City of Portland, Oregon

Water Pollution Control Facilities (WPCF) Permit for
Class V Stormwater Underground Injection Control Systems

Permit Number: 102830

Annual Stormwater Discharge Monitoring Report
Year 10 – October 2014 - May 2015

Underground Injection Control Systems
System Monitoring

November 2015

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List of Acronyms

BES	City of Portland, Bureau of Environmental Services
BMP	best management practice
City	City of Portland
C	Celsius
COC	chain-of-custody
DEHP	di(2-ethylhexyl)phthalate or bis(2-ethylhexyl)phthalate
DEQ	Oregon Department of Environmental Quality
DFR	daily field report
DQO	data quality objective
EOP	end-of-pipe
EPA	U.S. Environmental Protection Agency
FDS	field data sheet
GIS	geographic information systems
GRTS	Generalized Random Tessellation Stratified
HYDRA	Hydrological Data Retrieval and Alarm System
IMS	BES Investigation and Monitoring Services
LIMS	BES Laboratory Information Management System
MADL	maximum allowable discharge limit
MDL	method detection limit
mg/L	milligrams per liter
MRL	method reporting limit
MS/MSD	matrix spikes and matrix spike duplicates
µmhos/cm	micromhos per centimeter
µg/L	micrograms per liter
OAR	Oregon Administrative Rule
PAH	polycyclic aromatic hydrocarbon
PAL	Pacific Agricultural Laboratory
PPS	priority pollutant screen
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
ROW	right(s)-of-way
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SDMP	Stormwater Discharge Monitoring Plan
SOP	Standard Operating Procedures

List of Acronyms (continued)

SVOC	semivolatile organic compound
TA	Test America
TPD	trips per day
TSS	total suspended solids
UIC	underground injection control
UICMP	UIC Management Plan
VOC	volatile organic compound
WQDB	Water Quality Database
WPCF	Water Pollution Control Facilities
WPCL	Water Pollution Control Laboratory

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Executive Summary

The annual *Stormwater Discharge Monitoring* report is required by the Water Pollution Control Facilities (WPCF) permit issued to the City of Portland (City) in June 2005 by the Oregon Department of Environmental Quality (DEQ). The City is required to monitor stormwater entering City-owned Underground Injection Control (UIC) systems throughout the life of the permit and to submit this annual monitoring report.

During Permit Years 7 and 8 two permit modifications were issued by DEQ that impacted monitoring for the remainder of the permit term.

- Permit Modification No. 3 dated April 19, 2012:
  - Reduced storm events from five to three
  - Moved benzene, toluene, ethylbenzene, and xylenes (BTEX) from the common pollutant list to the priority pollutant screen (PPS)
- Permit Modification No. 4 dated December 6, 2012:
  - Increased Maximum Allowable Discharge Limits (MADL) by 10 times the original MADL to 10 µg/L for pentachlorophenol (PCP), 60 µg/L for di(2-ethylhexyl)phthalate (DEHP), 2 µg/L for benzo(a)pyrene (B[a]P), and 500 µg/L for total lead (Pb). For these constituents, all comparisons to MADLs in this Year 10 report refer to the Permit Modification No. 4 approved MADLs.

Year 10 Monitoring Program: The City's UIC monitoring program was implemented in accordance with the permit modifications listed above, and the *Stormwater Discharge Monitoring Plan* (SDMP), Version 2 (City of Portland, December 2012). The monitoring program was designed to be representative of the estimated 9,000 City-owned UICs using a statistically robust method to identify a subset of UICs for monitoring. Thirty UIC locations (*i.e.*, Panels 5 and 6) were sampled in Year 10, and are described in the SDMP Version 2. Panel 5 was also sampled in Permit Year 5. Panel 6 was also sampled in Years 1 through 7.

UIC monitoring locations were selected on the basis of two traffic flow categories: <1,000 trips per day (TPD) and ≥1,000 TPD. Year 10 locations included 15 UIC locations in the <1,000 TPD category and 15 locations in the ≥1,000 TPD category.

Year 10 Results: Sampling events were completed during the specified wet season, October 1, 2014 through May 31, 2015. Stormwater discharge samples were analyzed for common pollutant analytes (*e.g.,* PCP, DEHP, and B[a]P), and for PPS analytes (*e.g.*, BTEX and pesticides) as defined by the permit. These pollutants are specifically named in the Permit. Additional "ancillary pollutants" are reported if they are detected in the U.S. Environmental Protection Agency (EPA) test methods for the common pollutants. Year 10 field and laboratory data collected met the SDMP data quality objectives.

All nine common pollutants and 10 PPS analytes were detected in Year 10. Twenty-nine ancillary pollutants were generally detected at low concentrations. The five ancillary

pollutants detected at the highest frequencies (>50%) during all individual sampling events are polycyclic aromatic hydrocarbons (PAHs). PAHs are expected in urban rights-of-way. Generally sources include fresh and used petroleum products associated with motor vehicle combustion, exhaust, and wear and tear; and also include other sources such as wood preservatives and cigarette filters.

Maximum Allowable Discharge Limit (MADL) Exceedances: No common pollutants were detected in Year 10 at concentrations above their MADLs. One PPS analyte, benzene, was detected at a concentration of 5.68 ug/L (which is above the MADL of 5 ug/L) at one UIC location (P6_8) during Event 3. Benzene was not detected at this location upon resampling, nor was it detected during Events 1 and 2.

Annual Geometric Mean Concentrations: Annual geometric means are calculated when pollutants are detected at a concentration greater than 50 percent of their MADLs. Annual geometric mean concentrations were calculated for benzene and total zinc in Year 10 (the maximum total zinc concentration was 2,600 ug/L; the MADL is 5,000 ug/L). Both geometric mean concentrations were less than 50 percent of their respective MADLs.

Preliminary Trend Analysis: The following general observations were made for PCP, DEHP, B[a]P, lead, chromium, and arsenic, which were previously detected at greater than 50 percent of the MADL prior to Permit Modification No. 4, by comparing the two years in which Panels 5 and 6 were sampled (Years 5 and 10):

- Concentration ranges and distributions are very similar between the two permit years in which Panel 5 and 6 locations were sampled.
- All annual geometric mean concentrations of the evaluated compounds are <50 percent of their respective MADLs for both years.
- The >1,000 TPD traffic category has a slightly higher geometric mean and median concentrations than the <1,000 TPD category for the evaluated compounds.
- A change in detection limit for DEHP during Year 10 gives the appearance that concentrations are more variable, even though differences between the two monitoring years are minor.

Year 10 Response Actions: Source investigations are conducted when new data are inconsistent with previous results or observations. A source investigation was initiated at one UIC location because of the single MADL exceedance for benzene (noted previously). In follow-up to this exceedance, the location was visually inspected and resampled. The inspection did not identify a cause of the exceedance. The result of the re-sample was non-detect.

Category 4 UICs: No new Category 4 UICs were identified in Year 10. A total of seventeen locations have been identified as Category 4 UICs based on sampling results throughout the permit term. The corrective action for each of these UICs was a groundwater protectiveness demonstration.

Additional Monitoring: In Year 10, no UIC locations had geometric means that exceeded the MADL for any pollutant.

Permit compliance is demonstrated in this report by documenting that Year 10 sampling, analyses, data evaluation, and response actions are performed in accordance with the City's Permit, SDMP Version 2, and UICMP (December 2006).

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Section 1

1 Introduction and Organization

1.1 Purpose

This *Annual Stormwater Discharge Monitoring Report* presents the results of the City of Portland's (City) tenth year of stormwater sampling, conducted between October 1, 2014 and May 31, 2015, under Version 2 of the *Stormwater Discharge Monitoring Plan* (SDMP) (City of Portland, 2012a). This report is a requirement of the Water Pollution Control Facilities (WPCF) permit (number 102830) issued to the City in June 2005 by the Oregon Department of Environmental Quality (DEQ). The permit requires the City to monitor stormwater entering City-owned or operated (i.e., public) underground injection control (UIC) structures throughout the life of the permit (10 years, or permit term) and to submit annual monitoring reports. This is the final annual monitoring report required under the June 2005 permit. In this report, the terms "WPCF permit" or "permit" refer to the 2005 permit.

Underground Injection Control

UIC, as used in this document, means any Class V underground stormwater control system owned or operated by the City of Portland.

This report includes:

- Sampling data collected during three sampling events in Year 10[1]
- Descriptive information for the UICs sampled (e.g., location, surrounding land use)
- Description of the individual storms constituting each sampling event
- Identification of maximum allowable discharge limit (MADL) concentration exceedances
- Identification and discussion of common pollutants, priority pollutant screen (PPS) pollutants, and ancillary pollutants detected
- Discussion of Year 10 response actions

1.2 Background

The City currently has an estimated 9,000 Class V UICs, which collect stormwater from public rights-of-way (ROW) and discharge it to the subsurface. UICs are an essential element of the City's comprehensive watershed strategy to use stormwater as a resource by infiltrating it back into the ground.

