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Condition of Freshwaters in Washington State

Technical Appendix

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Condition of Freshwaters in Washington State

Technical Appendix

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Abstract

This document presents further details about the assessment methods and information about specific sampling locations used to develop the report "Conditions of Freshwaters in Washington State" (Ecology Publication Number 01-03-025). Five different analyses are presented:
(1) Washington's Water Quality Index is derived from eight variables collected from all sampling stations measured in water year 2000; (2) Trends in seven water quality indicators from Ecology's core sampling stations and ecoregions were evaluated from data collected over the last 10 years; (3) The reductions in fecal coliform bacteria levels needed to meet sanitary standards was calculated for Ecology's core sampling stations; (4) The trophic state of lakes sampled in the summer of 2000 was derived from transparency data; and (5) The Benthic Index of Biological Integrity was derived from stream macroinvertebrate data collected since 1992.

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Introduction

This document presents further details about the assessment methods and information about specific sampling locations used to develop the report "Conditions of Freshwaters in Washington State" (Ecology Publication Number 01-03-025).

Washington’s 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. Several water quality indices that summarize data in an easily understood format are reviewed by Couillard and Lebebvre (1985).

Washington’s Water Quality Index (WQI) is a unitless number ranging from 10 to 100 that is intended to represent general water quality. A higher number indicates better water quality. For constituents with established water quality standards (based on criteria in Washington’s Water Quality Standards, WAC 173-201A), the index expresses results relative to levels required to meet these standards. For constituents without specific standards, results are expressed relative to expected conditions in the appropriate region. Multiple constituents 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 that 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?). Indexes are less suited to 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 indexes are based on a pre-identified set of water quality constituents. A particular station may receive a good WQI score, and yet have water quality impaired by constituents 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 constituents, at least) was not chronic.

Strategies

Different approaches to indexing water quality results are possible. One approach is to rate quality objectively, for example, using ranked data (e.g. 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. Anytime 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 to management is one that allows water quality to be compared to that necessary to support beneficial uses. However, this approach requires subjective determinations of the beneficial uses that a particular stream segment should support, the level of water quality required to support those uses, and how critical variations from that level of quality are. For several key parameters, first two of these determinations are already codified in Washington's Administrative Code (WAC 173-201A). Washington's WQI follows this approach.

Methodology

The methodology used to determine WQI scores was originally developed by the 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 constituents 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).

In the 1980s, Ecology produced a WQI using the EPA methods, with further modifications of some curves to align curves with water quality standards (e.g. Hallock, 1990). The index was calculated by a Fortran program run on an EPA mainframe computer using data in the national STORET database. These procedures were somewhat cumbersome and Ecology stopped producing the index in the early 1990s. Ecology recently re-programmed the WQI procedures to assess data in Ecology's ambient stream monitoring database. (Differences from the 1980s methodology are described below.)

Water Quality Constituents Included in the Index

For this analysis, index scores were determined for eight constituents monitored monthly by Ecology's Freshwater Monitoring Unit: temperature, dissolved oxygen (DO), pH, fecal coliform bacteria (FC), total nitrogen (TN), total phosphorus (TP), total suspended sediment (TSS), and turbidity. Rather than aggregating scores for TN and TP separately, the harmonic mean was used in the aggregation of the overall index because TN and TP are highly correlated and they measure similar impacts on water quality. Similarly, a harmonic mean of sediment-related constituents (TSS and turbidity) was also used. Future WQI analyses may include an evaluation of percent oxygen saturation and unionized ammonia. Data collection and quality control are discussed in our annual reports (e.g. Hallock and Ehinger, 2000).

Calculation of the Index

There are three parts to calculating the index:

Convert each result to an index score ranging from 10 to 100.

Every result in the selected date range was converted to an index score by a quadratic equation. For temperature, oxygen, pH, and fecal bacteria, formulas were scaled to yield a score of approximately 80 for results at the water quality criterion for that constituent. For example, a temperature of 18 °C in a Class A stream would yield an index score of approximately 80. For nutrient and sediment constituents, formulas were designed so that about 20 percent of the data from long-term stations would convert to index scores below 80.

Aggregate index scores.

For WQI analyses using data from multiple years, one score for constituent of each month was determined as the mean of all scores for that constituent and that month (e.g., all January values are averaged). The WQIs for the different constituents were then aggregated for each month by calculating a simple average and subtracting a penalty factor for scores less than 80. The penalty factor was (85-WQI Score)/2. (For example, if the average WQI score in January was 89 and the only constituent below 80 was pH which equaled 75, the penalty factor for pH would be (85-75) / 2 = 5 and the overall average score for that month would be 89-5=84.) The penalty factor approach was used to weight low scoring (poor water quality) constituents more heavily and thus reduce the likelihood of one low-scoring constituent—which could have severe affects on the ecosystem—being masked by the averaging process. (Oregon uses a square harmonic mean to weight low-scoring constituents (Cude, 2001).) The overall WQI for a station was the average monthly overall score for the three lowest-scoring consecutive months. (December and January are considered consecutive.) A WQI was also determined for each water quality constituent as the average of the three lowest-scoring consecutive months for that constituent.

Apply weightings and other miscellaneous rules.

Some adjustments were made to moderate low scores that could be attributed to naturally occurring influences. The following rules were applied by default:

a) A minimum WQI score of 75 was set for turbidity and suspended solids at sites influenced by glacial runoff.

b) Prior to calculating the WQI, the pH was adjusted downward (0.5 standard units is the default) at stations in Columbia Basin and Rocky Mountain Ecoregions, where pH tends to naturally be more alkaline. Median pH at stations in these ecoregions is about 0.5 units higher that at stations in other ecoregions (Table 1). This adjustment applied only when pH was greater than 8.0.

c) A harmonic mean was used for turbidity and suspended solids. This prevents double-weighting these strongly correlated constituents.

d) A harmonic mean was used for total phosphorus and total nitrogen. This prevents double weighting of a nutrient index.

e) A maximum penalty (default=20) was set for nutrient and sediment scores below 80 because these scores are based on distribution of historical data and not on environmental impact or beneficial use support.

Table 1. Distribution of pH Data by Ecoregion based on Data Collected from Long-term Monitoring Stations between October 1990 and September 2000.

Ecoregion	**Number of Samples**	**Min**	**Percentiles**					**Max**
			10	**25**	**50**	**75**	**90**	
Coast Range	417	6.3	7.0	7.2	7.4	7.6	7.8	8.2
Puget Lowlands	1427	6.2	7.0	7.2	7.4	7.6	7.7	8.6
Cascades	175	6.4	6.8	7.1	7.4	7.6	7.9	8.6
Columbia Basin	1277	5.4	7.5	7.8	8.1	8.3	8.6	9.7
Northern Rockies	295	6.5	7.5	7.8	8.0	8.2	8.4	8.9

Converting Raw Data to WQI Scores

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, TSS, TP, and TN do not account for natural differences caused by to wide variations in geomorphology across the state. Furthermore, there are no water quality standards criteria for these constituents. Therefore, Ecology developed new curves based on the distribution of data at stations within each ecoregion during high- and low-flow seasons. Data from long-term stations collected from October 1990 through September 2000 were used to develop the curves. Stations influenced by glaciers were excluded from this analysis for turbidity and TSS. WQI scores were matched to various quantiles (Table 2). A quadratic equation was then fit to the WQI-concentration relationships. (Table 3). The particular formulas used for a particular station and constituent depended on the stream class or ecoregion for that station. The "Log" column indicates whether the natural log of the constituent was used.

Table 2. WQI Scores Assigned to Various Quantiles for Curve Development for TP, TN, Turbidity, and TSS.

WQI	Quantile	Comment
100	10^{th} percentile	Concentrations less than the 10^{th} percentile are considered to be the lowest reasonably achievable. This point was frequently at or near our detection limits. (The low flow season quantile was applied to both seasons.) Concentrations below the 90^{th} percentile are considered to be of **"Lowest Concern"** (WQI > 80).
80	90^{th} percentile	Concentrations above the 90^{th} and 95^{th} percentiles are considered to be of **"Moderate Concern"**. ($40 \leq$ WQI < 80)
40	95^{th} percentile	Concentrations above the 95^{th} percentile are considered of **"Highest Concern"**. (WQI < 40)
20	99^{th} percentile	Approximately one percent of the data will be assigned WQI scores < 20

Table 3. Coefficients of the Quadratic Equation Used to Convert Results to Index Scores ($WQI=a + b_1 (Constituent) + b_2 (Constituent)^2$)

Constituent	Class or Ecoregion	Season	a	b_1	b_2	Log
FC	A	All	100.19	0.810055	-1.28485	Yes
FC	AA	All	101.25	-0.5832	-1.35641	Yes
FC	B	All	100.544	2.59723	-1.30612	Yes
DO	A	All	-62.3255	27.5473	-1.14663	No
DO	AA	All	-129	33.81	-1.22397	No
DO	B	All	-104.009	43.6529	-2.23081	No
DO Saturation	A	All	-84.7458	2.35876	-0.00537	No
DO Saturation	AA	All	-84.7458	2.35876	-0.00537	No
DO Saturation	B	All	-84.7458	2.35876	-0.00537	No
pH < 7.5	All	All	-530.322	158.619	-9.92672	No
pH >= 7.5	All	All	-338.812	128.627	-9.33089	No
TSS	Coast	Summer	102.1	-20.97	0.4879	Yes
TSS	Coast	Winter	99.91	-2.672	-1.586	Yes
TSS	Puget	Summer	101.9	-13.23	-0.8714	Yes

Constituent	**Class or Ecoregion**	**Season**	**a**	**b_1**	**b_2**	**Log**
TSS	Puget	Winter	104.45	-3.582	-1.534	Yes
TSS	Cascades	Summer	100.2	-11.53	-5.797	Yes
TSS	Cascades	Winter	100	-0.8133	-4.244	Yes
TSS	Columbia	Summer	100.3	9.301	-5.302	Yes
TSS	Columbia	Winter	101.3	-5.244	-1.074	Yes
TSS	Rockies	Summer	101.7	-15.27	-1.822	Yes
TSS	Rockies	Winter	102.7	-17.78	0.5713	Yes
Temperature	A	All	105.715	0.923907	-0.13556	No
Temperature	AA	All	100	0.923907	-0.13556	No
Temperature	B	All	80.6234	3.9808	-0.20789	No
TP	Coast	Summer	-88.81	-49.36	-1.713	Yes
TP	Coast	Winter	-28.18	-39.85	-2.531	Yes
TP	Puget	Summer	-65.22	-56.47	-4.399	Yes
TP	Puget	Winter	-23.78	-44.2	-3.7	Yes
TP	Cascades	Summer	102.9	72.75	15.7	Yes
TP	Cascades	Winter	22.57	11.14	6.208	Yes
TP	Columbia	Summer	28.11	-17.39	-0.2926	Yes
TP	Columbia	Winter	25.24	-27.78	-2.455	Yes
TP	Rockies	Summer	-24.76	-22.64	1.086	Yes
TP	Rockies	Winter	-28.91	-41.18	-2.787	Yes
TN	Coast	Summer	103.3	-81.96	-13.03	No
TN	Coast	Winter	102	-33.92	-27.22	No
TN	Puget	Summer	103.1	-41.01	-53.19	No
TN	Puget	Winter	102.8	-7.019	-58.26	No
TN	Cascades	Summer	121.8	-653.3	761.5	No
TN	Cascades	Winter	132.1	-616.2	835	No
TN	Columbia	Summer	107.2	-36.82	3.577	No
TN	Columbia	Winter	101.1	-15.31	0.6726	No
TN	Rockies	Summer	94.71	74.5	-78.95	No
TN	Rockies	Winter	100.4	4.614	-32.56	No
Turbidity	Coast	Summer	101.2	-22.46	0.4797	Yes
Turbidity	Coast	Winter	100.2	-3.15	-2.148	Yes
Turbidity	Puget	Summer	101.7	-18.88	-0.3592	Yes
Turbidity	Puget	Winter	101.1	-3.795	-1.812	Yes
Turbidity	Cascades	Summer	99.85	-11.73	-23.26	Yes
Turbidity	Cascades	Winter	102.5	-27.99	1.922	Yes
Turbidity	Columbia	Summer	101	-5.751	-2.913	Yes
Turbidity	Columbia	Winter	101.4	-6.728	-1.256	Yes
Turbidity	Rockies	Summer	100.8	-33.21	1.393	Yes
Turbidity	Rockies	Winter	102.9	-21.51	0.9856	Yes

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.

