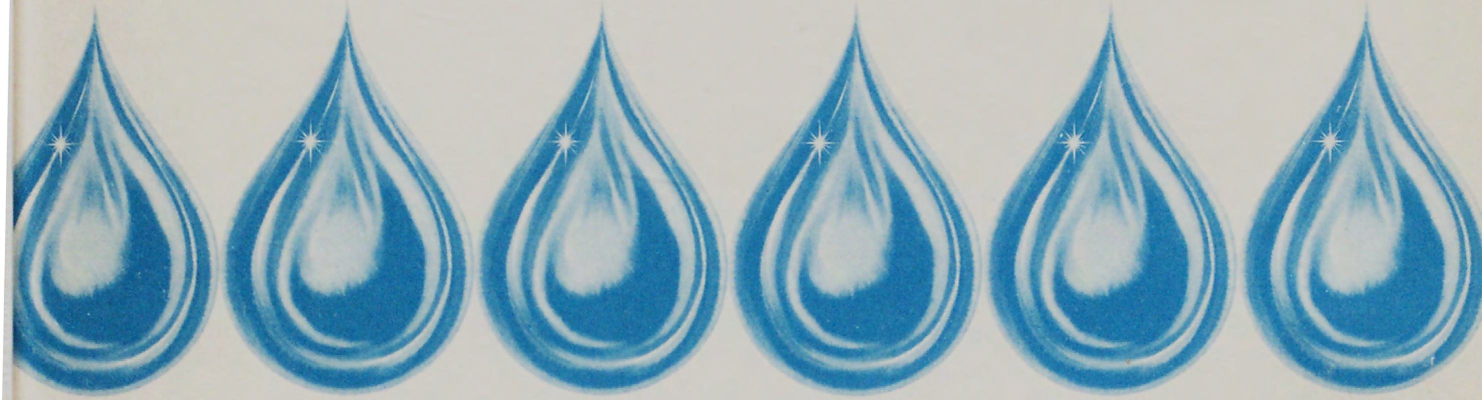

PRELIMINARY WATER-QUALITY CHARACTERIZATION OF LAKES IN WASHINGTON

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 77-94

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PRELIMINARY WATER-QUALITY CHARACTERIZATION OF LAKES IN WASHINGTON

By G. C. Bortleson

ABSTRACT

This report describes a method for comparing and characterizing lakes in Washington on the basis of water quality. The method can aid in selecting lakes for lake-restoration efforts. To simplify comparisons, a characteristic value (CV) was developed for each of 617 lakes in Washington using principal-component analysis. Three of 14 water-quality properties measured were used in this analysis because the principal component of the three properties accounted for 63 percent of the variance in the correlation matrix. The three properties were Secchi-disc visibility and concentrations of phosphorus and organic nitrogen. The significance of the derived CV's was evaluated by regression of chlorophyll *a* concentration against CV. The resulting standard error of estimate of ± 1.8 micrograms per liter of chlorophyll *a* indicated that the CV can be a useful index in assessing relative water-quality and trophic conditions among lakes.

Prior to 1973 most of Washington's lakes were studied only superficially. In 1973-74 a reconnaissance study of 760 selected lakes and reservoirs in the State was carried out by the U.S. Geological Survey in cooperation with the Washington Department of Ecology. Most of the lakes investigated were selected because they have shorelines that may be regulated under the Shoreline Management Act of 1971 (Washington Department of Ecology, 1973). The statewide survey consisted in general of a data-collection program designed to document the present water quality of the lakes, and to provide basic data pertaining to physical and cultural characteristics of the lakes and their drainage basins. The results of the reconnaissance study are presented for each lake in a seven-volume series of reports (Bortleson and others, 1976a-d; Dion and others, 1976b-d). The data-collection program was designed to be useful to planning groups involved in lake management, and to sportsmen, tourists, and others interested in Washington's lakes.

A problem frequently encountered is that of comparing the water quality of one lake with that of another. The concept that each lake is unique has considerable scientific merit, but it provides little help to those who must make decisions based on comparisons between lakes. For example, in the State of Washington the lake-restoration program requires that comparisons of lake-water quality be made as part of the process of selecting candidate lakes for rehabilitation. The need to characterize lakes according to their water-quality condition is specifically required in Section 314(a) of the 1972 Amendments to the Federal Water Pollution Control Act, which states that,

> "Each State shall prepare or establish, and submit to the Administrator for his approval:
>
> 1) an identification and classification according to eutrophic condition of all publicly owned fresh water lakes in such State;
> 2) procedures, processes, and methods (including land use requirements) to control sources of pollution of such lakes; and
> 3) methods and procedures, in conjunction with appropriate Federal agencies, to restore quality of such lakes."

In response to the foregoing needs, this report was prepared to characterize the water quality of Washington lakes quantitatively. The data from the reconnaissance study provide the basis for this report because they are the only consistently determined information available for characterizing lake-water quality.

Lake-water quality cannot be defined by a single variable. The trophic state of a lake can, however, be expressed by a set of interrelated physical, chemical, and biological variables that influence plant and animal production. The water quality of a given lake, identified by a single sample taken at a specified site and time, may be described as a multivariate statistic of order i, where i denotes the number of water-quality constituents. Principal-component analysis then can be used to examine the dependence structure of the multivariate data. The usefulness of principal-component analysis in reducing the complexity of a large data set makes it particularly attractive for developing a quantitative, but relatively simple, characterization of lake-water quality.

In previous studies (Dawdy and Feth, 1967; Shannon and Brezonik, 1972; Steele and Matalas, 1974), principal components were derived to study interrelationships between water-quality constituents. The approach used in this study was similar to that of Shannon and Brezonik (1972), who used principal-component analysis to derive a trophic-state index for 55 Florida lakes, and Boland (1976), who used the same technique for 100 lakes in Minnesota, Wisconsin, Michigan, and New York.

The lake variables used in the principal-component analyses by the above investigators are listed below:

<u>Shannon and Brezonik (1972)</u>

1. Secchi-disc visiblity
2. Specific conductance
3. Total organic nitrogen
4. Total phosphorus
5. Chlorophyll <u>a</u>
6. Primary productivity
7. Pearson's cation ratio

<u>Boland (1976)</u>

1. Secchi-disc visibility
2. Specific conductance
3. Total organic nitrogen
4. Total phosphorus
5. Chlorophyll <u>a</u>
6. Algal assay

In all cases, principal-component analysis yielded a numerical expression describing the relation between the variables. Use of the expression to characterize lakes provides results which are relative rather than absolute. The lakes are characterized only with respect to one another; consequently, the classification of a particular lake may change if additional lakes are included in the data set.

