River and Stream Water Quality Monitoring Report

Water Year 2013

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Cover photo: Mike McKay sampling at Trapper Creek.

River and Stream
Water Quality Monitoring Report

Water Year 2013

by

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Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

This is a statewide study.

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Abstract

The Washington State Department of Ecology (Ecology) collected monthly water quality data at 91 stream monitoring stations during Water Year 2013 (October 1, 2012 through September 30, 2013). We also collected 30-minute interval temperature data at 25 stations, mostly from early July through September 2013, and year-round temperature data from 9 of those stations. Finally, we also maintained a continuous oxygen monitoring program at 8 sites.

The principal goals of our ongoing program are to monitor trends in water quality of rivers and streams in Washington State, support a probabilistic monitoring program (Merritt, 2006), and support Clean Water Act Section 303(d) reporting.

This report documents methods and data quality for Water Year 2013. This report includes:

- A continued trend analysis from Hallock (2009a) for nitrogen concentrations and yields for major river systems residing within the Puget Sound region.
- A quality control evaluation of data collection for continuous water quality information using multi-parameter (oxygen, temperature, pH, and conductivity) instruments.

A description of Ecology's long-term monitoring program and access to historical data can be found on Ecology's *River and Stream Water Quality Monitoring* website at www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

Acknowledgements

The success of the Water Year 2013 ambient monitoring program, and the quality of the data, are attributable to the following people:

- Our dedicated monitoring staff spent long hours working in all kinds of weather, traffic, and road conditions. Without this commitment, Appendix D would be much longer. Water Year 2013 samplers (and their lifetime sample counts, since we began keeping track) were: Bill Ward (3944), Casey Clishe (1103), Dan Dugger (824), Howard Christensen (544), Mike Anderson (667), Brain Gallagher (249), Urmos-Berry (89), and Markus Von Prause (83).
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- Joan LeTourneau and Cindy Cook formatted and edited the final report.

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- Nancy Rosenbower and Leon Weiks performed sample coordination services with help from Deborah Clark, Susan Carrell, Rebecca Wood, and Crystal Bowlen.
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- Edlin Limmer, supported by Susan, was responsible for the microbiology.
- Karin Feddersen provided Quality Assurance.
- Meredith Jones and Rebecca, supported by Dean, worked on low-level metals analyses.
- Leon and Dean provided transport services.
- Joel Bird managed the lab and kept everything working smoothly.

Introduction

The Washington State Department of Ecology (Ecology) and its predecessor agency have operated an ambient water quality monitoring program since 1959. Between 1995 and 2010, the basic program consisted of monthly water quality monitoring for conventional parameters at 62 long-term stations and 20 basin (rotating) stations on rivers and streams throughout Washington State. Beginning with Water Year (WY) 2011, we added more long-term stations and reduced the number of basin stations.

Our data are provided free to the public and are widely used by academics, consultants, local governments, schools, and others interested in the quality of Washington's flowing waters.

Within Ecology, data generated by ambient monitoring are used to:

- Determine if waters are meeting standards or are in need of cleanup (e.g., www.ecy.wa.gov/programs/wq/303d/index.html).
- Identify trends in water quality characteristics (e.g., Hallock, 2005).
- Refine and verify Total Maximum Daily Load (TMDL) models.
- Develop water quality-based permit conditions.
- Conduct site-specific evaluations (e.g., Hallock, 2004).
- Determine the effectiveness of TMDL implementation plans.

A generalized assessment of water quality at particular stations is provided online (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html) in the form of a water quality index (WQI; Hallock, 2002). The WQI and trends at long-term stations are reported in *Washington State Water Quality Conditions in 2005 based on Data from the Freshwater Monitoring Unit* (Hallock, 2005).

This report describes the WY 2013 monitoring program and discusses the quality of data collected in WY 2013. More detailed analyses and interpretations of ambient monitoring data are reported elsewhere (e.g., see our reports at www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

Other Ecology programs conduct some of their own analyses. For example, Ecology's Water Quality Program applies its own data reduction procedures prior to producing Washington State's Water Quality Assessment [303(d) & 305(b) Report], which includes the list of waters needing to be cleaned up (www.ecy.wa.gov/programs/wq/303d/index.html).

Goals and Objectives

The primary goals of the River and Stream Ambient Monitoring Program are to monitor trends in the water quality of Washington's rivers and streams, support a companion probabilistic biological monitoring program (Merritt, 2006), and support Clean Water Act Section 303(d) reporting.

Beginning with WY 2011, we modified the objectives for basin stations and added a new station type. See Hallock (2011) for a description of our previous monitoring design; a white paper discussing the redesign of our monitoring objectives is available on request.

- **Long-term station** objectives are unchanged. Stations are monitored every year to track water quality changes over time (trends), assess inter-annual variability, and collect current water quality information. These stations are generally located near the mouths of major rivers, below major population centers, where major streams enter the state, or upstream from most anthropogenic (human-caused) sources of water quality problems.
- **Basin stations** are selected to support the "Water Quality Assessment" process and Clean Water Act (303(d)) listings (http://ecy.wa.gov/programs/wq/303d/index.html). Specific objectives are to:
  - Confirm current Category 5 ("Polluted waters") listings. Some listings are based on old or suspect data. Recent data of known quality will help remove waterbodies from the Category 5 list.
  - Determine a category for currently unlisted waterbodies.
  - Better define current Category 5 listings.
  - Resolve Category 2 ("Waters of concern") listings. Should they be Category 1 ("Meets standards") or Category 5?
  - Identify "high quality" Tier III waters.
- **Sentinel Stations** are "long-term" sites with the following objectives:
  - Support Ecology's probabilistic "watershed health" monitoring program.
  - Characterize reference conditions.
  - Provide trend data for reference conditions.
  - Monitor climate change.
- **Special project station** objectives are unchanged. These stations are typically sampled to address a particular question, and they are usually supported by funding external to the ambient monitoring program. We may not sample these stations for the entire usual suite of parameters, or we may sample extra parameters. Special project stations will not necessarily represent typical water quality conditions.

Monitoring in Water Year 2013

In WY 2013, we monitored 66 long-term, 11 basin, and 7 sentinel stations (84 total). In addition, we monitored 7 stations associated with special projects (with external funding). All of these stations are located in Ecology's Southwest Region. All the special project stations were associated with the Intensively Monitored Watersheds (IMW) project (see www.ecy.wa.gov/programs/eap/imw).

Besides routine grab-sample monitoring, we conducted the following activities:

- Collected 30-minute interval temperature data from about July through September 2013 at 25 long-term and basin stations (9 of the stations were year-round).
- Conducted every other month (bi-monthly) metals monitoring at 9 selected stations.
- Conducted continuous monitoring for temperature, dissolved oxygen, pH, and conductivity at 8 stations, including 6 stations in support of IMW work. Results were delivered in near-real-time to the Internet by satellite telemetry at all stations.

Methods

Sampling Network

The ambient monitoring network in WY 2013 consisted of monthly water collection at all stations.

Ambient stations monitored during WY 2013 are listed in Table 1. Appendix A lists current and historical monitoring locations and the years they were monitored by Ecology and its predecessor agency.

A description of our long-term monitoring program, access to most historical data, and previous annual reports can be found on Ecology's Internet website at www.ecy.wa.gov under the "Environmental Assessment" program and "River and Stream Water Quality."

Table 1. Ecology stream ambient monitoring stations, Water Year 2013.
Also see Appendix A.

Key	Station	Location	Status[a]	Key	Station	Location	Status[a]
1	01A050	Nooksack R @ Brennan	C	48	34A070	Palouse R @ Hooper	C
2	01A120	Nooksack R @ No Cedarville	C	49	34A170	Palouse R @ Palouse	C
3	03A060	Skagit R nr Mount Vernon	C	50	34B110	SF Palouse R @ Pullman	C
4	03B050	Samish R nr Burlington	C	51	35A150	Snake R @ Interstate Br	C
5	04A100	Skagit R @ Marblemount	C	52	35B060	Tucannon R @ Powers	C
6	05A065	N Slough Stillaguamish @ Pioneer Hwy	B	53	35D070	Asotin Cr @ 2nd Street	B
7	05A070	Stillaguamish R nr Silvana	C	54	35D120	NF Asotin Cr blw Lick Cr	S
8	05A090	SF Stillaguamish R @ Arlington	C	55	36A070	Columbia R nr Vernita	C
9	05A110	SF Stillaguamish R nr Granite Falls	C	56	37A090	Yakima R @ Kiona	C
10	05B070	NF Stillaguamish R @ Cicero	C	57	37A205	Yakima R @ Nob Hill	C
11	05B110	NF Stillaguamish R nr Darrington	C	58	37E070	Wide Hollow Cr @ Union Gap	B
12	07A090	Snohomish R @ Snohomish	C	59	37E100	Wide Hollow Cr @ 40th Ave	B
13	07C070	Skykomish R @ Monroe	C	60	38A050	Naches R @ Yakima on US HWY 97	C
14	07D050	Snoqualmie R nr Monroe	C	61	39A055	Yakima R @ Umtanum Cr Footbridge	C
15	07D130	Snoqualmie R @ Snoqualmie	C	62	39A090	Yakima R nr Cle Elum	C
16	08C070	Cedar R @ Logan St/Renton	C	63	39F050	Wenas Cr nr Selah	B
17	08C110	Cedar R nr Landsburg	C	64	39K060	Reecer Cr in Irene Rinehart Park	B
18	09A080	Green R @ Tukwila	C	65	39R050	Umtanum Cr nr mouth	S
19	09A190	Green R @ Kanaskat	C	66	41A070	Crab Cr nr Beverly	C
20	10A070	Puyallup R @ Meridian St	C	67	41E070	Sand Hollow Cr on Hwy 26	B
21	11A070	Nisqually R @ Nisqually	C	68	45A070	Wenatchee R @ Wenatchee	C
22	13A060	Deschutes R @ E St Bridge	C	69	45A110	Wenatchee R nr Leavenworth	C
23	14D070	Sherwood Cr abv mouth	B	70	46A070	Entiat R nr Entiat	C
24	16A070	Skokomish R nr Potlatch	C	71	48A075	Methow R nr Pateros @ Metal Br	C
25	16B130	Hamma Hamma R @ Lena Creek Camp	S	72	48A140	Methow R @ Twisp	C
26	16C090	Duckabush R nr Brinnon	C	73	48E070	Poorman Creek at Poorman Cutoff Rd	S
27	18B070	Elwha R nr Port Angeles	C	74	49A070	Okanogan R @ Malott	C
28	19C060	West Twin R nr mouth	P	75	49A190	Okanogan R @ Oroville	C
29	19D070	East Twin R nr Mouth	P	76	49B070	Similkameen R @ Oroville	C
30	19E060	Deep Cr nr mouth	P	77	53A070	Columbia R @ Grand Coulee	C
31	20B070	Hoh R @ DNR Campground	C	78	54A090	Spokane R @ Ninemile Br	P
32	20E100	Twin Cr @ Upper Hoh Rd Br	S	79	54A120	Spokane R @ Riverside State Pk	C
33	22A070	Humptulips R nr Humptulips	C	80	55B070	Little Spokane R nr Mouth	C
34	23A070	Chehalis R @ Porter	C	81	56A070	Hangman Cr @ Mouth	C
35	23A160	Chehalis R @ Dryad	C	82	57A150	Spokane R @ Stateline Br	C
36	24B090	Willapa R nr Willapa	C	83	59A080	Colville R @ Greenwood Loop Rd	C
37	24F070	Naselle R nr Naselle	C	84	59B200	Little Pend Oreille R nr NatWildRef	S
38	25D050	Germany Cr @ mouth	P	85	59D070	Hunters Creek at Hunters Inn	B
39	25E060	Abernathy Cr nr mouth	P	86	60A070	Kettle R nr Barstow	C
40	25F060	Mill Cr nr mouth	P	87	61A070	Columbia R @ Northport	C
41	26B070	Cowlitz R @ Kelso	C	88	61E070	Meadow Creek at Aladdin Rd	B
42	26G050	Lacamas Cr @ SR506	B	89	62A090	Pend Oreille R @ Metaline Falls	C
43	27B070	Kalama R nr Kalama	C	90	62A150	Pend Oreille R @ Newport	C
44	27D090	EF Lewis R nr Dollar Corner	C	91	62C070	NF Sullivan Creek	S
45	31A070	Columbia R @ Umatilla	C				
46	32A070	Walla Walla R nr Touchet	C				
47	33A050	Snake R nr Pasco	C				

[a] C = long-term; S = Sentinel; B = basin; P = Special Project (Intensively Monitored Watersheds).

Sample Collection and Analysis

We collected water samples from the majority of stations as single, near-surface grab samples from highway bridges. We sampled a small subset of stations from the bank, off of culverts, and from other locations. Sampling locations are identified on our website.

We monitored monthly for 12 standard water quality parameters at all stations (Table 2).

Table 2. Water quality parameters monitored, Water Year 2013.
*Standard parameters collected at all stations are in **bold**.*

Parameter	Method	Typical Reporting Limit
Ammonia, total	SM 4500 NH3H	0.01 mg/L
Carbon, dissolved organic	SM 5310 B	1 mg/L
Carbon, total organic	SM 5310 B	1 mg/L
Chlorophyll	SM 10200H3	0.1 ug/L
Conductivity	SM 2510 B	NA
Fecal coliform bacteria	SM 9222 D	1 colony/100 mL
Hardness	SM 2340 B	Not specified
Metals: mercury	EPA 245.7	0.002 ug/L
Metals: other	EPA 200.8	various
Nitrate + nitrite-nitrogen, total	SM 4500 NO3I	0.01 mg/L
Nitrogen, total	SM 4500 NB	0.025 mg/L
Nitrogen, total (dissolved)	SM 4500 NB	0.025 mg/L
Oxygen, dissolved	SM 4500 OC	NA
pH	SM 4500 H+	NA
Phosphorus, soluble reactive	SM 4500 PG	0.003 mg/L
Phosphorus, total	SM 4500 PH	0.005 mg/L
Suspended solids, total	SM 2540 D	1 mg/L
Suspended sediment	ASTMD3977B	1 mg/L
Temperature	SM 2550 B	NA
Turbidity	SM 2130	0.5 NTU

SM: APHA 2005.
EPA: U.S. Environmental Protection Agency, 1983.

Besides the 12 water quality parameters, we also recorded barometric pressure (to calculate percent oxygen saturation) and stream stage measurements, where necessary, to enable streamflow determination for most long-term stations and some basin stations. We collected metals samples bi-monthly at 12 stations and measured additional parameters, such as total organic carbon and chlorophyll, by request at selected stations.

Sample collection and analytical methods are described in our standard operating procedures (SOPs; Ward, 2007; Ward, 2011), ambient monitoring quality assurance (QA) documents (Hallock and Ehinger, 2003; Hallock, 2012a; and Hopkins, 1996), and Manchester Environmental Laboratory's *Lab Users Manual* (MEL, 2008). Further, to ensure sampler consistency, we use a new staff training program, do annual staff training, and conduct annual staff method audits ("ride-alongs").

Program Changes

All long-term monitoring programs experience changes in sampling or analytical procedures that can potentially affect results. Normally, these changes are implemented to improve precision or reduce bias. Most changes will have only a minor effect on a synoptic analysis of the data, but even minor improvements in procedures should be considered when evaluating long-term trends.

In WY 2013, we made no changes to collection, analytical, or quality control (QC) procedures that we believe will materially affect trends. However, we examined the following topics and made some minor modifications:

- We reviewed the overall data quality of continuous water quality data obtained during WY 2013. The objective of this review was to examine the proficiency and accuracy of QA procedures used when comparing discrete and continuous sample data for standard water quality parameters (i.e., conductivity, dissolved oxygen, pH, and temperature). Evaluation of the sources that contribute to error and bias between continuous and discrete sample results were also evaluated.

All known and suspected changes to methods and procedures during the history of the stream monitoring program, as well as large-scale environmental changes that may affect a trend analysis, are documented in Appendix B.

Continuous Multiple Parameter Monitoring Quality Assurance Review

The river and stream monitoring program has been collecting continuous water quality information since 2009. Methods and QA protocols for continuous monitoring are defined in Hallock (2009b). There are usually 35,000+ measurements obtained for each water quality parameter at one site during the course of an entire water year. Site selection for continuous monitoring at long-term and basin stations involve an annual scoping process (March-July) to evaluate the need for continuous monitoring. This is based of criteria defined in the primary goals of the River and Stream Ambient Monitoring Program objectives to support a companion probabilistic biological monitoring program (Merritt, 2006) and the Clean Water Act Section 303(d) reporting.

In WY 2013, a total (n) of 707,320 water quality data points were obtained from all monitoring sites. A total of 694,718 (98%) water quality data points were obtained and reported as quantifiable measurements. However, 12,601 data points were unobtainable due to various factors (i.e., sensor failure resulting from physical variations in the stream channel). These estimates are based on initial continuous data returns via telemetry.

Inaccuracies in the continuous data are reviewed annually as part of the water year QA review. All procedures associated with QC of continuous and discrete samples are described in Hallock and

Ehinger (2003) and Hallock (2009b). If discrete samples and post-deployment calibrations indicate an offset or a linear drift, continuous data may be adjusted as necessary prior to evaluating against data quality objectives. Data adjustments are primarily based on the differences between continuous and discrete grab samples, while the relative standard deviation between continuous measurements and checks must be < 10% to pass QA criteria (Hallock, 2009b). Coefficients used for the continuous data adjustments are provided in the Multiple Parameters Monitoring section of the water year annual reports.

Those who use continuous water quality information obtained from the river and stream monitoring program should be aware that there is a certain degree of error regarding data quality even after data adjustments are applied. Accurate water quality measurements can often be biased by many types of environmental factors (sedimentation/leaf letter deposition, bio-fouling), sensor calibration, or drift and field collection methods. The representativeness of the data is often determined by comparing continuous measurements.

Inferring representative data accuracy derived from comparing continuous measurements and discrete samples are problematic because of:

- Small sample sizes (n) of discrete measurements are not adequate for comparisons to large sample sizes of continuous measurements for each parameter during a complete water year. One discrete sample is not a representative size to compare against 2974 continuous temperature, pH, conductivity, and dissolved oxygen measurements during a 30-day period. Furthermore, the variability dissolved oxygen measurements will vary by 1 mg/L during a 24-hour diurnal period for many of the sites surveyed.
- There are technological differences in manufacturers' specifications between sensors used for continuous monitoring and field meters used for obtaining validation measurements.

Due to the volume of continuous water quality information obtained each year, the QC review can be time-consuming and requires specific evaluation procedures and criteria for different parameters. Furthermore, a thorough QC review requires many dedicated staff and additional resources to ensure the water quality data are accurately assessed and qualified with a certain degree of confidence before the data are made available to public entities to use for various purposes (i.e., baseline river/stream and watershed health monitoring, water quality modeling, effectiveness monitoring, and public outreach).

Applying data adjustments may introduce some new bias to the overall data distribution during a deployment period. Furthermore, such a bias may also cause an un-representative estimate of water quality undergoing variations of natural processes within the stream channel (i.e., daily and seasonal diurnal variations).

Based on the initial QA review during WY 2013, the following program improvements were implemented:

- Data adjustments for continuous data will no longer be applied within Ecology's Freshwater Monitoring Unit databases containing continuous monitoring information.

- Correction coefficients will continue to be provided as supplementary information within the monitoring section of the water year annual reports.
- Coefficients will be provided as supplementary information to “adjust” or “non adjust” continuous data based on the end users discretion.

Based on initial findings from the WY 2012 and WY 2013 annual review of continuous and discrete water quality results, the following improvements will be applied during the course of WY 2014:

- New follow-up examination of site maintenance procedures at continuous monitoring sites will be implemented. The purpose of this follow-up review is to minimize the potential for unreliable data to be embedded in the data set due to biofouling and calibration drift. This review will help address and track any reasons for data consistency issues from when the continuous datasondes (Hydrolabs) are cleaned and maintained.
- A tiered cleaning and maintenance system will be implemented. Under this new system, when Level 1 cleaning is completed, it will be the same as any other Level 1 cleaning at all continuous monitoring sites.
- Corrective action procedures will be proposed and evaluated in the field. A proposed corrective action may entail: if after the cleaning, the sonde readings fall outside a specified range, the sonde will be reported to field staff for a follow-up maintenance visit. A second more in-depth cleaning will be performed; if the sonde is reading within an acceptable range, it will be redeployed. If the sonde cannot be brought within the specified range, it will be removed and replaced with a lab calibrated sonde. This change will also include the addition of new field forms to document the process.
- New forms will be developed to track the equipment number used for each site, including calibration dates and calibration checks that have been done on the equipment. While a similar process has been in place in the past, the forms, data collection, and calibration checks will be refined to allow for easier tracking and consistency of data collected.
- The previous annual review of our continuous data records shows that dissolved oxygen measurement accuracy has been a little problematic parameter. Calibration methods and standards for the hand held-LDO electrodes will be refined during the course of WY 2014.

Continuous Temperature Monitoring

This program’s goal is to collect summer, diel (24-hour) temperature data with 30-minute monitoring intervals at most long-term and current basin ambient monitoring stations, as well as at some special request stations. The data are primarily used for trend analyses and to determine the stream’s compliance with Washington State water quality standards.
The scope of this program has been incrementally expanded, as resources and locations allow, with the establishment of more year-round temperature (and in some instances, seasonal oxygen) monitoring stations.

We try to deploy the loggers that collect summer data by early July and retrieve them in late September. We also try to swap out the loggers at our year-round stations following a similar (June-September) schedule.

We typically deploy two Onset StowAway TidbiT® temperature loggers at each site, one in water and one in air. All deployed loggers are shaded with a PVC pipe and installed in a location considered representative of the surrounding environment. We usually install stream temperature loggers about 6 inches off the stream bottom to minimize potential influence from groundwater inflow. Loggers are placed in a free-flowing location at a depth to avoid exposure to air resulting from low streamflows.

As of WY 2012, all deployed loggers are set to *standard time*. Previously, we deployed loggers primarily during daylight savings time, and we used local time because it matched field sample times. However, we found that the new loggers would not follow local time; this caused year-round deployment sample time issues (local time has twice-yearly time shifts). In addition, we adjusted all our historical logger data sample times to *standard time*.

Detailed protocols are found in Ward (2011), and QC requirements are found in Ward (2005).

Continuous Oxygen Monitoring

As with temperature, oxygen concentration changes in a sinusoidal pattern over a 24-hour period. Oxygen concentration is typically lowest in the morning and highest in the late afternoon. Usually daily lows are of the most interest because they have the most impact on aquatic life. Due to sampling logistics and laboratory sample holding time issues, our grab-sample monitoring program typically does a poor job of capturing daily low oxygen concentrations.

To measure daily low oxygen concentrations, we need to collect diel oxygen data. We are primarily interested in annual lows (usually occurring in mid to late summer), but we are also interested in concentrations that coincide with the beginning and ending of salmonid spawning seasons, which vary according to location.

In WY 2013, we deployed Hydrolab® Minisondes with optical oxygen sensors (LDOs) or In Situ® optical oxygen sensors (RDOs) at 8 stations, 6 in support of the IMW project and 2 to supplement grab sample monitoring (Table 3). All instruments were connected to near real-time telemetry stations. All instruments recorded temperature, oxygen, and conductivity readings every 15 minutes. One instrument also recorded pH at Cedar River near Landsburg (08C110).

Our methods are described in Hallock (2009b**).** We hope to expand this program in the future; however, we have no dedicated funding and are dependent on available resources.

Table 3. Stations monitored for continuous oxygen, in Water Year 2013.

Station	Name	Objective
08C110	Cedar River near Landsburg	Long-term; reference conditions
19C060	West Twin River near mouth	Support IMW project
19D070	East Twin River near mouth	Support IMW project
19E060	Deep Creek near mouth	Support IMW project
25D050	Germany Creek at mouth	Support IMW project
25E060	Abernathy Creek near mouth	Support IMW project
25F060	Mill Creek near mouth	Support IMW project
41A070	Crab Creek near Beverly	Oxygen is Category 2 (pH is 5)

IMW: Intensively Monitored Watersheds

Metals Monitoring

Metals monitoring continued in WY 2013 at 10 stations (Table 4). Metals samples were collected every other month beginning in October 2012.

Table 4. Bi-monthly sampling stations for metals, Water Year 2013.

Station	Name
01A120	Nooksack R @ No Cedarville
26G050	Lacamas Cr @ SR506
10A070	Puyallup R @ Meridian St
39A055	Yakima R @ Umtanum Cr Footbridge
34A170	Palouse R @ Palouse
41E070	Sand Hollow Cr on Hwy 26
49B070	Similkameen R @ Oroville
59D070	Hunters Creek at Hunters Inn
59A080	Colville R abv Kettle Falls
57A150	Spokane R @ Stateline Br

Samples were analyzed for hardness, and total mercury, as well as total and dissolved arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc, except at Nooksack at North Cedarville and at Puyallup at Meridian Street, which were analyzed only for total mercury.

Collection procedures and analytical methods are discussed in more detail in Ward (2007) and Hopkins (1996).

Our current objectives for metals monitoring are as follows:

- Continue trend monitoring in the Spokane River at Stateline Bridge.
- Assess metals at the few remaining long-term stations where we have never collected metals data.
- Assess metals at basin stations in developed areas or in areas with a history of mining in the watershed.
- Assess for mercury in the Puyallup and Nooksack Rivers, which receive glacial melt water.

Nitrogen in Puget Sound Area Rivers

Nitrogen is the nutrient most typically limiting to algal growth in marine systems. Increased nitrogen concentrations in Puget Sound can lead to increased algal growth. This report includes a trend analysis of major Puget Sound area river systems for total nitrogen (TN) and nitrate + nitrite-nitrogen (NO2+NO3). Discrete data for this analysis were obtained from Ecology's River and Stream Monitoring Program. Trends for ammonia are not included because at most stations we detected ammonia in less than 50% of the samples.

This trend analysis for TN and NO2+NO3 is a continuation of the trend analysis presented in the WY 2008 Annual Report (Hallock, 2009a). The methodologies and sites used for evaluating trends were similar in order to ensure a uniformed comparison of results from two separate time periods. This analysis has evaluated trends from 24 long-term stations in Puget Sound (Table 5). Eleven of these stations are upstream sites. Identified trends at the downstream stations are most directly related to effects on the marine environment.

