A Monitoring Quality Assurance Project Plan for Bear Creek Watershed-Scale Stormwater Plan

September 2015

King County

Department of Natural Resources and Parks
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A Monitoring Quality Assurance Project Plan for Bear Creek Watershed-Scale Stormwater Plan

Submitted by:

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King County Water and Land Resources Division
Department of Natural Resources and Parks

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Record of Changes		
Section	**Changed Date**	**Description**
Section 5.1.2	**June 2015**	**Base flow sample collection changed to one sampling event taken in the PM time period of the day. Changed made prior to the 3rd base flow event.**

Changes that have occurred during the collection of data after initial agreement of QAPP language in March 2015 from all participating partners: Snohomish County; cities of Redmond and Woodinville, and Washington State Department of Transportation.

Citation

King County. 2015. A Monitoring Quality Assurance Project Plan for Bear Creek Watershed-Scale Stormwater Plan. Prepared by Jeff Burkey, Eric Ferguson, Katherine Bourbonais, Water and Land Resources Division. Seattle, Washington.

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EXECUTIVE SUMMARY

King County is required to conduct a watershed-scale stormwater planning effort to satisfy permit obligations under section (S5.C.5.c.ii) in the National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (permit) issued by the Washington State Department of Ecology (Ecology), effective August 1, 2013, modified January 16, 2015, and expires July 31, 2018. This report is a quality assurance project plan for monitoring activities related to the implementation of the permit monitoring (precipitation, flow, surface water quality, and macroinvertebrates) within Bear Creek Basin study area.

For this work, the Bear Creek watershed is defined as including Bear Creek and lands that drain to Bear Creek, with the following exclusions:

- The Evans Creek basin (a tributary to Bear Creek) is not included in King County's selection
- The reach of Bear Creek downstream of the confluence to Evans Creek, along with small direct drainages and tributaries to this reach of Bear Creek, is not included in King County's selection
- Cottage Lake and the area that drains to Cottage Lake are not included in King County's selection.

King County, City of Redmond, City of Woodinville, Snohomish County, and Washington State Department of Transportation are entering into a partnership to evaluate existing conditions of Bear Creek Basin. This project will include extensive mapping, gauging and water quality testing.

Objectives for this monitoring study plan are described in the following list.

- Characterize existing conditions for the study area including base and storm flow situations
- Compare existing conditions to historical values where feasible
- Support development and calibration of a watershed model(s)

Parameters targeted for analysis include *conventionals*, pathogen indicators, trace metals, and macroinvertebrates. Conventional parameters include: ammonia-N, nitrate+nitrite, total nitrogen, total suspended solids, laser particle size distribution/sediment concentration, and turbidity. Field parameters measured will be: continuous water level and temperature at 15-minute intervals, dissolved oxygen, conductivity, and pH. The pathogen indicator will include analysis of fecal coliforms. Metals analyzed will include copper and zinc, and to calculate hardness calcium and magnesium.

This work will be assessed, reported and incorporated into a basin-wide stormwater plan of Bear Creek. The existing conditions monitoring will be completed by end of 2016.

The following signatures of King County staff indicate the review of this Quality Assurance Project Plan for monitoring, as a component of the stormwater basin planning in the Bear Creek watershed, in accordance with Special Condition S5.C.5.c of the NPDES Phase I municipal stormwater permit.

Jeff Burkey, King County, Project Manager — Date

Katherine Bourbonais, King County, Laboratory Project Manager — Date

1.0 INTRODUCTION

King County is required to conduct a watershed-scale stormwater planning effort to satisfy permit obligations under section (S5.C.5.c.ii) in the National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (permit) issued by the Washington State Department of Ecology (Ecology), effective August 1, 2013, modified January 16, 2015, and expires July 31, 2018. This report is a quality assurance project plan for monitoring activities related to the implementation of the permit monitoring (precipitation, flow, surface water quality, and macroinvertebrates) within Bear Creek Basin study area.

1.1 Bear Creek Watershed

King County has selected the Bear Creek watershed for the watershed-scale stormwater planning effort. For this work, the Bear Creek watershed is defined as including Bear Creek and lands that drain to Bear Creek, with the following exclusions:

- The Evans Creek basin (a tributary to Bear Creek) is not included in King County's selection
- The reach of Bear Creek downstream of the confluence to Evans Creek, along with small direct drainages and tributaries to this reach of Bear Creek, is not included in King County's selection
- Cottage Lake and the area that drains to Cottage Lake are not included in King County's selection.[1]

King County's selection of the Bear Creek watershed, as defined above, has been approved by Ecology (NPDES Phase I Municipal Stormwater Permit, August 1, 2013, Modified January 16, 2015, S5.C.5.c.i.). The Bear Creek basin as defined (Figure 1) encompasses about 26 square miles. About 2.4 square miles are in the City of Redmond, 1.1 square miles are in the City of Woodinville, 1.9 acres are owned by the Washington State Department of Transportation, 3.7 square miles are in unincorporated Snohomish County, and 18.9 square miles [73 percent] are in unincorporated King County. The majority of the unincorporated King County area is designated rural except for about 1.9 square miles residing on the urban side of the Urban Growth Boundary (Figure 1). However, a large portion of the study area including unincorporated areas (39%) have existing parcel densities greater than rural zoning RA 2.5.

[1] Drainages upstream of Cottage Lake are not included in the project area because Cottage Lake serves to substantially mitigate the effects of land use change upstream of the lake. The drainage area feeding to Cottage Lake is approximately 4300 acres, with over 100 acres comprised of lakes (Cottage, Crystal, and Little) and about 100 acres of wetlands (source: Small lakes program, and Lakes of Washington Vol 2.).

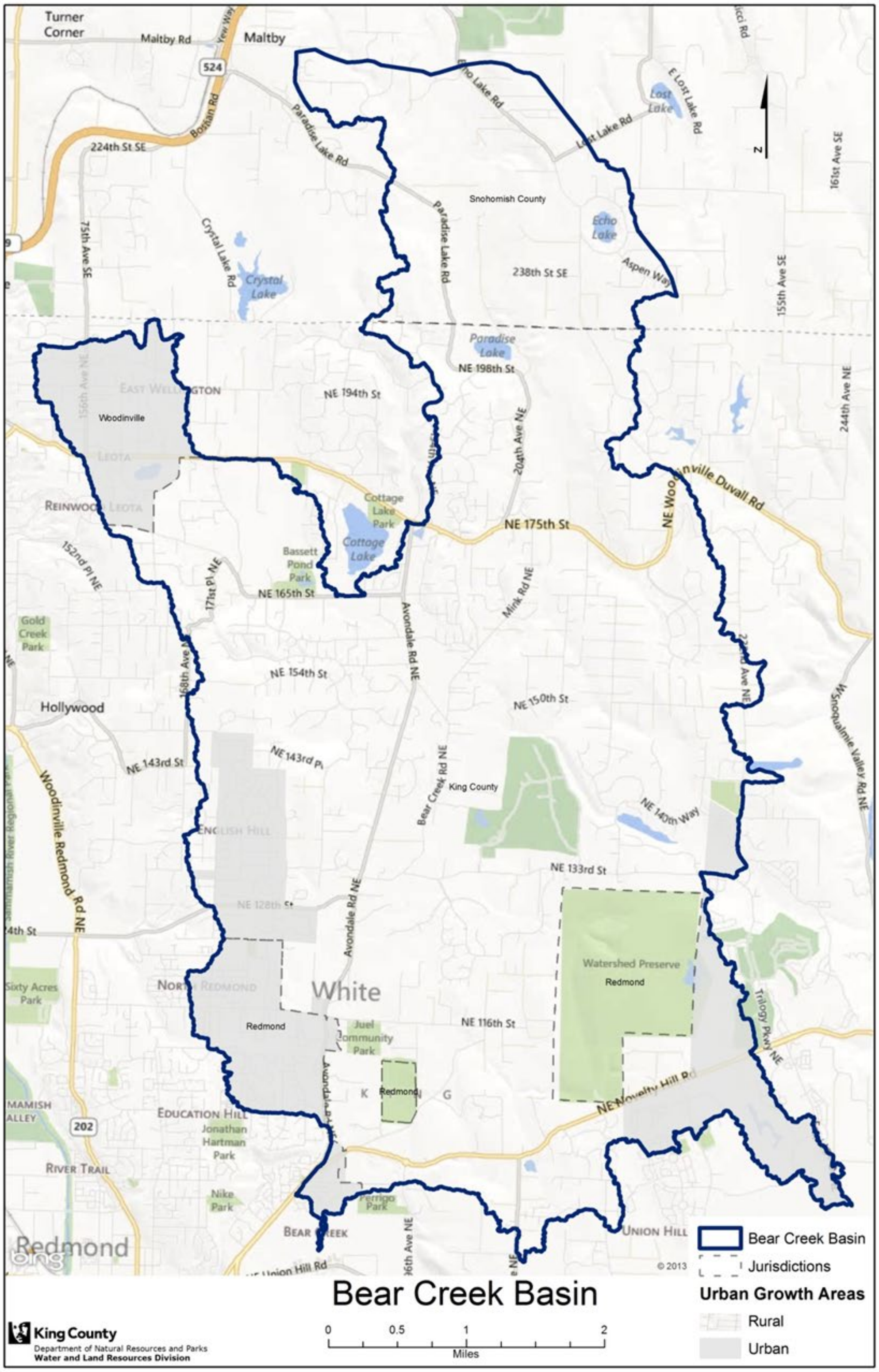

Figure 1. Bear Creek Study Area. Jurisdictions (Redmond, Woodinville, and Snohomish County) along with Washington State Department of Transportation roadways are shown within the study area.

1.2 Partnerships

King County is partnering with the cities of Redmond and Woodinville, Snohomish County and Washington State Department of Transportation in the Bear Creek Watershed-scale stormwater plan. This QAPP reflects the collaboration among all five partners and satisfies the water quality monitoring design of the Municipal Phase I & II watershed-scale full participation requirements.

1.3 Previously Established Monitoring Stations and Data

King County has numerous existing monitoring sites within the Bear Creek study area (Figure 2). These sites are monitored for a variety of projects and studies, such as stream macroinvertebrate monitoring which has 15 BIBI sites within the study area. Precipitation and weather are monitored at 4 sites—3 precipitation and 1 weather station recording the following parameters: air temperature, barometric pressure, precipitation, relative humidity, solar radiation, and wind speed. Stream flow is currently measured at three sites within the study area (historically there have been eight sights in total). Stream water quality is currently sampled at two sites as part of the county-wide monthly streams assessment program.

1.3.1 Partner data

Each partner has collected water quality data within the greater bear creek basin area. The following is a brief summary of their datasets:

- City of Redmond
    - 21 sites
    - time frame: 1995 to 2010
    - types of data: water quality, flow, water temperature, BIBI, rain
- City of Woodinville
    - 5 sites
    - Lake Leota and time frame: 2010 to 2014
    - types of data: water quality, water temperature
- Snohomish County
    - 2 sites
    - time frame: 2005, 2008 to 2010, and 2012
    - types of data: water temperature, BIBI
- WA State DOT
    - None within the Bear Creek study area

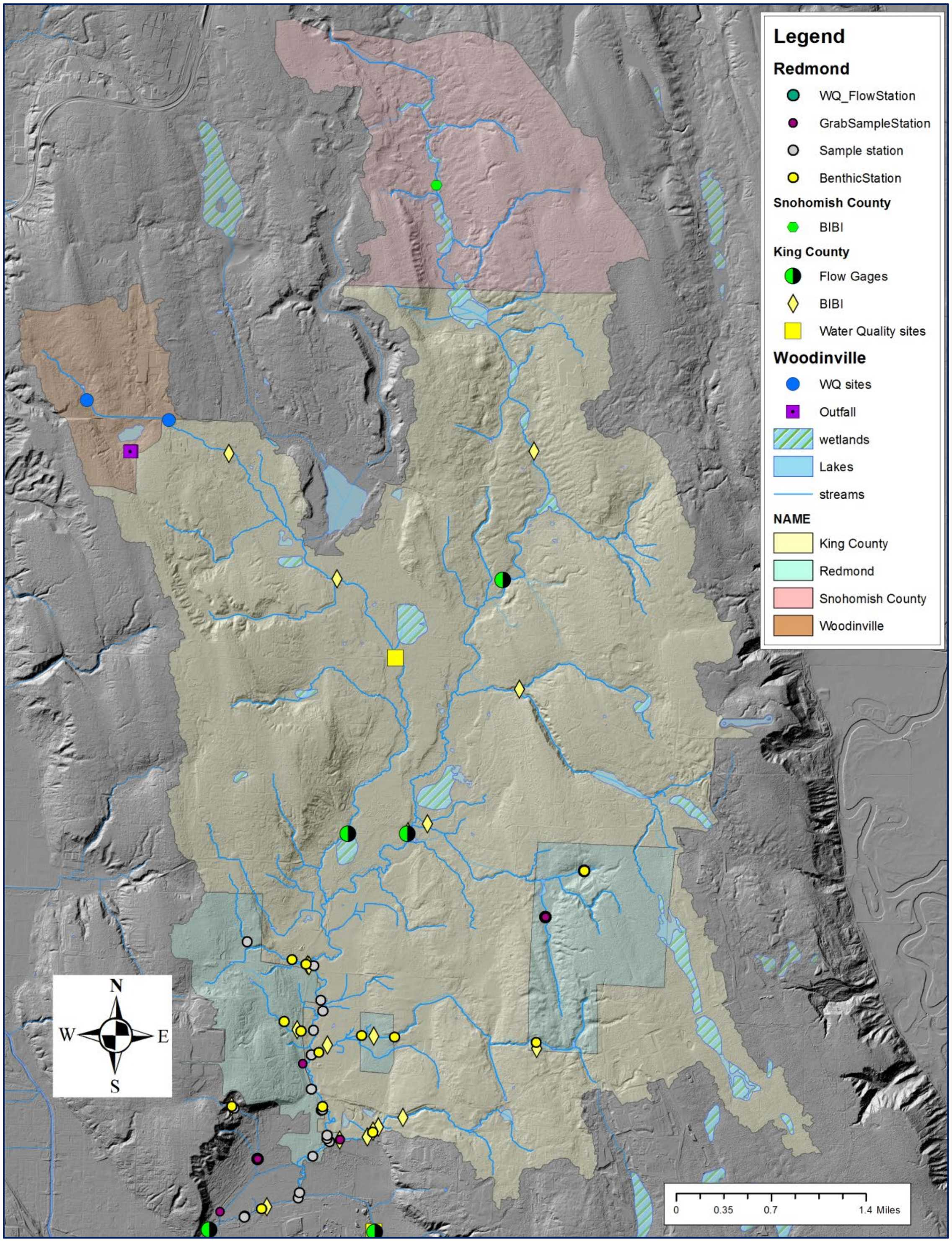

Figure 2. Bear Creek – Existing (including King County historical) monitoring sites within the study area.