Because the index scores for nutrient and sediment constituents are based on the distribution of past data and not on ecological impacts or degree of degradation, poor index scores for these constituents 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 constituents may not necessarily indicate a lack of impairment or an ability to support beneficial uses. Calculated results <10 or >100 are converted to 10 or 100, respectively.

The WQI was applied to water quality data collected from October 1999 to September 2000 (Table 4). To place the WQI scores into categories used for statewide assessment, the cut-points used by EPA in the original WQI was used. According to this categorization scheme, stations with WQI scores 80 and above are considered the 'Lowest Concern", scores from 40 to 79 are of "Moderate Concern", and those below 40 are of the "Highest Concern".

Table 4. Water Quality Index Scores for Stations Sampled in the Year 2000.

Station ID	**Station Name**	**Ecoregion**	**WQI**
01A050	Nooksack R @ Brennan	Puget Lowlands	69
01A120	Nooksack R @ No Cedarville	Puget Lowlands	81
03A060	Skagit R nr Mount Vernon	Puget Lowlands	89
03A080	Skagit abv Sedro Wooley	Puget Lowlands	83
03B045	Samish R nr Mouth	Puget Lowlands	60
03B050	Samish R nr Burlington	Puget Lowlands	68
03D050	Nookachamp Cr nr Mouth	Puget Lowlands	31
03E050	Joe Leary Slough nr Mouth	Puget Lowlands	10
03F070	Hill Ditch @ Cedardale Rd	Puget Lowlands	35
04A100	Skagit R @ Marblemount	Cascades	93
05A070	Stillaguamish R nr Silvana	Puget Lowlands	70
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	54
05A110	SF Stillaguamish nr Granite Falls	Puget Lowlands	56
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	68
05B110	NF Stillaguamish nr Darrington	Puget Lowlands	97
07A090	Snohomish R @ Snohomish	Puget Lowlands	91
07C070	Skykomish R @ Monroe	Puget Lowlands	95
07D050	Snoqualmie R nr Monroe	Puget Lowlands	88
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	93
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	84
08C110	Cedar R nr Landsburg	Puget Lowlands	96
09A080	Green R @ Tukwila	Puget Lowlands	76
09A190	Green R @ Kanaskat	Puget Lowlands	93

Station ID	Station Name	Ecoregion	WQI
10A070	Puyallup R @ Meridian St	Puget Lowlands	59
10C095	White R @ R Street	Puget Lowlands	65
11A070	Nisqually R @ Nisqually	Puget Lowlands	74
13A060	Deschutes R @ E St Bridge	Puget Lowlands	62
16A070	Skokomish R nr Potlatch	Puget Lowlands	93
16C090	Duckabush R nr Brinnon	Coast Range	96
17A060	Big Quilcene R nr Mouth	Coast Range	87
17C070	Jimmycomelately Cr nr Mouth	Coast Range	78
18A070	Dungeness R nr Sequim	Coast Range	88
18B070	Elwha R nr Port Angeles	Coast Range	88
20B070	Hoh R @ DNR Campground	Coast Range	82
22A070	Humptulips R nr Humptulips	Coast Range	84
23A070	Chehalis R @ Porter	Puget Lowlands	62
23A160	Chehalis R @ Dryad	Coast Range	71
24B090	Willapa R nr Willapa	Coast Range	63
24F070	Naselle R nr Naselle	Coast Range	72
26B070	Cowlitz R @ Kelso	Puget Lowlands	78
27B070	Kalama R nr Kalama	Puget Lowlands	94
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	87
28B110	Washougal R blw Canyon Cr	Willamette Valley	91
31A070	Columbia R @ Umatilla	Columbia Basin	84
32A070	Walla Walla R nr Touchet	Columbia Basin	66
32A100	Walla Walla @ East Detour Rd Br	Columbia Basin	67
32B080	Touchet R at Sims Rd	Columbia Basin	94
32B100	Touchet R @ Bolles	Columbia Basin	90
33A050	Snake R nr Pasco	Columbia Basin	81
34A070	Palouse R @ Hooper	Columbia Basin	55
34A170	Palouse R @ Palouse	Columbia Basin	69
34B110	SF Palouse R @ Pullman	Columbia Basin	33
35A150	Snake R @ Interstate Br	Columbia Basin	82
35B060	Tucannon R @ Powers	Columbia Basin	73
36A070	Columbia R nr Vernita	Columbia Basin	94
37A090	Yakima R @ Kiona	Columbia Basin	57
37A205	Yakima R @ Nob Hill	Columbia Basin	78
38A050	Naches R @ Yakima on Hwy 97	Columbia Basin	87
39A050	Yakima R @ Harrison Br	Columbia Basin	77
39A060	Yakima R @ Ellensburg	Columbia Basin	85
39A090	Yakima R nr Cle Elum	Cascades	76
41A070	Crab Cr nr Beverly	Columbia Basin	41
45A070	Wenatchee R @ Wenatchee	Columbia Basin	89
45A110	Wenatchee R nr Leavenworth	Cascades	79
45C070	Chumstick Cr nr Leavenworth	Cascades	42
45D070	Brender Cr nr Cashmere	Cascades	18
45E070	Mission Cr nr Cashmere	Cascades	33

Station ID	Station Name	Ecoregion	WQI
46A070	Entiat R nr Entiat	Columbia Basin	92
48A070	Methow R nr Pateros	Columbia Basin	92
48A140	Methow R @ Twisp	Columbia Basin	94
49A070	Okanogan R @ Malott	Columbia Basin	82
49A190	Okanogan R @ Oroville	Columbia Basin	84
49B070	Similkameen R @ Oroville	Columbia Basin	85
49B110	Similkameen R @ Chopaka Br	Columbia Basin	77
53A070	Columbia R @ Grand Coulee	Columbia Basin	93
54A090	Spokane R @ Ninemile Br	Northern Rockies	66
54A120	Spokane R @ Riverside State Pk	Northern Rockies	65
55B070	Little Spokane R nr Mouth	Northern Rockies	56
56A070	Hangman Cr @ Mouth	Columbia Basin	58
57A150	Spokane R @ Stateline Br	Columbia Basin	82
59A080	Colville R abv Kettle Falls	Northern Rockies	25
59A110	Colville R @ Blue Cr	Northern Rockies	21
59B070	Little Pend Oreille R @ Hwy 395	Northern Rockies	35
60A070	Kettle R nr Barstow	Northern Rockies	73
61A070	Columbia R @ Northport	Northern Rockies	88
61B070	Deep Cr nr Mouth	Northern Rockies	55
62A090	Pend Oreille R @ Metaline Falls	Northern Rockies	82
62A150	Pend Oreille R @ Newport	Northern Rockies	86

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. Formal statistical trend analysis provides a rational, scientific basis for addressing issues with natural variations in water quality. This natural variability can be assessed such that a trend in human-caused changes in water quality can be determined.

If a distinct relationship exists between stream flow and the concentration of a water quality indicator, then a trend in flows may create a trend in the indicator data or obscure a human-caused trend. A regression approach is to remove the variability associated with stream flows. Seven water quality indicators, collected from Ecology's core freshwater stations over the past 10 years (1991-2000) were evaluated for a relationship with flow. Ten regression models were tested using the statistical software called WQHYDRO (Aroner, 2001). These represented various linear, quadratic and hyperbolic regression models with and without log transformations (Table 5). An ordinary least squares regression was conducted at a 95% confidence level for statistical significance for each model. The significant regression model with the relatively lowest standard error and highest explained variance was selected to adjust the data for streamflow effects. Most of the water quality indicators at many stations showed a significant relationship with streamflow (Table 6). Regressions were conducted with the selected model and residuals were derived for use in the subsequent trend test.

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 values are below the analytical detection limit. The validity of the test does not depend on data being normally distributed. When the test is run on the residuals from a significant regression model, the influences of stream flow are removed from the trend test. The statistical software called WQHYDRO was used to evaluate for trends at each station using the residual or raw indicator data at a 95% confidence level for statistical significance. Most of the indicators exhibit significant trends at some stations (Tables 7 to 13). Some indicators show a significant trend with a slope near zero. This anomaly is a result of many indicator values being reported below the detection limit (e.g. total phosphorus) or with numerous tied values (e.g., pH).

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 for each group. Stations were grouped according to their location in each ecological region as defined by the U.S EPA (Omernick 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. Most of the indicators exhibit significant trends in one or more ecoregions and a statewide basis (Tables 14 to 20). In addition, the station showing the largest significant change in each indicator over the 10-year period is presented in Table 21.

Table 5. Regression Models Tested for Stream Flow Relationships.

#	**Model Type**	**Model Formula**
1	Linear- Linear	Y = a + bX
2	Linear- Log	Y = a + b*ln(X)
3	Log- Linear	Y = a*EXP(b*X)
4	Log- Log	Y = aX(power B)* Bias
5	Log- Log	Y = aX(power B)*MVUE-Bias
6	Inverse Linear	Y = a + b(1/X)
7	Hyperbolic	$Y = a + b_1*(1/(1+b_2*X))$
8	Quadratic	$Y = a + b_1*X + b_2*X^2$
9	Linear- Log Quadratic	$Y = a + b_1*\ln(X) + b_2*\ln(X)^2$
10	Log Quadratic	$Y = EXP[a + b_1*\ln(X) + b_2*\ln(X)^2*Bias$

Table 6. Mean Percent Explained Variance of Significant Indicator-Flow Relationships.