[1] Sampling three storm events represents a change from the first seven years of stormwater discharge monitoring, when five storm events were sampled. On April 19, 2012, DEQ approved a major permit modification authorizing the City to reduce sampling to three storm events. Section 2.1.2 provides more information about the statistical analysis used to identify this change.

In the Portland area, groundwater serves as a backup drinking water supply to the Bull Run reservoirs. State regulations require that groundwaters of the state be protected from pollution that could impair existing or potential beneficial uses for which the natural water quality of the groundwater is adequate and maintain the existing high quality of groundwater to support those beneficial uses, including domestic water supply (Oregon Administrative Rule [OAR] 340-040-0020(3)). The WPCF permit establishes the UIC construction, operation, and maintenance requirements the City must implement to protect groundwater for use as a drinking water resource. The permit is designed to protect groundwater by implementing a comprehensive stormwater management strategy to prevent, minimize, and control pollutants at the surface before stormwater is discharged into the ground.

Version 2 of the SDMP (December 2012a) was used to direct Year 10 sampling. It consists of the *Sampling and Analysis Plan* (SAP) and the *Quality Assurance Project Plan* (QAPP). Adherence to the SAP and QAPP ensures that the stormwater data collected are of known and acceptable quality and can be used to demonstrate permit compliance. The City submitted the SDMP Version 2 to DEQ in January 2013. Much of the background information in this report is summarized from that document.

1.3 Permit Requirements and Monitoring Program Goals and Objectives

As designated in a July 2011 WPCF permit action letter from DEQ, the City must submit to DEQ by November 1 of each permit year an annual stormwater discharge monitoring report that contains specific monitoring and reporting requirements. Table 1-1 identifies those requirements and where they are met in this annual report. This report documents that Year 10 sampling, analyses, and data evaluation were conducted in accordance with the WPCF permit and SDMP (e.g., in accordance with EPA- approved sample design) and that results are statistically representative of the City's UIC system.

The permit also requires the City to submit a *UIC Management Plan* (UICMP) annual report by November 1 of each year. Information presented in the annual UICMP report supplements this monitoring report by:

- Identifying traffic or land use changes, if any, that may impact sampling protocols or the sampling network.
- Presenting programmatic activities and best management practices (BMPs) performed to prevent, minimize, and control pollutants.
- Presenting corrective actions performed to correct UICs that have been identified as non-compliant.

1.3.1 Monitoring Program Goals

The primary goals of the City's UIC monitoring program relate to complying with the WPCF permit and fulfilling the City Bureau of Environmental Services' (BES) mission.[2] The goals are to:

- Demonstrate that the quality of stormwater discharged into City-owned UICs meets permit conditions and that it is protective of groundwater quality (i.e., protects beneficial uses).
- Produce results that can be used to ensure that UICs are constructed and operated in a manner that protects groundwater and provides multiple watershed benefits.

UICs are an essential element of a comprehensive watershed strategy to use stormwater as a resource by infiltrating it back into the ground to help restore normative hydrology. Demonstrating permit compliance is important to the City to ensure that UICs continue to help achieve BES's mission.

1.3.2 Monitoring Program Objectives

The UIC monitoring program was designed to satisfy the following specific objectives, which are described in more detail in the SDMP:

- Monitor the quality of stormwater discharged into public UICs and demonstrate that groundwater is protected by meeting MADLs established in the WPCF permit (DEQ, 2005, Table 1) and subsequent DEQ-approved permit modifications.
- Provide a high degree of confidence that the sampling design used for this program is representative of all UICs covered by the permit.
- Provide data that will be used to conduct trend analysis of the stormwater quality discharged into public UICs.
- Identify factors that strongly influence the quality of stormwater draining to public UICs to assist in enhancing groundwater protection.
- Evaluate the effectiveness of actions implemented to improve stormwater quality and meet MADLs.
- Provide data that can be compared with data collected from previous investigations conducted by the City and/or split/duplicate samples collected by others.

In addition, the monitoring data will inform decision-making processes to identify actions that will protect groundwater quality, improve UIC management practices, and improve overall watershed health.

[2] The Bureau of Environmental Services' mission is to serve the Portland community by protecting public health, water quality, and the environment. BES provides sewage and stormwater collection and treatment services to accommodate Portland's current and future needs. BES protects the quality of surface water and groundwater, and conducts activities that plan and promote healthy ecosystems in Portland's watersheds.

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Section 2

2 Monitoring Design and Locations

This section summarizes the UIC system monitoring design and presents the Year 10 monitoring locations and characteristics. The SDMP describes the basis and details of the UIC monitoring program.

2.1 Overview of Monitoring Design

It is not technically practicable or financially feasible to collect and analyze stormwater from each of the estimated 9,000 active City-owned UICs (Figure 2-1) during every storm event. Therefore, a statistically robust method, the Generalized Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen, 2004), was used to identify a representative subset of the City's UICs for monitoring. This method, which is described in detail in the SAP, provides a high degree of confidence that a monitored subset is reasonably representative of the entire system. This allows the characteristics of the entire UIC population to be estimated using the measured results of a representative sampling subset.

This section presents background information about the sampling design. Section 2.2 discusses information specific to the Year 10 design.

2.1.1 Sample Locations

UICs are sampled to evaluate permit compliance during the 10-year permit term, perform long-term trend analysis, and assess temporal and spatial trends in stormwater quality. The UIC sampling network consists of one stationary and five rotating panels for a total of six panels. The intent of the stationary panel is to assess for temporal trends in pollutant concentrations at the same UIC locations over time. The intent of the rotating panels is to assess for spatial trends in pollutant concentrations. The six panels consist of 15 UICs each, for a total of 90 unique UIC locations. UIC locations were identified using the GRTS survey design.

2.1.2 Frequency of Sampling and Major Permit Modification No. 3

The City evaluated, and DEQ approved, a change in sampling frequency in Year 8. The 2005 permit stipulated that 15 locations were required to be sampled in the stationary panel (i.e., Panel 6), and an additional 15 locations were required to be sampled in the rotating panel (i.e., Panel 5) for Year 10. However, the first six years of monitoring demonstrated that most analyte concentrations are generally well below MADLs and are protective of groundwater. Therefore, in 2012, the City conducted a statistical power analysis to evaluate the impact of reducing the frequency of sampling during annual monitoring. Based on the results of the power analysis, DEQ approved the City's *Major Permit Modification Request No. 3* in April 2012, authorizing the City to reduce the frequency of sampling from five storm events to three events annually and to discontinue

stationary Panel 6 sampling in Years 8 and 9. Panel 6 monitoring was resumed in Year 10 to support the trend analysis. The City included a summary of this statistical power analysis in the Year 8 *Annual Stormwater Discharge Monitoring Report* (City of Portland, 2013b). Detailed information about this analysis can be found in Attachment A to *Major Permit Modification Request No. 3* (City of Portland, 2012b).

2.1.3 Sample Size

The sample size ("n") for the UIC monitoring locations was selected to be representative of the City's UIC system and is described in detail in the SDMP. The sample size is based on a specified confidence level, interval width, and the estimated proportion of UICs exceeding the MADL. (Definitions of these measurements are provided in the *Annual Stormwater Discharge Monitoring Report - Year 1*; City of Portland, 2006a.) To limit the amount of uncertainty around the estimated proportion of exceedances, the confidence interval was set (in partnership with EPA) at a 90 percent confidence level and a half-width of 12 percent, as described in the SAP.

The proportion of UICs expected to exceed a MADL was estimated from stormwater discharge data collected during a pre-permit pilot study (described in the SAP). That study indicated that the proportion of all City-owned UICs estimated to exceed the pentachlorophenol MADL was 8.1 percent. Using the 90 percent confidence interval and a 12 percent precision half-width, 30 UIC locations were initially selected to be representative of the City's UIC population.

In January 2012, all stormwater discharge monitoring data were used to evaluate the pilot study conclusion. Assigning weights to accurately represent the City's UIC population (e.g., the greater proportion of UICs that receive runoff from streets with <1,000 vehicle trips per day [TPD] than UICs that receive runoff from streets with ≥1,000 vehicle TPD, the proportion of UICs in commercial/industrial areas versus in other land use areas, etc.), the revised proportion of all City-owned UICs estimated to exceed the pentachlorophenol MADL is 10.6 percent, within a 95 percent confidence interval of 5.7-15.5 percent, supporting the sample size initially selected.

