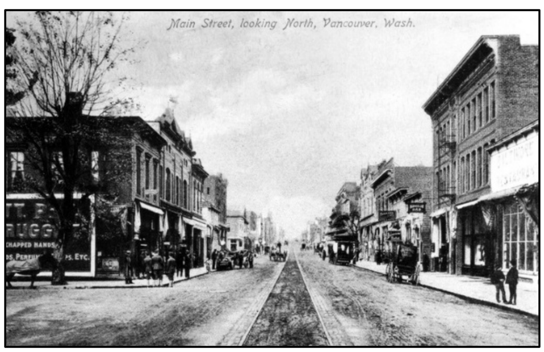
DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan

Columbia River Basin (Clark County WA) Local Source Control Monitoring for Toxics: Phase I - Screening Study



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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1703102.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID JMED0001.

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Cover photo
Left: Main and 6th Street looking north, City of Vancouver, ca. 1920, Charles A. Gauld.
Right: Google Earth street view, 2015.

Quality Assurance Project Plan

Columbia River Basin (Clark County WA)
Local Source Control Monitoring for Toxics:
Phase 1 – Screening Study

January 2017

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EAP: Environmental Assessment Program
HWTR: Hazardous Waste and Toxics Reduction
LSC: Local Source Control
NPDES: National Pollutant Discharge Elimination System

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2.0 Abstract

Stormwater runoff and transport of persistent pollutants due to urban land-use activities present a threat to the health and protection of Washington State's receiving waters and designated uses (water supply, fish, shellfish, wildlife, recreation, agriculture, industry, navigation, and aesthetics). Persistent pollutants such as mercury, flame retardants, polychlorinated biphenyls, and heavy metals have been showing up in "hot-spots" around the state. Source control has been identified as one of the most effective means of reducing stormwater pollution as it reduces their disbursement at the source.

Local Source Control (LSC) staff from the Washington State Department of Ecology and the Clark County Public Works Clean Water Division will work in partnership to identify and prioritize sites for Municipal Separate Stormwater Sewer System (MS4) screening and analysis. Screening will target a broad range of toxic parameters. Findings will assist in selecting sites and prioritizing parameters for future phases of the project which include effectiveness and hot-spot identification. The study will target commercial drainages within the unincorporated areas of Clark County.

3.0 Background

In 2007, the Washington State Legislature allocated funding to establish the Local Source Control Partnership, a technical assistance program that helps small quantity generators (those generating under 220 pounds of dangerous waste or less than 2.2 pounds of highly toxic waste in a month), who (1) are largely unregulated under current programs, and (2) manage and reduce toxics to prevent pollution and protect water quality.

The Washington State Department of Ecology (Ecology) funds and supports Local Source Control (LSC) Specialists throughout the state to provide technical and regulatory assistance to small businesses. LSC assistance is being applied towards preventing spills, identifying illicit wastewater discharges, correcting problems with oil/water separators, ensuring storm drains are protected, and protecting employees through properly storing and labeling chemicals and hazardous waste. Originally, the LSC partnership was limited to the Puget Sound basin and the Spokane River basin. LSC has now expanded to include the Columbia River basin.

As the LSC is expanded into the Columbia River basin and other priority watersheds, Ecology is seeking an efficient source control monitoring program to conduct sampling and testing and also assess sources of contamination from stormwater and point sources. The intent of this programmatic Quality Assurance Project Plan (QAPP) is to develop such a program and serve as a foundation as more information is collected and details for future phases of the QAPP become clearer. The pilot study will consist of three phases:

- Phase I - Pollutant Screening.
- Phase II - Before After Control Impact (BACI) Study.
- Phase III - Hot-Spot Identification and Prioritization for Future Source Investigation.

This QAPP begins with Phase I - Pollutant Screening. Phases II and III will be added as an addendum to this QAPP after the screening phase is complete and sufficient data can be collected. The pollutant screening phase is key in eliminating parameters from the study that are not detected in the MS4 system, freeing up resources for those parameters that are found.

Ecology's LSC program staff will work in partnership with the Clark County Clean Water Division's LSC Specialist to identify and prioritize MS4 drainages for screening. This study will be implemented in targeted commercial drainages in the unincorporated areas of Clark County.

Study parameters for screening will include LSC program-targeted parameters (most likely to be reduced through business source control) and persistent toxic pollutants. Persistent toxic pollutants will be screened to develop a better understanding of their concentrations and sources in the Columbia River basin. Screening findings will serve to determine the feasibility of, and to prioritize, parameters and sites for implementation of Phase II and III follow-up studies.

This QAPP has been prepared in accordance with the Washington State Department of Ecology's guidelines and serves to implement quality assurance (QA) for program planning, monitoring, analysis, and reporting. The following sections detail these proposed activities.

3.1 Study area and surroundings

Clark County is located in the Columbia River basin in Southwest Washington. The county is bordered by the Columbia River to the west and south, and the east fork of the Lewis River to the north. The total area of Clark County is approximately 656 square miles, and the population is over 459,495 according to the US Census Bureau's 2015 Quick Facts (Census, 2015). Of the total population, approximately half can be found in the County's incorporated cities (in order from greatest population to least) of Vancouver, Camas, Battleground, Washougal, Ridgefield, La Center, and Yacolt, and (Census 2015). The other half of the population is in the unincorporated areas of Clark County.

The LSC partnership area includes the unincorporated areas of Clark County covered under the State of Washington's 2013-2018 NPDES Phase I Municipal Stormwater Permit (Ecology, 2012), an area of approximately 549 square miles. The boundaries of the permit area can be seen in Figure 3-1.

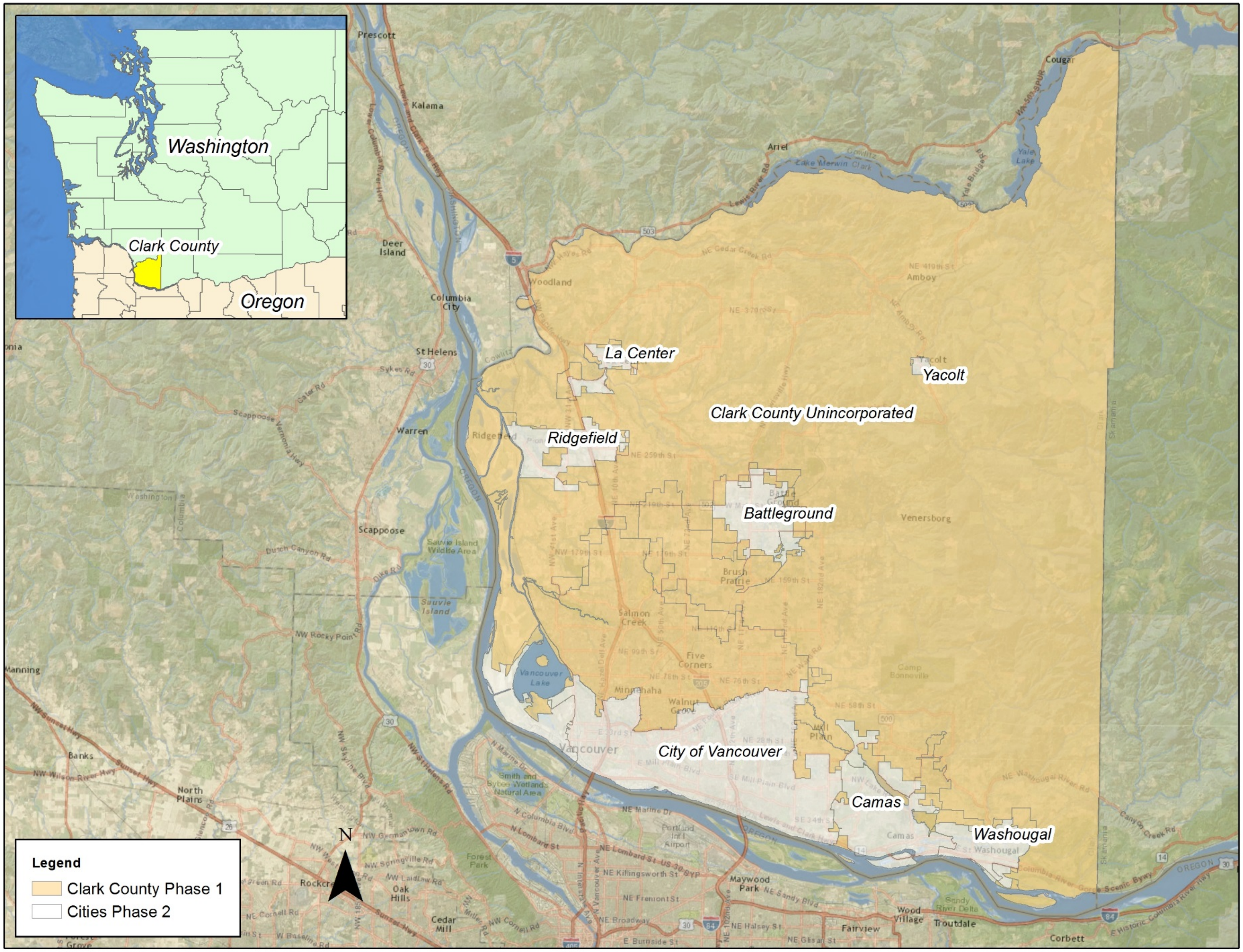

Figure 1. Clark County Phase I Permit Area.

Clark County contains four major ecoregions: the Portland Vancouver Basin, the Valley Foothills, the Western Cascades Lowlands and Valleys, and the Western Cascades Montane Highlands (from west to east respectively) (EPA, 2016). These ecoregions can be used to characterize topography and population distribution. Populous areas in the County are built within the low-lying Portland Vancouver basin and the foothill valleys in the western portion of the County adjacent to the Columbia River, with increasingly sparser population spanning east through the Western Cascades Lowlands and Valleys and the steeper slopes and higher elevations of the Western Cascades Montane Highlands along the western fringe of the Cascades.

This study is targeting surface water toxics, which can be directly linked to anthropogenic activities. The highest density of anthropogenic activities can be found in the most populous areas of the County: the Portland Vancouver Basin and the Valley Foothills.

Human influence is most appreciable in the southern portion of the County along the Columbia River in the City of Vancouver. From Vancouver, population sprawls along major arterial corridors northwards, currently rapidly expanding towards less developed portions of the County within the Portland Vancouver Basin Ecoregion.

The annual mean precipitation for Clark County varies with elevation. In the lower elevation along the Columbia River (adjacent basin and lowlands and valleys), annual precipitation ranges from 35 to 60 inches. In the higher mountainous elevations to the north and east, precipitation ranges from 70 to 110 inches (NOAA, 1973) due to the orographic effects of the Cascades.

Major watersheds in Clark County include (10-digit HUCs): Middle Lewis River, Lower Lewis River, East Fork Lewis River, Washougal River, Salmon Creek-Frontal Columbia River, and Hayden Island-Columbia River. Rivers, creeks, and surface waters in the County generally trend from the mountainous areas to the north and east, and flow southerly and westerly towards their terminus at the Columbia River. A majority of rivers and creeks within Clark County make their way to confluence with the Columbia River. Rivers and creeks within the County receive runoff from the County's MS4 system. The MS4 system receives urbanized/developed impervious surface flows, which can lead to the accumulation of toxic pollutants during dry periods of the year.

Land use in the permit area, based on Ecology's land-use data shapefile, can be found in Table 1, (Ecology, 2010).

As seen in the table, a majority of land use in the Clark County Phase I Permit area is residential, followed by undeveloped land, non-commercial forest, commercial forest, and open space. Land use plays an important role in the generation and distribution of toxic pollutants to surface waters. This study will target commercial and industrial sources of pollutants, which accounts for approximately 3% of the study area's land use. Though commercial and industrial land use comprise a minority of total land use, analysis of Phase I Municipal Stormwater Permit Monitoring data from 2009 to 2013 shows that these land use types produce the highest concentrations of toxics (Hobbs et al., 2015).

Table 1. Land Use in the Clark County Permit Area.

Land Use[1]	Acres	Percent Permit Area
Agriculture	4304.4	1.7%
Aircraft Transportation	137.9	0.1%
Amusements	507.4	0.2%
Commercial	7154.0	2.8%
Commercial Forest	27094.6	10.5%
Industrial	456.8	0.2%
Non-commercial Forest	27439.2	10.6%
Open Space	12883.2	5.0%
Public Assembly	687.6	0.3%
Residential	126641.9	48.9%
Transportation	552.6	0.2%
Undeveloped Land	50823.7	19.6%
Utilities	272.2	0.1%
Total	258956.6	100.0%

[1] Land use types whose area is < .1% were not displayed.

3.1.1 Logistical problems

Rain events and the timing of storms for screening studies present logistical concerns. Additionally, coordinating with Clark County to provide access (to manhole covers) or sites may be needed. The County's LSC Specialist will be the point of contact for coordinating activities under this study.

3.1.2 History of study area

Clark County began its current stormwater management program in the late 1990s with the first Phase I NPDES stormwater permit issued in 1999. The county program included legal authority to control pollutant discharges to the county MS4, storm sewer system mapping, development regulations equivalent to the state manual, source control standards, a stormwater capital improvement program, illicit discharge detection and elimination, storm system operation and maintenance, and an education and outreach program.

The County enacted a water quality ordinance in 1998 prohibiting the discharge of pollutants to surface water, groundwater, and storm drainage systems.

The 2007 Phase I general municipal permit, which included Clark County, Snohomish County, King County, Pierce County, Seattle, and Tacoma initiated the systematic source control inspection program for sites that are probable pollutant generators. Clark County began its current source control program in 2008.

As required in the 2012 NPDES permit, Clark County has been monitoring stormwater and sediment at three sites, to track pollutant trends over time. In addition, the County has been conducting business and storm-drain inspections.

Special monitoring and studies in the region have also been conducted by stakeholders to characterize and find solutions to curbing and offsetting surface water run-off pollutants and accumulative and persistent toxic effects on the environment (see Section 3.1.3 for study details).

3.1.3 Parameters of interest

The LSC monitoring program will target persistent toxics and indicator parameters in support of the LSC partnership's goal to reduce their sources. Parameters of interest were chosen based on the following criteria:

- Constituents of Emerging Concern - Parameters recently targeted for their persistent and bio-accumulative effects on the environment that have been found ubiquitously in the environment.
- Results from stormwater and sediment status and trends monitoring under Clark County's NPDES Phase I permit area as well as regional studies and investigations.
- Project stakeholder input, including Clark County Clean Water Division input and Ecology's Hazardous Waste and Toxics Reduction Program input (regarding analytes of concern and scope of work).
- Clark County's Phase I Municipal Permit requirements for stormwater and sediment monitoring parameters.

Parameters were refined through review of the Western Washington NPDES Phase I Permit Final S8.D Data Characterization, 2009-2013 findings (Hobbs et al., 2015). The S8.D data characterization study provides information in regards to the concentrations of parameters that can be expected to be found in the County's MS4 system for both stormwater and sediment.

Table B-1 (Appendix B) details the proposed stormwater and sediment parameters monitored under the program, their common sources, and potential health effects on aquatic and terrestrial organisms (ATSDR, 2016).

3.1.4 Results of previous studies

Previous and ongoing water quality studies and programs in the County were reviewed through query of Ecology's Environmental Information Management system (EIM). A summary of this review can be found in Table 2.

As summarized in the table, frequently found toxics through monitoring and analysis in the Clark County region of the Columbia River basin include: DDT and degradates, diesel hydrocarbons, metals, PAHs, PBDEs, PCBs, and phthalates/plasticizers. Toxics were found at highest concentrations in drainages with urban high density, commercial, and industrial land uses. These studies were conducted by Ecology, the United States Geologic Services (USGS), the City of Portland, and Clark County.

Table 2. Summary of Previous Study Findings.

Study Name	Parameters	Summary of Findings
Western Washington NPDES Phase I Stormwater Permit: Final Data Characterization 2009-2013 (Hobbs et al., 2015)	Comprehensive, permit required	Composite stormwater and sediment monitoring of commercial and residential land use areas. Metals (except mercury), PAHs, Diesel, and Phthalates were most frequently detected in stormwater.
Burnt Bridge Creek PCB and Dieldrin Screening (Ecology, 2014)	Sediment- PCB and Dieldrin	Dieldrin concentrations in water were high for fall and spring, and PCB in sediment was moderate.
Seasonal Water Quality Study Vancouver Lake Tributaries for PCBs, Dioxin, and Chlorinated Pesticides (Ecology, 2010)	Sediment- PCBs, Dioxin, Chlorinated Pesticides	PCBs exceeded FTEC levels in all seasons and dieldrin in Burnt Bridge Creek. Burnt Bridge Creek was ranked the most contaminated site in the study.
Source Identification and Control in Stormwater Conveyance Systems - Portland Harbor (City of Portland, 2009)	Sediment- PCBs, PAHs, Pesticides, Metals, and Phthalates	PCBs found at all land uses with highest concentration at historic and current industrial land uses.
Columbia River Basin: State of the River Report for Toxics (EPA, 2009)	Mercury, DDT, PCBs, and PBDEs	Study found that the main toxic contaminants in the Columbia River were mercury, DDT, PCBs, and PBDEs.
Columbia River Contaminants and Habitat Characterization: Tracking the Occurrence and Food-Web Effects of Polybrominated Flame Retardants and Endocrine Disrupting Compounds, FY08-FY11 (USGS, 2012)	Poly Brominated Flame Retardants and EDCs	Investigation of transport pathways, chemical fate and effects of PBDEs and EDCs in aquatic media and through several levels of the food-web in the Lower Columbia River. Target contaminants were found at levels of concern in the food web.
Contaminants in Wastewater-Treatment-Plant Effluent and Stormwater Runoff, Columbia River Basin, Washington and Oregon, 2008-10 (USGS, 2012)	Flame Retardants, PCBs, Pesticides, Miscellaneous, PAHs, Trace Elements	Parameters were detected in 58% of all stormwater runoff samples.
Spatial and Temporal Trends in occurrence of emerging and legacy contaminants in the Lower Columbia River 2008-2010 (USGS, 2013)	Organic Toxics	Sampling along 86 miles of the Lower Columbia River basin over 3 years to determine spatial and temporal trends of organics. Lower concentrations in rural and higher in urbanized areas. Industrial chemicals, plasticizers, and PAHs were present at highest concentrations.
Flame Retardants, A Report to the Legislature (Ecology, 2015)	Flame Retardants	Flame Retardants PBDEs are found ubiquitously in Washington State's environment. TPP, PBDEs, and Dechlorane Plus have been found in sediment samples in the Lower Columbia River, with TPP being detected at highest levels.
Quality Assurance Project Plan: Statewide Survey of Per- and Poly-fluoroalkyl Substances in Washington State Rivers and Lakes (in draft)	PFAS	Washington State is developing a chemical action plan to address Perfluoroalkyl Substances (PFASs). PFASs have been found to be widespread, highly persistent, and bioaccumulative in the environment.

TPP: triphenyl phosphate

The most extensive (and relevant) monitoring effort in the permit area to date is the County's Status and Trends stormwater monitoring program. Under the Municipal Phase I Permit requirements (Ecology, 2012), the County has implemented the multi-year Status and Trends monitoring program (2010-2015) to characterize the quantity and quality of stormwater from one commercial and one high-density residential land use area. The program also collects annual sediment samples. Data collected are being used to assess long-term changes in pollutant loadings and stormwater quality. Table B-2 (Appendix B) summarizes data collected under the County's Phase I Permit Status and Trends Monitoring Program.

For comparison to standards (as available), a percent exceedance and criteria type are defined in Table B-2. As seen in Table B-2, dissolved lead, copper, and zinc were detected in almost all stormwater samples and exceeded water quality standards 15-21% of the time (Ecology, 2012a). Several PAH compounds in stormwater exceeded the EPA's National Toxics Rule (NTR) (EPA, 1992). Herbicides and insecticides were largely non-detected during the monitoring period and were deprioritized as a monitoring parameter for this study.

Phthalates were shown to exceed the NTR on some events. PCBs in sediment were not detected in any of the samples, but the recommended test method was low resolution, thus a high reporting limit. The study will resample for PCBs using higher resolution methods to ensure PCBs are not problematic. Petroleum hydrocarbons found in the form of diesel were detected in a majority of sampling events for stormwater. Flame retardants and perfluoroalkyl substances, not collected under the County's monitoring regime, will be monitored, due to their persistence in the environment.

Not all parameters can be analyzed for. This study seeks to characterize current or recent-use toxics. As a persistent, legacy, banned-use toxic, DDT and associated degradates will not be monitored in this study.