Indicator	**Mean Explained Variance with Streamflow**
Temperature	38%
Dissolved Oxygen	34%
pH	22%
Total Nitrogen	33%
Total Phosphorus	45%
Turbidity	62%
Fecal Coliform	22%

Table 7. Trend Analysis Data for Temperature Collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (°C/yr)	Standard Normal Deviate (Z)	Probability
01A050	**Nooksack R @ Brennan**	**Puget Lowlands**	**23**	**7**	**-0.220**	**-2.890**	**0.004**
01A120	**Nooksack R @ No Cedarville**	**Puget Lowlands**	**13**	**9**	**-0.270**	**-2.770**	**0.006**
03A060	Skagit R nr Mount Vernon	Puget Lowlands	14	8	-0.050	-0.870	0.383
03B050	Samish R nr Burlington	Puget Lowlands	51	7	-0.070	-0.590	0.555
04A100	**Skagit R @ Marblemount**	**Cascades**	**18**	**9**	**-0.220**	**-3.580**	**>0.001**
05A070	Stillaguamish R nr Silvana	Puget Lowlands	60	7	0.400	-0.620	0.533
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	43	7	-0.007	0.000	1.000
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	53	7	0.062	0.590	0.555
07A090	Snohomish R @ Snohomish	Puget Lowlands	47	7	-0.145	-1.720	0.086
07C070	Skykomish R @ Monroe	Puget Lowlands	42	7	-0.110	-0.908	0.364
07D050	Snoqualmie R nr Monroe	Puget Lowlands	51	7	-0.364	-1.768	0.077
07D130	**Snoqualmie R @ Snoqualmie**	**Puget Lowlands**	**47**	**7**	**-0.196**	**-2.298**	**0.022**
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	65	7	-0.003	0.000	1.000
08C110	Cedar R nr Landsburg	Puget Lowlands	49	9	-0.051	-0.509	0.611
09A080	Green R @ Tukwila	Puget Lowlands	58	7	0.061	0.434	0.664
09A190	Green R @ Kanaskat	Puget Lowlands	63	9	-0.073	-1.686	0.092
10A070	Puyallup R @ Meridian St	Puget Lowlands	20	8	-0.117	-1.655	0.098
11A070	Nisqually R @ Nisqually	Puget Lowlands	56	9	-0.128	-1.655	0.098
13A060	**Deschutes R @ E St Bridge**	**Puget Lowlands**	**40**	**7**	**-0.261**	**-2.890**	**0.004**
16A070	Skokomish R nr Potlatch	Puget Lowlands	46	9	-0.079	-1.280	0.200
22A070	Humptulips R nr Humptulips	Coast Range	64	9	-0.293	-3.100	0.002
23A070	Chehalis R @ Porter	Puget Lowlands	61	7	-0.053	-0.813	0.416
23A160	Chehalis R @ Dryad	Coast Range	52	7	-0.212	-1.896	0.058
24B090	Willapa R nr Willapa	Coast Range	63	7	-0.164	-1.500	0.134
26B070	Cowlitz R @ Kelso	Puget Lowlands	35	8	-0.021	0.282	0.778

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 7. Trend Analysis Data for Temperature Collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (°C/yr)	Standard Normal Deviate (Z)	Probability
27B070	Kalama R nr Kalama	Puget Lowlands	61	10	-2.037	-1.828	0.068
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	57	7	0.155	1.549	0.121
31A070	Columbia R @ Umatilla	Columbia Basin	8	9	0.031	0.918	0.358
32A070	Walla Walla R nr Touchet	Columbia Basin	45	7	0.259	1.406	0.160
33A050	Snake R nr Pasco	Columbia Basin	8	9	0.043	0.594	0.553
34A070	**Palouse R @ Hooper**	**Columbia Basin**	**31**	**9**	**0.363**	**2.576**	**0.010**
34B110	SF Palouse R @ Pullman	Columbia Basin	34	7	-0.136	-1.029	0.304
35A150	**Snake R @ Interstate Br**	**Columbia Basin**	**ns**	**ns**	**-0.143**	**-3.243**	**0.001**
35B060	**Tucannon R @ Powers**	**Columbia Basin**	**14**	**7**	**0.374**	**2.728**	**0.006**
37A090	Yakima R @ Kiona	Columbia Basin	22	7	0.179	1.655	0.098
39A090	**Yakima R nr Cle Elum**	**Cascades**	**ns**	**ns**	**-0.154**	**-3.473**	**0.001**
41A070	Crab Cr nr Beverly	Columbia Basin	26	8	-0.094	-0.500	0.617
45A070	Wenatchee R @ Wenatchee	Columbia Basin	ns	ns	-0.100	-1.613	0.107
46A070	Entiat R nr Entiat	Columbia Basin	ns	ns	-0.124	-1.932	0.053
48A070	**Methow R nr Pateros**	**Columbia Basin**	**9**	**9**	**-0.219**	**-2.618**	**0.009**
48A140	Methow R @ Twisp	Columbia Basin	15	9	-0.121	-1.476	0.140
49A070	Okanogan R @ Malott	Columbia Basin	ns	ns	-0.038	-0.493	0.622
49A190	Okanogan R @ Oroville	Columbia Basin	12	9	-0.113	-1.084	0.278
49B070	Similkameen R @ Oroville	Columbia Basin	ns	ns	-0.043	-0.891	0.373
53A070	Columbia R @ Grand Coulee	Columbia Basin	ns	ns	-0.050	-0.840	0.401
54A120	Spokane R @ Riverside State Pk	Northern Rockies	28	9	-0.040	-0.602	0.547
55B070	Little Spokane R nr Mouth	Northern Rockies	16	10	0.163	1.365	0.172
56A070	Hangman Cr @ Mouth	Columbia Basin	30	7	-0.136	-1.380	0.168
57A150	**Spokane R @ Stateline Br**	**Columbia Basin**	**40**	**7**	**0.253**	**2.252**	**0.024**
61A070	**Columbia R @ Northport**	**Northern Rockies**	**ns**	**ns**	**-0.133**	**-3.147**	**0.002**
62A150	Pend Oreille R @ Newport	Northern Rockies	ns	ns	-0.075	-1.716	0.086

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 8. Trend Analysis Data for Dissolved Oxygen Collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L/yr)	Standard Normal Deviate (Z)	Probability
01A050	Nooksack R @ Brennan	Puget Lowlands	15	10	-0.011	-0.434	0.664
01A120	Nooksack R @ No Cedarville	Puget Lowlands	8	10	-0.005	-0.139	0.890
03A060	Skagit R nr Mount Vernon	Puget Lowlands	14	10	-0.006	-0.391	0.696
03B050	Samish R nr Burlington	Puget Lowlands	50	10	-0.025	-0.591	0.555
04A100	**Skagit R @ Marblemount**	**Cascades**	**21**	**10**	**-0.038**	**-0.298**	**0.003**
05A070	Stillaguamish R nr Silvana	Puget Lowlands	53	10	-0.007	-0.126	0.899
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	50	10	-0.019	-0.406	0.685
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	36	10	-0.021	-0.601	0.548
07A090	Snohomish R @ Snohomish	Puget Lowlands	52	10	-0.011	-0.665	0.506
07C070	Skykomish R @ Monroe	Puget Lowlands	39	7	0.032	0.200	0.842
07D050	Snoqualmie R nr Monroe	Puget Lowlands	54	10	0.009	0.217	0.829
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	63	10	-0.004	0.000	1.000
08C070	**Cedar R @ Logan St/Renton**	**Puget Lowlands**	**17**	**8**	**-0.083**	**-3.292**	**0.001**
08C110	**Cedar R nr Landsburg**	**Puget Lowlands**	**45**	**10**	**-0.048**	**-2.450**	**0.014**
09A080	**Green R @ Tukwila**	**Puget Lowlands**	**52**	**10**	**-0.098**	**-2.027**	**0.043**
09A190	Green R @ Kanaskat	Puget Lowlands	63	8	-0.038	-1.505	0.132
10A070	Puyallup R @ Meridian St	Puget Lowlands	20	10	-0.003	-0.123	0.902
11A070	Nisqually R @ Nisqually	Puget Lowlands	36	10	0.016	0.615	0.538
13A060	**Deschutes R @ E St Bridge**	**Puget Lowlands**	**11**	**10**	**-0.145**	**-3.982**	**>0.001**
16A070	Skokomish R nr Potlatch	Puget Lowlands	51	10	-0.020	-0.602	0.547
22A070	Humptulips R nr Humptulips	Coast Range	49	10	-0.024	-1.066	0.286
23A070	Chehalis R @ Porter	Puget Lowlands	36	7	-0.057	-1.858	0.063
23A160	**Chehalis R @ Dryad**	**Coast Range**	**50**	**7**	**-0.080**	**-2.561**	**0.011**
24B090	Willapa R nr Willapa	Coast Range	56	10	-0.064	-1.895	0.058
26B070	Cowlitz R @ Kelso	Puget Lowlands	36	8	-0.034	-1.394	0.163
27B070	Kalama R nr Kalama	Puget Lowlands	53	10	0.536	1.830	0.068

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 8. Trend Analysis Data for Dissolved Oxygen Collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L/yr)	Standard Normal Deviate (Z)	Probability
27D090	**EF Lewis R nr Dollar Corner**	**Willamette Valley**	**49**	**7**	**-0.066**	**-2.130**	**0.033**
31A070	**Columbia R @ Umatilla**	**Columbia Basin**	**25**	**8**	**-0.073**	**-2.565**	**0.010**
32A070	Walla Walla R nr Touchet	Columbia Basin	ns	ns	-0.034	-0.949	0.342
33A050	Snake R nr Pasco	Columbia Basin	32	10	-0.034	-9.690	0.333
34A070	Palouse R @ Hooper	Columbia Basin	12	7	0.030	0.637	0.524
34B110	**SF Palouse R @ Pullman**	**Columbia Basin**	**17**	**7**	**-0.149**	**-2.370**	**0.018**
35A150	Snake R @ Interstate Br	Columbia Basin	ns	ns	0.000	-0.643	0.521
35B060	**Tucannon R @ Powers**	**Columbia Basin**	**9**	**7**	**-0.072**	**-2.227**	**0.026**
37A090	Yakima R @ Kiona	Columbia Basin	23	10	-0.056	-1.294	0.196
39A090	Yakima R nr Cle Elum	Cascades	ns	ns	0.025	1.705	0.088
41A070	Crab Cr nr Beverly	Columbia Basin	28	7	0.039	0.136	0.892
45A070	Wenatchee R @ Wenatchee	Columbia Basin	5	7	0.038	1.328	0.184
46A070	Entiat R nr Entiat	Columbia Basin	10	10	0.003	0.110	0.912
48A070	Methow R nr Pateros	Columbia Basin	14	10	0.055	1.745	0.081
48A140	Methow R @ Twisp	Columbia Basin	17	7	0.031	0.671	0.502
49A070	Okanogan R @ Malott	Columbia Basin	ns	ns	-0.017	-0.467	0.641
49A190	Okanogan R @ Oroville	Columbia Basin	ns	ns	-0.050	-1.498	0.134
49B070	Similkameen R @ Oroville	Columbia Basin	ns	ns	-0.050	-1.870	0.062
53A070	**Columbia R @ Grand Coulee**	**Columbia Basin**	**16**	**10**	**-0.119**	**-2.950**	**0.003**
54A120	**Spokane R @ Riverside State**	**Northern Rockies**	**48**	**8**	**-0.147**	**-6.350**	**>0.001**
55B070	Little Spokane R nr Mouth	Northern Rockies	ns	ns	-0.017	-1.266	0.250
56A070	Hangman Cr @ Mouth	Columbia Basin	17	9	-0.091	-1.472	0.141
57A150	**Spokane R @ Stateline Br**	**Columbia Basin**	**60**	**7**	**-0.051**	**-2.129**	**0.033**
61A070	Columbia R @ Northport	Northern Rockies	ns	ns	0.000	0.027	0.978
62A150	Pend Oreille R @ Newport	Northern Rockies	ns	ns	0.000	-0.163	0.871

