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|---|---|
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| Impoundments | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Methods for predicting eutrophication and related water quality effects are required to aid in the design and operation of U. S. Army Corps of Engineers (CE) reservoirs in ways compatible with water quality and use objectives. In many instances, simple empirical techniques are favored over complex simulation models because they require less extensive data. This report compiles existing empirical techniques and model structures from the literature

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20. ABSTRACT (Continued).

and evaluates them using an extensive data base describing 299 CE reservoirs. Models evaluated were designed to predict phosphorus and chlorophyll-a concentration, transparency, and hypolimnetic oxygen depletion.

Models are tested herein with both original and optimized parameter estimates. Residuals (errors) and parameter stability are analyzed to assess model generality and regional influences. The needs for restructuring models to improve generality and/or reduce prediction error are outlined.

A model network relating reservoir-average water quality conditions to external loadings is presented and tested using independent data sets compiled from the literature.

Empirical eutrophication models, it is found, can be adapted for use for reservoirs, with expected errors which are similar in magnitude to those reported in global studies of natural lakes.

The first report in this series, Technical Report E-81-9, is entitled "Empirical Methods for Predicting Eutrophication in Impoundments; Report 1, Phase I: Data Base Development."

# PREFACE

This report was prepared by Dr. William W. Walker, Jr., Environmental Engineer, Concord, Mass., for the U. S. Army Engineer Waterways Experiment Station (WES) under Contract No. DACW39-78-C-0053 dated 7 June 1978. It is one of a series of reports, the first of which was entitled "Empirical Methods for Predicting Eutrophication in Impoundments; Report 1, Phase I: Data Base Development." The study forms part of the Environmental and Water Quality Operational Studies (EWQOS) Work Unit IE, Simplified Techniques for Predicting Reservoir Water Quality and Eutrophication Potential. The EWQOS Program is sponsored by the Office, Chief of Engineers, and is assigned to the WES under the purview of the Environmental Laboratory (EL).

The study was conducted under the direct WES supervision of Dr. Robert H. Kennedy and the general supervision of Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division, and Dr. John Harrison, Chief, EL. Dr. Jerry Mahloch was the EWQOS Program Manager.

The Commander and Director of WES during this study was COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.

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## CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENT

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| acres | 0.4047 | hectares |
| acre feet | 1233.489 | cubic metres |
| cubic feet per second | 0.028317 | cubic metres per second |
| feet | 0.3048 | metres |
| square miles (U. S. statute) | 2.5899 | square kilometres |

# EMPIRICAL METHODS FOR PREDICTING EUTROPHICATION IN IMPOUNDMENTS

## PART I: INTRODUCTION

1. Eutrophication has several important effects on impoundment water quality and potential uses. There are direct causal linkages between algal growth in reservoirs and water transparency, organic matter content, and hypolimnetic oxygen concentrations. The loss of oxygen from the bottom waters of stratified reservoirs is partially attributed to the respiration and decay of algae which have settled out of the surface layers. Oxygen depletion promotes the recycling of nutrients, iron, manganese, and trace metals from bottom sediments, limits biological habitat, and is conducive to the formation of hydrogen sulfide, methane, and other reduced organic compounds. These processes may have direct implications for potential uses of the water in and downstream of the impoundment, including recreation, water supply, and wildlife propagation. Methods for predicting eutrophication and related water quality effects are required to aid in the design and operation of reservoirs in ways which are consistent with water quality and use objectives.

2. Complex simulation models have been developed for this purpose, based upon hydrodynamic and ecological theory. While appropriate in some management situations, their roles have been limited primarily to research because of extensive data requirements and the subjective decisions and expertise required for calibration in each application. They are the only alternatives for applications requiring high spatial and temporal resolution and/or simulation of cause-effect relationships which cannot be represented using simpler models. The complexity of these models does not guarantee, however, that they are more accurate for predicting average water quality conditions than are the simpler models discussed below.

3. Simpler, empirical techniques, derived largely from the original concepts of Vollenwieder (1968), have much lower data requirements, principally because they deal with average conditions and do not (or should not) have to be recalibrated and retested in each application. These are based upon the annual phosphorus balance of the

impoundment and empirical relationships among average phosphorus, chlorophyll, transparency, and oxygen depletion measurements derived from groups of lakes and/or reservoirs. Vollenweider's original work and most of the numerous modifications which have followed in the literature have been based upon data from natural lakes. When data from collections of lakes and reservoirs are compared, significant differences have been found in many factors which may influence nutrient and algal dynamics and which are not explicitly accounted for in these models, including hydrodynamics, sediment accumulation rate, region, and certain morphometric characteristics (such as shoreline development and length/width ratio) (Thornton, et al., 1980). Since these methods are essentially "interpolation" schemes, there are possible needs for recalibration and/or restructuring for use for reservoirs.

4. These needs are supported by analysis of data from the U. S. Environmental Protection Agency's (EPA) National Eutrophication Survey (NES) indicating that, on the average, Corps of Engineers (CE) reservoirs have higher normalized phosphorus loadings, but lower average concentrations of phosphorus and chlorophyll, as compared with natural lakes (Walker, 1981). Regional analysis shows, however, that CE reservoirs tend to be located, on the average, at latitudes where there are relatively few natural lakes (Walker, 1980a). Thus, it is difficult to distinguish the potential effects of impoundment type from those of region. Canfield and Bachman (1981) also found statistically significant differences between lakes and reservoirs in the parameters of a model for predicting phosphorus sedimentation rate and suggested that the differences could be attributed to "qualitative differences in the phosphorus inputs related to geographic location," specifically referring to the fact that the populations of reservoirs examined were, on the average, located in regions where particulate phosphorus loadings were more important.

5. Canfield and Bachman also suggested that lakes and reservoirs "represent a range of limnological conditions and should not be treated as distinctly different lake types." While it seems feasible that a single model or set of models could be devised for use in both lakes and reservoirs, most of those existing consider only total phosphorus

loading, mean depth, and hydraulic residence time as independent variables, and do not account for variations in particulate phosphorus or other important factors related to region and/or to impoundment type. Structural modifications would have to be made and tested to account for these additional factors if one model is to be used over the "continuum of limnological conditions" discussed by Canfield and Bachman without risk of bias at one end or the other.

6. Regardless of lake/reservoir differences, the limnological literature presents a wide range of empirical eutrophication models, some of which may be of use in reservoir management. The objective of the research described in this report is to identify those methods which seem appropriate for use in reservoirs operated by the U.S. Army Corps of Engineers. An extensive data base describing 299 CE impoundments has been compiled under Phase I of this study and used here as the primary source of information (Walker, 1981). The data base (Figure 1) includes the morphometric, hydrologic, and water quality information required for model testing. Table 1 lists 108 CE reservoirs which were sampled by the EPA's National Eutrophication Survey between 1972 and 1975. Because of relatively stringent data requirements for estimation of nutrient balances, these projects represent the primary focus of this study, although data from other projects are also used in testing models which do not require nutrient loading estimates.

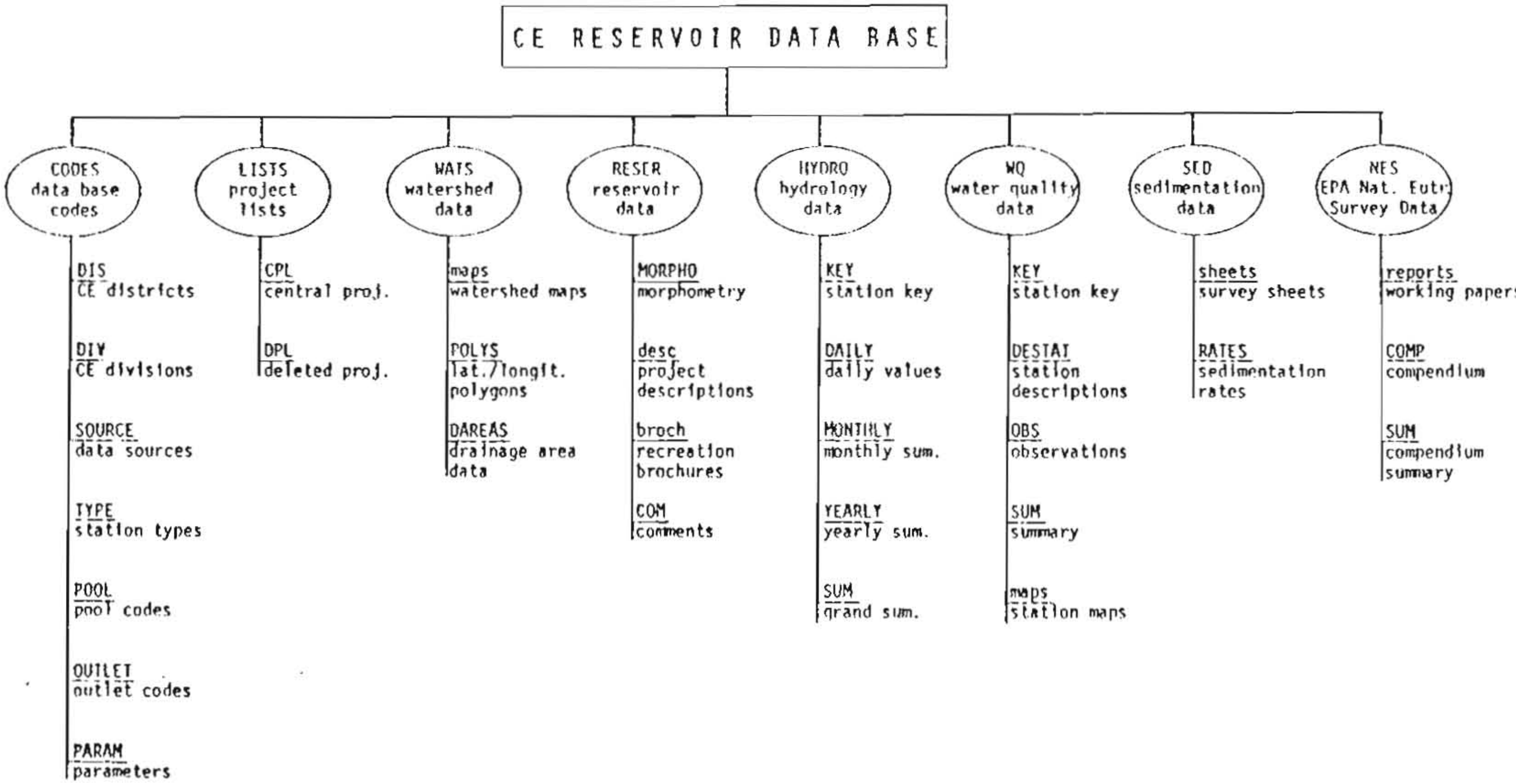
7. Scope is limited to evaluation of existing model structures compiled from the literature and summarized in Appendix E. The models are designed to predict the following eutrophication-related water quality characteristics:

- a. phosphorus concentration
- b. chlorophyll-a concentration
- c. transparency
- d. hypolimnetic oxygen depletion

This work does not cover classification systems, index systems, or any of the various methods for predicting "trophic state", definitions of which are variable, subjective, misleading, and of questionable

Figure 1

Elements and Structure of the CE Reservoir Data Base



| | | | |
|---|---|---|---|
| 02 | NEW YORK | 176 | WATERBURY |
| 03 | PHILADELPHIA | 307 | BELTZVILLE |
| 04 | BALTIMORE | 312 | F J SAYERS (BLA |
| 06 | WILMINGTON | 372 | JOHN H KERR |
| 08 | SAVANNAH | 074 | CLARK HILL |
| 08 | SAVANNAH | 330 | HARTWELL |
| 10 | MOBILE | 003 | HOLT |
| 10 | MOBILE | 069 | ALLATOONA |
| 10 | MOBILE | 071 | SEMINOLE (WOODR |
| 10 | MOBILE | 072 | WALTER F GEORGE |
| 10 | MOBILE | 076 | SIDNEY LANIER |
| 10 | MOBILE | 411 | BANKHEAD |
| 14 | ROCK ISLAND | 099 | RED ROCK |
| 15 | ST PAUL | 178 | GULL |
| 15 | ST PAUL | 181 | LEECH |
| 15 | ST PAUL | 237 | ASHTABULA (BALD |
| 16 | PITTSBURGH | 243 | BERLIN |
| 16 | PITTSBURGH | 254 | MOSQUITO CREEK |
| 16 | PITTSBURGH | 317 | SHENANGO RIVER |
| 16 | PITTSBURGH | 328 | ALLEGHENY (KINZ |
| 16 | PITTSBURGH | 393 | TYGART |
| 17 | HUNTINGTON | 241 | ATWOOD |
| 17 | HUNTINGTON | 242 | BEACH CITY |
| 17 | HUNTINGTON | 245 | CHARLES MILL |
| 17 | HUNTINGTON | 247 | DEER CREEK |
| 17 | HUNTINGTON | 248 | DELAWARE |
| 17 | HUNTINGTON | 249 | DILLON |
| 17 | HUNTINGTON | 256 | PLEASANT HILL |
| 17 | HUNTINGTON | 258 | TAPPAN |
| 17 | HUNTINGTON | 373 | JOHN W FLANNAGA |
| 17 | HUNTINGTON | 389 | BLUESTONE |
| 17 | HUNTINGTON | 391 | SUMMERSVILLE |
| 18 | LOUISVILLE | 092 | MISSISSINEWA |
| 18 | LOUISVILLE | 093 | MONROE |
| 18 | LOUISVILLE | 120 | BARREN RIVER |
| 19 | NASHVILLE | 119 | BARKLEY |
| 19 | NASHVILLE | 122 | CUMBERLAND (WOL |
| 19 | NASHVILLE | 338 | CHEATHAM |
| 19 | NASHVILLE | 340 | J PERCY PRIEST |
| 19 | NASHVILLE | 342 | OLD HICKORY |
| 19 | NASHVILLE | 343 | DALE HOLLOW |
| 20 | ST LOUIS | 081 | CARLYLE |
| 20 | ST LOUIS | 087 | SHELBYVILLE |
| 20 | ST LOUIS | 088 | REND |
| 21 | MEMPHIS | 196 | WAPPAPELLO |
| 22 | VICKSBURG | 014 | DE GRAY |
| 22 | VICKSBURG | 019 | OUACHITA (BLAKE |
| 22 | VICKSBURG | 188 | ARKABUTLA |
| 22 | VICKSBURG | 189 | ENID |
| 22 | VICKSBURG | 190 | GRENADA |
| 22 | VICKSBURG | 192 | SARDIS |
| 23 | NEW ORLEANS | 352 | LAKE OF THE PIN |
| 23 | NEW ORLEANS | 353 | TEXARKANA(WRIGH |
| 23 | NEW ORLEANS | 413 | CADDO |

| | | | |
|---|---|---|---|
| 24 | LITTLE ROCK | 011 | BEAVER |
| 24 | LITTLE ROCK | 012 | BLUE MOUNTAIN |
| 24 | LITTLE ROCK | 013 | BULL SHOALS |
| 24 | LITTLE ROCK | 016 | GREERS FERRY |
| 24 | LITTLE ROCK | 021 | NIMROD |
| 24 | LITTLE ROCK | 022 | NORFOLK |
| 24 | LITTLE ROCK | 193 | CLEARWATER |
| 24 | LITTLE ROCK | 200 | TABLE ROCK |
| 25 | TULSA | 020 | MILLWOOD |
| 25 | TULSA | 102 | COUNCIL GROVE |
| 25 | TULSA | 103 | ELK CITY |
| 25 | TULSA | 104 | FALL RIVER |
| 25 | TULSA | 105 | JOHN REDMOND |
| 25 | TULSA | 107 | MARION |
| 25 | TULSA | 112 | TORONTO |
| 25 | TULSA | 267 | EUFAULA |
| 25 | TULSA | 269 | FORT SUPPLY |
| 25 | TULSA | 273 | KEYSTONE |
| 25 | TULSA | 275 | OOLOGAH |
| 25 | TULSA | 278 | TENKILLER FERRY |
| 25 | TULSA | 281 | WISTER |
| 25 | TULSA | 348 | TEXOMA (DENNISO |
| 25 | TULSA | 370 | KEMP |
| 26 | FORT WORTH | 345 | BELTON(BELL) |
| 26 | FORT WORTH | 347 | CANYON |
| 26 | FORT WORTH | 354 | LAVON |
| 26 | FORT WORTH | 355 | LEWISVILLE(GARZ |
| 26 | FORT WORTH | 359 | SAM RAYBURN (MC |
| 26 | FORT WORTH | 360 | O C FISHER (SAN |
| 26 | FORT WORTH | 361 | SOMERVILLE |
| 26 | FORT WORTH | 362 | STILLHOUSE HOLL |
| 26 | FORT WORTH | 364 | WHITNEY |
| 28 | ALBUQUERQUE | 219 | CONCHAS |
| 29 | KANSAS CITY | 100 | RATHBUN |
| 29 | KANSAS CITY | 106 | KANOPOLIS |
| 29 | KANSAS CITY | 108 | MILFORD |
| 29 | KANSAS CITY | 109 | MELVERN |
| 29 | KANSAS CITY | 110 | PERRY |
| 29 | KANSAS CITY | 111 | POMONA |
| 29 | KANSAS CITY | 113 | TUTTLE CREEK |
| 29 | KANSAS CITY | 114 | WILSON |
| 29 | KANSAS CITY | 194 | POMME DE TERRE |
| 29 | KANSAS CITY | 195 | STOCKTON |
| 29 | KANSAS CITY | 207 | HARLAN COUNTY |
| 30 | OMAHA | 064 | CHERRY CREEK |
| 30 | OMAHA | 215 | PAWNEE |
| 30 | OMAHA | 217 | BRANCHED OAK |
| 30 | OMAHA | 235 | SAKAKAWEA(GARRI |
| 31 | WALLA WALLA | 077 | DWORSHAK |
| 32 | SEATTLE | 204 | KOOKANUSA(LIBBY |
| 33 | PORTLAND | 300 | HILLS CREEK |
| 34 | SACRAMENTO | 048 | NEW DON PEDRO |
| 35 | SAN FRANCISCO | 029 | MENDOCINO |
| 35 | SAN FRANCISCO | 039 | SANTA MARGARITA |

applicability (Maloney, 1979, Taylor et. al, 1980). Each model is tested both with original and with optimized parameter estimates. Residuals (errors) and parameter stability are analyzed to assess model generality and regional influences. Based upon the results of model testing, needs for restructuring to improve model generality and/or reduce prediction error are outlined herein; these needs are being pursued in current research.

8. The report is organized in nine sections. Parts II, III, and IV describe data base refiniments, data reduction procedures, and model testing methods, respectively. Part V evaluates "internal models", or relationships among water quality measurements within the reservoirs. Part VI tests models which relate water quality to external phosphorus loading, morphometric variables, and hydrologic variables. Part VII evaluates methods for predicting hypolimnetic oxygen depletion. Key results for each model category are summarized at the ends of Parts V, VI, and VII, respectively. Part VIII summarizes and extends the results of previous sections in the form of a model "network" relating reservoir-average water quality conditions to external nutrient loadings. The network is tested using independent data sets compiled from the literature. Multivariate and error analyses also provide additional insights into model structure and adequacy. Part IX outlines some general conclusions and recommendations. Appendices A-D contain supplementary tables, including the data sets used in testing and error statistics by model category. A compilation of models derived from a literature survey is presented in Appendix E. Appendix F lists and displays the independent data sets used in testing the network presented in Part VIII.

# PART II: DATA BASE REFINEMENTS

## Introduction

9. The CE reservoir data base developed previously (Walker, 1981) has been augmented with additional morphometric and hydrologic data obtained from various sources, including CE District offices, project brochures, and USGS District offices. Because these sources are relatively diffuse, the additional data compilation has been directed specifically at reservoirs, time periods, and characteristics which were not available from centralized sources, such as WATSTORE. The objective has been to fill in missing hydrologic and morphometric information for projects and time periods with adequate water quality data to support model testing. Some additional data base refinements have been made, as discussed below.

## Morphometric Data

10. A review of the morphometric data file indicated that pool and shoreline length data were missing for 57 and 13 projects, respectively, out of 108 projects sampled by the EPA/NES. Additional pool and shoreline length data have been compiled and added to the existing morphometric data file. This effort has relied primarily upon District contacts and project brochures. The final tally includes length data and shoreline length data for 101 and 100 EPA/NES projects, respectively. A few additional modifications have also been made to the morphometric data file in response to District feedback. The modified file contains 4100 records referenced to project and elevation, with pool length data for 259 projects and shoreline length data for 234 projects, out of a total of 299 reservoirs in the data base.

11. Reservoirs with significant pool areas extending up secondary tributaries have potentially greater spatial variations in water quality than those with simpler morphometry. These variations may, in turn, influence loading model performance, especially if nutrient

concentrations in the secondary tributary inflow are significantly different from those in the major tributary inflow and advection dominates over dispersion. To provide a basis for assessing the effects of morphometric complexity on loading model performance, each reservoir has been classified according to the number of major tributary arms. This work has been based upon the project map file. Note that the classification system is based upon the number of reservoir arms, not upon the number of tributaries, i.e., the reservoir surface must extend for a significant distance up a secondary tributary in order for it to be included in the classification.

## Hydrologic Data

12. In attempting to formulate hydrologic balances for 108 projects sampled by the EPA/NES, data on reservoir discharge and elevation/volume were found to be lacking in 8 projects and 42 projects, respectively. An additional 19,000 daily or monthly records of pool elevation and discharge have been obtained from CE District offices. Daily records have been summarized on a monthly basis, including mean flows, mean elevations, and month-end elevations. Data requests have also been filed with 16 USGS District offices, which have provided an additional 1008 monthly records. After merging the new information with the existing data base, project coverage has increased substantially. During the periods of tributary sampling by the EPA/NES, the data base contains monthly discharge records for all 108 projects and elevation/contents records for 107 projects. During the hydrologic year which brackets the period of pool water quality sampling by the EPA/NES in each project, monthly discharge records are available for 103 projects and elevation/contents records, for 107 projects.

13. The drainage area file has been updated to include information on total, water-contributing, and sediment-contributing areas for 287, 280, and 256 projects, respectively. USGS monitoring station descriptions have been reviewed to estimate water-contributing areas. Sediment-contributing (or direct) drainage has been estimated from

sediment survey sheets and from drainage basin maps, by identifying upstream impoundments and subtracting their water-contributing drainage areas and the project surface area from the project water-contributing drainage area.

## Water Quality Data

14. Spatial gradients in water quality are important in many reservoirs. A preliminary classification system which permits sorting of water quality stations in downstream order within each major tribuary arm has also been developed and coded. It is based upon the water quality station map file, station descriptions, and latitude/longitude coordinates. Sort keys have been added to the existing water quality station key file, but additional verification of the coding system is needed. This system will be useful in future studies of spatial gradients and their controlling factors, but has not been applied in the model testing completed thus far.

## PART III: DATA REDUCTION AND SUMMARY

### Morphometric Data

15. In calculating water and nutrient balances, the elevation/volume/area points listed in the morphometric file have been used to estimate changes in volume or area as functions of elevation and vice-versa. To facilitate these calculations and other uses of the morphometric file, elevation/volume/area data points contained in the data file have been summarized as polynomial functions of the general form:

$$LZ^{*} = \ln(Z) = \ln(E - E0) \qquad (1)$$

$$\log(V) = C1 + C2\ LZ + C3\ LZ^{2} + C4\ LZ^{3} + C5\ LZ^{4} \qquad (2)$$

where,

ln = base-e logarithm
Z = total depth (feet)
V = total volume (acre-feet)
E = elevation (feet above mean sea level)
E0 = elevation at zero volume (feet above msl)
C1 - C5 = polynomial coefficients

These curves are used essentially for interpolation and smoothing of the elevation/volume profile. While previous work (Walker, 1981) indicated that a third-degree equation generally provided an adequate fit, adding a fourth degree significantly improved the fit of many of the volume/elevation curves in the current version of the morphometric file. Differentiation of the volume polynomial can be used to estimate area at any elevation:

$$A_{s} = [C2 + 2\ C3\ LZ + 3\ C4\ LZ^{2} + 4\ C5\ LZ^{3}]\ V\ /\ (E - E0) \qquad (3)$$

where,

$A_s$ = surface area at elevation E (acres)

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* For convenience, symbols and unusual abbreviations are listed and defined in the Notation, Appendix G.

A weighted polynomial regression has been done on logarithmic scales to estimate the parameters C1 - C5 for each reservoir. Since only volume/elevation points have been used in the regressions, the consistency of a given morphometric curve can be checked by comparing reported and estimated surface areas. To reflect the relative accuracy and importance of morphometric data points at higher elevations in a given reservoir and to offset the greater weights inherently given to lower elevation points in logarithmic regressions, points have been weighted by the square of the total depth (E - E0) in performing the regressions. Lower-order polynomial regressions have been used for reservoirs with an insufficient number of data points to justify a fourth-order fit. Generally, the curve fitting process has been iterative, with reference to residuals plots to assess fit adequacy for each reservoir.

16. For reservoirs without reported E0 values, a single-term power function has been fit to the first two complete sets of elevation, area, volume points in order to estimate E0. According to this model, mean depth is proportional to total depth:

$$Y = (V1/A1) / (V2/A2) = (E1 - E0) / (E2 - E0) \tag{4}$$

$$E0 = (E1 - Y\ E2)/(1 - Y) \tag{5}$$

where,

E1,A1,V1 = elevation, area, and volume at first level

E2,A2,V2 = elevation, area, and volume at second level

Y = mean depth ratio

In a few cases, there were insufficient data to apply this estimation procedure and E0 values have been estimated based upon maximum reservoir depths and surface elevations reported by Leidy and Jenkins (1977).

17. For five reservoirs in St. Paul District (Lac Qui Parle (179), Gull(178), Pine River(187), Winnibigoshish(186), and Pokegama(184)), useable volumes above specified elevations are listed in the morphometric file. To estimate dead storage for these projects, total volume development has been assumed to follow a single-term power

function in total depth. The following equation has been solved for VD:

$$[(VU1+VD)/A1] \; / \; [(VU2+VD)/A2] = (E1-E0) \; / \; (E2-E0) \qquad (6)$$

where,

VU1 = useable volume below first listed elevation point

VU2 = useable volume below second listed elevation point

VD = dead storage (acre-feet)

Estimated dead storage values have been added to the reported useable volumes prior to estimating the coefficients of the morphometric curves.

18. To test the adequacy of each fit, plots of observed and estimated volume and area profiles have been generated for each reservoir. These have been assembled in a notebook for future reference by data-base users. Examination of these plots has provided a basis for refining the fits, where necessary, by (1) identifying errant values in the morphometric file; (2) increasing or decreasing the degree of the polynomial; or (3) supplementing the morphometric file with additional volume/elevation points derived from USGS Water Resources Data Reports (USGS,1977).

19. A file describing these curves has been created containing the following information:

- a. district code
- b. reservoir code
- c. minimum elevation used in regression
- d. maximum elevation used in regression
- e. zero-volume elevation
- f. coefficients (C1 - C5)

In applying these functions to estimate volume or area at any elevation, tests should be performed to insure that the elevation is within the range used in the regression. A listing of estimated morphometric curve parameters is given in Appendix A for the 285 projects with sufficient data.

20. Accuracies of these curves have been assessed by computing the

following statistics for three types of applications:

- a. estimating volume from elevation: $|V - V'|/V'$
- b. estimating area from elevation: $|A_s - A_s'|/A_s'$
- c. estimating elevation from volume: $|E - E'|$

where,

$'$ = superscript denoting estimated value

$|X-X'|$ = absolute value of $X-X'$

Since the polynomials cannot be solved explicitly for E as a function of V, an iterative procedure is used to estimate elevation consistent with a given total volume. The third type of application has been included because elevations must be estimated from total volumes in completing the hydrologic data file, which contains many USGS stations with volume but without elevation data.

21. Median estimation errors have been calculated for each project and type of application and summarized in Table 2. At the 50th percentile, estimation errors amount to 1.0% for total volume, 3.2% for surface area, and .21 feet for elevation. At the 95% percentile, the errors are 5.3%, 13.3%, and .99 feet, respectively. The relative inaccuracy of the area estimation is attributed to the fact that reported areas were not used in estimating the coefficients and some inconsistencies in the area and volume data may remain in the morphometric data file. Percentage estimation errors generally decrease at higher elevations in a given reservoir, owing to the greater accuaracy of morphometric information at elevations nearer the surface.

22. Table 3 lists twelve projects included in the data base but without sufficient data for estimation of morphometric curves. These are primarily run-of-the-river impoundments or locks and dams, which have not been used in model testing because of water quality data limitations. Future refinements of the data base could involve compilation of additional data for these projects and for others with relatively limited morphometric information. Available data are generally adequate, however, for the purposes of this research.

Table 2

Summary of Morphometric Curve Error Statistics
(Within-Project Median Absolute Deviations)

| Variable: | Volume | Area | Elevation | |
|---|---|---|---|---|
| Statistic: | $\|V-V'\|/V'$ | $\|A_S-A'_S\|/A'_S$ | $\|E-E'\|$ | |
| Units: | - | - | feet | |
| 100%* | .095 | .434 | 2.95 | maximum |
| 95% | .053 | .133 | 0.99 | |
| 90% | .037 | .087 | 0.77 | |
| 75% | .019 | .057 | 0.44 | upper quartile |
| 50% | .0098 | .032 | 0.21 | median |
| 25% | .0042 | .015 | 0.081 | lower quartile |
| 10% | .0017 | .0078 | 0.030 | |
| 5% | .00069 | .0056 | 0.013 | |
| 0% | .00002 | .0004 | 0.0005 | minimum |
| Number of Projects | 285 | 277 | 285 | |

* Percentile

Table 3

Projects Lacking Sufficient Data for
Estimation of Morphometric Curves

| Code | District | Project |
|---|---|---|
| 10-002 | Mobile | Coffeeville |
| 10-005 | " | Demopolis |
| 10-007 | " | Warrior |
| 10-191 | " | Okatibbee |
| 10-415 | " | Gainesville |
| 15-180 | St. Paul | Traverse |
| 15-181 | " | Leech |
| 15-183 | " | Cross |
| 15-185 | " | Sandy |
| 17-127 | Huntington | Greenup |
| 17-394 | " | Winfield |
| 17-416 | " | Alum Creek |
| 33-289 | Portland | Bonneville |
| 33-301 | " | John Day |

## Water Balances

23. Reasonably accurate hydrologic balances are required as bases for formulating reservoir nutrient balances and testing nutrient load/trophic state response relationships. Unlike nutrient balances, water balances can be checked by comparing estimates of total inflow and outflow over a given period, while correcting for any change in storage within the reservoir. The basic water balance equation is:

$$\text{INPUT} = \text{OUTPUT} + \text{CHANGE IN STORAGE} \quad (7)$$

where a change in storage is positive if the total volume of the reservoir at the end of the period is greater than the total volume at the beginning and the output term includes evaporation, discharge, and withdrawal. Because of fluctuations in pool levels, the change in storage term is of potential importance to the short-term water and nutrient balances of many reservoirs, although it should be relatively small over an average annual period in reservoirs with stable operating policies.

24. A water balance has been estimated for each of the 108 CE reservoirs sampled by the EPA National Eutrophication Survey during the year monitored (see Table 1). Data sources for the water balance calculations include the following:

- a. EPA/NES (mean monthly flows in gauged tributaries and discharges, mean precipitation, drainage area)
- b. USGS (discharge flows, elevations/contents)
- c. CE District offices (discharge flows, elevations)
- d. US Weather Bureau (Kohler et al.,1959) (evaporation)

Calculations are outlined and results are presented in metric units for use in nutrient balance estimation and model testing. The potential implications of errors in the data and/or estimation methods used in formulating these balances are discussed following the calculations.

25. The first step involves the formulation of a drainage area "balance":

$$AT = AG + AU + AR \tag{8}$$

where,

- AT = drainage area at reservoir discharge (km2)
- AG = drainage area of gauged tributaries (km2)
- AU = drainage area of ungauged tributaries (km2)
- AR = reservoir surface area (km2)

The above drainage areas are water-contributing. Reservoir areas correspond to mean surface elevations over the monitoring period. Ungauged areas are estimated by difference, according to the above equation.

26. Available data permit estimation of the following water input components:

$$QI = QG + QU + QP \tag{9}$$

where,

- QI = total water input (hm3/yr = $10^6$ m3/yr)
- QG = gauged tributary input (hm3/yr)
- QU = ungauged tributary input (hm3/yr)
- QP = precipitation input (hm3/yr)

Ungauged inflows are estimated based upon gauged inflows and drainage areas:

$$QU = AU\ QG\ /\ AG \tag{10}$$

This assumes that the runoff coefficient (QG/AG) is a regional characteristic. In the case of a mainstem reservoir, much of the gauged drainage area may be remote from the waterbody and not representative of local watersheds; the runoff coefficient is estimated from the total flows and drainage areas of immediate tributaries only.

27. Precipitation inputs are estimated from reservoir areas and annual precipitation rates:

$$QP = AR\ YP \tag{11}$$

where,

inflow estimates, these components contribute to errors in the water balances.

28. The output term of each water balance is estimated as the sum of the following components:

$$QO = QD + QW + QE \tag{12}$$

where,

QO = total output (hm3/yr)

QD = discharge from reservoir (hm3/yr)

QW = withdrawal from reservoir (hm3/yr)

QE = evaporation (hm3/yr)

Discharge rates are based upon reported values. Withdrawals reflect uses for water supply, irrigation, etc.,and are based upon estimates in the EPA/NES working papers. Evaporation losses are estimated from:

$$QE = YE\ AR \tag{13}$$

where,

YE = average evaporation rate (m/yr)

Evaporation rates are assumed to be regional characteristics, estimated from maps compiled by Kohler et al. (1959) and reflect average conditions from 1946 to 1955. Year-to-year variations in climate and local variations in watershed/reservoir morphology (as they may determine wind fetch, etc.) may influence evaporation rates and contribute to the error term in the water balance equation.

29. The change-in-storage term of the water balance is calculated from:

$$QV = ( V2 - V1) / T \tag{14}$$

where,

QV = change in storage (hm3/yr)

V2 = reservoir volume at end of period (hm3)

V1 = reservoir volume at beginning of period (hm3)

T = length of monitoring period (yrs)

Reservoir volumes refer to month-end values immediately before and after the sampling period. The length of the monitoring period generally ranges from 12 to 13 months for the sampling schedules employed by the EPA/NES in these reservoirs.

30. Using the above framework, an error term can be calculated for each balance:

$$QN = QI - QO - QV \qquad (15)$$

$$QN = QG + QU + QP - QD - QW - QE - (V2 - V1)/T \qquad (16)$$

where,

QN = net inflow (hm3/yr)

Net inflow results from the influences of the following error sources:

a. errors in the drainage areas, reservoir volumes, and gauged flows

b. local morphologic or climatologic factors which may influence precipitation and evaporation

c. year-to-year climatologic variations which may cause evaporation rates to deviate from long-term regional averages

d. variations in watershed characteristics which may contribute to errors in estimates of ungauged tributary flows

e. diversions from or to the reservoirs which are not noted in the EPA/NES reports

31. To aid in water balance computations and permit examination of within-year variations in hydrologic conditions, a file of monthly values has been assembled, covering the monitoring periods. It includes the following:

a. mean reservoir discharge, estimated from each of three sources (where available):

1. EPA/NES
2. USGS/WATSTORE
3. CE District offices

b. mean and month-end elevations, estimated from (2) & (3)

c. mean and month-end volumes, estimated from (2) & (3)

d. mean and month-end surface areas, estimated from elevations (b) and morphometric curves

In most cases, agreement among the various sources of monthly discharge data has been found to be good (within 10%) and the EPA/NES estimates have been used. Other sources have been used in cases where the EPA/NES data were incomplete or apparently in error, based upon comparison with other sources and resultant errors in the water balances. Polynomials derived from the CE morphometric file (see above) have been applied to estimate missing elevations, volumes, and/or surface areas based upon elevations or volumes reported by the USGS. A summary of this file is given in Table 4, which also identifies the periods of tributary monitoring by the EPA/NES.

32. The terms of the water balance for each of the 108 projects sampled by the EPA/NES are listed along with corresponding terms in the nutrient balances in Appendix B. Elevation/contents data were not available for Caddo Lake (23-413), which is not currently under CE control. Accordingly, the change-in-storage term for this reservoir has not been estimated and data from this project have not been used in testing loading models.

33. Considering the error sources mentioned above, the following statistics can be used as measures of the relative reliability of a given flow balance:

$$QN / QI = \text{net flow (error) significance} \quad (17)$$

$$QU / QI = \text{ungauged inflow significance} \quad (18)$$

$$QP / QI = \text{precipitation significance} \quad (19)$$

$$QE / QO = \text{evaporation significance} \quad (20)$$

These represent net, ungauged, and precipitation inflows expressed as

Table 4

Reservoir Operating Ranges During Tributary Monitoring Period

| Symbol | Meaning |
|---|---|
| YR | year tributary sampling began |
| MO | month tributary sampling began |
| EMIN* | minimum pool elevation (ft,msl) |
| EMAX* | maximum pool elevation (ft,msl) |

* derived from month-end measurements

| DIS | RES | | YR | MO | EMIN | EMAX |
|---|---|---|---|---|---|---|
| 02 | 176 | WATERBURY | 72 | 7 | 573.8 | 593.0 |
| 03 | 307 | BELTZVILLE | 73 | 5 | 622.6 | 629.6 |
| 04 | 312 | F J SAYERS (BLA | 73 | 5 | 610.1 | 630.0 |
| 06 | 372 | JOHN H KERR | 73 | 7 | 297.1 | 304.0 |
| 08 | 074 | CLARK HILL | 73 | 3 | 326.3 | 331.5 |
| 08 | 330 | HARTWELL | 73 | 2 | 657.1 | 662.3 |
| 10 | 003 | HOLT | 73 | 3 | 186.7 | 187.0 |
| 10 | 069 | ALLATOONA | 73 | 3 | 826.2 | 843.7 |
| 10 | 071 | SEMINOLE (WOODR | 73 | 3 | 76.9 | 77.5 |
| 10 | 072 | WALTER F GEORGE | 73 | 3 | 185.6 | 189.4 |
| 10 | 076 | SIDNEY LANIER | 73 | 3 | 1066.5 | 1072.5 |
| 10 | 411 | BANKHEAD | 73 | 3 | 254.5 | 255.0 |
| 14 | 099 | RED ROCK | 74 | 8 | 724.8 | 746.9 |
| 15 | 178 | GULL | 72 | 10 | 1192.7 | 1194.0 |
| 15 | 181 | LEECH | 72 | 10 | 1293.7 | 1294.9 |
| 15 | 237 | ASHTABULA (BALD | 74 | 9 | 1263.3 | 1266.6 |
| 16 | 243 | BERLIN | 73 | 5 | 1015.7 | 1026.5 |
| 16 | 254 | MOSQUITO CREEK | 73 | 5 | 898.1 | 902.0 |
| 16 | 317 | SHENANGO RIVER | 73 | 5 | 885.9 | 899.2 |
| 16 | 328 | ALLEGHENY (KINZ | 73 | 5 | 1294.1 | 1328.8 |
| 16 | 393 | TYGART | 73 | 7 | 1025.6 | 1095.5 |
| 17 | 241 | ATWOOD | 73 | 5 | 923.9 | 928.8 |
| 17 | 242 | BEACH CITY | 73 | 5 | 948.7 | 953.0 |
| 17 | 245 | CHARLES MILL | 73 | 5 | 997.2 | 1001.3 |
| 17 | 247 | DEER CREEK | 73 | 5 | 790.7 | 815.9 |
| 17 | 248 | DELAWARE | 73 | 5 | 910.1 | 915.9 |
| 17 | 249 | DILLON | 73 | 5 | 735.4 | 747.1 |
| 17 | 256 | PLEASANT HILL | 73 | 5 | 1017.5 | 1021.5 |
| 17 | 258 | TAPPAN | 73 | 5 | 894.1 | 899.1 |
| 17 | 373 | JOHN W FLANNAGA | 73 | 7 | 1410.5 | 1428.0 |
| 17 | 389 | BLUESTONE | 73 | 7 | 1410.3 | 1444.0 |
| 17 | 391 | SUMMERSVILLE | 73 | 7 | 1536.2 | 1652.7 |
| 18 | 092 | MISSISSINEWA | 73 | 6 | 727.9 | 749.5 |
| 18 | 093 | MONROE | 73 | 6 | 536.9 | 546.6 |
| 18 | 120 | BARREN RIVER | 73 | 3 | 529.1 | 559.2 |
| 19 | 119 | BARKLEY | 73 | 3 | 354.6 | 367.3 |
| 19 | 122 | CUMBERLAND (WOL | 73 | 3 | 694.5 | 732.3 |
| 19 | 338 | CHEATHAM | 73 | 4 | 384.2 | 385.6 |
| 19 | 340 | J PERCY PRIEST | 73 | 4 | 483.2 | 494.1 |
| 19 | 342 | OLD HICKORY | 73 | 4 | 444.1 | 445.4 |
| 19 | 343 | DALE HOLLOW | 73 | 3 | 639.8 | 654.6 |
| 20 | 081 | CARLYLE | 73 | 6 | 444.0 | 455.3 |
| 20 | 087 | SHELBYVILLE | 73 | 6 | 595.6 | 616.6 |
| 20 | 088 | REND | 73 | 6 | 403.7 | 409.3 |
| 21 | 196 | WAPPAPELLO | 74 | 9 | 351.6 | 371.8 |
| 22 | 014 | DE GRAY | 74 | 6 | 400.9 | 410.9 |
| 22 | 019 | OUACHITA (BLAKE | 74 | 6 | 573.2 | 580.9 |
| 22 | 188 | ARKABUTLA | 73 | 8 | 213.3 | 232.1 |

Table 4 (continued)

| DIS | RES | | YR | MO | EMIN | EMAX |
|---|---|---|---|---|---|---|
| 22 | 189 | ENID | 73 | 8 | 237.2 | 265.7 |
| 22 | 190 | GRENADA | 73 | 8 | 208.6 | 227.9 |
| 22 | 192 | SARDIS | 73 | 8 | 260.0 | 276.6 |
| 23 | 352 | LAKE OF THE PIN | 74 | 9 | 228.8 | 231.7 |
| 23 | 353 | TEXARKANA(WRIGH | 74 | 9 | 221.0 | 232.9 |
| 23 | 413 | CADDO | 74 | 6 | . | . |
| 24 | 011 | BEAVER | 74 | 6 | 1116.2 | 1125.7 |
| 24 | 012 | BLUE MOUNTAIN | 74 | 6 | 384.9 | 403.9 |
| 24 | 013 | BULL SHOALS | 74 | 6 | 652.5 | 676.2 |
| 24 | 016 | GREERS FERRY | 74 | 6 | 454.7 | 474.2 |
| 24 | 021 | NIMROD | 74 | 6 | 342.0 | 364.8 |
| 24 | 022 | NORFOLK | 74 | 6 | 551.2 | 568.9 |
| 24 | 193 | CLEARWATER | 74 | 9 | 494.4 | 518.8 |
| 24 | 200 | TABLE ROCK | 74 | 9 | 909.0 | 919.2 |
| 25 | 020 | MILLWOOD | 74 | 6 | 255.2 | 262.3 |
| 25 | 102 | COUNCIL GROVE | 74 | 10 | 1269.4 | 1276.1 |
| 25 | 103 | ELK CITY | 74 | 10 | 787.7 | 811.9 |
| 25 | 104 | FALL RIVER | 74 | 10 | 948.1 | 961.2 |
| 25 | 105 | JOHN REDMOND | 74 | 10 | 1036.8 | 1046.1 |
| 25 | 107 | MARION | 74 | 10 | 1349.5 | 1351.3 |
| 25 | 112 | TORONTO | 74 | 10 | 901.2 | 917.6 |
| 25 | 267 | EUFAULA | 74 | 11 | 580.4 | 589.2 |
| 25 | 269 | FORT SUPPLY | 74 | 11 | 2001.8 | 2004.5 |
| 25 | 273 | KEYSTONE | 74 | 11 | 716.2 | 733.8 |
| 25 | 275 | OOLOGAH | 74 | 11 | 636.2 | 648.3 |
| 25 | 278 | TENKILLER FERRY | 74 | 11 | 628.4 | 647.4 |
| 25 | 281 | WISTER | 74 | 11 | 474.5 | 487.7 |
| 25 | 348 | TEXOMA (DENNISO | 74 | 11 | 613.7 | 620.2 |
| 25 | 370 | KEMP | 74 | 9 | 1126.6 | 1140.9 |
| 26 | 345 | BELTON(BELL) | 74 | 9 | 592.5 | 605.2 |
| 26 | 347 | CANYON | 74 | 9 | 904.5 | 914.6 |
| 26 | 354 | LAVON | 74 | 9 | 470.5 | 484.6 |
| 26 | 355 | LEWISVILLE(GARZ | 74 | 9 | 513.1 | 524.7 |
| 26 | 359 | SAM RAYBURN (MC | 74 | 9 | 157.5 | 166.6 |
| 26 | 360 | O C FISHER (SAN | 74 | 9 | 1863.0 | 1890.5 |
| 26 | 361 | SOMERVILLE | 74 | 9 | 237.6 | 246.9 |
| 26 | 362 | STILLHOUSE HOLL | 74 | 9 | 621.6 | 635.4 |
| 26 | 364 | WHITNEY | 74 | 9 | 523.0 | 534.6 |
| 28 | 219 | CONCHAS | 74 | 12 | 4157.9 | 4173.6 |
| 29 | 100 | RATHBUN | 74 | 8 | 902.0 | 906.2 |
| 29 | 106 | KANOPOLIS | 74 | 10 | 1455.0 | 1468.4 |
| 29 | 108 | MILFORD | 74 | 10 | 1141.7 | 1146.8 |
| 29 | 109 | MELVERN | 74 | 10 | 1029.9 | 1037.6 |
| 29 | 110 | PERRY | 74 | 10 | 888.9 | 895.6 |
| 29 | 111 | POMONA | 74 | 10 | 972.3 | 979.9 |
| 29 | 113 | TUTTLE CREEK | 74 | 10 | 1069.2 | 1081.4 |
| 29 | 114 | WILSON | 74 | 10 | 1514.4 | 1517.1 |
| 29 | 194 | POMME DE TERRE | 74 | 9 | 837.9 | 843.7 |
| 29 | 195 | STOCKTON | 74 | 9 | 863.1 | 872.4 |
| 29 | 207 | HARLAN COUNTY | 74 | 8 | 1938.2 | 1947.9 |
| 30 | 064 | CHERRY CREEK | 74 | 9 | 5548.5 | 5551.2 |
| 30 | 215 | PAWNEE | 74 | 8 | 1243.8 | 1244.6 |
| 30 | 217 | BRANCHED OAK | 74 | 8 | 1283.0 | 1284.4 |
| 30 | 235 | SAKAKAWEA(GARRI | 74 | 9 | 1838.7 | 1853.7 |
| 31 | 077 | DWORSHAK | 74 | 10 | 1443.9 | 1597.0 |
| 32 | 204 | KOOKANUSA(LIBBY | 74 | 10 | 2286.7 | 2457.1 |
| 33 | 300 | HILLS CREEK | 74 | 10 | 1453.1 | 1541.2 |
| 34 | 048 | NEW DON PEDRO | 74 | 11 | 758.0 | 816.7 |
| 35 | 029 | MENDOCINO | 74 | 11 | 721.7 | 749.1 |
| 35 | 039 | SANTA MARGARITA | 74 | 11 | 1289.7 | 1303.5 |

fractions of the total inflow and evaporation expressed as a fraction of the total outflow, respectively. The first statistic is a direct measure of error, while the last three are indicators of potential error.

34. The distributions of these error statistics are summarized in Table 5. To provide a basis for screening the data set, a cutpoint has been selected for each statistic and used to tag projects with potentially greater water balance errors. Cutpoints (generally in the 90-95 percentile range) have been selected to isolate outliers, after examining histograms of the error statistics. Because the first statistic is the only direct measure of error, it has been given greater weight in data screening.

35. As shown in Table 5, eight out of 108 projects have water balances errors exceeding 25%. Some of these are attributed to severe data limitations (e.g., 93% of the drainage area of Lake Kookanusa, 32-204, is ungauged). Attempts have been made to identify the sources of errors through additional data compilation and verification. In some cases, additional data compilation effort not feasible within the scope of this project might be helpful in resolving water balance errors. The possiblity of other sources of error and the subjective nature of the cutpoint selection indicate that the screening procedure applied above is only approximate. The error statistics have been carried through the loading model evaluations in order to provide a means for testing whether differences between model predictions and observations can be partially explained by errors in the hydrologic balances.

36. The water balances formulated above cover the period of tributary sampling by the EPA/NES in each project. For most projects, this period does not include the period in which pool water quality measurements were made by the EPA/NES, i.e., tributary and pool surveys were generally conducted in different (though adjacent) hydrologic years. There is a potential problem in relating the loadings to the pool measurements because of the effects of year-to-year variations in hydrologic conditions. The data base permits comparisons of reservoir discharges and volumes during the two monitoring periods. This

| | | | | | |
|---|---|---|---|---|---|
| \|net flow\|/total inflow | .010 | .045 | .212 | <.25 | 100 |
| ungd. flow/total inflow | .027 | .130 | .357 | <.40 | 102 |
| prec. flow/total inflow | .007 | .035 | .181 | <.25 | 104 |
| evap./total outflow | .007 | .035 | .336 | <.25 | 96 |

* out of 108 projects

information has been used to modify the above water balances to correspond with the hydrologic year which includes the period of EPA/NES pool monitoring. Corresponding estimates have also been developed for "normal" hydrologic years, based upon average annual outflows estimated from the period of record and normal pool elevations.

37. Since direct inflow measurements are available only for the tributary sampling period, annual inflows during other years have been inferred from outflow, change-in-storage, and evaporation. In order to permit adjustment of water and nutrient balances estimates, it is assumed that the error term (QN) in the water balance formulated above can be attributed primarily to errors in the inflow estimates. Annual inflows during the pool monitoring periods are based upon the annual water balance, assuming no net error:

$$QI' = QD' + QV' + QE \qquad (21)$$

where,

$QI'$ = total inflow (hm3/yr)

$QD'$ = total discharge (including withdrawals) (hm3/yr)

$QV'$ = change in storage (hm3/yr)

$'$ = superscript denoting pool monitoring year

Evaporation rates are assumed to be constant from year to year. The above calculations have been repeated for an average hydrologic year, using average annual discharge in place of $QD'$ and assuming no net change in storage over an average year. Outflows during the tributary and pool sampling periods each tended to be greater than average outflows by about 50% (median value). Sufficient data are available to characterize hydrologic conditions during each monitoring period for all but six projects, five of which lack outflow data for the pool monitoring period. Appendix B lists the terms in equation (21), along with average morphometric and nutrient inflow characteristics, for each hydrologic period.

38. The procedures used above to screen project water balances for potential errors are based upon calculated net water balances. Because of the possiblities for offsetting errors, there is no guarantee that a

water balance which balances is "correct". Error components are introduced by gauging errors, data recording errors, missing data, morphometric errors, and by the required estimation of evaporation and ungauged flows. While nominal estimates for these types of errors might be employed (Winter, 1980), existing data do not permit assessment of how they might vary from project to project. Thus, direct consideration of these types of errors would be of little use in data screening.

39. In applications of empirical eutrophication models, the effects of flow balance errors are generally not as significant as one might expect, especially in relation to other error sources (e.g., those inherent in the models or in the average tributary phosphorus concentration estimates). This results from the fact that predictions of impoundment response are more sensitive to the average inflow total phosphorus concentration (mass/volume) than to loading (mass/time). The average inflow concentration is essentially calculated as the flow-weighted average of all concentration estimates made in tributary streams, adjusted for effects of direct and atmospheric loadings. In this calculation, flows appear as weighting factors, i.e., both in the numerator and in the denominator, so that the effects of flow balance errors on inflow concentrations are always less than proportional and far less than proportional in reservoirs with tributaries which are more or less of uniform quality. In the case of a reservoir with a short residence and one major tributary, estimates of impoundment phosphorus or chlorophyll concentration derived from a typical loading model are completely independent of biases in the average tributary flow or reservoir discharge estimates.

40. Thus, because of generally lower sensitivity and lack of an independent basis for estimating and comparing the unknown error components of each flow balance, screening for hydrologic data errors has been limited to a check on the net flow balance. Checks for representative sampling of tributaries and flow regimes are incorporated into the nutrient balance screening procedures described in the next section. A greater emphasis has been placed on errors associated with estimating average tributary concentrations based upon limited numbers

of grab samples, because loading model predictions are more sensitive to these types of errors, which can be estimated directly from the data using the methods employed in the next section.

## Nutrient Balances

41. Nutrient balance calculations are built largely upon the water balances described in the previous section. For a non-conservative material, the basic mass balance equation is:

$$\text{INPUT} = \text{OUTPUT} + \text{CHANGE IN STORAGE} + \text{ACCUMULATION} \qquad (22)$$

where the accumulation term reflects non-conservative behavior and is positive if there is a net loss of the material within the reservoir. The mass balance is formulated such that a net internal loading (net phosphorus release from bottom sediments, for example) would show up as a negative accumulation rate. Since it is determined by difference from the other terms, however, the accumulation term is subject to considerable estimation error. An attempt has been made to quantify this estimation error in formulating the nutrient budgets.

42. A nutrient balance has been estimated for each CE reservoir sampled by the EPA National Eutrophication Survey (see Table 1) during the year monitored. The EPA/NES has provided flow and concentration data from gauged and ungauged tributaries and outflows, as well as estimates of point sources and other direct or indirect sources (septic tanks, wild fowl, etc.). Balances have been estimated for the following components:

- _a_. total phosphorus
- _b_. dissolved orthophosphorus
- _c_. total nitrogen
- _d_. inorganic (ammonia + nitrite + nitrate) nitrogen

While they do not include organic fractions, components _b_ and _d_ are referred to as "dissolved" forms of phosphorus and nitrogen, respectively, in the remainder of this report. These have been included in the nutrient balance calculations to provide bases for assessing the impacts of nutrient availability on load/response relationships.

43. Errors in the water balances propagate to the corresponding nutrient balances, though, as discussed in the previous section, average inflow concentrations are most important in empirical model applications and are generally not very sensitive to errors in average flow estimates. More important errors are introduced when grab-sample concentration data (in this case 10-14 samples per station-year) are used along with a continuous flow record to estimate average mass flux (or flow-weighted average concentration) over a yearly period. The regression/error analysis method described in the Phase I report (Walker,1981) has been applied to quantify the latter type of error. In formulating the mass balances, the mean and standard error of each term has been estimated. This has required subjective estimation of some error terms (precipitation and point-source loading errors, for example), but has provided an approximate basis for ranking the reservoirs with respect to data adequacy for use in model testing.

44. Total nutrient input consists of the following elements:

$$WI = WG + WU + WP + WX + WA \qquad (23)$$

where,

WI = total input (metric tons/yr)

WG = input from gauged tributaries (mt/yr)

WU = input from ungauged tributaries (mt/yr)

WP = input from point source discharges (mt/yr)

WX = input from septic tanks and wildfowl (mt/yr)

WA = input from atmosphere (mt/yr)

The first term, WG, is estimated from flow and concentration measurements at each gauged tributary stream using a regression analysis procedure described previously (Walker, 1981). Estimates of ungauged tributary inputs are based upon:

$$WU = QU\ (WGN/QGN) \qquad (24)$$

where,

QU = estimated inflow from ungauged tributaries (hm3/yr)

WGN = nutrient input from gauged tributaries not under the influence of upstream point sources (mt/year)

QGN = inflow from gauged tributaries not under the influence of point sources (hm3/yr)

This assumes that the flow-weighted nutrient concentration (WGN/QGN) is representative of local watersheds. In order to apply this method, gauged tributaries not under point-source influence have been identified for each reservoir, based upon the EPA/NES reports and watershed maps. In some cases, no flow data were available for non-point-source tributaries and ungauged loadings have been estimated from:

$$WU = QU \; CGN \qquad (25)$$

where,

CGN = average nutrient concentration in sampled, but ungauged tributaries not under point source influence (g/m3)

To carry the error terms, the above equations have been applied to the mean and variance of each estimate. To reflect their relative uncertainty, variance estimates for ungauged loadings have been doubled relative to estimates derived from variances of gauged loadings. For example, the squared coefficient of variation WU is given by:

$$CV^2(WU) = 2 \; CV^2(WGN) \qquad (26)$$

if equation (24) is used, or

$$CV^2(WU) = 2 \; CV^2(CGN) \qquad (27)$$

if equation (25) is used. Note that these error variances reflect only the errors associated with integrating flow and concentration to estimate the flow-weighted-average concentration for each tributary.

45. Estimates of point sources, WP, and other direct inputs, WX, are derived from EPA/NES working papers. In formulating nutrient budgets, the EPA/NES included many point sources which were relatively remote from the reservoirs and often above tributary monitoring sites.

The loadings used here include only those point sources which discharge directly to the reservoir, to ungauged tributaries, or to gauged tributaries below the monitoring stations. These sources have been isolated using EPA/NES watershed maps, which indicate locations of point sources and tributary stations. It is assumed that the influences of point sources above monitoring stations on gauged tributaries are reflected in the concentration measurements made at those stations. The WP and WX estimates are assumed to have coefficients of variation of .1 and .2, respectively. Both are assumed to be in or eventually converted to dissolved (available) forms.

46. Estimates of precipitation input are derived from:

$$WA = .001\ AR\ YA \qquad (28)$$

where,

AR = reservoir surface area (km2)

YA = atmospheric nutrient loading (kg/km2-yr)

Atmospheric loadings include precipitation and dustfall. Loading rates of 30 and 1000 kg/km2-yr have been assumed for total phosphorus and total nitrogen, respectively. (Reckhow, 1980, EPA/NES,1974). Half of the total loadings are assumed to be in dissolved form. Literature values for atmospheric loadings are highly variable, owing to regional variations as well as sampling difficulties. These estimates are assumed to have coefficients of variation equal to .4.

47. The outflow term of the nutrient balance is estimated from measured flows and concentrations in reservoir discharges and withdrawals using the same calculation procedure employed for gauged tributary loadings. In cases where concentration data are not available for one or more withdrawals, each withdrawal is assumed to have the same flow-weighted concentration as the reservoir discharge.

48. In order to permit detailed quantification of the change-in-storage term of the nutrient balance equation, reservoir quality surveys at the beginning and end of the monitoring period would be required. Since these are generally not available, this term can be quantified only with respect to the influences of change in reservoir

volume:

$$WV = QV\ [\ WO\ /\ (QO-QE)\ ] \quad (29)$$

where,

WV = change in nutrient storage (mt/yr)

WO = total nutrient outflow (mt/yr)

QV = change in water storage (hm3/yr)

QO = total reservoir outflow (including evap.) (hm3/yr)

QE = evaporation (hm3/yr)

The term in brackets represents the flow-weighted-average concentration of the reservoir discharge. This essentially assumes that the outflow concentration is representative of the reservoir as a whole and that the concentration at the beginning of the monitoring period is equal to the concentration at the end. In many reservoirs, these assumptions are likely to be in error. Considering the change-in-volume effect is preferable to ignoring this term completely. In most cases, the magnitude of this term is insignificant relative to the other elements of the nutrient balance. The term does not influence the loading or inflow concentration estimates, which are the most important for model testing purposes.

49. Table 6 is an example of the format used in the nutrient balance calculations. A similar table has been generated for each nutrient/reservoir combination. Results have been stored in a SAS data base (SAS Institute, 1979) and in hard copy form. Appendix B summarizes the mass balance terms for each reservoir and nutrient.

50. Attempts have been made to correct the total loading and inflow concentration estimates for the effects of errors in the hydrologic balances. In order to make these corrections, it is assumed that water balance errors can be attributed primarily to errors in the inflow estimates and that the total nutrient loading can be partitioned into two terms, one flow-independent and the other flow-dependent:

$$QIC = QI + QN \quad (30)$$

$$WIC = QIC\ CIC = (WP + WX) + (WI - WP - WX)\ QIC\ /\ QI \quad (31)$$

| | |
|---|---|
| OBS | sequence number in file |
| STA | station code |
| NESTA | EPA/NES station code |
| TYPE | station type code (0,1 = input; 3 = output) |
| NPS | non-point-source code<br>(1 = used to estimate ungauged flow and concentration)<br>(2 = used to estimate ungauged flow) |
| LOC | location description |
| DAREA | drainage area or surface area (mi2) |
| OFLOW | mean flow during year sampled (cfs) |
| LOAD | estimated loading (cfs*g/m3) |
| VLOAD | variance of above loading estimate |
| CLOAD | coefficient of variation of loading estimate |
| ORUN | water runoff rate (cfs/mi2) |
| EXPORT | nutrient export coefficient ((cfs*g/m3)/mi2) |
| CQW | flow-weighted nutrient concentration (g/m3) |
| N | number of water quality samples used to estimate loading |
| QMEAN | mean flow on water quality sampling days (cfs) |
| B | slope of log(concentration) vs. log(flow) regression |

CE DISTRICT CODE=31 CE RESERVOIR CODE=077

| OBS | STA | NESTA | TYPE | NPS | LOC | DAREA | OFLOW | LOAD | VLOAD | CLOAD | ORUN | EXPORT | CQW | N | QMEAN | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1731 | 000 | 1604AA | 0 | | DWORSHAK RESERVOIR | 22.01 | 41.42 | 1.910 | 0.58 | 0.400 | 1.882 | 0.087 | 0.046 | . | 41.42 | 0.000 |
| 1732 | 000 | 1604AB | 3 | | EVAPORATION | . | 43.77 | 0.000 | 0.00 | . | . | . | 0.000 | . | 0.00 | 0.000 |
| 1733 | 301 | 1604A1 | 3 | | CLEARWATER RIVER | 2440.00 | 6158.00 | 107.487 | 370.34 | 0.188 | 2.524 | 0.042 | 0.017 | 11 | 7470.00 | 0.069 |
| 1734 | 302 | 1604A2 | 1 | 1 | N FK CLEARWATER RIVER | 1360.00 | 3476.50 | 52.645 | 182.81 | 0.257 | 2.556 | 0.039 | 0.015 | 7 | 3020.00 | 0.005 |
| 1735 | 303 | 1604B1 | 1 | 2 | ELK CREEK | 92.79 | 237.08 | 7.364 | 2.88 | 0.230 | 2.555 | 0.079 | 0.031 | 7 | 305.00 | 0.191 |
| 1736 | 307 | 1604F1 | 1 | 2 | REEDS CREEK | 62.39 | 175.00 | 5.938 | 255.48 | 2.692 | 2.805 | 0.095 | 0.034 | 8 | 1190.00 | -0.155 |
| 1737 | 308 | 1604G1 | 1 | 1 | BREAKFAST CREEK | 129.00 | 369.67 | 7.700 | 7.92 | 0.366 | 2.866 | 0.060 | 0.021 | 8 | 436.00 | 0.118 |
| 1738 | 309 | 1604H1 | 1 | 1 | LTTL N FK CLRWATER RIV | 262.00 | 857.83 | 24.816 | 196.01 | 0.564 | 3.274 | 0.095 | 0.029 | 8 | 1020.00 | 0.285 |
| 1739 | 666 | | | | POINT SOURCES | . | . | 0.000 | 0.00 | . | . | . | . | . | . | . |
| 1740 | 777 | | | | OTHER LOADING | . | . | 0.000 | 0.00 | . | . | . | . | . | . | . |
| 1741 | 901 | | . | . | UNGAUGED INPUT | 511.81 | 1373.68 | 24.859 | 65.96 | 0.327 | 2.684 | 0.049 | 0.018 | . | 1603.22 | 0.000 |
| 1742 | 902 | | . | . | ***TOTAL INPUT | 2440.00 | 6531.18 | 125.242 | 711.64 | 0.213 | 2.677 | 0.051 | 0.019 | . | 7615.64 | 0.063 |
| 1743 | 903 | | . | . | ***TOTAL OUTPUT | 2440.00 | 6201.77 | 102.487 | 370.34 | 0.188 | 2.542 | 0.042 | 0.017 | . | 7470.00 | 0.069 |
| 1744 | 904 | | . | . | ***CHANGE IN STORAGE | . | -213.90 | -3.560 | . | . | . | . | . | . | . | . |
| 1745 | 905 | | . | . | ***NET | 0.00 | 543.31 | 26.315 | 1081.98 | 1.250 | . | . | 0.003 | . | . | . |
| 1746 | 906 | | . | . | ***PERCENT ERROR | 0.00 | 8.32 | 21.012 | . | . | . | . | 13.823 | . | . | . |

$$CIC = (WP + WX) / QIC + (WI - WP - WX) / QI \tag{32}$$

where,

QIC = corrected total inflow (hm3/yr)

QN = net inflow (error, see equation (15)) (hm3/yr)

WIC = corrected total loading (mt/yr)

CIC = corrected inflow concentration (g/m3)

Equation(30) adjusts the total inflow estimate to force a water balance. Equation (31) assumes that the point-source and septic-tank loading component (WP + WX) is independent of inflow (and inflow errors) and that other components are proportional to inflow. Table 7 lists the corrected inflow concentrations and outflow concentrations for each reservoir and nutrient, along with the terms of the water balance during the tributary monitoring period.

