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Quality Assurance Project Plan

Grays Harbor Fecal Coliform Bacteria Monitoring to Characterize Water Quality in Urban Stormwater Drains

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Quality Assurance Project Plan

Grays Harbor Fecal Coliform Bacteria Monitoring to Characterize Water Quality in Urban Stormwater Drains

October 2010

Approved by:

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Abstract

Grays Harbor was on the list of the Washington State Department of Ecology's (Ecology) impaired waters (303(d) list) (Appendix A) for fecal coliform (FC) bacteria in 1996. This prompted Ecology's Environmental Assessment Program to conduct a Total Maximum Daily Load Study (TMDL) during March 1997 – April 1998. Urban storm drains were sampled as part of the TMDL during the wet season of November 1997 – April 1998. This Quality Assurance Project Plan (QAPP) describes a sampling plan to follow-up on the high bacteria concentrations identified in the urban drains during the TMDL.

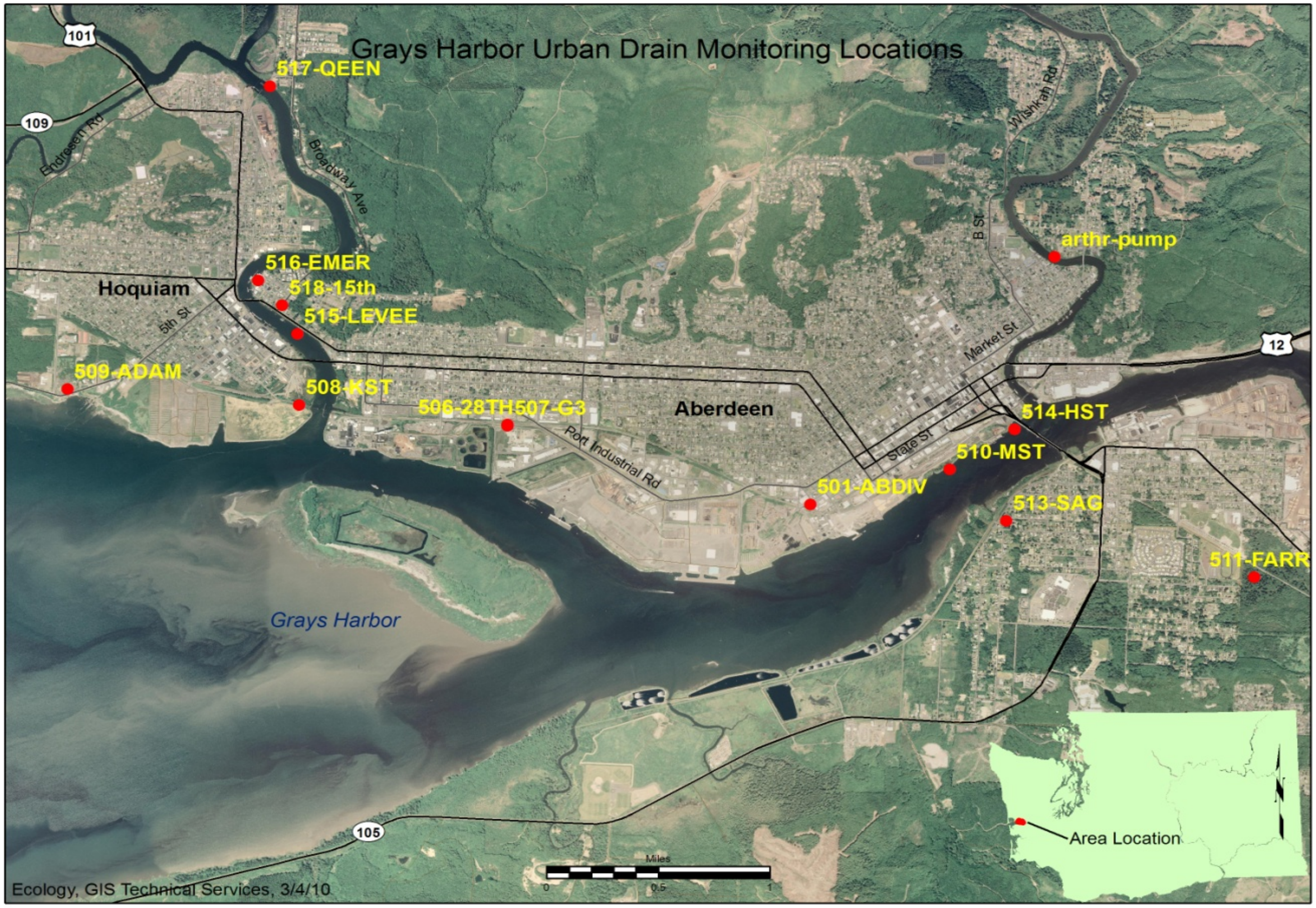
Each study conducted by Ecology must have an approved QAPP. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives (Lombard, 2004). After completion of the study, a final report describing the study results will be posted to the Internet.

