

**KITSAP PUBLIC HEALTH DISTRICT
ENVIRONMENTAL HEALTH DIVISION
POLLUTION IDENTIFICATION & CORRECTION PROGRAM**



**PORT ORCHARD PASSAGE RESTORATION PROJECT
FINAL REPORT**

**Lucas Jordan
Stuart Whitford
June 2013**

Funding by:





**KITSAP PUBLIC
HEALTH DISTRICT**



TABLE OF CONTENTS

List of Figures	2
List of Tables	3
List of Appendices	4
Acknowledgments	5
Executive Summary	6
1.0 BACKGROUND AND PROBLEM STATEMENT	9
2.0 PROJECT AREA DESCRIPTION	11
3.0 GOALS, OUTCOMES, PROJECT DELIVERABLES	21
4.0 PROJECT DESIGN AND METHODS	22
4.1 Shoreline Surveys	22
4.2 Property Surveys	23
4.3 Education & Outreach	24
4.4 Water Quality Monitoring	24
5.0 RESULTS AND DISCUSSION	24
5.1 Shoreline Surveys	26
5.2 OSS Property Survey Results	28
5.3 Education & Outreach	31
5.4 Water Quality Monitoring	33
6.0 CONCLUSIONS	41
7.0 RECOMMENDATIONS	41
8.0 REFERENCES	43

LIST OF FIGURES

Figure #	Description	Page #
1	Port Orchard Passage Restoration Project – Shoreline Areas	12
2	Northern Port Orchard Passage Shellfish Growing Areas	16
3	Southern Port Orchard Passage Shellfish Growing Areas	17
4	Agate Passage Shoreline Survey Area	18
5	Crystal Springs Shoreline Survey Area	19
6	University Point / Illahee Shoreline Survey Area	20
7	Location of OSS Failures	30
	Fecal Coliform Bacteria Trend Analysis Steele Creek (Station ST01), 1996 – 2012	
8	Fecal Coliform Bacteria Trend Analysis Illahee Creek (Station IC01), 1996 – 2012	36
9	Fecal Coliform Bacteria Trend Analysis Illahee State Park Creek (Station SP01), 1996 – 2012	37
10	Fecal Coliform Bacteria Trend Analysis Enetai Creek (Station DE01), 1996 – 2012	38
11	Port Orchard Passage/Burke Bay Marine Water Summary, 1996-2012	39
12	Port Orchard Passage Restoration Project – Shoreline Areas	40

LIST OF TABLES

Table #	Description	Page #
E-1	Comparison of Project Results to Project Goals, Outcomes and Deliverables	7
1	Washington State Surface Water Quality Standards	9
2	Summary of Historical Water Quality Data for Port Orchard Passage - Freshwater	10
3	Summary of Historical Water Quality Data for Port Orchard Passage – Marine Water	10
4	Comparison of Project Results to Project Goals, Outcomes and Deliverables	25
5	Summary of Pollution Identification and Correction Results	28
6	Onsite Sewage System Failure Type	29
7	Fresh Water Trend Monitoring (FC) Results 10/1/2011 to 9/30/2012	34
8	GMV by Water Year Summary Table	34
9	Marine Water Trend Monitoring (FC) Results 10/1/2011 – 9/30/2012	35

LIST OF APPENDICES

Appendix #	Description
A	Health District Trend Plan
B	Trend Monitoring Station List
C	Criteria for Rating OSS
D	Shoreline Survey Results
E	Trend Station Sample Results
F	Trend Station Statistical Analysis
G	Public Education and Outreach Documentation

ACKNOWLEDGMENTS

The author would like to thank the fellow Kitsap Public Health District staff, the City of Bainbridge Island Water Resources Program, the Puget Sound Restoration Fund, and the Kitsap County Surface and Storm Water Management for their assistance in completing the Port Orchard Passage Restoration Project.

PORT ORCHARD PASSAGE RESTORATION PROJECT FINAL REPORT

EXECUTIVE SUMMARY

The Port Orchard Passage Restoration Project was initiated by the Kitsap Public Health District (Health District) in November, 2010, to address serious fecal coliform (FC) pollution problems in Port Orchard Passage. Funding was provided with a Washington State Department of Ecology (Ecology) Centennial Clean Water Fund grant, with matching funds provided by the Kitsap County Surface and Stormwater Management Program and the City of Bainbridge Island Water Resources Program.

Washington State Department of Health Shellfish Program conducted a routine shoreline survey of the Port Orchard Passage growing area in 2009. After confirming multiple fecal coliform bacteria (FC) “hot spots” during their shoreline survey, DOH established two large shellfish closure zones along the western shoreline of Bainbridge Island; a 1.3-mile stretch along the southwest portion of Bainbridge Island in an area referred to as Crystal Springs, a 0.6-mile stretch along the northwest portion of Bainbridge Island along Agate Passage, and isolated closure zones on the west side near Illahee and Gilberton.

In response to the closure, the Health District implemented a four tier plan to clean up the degraded shoreline areas. This plan involved intensive shoreline monitoring, property inspections, public education/outreach focusing on prevention of nonpoint source pollution, and trend monitoring of local marine waters and major streams.

Staff walked the shoreline area four (4) times during the project; twice during the wet season (November – April) and twice during the dry season (May – October). FC “hot spots” were identified, prioritized and investigated. A total of 23 FC “hot spots” were identified in the growing area. Four (4) of these “hot spots” were at least partially related to failing oss. Two (2) of the “hot spots” were determined to be related to raccoon and otter activity based upon visual observation by Health District inspectors and area property owners. No human related FC sources were identified in the 17 remaining “hot spots”.

Staff inspected 172 properties in the project area, many of which were directly associated with FC “hot spots”. Eighteen (18) failing onsite sewage systems were discovered during the project and all have been repaired or are in process.

Table E1 below describes how this project met its goals, anticipated outcomes, and required deliverables.

Table E1. Comparison of Project Results to Project Goals, Outcomes and Deliverables

<u>Goals</u>	<u>Status</u>	<u>Comments</u>
Restore 303(d) listed water bodies to water quality standards	Progress	Remaining failing OSS must be repaired, and flushing of contaminated discharges must occur before data review can occur.
Restore and protect designated beneficial uses in Port Orchard Passage and Agate Passage receiving waters	Progress	Beneficial uses were protected by educating (172) project area residents about preventing nonpoint source pollution from their properties. Restoration cannot be evaluated until all failing OSS have been repaired.
Protect healthy waters from degradation	Achieved	18 failing OSS were identified and have been or will soon be corrected. All property owners who participated in the project (172) received education about preventing nonpoint source pollution from their property.
Respond to shellfish downgrade by DOH	Achieved	Pending correction of 10 failing onsite sewage system and post project follow up investigation of selected "hot spots"
<u>Water Quality & Environmental Outcomes</u>	<u>Status</u>	<u>Comments</u>
Significantly reduce FC bacteria levels in fresh water drainages to shellfish growing areas of Port Orchard Passage	Progress	A true post-corrective water quality assessment cannot be completed until all OSS repairs are complete. The project did not include PIC investigations on the four (4) streams that were monitored, so they cannot be assessed for improvement.
Locate failing onsite sewage systems that contribute to FC pollution in the area and repair or replace 100% of them.	Progress	18 failing OSS were identified and have been or will soon be corrected.
Correct any animal waste management problems through education and/or enforcement	Progress	One property owner admitted to feeding raccoons, which created a "hot spot" on the shoreline. After being asked to cease this activity, water quality improved in the drainage.
DOH upgrades classification of shellfish growing areas in project area	Progress	Pending correction of 10 failing onsite sewage system and post project follow up investigation of selected "hot spots"
<u>Performance Items & Deliverables</u>	<u>Status</u>	<u>Comments</u>
Public education and outreach	Achieved	172 property owners received education about preventing nonpoint source pollution from their property. Two (2) public meetings were held in the project area, and the Puget Sound Restoration Fund conducted education programs focusing on the link between good water quality and safe shellfish farming and harvesting.
Shoreline surveys to locate FC pollution sources	Achieved	Four (4) complete marine shoreline surveys were completed in the project area.
Technical assistance and enforcement to ensure correction of pollution sources	Progress	Property owners with failing or suspect onsite sewage systems received technical assistance re the repair process.
QAPP for post corrective monitoring	Achieved	Approved by Ecology 2/2011 .
Post corrective monitoring to document improvements in water quality	Progress	Monitoring has been completed for "hot spots" where failing onsite sewage systems were corrected, and for a "hot spot" associated with a property owner who was required to stop feeding raccoons and creating a nuisance. Those results show some improvement. No improvements noted at the three (3) marine stations. The project did not include PIC investigations on the four (4) streams that were monitored, so they cannot be assessed for improvement. A true post-corrective water quality assessment cannot be completed until all OSS repairs are complete.
Final Report	Achieved	Submitted to Ecology 5/2013 .

As a result of samples collected, residents surveyed and observations made during the Port Orchard Passage Restoration project, the Health District's Water Pollution Identification and Correction Program recommends the following:

- Conduct periodic shoreline surveys along the Port Orchard Passage to maintain the progress made by the Port Orchard Passage Restoration Project. Older gravity OSS along the shoreline will likely continue to fail as they age.
- The Health District will continue to be involved in the Port Orchard Passage watershed through public complaint response, water quality trend monitoring, and follow-up of reports submitted by certified monitoring and maintenance specialists and pumpers. In addition, properties with ongoing concerns will be flagged in Health District records to assist future inspections.
- Steele Creek, Illahee Creek, Illahee State Park Creek, Enetai Creek, and Port Orchard Passage shoreline watersheds will need ongoing work to prevent water quality degradation due to elevated FC levels. Many of the OSS in the area experience risk factors that can lead to failure including age, lack of permit records, shallow ground water, inadequate setback to surface waters, and deeper installation depths that can degrade the ability of soil bacteria and microbes to provide adequate treatment.
- Continue to be proactive in OSS maintenance. Alternative OSS are inspected annually by their maintenance provider. Standard gravity OSS and drainfields should be inspected every three years (at minimum).
- Kitsap County residents are urged not feed wildlife. Multiple FC "hot spots" in the growing area were confirmed or suspected to be wildlife related. Feeding wildlife is not healthy for them, water quality or public health.

