Salmon Creek Watershed Low Dissolved Oxygen and pH Characterization Study

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For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

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

- Headquarters, Olympia (360) 407-6000
- Northwest Regional Office, Bellevue (425) 649-7000
- Southwest Regional Office, Olympia (360) 407-6300
- Central Regional Office, Yakima (509) 575-2490
- Eastern Regional Office, Spokane (509) 329-3400

Cover photo: Salmon Creek at 36th Ave, looking downstream from bridge.
(Photo taken 10/19/2011 by Nuri Mathieu.)

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by

Nuri Mathieu

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Waterbody Number: WA-28-1020

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Abstract

Washington State water quality criteria set minimum acceptable values for dissolved oxygen (DO) concentrations and an acceptable range of values for pH. Low DO and pH values, below minimum criteria, can be influenced by both natural processes and human-caused activities. Clark County has measured low DO and pH in the Salmon Creek watershed, including at their furthest upstream site on Salmon Creek.

This 2011-12 study by the Washington State Department of Ecology (Ecology) characterized DO and pH values in the Salmon Creek watershed and investigated the influence of natural processes. DO levels fell below criteria at all locations, with the exception of Cougar Creek. Ecology did not observe pH excursions, above or below water quality criteria, in Salmon Creek or its major tributaries.

Temperature levels above maximum criteria occurred at all sites, except for Cougar and Curtin Creeks. Elevated temperatures are partly responsible for low DO levels at sites above maximum temperature criteria. Excess nutrient levels and aquatic plant growth in Curtin Creek suggest that human-caused influence may further lower naturally low DO levels.

The lowest pH levels, approaching the minimum criterion, occurred during large wet-season precipitation events. Low pH in the Upper Salmon Creek watershed likely results from a natural condition. Acidic precipitation, combined with poorly buffered soils, geology, and stream water, results in decreases in instream pH.

The report recommends ranking DO listings in the watershed as low priority. While human-caused influence likely impacts DO in these waterbodies, the ongoing temperature and nonpoint source total maximum daily loads (TMDLs; water cleanup plans) are expected to improve DO levels in the watershed. The report also recommends removing 5 pH listings from the 303(d) list of impaired waters due to a natural condition of low pH in the watershed during large winter precipitation events.

Acknowledgements

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- Jeff Schnabel, Clark County Environmental Services-Clean Water Program, for review of the project plan and final report.
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Introduction

Between 1997 and 2007, Clark County observed low dissolved oxygen (DO) and pH values at several locations in the Salmon Creek watershed (Figure 1), including at their furthest upstream site, Salmon Creek at 199th (SMN080) (Hutton and Hoxeng, 2007). SMN080 served as the background site for the Salmon Creek Bacteria Total Maximum Daily Load (TMDL) study (Cusimano and Giglio, 1995) and the subsequent TMDL effectiveness monitoring study (Collyard, 2009). The occurrences of low DO and pH conditions at this site in the upper watershed, where human-caused (anthropogenic) impacts should be relatively few because of lack of development and a high percentage of forested land, suggest these conditions may be influenced by natural processes.

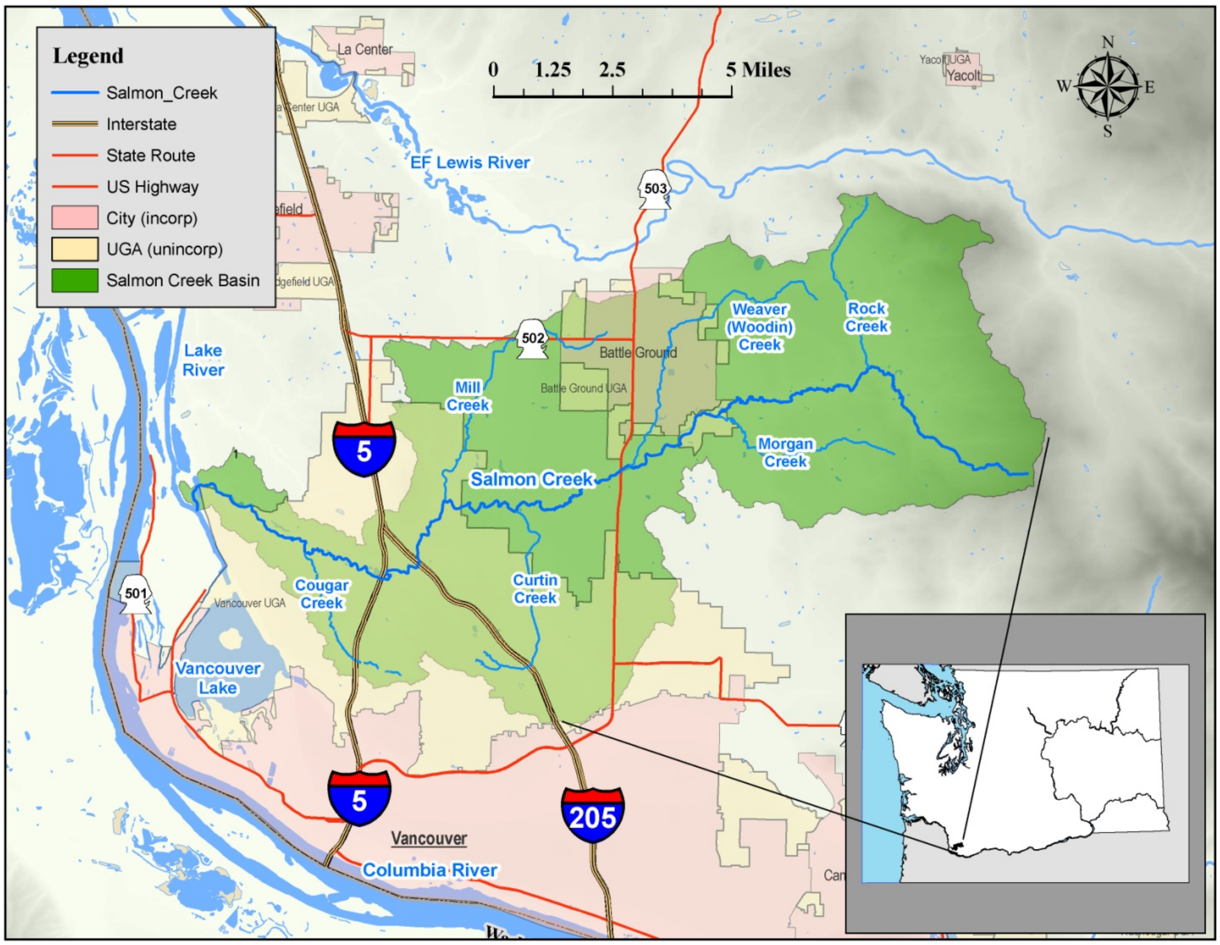

Figure 1. Overview map of Salmon Creek watershed.

In 2011-12, the Washington State Department of Ecology (Ecology) conducted a follow-up field study to better characterize the extent and duration of low DO and pH conditions in the Salmon Creek watershed. A secondary goal was to assess whether or not these conditions were influenced by natural processes. The Quality Assurance (QA) Project Plan describes the study objectives, design, and QA measures in greater detail (Mathieu, 2011).

Water Quality Criteria

Washington State water quality criteria (WAC 173-201A) set minimum acceptable values for DO concentrations and an acceptable range of values for pH (Table 1).

Table 1. Water quality criteria for dissolved oxygen and pH in the Salmon Creek watershed.

Parameter	Classification	Criteria
Salmon Creek and tributaries from mouth to latitude 45.7176, longitude -122.6958 (~RM 3)		
pH	Salmonid Spawning, Rearing, and Migration	pH shall be within the range of 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 units.
DO		Lowest 1-day minimum = 8.0 mg/L
Temperature		7 day average daily maximum < 17.5°C
Salmon Creek and tributaries upstream of latitude 45.7176, longitude -122.6958 (~RM 3)		
pH	Core Summer Salmonid Habitat	pH shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units.
DO		Lowest 1-day minimum = 9.5 mg/L
Temperature		7 day average daily maximum < 16°C

RM: River mile

Watershed Description

The Salmon Creek watershed (Figure 1), located in Clark County of southwest Washington, drains an area of approximately 93 square miles immediately north of the city of Vancouver. Salmon Creek originates on the slopes of Elkhorn Mountain (elevation = 2230 ft) and flows approximately 26 river miles to its confluence with Lake River (elevation = ~10 ft).

Land use varies throughout the watershed, with commercial timberland and rural residences dominating the upper watershed. Urbanization increases moving downstream through the watershed, with fairly developed commercial and residential areas in the lower watershed. The city of Battle Ground (population of 17,571), located at the north end of the middle of the Salmon Creek watershed, is the largest urban center. Some small communities are scattered throughout the mid and upper watershed. The majority of the lower watershed falls within the City of Vancouver urban growth area.

The mild, wet, maritime weather regime, typical of lower elevation areas of western Washington, dominates the local climate. The air temperatures in Battle Ground reach an average daily high of 79°F (26°C) in July and August with the average daily low dropping to 31°F (-0.6°C) in January (WRCC, 2011). The watershed receives an average of 58 inches of precipitation annually, over half of which falls from November through February. Winter precipitation in southwestern Washington typically ranges in pH from 4.8 to 5.5 with a median of 5.1[1].

[1] Based on data collected for the National Atmospheric Deposition Program at two National Trend Network stations: La Grande (WA21) and the Columbia River Gorge (WA98). Data collection range: Months= November to February; Years= 1988-2004 (NADP, 2011).

The geology of the watershed is characterized by older consolidated bedrock that has been filled, particularly at lower elevations, by a series of younger sedimentary deposits (Mundorff, 1964). Hydrogeologic units of Clark County have been identified by R.D. Swanson, amongst others, and summarized in a U.S. Geological Survey (USGS) report (Turney, 1990). In general, the surficial geology consists of the older bedrock unit in the Upper Salmon Creek watershed and an unconsolidated sedimentary aquifer in the lower watershed. Due to its productivity, the Troutdale gravel aquifer unit is the primary source of groundwater in Clark County. This unit begins in the Middle to Upper Salmon Creek watershed as the surface unit and is present throughout the rest of the watershed (downgradient), immediately beneath the unconsolidated sedimentary aquifer unit. A more detailed description of geology and hydrogeology in the watershed can be found in Mundorff (1964) and Turney (1990).

Comparison of the Jones and Upper Salmon Basins

Jones Creek, located approximately 5 miles north of the City of Washougal, is a tributary to the Little Washougal River.

Jones Creek served as a relatively low-impact control site for the study. The extent of human development and resource management in the lower elevation basins of Western Washington make it difficult to locate an appropriate reference/control basin for Salmon Creek.

Ecology compared characteristics of the Jones Creek basin and the Upper Salmon Creek basin to assess similarities and the level of anthropogenic impact in each basin. For the purpose of this report, the 'Jones basin' refers to the area that drains to the sampling location Jones (JON010) and the 'Upper Salmon basin' refers to the area that drains to the sampling location Upper Salmon (SMN086).

The two basins exhibit fairly similar physical (geography, climate, geology) and land use characteristics with a few notable differences (Table 2). The Jones basin is slightly smaller, wetter, steeper, and higher in elevation with primarily Olympic clay loam soils. A similar soil type, Olympic stony clay loam covers the majority of the Upper Salmon basin.

The Olympic series typically drains well and produces slow to medium runoff; soil acidity ranges from slightly acidic (pH~6.2), at shallow soil horizons, to very strongly acidic (pH~4.8), at deeper soil horizons (USDA, 2012). An older basalt bedrock unit dominates the surficial geology of both basins. Presumably, the surficial bedrock and acidic soil type contribute to the poor buffering capacity of both Jones and Upper Salmon Creeks.

Approximately 85% of the Upper Salmon basin is forested land (private managed, public managed, or private undeveloped), whereas 100% of the Jones basin is forested. Most of the remaining land in the Upper Salmon basin (12.9%) is low-density rural residential with on-site septic systems. Approximately one-third of the Jones basin is owned by the City of Camas and protected as a municipal drinking water source.

Table 2. Comparison of the Jones and Upper Salmon basins.

	JON010	SMN086
General		
Drainage area (square miles)	2.99	4.13
Elevation (ft)	714	506
Basin relief (ft)	2430	1720
Average slope	24.7%	17.6%
Average precipitation (in/yr)	82	76
Dominant soil type	Ol	Om
Surficial geology	BR	BR
Land Use		
% Commercial Timber Forest	30.7%	64.0%
% Public Forest	35.9%	8.8%
% Protected Watershed*	33.4%	0.0%
% Residential	0.0%	12.9%
% Undeveloped	0.0%	13.0%
% Agriculture	0.0%	0.0%
% Impervious	0.1%	0.3%
Acres of Wetlands	26.18	2.88
Acres of Lakes and Ponds	0.13	3.82
Miles of Road (digitized from 2011 orthophotos)	10.1	21.2
Road Density	3.39	5.14

BR: Older bedrock unit
Ol: Olympic clay loam (3% -60% slopes)
Om: Olympic stony clay loam (3% -60% slopes)
* The City of Camas protects a portion of the Jones Creek watershed as a drinking water supply.

Logging poses the only potential anthropogenic impact to water quality within the Jones basin. Several human activities within the Upper Salmon basin could potentially impact water quality including logging, on-site septic systems, residential fertilizer application, man-made water features (e.g., ponds), and domestic pets or livestock. Any logging impact would likely be greater in the Upper Salmon basin, given that it contains more acres of managed forest (1,942 vs. 1,271), more miles of road, and a greater road density. However, the steeper topography of the Jones basin may increase the efficiency of transportation of sediments and organic material from logging roads and harvested areas.

The Jones basin contains nearly 10 times the Upper Salmon basin wetland acreage (26.18 vs 2.88) and almost no acreage with lakes or ponds (0.13). The Upper Salmon basin contains 3.82 acres of, mostly man-made, ponds or small lakes. Wetland processes could present a significant natural influence in the Jones basin but are unlikely to significantly impact the Upper Salmon basin.

Methods

Staff from Ecology's Environmental Assessment Program collected all measurements and samples for the study following well established and documented protocols. Ecology's Manchester Environmental Laboratory performed all laboratory analysis, with the exception of periphyton and macroinvertebrate identification, which was performed by Rhithron Associates, Inc.

The QA Project Plan provides a more detailed description of field, laboratory, and quality control methods (Mathieu, 2011).

Sampling Locations and Dates

Field staff collected data from two networks of monitoring locations, the base network and the extended network.

The base network consisted of 11 stations throughout the Salmon Creek watershed and one reference/control basin outside the watershed, Jones Creek at Boulder Creek Road (JON010) (Table 3 and Figure 2).

Several differences in sample location and naming convention exist between the base network locations table in the QA Project Plan and this report. Location IDs were already established in Ecology's Environmental Information Management (EIM) database for most of the sites, so Ecology changed the Location IDs for this study to match. In addition, the location of Salmon Creek at end of Westerholm (SMN095) was moved downstream to Salmon Creek at Westerholm (SMN086) because Ecology was unable to obtain access on the private timberland at the desired upstream location (SMN095).

When referencing locations within this report, the author has used an abbreviation of the station description, followed by the study location name in parentheses, to provide multiple references to station location:

- For example, Salmon Creek at 36th Ave becomes Salmon at 36th (SMN010), and Salmon Creek at Westerholm Rd becomes Upper Salmon (SMN086).

The number in the study location name refers to the approximate percent of the total stream length in reference to the mouth.

- For example, the distance from the mouth of Salmon Creek to SMN<u>010</u> is approximately 10% of the total length of Salmon Creek.

The extended network consisted of additional locations concentrated in the Upper Salmon and Curtin Creek watersheds (Tables 4-5; Figures 3-4).

Table 3. Location IDs, names, descriptions, and coordinates for the base network sites.

Map ID#	Location ID	Study Location Name	Station Description	Latitude (Degree Decimal)	Longitude (Degree Decimal)
1	SMN010	SMN010	Salmon Creek at 36th Ave	45.72287758	-122.70754378
2	SMN030	SMN030	Salmon Creek at 50th Ave	45.72886236	-122.61857766
3	SMN050	SMN050	Salmon Creek at Caples Rd	45.74180846	-122.54639805
4	SMN080	SMN080	Salmon Creek at 199th St	45.76614460	-122.43103274
5	SMN086	SMN086	Salmon Creek at Westerholm Rd; downstream crossing	45.75580654	-122.4229223
6	CGR020	CGR020	Cougar Creek at 119th St	45.70717275	-122.68254702
7	MIL010	MIL010	Mill Creek at Salmon Ck Rd	45.73113810	-122.62754723
8	CUR020	CUR020	Curtin Creek at 139th St	45.72225906	-122.59098664
9	WDN010	WDN010	Weaver (Woodin) Ck at Caples Rd	45.74292195	-122.54617523
10	MOR010	MOR010	Morgan Creek at 167th Ave	45.75519180	-122.50055519
11	ROC005	RCK010	Rock Creek at Risto Rd	45.78361915	-122.44885497
12	28-JON-0.3	JON010	Jones Creek at Boulder Creek Rd	45.6670709	-122.3196066

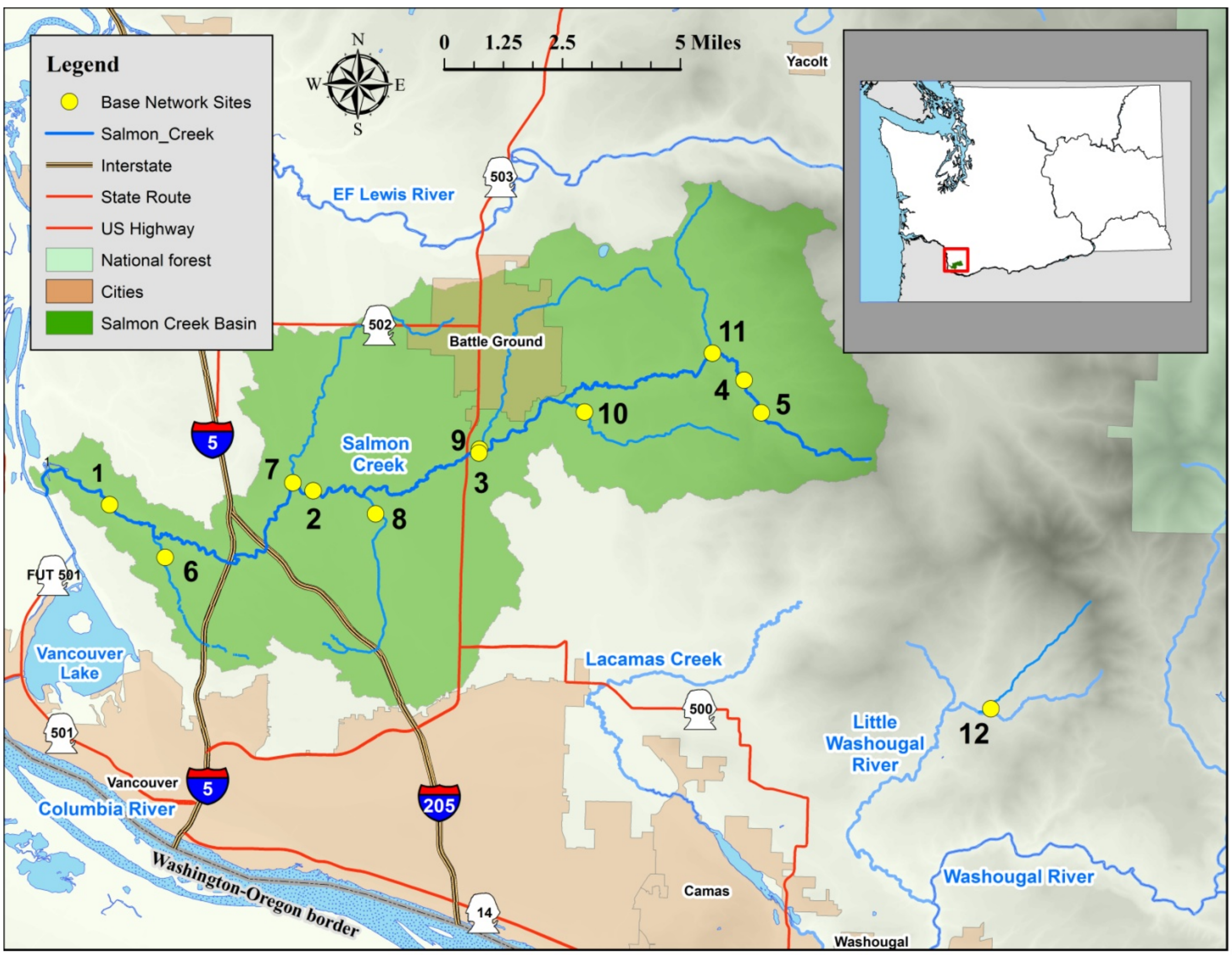

Figure 2. Map of base network sites.

Table 4. Location IDs, names, descriptions, and coordinates for the Upper Salmon basin extended network sites.

Map Index #	Location ID	Study Location Name	Station Description	Latitude (Degree Decimal)	Longitude (Degree Decimal
s-1	SMN088	SMN088	Salmon Ck at Westerholm Rd; upstream crossing	45.7532314	-122.4197251
s-2	28-Sal-Trib2	ST2	Trib to Salmon Ck at Richards Rd	45.75916004	-122.4329215
s-3	28-Sal-Trib1	ST1	Trib to Salmon Ck at NE 189th St	45.75916004	-122.4329001
s-4	28-Sal-Trib3	ST3	Trib to Salmon Ck at NE Erion Rd	45.76471382	-122.4220425
s-5	28-Sal-Trib4	ST4	Trib to Salmon Ck at NE 209th St	45.77361967	-122.4137813
s-6	28-Sal-Trib5	ST5	Trib to Salmon Ck at NE 262nd Ave	45.77219782	-122.4039751
	28-Rock-Trib1	RT1	Trib to Rock Ck at NE 222nd Ave	45.80279694	-122.4452382
	28-Rock-3.57	ROC081	Rock Creek at NE 212th Ave	45.8160339	-122.455495

Trib: tributary

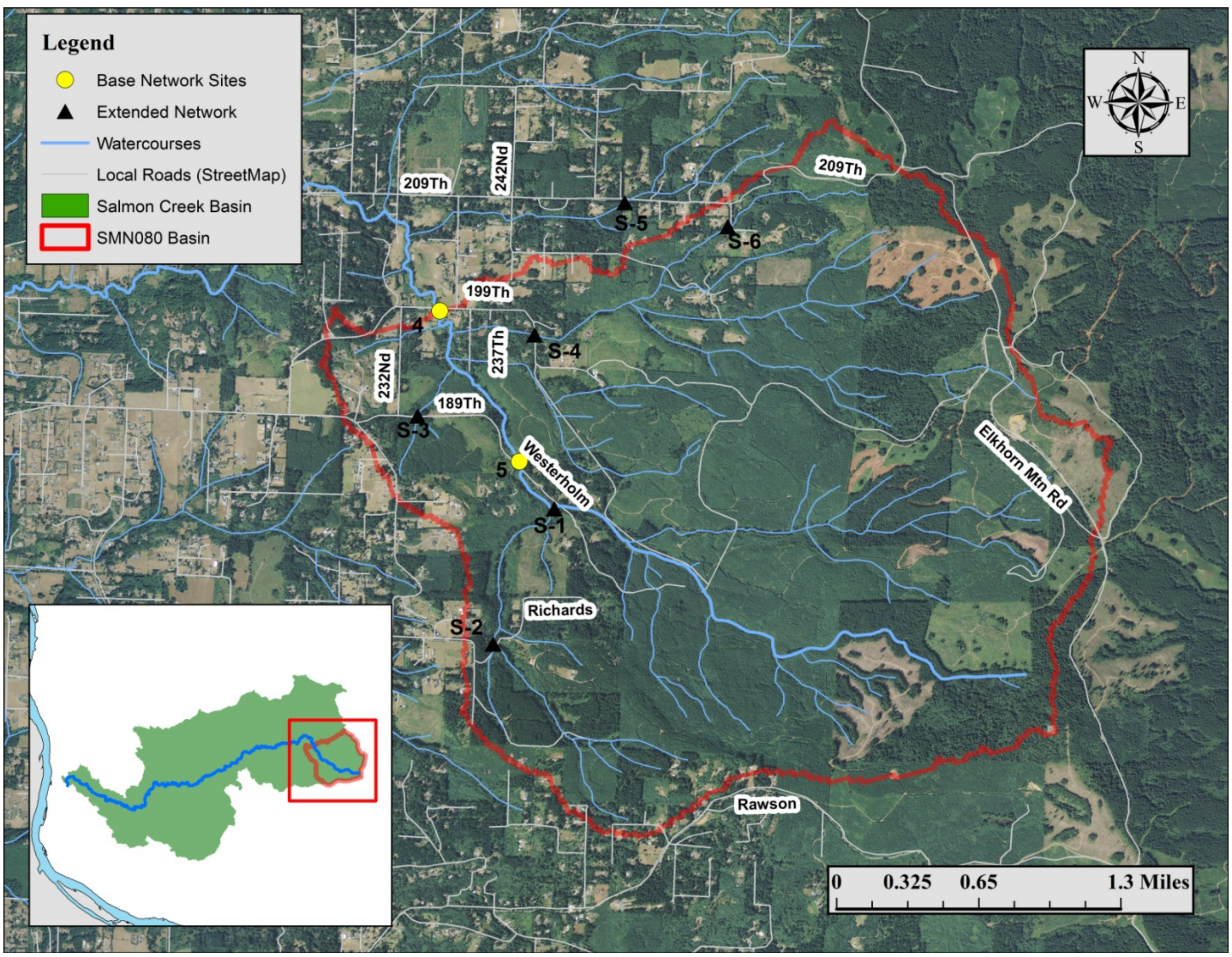

Figure 3. Map of Upper Salmon basin extended network sites.

Table 5. Location IDs, names, descriptions, and coordinates for the Curtin Creek extended network sites.

