

Monitored water body	Bacteria	Temperature	Dissolved oxygen (DO)	Ammonia	Phosphorus	pH/chlorophyll a	Mercury	PCBs	TCE	PAHs	DDE/DDT	Pesticides (dieldrin, eldrin aldehyde, endosulfan)	Arsenic	Thallium	Iron	Lead	Copper	Manganese	Zinc
TMDLs																			
Willamette River (and tributaries) (2006)	✓	✓					✓												
Johnson Creek (2006)	✓	✓					✓				✓	✓							
Tualatin River (1998/2001)	✓	✓	✓		✓	✓	✓												
2010 (effective) 303(d) list																			
Johnson Creek								✓		✓									
Willamette River (Lower or Middle)						✓		✓		✓	✓	✓			✓			✓	
Tualatin River/Fanno Creek			✓									✓			✓			✓	
2012 (proposed) 303(d) list (additional parameters)																			
Johnson Creek											✓	✓				✓			
Abernethy Creek			✓																
Kellogg Creek			✓																
Fanno Creek			✓						✓				✓	✓	✓	✓	✓		✓
Willamette River (lower or middle)			✓				✓									✓	✓		
Tualatin River				✓			✓									✓	✓		✓

DDE = dichlorodiphenyldichloroethylene

DDT = dichlorophenyltrichloroethane

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

TCE = trichloroethylene

Instream monitoring site selection was also based on the length of record of historical data. Locations are primarily consistent with those included in the 2006 Plan and subsequent updates, to ensure a long enough period of record to inform future trends analyses. Finally, site selection was made to ensure geographic coverage of the participating co-permittees' MS4 permit areas.

Paired instream monitoring locations were selected when possible. Paired monitoring locations include one upstream location that represents more baseflow and/or rural conditions, generally located close to the co-permittee's MS4 permit area boundary, and one downstream location that represents urban MS4 stormwater runoff and baseflow conditions generated inside of the co-permittee's MS4 permit boundary. Paired monitoring was selected to help identify the effects of urban development on receiving water quality.

Figure 1 identifies the instream monitoring locations and includes the specific water body, responsible jurisdiction, and type of sampling method employed (see Section 5.1.2). Table 2 summarizes the total number of locations and the total number of data points (product of monitoring location and frequency) collected by participating co-permittees each year.

Table 2. Summary of the Clackamas County Co-permittee Instream Monitoring Efforts

Jurisdiction	Total number of monitoring locations	Data points/year
CCSD #1	8	72
SWMACC	1	9
Milwaukie	1	4
Oregon City	6	24
West Linn	3	15
Gladstone	1	3
OLWSD	3	12
Wilsonville	2	8
Total	25	147

5.1.2 Sample Collection Methods

Instream sample collection methods vary by jurisdiction and include either storm-targeted sample collection efforts or routine sample collection efforts. A description of both methods is provided below.

5.1.2.1 Targeted Sample Collection

The 2006 Plan's instream monitoring efforts were focused on collecting ambient water quality data during both dry weather and wet weather conditions. As instream water quality tends to vary during storm events, sample collection that is targeted during storm events and during dry weather conditions allows jurisdictions that conduct monitoring less frequently to assess water quality impacts associated with MS4 discharges. For this 2017 Plan, select jurisdictions (Milwaukie, West Linn, and OLWSD) opted to continue targeting storm events to meet their instream sampling requirements.

Grab samples will be collected instream during dry weather conditions. During storm events, multiple time-spaced grab samples will be collected throughout the storm event to provide a single time-composited sample. A composite sample collected during a storm event allows for capture of a larger portion of the storm hydrograph and better represents fluctuating pollutant concentrations. Rationale related to the use of a time-composite sampling approach was previously submitted to DEQ in 2012.

Instream sampling procedures applicable to this 2017 Plan are as follows:

1. Instream water quality samples will be collected during both dry and wet weather conditions, to support future trends analyses and evaluate differences in receiving water quality due to weather conditions and MS4 stormwater runoff. A select (varies by jurisdiction) number of samples will be collected during storm events (see Table 3).
2. Samples collected during a storm event will be collected as time-composited grab samples, which will require grab samples to be collected at a defined frequency and combined prior to analysis.
3. A minimum of 14 days shall be maintained between consecutive instream sampling events.

Table 3 outlines the storm-targeted instream monitoring locations, frequencies, and responsible jurisdiction. As shown in Table 3, a total of 31 individual samples are planned for collection via the storm-targeted instream sampling method per year, representing 7 water bodies. Approximately 17 of those samples are time-composited samples collected during storm events.

NOTE: The most resource-intensive element of water quality monitoring is sampling during storm events. Because of the difficulty in identifying suitable storms, the uncertainty associated with weather forecasts, and the need to mobilize in a timely manner to allow for characterizing the storm, storm-targeted sampling requires a significant time commitment. Staff conducting the sampling are typically assigned other responsibilities in addition to stormwater monitoring. To ensure that monitoring does not consume inordinate resources at the expense of activities that reduce pollution, the following limitations apply to the commitments made in this 2017 Plan related to storm event sample collection.

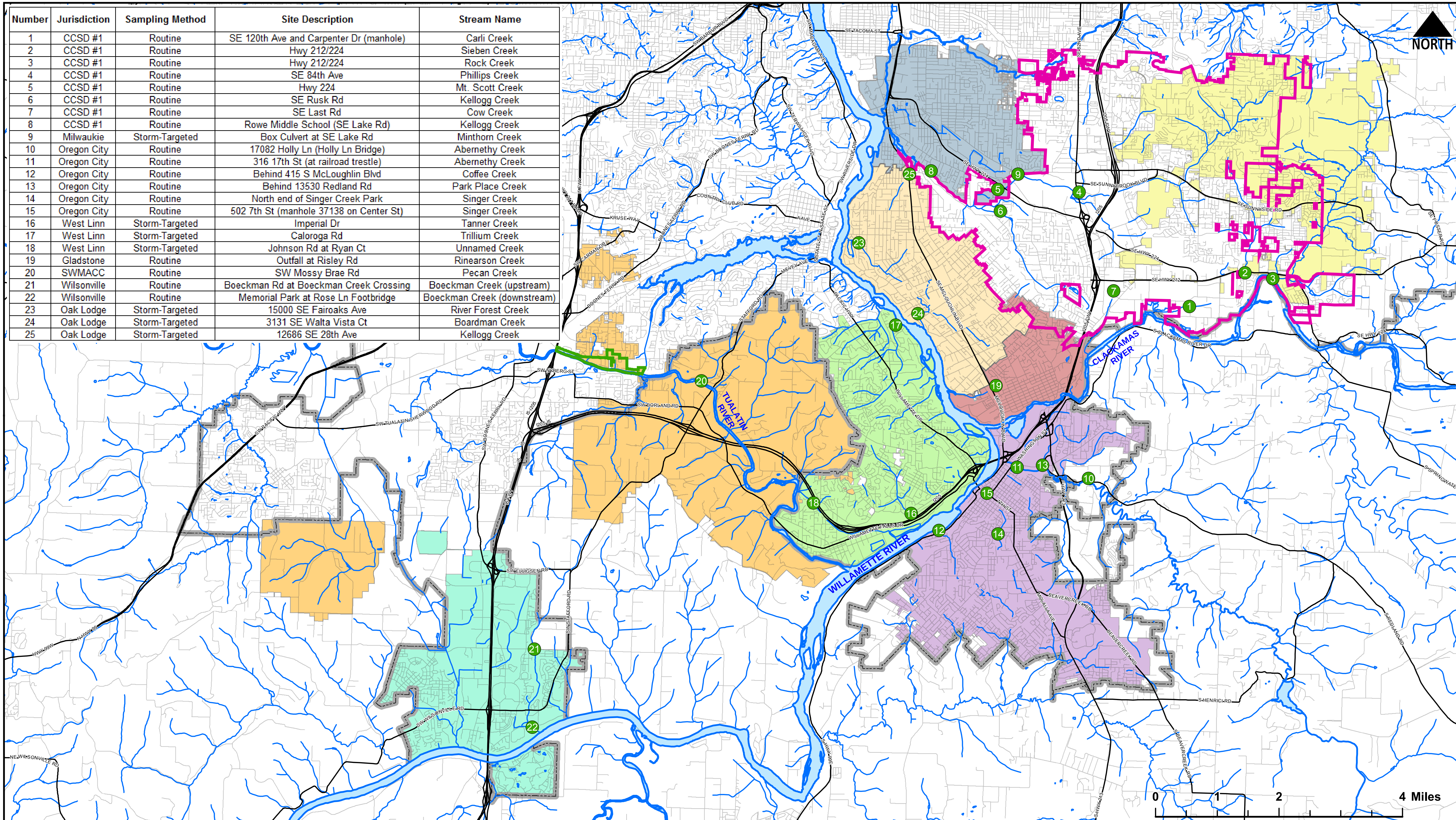
- Storms will not be sampled on major holidays including Thanksgiving Day, Christmas Eve, Christmas Day, New Year's Eve, New Year's Day, President's Day, Independence Day, Labor Day, Memorial Day, and Easter.
- Storm events shall be a minimum of 0.1 inch of rainfall and of a size for which, once a crew is mobilized, runoff is anticipated to occur for a minimum of 2 hours.
- For time-composite sample collection, the duration of time between the collection of individual grab samples will vary as necessary to meet the goal of obtaining at least three grab samples per storm event (these three grab samples will then be combined into one composited sample for analyses). In some cases, a storm may not last long enough to collect three individual grab samples. In these cases, the samples that are collected will be composited and analyzed; no minimum number of samples is specified.