Table 5. Long-term ambient monitoring stations in Puget Sound.
** in the downstream (D/S) column indicates stations that are nearest Puget Sound.*

D/S	Station	Station Name		D/S	Station	Station Name
*	01A050	Nooksack R @ Brennan			07D050	Snoqualmie R nr Monroe
	01A120	Nooksack R @ No Cedarville			07D130	Snoqualmie R @ Snoqualmie
*	03A060	Skagit R nr Mount Vernon		*	08C070	Cedar R @ Logan St/Renton
*	03B050	Samish R nr Burlington			08C110	Cedar R nr Landsburg
	04A100	Skagit R @ Marblemount		*	09A080	Green R @ Tukwila
*	05A070	Stillaguamish R nr Silvana			09A190	Green R @ Kanaskat
	05A090	SF Stillaguamish @ Arlington		*	10A070	Puyallup R @ Meridian St
	05A110	SF Stillaguamish nr Granite Falls		*	11A070	Nisqually R @ Nisqually
	05B070	NF Stillaguamish @ Cicero		*	13A060	Deschutes R @ E St Bridge
	05B110	NF Stillaguamish nr Darrington		*	16A070	Skokomish R nr Potlatch
*	07A090	Snohomish R @ Snohomish		*	16C090	Duckabush R nr Brinnon
	07C070	Skykomish R @ Monroe		*	18B070	Elwha R nr Port Angeles

The date range used in this analysis was WY 1995-2013. This includes seven (n) additional years to the date range presented in Hallock (2009a) (i.e., WY 1995-2008). TN and NO2+NO3 data were collected through September 2013. Hallock (2009a) also conducted a second NO2+NO3 analysis beginning in WY 1988. However, I used only TN and NO2+NO3 from WY 1995-2008 for comparison. For trends in flow, data were evaluated form WY 1995-2008. Note that flow-adjusted trends may not be fully comparable to the baseline trend. Annual trends were analyzed for all months according to water year (October –September) and for the summer growing season (July through September).

WQHydro (Aroner, 2008) was used for all standard statistical analyses. A seasonal Kendall test (Aroner, 2008; Sokal and Rohlf, 1995) was used for trend analysis. To maintain consistency with the Hallock (2009a) in overall multiple station trend analysis, the significance level (alpha value) for the seasonal Kendall tests was $p < .10$. However, for individual station trends, the significance level (alpha value) for the seasonal Kendall tests was $p < 0.05$. The data were flow-adjusted by conducting a hyperbolic regression for each station in the form of:

$$TN \text{ (or NO2+NO3)} = a + b1 * (1/(1+b2*Flow))$$

where a, b1, and b2 are empirically-determined coefficients. The residuals were analyzed for the regression for trends.

Instantaneous flux was determined by:

Monthly flux (kg/sq. km/month) = (conc (mg/L) * flow (cfs)* 73.3973 (unit conversion factor) / watershed area (sq. km))

Yield was determined by dividing the flux by the watershed area in square kilometers. Note that this procedure should not be confused with standard load analyses that are applied in TMDL related studies. The scope of this analysis reflects baseline trend results and comparative yields, not the actual yields at particular stations.

Differences in average summer (July through September) NO2+NO3 yields (kg/sq. km/month) at long-term Puget Sound stations between the date ranges of 1995-2008 and 1995-2013 were also examined. The rationale behind this approach was to compare differences and evaluate the overall mean difference for all sites combined between date ranges. Furthermore, it assisted with the identification of specific patterns/rates of change between sites for summer NO2+NO3 yields from 2008-2013.

Important issues to consider when evaluating the reported trends:

- The sampling network was not stable until WY 1995; NO2+NO3 trend analyses at different stations prior to that date may not be comparable, since different years may be included.
- Results are derived from a discrete grab sampling monitoring design which does not capture peak flow events and 24-hour diurnal patters for nutrient uptake. A continuous monitoring design may address these issues; however, results may not be comparable for each respective site depending on the extent of the continuous monitoring network.
- Grab samples are typically less representative than horizontally and vertically integrated samples.

- We do not specifically target collection of stormwater data, so nutrient concentrations related to runoff and flushing effects have a high probability of being missed.

However, the last two points are generally more problematic with sediment-associated parameters such as total phosphorus than with TN or NO2+NO3 (see Hallock, 2005b).

Quality Assurance

The Freshwater Ambient Monitoring QA program can be broken out into two primary focus areas: (1) those that involve laboratory analysis of the samples and (2) those concerning the collection and processing of the water samples in the field.

Ecology's Manchester Environmental Laboratory QA program includes the use of QC charts, check standards, in-house matrix spikes, laboratory blanks, and performance evaluation samples. For a more complete discussion of laboratory QA, see Manchester Laboratory's *Quality Assurance Manual* (MEL, 2012) and *Lab Users Manual* (MEL, 2008).

The QA program for field sampling consisted of three parts:

1. Adherence to standard operating procedures for sample/data collection and periodic evaluation of sampling personnel.
2. Consistent instrument calibration methods and schedules.
3. Collection of field QC samples during each sampling run.

Our QA program is described in detail in Hallock and Ehinger (2003) and Hallock (2012).

Three types of field QC samples were collected:

1. *Duplicate (Sequential) Field Samples.* These consisted of an additional sample collection made approximately 15-20 minutes after the initial collection at a station. These samples represent the total variability due to short-term, instream dynamics; sample collection and processing; and laboratory analysis.
2. *Duplicate (Split) Field Samples.* These consisted of one sample (usually the duplicate sequential sample) split into two containers that are processed as individual samples. We do this to eliminate instream and sample collection variability so we can assess the remaining variability attributable to field processing and laboratory analysis.
3. *Field Blank Samples.* These consisted of the submission and analysis of de-ionized water and are true field process blanks. The blank de-ionized water was poured into cleaned sample collection equipment, and the sampler simulated collecting a water sample, including lowering the sampling device to the water surface. The expected value for each analysis is the reporting limit for that analysis. Significantly higher results would indicate that sample contamination had occurred during field processing or during laboratory analysis.

We submit QC samples semi-blind to the laboratory. Samples are identified as QC samples, but sample type (duplicate, split, or blank) and station are not identified.

In WY 2013, we processed 117 field QC samples for standard parameters: 12 field blanks, 54 field duplicates (sequential), and 51 field split samples. In addition, the laboratory conducted its own splits of some field QC samples. The central tendency of the variance of pairs of split field samples was summarized by calculating the square root of the mean of the sample-pair variances (root-mean-square; RMS). These figures provide an unbiased and higher estimate than other commonly used statistics (e.g., mean or median of the standard deviations).

We use a two-tiered system to evaluate data quality of individual results based on field QC. The first tier consists of four automated checks: holding time, variability in field duplicates, reasonableness of the result, and the balance of nutrient species. Results exceeding pre-set limits are flagged. The second tier consists of a manual review of the data flagged in the first tier. Data are then coded from 1 through 9 (1 = data meet all QC requirements, 9 = data are unusable). Criteria for assigning codes are discussed in more detail in Hallock and Ehinger (2003). We do not routinely use or distribute data with quality codes greater than 4.

Finally, data management includes verification at several stages:

- We verify field data entry quarterly by comparing field data forms to printouts from the database.
- At the end of the WY, we electronically compare data in Ecology's EIM database, and in the database used for our web presentation, to the primary database.
- We visually check plots of streamflow versus stage height for anomalies. For flows determined independent of stage records, this method confirms the flow. (Most flows are derived from continuous recorders and based on date and time, not stage.) For flows based on stage, this method confirms that the flow was correctly determined from the flow curve, but the method cannot ensure that stage was correctly recorded.

Continuous Temperature Monitoring

The quality of the continuous temperature data was assessed by calibration checks using a certified reference thermometer before and after deployment. If a pre-survey calibration check indicated that a logger's accuracy was not within the required limits (0.2 °C) when compared to a certified reference thermometer, the logger was rejected and not deployed (Ward, 2005).

If a logger failed a post-survey calibration check, the results may be rejected or we may adjust results if the change in bias between pre- and post-deployment calibration checks was <0.05 ºC (i.e., the pre-deployment bias was just within the required limits and the post-deployment bias was just outside the limits).

All data sets are graphically reviewed to identify and delete anomalies. In addition, the river and stream monitoring database initiates automated QC checks and compares the data to the field temperature measurements taken at deployment and retrieval with a calibrated checked alcohol thermometer or thermistor. We also have the database assess the differences between the continuous results recorded by the logger and monthly results collected during grab-sample monitoring surveys.

We upload all finalized results and summaries into our database, our webpage, and Ecology's EIM database.

Continuous Multiple Parameter Monitoring

We used Hallock (2009b) to assess the quality of data collected by multi-parameter probes. In most cases, we compared grab sample results to continuous results determined by linear interpolation between the recorded results preceding and following the grab sample time. All times were first adjusted to Pacific Standard Time. We performed the following QC checks:

- Examination of a plot of continuous data overlaid with grab sample data for signs of outliers (caused, for example, by signal noise) in the continuous data, or drift in the continuous data compared to the grab data.
- Calculation of the mean difference between continuous and grab sample results. If >2%, continuous results were adjusted for offset and drift, where such adjustment was appropriate as indicated by a plot of the data. This adjustment was made prior to conducting additional QC evaluations.
- Comparison of the average relative standard deviation (RSD) of continuous and grab sample data pairs to the precision requirements in Hallock (2009b).
- Comparison of individual differences between continuous and grab sample results to the accuracy requirements in Hallock (2009b).

Results and Discussion

The primary purpose of this report is to present the results of Ecology's stream monitoring in WY 2013. The main body of the report describes the sampling program and interprets QC results. Appendix C describes where our monitoring data can be found.

Raw data are available in computer formats on request and are posted on Ecology's web pages (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html). Unpublished data are also available online but are considered "preliminary."

Monthly Ambient Monitoring

A station-by-station data analysis is not within the scope of this report. Individual results not meeting the 2006 water quality criteria in Washington's Water Quality Standards (WAC Chapter 173-201A), excluding un-ionized ammonia (NH_3), are identified in reports on our website: www.ecy.wa.gov/apps/watersheds/riv/exceed. Un-ionized ammonia criteria are complicated to determine. Furthermore, the criteria are rarely exceeded (not met) in ambient waters. However, during the summer months some violations are likely to occur, resulting from seasonal variations in temperature and pH.

In WY 2013, no samples exceeded the chronic results for the un-ionized ammonia criteria (i.e., $NH_3 > NH_{4+}$). Concentrations of un-ionized ammonia were greater than 15% of the chronic criterion at two stations: Palouse River @ Hooper (34A070**;** 21% of criterion) and Hangman Creek @ Mouth (56A070; 18% of criterion). Un-ionized ammonia results equal to or greater than 10% of the criteria are listed in Table 6.

Effective December 20, 2006, Ecology adopted an aquatic life system for classifying the state's waterbodies, dropping the AA, A, B, and C system in the 1997 standards (Ecology, 2006). Some of the numeric criteria from the new 2006 water quality standards are listed in Tables 7 and 8. The Ecology ambient monitoring program's comparison of results to water quality criteria on our web pages is not a formal determination of water quality *violations*. Determining violations requires additional considerations such as human impact or multiple results not meeting a criterion, and in some cases continuous data are desired.
(See www.ecy.wa.gov/programs/wq/303d//policy1-11Rev.html.)

Of the nearly 13,000 possible standard water quality results in WY 2013, we missed only 115. A total of 14 missed samples were due to scheduling problems or delays that resulted in a station being dropped. Weather-related causes, such as the station being frozen or inaccessible due to snow, resulted in 26 missed samples. Other reasons for missed results included road construction or other access problems (45), and equipment failure (1). Finally, 18 results were missed due to miscellaneous reasons Appendix D gives more detailed explanations for each missed result.

Table 6. Results for un-ionized ammonia ranging from 10-15% and greater than 15% of the chronic criteria, Water Year 2013.

Station	Name	Date/ Time	Un-ionized ammonia 10-15% ^	Un-ionized ammonia >15% ^
34A070	Palouse R @ Hooper	6/11/2013 3:10:00 PM	12%	
34A070	Palouse R @ Hooper	7/16/2013 2:33:00 PM		21%
34A070	Palouse R @ Hooper	8/13/2013 9:35:00 AM	10%	
37A090	Yakima R @ Kiona	7/15/2013 3:21:00 PM	11%	
37A090	Yakima R @ Kiona	8/12/2013	11%	
41A070	Crab Cr nr Beverly	7/17/2013 2:05:00 PM	11%	
56A070	Hangman Cr @ Mouth	7/10/2013 5:22:00 PM	15%	
56A070	Hangman Cr @ Mouth	8/7/2013 5:46:00 PM		18%

Table 7. Water quality criteria in the 2006 water quality standards associated with aquatic life uses.[a] *Results outside these ranges do not meet the criterion.*

Aquatic Life Use	Temperature (7-DADMax)[b] (°C)	Oxygen (1-day minimum) (mg/L)	pH (standard units)
Char spawning	<=9		
Char spawning and rearing	<=12	>9.5	6.5<=pH<=8.5
Salmon and trout spawning[c]	<=13		
Core summer salmonid habitat	<=16	>9.5	6.5<=pH<=8.5
Salmonid spawning rearing and migration	<=17.5	>8.0	6.5<=pH<=8.5
Salmonid rearing and migration only	<=17.5	>6.5	6.5<=pH<=8.5
Non-anadromous interior redband trout	<=18	>8.0	6.5<=pH<=8.5
Indigenous warm-water species	<=20	>6.5	6.5<=pH<=8.5

[a] WAC 173-201A-602 (Ecology, 2006) identifies use designations for waterbodies and some exceptions to the standard criteria listed above. Metals criteria, most of which are a function of hardness, are not listed here.
[b] 7-DADMax = 7-day average of the daily maximum temperature.
[c] An additional temperature criterion applies during specified seasons for some waterbodies (Payne, 2006).

Table 8. Water quality criteria in the 2006 water quality standards associated with contact recreation.[a]

Results outside these ranges do not meet the criterion.

Recreation Use	Fecal Coliform Bacteria (cfu/100 mL)	
	10%	Geometric Mean
Extraordinary primary contact recreation	<=100	<=50
Primary contact recreation	<=200	<=100
Secondary contact recreation	<=400	<=200

[a] WAC 173-201A-602 (Ecology, 2006) identifies use designations for waterbodies.

Flows were not available for 9 of 12 basin stations (Table 9). However, 4 alternative flow sources were used from USGS gages in the nearest proximity (Table 9) to create flow rating curves for Lacamas Creek SR 506 (26G050), Asotin Cr @ 2nd St (35D070), Reecer Cr in Irene Rinehart Park (39K060), and Hunters Creek at Hunters Inn (59D070).

In addition, 146 out of 1055 flow results were not available at various times and stations due to non-existing USGS flow information, ice, equipment failure, failure of the sampler to record stage, or unknown reasons. We identified all flows from 12 stations as “estimated” because rating curves were out of date or imprecise, mean daily flow (rather than instantaneous) was used, or of other reasons. Furthermore, estimated flow was derived from theoretical stage heights from USGS gage site (12484500) and the Ecology flow gage located on Little Pend Oreille @ Hwy 395 (59B070), Reecer Creek (39K060), and Hunters Creek (59D070).

Table 9. Basin stations with flow results not available.

Station	Station Name	Station Type	Alternative Flow Source
14D070	Sherwood Cr abv mouth	Basin	NA
26G050	Lacamas Cr @ SR 506	Basin	USGS gage 14243000
28D170	Salmon Creek @ NE 199th/Hill Rd	Basin	NA
35D070	Asotin Cr @ 2nd ST	Basin	ECY gage 35D100
37E070	Wide Hollow Cr @ Union Gap	Basin	No Flow
39K060	Reecer Creek in Irene Rinehart Park	Basin	USGS gage 12484500
41E070	Sand Hollow Creek on Hwy 26	Basin	NA
59D070	Hunters Creek @ Hunter Inn	Basin	ECY gage 59B070
61E071	Meadow Creek @ Aladdin Rd	Basin	NA

NA: Not available

USGS: U.S. Geological Survey

Continuous Temperature Monitoring

During WY 2013, our summer monitoring goals were met at 15 western Washington and 9 eastern Washington stations (Table 10). In addition, 8 of the western Washington stations and 1 of the eastern Washington stations were year-round deployments (September 2012 to September 2013). Unfortunately we lost water loggers at 4 western Washington stations and failed to have loggers deployed at several southeastern Washington stations due to a communication error.

The seven-day average of the daily maximum temperature (7-DADMax) failed to meet the basic 2006 criteria at most stations (18 of 37 stations, 48%). Nine stations did not meet supplemental temperature criteria (Table 11). More stations would probably have failed the supplemental criteria, but deployment dates at most stations rarely include the beginning or ending of the supplemental season.

Seasonal maximum temperatures have remained consistent over the previous two years. In WY 2012, maximum temperatures at the warmest 5 stations ranged from 23.9 to 29.3 ºC (Table 12). In WY 2013, maximum temperatures at the warmest five stations ranged from 23.4 to 27.4 ºC (Table 12).

Table 10. Temperature summary, Water Year 2013 (°C).

Stations with 7-DADMax exceeding criteria (excluding special seasonal criteria) are shown in bold.

Station	Criterion	Sup. Criterion[a]	Deployment Maximum		7-DADMax [b]		Deploy Date	Retrieve Date
			Max	Date/Time [c]	Max	Date [c]		
01F070	16	Yes	22.6	08-Aug-13	22.2	07-Aug-13	08-May-13	18-Dec-13
05A070	17.5	Yes	22.4	10-Aug-13	22.1	08-Aug-13	11-Oct-12	25-Sep-13
05B070	16	Yes	21.2	05-Aug-13	20.8	07-Aug-13	02-Jul-13	25-Sep-13
09A190	16	Yes	19.4	11-Sep-13	18.6	11-Sep-13	21-Sep-12	23-Sep-13
11A070	16	Yes	17.8	11-Sep-13	17.0	08-Aug-13	17-Jul-13	27-Sep-13
13A060	17.5	No	21.5	01-Jul-13	20.1	01-Jul-13	24-Sep-12	01-Nov-13
16A070	16	Yes	15.6	01-Jul-13	14.8	23-Jul-13	01-Jul-13	19-Sep-13
20E100	12	No	11.7	30-Jun-13	11.0	01-Jul-13	30-May-13	26-Sep-13
22A070	16	Yes	20.6	25-Jul-13	19.7	07-Aug-13	20-Sep-12	19-Sep-13
23A070	17.5	Yes	23.4	01-Jul-13	22.5	03-Jul-13	23-Oct-12	18-Sep-13
23A160	16	Yes	23.4	01-Jul-13	21.6	07-Aug-13	01-Jul-13	18-Sep-13
24F070	16	Yes	20.6	01-Jul-13	19.4	02-Jul-13	17-Sep-12	17-Sep-13
26B070	17.5	No	19.1	05-Aug-13	18.0	07-Aug-13	23-Oct-12	18-Sep-13
26G050	16	No	22.0	01-Jul-13	19.7	23-Jul-13	01-Jul-13	17-Sep-13
27B070	16	Yes	19.5	02-Jul-13	18.4	01-Jul-13	18-Sep-12	18-Sep-13
35B060	17.5	No	27.4	02-Jul-13	25.5	01-Jul-13	27-Jun-12	17-Sep-13
35D120	12	Yes	19.3	25-Jul-13	19.1	22-Jul-13	06-Jun-13	15-Oct-13
55B070	16	No	18.5	19-Jul-13	18.3	21-Jul-13	11-Jul-13	20-Nov-13
56A070	17.5	No	25.0	19-Jul-13	24.7	21-Jul-13	18-Jul-12	20-Nov-13
59A080	17.5	No	25.0	11-Aug-13	24.7	23-Jul-13	17-Jul-12	19-Nov-13
59B200	17.5	No	21.0	11-Aug-13	20.7	23-Jul-13	18-Jul-12	19-Nov-13
59D070	16	No	21.7	10-Aug-13	21.0	11-Aug-13	09-Jul-13	19-Nov-13
61E070	16	No	15.9	11-Aug-13	15.7	23-Jul-13	09-Jul-13	19-Nov-13
62C070	16	No	12.0	12-Aug-13	11.9	12-Aug-13	18-Jul-12	19-Nov-13

[a] Indicates whether station has Supplemental Spawning and Incubation protection temperature criteria (Payne, 2006).
[b] 7-day period with the highest average of daily maximum temperatures.
[c] There may be other dates or other 7-day periods with the same maximum. Date shown is middle of 7-day period.

Table 11. Stations exceeding the 13 ºC supplemental temperature criterion, Water Year 2013 (Payne, 2006).

Station	Station Name	7-DADMax [a]		Supplemental Season	Deploy Date	Retrieve Date
		Max	Date			
01F070	SF Nooksack @ Potter Rd	16.9	1-Jul	01/01-07/01	08-May-13	18-Dec-13
01F070	SF Nooksack @ Potter Rd	20.3	11-Sep	09/01-12/31	08-May-13	18-Dec-13
05B070	NF Stillaguamish R @ Cicero	18.6	11-Sep	09/01-12/31	02-Jul-13	25-Sep-13
09A190	Green R @ Kanaskat	14.3	1-Jul	01/01-07/01	21-Sep-12	23-Sep-13
09A190	Green R @ Kanaskat	17.7	18-Sep	09/15-12/31	21-Sep-12	23-Sep-13
11A070	Nisqually R @ Nisqually	16.2	16-Sep	09/15-12/31	17-Jul-13	27-Sep-13
22A070	Humptulips R nr Humptulips	17.9	3-Jul	02/15-07/01	20-Sep-12	19-Sep-13
23A070	Chehalis R @ Porter	17.5	6-May	01/01-05/01	23-Oct-12	25-Jun-13
23A160	Chehalis R @ Dryad	18.6	13-Sep	09/15-12/31	01-Jul-13	18-Sep-13
24F070	Naselle R nr Naselle	15.7	6-June	02/15-06/15	17-Sep-12	17-Sep-13
27B070	Kalama R nr Kalama	13.8	6-June	02/15-06/15	18-Sep-12	18-Sep-13

[a] Middle of the 7-day period with the highest average of daily maximum temperatures during the first or last part of the supplemental season. Stations that exceeded (did not meet) the criterion at both the beginning and ending of the season are listed twice.

Table 12. Five stations with the warmest maximum temperatures in Water Year 2013 and the maximum temperatures at those stations since Water Year 2010 (ºC).

NS=Not Sampled.

Station	Station Name	2013	2012	2011	2010
35B060	Tucannon R @ Powers	27.4	25.6	23.9	25.3
56A070	Hangman Cr @ Mouth	25.0	24.2	NS	NS
59A080	Colville R @ Greenwood Loop Rd	25.0	22.3	NS	NS
23A160	Chehalis R @ Dryad	23.4	23.6	22.7	23.2
23A070	Chehalis R @ Porter	23.4	23.7	22.9	23.4

Continuous Multiple Parameter Monitoring

Continuous data from multiple parameter monitoring are maintained at the River and Stream Flow Monitoring web pages (www.ecy.wa.gov/programs/eap/flow/shu_main.html). Continuous monitoring data from the IMW stations were presented in this report as well. We rejected all results from 28D170 Salmon Creek @ NE 199th/Hill because results did not meet QC criteria Furthermore, results from 19D070 East Twin River at the mouth did not meet QC criteria from the 10/23-11/27 deployment period due to a sensor malfunction (see the *Quality Control* section). However, 7-DADMin oxygen concentration data are presented for 19D070 in Table 13. Results from other continuous multiple parameter monitoring stations are discussed below.

Dissolved Oxygen

Four stations (08C110-Cedar R nr Landsburg, 25D050-Germany Cr @ mouth, 25E060-Abernathy Cr nr mouth, and 25F060-Mill Cr nr mouth) met criteria for 7-day averages of daily minimums (7-DADMin) for dissolved oxygen concentrations. Four stations (41A070-Crab Creek near Beverly, 19C060-West Twin River near mouth, 19D070-East Twin River near mouth, and 19E060-Deep Creek near mouth) did not meet criteria for 7-day averages of daily minimums (7-DADMin) of dissolved oxygen concentrations during the critical period (July-September), when the highest annual temperatures and lowest annual oxygen concentrations are expected (Table 13).

Station 41A070-Crab Creek near Beverly had the lowest daily minimum dissolved oxygen concentration, 6.01 mg/L. As reported in 2012, the criterion (7-DADMin >6.5 mg/L) for station 41A070 is considerably low when compared to other stream segments within the Lower Crab Creek watershed. Currently, Lower Crab Creek is under a Category 2 listing for dissolved oxygen.

Temperature

7-DADMax for temperature was warmer than the basic criteria at 41A070-Crab Cr nr Beverly, 25D050-Germany Cr @ mouth, and 19C060-West Twin River at the mouth. Station 41A070-Crab Cr nr Beverly exceeded the 7-DADMax temperature criteria by 12.1 °C (Table 13). Five stations (08C110-Cedar R nr Landsburg, 25E060-Abernathy Cr nr mouth, 25F060-Mill Cr nr mouth, 19D070-East Twin R nr Mouth, 19E060-Deep Cr nr mouth) met seasonal criteria of daily maximums (7-DADMax) for temperature. One or more reaches of Germany Creek, Abernathy Creek, Mill Creek, and Crab Creek are already listed as Category 5 for temperature in the 2012 Water Quality Assessment.

pH

Station 08C110-Cedar River at Landsburg was the only station monitored for pH in WY 2013 (Table 13). This station met pH criteria ($6.5 \leq pH \leq 8.5$) from October 1 to August 18. The Individual daily maximum was 8.06 on April 2, 2013.

Table 13. 7-DADMin oxygen and 7-DADMax temperature and pH compared to water quality criteria, Water Year 2013.

Values not meeting criteria are in bold.

Station	7-DADM[a]	Date[b]	Criteria/Comment
Dissolved Oxygen (mg/L)			
08C110	10.51	7/1/2013	7-DADMin > 9.5 mg/L; data available between 10/1 and 8/18. Minimum single-day DO was 10.38 on 6/30.
41A070	**6.01**	9/13/2013	7-DADMin > 6.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 5.81 on 9/16.
25D050	9.51	10/1/2012	7-DADMin > 8.0 mg/L; data available between 10/1 and 11/18. Minimum single-day DO was 9.02 on 10/2.
25E060	8.87	7/1/2013	7-DADMin > 8.0 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.57 on 6/30.
25F060	8.87	6/28/2013	7-DADMin > 8.0 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.77 on 7/2.
19C060	**8.49**	9/13/2013	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.43 on 9/11.
19E060	**8.21**	9/7/2012	7-DADMin > 9.5 mg/L; data available between 10/1 and 9/30. Minimum single-day DO was 8.19 on 9/19.
Temperature (ºC)			
08C110	13.65	6/28/2013	7-DADMax ≤ 16.0 °C and 13 °C; seasonal criterion 9/15 through 5/15; data available between 10/1 and 9/30.
41A070	**29.15**	6/28/2013	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30; Temperature was 29.6 on 7/2.
25D050	**18.81**	7/21/2013	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30; Temperature was **20.0** on 7/1.
25E060	18.97	7/24/2013	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30; Temperature was 19.6 on 7/01.
25F060	17.50	7/01/2013	7-DADMax ≤ 17.5 °C; data available between 10/1 and 9/30; Temperature was on **18.5** on 7/1.
19C060	**16.30**	7/19/2013	7-DADMax ≤ 16.0 °C and 13 °C; seasonal criterion (≤ 16.0 °C) 01/01 through 2/14; 07/02 through 12/31; seasonal criterion (≤ 13.0 °C) 10/1 through 09/30. Temperature was on **16.7** on 9/11.

