WATER QUALITY DATA ANALYSIS REPORT

Prepared for
City of Sequim

Prepared by
Herrera Environmental Consultants, Inc.

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Water Quality Data Analysis Report

Prepared for
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INTRODUCTION

The City of Sequim (City) is actively addressing stormwater quantity and quality issues. Herrera Environmental Consultants, Inc. (Herrera) is assisting with development of the City's first Storm and Surface Water Master Plan (Master Plan). The purpose of the Master Plan is to set goals, determine strategies, define actions, and identify funding strategies for risk management, environmental stewardship, and regulatory compliance with regard to stormwater and surface water as the city grows. One of the first tasks in the Master Plan development is the evaluation and assessment of existing information. The purpose of this report is to assess available water quality data pertinent to the Master Plan. This data analysis will be used to evaluate and prioritize potential water quality improvement projects and targeted programmatic efforts.

From 2008 through 2011, the Clallam County Streamkeepers volunteer monitoring organization (Streamkeepers) conducted monitoring on streams, ditches, sediments, and storm drains within Clallam County. Data analyzed for this report includes the subset of sites monitored by Streamkeepers that pertains to streams and stormwater runoff in and around the city. To date, a comprehensive analysis of these water quality data has not been performed. This report presents a summary and limited analysis of these data. Water quality and sediment data availability and monitoring locations are initially summarized, followed by an assessment of the quality of the existing data. The report then provides an interpretation of the data organized by stream. Conclusions (including monitoring recommendations) are presented at the end of the report.

WATER QUALITY AND SEDIMENT STUDIES

Water quality and sediment data summarized in this report was collected by the Streamkeepers for the following studies:

- **Clallam County Comprehensive Stormwater Monitoring (referred to as "Clallam County SW" in this report):** Water quality from base flow and storm events was collected in 2008 through 2011, and sediment quality data was collected in 2009 by the Streamkeepers to support a United States Environmental Protection Agency (EPA) funded project to develop a comprehensive stormwater monitoring program for Clallam County. These data were obtained from Clallam County Streamkeepers (Ed Chadd, Streamkeepers program coordinator, personal communication January 6, 2015) and EPA's Storage and Retrieval (STORET) database (EPA 2014a, EPA2014b).

- **Clean Water District monitoring (referred to as "Clean Water District" in this report):** Ambient water quality data collected during three monitoring dates in 2010 by the Streamkeepers on behalf of the Clallam County Clean Water District on streams contributing to Dungeness and Sequim Bays. These data were obtained from Ecology's EIM database (Ecology 2014).

- **Routine Streamkeepers monitoring:** Benthic Index of Biotic Integrity (B-IBI) data collected annually in Bell Creek from 1999 through 2003 by the Streamkeepers. B-IBI data was also collected in Bell Creek 2003, 2005, 2008, and 2010 and in Johnson Creek in 1999, 2007, and 2009.

- **Potential Stormwater Impacts on Sediment Quality in Urbanizing Clallam County Streams (referred to as "Brandenberger study" in this report):** Battelle Marine Sciences Laboratory was commissioned by Clallam County to conduct an analysis of heavy metal and total petroleum hydrocarbon (TPH) concentrations in streambed sediment (Brandenberger et al. 2003). Five streams, including Bell Creek, were sampled and analyzed for heavy metals and TPH in 2003. Results of the Brandenberger study are discussed in this report as a means of comparison.

MONITORING LOCATIONS

Multiple locations within the Bell Creek, Johnson Creek, and Gierin Creek drainage basins have been monitored since 1996. The drainage basin land area, percentage of the drainage basin within the city limits, and the land cover composition are summarized in Table 1 for the Bell, Johnson, and Gierin Creek basins based on data from the National Land Cover Database (NLCD) (NLCD 2011). The drainage basin locations and boundaries are depicted on Figure A-1 in Appendix A.

Table 1. Drainage Basin Size and Land Cover for Basins Located Within the City of Sequim.

	Bell Creek	Johnson Creek	Gierin Creek
Total Area	7.4 square miles	6.3 square miles	5.3 square miles
Basin Area Within City Limits	40%	14%	35%
City Area Within Basin[a]	46%	15%	29%
Land Cover (% of total basin)			
Developed, high intensity and medium intensity	16%	5%	26%
Developed, low intensity and open space	16%	7%	21%
Barren[b]	0%	1%	1%
Forest[c]	23%	44%	13%
Shrub/scrub[d]	2%	16%	0%
Herbacious[e]	1%	3%	2%
Planted/Cultivated[f]	39%	22%	29%
Wetlands[g]	2%	1%	6%
Water[h]	0%	2%	0%

Land cover category descriptions:

[a] The remaining 11% of the city includes small portions of Cassalery Creek (2.4%), the Dungeness River (2.9%), and two unnamed basins (4.7%).

[b] Barren areas are characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no vegetation present.

[c] Forest areas are characterized by tree cover where the tree canopy accounts for 25% to 100% of the cover. This category includes deciduous, evergreen, and mixed forest.

[d] Shrub/scrub areas are characterized by natural or semi-natural woody vegetation with aerial stems.

[e] Herbaceous areas are characterized by natural or semi-natural herbaceous vegetation. This category includes grassland/herbaceous and sedge/herbaceous.

[f] Planted/Cultivated areas are characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber. This category includes pasture/hay and cultivated crops.

[g] Wetlands are areas that are characterized by soil or substrate that is periodically saturated with or covered with water. This category includes woody wetlands and emergent herbaceous wetlands.

[h] Water includes open water and perennial ice/snow cover.

Each drainage basin contains multiple monitoring stations. In-stream monitoring stations are designated by the stream name (e.g., Bell) and the stream mile (e.g., 0.0 for the mouth of

the stream). Monitoring stations in the stormwater/irrigation drainage system are designated by the station name. The broad prairie in and around Sequim is flat with undistinguishable drainage basins. Irrigation ditches often cross these drainage basins, carrying stormwater runoff and irrigation water from one basin into another. A list of the monitoring stations is provided in Table 2 and depicted on a separate drainage basin figure for each of the three stream basins in Appendix A. The drainage basin figures in Appendix A also include the irrigation system and stormwater pipes since these systems influence drainage patterns in each basin.

Table 2. Monitoring Stations and Drainage Basins/Receiving Waters in the City of Sequim.

Monitoring Station/Landmark	Drainage Basin/Receiving Water	Study Name
Bell Creek		
Bell 0.2/Schmuck Road	Bell Creek/Washington Harbor and Sequim Bay	Clallam County SW, Clean Water District
Bell 0.8/Upstream of City Water Reclamation Facility and dairy farm		Clean Water District
Bell 1.6/N Blake Avenue		Clallam County SW
Bell 1.75/Les Schwab		Clallam County SW
Bell 4.2/Happy Valley		Clean Water District
Johnson Creek		
Johnson 0.0/mouth	Johnson Creek/Sequim Bay	Clean Water District
Johnson 2.0/Upstream of irrigation tailwater discharge		Clean Water District
Stormwater and Irrigation System		
Safeway Catch Basin	Shallow Aquifer (within the Gierin Creek drainage basin)	Clallam County SW
Sequim Bay Road	Bell Creek (via stormwater ditch)	Clallam County SW
Highland Ditch at E Washington St.	Bell Creek (direct)	Clallam County SW
Highland Ditch at Happy Valley Rd.	Johnson Creek (direct)	Clallam County SW
Eureka Ditch	Gierin and/or Cassalery Creeks (direct)	Clallam County SW

Basin characteristics are summarized separately below for Bell Creek, Johnson Creek, and Gierin Creek and the sampled stormwater systems and irrigation ditches. Gierin Creek basin land-cover data were also compiled, and the basin is described below, although only stormwater and irrigation system monitoring data were collected; no in-stream monitoring data are available for this basin.

Bell Creek

The Bell Creek drainage basin is bordered on the north by the Gierin Creek drainage basin and on the south by the Johnson Creek drainage basin. Bell Creek flows a total of 3.8 miles from the uplands of Happy Valley, where it receives runoff from Bell Hill and Burnt Hill, through the eastern portion of the city of Sequim, and discharges to Washington Harbor at the north end of Sequim Bay (Elwha-Dungeness Planning Unit 2005). Until recently, the middle and lower reaches of Bell Creek were supplemented with irrigation water from the Dungeness

River for the Highland Irrigation District for the duration of the irrigation season (Sequim 2014). Now, Bell Creek is known as an ephemeral stream fed primarily by groundwater and by stormwater runoff. Without supplementation with Dungeness River flow, the middle reaches of Bell Creek are dry during the summer months. The Highland Irrigation District maintains a separate irrigation system that, in the summer, conveys Dungeness River water as far east as Sequim Bay in both open ditch and piped segments, which cross or discharge to Bell Creek at multiple locations. In the winter, the irrigation system conveys Dungeness River water during dry weather, and intercepts runoff from west of the Bell Creek drainage basin into Bell Creek or Johnson Creek during wet weather. The Sequim Prairie Tri-Irrigation Company also maintains a separate irrigation system of pipes and ditches, some of which discharge runoff and/or irrigation tail water to Bell Creek. A wetland complex is located between Bell 1.3 and Bell 0.6.

The Jamestown S'Klallam Tribe monitors coho, steelhead, and cutthroat salmon outmigration in Bell Creek each spring, and federal assessments designate most of Bell Creek from the mouth to the crossing of the Highland Irrigation canal as critical habitat for threatened/endangered bull trout (USFWS 2010). A critical habitat designation is also proposed for Puget Sound steelhead in Bell Creek (NOAA 2013). Washington State Department of Ecology (Ecology) has included several lower reaches of Bell Creek on the 2012 303(d) list of impaired waters (Category 5) for fecal coliform bacteria, dissolved oxygen, and bioassessment (Benthic Index of Biological Integrity, B-IBI). Additional parameters (pH, temperature) and/or reaches are listed as Category 2, "waters of concern."

As indicated in Table 1, the total drainage basin area for Bell Creek is approximately 7.4 square miles, 40 percent of which is located within the city limits. Approximately 32 percent of the drainage basin is comprised of urban and rural development based on data from the National Land Cover Database (NLCD) with the remainder of the drainage basin primarily comprised of planted/cultivated areas (39 percent), forest (23 percent), and shrub/scrub (2 percent).

Water quality monitoring locations in the Bell Creek drainage basin are shown on Figure A-2 in Appendix A. A total of seven in-stream stations and two stormwater and irrigation system stations have been monitored in the Bell Creek basin.

Johnson Creek

The Johnson Creek drainage basin is bordered on the northwest by Bell Creek basin and on the southeast by an unnamed drainage basin in the county (Sequim 2014). Johnson Creek drains eastern portions of Bell Hill, Happy Valley, Burnt Hill, and county areas that drain directly to the Highland Irrigation canal (which empties into Johnson Creek at RM 1.5). The stream enters the city just upstream of SR 101, runs along the eastern edge of the city, and discharges into Sequim Bay just south of Pitship Point (John Wayne Marina).

Johnson Creek is considered suitable habitat for salmonids and is designated critical habitat for bull trout by the United States Fish and Wildlife Service (USFWS 2010). A critical habitat designation is also proposed for Puget Sound steelhead in Johnson Creek (NOAA 2013). Ecology included the lower reaches of Johnson Creek on the 2012 303(d) list of impaired

waters (Category 5) for fecal coliform bacteria. Additional parameters (pH, bioassessment) and/or reaches are listed Category 2, waters of concern.

As indicated in Table 1, the total drainage basin area for Johnson Creek is approximately 6.3 square miles, 14 percent of which is located within the city limits. Approximately 11 percent of the drainage basin is developed based on data from the NLCD with the remainder of the drainage basin primarily comprised of planted/cultivated areas (22 percent) and forest (44 percent).

Water quality monitoring locations in the Johnson Creek drainage basin are shown on Figure A-3 in Appendix A. A total of four in-stream stations and one stormwater and irrigation system station have been monitored in the Johnson Creek basin.

Gierin Creek

Gierin Creek basin is a small drainage basin, bordered on the south by Bell Creek basin and in the north by the Cassalery Creek basin. A large portion of what is known as Sequim Prairie comprises the upper Gierin Creek Basin. Sequim Prairie is characterized by flat topography, gravelly soils, and arid climate. Gierin Creek rarely has base flow until outside the city limits.

Gierin Creek is supplemented directly by Dungeness River water conveyed through the city in irrigation ditches during the summer, and receives stormwater runoff (via sheet flow and stormwater roadside ditches) carried in these irrigation ditches during the winter. Groundwater recharge in this basin is of particular importance, since the zone of contribution for the City's Port Williams well field is in this basin, and a portion of the basin (6 percent, in the lowest reach) is comprised of wetlands that are fed by groundwater (Sequim 2014).

Gierin Creek is not included on the 303(d) list of impaired waters (Category 5). No fish habitat has been identified in the Gierin Creek basin within the city or its Urban Growth Area.

As indicated in Table 1, the total drainage basin area is approximately 5.3 square miles, 35 percent of which is located within the city limits where drainage either infiltrates or is controlled by irrigation and SR 101 infrastructure. Approximately 49 percent of the drainage basin is developed based on data from the NLCD with the remainder of the drainage basin primarily comprised of planted/cultivated areas (29 percent), forest (13 percent), and wetlands (6 percent).

Water quality monitoring locations in the Gierin Creek drainage basin are shown on Figure A-4 in Appendix A. One stormwater and one irrigation system station have been monitored in the Gierin Creek basin.

Stormwater and Irrigation System Stations

Safeway Catch Basin

This monitoring location is a storm drain catch basin within the Safeway plaza parking lot at the northeast corner of Seventh Avenue and West Washington Street. This drainage area was selected by Streamkeepers because it is one of the largest and older impervious surfaces in the city. Stormwater collected in the catch basin infiltrates to a shallow aquifer within the

Gierin Creek basin, but does not directly discharge to a surface water. Contributing runoff to this catch basin are typical urban land uses including roofs, parking, and some landscaping (Clallam County 2008).

Sequim Bay Road

This monitoring location is located on a stormwater ditch along East Washington Street downstream of its intersection with a Highland Ditch lateral, and across from the intersection of West Sequim Bay Road. Contributing land uses include rural and suburban residential, roads, and commercial (Clallam County 2008).

Eureka Ditch

This monitoring location is on the Eureka Irrigation Ditch (Sequim Prairie Tri-Irrigation system) just before it is piped under the commercial zone near Seventh Avenue and West Washington Street. This conveyance runs through the commercial zone in a pipe that daylights in the mobile home park on West Spruce Street. Contributing runoff to this location includes mostly rural residential, road, and agricultural (both crop and stock) land use.