3.1.5 Regulatory criteria or standards

Regulatory criteria and standards for both sediment and stormwater will be used to (1) assess when toxics are at a level of concern and (2) identify sites in need of further investigation. Washington's sediment management standard criteria will be used to compare the study's proposed initial sediment screening results (Brown, 2016).

Stormwater criteria will reference Human Health Criteria (HHC) to determine when study parameters are of concern (McGowan, 2016). Washington State updated and proposed new HHC, which were recently adopted into state rule. Approximately one-fourth of the Washington State updated HHC were approved by EPA. The other three-fourths were federally promulgated by EPA. The EPA ultimately adopted standards with the most stringent criteria. This study will screen stormwater data in alignment with the newly finalized HHC criteria for Washington State (Brown, 2016).

4.0 Project Description

Phase I of the project will screen sediment and stormwater to help refine the study's list of proposed parameters for further study in Phases II and III. Screening data collected will be used to characterize concentrations and sources of persistent toxics within Clark County's Phase I MS4 Permit area (Figure 3-1).

Monitoring under this study is not intended to be used for meeting the County's 2013-2018 Phase I Municipal Stormwater Permit (Ecology, 2012) requirements. Clark County is currently in compliance through implementation of (1) status and trends and Illicit Discharge Detection and Elimination (IDDE) monitoring, (2) business inspections and outreach, and (3) the Clark County Stormwater Management Plan (Clark County, 2016).

Ecology staff and Clark County Clean Water Division staff have worked in partnership to select drainages using site selection criteria developed for the study (Section 7.1.1.1). Selected sites are primarily commercial business areas with less than 50% residential land use.

Screening will monitor selected drainages from January through June 2017. After this period, an assessment of study results will be conducted. Parameters and drainage areas will be selected for future study phases based on results from this analysis. Sediment and water quality standards will be used as benchmarks to help prioritize parameters (detailed in Section 3.1.5). For parameters with no criteria, existing MS4 monitoring data will be referenced (Appendix B, Table B-2) and the median value of the parameter in question will be used as a benchmark. Also taken into account will be project budget, site access, and LSC partnership input.

The LSC program's highest priority is stopping pollution at its source. During the study period, the County's regularly scheduled MS4 operations and maintenance (per NPDES permit requirements) will continue. If illicit discharges are discovered or reported by the community within the study area during the study period, Clark County will act accordingly based on NPDES requirements.

4.1 Project goals

The goal of this phase of the project is to conduct water quality and sediment screening to characterize and prioritize parameters and locations for future phases of the study.

4.2 Project objectives

Study objectives relate to the screening of stormwater and sediment and the data analysis and prioritization process that follows. Section 7 of this QAPP, *Sampling Process Design* details actions supportive of these objectives. The following objectives will be implemented in coordination with the Clark County Clean Water Division:

- Screen stormwater pollutant concentrations in priority MS4 drainage-area outfalls and vaults from January through June 2017.

- Screen sediment pollutant concentrations in selected MS4 drainage area outfalls and vaults from January through June 2017 during antecedent dry periods.
- Analyze results and also condense and prioritize study parameters for focus in future phases of the study.

4.3 Information needed

Information needed for the study has been collected and incorporated into this QAPP.

4.4 Target population

The LSC monitoring program will (1) target commercial stormwater runoff and sediments in storm drains and (2) analyze for indicator inorganic and organic persistent toxic parameters.

4.5 Study boundaries

The study area boundaries include the unincorporated areas of Clark County, covered under the Phase I MS4 Permit (Figure 2). Clark County is located in Water Resource Inventory Area (WRIA) 27-Lewis and 28-Salmon-Washougal, and three Hydrologic Unit Code (HUC) 8-digit watershed boundaries listed below, and displayed in Figure 2 following:

- 17080001 – Lower Columbia River – Sandy
- 17080002 – Lewis
- 17080003 – Lower Columbia River – Clatskanie

The entire unincorporated area of the County was considered when selecting study monitoring sites and includes the three major watersheds (HUC 8) above. Study sites were ultimately selected in the Lower Columbia – Clatskanie watershed.

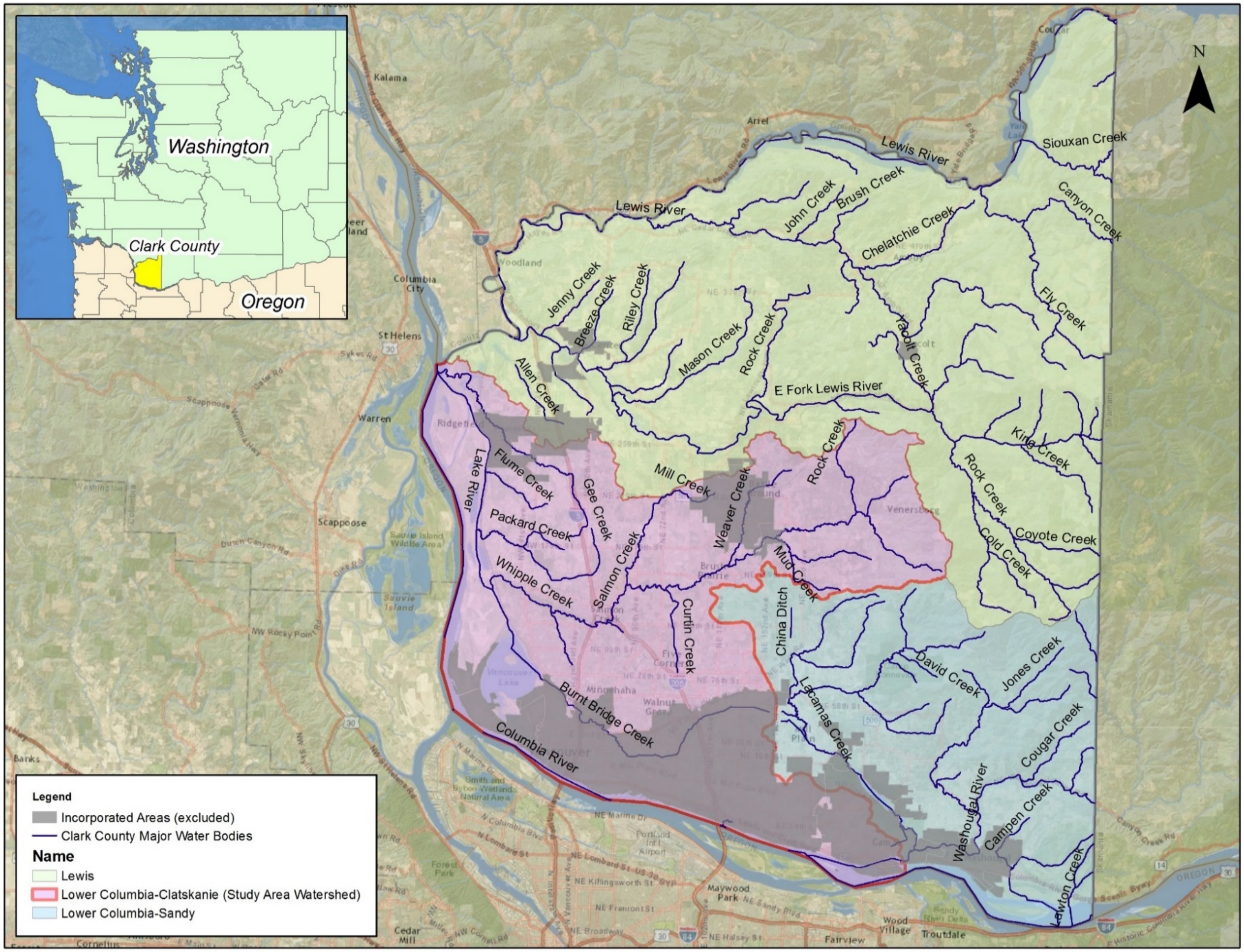

Figure 2. Clark County HUC 8 Watershed Boundaries.

4.6 Tasks required

Specific tasks for this study include:

- Spatial data and regional studies review.
- QAPP development.
- Monitoring site selection.
- Coordination with Clark County Clean Water Division Staff.
- December 2016 equipment inventory, ordering, and set-up.
- January through April 30, 2017 stormwater screening at selected sites.
- January through June 30, 2017 sediment screening.
- Screening study findings report (September 30, 2017) to inform stakeholders of study accomplishments and findings.

4.7 Practical constraints

The study will target stormwater events; precipitation forecast is not an exact science and storm events need to be timed succinctly to collect samples. To the maximum extent possible, all proposed stormwater monitoring will be completed.

During the screening phase, the project will not have sufficient funding to collect a large enough sample size for statistical analysis. In lieu, the study will take sediment and stormwater grab samples (snapshots) over a large area for 6 months to determine which parameters are elevated in concentration and in need of further study.

Monitoring will also capture pollutant sources that are not directly associated or linked to targeted commercial land use. These discharges may include: regional or aerial deposition, upstream residential run-off, automobiles and roadways, industrial illicit discharges, etc.

4.8 Systematic planning process

Preparation of this QAPP is adequate for systematic planning purposes.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 3. Organization of Project Staff and Responsibilities.

Staff	Title	Responsibilities
Ken Zarker/Peggy Morgan Local Source Control, HWTR Phone: 360- 407-6724	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Jim Medlen Toxic Studies Unit, SCS, EAP Phone: 360-707-6194	Project Manager and Principal Investigator	Writes the QAPP. Oversees field crew sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Bob Patterson Clark County, Clean Water Phone: 360-397-6118 ext. 4493	Senior Environmental Outreach Specialist	Coordinates LSC activities at Clark County Public Works.
Rod Swanson Clark County, Clean Water Phone: 360-397-6118 ext. 4581	NPDES Manager	Review of QAPP, Clark county monitoring supervisor, advises on program approach.
Debby Sargeant Toxic Studies Unit, SCS, EAP Phone: 360-407-6775	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Jessica Archer SCS, EAP Phone: 360-407-6698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory, EAP Phone: 360-871-8801	Director	Reviews and approves the final QAPP.
Ginna Grepo-Grove Manchester Environmental Laboratory, EAP Phone: 360-871-8829	QA Coordinator	Reviews QAPP, coordinates and obtains analytical services with contract laboratories. Validates the contract labs analytical data
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

HWTR: Hazardous Waste & Toxics Reduction Program.
EAP: Environmental Assessment Program.
EIM: Environmental Information Management database.
QAPP: Quality Assurance Project Plan.
SCS: Statewide Coordination Section.

5.2 Special training and certifications

Ecology staff responsible for development of the LSC program and field sampling are qualified to conduct work under this program through education and field experience; no special training is required. Monitoring work may require access to stormwater catch basins, which requires a confined spaces entry certification. Ecology staff are not certified to enter confined spaces; therefore, certified County staff will assist as needed. If the County does not have the staff resources necessary, confined spaces work will be reconsidered.

5.3 Organization chart

See Table 3 for the organizational chart.

5.4 Project schedule

Table 4 displays the project schedule.

Table 4. Project Schedule.

Stormwater Screening		
Product	**Due date**	**Lead staff**
Stormwater screening samples	January - April 30, 2017	Jim Medlen
QA review and analytical data validation	Each sample batch analysis	Ginna Grepo-Grove
Laboratory analysis completed	July 1, 2017	Jim Medlen
Sediment Screening		
Product	**Due date**	**Lead staff**
Sediment screening activities	January - June 1, 2017	Jim Medlen
QA review and analytical data validation	Each sample batch analysis	Ginna Grepo-Grove
Laboratory analysis completed	August 1, 2017	Jim Medlen
Environmental Information System (EIM) database		
EIM data loaded [1]	October 31, 2017	Jim Medlen
EIM data entry review [2]	November 30, 2017	Melissa McCall
EIM complete [3]	November 30, 2017	Melissa McCall
Reports		
Product	**Due Date**	**Lead Staff**
2017 Findings and Recommendations Report	September 30, 2017	Jim Medlen

[1] All data entered into EIM by the lead person for this task.
[2] Data verified to be entered correctly by a different person; any data entry issues identified.
[3] All data entry issues identified in the previous step are fixed (usually by the original entry person); EIM Data Entry Review Form signed off and submitted to Melissa McCall (who then enters the "EIM Completed" date into Activity Tracker).

5.5 Limitations on schedule

The LSC program's schedule will be adjusted as needed to target optimal weather conditions for performing the proposed sediment and stormwater monitoring.

5.6 Budget and funding

Table 5 describes the study's budget during year one. The study is funded on a biennial basis. The first allocation includes the 2016 and 2017 fiscal year (FY) biennium budget. Since 2017 is the first year of monitoring implementation, budget not spent in the FY 2016 will be used to conduct sediment screening and to purchase additional monitoring equipment and supplies. Table 6 details the Phase I project budget.

Table 5. Phase I Budget.

Parameter	Number of Samples/ year [4]	Number of QA Samples [2,3]	Total Number of Samples	Cost Per Sample	MEL Subtotal	Contract Fee[1]
Sediment Screening						
Percent solids	10	1	11	$15	$165	$0
Total organic carbon	10	1	11	$45	$495	$0
Grain size[1]	10	1	11	$100	$275	$1,100
Total volatile solids	10	1	11	$15	$165	$0
Metals (Ag,As,Cd, Co,Cu,Pb,Sb,Ti,Zn)	10	2	12	$167	$2,004	$0
Mercury (Hg)	10	2	12	$52	$624	$0
PAHs	10	2	12	$200	$2,400	$0
PCB (209 congeners)[1]	10	1	11	$800	$2,200	$8,800
Phthalates	10	2	12	$185	$2,220	$0
Petroleum Hydrocarbons (NWTPH-DX) + (NWTPH-GX)	10	1	11	$200	$2,200	$0
Flame Retardants	10	2	12	$800	$9,600	$0
PFAS[1]	10	1	11	$800	$2,200	$8,800
Stormwater Screening						
Total Suspended Solids	16	3	19	$15	$285	$0
Hardness as CaCO3	16	3	19	$25	$475	$0
Oil and Grease (HEM)	16	3	19	$60	$285	$1,140
Metals (Ag,As,Cd, Co,Cu,Pb,Sb,Ti,Zn) dissolved + total	16	4	20	$160	$3,200	$0
Mercury (Hg) Low level dissolved + total	16	4	20	$82	$1,640	$0
PAHs	16	4	20	$185	$3,700	$0

Parameter	Number of Samples/ year [4]	Number of QA Samples [2,3]	Total Number of Samples	Cost Per Sample	MEL Subtotal	Contract Fee[1]
PCB (209 congeners)[1]	16	3	19	$800	$3,800	$15,200
Petroleum Hydrocarbons (Dx and Gx)	16	4	20	$200	$4,000	$0
Phthalates	16	4	20	$200	$4,000	$0
Flame Retardants	16	3	19	$800	$15,200	$0
PFAS[1]	16	3	19	$800	$3,800	$15,200
[1] Constituents analyzed at contract lab. [2]Sediment screening and source tracing QA includes 1 field duplicate and 1 matrix spike/matrix spike duplicate charged by MEL laboratory for metals, organics, and hydrocarbons. [3]Stormwater samples include 2 replicates and 1 equipment blank for all parameters, and 1 matrix spike/matrix spike duplicate for organics, metals, and TPH per season. [4] Additional sediment and stormwater samples have been added to screening as a backup, or to sample receiving water if high levels are detected or suspected.			Sediment Screening Subtotal		$24,548	$18,700
			Stormwater Monitoring Subtotal		$40,385	$31,540
			Contracting Subtotal			$50,240
			Lab Grand Total		**$115,173**	
Equipment and Monitoring Supplies						
Misc Equipment and Supplies					$34,827	
Lab and Equipment Grand Total					**$150,000**	

MEL: Ecology's Manchester Environmental Laboratory.

6.0 Quality Objectives

6.1 Data Quality Objectives

Monitoring activities conducted under this project will follow Ecology's Standard Operating Procedures (SOPs). This project will not require additional data quality objectives (DQOs).

6.2 Measurement Quality Objectives

All measurement quality objectives (MQOs) for this study can be found and are detailed in Appendix B: Tables B-3 for stormwater and Table B-4 for sediment. Field equipment MQOs, which include pH, conductivity, and temperature can be found in Table B-5.

6.2.1 Targets for precision, bias, and sensitivity

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Precision will be measured as the relative percent difference (RPD) for replicate samples. If more than two replicate samples are analyzed, precision will be listed as relative standard deviation (RSD).

Quality objectives for precision, which include duplicate and matrix spike duplicate samples are detailed in Table B-3 for stormwater and Table B-4 for sediment.

6.2.1.2 Bias

Bias is the difference between the population mean and the true value and will be measured as acceptable % recovery. Bias is the systematic error due to contamination, sample preparation, calibration, or the analytical process. Most sources of bias are minimized by adherence to established protocols for the collection, preservation, transportation, storage, and analysis of samples. Check standards (also known as laboratory control standards, LCS) contain a known amount of an analyte and indicate bias due to sample preparation or calibration.

Acceptance limits for laboratory check standards can be found in Appendix B, Table B-3 for stormwater, Table B-4 for sediment, and Table B-5 for field parameters.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to isolate the concentration of a substance from the analytical method's background noise. Sensitivity is commonly described as reporting limit, or detection limit. Laboratory Reporting Limits can be found in Table B-3 for stormwater, Table B-4 for sediment, and Table B-5 for field parameters.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Section 8 details all SOPs for sediment and stormwater field monitoring.

6.2.2.2 Representativeness

Representativeness is the measure of how well a sample reflects environmental conditions. Ecology SOPs and sampling methods will be followed strictly to ensure representativeness is met.

6.2.2.3 Completeness

A minimum of 90% of proposed monitoring data will be collected under this project to be accepted as complete. If stormwater samples are postponed due to an unusually dry year, stormwater monitoring will be extended to the dry season, or following season, until all proposed monitoring events are captured.

7.0 Sampling Process Design (Experimental Design)

7.1 Study design

Phase I of the study has been designed to characterize sediment and stormwater quality in Clark County's MS4 system through screening to support future phases of the project. Screening is a necessary step in confirming the presence or absence of contaminants at priority sites and will ensure that more extensive and costly investigation/analysis is warranted.

Sediment from MS4 drainage-area outfalls and vaults will be collected from January through June 2017 during antecedent dry periods. An antecedent dry period is defined as less than 0.02″ precipitation in the preceding 48 hours. A total of one sample for each site will be collected.

Selected outfalls and catch basins will be checked for visual signs of illicit discharges during the sediment screening process. Coordination with the County's LSC specialist and their Clean Water Division will ensure that site access during screening and sediment collection is feasible and permitted.

Sites with elevated toxic concentrations, or which exceed the Washington Sediment Management Standards (Chapter 173-204 WAC), will be earmarked for prioritizing future toxic sources investigation.

During Phase I, the study will sample surface water during storm events at selected drainages in the wet season (January through April 30, 2017). One grab sample per storm event will be captured for each site. Samples will be analyzed for the project's proposed suite of parameters. Like sediment samples, stormwater parameters detected at levels in exceedance to existing regulatory criteria (human health criteria), or at elevated levels if no criteria exists (median value exceedance of existing MS4 data), will be selected for further investigation during future phases of the project.

At the end of the first year (June 2017), an analysis of stormwater and sediment lab results will be conducted. Parameters will be ranked and prioritized for future phases of the project based on lab results. Several metrics will be considered during this ranking process. These metrics include:

- Detection frequency of parameters.
- Concentrations of parameters and exceedances of action levels.
- Discussion and consensus of recommendations with project stakeholders.
- Cost feasibility of further investigation during future phases of project.

7.1.1 Field measurements

Field measurements during the screening and stormwater monitoring process will include pH, conductivity, temperature, and a qualitative estimate of flow. Standard Operating Procedures (SOPs) for field measurements will be strictly adhered to and can be found in Section 8 of this QAPP. If signs of an illicit discharge are detected during fieldwork, the Clark County Clean Water Division will be notified to investigate at their own discretion, and additional IDDE program field measurements and analysis may be implemented separately from this project.

7.1.2 Sampling location and frequency

Clark County's Municipal Phase I Permit area is approximately 549 square miles and contains over 4,040 miles of combined channels, culverts, ditches, and storm-drain line infrastructure.

Extensive background research and analysis are crucial in characterizing land-use practices. ArcGIS 10.2.2 was used for analysis of Ecology and the County's spatial data sets in shapefile format. For seamless viewing of data layers, shapefiles were exported to Google Earth. Following is a description of the 7 steps involved in the identification process:

1. Land-use parcel spatial data has been used as the foundation for the site selection process. Ecology's 2010 and Clark County's updated and dedicated land-use parcel shapefile was queried and selected for industrial and commercial land-use activities. Criteria found in the Municipal Permit, *Appendix 8 - Business and Activities that are Potential Sources of Pollutants,* were used as a reference in the site selection process.

