Quality Assurance Project Plan
for
Field Data Collection for the Development of a Stormwater Retrofit Plan for Water Resource Inventory Area (WRIA) 9

A Project Funded by the Puget Sound Watershed Management Assistance Program FY 2009

December 2010

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Water and Land Resources Division
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Prepared by

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and

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ACRONYMS AND ABBREVIATIONS

Following are acronyms and abbreviations used frequently in this document:

BMP	Best Management Practice
CSO	Combined Sewer Overflow
DHSVM	Distributed Hydrology Soil Vegetation Model
DNRP	Department of Natural Resources and Parks
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database (Ecology)
HSPF	Hydrologic Simulation Program – Fortran
LID	Low Impact Development
MQO	Method Quality Objectives
NPDES	National Pollution Discharge Elimination System
QA	quality assurance
QAPP	Quality Assurance Project Plan
RSD	relative standard deviation
SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration Model
USGS	United States Geologic Survey
UW	University of Washington
WLRD	Water Land Resource Division (King County)
WRIA	Water Resource Inventory Area

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ABSTRACT

Stream flow, turbidity, and specific conductance will be measured in streams in Water Resource Inventory Area (WRIA) 9 to provide data needed to refine calibration of watershed hydrologic and water quality models. These measurements will be made using established protocols to ensure that the data are of sufficient quality for the intended purpose. These data are being collected as part of a larger project to develop a stormwater retrofit plan for WRIA 9. This project includes stream flow, turbidity, and specific conductance measurements, watershed hydrologic model development and calibration, development of in-stream flow and water quality targets, and stormwater retrofit modeling. The plan will include a prioritized description of the types, amounts, and costs of stormwater retrofits needed to achieve the flow and water quality targets. Cost estimates for WRIA 9 stormwater retrofits will be extrapolated to provide a cost estimate to implement stormwater retrofits in the Puget Sound basin. It is anticipated that this project will contribute to the development of a comprehensive stormwater retrofit program, which will contribute to improved flow and water quality conditions in the Puget Sound basin.

1.0. INTRODUCTION

King County was awarded a Puget Sound Watershed Management Assistance Program FY 2009 grant by Region 10 of the U.S. Environmental Protection Agency (EPA) to conduct the project titled: "Development of a Stormwater Retrofit Plan for Water Resource Inventory Area (WRIA) 9 and Estimation of Costs for Retrofitting all Developed Lands of Puget Sound." The goal of this project is to develop a cost estimate and prioritization plan for systematically implementing stormwater best management practices (BMPs) and low impact development (LID) techniques in previously developed areas of WRIA 9, and to extrapolate these results to develop a cost estimate for retrofitting the Puget Sound region. Partners working with King County on this grant-funded project include the University of Washington (UW), and the cities of Auburn, Covington, and SeaTac. The Washington Department of Ecology (Ecology) will also participate in the project management team, and the Puget Sound Partnership will also remain actively engaged throughout the life of the project. This Quality Assurance Project Plan (QAPP) describes the field data collection conducted as part of this grant-funded project.

1.1 Project Need

The current NPDES Municipal Stormwater Permits require municipalities to have a stormwater management program to reduce pollutant discharge to the maximum extent practicable. Unfortunately, the permit requirements focus primarily on preventing existing stormwater impacts from getting worse through the regulation of new development and through illicit discharge prevention, facility maintenance, and education. There is no provision in the permit to systematically eliminate existing ongoing impacts associated with the existing land cover conversion in older developed areas.

Past basin planning efforts to quantify stormwater impacts and necessary mitigation also focused mainly on preventing further flow impairments from new development. These efforts emphasized controlling the high flow portion of the flow regime for the purposes of flood risk reduction and to prevent excessive stream bed erosion. No planning efforts have been conducted to identify the type and cost of mitigation necessary to achieve flows that are more representative of pre-development or normative flow conditions and that meet water quality standards. Such an effort would need to also address changes that would occur due to redevelopment of previously developed areas to accommodate population increases.

This project takes a landscape level approach to quantify stormwater management options and costs for existing development, including evaluation of retrofits and development in a densely populated, multijurisdictional watershed in the South Central Action Area of Puget Sound. The recent availability of the USEPA's System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model greatly reduces the level of effort required to assess stormwater mitigation needs across the landscape. SUSTAIN was developed specifically to facilitate the selection and placement of stormwater management BMPs and LID techniques to improve flow and water quality conditions to enable them to meet watershed goals. SUSTAIN includes an optimization feature that allows for designing an optimized suite of stormwater improvements that result in achievement of the watershed goals at the lowest anticipated cost. This project will be a pilot test case for the use of SUSTAIN for future application in the Puget Sound region.

Information about SUSTAIN is available at:
http://www.epa.gov/ednnrmrl/models/sustain/index.html.

1.2 Description of Study Area

The project area includes the Green/Duwamish watershed and portions of the Central Puget Sound watershed that comprise WRIA 9, excluding the areas upstream of the Howard Hanson Dam and the City of Seattle (approximately 282 mi^2) (Figure 1). Vashon-Maury Island, which is technically in WRIA 15 but is included in WRIA 9 for planning and restoration purposes, is also excluded from the study area. In total, WRIA 9 comprises 536 mi^2. The Watershed Ecosystem Forum of WRIA 9 (the Forum) oversees efforts to improve watershed health and salmon habitat recovery in WRIA 9. The Forum includes representatives of all of the WRIA 9 partner governments and federal and state agencies, nonprofits, and business interests, some of which are enumerated below. WRIA 9 is one of the most diverse and natural resource-productive watersheds in the Puget Sound region, with almost 5,000 acres (about 7.8 mi^2) designated for agriculture in an Agricultural Production District and more than 286 mi^2 of commercial forest land. At its mouth, the estuary is the industrial heart of Seattle and supports one of the largest container ports on the West Coast.

The project study area encompasses a large and growing population. The Puget Sound Regional Council has projected that the study area population will increase by about a quarter of a million people between 2000 and 2040, to just over 765,000 people in 2040. Along with unincorporated King County, there are 15 cities within the study area, (including the cities of Algona, Auburn, Black Diamond, Burien, Covington, Des Moines, Enumclaw, Federal Way, Kent, Maple Valley, Normandy Park, Renton, SeaTac, and Tukwila) and the Muckleshoot Indian Reservation. Lands within the City of Seattle are not included in the study area because the vast majority of Seattle's lands within WRIA 9 are served by a combined sewer and stormwater system and CSO control programs are already underway in this area. The area of WRIA 9 upstream of the Howard Hanson Dam is not included in the study area because it is primarily forested and maintained for the City of Tacoma's water supply.

