DEPARTMENT OF
ECOLOGY
State of Washington

Quality Assurance Project Plan

You & I Market, Pacific Beach
Groundwater Performance Monitoring

May 2016

Publication No. 16-03-107

Publication Information

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

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1603107.html

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID: FS86125878

Ecology's Activity Tracker Code for this study is 16-006.

Author and Contact Information

Pamela B. Marti, LHg
P.O. Box 47600
Environmental Assessment Program
Washington State Department of Ecology
Olympia, WA 98504-7710

This plan was prepared by a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

Communications Consultant: phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Lacey 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Lacey 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Quality Assurance Project Plan

You & I Market, Pacific Beach
Groundwater Performance Monitoring

May 2016

Approved by:

Signature:	Date: April 2016
Aaren Fiedler, Client, TCP, Southwest Regional Office Signature:	Date: May 2016
Rebecca Lawson, Client's Section Manager, TCP, Southwest Regional Office Signature:	Date: April 2016
Pam Marti, Author / Project Manager, EAP Signature:	Date: April 2016
Martha Maggi, Author's Unit Supervisor, EAP Signature:	Date: April 2016
Jessica Archer, Author's Section Manager, EAP Signature:	Date: April 2016
Dale Norton, Section Manager for Project Study Area, EAP Signature:	Date: April 2016
Joel Bird, Director, Manchester Environmental Laboratory Signature:	Date: April 2016
Bill Kammin, Ecology Quality Assurance Officer	

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
TCP: Toxics Cleanup Program

1.0 Title Page and Table of Contents

Table of Contents

List of Figures and Tables

Figures

Tables

2.0 Abstract

The You & I Market is a gasoline station and convenience store located in the town of Pacific Beach, Washington. In 1997, during excavation of a nearby utility vault, workers noted a strong petroleum odor in the soils. Subsequent investigations at the site documented weathered gasoline and diesel contamination exceeding Model Toxics Control Act (MTCA) Method A soil cleanup levels beneath and around the store's pump islands. Final site characterization and initial cleanup activities began in 2011. To treat the site's contaminated soils and groundwater, chemical and biological oxidants and biological nutrients were injected into the subsurface in September 2011. Following the injection, the groundwater was monitored from September 2011 to February 2013. Groundwater samples showed that while diesel contamination was reduced, the gasoline contamination increased in the groundwater. As of the last sampling in February 2013, benzene and TPH-G concentrations still exceeded the MTCA cleanup levels for groundwater.

The goal of this project is to collect groundwater quality data from the shallow aquifer underlying the You & I Market to assess the current petroleum contaminant concentrations. The information will assist the Washington State Department of Ecology's Toxics Cleanup Program in determining if further remedial work is needed at the site.

3.0 Background

The You & I Market is a gasoline station and convenience store located at 51 Main Street in the town of Pacific Beach, Washington (Figure 1). In 1997, during excavation of a utility vault near the market, workers noted a strong petroleum odor in the soils. Two follow-up field investigations were conducted (AEA, 1998 and NWT, 2000). Both investigations documented weathered gasoline and diesel contamination exceeding their respective Model Toxics Control Act (MTCA) Method A soil cleanup levels beneath and around the market's pump islands.

