City of Salem

National Pollutant Discharge Elimination System (NPDES)

Municipal Separate Storm Sewer System (MS4)

Surface Water and Stormwater Monitoring Plan

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Stormwater Services

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Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Introduction and Purpose

As a condition of its Oregon Department of Environmental Quality (DEQ) issued National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, issued September 15, 2021, the City of Salem developed this "Surface Water and Stormwater Monitoring Plan", which implements the monitoring elements identified in Schedule B of the permit.

Data collected through the implementation of this monitoring plan will undergo review and analysis before becoming integral components of both the Annual Reporting and Permit Renewal process. Statistical summaries of monitoring data will assist the City in an ongoing assessment of the effectiveness of the Best Management Practices (BMPs) that have been identified in the City's Stormwater Management Program (SWMP) Document. The City will ultimately utilize the collected data to evaluate and adaptively manage its SWMP, thereby limiting pollutants entering receiving streams from the MS4 to the Maximum Extent Practicable (MEP). The long-term goal of this monitoring plan is to maintain permit compliance while providing high quality data to assist in decision-making and the adaptive management process.

1.2 Monitoring Plan Requirements

The requirements of this monitoring plan are detailed in Schedule B of the City's NPDES MS4 permit, including the requirement to incorporate the specific monitoring objectives found in Schedule B.1.a. These monitoring objectives include:

i. Evaluate the source(s) of and means for reducing the pollutants of concern applicable to the permittee's permit area, including 2018/2020 303(d) listed pollutants, as applicable;
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 reducing TMDL pollutant loads.

This monitoring plan describes six different environmental monitoring elements the City will utilize (along with programmatic monitoring elements identified in the City's SWMP, historical monitoring data, stormwater modeling, national stormwater monitoring data, and/or literature reviews) to address the above objectives. The environmental monitoring elements described in this plan have been divided into either storm event dependent or non-storm event dependent. Environmental monitoring elements include:

Storm Event Dependent Monitoring Elements

1. Instream Storm monitoring (section 2.1)
2. Stormwater and Structural BMP monitoring (section 2.2)
3. Stormwater Pesticide Monitoring (section 2.3)

Non-Storm Event Dependent Monitoring Elements

4. Continuous Instream monitoring (section 3.1)
5. Monthly Instream monitoring (section 3.2)
6. Macroinvertebrate monitoring (section 3.3)

The City will implement these monitoring elements during the newly issued NPDES MS4 permit term, which expires September 30, 2026.

Additionally, the permit requires that the following information is provided for the above monitoring elements:

- Project/task organization
- Monitoring objectives, including monitoring question and background
- Documentation and record-keeping procedures;
- Monitoring process/study design, including monitoring location, description of sampling event or storm selection criteria, monitoring frequency and duration, and responsible sampling coordinator;
- Sample collection methods and handling/custody procedures;
- Analytical methods for each water quality parameter to be analyzed;
- Quality control procedures, including quality assurance, the testing, inspection, maintenance, calibration of instrumentation and equipment;
- Data management, review, validation, and verification;[4] and,
- Data analysis methodology and quality criteria, and assumptions and rationale.

1.2.1 Adaptive Management

To maintain permit compliance an adaptive management process needs to be implemented annually and at the time of permit renewal. This process is used to assess and modify the City's SWMP Document, prioritize structural BMP retrofit projects including treatment strategies, and identify potential changes to construction design standards in ways that help remove stormwater pollutants to the maximum extent practicable. The City will utilize programmatic data to aid in the analyses of the data collected through this plan. Examples of programmatic data that may be used for analyses of the environmental data include, but are not limited to: structural BMP inspections and maintenance activities, outreach strategies, street sweeping schedule, catch basin cleaning, etc. The implementation of this monitoring plan and performing routine analyses of the data collected will directly aid the City in the adaptive management process.

If at any point the city needs to modify this monitoring plan for adaptive management purposes or other unforeseen conditions, changes to the monitoring plan along with notification to the DEQ will be done in accordance with NPDES MS4 permit Schedule B.1.c.vi.

Annual Reporting

To help facilitate using the data collected through this monitoring plan for adaptive management purposes the data needs to be analyzed on an annual basis. Analysis completed annually will include, at a minimum, a review of all data collected looking for outliers, identifying receiving waterbody water quality exceedances, and identification of improving or deteriorating trends on a small temporal scale that could indicate the presence of discharges that could potentially require follow-up through the City's Illicit Discharge Detection and Elimination Program. Information on any exceedances or changing trends discovered during the review and analysis of data will be included with the Annual Report.

Permit Renewal

During the permit renewal application process, the City will evaluate the overall effectiveness of its SWMP. The data collected through the implementation of this monitoring plan and the analyses performed will contribute to this assessment; thus supporting the adaptive management process.

1.2.2 Environmental Monitoring and Long-term Monitoring Program Strategy

There is a direct relationship between the environmental monitoring implemented through this monitoring plan and the long-term monitoring program strategy. The City was issued its first NPDES MS4 permit in 1997. One of the first monitoring objectives was to characterize stormwater discharges. To do this the City worked with other Phase 1 communities in Oregon and developed a range of event mean concentrations of stormwater pollutants based on land use types. These data have since been revised and are currently used as baseline data, i.e. representing stormwater discharge quality prior to implementation of the City's first SWMP. Since that time, the City's SWMP BMPs and environmental monitoring activities/elements have continued to evolve. This evolution has resulted in numerous changes to construction design standards, programmatic pollution control activities, changes in asset inspections, maintenance activities, outreach strategies, etc.

More specific information regarding the relationship between the current permit's monitoring approach and long-term monitoring strategy has been provided in each of the monitoring elements below.

2 Storm Event Based Monitoring Elements

Storm Criteria

The City of Salem has three monitoring elements: Instream Storm, Stormwater and Structural BMP, and Stormwater Pesticide Monitoring which require sample collection during storm events that meet specific storm criteria. These criteria include the following: a predicted rainfall depth of over 0.1", minimum antecedent dry period (defined by the permit as being the dry time before precipitation events that include less than 0.1 inches of precipitation) of 12 hours, lacking an intra-event dry period that exceeds 6 hours, and each sampling event for a specific monitoring element must be at least 72 hours apart.

Weather Forecasting Service

The City of Salem utilizes quantitative precipitation forecasts (QPF) from the National Weather Service and a private meteorological service. These QPFs are monitored throughout the year and are used to select storm events to sample, determine the flow interval quantities (FIQ) that are used for flow-paced storm sampling for Instream Storm sampling, and to create a schedule for grab and field measurement sample collection.

Storm Sampling Response Team

One of the City's two Stormwater Monitoring Analysts will act as the Responsible Sampling Coordinator (RSC) for each storm sampling event. This person will be responsible for coordinating with the laboratory, organizing the sampling teams, being the contact person for the private meteorological service, and ensuring that all sampling equipment is ready before the start of the storm event.

Once the decision has been made to sample a storm, the RSC will coordinate with Salem's Willow Lake Laboratory and Portland Water Pollution Control Laboratory (WPCL) to ensure there

are not any personnel or material shortages that may compromise hold times or other analytical method requirements. Before the start of the storm event, the Storm Sampling Response Team will program and deploy portable samplers, prepare field instrumentation, inspect bottleware, field filtering equipment, gloves, etc., and print off field data collection and chain of custody forms. The City's private meteorological service will call the RSC to provide notification before the start of the storm event (typically one hour prior to the predicted start of the rainfall). This process is in place to ensure that the collection of grab samples and field measurements will start during the first few hours of the storm event. As the event progresses, the meteorological service will continue to provide updated QPFs to the RSC so that they can time all follow-up grab sampling for Stormwater and Structural BMP sampling times accordingly.

The City has four staff members available to collect samples during a storm event, all of whom are trained in the following:

- Calibration of field instruments and programming of automated samplers.
- Ensuring all field data sheets and chain of custody forms are filled out properly and completely.
- Ensuring that all grab and composite samples are collected, stored, and delivered to the laboratory in accordance with this monitoring plan and the applicable analytical methods.
- Ensuring that all appropriate traffic control measures and necessary personal protective equipment are used.
- Collection of Total Hg samples in adherence to EPA Method 1669 using clean hands/dirty hands handling procedures.

2.1 Instream Storm

2.1.1 Project / Task Organization

Instream Storm refers to the sampling of small MS4 receiving streams during storm events that are selected based on the criteria defined in section 2.0 above. The City's Stormwater Monitoring Analyst will serve as the RSC and Quality Assurance Officer for this monitoring element. The City's Stormwater Quality workgroup will calibrate field instruments, program mechanical samplers, perform sampling and collect field measurement data. The City's Willow Lake Laboratory and Portland's WPCL will perform all analytical laboratory analyses. Ongoing analyses of the data for abnormally large pollutant concentrations, annual reporting, and permit renewal will be completed by the Stormwater Monitoring Analyst(s).

2.1.2 Monitoring Objectives

There are over 90 miles of small streams that are identified as MS4 receiving waterbodies of Salem's MS4 discharges. This monitoring element was developed with the understanding that the data collected would represent stormwater-related impacts, not only for the streams specifically monitored, but for all other small streams that receive MS4 discharges in Salem.