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 9. Trend Analysis Data for pH Collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (std/yr)	Standard Normal Deviate (Z)	Probability
01A050	Nooksack R @ Brennan	Puget Lowlands	6	7	0.006	0.807	0.420
01A120	Nooksack R @ No Cedarville	Puget Lowlands	13	7	0.015	1.270	0.204
03A060	Skagit R nr Mount Vernon	Puget Lowlands	ns	ns	0.003	1.668	0.095
03B050	Samish R nr Burlington	Puget Lowlands	10	7	0.032	1.724	0.085
04A100	Skagit R @ Marblemount	Cascades	11	10	-0.011	-1.362	0.173
05A070	**Stillaguamish R nr Silvana**	**Puget Lowlands**	**12**	**9**	**0.033**	**4.028**	**>0.001**
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	13	8	0.022	0.892	0.372
05B070	**NF Stillaguamish @ Cicero**	**Puget Lowlands**	**46**	**10**	**0.025**	**2.341**	**0.019**
07A090	Snohomish R @ Snohomish	Puget Lowlands	15	8	0.002	0.324	0.746
07C070	**Skykomish R @ Monroe**	**Puget Lowlands**	**15**	**9**	**0.024**	**2.678**	**0.007**
07D050	Snoqualmie R nr Monroe	Puget Lowlands	31	9	0.013	0.361	0.718
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	8	9	0.000	-0.132	0.895
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	24	9	0.003	0.285	0.776
08C110	Cedar R nr Landsburg	Puget Lowlands	ns	ns	0.000	0.499	0.618
09A080	**Green R @ Tukwila**	**Puget Lowlands**	**ns**	**ns**	**0.008**	**2.297**	**0.022**
09A190	Green R @ Kanaskat	Puget Lowlands	ns	ns	-0.020	-1.515	0.130
10A070	Puyallup R @ Meridian St	Puget Lowlands	ns	ns	0.000	1.712	0.087
11A070	**Nisqually R @ Nisqually**	**Puget Lowlands**	**19**	**10**	**0.020**	**2.499**	**0.013**
13A060	**Deschutes R @ E St Bridge**	**Puget Lowlands**	**22**	**9**	**-0.026**	**-2.607**	**0.009**
16A070	**Skokomish R nr Potlatch**	**Puget Lowlands**	**9**	**8**	**0.011**	**2.058**	**0.040**
22A070	Humptulips R nr Humptulips	Coast Range	24	7	-0.001	-0.335	0.738
23A070	Chehalis R @ Porter	Puget Lowlands	27	10	0.008	0.586	0.558
23A160	Chehalis R @ Dryad	Coast Range	23	7	-0.004	-0.331	0.741
24B090	Willapa R nr Willapa	Coast Range	30	7	0.004	0.819	0.413
26B070	Cowlitz R @ Kelso	Puget Lowlands	9	10	0.017	1.088	0.277

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 9. Trend Analysis Data for pH Collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (std/yr)	Standard Normal Deviate (Z)	Probability
27B070	Kalama R nr Kalama	Puget Lowlands	60	7	-0.093	-0.261	0.794
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	39	7	0.009	0.358	0.721
31A070	Columbia R @ Umatilla	Columbia Basin	17	9	0.006	0.412	0.681
32A070	Walla Walla R nr Touchet	Columbia Basin	51	7	0.014	1.406	0.160
33A050	Snake R nr Pasco	Columbia Basin	ns	ns	0.000	0.557	0.577
34A070	**Palouse R @ Hooper**	**Columbia Basin**	**38**	**10**	**0.042**	**2.513**	**0.012**
34B110	**SF Palouse R @ Pullman**	**Columbia Basin**	**20**	**7**	**-0.027**	**-2.865**	**0.004**
35A150	Snake R @ Interstate Br	Columbia Basin	14	7	-0.119	-1.552	0.121
35B060	**Tucannon R @ Powers**	**Columbia Basin**	**13**	**10**	**0.032**	**2.370**	**0.018**
37A090	Yakima R @ Kiona	Columbia Basin	16	7	0.022	1.882	0.060
39A090	Yakima R nr Cle Elum	Cascades	ns	ns	-0.029	-2.052	0.040
41A070	Crab Cr nr Beverly	Columbia Basin	12	8	-0.023	-1.081	0.279
45A070	**Wenatchee R @ Wenatchee**	**Columbia Basin**	**29**	**9**	**0.077**	**4.551**	**>0.001**
46A070	Entiat R nr Entiat	Columbia Basin	17	10	0.016	1.109	0.267
48A070	Methow R nr Pateros	Columbia Basin	32	8	0.011	1.174	0.240
48A140	Methow R @ Twisp	Columbia Basin	15	10	0.004	0.047	0.963
49A070	Okanogan R @ Malott	Columbia Basin	8	8	0.019	1.813	0.070
49A190	Okanogan R @ Oroville	Columbia Basin	ns	ns	-0.167	-1.276	0.202
49B070	Similkameen R @ Oroville	Columbia Basin	8	8	-0.019	-1.182	0.237
53A070	Columbia R @ Grand Coulee	Columbia Basin	ns	ns	-0.018	-1.193	0.233
54A120	Spokane R @ Riverside State Pk	Northern Rockies	24	7	-0.017	-1.402	0.161
55B070	Little Spokane R nr Mouth	Northern Rockies	51	7	0.001	0.000	1.000
56A070	Hangman Cr @ Mouth	Columbia Basin	53	7	-0.016	-1.012	0.311
57A150	**Spokane R @ Stateline Br**	**Columbia Basin**	**6**	**2**	**0.034**	**2.466**	**0.014**
61A070	Columbia R @ Northport	Northern Rockies	15	8	0.013	1.678	0.093
62A150	**Pend Oreille R @ Newport**	**Northern Rockies**	**ns**	**ns**	**-0.025**	**-3.282**	**0.001**

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 10. Trend Analysis Data for Total Nitrogen collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L/yr)	Standard Normal Deviate (Z)	Probability
01A050	Nooksack R @ Brennan	Puget Lowlands	12	9	-0.0047	-0.442	0.659
01A120	Nooksack R @ No Cedarville	Puget Lowlands	19	10	0.0010	0.226	0.821
03A060	Skagit R nr Mount Vernon	Puget Lowlands	20	9	0.0009	0.488	0.626
03B050	Samish R nr Burlington	Puget Lowlands	37	10	0.0083	0.919	0.358
04A100	Skagit R @ Marblemount	Cascades	11	8	0.0003	0.163	0.871
05A070	Stillaguamish R nr Silvana	Puget Lowlands	16	10	-0.0159	-1.309	0.191
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	ns	ns	0.0036	0.652	0.515
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	28	10	-0.0041	-0.226	0.821
07A090	Snohomish R @ Snohomish	Puget Lowlands	7	7	-0.0061	-0.955	0.339
07C070	Skykomish R @ Monroe	Puget Lowlands	15	9	-0.0001	0.000	1.000
07D050	**Snoqualmie R nr Monroe**	**Puget Lowlands**	**14**	**7**	**-0.0218**	**-2.334**	**0.020**
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	ns	ns	0.0005	0.435	0.664
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	24	10	-0.0061	-0.922	0.357
08C110	Cedar R nr Landsburg	Puget Lowlands	ns	ns	-0.0017	-1.017	0.309
09A080	Green R @ Tukwila	Puget Lowlands	10	8	-0.0130	-0.993	0.321
09A190	Green R @ Kanaskat	Puget Lowlands	10	9	-0.0034	-0.993	0.321
10A070	Puyallup R @ Meridian St	Puget Lowlands	22	9	-0.0048	-0.705	0.481
11A070	**Nisqually R @ Nisqually**	**Puget Lowlands**	**37**	**7**	**-0.0162**	**-2.007**	**0.045**
13A060	Deschutes R @ E St Bridge	Puget Lowlands	13	9	-0.0131	-1.061	0.289
16A070	**Skokomish R nr Potlatch**	**Puget Lowlands**	**ns**	**ns**	**-0.0080**	**-4.377**	**>0.001**
22A070	Humptulips R nr Humptulips	Coast Range	39	7	-0.0058	-1.766	0.077
23A070	**Chehalis R @ Porter**	**Puget Lowlands**	**45**	**9**	**-0.0291**	**-2.980**	**0.003**
23A160	**Chehalis R @ Dryad**	**Coast Range**	**62**	**7**	**-0.0292**	**-3.525**	**>0.001**
24B090	**Willapa R nr Willapa**	**Coast Range**	**74**	**7**	**-0.0416**	**-3.465**	**0.001**
26B070	Cowlitz R @ Kelso	Puget Lowlands	60	7	-0.0104	-1.696	0.090

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 10. Trend Analysis Data for Total Nitrogen collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L)	Standard Normal Deviate (Z)	Probability
27B070	Kalama R nr Kalama	Puget Lowlands	73	7	0.0104	0.000	1.000
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	48	7	-0.0089	-0.883	0.378
31A070	Columbia R @ Umatilla	Columbia Basin	ns	ns	0.0035	0.353	0.724
32A070	Walla Walla R nr Touchet	Columbia Basin	28	7	-0.0044	-0.393	0.694
33A050	Snake R nr Pasco	Columbia Basin	ns	ns	0.0049	0.397	0.691
34A070	Palouse R @ Hooper	Columbia Basin	70	7	0.0531	1.031	0.303
34B110	SF Palouse R @ Pullman	Columbia Basin	18	7	0.0280	0.075	0.940
35A150	Snake R @ Interstate Br	Columbia Basin	19	3	0.0166	2.353	0.019
35B060	Tucannon R @ Powers	Columbia Basin	26	10	-0.0440	-1.583	0.113
37A090	Yakima R @ Kiona	Columbia Basin	41	8	0.0008	0.054	0.957
39A090	Yakima R nr Cle Elum	Cascades	15	10	0.0003	0.074	0.941
41A070	Crab Cr nr Beverly	Columbia Basin	31	7	0.0888	1.718	0.086
45A070	**Wenatchee R @ Wenatchee**	**Columbia Basin**	**62**	**9**	**0.0082**	**2.570**	**0.010**
46A070	Entiat R nr Entiat	Columbia Basin	17	10	0.0040	0.361	0.718
48A070	**Methow R nr Pateros**	**Columbia Basin**	**46**	**10**	**0.0136**	**2.870**	**0.004**
48A140	Methow R @ Twisp	Columbia Basin	35	9	0.0044	0.794	0.427
49A070	Okanogan R @ Malott	Columbia Basin	ns	ns	0.0050	1.586	0.113
49A190	Okanogan R @ Oroville	Columbia Basin	8	4	0.0078	1.909	0.056
49B070	Similkameen R @ Oroville	Columbia Basin	39	9	0.0019	1.068	0.286
53A070	Columbia R @ Grand Coulee	Columbia Basin	ns	ns	-0.0030	-1.382	0.167
54A120	**Spokane R @ Riverside State**	**Northern Rockies**	**57**	**10**	**0.0377**	**3.091**	**0.002**
55B070	**Little Spokane R nr Mouth**	**Northern Rockies**	**52**	**10**	**0.0239**	**2.978**	**0.003**
56A070	Hangman Cr @ Mouth	Columbia Basin	62	7	-0.0590	-0.377	0.706
57A150	Spokane R @ Stateline Br	Columbia Basin	14	9	-0.0006	-0.221	0.825
61A070	Columbia R @ Northport	Northern Rockies	ns	ns	-0.0009	-0.434	0.664
62A150	Pend Oreille R @ Newport	Northern Rockies	ns	ns	-0.0021	-1.346	0.178

