WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Washington State Water Quality Conditions in 2005, based on Data from the Freshwater Monitoring Unit

Technical Appendix

November 2006

Publication No. 06-03-031
printed on recycled paper

Publication Information

Washington State Water Quality Conditions in 2005, based on Data from the Freshwater Monitoring Unit: Technical Appendix

This technical appendix is available on the Department of Ecology's website at www.ecy.wa.gov/biblio/0603031.html

Washington State Water Quality Conditions in 2005, based on Data from the Freshwater Monitoring Unit

The parent publication is available at www.ecy.wa.gov/biblio/0603030.html

For more information contact:

Environmental Assessment Program
P.O. Box 47600
Olympia, WA 98504-7600

E-mail: csme461@ecy.wa.gov
Phone: 360.407.6677

If you need this publication in an alternate format, call Cindy Cook at 360.407.6677. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877.833.6341.

Washington State Water Quality Conditions in 2005, based on Data from the Freshwater Monitoring Unit

Technical Appendix

by
Dave Hallock and Jenifer Parsons

Freshwater Monitoring Unit
Environmental Monitoring and Trends Section
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710
Yakima, Washington 98902-3452

November 2006

Publication No. 06-03-031
printed on recycled paper

This page is purposely left blank for duplex printing.

Table of Contents

List of Tables

Abstract

This technical appendix presents details about the assessment methods and sampling locations used to develop the report, *Washington State Water Quality Conditions in 2005, Based on Data from the Freshwater Monitoring Unit* (Ecology Publication Number 06-03-030).

Six analyses are presented:

1. The Stream Water Quality Index, derived from eight variables that describe water quality at river and stream monitoring stations measured in water year 2005 (October 2004 through September 2005).

2. Trends in the Stream Water Quality Index, derived from data that describe water quality at long-term river and stream monitoring stations over the last 10 years.

3. An analysis of water quality, based on a comparison of water quality results to water quality criteria, at stations monitored in water year 2005.

4. Temperature assessments and compliance with water quality standards, from continuous measurements collected during the summer of 2005.

5. Reductions in fecal coliform bacteria levels needed to meet sanitary standards, estimated from data collected in water year 2005 at basin and long-term river and stream monitoring stations.

6. A listing of locations where invasive exotic aquatic weeds have been identified by the Department of Ecology since 1994.

Acknowledgements

We would like to thank the following people for help in producing this technical appendix and the main report, *Washington State Water Quality Conditions in 2005, Based on Data from the Freshwater Monitoring Unit*:

- Maggie Bell-McKinnon, Casey Clishe, Chris Coffin, Glenn Merritt, George Onwumere, Rob Plotnikoff, Jim Ross, and Bill Ward for collecting the data and for their written contributions to the main report.

- George Onwumere, Rob Plotnikoff, Bob Cusimano, Greg Pelletier, and Melissa Gildersleeve for reviewing the reports.

- Cindy Cook, Joan LeTourneau, and Tom Leonard for formatting and editing the reports.

Introduction

This technical appendix presents details about the assessment methods, sampling locations, and fine-scale results used to develop the report, *Washington State Water Quality Conditions in 2005, Based on Data from the Freshwater Monitoring Unit.*

This page is purposely left blank for duplex printing.

Stream Water Quality Index

Water quality indices have been developed to compile large quantities of water quality data into single values in much the same way that the Dow-Jones summarizes conditions in financial markets. Although much detail is lost in summarizing information in this way (see *Uses and Limitations*), indices make water quality information accessible to a much wider audience, including elected officials, administrators, and the general public. Couillard and Lefebvre (1985) review several water quality indices that summarize data in an easily understood format.

The index used here, the stream Water Quality Index (WQI), is a unitless number ranging from 1 to 100 that is intended to represent general water quality. A higher number indicates better water quality. For indicators with established water quality standards (based on criteria in Washington State's Water Quality Standards, Chapter 173-201A WAC), the index expresses results relative to levels required to meet these standards; for example, scores below 80 indicate results exceeded the water quality standard. For indicators without specific standards, results are expressed relative to expected conditions in the appropriate region. Multiple indicators are combined and results aggregated over time to produce a single score for each sample station.

Uses and Limitations

By design, indices contain less information than the raw data they summarize. An index cannot provide all the information expressed by the original water quality data. An index is most useful for comparative purposes (*What stations have particularly poor water quality*?) and for general questions (*What is the general water quality in my stream*?). Indices are less suited for answering specific questions. Site-specific decisions should be based on an analysis of the original water quality data. In short, an index is a useful tool for "*communicating water quality information to the lay public and to legislative decision makers*;" it is not "*a complex predictive model for technical and scientific application*" (McClelland, 1974).

Besides being general in nature, there are at least two reasons that an index may fail to accurately communicate water quality information. First, most indices are based on a pre-identified set of water quality indicators. A particular station may receive a good WQI score, and yet have water quality impaired by indicators not included in the index. Second, aggregation of data may mask short-term water quality problems. A satisfactory WQI at a particular station does not necessarily mean that water quality was always satisfactory. A good score should, however, indicate that poor water quality (for evaluated indicators, at least) was not chronic.

Strategies

Different approaches to indexing water quality results are possible. One approach is to rate quality objectively (e.g., using ranked data) (Harkins, 1974). While this approach does not require developing subjective rating curves, it also does not permit comparisons between values generated from different data sets. For example, results between years could not be compared unless scores were re-calculated using data from all years. Any time additional data are added and the index re-calculated (for example, to compare years), results for the same stations and dates would change because the rank order changes. Finally, this approach ranks results from pristine stations where high quality would be expected, along with stations where water quality would not be expected to be pristine (regardless of human impacts). Hence, a score could only be interpreted in comparison to another known station.

A more useful index for managing environmental resources is one that allows water quality comparisons with criteria that support beneficial uses. However, this approach requires (1) subjective determinations of the beneficial uses that a particular stream segment should support, (2) the level of water quality required to support those uses, and (3) knowledge of how critical variations from that level of quality are. For several key parameters, the first two of these determinations are already codified in Washington's Administrative Code (Chapter 173-201A WAC). Washington's WQI follows this approach.

Water Quality Indicators Included in the Index

For this analysis, index scores were determined for eight indicators monitored monthly by the Washington State Department of Ecology (Ecology) Freshwater Monitoring Unit: temperature, dissolved oxygen, pH, fecal coliform bacteria, total nitrogen, total phosphorus, total suspended sediment, and turbidity.

Rather than aggregating scores for total nitrogen and total phosphorus separately, the score for the limiting nutrient was used in the aggregation of the overall index because total nitrogen and total phosphorus are highly correlated and they measure similar impacts on water quality. Similarly, a harmonic mean of sediment-related indicators (total suspended solids and turbidity) was used. Data collection and quality control are discussed in our annual reports (e.g., Hallock, 2005).

Methodology

The methodology used to determine WQI scores was originally developed by the U.S. Environmental Protection Agency (EPA), Region 10. Initial development was documented only in the "*gray*" literature (Peterson and Bogue, 1989), but the methodology appears to be based on the well-known National Sanitation Foundation index. This index used curves to relate concentrations or measurements of various indicators to index scores and then aggregated the scores into a single number (Brown et al., 1970). The EPA curves were "*a synthesis of national criteria, state standards, information in the technical literature, and professional judgment*" (Peterson and Bogue, 1989).

For temperature, oxygen, pH, and fecal coliform bacteria, data were converted to index scores using the same relationships used by EPA's WQI, except that the original tabulated results have been converted to quadratic equations. Because there were discontinuities in the original tables, the equations do not fit the tabulated data perfectly. For these parameters, a WQI score is related to the water quality standards criteria for that waterbody and, therefore, to the support of beneficial uses.

The original curves for turbidity, total suspended solids, total phosphorus, and total nitrogen do not account for natural differences caused by wide variations in geomorphology across the state. Furthermore, there are no water quality standards criteria for these indicators. Therefore, Ecology developed new curves based on the distribution of data at stations within each ecoregion (Omernik and Gallant, 1986) during high- and low-flow seasons. WQI scores were matched to various quantiles and a quadratic equation was then fit to the WQI-concentration relationships.

Because the index scores for nutrient and sediment indicators are based on the distribution of past data and not on ecological impacts or degree of degradation, poor index scores for these indicators indicate poor water quality relative to other stations in the same ecoregion, and may not necessarily indicate impairment or inability to support beneficial uses. Conversely, good index scores for these indicators may not necessarily indicate a lack of impairment or an ability to support beneficial uses.

The formulas used for a station and indicator depend on the stream class or ecoregion for that station. Calculated results <1 or >100 are converted to 1 or 100, respectively.