2. To increase the efficiency of targeting toxic land-use activities, selected land-use parcels were qualitatively prioritized for internal review, based on a scale of 1-3 (highest priority = 1 to lowest priority = 3). Aerial imagery interpretation and best professional judgment were used to remotely ground truth selected land-use types (in total 875 land-use parcels were interpreted and prioritized for the Clark County Municipal Permit area). Following is a description of the priority scale:

   - Priority 1 **–** Parcels with pollution-intensive land-use activities, including, but not limited to: storage of junk vehicles, RV, auto, and boat repair bays, scrap metal stock piles and building materials, concrete manufacturing, mining activities, car washing and detailing, industrial cleaning, and nurseries. In general, stockpiles and pollutant-generating activities that are exposed to weathering, precipitation, and/or have the potential to be carried off-site via stormwater were categorized as a priority 1.

   - Priority 2 **–** Restaurants and shops that sell and dispose of food products, or light industrial uses with site containment (i.e., dumpster and wash out areas visible in aerial imagery, but no immediate threat). In general, land-use parcels categorized as priority 2 have the potential to generate toxic pollutants, but operations are covered in a building/structure.

   - Priority 3 **–** Commercial facilities with no visible signs of potential pollutant-generating exterior activities. The land-use parcel may contain a covered dumpster area and parking lot, but land use is primarily related to office activities (e.g., financial institutions, real estate brokerages, government buildings).

3. When sampling drainages with permitted industrial sites, a thorough review of the drainage area's permitted conditions and coordination with Ecology's municipal and industrial permit managers will be conducted to (1) ensure consistency with permit requirements and (2) prime compliance actions if pollutant sources are found.

4. A qualitative assessment of the County's MS4 storm-drain catchment area was conducted to de-prioritize areas receiving large upstream inputs from non-targeted land-use types (residential areas, parks, universities) to reduce background noise when monitoring. Using best professional judgment, data collection, and consultation with Clark County staff, proposed sites were filtered out. Tentatively, all proposed monitoring sites that receive effluent from residential areas greater than 50% of the total drainage area will be deprioritized.

5. A hydrologic review of the selected and prioritized sites was conducted using the National Hydrology Data (NHD) and the County's storm-drain GIS spatial data set. These data layers are analyzed to determine if a hydrologic connection to major tributaries and river systems exist; areas with hydrologic connections will be prioritized and chosen first for screening. Hydrologic connections will be determined by using the NHD overlay and aerial imagery to determine if tributaries or water bodies coincide with monitoring sites or reveal indication of riparian conditions, respectively. Sites that lack a visible hydrologic connection with receiving waters have been de-prioritized.

   A review of the County's on-line stormwater maps was used to identify flow direction, flow treatment areas, and best management practices (BMP) locations. In lieu of flow-direction data, invert elevation found in storm drain shapefiles or as-builts was used. Flow treatment and BMP location data assisted in determining engineered hydrologic alterations to the channel flow path (e.g., BMP detention/retention, bio-filtration) and was taken into account for locating monitoring sites.

   Monitoring will occur within the County's MS4 system. The Municipal Permit defines the MS4 system in *Section S.1 Permit Coverage and Permittees.* However, it may be necessary to (1) monitor upstream or downstream of the MS4 system to characterize influent and effluent flows and/or (2) conduct source tracing activities. Prior to monitoring or site access, the owner and operator of the MS4 or drainage system will be contacted for permission(s). If permission is not granted, the affected monitoring site will be moved up or downstream as feasible, or eliminated.

6. To maximize the potential for pollution reduction and provide context, an extensive data and water quality review was implemented in the preliminary stages of the project. This review resulted in the identification of current monitoring/source identification efforts and data gaps, hot-spots, legacy pollutants, permitted conditions (e.g., industrial, NPDES, construction, permits), and impaired or sensitive water bodies. The data review was a key component in determining monitoring site-selection and parameters chosen for monitoring. The following major sources were reviewed:

- Washington State Phase I Municipal Stormwater Permit – Provides municipal permit conditions, monitoring requirements and parameters, and land-use-based potential sources of pollutants.
- Environmental Information Management system (EIM) – State of Washington's data repository includes supplemental mapping of historic and on-going monitoring efforts and special studies, permit required monitoring, and monitoring results.
- Permit and Reporting Information System (PARIS) – State of Washington's permit database which contains the status of permitted land-use activities, locations, requirements, and permit-driven monitoring results.
- County Stormwater Management Plan – Municipal Stormwater Permit implementation and management strategies including IDDE program and Local Source Control (LSC) protocols and activities.

7. Accessibility to the County's MS4 system to conduct the proposed monitoring will be evaluated during the subsequent field screening phase. Coordination with the LSC Specialist and other pertinent County staff will be required due to the potential of monitoring within the County's MS4 system catch basins. Particularly, confined spaces entry during the source tracing phase of the project will require certified County staff. The County's maintenance schedule for catch basin and MS4 system cleaning will be requested, and coordination with the proper departments will occur to ensure that cleaning does not occur before a sediment sampling event.

In summary of Section 7.1.2 above, source control monitoring locations are selected based on land use and the current status of outreach activities within the targeted drainage areas. To qualify for monitoring, a drainage area could not have had source control outreach for 2-3 years under Municipal Permit activities or the LSC program. A considerable amount of time and effort was spent collecting spatial data and conducting aerial reconnaissance (Google Earth and ArcGIS) in order to effectively evaluate, rank, and prioritize land use parcels (875 parcels selected and ranked in Clark County). When considering drainage areas with industrial permitted sites, a thorough review of permitted conditions and coordination with Ecology permit managers will be conducted.

In November 2016, monitoring sites were visited based on the site-selection criteria detailed above in Section 7.1.1.1. A photo log which details the November site visits can be found in Appendix C. The photo log displays drainage location maps detailing the proposed sites, which include land use for each site.

Table 6 lists the study's monitoring sites.

Table 6. Proposed Monitoring Sites.

Site ID	Receiving Water	Latitude	Longitude
LS_NE102	Lower Salmon Creek	45.695832	-122.656969
LR_NW3RDCT	Lake River	45.726226	-122.677977
CC_NE85	Cougar Canyon Creek	45.684165	-122.669689
CC_CCAPT	Cold Creek	45.669422	-122.644967
BB_STJOHNSMINNEHAHA	Cold Creek	45.668908	-122.643628
SCTRIB	Salmon Creek	45.706814	-122.650331
WC_NE10NE149	Whipple Creek	45.724306	-122.674389

The study will visit selected outfalls and conduct sediment sampling once per site during dry-weather conditions in winter/spring 2017. Dry-weather conditions have been defined as an antecedent dry period, which has had less than or equal to 0.02 inches of rain in the previous 48 hours. A wet-weather storm event will be defined as >.2 inches of precipitation. Definitions of antecedent dry and wet weather can be found in Appendix 9 of the Municipal Permit, (Ecology, 2012).

Stormwater grab sampling will commence during the wet season, January to April 30, 2017, and will capture a minimum of one storm event per site during the screening period. In the rare event that the wet season does not produce a minimum of one precipitation event of >.2 inches, monitoring will continue into the dry weather season using the >.2 inches of precipitation criteria, until all, or as many storm events as feasible are captured. The first phase of the project will continue through June 2017.

7.1.3 Parameters to be determined

All proposed parameters (Appendix B, Table B-1) for the project are being screened in the first phase of the project to determine their concentrations. In the second phase of the project, parameters that are insignificant, or not detected, will be eliminated for future investigation. Additional parameters may be added during the second phase of the project based on screening results.

7.2 Maps or diagram

Figures 3 through 9 are maps of the project's 7 sample locations. These maps include percent land use of sample-site drainage area, MS4 stormwater lines, and other general information.

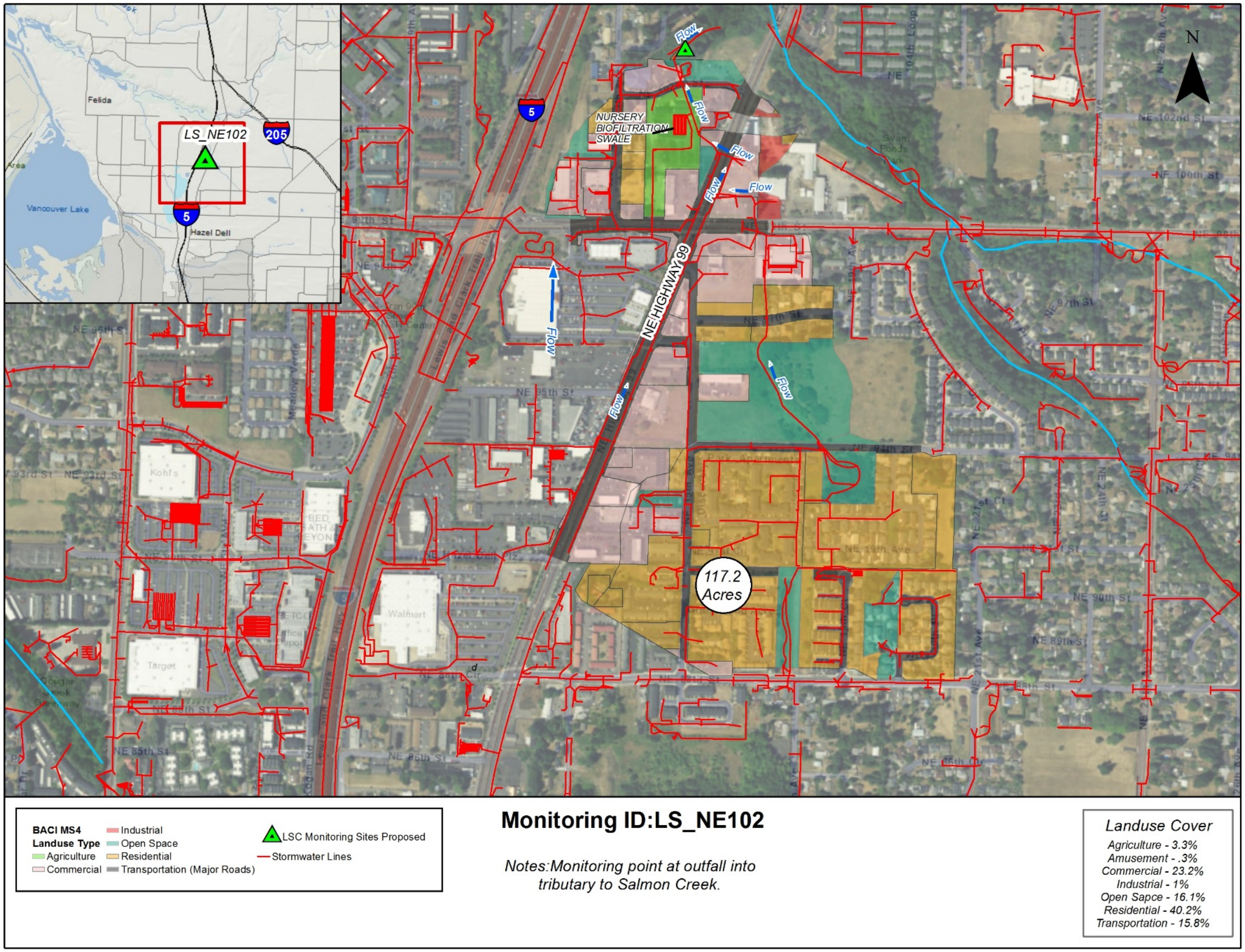

Figure 3. Outfall at tributary to Lower Salmon Creek - across from nursery.

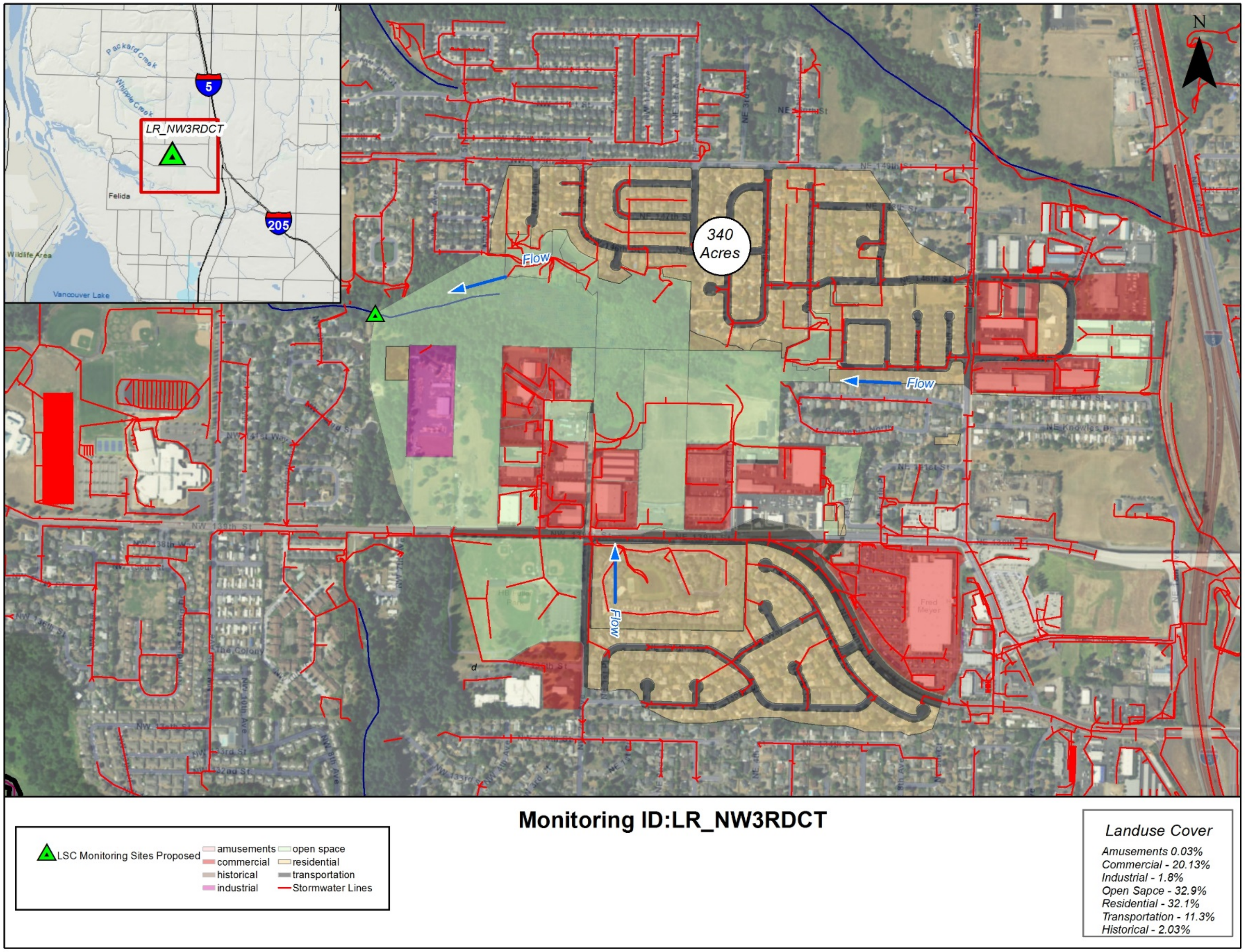

Figure 4. Lake River @ NW 3rd Court – Sample taken at park D/S.

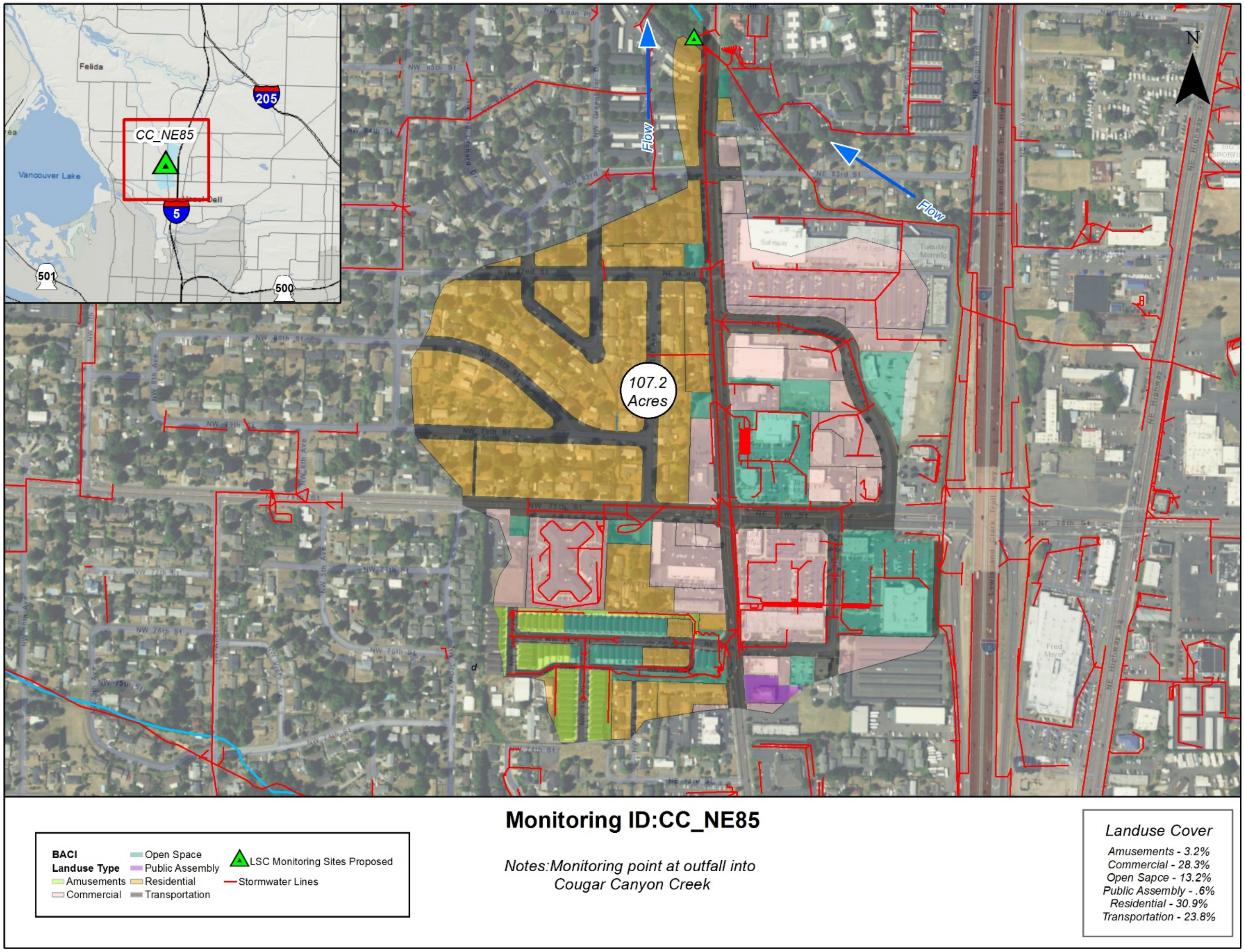

Figure 5. Cougar Canyon Creek Culvert Crossing @ NE Hazel Dell Ave and NE 85th Street.