EVALUATION OF LAKE-WATER QUALITY
BY PRINCIPAL-COMPONENT ANALYSIS

Method of Analysis

After editing and screening, complete data sets became available for 617 of the original 760 lakes studied. The 14 water-quality variables determined for each lake and their corresponding symbol used in the tables in this report, are listed below:

		Symbol
1.	Total inorganic nitrogen (nitrite, nitrate, and ammonia), upper water (mg/L, milligrams per liter)	Inorg N(u)
2.	Total inorganic nitrogen, bottom water (mg/L)	Inorg N(b)
3.	Total organic nitrogen, upper water (mg/L)	Org N(u)
4.	Total phosphorus, upper water (mg/L)	P(u)
5.	Total phosphorus, bottom water (mg/L)	P(b)
6.	Total orthophosphate phosphorus, upper water (mg/L)	PO_4(u)
7.	Specific conductance, upper water (micromhos)	Sp cond
8.	Temperature, bottom water (degrees Celsius)	Temp
9.	Dissolved oxygen, bottom water (mg/L)	Oxy
10.	Color, upper water (cobalt-platinum units)	Color
11.	Secchi-disc visibility (meters)	Secchi disc
12.	Percent shoreline covered by emersed plants (macrophytes)	Shoreline veg
13.	Percent lake surface covered by emersed plants (macrophytes)	Lake sfc veg
14.	Fecal-coliform bacteria (colonies per 100 milliliters)	Fecal bac

Water samples for chemical analyses were collected from the upper and lower waters of each lake, defined herein as at depths of 1 meter below the water surface and 1 to 2 meters above the lake bottom, respectively. Lakes too shallow to sample at these depths were sampled at about one-third and two-thirds the depth of the lake. Additional details of the data collection are given by Bortleson and others (1976a-1976d). In this study, concentrations of nitrogen and phosphorus were emphasized because under most lake conditions these nutrients are usually responsible for causing a shift from a low to a more productive state (Wetzel, 1975, p. 640).

Data for each of the 14 variables were transformed into normalized values before computation of the principal components. Each variable for each lake, L_{im}, was converted to the form

$$X_{im} = \frac{L_{im} - \overline{L}_i}{S_i} , \tag{1}$$

where X_{im} is the normalized value for variable i of lake m (m varies from 1 to 617) and $\overline{L}_i$ and S_i denote mean and standard deviation, respectively, of the observed values for variable i. In order to make all variables unidirectional--so that a large value always indicates "poor" lake-water quality--the data for Secchi-disc visibility and dissolved oxygen were inverted prior to analysis. A correlation matrix and the principal components were then computed from the sets of normalized data, rather than from the original variables.

The matrix of correlation coefficients is presented in table 1. The correlation coefficient is a measure of the interrelation for pairs of water-quality variables, with a coefficient of 1.00 indicating complete agreement for the pair of variables. The matrix shows coefficients for all possible pairs.

The correlation coefficients are low for nearly all pairs of constituents. The paired variables that exhibited the highest correlation were concentrations of total phosphorus in upper water and total orthophosphate phosphorus in upper water. The only other paired variables which had a correlation coefficient greater than 0.75 were total inorganic nitrogen in bottom water and total phosphorus in bottom water.

Because principal-component analysis may be unknown to many readers, a brief explanation is given for the benefit of those with a technical interest. Principal-component analysis is a technique which rearranges the data contained in the correlation matrix so as to present it in a manner that explains the structure of the underlying system that produced the data. That is, the analysis redistributes the explained variance in the correlation matrix among a set of principal components (so-called eigenvectors) that reveal the underlying linear combinations of the original variables. The jth principal component of the ith variate system is the linear expression,

$$C_j = b_{1j}X_{1m} + b_{2j}X_{2m} + \ldots b_{ij}X_{im} \quad , \tag{2}$$

where C_j is the jth principal component, X_{im} is the ith normalized variable for lake m (j varies from 1 to i), and b_{ij} (for each variable in the analysis) is the coefficient. The coefficients are scaled so that they may range from -1.0 to +1.0, and the absolute value of the coefficient is a measure of the variance each variable contributes to each of the principal components. The coefficients are sometimes referred to as factor loadings, and this convention will be used herein.

The first principal component is defined as that combination of X_i's that explains the greatest possible amount of variance in the correlation matrix. Each succeeding principal component is chosen as an independent combination of X_i's, with each contributing less to the explained variance than the preceding one. By this method, as many principal components can be derived as there are variables in the original correlation matrix.

In most applications of this technique, however, a large portion of the variance is found to be accounted for by the first few components (Kutzbach, 1967, p. 793). If the variables have significant interrelationships, the first few principal components will account for a large part of the total variance. Each principal component is by definition independent of (orthogonal to) all other principal components. A more thorough discussion of this technique is given in mathematical terms by Morrison (1967).

TABLE 1.--Matrix of correlation coefficients for 14 water-quality variables from 617 lakes in Washington

Variable	Correlation coefficients													
	Inorg N(u)	Inorg N(b)	Org N(u)	P(u)	P(b)	PO_4(u)	Sp cond	Temp	Oxy	Color	Secchi disc	Shore-line veg	Lake sfc veg	Fecal bac
1 Inorg N(u)	1.0	-0.01	0.17	0.18	0.02	0.16	0.16	0.10	-0.05	0.21	0.33	0.06	0.03	0.09
2 Inorg N(b)		1.0	.03	.01	.82	.01	.25	-.10	.13	-.02	-.02	-.07	-.05	-.03
3 Org N(u)			1.0	.52	.15	.44	.27	.45	-.01	.45	.52	.31	.14	.16
4 P(u)				1.0	.20	.98	.33	.23	-.05	.28	.29	.16	.04	.08
5 P(b)					1.0	.20	.38	-.03	.08	.02	.03	-.03	-.03	-.01
6 PO_4(u)						1.0	.30	.18	-.03	.22	.20	.13	-.03	.05
7 Sp cond							1.0	.12	-.01	.25	.19	.03	.00	.00
8 Temp								1.0	-.33	.30	.35	.42	.26	.15
9 Oxy									1.0	-.01	-.10	.06	-.06	-.07
10 Color										1.0	.44	.34	.22	.09
11 Secchi disc											1.0	-.23	.06	.28
12 Shoreline veg												1.0	.46	.10
13 Lake sfc veg													1.0	.05
14 Fecal bac														1.0

Application and Results

The principal component matrix for data in this study is given in table 2. Fourteen variables were used in the matrix with only 3 of the 14 possible principal components being listed in the table. The first principal component explained 26 percent of the variability of the lake variables, and the second component explained an additional 15 percent. The first three principal components account for 51 percent of the total variance in the original data. The low percentage of variability explained by the first component is attributed to the low correlations between the water-quality variables given in table 1. Some indication of the meaning of the principal components is made by examining the magnitude and algebraic sign of the factor loadings (table 2) and noting the relationship to the original variables. Loading of certain variables dominates each principal component and often suggests a descriptive label for that component. Because the components are by definition independent, each one may be interpreted independently with respect to its relationship to the original variables. Loadings whose absolute values are 0.33 or greater are underlined to indicate those variables that contribute most to each component.