1.4 Property Access

Monitoring stations in the rural environment routinely require cooperation with private property owners to gain access to the desired points in the stream system, and when necessary, installation of needed monitoring equipment. Given the requirement to install stream flow gauges in the basin, verbal agreements will be attempted. However, not all property owners are cooperative. Denial of access will prompt relocating to another site capable of meeting the objectives of the study plan. Property access is and will be required for all types of monitoring – gage activities, stream water quality, sediment and benthic sampling,

1.5 Water Quality Standards and Parameters of Concern

1.5.1 Washington State Administrative Code

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, water body classifications, and numeric and narrative water quality criteria for surface waters of the state. Water bodies are not explicitly listed in the Washington Administrative Code but receive classifications as discharges to Lake Washington.

Stream reaches identified as core rearing are for the protection of spawning, core rearing, and migration of salmon and trout, and other associated aquatic life. Characteristic uses for Class AA water bodies include water supply (domestic, industrial, and agricultural), stock watering, fish and shellfish (salmonid and other fish migration, rearing, spawning, and harvesting), wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), and commerce and navigation. Numeric criteria for specific water quality parameters are intended to protect designated uses.

Ecology revised the state water quality standards in July 2003; however, EPA disapproved the aquatic life designations and associated temperature criteria in March 2006 (Gearheard, 2006). In the Bear Creek, there was no change to the designated aquatic life use of core rearing (EPA, 2006).

1.5.2 National Pollutant Discharge Elimination System (NPDES)

The NPDES Phase I Municipal Stormwater Permit requires water quantity and quality data to support the Watershed-Scale Stormwater Plan, S5.C.5.c.iv.(1). The existing conditions assessment requires the availability, or if inadequate, the collection of several environmental measures. At minimum the assessment is required to include hydrologic, biologic, water quality, and the aquatic community.

The minimum types of data evaluated for this permit requirement includes:

- continuous stream flows and precipitation
- benthic macro-invertebrates
- dissolved copper and zinc concentrations2
- water temperature2
- fecal coliforms2
- the presence and distribution of salmonid uses[3]

1.5.3 Temperature

Freshwater temperature shall not exceed 16.0°C due to human activities. When natural conditions exceed 16.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C. Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C when the temperatures are less than the standard.

The July 2003 temperature standards do not use the class distinction but depend on whether streams are, or could be, salmonid or trout core-rearing or non-core-rearing water bodies. However, streams that were previously identified as Class AA are designated as salmonid or trout spawning, core rearing, and migration streams which must not exceed a seven-day average maximum temperature of 16°C. (The previous standard also used 16°C but as the instantaneous maximum temperature.)

In addition, Bear Creek mainstem must not exceed 13°C between September 15 and May 15. Figure 3 presents the extent of the revised classification

1.5.4 Dissolved Oxygen

Freshwater dissolved oxygen shall exceed 9.5 mg/L. When natural conditions occur causing the dissolved oxygen to be depressed near or below the levels described above by class, natural dissolved oxygen levels may be degraded by no more than 0.2 mg/L by the combined effect of all human-caused activities.

1.5.5 Metals: Copper and Zinc

Major sources of copper in urban run-off are from vehicle brake pads, architectural uses and in pesticides. Each time drivers apply their brakes a small amount of brake wear debris is released to the environment. Estimates of the contribution of vehicle brake pads to copper levels in San Francisco Bay are around 10,000 pounds per year of copper. Architectural copper sources are roofs, gutters, and copper-treated composite shingles. While all copper pieces start with a shiny metal appearance, if left untreated, the copper

[2] Thresholds are established in the Washington State Administrative Code.
[3] If available data are inadequate, permit does not require the collection of any new data needed for a complete assessment.

will develop a patina, oxidizing to shades of green and brown as it ages. Factory or field copper oxidation treatments are often used to give the copper a desired patina immediately. Oxidation forms compounds that are soluble in water to varying degrees;

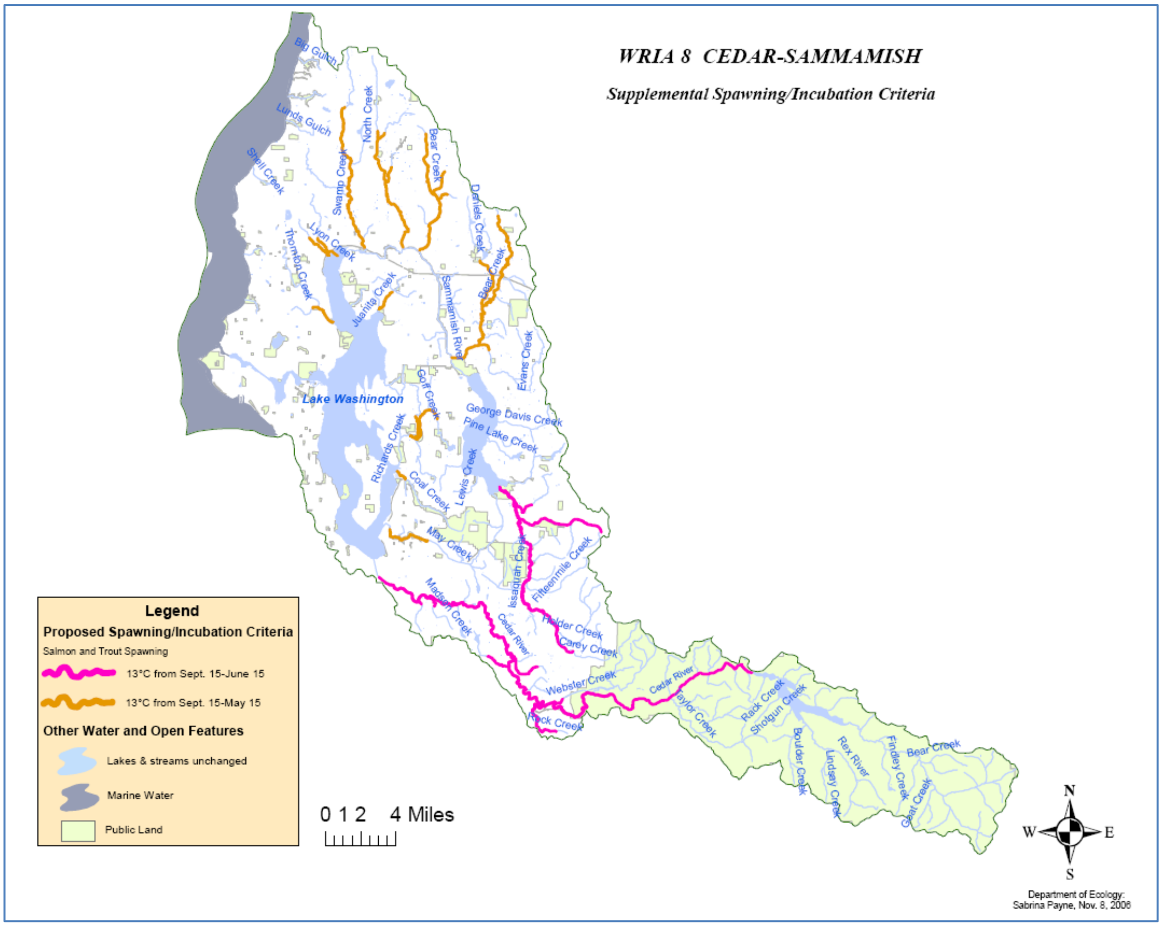

Figure 3. Ecology Waters Requiring Supplemental Spawning and Incubation Protection for Salmonid Species—WRIA 8. Ecology publication number: 06-10-038

these are incrementally washed off in runoff. Copper metal exposed to air continues to oxidize and incrementally wash off throughout its service life, which may extend for 100 years or longer. Copper-containing pesticides are widely used to control fungi, mildew, algae, and roots. Primary uses are as algaecides, marine antifouling paint biocides, root killers, wood preservatives, and agricultural and garden fungicides.

Most zinc is released from industries such as iron and steel production and non-ferrous metal production. Another significant source is road transport due to vehicle tire wear, as zinc is used in rubber manufacture. Zinc has many commercial uses such as being used as coatings to prevent rust, in dry-cell batteries and importantly, in many alloys, such as brass and bronze. Large quantities are also used in the production of die castings. Compounds of zinc are used in industry in the manufacture of paints, plastics, rubber, dyes, wood preservatives, and cosmetics. Zinc pyrithione prevents the growth of microorganisms and is an active substance in dandruff shampoo and boat hull paint.

The toxicity to rainbow trout of a mixture of zinc and copper sulfates in relatively low concentrations can be calculated from the toxicities of the individual metals by assuming that they exert a similar joint action. Higher concentrations of the mixture in soft water exhibit a synergistic action

1.5.6 Bacteria (Fecal Coliform)

Bear Creek is designated as Extraordinary Primary Contact Recreation for water contact recreation bacteria criteria in fresh water. The fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL to protect water contact recreation in fresh waters

1.5.7 Turbidity

Turbidity is measured in "nephelometric turbidity units" or "NTUs" and for Bear Creek the maximum turbidity shall not exceed 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU

1.6 Previous Studies

Numerous studies have been conducted in the Bear Creek watershed. These studies will provide foundational material for this project. Some examples include:

Fevold, K. and J. Vanderhoof. 2002. Freshwater Mussels Found in Bear and Cottage Lake Creeks During Habitat Assessments in 2001.

Kerwin, J. 2001. Salmon and Steelhead Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission. Olympia, WA.

King County. 1995. Bear Creek Basin Plan. The basin plan, adopted by the King County Council, covered the entire basin.

King County. 2002. Water Quality Monitoring of Northern Lake Washington Streams. Water and Land Resources Division. Seattle, Washington.

King County. 2004. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2002 Data Analysis. Submitted by EVS Environmental Consultants. Water and Land Resources Division, Seattle, Washington.

King County. 2005. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2003 Data Analysis. Submitted by EVS Environmental Consultants. Water and Land Resources Division, Seattle, Washington.

King County. 2005. Results of a Pilot Freshwater Mussel Survey in King County. Prepared by Bob Brenner. Water and Land Resources Division. Seattle, Washington.

King County. 2006. Timing, abundance, and population characteristics of spawning Chinook salmon in the Cedar/Sammamish Watershed. Prepared by Hans B. Berge and Mistie L. Hammer, King County Department of Natural Resources and Parks, and Steve R. Foley, Washington Department of Fish and Wildlife—Region 4.

King County. 2007. Cold Creek Aquifer Study of Surface Water / Groundwater Interactions, Phase 2. Prepared by Sevin Bilir, Water and Land Resources Division. Seattle, Washington.

King County. 2010. Working Draft Identification of Streams with Declines in Summer Low Flows. Prepared by Curtis DeGasperi and Jeff Burkey, Water and Land Resources Division. Seattle, Washington.

King County. 2010. Working Draft Preliminary Estimates of Summer Environmental Restoration Flow Targets for Basins in King County with Declines in Summer Low Flows. Prepared by Curtis DeGasperi and Jeff Burkey, Water and Land Resources Division. Seattle, Washington.

Kiyohara, Kelly. 2013. Evaluation of Juvenile Salmon Production in 2012 from the Cedar River and Bear Creek. Prepared by Kelly Kiyohara, Science Division, Fish Program, Washington Department of Fish and Wildlife. Olympia, Washington.

Lee, Sinang, 2008. Bear-Evans Watershed Fecal Coliform Bacteria Total Maximum Daily Load—Water Quality Improvement Report. Prepared for Washington State Department of Ecology. Publication No. 08-10-026. Prepared by Sinang H. Lee, Water Quality Program, Northwest Regional Office, Washington State Department of Ecology. Bellevue, Washington.

Massmann, J. 2000. Effects of Groundwater Extraction on Stream Flow in Bear-Evans Creek Watershed. Prepared for The Muckleshoot Indian Tribe, Fisheries Department. Auburn, Washington.

Mohamedali, T., S. Lee. 2008. Bear-Evans Watershed Temperature and Dissolved Oxygen Total Maximum Daily Load—Water Quality Improvement Report. Prepared for Washington State Department of Ecology. Publication No. 08-10-058. Prepared by Teizeen Mohamedali, Environmental Assessment Program (Olympia) and Sinang

H. Lee, Water Quality Program, Northwest Regional Office (Bellevue), Washington State Department of Ecology. Olympia, Washington. www.ecy.wa.gov/biblio/0810058.html

Roberts, M. and R. Jack. 2006. Sampling and Analysis Plan and Quality Assurance Project Plan—Bear/Evans Watershed Temperature and Dissolved Oxygen Total Maximum Daily Load Study. Prepared for Washington State Department of Ecology. Publication No. 06-03-107. Prepared by Dr. Mindy Roberts, Environmental Assessment Program, Olympia, Washington, and Richard Jack, King County Department of Natural Resources and Parks. Seattle, Washington. www.ecy.wa.gov/biblio/0603107.html

Thomas, A.C. 2008. Investigation of Western Pearshell Mussel (*Margartifera falcata*) Mortality in Bear Creek, King County, Washington: A Disease Ecology Approach. University of Washington.