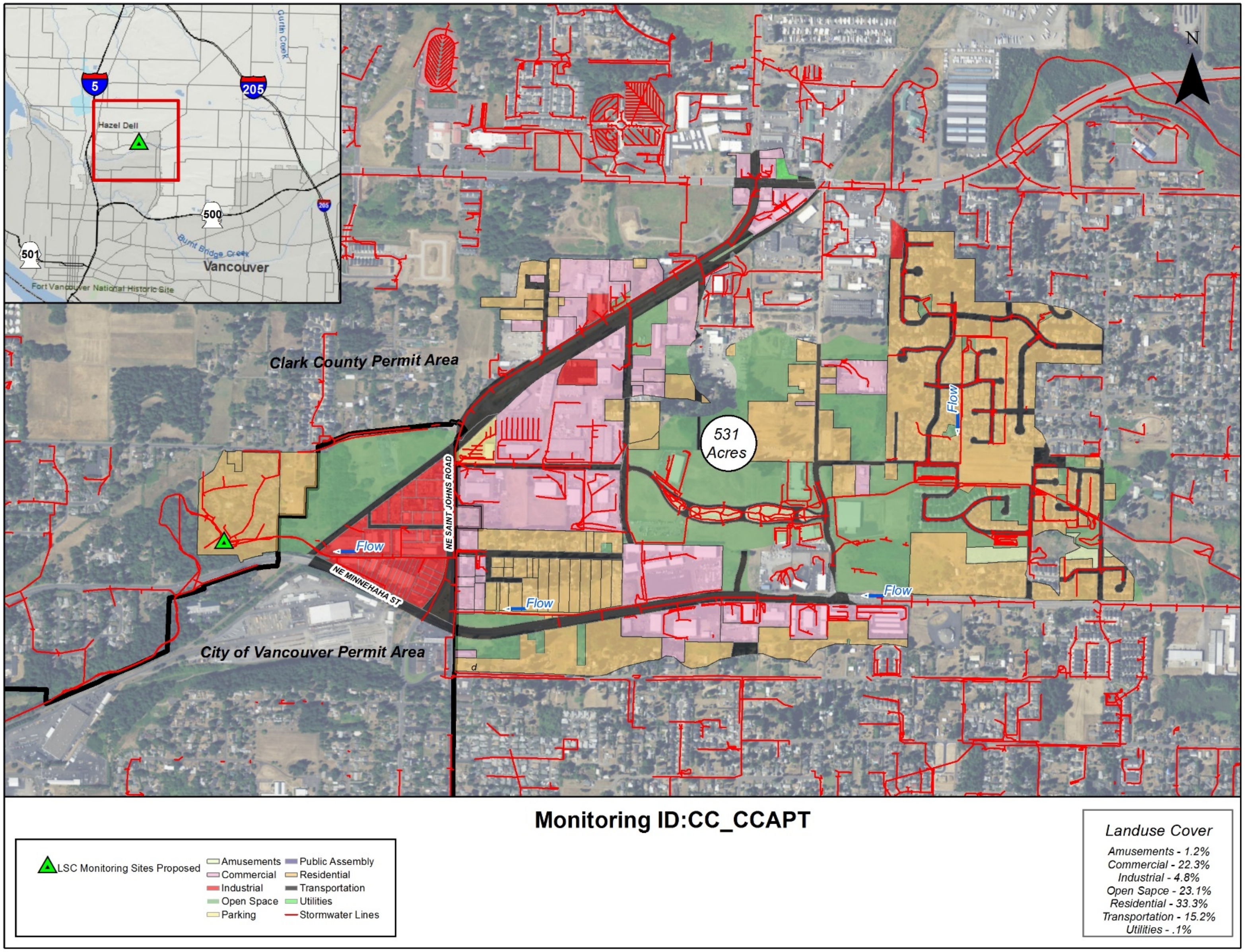

Figure 6. Cold Creek @ Crystal Court Apartment Complex.

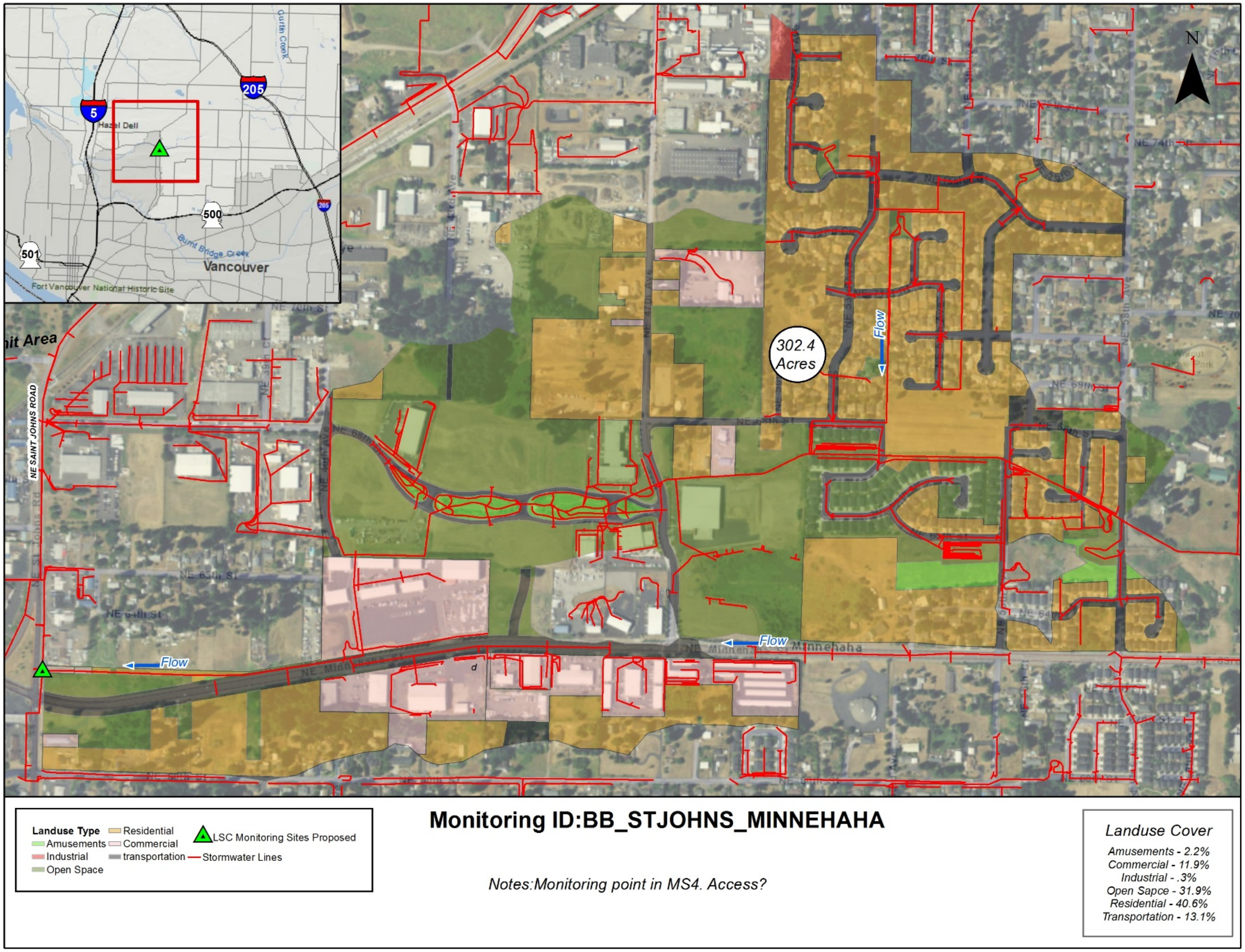

Figure 7. St. Johns Minnehaha V-ditch Drainage.

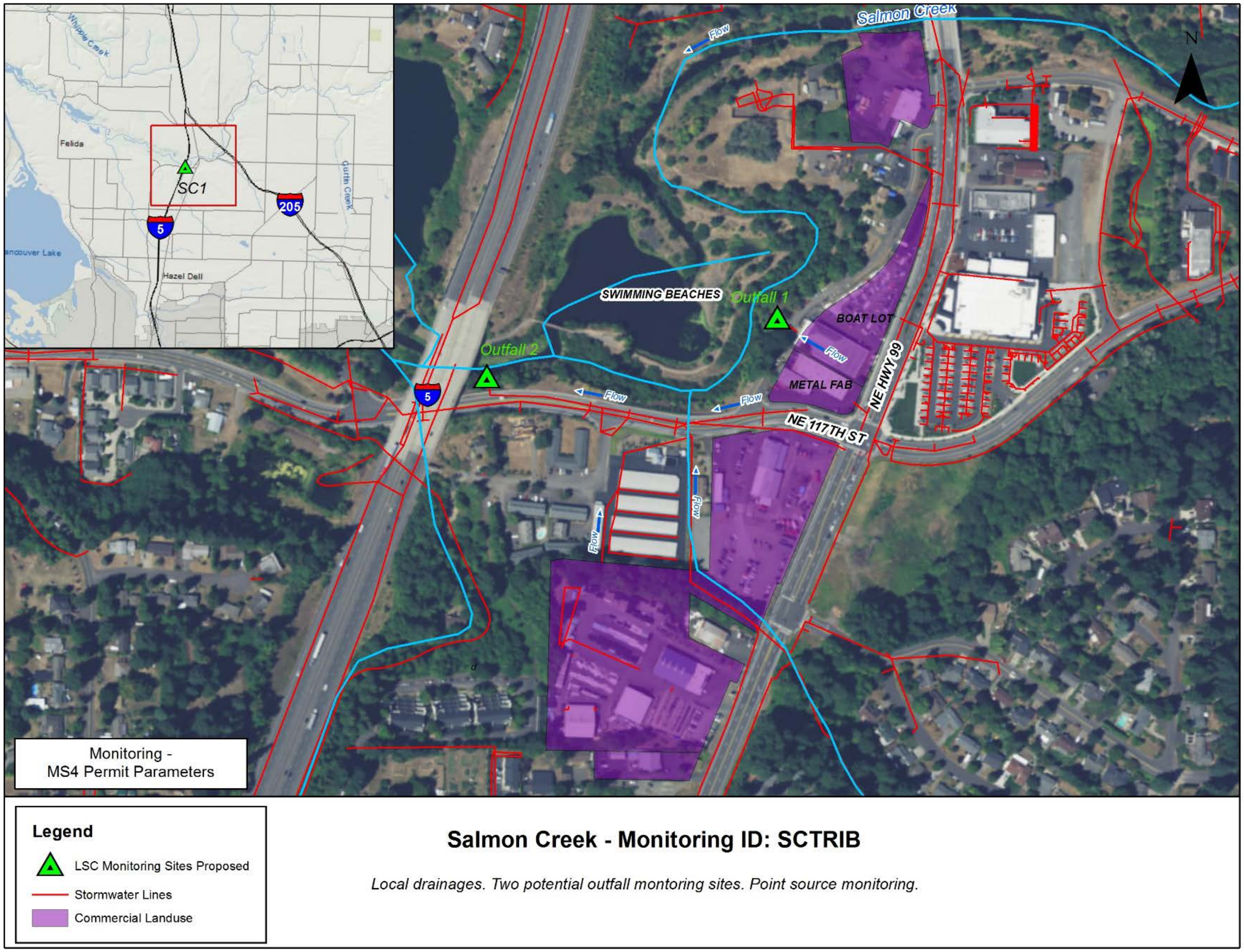

Figure 8. Highway 99 and NE 117th Street.

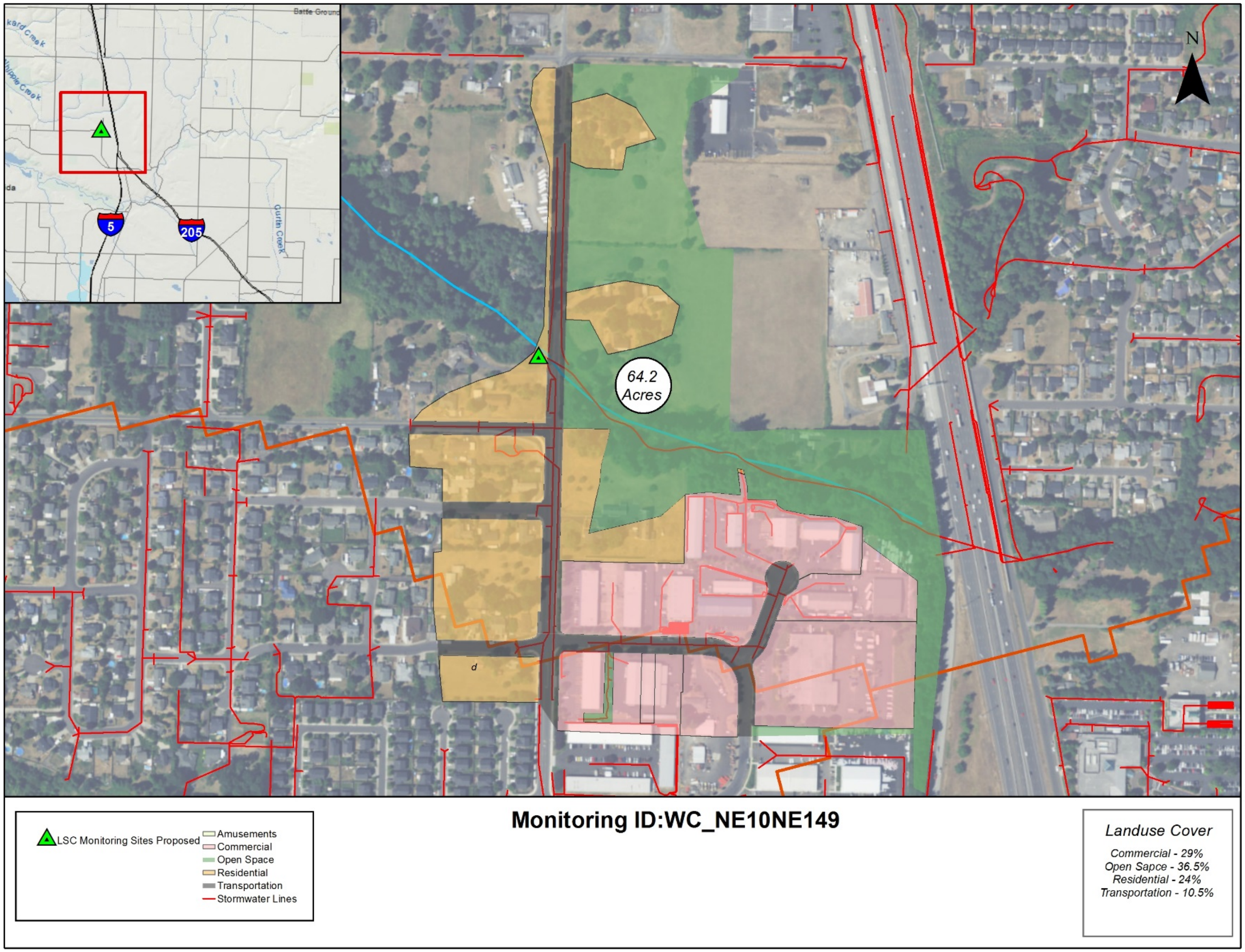

Figure 9. Whipple Creek Tributary.

7.3 Assumptions underlying design

The overall assumption is that the screening phase of the study will be adaptive in nature and flexible enough to modify if the proposed approach is insufficient, or needs to be refined, to meet project goals and objectives. Several assumptions which underlie the program's design are listed below.

- Aerial reconnaissance can be conducted to pre-identify and select monitoring sites with a high success rate, but must be reviewed by the County and be ground-truthed before monitoring commences.
- Toxic sources of pollutants are present in Washington State's urban water bodies, and their sources are most prominent at industrial and commercial land uses.
- Industrial sites not covered under the municipal permit and covered under separate industrial permits should not be ruled out as potential sources of toxic pollutants for investigation under this program.
- The screening process will indicate the presence or absence of toxic parameters at study locations.
- Screening will provide a general background of the expected pollutant concentrations during stormwater and sediment monitoring.
- Parameters not detected or in low levels in stormwater and sediment during the screening phase will be considered for elimination; regional monitoring study results will be referenced to verify.
- Sediment sampling in the County's storm-drain system will be conducted where confined spaces entry personnel are not required.
- Sediment will be of sufficient quantity and quality within the MS4 system; in lieu, sediment will be collected at the top-layer sediment of the outfall's immediate receiving water.
- Program data will support the County's efforts to identify and expand future source control priorities.

7.4 Relation to objectives and site characteristics

The study's objectives support the primary goal of screening the proposed parameters. The study design process followed objectives that helped in (1) targeting desirable drainages for toxics monitoring and (2) collecting appropriate data supportive of the study design.

Though the LSC study data collection efforts will not be as extensive in duration as Clark County's Status and Trends NPDES monitoring program, the study will collect data in areas of commercial/industrial land use that have not been monitored for toxics previously. Most importantly, the LCS study will attempt to quantify the effectiveness of the County's LSC outreach program and also prioritize drainages for future source tracing.

7.5 Characteristics of existing data

As discussed in Section 3, a long-term status and trends data set implemented in Clark County has provided insight into the concentrations of toxic pollutants found in commercial and residential land-use types in the study area.

For a complete summary of studies reviewed to determine the characteristics of existing data, see Section 3.1.3.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

This section will detail the program's water-quality-monitoring field measurement and sampling Standard Operating Procedures (SOPs). Approved Ecology SOPs will be used as reference.

8.1.1 Dry weather outfall screening and monitoring

8.1.1.2 Visual screening

Outfall and catch-basin reconnaissance was conducted in fall 2016. Site screening is planned for implementation in late January 2017. During the screening process, visual observations will be recorded, and signs of illicit discharges will be noted. Ecology, in coordination with the Clark County Clean Water Division, will visit outfalls and conduct visual observations. If indicators of illicit discharge are visible during screening, Clark County will be advised at their discretion to conduct Illicit Discharge Detection and Elimination (IDDE) inspections as well as field monitoring and analysis per established program protocols. The visual observations and field measurements in Table 7 will be consistent with Clark County's IDDE outfall screening program parameters.

Table 7. Outfall Visual Observation Parameters.

Category	Indicators
Outfall or Catch Basin Description	type
	shape and dimensions
	material
Physical Indicators - flowing outfalls	floatables
	odor
Physical Indicators - non-flowing outfalls	deposits/stains
Field Measurements - flowing only	discharge (estimated)
	temperature
	pH
	turbidity
	conductivity

Conditions for dry-weather screening are defined as an antecedent dry period of at least 48 hours with less than .02 inches of precipitation, as described in Appendix 9 of the Municipal Permit, (Ecology, 2012). In the rare event that the dry-weather period does not provide a window of opportunity for screening, or the timing is not feasible, the first opportunity in the wet season will be used. Wet-season dry-weather conditions are defined as an antecedent dry period of at least 24 hours and less than .05 inches of precipitation.

8.1.1.3 Sediment screening samples

Sediment samples will be collected by field staff who are familiar with protocols found in *Standard Operating Procedure for Obtaining Freshwater Sediment Samples* (Blakley, 2016). Sediment will be sampled at a representative catch basin, sump, pipe, or other feature within the storm-drain network.

The top 2 centimeters (cm) of surface sediment will be collected by a stainless steel spoon or 0.05 m^2 Petite Ponar grab sampler. If overlying water is shallow and sediment is accessible and easily reached by hand, a stainless steel spoon will be used to collect samples. The Petite Ponar sampler will be used in areas that have deeper overlying water, or in areas that are more easily accessible from above (i.e., bridge or manhole cover). The field crew will use discretion and collect sediment by one of these two methods.

Following collection of each sediment grab, the sample will be checked for acceptability. A Petite Ponar grab will be considered acceptable if it is not overfilled, overlying water is present and not overly turbid, the sediment surface appears intact, and the desired sample depth and target area has been achieved. Information about each grab will be recorded in the program's field log (Section 8.7).

It is anticipated that sediment deposition within the storm-drain system will not have sufficient depth to show signs of stratification in a grab sample. Stratification is more likely to occur at receiving-water sample locations. If sediment samples are stratified, the top 2 cm of the sediment layer indicative of the most recent sediment deposition should be sampled.

After collection of a sediment sample, any remaining sediment should be returned to the storm-drain system downstream in an open channel, or removed and disposed of if taken from a storm-drain vault. If sediment samples show visible signs of impairments like oil, sheen, paint chips, grit, or other waste, sediments should be retained for later disposal.

Any overlying water will be siphoned off prior to sub-sampling. Equal volumes of sediment will be removed from three separate grabs per site when available. Dedicated stainless steel bowls and spoons will be used for sub-sampling and homogenizing sediment or soil from each station to a uniform color and consistency. Debris on the sediment surface will be discarded before sampling the top 2 cm of the sediment.

After homogenization, sediment will be placed in jars with Teflon-lined lids for analysis of organics. Sample containers will be cleaned to quality assurance/quality control (QA/QC) specifications and certified for trace organic analyses. Additional glass jars will be filled with homogenate for total organic carbon (TOC) analysis, and plastic jars will be filled to determine grain size.

All equipment used to collect sediment or soil samples will be washed thoroughly with tap water and Liquinox detergent, followed by sequential rinses of hot tap water, de-ionized water, and pesticide-grade acetone. Sampling equipment will be air-dried between each cleaning step under a fume hood. Following the last rinse, the air-dried equipment will be wrapped in aluminum foil, dull side contacting equipment, until used in the field. The same cleaning procedure will be used on the grab sampler.

Immediately after collection, samples will be placed in coolers on ice at < 4°C and transported to Manchester Environmental Laboratory (MEL) within 48 hours. MEL will repack samples in coolers and ship frozen any samples requiring analysis by a contract laboratory.