Table 3. Targeted Instream Monitoring Site Summary

Monitored water body	Responsible party	Number of locations	Sampling frequency	Parameters monitored (field/lab)[a]	Storm events targeted
Minthorn Creek	Milwaukie	1	4/year	Field and lab	Y (2 of 4)
Summerlinn Creek	West Linn	1	5/year	Field and lab	Y (3 of 5)
Tanner Creek	West Linn	1	5/year	Field and lab	Y (3 of 5)
Trillium Creek	West Linn	1	5/year	Field and lab	Y (3 of 5)
River Forest Creek	OLWSD	1	4/year	Field and lab	Y (2 of 4)
Boardman Creek	OLWSD	1	4/year	Field and lab	Y (2 of 4)
Kellogg Creek	OLWSD	1	4/year	Field and lab	Y (2 of 4)

a. The term "field" indicates samples that are analyzed using meters in the field–typically for temperature, conductivity, DO, and pH.

Number	Jurisdiction	Sampling Method	Site Description	Stream Name
1	CCSD #1	Routine	SE 120th Ave and Carpenter Dr (manhole)	Carli Creek
2	CCSD #1	Routine	Hwy 212/224	Sieben Creek
3	CCSD #1	Routine	Hwy 212/224	Rock Creek
4	CCSD #1	Routine	SE 84th Ave	Phillips Creek
5	CCSD #1	Routine	Hwy 224	Mt. Scott Creek
6	CCSD #1	Routine	SE Rusk Rd	Kellogg Creek
7	CCSD #1	Routine	SE Last Rd	Cow Creek
8	CCSD #1	Routine	Rowe Middle School (SE Lake Rd)	Kellogg Creek
9	Milwaukie	Storm-Targeted	Box Culvert at SE Lake Rd	Minthorn Creek
10	Oregon City	Routine	17082 Holly Ln (Holly Ln Bridge)	Abernethy Creek
11	Oregon City	Routine	316 17th St (at railroad trestle)	Abernethy Creek
12	Oregon City	Routine	Behind 415 S McLoughlin Blvd	Coffee Creek
13	Oregon City	Routine	Behind 13530 Redland Rd	Park Place Creek
14	Oregon City	Routine	North end of Singer Creek Park	Singer Creek
15	Oregon City	Routine	502 7th St (manhole 37138 on Center St)	Singer Creek
16	West Linn	Storm-Targeted	Imperial Dr	Tanner Creek
17	West Linn	Storm-Targeted	Caloroga Rd	Trillium Creek
18	West Linn	Storm-Targeted	Johnson Rd at Ryan Ct	Unnamed Creek
19	Gladstone	Routine	Outfall at Risley Rd	Rinearson Creek
20	SWMACC	Routine	SW Mossy Brae Rd	Pecan Creek
21	Wilsonville	Routine	Boeckman Rd at Boeckman Creek Crossing	Boeckman Creek (upstream)
22	Wilsonville	Routine	Memorial Park at Rose Ln Footbridge	Boeckman Creek (downstream)
23	Oak Lodge	Storm-Targeted	15000 SE Fairoaks Ave	River Forest Creek
24	Oak Lodge	Storm-Targeted	3131 SE Walta Vista Ct	Boardman Creek
25	Oak Lodge	Storm-Targeted	12686 SE 28th Ave	Kellogg Creek



Brown AND Caldwell

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FIGURE 1. INSTREAM MONITORING LOCATIONS

CCSD #1, SWMACC, Happy Valley, Rivergrove, Gladstone, Milwaukie, Oak Lodge, Oregon City, West Linn, and Wilsonville

5.1.2.2 Routine Sample Collection Methods

Routine instream monitoring efforts are focused on collecting ambient water quality data year round during both dry weather and wet weather seasons in accordance with a predetermined schedule.

For this 2017 Plan update, select jurisdictions (Wilsonville, Oregon City, Gladstone, SWMACC, and CCSD #1) opted to conduct routine instream monitoring instead of specifically targeting dry weather events and storm events to meet their instream sampling requirements. Routine sampling provides a more unbiased and comprehensive picture of ambient water quality conditions. Routine sampling requires prescheduling of sampling activities, reflective of consistent timing and frequency over the monitoring year. When prescheduled, samples will presumably be collected during both dry weather and wet weather conditions to allow for assessment of water quality impacts associated with MS4 discharges.

As with the storm-targeted instream sampling method, grab samples will be collected instream during dry weather conditions. During storm events, multiple time-spaced grab samples will be collected throughout the storm event to provide a single time-composited sample.

Instream sampling procedures applicable to this 2017 Plan are as follows:

1. Prior to the start of the monitoring year, the co-permittee shall establish an instream sampling schedule, based on frequencies shown in Table 4. Deviation from the predetermined schedule during the monitoring year is to be avoided to the extent possible.
2. Instream water quality samples will be scheduled and collected during both the dry and wet weather seasons. A minimum of 50 percent of the samples will be collected during the wet weather season (October 1 to April 30).
3. If it is raining on a prescheduled sampling day, samples shall be collected as time-composited grab samples, which will require grab samples to be collected at a defined frequency and then combined prior to analysis. Detail related to the time-composite sample collection procedures is provided in Section 5.1.2.1.
4. A minimum of 14 days shall be maintained between consecutive instream sampling events.

Table 4, below, outlines the routine instream monitoring locations, frequencies, and responsible jurisdiction. As shown in Table 4, a total of 116 individual samples are planned for collection via the routine instream sampling method per year, representing 18 locations across 14 water bodies.

Table 4. Routine Instream Monitoring Site Summary				
Monitored water body	Responsible party	Number of locations[a]	Sampling frequency	Parameters monitored (field/lab)[b]
Carli Creek	CCSD #1	1	9/year	Field and lab
Cow Creek	CCSD #1	1	9/year	Field and lab
Kellogg Creek	CCSD #1	2	9/year	Field and lab
Mt Scott Creek	CCSD #1	1	9/year	Field and lab
Phillips Creek	CCSD #1	1	9/year	Field and lab
Rock Creek	CCSD #1	1	9/year	Field and lab
Sieben Creek	CCSD #1	1	9/year	Field and lab
Abernethy Creek	Oregon City	2	4/year	Field and lab
Coffee Creek	Oregon City	1	4/year	Field and lab
Park Place Creek	Oregon City	1	4/year	Field and lab
Singer Creek	Oregon City	2	4/year	Field and lab
Pecan Creek	SWMACC	1	9/year	Field and lab
Rinearson Creek	Gladstone	1	3/year	Field and lab
Boeckman Creek	Wilsonville	2	4/year	Field and lab

a. Two locations on the same monitored water body reflects paired sampling sites.

b. The term “field” indicates samples that are analyzed using meters in the field–typically for temperature, conductivity, DO, and pH.

5.1.3 Additional Instream Monitoring Efforts

Since 1998, the City of Milwaukie and Clackamas County Water Environment Services (WES) have participated in a cooperative Johnson Creek watershed study with the U.S. Geological Survey (USGS) and other partners (Gresham, Portland, etc.). The project objectives included the following:

- Assess hydrologic hazards: Analysis of real-time flow and water surface elevations will allow for assessment of flooding conditions as a result of ongoing, significant changes in land use and groundwater discharges.
- Assess water quality: Analysis of stream temperature and turbidity data will provide insight into the effects of land use practices and pollutant sources.
- Assess the interaction between surface water and groundwater: The study provides data and analyses that relate directly to the inter-related nature of the surface and groundwater systems.

As part of this ongoing project, multiple technical reports and publications have been developed. Publications are available for public use and include topics such as: (1) pesticide contributions and transport, (2) overall system hydrology, and (3) suspended sediment loading and the relationship to turbidity levels.

In 2014, the City of Milwaukie and WES (on behalf of CCSD #1) agreed to extend participation in the study through September 2019. Joint Funding Agreements (JFAs) are prepared annually for each partner in order to provide funds to USGS (in part) to operate and monitor continuous flow gauges on Johnson Creek. This monitoring effort directly supports monitoring objective 4 and helps to assess ambient conditions in Johnson Creek. Because of the variable nature of the funding of this study and because future participation is unknown, this effort is referenced separately as an additional instream monitoring activity.