There were insufficient data from three ecoregions to develop independent curves. Curves developed for the Puget Lowlands, Cascades, and Northern Rockies are used for stations in the Willamette Valley, Eastern Cascades Slopes and Foothills, and Blue Mountains ecoregions, respectively. For more information on the WQI methodology, see Hallock (2002).

Scores should not be compared between various "Conditions" reports due to possible changes in methodologies or station classification. To compare year-to-year changes, see results posted to our website (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html), where scores will be re-calculated as necessary using consistent procedures.

Results

The WQI was applied to water quality data collected from 2005 (Table 1). To place the WQI scores into categories used for statewide assessment, the cut-points used by EPA in the original WQI were used. According to this categorization scheme, stations with WQI scores 80 and above are considered to be of *lowest concern*, scores from 40 to 79 are of *moderate concern*, and those below 40 are of the *highest concern*. In 2005, 44 stations were categorized as *lowest concern*, 47 as *moderate concern*, and 4 as *highest concern*.

Table 1. Water Quality Index (WQI) scores for stations sampled in 2005.

Station	Location	Ecoregion	Overall WQI
01A050	Nooksack R @ Brennan	Puget Lowlands	58 (71) [a]
01A120	Nooksack R @ No Cedarville	Puget Lowlands	69 (86) [a]
01T050	Anderson Cr @ South Bay Rd	Puget Lowlands	68
03A060	Skagit R nr Mount Vernon	Puget Lowlands	76 (88) [a]
03A080	Skagit R abv Sedro Woolley	Puget Lowlands	82 (88) [a]
03B050	Samish R nr Burlington	Puget Lowlands	72
04A100	Skagit R @ Marblemount	Cascades	81 (89) [a]
04C070	Sauk R nr Rockport	Cascades	57 (82) [a]
04C120	Sauk R @ Backman Park	Cascades	59 (82) [a]
05A070	Stillaguamish R nr Silvana	Puget Lowlands	68 (80) [a]
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	69 (80) [a]
05A110	SF Stillaguamish nr Granite Falls	Puget Lowlands	68 (82) [a]
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	79 (84) [a]
05B110	NF Stillaguamish nr Darrington	Cascades	55 (72) [a]
07A090	Snohomish R @ Snohomish	Puget Lowlands	76
07C070	Skykomish R @ Monroe	Puget Lowlands	93
07D050	Snoqualmie R nr Monroe	Puget Lowlands	84
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	92
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	88
08C110	Cedar R nr Landsburg	Puget Lowlands	96
09A080	Green R @ Tukwila	Puget Lowlands	49
09A190	Green R @ Kanaskat	Puget Lowlands	92
09K070	Fauntleroy Cr nr mouth	Puget Lowlands	26
10A070	Puyallup R @ Meridian St	Puget Lowlands	61 (82) [a]
10A075	Puyallup R @ East Main St	Puget Lowlands	59 (82) [a]
10C095	White River @ R Street	Puget Lowlands	56 (75) [a]
11A070	Nisqually R @ Nisqually	Puget Lowlands	75 (82) [a]
13A060	Deschutes R @ E St Bridge	Puget Lowlands	84
15F050	Big Beef Cr @ mouth	Puget Lowlands	88
15L050	Seabeck Cr @ mouth	Puget Lowlands	90
15M070	Llt Anderson Cr @ Anderson Hill Rd	Puget Lowlands	82
15N070	Stavis Cr nr mouth	Puget Lowlands	89
16A070	Skokomish R nr Potlatch	Puget Lowlands	67
16C090	Duckabush R nr Brinnon	Coast Range	94
18A050	Dungeness R nr mouth	Puget Lowlands	92
18B070	Elwha R nr Port Angeles	Coast Range	73
19C060	West Twin R nr mouth	Coast Range	87
19D070	East Twin R nr mouth	Coast Range	92
19E060	Deep Cr nr mouth	Coast Range	81
20B070	Hoh R @ DNR Campground	Coast Range	57
22A070	Humptulips R nr Humptulips	Coast Range	79
23A070	Chehalis R @ Porter	Puget Lowlands	68

Station	Location	Ecoregion	Overall WQI
23A100	Chehalis R @ Prather Rd	Puget Lowlands	67
23A160	Chehalis R @ Dryad	Puget Lowlands	82
24B090	Willapa R nr Willapa	Coast Range	74
24F070	Naselle R nr Naselle	Coast Range	88
25D050	Germany Cr @ mouth	Coast Range	84
25E060	Abernathy Cr nr mouth	Coast Range	90
25F060	Mill Cr nr mouth	Coast Range	85
26B070	Cowlitz R @ Kelso	Puget Lowlands	64
27B070	Kalama R nr Kalama	Puget Lowlands	93
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	89
28C070	Burnt Br Cr @ mouth	Willamette Valley	36
31A070	Columbia R @ Umatilla	Columbia Basin	90
32A070	Walla Walla R nr Touchet	Columbia Basin	65
33A050	Snake R nr Pasco	Columbia Basin	84
34A070	Palouse R @ Hooper	Columbia Basin	72
34A170	Palouse R @ Palouse	Columbia Basin	82
34B110	SF Palouse R @ Pullman	Columbia Basin	36
34B130	SF Palouse R blw Sunshine	Columbia Basin	65
34C060	Paradise Cr at mouth	Columbia Basin	53
34C100	Paradise Cr @ Border	Columbia Basin	31
35A150	Snake R @ Interstate Br	Columbia Basin	80
35B060	Tucannon R @ Powers	Columbia Basin	85
36A070	Columbia R nr Vernita	Columbia Basin	88
37A090	Yakima R @ Kiona	Columbia Basin	63
37A205	Yakima R @ Nob Hill	Columbia Basin	77
37E050	Wide Hollow Cr @ Main Street	Columbia Basin	56
37I070	Moxee Drain @ Birchfield Rd	Columbia Basin	44
38G070	Cowiche Cr @ Powerhouse Rd	Columbia Basin	70
39A090	Yakima R nr Cle Elum	Cascades	70
39C070	Wilson Cr @ Highway 821	Columbia Basin	57
41A070	Crab Cr nr Beverly	Columbia Basin	54
45A070	Wenatchee R @ Wenatchee	Columbia Basin	83
45A110	Wenatchee R nr Leavenworth	Cascades	84
45D080	Brender Cr abv Noname Cr	Columbia Basin	63
45R070	Noname Cr on Mill Rd	Columbia Basin	54
46A070	Entiat R nr Entiat	Columbia Basin	90
48A070	Methow R nr Pateros	Columbia Basin	91
48A140	Methow R @ Twisp	Columbia Basin	95
49A070	Okanogan R @ Malott	Columbia Basin	78
49A190	Okanogan R @ Oroville	Columbia Basin	80
49B070	Similkameen R @ Oroville	Columbia Basin	78
53A070	Columbia R @ Grand Coulee	Columbia Basin	90
54A120	Spokane R @ Riverside State Pk	Northern Rockies	69
55B070	Little Spokane R nr mouth	Northern Rockies	77

Station	Location	Ecoregion	Overall WQI
56A070	Hangman Cr @ mouth	Columbia Basin	65
57A150	Spokane R @ Stateline Br	Columbia Basin	83
59A130	Colville R @ Chewelah	Northern Rockies	61
60A070	Kettle R nr Barstow	Northern Rockies	75
61A070	Columbia R @ Northport	Northern Rockies	86
62A090	Pend Oreille R @ Metaline Falls	Northern Rockies	81
62A150	Pend Oreille R @ Newport	Northern Rockies	83

[a] Streams with glacial influence may receive inappropriately low scores since scores for these streams are unduly affected by glacial sediment. The score shown in parentheses is based on minimum sediment-related scores of 75.

Trend Analysis

The presence or absence of trends over time is a good indication of the degree to which water quality is responding to changes in the watershed and climate. Human-caused changes in water quality can sometimes be masked by natural variability. Formal statistical trend analysis provides a rational, scientific basis for addressing issues with natural variations in water quality that can obscure human-caused trends. For example, if a distinct relationship exists between streamflow and a water quality indicator, then a trend in flow may obscure a human-caused trend or create a trend in the indicator data not due to watershed changes.

The Seasonal Kendall's Tau test is a good choice for evaluating trends when water quality varies by season (Gilbert, 1987). This test can be used even if there are missing values or if some values are below the analytical detection limit. The validity of the test does not depend on data being normally distributed. The Seasonal Kendall test with correction for autocorrelation was used when autocorrelation was present. The statistical software WQHYDRO (Aroner, 2002) was used to evaluate for trends at each station using the flow-adjusted residual (see below) or raw indicator data at a 95% confidence level for statistical significance.