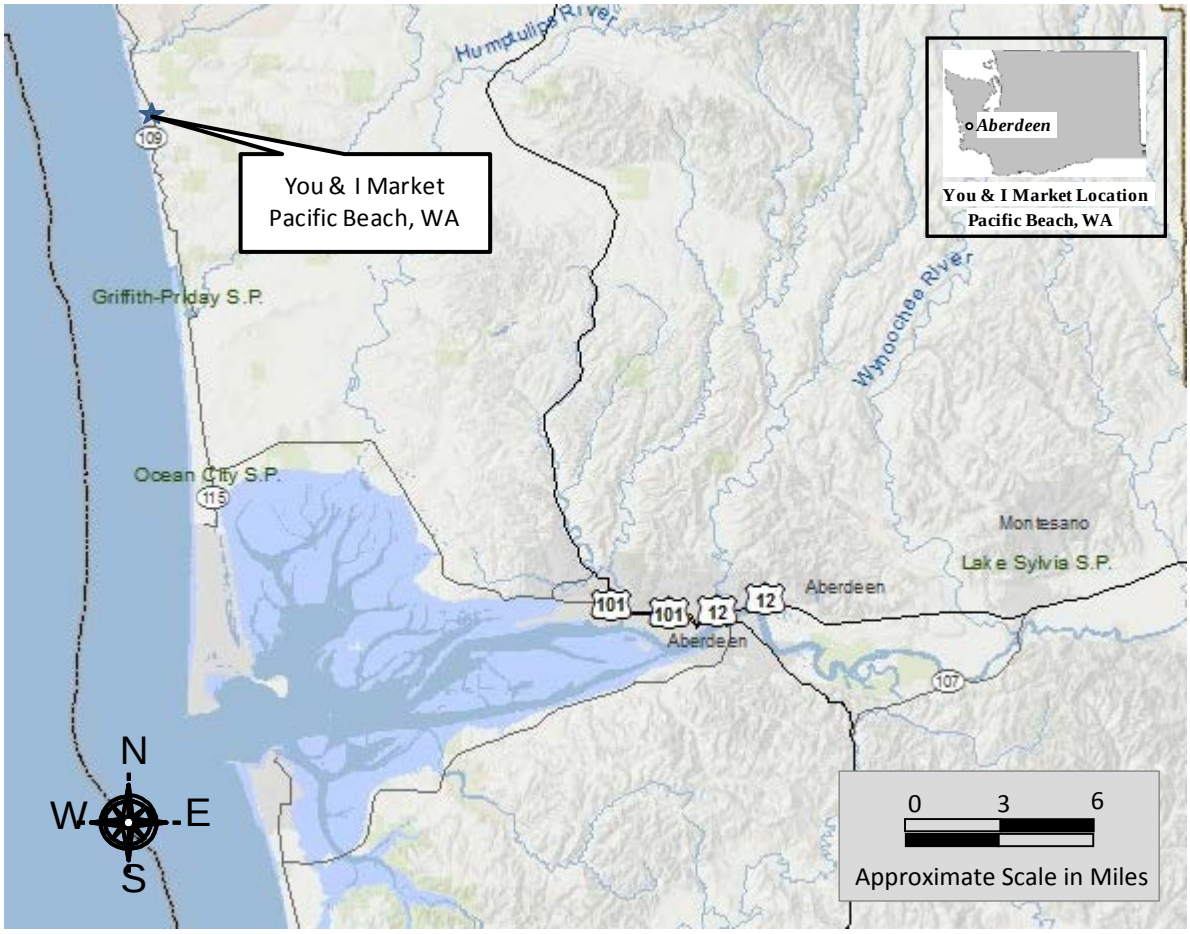

Figure 1. You & I Market site, vicinity map.

Site cleanup was initiated in 2011 and included the injection of chemical and biological oxidants and biological nutrients into the subsurface to treat the site's contaminated soils and groundwater. Following the injection, groundwater beneath the site was monitored periodically from September 2011 to February 2013. Groundwater samples showed that while diesel contamination was greatly reduced, the gasoline contamination increased in the groundwater (Hart Crowser, 2013).

It has been over four years since the interim remedial action. Ecology's Toxics Cleanup Program (TCP) has requested the Environmental Assessment Program (EAP) to collect groundwater quality

data from the aquifer beneath the You & I Market to assess current petroleum contaminant concentrations. The information will help inform TCP if further remedial work is needed at the site.

3.1 Study area and surroundings

The You & I Market is located on Washington's north coast in the town of Pacific Beach, Grays Harbor County. The site sits on a small bluff approximately 600 feet west of the Pacific Ocean and 40 feet above mean sea level.

Pacific Beach is located in the Water Resource Inventory Areas (WRIA) 21 – Queets-Quinault. WRIA 21 covers the southwest portion of the Olympic Peninsula, from the Olympic Mountains to the Pacific Ocean. Major rivers in the WRIA include the Queets, Quinault, Moclips, and Copalis, along with many additional tributary creeks and streams. The You & I Market is located within the southern portion of the watershed. Joe Creek, to the south of Pacific Beach and the site, is the closest waterbody.

Annual precipitation in the Queets-Quinault Watershed ranges from 100 inches along the coastal lowlands to 180 inches per year in the Olympic Mountains. Most precipitation arrives during the winter months. During the summer there is little rain, and naturally low stream flows are dependent on groundwater inflow. (Ecology, 2012)

The You & I Market site consists of a 0.29 acre parcel in the town of Pacific Beach. Main Street borders the property to the north, Second Street provides the eastern boundary for the property, and an alley provides the southern boundary of the property (Figure 2).

Geology of the site was defined during the 2011 investigation (Hart Crowser, 2011). Silty, sandy gravel to a gravely, sandy silt fill forms the uppermost unit beneath the site. The fill unit varies in thickness from 0.5 to 4 feet. The unconsolidated deposits beneath the fill vary across the site but in general consist of units of clayey silt, sandy silt, silty sands, and an organic silt unit. The thickness of each unit varies across the site.

Groundwater was encountered at depths ranging from 1 to 6 feet below ground surface during the push-probe explorations in 2011. This shallow groundwater was interpreted as perched water (Hart Crowser, 2011). Over the monitoring period from 2011 to 2013, depth to groundwater in the monitoring wells ranged from about 1 to 9 feet with a seasonal fluctuation of 4 to 7 feet. Groundwater was mapped as flowing southeast towards Joe Creek, which is consistent with site topography and the orientation of the petroleum hydrocarbon plume.

3.1.1 Logistical problems

The site is an operating gas station and convenience store. The property owner will be contacted prior to sampling. The two monitoring wells located near the pump island will be sampled during non-peak business hours.

Any circumstance that interferes with data collection and quality will be noted and discussed in the final report.

3.1.2 History of study area

The You & I Market, formerly known as Joe's Market, is located at 51 Main Street in the town of Pacific Beach, Washington (Figure 2). The site has been identified by Ecology's Toxics Cleanup Program as an active Leaking Underground Storage Tank (LUST) site. The Site name is listed as *You & I Market* with an Ecology Facility Site ID 86125878 and a Cleanup Site ID 7139. Its status is listed as Cleanup Started.

The site is currently used as a gasoline station and convenience store. In 1995, three underground storage tanks (USTs) that had contained leaded gasoline, unleaded gasoline, and diesel fuel were removed. At the time of the removal two new USTs were installed for unleaded regular gasoline and premium unleaded/diesel fuel.

In 1997, during excavation of a nearby utility vault, workers noted a strong petroleum odor in the soils. This excavation was approximately 100 feet southeast of the site. Two follow-up field investigations were conducted (AEA, 1998 and NWT, 2000). Both investigations documented weathered gasoline and diesel contamination exceeding MTCA Method A soil cleanup levels beneath and around the pump islands. The petroleum contamination was observed to extend over 100 feet southeast of the pump island at depths of 4 to 9 feet below ground surface. Petroleum contamination was also encountered south of the USTs. The downgradient extent of the petroleum contamination off the site was not defined by these studies.

In 2009, the property owner hired Environmental Services Network to advance six borings to analyze soil and groundwater quality. Although there was no formal report, laboratory results confirmed the presence of gasoline-range hydrocarbons exceeding MTCA cleanup levels in the soil and groundwater southeast of the pump island.

In 2010, during a heavy rainfall, fuel was reported to have bubbled up from the east side of the pump islands' concrete pad. The fuel flowed into a storm drain a few hundred yards away from the subject site. The storm drain emptied into Joe Creek, which flows into the Pacific Ocean.