5.2 Stormwater System Monitoring Efforts

Stormwater monitoring throughout the Clackamas County MS4 permit area addresses objectives 1, 2, 3, 5, and 6 from Schedule B.1.a of the 2012 permit:

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

Stormwater (outfall) monitoring activities will attempt to address the following questions:

- Are stormwater-related sources of 303(d) pollutants discharging to receiving waters?
- How do stormwater pollutant concentrations vary based on land use?
- How do stormwater pollutant concentrations vary based on BMP implementation upstream?
- Are pollutant loads from stormwater being reduced over time?

The following sections describe outfall monitoring locations (Section 5.2.1) and sample collection methods (Section 5.2.2).

5.2.1 Description of Stormwater Monitoring Locations

Stormwater monitoring efforts conducted by the participating Clackamas County co-permittees as part of this 2017 Plan represent a total of 11 sampling locations and five land use categories. As with the instream monitoring locations, stormwater outfall monitoring locations were originally selected as part of the 2006 Plan development and have been continually refined based on site accessibility and safety.

In 2006, stormwater monitoring locations were originally selected based on the distribution and consistency of the upstream land use type or category (i.e., residential, commercial, industrial, and mixed use). Classification of stormwater quality by land use allows for estimation and evaluation of the sources of specific pollutants. Additionally, the classification of stormwater quality based on land use can be used for pollutant load modeling efforts, and the identification and application of specific BMPs to address specific pollutant loading from a particular land use. Monitoring locations were also selected based on whether non-stormwater flow (e.g., baseflow from groundwater) was present. Samples collected during a storm event from locations with significant baseflow would not be entirely representative of MS4 discharges. Therefore, sites with baseflow were avoided.

Figure 2 identifies the selected stormwater monitoring locations and includes the associated receiving water, upstream contributing land use, and sampling frequency. Table 5, below, summarizes the total number of locations and total number of data points (product of monitoring location and frequency) collected by participating co-permittees each year.

Table 5. Summary of the Clackamas County Co-permittee Stormwater Monitoring Efforts

Upstream land use	Number of outfalls monitored	Total number of samples collected per year
Residential	4	12
Multifamily residential	1	3
Commercial	2	6
Mixed use	3	9
Industrial	1	3
Total	11	33

5.2.2 Sample Collection Methods

Stormwater monitoring efforts are focused on capturing storm-specific data from select outfall locations representing drainage from various land use categories. In conjunction with the monitoring objectives, collection of stormwater samples allows for the identification of pollutant sources, characterization of stormwater (based on land use), and indication of the effects that stormwater runoff may have on instream water quality when compared with instream water quality data.

Samples will be collected as time-composite grab samples. Given the number of stormwater monitoring sites and the geographic coverage of sites, a time-composite sampling method is preferred for participants in the Comprehensive Clackamas County Monitoring Program as opposed to flow composite sampling. Composited samples (either time- or flow-composited samples) collected during storm events allow for capture of a larger portion of the storm hydrograph. As fluctuations of pollutant concentrations vary throughout a storm event, use of composite sampling techniques will better represent those variations during storm events.

Stormwater sampling procedures are as follows:

1. Qualifying stormwater monitoring events must be associated with a storm event resulting in greater than 0.1 inch of rainfall.
2. As possible, qualifying stormwater monitoring events shall occur after a minimum 24-hour antecedent dry period.
3. Stormwater samples will be collected during three storm events per year per location.
4. For each sampling event, a minimum of three time-spaced grab samples will be collected throughout the storm event. As possible, based on the number and location of stormwater monitoring sites, sample collection will be initiated toward the beginning of the storm event and individual grab samples will be collected throughout the storm event, but no more frequently than one sample per 30 minutes.
5. The time-spaced grab samples collected will be combined into a single time-composited sample in accordance with the field collection methods outlined in Appendix A.

The discussion in Section 5.1.2.1 regarding limitations on the commitments for storm event sampling for instream monitoring efforts is also applicable to stormwater monitoring efforts.

For each monitored storm event, the contributing storm event rainfall depth will be estimated based on local rainfall gauge records. In lieu of storm event rainfall depth estimates, the flow rate in the pipe may be estimated. Flow rate may be estimated using the average depth of flow measurement taken in the pipe (or outfall) during sample collection activities, the pipe (or outfall) slope and diameter, and Manning's equation.

Number	Juristiction	Site Description	Receiving Water	Associated Land Use	Sampling Frequency
1	CCSD #1	Outfall #19 at SE Webster Rd	Kellogg Creek	Residential	3 / Year
2	CCSD #1	Outfall #12 at Pheasant Ct	Mt. Scott Creek	Mixed Use	3 / Year
3	CCSD #1	Sunnyside Village Apartments	Sieben Creek	Multi-family Residential	3 / Year
4	CCSD #1	SE Oregon Trail Dr. near SE Sieben Park Way	Unnamed tributary to Sieben Creek	Commercial	3 / Year
5	Milwaukie	Outfall #23003 at Roswell Street	Johnson Creek	Residential	3 / Year
6	Oregon City	Oregon City Shopping Center	Clackamas River	Commercial	3 / Year
7	Oregon City	Clackamette Cove at Agnes Ave	Clackamas River	Industrial	3 / Year
8	SWMACC	Rivergrove Boat Ramp at SW Dogwood Dr	Tualatin River	Residential	3 / Year
9	West Linn	Summit St & Horton Rd	Barlow Creek	Residential	3 / Year
10	Wilsonville	Library Detention Pond Inlet at Memorial Park	Tributary to Boeckman Creek	Mixed Use	3 / Year
11	Oak Lodge	SE Naef Rd (Stringfield Park)	Boardman Creek	Mixed Use	3 / Year

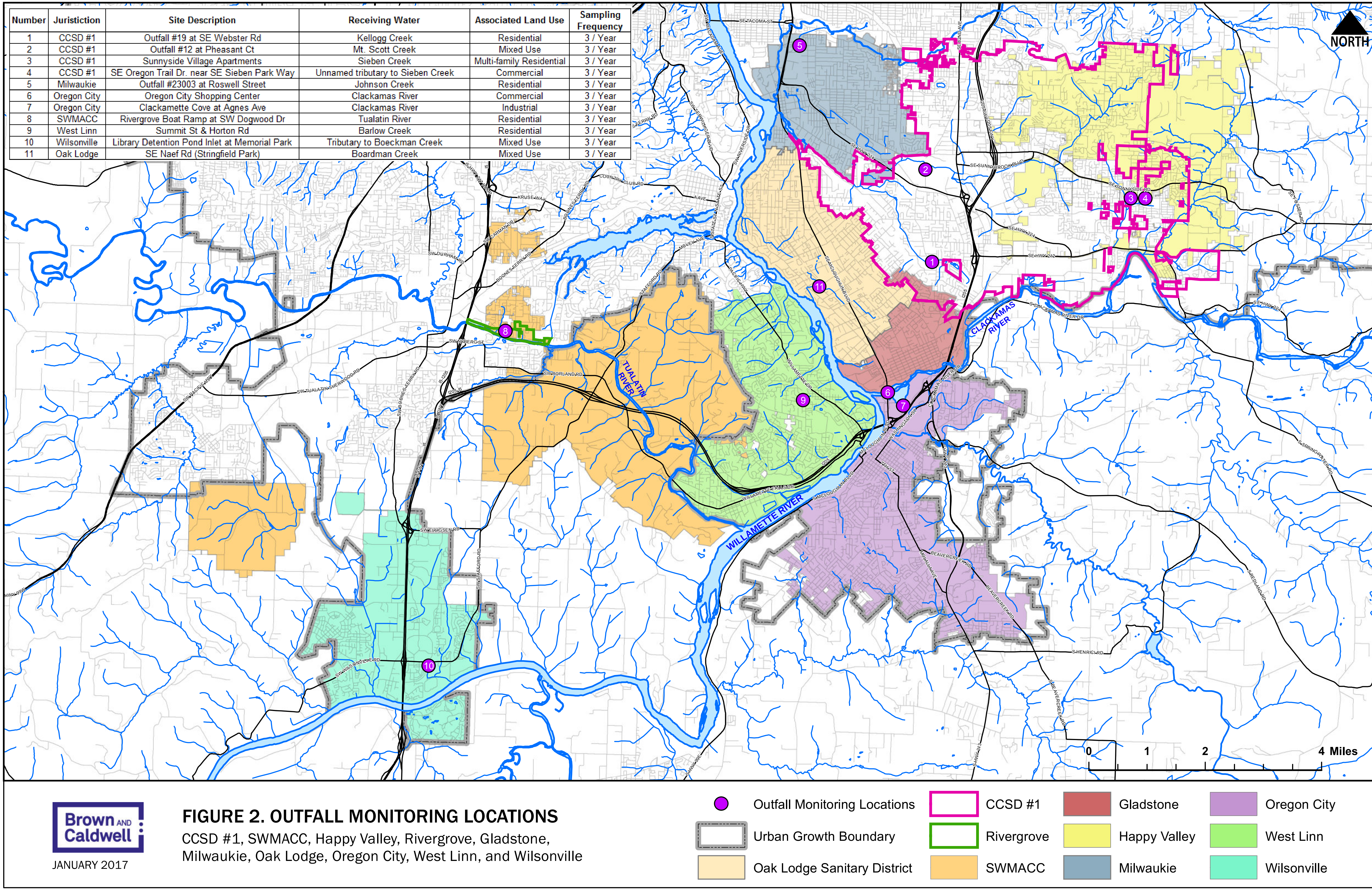

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FIGURE 2. OUTFALL MONITORING LOCATIONS

CCSD #1, SWMACC, Happy Valley, Rivergrove, Gladstone, Milwaukie, Oak Lodge, Oregon City, West Linn, and Wilsonville

Each stormwater monitoring location is listed in Table 6, along with a reference regarding the sampling frequency and parameters monitored.