Within the study area, about 149 mi^2 (about 53%) are designated as urban and lie within the urban growth area while 133 mi^2 (about 47%) are designated as rural and fall outside of the urban growth area. Within the rural area, 65 mi^2 (about 23%) are zoned as forest production. About three-quarters of the urban lands in the study area were developed with no or ineffective stormwater controls. In addition, about 40 percent of the land within the urban growth area is impervious cover, such as roads, rooftops, and parking lots.

The study area is home to a wide array of wildlife; many species of which are threatened by stormwater-related pollution. Between 2,500 and 11,500 Chinook salmon and thousands of other salmonids migrate up the Green/Duwamish River every year to naturally spawn, using miles of good habitat on the mainstem and tributaries. Lakes and wetlands along the river host major populations of migratory and resident birds and other wildlife. Bear, elk, eagles and cougar roam the Cascade foothills and mountain peaks in the headwaters.

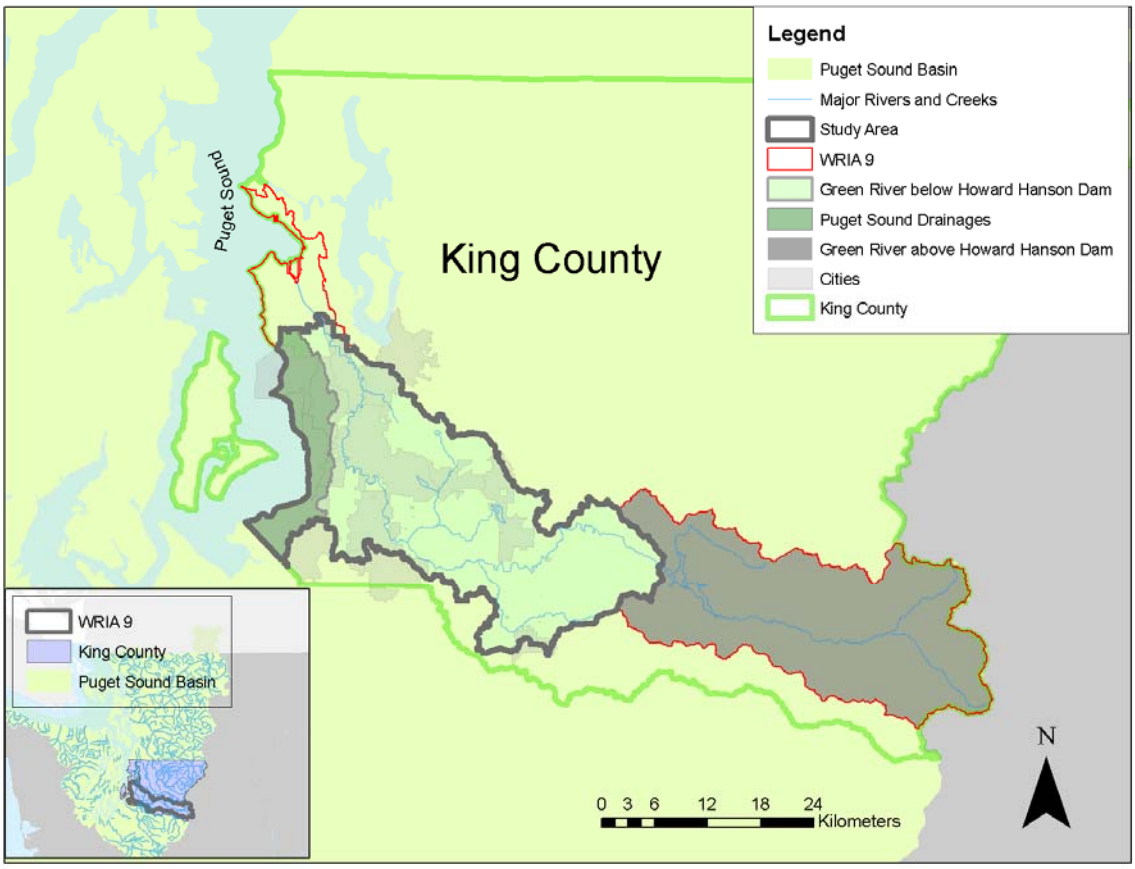


Figure 1. Map of WRIA 9 showing the project area.

1.3 Historical Data Review

The Green-Duwamish watershed and the central Puget Sound watershed have been extensively studied for many years. Of critical relevance are several studies that have occurred in the past decade associated with watershed characterization. These studies are summarized below. However, these summaries are not intended to be exhaustive. The reader is referred to the original sources for more detailed information.

1.3.1 Routine Monitoring

Routine monitoring currently occurs in many locations within the project area. Routine monitoring includes

- River and stream flow gauging by USGS: http://waterwatch.usgs.gov/
- Stream flow, temperature, and weather gauging by King County: http://green.kingcounty.gov/wlr/waterres/hydrology/
- Weather monitoring by the National Weather Service: http://www.wrh.noaa.gov/mesowest/mwmap.php?wfo=sew&map=sew&list=1&sort=name&limit=1

- Routine stream water quality monitoring by King County: http://green.kingcounty.gov/WLR/Waterres/StreamsData/
- Routine stream benthic macroinvertebrate monitoring by King County, Federal Way, and other jurisdictions: http://pugetsoundstreambenthos.org/Default.aspx
- Water Quality and stream stage height by Washington State Department of Ecology: http://www.ecy.wa.gov/apps/watersheds/riv/stationlistbywria.asp?wria=09 and https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp?region=2.

1.3.2 Green-Duwamish Water Quality Assessment

King County undertook the Green-Duwamish Water Quality Assessment (GDWQA) to assess water quality and quantity concerns throughout the watershed, with a focus on trying to understand the sources of chemical loadings to the Duwamish River. During this study, multiple small catchments, representing discrete land uses, were sampled for water quality and stream flow was measured throughout the watershed. Hydrologic models were developed for the watersheds using Hydrologic Simulation Program – Fortran (HSPF). Data collected during this project are presented on the following website: http://www.kingcounty.gov/environment/watersheds/green-river/watershed-quality-assessment.aspx.