Water quality indicators are frequently correlated with flow. During high-flow years, some indicators are typically higher (e.g., sediment) and others lower (e.g., temperature) than during low-flow years. As a result, year-to-year changes in an index could actually be attributable to variability in flow (natural or human-caused), rather than to changes in watershed conditions. Therefore, a second set of annual flow-adjusted WQI scores was calculated for long-term stations after removing variability in water quality indicators due to flow. This was done for each station by (1) determining the residuals from a hyperbolic regression of each indicator (raw data) with flow, (2) adding the mean of each indicator back to the residuals, (3) calculating WQIs on the adjusted data, and (4) adjusting mean flow-adjusted annual scores to match the raw indicator means for each station. Flow-adjustments were done with WQHYDRO (Aroner, 2002) and Access.

An analysis was performed of trends in monthly WQI scores, calculated using data collected from water year 1996 through 2005 at long-term stations. Trends were also performed on monthly scores adjusted for variability in flow, as described above. Reported probabilities include corrections for auto-correlation.

Prior to adjusting for flow, statistically significant ($p < 0.05$) improving trends were indicated at 25 stations and declining trends at no stations (Table 2). Adjusting for flow decreased the trend slope at 85 percent of the stations, and resulted in improving trends at 15 stations and declining trends at four stations. That is, variability in flow was responsible for some of the apparent improving trends in water quality at most stations. Whether this is because flows were increasing or decreasing has not been evaluated and is station-specific, depending on which indicator(s) drive the WQI at a particular station. Some indicators are positively correlated with flow (e.g., sediment and nutrients) and some negatively (e.g., temperature and pH).

Table 2. Trend analysis of monthly overall WQI scores from 1996 through 2005. Statistically significant trends ($p<0.05$) are shown in bold. Positive slopes indicate improving conditions.

Station	Location	Not Flow-adjusted		Adjusted for Flow	
		Slope	Probability (p)	Slope	Probability (p)
01A050	Nooksack R @ Brennan	0.5	0.159	0.12	0.772
01A120	Nooksack R @ No Cedarville	-0.02	0.933	**-0.33**	**0.045**
03A060	Skagit R nr Mount Vernon	-0.09	0.612	**-0.72**	**0.014**
03B050	Samish R nr Burlington	**0.67**	**0.015**	**0.75**	**0.038**
04A100	Skagit R @ Marblemount	0.29	0.151	-0.38	0.218
05A070	Stillaguamish R nr Silvana	0.05	0.754	-0.22	0.402
05A090	SF Stillaguamish @ Arlington	-0.29	0.267	NA	NA
05A110	SF Stillaguamish nr Granite Falls	-0.27	0.366	NA	NA
05B070	NF Stillaguamish @ Cicero	0.21	0.192	0.12	0.483
05B110	NF Stillaguamish nr Darrington	**1.28**	**0.000**	-0.37	0.742
07A090	Snohomish R @ Snohomish	0.28	0.120	0.09	0.440
07C070	Skykomish R @ Monroe	**0.16**	**0.002**	0.13	0.184
07D050	Snoqualmie R nr Monroe	**0.61**	**0.021**	**0.51**	**0.017**
07D130	Snoqualmie R @ Snoqualmie	0.07	0.394	-0.01	0.982
08C070	Cedar R @ Logan St/Renton	0.17	0.394	0.08	0.347
08C110	Cedar R nr Landsburg	0.04	0.171	**0.1**	**0.005**
09A080	Green R @ Tukwila	0.91	0.072	**0.57**	**0.032**
09A190	Green R @ Kanaskat	**0.12**	**0.026**	0.08	0.067
10A070	Puyallup R @ Meridian St	0.29	0.115	-0.07	0.859
11A070	Nisqually R @ Nisqually	**0.18**	**0.021**	-0.17	0.512
13A060	Deschutes R @ E St Bridge	**1.39**	**0.025**	1.12	0.130
16A070	Skokomish R nr Potlatch	-0.07	0.290	-0.01	0.812
16C090	Duckabush R nr Brinnon	-0.02	0.666	-0.14	0.076
18B070	Elwha R nr Port Angeles	-0.12	0.188	**-0.44**	**0.000**
20B070	Hoh R @ DNR Campground	-0.34	0.256	-0.18	0.389
22A070	Humptulips R nr Humptulips	-0.09	0.339	0.2	0.140
23A070	Chehalis R @ Porter	**1.27**	**0.010**	0.64	0.064
23A160	Chehalis R @ Dryad	-0.03	0.897	-0.13	0.188
24B090	Willapa R nr Willapa	0.95	0.058	**1.03**	**0.002**
24F070	Naselle R nr Naselle	0.16	0.545	0.14	0.349
26B070	Cowlitz R @ Kelso	0.51	0.179	-0.27	0.055
27B070	Kalama R nr Kalama	0.05	0.454	-0.19	0.192
27D090	EF Lewis R nr Dollar Corner	0.14	0.157	0.23	0.070
31A070	Columbia R @ Umatilla	0.18	0.071	0.08	0.301
32A070	Walla Walla R nr Touchet	**2.4**	**0.004**	0.39	0.114
33A050	Snake R nr Pasco	**0.5**	**0.008**	**0.32**	**0.002**
34A070	Palouse R @ Hooper	**3.38**	**0.005**	**1.61**	**0.015**
34A170	Palouse R @ Palouse	**0.91**	**0.000**	**0.82**	**0.000**
34B110	SF Palouse R @ Pullman	**3.68**	**0.000**	**2.2**	**0.000**
35A150	Snake R @ Interstate Br	0.27	0.115	0.09	0.634
35B060	Tucannon R @ Powers	**1.74**	**0.003**	0.29	0.234
36A070	Columbia R nr Vernita	0.16	0.180	0.15	0.210

Station	Location	Not Flow-adjusted		Adjusted for Flow	
		Slope	Probability (p)	Slope	Probability (p)
37A090	Yakima R @ Kiona	**1.09**	**0.000**	**0.87**	**0.000**
37A205	Yakima R @ Nob Hill	0.08	0.809	-0.26	0.138
39A090	Yakima R nr Cle Elum	0.22	0.241	**-0.53**	**0.043**
41A070	Crab Cr nr Beverly	**1.12**	**0.000**	**0.94**	**0.000**
45A070	Wenatchee R @ Wenatchee	**0.3**	**0.002**	**0.29**	**0.006**
45A110	Wenatchee R nr Leavenworth	**0.6**	**0.000**	0.11	0.211
46A070	Entiat R nr Entiat	0.07	0.348	0	1.000
48A070	Methow R nr Pateros	-0.01	0.864	-0.04	0.471
48A140	Methow R @ Twisp	0	0.769	-0.02	0.780
49A070	Okanogan R @ Malott	0.29	0.196	-0.03	0.756
49A190	Okanogan R @ Oroville	0.02	0.908	-0.01	0.922
49B070	Similkameen R @ Oroville	**0.13**	**0.042**	0.08	0.557
53A070	Columbia R @ Grand Coulee	**0.16**	**0.009**	0.13	0.052
54A120	Spokane R @ Riverside State Pk	**1.07**	**0.000**	**0.73**	**0.009**
55B070	Little Spokane R nr mouth	**1.82**	**0.041**	**0.5**	**0.047**
56A070	Hangman Cr @ mouth	**2.05**	**0.003**	0.34	0.135
57A150	Spokane R @ Stateline Br	0.07	0.286	0.15	0.098
60A070	Kettle R nr Barstow	0.06	0.724	-0.1	0.628
61A070	Columbia R @ Northport	0.12	0.096	-0.09	0.406
62A090	Pend Oreille R @ Metaline Falls	**0.31**	**0.005**	**0.27**	**0.014**
62A150	Pend Oreille R @ Newport	**0.28**	**0.000**	0.01	0.902

Trends of multiple stations can be evaluated together using a statistical method called meta-analysis (Reckhow et al., 1993). Stations can be grouped from various geographic regions or watershed land uses to draw a collective assessment of trend. Stations were grouped according to their location in each ecological region as defined by EPA (Omernik and Gallant, 1986). Results of the station trend test were used in meta-analysis to evaluate trends in indicators for each ecoregion and also on a statewide basis.

For the ten-year period evaluated, a statistically significant improvement in water quality was observed statewide, with the greatest improvement in the Columbia Basin Ecoregion. Statewide, WQI scores improved by five WQI units over the ten years; in the Columbia Basin, scores improved more than eight units (Table 3).

Table 3. Regional trends in WQI (not flow-adjusted). Positive Z scores indicate improving water quality. Significant ($p<0.05$) trends are shown in bold.