Station	7-DADM[a]	Date[b]	Criteria/Comment
19D070	10.18	10/13/2013	7-DADMax ≤ 16.0 °C and 13 °C; seasonal criterion (≤ 16.0 °C) 01/01 through 2/14; 07/02 through 12/3. seasonal criterion (≤ 13.0 °C) 02/15 through 07/01. Temperature was 11.2 on 10/14.
19E060	16.10	07/07/2013	7-DADMax ≤ 16.0 °C and 13 °C; seasonal criterion (≤ 16.0 °C) 01/01 through 2/14; 07/02 through 12/31. seasonal criterion (≤ 13.0 °C) 02/15 through 07/01. 7-DADMax from 02/15 through 07/01 was 16.50 on 6/18.
pH (standard units)			
08C110	8.04	4/1/2013	6.5 ≤ pH ≤ 8.5; data available between 10/1 and 8/18. Individual daily maximum was 8.06 on 4/2.

[a] The highest seven-day average of daily maximums in each dataset for temperature or pH, or the lowest seven-day average of daily minimums for dissolved oxygen datasets.
[b] Date is the middle of the averaged 7-day period.
DO: Dissolved oxygen

Metals Monitoring

During WY 2013, we collected all of the possible metals results at 9 of the 10 stations. We also collected a few additional metals, on occasion, from stations that were intended to be for mercury only.

Of the 459 dissolved metals and total mercury results reported, 6 (0.01%) exceeded 2006 Washington State water quality standards chronic criteria (Table 14). Dissolved zinc exceeded criterion in the Spokane River at Stateline in most months. The Spokane River has a TMDL for metals, mostly due to legacy contamination from upstream mining practices. See Hallock (2010) for a review of long-term metals monitoring in the Spokane River.

Table 14. Metals results exceeding 2006 water quality criteria, Water Year 2013.

Date	Parameter	Hardness (mg/L)	Result (ug/L)	Chronic Criterion (ug/L)	Percent Over Chronic Criterion	Acute Criterion (ug/L)	Percent Over Acute Criterion
57A150 Spokane River at Stateline Bridge							
4/3/2012	Zn_DIS	21.4	54.6	28.3	92.9	25.4	53%
10/17/2012	Zn_DIS	20.3	30.8	27.0	13.8	25.4	17%
12/5/2012	Zn_DIS	19.3	48.2	48.2	85.8	25.4	47%
2/6/2013	Zn_DIS	22.1	54.3	29.0	86.7	25.4	53%
6/5/2013	Zn_DIS	23	33.9	30.0	12.6	25.4	25%

Hg: mercury.
Zn_DIS: dissolved zinc.

Nitrogen in Puget Sound Area Rivers

Concentration Trends

The identification of significant long-term trends from multiple stations can vary by availability of time series information. For example, significant trends from shorter time periods may be different at some stations than at stations with longer time period information. Furthermore, the significant detection of trends in general may also be due to factors other than anthropogenic loading.

Trends and patterns at long-term Puget Sound stations from 1995-2013 (Table 15 and Appendix E):

- The Skokomish River (16A070) continues to show the greatest increase in annual and summer flows since the previous trend analysis in Hallock (2009a).
- Overall summer flows (July–September) have significantly increased at Cedar River @ Logan St (08C070) and Green River at Tukwila (09A080) since 2008 as well.
- Overall TN concentrations at most Puget Sound sites (Table 15) have significantly decreased in most cases (i.e., annual, summer periods). Since 2008, annual TN concentrations at 8 (01A050, 04A100, 05B070, 07A090, 07D050, 07D130, 09A080 and 16A070) more sites have significantly decreased from the initial 10 sites (Table 15 identified in Hallock (2009a). Furthermore, declining TN concentrations are more apparent during the summer at 17 out the total (n) 24 sites, respectively.
- Overall NO2+NO3 concentrations continue to significantly decrease annually at 10 sites (Table 15) as compared to 2 sites (Skokomish River- 08C070, Cedar River- 08C110) identified in Hallock (2009a). Statistically significant ($p < 0.05$) declining trends for summer NO2+NO3 concentrations are more apparent in the Skagit River (03A060). However, they are not so apparent in the Snohomish watershed (WRIA 07; 07A090, 07C070, 07D050, and 07D130).
- Annual trend for NO2+NO3 for the Deschutes River (Figure 1) is less significant than indicated in Hallock (2009a). However, summer NO2+NO3 concentrations continue to show indications of increasing trends in the Deschutes River. Furthermore, the Snohomish and Green Rivers no longer show an apparent trend for prominent increasing summer NO2+NO3 concentrations.

Table 15. Statistically significant ($p<0.05$) trends in flow, TN, and NO2+NO3, Water Years 1995-2013.

"All" refers to all months; "Sum" includes July through September; "FA" indicates data were flow-adjusted; shaded station names indicate downstream stations; arrows indicate increasing (↑) and decreasing (↓) trends.

Puget Sound Area Station	Flow		Total Nitrogen (TN)				Nitrate+Nitrite-Nitrogen (NO2+NO3)			
	All	Sum	All	FA All	Sum	FA Sum	All	FA All	Sum	FA Sum
01A050			↓	↓	↓	↓				
01A120			↓	↓	↓	↓	↓		↓	
03A060			↓	↓	↓	↓				
03B050			↓	↓	↓		↓		↓	
04A100			↓	↓						
05A070			↓	↓	↓	↓	↓	↓	↓	↓
05A090			↓	↓	↓		↓		↓	
05A110										
05B070			↓	↓	↓	↓				
05B110			↓	↓	↓	↓				
07A090			↓	↓	↓	↓	↓	↓	↓	
07C070					↓	↓				
07D050			↓	↓	↓	↓	↓	↓	↓	
07D130			↓	↓	↓	↓	↓	↓	↓	↓
08C070		↑	↓	↓	↓	↓	↓	↓	↓	↓
08C110			↓	↓	↓	↓	↓	↓	↓	↓
09A080		↑	↓	↓						
09A190				↓						
10A070			↓	↓	↓	↓				
11A070			↓	↓	↓	↓		↓		↓
13A060										
16A070	↑	↑	↓	↓	↓	↓	↓	↓	↓	↓
16C090										
18B070							↓		↓	

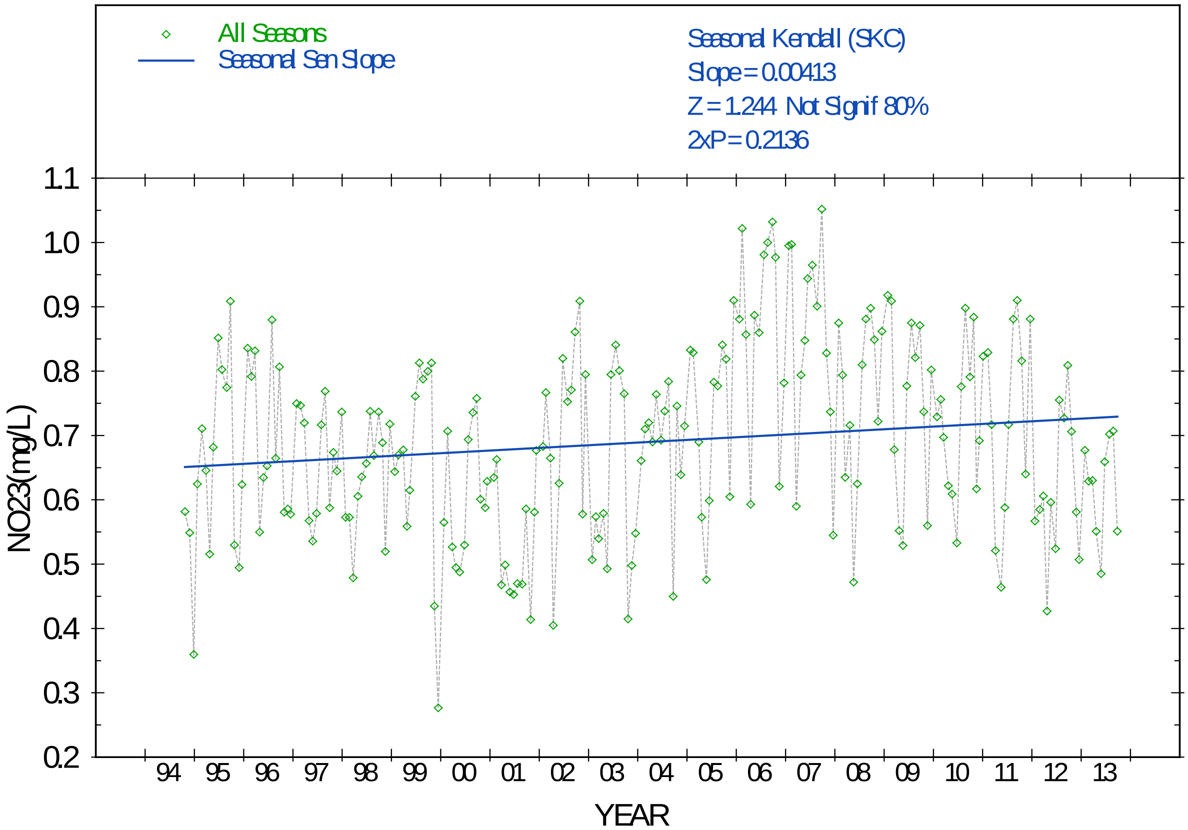

Figure 1. Nitrate + nitrite-nitrogen (NO2+NO3) in the Deschutes River at E Street, Water Years 1995-2013.

Flux and Yield

Flux and yield patterns are particularly important in evaluating watershed processes for nitrogen. Flux is the amount of a constituent passing through a spatial location (site) at a specific period in time, and yield is flux normalized for a watershed area. Large watersheds (i.e., x sq. km) that have more confounding effects driven by runoff will have more overall flux. Yields may indicate higher natural sources in the watershed or greater anthropogenic effects resulting from land-use activities and human impacts.

Annual TN and NO2+NO3 yields from major Puget Sound river systems during 1995-2013 continue to be fairly uniform since 1995 (Figure 2). The top 4 ranked Puget Sound river systems with the greatest yields for NO2+NO3 are Nooksack River (01A050), Samish River (03B050), Cedar River (08070), and Stillaguamish River near Silvana (05A070). The greatest yields for TN are Stillaguamish River near Silvana (05A070), Nooksack River (01A050), and Samish River (03B050) (Table 16). Summer TN and NO2+NO3 yields are the greatest in Nooksack River (01A050), Deschutes River (13A060), and Cedar River (08C110) (Figure 2). Generally, the Stillaguamish and Nooksack River systems are the largest contributors of annual nitrogen per unit of watershed area in the Puget Sound Region.

Significant yield trends were generally downward and very similar to the yield trends evaluated in Hallock (2009a). Significant annual declining trends identified in both evaluations are Nooksack River @ North Cedarville (01A120), Samish River near Burlington (03B050), Stillaguamish River near Silvana (05A070), and Nisqually River @ Nisqually (11A070) for TN. However, no downward trends were indicated at Snohomish R @ Snohomish (07D130), Cedar River @ Logan St (08C070), and Nisqually River @ Nisqually (11A070) as in Hallock (2009a). Furthermore, there was a noticeable increasing trend at Elwha River near Port Angeles (18B070) after the Elwha Dam removal in 2012.

Significant declining summer yields are prevalent at the same sites with significant annual yields. Since 2008, the mean difference in summer NO2+NO3 yields for all Puget Sound sites combined has increased slightly by 0.18 kg/sq. km/month with a relative percent difference of 1.93%. However, this is relativity small considering inter-annual variability between time periods.

Annual NO2+NO3 yield decreasing trends are only significant at one site, SF Stillaguamish @ Arlington (05A090), as compared to 5 sites (03A060, 03B050, 05A070, 05B110, 07D050) identified in Hallock (2009a). Annual positive trends for NO2+NO3 yield continue to be prevalent at Puyallup R @ Meridian St (10A070). An additional NO2+NO3 yield positive trend was identified at Elwha R nr Port Angeles (18B070).

Summer NO2+NO3 yield decreasing trends are only significant at SF Stillaguamish @ Arlington (05A090), while increasing trends were found at Green R @ Tukwila (09A080).

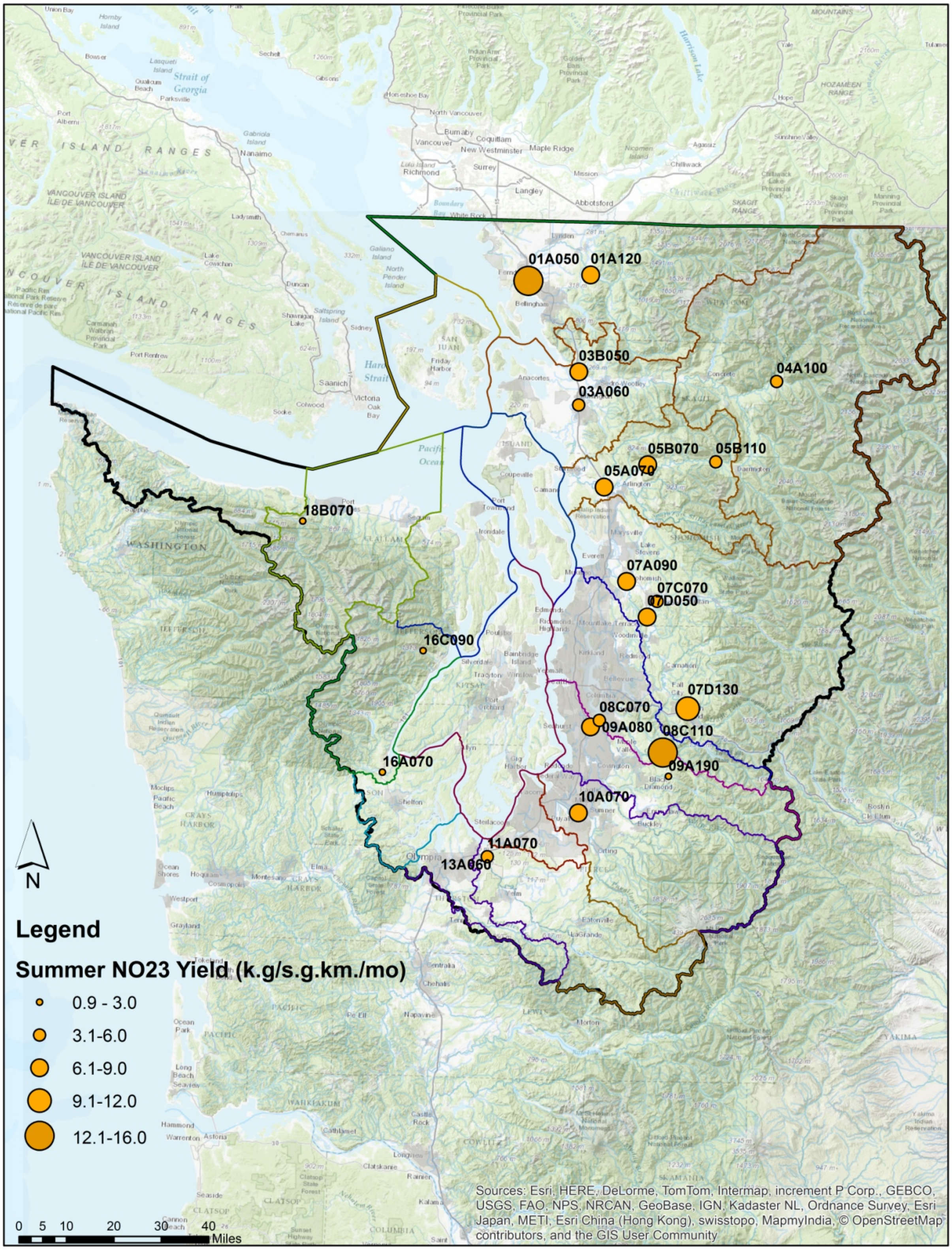

Figure 2. NO2+NO3 yields at long-term Puget Sound area stations.

Table 16. Average yields at long-term Puget Sound area stations (kg/sq. km/month).

"All" refers to all months, "Summer" refers to July through September. Data are from WY 1995 through WY 2013 unless otherwise indicated. Shaded station names indicate downstream stations. Darker shading in the table body indicates higher relative yield within a column.

Station	TN (All)	NO2+NO3 (All)	TN (Summer)	NO2+NO3 (Summer)
01A050	90.54	64.43	19.74	14.71
01A120	41.39	32.35	10.27	7.75
03A060	23.56	15.93	8.13	4.78
03B050	81.3	64.15	10.15	8.7
04A100	13.48	9.4	7.81	5.63
05A070	92.04	49.2	12.8	8.37
05B070	56.18	44.74	10.28	6.89
05B110	54.24	41.24	6.12	4.47
07A090	52.89	41.4	11.75	8.14
07C070	36.63	28.61	8.08	5.06
07D050	53.37	41.44	11.06	8.26
07D130	45.36	37.39	13.03	10.4
08C070	40.39	53.49	7.52	4.47
08C110	26.78	23	14.17	12.63
09A080	52.1	36.17	12.41	8.82
09A190	21.7	16.81	3.9	2.13
10A070	36.46	23.47	14.21	7.53
11A070	29.05	19.19	6.9	4.39
13A060	49.7	41.22	17.95	15.47
16A070	34.56	13.03	4.57	2.69
16C090	9.78	5.01	2.64	1.13
18B070	10.4	4.23	3.62	0.95

Hallock (2009a) found only significant declining summer NO2+NO3 yields at 4 sites (03A060, 05A070, 05B070,11A070) and significant increasing summer NO2+NO3 yields at 3 sites (07C070,09A190,10A070). Overall, the total amount of significant yield trends (n=15) for annual and summer TN and NO2+NO3 is less than the total number detected in Hallock (2009a)(n=17) (Tables 17 and 18 and Figure 3).

Table 17. Average summer (July through September) NO2+NO3 yields and yield differences at long-term Puget Sound area stations (kg/sq. km/month).

"95-2008" refers to yield results from Hallock (2009a). "08 & 2014 Yield Difference" are calculated differences for NO2+NO3 yields evaluated during two time periods (95-2008 and 95-2014). Shaded station names indicate downstream stations. Darker shading in the table body indicates higher relative yield within a column.

Station	95-2014 NO2+NO3 (Summer)	95-2008 NO2+NO3 (Summer)	08 & 2014 Yield Difference
01A050	14.71	13	1.71
01A120	7.75	8.8	-1.05
03A060	4.78	4.5	0.28
03B050	8.7	8.6	0.1
04A100	.5.63	5.1	0.53
05A070	8.37	7.5	0.87
05B070	6.89	6.5	0.39
05B110	4.47	3.9	0.57
07A090	8.14	8.3	-0.16
07C070	5.06	5.5	-0.44
07D050	8.26	9.2	-0.94
07D130	10.4	10.1	0.3
08C070	4.47	6.4	-1.93
08C110	12.63	13.5	-0.87
09A080	8.82	7.6	1.22
09A190	2.13	2.3	-0.17
10A070	7.53	6.3	1.23
11A070	4.39	4.6	-0.21
13A060	15.47	14	1.47
16A070	2.69	1.7	0.99
16C090	1.13	1.2	-0.07
18B070	0.95	0.8	0.15

Table 18. Trends in TN and NO2+NO3 yields, 1995-2013.

"All" refers to all months; "Sum" refers to July through September; shaded station names indicate downstream stations; arrows indicate statistically significant increasing (↑) and decreasing (↓) trends at the 90% confidence level.

Station	TN		NO2+NO3	
	All	Sum	All	Sum
	1995	1995	1995	1995
01A050				
01A120	↓			
03A060				
03B050	↓	↓		
04A100				
05A070	↓	↓		
05A090	↓	↓	↓	↓
05A110				
05B070				
05B110				
07A090				
07C070				
07D050		↓		
07D130				
08C070				
08C110				
09A080				↑
09A190				
10A070			↑	
11A070	↓			
13A060				
16A070				
16C090				
18B070			↑	

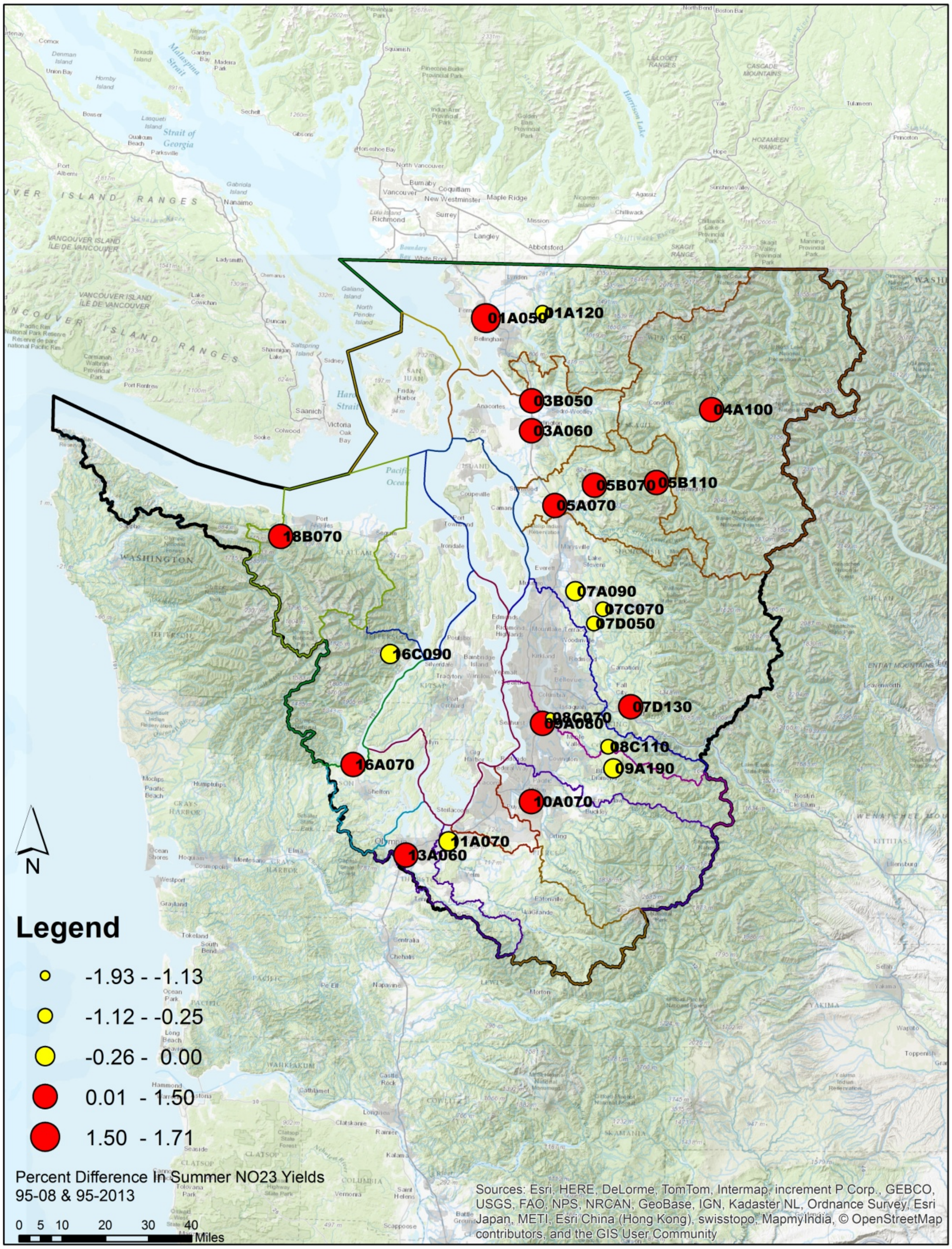

Figure 3. Difference in summer NO2+NO3 yields (kg/sq. km/month) for two time periods, 1995-2008 and 1995-2013.

Watershed areas that continue to show the greatest annual summer flux are the Snohomish River (07A090; 4439 sq.km), the Skagit River (03A060; 8010 sq.km) and in recent years the Nooksack River (01A050; 2046 sq.km) (Table 19). There continues to be no significant trend in NO2+NO3 flux from all sites combined entering Puget Sound. However, there is a small decreasing trend in TN (Figure 5). Overall flux continues to be driven by seasonal effects (i.e., precipitation) with high results in the winter (November-January) and low results in the summer.

Table 19. Flux at long-term Puget Sound stations (kg/month).

"All" refers to all months; "Summer" refers to July through September. Data are from WY 1995 through WY 2013. Shaded station names indicate downstream stations. Darker shading in the table body indicates higher relative flux within a column.

Station	TN (All)	NO2+NO3(All)	TN (Summer)	NO2+NO3 (Summer)
01A050	184702	30277	40275	30019
01A120	63883	49930	15860	11955
03A060	64127	127647	15860	38323
03B050	18529	14620	2314	1982
04A100	43987	14620	25496	18376
05A070	132770	30671	18462	12292
05B070	132770	71288	6975	4676
05B110	11521	30360	1299	949
07A090	234791	183763	52144	36127
07C070	79117	61804	17488	10928
07D050	95105	73848	19715	14723
07D130	43986	36313	12654	10100
08C070	19456	12991	3624	2639
08C110	8463	7268	4478	3991
09A080	59371	41224	14146	10051
09A190	12928	10013	2324	1271
10A070	88847	10055	34600	18324
11A070	53562	35381	12718	8088
13A060	20723	17188	7485	8088
16A070	20320	17250	2688	6450
16C090	1670	7686	451	193
18B070	7921	3224	2758	722

As stated in Hallock (2009a), Total flux should have the strongest relationship to nitrogen-related trends within Puget Sound. This continued analysis implies that the freshwater contributions to nitrogen in the marine environment have not increased during the 19 years evaluated (Figures 4 and 5). Furthermore, there is an overall slight decreasing trend for total TN flux from freshwater systems in the Puget Sound area from 1995-2013 at a rate of -0.006 kg per year * 10^{-6}. The source of nitrogen trends from other potentially significant sources remains unknown.

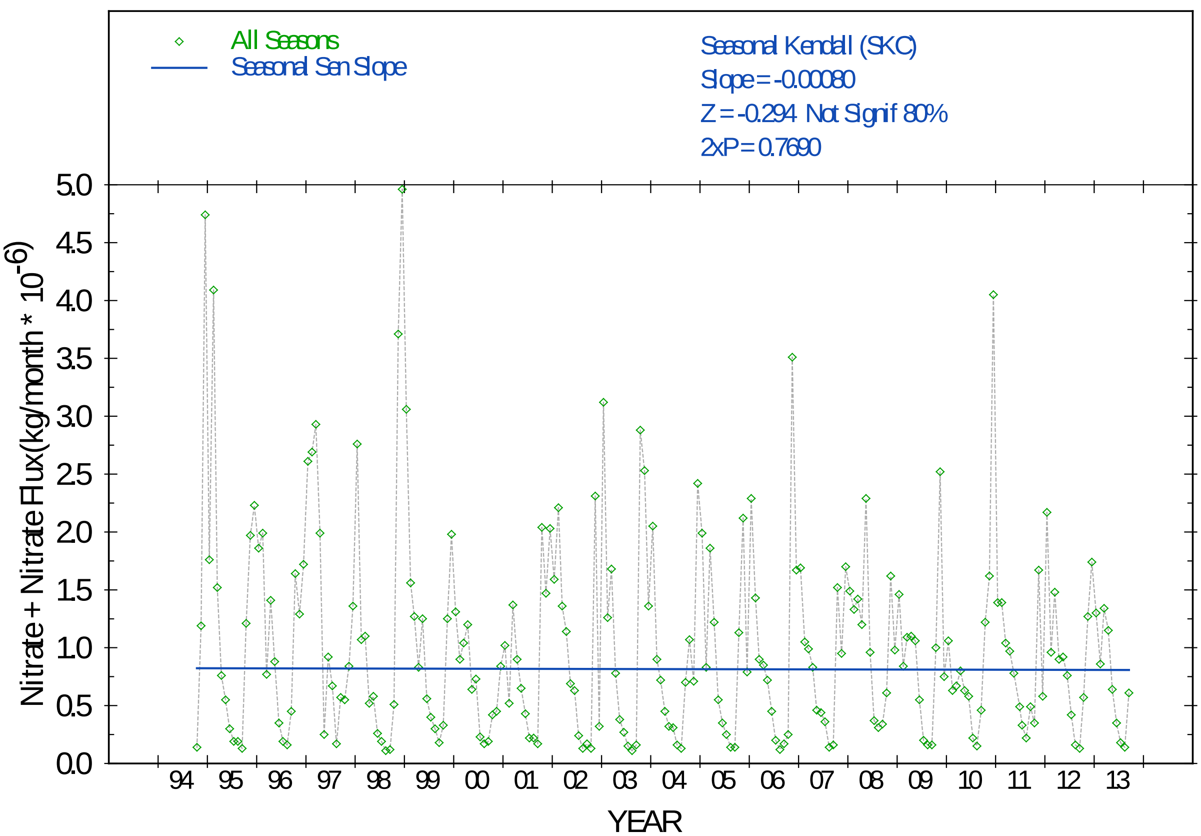

Figure 4. NO2+NO3 entering Puget Sound from the 13 largest rivers.