Map Index #	Location ID	Study Location Name	Station Description	Latitude (Degree Decimal)	Longitude (Degree Decimal)
c-1	28-Curt-2.37	CUR040	Curtain Ck at downstream end of large wetlands restoration area	45.70033991	-122.5887364
c-2	28-Curt-2.95	CUR050	Curtain Ck at upstream end of large wetlands restoration area	45.69324345	-122.5869608
c-3	28-Curt-3.48	CUR060	Curtain Ck at NE 88th St	45.68601869	-122.5863707
c-4	28-Curt-3.65	CT2	Curtain Ck at NE Padden Pkwy; just east of I-205	45.68370267	-122.5866175
c-5	28-Curt-4.75	CT1	Curtain Ck, or tributary, near headwaters at NE Padden Pkwy; just west of I-205 behind Costco	45.68225229	-122.6053125
c-6	28-Padd-0.15	CT3	Padden Ck at NE Padden Pkwy; just east of I-205	45.67471125	-122.5825164
c-7	28-Padd-1.15	CT4	Padden Ck near headwaters at NE 88th Ave	45.68335788	-122.5854051

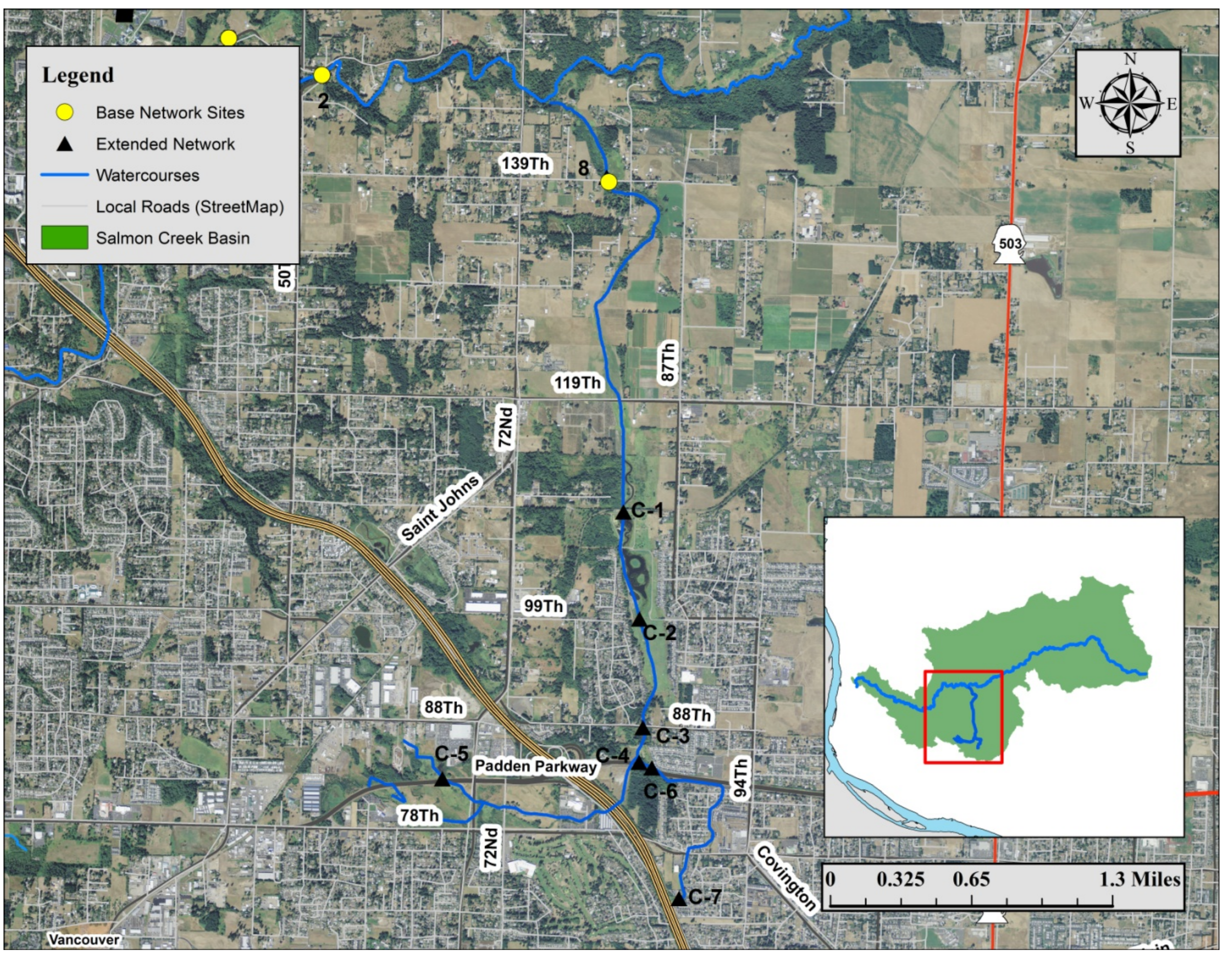

Figure 4. Map of Curtin Creek extended network sites.

Study Design

Data collection for the study consisted of five main components:

1. A long-term deployment at the *master station*, Salmon at 199th (SMN080), to collect continuous water quality measurements and establish a baseline of water quality throughout the year. Parameters measured included temperature, specific conductance, DO, and pH.
2. Monthly nutrient sampling (total nitrogen and phosphorus) at Upper Salmon (SMN086) and the reference site, Jones (JON010), and monthly water quality measurements (temperature, specific conductance, DO, pH, chlorophyll *a*, and ORP) at the base network sites.
3. A synoptic survey in mid-August 2011 to characterize diel water quality, nutrient fluxes, and periphyton biomass throughout the watershed.
    a. Parameters measured included temperature, specific conductance, DO, pH, chlorophyll *a*, and Oxidation-Reduction Potential (ORP).
    b. Parameters sampled included alkalinity, chloride, ammonia, total persulfate nitrogen (TPN), nitrite-nitrate, orthophosphate, total phosphorus (TP), dissolved organic carbon (DOC), and total organic carbon (TOC).
    c. Field staff conducted additional Hydrolab deployments in early September 2011 to supplement synoptic survey.
4. Wet-season low pH synoptic surveys to characterize pH in the Upper Salmon and Curtin Creek basins during winter storms or low pH events.
    a. Parameters measured included streamflow, temperature, specific conductance, DO, and pH.
    b. In addition, TPN, TP, and alkalinity samples were collected at Jones (JON010) and Upper Salmon (SMN086).
5. Macroinvertebrate and periphyton sampling and taxonomy at three locations: Upper Salmon (SMN086), Jones (JON010), and Salmon at Caples (SM050).

Table 6 and Figure 5 outline the monitoring event types, dates, and associated flows for the 2011-12 study.

Table 6. Monitoring dates for the 2011-12 field study components.

1. Long-Term SMN080 Sonde Deployment	2. Monthly Monitoring	3. Synoptic Survey	3c. Additional Sonde Deployments	4. Wet-Season Low pH Surveys	5. Periphyton/ Macroinvertebrate Taxonomy
11/16/2011 to 11/30/2012	9/29/2011 10/19/2011 12/14/2011 1/26/2012 2/14/2012 3/6/2012	8/15/2011 to 8/18/2011	9/7/2011 to 9/9/2011	11/16/2011 1/25/2012 2/22/2012	9/28/2011

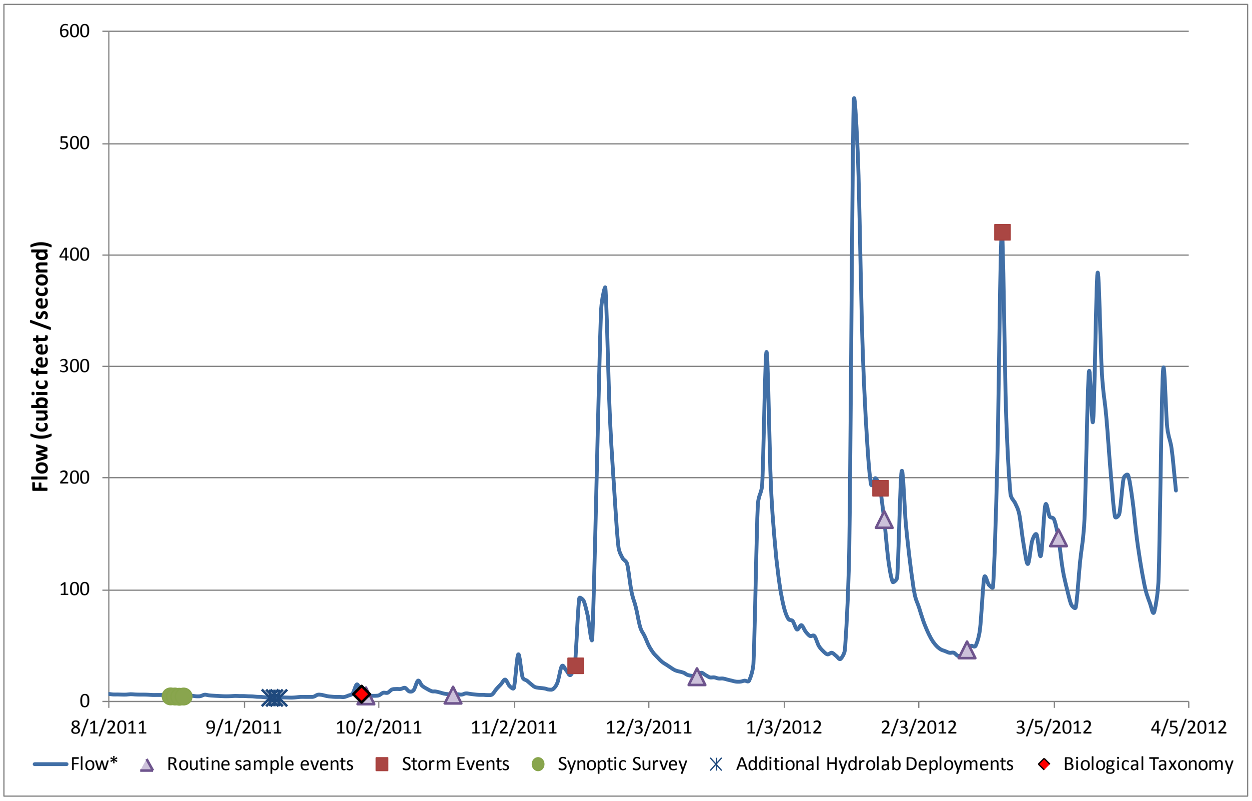

Figure 5. Plot of monitoring event types, dates, and streamflow.

Results

Data Quality Results

Completeness

In 2011, the Washington State Department of Labor and Industries began requiring a permit for solar panel installations; a permit was not previously required for this type of station installation. The permit requirement delayed the installation of the continuous water quality station at Salmon at 199th until November 2011.

The permit also required that the station be grounded in a specific way. The grounding method resulted in electrical interference to the pH sensor that caused unstable readings and rapid drift. After several months of working to identify the problem and troubleshoot a solution, the issue was resolved and the pH readings stabilized. As a result, Ecology did not obtain quality continuous pH data until early February 2012.

To compensate for the lack of continuous data collected to-date, the station installation was extended through the end of October 2012 to capture continuous water quality during an entire summer.

Due to these complications with the continuous water quality station, the project completeness goal of successfully collecting greater than 95% of the data described in the QA Project Plan was not met; however, with the extended deployment, Ecology collected continuous water quality throughout an entire summer (June –September 2012), as well as during several consecutive months of the winter low pH season (February to April 2012). This revised data collection plan is sufficient to meet the project goals and objectives.

Field and Laboratory Quality Control Procedures and MQOs

All laboratory and field duplicates samples, with results greater than five times the reporting limit, passed their respective measurement quality objectives (MQOs). The project manager reviewed all duplicates with results less than five times the reporting limit and deemed the result quality acceptable. Field duplicate measurements met their respective MQOs.

All field blank results fell below their respective method reporting limits. All but two lab blank results fell below the reporting limits. The two errant lab blanks resulted in volatile organic matter (ash-free dry weight) results of 5.05 and 4 mg/L respectively (reporting limit of 1 mg/L). The potential contamination level was equal to approximately 3% of the lowest reported result for the study, which met the MQO for acceptable bias.

All matrix spike and laboratory control sample recoveries fell within Manchester Laboratory's acceptance limits as well as MQOs outlined in the QA Project Plan (MEL, 2012).

Field staff conducted periodic representativeness measurement checks across a stream transect at the given location. The check results met the MQOs outlined in the QA Project Plan.

In general, field measurement equipment met the post-check MQOs outlined in the QA Project Plan. Some results were qualified based on post-checks; however, qualified results were deemed of acceptable quality for study objectives and used in analysis. Table 7 summarizes field measurement data quality results from Hydrolab post-checks. For locations with qualified continuous records, data were corrected if an acceptable correction factor could be applied. The resulting data correction was assigned a quality rating of either *good* or *fair*, based on USGS protocols (Wagner, 2006). Records with a quality rating of *excellent* were not qualified or corrected.

Table 7. Data quality ratings for Hydrolab monitoring results.

Parameter	Qualified Records	Total Records	Percent Qualified	Data Quality Ratings Records Count			Data Quality Ratings Percent of Total		
				Excellent	Good	Fair	Excellent	Good	Fair
Continuous Data (Synoptic Survey and Additional Deployments)									
SpCond	1207	3171	38%	1964	948	259	62%	30%	8%
pH	1661	3201	52%	1540	1661	0	48%	52%	0%
DO	1447	3177	46%	1730	1182	265	54%	37%	8%
Single Measurement Data (Monthly Monitoring and Field Checks)									
SpCond	77	189	41%	112	77	0	59%	41%	0%
pH	30	192	16%	162	30	0	84%	16%	0%
DO	22	192	11%	170	22	0	89%	11%	0%
Chl-a	9	69	13%	60	9	0	87%	13%	0%
ORP	0	68	0%	68	0	0	100%	0%	0%

Study Results

August 2011 Synoptic Survey

Figure 6 depicts sample results for the Salmon Creek mainstem and Jones Creek sites, collected during the synoptic survey on August 16 and 17, 2011. In general, parameter concentrations were relatively low in Upper Salmon Creek and in Jones Creek but increased at the downstream locations in Salmon Creek.

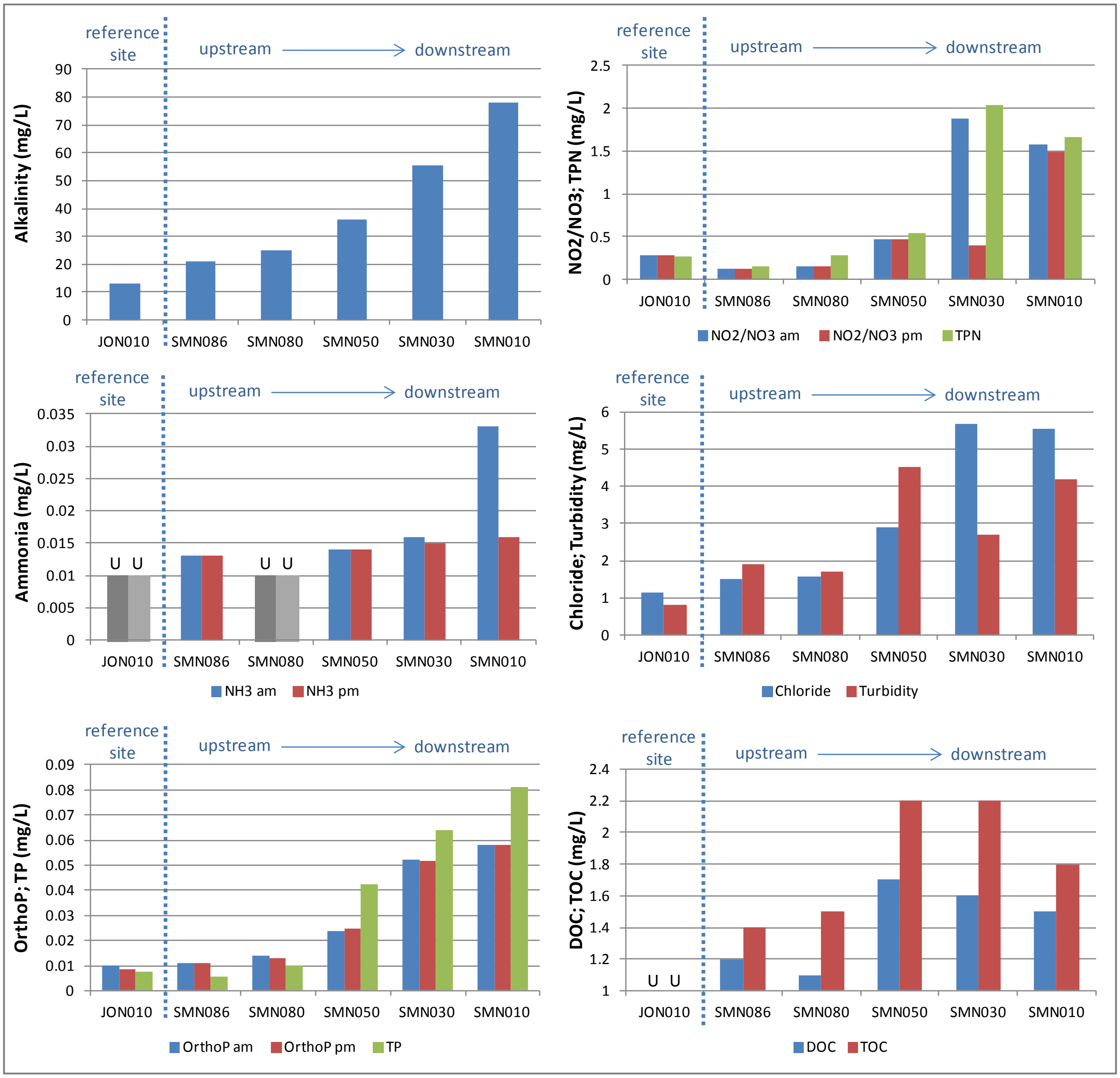

Figure 6. Nutrient and general chemistry sampling results for Salmon Creek mainstem sites and Jones Creek.

U = Analyte was not detected at or above the level displayed.

Figure 7 depicts sample results for the Salmon Creek tributary sites, collected during the synoptic survey on August 16 and 17, 2011. In general, alkalinity concentrations were relatively low in the upper watershed tributaries and increased at the lower watershed tributaries. Morgan (MOR010) exhibited the highest ammonia, turbidity, DOC, and TOC levels of all tributary sites. Curtin (CUR020) exhibited the highest nitrite-nitrate concentrations and diel variability in nitrate of greater than 4 mg/L.

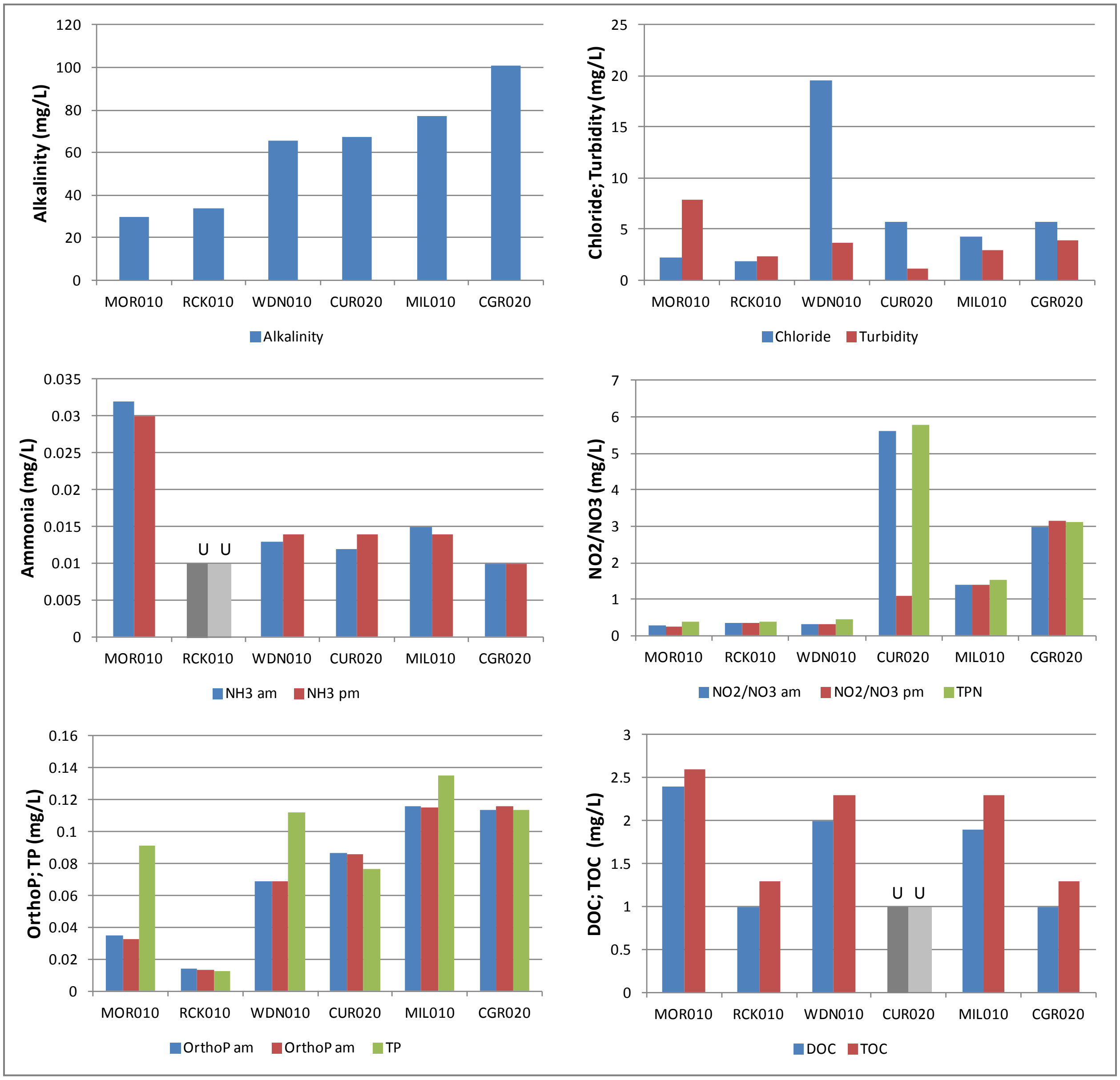

Figure 7. Nutrient and general chemistry sampling results for Salmon Creek tributary sites.

Figure 8 depicts continuous water quality results for the Salmon and Jones Creek sites, collected during the August survey. In general, the Upper Salmon and Jones sites (SMN080, SMN086, and JON010) exhibited lower temperature and pH and higher DO, whereas the Lower Salmon sites (SMN050, SMN030, and SMN010) exhibited higher temperatures and pH and lower DO.

Excursions above temperature and below DO criteria occurred at all mainstem Salmon Creek sites. Salmon at 36th (SMN010) had the greatest observed maximum temperature (19.96°C) and lowest observed DO (6.97 mg/L) of all sites. At Jones Creek, an excursion (9.4 mg/L) below the minimum DO criterion (9.5 mg/L) occurred; however, the maximum temperature (15.15°C) fell below criteria. No excursions of pH criteria occurred; values ranged from 6.74 (SMN080) to 7.83 (SMN030).

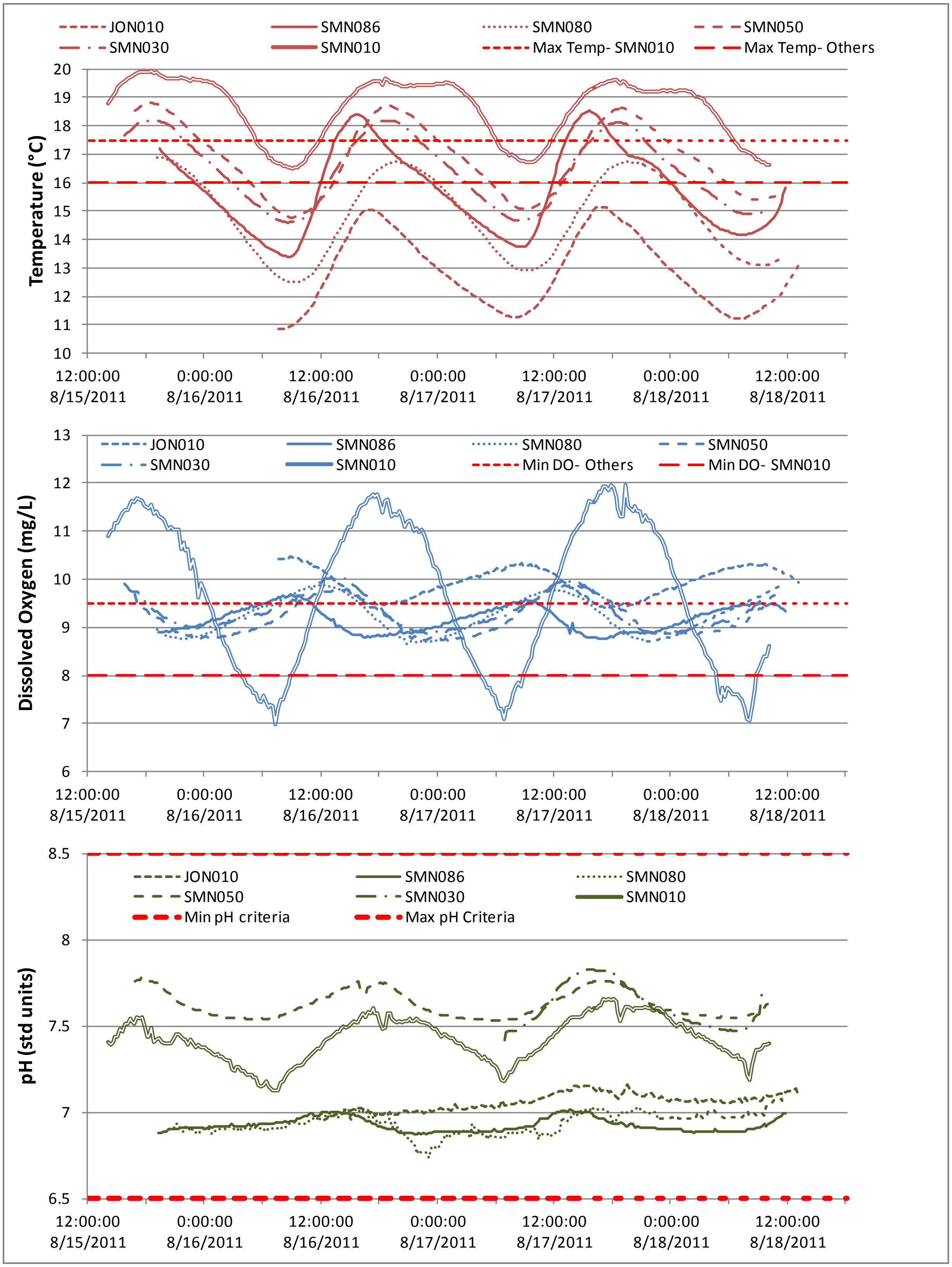

Figure 8. Continuous water quality data for Salmon Creek mainstem sites and Jones Creek collected during the August synoptic survey.

Figure 9 depicts continuous water quality results for the Salmon Creek tributary sites, collected during the August synoptic survey.

DO excursions below the minimum criterion occurred at five out of six tributary sites. Morgan (MOR010), Weaver (WDN010), and Curtin (CUR020) exhibited the lowest DO minimum values (7.79, 8.08, and 8.16 mg/L, respectively; criterion = 9.5 mg/L). Rock (ROC005) and Mill (MIL010) DO minima also fell below the criterion (9.05 and 9.04 mg/L, respectively; criterion = 9.5 mg/L), while Cougar (CGR020) was the only site where the DO minimum (9.77 mg/L) did not fall below the criterion (criterion = 8.0 mg/L).

Temperature excursions above criteria occurred at four of six sites. Weaver (WDN010) displayed the highest temperature maximum (18.94°C), followed by Rock (ROC005) (17.09°C), Morgan (MOR010) (16.54°C), and Mill (MIL010) (16.13°C); all four of these sites had excursions above the criterion (16°C). Temperature maxima at Cougar (CGR020) (15.10°C) and Curtin (CUR020) (14.45°C) fell below their respective criteria (17.5°C and 16°C).

No pH excursions, above or below criteria, occurred at the six tributary sites. Morgan (MOR010) displayed the lowest range of pH values (6.75 – 6.86), while Cougar (CGR020) displayed the highest range (7.99 – 8.05). pH values at the other four sites ranged from 6.95 to 7.81.

On September 7 – 9, 2011 Ecology conducted an additional short-term continuous water quality deployment at Salmon at 199th (SMN080), Upper Salmon (SMN086), and Jones (JON010). Ecology performed the second survey to confirm results from the first survey that were qualified based on post-deployment evaluation (comparison to buffers) and evidence of sensor drift at Jones (JON010). Figure 10 contains the results of the additional deployment.

During the September deployment, temperature excursions above criteria and DO excursions below criteria occurred at all three sites. Observed pH values fell within criteria, ranging from a low of 6.89 (SMN086) to a high of 7.25 (SMN080).

Figure 11 contains the results of the periphyton biomass sampling performed during the August synoptic survey. For the mainstem sites, biomass levels generally increased moving downstream from the upper to lower watershed.

The lowest chlorophyll *a* (CHL*a*) and ash-free dry weight (AFDW) biomass levels occurred at Jones (JON010)(CHL*a* = 5.0 mg/m^3; AFDW = 1,441 mg/m^3) and Salmon at 199th (SMN080)(CHL*a* = 2.0 mg/m^3; AFDW = 1,598 mg/m^3).

The mid-watershed sites, Salmon at Caples (SMN050) and Salmon at 50th (SMN030) displayed moderate levels (CHL*a* = 8.8 and 12.1 mg/m^3; AFDW = 2,863 and 3,917 mg/m^3, respectively).