51. Adjustments to the above inflow concentration estimates are required in order to estimate average inflow concentrations during the pool monitoring periods or during normal hydrologic years because of the influences of year-to-year flow variations on inflow water quality. These adjustments are based upon the calculated sensitivities of inflow concentrations to flow during the tributary monitoring period. Modified inflow concentration estimates are estimated from:

$$CI' = CIC\ (QIC/QI')\ [\ F + (1-F)\ (QI'/QIC)^{b+1}\ ] \tag{33}$$

$$F = (WP + WX) / WIC \tag{34}$$

where,

CI′ = inflow concentration estimate at QI′ (g/m3)

QI′ = total inflow during pool monitoring period (hm3/yr)

F = fraction of loading attributed to point sources, septic tanks, and wildfowl

b = sensitivity of inflow concentration to flow

The inflows QI′ have been estimated according to equation (21). The sensitivity parameter (b) has been estimated for each reservoir and nutrient. It represents the flow-weighted-average slope of the

Table 7

Listing of Corrected Water and Nutrient Balances for Tributary Monitoring Period

| Symbol | Definition |
|---|---|
| DIS | CE district code |
| RES | CE reservoir code |
| GP | data screering code<br>(A = high priority, B = low priority) |
| QIN | total inflow (hm3/yr) |
| QEVAP | evaporation (hm3/yr) |
| QOUT | total discharge and withdrawal (hm3/yr) |
| QSTOR | change-in-storage (hm3/yr) |
| QNET | net inflow (error) (hm3/yr) |
| IPTL | inflow total P (mg/m3) |
| OPTL | outflow total P (mg/m3) |
| IPDS | inflow ortho P (mg/m3) |
| OPDS | outflow ortho P (mg/m3) |
| INTL | inflow total N (mg/m3) |
| ONTL | outflow total N (mg/m3) |
| ININ | inflow inorganic N (mg/m3) |
| ONIN | outflow inorganic N (mg/m3) |

Table 7 (continued)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

| DIS | RES | GP | QIN | QEVAP | QOUT | QSTOR | QNET | IPTL | OPTL | IPDS | OPDS | INTL | ONTL | ININ | ONIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 087 SHELBYVILLE | A | 1694.4 | 47.2 | 1589.8 | 128.9 | -71.4 | 170 | 106 | 95 | 54 | 8008 | 6194 | 7325 | 4788 |
| 20 | 088 REND | A | 517.8 | 75.8 | 462.9 | -51.1 | 30.2 | 259 | 86 | 47 | 23 | 2279 | 1418 | 781 | 371 |
| 21 | 196 WAPPAPELLO | B | 1790.2 | 25.1 | 1982.3 | -21.4 | -195.8 | 86 | 49 | 16 | 10 | 1501 | 1357 | 348 | 328 |
| 22 | 014 DE GRAY | B | 1373.1 | 60.5 | 1345.7 | -41.3 | 8.2 | 16 | 20 | 6 | 6 | 190 | 554 | 73 | 86 |
| 22 | 019 OUACHITA (BLAKE | B | 2887.7 | 170.7 | 2697.3 | -51.8 | 71.5 | 21 | 16 | 12 | 7 | 671 | 457 | 162 | 168 |
| 22 | 188 ARKABUTLA | B | 3209.3 | 66.1 | 1617.9 | -26.1 | 1551.4 | 106 | 279 | 47 | 76 | 967 | 1267 | 797 | 486 |
| 22 | 189 ENID | A | 1548.0 | 75.2 | 1308.1 | 136.3 | 28.4 | 271 | 65 | 78 | 23 | 1570 | 875 | 455 | 372 |
| 22 | 190 GRENADA | B | 4001.2 | 180.7 | 2854.7 | -151.0 | 1116.8 | 115 | 106 | 32 | 25 | 714 | 939 | 200 | 209 |
| 22 | 192 SARDIS | B | 3696.5 | 185.3 | 3636.9 | -235.1 | 109.5 | 76 | 18 | 15 | 10 | 642 | 687 | 262 | 75 |
| 23 | 352 LAKE OF THE PIN | B | 1678.6 | 110.6 | 1594.9 | -12.0 | -14.8 | 94 | 27 | 50 | 8 | 919 | 730 | 190 | 71 |
| 23 | 353 TEXARKANA(WRIGH | B | 6043.7 | 171.8 | 5109.8 | -9.1 | 771.2 | 116 | 129 | 52 | 56 | 885 | 864 | 216 | 207 |
| 23 | 413 CADDO | B | 4352.9 | 164.8 | 4637.4 | | -449.3 | 50 | 46 | 18 | 15 | 686 | 835 | 82 | 44 |
| 24 | 011 BEAVER | A | 2318.4 | 129.8 | 2219.3 | -134.7 | 104.0 | 59 | 16 | 16 | 6 | 954 | 773 | 453 | 279 |
| 24 | 012 BLUE MOUNTAIN | B | 767.4 | 19.7 | 742.5 | 2.3 | 2.8 | 25 | 74 | 12 | 22 | 806 | 788 | 90 | 183 |
| 24 | 013 BULL SHOALS | A | 9577.3 | 213.6 | 9881.6 | -609.1 | 91.3 | 18 | 12 | 7 | 6 | 748 | 777 | 463 | 370 |
| 24 | 016 GREERS FERRY | B | 2292.7 | 139.0 | 2135.1 | -29.7 | 48.2 | 32 | 11 | 10 | 5 | 460 | 1070 | 129 | 160 |
| 24 | 021 NIMROD | B | 1362.0 | 16.3 | 1302.1 | 13.4 | 30.2 | 30 | 39 | 12 | 11 | 1051 | 643 | 224 | 89 |
| 24 | 022 NORFOLK | B | 2431.0 | 92.9 | 2557.3 | -301.5 | 82.2 | 15 | 19 | 8 | 11 | 1018 | 1042 | 660 | 346 |
| 24 | 193 CLEARWATER | B | 1029.2 | 6.4 | 1074.0 | -4.6 | -46.5 | 14 | 34 | 8 | 7 | 1408 | 1356 | 360 | 194 |
| 24 | 200 TABLE ROCK | A | 5379.7 | 180.5 | 5703.1 | -296.5 | -207.4 | 47 | 18 | 45 | 13 | 2033 | 1418 | 900 | 556 |
| 25 | 020 MILLWOOD | A | 10619.6 | 142.0 | 10501.4 | 0.0 | -23.9 | 62 | 48 | 17 | 12 | 713 | 459 | 197 | 118 |
| 25 | 102 COUNCIL GROVE | B | 133.8 | 18.3 | 107.0 | 1.2 | 7.2 | 342 | 99 | 75 | 41 | 5379 | 1647 | 2554 | 538 |
| 25 | 103 ELK CITY | B | 963.4 | 21.2 | 811.9 | -8.9 | 139.1 | 80 | 146 | 19 | 30 | 1653 | 1535 | 753 | 518 |
| 25 | 104 FALL RIVER | B | 601.2 | 15.1 | 549.0 | -2.7 | 39.8 | 48 | 107 | 17 | 20 | 1493 | 1352 | 394 | 426 |
| 25 | 105 JOHN REDMOND | A | 1837.5 | 48.8 | 1753.0 | 0.6 | 35.1 | 366 | 178 | 103 | 71 | 3357 | 1976 | 1338 | 741 |
| 25 | 107 MARION | B | 92.1 | 34.8 | 49.2 | 3.0 | 5.1 | 159 | 60 | 49 | 18 | 2378 | 1229 | 739 | 162 |
| 25 | 112 TORONTO | B | 576.5 | 16.1 | 719.1 | -1.7 | -157.1 | 52 | 88 | 13 | 18 | 1240 | 1486 | 349 | 404 |
| 25 | 267 EUFAULA | A | 9164.8 | 536.7 | 9593.9 | -757.4 | -208.4 | 340 | 191 | 78 | 59 | 1825 | 1475 | 266 | 484 |
| 25 | 269 FORT SUPPLY | A | 30.8 | 12.1 | 23.9 | -5.5 | 0.3 | 44 | 52 | 12 | 15 | 901 | 892 | 272 | 77 |
| 25 | 273 KEYSTONE | A | 13117.2 | 153.8 | 13870.8 | -437.4 | -469.9 | 382 | 109 | 123 | [illegible] | 3095 | 1463 | 865 | 771 |
| 25 | 275 OOLOGAH | B | 4401.6 | 174.4 | 4823.4 | -134.9 | -461.3 | 220 | 86 | 45 | 33 | 1906 | 1825 | 450 | 481 |
| 25 | 278 TENKILLER FERRY | A | 2506.0 | 66.6 | 2511.4 | -47.8 | -24.2 | 91 | 48 | 53 | [illegible] | 1906 | 1843 | 760 | 631 |
| 25 | 281 WISTER | A | 1635.1 | 44.7 | 1594.4 | -42.8 | 38.8 | 69 | 71 | 21 | 26 | 929 | 903 | 129 | 166 |
| 25 | 348 TEXOMA (DENNISO | A | 8139.9 | 561.3 | 8490.5 | -651.1 | -260.9 | 376 | 92 | 79 | 16 | 2525 | 1188 | 420 | 245 |
| 25 | 370 KEMP | B | 213.8 | 56.0 | 68.3 | 142.9 | -53.4 | 43 | 28 | 13 | 6 | 853 | 671 | 487 | 75 |
| 26 | 345 BELTON(BELL) | B | 736.0 | 77.2 | 1080.1 | 11.9 | -433.2 | 387 | 23 | 312 | 8 | 1535 | 838 | 865 | 302 |
| 26 | 347 CANYON | A | 885.8 | 49.8 | 829.5 | -38.1 | 44.6 | 17 | 11 | 8 | 6 | 1320 | 727 | 901 | 425 |
| 26 | 354 LAVON | A | 1155.0 | 91.2 | 956.9 | -28.5 | 135.4 | 208 | 49 | 69 | 24 | 1968 | 888 | 618 | 203 |
| 26 | 355 LEWISVILLE(GARZ | A | 1538.1 | 157.3 | 1458.6 | 0.2 | -78.1 | 233 | 77 | 82 | 44 | 1795 | 956 | 505 | 449 |
| 26 | 359 SAM RAYBURN (MC | B | 4533.8 | 586.6 | 3627.8 | 152.0 | 167.4 | 83 | 27 | 29 | 10 | 897 | 759 | 197 | 171 |
| 26 | 360 O C FISHER (SAN | B | 88.3 | 19.0 | 9.0 | 42.3 | 18.0 | 53 | 130 | 22 | 25 | 4006 | 2113 | 10242 | 26 |
| 26 | 361 SOMERVILLE | A | 731.7 | 69.2 | 747.0 | 0.0 | -84.5 | 111 | 66 | 45 | 20 | 1679 | 1225 | 249 | 90 |

Table 7 (continued)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

| DIS | RES | GP | QIN | QEVAP | QOUT | QSTOR | QNET | IPTL | OPTL | IPDS | OPDS | INTL | ONTL | ININ | ONIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 WATERBURY | B | 300.9 | 2.1 | 292.8 | 10.8 | -4.8 | 23 | 18 | 7 | 6 | 917 | 607 | 500 | 397 |
| 03 | 307 BELTZVILLE | A | 210.5 | 3.1 | 208.0 | -1.9 | 1.3 | 13 | 11 | 7 | 7 | 1143 | 1149 | 694 | 739 |
| 04 | 312 F J SAYERS (BLA | A | 478.6 | 3.5 | 460.9 | -7.5 | 21.8 | 167 | 83 | 106 | 42 | 2670 | 2032 | 1790 | 1236 |
| 06 | 372 JOHN H KERR | A | 7412.7 | 196.2 | 7262.4 | -78.5 | 32.5 | 129 | 26 | 36 | 13 | 1315 | 1225 | 354 | 302 |
| 08 | 074 CLARK HILL | A | 12064.8 | 300.7 | 11483.1 | 112.6 | 168.5 | 54 | 24 | 16 | 9 | 679 | 892 | 267 | 225 |
| 08 | 330 HARTWELL | A | 5781.9 | 228.9 | 5801.8 | 122.9 | -371.6 | 52 | 9 | 20 | 6 | 669 | 1004 | 248 | 208 |
| 10 | 003 HOLT | A | 10077.9 | 14.2 | 10372.6 | -0.4 | -308.5 | 39 | 34 | 11 | 10 | 1272 | 1676 | 622 | 824 |
| 10 | 069 ALLATOONA | A | 2454.8 | 42.1 | 2480.1 | 22.7 | -90.0 | 75 | 26 | 16 | 9 | 722 | 562 | 297 | 220 |
| 10 | 071 SEMINOLE (WOODR | A | 26483.7 | 180.2 | 26808.1 | 6.7 | -511.3 | 94 | 76 | 30 | 23 | 1397 | 1334 | 442 | 314 |
| 10 | 072 WALTER F GEORGE | A | 12843.2 | 192.0 | 12518.1 | -11.7 | 144.8 | 93 | 90 | 33 | 33 | 1017 | 1145 | 423 | 462 |
| 10 | 076 SIDNEY LANIER | A | 3434.2 | 161.5 | 2646.5 | 80.2 | 546.1 | 75 | 19 | 31 | 5 | 986 | 801 | 447 | 412 |
| 10 | 411 BANKHEAD | A | 9272.3 | 41.4 | 9522.7 | 5.9 | -297.7 | 64 | 53 | 15 | 11 | 1672 | 1557 | 911 | 728 |
| 14 | 099 RED ROCK | A | 4964.5 | 48.5 | 4981.3 | -202.6 | 137.3 | 606 | 217 | 179 | 120 | 9375 | 7298 | 7059 | 5952 |
| 15 | 178 GULL | B | 176.3 | 37.4 | 148.8 | 1.8 | -11.8 | 28 | 19 | 10 | 8 | 937 | 647 | 242 | 52 |
| 15 | 181 LEECH | B | 751.5 | 300.0 | 368.6 | -58.3 | 141.2 | 34 | 22 | 17 | 9 | 1569 | 1134 | 367 | 436 |
| 15 | 237 ASHTABULA (BALD | A | 184.0 | 16.0 | 163.4 | 1.3 | 3.3 | 269 | 225 | 142 | 174 | 2627 | 2211 | 708 | 512 |
| 16 | 243 BERLIN | A | 276.6 | 9.5 | 280.2 | -9.1 | -4.0 | 253 | 58 | 146 | 21 | 2808 | 2109 | 1736 | 1165 |
| 16 | 254 MOSQUITO CREEK | B | 116.3 | 22.7 | 94.8 | -1.6 | 0.3 | 148 | 59 | 64 | 15 | 1862 | 1747 | 922 | 370 |
| 16 | 317 SHENANGO RIVER | A | 665.2 | 10.2 | 812.0 | -6.9 | -150.0 | 96 | 70 | 35 | 13 | 1497 | 1491 | 698 | 656 |
| 16 | 328 ALLEGHENY (KINZ | A | 3893.9 | 31.4 | 3647.9 | -60.0 | 274.6 | 45 | 31 | 12 | 9 | 682 | 1301 | 371 | 640 |
| 16 | 393 TYGART | B | 2938.0 | 4.5 | 2912.9 | 0.7 | 19.8 | 20 | 32 | 6 | 9 | 604 | 676 | 451 | 497 |
| 17 | 241 ATWOOD | A | 108.3 | 4.9 | 89.5 | -2.0 | 15.9 | 84 | 28 | 20 | 9 | 2296 | 948 | 1479 | 362 |
| 17 | 242 BEACH CITY | A | 310.7 | 2.0 | 288.3 | -0.4 | 20.8 | 256 | 210 | 53 | 36 | 4082 | 3811 | 2979 | 2565 |
| 17 | 245 CHARLES MILL | A | 279.5 | 4.9 | 280.2 | -2.2 | -3.3 | 173 | 156 | 50 | 26 | 3235 | 2920 | 1862 | 1411 |
| 17 | 247 DEER CREEK | B | 379.3 | 3.9 | 368.1 | -0.2 | 7.5 | 91 | 128 | 35 | 59 | 3180 | 3920 | 2342 | 3113 |
| 17 | 248 DELAWARE | A | 424.7 | 4.0 | 425.9 | -0.1 | -5.1 | 265 | 175 | 94 | 72 | 4461 | 4001 | 3214 | 2868 |
| 17 | 249 DILLON | A | 1023.3 | 5.8 | 1020.7 | -1.7 | -1.5 | 168 | 130 | 91 | 49 | 2562 | 2588 | 1661 | 1750 |
| 17 | 256 PLEASANT HILL | A | 221.8 | 2.4 | 205.3 | -1.1 | 15.2 | 55 | 56 | 25 | 28 | 2023 | 1560 | 1397 | 1006 |
| 17 | 258 TAPPAN | B | 57.9 | 8.0 | 61.6 | 0.0 | -3.9 | 29 | 30 | 10 | 9 | 996 | 1088 | 623 | 139 |
| 17 | 373 JOHN W FLANNAGA | A | 424.0 | 5.4 | 397.5 | 2.9 | 18.1 | 77 | 12 | 7 | 5 | 1291 | 1341 | 431 | 382 |
| 17 | 389 BLUESTONE | A | 6991.1 | 12.0 | 6611.7 | 132.5 | 234.9 | 46 | 46 | 18 | 19 | 1387 | 1418 | 1013 | 1062 |
| 17 | 391 SUMMERSVILLE | A | 2311.2 | 5.4 | 2353.7 | -1.0 | -46.9 | 24 | 15 | 7 | 7 | 914 | 858 | 698 | 701 |
| 18 | 092 MISSISSINEWA | A | 1020.8 | 10.5 | 1032.6 | 0.0 | -22.3 | 333 | 132 | 106 | 61 | 5639 | 3955 | 3397 | 2908 |
| 18 | 093 MONROE | A | 546.7 | 39.3 | 515.8 | -15.3 | 7.0 | 28 | 13 | 8 | 6 | 869 | 701 | 553 | 351 |
| 18 | 120 BARREN RIVER | A | 2314.2 | 33.7 | 1797.6 | 123.7 | 359.2 | 54 | 47 | 45 | 18 | 1987 | 1239 | 1067 | 877 |
| 19 | 119 BARKLEY | A | 48061.6 | 219.9 | 50941.7 | 48.4 | -3148.4 | 133 | 122 | 48 | 42 | 1182 | 1138 | 634 | 505 |
| 19 | 122 CUMBERLAND (WOL | A | 14746.2 | 171.0 | 15174.7 | -826.6 | 227.1 | 57 | 34 | 12 | 8 | 1026 | 905 | 373 | 608 |
| 19 | 338 CHEATHAM | B | 34315.9 | 28.9 | 35726.5 | 16.7 | -1456.2 | 170 | 255 | 61 | 75 | 1147 | 969 | 487 | 449 |
| 19 | 340 J PERCY PRIEST | A | 2427.3 | 52.1 | 2190.7 | -79.0 | 263.4 | 136 | 103 | 90 | 56 | 859 | 886 | 682 | 522 |
| 19 | 342 OLD HICKORY | A | 27504.0 | 82.8 | 28375.0 | -10.8 | -943.0 | 106 | 94 | 32 | 26 | 1006 | 927 | 452 | 414 |
| 19 | 343 DALE HOLLOW | A | 2986.7 | 97.7 | 2348.4 | -68.1 | 608.7 | 17 | 8 | 7 | 6 | 635 | 1485 | 362 | 818 |
| 20 | 081 CARLYLE | A | 3822.7 | 117.0 | 3956.2 | -210.6 | -39.9 | 192 | 121 | 60 | 57 | 4078 | 3599 | 2873 | 2100 |

Table 7 (concluded)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

| DIS | RES | | GP | QIN | QEVAP | QOUT | QSTOR | QNET | IPTL | OPTL | IPDS | OPDS | INTL | ONTL | ININ | ONIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 362 | STILLHOUSE HOLL | A | 695.2 | 38.1 | 714.1 | -26.1 | -30.9 | 46 | 17 | 14 | 6 | 1295 | 649 | 423 | 258 |
| 26 | 364 | WHITNEY | B | 2154.2 | 121.4 | 1985.0 | 193.6 | -145.8 | 285 | 14 | 45 | 10 | 1633 | 1219 | 363 | 818 |
| 28 | 219 | CONCHAS | B | 18.2 | 28.2 | 53.2 | -59.3 | -3.8 | 85 | 37 | 30 | 6 | 1662 | 1535 | 633 | 59 |
| 29 | 100 | RATHBUN | B | 256.3 | 42.3 | 175.2 | -3.7 | 42.6 | 384 | 53 | 122 | 10 | 2808 | 1734 | 1847 | 831 |
| 29 | 106 | KANOPOLIS | A | 267.7 | 18.9 | 193.8 | 37.9 | 17.2 | 543 | 90 | 128 | 29 | 2475 | 1584 | 569 | 436 |
| 29 | 108 | MILFORD | A | 574.2 | 89.1 | 456.7 | 30.4 | -2.0 | 449 | 60 | 178 | 28 | 2339 | 1491 | 832 | 237 |
| 29 | 109 | MELVERN | B | 262.7 | 36.6 | 210.3 | 31.7 | -16.0 | 199 | 36 | 40 | 13 | 3638 | 1734 | 851 | 386 |
| 29 | 110 | PERRY | B | 379.2 | 60.3 | 370.8 | -9.1 | -42.8 | 410 | 62 | 117 | 20 | 2844 | 1188 | 1465 | 671 |
| 29 | 111 | POMONA | A | 217.1 | 20.8 | 243.5 | -5.1 | -42.1 | 128 | 59 | 49 | 15 | 2983 | 2280 | 982 | 722 |
| 29 | 113 | TUTTLE CREEK | A | 1522.3 | 94.6 | 1491.7 | 65.5 | -129.5 | 990 | 136 | 256 | 77 | 4604 | 2298 | 1754 | 1197 |
| 29 | 114 | WILSON | B | 96.8 | 53.4 | 83.5 | -8.3 | -31.7 | 204 | 38 | 39 | 12 | 1794 | 1083 | 504 | 237 |
| 29 | 194 | POMME DE TERRE | B | 678.6 | 35.3 | 676.9 | -3.7 | -30.0 | 41 | 65 | 42 | 31 | 1758 | 1776 | 482 | 411 |
| 29 | 195 | STOCKTON | B | 1367.0 | 111.8 | 1376.4 | 14.8 | -136.1 | 70 | 20 | 31 | 7 | 2508 | 2754 | 1410 | 582 |
| 29 | 207 | HARLAN COUNTY | A | 253.4 | 65.4 | 172.7 | -24.7 | 40.0 | 304 | 122 | 261 | 66 | 5182 | 1235 | 693 | 178 |
| 30 | 064 | CHERRY CREEK | B | 2.4 | 4.1 | 2.4 | 0.0 | -4.1 | 246 | 161 | 108 | 83 | 2758 | 1480 | 1292 | 365 |
| 30 | 215 | PAWNEE | B | 8.0 | 3.3 | 3.0 | 0.2 | 1.5 | 278 | 251 | 163 | 76 | 1898 | 1691 | 665 | 689 |
| 30 | 217 | BRANCHED OAK | B | 21.4 | 8.0 | 9.4 | 1.0 | 2.9 | 291 | 255 | 176 | 189 | 2981 | 1470 | 1188 | 714 |
| 30 | 235 | SAKAKAWEA(GARRI | A | 32990.3 | 1341.9 | 28651.0 | 1515.6 | 1481.7 | 341 | 27 | 21 | 12 | 1369 | 547 | 170 | 167 |
| 31 | 077 | DWORSHAK | A | 5847.7 | 39.2 | 5513.5 | -191.5 | 486.5 | 19 | 17 | 8 | 8 | 689 | 387 | 35 | 78 |
| 32 | 204 | KOOKANUSA(LIBBY | B | 4962.8 | 85.3 | 9670.4 | -0.6 | -4792.3 | 23 | 24 | 8 | 20 | 252 | 434 | 36 | 86 |
| 33 | 300 | HILLS CREEK | A | 1139.1 | 5.4 | 1127.8 | -24.9 | 30.8 | 40 | 36 | 31 | 24 | 189 | 246 | 32 | 48 |
| 34 | 048 | NEW DON PEDRO | B | 2071.6 | 61.7 | 2042.9 | 163.1 | -196.1 | 34 | 16 | 18 | 8 | 815 | 1069 | 87 | 122 |
| 35 | 029 | MENDOCINO | A | 407.7 | 6.5 | 365.9 | 18.3 | 17.0 | 127 | 63 | 26 | 25 | 931 | 750 | 149 | 118 |
| 35 | 039 | SANTA MARGARITA | B | 10.1 | 3.8 | 4.9 | -3.8 | 5.2 | 69 | 26 | 33 | 9 | 487 | 463 | 302 | 30 |

log(concentration) vs. log(flow) relationship across all gauged tributaries, precipitation, and ungauged inputs. In computing the average b values, precipitation and ungauged inputs are assumed to have b values of zero. The above calculations have been repeated to calculate inflow concentrations for normal hydrologic years. No reasonable means of correcting average outflow concentrations for changes in flow regime are available, since they would depend upon reservoir nutrient dynamics. Thus, outflow concentrations can be validly compared only with inflow concentrations corresponding to periods of tributary and outflow sampling.

52. Results of the above calculations are tabulated in Appendix B, Table B2, which lists the terms of the water balance, estimated inflow concentrations, and average morphometric characteristics for each monitoring period and reservoir. Morphometric properties during "normal" hydrologic years refer to normal summer pool levels, as identified in the morphometric file; otherwise summer pool levels typical of the EPA/NES monitoring periods have been used. Supplementary files describing average spring and summer morphometric and hydrologic characteristics during the tributary and pool monitoring periods have also been assembled for use in model testing.

53. In relating inflow concentrations to outflow or pool concentrations, evaporation may have significant effects. If the nutrient behaved conservatively, for example, the outflow and pool concentrations would tend to be higher than the inflow concentrations, especially if evaporation accounts for a large portion of the total outflow. In using the inflow concentration data for model testing, a final adjustment has been applied for each time period, nutrient, and reservoir:

$$CICE = CIC / (1-FE) \qquad (35)$$

where,

CICE = inflow concentration, adjusted for evaporation (g/m3)

FE = evaporation / total inflow

With some algebra, it can be shown that the above adjustment scheme is equivalent to defining the average inflow concentration as the total loading divided by the reservoir discharge (when the flow-balance error and change-in-storage terms are negligible).

54. The significance of the correction depends upon the inflow ratio (QI′/QIC), point-source significance (F), flow/concentration sensitivity (b), and evaporation significance (FE). Table 8 summarizes the distributions of the hydrologic correction factors applied above. In the case of total phosphorus, inflow concentrations are modified by less than 10% in all but 9 of the 102 projects with sufficient data to make the corrections to pool monitoring year. The significance of the concentration corrections in relation to the errors which are inherent in this modelling approach seems small, but will be examined. Of potentially greater importance are the year-to-year variations in inflow rates and their resultant impacts on pool hydraulic residence times. Table 8 indicates that inflows during the tributary and pool monitoring periods tended to be greater than average by roughly 50% in both cases (median values). Formulating the inflow conditions in terms of concentration and flow shows that average inflow concentrations are much less sensitive to hydrologic variations than are average loadings. This is fortunate, since model predictions are more sensitive to inflow concentrations than to loadings (see <u>Water Balances</u>).

55. As a means of selecting projects with relatively reliable information for use in model testing, a set of screening criteria has been designed and applied to the total phosphorus budget of each reservoir. The definitions and distributions of the ranking statistics are given in Table 9. The first three criteria reflect water balance accuracy, loading accuracy, and significance of ungauged nutrient sources. The fourth is the ratio of the mean tributary flows on days when concentrations were measured to the mean tributary flows over the entire monitoring period. This has been included to reflect the potential errors involved in estimating loadings if the streamflows on the days in which concentration samples were taken were not representative of the annual period. To some extent, the calculation procedure used in estimating loadings corrects for the effects of flow

Table 8

Distributions of Water and Phosphorus Inflow Adjustment Factors for Pool Sampling, Tributary Sampling, and Normal Hydrologic Years

| | PERCENTILE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable* | 1% | 5% | 10% | 25% | 50% | 75% | 90% | 95% | 99% |
| Inflow Ratios | | | | | | | | | |
| pool/trib | 0.23 | 0.43 | 0.63 | 0.93 | 1.04 | 1.23 | 1.79 | 2.40 | 6.20 |
| pool/normal | 0.33 | 0.54 | 0.86 | 1.25 | 1.48 | 1.75 | 1.92 | 2.12 | 2.41 |
| trib/normal | 0.09 | 0.67 | 0.87 | 1.18 | 1.47 | 1.68 | 2.00 | 2.28 | 2.46 |
| Inflow Total P Concentration Ratios | | | | | | | | | |
| pool/trib | 0.61 | 0.93 | 0.96 | 0.99 | 1.00 | 1.02 | 1.06 | 1.20 | 1.66 |
| pool/normal | 0.80 | 0.84 | 0.87 | 0.98 | 1.01 | 1.04 | 1.15 | 1.20 | 1.44 |
| trib/normal | 0.81 | 0.86 | 0.90 | 0.97 | 1.00 | 1.03 | 1.14 | 1.14 | 1.31 |

* pool = pool monitoring year
trib = tributary monitoring year
normal= normal hydrologic year

Table 9

Statistics Used for Screening Nutrient Budgets

Definitions:

K1 = error in water balance = QN/QI
K2 = coef. of variation of total P loading = CV(WI)
K3 = ungauged loading fraction = (WP + WU)/WI
K4 = inflow sampling ratio = QIS/QIM
K5 = total P retention coefficient = 1 - Po (1-FE) / Pi
K6 = pool year inflow/tributary year inflow = QI′/QI

where,

Po = average outflow total P concentration, $gm/m^3$
Pi = average inflow total P concentration, $gm/m^3$
QIS = mean inflow on tributary sampling days, $hm^3/yr$
QIM = mean inflow over monitoring period, $hm^3/yr$
FE = evaporation/total inflow

| | Percentile | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5% | 10% | 50% | 90% | 95% | criterion | number* |
| K1 | -.26 | -.11 | .01 | .15 | .20 | \|K1\| < .25 | 100 |
| K2 | .05 | .06 | .14 | .39 | .58 | K2 < .40 | 99 |
| K3 | .01 | .02 | .11 | .37 | .47 | K3 < .25 | 84 |
| K4 | .43 | .53 | .93 | 1.47 | 1.60 | .5 < K4 < 2.0 | 97 |
| K5 | -.78 | -.40 | .47 | .85 | .91 | K5 > -.2 | 94 |
| K6 | | | - | | | K6 is nonmissing | 102 |
| all | | | | | | - | 62 ** |

* number of reservoirs satisfying criterion (total = 108)
** satisfy all criteria applied simultaneously

variations; these corrections are limited, however, particularly if important flow regimes (e.g., high-flow seasons or events) were not included in the range of conditions sampled. The fifth criterion has been included to eliminate those projects in which unsteady-state conditions and/or omissions of significant nutrient sources in the sampling program might have resulted in retention coefficients which are considerably less than zero. The sixth criterion requires hydrologic data availability during both the tributary and the pool monitoring periods.

56. Reservoirs have been placed into group A when all of the above criteria have been satisfied, and group B when they have not. A listing of the criteria values and groupings is given in Table 10. Groupings are also identified in Appendix B, Tables B2-B4. The 62 "A" projects conforming to each of the above criteria have been keyed into the nutrient budget files and used as the principal data base for model testing. The distributions of various morphometric, hydrologic, and nutrient concentration statistics for reservoirs in this group are summarized in Table 11.

## Water Quality Data

57. To provide a basis for testing internal and load/response relationships, water quality data have been retrieved from the OBS file (see Figure 1) and averaged by station and growing season. Station-year averages have been used for testing internal models (relationships among trophic state indicators measured within reservoir pools). In testing load/response models, station-year averages have been averaged by reservoir. Because of the significance of spatial gradients in many reservoirs, spatial averaging can be difficult without detailed consideration of reservoir morphometry in relation to sampling station location. This type of detail has not been feasible within the current project scope. Thus, the reservoir-average water quality conditions do not include spatial weighting factors or account for possible variations in water quality, either along the mainstem or among tributary arms.

Table 10

Listing of Nutrient and Water Balance Screening Criteria

(note: statistics defined in Table 9)

| DIS | RES | | GP | K1 | K2 | K3 | K4 | K5 | K6 |
|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | WATERBURY | B | -0.02 | 0.18 | 0.33 * | 0.71 | 0.22 | . * |
| 03 | 307 | BELTZVILLE | A | 0.01 | 0.10 | 0.14 | 0.94 | 0.19 | 1.02 |
| 04 | 312 | F J SAYERS (BLA | A | 0.05 | 0.27 | 0.01 | 1.24 | 0.51 | 1.04 |
| 06 | 372 | JOHN H KERR | A | 0.00 | 0.08 | 0.02 | 0.93 | 0.80 | 1.47 |
| 08 | 074 | CLARK HILL | A | 0.01 | 0.17 | 0.05 | 1.12 | 0.56 | 1.05 |
| 08 | 330 | HARTWELL | A | -0.06 | 0.07 | 0.09 | 1.03 | 0.83 | 0.94 |
| 10 | 003 | HOLT | A | -0.03 | 0.13 | 0.02 | 0.84 | 0.11 | 0.92 |
| 10 | 069 | ALLATOONA | A | -0.04 | 0.12 | 0.11 | 0.99 | 0.66 | 1.04 |
| 10 | 071 | SEMINOLE (WOODR | A | -0.02 | 0.05 | 0.02 | 0.89 | 0.20 | 1.08 |
| 10 | 072 | WALTER F GEORGE | A | 0.01 | 0.05 | 0.01 | 1.12 | 0.05 | 1.03 |
| 10 | 076 | SIDNEY LANIER | A | 0.16 | 0.16 | 0.17 | 0.82 | 0.77 | 1.04 |
| 10 | 411 | BANKHEAD | A | -0.03 | 0.14 | 0.01 | 0.87 | 0.18 | 0.92 |
| 14 | 099 | RED ROCK | A | 0.03 | 0.17 | 0.01 | 1.35 | 0.65 | 1.93 |
| 15 | 178 | GULL | B | -0.07 | 0.14 | 0.34 * | 0.99 | 0.46 | 1.29 |
| 15 | 181 | LEECH | B | 0.19 | 0.22 | 0.60 * | 1.05 | 0.66 | 1.45 |
| 15 | 237 | ASHTABULA (BALD | A | 0.02 | 0.22 | 0.08 | 1.74 | 0.24 | 1.26 |
| 16 | 243 | BERLIN | A | -0.01 | 0.09 | 0.14 | 0.98 | 0.78 | 1.14 |
| 16 | 254 | MOSQUITO CREEK | B | 0.00 | 0.60 * | 0.47 * | 2.43 * | 0.68 | 1.07 |
| 16 | 317 | SHENANGO RIVER | A | -0.23 | 0.11 | 0.02 | 1.00 | 0.28 | 1.01 |
| 16 | 328 | ALLEGHENY (KINZ | A | 0.07 | 0.20 | 0.04 | 1.17 | 0.32 | 1.03 |
| 16 | 393 | TYGART | B | 0.01 | 0.11 | 0.13 | 1.04 | -0.59 * | 0.88 |
| 17 | 241 | ATWOOD | A | 0.15 | 0.11 | 0.15 | 0.52 | 0.69 | 0.88 |
| 17 | 242 | BEACH CITY | A | 0.07 | 0.21 | 0.15 | 1.37 | 0.18 | 1.32 |
| 17 | 245 | CHARLES MILL | A | -0.01 | 0.19 | 0.04 | 1.04 | 0.11 | 1.12 |
| 17 | 247 | DEER CREEK | B | 0.02 | 0.14 | 0.03 | 0.92 | -0.39 * | 1.07 |
| 17 | 248 | DELAWARE | A | -0.01 | 0.12 | 0.14 | 0.85 | 0.34 | 1.24 |
| 17 | 249 | DILLON | A | -0.00 | 0.17 | 0.02 | 0.67 | 0.23 | 1.06 |
| 17 | 256 | PLEASANT HILL | A | 0.07 | 0.11 | 0.06 | 0.78 | 0.01 | 1.23 |
| 17 | 258 | TAPPAN | B | -0.07 | 0.13 | 0.58 * | 0.87 | 0.11 | 1.38 |
| 17 | 373 | JOHN W FLANNAGA | A | 0.04 | 0.16 | 0.21 | 0.97 | 0.84 | 0.80 |
| 17 | 389 | BLUESTONE | A | 0.03 | 0.07 | 0.02 | 0.99 | 0.01 | 0.98 |
| 17 | 391 | SUMMERSVILLE | A | -0.02 | 0.13 | 0.05 | 1.08 | 0.37 | 1.10 |
| 18 | 092 | MISSISSINEWA | A | -0.02 | 0.25 | 0.04 | 0.78 | 0.61 | 1.05 |
| 18 | 093 | MONROE | A | 0.01 | 0.09 | 0.21 | 0.72 | 0.58 | 1.27 |
| 18 | 120 | BARREN RIVER | A | 0.16 | 0.04 | 0.08 | 0.77 | 0.15 | 0.95 |
| 19 | 119 | BARKLEY | A | -0.07 | 0.09 | 0.01 | 0.99 | 0.08 | 1.00 |
| 19 | 122 | CUMBERLAND (WOL | A | 0.02 | 0.17 | 0.12 | 1.14 | 0.42 | 0.86 |
| 19 | 338 | CHEATHAM | B | -0.04 | 0.15 | 0.05 | 1.10 | -0.50 * | 0.91 |
| 19 | 340 | J PERCY PRIEST | A | 0.11 | 0.10 | 0.11 | 0.53 | 0.26 | 1.00 |
| 19 | 342 | OLD HICKORY | A | -0.03 | 0.17 | 0.11 | 1.10 | 0.11 | 0.87 |
| 19 | 343 | DALE HOLLOW | A | 0.20 | 0.05 | 0.12 | 0.60 | 0.52 | 0.91 |
| 20 | 081 | CARLYLE | A | -0.01 | 0.09 | 0.05 | 0.90 | 0.39 | 1.01 |
| 20 | 087 | SHELBYVILLE | A | -0.04 | 0.12 | 0.10 | 0.83 | 0.39 | 0.98 |
| 20 | 088 | REND | A | 0.06 | 0.18 | 0.16 | 1.00 | 0.72 | 0.94 |
| 21 | 196 | WAPPAPELLO | B | -0.11 | 0.90 * | 0.07 | 1.59 | 0.44 | 1.15 |
| 22 | 014 | DE GRAY | B | 0.01 | 0.06 | 0.31 * | 0.42 * | -0.25 * | 0.36 |
| 22 | 019 | OUACHITA (BLAKE | B | 0.02 | 0.09 | 0.34 * | 0.67 | 0.28 | 0.93 |
| 22 | 188 | ARKABUTLA | B | 0.48 * | 0.05 | 0.08 | 0.33 * | -1.54 * | 1.43 |
| 22 | 189 | ENID | A | 0.02 | 0.23 | 0.01 | 1.00 | 0.77 | 1.07 |
| 22 | 190 | GRENADA | B | 0.28 * | 0.04 | 0.01 | 0.45 * | 0.14 | 1.05 |
| 22 | 192 | SARDIS | B | 0.03 | 0.04 | 0.06 | 0.41 * | 0.77 | 1.13 |
| 23 | 352 | LAKE OF THE PIN | B | -0.01 | 0.14 | 0.26 * | 1.21 | 0.74 | . * |
| 23 | 353 | TEXARKANA(WRIGH | B | 0.13 | 0.16 | 0.28 * | 1.26 | -0.07 | . * |
| 23 | 413 | CADDO | B | -0.10 | 0.11 | 0.06 | 1.09 | 0.10 | . * |

Table 10 (continued)

| DIS | RES | | GP | K1 | K2 | K3 | K4 | K5 | K6 |
|---|---|---|---|---|---|---|---|---|---|
| 24 | 011 | BEAVER | A | 0.04 | 0.20 | 0.16 | 0.94 | 0.74 | 1.01 |
| 24 | 012 | BLUE MOUNTAIN | B | 0.00 | 0.17 | 0.09 | 0.57 | -1.88 * | 0.75 |
| 24 | 013 | BULL SHOALS | A | 0.01 | 0.14 | 0.12 | 0.91 | 0.32 | 0.98 |
| 24 | 016 | GREERS FERRY | B | 0.02 | 0.42 * | 0.42 * | 1.51 | 0.67 | 0.98 |
| 24 | 021 | NIMROD | B | 0.02 | 0.11 | 0.13 | 0.57 | -0.29 * | 0.75 |
| 24 | 022 | NORFOLK | B | 0.03 | 0.10 | 0.18 | 0.77 | -0.25 * | 1.23 |
| 24 | 193 | CLEARWATER | B | -0.05 | 0.13 | 0.14 | 0.98 | -1.50 * | 1.33 |
| 24 | 200 | TABLE ROCK | A | -0.04 | 0.09 | 0.07 | 1.24 | 0.63 | 1.09 |
| 25 | 020 | MILLWOOD | A | -0.00 | 0.14 | 0.22 | 0.58 | 0.23 | 0.84 |
| 25 | 102 | COUNCIL GROVE | B | 0.05 | 0.46 * | 0.36 * | 1.48 | 0.75 | 1.81 |
| 25 | 103 | ELK CITY | B | 0.14 | 0.05 | 0.26 * | 0.32 * | -0.79 * | 0.97 |
| 25 | 104 | FALL RIVER | B | 0.07 | 0.07 | 0.28 * | 0.56 | -1.18 * | 1.09 |
| 25 | 105 | JOHN REDMOND | A | 0.02 | 0.11 | 0.10 | 0.81 | 0.53 | 1.43 |
| 25 | 107 | MARION | B | 0.06 | 0.39 | 0.36 * | 2.55 * | 0.77 | 2.02 |
| 25 | 112 | TORONTO | B | -0.27 * | 0.06 | 0.25 | 0.78 | -0.65 * | 1.23 |
| 25 | 267 | EUFAULA | A | -0.02 | 0.06 | 0.06 | 0.98 | 0.47 | 0.76 |
| 25 | 269 | FORT SUPPLY | A | 0.01 | 0.23 | 0.19 | 1.17 | 0.30 | 1.09 |
| 25 | 273 | KEYSTONE | A | -0.04 | 0.15 | 0.04 | 0.76 | 0.72 | 1.00 |
| 25 | 275 | OOLOGAH | B | -0.10 | 0.62 * | 0.03 | 1.56 | 0.62 | 1.07 |
| 25 | 278 | TENKILLER FERRY | A | -0.01 | 0.14 | 0.07 | 0.88 | 0.49 | 1.07 |
| 25 | 281 | WISTER | A | 0.02 | 0.12 | 0.11 | 0.61 | 0.01 | 0.93 |
| 25 | 348 | TEXOMA (DENNISO | A | -0.03 | 0.31 | 0.02 | 1.17 | 0.77 | 0.61 |
| 25 | 370 | KEMP | B | -0.25 | 0.49 * | 0.20 | 0.77 | 0.47 | 0.54 |
| 26 | 345 | BELTON(BELL) | B | -0.59 * | 0.06 | 0.21 | 0.63 | 0.95 | 0.25 |
| 26 | 347 | CANYON | A | 0.05 | 0.19 | 0.11 | 1.05 | 0.39 | 0.58 |
| 26 | 354 | LAVON | A | 0.12 | 0.32 | 0.02 | 1.47 | 0.79 | 0.60 |
| 26 | 355 | LEWISVILLE(GARZ | A | -0.05 | 0.30 | 0.11 | 1.30 | 0.70 | 0.42 |
| 26 | 359 | SAM RAYBURN (MC | B | 0.04 | 0.06 | 0.32 * | 0.99 | 0.72 | . * |
| 26 | 360 | O C FISHER (SAN | B | 0.20 | 0.05 | 0.21 | 0.15 * | -0.78 * | 1.01 |
| 26 | 361 | SOMERVILLE | A | -0.12 | 0.09 | 0.16 | 0.59 | 0.46 | 0.56 |
| 26 | 362 | STILLHOUSE HOLL | A | -0.04 | 0.34 | 0.05 | 0.71 | 0.65 | 0.36 |
| 26 | 364 | WHITNEY | B | -0.07 | 1.32 * | 0.01 | 1.59 | 0.95 | 0.22 |
| 28 | 219 | CONCHAS | B | -0.21 | 0.56 * | 0.41 * | 2.26 * | 1.12 | 6.31 |
| 29 | 100 | RATHBUN | B | 0.17 | 0.06 | 0.35 * | 0.65 | 0.89 | 2.24 |
| 29 | 106 | KANOPOLIS | A | 0.06 | 0.15 | 0.08 | 0.51 | 0.85 | 2.44 |
| 29 | 108 | MILFORD | A | -0.00 | 0.08 | 0.08 | 0.85 | 0.89 | 2.47 |
| 29 | 109 | MELVERN | B | -0.06 | 0.26 | 0.46 * | 0.68 | 0.84 | . * |
| 29 | 110 | PERRY | B | -0.11 | 0.06 | 0.05 | 0.49 * | 0.87 | 2.05 |
| 29 | 111 | POMONA | A | -0.19 | 0.27 | 0.18 | 0.93 | 0.57 | 1.04 |
| 29 | 113 | TUTTLE CREEK | A | -0.09 | 0.07 | 0.02 | 0.85 | 0.87 | 1.61 |
| 29 | 114 | WILSON | B | -0.33 * | 0.18 | 0.06 | 0.70 | 0.89 | 1.75 |
| 29 | 194 | POMME DE TERRE | B | -0.04 | 0.25 | 0.13 | 0.60 | -0.51 * | 0.92 |
| 29 | 195 | STOCKTON | B | -0.10 | 0.22 | 0.41 * | 1.08 | 0.73 | 1.08 |
| 29 | 207 | HARLAN COUNTY | A | 0.16 | 0.09 | 0.03 | 0.58 | 0.72 | 1.28 |
| 30 | 064 | CHERRY CREEK | B | -1.71 * | 0.96 * | 0.23 | 1.62 | 0.76 | 0.99 |
| 30 | 215 | PAWNEE | B | 0.19 | 0.08 | 0.30 * | 0.60 | 0.55 | 2.43 |
| 30 | 217 | BRANCHED OAK | B | 0.14 | 0.11 | 0.37 * | 0.49 * | 0.50 | 2.76 |
| 30 | 235 | SAKAKAWEA(GARRI | A | 0.04 | 0.24 | 0.03 | 1.16 | 0.92 | 0.67 |
| 31 | 077 | DWORSHAK | A | 0.08 | 0.21 | 0.21 | 1.17 | 0.14 | 1.01 |
| 32 | 204 | KOOKANUSA(LIBBY | B | -0.97 * | 0.07 | 0.79 * | 0.88 | -0.05 | 1.07 |
| 33 | 300 | HILLS CREEK | A | 0.03 | 0.12 | 0.20 | 1.17 | 0.11 | 1.03 |
| 34 | 048 | NEW DON PEDRO | B | -0.09 | 0.23 | 0.47 * | 0.90 | 0.53 | 0.99 |
| 35 | 029 | MENDOCINO | A | 0.04 | 0.35 | 0.10 | 1.36 | 0.52 | 1.01 |
| 35 | 039 | SANTA MARGARITA | B | 0.52 * | 0.39 | 0.36 * | 0.73 | 0.92 | 1.45 |

*SCREENING CRITERION VIOLATED

Table 11

Statistical Summary of Nutrient Concentration, Morphometric, and Hydrologic Data from 62 Reservoirs

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| IPTL | INFLOW TOTAL P (MG/M3) | 62 | 179.13 | 185.85 | 13.46 | 1050.46 |
| OPTL | OUTFLOW TOTAL P (MG/M3) | 62 | 72.17 | 56.67 | 8.29 | 224.80 |
| IPDS | INFLOW DISSOLVED P (MG/M3) | 62 | 61.97 | 67.92 | 6.68 | 375.65 |
| OPDS | OUTFLOW DISSOLVED P (MG/M3) | 62 | 30.52 | 30.44 | 5.22 | 174.14 |
| INTL | INFLOW TOTAL N (MG/M3) | 62 | 2214.49 | 1824.22 | 190.25 | 9469.81 |
| ONTL | OUTFLOW TOTAL N (MG/M3) | 62 | 1596.49 | 1266.84 | 245.54 | 7298.11 |
| CVI | COEF. OF VAR. OF INFLOW TOTAL P | 62 | 0.15 | 0.08 | 0.04 | 0.35 |
| CVO | COEF. OF VAR. OF OUTFLOW TOTAL P | 62 | 0.19 | 0.10 | 0.04 | 0.55 |
| RPTL | TOTAL P RETENTION COEF. | 62 | 0.46 | 0.27 | 0.01 | 0.92 |
| RNTL | TOTAL N RETENTION COEF. | 62 | 0.18 | 0.34 | -1.24 | 0.83 |
| SEDM | SEDIMENTATION RATE (KG/M2-YR) | 17 | 35.79 | 39.80 | 3.97 | 142.10 |
| ZMAX | MAXIMUM DEPTH (M) | 62 | 30.04 | 26.45 | 4.09 | 174.77 |
| ZMEA | MEAN DEPTH (M) | 62 | 9.81 | 8.97 | 1.53 | 57.59 |
| THYD | RESIDENCE TIME (YR) | 62 | 0.32 | 0.33 | 0.01 | 1.89 |
| QSOV | OVERFLOW RATE (M/YR) | 62 | 81.59 | 123.88 | 3.23 | 779.14 |
| SHDV | SHORELINE DEVELOPMENT RATIO | 59 | 10.92 | 8.06 | 2.57 | 34.18 |
| LNWD | LENGTH/WIDTH RATIO | 59 | 60.49 | 72.11 | 2.20 | 387.78 |
| DAWCSA | WATER CONTR DA / SURFACE AREA | 62 | 256.44 | 370.09 | 15.08 | 1966.83 |

The effects of the averaging procedures on the model evaluations warrant additional analysis. Thus, the accuracy of the reservoir averages depends, in part, upon reasonable distribution of sampling stations among representative areas of each reservoir, as was a key objective of the EPA/NES survey designs.

58. In reducing the station-year-average file, the first step has been to retrieve data for 1509 station-years with at least three total phosphorus sampling dates at pool monitoring locations. Additional requirements for at least two sampling dates for chlorophyll-a and transparency (Secchi depth) have been applied to yield a total of 525 station-years. The retrieval includes data from April through October at depths less than 15 feet, i.e., growing-season, surface-layer concentrations. In the first reduction stage, the data from each station, year, and sampling date have been averaged over depth:

$$Csi = \sum_{j=1}^{Nsi} Csij \;/\; Nsi \qquad (36)$$

where,

Csij = measurement for station s, date i, depth j

Nsi = number of depths sampled on date i

Csi = depth-averaged value on date i

The above variables refer to a given year and water quality variable. Because averaging is done within the surface layer, there is little point in applying areal weighting factors with depth. Depth-averaging is generally not applicable to chlorophyll because the samples themselves are depth-integrated. The next step is to average across dates within each year:

$$Cs = \sum_{i=1}^{Ns} Csi \;/\; Ns \qquad (37)$$

where,

Cs = station-year average

Ns = number of sampling dates for station-year s

The standard error of Cs has also been estimated (as the standard deviation divided by the square root of Ns) for total phosphorus, total nitrogen, chlorophyll-a, and transparency. Standard errors provide approximate means for assessing the reliability of the station-year summaries and are useful in error analyses. Estimates of maximum, spring-average, and summer-average conditions have also been computed for nutrients, chlorophyll, and transparency, where sampling schedules permit. Seasonal averages are of relatively low reliability, however, because they are based upon minimal data.

59. The following screening criteria have been applied to divide the station-year-average data set into two groups reflecting data reliability:

$$Ns(P,N,B,S) > 2 \quad (38)$$

$$CV(P,N,B,S) < .5 \quad (39)$$

where,

P = total phosphorus (mg/m3)

N = total N (mg/m3)

B = chlorophyll-a (mg/m3)

S = transparency (m)

CV(X) = coefficient of variation for mean X

The high-priority ("group A") data set used for model testing includes 258 station-years with at least 3 sampling dates and with coefficients of variation less than 0.5 for the above variables. All of the high-priority station-years also include measurements of ortho (or dissolved) phosphorus and inorganic nitrogen. In addition, the unaveraged data have been inspected to identify a few station-years with high percentages of low accuracy phosphorus measurements, based upon frequent recordings of < 20 mg/m3; for example. These data are derived from agencies other than the EPA/NES and have been placed in the low priority data set. A listing of the data is given in Appendix B, Table B3; the high-priority data are summarized in Table 12.

Table 12

Statistical Summary of High-Priority ("group A") Pool Water Quality Data from 258 Station-Years Passing Screening Procedures

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 258 | 56.63 | 52.23 | 4.89 | 293.19 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 223 | 18.82 | 25.92 | 2.83 | 220.91 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 35 | 25.44 | 28.98 | 10.00 | 155.00 |
| CNTL | TOTAL NITROGEN (MG/M3) | 258 | 981.94 | 857.06 | 236.45 | 6075.00 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 258 | 521.15 | 704.99 | 39.96 | 5064.16 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 218 | 10.61 | 11.77 | 0.97 | 83.41 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 40 | 13.85 | 7.91 | 2.68 | 31.25 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 218 | 16.11 | 16.67 | 1.30 | 97.00 |
| CSEC | SECCHI DEPTH (M) | 258 | 1.50 | 1.23 | 0.16 | 6.97 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 258 | 3.66 | 1.70 | 3.00 | 21.00 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 258 | 3.40 | 0.68 | 3.00 | 7.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 258 | 3.57 | 1.26 | 3.00 | 13.00 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 258 | 3.46 | 0.78 | 3.00 | 6.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 258 | 0.18 | 0.10 | 0.01 | 0.48 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 258 | 0.28 | 0.12 | 0.01 | 0.50 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 258 | 0.15 | 0.08 | 0.01 | 0.37 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 258 | 0.18 | 0.10 | 0.00 | 0.49 |
| CDEP | STATION DEPTH (M) | 227 | 21.25 | 27.38 | 1.22 | 175.38 |
| CPHF | PH (STANDARD UNITS) | 258 | 7.85 | 0.47 | 6.27 | 8.70 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 258 | 493.30 | 548.24 | 22.50 | 4948.16 |
| CALK | ALKALINITY (MG/L) | 255 | 96.61 | 57.36 | 10.00 | 309.28 |
| CTMP | TEMPERATURE (DEG-C) | 258 | 20.69 | 2.96 | 13.18 | 27.89 |
| CTRJ | TURDIBITY (JTU) | 3 | 17.89 | 2.59 | 16.37 | 20.88 |
| CTRH | HACH TURBIDITY (NTU) | 46 | 10.16 | 11.31 | 1.60 | 40.00 |
| CTRN | -LOG(% TRANS./100) | 209 | 0.35 | 0.43 | 0.02 | 2.48 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 17 | 56.49 | 37.62 | 15.00 | 105.00 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 258 | 0.87 | 0.79 | 0.08 | 6.02 |
| CRTL | TOTAL SOLIDS (MG/L) | 24 | 159.25 | 78.42 | 5.00 | 389.58 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 33 | 115.46 | 51.34 | 44.80 | 208.50 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 41 | 11.60 | 10.18 | 1.00 | 39.33 |
| CALG | ALGAL COUNT (NO/LITER) | 2 | 178350.00 | 157614.10 | 66900.00 | 289800.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 2 | 0.04 | 0.01 | 0.04 | 0.05 |

60. Means by reservoir-year have been calculated directly from the station-year averages. Based upon the variance component analyses conducted previcusly (Walker, 1980a, 1981), on the average, about half of within-station variance (expressed in logarithmic terms or, approximately, as coefficients of variation) can be attributed to variance between dates and about half to random effects. The following formula has been used to estimate the coefficients of variation of the reservoir mean phosphorus, nitrogen, chlorophyll, and transparency values computed from the station data summaries:

$$CV^2 = .5\ CVS^2\ [\ 1 + 1/M\ ]\ /\ N \qquad (40)$$

where,

$CV$ = coefficient of variation of reservoir mean estimate

$CVS^2$ = mean squared within-station coefficient of variation

N = average number of sampling dates

M = total number of stations in the reservoir

The effects of spatial variance on errors in the the reservoir means have not been included because of lack of spatial weighting factors and because serial, spatial correlation would tend to reduce their significance (Walker, 1980a, 1981). The above error equation assumes reasonable distribution of the stations among representative areas of the reservoir.

61. The screening procedures described above have also been applied to the reservoir-average data set, yielding a total of 86 high-priority and 72 low-priority reservoir-years for use in model testing. A listing is given in Appendix B, Table B4; the high-priority ("group A") data are summarized in Table 13.

62. In the high-priority data set, chlorophyll-a measurements for 50 out of 258 station-years were not corrected for phaeophytin, based upon the codes used in entering the data into STORET or the Ohio River Division (ORD) data base. The EPA/NES chlorophyll data are measured and corrected for phaeophytin according to the fluorometric method described by Yentch and Mentzel (1963) (personal communication, Frank

Table 13

Statistical Summary of High-Priority ("group A") Pool Water Quality Data from 85 Reservoir-Years Passing Screening Procedures

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 85 | 66.83 | 58.21 | 5.63 | 277.04 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 67 | 22.70 | 28.12 | 3.83 | 187.72 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 18 | 21.34 | 17.57 | 10.00 | 79.05 |
| CNTL | TOTAL NITROGEN (MG/M3) | 85 | 1159.05 | 973.24 | 247.34 | 6075.00 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 85 | 651.38 | 800.26 | 44.54 | 5064.16 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 65 | 13.04 | 11.52 | 1.18 | 67.13 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 20 | 9.73 | 6.56 | 2.68 | 27.47 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 65 | 20.97 | 17.48 | 1.73 | 84.19 |
| CSEC | SECCHI DEPTH (M) | 85 | 1.33 | 0.96 | 0.19 | 4.32 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 85 | 3.80 | 1.89 | 2.11 | 16.80 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 85 | 3.28 | 0.71 | 2.11 | 6.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 85 | 3.70 | 1.52 | 2.11 | 12.40 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 85 | 3.53 | 1.07 | 2.11 | 6.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 85 | 0.18 | 0.09 | 0.04 | 0.42 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 85 | 0.26 | 0.10 | 0.06 | 0.49 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 85 | 0.14 | 0.06 | 0.05 | 0.35 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 85 | 0.17 | 0.09 | 0.03 | 0.45 |
| CDEP | STATION DEPTH (M) | 66 | 18.90 | 27.11 | 2.18 | 175.40 |
| CPHF | PH (STANDARD UNITS) | 85 | 7.84 | 0.49 | 6.37 | 8.48 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 85 | 512.29 | 589.18 | 23.50 | 4599.87 |
| CALK | ALKALINITY (MG/L) | 82 | 97.05 | 59.24 | 10.50 | 293.75 |
| CTMP | TEMPERATURE (DEG-C) | 85 | 20.46 | 2.80 | 14.85 | 27.56 |
| CTRJ | TURDIBITY (JTU) | 1 | 17.62 | . | 17.62 | 17.62 |
| CTRH | HACH TURBIDITY (NTU) | 22 | 9.29 | 10.76 | 2.25 | 34.81 |
| CTRN | -LOG(% TRANS./100) | 62 | 0.48 | 0.49 | 0.05 | 2.15 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 6 | 54.09 | 38.19 | 13.33 | 98.65 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 85 | 0.98 | 0.84 | 0.15 | 5.24 |
| CRTL | TOTAL SOLIDS (MG/L) | 8 | 155.36 | 115.94 | 9.50 | 389.58 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 8 | 101.02 | 47.64 | 48.42 | 165.32 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 20 | 8.52 | 9.32 | 1.00 | 38.56 |
| CALG | ALGAL COUNT (NO/LITER) | 3 | 166558.33 | 113305.93 | 66900.00 | 289800.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 3 | 0.03 | 0.02 | 0.01 | 0.05 |

Morris, USEPA Environmental Monitoring and Support Laboratory, Las Vegas). Chlorophyll model testing and calibrations are based exclusively upon data from the 218 station-years with corrected measurements. One would expect, therefore, that the calibrated models would tend to under-predict chlorophyll-a measurements which are not corrected for phaeophytin. About 15% of the station-years employed total dissolved phosphorus, as opposed to orthophosphorus, as a measure of the available fraction. These have been used in combination with inorganic nitrogen (nitrate+nitrate+ammonia) for assessment of limiting nutrients.

63. Operating within the constraints of available data, the median sampling frequency in the high-priority data set used for model testing is 3 per station per year. Considering within-station variability, a higher sampling frequency would have been desirable to provide better estimates of average conditions at each station or in each reservoir for use in model testing. Average coefficients of variation of average phosphorus, chlorophyll, and transparency estimates are 18%, 28%, and 18%, respectively. These errors are of concern in model calibration because they influence the accuracies of model parameter estimates. The variances of parameter estimates derived from a given data set are proportional to the gross error variance of the model and inversely related to the number of cases (stations) (Snedecor and Cochran, 1972). Thus, while the limited sampling regime at each station increases the gross error variance of the model, effects on the variance of parameter estimates (and on model testing conclusions) can be partially offset by using data from a large number of stations (258). These relationships are demonstrated further in the error analyses conducted in Part VIII. While more than three sampling dates per station per growing season would be advisable for model applications, the data set assembled above is adequate for testing purposes.