Instream Storm monitoring will contribute to permit monitoring objectives i, ii, iv, v, and vi, as identified in Section 1.2 above.

2.1.2.1 Background

The Instream Storm monitoring element was implemented at the start of the last permit cycle (December 29, 2010). All monitoring sites associated with this monitoring element are within the Pringle Creek Watershed and are located at permanent continuous flow and water quality monitoring locations. This watershed was chosen because it is almost entirely within Salem's city limits, therefore limiting stressors and pollutant sources that are outside of the City's control and jurisdiction. Furthermore, the monitoring sites associated with this monitoring element represent similar land use and geography that is typical for numerous other small stream (1st through 3rd order) MS4 discharge receiving waterbodies within Salem.

Change Made for this Permit Term

One of the three monitoring sites for this monitoring element has changed for this permit cycle. The PRI12 site is located at the city boundary and represents the only portion of the Pringle Creek Watershed that is outside of Salem's city limits and City jurisdiction. This site was monitored from 2011 through 2021 and the water quality data collected during storm events for this site have been well characterized. However, future staff will want to consider recommencing instream storm monitoring at this site during future permit terms as more development and as annexation of the catchment area occurs.

For this permit term, the PRI12 site will be replaced by the CLK12 site. This change resulted from analyses of the data from the existing Instream Storm site on Clark Creek, CLK1. This analysis showed significantly higher concentrations of pollutants during storm events than at the Instream Storm sites on Pringle Creek. This resulted in the reallocation of resources towards additional monitoring of upper Clark Creek (CLK12 is upstream of CLK1) to help inform the City on the sources of pollutants and means to limit them within stormwater discharges. The CLK12 site, like all other sites sampled through this monitoring element, is located at a permanent continuous flow and water quality monitoring location.

2.1.3 Study Design / Sampling Process

2.1.3.1 Study Design

All sampling sites for this monitoring element are on small streams (i.e., all receiving streams in Salem except for the Willamette River, Mill Creek and Shelton Ditch). Monitoring these small streams during storm events was developed with the assumption that these data would represent water quality stressors related to the MS4 system for the streams monitored, and for other small stream receiving waterbodies in Salem.

The study design is a spatial layout of the three different sites that are to be monitored during storm events only. The name of each site, the receiving stream, and the location are included in Table 1 and are identified in Figure 1. Relevant characteristics for each site are as follows:

- **CLK12-** This site on Clark Creek is located approximately 175 feet from where the stream first daylights and upstream of the two sites listed below. The catchment area is entirely inside the city limits, is mostly built-out, and has limited stormwater structural BMP controls. The catchment is the smallest of the three sites at approximately 280 acres and is dominated by residential and land use.

- **CLK1-** This site on Clark Creek is located just above the confluence with Pringle Creek and represents an older portion of town. The majority of the catchment is built-out, is entirely inside the city limits, and has limited stormwater structural BMP controls. The catchment is approximately 1550 acres and is characterized predominately as residential land use with approximately 10% commercial land use.

- **PRI3-** This site on the main fork of Pringle Creek is located just before the confluence of Shelton Ditch with Pringle Creek and downstream of both sites listed above. This site represents a portion of the city with a larger percentage of catchment being treated by stormwater structural BMP controls. The catchment is approximately 8300 acres with over 90% of the total catchment being inside city limits. The breakdown of acres of residential, commercial, and industrial land use for the catchment area within the city is 3300, 350, and 1050 acres, respectively.

Table 1: Instream Storm Monitoring Sites

Site ID	Creek Name	Site Location	Aquarius Database Name
PRI3	Pringle Creek	Pringle Park	Instream3-PRI3
CLK12	Clark Creek	Ewald Ave SE	Instream4-CLK12
CLK1	Clark Creek	Bush Park	Instream3-CLK1

2.1.3.2 Frequency and Duration / Storm Selection Criteria

Instream Storm monitoring will be conducted during fifteen storm events at each of the three sites throughout the permit term. Each storm event will be chosen based on the following criteria:

- Storm event must be greater than 0.1 inch of rainfall;
- A minimum of 50% of the water quality sample events must be collected during the wet season (September 1 to April 30); and,
- Each unique sample event must occur at a minimum of 72 hours apart.

Although it is anticipated that fifteen samples from each of the three sites will be collected over the five-year permit term, unanticipated circumstances including, but not limited to, weather, personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues could prevent the collection of some of the samples. If such a situation arises, Oregon DEQ will be informed following notification procedures listed in the MS4 permit.

2.1.3.3 Sample Collection Method

Sample collection methods are parameter specific (see Table 2) and include grab samples, composited grab samples, in-situ field measurements, and flow-weighted compositesi. Samples will be collected directly from the stream where the water is well mixed and representative of the ambient conditions of the site's wetted perimeter.

Portable mechanical sampling units will be programmed to collect a flow-weighted composite sample. The flow-weighted composite sample will be comprised of 24 sample collection events over the runoff duration produced by the sampled storm. A spreadsheet model that utilizes the predicted precipitation depth for the storm event has been developed for each site. These models are used to determine the flow interval quantity (FIQ) that will be used to trigger the sampler to collect a sample. The result is a sample that is representative of an event mean concentration (EMC) for each parameter sampled with this collection method. The portable

sampling units will remain in the field until the program is completed or 24 hours from the start of the runoff event, whichever comes first.

Note, If stream gauging equipment fails and it is infeasible to repair equipment before a targeted storm event starts, a time-composite sample will be collected in lieu of a flow-paced sample.

Total Mercury samples will be collected in adherence to EPA Method 1669 sampling protocol and will be conducted by collecting grab samples with a target of three, throughout the storm duration, and then composited into a single representative sample.

A grab sample for E.Coli and all field parameters will be collected on the rising limb of the storm hydrograph.

The collection method for each Instream Storm parameter can be found in Table 2 below.

Table 2: Instream Storm Parameter List and Collection Method

Instream Storm Parameters	Collection Method
TSS	Portable Mechanical Sampler
BOD ('stream')	Portable Mechanical Sampler
Total Phosphorus	Portable Mechanical Sampler
Ortho-Phosphorus	Portable Mechanical Sampler
Nitrate+Nitrite as Nitrogen	Portable Mechanical Sampler
Total Kjeldahl Nitrogen	Portable Mechanical Sampler
Ammonia Nitrogen	Portable Mechanical Sampler
Copper (Total Recoverable & Dissolved)	Portable Mechanical Sampler
Lead (Total Recoverable & Dissolved)	Portable Mechanical Sampler
Zinc (Total Recoverable & Dissolved)	Portable Mechanical Sampler
Hardness	Portable Mechanical Sampler
Specific Conductivity	In-Situ and Portable Mechanical Sampler
Dissolved Oxygen	In-Situ (rising limb)
Temperature	In-Situ (rising limb)
pH	In-Situ (rising limb) and Portable Mechanical Sampler
Turbidity	In-Situ (rising limb) and Portable Mechanical Sampler
E. coli	Grab (rising limb)
Total Mercury	Grab (total of 3 grabs that are composited)
Total Alkalinity	Portable Mechanical Sampler
Dissolved Organic Carbon	Portable Mechanical Sampler

Note: BOD ('stream') analytical method is not identified in 40 CFR 136; however, this method has been identified as an acceptable method under schedule B.1.d.iii in the City's NPDES MS4 permit issued in 2010. Additionally, this parameter is not a current permit listed parameter; however, the City will continue to monitor this parameter to ensure the uninterrupted longevity of the data set.

2.1.4 Long-term Strategy

This monitoring element supports the long-term monitoring program strategy by providing environmental data that will contribute to understanding the relationship between the water quality of small receiving streams during MS4 discharge events and current nonstructural programmatic SWMP activities, as well as post-construction structural stormwater controls. The sites selected for sampling have catchments with differing amounts of impervious acres treated

by structural stormwater controls. Furthermore, the CLK12 site is small enough that potential changes to various nonstructural programmatic SWMP activities can be piloted in hopes that the data collected can be used as a guide for future SWMP revisions. Evaluating data by these catchment characteristics and/or programmatic efforts is intended to provide the City a basis to assess the aggregate effectiveness of structural and nonstructural stormwater controls. Which will, in turn, help the City prioritize available funds for retrofitting projects and programmatic efforts.

This monitoring element was first implemented during the last permit term, starting in June 2011 (when the City's monitoring plan was approved by DEQ), and it is expected that this element will continue beyond this permit term and provide a long-term dataset for time and spatial trends analyses as well as other types of analyses.

2.2 Stormwater and Structural BMP

2.2.1 Project / Task Organization

Stormwater and structural BMP monitoring refers to the monitoring of MS4 stormwater runoff at the inlets and outlets of selected structural stormwater BMPs during defined storm criteria, as defined in section 2.0 above. The City's Stormwater Monitoring Analyst(s) will serve as the RSC and Quality Assurance Officer for this monitoring element. The City's Stormwater Quality workgroup will calibrate field instruments, program mechanical samplers, perform sampling and collect field measurement data. The City's Willow Lake Laboratory and Portland's WPCL will perform all analytical laboratory analyses. Ongoing analyses of the data for abnormally large pollutant concentrations, annual reporting, and permit renewal will be completed by the Stormwater Monitoring Analyst(s).