Background

Grays Harbor estuary is in Southwest Washington (Figure 1) in Water Resource Inventory Area 22. The drainage area for Grays Harbor is approximately 2,550 square miles. The large tributaries include the Chehalis, Hoquiam, Wishkah, Humptulips, Johns, and Elk Rivers. The Chehalis River supplies approximately 80 percent of the freshwater to Grays Harbor.

Grays Harbor was on the list of Ecology's impaired waters (303(d) list) for FC bacteria in 1996 (Appendix A). This prompted Ecology's Environmental Assessment Program to conduct a TMDL during March 1997 – April 1998 (Pelletier and Seiders, 2000). The FC TMDL was conducted in the inner and outer Harbor. Sampling the urban drains from the Aberdeen, Hoquiam, and Cosmopolis area was not part of the original QAPP for the TMDL (Pelletier, 1997). However, high concentrations were found in a separate study monitoring FC bacteria in urban drains during July 1987 (Pelletier and Determan, 1988). As a result, sampling of representative urban storm drains was added as part of the TMDL during the wet season of November 1997 – April 1998 (Seiders, 2010) in the inner harbor. The site locations are described in Appendix B. The data collected in the urban drains for the TMDL can be reviewed in Appendix C. A loading reduction target was set for the drains as a whole.

This QAPP describes a sampling plan to follow-up on the high bacteria concentrations identified in the urban drains during the TMDL. Figure 1 is a map of the sampling locations.



Grays Harbor with Sampling Locations and Site Names used in the 1997/98 TMDL

Project Description

The overall goal of the monitoring project described in this QAPP is to:

> Characterize FC bacteria concentrations in the urban stormwater drains in the cities of Aberdeen, Hoquiam, and Cosmopolis during the wet season of 2010 – 2011.

The objectives established to meet the goal are:

1. Include the cities of Aberdeen, Hoquiam and Cosmopolis in the study planning and invite them to participate in implementation.
2. Collect, analyze, and interpret FC bacteria data to determine if Washington State water quality standards for Class A waters are being met. The criteria state that the geometric mean of the samples must not exceed 100 colonies/100mL with 10% of the samples not to exceed 200 colonies/100mL (WAC 173-201A).
3. Compare data collected in 2010-2011 to the 1998 TMDL data set.
4. Make the data obtained from this study available to the cities of Aberdeen, Hoquiam, and Cosmopolis for their use in protecting water quality.