As part of the GDWQA, water quality during baseflow and storm events was measured in small stream catchments representing different land uses (forest, agriculture, low- to medium-density development, and high-density development). This information was then used to calculate loadings per land use category. This information will provide the basis for the watershed modeling.

In general, the total suspended solids (TSS) loading estimates developed in the GDWQA indicated that storm runoff was the predominant source of TSS in all of the land use types assessed during the study. Although there was variability in areal loading rates among and within the land use types assessed, the two highest loading rates were estimated for basins draining low- to medium- and high-density development.

1.3.3 WRIA 9 Salmon Recovery Plan

The Green-Duwamish and Central Puget Sound Watershed Salmon Habitat Plan for the period 2006 – 2015 was completed in 2005 (http://www.govlink.org/watersheds/9/plan-implementation/HabitatPlan.aspx). The development of this plan included the collection of extensive habitat and fish community data. Existing water quality data were used to inform the analyses of the factors of decline. The factors of decline identified for tributaries to the lower and middle Green River included the effects of forest clearing, agriculture and residential development on flow and water quality.

1.3.4 Miller Walker Basin Plan

Investigations into Miller and Walker creeks, which drain directly to Puget Sound, have occurred for about the past decade as part of a cooperative arrangement between the cities of Burien and Normandy Park, King County, and the Port of Seattle. This work has focused on identifying stream characteristics, including flow and water quality characteristics, developing goals for future health of the basin, and developing a plan for achieving these future goals. Development

of a basin plan began in 2002 and was completed in 2006 (http://www.kingcounty.gov/environment/watersheds/central-puget-sound/miller-walker-creeks/basin-plan.aspx). The plan calls for ongoing monitoring of stream flows and water quality. Also ongoing are investigations in pre-spawn mortality (http://www.kingcounty.gov/environment/watersheds/central-puget-sound/miller-walker-creeks.aspx).

1.3.5 Newaukum Creek Basin Characterization Project Report

This report provides a comprehensive update on the status of the Newaukum Creek basin which represents a microcosm of the WRIA 9 area. The Newaukum Creek basin includes commercial, residential, agricultural, and forested land cover, with little or no storm water management facilities. Assessments included past and current hydrology, water quality, and ecological conditions; identifying data gaps, and potential future conditions in the basin. The report can be found online using the following link: http://green.kingcounty.gov/WLR/Waterres/StreamsData/reports/Newauk-Basin-Characterization-Report.aspx.

1.3.6 Des Moines Creek Basin Plan

Des Moines Creek, which also drains directly to Puget Sound, drains a highly urbanized basin within the cities of Des Moines and SeaTac. The basin includes a large part of SeaTac International Airport as well as extensive commercial and high-density residential development. Because much of the basin was developed prior to the implementation of effective stormwater detention requirements, the stream experiences erosive flows in the winter and chronically low flows in the summer. The flows have degraded Des Moines Creek by increasing channel erosion and downcutting, washing away salmon spawning gravel and large woody debris, and decreasing the number and quality of pools available for habitat within the stream. The Des Moines Creek Basin Plan, completed in 1997, assessed water resource conditions including aquatic habitat and evaluated surface water-related problems including flooding, erosion, sedimentation, and water quality impairment.

2.0. PROJECT GOAL AND OBJECTIVES

2.1 Project Goal

The purpose of this project is to develop a stormwater retrofit plan for WRIA 9 that identifies the amounts, types, and costs of stormwater retrofits necessary to achieve various flow and water quality targets. Cost estimates for retrofitting the Puget Sound basin will then be developed via extrapolation. These outcomes will be useful during development of an overall stormwater retrofit strategy for Puget Sound.

2.2 Project Objectives

The objectives of the study are:

1. Characterize flow and turbidity (a surrogate measure of total suspended solids) in streams throughout the study area for at least one wet season to assist with refining model calibration.
2. To model stream flow and total suspended solids in streams in the study area, calibrating the models to data collected in the study area.
3. To develop in-stream flow and total suspended solid targets, or range of targets, to use to evaluate future stormwater management needs in each catchment in the study area.
4. To model the types, amounts, and costs of stormwater management BMPs or low impact development techniques necessary to achieve the range of in-stream flow and total suspended solids targets by catchments.
5. To develop a prioritized stormwater retrofit plan for WRIA 9 and present the plan to WRIA 9 Watershed and Ecosystem Forum.
6. To develop a cost estimate for implementing stormwater retrofits in the Puget Sound basin.

It is anticipated that this project will contribute to the future development and implementation of a comprehensive stormwater retrofit program, which would improve stream flow and stream water quality in the Puget Sound basin.

2.3 Project Management and Oversight

This project will be managed by King County and includes collaborators from the University of Washington (UW), the cities of Auburn, Covington, and SeaTac, and the Department of Ecology. Funding will be provided by the EPA Watershed Management Assistance Program, with matching funds (primarily in the form of staff time) from King County, UW, and the cities of Auburn, Covington, and SeaTac. The project team plans to meet at least quarterly to communicate progress, problems, and plan future activities. All products, including this QAPP, will be reviewed by the project team and technical reviewers assigned by EPA Region 10, primarily the EPA Project Monitor assigned to this grant.

3.0. FIELD SAMPLING DESIGN

The field sampling effort is designed to collect data needed to improve the geographic scale of the hydrologic model calibration throughout the project area. The overall design of the field data collection effort includes flow monitoring, water quality monitoring, and meteorological monitoring as described below.

3.1 Ongoing Stream Gaging

Figure 2 displays the location of existing stream gauges in the study area. The data from these gauges will be used to help calibrate the watershed hydrologic models. King County maintains stream flow gauges at 16 locations in the project area as part of its routine environmental monitoring program and special project monitoring. USGS maintains stream flow gauges at five locations in the project area. Both King County and USGS measure stream flow continuously

(15-minute intervals) at these sites. The city of Federal Way maintains a stream gauge in the project area that will be upgraded to improve accuracy.

3.2 Ongoing Stream Water Quality Monitoring

King County measures field water quality parameters during each site visit to the 16 stream gauges maintained in the project area. The parameters measured include temperature, turbidity, specific conductance, pH, and dissolved oxygen. In addition, King County conducts monthly water quality monitoring at six sites in the project area, two of which are on the main stem of the Green River. A map and list of locations, parameters measured and data results are available at http://green.kingcounty.gov/WLR/Waterres/StreamsData/Default.aspx.