The furthest downstream site, Salmon at 36th (SMN010), exhibited the highest biomass levels (CHL*a* = 19.6 mg/m^3; AFDW = 29,648 mg/m^3). Field staff observed filamentous benthic algal growth at this location.

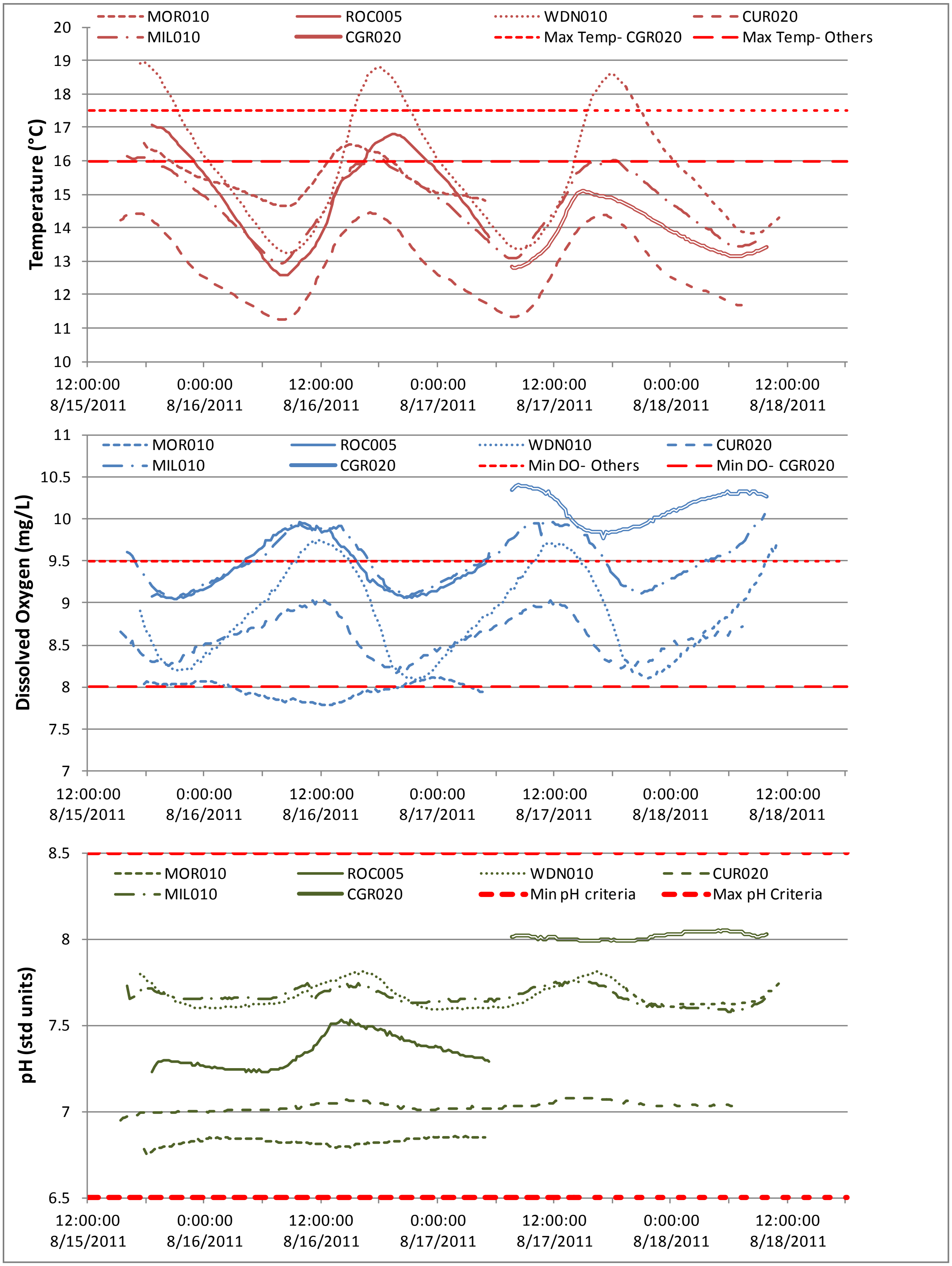

Figure 9. Continuous water quality data for Salmon Creek tributary sites collected during the August synoptic survey.

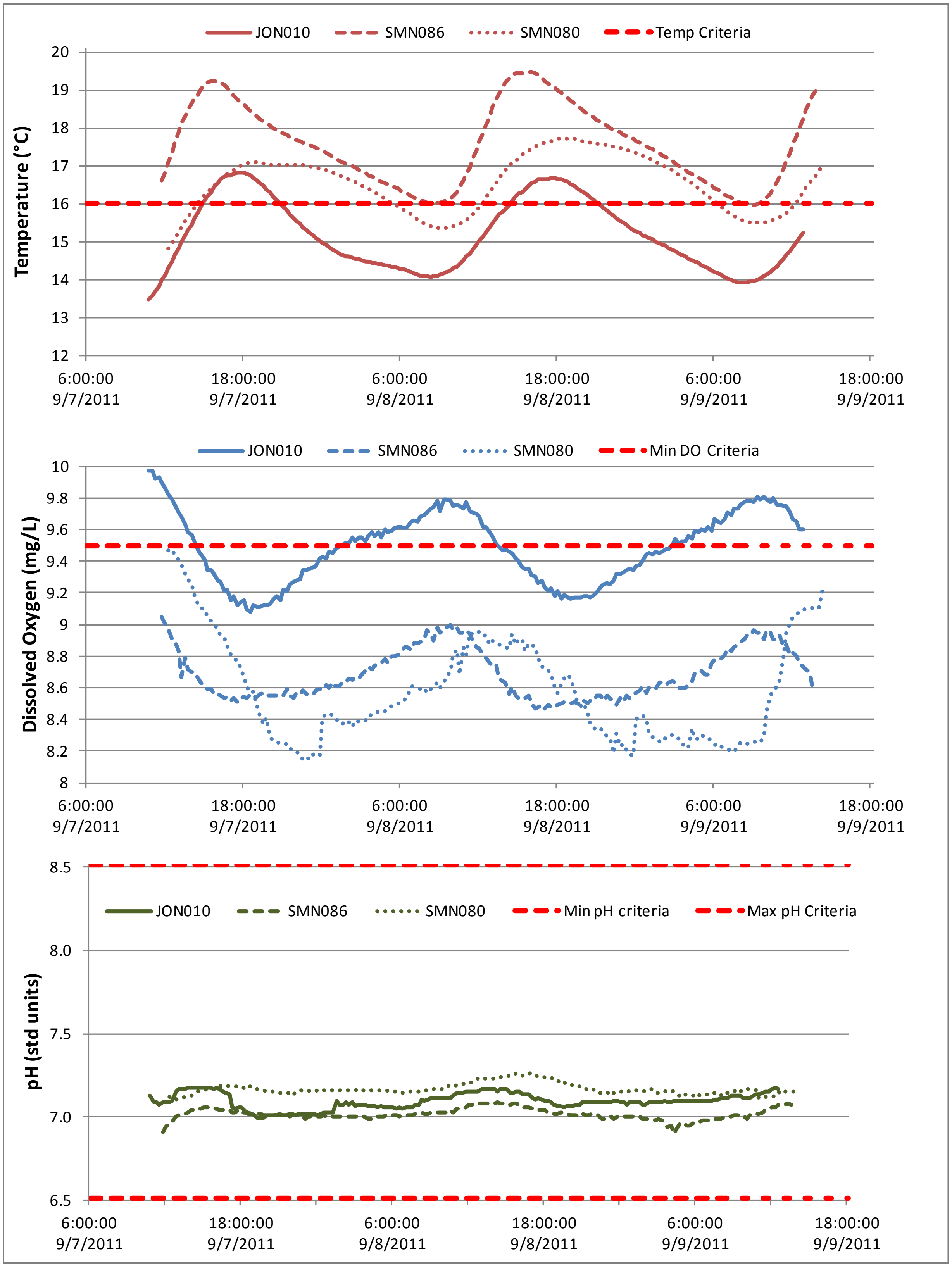

Figure 10. Continuous water quality data for Upper Salmon Creek sites and Jones Creek collected during the additional deployment in early September 2011.

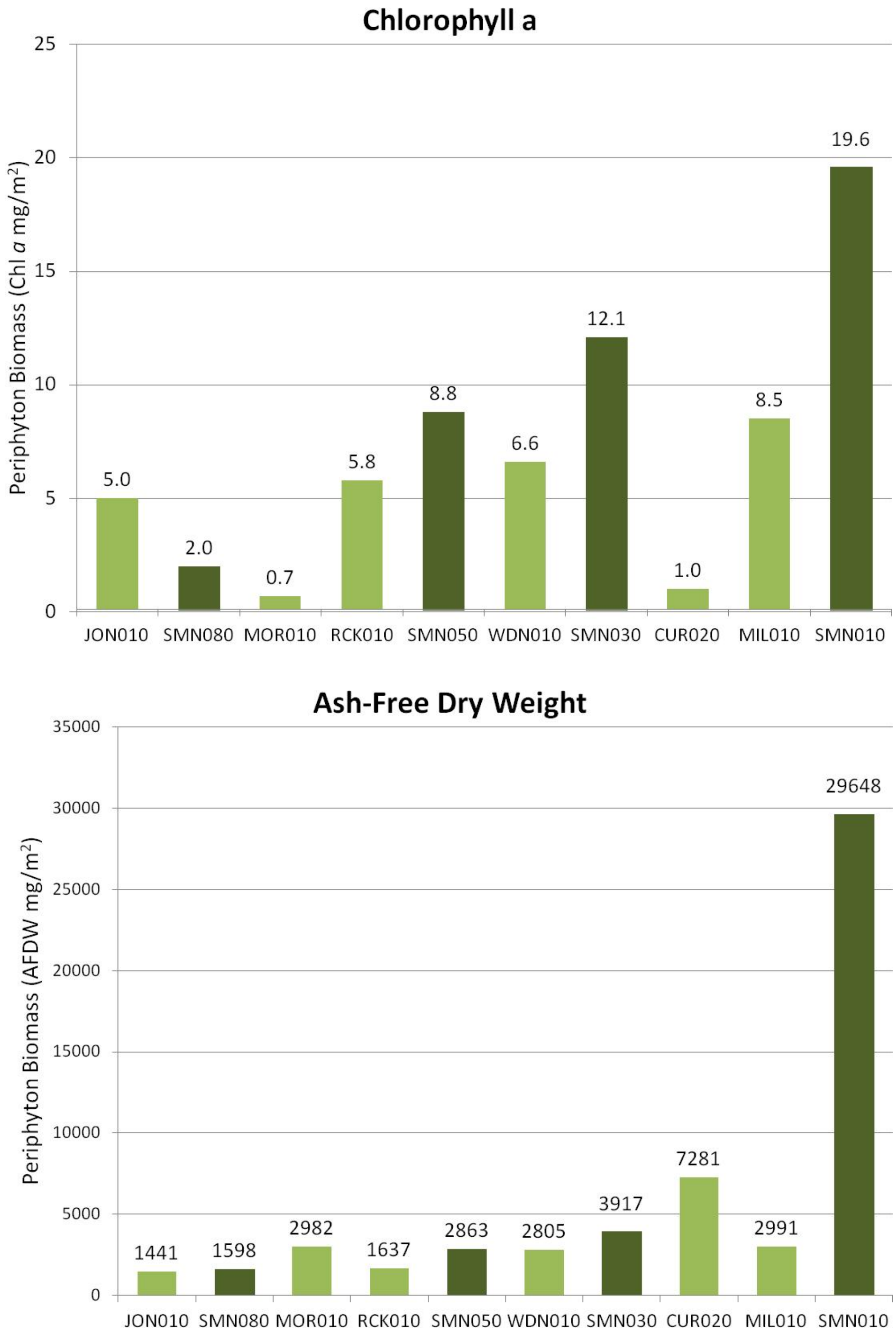

Figure 11. Chlorophyll *a* and ash-free dry weight periphyton biomass results.

Compared to the mainstem, the tributary sites exhibited low to moderate biomass levels, with very low CHL*a* results at Morgan (MOR010)(0.7 mg/m^3) and Curtin (CUR020)(1.0 mg/m^3). Curtin also displayed the highest AFDW levels (7,281 mg/m^3) of the tributary sites; however, this may be attributable to the substrate medium (wood organic debris) sampled at this site. At all other locations, Ecology sampled inorganic rock substrate.

Monthly Monitoring

Figure 12 displays results from monthly measurements taken at the Salmon Creek mainstem locations between 9/29/2011 and 3/6/2012. For comparability between sites, results from the August synoptic survey, additional September deployment, and wet-season synoptic were not included. In general pH, specific conductance, and CHL*a* values increased moving downstream from the upper watershed sites, and control site, to the lower watershed sites.

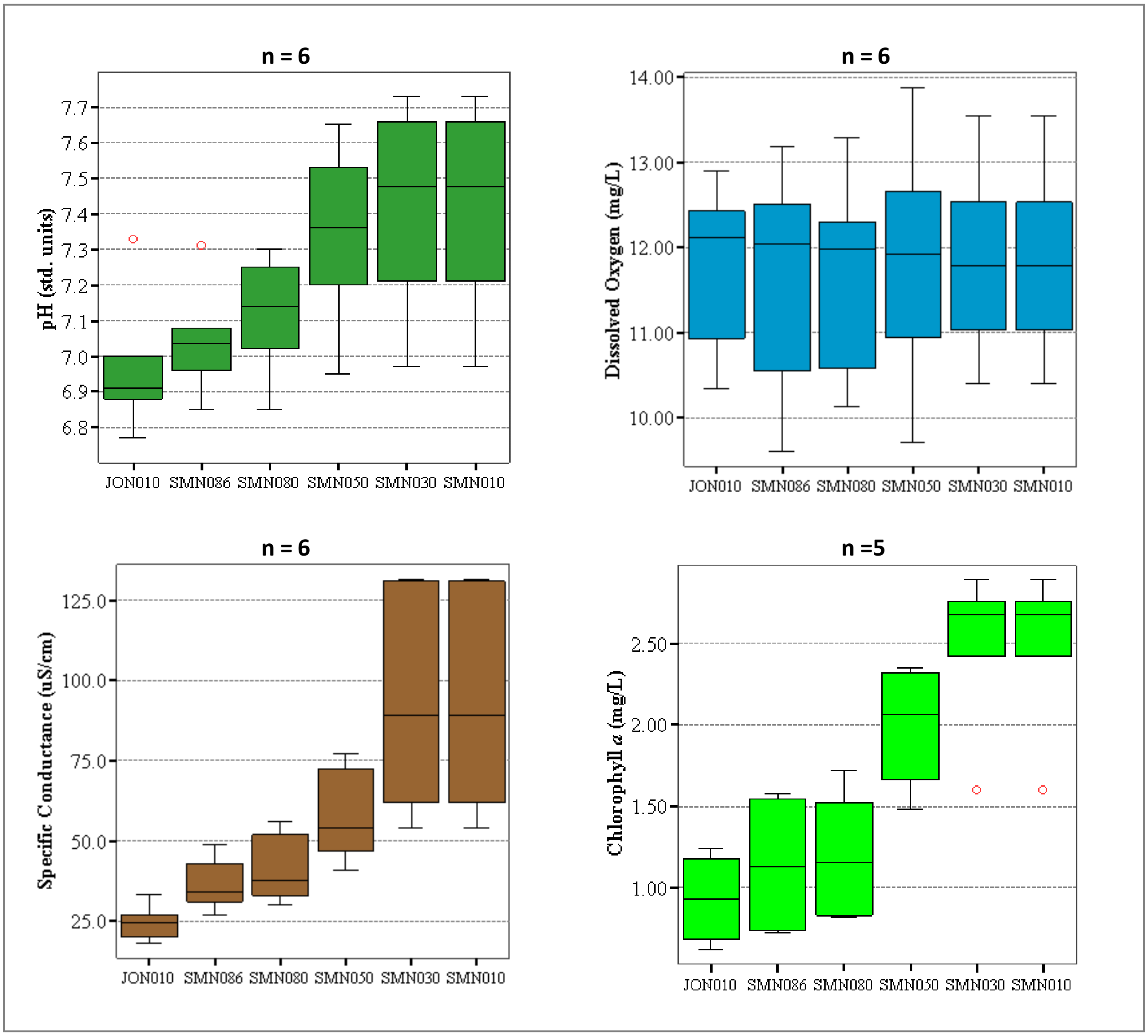

Figure 12. Monthly monitoring water quality results for Salmon Creek mainstem and Jones Creek.

Figure 13 displays results from monthly measurements taken at the Salmon Creek tributary sites between 9/29/2011 and 3/6/2012. In general, pH, specific conductance, and CHL*a* values increased from the upper to lower watershed sites, with the exception of Curtin (CUR020) in the lower watershed where relatively low DO and pH, and high specific conductance, levels were observed.

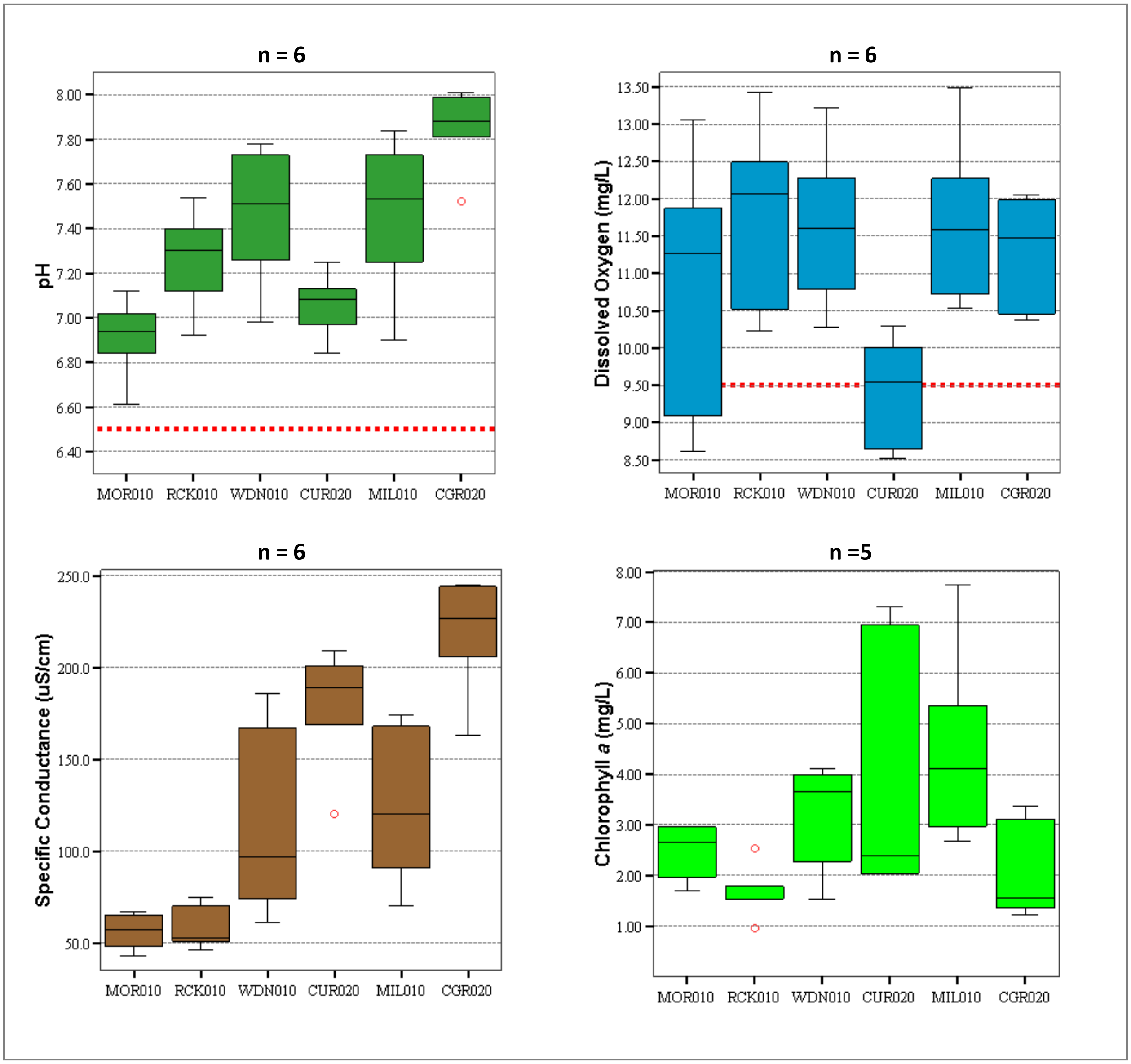

Figure 13. Monthly monitoring water quality results for Salmon Creek tributaries.

Figure 14 contains box plots of nutrient concentrations at Upper Salmon (SMN086) and Jones (JON010) for samples collected between 8/18/2011 and 3/6/2012. For comparison, box plots were created both with and without wet-season synoptic samples included.

If wet-season synoptic samples are removed, TPN concentrations display similar distributions, with lower minimum and lower quartile values observed at Upper Salmon (SMN086), but comparable median, upper quartile, and maximum statistics, for both sites. Both sites displayed similar TP concentrations, with slightly lower values in general at Jones (JON010). The following section contains a more detailed description of the wet-season synoptic surveys.

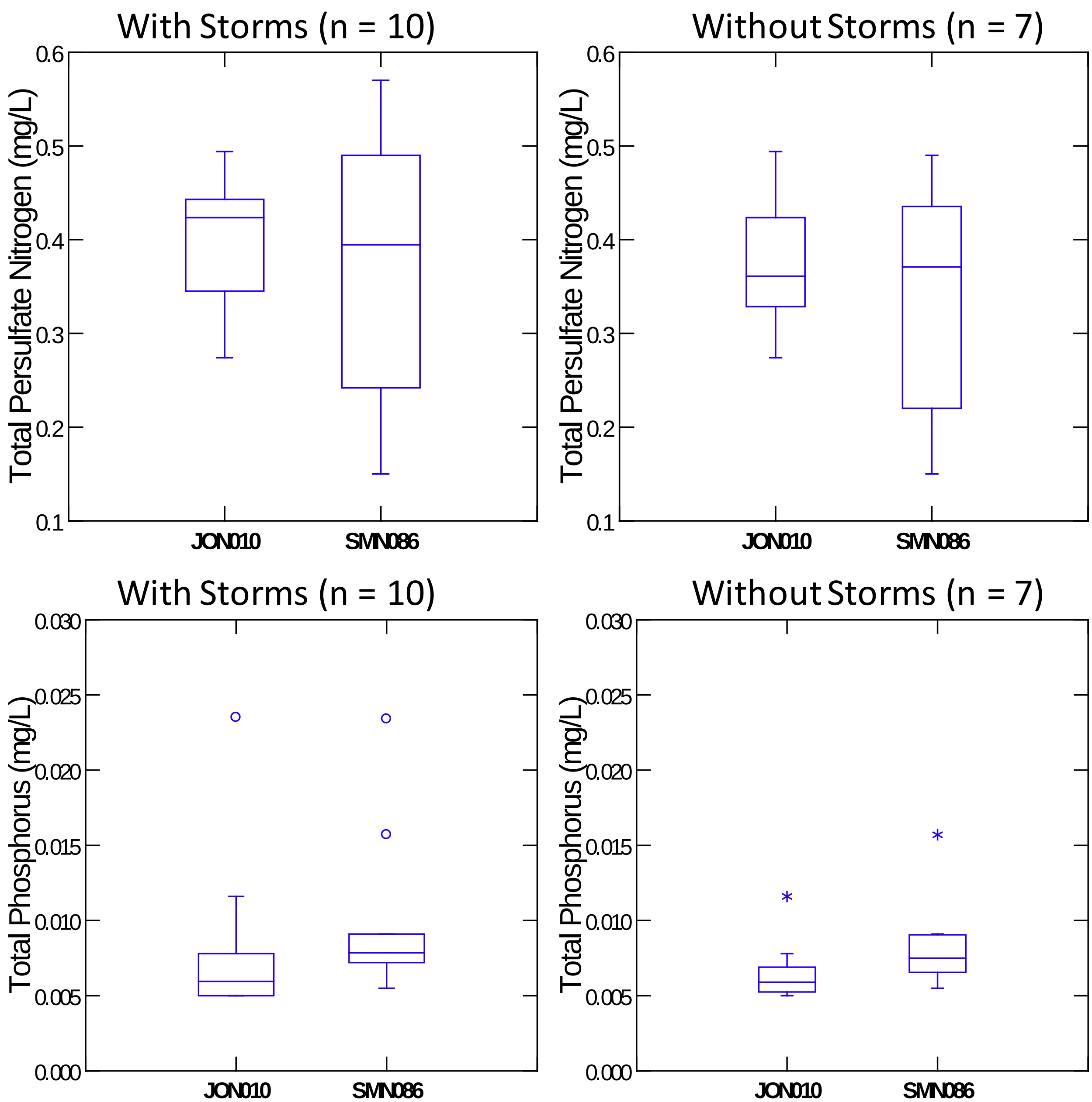

Figure 14. Boxplots of nutrient concentrations at Upper Salmon (SMN086) and Jones Creek (JON010) with and without wet-season synoptic results included.

Wet-Season Monitoring

Ecology conducted three wet-season low pH synoptic surveys to characterize pH in the Upper Salmon and Curtin Creek basins during winter storms on 11/16/2011, 1/25/2012, and 2/22/2012.

On 11/16/2011, field staff collected samples and measurements from approximately 11:00 to 17:00 in an attempt to collect measurements during the rising limb or peak of the hydrograph. Precipitation occurred later than forecasted, so the survey occurred during the very beginning of the rain event and associated rise in the hydrograph (Figure 15).

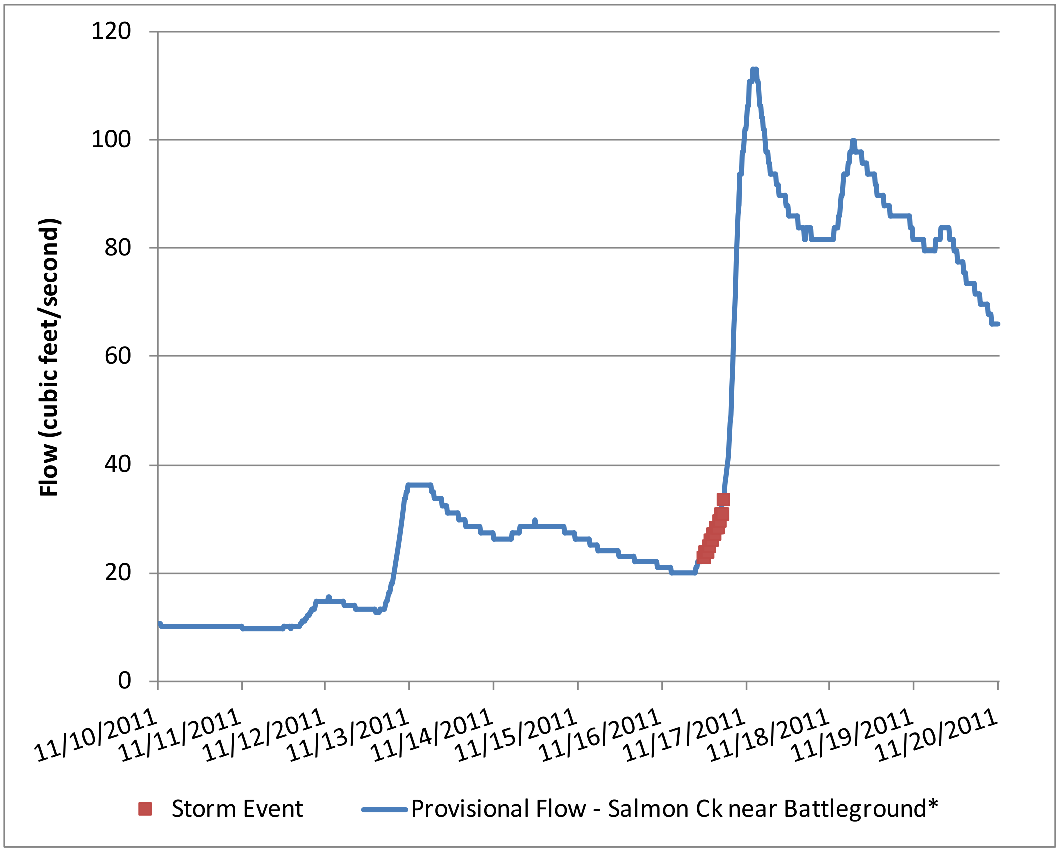

Figure 15. Hydrograph and timing for the 11/16/2011 wet-season synoptic survey.