Organization and Schedule

Table 1. Organization of Project Staff and Responsibilities

Staff	Title	Responsibilities
David Rountry Water Quality Program Southwest Region Phone: (360) 407-6276	Client	Clarifies project scope. Provides review and approval of QAPP and technical report.
Betsy Dickes Water Quality Program Southwest Region Phone: (360 407-6296	Project Manager & Principal Investigator	Writes the QAPP. Conducts field sampling and oversees transportation of samples to the laboratory. Conducts quality assurance review of data. Analyzes and interprets data, and enters data into EIM. Writes the technical report.
Variable Ecology Staff	Field Assistant	Assists with sample collection.
Scott Collyard Environmental Assessment Program	Technical Assistant	Provides internal review of the QAPP and technical report.
Kim McKee Water Quality Program Southwest Region Phone: (360) 407-6407	Unit Supervisor	Provides review and approval of the project scope and budget, tracks progress, and approves the QAPP and technical report.
Garin Schrieve Water Quality Program Southwest Region Phone: (360) 407-6271	Section Manager	Provides review and approval of the project scope and budget. Provides review and approval of QAPP and technical report.
Stuart Magoon Manchester Environmental Laboratory Phone: (360) 871-8801	Lab Director	Provides laboratory staff and resources.
Mike Herold, Headquarters, Water Quality Program Phone: (360) 407-6434	Quality Assurance Officer	Provides internal review of QAPP.
Shawna Beers Water Quality Program Southwest Region Phone: (360) 407-6270	Secretary Lead	Formats draft QAPP and report.
Kelsey Highfill Water Quality Program Phone: (360) 407-6722	Communication Consultant	Formats final QAPP and report. Arranges to load documents onto the web.

EIM – Environmental Information Management system.
QAPP – Quality Assurance Project Plan.

Table 2. Proposed Schedule

Field and laboratory work	Due date	Lead staff
Reconnaissance	August 2010	Betsy Dickes
Field work initiated	November 2010	
Field work completed	April 2011	
Laboratory analyses completed	May 2011	
Environmental Information System (EIM) database		
EIM user study ID	BEDI0015	
Product	Due date	Lead staff
EIM data loaded	June 2011	Betsy Dickes
Final report		
Author/project manager	Betsy Dickes	
Schedule		
Draft due to supervisor and client	June 2011	
Draft due to external reviewer(s)	July 2011	
Final (all reviews done) due to publications coordinator (Kelsey)	August 2011	
Final report due on web	September 2011	

Quality Objectives

Measurement quality objectives will vary for parameters based on their ability to be measured in the natural environment. Quality objectives are statements of the precision, bias, and lower reporting limits necessary to address project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness.

Precision is a measure of data consistency. It is expressed as the relative standard deviation (RSD) and derived from replicate sample analyses. RSD is the standard deviation of the replicates divided by the average of the replicates, expressed as a percentage. Increasing the number of bacteria replicates will improve precision estimation and confidence in decision-making. For example, we have planned a 20% replication for fecal coliform sampling because this parameter has inherently large variability. Precision quality will follow the guidelines established by Mathieu, 2006a.

Bias is a measure of the systematic error between an estimated value for a parameter and the true value. Systemic errors can occur through poor technique in sampling, sample handling, or analysis. We will minimize the bias through strict adherence to standard operating protocols (SOPs). Field staff will follow the SOPs listed in this plan for FC bacteria and conductivity (Mathieu 2006b, Ward, 2007). Sample contamination will be prevented through careful bottle handling and sample collection. The field conductivity meter will be calibrated before and checked after each sampling day using a standard solution of known conductivity.

The measurement quality objectives for this project are listed in Table 3.

Table 3. Measurement Quality Objectives

Analysis	Precision of Paired Replicates (Relative Standard Deviation (RSD))	Lower Reporting Limit	Bias
Fecal Coliform (MF)*	90% of pairs < 50%RSD and 50% of pairs < 20% RSD**	1 cfu/100 mL	N/A
Conductivity	10 %	1 µS/cm @ 25° C	5 µS/cm @ 25° C

* Membrane Filter method (APHA, 1998, Standard Methods 9222D)
**Samples must have means > 20 cfu/100 mL (Mathieu, 2006a)

Representativeness will be assured through the use of standardized Ecology protocols (Mathieu, 2006b, Ward, 2007, Sullivan, 2007). FC bacteria will be analyzed using the membrane filter method (MF). This is a variation from the TMDL which analyzed bacteria with both the Most Probable Number method and MF. Because of bacteria inherent variability we are confident that the difference between MF and MPN is not significant (Pelletier, 2000, Massa, et al.. 1989). For this reason, analyzing bacteria only using the MF method is considered valid. Additionally, we believe the data will meet the study objective of characterizing conditions.