Table 6. Stormwater System Monitoring Site Summary

Upstream land use	Outfall description	Receiving water	Responsible party	Sampling frequency	Parameters monitored (field/lab)
Residential	Outfall 19: SE Webster Road	Kellogg Creek	CCSD #1	3/year	Field and lab
Residential	Rivergrove Boat Ramp at SW Dog-wood Drive	Tualatin River	SWMACC	3/year	Field and lab
Residential	Outfall 23003 at Roswell Street	Johnson Creek	Milwaukie	3/year	Field and lab
Residential	Summit Street and Horton Road	Barlow Creek	West Linn	3/year	Field and lab
Multifamily residential	Sunnyside Village Apartments	Sieben Creek	CCSD #1	3/year	Field and lab
Mixed use (industrial, highway, commercial, residential)	Outfall 12: SE Pheasant Court	Mt. Scott Creek	CCSD #1	3/year	Field and lab
Mixed use (park, school, commercial, residential)	Inlet to Library Detention Pond at Memorial Park	Unnamed tributary to Boeckman Creek	Wilsonville	3/year	Field and lab
Mixed use (park, highway, commercial, residential)	SE Naef Road at Stringfield Park	Boardman Creek	OLWSD	3/year	Field and lab
Commercial	SE Oregon Trail Drive near SE Sieben Park Way	Unnamed tributary to Sieben Creek	CCSD #1	3/year	Field and lab
Commercial	Oregon City Shopping Center	Clackamas River	Oregon City	3/year	Field and lab
Industrial	Clackamette Cove at Agnes Avenue	Clackamas River	Oregon City	3/year	Field and lab

5.3 Biological Monitoring Efforts

Biological monitoring throughout the Clackamas County MS4 permit area addresses objective 5 from Schedule B.1.a of the 2012 permit:

5. *Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters.*

Biological monitoring activities will attempt to address the following questions:

- What are the biologic conditions of receiving waters?
- Based on past macroinvertebrate sampling activities, are there noticeable trends of improvement or impairment in receiving waters?

The following sections describe the macroinvertebrate monitoring site locations (Section 5.3.1), sample collection methods (Section 5.3.2), and connection to physical condition monitoring (Section 5.3.3).

5.3.1 Description of Biological Monitoring Locations

Biological monitoring efforts conducted by the participating Clackamas County co-permittees as part of this 2017 Plan include a total of 21 sampling locations representing 17 water bodies.

Biological monitoring sites reflect locations where biologic and water quality sampling has historically been conducted. In some cases, the locations are consistent with previous pesticide monitoring activities and/or ongoing instream water quality monitoring. Conclusions and recommendations from previous biological monitoring efforts related to site conditions and site adjustments were considered for this 2017 Plan.

For CCSD #1 and SWMACC, biological monitoring locations reflect the Clackamas County Water Environmental Services (WES) clustered monitoring approach and locations of detailed, in-stream physical condition assessments, not directly included in this 2017 Plan. WES's clustered monitoring approach is internal to CCSD #1 and SWMACC and is intended to allow for a more comprehensive assessment of watershed conditions at specific sites.

The biological monitoring locations are described in Table 7 and shown graphically in Figure 3.

Table 7. Biologic Monitoring Site Summary

Jurisdiction	Target monitoring date	Site description	Receiving water	Past biologic monitoring efforts?	Existing instream water quality monitoring location?
CCSD #1	2018	Rowe Middle School (SE Lake Road)	Kellogg Creek	Y (2009, 2011, 2015)	Y
CCSD #1	2018	Downstream of 11814 Jennifer Street	Carli Creek	Y (2007, 2009, 2011, 2015)	Y[a]
CCSD #1	2018	Highway 212/224, near SE 135th	Sieben Creek	Y (2007, 2009, 2011, 2015)	Y
CCSD #1	2018	SE Troge Road and SE Foster Road	Rock Creek	Y (2007, 2009, 2011, 2015)	N
CCSD #1	2018	SE Rusk Road	Kellogg Creek	Y (2007, 2009, 2011, 2015)	Y
CCSD #1	2018	Highway 224	Mt. Scott Creek	Y (2007, 2009, 2011, 2015)	Y[b]
CCSD #1	2018	Highway 212/224, near SE 142nd Avenue, upstream of confluence with Trillium Creek	Rock Creek	Y (2007, 2009, 2011, 2015)	Y
CCSD #1	2018	Downstream of SE Dean Drive	Cow Creek	Y (2007, 2009, 2011, 2015)	N
SWMACC	2018	SW Mossy Brae Road	Pecan Creek	Y (2007, 2009, 2011, 2015)	Y
Gladstone	2018	River Road (Brookside Village Apartments)	Rinearson Creek	N[c]	N
Milwaukie	2018	SE Lake Road	Minthorn Creek	Y (2013)	Y
Oregon City	2018	Singer Creek Park	Singer Creek	Y (2013)	Y
Oregon City	2018	Lower Coffee Creek	Coffee Creek	Y (2013)	Y
West Linn	2018	Imperial Drive	Tanner Creek	Y (2013)	Y
West Linn	2018	Caloroga Road	Trillium Creek	Y (2013)	Y
Wilsonville	2018	Memorial Park at Rose Lane footbridge	Boeckman Creek	Y (2013)	Y
Wilsonville	2018	Kolbe Lane Bridge	Boeckman Creek	Y (2004, 2013)	N
Wilsonville	2018	Boeckman Creek footbridge	Boeckman Creek	Y (2004, 2013)	N
OLWSD	2018	2350 SE Swain Avenue	River Forest Creek	Y (2013)	N
OLWSD	2018	SE Naef Road at Stringfield Park	Boardman Creek	Y (2013)	N
OLWSD	2018	4507 SE Boardman Avenue	Boardman Creek	Y (2013)	N

a. *The Carli Creek biologic monitoring location corresponds to the CCSD #1 instream monitoring location at SE 120th Avenue and Carpenter Drive. This biologic monitoring site description is consistent with the historical biologic monitoring reports.*

b. *The Mt. Scott Creek biologic monitoring location corresponds to the historical CCSD #1 instream and biologic monitoring location at North Clackamas Park. The past biologic monitoring efforts refer to the North Clackamas Park location. The instream and biologic monitoring site was relocated to Highway 224 for the 2013–14 monitoring year.*

c. *This site was relocated from the Risley Road instream monitoring location based on recommendations following Gladstone's 2013 biological monitoring effort.*

Number	Juristiction	Site Description	Stream Name
1	CCSD #1	Downstream of 11814 Jennifer St	Carli Creek
2	CCSD #1	Hwy 212/224	Sieben Creek
3	CCSD #1	SE Troge Rd and SE Foster Rd	Rock Creek
4	CCSD #1	SE Rusk Rd	Kellogg Creek
5	CCSD #1	Hwy 224	Mt. Scott Creek
6	CCSD #1	Hwy 212/224	Rock Creek
7	CCSD #1	Downstream of SE Dean Dr	Cow Creek
8	CCSD #1	Rowe Middle School (SE Lake Rd)	Kellogg Creek
9	SWMACC	SW Mossy Brae Rd	Pecan Creek
10	Milwaukie	Box Culvert at SE Lake Rd	Minthorn Creek
11	Oregon City	Singer Creek Park	Singer Creek
12	Oregon City	Lower Coffee Creek	Coffee Creek
13	Gladstone	19535 River Rd (Brookside Village Apartments)	Rinearson Creek
14	West Linn	Imperial Dr	Tanner Creek
15	West Linn	Caloroga Rd	Trillium Creek
16	Wilsonville	Memorial Park at Rose Ln Footbridge	Boeckman Creek
17	Wilsonville	Kolbe Ln Bridge	Boeckman Creek
18	Wilsonville	Boeckman Creek Footbridge	Boeckman Creek
19	Oak Lodge	2350 SE Swain Ave	River Forest Creek
20	Oak Lodge	SE Naef Rd (Stringfield Park)	Boardman Creek
21	Oak Lodge	4507 SE Boardman Ave	Boardman Creek