## Sediment Accumlation Rates

64. Appendix C (Table C1) contains a listing of sediment accumulation rates which have been extracted from the data base (Figure 1) for

use in model testing. Sediment survey sheets have been reviewed and the data screened to eliminate estimates which were pre-1950 and/or based upon inconsistent survey designs, with respect to range number or calculation method. Sediment accumulation data from a total of 17 projects with relatively reliable nutrient balances have survived the data screening procedure and have been used in model testing. Rates are expressed in terms of mass per unit area of reservoir per year and reflect long-term averages. These estimates are probably less accurate than the nutrient balances developed above and do not necessarily reflect the hydrologic or meteorologic conditions present during the periods of sampling by the EPA/NES.

## Data Inventories

65. Table 14 inventories and classifies the model testing data sets developed above, according to priority group, region, year, station type, and monitoring agency. The data sets include the following:

a. water quality summary by station-year
b. water quality summary by reservoir-year
c. nutrient balances by reservoir-year
d. load/response by reservoir-year

In the fourth data set, which is a cross between data sets b and c, observations have been placed in the high-priority group only if both the nutrient balances and the water quality summaries are also classified as high-priority. The resultant data set includes a total of 43 high-priority reservoir-years for use in evaluating load/response relationships.

66. In Table 14, "regions" are defined based upon CE Divisions, with the exceptions of the Ohio River and Southwest Divisions, which have been subdivided by District to reflect data densities and geographic diversities. In all data sets, regional weaknesses are apparent in the East and Far West. The New England Division is not represented in any of the data sets because no chlorophyll,

Table 14

Inventory and Classification of Model Testing Data Sets

| Code: | | a | | | b | | | c | | | c x b (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data Set: | | Water Quality | | | Water Quality | | | Loadings | | | Load/Response | | |
| Basis: | | Station-Yrs | | | Reservoir-Yrs | | | Reservoir-Yrs | | | Reservoir-Yrs | | |
| Group:* | N | A | B | All | A | B | All | A | B | All | A | B | All |
| Total | 299 | 258 | 267 | 525 | 85 | 73 | 158 | 62 | 46 | 108 | 43 | 53 | 96 |
| Region** | | | | | | | | | | | | | |
| NED | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NAD | 15 | 4 | 6 | 10 | 2 | 2 | 4 | 2 | 1 | 3 | 2 | 1 | 3 |
| SAD | 24 | 24 | 54 | 78 | 8 | 6 | 14 | 9 | 0 | 9 | 3 | 6 | 9 |
| NCD | 16 | 4 | 21 | 25 | 2 | 8 | 10 | 2 | 2 | 4 | 1 | 3 | 4 |
| ORD - Pitts. | 14 | 15 | 4 | 19 | 5 | 1 | 6 | 3 | 2 | 5 | 3 | 2 | 5 |
| ORD - Hunt. | 28 | 22 | 12 | 34 | 10 | 1 | 11 | 9 | 2 | 11 | 8 | 3 | 11 |
| ORD - Louis. | 15 | 31 | 19 | 50 | 17 | 15 | 32 | 3 | 0 | 3 | 3 | 0 | 3 |
| ORD - Nash. | 7 | 38 | 19 | 57 | 9 | 0 | 9 | 5 | 1 | 6 | 5 | 1 | 6 |
| LMVD | 15 | 16 | 25 | 41 | 4 | 6 | 10 | 4 | 9 | 13 | 3 | 6 | 9 |
| SWD - L. Rock | 10 | 36 | 5 | 41 | 6 | 2 | 8 | 3 | 5 | 8 | 3 | 5 | 8 |
| SWD - Other | 56 | 36 | 57 | 93 | 10 | 19 | 29 | 13 | 12 | 25 | 6 | 14 | 20 |
| MRD | 31 | 24 | 35 | 59 | 10 | 5 | 15 | 6 | 9 | 15 | 5 | 10 | 15 |
| NPD | 27 | 8 | 3 | 11 | 2 | 1 | 3 | 2 | 1 | 3 | 1 | 2 | 3 |
| SPD | 19 | 0 | 7 | 7 | 0 | 7 | 7 | 1 | 2 | 3 | 0 | 0 | 0 |
| Year | | | | | | | | | | | | | |
| 71 | | 0 | 1 | 1 | 0 | 1 | 1 | | | | | | |
| 72 | | 0 | 11 | 11 | 0 | 5 | 5 | 0 | 4 | 4 | 0 | 4 | 4 |
| 73 | | 98 | 100 | 198 | 32 | 13 | 45 | 35 | 8 | 43 | 27 | 16 | 43 |
| 74 | | 97 | 106 | 203 | 26 | 26 | 52 | 24 | 29 | 53 | 15 | 38 | 53 |
| 75 | | 24 | 21 | 45 | 9 | 10 | 19 | 3 | 5 | 8 | 1 | 7 | 8 |
| 76 | | 7 | 6 | 13 | 1 | 4 | 5 | | | | | | |
| 77 | | 21 | 8 | 29 | 14 | 7 | 21 | | | | | | |
| 78 | | 11 | 8 | 19 | 3 | 5 | 8 | | | | | | |
| 79 | | 0 | 6 | 6 | 0 | 2 | 2 | | | | | | |
| Agency | | | | | | | | | | | | | |
| EPA/NES | | 209 | 207 | 416 | | | | | | | | | |
| ORD | | 32 | 22 | 54 | | | | | | | | | |
| Other | | 17 | 38 | 55 | | | | | | | | | |
| Station Type | | | | | | | | | | | | | |
| Upper Pool | | 58 | 65 | 123 | | | | | | | | | |
| Mid Pool | | 128 | 126 | 254 | | | | | | | | | |
| Near Dam | | 72 | 76 | 148 | | | | | | | | | |

* N = total number of projects included in CE data base
A = data passing screening procedures (high-priority)
B = data not passing screening procedures (low-priority)
All = all data

** Regions are CE Divisions, except ORD and SWD, which are divided by District transparency, or nutrient budget estimates were available from NED during Phase I of this project. The South Pacific Division is not represented in the fourth data set because the monitoring program design employed by the EPA/NES in that Division involved pool sampling in March, mid-summer, and November. Thus, these data did not survive screening for at least two sampling rounds per growing season, defined as April-October. Future analyses might incorporate these data, since seasonal factors might not be as important in California as in other regions.

67. The intent of the screening procedures employed above has been to assemble data sets with reliable information for use in preliminary model testing. "Reliable" is defined relatively and within the constraints of available data. The screening procedure is based upon relative data values, sampling designs, and internal checks (e.g. water balances). Other types of errors, such as biases or systematic errors in the sampling designs or analytical measurements, may have gone undetected.

68. In some cases, the screening procedure may have been too conservative, resulting in rejection of data which may be adequate for some purposes. For example, some reservoir-years have been eliminated from data sets c and d because of high variability in the mean chlorophyll-a estimates. These data might still be adequate, for testing models which predict other response variables (e.g.,phosphorus, transparency). These observations could be considered in future studies and refinements of the work described below.

## PART IV: MODEL TESTING METHODS

69. Appendix E contains a compilation of empirical eutrophicatic models derived from the general literature. Models are identified wit respect to variables, equation(s), author(s), data set characteristics percent of dependent variablility explained, and, when available, erro statistics. A systematic approach has been designed for calibrating an testing these models using the data sets described in Part III. Th following steps are involved:

- a. Model Classification
- b. Preliminary Testing
- c. Parameter Estimation
- d. Residuals Analysis
- e. Parameter Stability Analysis

Each of these steps is outlined below.

70. The models compiled in Appendix E have been reviewed and classified according to predicted variable and functional form. This reduces the number of separate equations to be evaluated, since many of the models are similar in structure but differ only with respect to parameter estimates, which depend upon the data sets and methods used for calibration. A model coding system has been designed in order to keep track of the equations, parameter estimates, and calibration data sets. Each model is represented by a 6-digit code, as defined below:

| Digits | Code |
|---|---|
| 1 | predicted variable:<br>P = pool phosphorus R = outflow phosphorus<br>B = chlorophyll S = secchi depth<br>D = oxygen depletion |
| 2-3 | model formulation number |
| 4 | parameter estimates:<br>A = original parameters<br>X = optimal parameters |
| 5-6 | sequence number, reflecting data sets and/or sources |

For example, model B01A02 predicts chlorophyll, using formulation number 1 (log(Chlorophyll) vs. log(Phosphorus) regression), with original parameters reported by investigator 2. Models B01X01, B01X02, and B01X03 represent the same model with parameters optimized for different subsets of reservoir data. Model codes are identified according to formulation, source, and sequence number at the beginning of each analysis. The codes are used to identify and store residuals in model testing data sets.

71. In the preliminary testing stage, each model is applied to the data with its original parameter estimates. Residuals are characterized with respect to bias (mean), variance, and fraction of dependent variablility explained (R-Squared). Note that in cases of poorly fitting models with their respective original coefficients, it is possible for computed R-Squared values to be less than zero. This indicates that the variance of the residuals is greater than the variance of the dependent variable. Median absolute deviations, more robust estimates of error, (Mosteller and Tukey, 1977) are also calculated.

72. For a given formulation and data set, parameters are optimized using least-squares regression, with the dependent variable consistently transformed to base-10 logarithmic scales. Thus, the objective function minimized is the sum of the squares of the logarithmic deviations. Predicted variables and residuals from these models generally tend to be log-normally distributed. This results from the fact that errors associated with measurement, sampling, and the models themselves are more stable when expressed on a percentage basis than on an absolute basis. Stability of variance (homoscedasticity) is a desirable property for parameter estimation purposes (Snedecor and Cochran, 1972). In cases where non-linear estimation methods are required the SAS procedure NLIN is used (SAS Institute, 1979). Grid searches are employed to determine reasonable starting points for implemetation of the Marquardt optimization algorithm. Estimates of parameter standard errors are approximate when non-linear estimation methods are required. The special parameter estimation procedures used for the oxygen depletion

models, which are posed as discriminant functions, are described in Part VII.

73. In some cases, model parameters are estimated for several alternative data sets, defined by various morphometric, hydrologic, and water quality characteristics. Some formulations are appropriate only under certain conditions. For example, the chlorophyll/phosphorus model has been fit to several data sets, based upon turbidity concentrations and N/P ratios. This provides insights into parameter stability, model error, and model applicability under various conditions. Data set limits are defined by plotting residuals against potentially important factors (e.g., N/P) and identifying factor levels at which systematic deviations begin to occur.

74. Residuals from a given model and data set are subjected to a standard battery of tests, which includes the following:

a. statistical summary
b. plotting
c. correlations
c. stepwise regressions
d. regional tests

These analyses, generally conducted for models with optimized coefficients, provide additional insights into model adequacy under various conditions and suggest possible improvements. Results are tabulated in Appendix D and discussed in appropriate areas of the text.

75. The SAS procedure UNIVARIATE is used to calculate a standard set of statistics for each calibrated model:

a. number of observations
b. bias (mean error)
c. t-test for significance of bias
d. standard deviation
e. mean squared error
f. minimum
g. maximum
h. median absolute deviation

i. Chi-squared

In some cases, these are calculated for different data groupings, defined by data reliability and averaging method. The median absolute deviation is an alternative measure of error spread which is less sensitive to outlying values than the mean squared error (Mosteller and Tukey, 1977).

76. The Chi-squared statistic (Bevington, 1969) is a weighted mean squared error, with weights calculated as the inverses of the estimated data error variances. Estimates of model dependent variables and some independent variables generally represent averages over space and/or time in a given reservoir or its tributaries. Because of variability within the averaging realm and limited number of sampling dates and/or locations, estimates of average conditions are subject to error. Approximate methods used for estimating these "data errors" are described in Part III. For a given model and observation, the weighting factor used in the Chi-Squared calculation is given by:

$$W = 1 / [ Var(Y) + D^2 Var(X) ] \qquad (41)$$

where,

W = weighting factor used for a given observation

Var(Y) = variance of estimated dependent variable

Var(X) = variance of estimated independent variable

D = derivative of predicted Y with respect to X

In a linear model, for example, the D factor represents the coefficient for variable X. Ranking models based upon Chi-squared puts less weight on observations which are less reliable and provides an indication of error sources. For example, a Chi-squared statistic approaching 1.0 indicates that all of the residual variance can be explained by potential errors in the data, i.e., model error is insignificant. A Chi-squared of 2.0 indicates that the error is partitioned equally between model and data error effects.

77. Model residuals are tested for association with various morphometric, hydrologic, and water quality characteristics by a

combination of plotting, correlation, and stepwise regression analyses. These analyses provide general indications of conditions under which a given model may be biased and suggest modifications which may improve model generality. Plotting and examination of residuals is perhaps the most important of these analyses, although it is not feasible to reproduce these displays in a report context.

78. Interpretation of these association tests can be difficult because of correlations among the factors investigated. If two factors are highly correlated with each other, both may be correlated with a model residual, but only one may be significant from a causation standpoint. A statistically significant correlation coefficient is not, in itself, adequate evidence of a real effect. Similarly, the stepwise regressions include only statistically significant terms ($p<.05$), but direct interpretation of the coefficients can be misleading. The multivariate R-squared statistic derived from the stepwise regressions is a indicator of model generality over the range of reservoir characteristics.

79. Analyses of variance have been conducted to test for significant regional effects on model residuals. With some exceptions, regions are defined by CE Divisions. Because the Ohio River and Southwest Divisions are relatively rich in data and diverse in terrain, they are subdivided by CE District. Schematic plots generated by the SAS procedure SPLOT have been used to display regional variations in residuals and important related variables. Regional groupings have been identified using Duncan's multiple-range test (Snedecor and Cochran,1972). In many cases, regional variations in residuals can be explained by corresponding variations in reservoir morphometric, hydrologic, and/or water quality characteristics, as identified through the association tests described above.

80. A final test involves an examination of parameter stability. One characteristic of a "good" model is that its parameter or coefficient values are stable over the range of model application. Fitting the model to different subsets of data provides a basis for assessing parameter stability. Subsets may be defined by region,

impoundment type, or ranges of important independent variables. Basically, this test attempts to determine whether the model "constants" are constant. This type of test is more elaborate and potentially more powerful than those discussed above and has been applied to the models which seem to work best in each category.

# PART V: INTERNAL MODELS

## Introduction

81. This report defines "internal models" as relationships among nutrient concentrations, transparency, chlorophyll-a, and hypolimnetic oxygen depletion, measured within impoundments. In some cases, morphometric and hydrologic factors are also included in these models. These are distinguished from "external models", which relate water quality measurements to external nutrient loadings and are discussed in Part VI. Internal models are classified into three categories, based upon predicted variables:

- a. Transparency
- b. Chlorophyll
- c. Oxygen Depletion

The first two categories are treated in the following sections. The fourth section analyzes regional variations in these measurements and related factors. Because the models and testing methods employed for the oxygen depletion models are of a unique character, they are described and tested separately in Part VII.

## Transparency Models

82. In many impoundments, absorption and scattering of light by phytoplankton limits water transparency. Other biological materials, dissolved humic materials (color), and inorganic suspended solids may also regulate transparency. While not necessarily proportional to algal biomass, chlorophyll-a is the most widely used measure of phytoplankton standing crop. The relationship between chlorophyll-a and transparency is important to assessing the roles of algae vs. other materials in the partitioning of light extinction and nutrients. As demonstrated in subsequent sections, this partitioning has important implications for calibrating and applying empirical eutrophication models to reservoirs.

83. The relationship between station-year-average chlorophyll and transparency measurements is shown in Figure 2. The following model formulations have been tested for summarizing this relationship:

| Model Code | Equation |
|---|---|
| S01 | $\log(S) = K1 + K2 \log(B)$ |
| S02 | $1/S = K1 + K2\ B$ |
| S03 | $1/S = K1 + K2\ B^{K3}$ |

Parameter estimates and error statistics for these models are summarized in Table 15. For model S03, the best estimate of parameter K1 is zero, so that the model is equivalent to model S01, which explains 31 percent of the variance in the transparency data, as compared with 26 percent for model S02. It is apparent from these error statistics and from Figure 2 that transparency is regulated in many of these reservoirs by factors which are not related to chlorophyll-a. The parameter K1 in models S01 and S02 varies significantly from station to station, as influenced by allocthonous suspended solids, dissolved color, and biological materials which are not related to chlorophyll-a. These variations are important because they influence the availability of light and nutrients for photosynthesis. To some extent, the slope parameter, K2, may also vary because of fluctuations in chlorophyll/biomass ratios, as influenced by algal species, environmental factors, and growth stage. Available data do not permit assessment of K2 variations or their effects, however.

84. The S02 model has been recalibrated in order to provide a means for estimating the effects of non-chlorophyll-related materials on light extinction at each station. This has been done by transposing the model equation:

$$A = 1/S - K2\ B \qquad (42)$$

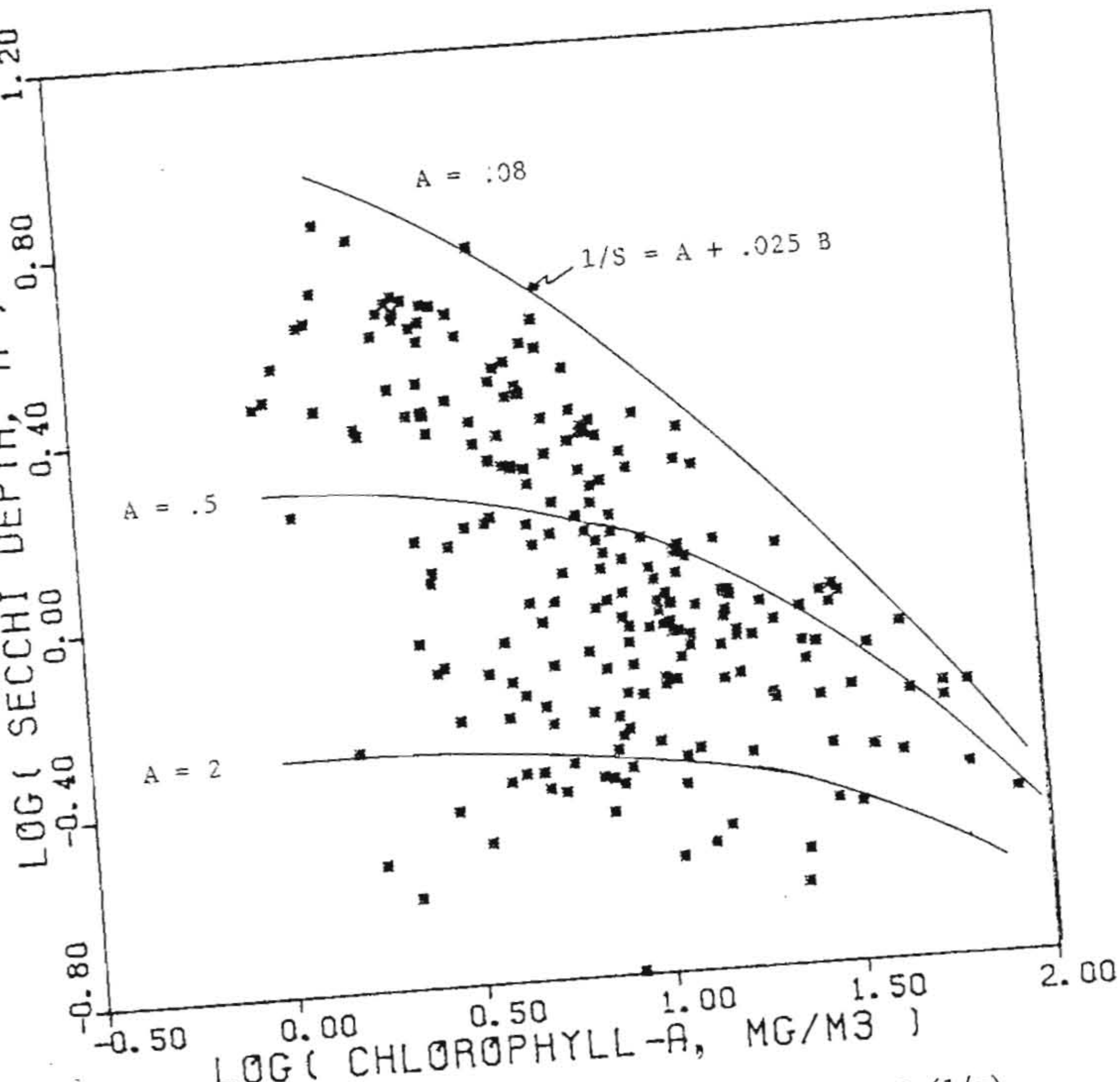
where,

A = effect of non-chlorophyll-related materials on S (1/m)

K2 = slope parameter = .025 m2/mg

Figure 2

Transparency vs. Chlorophyll-a




A = effect of nonchlorophyll-related materials on S (1/m)

B = chlorophyll

S = transparency

Table 15

Formulations, Parameter Estimates, and Error Statistics for Internal Chlorophyll/Transparency Models

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Definitions :

---

K1-K3 = model parameter values
N= number of station-years
R2 = fraction of variance explained
MSE = mean squared error (log10)

---

Model S01: Log Transparency vs. Chlorophyll

Equation: $\log(S) = K1 + K2 \log(B)$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S01A01 | Carlson (1977) | .89 | -.68 | 218 | -.39 | .145 |
| S01A02 | Jones & Bachman (1978) | .81 | -.55 | 218 | -.50 | .156 |
| S01X01 | Optimal - All Data | .49 | -.49 | 218 | .31 | .082 |
| | standard errors | .046 | .050 | | | |

---

Model S02: Linear Transparency vs. Chlorophyll

Equation: $1/S = K1 + K2\ B$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S02A01 | Classen (1980) | .21 | .014 | 218 | -1.42 | .252 |
| S02X01 | Optimal - All Data | .41 | .052 | 218 | .26 | .087 |
| | standard errors | .051 | .070 | | | |

---

Model S03: Log/Linear Transparency vs. Chlorophyll

Equation: $1/S = K1 + K2\ B^{K3}$

| Code | Coefficients | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| S03A01 | Walker (1979) | .08 | .059 | .74 | 218 | -1.29 | .239 |
| S03X01 | Optimal - All Data | .00 | .32 | .49 | 218 | .31 | .082 |
| | standard errors | .30 | .24 | .10 | | | |

---

For simplicity, the variable "A" is referred to as "turbidity" in the remainder of this report, although it may be influenced by color and nonchlorophyll-related biological materials at some stations.

85. Use of the least squares K2 estimate in Table 15 (K2=.052 m2/mg) is not appropriate in this case, because it does not represent the relationship at low turbidity and many stations would have calculated turbidity values less than zero. In the absence of algae, other suspended solids, and color, there is an upper limit to transparency, because of light extinction by pure water. In terms of the above model, this translates into a minimum calculated A value. The slope parameter estimate (K2=.025 m2/mg) has been selected so that the predicted transparency at a minimum A value of .08 1/m follows the upper edge of the chlorophyll/transparency relationship in Figure 2. The minimum A value corresponds to a maximum transparency of 12.5 meters in the absence of chlorophyll-a and turbidity, a practical upper limit for most reservoirs. The slope parameter is higher than values derived from pure algal cultures (approximately .014 m2/mg, Lorenzen, 1980), possibly because it accounts for light extinction both by chlorophyll-a and by other related substances, including other pigments, biomass, and detritus. Literature estimates for the slope parameter derived from regression analyses of data from individual lakes range from .008 to .054 m2/mg (Carlson,1980).

86. The lines in Figure 2 depict the chlorophyll/transparency relationship for different levels of turbidity. Based upon this relationship, a turbidity value has been calculated for each station-year and used in subsequent analyses. Turbidity values calculated according to equation (42) are positively correlated with Hach turbidity, (r=.76, n=74), total suspended solids (r=.57, n=79), and true color (r=.54, n=23), where all correlation coefficients are calculated on logarithmic scales.

87. It is apparent that the class of models for predicting transparency as a function of chlorophyll (or vice-versa) is not generally useful in these reservoirs because of the influences of

factors unrelated to chlorophyll. Additional analysis is needed to develop predictive models for turbidity, which is expected to be regulated by regional factors (erosion rates, soil types, land use, topography, etc.), as well as reservoir morphometric and hydrologic characteristics which influence the sedimentation process.

88. An alternative set of models relates transparency directly to total phosphorus concentration. The relationship would reflect the combined influences of the partitioning of phosphorus and light extinction between algal cells and substances unrelated to algae. The formulations tested are analogous to those employed for predicting transparency as a function of chlorophyll:

| Model Code | Equation |
|---|---|
| S04 | $\log(S) = K1 + K2 \log(P)$ |
| S05 | $1/S = K1 + K2\ P$ |
| S06 | $1/S = K1 + K2\ P^{K3}$ |

Residuals analyses suggest that these models tend to under-predict transparency at stations with N/P ratios (inorganic or total) less than about 8, which corresponds to a typical algal physiologic ratio (Wetzel, 1975). To eliminate possible nitrogen-limitation effects, each model has been fit to two data sets: one containing all station-years and the other containing station years with N/P ratios greater than 8. Parameter estimates and statistics for each data set and model are summarized in Table 16. For a given data set, it is difficult to distinguish among these models, since the error statistics are nearly identical. Model S05 has been selected for further analysis because of its relative simplicity and theoretical appeal. It suggests that the light extinction coefficient (inversely related to transparency) is a linear function of phosphorus and that the intercept (K1) is attributed to light extinction by factors unrelated to phosphorus, including extinction by water alone.

89. The transparency/phosphorus relationship is displayed in Figure 3. The regression line (model S05X02) has been fit to data from stations with N/P ratios exceeding 8. To illustrate the typical effects

Table 16

Formulations, Parameter Estimates, and Error Statistics for Internal Phosphorus/Transparency Models

Model S04: Log Transparency vs. Phosphorus

Equation: $\log(S) = K1 + K2 \log(P)$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S04A01 | Placke et al. (1980) | 1.05 | -.61 | 258 | .66 | .036 |
| S04A02 | Oglesby et al. (1978) | 1.36 | -.76 | 258 | .59 | .043 |
| S04X01 | Optimal - All Data | 1.20 | -.72 | 258 | .67 | .034 |
| | standard errors | .031 | .051 | | | |
| S04X02* | Optimal | 1.40 | -.87 | 212 | .77 | .024 |
| | standard errors | .050 | .032 | | | |

Model S05: Linear Transparency vs. Phosphorus

Equation: $1/S = K1 + K2\ P$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S05A01 | Carlson (1977) | 0 | .021 | 258 | .57 | .045 |
| S05A02 | Carlson (1977) | 0 | .015 | 258 | .29 | .075 |
| S05X01 | Optimal - All Data | .18 | .017 | 258 | .64 | .036 |
| | standard errors | .027 | .001 | | | |
| S05X02* | Optimal | .082 | .022 | 212 | .77 | .024 |
| | standard errors | .023 | .001 | | | |

Model S06: Log/Linear Transparency vs. Phosphorus

Equation: $1/S = K1 + K2\ P^{K3}$

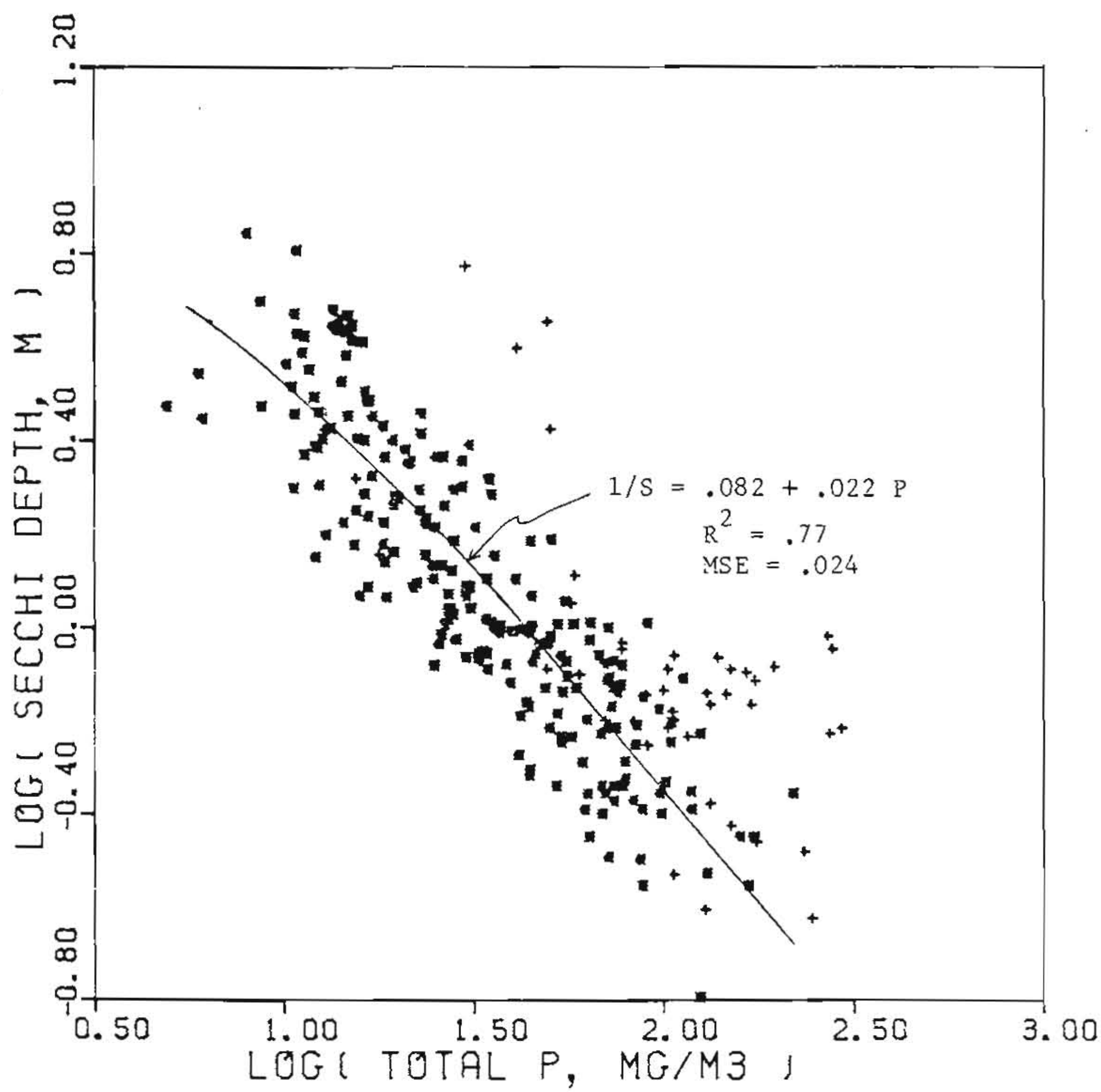
| Code | Coefficients | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| S06A01 | Walker (1979) | .08 | .0093 | 1.03 | 258 | .11 | .093 |
| S06X01 | Optimal - All Data | .00 | .063 | .72 | 258 | .68 | .034 |
| | standard errors | .10 | .029 | .093 | | | |
| S06X02* | Optimal | .030 | .033 | .91 | 212 | .77 | .024 |
| | standard errors | .064 | .014 | .091 | | | |

* Data set restrictions:
Inorganic N/P > 8
Total N/P > 8

Figure 3

Transparency vs. Total Phosphorus

( * N/P > 8, + N/P < 8 )




MSE = mean squared error
P = total phosphorus
$R^2$ = fraction of variance explained
S = transparency

of nitrogen limitation, different symbols to distinguish stations with N/P ratios less than 8. The relationship ($R^2$=.77, $SE^2$=.024) is much stronger than the transparency/chlorophyll relationship ($R^2$=.31, $SE^2$=.082). This results from the correlation between total phosphorus and non-algal turbidity, which is described in more detail below. The partitioning of phosphorus and light extinction between chlorophyll-related components and non-chlorophyll-related components is more critical for correlating chlorophyll to transparency (or to phosphorus) than for correlating phosphorus to transparency.

90. Residuals analyses have indicated, however, that the transparency/phosphorus relationship is somewhat sensitive to the partitioning of light extinction between chlorophyll and turbidity. According to the chlorophyll/transparency model described above, the product of chlorophyll and transparency is proportional to the fraction of light extinction attributed to chlorophyll. Assuming that transparency is inversely related to the light extinction coefficient, the product is also proportional to the daily photosynthesis integral under light-limited conditions (Vollenweider, 1970; Vollenweider and Kerekes, 1980). This product averages about 9 $mg/m^2$, which corresponds to 23% light extinction attributed to chlorophyll-a and related substances. A plot of residuals from model S05X02 against the chlorophyll-transparency product indicates negative bias for products less than about 5 $mg/m^2$. The following table summarizes the residual distributions above and below this value:

| B×S Group | N | Mean | Std. Dev. | t* | Prob(t) |
|---|---|---|---|---|---|
| > 5 | 144 | .060 | .136 | 5.29 | <.001 |
| < 5 | 45 | -.152 | .091 | -11.20 | <.001 |

* t test for Ho: Mean=0

Thus, the phosphorus/transparency model tends to over-predict transparency by an average of .15 log units ( 35 %) at stations where algae account for less than about 12% of the total light attenuation. This effect accounts for about 25% of the total variance in the residuals from model S05X02. This suggests that phosphorus associated with algae has somewhat less of an impact on transparency than phosphorus associated with turbidity.

91. Stepwise regressions explain 39% of the variance in residuals from model S05X02 (see Appendix D), with positive terms for station total depth, pH, shoreline development, and total nitrogen, and a negative term for inorganic nitrogen. The positive term for station total depth is the most significant. The signs of the nitrogen terms suggest a positive correlation with organic nitrogen. Since higher pH and organic nitrogen levels would tend to be found at stations with higher chlorophyll levels (and chlorophyll-Secchi products), these effects are consistent with those discussed above. The depth effect may be also be related to the chlorophyll-Secchi product, since resuspension of bottom sediments would tend to raise turbidity and lower the product at shallow stations.

92. The following model accounts for biases in model S05 discussed above and is useful for representing the partitioning of phosphorus:

$$P = K1 + K2\ B + K3\ A \qquad (43)$$

where,

K1 = 2.0 (Std. Error = .80)

K2 = 1.76 (Std. Error = .13)

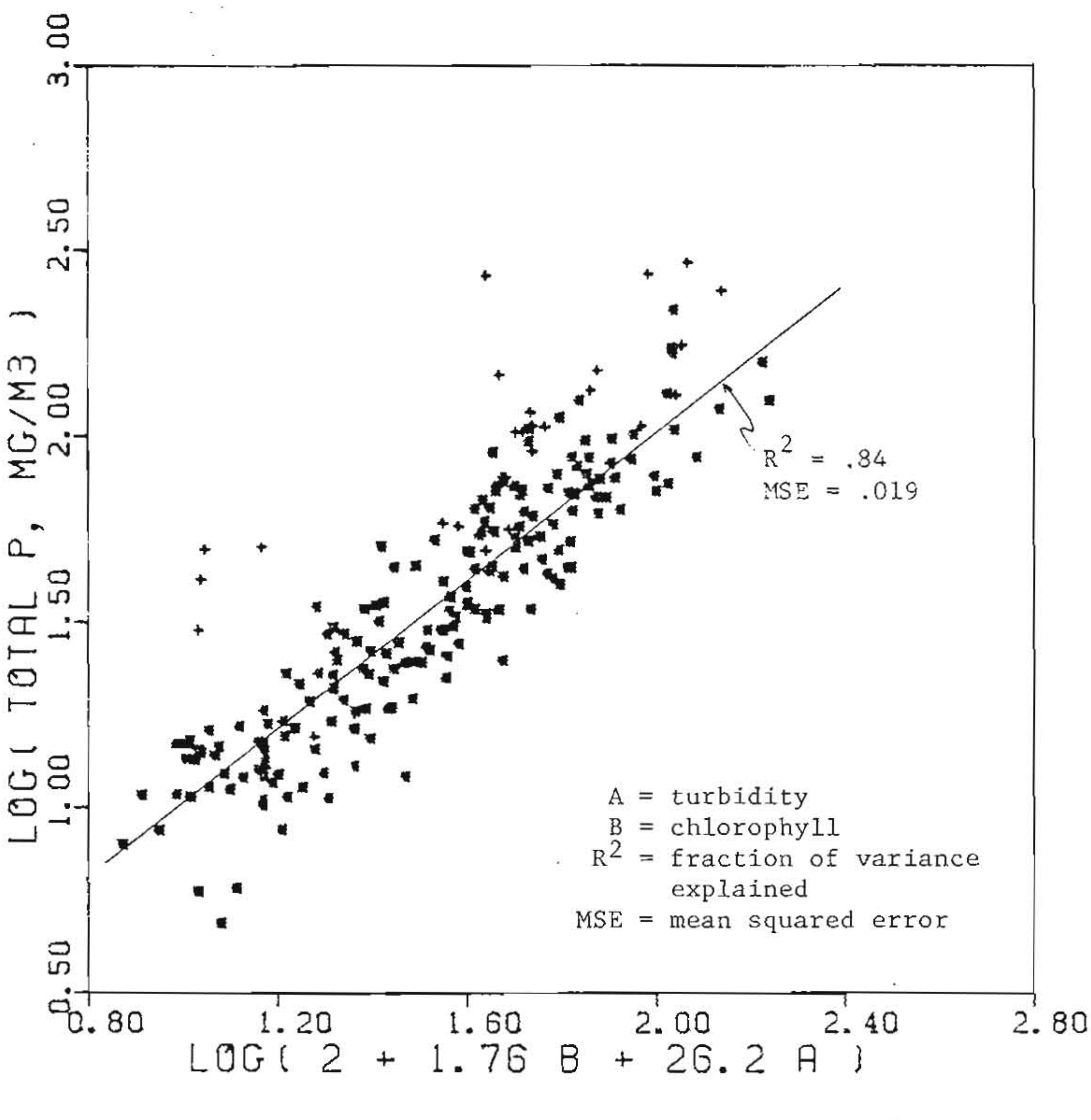
K3 = 26.2 (Std. Error = 1.71)

Based upon data from 189 station-years with inorganic and total (N/P) ratios exceeding 8, this equation explains 84% of the variance in the total phosphorus data. The residual mean squared error, .019 in logarithmic units, is considerably lower than the errors in the other transparency or chlorophyll models evaluated. Observed and predicted phosphorus concentrations are plotted in Figure 4. The intercept, 2 mg/m3, represents the phosphorus which is not associated with chlorophyll or turbidity. This value tends to be higher at N-limited

Figure 4

Total Phosphorus vs. Turbidity and Chlorophyll-a

( * N/P > 8, + N/P < 8 )



stations. The slope parameters indicate that, on the average, 1.76 mg/m3 of phosphorus is associated with each mg/m3 of chlorophyll-a, and 26.2 mg/m3 of phosphorus is associated with each unit of turbidity (1/m). The biases in the phosphorus/transparency model S05 can be explained by multiplying both sides of equation (43) by transparency and substituting equation (42) for turbidity, yielding:

$$P\ S = 26.2 + 2\ S + 1.11\ B\ S \tag{44}$$

This equation predicts that the product of transparency and phosphorus will be higher for reservoirs in which chlorophyll accounts for a greater fraction of the total light extinction. Despite the relatively low errors characteristic of equation (43), the equation cannot be transposed, to permit equally accurate chlorophyll predictions, for example, without a predictive basis for non-algal turbidity.

## Chlorophyll Models

93. The direct relationship between algal standing crop and nutrient concentrations (specifically, phosphorus) is the basis of the empirical eutrophication modelling approach. More complex models relating chlorophyll to phosphorus, nitrogen, turbidity, and reservoir morphometric and hydrologic variables also fall in this category, as outlined in Part I of Appendix E.

94. A variety of seasonal averaging schemes have been used in developing phosphorus/chlorophyll models (Appendix E). For chlorophyll, these include growing-season means, summer means, and maximum values. Spring phosphorus and growing-season-mean phosphorus have been used as independent variables. Table 17 summarizes the results of regression analyses relating each pair of variables using two data sets: one contains all station-years and the other, station-years with mean inorganic and total N/P ratios greater than 8 and non-algal turbidities less than 1.0 1/m. The basis for the turbidity cut-point is developed in detail below. In each case, the best correlation is found by averaging both chlorophyll and phosphorus over the growing season.

Table 17

Seasonal Chlorophyll/Phosphorus Regressions

| Dependent Variable | Independent Variable | Slope | Intercept | N | R-Squared | MSE |
|---|---|---|---|---|---|---|
| All Data | | | | | | |
| B | P | .699 | -.251 | 218 | .437 | .084 |
| B | Pspring | .563 | -.018 | 203 | .297 | .108 |
| Bmax | P | .697 | -.064 | 218 | .427 | .087 |
| Bmax | Pspring | .557 | .178 | 203 | .288 | .110 |
| Bsummer | P | .603 | -.053 | 194 | .310 | .114 |
| Bsummer | Pspring | .437 | .235 | 179 | .167 | .140 |
| N/P > 8, A < 1.0 1/m | | | | | | |
| B | P | 1.13 | -.76 | 137 | .720 | .045 |
| B | Pspring | 0.76 | -.25 | 131 | .359 | .104 |
| Bmax | P | 1.11 | -.55 | 137 | .665 | .055 |
| Bmax | Pspring | .74 | -.04 | 131 | .328 | .112 |
| Bsummer | P | 1.04 | -.57 | 124 | .604 | .066 |
| Bsummer | Pspring | 0.63 | .01 | 118 | .235 | .129 |

MSE = Mean Squared Error

Restricting the sampling periods to summer and/or spring reduces the average number of samples per station and, thus, the reliability of the station summary values. Based upon these results, growing-season-mean values are used in further model testing below.

95. The seasonal maximum chlorophyll value is of interest as an indicator of the most severe condition at a given station. Various regression models have been used for estimating maximum chlorophyll-a as a function of the mean value (Lee, Rast, and Jones, 1977). One problem with these models is that the maximum chlorophyll detected at a given location over a given period is not independent of the number of samples taken. For a given average value, the maximum estimated from 6 sampling dates is likely to be greater than the maximum estimated from 3 dates, for example.

96. Table 18 outlines and tests a method for calculating the maximum-to-mean chlorophyll ratio as a function of the number of sampling dates. Observed ratios increase consistently with the number of sampling dates, with the exception of the last categories (6 and 7), which are based upon only 3 and 5 station-years of data, respectively. The relationship has been fit by treating the sampling process as independent draws from a log-normal distribution. Application of the scheme beyond 5 sampling dates is an extrapolation beyond the range of the data and may be invalid because of possible violations in the independent sample assumption. At high sampling frequencies, serial correlation between successive samples may be significant. In the range of 2 to 5 sampling dates, however, the scheme works well and explains 97% of the variance in the maximum chlorophyll levels (Figure 5). The Lee, Rast, and Jones (1977) model suggests a (Bmax/B) ratio of 1.6, or .2 on a log scale. This agrees well with the model predictions for 3-4 sampling dates.

97. The chlorophyll models compiled in Appendix E can be classified by the following scheme:

Table 18

Scheme for Predicting Ratio of Maximum-to-Mean Chlorophyll-a as a Function of Number of Sampling Dates

| number of dates | Mean log (Bmax/B) Observed** | Predicted | number of station-yrs |
|---|---|---|---|
| 2 | .11 | .12 | 124 |
| 3 | .19 | .19 | 257 |
| 4 | .23 | .24 | 50 |
| 5 | .29 | .27 | 9 |
| 6 | .40 | .30 | 3 |
| 7 | .30 | .32* | 5 |
| 8 | - | .34* | 0 |
| 9 | - | .36* | 0 |

* extrapolation
** analysis of variance indicates significant differences among groups (F=28.9, p<.001)

Model:

$$\log(Bmax/B) = .28\,Y$$

where Y is chosen such that:

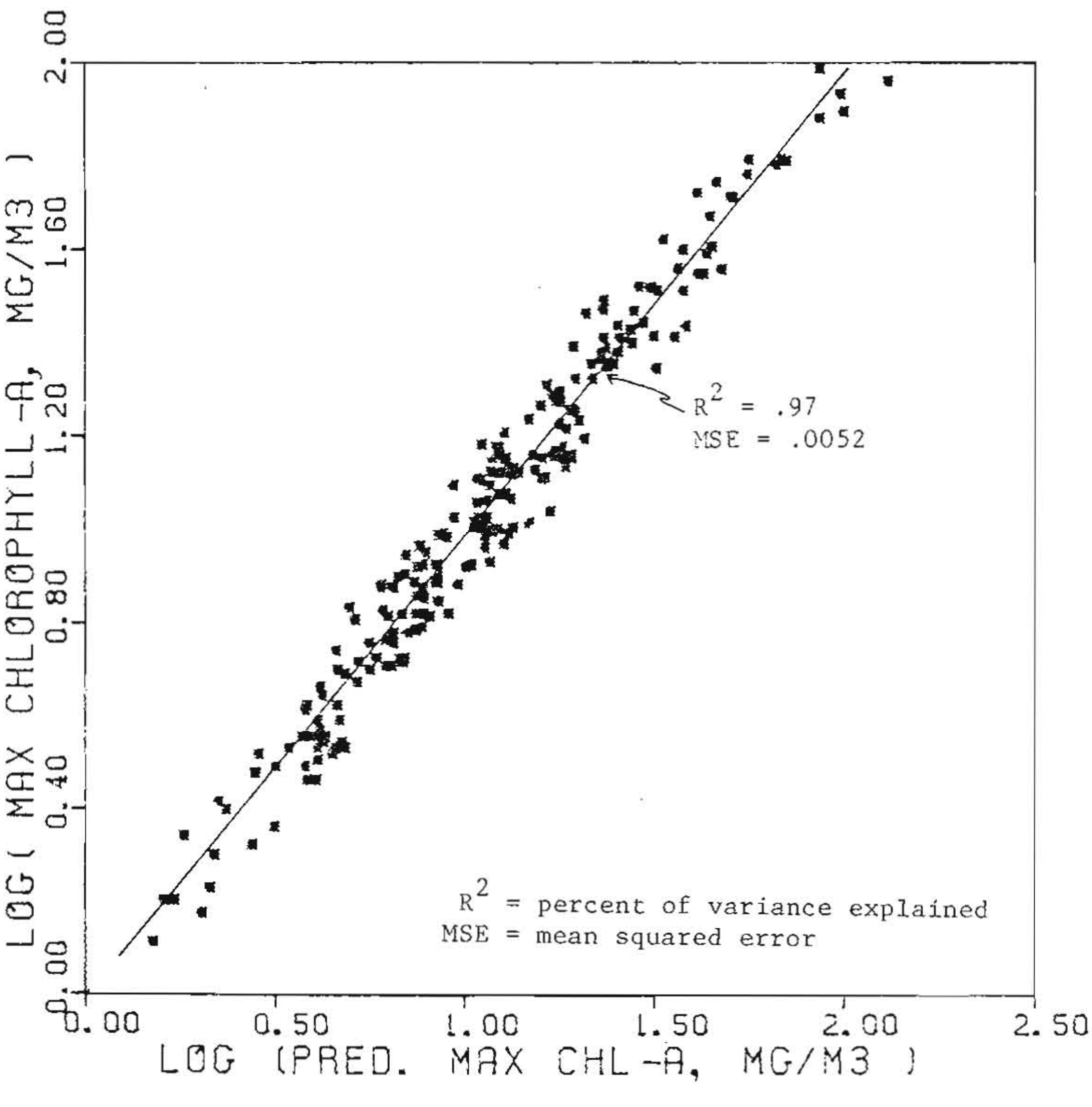
$$\int_{y=-\infty}^{y=Y} f(y)\,dy = n / (n+1)$$

where,

y = standard normal variable (mean=0, standard deviation=1)
f(y) = normal frequency distribution function
n = number of sampling dates / growing season

Figure 5

Observed vs. Predicted Maximum Chlorophyll-a



| Model Code | Equation |
|---|---|
| B01 | log(B) = K1 + K2 log(P) |
| B02 | B = K1 + K2 P |
| B03 | log(B) = K1 + K2 log(N + K3 P) |
| B04 | log(B) = K1 + K2 log(P) + K3 A + K4 log(Z) + K5 Qs |
| B05 | 1/B = K1/Bp + K2/Bn + K3/B1 |

Models B01 and B02 relate chlorophyll to total phosphorus on logarithmic and linear scales, respectively, and have been calibrated to several different lake and reservoir data sets by various authors (see Appendix E). Model B03, developed by Smith (1980), relates chlorophyll to nitrogen and phosphorus. Model B04, developed by Walker and Kuhner (1978), includes terms for the influences of phosphorus, turbidity, mean depth, and surface overflow rate on chlorophyll-a levels. Model B05, developed by Meta Systems (1979), is a theoretical formulation which considers the effects of phosphorus (Bp), nitrogen (Bn), and light (B1) limitation on algal growth. Original and optimal parameter estimates for these models and various data categories are given in Table 19.

98. Models B01 and B02 assume a direct relationship between chlorophyll and phosphorus, when averaged over a growing season at a given location. Figure 6 depicts this relationship on logarithmic scales, using data from all station-years with at least three sampling dates. Stations with inorganic or total N/P ratios less than 8 are distinguished by different symbols and tend to lie in the lower, right-hand portion of the plot. Also shown in Figure 6 are regression lines calculated for other lake and reservoir data sets by Jones and Bachman (1976), the OECD Eutrophication Progam (Kerekes,1981), and Hern et al. (1981). These models are representative of the ranges of slopes and yields in the models listed in Appendix E. The regression line for this data set, also shown in Figure 6, explains 44% of the chlorophyll variance and is nearly identical to the line calculated by Hern et al.(1981), based upon EPA National Eutrophication Survey data from over 700 U.S. lakes and reservoirs. It is apparent from the variability in

Table 19

Formulations, Parameter Estimates, and Error Statistics for Internal Models Predicting Chlorophyll-a

Model B01: Log Phosphorus/Chlorophyll
Equation: log(B) = K1 + K2 log(P)

| Code | Coefficients | Data* | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| B01A01 | Hern et al. (1981) | 1 | -.11 | .64 | 218 | .42 | .086 |
| B01A02 | Kerekes (1981) | 1 | -.55 | .96 | 218 | .29 | .104 |
| B01A03 | Jones & Bachman (1976) | 1 | -1.09 | 1.46 | 218 | -.95 | .288 |
| B01X01 | Optimal- all data | 1 | -.25 | .70 | 218 | .44 | .084 |
| | standard errors | | .087 | .054 | | | |
| B01X02 | Optimal- N/P>8 | 2 | -.38 | .80 | 187 | .51 | .071 |
| | standard errors | | .090 | .058 | | | |
| B01X03 | Optimal- N/P>8, A<1.58 1/m | 3 | -.60 | .98 | 161 | .64 | .057 |
| | standard errors | | .088 | .059 | | | |
| B01X04 | Optimal- N/P>8, A<1.0 1/m | 4 | -.76 | 1.13 | 157 | .72 | .045 |
| | standard errors | | .087 | .060 | | | |
| B01X05 | Optimal- Ni/Pi>10, A<.37 1/m | 5 | -1.09 | 1.44 | 62 | .76 | .039 |
| | standard errors | | .131 | .105 | | | |

Model B02: Linear Phosphorus/Chlorophyll
Equation: B = K1 + K2 P

| Code | Coefficients | Data | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| B02A01 | Oglesby et al. (1978) | 1 | -2.90 | .57 | 218 | -.81 | .267 |
| B02X01 | Optimal - all data | 1 | 1.65 | .13 | 218 | .41 | .087 |
| | standard errors | | .37 | .012 | | | |
| B02X02 | Optimal - Ni/Pi>10,A<.37 1/m | 5 | -.97 | .35 | 62 | .72 | .045 |
| | standard errors | | .37 | .035 | | | |

Model B03: Smith (1980), variable yield model
Equation: log(B) = K1 + K2 log(N + K3 P)

| Code | Coefficients | Data | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| B03A01 | Smith (1980) | 1 | -3.71 | 1.55 | 16.4 | 218 | -.64 | .242 |
| B03X01 | Optimal - all data | 1 | -1.96 | .81 | 55.5 | 218 | .45 | .082 |
| | standard errors | | .21 | .068 | 27.7 | | | |
| B03X02 | Optimal - A < .37 1/m | 6 | -4.09 | 1.53 | 35.7 | 73 | .66 | .059 |
| | standard errors | | .41 | .15 | 12.7 | | | |

(continued)

Table 19 (continued)

Model B04: Walker and Kuhner (1978), Multivariate Model
Equation: $\log(B) = K1 + K2 \log(P) + K3\ A + K4 \log(Z) + K5\ Qs$

| Code | Coefficients | Data | K1 | K2 | K3 | K4 | K5 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|---|---|
| B04A01 | Walker & Kuhner (1978) | 1 | .49 | .88 | -.23 | -.59 | -.00070 | 218 | .27 | .108 |
| B04X01 | Optimal - All Data | 1 | .44 | .70 | -.21 | -.51 | -.00047 | 218 | .67 | .049 |
| | standard errors | | .14 | .064 | .023 | .065 | .00014 | | | |
| B04X02 | Optimal- N/P > 8 | 2 | .22 | .83 | -.23 | -.46 | -.00046 | 189 | .72 | .041 |
| | standard errors | | .16 | .075 | .025 | .07 | .00017 | | | |

Model B05: Meta Systems (1979), Limiting Factor Model
Equation:
- Bp = P-limited biomass, mg/m3 = P - 2.2
- Bn = N-limited biomass, mg/m3 = (N - 2.2)/7
- Bl = Light-limited biomass, mg/m3 = 440/Zm - A/b >= 20 mg/m3
- b = algal light extinction coef. = .025 m2/mg
- A = non-algal turbidity, 1/m = 1/S - .025 B
- Zm = mid-thermocline depth (m)
- As = surface area (km2)
- Z = mean depth (m)

$$\log(Zm) = .587 + .084 \log(As) + .203 \log(Z) \quad **$$

$$1/B = K1/Bp + K2/Bn + K3/Bl$$

| Code | Coefficients | Data | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| B05A01 | Meta Systems (1979) | 1 | 1.89 | 0 | 1.36 | 218 | .51 | .072 |
| B05X01 | Optimal - All Data | 1 | 2.28 | 1.91 | 1.24 | 218 | .57 | .063 |
| | standard errors | | .29 | 1.21 | .20 | | | |

* Summary of Data Set Codes

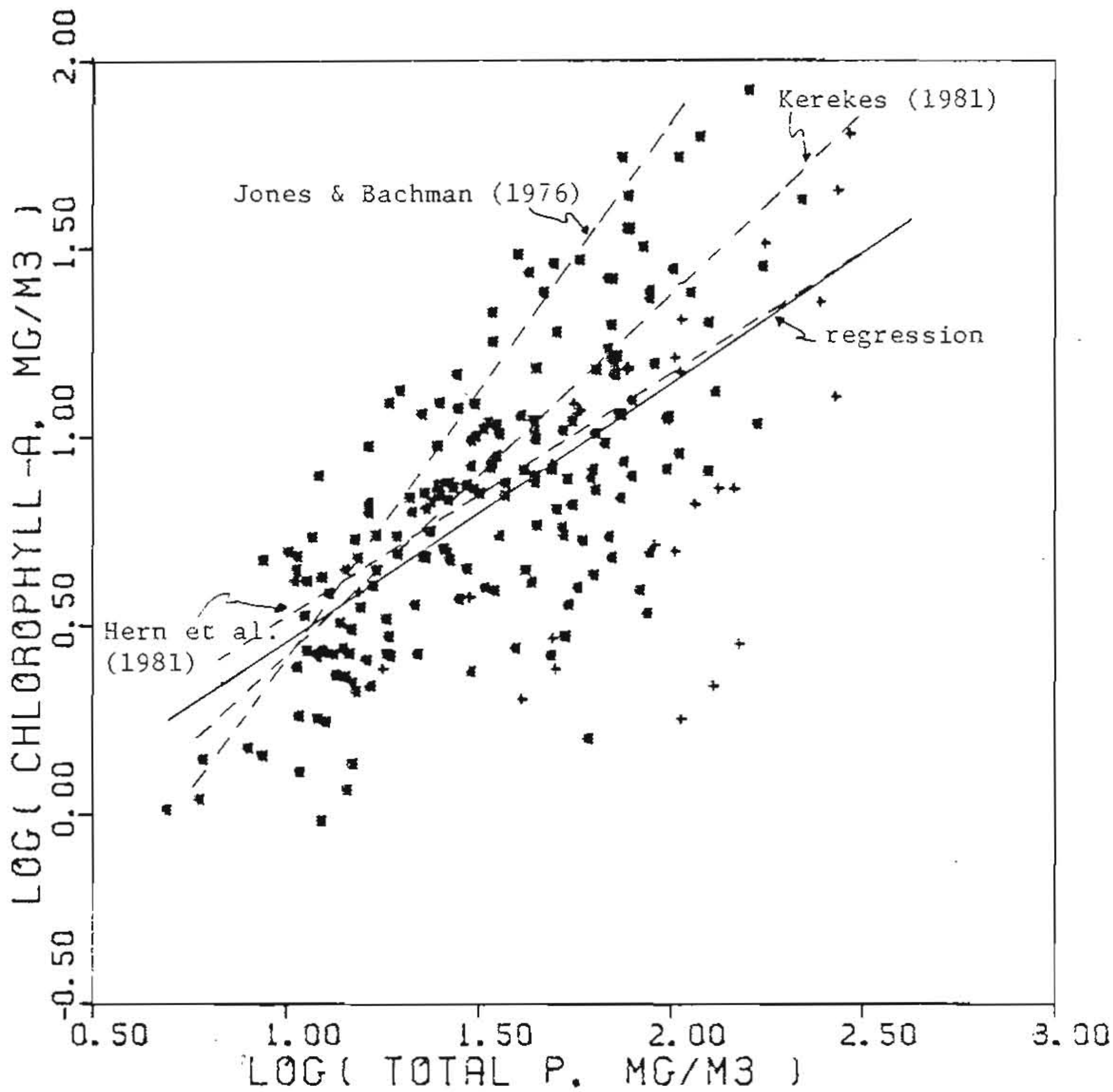
| | Constraint | | | | |
|---|---|---|---|---|---|
| | Inorganic N/P | Total N/P | Turbidity | Other | N |
| 1 | - | - | - | - | 218 |
| 2 | >8 | >8 | - | - | 189 |
| 3 | >8 | >8 | <1.58 | - | 161 |
| 4 | >8 | >8 | <1.00 | - | 137 |
| 5 | >10 | - | <.37 | - | 62 |
| 6 | - | - | <.37 | - | 73 |

** formulation for thermocline depth based upon regression analysis of data from 86 reservoirs (R2=.45, MSE=.012); used if measured Zm values are missing (see Part VII)

Figure 6

Chlorophyll-a vs. Total Phosphorus

( * N/P > 8, + N/P < 8 )



the regression lines and the data scatter that the chlorophyll/phosphorus relationship is not stable across data sets and that this model is of limited use in this collection of reservoirs as a whole.

99. Additional analysis shows that nitrogen and turbidity are related to chlorophyll in ways which may account for at least some of the variability in the chlorophyll/phosphorus response. Possible effects of nitrogen and turbidity have been analyzed by plotting residuals and fitting the models to various data categories, defined by N/P ratio and turbidity. With these data, it is difficult to distinguish the performance of the log-linear model B01 from the linear model B02. Since for all data sets, residual variance was slightly lower for B01, this model is the focus of further analysis presented below.

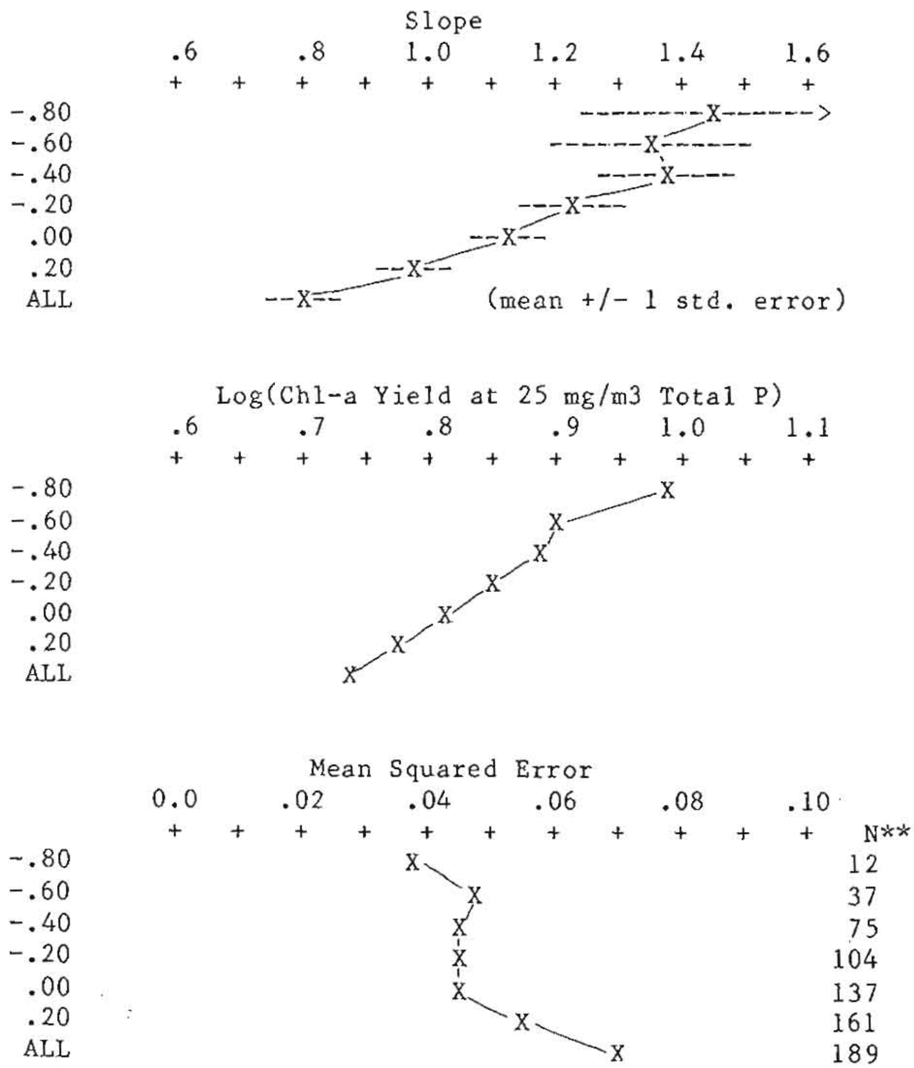
100. To test for turbidity effects, chlorophyll/phosphorus regressions have been run for groups of stations defined by maximum turbidity values, ranging from -.8 to .6 on logarithmic scales. To eliminate possible nitrogen effects, 31 stations with inorganic N/P or total N/P ratios less than 8 have been excluded from the regressions, leaving a total of 187 station-years for the analysis. This cutpoint has been determined through residuals analysis and seems to be valid for most turbidity levels, although a cutpoint of 10 may be more appropriate at extremely low turbidities (< .37 1/m). Figure 7 plots the slope, yield, and mean squared error as functions of maximum turbidity. The "yield" is defined as the logarithm of the predicted chlorophyll-a concentration at an average total phosphorus concentration of 25 mg/m3. The yield tends to be more stable and statistically independent of slope than the intercept parameter (K1).

101. Figure 7 shows that both the regression slope and yield decrease with increasing turbidity limit. The slope varies from 1.44 to .80 and the yield, from .99 to .74 on log scales, or 10 to 5.5 mg/m3 on linear scales. The mean squared error is relatively stable at about .045 for maximum turbidities up to about 1.0 1/m (0. log units), but increases to about .07 at higher turbidities.