TABLE 2.--Principal-component analysis with factor loadings on the first three principal components for 14 water-quality variables from 617 lakes

[Underline indicates variable with dominant loadings]

Variable	Principal component 1	2	3
1 Inorg N(u)	0.190	0.024	-0.070
2 Inorg N(b)	.041	-<u>.538</u>	<u>.393</u>
3 Org N(u)	<u>.414</u>	.023	.001
4 P(u)	<u>.400</u>	-.156	-<u>.414</u>
5 P(b)	.129	-<u>.558</u>	.305
6 PO_4(u)	<u>.365</u>	-.174	-<u>.433</u>
7 Sp cond	.245	-.301	.022
8 Temp	.303	.255	.182
9 Oxy	-.067	-.178	.087
10 Color	<u>.327</u>	.119	.149
11 Secchi disc	<u>.339</u>	.120	.052
12 Shoreline veg	.252	.248	.372
13 Lake sfc veg	.148	.228	<u>.412</u>
14 Fecal bac	.131	.115	.064
Percent of variance	26	15	10
Cumulative proportion of total variance	26	41	51

For the first principal component (table 2, column 1), the highest factor loadings are for total organic nitrogen in upper water, total phosphorus in upper water, orthophosphate phosphorus in upper water, color, and Secchi-disc visibility. These are a combination of interrelated variables of nutrient concentrations and water clarity. The second component (column 2) is dominated by inorganic nitrogen in bottom water, and total phosphorus concentration in bottom water. Both variables represent summer buildup of nutrients in the lower water. Usually, the first few components reflect information in the data, but beyond that the pattern is less discernible. An inverse relationship exists between those variables of opposite sign.

The statistical stability of the factor loadings for each of the 14 variables was tested by performing principal-component analysis on subsets of 617 lakes. The subsets correspond to geographic regions shown in previous reports (Bortleson and others, 1976a-d; Dion and others, 1976b-d). The factor loadings for the 14-variable analysis from regional subsets are given in table 3. The five variables with highest loadings ($\geq$0.33) on the first principal component for the overall State analysis also have the highest loadings for the regional subset analysis in 29 out of 35 cases (7 regions x 5 variables equal 35). The variables with highest loadings on the second component for the overall State analysis (table 2) also load highest on component analysis for subsets, but the remaining components do not show consistent factor-loading patterns.

TABLE 3.--Principal-component analysis with factor loadings on the first principal component for 14 water-quality variables from subsets of 617 lakes

[Underline indicates variable with dominant loading]

Variable	State	Regional subset						
		1	2	3	4	5	6	7
1 Inorg N(u)	0.190	0.306	0.349	0.327	0.279	0.121	-0.032	0.318
2 Inorg N(b)	.041	-.060	-.012	.306	.120	.002	.124	-.032
3 Org N(u)	.414	.315	.388	.373	.342	.380	.433	.310
4 P(u)	.400	.381	.394	.388	.365	.425	.432	.408
5 P(b)	.129	.136	.020	.376	.301	.035	.187	.173
6 PO_4(u)	.365	.370	.382	.360	.330	.375	.400	.390
7 Sp cond	.245	.318	.190	.287	.292	-.087	.342	.301
8 Temp	.303	.212	.175	.042	.234	.271	.234	.273
9 Oxy	-.067	-.039	.086	.184	-.039	-.041	-.121	-.096
10 Color	.327	.389	.327	.242	.340	.424	.351	.350
11 Secchi disc	.339	.412	.402	.217	.292	.429	.204	.365
12 Shoreline veg	.252	.154	.235	.105	.266	.179	.212	.118
13 Lake sfc veg	.148	.079	.151	.043	.178	.159	.084	.090
14 Fecal bac	.131	-.016	.053	.027	.113	.118	.101	-.036
Percent of variance	26	38	38	38	41	30	24	31
Number of lakes	617	73	136	60	57	73	143	75

The first principal component accounts for the largest percentage of the variance explained, remains consistent among subsets, and appears to show the most conspicuous pattern for characterizing lake-water quality. Thus, the first principal component was chosen to formulate a characteristic value (CV) for lake-water quality. From this first component each lake can be quantified as a linear function of the original normalized variables. In deciding how many variables to use to derive the CV, a rationalization must be made between simplicity (number of variables) and the amount of acceptable variance to be explained.

An evaluation was thus made of the effect on the first principal component of dropping variables from the data-correlation matrix that have low loadings on the first principal component, or conversely, of retaining those variables with high factor loadings (table 3). As expected, the amount of variance explained is increased when poorly correlated variables are omitted from the principal-component analysis (table 4). The first principal component accounts for 55 and 63 percent of the variance using five and three variables, respectively. These variables were measures of nutrient concentration and water clarity. The first principal component using three variables was chosen to derive the CV due to (1) the documented significance of total organic nitrogen, total phosphorus, and Secchi-disc visibility in assessing the trophic state of lakes (Dillon and Rigler, 1974; Lueschow and others, 1970; Shapiro and others, 1975; U.S. Environmental Protection Agency, 1974); (2) the larger percentage of variance accounted for; and (3) the fewer number of variables needed for definition. The CV's generated, using phosphorus and nitrogen concentrations and Secchi-disc visibility, are probably a greater reflection of open water rather than nearshore processes. The first principal component of a three-variate system for each lake can thus be derived according to:

$$C_{1m} = b_{11}X_{1m} + b_{21}X_{2m} + b_{31}X_{3m} \quad , \qquad (3)$$

where C_{1m} is the first principal component for lake m (m varies from 1 to 617); X_{1m}, X_{2m}, and X_{3m} are normalized variables for lake m; and b_{11}, b_{21}, and b_{31} are factor loadings corresponding to each of the three variables in the first principal component.

TABLE 4.--Principal-component analysis with factor loadings on the first principal component for 5 and 3 variable analysis from 617 lakes

Variable	First principal component using 5 variables	Variable	First principal component using 3 variables
Org N(u)	0.471	Secchi disc	0.548
P(u)	.525	Org N(u)	.635
PO_4(u)	.491	P(u)	.545
Color	.352		
Secchi disc	.367		
Percent of variance	55		63

The CV's in this report are derived from equation 3 by a minor modification of the respective principal components. The modification consisted of adding a constant value to the principal component and multiplying the sum by 100 so that the CV's would always be positive and greater than unity. The constant was obtained by evaluating the first principal component with raw-data values of zero for total organic nitrogen and total phosphorus concentrations and 34 meters for Secchi-disc visibility (highest observed for the study). Thus, a lake with the above water-quality characteristics would have a CV of one, and lakes with increasing total organic nitrogen and total phosphorus concentrations and decreasing Secchi-disc values would exhibit increasingly higher CV's. The absolute magnitude of the resulting CV has no physical meaning, but it should be a good relative value for water-quality comparison between lakes. An example of a typical CV computation is given in the Appendix and the computed CV's for 617 lakes are given in table 5 (at end of report). The lakes are arranged in descending order of CV for seven regions throughout the State.

In order for the lake data to be of maximum use to water managers, the counties of the State were grouped into seven regions roughly corresponding to physiographic provinces (Bortleson and others, 1976a, fig. 1). On a statewide basis, the maximum, minimum, mean, and median CV's were 1,259, 1, 104, and 55, respectively. A plot of lake CV's on a statewide map indicated that the only conspicuous patterns were higher CV's in the Columbia Plateau of eastern Washington and lower CV's in the higher-altitude Cascade Range. In general, throughout most of the State CV's varied considerably from lake to lake within a region. To illustrate general trends occurring in the transition from high to low CV's, three lakes from table 5 (region 1) are listed in a comparison below.

Lakes	CV	Secchi disc (meters)	Org N (u) (mg/L)	P (u) (mg/L)
Kah Tai	625	0.30	3.2	1.2
Big	46	2.4	.31	.016
Wiseman	2	21	.03	.001

Kah Tai Lake is a shallow, nutrient-rich lake that is high in biological productivity. Big Lake has nitrogen and phosphorus concentrations several orders of magnitude less than Kah Tai Lake and is considered moderate in biological productivity (Dion and others, 1976a). Wiseman Lake is a low-productivity lake with extremely clear water. Thus, the assigned CV's and the rankings of lakes shown in table 5 allow the lake manager to make between-lake comparisons from a large, diverse sample of lakes.