2.1.4 Stratification

The permit requires the sampled UIC population to be divided into two traffic volume-based sub-populations, which are assumed to be associated with different stormwater qualities. These two traffic volume categories are identified in Table 2 of the WPCF permit and are presented in Table 2-1 of this report. The lower traffic volume category (<1,000 TPD) is presumed to be associated with lower pollutant concentrations. The higher traffic volume category (≥1,000 TPD) is presumed to be associated with higher pollutant concentrations. After the sample size was determined, the sampling design was stratified in accordance with the two identified traffic volume categories. Randomly selecting sampling locations and then stratifying them based on traffic category also randomizes information for multiple other factors that may affect stormwater quality.

As explained in the SAP, preliminary work by the City determined that approximately 57 percent of active City-owned UICs are in the <1,000 TPD category and 43 percent are in the ≥1,000 TPD category. To ensure there were enough data points in each traffic category for statistical analysis, 50 percent of the sample locations initially were selected from the <1,000 TPD category, and 50 percent of the sample locations were selected from the ≥1,000 TPD category. Because most active UICs are in the <1,000 TPD category and predominantly in residential areas, the sample design is considered to be conservative.

2.2 Year 10 Monitoring Locations and Characteristics

2.2.1 Overview

Thirty rotating UIC locations (discussed in Sections 2.2.2 and 2.2.3 below) were sampled to implement the required Year 10 compliance monitoring. In accordance with the SAP, each selected UIC sampling location was inspected in August and September 2014, before sampling began, to confirm UIC information (e.g., location, type of construction) and to determine suitability for sampling (e.g., accessibility, potential health and safety concerns). Tables 2-2 and 2-3 summarize the characteristics of Year 10 UIC monitoring locations. Figure 2-2 shows Year 10 sampling locations, and Appendix A contains detailed maps of all Year 10 locations. The SAP describes the UIC sampling design in detail.

2.2.2 Rotating Panel (Panel 5)

Fifteen randomly selected UICs (Panel 5) were sampled from October 2014 to May 2015. Panel 5 was previously sampled in Year 4 of the permit. Panel 5 includes seven UICs with traffic counts <1,000 TPD and eight UICs with traffic counts ≥1,000 TPD. UIC locations were sampled during three storm events, as discussed in Section 2.1.2.

2.2.3 Stationary Panel (Panel 6)

Fifteen randomly selected UICs (Panel 6) were sampled from October 2014 to May 2015. Panel 6 was previously sampled in Years 1 through 7 of the permit. Panel 6 includes eight UICs with traffic counts <1,000 TPD and seven UICs with traffic counts ≥1,000 TPD. UIC locations were sampled during three storm events, as discussed in Section 2.1.2.

2.2.4 Oversample Panel

As described in the SAP, an oversample panel of 85 alternate locations was generated to develop compliance sampling panels if needed. UICs that cannot be sampled (e.g., due to access issues, safety issues, etc.) are replaced by selecting the next location in a similar

traffic categorization from the oversample panel list. No replacement locations were used for compliance monitoring of Panels 5 or 6.

2.2.5 Carry-Over Locations and Major Permit Modification No. 4

Geometric mean stormwater concentrations are calculated for locations where an individual analyte is detected in at least one sampling event at a concentration ≥50 percent of the analyte's MADL. If the annual geometric mean concentration exceeds the MADL at a given UIC and the UIC has not previously received a no further action letter from DEQ (from past exceedances), the UIC is sampled again (i.e., carried over to) the following year.

In Year 8, DEQ approved the City's *Major Permit Modification Request No. 4* (City of Portland, 2012c), authorizing the City to increase the MADL for four common pollutants by a factor of 10. As a result, annual mean concentrations were compared to modified MADLs for pentachlorophenol, di(2-ethylhexyl)phthalate (DEHP), benzo(a)pyrene, and total lead and to the original 2005 Permit MADLs for the remaining pollutants. No UIC locations were identified with annual geometric mean concentrations exceeding MADLs in Year 9, and therefore no UICs were required to be carried over for additional sampling in Year 10.

Section

3

3 Monitoring Implementation

This section describes how key elements of the SDMP were implemented in Year 10. Section 4 presents analytical results.

3.1 Sampling Procedures

Procedures for staffing and coordinating event sampling teams and for collecting and documenting field data were conducted in accordance with the SDMP. Appendix B describes field sampling issues encountered during Year 10 monitoring events and includes copies of all data collection and Water Pollution Control Laboratory (WPCL) chain-of-custody (COC) forms. Appendix C documents that field audits of sampling procedures were conducted, as required by the QAPP.

3.2 Analytes

Table 1 of the WPCF permit lists the analytes required to be sampled as part of the City's compliance monitoring. If information or data indicate that additional pollutants should be added to Table 1, UIC Program staff will notify DEQ. No additional pollutants were identified for monitoring during Years 1 through 10 of the first permit term.

3.2.1 Common Pollutants

The permit requires the common pollutants listed in Table 3-1 to be monitored annually. This list represents a change from Years 1 through 6 because *Major Permit Modification No. 2* (City of Portland, 2011) approved moving five common pollutants (benzene, toluene, ethylbenzene, and xylenes (BTEX) and nitrate-nitrogen) to the PPS analyte list (see following section). Common pollutants were measured at all UIC monitoring locations during each stormwater sampling event. All samples required by the permit and by the SAP were collected for Year 10. Table 3-2 lists analytical laboratories, analytical methods, method detection limits (MDL), method reporting limits (MRL), and MADLs for common pollutants.

3.2.2 Priority and Ancillary Pollutants

The permit initially required the PPS analytes listed in Table 3-1 to be monitored for the first storm event in Years l, 4, and 9. However, as a result of *Major Permit Modification No. 3* (City of Portland, 2012b), which changed the Panel 6 monitoring frequency (see Section 2.1.2), the PPS pollutants were monitored in Year 10 rather than Year 9. This enabled the City to monitor both compliance panels in Year 10. PPS pollutants were measured at all UIC monitoring locations during each stormwater sampling event in Year 10. All samples required by the permit and by the SAP were collected. Table 3-3 lists analytical laboratories, analytical methods, MDLs, MRLs, and MADLs for the PPS pollutants.

The permit defines ancillary pollutants as those analytes that are detected during the required monitoring for common pollutant or PPS analytes using Environmental Protection Agency (EPA) approved analytical methods. For the purposes of this report, any ancillary pollutants that are listed in the permit as PPS analytes are reported as PPS analytes; all other detected pollutants are reported as ancillary.

3.2.3 Additional Testing

The City conducted the following additional stormwater characterization testing in Year 10 for UIC analysis:

- Field parameters, including pH (EPA Method SM4500-HB), conductivity (EPA Method SM2510B), and temperature (EPA Method SM2550B), were measured at all UIC monitoring locations during each sampling event to assist with interpreting analytical results.
- Total suspended solids (TSS) were measured at all UIC monitoring locations during each sampling event, using EPA Method SM2540D. TSS is considered to be an indicator pollutant because elevated levels can be associated with higher levels of some pollutants.
- Dissolved copper, lead, zinc, and mercury were measured at all UIC monitoring locations during each sampling event to help understand the mobile portion of total metals that could conceivably pass through the UIC. (Total metals are considered more conservative measurements and are required by the permit.) Samples were:
    - Filtered by WPCL staff within 24 hours of collection, using a 0.45 micron filter
    - Preserved using nitric acid (pH < 2) before analyses
    - Analyzed using the EPA methods specified in the SDMP for metals

The City conducted the following additional stormwater characterization testing in Year 10 for analysis for the City's National Discharge Pollutant Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit program. This monitoring was not a direct requirement of the UIC permit or monitoring plan, but because it was collected from a UIC, the City is required to report this information and include the raw data in this report:

- E. coli (Colilert QT), total organic carbon (SM 5310B), ammonia-nitrogen (EPA 350.1), nitrate-nitrogen (EPA 300.0), orthophosphate (EPA 365.1), total phosphorus (EPA 365.4), and hardness (SM 2340B) were measured at all UIC Panel 5 and Panel 6 monitoring locations during each sampling event. These analyses were performed to meet MS4 permit monitoring requirements, and data are reported in Appendix D.

- Multi-residue pesticide screens were conducted during each event at all UIC Panel 5 and Panel 6 monitoring locations for MS4 permit compliance. Samples were analyzed at Pacific Agricultural Laboratory (PAL) using a combination of EPA Methods 8081B, 8141B, 8270D, and 8321B. Data for MS4 pollutants that are also PPS analytes are reported in Table 4-2 and Appendix D.