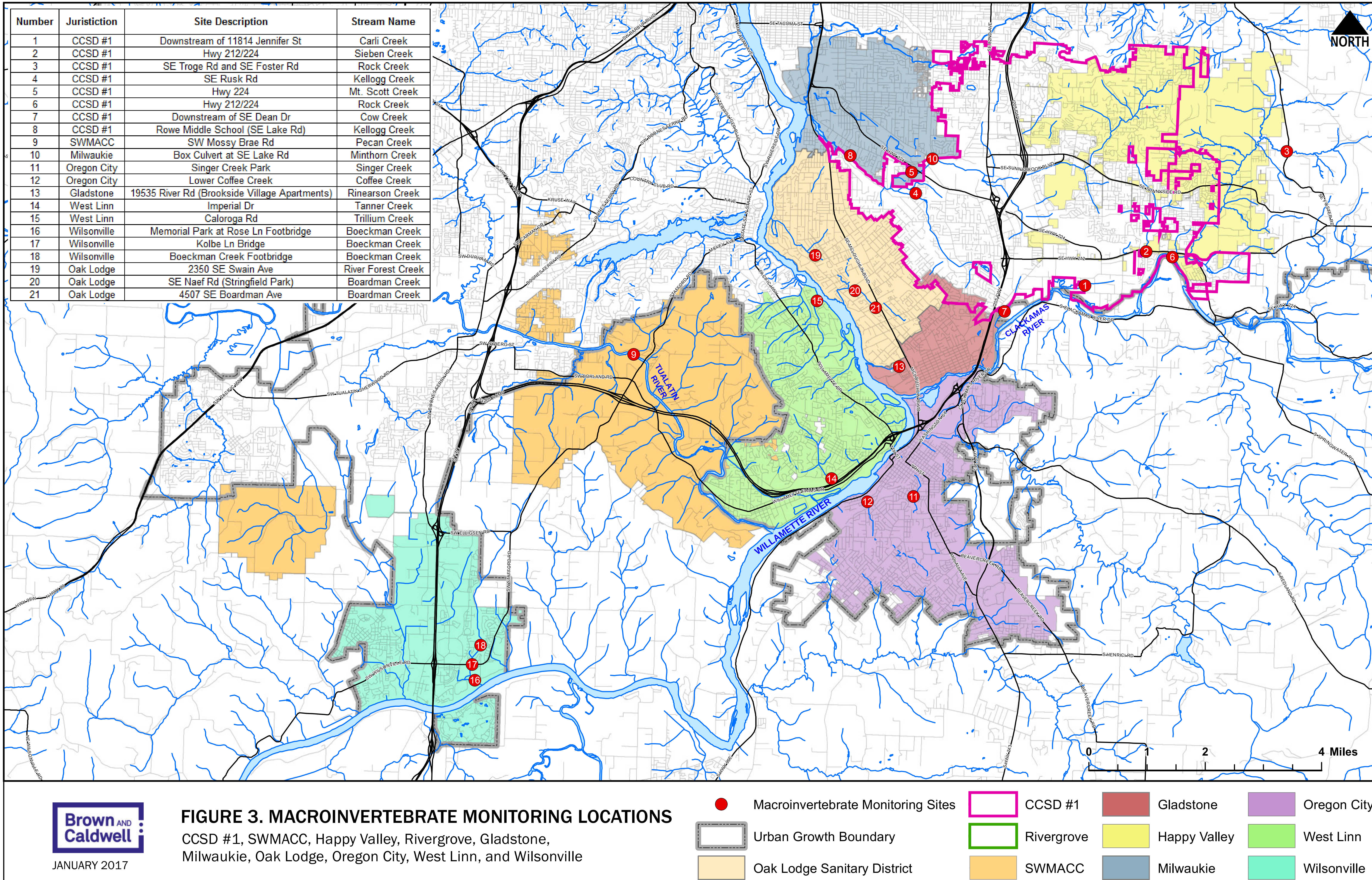

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FIGURE 3. MACROINVERTEBRATE MONITORING LOCATIONS

CCSD #1, SWMACC, Happy Valley, Rivergrove, Gladstone, Milwaukie, Oak Lodge, Oregon City, West Linn, and Wilsonville

5.3.2 Sample Collection Methods

Biological monitoring efforts will be conducted by each participating co-permittee a minimum of once over the next 5 years (i.e., July 2017 through July 2022). Efforts include macroinvertebrate sampling and associated physical habitat, riparian assessment, and water chemistry sampling that accompanies the sample collection. Historically, the co-permittees have used a contractor to conduct the sampling and prepare the documentation in a separate report.

Sampling efforts are typically targeted for summer or early fall, low-flow conditions.

Sample collection processes and methods summarized below are consistent with methods previously employed. Detailed documentation of methods can be referenced in the *Clackamas County NPDES MS4 2013 Coordinated Macroinvertebrate Assessment* (February 2014), prepared by Cole Ecological, Inc. on behalf of the cities of Gladstone, Lake Oswego, Milwaukie, Oregon City, West Linn, and Wilsonville. At the time of sampling, sampling methods may be slightly adjusted to conform to new technologies. Such changes will be documented in a final assessment report at the conclusion of the monitoring event.

Macroinvertebrate community sampling will be conducted using the *Benthic Macroinvertebrate Sampling Protocol for Wadeable Rivers and Streams* (DEQ 2003). Samples are sorted and identified to the level of taxonomic resolution recommended for Level 3 macroinvertebrate assessments. Level 3 protocols include duplicate composite sampling for quality assurance. Both glide and riffle samples are assessed using a multi-metric analysis and using a predictive model.

Water temperature, dissolved oxygen (DO), and specific conductivity will be measured at each site. Standard operating procedures (SOPs) and calibration procedures will be provided to participating co-permittees by the contractor prior to field sampling efforts.

5.3.3 Connection to Physical Condition Monitoring

With urbanization and increased development along the stream corridor, the timing and magnitude of discharge to stream channels often results in changes to the geomorphic character of the channel. This physical change to the stream channel can be observed through changes to stream channel width and depth and changes to the riparian vegetation.

During macroinvertebrate community sampling activities, habitat surveys and riparian assessments are conducted to inform the presence or lack of macroinvertebrates. Habitat surveys and riparian assessments are a type of physical condition monitoring that also help to locate areas of erosion, incision, and migration, and other changes to the stream corridor.

The physical conditions of the stream corridor are assessed using the modified Rapid Assessment Technique (RSAT), which includes data collection from channel habitat units (a sample reach equal to 20 times the wetted width or 75 meters, whichever is greater), channel cross sections, and the adjacent riparian zone. Habitat surveys are conducted to measure or visually estimate the number, length, gradient, and depth of pools and riffles instream; the percent of eroding or downcutting banks; woody debris characteristics; and substrate characteristics. Riparian assessment efforts include identification of riparian plant community type and percent vegetative cover present in the riparian area.

5.4 BMP Monitoring Efforts

Monitoring to analyze the effectiveness of BMPs is conducted to address monitoring objective 2 from Schedule B.1.a of the 2012 permit:

2. *Evaluate the effectiveness of BMPs in order to help determine BMP implementation priorities; and,*
6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

BMP monitoring activities will attempt to address the following questions:

- What are the relative pollutant removal capabilities of BMPs being used/implemented in the jurisdiction?
- Has implementation of programmatic BMPs provided information to validate whether stormwater quality improvement is being made, based on defined schedules, and frequencies in the SWMP?

BMP is a broad term that can be used to describe structural water quality facilities and source control/programmatic activities (as reported in the co-permittees' SWMPs). Both are implemented to achieve a net water quality benefit. The monitoring of a structural BMP facility (e.g., detention and retention ponds, swales, constructed wetlands, proprietary systems) would represent an environmental monitoring effort, while monitoring (tracking) of source control/ programmatic activities (erosion and sediment control, stormwater conveyance system cleaning and maintenance, industrial and business inspection programs, and public education and outreach) would represent a program monitoring effort.

This 2017 Plan focuses on environmental monitoring efforts. However, program monitoring is referenced because it also addresses objective 2 from Schedule B.1.a of the 2012 permit. Additionally, the evaluation of stormwater monitoring data, when combined with programmatic monitoring information, may help to quantify the water quality benefit of BMPs.

BMP monitoring also helps indirectly to address monitoring objective 6: *Assess progress towards meeting applicable pollutant load reduction benchmarks*. BMP effectiveness data are used in pollutant load modeling and the development of pollutant load reduction estimates in order to meet requirements for TMDL compliance. Evaluating BMP effectiveness allows for refinement of these effectiveness values used in the model and allows for the pollutant load modeling to reflect current conditions more accurately.