2.2.2 Monitoring Objectives

This monitoring element was developed with the understanding that samples collected at the inlets of structural BMPs will add to the continued refinement of the land use characterization of stormwater pollutant concentrations. The samples collected at the outlets would be used to calculate removal efficiencies and add to the characterization of structural BMP effluent pollutant concentrations for various structural BMP types, a critical piece of data used in the TMDL pollutant load reduction permit requirement.

Stormwater and Structural BMP monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1.a of the City of Salem's NPDES MS4 Permit.

2.2.3 Background

The City of Salem began collecting stormwater samples from four land use-based monitoring sites (Redleaf, Edgewater, Cottage, and Commercial) in January 1995. The City's first NPDES MS4 permit was subsequently issued in 1997. Annual stormwater sampling continued at these four sites through the winter of 2005. In 2006, the City discontinued these sites and began sampling four new stormwater sites. These new sites were selected to represent stormwater discharges to 303(d) listed streams and were identified by the associated stream name (Clark Storm, Mill Storm, Pringle Storm, and Glenn Storm).

During the last NPDES MS4 permit term (December 2010 - December 2015) the City resumed land use-based stormwater monitoring with three sites, Electric, Hilfiker, and Salem Industrial,

which represented residential, commercial, and industrial land use in Salem, respectively. The commercial and industrial sites were new locations, while the residential site was the Clark Storm location from the previous permit.

For the current permit term, the City will continue with land use-based monitoring with a total of six structural BMP monitoring inlet sites selected, 2 for each major land use (residential, commercial, and industrial). Furthermore, this monitoring element will be paired with samples being collected at the structural BMP outlet sites. See Figure 1 for the locations of the sites the City has identified and Tables 3 and 4 for the descriptions of the sites for this monitoring element.

2.2.4 Study Design / Sampling Process

2.2.4.1 Study Design

The study design for this monitoring element includes two separate sets of samples being collected at each structural BMP. The first set comprises stormwater structural BMP inlet samples, without any preceding structural stormwater controls. These data will be used for the characterization of MS4 stormwater runoff on commercial, industrial, and residential land uses. A total of six sites (two for each land use type) have been identified for stormwater BMP inlet monitoring. During each sampling event, three of the six sites, representing residential, industrial, and commercial land use will be sampled, and each land use type will be sampled a total of 15 times during the permit term.

The second component of the study design for this monitoring element is the monitoring at structural BMP outlet sites, which represent effluent concentrations of the BMP. These data will be used for the characterization of structural BMP effluent pollutant concentrations per structural BMP type and the paired data from inlet and outlet sites will be used to calculate removal efficiencies. Just as described for the stormwater structural BMP inlet sites, a total of six sites (two for each land use type) have been identified for structural BMP outlet monitoring. During each sampling event, three of the six, representing a residential, industrial, and commercial land use site will be sampled, and each land use type will be sampled a total of 15 times during the permit term.

Of note, Schedule B, Table 2 of the permit labels monitoring locations for the Stormwater and Structural BMP monitoring type as three sites, at inlet and outlet, and monitoring frequency as 15 total storm events/permit term per land use type. The City is interpreting "site" as a "land use" based structural BMP inlet site as well as a structural BMP outlet site. Additional monitoring sites for this monitoring element have been written into this monitoring plan because the City recognizes that there may be times that certain structural BMPs are undergoing maintenance activities, thus limiting the ability to perform sampling. Given that one of the objectives of this monitoring element is to characterize structural BMP effluent pollutant concentrations, it was concluded that having only 3 sites could jeopardize the City meeting this objective and would likely increase uncertainty in the data.

All six of the stormwater structural BMP influent and effluent locations are new locations and will be sampled for the first time this permit term.

Table 3: Stormwater Structural BMP-Inlet Monitoring Sites

Dominant Land Use	Residential	Residential	Industrial	Industrial	Commercial	Commercial
Site Identifier (database name)	Ptarmigan-In	Landau-In	22nd-In	Henningsen-In	Market-In	Edgewater-In
Asset # identifier	180210	34692	23969	29071	113667	16082/16208
BMP Facility #	19413	608	1301	8536	34773	223/298
BMP Type	Water Quality Swale	Infiltration Basin	Water Quality Planter	Water Quality Swale	Water Quality Swale	Raingarden
Number of Events	15 total events		15 total events		15 total events	
Watershed	Gibson	Pringle	Pringle	Mill	Claggett	Willamette
Receiving Stream	Gibson	West Middle Fork Pringle	East Fork Pringle	Mill Creek	Claggett	Willamette

Table 4: Stormwater Structural BMP-Outlet Monitoring Sites

Dominant Land Use	Residential	Residential	Industrial	Industrial	Commercial	Commercial
Site Identifier (database name)	Ptarmigan-Out	Landau-Out	22nd-Out	Henningsen-Out	Market-Out	Edgewater-Out
Asset # identifier	8309	34562	23979	(8536 exit to 16214)	113666	16121/16240
BMP Facility #	19413	608	1301	8536	34773	223/298
BMP Type	Water Quality Swale	Infiltration Basin	Water Quality Planter	Water Quality Swale	Water Quality Swale	Raingarden
Number of Events	15 total events		15 total events		15 total events	
Watershed	Gibson	Pringle	Pringle	Mill	Claggett	Willamette
Receiving Stream	Gibson	West Middle Fork Pringle	East Fork Pringle	Mill Creek	Claggett	Willamette

2.2.4.2 Frequency and Duration / Storm Selection Criteria

Stormwater structural BMP inlet and outlet monitoring will be conducted during fifteen storm events at each of the three land use site types (residential, commercial, and industrial) throughout the permit term. Storms of varying intensity and duration will be targeted. Each storm event will be chosen based on the following criteria:

- Storm event must produce more than 0.1 inch of rainfall.

- When possible, samples must be collected after an antecedent dry period of a minimum of 12 hours and less than 0.1" in the previous 24-hour period.
- Precautions will be taken to avoid the collection of samples lacking stormwater runoff, e.g. an intra-event dry period of a storm that exceeds 6 hours.

Although it is anticipated that fifteen samples from each of the three sites will be collected over the five-year permit term, unanticipated circumstances including, but not limited to, weather, personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues could prevent the collection of all the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures outlined in the MS4 permit.

2.2.4.3 Sample Collection Method

Sample collection methods will include a target of three time-based grab samples, and three time-based field measurements collected at six sites. Three of the sites will be at structural BMP inlets and three will be at the accompanied structural BMP outlets representing residential, commercial, and industrial land use types. The first of the grab samples and field measurements for inlet samples will be taken during the first three hours of the sampled storm event. If at the time of the first inlet samples being collected there is adequate flow to sample the outlet, the first outlet samples will be collected at that time. Sampling times from that point on will be based on the forecasted rain event, with the focus being to collect the following two inlet grab samples during times with expected increased flow rates (based on QPF data) into the BMP structure. If a forecast is calling for an extended storm event the inlet samples will be collected at a frequency of no more than one sample per hour. The structural BMP outlet grab samples and field measurements will be based on the expected hydraulic detention time for the specific BMP being sampled, noting that there may be a significant lag between the cessation of the inlet and outlet sampling. As time progresses, it is expected that staff will be able more accurately predict when adequate flow for outlet sampling will be occurring.

Once all stormwater inlet and outlet grab samples have been collected, the three samples for each site/land use type will be composited for laboratory analyses. Table 5 below details the parameters that will be analyzed for both the structural BMP inlet and outlet sites.

The one exception to the above paragraph is for E. coli samples. Due to the short hold time, a total of one E.coli grab sample will be collected for each structural BMP inlet and outlet site on the rising limb of the hydrograph. This strategy for E. coli sample collection matches how Salem has historically collected E. coli samples during storm events.

Rainfall Monitoring

The City of Salem has a rainfall monitoring system that is comprised of six rain gauges within Salem's jurisdictional limits that report in near real-time. These data are then uploaded to a city-managed website, hww.onerain.com. A dashboard for viewing these data and creating automated alerts has been developed to aid staff in the timing for the collection samples associated with this monitoring element.

