Quartermaster Harbor Nearshore Freshwater Inflows Assessment Quality Assurance Project Plan

Part of the Quartermaster Harbor Nitrogen Management Study

September 2010

King County

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Quartermaster Harbor Nearshore Freshwater Inflows Assessment

Quality Assurance Project Plan

A Targeted Watershed Grant
under the
2008 Puget Sound Initiative

Prepared by

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ABSTRACT

This study proposes to assess the nitrogen concentrations of surface inflows of freshwater into Quartermaster Harbor on Vashon-Maury Island. Samples of small, previously unsampled streams will provide a snapshot during the critical period for dissolved oxygen of the nitrogen flowing in via these freshwater inputs to Quartermaster Harbor. This work will assess nitrogen concentrations and loads in from freshwater sources in different areas within the harbor. This information will be incorporated into the overall study identifying nitrogen loading sources and potential management strategies of those sources.

1.0. INTRODUCTION

King County was awarded a West Coast Estuaries Initiative (WEI) grant by Region 10 of the U.S. Environmental Protection Agency (EPA) to conduct the Quartermaster Harbor Nitrogen Management Study. The goal of this study is to support the protection and restoration of Quartermaster Harbor – a high value, coastal aquatic resource on Vashon-Maury Island (VMI) in Puget Sound. Partners working with King County on this grant-funded study include the University of Washington-Tacoma (UWT) and the Washington Department of Ecology (Ecology). The WEI grant will also support the enhancement of aquatic resource protection programs in an area threatened by growth pressures. This assessment of nitrogen loading to Quartermaster Harbor from previously unmonitored surface inflows provides additional information on sources of nitrogen to the harbor and data that will be used to refine initial estimates of nitrogen loading to the harbor as part of the development of a water quality model of the harbor.

1.1 Study Need

Dissolved oxygen levels below state marine water quality standards have been observed in Quartermaster Harbor over the last four years of monthly monitoring by King County, with lowest levels typically observed in September (Figure 1). Dissolved oxygen is essential for fish and other marine life, which can become stressed or killed or escape to more oxygenated waters if possible. Low dissolved oxygen levels, combined with the high habitat value of Quartermaster Harbor, increased frequency of detections of nitrate nitrogen in VMI groundwater, and ongoing population growth, make this project a high priority for King County. Quartermaster Harbor has many similarities with South Puget Sound embayments which do not meet state dissolved oxygen standards established for the protection of aquatic life.

Quartermaster Harbor was one of 19 areas of Puget Sound judged to be relatively sensitive to anthropogenic nutrient inputs (Rensel Associates and PTI 1991). Excess nutrients, nitrogen compounds in particular, can lead to excessive phytoplankton and algae growth which can then deplete oxygen concentrations when the algae die (Figure 2). Nitrogen and phosphorus are essential nutrients for marine plants and phytoplankton, particularly nitrogen as phytoplankton preferentially take up ammonium and other nitrogen compounds. Although phosphorus compounds are important for phytoplankton growth, nitrogen is generally considered to be the limiting nutrient in marine waters of Puget Sound (Rensel Associates and PTI 1991).

Of the external, non-oceanic sources of nutrients to Quartermaster Harbor, tributary streams have been estimated to be the most significant source of nitrogen to Quartermaster Harbor (King County, 2010). Yet only three tributaries (Fisher, Judd and Mileta Creeks) to the harbor are being monitored routinely for nitrogen levels. Shoreline surveys done in 2003 and 2005 documented over 40 unmonitored freshwater inflows including 19 stream mouths in the harbor (see Section 1.3).

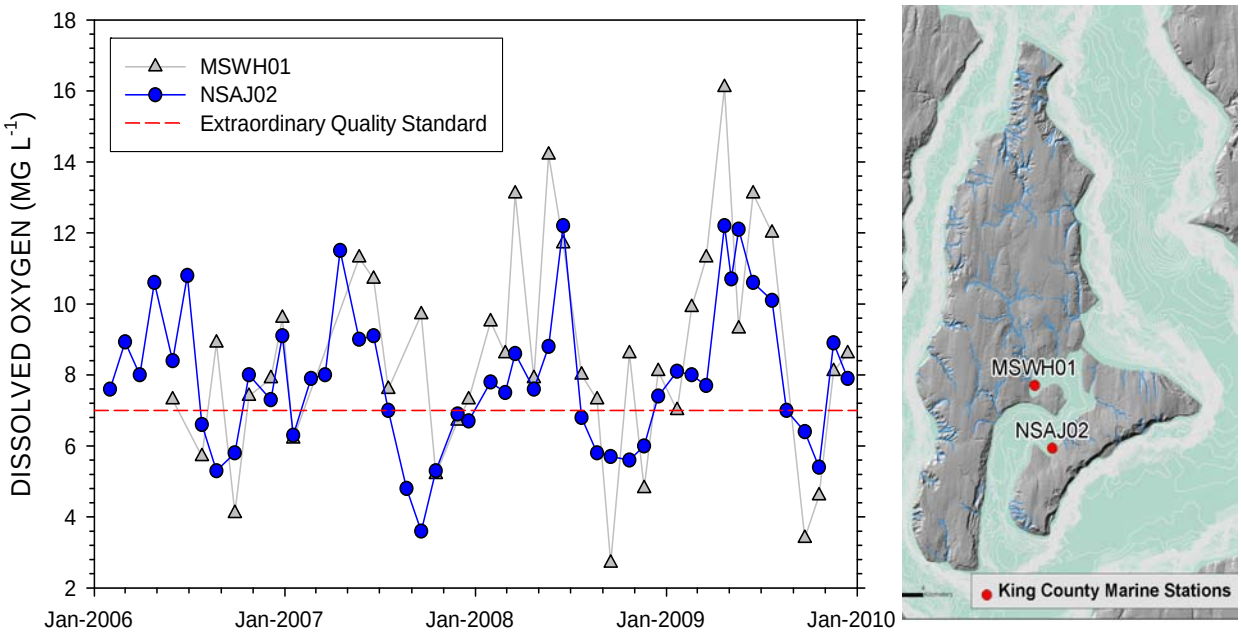

Figure 1. Monthly dissolved oxygen concentrations measured in bottom waters of Quartermaster Harbor by King County. MSWH01 is a site at the marina and NSAJ02 is a sample site at Dockton Park.

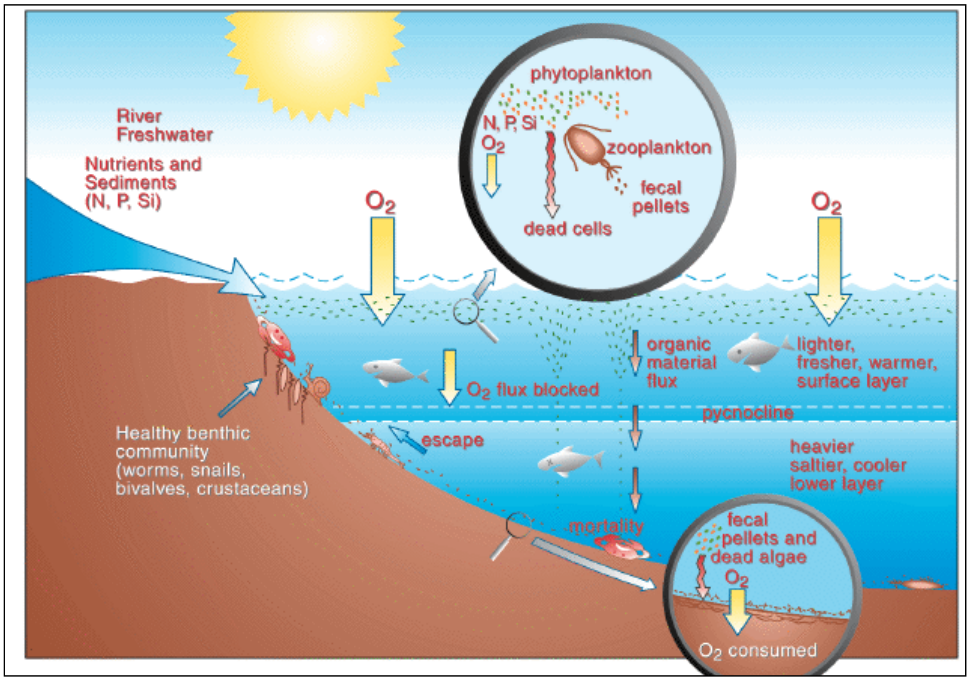

Figure 2. Conceptual diagram of marine nutrient-oxygen dynamics (Source: Downing JA, et al. Gulf of Mexico hypoxia: land and sea interactions.