In February and March of 2011, an investigation was conducted to better define the extent of the contamination; at this time a network of six shallow monitoring wells was installed. Petroleum contamination was identified up to 120 feet southeast (downgradient) of the pump island. In September 2011, chemical and biological oxidants and biological nutrients were injected to a depth of approximately 8 feet at 70 locations at the site, to treat both the source area soil and the downgradient soil and groundwater contamination. Following the injection, the groundwater was monitored periodically from September 2011 to February 2013. Groundwater samples showed that while diesel contamination was greatly reduced, the gasoline contamination increased in the groundwater (Hart Crowser, 2013). As of the last sampling in February 2013, benzene and TPH-G concentrations still exceeded the MTCA cleanup levels for groundwater.

3.1.3 Parameters of interest

The You & I Market is an active Leaking Underground Storage Tank (LUST) site. The parameters of interest are total petroleum hydrocarbons as gasoline (TPH-G) and diesel (TPH-D); and gasoline compounds: benzene, toluene, ethylbenzene and xylene (BTEX).

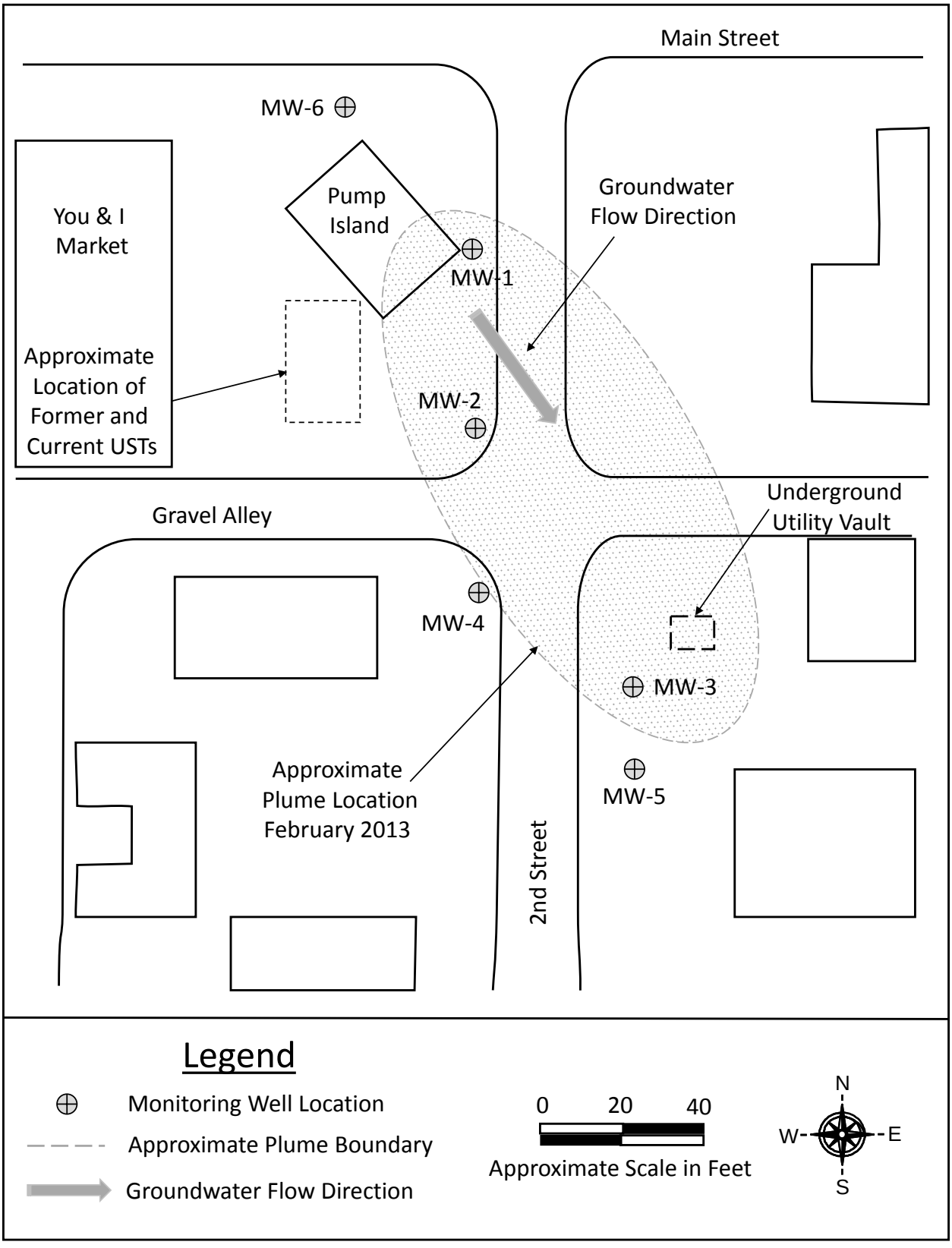

Figure 2. Project study area and sample locations.

3.1.4 Results of previous studies

Several studies have been conducted on this site since it was discovered in 1997. Monitoring wells were installed in March 2011 as part of the effort to better define the extent of the plume and to monitor groundwater quality following cleanup activities. Table 1 is a summary of groundwater petroleum results between March 2011 and February 2013.

Table 1. You & I Market groundwater sample results, March 2011 to February 2013.