We will assure that samples represent freshwaters by measuring conductivity and ensuring that it measures less than 3750 µS/cm @ 25°C (salinity < 2 ppt) when fecal coliform samples are collected.

Completeness will be assessed by examining:

- The number of samples collected compared to the sampling plan;
- The number of samples shipped and received at Manchester Laboratory in good condition;
- The laboratory's ability to produce usable results for each sample; and
- Sample results accepted by the project manager.

The objective for sampling completeness is 90%. The level of uncertainty is due to the dependence on pump stations to be pumping and if the tides will be low enough for the tide gates to be open. The Cities will be consulted to assist in determining the tidal height necessary to collect representative samples.

Sampling Process Design (Experimental Design)

Samples will be collected at 14 stormwater sites twice a month on an ebbing tide (Figure 1 and Appendix C-1). Sample locations for this study are the same as used in the TMDL. It may take two days to complete sample collection during appropriate tidal conditions. Attempts at source identification will be initiated if high concentrations are found at any site.

Sampling Procedures

Safety

Field personnel have the authority to ensure their safety. Reviewing environmental conditions for safety will always be a priority before accessing a sampling site. Personnel can refuse to proceed if they believe safety hazards are present.

Sampling

Standard Ecology Program protocols will be used for sample collection. Field sampling and measurement protocols will follow those described in Mathieu, 2006b, Ward, 2007 Sullivan, 2007. Grab samples for FC bacteria will be collected directly into pre-cleaned containers supplied by the laboratory and described in Manchester Environmental Laboratory (MEL, 2008). Plastic polyethylene bottles will be used to prevent bottle breakage and sample loss. Water samples will be collected below the surface using a sampling pole. Caution will be exercised not to stir up sediment. Each sample will be labeled and immediately placed in a dark thermal cooler with ice. Samples will be kept in conditions between 0°C and 4°C until the samples are processed by the laboratory. Samples arrive and will be processed at the Manchester Laboratory within 24 hours of collection.

The sample bottles will be labeled with:

- Project name
- Date
- Site name
- Name of lead sampler
- Laboratory ID number
- Analyte
- Sampling time

Conductivity samples will be collected and analyzed before the FC sample is taken to verify freshwater conditions. Conductivity samples will be collected in a 500 mL polyethylene bottle and measured on site using a Symphony SP7OC meter.

A waterproof loose-leaf field notebook will be used to record typical field data and any unusual occurrence that may have impacts on the project or sample results.

The project manager will provide training for anyone who is assisting with field work. This will include discussion of quality assurance and contamination prevention. Upon completion of sampling at each site, the notes will be reviewed by the project manager to ensure all activities were performed and records are legible.

The project manager will coordinate sampling dates, laboratory identification numbers, and methods with MEL, using standard Ecology protocol. The samples and completed *Laboratory Analysis Required* form will be picked up at the Ecology Headquarters Chain of Custody Room by the Manchester Courier. The Courier will transfer the cooler, containing samples and ice, to the lab vehicle and transport the samples to Ecology's Manchester Laboratory using chain of custody protocol.

Laboratory Measurement Procedures

Laboratory analyses will be performed in accordance with the *Manchester Environmental Laboratory Users Manual* (MEL, 2008). The laboratory staff will consult with the project manager if there are any changes in procedures over the course of the project. Table 4 summarizes laboratory analysis procedures for FC bacteria.

The field crew will communicate with the laboratory to ensure that laboratory resources are available. The project team will follow normal Manchester Laboratory procedures for sample notification and scheduling. With adequate communication, sample quantities and processing procedures should not overwhelm the laboratory capacity. When laboratory-sample load capacities are heavy, rescheduling of individual surveys may be necessary.