Note: Task force report no. 134. Ames, IA:Council for Agricultural Science and Technology, 1999 (http://www.ehponline.org/docs/2000/108-3/focusfig2B.GIF)

1.2 Description of Study Area

Vashon-Maury Island lies in Puget Sound within the boundaries of King County, Washington, and is situated southwest of Seattle and north of Tacoma. Vashon-Maury Island encompass approximately 37 square miles of which 29.7 square miles are on Vashon Island and 7.0 square miles on Maury Island (Figure 3). All of Vashon-Maury Island is designated as rural and as such is outside the urban growth boundary. Low-density residential development covers much of the Island with zoning of one home per five and ten acres. Higher density residential areas are concentrated in the Vashon Town Center, Vashon Heights, Burton, Dockton, and along parts of the shoreline.

Quartermaster Harbor (QMH), located between Vashon and Maury Islands, is sheltered from the wind and waves and receives runoff from about 40 percent of Vashon-Maury Island. It is a shallow, protected embayment that comprises approximately 12.1 km^2 (3,000 acres) of water surface area in an inner and outer harbor. Inner QMH is especially sheltered and Judd Creek, located in the northwestern portion of the inner harbor, is the largest freshwater input. Transition zones between freshwater surface flows and the marine water within the bay include the estuaries at the mouth of Judd Creek, Fisher Creek, and Raab's Lagoon along with numerous smaller streams. Inner QMH is shallow, with a greatest depth of about 5 meters and very little tidal flushing. Outer QMH water depths range from about 11-46 meters with rapid tidal flushing.

1.3 Historical Data Review

Vashon-Maury Island has been the subject of numerous near shore environment assessments. Not many of these studies have/had a focus of looking at the freshwater inflows to Quartermaster Harbor. The study summaries presented below are not intended to be exhaustive but to provide an overview of available data. The reader should refer to the original sources for more detailed information.

1.3.1 Marine Shoreline Inventory – WRIA 9

A marine shoreline inventory was conducted for shorelines of WRIA 9 in 2003 that inventoried selected shoreline features that provide nearshore habitat for juvenile salmonids (Anchor Environmental, 2004). For this work, Vashon-Maury Island was included in their assessment of WRIA 9, although Vashon-Maury Island is actually part of WRIA 15. Results are presented in part using high-resolution aerial photos with overlays that classify the types of habitat. The report identified 28 freshwater inflows along the shoreline (Figure 4). Classification of the inflows was not done as part of this survey.

1.3.2 Accretion Shoreforms – WRIA 8 & 9

In 2004, Coastal Geologic Services assessed and inventoried current and historic beach feeding sources/erosion and accretion areas for marine shorelines within WRIAs 8 and 9 (Coastal Geologic Services, 2005). As in the previous study (Anchor Environmental, 2004), Vashon-Maury Island was assessed during the WRIA 9 survey work. During the shoreline assessments, freshwater inflows were classified as an outfall, seep, creek or stream.

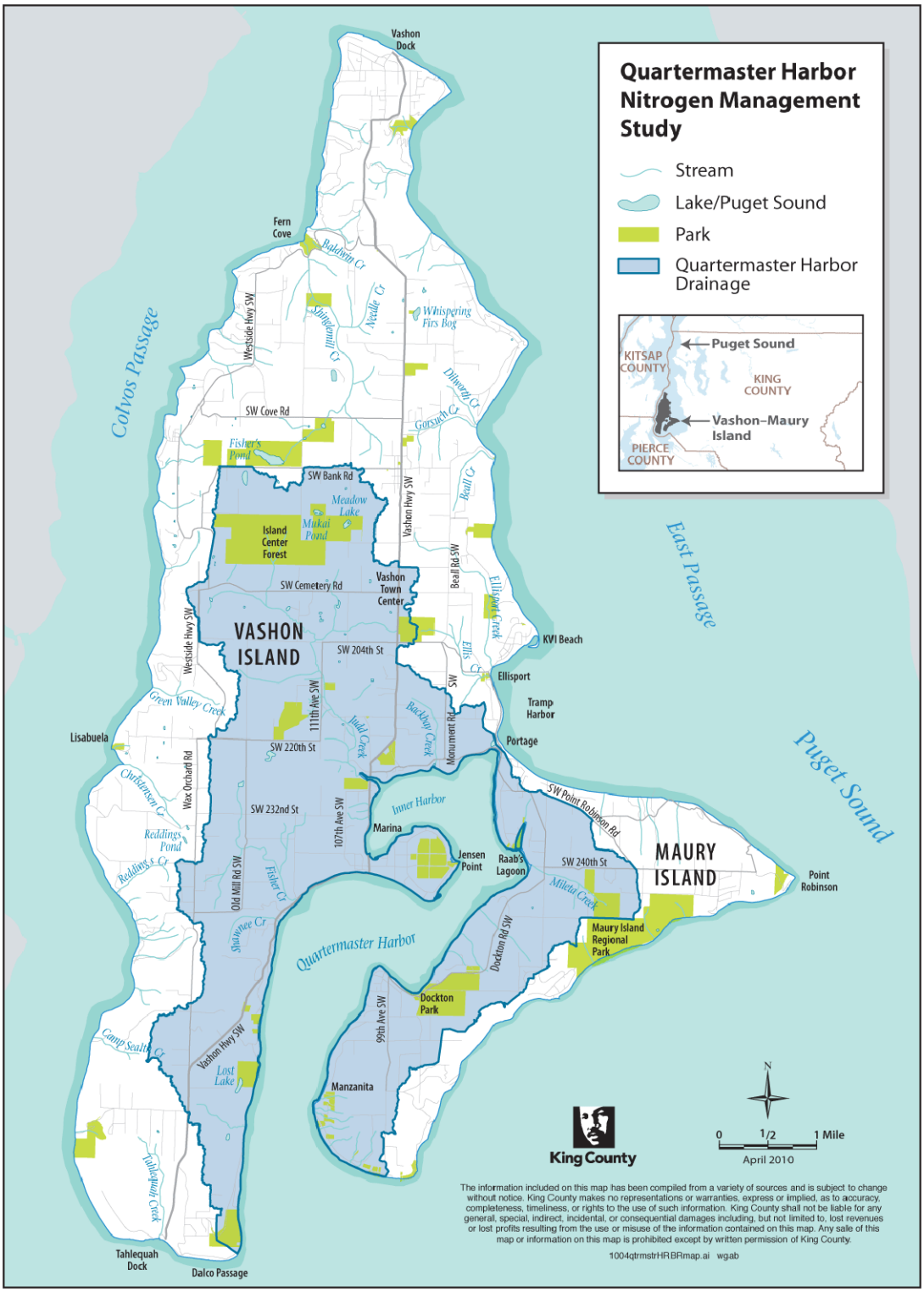

Figure 3. Map of Vashon-Maury Island highlighting the drainage area of the Quartermaster Harbor.