*Clark County flow gage.

Figure 16 illustrates pH and streamflow levels measured at stations in the extended Upper Salmon and Curtin Creek sub-basins during the 11/16/2011 survey. Curtin/trib near Headwaters (CT1), Curtin at 139th (CUR020), and Salmon at 199th (SMN080) exhibited the lowest pH values (6.58, 6.68, and 6.58, respectively).

The observed nutrient concentrations on 11/16/2011 at Upper Salmon (SMN086) (TPN= 0.359 mg/L, TP=0.0075 mg/L) fell within the interquartile range for all samples collected at this site. The observed nutrient concentrations on 11/16/2011 at Jones (JON010) (TPN= 0.430 mg/L, TP=0.0061 mg/L) fell within the interquartile range for all samples collected at this site (see Figure 14 *With Storms* box plots).

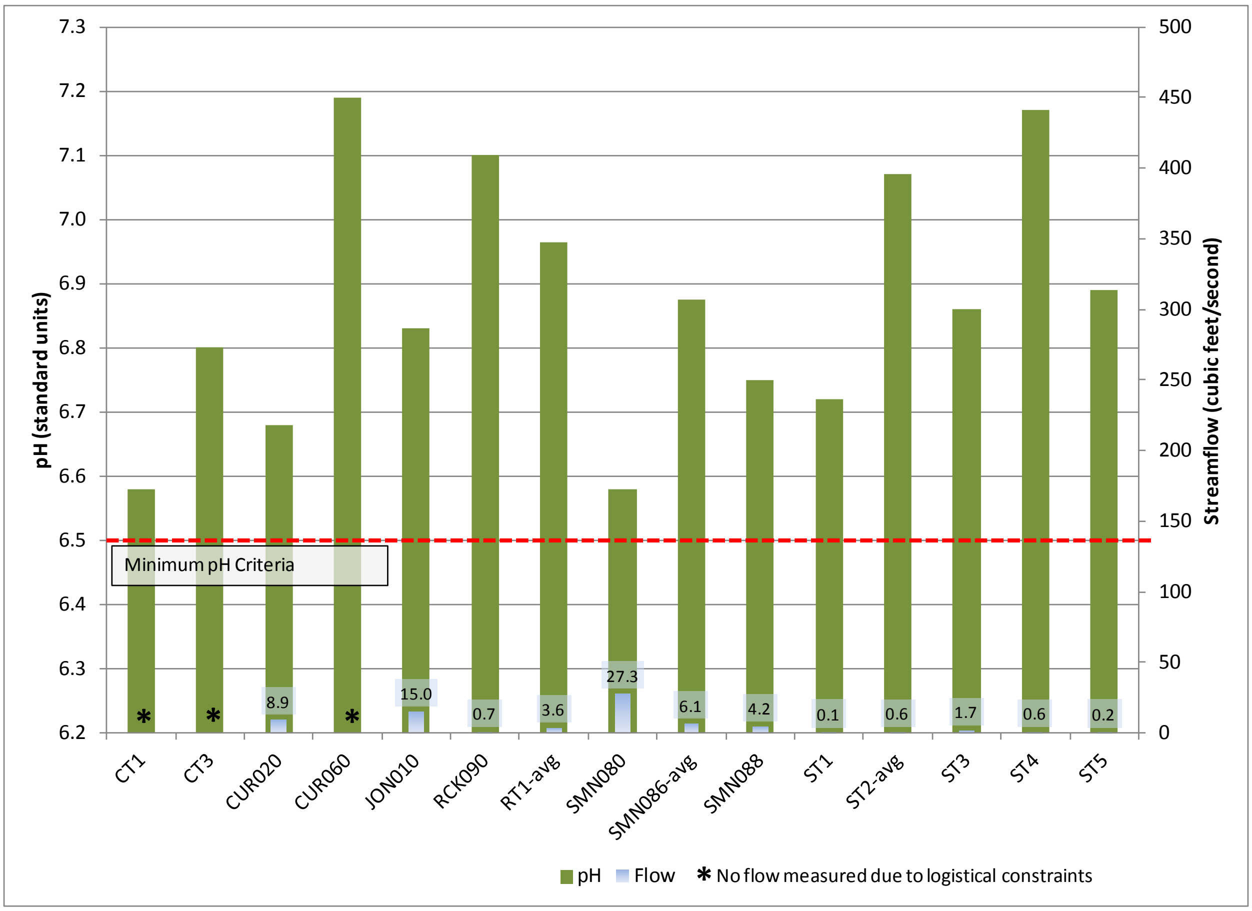

Figure 16. pH and streamflow at extended network sites during the 11/16/2011 wet-season synoptic survey.

On 1/25/12, field staff conducted a second wet-season synoptic survey after the largest storm event of the water year (WY) 2012, where approximately 4.5 inches of precipitation fell from 1/17- 20/2012 and flows peaked at 913 cfs on the afternoon of 1/19/2012 (peak flow for WY 2012). An additional 0.7 inches of precipitation fell on 1/24/12, prior to the sample event.

The survey occurred during the tail of the hydrograph response to this January 2012 series of precipitation events at flows of approximately 200 cfs (Figure 17), nearly ten times the flow during the 11/16/2011 wet-season survey.

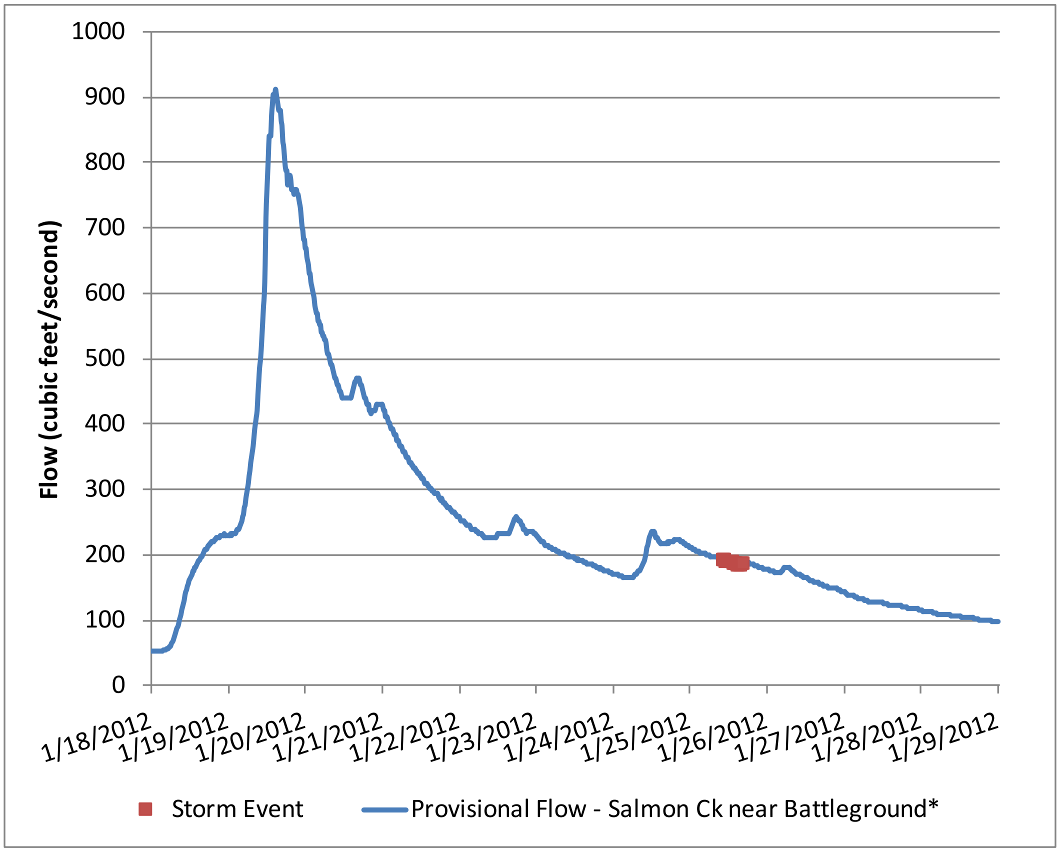

Figure 17. Hydrograph and timing for the 1/25/2012 wet-season synoptic survey.

**Clark County flow gage.*

Figure 18 illustrates pH and streamflow levels measured at stations in the extended Upper Salmon and Curtin Creek sub-basins during the 1/25/2012 survey. Curtin/trib near Headwaters (CT1), Jones (JON010), Salmon Trib at 189th (ST1), and Salmon Trib at Firwood (ST2), exhibited the lowest pH values (6.61, 6.57, 6.37, and 6.65, respectively).

The observed nutrient concentrations on 1/25/2012 at Upper Salmon (SMN086) (TPN=0.514 mg/L, TP=0.0082 mg/L) fell above the 75th percentile for TPN and within the interquartile range for TP for all samples collected at this site. The observed nutrient concentrations on 1/25/2012 at Jones (JON010) (TPN=0.443 mg/L, TP=0.005 mg/L) fell at the 75th percentile for TPN and at the observed minimum for TP for all samples collected at this site (see Figure 14 *With Storms* box plots).

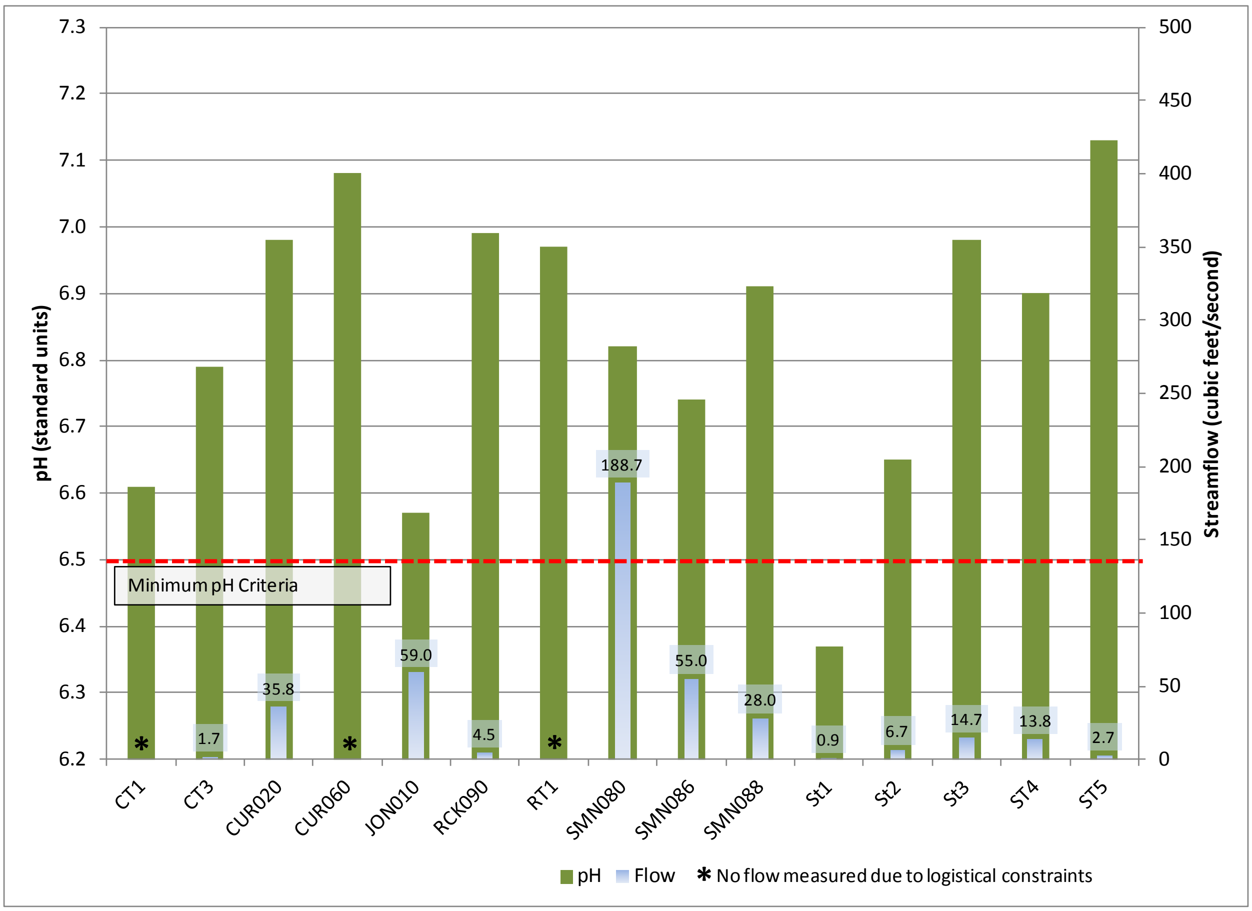

Figure 18. pH and streamflow at extended network sites during the 1/25/2012 wet-season synoptic survey.

On 2/22/12, from approximately 11:30 to 16:30, field staff conducted the third and final wet-season synoptic survey just after the peak of the second largest hydrologic event of WY 2012, where flows peaked at 524 cfs at approximately 8:00 on 2/22/12. Approximately 0.31 (2/21/12) and 0.27 (2/22/12) inches of precipitation fell prior to sampling.

The survey occurred during the tail of the hydrograph response to this precipitation event at flows of approximately 410-475 cfs (Figure 19), the largest flows of the three wet-season synoptic surveys.

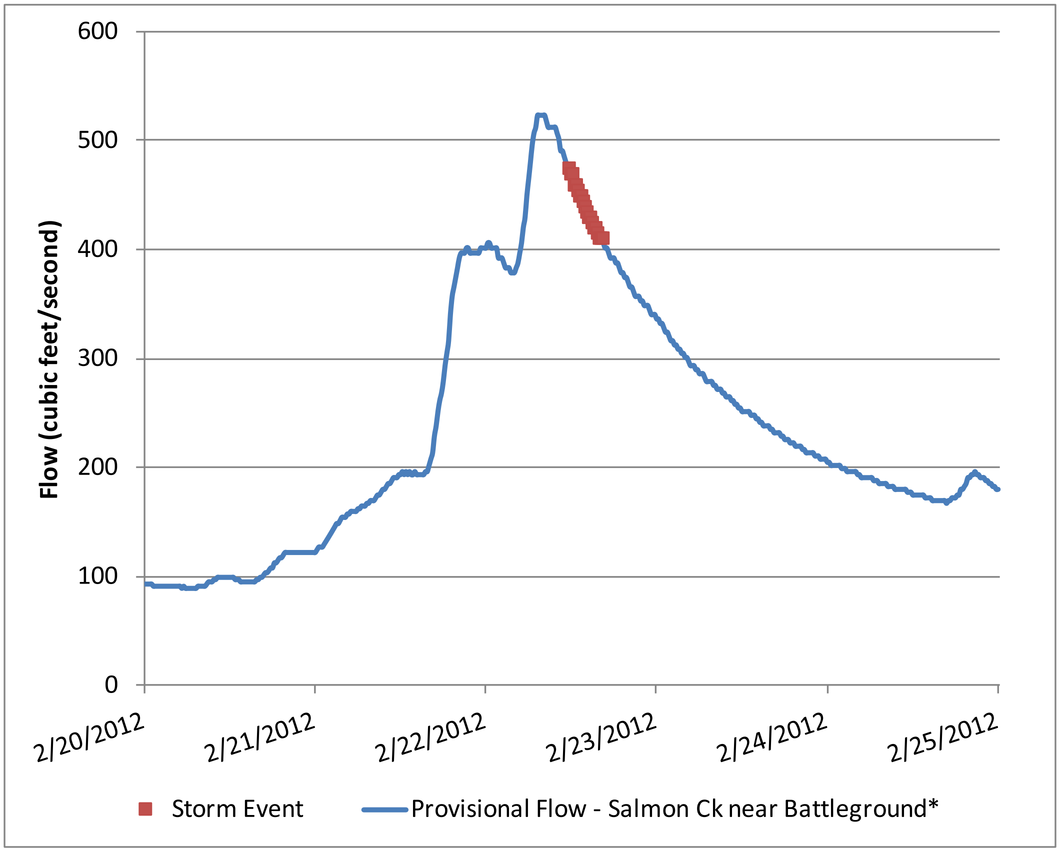

Figure 19. Hydrograph and timing for the 2/22/2012 wet-season synoptic survey.

**Clark County flow gage.*

Figure 20 illustrates pH and streamflow levels measured at stations in the extended Upper Salmon and Curtin Creek sub-basins during the 2/22/2012 survey. Jones (JON010) and Salmon Trib at 189th (ST1) exhibited the lowest pH values (6.68 and 6.60, respectively).

The observed nutrient concentrations on 2/22/2012 at Upper Salmon (SMN086) (TPN= 0.570 mg/L, TP=0.0234 mg/L) were the highest observed for all samples collected at this site. The observed nutrient concentrations on 2/22/2012 at Jones (JON010) (TPN= 0.483 mg/L, P=0.0235 mg/L) fell above 75th percentile for TPN and at the observed maximum for TP for all samples collected at this site (see Figure 14 *With Storms* box plots).

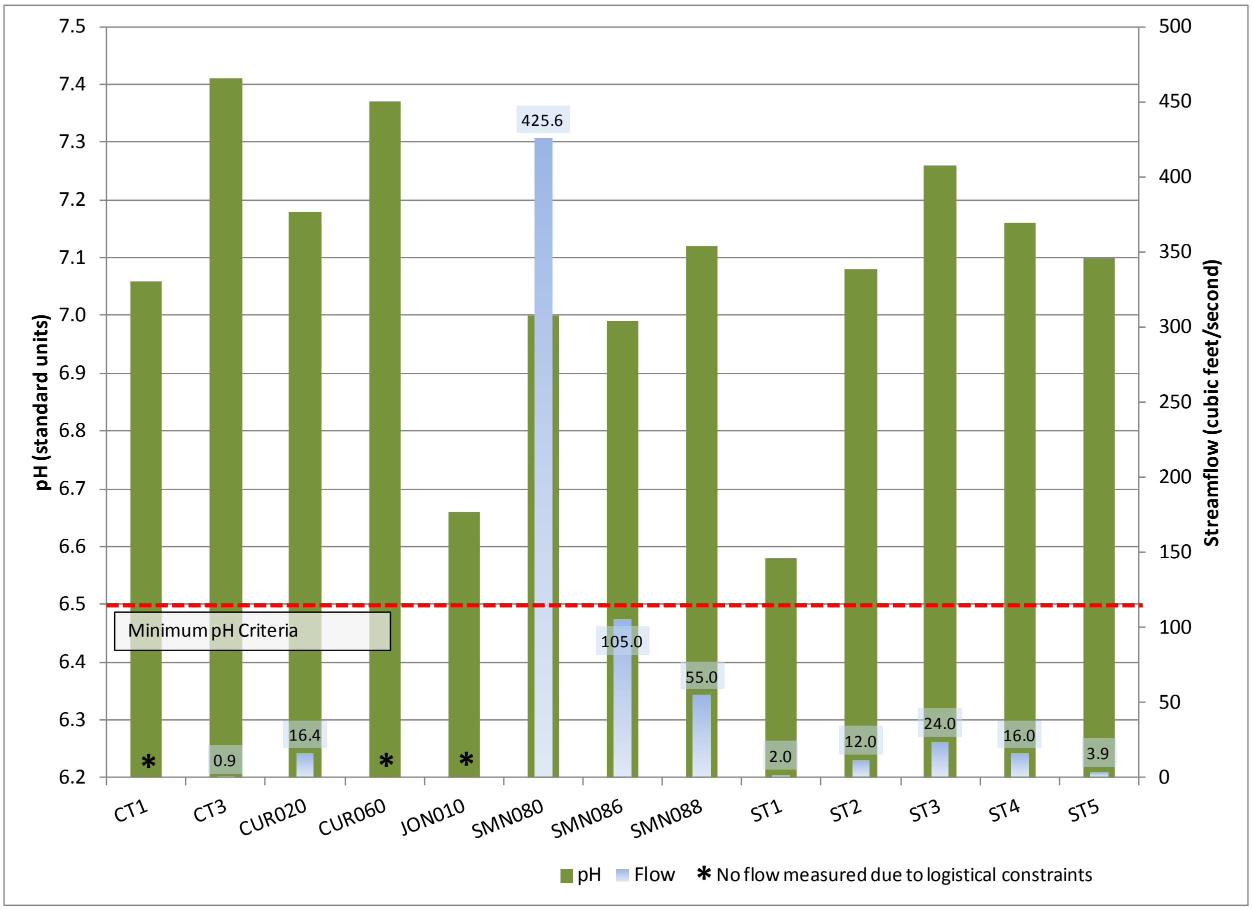

Figure 20. pH and streamflow at extended network sites during the 2/22/2012 wet-season synoptic survey.

Ecology field staff also collected continuous pH data at Salmon at 199th (SMN080) starting on 2/2/2012 (see discussion of continuous station in *Data Quality Results* section of the report). During the wet-season months of February and March 2012, pH values fell between 6.8 and 7.2 (Figure 21). During these months, pH only dropped to the lowest levels during the three hydrologic events in February and March with flows greater than 300 cfs.

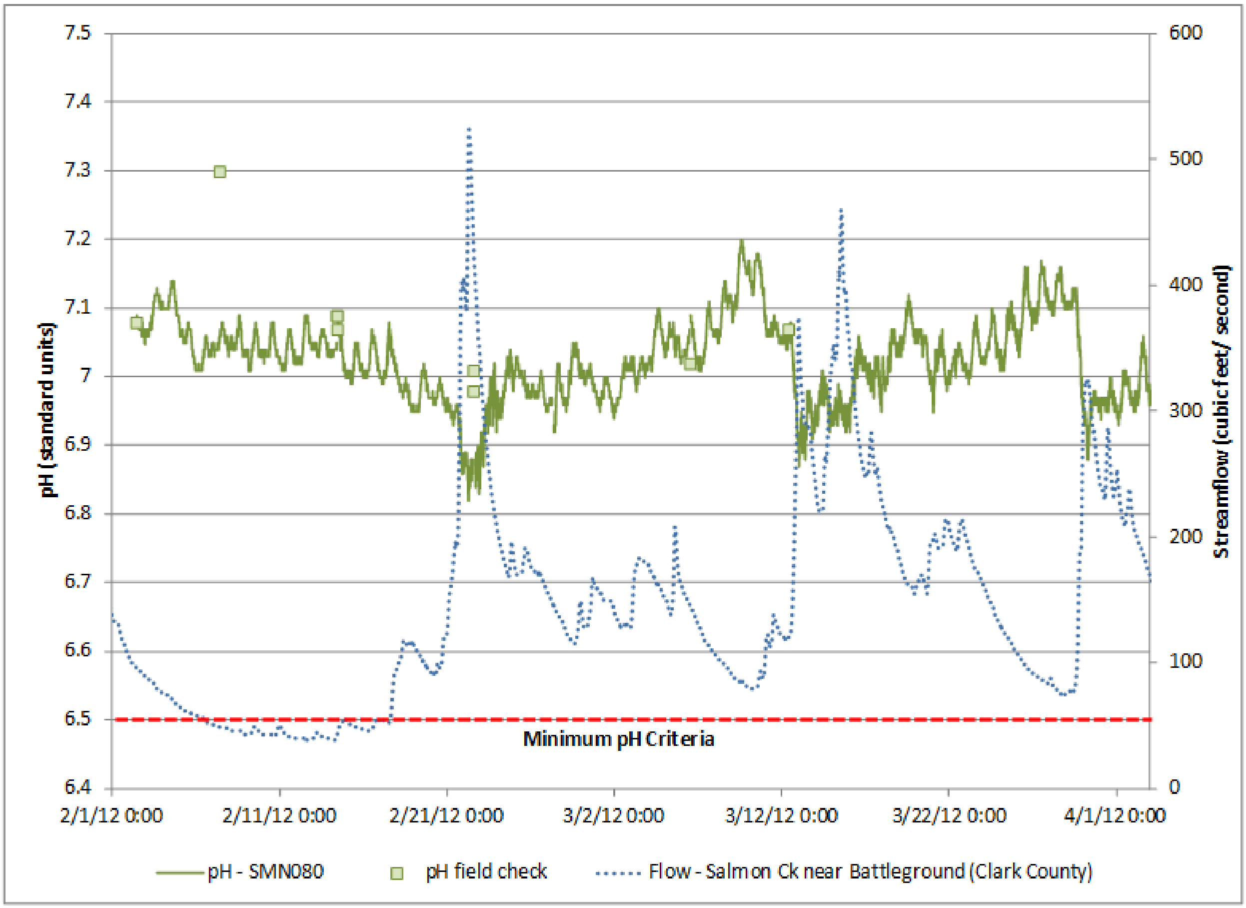

Figure 21. Continuous pH data collected during February and March 2012.

Macroinvertebrates and Periphyton Monitoring

Tables 8 and 9 contain metrics and Benthic Index of Biotic Integrity (B-IBI) scores, calculated by Rhithron Associates Inc., for macroinvertebrate samples collected during the 2011-2012 study. The B-IBI consists of ten metrics that measure indicators of degradation of the macroinvertebrate community. Each metric is given a raw score of 1, 3, or 5, with a 1 representing considerable impact and a 5 representing little or no impact. Added together, the metric scores provide a relative indicator of the health of the biotic community at a given location.

Table 8. Selected macroinvertebrate metrics from samples collected on 9/28/2011. (Metric Score calculations by Rhithron Associates, Inc.)

Metric	SMN050-Salmon at Caples	SMN050-Salmon at Caples (Rep)	SMN086-Upper Salmon	JON010-Jones Creek
Clinger Richness	20	19	31	23
Dominant Taxa (3) Percent	36.01%	43.63%	38.30%	37.79%
Ephemeroptera Richness	7	4	8	8
EPT Richness	18	15	24	23
Plecoptera Richness	4	3	6	6
Pollution Sensitive Richness	2	1	5	4
Pollution Tolerant Percent	29.06%	27.29%	9.67%	3.80%
Predator Percent	6.95%	6.64%	12.57%	9.95%
Predator Richness	10	11	16	16
Sediment Sensitive Percent	1.25%	5.03%	6.00%	15.37%
Sediment Sensitive Richness	3	1	3	2
Sediment Tolerant Percent	8.73%	8.44%	5.80%	1.81%
Sediment Tolerant Richness	3	4	5	4
Semivoltine Richness	7	6	10	6
Trichoptera Richness	7	8	10	9
Taxa Richness	47	41	57	56

EPT: Ephemeroptera, Plecoptera, and Trichoptera.

Table 9. Macroinvertebrate metric and B-IBI scores from samples collected on 9/28/2011. (Metric Score calculations by Rhithron Associates, Inc.)

Metric Scores	SMN050- Salmon at Caples	SMN050- Salmon at Caples (Rep)	SMN086- Upper Salmon	JON010- Jones Creek
Taxa Richness	5	5	5	5
Ephemeroptera Richness	3	1	3	3
Plecoptera Richness	3	1	3	3
Trichoptera Richness	3	3	5	3
Pollution Sensitive Richness	1	1	5	5
Clinger Richness	5	3	5	5
Semivoltine Richness	5	5	5	5
Pollution Tolerant Percent	3	3	5	5
Predator Percent	1	1	3	1
Dominant Taxa (3) Percent	5	5	5	5
Sample Score	34	28	44	40

Figure 22 illustrates the 20 most frequently identified species from each sample and their respective percentage of the total number of organisms identified.