Highland Ditch at East Washington Street

This monitoring location is on a Highland Irrigation Ditch lateral on the north side of East Washington Street between Highway 101 Outpost (a convenience store) and what used to be Staples (now closed), just upstream of Bell Creek Plaza. Contributing land uses include rural and suburban residential and roads (Clallam County 2008).

Highland Ditch at Happy Valley Road

This monitoring location is on Highland Irrigation Ditch main canal just downstream of the east end of Happy Valley Road, near Huffman Heights Road. This ditch runs past the Bell Hill and Huffman Heights residential developments. Contributing land uses include rural and suburban residential, roads, and stock (Clallam County 2008).

AVAILABLE WATER AND SEDIMENT QUALITY DATA

The water quality parameters, monitoring periods, and numbers of stations and samples evaluated in this report are summarized in Table 3. Additional water quality parameters were collected; however, the analysis presented in this report focuses on the water quality parameters that are of highest concern in relation to stormwater runoff and groundwater quality, due to budget and time limitations.

Table 3. Water Quality Data Evaluated for the City of Sequim.

Water Quality Parameter	Monitoring Period	Number of Stations/Samples per Station		
		Bell Creek	Johnson Creek	Stormwater and Irrigation System
Clallam County Stormwater				
Ammonia nitrogen, total	2008	1 | 21	NA	NA
Ammonia nitrogen, dissolved	2008–2011	3 | 1–5	NA	5 | 1–12
Arsenic, total	2009	2 | 1	NA	1 | 2
Chromium, total	2009	2 | 1	NA	1 | 2
Copper, total	2008–2011	3 | 1–26	NA	1 | 2
Copper, dissolved	2008–2011	3 | 1–26	NA	3 | 2–9
Fecal coliform bacteria	2009–2011	2 | 1–23	NA	5 | 1–6
Hardness	2008–2011	3 | 1–26	NA	3 | 1–9
Lead, total	2009	2 | 1	NA	1 | 2
Nitrate+nitrite nitrogen, total	2009–2010	1 | 21	NA	1 | 1
Nitrate+nitrite nitrogen, dissolved	2008–2011	3 | 1–5	NA	5 | 6–11
pH	2010–2011	1 | 22	NA	NA
Suspended sediment (SSC)	2008–2011	3 | 1–27	NA	5 | 6–12
Temperature	2010–2011	1 | 24	NA	NA
Total phosphorus	2008–2011	3 | 1–26	NA	5 | 6–12
Turbidity	2008–2011	3 | 1–27	NA	5 | 7–16
Clean Water District				
Fecal coliform bacteria	2010	3 | 2	2 | 1–2	NA
Routine Streamkeepers Monitoring				
B-IBI	1999–2010	6 | 1–4	3 | 1–2	NA

B-IBI = Benthic Index of Biotic Integrity.
SSC = Suspended Sediment Concentration.
NA = not available.

Flow was not measured during water quality monitoring. Hydrologic conditions (pre-storm, first flush, and peak storm) were included in the water quality dataset for a portion of the data collected. Since the base (pre-storm) and storm event (first flush and peak storm)

designations were not available for the entire dataset, precipitation data (see following section) was evaluated to apply a base flow or storm event designation to each of the collected samples.

Sediment quality parameters, monitoring periods, and numbers of stations and samples evaluated in this report are summarized in Table 4. Additional sediment quality parameters were collected; however, the analysis presented in this report focuses on the sediment quality parameters that are of highest concern in relation to stormwater runoff and surface water quality, due to budget and time limitations.

Table 4. Sediment Quality Data Evaluated for the City of Sequim.

Sediment Quality Parameter	Monitoring Period	Number of Stations/Samples per Station		
		Bell Creek	Johnson Creek	Stormwater and Irrigation System
Arsenic	2009	2 | 1	NA	2 | 1
Copper	2009	2 | 1	NA	2 | 1
Lead	2009	2 | 1	NA	2 | 1
Zinc	2009	2 | 1	NA	2 | 1
Lube oil	2009	2 | 1	NA	2 | 1
Diesel #2	2009	2 | 1	NA	2 | 1

NA = not available.

A cursory data quality assurance review was performed on the water quality data collected by the Streamkeepers. This quality assurance review focused on the discrepancies in the Streamkeepers data files downloaded from STORET (EPA 2014a and EPA 2014b) and the master database provided by Streamkeepers (Ed Chadd, Streamkeepers program coordinator, personal communication January 6, 2015).

The primary quality assurance issues and corrective actions performed for this evaluation included:

- Where different result values were reported in each Excel file for a particular sampling location and date—Herrera followed up with Streamkeepers to determine which value should be used.
- Where two or more result values are listed for the same monitoring location and date (with no associated time of day)—the primary samples and the replicate samples were identified based on the master data reports provided by the Streamkeepers.
- Where a sample was assigned a result value at or below the detection limit—these values were set at the detection limit based on feedback and master data reports provided by the Streamkeepers.
- Where differences occurred in location names and river miles in the database—the correct locations were verified by the Streamkeepers.
- Where replicate result value was above or below the primary sample result value by 25 percent or more—samples were flagged as estimated (with a J).

- Where replicate data was above or below the primary sample quantity by 50 percent or more—samples were rejected (with a R) and not included in further analysis.
- Rejected all zinc data based on Streamkeepers recommendation. Streamkeepers rejected all total and dissolved zinc data collected due to a potential issue with contaminated blank samples.

A data quality assurance review was not performed on water quality data collected as part of the Clean Water District study, the B-IBI data, or sediment quality data. The quality assurance procedures established by the Streamkeepers were assumed to be sufficient for data collection and entry.

PRECIPITATION DATA EVALUATION

To determine if monitoring was performed in years with typical precipitation and because some of the sampling was storm event-based, precipitation data were compiled from the following two rain gauges (see Appendix A):

- Sequim 2E gauge – located in the lower Bell Creek basin (Sequim Water Reclamation Facility) with daily data from October 1, 1980 through present (NCDC 2014)
- Sequim 5.8 WNW gauge – located outside of the city boundary between Sequim and Port Angeles, just west of Carlsborg, with daily data from November 16, 2009 through present (NCDC 2014)

Annual precipitation amounts for each of these data sources are compared for the monitoring periods (1996 through 1998 and 2008 through 2011) in Table 5. Data for rain gauge Sequim 1.3 SE were also compiled, but data were only available from June 5, 2012 through present (NCDC 2014). Because this time period does not correspond to any of the sample collection dates, the data from Sequim 1.3E were not evaluated or included in Table 5 below.

Table 5. Annual Precipitation Amounts for Sequim from 1996 Through 1998 and 2008 Through 2011.

Calendar Year	Annual Precipitation (inches)	
	Sequim 2E Gauge (Lower Bell Creek)	Sequim 5.8 WNW Gauge (west of Carlsborg)
1996	22.58	NA
1997	20.42	NA
1998	16.47	NA
2008	15.35	NA
2009	19.28	NA
2010	17.17	17.81
2011	**19.80**	**23.89**

Source: NCDC (2014).

Values in **bold** exceed the 75th percentile value of historical data for 1971 through 2000 (WRCC 2014).

NA = not available.

Based on a historical climate summary (1971 through 2000), the average annual precipitation amount in Sequim is 15.8 inches (WRCC 2014). Annual precipitation totals for the years evaluated in this study were slightly higher than the historical annual average for every year except 2008 (15.4 inches). Annual precipitation totals for Sequim 2E were substantially higher in 1996 (22.6 inches), 1997 (20.4 inches), and 2011 (19.8 inches), exceeding the 75th percentile of the historical data (see Table 5). Thus, the evaluated water quality data generally represent wet conditions for Sequim.

Comparison of annual totals for 2010 and 2011 at the Sequim 2 E and the Sequim 5.8 WNW rain gauges shows that more precipitation was typically observed at the Sequim 5.8 WNW gauge. Data gaps are summarized for each rain gauge in Table 6. Based on the data gaps and length of precipitation record, the Sequim 2E rain gauge is the most complete long-term record for Sequim.

Table 6. Gaps in Precipitation Records for the City of Sequim from 1996 Through 1998 and 2008 Through 2011.

Year	Number of Days with No Data	
	Sequim 2E Daily Data[a]	Sequim 5.8 WNW Daily Data[a]
1996	32	NA
1997	5	NA
1998	2	NA
2008	0	NA
2009	0	NA
2010	0	27
2011	0	3

[a] Source: NCDC (2014).

NA = not available.

Because the storm sample timing data collected in the Clallam County Stormwater project was incomplete, precipitation data collected at the Sequim 2E rain gauge was used to determine whether water quality samples were likely collected during base flow or storm event conditions.

WATER QUALITY DATA SUMMARY

Water quality data are presented and summarized first for the following parameters:

- pH (field measurement)
- Temperature (field measurement)
- Turbidity (field measurement)
- Suspended sediment concentration (SSC)
- Hardness
- Metals (arsenic, chromium, copper, and lead)
- Nutrients (ammonia, nitrate+nitrite, and phosphorus)
- Fecal coliform bacteria

B-IBI data are presented and summarized at the end of this section.

The discussion in each subsection begins with a brief overview of the purpose, relevance of the parameter, and typical sources/causes, followed by a discussion of the summary statistics of samples collected during base flow and storm events and a comparison of the results to any applicable state surface water quality standards (WAC 173-201A). Because Bell Creek and Johnson Creek are not named in Table 602 of WAC 173-201A, which lists beneficial use designations for specific fresh waters, they are to be protected for the default designated uses of salmonid spawning, rearing, and migration and primary contact recreation. The stormwater and irrigation system are not regulated under the state water quality standards; however, exceedances at these locations could contribute to issues in Sequim creeks and groundwater; thus, they are evaluated as part of this report as well.

pH

pH is a measure of the hydrogen ion activity in water on a scale from 1 to 14, which can have a direct effect on aquatic organisms or an indirect effect since the toxicity of various common pollutants are markedly affected by changes in pH. Waters that have pH levels ranging from 0 to 7 are considered acidic, while waters with pH levels ranging from 7 to 14 are considered alkaline or basic. Waters that have a pH of approximately 7 are considered neutral. Common sources of low pH values include:

- Dairy products
- Fertilizers and pesticides

- Metal finishers and fabricators
- Wineries

Common sources of high pH values include:

- Disinfectants and sanitizer
- Latex paint
- Poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials
- Soaps and detergents

Washington State surface water quality standards for fresh waters designated as salmonid spawning, rearing, and migration require pH to be within the range of 6.5 to 8.5 (WAC 173-201A). The pH data were collected *in situ* by the Streamkeepers using an electrode field meter. Summary statistics for pH are presented in Table 7.

Similar values were measured for pH during base flow (median of 7.89) and storm events (median of 8.00). The pH values measured in Bell Creek fell within the acceptable pH ranges for fresh waters. None of the waterbodies in the city are listed for pH on Ecology's 2012 303(d) list of impaired waters (Category 5), but Bell and Johnson Creeks are Category 2, waters of concern, due two pH measurements above 8.5 from historic monitoring data in Bell Creek in 2003 and 2004 and one pH measurement above 8.5 in Johnson Creek in 1998-2000 (see Appendix B).

Table 7. Summary Statistics for pH from 2010 Through 2011.

Monitoring Location[a]	pH (standard units)									
	Base Flow					Storm Events				
	n	Min	Median	Max	WQ[b]	n	Min	Median	Max	WQ[b]
Bell Creek										
Bell 0.2	7	7.61	7.89	8.06	0%	15	7.31	8.00	8.32	0%

Bold values indicate an exceedance of state water quality standards.

[a] Source: Clallam County Stormwater Project (collected in 2010–2011).

[b] Percentage of collected samples that exceed the applicable water quality (WQ) standard.

Temperature

Water temperature is critical to the health and survival of fish and other aquatic species in many life stages including embryonic development, juvenile growth, and adult migration. The relative species composition, metabolism, and reproductive effectiveness of cold-blooded aquatic species are also affected by the water temperature. An increase in water temperature accelerates the biodegradation of organic matter and increases the dissolved

oxygen demand as well as decreasing the solubility of oxygen. Common causes of elevated water temperature in surface water include:

- Lack of vegetation cover
- Industrial cooling water discharges
- Sanitary wastewater discharges

The state water quality standards for temperature are based on a 7-day average daily maximum (7-DADMax). The maximum allowable 7-DADMax is 16 degrees Celsius (°C) in fresh waters designated as core summer salmonid habitat. The maximum allowable 7-DADMax is 13 °C in marine waters designated as extraordinary quality (such as Sequim Bay).

Water temperature was measured *in situ* by the Streamkeepers either using a multi-parameter water quality field meter or a thermistor. Summary statistics for water temperature are presented in Table 8. Similar temperatures were measured during base flow (median of 9.22 °C) and storm events (median of 8.97 °C). Temperature measurements were collected one to four times per month in February, March, May, August, September through December of 2010, and February and March of 2011. Because continuous temperature data were not specifically measured for this analysis, exceedance of the temperature standard was not calculated.

Table 8. Summary Statistics for Temperature from 2010 Through 2011.

Monitoring Location[a]	Temperature (degrees Celsius)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	7	4.62	9.22	13.7	17	5.72	8.97	14.3

[a] Source: Clallam County Stormwater Project (collected in 2010–2011).

Turbidity

Turbidity is a measure of water clarity that is determined by how the transmission of light is scattered as it passes through water. An increase in the amount of particulate matter in water (such as in most stormwater runoff) reduces clarity (or transparency) by increasing the scattering of light. Measurements of turbidity are expressed in nephelometric turbidity units (NTU). Common causes of high turbidity in stormwater include:

- Chemical manufacturing discharges
- Construction activities with improper stormwater controls
- Industrial washwater discharges
- Landscaping activities
- Leaking underground storage tanks
- Sanitary wastewater

- Soil erosion
- Waste products from food processing industries

Washington State surface water quality standards restrict turbidity increases to a maximum of 5 NTU more than background when background turbidity is 50 NTU or less, and to no more than a 10 percent increase in turbidity when the background turbidity is greater than 50 NTU (WAC 173-201A). Because background (upstream) levels were not specifically measured for this analysis, exceedance of the turbidity standard was not calculated as part of this analysis; however, since both base flow and storm event median turbidity measured at Bell 0.2 are less than 5 NTU, the standard is not likely to be exceeded at this location even if background data were available. None of the waterbodies in Sequim are on the Ecology 2012 303(d) list for turbidity.

Turbidity was measured in the field by the Streamkeepers using a nephelometric field meter. Summary statistics for turbidity are presented in Table 9.

Table 9. Summary Statistics for Turbidity from 2008 Through 2011.