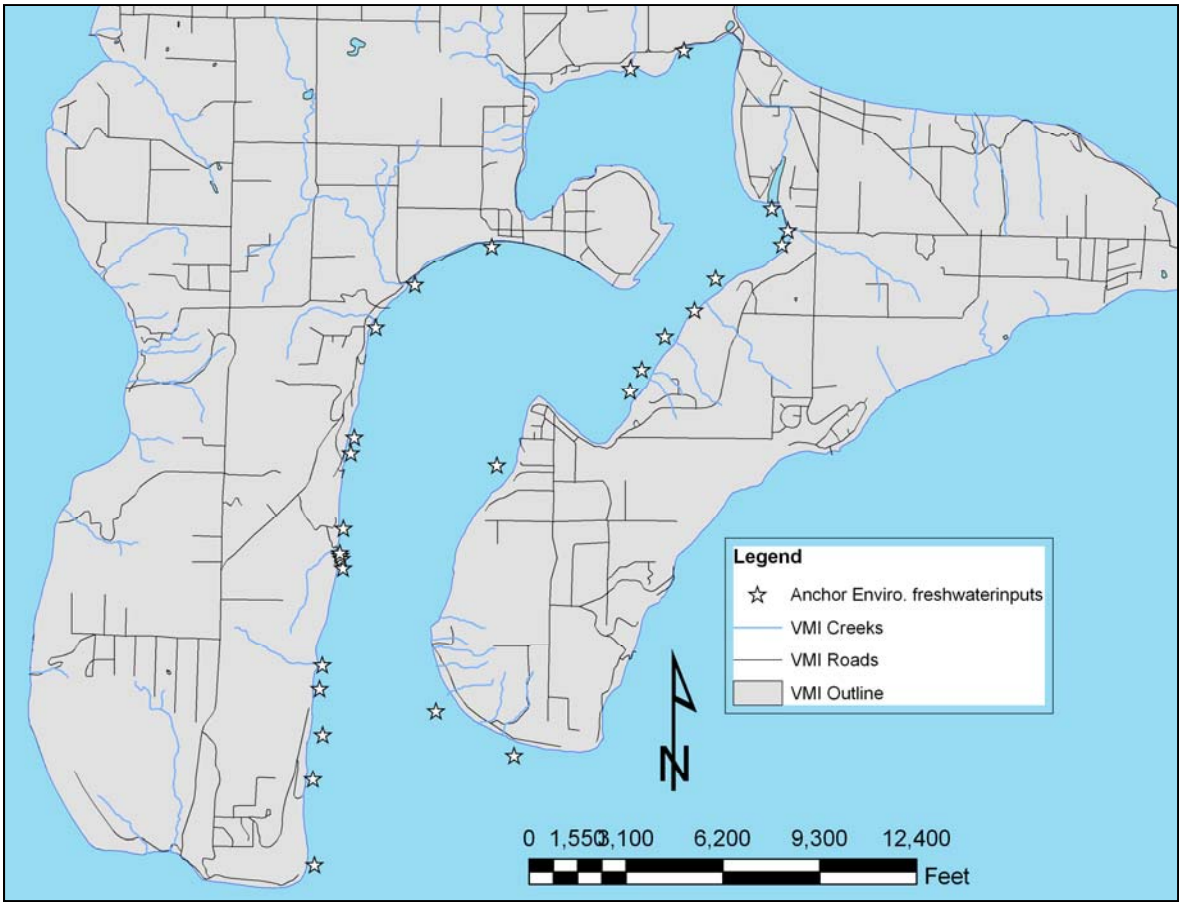

Figure 4. Freshwater Inputs into Quartermaster Harbor as part of the Marine Shoreline Inventory Report. This work was done by Anchor Environmental in 2003 and identified 28 freshwater inflows. Classification of the inflows was not done as part of this survey.

Thirty six freshwater inflows were identified by Coastal Geological Services (2005) within Quartermaster Harbor (Figure 5). Although assessments of flow were made by the field crew at many of the survey sites in WRIAs 8 and 9, no flow estimates were made for inflows to Quartermaster Harbor.

1.3.3 Washington State Department of Health Shellfish Data

The Washington State Department of Health (DOH) has an on-going nearshore sampling program evaluating the health of the shellfish beds. Quartermaster Harbor is sampled every other month at 22 sites (Figure 6). This sampling effort focuses on fecal contamination and does not have specific data on nitrogen concentrations in freshwater inflows. As part of this overall program, shoreline surveys are done periodically to identify pollution sources that may be impacting water quality. The most recent survey in the harbor was done in 2000. The data from DOH are the basis for the designation of the west side of Outer Quartermaster Harbor south of

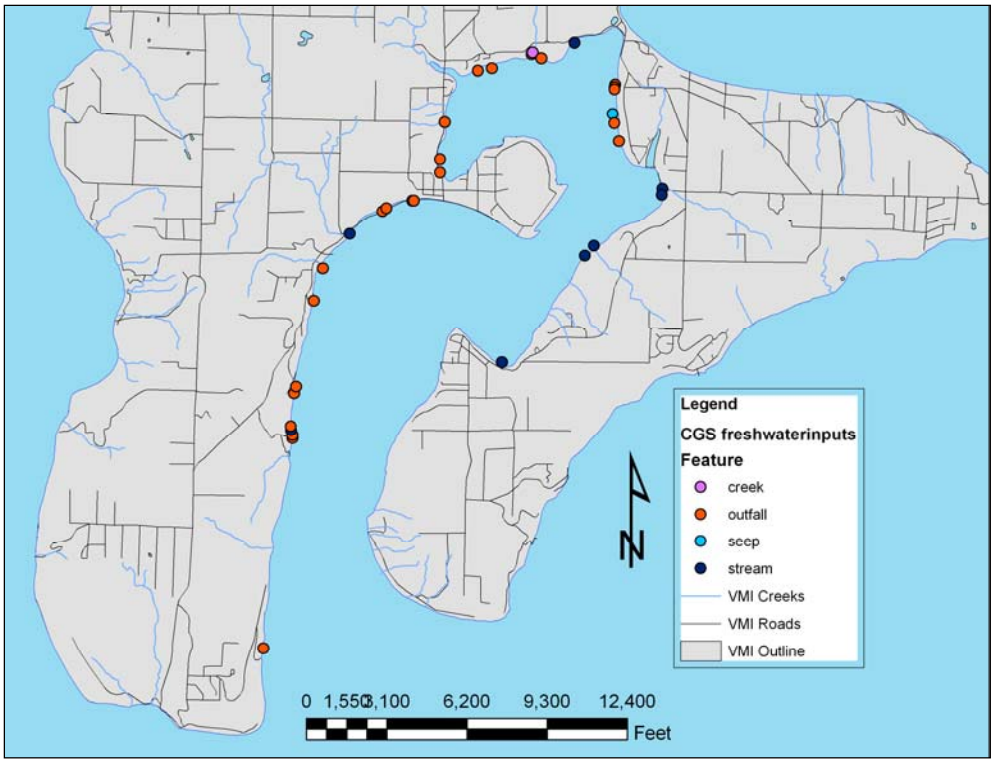

Figure 5. Freshwater inputs into Quartermaster Harbor as part of the Accretionary Shoreforms study. This work was done by Coastal Geologic Services in 2004 and identified 36 freshwater inflows.

the Burton peninsula as a Marine Recovery Areas (MRA) by the local health department, Public Heath – Seattle & King County (PHSKC) (Figure 6). These areas also contain numerous freshwater inflows (Figure 4 and Figure 5). The MRA designation requires property owners within the MRA to inspect, and repair or replace their On-Site Sewage (OSS) system if needed by July 1, 2012, then annually inspect OSS function after 2012.

1.3.4 King County Water Resources Evaluation

The Water Resource Evaluation (WRE) project, started in 2004, was designed to assess the status of the water resources on VMI. During this time, stream gauge activity was expanded from two sites to five for the continuous monitoring. Additional stream flow measurements have been done twice a year at another 20 sites for stage measurements (Figure 7). Stream water quality monitoring was added to the project in November 2006 and currently is being done monthly at four sites — Shinglemill, Fisher, Judd and Mileta Creeks (Figure 7).