Well ID	Sample Date	Well Depth in Feet (TOC)	Depth to Water in Feet (below TOC)	MTCA Method A Cleanup Levels					
				5 ug/L	1000 ug/L	700 ug/L	1000 ug/L	800/1000 ug/L[a]	500 ug/L
				Benzene	Toluene	Ethyl Benzene	Total Xylene	TPH-G	TPH-D
MW-1	3/11	10.0	3.02	**33**	**98**	**1400**	**5220**	**47,200**	**6840**
	9/11		6.17	**28**	**95**	**1250**	**4460**	**23,330**	**2750**
	9/12		8.54	**148**	**125**	**915**	**2780**	**74,000**	<200
	12/12		4.15	**331**	**407**	**6580**	**14,300**	**74,400**	<200
	2/13		2.43	**35**	**38**	**1130**	**3290**	**105,000**	<200
MW-2	3/11	10.0	2.49	**137**	**100**	**256**	**803**	**8360**	**1910**
	9/11		5.71	**214**	**19**	**43**	**128**	**4200**	**1230**
	9/12		8.00	**502**	**152**	**477**	**485**	**20,900**	<200
	12/12		3.60	**243**	**95**	**373**	**267**	**13,500**	<200
	2/13		3.00	**87**	**13**	**262**	**45**	**22,500**	<200
MW-3	3/11	10.0	1.37	<0.25	<1	<0.5	<1.5	**145**	<236
	9/11		4.26	<0.2	<0.5	0.66	1.44	**120**	<120
	9/12		6.50	<1	<2	<1	<3	<100	<200
	12/12		2.10	<1	**2.5**	<1	<3	**849**	<200
	2/13		1.60	<1	<2	<1	<3	**890**	<200
MW-4	3/11	10.0	1.43	<0.25	<1	<0.5	<1.5	<100	<236
	9/11		4.66	<0.2	<0.5	<0.5	<1	<80	<100
	9/12		7.02	<1	<2	<1	<3	<100	<200
	12/12		2.40	<1	<2	<1	<3	<100	<200
	2/13		1.80	<1	<2	<1	<3	<100	<200
MW-5	3/11	10.0	1.48	<0.25	<1	<0.5	<1.5	<100	<245
	9/11		4.55	<0.2	<0.5	<0.5	<1	<80	<98
	9/12		6.75	<1	<2	<1	<3	<100	<200
	12/12		2.60	<1	<2	<1	<3	<100	<200
	2/13		1.85	<1	<2	<1	<3	<100	<200
MW-6	3/11	10.0	0.15	<0.25	<1	<0.5	<1.5	<100	<236
	9/11		4.67	<0.2	<0.5	<0.5	<1	<80	<98
	9/12		7.30	<1	<2	<1	<3	<100	<200
	12/12		1.01	<1	<2	<1	<3	<100	<200
	2/13		0.28	<1	<2	<1	<3	<100	<200

TOC: Top of Casing
MTCA: MTCA Method A Cleanup Level
a: MTCA Method A Cleanup Level for Gasoline is 800 ug/L if benzene is present in groundwater and 1000 ug/L if benzene is not detectable in groundwater.
Bold: Analyte was detected.
Shade: Values are greater than the MTCA cleanup levels.

3.1.5 Regulatory criteria or standards

This site is regulated under Washington's Model Toxics Control Act (MTCA) - WAC 173-340. The cleanup criteria established for this site are:

Table 2. MTCA Method A cleanup levels for groundwater.

Parameters of Interest	MTCA Method A Cleanup Level	Units
Benzene	5	ug/L
Toluene	1000	ug/L
Ethylbenzene	700	ug/L
Total Xylene	1000	ug/L
TPH – gasoline	800-1000*	ug/L
TPH - diesel	500	ug/L

* MTCA Method A Cleanup Level for Gasoline is 800 ug/L if benzene is present in groundwater and 1000 ug/L if benzene is not detectable in groundwater.

4.0 Project Description

Ecology's Toxics Cleanup Program (TCP) requested EAP to collect groundwater quality data from the You & I Market. It has been over four years since the interim remedial action. At the time of the last groundwater monitoring in February 2013, contaminant concentrations still exceeded MTCA cleanup levels. Current groundwater data is needed to assess the present-day petroleum contaminant concentrations. This information will assist TCP in determining if further remedial work is needed at the site.

4.1 Project goals

The project goals are:

- Procure groundwater quality data for petroleum constituents that are representative of current site groundwater conditions.

4.2 Project objectives

The project objective is:

- Collect groundwater samples in the spring of 2016 for petroleum constituents from the 6 site monitoring wells (Figure 2).

4.3 Information needed and sources

Groundwater petroleum constituent data for this project are available from March 2011 to February 2013 as shown in Table 1. Data from this project are needed to assess the current petroleum contaminant concentrations and will be compared to the historical data.

4.4 Target population

The target population is the shallow groundwater at the You & I Market site.

4.5 Study boundaries

The study boundaries are shown in Figure 2.

The site is located in:

- Water Resource Inventory Area (WRIA): 21
- Hydrologic Unit Code (HUC): 17100102.

4.6 Tasks required

- Measure water levels in the 6 monitoring wells in the spring of 2016.
- Sample the 6 monitoring wells for water quality parameters and petroleum constituents in the spring of 2016.
- Compare petroleum analytical groundwater data to historical site data.
- Prepare data analysis report.

4.7 Practical constraints

The site wells are screened in clayey silt, sandy silt, and silty sand units. Due to these conditions, the wells may be low-yielding and slow to recover if over-pumped. The wells will be pumped at a rate that minimizes this potential impact.

4.8 Systematic planning process

This QAPP is the systematic planning process for the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 3. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Aaren Fiedler Toxics Cleanup Program Southwest Regional Phone: 360-407-6179	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Pam Marti EAP - GWFF Unit SCS Phone: 360-407-6768	Project Manager/Principal Investigator/Licensed Hydrogeologist	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Varies per sampling event	Field Assistant	Helps collect samples and records field information.
Martha Maggi EAP - GWFF Unit SCS Phone: 360-407-6453	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Jessica Archer EAP - SCS Phone: 360-407-6698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Dale Norton EAP - Western Operations Section Phone: 360-407-6596	Section Manager for the Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Joel Bird EAP - Manchester Environmental Laboratory Phone: 360-871-8801	Director	Reviews and approves the final QAPP.
Karin Feddersen EAP - Manchester Environmental Laboratory Phone: 360-871-8829	Data and Quality Assurance Reviewer	Coordinates contract laboratory services and reviews quality of lab data packages.
William R. Kammin EAP Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
GWFF: Groundwater Forests & Fish Unit
MEL: Manchester Environmental Laboratory
QAPP: Quality Assurance Project Plan
SCS: Statewide Coordination Section

5.2 Special training and certifications

A hydrogeologist license is required for the person overseeing hydrogeologic studies (Chapter 18.220.020 RCW).