1.0 BACKGROUND AND PROBLEM STATEMENT

The “Water Quality Standards for Surface Waters of the State of Washington” are codified in Chapter 173-201A of the Washington Administrative Code. The surface waters in the project area are currently designated in the WAC as Extraordinary Primary Contact Recreational Waters. Freshwater and marine water standards for fecal coliform (FC) bacteria are shown in **Table 1**.

Table 1
Washington State Surface Water Quality Standards
(Chapter 173-201A-030 WAC)

Parameter	Freshwater - Extraordinary Primary Contact	Marine - Extraordinary Aquatic Primary Contact
Fecal Coliform bacteria (FC)	<p>Part 1: ≤ 50 FC/100ml (geometric mean)</p> <p>Part 2: Not more than 10% of all samples obtained for calculating a geometric mean >100 FC/100 ml</p>	<p>Part 1: ≤ 14 FC/100ml (geometric mean)</p> <p>Part 2: Not more than 10% of all samples obtained for calculating a geometric mean >43 FC/100 ml</p>

Table 2 and Table 3 provide a summary of pre-project FC data collected by the Health District for Port Orchard Passage watershed tributaries and salt water stations. Enetai, Illahee State Park, and Steele Creeks had periodic bacteria problems or failed the standard. Additionally, one marine station located at the mouth of Enetai Creek had a history of failing standard. Port Orchard Passage was listed for FC contamination on the Clean Water Act 2008 303(d) list.

Table 2
Summary of 2009 Water Year (FC) data for
Port Orchard Passage Freshwater Tributaries

Stream Station	2009 Water Year (October 2008 – September 2009)					
	Number of samples	Range (FC/100 ml)	GMV (FC/100 ml) ^{1,2}	#Samples exceeding standard	%Samples exceeding standard ²	Meets Washington Dept. of Ecology Standard?
Steel Creek ST01	12	8 - 1600	49	4	33%	NO
Illahee Creek IC01	12	<2 - 110	11	1	8%	YES
Illahee State Park Creek SP01	12	<2 - 300	35	4	33%	NO
Enetai Creek DE01	12	8 - 1600	56	4	33%	NO

1. GMV = geometric mean value

2. Shaded entries indicate an exceedance of the applicable water quality standard

(**Extraordinary Primary Contact** - Chapter 173-201A-030 WAC) during Water Year 2008. FC levels shall not exceed a GMV of 50 FC/100ml, and not have more than 10% of all samples exceed 100 FC/100 ml

Table 3
Summary of 2009 Water Year (FC) data for
Port Orchard Passage Marine Stations

Marine Station	2009 Water Year (October 2008 – September 2009)						Number of water years (1999-2009) in which the station has <i>failed</i> WDOE standard
	Number of samples	Range (FC/100 ml)	GMV ¹ (FC/100 ml)	#Samples >43 FC/100 ml	%Samples >43 FC/100 ml ²	Meets Washington Dept. of Ecology Standard?	
PO13	12	<2 - 30	3	0	0%	YES	1
BU01	12	<2 - 170	5	2	17%	NO	5
PO04	12	<2 - 4	<2	0	0%	YES	4

1. GMV = Geometric mean value.

Other than in permanent closure zones located around sewage treatment plant outfalls and marinas, all of Port Orchard Passage was open to shellfish harvest prior to the 2009 Shoreline Survey of the Port Orchard Passage Shellfish Growing Area, published by Washington State Department of Health (DOH) in March 2009. As a result of the shoreline survey, DOH established two large shellfish closure zones along the western shoreline of Bainbridge Island; a 1.3-mile stretch along the southwest portion of Bainbridge Island in an area referred to as Crystal Springs, a 0.6-mile stretch along the northwest portion of Bainbridge Island along Agate Passage, and isolated closure zones on the west side near Illahee and Gilberton.

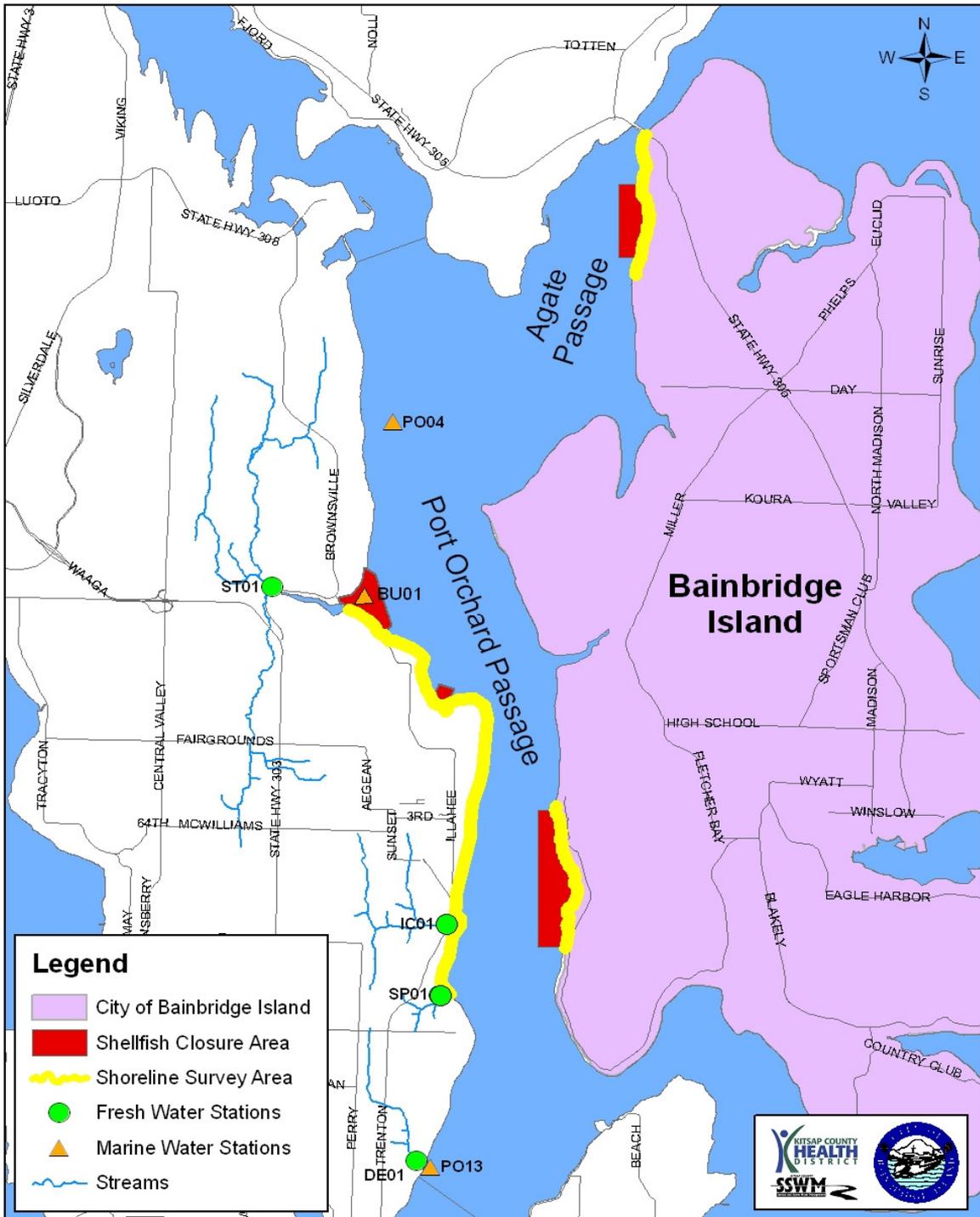
The Port Orchard Passage Restoration Project was initiated in November 2010 with funding from a grant from the Washington State Department of Ecology (Ecology) Centennial Clean Water Fund (CCWF), with matching funds provided by the Kitsap County Surface and Stormwater Management Program and the City of Bainbridge Island Water Resources Program.

The project goals of the Port Orchard Passage Restoration Project were: to restore and protect beneficial uses in the Port Orchard Passage watershed, restore and protect 303(d) listed water bodies, and to prevent the degradation of healthy waters. To accomplish these goals, the Health District applied its FC bacteria pollution identification and correction process as outlined in its “Manual of Protocol: Fecal Coliform Bacteria Pollution Identification and Correction” (November 2011).

2.0 PROJECT AREA DESCRIPTION

There are three major shoreline areas within the project area: Agate Pass, Crystal Springs, and University Point/Illahee. The Agate Pass and Crystal Springs sections are located immediately surrounding the prohibited commercial shellfish growing areas on the Western shores of Bainbridge Island. The University Point/Illahee section is located on the Eastern Shore of Port Orchard Passage between Steele Creek and the Illahee State Park. The Port Orchard Passage Restoration Project area is mapped in **Figure 1** below:

Figure 1
Port Orchard Passage Restoration Project Shoreline Areas



Port Orchard Passage

Port Orchard Passage is an approximately 7.5 mile long waterway that separates western Bainbridge Island from the Kitsap Peninsula. It extends from the southern end of Bainbridge Island and the East Bremerton peninsula north towards Liberty Bay, Pt. Bolin, and Agate Passage. The 4.5 mile stretch from Steele Creek / Burke Bay to Illahee State Park Creek, and the 1.3 mile stretch from Baker Hill Rd north to the end of Crystal Springs Dr on Bainbridge Island were evaluated during the project. Land use along this section is mostly residential with some large forested areas. Numerous footing drains, downspouts, curtain drains, storm drains and small streams discharge to the shoreline.



View of Port Orchard Passage from the southern end of Crystal Springs shoreline

Agate Passage

Agate Passage is an approximately three mile long waterway that separates the northwestern Bainbridge Island from the Kitsap Peninsula. It extends from Port Orchard Passage and Pt. Bolin to the northern tip of Bainbridge Island and Port Madison Bay. The project evaluated the 1.2-mile stretch south of the Agate Pass Bridge, including the 0.6-mile long commercial shellfish closure area. Land use along this section is mostly residential with medium and high-bank water front. Numerous footing drains, downspouts, curtain drains, storm drains and small streams discharge to the shoreline.



View of Agate Passage and the Agate Pass Bridge from Port Madison Bay

Steele Creek

Steele Creek and its tributaries combine for over six miles of stream corridor. These flow from the north and south and then discharge into Burke Bay near Brownsville. Land use in the Steele Creek drainage is a combination of rural and urban residential, agricultural, commercial, and light industrial. Steele Creek has previously been posted with a public health advisory due to high levels of bacteria. After some pollution sources were corrected, more recent data showed improvement and the advisory was lifted in 2009.