Table 4. Summary of Laboratory Analysis Procedures for Fecal Coliform Bacteria

Method	Estimated Range (cfu/100 mL)	Detection Limit (cfu/100 mL)	Holding Time	Preservation	Container
MF	< 1 to 24,000	1	24 hrs	Chill (4 °C)	250 mL poly autoclaved

Quality Control Procedures

Variability that comes from field sampling and from laboratory analyses will be assessed by collecting replicate samples and by performing replicate analyses. Bacteria sample concentrations are inherently variable, compared to other water quality parameters. Bacteria sample precision will be assessed by collecting replicates at two out of the 14 sites. MEL will analyze a duplicate sample from each sampling event to determine the presence of bias in analytical methods.

All water samples will be analyzed at MEL following standard quality control procedures (MEL, 2006). The laboratory's data quality objectives are documented in MEL (2005).
As mentioned previously, field sampling and measurements will follow quality control protocols described in Mathieu, 2006b, Ward, 2007 and Sullivan, 2007. If any of these quality control procedures are not met, the associated results will be qualified and used with caution. Professional judgment and peer review will determine if the data are used in analysis.

Replicate samples and measurements will be obtained at frequencies indicated in Table 5.

Table 5. Frequency of Quality Control Procedures

Analysis	Meter Calibration	Field Duplicates
Fecal Coliform (MF)	N/A	2/14 samples
Conductivity	1/use[1]	1/14 sites

N/A = not applicable.

Data Management Procedures

Data reduction, review, and reporting will follow the procedures outlined in MEL's Lab Users Manual (MEL, 2008). Laboratory staff will be responsible for internal quality control verification, proper data transfer, and reporting data to the project manager via the Laboratory Information Management System (LIMS).

All water quality data will be electronically transferred from LIMS into Ecology's Environmental Information Management (EIM) system. Data will be verified and reviewed for errors. Errors will be corrected and data reviewed again for accuracy.

The project manager will assess the quality of the data received from the laboratory and collected in the field. The review of measurement quality objectives will be performed within one month of data collection and adjustments to field or laboratory procedures will be made, as necessary. The TMDL lead will be notified if major changes are made to the sampling plan. Data that do not meet objectives may be approved for use by the project manager, but this data will be qualified appropriately. Elevated fecal coliform densities will be reported to the TMDL Lead as soon as possible.

Laboratory values below the detection limit will be assumed to be the detection limit for analysis purposes. Data from field replicates will be arithmetically averaged for data analysis. Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate data transformations. Estimation of univariate statistical parameters and graphical presentation of the data will be made using Microsoft Excel software (Microsoft, 2007). Use of any additional statistical analysis will be determined based on results and time available. This study is not a TMDL or a formal effectiveness monitoring study, but our findings are intended to support water cleanup. Precipitation will be determined using weather station KHQM at Bowerman Airport in Hoquiam. The tidal stage will be determined using information from the Aberdeen tide station (Station ID 957).

Audits and Reports

Manchester Laboratory will submit laboratory reports, QA worksheets, and chain-of-custody records to the project manager. Documentation from the lab should include any quality control results associated with the data in order to evaluate the accuracy of the data and to verify that the quality objectives are met.

Data Verification and Validation

Data verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Once measurement results have been recorded, they are verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results for QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers are properly assigned where necessary.
- Data specified in Sampling Process Design were obtained.
- Methods and protocols specified in the QA Project Plan were followed.

The project manager is responsible for verifying that field data entries are complete and correct (e.g., decimal point missing from an entry or something doesn't look right, based on experience).

Qualified and experienced laboratory staff will examine lab results for errors, omissions, and compliance with QC acceptance criteria. Findings will be documented in each case narrative sent to the project manager. MEL is responsible for verifying the staff's analytical results. Analytical data will be reviewed. It will be verified according to the data review procedures outlined in the Lab Manual (MEL, 2006). Results that do not meet quality assurance requirements will be labeled with appropriate qualifiers, and an explanation will be provided in a quality assurance memorandum attached to the data package.