At Salmon at Caples (SMN050), the three most frequently identified species of macroinvertebrates represented approximately 31% of the sample (average of two replicates): two species of caddisfly (*Cheumatopsyche* and *Hydropsche*) and one species of mayfly (*Rhitrogena*). SMN050 scored 28 and 34 (field replicate), respectively, on the B-IBI scale, with a mean score of 31.

At Upper Salmon (SMN086), the three most frequently identified species of macroinvertebrates represented approximately 32% of the sample: one species of mayfly (*Baetis tricaudatus*), one species of riffle beetle (*Cleptelmis addenda*), and one species of black fly (*Simulium*). SMN086 scored a 44 on the B-IBI scale.

At Jones Creek (JON010), the three most frequently identified species of macroinvertebrates represented approximately 34% of the sample: two species of caddisfly (*Glossoma* and *Hydropsche*) and one species of mayfly (*Baetis tricaudatus*). JON010 scored a 40 on the B-IBI scale.

JON010 and SMN086 exhibited identical B-IBI metric scores (Table 9), with the exception of higher scores for predator percent and caddisfly (Trichoptera) richness at SMN086.

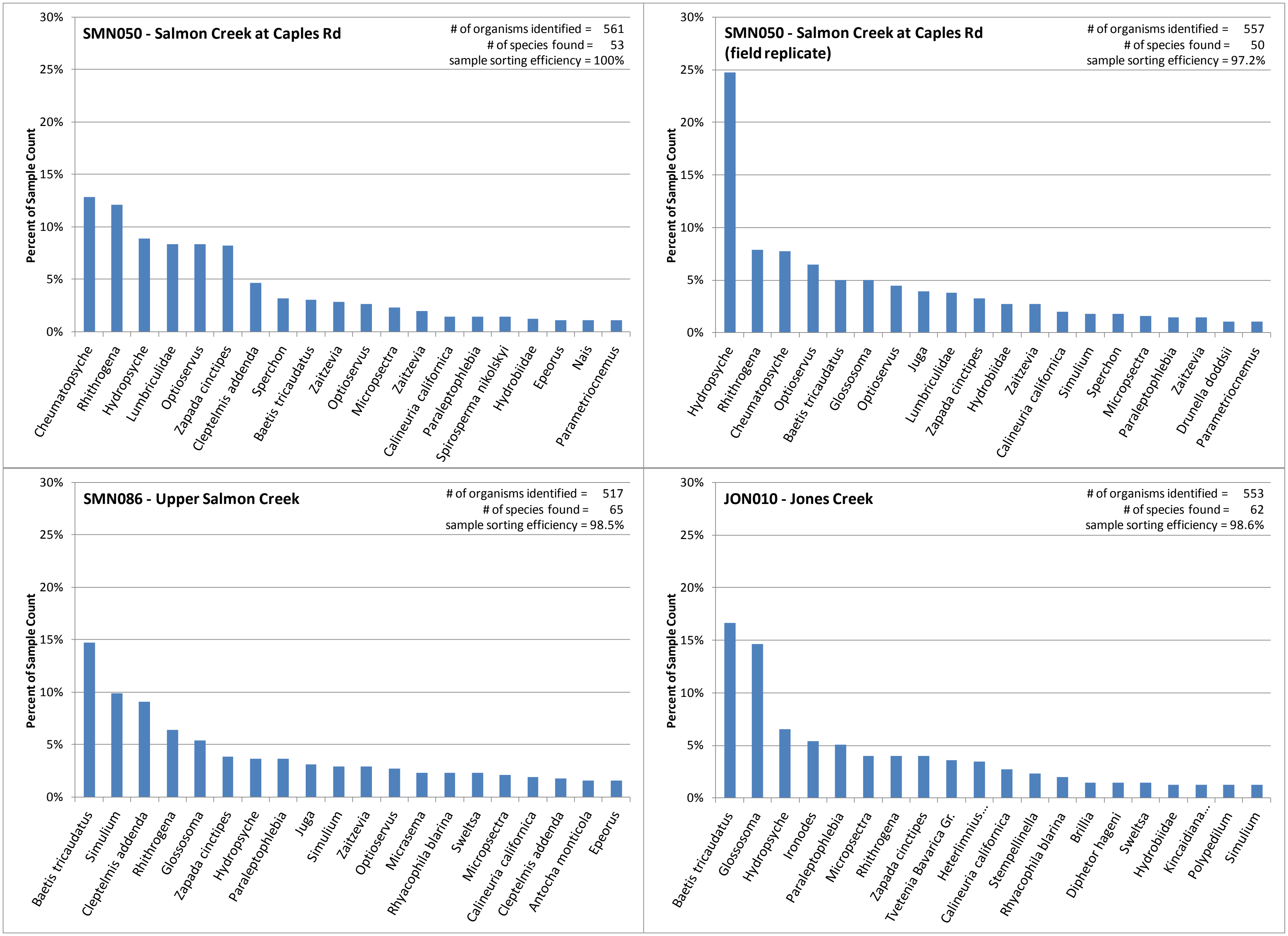

Figure 22. Frequency distribution of top 20 species identified from macroinvertebrate samples collected on 9/28/2011.

Table 10 presents diatom metrics, calculated by Rhithron Associates Inc., for periphyton samples collected during the study. Appendix A contains more detailed macroinvertebrate and diatom taxonomy results.

Table 10. Selected periphyton metrics for samples collected on 9/28/2011.
(Metric Score calculations by Rhithron Associates, Inc.)

Group	Metric	SMN050	SMN050-R	SMN086	JON010
Diversity	Shannon H (log2)	2.90	3.46	3.26	3.26
	Species Richness	34	39	41	33
Dominance	% Dominant Taxon	42.83%	34.33%	40.17%	26.67%
Autotrophism	% Nitrogen Autotroph Taxa	40.83%	63.33%	62.67%	59.67%
Trophic State	% Eutraphentic Taxa	35.17%	52.17%	12.17%	32.00%
Acid Tolerance	% Acidophilous Taxa	0.67%	0.17%	1.00%	1.50%
Heterotrophism	% Nitrogen Heterotroph Taxa	0.67%	1.67%	3.17%	2.00%
Oxidation	% Low DO Taxa	0.17%	0.67%	2.50%	1.67%

Additional Continuous Monitoring (Summer 2012)

Ecology also conducted continuous water quality monitoring at Salmon at 199th (SMN080) during the summer of 2012 due to the absence of these data for Summer 2011(see discussion of continuous station in *Data Quality Results* section of the report).

Observed daily minimum DO levels fell below the minimum criterion during the majority of the months of July, August, and September (Figure 23). The earliest excursion of the criteria occurred on 6/21/2012 and the latest on 9/29/2012. A gap in the data exists for all parameters from 8/22/2012 to 8/30/2012 due to a failure of the station battery.

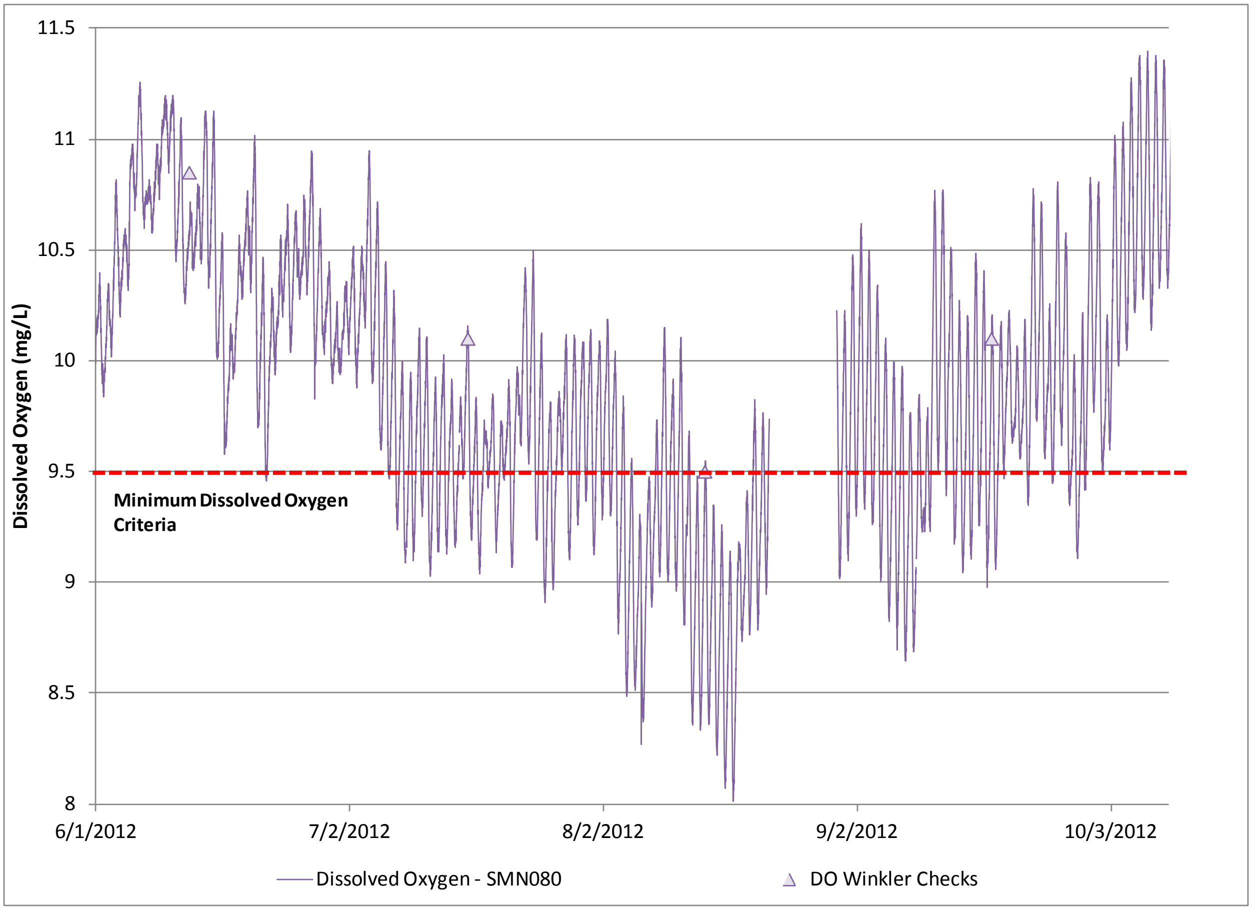

Figure 23. Continuous dissolved oxygen for Salmon at 199th (SMN080) during the 2012 dry season.

Observed pH levels fell within the criteria for the entire deployment, ranging between 6.9 and 7.5 for the months of July, August, and September (Figure 24). pH levels steadily increased from early July until the first significant rain event of the dry season on 10/14/2012.

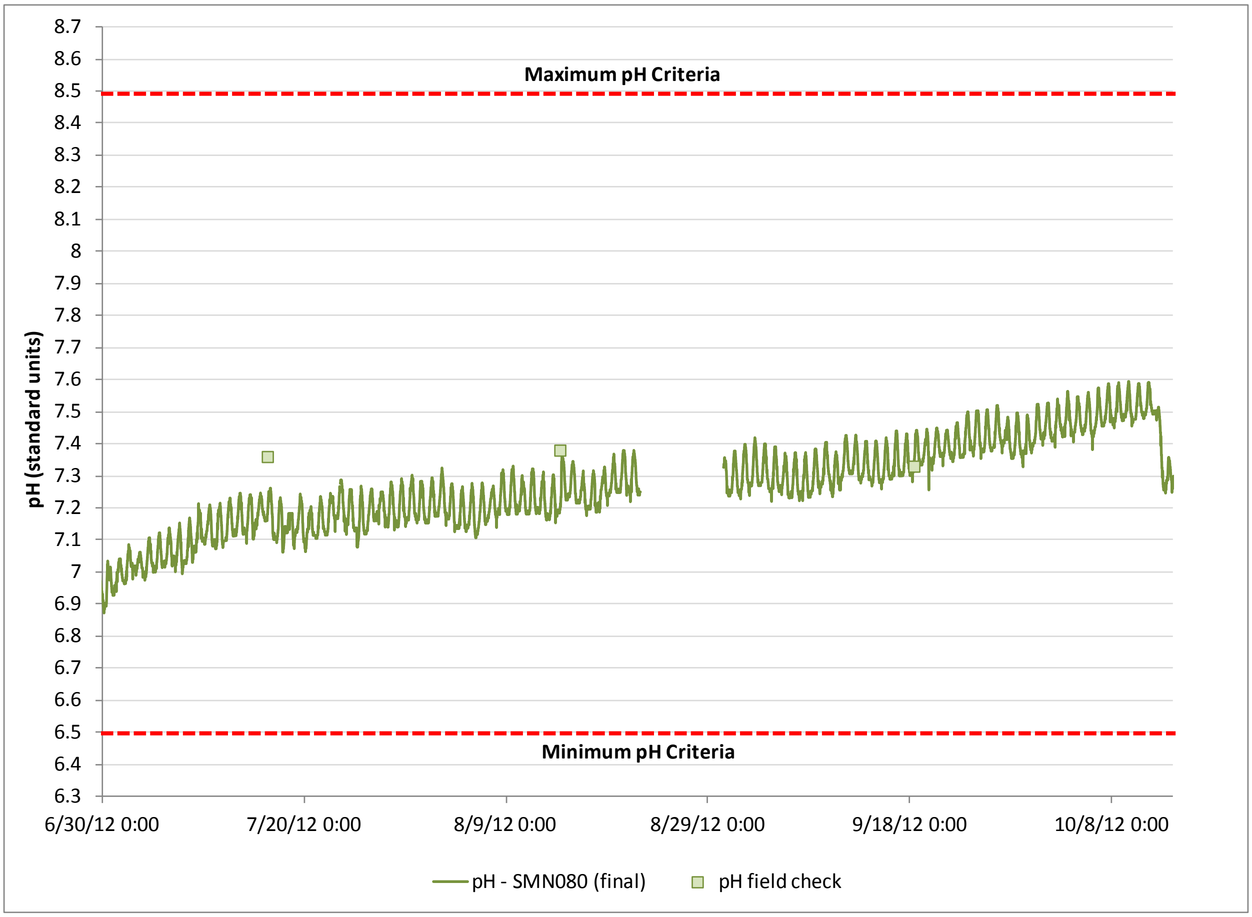

Figure 24. Continuous pH for Salmon at 199th (SMN080) during the 2012 dry season.

The calculated 7-day average of the daily maximum temperatures (7-DADMax) values fell above the maximum criterion (16°C) during the summer between 7/8/12 and 9/9/12 (Figure 25). 7-DADMax values also exceeded supplemental spawning criteria (13°C) on nine days between 5/14/2012 and 6/15/2012 (Figure 26).

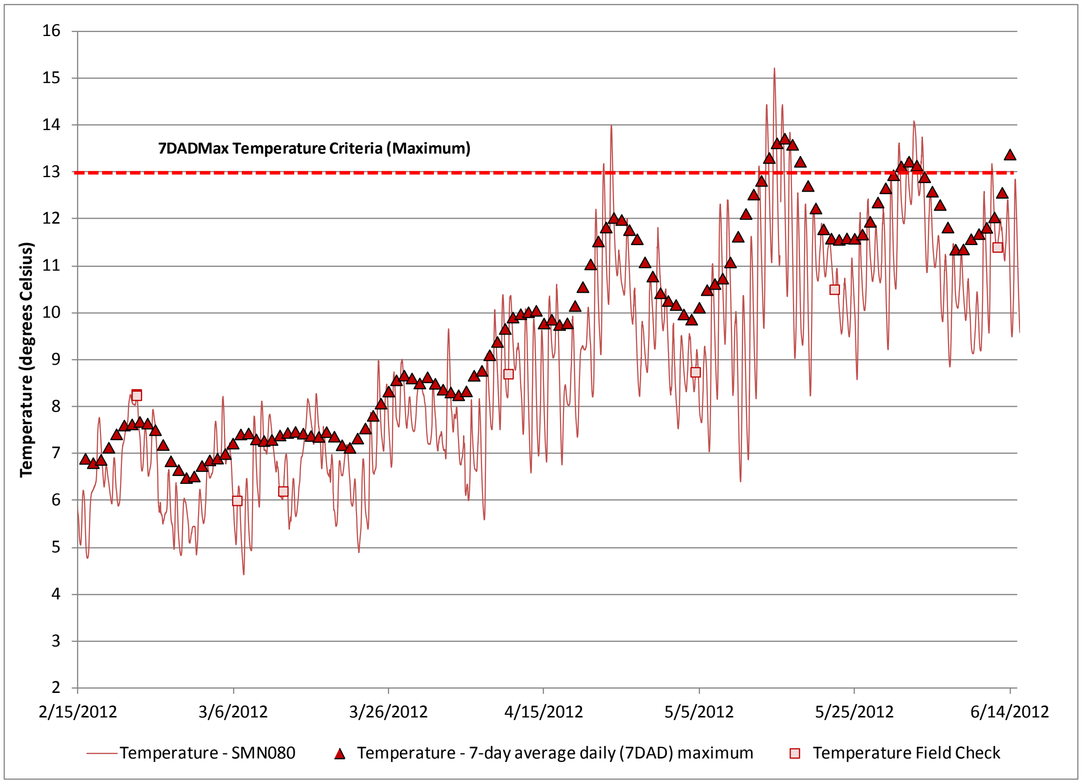

Figure 25. Continuous temperature for Salmon at 199th (SMN080) during the spring of 2012.

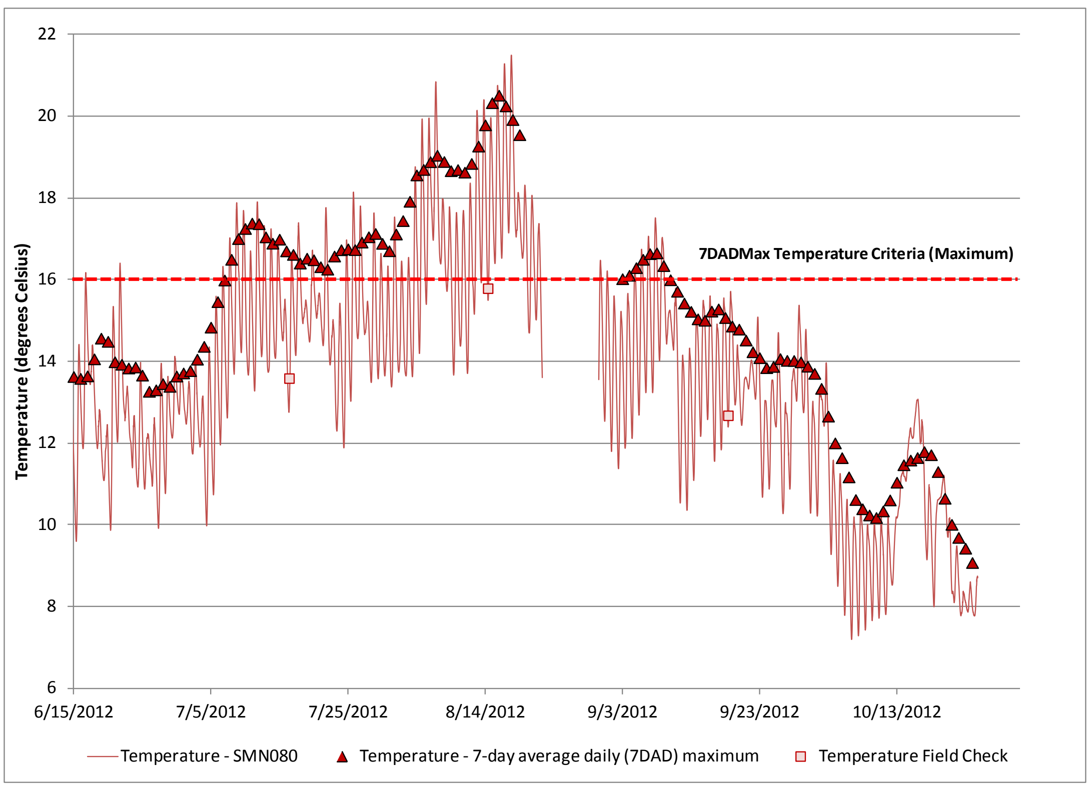

Figure 26. Continuous temperature for Salmon at 199th (SMN080) during the 2012 dry season.

Discussion

This study provides a characterization of continuous DO and pH throughout the watershed under varying seasonal and hydrologic conditions. Low DO excursions occurred throughout the watershed, confirming results from previous studies (Hutton and Hoxeng, 2007; Cusimano and Giglio, 1995). No pH excursions occurred throughout the watershed, with the exception of one small tributary, Salmon Trib at 189th (ST1), where a pH of 6.37 was observed on 1/25/2012.

Comparison of the Jones Creek and Upper Salmon Creek Basins

Ecology compared results from the Jones Creek and Upper Salmon Creek basins to assess the level of impact to Upper Salmon Creek and observe whether low DO and pH levels also occurred in Jones Creek.

The two basins displayed multiple similarities in biological communities and metrics as well as algal biomass (Tables 8-10; Figures 11 and 22). The most dominant species (*Baetis tricaudatus*) was the same at both sites, and both communities had very similar results for most other metrics (Table 8). The lower percentage of pollution and sediment-tolerant species at the Jones site, suggests it may be less impacted by nutrient and sediment pollution than the Upper Salmon sites.

Water chemistry in the two basins showed several similarities as well, most notably relatively low pH, specific conductance, alkalinity, and nutrient levels (Table 11). Jones (JON010) typically displayed slightly lower pH, specific conductance, and alkalinity.

Table 11. Comparison of water chemistry at the Jones and Upper Salmon sites.

	JON010	SMN086		JON010	SMN086
Monthly monitoring			**Dry-season synoptic survey**		
pH- median	6.91	7.04	pH- maximum	7.15	7.08
pH- minimum	6.77	6.85	pH- minimum	7.00	6.98
SpCond median	24.5	34.1	Temperature- max	16.67	19.47
Chl a (ug/L)- median	0.93	1.13	DO (mg/L) min	9.16	8.47
ORP- median	391	320	TPN	0.274	0.150
TPN- median	0.361	0.371	TP	0.0078	0.0055
TP- median	0.0060	0.0070	Alkalinity	13.1	21.2
Wet-season synoptic surveys			Chloride	1.15	1.49
pH- minimum	6.57	6.74	Turbidity	0.8	1.9
SpCond minimum	18	29	DOC	1.0 U	1.2
TPN- maximum	0.483	0.570	TOC	1.0 U	1.4
TPN- mean	0.452	0.481	Nitrite-nitrate- am	0.290	0.131
TP- maximum	0.0235	0.0234	Nitrite-nitrate- pm	0.282	0.121
TP- mean	0.0115	0.0130	Ammonia- am	0.01 U	0.013
			Ammonia- pm	0.01 U	0.013
			Orthophosphate- am	0.0099	0.0112
			Orthophosphate- pm	0.0084	0.0111

See Appendix B for definitions of acronyms.

Ecology calculated individual parameter water quality index (WQI) scores for total nitrogen and phosphorus using parameter curves developed for Ecology's ambient monitoring program (Hallock, 2002). Ecology has developed parameter curves for each Eco-Region of the state, as well as for each season. Table 12 represents nutrient WQI scores for Jones and Upper Salmon. Ecology used seasonal curves for the Puget Lowlands Eco-Region because not enough data have been collected from the Willamette Valley Eco-Region to develop curves.

Table 12. Comparison of nutrient water quality index (WQI) scores at the Jones and Upper Salmon sites.

	SMN086				JON010			
	TP-result	TP-WQI	TPN-result	TPN-WQI	TP-result	TP-WQI	TPN-result	TPN-WQI
Dry Season								
8/16/2011	0.0055	100	0.150	96	0.0078	100	0.274	88
9/28/2011	0.0157	93	0.242	90	0.0116	99	0.494	62
10/19/2011	0.0075	100	0.198	93	0.0059	100	0.312	85
Average =	0.0096	**98**	0.197	**93**	0.0084	**100**	0.360	**78**
Wet Season - Low Flow (<100 cfs)								
11/16/2011	0.0075	100	0.359	93	0.0061	100	0.430	90
12/14/2011	0.0059	100	0.418	90	0.0050	100	0.417	90
2/14/2012	0.0091	100	0.371	93	0.0055	100	0.345	85
3/6/2012	0.0072	100	0.453	88	0.0050	100	0.361	93
Average =	0.0074	**100**	0.400	**91**	0.0054	**100**	0.388	**90**
Wet Season - High Flow (>100 cfs)								
1/25/2012	0.0082	100	0.514	84	0.0050	100	0.443	89
1/26/2012	0.0090	100	0.490	86	0.0060	100	0.430	90
2/22/2012	0.0234	90	0.570	80	0.0235	90	0.483	86
Average =	0.0135	**97**	0.525	**84**	0.0115	**97**	0.452	**88**

In general, the nutrient WQI scores suggest nutrient pollution is relatively low in the Jones and Upper Salmon basins. Of note, Jones (JON010) exhibited nitrogen levels of moderate concern during the dry season, particularly on 9/28/2011 following a small "first-flush" precipitation event (~0.30") on 9/27/2011. Upper Salmon exhibited slightly reduced nitrogen WQI scores (higher nitrogen concentrations) during the wet season when flows were greater than 100 cfs.

Land-use analysis, biological, and water chemistry results suggest that the Jones and Upper Salmon basins are both reasonably comparable and have a relatively low level of anthropogenic impacts to water quality.

Low pH in the Upper Salmon Creek Basin

Ecology did not observe pH below the water quality criterion at the mainstem Salmon Creek sites during the study period. Lower pH levels were observed at Upper Salmon Creek mainstem sites compared to locations lower in the watershed (Figures 8 and 12). A Wilcoxon Signed Rank test between Salmon Creek mainstem sites found that pH significantly increased between Salmon at 199th (SMN080) and Salmon at Caples (SMN050) (p=0.03), and between SMN050 and Salmon at 50th (SMN030)(p=0.03).

Decreases in pH occurred during high flows and associated precipitation events in February and March of 2012 (Figure 21), as well as October 2012 (Figure 24).

All available information suggests that low pH in the Upper Salmon basin occurs infrequently and is likely a result of the combination of large wet-season precipitation events, the acidity of rainfall and shallow groundwater, and the poor buffering capacity of the stream and surrounding landscape. The observed slightly lower wet-season pH levels in the Jones Creek basin, which has lower alkalinity and specific conductance (less buffering capacity), supports this theory.

Anthropogenic influences do not reasonably explain the reduced pH during these events, particularly given that Upper Salmon basin has relatively low impacts and Jones Creek, which has fewer land uses and anthropogenic impacts, has slightly lower pH levels.

Historic low pH data below 6.5, measured during previous studies, could be the result of several possibilities, including timing of and magnitude of the preceding precipitation events, improper maintenance or calibration of pH sensors, or inherent difficulty of measuring pH in cold, low-ionic strength waters.

A multi-parameter TMDL developed for the Tualatin basin in northwest Oregon found "…that improper calibration and/or maintenance of field pH meters, coupled with the difficulty of measuring pH in low ionic strength surface waters, [likely] resulted in erroneously low pH values" and that a pH TMDL should not be established for low pH listings on several creeks in the basin (Oregon DEQ, 2001).

Flushing of acidic water stored in wetlands is another potential mechanism that causes low pH in streams. Decomposition of organic matter within the wetlands results in the production and accumulation of humic acids. Under this scenario, low pH events would be expected following late summer or early fall "first-flush" precipitation events, given that decomposition would actively occur during warmer months and build up in wetlands during dry periods when flushing is reduced or eliminated.

A study of the Sammamish River found that DO and pH were lowest following a small "first-flush" precipitation event in early September (King County, 2005). Subsequent precipitation events of greater magnitude did not have as significant of an effect on DO and pH.

Following a small "first-flush" precipitation event on 9/27/2011, Salmon at 199th (SMN080), Upper Salmon (SMN086), and Jones (JON010) exhibited the highest observed pH values for these sites during the study on 9/28/2011 (7.30, 7.31 and 7.33, respectively). It is possible that little runoff was generated from this event given the antecedent dry conditions; however, nutrient concentrations were elevated on 9/28/2011, suggesting runoff as a potential source (see previous section).