All EAP field staff who work on hazardous waste sites are required to complete a 40-hour Hazardous Materials Safety & Health Training and take an 8-hour annual hazard recognition refresher training. They are also required to maintain certification in First Aid/CPR.

All field staff should have a detailed working knowledge of the project QAPP and any applicable SOPs to ensure credible and useable data are collected. This includes being familiar with the sample equipment and instruments being used.

5.3 Organization chart

See Table 3 for project organization.

5.4 Project schedule

Table 4. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	March 2016	Pam Marti
Laboratory analyses completed	May 2016	
Environmental Information System (EIM) database		
EIM Study ID	FS86125878	
Product	Due date	Lead staff
EIM data loaded	June 2016	Pam Marti
EIM data entry review	June 2016	Pam Marti
EIM complete	June 2016	Pam Marti
Final report		
Author lead / Support staff	Pam Marti	
Schedule		
Draft due to supervisor	June 2016	
Draft due to client/peer reviewer	July 2016	
Draft due to external reviewer(s)	NA	
Final (all reviews done) due to publications coordinator	August 2016	
Final report due on web	September 2016	

5.5 Limitations on schedule

Refer to sections 3.1.1 or 4.7.

5.6 Budget and funding

Table 5 presents the estimated analytical costs for one round of sampling on this project. Samples will be analyzed by Manchester Laboratory.

Table 5. Project budget and funding.

Parameter	Number of Samples [1]			Cost per Sample [2]	Cost per Parameter
	Field	QC	Total		
BTEX	6	2	8	$82	$656
TPH-Gx	6	2	8	$82	$656
TPH-Dx	6	2	8	$141	$1,128
Total Project Cost					$2,440

[1] Assumes 6 monitoring wells, 1 duplicate and 1 quality assurance sample for each parameter per sample event.
[2] Assumes Manchester Environmental Laboratory (MEL) planned price.

6.0 Quality Objectives

The quality objective for this project is to collect groundwater data of known, acceptable, and documentable quality. This will be achieved by establishing measurement quality objectives for precision and bias (accuracy), sensitivity, comparability, representativeness, and completeness, and by testing data against these criteria.

6.1 Decision quality objectives (DQOs)

This study will provide current BTEX, TPH-G and TPH-D concentrations in the site's groundwater. The data will be used to determine compliance with MTCA Method A groundwater cleanup levels as shown in Table 2.

6.2 Measurement quality objectives (MQOs)

The sample design and procedures followed in the field and laboratory are set to provide high-quality data for use in this project. Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, sensitivity, and completeness) and qualitative factors (representativeness and comparability). The measurement quality objectives associated with these data quality factors are summarized in Table 6 and discussed below.

Table 6. Measurement quality objectives for field and laboratory analyses**.**

Parameter	Verification Standards (LCS, CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference	% Recovery Limits	Relative Percent Difference	Units
Field measurements					
Water Level	NA	+/-0.03'	NA	NA	0.01 ft
Temperature	NA	10%	NA	NA	0.1 °C
pH	NA	10%	NA	NA	0.1 standard unit
Specific Conductivity	NA	10%	NA	NA	10 umhos/cm
Dissolved Oxygen	NA	10%	NA	NA	0.1 mg/L
Oxidation Reduction Potential	NA	10%	NA	NA	0.1 millivolts
Laboratory analyses					
BTEX	75-125%	30%	75-125%	30%	1 ug/L
TPH-Gx	70-130%	30%	NA	NA	0.14 mg/L
TPH-Dx	50-150%	25%	NA	NA	0.1 mg/L

6.2.1 Targets for precision, bias, and sensitivity

Precision and *bias* are data quality criteria used to indicate conformance with MQOs. *Accuracy* refers to the combined effects of precision and bias (Ecology, 2004). For this project to succeed, the precision and bias must be low to reveal variability in concentrations between samples.

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision is assessed by analyzing duplicate samples.

Duplicate samples will be collected in the field by filling two sets of bottles at the same time from a pre-selected well. Previous analytical results will be used to select an appropriate well.

Precision for field and laboratory duplicate samples will be expressed as relative percent difference (RPD) as shown in Table 6. The smaller the RPD, the more precise the measurement process. Good precision is indicative of relative consistency and comparability between different samples.

6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures.

Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols. Field sampling precision bias will be addressed by submitting replicate samples (Table 9, Section 10.1). The analytical laboratory will assess bias by analyzing lab control samples, matrix spikes, and standard reference materials.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit. In a regulatory sense, the method detection limit (MDL) is usually used to describe sensitivity. Targets for field and lab measurement sensitivity required for the project are listed in Table 6.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability expresses the confidence with which one set of data can be compared to another.

The 2015 study will follow the same field and laboratory methods that were used in the previous monitoring that was conducted from 2011 to 2013 (Hart Crowser, 2013).

SOPs to be used during the study are listed in Section 8.1.

6.2.2.2 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions.

Groundwater samples will be collected in March 2016. Samples will be representative of high water-table conditions. The site has previously been sampled in March 2011 and February 2013.

6.2.2.3 Completeness

Completeness establishes whether a sufficient amount of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness.