Vanderhoof, J., S. Stolnack, K. Rauscher, and K. Higgins. 2011. Lake Washington/ Cedar/ Sammamish Watershed (WRIA 8) Land Cover Change Analysis. Prepared for WRIA8 Technical Committee by King County Water and Land Resources Division, Department of Natural Resources and Parks. Seattle, Washington

WRIA 8 Steering Committee, 2005. Final—Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan, Volumes I-III. Prepared by the WRIA 8 Technical Committee.

2.0 PROJECT DESCRIPTION

This watershed-scale planning effort is intended to identify stormwater management strategies that would result in hydrologic and water quality conditions that fully support *existing* and *designated* uses as defined in the Washington Administrative Code (WAC 173-201A-020).

King County will lead this planning process (S5.C.5.c.ii) and coordinate with the other jurisdictions and partners to allow for their input during the life of the project. The watershed-scale plan will include assessments of the landscape based on historic, existing, and projected future conditions. Stormwater management strategies will be evaluated, using these landscape baselines, for stream health based on stream hydrology, water quality, and aquatic biota (life forms). The evaluations will be derived from previous study results; interpretations of existing and collection of new data; and development of computer models that will project historic and future conditions and characterize the effectiveness of stormwater management strategies. An implementation plan will be designed using these results, which will include stormwater management strategies, estimated costs, and potential funding mechanisms.

2.1 Existing Conditions Assessment

King County, City of Redmond, City of Woodinville, Snohomish County, and Washington State Department of Transportation are entering into a partnership to evaluate existing conditions of Bear Creek Basin. This project will include extensive mapping, gauging and water quality testing,

Natural environmental forces along with anthropogenic activities result in variable concentrations and mass loadings of the water quality parameters in space and time. Consequently, designs of this study plan include taking measurements multiple times during storm events and base flow conditions.

Objectives for this monitoring study plan are described in the following list.

- Characterize existing conditions for the study area including base and storm flow situations.
- Compare existing conditions to historical values where feasible.
- Support development and calibration of a watershed model(s)

Parameters targeted for analysis include *conventionals*, pathogen indicators, trace metals, and macroinvertebrates. Conventional parameters include: ammonia-N, nitrate+nitrite, total nitrogen, total suspended solids, laser particle size distribution/sediment concentration, and turbidity. Field parameters measured will be: continuous water level and temperature at 15-minute intervals, dissolved oxygen, conductivity, and pH. The pathogen indicator will include analysis of fecal coliforms. Metals analyzed will include copper and zinc, and to calculate hardness calcium and magnesium. Particle size distribution will be analyzed on suspended solids in the water-column and sediment samples taken from the stream bottom.

2.1.1 Co-location of equipment

Well behaved and measurable stream channel hydraulics can be challenging to find, especially when locations of the monitoring sites need to meet certain requirements. Sampling sites were located to characterize most of the major loadings of the tributaries in the basin. This will be accomplished by taking measurements near the confluences of the various tributaries. However, measuring stream flows with reasonable accurateness sometimes requires relocating where stream flows are measured. Variability and predictiveness of concentrations are lower for water quality than quantity. Consequently, priority of site locations is given to water quality grab samples and accuracy of stream flow measurements. As a result, stream flow gauges are located a short distance from the sample locations where conditions were optimal for measuring stream flow.

2.1.2 Site Access

Reconnaissance for site location was conducted during lower flow conditions. It's possible that during large enough runoff events, water quality site locations may become inaccessible. If this occurs, field staff will re-locate upstream to the next feasible location, noting any changes on the field sheets.

2.1.3 Installed Equipment

Three precipitation gauges and one weather station are located in the basin. Two of those gauges (weather station and 1 precipitation) are equipped with telemetry allowing remote access and real-time reporting. Eight stream flow gauges are located within the study area. None of these sites have telemetry equipment for real time assessment of flow; that ability is available at site 02a, near the mouth Bear Creek below the confluence of Evans Creek, just outside the study area.

2.1.4 Preparation of Sampling Event

As much as possible, preparations of sampling events will be done as far in advance as possible—with bottle preparation having no expiration date prior to execution of the sampling event. Other equipment requiring calibrations that are time sensitive will be performed as specified in the sample design section of the plan.

2.1.5 Storm Event Criteria Defined

Preparations for storm event sampling begin with weather forecasts predicting 24-hour accumulations of precipitation greater than 0.30-inches or greater than and/or equal to 0.50 inches in a 48 hour period. At which time, field staff (or consultant) will be on call and begin monitoring data downloaded from the telemetered gauges. Mobilization will begin when the targeted storm event is seemingly eminent based on available weather tracking information.

Using remotely accessible data will greatly reduce the possibility of false starts or starting too late for the targeted storm and missing the rising limb of the hydrograph.

Telemetered stream flow data will be used to delay deployment if targeted storms have had dry antecedent conditions lagging the runoff response as rainfall exceeds infiltration rates into the ground (i.e. creates surface runoff).

Storm events require less than 0.05 inches of rainfall within the preceding 24 hours to be considered as meeting antecedent conditions.

Note: criteria specified here are subject to change.

2.1.6 Base Event Criteria Defined

Definitions for base flow events are simply defined as no precipitation occurring three to five days prior to the planned sampling event. Specifically, base flow conditions are defined as the flow rates that occur before the rise and after the drop in elevated stream flows resulting from precipitation. These flow rates generally require two to five days of no rainfall, depending on the site, so that recession of the hydrograph has occurred.

Note: criteria specified here are subject to change.

3.0 PROJECT MANAGEMENT

3.1 Roles and Responsibilities

Project team members and their responsibilities are summarized in Table 1.

Table 1. Project Staff and responsibilities.

Staff	Title	Jurisdiction	Responsibility
Jeff Burkey	Project Manager	King County	Overall Project
Katherine Bourbonais	Lab Project Manager	King County	KCEL – base flow
Fritz Grothkopp	Lab Project Manager	King County	KCEL – Storm flow
Christopher Barnes	FSU staff	King County	Sampling – sediment and base events
Dave Funke	Engineer – Gauging group	King County	Gauge work oversight
Dan Smith	Stream Gauger	King County	Stream flow, water temperature, and precipitation sites
Eric Ferguson	Hydrogeologist	King County	Manage monitoring for this QAPP
Jennifer Vanderhoof	Ecologist	King County	Wetland work, reporting
Jo Opdyke Wilhelm	Ecologist	King County	Macroinvertebrate sampling, reporting
Chris Gregersen	Ecologist	King County	Macroinvertebrate sampling, reporting
Dan Lantz	Ecologist	King County	Aquatic sampling, reporting
Andy Rheaume	Watershed Planner / Partner	City of Redmond	Project support
Tom Hansen	Public Works Director / Partner	City of Woodinville	Project support
Bill Leif	Environmental Program Specialist / Partner	Snohomish County	Project support
Dick Gersib	Program Manager / Partner	Washington Dept. of Transportation	Project support
Consultant	Tetra Tech staff	Consultant	Sample Collection – Storm events

3.2 Schedule

This existing conditions assessment work will be conducted over approximately a 23 month period from February 2015 to December 2016. The schedule of specific work items are presented in Table 2

Table 2. Summary of schedule for monitoring activities.

Task	Schedule	Responsibility
Stream flow	On-going	Dan S
Precipitation / weather station	On-going	Dan S & Dave F
Water temperature	On-going	Dan S.
Water Quality Sampling – storm events	~1 every other month: March 2015 – January 2016 a total of 6 total	Consultant
Water Quality Sampling – base flow events	~ 1 every other month: February 2015 – January 2016, a total of 6 total	KCEL FSU staff
Macroinvertebrate Sampling	August/September 2014* and August/September 2015	Jo Opdyke Wilhelm
Stream Sediment Sampling	1 event, any time before September 2015 except during storm events	KCEL FSU staff
Aquatic Sampling	Jan – July 2015, or Jan – July 2016	Dan Lantz & TBD
Riparian and Wetland Vegetation	1st quarter 2015 through 3rd quarter 2016	Jennifer Vanderhoof & TBD
*Due to NPDES permit schedule needs, macroinvertebrate sampling was conducted in 2014 prior to finalization of QAPP.		

3.3 Reporting

This work will be assessed, reported and incorporated into a basin-wide stormwater plan of Bear Creek. The existing conditions monitoring will be completed by end of 2016.

4.0 QUALITY OBJECTIVES

The most critical requirements for data quality are driven by the needs to accurately characterize runoff from the land cover in the basin. To meet these needs the following data quality objectives have been established.

4.1 Precision, Accuracy, and Bias of Field and Laboratory Measurements

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for analytical chemistry may be measured by one or more of the following quality control (QC) procedures:

- Analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory duplicates (laboratory QC results will be evaluated against the control limits presented in Section 8).
- Collection and analysis of replicate field samples for laboratory and field measurement (see Table 3 for a listing of relative percent differences in the evaluation of the spatial and temporal chemical concentrations to be meaningful)
- Collection and analysis of field filtration blanks for dissolved metals. Results should be less than the method detection limit.

The recommended QC limits associated with chemistry testing are summarized in Table 3.

4.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Samples for chemistry analysis will be collected from stations with pre-selected coordinates to represent specific site locations. Samples are to be collected to minimize potential contamination and other types of degradation in the chemical and physical composition of the water. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (section 5.0) will help ensure that samples are representative. Laboratory representativeness is achieved by proper preservation and storage of samples along with appropriate subsampling and preparation for analysis. The storm and baseflow conditions in section 5.1.1 and 5.1.2 should also be met. Data that is not representative as defined above should not be used for characterization.

Table 3. Recommended chemistry QC limits for water samples.

Parameter	Blank†	Replicate‡	Matrix Spike*	Blank Spike*	LCS/CS*
Total Suspended Solids	< MDL	≤ 25%	N/A	N/A	80 – 120%
Ammonia Nitrogen	< MDL	≤ 20%	75 – 125%	80-120%	85 – 115%
Nitrate+Nitrite Nitrogen	< MDL	≤ 20%	75 – 125%	80-120%	85 – 115%
Total Nitrogen	< MDL	≤ 20%	75 – 125%	80-120%	85 – 115%
Metals	< MDL	≤ 20%	75 – 125%	85 – 115%	N/A
Turbidity	N/A	≤ 25%	N/A	N/A	90 – 110%
Laser Particle Size Distribution / Sediment Concentration	N/A (Laser PSD), <MDL (sediment concentration)	≤ 20%	N/A	N/A	N/A

†Concentration of all analytes should be less than the method detection limit (< MDL).
‡Relative percent difference (RPD) for duplicate analysis.
*Percent recovery for matrix spikes. N/A = Not applicable.

Table 3B. Recommended chemistry QC limits for stream sediment samples

Parameter	Blank	Triplicate†	Matrix Spike	Blank Spike	LCS/CS
Particle Size Distribution	N/A	≤ 20%	N/A	N/A	N/A

†Relative standard deviation (RSD) for triplicate analysis.
N/A = Not applicable.

The sampling design of this water quality project may cause some samples to arrive at the laboratory having exceeded either a parameter method holding time or a sample preparation/preservation time. These sample results will be flagged in the laboratory database with the "H" (holding time) and/or the "SH" (sample handling) qualifier, depending on the situation. A qualifier will be applied on a method/parameter/purpose-specific basis, as necessary. For example, a "J" flag will be included for fecal coliforms held for analysis greater than 6 hours but less than 24[4]. This situation may be unavoidable and will not necessarily be used to exclude data from use in model development and calibration.

4.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable and representative analytical data are generated, compared to the total number of samples to be analyzed. Sampling at stations with known position coordinates in favorable conditions

[4] Ecology's NPDES program correspondence with King County, January 28, 2015, regarding fecal coliform hold times.

and at the appropriate time points, along with adherence to standardized sampling and testing protocols, will aid in providing a complete set of data for this project. The goal for completeness is 100%. During base flow events, it is likely samples can only be obtained in the primary drainages. Where samples are collected from waters leaving the site, every effort should be made to collect from as many flows entering the site that are connected to the samples taken leaving the site. In addition, at least 90% of the samples collected per event should pass QC criteria as described in Section 8.0.

4.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. Changes or updates to analytical methods and sampling techniques midway into the project must be validated and shown to be equivalent to existing methods before being implemented.

4.5 General Health and Safety Requirements

The following general health and safety guidelines have been provided in lieu of a project-specific Health and Safety Plan. These guidelines will be read and understood by all members of the sampling crew prior to any sampling activities.

- Sampling personnel will wear chemical-resistant gloves whenever coming into contact with samples.
- No eating, drinking, smoking or tobacco chewing by sampling personnel will be allowed during active sampling operations.
- All accidents, "near misses," and symptoms of possible exposure will be reported to a sampler’s supervisor within 24 hours of occurrence.
- All crewmembers will be aware of the potential hazards associated with chemicals used during the sampling effort.

5.0 SAMPLING PROCESS DESIGN

Characterization of water quality conditions in the basin will be based on sampling of storm events and base flow conditions over approximately a 12 month period (February 2015 through January 2016). The goal is to capture water quality conditions throughout the year and not just during extreme conditions. Primary goals are to characterize effects of existing storm water conditions and base flow sampling to support calibration of a watershed model. Additionally, segments of Bear creek have been listed on the 303(d) list for water temperature, dissolved oxygen and fecal coliforms.