Table 5: Structural BMP Inlet and Outlet Parameter List

Instream Storm Parameters	Collection Method
TSS	Grab (total of 3 time based then composited)
BOD ('stream')	Grab (total of 3 time based then composited)
Total Phosphorus	Grab (total of 3 time based then composited)
Ortho-Phosphorus	Grab (total of 3 time based then composited)
Nitrate+Nitrite as Nitrogen	Grab (total of 3 time based then composited)
Total Kjeldahl Nitrogen	Grab (total of 3 time based then composited)
Ammonia Nitrogen	Grab (total of 3 time based then composited)
Copper (Total Recoverable & Dissolved)	Grab (total of 3 time based then composited)
Lead (Total Recoverable & Dissolved)	Grab (total of 3 time based then composited)
Zinc (Total Recoverable & Dissolved)	Grab (total of 3 time based then composited)
Hardness	Grab (total of 3 time based then composited)
Specific Conductivity	In-Situ field measurement (total of 3 time based)
Dissolved Oxygen	In-Situ field measurement (total of 3 time based)
Temperature	In-Situ field measurement (total of 3 time based)
pH	In-Situ field measurement (total of 3 time based)
Turbidity	In-Situ field measurement (total of 3 time based)
E. coli	Grab (1 on rising limb only)
Total Mercury	Grab (total of 3 time based then composited)
Total Alkalinity	Grab (total of 3 time based then composited)
Dissolved Organic Carbon	Grab (total of 3 time based then composited)

2.2.5 Long-term Strategy

This monitoring element contributes to the long-term monitoring program strategy by providing data that characterizes the quality of MS4 discharges, both prior to and post-structural BMP controls, and supports long-term evaluation of the effectiveness of the City's SWMP. Datasets can be utilized for comparison between ACWA concentration values used for estimating total annual pollutant loads and TMDL benchmark analysis completed as part of the 2008 and 2015 permit renewal packages and future TMDL benchmark development. Thus, providing a gauge of the effectiveness of both structural and non-structural stormwater controls. Additionally, seasonal and geographic characterization will also be evaluated to help identify future stormwater control facility implementation priorities.

2.3 Pesticides

2.3.1 Project / Task Organization

Pesticide monitoring refers to the monitoring of MS4 stormwater runoff during defined storm criteria, as defined in section 2.0 above with a focus on fall and spring storm events. The City's Stormwater Monitoring Analyst(s) will serve as the RSC and Quality Assurance Officer for this monitoring element. The City's Stormwater Quality workgroup will perform sampling and Pacific Agricultural Laboratory will perform the analysis.

2.3.2 Monitoring Objectives

This monitoring element was developed with the understanding that data will help fill a data gap related to the characterization of stormwater pesticide pollutant concentrations, and aid in assessing the chemical and biological effects of MS4 discharges on receiving waterbodies.

Pesticide monitoring will contribute, at least in part, to monitoring objectives iii and v, as identified in Schedule B.1.a of the City of Salem's NPDES MS4 Permit.

2.3.3 Background

The City incorporated pesticide monitoring as a new stormwater monitoring element in its last permit cycle. A total of 188 different types of pesticides were analyzed at three different land use-based sites (residential, commercial, and industrial) during each sampling event. A total of six different storm events were sampled for pesticides between 2012 and 2018. Of these events, three were collected in the fall, and three were collected in the spring. Combining all events, a total of 13 individual pesticide types were identified. Independent of pesticide type and sampling event, a total of 47 pesticides were detected. Of the detected pesticides, 20 were present in spring samples and 27 were present in fall samples. The land use type breakdown of pesticides present in both spring and fall samples for residential, commercial, and industrial land uses were 13 (27.7%), 11 (23.4%), and 23 (48.9%), respectively.

2.3.4 Study Design / Sampling Process

2.3.4.1 Study Design

The study design for this monitoring element will be similar to the last permit term, with the most significant change being different pesticide types will be screened/analyzed for. The permit states the requirement of a total of 3 sites to be monitored during 4 total storm events/site. The three sites to be monitored will be the same three that were monitored last permit term, representing residential, commercial, and industrial land use types. See figure 1 for the location of each. There will be 2 sampling events taking place in the spring and two sampling events in the fall.

Pesticides to be Monitored

Schedule B. Table 2, Special Condition #5 specifies that the City must consider monitoring for a list of specified pesticides as well as any pesticides that are in use by the City within the MS4 jurisdictional area. Legacy pesticide monitoring (DDT, Dieldrin) must also be conducted for streams where an established TMDL requires it. The City has considered each of the permit specified pesticides and will monitor for them all, with the exception of 2,6-dichlorobenzamide (dichlobenil degradate). Multiple laboratories explained that analysis for this compound has little to no recovery in water, and that the limit of quantitation (LOQ) will be high and of minimal usefulness. For a complete list of pesticides that will be analyzed for see Table 6, below.

Table 6: Pesticide Analysis

Pesticide	Method	Reporting Limit (ug/L)	Pesticide Selection Rationale
Bifenthrin	EPA 8321B Modified	0.06	Permit Specified
Chlorpyrifos	EPA 8321B Modified	0.06	Permit Specified
Imidacloprid	EPA 8321B Modified	0.06	Permit Specified
Fipronil	EPA 8321B Modified	0.06	Permit Specified
Atrazine	EPA 8321B Modified	0.06	Permit Specified
Simazine	EPA 8321B Modified	0.06	Permit Specified
Sulfometuron Methyl	DuPont	0.008	Permit Specified
Diuron	EPA 8321B Modified	0.06	Permit Specified
2,4-D	EPA 8151A Modified	0.08	Permit Specified
Glyphosate & degradate (AMPA)	EPA 547 Modified	10	Permit Specified
DDT	EPA 8321B Modified	0.06	Permit Specified
Dieldren	EPA 8321B Modified	0.06	Permit Specified
Triclopyr	EPA 8151A Modified	0.08	City of Salem
Dithiopyr	EPA 8321B Modified	0.06	City of Salem
Dichlobenil	EPA 8321B Modified	0.06	City of Salem
Picloram	EPA 8151A Modified	0.08	City of Salem
Aminopyralid	EPA 8321B Modified	0.2	City of Salem
Chlorsulfuron	DuPont	0.008	City of Salem
Isoxaben	EPA 8321B Modified	0.06	City of Salem

2.3.4.2 Frequency and Duration / Storm Selection Criteria

For pesticide monitoring two storm events will be sampled in the spring and two storm events will be sampled in the fall for a total of 4 storm events per site for the permit term. Beyond the spring and fall criteria, each sampled storm event will be chosen based on the following criteria:

- Storm event must produce more than 0.1 inch of rainfall.
- When possible, samples must be collected after an antecedent dry period of a minimum of 12 hours and less than 0.1" in previous 24-hour period.
- Precautions for stormwater influent will be taken to avoid the collection of samples lacking stormwater runoff, e.g. an intra-event dry period of a storm that exceeds 6 hours.

2.3.4.3 Sample Collection Method

Sample collection methods will include grab samples after at least 0.1 inches of rainfall at the nearest rain gauge has been recorded, but no more than 6 hours after the start of the storm, i.e. the time since the first recorded rainfall occurred.

Rainfall Monitoring

The City of Salem has a rainfall monitoring system that is comprised of six rain gauges within Salem's jurisdictional limits that report in near real-time. These data are then uploaded to a city-managed website, hww.onerain.com . A dashboard for viewing these data and creating automated alerts has been developed to aid staff in the timing for the collection samples associated with this monitoring element.

2.3.5 Long Term Strategy

This monitoring element was first implemented during the last permit term, starting in June 2011 (when the City's monitoring plan was approved by DEQ), and it is expected that this element will continue beyond this permit term; ultimately providing a long-term dataset for time and spatial trends analyses.

This monitoring element supports the long-term monitoring program strategy by providing environmental data that will contribute to understanding pesticide discharges to receiving waterbodies from the MS4 system. Gaining this knowledge helps brings to light the necessity of always exploring new and innovative efforts toward controlling pesticides from entering the MS4 system to the maximum extent practicable.

3 Non-Storm Event Dependent Monitoring Elements

The City has three monitoring elements that do not require sample collection during storm events, and are intended to provide the City with the means to assess overall stream health and long-term trends. These include Continuous Instream, Monthly Instream, and Macroinvertebrate monitoring.

3.1 Continuous Instream

3.1.1 Project / Task Organization

Continuous Instream monitoring refers to the continuous monitoring of MS4 receiving streams at fixed sites (monitoring stations). The City's Stormwater Monitoring Analyst(s) will serve as the Responsible Sampling Coordinator. The City's Stormwater Quality monitoring workgroup will perform all operation/maintenance and quality assurance/quality control procedures.

3.1.2 Monitoring Objectives

Continuous Instream monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1.a of the City of Salem's NPDES MS4 Permit.

3.1.3 Background

Continuous Instream monitoring began in 2006 with a total of six stations, including two on Mill Creek, two on Pringle Creek, and two on Clark Creek. In 2007, three more stations were added, two on Glenn Creek, and one on Mill Creek. In 2008, two stations were added on Battle Creek. Due to concerns with data quality and maintenance, the furthest downstream station on Mill Creek, just before the creek flows into the Willamette River, was removed in 2012 and a new station was put in on Shelton Ditch. Also in 2012, two stage-only monitoring stations were added, one on Pringle Creek and one on the West Fork Little Pudding River. In 2014, the Shelton Ditch station was converted to record stage only during the replacement of the Winter St. bridge. 2018 saw the addition of another stage-only monitoring station on Waln Creek, and in 2019 another stage-only station was installed on Clark Creek.