The completeness goal for this project is to collect and analyze 100% of the measurements and samples. However, problems occasionally arise during sample collection that cannot be controlled; thus a completeness of 95% is acceptable. Example of potential problems that may be encountered are low yielding wells or equipment failure.

7.0 Sampling Process Design (Experimental Design)

7.1 Study design

It will be over 4 years since chemical and biological oxidants and biological nutrients were injected into the subsurface of the site to remediate the petroleum contaminated groundwater. This study is designed to collect groundwater monitoring data to assess the current concentrations of the petroleum constituents of concern.

7.1.1 Field measurements

Field measurements will be recorded from each monitoring well and will include water level measurements and water quality parameters (pH, temperature, specific conductivity, dissolved oxygen, and oxidation reduction potential) as listed in Table 6.

7.1.2 Sampling location and frequency

Groundwater samples will be collected once from each of the six monitoring wells in the spring of 2016.

Well locations are shown in Figure 2. All wells are constructed of 2" PVC and are completed to a depth of 10 feet below ground surface. The screen interval is reported to be from 3 to 10 feet.

7.1.3 Parameters to be determined

The primary parameters to be determined are petroleum constituents: benzene, toluene, ethylbenzene, and xylene (BTEX); and total petroleum hydrocarbons as gasoline (TPH-G) and diesel (TPH-D). See Table 6 (Section 6.2) for other water quality parameters to be determined.

7.2 Maps or diagram

See Figure 2.

7.3 Assumptions underlying design

Assumptions underlying the study design include:

- Existing monitoring wells will provide information representative of site conditions.
- The number and position of groundwater sampling locations will be adequate to provide data on the site's groundwater quality.

7.4 Relation to objectives and site characteristics

Not applicable.

7.5 Characteristics of existing data

Groundwater data have been collected from the sites monitoring wells five times between March 2011 and February 2013. This covers the period from the initial petroleum plume investigation to post interim action activities which included the injection of chemical and biological oxidants and nutrients into the subsurface to treat the sites contaminated soils and groundwater. The proposed sampling will provide current groundwater data of the site conditions.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Groundwater samples and procedures for the study will follow Ecology SOPs:

- EAP052 for depth to water measurements (Marti, 2009)
- EAP078 for purging and sampling monitoring wells (Marti, 2011)

Field measurements will be made at all sampling sites and recorded on waterproof paper in a field notebook at regular intervals.

Staff will measure static water levels in all the monitoring wells upon arriving at the site. Staff will also measure water levels before and during the purging process to ensure the wells are not being over pumped. For optimal sampling the drawdown should not exceed 0.3 ft. Measurements will be collected according to SOP EAP052 (Marti, 2009).

Wells will be sampled in order of the historically lowest concentration of contaminants to the highest. Sample order will be based on previous sample results (Table 1).

Monitoring wells will be purged and sampled using a peristaltic pump. This is consistent with previous sample methods used at this site. The wells will be purged using standard low-flow techniques (e.g. < 0.5-liter/minute). Dedicated tubing will be used at each well. The wells will be purged through a continuous flow cell until field parameters stabilize (pH, temperature, specific conductance, dissolved oxygen, and oxidation reduction potential) as specified in SOP EAP078 (Marti, 2011).

All the wells are constructed and screened in fine-grained formation materials. Because of this the wells may be low yielding. Should any water levels drop more than the accepted criteria, they will be allowed to recharge with native formation water to complete the purging process and before sampling. If it appears a well may purge dry then it will be determined in the field what actions will be taken. Either the well will be allowed to recharge and equilibrate before sampling or samples will be collected with minimal purging. Any deviations from the sample plan will be discussed in the technical memo.

Samples will be collected from the monitoring wells directly from the pump discharge line after they are fully purged.

Groundwater samples will be analyzed in the laboratory for the parameters shown in Table 5.

8.2 Containers, preservation methods, holding times

Table 7 shows the parameter, sample containers, preservation and holding time required to meet the goals and objectives of this project.

Table 7. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
BTEX	Groundwater	40 mL No Headspace	(3) 40 mL VOA vials with septum	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C	14 days if preserved
TPH-Gx	Groundwater	40 mL No Headspace	(3) 40 mL VOA vials with septum	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C	14 days if preserved
TPH-Dx	Groundwater	1 Liter	1L narrow-mouth glass jar	Cool to ≤6°C	7 days

8.3 Invasive species evaluation

Does not apply to this study.

8.4 Equipment decontamination

Sample equipment that will be used at more than one well, such as the E-tape, will be decontaminated between sample locations. The E-tape probe will be washed in a laboratory grade detergent/water, followed by a clean water rinse, then a deionized water rinse. Pump tubing will be dedicated to each well and not reused.

8.5 Sample ID

Ecology's Manchester Environmental Laboratory (MEL) will provide the field lead with work order numbers for all scheduled sampling dates. The work order number will be combined with a field ID number that is given by the field lead. This combination of work order number and field ID number constitute the sample ID. All sample IDs will be recorded in field logs and in an electronic spreadsheet for tracking purposes.

8.6 Chain-of-custody, if required

Chain-of-custody procedures will be followed according to Manchester Environmental Laboratory protocol (Ecology, 2008).

Once collected, samples will be properly labeled and stored in an ice-filled cooler inside the sampling vehicle. If the sample vehicle is left unattended, it will be locked to maintain chain-of-custody. Samples will be transported to Ecology's Operation Center in Lacey, Washington. Samples will be kept in the walk-in cooler until picked up by the laboratory courier and transported to the MEL in Manchester, Washington.

8.7 Field log requirements

A field log will be maintained by the field lead and used during each sampling event. The following information will be recorded:

- Name of sample location
- Field staff
- Environmental conditions
- Field measurement results
- Date, Time, Sample ID, description of collected samples
- Identity of QC samples (if appropriate)
- Pertinent observations and/or any problems with sampling, including deviations from the QAPP
- Unusual circumstances that might affect interpretation of results

Field logs will consist of waterproof 8.5 x 11" field sheets pre-printed for ease of recording and kept in an enclosed metal clipboard. Permanent, waterproof ink or pencil will be used for all entries. Corrections will be made with single line strikethroughs; initialed and dated.