5.1 Water Quality Study Design

Locations of sample collections will be located near the boundary of existing jurisdictional areas (i.e., Woodinville, Snohomish County and Redmond) as well as on most major tributaries to Bear Creek mainstem—generally near confluences. In total, 13 sites will be sampled during water quality events (Figure 4). As noted in previous elements, location of water quality sampling most often will be slightly downstream of where stream gauge are installed. Priority was placed on more accurately capturing as much of the drainage area as possible prior to entering into the mainstem of the creek.

Table 4 provides a summary of stations monitored by locator names, State Plane coordinates, and function of site as water quality samples or gauge sites for flow or weather, Figures 4 and 5 displays their locations on a map.

5.1.1 Storm Event (target 6 storms)

The goal for storm event sampling is to target six storms during this calendar year starting in February 2015. Three sets of grab samples will be collected at each station approximately 12 hours apart for each storm event. However, lag time to conduct the 3rd circuit will be evaluated, and extended if necessary to collect samples on the receding limb of the hydrograph. Given logistics of the sample sites and laboratory, it is estimated that it will take approximately six to eight hours to complete one full circuit at all 13 locations.

5.1.1.1 Sequence of Events to Execute a Storm Sampling Event

Weather forecasts are monitored for the duration of the study plan. When a weather forecast predicts precipitation of greater than 0.30-inches to occur in a 24-hour period, or greater than and/or equal to 0.50 inches in a 48 hour period, field and lab staff are notified to be on call (lab staff can lag 18-hours). The precipitation stations are then monitored as well. Depending on the type of storm forecasted, mobilization of field staff should occur anywhere between the gauge reading 0.01-inches and 0.10-inches. Storm events require less than 0.05 inches of rainfall within the preceding 24 hours to be considered as meeting antecedent conditions.

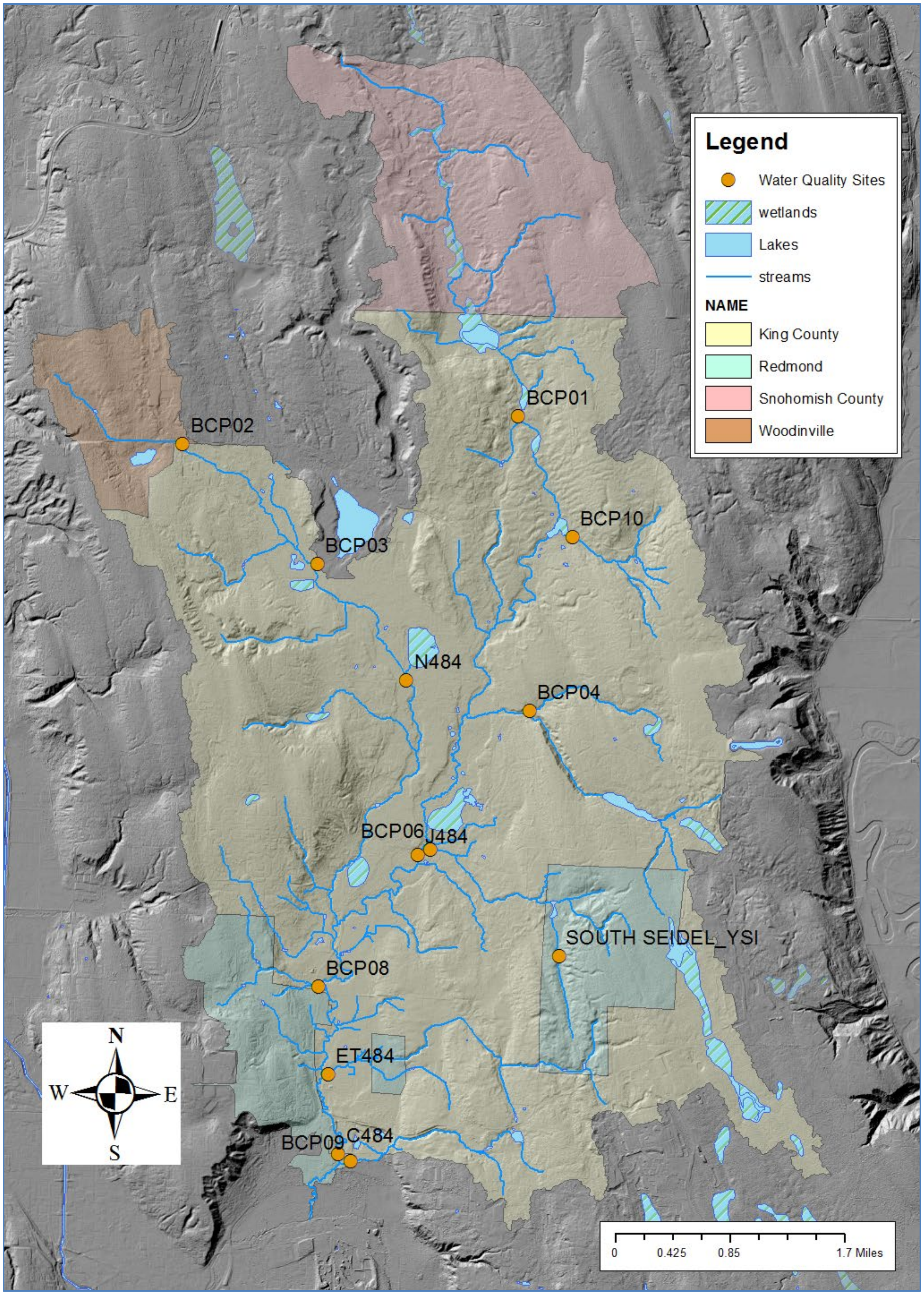

Figure 4. Water Quality Monitoring Locations. Thirteen sites will be monitored; see Table 4 for site information.

Table 4. Station summary of monitoring locations within the study area. Twenty-nine sites to be monitored: 13 water quality; 12 stream flow; 3 weather / precipitation. See Figures 4 and 5.

Station		Type	Coordinates^	
ID	Name		Northing	Easting
C484*	Bear Creek - Redmond Limit	Water Quality	252592	1331167
ET484	Mackay Creek		255754	1330832
J484	Bear Creek - DS of Seidel		264277	1334271
N484*	Cottage Lake Creek		271114	1333821
South Seidel_YSI	South Seidel Creek		260343	1339785
BCP01	Bear Creek - Sno Co		281470	1338207
BCP02	Cold Creek - Woodinville Limit		280362	1325067
BCP03	Cottage Lake Creek – outlet		275650	1330330
BCP04	East Struve Creek		269924	1338755
BCP06	Seidel Creek		264453	1335222
BCP08	Monticello Creek		259136	1330378
BCP09	Bear Trib (Stensland)		252324	1331639
BCP10	Bear Trib (upper basin)		276729	1340305
02V	Blakely Ridge	Gauge – weather station and precipitation	264452	1342677
Trilogy_met	Trilogy weather station		257614	1346305
NOVH	Novelty Hill		254885	1331217
02R	Bear Creek – Friendly Village	Gauge – stream flow and water temperature	251651	1330256
02e	Bear Creek – 133rd St NE		264261	1334284
02f2	Bear Creek – NE 162nd		277752	1339828
02M	Struve Creek		269915	1337424
02M2	Struve Creek (north fork)		269903	1338628
02o	East Fork Seidel Creek		261985	1340446
02P	South Fork Seidel Creek		260337	1339783
BC0119	Monticello Creek		259154	1330344
BC0114	Stensland Creek		252324	1331654
02Q	Mackey Creek		255723	1330752
02G	Cottage Lake Creek		264259	1331965
02L-temp	Cottage Lake at NE 159th St.		273497	1332720

^ = Coordinates are presented as Washington State Plane Feet North
* refers to active long-term water quality sites in King County Streams program.

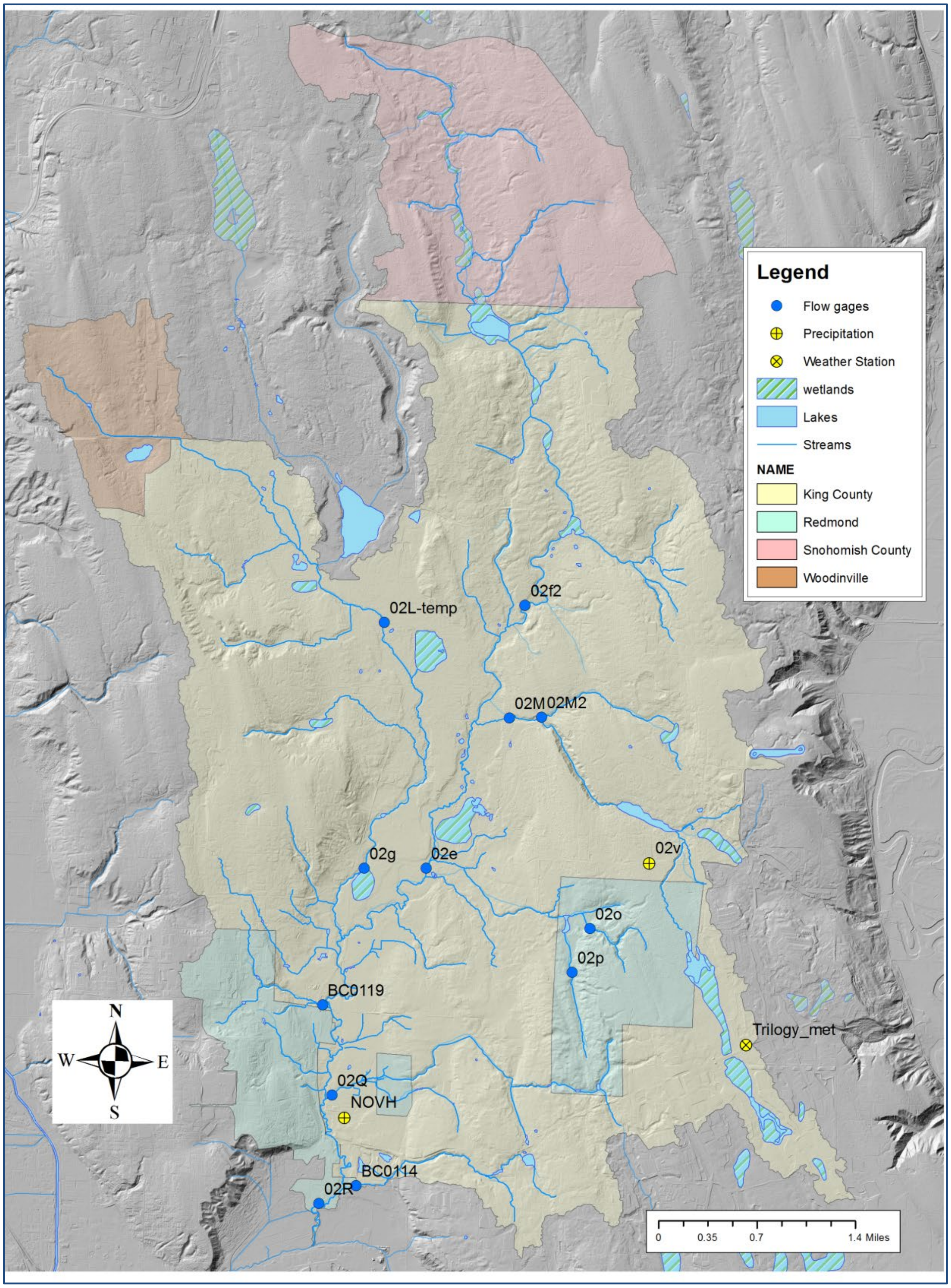

Figure 5. Gauging Locations. Fifteen sites will be monitored – 2 precipitation; 1 weather station, 12 stream flow; see table 4 for site information.

5.1.2 Base Flow Event (target 6 base flow)

Base flow events will be scheduled events that can be delayed if defined antecedent conditions change. Antecedent conditions are defined as less than 0.05 inches within a 24-hour period. These sampling events are planned throughout the year: fall, winter, spring and summer. Base flow samples will be collected twice in one day at the various sites. Sample frequency will be done every 8 to 12 hours to obtain 2 samples per base flow event. If an analyte(s) show(s) little diurnal change, the one round of collection for that analyte(s) will be discontinued in subsequent event samplings.

5.1.3 Stream sediments

At or near each of the 13 sampling sites, stream sediment samples will be taken to assess the stream bed substrate. This will be a one-time collection effort. Sediment sampling should occur when mobility of bed is minimal. Particle size analysis will be done to determine the physical makeup of sediments by determining the portion of fine silt, clay, sand, or gravel present within a sediment sample.

5.1.4 Summary of Water Quality Parameters Analyzed

The table below summarizes all the water quality parameters to be sampled and/or analyzed.

Table 5. Summary of water quality sampling design.