Data validation

Professional judgment will be used to determine whether data quality objectives have been met. The project manager will examine the complete data package in detail to determine whether the procedures in the methods and procedures specified in this QAPP were followed. The usability determination will entail evaluation of field and laboratory results and relative standard deviation between field replicates. Adherence to established protocols should eliminate most sources of bias (Lombard and Kirchmer, 2004). Laboratory duplicates help estimate laboratory precision. Field replicates should indicate *overall* variability (environmental + sampling + laboratory).

Laboratory Costs

Laboratory costs were calculated using the Manchester Laboratory's price list for FY2011. The total laboratory cost will be approximately $6500. This reflects 16 samples (14 samples from sites plus approximately 20 percent replication per event) for 13 events. The value was rounded up to account for potential source identification sampling. The MF techniques for FC bacteria will be used at $23.88/sample. Costs include 50% discount for Manchester Laboratory analyses.

References

APHA, AWWA, and WEF, 1998. Standard Methods for the Examination of Water and Wastewater 20th Edition. American Public Health Association, Washington, D.C.

Lombard, S. and C. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030. www.ecy.wa.gov/biblio/0403030.html.

Massa, S., Maria Grandi, G. Poda, Daniela Cesaroni, F. Cangamella, and L. D. Trovatelli. Coliform detection from river waters: Comparison between MPN and MF techniques. Water, Air, and Soil Pollution. Vol (43) Numbers 1-2. January 1989. Pgs 135-145.

Mathieu, N. 2006a. *Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters*. Washington State Department of Ecology, Olympia, Washington. Publication No. 06-03-044. http://www.ecy.wa.gov/pubs/0603044.pdf

Mathieu, N., 2006b. Standard Operating Procedures for Sampling Bacteria in Water, Version Washington State Department of Ecology, Olympia, WA. SOP No. EAP012. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_012SamplingBacteriaInWater.pdf

MEL, 2006. Manchester Environmental Laboratory Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

MEL, 2008. Manchester Environmental Laboratory Lab Users Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Microsoft, 2007. Microsoft Office XP Professional, Version 10.0. Microsoft Corporation.

Pelletier, G., 1997. Grays Harbor Fecal Coliform Total Maximum Daily Load Study; Final Quality Assurance Plan. Washington State Department of Ecology, Olympia, WA.

Pelletier, G. and T. Determan, 1998. Urban Storm Drain Inventory Inner Grays Harbor Washington State Department of Ecology, Olympia, WA. http://www.ecy.wa.gov/pubs/88e31.pdf

Pelletier, G. and K. Seiders, 2000. Grays Harbor Fecal Coliform Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 00-03-020. http://www.ecy.wa.gov/pubs/0003020.pdf

Seiders, 2010. Personal Communication February 17, 2010. Washington State Department of Ecology, Olympia, WA.

Sullivan, L., 2007. Standard Operating Procedure for Estimating Streamflow, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP024. www.ecy.wa.gov/programs/eap/quality.html

WAC 173-201A. Water Quality Standards for Surface Waters in the State of Washington Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html

Ward, W.J., 2007. Collection, Processing, and Analysis of Stream Samples, Version 1.3. Washington State Department of Ecology, Olympia, WA. SOP Number EAP034. www.ecy.wa.gov/programs/eap/quality.html

Appendices

Appendix A. Glossary, Acronyms, and Abbreviations

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.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

QAPP: Quality Assurance Project Plan. A guide for the planning process. Promotes communication among those who contribute to the study. The completed plan provides direction to those who carry out the study and forms the basis for the written reports.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots. Was this word used in this document? I noticed consistent use of the term "urban drains", and wondered if there should be clarification. It could be as simple as saying …urban drains (e.g., stormwater conveyances and discharge points)

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water

– such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
RPD	Relative percent difference
RSD	Relative standard deviation
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WRIA	Water Resources Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cfu	colony forming unit
ft	feet
mg/L	milligrams per liter (parts per million)
µS/cm	micro Siemens per centimeter, a unit of conductivity

Appendix B. Grays Harbor Urban Drain Monitoring Locations

Grays Harbor Urban Drain Monitoring Locations.