While Steele Creek was not directly investigated as part of the Port Orchard Passage Restoration Project, the creek serves as a northern boundary for the University Point/Illahee section of shoreline. The Health District has monitored this creek since 1996 as part of its county-wide trend monitoring program for FC bacteria. See Appendix A for a copy of the monitoring plan. This program tracks short and long term trends for stream FC concentrations.



Steele Creek monitoring station ST01
near Brownsville

Illahee Creek

Illahee Creek originates near the Rolling Hills golf course in east Bremerton and travels for approximately 3.7 miles to its discharge point into Port Orchard Bay near Illahee. Land use in the Illahee Creek drainage is primarily urban residential, with some commercial, light industrial, and forestland. This includes the Illahee Forest Preserve, a 352 acre conservation area. The Health District has monitored this creek since 1996 as part of its county-wide trend monitoring program for FC bacteria. See Appendix A for a copy of the monitoring plan. This program tracks short and long term trends for stream FC concentrations.



Illahee Creek monitoring station IC01

Illahee State Park Creek

Illahee State Park Creek is a small spring fed stream less than one mile in length. The headwaters are located near the Illahee Mobile Home Park, and the stream flows northeast to its discharge point in Port Orchard Bay, just north of Illahee State Park. Land use in the Illahee State Park Creek drainage is urban residential and commercial. Illahee State Park Creek also marks the southern boundary of the University Point / illahee shoreline survey area. The Health District has monitored this creek since 1996 as part of its county-wide trend monitoring program for FC bacteria. See Appendix A for a copy of the monitoring plan. This program tracks short and long term trends for stream FC.



Illahee State Park Creek where it flows into Port Orchard Bay

Enetai Creek

Enetai Creek is a small stream located in east Bremerton. The stream is approximately two miles long, flowing south between Perry Avenue and Trenton Avenue, then discharging into Port Orchard Bay. Land use in the drainage is predominately urban residential and commercial. Bacterial pollution in this stream was so bad that the Health District issued a public health advisory in 2005. The Enetai Creek Restoration Project was initiated to reduce bacterial contamination in the creek. During the Enetai Creek Restoration Project, 255 properties were inspected and 10 failing septic systems identified and corrected. This work resulted in a dramatic improvement in water quality, and the health advisory was lifted in 2009. The Health District has monitored this creek since 1996 as part of its county-wide trend monitoring program for FC bacteria. See Appendix A for a copy of the monitoring plan. This program tracks short and long term trends for stream FC.