Parameter	Type	Event Type	# per Event	# of Events	Rationale	Permit Required†
Temperature, DO, pH, conductivity	In-situ point measurement	Storm	3	6	Temperature sensors are part of the flow gauging equipment and no additional cost for collecting temperature at the flow gauges. Eighteen18 stations of temperature and DO were collected during Bear Creek TMDL occurred during the summer in 2006.	yes
		Base	2	6		yes
Total Nitrogen	Grab Sample (unfiltered)	Storm	3	6	Monitoring for Nitrogen and its speciation will help in the model development process by more accurately representing OSS since most of the watershed is on septic. The speciation will further help separate what may be septic versus pasture land runoff. These analyses may be dropped and replaced with qPCR analyses (see below in table).	no
		Base	2	6		no
Nitrate + Nitrite, ammonia nitrogen,	Grab Sample (lab filtered)	Storm	3	6		yes‡
		Base	2	6		yes‡
Total Suspended Solids	Grab Sample	Storm	3	6	Metal pollutants start on the landscape sorbed to particulates (i.e. not dissolved). Moreover, the fate and transport of dissolved Cu and Zn includes the process of sorption desorption to solids. Part of the	yes‡

Parameter	Type	Event Type	**# per Event**	# of Events	Rationale	Permit Required†
		Base	2	6	solids is in the form of organic matter (particulate and dissolved). Given copper has an affinity to bind with organic matter; TOC/DOC was proposed to help improve copper simulations. However, Laser PSD will be used as a surrogate particulate.	yes‡
Hardness	Grab Sample	Storm	3	6	Required for determination of toxicity in metals.	yes
		Base	2	6		yes
Total Copper, Zinc	Grab Sample	Storm	3	6	Fate and transport of metals in the stream system includes adsorption and desorption to solids. Given the number of lakes and wetlands, this process is an important element to include in the model calibration. Thus, Total and dissolved are needed.	yes‡
		Base	2	6		yes‡
Dissolved Copper, Zinc	Grab Sample (field filtered)	Storm	3	6		yes
		Base	2	6		yes
Fecal Coliforms	Grab Sample	Storm	3	6	Permit requirement	yes
		Base	2	6		yes
qPCR test (Bacteria)	Grab Sample	Storm	3	6	Quantitative Human bacteroides testing (Hu2Bac) can be used to identify if sources of bacteria are from humans (thus assumed failing septic systems). This analysis, if done, will be done in substitute of Nitrogen analyses.	No
		Base	2	6		no
Laser PSD / Sediment Concentration	Grab Sample	Storm	3	2	Dissolved metals have an affinity to bind to organic material, fines in TSS are characterized between sand and silt/clay. This analysis is planned to be done twice.	yes‡
		Base	2	2		yes‡

Parameter	Type	Event Type	**# per Event**	# of Events	Rationale	Permit Required†
Turbidity	Grab Sample	Storm	3	6	Synoptically analyzing for turbidity and TSS will establish a relationship that generally is specific to a stream system. This relationship can be used to improve accuracy in simulating metals in the watershed if continuous sensors are deployed (TBD). In addition, WAC standards are based on turbidity.	No
		Base	2	6		no
PSD Streambed	Grab Sample	Storm	1	1	Establishing streambed particle size distributions at a few locations will be used to support analysis when evaluating bed scour and deposition.	yes‡
Field Sampling		Storm	3	6	36 hours for 2-person teams per event.	yes‡
Field Sampling		Base	2	6	24 hours for 2-person teams per event	yes‡

†Only analyses on parameters identified as permit required will be cost shared among the partners in the watershed-scale plan.

‡Designates a parameter needed to support calibration of deterministic-mechanistic watershed models simulating the key primary parameters listed in the permit.

5.2 Benthic Macroinvertebrates

Stream benthic macroinvertebrate monitoring data is available for 28 locations within the Bear Creek watershed upstream of the confluence with Evans Creek as noted in section 1.1. It is anticipated stream benthos macroinvertebrates will be monitored at these locations; other agencies (City of Redmond and King County Roads Division) are monitoring an additional 7 sites and potentially an additional 5 sites, for a total of 40 sites (Figure 6). Site information is presented in Table 6. Potential factors that may alter the number and location of benthos monitoring stations may be, for example, property access and/or adequacy of stream channel conditions. Sampling at these locations was conducted during late summer in 2014 and will continue in summer of 2015. Thirty sites of the 40 were sampled in 2014. The remaining sites were not sampled due to property access, close proximity of sites from different monitoring programs and/or adequacy of stream channel conditions at the time of sampling (Figure 6).

King County's macroinvertebrate sampling method is same as Ecology's method and is presented in full detail in Appendix A. The summary of this method is as follows:

- 2 square feet sampled from each of 4 riffles;
- Composited into 1 sample.
- Collection done with a 12" by 12" Surber sampler with 500 micron mesh net.

5.3 Riparian Vegetation

The intent of the riparian vegetation study is to catalog riparian conditions over the past 35 years, report on current conditions to the finest scale available, analyze where improvements to current conditions may be made, and suggest methods to bolster restoration efforts against the impacts of climate change. Portions of Bear, Cold, Cottage Lake, Mackey, Seidel, and Struve creeks as well as some of their tributaries are included in this study. There are approximately 27 miles of stream in the study area, and these streams have riparian buffers that are protected through regulation. Depending on the stream, in the Bear Creek Basin these buffers range from 100 to 165 feet on each side of the stream.

5.4 Wetlands

There are approximately 65 wetlands in the Big Bear Creek basin, depending on the data source used, and these wetlands all have regulatory buffers around them. Depending on the wetland type, these buffers range from 50 to 225 feet in width. The intent of this wetlands study is to catalog wetlands presence and condition over the past 35 years, report on current conditions to the finest scale available, analyze where improvements to current conditions may be made, and suggest methods to bolster restoration efforts against the impacts of climate change.

5.5 Aquatic Community

Fish community monitoring has been conducted in the Bear Creek watershed since 2009 as part of a grant project funded by the United States Environmental Protection Agency

(USEPA). This monitoring effort uses electrofishing techniques to assess the fish community in streams. In addition, several studies have been conducted over the last several years that include salmonid monitoring (e.g., Kiyohara 2013, WRIA 8 Chinook Salmon Conservation Plan). Missing from these studies are measures of fish abundance characterizing preference of stream channel habitat.

Chinook in the Bear Creek basin spawn in Bear and Cottage Lake Creeks in the autumn (September through October) and emigrate during the winter and spring as subyearlings (both fry and parr lifestages). The fry migrants emerge from the gravel and immediately migrate downstream to the Sammamish River in February through March, while the parr migrants reside in Bear Creek until migrating at a much larger size than the fry in May and June (Kiyohara 2014). This is important, because parr migrants are larger than fry, and are therefore likely to survive at a higher rate (Koenings et al 1993; Ward and Slaney 1988). Locally, Kennedy and Gayeski (*in prep*) found that Chinook that migrate as fry from the Cedar River are only 17% as likely to produce a returning adult as those that migrate as parr. Stakeholders participating in Chinook recovery within WRIA (Water Resource Inventory Area) 8 are interested in improving rearing habitat to support a larger population of parr, and subsequently reversing the declining trend of Chinook in Bear Creek through habitat restoration.

Although this strategy is straightforward, very little information exists on habitat preferences of juvenile ocean type fall-Chinook salmon in small streams. A thorough understanding of preferred habitat of rearing Chinook is necessary in order to focus important restoration actions to improve growth and survival of juvenile Chinook, and in-turn, produce more parr in the Bear Creek basin.

The goal of this project is to identify habitat preferences of rearing juvenile Chinook salmon in the Bear Creek basin. These data will be used to target restoration actions to restore natural processes to create and maintain productive rearing habitat for juvenile Chinook that ultimately increase the capacity of the Bear Creek basin to produce Chinook parr. The additional monitoring of surveyed stream reaches will be dependent on property access and navigability of stream. Possible limitations conducting the survey may include: poor weather conditions, property access, equipment failure, etc.

This additional monitoring work is discretionary and not part of the NPDES permit requirements.

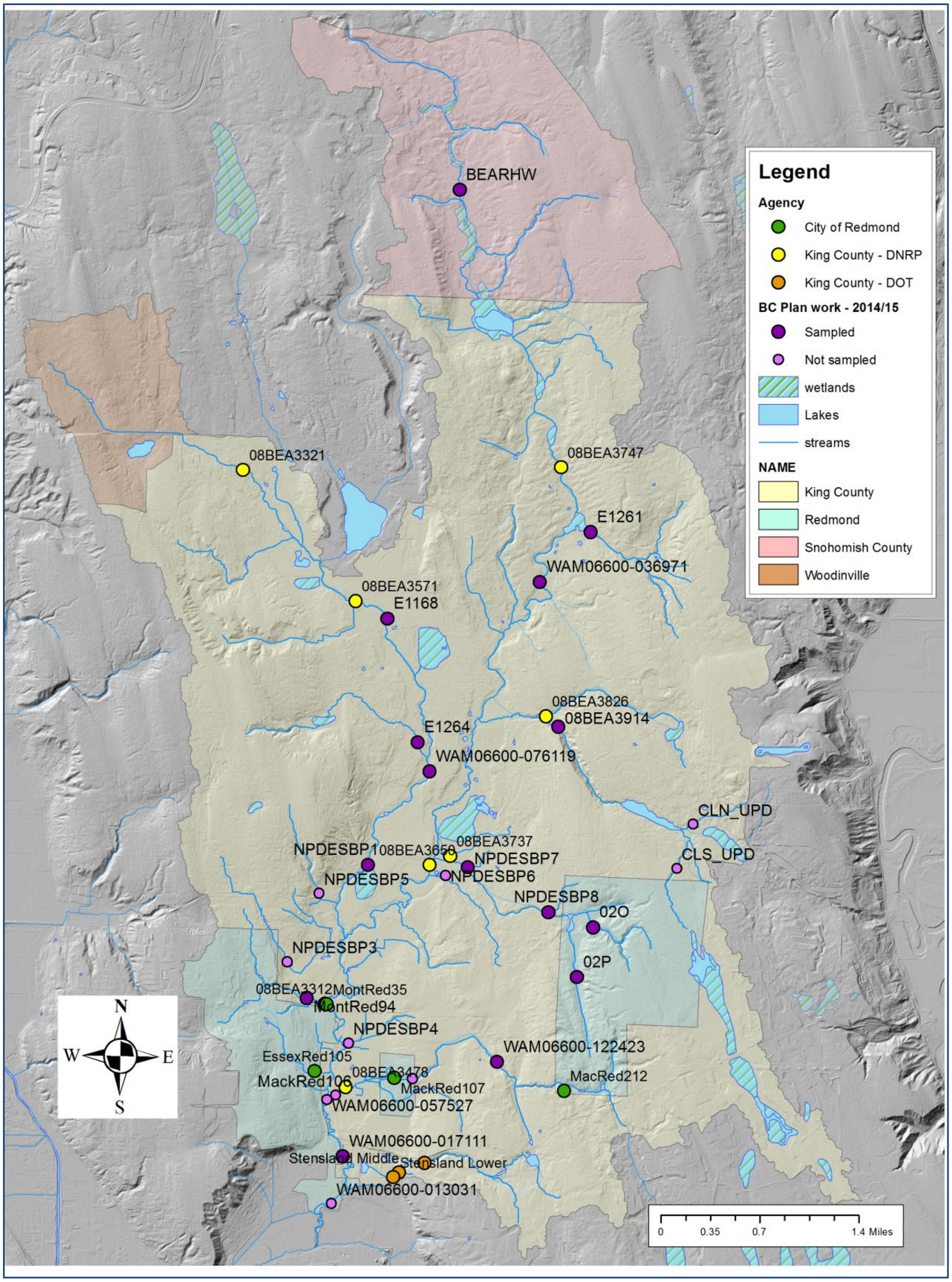

Figure 6. Macroinvertebrate Sampling Locations. Forty potential sites - 28 sites have been monitored recently, 7 sites monitored by other agencies and 5 new sites added for this sampling. See table 6 for site information.

Table 6. Station summary of macroinvertebrate monitoring locations within the study area. Forty sites to be monitored see figure 6. Thirty sites sampled in 2014.

Site Code	Site Name	Northing	Easting	Sampled 2014	Responsible Party*
BEARHW	Bear Creek	289531.2	1335411.2	Yes	Permit
08BEA3747	Bear Creek	279159.6	1339208.4	Yes	Ambient
WAM06600-036971	Bear Creek	274887.9	1338415.9	Yes	Permit
WAM06600-057527	Bear Creek	255564.3	1330453.3	No	Permit
WAM06600-017111	Bear Creek	253442.7	1331044.0	Yes	Permit
08BEA3650	Bear Creek	264327.6	1334290.2	Yes	Ambient
WAM06600-013031	Bear Creek	251690.8	1330622.5	No	Permit
08BEA3737	Bear Creek trib	264663.6	1335044.3	Yes	Ambient
NPDESBP6	Bear Creek trib	263951.7	1334896.7	No	Permit
NPDESBP3	Bear Creek trib	260751.2	1328975.7	No	Permit
NPDESBP4	Bear Creek trib	257695.7	1331257.4	No	Permit
CLN_UPD	Colin Creek	265846.7	1344137.7	No	Permit
CLS_UPD	Colin Creek	264197.1	1343528.1	No	Permit
08BEA3914	Colin Creek	269679.6	1338701.3	Yes	Permit
08BEA3321	Cold Creek	279078.2	1327323.6	Yes	Ambient
08BEA3571	Cottage Lake Creek	274225.2	1331506.9	Yes	Ambient
E1168	Cottage Lake Creek	273525.6	1332715.9	Yes	Permit
WAM06600-076119	Cottage Lake Creek	267224.7	1333620.3	Yes	Permit
E1264	Cottage Lake Creek trib	268902.1	1333846.4	Yes	Permit
NPDESBP5	Cottage Lake Creek trib	263292.9	1330170.1	No	Permit
NPDESBP1	Cottage Lake Creek	264325.8	1331993.9	Yes	Permit
08BEA3312	Monticello Creek	259362.1	1329712.1	Yes	Ambient
MontRed35	Monticello Creek	259127.7	1330440.9	Yes	Redmond
MontRed94	Monticello Creek	259362.2	1329712.1	Yes	Permit
08BEA3478	Mackey Creek	256039.5	1331159.7	Yes	Ambient
MackRed106	Mackey Creek	255732.9	1330782.8	No	Permit
MackRed107	Mackey Creek	256381.1	1332965.5	Yes	Redmond
MackRed108	Mackey Creek	256346.2	1333642.4	No	Permit
WAM06600-122423	Mackey Creek	256966.5	1336813.4	Yes	Permit
MacRed212	Mackey Creek	255905.0	1339310.4	Yes	Redmond
02O	Seidel Creek	261998.6	1340397.2	Yes	Permit
02P	Seidel Creek	260133.7	1339798.4	Yes	Permit
NPDESBP8	Seidel Creek	262570.7	1338725.7	Yes	Permit
NPDESBP7	Seidel Creek	264255.6	1335721.3	Yes	Permit
Stensland Upper	Stensland Creek	253202.9	1334105.5	Yes	Roads

Site Code	Site Name	Northing	Easting	Sampled 2014	Responsible Party*
Stensland Mid	Stensland Creek	252837.5	1333139.8	Yes	Roads
Stensland Lower	Stensland Creek	252664.6	1332934.5	Yes	Roads
E1261	Struve Creek	276750.3	1340315.3	Yes	Permit
08BEA3826	Struve Creek	269884.6	1338637.1	Yes	Ambient
EssexRed105	Tylers Creek	256630.3	1329987.7	Yes	Redmond

* = Program responsible for the BIBI sampling:
Permit: Bear Creek Basin Plan monitoring – NPDES permit related;
Ambient: King County Water and Land Resources Division ambient monitoring
Redmond: City of Redmond ambient monitoring
Roads: King County Roads Division ambient monitoring

6.0 SAMPLING PROCEDURES

Consistent sample handling procedures are necessary to maintain sample integrity and provide data that is as defensible and as high a quality as possible under the sampling conditions. This section provides requirements for proper sample containers, labeling, preservation and storage, and chain-of-custody practices.