As an aid in estimating the significance of CV, regression analysis was performed with chlorophyll a as a dependent variable and the CV as an independent variable. Secchi-disc visibility and concentrations of nitrogen and phosphorus (variables defining the CV) are commonly correlatable to chlorophyll a concentration, a measure of algal biomass (Bachmann and Jones, 1974; Dillon and Rigler, 1974; U.S. Environmental Protection Agency, 1974). Data on chlorophyll a concentrations were obtained from 104 of 617 lakes. These lakes were sampled in 1972-75 (Bortleson and others, 1976e; McConnell and others, 1976; Dion and others, 1976a; Uchida and others, 1976; Dion and others, (1978), independently of the reconnaissance study. A regression analysis of the data resulted in the following relationship:

$$\log_{10} \text{CHLA} = 0.682 \log_{10} \text{CV} - 0.443 \quad ,$$

where chlorophyll a concentrations (CHLA) are expressed in ug/L (micrograms per liter) and represent the average of four samples taken seasonally--winter, spring, summer, and autumn. The correlation coefficient for this relation was 0.58. The predicted chlorophyll a concentrations computed from CV's are given in table 5 for 100 of 104 lakes used to derive the relationship. The accuracy of the regression equation is shown by the standard error, $\pm$1.8 ug/L chlorophyll a. Estimates of chlorophyll a concentration computed from this equation will be, on the average, within the stated range of standard error of the equation two-thirds of the time. Applications of this simple relation can be used, with limitations, to estimate the chlorophyll a concentration from a CV. For example, a CV of 130 yields a chlorophyll a of approximately 10 ug/L. Nuisance algal growth is often considered to exist when chlorophyll a concentrations exceed 10 ug/L (U.S. Environmental Protection Agency, 1974, p. 9). On a statewide basis, 139 of 617 lakes had CV values greater than 130. About 63 percent of these lakes are in the Columbia Plateau of eastern Washington.

LIMITATIONS OF LAKE COMPARISONS

The preliminary characterization of lake-water quality is intended only to aid in comparisons between lakes. Limitations of such comparisons are generated both by the input data and the statistical procedure used.

The basic data should not be abandoned in favor of total reliance on single characterizing values for several reasons:

1. Lake ecosystems are highly complex and often show integrated patterns of both "poor" and "good" limnological characteristics. For this reason, independent evaluation of several critical factors is often useful.

2. Because limnological characteristics may be highly variable seasonally and spatially, the CV described by principal-component analysis for a given lake applies only to a specified time and sampling site. The analyses described in this report were necessarily restricted to a study of midsummer values of lake-water-quality variables.

3. Each lake should be viewed with the needs of a variety of potential users in mind. The CV is formulated on the premise that "wanted conditions" embrace a set of generally accepted water-quality variables that influence the human uses of the water resource, such as drinking-water supplies, trout (cold-water) fishing, and bathing. The above conditions, for example, may not reflect water quality needed for warm-water fish or for waterfowl breeding and feeding.

The use of principal-component analysis to yield a quantitative, algebraic expression is a relative system and should be viewed as a dynamic rather than a static concept. That is, the lakes are quantified only relative to one another, the principal components are defined by only one set of input data, and the CV for a particular lake may change if additional lakes are analyzed or if other data sets are used. Thus, extrapolation of the CV concept to other lakes is not suggested or recommended. If data based on more frequent sampling or new variables should become available, then the input data set should be redefined, and, as a result, the CV expression could change.

SUMMARY

The principal-component technique as applied allows for the simultaneous examination of all lakes and all variables in a large data set in an objective and repeatable manner. The technique was applied to expedite the description and interpretation of water-quality data from several hundred lakes in Washington. An examination of the correlation and principal-component matrices provides information on the interrelationship of the 14 lake-water-quality variables. The assigned characteristic values (CV's) and ranking of lakes shown in table 5 allow the lake manager to make between-lake comparisons from a large, diverse sample of lakes.

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APPENDIX.--Calculation of a Characteristic Value for Lake-Water Quality

Using Lake Aldwell (number 51 in table 5) for an example:

Equation 3, p. 10: $C_{1m} = b_{11}X_{1m} + b_{21}X_{2m} + b_{31}X_{3m}$,

where C_{1m} is the first principal component of lake number m (or 51); and b_1 (0.548), b_2 (0.635), and b_3 (0.545) are factor loadings corresponding to the first principal component for Secchi-disc visibility, total organic nitrogen, and total phosphorus, respectively.

Substituting equation 1 (p. 5) into equation 3:

$$C_{51} = 0.548 \frac{1/L_1 - \bar{L}_1}{S_1} + 0.635 \frac{L_2 - \bar{L}_2}{S_2} + 0.545 \frac{L_3 - \bar{L}_3}{S_3} ,$$

where $1/L_1$ (0.40), L_2(0.02), and L_3 (0.004) are values for Secchi-disc visibility, in meters (inverted, see p.); and total organic nitrogen and total phosphorus are in milligrams per liter. $\bar{L}_1$ (0.661), $\bar{L}_2$ (0.697), $\bar{L}_3$ (0.124), S_1 (0.923), S_2 (0.848), and S_3 (0.433) denote the mean and standard deviation, respectively, of the observed variates.

The first principal component for Lake Aldwell is calculated as follows:

$$C_{51} = 0.548 \frac{(0.40-0.661)}{0.923} + 0.635 \frac{(0.02-0.697)}{0.848}$$

$$+ 0.545 \frac{(0.004-0.124)}{0.432} = -0.813$$

Modification of first principal component (p.11):