Stream water quality data from these sites in Quartermaster Harbor have average concentrations of nitrate+nitrite around 1 mg/L. Elevated nitrate+nitrite concentrations of over 4 mg/L have been observed during winter months in Mileta Creek since November 2006 (Figure 8). The cause of the elevated winter nitrate concentrations in Mileta Creek is unknown and is the focus of another study planned as part of the overall Quartermaster Harbor Nitrogen Management Study (King County, 2010b).

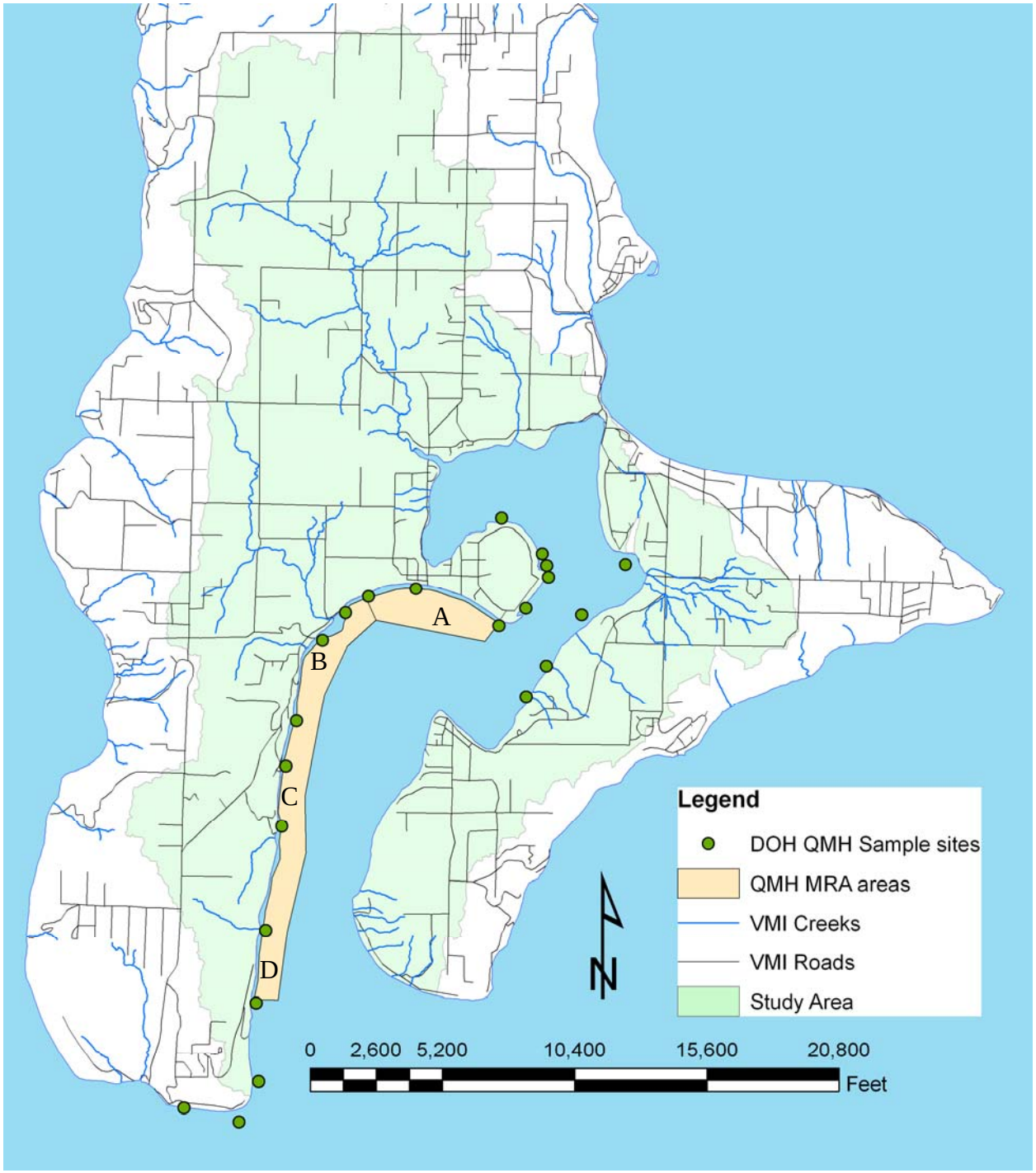

Figure 6. Washington State Department of Health sample sites within Quartermaster Harbor. These sample sites are in the marine water analyzing for bacteria (fecal coliform). The data from these sites help delimit area of concern. The Marine Recovery Areas were designated by Public Health – Seattle & King County in 2008 for four areas within Quartermaster Harbor. A — Governor's Lane, B — Shawnee-Magnolia Beach, C — Harbor Heights and D — Tahlequah-125th Pl. Ongoing activities within the marine recovery area is trying to reduce any impacts to the shellfish beds.

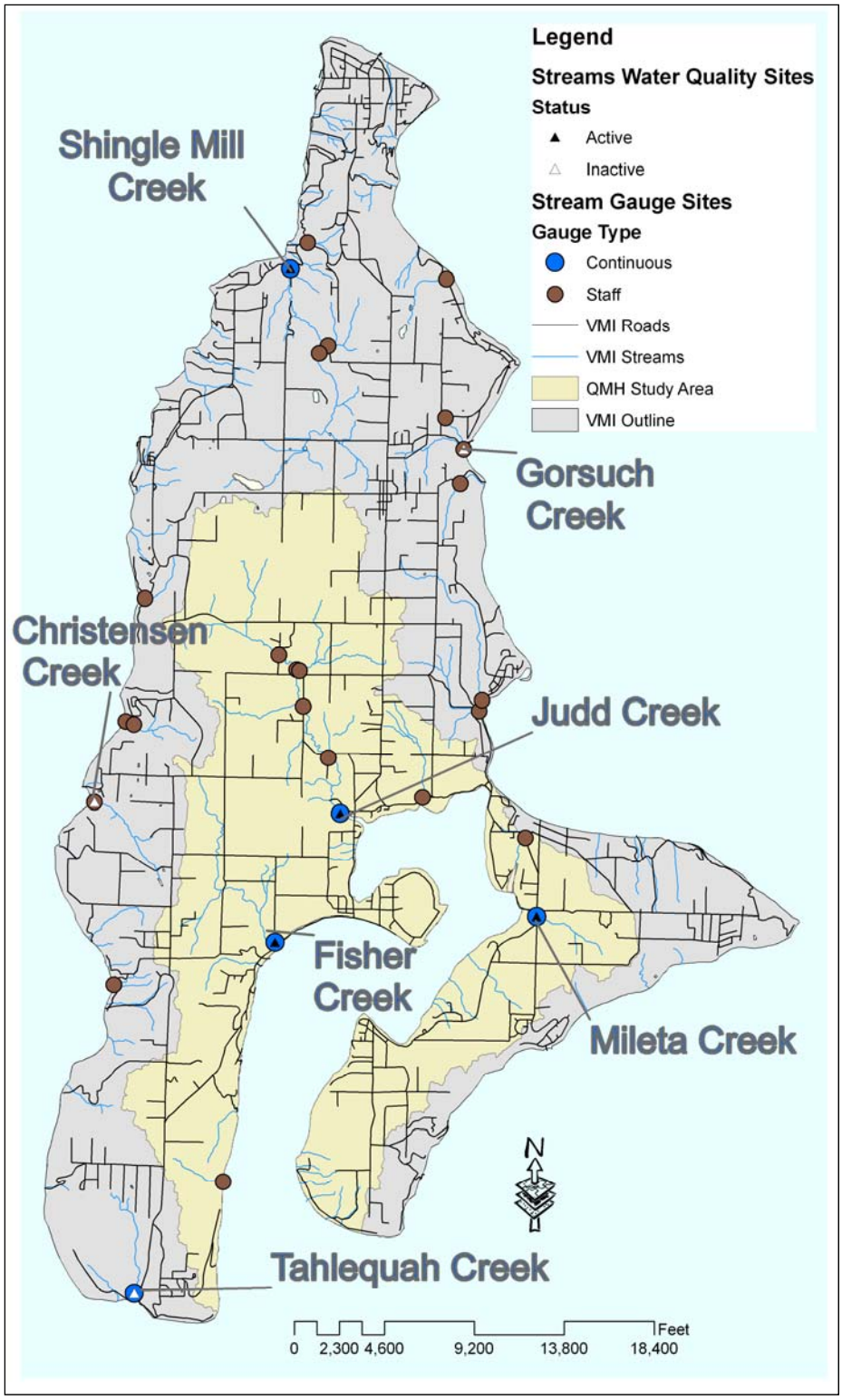

Figure 7. Map showing stream gauge and water quality sites on Vashon-Maury Island as of 2010. Colored circles represent stream gauge sites – blue are continuous; brown are stage measurements. Stream water quality sites are identified by name.