3.3 Ongoing Meteorological Monitoring

Meteorological data will be collected at a variety of sites throughout the study area. Precipitation will be measured at 18 locations shown in Figure 3. Two sites, one at Summit King County Roads maintenance facility, the other maintained by Washington State University in Puyallup, Washington (http://www.weather.wsu.edu/awn.php), have meteorological stations which measure precipitation, air temperature, wind speed, wind direction, solar radiation, relative humidity, and dew point temperature.

3.4 Project-Specific Stream Gauging

As part of this project, ongoing stream gauging activities will be augmented with additional stream gauges to allow for refined calibration of the watershed hydrologic models to smaller catchment scales. As part of this project, 10 stream gauges will be installed (Figure 4). Stream gauges will be maintained for a minimum of three months during the wet season (October 2010 through March 2011). Field measurements of stream summer baseflow will be made at these same sites in August 2011. Weather conditions and flows in August 2011 will be compared to those from previous years to assess the representativeness of the 2011 baseflow measurements.

3.5 Project-Specific Water Quality Monitoring

As part of this project, ongoing water quality monitoring activities will be augmented with additional continuous turbidity and specific conductance monitoring. Turbidity and specific conductance will be measured with sondes at 14 locations, each continuously for at least a one-month period during the wet season between October 2010 and March 2011. At six locations, turbidity probes will be installed with the stream gauge equipment and will record turbidity during the monitoring period. Figure 5 shows the locations of the turbidity monitoring sites. Table 1 lists the sites with the method that will be used at each site for measuring turbidity. Measurement differences between different turbidity probes will be assessed as part of the calibration process and measurements will be scaled as appropriate to minimize any observed differences.

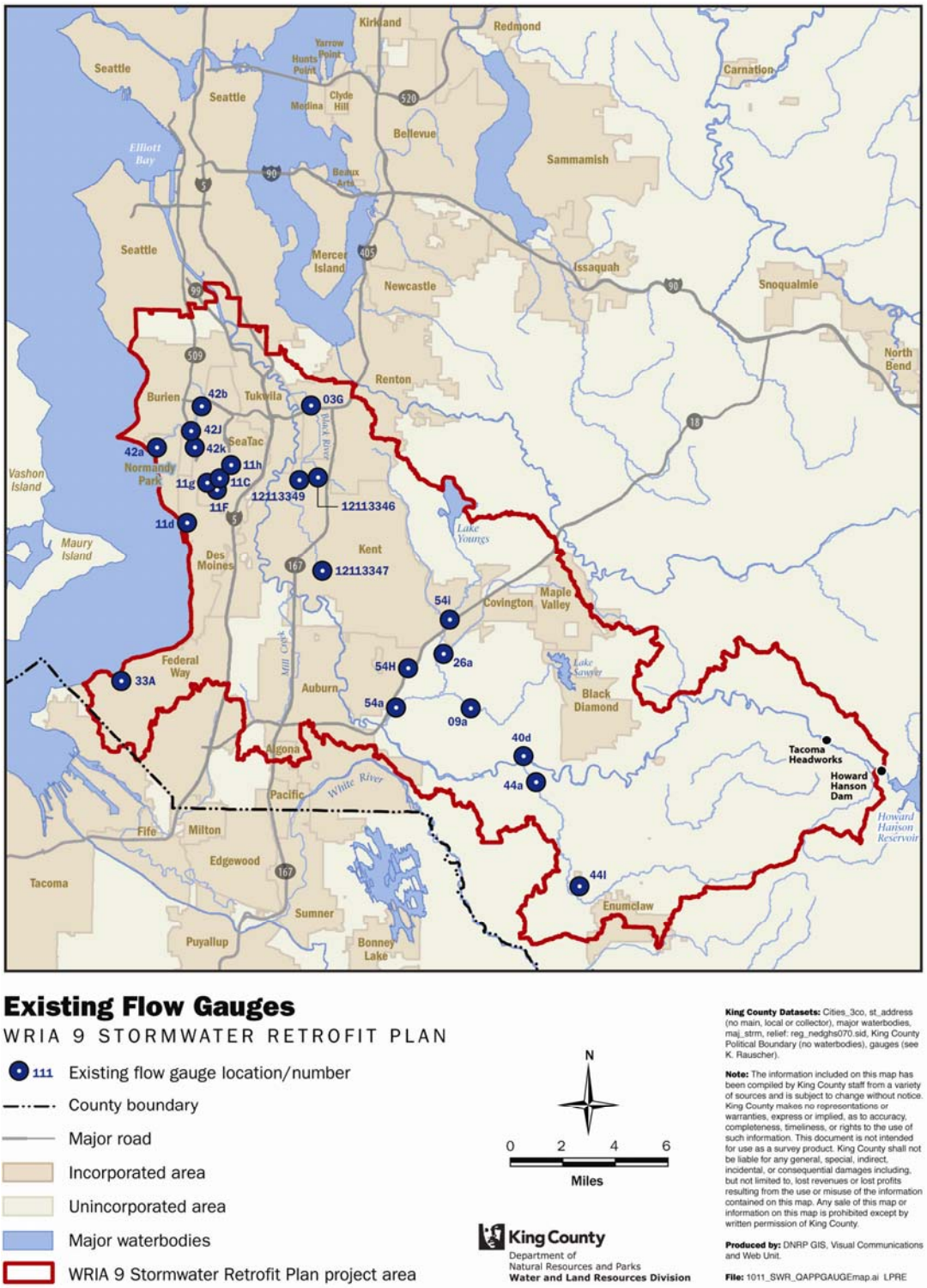
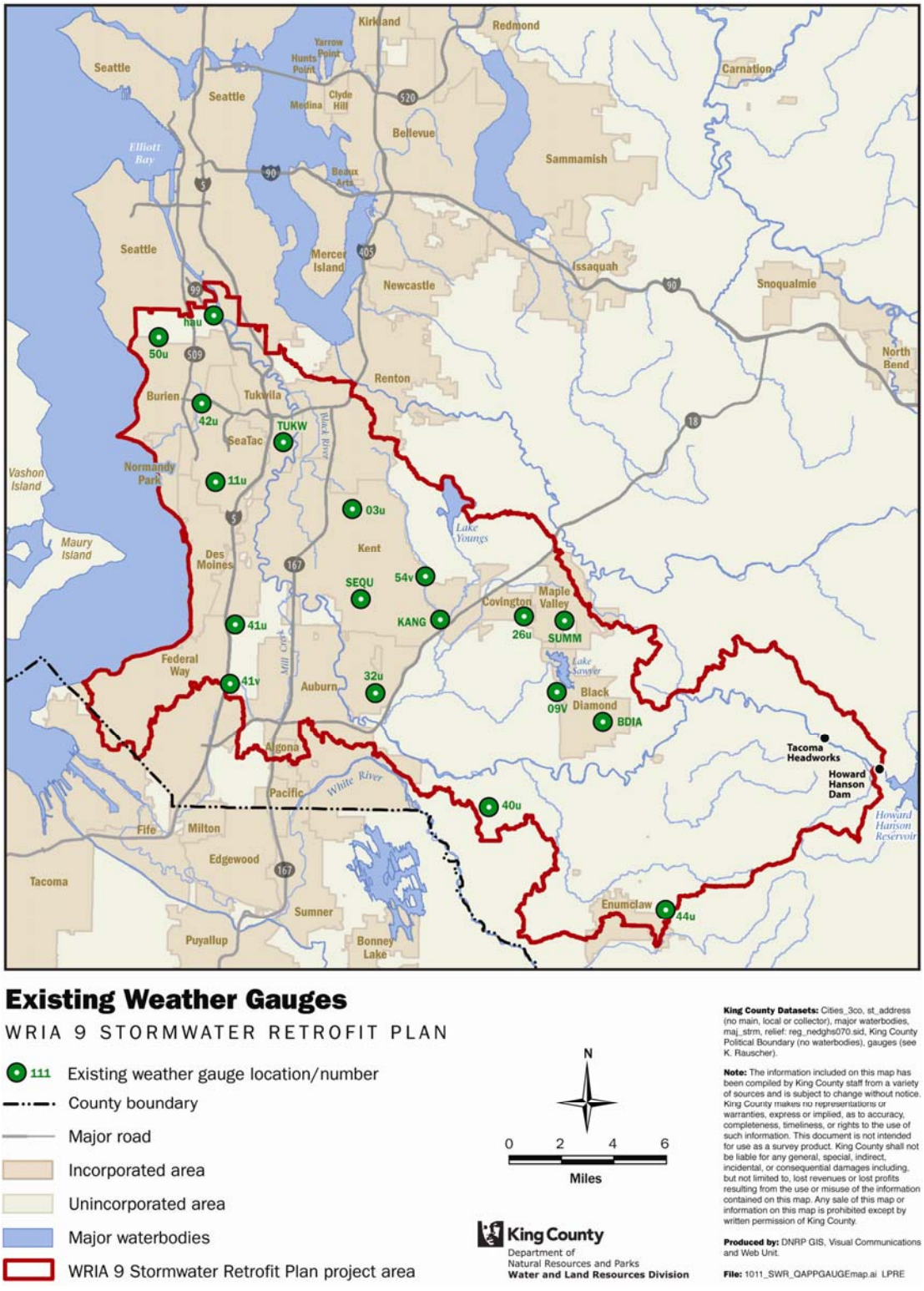