Monitoring Location[a]	Turbidity (NTU)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	9	1.69	2.02	9.38	18	1.24	3.40	38.1
Bell 1.6	2	1.88	7.27	12.7	3	13.8	16.5	37.4
Bell 1.75	0	NA	NA	NA	1	9.55	NA	9.55
Stormwater and Irrigation System								
Safeway Catch Basin[b]	7	26.7	253	821 G	NA	NA	NA	NA
Sequim Bay Road	2	16.5	148	279	12	8.44	145	659
Highland Ditch at East Washington Street	2	2.44	10.3	18.1	9	2.01	13.0	28.7
Highland Ditch at Happy Valley Road	2	3.69	20.0	36.3	13	2.12	10.8	65.8
Eureka Ditch	2	1.29	2.58	3.88	14	0.60	4.58	45.0

G = estimated value.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

NTU = nephelometric turbidity units.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Turbidity was low in Bell Creek with a lower median turbidity at Bell 0.2 (2 NTU during base flow and 3.4 NTU during storm events in 2010–2011) than Bell 1.6 (7.27 NTU during base flow and 16.5 NTU during storm events in 2008–2009). This may be due to filtration of suspended sediments through the wetland complex located between Bell 1.3 and Bell 0.6. Turbidity was also low in three out of the five stormwater and irrigation system stations (Eureka Ditch, Highland Ditch at East Washington Street, and Highland Ditch at Happy Valley Road). The highest median turbidity measurements were recorded at the Safeway Catch Basin (253 NTU

during base flow) and at Sequim Bay Road (143 NTU during base flow and 145 NTU during storm events). The high turbidity at the Safeway Catch Basin is likely a result of commercial stormwater runoff.

Suspended Sediment Concentration

Suspended sediment concentration (SSC) is a measure of suspended solid-phase material in surface waters. Common causes of elevated SSC include runoff from agricultural areas, logged areas, erosion, and construction activities.

There are no state water quality standards for SSC.

SSC was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project from 2008 through 2011. Summary statistics for SSC are presented in Table 10. These results are similar to those for turbidity where the median SSC was lowest measured during Streamkeepers monitoring at Bell 0.2 (3.1 milligrams per liter [mg/L] during base flow and 4.75 during storm events), low to moderate at three out of the five stormwater and irrigation system stations (Eureka Ditch, Highland Ditch at East Washington Street, and Highland Ditch at Happy Valley Road), and highest at the Safeway Catch Basin (172 mg/L during storm events) and at Sequim Bay Road (172 mg/L during storm events). Turbidity and SSC are often correlated; however, there is not an established conversion factor between these two parameters.

Table 10. Summary Statistics for Suspended Sediment Concentration from 2009 Through 2011.

Monitoring Station[a]	Suspended Sediment Concentration (mg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	9	1.9	3.1	15	18	2.3	4.75	73.5
Bell 1.6	1	7	NA	7	1	9.9	NA	9.9
Bell 1.75	0	NA	NA	NA	1	6.50	NA	6.50
Stormwater and Irrigation System								
Safeway Catch Basin[b]	0	NA	NA	NA	6	13.0	172	439
Sequim Bay Road	1	20.0	NA	20.0	8	15.0	172	429
Highland Ditch at East Washington Street	1	33.0	NA	33.0	6	4.00	20.3	195
Highland Ditch at Happy Valley Road	1	8.00	NA	8.00	10	1.20	4.50	29.9
Eureka Ditch	1	5.00	NA	5.00	11	1.00 U	10.0	148

U = undetected at the detection limit noted.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

mg/L = milligrams per liter.

[a] Source: Clallam County Stormwater Project (collected in 2009–2011).

[b] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Hardness

Heavy metal toxicity and solubility often depends on the water's hardness, which is a measure of the amount of calcium and magnesium. High or low hardness values are typically a result of local geology. Natural sources of hardness include limestone (which introduces calcium) and dolomite (which introduces magnesium).

There are no state water quality standards for hardness; however, as water hardness decreases, some metals (e.g., copper and zinc) become more toxic. Water quality criteria to protect aquatic life from dissolved metals are typically calculated based on hardness.

Hardness was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project from 2008 through 2011. Summary statistics for hardness are presented in Table 11. Hardness appeared to increase downstream to the highest median value observed during Streamkeepers monitoring in lower Bell Creek (190 mg/L during base flow and 200 mg/L during storm events at Bell 0.2) and was also high in one sample from the stormwater and irrigation system (240 mg/L at Highland Ditch at East Washington Street). Low hardness concentrations (median of 21.2 mg/L and 18.5 mg/L, respectively) were observed during storm events at the Safeway Catch Basin and Sequim Bay Road, which is indicative of urban stormwater runoff. Since the hardness at these two monitoring locations is on the low end of the hardness range, the metals present in these samples are more likely to be toxic.

Table 11. Summary Statistics for Hardness from 2008 Through 2011.

Monitoring Location[a]	Hardness (mg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	8	176	190	220	18	135	200	230
Bell 1.6	1	131	NA	131	1	136	NA	136
Bell 1.75	0	NA	NA	NA	1	12.0	NA	12.0
Stormwater and Irrigation System								
Safeway Catch Basin[b]	0	NA	NA	NA	6	16.2	21.2	91.4
Sequim Bay Road	1	41.6	NA	41.6	8	11.8	18.5	114
Highland Ditch at East Washington Street	0	NA	NA	NA	1	240	NA	240

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

mg/L = milligrams per liter.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Metals

Heavy metals are a particular concern in stormwater runoff due to their toxicity and the fact that they do not degrade in the environment. Heavy metals can bioaccumulate in sediments and in living organisms, and can lead to poisoning, diseases, and death to fish. Sources of heavy metals in stormwater runoff include pollution-generating impervious areas such as highways, roads, and roofs subject or exposed to tires, automobile exhaust, asphalt, concrete, engine wear, brake linings, or metal roof materials. Heavy metals also occur naturally in freshwater at varying concentrations as a result of weathering of soils and rocks. Heavy metals may occur in dissolved or particulate-bound forms. The total concentration of a metal is the sum of the concentrations of dissolved and particulate bound metals. Long-term exposure to heavy-metal-contaminated stormwater or sediment can cause long-term toxic effects in benthic invertebrates, aquatic microorganisms, and fish.

State water quality standards vary for each heavy metal and are described for each of the parameters summarized below.

Streamkeepers collected copper samples as part of the Clallam County Stormwater Project from 2008 through 2011. Limited water quality sampling was performed for arsenic, chromium, and lead in 2009. Zinc data was also collected; however, it is not summarized in this report due to a potential issue with contaminated blank samples.

Total Arsenic

Arsenic is naturally occurring in the earth's crust; however, it is a concern in freshwater systems due to its potential toxicity to aquatic life. It is also a concern in groundwater because it is recognized as a potential human carcinogen. Toxicity of arsenic varies between various arsenic compounds, but in general, acute toxicity is higher for inorganic arsenic than it is for organic arsenic compounds.

Washington State has surface water quality standards for dissolved arsenic, but not total arsenic. There is also a state groundwater water quality criterion for total arsenic, which is 0.05 µg/L (WAC 173-200-040).

Total arsenic was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2009. Summary statistics for total arsenic are presented in Table 12. Limited water quality data were collected for total arsenic in Bell Creek (n = 2) and Highland Ditch at East Washington Street (n = 2). Although state surface water quality criteria are based on dissolved arsenic, the range of total arsenic concentrations observed (0.4 to 0.8 micrograms per liter [µg/L]) are well below the acute and chronic criteria (360 and 190 µg/L) for dissolved arsenic. For comparison, the state groundwater quality criterion for total arsenic (0.05 µg/L), is much lower than the observed concentrations. Although some of the measured arsenic may migrate from surface water to groundwater, these concentrations are not expected to be a concern since they are currently meeting state surface water quality criteria and are still in the very low range (less than 1 µg/L) for what is typically measured in groundwater in the United States (Welch et al. 2000).

Table 12. Summary Statistics for Total Arsenic in 2009.								
	Total Arsenic (µg/L)							
	Base Flow				Storm Events			
Monitoring Location[a]	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 1.6	0	NA	NA	NA	1	0.62	NA	0.62
Bell 1.75	0	NA	NA	NA	1	0.39	NA	0.39
Stormwater and Irrigation System								
Highland Ditch at East Washington Street	0	NA	NA	NA	2	0.46	0.62	0.78

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

µg/L = micrograms per liter.

[a] Source: Clallam County Stormwater Project (collected in 2009).

Total Chromium

Chromium is typically not an issue in stormwater, but can be a human health concern in groundwater used for drinking water. Chromium is necessary for glucose tolerance in animals (including humans), but is considered to be a primary contaminant in groundwater at high levels.

Washington State has surface water quality standards for dissolved chromium, but not total chromium. There is also a state groundwater water quality criterion for total chromium, which is 50 µg/L (WAC 173-200-040).

Total chromium was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2009. Summary statistics for chromium are presented in Table 13. Limited water quality data were collected for total chromium in Bell Creek (n = 2) and Highland Ditch at East Washington Street (n = 2). Although state surface water quality criteria are based on dissolved chromium, the range of total chromium concentrations observed (1.5 to 4.1 µg/L) are well below the acute and chronic criteria (15 and 10 µg/L) for dissolved chromium. For comparison, the state groundwater quality criterion for total chromium (50 µg/L) is much higher than the values measured in Bell Creek and Highland Ditch in 2009.

Table 13. Summary Statistics for Total Chromium in 2009.								
	Total Chromium (µg/L)							
	Base Flow				Storm Events			
Monitoring Location[a]	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 1.6	0	NA	NA	NA	1	1.50	NA	1.50
Bell 1.75	0	NA	NA	NA	1	1.56	NA	1.56
Stormwater and Irrigation System								
Highland Ditch at East Washington Street	0	NA	NA	NA	2	1.22	2.66	4.10

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

µg/L = micrograms per liter.

[a] Source: Clallam County Stormwater Project (collected in 2009).

Copper

Copper, particularly dissolved copper, is a known surface-water pollutant that causes a range of adverse effects in fish. One known issue with dissolved copper is the serious disruption to sensory systems in juvenile salmonids.

Surface water quality criteria for the state of Washington include criteria for dissolved copper that are based on water hardness. Equations used to calculate the acute and chronic criteria for dissolved copper are provided in WAC 173-201A. These criteria were used for comparison to the dissolved copper results.

Dissolved copper was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2008 through 2011. Summary statistics for dissolved copper are presented in Table 14. Dissolved copper concentrations were typically low in the lowest reach of Bell Creek at RM 0.2 (median of 2.07 µg/L during base flow and 2.32 µg/L during storm events) and never exceeded water quality criteria, which is consistent with the high hardness concentrations measured at this downstream location. Dissolved copper criteria exceeded chronic criteria, but not acute criteria at the upstream stations in Bell Creek (one sample at Bell 1.6 during base flow and one sample at Bell 1.75 during storm events). Dissolved copper concentrations exceeded acute and chronic criteria in 100 percent of the storm event samples collected from the Safeway Catch Basin and a majority of the samples collected from Sequim Bay Road (75 percent exceeding acute and 88 percent exceeding chronic water quality criteria). Based on this evaluation, dissolved copper concentrations are a concern for stormwater runoff in Sequim.

Total copper was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2008 through 2011. Summary statistics for total copper are presented in Table 15. Total copper concentrations were similar to dissolved copper concentrations, indicating that most of the copper was in a dissolved state that is disruptive to juvenile salmonids. One exception is that dissolved copper concentrations exceeded the total copper concentrations for Bell 1.6, indicating potential contamination of the dissolved copper samples. This contamination may be attributed to miscommunication with the lab, resulting in some of the sample collection containers not being cleaned appropriately.

Table 14. Summary Statistics for Dissolved Copper from 2008 Through 2011.

Monitoring Location[a]	Dissolved Copper (µg/L)											
	Base Flow						Storm Events					
					WQ[b, c]						WQ[b, c]	
	n	Min	Median	Max	Acute	Chronic	n	Min	Median	Max	Acute	Chronic
Bell Creek												
Bell 0.2	7	1.20	2.07	2.60	0%	0%	20	0.95	2.32	3.52	0%	0%
Bell 1.6	1	**15.5**	NA	**15.5**	0%	100%	1	14.0	NA	14.0	0%	0%
Bell 1.75	0	NA	NA	NA	NA	NA	1	**2.04**	NA	**2.04**	0%	100%
Stormwater and Irrigation System												
Safeway Catch Basin[d]	0	NA	NA	NA	NA	NA	6	**6.74**	**12.7**	**24.8**	100%	100%
Sequim Bay Road	1	**6.22**	NA	**6.22**	0%	100%	8	**3.09**	**8.53**	**15.4**	75%	88%
Highland Ditch at East Washington Street	0	NA	NA	NA	NA	NA	1	5.42	NA	5.42	0%	0%

Bold values indicate an exceedance of state water quality standards.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

U = undetected at the detection limit noted.

µg/L = micrograms per liter.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Exceedance of acute criteria based on hardness measured in all but two samples from Bell 0.2 (WAC 173-201A).

[c] Exceedance of chronic criteria based on hardness measured in all but two samples from Bell 0.2 (WAC 173-201A).

[d] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Table 15. Summary Statistics for Total Copper from 2008 Through 2011.

Monitoring Location[a]	Total Copper (µg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	8	0.96	1.41	3.82	18	1.12	2.23	6.85
Bell 1.6	0	NA	NA	NA	1	3.76	NA	3.76
Bell 1.75	0	NA	NA	NA	1	2.95	NA	2.95
Stormwater and Irrigation System								
Highland Ditch at East Washington Street	0	NA	NA	NA	2	3.73	5.19	6.64

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

µg/L = micrograms per liter.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

Total Lead

Lead can be a pollutant of concern in stormwater runoff in urban areas and from highways. Due to the past use of lead in gasoline, it is typically present and persistent in soils near highways and streets and can enter surface water via runoff when these soils are eroded. Lead in groundwater is a human health concern resulting in behavioral problems and learning disabilities. Human exposure to lead primarily occurs from lead-based paint and older plumbing.

Washington State has surface water quality standards for dissolved lead, but not total lead. There is also a state groundwater water quality criterion for total lead which is 50 µg/L (WAC 173-200-040).

Total lead was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2009. Summary statistics for total lead are presented in Table 16. Limited water quality data were collected for total lead in Bell Creek (n = 2) and Highland Ditch at East Washington Street (n = 2). Although state surface water quality criteria are based on dissolved lead, hardness was measured in the two Bell Creek samples and could be used to calculate the dissolved lead criteria. The total lead concentration did not exceed the chronic criterion for dissolved lead at Bell 1.6, but did at Bell 1.75 due to the lower hardness in that sample. Total lead concentrations did not exceed chronic criterion for dissolved lead at the Highland Ditch at East Washington Street based on an assumed hardness of 240 mg/L measured on another monitoring date at that location. For comparison, the state groundwater quality criterion for total lead (50 µg/L) is much higher than the values measured in Bell Creek and Highland Ditch in 2009.