At Salmon at 199th (SMN080), the lowest observed pH value (6.58) for the Salmon Creek mainstem sites occurred on 11/16/11 during the leading edge of the first larger precipitation event of the season. Curiously, Jones (JON010) and Upper Salmon (SMN086) did not exhibit comparably low pH during this event (6.83 and 6.88 respectively). This pattern was reversed during subsequent precipitation events in January and February when pH was lower at SMN086 and JON010 compared to SMN080.

One possibility is that the pH value of 6.58 was due to flushing of wetlands immediately adjacent to Salmon at 199th (SMN080). According to the National Wetlands Inventory GIS data, approximately 26.3 acres of wetlands exist in the upstream drainage area within a half-mile radius of SMN080; these wetlands drain to SMN080 downstream of Upper Salmon (SMN086).

Low DO in the Upper Salmon Creek Basin

Lower DO concentrations in the Upper Salmon basin occur during the summer and early fall months when flows are lowest, temperatures are highest, and instream productivity is, theoretically, greatest.

DO saturation levels displayed relatively muted fluctuations, ranging between 96 – 103%, suggesting that low DO concentrations may be the result of a combination of natural DO concentrations and temperature fluctuations. In addition, the DO maxima occurred in the early morning, when temperatures were the lowest, and the DO minima occurred in the late afternoon, when temperatures were the highest. Gross primary productivity typically peaks during the day, increasing instream DO concentrations as benthic algae release oxygen; the diel DO curve at Upper Salmon did not display evidence of this influence from productivity.

Ecology has developed a tool for estimating gross primary productivity (GPP), ecosystem respiration (ER), and DO reaeration coefficients using continuous water quality data called the River Metabolism Analyzer (RMA) tool (Ecology, 2013). The RMA tool estimated daily average GPP (2.4-2.7 $g/O^2/m^2/day$) and ER (20.2-20.6 $g/O^2/m^2/day$) based on the results of the August and September 2011 deployments at Upper Salmon (SMN086). This low GPP:ER ratio (~0.12-0.13) suggests that Upper Salmon Creek is likely a heterotrophic system, with little autotrophic benthic productivity. The low algal biomass observed at this site further supports the evidence indicating little gross primary productivity at this site (Figure 11).

Low pH in the Curtin Creek Basin

The study did not observe pH levels below 6.5 in the Curtin Creek watershed. The lowest pH values (6.68 and 6.58, respectively) occurred at Curtin at 139th (CUR020) and Curtin/trib near Headwaters (CT1) during the 11/16/11 wet-season synoptic event. Interestingly, the next upstream station from CUR020, Curtin at 88th (CUR060), exhibited a relatively high pH of 7.19 on 11/16/11. During subsequent wet-season events in January and February, pH dropped between CUR060 and CUR020, but less drastically (0.1 – 0.2 standard units).

Two possibilities explain the large drop on 11/16/11 between Curtin at 88th (CUR060) and Curtin at 139th (CUR020). Acidic groundwater inputs between the sites could account for the change in pH. Curtin Creek is influenced by groundwater (Clark County, 2008), particularly at low flows when the proportion of groundwater to surface water is greater. Another possibility is the influence of a large complex of wetlands located between these two sites within a Clark County habitat restoration site. Similar to the possible scenario at Salmon at 199th (SMN080), a “first-flush” of acidic material in the wetland could be responsible for the drop in pH.

Low DO in the Curtin Creek Basin

Clark County has documented low DO in Curtin Creek and the year-round influence of groundwater on the system (Clark County, 2008). Water chemistry results indicate a groundwater signature in Curtin Creek, particularly compared to nearby tributaries, with relatively low temperature, DO, pH, and organic matter (TOC/DOC) as well as high specific conductance and nitrates (Figures 7, 9, and 13).

Sands dominate the substrate at Curtin at 139th (CUR020), and little benthic algal growth was measured or observed during the study (Figure 11). However, field staff observed significant duckweed growth at this location during the summer and fall of 2011.

In addition, a large daily fluctuation in nitrate concentrations occurred during the August synoptic survey (Figure 7). Nutrient uptake by floating macrophytes or attached epiphytic algae could potentially be responsible for the large change in nitrate concentrations; however, the lack of diel change in phosphorus concentrations and the small amount of residual ammonia at this site do not support this theory. The change in nitrate could also have resulted from natural variability of nitrogen loading within the basin.

A diel swing in DO concentration of 0.8 mg/L occurred at CUR020 during the August synoptic survey, with saturation levels consistently under-saturated (79-86%). The DO maxima occurred near noon each day, while DO minima occurred in the evening several hours after the temperature peaked. This pattern suggests relatively high DO reaeration rates, significant DO effects from instream productivity, and/or naturally low groundwater DO levels may influence the diel DO curve at this site.

Low DO concentrations (9.48 – 10.29 mg/L) persisted at Curtin at 139th (CUR020) during the wet-season monthly monitoring, with generally lower concentrations occurring during wet-season synoptic events (8.72 – 9.69 mg/L). DO saturation levels also remained consistently under-saturated throughout the wet season.

Naturally low groundwater DO levels are likely an influence on Curtin Creek DO year-round; however, the high nitrate concentrations, observed diel DO swings, and observed macrophyte growth suggest that anthropogenic sources could potentially lower DO levels further during the dry season. A calibrated water quality model is likely needed to determine whether the anthropogenic influence causes a reduction of DO greater than 0.2 mg/L.

Previously developed models of the Curtin Creek basin (MGS, 2004; WEST, 2005) could potentially provide channel geometry and nutrient loading inputs to a water quality model of the basin.

Low DO and pH in the Lower and Mid-Salmon Creek Basin

Salmon Creek Mainstem

Observed pH values fell within water quality criteria at all three Lower Salmon Creek locations: Salmon at Caples (SMN050), Salmon at 50th (SMN030), and Salmon at 36th (SMN010). Wet-season pH at these lowers sites remained consistently higher than upstream values (Figures 8 and 12).

Observed DO levels fell below the water quality criterion at Salmon at Caples (SMN050), Salmon at 50th (SMN030), and Salmon at 36th (SMN010) during the August 2011 synoptic survey. Increased stream temperatures likely heavily influence DO levels and diel swings at these sites; however, some evidence of potential productivity, due to anthropogenic nutrient eutrophication, does exist. Relatively large diel DO fluctuations, daytime DO maxima, increased periphyton biomass levels, and significant diel nutrient fluctuations occurred at SMN030 (nitrate) and SMN010 (ammonia).

Similar to Curtin Creek, the lack of significant diel change in phosphorus concentrations and the small amount of residual ammonia are contrary to the theory that the dissolved inorganic nitrogen fluctuations are the result of primary productivity.

Best management practices (BMPs) and increased riparian shading, implemented as part of the approved temperature and bacteria TMDLs, should reduce instream temperatures and will likely increase DO levels throughout the watershed.

Salmon Creek Tributaries, Excluding Curtin Creek

Observed pH values fell within water quality criteria at all Salmon Creek tributaries. The lowest tributary pH values, excluding Curtin Creek, occurred at Morgan Creek (MOR010), an upper watershed tributary that drains a mix of agricultural, residential, and undeveloped land.

DO and pH daily signals (Figure 9) were relatively muted at Morgan (MOR010), and benthic algal biomass (Figure 11) was very low, suggesting that source waters in this basin may have low pH and DO. The lowest pH (6.61) occurred at the highest observed flow (39 cfs), and significant negative correlation occurred (Pearson's $r = -0.90$; $p=0.01$) between pH and flow at this site. MOR010 also exhibited relatively high ammonia levels (Figure 8) suggesting agricultural or septic waste may be present in the stream or groundwater.

DO levels at the remaining tributaries fell below the water quality criterion during the August 2011 survey. These tributaries exhibited temperatures above criteria and moderate diel DO swings.

Conclusions

Results of this 2011-12 study support the following conclusions:

- Ecology did not observe pH excursions, above or below water quality criteria, in Salmon Creek or its major tributaries.
- The lowest observed pH levels, approaching the minimum criterion, occurred during wet-season precipitation or high-flow events. Decreasing pH was correlated to increasing flow at nearly all stations, particularly those in the upper watershed.
- Localized wetland flushing, during "first-flush" precipitation events in the fall, may influence (lower) pH levels at Salmon Creek at 199th (SMN080) and Curtin Creek at 139th (CUR020). Further investigation is needed to confirm this phenomenon.
- Wet-season continuous pH levels at Salmon at 199th (SMN080) dropped infrequently and for a short duration during high-flow events.
- Land-use analysis, biological assessment, and water chemistry results suggest that the Jones Creek and Upper Salmon Creek basins are both reasonably comparable and have a relatively low level of anthropogenic impacts to water quality.
- Low pH levels in the Upper Salmon Creek basin likely result from a natural condition, where large influxes of acidic precipitation, combined with poorly buffered soils, surficial geology, and stream water, result in decreases in instream pH.
- Dissolved oxygen (DO) levels fell below the minimum criterion at all locations, with the exception of Cougar Creek at 139th (CGR020).
- Temperature levels above the maximum criterion occurred at all sites, with the exception of the Cougar (CGR020) and Curtin Creek (CUR020) sites. Elevated temperature levels are partly responsible for low DO levels at these sites.
- Evidence suggests anthropogenic influences on DO, not related to temperature, are likely minimal in the Upper Salmon and Jones Creek basins, but could be significant at all other study locations.
- High nutrient concentrations, macrophyte growth, and relatively large diel DO swings at Curtin Creek at 139th (CUR020) suggest anthropogenic influence may further lower the naturally low DO levels in this heavily developed, groundwater-influenced system.

Recommendations

Results of this 2011-12 study support the following recommendations:

- Low pH should be removed from the 303(d) list of impaired waters based on data from Salmon at 199th (SMN080) (Listing ID 22066). Available information likely meets EPA criteria for category 1 determination due to natural conditions.
- Low pH should be removed from the 303(d) list of impaired waters based on data from Salmon at 36th (SMN010) (Listing ID 22063), Salmon at Caples (SMN050) (Listing ID 22065), Curtin at 139th (SMN080) (Listing ID 22061), and Weaver (WDN010) (Listing ID 22067).
    - o Recent low pH values at these locations occurred during large wet-season precipitation events when pH was also low in the low-impacted areas of the upper watershed.
    - o Decreasing pH was significantly correlated to increasing flow at these locations.
    - o These locations should be changed to category 2, *Waters of Concern*, since they drain more heavily developed areas.
- If these pH listings cannot be removed from the 303(d) list, these listings should be ranked as very low priority for TMDL development.
    - o In these waterbodies, low pH has rarely been observed during recent years and decreased pH occurs during very infrequent, short-duration events.
    - o An effective pH TMDL would likely be very difficult to develop.
- The dissolved oxygen (DO) listings should remain on the 303(d) list, but should be assigned as low priority for TMDL development.
    - o Anthropogenic influences could potentially lower DO in the watershed.
    - o BMPs implemented as part of the Salmon Creek Temperature TMDL should significantly increase DO levels in the watershed, with the exception of Curtin Creek where temperatures are already below the maximum criterion.
- A water quality model of the Curtin Creek basin during the low-flow critical season is necessary to develop a TMDL in this watershed. The model would need to determine the degree to which anthropogenic eutrophication effects naturally occurring low DO levels.
- The Curtin Creek DO listing should also be assigned a relatively low priority.
    - o Given the complexity of this groundwater and wetland influenced system, significant resources would be necessary to develop and calibrate a TMDL to address a single listing on a very small waterbody.
    - o Available resources would likely be better spent first addressing other impaired waterbodies with multiple parameters and listings.

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Appendices

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Appendix A. Detailed Biological Results

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Analysis of biological samples:
Technical summary of methods and quality assurance procedures
Prepared for Washington Department of Ecology
Karen Adams and Scott Collyard, Project Managers
May 4, 2012

by
W. Bollman, Chief Biologist
Rhithron Associates, Inc.
Missoula, Montana

METHODS

Sample processing

Twelve macroinvertebrate samples and 14 periphyton samples collected for the Deschutes Monitoring Project were delivered to Rhithron's laboratory facility in Missoula, Montana on November 3, 2011. All samples arrived in good condition. A chain of custody document containing sample identification information was provided by the Washington Department of Ecology (WADOE) Project Managers. Upon arrival, samples were unpacked and examined, and checked against the WADOE chain of custody. An inventory spreadsheet was created and sent to the WADOE Project Managers. This spreadsheet included project code and internal laboratory identification numbers and was verified by the WADOE Project Managers prior to upload into the Rhithron database.

Standard sorting protocols (Plotnikoff and Wiseman 2001) were applied to achieve representative subsamples of a minimum of 500 organisms. Caton sub-sampling devices (Caton 1991), divided into 30 grids, each approximately 5 cm by 6 cm were used. Each individual sample was thoroughly mixed in its jar(s), poured out and evenly spread into the Caton tray, and individual grids were randomly selected. The contents of each grid were examined under stereoscopic microscopes using 10x-30x magnification. All aquatic invertebrates from each selected grid were sorted from the substrate, and placed in 95% ethanol for subsequent identification. Grid selection, examination, and sorting continued until at least 500 organisms were sorted. The final grid was completely sorted of all organisms. After the target number of organisms was obtained in the subsample, a large/rare search was performed: the Caton tray was scanned for additional organisms that were not collected in the subsample. These organisms were placed in a separate vial and labeled as "Large/Rare Organisms". As requested by the WADOE Project Manager, the large/rare search also included adult aquatic invertebrates. All unsorted sample fractions were retained and stored at the Rhithron laboratory.

Organisms were individually examined by certified taxonomists, using 10x – 80x stereoscopic dissecting scopes (Leica S8E and S6E) and identified to target taxonomic levels specified by the WADOE Project Manager (Appendix A and B of the Request for Quote), using appropriate published taxonomic references and keys.

Midges and worms were carefully morphotyped using 10x – 80x stereoscopic dissecting microscopes (Leica S8E and S6E) and representative specimens were slide mounted and examined at 200x – 1000x magnification using an Olympus BX 51 compound microscope.

Identification, counts, life stages, and information about the condition of specimens were recorded on bench sheets. Organisms that could not be identified to the taxonomic targets because of immaturity, poor condition, or lack of complete current regionally-applicable published keys were either left at appropriate taxonomic levels that were coarser than those specified or aggregated following procedures provided in Appendix C of the Request for Quote. Organisms designated as "unique" were those that could be definitively distinguished from other organisms in the sample. Large/Rare organisms were identified, and these were recorded with a count of "1". Identified organisms, separated by taxon, were preserved in 95% ethanol in voucher labeled vials. Large/Rare organisms were placed in separate labeled vials. Voucher specimens, large/rare organisms and slide mounted organisms were shipped to the Orma J. Smith Museum of Natural History upon completion of the project.

A number of taxonomic nomenclature changes went into effect during the 2011 calendar year. Taxonomic name changes that have relevance to the WADOE data set are described in the table below.

Taxon (current)	Synonym (past data)
Antocha monticola	*Antocha* sp.
Ephemerella excrucians	*Ephemerella inermis*
Ephemerella dorothea	*Ephemerella infrequens*
Ephemerella tibialis	*Serratella tibialis*
Hydrozoa	*Hydra* sp.
Labiobaetis sp.	*Pseudocloeon* sp.
Matriella teresa	*Serratella teresa*
Nemata	Nematoda
Ochrotrichia sp.	Hydroptilidae sp. (RAI Taxon # 0001)
Tvetenia tshernovskii	*Tvetenia vitracies*

The periphyton samples, preserved with Lugol's solution, were topped-off upon arrival at the laboratory. The samples were thoroughly mixed by shaking. Permanent diatom slides were prepared: subsamples were taken and treated with concentrated H_2SO_4 and 30% H_2O_2. The samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities. Small amounts of the samples were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 600 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For the soft-bodied (non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random sub-sample of algal material was pipetted onto a standard glass microscope slide using a disposable dropper or soda straw. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated importance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The wet mount was then covered with a 22X30 mm cover slip.

Soft-bodied (non-diatom) algae were identified to genus using an Olympus BHT compound microscope under 200X and 400X. The relative abundance of each algal genus (and of all diatom genera collectively) was estimated for comparative purposes, and abundances were expressed according to the following system:

- rare (r): represented by a single occurrence in the sub-sample
- occasional (o): multiple occurrences, but infrequently seen
- common (c): multiple occurrences, regularly seen
- frequent (f): present in nearly every field of view
- abundant (a): multiple occurrences in every field of view, but well within limits of enumeration
- dominant (d): multiple occurrences in every field of view, but generally beyond practical limits of enumeration

Soft-bodied genera (and the diatom component) were also ranked according to their estimated contribution to the total algal biovolume present in the sample.

Quality control procedures

Quality control procedures for initial sample processing and subsampling involved checking sorting efficiency. These checks were conducted on 100% of the samples by independent observers who microscopically re-examined at least 20% of sorted substrate from each sample. Quality control procedures for each sample proceeded as follows:

The quality control technician poured the sorted substrate from a processed sample out into a Caton tray, redistributing the substrate so that 20% of it could be accurately lifted out by removing entire grids in a random fashion. Grids were selected, and re-examined until 20% of the substrate was re-sorted. All organisms that were missed were counted and this number was added to the total number obtained in the original sort. Sorting efficiency was evaluated by applying the following calculation:

$$SE = \frac{n_1}{n_1 + n_2} \times 100$$

where: SE is the sorting efficiency, expressed as a percentage, n_1 is the total number of specimens in the first sort, and n_2 is the total number of specimens expected in the second sort, based on the results of the re-sorted 20%.

Quality control procedures for taxonomic determinations of invertebrates involved checking accuracy, precision and enumeration. Two samples were randomly selected and all organisms re-identified and counted by an independent taxonomist. Taxa lists and enumerations were compared by calculating a Bray-Curtis similarity statistic (Bray and Curtis 1957) for each selected sample. Routinely, discrepancies between the original identifications and the QC identifications are discussed among the taxonomists, and necessary rectifications to the data are made. Discrepancies that cannot be rectified by discussions are routinely sent out to taxonomic specialists for identification.

Quality control procedures for periphyton taxonomy involved the re-identification of diatoms and non-diatom algae from 2 randomly selected samples by independent taxonomists. Re-identifications of diatoms and non-diatom algae were made internally at Rhithron. Bray-Curtis similarity statistics were generated by comparing the original identifications with the re-identifications, and adjustments to taxonomy were made where appropriate. Discrepancies in identifications were discussed, and rectifications were made to the data.

Data analysis

Taxa and counts for each sample were entered into Rhithron’s customized database software. Standard metric calculations for aquatic invertebrate and periphyton assemblages were made using Rhithron’s customized database software. Final invertebrate data including sample identifiers, taxon names, counts, life stages, uniqueness designations, qualifiers, and proportion of sample sorted was compiled in Microsoft Excel. Non-diatom algae identifications, relative abundances and biovolume rankings were also compiled in Microsoft Excel.

Rhithron's customized database application was also used to produce species lists and counts in upload files for the King County Macroinvertebrate Data Management System.

RESULTS

Quality Control Procedures

Results of quality control procedures for subsampling and taxonomy are given in Table 1. Sorting efficiency averaged 98.82% for macroinvertebrate samples, taxonomic precision for identification and enumeration averaged 95.00% for the randomly selected macroinvertebrate QA samples, and data entry efficiency averaged 100% for the project. Taxonomic precision for identification and enumeration averaged 93.25% for the randomly selected periphyton QA samples. These similarity statistics fall within acceptable industry criteria (aquatic invertebrates: Stribling et al. 2003; periphyton: Bahls pers. comm.)

Data analysis

Taxa lists and counts, and values and scores for various standard bioassessment metrics and indices calculated by Rhithron are given in the Appendix. Electronic spreadsheets were provided to the WADOE Project Managers via e-mail. Appropriate data files were uploaded to the Puget Sound Stream Benthos website. The complete, verified invertebrate voucher collections were shipped to the Orma J. Smith Museum. Diatom slides were shipped to the WADOE Project Managers.

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APPENDIX

Invertebrate taxa lists and metric summaries
Diatom taxa lists and metric summaries
Non-diatom algae identifications

Deschutes Monitoring

2011

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS009

RAI No.: WADOE11DS009
Sta. Name: Salmon Creek at 122nd Ave
Client ID: SMN050
Date Coll.: 9/28/2011
No. Jars: 1
STORET ID: SMN050-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Other Non-Insect							
Nemata	1	0.18%	Yes	Unknown		5	UN
Ancylidae							
Ferrissia sp.	1	0.18%	Yes	Unknown		6	SC
Astacidae							
Pacifastacus leniusculus	1	0.18%	Yes	Unknown		6	SH
Crangonyctidae							
Crangonyx sp.	5	0.89%	Yes	Unknown		6	CG
Hydrobiidae							
Hydrobiidae	7	1.25%	Yes	Unknown		8	SC
Hygrobatidae							
Hygrobatidae	1	0.18%	Yes	Larva		8	PR
Lebertiidae							
Lebertia sp.	1	0.18%	Yes	Adult		8	PR
Sperchonidae							
Sperchon sp.	18	3.21%	Yes	Adult		11	PR
Oligochaeta							
Lumbriculidae							
Kincaidiana hexatheca	2	0.36%	Yes	Unknown		11	CG
Lumbriculidae	47	8.38%	Yes	Unknown	Damaged	4	CG
Naididae							
Nais sp.	6	1.07%	Yes	Unknown		8	CG
Spirosperma nikolskyi	8	1.43%	Yes	Unknown		10	CG
Ephemeroptera							
Baetidae							
Acentrella turbida	1	0.18%	Yes	Larva		4	CG
Baetis tricaudatus	17	3.03%	Yes	Larva		4	CG
Diphetor hageni	2	0.36%	Yes	Larva		5	CG
Ephemerellidae							
Drunella doddsii	2	0.36%	Yes	Larva		1	SC
Heptageniidae							
Epeorus sp.	6	1.07%	Yes	Larva		2	CG
Rhithrogena sp.	68	12.12%	Yes	Larva		0	SC
Leptophlebiidae							
Paraleptophlebia sp.	8	1.43%	Yes	Larva		1	CG
Plecoptera							
Capniidae							
Capniidae	5	0.89%	Yes	Larva	Early Instar	1	SH
Nemouridae							
Zapada cinctipes	46	8.20%	Yes	Larva		3	SH
Perlidae							
Calineuria californica	8	1.43%	Yes	Larva		2	PR
Hesperoperla pacifica	2	0.36%	Yes	Larva		1	PR
Megaloptera							
Sialidae							
Sialis sp.	1	0.18%	Yes	Larva		4	PR

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS009

RAI No.: WADOE11DS009 Sta. Name: Salmon Creek at 122nd Ave
Client ID: SMN050
Date Coll.: 9/28/2011 No. Jars: 1 STORET ID: SMN050-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Glossosomatidae							
Glossosoma sp.	4	0.71%	Yes	Larva		0	SC
Glossosomatidae	1	0.18%	No	Pupa		0	SC
Hydropsychidae							
Cheumatopsyche sp.	72	12.83%	Yes	Larva		5	CF
Hydropsyche sp.	50	8.91%	Yes	Larva		5	CF
Hydropsychidae	1	0.18%	No	Pupa		4	CF
Philopotamidae							
Dolophilodes sp.	2	0.36%	Yes	Larva		0	CF
Psychomyiidae							
Psychomyia sp.	1	0.18%	Yes	Larva		2	CG
Rhyacophilidae							
Rhyacophila sp.	1	0.18%	No	Pupa		1	PR
Rhyacophila blarina	3	0.53%	Yes	Larva		1	PR
Rhyacophila Brunnea Gr.	2	0.36%	Yes	Larva		2	PR
Coleoptera							
Dytiscidae							
Oreodytes sp.	1	0.18%	Yes	Adult		5	PR
Elmidae							
Cleptelmis addenda	26	4.63%	Yes	Larva		4	CG
Optioservus sp.	47	8.38%	No	Larva		5	SC
Optioservus sp.	15	2.67%	Yes	Adult		5	SC
Zaitzevia sp.	16	2.85%	No	Larva		5	CG
Zaitzevia sp.	11	1.96%	Yes	Adult		5	CG
Diptera							
Simuliidae							
Simulium sp.	6	1.07%	Yes	Larva		6	CF
Simulium sp.	1	0.18%	No	Pupa		6	CF
Tipulidae							
Dicranota sp.	1	0.18%	Yes	Larva		3	PR
Chironomidae							
Chironomidae							
Brillia sp.	3	0.53%	Yes	Larva		4	SH
Eukiefferiella sp.	3	0.53%	Yes	Larva		8	CG
Micropsectra sp.	13	2.32%	Yes	Larva		4	CG
Orthocladius sp.	1	0.18%	Yes	Larva		6	CG
Parametriocnemus sp.	6	1.07%	Yes	Larva		5	CG
Polypedilum sp.	1	0.18%	Yes	Larva		6	SH
Rheotanytarsus sp.	1	0.18%	Yes	Pupa		6	CF
Synorthocladius sp.	3	0.53%	Yes	Pupa		2	CG
Thienemanniella sp.	2	0.36%	Yes	Larva		6	CG
Tvetenia Bavarica Gr.	3	0.53%	Yes	Larva		5	CG
Sample Count	561						

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS010

RAI No.: WADOE11DS010 Sta. Name: Salmon Creek at 199th
Client ID: SMN085
Date Coll.: 9/28/2011 No. Jars: 1 STORET ID: SMN080-09-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Other Non-Insect							
Cladocera	1	0.19%	Yes	Unknown		8	CF
Ancylidae							
Ferrissia sp.	3	0.58%	Yes	Unknown		6	SC
Astacidae							
Pacifastacus leniusculus	1	0.19%	Yes	Unknown		6	SH
Hydrobiidae							
Hydrobiidae	1	0.19%	Yes	Unknown		8	SC
Hygrobatidae							
Hygrobates sp.	1	0.19%	Yes	Adult		8	PR
Lebertiidae							
Lebertia sp.	4	0.77%	Yes	Adult		8	PR
Pisidiidae							
Pisidium sp.	1	0.19%	Yes	Unknown		5	CF
Pleuroceridae							
Juga sp.	16	3.09%	Yes	Unknown		7	SC
Sperchonidae							
Sperchon sp.	6	1.16%	Yes	Adult		11	PR
Sperchonopsis sp.	2	0.39%	Yes	Adult		11	PR
Oligochaeta							
Lumbriculidae							
Kincaidiana hexatheca	2	0.39%	Yes	Unknown		11	CG
Lumbriculidae	1	0.19%	Yes	Unknown	Damaged	4	CG
Naididae							
Naididae (Tubificinae) - with capillary setae	1	0.19%	No	Immature		11	CG
Pristina sp.	1	0.19%	Yes	Unknown		8	CG
Spirosperma nikolskyi	1	0.19%	Yes	Unknown		10	CG
Ephemeroptera							
Baetidae							
Baetis tricaudatus	76	14.70%	Yes	Larva		4	CG
Diphetor hageni	2	0.39%	Yes	Larva		5	CG
Ephemerellidae							
Attenella margarita	2	0.39%	Yes	Larva		3	CG
Drunella doddsii	4	0.77%	Yes	Larva		1	SC
Heptageniidae							
Cinygmula sp.	1	0.19%	Yes	Larva		0	SC
Epeorus sp.	8	1.55%	Yes	Larva		2	CG
Rhithrogena sp.	33	6.38%	Yes	Larva		0	SC
Leptophlebiidae							
Paraleptophlebia sp.	19	3.68%	Yes	Larva		1	CG