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 11. Trend Analysis Data for Total Phosphorus collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L)	Standard Normal Deviate (Z)	Probability
01A050	Nooksack R @ Brennan	Puget Lowlands	78	8	-0.0005	-0.810	0.418
01A120	Nooksack R @ No Cedarville	Puget Lowlands	74	8	-0.0004	-0.644	0.520
03A060	Skagit R nr Mount Vernon	Puget Lowlands	32	10	-0.0001	-0.152	0.879
03B050	Samish R nr Burlington	Puget Lowlands	32	10	0.0008	1.433	0.152
04A100	Skagit R @ Marblemount	Cascades	32	8	-0.0158	-0.457	0.648
05A070	Stillaguamish R nr Silvana	Puget Lowlands	80	8	0.0005	0.632	0.528
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	75	10	0.0011	1.767	0.077
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	71	8	-0.0008	-0.416	0.677
07A090	Snohomish R @ Snohomish	Puget Lowlands	51	8	0.0002	0.758	0.449
07C070	Skykomish R @ Monroe	Puget Lowlands	33	8	-0.0001	-0.321	0.748
07D050	Snoqualmie R nr Monroe	Puget Lowlands	68	8	0.0001	0.071	0.944
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	28	10	0.0002	0.521	0.603
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	31	8	0.0011	1.919	0.055
08C110	**Cedar R nr Landsburg**	**Puget Lowlands**	**5**	**7**	**0.0009**	**3.652**	**>0.001**
09A080	Green R @ Tukwila	Puget Lowlands	41	8	0.0013	1.505	0.132
09A190	**Green R @ Kanaskat**	**Puget Lowlands**	**27**	**1**	**0.0008**	**3.260**	**0.001**
10A070	Puyallup R @ Meridian St	Puget Lowlands	22	9	-0.0003	-0.331	0.741
11A070	**Nisqually R @ Nisqually**	**Puget Lowlands**	**34**	**9**	**0.0022**	**2.919**	**0.004**
13A060	**Deschutes R @ E St Bridge**	**Puget Lowlands**	**33**	**8**	**0.0015**	**2.679**	**0.007**
16A070	**Skokomish R nr Potlatch**	**Puget Lowlands**	**59**	**8**	**0.0007**	**2.535**	**0.011**
22A070	**Humptulips R nr Humptulips**	**Coast Range**	**85**	**8**	**0.0004**	**2.285**	**0.022**
23A070	Chehalis R @ Porter	Puget Lowlands	42	8	-0.0002	-0.031	0.976
23A160	**Chehalis R @ Dryad**	**Coast Range**	**76**	**8**	**0.0010**	**2.618**	**0.009**
24B090	**Willapa R nr Willapa**	**Coast Range**	**74**	**8**	**0.0012**	**2.046**	**0.041**
26B070	**Cowlitz R @ Kelso**	**Puget Lowlands**	**81**	**8**	**0.0016**	**2.244**	**0.025**

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 11. Trend Analysis Data for Total Phosphorus collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (mg/L/yr)	Standard Normal Deviate (Z)	Probability
27B070	Kalama R nr Kalama	Puget Lowlands	74	8	-0.0006	-0.261	0.794
27D090	**EF Lewis R nr Dollar Corner**	**Willamette Valley**	**18**	**8**	**0.0010**	**2.979**	**0.003**
31A070	Columbia R @ Umatilla	Columbia Basin	19	10	0.0003	0.867	0.386
32A070	Walla Walla R nr Touchet	Columbia Basin	53	8	-0.0001	-0.032	0.975
33A050	Snake R nr Pasco	Columbia Basin	ns	ns	0.0012	1.807	0.071
34A070	Palouse R @ Hooper	Columbia Basin	12	8	0.0001	0.065	0.949
34B110	**SF Palouse R @ Pullman**	**Columbia Basin**	**61**	**10**	**-0.0294**	**-2.635**	**0.008**
35A150	**Snake R @ Interstate Br**	**Columbia Basin**	**10**	**8**	**0.0016**	**2.215**	**0.027**
35B060	Tucannon R @ Powers	Columbia Basin	35	10	0.0020	1.458	0.145
37A090	Yakima R @ Kiona	Columbia Basin	24	8	0.0035	1.859	0.063
39A090	**Yakima R nr Cle Elum**	**Cascades**	**33**	**8**	**0.0007**	**2.500**	**0.012**
41A070	Crab Cr nr Beverly	Columbia Basin	13	10	0.0008	0.231	0.817
45A070	**Wenatchee R @ Wenatchee**	**Columbia Basin**	**22**	**8**	**0.0010**	**2.651**	**0.008**
46A070	**Entiat R nr Entiat**	**Columbia Basin**	**29**	**8**	**0.0012**	**2.682**	**0.007**
48A070	**Methow R nr Pateros**	**Columbia Basin**	**49**	**8**	**0.0001**	**3.495**	**0.001**
48A140	**Methow R @ Twisp**	**Columbia Basin**	**49**	**8**	**0.0001**	**2.267**	**0.023**
49A070	**Okanogan R @ Malott**	**Columbia Basin**	**54**	**10**	**0.0013**	**3.496**	**0.001**
49A190	Okanogan R @ Oroville	Columbia Basin	ns	ns	0.0000	1.082	0.279
49B070	Similkameen R @ Oroville	Columbia Basin	61	8	0.0004	1.860	0.063
53A070	Columbia R @ Grand Coulee	Columbia Basin	ns	ns	0.0000	0.019	0.085
54A120	**Spokane R @ Riverside State**	**Northern Rockies**	**ns**	**ns**	**0.0013**	**2.837**	**0.005**
55B070	**Little Spokane R nr Mouth**	**Northern Rockies**	**70**	**8**	**0.0013**	**2.227**	**0.026**
56A070	Hangman Cr @ Mouth	Columbia Basin	64	10	-0.0013	-1.359	0.174
57A150	**Spokane R @ Stateline Br**	**Columbia Basin**	**5**	**1**	**0.0008**	**2.844**	**0.005**
61A070	**Columbia R @ Northport**	**Northern Rockies**	**ns**	**ns**	**0.0000**	**-2.794**	**0.005**
62A150	**Pend Oreille R @ Newport**	**Northern Rockies**	**ns**	**ns**	**0.0000**	**2.892**	**0.004**

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 12. Trend Analysis Data for Turbidity collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (NTU/yr)	Standard Normal Deviate (Z)	Probability
01A050	Nooksack R @ Brennan	Puget Lowlands	79	8	0.251	0.686	0.493
01A120	Nooksack R @ No Cedarville	Puget Lowlands	83	8	0.032	0.046	0.964
03A060	Skagit R nr Mount Vernon	Puget Lowlands	47	10	0.022	0.031	0.976
03B050	Samish R nr Burlington	Puget Lowlands	71	10	-0.124	-0.105	0.296
04A100	Skagit R @ Marblemount	Cascades	39	10	-0.016	-0.457	0.648
05A070	Stillaguamish R nr Silvana	Puget Lowlands	77	10	0.470	1.434	0.152
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	70	10	0.993	0.712	0.477
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	86	8	0.342	1.227	0.220
07A090	**Snohomish R @ Snohomish**	**Puget Lowlands**	**85**	**8**	**0.132**	**1.995**	**0.046**
07C070	Skykomish R @ Monroe	Puget Lowlands	74	10	-0.039	-0.592	0.554
07D050	Snoqualmie R nr Monroe	Puget Lowlands	87	8	-0.309	-1.061	0.289
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	71	10	0.098	1.171	0.242
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	59	8	0.017	0.692	0.489
08C110	Cedar R nr Landsburg	Puget Lowlands	51	10	-0.026	-1.895	0.058
09A080	Green R @ Tukwila	Puget Lowlands	72	8	0.125	1.810	0.070
09A190	**Green R @ Kanaskat**	**Puget Lowlands**	**89**	**8**	**0.126**	**2.859**	**0.004**
10A070	Puyallup R @ Meridian St	Puget Lowlands	20	8	0.349	0.572	0.567
11A070	Nisqually R @ Nisqually	Puget Lowlands	50	8	0.215	1.716	0.086
13A060	Deschutes R @ E St Bridge	Puget Lowlands	74	10	0.060	1.138	0.255
16A070	Skokomish R nr Potlatch	Puget Lowlands	79	10	0.103	1.678	0.093
22A070	**Humptulips R nr Humptulips**	**Coast Range**	**88**	**8**	**0.252**	**2.773**	**0.006**
23A070	Chehalis R @ Porter	Puget Lowlands	84	10	0.054	1.188	0.235
23A160	Chehalis R @ Dryad	Coast Range	94	8	-0.027	-0.457	0.648
24B090	Willapa R nr Willapa	Coast Range	95	8	-0.003	0.000	1.000
26B070	Cowlitz R @ Kelso	Puget Lowlands	66	10	0.062	0.083	0.934
27B070	Kalama R nr Kalama	Puget Lowlands	97	10	-0.234	-0.261	0.794

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 12. Trend Analysis Data for Turbidity collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (NTU/yr)	Standard Normal Deviate (Z)	Probability
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	87	8	0.039	1.073	0.283
31A070	**Columbia R @ Umatilla**	**Columbia Basin**	**40**	**10**	**0.168**	**2.600**	**0.009**
32A070	Walla Walla R nr Touchet	Columbia Basin	45	3	0.383	0.947	0.344
33A050	Snake R nr Pasco	Columbia Basin	44	10	0.031	0.285	0.776
34A070	Palouse R @ Hooper	Columbia Basin	28	10	-1.338	-1.256	0.209
34B110	SF Palouse R @ Pullman	Columbia Basin	64	10	-0.830	-0.671	0.502
35A150	Snake R @ Interstate Br	Columbia Basin	58	10	0.072	1.108	0.268
35B060	Tucannon R @ Powers	Columbia Basin	38	10	-0.662	-1.744	0.081
37A090	**Yakima R @ Kiona**	**Columbia Basin**	**83**	**8**	**0.509**	**3.160**	**0.002**
39A090	**Yakima R nr Cle Elum**	**Cascades**	**24**	**10**	**-0.104**	**-2.013**	**0.044**
41A070	**Crab Cr nr Beverly**	**Columbia Basin**	**17**	**8**	**0.640**	**2.046**	**0.041**
45A070	Wenatchee R @ Wenatchee	Columbia Basin	45	10	0.072	1.953	0.051
46A070	Entiat R nr Entiat	Columbia Basin	48	10	0.097	1.435	0.151
48A070	Methow R nr Pateros	Columbia Basin	67	8	0.030	1.683	0.092
48A140	**Methow R @ Twisp**	**Columbia Basin**	**67**	**10**	**0.045**	**3.671**	**>0.001**
49A070	Okanogan R @ Malott	Columbia Basin	70	10	0.046	0.057	0.566
49A190	Okanogan R @ Oroville	Columbia Basin	5	4	0.018	1.431	0.153
49B070	Similkameen R @ Oroville	Columbia Basin	77	10	0.060	1.448	0.148
53A070	Columbia R @ Grand Coulee	Columbia Basin	24	10	-0.035	-1.296	0.195
54A120	**Spokane R @ Riverside State**	**Northern Rockies**	**28**	**10**	**-0.243**	**-2.197**	**0.028**
55B070	**Little Spokane R nr Mouth**	**Northern Rockies**	**57**	**10**	**-0.347**	**-5.151**	**>0.001**
56A070	**Hangman Cr @ Mouth**	**Columbia Basin**	**83**	**10**	**-0.380**	**-3.589**	**>0.001**
57A150	Spokane R @ Stateline Br	Columbia Basin	42	10	-0.011	-0.586	0.558
61A070	Columbia R @ Northport	Northern Rockies	67	8	0.018	0.906	0.365
62A150	**Pend Oreille R @ Newport**	**Northern Rockies**	**70**	**8**	**0.063**	**3.406**	**0.001**