Figure 7

Parameter Stability of the Chlorophyll/Phosphorus Model
Versus Maximum Turbidity *

Log(Maximum Turbidity, 1/m)




* based upon station-years with total and inorganic N/P > 8

** N = number of station years in category

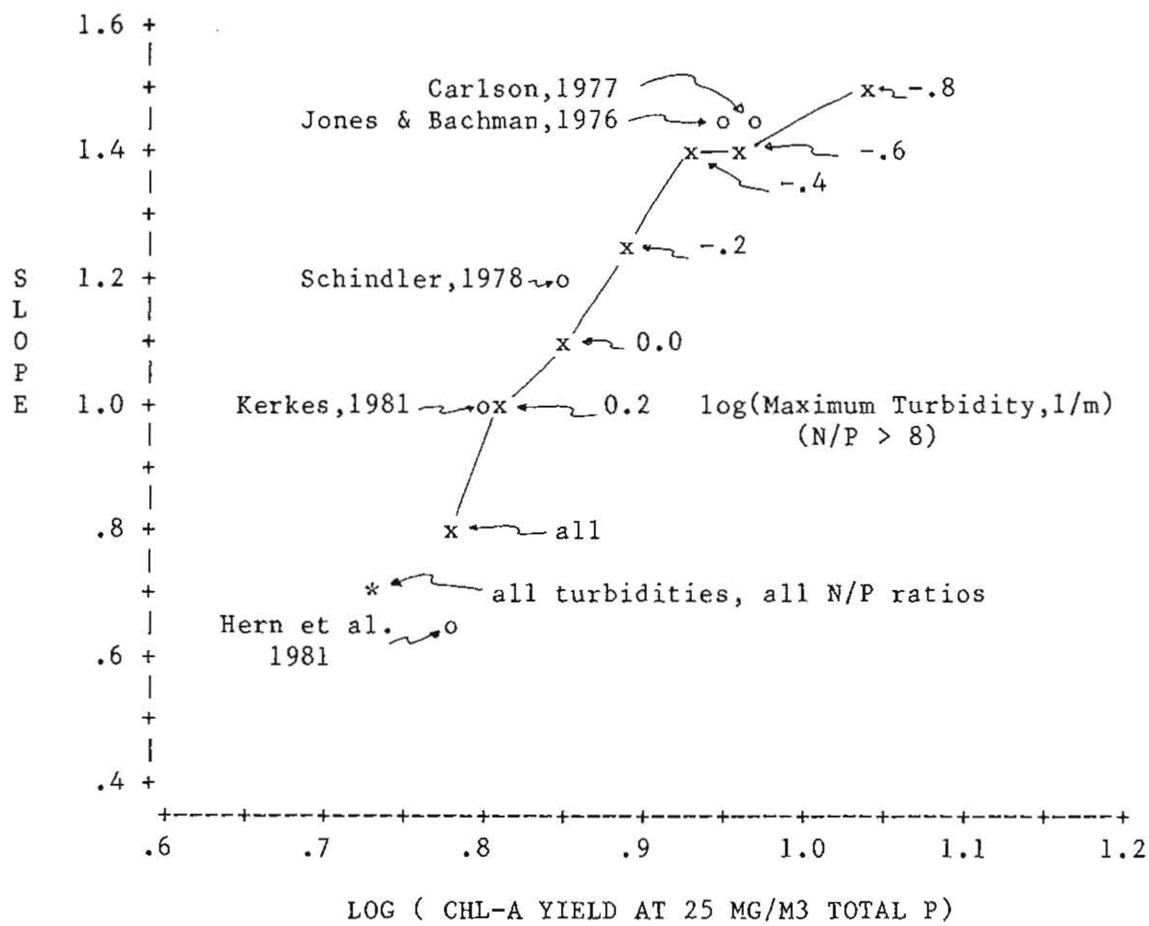
102. Figure 8 plots the path of the slope and yield parameters for increasing maximum turbidities. The path is shown in relation to the regression lines reported in other studies (see Figure 6). For a maximum turbidity of about .4 1/m, the regression is similar to the Jones and Bachman (1976) relationship. The regression calculated for a maximum turbidity value of 1.58 1/m (.2 log units) is similar to the O.E.C.D. summary relationship (Kerekes,1981). When the entire turbidity and N/P ranges are included, the parameters are similar to the regression calculated by Hern et al. (1981). These results suggest that variations in turbidity, as defined above, may explain some of the variations in the phosphorus/chlorophyll regression lines reported in the literature and some of the scatter in Figure 6.

103. Model B01 has been fit to five different data sets with various turbidity and N/P bounds (Table 19). Generally, as the maximum turbidity limit increases, the model becomes more general (i.e. more stations are included), but model error increases and phosphorus sensitivity decreases. Thus, information on likely turbidity levels is important to selecting appropriate model parameters for a given application. If no basis for turbidity estimation is available, then the most general model must be used, but at the expense of increased prediction error.

104. Both N/P and turbidity are positively correlated with total phosphorus. Analysis of the distributions of these variables indicates that out of 125 station-years with mean total phosphorus concentrations less than 40 mg/m3, only one had an N/P ratio less than 8 (inorganic) and none had a turbidity greater than 1.58 1/m (.2 log units). Thus, for practical purposes, model B01X03 in Table 19, in which chlorophyll is roughly porportional to total phosphorus, is applicable to all station-years in this low total phosphorus range. This relationship is nearly identical to the O.E.C.D. summary relationship (Kerekes, 1981). Similarly, all 80 station-years from reservoirs with mean depths in excess of 10 meters have turbidities less than 1.58 1/m. There is room for improvement in this model, however, since residuals are negatively correlated with turbidity and mean depth.

Figure 8

Slope and Yield Variations in the Chlorophyll/Phosphorus Model



105. Smith's (1980) model, B03, relates chlorophyll to total phosphorus and total nitrogen. This has been calibrated to two data sets: one containing all station-year averages and the other containing station-years with turbidities less than .37 1/m. The second group corresponds to the lowest turbidity group used in the chlorophyll/phosphorus model calibrations (model B01X05). This model does not explain appreciably more variance than model B01, even for N-limited, low-turbidity stations. The formulation of the model seems theoretically inadequate because it predicts finite chlorophyll-a concentrations at nitrogen or phosphorus concentrations approaching zero. At a given nitrogen concentration, for example, chlorophyll becomes less sensitive to phosphorus as phosphorus concentration decreases, which seems contra-intuitive. While it may be possible to formulate a model to include both phosphorus and nitrogen effects, this particular model does not appear useful for these reservoirs and is not analyzed further.

106. The Walker-Kuhner model (B04) is a multiple regression model with terms for total phosphorus, mean depth, turbidity, and surface overflow rate. This model was originally fit to EPA National Eutrophication Survey data from 23 reservoirs in Ohio, Indiana, and Illinois, none of which were nitrogen limited. Note that chlorophyll, total P, and mean depth are log-transformed, while turbidity and surface overflow rate are not. Thus, predicted chlorophyll-a is less sensitive to turbidity and surface overflow rate at low values than at high values.

107. Because the model does not include a term for nitrogen, it has been fit to two data sets: one containing all the data, and the other containing 189 station years with inorganic and total N/P ratios greater than 8. Many of the reservoirs included in the Walker-Kuhner data set are also included here. To test for parameter stability, the model has been fit to an additional data set which includes 131 station-years with the above N/P constraints from reservoirs outside of the Ohio, Indiana, and Illinois region. The magnitudes and signs of the regression coefficients compare reasonably with the originally-reported values:

| | | optimal (B04X02) | | optimal* | |
|---|---|---|---|---|---|
| coefficient | original | mean | std. error | mean | std. error |
| intercept | .49 | .22 | .16 | .12 | .22 |
| phosphorus | .88 | .83 | .075 | .76 | .104 |
| mean depth | -.59 | -.46 | .071 | -.32 | .100 |
| turbidity | -.23 | -.23 | .025 | -.19 | .034 |
| overflow rate | -.00070 | -.00047 | .00020 | -.00041 | .0002 |

* excluding station-years from Ohio, Indiana, and Illinois

108. Figure 9 summarizes the results of a parameter stability analysis of this model. Following the scheme used in Figure 7, the model has been fit to different data sets of increasing maximum turbidity levels. Figure 9 tracks the coefficient and mean squared error values. Mean squared error is relatively stable up to turbidities of 1.58 1/m (.25 log units), but increases at higher values. As in the case of the log-linear model (B01), sensitivity to phosphorus tends to decrease with increasing maximum turbidity, although the range of coefficients is considerably lower for model B04. The decreasing trend suggests an interaction between turbidity and phosphorus effects which is not accounted for in the model formulation. Depth and turbidity coefficients are relatively stable. At low turbidities, the turbidity coefficient is not significant. This is consistent with the turbidity coefficient in B04X02, -.23, since at a maximum turbidity of .56 1/m (-.25 log units) the estimated turbidity effect would be -.13, which would be difficult to identify in relation to the model standard error when higher turbidity stations are excluded. The overflow rate coefficient shows a decreasing trend with increasing turbidity. This trend may result from an interaction between turbidity and overflow rate effects or from exclusion of stations with high overflow rates (where the effect is detectable) when low turbidity constraints are applied. The magnitude of the overflow rate coefficient (-.00047) indicates that

Figure 9
Parameter Stability of the Multivariate Chlorophyll Model (B04)
as a Function of Maximum Turbidity *

```
 Log Maximum
Turbidity,1/m         Regression Coefficient
------------------------------------------------------------
                            Phosphorus
               .8     1.0     1.2     1.4     1.6     1.8
               +   +   +   +   +   +   +   +   +   +   +
   -.50                    ------X-----
   -.25          --X---
   -.00          ---X---
    .25          --X--
    all        --X--     (mean  +/- 1 std. error)

                            Mean Depth
             - .8     -.6     -.4     -.2     0.0      .2
               +   +   +   +   +   +   +   +   +   +   +
   -.50                      ----X----
   -.25                    ---X---
   -.00                    ---X---
    .25                    --X--
    all                     -X-

                            Turbidity
             - .8    - .6     -.4     -.2     0.0      .2
               +   +   +   +   +   +   +   +   +   +   +
   -.50        <-----X------------------                  **
   -.25                          ------X------            **
   -.00                      ---X---
    .25                      --X--
    all                              -X-

                        Overflow Rate X 1000
              -.8     -.6     -.4     -.2     0.0      .2
               +   +   +   +   +   +   +   +   +   +   +

   -.50                          --------------X-->**
   -.25                    ----------X----------          **
   -.00                    ------X------                  **
    .25               ------X------
    all             ------X------

                        Mean Squared Error
               .0     .01     .02     .03     .04     .05
            N  +   +   +   +   +   +   +   +   +   +   +
   -.50    55                              X
   -.25    92                              X
   -.00   137                            X
    .25   167                             X
    all   189                                X
------------------------------------------------------------
```

* data from stations with inorganic and total N/P > 8

** coefficient not significantly different from zero (p<.05) its impact on predicted chlorophyll-a is appreciable (greater than or equal to .1 log units) only in reservoirs with overflow rates greater than 212 m/yr.

109. Stepwise regression (Appendix D) explains 18% of the variance in residuals from the multivariate model (B04X02), with significant positive terms for mean depth and significant negative terms for station total depth, surface area, drainage area/surface area. The depth term suggests that substitution of a station total depth term for the reservoir mean depth term may reduce model error, although the effects are probably small, based upon the low percentage of residual variance explained. The regional analysis of variance (Appendix D) explains only 7% of residual variation and is not statistically significant.

110. The fifth chlorophyll model (B05), developed by Meta Systems (1979) includes terms for the effects of algal growth limitation by phosphorus, nitrogen, and light. Theoretical expressions for the maximum algal biomass in a batch culture limited by each of these factors separately (Bp, Bn, and Bl) are based upon algal growth kinetics and stoichiometry (see Table 19). To provide for the effects of simultaneous limitation by more than one factor, the inverses of the limiting biomass levels are used as independent variables in the regression equation for chlorophyll. Using an electrical circuit analogue, the inverses of the potential biomass levels are represented as resistances to algal growth, which are summed, with empirical weighting factors to calculate the total growth "resistance". Calculated light-limited chlorophyll levels are negative for several station-years. Following the original model, a minimum Bl value of 20 mg/m3 has been assumed. Theoretical shortcomings of this model include failure to account for possible effects of (1) flushing on the limiting biomass levels, or (2) turbidity on the bio-availablity of total phosphorus or total nitrogen.

111. With its original parameter values (K1=1.89, K2=0, K3=1.36), this model explains more chlorophyll variance ($R^2$=.51, $SE^2$=.072) than any of the other models investigated with their respective original parameter values. Optimization of the parameters (K1=2.28, K2=1.91,

K3=1.24) has little influence on the fit ($R^2$=.57, $SE^2$=.063). For most station-years, the phosphorus term is of greatest importance in determining the predicted chlorophyll-a concentration. The parameter estimate for the nitrogen-limitation term, 1.91, is not statistically significant ($p<.05$). Compared with residuals from the multivariate model (B04), residuals from B05 show greater association with reservoir morphometric, hydrologic, and water quality characteristics ($R^2$=.40) and with region ($R^2$=.23).

112. Further comparisons of model performance in various data categories defined by turbidity limits are given in Table 20, which lists bias (mean error), mean squared error, and median absolute error by model and turbidity range for stations with inorganic and total N/P ratios exceeding 8. In the lowest turbidity category (< .18 1/m), model B01X05 (similar to the Jones and Bachman (1976) regression) has the lowest median and mean squared error. As turbidity is increased, the error from this model blows up and the multivariate model (B04X02) becomes the most accurate. Differences among the models are more pronounced at higher turbidities, particularly with respect to bias.

113. On the basis of minimum error likely to be encountered over the range of turbidity conditions, the multivariate model (B04) seems attractive. In order to apply this model, however, an independent estimate of turbidity is required. Since the error statistics for this model are based upon measured values, model error would be greater under conditions where turbidities must be estimated. The fact that values of turbidity used in calibration have been estimated from measured chlorophyll values (equation (42)) may also artificially reduce the error associated with this model. Thus, while the multivariate model seems attractive from a minimum error point of view, the practicality of the model depends upon the feasiblity of estimating turbidity, which has yet to be evaluated. The multivariate model also contains more terms than the others and alternative transformations or re-expressions of the individual terms may provide a fit which is of equal or superior quality.

114. Many of the above models suggest an approximate proportionality between total phosphorus and chlorophyll in the low- to

Table 20

Effect of Turbidity Range on Chlorophyll Model Error*

| Group | Log Max. Turbidity (1/m) | N | Model B01X01 | B01X02 | B01X03 | B01X04 | B01X05 | B04X02 | B05X01 |
|---|---|---|---|---|---|---|---|---|---|
| Bias x 1000 | | | | | | | | | |
| 1 | -.75 | 20 | 17 | 33 | 47 | 35 | 10 | 0 | -28 |
| 2 | -.50 | 35 | 73 | 75 | 65 | 34 | -32 | 42 | 20 |
| 3 | -.25 | 37 | 108 | 101 | 76 | 31 | -62 | 57 | 52 |
| 4 | .00 | 45 | 106 | 73 | 0 | -84 | -260 | -10 | 71 |
| 5 | .25 | 30 | -70 | -119 | -221 | -330 | -556 | -62 | -20 |
| 6 | .75 | 22 | -203 | -264 | -389 | -516 | -779 | 7 | -98 |
| Mean Squared Error x 1000 | | | | | | | | | |
| 1 | -.75 | 20 | 61 | 56 | 50 | 43 | 38 | 39 | 49 |
| 2 | -.50 | 35 | 73 | 66 | 53 | 44 | 40 | 39 | 49 |
| 3 | -.25 | 37 | 76 | 69 | 57 | 50 | 58 | 35 | 50 |
| 4 | .00 | 45 | 58 | 47 | 35 | 39 | 101 | 24 | 47 |
| 5 | .25 | 30 | 74 | 79 | 108 | 165 | 362 | 47 | 75 |
| 6 | .75 | 22 | 99 | 127 | 208 | 324 | 670 | 75 | 72 |
| Median Absolute Error x 100 | | | | | | | | | |
| 1 | -.75 | 20 | 20 | 18 | 16 | 15 | 14 | 18 | 21 |
| 2 | -.50 | 35 | 14 | 12 | 11 | 10 | 14 | 12 | 11 |
| 3 | -.25 | 37 | 15 | 16 | 19 | 19 | 17 | 13 | 14 |
| 4 | .00 | 45 | 16 | 12 | 14 | 15 | 26 | 10 | 15 |
| 5 | .25 | 30 | 21 | 21 | 28 | 35 | 60 | 16 | 21 |
| 6 | .75 | 22 | 22 | 25 | 37 | 50 | 79 | 13 | 16 |

* includes station-years with at least 3 sampling dates and inorganic and total N/P > 8

mid-turbidity ranges at P-limited stations. For stations with N/P ratios exceeding 8, the following model relates the "response ratio" (Hern et al., 1981) to depth and turbidity:

$$\log(B/P) = -.39 - .46\ \log(Z) - .58\ \log(A) \qquad (45)$$
$$(R^2=.45,\ SE^2=.042)$$

The above model explains 75% of the variance in chlorophyll-a and suggests that the response ratio varies roughly inversely as the square root of the product of mean depth and turbidity. It is interesting that the depth alone is not significantly correlated with the response ratio ($R^2$=.01). Turbidity alone yields an R-Squared of .27, which increases to .45 when the depth term is added. This suggests that the product of depth and turbidity is of some significance, as predicted by the kinetic theory of algal growth under light-limited conditions, since it is directly related to the depth-averaged light intensity (Oskam,1973, Lorenzen and Mitchell,1973). Residuals plots indicate a negative bias (over-prediction) of about .2 log units in the above model for reservoirs with overflow rates exceeding 100 m/yr or residence times less than .03 years. This and alternative methods for representing phosphorus/turbidity/chlorophyll relationships (e.g., model B04, B05, equation (43)) should be more thoroughly investigated for their potential uses in reservoirs.

## Regional Analysis

115. Regional distributions in transparency, chlorophyll, nutrients, and related factors provide additional insights into factors controlling transparency and chlorophyll. Table 21 summarizes the geometric mean concentrations of these variables on a regional basis. To provide the broadest possible data base for regional analysis, mean concentrations have been computed using data from 448 station-years with at least two sampling dates for corrected chlorophyll-a. Analysis based upon 218 station-years with at least 3 sampling dates excludes one region (South Pacific) but gives similar results. Analyses of variance

Table 21

Regional Variations in Chlorophyll, Transparency, and Nutrient Data from Station-Years with at Least Two Sampling Dates

| Reg* | N | B | S | A | TP | TN | B×S | B/TP | TP×S | TN/TP | IN/DP** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Variable | | | | | | |
| Regional Geometric Means | | | | | | | | | | | |
| All | 448 | 7.9 | 1.14 | .58 | 40 | 755 | 9.0 | .20 | 45 | 19 | 22 |
| 02 | 7 | 6.5 | 2.28 | .26 | 17 | 1195 | 14.7 | .38 | 38 | 46 | 65 |
| 03 | 70 | 6.9 | 1.45 | .47 | 24 | 585 | 10.1 | .29 | 35 | 24 | 29 |
| 04A | 19 | 8.4 | 1.29 | .45 | 30 | 989 | 10.8 | .28 | 39 | 33 | 56 |
| 04B | 34 | 14.1 | 0.87 | .64 | 51 | 1416 | 12.3 | .28 | 44 | 28 | 59 |
| 04C | 19 | 8.5 | 1.09 | .68 | 38 | 943 | 9.2 | .22 | 41 | 25 | 45 |
| 04D | 34 | 6.5 | 1.28 | .59 | 39 | 580 | 8.4 | .17 | 50 | 15 | 15 |
| 05 | 25 | 17.7 | 1.31 | .22 | 67 | 1679 | 23.2 | .26 | 88 | 16 | 7 |
| 06 | 41 | 9.3 | 1.09 | .58 | 43 | 838 | 10.2 | .21 | 47 | 19 | 29 |
| 07A | 41 | 4.8 | 2.29 | .29 | 21 | 486 | 11.1 | .23 | 48 | 23 | 33 |
| 07B | 81 | 7.8 | 0.58 | 1.39 | 71 | 792 | 4.6 | .11 | 41 | 11 | 12 |
| 08 | 59 | 10.0 | 0.89 | .76 | 51 | 978 | 8.9 | .20 | 45 | 19 | 27 |
| 09 | 11 | 2.5 | 2.92 | .27 | 24 | 265 | 7.2 | .10 | 70 | 11 | 4 |
| 10 | 7 | 1.0 | 4.88 | .18 | 14 | 198 | 4.9 | .07 | 69 | 13 | 3 |
| Analyses of Variance | | | | | | | | | | | |
| Mean Squares (base 10 logarithms) | | | | | | | | | | | |
| Within | | 1.412 | 1.503 | 2.124 | 1.430 | .990 | 1.127 | .991 | .329 | .807 | 3.504 |
| Among | | .101 | .083 | .127 | .118 | .047 | .094 | .093 | .041 | .066 | .121 |
| F† | | 13.98 | 18.20 | 16.66 | 12.11 | 21.15 | 11.93 | 10.66 | 8.04 | 12.28 | 29.04 |

* Regional Codes (C.E. Divisions)

02 = North Atlantic
03 = South Atlantic
04A = Ohio River (Pittsburg)
04B = Ohio River (Huntington)
04C = Ohio River (Louisville)
04D = Ohio River (Nashville)
05 = North Central
06 = Lower Mississippi
07A = Southwest (Little Rock)
07B = Southwest (other)
08 = Missouri River
09 = North Pacific
10 = South Pacific

** Inorganic nitrogen/dissolved phosphorus ratio

† All F statistics significant at $p < .001$; ANOVA's conducted on log scales

indicate significant regional variations for all variables and variable combinations investigated. Three variable combinations are particularly useful:

B*S = chlorophyll * transparency (mg/m2)

B/P = chlorophyll / total phosphorus -

P*S = total phosphorus * transparency (mg/m2)

The first statistic provides an indication of the percentage of light extinction attributed to chlorophyll and related substances. The second, termed the "response ratio" by Hern et al. (1981), is an indicator of the amount of chlorophyll produced per unit of total phosphorus. The third, derived from the phosphorus/transparency model calibrated above (S05X02), reflects the percentage of light extinction attributed to materials associated with phosphorus, whether organic or inorganic in form. Other important factors include the total N/P ratio and inorganic N/P ratio, as indicators of the potential nitrogen limitation.

116. Analyses of variance indicate that regional factors are strongest in the case of the inorganic N/P ratio (F=29.0) and weakest in the case of P*S (F=8.0). The relatively low variablity in P*S reflects the low mean squared error of the phosphorus/transparency model and covariance attributed to non-algal suspended solids.

117. Stem-and-leaf (Mosteller and Tukey, 1977) diagrams of these factors (Figure 10) facilitate analysis of regional variations. The chlorophyll*transparency distribution has two low outliers: region 7B (Southwest Division, exclusive of Little Rock District) and region 10 (South Pacific Division, although this average is derived from only 7 station-years of data, all from one reservoir, and may not be representative of the Division as a whole). In these regions, relatively low percentages of incident light are available for photosynthesis and relatively high percentages of nutrients may be tied up in inorganic forms. N/P ratios generally show a decreasing trend from east to west. There are three regions where the inorganic N/P ratio averages less than 8: region 5 (North Central Division), region 9

Figure 10

Stem-and-Leaf Diagrams of Eutrophication-Related Factors by Region *

Station-Years with at Least Two Sampling Dates

| Chl-a×Secchi | | Chl-a/Total P | | Total P×Secchi | |
|---|---|---|---|---|---|
| 1.3 | 5 | -.4 | | ** 2.1 | |
| 1.2 | | -.5 | | 2.0 | |
| 1.1 | 2 | -.6 | 2 3 4A 4B 5 | 1.9 | 5 |
| 1.0 | 3 4A 4B 6 7A | -.7 | 4C 4D 6 7A 8 | 1.8 | 9 10 |
| .9 | 8 4C 4D | -.8 | | 1.7 | 4D |
| .8 | 9 | -.9 | | 1.6 | 4B 4C 6 7A 8 7B |
| .7 | | -1.0 | 7B 9 | 1.5 | 2 3 4A |
| .6 | 7B 10 | -1.1 | | 1.4 | |
| .5 | | -1.2 | 10 | 1.3 | |

| Total N/P | | Inorganic N/P | | Turbidity | |
|---|---|---|---|---|---|
| 1.6 | 2 | 2.0 | | .1 | 7B |
| 1.5 | 4A | 1.8 | 2 | .0 | |
| 1.4 | 4B | 1.6 | 4A 4B 4C | -.1 | |
| 1.3 | 7A 3 4C | 1.4 | 3 6 8 7A | -.2 | 4B 4C 8 |
| 1.2 | 5 6 8 | 1.2 | | -.3 | 4D 6 |
| 1.1 | 4D 10 | 1.0 | 4D 7B | -.4 | 4A 3 |
| 1.0 | 7B 9 | .8 | 5 | -.5 | |
| .9 | | .6 | 9 | -.6 | 2 7A 9 |
| .8 | | .4 | 10 | -.7 | 5 |
| .7 | | .2 | | -.8 | 10 |

| Mean Depth | | Residence Time | | Overflow Rate | |
|---|---|---|---|---|---|
| 1.6 | 9 | -.2 | 8 | 2.1 | 10 |
| 1.5 | | -.3 | | 2.0 | |
| 1.4 | | -.4 | 5 7A 9 | 1.9 | 4B 4D 9 |
| 1.3 | | -.5 | 6 7B | 1.8 | 2 |
| 1.2 | 10 | -.6 | | 1.7 | 4A |
| 1.1 | 7A | -.7 | | 1.6 | 3 4C |
| 1.0 | | -.8 | 3 4C | 1.5 | 7A |
| .9 | 2 3 4D 8 | -.9 | 2 4A | 1.4 | |
| .8 | 4A 4C 6 | -1.0 | 10 | 1.3 | |
| .7 | 4B 7B | -1.1 | 4D | 1.2 | 6 7B |
| .6 | 5 | -1.2 | 4B | 1.1 | |
| .5 | | -1.3 | | 1.0 | 5 8 |

* regional codes defined in Table 21
** minimum of interval (log10 scales)

(North Pacific) and region 10 (South Pacific). In these regions, algal growth is more likely to be limited by nitrogen than by phosphorus, on the average. Regions 9 and 10 also lie at the upper ends of the mean depth and surface overflow rate distributions.

118. The above outlier groups can be used to explain some of the regional variations in chlorophyll and transparency responses to phosphorus. Region 10 has the lowest chlorophyll/phosphorus ratio (.07) and is also found in all of the above outlier groups. Region 9 has the next lowest B/P ratio (.10) and is in the low N/P and deep groups. Region 7B has the next lowest B/P value (.11), the lowest chlorophyll*transparency product, and the highest average turbidity. The remaining regions are clustered are higher B/P ratios. The phosphorus*transparency distribution shows three high outliers, regions 5, 9, and 10. These correspond to the regions with lowest inorganic N/P ratios and lowest turbidities. In N-limited situations, appreciable fractions of total phosphorus may be in dissolved form and have little impact on transparency. While the data base is relatively weak in some regions (especially New England, North Atlantic, North Pacific, South Pacific), variations in turbidity, N/P ratio, and depth, which show strong regional patterns, determine the average responses of transparency and chlorophyll to total phosphorus.

## Conclusions

119. The following conclusions can be drawn from the internal model testing described above:

a. Predicting transparency as a function of chlorophyll is difficult in these reservoirs because of the influences of substances unrelated to chlorophyll on light extinction.

b. The following model can be used to partition light into two components:

$$1/S = A + .025\ B$$

where,

$S$ = mean transparency (m)

$B$ = mean chlorophyll-a ($mg/m^3$)

$A$ = non-algal turbidity (1/m)

Variations in the intercept term ("A") are large and tend to obscure the chlorophyll/transparency relationship. Independent data indicate that "A" values calculated from the above equation are positively correlated with Hach turbidity, suspended solids, and true color.

c. At stations with inorganic and total N/P ratios exceeding 8, transparency can be related to total P using model S05X02:

$$1/S = .082 + .022\,P \qquad (R^2 = .77, SE^2 = .024)$$

where,

$P$ = mean total phosphorus ($mg/m^3$)

The above model over-predicts transparency by an average of 35% at stations where chlorophyll accounts for less than about 12% of the total light extinction. Transparency is under-predicted in northern reservoirs, which tend to have lower N/P ratios and lower non-algal turbidity levels. Phosphorus associated with algae has a somewhat smaller influence on transparency than that associated with turbidity.

d. The following model represents the partitioning of phosphorus at stations with N/P ratios exceeding 8:

$$\log(P) = \log(2.0 + 1.76\,B + 26.2\,A) \qquad (R^2 = .84, SE^2 = .019)$$

This model has relatively low error, but cannot be used in reverse (to predict chlorophyll, for example), without a predictive basis for turbidity.

e. Effects of nitrogen, turbidity, depth, and overflow rate contribute to variations in phosphorus/chlorophyll relationships.

f. Phosphorus/chlorophyll models fit to data sets with increasingly restrictive N/P and turbidity limits show increased phosphorus sensitivity and yield, reduced error, reduced association with reservoir morphometric, hydrologic, and water quality characteristics, and reduced association with region, but reduced generality and robustness.

g. The multivariate model (B04X02) which includes terms for the effects of phosphorus, depth, turbidity, and overflow rate on chlorophyll has fairly stable coefficients and applies to 87% of the station-years studied (exclusive of N-limited stations):

$$\log(B) = .22 + .83 \log(P) - .23\ A - .46 \log(Z) - .00046\ Qs \qquad (R^2 = .72, SE^2 = .041)$$

Parameter stability tests indicate an interaction between phosphorus and turbidity effects which is not accounted for in the model.

h. Model selection and, in the cases of models B04 and B05, model use depend upon estimates of turbidity and N/P ratio. Means for estimating these variables *a priori* are needed if these models are to be used in a reservoir planning context. Additional investigation of alternative means for representing the effects of turbidity and N/P ratio on phosphorus/chlorophyll relationships is needed.

i. In the absence of a basis for estimating turbidity or N/P ratio, model B01X03 may be applied to stations with mean total phosphorus concentrations less than 40 mg/m3:

$$\log(B) = -.60 + .98 \log(P) \qquad (R^2 = .64, SE^2 = .057)$$

This model also applies to all stations with N/P ratios > 8 and turbidities < 1.58 1/m, or 74% of the station-years studies. Errors are not independent of mean depth or turbidity, however.

j. Regional variations in average chlorophyll-transparency products, inorganic N/P ratios, and reservoir mean depths explain regional variations in the responses of transparency and chlorophyll to total phosphorus.

## PART VI: LOADING MODELS

### Introduction

120. Another class of models relates reservoir water quality characteristics to external phosphorus loading, morphometric characteristics, and hydrologic characteristics. These models can be classified according to predicted variable:

- a. mean, annual, outflow phosphorus concentration
- b. mean, growing-season, epilimnetic phosphorus concentration
- c. mean, growing-season, epilimnetic chlorophyll-a concentration
- d. mean, growing-season transparency
- e. hypolimnetic oxygen depletion

The calibration and testing of models in the first four classes are described in the following sections. The fourth section discusses the potential effects of spatial gradients on these relationships. Hypolimnetic oxygen depletion is treated separately in Part VII.

### Outflow Phosphorus

121. Prediction of outflow phosphorus concentration provides a basis for establishing a phosphorus mass balance around the reservoir, since the outflow concentration estimates are flow-weighted and averaged on an annual basis. Nutrient and water budgets for the EPA/NES tributary sampling years have been used to provide estimates of inflow phosphorus concentration, mean depth, and hydraulic residence time. After application of the screening criteria described in Part III, data from 62 "group A" reservoirs are available for model testing. The data set is listed and summarized in Appendix C.

122. A total of 16 different model formulations have been compiled from the literature. Formulations, parameters, and error statistics for the original and optimized models are listed in Table 22. Complete statistical summaries of model residuals, regional analyses, correlation

Table 22

Formulations, Parameter Estimates, and Error Statistics for Models Predicting Outflow Phosphorus Concentration

Model R01: first-order sedimentation

Equation: $\log(Po) = \log(Pi) - \log(1 + K1\ T)$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| R01A01 | Vollenweider(1969) | .65 | 62 | .135 | .128 |
| R01A02 | Mueller(1980) | 2.00 | 62 | .499 | .074 |
| R01X01 | Optimal | 4.24 | 62 | .633 | .055 |
| | standard error | .57 | | | |
| R01X02 | Optimal * | 3.31 | 56 | .724 | .041 |
| | standard error | .45 | | | |

Model R02: first-order settling

Equation: $\log(Po) = \log(Pi) - \log(1 + K1/Qs)$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| R02A01 | Vollenweider(1969) | 10.0 | 62 | .287 | .106 |
| R02A02 | Dillon(1975) | 13.2 | 62 | .368 | .094 |
| R02A03 | Chapra (1976) | 16.0 | 62 | .420 | .086 |
| R02A04 | Higgins et al(1980) | 92.0 | 62 | .104 | .133 |
| R02X01 | Optimal | 33.3 | 62 | .534 | .070 |
| | standard error | 5.1 | | | |
| R02X02 | Optimal * | 25.1 | 56 | .655 | .051 |
| | standard error | 3.9 | | | |

Model R03: Vollenweider(1976) and others

Equation: $\log(Po) = \log(Pi) - \log(1 + K1\ T^{K2})$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R03A01 | Vollenweider(1976) | 1.00 | .50 | 62 | .426 | .085 |
| R03A02 | Walker(1977) | .82 | .45 | 62 | .369 | .094 |
| R03A03 | Larsen et al (1976) | .89 | .51 | 62 | .379 | .092 |
| R03A04 | Mueller (1980) | 2.09 | .83 | 62 | .564 | .065 |
| R03A05 | Clasen (1980) | 2.27 | .59 | 62 | .647 | .052 |
| R03A06 | Clasen (1980) | 2.00 | .50 | 62 | .638 | .054 |
| R03A07 | Fricker (1980) | 1.42 | .049 | 62 | .534 | .069 |
| R03X01 | Optimal | 2.98 | .59 | 62 | .671 | .051 |
| | standard errors | .59 | .13 | | | |
| R03X02 | Optimal * | 2.13 | .50 | 56 | .775 | .033 |
| | standard errors | .39 | .12 | | | |

(continued)

Table 22 (continued)

Model R04
Equation: log(Po) = log(Pi) - log(K1 + K2 T)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R04A01 | Jones&Bachman(1976) | 1.18 | .76 | 62 | .377 | .092 |
| R04A02 | Reckhow (1977) | 1.13 | .17 | 62 | .058 | .140 |
| R04A03 | Mueller (1980) | 1.14 | 1.83 | 62 | .547 | .067 |
| R04X01 | Optimal | 1.36 | 3.16 | 62 | .660 | .052 |
| | standard errors | .17 | .69 | | | |
| R04X02 | Optimal * | 1.38 | 2.16 | 56 | .760 | .036 |
| | standard errors | .14 | .53 | | | |

Model R05: Reckhow (1978)
Equation: log(Po) = log(Pi) - log(K1 + K2/Qs)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R05A01 | Reckhow(1978) | 1.20 | 11.6 | 62 | .461 | .080 |
| R05X01 | Optimal | 1.56 | 18.1 | 62 | .581 | .064 |
| | standard errors | .20 | 5.4 | | | |
| R05X02 | Optimal * | 1.56 | 10.7 | 56 | .715 | .043 |
| | standard errors | .15 | 3.8 | | | |

Model R06: Kirchner & Dillon (1975)
Equation: log(Po) = log(Pi)-log(1-K1 EXP(-K2 Qs)-K3 EXP(-K4 Qs))

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| R06A01 | Kirchner et al (1975) | .426 | .271 | .574 | .00949 | 62 | .508 | .073 |
| R06A02 | Ostrofski (1978) | .201 | .0425 | .574 | .00949 | 62 | .593 | .060 |
| R06A03 | Mueller (1980) | .29 | .556 | .71 | .00483 | 62 | .647 | .052 |
| R06X01 | Optimal | ** | ** | .76 | .0073 | 62 | .663 | .052 |
| | standard errors | | | .050 | .0022 | | | |
| R06X02 | Optimal * | ** | ** | .70 | .0074 | 56 | .783 | .032 |
| | standard errors | | | .050 | .0021 | | | |

** term not significant

Model R07: Norvell, Frink, and Hill (1979)
Equation: log(Po) = log(Pi) + log((K1 + Qs)/(K2 + Qs))

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R07A01 | Norvell et al (1979) | 1.2 | 12.0 | 62 | .298 | .104 |
| R07X01 | Optimal | 23.1 | 103.4 | 62 | .660 | .052 |
| | standard errors | 14.4 | 40.0 | | | |
| R07X02 | Optimal * | 28.3 | 99.3 | 56 | .781 | .032 |
| | standard errors | 16.5 | 38.9 | | | |

(continued)

Table 22 (continued)

Model R08: Higgins and Kim (1981)

Equation: $\log(Po) = \log(Pi) + \log(K1 + K2 \log(Qs))$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R08A01 | Higgins et al. (1981) | .54 | .51 | 62 | .114 | .130 |
| R08X01 | Optimal | .084 | .237 | 62 | .622 | .056 |
| | standard errors | .085 | .059 | | | |
| R08X02 | Optimal * | .144 | .232 | 56 | .756 | .037 |
| | standard errors | .084 | .056 | | | |

Model R09: plug flow settling

Equation: $\log(Po) = \log(Pi) - K1/Qs$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| R09A01 | Higgins et al (1981) | 26.5 | 62 | -16. | 2.500 |
| R09X01 | Optimal | 3.74 | 62 | .199 | .121 |
| | standard errors | .62 | | | |
| R09X02 | Optimal * | 3.06 | 56 | .427 | .084 |
| | standard errors | .55 | | | |

Model R10: Clasen (1980)

Equation: $\log(Po) = \log(Pi) - \log(1 + K1\, T^{K2}\, Z^{K3})$

| Code | Coefficients | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| R10A01 | Classen (1980) | 7.24 | .608 | -.50 | 62 | .635 | .054 |
| R10A02 | Fricker (1980) | 9.35 | 1.00 | -.69 | 62 | .486 | .076 |
| R10X01 | Optimal | 4.16 | 0.62 | -.14 | 62 | .675 | .051 |
| | standard errors | 1.95 | .14 | .18 | | | |
| R10X02 | Optimal * | 3.24 | .54 | -.17 | 56 | .780 | .034 |
| | standard errors | 1.41 | .13 | .17 | | | |

Model R11: Clasen (1980)

Equation: $\log(Po) = K1 \log(Pi) + K2$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R11A01 | Classen (1980) | .85 | -.11 | 62 | .554 | .066 |
| R11A02 | Fricker (1980) | 1.01 | -.35 | 62 | .494 | .075 |
| R11A03 | Fricker (1980) | .88 | -.18 | 62 | .533 | .069 |
| R11X01 | Optimal | .70 | .28 | 62 | .622 | .058 |
| | standard errors | .07 | .15 | | | |
| R11X02 | Optimal * | .81 | .088 | 56 | .711 | .043 |
| | standard errors | .07 | .14 | | | |

(continued)

Table 22 (continued)

Model R12: Clasen (1980)

Equation: $\log(Po) = \log(Pi)\,(1 - K1\,T^{K2})$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R12A01 | Clasen (1980) | .25 | .32 | 62 | .747 | .038 |
| R12X01 | Optimal | .29 | .34 | 62 | .763 | .036 |
| | standard errors | .024 | .064 | | | |
| R12X02 | Optimal * | .25 | .32 | 56 | .813 | .028 |
| | standard errors | .024 | .068 | | | |

Model R13: Fricker (1980)

Equation: $\log(Po) = K2 + K1\,\log(Pi/(1+T^{.5}))$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R13A01 | Fricker (1980) | .906 | .104 | 62 | .613 | .057 |
| R13A02 | Fricker (1980) | .754 | .254 | 62 | .709 | .043 |
| R13A03 | Ryding (1980) | .96 | -.02 | 62 | .613 | .058 |
| R13X01 | Optimal | .74 | .32 | 62 | .718 | .043 |
| | standard errors | .060 | .12 | | | |
| R13X02 | Optimal * | .83 | .19 | 56 | .794 | .031 |
| | standard errors | .057 | .11 | | | |

Model R14: multivariate, Walker (1977)

Equation: $\log(Po) = K1 + K2\,\log(Pi) + K3\,\log(Z) + K4\,\log(T)$

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| R14A01 | Walker (1977a) | -.02 | .88 | -.15 | -.17 | 62 | .672 | .049 |
| R14X01 | Optimal | .48 | .61 | -.22 | -.23 | 62 | .810 | .030 |
| | standard errors | .20 | .061 | .093 | .048 | | | |
| R14X02 | Optimal * | .18 | .73 | -.11 | -.22 | 60 | .837 | .025 |
| | standard errors | .21 | .067 | .091 | .045 | | | |

Model R15

Equation: $\log(Po) = \log(Pi) - \log(1 + 10^{K1}\,Pi^{K2}\,Z^{K3}\,T^{K4})$

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| R15A01 | Canfield & Bachman(1981) | -.89 | .55 | 0. | .45 | 62 | .749 | .037 |
| R15A02 | Canfield & Bachman(1981) | -.79 | .46 | 0. | .54 | 62 | .653 | .051 |
| R15A03 | Canfield & Bachman(1981) | -.94 | .59 | 0. | .41 | 62 | .768 | .034 |
| R15X01 | Optimal | -1.50 | .70 | .46 | .43 | 62 | .813 | .030 |
| | standard errors | .40 | .11 | .18 | .11 | | | |
| R15X02 | Optimal * | -.93 | .51 | .23 | .44 | 56 | .828 | .027 |
| | standard errors | .68 | .14 | .20 | .11 | | | |
| R15X03 | Optimal * | -.68 | .50 | .00 | .50 | 56 | .828 | .027 |
| | standard errors | .045 | ** | ** | ** | | | |

** parameters constrained to above values

(continued)

Table 22 (continued)

Model R16: Walker and Kuhner (1978)

Equation $\log(Po) = \log(Pi) - \log(1 + (K1 + K2\ Sr)/Qs)$

Sr = sedimentation rate (kg/m2-yr)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| R16A01 | Walker & Kuhner (1978) | -4.0 | 1.0 | 17 | .099 | .056 |
| R16X01 | Optimal ** | -5.5 | .92 | 17 | .110 | .055 |
| | standard errors | 6.2 | .38 | | | |

** cases with sedimentation rate data conform to restricted data set described below (i.e., R16X02=R16X01).

* restricted data set includes reservoirs with:
inflow (Ortho-P/Total P) > .12
inflow Total P < 500 mg/m3

matrices, and results of stepwise regressions are given in Appendix D. Models R01-R10 can be described as first-order models in which the retention coefficient:

$$R = 1 - Po/Pi \tag{46}$$

where,

R = total phosphorus retention coefficient

Pi = average inflow concentration (mg/m3)

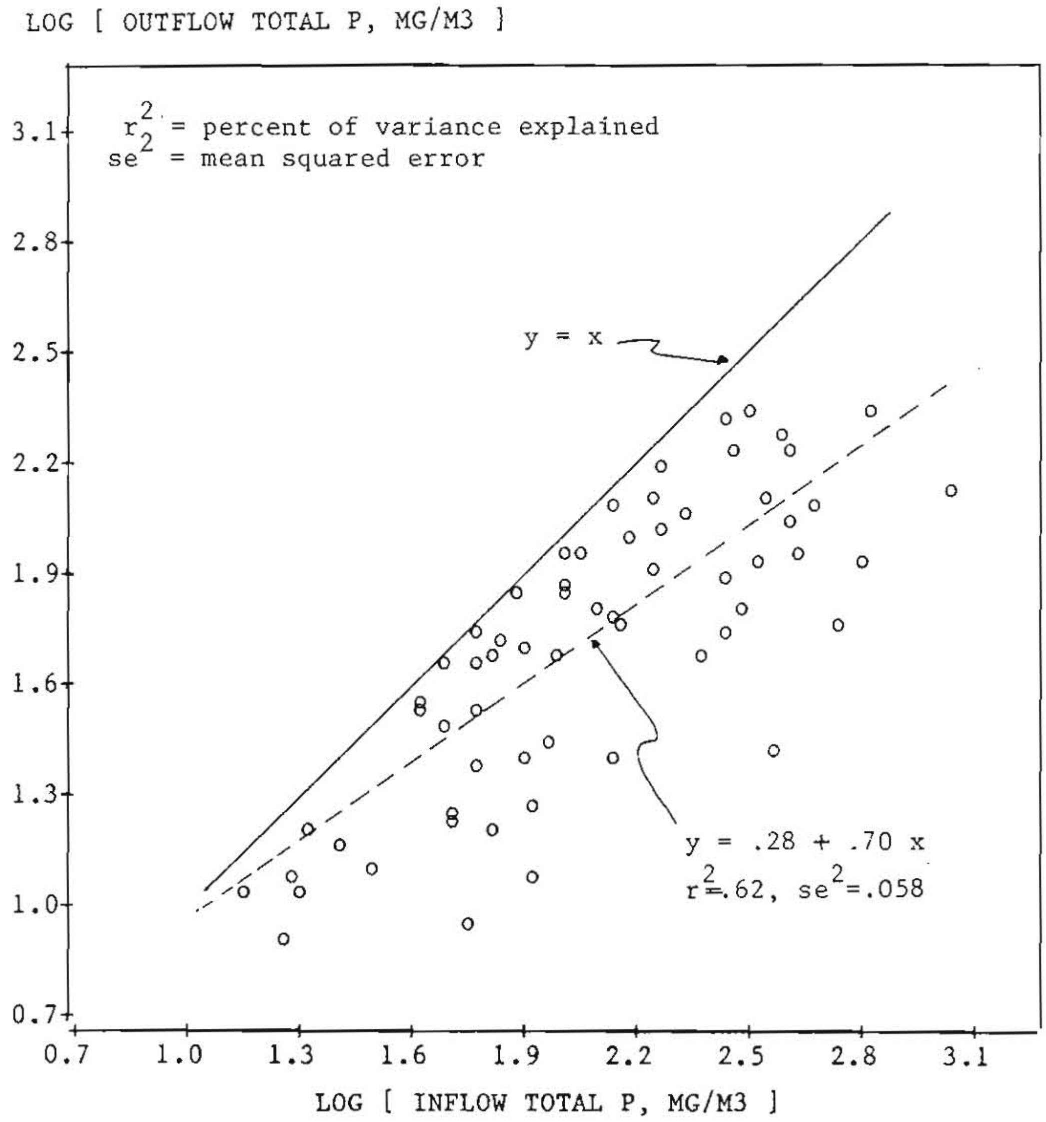
Po = average outflow concentration (mg/m3)

is estimated exclusively as a function of morphometric/hydrologic characteristics. As discussed in Part III, inflow concentrations have been corrected for evaporation effects according to equation (35) and correspond to the total loading divided by the reservoir discharge. For models R01-R10, outflow phosphorus concentration is assumed to be proportional to the inflow concentration, with the proportionality constant estimated from mean depth, hydraulic residence time, and/or surface overflow rate. This amounts to assuming that the removal of phosphorus from the water column is a first-order reaction. For models R11-R15, proportionality between inflow and outflow concentration is not assumed, i.e., the retention coefficient may depend upon phosphorus concentration, as well as upon morphometric/hydrologic variables. For model R16, the sedimentation rate is an important independent variable; however, sediment survey data are available for only 17 "group A" reservoirs for calibration and testing of this model (see Part III).

123. The relationship between inflow and outflow total P concentrations is depicted in Figure 11. The regression model R11 relates Po directly to Pi without accounting for morphometric/hydrologic effects on the retention coefficient and explains 62% of the variance in the outflow concentration values with a mean squared error of .058. For most models, residuals plots have revealed significant negative deviations (model over-predictions by .2 to .5 log units) for reservoirs with extremely high concentrations of inflow total phosphorus (> 500 mg/m3) or with low percentages of orthophosphorus loading ( < 12 %). To eliminate the influences of these reservoirs on the model parameter

Figure 11

Outflow Total P vs. Inflow Total P



estimates, all models have been fit to an additional data set which excludes six reservoirs in the above categories. For most models, errors are significantly lower for the restricted data set. Observed and predicted outflow phosphorus concentrations are plotted in Figure 12 for models R03, R12, and R15.

124. Model R01 is the first-order sedimentation model proposed by Vollenweider (1969). This represents the reservoir as a completely mixed reactor at steady-state. For the restricted data set, the optimal decay rate parameter is 3.3 1/yr, as compared with the originally proposed value of .65 1/yr. Similarly, the optimal coefficient for the settling velocity model (R02) is 25 m/yr, as compared with lake values in the range of 10 - 16m/yr and with a value of 92 m/yr found by Higgins and Kim (1981) for TVA reservoirs with total P concentrations greater than 25 mg/m3 (Appendix E).

125. Model R03 permits the sedimentation coefficient to vary as a power function of residence time. The optimal exponent is -.50, identical to the original value found by Vollenweider (1976), Larsen and Mercier (1976), and others. The optimal coefficient, however, is 2.1 (standard error .39), compared with original values ranging from .82 to 1.0 for lake data sets and 2 to 2.3 for other reservoir data sets (Mueller,1980, Clasen,1980). Thus, calibration of models R01-R03 indicates that, for a given residence time and mean depth, these reservoirs tend to be more effective at removing phosphorus from the water column than are the natural lakes used in empirical model development. Some the difference may be attributed to plug-flow behavior (i.e., significant spatial gradients) and some to higher sedimentation rates in reservoirs.

126. The potential effects of plug flow can be calculated by assuming that the reservoir consists of a series of n linked segments of equal volume and applying Vollenweider's model (R03A01) to each segment. The resulting expression for the outflow/inflow concentration ratio is:

$$Po/Pi = [\ 1 + (T/n)^{.5}\ ]^{-n} = [\ 1 + KE\ T^{.5}\ ]^{-1} \qquad (47)$$

where,

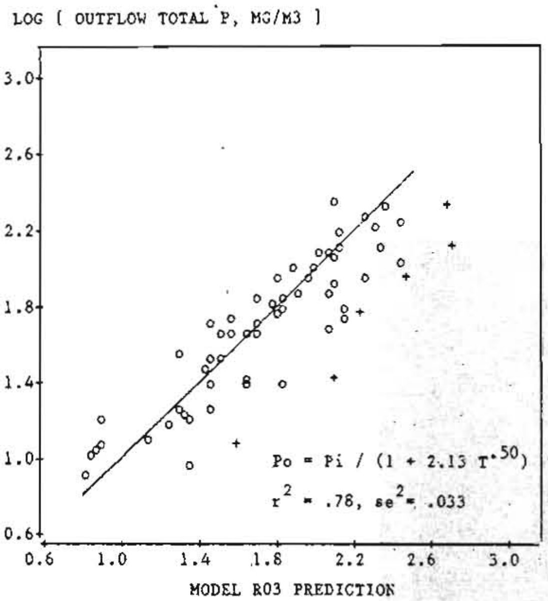
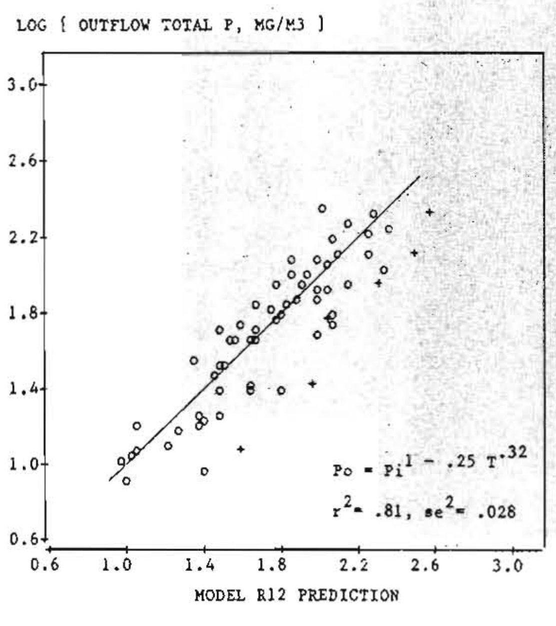
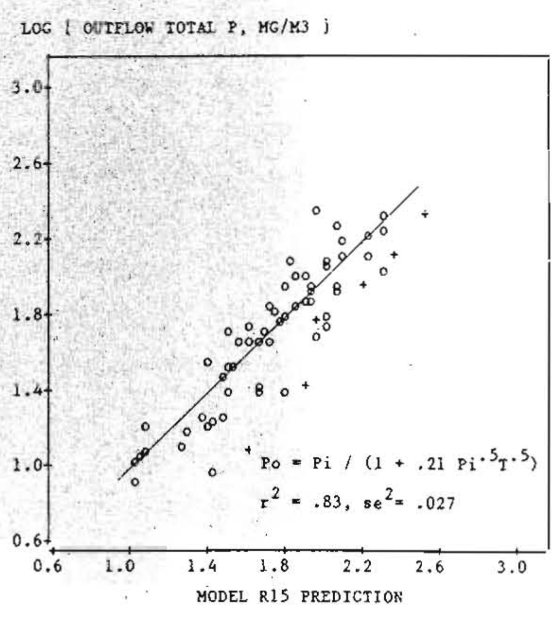



Figure 12

Observed and Predicted
Outflow P Concentrations

o = points included in regression
\+ = points excluded from regression
Pi > 500 mg/m3, or
Inflow Ortho-P/Total P < .12



T = total residence time (yr)

n = number segments of equal residence time in series

KE = effective rate constant for mixed model (R03)

The effective rate constant, KE, corresponds to the parameter estimate which would result from optimization of the model, assuming mixed conditions (or one segment). Table 23 presents calculated ratios and effective rate constants for values of T ranging from .1 to .9 years and values of n ranging from 1 to 5 cells. For a given residence time, plug flow effects could clearly result in lower outflow concentrations and higher effective rate constants, especially as residence time and number of cells increase. For three cells at a residence time of .5 year, for example, an effective rate constant of about 2.5 is calculated, where each of the three segments has a rate constant of 1.0 (i.e., obeys the original Vollenweider/Larsen-Mercier model).

127. Thus, it seems likely that plug flow effects could partially account for the higher rate coefficients estimated for models R01 - R03, although residuals analyses described below suggest that higher sediment accumulation rates may also be involved. The above analysis is theoretical and may over-estimate the plug-flow effects, since it has not been demonstrated that Vollenweider's model can be successfully applied to separate reservoir segments, especially in series. It seems unlikely that the same rate coefficients could apply to each reservoir segment, since, in many cases, upper pool segments would tend to have higher percentages of allochthonous particulate phosphorus and have different removal mechanisms, compared with near-dam segments (Thornton et al, 1980). More detailed modelling of spatial gradients within reservoirs, similar to the work done by Higgins and Kim (1981) on Cherokee Reservoir, is needed in order to sort out these factors. Calibration of the plug-flow, settling model proposed by Higgins and Kim (model R09) is largely unsuccessful ($R^2$=.31, $SE^2$=.084) because the model requires a much higher sensitivity to overflow rate than the data support. It is possible that their approach could be applied successfully to reservoirs in certain morphometric and inflow concentration ranges. The current study is limited, however, to a

Table 23

Potential Effects of Plug Flow Behavior on Phosphorus Removal and Effective Rate Coefficients

| | n = Effective Number of Cells | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| T(yr) | ---------- | Po/Pi | ---------- | | |
| .10 | .760 | .668 | .605 | .556 | .516 |
| .20 | .691 | .577 | .502 | .446 | .402 |
| .30 | .646 | .520 | .439 | .380 | .334 |
| .40 | .613 | .477 | .393 | .333 | .288 |
| .50 | .586 | .444 | .358 | .298 | .253 |
| .60 | .564 | .417 | .330 | .270 | .226 |
| .70 | .544 | .395 | .307 | .247 | .204 |
| .80 | .528 | .375 | .287 | .228 | .186 |
| .90 | .513 | .358 | .270 | .212 | .171 |
| T (yr) | ---------- | KE | ---------- | | |
| .10 | 1.00 | 1.57 | 2.06 | 2.52 | 2.96 |
| .20 | 1.00 | 1.63 | 2.21 | 2.77 | 3.32 |
| .30 | 1.00 | 1.68 | 2.33 | 2.98 | 3.63 |
| .40 | 1.00 | 1.73 | 2.44 | 3.16 | 3.91 |
| .50 | 1.00 | 1.76 | 2.53 | 3.33 | 4.17 |
| .60 | 1.00 | 1.80 | 2.62 | 3.49 | 4.42 |
| .70 | 1.00 | 1.83 | 2.70 | 3.64 | 4.66 |
| .80 | 1.00 | 1.81 | 2.70 | 3.76 | 4.85 |
| .90 | 1.00 | 1.88 | 2.85 | 3.92 | 5.12 |

* Po/Pi = outflow/inflow concentration
KE = effective rate parameter for completely mixed model
n = number of segments of equal T connected in series

"black-box" input/output analysis.

128. Of the models requiring that the retention coefficient be independent of concentration (R01-R10), model R03X02 (see Figure 12) has the best fit:

$$Po = Pi/(1 + 2.1\ T^{.5}) \qquad (R^2 = .78,\ SE^2 = .033) \qquad (48)$$

Modification of the model to include a depth term (model R10) does not improve the fit, since the optimal depth exponent is not significantly different from zero. Parameter estimates are identical to those found by Clasen (1980) for the OECD Reservoir and Shallow Lakes data base (model R03A06). As demonstrated below (Table 24), errors from this and other retention models are not independent of morphometric complexity. The optimal residence time coefficient (2.1 in equation 48) is 1.8 (standard error = .25) for 36 reservoirs with one major tributary and 2.8 (standard error = .51) for 20 reservoirs with more than one tributary arm. As demonstrated in Figure 13, residuals from this model are also negatively correlated with inflow phosphorus concentration (r =-.49. This result, coupled with the lower errors generally observed for models R11-R15, suggests that the retention coefficient should not be considered independent of concentration.

129. Of the models not requiring first-order concentration response, the multiple regression model (R14) has the lowest mean squared error (.025). This model, however, along with R11 and R13, is somewhat deficient theoretically, since it does not require the outflow concentration to approach the inflow concentration as the residence time approaches zero. Model R15 is an extension of the original phosphorus sedimentation models (R01, R02, R03, R10) which permits the sedimentation coefficient to vary as a function of residence time, mean depth, and inflow phosphorus concentration:

$$Po = Pi/(1 + .12\ Pi^{.70}\ Z^{.23}\ T^{.44}) \qquad (R^2 = .83, SE^2 = .026) \qquad (49)$$

Considering the variances of the above parameter estimates, this can be simplified to R15X03:

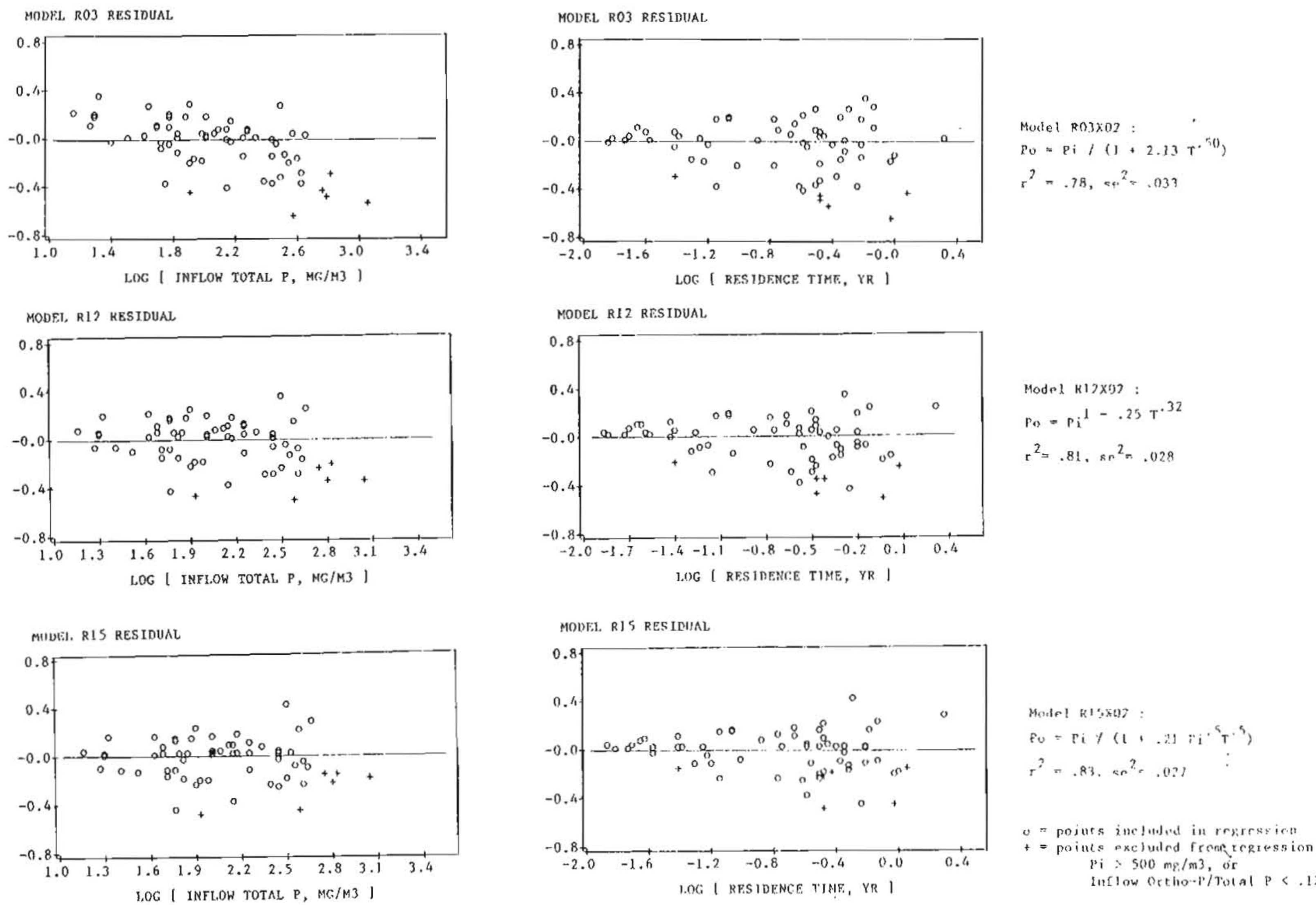


Figure 13
Residuals Plots of Outflow P Concentration Models

MODEL R03 RESIDUAL

Figure 13

Residuals Plots of Outflow P Concentration Models



$$Po = Pi/(1 + .21\, Pi^{.5}\, T^{.5}) \qquad (R^2=.83, SE^2=.026) \qquad (50)$$

Observations and predictions are plotted in Figure 12. The above model is equivalent to the following formulation for the first-order sedimentation coefficient:

$$K = .21\, T^{-.5}\, Pi^{.5} \qquad (51)$$

where,

$K$ = effective first-order sedimentation coefficient ($yr^{-1}$)

The parameter K represents the rate of removal of phosphorus from the water column per unit of phosphorus concentration. The significant dependence on Pi suggests a nonlinear response to concentration. Since Pi/T is equal to volumetric phosphorus loading, equation (51) is similar to relationships found by Canfield and Bachman (1981), as discussed in detail in the next section.