3.1.4 Study Design / Sampling Process

3.1.4.1 Study Design

A total of fifteen continuous monitoring stations are installed on Battle Creek, Clark Creek, Glenn Creek, Mill Creek, Pringle Creek, Shelton Ditch, Waln Creek, and West Fork Little Pudding River. Stations are positioned in an upstream/downstream configuration. The exceptions to this

are Shelton Ditch, West Fork Little Pudding, and Waln Creek, which each have only one station. Additionally, Clark Creek and Pringle Creek each have a third station located between the upstream/downstream sites. The upstream sites are adjacent to where the stream enters the City, and the downstream sites are either above the confluence with another stream or where the stream exits the City's jurisdictional boundary. The positioning of these sites is identified in Figure 1 and described in Table 7. Schedule B, Table 2 of the permit requires a total of ten continuous monitoring stations that collect field parameters (labeled as water quality in the table below) including dissolved oxygen, pH, temperature, and specific conductivity, as well as stage/flow. Turbidity, while not a direct permit requirement, has and will continue to be monitored at the continuous water quality stations.

Table 7: Continuous Instream Monitoring Sites

Site ID & Database ID	Stream Location	Creek Name	Station Monitoring Type	Site Location
BAT3	Downstream	Battle Creek	Water Quality and Stage/Flow	Commercial St SE
BAT12	Upstream	Battle Creek	Water Quality and Stage/Flow	Lone Oak Rd SE
CLK1	Downstream	Clark Creek	Water Quality and Stage/Flow	Bush Park
CLK3	Middle	Clark Creek	Stage Only	Hoyt St SE
CLK12	Upstream	Clark Creek	Water Quality and Stage/Flow	Ewald St SE
GLE3	Downstream	Glenn Creek	Water Quality and Stage/Flow	Wallace Rd NW
GLE12	Upstream	Glenn Creek	Water Quality and Stage/Flow	Hidden Valley Dr NW
MIC3	Downstream	Mill Creek	Water Quality and Stage/Flow	North Salem High School
MIC12	Upstream	Mill Creek	Water Quality and Stage/Flow	Turner Rd SE
PRI3	Downstream	Pringle Creek	Water Quality and Stage/Flow	Pringle Park
PRI4	Middle	Pringle Creek	Stage Only	Salem Hospital
PRI12	Upstream	Pringle Creek	Water Quality and Stage/Flow	Trelstad Ave SE
SHE3	Downstream	Shelton Ditch	Stage/Flow	Winter St Bridge
LPW1	Downstream (at city limit)	West Fork Little Pudding River	Stage/Flow	Cordon Rd
WAL3	Middle	Waln Creek	Stage/Flow	Wiltsey Rd SE

All monitoring equipment was installed so that it collects a representative dataset within each stream that describes the ambient conditions during both storm and non-storm conditions. This study design allows for long-term, time-based, and spatial trends analyses.

Additionally, the continuous monitoring stations aid in the Illicit Discharge Detection and Elimination (IDDE) program by utilizing near real-time monitoring capabilities to detect parameter readings that fall outside of the normal range and therefore may be the result of an illicit discharge and the system then sends an alarm to response staff to investigate.

3.1.4.2 Frequency and Duration

The City's network of fifteen continuous monitoring stations runs 24 hours a day, 365 days a year, and collects and logs data every 15 minutes. Infrequent disruptions to data collection can result from station maintenance, power outages, or equipment failures, creating 'gaps' in the continuous data time series record.

3.1.4.3 Collection Method

Data are collected in situ using automated datasondes for the following water quality parameters: temperature, pH, dissolved oxygen, specific conductivity, and turbidity. Stage readings are also measured in situ using automated equipment. Data are sent from the field to a base station via radio or cell modem telemetry and stored in a database on the City's IT servers. Provisional flow measurements are also computed in real-time. Finalized flow measurements are computed by the Stormwater Monitoring Analyst(s) using proprietary rating curve software (Aquarius). Table 8 details each of the parameters and the sample collection method.

Table 8: Continuous Instream Parameter List and Collection Method

Continuous Instream Parameters	Collection Method
Temperature	In-situ with YSI datasonde
pH	In-situ with YSI datasonde
Dissolved Oxygen	In-situ with YSI datasonde
Specific Conductivity	In-situ with YSI datasonde
Turbidity	In-situ with YSI datasonde
Stage	In-situ with Campbell Scientific pressure transducer or YSI bubbler with Integrated Pressure Sensor

3.1.5 Long-Term Strategy

All monitoring sites for this element are at fixed locations that are either on City-owned property or located within City easements. This ensures that sites will continue to be operated and maintained for stream discharge and water quality monitoring into the future.

This monitoring element provides data that will support multiple long-term monitoring program strategies. Examples of the intended use of the data include: aiding and showing progress in the IDDE program (by use of station alarms); studying the impacts of hydromodification and strategies to address hydromodification (stream flow/stage data); continued evaluation of receiving stream status and 303(d) listings (water quality data); examining the cumulative effects (chemical, physical, and biological) of the City's MS4 stormwater runoff on receiving streams; and assessing progress towards meeting TMDL load reduction benchmarks.

3.2 Monthly Instream

3.2.1 Project / Task Organization

Monthly Instream refers to the monitoring of MS4-receiving streams, where sampling is to occur once a month on a schedule that is determined at the beginning of each calendar year. The City's Stormwater Monitoring Analyst(s) will serve as the Responsible Sampling Coordinator. The City's Stormwater Quality monitoring workgroup will collect all field measurements and grab samples. The City's Willow Lake Laboratory and Portland's Water Pollution Control Lab (WPCL) will perform all analytical laboratory analyses.

3.2.2 Monitoring Objectives

Monthly Instream monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1.a of the City of Salem's NPDES MS4 Permit.

3.2.3 Background

Monthly Instream monitoring began in 2001 with 21 sampling sites on local streams and all but one has remained at the same location. The exception is the upstream Battle Creek site which was moved in 2003 due to lack of access, and again in 2020 to correspond with the upstream Battle Creek continuous monitoring station location. Additionally, in July of 2013, the City added three sampling sites on the Willamette River, bringing the total number of sites to 24. The sampling sites are identified in Figure 1 and locations are described in Table 9 below.

3.2.4 Study Design / Sampling Process

3.2.4.1 Study Design

The study design for this monitoring element is a paired design, where samples are collected monthly at upstream and downstream sites on Battle Creek, Claggett Creek, Clark Creek, Croisan Creek, Gibson Creek, Glenn Creek, Mill Creek, Mill Race, Pringle Creek, and Shelton Ditch, as well as the Willamette River (there is a third, mid-way sampling point on the Willamette). The eleventh MS4 receiving stream, West Fork Little Pudding River, has only one monitoring site because it begins as a trickle outside of Salem city limits, and tends to run dry during the summer months, so an upstream site was not selected. Dates for sampling are determined at the beginning of each calendar year and are therefore independent of weather conditions.

Due to the number of sites needing to be collected in one day, a narrowed set of parameters were chosen for this monitoring element. When initiated in 2001, this monitoring element was intended to produce a dataset that could provide an index of stream quality, as well as data for spatial and trend analyses. During the last permit cycle, 303(d) and TMDL listed parameters were added to the study design. As a requirement of the current permit, total suspended solids (TSS) will also be monitored at all site locations. Refer to Table 10 for a list of parameters for all sites.

Table 9: Monthly Instream Monitoring Sites

Site ID	Creek Name	Site Location
BAT1	Battle Creek	Commercial St SE
BAT12	Battle Creek	Lone Oak Rd SE
CGT1	Claggett Creek	Mainline Dr NE
CGT5	Claggett Creek	Hawthorne St NE @ Hyacinth St NE
CLA1	Clark Creek	Bush Park
CLA10	Clark Creek	Ewald St SE
CRO1	Croisan Creek	Courthouse Athletic Club
CRO10	Croisan Creek	Ballantyne Rd S
GIB1	Gibson Creek	Wallace Rd NW
GIB15	Gibson Creek	Brush College Rd NW
GLE1	Glenn Creek	River Bend Rd NW
GLE10	Glenn Creek	Hidden Valley Dr NW
MIC1	Mill Creek	Front St Bridge
MIC10	Mill Creek	Turner Rd SE
MRA1	Mill Race	High St SE
MRA10	Mill Race	Mill Race Park
PRI1	Pringle Creek	Riverfront Park
PRI5	Pringle Creek	Bush Park
SHE1	Shelton Ditch	Church St SE
SHE10	Shelton Ditch	State Printing Office
LPW1	West Fork Little Pudding River	Cordon Rd NE
WR1	Willamette River	Sunset Park (Keizer)-River Mile 81
WR5	Willamette River	Railroad Bridge-River Mile 83
WR10	Willamette River	Halls Ferry-River Mile 91

3.2.4.2 Frequency and Duration

The sampling frequency will be once a month at all 24 sites as long as there is flow. Three of the sites (LPW1, CGT5, GLE10) typically run dry during the summer months, often resulting in fewer samples collected at these sites each year. Per Table B-2 in the City's NPDES MS4 permit, a minimum of 48 sample events, from each of the 24 sites, will be collected. However, Table B-2 Special Condition #8 states that the minimum number of sample events may be reduced to 30 if insufficient flow does not allow for sample collection.