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 13. Trend Analysis Data for Fecal Coliform collected from 1991-2000.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (cfu/100 mL/yr)	Standard Normal Deviate (Z)	Probability
01A050	**Nooksack R @ Brennan**	**Puget Lowlands**	**8**	**10**	**-5.621**	**-2.992**	**0.003**
01A120	Nooksack R @ No Cedarville	Puget Lowlands	15	10	0.449	0.329	0.742
03A060	Skagit R nr Mount Vernon	Puget Lowlands	10	8	-0.242	-0.813	0.416
03B050	Samish R nr Burlington	Puget Lowlands	11	10	2.451	0.500	0.617
04A100	Skagit R @ Marblemount	Cascades	ns	ns	0.000	-0.903	0.367
05A070	**Stillaguamish R nr Silvana**	**Puget Lowlands**	**13**	**10**	**-4.420**	**-3.677**	**>0.001**
05A090	**SF Stillaguamish @ Arlington**	**Puget Lowlands**	**ns**	**ns**	**-1.500**	**-2.333**	**0.020**
05B070	**NF Stillaguamish @ Cicero**	**Puget Lowlands**	**ns**	**ns**	**-1.667**	**-4.218**	**>0.001**
07A090	**Snohomish R @ Snohomish**	**Puget Lowlands**	**ns**	**ns**	**-5.199**	**-4.325**	**>0.001**
07C070	Skykomish R @ Monroe	Puget Lowlands	13	10	-0.298	-1.685	0.092
07D050	Snoqualmie R nr Monroe	Puget Lowlands	ns	ns	-4.200	-1.810	0.073
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	29	9	-0.181	0.313	0.754
08C070	**Cedar R @ Logan St/Renton**	**Puget Lowlands**	**21**	**10**	**4.912**	**2.622**	**0.009**
08C110	Cedar R nr Landsburg	Puget Lowlands	16	10	-0.090	-1.144	0.253
09A080	**Green R @ Tukwila**	**Puget Lowlands**	**ns**	**ns**	**-5.700**	**-3.233**	**0.001**
09A190	Green R @ Kanaskat	Puget Lowlands	21	10	0.052	0.432	0.666
10A070	**Puyallup R @ Meridian St**	**Puget Lowlands**	**21**	**9**	**-16.051**	**-2.894**	**0.004**
11A070	Nisqually R @ Nisqually	Puget Lowlands	15	8	-1.254	-1.919	0.055
13A060	Deschutes R @ E St Bridge	Puget Lowlands	7	10	-1.469	-0.753	0.451
16A070	Skokomish R nr Potlatch	Puget Lowlands	18	10	-0.011	-0.063	0.950
22A070	Humptulips R nr Humptulips	Coast Range	15	10	0.131	0.579	0.563
23A070	Chehalis R @ Porter	Puget Lowlands	72	8	-0.476	-0.457	0.647
23A160	Chehalis R @ Dryad	Coast Range	4	3	0.084	0.091	0.927
24B090	Willapa R nr Willapa	Coast Range	23	10	-3.499	-1.618	0.106
26B070	Cowlitz R @ Kelso	Puget Lowlands	30	8	-0.064	-0.582	0.561
27B070	Kalama R nr Kalama	Puget Lowlands	51	8	-5.347	-1.828	0.068

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 13. Trend Analysis Data for Fecal Coliform collected from 1991-2000 continued.

Station ID	Station Name	Ecoregion	Explained Variance (%)	Regression Model Used	Slope (cfu/100 mL/yr)	Standard Normal Deviate (Z)	Probability
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	16	10	0.011	0.000	1.000
31A070	**Columbia R @ Umatilla**	**Columbia Basin**	**10**	**10**	**-1.087**	**-4.154**	**>0.001**
32A070	Walla Walla R nr Touchet	Columbia Basin	ns	ns	-1.875	-0.998	0.319
33A050	Snake R nr Pasco	Columbia Basin	13	10	-0.133	-0.428	0.669
34A070	**Palouse R @ Hooper**	**Columbia Basin**	**ns**	**ns**	**-3.817**	**-2.052**	**0.040**
34B110	**SF Palouse R @ Pullman**	**Columbia Basin**	**ns**	**ns**	**-42.237**	**-3.793**	**>0.001**
35A150	**Snake R @ Interstate Br**	**Columbia Basin**	**28**	**10**	**-0.532**	**-3.613**	**>0.001**
35B060	**Tucannon R @ Powers**	**Columbia Basin**	**ns**	**ns**	**-5.889**	**-2.576**	**0.010**
37A090	Yakima R @ Kiona	Columbia Basin	16	7	0.439	0.344	0.731
39A090	Yakima R nr Cle Elum	Cascades	11	7	-0.257	-0.962	0.336
41A070	Crab Cr nr Beverly	Columbia Basin	30	10	-1.280	-0.423	0.672
45A070	Wenatchee R @ Wenatchee	Columbia Basin	ns	ns	0.000	-1.043	0.297
46A070	**Entiat R nr Entiat**	**Columbia Basin**	**34**	**8**	**-0.562**	**-2.634**	**0.008**
48A070	Methow R nr Pateros	Columbia Basin	61	8	0.001	0.190	0.850
48A140	Methow R @ Twisp	Columbia Basin	33	8	-0.103	-0.231	0.817
49A070	Okanogan R @ Malott	Columbia Basin	21	9	-0.205	-0.257	0.798
49A190	Okanogan R @ Oroville	Columbia Basin	8	10	0.162	1.365	0.172
49B070	Similkameen R @ Oroville	Columbia Basin	45	10	0.115	0.460	0.646
53A070	Columbia R @ Grand Coulee	Columbia Basin	ns	ns	0.000	-0.577	0.564
54A120	Spokane R @ Riverside State Pk	Northern Rockies	ns	ns	0.875	1.288	0.198
55B070	Little Spokane R nr Mouth	Northern Rockies	ns	ns	-0.600	-0.672	0.501
56A070	Hangman Cr @ Mouth	Columbia Basin	9	10	5.495	1.889	0.059
57A150	Spokane R @ Stateline Br	Columbia Basin	31	10	0.166	1.059	0.290
61A070	Columbia R @ Northport	Northern Rockies	ns	ns	0.000	-1.421	0.155
62A150	Pend Oreille R @ Newport	Northern Rockies	24	9	-0.014	-0.523	0.601

ns = no statistically significant relationship was found with flow
bold-underline indicates a statistically significant trend was found

Table 14. Regional Trends in Temperature.

Ecoregion	Number of Stations	Temperature		
		Regional Z score	Probability	Mean Change last 10 years (°C)
Coast Range	3	-3.750	0.064	-2.2
Puget Lowlands	**22**	**-5.425**	**0.001**	**-1.7**
Willamette Valley	1	1.549	0.121	+1.5
Cascades	2	-7.053	0.090	-1.9
Columbia Basin	19	-1.140	0.269	+0.1
Northern Rockies	4	-2.050	0.133	-2.1
Statewide	**51**	**-6.513**	**0.001**	**-0.9**

bold-underline indicates a statistically significant trend was found

Table 15. Regional Trends in Dissolved Oxygen.

Ecoregion	Number of Stations	Dissolved Oxygen		
		Regional Z score	Probability	Mean Change last 10 years (mg/L)
Coast Range	3	-3.188	0.086	-0.6
Puget Lowlands	**22**	**-3.779**	**0.001**	**-0.1**
Willamette Valley	**1**	**-2.130**	**0.033**	**-0.7**
Cascades	2	1.407	0.393	0.0
Columbia Basin	**19**	**-5.849**	**0.001**	**-0.3**
Northern Rockies	4	-3.876	0.030	-0.4
Statewide	**51**	**-8.012**	**0.001**	**-0.2**

bold-underline indicates a statistically significant trend was found

Table 16. Regional Trends in pH.

Ecoregion	Number of Stations	pH		
		Regional Z score	Probability	Mean Change last 10 years (std units)
Coast Range	3	0.088	0.938	0.0
Puget Lowlands	**22**	**4.818**	**0.001**	**+0.05**
Willamette Valley	1	0.358	0.721	+0.09
Cascades	2	-3.414	0.181	-0.2
Columbia Basin	**19**	**2.326**	**0.032**	**-0.06**
Northern Rockies	4	-1.503	0.230	-0.07
Statewide	**51**	**3.757**	**0.001**	**-0.01**

bold-underline indicates a statistically significant trend was found

Table 17. Regional Trends in Total Nitrogen.

Ecoregion	Number of Stations	Total Nitrogen		
		Regional Z score	**Probability**	**Mean Change last 10 years (mg/L)**
Coast Range	**3**	**-5.055**	**0.037**	**-0.30**
Puget Lowlands	**22**	**-4.114**	**0.001**	**-0.06**
Willamette Valley	1	-0.883	0.378	-0.09
Cascades	2	0.236	0.852	0.0
Columbia Basin	**19**	**3.024**	**0.007**	**+0.07**
Northern Rockies	4	2.144	0.121	+0.15
Statewide	51	-1.572	0.122	-0.01

bold-underline indicates a statistically significant trend was found

Table 18. Regional Trends in Total Phosphorus.

Ecoregion	Number of Stations	Total Phosphorus (mg/L)		
		Regional Z score	**Probability**	**Mean Change last 10 years (mg/L)**
Coast Range	3	4.012	0.057	+0.01
Puget Lowlands	**22**	**4.888**	**0.001**	**0.00**
Willamette Valley	**1**	**2.979**	**0.003**	**+0.01**
Cascades	2	2.043	0.290	-0.08
Columbia Basin	**19**	**5.706**	**0.001**	**-0.01**
Northern Rockies	4	2.581	0.082	+0.01
Statewide	**51**	**9.092**	**0.001**	**-0.003**

bold-underline indicates a statistically significant trend was found

Table 19. Regional Trends in Turbidity.

Ecoregion	Number of Stations	Turbidity		
		Regional Z score	Probability	Mean Change last 10 years (NTU)
Coast Range	3	1.337	0.313	+0.7
Puget Lowlands	**22**	**3.224**	**0.004**	**+1.2**
Willamette Valley	1	1.073	0.284	+0.4
Cascades	2	-2.470	0.245	-0.6
Columbia Basin	**19**	**2.909**	**0.009**	**-0.6**
Northern Rockies	4	-1.518	0.226	-1.3
Statewide	**51**	**3.597**	**0.001**	**+0.3**

bold-underline indicates a statistically significant trend was found

Table 20. Regional Trends in Fecal Coliform.

Ecoregion	Number of Stations	Fecal Coliform		
		Regional Z score	Probability	Mean Change last 10 years (cfu/100mL)
Coast Range	3	-0.547	0.639	-11
Puget Lowlands	**22**	**-6.509**	**0.001**	**-21**
Willamette Valley	1	0.000	1.000	0
Cascades	2	-1.865	0.313	-1
Columbia Basin	**19**	**-4.008**	**0.001**	**-35**
Northern Rockies	4	-0.664	0.554	+1
Statewide	**51**	**-7.301**	**0.001**	**-23**

bold-underline indicates a statistically significant trend was found

Table 21. Largest Significant Trend of Indicator from 1991-2000.

Station ID	Station Name	Indicator	Mean Change Last 10 Years
35B060	Tucannon R @ Powers	Temperature	+3.7 °C
34B110	SF Palouse R @ Pullman	Dissolved Oxygen	-1.5 mg/L
45A070	Wenatchee R @ Wenatchee	pH	+0.8 std units
24B090	Willapa R nr Willapa	Total Nitrogen	-0.416 mg/L
34B110	SF Palouse R @ Pullman	Total Phosphorus	-0.294 mg/L
41A070	Crab Cr nr Beverly	Turbidity	+6.4 NTU
34B110	SF Palouse R @ Pullman	Fecal Coliform	-422 cfu/100mL

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Sanitary Conditions

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

Water quality data collected by Ecology show that standards over the past 5 years have not been met for fecal coliform at 8 of the core stream monitoring stations. The water quality standards for fecal coliform are based on statistical criteria of the data distribution. The standard has two criteria based on the geometric mean and the 10th percentile. Data collected from each station must be assessed for compliance using the distribution of the data. Also, any evaluation of the reduction in fecal coliform needed to comply with standards must take into account this site-specific distribution so that both criteria are met.