$$CV = 100 \times (C_{51} + 1.0410), \text{ or } 100 \times (-0.813 + 1.0410)$$

$$= 23 \text{ for Lake Aldwell.}$$

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (ug/L) measured	predicted from CV
		Region 1			
1	Kah Tai	Jefferson	625	-	-
2	Hummel	San Juan	382	-	-
3	Crockett	Island	195	-	-
4	Lone	Island	174	-	-
5	Zylstra	San Juan	158	-	-
6	Pass	Skagit	146	-	-
7	Anderson	Jefferson	141	-	-
8	Kristoferson	Island	141	-	-
9	Heart (36N-7E-5)	Skagit	139	-	-
10	Campbell	do.	134	-	-
11	Unnamed (33N-2E-7)	Island	127	-	-
12	Seafield	Clallam	120	-	-
13	Cranberry	Island	113	-	-
14	Fazon	Whatcom	101	-	-
15	Terrell	Whatcom	95	-	-
16	Squalicum	do.	94	-	-
17	Leland	Jefferson	92	-	-
18	Gibbs	do.	88	-	-
19	Briggs	San Juan	83	-	-
20	Louise	Whatcom	79	-	-
21	Martins	San Juan	77	-	-
22	Heart (35N-1E-36)	Skagit	66	-	-
23	Cranberry	do.	65	-	-
24	Crocker	Jefferson	62	-	-
25	Pine	Whatcom	59	-	-
26	Caskey	Skagit	53	-	-
27	Devils	do.	52	-	-
28	Peterson	Jefferson	51	-	-
29	Shannon	Skagit	48	-	-
30	Horseshoe	San Juan	47	-	-
31	Big	Skagit	46	6.2	4.9
32	Wentworth	Clallam	46	-	-
33	Dickey	do.	45	-	-
34	Elk	do.	44	-	-
35	Beaver	do.	42	-	-
36	Silver	Whatcom	42	-	-
37	Tarboo	Jefferson	41	-	-
38	Reed	Whatcom	40	-	-
39	Cain	do.	40	-	-
40	Trout	San Juan	37	-	-
41	Ozette	Clallam	37	2.6	4.2
42	Sixteen	Skagit	36	-	-
43	Toad (Emerald)	Whatcom	35	5.2	4.1
44	Spencer	San Juan	33	-	-
45	Cascade	do.	33	-	-
46	Sandy Shore	Jefferson	31	-	-
47	Canyon	Whatcom	31	-	-
48	Padden	do.	29	2.1	3.5
49	Day	Skagit	26	1.1	3.3
50	Pleasant	Clallam	25	-	-
51	Aldwell	do.	23	-	-
52	Whatcom	Whatcom	23	-	-
53	Ten	Skagit	21	-	-
54	Mountain	San Juan	21	-	-
55	Myrtle	Skagit	20	-	-
56	Deer	Island	18	2.6	2.6
57	Goss	do.	17	3.5	2.5
58	McMurray	Skagit	16	5.4	2.4
59	Clear (34N-5E-7)	do.	15	2.4	2.3
60	Shuksan	Whatcom	12	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L) measured	predicted from CV
		Region 1--continued			
61	Jordan, Lower	Skagit	8	-	-
62	Tomyhoi	Whatcom	8	-	-
63	Bluff	Skagit	7	-	-
64	Clear (36N-9E-23)	do.	6	-	-
65	Twin, Lower	Whatcom	6	-	-
66	Maiden	do.	6	-	-
67	Blue	do.	5	-	-
68	Twin, Upper	Whatcom	5	-	-
69	Sutherland	Clallam	5	-	-
70	Whale	Skagit	4	-	-
71	Falls, Upper	do.	3	-	-
72	Falls, Lower	do.	2	-	-
73	Wiseman	Whatcom	2	-	-
		Region 2			
74	Larsen	King	610	-	-
75	Sturtevant	do.	292	-	-
76	Geneva	do.	178	-	-
77	Howard	Snohomish	166	3.4	12
78	Bryant	do.	148	-	-
79	Moneysmith	King	123	-	-
80	Dolloff	do.	118	-	-
81	Cassidy	Snohomish	107	14	8.7
82	Black	King	90	-	-
83	Desire	do.	78	20	7.0
84	Fivemile	King	74	-	-
85	Neilson (Holm)	do.	71	-	-
86	Pine	do.	71	10	6.6
87	Wallace	Snohomish	68	-	-
88	Bridges	King	67	-	-
89	Crystal	Snohomish	66	-	-
90	Paradise	King	65	-	-
91	Loma	Snohomish	62	6.1	6.0
92	Stickney	do.	61	-	-
93	Francis	King	59	-	-
94	Armstrong	Snohomish	58	-	-
95	Beaver	King	58	-	-
96	Trout	do.	57	-	-
97	Marie	do.	56	-	-
98	Chain	Snohomish	55	-	-
99	Storm	do.	55	-	-
100	Kellogg	do.	55	-	-
101	Bass	King	55	-	-
102	Boren	do.	53	5.3	5.4
103	Echo	Snohomish	53	-	-
104	Weallup	Snohomish	53	-	-
105	Boyle	King	52	-	-
106	Beaver No. 1	do.	52	-	-
107	Morton	do.	51	-	-
108	Shady	do.	51	-	-
109	Panther	Snohomish	50	-	-
110	Devils	do.	49	-	-
111	Joy	King	49	-	-
112	Sunday	Snohomish	48	-	-
113	Serene (28N-4E-34)	do.	48	-	-
114	Roesiger (north arm)	Snohomish	48	2.3	5.0
115	Riley	do.	48	-	-
116	Goodwin	do.	47	6.4	4.9
117	Martha (31N-4E-18)	do.	47	3.5	4.9
118	Shadow	King	46	3.7	4.9
119	Meridian	do.	46	-	-
120	Number Twelve	do.	45	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L) measured	predicted from CV
		Region 2--continued			
121	Crabapple	Snohomish	45	2.3	4.8
122	Echo (26N-4E-6)	King	44	4.1	4.8
123	Cottage	do.	44	-	-
124	Otter (Springs)	King	42	-	-
125	Mirror	do.	42	-	-
126	Ballinger	Snohomish	42	-	-
127	Roesiger (south arm)	do.	41	2.9	4.5
128	Woods	do.	41	-	-
129	Leota	King	40	-	-
130	Flowing	Snohomish	39	-	-
131	Bitter	King	39	-	-
132	Stevens	Snohomish	38	3.5	4.3
133	Hughes	do.	38	-	-
134	Blanca	Snohomish	38	-	-
135	Burien	King	37	-	-
136	Union	do.	36	-	-
137	Phantom	do.	35	-	-
138	Fish	do.	35	-	-
139	Killarney (north arm)	do.	35	4.7	4.1
140	Star	do.	34	-	-
141	McDonald	do.	34	-	-
142	King	Snohomish	34	2.3	4.1
143	Fontal	do.	34	-	-
144	Martha (27N-4E-1)	do.	33	-	-
145	Klaus	King	33	-	-
146	Killarney (south arm)	do.	33	3.2	3.9
147	Kathleen	do.	33	-	-
148	Fenwick	do.	33	-	-