In addition, personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues, including flooding and/or high flows and debris could prevent the collection of some of the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures listed in the MS4 permit.

3.2.4.3 Sample Collection Method

Sample collection will include grab samples and field measurements. For the 21 monitoring sites on streams (not including Willamette River sites), grab samples and field measurements will be collected directly from the stream where the water is well mixed and representative of the ambient conditions. For the three Willamette River monitoring sites, samples will be collected from within fifty feet of the bank of the Willamette River (west bank for upstream site,

east bank for the midway and downstream sites). The sample collection method for each parameter can be found in Table 10, below.

Table 10: Monthly Instream Parameter List and Collection Method

Monthly Instream Parameters	Collection Method	Site
BOD ('stream')	Grab Sample	All 24 sites
Nitrate-Nitrite (NO3-NO2)		
E. coli		
TSS		
Dissolved Oxygen	In-Situ	All 24 Sites
Temperature		
Specific Conductivity		
pH		
Turbidity		
Copper (Total & Dissolved)	Grab Sample	Pringle Creek and Clark Creek sites
Lead (Total & Dissolved)		
Zinc (Total & Dissolved)		
Hardness		
TDS	Grab Sample	Willamette Sites
TS		
Total Phosphorus		
Ammonia		
Alkalinity		

Note: BOD ('stream') analytical method is not identified in 40 CFR 136; however, this method has been identified as an acceptable method under schedule B.1.d.iii in the City's NPDES MS4 permit issued in 2010. Additionally, this parameter is not a current permit listed parameter; however, the City will continue to monitor this parameter to ensure the uninterrupted longevity of the data set.

3.2.5 Long-term Strategy

By providing the oldest continuous dataset of instream water quality data, the Monthly Instream monitoring element is essential to the long-term monitoring program strategy. Data collected through this monitoring element have been used (and will continue to be used) for long-term trending, spatial analysis, and seasonal differences.

3.3 Macroinvertebrate

3.3.1 Project / Task Organization

Macroinvertebrate monitoring will consist of the collection of benthic macroinvertebrates and physical habitat data on Clark Creek (in Gilmore Field), West Fork Pringle Creek (immediately downstream of Madrona Ave.), and mainstream Pringle Creek (upstream of the confluence of Shelton Ditch). All sampling site reaches are within the Pringle Creek Watershed. The City's Stormwater Monitoring Analyst will serve as the Responsible Sampling Coordinator. The City's Stormwater Quality monitoring workgroup will be responsible for the completion of this monitoring element.

3.3.2 Monitoring Objectives

Macroinvertebrate monitoring will contribute, at least in part, to monitoring objectives iv and v as identified in Schedule B.1.a of the City of Salem's NPDES MS4 Permit.

3.3.3 Background

Macroinvertebrate monitoring was a new monitoring element prescribed in the City's last permit (2010-2015), and it was designed to help the City assess the biological effects of MS4 discharges on receiving waters. The City had collected macroinvertebrate and physical habitat data within the Pringle Creek Watershed as part of a non-permit-related project in 2000 and 2001. With that data collection effort, the City followed a transect sampling approach for collecting benthic macroinvertebrate samples and the methodologies found in the Environmental Protection Agency's Environmental Monitoring and Assessment Program Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams (EMAPSW) for collecting physical habitat data. For the 2010-2015 permit term, the same methodologies were followed at three site reaches within the Pringle Creek watershed. The site reaches included Coats Lateral (also known as East Fork Pringle Creek) downstream of Trelstad Avenue, Clark Creek at Gilmore Field, and mainstem Pringle Creek immediately upstream of the confluence of Shelton Ditch. This was done so that the City could compare the data from the 2000-2001 macroinvertebrate and physical habitat study.

In addition to sampling the three sites within the Pringle Creek Watershed as part of the prescribed monitoring requirements of the last permit, the City also chose to perform sampling, following the same methodologies, at four additional sites on Waln and Battle Creeks within the old Battle Creek golf course. This sampling was conducted in the fall of 2011, before a large mitigation project that realigned the creek, added woody debris, replanted riparian areas within the reach, and added detention. The sampling effort assessed the type of habitat that existed prior to the construction of the mitigation project. In 2017 these sites were resampled with results very similar to the 2011 study, with total Benthic Index of Biological Integrity (BIBI) scores in the mid 20's, indicating low biological integrity overall. Since that time, beaver activity and the encroachment of reed canary grass in Waln Creek have altered channel conditions to the point where macroinvertebrate sampling would not be practical at this time. Rehabilitation efforts are currently in process and the City intends to complete follow-up sampling at these sites in the future.

3.3.4 Study Design / Sampling Process

3.3.4.1 Study Design

The study design for this monitoring element is a transect sampling approach, where macroinvertebrates and physical habitat data will be collected at two of the three site reaches in the Pringle watershed that have been sampled repeatedly since the year 2000. The third site reach is a new site on the Middle Fork Pringle Creek that is currently listed on the 303d list as Category 5 for Biocriteria. This study design intends to continue the collection of data on benthic macroinvertebrate communities and physical habitat characteristics at the two existing site reaches on lower Pringle and Clark Creeks and begin collection on the impaired Middle Fork Pringle site reach. The data collected at the existing sites can be compared to historical data to look for trends in improving or decreasing biological integrity, while data collected at Middle Fork Pringle will begin building a dataset to establish baseline biological integrity levels within the stream reach.

3.3.4.2 Frequency and Duration

Macroinvertebrate sample collection will be completed twice during the permit term for a total of two samples per site. Sampling collection will occur during the in-water work period.

3.3.4.3 Sample Collection Method

The City will follow Oregon Department of Environmental Quality's Water Monitoring and Assessment Mode of Operations Manual (MOMs) (June 2010) transect sampling approach for collecting benthic macroinvertebrate samples and the methodologies found in the Environmental Protection Agency's Environmental Monitoring and Assessment Program - Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams (EMAP-SW) for collecting physical habitat data. Both protocols require the collection of data at evenly spaced transects within the sampling reach. Since the Clark Creek and mainstem Pringle Creek sites were sampled during the previous permit term, permanent transects for sampling have been established. Permanent transects will also be established for the Middle Fork Pringle Creek site reach.

Oregon DEQ MOMs and EMAP-SW protocols specify that the length of the sampling reach is forty times the average wetted width of the channel or a minimum of 150 meters long when the average wetted width is less than four meters. Two of the sites, Middle Fork Pringle Creek and Clark Creek, have an average wetted width of fewer than four meters, therefore will have reach lengths of 150 meters. Whereas the average wetted width of the mainstem Pringle Creek site reach is approximately 7.31 meters, thus the total site reach length is 292.5 meters.

3.3.5 Quality Criteria

3.3.5.1 Comparability

Targeted sampling at the same time of year at permanently established transects while using the same previously used methodologies will reduce the potential for spatial and temporal sample variation while increasing the comparability of data in the long term.

3.3.6 Quality Assurance / Quality Control / Record Keeping

3.3.6.1 Duplicate Samples

Field and laboratory duplicates will be collected for 10% of all samples.

3.3.6.2 Handling / Custody Procedures

All samples will be preserved in the field using a 70-95% ethanol concentration and labeled with sample collection information. This information will also be documented in pencil on waterproof paper and placed inside the preserved sample jar. If the sample is not immediately sent off to the lab for identification, the preservative will be replaced with fresh solution within one week of sample collection. Chain of custody forms will be completed for each sampling event.

3.3.6.3 Documentation and Records

Field sheets documenting the site, date, and sampling personnel will be completed for each macroinvertebrate sampling event. This information will be combined with a set of additional field sheets designed to document the associated physical habitat data. It is the responsibility of the Responsible Sampling Coordinator to ensure that these documents are correctly completed for each sampling event.

3.3.6.4 Data Management

All field documents and data received from the laboratory will be kept as paper and electronic copies.

3.3.6.5 Data Validation and Verification

Macroinvertebrate samples will be preserved in the field, with sorting and identification conducted by a qualified taxonomist (past efforts used Aquatic Biology Associates and effort will be made to continue using this company). Identification of organisms will be performed following the Oregon DEQ Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams.

3.3.7 Long-term Strategy

The macroinvertebrate monitoring completed during this permit term will provide a measure of the biological conditions at targeted sites within the Pringle Creek Watershed. These data can be compared with past data collected from the Pringle and Clark creek sites, while the collection of data at the Middle Fork Pringle site will establish baseline biological integrity scores for that site reach. These data will inform the City's adaptive management practices and future data collected at these sites will provide a long-term assessment of changes in macroinvertebrate communities and help to evaluate the overall effectiveness of the City's SWMP. Performing macroinvertebrate monitoring at the same sites during subsequent permit cycles, if feasible, will continue to be a key element of the long-term monitoring program strategy.