6.1 Sample Containers and Labels

All samples will be collected or split into pre-cleaned, laboratory-supplied containers affixed with computer-generated labels. Any low-level metals analysis sample bottles will be acid-washed. Information contained on sample labels will include: a unique sample number; information about the sampling location; the collection date; the requested analyses; and information about any chemical used in sample preservation. Sample containers required for the various analyses are summarized in Table 7.

6.2 Sample Preservation and Storage Requirements

Stream stormwater samples will be stored refrigerated at a temperature of approximately 4° C, or preserved appropriately. Sample preservation requirements and storage conditions as well as analytical holding times are summarized in Table 7.

6.3 Chain-of-Custody Practices

During sample collection, all sample bottles will be in the custody of the sampling personnel. Sampling personnel will deliver all samples to KCEL Sample Receiving and enter them into the Logbook, as described in KCEL SOP # 103v4 (Sample Management). Field sheets will be used to document the transfer of custody from the sampler to the laboratory. If any samples require analyses that are to be conducted by a subcontracting laboratory, then samples are released according to KCEL SOP # 103v4 (Sample Management).

6.4 Sample Retention and Disposal

The laboratory will hold, where practical, unused sample that has not exceeded holding time for at least 30 days after the release of results. Unused samples categorized as hazardous according to state or federal guidelines will be disposed of by the laboratory.

6.5 In situ Measurements

Field sheets are printed on Rite in the Rain® paper. Each station has a set of field observation parameters that must be filled in by field personnel prior to or during sampling. Any field observations should be written on field sheets at the time of observation. Field measurements for temperature, dissolved oxygen, conductivity, and pH will be recorded using a multi-parameter probe, such as Hydrolab, YSI or similar equipment, according to KCEL SOP # 205v4 (Field Measurement using an Attended Hydrolab).

Table 7. Sample containers, preservation, and holding times for Water Matrix.

Analysis	Container	Preservation	Holding Time*
Total Suspended Solids	1-Liter HDPE, CWM	Refrigerate, <6°C	7 days
Dissolved nutrients (NH3, NO23) collected together with TOTN.	250-ml HDPE, CWM	Filter within 1 day and freeze @ -20°C	14 days @ -20°C
Total Nitrogen (collected together with NH3 and NO23)	250-ml HDPE, CWM	Refrigerate, <6°C and freeze within 2 days @ -20°C	28 days @-20°C
Metals, Total by ICPMS-routine	500-ml HDPE, Acid washed	HNO_3, pH <2	180 days
Metals, Dissolved, by ICPMS-routine	500-ml HDPE, Acid washed	Field filter; HNO_3, pH <2	180 days **
Turbidity	500-ml HDPE, CWM	Refrigerate, <6°C	2 days
Laser PSD / Sediment Concentration	1-Liter HDPE, CWM	Refrigerate, <6°C	7 days
Fecal Coliform (together with qPCR)	500-ml HDPE, sterile	Refrigerate, 4 °C	6+2 hours***

* The start of the holding time for grab samples is the time collected in the field.
** Field filter dissolved metals within 15 minutes of sample collection.
***Ecology's NPDES program will allow samples up to 24 hour hold time, if flagged, beyond the standard compliance of '6+2' hour holding time.

Table 7B. Sample containers, preservation, and holding times for Stream Sediments.

Analysis	Container	Preservation	Holding Time*
Particle Size Distribution	16-oz PP or glass	Refrigerate, 4°C	6 months

* The start of the holding time for grab samples is the time collected in the field.

A field measurement replicate is defined as a separate in situ measurement made following all procedures typically done between individual measurements. The probe typically would be removed from the water body and then returned to the same depth and position used in the original measurement.

One field replicate per twenty samples should be analyzed to assess precision of the temperature, dissolved oxygen, conductivity, and pH sensors. If any of the parameters are found to be outside of control limits, the sensors must be recalibrated before further use. Upon returning to the lab, a post-run analysis of dissolved oxygen, conductivity, and pH should be completed and documented on the ESS multi-parameter probe calibration and QC checklist and filed in the multi-parameter probe Quality Control (QC) notebook. If QC results are found to be outside of control limits, results may be qualified according to standards documented in the King County Environmental Laboratory's (KCEL) Quality Assurance Manual (King County Environmental Laboratory, 2006), see section 6.8 (Table 8) for details on QC practices for multi-parameter probe field measurements.

6.6 Continuous Precipitation

Rainfall will be measured with tipping bucket rain gages calibrated to 0.01 inches per tip. Electronic data loggers will record the time of each tip and 15 minute accumulations. The rain gages will have their calibration checked in early fall and late spring.

6.7 Continuous Flows

Operation of the stream gages for this project will follow the procedures described in the document SOP # NPDES CM 1000 – Continuous Monitoring of Discharge.

6.8 Continuous Temperature

The Onset devices are deployed by County staff to monitor continuous water temperature. Field sampling and measurements will follow standard King County quality control protocols.

The multi-parameter probe calibration and QC sheets are intended for documentation of the probe QC samples (Table 8). This includes initial calibration, continuing calibration verification replicates, duplicates, and post-run calibration check. The analyst will include the calibration and analysis date; standard lot numbers and concentrations; and instrument readings, recovery calculations, and initials.

Table 8. Multi-parameter probe quality and control requirements.

Parameter	Replicate Samples	Field Calibration Check Standards	Calibration Drift End Check
Dissolved Oxygen	RPD ≤ 20%	Not applicable	± 4 %
Temperature	± 0.3°C	Not applicable	Not applicable
Conductivity	RPD ≤ 10%	± 10 %	± 10 %
pH	± 0.2 pH units	± 0.2 pH units	± 0.2 pH units

Relative Percent Difference (RPD) is defined as the absolute difference between the two measurements divided by the average of the two measurements. See the below equation:

$$RPD = \left(\frac{|r_1 - r_2|}{r_1 + r_2} \right) \times 200$$

Where, r1 = result for first measurement and r2 = result for second measurement.

6.9 Flow Measurements

All flow measurements will follow standard Ecology protocols and King County Environmental Laboratory's SOP (NPDES SOP # CM 1000 (Continuous Monitoring of Discharge)). Stream flow measurements will be conducted at each flow monitoring location during steady, low-flow conditions and during storm events. Water depth and velocity will be recorded at a minimum of five to seven cross sections using wading rods and velocity meters calibrated to manufacturer's recommendations. Field teams will use consistent techniques described at a pre-sampling meeting to minimize variability among teams.

6.10 Sample Collection

Samples are collected by one of three methods: grab sampling, bucket, or Richards bottle. Grab sampling by hand-dipping sample bottles is one method that does not require decontamination techniques. The cap is removed from the bottle and it is simply dipped into the stream or river. Using a bucket with a bottom drain or a Richards bottle requires scrubbing with a brush and reverse osmosis water at the lab, followed by thoroughly rinsing three times with ambient stream water to be sampled.

Samples will be collected from the thalweg, within free-flowing stream sections, and away from channel boundaries. Where access is from a bridge or roadway because of loss of access, the sample will be collected from the upstream side. These procedures are described in King County Environmental Laboratory's SOP (214v3).

6.10.1 Grab Sampling

Grab samples will be collected while facing upstream to minimize contamination from field equipment. Whenever possible, the sampling should be conducted while facing the prevailing winds. Sampling personnel will wear clean PVC gloves for personal protection and to prevent contamination of the samples. The low-level metal sample bottles for base flow measurements will be filled first. The remaining sample bottles will be filled after the metals sample bottles.

The total metals bottle will be immersed in the stream with the neck facing down, and then will be filled, leaving some headspace to allow room to add preservative.

The microbiology sample bottle will be filled by lowering the bottle, open with the neck faced down, into the stream to a depth of 1 to 3 inches. The bottle is rotated and allowed to fill up just below the top shoulder of the bottle. The extra headspace is required so that the bottle may be agitated before filtering. The bottle is not to be rinsed with sample.

Finally, the conventional analysis bottles are filled in a similar manner as the microbiology sample, using face down immersion and capping after the container is removed from the stream flow. All sample and blank containers will be placed in a cooler with ice until transported to sample receiving at the laboratory.

The Laser PSD / Sediment Concentration (Particle Size Distribution) collection and analysis is planned for two storm and two base flow events.

6.10.2 Field filtration procedures

6.10.2.1 Metals Samples

The dissolved metals filter blank is collected first and will be collected once per event. Sampling personnel will don clean PVC gloves, set up the peristaltic pump and attach the battery. A laboratory-bagged pre-cleaned filter apparatus will be selected and removed from the bag. The pump tubing will be attached to the filter suction port. The filter blank bottle filled with RO water will be opened, the filter unit lid will be removed, and the contents of the blank bottle will be poured into the filter apparatus. Once this is done, the filter apparatus lid is replaced. The peristaltic pump will be turned on. When the blank water has filtered, the pump will be turned off, and the tubing removed from the port. The filter unit top will be unscrewed from the filtrate bottom and the filtrate bottle capped. The sample will then be placed into the sample cooler. Sample filtration will follow the same procedures as collection of the blank. The dissolved portion of each sample will be filtered within 15 minutes of sample collection.

6.10.3 Stream Base flow Sampling

All sample locations sampled during storms will be sampled during base flow conditions when feasible. The techniques and requirements for sampling will be the same as those detailed in section 6.9. The only difference will be the frequency of base flow event sampling. Base flow conditions are defined as the flow rates that occur before the rise and after the drop in elevated stream flows resulting from precipitation. These flow rates generally require two to five days of no rainfall, depending on the site, so that recession of the hydrograph has occurred. If standing water is present at the base flow sampling location, but there is no discernable velocity, a grab sample will be collected and field notes and database comments will reflect lack of flow. Samples should not be collected in stagnant pools just for the sake of collecting a sample.

6.10.4 Stream Sediment sampling

Sediment samples will be collected according to ESS SOP # 237v0 (Sampling Methods for Wadeable Stream Sediments). After arriving on station, the sampling person surveys the stream bottom for an appropriate area of substrate from which to collect a set of subsamples. A pre-cleaned 3” diameter PVC core tube is then used to penetrate the substrate to a desired depth (5-10 cm for the King County streams program). Using a gloved hand, the sampler traps the sediment inside the tube. Alternatively, a pre-cleaned stainless steel spatula may also be used. The sampler removes the tube from the stream by inclining it to an approximately 45 degree angle, taking care not to lose sediment or water from the bottom of the tube. The sampler then slowly decants off any water on top of the sediment inside further tipping the tube and allowing it to pour from the top of the tube. The remaining sediment is then transferred from the bottom of the tube to a precleaned stainless steel bowl for compositing. If the substrate is too rocky for use of the core tube, a stainless steel spoon may be used to collect the sediment. The subsamples are homogenized and split into individual sample containers for transport to the laboratory.

The sampling person also records information about the location, procedure used, and the qualities of the sample onto associated field sheets and "field observations" sheet.

The sediment sampling will be a one-time collection effort during this project as noted in Section 5.1.3

6.11 Benthic Sampling

King County's macroinvertebrate sampling method is same as Ecology's method and is presented in full detail in Appendix A. The summary of this method is as follows:

- 2 square feet sampled from each of 4 riffles;
- Composited into 1 sample.
- Collection done with a 12" by 12" Surber sampler with 500 micron mesh net

The following habitat and physical stream parameters will be measured at each benthic sampling site:

- Water and air temperature
- Riffle width, length, depth and flow velocity
- Water clarity
- Riparian bank vegetation parameters including; vegetation type, density, and size class
- Woody debris presence
- Wolman pebble counts (Wolman, 1954): 35 particles are counted just upstream of each Surber sample location to be combined for a total count of >100 particles.
- Distance to nearest known road crossing noted as either upstream or downstream and within set distance categories.

6.12 Riparian Vegetation Sampling

Portions of Bear, Cold, Cottage Lake, Mackey, Seidel, and Struve creeks as well as some of their tributaries are included in this study. There are approximately 27 miles of stream in the study area, and these streams have riparian buffers that are protected through regulation. Depending on the stream, in the Bear Creek Basin these buffers range from 100 to 165 feet on each side of the stream. The riparian vegetation study is to catalog riparian conditions over the past 35 years, report on current conditions to the finest scale available, analyze where improvements to current conditions may be made, and suggest methods to bolster restoration efforts against the impacts of climate change.