8.1.1.3 Field parameters

During sediment and outfall screening and storm event monitoring, temperature, pH, and conductivity will be measured. The following Ecology SOPs will be used as guidance:

- *Standard Operating Procedure for Collection and Analysis of pH Samples* (Ward, 2007a).
- *Standard Operating Procedure for Instantaneous Measurement of Temperature in Water* (Nipp, 2006).
- *Standard Operating Procedure for Collection and Analysis of Conductivity Samples* (Ward, 2007b).

8.1.1 Stormwater monitoring

As described in Section 7.1.3, Sampling Location and Frequency, stormwater samples will be collected at each site a minimum of once per year in the wet season, January through April 30, 2017. Stormwater screening protocols will follow guidelines in *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges* (De Leon and Lowe, 2009). The protocol defines a grab sample as: “A sample collected during a short time period at a single location.”

Two approaches will be used to collect grab samples, depending on site accessibility:

- Direct sampling of stormwater without the use of intermediate equipment. In this approach, the stormwater outfall will be monitored by holding a sample container by gloved hand and plunging it directly into the outfall’s flow. This approach will be used only when sample flow can be safely accessed.
- Use intermediate equipment, such as a sampling pole, rope and bucket, or sampler to collect the sample. This approach will be used at sites where confined access is required or the outfall is not safely accessed for sampling by hand.

Protocols for both approaches are outlined in Section 6.6 for direct sampling and Section 6.7 for intermediate equipment sampling in *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges* (De Leon and Lowe, 2009).

Each drainage’s hydrology will vary based on slope, size of pipe, land use, and the intensity and location of the storm event. Before each event, an estimate of the predicted storm event’s duration, volume, and peak flows will be calculated for grab sample timing. Sampling will target the first 12 hours of the storm.

To calculate total volume, the County will provide rainfall-to-runoff relationships for each selected storm drain system and provide associated storm drain as-builts. In the absence of rainfall-to-runoff relationship data, stormwater runoff will be calculated using the following equation:

Example Equation: $V_r/V_{fi} \approx N \approx V_s/V_a$

Where,
V_r = total runoff volume
V_{fi} = flow quantity interval
N = number of sample aliquots
V_s = total sample volume
V_a = volume of sample aliquot

(WEF, 1993 and California DOT, 2000)

Examples of this equation can be found in Section 6 of *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring* (De Leon and Lowe, 2009).

8.2 Containers, preservation methods, holding times

Table 8 lists requirements for stormwater sample containers, preservation, and holding times for study parameters, followed by Table 9 for sediment (MEL, 2016). Chain-of-custody procedures will be maintained throughout the sampling and analysis process.

Table 8. Stormwater Sample Containers, Preservation, and Holding Times by Parameter.

Group	Analysis	Matrix	Quantity Needed	Container	Holding Time	Preservative
Conventionals	Suspended Solids (TSS)	Water	1000 mL	1000 mL w/m poly bottle	7 days	Cool to ≤6°C
	Total Organic Carbon	Water	125 mL	125 mL w/m poly bottle	28 days	1:1 HCl to pH <2; Cool to ≤6°C
	Hardness	Water	100 mL	125 mL w/m poly bottle	6 months	H2SO4 to pH <2, cool to ≤6°C until preservation
	Oil and Grease	Water	500 mL (if dirty or turbid) to 1 Liter (if clear)	1 Liter glass bottle narrow or wide mouth	28 days if preserved, 4 hours if unpreserved	1:1 HCl to pH <2; Cool to ≤ 6°C Request acid from lab; provided in 15 mL droppers
Metals	Low Level Dissolved Metals	Water	350 mL	500 mL poly bottle	6 months	Filter[7] within 15 minutes of collection; then add HNO3[8] to pH <2 , Cool to ≤6°C until preservation
	Low Level Total Metals	Water	350 mL	500 mL poly bottle	6 months	HNO3 11 to pH <2 ; Cool to ≤6°C until preservation
	Low Level Dissolved Mercury	Water	350 mL	500 mL Teflon bottle, Zero headspace	28 days	Fill completely; Cool to ≤6°C until preservation (preserved at lab); Must be preserved within 48 hours of collection
	Low Level Total Mercury	Water	350 mL	500 mL Teflon bottle, Zero headspace	28 days	Fill completely; Cool to ≤6°C until preservation (preserved at lab); Must be preserved within 48 hours of collection
Nutrients	Total Phosphate Nitrogen (TPN)	Water	125 mL	125 mL w/m poly bottle	28 days	Cool to ≤6°C
	Ammonia (NH3)	Water	125 mL	125 mL w/m poly bottle	28 days	H2SO4 to pH <2; Cool to ≤6°C
	Nitrate (NO3-) + Nitrite (NO2-)	Water	125 mL	(1) 125 mL amber and (1) 125 mL clear w/m poly bottle	48 hours	Cool to ≤6°C; H2SO4 to pH <2 for clear bottle
	Total Phosphorous	Water	60 mL	(1) 125 mL clear w/m poly bottle	28 days	H2SO4; Cool to ≤6°C
	Orthophosphate	Water	125 mL[1]	125 mL amber w/m poly bottle 0.45 um pore size filters for dissolved orthophosphate (OP)	48 hours	Filter in field with 0.45 um pore size filter; Cool to ≤6°C

Group	Analysis	Matrix	Quantity Needed	Container	Holding Time	Preservative
Persistent Organics	PCB + Congeners (209)	Water	1 to 4 L	1 Liter amber glass bottle	1 year	Cool to ≤6°C
	Flame Retardants	Water	1 Liter	1 Liter amber glass bottle	1 year	Cool to ≤6°C
	PFAS	Water	500 mL	HDPE jar	60 days	Cool to 0-4°C
Semi-Volatile Organics	Phthalates	Water	1 Liter	1 Liter amber glass bottle	7 days	Cool to ≤6°C
	PAHs	Water	1 Liter	1 Liter amber glass bottle	7 days	Cool to ≤6°C
Total Petroleum Hydrocarbons	NWTPH-Gx (gasoline)	Water	1 Liter	1 Liter narrow-mouth glass jar	7 days unpreserved	Cool to ≤6°C
	NWTPH-Dx (diesel)	Water	1 Liter	1 Liter narrow-mouth glass jar	7 days unpreserved	Cool to ≤6°C

Table 9. Sediment Sample Containers, Preservation, and Holding Times by Parameter.

Group	Analysis	Matrix	Recommended Quantity	Container	Holding Time	Preservative
Conventionals	Grain Size	Soil/Sed	100 g	8 oz plastic jar	6 months	Cool to ≤6°C
	pH	Soil/Sed	Fill jar completely	2 oz glass jar	24 hours	Cool to ≤6°C
	Percent (%) Solids	Soil/Sed	25 g	2 oz glass jar	7 days	Cool to ≤6°C
	Total Volatile Solids	Soil/Sed	25 g	2 oz glass jar	7 days	Cool to ≤6°C
Metals	Total Metals	Soil/Sed	50 g	4 oz glass jar	6 months	Cool to ≤6°C
	Mercury	Soil/Sed	50 g	4 oz glass jar	28 days	Cool to ≤6°C; or freeze at ≤-10°C
Semi-Volatile Organics	PAHs	Soil/Sed	100 g	8 oz plastic jar	14 days; 1 year if frozen	Cool to ≤6°C; or freeze at ≤-10°C
	Phthalates	Soil/Sed	250 g	8 oz glass jar	14 days; 1 year if frozen	Cool to ≤6°C; or freeze at ≤-10°C
Persistent Organics	PCB + Congeners (209)	Soil /Sed	250 g	8 oz glass jar	14 days; 1 year if frozen	Cool to ≤6°C; or freeze at ≤-10°C
	Flame Retardants	Soil/Sed	250 g	8 oz glass jar	14 days; 1 year if frozen	Cool to ≤6°C; or freeze at ≤-10°C
	PFAS	Soil/Sed	250 g	8 oz glass jar	14 days; 1 year if frozen	Cool to ≤6 °C; or freeze at ≤-10°C
Total Petroleum	NWTPH- Dx	Soil/Sed	250 g	8 oz glass jar	14 days; 1 year if frozen[10]	Cool to ≤6°C; or freeze at ≤-10°C

Approximately 8 liters of sample volume will be required (conservatively) to run analysis for stormwater samples. Samples with scheduled QC will need additional sample volume and bottles. This will be accomplished by scheduling parameters for QC analysis on a rotating schedule through the stormwater collection season. One group of parameters (metals, PAHs and phthalates, PCBs, flame retardants, and PFAS) will be collected for QA for each of the four events.

8.3 Invasive species evaluation

Clark County is considered an "Area of Extreme Concern" for the spread of invasive species. Invasive species of concern include the New Zealand mud snail (NZMS) or *Potamopyrgus antipodarum*. The mud snail has been found in the Columbia River and tributary Burnt Bridge Creek and is potentially found in adjoining drainages: Lake River-Frontal Columbia River, Lower Salmon Creek, Gee Creek, Lewis River, and Burris Creek–Lower Columbia River. This designation requires field staff to use special decontamination procedures when engaged in any field activities within the area.

Ecology's Environmental Assessment Program developed a *Standard Operating Procedure to Minimize the Spread of Invasive Species* (Parsons et al., 2012). This SOP must be followed if field work is conducted within a designated area of extreme concern for the spread of invasive species. It covers all field operations and also applies to contractors or organizations working jointly with Ecology.

Washington State law prohibits the transportation of noxious aquatic plants, animals, and many weeds. The SOP was developed to meet the law's requirement and to minimize risk of spreading any organisms, especially aquatic invasive species (AIS), within or between water bodies or sites. All field operations, sample equipment, supplies, and gear are covered in the SOP.

8.4 Equipment decontamination

Conductivity and pH probes will be calibrated and cleaned prior to each field visit using the manufacturer's guidance. At a minimum, a triple wash of de-ionized water and then sample water will be conducted before each sampling event.

Equipment used in the field for collection or processing of sediment and stormwater samples will be decontaminated using Ecology's SOP, *Decontamination of Sampling Equipment for Use in Collecting Toxic Chemical Samples* (Friese, 2014). Before fieldwork, sample equipment will be washed thoroughly with hot tap water and Liquinox detergent, followed by sequential rinses of 10% nitric acid, de-ionized water, and pesticide-grade acetone. Equipment will then be air-dried under a fume hood and covered with aluminum foil, dull side contacting equipment.

8.5 Sample ID

Sample IDs will consist of the sampling watershed name, street name, and sample type. Abbreviations will be formed by the first two letters of the name of the drainage/water body and the abbreviated street name. A SED or SW will be placed at the end of the sample ID to indicate whether the sample needs to be analyzed for sediment (SED) or stormwater (SW).

Example:

Watershed Name = Lower Salmon Creek (LS)
Nearest Street Name = Northeast 102nd Avenue
Sample Type = Sediment (SED)
Sample ID = LS_NE102 (SED)

8.6 Chain-of-custody

A Chain of Custody (COC) form obtained from Manchester Environmental Laboratory (MEL) will be completed for all sampling events. Samples will be stored in a cooler in route or freezer at the COC room at Ecology headquarters at a temperature of 4°C. MEL will provide transport of the samples from the COC room to MEL.

8.7 Field log requirements

A field log will be used to keep track of and record observations and field measurements pertinent to the characterization of site conditions. The following information will be included in the field log:

- Site name
- Date
- Time sample was collected
- Sample volume
- Field equipment calibration date
- Weather conditions
- Photographs for documentation of sample collection and site conditions
- Name of field personnel conducting sampling
- Field grab sample results (e.g., pH, temperature, conductivity, flow)
- Number and types of samples collected
- Signs of illicit discharge (County IDDE screening form integrated into field log)
- Comments: working condition of equipment, deviation of sampling procedures
- Map showing storm-drain outfall, or catch basin
- Date the catch basin was last cleaned
- Unusual circumstances or changes from the QAPP

An electronic template will be created and used in the field for easy upload into the program's Field Results spreadsheet. Required EIM fields and formatting will be considered in the creation of the field log to make the data entry process easier and more automated.

8.8 Other activities

Not applicable. Required activities are described in other sections of this QAPP.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

A site visit during the storm event will be used to conduct the following measurements in the field: temperature, pH, and conductivity. Field measurements will be taken following guidance in Ecology's SOPs listed in Section 8.1 using the project's Oakton pH and conductivity meters. Table 10 displays the expected concentrations and reporting limits of field parameters.

Table 10. Stormwater Field Equipment Measurement Methods.

Analyte Group	Analyte	Sample Matrix	Expected Concentration	Reporting Limit	Analytical (Instrument Method)
Conventionals	pH	Stormwater	pH 6 to pH 8	.01 pH	8156 pH Electrode
	Temperature	Stormwater	>32° to 75° F	0.5° C	NIST Traceable
	Conductivity	Stormwater	.01 – 10,000 uS/cm	.01 uS/cm	8160 Direct Measure

9.2 Lab procedures table

Tables 11 and 12 summarize the study's lab procedures for stormwater and sediment parameters.

Table 11. Stormwater Measurement Methods

Analyte Group	Analyte	Sample Matrix	Expected Concentration	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Conventionals	Total Suspended Solids	Stormwater	N/A	1.0 mg/L	Gravimetric, Dried 103-105C	N/A	SM2540D
	Hardness as CaCO3	Stormwater	N/A	.33 (mg CaCO3)	EPA 200.7	N/A	EPA 200.7
	Oil and Grease	Stormwater	N/A	5.0 mg/L	N/A	N/A	EPA Method 1664
Metals total (t) and dissolved (d)	Zinc (Zn)	Stormwater	<5.0-421 µg/L	5 ug/L (t) and 1 ug/L (d)	EPA 200.8	N/A	EPA Method 200.8 (ICP/MS)
	Lead (Pb)	Stormwater	<.1-101 µg/L	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Copper (Cu)	Stormwater	<5.0-70 µg/L	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Cadmium (Cd)	Stormwater	< .2 -1.0 µg/L	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Silver (Ag)	Stormwater	N/A	.1 ug/L (t) and .02 ug/L (d)	EPA 200.8	N/A	
	Titanium (Ti)	Stormwater	N/A	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Antimony (Sb)	Stormwater	N/A	.2 ug/L (t) and (d)	EPA 200.8	N/A	
	Arsenic (As)	Stormwater	N/A	.1 ug/L (t) and (d)	EPA 200.8	N/A	
	Cobalt (Co)	Stormwater	N/A	5 ug/L (t) and (d)	EPA 200.8	N/A	
	Mercury (Hg)	Stormwater	N/A	.05 ug/L (t) and (d)	EPA Method 245.1	N/A	EPA Method 245.1
Nutrients	Total P	Stormwater	0.01 – 10 mg/L	.005 mg/L	N/A	N/A	SM 4500
	Ortho P	Stormwater	0.01 – 5.0 mg/L	.003 mg/L	N/A	N/A	SM 4500
	NH3	Stormwater	<0.01 – 30 mg/L	.1 mg/L	N/A	N/A	SM 4500

Analyte Group	Analyte	Sample Matrix	Expected Concentration	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
	NO3/NO2	Stormwater	<0.01 – 30 mg/L	.1 mg/L	N/A	N/A	SM 4500
	TPN	Stormwater	mg/L	0.01	SM 4500PI	SM 4500PI	SM 4500PI
Persistent Organic Compounds	Polychlorinated Biphenyls (209)	Stormwater	N/A	Varies by congener pg/L	DCM	Chromatographic	EPA Method 1668C
	Flame Retardants	Stormwater	N/A	Varies by species	N/A	EPA 3620, 3665	EPA Method 1614
	PFAS	Stormwater	<1.0-1,000 ng/L	Varies by species ng/L	SPE Cartridge	SPE Cartridge	AXYS MLA-110 LC-MS/MS; isotopic dilution
Petroleum Hydrocarbons	Diesel	Stormwater	280 - 4800 µg/L	.05 ug/L	NWTPH-Dx	NWTPH-Dx	NWTPH-Dx
	Gasoline	Stormwater	N/A	.05 ug/L	NWTPH-Gx	NWTPH-Gx	NWTPH-Gx
Semivolatile Organic Compounds	PAHs	Stormwater	<.1-.8µg/L	.05 ug/L	N/A	EPA 3630C	EPA Method 8270 D
	Phthalates	Stormwater	<.1ug/L-6 ug/L	.2-.5 ug/L	N/A	EPA 3630C	EPA Method 8270 D

Table 12. Sediment Measurement Methods.

Analyte Group	Analyte	Sample Matrix	Expected Concentrations	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Conventionals	Percent solids	Sediment	N/A	N/A	N/A	N/A	SM 2540G (PCT)
	Total Organic Carbon (TOC)	Sediment	N/A	0.1%	N/A	N/A	PSEP (1986)
	Grain size	Sediment	<20% - >80% silt and sand	N/A	N/A	N/A	Sieve and Pipette (ASTM 1997)
	pH	Sediment	NA	NA	NA	NA	EPA 9045
	Total Volatile Solids (TVS)	Sediment	NA	NA	NA	NA	SM 2540G

Analyte Group	Analyte	Sample Matrix	Expected Concentrations	Reporting Limit	Extraction Method	Clean-Up Method	Analytical (Instrument Method)
Metals	Zinc (Zn)	Sediment	< 5 .0 - 541 mg/kg	5.0 mg/kg	EPA 3050B	N/A	SW6020A
	Lead (Pb)	Sediment	< 0.1 - 74.0 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Copper (Cu)	Sediment	< 0.1 - 90.0 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Cadmium (Cd)	Sediment	< 0.1 - 1.20 mg/kg	0.1 mg/kg	EPA 3050B	N/A	
	Silver (Ag)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Titanium (Ti)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Antimony (Sb)	Sediment	N/A	0.2 mg/kg	EPA 3050B	N/A	
	Arsenic (As)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Cobalt (Co)	Sediment	N/A	0.1 mg/kg	EPA 3050B	N/A	
	Mercury (Hg)	Sediment	< 0.005 - .05 mg/kg	0.005 mg/kg	EPA 245.5	N/A	EPA 245.5
Persistent Organic Compounds	Polychlorinated Biphenyls (209)	Sediment	N/A	20 ng/kg	EPA 3541	EPA 3620, 3665	EPA 1668C
	Flame Retardants	Sediment	N/A	2 ng/kg	EPA 3541	EPA 3620, 3665	EPA 1614
	PFAS	Sediment	<.5-1,000 ng/g	Varies by species ng/g	NA	NA	AXYS MLA-110 LC-MS/MS; isotopic dilution
Petroleum Hydrocarbons	NWTPH-Dx	Sediment	N/A	25.0-100.0 mg/kg	NWTPH-Dx	NWTPH-Dx	NWTPH-Dx
Semivolatile Organic Compounds	Phthalates	Sediment	<12 - 1600 ug/kg	12.5-125 ug/kg	EPA 3541	EPA 3630C	EPA 8270 D
	PAHs	Sediment	>300 ug/kg	12.5-50 ug/kg	N/A	EPA 3630C	EPA 8270 D

9.3 Sample preparation methods

See Table 11 for stormwater and Table 12 for sediment (above) under extraction and cleanup methods.

9.4 Special method requirements

High resolution PCB, PFAS, and PBDE analysis will be subcontracted out to an independent lab to be selected in January 2017.

9.5 Labs accredited for methods

All analyses will be carried out Ecology's Manchester Environmental Laboratory (MEL), with the exception of high resolution PCBs, PFAS, and PBDEs. High resolution work will be carried out by an accredited laboratory.

10.0 Quality Control Procedures

10.1 Table of field and lab quality control required

Quality control (QC) during stormwater field equipment use will consist of replicate samples in-situ at a minimum of 10%. A grab sample will be taken using a bucket and rope if sampling is conducted in a confined space, or direct measurement at an outfall.

For stormwater, a replicate sample will be collected in the field using intermediate sampling equipment twice per storm monitoring season. The replicate sample will be collected identical to the sample. The replicate will help determine the random variability between samples.

An equipment blank will be taken in the field by filling sample bottles with de-ionized water to determine interference due to sample handling protocols.

In the laboratory, check standards in the form of control samples will be used to determine if laboratory equipment and procedures are able to accurately recover a known amount of spiked analyte at an expected range. Check standards are run alongside of, and in an identical manner as, the sample. Control samples will be conducted for all metals, nutrients, and organics.

Method blanks will be run on all metals, nutrients, and organics samples in the lab to ensure that lab analysis and procedures are not causing contamination to the sample matrix. At a minimum, one project sample per batch will require a matrix spike for QC.

Matrix spikes and matrix spike duplicates (ms/msd) will be run on metals, organics, and petroleum hydrocarbons at a minimum of once per storm season. One group of parameters will be selected for each sampling event until all parameters have been rotated through the season. This approach is necessary due to the large quantity of sample volume needed if ms/msd were conducted at the same time.