Station DE01 downstream of Enetai Beach Road

Figure 2. Northern Port Orchard Passage Shellfish Growing Areas

Port Orchard Passage 03/01/11

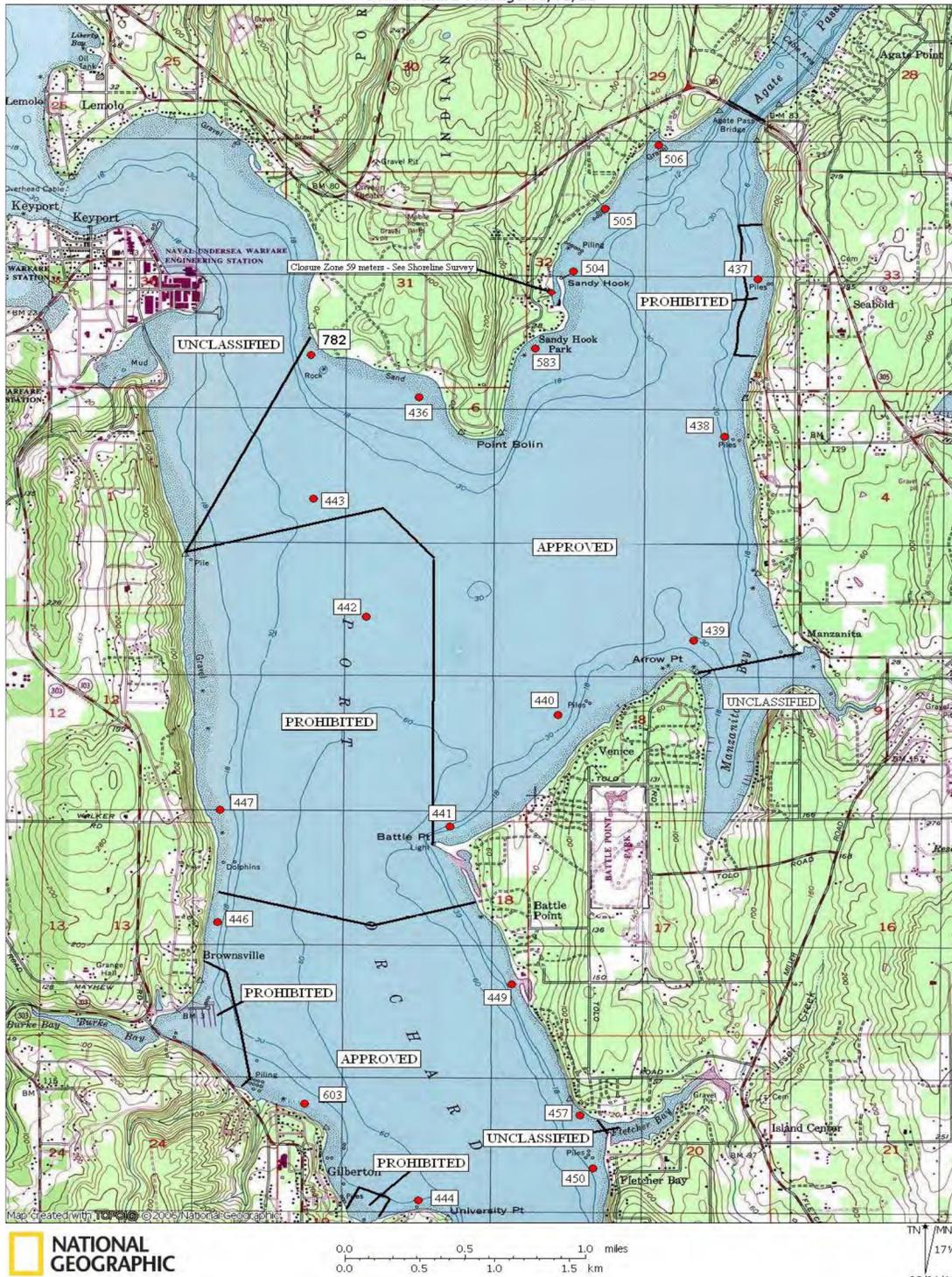


Figure 3. Southern Port Orchard Passage Shellfish Growing Areas

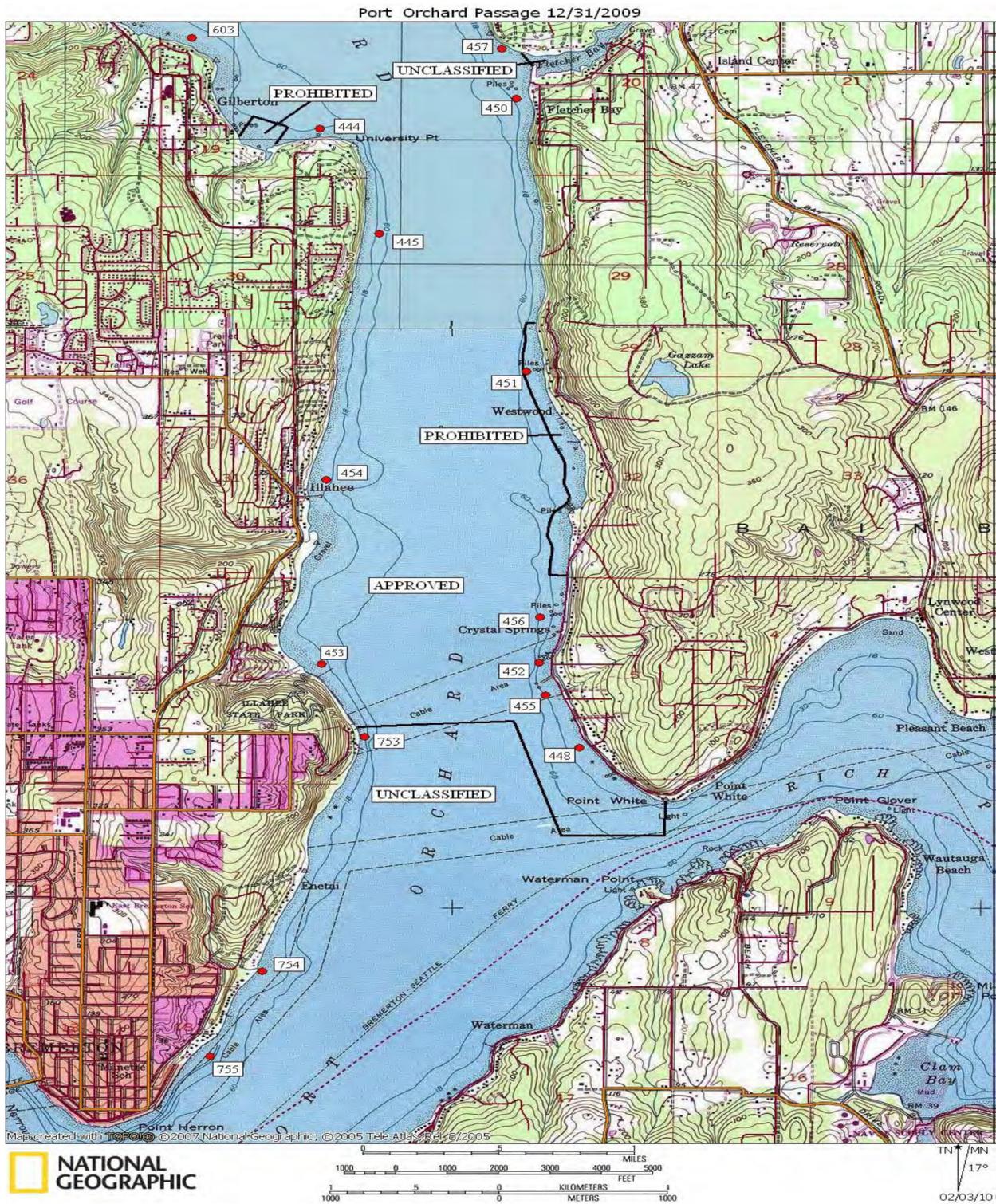


Figure 4. Agate Passage Shoreline Survey Area

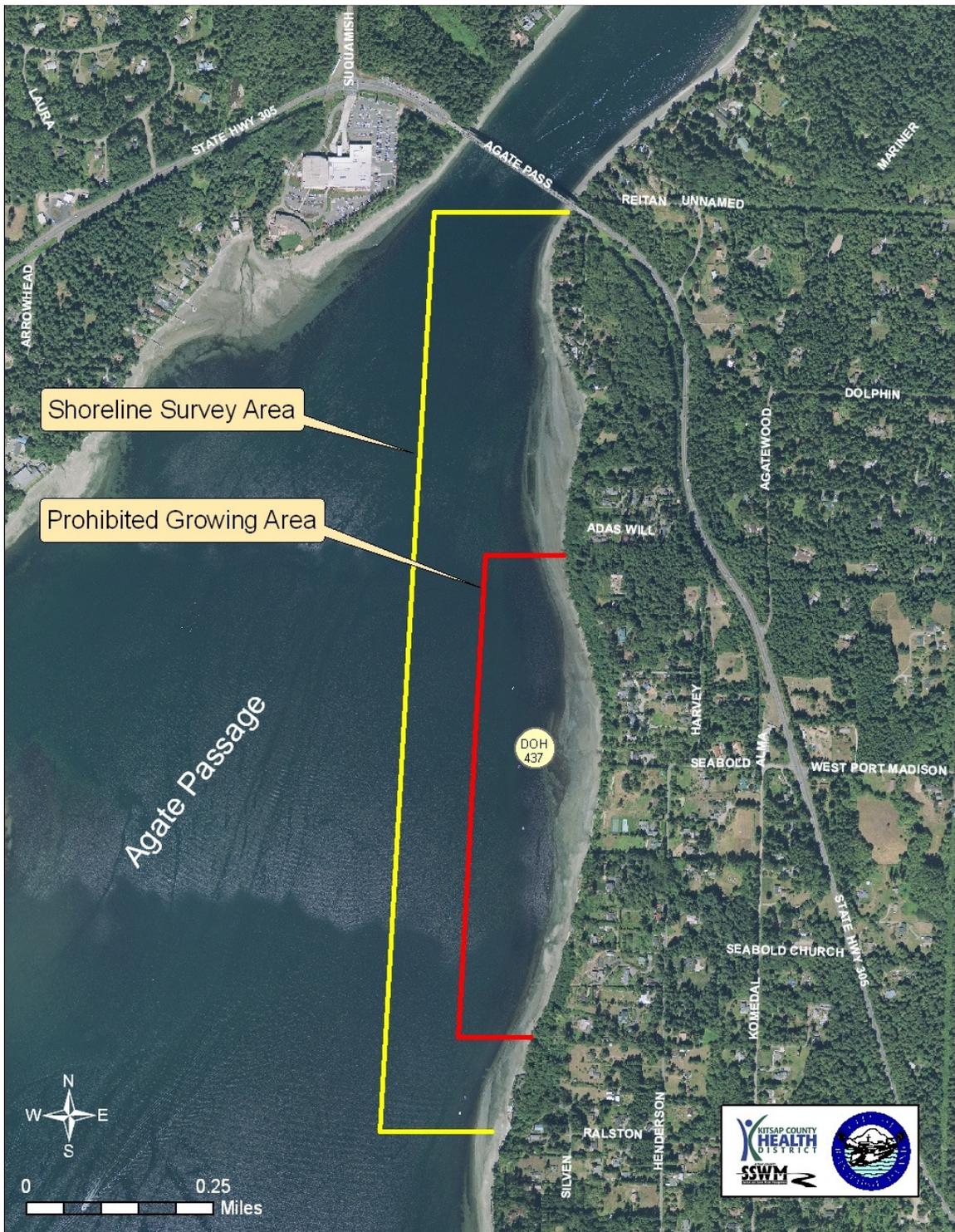


Figure 5. Crystal Springs Shoreline Survey Area



Figure 6. University Point / Illahee



3.0 GOALS AND OUTCOMES AND PROJECT DELIVERABLES

The goals of the Port Orchard Passage Restoration Project were to:

- Restore 303(d) listed water bodies to water quality standards.
- Restore and protect designated beneficial uses in Port Orchard Passage and Agate Passage receiving waters.
- Protect healthy waters from degradation.
- Respond to shellfish classification downgrade by DOH.

The water quality and environmental outcomes of the Port Orchard Passage Project were:

- Significantly reduce FC bacteria levels in fresh water drainages to shellfish growing areas of Port Orchard Passage.
- Locate failing onsite sewage systems that contribute to FC pollution in the area and repair or replace 100% of them.
- Correct any animal waste problems through education and/or enforcement.
- DOH upgrades classification of shellfish growing areas in project area.

Performance Items and Deliverables:

- Public education and outreach
- Shoreline surveys to locate FC pollution sources
- Technical assistance and enforcement to ensure correction of pollution sources.
- QAPP for post corrective monitoring
- Post corrective monitoring to document improvements in water quality
- Final report

Section 4, Project Design and Methods describes the Health District's four tier plan that was implemented to accomplish the goals and expected outcomes listed above. Section 5, Results and Discussion, presents project results as compared to these goals and expected outcomes.

4.0 PROJECT DESIGN AND METHODS

4.1 Shoreline Surveys

The core activity completed by the Health District to achieve project goals and outcomes was marine shoreline surveys in the areas described in Figures 1, 4, 5 and 6. Wet season shoreline surveys were performed in April 2011 and February 2012, and dry season shoreline surveys were performed in June 2011 and June 2012. All three sections of shoreline, totaling 7 miles, were sampled during each survey. Wet season shoreline surveys screen for OSS that fail due to surface or groundwater intrusion. Dry season surveys can identify failures masked by dilution during the wet season.

During the shoreline survey, all significant discharges to the marine environment were sampled for FC bacteria. Typical discharges included: curtain drains, bulkhead drains, roof drains, culverts, small streams and bank seeps. Samples were collected at low tide to target the discharge of fresh water versus the drainage of residual marine water.

Sampling stations were given an identification number in sequence from the starting point to the endpoint of the survey. They were also photographed, noted, and global position system (GPS) coordinates were recorded. Location descriptions were recorded at each sample station in the field notebook.

Pursuant to an interlocal agreement, the City of Bainbridge Island assisted with the shoreline surveys and related confirmation sampling. Their labor served as local match for this project and helped reduce travel expenses for this project.

Discharges exceeding screening criteria of 200 FC/100ml were resampled twice to confirm contamination. If the geometric mean of the samples exceeded screening criteria, then the location was designated a hot spot and the source identification process was initiated. The purpose of this is to ensure that only stable and consistent “hot spots” are investigated, which improves our efficiency.

Properties associated with the FC hot spots were inspected to identify and correct any human caused FC sources.

4.2 Property Surveys

In addition to inspecting properties associated with FC hot spots, the Health District inspected additional properties that had the possibility of impacting water quality in the shellfish closure areas.

Individual property surveys were conducted according to the “Manual of Protocol: Fecal Coliform Bacteria Pollution Identification and Correction” (Health District, 2011). A property survey consisted of an OSS record search, homeowner/resident interview, field inspection, and water sampling and dye test when necessary. The purpose of the survey was to identify all potential sources of FC contamination (including failing OSS and inadequate animal waste management). Surveys included an educational component to provide information to property owners about how to operate and maintain their OSS and to identify any non-conforming conditions that could cause premature OSS failure. Property owners were given copies of their OSS records, a fact sheet about the project, and information about septic loan programs when appropriate. Homeowners were encouraged to inspect their drainfield and tank areas with Health District staff to learn the symptoms of a failing OSS. Often these inspections revealed non-conforming conditions and potential problems, such as improper placement of roof drains, damage to a drainfield by parking vehicles over the laterals, or unwanted growth of blackberry bushes and tree roots that could obstruct the disposal lines. Many properties were selected based on the watershed boundaries, but others were selected based upon proximity to marine shoreline FC “hot spots”, public sewage complaints and “deficient” OSS monitoring and maintenance or pumper reports.

Some of the surveys required additional inspections due to conditions that suggested a failing OSS. These “suspect” systems required laboratory samples of surface water and dye testing. A system with suspect conditions, such as a saturated drainfield area, or a negative dye test with high FC counts, received a rating of “suspect,” and the homeowner was encouraged to take the necessary steps to improve the operation of the OSS. When an OSS received a rating of “non-conforming,” such as non-permitted repairs or alterations or additional bedrooms added to the home, the homeowner was informed of the issues, their impact on the OSS, and the necessary steps to resolve the issues. Suspect and non-conforming systems found during this project were recorded in Health District records without corrective enforcement. Inspectors also identified potential non-OSS FC sources like pet waste, livestock waste, as well as nutrient sources during the survey. Property survey results are located in Section 5.1.

4.3 Education and Outreach

Educating homeowners on potential FC and nutrient sources and how to prevent them was a critical part of the Port Orchard Passage Restoration Project. Public education was accomplished in four primary ways:

- During property surveys
- Public meetings
- Partnership with Bainbridge Island Land Trust on educating local high school students
- Partnership with the Puget Sound Restoration Fund on activities related to community shellfish farms and the importance of good water quality.

4.4 Water Quality Monitoring

Water quality monitoring was conducted pursuant to the approved “Port Orchard Passage Restoration Project Quality Assurance Project Plan” (February 2011).

4.3.1 Trend Monitoring

The Health District has conducted trend monitoring of Kitsap County streams and marine waters since January 1996, through funding from KCSSWM. Trend monitoring is conducted pursuant to the Health District’s Trend Monitoring Plan, see **Appendix A** for Trend Plan.

The Health District conducted monthly trend monitoring of four stream mouth stations (Steele Creek, Illahee Creek, Illahee State Park Creek, Enetai Creek), and three marine stations in the vicinity of the project area. Please see **Appendix B** for a list of monitoring stations, and **Figure 1** for their locations.