3.3 Storm Events

The Storm Event Coordinator worked directly with the City's contract weather forecasting service, Extended Range Forecasting Company, Inc., to obtain weather forecasts and decide whether to proceed with a stormwater sampling event. To the extent practicable, staff adhered to target storm criteria to help ensure that stormwater runoff would be adequate for sample collection, representative of stormwater runoff, and consistent among sampling events. Before initiating a sampling event, the storm forecast was evaluated against the following three target storm criteria:

- Predicted rainfall amount of $\geq$0.2 inch per storm
- Predicted rainfall duration of $\geq$6 hours
- Antecedent dry period of $\geq$6 hours (as defined by <0.1 inch of precipitation during the previous 6 hours)

Storms meeting these criteria were expected to provide the volume of runoff necessary to implement sampling. Some sampled storms may not have met the criteria when the sampling event was completed.

After a sampling event was completed, the characteristics of the storm (or individual storms comprising the sampling event) were evaluated using data from the City's Hydrological Data Retrieval and Alarm (HYDRA) system rain gage network. Rain gage data are available at http://or.water.usgs.gov/non-usgs/bes/raingage_info/. That website also provides a map of rain gage locations.

Precipitation data from the following 13 rain gages across Portland were averaged and used to characterize individual storms for Years 1 through 10:

HYDRA (Rain Gage) Station	**Address**
Station #1: Airport Way 52 P.S.	14614 NE Airport Way
Station #2: Arleta School	5109 SE 66th Ave.
Station #3: Astor School	5601 N Yale St.
Station #4: Beaumont School	4043 NE Fremont St.
Station #5: Cascade PCC_02	705 N Killingsworth St.
Station #6: Holgate	4507 SE 136th Ave.

HYDRA (Rain Gage) Station	Address
Station #7: Kelly School	9030 SE Cooper St.
Station #8: Mallory	8030 NE Mallory Ave.
Station #9: Open Meadows School	7602 N Emerald Ave.
Station #10: PDX Post Office	7660 NE Airport Way
Station #11: Swan Island	2600 N Going St.
Station #12: Vernon School	2044 NE Killingsworth St.
Station #13: Water Pollution Control Laboratory	6543 N Burlington Ave.

Sampling staff attempted to sample all locations that were scheduled for Year 10 during discrete storms; however, if rainfall ceased before the collection of all required samples, the sampling event was extended over additional storms (i.e., sample collection period) as necessary. Each of the three Year 10 stormwater sampling events comprised several storms or sample collection periods. The dates of individual sample collection periods for each event were:

- Event 1: 10/22/14, 10/31/14, 11/6/14, 11/21/14, 12/10/14, and 1/16/15
- Event 2: 2/3/15, 2/5/15, 2/6/15, and 4/13/15
- Event 3: 3/14/15, 3/15/15, and 3/24/15

Tables 3-4 through 3-6 summarize hourly average precipitation records for each storm event. Figures 3-1 through 3-3 provide hydrographs for each storm event. This information was used to estimate the duration, intensity, and antecedent dry period[3] for each sample collection period in each storm event. Table 3-7 summarizes these storm characteristics for Events 1 through 3. The *Data Usability Report* in Appendix B provides additional information about forecasted rainfall for individual storms in a storm event.

The first predicted storm during Year 10 was targeted for sampling to investigate water quality differences that may be associated with the first significant rainfall of the fall season. The remaining monitoring events (Events 2 and 3) were distributed across the monitoring season as storms occurred that met the target storm event criteria.

Table 3-8 summarizes long-term (30-year) and Years 1 through 10 precipitation and temperature records for the Portland area. (See Table 3-8 footnotes for specific data sources used to generate climatological data.) The permit-defined wet-season months are shaded. The average annual temperature for Year 10 at the Portland International Airport was the warmest for the entire 10-year permit monitoring period, at 57.1 degrees

[3] The duration of an individual sample collection period was defined as a continuous rainfall event, preceded and followed by 0.0 inch of rain in an hour (i.e., a dry hour). The intensity of an individual sample collection period was defined as the amount of precipitation recorded for the duration of the event. The antecedent dry period for each sample collection period was defined as the number of dry hours before the first measured rainfall in the sampling event.

Fahrenheit. Average temperature between Years 1 and 10 has ranged from 50.1 (Year 6) to 57.1 (Year 10) degrees, although for eight of the ten years, it has been fairly constant at around 54 degrees. The long-term average annual temperature (1981-2010) is 54.5 degrees Fahrenheit.

Total annual precipitation for Year 10 at the Portland Airport was the second lowest during the permit monitoring permit, at 33.44 inches. Total precipitation between Years 1 and 10 has ranged from 27.2 inches (Year 4) to 50.70 inches (Year 6) per year. The long-term average annual precipitation (1981-2010) is 36.03 inches. Year 10 had approximately 2.59 inches less precipitation than the long-term average. Figure 3-4 depicts precipitation totals for these time periods graphically.

3.4 UIC Infiltration Volumes

The permit requires the Annual Stormwater Discharge Monitoring Report to provide information on the total volume of recharge (i.e., stormwater infiltration) to the subsurface (i.e., aquifer) from City-owned UICs. This section describes the methods used to estimate the volume of water infiltrated to City-owned UICs.

BES estimated the catchment area (i.e., basin drainage area) and impervious surface area (e.g., roofs, parking lots, streets) for each known and active City-owned UIC. The impervious portion is the UIC basin area assumed to provide stormwater runoff to the UIC. It was conservatively assumed that all of the identified impervious areas directed stormwater only to the subject UIC (i.e., no infiltration into pavement, unpaved, or curbless areas).

The equation used to calculate infiltration volume for each UIC is:

Infiltration Volume (cubic feet) = AP x (1ft/12 inches) x IA x LE

Where:

AP = Annual precipitation (inches)
IA = Impervious area within UIC catchment (square feet)
LE = Loss to evaporation (1.0 – ELF)

Where:

ELF = Evaporative loss factor assumed to be 26 percent (0.26) (Snyder et al., 1994)

Table 3-9 summarizes the total estimated stormwater infiltration volumes calculated for the City-owned UIC system for Years 7 through 10. Infiltration volumes for Years 1 through 6 are available in the annual monitoring reports for those years.

The total volume of stormwater infiltration was estimated for June 1 through May 31 each year, using annual precipitation measurements from the following sources:

- Years 1 through 4: Portland International Airport
- Years 5 and 6: National Weather Service
- Years 7 through 10: The average of 13 rain gages in North, Northeast, and Southeast Portland

Annual precipitation measurements are shown in Table 3-8. The actual precipitation total for Year 10 (2014-2015) was 33.44 inches.

UIC drainage (i.e., catchment) areas were estimated using GIS, as described in the Years 1 through 3 reports. A number of the delineated drainage areas contained more than one UIC. When this was the case, the effective drainage area was assigned to an individual UIC, and the other UICs were removed from the calculation. Approximately 731 UICs were identified and removed for the Year 10 calculation.

Based on these calculations, the City-owned UICs drain a total adjusted catchment area of approximately 613,752,000 square feet (14,090 acres), of which approximately 233,028,500 square feet (5,350 acres) are impervious. Using these values, approximately 38 percent of the drainage area is considered impervious. The average area drained by a UIC system in the City of Portland was estimated to be approximately 76,600 square feet (1.8 acres), of which an average 37 percent, or 28,900 square feet (0.66 acre), is impervious. The stormwater infiltration volumes for the City's UIC system were estimated to be approximately:

- 589 million cubic feet (4.4 billion gallons) in Year 1 (June 1, 2005 through May 31, 2006)
- 474 million cubic feet (3.5 billion gallons) in Year 2 (June 1, 2006 through May 31, 2007)
- 481 million cubic feet (3.6 billion gallons) in Year 3 (June 1, 2007 through May 31, 2008)
- 385 million cubic feet (2.9 billion gallons) in Year 4 (June 1, 2008 through May 31, 2009)
- 570 million cubic feet (4.3 billion gallons) in Year 5 (June 1, 2009 through May 31, 2010)
- 604 million cubic feet (4.5 billion gallons) in Year 6 (June 1, 2010 through May 31, 2011)
- 582 million cubic feet (4.4 billion gallons) in Year 7 (June 1, 2011 through May 31, 2012)
- 562 million cubic feet (4.2 billion gallons) in Year 8 (June 1, 2012 through May 31, 2013)

- 433 million cubic feet (3.2 billion gallons) in Year 9 (June 1, 2013 through May 31, 2014)
- 480 million cubic feet (3.6 billion gallons) in Year 10 (June 1, 2014 through May 31, 2015)

The simplified method used in this report to calculate runoff assumes that all rain that falls on impervious area (less the evaporative loss factor) becomes runoff, and all rain that falls on pervious area does not. *The method used to estimate stormwater infiltration volume described above is believed to overestimate the actual stormwater infiltration volume*. All stormwater runoff from identified impervious areas (less the evaporative loss factor) is assumed to enter the UIC. This assumption overestimates the recharge volume because some runoff may be distributed to detention or other types of infiltration facilities.