Table 16. Summary Statistics for Total Lead in 2009.

Monitoring Location[a]	Total Lead (µg/L)									
	Base Flow				Storm Events					
	n	Min	Median	Max	n	Min	Median	Max	WQ[b, c] Acute	WQ[b, c] Chronic
Bell Creek										
Bell 1.6	0	NA	NA	NA	1	0.76	NA	0.76	0%	0%
Bell 1.75	0	NA	NA	NA	1	1.18	NA	1.18	0%	**100%**
Stormwater and Irrigation System										
Highland Ditch at East Washington Street	0	NA	NA	NA	2	0.22	1.31	2.40	0%	0%

Bold values indicate an exceedance of state water quality standards.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

µg/L = micrograms per liter.

[a] Source: Clallam County Stormwater Project (collected in 2009).

[b] Exceedance of acute criteria was calculated based on hardness measured in Bell 1.6 and Bell 1.75, and assumed hardness in Highland Ditch at East Washington Street (WAC 173-201A).

[c] Exceedance of chronic criteria was calculated based on hardness measured in Bell 1.6 and Bell 1.75, and assumed hardness in Highland Ditch at East Washington Street (WAC 173-201A).

Nutrients

Nutrients (primarily nitrogen and phosphorus) are a concern in fresh water because high levels can lead to accelerated plant growth, algal blooms, low dissolved oxygen, decreases in aquatic diversity, and eutrophication. Sources of nutrients in surface waters typically consist of natural sources (e.g., weathered rocks, dead and decaying plant and animal material, and microbial life) and anthropogenic sources (e.g., wastewater treatment plants, septic system failures, washwater, animal manure storage, and fertilizer runoff).

State water quality standards vary for each nutrient and are described for each of the parameters summarized below.

Ammonia

Ammonia nitrogen is a concern in freshwater systems due to its potential toxicity to aquatic life. Within most freshwater systems, ammonia is readily converted to nitrate when oxygen is present. The toxicity of ammonia increases when the pH or temperature of a water body decreases. Hatching, growth rate, and structural development of fish can all be affected by high levels of ammonia. Human health can also be adversely affected by high levels of ammonia in aquatic systems through consumption of fish and shellfish and recreational contact.

Washington State has surface water quality standards for chronic and acute concentrations of ammonia (WAC 173-201A) that vary depending on the ambient water temperature, pH, and the presence or absence of salmonids. Since Bell 0.2 was the only monitoring station for which temperature and pH were available, only the ammonia data for this monitoring station were compared to state water quality criteria.

Total and dissolved ammonia nitrogen was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project in 2008 through 2011. Summary statistics for total and dissolved ammonia are presented in Table 17 and Table 18, respectively. Total ammonia nitrogen concentrations were typically low in Bell Creek at Bell 0.2 during base flow and storm events (median less than 0.05 mg/L). During base flow, dissolved ammonia nitrogen concentrations in Bell Creek and in the stormwater and irrigation system were lower than the laboratory detection limit. During storm events, dissolved ammonia nitrogen concentrations were typically low in Bell Creek (maximum of 0.03 mg/L at Bell 1.75), low in three of the stormwater and irrigation system stations (Highland Ditch at East Washington Street, Highland Ditch at Happy Valley Road, and Eureka Ditch), and elevated in the Safeway Catch Basin and at Sequim Bay Road (median of 0.48 mg/L and 0.31 mg/L during storm events, respectively). None of the Bell Creek samples exceeded ammonia surface water quality criteria (calculated based on available temperature and pH data), and it is unlikely that ammonia surface water quality criteria were exceeded at the other monitoring stations based on typical temperature and pH data measured at those stations).

Table 17. Summary Statistics for Total Ammonia Nitrogen from 2008 Through 2011.

Monitoring Location[a]	Total Ammonia Nitrogen (mg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	7	0.01 U	0.04	0.05	14	0.01 U	0.03	0.10

U = undetected at the detection limit noted.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

Table 18. Summary Statistics for Dissolved Ammonia Nitrogen from 2008 Through 2011.

Monitoring Location[a]	Dissolved Ammonia Nitrogen (mg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	1	0.01 U	NA	0.01 U	4	0.01 U	0.01 U	0.01 U
Bell 1.6	1	0.01 U	NA	0.01 U	1	0.014	NA	0.014
Bell 1.75	0	NA	NA	NA	1	0.03	NA	0.03
Stormwater and Irrigation System								
Safeway Catch Basin[b]	0	NA	NA	NA	6	0.25	0.48	1.80
Sequim Bay Road	1	0.01 U	NA	0.01 U	8	0.05	0.31	0.65
Highland Ditch at East Washington Street	1	0.01 U	NA	0.01 U	6	0.01 U	0.03	0.31
Highland Ditch at Happy Valley Road	1	0.01 U	NA	0.01 U	10	0.01 U	0.01 U	0.07
Eureka Ditch	1	0.01 U	NA	0.01 U	11	0.01 U	0.01 U	0.13

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

U = undetected at the detection limit noted.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Nitrate+Nitrite Nitrogen

Nitrate+nitrite nitrogen is a concern in fresh water (surface water) because it may contribute to an overabundant growth of algae and aquatic plants, and to a decline in diversity of the biological community.

Washington State does not have a surface water quality standard for nitrate+nitrite nitrogen; however, it is a regulated parameter in the state ground water standards (WAC 173-200-040) and the state drinking water standards (WAC 246-290-310) for the protection of human health. To prevent a potentially fatal blood disorder in infants called "blue baby syndrome" as well as other human health problems, both standards specify that nitrate+nitrite nitrogen concentrations shall not exceed 10 mg/L in public drinking water supplies.

The US EPA recommended a total nitrogen nutrient criterion of 0.12 mg/L for rivers and streams in Aggregate Ecoregion II (EPA 2000). Total nitrogen is the sum of ammonia nitrogen (summarized in the previous section) and nitrate+nitrite nitrogen. This criterion was used for comparison to the sampling results shown below, and represents reference conditions that are equivalent to the median of the 25th percentiles for all four seasons using all of the data compiled from rivers and streams in this ecoregion (refer to Appendix B for these reference data). The US EPA has not established a criterion for dissolved nitrate+nitrite nitrogen.

Nitrate+nitrite nitrogen was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project from 2008 through 2011. Summary statistics for total and dissolved nitrate+nitrite are presented in Tables 19 and 20, respectively.

Total nitrate+nitrite nitrogen levels ranged from less than 0.01 mg/L at Eureka Ditch to 3.4 mg/L at Bell 0.2. Total nitrate+nitrite nitrogen levels in Bell 0.2 were similar during base flow and storm events (median of 2.55 mg/L and 2.65 mg/L, respectively). All of the samples collected at Bell 0.2 during base flow and storm events exceeded the total nitrogen nutrient criterion recommended by the EPA.

Table 19. Summary Statistics for Total Nitrate+Nitrite Nitrogen from 2009 Through 2010.

Monitoring Location[a]	Total Nitrate+Nitrite (mg/L)									
	Base Flow					Storm Events				
	n	Min	Median	Max	WQ[b]	n	Min	Median	Max	WQ[b]
Bell Creek										
Bell 0.2	7	2.30	2.55	3.00	100%	14	1.40	2.65	3.40	**100%**
Stormwater and Irrigation System										
Eureka Ditch	0	NA	NA	NA	NA	1	0.01 U	NA	0.01 U	0%

Bold values indicate an exceedance of nutrient criteria recommended by the EPA.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

U = undetected at the detection limit noted.

[a] Source: Clallam County Stormwater Project (collected in 2009–2010).

[b] Percentage of collected samples that exceed the total nitrogen nutrient criterion recommended by the EPA. Note that total nitrate+nitrite nitrogen is only a portion of total nitrogen. Total ammonia nitrogen would also need to be added for a more direct comparison.

Dissolved nitrate+nitrite nitrogen levels were highly variable among the monitoring stations, ranging from 0.25 mg/L (Eureka Ditch) to 1.97 mg/L (Bell 0.2) during base flow and less than 0.01 mg/L (Eureka Ditch) to 3.39 mg/L (Bell 0.2) during storm flow. Relatively low dissolved nitrate+nitrite nitrogen concentrations were measured in Highland Ditch at Happy Valley Road and Eureka Ditch (median values of 0.05 mg/L and 0.02 mg/L during storm events, respectively). Median dissolved nitrate+nitrite nitrogen values at Highland Ditch at East Washington Street (0.39 mg/L), the Safeway Catch Basin (0.18 mg/L), and Sequim Bay Road (0.38 mg/L) were elevated during storm events. Relatively high dissolved nitrate+nitrite concentrations compared to the other samples collected during Streamkeepers monitoring

were consistently observed near the mouth of Bell Creek (median value of 1.87 mg/L during storm events and 1.97 mg/L for one base flow sample at Bell 0.2), indicating likely impairment of the biological community at this monitoring station. Additional monitoring is needed during base flow conditions in order to determine if this elevated dissolved nitrate+nitrite nitrogen can be linked to stormwater runoff.

Table 20. Summary Statistics for Dissolved Nitrate+Nitrite Nitrogen from 2008 Through 2011.

Monitoring Location[a]	Dissolved Nitrate+Nitrite (mg/L)							
	Base Flow				Storm Events			
	n	Min	Median	Max	n	Min	Median	Max
Bell Creek								
Bell 0.2	1	1.97	NA	1.97	4	1.03	1.87	3.39
Bell 1.6	1	0.48	NA	0.48	1	0.18	NA	0.18
Bell 1.75	0	NA	NA	NA	1	0.44	NA	0.44
Stormwater and Irrigation System								
Safeway Catch Basin[b]	0	NA	NA	NA	6	0.11	0.18	2.30
Sequim Bay Road	1	0.27	NA	0.27	8	0.13	0.38	2.52
Highland Ditch at East Washington Street	1	0.88	NA	0.88	6	0.26	0.39	1.13
Highland Ditch at Happy Valley Road	1	0.36	NA	0.36	10	0.04	0.05	0.81
Eureka Ditch	1	0.25	NA	0.25	10	0.01 U	0.02	0.08

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

U = undetected at the detection limit noted.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Total Phosphorus

Total phosphorus is a combination of inorganic and organic forms of phosphorus. Phosphorus is a concern in fresh water (surface water) because high levels can lead to accelerated plant growth, algal blooms, low dissolved oxygen, decreases in aquatic diversity, and eutrophication.

Currently, Washington State does not have surface water quality standards for total phosphorus in streams; however, standards have been established for lakes. The US EPA recommended a total phosphorus nutrient criterion of 0.01 mg/L for rivers and streams in Aggregate Ecoregion II (EPA 2000).

Total phosphorus was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project from 2008 through 2011. Summary statistics for total phosphorus are presented in Table 21.

Table 21. Summary Statistics for Total Phosphorus from 2008 Through 2011.

Monitoring Location[a]	Total Phosphorus (mg/L)									
	Base Flow					Storm Events				
	n	Min	Median	Max	WQ[b]	n	Min	Median	Max	WQ[b]
Bell Creek										
Bell 0.2	8	**0.06**	**0.12**	**0.23**	**100%**	18	**0.05**	**0.10**	**0.42**	**100%**
Bell 1.6	1	**0.13**	NA	**0.13**	**100%**	1	**0.10**	NA	**0.10**	**100%**
Bell 1.75	0	NA	NA	NA	NA	1	**0.10**	NA	**0.10**	**100%**
Stormwater and Irrigation System										
Safeway Catch Basin[c]	0	NA	NA	NA	NA	6	**0.20**	**0.28**	**0.71**	**100%**
Sequim Bay Road	1	**0.14**	NA	**0.14**	**100%**	8	0.09	0.25	0.84	**100%**
Eureka Ditch	1	**0.060**	NA	**0.060**	**100%**	11	**0.0115**	**0.030**	**0.45**	**100%**

Bold values indicate an exceedance of nutrient criteria recommended by the EPA.

NA = not applicable; median was not calculated unless a minimum of 2 samples were collected.

[a] Source: Clallam County Stormwater Project (collected in 2008–2011).

[b] Percentage of collected samples that exceed the nutrient criterion recommended by the EPA.

[c] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

Total phosphorus concentrations ranged from 0.012 mg/L to 0.84 mg/L and typically exceeded the recommended phosphorus nutrient criterion of 0.01 mg/L at all stations. The lowest total phosphorus concentrations were measured in Eureka Ditch, where the median concentration was 0.030 mg/L during storm flow. Moderate total phosphorus concentrations were observed in Bell Creek where the median concentration was 0.12 mg/L during base flow and 0.10 mg/L during storm events at Bell 0.2. The highest total phosphorus concentrations were measured in storm event samples from the Safeway Catch Basin (median of 0.28 mg/L) and Sequim Bay Road (median of 0.25 mg/L).

Fecal Coliform Bacteria

Urban, residential, and agricultural runoff characteristically contains elevated levels of fecal coliform bacteria. These organisms are used as indicators of fecal contamination from humans and other warm-blooded animals. Human sources may include failing septic systems, municipal wastewater discharges, leaking wastewater conveyance systems or side sewers, and cross connections with municipal wastewater systems. Animal sources may include pets, livestock, and wildlife (e.g., birds and mammals). The simple presence of these bacteria does not necessarily indicate a threat to public health because only a small portion is likely to be pathogenic to humans. However, their use as an indicator of potential fecal contamination and presence of pathogens is considered important in the early detection of problems that could lead to public health concerns.

Bell Creek, Johnson Creek, and Sequim Bay are included on the Ecology 2012 303(d) list for fecal coliform bacteria. Washington State surface water quality standards (WAC 173-201A) for

primary contact recreation in fresh water include the following fecal coliform bacteria criteria:

- Geometric mean (geomean)that does not exceed 100 colonies per 100 mL; or
- Not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) exceeding 200 colonies per 100 mL

Fecal coliform bacteria was analyzed at an analytical laboratory based on grab samples collected during Streamkeepers monitoring as part of the Clallam County Stormwater Project from 2009 through 2011 and the Clean Water District study in 2010. The monitoring data for fecal coliform bacteria is summarized below in Table 22. Fecal coliform data are reported in units of colony forming units (CFU) per 100 milliliters (mL), which is equivalent to colonies per 100 mL.

Table 22. Summary Statistics for Fecal Coliform Bacteria from 2009 Through 2011.