The following sections describe BMP monitoring efforts pertaining to environmental monitoring (Section 5.4.1) and program monitoring (Section 5.4.2).

5.4.1 BMP Monitoring (Environmental)

Limited environmental monitoring is currently being conducted by Clackamas County co-permittees associated with the performance of structural or source control BMPs. Structural BMP monitoring can be a very time- and cost-intensive activity, while the results apply only to the specific characteristics of the sampled BMP. Sampling of stormwater for purposes of evaluating source control activities often provides inconclusive results because of the variability of stormwater runoff, pollutant sources, and implementation efforts.

As stormwater management and stormwater treatment are continually changing and evolving fields, extensive literature regarding the monitoring of various treatment technologies and practices (structural and source control BMPs) is being generated by researchers, public entities, and private companies to meet both regulatory and non-regulatory needs. Clackamas co-permittees collect effectiveness information and cost information for various BMPs in conjunction with implementation of their stormwater programs. When made available from local, regional, and national sources, Clackamas County co-permittees obtain information that aids their individual stormwater management efforts and influences future decision making regarding appropriate levels of treatment technology to require for new development and redevelopment. Review and application of these findings provides a more cost-effective means of addressing monitoring objective 2.

A number of Clackamas County co-permittees are actively involved in ACWA, which provides an open forum for stormwater management discussions and provides additional educational opportunities for local officials regarding stormwater quality and treatment. Participation in ACWA will continue to support literature tracking efforts.

Finally, the City of Milwaukie will begin monitoring a large, structural BMP that serves as a regional water quality facility. Objectives of the monitoring include evaluation of the performance of the system (from a water quality perspective) and potential refinement of the BMP effluent concentrations used to evaluate pollutant load reduction of the facility in order to establish TMDL benchmarks. Table 8 summarizes the structural BMP to be evaluated, the proposed sampling frequency, and the parameters to be evaluated.

Table 8. Structural BMP Monitoring Site Summary

Responsible party	Structural BMP description	Receiving water	Sampling frequency	Parameters monitored (field/lab)
Milwaukie	Roswell detention facility	Johnson Creek	1/year	Field and lab

5.4.2 BMP Monitoring (Programmatic)

Clackamas County co-permittees currently conduct a variety of program monitoring efforts, generally related to implementation of their SWMPs. Qualitative information is currently collected in the form of tracking measures. These tracking measures provide valuable information to assist in the assessment of BMPs. Examples of BMP categories that are assessed for effectiveness through the use of tracking measures include the following:

- Illicit discharge detection and elimination (e.g., have the number of illicit discharge incidents decreased?)
- Public education (e.g., based on survey information, is there increased public awareness related to the jurisdiction’s stormwater program and overall stormwater management?)
- Maintenance of structural controls (e.g., based on inspection records, is maintenance being performed more regularly? Are facilities operating more consistently?)

Specific tracking measures for these BMP categories are described in each of the co-permittees’ SWMPs and are reported on with annual reports.

Quantitative effectiveness data for the programmatic elements outlined in the SWMP are currently not collected, but efforts to look at the effectiveness of these source control activities may occur as discussed above under Section 5.4.1.

Section 6 Sampling Parameters, Analytical Methods, and Quality Assurance and Quality Control

This section includes a summary of sampling parameters and analytical methods (Section 6.1) and a summary of QA/QC procedures (Section 6.2).

6.1 Sampling Parameters and Analytical Methods

The purpose of both instream and stormwater outfall monitoring efforts is to assess the degree to which ambient water quality is impacted by stormwater runoff. Therefore, consistent pollutant parameters are monitored for both instream and outfall (stormwater) sampling locations.

Pollutant parameters for this 2017 Plan are based on Table B-1 of the 2012 permit and are listed below in Table 9. A suggested analytical method is also identified in Table 9; however, use of an alternative, U.S. Environmental Protection Agency (EPA)-approved method listed in the most recent publication of 40 CFR 136 is permissible. The suggested analytical methods documented in Table 9 include both EPA and Standard Methods and (SM) are consistent with provisions of 40 CFR 136.

Table 9. Pollutant Parameters and Analytical Methods

Type (field or lab)	Analyte	Sample type (grab or time-spaced composite)	Unit	Suggested analytical method	Target MDL	Notes
Field	Specific conductivity	Grab	µmhos/cm	SM 2510 B	1	Method assumes use of probe
Field	pH	Grab	Standard units	SM 4500-H B	0.1	Method assumes use of probe
Field	Temperature	Grab	°C	SM 2550-B	0.1	Method assumes use of probe
Field	DO	Grab	mg/L	EPA 360.1	0.1	Method assumes use of probe
Lab	Copper, total	Composite	µg/L	EPA 200.8	0.1	
Lab	Copper, dissolved	Composite	µg/L	EPA 200.8	0.1	
Lab	DO[a]	Grab	mg/L	SM 4500-C	0.02	Conducted to verify field reading
Lab	*E. coli*	Grab	MPN/100 mL	SM 9223 B	1.0	
Lab	Total hardness	Composite	mg $CaCO_3$/L	SM 2340 C	5	
Lab	Lead, total	Composite	µg/L	EPA 200.8	0.01	
Lab	Lead, dissolved	Composite	µg/L	EPA 200.8	0.01	
Lab	Nitrogen: ammonia	Composite	mg/L	SM 4500 NH_3G	0.05	
Lab	Nitrogen: nitrate	Composite	mg/L	SM 4500-NO_3 F	0.04	
Lab	Phosphorus, total	Composite	mg/L	SM 4500-P A, B, & E	0.04	
Lab	Phosphorus, ortho-phosphate	Composite	mg/L	SM 4500-P FEPA 300.0 365.3	0.02	
Lab	Solids: total suspended	Composite	mg/L	SM 2540 D	1.0	
Lab	Solids: total dissolved	Composite	mg/L	SM 2540 C	5.6	
Lab	Solids: total volatile[b]	Composite	mg/L	SM 2540 B	5.0	
Lab	Zinc, total	Composite	µg/L	EPA 200.8	1	
Lab	Zinc, dissolved	Composite	µg/L	EPA 200.8	1	

a. *The Winkler Titration Method is employed to verify field DO readings in accordance with field sampling procedures outlined in Appendix A. Some jurisdictions may opt to analyze DO using only the Winkler Titration Method instead of collecting field samples.*

b. *Parameter is monitored by SWMACC and West Linn only.*

°C = degrees Celsius; µg/L = micrograms per liter; $CaCO_3$ = calcium carbonate; cm = centimeters; mg/L = milligrams per liter; mL = milliliters; MPN = most probable number.

Water quality monitoring conducted as part of the macroinvertebrate sampling will conform to documented SOPs and may deviate from the approved methods listed in 40 CFR 136.

6.2 Quality Assurance and Quality Control Procedures

For purposes of this 2017 Plan, QA/QC procedures for field analysis are initiated directly by the jurisdiction. QA/QC procedures for laboratories are developed by the individual laboratories and available on request.

Field QA/QC procedures are outlined in Appendix A and included in the SOPs for field sample collection (SOP A-1), chain of custody (SOP A-2), and sample handling and transportation (SOP A-3). General sampling procedures for parameters analyzed in the field are provided in SOP A-4. ACWA developed detailed QA/QC procedures for stormwater data collection and sample handling and custody as part of the ACWA UIC [Underground Injection Control] Monitoring Study. Provisions from this ACWA study have been incorporated into the field QA/QC procedures in Appendix A as appropriate.

Co-permittees will use laboratories that have comprehensive QA programs and are DEQ-accredited. The WES water quality laboratory, which currently conducts laboratory analysis for samples collected by some Clackamas County co-permittees operating under this 2017 Plan, operates under the WES *Water Quality Assurance Manual* (May 17, 2007). This manual outlines pertinent test methods, validation, and reporting limits; equipment calibration and maintenance procedures; sample handling and storage procedures; sample acceptance and results reporting procedures; and data qualification and validation procedures. This manual is available by request from the WES Water Quality Laboratory.

Contracted monitoring activities related to biologic monitoring employ field procedures and protocols unique to the monitoring effort. A description of study methods and QA/QC guidelines will be documented in the final assessment report provided to each jurisdiction at the conclusion of the monitoring event.

Section 7 Monitoring Data Management and Plan Modifications

This section includes a summary of data management procedures (Section 7.1) and procedures for modifying this 2017 Plan (Section 7.2).