130. Model R12 is another non-linear formulation with relatively low error. This model, developed by Clasen (1980), is of the following form:

$$Po = Pi^{(1 - .25\, T^{.32})} \qquad (R^2=.81, SE^2=.027) \qquad (52)$$

The above coefficients, based upon the restricted data set, are identical to the original values found by Clasen. Compared with model R03 (equation 48), model error is somewhat lower for both this data set ($SE^2$=.027 vs. .034) and for the OECD/RSL data set ($SE^2$=.050 vs. .070, see Appendix E). The stability of the parameters and model comparisons derived from both data sets suggest model generality. The lower mean squared errors for this data set may reflect the greater flexibility for data screening which has been possible for the CE data base. The formulation of the model suggests that the sensitivity (exponent) of outflow concentration with respect to inflow concentration decreases with increasing residence time. In the limit of low residence times, the outflow concentration approaches the inflow value, i.e., the exponent approaches 1.0.

131. Residuals plots (Figure 13) for all of the retention models show a tendancy for error variance to increase as a function of residence time. Thus, the notion of decreasing inflow concentration sensitivity with increasing residence time may have some validity. It seems reasonable that as residence time increases, the potential for changes in water quality induced by the reservoir environment increases and the inflow/outflow sensitivity decreases. In analyzing EPA/NES data from over 100 lakes and reservoirs in the northeastern and northcentral U.S., Walker (1977a) also found that model errors (R03A02) increased with residence time. This can be explained by assuming that estimation errors for the effective sedimentation coefficient are stable and by demonstrating that the sensitivity of the predicted outflow concentration to the sedimentation coefficient increases with residence time, according to the following error analysis scheme for model R01:

$$\log(Po) = \log(Pi) - \log(1 + KT) \qquad (53)$$

$$\mathrm{Var}(\log(Po)) = DK^2\ \mathrm{Var}(\log(K)) + DI^2\ \mathrm{Var}(\log(Pi)) \qquad (54)$$

$$= [KT/(1+KT)]^2\ \mathrm{Var}(\log(K)) + \mathrm{Var}(\log(Pi)) \qquad (55)$$

where,

DK = derivative of log(Po) with respect to log(K)

DI = derivative of log(Po) with respect to log(Pi)

As T approaches zero, the first term in equation (55) approaches zero and errors in estimated Po values are attributed exclusively to errors in the inflow estimates (Var(log(Pi)). As T increases, the first term becomes more significant and approaches the variance in the estimated sedimentation rates, since the term in brackets approaches one. Error analysis results are qualitatively similar for other phosphorus retention models and are consistent with the variance patterns evident in Figure 13.

132. As discussed above, data from only 17 reservoirs are available to permit testing for the effects of sediment accumulation rate (as estimated from sediment surveys) on phosphorus retention.

Model P17 (Walker and Kuhner, 1978) relates the effective settling velocity to the sedimentation rate:

$$Po = Pi/(1 + U/Qs) \qquad (R^2=.11, SE^2=.055) \qquad (56)$$

$$U = -5.5 + .92\ Sr \qquad (57)$$

where,

U = effective settling velocity for total P (m/yr)

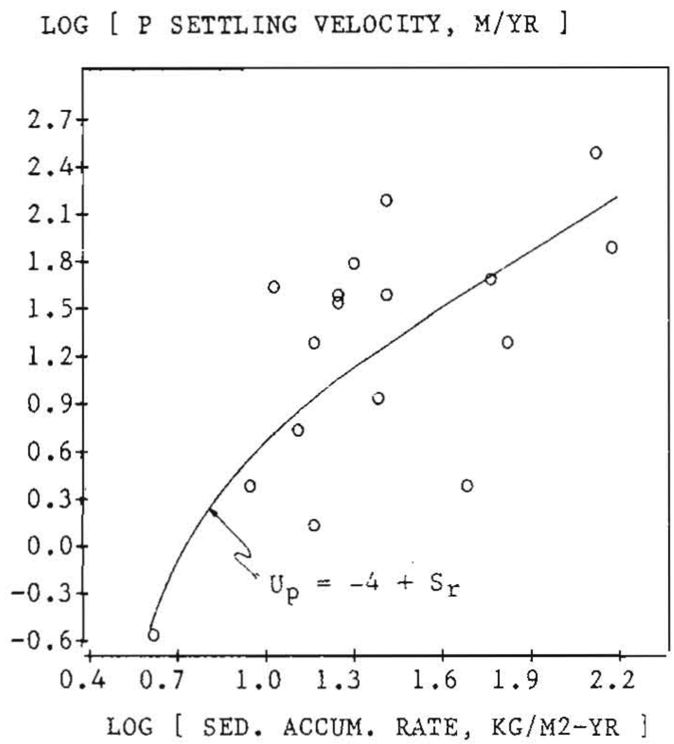
Sr = sedimentation rate (kg/m2-yr)

Optimal parameter values for this model (-5.5 and .92) are not significantly different from the original model formulation (-4 and 1.0). Five out of the 17 reservoirs included in this data set were also included in the data set used for model development (Walker and Kuhner, 1978) and may partially account for the stability of the parameter estimates. Figure 14 plots the relationship between settling velocity and sedimentation rate on log scales. While there is a positive correlation between these two variables, model error for predicting outflow phosphorus concentrations is higher than many of the other formulations tested. The low R-squared of this model is related to the low variance of the observed outlet concentrations in this subset of data, compared with the complete data set (.062 vs. .156). Year-to-year variability in the hydrologic conditions may contribute to variability in this relationship, since the overflow rates refer to the year of EPA/NES sampling and the sedimentation rates reflect long-term averages. The availability and reliability of the sediment survey information also limit potential applications of this model.

133. Appendix D (Table D12) presents a correlation matrix of the residuals from five of the retention models discussed above against various reservoir characteristics. Significant negative correlations are apparent for shoreline development ratio, surface area, and sedimentation rate. While the data base on sedimentation rates is limited, residual correlations are generally strongest with this variable, a result which supports the correlation of phosphorus setting velocity with sedimentation rate shown in Figure 14. Negative

Figure 14

Effective Phosphorus Settling Velocity
vs. Sediment Accumulation Rate



correlations with shoreline development and surface area may reflect the influences of spatial variations on the retention model performance, since reservoirs with greater shoreline development and surface area would have greater potential for spatial heterogeneity in water quality. Significant positive correlations are apparent for the inflow dissolved P/total P ratio, which may reflect greater trapping efficiency for particulate vs. dissolved phosphorus.

134. To investigate the effects of morphometric complexity on model performance, the data set has been divided into two groups according to whether the reservoirs contain one or more than one major tributary arm. Table 24 summarizes model errors by group and uses t-tests to identify significant differences in the mean errors. Differences are significant at between p=.04 and p=.07 for the models tested. The group with simpler morphometry (one tributary) has higher mean residuals than the group with more complex morphometry by about .1 log units. This difference is not large in relation to the model standard errors. While residual variances tend to be higher in the second group, the differences in variance are not statistically significant, based upon F ratio tests.

Table 24

Effect of Number of Major Tributary Arms on Retention Model Error and Parameter Estimates

| Model | Number of Major Tributaries | N | Mean | Std.Dev. | t* | Pr(>t) |
|---|---|---|---|---|---|---|
| R03X02 | 1 | 36 | .036 | .164 | 1.97 | .054 |
| | >1 | 20 | -.062 | .200 | | |
| R12X02 | 1 | 36 | .042 | .149 | 2.10 | .041 |
| | >1 | 20 | -.052 | .180 | | |
| R13X02 | 1 | 36 | .03 | .153 | 2.04 | .046 |
| | >1 | 20 | -.067 | .194 | | |
| R14X02 | 1 | 36 | .017 | .145 | 1.81 | .076 |
| | >1 | 20 | -.060 | .164 | | |
| R15X02 | 1 | 36 | .036 | .146 | 1.92 | .060 |
| | >1 | 20 | -.047 | .171 | | |

* t statistic for Ho: mean(1)=mean(2), variances equal in all cases, based upon F test (SAS Institute,1979)

## Reservoir Water Quality

135. Models in this category predict reservoir phosphorus, chlorophyll, and transparency as functions of external phosphorus loading, morphometry, and hydrology. Calibration for predicting growing-season, reservoir-average values is described below. Formulations and parameter estimates are given in Tables 25, 26, and 27, for phosphorus, chlorophyll-a, and transparency models, respectively. The data reduction and screening procedures described in Part III have provided a total of 43 reservoir-years for testing these relationships. The data set is listed in Appendix C, Table C2. Potential effects of spatial variance within reservoirs on these relationships are discussed in a subsequent section.

136. The models listed in Table 25 predict average, growing-season, surface-layer concentrations of total phosphorus. They correspond to those described previously for predicting outflow phosphorus concentration (Table 22), but in many cases the optimal parameter estimates are significantly different. Figure 15 depicts the relationship between pool and outflow phosphorus concentrations. The regression equation is:

$$\log(P) = .26 + .85 \log(Po) \qquad (R^2 = .78, SE^2 = .033) \qquad (58)$$

where,

P = growing-season, surface-layer, total phosphorus (mg/m3)

Po = annual-mean, outflow total phosphorus (mg/m3)

This relationship is not significantly different from a simple equality (P=Po), also shown in Figure 15. Differences between P and Po reflect the combined influences of (1) spatial variations within the pool, (2) epilimnetic vs. hypolimnetic withdrawals, (3) seasonal variations, and (4) flow-weighting of the outflow concentrations. One would expect the first mechanism to result in P/Po ratios greater than 1.0 because of negative concentration gradients moving downstream in the reservoirs. Stratified impoundments with bottom outlets would probably tend to have lower P/Po ratios, owing to accumulation of phosphorus in the

Table 25

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Average Phosphorus Concentrations

Model P01: first-order sedimentation

Equation: $\log(P) = \log(Pi) - \log(1 + K1\ T)$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| P01A01 | Vollenweider(1969) | .65 | 43 | .133 | .126 |
| P01A02 | Mueller(1980) | 2.00 | 43 | .373 | .091 |
| P01X01 | Optimal | 3.21 | 43 | .415 | .087 |
| | standard error | .73 | | | |
| P01X02 | Optimal * | 2.55 | 39 | .639 | .054 |
| | standard error | .54 | | | |

Model P02: first-order settling velocity

Equation: $\log(P) = \log(Pi) - \log(1 + K1/Qs)$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| P02A01 | Vollenweider(1969) | 10.0 | 43 | .270 | .106 |
| P02A02 | Dillon(1976) | 13.2 | 43 | .329 | .097 |
| P02A03 | Chapra (1976) | 16.0 | 43 | .365 | .092 |
| P02A04 | Higgins et al.(1980) | 92.0 | 43 | -.082 | .157 |
| P02X01 | Optimal | 28.1 | 43 | .420 | .086 |
| | standard error | 6.4 | | | |
| P02X02 | Optimal * | 20.5 | 39 | .651 | .052 |
| | standard error | 4.4 | | | |

Model P03: Vollenweider (1976) and others

Equation: $\log(P) = \log(Pi) - \log(1 + K1\ T^{K2})$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P03A01 | Vollenweider(1976) | 1.00 | .50 | 43 | .406 | .086 |
| P03A02 | Walker(1977a) | .82 | .45 | 43 | .367 | .092 |
| P03A03 | Larsen et al.(1976) | .89 | .51 | 43 | .367 | .092 |
| P03A04 | Mueller (1980) | 2.09 | .83 | 43 | .443 | .081 |
| P03A05 | Clasen (1980) | 2.27 | .59 | 43 | .547 | .066 |
| P03A06 | Clasen (1980) | 2.00 | .50 | 43 | .564 | .063 |
| P03A07 | Fricker (1980) | 1.42 | .049 | 43 | .570 | .062 |
| P03X01 | Optimal | 1.80 | .26 | 43 | .606 | .060 |
| | standard errors | .46 | .13 | | | |
| P03X02 | Optimal * | 1.43 | .25 | 39 | .776 | .034 |
| | standard errors | .32 | .12 | | | |

(continued)

Table 25 (continued)

Model P04: Jones and Bachman (1976)
Equation: log(P) = log(Pi) - log(K1 + K2 T)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P04A01 | Jones et al. (1976) | 1.18 | .76 | 43 | .370 | .091 |
| P04A02 | Reckhow (1977) | 1.13 | .17 | 43 | .119 | .128 |
| P04A03 | Mueller (1980) | 1.14 | 1.83 | 43 | .449 | .080 |
| P04X01 | Optimal | 1.86 | .93 | 43 | .582 | .064 |
| | standard errors | .24 | .66 | | | |
| P04X02 | Optimal * | 1.66 | .87 | 39 | .767 | .036 |
| | standard errors | .17 | .49 | | | |

Model P05: Reckhow (1978)
Equation: log(P) = log(Pi) - log(K1 + K2/Qs)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P05A01 | Reckhow(1978) | 1.20 | 11.6 | 43 | .448 | .080 |
| P05X01 | Optimal | 1.87 | 7.2 | 43 | .585 | .063 |
| | standard errors | .24 | 5.2 | | | |
| P05X02 | Optimal * | 1.65 | 7.1 | 39 | .777 | .034 |
| | standard errors | .16 | 3.6 | | | |

Model P06: Kirchner & Dillon (1975)
Equation: log(P) = log(Pi)-log(1-K1 EXP(-K2 Qs)-K3 EXP(-K4 Qs))

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| P06A01 | Kirchner et al.(1975) | .426 | .271 | .574 | .00949 | 43 | .448 | .080 |
| P06A02 | Ostrofski (1978) | .201 | .043 | .574 | .00949 | 43 | .476 | .076 |
| P06A03 | Mueller (1980) | .29 | .556 | .710 | .00483 | 43 | .492 | .074 |
| P06X01 | Optimal | .387 | .353 | .613 | .0023 | 43 | .605 | .062 |
| | standard errors | .074 | .394 | .074 | .0017 | | | |
| P06X02 | Optimal * | .502 | .216 | .498 | .0012 | 39 | .779 | .035 |
| | standard errors | .066 | .112 | .066 | .0013 | | | |

Model P07: Norvell, Frink, and Hill (1978)
Equation: log(P) = log(Pi) + log((K1 + Qs)/(K2 + Qs))

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P07A01 | Norvell et al.(1978) | 1.2 | 12.0 | 43 | .276 | .105 |
| P07X01 | Optimal | 102.1 | 285.5 | 43 | .603 | .060 |
| | standard errors | 95.9 | 221.6 | | | |
| P07X02 | Optimal * | 116.1 | 276.2 | 39 | .767 | .036 |
| | standard errors | 99.1 | 116.1 | | | |

(continued)

Table 25 (continued)

Model P08: Higgins and Kim (1980)
Equation: $\log(P) = \log(Pi) + \log(K1 + K2 \log(Qs))$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P08A01 | Higgins et al. (1980) | .54 | .51 | 43 | -.905 | .262 |
| P08X01 | Optimal | .214 | .156 | 43 | .598 | .061 |
| | standard errors | .127 | .080 | | | |
| P08X02 | Optimal * | .252 | .166 | 39 | .776 | .034 |
| | standard errors | .109 | .068 | | | |

Model P09: plug flow settling
Equation: $\log(P) = \log(Pi) - K1/Qs$

| Code | Coefficients | K1 | N | R2 | MSE |
|---|---|---|---|---|---|
| P09A01 | Higgins et al. (1980) | 26.5 | 43 | -12.0 | 1.890 |
| P09X01 | Optimal | 4.03 | 43 | .245 | .112 |
| | standard errors | .82 | | | |
| P09X02 | Optimal * | 3.53 | 39 | .558 | .066 |
| | standard errors | .65 | | | |

Model P10: Clasen (1980)
Equation: $\log(P) = \log(Pi) - \log(1 + K1\, T^{K2}\, Z^{K3})$

| Code | Coefficients | K1 | K2 | K3 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|
| P10A01 | Clasen (1980) | 7.24 | .608 | -.50 | 43 | .560 | .064 |
| P10A02 | Fricker (1980) | 9.35 | 1.00 | -.69 | 43 | .396 | .088 |
| P10X01 | Optimal | 2.26 | 0.29 | -.09 | 43 | .607 | .061 |
| | standard errors | 1.54 | .15 | .25 | | | |
| P10X02 | Optimal * | 2.13 | .30 | -.16 | 39 | .780 | .035 |
| | standard errors | 1.21 | .13 | .22 | | | |

Model P11: Clasen (1980), Fricker (1980)
Equation: $\log(P) = K1 \log(Pi) + K2$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P11A01 | Clasen (1980) | .85 | -.11 | 43 | .597 | .059 |
| P11A02 | Fricker (1980) | 1.01 | -.35 | 43 | .549 | .065 |
| P11A03 | Fricker (1980) | .88 | -.18 | 43 | .574 | .062 |
| P11X01 | Optimal | .70 | .28 | 43 | .682 | .048 |
| | standard errors | .075 | .16 | | | |
| P11X02 | Optimal * | .67 | .37 | 39 | .793 | .032 |
| | standard errors | .074 | .15 | | | |

(continued)

Table 25 (continued)

Model P12: Clasen (1980)

Equation: $\log(P) = \log(Pi)\ (1 - K1\ T^{K2})$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P12A01 | Clasen (1980) | .25 | .32 | 43 | .678 | .047 |
| P12X01 | Optimal | .23 | .17 | 43 | .711 | .044 |
| | standard errors | .029 | .072 | | | |
| P12X02 | Optimal * | .20 | .20 | 39 | .834 | .025 |
| | standard errors | .025 | .067 | | | |

Model P13: Fricker (1980)

Equation: $\log(P) = K1\ \log(Pi/(1+T^{.5})) + K2$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P13A01 | Fricker (1980) | .906 | .104 | 43 | .608 | .057 |
| P13A02 | Fricker (1980) | .754 | .254 | 43 | .707 | .042 |
| P13A03 | Ryding (1980) | .96 | -.02 | 43 | .595 | .059 |
| P13X01 | Optimal | .704 | .396 | 43 | .726 | .042 |
| | standard errors | .067 | .131 | | | |
| P13X02 | Optimal * | .677 | .463 | 39 | .833 | .026 |
| | standard errors | .064 | .125 | | | |

Model P14: multivariate, Walker (1977a)

Equation: $\log(P) = K1 + K2\ \log(Pi) + K3\ \log(Z) + K4\ \log(T)$

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| P14A01 | Walker (1977a) | -.02 | .88 | -.15 | -.17 | 43 | .645 | .051 |
| P14X01 | Optimal | .96 | .53 | -.41 | -.053 | 43 | .807 | .031 |
| | standard errors | .26 | .075 | .12 | .057 | | | |
| P14X02 | Optimal * | .96 | .51 | -.39 | -.078 | 39 | .869 | .021 |
| | standard errors | .25 | .073 | .12 | .051 | | | |

Model P15: generalized phosphorus sedimentation

Equation: $\log(P) = \log(Pi) - \log(1 + 10^{K1}\ Pi^{K2}\ Z^{K3}\ T^{K4})$

| Code | Coefficients | K1 | K2 | K3 | K4 | N | R2 | MSE |
|---|---|---|---|---|---|---|---|---|
| P15A01 | Canfield & Bachman(1981) | -.89 | .55 | 0.0 | .45 | 43 | .712 | .042 |
| P15A02 | Canfield & Bachman(1981) | -.78 | .46 | 0.0 | .54 | 43 | .610 | .057 |
| P15A03 | Canfield & Bachman(1981) | -.94 | .59 | 0.0 | .41 | 43 | .737 | .038 |
| P15X01 | Optimal | -2.45 | .89 | .78 | .06 | 43 | .804 | .031 |
| | standard errors | .57 | .16 | .25 | .12 | | | |
| P15X02 | Optimal | -2.95 | 1.0 | 1.0 | .00 | 43 | .800 | .030 |
| | standard errors | .05 | - | - | - | | | |
| P15X03 | Optimal * | -2.98 | 1.0 | 1.0 | .00 | 39 | .841 | .023 |
| | standard errors | .05 | - | - | - | | | |
| P15X04 | Optimal * | -1.75 | .68 | .52 | .16 | 39 | .859 | .022 |
| | standard errors | .60 | .18 | .25 | .11 | | | |

(continued)

Table 25 (continued)

Model P16

Equation $\log(P) = \log(Pi) - \log(1 + (K1 + K2\ Sr)/Qs)$

Sr = sedimentation rate (kg/m2-yr)

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| P16A01 | Walker & Kuhner (1978) | -4.0 | 1.00 | 13 | .252 | .035 |
| P16X01 | Optimal | -5.0 | .95 | 13 | .264 | .035 |
| | standard errors | 7.1 | .41 | | | |

* restricted data set includes reservoirs with:
  Inflow Total P < 500 mg/m3
  Inflow (Dissolved P/Total P) > .12

## Table 26

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Chlorophyll-a

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Model B10

Equation: $\log(B) = K1 + K2 \log[\, Pi/(1 + 12.4/Qs) \,]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B10A01 | Chapra (1976) | -1.08 | 1.45 | 43 | -5.5 | .733 |
| B10X01 | Optimal | .13 | .46 | 43 | .345 | .077 |
| | standard errors | .19 | .10 | | | |
| B10X02 | Optimal * | .06 | .51 | 39 | .352 | .081 |
| | standard errors | .22 | .11 | | | |

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Model B11

Equation: $\log(B) = K1 + K2 \log[\, Pi/(1 + T^{.5}) \,]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B11A01 | Vollenweider (1976) | -.44 | .91 | 43 | -.636 | .184 |
| B11A02 | Rast & Lee (1978) | -.26 | .76 | 43 | -.006 | .113 |
| B11A03 | Clasen (1980) | -.02 | .58 | 43 | .360 | .072 |
| B11A04 | Fricker (1980) | -.22 | .68 | 43 | .328 | .075 |
| B11A05 | Fricker (1980) | -.22 | .71 | 43 | .211 | .089 |
| B11A06 | Ryding (1980) | -.31 | .81 | 43 | -.221 | .137 |
| B11A01 | Ryding (1980) | -.82 | 1.01 | 43 | -.182 | .110 |
| B11X01 | Optimal | .10 | .48 | 43 | .432 | .067 |
| | standard errors | .17 | .086 | | | |
| B11X02 | Optimal * | .04 | .52 | 39 | .439 | .070 |
| | standard errors | .19 | .096 | | | |
| B11X03 | Optimal ** | -.15 | .66 | 29 | .583 | .062 |
| | standard errors | .19 | .107 | | | |

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Model B12

Equation: $\log(B) = K1 + \log[\, 1 - \exp( -K2\, Pi/(1 + 2\, T^{.5} ))]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B12A01 | Clasen (1980) | 1.70 | .007 | 43 | .020 | .110 |
| B12X01 | Optimal | 1.21 | .022 | 43 | .408 | .069 |
| | standard errors | .07 | .0067 | | | |
| B12X02 | Optimal * | 1.23 | .025 | 39 | .410 | .077 |
| | standard errors | .071 | .0081 | | | |

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(continued)

Table 26 (continued)

Model B13

Equation: $\log(B) = K1 + K2 \log( Pi/(1 + 2\,T^{.5} )]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B13A01 | Clasen (1980) | .06 | .58 | 43 | .320 | .075 |
| B13X01 | Optimal | .17 | .46 | 43 | .431 | .067 |
| | standard errors | .15 | .083 | | | |
| B13X02 | Optimal * | .13 | .50 | 39 | .432 | .071 |
| | standard errors | .17 | .093 | | | |

Model B14

Equation: $\log(B) = K1 + K2 \log[ Pi/(1 + 92/Qs) ]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B14A01 | Walker (1980b) | .49 | .34 | 43 | .204 | .089 |
| B14X01 | Optimal | .51 | .32 | 43 | .205 | .089 |
| | standard errors | .16 | .10 | | | |
| B14X02 | Optimal * | .52 | .32 | 39 | .187 | .099 |
| | standard errors | .17 | .11 | | | |

Model B15

Equation: $\log(B) = K1 + K2 \log[ Pi/(1 + .001\,Pi\,Z) ]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| B15X01 | Optimal | -.24 | .71 | 43 | .540 | .054 |
| | standard errors | .18 | .10 | | | |
| B15X02 | Optimal * | -.23 | .71 | 39 | .520 | .060 |
| | standard errors | .20 | .11 | | | |
| B15X03 | Optimal ** | -.48 | .89 | 29 | .710 | .042 |
| | standard errors | .18 | .10 | | | |

* data set excludes:

Inflow (ortho P/total P) < .12

Inflow total P > 500 mg/m3

** data set excludes:

Inflow (ortho P/total P) < .12

Inflow total P > 500 mg/m3

Inflow total (N/P) < 8

Nonalgal turbidity > 1.58 1/m (.2 log units)

Table 27

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Transparency

Model S10: Rast and Lee (1978)

Equation: $\log(S) = K1 + K2 \log[\, Pi/(1 + T^{.5})]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S10A01 | Rast & Lee (1978) | .93 | -.36 | 43 | .044 | .101 |
| S10A02 | Ryding (1980) | 1.12 | -.51 | 43 | .485 | .054 |
| S10A03 | Clasen (1980) | .93 | -.20 | 43 | -2.41 | .360 |
| S10X01 | Optimal | 1.13 | -.60 | 43 | .717 | .031 |
| | standard errors | .11 | .058 | | | |
| S10X02 | Optimal * | 1.20 | -.65 | 39 | .807 | .021 |
| | standard errors | .10 | .054 | | | |
| S10X03 | Optimal ** | 1.08 | -.56 | 29 | .828 | .013 |
| | | .088 | .049 | | | |

Model S11

Equation: $\log(S) = K1 + K2 \log[\, Pi/(1 + .001\, Pi\, Z)]$

| Code | Coefficients | K1 | K2 | N | R2 | MSE |
|---|---|---|---|---|---|---|
| S11X01 | Optimal | 1.47 | -.84 | 43 | .795 | .023 |
| | standard errors | .12 | .066 | | | |
| S11X02 | Optimal * | 1.43 | -.82 | 39 | .800 | .022 |
| | standard errors | .12 | .066 | | | |
| S11X03 | Optimal ** | 1.25 | -.69 | 29 | .845 | .012 |
| | standard errors | .10 | .056 | | | |

* data set excludes:

Inflow (ortho P/total P) < .12

Inflow total P > 500 mg/m3

** data set excludes:

Inflow (ortho P/total P) < .12

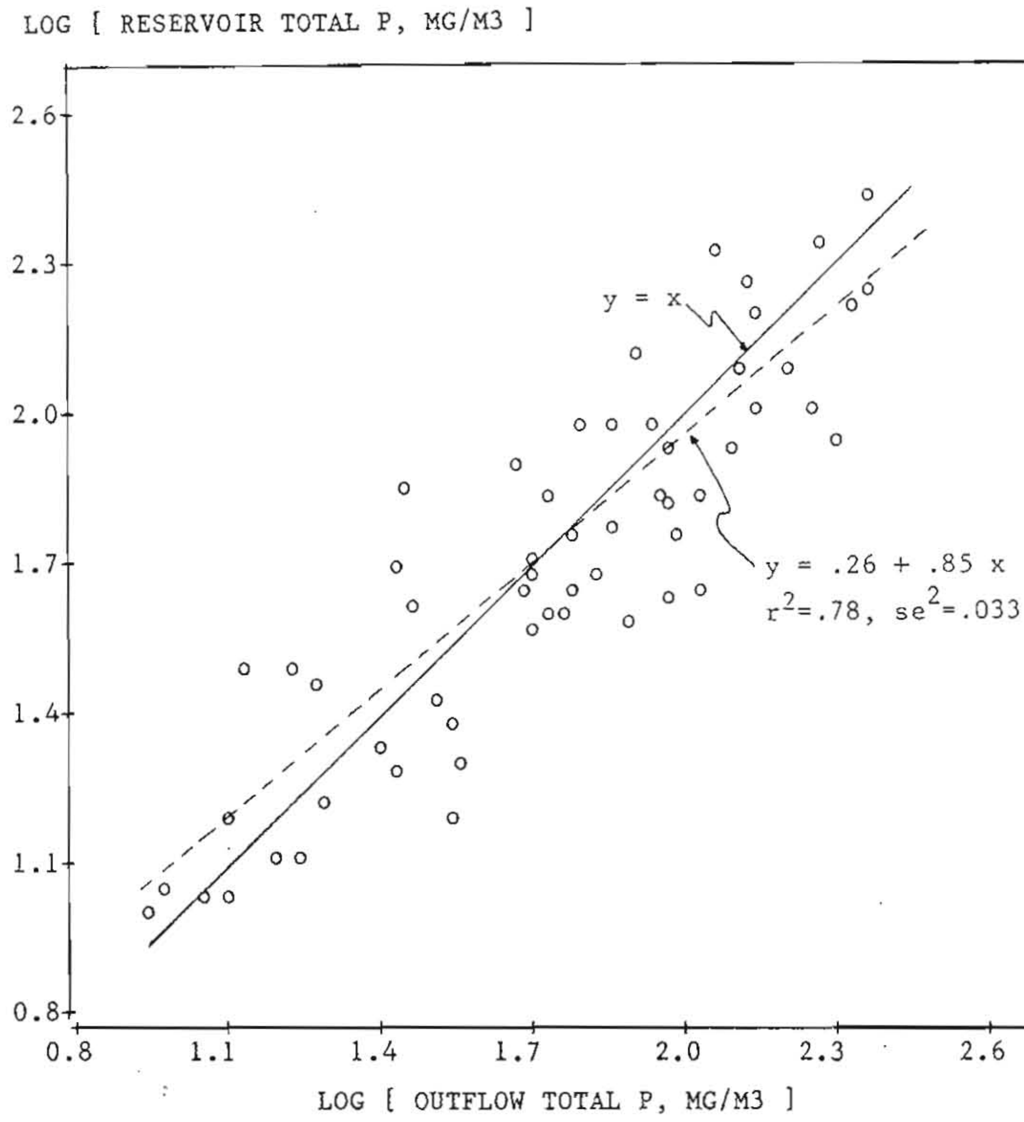
Inflow total P > 500 mg/m3

Inflow total (N/P) < 8

Nonalgal turbidity > 1.58 1/m (.2 log units)

Figure 15

Reservoir Total P vs. Outflow Total P



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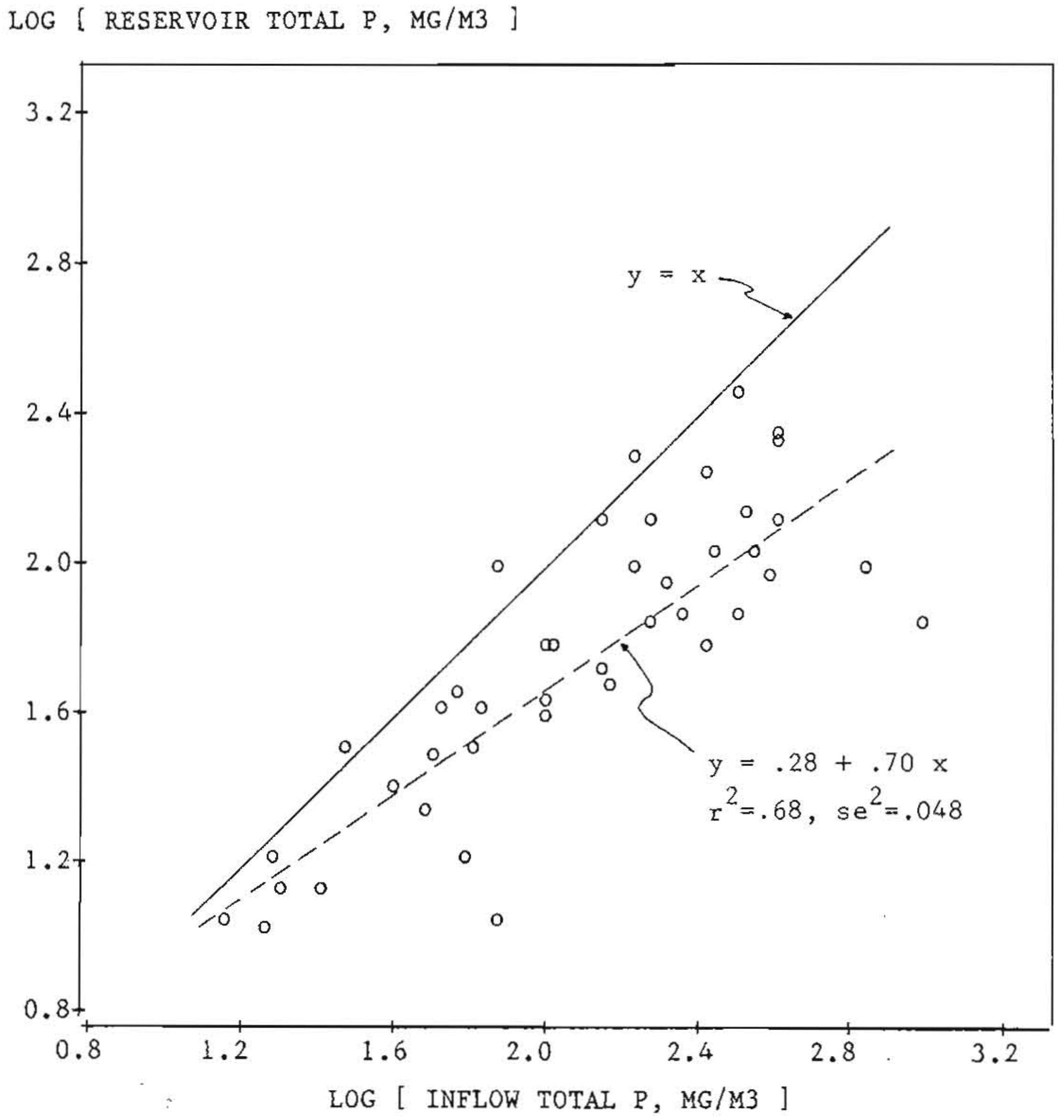
hypolimnion during the summer. (Compilation of data on principal outlet levels is currently underway to provide a means for testing effects of outlet level on reservoir nutrient balances.) Seasonal variations could increase or decrease the ratio, depending upon the significance of seasonal hydrologic variations, dilution effects on point-source discharges, internal phosphorus loadings, algal growth and sedimentation patterns, etc. Correlation studies indicate that the P/Po ratio is not significantly associated with hydraulic residence time, mean depth, or surface overflow rate.

137. The relationship between average pool phosphorus and average inflow phosphorus is shown in Figure 16. The regression line (model P11X01) explains 68% of the variance with a mean squared error of .048 log units. The slope of the line, .70, is significantly different from 1.0. The fact that a few reservoirs have pool phosphorus concentrations which exceed the inflow values may result from the combined influences of seasonal variations, internal or unaccounted-for loadings, and sampling variability.

138. Following the outflow phosphorus analysis, each model has been fit to an additional data set which excludes 4 reservoirs with inflow concentrations exceeding 500 mg/m3 or with inflow dissolved P/total P ratios less than .12. Residuals plots indicate negative biases for reservoirs in the above categories for most models. Results of the internal model evaluations (Part V) indicate that chlorophyll-a levels are roughly proportional to total phoshorus concentrations for non-algal turbidity concentrations less than 1.58 1/m (.2 log units). To reduce the effects of relatively turbid or N-limited reservoirs on model coefficients, a third data set which has the above constraints on inflow total P and inflow dissolved P/total P and which also excludes reservoirs with average turbidities greater than 1.58 1/m or inflow total N/P ratios less than 8 has also been used in fitting some models. The third data set includes 29 reservoirs. Residuals plots verify use of the above limits, particularly for chlorophyll models, although some turbidity effects remain within the restricted data set, as discussed below.

Figure 16

Reservoir Total P vs. Inflow Total P



139. Of the models which assume that the retention coefficient, in this case estimated from the pool and inflow P values, is independent of concentration (P01-P10), mean squared errors range from .034 to .066. An average sedimentation coefficient of 3.6 1/yr is estimated for model P01 and an average settling velocity of 21 m/yr, for model P02. These parameters are somewhat lower than those estimated for outflow phosphorus predictions, although they are still generally higher than values derived from lake data (Appendix E). The optimal parameters for model P03 suggest a lower sensitivity to residence time (.26) than predicted by the original Vollenweider/Larsen-Mercier model:

$$P = Pi/(1 + 1.8\ T^{.26}) \qquad (R^2 = .61, SE^2 = .06) \qquad (59)$$

Models P11-P12 have a lower mean squared error range (.024-.036).

140. When the sedimentation coefficient is allowed to vary as a function of inflow concentration, mean depth, and residence time, the following model results (P15X01):

$$P = Pi/(1 + .0035\ Pi^{.89}\ Z^{.78}\ T^{.06}) \qquad (R^2 = .80, SE^2 = .031) \qquad (60)$$

Considering the variabilities in the coefficients, this is equivalent to:

$$P = Pi/(1 + .001\ Pi\ Z) \qquad (R^2 = .80, SE^2 = .030) \qquad (61)$$

The above statistics refer to the complete data set. Excluding reservoirs with inflow total P greater the 500 mg/m3 and inflow dissolved P/total P less than .12, the coefficients are stable but the mean squared error reduces to .024 (model P15X03 in Table 25). The above result is equivalent to the following expression for the total phosphorus sedimentation coefficient:

$$K = .001\ (Pi\ Z\ /\ T) = .001\ L \qquad (62)$$

where,

$K$ = effective first-order decay rate ($yr^{-1}$)

$L$ = total phosphorus loading (mg/m2-yr)

Thus, optimal coefficients suggest that the average decay rate is proportional to areal phosphorus loading. This is consistent with results obtained by Canfield and Bachman (1981) in their analysis of data from 704 natural lakes and reservoirs, 626 of whose data were derived from the EPA National Eutrophication Survey. When lake and reservoir data were combined, Canfield and Bachman found that the phosphorus sedimentation coefficient was correlated with volumetric and areal loading (r = .78 and .76, respectively). Correlation coefficients for 433 reservoirs were .76 and .76, respectively. Their models (P15A01, P15A02, P15A03) were calibrated to all data combined, lake data alone, and reservoir data alone, respectively. Their reservoir model (P15A03) performs better on this data set than any of the other models tested (R2=.74,SE2=.038) with original coefficients.

141. Models P01, P02, P03, and P10 are special cases of model P15, with the inflow concentration sensitivity parameter equal to zero and different values for the residence time and depth exponents. Table 28 compares the average absolute errors and mean squared errors from these models with various forms of model P15. An approximate F-test (Bard,1974) is used to test for significant differences in the mean squared errors and parameter values between the original models and the optimal forms of P15, using each of the three data sets described above. Results indicate that two Canfield/Bachman models (P15A01 and P15A03) are not significantly different from the optimized forms for the restricted data sets (B and C). For these data sets, errors from the Canfield/Bachman reservoir model (P15A03) with Pi, Z, and T exponents of .59, 0., and .41, respectively, are not significantly lower than model P15X02, with corresponding exponents of 1.0, 1.0, and 0.0.

142. To better define the confidence ranges for model P15 parameters, residual mean squares are mapped for various values of the Pi, Z, and T exponents in Table 29. The model intercept (parameter K1 in Table 25) has been optimized for each set of exponents. Confidence regions are defined based upon the F-test given in Table 28 and a significance level of .05. Optimal exponent ranges for Pi, Z, and T are .4 to 1.2, 0. to 1.2, and 0. to .4, respectively. These ranges are conditional; i.e., the parameters are not independent of each other.

Table 28

Tests for Variations in Model P15 Parameters

| | Parameters | | | | Data Set | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | A | | B | | C | |
| Model | bi | bt | bz | c | AE | MSE | AE | MSE | AE | MSE |
| P01A01 | .00 | 1.00 | .00 | -.19 | 283 | 1322 | 240 | 831 | 220 | 735 |
| P01A02 | .00 | 1.00 | .00 | .30 | 248 | 961 | 211 | 572 | 199 | 517 |
| P02A01 | .00 | 1.00 | -1.00 | 1.00 | 254 | 1103 | 209 | 633 | 193 | 561 |
| P02A03 | .00 | 1.00 | -1.00 | 1.20 | 229 | 959 | 189 | 543 | 170 | 489 |
| P02A04 | .00 | 1.00 | -1.00 | 1.96 | 298 | 1534 | 285 | 1474 | 296 | 1534 |
| P03A01 | .00 | .50 | .00 | .00 | 228 | 909 | 189 | 515 | 169 | 442 |
| P03A02 | .00 | .45 | .00 | -.09 | 236 | 972 | 195 | 559 | 173 | 480 |
| P03A03 | .00 | .51 | .00 | -.05 | 236 | 968 | 196 | 557 | 175 | 480 |
| P03A04 | .00 | .83 | .00 | .32 | 233 | 852 | 198 | 500 | 186 | 455 |
| P03A05 | .00 | .59 | .00 | .36 | 205 | 691 | 174 | 405 | 165 | 384 |
| P03A06 | .00 | .50 | .00 | .30 | 197 | 665 | 165 | 378 | 155 | 350 |
| P03A07 | .00 | .05 | .00 | .15 | 196 | 646 | 170 | 428 | 166 | 378 |
| P10A01 | .00 | .61 | -.50 | .86 | 194 | 661 | 163 | 382 | 154 | 352 |
| P10A02 | .00 | 1.00 | -.69 | .97 | 228 | 913 | 192 | 520 | 174 | 464 |
| P15A01 | .55 | .45 | .00 | -.89 | 157 | 437 | 131 | 260* | 121 | 233* |
| P15A02 | .46 | .54 | .00 | -.79 | 187 | 593 | 157 | 341 | 145 | 306 |
| P15A03 | .59 | .41 | .00 | -.94 | 148 | 396 | 124 | 249* | 114 | 220* |
| P15X02 | 1.00 | .00 | 1.00 | -2.95 | 138 | 309* | 123 | 238* | 108 | 189* |
| P15X04 | .68 | .16 | .52 | -1.75 | 140 | 330* | 119 | 211* | 105 | 175* |

Model: $P/Pi = 1/(1 + 10^{c}\ Pi^{bi}\ Z^{bz}\ T^{bt})$

Data Sets:

A = all data (n=43)

B = Pi < 500 mg/m3, Inflow Ortho-P/Total P > .12 (n=39)

C = B constraints + Turbidity < 1.58 1/m, Inflow N/P > 8 (n=29)

AE = average absolute error x 1000

MSE = mean squared error x 10000

* mean squared error and parameters not significantly different from optimal values (p<.05), based upon F-ratio test (Bard, 1974):

$$MSE/MSE^* = 1 + p\ F\ /\ (n-p)$$

where,

MSE* = minimum mean squared error

p = number of model parameters = 4

n = number of observations (29, 39, or 43)

F = F Statistic with p and n-p degrees of freedom

Table 29

Confidence Regions for Model P15 Parameters

| bz | bt -.4 | -.2 | 0. | .2 | .4 | .6 | bt -.4 | -.2 | 0. | .2 | .4 | .6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | bi=.4 | | | | | | bi=1.0 | | | | | |
| .0 | 63 | 45 | 34 | 27* | 26* | 30 | 72 | 50 | 36 | 31 | 32 | 41 |
| .2 | 56 | 41 | 31 | 26* | 26* | 32 | 62 | 43 | 31 | 27* | 30 | 39 |
| .4 | 52 | 38 | 30 | 27* | 28 | 35 | 54 | 37 | 28 | 25* | 28 | 38 |
| .6 | 49 | 37 | 31 | 29 | 31 | 40 | 48 | 33 | 25* | 23* | 28 | 38 |
| .8 | 47 | 38 | 33 | 32 | 37 | 49 | 43 | 30 | 24* | 23* | 29 | 40 |
| 1.0 | 48 | 40 | 37 | 39 | 46 | 60 | 40 | 29 | 24* | 25* | 31 | 45 |
| 1.2 | 51 | 45 | 44 | 48 | 58 | 75 | 38 | 29 | 26* | 28 | 36 | 52 |
| 1.4 | 56 | 52 | 53 | 60 | 73 | 93 | 38 | 31 | 29 | 33 | 44 | 62 |
| | bi=.6 | | | | | | bi=1.2 | | | | | |
| .0 | 64 | 45 | 32 | 26* | 25* | 30 | 81 | 57 | 43 | 38 | 41 | 51 |
| .2 | 56 | 39 | 29 | 24* | 24* | 30 | 69 | 48 | 37 | 33 | 37 | 48 |
| .4 | 50 | 36 | 27 | 23* | 25* | 32 | 59 | 42 | 32 | 30 | 35 | 46 |
| .6 | 46 | 34 | 26* | 24* | 27* | 35 | 52 | 37 | 29 | 28 | 33 | 46 |
| .8 | 44 | 33 | 27 | 26* | 31 | 41 | 46 | 33 | 27* | 27* | 33 | 46 |
| 1.0 | 43 | 34 | 30 | 31 | 37 | 50 | 42 | 31 | 26* | 27* | 35 | 49 |
| 1.2 | 44 | 37 | 34 | 37 | 46 | 62 | 39 | 30 | 26* | 29 | 38 | 54 |
| 1.4 | 47 | 42 | 41 | 47 | 58 | 77 | 38 | 30 | 28 | 33 | 43 | 62 |
| | bi=.8 | | | | | | bi=1.4 | | | | | |
| .0 | 67 | 46 | 33 | 27* | 27* | 34 | 92 | 67 | 53 | 48 | 53 | 66 |
| .2 | 58 | 40 | 29 | 24* | 25* | 33 | 79 | 57 | 45 | 43 | 48 | 62 |
| .4 | 51 | 35 | 26* | 23* | 25* | 33 | 68 | 49 | 40 | 39 | 45 | 59 |
| .6 | 46 | 32 | 25* | 22* | 25* | 35 | 59 | 43 | 36 | 36 | 43 | 57 |
| .8 | 42 | 30 | 24* | 23* | 28 | 39 | 52 | 39 | 33 | 34 | 42 | 56 |
| 1.0 | 40 | 30 | 25* | 26* | 32 | 45 | 47 | 35 | 31 | 33 | 42 | 58 |
| 1.2 | 40 | 31 | 28 | 31 | 39 | 54 | 43 | 34 | 30 | 34 | 44 | 61 |
| 1.4 | 41 | 35 | 33 | 38 | 49 | 67 | 41 | 33 | 31 | 36 | 47 | 66 |

Model : $P/Pi = (1 + c\ Pi^{bi}\ Z^{bz}\ T^{bt})$

parameter c values optimized for each set of bi,bz, and bt values

table entries are values of residual mean square x 1000 for estimating base-10 logarithm of P, using restricted data set (Pi< 500 mg/m3, Inflow Ortho-P/Total P > .12 n = 39)

* parameters not significantly different from optimal values (p<.05)

This parameter variability is also reflected in the coefficient standard errors in Table 25. This suggests that, while model P15 performs somehat better than the other formulations, the optimal coefficients are not well-defined, i.e., the coefficients can vary over fairly wide ranges without significant changes in error because of correlations among the independent variables (Pi, Z and T).

143. The most curious aspect of equation (61) is that the predicted total phosphorus concentration is independent of hydrologic factors (residence time or overflow rate). The low hydrologic sensitivity may reflect the fact that the completely mixed, "bathtub" assumption inherent in the calculation of mean hydraulic residence time is inadequate as a representation of reservoir hydrodynamics. The significance of mean depth may be related to internal loading or phosphorus exchange with the bottom sediments. The fact that reservoir phosphorus and other response variables can be predicted independently of hydrologic factors considerably reduces the data requirements for model implementation. The original concept of a first-order sedimentation reaction in a mixed vessel as a model for predicting average phosphorus concentrations does not appear to be valid, since the "constant" (K) depends so strongly upon the key system variables (Pi, Z, and T). Equations (60)-(62) are purely empirical results, i.e., they have no theoretical basis.

144. For each response variable, it is difficult to select the "best" formulation for normalized loading based upon residual error alone, because the error ranges are generally small and the independent variables are correlated with each other. The normalized loading expressions are most sensitive to inflow phosphorus concentration and differ primarily with respect to morphometric or hydrologic coefficients. Because variations in inflow concentration account for most of the variations in the normalized loading statistics, it is difficult to distinguish among the model formulations. Table 30 presents correlation coefficients for each response variable (total P, chlorophyll-a, and transparency) against seven alternative expressions of normalized phosphorus loading, derived from the model calibrations in

Table 30

Correlation of Response Variables with Normalized Phosphorus Loadings**

| Expression | Total P | Chl-a | Transparency |
|---|---|---|---|
| **Data Set 1*** | | | |
| 1 Pi | .826 | .643 | -.794 |
| 2 $Pi/(1+T^{.5})$ | .852 | .657 | -.847 |
| 3 $Pi/(1+2T^{.5})$ | .857 | .657 | -.863 |
| 4 $Pi/(1+1.43T^{.25})$ | .853 | .655 | -.841 |
| 5 $Pi^{(1-.2T^{.2})}$ | .856 | .654 | -.855 |
| 6 $Pi/\left(1+.114\ Pi^{.59}T^{.41}\right)$ | .863 | .651 | -.879 |
| 7 Pi/(1+.001 Pi Z) | .895 | .732 | -.892 |
| **Data Set 2*** | | | |
| 1 Pi | .891 | .656 | -.849 |
| 2 $Pi/(1+T^{.5})$ | .912 | .662 | -.888 |
| 3 $Pi/(1+2T^{.5})$ | .914 | .657 | -.897 |
| 4 $Pi/(1+1.43T^{.25})$ | .914 | .662 | -.885 |
| 5 $Pi^{(1-.2T^{.2})}$ | .916 | .658 | -.896 |
| 6 $Pi/\left(1+.114\ Pi^{.59}T^{.41}\right)$ | .910 | .645 | -.899 |
| 7 Pi/(1+.001 Pi Z) | .918 | .723 | -.894 |
| **Data Set 3*** | | | |
| 1 Pi | .904 | .758 | -.876 |
| 2 $Pi/(1+T^{.5})$ | .915 | .763 | -.910 |
| 3 $Pi/(1+2T^{.5})$ | .910 | .756 | -.916 |
| 4 $Pi/(1+1.43T^{.25})$ | .917 | .763 | -.908 |
| 5 $Pi^{(1-.2T^{.2})}$ | .918 | .762 | -.911 |
| 6 $Pi/\left(1+.114\ Pi^{.59}T^{.41}\right)$ | .906 | .745 | -.914 |
| 7 Pi/(1+.001 Pi Z) | .929 | .842 | -.920 |

| * data set restrictions: | 1 | 2 | 3 |
|---|---|---|---|
| Inflow Total P (mg/m3) | - | < 500 | < 500 |
| Inflow (Diss P/Total P) | - | > .13 | > .13 |
| Inflow (Total N/Total P) | - | - | > 8 |
| Turbidity (1/m) | - | - | < 1.58 |
| Number of Reservoirs | 43 | 39 | 29 |

** all variables log-transformed

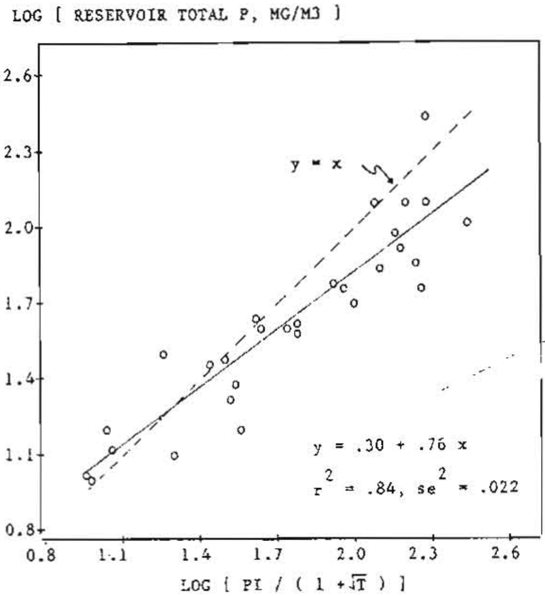
Table 25. Coefficients are listed for each of the three data sets described above. For most data set/response variable combinations, correlation coefficients are somewhat higher for normalized loadings calculated according to equation (61). Coefficient differences are greatest in the case of chlorophyll, which has a range of .745 to .842 for the third data set. In no cases, however, do the correlations coefficients differ by more than .1 among the expressions tested for a given data set and response variable.

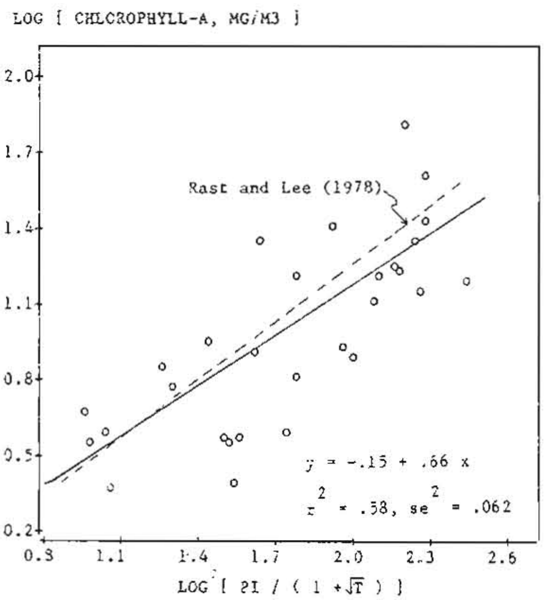
145. Figures 17 and 18 illustrate response variable correlations with two normalized loading statistics: Pv (the Vollenweider/Larsen-Mercier expression, model B11A01) and Pn (equation (61)), respectively. Plots for other normalized loading statistics listed in Table 30 are not substantially different. Regression lines and data in these figures correspond to the third (most restricted) data set in Table 30. Figure 17 indicates that the regression model for predicting mean chlorophyll-a as a function of the Vollenweider/Larsen-Mercier normalized loading is not significantly different from that derived by Rast and Lee (1978) using the OECD North American data set. Chlorophyll models developed by Clasen (1980) and Vollenweider and Kerekes (1980) are also similar. The Rast and Lee model for transparency has a significant positive bias which might be attributed to regional factors, since most of the OECD North American impoundments are north of the impoundments in this data set (see Part VIII, paragraphs 189-192).

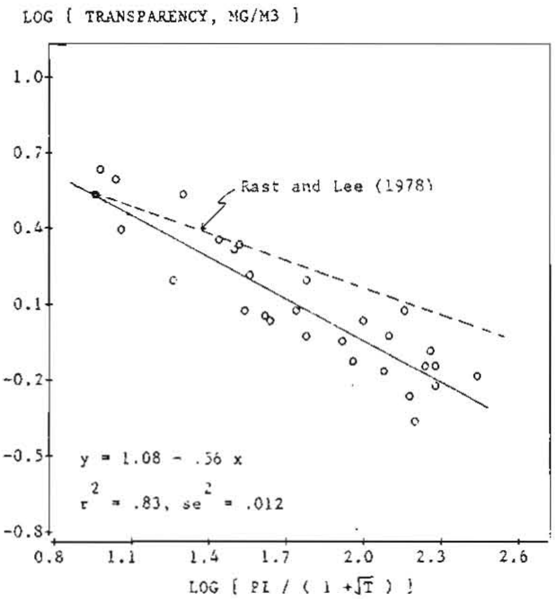
146. When the Vollenweider/Larsen-Mercier expression (Pv) is used for normalized phosphorus loading, stepwise regressions (Appendix D, Table D16) explain 20%, 74%, and 50% of the residual variance in phosphorus, chlorophyll, and transparency, respectively. When equation (61) (Pn) is used for normalized loading, regressions explain 0%, 70%, and 18% of the residual variance, respectively. High percentages for chlorophyll models are primarily attributed to residual correlations with the product of mean depth and turbidity. The effects of depth and turbidity are consistent with the results of internal model evaluations (Part V); for example, equation (45) suggests that the chlorophyll/total

Figure 17

Observed and Predicted Water Quality
Using Pv for Normalized
Phosphorus Loading



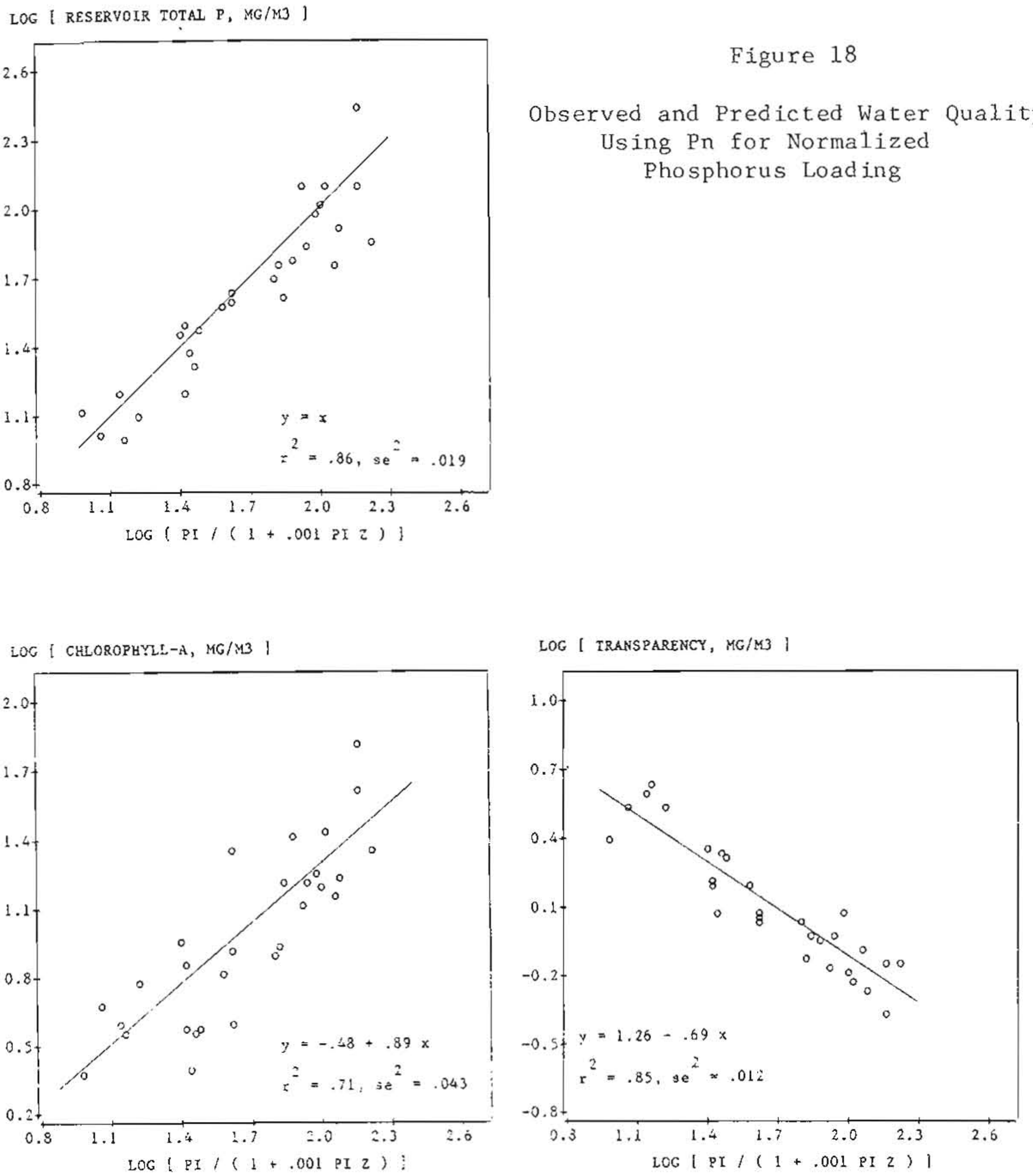



Figure 18

Observed and Predicted Water Quality Using Pn for Normalized Phosphorus Loading

P ratio at P-limited stations is inversely related to the square root of the product of mean depth and turbidity, possibly owing to effects of light-limitation and/or nutrient availablility.

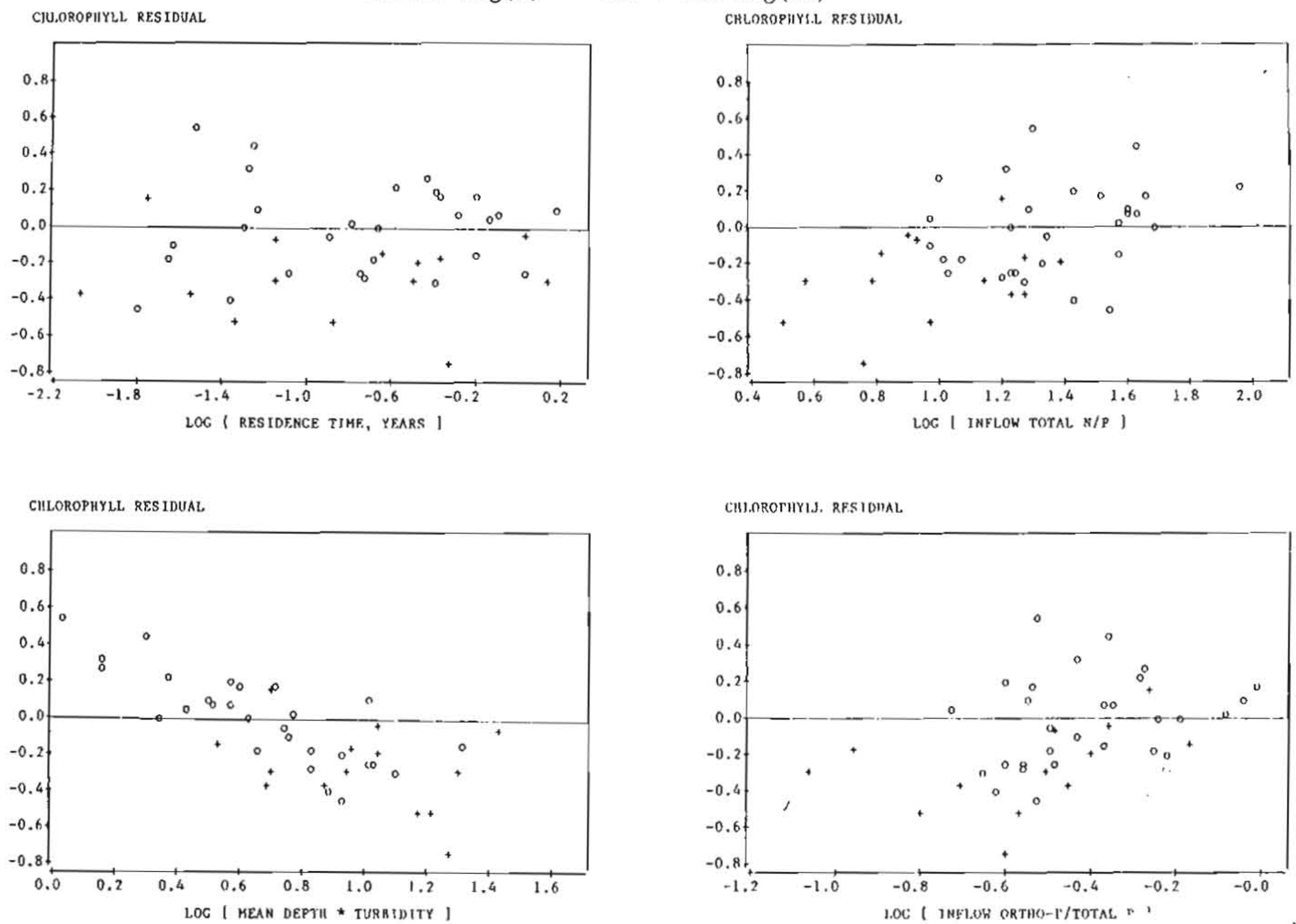
147. Plots of chlorophyll-a residuals against residence time, the product of turbidity and mean depth, inflow total N/P ratio, and inflow ortho-P/total P ratio are shown in Figures 19 and 20. For both models, residuals are unrelated to residence time, except for negative biases (model over-predictions) for two reservoirs with residence times less than about .02 years. These biases may be related to kinetic control of algal growth by flushing rate. Residual correlations are much stronger with the other three factors. The models tend to over-predict chlorophyll in reservoirs with turbidity-depth products exceeding about 6, inflow total N/P ratios less than about 8, or inflow ortho-P/total P ratios less than about .2. Chlorophyll is under-predicted in reservoirs with turbidity-depth products less than about 2.5 or inflow total N/P ratios greater than about 40. Because of correlations among these factors, it is difficult to establish which is the most important. Stepwise regressions indicate, however, that the product of turbidity and mean depth explains most of the residual variance. These residual associations suggest possibilities for chlorophyll model improvement over the simple relationships depicted in Figures 17 and 18.