6.12.1 Review of Previous Reports and Studies

Previous reports will be reviewed for descriptive information and data on historic riparian conditions in the study area. In some cases, GIS data were generated for these reports and studies, and the GIS data will also be included in this review when available. This information will be summarized in narrative and tabular format to provide an historical perspective. For those reports where recommendations were made for restoration projects and other actions, a status update will be provided as to whether the project was implemented. Previous reports may include but not be limited to:

- 1982 Bear-Evans Creek Stream Resource Inventory
- 1989 Bear Creek Community Plan and Area Zoning
- 1987 Basin Reconnaissance Program Report .
- 1994 Bear, Evans, Cottage Lake, and Mackey Creeks: Habitat Problems, Prioritization, and Solution Development - Technical Memorandum
- 1995 Bear Creek Basin Plan (King County 1995)
- 2001 DRAFT Big Bear Creek Basin Monitoring Results, 1995 to 1998
- 2008 Streams and Surface Water Technical Report for the NE Novelty Hill Project
- 2011 WRIA 8 Land Cover Change Analysis (Vanderhoof et al. 2011). GIS data available.
- 2011 Trilogy and Redmond Ridge Urban Planned Development Final Monitoring Report: 2008-2010 (sampling location on Colin Creek)

6.12.2 Assessment of Present Condition

A GIS analysis will be performed to determine how much of the riparian area is currently forested and what the current non-forested land uses are. Data sources for this analysis include:

- 2014 CAO Monitoring report - included Redmond Watershed basins (East and South Seidel).
- 2013 aerial imagery analysis utilizing the same technique as the 2011 WRIA 8 study -- that was done with 2005 and 2009 imagery. There are 10 reaches total in Upper and Lower Bear Basin.
- 2011 CCAP GIS data
- 2011 NLCD GIS data
- 2011 NAIP GIS data

A literature review will be conducted to determine what climate change impacts to the riparian vegetation are possible in the Bear Creek Basin.

Data collected and collated will be analyzed to answer the following question: Of the amount of riparian area that is not currently forested, how much could potentially be? One approach to answering that question will be to determine how much of the riparian area is currently in grass or non-native shrub. Another approach to answering the question would be to determine how much of the non-forested portion of the riparian area is in public ownership. Private, undeveloped parcels containing large stream buffer areas will be identified as potential targets for acquisition.

A literature review will be conducted to determine what climate change adaptation strategies would be potentially appropriate for maintaining and enhancing riparian conditions in the Bear Creek Basin given the potential impacts identified.

6.13 Wetland Sampling

There are approximately 65 wetlands in the Big Bear Creek basin area, depending on the data source used, and these wetlands all have regulatory buffers around them. Depending on the wetland type, these buffers range from 50 to 225 feet in width. The intent of this wetlands study is to catalog wetlands presence and condition over the past 35 years, report on current conditions to the finest scale available, analyze where improvements to current conditions may be made, and suggest methods to bolster restoration efforts against the impacts of climate change.

6.13.1 Review of Previous Reports and Studies

Previous reports will be reviewed for descriptive information and data on historic wetland conditions in the study area. In some cases, GIS data were generated for these reports and studies, and the GIS data will also be included in this review when available. This information will be summarized in narrative and tabular format to provide an historical perspective. For those reports where recommendations were made for restoration projects and other actions, a status update will be provided as to whether the project was implemented. Previous reports may include but not be limited to:

- 1982 Bear-Evans Creek Stream Resource Inventory
- 1989 Bear Creek Community Plan and Area Zoning
- 1987 Basin Reconnaissance Program Report .
- 1994 Bear, Evans, Cottage Lake, and Mackey Creeks: Habitat Problems, Prioritization, and Solution Development - Technical Memorandum
- 1995 Bear Creek Basin Plan (King County 1995)
- 2001 DRAFT Big Bear Creek Basin Monitoring Results, 1995 to 1998
- 2007 Wetland Biology Discipline Report – NE Novelty Hill Road Project
- 2011 WRIA 8 Land Cover Change Analysis (Vanderhoof et al. 2011). GIS data available.
- 2011 Trilogy and Redmond Ridge Urban Planned Development Final Monitoring Report: 2008-2010
- King County SAO and NWI wetlands GIS data.
- King County wetland delineated under CAO requirements and digitized in GIS.

6.13.2 Assessment of Present Condition

Wetlands located where King County SAO and NWI wetlands are mapped will be hand-digitized using 2013 aerial imagery, and notes will be made as to whether part or all of formerly mapped wetlands have been filled/developed.

A literature review will be conducted to determine what climate change impacts to wetlands are possible in the Bear Creek Basin.

Locations where wetlands no longer exist that were present historically (identified as sections having been filled in) will be analyzed to determine which ones could be potential sites for restoration projects (that is, which sites that historically had wetlands are not currently covered in impervious surface and/or are publicly owned). Category I and II wetlands will be identified and cross-referenced with current land-use to determine level of risk and/or restoration (vegetation) need and potential for both wetland and buffer area. Private, undeveloped parcels containing large wetland areas will be identified as potential targets for acquisition.

A literature review will be conducted to determine what climate change adaptation strategies would be potentially appropriate for maintaining and enhancing wetland conditions in the Bear Creek Basin given the potential impacts identified in Section

6.14 Aquatic Monitoring

The Bear Creek basin is approximately 26 square miles in size, of which approximately 73 percent is in unincorporated King County. The mean annual flow is approximately 78 cubic feet per second. Land use is comprised largely of a mixture of light urban, medium urban, deciduous/mixed forest, and grass. Chinook spawning takes place in the mainstem of Bear and Cottage Lake Creeks. In Bear Creek, spawning occurs from its confluence with Evans Creek upstream to the Woodinville-Duvall Road (approximately 13.5 miles; Figure 1). The highest density of Chinook spawning in WRIA 8 occurs in Cottage Lake Creek in only approximately 3.7 miles.

6.14.1 Methods

Juvenile chinook salmon prefer to utilize low velocity habitat in freshwater (Johnson 2014; Beechie et al. 2005). Cover, substrate, and velocity are the most important factors that influence rearing habitat of subyearling Chinook, although other attributes such as depth may also be important (Murphy et al 1989; Lister and Genoe 1970).

Mainstem habitat in Bear and Cottage Lake Creeks where Chinook spawning occurs will represent the sample frame. Within each stream, three reaches will be identified that correspond to “upper,” “middle,” and “lower” designations. The exact locations of these reaches will be determined from a field reconnaissance, and will be based upon the distribution of Chinook spawning site distribution, and correspond to “thirds” of the sampling frame.

Within each reach, three sampling sites will be located based upon property access. Each of these sites will be a minimum of 150 feet, and the exact length will need to be at least equivalent to 5 average bankfull channel widths. All habitat units will be surveyed of each site that include lengths, width, average depth, counts of large woody debris, substrate and bank angle classifications (Merritt 2009). Gradient will also be calculated for each site. Each habitat unit will be given a specific number, and all corresponding observations and subsequent surveys will cross reference the habitat unit where the observation was made.

Snorkel surveys will be the primary method used to identify stream fishes at each site, and data will be summarized for each habitat unit. Surveys will occur once per month, starting in February and continuing through June. Surveys will be conducted at night, following the protocols of Dolloff et al. (1996). All fish will be identified, and estimates of fork length in 50 mm increments will be done for each observations. Calibration will occur at each site prior to survey following the procedures described in Dolloff et al. (1996).

Once data are collected, habitat suitability curves will be constructed following the methods outlined by Vadas and Orth (2000) using discriminant analysis. Fish data will be summarized by species and fork length. Fish densities will be the dependent variable for each individual habitat unit measurement, and species specific preferences will be easily compared. Preferences identified for Chinook will be used in assessing restoration action alternatives.

6.15 Field QC

In addition to the field blank described in Section 6.10.2, field duplicates will be collected once per storm or base flow event. Replicate samples at one randomly selected grab site will be collected for all parameters. A field replicate is a separate sample collection done repeating the sampling steps and appropriate rinsing procedures but with separate sample containers.

6.16 Sample Documentation

This section provides guidance for documenting sampling and data gathering activities. The documentation of field activities provides important project information and data that can support data generated by laboratory analyses.

6.16.1 Sample Numbers and Labels

Unique sample numbers will be assigned to each sampling location for which individual stream water samples are collected for in-situ multi-parameter probe parameters, chemical and microbiological analysis. Sample numbers will be assigned prior to the sampling event and waterproof labels generated for each sample container.

6.16.2 Field Notes

Field data will be maintained using pre-printed field sheets for all field activities, including the collection of samples and the gathering of field meter data. The field sheets will be printed on water-resistant paper and all field documentation will be recorded in indelible, blue or black ink. Information recorded on field notes will include, but not be limited to:

- name of recorder,
- sample or station number,
- sample station locator information,
- date and time of sample collection,
- results for all field measurements (temperature, pH, dissolved oxygen and conductivity),
- physical characteristics of sediment such as color, gross grain size distribution, debris and odor,
- staff height or flow estimate

Additional information that may be recorded on the field sheets includes sampling methodology and any deviations from established sampling protocols. Additional anecdotal information pertaining to observations of unusual sampling events or circumstances may also be recorded on the field sheets.

6.16.3 Field Analytical Results

Field analytical and QC results will be recorded on field sheets in a manner that easily identifies the information as analytical or QC data. Daily field instrument calibration records will be recorded in instrument-specific logbooks. All entries will be recorded in waterproof, indelible blue or black ink.

7.0 MEASUREMENT PROCEDURES

Adherence to standardized analytical protocols and associated QA/QC guidelines for both chemical and biological testing will help produce data able to meet the project goals and objectives.

7.1 Chemical Testing

This section presents the chemical analytical methodologies that will be employed during this project, along with associated detection limits. The King County Environmental Laboratory distinguishes between a method detection limit (MDL) and a reporting detection limit (RDL).

- The MDL is defined as the minimum concentration of a chemical constituent that can be detected.
- The RDL is defined as the minimum concentration of a chemical constituent that can be reliably quantified.

7.2 Conventional Analyses and Detection Limits

Conventional analyses, analytical methods, and associated detection limits are summarized in Table 9. All conventional analyses will be performed at the King County Environmental Laboratory.

7.3 Metal Analyses and Detection Limits

Target elements, analytical methods and associated detection limits are summarized in Table 10. Sample collection methods and methods of analysis are designed to achieve the multiple project goals. Grab samples will be analyzed using the most sensitive methods to achieve the lowest detection limits necessary. It is anticipated that routine ICPMS will be sufficient for reliable detection and reporting.

7.4 Microbiology Analyses and Detection Limits

Microbiology analyses, methodologies, and associated detection limits are summarized in Table 11. The King County Environmental Laboratory will perform all microbiology analyses. Upon delivery to the lab, an aliquot from each sterile microbiology bottle will be filtered, extracted, and archived at -20°C or below for possible future qPCR analysis.

Table 9. Conventional Analyses.

Analysis/Method	Method Summary	MDL (mg/L)	RDL (mg/L)
Total Suspended Solids SM 2540 D	Gravimetric	0.5	1
Ammonia Nitrogen Kerouel & Aminot, 1997	Fluorometric, Automated	0.002	0.01
Nitrate+Nitrite Nitrogen SM 4500-NO_3-F	Colorimetric, Cd Red., Automated	0.01	0.02
Turbidity SM 2130-B	Nephelometric	0.2 NTU	0.5 NTU
Total Nitrogen SM 4500-N-C	Persulfate Digestion, Colorimetric, Cd Red., Automated	0.05	0.1
Laser Particle Size Distribution (ISO 13320:2009) and sediment concentration (ASTM D422/D3977-97)€	Laser Diffraction PSD Analyzer / Gravimetric	0.01% by volume (Laser PSD) 0.5 mg/L (sediment concentration)	0.01% by volume (Laser PSD) 1.0 mg/L (sediment concentration)
Particle Size Distribution ASTM D422 (stream sediments only)	Sieve and hydrometer	0.1% (sieve) 0.5% (hydrometer)	1%

Table 10. Total and dissolved metal analyses for water samples.

ICP-MS Routine Analysis

Element	Analytical Method	MDL (mg/L)	RDL (mg/L)
Copper	ICP-MS (EPA 200.8)	0.0004	0.002
Zinc	ICP-MS (EPA 200.8)	0.0005	0.0025
Hardness[1]	ICP-MS (EPA 200.8/ SM2340B)	.331 mg CaCO3/L	.331 mg CaCO3/L

[1] Hardness may also be done by ICP (EPA Method 200.7 / SM 2340B) in which case the MDL and RDL would be 0.25 mg $CaCO_3$/L and 1.25 mg $CaCO_3$/L.

Table 11. Microbiology Analyses.

Analysis/Method	Method Summary	MDL (cfu/100ml)	RDL (cfu/100ml)
Fecal coliform by Membrane Filtration	Std Method 21s ed., 9222D	1	N/A
Human Bacteroides (Hu-2-Bac) by qPCR	KCEL Draft SOP 563v0 Real Time PCR (qPCR) Converse, R. et al, 2009 Field, K. et al, 2000.	N/A	10/100mL

8.0 QUALITY CONTROL

8.1 QC Practices for Chemistry Analysis

The QC samples that will be analyzed in association with chemical testing are summarized in Table 12.

Table 12. Chemistry QC samples for water analysis.

Parameter	Blank	Replicate[1]	Matrix Spike	Blank Spike	LCS[2] / CS[3]
Ammonia Nitrogen	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch
Nitrate+Nitrite Nitrogen	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch
Total Nitrogen	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch
Turbidity	No	1 Per Batch	No	No	1 Per Batch
Total Suspended Solids	1 Per Batch	1 Per Batch	No	No	1 Per Batch
Laser PSD / Sediment Concentration	No / 1 Per Batch	1 Per Batch	No	No	No
Metals	1 Per Batch	1 Per Batch	1 Per Batch	1 Per Batch	No

[1]Replicate - Duplicate analysis for all conventional and metals parameters.
[2]Laboratory Control Standard
[3]Check Standard

Table 12B. Microbiology QC samples for water analysis.