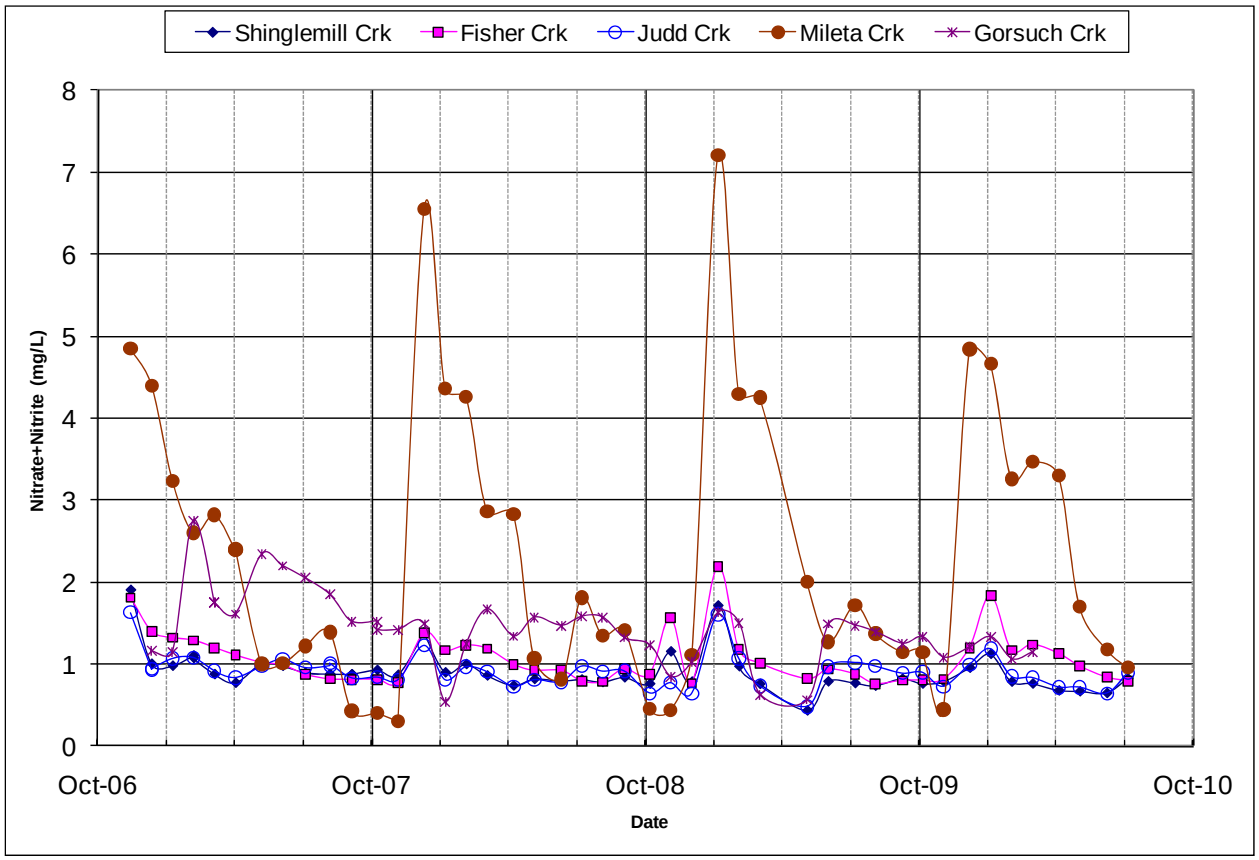

Figure 8. Nitrate + Nitrite water quality data from Vashon-Maury Island Creeks since November 2006 to July 2010. The sites sampled are Shingle Mill (VA12A), Fisher (VA41A), Judd (VA42A), Mileta (VA45A), and Gorsuch Creek (VA65A). Location of stream sampling sites can be seen in Figure 7.

2.0. STUDY GOAL AND OBJECTIVES

2.1 Study Goal

The purpose of this study is to measure nitrogen inputs from previously unmonitored surface water inputs to Quartermaster Harbor by measuring nitrate+nitrite, ammonia and total nitrogen and flow rate in tributary streams and outfalls to Quartermaster Harbor. Samples will be collected from identified nearshore areas where freshwater inputs flow into Quartermaster Harbor on Vashon-Maury Island. This information will be incorporated into the overall study identifying nitrogen loading sources and potential management strategies of those sources.

2.2 Project Management and Oversight

The overall Quartermaster Harbor Nitrogen Management Study is managed by King County and includes collaborators from the UWT, Ecology and the Groundwater Protection Committee. The Nearshore Freshwater Inflows Assessment Study will be managed and implemented by King County. This QAPP and products resulting from this study 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. STUDY DESIGN

Samples from surface water inputs along the nearshore will be collected in identified areas around Quartermaster Harbor during one day. Only one sampling event is planned. The data generated will be incorporated into the overall Quartermaster Harbor Nitrogen Management Study identifying nitrogen loading sources and potential management strategies of those sources.

The timing of this synoptic sampling event will be September/October 2010 near to or during low tide when freshwater inflows are most apparent. Sites will be assessed before the sampling event to ensure feasibility, site access, and location. Sampling will occur at the designated sites for three forms of nitrogen — nitrate+nitrite; ammonia and total nitrogen. In addition, the following field parameters will be measured during sample collection: specific conductance, dissolved oxygen, temperature and pH.

3.1 Site Assessment

Two studies have collectively identified up to 64 locations of freshwater inflows into Quartermaster Harbor (Figure 4 and Figure 5). Twelve locations are identified by both studies as a source for freshwater inflow. Between the two studies, there are 40 sites remaining. The purpose of the site assessment is to determine the feasibility of proposed location before collecting any samples. An estimated 21 areas will be included with the total number of samples not exceeding 40, including field replicates.

3.1.1 Site Location

Specific sampling locations will be determined based on site assessments and access from the nearshore. Initial assessments done using ArcGIS data layers have provided areas of interest. Preliminary assessment has yielded 21 areas of interest with the potential to collect from 37 specific locations within these areas (Table 1, and Figure 9). These areas were initially chosen based upon data from previous work by Anchor Environmental (2006, 2004) and Coastal Geologic Services (2005). Other un-monitored creek sites and mapped spring locations were also chosen as potential sampling areas and/or locations.

If the location is sampled, the site position will be located via differential global position system (dGPS). Pictures will be taken to record the location. An estimate of flow will be done at the time of sampling, if possible. Possible methods of flow estimation include recording the time of a floating item down a measured distance or a bucket with stop watch if flowing from an outfall pipe – and measuring the dimensions (wetted depth and width) of the pipe. Beach seeps will not be considered sampling locations for this study.

Table 1. Proposed sampling areas and locations for this study. Note proposed locations may change depending on site assessments.