Ecoregion	Number of Stations	Trend in Monthly WQI Scores		
		Regional Z score	Probability	Mean Annual Change Last 10 years (WQI units)
Coast Range	6	-0.55	0.59	Not significant
Puget Lowlands	24	**5.40**	**<0.01**	**0.28**
Willamette Valley	1	1.42	0.16	Not significant
Cascades	4	**5.21**	**<0.01**	**0.60**
Columbia Basin	22	**10.63**	**<0.01**	**0.85**
Northern Rockies	6	**5.92**	**<0.01**	**0.61**
STATEWIDE	63	**-0.55**	**<0.01**	**0.51**

Water Quality

Long-term stations are monitored monthly every year to track water quality changes over time (trends) and to assess inter-annual variability, as well as to collect current water quality information. These stations are generally located near the mouths of major rivers, below major population centers, upstream from most anthropogenic sources of water quality problems, or where major streams enter the state. Most of these stations are located low in their basins and integrate upstream water quality impacts.

Basin stations are generally monitored monthly for one year only (although they may be re-visited every five years) to collect current water quality information. The basin monitoring stations are selected to support Ecology's basin approach to water quality management and to address site-specific water quality issues. These stations are selected to support National Pollution Discharge Elimination System permits, Total Maximum Daily Load assessments, site-specific needs, and to allow expanded coverage over a long-term network. Often, basin stations are selected to target known problems and, as a group, will not reflect general ambient conditions. The current basin monitoring program conducts monthly monitoring of 12 water quality indicators at approximately 20 stations across the state. During some years we are able to sample more basin stations, depending on client needs and funding.

Water quality data collected at the long-term and basin monitoring stations sampled in water year 2005 were evaluated against the numeric criteria in Washington's water quality standards. These criteria are designed to protect beneficial uses. Tables 4 and 5 show the number of times criteria were exceeded for the 12 monthly samples at each station. Exceeding a criterion does not necessarily indicate a water quality violation. Ecology has established a listing policy that specifies the requirements for a result to be considered a "*violation*." There are also exceptions for natural causes. Ecology's Water Quality Program periodically promulgates a list of waterbodies in violation of state standards; this is known as the 303(d) list.

Table 4. Long-term monitoring stations and the number of monthly samples that exceeded criteria in 2005.

Station	Location	Temp.	pH	Oxygen	Bacteria [a]	Other
Long-term Stations						
01A050	Nooksack R @ Brennan					
01A120	Nooksack R @ No Cedarville					
03A060	Skagit R nr Mount Vernon					
03B050	Samish R nr Burlington				1	
04A100	Skagit R @ Marblemount					
05A070	Stillaguamish R nr Silvana	2			1	
05A090	SF Stillaguamish @ Arlington	2			1	
05A110	SF Stillaguamish nr Granite Falls	2		1		
05B070	NF Stillaguamish @ Cicero	2				
05B110	NF Stillaguamish nr Darrington					
07A090	Snohomish R @ Snohomish	2			1	
07C070	Skykomish R @ Monroe	1				
07D050	Snoqualmie R nr Monroe	2				
07D130	Snoqualmie R @ Snoqualmie					
08C070	Cedar R @ Logan St/Renton	1	1			
08C110	Cedar R nr Landsburg					
09A080	Green R @ Tukwila	2			2	
09A190	Green R @ Kanaskat					
10A070	Puyallup R @ Meridian St					
11A070	Nisqually R @ Nisqually				1	
13A060	Deschutes R @ E St Bridge				1	
16A070	Skokomish R nr Potlatch				1	
16C090	Duckabush R nr Brinnon					
18B070	Elwha R nr Port Angeles	2				
20B070	Hoh R @ DNR Campground				2	
22A070	Humptulips R nr Humptulips					
23A070	Chehalis R @ Porter	2		1	1	
23A160	Chehalis R @ Dryad	2	2			
24B090	Willapa R nr Willapa	2				
24F070	Naselle R nr Naselle					
26B070	Cowlitz R @ Kelso					
27B070	Kalama R nr Kalama					
27D090	EF Lewis R nr Dollar Corner	2				
31A070	Columbia R @ Umatilla	1	1			
32A070	Walla Walla R nr Touchet	2	2			
33A050	Snake R nr Pasco	2	1			
34A070	Palouse R @ Hooper	2	6			
34A170	Palouse R @ Palouse	1	1	1		
34B110	SF Palouse R @ Pullman	1		3	5	
35A150	Snake R @ Interstate Br	2	3			
35B060	Tucannon R @ Powers	2				
36A070	Columbia R nr Vernita	3				
37A090	Yakima R @ Kiona	2	8			
37A205	Yakima R @ Nob Hill		9			
39A090	Yakima R nr Cle Elum	1		4		
41A070	Crab Cr nr Beverly	2	5		1	
45A070	Wenatchee R @ Wenatchee	1	2			

Station	Location	Temp.	pH	Oxygen	Bacteria [a]	Other
45A110	Wenatchee R nr Leavenworth	1	1	1		
46A070	Entiat R nr Entiat	1	1			
48A070	Methow R nr Pateros	1				
48A140	Methow R @ Twisp					
49A070	Okanogan R @ Malott	2		1		
49A190	Okanogan R @ Oroville	3	1			
49B070	Similkameen R @ Oroville	1				
53A070	Columbia R @ Grand Coulee	2				
54A120	Spokane R @ Riverside State Pk				1	
55B070	Little Spokane R nr mouth			1		
56A070	Hangman Cr @ mouth	2		2	1	
57A150	Spokane R @ Stateline Br	2		2		6 [b]
60A070	Kettle R nr Barstow	2	1	1		
61A070	Columbia R @ Northport	1		1		
62A150	Pend Oreille R @ Newport	1				
Total number exceeding criteria		67	45	19	20	6
Total number of samples collected		734	734	736	738	216
Percent of samples exceeding criteria		9%	6%	3%	3%	3%

[a] Bacteria counts in Table 4 are based on single samples exceeding the 10 percent criterion. With 12 monthly samples, there must be at least two high counts for the 10 percent criterion to be exceeded.
[b] The Spokane River exceeded the dissolved zinc chronic criterion on six occasions.

Table 5. Basin monitoring stations and the number of monthly samples that exceeded criteria in 2005. (Basin stations may not be representative of statewide conditions.)

Station	Location	Temp.	pH	Oxygen	Bacteria [a]	Other
Basin Stations						
01T050	Anderson Cr @ South Bay Rd			1	2	
03A080	Skagit R abv Sedro Woolley					
04C070	Sauk R nr Rockport					
04C120	Sauk R @ Backman Park					
09K070	Fauntleroy Cr nr mouth				6	1 [b]
10A075	Puyallup R @ East Main St					
10C095	White River @ R Street				1	
15F050	Big Beef Cr @ mouth	1		1		
15L050	Seabeck Cr @ mouth				1	
15M070	Llt Anderson Cr @ Anderson Hill Rd					
15N070	Stavis Cr nr mouth					
18A050	Dungeness R nr mouth					
19C060	West Twin R. nr mouth	1		1		
19D070	East Twin R. nr mouth					
19E060	Deep Cr nr mouth			2		
23A100	Chehalis R @ Prather Rd	2				
25D050	Germany Cr @ mouth					
25E060	Abernathy Cr nr mouth				1	
25F060	Mill Cr nr mouth				1	
28C070	Burnt Br Cr @ mouth	2			6	
34B130	SF Palouse R blw Sunshine	1		3		
34C060	Paradise Cr at mouth	1	1		1	
34C100	Paradise Cr @ Border	2		2	5	
37E050	Wide Hollow Cr @ Main Street	2	4		6	
37I070	Moxee Drain @ Birchfield Rd	3	6		4	
38G070	Cowiche Cr @ Powerhouse Rd	1	1		1	
39C070	Wilson Cr @ Highway 821				5	
45D080	Brender Cr abv Noname Cr			4	3	
45R070	Noname Cr on Mill Rd			6	9	
59A130	Colville R @ Chewelah	2	5			
62A090	Pend Oreille R @ Metaline Falls	1	2			
Total number exceeding criteria		19	19	20	52	1
Total number of samples collected		388	388	388	370	432
Percent of samples exceeding criteria		5%	5%	5%	14%	0.2%

[a] Bacteria counts in Table 5 are based on single samples exceeding the 10 percent criterion. With 12 monthly samples, there must be at least 2 high counts for the 10 percent criterion to be exceeded.

[c] Fauntleroy Creek slightly exceeded the total mercury criterion on one occasion.

Continuous Temperature Measurements

In the summer of 2005, Ecology's Environmental Monitoring and Trends Section collected temperature data at 30-minute intervals at most of our long-term ambient monitoring stations as well as some basin stations. Seventy-six sites were monitored in 2005. The purpose of this monitoring is to collect season-long diel (24-hour) temperature data that may be used for trend analyses and to determine compliance with current and proposed water quality standards.

Seasonal maximums and the maximum seven-day average of daily maximums were derived for the 76 stations monitored in 2005. The seasonal maximum at 66 stations (87 percent) exceeded the 1997 water quality criteria (Table 6).

A new temperature criterion of 16˚C, based on the maximum seven-day average of maximum daily measurements, is being proposed as a water quality standard for most streams in Washington. Seventy stations exceeded this criterion.

Table 6. Temperature monitoring (30-minute intervals) summary for 2005. Deployment maximum temperatures in bold exceed the 1997 criterion and maximum seven-day mean temperatures in bold exceed the proposed criterion (16ºC).

Station	Location	Current Criterion	Deployment Maximum		Max 7-day Mean[a]	
			°C	Date/Time [b]	°C	Date [b,c]
01A050	Nooksack R @ Brennan	18	**19.4**	07 Aug 17:00	**19.2**	07 Aug
01A120	Nooksack R @ No Cedarville	18	**19.2**	31 Jul 19:00	**19.0**	28 Jul
01T050	Anderson Cr @ South Bay Rd	16	**21.3**	01 Aug 18:30	**18.5**	04 Aug
03A060	Skagit R nr Mount Vernon	18	**18.5**	30 Jul 23:00	**18.3**	28 Jul
03A080	Skagit R abv Sedro Woolley	18	**18.9**	28 Jul 19:30	**18.4**	28 Jul
03B050	Samish R nr Burlington	18	**18.1**	31 Jul 18:30	**17.6**	29 Jul
04A100	Skagit R @ Marblemount	16	15.1	05 Aug 18:30	14.9	06 Aug
04C120	Sauk R @ Backman Park	16	**18.4**	07 Aug 18:30	**18.0**	07 Aug
05A070	Stillaguamish R nr Silvana	18	**23.0**	31 Jul 20:00	**22.5**	07 Aug
05A110	SF Stillaguamish nr Granite Falls	16	**21.7**	15 Aug 15:00	**21.0**	06 Aug
05B070	NF Stillaguamish @ Cicero	18	**22.4**	14 Aug 18:00	**21.7**	06 Aug
05B110	NF Stillaguamish nr Darrington	18	**19.4**	14 Aug 17:00	**19.0**	06 Aug
07D050	Snoqualmie R nr Monroe	18	**21.9**	31 Jul 20:30	**21.3**	30 Jul
07D100	Snoqualmie R abv Carnation	18	**21.4**	15 Aug 17:30	**20.9**	07 Aug
07D125	Snoqualmie R @ Hwy 202	18	**19.5**	01 Aug 03:00	**18.9**	30 Jul
07D130	Snoqualmie R @ Snoqualmie	18	**19.7**	31 Jul 21:30	**19.3**	29 Jul
07D150	M F Snoqualmie R nr Ellisville	16	**21.1**	31 Jul 18:30	**20.7**	28 Jul
07G070	Tolt R nr Carnation	18	**24.1**	27 Jul 10:00	**20.9**	06 Aug
07M065	SF Snoqualmie @ Valley Trail	18	**18.7**	31 Jul 17:00	**18.3**	28 Jul
07M075	SF Snoqualmie @ Bendigo Blvd S	18	**18.4**	31 Jul 18:00	**18.0**	28 Jul
07N070	NF Snoqualmie R near Ellisville	16	**17.7**	31 Jul 18:30	**17.3**	29 Jul
07P070	Patterson Ck nr Fall City	18	**18.9**	31 Jul 18:30	**18.4**	28 Jul
07Q050	Raging R @ mouth	18	**24.1**	15 Aug 17:00	**23.1**	06 Aug
07S070	Cherry Cr @ Hwy 203	18	**20.9**	31 Jul 18:30	**20.1**	30 Jul
07T050	Tuck Cr @ mouth	18	**19.2**	31 Jul 21:30	**18.6**	30 Jul
07U070	Harris Cr @ Hwy 203	18	17.2	18 Jul 16:00	**16.7**	28 Jul
07V070	Ames Cr @ NE 100th St	18	**19.0**	17 Jul 17:00	**17.3**	20 Jul
07Y060	Kimball Cr @ Hwy 202	18	**19.2**	15 Aug 13:00	**18.0**	07 Aug

Station	Location	Current Criterion	Deployment Maximum		Max 7-day Mean[a]	
			°C	Date/Time [b]	°C	Date [b,c]
08C070	Cedar R @ Logan St/Renton	18	**20.4**	05 Aug 17:30	**19.7**	06 Aug
08C110	Cedar R nr Landsburg	16	13.9	28 Jul 15:30	13.7	28 Jul
08L070	Laughing Jacobs Cr nr mouth	16	15.5	15 Aug 18:00	14.9	06 Aug
08M070	SF Thornton Cr @ 107th Ave NE	16	**18.1**	15 Aug 18:00	**17.5**	29 Jul
09A190	Green R @ Kanaskat	16	**18.5**	26 Aug 18:30	**17.9**	06 Aug
09B090	Big Soos Cr nr Auburn	18	**18.7**	31 Jul 17:00	**18.2**	29 Jul
09C070	Des Moines Cr nr mouth	16	**18.3**	31 Jul 16:30	**17.8**	29 Jul
09D070	Miller Cr nr mouth	18	**18.2**	28 Aug 22:00	**17.7**	28 Jul
09F150	Newaukum Creek nr Enumclaw	18	17.4	31 Jul 17:30	**17.1**	29 Jul
09K070	Fauntleroy Cr nr mouth	16	15.6	31 Jul 20:30	15.2	02 Aug
11A070	Nisqually R @ Nisqually	18	16.7	05 Aug 18:00	**16.1**	28 Jul
13A060	Deschutes R @ E St Bridge	18	**20.0**	31 Jul 19:00	**19.6**	28 Jul
16A070	Skokomish R nr Potlatch	16	15.2	28 Jul 18:00	15.0	28 Jul
16C090	Duckabush R nr Brinnon	16	15.0	31 Jul 17:00	14.6	06 Aug
18A050	Dungeness R nr mouth	18	**19.0**	31 Jul 17:30	**18.6**	28 Jul
18B070	Elwha R nr Port Angeles	16	**19.2**	27 Aug 18:00	**18.9**	24 Aug
20A090	Soleduck R nr Forks	16	**18.8**	31 Jul 19:30	**18.2**	29 Jul
20B070	Hoh R @ DNR Campground	16	**18.2**	04 Aug 19:30	**17.8**	28 Jul
20D070	Dickey R nr La Push	16	**21.6**	27 Jul 16:00	**20.6**	02 Aug
22A070	Humptulips R nr Humptulips	18	**21.3**	14 Aug 19:30	**21.1**	29 Jul
23A070	Chehalis R @ Porter	18	**22.9**	05 Aug 18:30	**22.7**	30 Jul
23A160	Chehalis R @ Dryad	18	**22.8**	14 Aug 19:30	**21.9**	02 Aug
26B070	Cowlitz R @ Kelso	18	**20.3**	28 Jul 18:30	**19.1**	31 Jul
27B070	Kalama R nr Kalama	18	**19.7**	31 Jul 19:30	**19.1**	07 Aug
27D090	EF Lewis R nr Dollar Corner	18	**23.8**	31 Jul 18:30	**23.2**	06 Aug
28C070	Burnt Br Cr @ mouth	18	**21.3**	06 Aug 00:00	**20.8**	03 Aug
32A070	Walla Walla R nr Touchet	21	**30.1**	08 Aug 17:00	**29.0**	06 Aug
34A170	Palouse R @ Palouse	20	**27.3**	31 Jul 17:30	**26.6**	07 Aug
34B110	SF Palouse R @ Pullman	18	**21.1**	01 Jul 18:30	**20.4**	15 Jul
34B130	SF Palouse R blw Sunshine	18	**23.4**	12 Jul 18:30	**22.5**	04 Jul
34C100	Paradise Cr @ Border	18	**22.2**	09 Aug 18:30	**21.7**	30 Jul
35B060	Tucannon R @ Powers	18	**26.1**	31 Jul 18:30	**25.3**	28 Jul
37E050	Wide Hollow Cr @ Main Street	18	**22.1**	29 Jul 17:30	**21.8**	29 Jul
37I070	Moxee Drain @ Birchfield Rd	18	**23.6**	31 Jul 20:30	**23.2**	29 Jul
38G070	Cowiche Cr @ Powerhouse Rd	18	**23.2**	18 Jul 18:00	**22.4**	18 Jul
39A090	Yakima R nr Cle Elum	16	**22.3**	31 Jul 17:00	**21.8**	28 Jul
39C070	Wilson Cr @ Highway 821	18	**21.8**	21 Aug 18:30	**21.2**	28 Jul
41A070	Crab Cr nr Beverly	21	**28.7**	08 Aug 19:00	**28.0**	07 Aug
45A110	Wenatchee R nr Leavenworth	16	**23.6**	09 Aug 17:30	**23.3**	08 Aug
46A070	Entiat R nr Entiat	18	**24.8**	08 Aug 17:30	**24.3**	08 Aug
48A070	Methow R nr Pateros	18	**24.9**	08 Aug 18:30	**24.2**	08 Aug
48A140	Methow R @ Twisp	18	**21.6**	08 Aug 16:30	**21.1**	08 Aug
49A070	Okanogan R @ Malott	18	**26.2**	31 Jul 17:30	**25.4**	30 Jul
49A190	Okanogan R @ Oroville	18	**26.1**	07 Aug 21:00	**25.5**	08 Aug
55B070	Little Spokane R nr mouth	18	17.8	19 Jul 19:30	**17.4**	21 Jul
56A070	Hangman Cr @ mouth	18	**26.6**	31 Jul 19:30	**25.8**	30 Jul
59A130	Colville R @ Chewelah	18	**24.3**	09 Aug 20:00	**23.9**	08 Aug
60A070	Kettle R nr Barstow	16	**24.3**	08 Aug 18:00	**24.0**	08 Aug

a This is the seven-day period with the highest average of daily maximum temperatures.
b There may be other dates or other seven-day periods with the same maximum.
c Date shown is middle of seven-day period.

Sanitary Conditions

Acceptable water quality for the support of swimming and shellfish harvesting is commonly based on counts of fecal coliform bacteria (FC). Since it is impossible to test for all pathogenic organisms, FC counts are used as an indicator of pollution. FC originate in the intestinal tract of warm-blooded animals, and their levels in water are relatively easy to measure. Because of this, water quality standards for FC have been set to protect the beneficial water uses of swimming and shellfish harvesting.

Washington's water quality standard for FC has two criteria, one based on the geometric mean and one on the 90th percentile (i.e., not more than 10 percent of results may exceed the criterion).

Estimates of the amount of fecal coliform loading that needs to be reduced may help decide where pollution-control efforts should be targeted. One approach to determine the amount of reduction needed is the Statistical Rollback Method (Ott, 1995). The Statistical Rollback Method was applied to these data and the percent reduction in fecal coliform levels needed to meet both standards (percent and geometric mean) was derived (Table 6). These reductions assume that the FC data are log-normally distributed and that the distribution will not change when fecal coliform levels are reduced.

Water quality data collected by Ecology show that standards in 2005 were not met for fecal coliform bacteria at 11 of the long-term stream monitoring stations (18 percent) and 13 of the basin stations (42 percent). The percent of basin stations that exceeded criteria may not be representative of statewide conditions; basin stations are often sited in known problem areas. All 24 stations exceeded their 90th percentile criterion; one long-term station and seven basin stations also exceeded their geometric mean criterion.

Of the 24 stations exceeding their FC criterion, only two long-term and 12 basin stations require reductions based on the statistical rollback method (Table 7). (The difference is because the statistical rollback method calculates the 90th percentile based on an assumed log-normal distribution.)

Table 7. Fecal coliform levels sampled in 2005, and the percent reductions required to meet water quality standards. Only stations exceeding a criterion are shown; mean and percentile units are colonies/100mL. The percent reduction required is based on the statistical rollback method.

Station	Location	Water Class	Geometric Mean	90^{th} Percentile	Percent Reduction Required
Long-term Stations					
03B050	Samish R nr Burlington	A	51	210	0
05A070	Stillaguamish R nr Silvana	A	12	214	0
05A090	SF Stillaguamish @ Arlington	A	20	303	0
07A090	Snohomish R @ Snohomish	A	29	852	0
09A080	Green R @ Tukwila	A	59	896	34
11A070	Nisqually R @ Nisqually	A	13	285	0
16A070	Skokomish R nr Potlatch	AA	11	199	0
20B070	Hoh R @ DNR Campground	AA	19	194	0
23A070	Chehalis R @ Porter	A	23	254	0
34B110	SF Palouse R @ Pullman	A	173	3350	91
54A120	Spokane R @ Riverside State Pk	A	14	283	0
Basin Stations					
01T050	Anderson Cr @ South Bay Rd	AA	16	201	37
09K070	Fauntleroy Cr nr mouth	AA	132	369	68
10C095	White River @ R Street	A	13	237	0
25F060	Mill Cr nr mouth	A	33	258	3
28C070	Burnt Br Cr @ mouth	A	145	507	59
34C060	Paradise Cr at mouth	A	50	1180	50
34C100	Paradise Cr @ Border	A	143	1042	69
37E050	Wide Hollow Cr @ Main Street	A	95	448	69
37I070	Moxee Drain @ Birchfield Rd	A	158	652	62
38G070	Cowiche Cr @ Powerhouse Rd	A	29	526	31
39C070	Wilson Cr @ Highway 821	A	136	411	53
45D080	Brender Cr abv Noname Cr	A	157	508	47
45R070	Noname Cr on Mill Rd	A	382	1310	83

Aquatic Weeds

Ecology has been collecting information on aquatic plants from lakes and rivers throughout the Washington State since 1994. The main objective of this program is to inventory and monitor the spread of invasive exotic (non-native) aquatic plant species. Other objectives are to provide technical assistance on aquatic plant identification and control of invasive species, and to conduct special projects evaluating the impacts of invasive non-native species and their control.

For most lakes, the method used is to circumnavigate the littoral zone in a small boat. When a different plant or type of habitat is observed, samples are collected for identification. Notes on species distribution, abundance, and maximum depth of growth are made. In addition, Secchi depth and alkalinity data are collected.

Table 8 identifies lakes where invasive exotic aquatic plants have been discovered since 1994. This list only includes locations of the true Class A or B aquatic weeds. Class C weeds, such as fragrant waterlily or riparian weeds like yellow flag iris, are not included. (See www.nwcb.wa.gov for a definition of weed classes.)

Table 8. Location of invasive exotic aquatic weeds in Washington, by county.

County	Waterbody Name	Scientific name	Common name	Legal location
Adams	Hutchinson Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-28E-15
Chelan	Chelan Lake	Myriophyllum spicatum	Eurasian water-milfoil	27N-22E-13
Chelan	Cortez (Three) Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-21E-29
Chelan	Roses (Alkali) Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-21E-26
Chelan	Wapato Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-21E-23
Clallam	Sutherland Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-08W-22
Clallam	Unnamed (30N-04W-17)	Myriophyllum spicatum	Eurasian water-milfoil	30N-04W-17
Clark	Battleground Lake	Egeria densa	Brazilian elodea	04N-03E-30
Clark	Caterpillar Slough	Myriophyllum spicatum	Eurasian water-milfoil	03N-01W-36
Clark	Columbia River at Ridgefield	Myriophyllum spicatum	Eurasian water-milfoil	04N-01W-24
Clark	Klineline Pond	Egeria densa	Brazilian elodea	03N-01E-26
Clark	Lacamas Lake	Egeria densa	Brazilian elodea	01N-03E-02
Columbia	Snake River at Little Goose Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-38E-26
Columbia	Snake River near Lyons Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-37E-30
Cowlitz	Coweeman River	Egeria densa	Brazilian elodea	08N-02W-35
Cowlitz	Kress Lake	Myriophyllum spicatum	Eurasian water-milfoil	07N-01W-31
Cowlitz	Silver Lake	Utricularia inflata	big floating bladderwort	10N-01W-36
Cowlitz	Solo Slough	Cabomba caroliniana	fanwort	08N-03W-14
Cowlitz	Solo Slough	Egeria densa	Brazilian elodea	08N-03W-14
Cowlitz	Solo Slough	Ludwigia hexapetala	water primrose	08N-03W-14
Cowlitz	Solo Slough	Myriophyllum aquaticum	parrotfeather	08N-03W-14
Cowlitz	Willow Grove Slough	Cabomba caroliniana	fanwort	08N-03W-14
Cowlitz	Willow Grove Slough	Egeria densa	Brazilian elodea	08N-03W-14

County	Waterbody Name	Scientific name	Common name	Legal location
Cowlitz	Willow Grove Slough	Myriophyllum spicatum	Eurasian water-milfoil	08N-03W-14
Douglas	Big Bow Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-21E-23
Douglas	Pateros Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-24E-06
Franklin	Mesa Lake	Myriophyllum spicatum	Eurasian water-milfoil	13N-30E-34
Franklin	Scooteney Res	Myriophyllum spicatum	Eurasian water-milfoil	14N-30E-27
Franklin	Snake River at Ice Harbor Dam	Myriophyllum spicatum	Eurasian water-milfoil	09N-31E-24
Franklin	Snake River at Lower Monumental Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-34E-34
Franklin	Snake River at Lyons Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-37E-19
Grant	Babcock Ridge Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-23E-10
Grant	Banks Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-28E-33
Grant	Billy Clapp Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-28E-36
Grant	Burke Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-23
Grant	Caliche Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-23E-22
Grant	Columbia River at Crescent Bar	Myriophyllum spicatum	Eurasian water-milfoil	20N-23E-19
Grant	Evergreen Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-22
Grant	Moses Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-28E-09
Grant	Potholes Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	17N-28E-11
Grant	Priest Rapids Lake	Myriophyllum spicatum	Eurasian water-milfoil	14N-23E-16
Grant	Red Rock Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-26E-17
Grant	Stan Coffin Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-10
Grays Harbor	Chehalis River	Myriophyllum aquaticum	parrotfeather	17N-06W-02
Grays Harbor	Connor Creek	Myriophyllum spicatum	Eurasian water-milfoil	18N-12W-03
Grays Harbor	Duck Lake	Egeria densa	Brazilian elodea	17N-12W-14
Grays Harbor	Duck Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-12W-14
Island	Deer Lagoon	Myriophyllum aquaticum	parrotfeather	29N-02E-13
Island	Lone Lake	Egeria densa	Brazilian elodea	29N-03E-07
Island	Unnamed Pond	Egeria densa	Brazilian elodea	30N-03E-32
Island	Unnamed Pond (31N-02E-35)	Myriophyllum aquaticum	parrotfeather	32N-02E-35
Jefferson	Leland Lake	Egeria densa	Brazilian elodea	28N-02W-26
King	Bass Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-06E-02
King	Desire Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-05E-36
King	Dolloff Lake	Egeria densa	Brazilian elodea	21N-04E-10
King	Dolloff Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-04E-10
King	Fenwick Lake	Egeria densa	Brazilian elodea	22N-04E-26
King	Green Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-05
King	Lucerne Lake	Hydrilla verticillata	hydrilla	22N-06E-28
King	Lucerne Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-28
King	Meridian Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-05E-27
King	Neilson (Holm) Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-05E-14
King	North Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-04E-15
King	Number Twelve Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-06E-12
King	Otter (Spring) Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-06E-31
King	Phantom Lake	Myriophyllum spicatum	Eurasian water-milfoil	24N-05E-02

County	Waterbody Name	Scientific name	Common name	Legal location
King	Pipe Lake	Hydrilla verticillata	hydrilla	22N-06E-28
King	Pipe Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-28
King	Sammamish Lake	Egeria densa	Brazilian elodea	25N-04E-13
King	Sammamish Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-13
King	Sawyer Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-06E-04
King	Shadow Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-07
King	Shady Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-05E-01
King	Ship Canal	Myriophyllum spicatum	Eurasian water-milfoil	
King	Star Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-04E-34
King	Steel Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-04E-09
King	Union Lake	Egeria densa	Brazilian elodea	25N-04E-19
King	Union Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-19
King	Unnamed Pond, Bellevue	Myriophyllum aquaticum	parrotfeather	24N-05E-11
King	Walsh Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-07E-09
King	Washington Lake	Egeria densa	Brazilian elodea	25N-04E-16
King	Washington Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-16
King	Wilderness Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-27
Kitsap	Horseshoe Lake	Utricularia inflata	big floating bladderwort	22N-01E-10
Kitsap	Long Lake	Egeria densa	Brazilian elodea	23N-02E-17
Kitsap	Long Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-02E-17
Kitsap	Mission Lake	Utricularia inflata	big floating bladderwort	24N-01W-32
Kitsap	Square Lake	Utricularia inflata	big floating bladderwort	23N-01E-16
Kitsap	Tahuya Lake	Utricularia inflata	big floating bladderwort	24N-01W-20
Kitsap	Wye Lake	Utricularia inflata	big floating bladderwort	22N-01W-02
Kittitas	Fiorito Ponds	Myriophyllum spicatum	Eurasian water-milfoil	17N-19E-30
Kittitas	Lavender Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-14E-20
Kittitas	Mattoon Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-18E-11
Kittitas	McCabe Pond	Myriophyllum spicatum	Eurasian water-milfoil	17N-19E-31
Kittitas	Private Pond (20N-16E-10)	Myriophyllum spicatum	Eurasian water-milfoil	20N-16E-10
Klickitat	Columbia River at Bingen	Myriophyllum spicatum	Eurasian water-milfoil	03N-11E-32
Klickitat	Columbia River at Maryhill	Myriophyllum spicatum	Eurasian water-milfoil	02N-15E-14
Klickitat	Horsethief Lake	Myriophyllum spicatum	Eurasian water-milfoil	02N-14E-19
Lewis	Carlisle Lake	Myriophyllum spicatum	Eurasian water-milfoil	13N-01E-30
Lewis	Chehalis River	Egeria densa	Brazilian elodea	14N-03W-02
Lewis	Chehalis River	Myriophyllum aquaticum	parrotfeather	14N-03W-02
Lewis	Cowlitz River near Blue Cr	Myriophyllum spicatum	Eurasian water-milfoil	11N-01E-01
Lewis	Interstate Ave Slough	Myriophyllum aquaticum	parrotfeather	14N-02W-32
Lewis	Mayfield Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	12N-02E-29
Lewis	Plummer Lake	Egeria densa	Brazilian elodea	14N-02W-07
Lewis	Riffe Lake	Myriophyllum spicatum	Eurasian water-milfoil	12N-03E-10
Lewis	South County Park Pond	Myriophyllum spicatum	Eurasian water-milfoil	11N-01W-17
Lewis	Swofford Pond	Myriophyllum spicatum	Eurasian water-milfoil	12N-03E-26
Lincoln	Franklin D. Roosevelt Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-37E-33
Mason	Island Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-03W-06

County	Waterbody Name	Scientific name	Common name	Legal location
Mason	Limerick Lake	Egeria densa	Brazilian elodea	21N-03W-27
Mason	Limerick Lake	Utricularia inflata	big floating bladderwort	21N-03W-27
Mason	Mason Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-02W-34
Mason	Mason Lake	Sagittaria graminea	slender arrowhead	22N-02W-34
Mason	Mason Lake	Utricularia inflata	big floating bladderwort	22N-02W-34
Mason	Spencer Lake	Utricularia inflata	big floating bladderwort	21N-02W-32
Mason	Trails End (formerly Prickett)	Utricularia inflata	big floating bladderwort	22N-02W-23
Okanogan	Conconully (Salmon) Lake	Myriophyllum spicatum	Eurasian water-milfoil	35N-25E-06
Okanogan	Conconully Reservoir (35N-25E-18)	Myriophyllum spicatum	Eurasian water-milfoil	35N-25E-18
Okanogan	Osoyoos Lake	Myriophyllum spicatum	Eurasian water-milfoil	40N-27E-22
Okanogan	Palmer Lake	Myriophyllum spicatum	Eurasian water-milfoil	39N-25E-11
Okanogan	Rat Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-24E-22
Okanogan	Whitestone Lake	Myriophyllum spicatum	Eurasian water-milfoil	38N-27E-17
Pacific	Black Lake	Egeria densa	Brazilian elodea	10N-11W-28
Pacific	Black Lake	Myriophyllum spicatum	Eurasian water-milfoil	10N-11W-28
Pacific	Loomis Lake	Egeria densa	Brazilian elodea	11N-11W-21
Pacific	Loomis Lake	Myriophyllum spicatum	Eurasian water-milfoil	11N-11W-21
Pacific	Sloughs near Long Beach	Myriophyllum aquaticum	parrotfeather	10N-11W
Pend Oreille	Davis Lake	Myriophyllum spicatum	Eurasian water-milfoil	32N-44E-31
Pend Oreille	Diamond Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-44E-03
Pend Oreille	Fan Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-43E-32
Pend Oreille	Horseshoe Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-43E-08
Pend Oreille	Little Spokane River	Myriophyllum spicatum	Eurasian water-milfoil	56N-43E-34
Pend Oreille	Marshall Lake	Myriophyllum spicatum	Eurasian water-milfoil	32N-45E-23
Pend Oreille	Nile Lake	Myriophyllum spicatum	Eurasian water-milfoil	37N-42E-35
Pend Oreille	Pend Oreille River	Myriophyllum spicatum	Eurasian water-milfoil	38N-43E-32
Pend Oreille	Sacheen Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-43E-35
Pend Oreille	Wilderness Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-43E-04
Pierce	Clear Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-04E-27
Pierce	Harts Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-03E-07
Pierce	Hidden Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-05E-20
Pierce	Ohop Lake	Egeria densa	Brazilian elodea	16N-04E-10
Pierce	Rapjohn Lake	Utricularia inflata	big floating bladderwort	17N-04E-31
Pierce	Slough, Port of Tacoma	Myriophyllum aquaticum	parrotfeather	20N-03E-02
Pierce	Tapps Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-05E-08
Skagit	Beaver Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-05E-07
Skagit	Big Lake	Egeria densa	Brazilian elodea	34N-04E-36
Skagit	Big Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-04E-36
Skagit	Campbell Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-01E-13
Skagit	Clear Lake (34N-05E-07)	Myriophyllum spicatum	Eurasian water-milfoil	34N-05E-07
Skagit	Erie Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-01E-11
Skagit	Heart Lake (35N-01E-36)	Myriophyllum spicatum	Eurasian water-milfoil	35N-01E-36
Skagit	McMurray Lake	Myriophyllum spicatum	Eurasian water-milfoil	33N-05E-30

County	Waterbody Name	Scientific name	Common name	Legal location
Skagit	Sixteen Lake	Myriophyllum spicatum	Eurasian water-milfoil	33N-04E-15
Skamania	Drano	Myriophyllum spicatum	Eurasian water-milfoil	03N-09E-26
Skamania, Cowlitz	Coldwater Lake	Myriophyllum spicatum	Eurasian water-milfoil	10N-05E-31
Snohomish	Echo Lake	Sagittaria graminea	slender arrowhead	27N-06E-33
Snohomish	Goodwin Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-04E-33
Snohomish	Loma Lake	Sagittaria graminea	slender arrowhead	31N-04E-35
Snohomish	Martha Lake (27N-04E-01)	Myriophyllum spicatum	Eurasian water-milfoil	27N-04E-01
Snohomish	Meadow Lake	Hydrocharis morsus-ranae	European frog-bit	28N-07E-18
Snohomish	Nina Lake	Myriophyllum aquaticum	parrotfeather	31N-05E-32
Snohomish	Private Pond	Myriophyllum aquaticum	parrotfeather	28N-07E-26
Snohomish	Roesiger (north arm) Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-07E-21
Snohomish	Roesiger (north arm) Lake	Sagittaria graminea	slender arrowhead	29N-07E-21
Snohomish	Roesiger (south arm) Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-07E-28
Snohomish	Roesiger (south arm) Lake	Sagittaria graminea	slender arrowhead	29N-07E-28
Snohomish	Serene Lake (28N-04E-34)	Myriophyllum spicatum	Eurasian water-milfoil	28N-04E-34
Snohomish	Serene Lake (28N-04E-34)	Sagittaria graminea	slender arrowhead	28N-04E-34
Snohomish	Shoecraft Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-04E-33
Snohomish	Silver Lake (28N-05E-30)	Myriophyllum spicatum	Eurasian water-milfoil	28N-05E-30
Snohomish	Stevens Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-06E-08
Snohomish	Swartz	Egeria densa	Brazilian elodea	30N-07E-20
Spokane	Eloika Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-43E-15
Spokane	Liberty Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-42E-22
Spokane	Long Lake (Reservoir)	Myriophyllum spicatum	Eurasian water-milfoil	27N-39E-13
Spokane	Long Lake (Reservoir)	Nymphoides peltata	water fringe	27N-39E-13
Spokane	Newman Lake	Myriophyllum spicatum	Eurasian water-milfoil	26N-42E-10
Spokane	Silver Lake	Myriophyllum spicatum	Eurasian water-milfoil	24N-41E-32
Stevens	Black Lake	Myriophyllum spicatum	Eurasian water-milfoil	35N-41E-03
Stevens	Gillette Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-20
Stevens	Heritage Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-08
Stevens	Loon Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-41E-33
Stevens	McDowell Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-41E-06
Stevens	Sherry Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-20
Stevens	Thomas Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-18
Thurston	Capitol Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-02W-15
Thurston	Deep Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-02W-03
Thurston	Deep Lake	Sagittaria platyphylla	flat-leaf arrowhead	16N-02W-03
Thurston	Deep Lake	Utricularia inflata	big floating bladderwort	16N-02W-03
Thurston	Hicks Lake	Utricularia inflata	big floating bladderwort	18N-01W-27
Thurston	Long Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-01W-22
Thurston	Munn Lake	Utricularia inflata	big floating bladderwort	17N-02W-01
Thurston	Scott Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-02W-33
Thurston	Skiview Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-02W-08
Thurston	Susan Lake	Utricularia inflata	big floating bladderwort	17N-02W-01

County	Waterbody Name	Scientific name	Common name	Legal location
Wahkiakum	Brooks Slough	Myriophyllum aquaticum	parrotfeather	09N-06W-26
Wahkiakum	Columbia River at Cathlamet	Myriophyllum spicatum	Eurasian water-milfoil	08N-06W-02
Wahkiakum	Columbia River at Skamokawa	Myriophyllum aquaticum	parrotfeather	09N-06W-18
Wahkiakum	Puget Island Sloughs	Egeria densa	Brazilian elodea	08N-06W-14
Wahkiakum	Puget Island Sloughs	Myriophyllum aquaticum	parrotfeather	08N-06W-14
Wahkiakum	Puget Island Sloughs	Myriophyllum spicatum	Eurasian water-milfoil	08N-06W-14
Whatcom	Silver Lake	Butomus umbellatus	flowering rush	40N-06E-07
Whatcom	Unnamed Pond	Egeria densa	Brazilian elodea	40N-01E-22
Whatcom	Unnamed Pond (39N 3E 19)	Nymphoides peltata	water fringe	39N-03E-19
Whatcom	Unnamed Pond (40N-2E-2)	Myriophyllum aquaticum	parrotfeather	40N-02E-02
Whatcom	Whatcom Lake	Myriophyllum spicatum	Eurasian water-milfoil	38N-03E-28
Whitman	Snake River at Central Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-40E-08
Whitman	Snake River at Little Goose Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-38E-23
Whitman	Snake River at Lower Granite Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-43E-12
Yakima	Buena Lake	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-21
Yakima	Byron Lake	Myriophyllum spicatum	Eurasian water-milfoil	08N-23E-12
Yakima	Dog Lake	Myriophyllum spicatum	Eurasian water-milfoil	14N-12E-31
Yakima	Freeway (Rotary) Lake	Myriophyllum spicatum	Eurasian water-milfoil	13N-19E-07
Yakima	I-82 Pond, Exit 50	Myriophyllum aquaticum	parrotfeather	11N-20E-28
Yakima	I-82 Ponds, Exit 52	Myriophyllum aquaticum	parrotfeather	11N-20E-35
Yakima	Parker Ponds	Myriophyllum spicatum	Eurasian water-milfoil	12N-19E-20
Yakima	Pond 1	Myriophyllum spicatum	Eurasian water-milfoil	12N-19E-35
Yakima	Pond 2	Myriophyllum spicatum	Eurasian water-milfoil	12N-19E-35
Yakima	Pond 3	Myriophyllum spicatum	Eurasian water-milfoil	11N-19E-01
Yakima	Pond 4	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-17
Yakima	Pond 5	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-20

References Cited

Aroner, E.R., 2002. WQHYDRO –Water Quality/Hydrology/Graphics/Analysis System User's Manual. Portland, OR.

Brown, R.M., N.I. McClelland, R.A. Deininger, and R.G. Tozer, 1970. A Water Quality Index—Do We Dare? Wat. Sewage Wks. 339-343.

Couillard, D. and Y. Lefebvre, 1985. Analysis of Water Quality Indices. Journal of Environmental Management 21:161-179.

Gilbert, R.O., 1987. Statistical Methods for Environmental Pollution Monitoring. Va Nostrand Reinhold, New York, N.Y.

Hallock, D., 2005. River and Stream Ambient Monitoring Report for Water Year 2005. Publication No. 06-03-032. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/biblio/0603032.html

Hallock, D., 2002. A Water Quality Index for Ecology's Stream Monitoring Program. Publication No. 02-03-052. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/biblio/0203052.html

Harkins, R.D., 1974. An objective water quality index. J. Water Poll. Control Fed., 46(3): 588-591.

McClelland, N.I., 1974. Water Quality Index Application in the Kansas River Basin. EPA-907/9-74-001. U.S. Environmental Protection Agency, Kansas City, MO.

Omernik, J.M. and A.L. Gallant, 1986. Ecoregions of the Pacific Northwest. EPA 600/ 3-86/033. U.S. Environmental Protection Agency, Corvallis, OR.

Ott, W.R., 1995. Environmental Statistics and Data Analysis. Lewis Publishers, Boca Raton, FL.

Peterson, R. and B. Bogue, 1989. Water Quality Index used in Environmental Assessments. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

Reckhow, K.H., K. Kepford, and W. Warren Hicks, 1993. Methods for the Analysis of Lake Water Quality Trends. EPA 841-R-93-003. U.S. Environmental Protection Agency, Washington, D.C.