In addition, there are a number of uncertainties inherent in both the underlying information and the method used to estimate the stormwater infiltration volume at each UIC. Uncertainties in the estimates also may be the result of one or more of the following assumptions and factors:

- The evaporative loss factor used in the infiltration volume calculation was assumed to be constant at 26 percent. This value may vary as the result of weather conditions (ambient air temperature, impervious surface temperature, rainfall intensity, rainfall duration, land surface topography, impervious surface type and condition).
- Annual precipitation was based on data collected at the Portland International Airport for years 1 through 4, National Weather Service for years 5 and 6, and an average of the 13 rain gages (listed in Section 3.3) for years 7 through 10. Total rainfall amounts are known to vary across the Portland metropolitan area. A constant precipitation rate may result in either an overestimate or underestimate of stormwater infiltration volume.
- Storm duration and intensity. (Longer storms will produce more runoff, as will more intense storms; storm intensity in the Portland area usually is not very high.)
- Antecedent conditions. (There will be more runoff if the ground/pavement is already saturated.)
- Vegetative cover, which intercepts rainfall, was not considered in the stormwater infiltration estimates (such as areas with high density of evergreen trees, areas with significant tree cover over roads, and neighborhoods with no mature trees)
- Topography. (Flat areas generally will retain more water than steep slopes.)

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Section 4

4 Monitoring Results and Evaluation

This section presents the data collected, results, and evaluation during Year 10, in accordance with the permit and SDMP.

4.1 Monitoring Results

4.1.1 Common Pollutants

All nine common pollutants listed in Table 3-1 were detected during Year 10. Table 4-1 summarizes the information in Appendix D (Table D-1) and includes the number of detections (i.e., ≥MRL), number of samples analyzed, frequency of detection, range of concentrations, and maximum percent of the MADL detected (i.e., maximum concentration/MADL *x* 100).

The permit requires detected concentrations of common pollutants in each individual sampling event to be compared to their respective MADLs.[4] No common pollutants were detected at concentrations above their MADLs.

4.1.2 Priority Pollutant Screen Analytes

Major Permit Modification No. 3 required sampling the complete list of PPS analytes listed in Table 3-1 in Year 10. Some of these analytes are also collected as part of NPDES MS4 permit monitoring during Year 10. Ten of 32 PPS pollutants were detected in Year 10. Table 4-1 summarizes the PPS analytes detected in Year 10, including the number of detections (i.e., ≥ MRL), the number of samples analyzed, the frequency of detection, the range of concentrations, and the maximum percent of the MADL detected (i.e., maximum concentration/MADL *x* 100). All PPS analyte data are presented in Appendix D (Table D-2). Table 4-2 summarizes the PPS analytes that were analyzed but not detected, including the number of samples analyzed and the range of MRLs. The WPCF permit does not require sampling after Event 1 if the analyte is not detected; however, the NPDES permit does require sampling for all three

For more information about the data, see **Appendix**:

- **B**: Data Usability Report (QA/QC results, copies of all field and data forms)
- **C**: Year 10 Field Audit Report
- **D**: Year 10 Pollutant Summary Tables (for field parameters, common pollutants, and PPS pollutants)
- **E**: Year 10 Analytical Laboratory Reports (includes data flags)
- **F**: Year 10 Stormwater Discharge Monitoring Database (on CD) (analytical data and key UIC location characteristics)

[4] *Major Permit Modification No. 4* increased MADLs for four constituents by one order of magnitude (City of Portland, 2012c). These new MADLs are: pentachlorophenol 10 µg/L, DEHP 60 µg/L, benzo(a)pyrene 2µg/L, and lead 500 µg/L. For these constituents, all comparisons to MADLs in this Year 10 report refer to the MADLs in the approved *Major Permit Modification No. 4*.

events. Therefore, the non-detected WPCF analytes are reported for one event, and the non-detected WPCF/NPDES analytes are reported for three events.

The WPCF permit requires detected concentrations of PPS analytes from each individual sampling event to be compared to their respective MADLs. One PPS analyte, benzene, was detected at a concentration of 5.68 ug/L (which is above the MADL of 5 ug/L) at one UIC location during Event 3. Benzene was not detected at this location upon resampling during the next storm event, nor was it detected during Events 1 and 2.

4.1.3 Ancillary Pollutants

Table 4-3 lists ancillary pollutants detected in Year 10, as well as the analytical method, sampling event number, number of samples analyzed, number of detections, frequency of detection, and minimum and maximum concentrations.

Twenty-nine ancillary pollutants were detected in Year 10. Twelve of these pollutants were detected at maximum frequencies of below 10 percent. Twelve were detected at maximum frequencies between 10 percent and 50 percent. The five pollutants that were detected at the highest frequencies (>50 percent) during the individual sampling events are polycyclic aromatic hydrocarbons (PAHs): benzo(b) fluoranthene, benzo(g,h,i)perylene, fluoranthene, phenanthrene, and pyrene.

The detection of PAH compounds is an expected result because of the presence of numerous sources in an urban environment. PAH sources include, but are not limited to, fresh and used petroleum products (e.g., gasoline, diesel, motor oil, used oil), petroleum and coal combustion, motor vehicle exhaust, tire wear, wood ash, asphalt, insecticides, wood preservatives, used cigarette filters, and air deposition. PAHs tend to adhere to sediment particles rather than dissolve in water. PAHs will continue to be analyzed and reported as ancillary pollutants in future UIC sampling events.

4.1.4 Additional UIC Analyses

Dissolved Metals. Table 4-4 summarizes common pollutant and PPS total and dissolved metal analyses conducted in Year 10 under the WPCF permit. This table includes the number of samples analyzed; number of detected values; average (i.e., arithmetic mean) concentration; geometric mean, minimum, and maximum concentrations; and ratio of the dissolved average concentration to the total average concentration. There are no MADLs for dissolved metals, but dissolved metals results are well below their respective total metal MADLs. The ratios of dissolved to total metal concentrations for the <1,000 TPD traffic category were 44 percent for copper, 10 percent for lead, 34 percent for zinc, and 25 percent for mercury. Concentration ratios for the ≥1,000 TPD traffic category were 36 percent for copper, 4 percent for lead, 61 percent for zinc, and 22 percent for mercury.

Total Suspended Solids. Table 4-5 summarizes TSS results. TSS in stormwater was analyzed for each UIC location during each of the three sampling events. For UICs with <1,000 TPD, TSS concentrations ranged from less than 2 milligrams per liter (mg/L) to 458 mg/L. For UICs with ≥1,000 TPD, TSS concentrations ranged from <2 mg/L to 236 mg/L. The geometric mean TSS concentration for UICs with <1,000 TPD was 11.7 mg/L, and the geometric mean TSS concentration for UICs with ≥1,000 TPD was 19.3 mg/L.

Field Parameters. Field data were collected to help interpret analytical results. Three field parameters (pH, specific conductivity, and temperature) were measured at all UIC locations during each stormwater sampling event, except as noted in the *Data Usability Report* (Appendix B). Table 4-6 summarizes the results presented in Appendix D (Table D-3).

- **Conductivity**. Conductivity measurements ranged from 3 to 176 micromhos per centimeter (µmhos/cm) in stormwater discharge during Year 10. The mean conductivity readings for individual sampling events ranged from 17.5 to 37.9 µmhos/cm.
- **pH**. pH measurements ranged from 5.2 to 12.1 in stormwater discharge during Year 10. The mean pH readings for individual events ranged from 6.6 to 7.4.
- **Temperature**. Temperature measurements ranged from 6.3 to 15.7^{o} C in stormwater discharge during Year 10. The mean temperature measurements for individual sampling events ranged from 10.5 to 12^{o} C.

4.2 Comparison to Individual MADLs - Exceedances

4.2.1 Common Pollutants

The permit requires detected concentrations of common pollutants in each individual sampling event to be compared to their respective MADLs. However, no common pollutants were detected in Year 10 at concentrations exceeding their MADLs. One common pollutant, total zinc, was detected at a concentration (2600 ug/L) greater than half of the MADL (5000 ug/L) at UIC location P6_5 during Event 2. Zinc concentrations reported at this location for Events 1 and 3 were significantly lower, at 85.8 and 70.5 ug/L, respectively.

4.2.2 Priority Pollutant Screen Analytes

The permit requires detected concentrations of the PPS pollutants in each individual sampling event to be compared to their respective MADLs. Benzene was detected at a concentration (5.68 ug/L) exceeding the MADLs (5 ug/L) at UIC location P6_8 during Event 3. Benzene was not detected at this location upon resampling during the next storm event, nor was it detected during Events 1 and 2. The permit requires the City to report any observed MADL exceedances from each individual sampling event to DEQ in a

timely manner (within 7 days following the receipt of validated analytical data). The City reported this benzene exceedance to DEQ on May 11, 2015.