Figure 2 Location of Existing Stream Gauges



Existing Weather Gauges

WRIA 9 STORMWATER RETROFIT PLAN

111 Existing weather gauge location/number

County boundary

Major road

Incorporated area

Unincorporated area

Major waterbodies

WRIA 9 Stormwater Retrofit Plan project area

N

0 2 4 6

Miles

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

King County Datasets: Cities_3co, st_address (no main, local or collector), major waterbodies, maj_strm, relief: reg_nedghs070 sid, King County Political Boundary (no waterbodies), gauges (see K. Rauscher).

Note: The information included on this map has been compiled by King County staff from a variety of sources and is subject to change without notice. King County makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. This document is not intended for use as a survey product. King County shall not be liable for any general, special, indirect, incidental, or consequential damages including, but not limited to, lost revenues or lost profits resulting from the use or misuse of the information contained on this map. Any sale of this map or information on this map is prohibited except by written permission of King County.

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Figure 3 Location of Existing Weather Monitoring Sites

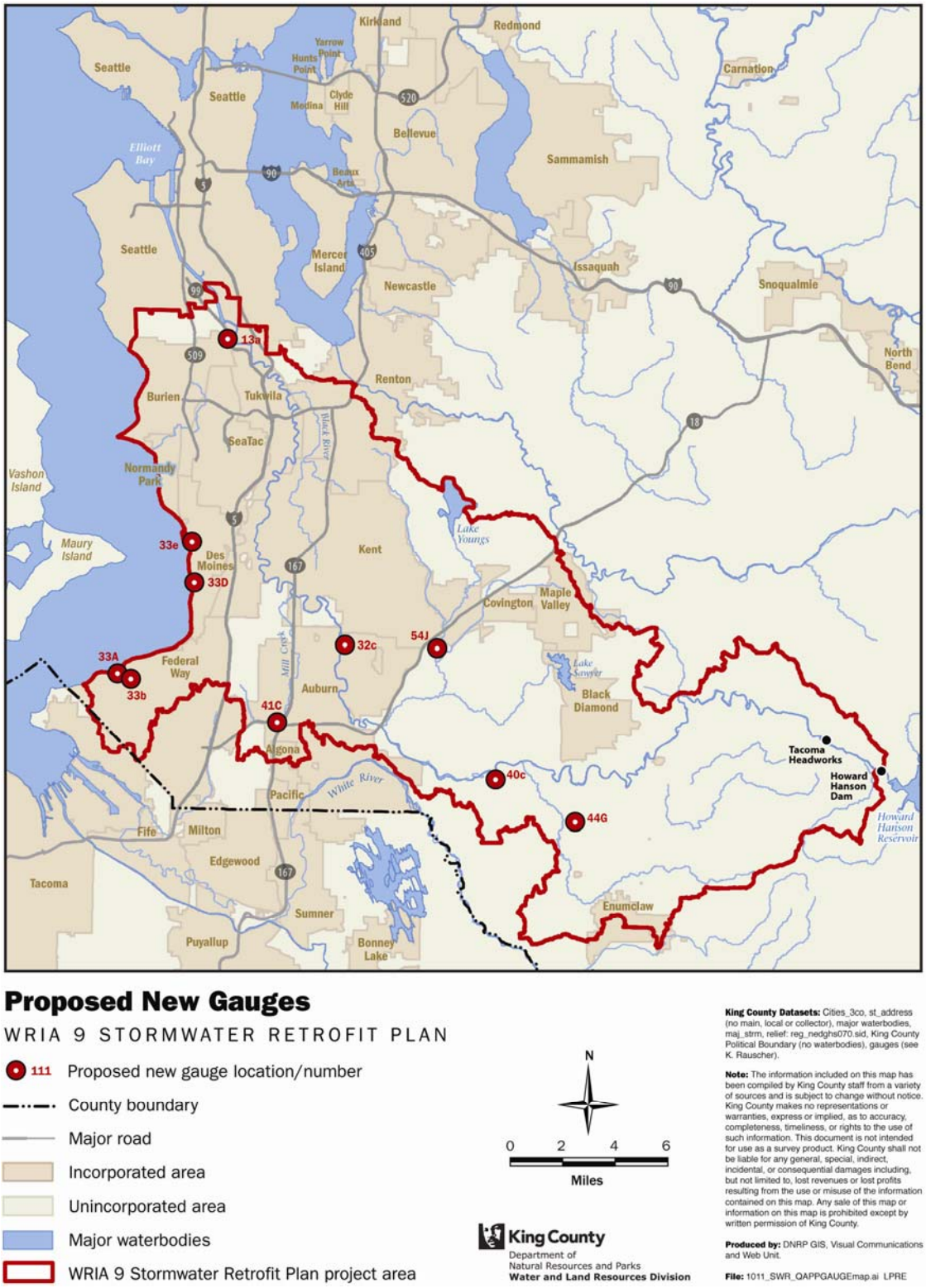

Figure 4 Location of New Stream Gauges

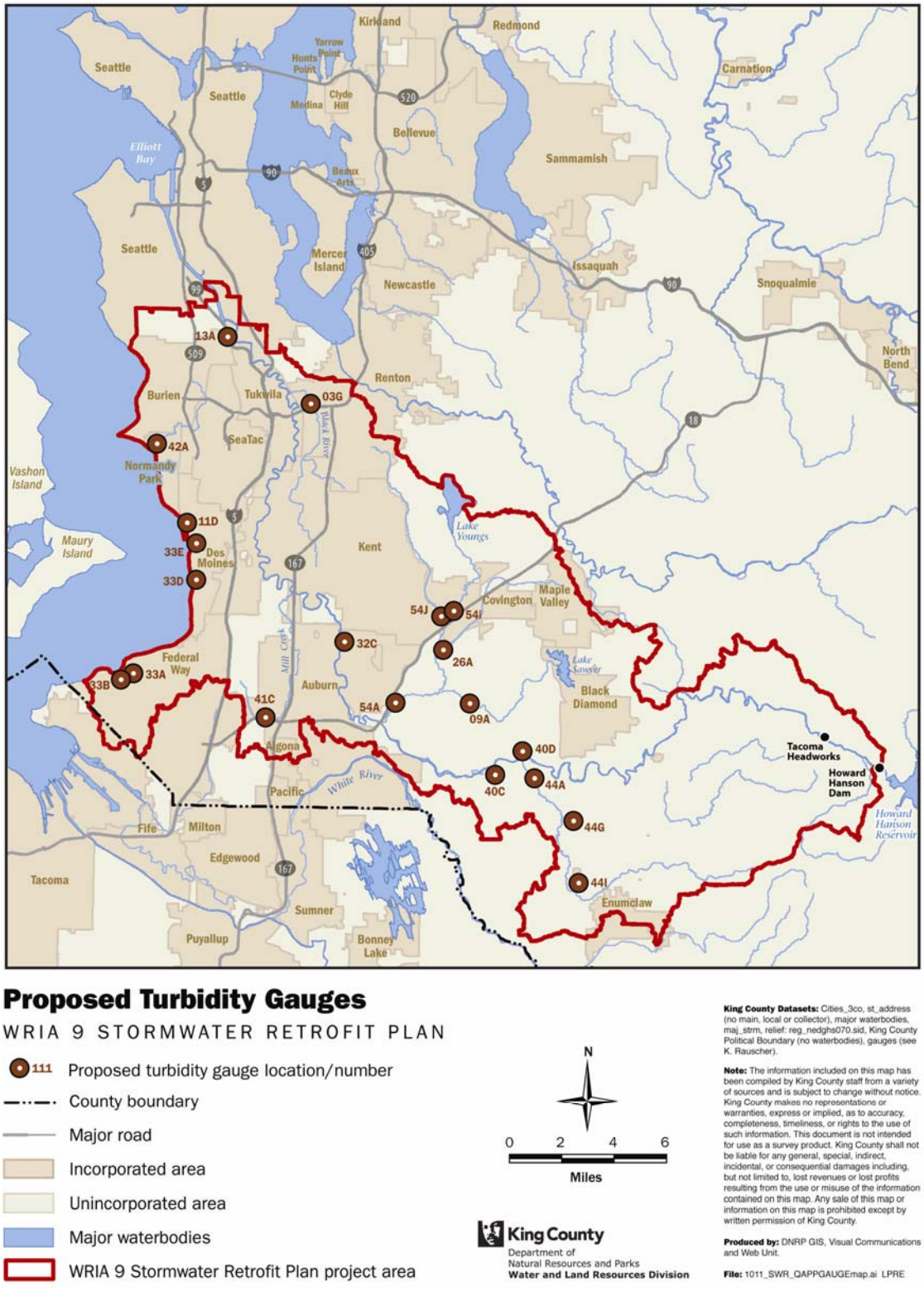

Figure 5 Location of Turbidity Monitoring Sites

Table 1 List of Stream Gauge and Turbidity Monitoring Locations

Site Code	Site Name	Latitude	Longitude	Turbidity Equipment	Specific Conductance	Stream Gauge
33A	Joes CR at Marine View DR, former USGS gauge 12103205	47.3265	122.3765	Sonde	Yes	Existing Federal Way
03G	Springbrook Creek at O'Grady Way	47.4681	122.2344	Probe	No	Existing KC
09A	Covington Creek near Mouth,	47.3126	122.1083	Probe	No	Existing KC
11D	Des Moines Creek below SR 509	47.4059	122.3277	Probe	No	Existing KC
26A	Jenkins Creek near Mouth	47.3404	122.1295	Probe	No	Existing KC
40D	Crisp Creek at Green River RD	47.2883	122.0672	Sonde	Yes	Existing KC
42A	Miller Creek near Mouth	47.4455	122.3520	Probe	No	Existing KC
44I	Big Spring CR	47.2210	122.0233	Sonde	Yes	Existing KC
54i	Little Soos Creek at SE 272nd	47.3582	122.1253	Probe	No	Existing KC
44A	USGS Gauge12108500 NEWAUKUM CREEK	47.2740	122.0579	Sonde	Yes	Existing USGS
54A	USGS Gauge 12112600 BIG SOOS CREEK ABOVE HATCHERY NEAR AUBURN	47.3125	122.1653	Sonde	Yes	Existing USGS
13A	Duwamish River Tributary 0003	47.5024	122.2994	Sonde	Yes	New
32C	Olsen CR Tributary 0069 at Green River RD	47.3437	122.2051	Sonde	Yes	New
33B	Lower Puget Sound Tributary 0386 (Lakota Creek) former USGS gauge 12103207	47.3260	122.3696	Sonde	Yes	New
33D	McSorley Creek former USGS gauge 12103220	47.3749	122.3212	Sonde	Yes	New
33E	Massey Creek	47.3964	122.3233	Sonde	Yes	New
40C	O'Grady Creek near Enumclaw	47.2756	122.0884	Sonde	Yes	New
41C	Mill Creek near Peasley Canyon	47.3035	122.2558	Sonde	Yes	New
44G	Green WQA-Agricultural	47.2534	122.0270	Sonde	Yes	New
54J	Soos Creek at Kent - Black Diamond RD	47.3435	122.1344	Sonde	Yes	New

4.0. QUALITY OBJECTIVES