Site Id	Area/Location	Samples^	Northing / Easting*	
1	Chen Creek Area	1	1229744.4	132198.1
2A-C	Lost Lake Creek Area	3	1230399.6	135313.7
3A-C	Harbor Heights Area	3	1230412.9	136584.0
4A-B	Wesleyan Way Area	2	1230331.2	136525.6
5	Magnolia Beach Area	1	1231147.8	141874.4
6	Shawnee Creek Area	1	1231504.6	143115.4
7A-B	115th Ave Area	2	1233812.7	145332.6
8	South of Burton	1	1234960.5	145750.2
9A-B	Inner Harbor Area	2	1236036.3	147345.3
10	228th St Area	1	1236211.6	148794.9
11A-B	99th Ln Area	2	1238036.7	150881.2
12A-B	Taugwalla Creek Area	2	1239587.8	151348.3
13	West Portage Area	1	1241226.3	151865.4
14A-B	South Portage Area	2	1242806.5	150261.4
15A-C	Kingsbury Rd Area	3	1242761.2	148765.4
16A-B	Mileta Creek Area	2	1244593.8	145972.3
17A-C	North Dockton Creek Area	3	1241976.9	143987.0
18	Middle Dockton Creek Area	1	1240688.2	142757.2
19A-B	South Dockton Creek Area	2	1239959.7	141696.1
20	Dockton Park Area	1	1238412.7	139480.4
21	262nd Pl Area	1	1235324.4	138623.5

^ = Potential number of samples for a given area of interest.

* = Coordinates are State Plane Zone: 5601 (Washington State Plane North; FIPS Zone 4601). Horizontal Datum HPGN with units in feet.

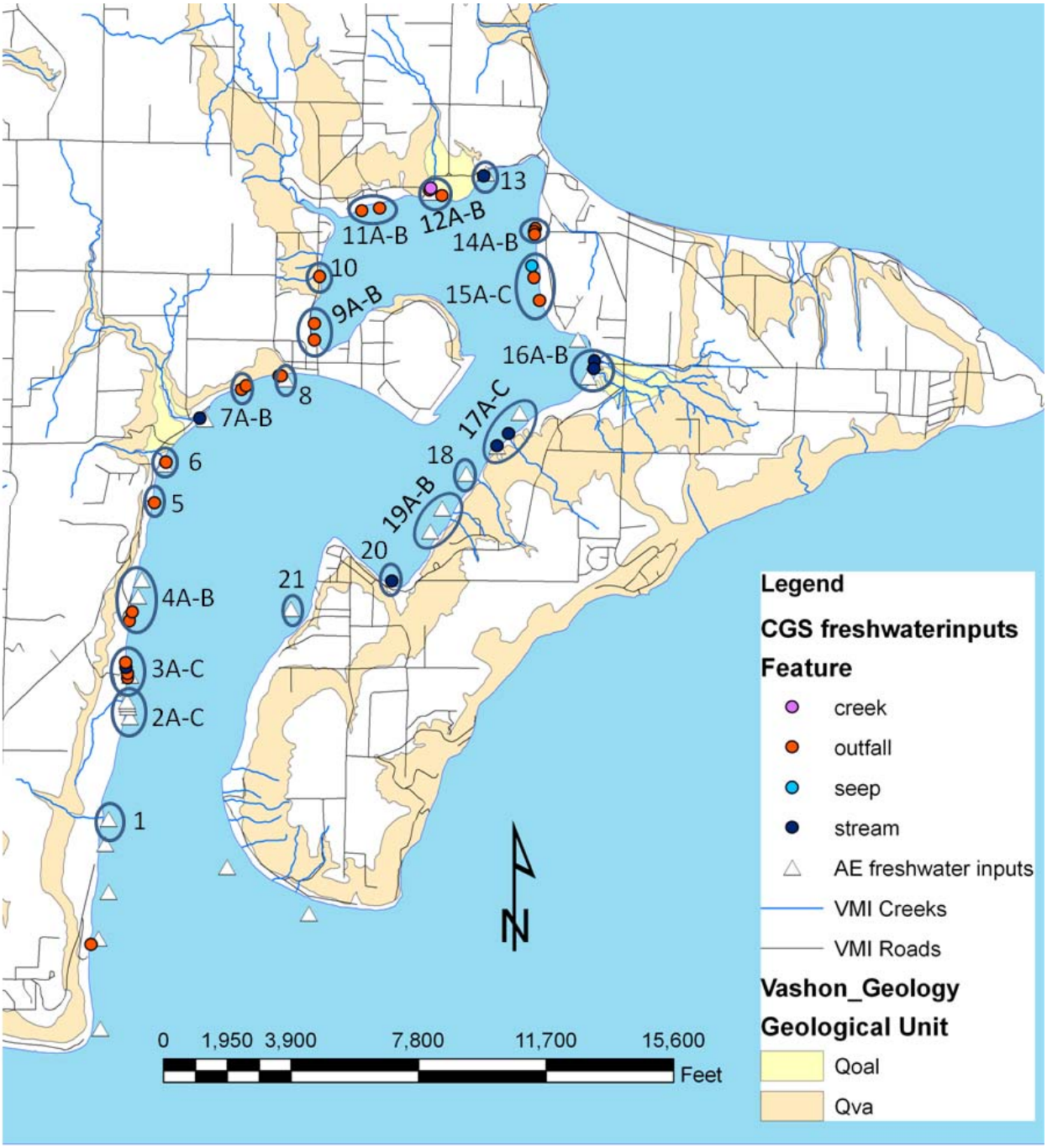

Figure 9. Proposed Sampling Areas and Sites of Freshwater Inflows into Quartermaster Harbor, Vashon-Maury Island. Circles designate the areas of interest. The letters represent the number of potential sampling locations within an area of interest. Preliminary assessment has 21 areas of interest with 37 sample sites. Total number of sampling locations will be finalized during the sampling event. The primary water-bearing geologic units are shown for reference.

4.0. QUALITY OBJECTIVES

There are two types of quality objectives that need to be identified: Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs). 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. DQOs are needed in projects where the results are compared to a standard or used to select between two alternative conditions.

4.1 Measurement Quality Objectives

The Measurement Quality Objectives for the field and lab measurements are presented in Table 2. Field crews and the King County Environmental Lab are responsible for adherence to objectives. King County will be responsible for verifying all MQOs are met.

4.2 Laboratory Data Quality Objectives

The data quality objectives (DQOs) of this study are to collect data of sufficient quantity and quality to meet the study goals. Statistical analysis of data collected for this study will be performed to evaluate whether a sufficient quantity of data has been collected to meet the study goals.

The study goals are to characterize flowing freshwater concentrations of various constituents at different sampling locations to evaluate any differences between sites. Statistical analysis of data that are "undetected"; i.e., laboratory analysis results reported as "<MDL", will use binomial calculations on the probability of a sample with a detectable concentration of the specific constituent and the probability of finding two and three samples in succession with detectable values at a given site or depth. Statistical analysis of data for those constituents that are detected regularly or occasionally will be accomplished through the use of medians and interquartile ranges.

4.2.1 Precision, Accuracy and Bias

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 evaluated by one or more of the following quality assurance/quality control (QA/QC) procedures (Table 2).

Table 2. Precision, accuracy and bias for analytical chemistry, field and laboratory

Measurement		Precision (RSD*)	Bias (% deviation from true value	Lowest Value/Range of Interest
pH	field	0.05 SU	N/A	1 to 14 SU
Temperature		0.01 °C	0.05 °C	0.1 °C
Dissolved Oxygen		10%	5%	0.1 mg/L
Specific Conductance		10%	5%	1 µS/cm
Ammonia Nitrogen	lab	20%	5%	0.02 mg/L
Nitrate + Nitrite Nitrogen		20%	5%	0.02 mg/L
Total Nitrogen		20%	5%	0.05 mg/L

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

- Collection and analysis of field replicate samples. Field replicate results should exhibit a relative percent difference less than 150% in order for the evaluation of the spatial and temporal chemical concentrations to be meaningful; and
- Analysis of various laboratory QC samples such as blanks, spikes and replicates.