5.0 RESULTS AND DISCUSSION

Table 4 compares project results to project goals, outcomes and deliverables described in Section 3.

Table 4. Comparison of Project Results to Project Goals, Outcomes and Deliverables

<u>Goals</u>	<u>Status</u>	<u>Comments</u>
Restore 303(d) listed water bodies to water quality standards	Progress	Remaining failing OSS must be repaired, and flushing of contaminated discharges must occur before data review can occur.
Restore and protect designated beneficial uses in Port Orchard Passage and Agate Passage receiving waters	Progress	Beneficial uses were protected by educating (172) project area residents about preventing nonpoint source pollution from their properties. Restoration cannot be evaluated until all failing OSS have been repaired.
Protect healthy waters from degradation	Achieved	18 failing OSS were identified and have been or will soon be corrected. All property owners who participated in the project (172) received education about preventing nonpoint source pollution from their property.
Respond to shellfish downgrade by DOH	Achieved	Pending correction of 10 failing onsite sewage system and post project follow up investigation of selected "hot spots"
<u>Water Quality & Environmental Outcomes</u>	<u>Status</u>	<u>Comments</u>
Significantly reduce FC bacteria levels in fresh water drainages to shellfish growing areas of Port Orchard Passage	Progress	A true post-corrective water quality assessment cannot be completed until all OSS repairs are complete. The project did not include PIC investigations on the four (4) streams that were monitored, so they cannot be assessed for improvement.
Locate failing onsite sewage systems that contribute to FC pollution in the area and repair or replace 100% of them.	Progress	18 failing OSS were identified and have been or will soon be corrected.
Correct any animal waste management problems through education and/or enforcement	Progress	One property owner admitted to feeding raccoons, which created a "hot spot" on the shoreline. After being asked to cease this activity, water quality improved in the drainage.
<u>Performance Items & Deliverables</u>	<u>Status</u>	<u>Comments</u>
DOH upgrades classification of shellfish growing areas in project area	Progress	Pending correction of 10 failing onsite sewage system and post project follow up investigation of selected "hot spots"
Public education and outreach	Achieved	172 property owners received education about preventing nonpoint source pollution from their property. Two (2) public meetings were held in the project area, and the Puget Sound Restoration Fund conducted education programs focusing on the link between good water quality and safe shellfish farming and harvesting.
Shoreline surveys to locate FC pollution sources	Achieved	Four (4) complete marine shoreline surveys were completed in the project area.
Technical assistance and enforcement to ensure correction of pollution sources	Progress	Property owners with failing or suspect onsite sewage systems received technical assistance re the repair process.
QAPP for post corrective monitoring	Achieved	Approved by Ecology 2/2011 .
Post corrective monitoring to document improvements in water quality	Progress	Monitoring has been completed for "hot spots" where failing onsite sewage systems were corrected, and for a "hot spot" associated with a property owner who was required to stop feeding raccoons and creating a nuisance. Those results show some improvement. No improvements noted at the three (3) marine stations. The project did not include PIC investigations on the four (4) streams that were monitored, so they cannot be assessed for improvement. A true post-corrective water quality assessment cannot be completed until all OSS repairs are complete.
Final Report	Achieved	Submitted to Ecology 5/2013 .

The following is a detailed discussion of project results organized by major activity. Each activity was one of the components of the Health District's four tier plan designed to clean up the degraded portions of the Port Orchard Passage shellfish growing area.

5.1 SHORELINE SURVEYS RESULTS

Shoreline sampling is an effective approach to restore and prevent further downgrades in shellfish growing areas along the Port Orchard Passage Shoreline. Shoreline surveys consist of walking the shoreline at low tide and sampling all discharges to the beach. A total of 7.0 miles of Port Orchard Passage and Agate Passage shoreline were surveyed during wet weather and dry weather; 1.2 miles along Agate Passage, 1.3 miles along Crystal Springs, and 4.5 miles along University Point / Illahee. A total of **624** initial FC samples and **78** sets of confirmation samples were collected from the Port Orchard Passage Shoreline during the course of the project. Subsequent confirmation sampling established a total of 23 FC hotspots in the growing area.

Wet season shoreline surveys were performed in April 2011 and February 2012, and dry season shoreline surveys were performed in June 2011 and June 2012. All three sections of shoreline, totaling 7 miles, were sampled during each survey. Please refer back to **Figures 4-6** for maps of the shoreline survey areas.

5.2.1. Agate Passage Shoreline

The 1.2-mile section of the project shoreline is predominantly high bank waterfront with some medium bank properties. Parts of the shoreline are protected by bulkheads or riprap, while the remainder of the embankments are unimproved. Significant sections of the shoreline in this area are stabilized by native vegetation and accessed by steep staircases from the shoreline residences. Approximately 75% of the shoreline parcels contain occupied structures. The area is almost exclusively residential, with no commercial properties, and only one "hobby" farm with small livestock in the upland area.

134 initial samples at **46** unique sampling stations were collected in the Agate Pass shoreline section during the project. **Five (5)** FC "hot spots" were identified in this area. No failing oss were identified in proximity to these FC "hot spots".

Two of the hotspots appear to be directly attributed to a very high density raccoon population within the drainages. The Health District found that one property owner had been daily feeding a population of raccoons, between 30 and 60 raccoons, which led to this abnormally high density of raccoons in the vicinity. We have observed multiple raccoon latrines located within the drainage, leading to the high fecal coliform bacteria levels in the basin.

The Health District has provided education information to the offending parties, and is working with local property owners and WA State Dept of Fish & Wildlife to remove the attractive nuisance, and reduce the raccoon population in this area.

5.2.2. Crystal Springs Shoreline

This 1.3-mile section of the project shoreline is an equal mix of low, medium, and high bank waterfront, with most properties including steep slopes on the property. True to its name, the Crystal Springs shoreline features a high water table with many natural springs throughout the area. Most of the shoreline in this area is protected by bulkheads or riprap, and there are five privately owned docks and many private boat ramps in the area. The area is exclusively residential; with approximately 90% of the shoreline parcels containing occupied structures. The upland area contains a large nature preserve, Gazzam Lake, which drains into Port Orchard Passage by the way of many small streams passing through the project area.

157 initial samples at **47** unique sampling stations were collected in the Crystal Springs shoreline section during the project. **Seven (7)** FC “hot spots” were identified in this area. Two failing OSS were found in proximity to one of the hotspots; both are scheduled for repair during the 2013 dry season.

Near the northern end of Crystal Springs, in the areas adjacent to the Gazzam Lake Nature Preserve, is heavily populated with raccoons, otters, and deer. Attempts to segment the hotspot drainages above the populated shoreline parcels have shown that the drainages have elevated fecal coliform bacteria upstream of human influenced stream sections. This information, combined with negative dye tests, suggests that the wildlife population may be a large contributor to the elevated fecal coliform bacteria levels in that area.

5.2.3. University Point / Illahee Shoreline

The shoreline around University Point is mostly medium and high bank properties, and contains long sections of native vegetation with the residences are set back from the immediate shoreline due to the high bank nature of the coastline in this area. The embankments gradually decrease as you head south towards Illahee, and become predominately low and no bank properties between Illahee Creek and Illahee State Park Creek. Most of the low and medium bank properties are protected by bulkheads or riprap. The properties are predominately residential, with very few commercial properties, and one “hobby” farm with small and medium livestock.

334 initial samples at **112** unique sampling stations were collected in University Point / Illahee shoreline section during the project. **Eleven (11)** FC hot spots were identified in this area. Failing OSS were found at two of the hotspots. All three failing oss will be repaired by July 2013. No FC sources were identified in the remaining hotspots.

5.2 OSS Property Survey Results

Pollution Identification and Correction (PIC) OSS surveys were conducted from March 2011 to April 2013.

Residents of **172** properties participated in the PIC survey and based upon the results of each survey, OSS were categorized as “Failing,” “Suspect,” “Non-Conforming,” “No Records,” or “No Apparent Problems.” **Table 5** summarizes the project OSS survey results. OSS were rated according to “Criteria for Rating OSS” in **Appendix C**.

**Table 5. Summary of Pollution Identification and Correction Results
1/1/2011 – 4/30/2013**

Project Areas	Participating Properties	Failing		Suspect		Non Conforming		No Records		No Problems	
		#	%	#	%	#	%	#	%	#	%
Bainbridge Shoreline	58	8	14%	2	4%	0	0%	7	12%	41	72%
KC Shoreline	114	10	8%	3	3%	9	8%	20	18%	72	63%
Total Project Area	172	18	10%	5	3%	9	5%	27	16%	113	66%

5.1.1 Analysis of Failures

Historically, the average life expectancy for onsite sewage systems in Kitsap County is approximately thirty years. Misuse and environmental factors can shorten their life and regular maintenance and good home practices can lengthen it. The most common factors observed in the project area that contributed to OSS failure were:

- Age of the OSS
- Poor soil types
- Shallow depth to water table or an impervious layer
- Hydraulic overload by the residents
- Inadequate or lack of maintenance of the OSS
- Root intrusion into OSS components

The **10%** failure rate found in the project area is within the expected range for properties in Kitsap County. Historically, similar projects conducted by the Health District since 1995 have found a failure rate between two and fifteen percent (2% - 15%).

Of the **18** failures identified during the project the most common identifying characteristic was sewage coming to the surface of the ground from the OSS. **Table 6** displays the types of failures observed during the project.

Table 6. Onsite Sewage System Failure Type

Number	Percent of total	Description
6	33%	Surfacing on ground
3	17%	Discharge to surface water
3	17%	Direct discharge to ground surface
2	11%	Backing into structure
2	11%	Cross connection to drain system
1	5.5%	Greywater Discharge
1	5.5%	Other

Figure 7 describes the location of the failing oss.

Ten (11) of eighteen (61%) failing OSS have been repaired: six (55%) were repaired with alternative on-site systems; five (45%) were repaired with minor repairs. The remaining seven (7) are in the repair process. All repairs should be completed by July 2013.