Table 4-1 presents the maximum percent of the MADLs detected for PPS analytes. With the exception of the single benzene concentration, the concentrations of the remaining PPS analytes are significantly less than their MADLs (<40 percent) for all sampling events. Therefore, response actions or source investigations were not conducted for any PPS pollutant except benzene (see Section 6 of this report). This is consistent with the PPS action levels defined in the permit and presented in Table 4-7.

4.3 Calculation of Annual Mean Concentrations

The permit requires the annual mean MADL concentration to be met at the end-of-pipe (EOP) discharge point after any pretreatment best management practices (BMPs) or structural controls. The annual mean concentration is calculated using the geometric mean of the three storm event concentrations for each pollutant. The QAPP provides additional details about the geometric mean calculation. Based on the considerations outlined in the QAPP, half of the MRL was used for non-detected values in calculating the geometric mean. In general, all data were used, except as noted in Section 7 of this monitoring report.

The annual geometric mean concentration is calculated for pollutants detected in at least one sampling event or individual sampling location at a concentration >50 percent of their MADLs. Therefore, geometric mean concentrations were calculated for benzene and zinc. The results, summarized in Table 4-8, indicate that the geometric mean benzene concentration in Year 10 was 0.61 ug/L, and the geometric mean zinc concentration in Year 10 was 250.5 ug/L. Both concentrations are significantly lower than their respective MADLs of 5 ug/L and 5000 ug/L.

4.4 Evaluation of Year 10 Results

This section evaluates Year 10 data, using statistical and graphical methods to look for potential differences or similarities among sample panels, sampling events, and traffic categories. Box plots were produced to present the results of selected analytes. Figure 4-1 illustrates and defines the components of a box plot.

4.4.1 Year 10 Concentration Data by Traffic Category

Box plots were prepared using Year 10 stormwater discharge data, including non-detect values. For concentrations reported as non-detect (<MRL), the MRL was used to generate the box plots to avoid any distortion of the data distribution caused by substituting a value other than the MRL. Figures were prepared to illustrate analyte concentrations by traffic category (<1,000 TPD and ≥1,000 TPD). Figure 4-2 presents box plots for six

pollutants: benzo(a)pyrene, DEHP, pentachlorophenol, total arsenic, total chromium, and total lead. The following general observations are made regarding this information:

- Pentachlorophenol, lead, arsenic, and DEHP generally appear to be symmetric on a log scale. However, benzo(a)pyrene and total chromium appear to be truncated by the non-detect values.
- The ≥1,000 TPD traffic category has a slightly higher median concentration than the <1,000 TPD category for benzo(a)pyrene, chromium, DEHP, lead, and pentachlorophenol. Concentrations in the two traffic categories were roughly equal for arsenic.
- No measurement exceeded 50 percent of the MADLs approved in *Major Permit Modification No. 4*.Very few measurements exceeded 10 percent of these MADLs.

4.4.2 Individual UIC Location Concentration Data by Sampling Event

Plots were prepared for total arsenic (Figure 4-3), benzo(a)pyrene (Figure 4-4), DEHP (Figure 4-5), total lead (Figure 4-6), pentachlorophenol (Figure 4-7), and total chromium (Figure 4-8).

These plots depict the pollutant concentration for each UIC sampling location in Year 10 by sampling event and traffic category. The UIC locations on these plots are ordered according to increasing average concentration along the *x*-axis. Concentrations reported as non-detect (<MRL) were plotted at the MRL. The following general observations are made regarding these plots:

- All individual sample concentrations (by event and by location) are below the MADLs approved in *Major Permit Modification No. 4*.
- Concentrations at most individual UIC locations are within a narrow concentration range (i.e., there is relatively little variability in concentration within a UIC).

4.4.3 Year 10 Concentration Data by Sampling Event

Box plots showing the concentrations by sampling event were prepared using Year 10 stormwater discharge data, including non-detect values. Figure 4-9 presents box plots for six pollutants: benzo(a)pyrene, DEHP, pentachlorophenol, total arsenic, total chromium, and total lead.

Box plots were generated using data from 30 UIC monitoring locations for each sampling event. For concentrations reported as non-detect (<MRL), the MRL was used to generate the box plot. The following general observations are made regarding these plots:

- There is no consistent relationship between concentration and event.

- In general, the distribution of concentrations from event to event is very similar.

Section 5

5 Preliminary Trend Analysis

5.1 General

This section presents stormwater discharge monitoring data from Panels 5 and 6 for Years 5 and 10, using statistical and graphical methods to identify potential differences or similarities between permit years and traffic categories. Complete Year 5 results are presented in the Year 5 *Annual Stormwater Discharge Monitoring Report* (City of Portland, 2010).

Box plots were prepared to present the results of selected analytes for Years 5 and 10. These plots are presented side by side to show both the general magnitude of stormwater concentrations and the distribution in each plot and to allow general comparisons to be made regarding the data sets.

In general, plots were prepared for pollutants where the stormwater concentration in at least one sampling event was detected at a concentration greater than 50 percent of the MADL in previous years. Plots were generated using data from the fifth and tenth (i.e., final) permit years, including values reported by the analytical laboratories as non-detect and flagged (i.e., estimated) data. Concentrations reported as non-detect (<MRL) were replaced with a value equal to the MRL in order to generate the box plots.

Additional data evaluation and analysis may be conducted and discussed in the UICMP annual report, as appropriate.

5.2 Permit Year

Plots were prepared to compare stormwater discharge concentrations of selected analytes by permit year. Figure 5-1 presents the plot comparisons for pentachlorophenol, total lead, benzo(a)pyrene, DEHP, total chromium, and total arsenic. The following observations are made regarding Figure 5-1:

- Concentration ranges and distributions are very similar between the two permit years in which Panel 5 and 6 locations were sampled (Years 5 and 10).
- All annual geometric mean concentrations of the evaluated compounds are <50 percent of their respective MADLs for both years.
- A change in detection limit in DEHP gives the appearance that concentrations are more variable during Year 10, even though they have not changed much between the two monitoring years.
- There is no evidence of significant trends in any of these analytes; the distributions of concentrations are very similar in Years 5 and 10.

5.3 Traffic Categories

Plots were prepared for Panel 5 and 6 data to compare the concentrations of selected analytes by traffic category (<1,000 TPD and ≥1,000 TPD) for Years 5 and 10. Figure 5-2 presents the box plots for pentachlorophenol, total lead, benzo(a)pyrene, DEHP, total chromium, and total arsenic by traffic category. The following observations are made regarding Figure 5-2:

- Patterns for both traffic categories have similar concentration ranges for both permit years.
- Distributions of total arsenic, total lead, total chromium, and pentachlorophenol are symmetric, with the geometric mean roughly equal to the median. Distributions of DEHP and benzo(a)pyrene are somewhat skewed by the truncation at the detection limit, but otherwise appear symmetric when the concentrations are further from the detection limit. Both of these patterns are consistent with a lognormal model that has been truncated at the detection limit (i.e., data are skewed by the non-detect values).
- All annual median and geometric mean concentrations of the evaluated compounds are <50 percent of their MADLs. In addition, for Year 10, all sample concentrations are <50 percent of their MADLs.
- The >1,000 TPD traffic category has higher geometric mean and median concentrations than the <1,000 TPD category for the evaluated compounds, although the difference is quite small.

Summary: Box plots were prepared to identify potential differences in pollutant concentrations between permit years and traffic categories. In general, data are similar for each variable for Panels 5 and 6 in Years 5 and 10. For most of the evaluated pollutants, the concentration ranges are generally narrow, and geometric means are well below their MADLs (i.e., <50 percent). Pollutant concentrations appear to be slightly higher in the ≥1,000 TPD traffic category than in the <1,000 TPD category and similar among sample panels.

Section 6

6 Response Actions

This section summarizes the actions taken during Year 10 to further understand pollutant sources, prevent pollutants of concern from exceeding their MADLs, and respond to conditions identified during implementation of the SDMP.

6.1 Source Investigations

Source investigations may be conducted when new data are inconsistent with previous results or observations. A source investigation was initiated at UIC location P6_8 in Year10 because of an individual MADL exceedance (i.e., not a geometric mean exceedance) for benzene in Event 3 (March 3, 2015). This was the first time benzene has exceeded the MADL at any location during the permit term. In follow-up to this exceedance, the location was visually inspected, and a resample was initiated. The inspection did not identify anything that may have caused the exceedance. The UIC was resampled on June 2, 2015 during the next storm event that generated runoff. The laboratory analysis result for benzene was non-detect.