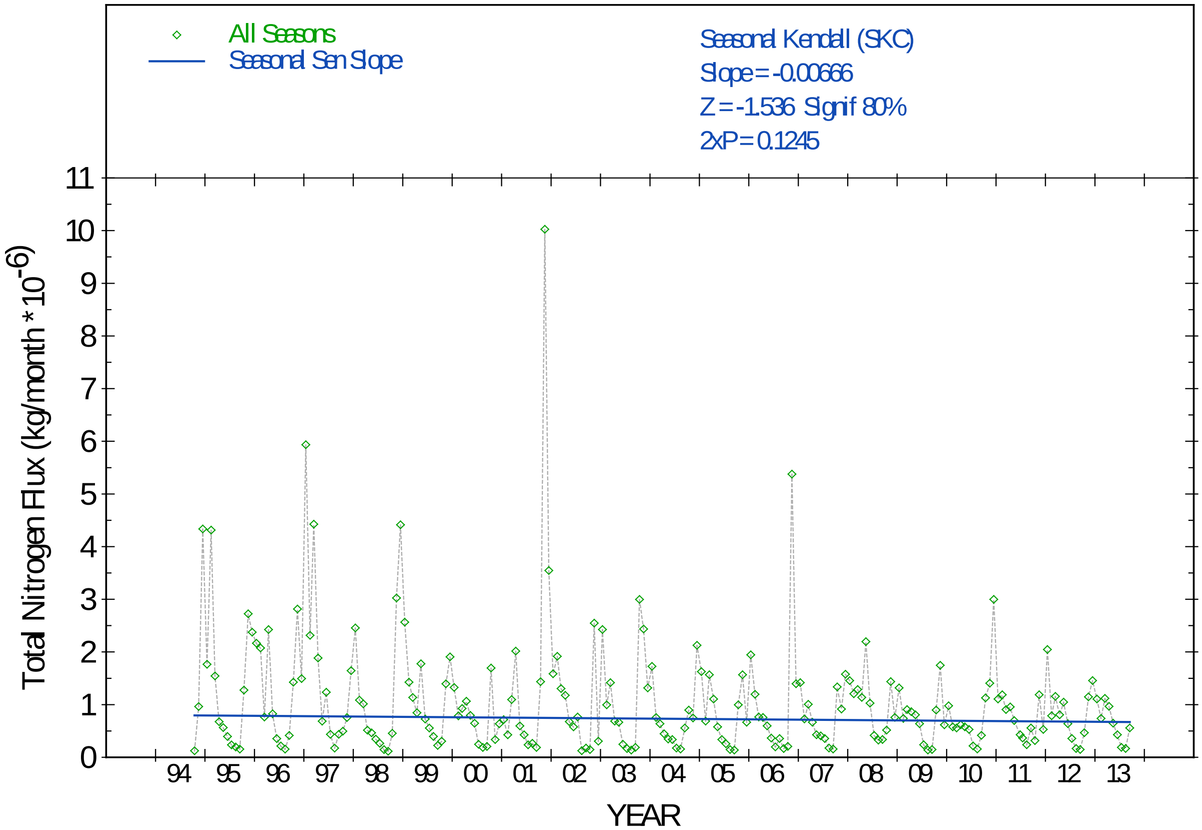

Figure 5. Total nitrogen (TN) flux entering Puget Sound from the 13 largest rivers.

Quality Assurance

In 2013, we collected 15,617 non-QC water quality results, including for metals, various other parameters, and the standard 12 parameters listed in Table 2.

- We coded one result "4," indicating that the results are usable, but there were questions about the quality. These were from a variety of stations, dates, and parameters.
- We coded 10 results (0.1%) "5" or greater, indicating serious data quality questions; these data will not be routinely used or provided. This practice gives us the opportunity to explain quality issues to prospective users before they obtain the data.

We qualified 2396 (15%) usable results out of 15,617 non-QC water quality results. Of these, 632 results (4.0%) were qualified as estimates ("J"), 1750 results (11%) were below the reporting limit ("U"), 9 results (<0.01%) were coded as both estimates and below the reporting limit ("UJ"), and one result (<0.01%) was listed as greater than the reported value ("G"). Seventy percent of all ammonia results were below the reporting limit, as were 14% of orthophosphate, 9% of NO2+NO3, and 41% of all metals (Table 20).

Table 20. Results qualified by Manchester Laboratory as being below the reporting limit.

Parameter	Reporting Limit (mg/L except where otherwise noted)	Number of results coded U or UJ	Total Number of results	Percent of results coded U or UJ
Ammonia	0.01	722	1032	70%
Chlorophyll	0.05 ug/L	2	33	6%
Fecal coliform bacteria	1	173	1041	16%
Hardness	Not specified	0	52	0%
Metals	Various	368	884	41%
Nitrate+Nitrite (NO2+NO3)	0.01	103	1054	9%
Nitrogen, total	0.025	14	1054	1%
Organic carbon, total	1	19	72	26%
Orthophosphate	0.003	149	1055	14%
Phosphorus, total	0.005	43	1054	4%
Phosphorus, total reactive	0.005	1	55	1%
Suspended sediment	1	12	72	16%
Total Suspended solids	1	220	1054	20%
Turbidity	0.5 NTU	125	1054	11%

Errors in EIM and Web Databases

The automated data verification process identified 121 instances where results in Ecology's EIM database ("transitional" project AMS001-2) were different than results in our primary database. However, 17 pH results and 1 water temperature result were actually in EIM and not detected in the validation procedure. This was due to EIM table structure changes from EIM database modifications in WY 2013. Fifty-six metal results also were not detected in the validation procedure because laboratory sample IDs were mismatched with station run information in our primary database. Furthermore, 54 total reactive phosphorus (TRP) results were mismatched in the validation procedure and were listed in EIM as total ortho-phosphate instead.

Comparison to Quality Control Requirements

Decision Quality Objectives

Decision quality objectives (DQOs) are based on root-mean-squared (RMS) values broken out by concentration range (Tables 21 and 22). In practice, estimates of variability are strongly influenced by extreme values, especially when the sample size (n) is small. Also, the variability estimate is skewed downward for the lowest concentration ranges because data below the reporting limit are censored and, therefore, sample pairs below this limit have a variance of zero.

In general, variability of repeated measures followed the expected pattern: field sequential samples > field split samples > lab split samples. However, in some cases, field split or lab split samples had greater variability than field QC samples. Why this should be for field splits is not clear. Lab splits are often based on different samples than field QC samples. In either case, often a single split pair with poor precision was responsible.

Three field split parameters and five concentration ranges failed our Quality Assurance Monitoring Plan (QAMP) DQO (Hallock and Ehinger, 2003), which specifies that DQOs be evaluated against field splits, where possible.

The mid-range and upper range for TN, the upper ranges for NO2+NO3 and the upper range for total phosphorus samples exceeded their DQOs. In the case of TN, 2 split pairs were particularly poor (0.116/0.184 ug/L and 0.078/0.053 ug/L) which drove the RMS to 32.06%. There was one particularly poor phosphorus sample pair (0.0332/0.0054 mg/L).

Several field sequential parameter categories failed to meet DQO criteria specifically for TN and NO2+NO3, but instream variability is included in these sample pairs so their variability is not a true measure of sampling plus analytical error.

As in years past, the variability in sequential samples for total suspended solids (TSS) concentrations tended to be particularly high. This underscores the inherent variability in measurements of stream sediment.

Table 21. Root mean square (RMS) of the standard deviation of sequential samples, field splits, and laboratory splits.

Results exceeding QAMP DQO criteria (Hallock and Ehinger, 2003) are shown in bold.

Parameter (units)	Range	$S_{err\ (mp)}$ [a]	Field Sequential RMS	*n*	Field Split RMS	*n*	Lab Split RMS	*n*
Specific conductance (µS/cm)	≤50 >50-100 >100-150 >150	4.4 8.8 13.2 26.4	0.40 1.90 1.5 1.37	9 25 10 9	No field splits		No lab splits	
Fecal col. bacteria (colonies /100 mL)	1-1000 >1000	88 176	18.07 0	48 0	No field splits		9.5 NA	42 0
Ammonia (ug N/L)	≤20 >20-100 >100	1.76 8.8 17.6	1.79 4.87 0.70	46 5 1	2.03 0.05 0.70	48 3 1	0.27 0.50 NA	14 2 0
Nitrogen, total (ug N/L)	≤100 >100-200 >200-500 >500	8.8 17.6 44 88	4.89 7.87 **22.89** 0.04	9 20 13 12	6.91 **13.11** **23.57** **27.02**	9 14 13 10	5.58 13.4 7.31 12.4	6 1 5 5
NO2+NO3 (ug N/L)	≤100 >100-200 >200-500 >500	8.8 17.6 44 88	1.10 **18.58** 6.82 0.16	19 14 9 18	0.62 1.56 6.21 **15.69**	19 12 8 10	1.54 1.41 3.97 13.3	7 1 4 4
Oxygen, dissolved (mg O_2 /L)	≤ 8 > 8-10 > 10-12 >12	0.70 0.88 1.06 2.11	0.06 0.10 0.10 0.14	12 20 16 22	No field splits		0.00 0.01 0.18 0.00	1 7 7 1
pH	All	0.66	0.06	53	No field splits		No lab splits	
Phosphorus, soluble reactive (ug P/L^{-1})	≤50 >50-100 >100	4.4 8.8 17.6	035 0.79 2.88	52 9 42	0.23 0.34 1.97	19 17 15	0.49 0.19 NA	20 4 0
Phosphorus, total (ug P/L)	≤50 >50-100 >100	4.4 8.8 17.6	0.35 0.82 2.92	52 10 42	0.06 6.17 8.10	3 12 33	0.48 0.67 NA	11 5 0
Solids, suspended (mg/L)	≤10 >10-20 >20-50 >50	0.88 1.76 4.4 8.8	0.65 1.00 **10.16** 6.27	36 5 7 4	No field splits		0.41 1.035 1.70 NA	15 7 5 0
Temperature (ºC)	All	2.64	0.00	9	No field splits		No lab splits	
Turbidity (NTU)	≤10 >10-20 >20-50 >50	0.88 1.76 4.4 8.8	0.26 0.35 0.40 3.53	45 4 4 1	No field splits		0.15 1.70 0.87 NA	19 2 4 0

[a] Maximum permissible standard error to meet Quality Assurance Monitoring Plan (QAMP) DQO (Hallock and Ehinger, 2003).

n: number of sample pairs.

NA: not applicable.

Table 22. Average relative standard deviation (RSD) of replicate samples collected, Water Year 2013.

Results exceeding QAMP MQO criteria (Hallock, 2012) are shown in bold.

Parameter (units)	Precision MQO (%)	Sequential Sample RSD (%)	n^a	Field Split RSD (%)	n^a
Carbon, total organic	10	**6.17**	3	0.00	3
Chlorophyll	25	5.8	1	No field splits	
Specific conductance	10	0.69	53	No field splits	
Fecal coliform bacteria (>20 colonies /100 mL)	≥50% < 20 ≥90% < 50	54.2[b] 81.3[b]	48 48	No field splits	
Ammonia	10	3.76	52	3.96	50
Nitrogen, total	10	4.49	50	4.81	49
Nitrate+nitrite-nitrogen	10	2.24	53	0.96	49
Oxygen, dissolved	10	0.72	51	No field splits	
pH	10	0.57	53	No field splits	
Phosphorus, soluble reactive	10	5.37	52	3.5	48
Phosphorus, total	10	6.5	51	**14.87**	49
Solids, suspended	15	10.36	52	No field splits	
Suspended sediment concentration	15	**33.59**	3	No field splits	
Temperature	10	0.17	53	No field splits	

No lab split parameter/concentration ranges failed DQO requirements. Manchester Laboratory still performs duplicate analyses and evaluates the results, but because of a change in data management procedures at the lab, we are no longer able to process the results electronically.

The criteria in Table 21 are based on desired trend power. (We want to be able to detect a 20% change over a ten-year period with 90% confidence.) Parameters that consistently do not meet the DQO criteria are unlikely to meet our goals for trend detection. The variability in most parameters indicates equivalent or greater trend power than the goal specified in our QAMP (Hallock and Ehinger, 2003). Our ability to detect trends in TSS, however, is likely to be worse than our goal.

Measurement Quality Objectives

Measurement quality objectives (MQOs) for accuracy are based on comparisons (usually against standards) during calibration checks (Hallock, 2012). Checks failing criteria cause an immediate corrective action (usually recalibration). Bias MQOs are evaluated at the laboratory based on spike recovery. Precision MQO evaluations are based on comparisons to average relative standard deviation (RSD) of field split pairs. Results are presented in Table 22.

Only total phosphorus (TP) and TSS exceeded MQO criteria based on field split samples or sequential samples. However, we collected only 3 total organic carbon (TOC) QC samples, and one pair was poor. TSS is notoriously imprecise, as we saw in the analysis of DQOs.

Blanks

Most results for analyses of blank samples were "below reporting limits" or less than 3.2 uS (microsiemens) for specific conductivity (Table 23). Blanks were not measured for temperature, dissolved oxygen, pH, or fecal coliform bacteria.

Table 23. Results of field process blank (de-ionized water) samples.

Parameter	Reporting Limit	Number Above Reporting Limit	Sample Size *n*
Metals (ug/L)	Various	1 [a]	34
Hardness (mg/L)	0.3	0	1
Ammonia (ug/L)	10	0	9
NO2+NO3 (ug/L)	10	0	9
Soluble reactive phosphorus (ug/L)	3	0	9
Specific conductivity (uS/cm)	NA	(mean: 1.23 uS, std dev: .43) [b]	7
Total suspended solids (ug/L)	1	0	7
Total nitrogen (ug/L)	25	0	9
Total phosphorus (ug/L)	5	0	9
Turbidity (NTU)	0.5	0	7

NA: not applicable.
[a] Dissolved zinc blank reported as 1.6J
[b] Excludes one result rejected due to sampler error.

Protocols specify that one dissolved metals blank sample should be submitted annually from each run that collects metals. In WY 2013, we failed to collect dissolved metals blanks from the East and the West runs.

Historically, blanks for dissolved zinc frequently (43% of the time) exceeded (did not meet) reporting limits of 1 ug/L (though results were always < 5 ug/L, the reporting limit for total zinc). As a result, we set the quality code field = 4 for detected dissolved zinc results < 5 ug/L. The effect of this action is that our low-level zinc data on the Internet will be annotated with the footnote: "Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person."

All conductivity blanks were less than 3 uS/cm, except one was rejected due to sampler error.

Laboratory staff assessed the remaining elements of the laboratory QA program through a manual review of laboratory QC results, including check standards, in-house matrix spikes, and laboratory blanks. Results were within acceptable ranges as defined by Manchester Laboratory's *Quality Assurance Manual* (MEL, 2012) or were either re-run or coded as determined by laboratory staff (e.g., as an estimate, "J").

Continuous Temperature Monitoring

The pre- and post-deployment calibration checks (using a certified reference thermometer) met or exceeded (were better than) the criteria for the instruments (Ward, 2005).

Most of the summer temperature loggers were deployed by July 24.

Continuous Multiple Parameter Monitoring

Some deployments extended beyond the water year reviewed in this annual report; however, for continuous multiple parameter monitoring, we reviewed all data from each location.

The Deployment at 28D170 Salmon Creek @ NE 199th/Hill Rd failed QC requirements for all parameters due to excess sedimentation and sensor malfunction. We rejected all data from this deployment. Due to budget constraints, station 28D170 was permanently removed in November 2012. Several stations that had only single QA grab samples obtained during the deployment periods were coded "estimates".

Continuous monitoring data from the IMW stations were processed in time to be included in this QC review, which is performed after visually reviewing data and removing anomalous data points.

Dissolved Oxygen

Besides 28D170 Salmon Creek @ NE 199th/Hill, Hydrolab®, dissolved oxygen sensors failed QC requirements (Table 24) at 41A070 Crab Creek near Beverly for a 3-month deployment period (7/17-9/18).

Constant adjustments (offset) information is provided to account for probable calibration errors. Slight positive offsets are suggested for 25E060, 25F060, 19D070, 19C060, 19E060, and 25D050. Station 08C110 required a positive offset during the 11/26- 1/14 deployment and negative offsets for the reminding 2 deployment periods.

Generally, most LDO sensors were extremely stable, with little or no drift over the course of the deployment. However, the sensors on 41A070 Crab Creek near Beverly had a greater average percent difference between continuous data and grab sample after applying offsets. During WY 2013, there was a lack of resources available for onsite servicing of the LDO sensors for 41A070 during the 3/13-9/18 deployment period.

On the whole, the RSD between the optical dissolved oxygen sensor results and Winkler results is 0.7% greater than the RSD between sequentially collected Winkler grab samples (Table 24).

In general long-term continuous monitoring for dissolved oxygen will require additional telemetry resources, regular maintenance of the dissolved oxygen sensors, maintenance of battery voltage, and regular check samples.

Temperature

The temperature signal from almost all sensors was both stable and clean. However, small constant positive and negative adjustments are suggested at various deployment periods for all stations. One sensor failed the QC requirements at 25D050 due to a sensor malfunction. In 73% of deployments, precision was satisfactory compared to the allowed ±0.4 ºC difference between grab sample temperatures and recorded temperatures. However, 27% of grab samples did not meet the allowed ±0.4 ºC difference prior to applying offset corrections. This may be caused by slightly different locations for grab samples and sensor deployments. We coded some continuous deployments as "estimates" because there was only one valid check sample obtained between deployment periods.

Conductivity

Some conductivity deployments exhibited apparent drift at 19C060 West Twin River near the mouth. We rejected part of the dataset from 19C060 because the check sample conductivity results from the 11/27-01/29 deployment period did not meet QC requirements to determine an offset with confidence. To bring continuous data in line with check sample results, offset adjustments coefficients are provided at various deployment periods (Table 24). Likewise, check sample conductivity did not meet QC requirements at Station 19D070 for the deployment period ending in 11/27. Conductivity data were rejected for the 10/23-11/27 deployment because continuous and check samples were inconstant. No conductivity data were obtained after 11/27 due to a sensor malfunction.

As previously observed in WY 2011 and 2012, the conductivity sensors during WY 2013 deployments exhibited more apparent "noise" than oxygen or temperature sensors. Noise was usually expressed as a single, unusually high value, though sometimes the value would be unusually low.

pH

In WY 2013, pH information was obtained only at 08C110 Cedar River near Landsburg for the determination of long-term reference conditions. QC results for pH at 08C110 are presented in Table 24. Generally, pH has not been a critical parameter for continuous monitoring at the long-term and IMW stations. However, in the past, pH information has been reported because most of the instruments included pH sensors.

Table 24. Quality control (QC) results from continuous multiple parameter monitoring.

*Average and RSD were calculated after applying offset and removing rejected data. A positive average indicates that check samples were higher than matching continuous results. Rejected deployments and data considered "unreliable estimates" are in **bold**.*

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
Dissolved Oxygen (mg/L)					
08C110	11/26 09:45	+0.16 (1.38)	0.03%	2.40%	
	1/14 09:15	-0.34 (-0.03)	0.02%	1.07%	
	9/23 11:00	-0.71 (-6.56)	-0.13%	1.38%	
41A070	2/13 13:15	-0.11 (-0.90)	**5.02%**	3.47%	Code "estimate" because only one valid check sample.
	3/13 14:00	+1.34 (11.45)	**7.16%**	5.25%	Code "estimate" because only one valid check sample.
	4/10 14:15	+.10 (1.00)	**-4.03%**	2.79%	Code "estimate" because only one valid check sample.
	5/15 03:15	+.63 (7.08)	1.43%	1.02%	Code "estimate" because only one valid check sample.
	7/17 14:45	+2.78 (27.80)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	9/18 13:45	-0.62 (-7.95)	**-14.40%**	**9.50%**	**Reject Data.** Only one check sample. **Code as "estimate": Positive drift is indicated after offset is applied. RSD is excessive, though within QC requirements.**
	10/1 0:00	-0.6 (-7.69)	0.00%	0.00%	Code "estimate" because only one valid check sample.
25E060	11/13 13:00	+0.41 (3.51)	0.02%	1.05%	
	1/22 14:00	+0.35 (0.03)	-0.02%	0.59%	
	6/24 14:00	+.54 (4.65)	0.06%	1.41%	
	9/17 15:30	+0.46 (4.65)	0.04%	1.11%	
25F060	10/22 14:32	+0.28 (2.43)	0.00%	0.61%	
	1/22 14:00	+.19 (0.01)	-0.23%	1.86%	
	6/24 14:00	+.41 (3.55)	-0.02%	0.54%	
	9/17 14:30	+0.56 (3.62)	-0.03%	0.91%	
19D070	11/27 16:00	+1.66 (13.19)	-0.26%	6.41%	
	5/29 16:00	+0.44 (3.61)	-0.04	1.06%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
	07/30 16:00	+0.83 (7.62)	0.78%	1.19%	
	08/27 16:15	+0.85 (8.10)	0.00%	0.00%	Code "estimate" because only one valid check sample
	9/23 15:15	+0.79 (7.12)	0.00%	0.00%	Code "estimate" because only one valid check sample
19C060	11/27 16:00	+1.61 (12.79)	-0.31%	6.73%	
	5/29 16:00	+0.78 (3.25)	**-3.26%**	2.26%	
	07/30 16:15	+0.48 (4.57)	0.01%	0.23%	
	08/27 16:15	+0.65 (6.31)	0.00%	0.00%	Code "estimate" because only one valid check sample
	09/23 15:15	+0.29 (2.74)	0.00%	0.00%	Code "estimate" because only one valid check sample
19E060	11/27 14:45	+0.55 (4.65)	0.05%	0.27%	
	12/18 15:15	+0.85 (6.64)	0.63%	0.44%	
	05/29 14:00	+0.77 (6.78)	0.58%	1.12%	
	07/30 14:45	+0.86 (8.10)	0.01%	0.43%	Code "estimate" because only one valid check sample
	08/27 14:30	+1.14 (11.29)	0.00%	0.00%	Code "estimate" because only one valid check sample
	09/23 14:30	+0.53 (5.20)	0.00%	0.00%	Code "estimate" because only one valid check sample
25D050	11/13 13:30	+0.16 (1.38)	0.03%	2.40%	
Temperature (ºC)					
08C110	11/26 09:30	-0.03 (-0.36)	0.09%	0.42%	
	01/14 09:15	+0.21 (3.20)	-0.37%	2.39%	
	09/23 11:00	-.04 (-0.20)	0.37%	1.69%	
41A070	10/17 13:30	-0.03 (-2.46)	0.00%	0.00%	
	4/10 14:15	-0.18 (0.54)	5.16%	5.65%	
	9/18 13:15	-0.65 (-2.75)	0.20%	0.85%	
19D070	11/27 15:45	-0.24 (-3.99)	-0.20%	7.63%	
	01/29 16:45	-1.02 (-11.61)	8.14%	6.00%	
	05/29 17:30	-0.60 (-7.15)	-7.15%	4.85%	
	07/30 17:30	-0.67 (-5.31)	-0.15%	1.09%	
	09/23 16:15	-0.62 (-4.95)	0.06%	0.83%	
19E060	11/27 14:45	+0.26 (3.34)	0.71%	3.29%	
	12/18 15:15	+0.35 (6.54)	0.44%	0.31%	
	03/26 15:45	+0.33 (5.22)	0.08%	0.48%	
	05/29 14:00	-0.35 (-5.29)	-1.02%	4.93%	
	07/30 17:45	-1.82 (-14.31)	-0.93%	7.33%	

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
	08/27 14:30	-0.67 (0.95)	8.20%	6.04%	
25D050	11/13 13:30	-1.22 (-12.90)	0.79%	**11.27%**	Data gap after 11/23 (sensor malfunction). Reject data. Drift and check samples inconsistent. RSD did not meet QC requirements.
25E060	11/13 13:00	-0.17 (-2.02)	-0.10%	1.20%	
	1/22 14:00	-0.32 (-8.18)	-1.57%	2.91%	
	6/24 14:00	-0.66 (-2.37)	3.28%	4.77%	
	9/17 14:15	+0.22 (1.78)	-0.59%	0.47%	
19C060	11/27 15:45	+0.06 (0.54)	0.33%	2.05%	
	01/29 16:15	-0.45 (-5.46)	-0.32%	2.27%	
	5/29 16:00	-0.45 (-5.46)	0.32%	2.27%	
	9/23 15:15	+0.19 (-1.47)	0.02	0.20%	
Conductivity (uS/cm)					
08C110	10/17 09:15	-0.5 (0.41)	1.65%	6.23%	
	01/14 09:15	+4.5 (10.07)	0.05%	0.79%	
	07/22 9:45	+4 (3.81)	-3.81%	2.64%	
19C060	11/27 15:45	-14.5 (19.92)	-0.36%	2.38%	
	01/29 16:00	**-23 (-33.13)**	**2.24%**	**13.46%**	Reject data. Drift and check samples inconsistent. RSD did not meet QC requirements
	05/29 16:00	-1 (-1.39)	0.00%	0.00%	
	07/30 16:00	**-9.5 (-11.05)**	**-11.05%**	**7.28%**	Code as "estimate": Positive drift is indicated after offset is applied. RSD is excessive, though within QC requirements.
	08/27 16:15	-5 (-5.05)	-5.05%	3.48	Code "estimate" because only one valid check sample.
	09/27 15:15	+1 (.92)	-5.46%	0.65%	Code "estimate" because only one valid check sample.
41A070	10/17 13:30	+105 (19.55)	0.00%	0.00%	
	4/10 14:15	+11.25 (1.50)	-0.30%	1.81%	
	8/14 14:15	+27 (5.64)	-1.31%	2.80%	
25E060	11/13 13:00	None (0.00)	0.00%	0.00%	
	1/22 14:00	+8.5 (19.16)	0.04%	0.80%	
	6/24 14:00	+10 (20.88)	0.06%	1.17%	
	9/17 14:15	+12 (18.79)	0.96%	0.67%	
25F060	11/13 14:32	-2 (-5.95)	0.40%	2.25%	
	1/22 14:00	-1 (-3.34)	0.00%	0.00%	
	6/24 14:00	-1.2 (-3.44)	-3.44%	3.21%	
	9/17 14:30	-1.4 (-4.20)	-0.04%	1.35%	
25D050	11/13 13:30	None (0.00)	0.00%	0.00%	Code "estimate" because only one valid check sample.
19D070	10/23 16:00	-4 (-4.40)	0.00%	0.00%	Code "estimate" because only one valid check

Station	Deployment End	Offset[a] (original difference)	Average Percent Difference [b]	RSD	Comment
					sample.
	11/27 15:30	**NA**	**NA**	**NA**	**Reject data. Drift and check samples inconsistent.**
19E060	11/27 14:45	-15 (-19.31)	-0.53%	5.29%	
	12/18 15:15	-10 (17.24)	0.00%	0.00%	Code "estimate" because only one valid check sample.
	03/26 15:45	-7.3 (-10.36)	1.09%	2.12%	
	05/29 14:00	-8 (-10.88)	0.00%	0.00%	
	07/30 17:45	-10 (-9.83)	1.02%	2.00%	
	9/23 14:30	-10 (-8.57)	0.29%	1.81%	
25E060	11/13 13:00	0 (0.00)	0.00%	0.00%	
	1/22 14:00	+8.5 (19.16)	0.04%	0.80%	
	6/24 14:00	+10 (20.88)	0.06%	1.17%	
	9/17 14:15	+12 (18.79)	0.96%	0.67%	
pH (standard units)					
08C110	11/26 09:30	-0.59 (4.04)	4.19%	3.03%	
	01/14 09:15	-0.57 (-0.08)	0.00%	0.39%	
	09/23 11:00	+0.07 (.97)	0.00%	2.21%	

[a] Constant added to continuous data only if original average percent difference (in parentheses) was >2.0%.
[b] Percent difference between continuous data and grab sample after applying offset.
RSD: Relative standard deviation.
NA: Not Available
QC: Quality control

Conclusions and Recommendations

Following are conclusions and recommendations that result from this Water Year (WY) 2013 study by Ecology's River and Stream Monitoring Program.

Conclusions

- Most quality control (QC) results were within the limits specified in our *Quality Assurance Management Plan* and were consistent with findings in previous years.
- Except where noted otherwise, data collected in WY 2013 can be used without qualification.
- Our analysis indicated that freshwater contributions to nitrogen in the marine environment have not increased since 1995. Furthermore, there is an overall slight decreasing trend for total nitrogen (TN) flux from freshwater systems in the Puget Sound area from WY 1995-2013.
- Annual nitrogen yields in the Puget Sound area continue to be the highest in the Samish, Nooksack, and Stillaguamish watersheds. Summer nitrogen yields were highest in the Nooksack and Deschutes watersheds.
- Among the major rivers, the Snohomish and Nooksack represent the largest sources of freshwater nitrogen contribution to Puget Sound.
- Most all long-term TN and most nitrate + nitrite-nitrogen (NO2+NO3) trends, where significant, were down (decreasing concentrations).
- Since 2008, the mean difference in summer NO2+NO3 yields for all Puget Sound sites combined has increased slightly by 0.18 kg/sq. km/month, with a relative percent difference of 1.93%.

Recommendations

- Quality assurance issues identified from the continuous multiple parameter monitoring should be addressed during monitoring in WY 2014.
- Calibration methods and standards for the hand held LDO electrodes should be refined during monitoring in WY 2014.

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Appendices

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Appendix A. Station Description and Period of Record

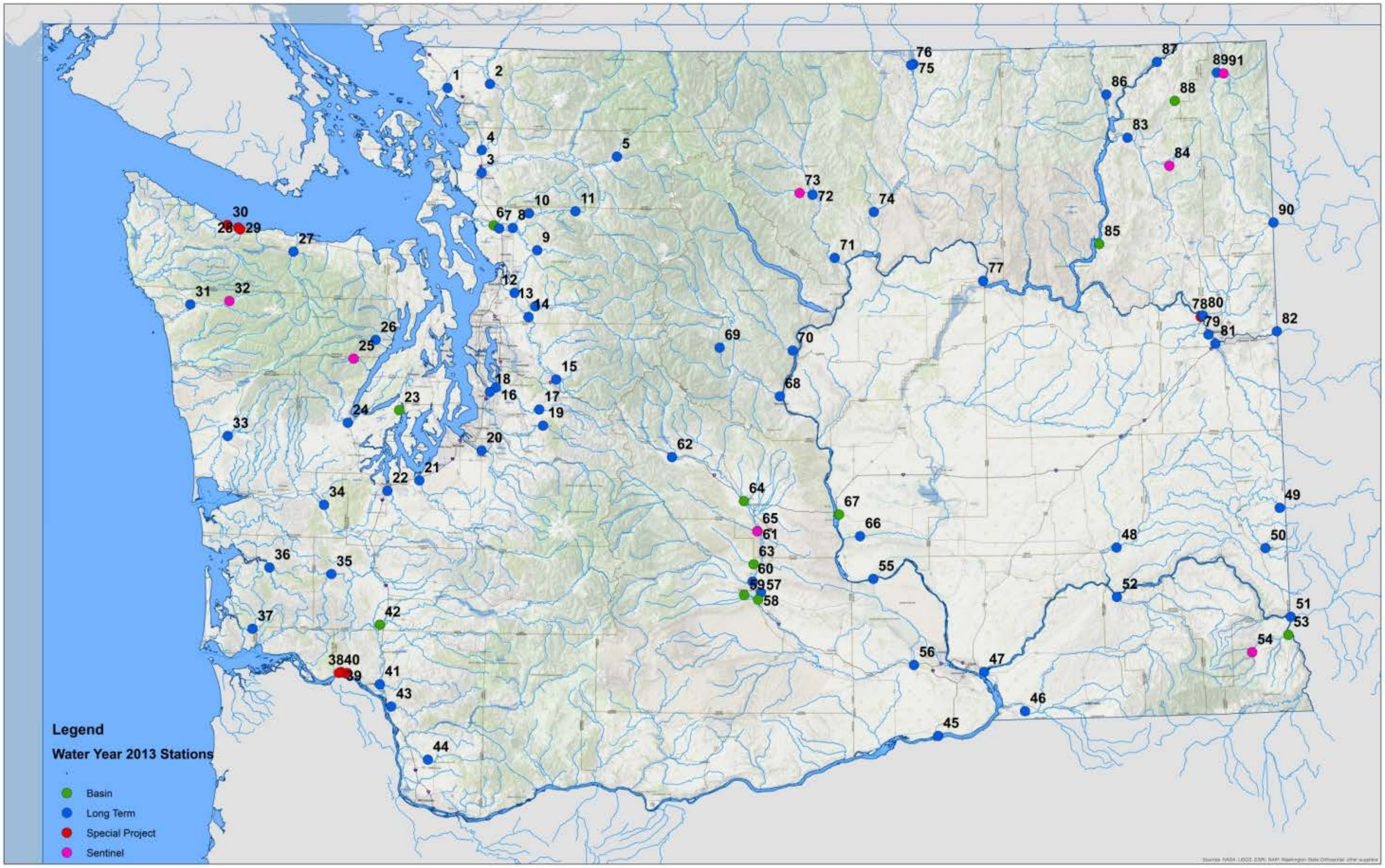

Figure A-1. Map showing stations monitored in Water Year 2013.

See Table 1 for the key.

The following 19-page table provides:

Monitoring History for Environmental Assessment Program Ambient Monitoring Stations

Monitoring History for Environmental Assessment Program Ambient Monitoring Stations

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
01A050	Nooksack R @ Brennan	L			X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
01A070	Nooksack R @ Ferndale	B		XXXXXXXX	XX X X				
01A090	Nooksack R nr Lynden	B			X X X				
01A120	Nooksack R @ No Cedarville	L	X	XXXXXXXX X	XX X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
01A140	Nooksack R above the MF	B					X	X X	
01B050	Silver Cr nr Brennan	B					XX		
01D070	Sumas R nr Huntingdon BC	B			X X XXX	XXXXXXXXXX	XXX X		
01D080	Sumas R @ Jones Road	B						X	
01D090	Sumas R @ Sumas	B			X X				
01D120	Sumas R nr Nooksack	B					X		
01E050	Whatcom Cr @ Bellingham	B			X X		X		
01E070	Whatcom Cr @ Lake Outlet	B			X				
01E090	Whatcom Lake nr Bellingham	B		XXX X	X				
01F070	SF Nooksack @ Potter Rd	B					X	X X	X
01G070	MF Nooksack R	B					X	X X	
01H070	Terrell Cr nr Jackson Rd	B						X	
01N060	Bertrand Cr @ Rathbone Rd	B						X	X
01N100	Bertrand @ 0 Ave	B							X
01T050	Anderson Cr @ South Bay Rd	B						X	
01U070	Fishtrap Cr @ Flynn Rd	B						X	
03A050	Skagit R @ Conway	B			X X				
03A060	Skagit R nr Mount Vernon	L	X	XXXXXXXX X	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
03A070	Skagit R nr Sedro Woolley	B			X X X				
03A080	Skagit R abv Sedro Woolley	B						X X	X
03B045	Samish R nr Mouth	B					X	X	
03B050	Samish R nr Burlington	L	X	XXXXXXXX X	XX X XXX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
03B070	Samish R nr Hoogdal	B			X				
03B077	Samish R abv Parson Cr	B							X
03B080	Samish R nr Prairie	B					X		
03C060	Friday Cr Blw Hatchery	B			X		X X		
03C080	Friday Cr at Alger	B			X				
03D050	Nookachamp Cr nr Mouth	B					X	X	
03E050	Joe Leary Slough nr Mouth	B						X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
03F070	Hill Ditch @ Cedardale Rd	B						X	
04A060	Skagit R @ Concrete	B			X X XXX	XXXXXXXXXX	XX X		
04A100	Skagit R @ Marblemount	L	X	XXXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
04A140	Skagit R @ Newhalem	B			X X				
04B070	Baker R @ Concrete	B		XXXX	XXX	XXXXXXXXXX	XX X		
04B150	Baker Lake @ Boulder Cr	B			XXXXX	X			
04C070	Sauk R nr Rockport	B			XXX	XXXXXXXXXX	XX X	X	
04C110	Sauk R @ Darrington	B	X	XX					
04C120	Sauk R @ Backman Park	B						X	
04E050	Finney Cr near Birdsview	B					X		
05A050	Stillaguamish R @ Stanwood	B			X				
05A055	Hat Slough nr Stanwood	B			X				
05A065	N Slough Stillaquamish@ Pioneer Hwy	B							X
05A070	Stillaguamish R nr Silvana	L	X	XXXXXXXXXX	XX X XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
05A080	Stillaguamish R @ Blue Stilly Park	B							XX
05A090	SF Stillaguamish R @ Arlington	L			X X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
05A110	SF Stillaguamish R nr Granite Falls	L	X	XXXXXXX	X		X XXXXX	XXXXXXXXXX	XXXX
05B070	NF Stillaguamish R @ Cicero	L		XXXXXXXX	XX X XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
05B090	NF Stillaguamish R @ Oso	B			X				
05B110	NF Stillaguamish R nr Darrington	L			X		X XXXXX	XXXXXXXXXX	XXXX
05G050	Jim Cr @ Jordan Rd	B							X
05L100	Church Cr @ 284th St	B							X
05M050	Montague Cr @ Hwy 530	B							X
07A090	Snohomish R @ Snohomish	L	X	XXXXXXXX X	XX X XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
07A100	Snohomish R @ Short School Rd	B							X
07A109	Snohomish R nr Monroe NE	B			X				
07A110	Snohomish R nr Monroe SW	B			X				
07A111	Snohomish R nr Monroe (USGS)	B			XX X	XX			
07B055	Pilchuck R @ Snohomish	B			X X XX	XXXXXXXXXX	XXX X		
07B075	Pilchuck R @ Russel Rd	B							X
07B090	Pilchuck R nr Lake Stevens	B			X				
07B120	Pilchuck R @ Robe-Menzel Rd	B						X	
07B150	Pilchuck R @ Menzel Lake Rd	B						X	
07C070	Skykomish R @ Monroe	L			X X XXX	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXXX

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
07C090	Skykomish R @ Sultan	B			X X				
07C120	Skykomish R nr Gold Bar	B	X	XXXXXXXXXX	X XX	XXXXXXXXXX	XXX	X	
07C170	Skykomish R nr Miller R	B			X				
07D050	Snoqualmie R nr Monroe	L			X		XX XXXXX	XXXXXXXXXX	XXXX
07D070	Snoqualmie R nr Carnation	B			X XX XXX	XXXXXXXXXX	XXX X		
07D100	Snoqualmie R abv Carnation	B						X	
07D130	Snoqualmie R @ Snoqualmie	L	X	XXXXXXXXXX	X XXX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
07D150	M F Snoqualmie R nr Ellisville	B					X	X	
07E055	Sultan R @ Sultan	B		XXXXXXXX X	XX X		X	X	
07F055	Woods Cr @ Monroe	B			X X		X X		
07G070	Tolt R nr Carnation	B		XXXXXXXXXX	X		X		
07M070	SF Snoqualmie R at North Bend	B					X		
07M120	SF Snoqualmie R @ 468th Ave SE	B						X	
07N070	NF Snoqualmie R near Ellisville	B					X		
07P070	Patterson Ck nr Fall City	B					X X		X
07Q070	Raging R @ Fall City	B					X	X	
07R050	French Cr nr Mouth	B					X		X
08A070	McAleer Cr nr Mouth	B			X				
08A090	Upper McAleer Cr	B			X				
08B070	Sammamish R @ Bothell	B	X	XXXXXXXXXX	XX X X XX	XXXXXXXXXX	XXXXX X		
08B110	Sammamish R @ Redmond	B			X		X		
08B130	Issaquah Cr nr Issaquah	B		XXX X	XX X X		X		
08C070	Cedar R @ Logan St/Renton	L	X	XXXXXXX	X X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
08C080	Cedar R @ Maplewood	B					X		
08C090	Cedar R @ Maple Valley	B			X		X		
08C100	Cedar R @ RR Grade Rd	B						X	
08C110	Cedar R nr Landsburg	L	X	XXX	X XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
08D070	Mercer Slough nr Bellevue	B			X				
08E090	Kelsey Cr @ Monitor Site	B			X				
08E110	Upper Kelsey Cr	B			X				
08F070	May Cr nr Mouth	B			X				
08G070	Valley Cr nr Mouth	B			X				
08H070	Thornton Cr nr Mouth	B			X				
08H100	North Branch Thornton Cr	B			X				

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
08J070	West Branch Thornton Cr	B			X				
08J100	Swamp Cr abv Lynnwood	B					X		
08K090	Ship Canal @ Freemont	B					X		
08K100	North Cr nr Everett	B					X		
08L070	Laughing Jacobs Cr nr Mouth	B						X	
08M070	SF Thornton Cr @ 107th Ave NE	B						X	
08N070	Johns Cr @ Gene Coulon Park	B						X	
09A060	Duwamish R @ Allentown Br	B				XXXXXXXXXX	XX		
09A070	Duwamish R @ Foster	B	X	XXXXXXXX					
09A080	Green R @ Tukwila	L					XXXXXXXXX	XXXXXXXXXX	XXXX
09A090	Green R @ 212th St nr Kent	B			X XX	XXXXXXXXXX	XX X		
09A110	Green R @ Auburn	B		XXXXX X	XX				
09A130	Green R Abv Big Soos/Auburn	B	X	XXXXXXXXXX	X		X		
09A150	Green R nr Auburn	B			X				
09A170	Green R nr Black Diamond	B			X				
09A190	Green R @ Kanaskat	L	X	XX	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
09B070	Big Soos Cr blw Hatchery	B			X X				
09B090	Big Soos Cr nr Auburn	B		XXXX	XX		X X		
09C070	Des Moines Cr nr Mouth	B			X		X	X	
09C090	Des Moines Cr @ So 200th	B			X				
09D070	Miller Cr nr Mouth	B			X			X X	
09D090	Miller Cr @ Ambaum Blvd SW	B			X				
09E070	Mill Cr @ Orillia	B				XXXXXX	X X		
09E090	Mill Cr @ Kent on W Valley Hwy	B				XXXXXX	X		
09F150	Newaukum Cr nr Enumclaw	B					X		
09H090	Black R @ Monster Rd SW	B					X	X	
09J090	Longfellow Cr abv 24-25th St juctn	B						XX	
09K070	Fauntleroy Cr nr Mouth	B						XX	
09L060	Walker Cr near mouth	B						X	
09M050	North Cr at Seahurst Pk	B						X	
09N050	Mullen Slough @ Frager Rd	B							X
09Q060	Redondo Cr abv Marine View Dr S	B							X
10A050	Puyallup R @ Puyallup	B	X	XXXXXXXX X	XXX XXXXX	XXX		XXX	
10A070	Puyallup R @ Meridian St	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
10A075	Puyallup R @ East Main St	B						X	
10A080	Puyallup R nr Sumner	B						X	
10A090	Puyallup R @ McMillin	B			X X				
10A110	Puyallup R @ Orting	B	X	XXX XXXXXX	XXX X XX	XXXXXXXXXX	XX X X		
10B070	Carbon R nr Orting	B		XX	XX		X		
10B090	Carbon R @ Fairfax	B			X				
10C070	White R @ Sumner	B			XX XX	XXXXXXXXXX	XX X X		
10C085	White R nr Sumner	B		X	X X		X		
10C090	White R @ Auburn	B		XXXXX	X X				
10C095	White R @ R Street	B					X	XXXXXXX X	
10C110	White R blw Buckley	B			X				
10C130	White R @ Buckley	B					X		
10C140	White R nr Buckley	B			X				
10C150	White R nr Greenwater	B			X				
10D070	Boise Cr @ Buckley	B		XXX	X			X	
10D090	Boise Cr nr Enumclaw	B		XXX					
10E070	Salmon Cr @ Sumner	B			X				
10F070	South Prairie Cr nr Crocker	B			X				
10F090	South Prairie Cr nr S Prairie	B					X		
10G080	Hylebos Cr @ 8th St E	B							X
10H070	Lake Tapps Tailrace @ E Valley Hwy	B						X	
10I050	Joe's Cr @ SR 509	B						X	
10J050	Lakota Cr @ Dumas Bay Center	B							X
11A070	Nisqually R @ Nisqually	L			X X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
11A080	Nisqually R @ McKenna	B	X	XXXXXXXXXX	X		XX X		
11A090	Nisqually R abv Powell Cr	B			X XX	XXXXXXXXXX	X		
11A110	Nisqually R @ LaGrande	B			X				
11A140	Nisqually R @ Elbe	B			X X XX	X			
12A070	Chambers Cr nr Steilacoom	B		XXXXX	XX X	XXXXXX	XX X X		
12A100	Chambers Cr blw Steilacoom Lk	B		XX	X		XXX		
12A110	Clover Cr abv Steilacoom Lk	B		XXX	X		XXXX		X
12A130	Clover Cr nr Parkland	B		XX					
12B070	Leach Cr nr Steilacoom	B		XXX	X			X	
12C060	Flett Cr @ 75th St W	B							X

Station Number	Name	Long-term or Basin	Water Year Sampled						
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
12C070	Flett Cr @ Custer Rd	B		XXX	X				
12D050	Ponce de Leon Cr nr mouth	B					XXX		
12F090	Spanaway Cr @ Old Military Rd	B						X	
13A050	Deschutes R @ Tumwater	B		XXXXX X	X X				
13A060	Deschutes R @ E St Bridge	L			XX	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXXX
13A080	Deschutes R nr Olympia	B			X X X				
13A150	Deschutes R nr Rainier	B	X	XXX	X X XX	XXXXXXXXXX	XX X		
14A060	Goldsborough Cr @ Shelton	B					X X		
14A070	Goldsborough Cr nr Shelton	B		XXX X	X				
14C050	Happy Hollow Cr at WA106	B							X
14D070	Sherwood Cr abv mouth	B							X
15A070	Dewatto R nr Dewatto	B			XXX		X	X	
15B050	Chico Cr nr Chico	B					X	X	
15B070	Chico Cr nr Bremerton	B		XXXXX	X				
15C070	Clear Cr @ Silverdale	B					X	X	
15D070	Tahuya R @ Tahuya River Rd	B						X	
15D090	Tahuya R nr Belfair	B					X		
15E070	Union R nr Belfair	B					X	X	
15F050	Big Beef Cr @ Mouth	B						XXXXX	XX
15G050	Little Mission Cr @ Hwy 300	B						X	
15H050	Stimson Cr @ Hwy 300	B						X	
15J050	Big Mission Cr @ Hwy 300	B						X	
15K070	Olalla Cr @ Forsman Rd	B						X	
15L050	Seabeck Cr @ mouth	B						XXXXX	XX
15M070	Llt Anderson Cr @ Anderson Hill Rd	B						XXXXX	XX
15N070	Stavis Cr nr Mouth	B						XXXXX	XX
16A070	Skokomish R nr Potlatch	L		XXXXXXXX X	X XXX XX	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
16B070	Hamma Hamma R nr Mouth	B		XXXXXX X	X X				
16B110	Hamma Hamma R nr Eldon	B			XX		X		
16B130	Hamma Hamma R @ Lena Creek Camp	B							XXX
16C070	Duckabush R @ Mouth	B		XXXXXXXX X	X X				
16C090	Duckabush R nr Brinnon	L			XXX		XXXXXX	XXXXXXXXXX	XXXX
16D070	Dosewallips R @ Brinnon	B	X	XXXXXXXXXX	X XXX		X		
16E070	Finch Cr @ Hoodsport	B					X X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
17A060	Big Quilcene R nr mouth	B						XX	X
17A070	Big Quilcene R nr Quilcene	B	X	XXXXXXX	XXX		X X		
17B070	Chimacum Cr nr Irondale	B					X		
17B090	Chimacum Cr @ Hadlock	B			X				
17B100	Chimacum Cr @ Chimacum	B					X		
17B110	Chimacum Cr nr Chimacum	B			X				
17C070	Jimmycomelately Cr near Mouth	B						XX	
17G060	Tarboo Cr nr mouth	B						X	
18A050	Dungeness R nr Mouth	B						XXXXXX	
18A070	Dungeness R nr Sequim	B	X	XXXXXXX	XXX		X X	XX	
18B070	Elwha R nr Port Angeles	L	X	XXXXXXX X	XXX		XXXXXX	XXXXXXXXXX	XXXX
18B080	Elwha R @ McDonald Br (USGS)	B			XXXXX	XX			
19A070	Pysht R nr Pysht	B			XXX				
19B070	Hoko R nr Mouth	B			X				
19B090	Hoko R nr Sekiu	B			XX				
19C060	West Twin R nr mouth	B						XXXXX	XXXX
19D070	East Twin R nr Mouth	B						XXXXX	XXXX
19E060	Deep Cr nr mouth	B						XXXXX	XXXX
20A090	Soleduck R nr Forks	B			XXX		X		
20A130	Soleduck R nr Fairholm	B		XXXXXXXX X	X				
20B070	Hoh R @ DNR Campground	L		XXXXXXXXXX	X XXX XX	X	XXXXXX	XXXXXXXXXX	XXXX
20C070	Ozette R @ Ozette	B	X	XX					
20D070	Dickey R nr La Push	B					X		
20E100	Twin Cr @ Upper Hoh Rd Br	B							XXX
20F070	Lake Cr at Hwy101	B							X
21A070	Queets R @ Queets	B		XXXXXXXXXX	X X		X		
21A080	Queets R nr Clearwater (USGS)	B			XX	XX			
21A090	Queets R abv Clearwater	B			XX				
21B090	Quinault R @ Lake Quinault	B	X	X XXXXXX	X XXX XX	X	X		
21C070	Clearwater R nr Queets	B			XX				
21D070	NF Quinault R @ Amanda	B			XXXXXXXXX	XX			
22A070	Humptulips R nr Humptulips	L	X	XXXXXXXXXX	X XXX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
22B070	WF Hoquiam R nr Hoquiam	B		XXXXX	XX		X		
22C050	Chehalis R nr Montesano	B			XX XX	XXXXXXXXXX	XXX		

Station Number	Name	Long-term or Basin		Water Year Sampled					
				<---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
22C070	Chehalis R nr Fuller	B			X X				
22D070	Wishkah R nr Wishkah	B		XXXXX	XX X				
22F090	Wynoochee R nr Montesano	B	X	XXXXXXXX X	X XX X				
22G070	Satsop R nr Satsop	B		XXXXXXXXXX	XX X XXX	XXXXXXXXXX	XX X		
22H070	Cloquallum Cr nr Elma	B		XXXX	X X X				
22J070	Wildcat Cr nr McCleary	B			X				
23A070	Chehalis R @ Porter	L	X	XXXXXXXXXX	XXXX XXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
23A100	Chehalis R @ Prather Rd	B					XXX	XXXX	
23A110	Chehalis R @ Galvin	B			X X X				
23A120	Chehalis R @ Centralia	B			XX	XXXXXXXXXX	XX X		
23A130	Chehalis R @ Claquato	B					X		
23A140	Chehalis R @ Adna	B			X X X				
23A160	Chehalis R @ Dryad	L	X	XXXXXXX	XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
23A170	Chehalis R nr Doty	B						X	
23B050	Newaukum @ Mouth	B					X		
23B070	Newaukum R nr Chehalis	B		XXXXXXXX	X X X		X		
23B090	SF Newaukum R @ Forest	B			X				
23C070	NF Newaukum R @ Forest	B			X				
23D055	Skookumchuck R @ Centralia	B					X X		
23D070	Skookumchuck R nr Centralia	B	X	X					
23E060	Black R @ Hwy 12	B						X	
23E070	Black R @ Moon Road Bridge	B					XX X XXX		
23F070	Mill Cr nr Bordeaux	B					X		
23G070	SF Chehalis R @ Beaver Creek Rd	B					X	X	
24B090	Willapa R nr Willapa	L		XX X	XXXXX XXXX	XX XXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
24B095	Willapa R nr Menlo	B						X	
24B130	Willapa R @ Lebam	B	X	XX X	XX	XXXXXXXXXX	XXX		X
24B150	Willapa R @ Swiss Picnic Rd	B						X	
24C070	SF Willapa R @ South Bend	B			X				
24D070	North R nr Raymond	B			X XX		XX		
24D090	North R @ Artic	B					X		
24E070	North Nemah R @ Nemah	B			X X				
24F040	Naselle R @ Mouth	B			X				
24F055	Naselle R @ Naselle	B			X				

Station Number	Name	Long-term or Basin	Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
24F070	Naselle R nr Naselle	L	XX X	X X XXXX	X	X XXXXX	XXXXXXXXXX	XXXX
24G070	Bear Branch nr Naselle	B	X	X				
24H070	Middle Nemah R nr Nemah	B		X				
24J070	South Nemah R nr Nemah	B		X				
24K060	Forks Cr abv Hatchery (outfall)	B						X
25A070	Columbia R @ Cathlamet	B	XX	X X				
25A075	Columbia R @ Bradwood	B		XXXXXX				
25A110	Columbia R @ Fisher Is Lt	B	XXXXX					
25A115	Columbia R nr Longview	B	XX	X X				
25A150	Columbia R blw Longview Br	B	X	X				
25B070	Grays R nr Grays River	B		X XX		X		X
25C070	Elochoman R nr Cathlamet	B	X	X XX		X	X	
25D050	Germany Cr @ mouth	B					XXXXX	XXXX
25E060	Abernathy Cr nr mouth	B					XXXXX	XXXX
25E100	Abernathy Cr @ DNR	B					XXXX	
25F060	Mill Cr nr mouth	B					XXXXX	XXXX
25F100	Mill Cr @ DNR	B					XXXX	
25G060	Coal Cr @ Harmony Rd	B						X
26B070	Cowlitz R @ Kelso	L	XXXXXXX	XX X XX	XXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
26B100	Cowlitz R @ Castle Rock	B	XXX	X XXXX			X	
26B150	Cowlitz R @ Toledo	B	XXXXX	X X XX	X	X		
26B180	Cowlitz R nr Kosmos B Cispus	B	X XXXXXXXX					
26B190	Cowlitz R nr Randle	B	X	X X X				
26B200	Cowlitz R nr Kosmos	B		X				
26C070	Coweeman R @ Kelso	B	XXXXX	XX X	XXXXXX	XXX X		
26C073	Coweeman R @ 3802 Allen Street	B						X
26C080	Coweeman R abv Goble Cr	B				X		
26C090	Coweeman R nr Rose Valley	B		X X				
26D070	Toutle R nr Castle Rock	B	XXXXXXXX X	X X X XX	XXXXXXXXXX	XXX		
26E070	Cispus R nr Kosmos	B		X	XXX			
26F050	Olequa Cr at 7th Street	B					X	
26G050	Lacamas Cr @ SR506	B						X
27A070	Columbia R @ Kalama	B	XX	X XX				
27A110	Columbia R nr St. Helens	B	XX	X				

Station Number	Name	Long-term or Basin		Water Year Sampled 1960s	1970s	1980s	1990s	2000s	2010s
27B050	Kalama R @ Kalama	B		XXXXXXXXXX	X				
27B070	Kalama R nr Kalama	L			XX XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
27B090	Kalama R @ Upper Hatchery	B			X				
27B110	Kalama R @ Pigeon Springs	B			X				
27C070	Lewis R @ Woodland @ I-5	B		XXXXX X	X XX				
27C080	Lewis R @ Co Rd 16	B					X		
27C110	Lewis R @ Ariel	B	X	X	XXX	X			
27D090	EF Lewis R nr Dollar Corner	L			XXX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
27E070	Cedar Cr nr Etna	B					X		
27F070	Gee Cr @ Ridgefield	B					X		
28A090	Columbia R blw Vancouver WA	B		XX	X				
28A091	Columbia R blw Vancouver OR	B		XX	X				
28A100	Columbia R @ Vancouver	B						X X	
28A165	Columbia R @ Warrendale	B			XXXXXXX				
28A170	Columbia R blw Bonneville	B		XX	X				
28A175	Columbia R @ Bonneville Dam	B		XX	X X				
28B070	Washougal R @ Washougal	B		X	X XX XX		X	X	
28B085	Washougal R abv Ltl Washougal R	B							X
28B090	Washougal R nr Washougal	B		XXXXXXXX	X				
28B110	Washougal R blw Canyon Cr	B					X X	X	
28C070	Burnt Br Cr @ Mouth	B			X			XX XX	
28C110	Burnt Br Cr @ Vancouver	B			X				
28D070	Salmon Cr @ Salmon Cr	B			X				
28D110	Salmon Cr nr Battle Ground	B			X				
28D170	Salmon Cr @ NE 199th/Hill rd	B							XX
28E070	Weaver Cr nr Battle Ground	B			X				
28F070	Lake R nr Ridgefield	B					X		
28G070	Gibbons Cr nr Washougal	B					X	X	
28H070	Campen Cr nr Washougal	B						X	
28I120	Lacamas Cr @ Goodwin Road	B						X	
28J070	Little Washougal Cr @ Blair Road	B						X	
29B070	White Salmon R nr Underwood	B		XXXXXXXXXX	X XX XXXX	XXXX	X		
29B090	White Salmon R @ Husum St	B						X	
29C070	Wind R nr Carson	B			X XXXX	XXXX	X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
29D070	Rattlesnake Cr nr Mouth	B					XXX	X	
29E070	Gilmer Cr nr Mouth	B					XXX		
30A070	Columbia R @ The Dalles	B		XX	XXXXXXXX		X		
30A090	Columbia R @ The Dalles Dam	B		X					
30B060	Klickitat R nr Lyle	B					XX		
30B070	Klickitat R nr Pitt	B		XXX	X XXXXXXX	X			
30C070	Little Klickitat R nr Wahkiacus	B			X		XX		
30C090	Little Klickitat R @ Olson Rd	B						X	
30C150	Little Klickitat R @ Hwy 97	B						X	
31A070	Columbia R @ Umatilla	L		X	XXXXX		XXXXXXXXX	XXXXXXXXXX	XXXX
31A090	Columbia R @ McNary Dam	B	X	XXXXXXXXXX					
31A130	Columbia R nr Yakima R Mouth	B		X					
31B110	Rock Cr @ Bickleton Hwy	B							X
31C012	Alder Cr @ 6 Prong Rd Bridge	B							X
31D010	Pine Cr @ One Mile Bridge	B							X
31E060	Glade Cr @ SR14	B							X
32A070	Walla Walla R nr Touchet	L	X	XXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
32A090	Walla Walla R nr Lowden	B			XX				
32A100	Walla Walla R at E Detour Road Br	B					X	X	
32A110	Walla Walla R @ College Place	B			XX XX				
32B070	Touchet R @ Touchet	B			X XX XX	XXXXXXXXXX	XXX X		
32B075	Touchet R @ Cummins Rd	B						X X	
32B080	Touchet R at Sims Rd	B					X	X	
32B100	Touchet R @ Bolles	B			XX		X	X	
32B120	Touchet R nr Dayton	B			XX				
32B130	Touchet R @ Dayton	B	X	X			XX		
32B140	Touchet R above Dayton	B					X		
32C070	Mill Cr @ Swegle Rd	B			X XX			X	
32C110	Mill Cr @ Tausick Way	B			X X		X		
33A010	Snake R nr Mouth	B		X					
33A050	Snake R nr Pasco	L		XXXXXXX X	X		XXXXXXXXX	XXXXXXXXXX	XXXX
33A070	Snake R blw Ice Harbor Dam	B		X	X XXXXXX	XXXXXXXXXX	XX		
34A070	Palouse R @ Hooper	L	X	XXXXXXXXXX	X XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
34A075	Palouse R @ Hwy 26	B						X	

Station Number	Name	Long-term or Basin	Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
34A080	Palouse R above Rebel Flat	B					X	
34A085	Palouse R @ Shields Rd Bridge	B				X	X	
34A090	Palouse R nr Diamond	B		X X				
34A109	Palouse R blw Colfax	B					X	
34A110	Palouse R abv Buck Canyon	B		X XX				
34A120	Palouse R at Colfax	B					X X	
34A170	Palouse R @ Palouse	L		X		XXXXXXXX	XXXXXXXXXX	XXXX
34A200	Palouse R nr Stateline	B					X	
34B070	SF Palouse R nr Colfax	B		X XX				
34B075	SF Palouse R @ Shawnee Rd	B					X	
34B080	SF Palouse R @ Albion	B					X	
34B090	SF Palouse R nr Pullman	B		X X				
34B110	SF Palouse R @ Pullman	L		X X XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
34B130	SF Palouse R blw Sunshine	B		X			XXX	
34B140	SF Palouse R @ Busby	B				X		
34C060	Paradise Cr at Mouth	B				X	XXX	
34C070	Paradise Cr nr Pullman	B		X				
34C100	Paradise Cr @ Border	B				X	XXX	
34D070	SF Palouse R Trib Whitman Fm	B		X				
34E070	Rock Cr at Revere	B				X		
34F090	Pine Cr @ Rosalia	B				X	X	
34H070	Pleasant Valley Cr blw St John	B					X	
34J050	Union Flat Cr nr Mouth	B					X	
34J070	Union Flat Cr @ Winona Rd	B					X	
34J090	Union Flat Cr @ Hwy 26	B					X	
34J120	Union Flat Cr @Almota Rd	B					X	
34K050	Rebel Flat Cr @ Mouth	B					X	
34K080	Rebel Flat Cr @ Repp Rd	B					X	
34K120	Rebel Flat Cr @ Fairgrounds	B					X	
34L050	Cow Cr @ mouth	B					X	
34M070	Dry Cr @ Pullman	B					X	
34N070	Missouri Flat Cr @ Pullman	B					X	
35A100	Snake R blw Lwr Granite Dam	B		X				
35A150	Snake R @ Interstate Br	L	XXXXX XX			XXXXXXXXX	XXXXXXXXXX	XXXX

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
35A200	Snake R nr Anatone	B			XXXXXXXX				
35B060	Tucannon R @ Powers	L			X XX	XXXXXXXXXX	XXX XXXXX	XXXXXXXXXX	XXXX
35B090	Tucannon R @ Smith Hollow	B						X	
35B100	Tucannon R @ Territorial Road	B						X	
35B110	Tucannon R nr Delaney	B	X	X					
35B120	Tucannon R @ Brines Road	B						X	
35B150	Tucannon R nr Marengo	B					X	X	
35C070	Grande Ronde R nr Anatone	B			X	XXX	X		
35D070	Asotin Cr @ 2nd Street	B			X		X X	X	X
35D120	NF Asotin Cr blw Lick Cr	B							XX
35E070	Clearwater R @ US12/95	B					X		
35F050	Pataha Cr near mouth	B						X X	X
35F070	Pataha Cr @ Archer Rd	B					X	X	
35F095	Pataha Cr @ Tatman Rd	B						X	
35F110	Pataha Cr @ Rosy Grade	B						X	
35L050	Almota Cr @ mouth	B						X	
35L140	Almota Cr @ Klemgard Rd	B						X	
35Q050	Little Almota Cr @ Mouth	B						X	
35R050	Steptoe Cr @ Mouth	B						X	
35R120	Steptoe Cr blw Stewart	B						X	
35R140	Steptoe Cr abv Stewart	B						X	
35S060	Wawawai Cr @ mouth	B						X	
35U070	Alkali Flat Cr nr Mouth	B						X	
35U090	Alkali Flat Cr abv Hay	B						X	
35U140	Alkali Flat Cr @ Little Alkali Rd	B						X	
35U190	Alkali Flat Cr @ Penewawa Rd	B						X	
35W070	Mud Flat Cr @ Mouth	B						X	
35Y070	Penewawa Cr nr Mouth	B						X	
35Y110	Penewawa Cr @ Looney Br	B						X	
35Y170	Penewawa Cr abv Goose cr	B						X	
35Z070	Little Penewawa Cr @ Mouth	B						X	
36A055	Columbia R @ Port of Pasco	B			X				
36A060	Columbia R @ Pasco	B		XX					
36A065	Columbia R @ Richland	B			X				

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
36A070	Columbia R nr Vernita	L		XX XX	X X XXX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
37A060	Yakima R @ VanGiesen Br	B			X XX				
37A070	Yakima R nr Richland	B			X				
37A090	Yakima R @ Kiona	L	X	XXX XXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
37A095	Yakima R 2 mi blw Prosser	B					X		
37A100	Yakima R below Prosser	B					X		
37A110	Yakima R @ Prosser	B			X XX				
37A130	Yakima R @ Mabton	B			X XX		X		
37A149	Yakima R @ Granger N Side	B			X				
37A150	Yakima R @ Granger S Side	B			X				
37A170	Yakima R nr Toppenish	B			X XX		X		
37A190	Yakima R @ Parker	B			X XXXXXXX	XXXXXXXXXX	XXX	X	
37A200	Yakima R abv Ahtanum Cr (USGS)	B			XX X	XX			
37A205	Yakima R @ Nob Hill	L					XXXXX	XXXXXXXXXX	XXXX
37A210	Yakima R nr Terrace Height	B			XX XX		X		
37B060	Satus Cr @ Satus	B			XX				
37C060	Toppenish Cr nr Satus	B			XX				
37D080	Marion Drain nr Granger	B			XX				
37E050	Wide Hollow Cr @ Main Street	B						XX	
37E070	Wide Hollow Cr @ Union Gap	B			X X		X		X
37E090	Wide Hollow Cr @ Goodman	B			X X				
37E100	Wide Hollow Cr @ 40th Ave	B							X
37E120	Wide Hollow Cr @ Randall Park	B						XX	
37F070	Sulphur Cr Wasteway @ McGee Rd	B					X		
37F080	Sulphur Cr @ Holaday Road	B						X	
37G050	Ahtanum Cr @ Fulbright Park	B						X	
37G120	Ahtanum Cr @ 62nd Ave	B						XX	
37I070	Moxee Drain @ Birchfield Rd	B						XX	
37J060	Snipes Cr nr Mouth	B							X
38A050	Naches R @ Yakima on US HWY 97	L		XXXXXXX			X XX	X X X	XXX
38A070	Naches R @ Yakima	B			X X				
38A110	Naches R @ Naches	B	X	X	X				
38A130	Naches R nr Naches	B		XXXX					
38B070	Tieton R @ Oak Cr	B		XXXX			X		

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
38C070	Rattlesnake Cr nr Nile	B		XX					
38D070	Bumping R @ American R	B		XX					
38E070	American R @ American R	B		XX					
38F070	Little Naches R nr Cliffdell	B		XXX			X		
38G070	Cowiche Cr @ Powerhouse Rd	B						XX	
38G120	Cowiche Cr @ Zimmerman Rd	B						XX	
39A050	Yakima R @ Harrison Bridge	B					XX	XXX X	
39A055	Yakima R @ Umtanum Cr Footbridge	L							XXXX
39A060	Yakima R @ Ellensburg	B					XX	XX	
39A070	Yakima R nr Thorp	B			X X				
39A080	Yakima R @ Cle Elum	B	X	XXXXXXXXXX	X				
39A090	Yakima R nr Cle Elum	L			X X		XXX XXXXX	XXXXXXXXXX	XXXX
39B070	Cle Elum R nr Cle Elum	B			X X				
39B090	Cle Elum R nr Roslyn	B					X		X
39C070	Wilson Cr @ Highway 821	B		XXXX	X X X		X	XX	
39D070	Teanaway R nr Cle Elum	B		XXXXX			X		
39F050	Wenas Cr nr Selah	B							X
39K060	Reecer Cr in Irene Rinehart Park	B							X
39M050	Swauk Cr nr Cle Elum	B							X
39M100	Swauk Cr @ Lauderdale Junction	B							X
39R050	Umtanum Cr nr mouth	B							XX
41A070	Crab Cr nr Beverly	L	X	XXXXXXXXXX	XXX XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
41A075	Crab Cr nr Smyrna	B		XXX					
41A090	Crab Cr nr Othello	B			X				
41A110	Crab Cr nr Moses Lake	B		X		XXXX	X X	X	
41D070	Rocky Ford Cr @ Hwy 17	B					X	X	
41E070	Sand Hollow Cr on Hwy 26	B					X		X
41F100	Rocky Ford Coulee Drain	B					X		
41G070	Rocky Coulee Wasteway @ K NE Road	B						X	
41H050	Moses Lake at South Outlet	B						X	
41J070	Lind Coulee @ Hwy 17	B						X	
42A070	Crab Cr below Adrian	B						X	
43A070	Crab Cr @ Irby	B		X			X	X	X
43A080	Crab Cr @ Odessa	B						X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
43A095	Crab Cr @ Amnen Road	B						X	
43A100	Crab Cr @ Marcelus Road	B					X	X	
43A110	Crab Cr at Tokio Road	B						X	
43A130	Crab Cr @ US23	B						X	
43A150	Crab Cr @ Bluestem Road	B					X	X	
43B090	Lake Cr @ Coffeepot Road	B					X		
43C070	Goose Cr nr Wilbur	B						X	
44A070	Columbia R blw Rock Is Dam	B			X XX XX	XXXXXXXXXX	XX		
44A190	Columbia R @ Hwy 2 Bridge	B						X	
45A070	Wenatchee R @ Wenatchee	L		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
45A075	Wenatchee R @ Sleepy Hollow Br	B						X	
45A085	Wenatchee R nr Dryden	B			X				
45A100	Wenatchee R @ Leavenworth	B			X				
45A110	Wenatchee R nr Leavenworth	L	X	XXXXXXXX	XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
45B070	Icicle Cr nr Leavenworth	B			X		X		
45C060	Chumstick Cr nr mouth	B						XX	
45C070	Chumstick Cr nr Leavenworth	B					XXX	X X	
45D070	Brender Cr nr Cashmere	B					XXX	X XX	
45D080	Brender Cr abv Noname Cr	B						X	
45E070	Mission Cr nr Cashmere	B					XXX	X XX	
45J070	Nason Cr nr mouth	B						X	
45K050	White R @ Road 6500 Bridge	B						X	
45L050	Little Wenatchee R @ 2 Rvr Grav Pit	B						X	
45Q060	Eagle Cr nr mouth	B						XX	
45R050	Noname Cr nr Cashmere	B						XX	
45R070	Noname Cr on Mill Rd	B						X	
46A070	Entiat R nr Entiat	L	X	XXXXXXX	X XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
47A070	Chelan R @ Chelan	B		XXXXXXXX X	X X XX XX	XXXXXXXXXX	XX X		
47B070	Columbia R @ Chelan Station	B					X X		
48A070	Methow R nr Pateros	L	X	XXXXXXX	X XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXX	
48A075	Methow R nr Pateros @ Metal Br	L						X	XXXX
48A130	Methow R nr Twisp	B			X XX	XXXXXXXXX			
48A140	Methow R @ Twisp	L				X	XX X XXXXX	XXXXXXXXXX	XXXX
48A150	Methow R @ Winthrop	B						X	

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
48A170	Methow R @ Weeman Br	B			X				
48A190	Methow R blw Gate Cr	B			X XX	X			
48B070	Chewuch R @ Winthrop	B			X			X	
48C070	Andrews Cr nr Mazama	B			XXXXXXXX	XX			
48D070	Twisp R nr Mouth	B						X	
48E070	Poorman Creek at Poorman Cutoff Rd	B							X
49A050	Okanogan R nr Brewster	B	X	XXXXXXX X	X				
49A070	Okanogan R @ Malott	L		XXX	X X XX XX	XX XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
49A090	Okanogan R @ Okanogan	B			X XX	XXXXXXXXX	X	X	
49A110	Okanogan R @ Omak	B						X	
49A130	Okanogan R @ Riverside	B						X	
49A170	Okanogan R @ Janis	B			X				
49A180	Okanogan R @ Tonaskat	B					X		
49A190	Okanogan R @ Oroville	L		XXXXXXX	XX XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
49B070	Similkameen R @ Oroville	L		XXXXXXX	XX XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
49B090	Similkameen R @ Nighthawk	B					X		
49B110	Similkameen R @ Chopaka, BC	B						XX	
49F070	Bonaparte Cr @ Tonasket	B						X	
49F105	Bonaparte Cr abv Tonasket	B						X	
50A070	Columbia R nr Brewster	B		X					
50A090	Columbia R @ Bridgeport	B		X					
50B070	Foster Cr @ Mouth	B						X	
51A070	Nespelem R @ Nespelem	B				XXXXXXXXXX	XX X		
52A070	Sanpoil R @ Keller	B		XXXXXXX	X XX XX	XXXXXXXXXX	XX X		
52A110	Sanpoil R 13 mi S Republic	B					X		
52A170	Sanpoil R blw Republic	B			X				
52A190	Sanpoil R abv Republic	B			X		X		
52B070	Lake Roosevelt from Keller Ferry	B					X		
53A070	Columbia R @ Grand Coulee	L			X XX XX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
53C070	Hawk Cr @ Miles-Creston Rd	B						X	X
54A050	Spokane R @ Mouth	B					XXXX		
54A070	Spokane R @ Long Lake	B	X	XXXXXXX X	XXXXXXXXXX	XX		XX	X
54A089	Spokane R 2 mi blw Ninemile dam	B			XX				
54A090	Spokane R @ Ninemile Br	B			X X			X XX	X X

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
54A120	Spokane R @ Riverside State Pk	L			XXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
54A130	Spokane R @ Fort Wright Br	B			X X				X
55B070	Little Spokane R nr Mouth	L			X X XXX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
55B075	Little Spokane R @ Painted Rocks	B					X		
55B080	Little Spokane R nr Griffith Spring	B					XX		
55B082	Little Spokane R abv Dartford Cr	B					XX X		
55B085	Little Spokane R nr Dartford	B		XXXXXXX					
55B090	Little Spokane R abv Wandermere	B			X				
55B100	Little Spokane R abv Deadman Cr	B					XX X		
55B200	Little Spokane R @ Chattaroy	B					X X		
55B300	Little Spokane R @ Scotia	B						X	
55C065	Deadman Cr nr Mouth	B					X		
55C070	Peone (Deadman) Cr abv Litt Deep Cr	B					XX	X	
55C200	Deadman Cr @ Holcomb Rd	B						X	
55D070	Deer Cr at Hwy 2	B					X		
55E070	Dragoon Cr at Crescent Road	B					X		
56A070	Hangman Cr @ Mouth	L			X X XXX	XXXXXXXXXX	XX X XXXXX	XXXXXXXXXX	XXXX
56A200	Hangman Cr @ Bradshaw Road	B					X		
57A120	Spokane R @ Spokane	B			X				
57A123	Spokane R @ Sandifer Bridge	B						X	X
57A125	Spokane R blw Monroe Street	B						X	
57A130	Spokane R @ Mission St Br	B			X X				
57A140	Spokane R @ Plante's Ferry Park	B						XX	X
57A145	Spokane R @ Trent Br	B			X				
57A146	Spokane R @ Sullivan Rd	B						X	X
57A148	Spokane R @ Barker Rd	B						X	
57A150	Spokane R @ Stateline Br	L	X	XXXXXX X	XX X X		XXXXXXXXX	XXXXXXXXXX	XXXX
57A190	Spokane R nr Post Falls	B			XXXXXXX	XXXXXXXXXX	XX		
57A240	Spokane R @ Lake Coeur d'Alene	B						XX	X
59A070	Colville R @ Kettle Falls	B		XXXXXXXXXX	X X XX XX	XXXXXXXXXX	XX X		
59A080	Colville R @ Greenwood Loop Rd	L					X	X	XXX
59A110	Colville R @ Blue Cr	B			X			X	X
59A130	Colville R @ Chewelah	B			X			XXX	
59A140	Colville R @ Newton Rd	B						XX	X

Station Number	Name	Long-term or Basin		Water Year Sampled <---1960s--->	<---1970s--->	<---1980s--->	<---1990s--->	<---2000s--->	<---2010s--->
59B070	Little Pend Oreille R @ Hwy 395	B						X	
59B200	Little Pend Oreille R nr NatWildRef	B							XXX
59C070	Sheep Cr at Long Prairie Rd	B							X
59D070	Hunters Creek at Hunters Inn	B							X
60A050	Kettle R @ Hedlund Bridge	B		X					
60A070	Kettle R nr Barstow	L		XXXXXXX X	X X XX XX	XXXXXXXXXX	XX XXXXXX	XXXXXXXXXX	XXXX
61A070	Columbia R @ Northport	L	X	XXXXXXXXXX	XXXXXXXXXX	XX	XXXXXXXXX	XXXXXXXXXX	XXXX
61B070	Deep Cr nr Mouth	B					X	X	X
61C070	Onion Cr nr Northport	B					X		
61C100	Onion Cr @ Widow-Hawks Rd	B							X
61D070	Sheep Cr nr Northport	B					X		
61E070	Meadow Creek at Aladdin Rd	B							X
62A070	Pend Oreille R @ Waneta BC (USGS)	B		XXX					
62A080	Pend Oreille R @ Border	B			XXXXXX	XX			
62A090	Pend Oreille R @ Metaline Falls	L	X	XXX			XX XX	XXXXXXXXXX	XXXX
62A150	Pend Oreille R @ Newport	L	X	XXXXXXX X	X XX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXX
62B070	Skookum Cr nr Mouth	B							X
62C070	NF Sullivan Creek	B							X

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Appendix B. Historical Changes in Sampling and Laboratory Procedures, as well as Large-Scale Environmental Changes Potentially Affecting Water Quality

This appendix provides a record of changes in methods and procedures used by Ecology's Freshwater Monitoring Unit to collect and analyze river and stream water quality data. Other environmental changes that may potentially affect water quality over a large area are also recorded here.

Many of the changes listed here are anecdotal and may or may not have affected data quality. Comments prior to October 1988 are based on interviews with individuals involved with the earlier program. Comments after that date have usually been recorded as the changes occurred.

General

- Jun to Sept 1985: Laboratory moved from Ecology's Southwest Regional Office to Manchester.
- Oct 1988: Implemented QA/QC program (See memo from David Hallock, October 17, 1988.)
- Prior to WY91: Samples were sent to contract labs from time to time. These occurrences are not all recorded here. Records are not detailed and only available from bench sheets archived by Manchester Laboratory.
- 1994: The use of Polyacrylamide (PAM) to control erosion from rill irrigation is becoming widespread in eastern Washington. Water quality effects are unknown.
- 1996: Began monitoring discharge at some stations ourselves (mostly basin stations), rather than contracting with USGS.
- 2001: Began running Central (Nov 2001) and Eastern (Feb 2002) runs out of regional offices. Barometric pressures calculated from airport readings, either uncorrected, if available, or re-converted to sea level.
- Jan-Jun 2002: Some barometric pressures collected from the western part of the state may be off by 1.0 mmHg due to calibration errors. The effect of this amount of error on the percent oxygen saturation calculation is insignificant.
- Oct 2005 (except the NW run, which made the change several months earlier): Previously, aliquots for pH, conductivity, and turbidity were obtained from the stainless steel bucket used to collect the oxygen. However, this presented a risk of contamination from the oxygen bottles. The sampler was re-designed so that only the oxygen sample is obtained from the bucket; all other samples are collected in passengers.
- Nov 2007: Implemented a Freshwater Technical Coordination Team-required "ride-along" procedure where a senior staff rides with each sampler once during the year to ensure SOP are followed uniformly.
- Jan 16, 2008: Implemented semi-annual calibration of Operation's Center digital barometer against Hg barometer in Air Lab at HQ. Digital BP read 30.86 before recalibration and 30.54 after. S, N, and W BP data since Oct 2006 could be up to 0.32 inches Hg high.
- Oct 1, 2010: Changed blank sample procedures. Previously, we added blank water to sample equipment then processed the water as a regular sample. Now, we are lowering the sample equipment from the bridge (without entering the water). This should capture potential contamination falling off the bridge during sampling.
- Sept 2013: Data adjustments for continuous data will no longer be applied within FMU databases containing continuous monitoring information. Coefficients will continue to be provided as

supplementary information within the monitoring section of the water year annual reports. Coefficients will be provided as supplementary information to adjust or non adjust continuous data based on the end users discretion.

Nutrients

- General: Prior to 1980, USGS labs analyzed samples.
- 1966-1969: One gallon of sample was collected in glass jars and held at room temperature for indefinite periods without preservative.
- 1970-1973: Unknown methods; may have been preserved with HgCl. Filtered in field.
- 1973: Laboratory moved from Tacoma to Salt Lake City.
- 1973-1974: Chilled, no preservative. Held as long as one week. Filtered in field; kept in brown poly bottle.
- 1972-1974?: For a short time, TP and NO3 may have been added by filters (probably 72-74). (Personal communications with Joe Rinnella, USGS).
- Sep 30, 1978: USGS Lab moved to Arvada, CO. Joint program samples sent there; samples collected for Ecology project only may have been analyzed in-house.
- ~1978: Chilled. Brown poly bottle? (the brown poly bottle may have been introduced later). 30-day holding time for NO2+NO3 implemented (status of other nutrients is unknown). (Source of methods prior to 1979: pers. comm. Joe Rinnella, USGS, and Skinner, Earl L. “Chronology of Water Resources Division activities that may have affected water quality values of selected parameters in Watstore, 1970-86. Provisional Report Feb 1989.)
- 1979: For a while, the USGS lab reported nutrient results to the nearest 0.01 units. Values below 0.005 were reported as 0.00. USGS decided to change all Watstore data = 0 to 0.01K back to 1973 for NO2+NO3. Decision on other nutrients is unknown, but they may also have been changed. Most of the 0s in our database have been converted to 0.01K (K-below the detection limit) but a few 0s may remain in the older data.
- 1980: USGS requires NO2+NO3 be preserved with HgCl. Status of other nutrients is unknown. Ecology requirements are unknown.
- Jun 1, 1980 to 1986: Nutrients analyzed by Pat Crawford at Southwest Regional Office.
- Aug 1985: High phosphate values, presumably a result of lab error. (Coded '9-do not use' in our database). (See “Trends in Puget Sound,” 1988, Tetra Tech, App. B.)
- 1986 to Apr 1987: Analyzed by various people, mostly Helen Bates, Steve Twiss, and Wayne Kraft at Manchester.
- Jun 1985: Switched from Technicon to Rapid Flow Analysis (Alpkem) auto-analyzers
- Apr 1987 to present: Analyzed by various people at Manchester.
- Jan 1987 to Jul 1987: NO3, NH3, and TP analyzed by contract lab.
- Mar 1990: Began using MFS cellulose acetate filters for field filtration of nutrients. Previously use Millipore, type HA (cellulose nitrate?).
- Sep 17 - Oct 12, 1990: All nutrient samples were contracted out.
- Oct 1990: Dissolved ammonia (P608) and dissolved nitrate+nitrite (P631) were added to the Marine network. Totals (P610 and P630) were dropped.
- Feb 1991: All nutrients sent to contract lab.
- Mar 1991: All nutrients sent to contract lab.
- ~1993: Began collecting nutrients in acid-washed poly-bottle passenger rather than in the stainless-steel bucket used for oxygen determinations.
- Jul 1994: The phosphorus content in laundry detergents is restricted to 0.5% and dishwashing detergent to 8.7% statewide (SSB 5320; WAC 70.85L.020). Phosphorus use had been limited in Spokane County one (?) year earlier.

- Feb 1999: Manchester Laboratory switched from manual to inline digestion for total phosphorus. In early 2003, during the course of evaluating a different method for phosphorus analysis, Manchester Laboratory discovered that the in-line method contained a high bias (4 to 20 ppb). Trend analyses of total phosphorus data should be interpreted carefully if results collected between Feb 1999 and Sept 2003 are included. (See email from Dean Momohara to David Hallock, 31 March 2003.) Total phosphorus data analyzed using this method have been coded "4" indicating a potential quality problem, and given a different name ("TP_PInline" rather than the usual "TP_P").
- Sep 2000: Nitrate+nitrite method nomenclature changed from EPA 353.2 to SM 4500NO3I because the latter method is more specific. The instrument used was changed at around this time from a "Flow analyzer" to a "Flow Injection" instrument and procedures may have changed slightly.
- Before Jul 2001: Ammonia method nomenclature changed from EPA 350.1 to SM 4500NH3H because the latter method is more specific. The instrument used was changed at around this time from a "Flow analyzer" to a "Flow Injection" instrument and procedures may have changed slightly.
- Before Aug 2001: Ortho-phosphorus method nomenclature changed from EPA 365.3M to SM 4500PG because the latter method is more specific. The instrument used was changed at around this time from a "Flow analyzer" to a "Flow Injection" instrument and procedures may have changed slightly.
- Before May 2000: Total nitrogen method nomenclature changed from VALDERRAMA to SM 4500NB because the latter method is more specific. The instrument used was changed at around this time from a "Flow analyzer" to a "Flow Injection" instrument and procedures may have changed slightly.
- Oct 2000: TP method changed from EPA 365.1 to SM4500PI. The former method specifies a manual digestion, while the latter correctly refers to the in-line digestion used by Manchester Laboratory's Lachat instrument.
- Oct 2000 to Feb 2001: A low bias may apply to TN data. Except for December data, Manchester Laboratory deemed the bias to be small enough that the data did not need to be qualified. December TN results were coded as estimates (See email from M. Lee to David Hallock, March 8, 2001.)
- Oct 2003: TP method changed from SM4500PI to EPA 200.8M, an ICP/MS method with low detection limits and without the bias associated with in-line digestion. Samples are collected in a 60mL container with HCl preservative instead of the earlier 125mL container with H_2SO_4 preservative.
- Oct 1, 2007 we changed total phosphorus analytical methods from EPA200.8M (ICP-MS) to SM4500PH (colorimetric with manual digestion). We made this change because we discovered that at turbidities greater than 4 NTUs, the ICP method is biased low compared to the colorimetric method. (See email from Dave Hallock to Bob Cusimano, October 25, 2007.)
- Jan 15, 2008: OP method changed from SM4500PG to SM4500PF and TOC method changed from EPA415.1 to SM5310B. Neither procedure actually changed.
- Jul 2008: The phosphorus content in dishwasher detergents is restricted in ~~certain counties~~ Spokane County ~~depending on population~~ as of this date (RCW 70.95L.020). (A new law signed in March 2008, eliminated Clark County from the July 1 deadline and weakened regulations that will start in Whatcom County. Phosphorus in laundry detergents has been restricted since 1994.)
- Jul 2010: The phosphorus content in dishwasher detergents will be restricted statewide as of this date (RCW 70.95L.020).

- Mar 2013 (after ERM analysis): TP method changed from SM4500PF to SM4500PH. In practices, pH is the same as PF but the instrument changed from Lachat 7500 to Lachat 8000. SM4500PF specifies 'Automated Ascorbic Acid Reduction Method' while SM4500PH specifies 'Manual Digestion and Flow Injection Analysis for Total Phosphorus'.
- Sept 2013: Changed peristaltic pump/filter stand from one using 142 mm diameter filters to one using 102 mm diameter filters. This apparatus filters samples for the laboratory analysis of orthophosphorus. For more information about this change, see the WY 2012 Annual Report.

Suspended Solids

- General: Filters were usually used, but sometimes Gooch crucibles were used.
- Feb 1978: Began collecting as passenger to oxygen sampler (was previously collected as aliquot of oxygen sampler). (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook.)
- Mid-1985: Amount filtered changed from 250 (?) to 500 ml.
- Sep 17 - Oct 12, 1990: Suspended sediment samples were contracted out.
- Apr 1991: Began collecting 1000 ml of sample.
- Jul 2002: A number of suspended solids results entered into our database as '0' were deleted. We do not know if these results were below reporting limits or "missing data"; 138 results collected between 1972 and 1981 were affected.
- Mar 2003: TSS method reference changed from EPA160.2 to SM 2540D. Methods did not change; the latter reference more accurately reflects analytical procedures. See email from Feddersen, Karin, March 24, 2003.

Conductivity

- Feb 1978: Began calibrating twice monthly using 40, 70, 140, and 200 umho/cm standards. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) Notebook)
- Oct 1991: All meters were re-calibrated Oct 11, 1991. One conductivity meter was not calibrated above 500 umhos/cm (and could not be calibrated). This meter had last been calibrated about 1 year earlier. Most meters read higher than the 100 umhos/cm standard.
- Oct 1994: Switched from Beckman model Type RB-5 (which could not be field calibrated) to Orion Model 126 meter, calibrated daily.
- 1998: Orion meter calibration began drifting during the day. Sometimes meter could only be calibrated to within 4 umhos/cm of the standard. At first, some samplers would correct the data, others would not. Now, these data are uncorrected and coded "J" (estimate).
- Oct 1, 2011: Dropped Orion model 126 meter and started using Hach model HQ40d combination meter for both pH and conductivity.
- Spring 2006: Changed from 500 mL to 100 mL "one-shot" standard, both from VWR.
- Summer 2009: Changed from 100 mL VWR snap-top standard to a 100 mL screw top by Ricca.
- Winter 2011: Changed from 100 mL screw top to 20 mL single use packets, both by Ricca.
- Sept 2013: Changed from single use packets to 500 mL bottle stock, with 100 mL aliquots used for calibration in the field. Also began measuring MEL-provided standard as a daily check standard. See the WY 2012 Annual Report for more discussion of conductivity standards.

Fecal Coliform Bacteria

- Early 1980s: field personnel may have analyzed some samples.

- Oct 7, 1975 to Nov 1981: fecal data from eastern Washington may be questionable during this period.
- 1980 to Mar 1988: No changes; analyzed by Nancy Jensen and others at Manchester. However, there is an apparent drop in monthly geometric means in late 1985. The may be coincident with moving the lab to Manchester (see memo from Dave Hallock to Dick Cunningham, June 18, 1991).
- Mar 1988: Switched to new filter with slightly better recovery.
- Nov 2000: Holding time was changed from 30 hours to 24 hours (Standard Methods changed to 24 hours with the 17th edition, 1989). As a result, more data have been coded "J" since then due to exceeding holding times.
- Sep 2003: FC method reference changed from SM 16-909C to SM 9222D. Methods did not change; the latter reference more accurately reflects analytical procedures. See email from Feddersen, Karin, September 15, 2003.
- ~Aug 2009: Pasco airport began x-raying water samples. Other airports may follow suit eventually. Exposure is < 1 millirad while doses used to kill bacteria on food are >30,000 rads. An unnamed contact at Washington's Department of Health stated that the dose is not a concern. We considered testing for an effect, but the number of samples required to detect a small effect is prohibitively large given the natural variance in bacteria data.

Turbidity

- 1970s: EPA specified a 2100A turbidimeter. Formerly, turbidity units were FTU (?)
- Jan 1976: Turbidity units changed from Jackson Turbidity Units (JTU) to Nephelometric Turbidity Units (NTU). (Source: review of historical reports.) These are roughly equivalent when greater than 25 JTU/NTU, otherwise not.
- Sep 1993: Lab began using a new turbidimeter, Hach model "Ratio X/R."
- Jan 2003: In our database, the units for turbidity results collected prior to January were changed from NTU back to JTU. Though roughly equivalent at JTUs > 25, these are not equivalent for lower measurements; the original units should have been retained.

Field pH

- Oct 7, 1975 to Nov 1981: pH data from eastern Washington are questionable during this period.
- Feb 1978: Began calibrating meter twice monthly. Previous procedures unknown. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook)
- 1986: Changed to Beckman digital pH meter with gel probe.
- Dec 1991: Changed to Orion model 250A meter with "spare water" liquid probe (uses 1M KCl, rather than 4M). Calibrate daily and check calibration three times during the sampling day.
- Oct 1, 2011: Dropped Orion model 250A meter and started using Hach model HQ40d combination meter for both pH and conductivity. See the WY 2011 Annual Report for results of a method comparison study.

Temperature

- Feb 1978: Switched from thermometer in bucket to thermistor in river. (See memo from Bill Yake, 30 Jan 1978 and Ambient Monitoring Procedure-1978(?) notebook.)

- Feb 1985: Checked thermistor calibration daily (internal calibration check based on red-lining needle, not a check against a NIST thermometer) (Memorandum from John Bernhardt, Feb 7, 1985).
- Spring 1994: Switched to YSI 300 meter (precision +/- 0.4C)
- Jan 1, 2001: Began calibrating thermistors prior to each run rather than annually. Some thermistors were found to be as much as 1-2 °C low.
- About May 2006: Began evaluating thermistor calibration at several temperatures and calculating correction coefficients based on a linear regression correction. Corrections are applied upon data entry by the database rather than by the sampler.

Oxygen

- Oct 1, 1977: Began measuring barometric pressure to calculate percent saturation. Previous saturation calculations were presumably based on elevation.
- Mar 1989: Began applying correction factor to results of Winkler analyses based on titration with sodium biiodate to correct sodium thiosulfate normality to 0.025. Previously, thiosulfate was standardized upon preparation, but not during use.

Barometric Pressure

- Feb 1985: Began calibrating barometer before each run based on National Weather Service report from Olympia airport (Memorandum from John Bernhardt, Feb 7, 1985).
- 1995: Began calibrating barometer prior to each run using an on-site mercury barometer rather than pressure as reported by the Olympia airport.
- 2003: Began calibrating barometer prior to each run using an on-site digital barometer rather than the mercury barometer. Calibrating digital barometer to mercury barometer annually.
- Jan 2008: Began calibrating on-site digital barometer twice yearly against a mercury barometer.
- ~April 2011: Evaluated historical data against elevation-based BP and adjusted quality codes for some data points. Implemented BP QC check which compares BP during data entry to expected BP based on elevation.

Chlorophyll

- Mar 15, 1990: Switched to fluorometric method (from spectrophotometric). New method has lower detection limit (0.02 ug/L) but less precision. (See memo from Despina Strong, April 12, 1990.)

Hardness

- Jul 1, 1991: Began using 125 ml bottle with HNO3 as preservative. (Previously, aliquot from unpreserved general chemistry bottle was used.)

Metals

- May 1994: Implemented low-level dissolved metals monitoring at selected stations. Metals results prior to this date are questionable unless well above detection limits and have been quality-coded "9" in our database so that they will not routinely be retrieved. Quality problems include inconsistent blank correction and indications of simultaneous peaks and troughs in data series from unrelated stations for results above reporting limits.

- Apr 2010: A review of historical blank data showed that dissolved zinc exceed reporting limits of 1 ug/L 43% of the time (though never greater than 5 ug/L). As a result, we have decided to set the quality code field = 4 for reported dissolved zinc results < 5 ug/L, which indicates a potential data quality issue.

Flow

- Oct 1, 2009: Began recording uncorrected stage, correction, and error estimate.
- Feb 2011: Processing of flow for ambient stations shifted from Howard Christensen to Jason Myers. Prior to this time, flows below some dams (e.g., Grand Coulee) were miss-calculated. (These flows have been corrected.)
- Oct 2011: Decided to remove flows from the web (and replace with a link to our source, typically USGS, USCOE, or in-house) and code flows in EIM "Instantaneous flow based on provisional data obtained from various sources. Not confirmed." We also developed procedures to automate retrieval of flow data and to document and manage metadata used for determining flow (e.g., time of travel correction).

Appendix C. Water Year 2013: Sources of Raw Data

Data discussed in this report are available in electronic format through various sources:

1. Ambient river and stream monitoring data are available on Ecology's web pages (www.ecy.wa.gov). Look under "Programs," "Environmental Assessment", and "River and Stream Water Quality."

2. Data are available in Ecology's Environmental Information Management (EIM) system. From Ecology's main page (www.ecy.wa.gov), look under "Scientists," "Environmental Monitoring Data", and "EIM." Our project IDs are listed in Table C-1.

Table C-1. Ambient Monitoring EIM projects.

Project ID	Description	Status	Start Date
AMS001	Statewide River and Stream Ambient Monitoring-WY2010 to present (published data)	ONGOING	10/1/2009
AMS001-2	Statewide River and Stream Ambient Monitoring-WY2011 to present-2 (provisional data)	ONGOING	10/1/2009
AMS001B	Statewide River and Stream Ambient Monitoring-Pre 1980	COMPLETED	1/1/1949
AMS001C	Statewide River and Stream Ambient Monitoring-WY1980 to WY1988	COMPLETED	1/1/1980
AMS001D	Statewide River and Stream Ambient Monitoring-WY1989 through WY1999	COMPLETED	10/1/1988
AMS001E	Statewide River and Stream Ambient Monitoring-WY2000 through WY2009	COMPLETED	10/1/1999
AMS002	Statewide Lake Monitoring	COMPLETED	1/1/1989
AMS002B	Lake Mini-Monitoring (published data)	ONGOING	1/1/2010
AMS002B-2	Lake Mini-Monitoring (provisional data)	ONGOING	1/1/2011
AMS004	Continuous Stream Monitoring	ONGOING	6/1/2001

3. Data are available by contacting the Ecology staff person responsible for ambient monitoring in the region, currently:

- Ecology Central Region: Dan Dugger (509.454.4183; ddug461@ecy.wa.gov)
- Ecology Eastern Region: Jim Ross (509.329.3425; jros461@ecy.wa.gov)
- Ecology Northwest Region: Bill Ward (360.407.6621; bwar461@ecy.wa.gov)
- Ecology Southwest Region: Bill Ward (360.407.6621; bwar461@ecy.wa.gov)

The first two digits of each station number is the Water Resource Inventory Area (WRIA) number. This number can be used to identify which Water Quality Management Area (WQMA) or "basin" each station is in, according to Table C-2.

Table C-2. Washington's Water Quality Management Areas.

Basin	WRIAs	Basin	WRIAs
Cedar/Green	8-9	Nooksack/San Juan	1-2
Columbia Gorge	27-29	Okanogan	48-53
Eastern Olympics	13-14, 16-19	Puyallup/Nisqually	10-12
Esquatzel/Crab Creek	36, 42-43	Skagit/Stillaguamish	3-5
Horseheaven/Klickitat	30-31	Spokane	54-57
Island/Snohomish	6-7	Upper and Lower Snake	32-35
Kitsap	15	Upper Columbia/Pend Oreille	58-62
Lower Columbia	24-26	Upper Yakima	38-39
Lower Yakima	37	Wenatchee	40, 44-47
Mid Columbia	41	Western Olympics	20-23

Codes for Ambient Monitoring Data Remarks

Remarks codes in historical data are defined below. Only "U", "J", and "G" were used in WY 2013.

B,V Analyte was found in the blank indicating possible contamination.
E Result is an estimate due to interference.
G, L True result is equal to or greater than reported value.
H Sample was analyzed over holding time.
J The reported result is an estimate.
K, U The analyte was not detected at or above the reported result.
N Spike sample recovery was outside control limits.
P Result is between the detection limit and the minimum quantitation limit (applied to metals).
S Spreader: one or more bacteria colonies were smeared, possibly obscuring other colonies.
X High background count of non-target bacteria, possibly obscuring additional colonies.

Appendix D. Water Year 2013: Missing Data

Table D-1. Missing data for the 12 standard parameters.
"X"=missing

Station	Date	Remarks	Temperature	Conductivity	Oxygen	pH	Suspended Solids, total	Total Persulfate Nitrogen	Ammonia-nitrogen	Nitrate+nitrite-nitrogen	Phosphorus, total	Orthophosphate	Turbidity	Fecal Coliform Bacteria
09A190	11/26/2012				X									
13A060	7/29/2013				X	X								
16B130	12/17/2012		X		X	X	X	X	X	X	X	X	X	X
16B130	1/28/2013		X		X	X	X	X	X	X	X	X	X	X
16B130	2/25/2013													X
19C060	12/18/2012													X
19D070	12/18/2012													X
19E060	12/18/2012													X
20B070	12/18/2012													X
20E100	12/18/2012													X
20E100	9/23/2013		X		X	X	X	X	X	X	X	X	X	X
22A070	12/18/2012													X
37A090	11/5/2012													X
45A110	11/13/2012		X		X	X	X	X	X	X	X	X	X	X
45A110	6/10/2013		X		X	X	X	X	X	X	X	X	X	X
48E070	2/4/2013					X								
49A070	2/4/2013		X		X	X	X	X	X	X	X	X	X	X
53A070	8/5/2013		X		X	X	X	X	X	X	X	X	X	X
54A120	10/17/2012						X	X	X	X	X		X	X
57A150	7/10/2013				X									
59A080	5/7/2013													X
59B200	5/7/2013													X
59D070	5/7/2013													X
60A070	5/7/2013													X
61A070	5/7/2013													X
61E070	5/7/2013													X
54A090	8/7/2013						X	X	X	X	X		X	X

Appendix E. Nitrogen Trends in Puget Sound Rivers

Table E-1. Tabulated trends at long-term ambient monitoring stations in Puget Sound area rivers.

N= number of data points; Z=test statistic; 2 P = 2-tailed probability: test =statistical test used. (sk = seasonal Kendall; Mann- Kendall; c = corrected for auto correlation. Significant trends are highlighted in **Bold**)*

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
Flow All Seasons (WY 1995-2013)							
01A050	1995-2013	238	8.6	0.4285	0.668	skc	N+
01A120	1995-2013	225	-10.0	-0.3024	0.762	skc	N-
03A060	1995-2013	239	-20.0	-0.2058	0.837	skc	N-
03B050	1995-2013	227	-1.1	-1.295	0.195	skc	N-
04A100	1995-2013	240	14.6	0.2874	0.774	skc	N+
05A070	1995-2013	227	-3.7	-0.2605	0.794	skc	N-
05A090	1995-2013	124	-32.2	-1.6466	0.100	skc	N-
05A110	1995-2013	117	11.2	1.6564	0.098	sk	N+
05B070	1995-2013	224	-0.8	-0.0969	0.923	skc	N-
05B110	1995-2013	222	-1.3	-0.382	0.702	skc	N-
07A090	1995-2013	237	13.1	0.2551	0.799	skc	N+
07C070	1995-2013	219	4.0	0.0961	0.923	skc	N+
07D050	1995-2013	203	-0.9	-0.0081	0.994	skc	N-
07D130	1995-2013	228	0.0	-0.0062	0.995	skc	N-
08C070	1995-2013	236	3.5	1.503	0.133	skc	N+
08C110	1995-2013	233	3.3	1.2826	0.200	skc	N+
09A080	1995-2013	239	8.0	1.6891	0.091	skc	N+
09A190	1995-2013	239	4.9	1.8069	0.071	skc	N+
10A070	1995-2013	240	18.2	1.0521	0.293	skc	N+
11A070	1995-2013	236	3.2	0.4372	0.662	skc	N+
13A060	1995-2013	223	0.7	0.4635	0.643	skc	N+
16A070	1995-2013	236	20.1	3.1232	**0.002**	skc	**YES+**
16C090	1995-2013	223	1.4	0.7411	0.459	skc	N+
18B070	1995-2013	240	10.1	1.4593	0.144	skc	N+
Flow July - September (WY 1995-2013)							
01A050	1995-2013	80	8.99694	0.4867	0.626	sk	N+
01A120	1995-2013	75	6.16655	0.1426	0.887	sk	N+
03A060	1995-2013	80	53.49195	0.3023	0.762	skc	N+
03B050	1995-2013	76	-1.41593	-1.5396	0.124	sk	N-
04A100	1995-2013	80	22.74995	0.4224	0.673	skc	N+
05A070	1995-2013	80	-18.1312	-0.7802	0.435	skc	N-

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
05A090	1995-2013	42	-40.4446	-1.8161	0.069	sk	N-
05A110	1995-2013	40	4.88438	0.5814	0.561	sk	N+
05B070	1995-2013	76	-2.23424	-0.1225	0.903	sk	N-
05B110	1995-2013	76	0.98742	0.3673	0.713	sk	N+
07A090	1995-2013	80	12.82417	0.2271	0.820	sk	N+
07C070	1995-2013	76	-3.93331	-0.105	0.916	sk	N-
07D050	1995-2013	75	-14.43161	-0.3386	0.735	sk	N-
07D130	1995-2013	76	-2.9054	-0.315	0.753	sk	N-
08C070	1995-2013	79	3.91929	1.9808	**0.048**	skc	**YES+**
08C110	1995-2013	80	2.62588	1.3167	0.188	sk	N+
09A080	1995-2013	80	7.22703	2.3853	**0.017**	sk	**YES+**
09A190	1995-2013	80	3.44382	1.7371	0.082	sk	N+
10A070	1995-2013	80	40.35157	1.8507	0.064	sk	N+
11A070	1995-2013	79	5.99897	0.6772	0.498	sk	N+
13A060	1995-2013	76	-0.2906	-0.2101	0.834	sk	N-
16A070	1995-2013	80	16.03268	3.165	**0.002**	sk	**YES+**
16C090	1995-2013	77	0.2672	0.0591	0.953	skc	N+
18B070	1995-2013	80	9.60574	1.0225	0.307	sk	N+
TN All Seasons (WY 1995-2013)							
01A050	1995-2013	236	-0.00397	-2.5177	**0.012**	skc	**YES-**
01A120	1995-2013	227	-0.00295	-5.2604	**0.000**	sk	**YES-**
03A060	1995-2013	238	-0.00144	-3.1009	**0.002**	skc	**YES-**
03B050	1995-2013	226	-0.01082	-3.348	**0.001**	skc	**YES-**
04A100	1995-2013	238	-0.00088	-2.498	**0.012**	skc	**YES-**
05A070	1995-2013	238	-0.00549	-3.6961	**0.000**	skc	**YES-**
05A090	1995-2013	227	-0.004	-3.0611	**0.002**	skc	**YES-**
05A110	1995-2013	227	-0.00129	-1.8727	0.061	skc	N-
05B070	1995-2013	226	-0.00226	-3.9502	**0.000**	sk	**YES-**
05B110	1995-2013	227	-0.00161	-2.3744	**0.018**	skc	**YES-**
07A090	1995-2013	240	-0.00314	-3.3496	**0.001**	skc	**YES-**
07C070	1995-2013	223	-0.00075	-1.4323	0.152	skc	N-
07D050	1995-2013	227	-0.00515	-3.598	**0.000**	skc	**YES-**
07D130	1995-2013	228	-0.00234	-3.1572	**0.002**	skc	**YES-**
08C070	1995-2013	239	-0.00501	-3.7514	**0.000**	skc	**YES-**
08C110	1995-2013	222	-0.00265	-3.3757	**0.001**	skc	**YES-**
09A080	1995-2013	237	-0.00473	-2.2062	**0.027**	skc	**YES-**
09A190	1995-2013	238	-0.0014	-1.7785	0.075	skc	N-
10A070	1995-2013	238	-0.00244	-2.3096	**0.021**	skc	**YES-**

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
11A070	1995-2013	240	-0.0047	-3.1919	**0.001**	skc	**YES-**
13A060	1995-2013	228	-0.0003	-0.105	0.916	skc	N-
16A070	1995-2013	235	-0.00206	-3.7153	**0.000**	skc	**YES-**
16C090	1995-2013	234	0.00E+00	0.0351	0.972	skc	N+
18B070	1995-2013	239	0.00042	1.7894	0.074	skc	N+
TN Summer (WY 1995-2013)							
01A050	1995-2013	80	-0.00363	-2.3363	**1.95E-02**	skc	**YES-**
01A120	1995-2013	76	-0.00323	-3.6612	**2.51E-04**	skc	**YES-**
03A060	1995-2013	80	-0.00132	-2.0713	**3.83E-02**	skc	**YES-**
03B050	1995-2013	76	-0.01189	-5.1787	**2.23E-07**	skc	**YES-**
04A100	1995-2013	80	-0.00079	-1.7057	8.81E-02	skc	N-
05A070	1995-2013	80	-0.00568	-4.1753	**2.98E-05**	skc	**YES-**
05A090	1995-2013	76	-0.00499	-2.526	**1.15E-02**	skc	**YES-**
05A110	1995-2013	76	-0.001	-0.9123	3.62E-01	skc	N-
05B070	1995-2013	76	-0.00231	-2.2792	**2.27E-02**	skc	**YES-**
05B110	1995-2013	76	-0.0015	-2.2603	**2.38E-02**	skc	**YES-**
07A090	1995-2013	80	-0.00265	-2.0123	**4.42E-02**	skc	**YES-**
07C070	1995-2013	76	-0.002	-2.4337	**1.49E-02**	skc	**YES-**
07D050	1995-2013	76	-0.00524	-4.0771	**4.56E-05**	skc	**YES-**
07D130	1995-2013	76	-0.00238	-2.3783	**1.74E-02**	skc	**YES-**
08C070	1995-2013	80	-0.00437	-3.6088	**3.08E-04**	sk	**YES-**
08C110	1995-2013	80	-0.00252	-2.7627	**5.73E-03**	sk	**YES-**
09A080	1995-2013	80	-0.00347	-1.4636	1.43E-01	skc	N-
09A190	1995-2013	80	-0.00128	-1.4934	1.35E-01	skc	N-
10A070	1995-2013	80	-0.00465	-3.2632	**1.10E-03**	skc	**YES-**
11A070	1995-2013	80	-0.00602	-3.2477	**1.16E-03**	skc	**YES-**
13A060	1995-2013	76	-0.0006	-0.4026	6.87E-01	skc	N-
16A070	1995-2013	80	-0.00177	-2.845	**4.44E-03**	skc	**YES-**
16C090	1995-2013	80	-0.00025	-0.832	4.05E-01	skc	N-
18B070	1995-2013	80	0.00041	1.6765	9.36E-02	skc	N+
NO2+NO3 All Seasons (WY 1995-2013)							
01A050	1995-2013	236	-0.00135	-1.266	0.206	skc	N-
01A120	1995-2013	227	-0.00074	-1.9738	**0.048**	sk	**YES-**
03A060	1995-2013	239	-0.0006	-1.4086	0.159	skc	N-
03B050	1995-2013	226	-0.00681	-2.4627	**0.014**	skc	**YES-**
04A100	1995-2013	239	-0.00039	-1.4698	0.142	skc	N-
05A070	1995-2013	239	-0.00299	-2.503	**0.012**	skc	**YES-**
05A090	1995-2013	228	-0.002	-2.305	**0.021**	skc	**YES-**

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
05A110	1995-2013	226	0.00029	0.6078	0.543	skc	N+
05B070	1995-2013	227	-0.00035	-0.4841	0.628	skc	N-
05B110	1995-2013	228	-0.00067	-1.0302	0.303	skc	N-
07A090	1995-2013	240	-0.00137	-2.727	**0.006**	sk	**YES-**
07C070	1995-2013	223	0.00E+00	0.1477	0.883	skc	N+
07D050	1995-2013	227	-0.0022	-2.508	**0.012**	skc	**YES-**
07D130	1995-2013	228	-0.00143	-2.51	**0.012**	skc	**YES-**
08C070	1995-2013	240	-0.00372	-5.023	**0.000**	sk	**YES-**
08C110	1995-2013	222	-0.00251	-6.662	**0.000**	sk	**YES-**
09A080	1995-2013	238	-0.00129	-0.9413	0.347	skc	N-
09A190	1995-2013	238	-0.00033	-1.0125	0.311	skc	N-
10A070	1995-2013	240	0.00127	1.5985	0.110	skc	N+
11A070	1995-2013	240	-0.00202	-1.5726	0.116	skc	N-
13A060	1995-2013	228	0.00413	1.2436	0.214	skc	N+
16A070	1995-2013	235	-0.00138	-3.1258	**0.002**	skc	**YES-**
16C090	1995-2013	235	0.00E+00	0.8341	0.404	skc	N+
18B070	1995-2013	239	0.00031	2.1763	**0.030**	skc	**YES+**
NO2+NO3	**July - September (WY 1995-2013)**						
01A050	1995-2013	80	-0.00199	-1.233	2.18E-01	sk	N-
01A120	1995-2013	76	-0.00143	-2.1551	**3.12E-02**	sk	**YES-**
03A060	1995-2013	80	-0.00099	-2.0637	**3.91E-02**	sk	**YES-**
03B050	1995-2013	76	-0.00758	-2.3471	**1.89E-02**	skc	**YES-**
04A100	1995-2013	80	-0.00055	-1.6684	9.52E-02	skc	N-
05A070	1995-2013	80	-0.00385	-3.2141	**1.31E-03**	sk	**YES-**
05A090	1995-2013	76	-0.00312	-2.5893	**9.62E-03**	sk	**YES-**
05A110	1995-2013	76	0.00E+00	0	1.00E+00	sk	N
05B070	1995-2013	76	-0.00061	-0.6134	5.40E-01	sk	N-
05B110	1995-2013	76	-0.001	-1.4889	1.37E-01	sk	N-
07A090	1995-2013	80	-0.00117	-1.4934	1.35E-01	sk	N-
07C070	1995-2013	76	-0.00116	-1.4451	1.48E-01	skc	N-
07D050	1995-2013	76	-0.00163	-1.4167	1.57E-01	skc	N-
07D130	1995-2013	76	-0.00143	-1.9063	5.66E-02	skc	**YES-**
08C070	1995-2013	80	-0.00381	-3.0027	**2.68E-03**	sk	**YES-**
08C110	1995-2013	80	-0.00309	-5.1835	**2.18E-07**	sk	**YES-**
09A080	1995-2013	80	-0.00017	-0.0849	9.32E-01	skc	N-
09A190	1995-2013	80	-0.00025	-0.6989	4.85E-01	sk	N-
10A070	1995-2013	80	0.00011	0.0649	9.48E-01	sk	N+
11A070	1995-2013	80	-0.00299	-2.0937	**3.63E-02**	skc	**YES-**

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
13A060	1995-2013	76	0.00363	1.2476	2.12E-01	skc	N+
16A070	1995-2013	80	-0.00134	-3.0544	**2.26E-03**	skc	**YES-**
16C090	1995-2013	80	0.00E+00	0.726	4.68E-01	sk	N+
18B070	1995-2013	80	0.00032	1.9613	**4.98E-02**	sk	**YES+**
Flow-Adjusted TN All Seasons (WY 1995-2013)							
01A050	1995-2013	235	-0.00437	-2.6675	**7.64E-03**	skc	**YES-**
03A060	1995-2013	236	-0.00172	-3.1577	**1.59E-03**	skc	**YES-**
03B050	1995-2013	225	-0.00879	-2.7305	**6.32E-03**	skc	**YES-**
04A100	1995-2013	237	-0.00095	-2.4915	**1.27E-02**	skc	**YES-**
05A070	1995-2013	225	-0.00541	-3.4336	**5.96E-04**	skc	**YES-**
05A090	1995-2013	123	-0.00358	-2.1394	**3.24E-02**	skc	**YES-**
05A110	1995-2013	116	-0.00072	-0.7217	4.70E-01	skc	N-
05B070	1995-2013	222	-0.00269	-2.5676	**1.02E-02**	skc	**YES-**
05B110	1995-2013	220	-0.0016	-2.0726	**3.82E-02**	skc	**YES-**
07A090	1995-2013	236	-0.00376	-3.3471	**8.17E-04**	skc	**YES-**
07C070	1995-2013	216	-0.00075	-1.1738	2.40E-01	skc	N-
07D050	1995-2013	202	-0.00523	-3.397	**6.81E-04**	skc	**YES-**
07D130	1995-2013	227	-0.00243	-3.1574	**1.59E-03**	skc	**YES-**
08C070	1995-2013	234	-0.00637	-3.66	**2.52E-04**	skc	**YES-**
08C110	1995-2013	221	-0.00269	-3.3875	**7.05E-04**	skc	**YES-**
09A080	1995-2013	236	-0.00499	-2.2688	**2.33E-02**	skc	**YES-**
09A190	1995-2013	237	-0.00143	-2.0234	**4.30E-02**	skc	**YES-**
10A070	1995-2013	237	-0.00308	-2.4321	**1.50E-02**	skc	**YES-**
11A070	1995-2013	235	-0.00659	-3.3597	**7.80E-04**	skc	**YES-**
13A060	1995-2013	222	0.0007	0.1756	8.61E-01	skc	N+
16A070	1995-2013	232	-0.00234	-3.9621	**7.43E-05**	skc	**YES-**
16C090	1995-2013	220	-0.00006	-0.1016	9.19E-01	skc	N-
18B070	1995-2013	238	0.00051	1.3468	1.78E-01	skc	N+
Flow-Adjusted TN July - September (WY 1995-2013)							
01A050	1995-2013	80	-0.00456	-2.19	**2.85E-02**	sk	**YES-**
03A060	1995-2013	80	-0.00138	-2.19	**2.85E-02**	sk	**YES-**
03B050	1995-2013	76	-0.00881	-4.0058	**6.18E-05**	sk	**YES-**
04A100	1995-2013	80	-0.00076	-1.6384	1.01E-01	sk	N-
05A070	1995-2013	80	-0.00456	-2.8389	**4.53E-03**	sk	**YES-**
05A090	1995-2013	42	-0.0027	-1.553	1.20E-01	skc	N-
05A110	1995-2013	40	-0.00025	-0.2236	8.23E-01	sk	N-
05B070	1995-2013	76	-0.00286	-2.2244	**2.61E-02**	skc	**YES-**
05B110	1995-2013	76	-0.00174	-2.1516	**3.14E-02**	sk	**YES-**

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
07A090	1995-2013	80	-0.00297	-2.2549	**2.41E-02**	sk	**YES-**
07C070	1995-2013	76	-0.00173	-1.9767	**4.81E-02**	sk	**YES-**
07D050	1995-2013	75	-0.00572	-3.6894	**2.25E-04**	sk	**YES-**
07D130	1995-2013	76	-0.00241	-2.6278	**8.59E-03**	skc	**YES-**
08C070	1995-2013	79	-0.00537	-4.0624	**4.86E-05**	sk	**YES-**
08C110	1995-2013	80	-0.00249	-3.7798	**1.57E-04**	sk	**YES-**
09A080	1995-2013	80	-0.00366	-1.4751	1.40E-01	skc	N-
09A190	1995-2013	80	-0.00106	-1.0755	2.82E-01	skc	N-
10A070	1995-2013	80	-0.005	-2.8713	**4.09E-03**	sk	**YES-**
11A070	1995-2013	79	-0.0079	-3.1373	**1.70E-03**	skc	**YES-**
13A060	1995-2013	76	-0.00095	-0.2865	7.74E-01	skc	N-
16A070	1995-2013	80	-0.0021	-3.0283	**2.46E-03**	skc	**YES-**
16C090	1995-2013	77	-0.00019	-0.6516	5.15E-01	sk	N-
18B070	1995-2013	80	0.00062	1.5087	1.31E-01	sk	N+
Flow-Adjusted NO2+NO3 All Seasons (WY 1995-2013)							
01A050	1995-2013	235	-0.00181	-1.5587	1.19E-01	skc	N-
01A120	1995-2013	223	-0.00124	-1.6676	9.54E-02	skc	N-
03A060	1995-2013	237	-0.00061	-1.4099	1.59E-01	skc	N-
03B050	1995-2013	225	-0.00547	-1.8127	6.99E-02	skc	N-
04A100	1995-2013	238	-0.00042	-1.513	1.30E-01	skc	N-
05A070	1995-2013	226	-0.00295	-2.3744	**1.76E-02**	skc	**YES-**
05A090	1995-2013	123	-0.00137	-0.8643	3.87E-01	skc	N-
05A110	1995-2013	115	-0.00122	-0.8124	4.17E-01	skc	N-
05B070	1995-2013	223	-0.00094	-1.0139	3.11E-01	skc	N-
05B110	1995-2013	221	-0.00091	-1.1514	2.50E-01	skc	N-
07A090	1995-2013	236	-0.00185	-2.3706	**1.78E-02**	skc	**YES-**
07C070	1995-2013	216	-0.00009	-0.2481	8.04E-01	skc	N-
07D050	1995-2013	202	-0.00233	-2.341	**1.92E-02**	skc	**YES-**
07D130	1995-2013	227	-0.00145	-2.5033	**1.23E-02**	skc	**YES-**
08C070	1995-2013	235	-0.0049	-5.5526	**2.81E-08**	sk	**YES-**
08C110	1995-2013	221	-0.00243	-6.7323	**1.67E-11**	sk	**YES-**
09A080	1995-2013	237	-0.00228	-1.2318	2.18E-01	skc	N-
09A190	1995-2013	237	-0.00066	-1.2545	2.10E-01	skc	N-
10A070	1995-2013	239	0.00078	1.1455	2.52E-01	skc	N+
11A070	1995-2013	235	-0.00295	-2.062	**3.92E-02**	skc	**YES-**
13A060	1995-2013	222	0.00422	1.3234	1.86E-01	skc	N+
16A070	1995-2013	232	-0.00168	-3.4909	**4.81E-04**	skc	**YES-**
16C090	1995-2013	221	-5.75E-06	-0.0357	9.72E-01	skc	N-

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
18B070	1995-2013	238	0.00015	1.087	2.77E-01	skc	N+
Flow-Adjusted NO2+NO3 July - September (WY 1995-2013)							
01A050	1995-2013	80	-0.00242	-1.3464	1.78E-01	sk	N-
01A120	1995-2013	75	-0.0019	-1.8001	7.18E-02	sk	N-
03A060	1995-2013	80	-0.00092	-1.8007	7.18E-02	sk	N-
03B050	1995-2013	76	-0.00587	-1.5539	1.20E-01	skc	N-
04A100	1995-2013	80	-0.00048	-1.5857	1.13E-01	skc	N-
05A070	1995-2013	80	-0.00335	-2.1344	**3.28E-02**	skc	**YES-**
05A090	1995-2013	42	-0.00066	-0.2476	8.04E-01	sk	N-
05A110	1995-2013	40	-0.00122	-0.8106	4.18E-01	skc	N-
05B070	1995-2013	76	-0.00085	-0.6368	5.24E-01	skc	N-
05B110	1995-2013	76	-0.00147	-1.7318	8.33E-02	sk	N-
07A090	1995-2013	80	-0.00166	-1.6709	9.47E-02	sk	N-
07C070	1995-2013	76	-0.00092	-1.2672	2.05E-01	skc	N-
07D050	1995-2013	75	-0.00179	-1.446	1.48E-01	skc	N-
07D130	1995-2013	76	-0.00166	-2.0828	**3.73E-02**	skc	**YES-**
08C070	1995-2013	79	-0.0051	-3.4349	**5.93E-04**	sk	**YES-**
08C110	1995-2013	80	-0.00275	-5.062	**4.15E-07**	sk	**YES-**
09A080	1995-2013	80	-0.00044	-0.097	9.23E-01	skc	N-
09A190	1995-2013	80	-0.0004	-0.6867	4.92E-01	skc	N-
10A070	1995-2013	80	-0.00041	-0.3082	7.58E-01	sk	N-
11A070	1995-2013	79	-0.00364	-2.1796	**2.93E-02**	skc	**YES-**
13A060	1995-2013	76	0.00326	1.0919	2.75E-01	skc	N+
16A070	1995-2013	80	-0.00158	-3.4592	**5.42E-04**	skc	**YES-**
16C090	1995-2013	77	0.00004	0.0686	9.45E-01	sk	N+
18B070	1995-2013	80	0.00018	1.3181	1.87E-01	skc	N+
NO2+NO3 Yield All Seasons (WY 1995-2013)							
01A050	1995-2013	236	786.46342	1.1017	2.71E-01	skc	N+
01A120	1995-2013	225	-221.0952	-0.4998	6.17E-01	skc	N-
03A060	1995-2013	238	-6002.626	-0.5707	5.68E-01	skc	N-
03B050	1995-2013	225	-3.926	-0.9777	3.28E-01	skc	N-
04A100	1995-2013	238	371.20729	0.1903	8.49E-01	skc	N+
05A070	1995-2013	227	-239.7727	-0.7805	4.35E-01	skc	N-
05A090	1995-2013	124	-196.6236	-2.2927	**2.19E-02**	sk	**YES-**
05A110	1995-2013	117	19.18949	0.4253	6.71E-01	skc	N+
05B070	1995-2013	224	-498.3023	-1.0222	3.07E-01	skc	N-
05B110	1995-2013	222	-6.31318	-0.7104	4.77E-01	skc	N-
07A090	1995-2013	237	-1352.094	-0.4822	6.30E-01	skc	N-

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
07C070	1995-2013	217	3064.3268	0.3617	7.18E-01	skc	N+
07D050	1995-2013	203	-8746.631	-1.2775	2.01E-01	skc	N-
07D130	1995-2013	228	-1751.43	-0.9888	3.23E-01	skc	N-
08C070	1995-2013	236	-185.4969	-0.6567	5.11E-01	skc	N-
08C110	1995-2013	222	-147.9817	-1.193	2.33E-01	skc	N-
09A080	1995-2013	238	3054.107	1.3333	1.82E-01	skc	N+
09A190	1995-2013	238	139.4191	1.1029	2.70E-01	skc	N+
10A070	1995-2013	240	15339.824	2.1219	**3.38E-02**	skc	**YES+**
11A070	1995-2013	236	-3189.946	-1.0319	3.02E-01	skc	N-
13A060	1995-2013	223	495.48439	0.8689	3.85E-01	skc	N+
16A070	1995-2013	233	1.65482	0.0394	9.69E-01	skc	**N+**
16C090	1995-2013	222	3.745	0.7006	4.84E-01	sk	N+
18B070	1995-2013	239	210.21731	2.0999	**3.57E-02**	skc	**YES+**
NO2+NO3 Yield July - September (WY 1995-2013)							
01A050	1995-2013	80	1077.5182	1.2655	2.06E-01	sk	N+
01A120	1995-2013	75	7.0179	0	1.00E+00	sk	N
03A060	1995-2013	80	3810.5727	0.1732	8.63E-01	skc	N+
03B050	1995-2013	76	-6.18657	-1.9245	5.43E-02	sk	N-
04A100	1995-2013	80	483.383	0.1475	8.83E-01	skc	N+
05A070	1995-2013	80	-399.7146	-1.2167	2.24E-01	sk	N-
05A090	1995-2013	42	-353.8041	-2.1463	**3.19E-02**	sk	**YES-**
05A110	1995-2013	40	-5.01881	-0.0447	9.64E-01	sk	N-
05B070	1995-2013	76	-104.1161	-0.19	8.49E-01	skc	N-
05B110	1995-2013	76	0.93169	0.0525	9.58E-01	sk	N+
07A090	1995-2013	80	-2367.955	-0.8273	4.08E-01	sk	N-
07C070	1995-2013	76	-2328.527	-0.2624	7.93E-01	sk	N-
07D050	1995-2013	75	-8999.855	-1.0872	2.77E-01	sk	N-
07D130	1995-2013	76	-2327.895	-1.277	2.02E-01	sk	N-
08C070	1995-2013	79	109.82679	0.4624	6.44E-01	sk	N+
08C110	1995-2013	80	-159.242	-1.01	3.13E-01	skc	N-
09A080	1995-2013	80	4183.0183	2.19	**2.85E-02**	sk	**YES+**
09A190	1995-2013	80	202.41606	0.8593	3.90E-01	skc	N+
10A070	1995-2013	80	16964.878	1.7682	7.70E-02	sk	N+
11A070	1995-2013	79	-2643.623	-0.9248	3.55E-01	sk	N-
13A060	1995-2013	76	165.30707	0.2288	8.19E-01	skc	N+
16A070	1995-2013	80	-15.18483	-0.2271	8.20E-01	sk	N-
16C090	1995-2013	77	2.63611	0.3772	7.06E-01	sk	N+
18B070	1995-2013	80	182.36736	1.7527	7.97E-02	sk	N+

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
TN Yield	**All Seasons (WY 1995-2013)**						
01A050	1995-2013	236	-0.14104	-0.6366	5.24E-01	skc	N-
01A120	1995-2013	224	-0.28217	-2.1023	**3.55E-02**	sk	**YES-**
03A060	1995-2013	237	-0.15029	-1.4338	1.52E-01	skc	N-
03B050	1995-2013	226	-0.48158	-2.3219	**2.02E-02**	skc	**YES-**
04A100	1995-2013	238	-8474.466	-1.1088	2.68E-01	sk	N-
05A070	1995-2013	226	-14892.03	-2.467	**1.36E-02**	skc	**YES-**
05A090	1995-2013	124	-7776.911	-2.6926	**7.09E-03**	skc	**YES-**
05A110	1995-2013	117	0.44762	1.1171	2.64E-01	skc	N+
05B070	1995-2013	223	-0.20077	-1.7304	8.36E-02	skc	N-
05B110	1995-2013	221	-0.16949	-1.1519	2.49E-01	skc	N-
07A090	1995-2013	237	-0.18273	-1.2476	2.12E-01	skc	N-
07C070	1995-2013	217	-0.0893	-0.5072	6.12E-01	skc	N-
07D050	1995-2013	203	-1.10406	-1.8003	7.18E-02	skc	N-
07D130	1995-2013	228	-0.23758	-1.3283	1.84E-01	skc	N-
08C070	1995-2013	235	-0.10612	-0.976	3.29E-01	skc	N-
08C110	1995-2013	222	-0.11929	-1.3514	1.77E-01	skc	N-
09A080	1995-2013	237	0.33046	0.8303	4.06E-01	skc	N+
09A190	1995-2013	238	0.0266	0.3917	6.95E-01	skc	N+
10A070	1995-2013	238	0.08143	0.23	8.18E-01	skc	N+
11A070	1995-2013	236	-0.21201	-2.2765	**2.28E-02**	skc	**YES-**
13A060	1995-2013	223	0.10996	0.3737	7.09E-01	skc	N+
16C090	1995-2013	221	14.14957	0.9801	3.27E-01	skc	N+
16A070	NA	NA	NA	NA	NA	NA	NA
18B070	1995-2013	239	657.37485	2.2287	**2.58E-02**	skc	**YES+**
TN Yield	**Summer (WY 1995-2013)**						
01A050	1995-2013	80	-0.14304	-0.8598	3.90E-01	sk	N-
01A120	1995-2013	75	-0.30052	-1.3724	1.70E-01	sk	N-
03A060	1995-2013	80	-0.0996	-0.73	4.65E-01	sk	N-
03B050	1995-2013	76	-0.66293	-2.9213	**3.49E-03**	sk	**YES-**
04A100	1995-2013	80	-8209.684	-0.5235	6.01E-01	skc	N-
05A070	1995-2013	80	-18156.31	-2.6442	**8.19E-03**	sk	**YES-**
05A090	1995-2013	42	-6387.832	-2.6416	**8.25E-03**	sk	**YES-**
05A110	1995-2013	40	0.27402	0.4711	6.38E-01	skc	N+
05B070	1995-2013	76	-0.16863	-1.312	1.90E-01	sk	N-
05B110	1995-2013	76	-0.04797	-0.4023	6.87E-01	sk	N-
07A090	1995-2013	80	-0.16805	-0.8598	3.90E-01	sk	N-
07C070	1995-2013	76	-0.19703	-1.0671	2.86E-01	sk	N-

Station ID	Water Years	N	Slope	Z	2*P	test	Signif
07D050	1995-2013	75	-1.50215	-2.4061	**1.61E-02**	sk	**YES-**
07D130	1995-2013	76	-0.2404	-1.5219	1.28E-01	sk	N-
08C070	1995-2013	79	0.03816	0.2312	8.17E-01	sk	N+
08C110	1995-2013	80	-0.07597	-0.6639	5.07E-01	skc	N-
09A080	1995-2013	80	0.35291	1.0544	2.92E-01	sk	N+
09A190	1995-2013	80	0.02432	0.2433	8.08E-01	sk	N+
10A070	1995-2013	80	0.08782	0.4056	6.85E-01	sk	N+
11A070	1995-2013	79	-0.14962	-1.6317	1.03E-01	skc	N-
13A060	1995-2013	76	-0.03963	-0.1581	8.74E-01	skc	N-
16C090	1995-2013	80	8.18048	0.0162	9.87E-01	sk	N+
16A070	NA	NA	NA	NA	NA	NA	NA
18B070	1995-2013	77	6.20511	0.12	9.04E-01	sk	N+

skc = Seasonal Kendall
sk = Mann-Kendall
N+ = Non-significant positive trend
N- = Non-significant negative trend
YES+ = Significant positive trend
YES- = Significant negative trend
NA = Not available

Appendix F. Glossary, Acronyms, and Abbreviations

Glossary

Ambient: Background or away from point sources of contamination.

Anadromous: Types of fish, such as salmon, that go from the sea to freshwater to spawn.

Anthropogenic: Human-caused.

Basin: A drainage area or watershed 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.

Bi-monthly: Every other month.

Char: Char (genus *Salvelinus*) are distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

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

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

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

Diurnal: Pertaining to the day or each day; daily.

Exceeded: Did not meet.

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

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

Grab sample: A discrete sample from a single point in the water column or sediment surface.

Hardness: A measure of the dissolved solids in a water sample (e.g., calcium, magnesium).

Noise: An unwanted perturbation to a wanted signal. Noise is used here to indicate any result not representative of the environmental conditions being monitored.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

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.

Salmonid: Fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char.

Sinusoidal: An oscillation that can be described with a sine function.

Spatial: How concentrations differ among various parts of the river.

Stage height: Water surface elevation.

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

Temporal: Characterize over time (e.g., temporal trends).

Thermistors: Data loggers.

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

Total suspended solids (TSS): Portion of solids retained by a filter.

Trend: A change over time.

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

Water Year (WY) 2013: October 1, 2012 through September 30, 2013.

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.

7-DADMax: Seven-day average of the daily maximum (usually temperature).

7-DADMin: Seven-day average of the daily minimum (usually oxygen).

Acronyms and Abbreviations

BP	Barometric Pressure
DQO	Data quality objective

DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EF	East Fork
EIM	Environmental Information Management database
IMW	Intensively Monitored Watersheds
EPA	U.S. Environmental Protection Agency
LDO	Luminescent Dissolved Oxygen
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
n	number
NF	North Fork
NO2+NO3	Nitrate + nitrite-nitrogen
QA	Quality assurance
QAMP	Quality Assurance Management Plan
QC	Quality control
RMS	Root mean squared
RSD	Relative standard deviation
SF	South Fork
SM	Standard method
Std dev	Standard deviation
TMDL	(See Glossary above)
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WQI	Water Quality Index
WRIA	Water Resource Inventory Area
WY	Water year

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cm	centimeter
kg	kilogram
mg/L	milligrams per liter (parts per million)
mL	milliliter
NTU	nephelometric turbidity unit
sq. km	square kilometer
s.u.	standard unit
ug/L	micrograms per liter (parts per billion)
uS	microsiemens per centimeter, a unit of conductivity