Measurement quality objectives (MQOs) are defined for this project. MQOs are "'acceptance criteria' for the quality attributes measured by project data quality indicators. They are quantitative measures of performance…" (USEPA, 2002). MQOs are the targets for precision, bias, and sensitivity against which QC results are compared. Precision is assessed from the results of replicate analyses of samples and standards. Bias is assessed from blanks and check standards and compared to their expected values. Sensitivity is related to the detection and reporting limits for the measurement method used.

4.1 Measurement Quality Objectives

The Measurement Quality Objectives for the field measurements are presented in Table 22. Field crews are responsible for adherence to objectives. King County will be responsible for verifying all MQOs are met.

Table 2. Measurement Quality Objectives for field data.

Measurement	Precision (RSD*)	Bias (% deviation from true value	Lowest Value/Range of Interest
Specific Conductance	10%	5%	1 µS/cm
Turbidity	10%	5%	1 NTU

*RSD (relative standard deviation) is calculated as the ratio of the standard deviation and the mean of several values.

Quality of in situ measurements is assured by following calibration and maintenance procedures specific to the instrument.

4.2 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 measure environmental parameters, along with standardized data validation and reporting procedures. By following the guidance of this QAPP, the goal of comparability of the measurements made over time will be achieved. Historical water quality and quantity data from the study area may be compared with data generated from this study to enhance data analysis efforts. Previous data will be used if comparable measurement and analytical techniques were employed.

5.0. MEASUREMENT PROCEDURES

Standard Rite-n-Rain or equivalent paper forms will be used to record observations made during monitoring site visits. Local time will be used on field sheets.

5.1 Field Water Quality Measurements

During site visits to the stream monitoring locations, measurements of field parameters–specific conductance, temperature, and turbidity will be taken. These field parameters are measured with a variety of multi parameter (KCEL SOP #205) and parameter specific hand held instruments. The measurement precision of these parameters are provided in Table 3.

Table 3. Water Quality Parameter Method and measurement precision for stream sampling sites.

Field Parameters	Method	Measurement Precision
Temperature	EPA 170.1	0.1 deg C
Specific Conductance	EPA 120.1	0.5 µmhos/cm
Turbidity	EPA 180.1	0.1 NTU

Use of the field instruments will follow the King County Environmental Lab standard operating procedures listed in Table 4. Manufacturers' recommendations for calibration and measurement procedure will give specific guidance for instrument use and maintenance.

Table 4. KCEL SOP for stream sampling sites.

SOP#	STANDARD OPERATING PROCEDURE
SOP #206v2	Field Measurement of Conductivity
SOP #203v3	Field Measurement of Temperature
SOP # 207v1	Field Measurement of Turbidity using Hach 2100P