Monitoring Station	Monitoring Period	Base Flow			Storm Events		
		n	Geomean (CFU/ 100 mL)	Samples Exceeding 200 CFU/ 100 mL (%)[a]	n	Geomean (CFU/ 100 mL)	Samples Exceeding 200 CFU/ 100 mL (%)[a]
Bell Creek							
Bell 0.2[b]	2010–2011	5	**116**	**60%**	18	74.3	**56%**
Bell 0.2[c]	2010	2	6.9	0%	0	NA	NA
Bell 0.8[c]	2010	1	NA	0%	1	NA	0%
Bell 1.6[b]	2009	0	NA	NA	1	NA	**100%**
Bell 4.2[c]	2010	1	NA	0%	1	NA	0%
Johnson Creek							
Johnson 0.0[c]	2010	1	22	0%	1	2.0	0%
Johnson 2.0[c]	2010	2	2.0	0%	0	NA	0%
Stormwater and Irrigation System							
Safeway Catch Basin[b, d]	2009	0	NA	NA	1	NA	0%
Sequim Bay Road[b]	2009	0	NA	NA	3	**191**	**33%**
Highland Ditch at East Washington Street[b]	2009	0	NA	NA	2	**2,070**	**100%**
Highland Ditch at Happy Valley Road[b]	2009	0	NA	NA	5	3.8	0%
Eureka Ditch[b]	2009	0	NA	NA	6	**1,070**	**100%**

Bold values indicate an exceedance of state water quality standards.

NA = not applicable; geomean was not calculated unless a minimum of 2 samples were collected.

CFU/100 mL = colony forming units per 100 milliliters.

[a] Percentage of collected samples that exceed the applicable water quality standard.

[b] Source: Clallam County Stormwater Project (collected in 2010–2011).

[c] Source: Clean Water District (collected in 2010).

[d] Stormwater collected in the catch basin infiltrates to a shallow aquifer within the Gierin Creek basin, but does not directly discharge to a surface water.

The geomean criterion was not exceeded at Bell 0.2 during storm flow (sampled in the Clallam County Stormwater Project), which is the only station with at least 10 samples; however, more than 10 percent of the samples collected did exceed 200 CFU/100 mL. The single event criterion (200 CFU/100 mL) was exceeded in Bell 0.2, Bell 1.6 (only one sample collected), Sequim Bay Road, Highland Ditch at East Washington Street, and Eureka Ditch. The high fecal coliform bacteria concentrations observed at Highland Ditch at East Washington Street and Eureka Ditch suggest that these and other runoff waters in irrigation ditches may be a substantial source of fecal coliform bacteria in Sequim surface waters.

Bell 0.1 and Johnson 0.0 have both been on the Ecology 303(d) list of impaired waters (Category 5) for fecal coliform bacteria since 1996. These ratings are based on samples collected by Clallam County Streamkeepers between 1987 and 2003 (see Appendix B). No fecal coliform bacteria data was available for Bell 0.1 in this analysis; however, data was available for Bell 0.2. There may be the possibility of a shellfish-growing area near the mouth of Bell Creek in the future; thus potential fecal coliform bacteria sources in the lower reach of Bell Creek should be investigated further.

B-IBI

The Benthic Index of Biotic Integrity (B-IBI) is a quantitative method for determining and comparing the biological condition of streams from analysis of benthic invertebrate samples. Samples were collected by the Streamkeepers and submitted to Aquatic Entomology or A.J. Frost Insect Identification for analysis. An overall B-IBI score was calculated for each sample from a series of metrics based on the relative diversity and abundance of invertebrates having different sensitivities to water quality conditions. The overall B-IBI scores and associated classifications are presented in Table 23.

The B-IBI scores range from 10 (critically impaired) near the mouth of Bell Creek (Bell 0.1) to 46 (healthy) above stormwater and irrigation tailwater input in Johnson Creek (Johnson 2.0). Of the 10 monitoring stations sampled, Johnson 2.0 is the only station that was rated as “healthy”; the remainder were rated as “compromised” or worse. The very low scores and progressive decline in scores over time in the lower reaches of Bell Creek indicate severe impairment of biological resources in this stream. Moreover, Ecology included Bell Creek at monitoring station Bell 0.1 on the 303(d) list for impaired waters (Category 5) for B-IBI in 2006. B-IBI scores in the two upper reaches of Bell Creek indicated that conditions were better upstream of urban areas, although still troublesome. There are no samples from headwater areas above suburban stormwater and irrigation ditch input.

Table 23. Benthic Index of Biotic Integrity Data from 1999 Through 2010.			
Monitoring Station[a]	**Monitoring Date**	**Overall B-IBI Score**	**B-IBI Classification**
Bell Creek			
Bell 0.1	10/10/1999	**18**	**Highly Impaired**
Bell 0.1	10/1/2000	**14**	**Critically Impaired**
Bell 0.1	9/30/2001	**12**	**Critically Impaired**
Bell 0.1	10/11/2005	**10**	**Critically Impaired**
Bell 0.5	10/10/1999	**26**	**Highly Impaired**
Bell 0.8	10/26/2002	**16**	**Critically Impaired**
Bell 0.8	10/17/2003	**12**	**Critically Impaired**
Bell 0.8	9/23/2010	**12**	**Critically Impaired**
Bell 1.0	9/30/2008	**16**	**Critically Impaired**
Bell 1.8	10/4/2000	**18**	**Highly Impaired**
Bell 2.8	9/13/2010	44	Compromised
Johnson Creek			
Johnson 0.0	10/9/1999	40	Compromised
Johnson 0.0	9/22/2009	42	Compromised
Johnson 0.6	10/9/1999	42	Compromised
Johnson 2.0	10/10/2007	46	Healthy

Bold values indicate values included in the basis of Ecology's 303(d) rating.

[a] Source: Clallam County 2012.

SEDIMENT QUALITY ANALYSIS

Streamkeepers conducted sediment sampling in June 2009 as part of the Clallam County Stormwater Project to assess the concentrations of pollutants sequestered in the streambed sediments. Some of these pollutants may be associated with contributions from stormwater runoff. Streambed sediment quality can play an important role in habitat conditions for macroinvertebrate communities.

A previous study, Brandenberger et al. (2003), evaluated the potential stormwater impacts on sediment quality in five Clallam County streams in 2003, including Bell Creek. Four stations along Bell Creek were monitored, two of which (BEL-1 and BEL-2) correspond to the Bell 0.1 and Bell 1.6 stations that were monitored in 2009.

Limited sampling (n = 1 per parameter and station) was performed as part of both studies.

Summary statistics for heavy metals concentrations in the sediment samples from the Clallam County Stormwater project and the Brandenberger study are presented in Table 24 and are also shown graphically in Figure 1.

Table 24. Summary Statistics for Heavy Metals Measured During Sediment Quality Monitoring in 2003 and 2009.

Monitoring Location	Arsenic (mg/kg)		Copper (mg/kg)		Lead (mg/kg)		Zinc (mg/kg)	
	n	Value	n	Value	n	Value	n	Value
Bell Creek								
Bell 0.1[a]	1	6.10	1	32.8	1	5.72	1	76.7
Bell 0.1 (BEL-1)[b]	1	8.13	1	53.4	1	8.91	1	117
Bell 1.6[a]	1	3.65	1	25.5	1	9.00	1	115
Bell 1.6 (BEL-2)[b]	1	4.21	1	43.4	1	26.5	1	380
Irrigation Ditches								
Highland Ditch at East Washington Street[a]	1	2.60	1	30.2	1	22.7	1	253
Stormwater System								
Safeway Catch Basin[a]	1	5.20	1	84.8	1	349	1	663

mg/kg = milligrams per kilogram.

[a] Source: Clallam County Stormwater Project (collected in 2009).

[b] Source: Brandenberger study (collected in 2003).

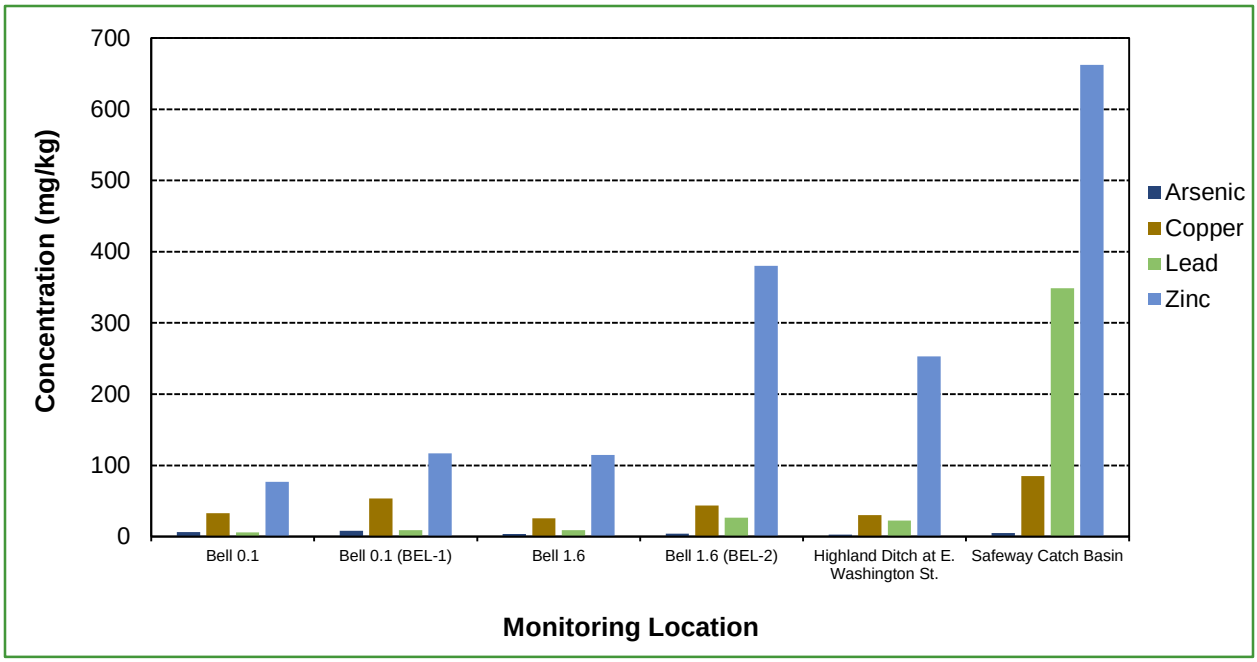

Figure 1. Summary Statistics for Heavy Metals Measured During Sediment Quality Monitoring in 2003 and 2009.

Chapter 173-204-340 WAC (freshwater sediment quality standards) states that Ecology shall determine on a case-by-case basis the criteria, methods, and procedures necessary to meet the intent of the Sediment Management Standards chapter. The Model Toxics Control Act (MTCA), Chapter 173-340 WAC includes the following Method A cleanup levels for arsenic and lead:

- Arsenic – 20 mg/kg
- Lead – 250 mg/kg

Levels for copper and zinc have also been established for priority contaminants of ecological concern (for sites that qualify for the simplified terrestrial ecological evaluation procedure):

- Copper – 100 mg/kg
- Zinc – 270 mg/kg

Based on this criteria, which is typically only applied to provide conservative cleanup levels at sites undergoing routine cleanup, thresholds were exceeded for lead and zinc in the Safeway Catch Basin sediment sample and for zinc in the Bell 1.6 sediment sample.

Samples collected in 2003 as part of the Brandenberger study had higher concentrations of arsenic, copper, lead, and zinc at Bell 0.1/BEL-1 and Bell 1.6/BEL-2 than measured in the Clallam County Stormwater Project samples. The Brandenberger study reported heavy metals values that were approximately 1.5 times the values reported by Clallam County Stormwater Project at Bell 0.1/BEL-1, and approximately 3 times the values reported by Clallam County

Stormwater Project at Bell 1.6/BEL-2. Based on the limited data available, no significant decreasing trend could be identified. Additional sediment quality sampling would be necessary to evaluate seasonal and temporal trends in the sediment quality data.

Summary statistics for #2 diesel and lube oil concentrations in sediment are presented in Table 25. MTCA Method A cleanup levels for total petroleum hydrocarbons include the following:

- Diesel range organics (includes Diesel #2) – 2,000 mg/kg
- Gasoline range organics – 100 mg/kg
- Heavy oils – 2,000 mg/kg
- Mineral oil – 4,000 mg/kg

Table 25. Summary Statistics for Diesel #2 and Lube Oil Measured During Sediment Quality Monitoring in 2003 and 2009.

Monitoring Location	Diesel #2 (mg/kg)		Lube Oil (mg/kg)	
	n	Value	n	Value
Bell Creek				
Bell 0.1[a]	1	120 U	1	300 U
Bell 0.1 (BEL-1)[b]	1	92.0	1	3,700
Bell 1.6[a]	1	50.0 U	1	120 U
Bell 1.6 (BEL-2)[b]	1	320	1	980
Irrigation Ditches				
Highland Ditch at East Washington Street[a]	1	110 U	1	260 U
Stormwater System				
Safeway Catch Basin[a]	1	880 U	1	110,000

mg/kg = milligrams per kilogram.

U = undetected at the detection limit noted).

[a] Source: Clallam County Stormwater Project (collected in 2010–2011).

[b] Source: Brandenberger study (collected in 2003).

Based on this criteria, which is typically only applied to provide conservative cleanup levels at sites undergoing routine cleanup, thresholds were exceeded for total petroleum hydrocarbons in the Safeway Catch Basin sediment sample. Due to the nature of this site and the proximity and number of pollutant sources, higher pollutant concentrations at this monitoring station than in the other in-stream or ditch monitoring stations may be expected.

CONCLUSIONS

Water quality and sediment data conclusions are presented in this section by drainage basin for Bell Creek, Johnson Creek, and Gierin Creek, as well as for the shallow aquifer. Recommendations for future monitoring are summarized at the end of the conclusions section.

Water Quality and Sediment Data Summary

Bell Creek

Bell Creek has the most robust water quality dataset of the streams in the city, representing data from four in-stream monitoring stations and two stormwater and irrigation system monitoring stations that discharge directly to the creek (Sequim Bay Road and Highland Ditch at East Washington Street) over a total of 4 years of monitoring (2008 through 2011) with B-IBI data from 1999 through 2010. One monitoring station in particular (Bell 0.2, close to the creek mouth) has the most consistent data record of all of the monitoring locations in the city. Sequim Bay Road and Highland Ditch at East Washington Street also have a fair amount of monitoring data, but only for specific water quality parameters.

In terms of general water quality conditions in Bell Creek, there is a documented declining trend in B-IBI scores over time as well as distance downstream; this represents the most notable evidence of poor water quality. There is also some evidence of elevated nutrient concentrations (e.g., dissolved nitrate+nitrite nitrogen and total phosphorus), elevated dissolved copper concentrations, and likely sources of fecal coliform bacteria. Some of these water quality problems appear to have a connection with stormwater runoff based on their values being elevated during storm event monitoring in the stormwater and irrigation system at some locations. During wet weather, the irrigation system conveys stormwater runoff; thus, it is effectively part of the stormwater system during storm events.