The laboratory will add a known amount of target analyte(s) to an aliquot of a sample to check for bias due to interference of matrix effects.

Organics samples will be processed by the lab with surrogates to track the efficiency of analyte recovery and extraction.

All QC procedures will strictly follow MQOs, as detailed in Section 6.2 of this QAPP. The QC samples all will have MQOs (evaluation criteria) associated with them. These are described in Section 6.2. These criteria must be met to obtain fully usable data.

10.2 Corrective action processes

The project manager will work closely with the MEL QA Coordinator conducting data review for internal and contracted analysis to examine any QC criteria discrepancies. The project manager will determine whether data should be re-analyzed, rejected, or used with appropriate qualification.

Prior to each sampling event, all field equipment will be checked for operation and calibrated at no more than a day in advance. Field equipment includes pH and conductivity meters. A calibration log will be kept on file for documentation of each calibration event.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

All field forms used for collecting data and observations will be printed on water-proof paper and kept in a field notebook. All field data and observations will be recorded in Excel spreadsheets at the end of each round of sample events. Data entry will be checked by another member of the project team for accuracy. Field and laboratory data for the project will be entered into Ecology's EIM system. Laboratory data will be uploaded into EIM using the EIM XML results template.

11.2 Laboratory data package requirements

The contract laboratory will deliver a data package to MEL with the complete raw laboratory dataset. After reviewing the data package from the contract laboratory, MEL will provide case narratives to the project manager with the final qualified results and a description of the quality of the contract laboratory data. Case narratives should include any problems encountered with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Narratives will also address the condition of samples on receipt, sample preparation, methods of analysis, instrument calibration, and results of QC tests.

11.3 Electronic transfer requirements

MEL will deliver case narratives in PDF format, and electronic data deliverables in an Excel spreadsheet format, to the project manager via email.

11.4 Acceptance criteria for existing data

Existing data will not be used for analysis.

11.5 EIM/STORET data upload procedures

All data submitted from MEL, internal or contracted, will be provided in an electronic data deliverable (EDD) format and must meet the requirements of Ecology's Environmental Information Management (EIM) database. After receipt of data and internal processing, data will be uploaded into the EIM database.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

MEL and contracted laboratories must participate in performance and system audits of their routine procedures. No audits are planned specifically for this project.

12.2 Responsible personnel

No audits are planned for this study.

12.3 Frequency and distribution of report

A Phase I screening report summary will be drafted at the end of year 1. The report will provide the following details:

- Status of the project and any potential problems in need of resolution.
- Data results summary.
- Accomplishments.
- Monitoring and laboratory QA/QC information for the affected period.
- Recommendations and prioritization of parameters for Phase II.

The report will be distributed internally to Ecology's HWTR Program management, Ecology's Toxic Studies Unit manager, and the Clark County Clean Water Division for review and comment. Reports will be completed September 2017.

12.4 Responsibility for reports

The author of the final report will be Ecology's Local Source Control monitoring lead.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Field data verification will be conducted by the project manager.

13.2 Lab data verification

Data verification involves examining the data for errors, omissions, and compliance with QC acceptance criteria. MEL's SOPs for data reduction, review, and reporting will meet the needs of the project.

MEL staff will provide a written report of their data review which will include a discussion of whether (1) MQOs were met, (2) proper analytical methods and protocols were followed, (3) calibrations and controls were within limits, and (4) data were consistent, correct, and complete, without errors or omissions.

The principal investigator/project manager is responsible for the final acceptance of the project data. The complete data package, along with MEL's written report, will be assessed for completeness and reasonableness. Based on these assessments, the data will either be accepted, accepted with qualifications, or rejected and re-analysis considered.

Accuracy of data entered into EIM will be verified by someone other than the data engineer per EIM data entry business rules.

13.3 Validation requirements, if necessary

Independent data validation will not be required for this project.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

During the study period, the LSC monitoring lead will decide if the project data are usable and meet the MQOs as outlined in Section 6. If the data meets all MQOs, they will be considered acceptable and used in further analysis. If some of the data do not meet the MQOs, the data will be considered usable but with appropriate qualifications. If a majority of data do not meet MQOs, the data will be rejected and additional data collected (budget pending).

14.2 Data analysis and presentation methods

Analysis of stormwater and sediment data will occur at the end of the Phase I screening period. Prioritization of parameters for future phases of the study will be conducted, and statistical results will be displayed in table and graph format. In addition, results will be displayed and summarized cartographically in GIS.

14.3 Treatment of non-detects

In the event that non-detects (NDs) become an issue and impede the ability to perform the study (data censorship), statistical methods will be used to assign values to non-detects. It is assumed that some parameters will be detected less frequently than others and should be considered a low priority. If needed, methods for performing statistical analysis to non-detect data can be found in Table 5 of *Western Washington NPDES Phase I Stormwater Permit, Final S8.D Data Characterization 2009-2013* (Hobbs, Lubliner, Kale, and Newell, 2015). Non-detect statistical analysis performed during the study period will be detailed in the final report.

14.4 Sampling design evaluation

The first phase of the study will monitor selected sites for stormwater and sediment a minimum of one time from January through May 2017. A "snapshot" of selected drainage toxic concentrations will evaluate and determine if future investigation/phases of the study are warranted and feasible.

14.5 Documentation of assessment

The final report will document and present study assessment findings, statistical analysis, and overall effectiveness of outreach efforts.

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16.0 Figures

The figures in this QAPP are inserted after they're first mentioned in the text.

17.0 Tables

The tables in this QAPP are inserted after they're first mentioned in the text.

18.0 Appendices

Appendix A. Laboratory Analyte Supplemental Information

Table A-1. PCB Congeners (209).

2-MoCB	1	2,2',6,6'-TeCB	54	2,3,3',4',5-PeCB	107	2,3,3',4,5,6-HxCB	160
3-MoCB	2	2,3,3',4'-TeCB	55	2,3,3',4,5'-PeCB	108	2,3,3',4,5',6-HxCB	161
4-MoCB	3	2,3,3',4'-TeCB	56	2,3,3',4,6-PeCB	109	2,3,3',4',5,5'-HxCB	162
2,2'-DiCB	4	2,3,3',5-TeCB	57	2,3,3',4',6-PeCB	110	2,3,3',4',5,6-HxCB	163
2,3-DiCB	5	2,3,3',5'-TeCB	58	2,3,3',5,5'-PeCB	111	2,3,3',4',5',6-HxCB	164
2,3'-DiCB	6	2,3,3',6-TeCB	59	2,3,3',5,6-PeCB	112	2,3,3',5,5',6-HxCB	165
2,4-DiCB	7	2,3,4,4'-TeCB	60	2,3,3',5',6-PeCB	113	2,3,4,4',5,6-HxCB	166
2,4'-DiCB1	8	2,3,4,5-TeCB	61	2,3,4,4',5-PeCB1,2	114	2,3,4,4',5,5'-HxCB2	167
2,5-DiCB	9	2,3,4,6-TeCB	62	2,3,4,4',6-PeCB	115	2,3',4,4',5',6-HxCB	168
2,6-DiCB	10	2,3,4',5-TeCB	63	2,3,4,5,6-PeCB	116	3,3',4,4',5,5'-HxCB1,2	169
3,3'-DiCB	11	2,3,4',6-TeCB	64	2,3,4',5,6-PeCB	117	2,2',3,3',4,4',5-HpCB1	170
3,4-DiCB	12	2,3,5,6-TeCB	65	2,3',4,4',5-PeCB1,2	118	2,2',3,3',4,4',6-HpCB	171
3,4'-DiCB	13	2,3',4,4'-TeCB1	66	2,3',4,4',6-PeCB	119	2,2',3,3',4,5,5'-HpCB	172
3,5-DiCB	14	2,3',4,5-TeCB	67	2,3',4,5,5'-PeCB	120	2,2',3,3',4,5,6-HpCB	173
4,4'-DiCB	15	2,3',4,5'-TeCB	68	2,3',4,5,6-PeCB	121	2,2',3,3',4,5,6'-HpCB	174
2,2',3-TrCB	16	2,3',4,6-TeCB	69	2',3,3',4,5-PeCB	122	2,2',3,3',4,5',6-HpCB	175
2,2',4-TrCB	17	2,3',4',5-TeCB	70	2',3,4,4',5-PeCB2	123	2,2',3,3',4,6,6'-HpCB	176
2,2',5-TrCB1	18	2,3',4',6-TeCB	71	2',3,4,5,5'-PeCB	124	2,2',3,3',4',5,6-HpCB	177
2,2',6-TrCB	19	2,3',5,5'-TeCB	72	2',3,4,5,6'-PeCB	125	2,2',3,3',5,5',6-HpCB	178

2,3,3'-TrCB	20	2,3',5',6-TeCB	73	3,3',4,4',5-PeCB1,2	126	2,2',3,3',5,6,6'-HpCB	179
2,3,4-TrCB	21	2,4,4',5-TeCB	74	3,3',4,5,5'-PeCB	127	2,2',3,4,4',5,5'-HpCB1	180
2,3,4'-TrCB	22	2,4,4',6-TeCB	75	2,2',3,3',4,4'-HxCB1	128	2,2',3,4,4',5,6-HpCB	181
2,3,5-TrCB	23	2',3,4',5-TeCB	76	2,2',3,3',4,5-HxCB	129	2,2',3,4,4',5,6'-HpCB	182
2,3,6-TrCB	24	3,3',4,4'-TeCB1,2	77	2,2',3,3',4,5'-HxCB	130	2,2',3,4,4',5',6-HpCB	183
2,3',4-TrCB	25	3,3',4,5-TeCB	78	2,2',3,3',4,6-HxCB	131	2,2',3,4,4',6,6'-HpCB	184
2,3',5-TrCB	26	3,3',4,5'-TeCB	79	2,2',3,3',4,6'-HxCB	132	2,2',3,4,5,5',6-HpCB	185
2,3',6-TrCB	27	3,3',5,5'-TeCB	80	2,2',3,3',5,5'-HxCB	133	2,2',3,4,5,6,6'-HpCB	186
2,4,4'-TrCB1	28	3,4,4',5-TeCB2	81	2,2',3,3',5,6-HxCB	134	2,2',3,4,5,5',6-HpCB1	187
2,4,5-TrCB	29	2,2',3,3',4-PeCB	82	2,2',3,3',5,6'-HxCB	135	2,2',3,4',5,6,6'-HpCB	188
2,4,6-TrCB	30	2,2',3,3',5-PeCB	83	2,2',3,3',6,6'-HxCB	136	2,3,3',4,4',5,5'-HpCB2	189
2,4',5-TrCB	31	2,2',3,3',6-PeCB	84	2,2',3,4,4',5-HxCB	137	2,3,3',4,4',5,6-HpCB	190
2,4',6-TrCB	32	2,2',3,4,4'-PeCB	85	2,2',3,4,4',5'-HxCB1	138	2,3,3',4,4',5',6-HpCB	191
2',3,4-TrCB	33	2,2',3,4,5-PeCB	86	2,2',3,4,4',6-HxCB	139	2,3,3',4,5,5',6-HpCB	192
2',3,5-TrCB	34	2,2',3,4,5'-PeCB	87	2,2',3,4,4',6'-HxCB	140	2,3,3',4',5,5',6-HpCB	193
3,3',4-TrCB	35	2,2',3,4,6-PeCB	88	2,2',3,4,5,5'-HxCB	141	2,2',3,3',4,4',5,5'-OcCB	194
3,3',5-TrCB	36	2,2',3,4,6'-PeCB	89	2,2',3,4,5,6-HxCB	142	2,2',3,3',4,4',5,6-OcCB1	195
3,4,4'-TrCB	37	2,2',3,4',5-PeCB	90	2,2',3,4,5,6'-HxCB	143	2,2',3,3',4,4',5,6'-OcCB	196
3,4,5-TrCB	38	2,2',3,4',6-PeCB	91	2,2',3,4,5',6-HxCB	144	2,2',3,3',4,4',6,6'-OcCB	197
3,4',5-TrCB	39	2,2',3,5,5'-PeCB	92	2,2',3,4,6,6'-HxCB	145	2,2',3,3',4,5,5',6-OcCB	198
2,2',3,3'-TeCB	40	2,2',3,5,6-PeCB	93	2,2',3,4',5,5'-HxCB	146	2,2',3,3',4,5,5',6'-OcCB	199

2,2',3,4-TeCB	41	2,2',3,5,6'-PeCB	94	2,2',3,4',5,6-HxCB	147	2,2',3,3',4,5,6,6'-OcCB	200
2,2',3,4'-TeCB	42	2,2',3,5',6-PeCB	95	2,2',3,4',5,6'-HxCB	148	2,2',3,3',4,5',6,6'-OcCB	201
2,2',3,5-TeCB	43	2,2',3,6,6'-PeCB	96	2,2',3,4',5',6-HxCB	149	2,2',3,3',5,5',6,6'-OcCB	202
2,2',3,5'-TeCB1	44	2,2',3',4,5-PeCB	97	2,2',3,4',6,6'-HxCB	150	2,2',3,4,4',5,5',6-OcCB	203
2,2',3,6-TeCB	45	2,2',3',4,6-PeCB	98	2,2',3,5,5',6-HxCB	151	2,2',3,4,4',5,6,6'-OcCB	204
2,2',3,6'-TeCB	46	2,2',4,4',5-PeCB	99	2,2',3,5,6,6'-HxCB	152	2,3,3',4,4',5,5',6-OcCB	205
2,2',3,4'-TeCB	47	2,2',4,4',6-PeCB	100	2,2',4,4',5,5'-HxCB1	153	2,2',3,3',4,4',5,5',6-NoCB1	206
2,2',4,5-TeCB	48	2,2',4,5,5'-PeCB1	101	2,2',4,4',5',6-HxCB	154	2,2',3,3',4,4',5,6,6'-NoCB	207
2,2',4,5'-TeCB	49	2,2',4,5,6'-PeCB	102	2,2',4,4',6,6'-HxCB	155	2,2',3,3',4,5,5',6,6'-NoCB	208
2,2',4,6-TeCB	50	2,2',4,5,6'-PeCB	103	2,3,3',4,4',5-HxCB2	156	DeCB1	209
2,2',4,6'-TeCB	51	2,2',4,6,6'-PeCB	104	2,3,3',4,4',5'-HxCB2	157		
2,2',5,5'-TeCB1	52	2,3,3'4,4'-PeCB1,2	105	2,3,3',4,4',6-HxCB	158		
2,2',5,6'-TeCB	53	2,3,3',4,5-PeCB	106	2,3,3',4,5,5'-HxCB	159		

Appendix B. Tables and Figures

Table B-1. LSC Study Parameters, Environmental Impacts, and Sources.

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
Conventionals	Total Suspended Solids	Stormwater	Indicator for metals. High concentrations can impair aquatic life: temperature, low DO, photosynthesis, degraded habitat, and fish health.	Natural processes and anthropogenic soil disturbances.
	Conductivity	Stormwater	Indicator of pollution.	Various; indication of dissolved solids (ions).
	pH	Stormwater + Sediment	pH >8 and pH <6 : increase toxic metals availability for aquatic life uptake, cause fish kills, invasive species promotion, and aquatic life reproduction impairment.	Combustion of fossil fuels.
	Hardness as CaCO3	Stormwater	Indicator used to calculate dissolved metals criteria.	Natural, underlying geology of water body.
	Percent solids	Sediment	Indicator	Percent non-organic material in sediment sample.
	Total organic carbon	Sediment	Indicator; high levels could indicate toxics compounds.	Amount of carbon in an organic compound.
	Grain size	Sediment	Indicator	Grain size for determination of toxics adsorption.
Hexane Extractable Material	Oil and Grease	Stormwater + Sediment	Indicator of spills or poor BMPs	Includes animal and vegetable based oils
Nutrients	Total Phosphorous	Stormwater	Too much can lead to eutrophication (algal growth) anoxic conditions for aquatic life.	Human and animal waste, fertilizers, laundry, cleaning, industrial and commercial effluents.

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
	Orthophosphate	Stormwater		Inorganic phosphate due to urban run-off.
	Ammonia (NH3)	Stormwater		Toxic as free ammonia (NH3) to aquatic life.
	Nitrite (NO2-)	Stormwater		NH3 is nitrified into NO2-
	Nitrate (NO3-)	Stormwater		NO2- is converted to NO3- by nitrobacters.
	TPN	Stormwater	TPN + NO3 + NO2 = Total N	See above.
Metals - Total (t) and Dissolved (d)	Zinc	Stormwater (t,d) +Sediment	Juvenile and adult salmonid gill and olfactory sub-lethal effects and mortality in higher concentrations.	Galvanized roofs, manufacturing processes, automobiles.
	Lead	Stormwater (t,d) +Sediment		Manufacturing, combustion of coal and oil, and waste incineration.
	Copper	Stormwater (t,d) +Sediment		Automobiles, rooftops, anti-fouling paints.
	Cadmium	Stormwater (t,d) +Sediment		Phosphate fertilizers, zinc production, sewage sludge.
	Mercury	Stormwater (t,d) +Sediment		Combustion of coal, metal processing, atmospheric deposition.
	Silver [1]	Stormwater (t,d) +Sediment	As nano-particles; ability to travel and bioaccumulate throughout the ecosystem and threaten aquatic and terrestrial populations of microbes at the corner stone of many ecosystems. Ultimate effects still unknown.	Sunscreen, textiles, cleaning products, personal care products, food, paints.
	Titanium [1]	Stormwater (t,d) +Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
	Antimony[4]	Stormwater (t,d) +Sediment	Experimental evidence demonstrates induction of lung tumors in rats following inhalation of antimony trioxide.	Antimony compounds are used in the manufacturing of pigments, paints, glass, pottery, and enamels. Antimony is common at low percentages in metal alloys and as a synergistic to flame retardants.
	Arsenic[4]	Stormwater (t,d) +Sediment	Arsenic exposure has been linked to lung cancer, bladder cancer, skin cancer, and cancers at several other sites in the body.	Historically inorganic arsenic compounds were used in wood preservatives, other pesticides, medicines, metal alloys, and paint pigments.
	Cobalt [4]	Stormwater (t,d) +Sediment	Inhalation of cobalt compounds can induce lung and other cancers in rats and mice.	Cobalt is used in alloys, pigments, and fertilizers; as a drying agent in paints, varnishes and inks; a component in porcelain enamel; and as a catalyst in synthesizing polyester and other materials.
Polycyclic Aromatic Hydrocarbons (PAHs)	Acenaphthene	Stormwater + Sediment	Persistent, toxic, carcinogenic, and mutagenic properties detrimental to aquatic and terrestrial life.	Wood burning, asphalt roads, automobile exhaust, cigarette smoke, coal, coal tar, wildfires, agricultural burning, residential wood burning, volcanoes, municipal and industrial waste incineration.
	Acenaphthylene	Stormwater + Sediment		
	Anthracene	Stormwater + Sediment		
	Benz[a]anthracene	Stormwater + Sediment		
	Benzo(a)pyrene	Stormwater + Sediment		
	Benzo(b)fluoranthene	Stormwater + Sediment		
	Benzo(ghi)perylene	Stormwater + Sediment		
	Benzo(k)fluoranthene	Stormwater + Sediment		
	Chrysene	Stormwater + Sediment		
	Dibenzo(a,h)anthracene	Stormwater + Sediment		
	Fluoranthene	Stormwater + Sediment		
	Fluorene	Stormwater + Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
	Indeno(1,2,3-cd)pyrene	Stormwater + Sediment		
	Naphthalene	Stormwater + Sediment		
	Phenanthrene	Stormwater + Sediment		
	Pyrene	Stormwater + Sediment		
Phthalates[4]	Bis(2-Ethylhexyl) Phthalate	Stormwater + Sediment	Endocrine disruptor, carcinogenic to humans and aquatic and terrestrial life.	Plasticizer in production of plastics, industrial uses. Found in many consumer products.
	Butyl benzyl phthalate	Stormwater + Sediment		
	Diethyl phthalate	Stormwater + Sediment		
	Dimethyl phthalate	Stormwater + Sediment		
	Di-N-Butylphthalate	Stormwater + Sediment		
	Di-N-Octyl Phthalate (DnOP)	Stormwater + Sediment		
Petroleum Hydrocarbons	NWTPH-Dx	Stormwater + Sediment	Harmful effects on the central nervous system.	Petroleum and natural gas production, fuel stations, leaky USTs (Dx and Gx), non-point source roadway runoff.
	NWTPH-Gx	Stormwater		
Polychlorinated Biphenyls (PCBs)	209 congeners[3]	Stormwater + Sediment	PCBs have been demonstrated to cause cancer, as well as a variety of other adverse health effects on the immune system, reproductive system, nervous system, and endocrine system.	Transformers and capacitors, electrical equipment, oil, fluorescent light ballasts, cable insulation, thermal insulation material, adhesives and tapes, oil-based paint, and caulking.
Flame Retardants	Polybrominated diphenyl ethers (PBDEs)	Stormwater + Sediment	Detrimental to brain development in animals and can cause estrogen and thyroid hormone disruption.	Flame retardants used in building materials, electronics, furnishings, motor vehicles, airplanes, plastics, polyurethane foams, and textiles.
	Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester	Stormwater + Sediment		
	V6	Stormwater + Sediment		
	Isopropylated triphenyl phosphate	Stormwater + Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
	Tris(1-chloro-2-propyl) phosphate (TCPP)	Stormwater + Sediment V6 (V6) Stormwater + Sediment		
	Bis (2-ethylhexyl) tetrabromophthalate (TBPH)			
	Triphenyl phosphate			
	Dechlorane plus			
	Tricresyl phosphate			
	1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPA)			
	Decabromodiphenylethane (DBDPE)			
Perfluoroalkyl Substances (PFAS)[2]	Perfluorobutane sulfonate (PFBS)	Stormwater + Sediment	Bioaccumulative and very persistent in the environment. Found across all matrices: air, water, sediment, and animal tissue. Animal tests show that PFOA can cause tumors and neonatal death and toxic effects on the immune, liver, and endocrine systems.	Water resistant textiles, fire-fighting foam, consumer products, and major commercial and industrial discharges.
	Perfluorohexane sulfonate (PFHxs)	Stormwater + Sediment		
	Perfluorooctane sulfonate (PFOS)	Stormwater + Sediment		
	Perfluorohexanoic acid (PFHxA)	Stormwater + Sediment		
	Perfluoroheptanoic acid (PFHpA)	Stormwater + Sediment		
	Perfluorooctanoic acid (PFOA)	Stormwater + Sediment		
	Perfluorononanoic acid (PFNA)	Stormwater + Sediment		
	Perfluorodecanoic acid (PFDA)	Stormwater + Sediment		

Group	Parameters	Matrix	Potential Impacts to Organisms	Common Sources
	Perfluorundecanoic acid (PFUnA)	Stormwater + Sediment		
	Perfluorododecanoic acid (PFDoA)	Stormwater + Sediment		

[1] Monitoring of metals to detect total concentrations; end goal to identify problematic areas that could be linked to nano-particle pollution.
[2] Source: Furl and Meredith, 2008
[3] See Appendix A for a complete list of congeners
[4] Source: CHCC, 2016
[5] VanBergen and Trumbull, 2016

Table B-2. Clark County Status and Trends Monitoring Results, 2010-2013.