SOP #205v4	Attended Hydrolab Multiprobe Operation

5.2 Continuous Stream Flow

A continuous flow monitoring station is commonly called a stream gauge or gauging station. The production of continuous stream flow records will use a SOP for continuous measurement of discharge developed by King County to meet NPDES monitoring requirements. (http://green.kingcounty.gov/wlr/waterres/hydrology/NPDES-SOP.doc). The methods closely follow guidance provided by WDOE (Butkus 2005; http://www.ecy.wa.gov/pubs/0503204.pdf). Both these procedures follow USGS standards described in the USGS Water-Supply Paper 2175 (Rantz, 1982).

The procedures describe equipment and site selection factors, installation, operation, and field measurement techniques. This project will use electronic equipment to measure and record water level in the selected streams. At the existing stream gauges as well as the new sites, a programmable data logger will operate a water level and other sensors and record measured values at 15 minute time increments. At each new site, a relationship between the water surface elevation and the flow rate (stage-discharge relationship) will be developed from a set of direct measurements of discharge. Already developed stage-discharge relationships, as updated as part of the ongoing stream gauge monitoring program, will be used for existing sites. Continuous stream flow is calculated by using the stage-discharge relationship to match a specific water level with a corresponding rate of flow.

The procedures and tasks involved with a stream gauge are designed to accurately measure and record water level and determine the stage-discharge relationship at the site. Discharge measurements are made at King County stream gauges every five to eight weeks. The newly established stream gauges for this project will be measured every four weeks on average, with attention to peak flows.

5.3 Continuous Measurement of Turbidity and Specific Conductance

The project will employ 17 Yellow Springs Instruments (YSI) sondes equipped for unattended monitoring to measure turbidity, specific conductance, and temperature at 14 locations. At six sites, turbidity probes will be connected as a sensor with the stream gauge data logger and record throughout the project duration. A variety of factors determine which type of instrument goes at a specific monitoring site. Factors include instrument size and typical stream depth, access to the site, potential for vandalism, and type of existing instrumentation. Table 1 lists the sites and type of instrument to be installed to record turbidity and specific conductance.

5.4 Stream Summer Baseflow Measurements

At each gauging site, a summer stream baseflow measurement will be taken in August 2011. This measurement will be taken by a King County WLRD Hydrologic Monitoring staff. Water depth and velocity will be recorded at each gauging location cross section. All flow measurements will follow Buchanan and Somers (1969) and standard King County Environmental Laboratory's SOP #02-02-004-000. Field teams will use consistent techniques described at a pre-sampling meeting to minimize variability among teams.