4 Data Quality and Documentation for Water Quality Monitoring Elements

As described in the introduction, the intent of this monitoring plan is that all environmental data collected will be used to support adaptive management of the stormwater monitoring program, as well as demonstrate the effectiveness of structural and non-structural BMPs in reducing the discharge of pollutants to MS4 receiving streams. This section documents the analytical methods, quality control procedures, data management, and documentation and record-keeping procedures for both field and laboratory data for all water quality monitoring elements found under this plan (Instream Storm, Stormwater and Structural BMP, Pesticides, Continuous Instream, and Monthly Instream).

All relevant data quality objectives for macroinvertebrate sampling are found under that specific section, 3.3.

General data quality objectives are that the data are representative of known precision and accuracy, will withstand scientific scrutiny, and are generated using approved sampling techniques, handling procedures, standardized calibration and maintenance of field equipment and instrumentation.

4.1 Data Quality Objectives

4.1.1 Field Measurement Data Quality Objectives

The minimum data quality objectives and analytical methods for field measurements for Instream Storm, Stormwater and Structural BMP, and Monthly Instream along with Continuous Instream monitoring elements are detailed in Table 11 below.

Table 11: Field Measurement Data Quality Objectives

Field Parameters	Accuracy	Precision	Analytical Methods
Temperature	± 0.5 °C	± 0.5 °C	NIST Traceable/Standard Method 2550
pH	± 0.2 SU	± 0.3 SU	Standard Method 4500 H+
Specific Conductivity	± 7% of standard value	± 10% of standard value	Standard Method 2510A
Dissolved Oxygen	± 0.2 mg/L	± 0.3 mg/L	ASTM Method D888-09 (C)
Turbidity	± 5%	± 5%	ATSM Method D7315-07a

4.1.1.1 Instrument Calibration / Inspection / Maintenance

Instruments will be inspected and calibrated prior to each sampling event. Instrument calibration, inspection, and maintenance procedures are all documented in the City's "Stormwater and Instream (Storm Only) Monitoring Standard Operating Procedures" (2022).

4.1.2 Duplicate and Blank Samples

Duplicates will be taken for a minimum of ten percent of the total number of grab samples and field measurements. Blank samples will be run at a minimum rate of ten percent of the total number of grab samples analyzed for total recoverable mercury. Portable mechanical samplers will also have blank samples performed at a rate of ten percent of all samples collected.

4.1.3 Sample Handling and Chain of Custody Procedures for Grab and Composite Samples

Grab samples will be collected using a sterilized beaker, transferred to appropriate bottles, and transported to Willow Lake Laboratory to be processed within their hold times. As soon as the portable mechanical samplers have completed their programs, the flow-weighted composite samples will be taken to Willow Lake Laboratory or put on ice and shipped to Portland's WPCL Laboratory. All grab and composite samples will have a chain of custody form associated with them.

4.1.4 Analytical Procedures – Laboratory

All grab and composite samples for the Instream Storm, Stormwater and Structural BMP and Monthly Instream programs will utilize the same handling requirements and laboratory procedures. Analytical methods for composite and grab samples analyzed at Willow Lake Laboratory and Portland WPCL are identified in 40 CFR 136 or otherwise identified in Schedule B.1.d.iii of the NPDES MS4 permit. Table 12 below shows the analytical method for each parameter, hold time, collection container, and reporting limit (Limit of Quantification).

Table 12: Laboratory Analytical Information for Water Quality Samples

Parameter	Analytical Method	Hold Time	Collection Container	Reporting Limit	Lab
E. coli	SM9223B	6 hours	Plastic sterile specimen cup	1 (MPN/100mL)	Willow Lake
Total Alkalinity	SM2320B	14 days	Plastic	5 (mg/l)	Willow Lake
Total Suspended Solids (TSS)	SM2540D	7 days	Plastic	0.2 (mg/l)	Willow Lake
Total Kjeldahl Nitrogen (TKN)	SM4500N-B	48 hours	Plastic	1 (mg/l)	Willow Lake
Nitrate-Nitrite (NO3-NO2)	SM4500NO3-F	48 hours (28 days if acidified)	Plastic	0.05 (mg/l)	Willow Lake
Ammonia Nitrogen (NH3-N)	SM4500NH3-D	7 days	Plastic	0.05 (mg/l)	Willow Lake
Total Phosphorus (TP)	SM4500PO4-BE	28 days	Plastic	0.01 (mg/l)	Willow Lake
Ortho-Phosphorus (O-PO4)	SM4500PO4-E	48 hours	Plastic	0.01 (mg/l)	Willow Lake
BOD ('stream' and 5 day)	SM5210B	24 hours	Plastic	2 (mg/l)	Willow Lake
Hardness	SM2340B	6 months	Plastic (acid rinsed)	0.253 (mg/l)	WPCL
Dissolved Organic Carbon (DOC)	5310B	7 days	Plastic (acid rinsed)	1 (mg/l)	WPCL
Total Copper	EPA 200.8	6 months	Plastic (acid rinsed)	0.000222 (mg/l)	WPCL
Dissolved Copper	EPA 200.8	6 months	Plastic (acid rinsed)	0.000212 (mg/l)	WPCL
Total Lead	EPA 200.8	6 months	Plastic (acid rinsed)	0.000111 (mg/l)	WPCL
Dissolved Lead	EPA 200.8	6 months	Plastic (acid rinsed)	0.000106 (mg/l)	WPCL
Total Zinc	EPA 200.8	6 months	Plastic (acid rinsed)	0.000556 (mg/l)	WPCL
Dissolved Zinc	EPA 200.8	6 months	Plastic (acid rinsed)	0.00053 (mg/l)	WPCL
Total Mercury	US EPA 1631E	90 days	Plastic	0.5 (ng/L)	ALS

4.1.5 Comparability

Field measurements, grab samples, and composite samples will utilize the same handling requirements and laboratory procedures for all water quality sampling monitoring elements.

All field measurements will utilize the same YSI sensors, following the same quality assurance and quality control protocols. Additionally, the recording of all field measurements are done in-situ, or when necessary, by immersing the sensors within a represented sample immediately after sample collection. This uniformity increases the validity of the data for analyses and comparison with other data collected within the scope of this plan.

Rainfall Monitoring

The City of Salem has a rainfall monitoring system that is comprised of six rain gauges within Salem's jurisdictional limits that report in near real-time. These data are then uploaded to a city-managed website, hww.onerain.com. A dashboard for viewing these data and creating automated alerts has been developed to aid staff in the timing for the collection samples associated with Instream Storm, Stormwater and Structural BMP, and Pesticide monitoring elements. Rainfall data is also imported into the City's Aquarius database where it can easily be analyzed for antecedent conditions and rainfall intensities, thus supporting mining of water quality data to help answer more specific questions.

4.2 Record Keeping and Data Management

4.2.1 Documentation and Records

A field data sheet will be completed for each monitoring element and each monitoring event. Information to be recorded on these field data sheets includes project name, sampler's name, date and time of sample collection, site ID, field measurement results for temperature, pH, dissolved oxygen, turbidity, and specific conductivity, and check boxes to verify all necessary grab samples were collected and record the time of sample collection.

4.2.2 Data Management

The sampling team is responsible for the completion of the field data sheet. Willow Lake Laboratory and Portland WPCL will provide laboratory results, which will be stored in their respective LIMS databases, as well as duplicated in the City of Salem's Aquarius Database. Field measurement data will also be entered into the Aquarius database.

4.2.3 Data Validation and Verification

The Responsible Sampling Coordinator will complete a review of all information on field data sheets. Once the data have been entered into the database, the Responsible Sampling Coordinator or other monitoring staff will compare the data in the database to the field sheets, and then have a second person do the same. Errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review. It is the responsibility of the Responsible Sampling Coordinator to investigate further and determine the validity of the data. Data quality issues will be addressed as they occur and will be identified in any dataset that is distributed to City staff and the public.

4.2.4 Pollutant Parameter Action Levels

The City has developed pollutant parameter action levels to evaluate water quality data collected in accordance with this plan. With the exception of E. coli, Total Mercury, and pH action levels represent the average of 95th and 99th percentile of all "wet weather" instream and stormwater data. "Wet weather" instream data is defined as data collection occurring within 24 hours of a storm event. Total Mercury action level represents the 95th percentile of data. E coli action level represents the 99th percentile.

The Quality Assurance Officer will be responsible for reviewing the data and identifying any parameters that exceeded the pollutant parameter action levels identified in Table 13 below. When an action level is exceeded, staff will begin investigating potential sources within 48 hours of becoming aware of the exceedance. Investigations may include reconnaissance of the catchment area for possible sources of the pollutant and/or the collection of additional samples of the piped conveyance system and of the receiving waterbody.

Furthermore, if it is determined that the source is coming from the City's MS4 system and is contributing to the exceedance of a water quality standard as established in OAR 340-041, the City will implement the corrective actions identified in Schedule A.1.b of the permit.