Group	Parameters	Matrix	#Results[1]	#Met RLs[1]	Years	Units	Min[1]	Max[1]	Mean[1]	Median[1]	% Exceedance	Criteria
Metals	Zinc	Stormwater Total	61	61	2010-2015	ug/L	39.6	421	130.5	104	-	-
		Stormwater Diss.	61	50	2010-2015	ug/L	13.8	106	27.9	23.6	21%	Table 240(3)[2]
		Sediment	4	4	2011-2014	mg/Kg	411	541	477.5	479	0%	SMS, CSL
	Lead	Stormwater Total	61	61	2010-2015	ug/L	4.62	101	19.99	13.8	-	-
		Stormwater Diss.	61	61	2010-2015	ug/L	0.025	0.74	0.13	0.08	20%	Table 240(3)[2]
		Sediment	4	4	2011-2014	mg/Kg	61.8	73.8	83.33	84.25	-	-
	Copper	Stormwater Total	61	55	2010-2015	ug/L	7.03	70.2	23.56	19.8	-	-
		Stormwater Diss.	61	24	2010-2015	ug/L	1.48	22.2	5.78	4.55	15%	Table 240(3)[2]
		Sediment	4	4	2011-2014	mg/Kg	77	89.3	81.2	79.25	-	-
	Cadmium	Stormwater Total	61	61	2010-2015	ug/L	0.07	0.98	0.25	0.21	-	-
		Stormwater Diss.	61	45	2010-2015	ug/L	0.02	0.14	0.04	0.03	0%	Table 240(3)[2]
		Sediment	4	4	2011-2014	mg/Kg	0.841	1.17	1.01	0.84	-	-
	Mercury	Stormwater Total	36	0	2010-2015	ug/L	ND	ND	ND	ND	-	-
		Stormwater Diss.	36	0	2010-2015	ug/L	ND	ND	ND	ND	0%	Table 240(3)[2]
		Sediment	4	4	2011-2014	mg/Kg	0.027	0.048	0.041	0.042	-	-
	Acenaphthene	Stormwater	61	0	2010-2015	ug/L	ND	ND	ND	ND	ND	-

Group	Parameters	Matrix	#Results[1]	#Met RLs[1]	Years	Units	Min[1]	Max[1]	Mean[1]	Median[1]	% Exceedance	Criteria
Poly Aromatic Hydrocarbons (PAHs)		Sediment	4	0	2011-2014	mg/Kg	ND	ND	ND	ND	ND	-
	Acenaphthylene	Stormwater	61	8	2010-2015	ug/L	0.02	0.12	0.05	0.03	-	-
		Sediment	4	0	2011-2014	ug/Kg	ND	ND	ND	ND	ND	-
	Anthracene	Stormwater	61	11	2010-2015	ug/L	0.02	0.13	0.04	0.03	0%	NTR[3]
		Sediment	4	0	2011-2014	mg/Kg	ND	ND	ND	ND	ND	-
	Benzo(a)anthracene	Stormwater	61	15	2010-2015	ug/L	0.02	0.4	0.12	0.09	100%	NTR[3]
		Sediment	4	1	2011-2014	ug/Kg	370	370	NA	NA	-	-
	Benzo(a)pyrene	Stormwater	61	24	2010-2015	ug/L	0.03	0.42	0.1	0.06	100%	NTR[3]
		Sediment	4	1	2011-2014	ug/Kg	490	490	NA	NA	-	-
	Benzo(b)fluoranthene	Stormwater	61	32	2010-2015	ug/L	0.039	0.53	0.16	0.14	100%	NTR[3]
		Sediment	4	2	2011-2014	ug/Kg	600	670	635	635	-	-
	Benzo(ghi)perylene	Stormwater	61	34	2010-2015	ug/L	0.06	0.39	0.19	0.16	-	-
		Sediment	4	3	2011-2014	ug/Kg	590	970	720	600	-	-
	Benzo(k)fluoranthene	Stormwater	61	10	2010-2015	ug/L	0.02	0.27	0.09	0.05	100%	NTR[3]
		Sediment	4	0	2011-2014	ug/Kg	ND	ND	ND	ND	-	-
	Chrysene	Stormwater	61	33	2010-2015	ug/L	0.03	0.6	0.26	0.18	100%	NTR[3]
		Sediment	4	3	2011-2014	ug/Kg	600	950	747	690	-	-
	Dibenzo(a,h) anthracene	Stormwater	61	54	2010-2015	ug/L	0.02	0.16	0.05	0.03	100%	NTR[3]

Group	Parameters	Matrix	#Results[1]	#Met RLs[1]	Years	Units	Min[1]	Max[1]	Mean[1]	Median[1]	% Exceedance	Criteria
		Sediment	4	0	2011-2014	ug/Kg	ND	ND	ND	ND	-	-
	2-methylnaphthalene	Stormwater	36	3	2010-2015	ug/L	0.05	0.31	0.29	0.29	-	-
		Sediment	4	0	2011-2014	ug/Kg	ND	ND	ND	ND	-	-
	Fluoranthene	Stormwater	61	38	2010-2015	ug/L	0.05	0.53	0.21	0.19	0%	NTR[3]
		Sediment	4	3	2011-2014	ug/Kg	650	870	743	710	-	-
	Fluorene	Stormwater	61	6	2010-2015	ug/L	0.02	0.03	0.02	0.02	0%	NTR[3]
		Sediment	4	0	2011-2014	ug/Kg	ND	ND	ND	ND	-	-
	Indeno(1,2,3-cd)pyrene	Stormwater	61	28	2010-2015	ug/L	0.03	0.37	0.1	0.09	100%	-
		Sediment	4	2	2011-2014	ug/Kg	390	420	405	405	-	-
	Naphthalene	Stormwater	61	16	2010-2015	ug/L	0.036	0.57	0.16	0.08	-	-
		Sediment	4	2	2011-2014	ug/Kg	ND	ND	ND	ND	-	-
	Phenanthrene	Stormwater	61	33	2010-2015	ug/L	0.04	0.32	0.13	0.12	-	-
		Sediment	4	2	2011-2014	ug/Kg	410	460	435	435	-	-
	Pyrene	Stormwater	61	27	2010-2015	ug/L	0.08	0.8	0.29	0.23	0%	NTR[3]
		Sediment	4	3	2011-2014	ug/Kg	730	1100	907	890	-	-
Herbicides	2,4-D (Dichlorophenol)	Stormwater	61	12	2010-2015	ug/L	0.09	3.54	1.05	0.43	0%	NTR[3]
	Mecoprop	Stormwater	36	7	2010-2013	ug/L	0.04	1.16	0.54	0.28	-	-
	Dichlobenil	Stormwater	36	1	2010-2013	ug/L	0.16	0.16	NA	NA	-	-

Group	Parameters	Matrix	#Results[1]	#Met RLs[1]	Years	Units	Min[1]	Max[1]	Mean[1]	Median[1]	% Exceedance	Criteria
	Prometon	Stormwater	35	0	2010-2013	ug/L	ND	ND	ND	ND	-	-
	Triclopyr	Stormwater	36	3	2010-2012	ug/L	0.1	0.34	0.23	0.11	-	-
Insecticides	Carbaryl	Stormwater	25	0	2013-2015	ug/L	ND	ND	ND	ND	-	-
	Chlorpyrifos	Stormwater	36	0	2010-2013	ug/L	ND	ND	ND	ND	-	-
		Sediment	4	0	2011-2014	mg/Kg	ND	ND	ND	ND	-	-
	Malathion	Stormwater	36	0	2010-2013	ug/L	ND	ND	ND	ND	-	-
Phthalates	Bis(2-ethylhexyl) phthalate	Stormwater	36	9	2010-2013	ug/L	1.5	13	5.5	5.5	96%	NTR[3]
	Di-n-octyl phthalate	Stormwater	61	7	2010-2015	ug/L	0.02	0.16	0.05	0.03	NA	NA
	Butyl benzyl phthalate	Stormwater	36	9	2010-2013	ug/L	0.21	0.99	0.43	0.36	-	-
		Sediment	4	3	2011-2014	ug/Kg	610	1600	1070	1000	-	-
	Dibutyl phthalate	Stormwater	36	11	2010-2014	ug/L	0.17	0.63	0.28	0.24	0%	NTR[3]
	Diethyl phthalate	Stormwater	36	1	2010-2014	ug/L	0.15	0.15	NA	NA	0%	NTR[3]
	Dimethyl phthalate	Stormwater	36	12	2010-2013	ug/L	0.063	2.1	0.29	0.21	0%	NTR[3]
PCBs (Aroclors)	1016	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
	1221	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
	1232	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
	1242	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
	1248	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]

Group	Parameters	Matrix	#Results[1]	#Met RLs[1]	Years	Units	Min[1]	Max[1]	Mean[1]	Median[1]	% Exceedance	Criteria
	1254	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
	1260	Sediment	5	0	2010-2014	ug/Kg	ND	ND	ND	ND	0%	Table 240(3)[2]
Petroleum Hydrocarbons	NWTPH-Dx	Stormwater	52	32	2010-2015	ug/L	280	4200	1203	900	-	-
	NWTPH-Gx	Stormwater	24	0	2010-2013	ug/L	ND	ND	ND	ND	-	-
	BTEX - Benzene	Stormwater	27	27	2013-2015	ug/L	ND	ND	ND	ND	0%	NTR[3]
	BTEX - Toluene	Stormwater	27	3	2013-2015	ug/L	1.1	7.3	3.6	2.3	0%	NTR[3]
	BTEX - Ethylbenzene	Stormwater	27	1	2013-2015	ug/L	0.8	0.8	0.8	0.8	0%	NTR[3]
	BTEX - meta+para-xylene	Stormwater	12	0	2014-2015	ug/L	ND	ND	ND	ND	-	-
	BTEX - ortho-xylene	Stormwater	27	1	2014-2015	ug/L	1.3	1.3	NA	NA	-	-

[1] Replicates are included in the #Results and min, max, mean, and median value calculations.
[2] (Ecology, 2012a)
[3] (EPA, 1992). Denotes no criteria or value.
ND: Nondetect.

Table B-3. Laboratory Measurement Quality Objectives (MQOs) for Stormwater Analysis.

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)%	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Unit of Concentration	
Conventional	Total Suspended Solids	80-120	± 20	NA	NA	NA	mg/L	1.0
	Conductivity	80-120	± 20	NA	NA	NA	umhos/cm	15
	Oil and Grease	78-114	± 20	78-114	NA	NA	mg/L	5
Nutrients	Total Phosphorous	80-120	± 20	75-125	NA	NA	mg/L	0.005
	Orthophosphate	80-120	± 20	75-125	NA	NA	mg/L	0.003
	Ammonia (NH3)	80-120	± 20	75-125	NA	NA	mg/L	0.01
	Nitrite (NO2-)	80-120	± 20	75-125	NA	NA	mg/L	0.01
	Nitrate (NO3-)	80-120	± 20	75-125	NA	NA	mg/L	0.01
	Total Phosphate Nitrogen (TPN)	80-120	± 20	75-125	NA	NA	mg/L	TBD
Metals - Total (t) and Dissolved (d)	Zinc (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Zinc (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Lead (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Lead (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Copper (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Copper(d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Cadmium (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Cadmium (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Mercury (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Mercury(d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Silver (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)%	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Unit of Concentration	
	Silver (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Titanium (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Titanium (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Antimony (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Antimony (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Arsenic (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Arsenic (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Cobalt (t)	85-115	± 20	75-125	NA	NA	ug/L	0.01
	Cobalt (d)	85-115	± 20	75-125	NA	NA	ug/L	0.01
Polycyclic Aromatic Hydrocarbons	Acenaphthene	40 - 112	40	55 - 97	40	surrogates[1]	ug/L	0.05
	Acenaphthylene	10 - 126	40	48 - 103	40	surrogates[1]	ug/L	0.05
	Anthracene	24 - 127	40	51 - 113	40	surrogates[1]	ug/L	0.05
	Benz[a]anthracene	38 - 147	40	59 - 137	40	surrogates[1]	ug/L	0.05
	Benzo(a)pyrene	14 - 129	40	42 - 110	40	surrogates[1]	ug/L	0.05
	Benzo(b)fluoranthene	42 - 133	40	53 - 99	40	surrogates[1]	ug/L	0.05
	Benzo(ghi)perylene	12 - 122	40	38 - 131	40	surrogates[1]	ug/L	0.05
	Benzo(k)fluoranthene	38 - 131	40	33 - 122	40	surrogates[1]	ug/L	0.05
	Chrysene	37 - 128	40	51 - 116	40	surrogates[1]	ug/L	0.05
	Dibenzo(a,h)anthracene	10 - 134	40	27 - 129	40	surrogates[1]	ug/L	0.05
	Fluoranthene	42 - 123	40	60 - 107	40	surrogates[1]	ug/L	0.05
	Fluorene	50 - 150	40	50 - 150	40	surrogates[1]	ug/L	0.05
	Indeno(1,2,3-cd)pyrene	29 - 129	40	37 - 135	40	surrogates[1]	ug/L	0.05

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)%	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Unit of Concentration	
	Naphthalene	41 - 105	40	41 - 97	40	surrogates[1]	ug/L	0.05
	Phenanthrene	18 - 105	40	18 - 105	40	surrogates[1]	ug/L	0.05
	Pyrene	43 - 131	40	61 - 118	40	surrogates[1]	ug/L	0.05
Phthalates	Bis(2-Ethylhexyl) Phthalate	80 - 128	40	34 - 127	40	surrogates[1]	ug/L	0.2
	Butyl benzyl phthalate	23 - 183	40	41 - 149	40	surrogates[1]	ug/L	0.2
	Diethyl phthalate	77 - 123	40	41 - 122	40	surrogates[1]	ug/L	0.2
	Dimethyl phthalate	74 - 122	40	41 - 127	40	surrogates[1]	ug/L	0.2
	Di-N-Butylphthalate	70 - 156	40	41 - 175	40	surrogates[1]	ug/L	0.2
	Di-N-Octyl Phthalate	75 - 135	40	39 - 146	40	surrogates[1]	ug/L	0.2
Petroleum Hydrocarbons	NWTPH-Dx	70 - 130	40	NA	50	50-150	mg/L	0.20
	NWTPH-GX	70-130	40	NA	50	70-130	mg/L	0.07
Polychlorinated Biphenyls (PCBs)	209 congeners	50-150	≤50	NA	NA	25-150	pg/L	<10
Flame Retardants	Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	V6	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Isopropylated triphenyl phosphate	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)%	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Unit of Concentration	
	Tris(1-chloro-2-propyl) phosphate (TCPP)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Bis (2-ethylhexyl) tetrabromophthalate (TBPH)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Triphenyl phosphate	50-151	≤51	NA	NA	25-151	ug/L	0.002-0.006
	Dechlorane plus	50-152	≤52	NA	NA	25-152	ug/L	0.002-0.007
	Tricresyl phosphate	50-153	≤53	NA	NA	25-153	ug/L	0.002-0.008
	1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPA)	50-154	≤54	NA	NA	25-154	ug/L	0.002-0.009
	Decabromodiphenylethane (DBDPE)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
Perfluoroalkyl Substances (PFAS)	Perfluorobutanoate (PFBA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluoropentanoate (PFPeA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorobutane sulfonate (PFBS)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorooctane sulfonate (PFOS)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorohexanoic acid (PFHxA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)%	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Unit of Concentration	
	Perfluoroheptanoic acid (PFHpA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorooctanoic acid (PFOA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorodecanoic acid (PFDA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorundecanoic acid (PFUnA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorooctane sulfonamide (PFOSA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0
	Perfluorododecanoic acid (PFDoA)	70-130	<40	NA	NA	40-150	ng/L	1.0-2.0

[1] Surrogates and percent recovery limits include: 2-Fluorobiphenyl (30-115%), Dimethylphthalate-D6 (50-150%), Acenaphthylene-D8 (50-150%), Fluorene-D10 (50-150%), Anthracene-D10 (50-150%), Pyrene-D10 (50-150%), Terphenyl-D14 (18-137%), Benzo(a)pyrene-D12, (50-150%).
LCS = laboratory control sample
CRM = certified reference materials
CCV = continuing calibration verification standards
RPD = relative percent difference

Table B-4. Sediment Parameters MQOs.

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration	
Conventionals	Percent solids	NA	± 20	NA	NA	NA	NA	NA
	Total organic carbon	80-120	± 20	NA	NA	NA	NA	0.10%
	Grain size	TBD	NA	NA	NA	NA	NA	NA
	Total volatile solids	NA	± 20	NA	NA	NA	NA	NA
Metals - Total (t)	Zinc (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Lead (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Copper (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Cadmium (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Mercury (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Silver (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Titanium (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Antimony (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Arsenic (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
	Cobalt (t)	85-115	± 20	75-125	± 20	NA	ug/L	0.1
Polycyclic Aromatic Hydrocarbons	Acenaphthene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Acenaphthylene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Anthracene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Benz[a]anthracene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25
	Benzo(a)pyrene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Benzo(b)fluoranthene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Benzo(ghi)perylene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration	
	Benzo(k)fluoranthene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Chrysene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Dibenzo(a,h)anthracene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25
	Fluoranthene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Fluorene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Indeno(1,2,3-cd)pyrene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Naphthalene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25
	Phenanthrene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Pyrene	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
Phthalates	Bis(2-Ethylhexyl) Phthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25
	Butyl benzyl phthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	25
	Diethyl phthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Dimethyl phthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Di-N-Butylphthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	12.5
	Di-N-Octyl Phthalate	50-150	40	50-150	40	surrogates[1]	ug/Kg dw	125
Petroleum Hydrocarbons	NWTPH-Dx	70 - 130	40	50-150	50		ug/Kg dw	20
Polychlorinated Biphenyls (PCBs)	209 congeners	50-150	≤50	NA	NA	25-150	ng/Kg	1
Flame Retardants	Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration	
	V6	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Isopropylated triphenyl phosphate	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Tris(1-chloro-2-propyl) phosphate (TCPP)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Bis (2-ethylhexyl) tetrabromophthalate (TBPH)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
	Triphenyl phosphate	50-151	≤51	NA	NA	25-151	ug/L	0.002-0.006
	Dechlorane plus	50-152	≤52	NA	NA	25-152	ug/L	0.002-0.007
	Tricresyl phosphate	50-153	≤53	NA	NA	25-153	ug/L	0.002-0.008
	1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPA)	50-154	≤54	NA	NA	25-154	ug/L	0.002-0.009
	Decabromodiphenylethane (DBDPE)	50-150	≤50	NA	NA	25-150	ug/L	0.002-0.005
Perfluoroalkyl Substances (PFAS)	Perfluorobutanoate (PFBA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluoropentanoate (PFPeA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorobutane sulfonate (PFBS)	70-130	<40	NA	NA	40-150	ng/g	0.5-1

Parameter Group	Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentration of Interest	Reporting Limit
		% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration	
	Perfluorooctane sulfonate (PFOS)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorohexanoic acid (PFHxA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluoroheptanoic acid (PFHpA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorooctanoic acid (PFOA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorodecanoic acid (PFDA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorundecanoic acid (PFUnA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorooctane sulfonamide (PFOSA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1
	Perfluorododecanoic acid (PFDoA)	70-130	<40	NA	NA	40-150	ng/g	0.5-1

[1] Surrogates and percent recovery limits include: 2-Fluorobiphenyl (30-115%), Dimethylphthalate-D6 (50-150%), Acenaphthylene-D8 (50-150%), Fluorene-D10 (50-150%), Anthracene-D10 (50-150%), Pyrene-D10 (50-150%), Terphenyl-D14 (18-137%), Benzo(a)pyrene-D12, (50-150%).

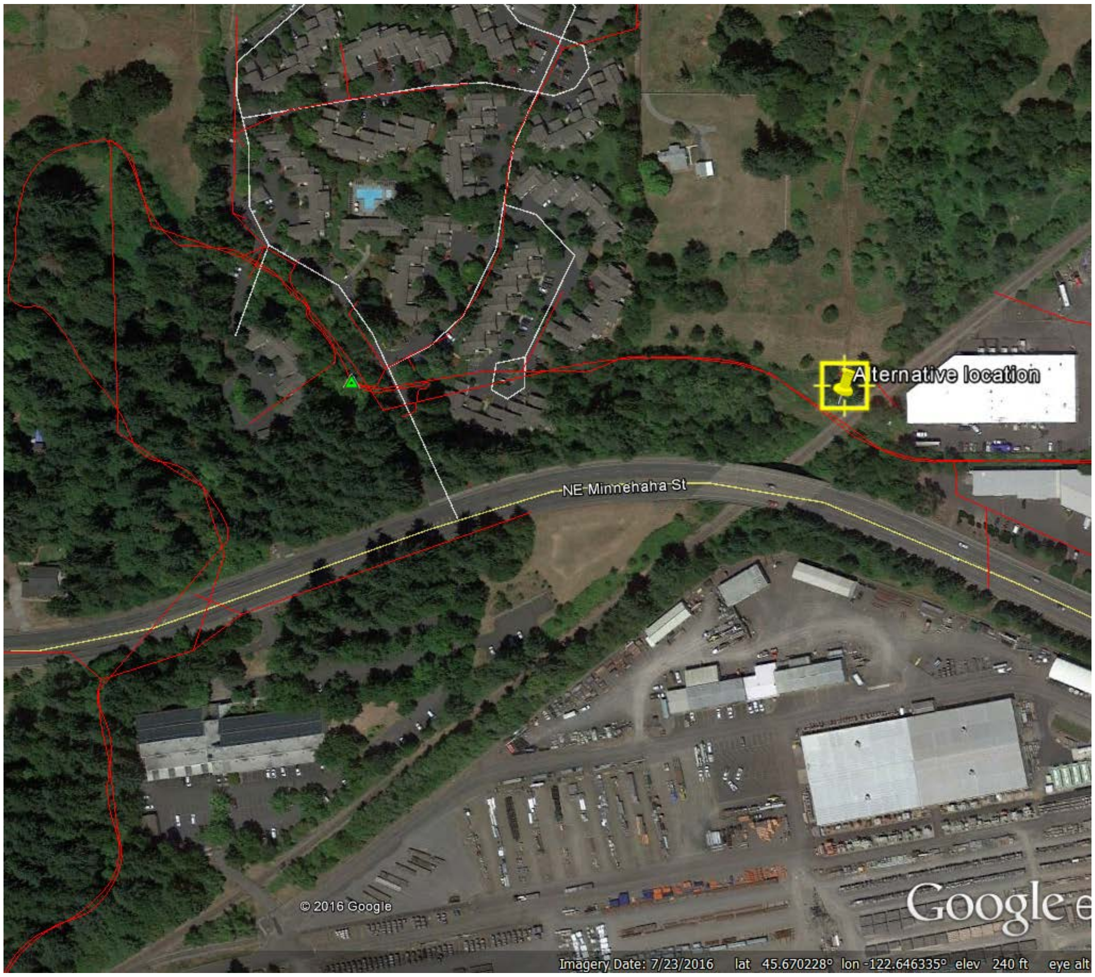
Table B-5. Field Parameter MQOs.

Parameter	Units	Accept	Qualify	Reject
pH	std. units	< or = + 0.01	> + 0.01 and < or = + 0.09	> + 0.1
Conductivity*	uS/cm	< or = + 1%	> + 1% and < or = + 1.9%	> + 2%
Temperature	° C	< or = + 0.5	> + 0.5 and < or = + 0.8	> + 0.8

* Criteria expressed as a percentage of full scale dependent upon 3 auto scales.
For example: buffer = 100.2 uS/cm and probe = 98.7 uS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 2%.

Appendix C. Photo Log, November 2016 Site Visit

<u>CC_CCAPT</u>
I5 North
Exit 3 NE HWY 99
Right NE Minnehaha Street
Left into Crystal Court Apartments Stream on Left



	Site ID: CC_CAPT Date: 11-3-2016 Location: Downstream of entrance road. Embankment. Comments: Looking upstream at concrete reinforced pipe. 48” in diameter. Riprap revetment at outfall, sediment infill.
	Site ID: CC_CAPT Date: 11-3-2016 Location: Looking downstream of outfall in wetland swale. Comments: Channelized wetland swale, flood reduction.

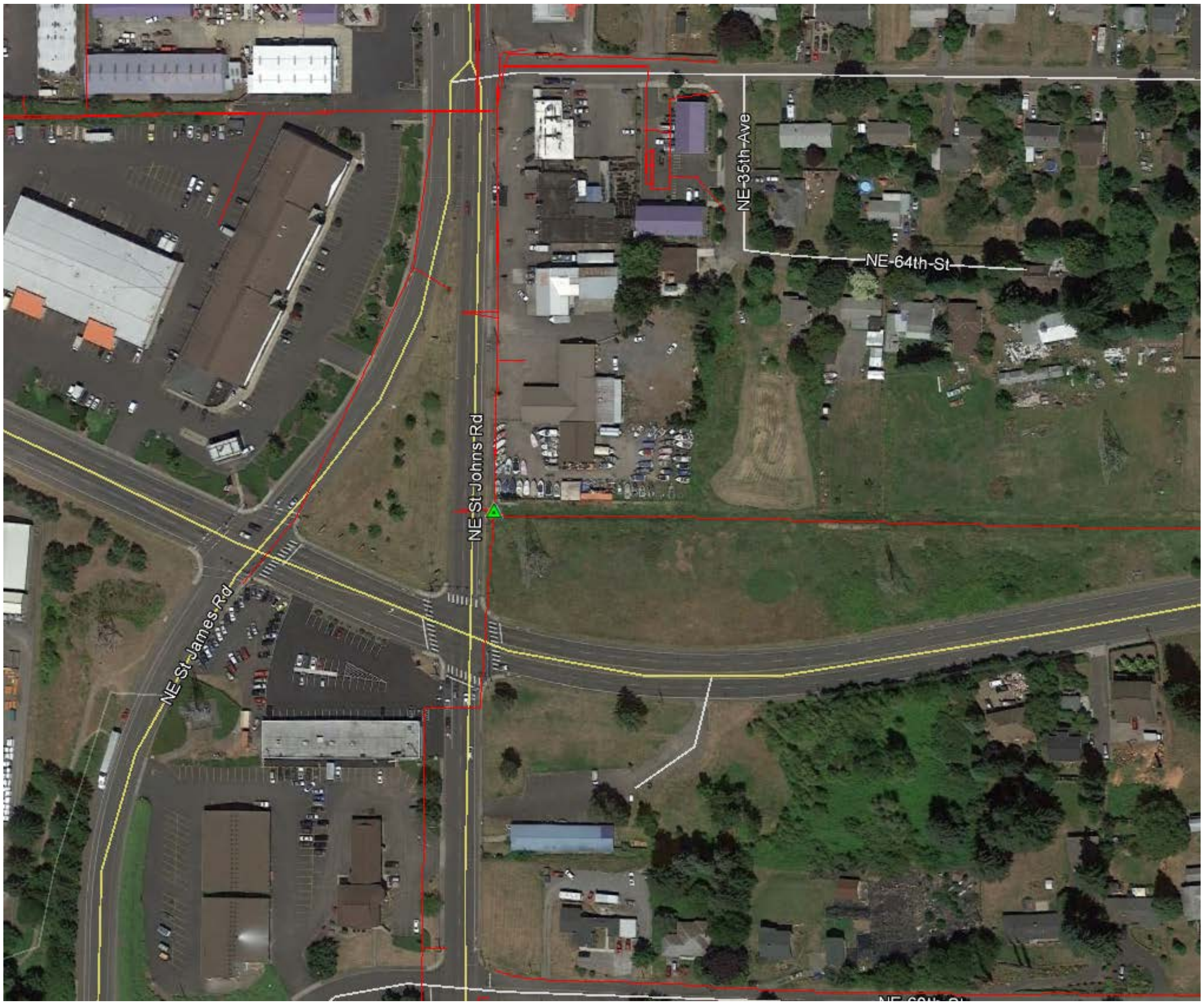
	Site ID: CC_CAPT Upstream Date: 11-3-2016 Location: Upstream of apt. complex. Influent to underground reinforced concrete pipe. Runs underground approximately 300’. Comments: Looking downstream at concrete reinforced pipe, 72” diameter. Propane tank caught in the inlet trash rack.
	Site ID: CC_CAPT Upstream Date: 11-3-2016 Location: Looking upstream of outfall in wetland swale from top of outfall. Comments: Channelized wetland swale, flood reduction.

Site ID: CC_CAPT
Date: 11-3-2016

Location: Upstream of wetland swale in industrial area behind “Punks” exhaust shop.

Comments: Potential upstream sample site. In City of Vancouver’s Phase II Permit area.

BB_STJOHNSMINNEHAHA
East on NE. Minnehaha St.
Left on NE St. Johns Road
V-ditch on west side of road before Maritime Mobile Service Inc.

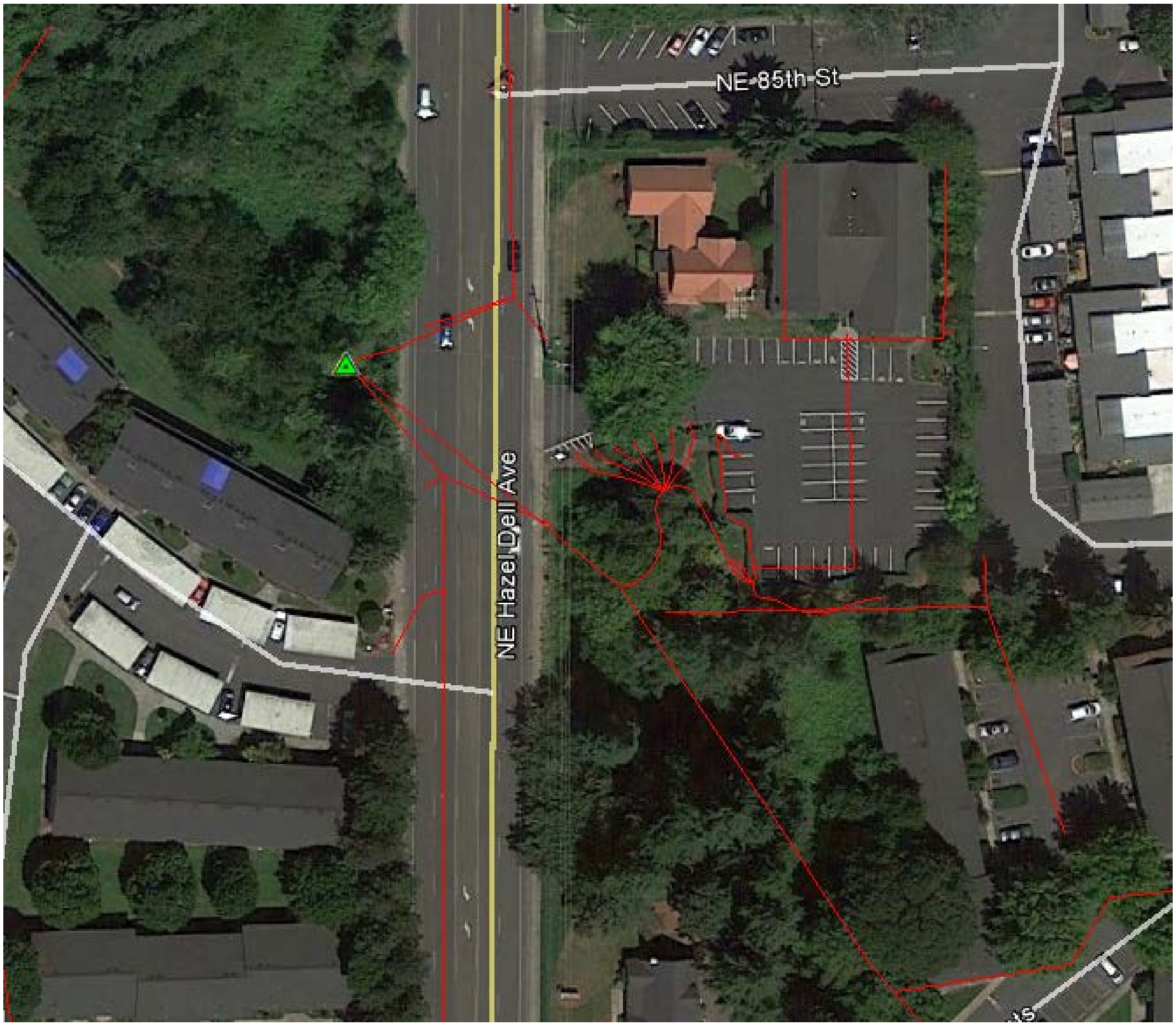


	Site ID: BB_STJOHNSMINNEHAHA Date: 11-3-2016 Location: Looking upstream of NE St. Johns Road at V-ditch Comments: Transitions to underground at NE St. Johns Road.
	Site ID: BB_STJOHNSMINNEHAHA Date: 11-3-2016 Location: Looking downstream at manhole vault cover and street catchment grate. Comments: NE St. Johns Road

LR_HWY99
North on NE St. Johns Road
Left on NE 68th Street
Right/North on NE HWY 99

	Site ID: LR_HWY99 Date: 11-3-2016 Location: Looking at catch basin junction south of Hot Wheel car dealership. Comments: Potential sampling site.
	Site ID: LR_HWY99 Date: 11-3-2016 Location: Car lot pressure washing run-off Comments: Lot drain to MS4 system.

CC_NE85
North HWY 99
Left NW 78th Street
Right NE Hazel Dell Ave
Past NW 83rd Street
Oak Place Professional Offices Parking. Across the street in ravine is outfall



	Site ID: CC_NE85 Date: 11-3-2016
	Location: Looking at stormwater outfall on west side of NE Hazel Dell Ave. Triple culvert. Middle Culvert target.
	Comments: Wooded area down in ditch. Cobble substrate, sediment.
	Site ID: CC_NE85 Date: 11-3-2016
	Location: Looking downstream of triple culvert.
	Comments:

	Site ID: CC_NE85 (Upstream) Date: 11-3-2016 Location: Looking at stormwater inlet on east side of Hazel Dell Ave. Comments: Corrugated Metal Pipe. Approximately 72" diameter.
	Site ID: CC_NE85 Date: 11-3-2016 Location: Looking upstream of culvert inlet. Comments: Channelized flow path approximately 5 feet wide.

LS_NE102

Yard 'n Garden Land 1501 NE 102nd St. Vancouver, WA 98686
Continue NE Hazel Dell Ave North
Right NW 99th Street
Left NE Hwy 99
Left NE 102nd Street
Park on right dirt lot

	Site ID: LS_NE102 (Upstream) Date: 11-3-2016 Location: Looking at retention basin downstream of garden center. Treats a portion of the local runoff. Comments: Looking south.
	Site ID: LS_NE102 Date: 11-3-2016 Location: Looking at outfall into open channel. Runoff contains BMP treated and untreated runoff. Comments: Drainage ravine.

SCTRIB – 11704 Pacific Boatland Boat; Shop floor drain to outfall behind shop
North NE HWY 99
Left NE 117th Street
Right Klineline Ave.

	Site ID: SCTRIB Date: 11-3-2016 Location: Looking at toe of slope below boat repair yard. Comments: Gas can and boat seat in ravine. Other various trash in area. Bait wrappers, buckets, propane tanks, etc.
	Site ID: SCTRIB Date: 11-3-2016 Location: Looking at ponded channel area, receives upslope drainage from culvert and associated land use. Could not find culvert, end of pipe. Submerged? Comments:

	Site ID: SCTRIB (Upslope) Date: 11-3-2016
	Location: Looking at floor drain at boat repair area.
	Comments: BMP placed around drain…

LR_NW3rdCT – 11704 Pacific Boatland Boat
Shop floor drain to outfall behind shop
North NE HWY 99
Left NE 139th St
Right NW 3rd CT

	Site ID: LR_NW3rdCT Date: 11-3-2016 Location: Looking into grass swale west. Comments:
	Site ID: LR_NW3rdCT Date: 11-3-2016 Location: Looking NE to private property, D&D door. Sample site to west of property. Comments: No access. May abandon site if landowner permission is needed.

WC_NE10NE149- Whipple Creek
Left NW 139th St (East)
Left NE 10th Ave (North)
Past NE 149th Ave gully to left

	Site ID: WC_NE10NE149 Date: 11-3-2016 Location: Looking into culvert running from the east side of NE 149th Street. Comments: Sediment and bed material have reduced capacity of culvert.
	Site ID: WC_NE10NE149 Date: 11-3-2016 Location: Looking downstream of culvert along creek bed. Comments: Riprap armoring transitions to sandy substrate.

Appendix D. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Anthropogenic: Human-caused.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Effluent: An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and Abbreviations

BMP	Best management practice
DO	Dissolved oxygen
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
e.g.	For example
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
e.g.	For example
GIS	Geographic Information System software
IDDE	Illicit Discharge Detection and Elimination
i.e.	In other words
LSC	Local Source Control
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MS4	Municipal Separate Stormwater Sewer System
NPDES	(See Glossary above)
NTR	National Toxics Rule
PBDE	polybrominated diphenyl ethers
PCB	polychlorinated biphenyls
PFAS	Perfluoroalkyl substances
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedure
TMDL	(See Glossary above)
TOC	Total organic carbon
TPN	Total Phosphate Nitrogen
TSS	(See Glossary above)
USGS	United States Geological Survey
WAC	Washington Administrative Code
WQA	Water Quality Assessment
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
dw	dry weight
ft	feet
g	gram, a unit of mass
kcfs	1000 cubic feet per second
kg	kilograms, a unit of mass equal to 1,000 grams
km	kilometer, a unit of length equal to 1,000 meters
l/s	liters per second (0.03531 cubic foot per second)
m	meter
mg	milligram
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliter
ng/g	nanograms per gram (parts per billion)
ng/Kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
ug/g	micrograms per gram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ug/L	micrograms per liter (parts per billion)
um	micrometer
umhos/cm	micromhos per centimeter
uS/cm	microsiemens per centimeter, a unit of conductivity

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

Bias: The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV): A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:
- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:
- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:
- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result: A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

Population: The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical): A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split sample: A discrete sample that is further subdivided into portions, usually duplicates. (Kammin, 2010)

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

References for QA Glossary

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