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS010

RAI No.: WADOE11DS010 | Sta. Name: Salmon Creek at 199th
Client ID: SMN085
Date Coll.: 9/28/2011 | No. Jars: 1 | STORET ID: SMN080-09-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Plecoptera							
Chloroperlidae							
Sweltsa sp.	12	2.32%	Yes	Larva		0	PR
Leuctridae							
Leuctridae	2	0.39%	Yes	Larva	Early Instar	0	SH
Nemouridae							
Zapada cinctipes	20	3.87%	Yes	Larva		3	SH
Peltoperlidae							
Yoraperla sp.	4	0.77%	Yes	Larva		0	SH
Perlidae							
Calineuria californica	10	1.93%	Yes	Larva		2	PR
Hesperoperla pacifica	4	0.77%	Yes	Larva		1	PR
Trichoptera							
Brachycentridae							
Micrasema sp.	12	2.32%	Yes	Larva		1	SH
Glossosomatidae							
Glossosoma sp.	28	5.42%	Yes	Larva		0	SC
Hydropsychidae							
Hydropsyche sp.	19	3.68%	Yes	Larva		5	CF
Philopotamidae							
Wormaldia sp.	2	0.39%	Yes	Larva		0	CF
Psychomyiidae							
Psychomyia sp.	1	0.19%	Yes	Larva		2	CG
Rhyacophilidae							
Rhyacophila sp.	1	0.19%	Yes	Larva	Early Instar	1	PR
Rhyacophila Betteni Gr.	3	0.58%	Yes	Larva		0	PR
Rhyacophila blarina	12	2.32%	Yes	Larva		1	PR
Rhyacophila Brunnea Gr.	4	0.77%	Yes	Larva		2	PR
Rhyacophila narvae	1	0.19%	Yes	Larva		0	PR
Coleoptera							
Elmidae							
Cleptelmis addenda	47	9.09%	No	Larva		4	CG
Cleptelmis addenda	9	1.74%	Yes	Adult		4	CG
Narpus concolor	1	0.19%	No	Larva		2	CG
Narpus concolor	1	0.19%	Yes	Adult		2	CG
Optioservus sp.	14	2.71%	Yes	Adult		5	SC
Optioservus sp.	2	0.39%	No	Larva		5	SC
Zaitzevia sp.	15	2.90%	Yes	Adult		5	CG
Hydraenidae							
Hydraena sp.	1	0.19%	Yes	Adult		5	PR
Psephenidae							
Ectopria sp.	1	0.19%	Yes	Larva		4	SC

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS010

RAI No.: WADOE11DS010
Sta. Name: Salmon Creek at 199th
Client ID: SMN085
Date Coll.: 9/28/2011
No. Jars: 1
STORET ID: SMN080-09-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Diptera							
Blephariceridae							
Blephariceridae	2	0.39%	Yes	Pupa		0	SC
Pelecorhynchidae							
Glutops sp.	2	0.39%	Yes	Larva		1	PR
Simuliidae							
Simulium sp.	15	2.90%	No	Pupa		6	CF
Simulium sp.	51	9.86%	Yes	Larva		6	CF
Tipulidae							
Antocha monticola	8	1.55%	Yes	Larva		3	CG
Dicranota sp.	1	0.19%	Yes	Larva		3	PR
Tipulidae	1	0.19%	No	Pupa		3	SH
Chironomidae							
Chironomidae							
Corynoneura sp.	1	0.19%	Yes	Larva		7	CG
Eukiefferiella sp.	2	0.39%	Yes	Larva		8	CG
Eukiefferiella sp.	1	0.19%	No	Pupa		8	CG
Micropsectra sp.	1	0.19%	No	Pupa		4	CG
Micropsectra sp.	11	2.13%	Yes	Larva		4	CG
Parametriocnemus sp.	1	0.19%	Yes	Larva		5	CG
Rheotanytarsus sp.	3	0.58%	Yes	Larva		6	CF
Stempellinella sp.	1	0.19%	Yes	Larva		4	CG
Thienemannimyia Gr.	1	0.19%	Yes	Larva		5	PR
Tvetenia Bavarica Gr.	2	0.39%	Yes	Larva		5	CG
Sample Count	517						

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS011

RAI No.: WADOE11DS011 Sta. Name: Jones Creek
Client ID: JON010
Date Coll.: 9/28/2011 No. Jars: 1 STORET ID: JON010-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Other Non-Insect							
Astacidae							
Pacifastacus leniusculus	1	0.18%	Yes	Unknown		6	SH
Hydrobiidae							
Hydrobiidae	7	1.27%	Yes	Unknown		8	SC
Planariidae							
Polycelis sp.	2	0.36%	Yes	Unknown		1	OM
Pleuroceridae							
Juga sp.	4	0.72%	Yes	Unknown		7	SC
Protziidae							
Protzia sp.	1	0.18%	Yes	Adult		11	PR
Sperchonidae							
Sperchon sp.	2	0.36%	Yes	Adult		11	PR
Oligochaeta							
Enchytraeidae							
Enchytraeus sp.	2	0.36%	Yes	Unknown		4	CG
Mesenchytraeus sp.	4	0.72%	Yes	Unknown		4	CG
Lumbriculidae							
Kincaidiana hexatheca	7	1.27%	Yes	Unknown		11	CG
Phagodrilus sp.	1	0.18%	Yes	Unknown		11	PR
Naididae							
Nais sp.	1	0.18%	Yes	Unknown		8	CG
Ephemeroptera							
Baetidae							
Baetis tricaudatus	92	16.64%	Yes	Larva		4	CG
Diphetor hageni	8	1.45%	Yes	Larva		5	CG
Ephemerellidae							
Attenella margarita	1	0.18%	Yes	Larva		3	CG
Drunella doddsii	3	0.54%	Yes	Larva		1	SC
Heptageniidae							
Cinygmula sp.	4	0.72%	Yes	Larva		0	SC
Ironodes sp.	30	5.42%	Yes	Larva		0	SC
Rhithrogena sp.	22	3.98%	Yes	Larva		0	SC
Leptophlebiidae							
Paraleptophlebia sp.	28	5.06%	Yes	Larva		1	CG
Plecoptera							
Chloroperlidae							
Sweltsa sp.	8	1.45%	Yes	Larva		0	PR
Leuctridae							
Despaxia augusta	1	0.18%	Yes	Larva		0	SH
Moselia infuscata	1	0.18%	Yes	Larva		0	SH
Nemouridae							
Zapada cinctipes	22	3.98%	Yes	Larva		3	SH
Perlidae							
Calineuria californica	15	2.71%	Yes	Larva		2	PR
Perlodidae							
Perlodidae	1	0.18%	Yes	Larva	Early Instar	2	PR

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS011

RAI No.: WADOE11DS011 | Sta. Name: Jones Creek
Client ID: JON010
Date Coll.: 9/28/2011 | No. Jars: 1 | STORET ID: JON010-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Brachycentridae							
Micrasema sp.	1	0.18%	Yes	Larva		1	SH
Glossosomatidae							
Glossosoma sp.	81	14.65%	Yes	Larva		0	SC
Glossosomatidae	3	0.54%	No	Pupa		0	SC
Hydropsychidae							
Hydropsyche sp.	36	6.51%	Yes	Larva		5	CF
Limnephilidae							
Limnephilidae	1	0.18%	Yes	Pupa		3	SH
Psychomyiidae							
Psychomyia sp.	4	0.72%	Yes	Larva		2	CG
Rhyacophilidae							
Rhyacophila Betteni Gr.	2	0.36%	Yes	Larva		0	PR
Rhyacophila blarina	11	1.99%	Yes	Larva		1	PR
Rhyacophila Brunnea Gr.	3	0.54%	Yes	Larva		2	PR
Rhyacophila narvae	3	0.54%	Yes	Larva		0	PR
Coleoptera							
Elmidae							
Heterlimnius corpulentus	19	3.44%	No	Larva		3	CG
Heterlimnius corpulentus	1	0.18%	Yes	Adult		3	CG
Optioservus sp.	5	0.90%	Yes	Adult		5	SC
Optioservus sp.	2	0.36%	No	Larva		5	SC
Zaitzevia sp.	7	1.27%	No	Larva		5	CG
Zaitzevia sp.	3	0.54%	Yes	Adult		5	CG
Diptera							
Ceratopogonidae							
Bezzia / Palpomyia	1	0.18%	Yes	Larva		6	CG
Empididae							
Wiedemannia sp.	1	0.18%	Yes	Larva		6	PR
Pelecorhynchidae							
Glutops sp.	1	0.18%	Yes	Larva		1	PR
Simuliidae							
Simulium sp.	7	1.27%	Yes	Larva		6	CF
Tipulidae							
Antocha monticola	3	0.54%	Yes	Larva		3	CG
Dicranota sp.	2	0.36%	Yes	Larva		3	PR
Hexatoma sp.	1	0.18%	Yes	Larva		2	PR

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS011

RAI No.: WADOE11DS011 Sta. Name: Jones Creek
Client ID: JON010
Date Coll.: 9/28/2011 No. Jars: 1 STORET ID: JON010-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Chironomidae							
Chironomidae							
Brillia sp.	8	1.45%	Yes	Larva		4	SH
Corynoneura sp.	2	0.36%	Yes	Larva		7	CG
Eukiefferiella sp.	3	0.54%	Yes	Larva		8	CG
Micropsectra sp.	22	3.98%	Yes	Larva		4	CG
Orthocladius sp.	1	0.18%	Yes	Pupa		6	CG
Parametriocnemus sp.	2	0.36%	Yes	Larva		5	CG
Polypedilum sp.	7	1.27%	Yes	Larva		6	SH
Reomyia sp.	2	0.36%	Yes	Larva		11	PR
Stempellinella sp.	3	0.54%	No	Pupa		4	CG
Stempellinella sp.	13	2.35%	Yes	Larva		4	CG
Thienemanniella sp.	1	0.18%	Yes	Larva		6	CG
Thienemannimyia Gr.	1	0.18%	Yes	Larva		5	PR
Tvetenia sp.	2	0.36%	No	Pupa		5	CG
Tvetenia Bavarica Gr.	20	3.62%	Yes	Larva		5	CG
Sample Count	553						

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS012

RAI No.: WADOE11DS012 **Sta. Name:** Salmon Creek at 122nd Ave Replicate
Client ID: SMN050-R
Date Coll.: 9/28/2011 **No. Jars:** 1 **STORET ID:** SMN050R-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Other Non-Insect							
Ancylidae							
Ferrissia sp.	3	0.54%	Yes	Unknown		6	SC
Astacidae							
Pacifastacus leniusculus	1	0.18%	Yes	Unknown		6	SH
Crangonyctidae							
Crangonyx sp.	3	0.54%	Yes	Unknown		6	CG
Hydrobiidae							
Hydrobiidae	15	2.69%	Yes	Unknown		8	SC
Pleuroceridae							
Juga sp.	22	3.95%	Yes	Unknown		7	SC
Protziidae							
Protzia sp.	1	0.18%	Yes	Adult		11	PR
Sperchonidae							
Sperchon sp.	10	1.80%	Yes	Adult		11	PR
Sperchonopsis sp.	1	0.18%	Yes	Adult		11	PR
Oligochaeta							
Lumbriculidae							
Lumbriculidae	21	3.77%	Yes	Unknown	Damaged	4	CG
Naididae							
Nais sp.	2	0.36%	Yes	Unknown		8	CG
Spirosperma nikolskyi	1	0.18%	Yes	Unknown		10	CG
Ephemeroptera							
Baetidae							
Baetis tricaudatus	28	5.03%	Yes	Larva		4	CG
Ephemerellidae							
Drunella doddsii	6	1.08%	Yes	Larva		1	SC
Heptageniidae							
Rhithrogena sp.	44	7.90%	Yes	Larva		0	SC
Leptophlebiidae							
Paraleptophlebia sp.	8	1.44%	Yes	Larva		1	CG
Plecoptera							
Chloroperlidae							
Sweltsa sp.	1	0.18%	Yes	Larva		0	PR
Nemouridae							
Zapada cinctipes	18	3.23%	Yes	Larva		3	SH
Perlidae							
Calineuria californica	11	1.97%	Yes	Larva		2	PR

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS012

RAI No.: WADOE11DS012
Sta. Name: Salmon Creek at 122nd Ave Replicate
Client ID: SMN050-R
Date Coll.: 9/28/2011
No. Jars: 1
STORET ID: SMN050R-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Brachycentridae							
Micrasema sp.	1	0.18%	Yes	Larva		1	SH
Glossosomatidae							
Glossosoma sp.	28	5.03%	Yes	Larva		0	SC
Glossosomatidae	2	0.36%	No	Pupa		0	SC
Goeridae							
Goera archaon	1	0.18%	Yes	Larva		1	SC
Hydropsychidae							
Cheumatopsyche sp.	43	7.72%	Yes	Larva		5	CF
Hydropsyche sp.	138	24.78%	Yes	Larva		5	CF
Hydropsychidae	1	0.18%	No	Pupa		4	CF
Rhyacophilidae							
Rhyacophila sp.	3	0.54%	No	Pupa		1	PR
Rhyacophila Betteni Gr.	3	0.54%	Yes	Larva		0	PR
Rhyacophila blarina	1	0.18%	Yes	Larva		1	PR
Rhyacophila Brunnea Gr.	2	0.36%	Yes	Larva		2	PR
Coleoptera							
Elmidae							
Cleptelmis addenda	3	0.54%	Yes	Larva		4	CG
Optioservus sp.	25	4.49%	Yes	Adult		5	SC
Optioservus sp.	36	6.46%	No	Larva		5	SC
Zaitzevia sp.	15	2.69%	No	Larva		5	CG
Zaitzevia sp.	8	1.44%	Yes	Adult		5	CG
Diptera							
Empididae							
Neoplasta sp.	1	0.18%	Yes	Larva		5	PR
Simuliidae							
Simulium sp.	10	1.80%	Yes	Larva		6	CF
Tipulidae							
Dicranota sp.	1	0.18%	Yes	Larva		3	PR
Chironomidae							
Chironomidae							
Eukiefferiella sp.	3	0.54%	Yes	Larva		8	CG
Eukiefferiella sp.	1	0.18%	No	Pupa		8	CG
Micropsectra sp.	9	1.62%	Yes	Larva		4	CG
Micropsectra sp.	1	0.18%	No	Pupa		4	CG
Nanocladius sp.	1	0.18%	Yes	Larva		3	CG
Parametriocnemus sp.	6	1.08%	Yes	Larva		5	CG
Polypedilum sp.	1	0.18%	No	Pupa		6	SH
Polypedilum sp.	5	0.90%	Yes	Larva		6	SH
Rheotanytarsus sp.	3	0.54%	Yes	Larva		6	CF
Rheotanytarsus sp.	3	0.54%	No	Pupa		6	CF
Synorthocladius sp.	1	0.18%	Yes	Pupa		2	CG
Thienemannimyia Gr.	2	0.36%	Yes	Larva		5	PR
Tvetenia Bavarica Gr.	3	0.54%	Yes	Larva		5	CG

Taxa Listing

Project ID: WADOE11DS
RAI No.: WADOE11DS012

RAI No.: WADOE11DS012
Sta. Name: Salmon Creek at 122nd Ave Replicate
Client ID: SMN050-R
Date Coll.: 9/28/2011
No. Jars: 1
STORET ID: SMN050R-9-28-2011

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Sample Count	557						

Metrics Report

Project ID: WADOE11DS
RAI No.: WADOE11DS009
Sta. Name: Salmon Creek at 122nd Ave
Client ID: SMN050
STORET ID SMN050-9-28-2011
Coll. Date: 9/28/2011

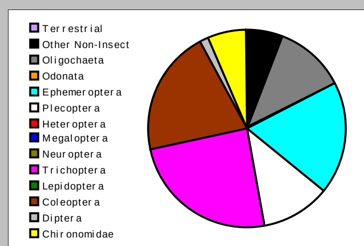
Abundance Measures

Sample Count: 561
Sample Abundance: 1,202.14 46.67% of sample used

Coll. Procedure:
Sample Notes: 1800

Taxonomic Composition

Category	R	A	PRA
Terrestrial			
Other Non-Insect	8	35	6.24%
Oligochaeta	4	63	11.23%
Odonata			
Ephemeroptera	7	104	18.54%
Plecoptera	4	61	10.87%
Heteroptera			
Megaloptera	1	1	0.18%
Neuroptera			
Trichoptera	7	137	24.42%
Lepidoptera			
Coleoptera	4	116	20.68%
Diptera	2	8	1.43%
Chironomidae	10	36	6.42%

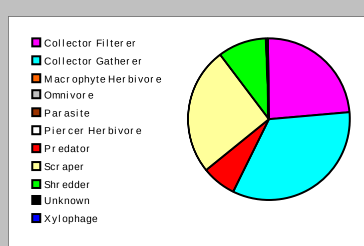


Dominant Taxa

Category	A	PRA
Cheumatopsyche	72	12.83%
Rhithrogena	68	12.12%
Optioservus	62	11.05%
Hydropsyche	50	8.91%
Lumbriculidae	47	8.38%
Zapada cinctipes	46	8.20%
Zaitzevia	27	4.81%
Cleptelmis addenda	26	4.63%
Sperchon	18	3.21%
Baetis tricaudatus	17	3.03%
Micropsectra	13	2.32%
Spirosperma nikolskyi	8	1.43%
Paraleptophlebia	8	1.43%
Calineuria californica	8	1.43%
Simulium	7	1.25%

Functional Composition

Category	R	A	PRA
Predator	10	39	6.95%
Parasite			
Collector Gatherer	20	187	33.33%
Collector Filterer	5	133	23.71%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	6	145	25.85%
Shredder	5	56	9.98%
Omnivore			
Unknown	1	1	0.18%

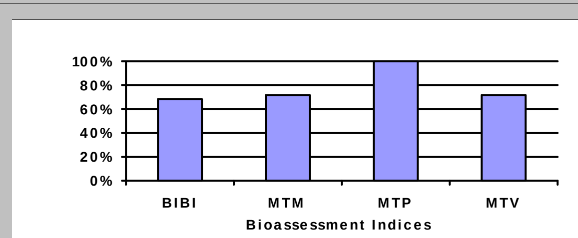


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	47	5	3		3
E Richness	7	3		3	
P Richness	4	3		3	
T Richness	7	3		3	
EPT Richness	18		3		2
EPT Percent	53.83%		3		1
All Non-Insect Abundance	98				
All Non-Insect Richness	12				
All Non-Insect Percent	17.47%				
Oligochaeta+Hirudinea Percent	11.23%				
Baetidae/Ephemeroptera	0.192				
Hydropsychidae/Trichoptera	0.898				
Dominance					
Dominant Taxon Percent	12.83%		3		3
Dominant Taxa (2) Percent	24.96%				
Dominant Taxa (3) Percent	36.01%	5			
Dominant Taxa (10) Percent	77.18%				
Diversity					
Shannon H (loge)	2.990				
Shannon H (log2)	4.313		3		
Margalef D	7.416				
Simpson D	0.076				
Evenness	0.046				
Function					
Predator Richness	10		3		
Predator Percent	6.95%	1			
Filterer Richness	5				
Filterer Percent	23.71%			1	
Collector Percent	57.04%		3		3
Scraper+Shredder Percent	35.83%		3		1
Scraper/Filterer	1.090				
Scraper/Scraper+Filterer	0.522				
Habit					
Burrower Richness	3				
Burrower Percent	9.09%				
Swimmer Richness	5				
Swimmer Percent	5.17%				
Clinger Richness	20	5			
Clinger Percent	73.08%				
Characteristics					
Cold Stenotherm Richness	2				
Cold Stenotherm Percent	0.71%				
Hemoglobin Bearer Richness	2				
Hemoglobin Bearer Percent	1.60%				
Air Breather Richness	2				
Air Breather Percent	0.36%				
Voltinism					
Univoltine Richness	21				
Semivoltine Richness	7	5			
Multivoltine Percent	13.55%		3		
Tolerance					
Sediment Tolerant Richness	3				
Sediment Tolerant Percent	8.73%				
Sediment Sensitive Richness	3				
Sediment Sensitive Percent	1.25%				
Metals Tolerance Index	3.404				
Pollution Sensitive Richness	2	1		2	
Pollution Tolerant Percent	29.06%	3		1	
Hilsenhoff Biotic Index	3.874		3		2
Intolerant Percent	20.68%				
Supertolerant Percent	4.63%				
CTQa	77.415				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	34	68.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	30	100.00%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	13	72.22%	Slight
MTM	Montana DEQ Mountains (Bukantis 1998)	15	71.43%	Slight



Friday, May 04, 2012

Metrics Report

Project ID: WADOE11DS
RAI No.: WADOE11DS010
Sta. Name: Salmon Creek at 199th
Client ID: SMN085
STORET ID SMN080-09-28-2011
Coll. Date: 9/28/2011

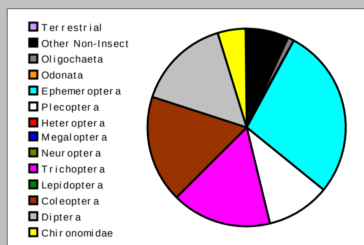
Abundance Measures

Sample Count: 517
Sample Abundance: 2,215.71 23.33% of sample used

Coll. Procedure:
Sample Notes: 1500

Taxonomic Composition

Category	R	A	PRA
Terrestrial			
Other Non-Insect	10	36	6.96%
Oligochaeta	4	6	1.16%
Odonata			
Ephemeroptera	8	145	28.05%
Plecoptera	6	52	10.06%
Heteroptera			
Megaloptera			
Neuroptera			
Trichoptera	10	83	16.05%
Lepidoptera			
Coleoptera	6	91	17.60%
Diptera	5	80	15.47%
Chironomidae	8	24	4.64%

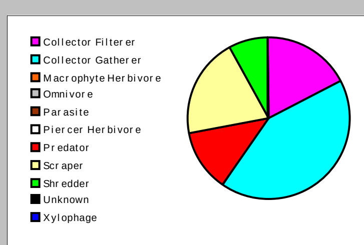


Dominant Taxa

Category	A	PRA
Baetis tricaudatus	76	14.70%
Simulium	66	12.77%
Cleptelmis addenda	56	10.83%
Rhithrogena	33	6.38%
Glossosoma	28	5.42%
Zapada cinctipes	20	3.87%
Paraleptophlebia	19	3.68%
Hydropsyche	19	3.68%
Optioservus	16	3.09%
Juga	16	3.09%
Zaitzevia	15	2.90%
Sweltsa	12	2.32%
Rhyacophila blarina	12	2.32%
Micropsectra	12	2.32%
Micrasema	12	2.32%

Functional Composition

Category	R	A	PRA
Predator	16	65	12.57%
Parasite			
Collector Gatherer	20	215	41.59%
Collector Filterer	6	92	17.79%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	10	105	20.31%
Shredder	5	40	7.74%
Omnivore			
Unknown			

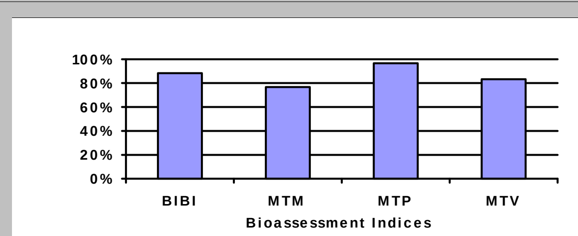


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	57	5	3		3
E Richness	8	3		3	
P Richness	6	3		3	
T Richness	10	5		3	
EPT Richness	24		3		3
EPT Percent	54.16%		3		1
All Non-Insect Abundance	42				
All Non-Insect Richness	14				
All Non-Insect Percent	8.12%				
Oligochaeta+Hirudinea Percent	1.16%				
Baetidae/Ephemeroptera	0.538				
Hydropsychidae/Trichoptera	0.229				
Dominance					
Dominant Taxon Percent	14.70%		3		3
Dominant Taxa (2) Percent	27.47%				
Dominant Taxa (3) Percent	38.30%	5			
Dominant Taxa (10) Percent	67.50%				
Diversity					
Shannon H (loge)	3.234				
Shannon H (log2)	4.665		3		
Margalef D	9.173				
Simpson D	0.063				
Evenness	0.038				
Function					
Predator Richness	16		3		
Predator Percent	12.57%	3			
Filterer Richness	6				
Filterer Percent	17.80%			1	
Collector Percent	59.38%		3		3
Scraper+Shredder Percent	28.05%		2		1
Scraper/Filterer	1.141				
Scraper/Scraper+Filterer	0.533				
Habit					
Burrower Richness	1				
Burrower Percent	0.39%				
Swimmer Richness	3				
Swimmer Percent	18.76%				
Clinger Richness	31	5			
Clinger Percent	70.79%				
Characteristics					
Cold Stenotherm Richness	5				
Cold Stenotherm Percent	2.71%				
Hemoglobin Bearer Richness	1				
Hemoglobin Bearer Percent	0.19%				
Air Breather Richness	2				
Air Breather Percent	1.93%				
Voltinism					
Univoltine Richness	28				
Semivoltine Richness	10	5			
Multivoltine Percent	22.44%		3		
Tolerance					
Sediment Tolerant Richness	5				
Sediment Tolerant Percent	5.80%				
Sediment Sensitive Richness	3				
Sediment Sensitive Percent	6.00%				
Metals Tolerance Index	3.385				
Pollution Sensitive Richness	5	5		3	
Pollution Tolerant Percent	9.67%	5		2	
Hilsenhoff Biotic Index	3.425		3		2
Intolerant Percent	32.30%				
Supertolerant Percent	2.32%				
CTQa	63.255				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	44	88.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	29	96.67%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	15	83.33%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	16	76.19%	Slight



Friday, May 04, 2012

Metrics Report

Project ID: WADOE11DS
RAI No.: WADOE11DS011
Sta. Name: Jones Creek
Client ID: JON010
STORET ID JON010-9-28-2011
Coll. Date: 9/28/2011

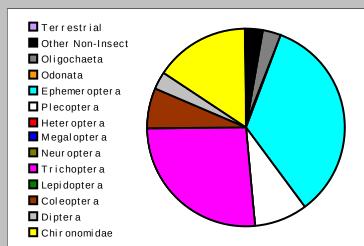
Abundance Measures

Sample Count: 553
Sample Abundance: 873.16 63.33% of sample used

Coll. Procedure:
Sample Notes: 1200

Taxonomic Composition

Category	R	A	PRA
Terrestrial			
Other Non-Insect	6	17	3.07%
Oligochaeta	5	15	2.71%
Odonata			
Ephemeroptera	8	188	34.00%
Plecoptera	6	48	8.68%
Heteroptera			
Megaloptera			
Neuroptera			
Trichoptera	9	145	26.22%
Lepidoptera			
Coleoptera	3	37	6.69%
Diptera	7	16	2.89%
Chironomidae	12	87	15.73%

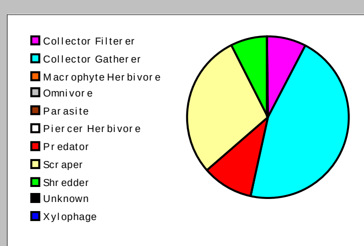


Dominant Taxa

Category	A	PRA
Baetis tricaudatus	92	16.64%
Glossosoma	81	14.65%
Hydropsyche	36	6.51%
Ironodes	30	5.42%
Paraleptophlebia	28	5.06%
Zapada cinctipes	22	3.98%
Rhithrogena	22	3.98%
Micropsectra	22	3.98%
Tvetenia Bavarica Gr.	20	3.62%
Heterlimnius corpulentus	20	3.62%
Stempellinella	16	2.89%
Calineuria californica	15	2.71%
Rhyacophila blarina	11	1.99%
Zaitzevia	10	1.81%
Sweltsa	8	1.45%

Functional Composition

Category	R	A	PRA
Predator	16	55	9.95%
Parasite			
Collector Gatherer	21	250	45.21%
Collector Filterer	2	43	7.78%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	8	161	29.11%
Shredder	8	42	7.59%
Omnivore	1	2	0.36%
Unknown			