In accordance with Schedule C.8 and C.9 of the City's WPCF permit, the City is required to provide written notification to DEQ if data from an individual sampling event indicate that a pollutant is detected at a concentration exceeding the MADL established in the permit. The City notified DEQ within the permit required timeframes.

6.2 UIC System Cleaning

As a result of observations during pre-sampling inspections or during stormwater event sampling, the City's UIC Program requested that selected UICs be cleaned by City Bureau of Maintenance crews or by the City's response contractor(s). Cleaning was requested for UICs with records showing that they had not been cleaned in four years or more. Cleaning activities were conducted in general accordance with the *Surface Stormwater Facilities Maintenance Management Manual* (Brown and Caldwell, 1997) and the UICMP (City of Portland, 2006b; revised 2012). Tables 2-2 and 2-3 identify the recent cleaning and/or maintenance activities conducted at Year 10 UIC sampling locations.

6.3 Investigation of Other Factors

One of the goals of the permit and the SDMP is to identify factors that have a substantive effect on the quality of stormwater entering City-owned UICs. To identify these factors, potential associations and relationships among stormwater quality, potential sources of pollution, traffic category, land use, etc., can be evaluated. As data are collected in successive years and a larger data set becomes available, additional analysis may be considered (e.g., detailed trend analysis, correlations, or logistic regression). If

appropriate, such evaluation and analyses will be conducted in Year 11 and included in that year's annual monitoring report.

Section 7

7 Data Management and Validation

This section summarizes the types of information managed and maintained during Year 10 of the Stormwater Discharge Monitoring Program. It also summarizes the results of data validation conducted in the field and analytical laboratory data collected during the 2014-2015 wet season. The QAPP describes specific procedures for data management and data validation.

7.1 Data Management

Technical data that were collected and used in the *Data Usability Report* (Appendix B) include:

- Field data (described below)
- Analytical laboratory data (described below)
- UIC locations (described in Section 2)
- Traffic volume data (described in Section 2)
- Sampling event data (described in Section 3)
- Calculated or manipulated data

During Year 10, there were no deviations from specific data management procedures described in the QAPP.

Additional technical data types are identified in the QAPP, but not specifically presented in this report. That information will be presented and discussed in other reports as appropriate.

7.1.1 Field Data

Field data were recorded on project-specific paperwork, as described in the SAP. BES maintains field records in both hard copy and electronic (pdf file) formats. Appendix B contains copies of the daily field reports (DFR) and field data sheets (FDS). Test America (TA), Water Pollution Control Laboratory (WPCL), ALS Global (ALS), and Pacific Agricultural Lab (PAL) chain-of-custody (COC) forms are included with the analytical laboratory data packages (Appendix E).

7.1.2 Laboratory Data

The BES Laboratory Information Management System (LIMS) functions as the WPCL database for data storage, sample tracking, and reporting. In November 2010, the WPCL began using Element by Promium as its LIMS. Before Element was implemented,

analytical laboratory data (sample information and analytical results from both the WPCL and TA) were manually entered into the LIMS. Following implementation of Element, most analytical results (nitrates, metals, and organics) were uploaded directly to the LIMS from the instruments via DataTool, a function of Element.

A WPCL chemist conducted manual checks of analytical data sheets and results of laboratory quality control (QC) samples to ensure that the QC statistics were within control limits and that appropriate corrective actions were taken if control limits were exceeded. The chemist also flagged or provided comments on results that did not strictly meet QC criteria. The WPCL uses customized flags to qualify results when necessary. TA uses customized flags to communicate detailed QC issues; these flags are included on the TA analytical laboratory reports.

WPCL staff verified the accuracy of data entry into the LIMS system against original hardcopy and electronic records and did not release data until the data validation process was complete. Once data were released, they were uploaded overnight to the Water Quality Database (WQDB), an Access© -based database. TA currently provides electronic data deliverables (EDDs), which are used for transferring herbicide data directly to the WQDB. The LIMS system and WQDB were backed up on a daily basis. Appendix E contains electronic copies of the TA and WPCL analytical data reports.

The WPCL maintains project files containing any records necessary to reconstruct the analytical events associated with this project. All procedures for storage of hard copy and electronic data comply with the *WPCL Quality Manual* (City of Portland, 2013a). Records related to analytical laboratory data that are maintained include:

- COC forms (copies included in analytical laboratory reports are presented in Appendix E)
- Instrument calibration and tuning records (as applicable)
- Analytical standards preparation logs
- Method standard operating procedures (SOP)
- Analytical QC results (including method blanks, internal standards, surrogates, replicates, spikes, and spike duplicate results, as applicable)
- Raw data, specifically instrument printouts
- Bench worksheets and/or quantification reports
- Corrective action reports (if any)
- Details of the quality assurance/quality control (QA/QC) program in place at the time the project analyses were conducted

Laboratory data were extracted from the WQDB system to generate Year 10 summary tables in an electronic format, by UIC location and analytical constituent. Appendix F

includes a copy of the Access© database containing a compilation of Years 1 through 10 monitoring data. Tables were checked against copies of the original final data sheets before data analysis. Data are tabulated as they are shown on the original data sheets. However, specific data flags by subcontract laboratories are not included in the Access© database. Noteworthy laboratory QC issues are included in the comments section of the spreadsheet.

7.1.3 Management Data

Management data include information that must be tracked to monitor, manage, and document the performance of the UIC program, such as schedules, cost estimates, and project reports. All original data, calculations, drawings, etc., are systematically filed as they are collected and are maintained by BES.

7.1.4 Data Storage

All technical and management data described above will be retained indefinitely, and no other records will be destroyed without prior permission of the City's UIC Program Manager and notification of the DEQ UIC Permit Manager, as specified in the QAPP.

7.2 Data Quality Objectives (DQO)

DQOs are defined for environmental sampling and laboratory activities as qualitative and quantitative statements that specify the quality of the data required to support the project objectives. DQOs provide the driving force for the level of QC required for any particular sampling or analytical task. The key DQOs for the City's UIC monitoring program are to provide environmental data that are of known and acceptable quality, are scientifically defensible, and demonstrate compliance with the WPCF permit. The quality of data is known when all components associated with data generation are thoroughly documented. Data are of acceptable quality when a rigorous QA/QC program is implemented and the QC indicators fall within predefined limits of acceptability. The project QAPP describes the methods of data documentation and the mechanisms to be used to attain data of acceptable quality.

Table 7-1 summarizes the project DQOs for analytical data. DQOs for Year 1 were carried forward into Years 2 through 10 without change. The QAPP provides additional information on DQOs.

Field and laboratory data collected during Year 10 were determined to meet the DQOs described in the QAPP and to be of known and acceptable quality. All data are considered usable as reported or with qualifiers.

7.3 Data Validation

This section summarizes the procedures used to review field and analytical data. The purpose of this review is to ensure that data collection and evaluation were conducted according to procedures specified in the SDMP. Deficiencies in field or analytical data, if any, are noted, as are the cause of these deficiencies. If these deficiencies required a corrective action, it is described in Section 7.4 of this report.

7.3.1 Field Data

This section notes any deviations from field procedures outlined in the SAP. Field data were collected in general accordance with the procedures described in the SDMP. The following paragraphs describe key components of the field program used to validate field data. All field data were determined to be valid and of acceptable quality.

Sample Locations. Pre-sampling investigations were conducted to determine whether any of the proposed UIC locations were unsuitable for sampling. Although Panel 5 UIC locations were already scouted prior to Year 4, they were included in Year 10 pre-sampling investigations to ensure that sample locations were still accessible and suitable for sampling. The SAP describes the factors used in this evaluation.

Sample Stratification. UIC monitoring locations are stratified by traffic category ($\geq$1,000 or <1,000 TPD).

Precipitation Events. Three sampling events were completed in Year 10. Table 3-7 describes the sampled precipitation events in more detail. Storms targeted for sampling met the criteria identified in the SAP to the extent practicable and were determined to be acceptable. As described in Section 6.1, one additional follow-up sample was collected on June 2, 2015 in response to a benzene MADL exceedance at location P6_8 during Event 3.

Sample Collection Procedures. There was a deviation from protocol during collection of the P6_14 sample collected on April 13, 2015. Nitrate-nitrogen is a PPS analyte and was detected at location P6_14 during Event 1; however, it was inadvertently left off the analyte list for Event 2. A separate additional sample was collected at location P6_14 on April 13, 2015. Since nitrate was the only parameter analyzed for this sample, the sample bottle was direct-filled instead of filled by using a stainless steel bailer.

No other issues associated with sample collection procedures occurred during the 2014-2015 wet season. Several samples needed to be collected from surcharged UICs; however, this is not generally believed to affect sample quality.