8.8 Other activities

Any field staff new to the type of sampling conducted for this study will be trained by senior field staff or the project manager following relevant Ecology SOPs and the site safety worksheet.

The field lead will notify MEL of the schedule for sampling events a few weeks before sampling. Samples will be collected between Monday and Wednesday so that holding times can be met. The lab will be notified immediately if there will be any deviations from the scheduled date of sampling. The field lead will work with the laboratory to develop a schedule for delivery of sampling containers in order to ensure that the appropriate number and type of required samples containers are available.

If a sample is damaged during transit or testing, a new sample may be collected and submitted for analysis. The laboratory should notify the project lead as soon as possible when a sample is unsuitable.

Purge water from the wells will be stored on-site in 55-gallon drums. This waste will be transported and disposed of in accordance with State of Washington regulations (Chapter 173-340-400 WAC).

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

Standard methods and reporting limits used for analysis of all groundwater samples are shown in Table 8.

Table 8. Field and laboratory measurement methods.

Field Measurements	No. of Samples	Expected Range of Results	Method	Sensitivity
Water Level	6	0.2-8.5 feet	Solinst E-Tape	±0.03 feet
Temperature	6	8-18 deg C	YSI ProPlus with Quatro Cable	±0.2 ºC
pH	6	4.5-6.5 S.U.	YSI ProPlus with Quatro Cable	±0.2 std. units
Specific Conductivity	6	50-900 umhos/cm	YSI ProPlus with Quatro Cable	±10 uS/cm
Dissolved Oxygen	6	0-8 mg/L	YSI ProPlus with Quatro Cable	±0.2 mg/L
Oxidation Reduction Potential	6	-330-+200 mV	YSI ProPlus with Quatro Cable	±5 millivolts
Laboratory Analytes				MDL
BTEX	6	< 1 – 6000 ug/L	EPA SW-846 Method 8021	0.2 ug/L
TPH-Gx	6	< 0.1 – 75 mg/L	NWTPH-Gx	0.14 mg/L
TPH-Dx	6	< 0.1 – 7 mg/L	NWTPH-Dx	0.1 mg/L

9.2 Lab procedures table

See Table 8 in Section 9.1.

9.2.1 Analyte

See Table 8 in Section 9.1.

9.2.2 Matrix

See Section 9.1.

9.2.3 Number of samples

See Table 8 in Section 9.1.

9.2.4 Expected range of results

See Table 8 in Section 9.1.

9.2.5 Analytical method

See Table 8 in Section 9.1.

9.2.6 Sensitivity/Method Detection Limit (MDL)

See Table 8 in Section 9.1.

9.3 Sample preparation method(s)

The laboratory will follow the standard sample preparation procedures for EPA Method 8021, NWTPH-Gx, and NWTPH-Dx.

9.4 Special method requirements

There are no special method requirements for this project.

9.5 Lab(s) accredited for method(s)

The analysis for BTEX, TPH-Gx, and TPH-Dx will be performed by Ecology's Manchester Laboratory.

10.0 Quality Control (QC) Procedures

10.1 Table of field and lab QC required

Table 9 shows the field and laboratory QC requirements for the project.

Table 9. Quality control samples, types, and frequency.

Parameter	Field		Laboratory			
	Blanks	Duplicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Temperature	NA	NA	NA	NA	NA	NA
pH	NA	NA	NA	NA	NA	NA
Specific conductivity	NA	NA	NA	NA	NA	NA
Dissolved oxygen	NA	NA	NA	NA	NA	NA
Oxidation Reduction Potential	NA	NA	NA	NA	NA	NA
BTEX	1/cooler	1/20 samples	1/batch	1/batch	1/batch	1/batch
TPH-G	NA	1/20 samples	1/batch	1/batch	1/batch	NA
TPH-D	NA	1/20 samples	1/batch	1/batch	1/batch	NA

The QC samples all will have MQOs (evaluation criteria) associated with them. These are described in Section 6.2. These criteria must be met to obtain fully usable data.

10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. A corrective action may need to be taken as a result of sampling as well as lab issues. Prescribed procedures will be followed to resolve the problems. Options for corrective actions might include:

- Retrieving missing information.
- Re-calibrating the measurement system.
- Re-analyzing samples within holding time requirements.
- Modifying the analytical procedures.
- Requesting collection of additional samples or taking additional field measurements.
- Qualifying results.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

All field data will be recorded in a field notebook/data sheets. Field notes will be checked for missing or improbable measurements before leaving each site. Field-generated data will be entered into EIM as soon as practical after returning from the field. Data entry will be checked against the field notes for any errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation.

Lab results will be checked for missing and/or improbable data. Data received from MEL through Ecology's Laboratory Information Management System (LIMS) will be checked for omissions against the *Request for Analysis* forms by the field lead. Data requiring additional qualifiers will be reviewed by the project manager.

11.2 Laboratory data package requirements

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Users Manual* (Ecology, 2008). Variability in lab duplicates will be quantified using the procedures outlined in the MEL *Users Manual*. Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

11.3 Electronic transfer requirements

MEL will electronically transfer all laboratory generated data to the project manager through the LIMS to EIM data feed. There is already a protocol in place for how and what MEL transfers to EIM through LIMS.

11.4 Acceptance criteria for existing data

Existing data will be accepted if they were collected with standardized sampling, analytical, and quality assurance methods that can be documented and that are comparable to those outlined in this study.