148. Residual mean squared errors for transparency models (Table 25) range from .012 to .018 and are considerably lower than the phosphorus (.019-.025) and chlorophyll (.043-.063) model error ranges. The relatively low errors characteristic of these models are also apparent in Figures 17 and 18. Figure 21 indicates that transparency residuals tend to be positively correlated with residence time and mean depth, possibly because concentrations of allochthonous particulates would tend to be greater in reservoirs which are shallower and/or more rapidly flushed. In contrast with chlorophyll residuals, transparency residuals are not correlated with inflow dissolved P/inflow total P. This may result from two partially offsetting mechanisms in reservoirs with lower inflow dissolved P/total P ratios: (1) higher turbidities associated with allochthonous particulate phosphorus (tending to

Figure 19

Residuals Plots of Chlorophyll-a vs. Pv

Model: log(B) = -.15 + .66 log(Pv)

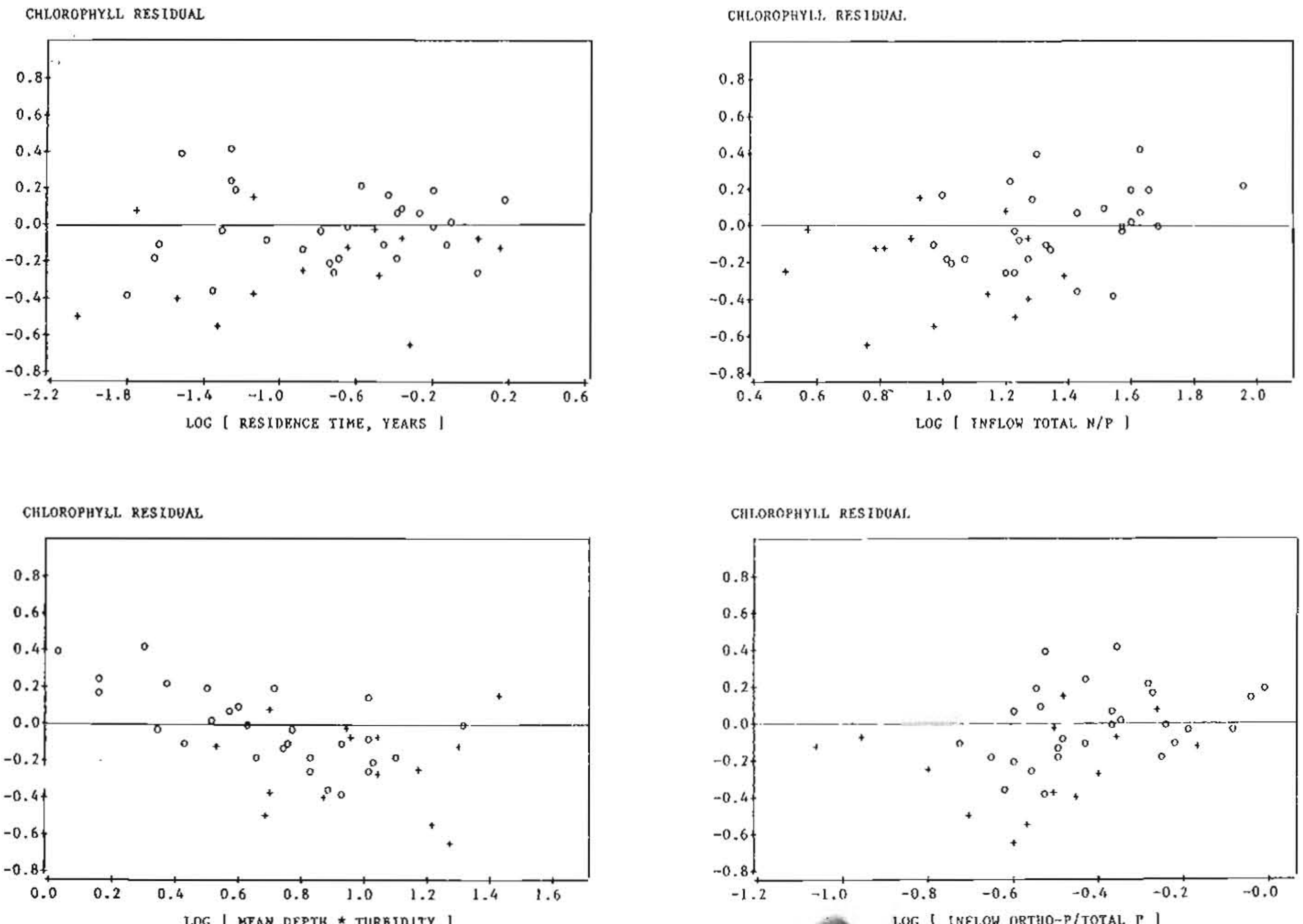



(+ points excluded from regression)

Figure 20

Residuals Plots of Chlorophyll-a vs. Pn

Model: log(B) = -.48 + .89 log(Pn)



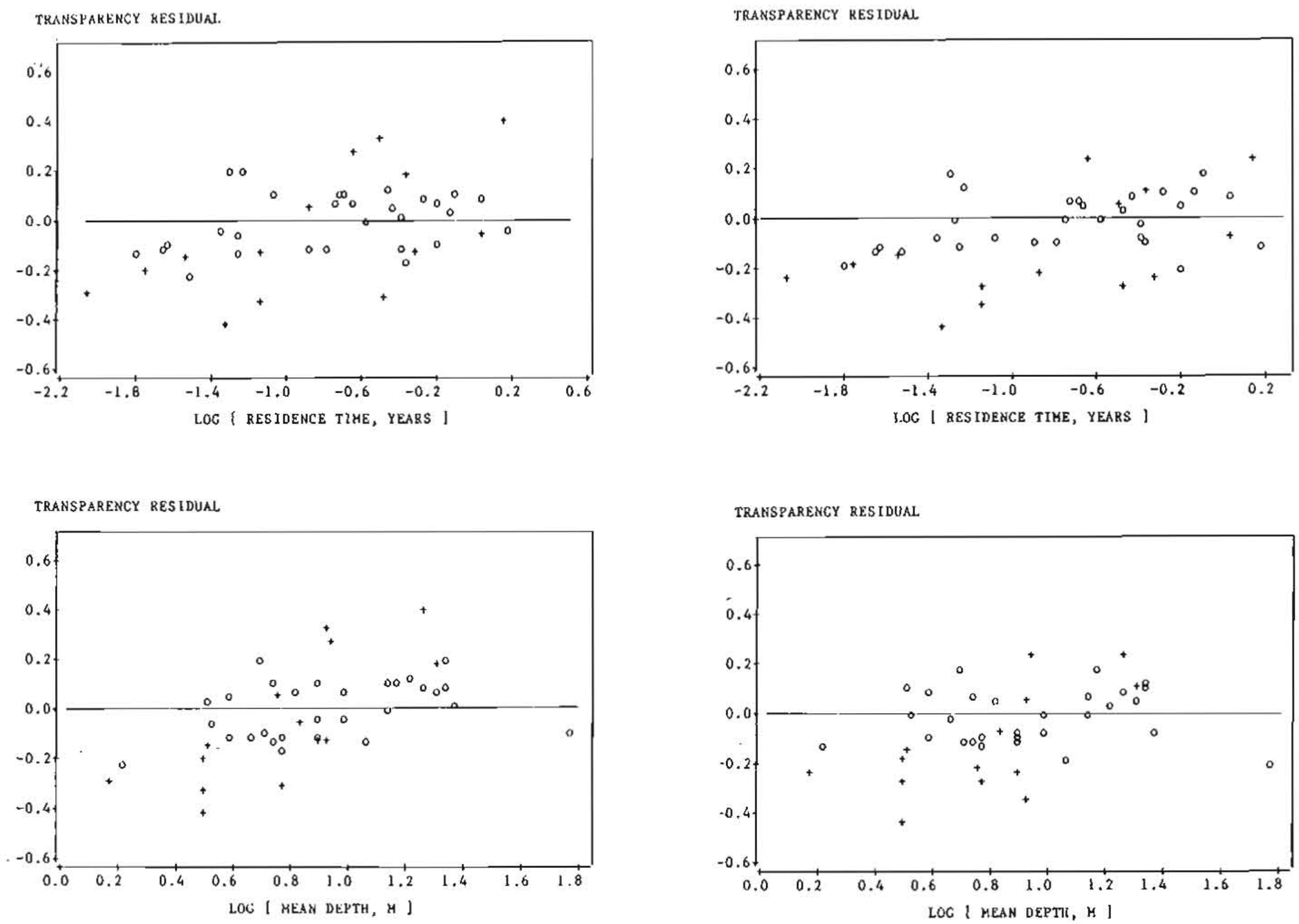

(+ points excluded [illegible] regression)

Figure 21

Residuals Plots of Transparency Models

Model: $\log(S) = 1.08 - .56 \log(Pv)$

Model: $\log(S) = 1.26 - .69 \log(Pn)$




(+ points excluded from regression)

decrease transparency) and (2) greater phosphorus trapping efficiency (tending to increase transparency). The apparent insensitivity of the transparency models to the dissolved fraction of the total phosphorus loading partially accounts for the lower prediction errors of these models.

149. Regional analyses suggest that both sets of loading models tend to under-predict transparency in northern impoundments (approximately above 42 degrees latitude), which tend to have lower non-algal turbidities owing to climatologic and/or geologic factors (glacial soils vs. sedimentary soils). Additional data from northern impoundments are needed to define these effects quantitatively.

150. Phosphorus, chlorophyll, and transparency residuals have also been tested for effects of morphometric complexity by comparing means and standard deviations from reservoirs with one tributary arm with those from reservoirs with more than one arm. Effects are not significant, however, except for transparency predicted according to model S11X03 (Table 27), for which mean residuals are higher by about .1 log units in reservoirs with more than arm. The effect is small in relation to the error correlations discussed above.

## Effects of Spatial Variations

151. The loading model evaluations described in the previous section are based upon predictions of reservoir-average phosphorus, transparency, and chlorophyll concentrations. As discussed in Part III, the accuracies of these averages depend upon reasonable distribution of sampling stations among representative reservoir areas, since it has not been possible within the scope of this project to estimate or apply areal weighting factors to the individual station averages.

152. To provide a basis for a preliminary assessment of spatial variance effects, the ranges of station-average phosphorus, transparency, and chlorophyll values have been calculated for each reservoir during the year sampled by the EPA/NES. Figure 22 displays the ranges in the average phosphorus concentrations against annual-average

outflow phosphorus concentration. Figures 23-25 display the ranges in the phosphorus, chlorophyll, and transparency averages against the average inflow phosphorus concentration.

153. Some of the within-reservoir variability depicted in Figures 22-25 is statistical, i.e., results from the limited accuracies of the station-mean estimates. The average coefficient of variation of the station-mean chlorophyll estimates is .28 (Table 12), or about .12 on a base-10 logarithmic scale. For sample sizes less than 10, the expected value of the range is given approximately by the standard deviation multiplied by the square root of the sample size (Snedecor and Cochran,1972). For an average of four stations per reservoir, then, the expected range of the station-average chlorophyll is about .24 log units. Corresponding calculations for phosphorus and transparency yield expected ranges of .13 and .15 log units, respectively. These calculations would tend to over-estimate the ranges because the errors in the station-mean estimates are not independent, owing to temporal variance effects (Walker, 1981).

154. Variance component analyses of station-average chlorophyll, transparency, and phosphorus values indicate that within-reservoir variability accounts for 36%, 24% , and 21% of the total variance, respectively. It is apparent that the ranges for many reservoirs in Figures 22-25 considerably exceed the expected values calculated above and thus represent real spatial variance. The reservoir with the most spatial variance is Sakakawea (30-235), on the Missouri River in North Dakota, in which station-average chlorophyll, phosphorus, and transparency values differ by factors of 23, 36, and 21, respectively from one end of the reservoir to the other.

155. While the models calibrated in the previous section are valid for predicting reservoir-average conditions, calculated as the simple arithmetic means across reasonably well-distributed stations, it is difficult to distinguish among alternative model formulations on the basis of minimum error. It seems possible that the model comparisons could be sensitive to the spatial averaging scheme employed, since within-reservoir variability seems to be appreciable in many cases.

Figure 22
Ranges of Station-Mean Phosphorus Concentrations vs.
Outflow Total Phosphorus

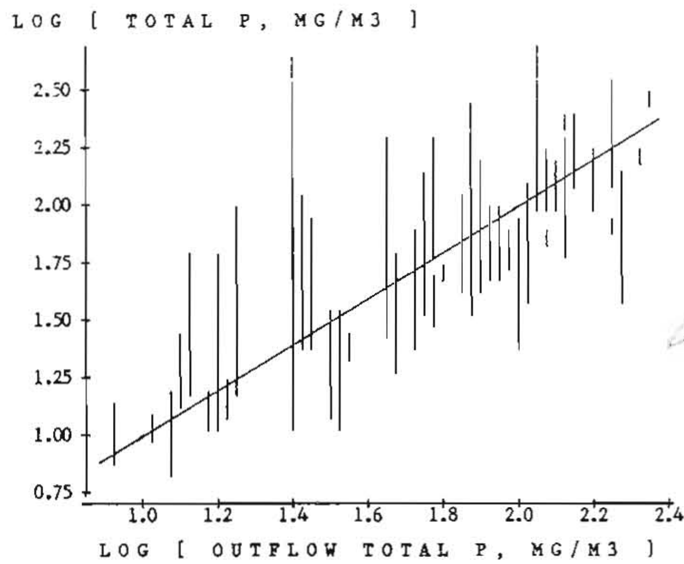
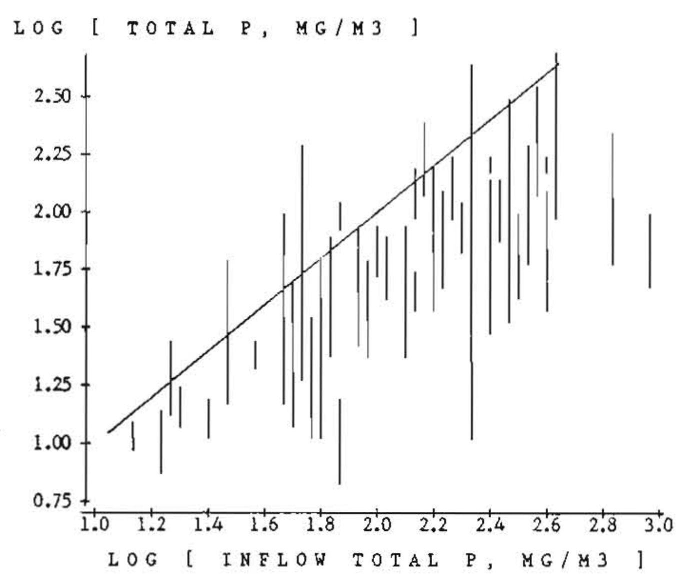



Figure 23
Ranges of Station-Mean Phosphorus Concentrations vs.
Inflow Total Phosphorus



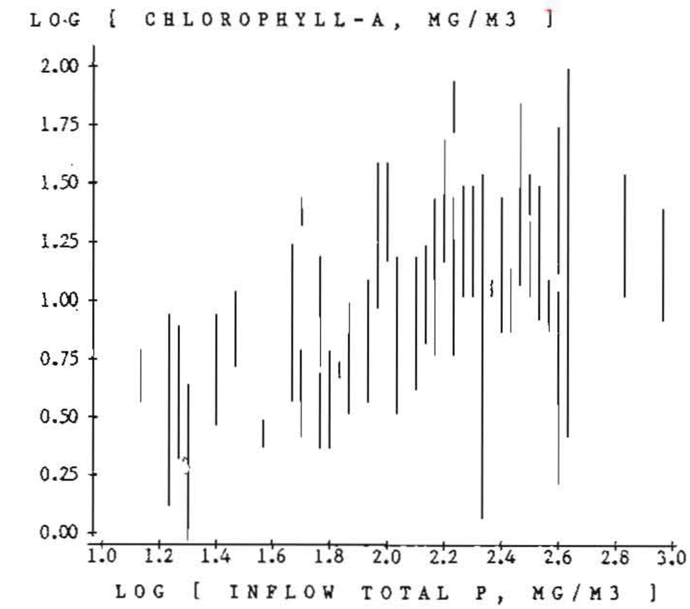
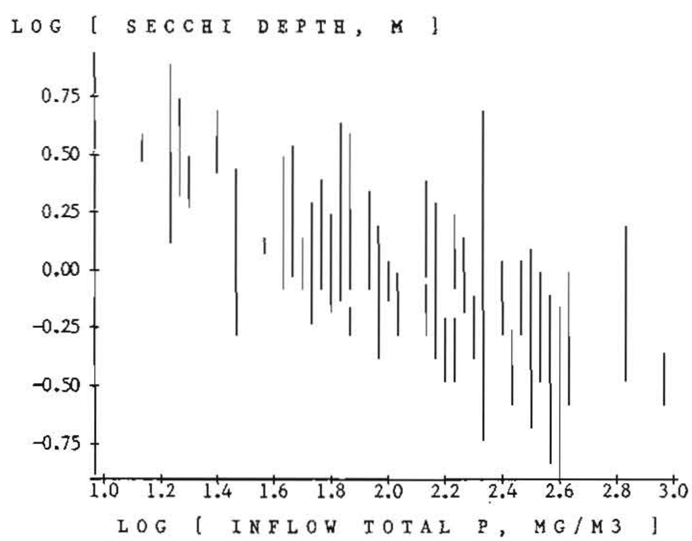



Figure 25
Ranges of Station-Mean Secchi Depths vs.
Inflow Total Phosphorus



Firm conclusions regarding appropriate nutrient loading models for reservoirs cannot be drawn without a more detailed analysis of spatial variance effects. This would involve, minimally, estimation of areal and/or volumetric weighting factors for each station and reservoir. A single reservoir-average value is misleading in many cases and adaptation of the empirical modelling approach to permit spatial gradient prediction seems appropriate. This would require a somewhat more theoretical modelling framework which disaggregates each reservoir into its major tributary arms and treats the nutrient balances and water quality responses separately within each arm, while considering the potential for longitudinal variations. The CE data base seems well-suited for this type of analysis, since the stations have already been classified and sorted in downstream order within each reservoir arm, although additional map work would be required to compile more detailed morphometric information.

## Conclusions

156. Results of the loading model evaluations conducted in the previous sections can be summarized by the following:

a. Coefficients and error statistics for models predicting annual-average outflow phosphorus and growing-season, reservoir-average, surface-layer, phosphorus concentrations indicate that the retention coefficient cannot be considered to be independent of concentration. For a given residence time and mean depth, a reservoir with a higher inflow phosphorus concentration will tend to have a higher retention coefficient. The concentration-dependence may be related to the influence of internal loading terms which are neglected in the nutrient balance formulation.

b. Retention model coefficients for predicting outflow phosphorus concentrations agree well with values found by Clasen (1980) in the

OECD Reservoir and Shallow Lakes Project. At a given mean depth and residence time, results suggest higher phosphorus removal rates in reservoirs, as compared with the lakes used in original model development. Some of this difference can be attributed to the effects of spatial variance or plug flow in reservoirs, although higher sediment accumulation rates are probably also involved, since residuals from all phosphorus models are negatively correlated with sediment accumulation rate.

c. Alternative formulations for predicting outflow phosphorus include:

$$Po = Pi/(1 + 2.1\ T^{.5}) \qquad (R^2=.70,\ SE^2=.034)$$

$$Po = Pi/(1 + .21\ Pi^{.5}T^{.5}) \qquad (R^2=.83,\ SE^2=.026)$$

$$Po = Pi^{(1 - .25\ T^{.32})} \qquad (R^2=.81,\ SE^2=.027)$$

where,

Po = outflow total P ($mg/m^3$)
Pi = inflow total P ($mg/m^3$)
T = hydraulic residence time (years)

The first expression is a calibration of the Vollenweider/Larsen-Mercier model which requires linear concentration response; errors from this model are negatively correlated with inflow concentration. The other formulations do not require a linear response and have somewhat lower mean squared errors. The above models tend to over-predict outflow concentration in reservoirs with low percentages of orthophosphorus loading (< 12%). Residuals are correlated with sediment accumulation rate, shoreline development ratio, surface area, and inflow ortho-P/total P.

d. Residual variance from the above models increases strongly with residence time. The variance pattern can be explained by the increased sensitivity of the predicted phosphorus concentration to the estimated phosphorus sedimentation coefficient at higher residence times.

e. Two alternative schemes for predicting surface phosphorus, chlorophyll, and transparency values, averaged by reservoir and growing season are:

$$Pv = Pi/(1 + T^{.5})$$

$$\log(P) = .30 + .76 \log(Pv) \qquad (R^2=.84, SE^2=.022)$$

$$\log(B) = -.15 + .66 \log(Pv) \qquad (R^2=.58, SE^2=.062)$$

$$\log(S) = 1.08 - .56 \log(Pv) \qquad (R^2=.83, SE^2=.013)$$

and,

$$Pn = Pi/(1 + .001\ Pi\ Z)$$

$$\log(P) = \log(Pn) \qquad (R^2=.86, SE^2=.019)$$

$$\log(B) = -.48 + .89 \log(Pn) \qquad (R^2=.71, SE^2=.043)$$

$$\log(S) = 1.26 - .69 \log(Pn) \qquad (R^2=.85, SE^2=.012)$$

where,

P = reservoir total P ($mg/m^3$)
B = reservoir chlorophyll-a ($mg/m^3$)
S = reservoir transparency (m)
Z = mean depth (m)

The first set of expressions are based upon normalized phosphorus loading calculated according to the Vollenweider/Larsen-Mercier model. The second form uses a normalized loading which is based upon the empirical finding that the effective sedimentation coefficient is approximately proportional to the areal phosphorus loading. This gives the curious result that all water quality predictions are independent of hydrologic factors (residence time or overflow rate).

f. Residual variance for the second set of models is slightly lower and shows less association with reservoir mean depth. Residuals for both chlorophyll models are negatively correlated with inflow dissolved P/total P and with the product of mean depth and turbidity. These correlations, which explain 76% and 60% of the residual variance from the respective chlorophyll equations, suggest effects of phosphorus availablility and light limitation on algal responses to phosphorus loading. These strong residual correlations also suggest that there is considerable room for model improvement.

g. Considering the error dependencies, the relatively low range of mean square error, and the potential effects of spatial variance discussed below, it is difficult to select a single "best" set of load/response model formulations, based upon the work completed thus far. While the second set of models performs somewhat better than the first on this data set, their lack of hydrologic dependence is a significant departure from previous models and analyses of other data sets are needed to assess generality (see Part VIII). If the response variables can be predicted independently of hydrologic variations (except as they may influence inflow phosphorus concentrations or reservoir depth), data requirements for model application are considerably reduced. The importance of depth, opposed to residence time, in the second set suggests the importance of exchange/equilibration with bottom sediments, as opposed to a kinetically limited sedimentation process, as the most important factor regulating reservoir phosphorus levels.

h. Spatial water quality variations within many reservoirs are substantial and need to be explicitly considered in order to refine the models tested above. This would minimally involve estimation of areal or volumetric weighting factors for application to stations in computing reservoir-averages. More elaborate modelling approaches which disaggregate the reservoirs into relatively homogeneous segments would permit more refined calibration and testing of load/response relationships and provide a framework for predicting spatial variations in eutrophication-related water quality characteristics in reservoirs.

# PART VII: OXYGEN DEPLETION MODELS

## Introduction

157. This section evaluates models for predicting reservoir oxygen status based upon internal measurements of phosphorus, transparency, and chlorophyll-a, external phosphorus loadings, and reservoir morphometric characteristics. The data sources and reduction procedures used to develop model testing data sets containing the independent variables of these models are described in Part III. The models investigated are summarized in Appendix E, Part IV.

## Data Set Development

158. Most of the models in this category are designed to predict areal or volumetric rates of hypolimnetic oxygen depletion during the stratified period. Estimation of depletion rates for these reservoirs would require detailed consideration of vertical, horizontal, and temporal variations in oxygen and temperature in relation to the morphometric characteristics of each reservoir and is beyond the scope of this work. During the stratified period and at a given location in the reservoir pool, anoxic conditions generally begin developing at the bottom of hypolimnion. As the season progresses, the depth of the anaerobic layer approaches the thermocline. In some reservoirs, metalimnetic demands may also be important, but these are not focused on here. If a prediction of hypolimnetic depletion rate is valid, then it should be useful as an indicator of oxygen status, as measured by the maximum fraction of the hypolimnion which is anoxic ( < 2 mg/liter) over the course of the stratified period.

159. To transform estimates of areal depletion rate into estimates of concentration, the depth of the hypolimnion must be taken into consideration, or the depletion rate must be expressed on a volumetric basis. This has been done by computing the "days of oxygen supply" equivalent to a given depletion rate, hypolimnetic depth, and spring

oxygen concentration (Walker, 1979):

$$TDO = DOsp\ Zh\ /\ HODa \tag{63}$$

where,

TDO = days of oxygen supply at onset of stratification (days)

DOsp = oxygen concentration at onset of stratification (g/m3)

Zh = mean hypolimnetic depth = volume/area (m)

HODa = estimated areal oxygen depletion rate (g/m2-day)

In testing an empirical model for predicting depletion rates in northern lakes as a function of phosphorus levels and morphometry, Walker (1979) found that "oxic" lakes could be distinguished from "anoxic" lakes at a TDO value of about 200 days, which is comparable to the length of the stratified period in the northern temperature zone. In the absence of spring oxygen measurements for each lake, calculations assumed a constant value of 12 g/m3 at spring turnover (saturation at 6.2 degrees C). A review of oxygen and temperature plots indicates that 12 g/m3 is a reasonable approximation for spring DO values in about 90% of the CE reservoirs used in the tests described below; a few of the (southern) reservoirs have values between 8 and 10 g/m3. In the absence of precise estimates of spring DO values for each reservoir, a constant value of 12 g/m3 is assumed below.

160. At a constant DOsp value, the TDO statistic is inversely proportional to the volumetric depletion rate. Discrimination between oxic and anoxic reservoirs at a calculated TDO value of 200 days is equivalent to discrimination at a volumetric depletion rate of 0.06 $g/m^3$-day. In addition to model errors in estimating depletion rates, variations in the length of the stratified period, variations in oxygen concentrations at spring turnover, and nonlinearities in oxygen deficit development contribute to the potential errors involved in using TDO as an indicator of oxygen status. The potential influences of spring DO variations on model testing results are small, since variations in areal depletion rate and mean hypolimnetic depth are dominant. On the average, calculated TDO values differ by more than an order of magnitude between oxic and anoxic reservoirs; additional TDO variance attributed to spring

D.O. variations would have negligible influence on group separation statistics, although they may contribute to individual classification errors. Classification errors are evaluated for each model with error tolerances of accounting for variations of plus or minus 26% in spring D.O. or length of stratified period.

161. Contour diagrams (depth x month) of oxygen and temperature variations have been generated for each reservoir after averaging all measurements at 5-foot, 1-week intervals. While anoxic conditions may develop earlier at relatively shallow, upper-pool stations in some reservoirs, data from mid-pool or near-dam stations would be more representative of the total hypolimnetic volume and have been used exclusively in these tests. Plots have been reviewed and the following data extracted:

*a*. maximum profile depth

*b*. mid-summer, mid-thermocline depth

*c*. mid-summer, top-to-bottom temperature difference

*d*. maximum extent (minimum depth) of anaerobic zone (D.O. < 2 mg/l)

*e*. mean hypolimnetic temperature

Because of the scale factors used in the contour diagrams, estimates of top-to-bottom temperature difference have an error margin of 0-6 degrees C. Each reservoir has been classified into one of three groups, based upon the fraction of the total hypolimnetic depth which is anaerobic:

| Group | Maximum Anaerobic Fraction | Number of Reservoirs |
|---|---|---|
| Oxic | < .2 | 5 |
| Intermediate | .2 - .8 | 12 |
| Anoxic | > .8 | 46 |

The data set includes 63 reservoirs with stable stratification and mid-summer, top-to-bottom temperature differences greater than 6 degrees C. This classification scheme provides an approximate basis for testing the TDO statistic and other discriminant functions (Reckhow, 1978) as predictors of oxygen status in stratified reservoirs. All of the reservoirs in the "Oxic" class had no observed anaerobic conditions. Contour plots indicate that metalimnetic oxygen demands are significant in about 10 of the above reservoirs.

162. Mean hypolimnetic depths have been estimated using mean pool elevations, mid-thermocline depths, and the morphometric polynomials described in Part III. Estimates of average water quality conditions needed for model testing have been derived by averaging mid-pool and near-dam stations within each reservoir. Phosphorus loading statistics refer to the year of pool sampling by the EPA/NES. Two sets of data have been used in model testing: one including all 63 reservoirs and another including 27 reservoirs which passed the screening criteria for water quality and nutrient loading data in Part III. Model comparisons are not significantly different, however, for the two data sets. Most of the misclassifications (model errors) cannot be explained on the basis of data screening codes. Thus, results from the larger data set are emphasized below. Appendix C, Table C3, lists the data set used for oxygen model testing.

## Statistical Methods

163. Figure 26 summarizes the theory of a univariate discriminant function for groups of unequal variance. The F-statistic derived from a one-way analysis of variance of the discriminant function (estimated TDO) grouped by observed oxygen status provides one measure of discriminating power. The following statistic is another useful measure of normalized distance between groups which does not assume homogeneity of variance:

$$Z^* = (M1 - M2) / (S1 + S2) \tag{64}$$

where,

$Z^*$ = normalized distance between groups 1 and 2

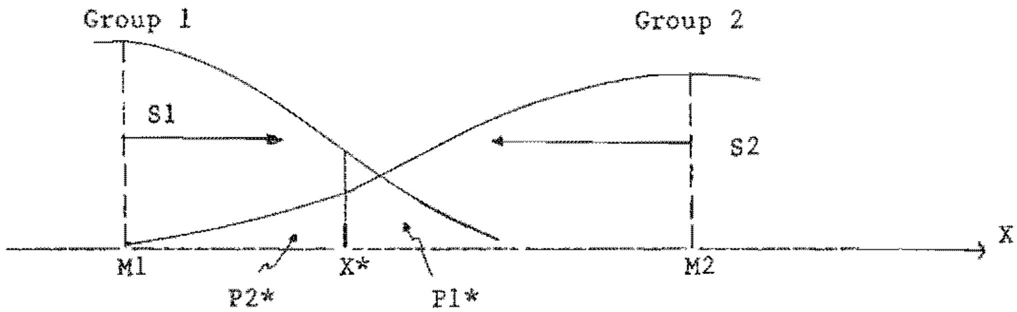
M1 = mean of group 1

M2 = mean of group 2

S1 = standard deviation of group 1

Figure 26

Theory of Univariate Discriminant Functions for Two Groups of Unequal Variance




Define error integral P* and critical value X* that:

$$P1^* = \int_{X^*}^{\infty} f1(X)\, dX \quad = \quad P2^* = \int_{\infty}^{X^*} f2(X)\, dX$$

where,

f1(X) = normal frequency distribution function of group 1 (M1,S1)
f2(X) = normal frequency distribution function of group 2 (M1,S1)
P1* = fraction of population X1 above X*
P2* = fraction of population X2 below X*

Solution given by:

$$Z^* = (X^* - M1) / S1 = (M2 - X^*) / S2$$

$$X^* = (M1\ S2 + M2\ S1) / (S1 + S2)$$

$$Z^* = (M2 - M1) / (S1 + S2)$$

S2 = standard deviation of group 2

As demonstrated in Figure 26, Z* reflects the overlapping of the populations and can be used to calculate P*, the probable classification error. The critical value of the discriminating variable at which the classification error probabilities are equal for each group is given by:

$$X^* = (M1\ S2 + M2\ S1) / (S1 + S2) \qquad (65)$$

Calculated values of X* for distinguishing between oxic and anoxic groups can be compared with the length of the stratified period in order to assess parameter stability.

164. Classification errors have been assessed by comparing predicted log(TDO) values with observed oxygen status, using a nominal estimate of 200 days (2.3 log units) as an average value for the length of the stratified period and as a rule for distinguishing anoxic reservoirs from the others. Misclassifications have also been computed allowing for an error margin of .1 log units in the discriminant function, to allow for potential variations in the length of the stratified period, spring oxygen concentration, and data variability. Reckhow's function (1978) has been evaluated using a discriminant value of 0 with an error margin of .5 units.

## Model Testing

165. Models can be broadly categorized into those based upon internal water quality measurements and those based upon external phosphorus loadings. Table 31 lists the codes, formulations, and original parameter estimates for each model evaluated. Models have been evaluated based upon the following criteria:

a. normalized distance measures and ANOVA statistics
b. classification errors
c. review of bivariate classification plots
d. parameter stability

Table 31

Models for Predicting Reservoir Oxygen Status

---

Model D01: Lasenby, 1975

D01A01 $\log(HODa) = .35 - 1.35 \log(S)$

S = mean Secchi depth (m)
HODa = areal hypolimnetic oxygen depletion rate (g/m2-day)

---

Model D02: Walker, 1979

D02A01 $\log(HODa) = Fm + .0204 ( -15.6 + 46.1 \log(P) )$
D02A02 $\log(HODa) = Fm + .0204 ( 75.3 + 44.8 \log(1./S - .08) )$
D02A03 $\log(HODa) = Fm + .0204 ( 20.0 + 33.2 \log(B) )$
D02A04 $\log(HODa) = Fm + .0204 ( -15.6 + 46.1 \log(Pv) )$
D02A05 $\log(HODa) = Fm + .0204 ( -15.6 + 46.1 \log(Pn) )$

$$Fm = -3.58 + 4.55 \log(Z) - 2.04 \log(Z)^2 \quad , \text{ for } Z < 20 \text{ m}$$
$$= -1.12 \quad , \text{ for } Z > 20 \text{ m}$$

$$Pv = Pi / (1 + T^{.5})$$

$$Pn = Pi / ( 1 + .001\ Pi\ Z)$$

Fm = morphometric factor
Z = mean depth (m)
P = mean total P (mg/m3)
B = mean chlorophyll-a (mg/m3)
Pi = average inflow total P concentration (mg/m3)
T = mean hydraulic residence time (yrs)
Pv = Vollenweider/Larsen-Mercier normalized phosphorus loading
Pn = normalized loading according to equation (61), Part VI

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Model D03: Welch and Perkins, 1979

D03A01 $\log(HODa) = -1.49 + .39 \log (Pi\ Z )$

---

(continued)

Table 31 (continued)

---

Model D04: Cornett and Rigler, 1979

D04A01 $HODa = -.277 + .0005\ Ap + .005\ Th^{1.74} + .150\ \ln(Zh)$

$Ap = Qs\ (Pi - Po)$

Ap = total phosphorus accumulation (trapping) rate (mg/m2-yr)
Po = average outflow total P (mg/m3)
Qs = surface overflow rate (m/yr)
Th = mean hypolimnetic temperature (deg C)
Zh = mean hypolimnion depth (m)

---

Model D05: Rast and Lee, 1978 (D05A01)
Vollenweider and Kerekes, 1980 (D05A02)
Ryding, 1980 (D05A03)

D05A01 $\log(HODa) = -1.07 + .467\ \log(Pv)$
D05A02 $\log(HODa) = -1.07 + .585\ \log(Pv)$
D05A03 $\log(HODa) = -2.42 + .67\ \log(Pv) + \log(Zh)$

---

Model D06: Reckhow, 1978

D06A01 $D = 2.33 - 4.61\ \log(Pi) + 5.73\ \log(Z) - 0.51\ \log(Qs)$

D = discriminant score (Oxic for $D > 0$)

---

*e*. interpretation of outliers (misclassified reservoirs)

Table 32 summarizes the ANOVA statistics and distributions of calculated discriminant functions for each reservoir group and model. For comparative purposes, the distributions of reservoir morphometric, hydrologic, and water quality characteristics within each group are also described. With the exception of Lake Sakakawea, described in detail below, none of the completely oxic reservoirs are misclassified by any of the models. The sample size for this group, however, is limited to 4. Table 33 presents group separation statistics for reservoirs classified into two categories, "anoxic" and "other", where the latter refers to the "oxic" and "intermediate" groups combined. Classification errors with and without tolerances are presented in Table 34 for the above categories. As discussed below, one oxic reservoir (Lake Sakakawea, 30-235) was misclassified by all of the models. The statistics in Tables 32-34 exclude this reservoir.

166. Graphical analysis is another important means of evaluating the models. Most of the models are separable into morphometric and water quality terms. Figures 27-35 plot these terms against each other for each model, using different symbols to distinguish reservoir groups. The solid line in each figure represents the solution of the model for a TDO value of 200 days (or a function value of 0. for model D06). Dashed lines reflect an error tolerance of .1 log units, as discussed above. The validity of each model is reflected by the separation of oxygen status groups by the TDO lines. The slopes of the lines reflect the relative sensitivities of oxygen status to water quality and morphometric factors.

167. Internal models (D01 and D02) relate oxygen status to surface measurements of chlorophyll, phosphorus, or transparency averaged over the growing season. F statistics range from 35.0 to 50.3 for the three-group classifications (Table 32) and from 70.0 to 96.0 for the two-group classifications (Table 33). Classification errors (Table 34) range from 4.8 to 14.0% without tolerance and 3.2 to 4.8% with tolerance. All of the models show reasonable group separation on bivariate plots (Figures 27-35), using a TDO value of 200 days to

Table 32

Distributions of Oxygen Discriminant Functions and other Reservoir Characteristics by Oxygen Status Group

| | Oxygen Status Group | | | | | | | | | ANOVA Results* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oxic | | | Intermediate | | | Anoxic | | | | |
| Variable | n | mean | std | n | mean | std | n | mean | std | F | F |
| **Internal Models **** | | | | | | | | | | | |
| D01A01 | 4 | 2.85 | 0.20 | 12 | 2.60 | 0.18 | 46 | 1.41 | 0.58 | 35.0 | 17.3 |
| D02A01 | 4 | 2.71 | 0.38 | 12 | 2.62 | 0.14 | 46 | 1.78 | 0.38 | 36.8 | 27.6 |
| D02A02 | 4 | 2.68 | 0.18 | 12 | 2.40 | 0.18 | 46 | 1.55 | 0.35 | 50.3 | 25.1 |
| D02A03 | 4 | 3.00 | 0.18 | 12 | 2.52 | 0.18 | 34 | 1.92 | 0.28 | 48.1 | 25.3 |
| **External Models **** | | | | | | | | | | | |
| D02A04 | 3 | 2.94 | 0.30 | 11 | 2.50 | 0.21 | 31 | 1.61 | 0.48 | 28.1 | 20.9 |
| D02A05 | 3 | 3.04 | 0.27 | 11 | 2.48 | 0.14 | 31 | 1.67 | 0.35 | 47.5 | 31.0 |
| D03A01 | 3 | 2.95 | 0.15 | 11 | 2.68 | 0.10 | 31 | 2.06 | 0.33 | 28.6 | 21.1 |
| D04A01 | 3 | 2.90 | 0.14 | 11 | 2.40 | 0.28 | 31 | 1.60 | 0.49 | 22.5 | 15.5 |
| D05A01 | 3 | 3.15 | 0.22 | 11 | 2.75 | 0.12 | 31 | 1.91 | 0.45 | 29.4 | 21.8 |
| D05A02 | 3 | 3.01 | 0.24 | 11 | 2.60 | 0.14 | 31 | 1.69 | 0.48 | 29.3 | 22.2 |
| D05A03 | 3 | 2.70 | 0.13 | 11 | 2.69 | 0.17 | 31 | 2.30 | 0.26 | 13.3 | 10.8 |
| D06A01 | 3 | 4.02 | 1.34 | 11 | 2.03 | 1.00 | 31 | -2.75 | 2.38 | 31.0 | 20.4 |
| **Morphometry/Hydrology** | | | | | | | | | | | |
| Hyp. Depth | 4 | 1.46 | 0.24 | 12 | 1.16 | 0.10 | 46 | 0.60 | 0.31 | 33.3 | 15.3 |
| Mean Depth | 4 | 1.51 | 0.23 | 12 | 1.25 | 0.07 | 46 | 0.83 | 0.22 | 37.0 | 15.5 |
| Max. Depth | 4 | 1.92 | 0.25 | 12 | 1.73 | 0.10 | 46 | 1.32 | 0.25 | 25.9 | 13.9 |
| Res. Time | 4 | -0.53 | 0.33 | 12 | -0.38 | 0.50 | 45 | -0.62 | 0.55 | 1.0 | 1.6 |
| Overf. Rate | 4 | 2.04 | 0.13 | 12 | 1.62 | 0.51 | 45 | 1.46 | 0.48 | 3.1 | .3 |
| **Water Quality** | | | | | | | | | | | |
| Total P | 4 | 1.33 | 0.24 | 12 | 1.09 | 0.15 | 46 | 1.62 | 0.31 | 17.1 | 18.0 |
| Chl-a | 4 | 0.34 | 0.22 | 12 | 0.58 | 0.28 | 34 | 0.96 | 0.27 | 15.6 | 7.6 |
| Secchi | 4 | 0.49 | 0.21 | 12 | 0.52 | 0.14 | 46 | 0.06 | 0.24 | 25.1 | 15.1 |
| Inflow P | 3 | 1.42 | 0.16 | 11 | 1.44 | 0.26 | 31 | 1.99 | 0.35 | 14.5 | 8.8 |
| Pv *** | 3 | 1.20 | 0.19 | 11 | 1.21 | 0.25 | 31 | 1.80 | 0.39 | 13.3 | 10.8 |
| Pn *** | 3 | 1.10 | 0.13 | 11 | 1.24 | 0.15 | 31 | 1.73 | 0.23 | 29.4 | 17.7 |

* F statistics derived from one-way analyses of variance; (F using all data (n=62), F′ using only data from reservoirs passing nutrient bugdet and water quality data screens (n=26)); statistics exclude Sakakawea (30-235)

** oxygen depletion models (Table 31) formulated to predict days of oxygen supply (equation 63), except for model D06

*** $Pv = Pi / (1 + \sqrt{T})$; $Pn = Pi/(1 + .001\ Pi\ Z)$

Table 33

Summary of Model Statistics for Distinguishing between Anoxic and Other Reservoirs

| | Reservoir Group | | | | | | ANOVA † | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Other | | | Anoxic | | | | | | |
| Model | n | mean | std | n | mean | std | F | F′ | Z*†† | X*†† |
| Internal Models | | | | | | | | | | |
| D01A01 | 16 | 2.66 | 0.21 | 46 | 1.41 | 0.58 | 70.0 | 35.0 | 1.58 | 2.33 |
| D02A01 | 16 | 2.64 | 0.21 | 46 | 1.78 | 0.38 | 74.4 | 49.6 | 1.46 | 2.33 |
| D02A02 | 16 | 2.47 | 0.22 | 46 | 1.55 | 0.35 | 96.2 | 48.1 | 1.62 | 2.12 |
| D02A03 | 16 | 2.64 | 0.28 | 34 | 1.92 | 0.28 | 70.9 | 35.8 | 1.28 | 2.28 |
| External Models | | | | | | | | | | |
| D02A04 | 14 | 2.60 | 0.29 | 31 | 1.61 | 0.48 | 51.6 | 35.0 | 1.30 | 2.23 |
| D02A05 | 14 | 2.60 | 0.29 | 31 | 1.67 | 0.35 | 75.0 | 43.9 | 1.45 | 2.18 |
| D03A01 | 14 | 2.74 | 0.15 | 31 | 2.06 | 0.33 | 53.8 | 38.2 | 1.41 | 2.52 |
| D04A01 | 14 | 2.50 | 0.33 | 31 | 1.60 | 0.49 | 39.9 | 27.1 | 1.11 | 2.14 |
| D05A01 | 14 | 2.83 | 0.22 | 31 | 1.91 | 0.45 | 54.1 | 38.1 | 1.39 | 2.53 |
| D05A02 | 14 | 2.69 | 0.23 | 31 | 1.69 | 0.48 | 54.6 | 39.2 | 1.41 | 2.37 |
| D05A03 | 14 | 2.69 | 0.16 | 31 | 2.30 | 0.26 | 27.1 | 21.7 | .94 | 2.54 |
| D06A01 | 14 | 2.46 | 1.33 | 31 | -2.75 | 2.38 | 58.4 | 36.1 | 1.41 | .59 |

† F statistics derived from analyses of variance; F′ includes only reservoirs passing data nutrient balance and water quality data screens

†† see Figure 26; Z* = normalized distance between groups; X* = function value for distinguishing between groups

Table 34

Classification Error Summary for Oxygen Depletion Models

| Observed : | Other* | Other | Anoxic | Anoxic | Total | Total | Percent |
|---|---|---|---|---|---|---|---|
| Estimated : | Anoxic | Other | Other | Anoxic | Proj. | Errors | Error |
| | ------ Oxygen Status ------- | | | | | | |
| **Internal Models** | | | | | | | |
| D01A01 | 0 (0)** | 16 | 3 (3) | 43 | 62 | 3 (3) | 4.8 (4.8) |
| D02A01 | 0 (0) | 16 | 4 (3) | 42 | 62 | 4 (3) | 6.5 (4.8) |
| D02A02 | 3 (2) | 13 | 1 (0) | 45 | 62 | 4 (2) | 6.5 (3.2) |
| D02A03 | 1 (1) | 15 | 6 (1) | 28 | 50 | 7 (2) | 14.0 (4.0) |
| **External Models** | | | | | | | |
| D02A04 | 2 (0) | 12 | 2 (2) | 29 | 45 | 4 (2) | 8.9 (4.4) |
| D02A05 | 1 (0) | 14 | 1 (1) | 30 | 45 | 2 (1) | 4.4 (2.2) |
| D03A01 | 0 (0) | 14 | 9 (5) | 22 | 45 | 9 (5) | 20.0 (11.1) |
| D04A01 | 4 (3) | 10 | 3 (2) | 28 | 45 | 7 (5) | 15.6 (11.1) |
| D05A01 | 0 (0) | 14 | 8 (5) | 23 | 45 | 8 (5) | 17.8 (11.1) |
| D05A02 | 0 (0) | 14 | 3 (1) | 28 | 45 | 3 (1) | 6.7 (2.2) |
| D05A03 | 0 (0) | 14 | 16 (12) | 15 | 45 | 16 (12) | 35.6 (26.7) |
| D06A01 | 0 (0) | 14 | 4 (2) | 27 | 45 | 4 (2) | 8.9 (4.4) |

* "Anoxic" group includes reservoirs with >80% anaerobic hypolimnia; "Other" group includes the rest of the reservoirs; none of the completely oxic reservoirs (0% anaerobic fraction) are misclassified by any of the the models; statistics exclude Sakakawea (reservoir 30-235)

** classification criterion: "Anoxic" if estimated log(TDO) < 2.3, 200 days for models D01 - D06; "Anoxic" if discriminant function < 0 for model D06; numbers in parentheses reflect classification errors with a tolerance of .1 (e.g. log(TDO) = 2.2 to 2.4) for models D01-D06 and with a tolerance of .5 for model D06 (discriminant function = -.5 to .5)

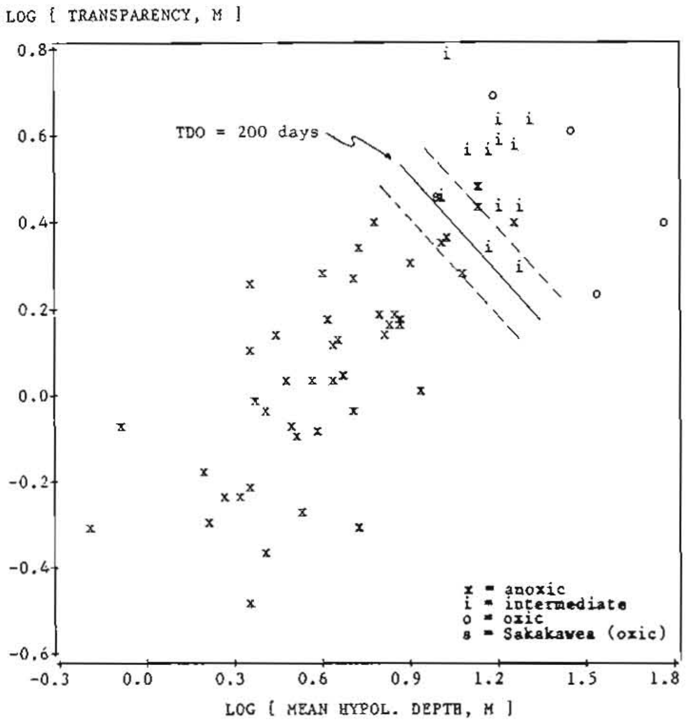


Figure 27

Oxygen Status Classification on Transparency vs. Hypolimnetic Depth Axes (Model D01A01)

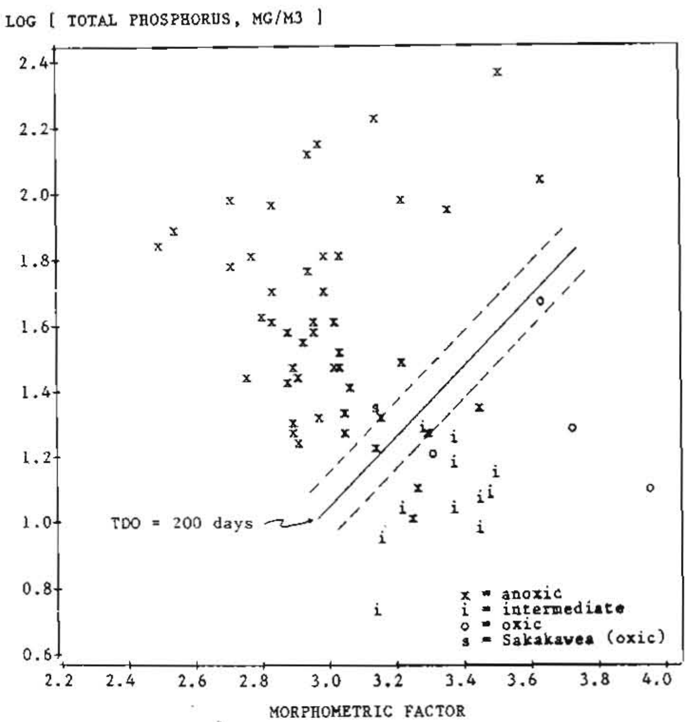


Figure 28

Oxygen Status Classification on Total P vs. Morphometric Factor* Axes (Model D02A01)

$$* \text{ Factor} = 4.66 - 4.55 \, LOG(Z) + 2.04 \, (LOG(Z))^2 + LOG(ZH)$$

Z = mean depth (m)

ZH = mean hypolimnion depth (m)

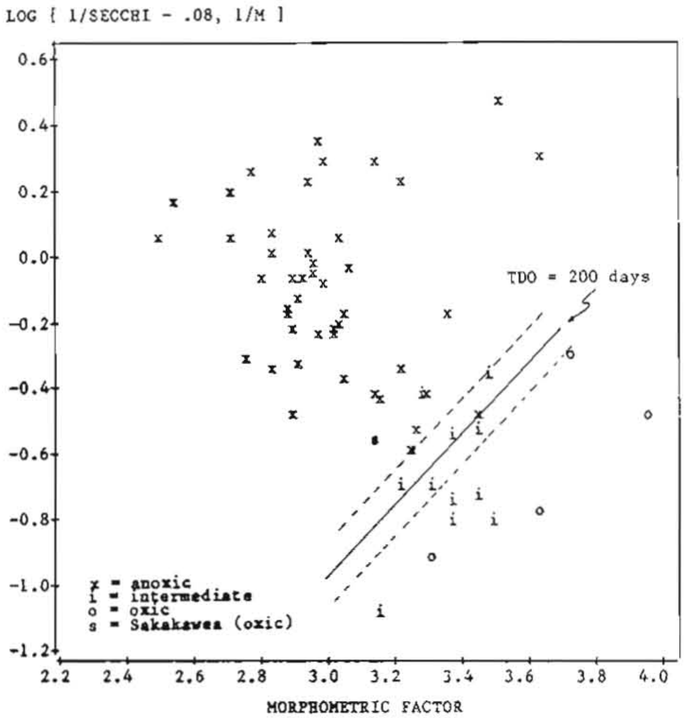


Figure 29

Oxygen Status Classification
on Transparency vs.
Morphometric Factor* Axes
(Model D02A02)

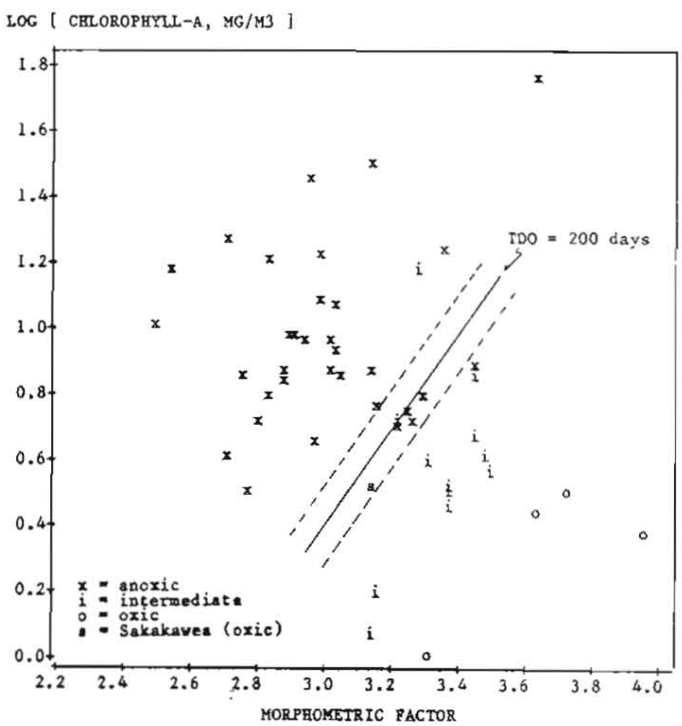


Figure 30

Oxygen Status Classification
on Chlorophyll vs.
Morphometric Factor* Axes
(Model D02A03)

$$* \text{ Factor} = 4.66 - 4.55\ LOG(Z) + 2.04\ (LOG(Z))^2 + LOG(ZH)$$

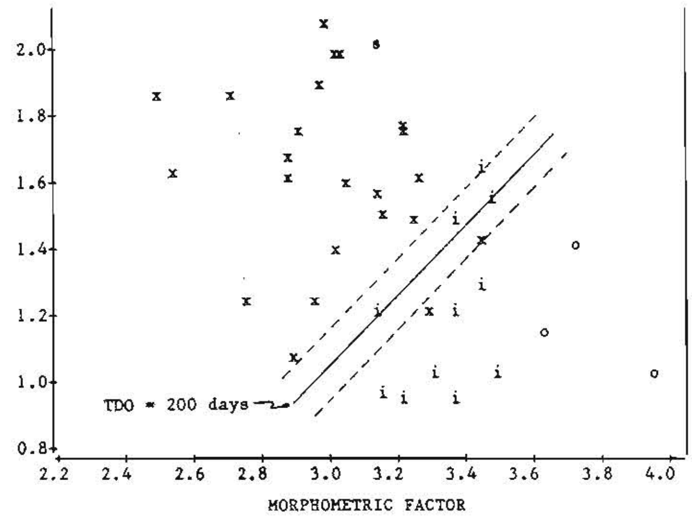


Figure 31

Oxygen Status Classification on Pv vs. Morphometric Factor* Axes (Model D02A04)

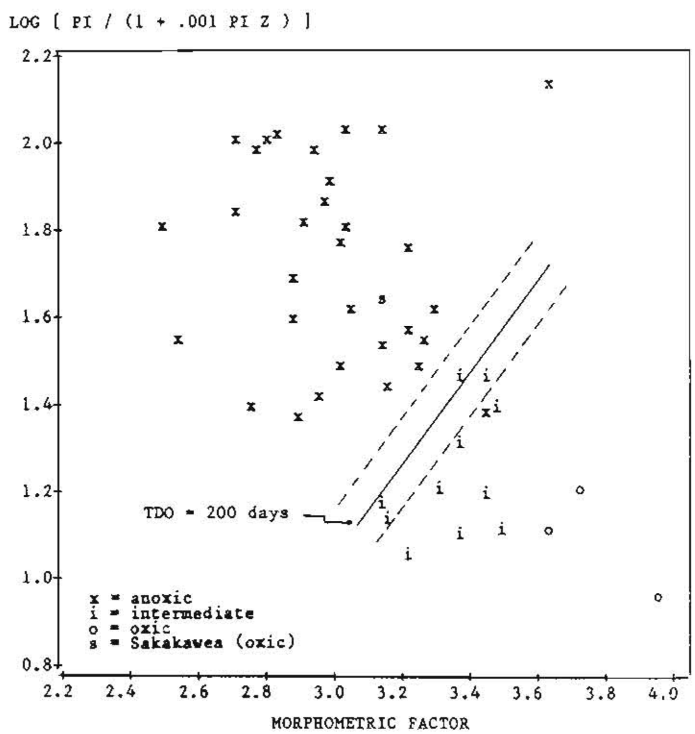


Figure 32

Oxygen Status Classification on Pn vs. Morphometric Factor* Axes (Model D02A05)

$$* \text{ Factor } = 4.66 - 4.55 \text{ LOG(Z)} + 2.04 (\text{LOG(Z)})^2 + \text{LOG(ZH)}$$

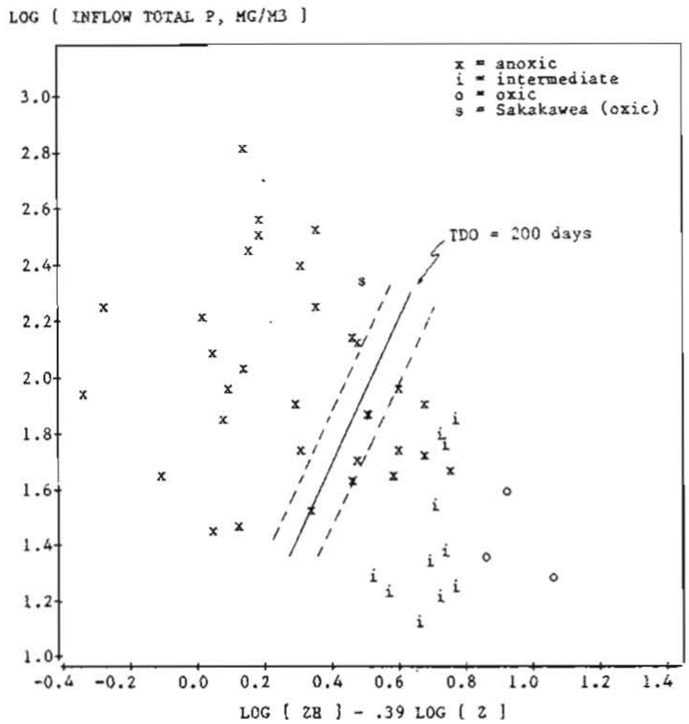


Figure 33

Oxygen Status Classification on Inflow P vs. Morphometric Factor Axes (Model D03A01)

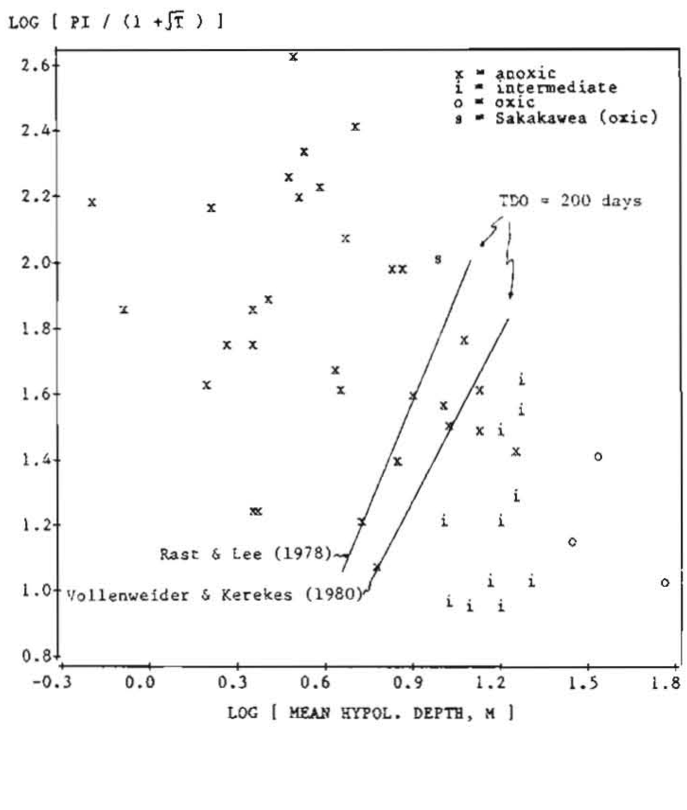


Figure 34

Oxygen Status Classification on Pv vs. Hypolimnetic Depth Axes (Models D05A01 and D05A02)

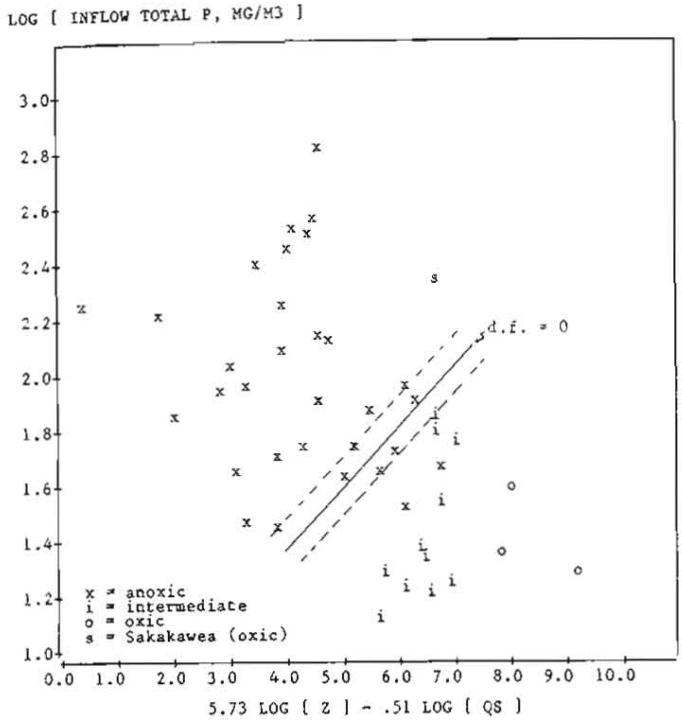


Figure 35

Oxygen Status Classification According to Reckhow (1978) Discriminant Function (Model D06A01) distinguish the anoxic reservoirs from the others. The model based upon chlorophyll (D02A03, Figure 30) shows the best separation of the completely oxic group from the intermediate group. The discriminant line for this separation corresponds roughly to a discriminant function value of 2.6 or 400 days. With the exception of the two outliers described below, the data do not provide any basis for rejecting these models with their original coefficients.