6.0. QUALITY ASSURANCE AND CONTROL

Quality assurance and control will be provided by project manager oversight, project staff training, and adherence to a combination of laboratory and field standard operating procedures referenced previously.

For measurements involving water quality sondes, maintenance schedules, calibration schedules, and deployment, instructions will be followed for all meters and sensors. For stream flow, only

specially trained and qualified gauging technicians will install, maintain, and extract data from gauges. Gauging technicians will maintain and calibrate gauges according to procedures to provide high quality data and gauging technicians or project staff will periodically (about every two weeks at minimum) visit the gauge site to ensure proper working condition. All data are reviewed, rated for accuracy, and approved by a county gauging supervisor before being submitted as a final product.

6.1 Field QC Procedures

Field QC includes proper documentation of field activities and sampling/handling procedures, as described in Sections 5 and 6.

6.1.1 Calibration and Use of Meters

Before use, field equipment must be cleaned and checked for malfunctions. Meters must be calibrated each morning before use in the field, following manufacturers' procedures. Other field equipment will be calibrated at least daily. All field monitoring equipment will be calibrated consistent with manufacturers' procedures using instrument calibration standards prepared according to the manufacture's specifications. In all cases, proper documentation of all calibration procedures must be completed for each sampling event, including calibration methodology (one- or two-point calibration, difference, standard concentration and expiration date).

Logbooks shall be maintained for all field meters. The logbooks must contain the same information as those for permanent laboratory instruments (serial number, name and model of meter, year purchased, etc.). The books also must contain QC results, maintenance performed by the factory, and calibration notes for each day the equipment is used. Instruments used to measure pH, dissolved oxygen and electrical conductivity should be calibrated at least once each day of sampling. Temperature-measuring devices should be calibrated against a standardized laboratory thermometer at a frequency recommended by the manufacturer. Field instruments used to measure other parameters, e.g., turbidity, should be calibrated in accordance with manufacturer recommendations and documented.

7.0. DATA MANAGEMENT PROCEDURES

Except where noted otherwise, all field data and associated observations will be recorded on standardized field sheets (physical or electronic) as described above (see Sampling Procedures) and entered or transferred into the King County hydrologic database in a timely manner, generally within one week of collection. All field data will be stored in King County's Hydrologic Information Center database.

The Lead Hydrologic Engineer will provide supervision of all data acquisition and management activities. Field sheets and instrument calibration logs will be maintained in paper files sorted by site and instrument. Project staff will enter all field data manually or download from electronic files.

8.0. AUDITS AND REPORTS

As per the EPA's contract requirements, semiannual project reports will be provided to the EPA by the Project Manager. The report will include a description of project activities and status including an overview of data collected, field and data problems encountered and solutions applied, and changes in schedule, measurements, database, and analysis. If needed, the EPA may conduct a Quality System Review on management and technical aspects of the project.

9.0. DATA VALIDATION

Data validation is critical in the evaluation of how well analytical and field data meet acceptability objectives for the project. All continuous data and field measurements will be entered into King County's Hydrologic Information Center database (HIC).

Field data, such as in situ data measurements or recorded environmental observations, are peer reviewed prior to entry into the Hydrologic Information Center SQL Server database. Continuous stream gauge and water quality data are reviewed for completeness and instrument calibration data are reviewed for compliance with project and method QA/QC requirements.

10.0. DATA ANALYSIS AND USE

Data quality will be evaluated against the objectives set in this document for precision. The data will also be evaluated for obvious errors, such as incorrect units.

10.1 Existing Data

No specific quality objectives are being specified for existing data or modeling results at this time. However, data from existing repositories will be used for evaluation and modeling purposes and the following acceptance criteria will be applied:

- *Data Reasonableness*–Data quality of existing data will be evaluated where possible. Best professional judgment will be used to identify erroneous or outlier data and these observations will be removed from the data set.
- *Data Representativeness*–Data will be used that are reasonably complete and representative of the location or time period under consideration. Incomplete data sets will be used if they are considered representative of the conditions during the period of interest. Data from outside the period of interest will be used only if no other data are available. In this case, best professional judgment will be used to determine the utility of the available data.
- *Data Comparability*–Long-term water quality monitoring programs often collect, handle, preserve, and analyze samples using methodologies that evolve over time. Best professional judgment will be used to determine whether/if data sets can be compared. The final project report will detail any caveats or assumptions that were made when using data collected with differing sampling or analysis techniques.

Previous stream gauge and water quality data collected by King County and USGS in the study area are the primary existing data that will be used in this study. The list below identifies studies and repositories that contain existing data that will be used in this project. However, additional sources of information may be considered as needed and/or as new sources are identified.

10.1.1 King County Hydrologic Monitoring Data

King County DNRP-WLRD has collected hydrologic data in the study area since 1988. URL: http://green.kingcounty.gov/wlr/waterres/hydrology/

The results of a three year (2001-2003) water quality study are presented in the report Green-Duwamish Water Quality Assessment.

URL: http://green.kingcounty.gov/WLR/Waterres/StreamsData/reports/green-duwamish-loading-report.aspx.

10.1.2 USGS Monitoring Data

The USGS has measured streamflow and water quality in the study area. Data are downloaded from the USGS NWIS database and are viewed at URL: http://waterdata.usgs.gov/wa/nwis/sw.

11.0. ORGANIZATION AND SCHEDULE

11.1 Field Collection Staff List and Roles

The field data collection effort will be conducted by members of the King County Department of Natural Resources and Parks (DNRP) hydrologic monitoring team. This team includes

- David Funke–King County DNRP–Lead hydrologic gauger responsible for ensuring proper field data are collected.
- Brendan Grant–King County DNRP – hydrologic monitoring team, responsible for maintaining stream gauges and continuous water quality equipment.
- Dan Smith–King County DNRP – hydrologic monitoring team, responsible for maintaining stream gauges and continuous water quality equipment.
- Jim Simmonds–King County DNRP, serves as the overall project manager.

11.2 Major Activities and Timelines

The major timelines of the field data collection include:

July – October 2010	Preparation, review and approval of QAPP
November 2010 – March 2011	Field data collection
March 2011 – September 2011	Data processing, analysis, and preparation of data report
August 2011	Site measurements of summer low flows

12.0. REFERENCES

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