7.1 Data Management

Participants in this 2017 Plan individually (or through an inter-governmental agreement) collect samples and are responsible for the quality control of their samples prior to delivery at the laboratory. Field sample collection procedures are outlined in Appendix A. Sample validation and verification is conducted at the laboratory and, following analysis, the monitoring results are provided to the responsible jurisdiction to validate and verify that the findings are consistent with their expectations. Questionable monitoring results will be flagged for further review and possible follow-up in the field. If data quality indicators (i.e., field blanks, field duplicates) suggest that contamination or corruption of the sample occurred, data may be discarded and sampling would be conducted again, and the cause of the failure would be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance techniques will be assessed and improved; if the cause is found to be with the sample collection process, field techniques will be assessed, revised, and retrained as appropriate.

Individual jurisdictions are responsible for the compilation of instream and stormwater monitoring data in database or spreadsheet format. Monitoring data are compiled by monitoring location and monitoring event, and data include times, concentrations, and indication of whether a sample represents a grab- or time-composited sample. Statistics (i.e., mean, maximum, minimum) may be calculated on the data by an individual jurisdiction for its own use. A summary of monitoring results is provided to DEQ with submittal of the individual jurisdiction's NPDES MS4 annual reports. Compiled monitoring data may be provided to DEQ in digital format upon request.

Technical reports documenting results of the biologic monitoring effort shall be maintained by individual jurisdictions and results shall be summarized or attached to the associated NPDES MS4 annual report.

A water quality trends analysis will be conducted during the fifth year of this 2017 Plan implementation, based on the instream monitoring data collected to date. The benefit of a coordinated monitoring program is that resources can be distributed more widely to produce data that will provide comprehensive information for Clackamas County as a whole. As a result, data analyses will be conducted specific to each jurisdiction and water body, but assessment and interpretation can be conducted for watersheds as a whole. As part of the water quality trends analysis effort, previously collected monitoring data specific to the water body will be reviewed.

7.2 Plan Modifications

Modifications to monitoring locations and frequency as outlined in this 2017 Plan are permissible as long as the number of monitoring data points collected on an annual basis (the product of monitoring location and frequency) is not reduced. Additionally, if on an annual basis a participating co-permittee is not able to collect the required samples because of climatic conditions, sampling conditions, equipment malfunction, monitoring location inaccessibility, etc., such inability is not directly reflective of a need to modify the monitoring plan.

Currently, as required in the extended 2012 permit, if a modification to this 2017 Plan is requested or required, such need will be documented to DEQ in the form of a 30-day notice of proposed monitoring plan modification. Written approval must be received from DEQ before such modification can take place. If DEQ does not respond within 30 days, the proposed modification is deemed to be approved without written approval.

Appendix A: Field QA/QC Procedures

Appendix A:
Field Quality Assurance and Control Procedures for Sample Collection, Handling, and Custody

SOP A-1: Field Sample Collection Procedures

Field crews are responsible for collecting samples, recording information, and transferring collected samples.

Prior to sample collection, field crews shall verify that adequate sample collection bottles and sample storage equipment are obtained. Sample collection bottles shall be of adequate size and appropriate material, per requirements of the applicable analytical method. Most sample collection bottles are pre-preserved by the laboratory for the appropriate analytical test. If necessary to meet preservation requirements, additional preserving agents will be added to samples by the laboratory upon receipt of the samples.

Upon arrival at the site, field crews shall establish a safety zone for sample collection if necessary (this may include the placement of traffic cones, etc.). Site conditions and other sampling notes shall be recorded in a monitoring log and/or on the Monitoring Field Data Sheet.

Procedures for conducting grab sampling and composite sampling are as follows.

Grab Sampling Procedures

Grab sample collection methods shall be employed for all dry weather instream monitoring activities and for wet weather instream and stormwater (outfall) monitoring activities for select parameters.

Bottle preparation

Obtain clean half-pint, pint, quart, or half-gallon sample bottles from the laboratory conducting the water quality analyses. Each monitoring site would require a minimum number of sample bottles such that separate sample bottles are obtained based on the analytical test methods to be employed by the laboratory. Bottles shall be pre-labeled by field crews or staff to include the site number and monitoring parameter. In some cases, the laboratory may pre-label sample bottles.

1. Based on the number of sampling sites, obtain additional sample bottles for the collection of grab sample duplicates and field blanks. Bottles for duplicate sampling and field blanks shall be obtained from the laboratory conducting the water quality analyses as required. Based on the number of analytical test methods to be employed, the appropriate number of bottles should be obtained for the collection of duplicate samples and field blanks at a site. Bottles for duplicate and field blank samples shall also be pre-labeled with the designated duplicate site number and monitoring parameter.
2. Procedures related to the collection of grab sample duplicates and field blanks are outlined under SOP A-1, QA/QC Sampling Procedures.

Grab sampling technique

Depending on the site characteristics, samples can be obtained by hand or with the aid of tools (i.e., a grab pole).

1. For sample collection from a (flowing) surface water body, the sample should be collected from the middle of the flow stream (if possible). Care must be taken to avoid collecting particulates that are suspended as a result of bumping the bottle on the

streambed. To sample with a hand-held bottle/container, stand downstream of the bottle while it is being filled.

2. If sampling at a surface water outfall, the sample should be collected, if possible, at the point where the flow leaves the pipe.
3. When no sample is collected because of lack of flow or any other circumstances beyond the sampler's control, the associated condition should be noted in the appropriate entry point on the Monitoring Field Data Sheet.
4. Once the bottle is filled to the proper level, replace the lid on the sample bottle and complete the Monitoring Field Data Sheet with appropriate information related to sample collection (i.e., time, sampling conditions, date, etc.).
5. As directed by the laboratory, filter or preserve samples as necessary in accordance with laboratory-issued standard operating procedures. As an example, the WES laboratory requires field filtration of ortho-phosphate at the time of sample collection.
6. Samples should be stored for transport to the laboratory in an "iced" cooler (i.e., using ice or an ice substitute that has been frozen).
7. If a grab sample duplicate is to be obtained at a particular sampling site, the duplicate samples will be obtained by completing the normal grab sampling procedures and documenting information on the Monitoring Field Data Sheet consistent with collection of an actual sample.
8. For samples that are collected for the analysis of bacteria, samples must be transported to the lab within 6 hours of sample collection.
9. Ensure that all elements of the Monitoring Field Data Sheet are complete prior to relinquishing the samples to the laboratory.

Composite Sampling Procedures

Composite sample collection methods shall be employed for wet weather instream and stormwater (outfall) monitoring activities for all laboratory parameters (with the exception of bacteria) as outlined in Table 9 of the Comprehensive Clackamas County NPDES MS4 Stormwater Monitoring Plan.

Bottle preparation

Obtain a minimum of one clean, half-gallon sample bottle from the laboratory or other clean sampling receptacle for collection of the individual samples and one carboy (i.e., large glass or plastic vessel) to combine the individual samples and mix the composited sample. The bottle(s) and the carboy shall be pre-labeled to include the site number.

Obtain additional, clean half-pint, pint, quart, or half-gallon sample bottles for transport of the composited sample to the laboratory. Each monitoring site would require a minimum number of sample bottles such that separate sample bottles are obtained based on the analytical test methods to be employed by the laboratory. Bottles shall be pre-labeled to include the site number and monitoring parameter.

1. Based on the number of sampling sites, obtain the same number of sample bottles as outlined above for the collection of a composite duplicate samples and field blank samples. Bottles for duplicate sampling and field blanks shall also be obtained from the laboratory conducting the water quality analyses as required.

2. Procedures related to the collection of composite duplicate samples and field blank samples are outlined under SOP A-1, QA/QC Sampling Procedures.

Composite sampling technique

Depending on site conditions, samples can be obtained by hand or with the aid of a tool (i.e., grab pole).

Grab sample collection methods, steps 1 through 4 as documented above, should be employed for each of the minimum three individual grab samples collected prior to pouring in the carboy. Composite samples are generally collected at timed intervals and/or on a sampling rotation. Following collection of the minimum three individual grab samples that will compose the composited sample, the following procedures should be followed:

1. Ensure equal portions from individual grab samples are poured into the pre-labeled carboy. This effort shall occur in a closed or covered environment.
2. Properly mix the composited sample and pour a sufficient quantity of water into each pre-labeled sample bottle that is to be relinquished to the lab for analysis.
3. Implement grab sample collection methods, steps 5 through 7.
4. Update the Monitoring Field Data Sheet to document completion of the composite sample collection efforts.

Please note if a composite sample duplicate is to be obtained at a particular sampling site, in order to test the accuracy of the sample collection procedures, the duplicate sample shall be obtained by completing the normal grab sampling procedures, compositing as indicated above, and transferring the composited sample into the pre-labeled sample collection bottles for the laboratory.

<u>QA/QC Sampling Procedures</u>

The use of field blanks and grab and composite sample duplicates will help to identify potential sources of error in the stormwater sampling process, specifically those associated with sample collection, transportation, and analytical procedures.