Table 13: Pollutant Parameter Action Levels

Parameter	Action Levels	Measurement Unit
E. coli	8000	MPN/100 mL
Ammonia Nitrogen (NH3-N)	0.31	mg/L
Total Phosphorus (TP)	0.91	mg/L
Dissolved Copper	0.013	mg/L
Dissolved Lead	0.0014	mg/L
Dissolved Zinc	0.36	mg/L
Total Mercury	35	ng/L
pH	5.5-8.5	pH units

5 Data Analysis

5.1 Questions

To address the permit monitoring objectives found under Schedule B.1.a. in the permit (or section 1.2 in this Plan), the City has developed a number of questions to answer with the data that are collected through this monitoring plan. Table 14 below provides these questions and the monitoring elements that will be used to answer the questions.

Table 14: Questions to be Answered with the Data

Question to Answer with the Data	Monitoring Element(s) Used to Answer the Question
What are the typical pollutant concentrations found in receiving water bodies during storm events?	Instream Storm, Monthly Instream
What are the typical pollutant concentrations found in receiving water bodies during non-storm events?	Monthly Instream, Continuous Instream
Are instream pollutant concentrations changing over time during storm events?	Instream Storm, Monthly Instream, Continuous Instream
Are instream pollutant concentrations changing over time during non-storm events?	Monthly instream, Continuous Instream
What are the typical pollutant concentrations of stormwater MS4 discharges based on land use, and how do those compare against past OR ACWA studies?	Stormwater and Structural BMP, Pesticide
What are the typical structural BMP effluent pollutant concentrations and how do these data compare with other studies?	Stormwater and Structural BMP
Can non-structural BMPs be implemented in a manner that shows a statistically significant difference in pollutant parameter concentrations during storm events?	Instream Storm, Stormwater and Structural BMP
Are stormwater MS4 discharges affecting biological communities?	Macroinvertebrate, Continuous Instream

5.2 Methodology and Rationale

Annual Report

Once data have been processed and validated, they will be categorized to account for variables such as rainfall, stream levels, and seasonality. Once this is done, basic summary statistics both in tabular and graphical form will be provided for each type of monitoring data. A narrative explaining the findings will accompany all graphical descriptions and tables. If additional analysis is completed within the reporting year, a report of the methodology and results of the analysis will be produced. This information will be included in an annual report that will be submitted by November 1st of each year.

The rationale for producing the tabular, graphical, and associated narrative for all data collected within the report is that it allows for an easy visual comparison of the data from year to year. For example, if a significant change was to occur from one year to the next that led to a noticeable increase in a pollutant, the source/cause of the increase can be investigated prior to the next wet weather (sampling) season.

Permit Renewal

Prior to the submittal of the permit renewal application, the data collected from implementing this monitoring plan will be used for statistical hypothesis testing.

For the water quality data collected via the monitoring elements explained within this plan, the statistical hypothesis testing analyses preformed will look for temporal trends and spatial observations. Temporal trends analysis will test if the water quality parameters change with time. The Seasonal Kendal test will be used for the temporal trends analysis. The rational for using the Season Kendal test is that these data tend to exhibit strong seasonal patterns, and this non-parametric test is able to account for this variability in the data. The spatial observations analysis will be used to better understand the influence of City discharges on receiving stream water quality. For spatial trends the City will use the Mann-Whitney rank sum test. The rational for using this non-parametric test is that the city has paired most of its monitoring in an upstream/downstream configuration. Furthermore, this test does not require assumptions or knowledge about the underlying probability distributions of the data.

Additional analyses looking at BMP effluent concentrations and removal efficiencies, impacts of programmatic (non-structural BMPs), B-IBI scoring comparisons, and habitat changes within macroinvertebrate sampling reaches will also be analyzed and document prior to the permit renewal application.

It is the goal that by answering the questions in Table 14 and fulfilling all the data collection and analyses outlined in this plan, the City can utilize these data to make informed decisions on future changes to the City's SWMP Document.

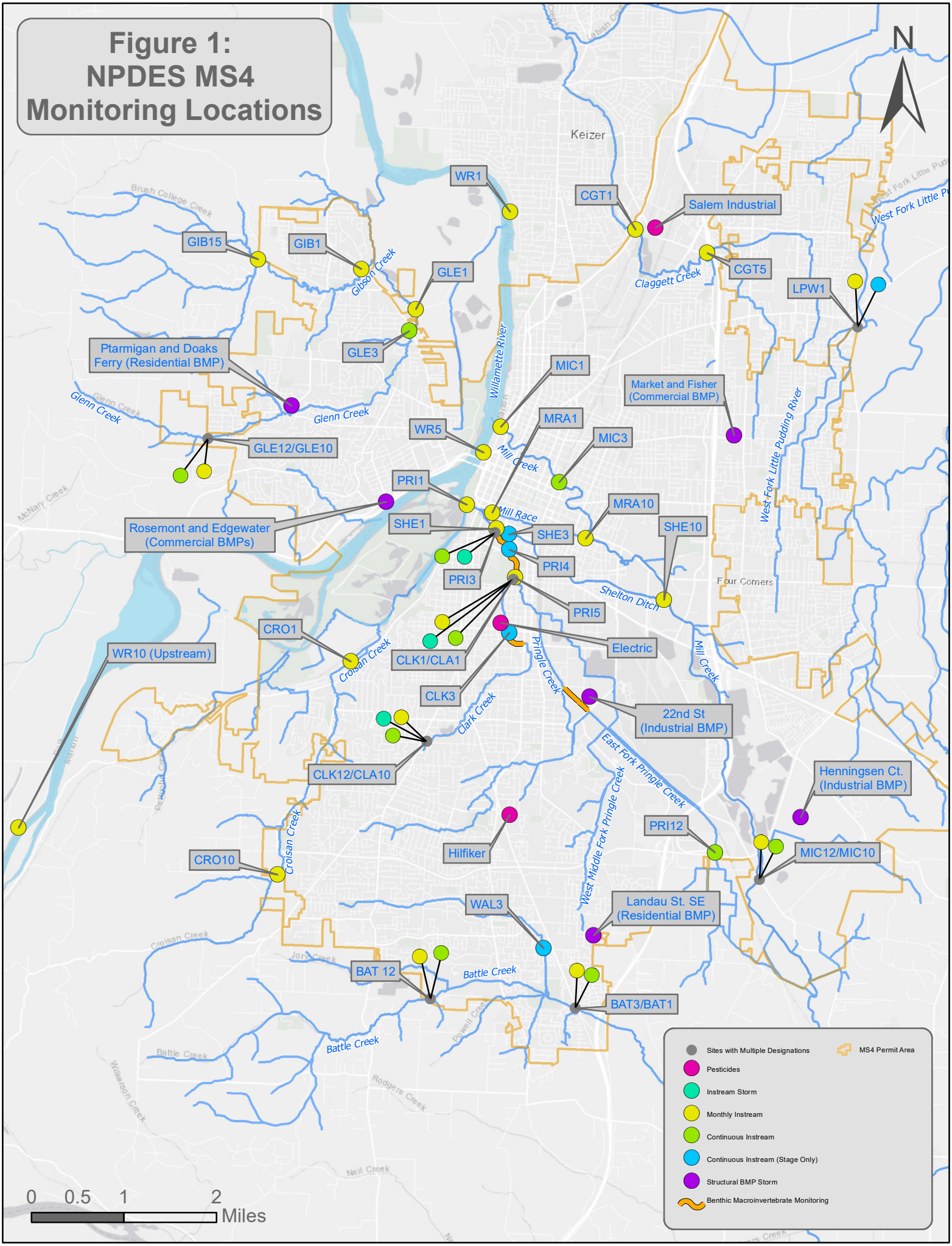
Figure 1:
NPDES MS4
Monitoring Locations
N
Keizer
WR1
CGT1
Salem Industrial
GIB15
GIB1
Gibson Creek
GLE1
Claggett Creek
CGT5
LPW1
West Fork Little Pudding River
Ptarmigan and Doaks
Ferry (Residential BMP)
GLE3
Willamette River
MIC1
Market and Fisher
(Commercial BMP)
Glenn Creek
MRA1
WR5
MIC3
GLE12/GLE10
Mill Creek
PRI1
MRA10
Mill Race
SHE1
SHE3
SHE10
Rosemont and Edgewater
(Commercial BMPs)
PRI4
PRI3
Four Corners
Shelton Ditch
PRI5
CRO1
Croisan Creek
Electric
WR10 (Upstream)
CLK1/CLA1
Pringle Creek
Mill Creek
CLK3
Clark Creek
22nd St
(Industrial BMP)
East Fork Pringle Creek
CLK12/CLA10
Henningsen Ct.
(Industrial BMP)
PRI12
Hilfiker
CRO10
West Middle Fork Pringle Creek
MIC12/MIC10
WAL3
Landau St. SE
(Residential BMP)
BAT 12
Battle Creek
BAT3/BAT1
Sites with Multiple Designations
MS4 Permit Area
Pesticides
Instream Storm
Monthly Instream
Continuous Instream
Continuous Instream (Stage Only)
Structural BMP Storm
Benthic Macroinvertebrate Monitoring
0 0.5 1 2
Miles