One approach to determine the amount of reduction need in fecal coliform levels is use of the Statistical Rollback Method (Ott, 1995). This approach can be used to evaluate the distribution of the existing data against the two fecal coliform criteria of the water quality standards. Sixty-three of Ecology's stream stations had data on fecal coliform that cover the last 5 years (1996 – 2000). Only eight of the stations evaluated violated the water quality standards over this period. Of these stations, most exceeded the 10^{th} percentile criterion, but not the geometric mean criterion. The Statistical Rollback Method was applied to these data and the percent reduction in fecal coliform levels needed to meet the standards were derived (Table 22). These reductions are based on the assumption that the distribution will not change when fecal coliform levels are reduced. This information on the amount of fecal coliform loading that needs to be reduced may help decide where pollution control efforts should be targeted.

Table 22. Fecal Coliform Loading Reductions Needed to Meet Standards.

Station ID	**Station Name**	**Ecoregion**	**Fecal Coliform Reduction (%)**
03D050	Nookachamp Creek near Mouth	Puget Lowlands	15
34B110	SF Palouse River at Pullman	Columbia Basin	19
45D070	Brender Creek near Cashmere	Cascades	15
45E070	Mission Creek near Cashmere	Cascades	1
56A070	Hangman Creek at Mouth	Columbia Basin	2
59A080	Colville River above Kettle Falls	Northern Rockies	13
59A110	Colville River at Blue Creek	Northern Rockies	21
59B070	Little Pend Oreille River at Hwy 395	Northern Rockies	6

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Lake Trophic State

Carlson's (1977) trophic state indices (TSI) for Secchi depth were used to estimate the trophic status of the lakes monitored in 2000. In general, TSI values of less than 40 indicate oligotrophy, between 40 and 50 indicate mesotrophy, and greater than 50 indicate eutrophy (Carlson, 1979). TSI values were calculated from the mean Secchi depth calculated from all Secchi data collected at each lake between mid-May and mid-October 2000 (Table 23).

Table 23. Trophic State Information for Lakes Sampled in the Year 2000.

Lake Name	**Ecoregion**	**Secchi Depth (m)**	**TSI**	**Trophic State**
Alice	Puget Lowlands	4.3	39	Oligotrophic
Big Meadow	Northern Rockies	3.9	40	Mesotrophic
Black	Northern Rockies	4.9	37	Oligotrophic
Bosworth	Northern Rockies	4.1	40	Mesotrophic
Clear	Columbia Basin	3.6	42	Mesotrophic
Conconully	Cascades	5.7	35	Oligotrophic
Crawfish	Northern Rockies	4.6	38	Oligotrophic
Curlew	Northern Rockies	4.6	38	Oligotrophic
Deep	Northern Rockies	4.4	39	Oligotrophic
Deer	Northern Rockies	7.0	32	Oligotrophic
Haven	Puget Lowlands	5.9	34	Oligotrophic
Hicks	Puget Lowlands	2.2	48	Mesotrophic
Horseshoe	Puget Lowlands	3.3	43	Mesotrophic
Isabella	Puget Lowlands	4.3	39	Oligotrophic
Kitsap	Puget Lowlands	4.7	38	Oligotrophic
Lawrence	Puget Lowlands	2.2	49	Mesotrophic
Leland	Puget Lowlands	2.6	46	Mesotrophic
Liberty	Columbia Basin	5.6	35	Oligotrophic
Limerick	Puget Lowlands	3.3	43	Mesotrophic
Loon	Northern Rockies	5.9	34	Oligotrophic
Martha	Puget Lowlands	4.7	38	Oligotrophic
Mason	Puget Lowlands	7.2	32	Oligotrophic
McIntosh	Puget Lowlands	1.7	53	Eutrophic
Nahwatzel	Puget Lowlands	5.1	37	Oligotrophic
Osoyoos	Columbia Basin	4.0	40	Mesotrophic
Patterson	Puget Lowlands	3.0	44	Mesotrophic
Phillips	Puget Lowlands	5.1	37	Oligotrophic
Roesiger	Puget Lowlands	5.4	36	Oligotrophic
Samish	Puget Lowlands	5.7	35	Oligotrophic
Spanaway	Puget Lowlands	2.9	45	Mesotrophic
St. Clair	Puget Lowlands	2.8	45	Mesotrophic
Summit	Puget Lowlands	7.2	32	Oligotrophic
Tapps	Puget Lowlands	0.9	62	Eutrophic
Trails End	Puget Lowlands	5.4	36	Oligotrophic
Wenatchee	Cascades	4.7	38	Oligotrophic

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Biological Health

The Benthic Index of Biotic Integrity (B-IBI) was used to indicate the biological health of freshwater streams. The B-IBI is an overall assessment of invertebrate condition represented by a single number. Several measures of the community condition (biometrics) are used to construct the B-IBI (Table 24). Each of these measures responds to different stream conditions and together are able to identify instances where aquatic life is in decline. The individual biometrics are combined into an overall B-IBI score

The B-IBI has been developed for use in Western Washington streams (Karr and Chu, 1997). The Department of Ecology stream biological monitoring program (Ecology) has modified this B-IBI by 1) employing a different taxonomic standard, 2) using different criteria for tolerance and intolerance, 3) omitting biometrics for the "number of clinger taxa", and 4) using different biometric scoring criteria. The B-IBI was developed for Western Washington, however, we expect that the B-IBI will correctly rank sites according to their relative level of degradation throughout Washington State.

Table 24. Biometrics used to construct the B-IBI.

Biometric	**Predicted Response**	**SCORE**		
		1	**3**	**5**
		BIOMETRIC RANGE		
Total # of taxa	decrease indicates degradation	<10	10-20	>20
Number of ephemeroptera taxa	decrease indicates degradation	<3	3-5.5	>5.5
Number of plecoptera taxa	decrease indicates degradation	<3	3-5.5	>5.5
Number of trichoptera taxa	decrease indicates degradation	<2	2-4.5	>4.5
Number of long-lived taxa	decrease indicates degradation	<0.5	0.5-2	>2
Number of intolerant taxa	decrease indicates degradation	<0.5	0.5-2	>2
Percent of individuals in tolerant taxa	increase indicates degradation	>50	20-50	<20
Percent of predator individuals	decrease indicates degradation	<5	5-10	>10
Percent dominance (2 or 3 taxa)	increase indicates degradation	>75	50-75	<50

The B-IBI was applied to invertebrate samples collected since 1992 (Table 25). EPA guidance for Section 305(b) was used to place the B-IBI values into categories used for this statewide assessment. According to the EPA categorization scheme, stations scoring 90% of the maximum possible score and above are 'good', 75% to 89% indicate 'fair' conditions, and below 75% may be considered 'poor'. Therefore, B-IBI scores 41 and above are considered 'good', scores from 34 to 40 are rated 'fair', and those below 34 have 'poor' biological health.

Table 25. Station Locations and the Resulting Benthic Index of Biotic Integrity (B-IBI).

Stream Name	**Ecoregion**	**Latitude**	**Longitude**	**B-IBI**
American River at Hells Crossing	Cascades	46.9614	121.2692	37
Appletree Creek	Puget Lowlands	46.8805	123.2243	39
Austin Creek	Puget Lowlands	48.7057	122.3394	43
Bacon Creek	Cascades	48.6500	121.4100	37
Bear Creek	Cascades	47.0762	121.2405	43
Bear Creek near Carson	Cascades	45.7870	121.8018	43
Bertrand Creek	Puget Lowlands	48.9632	122.5072	25
Big Bear Creek	Puget Lowlands	47.7564	122.0554	31
Big Muddy Creek	Northern Rockies	48.9428	117.4316	35
Big River	Coast Range	48.1446	124.5797	39
Big Sheep Creek	Northern Rockies	48.9428	117.7714	41
Big Soos Creek	Puget Lowlands	47.4165	122.1571	35
Bonaparte Creek	Columbia Basin	48.6861	119.4033	33
Bone River	Coast Range	46.6528	123.8700	19
Box Canyon Creek	Cascades	47.4102	121.2899	39
Breckenridge Creek	Puget Lowlands	48.9280	122.2662	41
Brooks Slough	Coast Range	46.2892	123.2598	39
Bumping River Tributary	Eastern Cascades	46.9212	121.1940	41
Butter Creek	Cascades	46.6277	121.6643	39
California Creek	Puget Lowlands	48.9082	122.6433	19
California Creek	Columbia Basin	47.5115	117.3470	21
Camp Creek	Puget Lowlands	47.0176	123.5478	37
Canon River	Coast Range	46.5717	123.8575	43
Carey Creek	Puget Lowlands	47.4256	121.9744	43
Catherine Creek	Puget Lowlands	48.0035	122.0453	37
Cedar River	Puget Lowlands	47.4083	121.8350	43
Cedar River	Cascades	47.3657	121.6220	41
Chambers Creek	Puget Lowlands	47.1768	122.5352	17
Chewack River	Cascades	48.5847	120.1747	45
Chewelah Creek	Northern Rockies	48.2828	117.7148	37
Chico Creek	Puget Lowlands	47.5870	122.7141	29
Chuckanut Creek	Puget Lowlands	48.7029	122.4841	34
Cle Elum River	Cascades	47.5550	121.1108	33
Clear Creek	Eastern Cascades	46.6540	121.3165	27
Clearwater River	Cascades	47.1285	121.8017	41
Cliff Point Creek	Coast Range	46.2671	123.8501	35

Stream Name	Ecoregion	Latitude	Longitude	B-IBI
Cloquallum Creek	Puget Lowlands	47.1042	123.3572	43
Cloquallum Creek Tributary	Puget Lowlands	47.1053	123.3631	19
Coal Creek	Coast Range	47.9711	124.5861	39
Cook Creek	Coast Range	47.3583	123.9669	41
Cook Creek	Puget Lowlands	47.0701	123.4742	38
Cooke Creek	Columbia Basin	46.9818	120.4254	25
County Creek	Cascades	47.0717	121.3178	41
Covington Creek	Puget Lowlands	47.3168	122.1170	42
Cummings Creek	Columbia Basin	46.3273	117.6720	39
Cummings Creek at Wooten	Columbia Basin	46.3273	117.6720	43
Days Creek	Columbia Basin	46.2831	119.5619	27
Deadfall Creek	Coast Range	47.8912	122.9891	37
Deep Creek	Northern Rockies	48.8843	117.7204	39
Deer Creek	Puget Lowlands	48.2716	121.9300	25
Deer Creek	Puget Lowlands	48.8452	122.5453	38
Delezene Creek	Puget Lowlands	46.9129	123.4636	36
Deruyter Ck	Eastern Cascades	46.3305	121.1542	35
Dewatto Riveriver	Puget Lowlands	47.5238	122.9568	37
Diobsud Creek	Cascades	48.5605	121.4150	41
Douglas Creek	Columbia Basin	47.5627	119.9950	23
Dragoon Creek	Northern Rockies	47.8755	117.3733	37
Dry Creek	Columbia Basin	46.2311	120.6225	27
Duckabush River	Coast Range	47.6832	123.1713	39
Duckabush River	Coast Range	47.6818	123.0190	37
Dungeness River	Coast Range	48.0212	123.1340	37
Dunn Creek	Puget Lowlands	46.6564	123.2642	39
East Branch Herman Creek	Coast Range	48.1784	124.3598	27
East Fork Grays River	Coast Range	46.4391	123.4028	37
Elbe Creek	Cascades	46.7709	122.0649	44
Elochaman River	Coast Range	46.2678	123.2849	37
Fall River	Coast Range	46.7083	123.4322	43
Fall River	Coast Range	46.7104	123.4753	39
Finney Creek	Cascades	48.5122	121.8220	41
Fish Creek	Eastern Cascades	46.6158	121.1128	37
Gold Creek	Cascades	47.3933	121.3807	35
Grant Creek	Puget Lowlands	48.2723	122.0140	31
Green Creek Tributary	Columbia Basin	47.1572	120.6207	17
Green River	Puget Lowlands	47.3189	121.8920	41
Griffin Creek	Puget Lowlands	47.6161	121.9030	38
Harris Creek	Puget Lowlands	47.6905	121.9007	41
Holder Creek near Hobart	Puget Lowlands	47.4348	121.9720	37
Huckleberry Creek	Cascades	47.0770	121.5873	41
Huckleberry Creek	Northern Rockies	48.2832	117.7165	41
Hutchinson Creek	Cascades	48.7197	122.1572	43