STATION NAME	TMDL Name	TMDL DESCRIPTION	LATITUDE	LONGITUDE
Bay Avenue	507-G3	28th St Pump Station 36" outlet and Henderson, Hoquiam	46° 58' 16.968"	123° 51' 32.7594"
Emerson	516-EMER	Emerson Ave Pump Station, at riverbank downstream of pump station Hoquiam .	46° 58' 51.4914"	123° 53' 0.312"
H St.	514-HST	H. St. stormwater drain on mudflats, 48" pipe with tide-flap, Aberdeen or H Street pump station	46° 58' 20.9994"	123°48' 39.528"
Division St.	501-ABDIV	Division St. Pump Station at Aberdeen WWTP	46° 57' 59.9034"	123° 49' 48.1074"
Adams	509-ADAM	Ditch at Adams St and Airport Way, outlet from pump station at 208 Adams St Hoquiam	46° 58' 21.864"	123° 54' 3.708"
M ST.	510-MST	M St. stormwater drain, south of RR tracks, Aberdeen or M Street pump station	46° 58' 10.1994"	123° 49' 1.0914"
Arthur ST.	arthr-pump	Arthur St. pump station, eastern most point of Arthurs St on right bank of Wishkah R., Aberdeen	46° 59' 5.3888"	123° 48' 28.6554"
Queen Ave.	517-QEEN	Queen Ave Pump Station. Outlet on riverbank upstream of RR bridge, Hoquiam	46° 59' 41.0274"	123° 52' 59.376"
K St.	508-KST	K St. Pump Station discharge on K St., at pump station or downstream at drop to river, Hoquiam	46° 58' 20.172"	123° 52' 44.364"
Saginaw Slough	513-SAG	Saginaw St at SW Front and McFarlane St, Aberdeen	46° 57' 57.672"	123° 48' 40.9314"
15th St.	518-15th	15th St. stormwater, 12" drain to beach at 15th and Riverside, Hoquiam	46° 58' 45.4714"	123° 52' 51.672"
28th St.	506-28TH	18 inch pipe at 28th and Henderson, adjacent to 507-G3	46° 58' 17.2194"	123° 51' 32.7594"
Farragut St	511-FARR	Farragut St pump at east end of W Harriman St	46° 57' 45.7194"	123° 47' 15.432"
Levee St.	515-LEVEE	Levee St. pump Station near 9th and Levee St nr Rayonier Point Park, Hoquiam	46° 58' 38.244"	123° 52' 46.0914"

Appendix C. Data for the Urban Drains Sampled in Grays Harbor in 1998

Data for the Urban Drains Sampled in Grays Harbor in 1998.

Site	Date	Time	FC (cfu/100 mL)	Tidal Height (Height (feet) at Aberdeen station #957)
501 - ABDIV	2/4/1998	1030	110	5.9
	2/10/1998	1635	350	4.5
	3/11/1998	1625	70	3.5
506 -28th	2/4/1998	1500	920	3.5
507-G3	2/4/1998	1540	1600	4.3
	2/10/1998	1715	130	2.0
	4/7/1998	1623	17000	1.8
508-KST	2/4/1998	1610	24000	5.0
	2/10/1998	1545	1100	7.0
509-ADAM	2/4/1998	1650	1700	5.0
	2/10/1998	0930	24000	7.8
	4/7/1998	1455	920	4.4
510-MST	2/10/1998	1810	2400	1.0
	3/11/1998	1950	130	1.6
	4/7/1998	1800	7.8	1.5
511-FARR	2/11/1998	1715	20	4.8
513-SAG	2/11/1998	1845	110	1.3
514-HST	2/11/1998	1930	3500	0.4
	3/11/1998	1910	2400	1.1
	4/7/1998	1740	79	1.3
515-LEVEE	2/26/1998	1430	6.8	10.2
516-EMER	2/26/1998	1450	240	10.2
	3/9/1998	1505	2400	3.6
	4/7/1998	1540	2400	2.5
517-QEEN	3/9/1998	1520	540	2.5
518-15th	3/9/1998	1650	110	1.0
Arth-pump	no data collected in TMDL			