4.2.2 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. Water samples will be collected from stations with predetermined coordinates to represent specific site conditions and compared to other locations.

4.2.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling at stations with known position coordinates in favorable conditions, 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%. If 100% completeness is not achieved, the project team will evaluate if the data quality objectives can still be met or if additional samples may need to be collected and analyzed.

4.2.4 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. By following the guidance of this QAPP, the goal of comparability between this study and other comparable studies conducted by King County will be achieved.

5.0. SAMPLING PROCEDURES

This section describes sample collection procedures that will be followed throughout the study to help ensure that project data quality objectives are met.

5.1 Sampling Methods

Grab samples will be collected by hand dipping. Sampling protocol is described in section 5.1.2 and King County Environmental Lab's "River and Stream Water Sampling" SOP #214v3.

5.1.1 Field Measurements

A set of field parameters — specific conductance, dissolved oxygen, temperature and pH — will be measured at the time of sample collection. Methods and detections limits for field measurements are presented in Section 6.1.

5.1.2 Sample Collection

Grab samples will be collected by King County WLRD staff with the assistance of King County Environmental Lab staff as necessary by hand dipping. Samples will be collected while facing toward the shoreline to minimize contamination from field equipment. Whenever possible, sample collection should be conducted while facing the prevailing winds.

The sample bottle, which will provide sufficient volume (for all requested lab analyses) will be filled by lowering the bottle, open and with the neck faced down, into the flowing freshwater to a depth of 1 to 3 inches. The bottle will be rotated, allowed to fill up just below the top shoulder of the bottle, and capped after it is removed from the freshwater flow.

After collection, capped samples will be placed in a sample cooler, to be kept chilled at 4°C until delivery to KCEL for analysis. The sample cooler must be kept as clean as possible to minimize the potential for cross-contamination. Bottle caps will be checked to ensure they are tight and will not become loose when inserted in the cooler. Frozen icepacks or ice will be placed into the sample cooler such that they are not in direct contact with sample containers. The laboratory will analyze samples for the constituents listed below in Table 3.

Table 3. Sample containers, preservation and holding times for samples.

Analysis	Container	Preservation	Holding Time*
Ammonia and Nitrate+Nitrite	250mL HDPE, CWM	Filter within 1 day and freeze within 2 days @ -20 ^{o}C	14 days @ -20 ^{o}C 2 days @ 4 ^{o}C
Total Nitrogen (collected together in the same bottle)	250mL HDPE, CWM	Digest within 2 days or freeze @ -20°C	28 days @-20 ^{o}C 2 days @ 4 ^{o}C

"*" = Holding time from collection to analysis

6.0. MEASUREMENT PROCEDURES

6.1 Field Measurements

During the sampling events, field parameters – pH, temperature, conductivity and dissolved oxygen– will be measured to assess field conditions at the time of sampling. All field parameters are measured with a multi-parameter probe (QED MP20 or similar probe). Calibration of field equipment will occur before any sampling event, as noted in section 7.1. The chamber of the probe will be filled with stream water collected at the time of sampling. The measurements for each of the field parameters will be recorded on the field sheet. The methods and detections limits for the field measurements are presented in Table 4.

The site position will be located via differential global position system (dGPS). Pictures will be taken to record the location. An estimate of flow will be done at the time of sampling, if possible. Flow estimation will be done by recording the time a ping pong ball takes to float a measured distance (three or five feet). This measurement will be done three time with each result recorded.

6.2 Laboratory Measurements

The freshwater near-shore sampling sites will be analyzed for the following water quality parameters: ammonia nitrogen, nitrate+nitrite nitrogen, and total nitrogen. The methods and detections limits for these parameters are presented in Table 4.

Table 4. Water Quality Parameters: Method and detection limits for surface water sites.

Parameters		Method	Detection Limit
Dissolved Oxygen	**Field**	EPA 360.2	0.5 mg/L
Temperature		EPA 170.1	0.1 deg C
Specific Conductance		EPA 120.1	0.1 mhos/cm
pH		EPA 150.1	0.1
Ammonia Nitrogen	**Laboratory**	Kerouel & Aminot, 1997	0.005 mg/L
Nitrite + Nitrate Nitrogen		SM 4500–NO3-F	0.01 mg/L
Total Nitrogen		SM 4500–N-C	0.05 mg/L

7.0. QUALITY ASSURANCE AND CONTROL

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

7.1 Field Measurement QC Procedures

Field QC includes proper documentation of field activities and sampling/handling procedures, as described in Sections 6.1.

7.1.1 Field QC Samples

Field QC samples will consist of the following:

- One replicate per 10 samples, to be analyzed for the entire suite of laboratory analyses.

7.1.2 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. All field monitoring equipment will be calibrated consistent with manufacturers' procedures using instrument calibration standards prepared according to the manufacture's specifications.

7.2 Lab QC requirements

In general and at minimum, laboratory QC will consist of the following:

- One matrix spike (MS) per 20 samples
- One method blank per 20 samples or 1 per batch, whichever is more frequent
- One lab duplicate (LD) per 20 samples

Method-specific QA/QC samples may include the following, and are as follows:

- Method blanks. A method blank is an aliquot of a clean reference matrix, such as deionized, distilled water for water samples, which is processed through the entire analytical procedure. Method blank results are used to evaluate the levels of contamination that might be associated with the processing and analysis of samples. Method blank results should be "less than the MDL" for all target analytes.
- Matrix spike samples. A matrix spike (MS) is a known concentration of one or more target analytes, introduced into a second aliquot from one analytical sample. The spiked sample is processed through the entire analytical procedure. Analysis of the MS is used as an indicator of sample matrix effect on the recovery of target analytes. Control limits are based on the percent recovery of the spiked compounds.

- Lab duplicate samples. A lab duplicate (LD) is a second aliquot removed from one analytical sample, processed through the entire analytical procedure as a separate sample. The RPD between the original sample and the LD is used as an indicator of method precision and sample homogeneity.
- Spiked blank samples. A spiked blank (SB) is an aliquot of clean reference matrix, such as deionized distilled water for water samples, to which a known concentration of one or more target analytes has been added. The spiked aliquot is processed through the entire analytical procedure. SB analysis is used as an indicator of method performance and can be used in conjunction with matrix spike results as an indicator of sample matrix effects. Control limits are based on the percent recovery of the spiked compounds.
- Laboratory control samples. A laboratory control sample (LCS) is a sample of known analyte concentration(s) that is prepared in the lab from a separate source of analyte(s) relative to the calibration standards. Since the LCS analysis should follow the entire analytical process, it should be stored and prepared following the same procedures as a field sample. Analysis of a LCS is used as an indicator of method accuracy and long-term analytical precision.
- Performance evaluation samples. KCEL participates twice annually in the WP Performance Evaluation programs. PE samples are single-blind samples supplied to the lab through vendors approved by the Washington DOE Lab Accreditation Program.

QC sample results that exceed control limits will be evaluated to determine appropriate corrective actions. Samples will typically be reanalyzed if unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by a particular sample or matrix will not require reanalysis unless an allowed method modification would improve the results. Analytical results that are outside of QC control limits for some QC sample types will be qualified and flagged according to procedures outlined in Section 7.2.2.

7.2.1 Conventionals QC Parameters

Laboratory QC samples for conventionals analyses and associated control limits are summarized in Table 5. These QC samples will be analyzed at a frequency of one per analytical batch of 20 or fewer samples.

7.2.2 Laboratory Data Review and Analysis

Data evaluation will include checking holding times, method blank results, field and laboratory duplicate results, completeness, detection limits, laboratory control sample results and COC forms. After the data has been checked, it may be entered into a project database with any assigned data qualifiers. Data evaluation is critical for evaluating how well analytical data meet project DQOs, and is performed, at some level, during several steps in the process of sample collection and analysis.