Turbidity, SSC, and dissolved ammonia nitrogen did not appear to be an issue at the in-stream monitoring locations; however, elevated levels were measured at one of the stormwater and irrigation system monitoring locations (Sequim Bay Road, downstream of suburban/rural land uses) during storm events.

No water quality issues were noted for pH or temperature in Bell Creek; however, these parameters were only measured at Bell 0.2, as grab samples. For temperature in particular, continuous monitoring or at least focused monitoring during the critical period (late summer and early fall) would be required to evaluate whether temperature exceedances are a problem in any given reach. The data were too limited (e.g., only one or two samples collected per monitoring location) to make a meaningful assessment for total arsenic, total chromium, dissolved lead, or for sediment quality. No additional study on these metals is recommended since elevated concentrations of these metals are not typically an issue associated with urban stormwater runoff.

Based on the evaluation of the available water quality monitoring data, priority areas were identified for future water quality improvement projects as well as future monitoring needs. One of the two priority areas identified in the city is the middle to lower reach of Bell Creek (between Bell 1.75 and Bell 0.2, from East Washington Street to near the creek mouth).

Johnson Creek

Water quality monitoring data from Johnson Creek represented data from three in-stream monitoring locations and one stormwater and irrigation system monitoring location that discharges directly to Johnson Creek (Highland Ditch at Happy Valley Road) over a total of 4 years of monitoring (2008 through 2011) with B-IBI data from 1999 through 2009. Limited in-stream sampling was conducted in Johnson Creek for two water quality parameters: B-IBI—four total samples collected at three locations in 1999, 2007, and 2009; and fecal coliform bacteria—four total samples collected at two locations in 2010. Highland Ditch at Happy Valley Road has a fair amount of monitoring data (more parameters than the in-stream monitoring in Johnson Creek), but only for a limited set of water quality parameters (fewer parameters than Bell 0.2).

In terms of general water quality conditions in Johnson Creek, there is a documented declining trend in B-IBI scores with distance downstream; however, not as notable as what has been observed in Bell Creek. B-IBI data in the lower reach of Johnson Creek (Johnson 0.6 to 0.0) is listed as compromised, whereas the lower reach of Bell Creek is either listed as highly or critically impaired. Although Johnson 0.0 has been on the Ecology 303(d) list of impaired waters (Category 5) for fecal coliform bacteria since 1996, limited fecal coliform bacteria sampling performed in Johnson Creek in 2010 did not show any exceedances of the single event criterion. The fecal coliform data for Johnson Creek analyzed in this report did not support Ecology's 303(d) listing for Johnson Creek; however, there were only two samples collected at each monitoring location (Johnson 0.0 and Johnson 2.0); therefore, the data is insufficient for drawing any conclusions. There were no sediment quality samples collected from the Johnson Creek drainage basin.

Turbidity, SSC, dissolved ammonia nitrogen, and dissolved nitrate+nitrite nitrogen did not appear to be an issue at Highland Ditch at Happy Valley Road based on the available data.

Based on the evaluation of the available water quality monitoring data, priority areas were identified for future water quality improvement projects as well as future monitoring needs. The second of two priority areas identified for the City is the lower reach of Johnson Creek due to limited water quality data; however, this is a lower priority than the middle to lower reach of Bell Creek.

Gierin Creek

In-stream or sediment quality monitoring data were not available for Gierin Creek. Numerous water quality samples were collected in Eureka Ditch which has a direct discharge to Gierin Creek 1.5 to 2 miles downstream, outside city limits.

In terms of general water quality conditions observed in Eureka Ditch, fecal coliform bacteria concentrations were elevated during storm event sampling. All six of the collected samples exceeded the primary contact recreation single event criterion.

Turbidity, SSC, dissolved ammonia nitrogen, dissolved nitrate+nitrite nitrogen, and total phosphorus did not appear to be an issue at Eureka Ditch based on the available data.

Shallow Aquifer

Available water quality and sediment data from the Safeway Catch Basin site indicates pollutants common in urban stormwater runoff, including copper, nutrients, turbidity, and hydrocarbons. Similar to most of the stormwater network in central Sequim, the Safeway Catch Basin discharges stormwater to the shallow aquifer via infiltration. Regular maintenance (cleaning/removal of solids) of this system and other similar systems is critical to the protection of the drinking water supply.

Monitoring Recommendations

Recommendations are provided for water quality monitoring and fecal source tracing based on the findings of this water quality and sediment data analysis.

Water Quality Monitoring

It is recommended that water quality monitoring be continued with a focus on the following parameters:

- Fecal coliform bacteria
- Nutrients (nitrate+nitrite nitrogen, phosphorus, and ammonia nitrogen)
- Metals (dissolved copper and dissolved zinc)

Fecal coliform bacteria and nutrients are the primary water quality problems observed in the monitored streams. Most of the dissolved zinc data was deemed inconclusive since there was a potential issue with contaminated blank samples, and only dissolved copper had sufficient data availability for further evaluation. It is recommended that Bell Creek and Johnson Creek be monitored for dissolved metals (dissolved copper and dissolved zinc) rather than total metals since the state surface water quality criteria are based on dissolved metals (WAC 173-201A).

The collection of additional fecal coliform bacteria, nutrients, and metals data at a consistent set of stream stations will allow for better analysis of temporal and spatial trends and evaluation of effects of future source control actions and stormwater retrofit projects.

Monitoring is recommended near the mouth of Bell and Johnson Creeks for future analysis of temporal trends. Fecal coliform bacteria monitoring should also be conducted at key upstream stations in both stream systems for evaluating background sources and effects of source control activities and stormwater management projects. Recommended future monitoring stations are presented in Table 26. It is strongly encouraged that monitoring be

continued at Bell 0.2 since this is the monitoring station with the most robust dataset and therefore the station where long-term trends can more easily be identified. It is also recommended that more consistent and frequent monitoring be conducted at Bell 0.8 and Bell 1.6 to help evaluate the upstream contributions of these pollutants. Bell 4.2 has been identified as a reference/background monitoring station located near the headwaters. Two monitoring stations are identified in Johnson Creek based on past monitoring data; Johnson 0.0 at the mouth of the creek and Johnson 2.0 as a reference/background monitoring station.

It is recommended that water samples be collected during targeted base flow and storm events throughout the seasons to evaluate fecal coliform bacteria, nutrient, and metal sources associated with different hydrologic conditions. For example, elevated fecal coliform bacteria concentrations during base flow (dry weather) are generally indicative of direct inputs from wildlife, illicit connections with sanitary sewage conveyance systems, or chronic failure of septic systems in unsewered areas while elevated fecal coliform bacteria concentrations during storm events are generally indicative of inputs from the wash off of fecal deposits on land, overflow of sanitary sewage systems, or hydraulic failure of septic systems in unsewered areas.

Table 26. Recommended Monitoring Stations and Parameters in Sequim Streams.

Monitoring Location	Fecal Coliform Bacteria	Nutrients	Metals
Bell Creek			
Bell 0.2	X	X	X
Bell 0.8	X	X	X
Bell 1.6	X	X	X
Bell 4.2	X	X	X
Johnson Creek			
Johnson 0.0	X	X	X
Johnson 2.0	X	X	X

It is recommended that a minimum of 12 samples be collected each year; 6 during wet weather and 6 during dry weather. Base flow (dry weather) samples should be collected once every second month on days preceded by dry weather (e.g., minimum antecedent dry period of 24 hours). Storm event (wet weather) samples should be collected on days preceded by at least 0.15 inches of rain. Water samples should be collected on the same date at all six monitoring stations to maximize the power of statistical trend analysis. As mentioned previously, the monitoring stations and parameters identified for Bell Creek are a higher priority than the monitoring stations and parameters identified for Johnson Creek.

It is also recommended that continuous monitoring of dissolved oxygen and temperature be conducted in Bell Creek during the summer months to evaluate temporal trends in the low dissolved oxygen concentrations historically observed at this station and to determine if temperature is an issue. No dissolved oxygen data were available for evaluation as part of this report, but Bell Creek is listed on Ecology's 2012 303(d) list of impaired waters (Category 5)

for dissolved oxygen, so this should be further investigated. Continuous temperature data has also not been collected in Bell Creek to date.

Fecal Source Tracing

Fecal source tracing should be conducted to identify sources of fecal coliform bacteria in the priority areas described above. Fecal source tracing should be conducted initially in the highest priority area of Bell Creek as described below, and findings from this source tracing should be used to adapt the source tracing methodology for areas in Johnson Creek.

The first step in fecal source tracing is to develop a detailed drainage map of the area. In Bell Creek, that includes the lowermost reach from Bell 1.6 to Bell 0.2. A drainage contaminant survey should then be conducted during dry and wet weather to refine the drainage map, measure discharge of drainage at key points in the area, identify potential human and animal sources of fecal coliform bacteria, and locate potential sites for source control or treatment.

The dry weather survey should be conducted first to establish sampling stations at key access locations in the stormwater drainage system. Generally, key sampling stations are located at each stream outfall (where surface runoff enters a stream) in the priority area and at upstream manholes, inlets, or ditches on the main stormwater drainage lines that contribute to the outfall. If flow is present at a sampling station, discharge should be measured and a water sample should be collected for analysis of fecal coliform bacteria. Discharge (flow) data will be used to identify the relative contribution of drainage to the stream and between upstream sampling stations, and can be used in combination with fecal coliform bacteria concentrations to calculate fecal coliform bacteria loading rates at the time of sample collection. A second dry weather survey may be needed to confirm the initial results and resolve unusually high increases in discharge or bacteria concentrations between sampling stations. The drainage contaminant survey should be repeated at the same stations during wet weather to identify potential fecal sources during storm events.

During each survey, land draining to the stormwater drainage system should be inspected for the presence of animal waste (e.g., birds, rodents, pets, and livestock). The land area should also be inspected for potential human waste sources from improperly stored garbage or unsanitary practices. Water samples should be inspected for an unusual odor, color, or turbidity that may be indicative of sanitary sewage. Locations of sampling stations should be recorded on a map or using a GPS unit. Visual observations and field meter or test kit results should be recorded in a field notebook or on a standardized field form.

The survey findings should be used to identify priority areas for source control or treatment. Appropriate source control activities may include programmatic solutions such as education of proper pet and livestock waste management, septic system maintenance, or street sweeping. Structural source control solutions may include disconnection of illicit sanitary waste connections or stormwater treatment at key inputs. Stormwater treatment may include installation of devices to remove fecal coliform bacteria by filtration or other means, such as ultraviolet radiation or approved biocides.

Fecal source tracing should be repeated at selected monitoring stations following source control or treatment actions to confirm the effectiveness of those actions.

Sediment Quality Monitoring

Based on the limited sediment quality monitoring results presented in this report, no clear water quality concerns were identified; thus, no additional sediment quality monitoring is recommended at this time.

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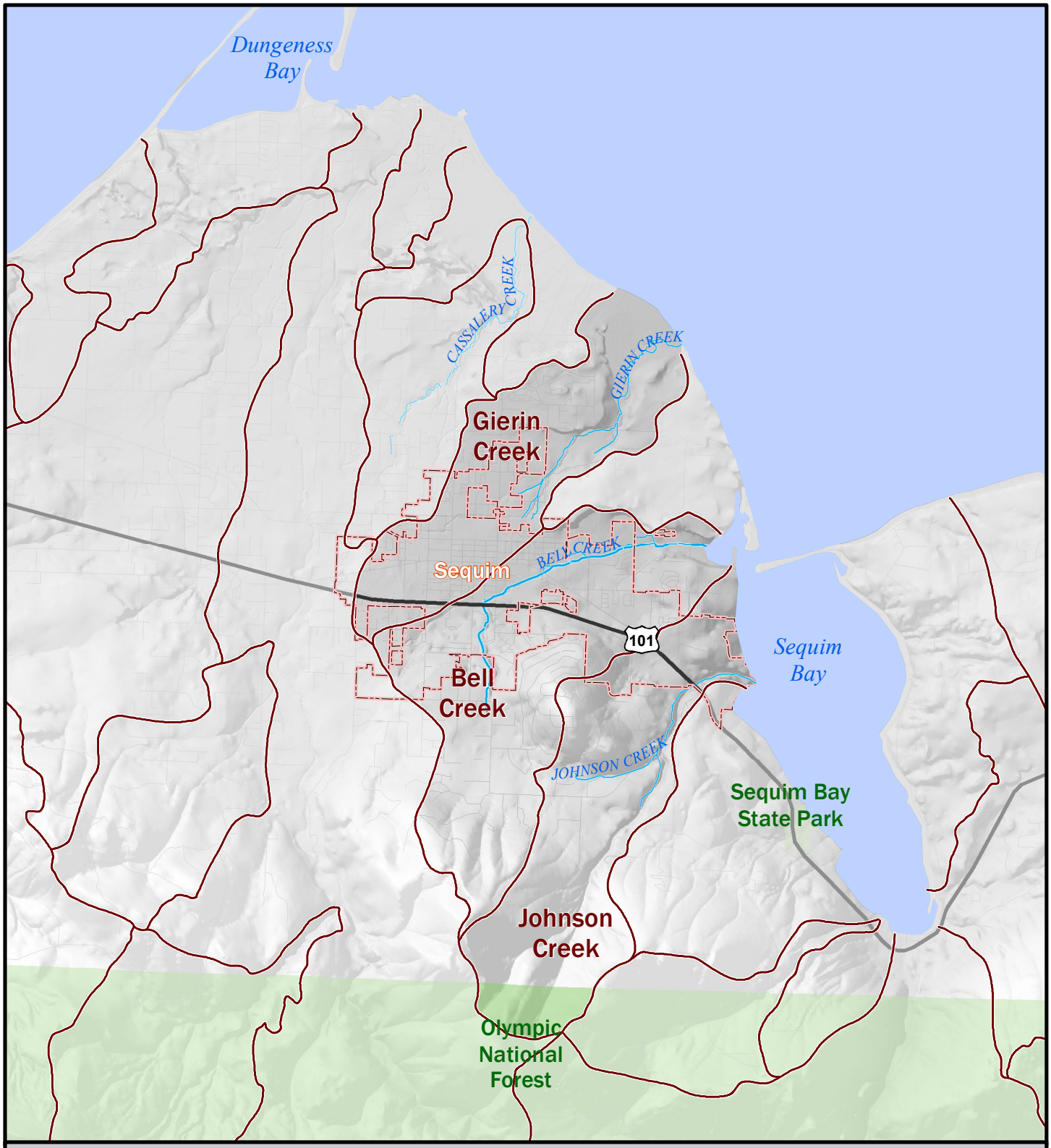
APPENDIX A

Drainage Basin Maps



Legend

- Subbasin
- City limit
- Stream
- Highway

Figure A-1.
City of Sequim, Washington
Vicinity Map and Drainage Basins.