Field Data Documentation. Both the BES Field Leader and the Monitoring Coordinator review field documentation to ensure that sample collection was conducted according to

procedures specified in the SDMP and that documentation is complete. Field records document that:

- SAP protocols are followed
- Field corrective actions are tracked
- Field procedures do not affect samples (i.e., collection of appropriate QC samples)
- Safe work practices are followed (i.e., adherence to the Health and Safety Plan)

Specific field records maintained by BES include:

- DFRs, FDSs, and COC forms
- Health and Safety Plan
- Field meter calibration and maintenance records (as applicable)
- Sample collection standard operating procedures
- Storm event information
- Sampling event summaries

Field data documentation for sampling met the objectives identified in the SAP to the extent practicable and was determined to be acceptable.

7.3.2 Laboratory Data

Year 10 analytical data validation included, but was not limited to, a review of:

- **Timeliness**. Verified that laboratory analyses were conducted within the recommended analytical holding times. Samples not extracted or tested within the specified period were noted or flagged.
- **Detection Limits**. Verified that analytical detection limits for each analysis met the project-specific limits. Sample MRLs were less than the MADLs specified in the permit and met the MRLs proposed in the QAPP, except as noted in Appendix B.
- **Chain-of-Custody**. Verified that COC procedures were followed by the laboratory.
- **Reagent Blanks/Trip Blanks**. Verified that blanks did not contain any analytes. Analytes detected in the reagent blank indicate laboratory-introduced contamination that can be identified and flagged.
- **Matrix Spikes and Matrix Spike Duplicates** (MS/MSD). Verified that the percent recoveries between the spike quantity recovered and the known spike

value were acceptable. The relative percent difference (RPD) was calculated using the duplicate analyses results.

- **Surrogate Spike Analyses**. Verified that percent recoveries were within acceptable ranges.
- **Blind Duplicates**. Verified that the RPD between the original sample and the blind duplicate was acceptable.
- **Equipment Blanks/Field Decontamination Blanks**. Verified that blanks did not contain any analytes. Analytes detected in the blank indicate introduced contamination from field or decontamination processes that can be identified and flagged.

Year 10 analytical data were determined to meet the identified DQOs and to be of acceptable quality. All planned data were collected and analyzed, and all permit-required data were considered usable, although some only with associated qualifiers. Several results were rejected; however, these were duplicate semivolatile organic compound (SVOC) data reported as part of PPS analyses and were not needed or used for permit compliance or data analysis. (Note that because of the number of additional analyses needed for PPS analytes, duplicate results were reported for many PAHs, phthalates, and some herbicides.) Year 10 monitoring resulted in a data completeness that exceeded the 95 percent goal set in the QAPP. Table 7-2 summarizes data QA/QC issues identified during the data validation process, as described below. Appendices B, E, and F include the following information used for data validation:

- WPCL Laboratory Analysis Reports
- Subcontract Laboratory Analysis Reports
- Data Usability Report
- Year 10 Analytical Data (e.g., Access© database, City of Portland Janus database)

Validation occurred throughout the sample collection and analytical process. Initial validation was conducted during sample receipt and log-in and included the following steps:

- Examination of the integrity of sample containers and labels, including suitability of containers for requested analyses
- Examination of the COC form for the presence of all required information and signatures
- Verification of sample container identification numbers against those listed on the COC form

Laboratory data validation also occurred during sample analysis and was carried out at the instrument by the analyst. This phase of validation involved performing and maintaining instrument calibration and assessing precision and accuracy of the data via

the analysis of the appropriate QC checks by the individual laboratories. The analyst ensured that the QC statistics were within control limits and took appropriate corrective actions during analysis if control limits were exceeded.

Laboratory data validation also included checking the data reduction and transcription/ data entry operations used to calculate final results. An analyst or chemist other than the one who conducted the analysis, but who was fully knowledgeable about the analysis, conducted this validation. Results were verified against the raw data, including checking calculations, use of correct units and/or conversion factors, and use of correct sample preparation conditions. The technical reviewer also confirmed that all relevant previous validation checks were applied correctly and that QC statistics were within control limits.

Results that did not meet quality criteria were flagged by TA, WPCL, WPCL QA Coordinator, or BES Investigation and Monitoring Services (IMS) staff. Selected samples were flagged by the WPCL QA Coordinator, using customized flags as described in the comments section of the WPCL Laboratory Analysis Reports and database. Subcontract laboratories used customized flags to communicate QC issues. Definitions for these data flags are included in the data reports (see Appendix E). Data qualifiers were assigned through project data validation and are defined in the *Data Usability Report* (see Appendix B). Most laboratory-assigned flags were carried through using project-specific data qualifiers, and additional qualifiers were assigned through data usability assessment.

The analytical data were entered into BES LIMS, and hard copies of the entered data were checked for data entry errors. After sample results (TA and WPCL) had undergone technical and data entry review, the WPCL QA Coordinator electronically marked the sample in LIMS. The mark indicates that all analyses for that sample are complete and have been checked for errors. Final laboratory reports were then generated and provided to the IMS Monitoring Coordinator. The data were released to the UIC program for use following preliminary data usability and field QC sample data review for each event by IMS.

Table 7-2 summarizes all noteworthy laboratory QC issues identified during the 2014-2015 wet season. The WPCL QA and IMS Monitoring Coordinators reviewed all QC issues. These issues are discussed in the comments section of the WPCL Laboratory Analysis Reports (see Appendix E) and/or the *Data Usability Report* (Appendix B). Additional detailed flags may be found on the Subcontract Laboratory Analysis Reports.

7.4 Monitoring Program Corrections

Any unusual condition that occurred during a monitoring event and could affect the monitoring results was noted and, if necessary, corrected. These conditions may be

classified as a deviation, nonconformance, or occurrence.[5] This section discusses conditions or issues related to field sampling and laboratory activities.

7.4.1 Deviations, Nonconformance, and Occurrences

Several deviations from the QAPP occurred during the 2014-2015 monitoring season, including deviations from sample collection procedures, QC sample collection, and laboratory and/or laboratory analytical methods. These deviations are described below:

- As noted in Section 7.3.1, there was one deviation from sampling protocol for sample location P6_14; however, data were consistent with past results and data quality is not likely affected.

- Because of an oversight, volatile organic compound (VOC) trip blanks were not collected, although VOC field and equipment blanks were collected. Over the first 9 years of the permit, only one analyte has been detected in a VOC trip blank, and it was likely introduced outside the laboratory. Since there were no detects in the field or equipment blanks, this is not anticipated to affect data quality. VOC trip blanks are typically used to identify contaminants such as methylene chloride or chlorofluorocarbons (e.g., freon) that can pass through the septum of a VOC vial. These contaminants are not currently expected to be associated with stormwater.

Several of the PPS analyses were conducted by laboratories and/or methods that differed from those presented in the QAPP (City of Portland, 2012a). PPS analytes were last reported in Year 4, and changes were primarily to ensure that MRLs were lower than MADLs and to improve efficiency where possible because of the large volume of sample bottles that needed to be filled at each sampling location during Event 1 (21 at each sampling location, 42 total for sample plus field duplicate). Laboratory and method deviations are summarized on the following page.

No other deviations, nonconformance, or occurrences were noted during the 2014-2015 wet season.

[5] A **deviation** is a planned or unplanned departure from a procedure deemed reportable and tracked by the City's UIC Program Manager. **Nonconformance** is a deficiency in characteristics, documentation, or procedures that renders the quality of an item or activity unacceptable or indeterminate. An **occurrence** is any condition or event that could affect the health and safety of the public, have an adverse effect on the environment, endanger the health and safety of workers, affect the operations and intended purpose of a facility, or result in loss or damage of property.

Summary of Laboratory and Method Deviations

Analyte	New/Old Lab	New/Old Method	Comments
Bis(2-chloroethyl) ether Bis(2-chloroisopropyl) ether	ALS/TA	8270D/8270C	Used ALS to meet required reporting limits
Alachlor Atrazine	PAL/TA	8081B Mod/8081	Not reported by ALS (8270D), reported as part of PAL Multi-Residue Screen
Carbofuran	PAL/TA	8321B Mod/531.2	Reported as part of PAL Multi-Residue Screen
Chlordane (tech) Lindane	PAL/TA	8081B Mod/8081	Reported as part of PAL Multi-Residue Screen
Diquat Glyphosate	PAL/TA	No change 547.2/547	Sampling efficiency (i.e., fewer sample bottles)

7.4.2 Field Corrective Actions

A field corrective action is initiated if problems associated with field measurements or field sampling equipment are observed. No corrective action was taken during the 2014-2015 wet season.

7.4.3 Laboratory Corrective Actions

The QAPP requires a laboratory corrective action to be initiated if problems associated with laboratory procedures or equipment are observed. These problems and associated corrective actions would be documented in a corrective action report specific to the laboratory in question. No corrective action was taken during the 2014-2015 wet season.

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Section 8

8 References

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