For grab and composite samples for all parameters, field blanks and grab or composite duplicates shall be collected at a minimum of 10 percent of the total number of monitoring locations for a single event and for samples collected by a single sampling crew. For example, if samples are to be collected at 10 sites or less for one monitoring event, then one field blank and one duplicate sample shall be obtained for that monitoring event. If individual grab samples are to be collected at 12 sites for one monitoring event, then two field blanks and two grab sample duplicates shall be obtained for that monitoring event. A minimum of one field blank and one duplicate shall be obtained for a single monitoring event.

Guidelines related to the collection of a field blank and duplicate sample are outlined below:

1. Procedures for collection of field blank samples should follow the appropriate grab or composite sampling procedures with the exception that the analyte bottle (in the case of grab sample collection) or half-gallon sample bottles (in the case of composite sample collection) are instead filled with deionized (DI) water as provided by the lab. The field blanks shall be transported to all sampling sites associated with a monitoring event in the storage containers with other sample bottles. This will assist with identifying any potential contamination that may occur with the sample collection and transportation of samples.
2. Procedures for collecting the duplicate sample should follow the appropriate grab or composite sample procedures. The duplicate sample bottles shall be pre-labeled with the designated duplicate site number and monitoring parameter. These duplicate samples will assist with identifying any potential contamination that may occur with sample collection or analytical procedures.

SOP A-2: Field Data Sheets and Chain-of-Custody Records

Monitoring Field Data Sheets are completed by field staff conducting the monitoring activities during sample collection activities. Monitoring Field Data Sheets are maintained with the samples during transport to the laboratory.

A chain-of-custody (COC) record is a legal document generated at the laboratory based on information contained in the Monitoring Field Data Sheet. The COC is prepared either prior to or during the delivery of the samples and identifies the person(s) responsible for the sample bottles during all elements of monitoring activity.

The Monitoring Field Data Sheet(s) shall be completed for each sampling location and event. The COC shall be maintained for each sampling event.

The procedures for filling out these forms are as follows.

Before and during Sample Collection

Before sample collection activities, field staff shall document the following general information on a Monitoring Field Data Sheet, unless otherwise documented on the COC:

- Source/location
- Site code or ID
- Person(s) sampling
- Type of sample (instream dry weather/season, instream wet weather/season, or stormwater outfall)
- Date of sample collection
- Time of sample collection
- Number of sample (if applicable): pertains to collection of multiple individual grab samples to compile as a time-composite sample
- Parameters desired for analysis

During sample collection, the Monitoring Field Data Sheet should remain with the sample bottles. During sampling, staff should add to the Monitoring Field Data Sheet for each individual grab sample to document the time and date that the sample was collected.

The Monitoring Field Data Sheets should remain with the samples for the duration of sampling.

After Sample Collection

If composite sampling methods are being used, the Monitoring Field Data Sheet should be updated to include the time and date at which the individual grab samples were composited. If a separate Monitoring Field Data Sheet is completed for the composite sample, any Monitoring Field Data Sheets associated with individual grab samples used to generate the composite sample should be maintained (e.g., stapled to the back) of the composite sample Monitoring Field Data Sheet.

At the Laboratory

The person responsible for completion of the Monitoring Field Data Sheets should be the one to relinquish this paperwork to laboratory personnel or other staff as necessary. At the time of transfer, information contained on the Monitoring Field Data Sheets shall be entered into the laboratory's tracking database (e.g., Clackamas County Water Environment Services Labworks program). In addition to information contained on the Monitoring Field Data Sheets, any special instructions and information related to the transfer of responsibility is also documented.

Using the laboratory's tracking system, the COC is recorded and internal tracking labels may be generated.

SOP A-3: Transporting, Packaging, and Shipping Samples from Field to Lab

Procedures for handling and transportation of samples to the applicable water quality laboratory are as follows:

1. Keep the Monitoring Field Data Sheet with the samples at all times.
2. Pack samples well within ice chest to prevent breakage or leakage.
3. As stated previously, samples should be packed in ice or an ice substitute with a goal to maintain a sample temperature of 4 degrees Celsius during transport. Acquire more ice or ice substitute as necessary.
4. Samples must be delivered to the water quality laboratory within 6 hours (standard for bacteria analysis) or in accordance with required holding times for other parameters.
5. Most samples will be collected in pre-preserved bottles. Some samples may require additional preservation agents to meet preservation requirements. If needed, additional preserving agents will be added to samples by the laboratory personnel upon receipt of the samples.

SOP A-4: Sampling Procedures for Parameters Analyzed in the Field

Sampling procedures for field parameters (i.e., dissolved oxygen [DO]/temperature, conductivity, and pH) are outlined below.

Field Dissolved Oxygen/Temperature Procedure

Meter preparation

1. Check the device for damage.
2. Check and replenish the field supply of deionized (DI) water.
3. Calibrate the device for DO (refer to current manufacturer's calibration instructions). Record calibration in a Calibration Log Book. As necessary, have experienced personnel calibrate the device prior to field sampling event.
4. Verify the device's temperature reading to a National Institute of Standards and Technology (NIST) thermometer. The temperature reading should be within ± 0.5 degree Celsius. Record the temperature verification in a Calibration Log Book.

Analysis timeline

1. All temperature and DO samples are obtained in the field.
2. Samples must be obtained in a fresh glass or plastic bottle or beaker.
3. Sample analysis is performed on site.

Technique

1. Immerse the device directly in the sample. The device is not to be moved around in the sample. Depending on the device used, measurement may occur in a pre-rinsed sample beaker or bottle or directly in the flow path.
2. Record the DO and temperature readings on the Monitoring Field Data Sheet.
3. Remove the device from the sample and rinse with DI water prior to storage or analysis of the next sample.

QA/QC

1. In order to verify DO concentrations obtained in the field, employ the Winkler Titration Method for one sample collected per event. A separate grab sample shall be collected and analyzed at the laboratory, and results shall be compared to the instrument analysis from the same location.
2. In accordance with the rationale outlined in SOP B-1, duplicate samples shall be collected.
3. Monitoring Field Data Sheets are completed during field sample collection and during grab sample collection (when conducting the Winkler test).

Field pH Procedure

Meter preparation

1. Set up the field pH meter(s).
2. Check the device for damage.
3. Check and replenish the buffer solution (4, 7, 10) and DI water.
4. Calibrate the device using at least two pH buffers (4 and 7) and document (refer to current manufacturer's calibration instructions). As necessary, be sure to remove the device's filling solution vent plug before making any pH measurements.

Analysis timeline

1. All pH samples are obtained in the field as grab samples.
2. Samples must be obtained in fresh glass or plastic bottles or beaker.
3. Sample analysis shall be performed on site within 15 minutes of grab time.

Technique

1. Remove device from the field storage solution. Do not remove from storage solution until water sample is ready for analysis.
2. Pre-rinse the sample bottle or beaker with sample water prior to obtaining the actual sample.
3. Collect a 200-milliliter (mL) sample (minimum).
4. Thoroughly rinse the device tip with DI water, pat dry with clean paper towel, and put the device into the sample.
5. Once the device is immersed in the sample, slowly rotate in a circular pattern until the reading stabilizes (30 seconds).
6. Record the pH (to nearest 0.1 unit).
7. Enter the pH data on the Monitoring Field Data Sheet.
8. Remove the device from the sample and rinse with DI water prior to storage or analysis of the next sample.

QA/QC

1. Monitoring Field Data Sheets are completed in the field as the samples are collected.
2. After the completion of each day's sampling, device calibration(s) must be verified and checked for accuracy. The verified pH readings shall be recorded in the pH Calibration Log Book. Devices should be cleaned with DI water and stored in the correct storage solution.
3. A low ionic strength pH probe and an automatic temperature compensation (ATC) probe should be used (e.g., pH probe Orion 815600 and ATC probe 917005).

Field Conductivity Procedure

Meter preparation

1. Set up the field conductivity meter.
2. Check the device for damage.
3. Calibrate the device according to current manufacturer's calibration instructions.
4. Check and replenish the field supply of DI water for rinsing the device following sampling.

Analysis timeline

1. All conductivity samples are obtained in the field as grab samples.
2. Samples must be obtained in fresh glass or plastic bottles or beaker.
3. Sample analysis is performed on site within 15 minutes of grab time.

Technique

1. Pre-rinse the sample bottle with sample water prior to obtaining the actual sample.
2. Collect 200 mL sample (minimum).
3. Ensure that the meter is reading in conductivity mode, if necessary.
4. Rinse device with DI water and pat dry with clean paper towel.
5. Immerse the device in the sample and do not allow the device to touch the bottom of the container or any solid object.
6. Enter the conductivity data on the Monitoring Field Data Sheet.
7. Remove the device from the sample and rinse with DI water prior to storage or the next analysis.

QA/QC

1. Monitoring Field Data Sheets are completed in the field as the samples are collected.
2. After the completion of each day's sampling, device calibration(s) must be verified, checked for accuracy, and recorded.
3. Devices should then be cleaned with DI water and stored appropriately.