N

0 3,000 6,000 12,000
Feet

HERRERA

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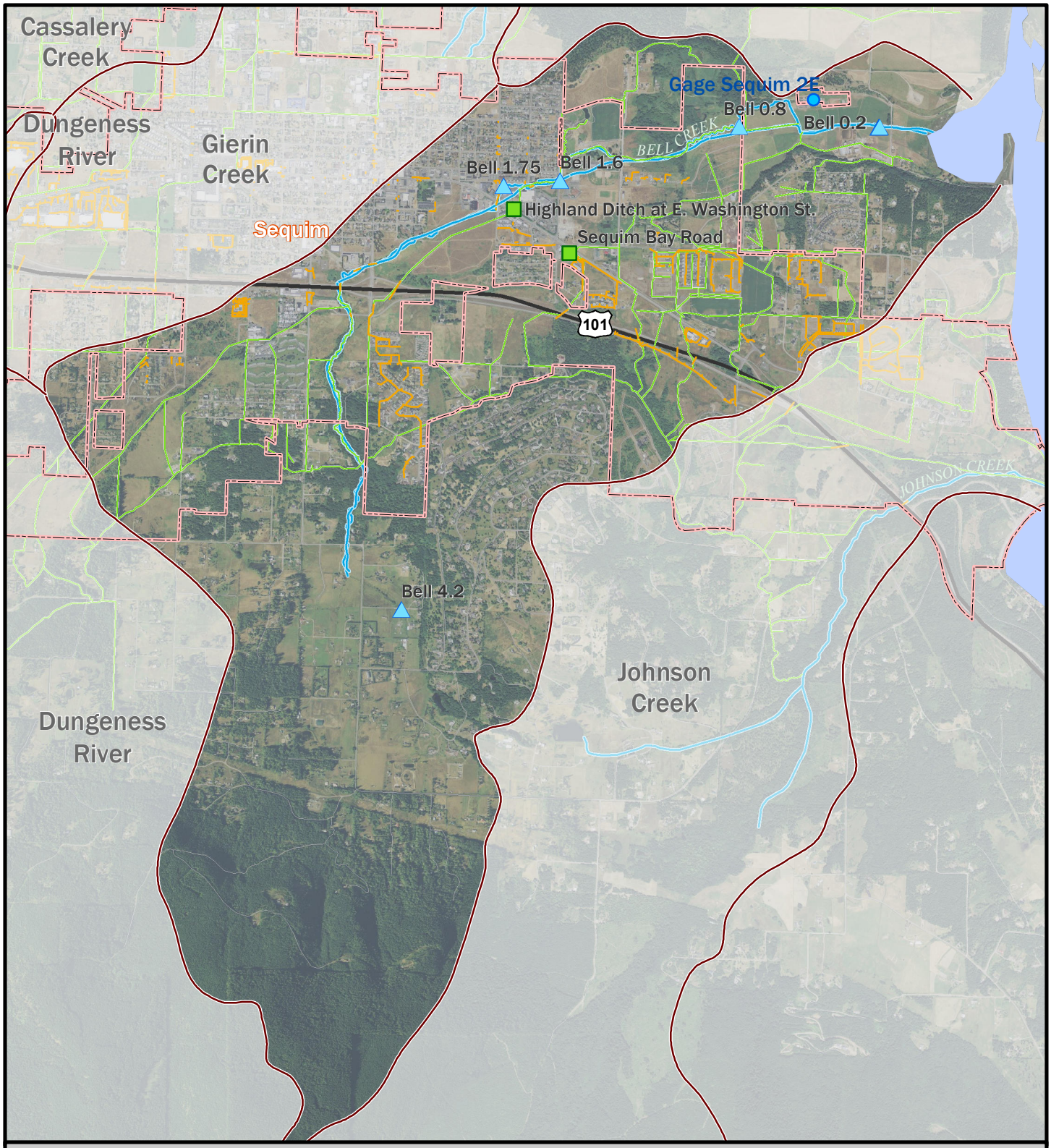

Legend

- City limit
- Stream
- Highway
- Subbasin
- Creek monitoring station
- Irrigation ditch monitoring station
- Stormwater system monitoring station
- Rain gauge station
- Irrigation ditch
- Stormwater pipe

Figure A-2.
Bell Creek Drainage Basin and Monitoring Station Locations.

N

0 1,500 3,000 6,000 Feet

HERRERA

USDA, Aerial (2013)

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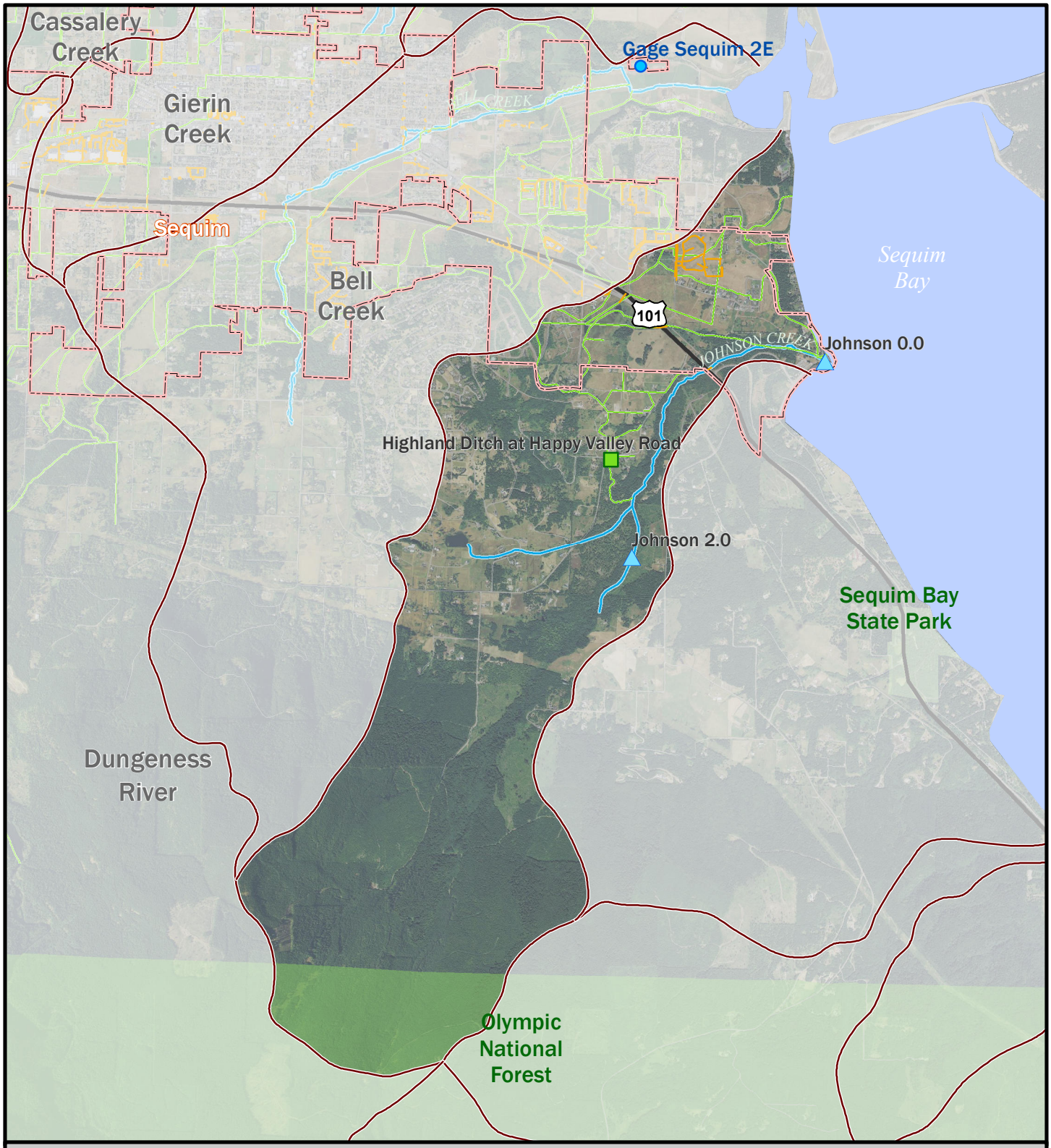

Legend

- City limit
- Stream
- Highway
- Subbasin
- Creek monitoring station
- Irrigation ditch monitoring station
- Stormwater system monitoring station
- Rain gauge station
- Irrigation ditch
- Stormwater pipe

Figure A-3.
Johnson Creek Drainage Basin and Monitoring Station Locations.

N

0 2,000 4,000 8,000 Feet

HERRERA

USDA, Aerial (2013)

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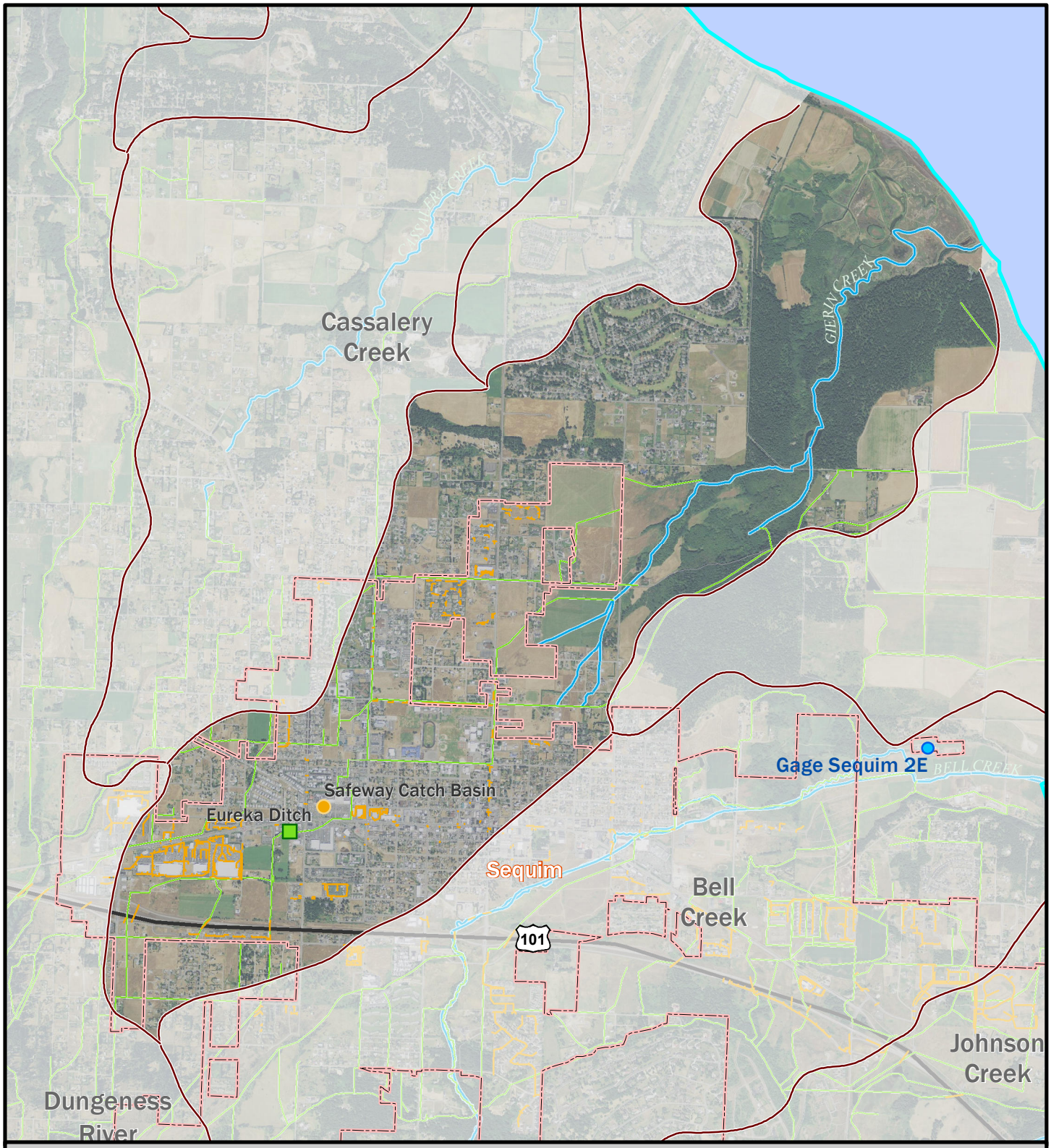

Legend

- City limit
- Stream
- Highway
- Subbasin
- Creek monitoring station
- Irrigation ditch monitoring station
- Stormwater system monitoring station
- Rain gauge station
- Irrigation ditch
- Stormwater pipe

Figure A-4.
Gierin Creek Drainage Basin and Monitoring Station Locations.

N

0 1,500 3,000 6,000 Feet

HERRERA

USDA, Aerial (2013)

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APPENDIX B

Additional Water Quality Standards and Assessments

EPA Ecoregion II Nutrient Criteria

The EPA's nutrient criteria for rivers and streams in Nutrient Ecoregions are recommendations to States and Tribes for establishing their water quality standards. The City of Sequim falls into the EPA Nutrient Ecoregion II: Western Forested Mountains. Ecoregion II nutrient reference conditions that are equivalent to the median of the 25th percentiles for all four seasons using all of the data compiled from rivers and streams in this ecoregion are shown in Table B-1.

Table B-1. Ecoregion II 25th Percentile Reference Conditions.

Nutrient Parameter	Aggregate Nutrient Ecoregion II Reference Conditions
Total phosphorus (ug/L)	10.0 ug/L
Total nitrogen (mg/L)	0.12 mg/L
Chlorophyll a (ug/L) (gluorometric method)	1.08 ug/L
Turbidity (NTU)	1.3 NTU

More information can be found in the EPA's Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion II (2000) (<http://www2.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-documents-rivers-and-streams>).

ECOLOGY WATER QUALITY ASSESSMENT AND 303(D) LISTINGS

Specific reaches of the following waterbodies in Sequim have been assessed and assigned Category 2 (waters of concern) or Category 4c (impaired by a non-pollutant) (Ecology 2012):

- Bell Creek: fecal coliform bacteria, pH, and temperature (Category 2)
- Johnson Creek: fecal coliform bacteria, pH, and bioassessment (Category 2)
- Dungeness River: bioassessment (Category 2)
- Sequim Bay: dissolved oxygen(Category 2)
- Independent irrigation ditch (Sequim Prairie Tri): pH (Category 2)
- Strait of Juan de Fuca East: fish and shellfish habitat (Category 4c)

Ecology (2012) has included the following waterbodies on the 303(d) list of impaired waters (Category 5) for the following parameters:

- The lower reaches of Bell Creek: fecal coliform bacteria, dissolved oxygen, and Benthic Index of Biotic Integrity (B-IBI)
- Lower reaches of Johnson Creek: fecal coliform bacteria
- Sequim Bay: fecal coliform bacteria and dissolved oxygen

Additional detail on the 2012 Water Quality Assessment is included in Table B-2.