Parameter	Blank	Duplicate	Matrix Spike	Blank Spike	PC/NC
Fecal coliforms	Yes	1 Per Batch	No	No	1 Per Batch

Table 12C. Chemistry QC samples for stream sediments.

Parameter	Blank	Triplicate	Matrix Spike	Blank Spike	LCS / CS
Particle Size Distribution	No	1 Per Batch	No	No	No

8.2 QC Practices for Microbiology Analysis

Routine QC analyses for Microbiology monitor method performance of each sample analysis batch for each method. A sample analysis batch should not exceed 20 samples of the same matrix which are all prepared together and analyzed using the same reagents, media, equipment and by the same analyst(s). The QC samples to be tested with this set of samples are described below:

8.2.1 Laboratory Duplicates

Laboratory duplicates are prepared for each matrix type at a frequency of 1 per batch or 5%, whichever is more frequent. The duplicate must be processed through all preparation and incubation steps used for the original sample. The acceptance limits are based on a 95% confidence limit as described in the appropriate reference methods.

8.2.2 Negative Controls

A negative control is prepared at a frequency of 1 per batch or 5%, whichever is more frequent. The negative control should show an appropriate qualitative response for the test organism and should not be identified as containing the target organism.

- For Fecal Coliform, the negative control organism is Proteus sp. or Enterobacter sp.
- For Bacteroides testing, negative controls (non-template/non-target controls), and calibrator samples will be included in each instrument run (qPCR).

8.2.3 Positive Control

A positive control is prepared at a frequency of 1 per batch or 5%, whichever is more frequent. The positive control should show an appropriate qualitative response for the test organism.

- For Fecal Coliform, the positive control organism is E. coli.
- For Bacteroides testing, positive controls (calibrator samples containing the target organism), and calibrator samples will be included in each instrument run (qPCR).

8.2.4 Sterility Controls

Pre-filtration and post-filtration blanks are prepared each working day to evaluate the sterility of the dilution water and filtration equipment. These sterility controls are considered acceptable if the target organism is not detected.

8.3 QC Practices for Field Measurements

Calibration QC requirements for attended multi-parameter probe field measurements involve determination of post-deployment calibration drift for the parameters of interest (except temperature). Calibration drift is determined by measuring the check standard solution at the conclusion of the field measurements. This check must be done within 12 hours of the last field measurement. The post-deployment checks must be done in the same order used for initial calibration and must be done before any maintenance or calibrations are performed, Table 13.

Table 13. Acceptance limits for post-deployment calibration check.

Parameter	Calibration Drift Check
Dissolved Oxygen	± 4 %
Temperature	Done annually only
Conductivity	± 10 %
pH	± 0.2 pH units

QC for field measurements is typically limited to measuring precision by collection of replicate field measurements. Replicates are done at a minimum frequency of 5% of measurements or at a minimum, once per day. A field replicate is defined as a separate in-situ measurement made following all procedures typically done between individual samples. The probe would typically be removed from the water body then returned to the same depth and position used in the original measurement. The table 14 describes the acceptance limits for field replicates.

Table 14. Acceptance limits for field replicate measurements.

Parameter	Duplicate Samples
Dissolved Oxygen	RPD ≤ 20%
Temperature	± 0.3 °C
Conductivity	RPD ≤ 10%
pH	± 0.2 pH units

Data sets that do not meet the field QC acceptance limits may require that the field measurement data be flagged. Comments on field QC results should be included in the QA review. If samples are not collected by King County staff, contracted field sampling personnel must forward field notes and data to the Environmental Laboratory LPM for review.

8.4 Corrective Actions

Individual SOPs describe specific corrective actions for each analytical procedure and QC measure. If QC samples exceed their control limits, the analysis is repeated, if possible, or documented and affected samples qualified. If samples are lost or compromised, the project manager must determine whether to re-sample or to disregard the station for the specific parameter or event.

King County Environmental Laboratory documentation and record keeping will follow standard protocols, as described in Kruger (2002). Within the analytical laboratory, each section and analytical procedure has its own documentation protocol. The minimum documentation required in the lab includes an instrument logbook, analysis log, calibration and analysis documentation, and LIMS hardcopy sheets.

For all analytical results generated by lab activities, sufficient hardcopy data must be stored such that a reviewer could verify that the requirements of the reference method and SOP were met. The format of stored data may include logbook entries, field notes, benchsheets, and printouts of instrument or data files. Storage of only the electronic version of these documents is not sufficient to meet current data storage requirements.

8.4.1 Logbooks

Hand written information used as supporting documentation, which is not stored directly with the analysis results, such as standards preparation records and equipment calibration checks, must be maintained in logbooks. All logbooks must be paginated. Logbooks prepared from instrument printout or other loose pages should be bound prior to storage. Logbook entries should be made using indelible black ink (no pencils) and dated and initialed. Logbooks and individual logbook entries must be uniquely identified if they are to be referenced in other documents. All deletions and corrections must be a single line cross-out, accompanied with the date and initials of the person making the correction.

8.4.2 Data Packages

For each run or analysis sequence, a data package for internal KCEL review will be produced which will include all appropriate data for standards, samples, and QC analyses. Data packages must include the inclusive dates and times of the analyses and the identity of the analyst(s). If corrective actions were taken or a compromised sample was analyzed, the data package will contain a copy of the Data Anomaly Form and/or a Compromised Sample Form (or their equivalent). Specific requirements for the contents of data packages are described in each method SOP. The analyst(s) who generated the data is responsible for compiling the data package and transferring it to the data reviewer. Prior to data review, the data packages are organized according to method SOPs. Data packages may reference other data sets or documents rather than requiring each data package to contain copies of all necessary information. All deletions and corrections to handwritten or printed documentation must be a single line cross-out, accompanied with the date and initials of the person making the correction.

8.4.3 Storage of Lab Data

Procedures for the storage and disposal of hardcopy lab data are summarized in King County Environmental Laboratory's SOP #1105v1 (Records Storage) which is based on King County and Washington State governmental records storage requirements. It is the policy of the lab to store all data packages, supporting documentation, and project records for a minimum of ten years, based on the date of sample, collection or field data measurement.

In LIMS, the final sample and QC data are maintained indefinitely in the EDS database, which is backed up daily. Additional LIMS information specific to sample management is maintained a minimum of one-year past the date the final results were posted. Other types of electronic data, such as instrument files, may be stored but no lab-wide policy is currently available.

9.0 DATA MANAGEMENT PROCEDURES

The King County Environmental Laboratory will provide a 30-day turnaround time for all analytical data with the exception of metals, starting upon receipt of the last sample collected per event. Each laboratory unit will prepare their data packages, including any notable information of interest to data reviewers or data users.

9.1 Interpretation of Chemical and Microbiological Data

Analytical results will be used to develop and calibrate the watershed water quality models.

9.2 Quality Assurance Reviews

Chemistry, microbiology and field measurement data will undergo standard QA review within each laboratory unit according to the Environmental Laboratory QA document and method-specific SOPs. Data will be flagged accordingly. A description of laboratory qualifiers is provided in Table 15. The Laboratory Project Manager (LPM) will review the QC results and provide a summary of the QC information in narrative form. This narrative will accompany the data when it is transmitted to the project and program managers. All reviews will be done on an event basis. This level of QA review is necessary to provide the project and program managers with the level of information needed to correctly interpret the data.

9.3 Record Keeping

All field analysis and sampling records, custody documents, raw laboratory data, data summaries and case narratives will be stored according to King County Environmental Laboratory policy.

9.4 Reporting

Project data will be presented to the project and program managers in a format that will include the following:

- King County Environmental Laboratory Comprehensive Reports consisting of spreadsheets of chemical, microbiological and field parameters;
- chemistry and microbiology supporting QC documentation (provided by the King County Environmental Laboratory);
- A cover letter summarizing field sampling, analytical work, and interpretation of the QC results (provided by the King County Environmental Laboratory).

Table 15. Laboratory qualifiers.

Qualifier	Description
General	
H	**H** indicates that a holding time criterion (preservation, filtration, preparation, or analytical) was not met prior to completion of analysis.
SH	**SH** indicates that a sample handling criterion was not met in some manner prior to analysis. The sample may have been compromised during the sampling procedure or may not comply with storage conditions or preservation requirements.
R	Indicates that the data are judged unusable by the data reviewer. The qualifier is applied based on the professional judgment of the data reviewer rather than any specific set of QC parameters and is applied when the reviewer feels that the data may not or will not provide any useful information to the data user. This qualifier may or may not be analyte-specific.
<MDL	Applied when a target analyte is not detected or detected at a concentration less than the associated method detection limit (MDL). MDL is defined as the lowest concentration at which an analyte can be detected. The MDL is the lowest concentration at which a sample result will be reported.
<RDL	Applied when a target analyte is detected at a concentration greater than or equal to the associated MDL but less than the associated reporting detection limit (RDL). RDL is defined as the lowest concentration at which an analyte can reliably be quantified. The RDL represents the minimum concentration at which method performance becomes quantitative and is not subject to the degree of variation observed at concentrations between the MDL and RDL.
RDL	Applied when a target analyte is detected at a concentration that, in the raw data is equal to the RDL.
TA	Applied to a sample result when additional narrative information is available in the text field. The additional information may help to qualify the sample result but is not necessarily covered by any of the standard qualifiers.
Chemistry	
B, B2, B3	B (including B2 and B3) are applied when the parameter was detected at a concentration at or above the MDL in the associated blank(s) and has met the appropriate rule or condition, as defined by the method or regulatory program. Use: Application of the "B" flags depends on the ratio of the sample to blank result, on a wet-weight basis, and the particular parameter according to these rules: - Add a "B" flag to all parameters if the associated blank is ≥ the MDL and the sample result is ≥ MDL but ≤ 5 times the blank. - Add a "B2" flag to common organic lab contaminants (Acetone, 2-Butanone, Methylene Chloride, Bis(2-ethylhexyl) Phthalate, Butyl Benzyl Phthalate and Di-n-butyl Phthalate) if the method blank is ≥ the MDL and the sample result is > 5 and ≤ 10 times the blank. - Add a "B3" flag to all other parameters if the associated blank is ≥ the MDL and the sample result is > 5 and ≤ 10 times the blank..
>MR	Applied when a target analyte concentration exceeds the instrument or method capacity to measure accurately. The qualifier is primarily in the organics section. It is applied when the detected analyte concentration exceeds the upper instrument calibration limit and further dilution is not feasible. The reported value is an estimated analyte concentration.
E	**E** is applied to a parameter result when the reported value is above the calibration range of the analysis. Use: The E flag, when applied under this general definition, should be used whenever the measured response is above the calibration range of the method but it was not possible to dilute and re-analyze the sample.
J	J is applied to a parameter result when the reported value is an estimated value.

Qualifier	Description
Microbiology	
FAIL	The result of the positive or negative control failed
PASS	The result of the positive or negative control passed
C	Value is an estimate, based on presence of confluent growth
J	Applied to a parameter result when samples held for greater than '6+2' hour hold time but less than 24 hours will not be rejected. The data reporting should include a "J" flag identifying that the result is an estimate, per Ecology.**

** Ecology's NPDES program correspondence with King County, January 28, 2015, regarding fecal coliform hold times.

10.0 AUDITS AND REPORTS

10.1 Audits

Audits will be performed by the LPM and monitoring project manager after each event has been analyzed and internally reported into our data management system (LIMS). If concentrations are below method detection limits for metals analyses, a more sensitive technique (ICPMS-UL) may be used for the next event.

However, budgetary constraints may only allow for a limited number of events to be collected and analyzed using the more stringent techniques. If necessary, a determination will be made whether to equate the non-detects to a typical 0.5*MDL, or use results that are generated with a lower method detection.

10.2 Reporting

One report will be created at the conclusion of the monitoring program and will include:

- Assessment of data accuracy and completeness
- Results of proficiency testing and/or technical systems audits
- Significant QA problems and corrective actions taken
- Any other information requested by management

11.0 DATA VERIFICATION AND VALIDATION

Data verification will be conducted using data collected on field sheets and results of lab analyses. Narrative summaries will be created by the LPM after each event, highlighting any anomalies that may need addressing and possible corrective actions to take.

Validation of data will be conducted during the QC process for in-situ measurements, and through laboratory QC processes previously described using replicates.

12.0 DATA USABILITY

Data collected during storm and base flow events will be used in the calibration of a hydrologic model (HSPF) for the Bear Creek basin. The calibration will use the discrete grab samples during each event as a guide to adjust variability of concentrations simulated during the specific events. Where other data may exist from previous monitoring efforts, those will additionally be used as guidance in seasonal and annual constituent loadings. As a result of the calibration, each land segment type in the model will have an associated loading coefficient. These calibrated loading coefficients will be compared to other studies conducted in nearby stream systems and literature values for reference.

13.0 REFERENCES

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Appendix A: King County Standard Operating Procedures (SOP) and benthic samping methods

List of Standard Operating Procedures (SOP) with hyperlinks

KCEL SOP # 103v4 (Sample Management)
KCEL SOP # 205v4 (Field Measurement using an Attended Hydrolab)
NPDES SOP # CM 1000 (Continuous Monitoring of Discharge)
KCEL SOP # 214v3 (Sampling Methods for Stream and River Water)
KCEL SOP # 222v2 (Clean Surface Grab Sampling)
KCEL SOP # 237v0 (Sampling Stream Sediments)
KCEL SOP #1105v1 (Records Storage)

King County Benthic invertebrate Methods (SAP) 2002 and/or Ecology BIBI QAPP 2009
Department of Ecology's methods for 8 sq ft are online
(http://www.ecy.wa.gov/programs/eap/stsmf/docs/01SnTWadeableManA-Vv3bhfl.pdf).