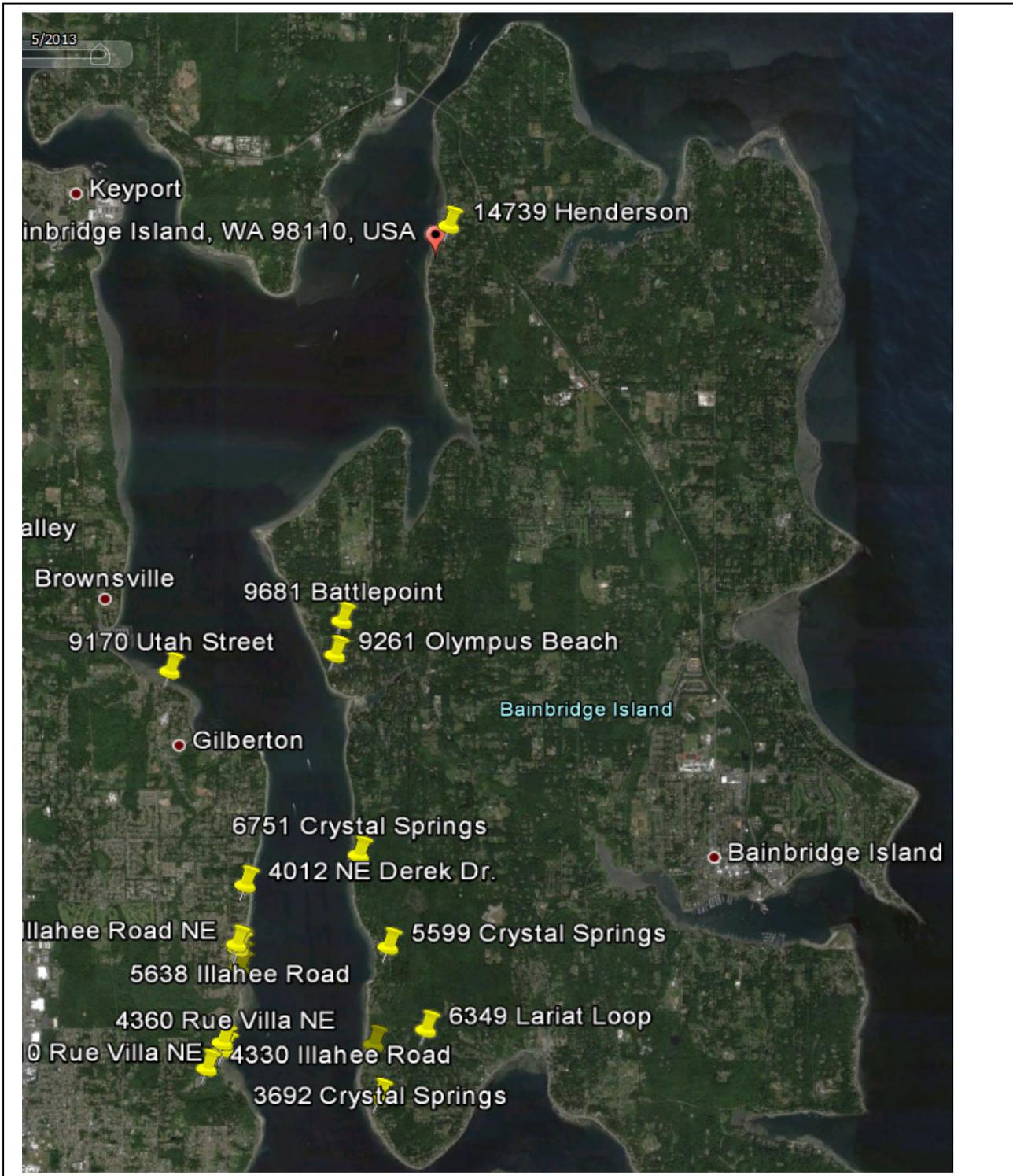
5.1.3 OSS Maintenance Requirements

State and local regulations require that all OSS be properly maintained and monitored. Kitsap County Board of Health Ordinance 2008A – 01, “Onsite Sewage System and General Sanitation Regulations” were applied to OSS problems during this project. All alternative septic systems are required to have ongoing operation and maintenance, and all standard gravity septic systems require tank inspection every three years.

5.1.2 Non-OSS FC Sources

PIC surveys include a non-OSS FC source component for animal, pet and livestock waste. Property owners and residents are asked if they have any animals, how many, and what type. They are asked to provide detail on how they manage the waste. Staff then determine if the management of the waste is in compliance with state and local regulations. These regulations

Figure7. Location of OSS Failures



If a problem with pet waste is observed, the owner is educated on how to manage it correctly. This includes a discussion of what the regulations require, and outreach materials from the Kitsap Peninsula Clean Runoff Collaborative. The Collaborative has provided new outreach materials to address the estimated eleven plus tons of dog waste dropped on the Kitsap Peninsula daily. This daily load is consistent with other Puget Sound communities. In extreme cases, the owner can be enforced to comply with local regulation.

The Health District investigates high priority agricultural properties in project areas and works cooperatively with the Kitsap Conservation District (KCD). Landowners are referred to KCD to address water quality violations due to animal waste management. Within the Port Orchard Passage Restoration Project area, there was minimal agricultural influence. Only two small agricultural properties were located within the project area, and both properties exhibited excellent waste management practices. Water quality monitoring results below agricultural properties in the Port Orchard Passage watershed have not demonstrated a detrimental effect from the farms.

Wildlife can adversely affect water quality by digging latrines, obstructing stormwater conveyances and burrowing into drainfields. Raccoons, mountain beavers, otters, waterfowl, and deer are present throughout the project area, and can be found in dense populations in certain areas. Additional site specific information on the potential effect of wildlife on the project is discussed below in the Shoreline Survey Results section.

5.3 EDUCATION AND OUTREACH

During property inspections, Kitsap Health staff provided homeowners with educational brochures, a copy of the sewage disposal permit, as-built, and OSS plans for their home. Health District staff also emphasized that operation and maintenance is crucial to prevent premature septic system failures and for protecting water quality in Port Orchard Passage. During the OSS inspection, the Health District staff shared site-specific recommendations on how to get the most life out of their septic system. Any practice that might stress the system or reduce performance was identified and possible solutions were provided. Informational brochures and water-conserving fixtures were made available to all residents.

Three public meetings were held in the project area to provide project updates and more detailed education for property owners and their tenants. The Health District conducted a basic Onsite System Workshops at the initial public meeting. And, the Health District attended and provided education at local events such as the Puget Sound Restoration Fund's Community Clam Dig.

The Puget Sound Restoration Fund (PSRF) provided education at outreach at many community events including: the PSRF Community Clam Dig, the Madrona School Auction, the Bainbridge Island Land Trust Auction, the Town and Country Earth Day Festival, and the Bainbridge Island Rowing Club Auction. All PSRF education activities focused on the linkage between good water quality, proper care and maintenance of OSS, and healthy shellfish resources.

The Health District partnered with the Bainbridge Island Land Trust to provide the Bainbridge Island High School Environmental Science class with a lesson plan on water quality monitoring, including field monitoring and hands on experience.

Specific accomplishments include, but are not limited to:

The Health District:

- Held a public meeting for the Port Orchard Passage PIC at the Bainbridge Island Commons from 6:00 to 8:00 on **March 31, 2011**. In addition, an Onsite Septic System Workshop was conducted at this time. A total of **15** attendees participated in both the project meeting and Workshop.
- Attended Puget Sound Restoration Fund's Community Clam Dig on **September 23, 2011**. During the dig, Health District Staff presented project and onsite septic system information. A total of **22** residents attended the meeting and two shellfish gardens were installed, bringing the total number of gardens along Crystal Springs Drive to four.
- Presented project findings to date at Illahee Homeowners' Association meeting on **February 11, 2013**.
- The Kitsap Public Health District held a public meeting on Tuesday, **December 18th, 2012**, from 6:00 p.m. to 8:00 p.m., at the Council Chambers in City Hall, 280 Madison Avenue N, Bainbridge Island. Health district staff presented an update on the restoration work completed and current level of water quality in the Port Orchard Passage watershed, as well as provide education on onsite septic systems. A question and answer period followed the presentation.

The Puget Sound Restoration Fund:

- Hosted a Crystal Springs neighborhood meeting with 18 property owners August 27, 2011.
- Constructed and installed 5 bag dispensing stations along Crystal Springs with signs to help reduce pet waste.
- Installed 3 bag dispensing stations around the Agate Pass neighborhood.
- Conducted an Agate Pass (Henderson Road) neighborhood meeting with 12 property owners September 25, 2011.
- Hosted Agate Pass clam bake September 25, 2011.
- Installed a total of 20 shellfish gardens (12 along Crystal Springs and 8 along Agate Pass).
- Sent two information letters to Agate Pass & Crystal Springs property owners.

- Involved 30 CSA members in the 2011 harvest season and 50 CSA members in the 2012 harvest season at the Port Madison Community Shellfish Farm. 81 volunteers helped harvest 643 dozen oysters in 2011 and 56 volunteers helped harvest 583 dozen oysters in 2012 for CSA members, restaurants and stores.
- Communicated with all gardeners and CSA members to alert them of PSP closures in 2011 and 2012.
- Sold Port Madison Petites at 4 Farmers Market Days in summer 2011.
- Distributed 225 dog biscuits with pet waste bags and information at Paws & Fins and Bay, Hay & Feed.
- Worked with Kitsap Public Health District and the Bainbridge Review to publish an article March 24, 2011.
- Prepared and staffed an educational display and filtration model for Town & Country's Earth Day Festival April 21, 2012.
- Hosted a clam dig May 11, 2012 for 5 residents along Henderson Rd.
- Hosted shellfish seed sales June 4, 2011 and June 2, 2012 and assisted with garden installations.
- Organized a final clam dig October 13, 2012 that had to be cancelled due to low attendance.
- Kicked off the Oyster-Giveaway program for island residents who get their septic systems inspected and pumped. The program was publicized in the Bainbridge Review and on the PSRF website beginning December 1st. Oysters will be distributed to people with inspection certificates in spring 2013 when harvest at the Port Madison Community Shellfish Farm resumes. For a link to the ad, go to: <http://www.bainbridgereview.com/calendar/#/?i=1> (Also see attachment).

The City of Bainbridge:

- Established a Mutt Mitt pet waste management station at the Point White Dock on Crystal Springs (**Summer 2012**)

5.4 WATER QUALITY MONITORING

5.3.1 Trend Monitoring Results

Trend monitoring was conducted at four stream mouth stations and three marine stations during the project to evaluate FC contamination in the vicinity of the project area. A summary of the sample results is presented in **Table 6** below.