149	Beaver No. 2	do.	33	-	-
150	Ames	do.	33	-	-
151	Blackmans	Snohomish	32	-	-
152	Menzel	do.	32	-	-
153	Ki	do.	32	2.0	3.9
154	Silver (28N-5E-30)	do.	32	-	-
155	Echo (23N-7E-2)	King	31	-	-
156	Portage Bay	do.	31	-	-
157	Steel	do.	30	-	-
158	Webster	do.	30	-	-
159	Cochran	Snohomish	30	-	-
160	Dagger	do.	29	-	-
161	Hanna	do.	29	-	-
162	Retreat	King	29	3.8	3.6
163	Angle	do.	29	2.8	3.6
164	Bosworth	Snohomish	27	-	-
165	North	King	24	6.8	3.1
166	Walker	do.	23	4.5	3.0
167	Deep	do.	21	-	-
168	Alice	do.	21	1.6	2.9
169	Margaret	do.	20	1.5	2.8
170	Lynch	do.	20	-	-
171	Sawyer	do.	19	2.0	2.6
172	Shoecraft	Snohomish	19	4.9	2.7
173	Tomtit	do.	18	-	-
174	Langlois	King	18	1.8	2.6
175	Eagle	do.	18	-	-
176	Janus	Snohomish	16	-	-
177	Calligan	King	16	-	-
178	Boardman	Snohomish	11	-	-
179	Tuscohatchie	King	10	-	-
180	Nadeau	do.	10	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L) measured	predicted from CV
		Region 2--continued			
181	North	Snohomish	10	-	-
182	Kelcema	do.	9	-	-
183	Greider, Big	do.	9	-	-
184	SMC	King	9	-	-
185	Rattlesnake	do.	8	-	-
186	Mason	do.	7	-	-
187	Helena	Snohomish	7	-	-
188	Cup	do.	6	-	-
189	Goat	do.	6	-	-
190	Isabel	do.	6	-	-
191	South	do.	6	-	-
192	Peek-a-boo	do.	6	-	-
193	Wildcat, Upper	King	6	-	-
194	Findley	do.	5	-	-
195	Saucer	Snohomish	5	-	-
196	Indigo	do.	5	-	-
197	Copper	do.	5	-	-
198	Peach	do.	4	-	-
199	Silver (29N-11E-28)	do.	4	-	-
200	Serene (27N-10E-31)	do.	3	-	-
201	Pear	do.	3	-	-
202	Twin, Upper	do.	3	-	-
203	Twin, Lower	do.	3	-	-
204	Moolock	King	3	-	-
205	Loch Katrine, Upper	do.	2	-	-
206	Boardman, East	Snohomish	2	-	-
207	Caroline	King	2	-	-
208	Annette	do.	2	-	-
209	Sunset	Snohomish	1	-	-
		Region 3			
210	Waughop	Pierce	400	-	-
211	Mud	do.	209	-	-
212	Stidham	do.	166	-	-
213	Mud Mountain	do.	156	-	-
214	Bay	do.	129	-	-
215	Cranberry	do.	114	-	-
216	Rapjohn	do.	114	-	-
217	Lagrande	do.	111	-	-
218	Alder	do.	95	-	-
219	Miller	Kitsap	95	-	-
220	Forbes	Mason	89	-	-
221	Fawn	do.	77	-	-
222	Stump	do.	76	-	-
223	Spencer	do.	75	-	-
224	Twentyseven	Pierce	71	-	-
225	Timber	Mason	66	-	-
226	Lystair	do.	63	-	-
227	Bennettsen	do.	63	-	-
228	Wapato	Pierce	61	10	5.9
229	Tapps	do.	60	-	-
230	Sequalitchew	do.	53	-	-
231	Long	Kitsap	51	8.7	5.3
232	Florence	Pierce	50	-	-
233	Limerick	Mason	50	-	-
234	Island	do.	47	-	-
235	Price	do.	47	-	-
236	Bonney	Pierce	45	-	-
237	William Symington	Kitsap	44	-	-
238	Josephine	Pierce	41	-	-
239	Prickett	Mason	41	-	-
240	Tee	do.	41	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV *	Seasonal average chlorophyll a concentration (µg/L)	
				measured	predicted from CV
		Region 3--continued			
241	Tahuya	Kitsap	40	-	-
242	Kapowsin	Pierce	39	-	-
243	Wooten	Mason	38	-	-
244	Surprise (20N-4E-4)	Pierce	35	-	-
245	Phillips	Mason	34	2.8	4.0
246	Spanaway	Pierce	32	6.3	3.8
247	Twin	Kitsap	31	-	-
248	Wye	do.	30	2.3	3.6
249	Stansberry	Pierce	30	-	-
250	Whitman	do.	30	-	-
251	Nahwatzel	Mason	27	-	-
252	Mason	do.	27	3.6	3.4
253	Devereaux	do.	24	-	-
254	Cushman	do.	23	-	-
255	Isabella	do.	22	5.6	3.0
256	Island	Kitsap	22	-	-
257	Benson	Mason	20	-	-
258	Wildcat	Kitsap	20	-	-
259	Carney	Pierce	18	-	-
260	Louise	do.	17	2.1	2.5
261	Horseshoe	Kitsap	16	2.9	2.4
262	Coplay	Pierce	13	-	-
263	Lost	Mason	13	1.4	2.1
264	Union River	Kitsap	12	-	-
265	Haven	Mason	11	-	-
266	Maggie	do.	9	-	-
267	Lily	Pierce	7	-	-
268	Cedar	do.	7	-	-
269	Summit	do.	1	-	-
		Region 4			
270	Duck	Grays Harbor	282	-	-
271	Unnamed (2N-1E-9)	Clark	274	-	-
272	Breaker	Pacific	272	-	-
273	Percival Cove	Thurston	167	-	-
274	Horseshoe	Cowlitz	162	-	-
275	Sacajawea	do.	147	-	-
276	Unnamed (2N-6E-35)	Skamania	147	-	-
277	Sunwood	Thurston	130	-	-
278	Pitman	do.	112	-	-
279	Island	Pacific	111	-	-
280	Lawrence	Thurston	105	10	8.6
281	Chambers	do.	104	9.0	8.6
282	Chambers, Little	do.	99	9.0	8.3
283	Round	Clark	99	-	-
284	Southwick	Thurston	95	-	-
285	Capitol (north arm)	do.	93	-	-
286	Green Leaf	Skamania	87	-	-
287	Ashes	do.	82	-	-
288	Tempo (Bushman)	Thurston	82	-	-
289	Simmons (Ken)	do.	79	-	-
290	Stevenson	Skamania	77	-	-
291	St. Clair (south arm)	Thurston	71	7.6	6.6
292	Elbow	do.	58	-	-
293	Deep	do.	58	11	5.8
294	Patterson (south arm)	do.	54	11	5.4
295	St. Clair (north arm)	do.	52	3.4	5.3
296	Patterson (north arm)	do.	50	8.2	5.2
297	Hicks	do.	49	4.3	5.1
298	Black	Pacific	47	-	-
299	Lackamas	Clark	47	11	5.0
300	Borst Park	Lewis	43	11	4.7