11.5 EIM/STORET data upload procedures

All field and laboratory data will be entered into EIM following existing Ecology business rules and the EIM User's Manual.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

Field audits are always appropriate for a project involving either field measurements or sampling. Insufficient QA resources are currently available for auditing activities. However, there could be a field consistency review of the project by another experienced EAP hydrogeologist. The aim of such reviews is to improve field work consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthening our data quality assurance program.

12.2 Responsible personnel

See Section 12.1.

12.3 Frequency and distribution of report

A final report will be published according to the project schedule shown in Section 5.4.

12.4 Responsibility for reports

Pam Marti will be the lead on the final report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Initial field data verification will be performed by the project manager immediately after completing field measurements/sample collection and prior to departing the site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier the measurement will be repeated.

After the sampling event, the project manager will compare all field data to determine compliance with MQOs. Values that are out of compliance with the MQOs will be noted. At the conclusion of the study, all out of compliance values (if any) will be compiled and assessed for usability by the project lead.

13.2 Lab data verification

MEL staff will perform the laboratory verification following standard laboratory practices. After the laboratory verification, a secondary verification of each data package will be performed by the project manager. This secondary verification will entail a detailed review of all parts of the laboratory data package with special attention being paid to laboratory QC results. If any issues are discovered they will be resolved by the project manager.

13.3 Validation requirements, if necessary

Data validation is not performed by the EAP project manager. Instead, once all laboratory data have been verified by MEL staff, the EAP project manager will complete a detailed quality review of the data set as part of the verification process. Field measurement data that were verified by a project staff member will be verified by a different staff member.

After data entry and data verification tasks are completed, all field and laboratory data will be entered into the EIM system. EIM data will be independently reviewed by another EAP field person for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

After all laboratory and field data are verified, a detailed examination of the data package using statistics and professional judgment will be performed. The project manager will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the project manager will decide if affected data should be qualified or rejected based upon the decision criteria from the QA Project Plan. The project manager will decide how any qualified data will be used in the technical analysis.

14.2 Data analysis and presentation methods

Once the data have been reviewed, verified, and validated, the project manager will determine if the data can be used toward the project goals and objectives. Validated analytical data will be shared with the TCP site manager in a technical memo.

The technical memo will be prepared at the completion of the sampling and will include the following:

- Maps of the study area showing sample sites, water levels, groundwater flow direction, contaminant concentrations and distribution.
- Description of field and laboratory methods.
- Discussion of data quality and the significance of any problems encountered.
- Summary tables of field and analytical data.
- Discussion of water quality results. Comparison of results to site's historical data.

14.3 Treatment of non-detects

Any non-detects will be included in the study analysis. The method described in MTCA [WAC 173-340-709(5)] for handling non-detect data is to:

(a) Assign a value equal to one-half of the method detection limit for measurements below the MDL.

(b) Assign a value equal to the MDL for measurements above the MDL but below the practical quantitation limit.

14.4 Sampling design evaluation

The project manager will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions can be drawn from the data. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

The project manager will include a section in the technical memo summarizing the findings of the data quality assessment.

15.0 References

AA Enviro Assessment Inc. (AEA), January 1998. Site Investigation.

Ecology, 1997. Analytical Methods for Petroleum Hydrocarbons. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA. Publication No. 97-602. https://fortress.wa.gov/ecy/publications/SummaryPages/97602.html

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies.https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

Ecology, 2008. Manchester Environmental Laboratory Lab Users Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA. http://aww.ecology/programs/eap/forms/labmanual.pdf

Ecology, 2009. Quality Assurance at Ecology. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. http://www.ecy.wa.gov/programs/eap/quality.html

Ecology, 2012. Water Resources Program – Focus on Water Availability: Queets-Quinault Watershed, WRIA 21. Publication No. 11-11-026. https://fortress.wa.gov/ecy/publications/summarypages/1111026.html.

EPA, 1996. Test Methods for Evaluating Solid Waste, SW-846. Office of Emergency Response, U.S. Environmental Protection Agency, Washington D.C.

Hart Crowser, 2011. Summary Report for Petroleum Plume Investigation; You & I Market, Pacific Beach, WA. May 25, 2011.

Hart Crowser, 2013. Groundwater Summary Report; You & I Market, Pacific Beach, WA. April 11, 2013. Project #17800-33.

Marti, P., 2009. Standard Operating Procedure for Manual Well-Depth and Depth-to-Water Measurements. Washington State Department of Ecology SOP EAP052. 31 p. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_ManualWellDepth%26DepthtoWaterMeasures_v_1_1EAP052.pdf

Marti, P., 2011. Standard Operating Procedure for Purging and Sampling Monitoring Wells. Washington State Department of Ecology SOP EAP078. 34 p. www.ecy.wa.gov/programs/eap/quality.html

WAC 173-340. Model Toxics Control Act-Cleanup. Washington State Department of Ecology, Olympia, WA. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340

16.0 Figures

See Table of Contents for list of figures in the report.

17.0 Tables

See Table of Contents for list of tables in the report.

18.0 Appendix. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

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

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

Groundwater: Water in the subsurface that saturates the rocks and sediment in which it occurs. The upper surface of groundwater saturation is commonly termed the water table.

Oxidation Reduction Potential: A measure of the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species affinity for electrons and tendency to be reduced.

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

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

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
SOP	Standard operating procedures
TCP	Toxics Cleanup Program
USGS	United States Geological Survey
UST	Underground storage tank
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
ft	feet
mg/L	milligrams per liter (parts per million)
mV	millivolt
NTU	nephelometric turbidity units
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter
uS/cm	microsiemens per centimeter, a unit of conductivity

Quality Assurance Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

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

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

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

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

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

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

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

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

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

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

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

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of

an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

References for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1997. Glossary of Quality Assurance Terms and Related Acronyms. U.S. Environmental Protection Agency. http://www.ecy.wa.gov/programs/eap/quality.html

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. U.S. Environmental Protection Agency. http://www.epa.gov/quality/qs-docs/g4-final.pdf

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf