APPENDIX 8 – Stormwater Discharge Monitoring

Stormwater discharge monitoring is intended to characterize stormwater runoff quantity and quality at a limited number of locations in a manner that allows analysis of loadings and changes in conditions over time and generalization across the Permittee's jurisdiction.

QAPP Preparation

Permittees shall prepare a Quality Assurance Project Plan (QAPP) in accordance with *Quality Assurance Project Plan Guidance, Special Condition S8.D, Phase I Municipal Stormwater Permit,* December 2010 (Ecology Publication no. 10-10-075 http://www.ecy.wa.gov/pubs/1010075.pdf). The QAPP shall be developed by qualified staff or contractors with experience in applying Ecology's or EPA's QAPP Guidelines. The QAPP shall describe each stormwater discharge monitoring site and associated drainage basin in detail. The QAPP shall also describe why and how each site was selected.

Stormwater discharge monitoring QAPPs shall be submitted to Ecology in accordance with the deadlines in S8.

Permittees are responsible for maintaining an up-to-date approved QAPP for stormwater discharge monitoring. Significant changes should be reviewed by Ecology and reflected in a revised QAPP. Significant changes can include, but are not limited to:

- Land disturbing activities over 10 acres in size within the sampled drainage area.
- Relocating a monitoring station.
- Introducing new sampling equipment.
- Unanticipated back water conditions or base flow influences.
- Changes in laboratories, analytical methods or reporting limits.

Site Selection

Stormwater monitoring sites shall have the tributary conveyance system and drainage area mapped, and be suitable for permanent installation and operation of flow-weighted composite sampling equipment. Additional site selection guidance, and information about how to estimate a rainfall to runoff relationship is available in *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring, ECY002* (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/SOPAutomatedSampling.pdf).

Permittees may identify a sampling site upstream in the conveyance system (*i.e.*, upgradient of the outfall) in order to achieve the desired land use, and/or to accommodate the installation of sampling equipment.

The QAPP must describe how each site was selected, the size of the drainage basin, the percentage of area in the drainage basin representing the following land uses: high density residential, low density residential, commercial, industrial, agriculture, and transportation right-of-way.

Sites must be evaluated for a rainfall to runoff relationship in order to ensure that the site will receive enough runoff for sufficient sample volume. This rainfall to runoff relationship will also assist in programming the automatic sampling equipment. In order to establish the rainfall to runoff relationship, one year of continuous flow recording (including base flow and all storm events) is necessary.

Monitoring Frequency

Permittees shall sample each stormwater discharge monitoring site according to the frequency described below.

The Permittee shall sample and analyze six qualifying storm events per water year. Qualifying storm event sampling must be distributed throughout the year, approximately reflecting the distribution of rainfall between the wet and dry seasons (with a goal of about five of the samples collected during the wet season and a goal of about one of the samples collected in the dry season). Documented good faith efforts with good professional practice by the Permittee which do not result in collecting a successful sample for the full number of required storms may be considered as contributing toward compliance with this requirement.

Additionally, the Permittee shall analyze up to a maximum of two samples that are collected as a result of attempts to sample the six required storm events and do not meet the rainfall volume storm event criterion but do meet the other storm event and sample criteria. The maximum number of sampled storm events to be analyzed is eight per year.

Qualifying Storm Event Criteria

The wet season is from October 1 through April 30. A qualifying wet season storm event is defined as follows:

- Rainfall volume: 0.15" minimum, no fixed maximum
- Rainfall duration: No fixed minimum or maximum
- Antecedent dry period: Less than or equal to 0.02" rain in the previous 12 hours
- Inter-event dry period: 12 hours

The dry season is from May 1 through September 30. A qualifying dry season storm event is defined as follows:

- Rainfall volume: 0.20" minimum, no fixed maximum
- Rainfall duration: No fixed minimum or maximum
- Antecedent dry period: less than or equal to 0.02" rain in the previous 72 hours
- Inter-event dry period: 24 hours

Types of Sampling

Storm events shall be sampled using flow-weighted composite sampling techniques. Automatic samplers shall be programmed to begin sampling as early in the runoff event as practical and to continue sampling past the longest estimated time of concentration for the tributary area. Refer to *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring, ECY002*

(http://www.ecy.wa.gov/programs/wq/stormwater/municipal/SOPAutomatedSampling.pdf) for guidance on how to conduct flow weighted composite sampling.

Samples shall be collected for at least seventy-five percent (75%) of the storm event hydrograph up to 24 hours. Each composite sample must consist of at least 10 aliquots. Composite samples with 7 to 9 aliquots are acceptable if they meet the other sampling criteria and help achieve a representative balance of wet season/dry season events and storm sizes.

Continuous flow recording of all storm events (not just sampled storm events) is necessary for at least one year to establish a baseline rainfall/runoff relationship. Ongoing continuous flow monitoring is necessary to properly operate the flow weighted composite sampling. Precipitation data shall be collected from the nearest rain gauge reporting at least hourly rainfall amounts.

Grab samples are necessary for some parameters (see below) and shall be collected early in the storm event. Refer to *Standard Operating Procedure for Grab Sampling for Stormwater Monitoring, ECY001* (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/SOPGrabSampling.pdf).

Sediment samples shall be collected once per water year at each stormwater discharge monitoring site, or in the vicinity of each stormwater monitoring site. Use of in-line sediment traps or similar collection system is preferred; refer to *Standard Operating Procedure for Collection of Stormwater Sediments using In-Line Sediment Traps, ECY003* (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/SOPSedimentTrapStormwaterSampleCollection.pdf). Sampling of receiving water sediment deposits is an alternative where approved by Ecology.

Parameters

Flow-weighted composite samples shall be analyzed for the following parameters utilizing an accredited laboratory and the methods and reporting limits as provided in this appendix.

- Conventional Parameters: TSS, turbidity, Conductivity, Chloride, Biochemical oxygen demand (BOD5), Hardness, and Methylene Blue Activating Substances (MBAS).
- Nutrients: Total phosphorus, Orthophosphate, Total Kjeldahl Nitrogen, and Nitrate plus nitrite.
- Metals: total and dissolved copper, zinc, cadmium, and lead; mercury shall also be sampled in commercial and industrial land use areas.
- Organics: PAHs including: Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h), Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, and Pyrene.

If the volume of stormwater sample collected from a qualifying storm is insufficient to allow analysis for all parameters listed above, the sample shall be analyzed for as many parameters as possible in the following priority order: 1. Metals and hardness; 2. TSS; 3. PAHs; 4. Nutrients; 5. Conductivity; and 6. BOD_5. If insufficient sample exists to run the next highest priority pollutant, that analysis should be bypassed and analyses run on lower priority pollutants in accordance with the remaining priority order to the extent possible.

Grab samples shall be analyzed for the following parameters utilizing an accredited laboratory and the methods and reporting limits provided in this appendix.

- Total Petroleum Hydrocarbons (TPH) using NWTPH-Gx and NWTPH-Dx and BTEX (benzene, toluene, ethyl-benxene, and xylenes).

Sediment samples shall be analyzed for the following parameters utilizing an accredited laboratory and the methods and reporting limits provided in this appendix. If the volume of sediment sample is insufficient to analyze for all of the parameters listed below, the sample shall be analyzed for as many parameters as possible in the following priority order:

- Grain size (visual, qualitative determination only), total organic carbon, copper, zinc, lead, cadmium, PAHs, percent solids.

A minimum of one sediment sample per year shall be collected. Parameters that are below detection limits after two years of data may be dropped from the analysis.

Recordkeeping and Reporting

For each stormwater monitoring site, calculate the following:

- Event Mean Concentrations (EMCs)
- Total annual pollutant load by parameter
- Seasonal pollutant loads by parameter for the wet and dry seasons

The annual pollutant load calculations must be based on a water year and include wet and dry season loads and total annual load (wet plus dry season load). The loadings shall be expressed as total pounds and as pounds per acre, and must take into account potential pollutant load from base flow. Loadings shall be calculated following *Standard Operating Procedure for Calculating Pollutant Loads for Stormwater Discharges, ECY004* (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/SOPPollutantLoadingCalculations.pdf). Pollutant loading information is required for water quality parameters only.

Annual Monitoring Reports shall be submitted with each Annual Report beginning with the first Annual Report following the first full water year of monitoring. Annual Monitoring Reports shall provide all monitoring data collected during the preceding water year (October 1 – September 30). Annual Monitoring Reports shall consist of a narrative report and a submittal to Ecology's Environmental Information Management (EIM) database. Guidance for EIM data submittals is provided in *Stormwater Monitoring Report Guidance, Phase I Municipal Stormwater Permit, Reporting Requirements for Special Condition S8*, November 2010 (Ecology Publication No. 10-10-028). For the Annual Monitoring Report to be considered on time, the EIM data submission process must be initiated before March 31 of each relevant year, and completed by May 31 of each relevant year.

Annual Monitoring Reports shall include:

- A brief summary of each monitored drainage basin (full details of the monitoring drainage basin should be in the QAPP), including any changes within the contributing

drainage area or changes to the monitoring station that could affect hydrology and/or pollutant loading.

- A description of each flow-weighted composite and grab sampled storm event, including:
    - General summary about storm event criteria, including:
        - Precipitation data including antecedent dry period and rainfall distribution throughout the event.
        - Flow and hydrograph data including sampled and total runoff time periods and volumes.
        - Total number of qualifying and non-qualifying storm events captured and analyzed at each monitoring location (specify which criteria were not met for each sampled non-qualifying event).
        - Whether or not 3 storm events were captured which did not reach the 0.20" rainfall depth criterion (how many and date of storm events).
        - Distribution of storms collected between wet and dry seasons (permit goals include 60-80% of storms during the wet season and 20-40% of storms during the dry season).
        - Logistical problems associated with any storm event criterion.
    - A hyetograph and a hydrograph for each sampled storm event. Include properly labeled graphs that display the following:
        - Date of the storm event,
        - Time of day versus precipitation information,
        - Time versus flow rate, and,
        - Time versus aliquot collection
        - Display the total duration of the storm event, not just the duration when samples were collected (remember your pollutant load calculation must include flow for the entire storm event, not just the water quality sampled portion)
    - A summary of (or in the graph) the total runoff volume in gallons/other appropriate unit of measure.
    - A rainfall/runoff relationship table used to estimate the un-sampled storm events (where water quality samples were not collected). This is used for future estimations of annual and seasonal loads.
    - Whether or not any chemicals were removed from the list of analysis due to two years of non-detect data.
    - A brief summary with storm event dates where insufficient volumes were collected. Include the parameters analyzed.
- A description of the sediment sampling event, including:
    - Whether or not any chemicals were removed from the list of analysis due to two years of non-detect data.
    - A summary of sediment sampling (including dates) where insufficient volumes were collected. Include the parameters analyzed.

- Event Mean Concentrations (EMCs)
- The wet and dry season pollutant loads and annual pollutant load based on water year for each site expressed in total pounds, and pounds/acre. Include the following:
    - For storm events where water quality samples were collected, the load for each parameter for each sampled storm event, include date of storm events.
    - An estimated seasonal pollutant load for each parameter at each site. This is calculated using all storm events (where water quality samples were collected and were not collected).
    - A total annual pollutant load (wet season load + dry season load) for each parameter (include estimated events).
    - The rainfall/runoff relationship including your pollutant load estimates for un-sampled events.
    - Note that if any data is unavailable to effectively estimate your rainfall to runoff relationship due to an incomplete water year, submit this information in the next year's stormwater monitoring report.
- Quality Assurance/Quality Control information for each *sampled storm event* at each site and *sediments* sampled at each site, including:
    - A narrative summary of your field and laboratory verification, validation results and quality control checks performed.
    - A narrative analysis of your field and laboratory quality control sample results and how they compare with your data quality objectives/indicators in your QAPP.
    - Corrective actions reported/taken.

An explanation and discussion of results from each *sampled storm event* at each monitoring site and *sediments* collected at each site, including:

- A narrative analysis of the event mean concentrations for each parameter.
- Any conclusions based on trend data that may result from this study or from previously collected data from these sites.
- A description of Stormwater Management Program activities currently taking place or planned within the monitoring station's drainage area that may have affected or may potentially affect future monitoring results.

If the Permittee monitors any pollutant more frequently at the stormwater discharge monitoring sites, then the results of this monitoring shall be included in the annual monitoring report reflecting the water year in which the monitoring occurred.

After 3 water years of data, the Annual Monitoring Report shall include an evaluation of the data as it applies to the SWMP, and shall identify any stormwater management activities that can be adjusted to respond to this data.

Laboratory Methods

The Permittee's stormwater discharge monitoring program shall use the following analytical methods unless alternative methods are approved by Ecology. Any alternative method proposed

by the Permittee must have a similar reporting limit, or must be justified as adequate for the likely range of concentrations. Permittees are not guaranteed approval of their alternative methods or reporting limits.

In cases where smaller volumes of water are expected to be collected, or to save analytical costs, Permittees may propose that some of the analyses be optimized for specific parameters or groups. The Permittee must, in consultation with a qualified chemist, define the exact volumes and optimization steps and include them in the QAPP.

Table A8-1 Analytical Procedures in Stormwater

Analyte	Method in Water	Reporting Limit Target[a]
Conventional Parameters		
Total suspended solids	SM 2540B[b] or SM 2540D	1.0 mg/L
Turbidity	EPA Method 180.1 or SM2130B	± 0.2 NTU
Conductivity	SM 2510 or EPA Method 120.1	± 1 umhos/cm
Chloride	EPA Method 300.0, EPA Method 325.2, or SM4110B	0.2 mg/L
BOD_5	SM5210B	2.0 mg/L
Particle Size Distribution	Coulter Counter, Laser diffraction, or comparable method - *see attached method*	NA
Grain Size	Ecology method sieve and pipette (ASTM 1997), PSEP 1986/2003, or comparable method	NA
pH	EPA Method 150.2 or SM 4500H^+	0.2 units
Hardness as $CaCO_3$	EPA Method 200.7, SM2340B(ICP), SM2340C (titration) or SM 3120B	1.0 mg/L
Methylene Blue Activated Substances (MBAS)	SM 2340B (ICP) or 2340C (Titration) CHEMetrics Colorimetric or SM5540C	0.025 mg/L
Nutrients		
Total phosphorus	EPA Method 365.3, EPA Method 365.4, SM 4500-P E or SM4500-P F	0.01 mg P/L
Orthophosphate	EPA Method 365.3, EPA Method 365.1, SM	0.01 mg P/L

	4500-P E or SM4500-P F	
Total kjeldahl nitrogen	EPA Method 351.2, EPA Method 351.1, SM 4500 Norg-B, SM 4500 Norg-C, SM 4500 NH3-D, SM 4500 NH3-G, SM 4500 NH3-E or SM4500 NH3-F	0.5 mg/L
Nitrate-Nitrite	EPA Method 353.2 or SM 4500 -$NO3^-$ E	0.01 mg/L
Metals		
Total recoverable zinc	EPA Method 200.8 (ICP/MS), EPA Method 200.7 (ICP/MS) or SM 3125 (ICP/MS)	5.0 µg/l
Dissolved zinc	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	1.0 µg/l
Total recoverable lead	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.1 µg/l
Dissolved lead	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.1 µg/l
Total recoverable copper	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.1 µg/l
Dissolved copper	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.1 µg/l
Total recoverable cadmium	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.2 µg/l
Dissolved cadmium	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	0.1 µg/l
Total Mercury	EPA Method 7470 (CVAA), EPA Method 245.7, or EPA Method 1631E	0.1 µg/l
Dissolved Mercury	EPA Method 7470 (CVAA), EPA Method 245.7, or EPA 1631E	0.1 µg/l
Organics		
PAH Compounds	EPA Method 8310 or 8270D	0.1 µg/l
Petroleum Hydrocarbons		
NWTPH-Dx	Ecology, 1997, (Publication No. 97-602) or EPA SW-846 method 8015B; lube oil fraction	0.01 mg/L
NWTPH-Gx	Ecology, 1997, (Publication No. 97-602)	0.01 mg/L

BTEX	EPA Method 602	

a. All results below reporting limits should also be reported and identified as such. These results may be used in the statistical evaluations.

b. To ensure accurate results, Ecology recommends modifying these methods to analyze (filter) the entire field sample. Research results indicate that errors may be introduced by decanting a subsample, although using a funnel splitter may help. The analyst may also consider analyzing several premixed subsamples from the same sample container to determine if significant variability occurred due to stratification. Reports shall indicate whether the entire field sample or a subsample was used.

NA – Not applicable

SM – Standard Methods

Table A8-2 Analytical Procedures in Sediments

Analyte	Method in Sediment	Reporting Limit Target[a]
Conventional Parameters		
Percent Solids	SM 2540B	NA
Total Organic Carbon	Puget Sound Estuary Protocols (PSEP 1997), SM 5310B, SM 5310C, SM 5310D or EPA Method 9060	0.1%
Grain-size	Ecology Method Sieve and Pipette (ASTM 1997), ASTM F312-97, ASTMD422 or PSEP 1986/2003	NA
Total Phosphorus	EPA Method 365.3, EPA Method 365.4, SM 4500 P E or SM 4500 P F	0.01 mg/kg
Total Volatile Solids	EPA Method 160.4 or SM 2540E	0.1%
Metals		
Total Recoverable Zinc	EPA Method 200.8 (ICP/MS), EPA Method 6010, EPA Method 6020 or SM 3125 (ICP/MS), or EPA Method 200.7 (ICP)	5.0 mg/kg
Total Recoverable Lead	EPA Method 200.8 (ICP/MS), EPA Method 6010, EPA Method 6020 or SM 3125 (ICP/MS)	0.1 mg/kg
Total Recoverable Copper	EPA Method 200.8 (ICP/MS), EPA Method 6010, EPA Method 6020 or SM 3125	0.1 mg/kg

	(ICP/MS)	
Total Recoverable Cadmium	EPA Method 200.8 (ICP/MS), EPA Method 6010, EPA Method 6020 or SM 3125 (ICP/MS)	0.1 mg/kg
Total Recoverable Mercury	EPA Method 245.5 or EPA Method 7471B	0.1 mg/kg
Organics		
PAH Compounds	EPA Method 8270D[b]	70 µg/Kg dry
Petroleum Hydrocarbons		
NWTPH-Dx	Ecology, 1997 (Publication No. 97-602) or EPA SW-846 method 8015B	25.0-100.0 mg/Kg
BTEX		

a. All results below reporting limits shall also be reported and identified as such. These results may be used in the statistical evaluations.

b. Sample preparation procedures followed: 3550, 3640, 3660G, and 3620

NA – Not applicable

SM – Standard Methods