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV *	Seasonal average chlorophyll a concentration (µg/L)	
				measured	predicted from CV
		Region 4--continued			
301	Failor	Grays Harbor	43	-	-
302	Offutt	Thurston	43	3.4	4.7
303	Scott	do.	43	8.1	4.7
304	Sylvia	Grays Harbor	42	-	-
305	Hewitt	Thurston	41	-	-
306	McIntosh	do.	34	2.5	4.0
307	Skookumchuck	do.	33	-	-
308	Ward	do.	32	3.7	3.9
309	Munn	do.	32	13	3.9
310	Mineral	Lewis	31	5.7	3.7
311	Battleground	Clark	28	2.2	3.4
312	Wauna	Skamania	28	-	-
313	Drano	do.	27	-	-
314	Swift	do.	26	-	-
315	Mayfield	Lewis	20	-	-
316	Davisson (Mossyrock)	do.	13	-	-
317	Northwestern	Skamania	13	-	-
318	Yale	Clark	12	-	-
319	Walupt	Lewis	11	-	-
320	Fawn	Cowlitz	11	-	-
321	Merwin	Clark	10	-	-
322	Spirit	Skamania	9	0.7	1.7
323	Elk	do.	8	-	-
324	Venus	do.	8	-	-
325	Merrill	Cowlitz	5	-	-
326	Hanaford	Skamania	3	-	-
		Region 5			
327	Horseshoe (9N-22E-22)	Yakima	467	-	-
328	Morgan	do.	343	-	-
329	Unnamed (36N-27E-30)	Okanogan	311	-	-
330	Giffin	Yakima	306	-	-
331	Meadow	Chelan	288	-	-
332	Horseshoe (9N-22E-25)	Yakima	271	-	-
333	Walker	Okanogan	210	-	-
334	Byron	Yakima	191	-	-
335	Horseshoe (39N-27E-27)	Okanogan	152	-	-
336	Roberts	do.	140	-	-
337	Molson	do.	131	-	-
338	Sidley	do.	130	-	-
339	Alkali	do.	126	-	-
340	Horseshoe (35N-36E-17)	do.	119	-	-
341	Mud	Ferry	119	-	-
342	Fish	Okanogan	113	-	-
343	Freeway	Yakima	104	-	-
344	Brown	Okanogan	94	-	-
345	Chopaka	do.	93	1.8	8.0
346	Dry (Grass)	Chelan	87	-	-
347	Evans	Okanogan	84	-	-
348	Blue (39N-26E-1)	do.	81	-	-
349	Leader	do.	80	-	-
350	Peninsula	do.	78	-	-
351	Unnamed (14N-19E-31)	Yakima	71	-	-
352	Cortez (Three)	Chelan	68	-	-
353	Davis	Okanogan	65	-	-
354	Wenas	Yakima	64	-	-
355	Aeneas	Okanogan	62	-	-
356	Medicine	do.	61	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L) measured	Seasonal average chlorophyll a concentration (µg/L) predicted from CV
		Region 5--continued			
357	Wapato	Chelan	61	4.2	6.0
358	Booher	Okanogan	58	-	-
359	Carp	Klickitat	57	-	-
360	Whitestone	Okanogan	57	-	-
361	Twin, Little	do.	56	-	-
362	Palmer	do.	56	8.4	5.6
363	Spearfish	Klickitat	56	-	-
364	Sanpoil	Ferry	56	-	-
365	Lemanasky	Okanogan	56	-	-
366	Wannacut	do.	55	0.7	5.6
367	Osoyoos	do.	52	-	-
368	Rat	do.	50	-	-
369	Alta	do.	49	5.7	5.1
370	Green	do.	45	-	-
371	Blue (37N-25E-22)	do.	44	-	-
372	Curlew	Ferry	44	-	-
373	Spectacle	Okanogan	43	7.1	4.7
374	Bonaparte	do.	40	-	-
375	Pearrygin	do.	39	12	4.4
376	Moccasin	do.	39	-	-
377	Duck (Bide-a-Wee)	do.	39	-	-
378	Spring-Hill (Black)	Chelan	37	-	-
379	Roses (Alkali)	do.	37	-	-
380	Fish	do.	37	4.4	4.3
381	Conconully (Salmon)	Okanogan	36	-	-
382	Conconully (35N-25E-18)	do.	31	4.4	3.8
383	Wheeler, Upper	Chelan	30	-	-
384	Twin, Big	Okanogan	29	2.9	3.6
385	Cle Elum	Kittitas	26	-	-
386	Antilon	Chelan	23	-	-
387	Patterson	Okanogan	21	2.8	2.8
388	Kachess	Kittitas	19	-	-
389	Cooper	do.	14	-	-
390	Snow, Upper	Chelan	13	-	-
391	Easton	Kittitas	11	-	-
392	Keechelus	do.	9	-	-
393	Wenatchee	Chelan	8	1.3	1.5
394	Eightmile	do.	5	-	-
395	Chiwaukum	do.	5	-	-
396	Lost	Kittitas	5	-	-
397	Loch Eileen	Chelan	4	-	-
398	Klonaqua, Upper	do.	4	-	-
399	Klonaqua, Lower	do.	2	-	-
		Region 6			
400	Stallard	Douglas	1259	-	-
401	Nigger	Adams	951	-	-
402	Peterson	Lincoln	819	-	-
403	Unnamed (22N-29E-26)	Grant	651	-	-
404	Soap, Little	do.	650	-	-
405	Coffee	do.	623	-	-
406	Bailie	Franklin	621	-	-
407	Curlew	Walla Walla	613	-	-
408	Goetz	Lincoln	576	-	-
409	Unnamed (29N-29E-22)	Douglas	574	-	-
410	Black	Grant	570	-	-
411	McElroy	Adams	563	-	-
412	Grimes	Douglas	558	-	-
413	Unnamed (25N-39E-9)	Lincoln	544	-	-
414	Alkali (Pines)	Adams	506	-	-
415	Sullivan	Lincoln	500	-	-
416	Wilson	Douglas	500	-	-
417	Webley (Wooley)	Lincoln	481	-	-
418	Unnamed (29N-27E-20)	Douglas	460	-	-
419	Sheep	Whitman	444	-	-
420	Unnamed (13N-29E-5)	Franklin	415	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll *a* concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll *a* concentration (µg/L)	
				measured	predicted from CV
		Region 6--continued			
421	"H"	Lincoln	400	-	-
422	Unnamed (19N-40E-23)	Whitman	369	-	-
423	Unnamed (14N-30E-33)	Franklin	361	-	-
424	Folsom	Whitman	351	-	-
425	Owl	Adams	328	-	-
426	Broken Rock	Grant	317	-	-
427	Rodeo	Adams	316	-	-
428	Haynes	Douglas	315	-	-
429	Florence	Lincoln	310	-	-
430	Murphy	Douglas	308	-	-
431	Bergeau	Lincoln	305	-	-
432	Elbow	Douglas	302	-	-
433	Phillips	Lincoln	299	-	-
434	Swanson (25N-34E-32)	do.	297	-	-
435	Long (28N-30E-25)	Grant	279	-	-
436	Clark	Franklin	272	-	-
437	Crescent Bay	Grant	268	-	-
438	Twelve-mile Slough	Adams	267	-	-
439	Soap	Grant	261	-	-
440	Tavares	Lincoln	258	-	-
441	Stan Coffin	Grant	256	-	-
442	Palm	Adams	254	-	-
443	Meadow	Lincoln	251	-	-
444	Bobs (Tule)	do.	250	-	-
445	Hallin	Adams	241	-	-
446	Unnamed (16N-29E-29)	do.	237	-	-
447	Neves	Lincoln	234	-	-
448	Unnamed (20N-28E-10)	Grant	227	-	-
449	Unnamed (20N-28E-4)	do.	219	-	-
450	Swanson (25N-34E-33)	Lincoln	218	-	-
451	Unnamed (29N-27E-17)	Douglas	218	-	-
452	Wall	Lincoln	214	-	-
453	Whittaker	do.	213	-	-
454	Cormana	do.	206	-	-
455	Unnamed (25N-35E-9)	do.	201	-	-
456	Ames	do.	199	-	-
457	Texas	Whitman	195	-	-
458	Alkali (Miller)	do.	194	-	-
459	Cow	Adams	191	-	-
460	Unnamed (19N-38E-15)	do.	186	-	-
461	Pacific	Lincoln	186	-	-
462	Smith	Douglas	183	-	-
463	Lavista	Whitman	179	-	-
464	Mesa	Franklin	177	-	-
465	Finnel	Adams	177	-	-
466	Unnamed (20N-39E-16)	Whitman	176	-	-
467	Willow, South	Grant	169	-	-
468	Unnamed (24N-35E-4)	Lincoln	168	-	-
469	Twin, Lower	do.	167	-	-
470	Wills	do.	166	-	-
471	"J" Line	Walla Walla	164	-	-
472	Rock	Whitman	161	-	-
473	Unnamed (25N-39E-15)	Lincoln	156	-	-
474	Willow	Grant	153	-	-
475	Long	Franklin	152	-	-
476	Frenchman Hills	Grant	150	-	-
477	Nunnally	do.	149	-	-
478	Green	Adams	144	-	-
479	Sprague	do.	142	20	11
480	Fourth of July	do.	138	-	-
481	Unnamed (13N-29E-15)	Franklin	138	-	-
482	Snyder	Whitman	138	-	-
483	Pot Holes	Grant	137	-	-
484	Winchester Wasteway	do.	134	-	-
485	Winchester Wasteway Extension	do.	134	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L)	
				measured	predicted from CV
		Region 6--continued			
486	Downs	Lincoln	131	-	-
487	Brook (Stratford)	Grant	126	-	-
488	Jameson	Douglas	124	13	9.6
489	Crooked Knee	Whitman	124	-	-
490	Unnamed (24N-34E-22)	Lincoln	121	-	-
491	Lenore	Grant	121	-	-
492	Jameson Pothole	Douglas	120	-	-
493	Kahlotus	Franklin	119	-	-
494	Windmill	Grant	119	-	-
495	Washtucna	Franklin	114	-	-
496	Linda	Adams	113	-	-
497	Unnamed (12N-30E-20)	Franklin	109	-	-
498	Browns	Lincoln	109	-	-
499	Ephrata	Grant	107	-	-
500	Unnamed (21N-39E-26)	Lincoln	106	-	-
501	Ancient	Grant	105	-	-
502	Moses	do.	103	-	-
503	Scootney	Franklin	98	-	-
504	Unnamed (14N-30E-34)	do.	97	-	-
505	Unnamed (14N-30E-14)	do.	97	-	-
506	Flat	Grant	97	-	-
507	Coffee Pot	Lincoln	97	34	8.2
508	Unnamed (14N-39E-11)	Franklin	95	-	-
509	Yellepit	Benton	93	-	-
510	Windmill, North	Grant	88	-	-
511	Warden	do.	87	9.5	7.6
512	Weir	Franklin	87	-	-
513	Deer (Deer Springs)	Lincoln	85	-	-
514	Mound	Benton	80	-	-
515	Twin, Upper	Lincoln	79	-	-
516	Twin, Upper	do.	79	-	-
517	Canal	Grant	75	16	6.8
518	Quincy	do.	70	-	-
519	Black	Adams	70	-	-
520	Sand	Grant	69	-	-
521	Bonnie	Whitman	69	-	-
522	Soda	Grant	66	13	6.3
523	Fishtrap	Lincoln	65	-	-
524	Goose, Lower	Grant	65	-	-
525	Eagle	Franklin	64	-	-
526	Susan	Grant	63	-	-
527	Heart	do.	61	4.3	5.9
528	Alkali	do.	61	-	-
529	"T"	Franklin	59	-	-
530	Thread	Adams	58	-	-
531	Corral	Grant	56	-	-
532	Long (17N-29E-32)	do.	51	-	-
533	Blue	do.	50	-	-
534	Dry Falls	do.	46	-	-
535	Goose, Upper	do.	46	3.6	4.9
536	Burke	do.	42	-	-
537	Billy Clapp	do.	42	-	-
538	Banks	do.	41	-	-
539	Park	do.	39	-	-
540	Evergreen	do.	34	-	-
541	Dusty	do.	33	-	-
542	Deep	do.	10	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L) measured	predicted from CV
		Region 7			
543	Unnamed (22N-41E-27)	Spokane	718	-	-
544	Woods	do.	566	-	-
545	Medical, West	do.	470	-	-
546	Queen Lucas	do.	352	-	-
547	Otter	do.	340	-	-
548	Alkali	do.	339	-	-
549	Feustal	do.	322	-	-
550	Amber	do.	303	4.4	18
551	Ring	do.	286	-	-
552	Unnamed (22N-40E-6)	do.	245	-	-
553	Medical	do.	238	19	15
554	Philleo	do.	200	-	-
555	Mason, Little	do.	163	-	-
556	Mason	do.	147	-	-
557	Lost	Pend Oreille	133	-	-
558	Shelley	Spokane	129	-	-
559	Chapman	do.	114	-	-
560	Newbell	Stevens	109	-	-
561	Horseshoe	Spokane	108	-	-
562	Silver	do.	102	10	8.4
563	Frater	Pend Oreille	99	3.7	8.3
564	Calispell	do.	98	-	-
565	Newman	Spokane	91	-	-
566	Unnamed (22N-41E-32)	do.	91	-	-
567	Bear (Kuester)	do.	85	-	-
568	Ryan	Stevens	85	-	-
569	Perkins	do.	85	-	-
570	Thomas	do.	83	3.8	7.3
571	Hog (Hog Canyon)	Spokane	83	-	-
572	Dilly	Stevens	76	-	-
573	Clear	Spokane	75	9.7	6.9
574	Williams	Stevens	68	-	-
575	Fish	Spokane	65	-	-
576	Kent Meadows	Pend Oreille	63	-	-
577	Gillette	Stevens	62	5.1	6.0
578	Eloika	Spokane	61	-	-
579	Hatch	Stevens	57	-	-
580	Horseshoe	Pend Oreille	57	-	-
581	Boundry	do.	57	-	-
582	Cedar	Stevens	56	-	-
583	Knight	Spokane	56	-	-
584	Falls, Little	Stevens	55	-	-
585	Twin (Spruce)	do.	55	-	-
586	Diamond	Pend Oreille	54	3.1	5.4
587	Mill	do.	54	-	-
588	Parker	do.	53	-	-
589	Heritage	Stevens	53	4.2	5.4
590	Badger	Spokane	52	5.7	5.3
591	Fan	Pend Oreille	47	-	-
592	Trout	do.	45	-	-
593	Leo	Stevens	43	6.8	4.7
594	Davis	Pend Oreille	41	-	-
595	Sacheen	do.	40	-	-
596	White Mud	Stevens	40	-	-
597	Williams	Spokane	40	3.7	4.5
598	Sherry	Stevens	37	4.3	4.2
599	Fourmile (Rainbow)	do.	36	-	-
600	Waitts	do.	35	-	-
601	Deer	do.	33	2.1	3.9
602	Jumpoff Joe	do.	31	-	-
603	Liberty	Spokane	31	-	-
604	Black	Stevens	29	-	-
605	Nile	Pend Oreille	29	-	-
606	Pierre	Stevens	27	9.2	3.4
607	Yocum	Pend Oreille	27	-	-
608	Skookum, South	do.	27	-	-

TABLE 5.--Preliminary water-quality characteristic values (CV) for 617 lakes and chlorophyll a concentration predicted from CV for 100 lakes in the State of Washington--continued

Lake number	Lake name	County	CV*	Seasonal average chlorophyll a concentration (µg/L)	
				measured	predicted from CV
		Region 7--continued			
609	Clark	Stevens	25	-	-
610	Power	Pend Oreille	25	-	-
611	Nelson	Stevens	21	-	-
612	Deep	do.	17	-	-
613	Marshall	Pend Oreille	15	-	-
614	Chain	do.	14	-	-
615	Browns	do.	10	-	-
616	Kings	do.	9	-	-
617	Scotchman	do.	8	-	-

*Higher CV's correspond to increasing total organic nitrogen and total phosphorus concentrations and decreasing Secchi-disc values.