Table 5. Laboratory QC Requirements

Analysis	Method Blank	Duplicate RPD (%)	Positive Control % Recovery	Matrix Spike % Recovery
Ammonia Nitrogen	<MDL	20	85-115	75-125

Nitrate+Nitrite Nitrogen	<MDL	20	85-115	75-125
Total Nitrogen	<MDL	20	85-115	75-125

RPD = Relative Percent Difference

All analytical data are entered into KCEL's Laboratory Information Management System (LIMS). LIMS may perform additional calculations such as conversion of concentrations measured directly by laboratory instrumentation to final sample results. Automatic calculation of QC results is also performed within LIMS, as well as comparison to acceptance limits.

Laboratory analytical data are reviewed first by the primary analyst and then by a senior peer reviewer prior to entry of the data into LIMS. Analytical data are reviewed for completeness and QC sample data are viewed for compliance with project and method QA/QC requirements. If there are any QC failures at this point, corrective action may be taken or qualifier flags applied to the data.

A laboratory project manager (LPM) will provide the next data review step, at a project level. The LPM will verify the completeness of an entire data set (multiple parameters for a particular sampling event) and report any QC failures or anomalies. An internal King County project data validator may provide a final review of the data to ensure they meet the project DQOs. Data may then be reported in a variety of formats, depending on project needs.

All laboratory analytical data are maintained in *perpetuity* on LIMS. Data may be viewed on-line in LIMS by King County personnel only. Project data may also be downloaded from LIMS into a hard copy format using Microsoft Excel©. Analytical data will be reported on a routine basis in Excel© format along with an accompanying QA/QC review narrative.

Laboratory analytical data may be stored with data qualifier flags indicating QC failures. The flag "B" is used to indicate possible laboratory contamination of a sample and is applied when the parameter of interest is also detected in the laboratory method blank. Sample results that are less than five times the concentration detected in the method blank will be qualified with a "B" flag. Sample results between five and ten times the concentration detected in the method blank will be qualified with a "B3" flag. The flag "SH" is used to indicate a sample handling condition that did not meet method requirements. Handling conditions may include an improper sample container, improper preservation of the sample. The "H" flag will be applied when there is an exceedance of the method-specific holding time. The flag "J" may be applied to sample data at the discretion of the laboratory analyst, data reviewer, or data analyst, should control limits on one or more QC samples not be met. The flag "J" indicates that sample numerical result should be viewed as *estimated*.

Analytical results from field blanks and field replicates will be reviewed to evaluate their impact on the quality and usability of sample analytical data. Results from field QC samples will not be used to flag sample analytical data but will be taken into consideration during final data review and analysis.

8.0. 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 one of several King County databases in a timely manner, generally within one week of collection. King County laboratory and field data will be stored in the King County Laboratory Information Management System.

The Project Manager will provide supervision of all data acquisition and management activities. The Data Management Section will maintain the project database and load data. Project staff will enter all other data manually or download from electronic field sheet.

9.0. AUDITS AND REPORTS

A quality assurance assessment will be conducted prior to using the data for analysis, and the results will be included in the final report for this project.

10.0.DATA VALIDATION

Data validation is critical in the evaluation of how well instrument data meet project DQOs. During data processing, data will be critically reviewed by a qualified reviewer to identify suspect data. Results that are suspect will be evaluated to determine appropriate corrective actions. Issues identified and any corrective action will be documented in reports associated with the use of these data in Quartermaster Harbor Nitrogen Management Study work products.

11.0.DATA ANALYSIS AND USE

Data will be analyzed using standard filtering and averaging techniques as appropriate to understand relationships between nitrogen concentrations and location of the sampling sites. The usability of the data will be confirmed by comparing this data to other freshwater/stream quality data collected by King County.

11.1 Reconciliation with User Requirements

Reports generated for this study will include identification of any data limitations determined through application of the Data Quality Objectives described in this project plan. This information will be communicated initially through annual project reports and will be mirrored in subsequent project reports that rely on data with known limitations, including, but not limited to, modeling reports and reports containing recommendations to decision makers who update the King County Comprehensive Plan.

12.0.ORGANIZATION AND SCHEDULE

12.1 Project Staff list and roles

The project involves staff from King County Departments of Natural Resources and Parks (DNRP, including the King County Environmental Lab, KCEL) in collaboration with the UWT Environmental Science program, Washington Dept. of Ecology's Marine Monitoring Unit and the Vashon-Maury Island Groundwater Protection Committee. Detailed roles and responsibilities are:

Core Project Team:

Curtis DeGasperi–King County DNRP - Project Manager - responsible for: (1) supervising project implementation; (2) coordinating and tracking work, budgets and personnel; (3) preparing and presenting presentations and written reports; and team member for all surface water activities. Curtis will also assist with the selection and development of watershed and QMH water quality models.

Eric Ferguson–King County DNRP–Core Team Member–Lead team member for all groundwater related activities; developing and implementing project database and assist project manager as directed in all facets of project implementation. Conduct groundwater and surface water monitoring field work and deliver samples to KCEL for laboratory analysis.

Kimberle Stark–King County DNRP–Core Team Member - Lead team member for all marine water related activities.

Laurence Stockton–King County DNRP–Core Team Member–Lead team member in the development of policy and management recommendations and public outreach and communication activities.

Extended Project Team:

King County Environmental Laboratory (KCEL)–Deploy and maintain King County marine moorings and associated meteorological stations and conduct King County monthly marine ambient monitoring at QMH sub-tidal and inter-tidal stations.

King County DNRP Hydrologic Monitoring Support–Maintain stream gauges and continuous temperature monitoring equipment as well as land-based precipitation and meteorological observation stations on VMI.

Cooperators:

Dr. Cheryl Greengrove–University of Washington -Tacoma–Dr. Greengrove and her staff and students will provide oceanographic instrumentation and scientific expertise: conduct marine sampling activities in QMH to augment existing data sets and fill data gaps for nutrients and dissolved oxygen for model ground truthing and assist in presenting results at scientific meetings, in reports and papers.

Skip Albertson - Washington Department of Ecology (Ecology) - Ecology staff will assist with model selection and develop model selected to simulate the hydrodynamics of QMH. Skip will also collaborate on the coupling of the modeled hydrodynamics into the model selected and

developed to simulate the effects of N-loadings on dissolved oxygen within QMH in current and BMP scenario conditions.

Vashon-Maury Island Groundwater Protection Committee (GWPC)–Committee members will facilitate public outreach on VMI, assist in developing Best Management Practices and policy recommendations.

12.2 Major Activities and Timelines

The major activities for this study are outlined below and the timelines are presented in Table 6.

This special study will begin to assess sites in early summer 2010. This assessment includes determining the site usability for ease of access, ability to take a sample and location within the study area.

Sample collection will occur in the fall during a low tide event. An assessment of data will be done after the sampling event and report-writing will began in 2011. This information will be incorporated into the overall study identifying nitrogen loading sources and potential management strategies of those sources.

Table 6. Timeline for the QMH Nearshore Fresh Water Inflows study activities.

Phase1 activities	Timeline	Organization	Description
Quartermaster Harbor Nearshore Freshwater Assessment QAPP	Summer 2010	King County - Lead	Write a Sampling and Analysis plan for this special study
Phase 2 activities	**Timeline**	**Organization**	**Description**
Site Selection	Summer 2010	King County	Assess and select appropriate locations for this study
Data collection	Fall 2010	King County	Sample nearshore freshwater study sites
Phase 3 activities	**Timeline**	**Organization**	**Description**
QMH Nearshore Freshwater Assessment study report	2011	King County	Write report on the findings of this special study as a part of the QMH Nitrogen management study

13.0. REFERENCES

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