Table 7. Freshwater Trend Monitoring (FC) Results 10/1/2011 to 9/30/2012

Station	Number of samples	Range (FC/100ml)	GMV	# Samples >100FC/100ml	% Samples > 100 FC/100ml	Meets FC Standard?
ST01	12	4 - >=2000	106	7	58%	No
IC01	12	4 - 1070	14	1	8%	Yes
SP01	12	10 - 480	41	4	33%	No
DE01	12	10 - >=2000	130	6	50%	No

ST01 - Steele Creek mouth station

IC01 –Illahee Creek mouth station

SP01 – Illahee State Park Creek mouth station

DE01– Enetai Creek mouth station

¹ Extraordinary Primary Use Category. FC levels shall not exceed a GMV of 50 FC/100 ml and not have more than 10% of all samples exceed 100 FC/100 ml.

Bold entries indicate an exceedance of the applicable water quality standard (Chapt.173 – 201A-030 WAC)

Table 8. GMV by Water Year Summary Table*

Water Year	Geomean Values (FC / 100ml)			
	Steele	Illahee	Illahee State Park	Enetai
2008	65	26	31	47
2009	49	11	35	56
2010	94	42	83	108
2011	51	37	33	89
2012	100	15	40	123

*Results are for stream mouth stations

Additional stream mouth station water quality information broken out by water year is presented in **Appendix E**.

Table 9. Marine Water Trend Monitoring (FC) Results 10/1/2011 to 9/30/2012

Station	Number of samples	Range (FC/100ml)	GMV	# Samples >43FC/100ml	% Samples > 43 FC/100ml	Meets FC Standard?
PO13	11	<2 - 349	6	2	18%	No
BU01	11	<2 - 20	4	0	0%	Yes
PO04	11	<2 - 8	<2	0	0%	Yes

PO13 – Mouth of Enetai Creek on south terminus of project area

BU01 – Burke Bay, mouth of Steele Creek

PO04 – Off Central Kitsap POTW outfall midway between Burke Bay and Keyport Naval Reserve

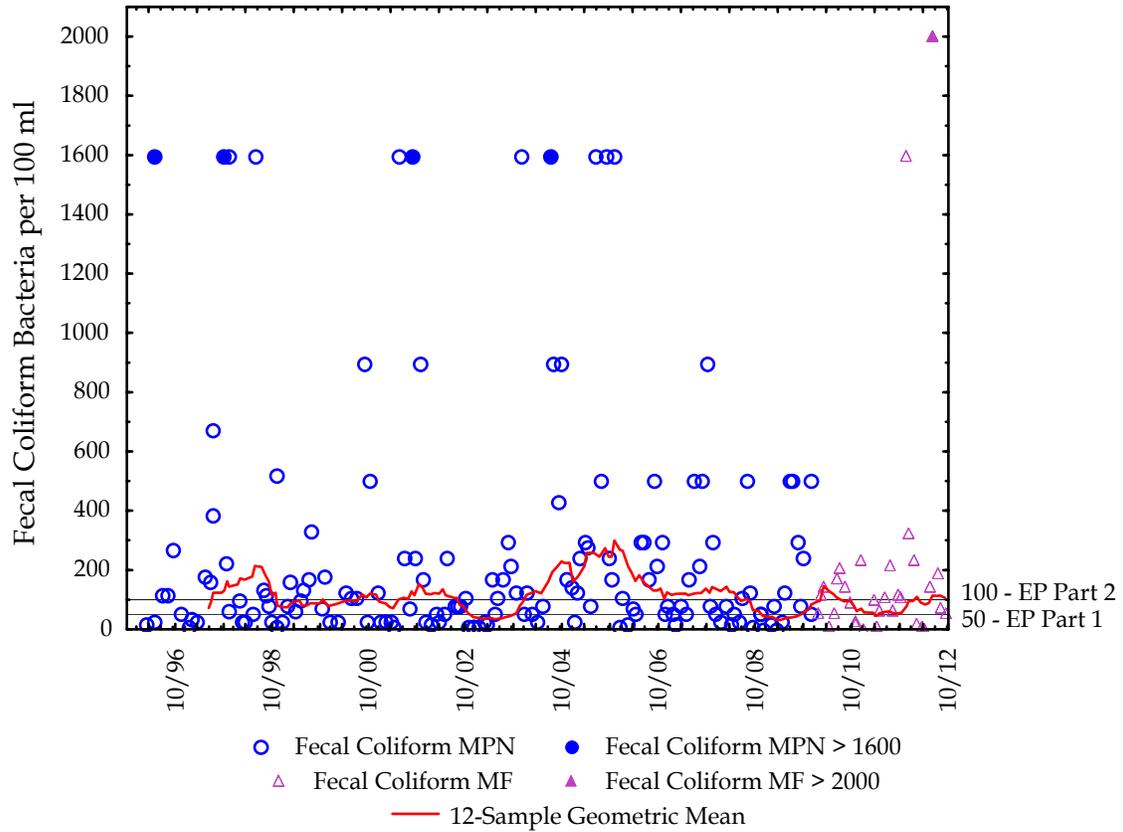
¹ Extraordinary Primary Use Category. FC levels shall not exceed a GMV of 14 FC/100 ml and not have more than 10% of all samples exceed 43 FC/100 ml.

Bold entries indicate an exceedance of the applicable water quality standard (Chapt.173 – 201A-030 WAC)

5.3.2 Trend Analysis

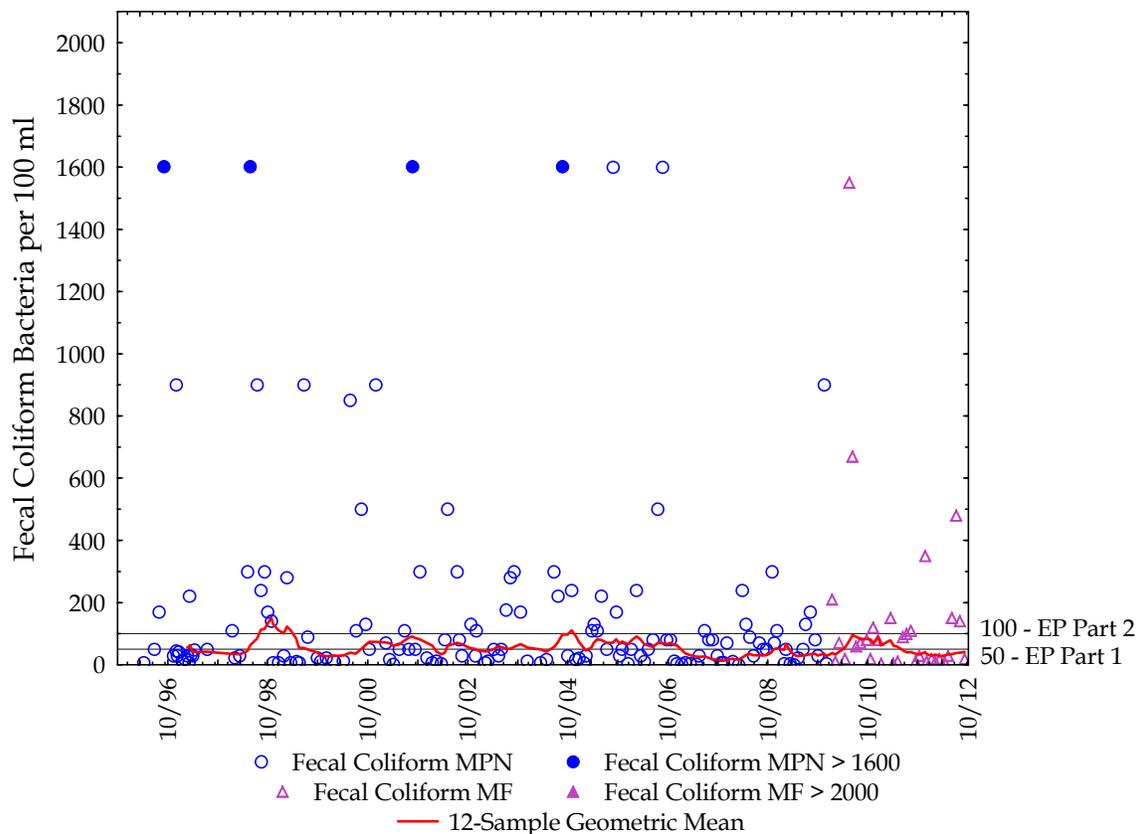
Statistical analysis of FC data was performed at the mouth stations of Steele, Illahee, Illahee State Park, and Enetai Creeks. **Figures 7 through 10** present summaries of the freshwater trend results. **Figures 11 through 14** present summaries of the marine water trend results. Kendall seasonal statistical data is available in **Appendix F**.

**Figure 8. Fecal Coliform Bacteria Trend Analysis
Steele Creek (Station ST01), 1996 - 2012**



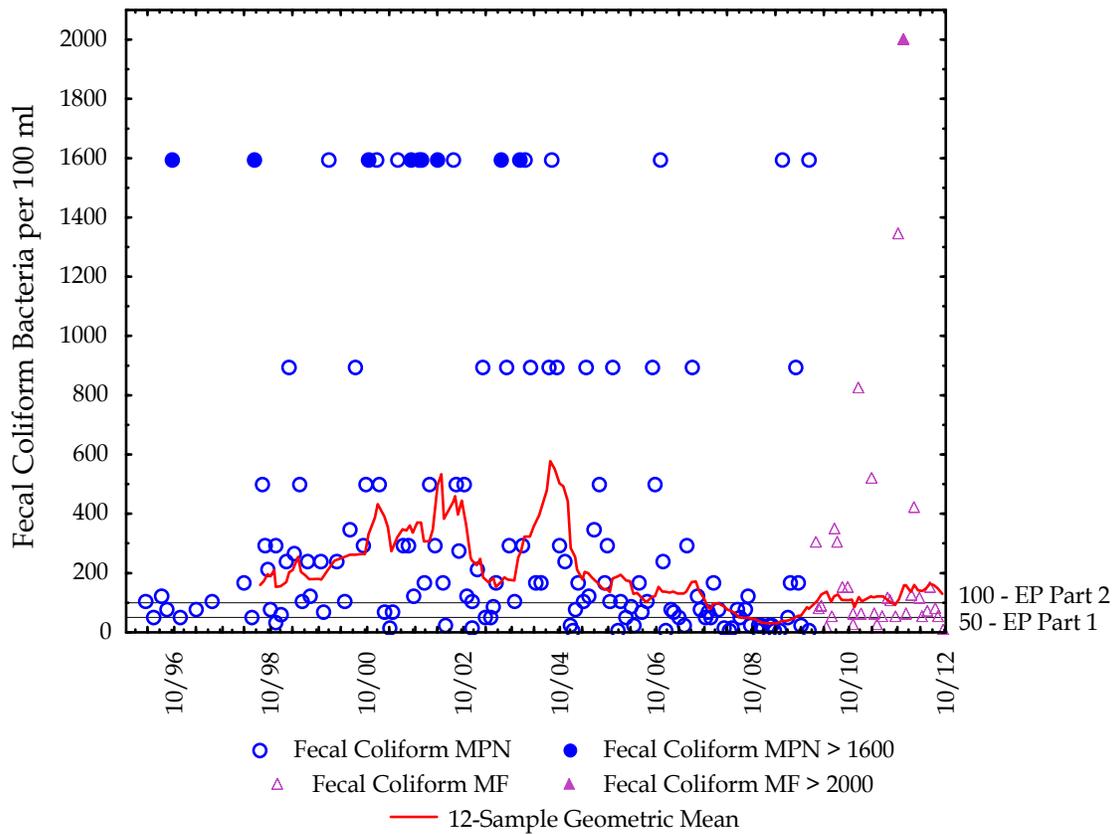
The overall water quality of Steele Creek remains poor, and failed both parts of the freshwater Extraordinary Primary Use Category for the 2012 water year. Both the long term trend (5+ years) and the short term (3 year) trend remain stationary. No property surveys were conducted along this stream as that was outside the scope of the project.

**Figure 10. Fecal Coliform Bacteria Trend Analysis
Illahee State Park Creek (Station SP01), 1996 - 2012**



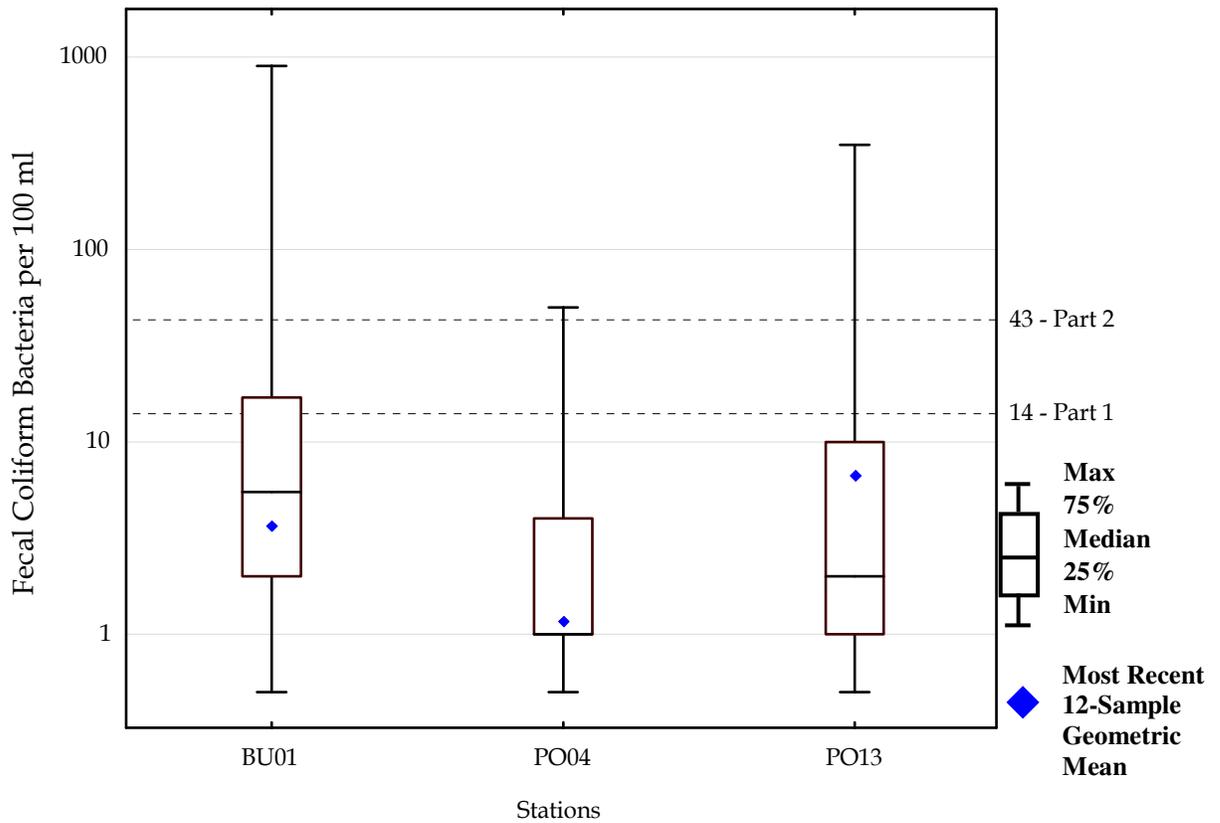
Water Quality in Illahee State Park Creek is good with the long term trend (5+ years) shows that the creek is improving, while the short term (3 year) trend remains stationary. In 2012, the Illahee State Park Creek met Part 1 of the freshwater Extraordinary Primary Water Quality Standard, but failed Part 2 of the standard. No property surveys were conducted along this stream as that was outside the scope of the project.

**Figure 11. Fecal Coliform Bacteria Trend Analysis
Enetai Creek (Station DE01), 1996 - 2012**



While the overall water quality of Enetai Creek remains poor, the long term trend (5+ years) shows that the creek is improving, while the short term (3 year) trend remains stationary. No property surveys were conducted along this stream as that was outside the scope of the project.

Figure 12. Port Orchard/Burke Bay Marine Water Summary 1996 – 2012



Port Orchard / Burke Bay marine waters are showing a significant improving global trend. One of the three individual sampling stations in the watershed (BU01) is showing significant, long-term improvement.

6.0 CONCLUSIONS

The goals of the Port Orchard Passage Restoration Project have been achieved:

- FC concentrations in many of the problem drainages have been reduced. The Health District expects to see more improvements after additional OSS repairs and follow-up work is completed. Unfortunately, those improvements may be masked by new FC sources.
- 59% of the failing OSS have been corrected, and 7 (41%) are in the correction process. Repairs should be complete by July 2013.
- Shoreline surveys were an effective method of finding OSS failures. OSS inspections and water quality monitoring activities are effective in the wet season to find OSS failures caused by surface or ground water intrusion. Dry season inspections and monitoring are effective to find OSS failures that are masked by storm water or are only occupied in the summer.
- Non-point pollution is best addressed by visiting as many watershed residents as possible. Door-to-door surveys are an excellent way to get site-specific information on local water quality problems and how to reduce bacterial and nutrient pollution sources.
- Analysis of wet and dry season monitoring indicates that FC levels are significantly higher during the dry season than during the wet season in various drainages. Decreased stream flow and external sources such as runoff from impervious surfaces may contribute to higher bacteria levels during dry weather.
- It is difficult to meet the extraordinary primary FC standard that applies in this watershed. This is particularly difficult in areas where there is a large population of wildlife, including raccoons and otters.
- This watershed will need an ongoing effort to protect water quality because many of the OSS are well past the average functional lifespan of approximately 30 years. Older OSS were designed through percolation tests and are designed for disposal rather than effluent treatment.

7.0 RECOMMENDATIONS

The following recommendations are presented as a result of interaction with homeowners, experience gained, and evaluation of sample results from the Jump off Joe Restoration Project:

- Complete correction of the remaining OSS failures and investigate remaining FC hotspots found through the Port Orchard Passage shoreline survey.
- Continue to track water quality trend data at mouth stations for post-corrective analysis and long-term correction. The Health District's annual project area ranking process automatically assesses water quality for FC problem areas. These are ranked by KCSSWM partners and guide program activities.
- Share project results with DOH's shoreline survey program to remove closure zones from areas established around OSS failure zones.
- Pursue funding to conduct future shoreline surveys to protect shellfish growing areas and continue to maintain other improvements gained by the project. Proactively promote water quality in the community at outreach events.
- Continue the strong partnership with DOH, Ecology and other water quality agencies to coordinate, assess and implement ongoing water quality restoration and protection tasks. Communicate significant water quality issues with DOH, Ecology and other appropriate agencies.
- Continue to seek technology and methods to better identify and correct FC pollution sources.
- Research potential methods to better build public trust, by actively working to provide accurate and representative data upon which to base regulation and legislation.
- Recommended follow-up work will be conducted through ongoing KCSSWM funding, the trend monitoring program, public OSS/water quality complaint process, and review and follow up of deficient tank pumping reports.
- Develop specific educational materials that apply to water quality impacts of wildlife. A brochure should be developed that highlights the importance of not feeding wildlife and managing garbage, manure, compost, etc. in such a way that prevents attractive nuisance.

8.0 REFERENCES

Kitsap County Board of Health Ordinance No. 2008A-01, "Rules and Regulations Governing On-Site Sewage Systems." 2008.

Bremerton-Kitsap County Health District, Ordinance 2010-1, Solid Waste Regulations. July 6, 2010.

Kitsap County Health District, Trend Monitoring Plan. March 2010.

Kitsap County Health District, Manual of Protocol: Fecal Coliform Bacteria Pollution Identification and Correction Projects. 2011.

Kitsap County Health District. Water Quality Monitoring Report. 2011-2012.

Kitsap County Stormwater Management Manual, Appendix 8A Maintenance Guidelines. April 1997.

Washington State Department of Ecology. Chapter 173-201A of the Washington Administrative Code Water Quality Standards for Surface Waters of the State of Washington. 1992.

Washington State Department of Ecology, Clean Water Act Section 303(d) List of Impaired Surface Waters. 1996, 1998, 2005, 2008 and 2012.

Washington State Department of Health, 2009 Shoreline Survey of the Port Orchard Passage Shellfish Growing Area, March 2009