Stream Name	Ecoregion	Latitude	Longitude	B-IBI
Hylebos Creek	Puget Lowlands	47.2480	122.3438	19
Illabot Creek	Cascades	48.4820	121.5010	31
Indian Creek	Eastern Cascades	46.6455	121.2516	39
Jack Creek	Cascades	47.3314	120.8350	39
Jack Creek	Cascades	47.3489	120.7639	43
Jack Creek near Campground	Cascades	47.6050	120.9110	41
Jackman Creek	Cascades	48.5242	121.7130	25
Jim Creek	Puget Lowlands	48.2230	121.9580	36
Jungle Creek	Cascades	47.3381	120.8597	39
Kimta Creek	Cascades	47.6537	123.6464	35
Kusshi Creek	Columbia Basin	46.0844	120.6308	27
Little Anderson Creek	Puget Lowlands	47.5672	122.9619	25
Little Bear Creek	Puget Lowlands	47.7556	122.1669	31
Little Naches River	Cascades	46.9872	121.0944	43
Little North River	Coast Range	46.8861	123.7112	35
Little Pilchuck Creek	Puget Lowlands	48.0035	122.0453	43
Little Rattlesnake Creek	Eastern Cascades	46.7549	121.0414	35
Little Spokane River	Northern Rockies	47.7920	117.3980	33
Little Spokane River	Northern Rockies	47.8892	117.3560	33
Long Creek	Cascades	48.0784	121.6880	41
Loup Loup Creek	Cascades	48.3663	119.7457	45
Lower Creekab Creek	Columbia Basin	46.9115	119.3092	23
Lyre River	Coast Range	48.1527	123.8320	33
Marshall Creek	Columbia Basin	47.5712	117.4750	29
McSorley Creek	Puget Lowlands	47.3736	122.3212	27
Methow River	Cascades	48.5631	120.3560	45
Middle Fork Little Naches River	Cascades	47.0850	121.3006	45
Middle Fork Satsop River	Coast Range	47.2661	123.4761	39
Middle Fork Satsop River	Coast Range	47.2822	123.4836	27
Middle Fork Teanaway River	Cascades	47.2953	120.9594	37
Middle Fork Teanaway River	Cascades	47.2873	120.9465	39
Middle Fork Toats Coulee Creek	Cascades	48.8833	119.9000	44
Mill Creek	Coast Range	46.6114	123.4867	43
Mill Creek	Columbia Basin	46.2725	120.8189	33
Monroe Creek	Puget Lowlands	46.9331	123.1356	40
Naneum Creek	Cascades	47.1392	120.4719	39
Naselle River	Coast Range	46.3713	123.7661	32
Newaukum Creek	Puget Lowlands	47.2740	122.0539	39
Newaukum Creek	Puget Lowlands	47.2827	122.0654	37
North Fork Asotin Creek	Columbia Basin	46.2442	117.3127	35
North Fork Creekooked Creek	Coast Range	48.1302	124.5372	43
North Fork Dakota Creek	Puget Lowlands	48.9628	122.6288	37
North Fork Newaukum River	Puget Lowlands	46.6828	122.7382	37
North Fork Palix River	Coast Range	46.6514	123.8450	29

Stream Name	Ecoregion	Latitude	Longitude	B-IBI
North Fork Porter Creek	Puget Lowlands	46.9872	123.1981	39
North Fork Salmon River	Coast Range	47.5303	124.0492	39
North Fork Sullivan Creek	Northern Rockies	48.8618	117.3332	41
North Fork Toppenish Creek	Eastern Cascades	46.3356	121.0019	45
North River Tributary	Coast Range	46.7697	123.4614	37
Oak Creek	Eastern Cascades	46.7290	120.8752	39
Ohanapecosh River	Cascades	46.7568	121.5564	39
O'Toole Creek	Puget Lowlands	48.5110	121.9194	40
Padden Creek	Puget Lowlands	48.7050	122.4645	37
Padden Creek	Puget Lowlands	48.7115	122.4932	37
Palouse River	Columbia Basin	46.9102	117.0737	29
Panther Creek	Eastern Cascades	46.6540	121.3165	25
Pine Creek	Coast Range	47.4400	123.4397	43
Portage Creek	Puget Lowlands	48.1838	122.1380	25
Porter Creek	Puget Lowlands	46.9756	123.2737	36
Pressentin Creek	Cascades	48.5180	121.8497	37
Pysht River	Coast Range	48.1693	124.2099	42
Quinalt River Tributary	Coast Range	47.3502	124.2645	35
Racehorse Creek	Cascades	48.8858	122.1325	37
Rattlesnake Creek	Eastern Cascades	46.8192	120.9337	43
Rock Creek	Puget Lowlands	46.8734	123.2972	33
Rock Creek	Puget Lowlands	47.3651	122.0121	31
Salmon Creek	Coast Range	46.3550	123.7306	31
Salmon Creek	Columbia Basin	48.3637	119.5883	25
Salmon Creek Tributary	Coast Range	46.3839	123.6364	37
Salmon River	Coast Range	47.5234	124.1741	41
Samish River	Puget Lowlands	48.5534	122.2880	25
Sand Dunes Creek	Columbia Basin	46.9953	119.4247	25
Seabeck Creek	Puget Lowlands	47.6233	122.8380	32
Siebert Creek	Coast Range	48.1085	123.2782	37
Simmons Creek	Puget Lowlands	46.5312	122.3312	43
Smith Creek	Puget Lowlands	48.8442	122.2775	33
Smith Creek Tributary	Coast Range	46.7467	123.6152	29
South Branch Little River	Coast Range	48.0527	123.5020	37
South Branch Little River	Coast Range	48.0527	123.5020	35
South Fork Calawah River Tributary	Coast Range	47.9334	124.1714	41
South Fork Hoh River Tributary	Cascades	47.7807	123.9353	39
South Fork Manashtash Creek	Eastern Cascades	46.9946	120.8718	43
South Fork Manashtash Creek Tributary	Eastern Cascades	46.9966	120.8693	31
South Fork Manastash Creek	Eastern Cascades	46.9911	120.8531	45
South Fork Palouse River	Columbia Basin	46.7203	117.1648	21
South Fork Pysht River	Coast Range	48.1755	124.1737	37
South Fork Salmon Creek	Cascades	48.5376	119.7768	45
South Fork Skokomish River	Coast Range	47.4519	123.4322	37

Stream Name	Ecoregion	Latitude	Longitude	B-IBI
South Fork Tieton River	Eastern Cascades	46.6136	121.1577	41
South Fork Toats Coulee Creek	Cascades	48.7833	119.8166	43
South Prairie Creek	Puget Lowlands	47.1333	122.0541	39
Squalicum Creek	Puget Lowlands	48.7758	122.4862	31
Stillman Creek	Puget Lowlands	46.5283	123.1473	37
Sumas River	Puget Lowlands	48.9193	122.3128	21
Swamp Creek	Puget Lowlands	47.7541	122.2331	29
Swauk Creek	Cascades	47.3219	120.6797	41
Swauk Creek	Cascades	47.2923	120.7018	39
Tahuya River	Puget Lowlands	47.5152	122.8810	34
Tahuya River	Puget Lowlands	47.5160	122.8799	29
Taylor Creek	Puget Lowlands	47.3843	121.8470	41
Thompson Creek	Cascades	48.8797	121.9089	41
Three Prune Creek	Cascades	47.6434	123.6716	31
Toppenish Creek	Columbia Basin	46.2981	120.8169	31
Trapper Creek	Cascades	45.8946	122.0134	41
Tucannon River	Columbia Basin	46.4510	117.7478	39
Twentyfivemile Creek	Puget Lowlands	46.9270	122.2561	39
Twisp River	Cascades	48.3368	120.4622	43
Twisp River	Columbia Basin	48.3709	120.1561	45
Umptanum Creek near Durr Road	Columbia Basin	46.8770	120.5710	41
Umtanum Creek	Columbia Basin	46.8548	120.4797	33
Upper Padden Creek	Puget Lowlands	48.7069	122.4673	35
Upper Slate Creek	Northern Rockies	48.9420	117.2828	41
Wapato Creek	Puget Lowlands	47.2257	122.3187	22
West Fork Dickey River Tributary	Coast Range	48.0299	124.5339	17
West Fork Hoquiam River	Coast Range	47.0962	123.9069	39
West Fork Teanaway River	Cascades	47.2711	120.9769	41
West Twin Creek	Coast Range	47.8342	124.0128	43
Whatcom Creek	Puget Lowlands	48.7547	122.4282	21
Williams Creek	Puget Lowlands	46.8584	123.3199	27
Woodcamp Creek	Eastern Cascades	46.8350	120.7397	23
Woods Creek	Puget Lowlands	47.8595	121.9592	35
Woods Creek	Puget Lowlands	47.9524	121.8862	39
Woods Creek	Puget Lowlands	47.9525	121.8870	41
Woods Creek	Puget Lowlands	47.9569	121.8818	39
Yakima River	Columbia Basin	46.9782	120.5647	33
Yakima River Tributary	Cascades	47.2603	121.2803	41
Yesmowit Creek	Eastern Cascades	46.3775	120.9458	41
Yesmowit Creek	Eastern Cascades	46.3781	120.9086	33
Zeigler Creek	Coast Range	47.4886	123.8153	19

References Cited

Aroner, E.R. 2001. 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.

Carlson, R.E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22: 361-369.

Carlson, R.E. 1979. A review of the philosophy and construction of trophic state indexes. *In* Maloney, T.E. Lake and Reservoir Classification Systems. U.S. Environmental Protection Agency Report No. EPA-600/3-79-074.

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

Cude, C. 2001. Oregon Water Quality Index: A Tool for Evaluating Water Quality Management Effectiveness. Journal of the American Water Resources Association 37(1): 125-137.

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

Hallock, D. and W. Ehinger. 2000. River and Stream Ambient Monitoring Report for Water Year 1998. Washington Department of Ecology, Environmental Assessment Program, Olympia, WA. 14 pp. + appendices.

Hallock, D. 1990. Results of the 1990 Water Quality Index Analysis. Washington Department of Ecology, Memorandum to Dick Cunningham, July 18, 1990. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

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

Karr. J.R and E.W. Chu. 1997. Biological Monitoring and Assessment: Using Multimetric Indexes Effectively. EPA 235-R97-001. University of Washington, Seattle.

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

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, EPA Region 10, Seattle WA.

Reckhow, K.H., Kepford, K. 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, DC.