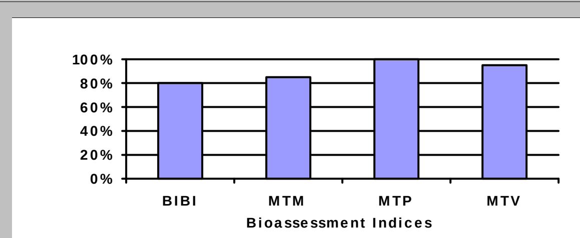


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	56	5	3		3
E Richness	8	3		3	
P Richness	6	3		3	
T Richness	9	3		3	
EPT Richness	23		3		3
EPT Percent	68.90%		3		2
All Non-Insect Abundance	32				
All Non-Insect Richness	11				
All Non-Insect Percent	5.79%				
Oligochaeta+Hirudinea Percent	2.71%				
Baetidae/Ephemeroptera	0.532				
Hydropsychidae/Trichoptera	0.248				
Dominance					
Dominant Taxon Percent	16.64%		3		3
Dominant Taxa (2) Percent	31.28%				
Dominant Taxa (3) Percent	37.79%	5			
Dominant Taxa (10) Percent	67.45%				
Diversity					
Shannon H (loge)	3.103				
Shannon H (log2)	4.477		3		
Margalef D	8.803				
Simpson D	0.077				
Evenness	0.042				
Function					
Predator Richness	16		3		
Predator Percent	9.95%	1			
Filterer Richness	2				
Filterer Percent	7.78%			2	
Collector Percent	52.98%		3		3
Scraper+Shredder Percent	36.71%		3		1
Scraper/Filterer	3.744				
Scraper/Scraper+Filterer	0.789				
Habit					
Burrower Richness	3				
Burrower Percent	1.81%				
Swimmer Richness	3				
Swimmer Percent	23.15%				
Clinger Richness	23	5			
Clinger Percent	57.14%				
Characteristics					
Cold Stenotherm Richness	4				
Cold Stenotherm Percent	1.08%				
Hemoglobin Bearer Richness	1				
Hemoglobin Bearer Percent	1.27%				
Air Breather Richness	3				
Air Breather Percent	1.08%				
Voltinism					
Univoltine Richness	31				
Semivoltine Richness	6	5			
Multivoltine Percent	34.72%		3		
Tolerance					
Sediment Tolerant Richness	4				
Sediment Tolerant Percent	1.81%				
Sediment Sensitive Richness	2				
Sediment Sensitive Percent	15.37%				
Metals Tolerance Index	2.937				
Pollution Sensitive Richness	4	5		3	
Pollution Tolerant Percent	3.80%	5		3	
Hilsenhoff Biotic Index	2.761		3		3
Intolerant Percent	40.69%				
Supertolerant Percent	1.99%				
CTQa	72.422				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	40	80.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	30	100.00%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	17	94.44%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	18	85.71%	None



Friday, May 04, 2012

Metrics Report

Project ID: WADOE11DS
RAI No.: WADOE11DS012
Sta. Name: Salmon Creek at 122nd Ave Replicate
Client ID: SMN050-R
STORET ID SMN050R-9-28-2011
Coll. Date: 9/28/2011

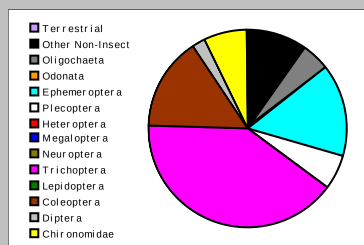
Abundance Measures

Sample Count: 557
Sample Abundance: 726.52 76.67% of sample used

Coll. Procedure:
Sample Notes: 1800

Taxonomic Composition

Category	R	A	PRA
Terrestrial			
Other Non-Insect	8	56	10.05%
Oligochaeta	3	24	4.31%
Odonata			
Ephemeroptera	4	86	15.44%
Plecoptera	3	30	5.39%
Heteroptera			
Megaloptera			
Neuroptera			
Trichoptera	8	223	40.04%
Lepidoptera			
Coleoptera	3	87	15.62%
Diptera	3	12	2.15%
Chironomidae	9	39	7.00%

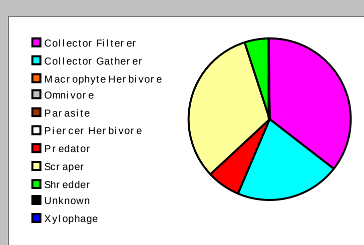


Dominant Taxa

Category	A	PRA
Hydropsyche	138	24.78%
Optioservus	61	10.95%
Rhithrogena	44	7.90%
Cheumatopsyche	43	7.72%
Glossosoma	28	5.03%
Baetis tricaudatus	28	5.03%
Zaitzevia	23	4.13%
Juga	22	3.95%
Lumbriculidae	21	3.77%
Zapada cinctipes	18	3.23%
Hydrobiidae	15	2.69%
Calineuria californica	11	1.97%
Sperchon	10	1.80%
Simulium	10	1.80%
Micropsectra	10	1.80%

Functional Composition

Category	R	A	PRA
Predator	11	37	6.64%
Parasite			
Collector Gatherer	14	114	20.47%
Collector Filterer	4	198	35.55%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	8	182	32.68%
Shredder	4	26	4.67%
Omnivore			
Unknown			

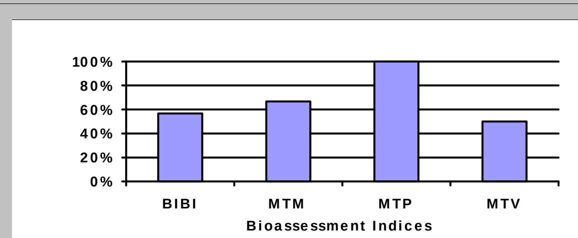


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	41	5	3		3
E Richness	4	1		2	
P Richness	3	1		2	
T Richness	8	3		3	
EPT Richness	15		3		1
EPT Percent	60.86%		3		2
All Non-Insect Abundance	80				
All Non-Insect Richness	11				
All Non-Insect Percent	14.36%				
Oligochaeta+Hirudinea Percent	4.31%				
Baetidae/Ephemeroptera	0.326				
Hydropsychidae/Trichoptera	0.816				
Dominance					
Dominant Taxon Percent	24.78%		3		3
Dominant Taxa (2) Percent	35.73%				
Dominant Taxa (3) Percent	43.63%	5			
Dominant Taxa (10) Percent	76.48%				
Diversity					
Shannon H (loge)	2.797				
Shannon H (log2)	4.036		3		
Margalef D	6.449				
Simpson D	0.110				
Evenness	0.053				
Function					
Predator Richness	11		3		
Predator Percent	6.64%	1			
Filterer Richness	4				
Filterer Percent	35.55%			0	
Collector Percent	56.01%		3		3
Scraper+Shredder Percent	37.34%		3		1
Scraper/Filterer	0.919				
Scraper/Scraper+Filterer	0.479				
Habit					
Burrower Richness	2				
Burrower Percent	3.95%				
Swimmer Richness	2				
Swimmer Percent	6.46%				
Clinger Richness	19	3			
Clinger Percent	75.04%				
Characteristics					
Cold Stenotherm Richness	1				
Cold Stenotherm Percent	1.08%				
Hemoglobin Bearer Richness	2				
Hemoglobin Bearer Percent	1.26%				
Air Breather Richness	1				
Air Breather Percent	0.18%				
Voltinism					
Univoltine Richness	20				
Semivoltine Richness	6	5			
Multivoltine Percent	14.18%		3		
Tolerance					
Sediment Tolerant Richness	4				
Sediment Tolerant Percent	8.44%				
Sediment Sensitive Richness	1				
Sediment Sensitive Percent	5.03%				
Metals Tolerance Index	3.855				
Pollution Sensitive Richness	1	1		1	
Pollution Tolerant Percent	27.29%	3		1	
Hilsenhoff Biotic Index	4.130		3		1
Intolerant Percent	20.11%				
Supertolerant Percent	3.95%				
CTQa	76.944				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	28	56.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	30	100.00%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	9	50.00%	Moderate
MTM	Montana DEQ Mountains (Bukantis 1998)	14	66.67%	Slight



Friday, May 04, 2012

Taxa Listing

Project ID: **WADOE11DSP**
RAI No.: **WADOE11DSP011**

RAI No.: WADOE11DSP011 **Sta. Name:** Salmon Creek at 122nd Ave
Client ID: SMN050
Date Coll.: 9/28/2011 **No Jars:** 1 **STORET ID:** WADOE11DSP011

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthes subhudsonis v. kraeuselii	5	0.83%	0	
Achnanthidium minutissimum	18	3.00%	0	
Achnanthidium rivulare	257	42.83%	0	
Amphora copulata	1	0.17%	0	
Aulacoseira sp.	3	0.50%	0	
Cocconeis pediculus	1	0.17%	0	
Cocconeis placentula	5	0.83%	0	
Cocconeis placentula v. euglypta	15	2.50%	0	
Cocconeis placentula v. lineata	124	20.67%	0	
Cymbella excisa	1	0.17%	0	
Fragilaria capucina v. gracilis	1	0.17%	0	
Geissleria acceptata	3	0.50%	0	
Gomphonema sp.	20	3.33%	0	
Gomphonema kobayasii	5	0.83%	0	
Gomphonema rhombicum	38	6.33%	0	
Gyrosigma nodiferum	1	0.17%	0	
Navicula antonii	1	0.17%	0	
Navicula cryptocephala	3	0.50%	0	
Navicula cryptotenella	13	2.17%	0	
Navicula cryptotenelloides	1	0.17%	0	
Navicula gregaria	1	0.17%	0	
Navicula parabilis	3	0.50%	0	
Nitzschia acidoclinata	1	0.17%	0	
Nitzschia amphibia	1	0.17%	0	
Nitzschia inconspicua	3	0.50%	0	
Nitzschia liebetruthii	1	0.17%	0	
Nitzschia sociabilis	1	0.17%	0	
Nupela lapidosa	1	0.17%	0	
Planothidium frequentissimum	3	0.50%	0	
Planothidium lanceolatum	3	0.50%	0	
Psammothidium ventralis	3	0.50%	0	
Pseudostaurosira parasitica	1	0.17%	0	
Reimeria sinuata	8	1.33%	0	
Rhoicosphenia abbreviata	54	9.00%	0	

Sample Count **600**

Taxa Listing

Project ID: WADOE11DSP
RAI No.: WADOE11DSP012

RAI No.: WADOE11DSP012 **Sta. Name:** Salmon Creek at 199th
Client ID: SMN085
Date Coll.: 9/28/2011 **No Jars:** 1 **STORET ID:** WADOE11DSP012

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthes nodosa	4	0.67%	0	
Achnanthidium deflexum	1	0.17%	0	
Achnanthidium minutissimum	241	40.17%	0	
Achnanthidium pyrenaicum	4	0.67%	0	
Achnanthidium rivulare	97	16.17%	0	
Cocconeis placentula	3	0.50%	0	
Cocconeis placentula v. lineata	25	4.17%	0	
Craticula molestiformis	3	0.50%	0	
Cyclotella sp.	3	0.50%	0	
Diadesmis contenta	4	0.67%	0	
Encyonema silesiacum	33	5.50%	0	
Encyonopsis subminuta	5	0.83%	0	
Eolimna minima	3	0.50%	0	
Eunotia sp.	5	0.83%	0	
Fragilaria capucina	3	0.50%	0	
Fragilaria capucina v. gracilis	3	0.50%	0	
Fragilaria vaucheriae	14	2.33%	0	
Frustulia vulgaris	1	0.17%	0	
Gomphonema sp.	74	12.33%	0	
Gomphonema angustatum	3	0.50%	0	
Gomphonema minusculum	1	0.17%	0	
Gomphonema parvulum	1	0.17%	0	
Navicula sp.	1	0.17%	0	
Navicula cryptocephala	5	0.83%	0	
Navicula cryptotenella	3	0.50%	0	
Navicula lanceolata	1	0.17%	0	
Navicula libonensis	4	0.67%	0	
Nitzschia acidoclinata	3	0.50%	0	
Nitzschia amphibia	1	0.17%	0	
Nitzschia capitellata	3	0.50%	0	
Nitzschia dissipata	3	0.50%	0	
Nitzschia frustulum	3	0.50%	0	
Nitzschia linearis	3	0.50%	0	
Nitzschia palea	7	1.17%	0	
Nupela lapidosa	3	0.50%	0	
Planothidium lanceolatum	5	0.83%	0	
Psammothidium chlidanos	1	0.17%	0	
Psammothidium ventralis	3	0.50%	0	
Reimeria sinuata	15	2.50%	0	
Sellaphora pupula	3	0.50%	0	
Sellaphora seminulum	1	0.17%	0	
Stauroneis kriegeri	1	0.17%	0	

Taxa Listing

Project ID: **WADOE11DSP**
RAI No.: **WADOE11DSP012**

RAI No.:	WADOE11DSP012			**Sta. Name:**	Salmon Creek at 199th
Client ID:	SMN085				
Date Coll.:	9/28/2011	**No Jars:**	1	**STORET ID:**	WADOE11DSP012

Taxonomic Name	Count	PRA	Abnorm.	Comment
Sample Count	**600**			

Taxa Listing

Project ID: WADOE11DSP
RAI No.: WADOE11DSP013

RAI No.: WADOE11DSP013 **Sta. Name:** Jones Creek
Client ID: JON010
Date Coll.: 9/28/2011 **No Jars:** 1 **STORET ID:** WADOE11DSP013

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthes nodosa	3	0.50%	0	
Achnanthes oblongella	2	0.33%	0	
Achnanthidium deflexum	1	0.17%	0	
Achnanthidium minutissimum	113	18.83%	0	
Achnanthidium pyrenaicum	3	0.50%	0	
Achnanthidium rivulare	160	26.67%	0	
Cocconeis pediculus	2	0.33%	0	
Cocconeis placentula	11	1.83%	0	
Cocconeis placentula v. lineata	142	23.67%	0	
Cymbella hustedtii	1	0.17%	0	
Diadesmis confervacea	2	0.33%	0	
Diatoma mesodon	6	1.00%	0	
Eolimna minima	6	1.00%	0	
Eunotia sp.	15	2.50%	0	
Eunotia minor	7	1.17%	0	
Fragilaria crotonensis	2	0.33%	0	
Fragilaria vaucheriae	6	1.00%	0	
Gomphonema sp.	22	3.67%	0	
Gomphonema minutum	4	0.67%	0	
Gomphonema parvulum	4	0.67%	0	
Gomphonema pumilum	11	1.83%	0	
Hannaea arcus	2	0.33%	0	
Navicula cryptotenelloides	2	0.33%	0	
Navicula lanceolata	1	0.17%	0	
Nitzschia dissipata	5	0.83%	0	
Nitzschia linearis	2	0.33%	0	
Nupela lapidosa	1	0.17%	0	
Planothidium frequentissimum	3	0.50%	0	
Planothidium lanceolatum	13	2.17%	0	
Psammothidium chlidanos	5	0.83%	0	
Psammothidium subatomoides	1	0.17%	0	
Reimeria sinuata	39	6.50%	0	
Rhoicosphenia abbreviata	1	0.17%	0	
Synedra ulna	2	0.33%	0	

Sample Count **600**

Taxa Listing

Project ID: WADOE11DSP
RAI No.: WADOE11DSP014

RAI No.: WADOE11DSP014 **Sta. Name:** Salmon Creek at 122nd Ave Replicate
Client ID: SMN050-R
Date Coll.: 9/28/2011 **No Jars:** 1 **STORET ID:** WADOE11DSP014

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthes subhudsonis v. kraeuselii	11	1.83%	0	
Achnanthidium deflexum	1	0.17%	0	
Achnanthidium exiguum	2	0.33%	0	
Achnanthidium minutissimum	40	6.67%	0	
Achnanthidium rivulare	95	15.83%	0	
Cocconeis placentula	10	1.67%	0	
Cocconeis placentula v. lineata	206	34.33%	0	
Diploneis oblongella	3	0.50%	0	
Discostella pseudostelligera	2	0.33%	0	
Eolimna minima	4	0.67%	0	
Eunotia implicata	1	0.17%	0	
Eunotia minor	1	0.17%	0	
Eunotia muscicola v. tridentula	2	0.33%	0	
Fragilaria nitzschioides	4	0.67%	0	
Gomphonema sp.	28	4.67%	0	
Gomphonema kobayasii	9	1.50%	0	
Gomphonema minutum	1	0.17%	0	
Gomphonema rhombicum	24	4.00%	0	
Melosira varians	1	0.17%	0	
Navicula sp.	2	0.33%	0	
Navicula cryptocephala	1	0.17%	0	
Navicula cryptotenella	4	0.67%	0	
Navicula cryptotenelloides	3	0.50%	0	
Navicula parabilis	13	2.17%	0	
Navicula radiosafallax	2	0.33%	0	
Navicula trivialis	5	0.83%	0	
Nitzschia angustiforaminata	2	0.33%	0	
Nitzschia dissipata	1	0.17%	0	
Nitzschia inconspicua	5	0.83%	0	
Nitzschia linearis	3	0.50%	0	
Nitzschia radicula	4	0.67%	0	
Parlibellus protracta	1	0.17%	0	
Pinnularia subrostrata	1	0.17%	0	
Planothidium frequentissimum	10	1.67%	0	
Planothidium lanceolatum	5	0.83%	0	
Reimeria sinuata	16	2.67%	0	
Rhoicosphenia abbreviata	73	12.17%	0	
Stauroneis thermicola	3	0.50%	0	
Synedra ulna	1	0.17%	0	
Sample Count	**600**			

Metrics Report

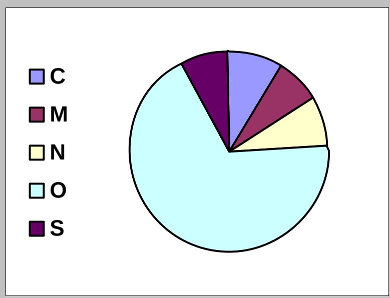
Project ID: WADOE11DSP
Sample ID: WADOE11DSP011
Station Name: Salmon Creek at 122nd
Client ID: SMN050
STORET ID:
Date Collected: 9/28/2011
Count Of Taxon: 34
Sum Of Count: 600

Table 1 Metrics

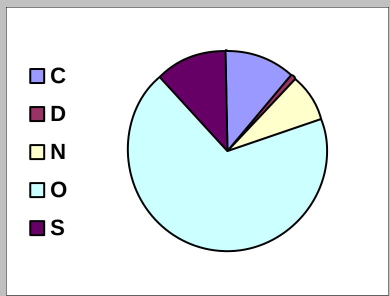
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	2.904	Good	Fair
Species Richness	34	Excellent	Good
Native Taxa Percent	50.50%		
Cosmopolitan Taxa Percent	42.83%		
Mountains Rare Taxa Percent	42.83%		
Plains Rare Taxa Percent	0.83%		
Dominant Taxon Percent	42.83%	Good	Good
Sediment			
Siltation Taxa Percent	5.33%	Excellent	Excellent
Motile Taxa Percent	7.00%		
Mountains Brackish Taxa Percent	44.33%		
Plains Brackish Taxa Percent	1.17%		
Organic Nutrients			
Pollution Index	2.938	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.67%		
Polysaprobous Taxa Percent	2.33%		
Low DO Taxa Percent	0.17%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	40.83%		
Eutraphentic Taxa Percent	35.17%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	3.00%	Excellent	Excellent
Acidophilous Taxa Percent	0.67%		
Metals Tolerant Taxa Percent	0.67%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	11.83%	25.46%
Mountains Metals Increasers Taxa Percent	9.33%	10.38%
Mountains Nutrient Increasers Taxa Percent	10.83%	15.39%
Mountains Sediment Increasers Taxa Percent	10.00%	22.97%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	1.33%	87.49%
Plains General Increasers Taxa Percent	14.67%	9.01%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Fair

Metrics Report

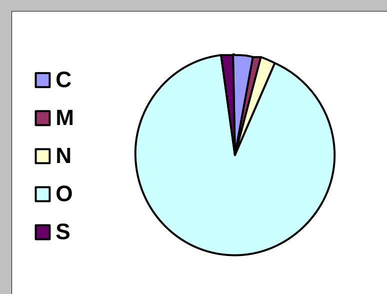
Project ID: WADOE11DSP
Sample ID: WADOE11DSP012
Station Name: Salmon Creek at 199th
Client ID: SMN085
STORET ID:
Date Collected: 9/28/2011
Count Of Taxon: 42
Sum Of Count: 600

Table 1 Metrics

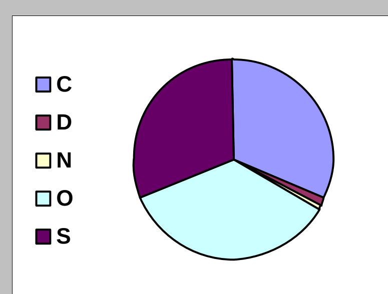
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	3.264	Excellent	Good
Species Richness	41	Excellent	Excellent
Native Taxa Percent	17.17%		
Cosmopolitan Taxa Percent	64.17%		
Mountains Rare Taxa Percent	16.17%		
Plains Rare Taxa Percent	0.17%		
Dominant Taxon Percent	40.17%	Good	Good
Sediment			
Siltation Taxa Percent	8.50%	Excellent	Excellent
Motile Taxa Percent	11.33%		
Mountains Brackish Taxa Percent	65.83%		
Plains Brackish Taxa Percent	1.00%		
Organic Nutrients			
Pollution Index	2.808	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	3.17%		
Polysaprobous Taxa Percent	13.33%		
Low DO Taxa Percent	2.50%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	62.67%		
Eutraphentic Taxa Percent	12.17%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	40.17%	Good	Good
Acidophilous Taxa Percent	1.00%		
Metals Tolerant Taxa Percent	11.67%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	3.83%	14.23%
Mountains Metals Increasers Taxa Percent	1.33%	3.67%
Mountains Nutrient Increasers Taxa Percent	2.17%	5.71%
Mountains Sediment Increasers Taxa Percent	2.17%	10.03%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	1.50%	87.29%
Plains General Increasers Taxa Percent	46.83%	83.15%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Good

Wednesday, March 14, 2012

Metrics Report

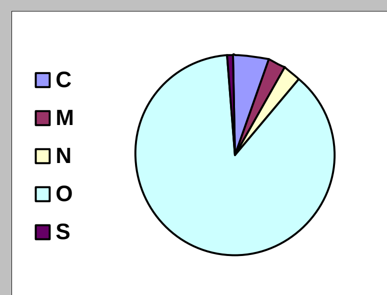
Project ID: WADOE11DSP
Sample ID: WADOE11DSP013
Station Name: Jones Creek
Client ID: JON010
STORET ID:
Date Collected: 9/28/2011
Count Of Taxon: 34
Sum Of Count: 600

Table 1 Metrics

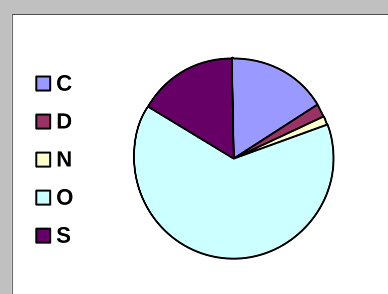
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	3.256	Excellent	Good
Species Richness	33	Excellent	Good
Native Taxa Percent	28.00%		
Cosmopolitan Taxa Percent	61.33%		
Mountains Rare Taxa Percent	26.67%		
Plains Rare Taxa Percent	0.17%		
Dominant Taxon Percent	26.67%	Good	Good
Sediment			
Siltation Taxa Percent	3.00%	Excellent	Excellent
Motile Taxa Percent	9.50%		
Mountains Brackish Taxa Percent	65.17%		
Plains Brackish Taxa Percent	2.33%		
Organic Nutrients			
Pollution Index	2.903	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	2.00%		
Polysaprobous Taxa Percent	6.17%		
Low DO Taxa Percent	1.67%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	59.67%		
Eutraphentic Taxa Percent	32.00%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	18.83%	Excellent	Excellent
Acidophilous Taxa Percent	1.50%		
Metals Tolerant Taxa Percent	5.17%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	6.33%	17.11%
Mountains Metals Increasers Taxa Percent	3.33%	4.85%
Mountains Nutrient Increasers Taxa Percent	3.17%	6.43%
Mountains Sediment Increasers Taxa Percent	1.00%	8.69%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	2.17%	86.43%
Plains General Increasers Taxa Percent	20.50%	17.88%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Good

Metrics Report

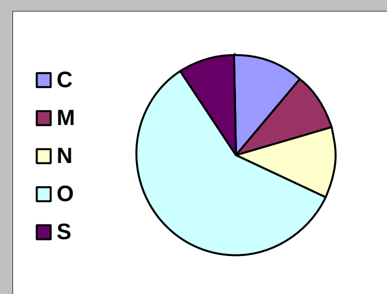
Project ID: WADOE11DSP
Sample ID: WADOE11DSP014
Station Name: Salmon Creek at 122nd
Client ID: SMN050-R
STORET ID:
Date Collected: 9/28/2011
Count Of Taxon: 39
Sum Of Count: 600

Table 1 Metrics

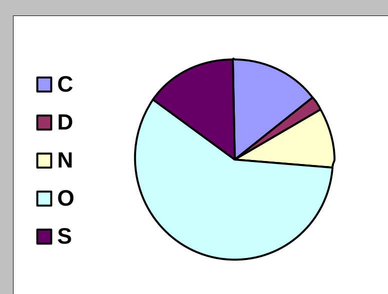
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	3.462	Excellent	Good
Species Richness	39	Excellent	Good
Native Taxa Percent	23.50%		
Cosmopolitan Taxa Percent	65.50%		
Mountains Rare Taxa Percent	15.83%		
Plains Rare Taxa Percent	1.67%		
Dominant Taxon Percent	34.33%	Good	Good
Sediment			
Siltation Taxa Percent	8.33%	Excellent	Excellent
Motile Taxa Percent	12.17%		
Mountains Brackish Taxa Percent	66.17%		
Plains Brackish Taxa Percent	0.17%		
Organic Nutrients			
Pollution Index	2.870	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	1.67%		
Polysaprobous Taxa Percent	5.67%		
Low DO Taxa Percent	0.67%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	63.33%		
Eutraphentic Taxa Percent	52.17%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	6.67%	Excellent	Excellent
Acidophilous Taxa Percent	0.17%		
Metals Tolerant Taxa Percent	1.67%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	17.00%	34.46%
Mountains Metals Increasers Taxa Percent	12.83%	15.39%
Mountains Nutrient Increasers Taxa Percent	15.33%	22.97%
Mountains Sediment Increasers Taxa Percent	13.17%	30.15%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	2.83%	85.54%
Plains General Increasers Taxa Percent	19.83%	16.60%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Good

Wednesday, March 14, 2012

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Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Anthropogenic: Human-caused.

Basin: A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation. Synonymous with the term *watershed*.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Diel: Of, or pertaining to, a 24-hour period.

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

Hydrograph: A graph showing the discharge of a river over a period of time.

Hydrologic: Relating to the scientific study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, and on or below the land surface.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System (NPDES) program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Oxidation-Reduction Potential (ORP) (also known as Redox) is a measurement of the voltage at an inert electrode, reflecting the extent of oxidation of a water sample. The more positive the ORP of a solution, the more oxidized the chemical components of the water (less positive indicates less oxidized, or more reduced).

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Periphyton: A complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces.

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

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Synoptic survey: Data collected simultaneously or over a short period of time.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

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

Water year (WY): October 1 through September 30. For example, WY12 is October 1, 2011 through September 30, 2012.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

Acronyms and Abbreviations

AFDW	Ash-free dry weight
B-IBI	Benthic Index of Biotic Integrity
BMP	Best management practice
CHLa	Chlorophyll *a*
DO	Dissolved oxygen
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology

EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System software
MQO	Measurement quality objective
n	number
ORP	(See Glossary above)
QA	Quality assurance
RM	River mile
SOP	Standard operating procedures
SpCond	Specific conductance
TMDL	(See Glossary above)
TOC	Total organic carbon
TP	Total phosphorus
TPN	Total persulfate nitrogen
WAC	Washington Administrative Code

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
g	gram, a unit of mass
m	meter
mg	milligrams
mg/L	milligrams per liter (parts per million)
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
uS/cm	microSiemens per centimeter