Ecology released additional 303(d) listings in the proposed 2015 303(d) list of impaired waters (Category 5) while the Water Quality Analysis was under development. The following waterbodies within the City are on the proposed 2015 303(d) list for the following parameters:

- The lower reaches of Bell Creek: pH, temperature
- Middle (ephemeral) reach of Bell Creek: pH, fecal coliform bacteria, dissolved oxygen, and bioassessment
- Upper (perennial) reaches of Bell Creek: fecal coliform bacteria and dissolved oxygen
- Johnson Creek (entire length): pH and fecal coliform bacteria

More information can be found on Ecology's proposed water quality assessment and 303(d) List at the following website: <http://www.ecy.wa.gov/programs/wq/303d/freshwtrassessmnt/index.html>.

Table B-2. Ecology 2012 Water Quality Assessment.

Listing ID	Name	Parameter	Medium	Category	Waterbody ID	Lower Address	Upper Address	Basis
42966	BELL CREEK	Dissolved Oxygen	Water	5	1230524480832	0.462	2.175	• Location ID [CCWR_00015]: o In 2004, 1 sample showed no excursion of the criteria for this waterbody, (criterion = 9.5 mg/L) o In 2003, 2 of 3 samples (66.7%) showed an excursion of the criteria for this waterbody o In 2002, 1 sample showed no excursion of the criteria for this waterbody o In 2001, 2 of 4 samples (50.0%) showed an excursion of the criteria for this waterbody • Streamkeepers of Clallam County data (submitted by Ed Chadd on 03/15/04), station Bell 0.8 shows 5 samples beyond the criterion collected on the following days: 10/3/2001, 8/15/2001, 1/20/2002, 1/20/2003, 10/17/2003
42963	BELL CREEK	Bioassessment	Other	5	1230524480832	0.462	2.175	• B-IBI score of 26 at Bell 0.5 10/10/1999 (CCSK) • B-IBI score of 16 @ Bell 0.8 10/26/2002 (CCSK) • B-IBI score of 12 @ Bell 0.8 10/17/2003 (CCSK) • Streamkeepers of Clallam County unpublished data show biological conditions are degraded based on the B-IBI scores from macroinvertebrate samples collected in 2002 and 2003 at site Bell 0.8.

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
42962	BELL CREEK	Bioassessment	Other	5	1230524480832	0	0.462	• B-IBI score of 18 @ Bell 0.1 10/10/1999 (CCSK) • B-IBI score of 16 @ Bell 0.1 10/1/2000 (CCSK) • B-IBI score of 12 @ Bell 0.1 9/30/2001 (CCSK) • B-IBI score of 10 @ Bell 0.1 10/11/2005 (CCSK) • Streamkeepers of Clallam County unpublished data show biological conditions are degraded based on the B-IBI scores from macroinvertebrate samples collected in 1999, 2000, and 2001 at site Bell 0.1.
7685	BELL CREEK	Bacteria	Water	5	1230524480832	0	0.462	• Location ID [CCWR_00192]: o 0 of 1 (0.0%) of samples collected in 2002 exceed the percent criterion (100 col/100mL) o Fewer than five samples were available in 2002, therefore a geometric mean was not calculated for this period • Streamkeepers of Clallam County data (submitted by Ed Chadd on 03/15/04), station Bell 0.1 shows in 2001 and 2003 at least one sample exceeded the criterion. • Streamkeepers of Clallam County unpublished data from Bell 0.1 show a geometric mean (cfu/100mL) of: o 12 from 4 samples collected in 2003 o 13 from 4 samples collected in 2002

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
7685 (cont.)								o 1 from 1 sample collected in 2002 o 17 from 6 samples collected in 2001 o 42 from 5 samples collected in 2000 o 38 from 3 samples collected in 1999 o 2070 from 6 samples collected in 1992 o 190 from 1 sample collected in 1990 o 267 from 5 samples collected in 1989 o 863 from 12 samples collected in 1988 o 724 from 4 samples collected in 1987
42965	BELL CREEK	Dissolved Oxygen	Water	5	1230524480832	0	0.462	• Location ID [CCWR_00012]: o In 2004, 1 of 2 samples (50.0%) showed an excursion of the criteria for this waterbody, (criterion = 9.5 mg/L). o In 2003, 1 of 3 samples (33.3%) showed an excursion of the criteria for this waterbody o In 2002, 1 of 8 samples (12.5%) showed an excursion of the criteria for this waterbody o In 2001, 2 of 7 samples (28.6%) showed an excursion of the criteria for this waterbody o In 2000, 3 of 4 samples (75.0%) showed an excursion of the criteria for this waterbody

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
42965 (cont.)								• Streamkeepers of Clallam County data (submitted by Ed Chadd on 03/15/04), station Bell 0.1 shows 7 samples beyond the criterion collected on the following days: 1/17/2000, 10/1/2000, 7/28/2000, 8/12/2001, 9/30/2001, 8/15/2002, 10/17/2003
6814	BELL CREEK	pH	Water	2	1230524480832	0	0.462	• Location ID [Data from multiple locations]: o In 2003, 1 of 4 samples (25.0%) showed an excursion of the criteria for this waterbody: 1 high pH excursion. o In 2002, 0 of 6 samples (0.0%) showed an excursion of the criteria for this waterbody. • Location ID [CCWR_00012] – In 2004, 1 of 1 sample (100.0%) showed an excursion of the criteria for this waterbody: 1 high pH excursion. • Streamkeepers of Clallam County unpublished data from Bell 0.1 show: o 0 excursions beyond the criterion out of 2 measurements collected in 2001–2003 o 0 excursions beyond the criterion out of 17 measurements collected in 1997–2002

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
15600	BELL CREEK	Bacteria	Water	2	1230524480832	0.462	2.175	• Jamestown S'Klallam Tribe unpublished data from station Bell 03 shows a geometric mean (cfu/100mL) of: o 12 from 4 samples collected in 2002 o 30 from 4 samples collected in 2001 o 43 from 4 samples collected in 2000 o 3 from 2 samples collected in 1999 o 8 from 4 samples collected in 1998 o 4 from 4 samples collected in 2002 o 98 from 4 samples collected in 2001 o 24 from 4 samples collected in 2000 o 7 from 4 samples collected in 1998
21441	BELL CREEK	Temperature	Water	2	1230524480832	0.462	2.175	• Streamkeepers of Clallam County unpublished data show: o 1 excursion beyond the criterion in measurements collected on 15 August 2001 at station Bell 0.8 (Bell @ Spath DOT site) o No excursions beyond the criterion in measurements collected between 1997–2002 at station Bell 1.5 (Bell Creek @ Carrie Blake Park @ w. foot bridge)

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
7674	JOHNSON CREEK	Bacteria	Water	5	1230394480628	1.528	1.543	• Streamkeepers of Clallam County unpublished data shows a geometric mean (cfu/100mL) of: o 103 from 8 samples collected in 1991 o 75 from 6 samples collected in 1992 o 64 from 4 samples collected in 1987 o 41 from 13 samples collected in 1988 o 26 from 5 samples collected in 1989 o 20 from 1 samples collected in 1990 o 6 from 2 samples collected in 1999 o 22 from 7 samples collected in 2000 o 22 from 6 samples collected in 2001 o 21 from 5 samples collected in 2002
21549	JOHNSON CREEK	pH	Water	2	1230394480628	1.528	1.543	• Location ID [Data from multiple locations]: o In 2005, 0 of 3 samples (0.0%) showed an excursion of the criteria for this waterbody o In 2006, 0 of 3 samples (0.0%) showed an excursion of the criteria for this waterbody • Streamkeepers of Clallam County unpublished data show : o 1 excursion beyond the criterion out of 7 measurements collected in 1998–2000 at station Johnson 0.6 (Johnson d/s of Hwy 101). o 0 excursions beyond the criterion out of 9 measurements collected in 1997–2000 at station Johnson 0.0 (Johnson upstream of Marina).

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	Name	Parameter	Medium	Category	Waterbody ID	Lower Address	Upper Address	Basis
21551	JOHNSON CREEK	pH	Water	2	1230394480628	1.714	3.504	• Location ID [Data from multiple locations]: o 2006, 1 of 1 sample (100.0%) showed an excursion of the criteria for this waterbody: 1 high pH excursion. • Streamkeepers of Clallam County unpublished data show 0 excursions beyond the criterion out of 3 measurements collected in 1997–1998 at station Johnson 1.4 (Johnson @ Happy Valley Rd).
42832	JOHNSON CREEK	Bioassessment	Water	2	1230394480628	0	1.528	• Streamkeepers of Clallam County unpublished data show biological conditions are degraded based on the BIBI scores from macroinvertebrate samples collected in: o 1999 at site Johnson 0.0. o 1999 at site Johnson 0.6.
42975	JOHNSON CREEK	Bacteria	Water	2	1230394480628	1.714	3.504	• Streamkeepers of Clallam County data (submitted by Ed Chadd on 03/15/04), station Johnson 1.7 shows in 2000, at least one sample exceeded the criterion.
47000	DUNGENESS RIVER	Bioassessment	Water	2	1231331481508	10.461	10.461	• B-IBI score of 36 @ Dungeness 6.6a 10/14/2004 (CCSK) B-IBI score of 42 @ Dungeness 5.9 9/27/2005 (CCSK)
7678	SEQUIM BAY	Dissolved Oxygen	Water	2	1224199478564	None	None	• Norman Associates (1978), 1 excursion beyond the criterion at station 017 on 5/18/87
7679	SEQUIM BAY	Dissolved Oxygen	Water	2	1224199478564	None	None	• Norman Associates (1978), 1 excursion beyond the criterion at station 019 on 5/18/87

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
7680	SEQUIM BAY	Dissolved Oxygen	Water	2	1224199478564	None	None	• Norman Associates (1978), 1 excursion beyond the criterion at station 018 on 5/18/87
10296	SEQUIM BAY	Dissolved Oxygen	Water	5	1224199478564	None	None	• Location ID [JDF007] – In 2007, 6 out of 10 (60%) samples showed an excursion of the criterion (7 mg/L) • Newton et al. (2002) Dept. of Ecology Ambient Monitoring Station JDF007 (Strait of Juan de Fuca – Sequim Bay Goose Point) shows 1 excursion beyond the criteria out of 2 samples collected between 1993–2000
10300	SEQUIM BAY	Dissolved Oxygen	Water	2	1224199478564	None	None	• Newton et al. (2002) Dept. of Ecology Ambient Monitoring Station JDF005 (Strait of Juan de Fuca – Sequim Bay) shows 3 excursions beyond the criterion out of 10 samples collected between 1993–2000 • Norman Associates (1978) 1 excursion beyond the criterion at station 028 on 5/18/87.
10302	SEQUIM BAY	Dissolved Oxygen	Water	2	1224199478564	None	None	• Location ID [LTMW119] – In 2000, 5 of 12 samples (41.7%) showed an excursion of the criteria for this waterbody, (criterion = 7.0 mg/L) • Newton et al. (2002) Dept. of Ecology Ambient Monitoring Station SEQ002 (Sequim Bay – Northern) shows 5 excursions beyond the criterion out of 12 samples collected between 1993–2000

40364	SEQUIM BAY	Bacteria	Water	5	1224199478564	None	None	• Location IDs [SEQUIM BAY 98], [SEQUIM BAY 78]: o In 2009, 0 out of 7 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 1.9 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2008, 0 out of 8 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 3.4 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2007, 0 out of 9 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 1.7 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). • Department of Health unpublished data collected from station SEQUIM BAY-78 show a geometric mean of 3 cfu/100mL and 7.4% of samples exceed the percentile criterion with the last sample collected on 17-Dec-2001. • Department of Health unpublished data collected from station SEQUIM BAY-98 show a geometric mean of 3 cfu/100mL and 0% of samples exceed the percentile criterion with the last sample collected on 17-Dec-2001. • BEACH ID [WA302512] – In 2009, 2 out of 10 (20%) sample events exceeded the enterococcus percent criterion (208 col/100 mL). The geometric mean of 29.7 col/100 mL did not exceed the enterococcus geometric **mean criterion (70 col/100 mL)**.

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
40365	SEQUIM BAY	Bacteria	Water	2	1224199478564	None	None	• Location ID [SEQUIM BAY 79]: o In 2009, 0 out of 6 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 2.5 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2008, 1 out of 5 (20%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 7.5 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2007, 0 out of 6 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 1.7 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). • Department of Health unpublished data collected from station SEQUIM BAY-79 show a geometric mean of 2 cfu/100mL and 3.4% of samples exceed the percentile criterion with the last sample collected on 17-Dec-2001.
40372	SEQUIM BAY	Bacteria	Water	2	1224199478564	None	None	• Location ID [SEQUIM BAY 91]: o In 2009, 0 out of 7 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 1.7 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2008, 0 out of 6 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 4.1 col/100mL did not exceed the geometric mean criterion (14 col/100 mL).

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
40372 (cont.)								o In 2007, 0 out of 6 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 1.8 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). • Department of Health unpublished data collected from station SEQUIM BAY-91 show a geometric mean of 3 cfu/100mL and 3.4% of samples exceed the percentile criterion with **the last sample collected on 17-Dec-2001**.
40373	SEQUIM BAY	Bacteria	Water	2	1224199478564	None	None	• Location IDs [SEQUIM BAY 93], [SEQUIM BAY 81] – o In 2009, 0 out of 7 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 2.2 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). In 2008, 1 out of 6 (16.7%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 3.3 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). o In 2007, 0 out of 6 (0%) samples exceeded the percent criterion (43 col/100 mL). The geometric mean of 2.2 col/100mL did not exceed the geometric mean criterion (14 col/100 mL). • Department of Health unpublished data collected from station SEQUIM BAY-93 show a geometric mean of 3 cfu/100mL and 0% of samples exceed the percentile criterion with the last sample collected on 17-Dec-2001.

Table B-2 (continued). Ecology 2012 Water Quality Assessment.								
Listing ID	**Name**	**Parameter**	**Medium**	**Category**	**Waterbody ID**	**Lower Address**	**Upper Address**	**Basis**
51385	INDEPENDENT MAIN CANAL	pH	Water	2	1230933480870	0.585	2.381	• Location ID [Data from multiple locations] – o In 2002, 1 of 2 samples (50.0%) showed an excursion of the criteria for this waterbody: 1 high pH excursion.
21727	STRAIT OF JUAN DE FUCA (EAST)	Fish And Shellfish Habitat	Habitat	4C	1224199478564	None	None	• Frankenstein, 2000. Show the patchy cover of ulvoid macroalgae are impairing aquatic life from identified human causes at Washington Harbor.