168. External models (D03 - D06) relate oxygen status to phosphorus loading, hydrology, and morphometry. External forms of model D02 have also been tested, by substituting two alternative expressions for normalized phosphorus loading for the observed phosphorus concentration in model D02A01. The expressions (see Table 31) include the Vollenweider/Larsen-Mercier statistic (D02A04) and the expression derived from the loading model calibrations in Part VI (D02A05). The latter model (Figure 32) yields the best group separation and least classification error of any of the external models evaluated. F and Z* statistics for models D05A01 (Rast and Lee, 1978) and D05A02 (Vollenweider and Kerekes, 1980) are also relatively high. Figure 33 shows that recalibration of D05A01 (or use of a discriminant value higher than 200 days) would be required in order to reduce classification errors. The plots indicate that external loading models D02 and D05 do not differ greatly with respect to discriminating power, if allowances for recalibration are made. Classification errors or parameter biases may be attributed to phosphorus retention model errors, as well as variations in the internal phosphorus/oxygen depletion relationships.

169. The F statistics for morphometric factors in Table 32 are appreciable in relation to those for the water quality variables or for the models discussed above. This suggests that morphometric effects are extremely important in determining oxygen status and is consistent with previous studies of data from natural lakes (Reckhow, 1978, Cornett and Rigler, 1979, Walker, 1979). All stratified reservoirs with mean depths less than 13 meters or mean hypolimnetic depths less than 9 meters are classified as anoxic, for example, regardless of water quality. Thus,

sensitivity to water quality is only apparent in the deeper reservoirs. In the relatively shallow reservoirs, nutrient and chlorophyll concentrations generally exceed the values required to maintain oxic conditions throughout the stratified period, although the length of the anoxic period (and the severity of any secondary water quality impacts, such as mobilization of iron, manganese, and nutrients or production of hydrogen sulfide) may be sensitive to these concentrations. The importance of the morphometric factors, however, makes it difficult to evaluate and compare the water quality factors used in these models.

170. Line slopes in the bivariate plots (Figures 27-35) reflect relative sensitivities to morphometry and water quality. Vertical lines would reflect a dominance of morphometric effects; most are diagonal. Adjustments in the slopes and/or intercepts of some lines may reduce classification error for some models. Estimation and use of oxygen depletion rates, rather than oxygen status, would provide a better basis for identifying water quality sensitivity and for recalibrating the models.

171. As shown in Figures 27-35, one oxic reservoir (Lake Sakakawea, 30-235) is misclassified by most models. Distinctive features of this mainstem reservoir on the Missouri River include (1) its length (178 miles); (2) the presence of significant spatial gradients in chlorophyll, phosphorus, and transparency, as discussed in Part VI; and (3) an unusually low percentage of orthophosphorus loading (9%). Average chlorophyll concentrations range from 30 mg/m3 at the upper end of the reservoir to 1.4 mg/m3 near the dam. Station total depths range from 5 to 180 feet and generally increase moving down the pool. The highest concentrations of chlorophyll and nutrients are found at the shallow, upper-pool and mid-pool stations and the lowest concentrations are found at the deep, near-dam stations. For the internal models, use of area-weighted averaging schemes, possibly excluding data from unstratified stations, would probably eliminate the misclassification. Modifications of the external models to account for the effects of plug flow and the high percentage of particulate phoshorus loadings would be needed for correct classification of this reservoir. The presence of

Lake Sakakawea as an "outlier" in the oxygen depletion data set is consistent with the results of Parts V and VI.

172. Table Rock Reservoir (24-200) is classified as anoxic, but has calculated TDO values greater than 200 days for all of the models tested. This reservoir has a substantial metalimnetic oxygen demand and a relatively long stratified period (mid-April through late November, about 230 days). The oxygen contour plot shows anaerobic conditions developing from the metaliminion and from the bottom, both beginning in mid-July. By the end of September, the bottom and mid-depth anaerobic zones have merged and the entire hypolimnion is anoxic. Classification of this reservoir as anoxic can be explained by the effects of the metalimnetic demand and long stratified period. Spatial gradients may also be of significance in Table Rock, since most of the phosphorus loading enters about mid-way down the pool, as a result of a major point source. Thus, the entire volume of the reservoir is not available to assimilate the loading and the reservoir-average nutrient and chlorophyll levels may be lower than those found near the dam.

173. Other anoxic reservoirs which are frequently misclassified include Hartwell (08-330) and Sydney Lanier (10-076), both of which are fairly large and complex reservoirs which were sampled only twice by the EPA/NES during the growing season for chlorophyll, transparency, and nutrients. Spring oxygen concentration below 12 g/m3 may also contribute to misclassification of these (southern) reservoirs.

174. None of the misclassifications from the internal or external models can be explained by nitrogen-limitation effects, although the separation between the oxic and anoxic groups would increase if N-limitation effects were taken into account, since three out of the five oxic reservoirs had average inorganic N/P ratios less than 8. If nitrogen were limiting, estimated TDO values based upon phosphorus loading (or phosphorus concentration) would tend to be biased on the low side. Nitrogen limitation effects may explain the somewhat less distinct group separations for models based upon phosphorus concentration or loading, as compared with models based upon transparency or chlorophyll.

## Conclusions

175. Results of the oxygen depletion model testing described above can be summarized as follows:

a. When formulated to predict days of oxygen supply or volumetric depletion rate, several of the existing hypolimnetic oxygen depletion models can be used to discriminate between anoxic reservoirs (those in which more than 80% of the hypolimnion falls below 2 g/m3 at some point during the stratified period) and other, stratified reservoirs, using a TDO value of 200 days or a HODv value of .06 g/m3-day.

b. Reservoir classifications do not provide any bases for rejecting or distinguishing between internal models D01 (Lasenby,1975) or D02 (Walker, 1979) in their original forms. The form of model D02 based upon chlorophyll-a provides the best separation between the completely oxic and partially anoxic reservoirs.

c. Among the models which employ normalized phosphorus loading as the water quality factor, model D02A05, based upon the phosphorus loading expression derived in Part VI (equation (61)), has the strongest discriminating power and least classification error. Thus, this expression seems to work best for predicting all response variables (chlorophyll, phosphorus, transparency, and oxygen depletion), despite its hydrologic independence. If allowances for recalibration are made, classification errors for model D05 (Rast and Lee, 1978, Vollenweider and Kerekes, 1980) and D06 (Reckhow, 1978) are equal to model D02A05, but group separation is less distinct, based upon analysis of variance statistics.

d. Two outliers (consistently misclassified reservoirs) can be explained by the effects of significant spatial gradients and metalimnetic oxygen demand.

e. The strong influence of morphometric factors on oxygen depletion makes it difficult to distinguish among alternative expressions for water quality or nutrient loading sensitivity. Estimation of areal depletion rates would provide a better basis for model comparisons. Potentials for metalimnetic demands and spatial variations in hypolimnetic deficits should also be considered in future development of empirical methods for predicting reservoir oxygen status.

# PART VIII: MODEL NETWORK

176. Previous chapters have identified, calibrated, and tested empirical models which seem to work best for CE reservoirs. This chapter presents a model "network" which summarizes relationships among external phosphorus loadings and reservoir-average water quality conditions. Presentation in the form of a network emphasizes the fact that these models, like the reservoir ecosystems which they partially represent, are not a series of unrelated equations or relationships, but a multivariate "system" with multiple controls and interactions.

177. The network is calibrated to data from 29 phosphorus-limited, low-turbidity impoundments, which are defined as reservoirs with inflow total N/P ratios greater than 8 and non-algal turbidities (1/Secchi - .025 Chl-a) less than 1.58 1/m (.2 log units). The above "operational" criteria are based upon the testing completed in previous sections and additional residuals analyses. The first criterion approximately distinguishes between N-limited and P-limited impoundments; it is not completely adequate, however, since the inflow total N/P ratio does not necessarily equal total N/P or inorganic N/P ratios measured within the reservoirs. Based upon the second criterion, all reservoirs with mean Secchi depths greater than .63 meters are included in the "low-turbidity" group, regardless of chlorophyll-a values.

178. As demonstrated in previous sections, some systematic effects of N/P ratios, inflow ortho-P/total P ratio, turbidity, mean depth, and residence time remain within the restricted data set. More complex empirical models are needed to account for the remaining effects, to include reservoirs not conforming to the above criteria, and to consider spatial variations within reservoirs. These will be addressed in future research.

179. The network is tested below using independent reservoir data sets compiled from the literature. The feasibility of using organic nitrogen as a fifth indicator of eutrophication (in addition to chlorophyll, phosphorus, transparency, and oxygen depletion) is demonstrated. Using multivariate statistical techniques, composite

measures of impoundment response are constructed and related to external phosphorus loadings. Error analyses are conducted to permit estimation of prediction confidence limits, as influenced by model errors and errors in the estimates of phosphorus loadings and reservoir-average water quality conditions.

180. All models in the network are one-variable, linear regressions with the dependent and independent variables transformed to base-10 logarithms. Two alternative expressions for normalized phosphorus loading are considered:

$$Pv = Pi / (1 + \sqrt{T}) \tag{66}$$

$$Pn = Pi / (1 + .001\ Pi\ Z) \quad \text{(61 bis)}$$

where,

Pv = Vollenweider/Larsen-Mercier expression (mg/m3)

Pn = normalized loading developed in Part VI (mg/m3)

Pi = average inflow total P concentration (mg/m3 )

T = mean hydraulic residence time (years)

Z = mean depth (m)

A unique feature of the second formulation is that it is independent of hydrologic factors (residence time or overflow rate). Based upon analyses in Parts VI and VII, Pn seems to work somewhat better than Pv as a predictor of all impoundment response variables. Tests using the independent data sets provide further discrimination between these formulations.

## Independent Testing

181. Table 35 summarizes the characteristics and sources of three independent data sets which have been compiled for use in model testing. These include:

(1) EPA National Eutrophication Survey Compendium (94 CE Reservoirs)

(2) Tennessee Valley Authority Reservoirs (19 Reservoirs)

Table 35
Additional Data Sets Used in Testing Models for Predicting Reservoir-Average Conditions

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1. EPA National Eutrophication Survey Compendium
   - 106 CE Reservoirs
   - Error Screening Criterion*:
     - Rp > -.1, based upon inflow/outflow data (n = 94)
   - Data Reduction:
     - Chlorophyll, Secchi: mean, spring-fall
     - Total P: median, spring-fall
   - Reference: USEPA (1978)

2. TVA Reservoirs:
     - 10 Tributary
     - 9 Mainstem Tennessee River
   - Error Screening Criteria*: none
   - Data Reduction:
     - Chlorophyll, Secchi: mean summer
     - Total P (EPA/NES): median spring-fall
   - References:
     - Higgins et al.(1980), Higgins and Kim (1981)
     - Walker (1980b) (Normandy)
     - USEPA (1978) (impoundment phosphorus data)

3. OECD Reservoir and Shallow Lakes Project
   - 43 Impoundments from Europe, Australia, Japan, U.S.
     - 8 (shallow) natural lakes
     - 8 artificial (pumped storage) reservoirs
     - 27 "semi-artificial" reservoirs (impounded natural valleys)
     - several sampled more than one year (reservoir-years = 83)
     - many impoundments sampled near dam only
   - Screening Criteria*:
     - include only data from "semi-artificial" reservoirs
     - exclude Mount Bold (heavy silt load (Clasen, 1980))
     - exclude Grafham Water (outlier, inflow P = 4900 mg/m3)
   - Data Reduction:
     - chlorophyll, total P: mean, annual, euphotic zone
     - transparency: median, annual
   - Reference: Clasen (1980)

---

* additional screening criteria applied in computing error statistics for all models:

| Criterion | EPA | TVA | OECD |
|---|---|---|---|
| Inflow Total N/P > 8 | x | na | x |
| Turbidity < 1.58 1/m | x | na | na |

na = no impoundments with data violated criterion

(3) OECD Reservoir and Shallow Lakes Progam (43 Impoundments)

Detailed screening similar to that conducted in Part IV has not been feasible for these data sets, though some impoundments have been excluded from error statistic calculations based upon the inflow N/P and turbidity criteria discussed above and upon other, limited criteria presented in Table 35. Data sets are listed in Appendix F, along with plots of observed and predicted conditions for each model and data set. Different symbols are used to identify impoundments in various categories. Factor-of-two accuracy limits are indicated in order to provide perspective on error magnitudes; they do not necessarily reflect prediction confidence limits.

182. Figures 36-38 illustrate the relationships for all data sets combined, using different symbols to differentiate data sources. Table 36 summarizes the formulations and error statistics for each model and data set. Mean squared errors and percents of variance explained are calculated for each of three sets of parameter estimates:

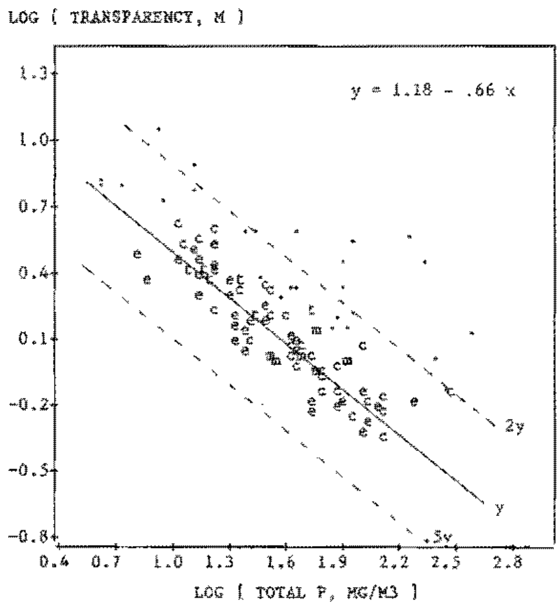
| | Parameter Set | | |
|---|---|---|---|
| | a | b | c |
| slope | original | original | optimized |
| intercept | original | optimized | optimized |

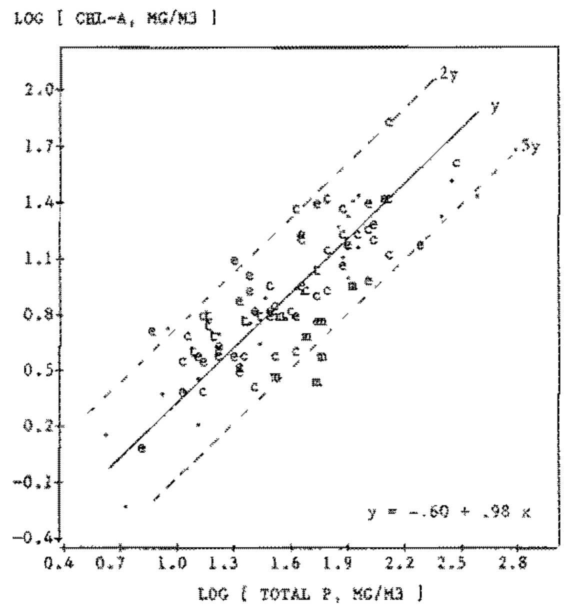
"Original" refers to coefficients estimated for the CE reservoir data set. "Optimized" refers to coefficients estimated for the independent data. Variance ratio statistics (see Table 28) are used to test for significant differences in mean squared errors among the parameter sets. Significant differences reflect instability in the optimal coefficients from data set to data set.

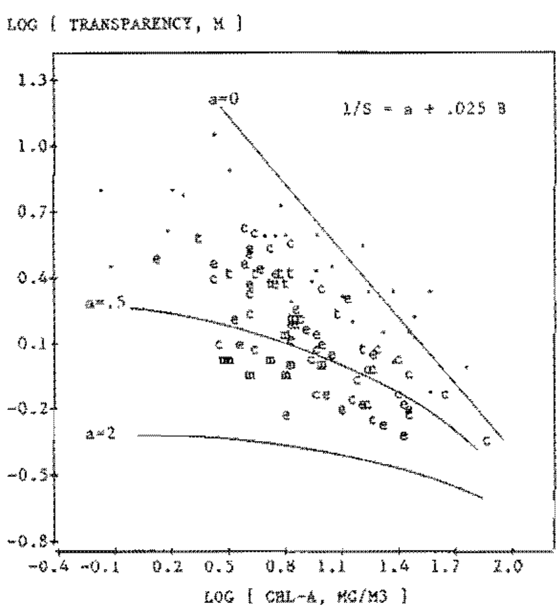
183. Differences in optimal intercept are indicated by differences in mean squared error between cases a and b. In some cases, instability in the intercept may be attributed to variations in data-reduction procedures. For example, median phosphorus concentrations are reported in the EPA/NES data set, as compared with arithmetic mean concentrations used in model calibration. Since within-reservoir variations tend to be

Figure 36

Internal Model Evaluations Using the Combined Data Set




| Symbol | Meaning |
|---|---|
| c | CE Reservoir, CE Data Set |
| e | CE Reservoir, EPA/NES Data Set |
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |
| . | OECD Reservoir |

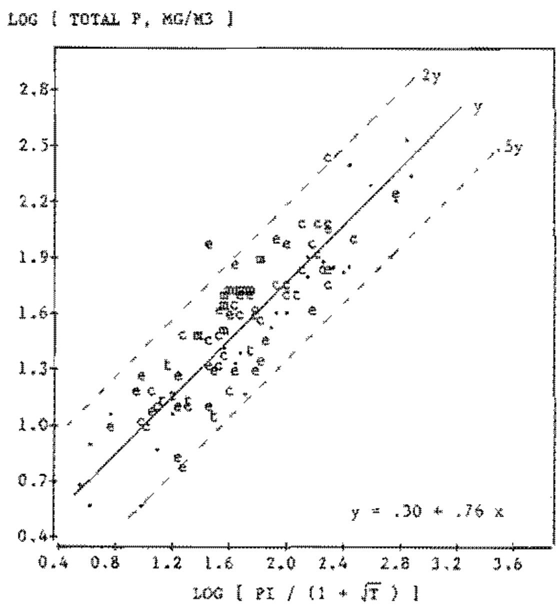
inflow N/P > 8, turbidity < 1.58 1/m

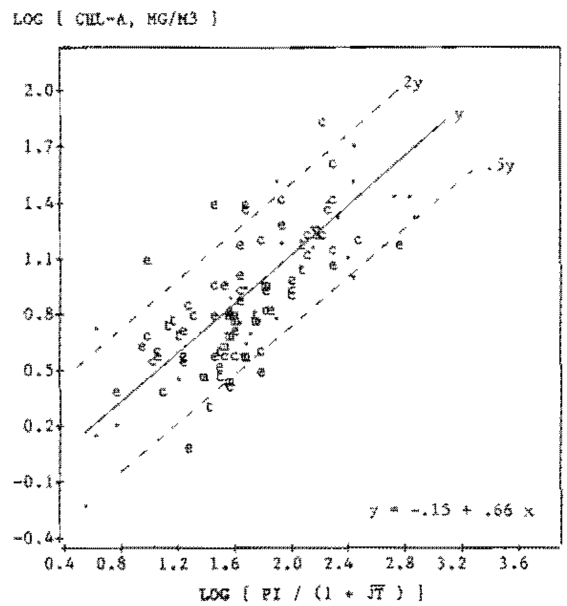
line = regression for CE reservoirs and CE data set

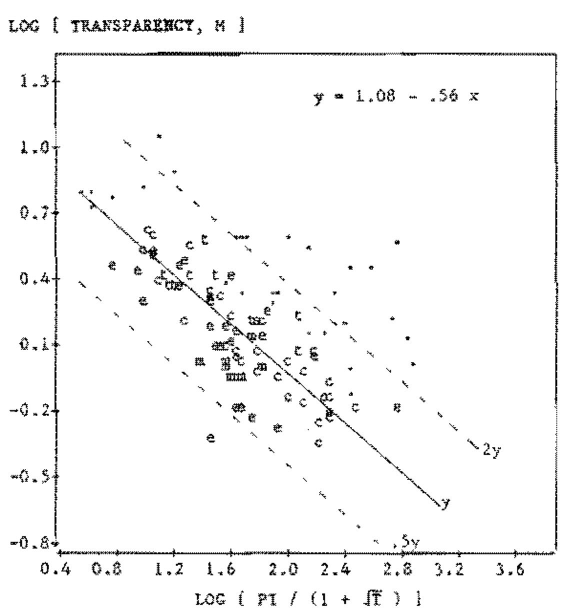
dashed line = 2-fold accuracy limits

Figure 37

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the Combined Data Set




| Symbol | Meaning |
|---|---|
| c | CE Reservoir, CE Data Set |
| e | CE Reservoir, EPA/NES Data Set |
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |
| . | OECD Reservoir |

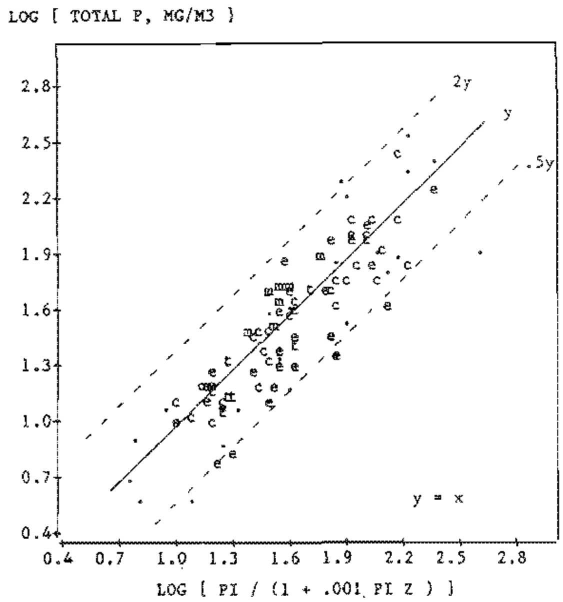
inflow N/P > 8, turbidity < 1.58 1/m

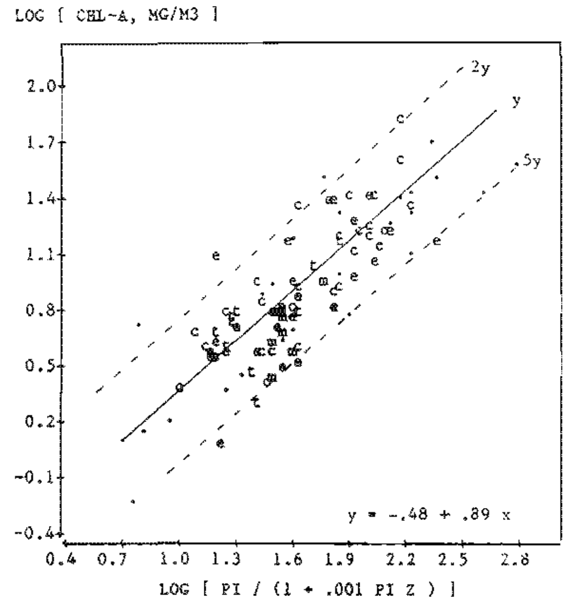
line = regression for CE reservoirs and CE data set

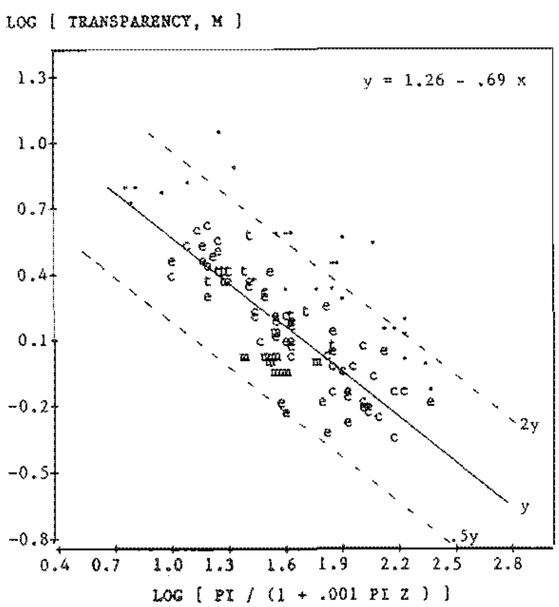
dashed line = 2-fold accuracy limits

Figure 38

Observed vs. Predicted Water Quality Using Pn for
Normalized Phosphorus Loading and the Combined Data Set




| Symbol | Meaning |
|---|---|
| c | CE Reservoir, CE Data Set |
| e | CE Reservoir, EPA/NES Data Set |
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |
| . | OECD Reservoir |

inflow N/P > 8, turbidity < 1.58 1/m

line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits

Table 36
Summary of Model Equations and Errors by Data Set

| Data | n | Vy | R-Squared a | b | c | Mean Sqd Error a | b | c | Mean | Med | Q3-Q1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| model: log(P) = log(Pn) | | | | | | | | | | | |
| CE | 29 | 133 | 857 | 859 | 857 | 19 | 19 | 19 | -29 | -21 | 178 |
| EPA | 51 | 131 | 563 | 704 | 705 | 57 | 39* | 39* | -138# | -130 | 310 |
| TVA | 15 | 75 | 701 | 719 | 753 | 22 | 21 | 18 | 53 | 75 | 273 |
| OECD | 27 | 316 | 774 | 778 | 769 | 71 | 70 | 73 | -60 | -24 | 411 |
| model: log(B) = -.48 + .89 log(Pn) | | | | | | | | | | | |
| CE | 29 | 143 | 717 | 707 | 696 | 41 | 42 | 44 | 0 | -13 | 342 |
| EPA | 51 | 102 | 567 | 611 | 624 | 44 | 40* | 38* | -73# | -88 | 193 |
| TVA | 19 | 44 | 78 | 267 | 272 | 40 | 32 | 32 | -100# | -103 | 297 |
| OECD | 26 | 234 | 749 | 750 | 747 | 59 | 59 | 59 | -48 | -95 | 332 |
| model: log(S) = 1.26 - .69 log(Pn) | | | | | | | | | | | |
| CE | 29 | 73 | 850 | 846 | 840 | 11 | 11 | 12 | 0 | 0 | 177 |
| EPA | 51 | 67 | 709 | 709 | 706 | 20 | 20 | 20 | -21 | 0 | 163 |
| TVA | 18 | 42 | 407 | 435 | 400 | 25 | 24 | 25 | -50 | -42 | 260 |
| OECD | 29 | 86 | -856 | 580 | 694 | 160 | 36* | 26* | 354# | 352 | 239 |
| model: log(P) = .30 + .76 log(Pv) | | | | | | | | | | | |
| CE | 29 | 133 | 843 | 839 | 833 | 21 | 22 | 22 | 0 | -12 | 173 |
| EPA | 51 | 131 | 616 | 638 | 641 | 50 | 47 | 47 | -62 | -110 | 330 |
| TVA | 19 | 75 | 528 | 533 | 497 | 35 | 35 | 38 | 52 | 132 | 322 |
| OECD | 27 | 316 | 875 | 899 | 896 | 40 | 32* | 33* | -94# | -113 | 195 |
| model: log(B) = -.15 + .66 log(Pv) | | | | | | | | | | | |
| CE | 29 | 143 | 595 | 581 | 561 | 58 | 60 | 63 | 0 | 0 | 396 |
| EPA | 51 | 102 | 436 | 441 | 469 | 58 | 57 | 54 | -41 | -43 | 248 |
| TVA | 15 | 44 | -162 | 235 | 265 | 51 | 33* | 32* | -138# | -170 | 262 |
| OECD | 26 | 234 | 734 | 749 | 744 | 62 | 59 | 60 | -76 | -107 | 316 |
| model: log(S) = 1.08 - .56 log(Pv) | | | | | | | | | | | |
| CE | 29 | 73 | 836 | 829 | 823 | 12 | 13 | 13 | 0 | 18 | 207 |
| EPA | 51 | 67 | 568 | 587 | 602 | 29 | 28 | 27 | -43 | -24 | 209 |
| TVA | 18 | 42 | 275 | 244 | 239 | 30 | 32 | 32 | -20 | -36 | 331 |
| OECD | 29 | 86 | -1631 | 280 | 590 | 227 | 62* | 35* | 409# | 414 | 391 |

(continued)

Table 36 (continued)

| Data | n | Vy | R-Squared a | b | c | Mean Sqd Error a | b | c | Mean | Med | Q3-Q1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | model: log(B) = -.60 + .98 log(P) | | | | | | | | |
| CE | 29 | 143 | 691 | 680 | 681 | 44 | 46 | 46 | 0 | -16 | 328 |
| EPA | 51 | 102 | 581 | 586 | 664 | 43 | 42 | 34 | -41 | -43 | 248 |
| TVA | 15 | 25 | -2835 | -2349 | -52 | 96 | 83 | 26* | -130 | -82 | 476 |
| OECD | 24 | 212 | 790 | 784 | 819 | 44 | 46 | 38 | -24 | -5 | 320 |
| | | | model: log(S) = 1.18 - .66 log(P) | | | | | | | | |
| CE | 29 | 73 | 801 | 793 | 786 | 15 | 15 | 16 | 0 | -21 | 175 |
| EPA | 51 | 67 | 719 | 822 | 817 | 19 | 12* | 12* | -84# | -82 | 178 |
| TVA | 15 | 34 | 733 | 727 | 721 | 9 | 9 | 10 | -21 | -26 | 151 |
| OECD | 27 | 82 | -994 | 434 | 646 | 165 | 47* | 29* | 346# | 314 | 283 |

Note: all statistics x 1000 (except n), log10 scales
data = data set, screened according to criteria in Table 35
n = number of impoundment-years
Vy = variance of dependent variable
R-squared = fraction of variance explained

| parameters | D.F. |
|---|---|
| a - original | n |
| b - intercept optimized | n-1 |
| c - slope and intercept optimized | n-2 |

D.F.= error degrees of freedom used in computing mean squared error and R-squared

error statistics for original parameters:

Mean = mean error (bias)
Med = median error
Q3-Q1 = interquartile range (75th - 25th percentile)

*mean squared error for case b or c significantly lower than mean squared error for case a (p<.05)

# mean error significantly different from zero at p<.05

log-normally distributed (Walker, 1981), the median would tend to be lower than the arithmetic mean for a given collection of measurements. This would cause a lower intercept for the EPA/NES data set and models which predict reservoir phosphorus. Differences between the mean April-October chlorophyll concentrations in the CE data set and the mean annual chlorophyll concentrations used in the OECD/RSL data set may also introduce some instability in model intercepts. Significant variations in model slope have been found only in the cases of models predicting transparency using the OECD/RSL data set. These variations are discussed below.

184. For each set of residuals calculated for data set a, Table 36 also lists the mean value, median value, and the inter-quartile range. Mean residuals are tested for significance (vs. 0) using a standard t-test. This test is equivalent to one for significant variations in the model intercept. The median and inter-quartile range are presented as robust measures of error bias and scale, respectively (Mosteller and Tukey, 1977).

185. Data from 94 CE reservoirs have been extracted from the EPA National Eutrophication Survey Compendium tape and used as one independent data set. Since this data set includes the reservoirs used in model calibration and is based, ultimately, upon the same set of tributary and impoundment measurements, it is not truly "independent". It has been included to permit model testing on a larger number of CE reservoirs (51 vs. 29 passing screening criteria). Since the EPA/NES employed a completely different set of data-reduction procedures (loading estimates, reservoir water quality summaries, screening), this data set also provides an indication of the sensitivity of model errors to these factors. To eliminate impoundments with possible errors in the nutrient balance estimates, twelve with reported phosphorus retention coefficients less than -.1 have been excluded from plots and error calculations; this value (vs. 0) allows for some statistical variability in the phosphorus loading and outflow estimates.

186. For the EPA/NES data set, significant adjustments in intercept are indicated for two models involving reservoir phosphorus.

With these adjustments, the loading models employing Pn as an independent variable explain between 61 and 71 percent of the variance in impoundment response variables. Explained variance is somewhat lower (44 - 64 percent) for models using Pv as an independent variable. The bias of -.073 log units for prediction of chlorophyll as a function of Pn might be related to seasonal factors, since the mean chlorophyll values computed by the EPA/NES include early spring (March) and late fall (November) sampling dates for many impoundments.

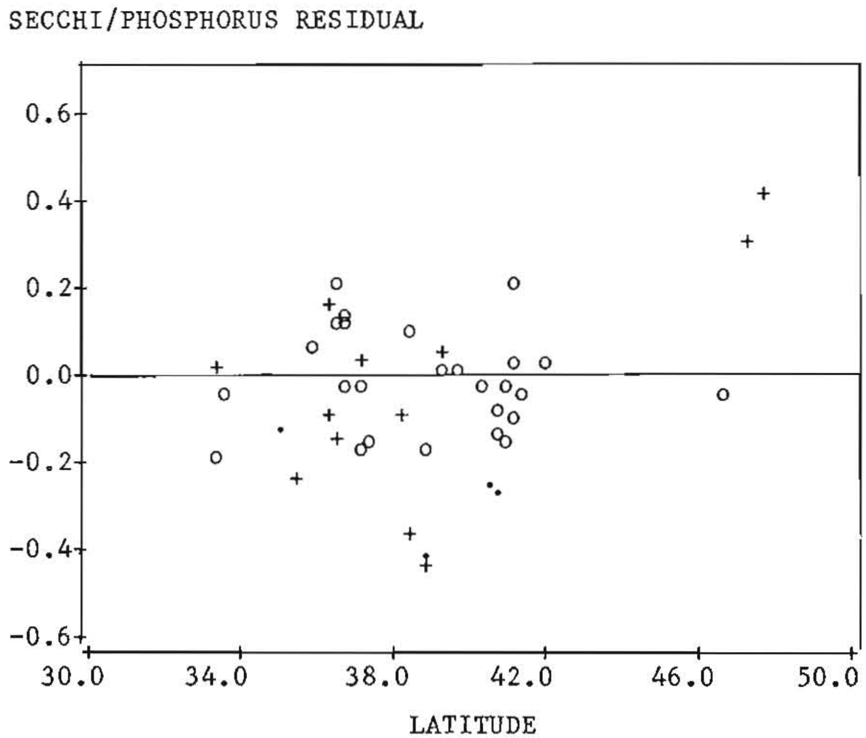
187. The TVA data set includes 10 tributary (storage) impoundments and 9 mainstem impoundments located on the Tennessee River and is derived primarily from work by Higgins and Kim (1981). Impoundment types are identified using different symbols on the plots in Appendix F. Compared with the tributary reservoirs, the mainstem impoundments tend to have higher non-algal turbidities and lower hydraulic residence times (.013 to .038 years vs. .12 to .69 years). Based upon the results of Parts V and VII, both of these factors would tend to inhibit the chlorophyll/phosphorus response. This is consistent with the over-prediction of chlorophyll in all mainstem impoundments by all models. Modifications of the model structures to account for turbidity and flushing controls (see Part V) would be needed to eliminate these biases. R-Squared values tend to be lower for this data set than for the others. This is attributed primarily to the relatively low variance in the observed data; mean squared errors are similar to and, in many cases, lower than errors determined for other data sets.

188. The OECD Reservoir and Shallow Lakes Project (Clasen, 1980) includes data from 8 shallow, natural lakes, 8 pumped-storage reservoirs, and 27 "semi-artificial" reservoirs from Europe, Japan, Australia, and North America. These are identified using different symbols on the plots in Appendix F. The pumped storage impoundments are formed by berms constructed on flat plains and, as such, are completely artificial; many have extremely high total phosphorus levels (exceeding 100 mg/m3). Error statistics are computed using data from the 27 "semi-artificial" reservoirs (impounded natural valleys), which are more typical of CE reservoirs than the other impoundment types included in

the OECD/RSL study.

189. The OECD reservoirs generally have lower non-algal turbidities than reservoirs in the other data sets; this may result primarily from the fact that most are located in northern, glaciated areas. All of the OECD/RSL impoundments in North America and Europe are above 42 degrees latitude, with the exception of Kerr Reservoir, a CE project in Virginia. CE reservoir models tend to under-predict transparency substantially (by roughly a factor of 2) in many of the OECD impoundments. Figure 39 plots the residuals from the phosphorus/transparency model as a function of latitude, using the CE data set. The tendency for positive residuals in northern latitudes is evident, although there are only three impoundments at latitudes higher than 42 degrees and two of these are potentially nitrogen-limited. Results of model testing in Part V indicate that phosphorus associated with non-algal turbidity tends to have somewhat greater effect on transparency than phosphorus associated with chlorophyll. The positive bias in the transparency models is consistent with the northern locations of most of the OECD reservoirs and latitude effects observed within the CE data set. Since the transparency (and other) models in Table 36 are based primarily upon data from projects below 42 degrees latitude, they cannot be reliably used in areas further north. Compilation of additional data from northern impoundments and modification of the models to account explicitly for effects of non-algal turbidity would be needed in order develop a single set of models which can be used in all CE Districts.

190. The OECD data set also includes many impoundments which are more highly enriched than those included in the CE data set. The OECD phosphorus/transparency plot suggests that the relationship flattens at total P concentrations exceeding about 100 mg/m3. Some of the bias in the transparency predictions may be attributed to impoundments above this value. The chlorophyll/transparency plot indicates that some of the OECD impoundments have non-algal turbidities which are less than zero. This suggests a possible bias in the chlorophyll light attenuation factor (.025 m2/mg) for these impoundments. Differences in




Model : log(S) = 1.18 - .66 log (P)

| symbol | meaning |
|---|---|
| o | CE Reservoir |
| . | turbidity > 1.58 1/m |
| + | inflow N/P < 10 |

data-reduction procedures may also contribute to variations in the chlorophyll/transparency relationship, since the OECD data set includes mean, annual chlorophyll and median, annual Secchi depths.

191. Despite the transparency model biases, the CE loading models explain 77-88% of the variance in OECD total phosphorus data and 73-75% of the variance in OECD chlorophyll data, without significant adjustments in slope or intercept. Error variances for the OECD data set are similar to or higher than error variances for the other data sets, despite the fact that the OECD sampling programs were more intensive temporally than the EPA/NES sampling programs used in development of the CE data set.

192. Comparisons of error variance for the two alternative expressions for normalized phosphorus loading, each data set, and each response variable indicate that, with the exception of phosphorus predictions in the OECD/RSL data set, Pn is equal to or better than Pv as a predictor of impoundment response, despite its hydrologic independence. While use of spatial weighting factors for averaging within-pool measurements may shed additional light on the differences between these two loading expressions, independent tests do not provide any basis for rejecting the notion that average reservoir conditions can be predicted with knowledge of inflow phosphorus concentration and mean depth alone; except that observed chlorophyll levels will tend to be lower than predicted in reservoirs with residence times less than about .03 years.

## Organic Nitrogen

193. Organic nitrogen has been suggested as a eutrophication indicator which is less sensitive to variations in nonalgal particulate materials than is total phosphorus; it has been included as a component in many of the various trophic state indices which have been proposed (Shannon and Brezonik, 1972; Boland, 1976; Taylor et al. ,1979; Witzig and Whitehurst, 1981). Primary productivity results in the conversion of inorganic to organic nitrogen in reservoirs, although a

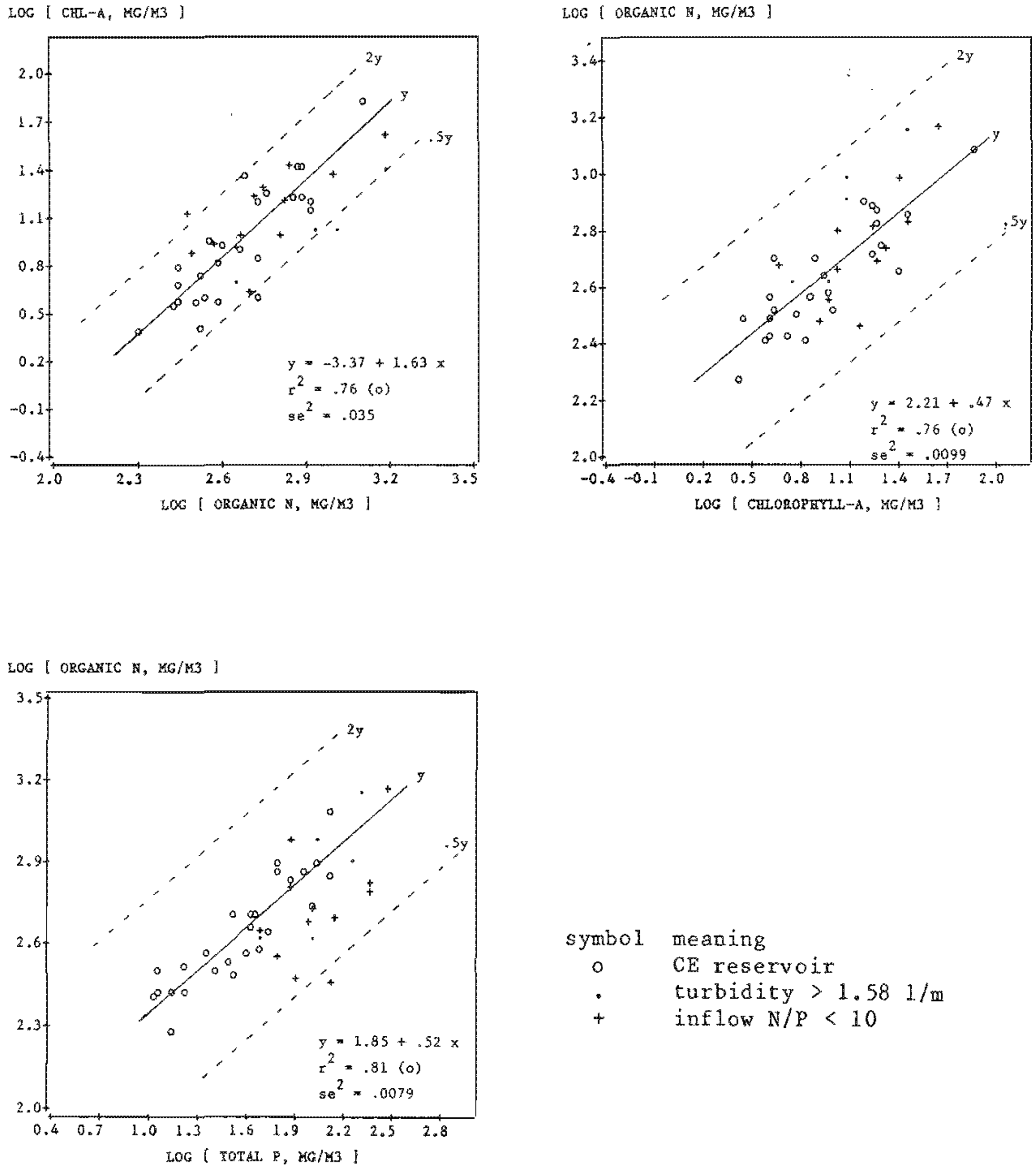
significant portion of the organic nitrogen may be allochthonous in some cases, especially those with significant point-source organic nitrogen loadings and low hydraulic residence times. The conversion of organic nitrogen to ammonia has been represented in various ecological models as a first-order process with a rate constant on the order of 0.1 $day^{-1}$ at 20 degrees C (Zison et al., 1980). At this rate, over 90% would be expected to be converted in a period of 25 days. Since this is much longer than mean-annual or mean growing-season hydraulic residence times of most CE reservoirs and primary production is essentially the only other important source of reduced nitrogen, there would seem to be a potential for relating pool organic N measurements to indicators of eutrophication, including chlorophyll, transparency, and phosphorus. This potential is investigated below; relationships between organic N and other eutrophication measures are developed and incorporated into the model network.

194. Models relating organic N to chlorophyll-a and total phosphorus are depicted in Figure 40. Residuals analyses indicate that the organic N models are somewhat more sensitive to inflow N/P or impoundment N/P ratio than are the other internal models. An inflow total N/P cutoff point of 10 seems to be more appropriate for distinguishing between N and P limitation than the cutoff point of 8 used for the other relationships. Accordingly, models involving organic N have been fit using data from 26 impoundments with inflow N/P ratios greater than 10 and non-algal turbidities less than 1.58 1/m.

195. The regressions presented in Figure 40 indicate that chlorophyll and total phosphorus explain 76% and 81% of the variance in organic N, respectively. In contrast, for the same impoundments, total nitrogen explains only 60% of the organic N variance. This is consistent with phosphorus limitation of primary production, which results in conversion of inorganic N to organic N. Residuals plots indicate higher levels of organic N than those predicted by chlorophyll in three impoundments with hydraulic residence times less than .02 years; allochthonous organic N may be important in these reservoirs. Based upon the symbol distributions in Figure 40, the organic

Figure 40

Organic N/Phosphorus/Chlorophyll Relationships



N/chlorophyll relationship seems to be relatively insensitive to N/P ratio; turbid reservoirs, however, tend to lie above the organic N/chlorophyll regression line, probably because a significant portion of the organic N in these impoundments is allochthonous and/or associated with non-algal particulates.

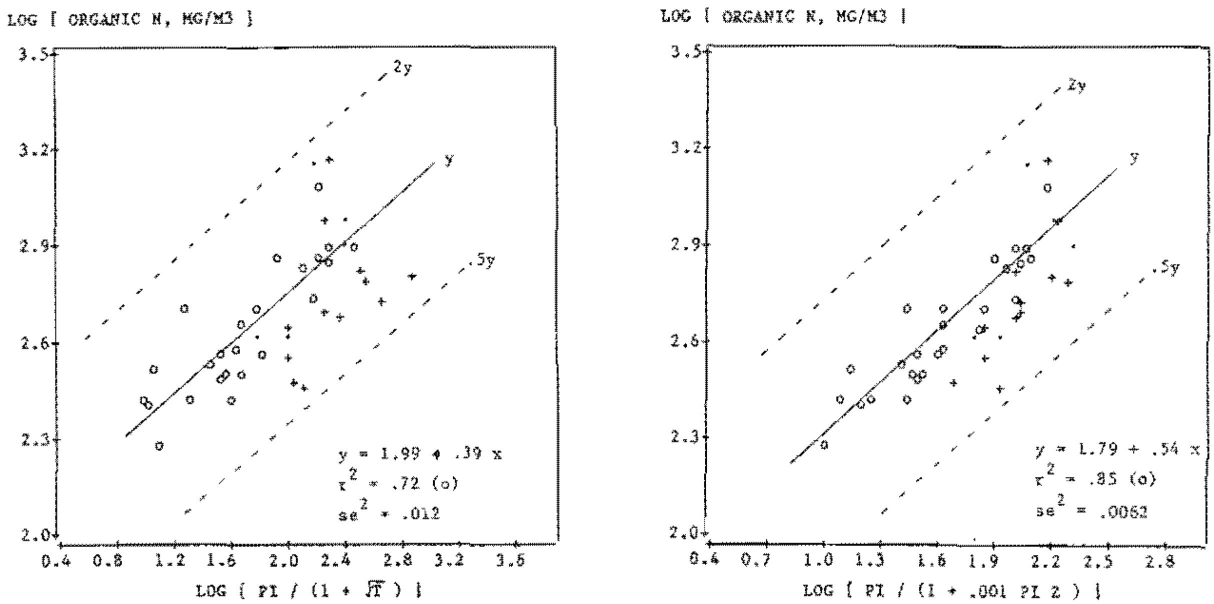
196. The reverse seems to be true for the organic N/total P relationship: turbid impoundments lie above and below the regression line, while most of the N-limited impoundments are below the line. The apparent lack of turbidity effect may be attributed to association of organic N and phosphorus with algal and non-algal particulates; this is analogous to the phosphorus/inverse transparency relationship in that variations in algal and non-algal particulates would tend to influence both measurements in the same direction (though not necessarily at the same rate). The potential for higher dissolved phosphorus levels would explain the locations of the N-limited impoundments in the organic N/total P plot.

197. Mean squared errors for predicting organic N as a function of chlorophyll-a and total phosphorus are .0099 and .0079, respectively, vs. errors in the range of .016 to .046 for other internal models in the network. The relatively high R-Squared values and low error variances suggest that organic nitrogen is a useful indicator of impoundment eutrophication. Because turbidity and N/P effects are apparently less strong, organic N is better than total phosphorus as a predictor of chlorophyll in the data set analyzed above (R2=.76 vs. R2=.66). This does not mean, however, that chlorophyll is nitrogen limited, since nitrogen supplies in these impoundments are in excess relative to algal physiologic requirements and the correlation of chlorophyll with total nitrogen is relatively weak (R2=.39). Essentially, organic N is a better "surrogate" variable for chlorophyll than is phosphorus or transparency, particularly when impoundments with short residence times are excluded.

198. Figure 41 shows the relationships between organic N and normalized phosphorus loadings. Regressions using Pv and Pn as independent variables explain 72% and 85% of the organic N variance with

Figure 41

Organic N/Normalized P Loading Relationships




| symbol | meaning |
| --- | --- |
| o | CE reservoir |
| . | turbidity > 1.58 1/m |
| + | inflow N/P < 10 |

mean squared errors of .012 and .0062, respectively. Most of the N-limited and/or turbid impoundments tend to lie below the regression lines; allochthonous organic N may be important in one turbid reservoir with a strong positive residual and a residence time of .017 years.

199. The potential use of organic N (vs. chlorophyll) in eutrophication assessment opens up larger data sets for analysis, since chlorophyll-a measurements are limiting in many cases and organic N is much more commonly measured. Total Kjeldahl nitrogen (TKN) would also be expected to perform well as an indicator, since the bulk of the inorganic nitrogen entering reservoirs not subject to large point-source loadings is generally in nitrate form and its conversion to reduced nitrogen forms (ammonia and organic) is directly related to primary production. Additional investigations of TKN and organic carbon as indices of eutrophication are warranted, particularly considering their significance in relation to trihalomethane problems in drinking water (Dorin, 1980). Means for predicting the significance of allochthonous organic N, particularly in impoundments with short residence times, should also be researched.

## Multivariate Analysis

200. Variations in total phosphorus, organic nitrogen, chlorophyll-a, and transparency from reservoir to reservoir partially reflect variations in algal densities and degree of eutrophication. As discussed previously, however, some of these measurements are influenced by factors unrelated to eutrophication, such as inorganic suspended solids loadings, organic nitrogen loadings, or color. Of these variables, chlorophyll is the most direct measure of algal standing crop, although it is not necessarily proportional to algal biomass and does not reflect other organic materials (detritus, zooplankton) which may result directly or indirectly from algal growth and which may have important water quality impacts, particularly on oxygen levels in the hypolimnion and near the sediment-water interface. The reliability of chlorophyll measurements is also limited by sampling error related to

high spatial and temporal variability and by variations in analytical procedures.

201. The method of partial correlation (Snedecor and Cochran,1972) can provide some useful insights into relationships among these measures of trophic state. Partial correlation coefficients among the four reservoir response measurements are given Table 37. The partial correlation coefficient "XY.Z" reflects the covariance between X and Y controlled for variations in Z. For example, if X and Y were regressed separately against Z, "XY.Z" would be the simple correlation coefficient between the residuals (observed minus predicted) from these regressions. Another way of interpreting "XY.Z" is as the correlation between X and Y for cases (reservoirs) having a fixed value of Z. When the network is controlled for variations in chlorophyll, correlations among the other three response measurements (phosphorus, transparency, and organic N) are at reduced but still significant levels. When the network is controlled for organic N, however, the phosphorus/chlorophyll and chlorophyll/transparency correlations become insignificant; this may reflect the relative strength of organic N as a trophic state indicator. The phosphorus/transparency correlation remains strong, even after controlling for both organic N and chlorophyll-a (r=-.71); this most likely reflects covariance attributed to non-algal suspended solids.

202. Given the relative strengths and weaknesses of these types of measurements as indicators of eutrophication, it is useful to summarize them in the form of one composite variable using a principle component analysis (Harris, 1975). This is the approach taken by Shannon and Brezonik (1972) and by Boland (1976) in developing regional, multivariate, trophic state indices for lakes. One advantage of a composite variable is that it helps to reduce the effects of random variations in the individual measurements. This pertains chiefly to analytical errors; it would not reduce biases attributed to unrepresentative sampling.

203. Results of a principle component analysis of the CE reservoir response measurements are summarized in Table 38. The first component explains 89% of the total variance in the individual measurements:

Table 37
Partial Correlation Coefficients Among Reservoir Response Measurements

| Coefficient | Data Set: All | Data Set: Restricted |
|---|---|---|
| PB. | .717 | .814 |
| SB. | -.567 | -.769 |
| NB. | .799 | .870 |
| NP. | .764 | .898 |
| SP. | -.851 | -.908 |
| SN. | -.698 | -.875 |
| NP.B | .455 | .663 |
| SP.B | -.775 | -.760 |
| SN.B | -.494 | -.654 |
| PB.N | .275 | .152 |
| SP.N | -.688 | -.573 |
| SB.N | -.021 | -.032 |
| SP.NB | -.710 | -.576 |

P = Total P
S = Secchi Depth
B = Chlorophyll-a
N = Organic N

XY.Z = correlation between X and Y controlled for variations in Z

All = 43 CE reservoirs
Restricted = 26 CE reservoirs with
Turbidity < 1.58 1/m
Inflow N/P > 10

All correlations on log scales

Table 38
Principal Components Analysis of Reservoir Response Measurements *

Correlation Matrix:

| | Total P | Chl-a | Secchi | Org-N |
|---|---|---|---|---|
| Total P | 1.000 | | | |
| Chl-a | .814 | 1.000 | | |
| Secchi | -.908 | -.769 | 1.000 | |
| Org-N | .898 | .870 | -.875 | 1.000 |
| Mean | 1.540 | .937 | .155 | 2.650 |
| Std. Dev. | .343 | .370 | .269 | .198 |

Principal Components of Covariance Matrix:

| | | | | |
|---|---|---|---|---|
| Eigenvalue | .325 | .029 | .008 | .004 |
| R-Squared | .887 | .079 | .022 | .012 |
| Coefficients | | | | |
| Total P | .577 | .458 | .658 | -.156 |
| Chl-a | .607 | -.768 | -.044 | -.198 |
| Secchi | -.436 | -.446 | .747 | .229 |
| Org-N | .330 | .023 | -.082 | .940 |

* restricted data set (Table 37);log10 scales

$$PC1 = .57 \log(P) + .61 \log(B) - .44 \log(S) + .33 \log(No) \quad (67)$$

where,

PC1 = first principal component

P = total phosphorus (mg/m3)

B = chlorophyll-a (mg/m3)

S = transparency (m)

No = organic nitrogen (mg/m3)

In a principal component analysis, the relative values of the coefficients are selected to maximize the variance of each successive composite variable. Harris (1975) suggests that this procedure is essentially an "internal discriminant analysis". The high percentage of variance explained by the first component indicates that it is a useful statistic for discriminating among (or ranking) reservoirs. The R-Squared value of 89% indicates that, if each of the response measurements were regressed separately against PC1, a total of 89% of the variance would be explained.

204. The magnitude and scale of PC1 are somewhat arbitrary; computed values for CE reservoirs range from 1.4 to 3.5. Table 39 lists the CE reservoirs in the data set, sorted according to increasing PC1 value. The statistical procedure does not guarantee that PC1 is a "trophic state index"; for example, some of the covariance of phosphorus, transparency, and organic nitrogen represented by PC1 may still be attributed to allochthonous suspended solids. The chlorophyll term has the highest coefficient, however, so that a significant portion of the variance in PC1 should be attributed to variance in chlorophyll and algal standing crop. Since the analysis has been done using data from phosphorus-limited, low-turbidity reservoirs only, the significance of the phosphorus and transparency terms may be inflated in N-limited and/or turbid impoundments, as identified in Table 39.

205. Table 39 indicates that PC1 does a reasonable job of discriminating among reservoir "trophic states" assessed by the EPA/NES. The oligo/mesotrophic and meso/eutrophic boundaries lie at PC1

Table 39
CE Reservoirs Ranked Based upon PC1 Values

| Code | Reservoir | * | PC1 | P | B | S | No | Pn | Pv | TS |
|---|---|---|---|---|---|---|---|---|---|---|
| 19343 | Dale Hollow | | 1.44 | 1.01 | 0.56 | 0.64 | 2.41 | 1.15 | 0.97 | OM |
| 31077 | Dworshak | | 1.45 | 1.11 | 0.38 | 0.40 | 2.28 | 0.96 | 1.04 | O |
| 03307 | Beltzville | | 1.58 | 1.03 | 0.69 | 0.54 | 2.43 | 1.05 | 0.95 | M |
| 24013 | Bull Shoals | | 1.63 | 1.20 | 0.60 | 0.60 | 2.52 | 1.12 | 1.03 | M |
| 17391 | Summersville | | 1.68 | 1.11 | 0.79 | 0.55 | 2.42 | 1.21 | 1.29 | M |
| 17373 | J.W. Flannagan | | 1.72 | 1.03 | 0.75 | 0.35 | 2.51 | 1.48 | 1.64 | M |
| 19122 | Cumberland | | 1.74 | 1.19 | 0.58 | 0.23 | 2.43 | 1.40 | 1.55 | M |
| 16328 | Allegheny | | 1.81 | 1.32 | 0.57 | 0.34 | 2.57 | 1.45 | 1.50 | M |
| 10003 | Holt | | 1.83 | 1.38 | 0.41 | 0.09 | 2.50 | 1.43 | 1.53 | E |
| 24011 | Beaver | | 1.89 | 1.49 | 0.59 | 0.33 | 2.49 | 1.47 | 1.49 | M |
| 24200 | Table Rock | | 2.11 | 1.47 | 0.96 | 0.36 | 2.53 | 1.39 | 1.43 | E |
| 10411 | Bankhead | | 2.15 | 1.60 | 0.60 | 0.08 | 2.70 | 1.60 | 1.73 | E |
| 25278 | Tenkiller Ferry | | 2.17 | 1.58 | 0.82 | 0.21 | 2.57 | 1.57 | 1.77 | E |
| 18093 | Monroe | | 2.19 | 1.49 | 0.86 | 0.21 | 2.71 | 1.40 | 1.25 | E |
| 30235 | Sakakawea | n | 2.26 | 1.86 | 0.87 | 0.36 | 2.48 | 1.65 | 2.01 | O-E |
| 19340 | J. Percy Priest | n | 2.33 | 1.65 | 1.00 | 0.25 | 2.65 | 1.81 | 1.98 | E |
| 18120 | Barren River | | 2.34 | 1.65 | 0.93 | 0.07 | 2.59 | 1.60 | 1.61 | E |
| 06372 | John H. Kerr | | 2.39 | 1.70 | 0.91 | 0.04 | 2.65 | 1.78 | 1.98 | E |
| 19342 | Old Hickory | n | 2.49 | 1.76 | 0.95 | -0.12 | 2.55 | 1.81 | 1.95 | E |
| 29111 | Pomona | t | 2.53 | 1.66 | 0.93 | -0.32 | 2.63 | 1.89 | 1.95 | E |
| 25267 | Eufaula | nt | 2.55 | 1.95 | 0.64 | -0.35 | 2.67 | 1.99 | 2.33 | E |
| 25281 | Wister | t | 2.55 | 1.98 | 0.71 | -0.23 | 2.64 | 1.77 | 1.75 | E |
| 17241 | Atwood | | 2.58 | 1.62 | 1.22 | -0.02 | 2.72 | 1.82 | 1.76 | E |
| 17256 | Pleasant Hill | | 2.62 | 1.61 | 1.36 | 0.04 | 2.67 | 1.60 | 1.62 | E |
| 16243 | Berlin | | 2.71 | 1.77 | 1.16 | -0.07 | 2.90 | 2.04 | 2.24 | E |
| 20087 | Shelbyville | | 2.75 | 1.84 | 1.23 | -0.01 | 2.84 | 1.92 | 2.08 | E |
| 19119 | Barkley | n | 2.77 | 2.10 | 1.12 | -0.16 | 2.46 | 1.91 | 2.06 | E |
| 04312 | F.J. Sayers | | 2.78 | 1.98 | 1.26 | 0.08 | 2.75 | 1.97 | 2.14 | E |
| 29108 | Milford | n | 2.85 | 1.98 | 1.28 | -0.07 | 2.73 | 2.01 | 2.63 | E |
| 16317 | Shenango River | | 2.85 | 1.78 | 1.43 | -0.03 | 2.87 | 1.87 | 1.90 | E |
| 29106 | Kanopolis | nt | 2.91 | 1.83 | 1.20 | -0.46 | 2.81 | 2.18 | 2.84 | E |
| 18092 | Mississinewa | | 2.92 | 2.02 | 1.20 | -0.17 | 2.90 | 1.98 | 2.42 | E |
| 20081 | Carlyle | | 2.92 | 1.93 | 1.24 | -0.25 | 2.87 | 2.06 | 2.17 | E |
| 26355 | Lewisville | nt | 2.95 | 2.12 | 1.24 | -0.20 | 2.70 | 2.02 | 2.20 | E |
| 17248 | Delaware | t | 2.95 | 2.01 | 1.04 | -0.39 | 2.99 | 2.17 | 2.36 | E |
| 20088 | Rend | n | 2.95 | 1.85 | 1.37 | -0.14 | 2.99 | 2.20 | 2.23 | E |
| 29207 | Harlan County | | 3.12 | 2.10 | 1.44 | -0.22 | 2.86 | 2.00 | 2.26 | HE |
| 17242 | Beach City | t | 3.12 | 2.22 | 1.04 | -0.55 | 2.92 | 2.28 | 2.38 | E |
| 25105 | John Redmond | nt | 3.19 | 2.34 | 0.98 | -0.73 | 2.80 | 2.25 | 2.50 | E |
| 25273 | Keystone | nt | 3.33 | 2.33 | 1.43 | -0.44 | 2.83 | 1.97 | 2.49 | E |
| 17249 | Dillon | t | 3.36 | 2.27 | 1.42 | -0.33 | 3.17 | 2.04 | 2.16 | E |
| 15237 | Ashtabula | n | 3.49 | 2.44 | 1.62 | -0.13 | 3.16 | 2.15 | 2.27 | E |
| 17245 | Charles Mill | | 3.50 | 2.10 | 1.83 | -0.35 | 3.10 | 2.14 | 2.18 | E |

* n = inflow total N/P < 10 , t = non-algal turbidity > 1.58 1/m
PC1 = first principal component of P, B, S, and No (Table 38)
All data in log10 units:
P = reservoir total P (mg/m3) B = chlorophyll-a (mg/m3)
S = transparency (m) No = organic N (mg/m3)
Pn = Pi / (1 + .001 Pi Z ) Pv = Pi / (1 + $\sqrt{T}$ )
TS = "trophic state" assessed by EPA National Eutrophication Survey
(O=Oligotrophic,M=Mesotrophic,E=Eutrophic,HE=Hypereutrophic)

values of approximately 1.5 and 2.0, respectively. As discussed in Parts VI and VII, Lake Sakakawea is eutrophic at one end and oligotrophic at the other. Its intermediate ranking (PC1=2.26) refers to "average" conditions and is somewhat deceptive; this further emphasizes the need for considering spatial variations in some reservoirs.

206. The second principal component of the reservoir response measurements is given by the following expression:

$$PC2 = .46 \log(P) - .77 \log(B) - .45 \log(S) + .02 \log(No) \quad (68)$$

While this component accounts for only 8 percent of the response variance from the low-turbidity, P-limited reservoirs, it may be of some physical significance. Table 40 presents correlations between the first two principal components and various reservoir characteristics, using data from all 43 reservoirs in the CE load/response data set. While PC1 as a possible measure of eutrophication is correlated best with total P, chlorophyll, transparency, organic N, normalized phosphorus, and mean depth, PC2 is correlated best with the chlorophyll/secchi product (r=-.90) and non-algal turbidity (r=.80), as shown in Figure 42. As demonstrated in Part V, the product of chlorophyll and transparency is proportional to the fraction of light extinction attributed to chlorophyll-related substances; it is also proportional to the daily-integral photosynthetic rate per unit area under light-limited conditions, since it is directly related to the total amount of light absorbed by chlorophyll (Vollenweider and Kerekes, 1980). Thus, PC2 may be an indicator of the partitioning of light extinction (and nutrients) between algal-related and other substances. Comparing the coefficients for phosphorus (.46) and organic N (.02) indicates that the former has a greater tendency for association with non-algal substances; this is also reflected by the stronger correlation between organic N and chlorophyll than between total P and chlorophyll and by the partial correlation coefficients listed in Table 37. Table 41 lists data from 43 CE reservoirs, sorted by increasing PC2 value.

Table 40

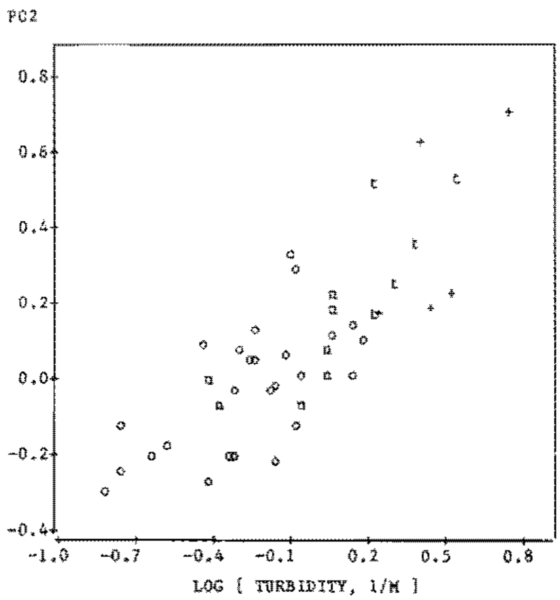
Correlations of Principal Components with Reservoir Characteristics

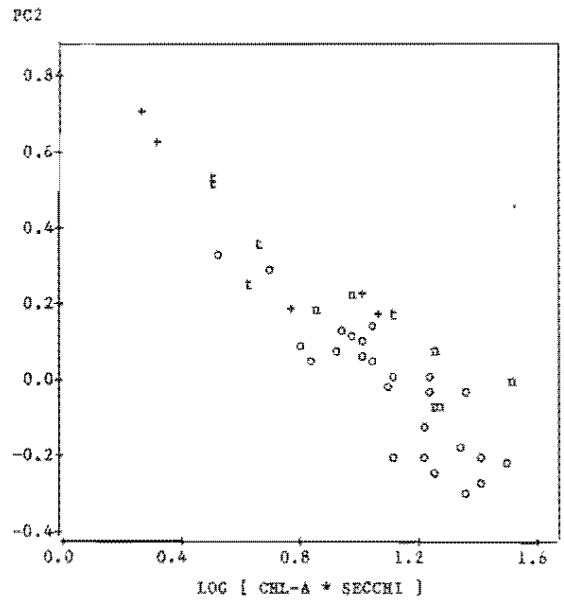
| Measurement | Component PC1 | Component PC2 |
|---|---|---|
| Chlorophyll-a | .873 | -.201 |
| Transparency | -.865 | -.645 |
| Total P | .947 | .499 |
| Organic N | .876 | .141 |
| Chl-a × Transparency | .040 | -.901 |
| Non-Algal Turbidity | .655 | .803 |
| Mean Depth | -.827 | -.304 |
| Residence Time | -.349 | -.329 |
| Pi / (1 + .001 Pi Z ) | .929 | .431 |
| Pi / $(1 + \sqrt{T})$ | .861 | .453 |

PC1 and PC2 defined in Table 37;
all variables on log scales
based upon data from 43 reservoirs

Figure 42

Second Principal Component vs. Turbidity and Chlorophyll/Secchi Product




| symbol | meaning |
|---|---|
| o | CE Reservoir |
| n | inflow N/P < 10 |
| t | turbidity > 1.58 1/m |
| + | inflow N/P < 10, turbidity >.58 1/m |

Table 41
CE Reservoirs Ranked Based upon PC2 values

| Code | Reservoir | * | PC2 | B*S | A | T |
|---|---|---|---|---|---|---|
| 17391 | Summersville | | -0.29 | 1.34 | -0.83 | -1.25 |
| 17256 | Pleasant Hill | | -0.27 | 1.40 | -0.44 | -1.28 |
| 03307 | Beltzville | | -0.24 | 1.23 | -0.78 | -0.61 |
| 16317 | Shenango River | | -0.21 | 1.40 | -0.36 | -1.29 |
| 17245 | Charles Mill | | -0.21 | 1.48 | -0.18 | -1.54 |
| 17373 | J.W. Flannagan | | -0.20 | 1.10 | -0.35 | -0.38 |
| 19343 | Dale Hollow | | -0.20 | 1.20 | -0.66 | -0.12 |
| 24200 | Table Rock | | -0.17 | 1.32 | -0.59 | -0.23 |
| 17241 | Atwood | | -0.13 | 1.20 | -0.09 | -0.42 |
| 24013 | Bull Shoals | | -0.12 | 1.20 | -0.78 | -0.30 |
| 20088 | Rend | n | -0.07 | 1.23 | -0.07 | -0.16 |
| 19340 | J. Percy Priest | n | -0.06 | 1.25 | -0.40 | -0.66 |
| 04312 | F.J. Sayers | | -0.03 | 1.34 | -0.34 | -1.32 |
| 20087 | Shelbyville | | -0.03 | 1.22 | -0.19 | -0.68 |
| 18093 | Monroe | | -0.01 | 1.07 | -0.17 | -0.39 |
| 15237 | Ashtabula | n | 0.01 | 1.49 | -0.43 | -0.45 |
| 16243 | Berlin | | 0.02 | 1.09 | -0.07 | -0.71 |
| 29108 | Milford | n | 0.02 | 1.21 | 0.02 | -0.52 |
| 29207 | Harlan County | | 0.02 | 1.22 | 0.13 | 0.16 |
| 19122 | Cumberland | | 0.05 | 0.81 | -0.27 | -0.42 |
| 25278 | Tenkiller Ferry | | 0.06 | 1.03 | -0.28 | -0.49 |
| 16328 | Allegheny | | 0.07 | 0.91 | -0.31 | -0.75 |
| 18120 | Barren River | | 0.07 | 1.00 | -0.13 | -0.82 |
| 30235 | Sakakawea | n | 0.08 | 1.23 | 0.03 | 0.12 |
| 31077 | Dworshak | | 0.09 | 0.78 | -0.46 | -0.22 |
| 20081 | Carlyle | | 0.11 | 0.99 | 0.16 | -0.91 |
| 06372 | John H. Kerr | | 0.12 | 0.95 | 0.05 | -0.76 |
| 24011 | Beaver | | 0.14 | 0.92 | -0.25 | 0.01 |
| 18092 | Mississinewa | | 0.14 | 1.03 | 0.13 | -1.10 |
| 17249 | Dillon | t | 0.17 | 1.09 | 0.21 | -1.77 |
| 26355 | Lewisville | nt | 0.17 | 1.04 | 0.22 | 0.02 |
| 29106 | Kanopolis | nt | 0.19 | 0.74 | 0.42 | -0.90 |
| 19342 | Old Hickory | n | 0.19 | 0.83 | 0.05 | -1.68 |
| 25273 | Keystone | nt | 0.23 | 0.99 | 0.51 | -1.17 |
| 19119 | Barkley | n | 0.23 | 0.96 | 0.05 | -1.66 |
| 29111 | Pomona | t | 0.25 | 0.61 | 0.28 | -0.50 |
| 10411 | Bankhead | | 0.30 | 0.68 | -0.10 | -1.38 |
| 10003 | Holt | | 0.34 | 0.50 | -0.12 | -1.82 |
| 17248 | Delaware | t | 0.36 | 0.65 | 0.37 | -1.57 |
| 17242 | Beach City | t | 0.53 | 0.49 | 0.52 | -2.09 |
| 25281 | Wister | t | 0.53 | 0.48 | 0.20 | -1.16 |
| 25267 | Eufaula | nt | 0.62 | 0.29 | 0.38 | -0.35 |
| 25105 | John Redmond | nt | 0.71 | 0.25 | 0.72 | -1.36 |

PC2 = second principal component (Table 38)
A = non-algal turbidity = 1/S - .025 B
B*S = secchi depth x chlorophyll-a (mg/m2)
T = mean hydraulic residence time (yrs)
* n = inflow N/P < 10 , t = turbidity > 1.58 1/m

207. Classification of reservoirs based upon PC1 and PC2 is shown in Figure 43, which plots PC2 against PC1 using different symbols to distinguish "N-limited" and "turbid" impoundments. The impoundments exceeding the non-algal turbidity limit of 1.58 1/m tend to lie in the upper right-hand region of the plot. The PC1 axis can be roughly considered as ranging from "oligotrophic" to "eutrophic", and the PC2 axis, from "algae-dominated" to "turbidity-dominated". Two impoundments (Holt and Bankhead) lie in the upper left-hand region of the plot, but are classified in the "low-turbidity" group. If the definition of "low-turbidity" were based upon chlorophyll/transparency product, rather than non-algal turbidity values, these reservoirs would be classified with the other impoundments with relatively high PC2 values (see Table 41). The models in Table 36 also tend to over-predict chlorophyll and transparency in these two impoundments. These results suggest that a classification system based upon PC2 or chlorophyll/Secchi product would be more appropriate than one based upon turbidity level. Future refinements in the model network should consider this revised classification system.

208. Regression analyses have been done to relate computed PC1 values to normalized phosphorus loading expressions, using data from 26 P-limited, low-turbidity impoundments:

$$PC1 = -.25 + 1.58\ Pn \qquad (R^2 = .89,\ SE^2 = .039) \qquad (69)$$

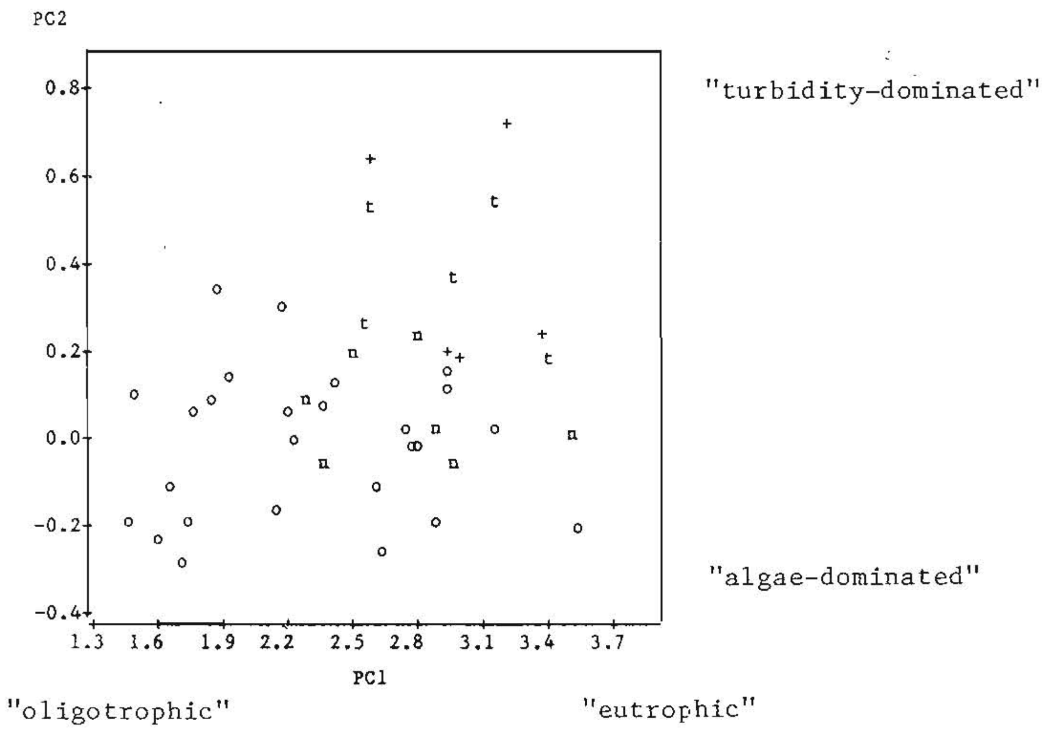
$$PC1 = .30 + 1.17\ Pv \qquad (R^2 = .78,\ SE^2 = .076) \qquad (70)$$

The error variance for the Pn regression is about half that for the Pv regression. These relationships are depicted in Figure 44. The high percentages of variance explained by the normalized loading statistics indicate that impoundment rankings based upon Pn (or Pv) should be similar to those based upon PC1. Thus, both PC1 and the loading expressions are useful for predictive and ranking purposes.

209. The above equations relating PC1 to Pn and Pv are tested using the EPA/NES data set in Figure 45. Using data from P-limited, low-turbidity impoundments, R-Squared values are .77 and .59 for the Pn

Figure 43

Second Principal Component vs. First Principal Component

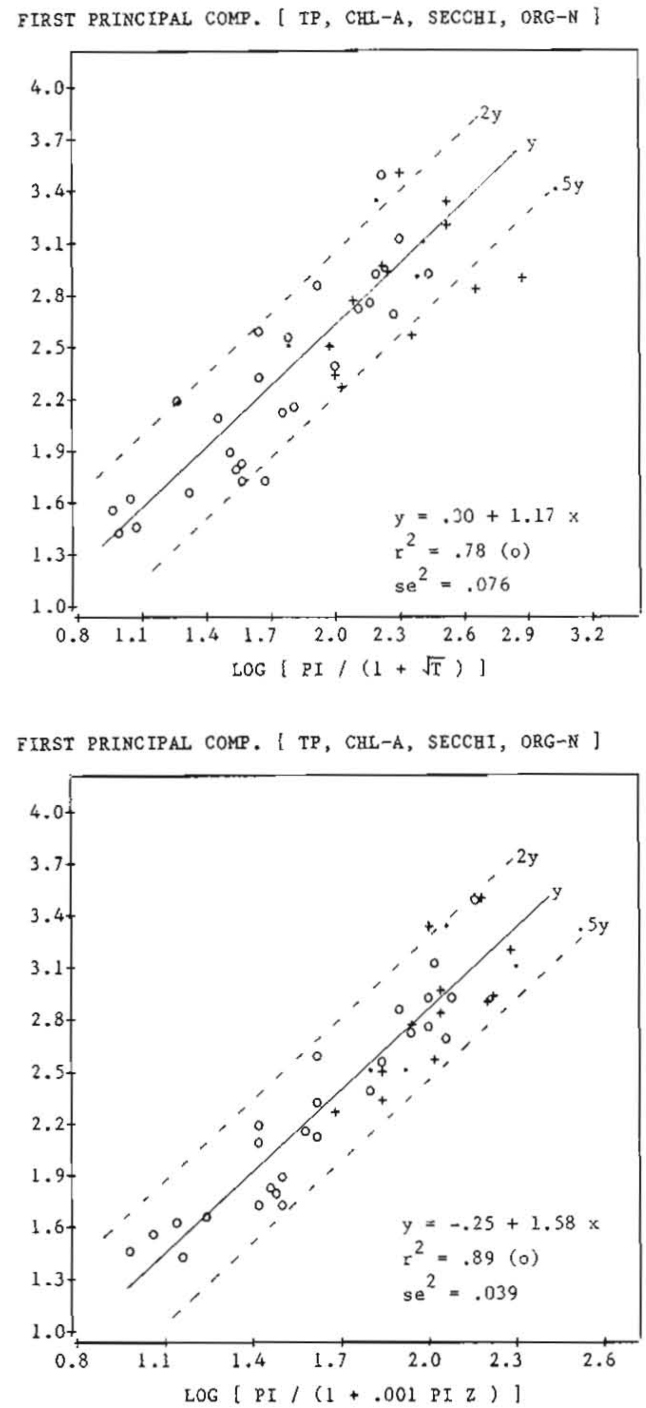



$$PC1 = .57 \log(P) + .61 \log(B) - .44 \log(S) + .33 \log(No)$$
$$PC2 = .46 \log(P) - .77 \log(B) - .45 \log(S) + .02 \log(No)$$

| symbol | meaning |
|---|---|
| o | CE Reservoir |
| n | inflow N/P < 10 |
| t | turbidity > 1.58 1/m |
| + | inflow N/P < 10, turbidity > 1.58 1/m |

Figure 44

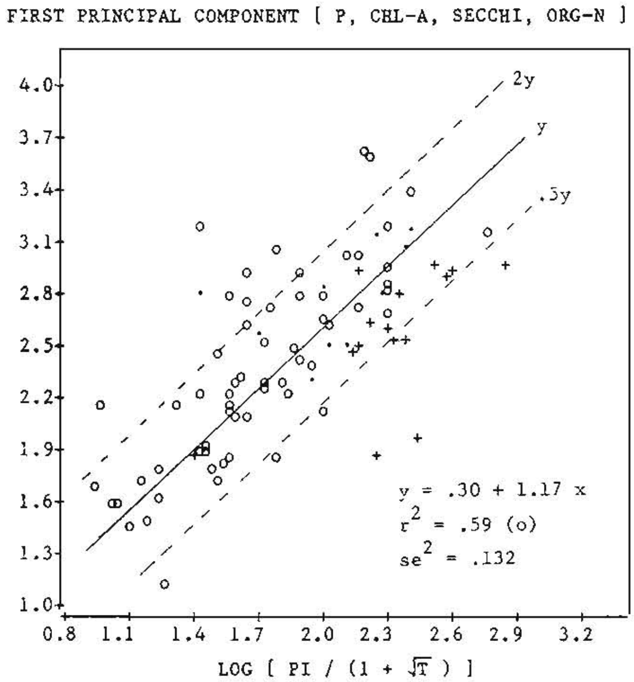
First Principal Component vs. Normalized Phosphorus Loading Statistics: CE Data Set

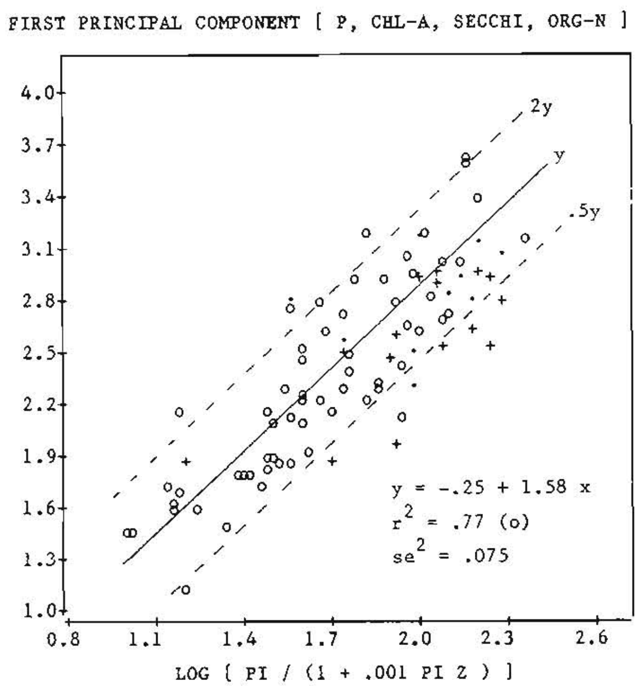



| symbol | meaning |
|---|---|
| o | CE Reservoir |
| . | turbidity > 1.58 1/m |
| + | inflow N/P < 10 |

Figure 45

First Principal Component vs. Normalized Phosphorus Loading Statistics:
EPA/NES Data Set




| symbol | meaning |
|---|---|
| o | CE Reservoir |
| . | turbidity > 1.58 1/m |
| + | inflow N/P < 10 |

and Pv equations, respectively. Mean squared errors (.075 and .132, respectively) are higher than those in Figure 44; this may be related to differences in data reduction procedures and limited screening of the EPA/NES data.

210. Figures 44 and 45 show that the above equations work well for some N-limited and/or high-turbidity impoundments. In some cases, this may be attributed to offsetting biases in the calculation of PC1; for example, in a turbid impoundment, both chlorophyll and transparency would tend to be lower than predicted based upon the loading models, but the effects on PC1 would be partially cancelled out because these factors have opposite signs in the PC1 expression. Thus, the PC1/PC2 classification system does not completely separate eutrophication from turbidity effects. Using factor analysis techniques (Harris, 1975), it may be possible to expand upon the above results and to develop summary statistics which separate these factors and which consider nitrogen limitation. This is left for future work.

## Error Analysis

211. In the data-reduction procedures described in Part IV, attempts were made to estimate the error variances associated with estimates of inflow nutrient concentrations and average water quality conditions for each impoundment. These error variances reflect spatial, temporal, sampling, and analytical variability in relation to the sampling program designs. Table 42 presents pooled estimates of total and error variance for impoundment response and inflow concentration variables. For the response measurements, between 4.8 and 10.3 percent of the total variance can be attributed to error variance; the remainder reflects true differences among reservoirs. Between 2.0 and 2.2 percent of variance in the normalized phosphorus loadings can be attributed to error. The 95% confidence factors for individual impoundment response values range from 1.36 to 1.75. The higher error in the case of chlorophyll reflects greater temporal, sampling, and/or analytical variability.

Table 42

Summary of Estimated Variance Components of Measurements Involved in Empirical Model Framework

| Variable | Total(a) Variance | Error Variance | Percent Error | f95(d) |
|---|---|---|---|---|
| ------ Reservoir-Average Conditions (b) ------ | | | | |
| Total P | .1332 | .0071 | 5.3 | 1.47 |
| Chl-a | .1429 | .0147 | 10.3 | 1.75 |
| Secchi | .0734 | .0058 | 7.9 | 1.42 |
| Organic N | .0630 | .0030 | 4.8 | 1.36 |
| ----- Normalized Phosphorus Loadings (c) ----- | | | | |
| Pv | .1918 | .0042 | 2.2 | 1.35 |
| Pn | .1282 | .0025 | 2.0 | 1.26 |

a Total variance reflects true differences among reservoirs and error variance, based upon data from 29 reservoirs with inflow N/P > 8 and non-algal turbidity < 1.58 1/m (.2 log units)

b Error variance reflects errors in estimating reservoir-average conditions based upon limited sampling (Part IV)

c Error variance reflects errors in estimating average inflow concentration based upon limited tributary sampling (Part IV)

$$Pv = Pi / (1 + \sqrt{T})$$
$$Pn = Pi / (1 + .001\ Pi\ Z)$$

d Approximate 95% confidence factor for impoundment mean value:

$$\hat{y} / f95 < y < \hat{y} * f95$$

212. The individual impoundment response statistics are generally less accurate than the inflow concentration statistics. This reflects an imbalance in the EPA/NES sampling program design: more than three or four sampling rounds per impoundment per year would have provided better estimates of average conditions. While the error variances are greater than desired for individual project assessments, their effects on model testing are minimal because they generally represent only a small fraction of the total variance across reservoirs.

213. Figure 46 summarizes all equations involved in the model network. Mean squared errors and 95% confidence factors are presented for total and model error components. The former is applicable for comparing predictions with observations based upon data similar to that used in model development (i.e., the EPA/NES sampling design). Model error variance is essentially the total error variance, corrected for the effects of data variance:

$$SE_m^2 = SE_t^2 - V_y - b^2 V_x \qquad (71)$$

where,

$SE_m^2$ = model mean squared error

$SE_t^2$ = total mean squared error

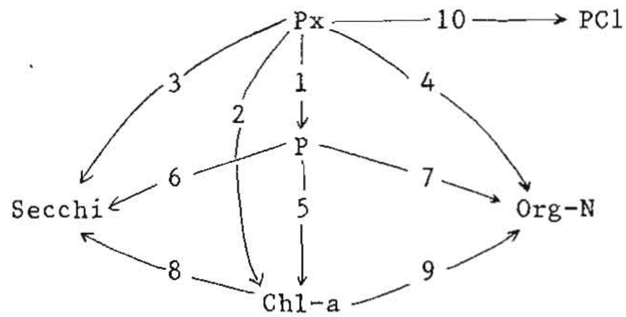
$V_y$ = estimated data error variance of dependent variable

$V_x$ = estimated data error variance of independent variable

$b$ = regression slope

The above equation is approximate, because it assumes that the error variances in the dependent and independent variables are uncorrelated. Because covariance terms would be expected to be important in calculation of PC1, partitioning of model and data error is not feasible for models involving this statistic. Model error statistics would reflect expected error distributions derived from comparing predictions

Figure 46
Summary of Empirical Model Network Relating
Reservoir-Average Conditions




| Model | y | x | a | b | $R^2$ | $SE^2$ | f95 | $SE^{*2}$ | f95* |
|---|---|---|---|---|---|---|---|---|---|
| 1a | P | Pn | .00 | 1.00 | .857 | .0190 | 1.89 | .0094 | 1.56 |
| 2a | Chl-a | Pn | -.48 | .89 | .717 | .0435 | 2.63 | .0268 | 2.13 |
| 3a | Secchi | Pn | 1.26 | -.69 | .840 | .0115 | 1.62 | .0045 | 1.36 |
| 4a | Org-N | Pn | 1.79 | .54 | .849 | .0062 | 1.44 | .0025 | 1.26 |
| 1b | P | Pv | .30 | .76 | .833 | .0220 | 1.98 | .0125 | 1.67 |
| 2b | Chl-a | Pv | -.15 | .66 | .561 | .0630 | 3.18 | .0465 | 2.70 |
| 3b | Secchi | Pv | 1.08 | -.56 | .823 | .0130 | 1.69 | .0059 | 1.42 |
| 4b | Org-N | Pv | 1.99 | .39 | .715 | .0117 | 1.65 | .0081 | 1.51 |
| 5 | Chl-a | P | -.60 | .98 | .681 | .0460 | 2.69 | .0260 | 2.10 |
| 6 | Secchi | P | 1.18 | -.66 | .786 | .0160 | 1.79 | .0071 | 1.47 |
| 7 | Org-n | P | 1.84 | .52 | .807 | .0079 | 1.51 | .0030 | 1.29 |
| 8 | Secchi | Chl-a | .65 | -.59 | .585 | .0316 | 2.27 | .0214 | 1.96 |
| 9 | Org-N | Chl-a | 2.21 | .47 | .756 | .0099 | 1.58 | .0037 | 1.32 |
| 10a | PC1 | Pn | -.25 | 1.58 | .886 | .0386 | 2.47 | - | - |
| 10b | PC1 | Pv | .30 | 1.17 | .775 | .0761 | 3.56 | - | - |

Equation: log(y) = a + b log(x), units mg/m3, except Secchi (m)
All statistics are for non-algal turbidity < 1.58 1/m and inflow N/P > 8, except those involving org-N (inflow N/P > 10)
f95 = approx. 95% confidence factor: $\hat{y}$/f95 < y < $\hat{y}$*f95
Px = normalized Inflow P Concentration (Pv or Pn)
Pv = Pi / (1 + $\sqrt{T}$ ) Pn = Pi / (1 + .001 Pi Z)
P = reservoir Total P Pi = Inflow Total P
PC1 = first principal component of P, Secchi, Chl-a, Org-N (R2=.887)
= .58 log(P) + .61 log(Chl-a) -.44 log(Secchi) + .33 log(org-N)
* estimated model mean squared error and f95, adjusted for data error component (see text and Table 41)

with error-free data (i.e., in the limit, data derived from highly intensive sampling programs).

214. All error statistics in Figure 46 refer to P-limited, low-turbidity impoundments. Chlorophyll values tend to be lower than predicted in N-limited and/or turbid impoundments. Based upon the results of residuals testing, the models also tend to over-predict transparency and chlorophyll in impoundments with residence times less than about .03 years. The framework is based largely upon data from reservoirs south of 42 degrees latitude. Tests described above indicate possible biases (particularly for transparency predictions) in reservoirs above this latitude. Augmentation of the data base would be required for development and testing of models applicable to northern impoundments.

215. Total and model errors for predicting transparency are generally lower than errors for predicting phosphorus or chlorophyll. This results from the relatively limited range of the Secchi measurement and from the phosphorus/transparency covariance attributed to non-algal suspended solids. The traditional approach to predicting transparency involves linkage of inflow P/pool P, pool P/chlorophyll, and chlorophyll/transparency models. This approach is clearly inferior to the direct inflow P/transparency model, based upon the error pathways depicted in Figure 46.

216. Predictions of chlorophyll are more uncertain than those of other response variables. Problems with the sampling and measurement of chlorophyll may be contribute to errors, along with variations of chlorophyll/biomass ratios as functions of algal species, growth stages, and environmental conditions. As demonstrated in Parts V and VI, errors can be reduced by incorporating the effects of turbidity, mean depth, and flushing rate on the chlorophyll/phosphorus response. This is a promising area for model improvement, although it is limited partially by the lack of a predictive basis for turbidity (or chlorophyll/transparency product).

217. As demonstrated in Part VI, spatial variance probably contributes to errors in all of the loading models and may influence

optimal model formulations and parameter estimates. These potential effects warrant additional investigation. Refinements to the network analysis should also consider parameter errors, more refined models, and possible application of path analysis techniques.

# PART IX: GENERAL CONCLUSIONS

218. Specific recommendations regarding models in each category can be found at the ends of Parts V, VI, and VII. Some general conclusions are outlined below:

a. Empirical eutrophication models can be adapted for use for reservoirs, with expected errors which are similar in magnitude to those reported in "global" studies of natural lakes. Error variance for predicting chlorophyll is generally more than twice that for predicting phosphorus or transparency. This difference reflects temporal variability in the sizes and compositions of algal populations and variability in the chlorophyll measurement process, both of which tend to reduce the reliability of the station-mean or reservoir-mean chlorophyll estimates derived from limited numbers of sampling dates. Organic nitrogen is useful as a trophic state indicator in most reservoirs; it is highly correlated with chlorophyll and does not appear to be as strongly influenced by allochthonous suspended solids as are the total phosphorus or transparency measurements.

b. The following factors have been shown to be correlated with model residuals and to induce variability in the parameter estimates of phosphorus-based models in various categories:
   1. turbidity
   2. inflow and reservoir N/P ratios
   3. flushing
   4. mean depth
   5. inflow ortho-P/total P ratio
   6. sediment accumulation rate
   7. morphometric complexity

   Modifications of existing model structures to account for some or all of the above factors would result in significant reductions in error. In particular, about 70% of the residual variance from models predicting chlorophyll as a function of normalized total phosphorus loading can be explained by effects of turbidity, mean depth, and/or inflow ortho-P/total P ratio. These effects are probably related to light-limitation and nutrient availability.

c. Since model applicability and potential biases, in many cases, depend upon turbidity and N/P ratio, predictive methods for these variables are needed if the models are to be used in a planning context.

d. Owing to data availability constraints, the regional distribution of the CE impoundments which have been used in model testing is heavily weighted in mid and southern latitudes of the U.S. (roughly, below 42 degrees). Because of regional geologic factors, the calibrated models may give biased predictions (particularly of transparency) in northern impoundments.

e. Since spatial gradients in phosphorus, chlorophyll, and transparency have been shown to be appreciable in many reservoirs, predictions of reservoir-average water quality conditions are potentially misleading. Modifications of these models to permit prediction of spatial variations would represent significant improvements.

f. Subsequent reports in this series will deal specifically with modifications of these models and recommendations concerning their use for evaluating and/or predicting water quality conditions in CE reservoirs.

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# APPENDIX A

## Morphometric Curve Parameters

This appendix contains a listing of estimated morphometric curve parameters* for 285 reservoirs, by reservoir.

| Symbol | Meaning | |
|---|---|---|
| DIS | CE district code | |
| RES | CE reservoir code | |
| EMIN | minimum elevation with volume data | (ft,msl) |
| EMAX | maximum elevation with volume data | (ft,msl) |
| EZERO | base (zero-volume) elevation | (ft,msl) |
| C1-C5 | morphometric curve parameters | |

* Equations for using the parameters to estimate reservoir total depth, volume, and area at any elevation are given in Part III of the main text (equations 1-3); equations should not be used outside of EMIN - EMAX range.

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 01 NEW ENGLAND DIV | 142 BUFFUMVILLE | 493.0 | 524.0 | 477.8 | 2.15 | 1.88 | 0.000 | 0.000 | 0.0000 |
| 01 NEW ENGLAND DIV | 144 EAST BRIMFIELD | 619.0 | 653.0 | 619.0 | 0.20 | 3.10 | -0.060 | 0.000 | 0.0000 |
| 01 NEW ENGLAND DIV | 147 LITTLEVILLE | 432.0 | 576.0 | 432.0 | -15.08 | 10.64 | -1.655 | 0.110 | 0.0000 |
| 01 NEW ENGLAND DIV | 148 TULLY | 625.0 | 668.0 | 625.0 | 1.58 | -0.22 | 1.321 | -0.177 | 0.0000 |
| 01 NEW ENGLAND DIV | 150 WESTVILLE | 515.0 | 572.0 | 515.0 | -0.77 | 2.31 | 0.380 | -0.244 | 0.0393 |
| 01 NEW ENGLAND DIV | 151 BLACK ROCK | 410.0 | 520.0 | 410.0 | -16.16 | 21.50 | -8.969 | 1.766 | -0.1251 |
| 01 NEW ENGLAND DIV | 152 COLEBROOK RIVER | 567.0 | 761.0 | 567.0 | 8.07 | -0.59 | -0.536 | 0.283 | -0.0260 |
| 01 NEW ENGLAND DIV | 155 HANCOCK BROOK | 454.0 | 484.0 | 454.0 | 1.65 | 1.09 | 0.491 | -0.070 | 0.0000 |
| 01 NEW ENGLAND DIV | 156 HOP BROOK | 292.0 | 364.0 | 292.0 | 6.10 | -15.70 | 10.661 | -2.444 | 0.1975 |
| 01 NEW ENGLAND DIV | 158 MANSFIELD HOLLO | 195.0 | 257.0 | 195.0 | -16.17 | 19.46 | -5.998 | 0.891 | -0.0474 |
| 01 NEW ENGLAND DIV | 159 NORTHFIELD BROO | 480.0 | 576.0 | 480.0 | 5.60 | -2.78 | 0.840 | 0.012 | -0.0085 |
| 01 NEW ENGLAND DIV | 162 WEST THOMPSON | 292.0 | 342.0 | 292.0 | 2.46 | 5.97 | -3.916 | 1.204 | -0.1187 |
| 01 NEW ENGLAND DIV | 164 EDWARD MCDOWELL | 904.0 | 946.0 | 904.0 | -16.23 | 19.29 | -5.366 | 0.547 | 0.0000 |
| 01 NEW ENGLAND DIV | 165 EVERETT | 325.0 | 418.0 | 325.0 | -24.40 | 34.75 | -15.027 | 2.953 | -0.2083 |
| 01 NEW ENGLAND DIV | 166 FRANKLIN FALLS | 300.0 | 389.0 | 300.0 | 4.41 | 4.00 | -1.939 | 0.526 | -0.0466 |
| 01 NEW ENGLAND DIV | 167 HOPKINTON | 370.0 | 416.0 | 370.0 | -11.36 | 13.03 | -2.912 | 0.274 | 0.0000 |
| 01 NEW ENGLAND DIV | 168 OTTER BROOK | 670.0 | 781.0 | 670.0 | 65.96 | -70.93 | 29.106 | -5.025 | 0.3196 |
| 01 NEW ENGLAND DIV | 169 SURRY MOUNTAIN | 485.0 | 550.0 | 485.0 | -12.64 | 13.63 | -3.052 | 0.266 | 0.0000 |
| 01 NEW ENGLAND DIV | 170 BALL MOUNTAIN | 806.0 | 1017.0 | 806.0 | 1.63 | -0.29 | 0.680 | -0.085 | 0.0053 |
| 01 NEW ENGLAND DIV | 172 NORTH HARTLAND | 390.0 | 546.0 | 390.0 | 1.54 | -1.23 | 1.892 | -0.390 | 0.0275 |
| 01 NEW ENGLAND DIV | 173 NORTH SPRINGFIE | 450.0 | 546.0 | 450.0 | -14.82 | 13.00 | -2.499 | 0.194 | 0.0000 |
| 01 NEW ENGLAND DIV | 174 TOWNSHEND | 457.0 | 553.0 | 457.0 | 15.84 | -17.04 | 8.366 | -1.556 | 0.1060 |
| 02 NEW YORK | 171 EAST BARRE | 1165.0 | 1179.8 | 1138.2 | 4.38 | 1.52 | 0.000 | 0.000 | 0.0000 |
| 02 NEW YORK | 176 WATERBURY | 530.0 | 625.0 | 501.3 | -37.39 | 29.99 | -6.708 | 0.535 | 0.0000 |
| 02 NEW YORK | 177 WRIGHTSVILLE | 620.0 | 715.0 | 607.4 | 1.91 | 1.54 | 0.070 | 0.000 | 0.0000 |
| 03 PHILADELPHIA | 307 BELTZVILLE | 501.0 | 672.0 | 501.0 | 11.38 | -13.13 | 6.658 | -1.219 | 0.0820 |
| 03 PHILADELPHIA | 313 FRANCIS E WALTE | 1250.0 | 1474.0 | 1250.0 | -16.13 | 18.69 | -6.511 | 1.090 | -0.0643 |
| 03 PHILADELPHIA | 316 PROMPTON | 1090.0 | 1205.0 | 1090.0 | 22.33 | -29.31 | 14.793 | -2.861 | 0.1976 |
| 04 BALTIMORE | 227 ALMOND | 1229.0 | 1300.0 | 1229.0 | -5.44 | 4.45 | -0.216 | 0.000 | 0.0000 |
| 04 BALTIMORE | 229 WHITNEY POINT | 950.0 | 1025.0 | 935.0 | -23.36 | -10.62 | 18.238 | -5.175 | 0.4520 |
| 04 BALTIMORE | 306 ALVIN R BUSH (K | 810.0 | 937.0 | 806.7 | -4.32 | 3.69 | -0.102 | 0.000 | 0.0000 |
| 04 BALTIMORE | 310 CURWENSVILLE | 1126.0 | 1228.0 | 1126.0 | -22.79 | 27.66 | -10.379 | 1.909 | -0.1317 |

## MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 04 BALTIMORE | 312 F J SAYERS (BLA | 580.0 | 657.0 | 580.0 | -38.46 | 30.15 | -6.019 | 0.239 | 0.0365 |
| 04 BALTIMORE | 320 RAYSTOWN | 600.0 | 826.0 | 600.0 | 16.06 | -13.40 | 5.290 | -0.743 | 0.0384 |
| 04 BALTIMORE | 329 STILLWATER | 1568.0 | 1621.0 | 1563.4 | 1.83 | 2.11 | -0.143 | 0.020 | 0.0000 |
| 04 BALTIMORE | 398 BLOOMINGTON | 1240.0 | 1509.0 | 1240.0 | -29.59 | 30.33 | -9.685 | 1.431 | -0.0772 |
| 04 BALTIMORE | 401 SAVAGE | 1313.0 | 1469.0 | 1313.0 | -3.86 | 2.73 | 0.000 | 0.000 | 0.0000 |
| 06 WILMINGTON | 233 B EVERETT JORDA | 154.0 | 260.0 | 154.0 | 11.40 | -9.30 | 3.684 | -0.334 | 0.0000 |
| 06 WILMINGTON | 372 JOHN H KERR | 193.0 | 330.0 | 193.0 | 14.40 | -16.88 | 9.166 | -1.772 | 0.1244 |
| 06 WILMINGTON | 375 PHILPOTT | 805.0 | 1016.0 | 805.0 | 15.62 | -18.17 | 8.553 | -1.485 | 0.0938 |
| 07 CHARLESTON | 232 W KERR SCOTT | 970.0 | 1075.0 | 951.8 | 13.11 | -16.07 | 7.752 | -1.302 | 0.0779 |
| 08 SAVANNAH | 074 CLARK HILL | 190.0 | 346.0 | 190.0 | 189.25 | -112.96 | 23.479 | -1.571 | 0.0000 |
| 08 SAVANNAH | 330 HARTWELL | 475.0 | 674.0 | 475.0 | -33.48 | 24.74 | -4.945 | 0.379 | 0.0000 |
| 09 JACKSONVILLE | 066 OCKLAWAHA(ROOMA | 0.0 | 23.0 | -13.4 | -18.10 | 11.36 | -0.848 | 0.000 | 0.0000 |
| 10 MOBILE | 001 CLAIBORNE | 2.0 | 50.0 | 0.8 | -0.77 | 3.43 | 1.317 | -0.641 | 0.0768 |
| 10 MOBILE | 003 HOLT | 115.0 | 202.0 | 115.0 | 4.67 | 0.41 | 0.485 | -0.047 | 0.0000 |
| 10 MOBILE | 004 JONES BLUFF | 64.0 | 140.0 | 61.6 | -47.09 | 40.88 | -10.228 | 0.923 | 0.0000 |
| 10 MOBILE | 008 MILLERS FERRY | 17.0 | 100.0 | 14.1 | 11.54 | -27.39 | 20.691 | -5.341 | 0.4725 |
| 10 MOBILE | 069 ALLATOONA | 700.0 | 860.0 | 700.0 | -31.00 | 36.67 | -13.061 | 2.039 | -0.1083 |
| 10 MOBILE | 070 GEORGE W ANDREW | 62.0 | 108.0 | 62.0 | 67.60 | -66.51 | 22.390 | -2.333 | 0.0000 |
| 10 MOBILE | 071 SEMINOLE (WOODR | 44.0 | 79.0 | 44.0 | 3.32 | 2.01 | 0.221 | -0.006 | 0.0000 |
| 10 MOBILE | 072 WALTER F GEORGE | 100.0 | 200.0 | 96.9 | -6.29 | 10.79 | -2.890 | 0.327 | 0.0000 |
| 10 MOBILE | 073 WEST POINT | 560.0 | 645.0 | 560.0 | 15.32 | -7.81 | 2.551 | -0.197 | 0.0000 |
| 10 MOBILE | 075 CARTERS | 660.0 | 1099.0 | 660.0 | 8.11 | -8.25 | 4.250 | -0.741 | 0.0471 |
| 10 MOBILE | 076 SIDNEY LANIER | 920.0 | 1086.0 | 920.0 | 1.89 | 1.68 | 0.236 | -0.014 | 0.0000 |
| 10 MOBILE | 411 BANKHEAD | 200.0 | 270.0 | 175.0 | 29.48 | -28.90 | 12.446 | -2.101 | 0.1291 |
| 11 BUFFALO | 228 MT MORRIS | 584.2 | 760.0 | 578.1 | 1.21 | 4.01 | -1.062 | 0.229 | -0.0176 |
| 14 ROCK ISLAND | 098 CORALVILLE | 652.0 | 712.0 | 652.0 | 18.04 | -12.66 | 4.514 | -0.420 | 0.0000 |
| 14 ROCK ISLAND | 099 RED ROCK | 690.0 | 780.0 | 690.0 | -0.33 | 3.11 | 0.037 | 0.000 | 0.0000 |
| 15 ST PAUL | 178 GULL | 1192.8 | 1194.8 | 1121.8 | 6.24 | 1.36 | 0.101 | -0.009 | 0.0000 |
| 15 ST PAUL | 179 LAC QUI PARLE | 924.0 | 948.0 | 918.2 | 8.42 | -1.44 | 1.214 | -0.132 | 0.0000 |
| 15 ST PAUL | 182 ORWELL | 1038.0 | 1075.0 | 1034.8 | 5.73 | -1.28 | 0.372 | 0.219 | -0.0388 |
| 15 ST PAUL | 184 POKEGAMA | 1270.4 | 1276.4 | 1173.2 | -2.10 | 2.71 | 0.196 | -0.017 | 0.0000 |
| 15 ST PAUL | 186 WINNIBIGOSHISH | 1294.9 | 1303.1 | 1241.0 | -39.37 | 34.25 | -8.345 | 0.772 | 0.0000 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 15 ST PAUL | 187 PINE RIVER | 1227.3 | 1230.3 | 1157.1 | 2.08 | 2.52 | 0.000 | 0.000 | 0.0000 |
| 15 ST PAUL | 236 HOMME | 1048.0 | 1092.3 | 1018.0 | 54.72 | -77.65 | 35.958 | -6.616 | 0.4364 |
| 15 ST PAUL | 237 ASHTABULA (BALD | 1238.0 | 1275.0 | 1222.6 | 6.14 | -10.63 | 7.807 | -1.765 | 0.1419 |
| 15 ST PAUL | 399 EAU GALLE | 925.0 | 1010.0 | 925.0 | 12.44 | -9.49 | 4.760 | -0.885 | 0.0612 |
| 16 PITTSBURGH | 243 BERLIN | 949.0 | 1032.0 | 949.0 | 6.24 | -6.59 | 3.649 | -0.626 | 0.0446 |
| 16 PITTSBURGH | 252 MICHAEL J KIRWA | 930.0 | 993.0 | 930.0 | -15.26 | 14.66 | -3.074 | 0.261 | 0.0000 |
| 16 PITTSBURGH | 254 MOSQUITO CREEK | 869.0 | 907.0 | 869.0 | -7.16 | 7.42 | -0.569 | -0.010 | 0.0000 |
| 16 PITTSBURGH | 308 CONEMAUGH RIVER | 848.0 | 986.0 | 848.0 | -31.25 | 39.79 | -16.277 | 3.045 | -0.2056 |
| 16 PITTSBURGH | 309 CROOKED CREEK | 804.0 | 940.0 | 804.0 | 18.97 | -19.68 | 8.941 | -1.535 | 0.0959 |
| 16 PITTSBURGH | 311 EAST BRANCH CLA | 1523.0 | 1685.0 | 1523.0 | 2.90 | -5.30 | 3.755 | -0.707 | 0.0469 |
| 16 PITTSBURGH | 314 LOYALHANNA | 869.0 | 975.0 | 869.0 | -17.83 | 18.20 | -6.828 | 1.407 | -0.1053 |
| 16 PITTSBURGH | 315 MAHONING CREEK | 1010.0 | 1162.0 | 1010.0 | 28.15 | -28.67 | 12.689 | -2.366 | 0.1677 |
| 16 PITTSBURGH | 317 SHENANGO RIVER | 881.2 | 919.0 | 873.5 | -6.66 | 17.64 | -7.989 | 1.754 | -0.1396 |
| 16 PITTSBURGH | 318 TIONESTA | 1043.0 | 1180.0 | 1043.0 | -11.09 | 9.92 | -1.714 | 0.132 | 0.0000 |
| 16 PITTSBURGH | 319 YOUGHIOGHENY RI | 1313.0 | 1480.0 | 1313.0 | -1.00 | 2.40 | 0.376 | -0.104 | 0.0078 |
| 16 PITTSBURGH | 322 WOODCOCK | 1138.0 | 1210.0 | 1138.0 | -6.51 | 5.90 | -0.708 | 0.053 | 0.0000 |
| 16 PITTSBURGH | 328 ALLEGHENY (KINZ | 1195.0 | 1365.0 | 1195.0 | -49.86 | 52.27 | -18.169 | 2.912 | -0.1723 |
| 16 PITTSBURGH | 393 TYGART | 960.0 | 1167.0 | 960.0 | 50.44 | -45.10 | 16.530 | -2.522 | 0.1423 |
| 17 HUNTINGTON | 123 DEWEY | 600.0 | 686.0 | 600.0 | 5.71 | -4.55 | 2.271 | -0.216 | 0.0000 |
| 17 HUNTINGTON | 124 FISHTRAP | 670.0 | 825.0 | 670.0 | 16.28 | -12.03 | 3.788 | -0.312 | 0.0000 |
| 17 HUNTINGTON | 125 GRAYSON | 585.0 | 681.0 | 585.0 | 20.72 | -19.48 | 7.870 | -1.159 | 0.0602 |
| 17 HUNTINGTON | 239 PAINT CREEK | 748.0 | 860.0 | 748.0 | 11.65 | -13.14 | 7.075 | -1.350 | 0.0948 |
| 17 HUNTINGTON | 241 ATWOOD | 890.0 | 941.0 | 887.2 | -0.83 | 2.57 | 0.248 | -0.040 | 0.0000 |
| 17 HUNTINGTON | 242 BEACH CITY | 948.4 | 977.0 | 936.3 | -0.33 | 3.88 | -0.461 | 0.068 | 0.0000 |
| 17 HUNTINGTON | 245 CHARLES MILL | 989.9 | 1020.0 | 985.0 | 4.31 | 0.64 | 0.628 | -0.070 | 0.0000 |
| 17 HUNTINGTON | 246 CLENDENING | 862.0 | 911.0 | 857.2 | 0.24 | 0.75 | 0.969 | -0.121 | 0.0000 |
| 17 HUNTINGTON | 247 DEER CREEK | 765.0 | 835.0 | 765.0 | -46.44 | 37.66 | -8.851 | 0.748 | 0.0000 |
| 17 HUNTINGTON | 248 DELAWARE | 880.0 | 947.0 | 880.0 | -16.13 | 15.07 | -3.341 | 0.317 | 0.0000 |
| 17 HUNTINGTON | 249 DILLON | 700.0 | 790.0 | 700.0 | -9.47 | 7.00 | -0.469 | 0.000 | 0.0000 |
| 17 HUNTINGTON | 251 LEESVILLE | 954.0 | 978.0 | 906.2 | 2.96 | -1.56 | 1.322 | -0.127 | 0.0000 |
| 17 HUNTINGTON | 255 PIEDMONT | 881.8 | 924.6 | 877.3 | -1.27 | 3.93 | -0.132 | -0.015 | 0.0000 |
| 17 HUNTINGTON | 256 PLEASANT HILL | 972.0 | 1065.0 | 972.0 | 0.38 | 2.20 | 0.044 | 0.000 | 0.0000 |

## MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 17 HUNTINGTON | 257 SENECAVILLE | 812.5 | 843.0 | 804.3 | 5.82 | -1.22 | 1.363 | -0.168 | 0.0000 |
| 17 HUNTINGTON | 258 TAPPAN | 893.9 | 909.0 | 856.6 | -2.70 | 4.16 | -0.174 | 0.000 | 0.0000 |
| 17 HUNTINGTON | 259 BURR OAK(TOM JE | 689.0 | 740.0 | 689.9 | 0.08 | 3.41 | -0.341 | 0.033 | 0.0000 |
| 17 HUNTINGTON | 261 WILLS CREEK | 733.0 | 779.0 | 716.8 | 37.62 | -30.99 | 9.745 | -0.904 | 0.0000 |
| 17 HUNTINGTON | 373 JOHN W FLANNAGA | 1210.0 | 1450.0 | 1210.0 | -1.72 | 3.25 | -0.441 | 0.055 | 0.0000 |
| 17 HUNTINGTON | 374 NORTH FORK OF P | 1550.0 | 1667.0 | 1550.0 | 10.78 | -7.32 | 2.374 | -0.183 | 0.0000 |
| 17 HUNTINGTON | 389 BLUESTONE | 1368.0 | 1520.0 | 1368.0 | -9.77 | 13.99 | -4.330 | 0.704 | -0.0427 |
| 17 HUNTINGTON | 390 EAST LYNN | 653.9 | 701.0 | 613.8 | 0.91 | 0.17 | 0.945 | -0.103 | 0.0000 |
| 17 HUNTINGTON | 391 SUMMERSVILLE | 1375.0 | 1711.7 | 1375.0 | 5.27 | -1.28 | 0.446 | 0.000 | 0.0000 |
| 17 HUNTINGTON | 392 SUTTON | 810.0 | 1000.0 | 810.0 | 5.41 | -6.32 | 3.879 | -0.702 | 0.0460 |
| 17 HUNTINGTON | 406 MOHICANVILLE | 932.0 | 963.0 | 929.6 | 3.24 | -2.03 | 2.237 | -0.280 | 0.0000 |
| 18 LOUISVILLE | 090 CAGLES MILL | 631.9 | 704.0 | 588.6 | 0.89 | 2.41 | 0.000 | 0.000 | 0.0000 |
| 18 LOUISVILLE | 091 HUNTINGTON | 715.0 | 798.0 | 715.0 | 1.46 | -4.46 | 5.500 | -1.510 | 0.1391 |
| 18 LOUISVILLE | 092 MISSISSINEWA | 665.0 | 779.0 | 665.0 | 12.40 | -12.36 | 6.817 | -1.383 | 0.1054 |
| 18 LOUISVILLE | 093 MONROE | 490.0 | 556.0 | 490.0 | 62.57 | -74.76 | 35.286 | -6.930 | 0.4995 |
| 18 LOUISVILLE | 094 SALAMONIE | 684.0 | 793.0 | 680.0 | -7.61 | 13.91 | -6.429 | 1.465 | -0.1136 |
| 18 LOUISVILLE | 095 C M HARDEN (MAN | 597.0 | 712.0 | 597.0 | 11.83 | -12.57 | 6.691 | -1.250 | 0.0850 |
| 18 LOUISVILLE | 097 BROOKVILLE | 628.0 | 775.0 | 628.0 | 19.40 | -13.06 | 3.793 | -0.289 | 0.0000 |
| 18 LOUISVILLE | 120 BARREN RIVER | 478.0 | 618.0 | 484.4 | 5.44 | -2.05 | 1.945 | -0.349 | 0.0230 |
| 18 LOUISVILLE | 121 BUCKHORN | 715.0 | 840.0 | 715.0 | -25.32 | 35.99 | -15.030 | 2.814 | -0.1893 |
| 18 LOUISVILLE | 126 GREEN RIVER | 590.0 | 713.0 | 590.0 | 24.87 | -34.35 | 17.247 | -3.261 | 0.2199 |
| 18 LOUISVILLE | 128 NOLIN RIVER | 415.0 | 560.0 | 415.0 | -2.10 | 6.11 | -2.316 | 0.558 | -0.0431 |
| 18 LOUISVILLE | 129 ROUGH RIVER | 430.0 | 524.0 | 420.7 | 25.73 | -29.79 | 13.383 | -2.278 | 0.1396 |
| 18 LOUISVILLE | 134 CAVE RUN | 656.0 | 765.0 | 656.0 | -27.30 | 19.81 | -3.435 | 0.226 | 0.0000 |
| 18 LOUISVILLE | 260 WEST FORK OF MI | 636.0 | 702.0 | 636.0 | -14.53 | 7.85 | -0.512 | 0.000 | 0.0000 |
| 18 LOUISVILLE | 263 CLARENCE J BROW | 965.0 | 1023.0 | 965.0 | -4.90 | 5.22 | -0.295 | -0.005 | 0.0000 |
| 19 NASHVILLE | 119 BARKLEY | 280.0 | 375.0 | 280.0 | -475.55 | 506.89 | -197.200 | 33.812 | -2.1433 |
| 19 NASHVILLE | 122 CUMBERLAND (WOL | 545.0 | 773.0 | 545.0 | 41.51 | -35.57 | 13.033 | -1.896 | 0.0998 |
| 19 NASHVILLE | 337 CENTER HILL | 525.0 | 685.0 | 477.7 | 11.50 | -4.81 | 1.707 | -0.131 | 0.0000 |
| 19 NASHVILLE | 338 CHEATHAM | 345.0 | 399.0 | 345.0 | -26.45 | 30.02 | -8.659 | 0.899 | 0.0000 |
| 19 NASHVILLE | 340 J PERCY PRIEST | 405.0 | 504.5 | 399.6 | -25.64 | 21.84 | -4.736 | 0.396 | 0.0000 |
| 19 NASHVILLE | 342 OLD HICKORY | 385.0 | 450.1 | 385.0 | 18.12 | -16.50 | 9.331 | -2.094 | 0.1769 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 19 NASHVILLE | 343 DALE HOLLOW | 508.0 | 663.0 | 508.0 | 25.48 | -16.71 | 4.759 | -0.373 | 0.0000 |
| 20 ST LOUIS | 081 CARLYLE | 406.0 | 465.0 | 406.0 | -82.81 | 97.80 | -39.983 | 7.462 | -0.5176 |
| 20 ST LOUIS | 087 SHELBYVILLE | 546.0 | 626.0 | 546.0 | 4.71 | 0.92 | 0.243 | 0.000 | 0.0000 |
| 20 ST LOUIS | 088 REND | 379.0 | 411.4 | 379.0 | 39.95 | -46.10 | 24.148 | -5.265 | 0.4269 |
| 21 MEMPHIS | 196 WAPPAPELLO | 320.0 | 420.0 | 310.5 | 69.94 | -77.44 | 31.480 | -5.163 | 0.3050 |
| 22 VICKSBURG | 014 DE GRAY | 210.0 | 450.0 | 210.0 | -6.22 | 7.52 | -1.613 | 0.187 | -0.0035 |
| 22 VICKSBURG | 018 GREESON (NARROW | 396.0 | 586.0 | 396.0 | -6.03 | 5.06 | -0.574 | 0.060 | 0.0000 |
| 22 VICKSBURG | 019 OUACHITA (BLAKE | 380.0 | 616.0 | 380.0 | 9.33 | -9.07 | 4.029 | -0.540 | 0.0261 |
| 22 VICKSBURG | 188 ARKABUTLA | 189.0 | 264.0 | 189.0 | 3.87 | -6.15 | 6.251 | -1.561 | 0.1331 |
| 22 VICKSBURG | 189 ENID | 194.0 | 293.0 | 194.0 | -33.25 | 25.88 | -5.197 | 0.395 | 0.0000 |
| 22 VICKSBURG | 190 GRENADA | 160.0 | 256.0 | 160.0 | 82.72 | -93.62 | 40.957 | -7.485 | 0.5027 |
| 22 VICKSBURG | 192 SARDIS | 204.0 | 311.0 | 204.0 | 20.38 | -22.43 | 11.710 | -2.275 | 0.1596 |
| 23 NEW ORLEANS | 138 WALLACE | 130.0 | 176.0 | 130.0 | -16.65 | 22.08 | -7.123 | 1.110 | -0.0600 |
| 23 NEW ORLEANS | 352 LAKE OF THE PIN | 185.0 | 255.0 | 180.1 | 20.35 | -30.95 | 16.637 | -3.203 | 0.2153 |
| 23 NEW ORLEANS | 353 TEXARKANA(WRIGH | 180.0 | 265.0 | 180.0 | -23.90 | 14.23 | -1.232 | 0.000 | 0.0000 |
| 23 NEW ORLEANS | 413 CADDO | 160.0 | 184.0 | 160.0 | 7.80 | 1.97 | -0.084 | 0.012 | 0.0000 |
| 24 LITTLE ROCK | 011 BEAVER | 914.0 | 1142.0 | 914.0 | -11.71 | 9.47 | -1.476 | 0.115 | 0.0000 |
| 24 LITTLE ROCK | 012 BLUE MOUNTAIN | 354.0 | 445.0 | 348.7 | 4.85 | -4.55 | 2.677 | -0.278 | 0.0000 |
| 24 LITTLE ROCK | 013 BULL SHOALS | 452.0 | 708.0 | 452.0 | 14.83 | -11.66 | 5.246 | -0.839 | 0.0499 |
| 24 LITTLE ROCK | 016 GREERS FERRY | 272.0 | 503.0 | 272.0 | -16.46 | 23.62 | -9.395 | 1.751 | -0.1152 |
| 24 LITTLE ROCK | 017 DARDANELLE | 287.0 | 354.0 | 287.0 | 5.40 | 0.54 | 0.330 | 0.007 | 0.0000 |
| 24 LITTLE ROCK | 021 NIMROD | 300.0 | 400.0 | 300.0 | 41.73 | -33.38 | 9.889 | -0.859 | 0.0000 |
| 24 LITTLE ROCK | 022 NORFOLK | 380.0 | 590.0 | 363.3 | 0.08 | -3.36 | 3.238 | -0.602 | 0.0388 |
| 24 LITTLE ROCK | 023 OZARK | 365.4 | 382.0 | 323.0 | 149.66 | -190.53 | 92.589 | -19.431 | 1.5114 |
| 24 LITTLE ROCK | 193 CLEARWATER | 460.0 | 608.0 | 460.0 | 0.41 | 0.75 | 1.511 | -0.380 | 0.0311 |
| 24 LITTLE ROCK | 200 TABLE ROCK | 695.0 | 947.0 | 695.0 | -6.14 | 6.21 | -0.780 | 0.065 | 0.0000 |
| 25 TULSA | 020 MILLWOOD | 213.0 | 287.0 | 213.0 | 129.96 | -113.15 | 33.325 | -3.084 | 0.0000 |
| 25 TULSA | 102 COUNCIL GROVE | 1224.0 | 1289.0 | 1224.0 | 14.00 | -13.64 | 5.483 | -0.563 | 0.0000 |
| 25 TULSA | 103 ELK CITY | 760.0 | 825.0 | 760.0 | -4.02 | 14.76 | -8.002 | 2.053 | -0.1809 |
| 25 TULSA | 104 FALL RIVER | 917.0 | 988.0 | 917.0 | 51.63 | -60.24 | 27.815 | -5.282 | 0.3675 |
| 25 TULSA | 105 JOHN REDMOND | 1009.0 | 1076.0 | 1009.0 | 79.39 | -107.30 | 54.219 | -11.317 | 0.8581 |
| 25 TULSA | 107 MARION | 1308.0 | 1363.0 | 1308.0 | 37.05 | -49.57 | 26.155 | -5.541 | 0.4279 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 25 TULSA | 112 TORONTO | 862.0 | 942.0 | 862.0 | 15.30 | -16.78 | 7.353 | -1.039 | 0.0467 |
| 25 TULSA | 264 BROKEN BOW | 424.0 | 628.0 | 424.0 | 8.54 | -8.79 | 4.606 | -0.745 | 0.0426 |
| 25 TULSA | 265 CANTON | 1580.0 | 1638.0 | 1580.0 | 9.83 | -9.14 | 6.436 | -1.476 | 0.1208 |
| 25 TULSA | 266 CHOUTEAU | 480.0 | 530.0 | 480.0 | 6.53 | -3.24 | 1.875 | -0.185 | 0.0000 |
| 25 TULSA | 267 EUFAULA | 495.0 | 612.0 | 495.0 | -11.20 | 10.35 | -1.104 | -0.094 | 0.0249 |
| 25 TULSA | 268 FORT GIBSON | 550.6 | 582.0 | 465.8 | -8.76 | 4.99 | -0.039 | 0.000 | 0.0000 |
| 25 TULSA | 269 FORT SUPPLY | 1988.0 | 2028.0 | 1988.0 | 2.74 | 3.49 | -0.735 | 0.168 | -0.0138 |
| 25 TULSA | 270 GREAT SALT PLAI | 1115.0 | 1138.5 | 1115.0 | -5.05 | 12.53 | -3.432 | 0.388 | 0.0000 |
| 25 TULSA | 271 HEYBURN | 730.0 | 792.0 | 730.0 | -38.41 | 57.48 | -28.794 | 6.473 | -0.5239 |
| 25 TULSA | 272 HULAH | 696.0 | 765.0 | 696.0 | 26.60 | -21.56 | 7.147 | -0.670 | 0.0000 |
| 25 TULSA | 273 KEYSTONE | 648.0 | 760.0 | 654.0 | 7.47 | -0.29 | 0.472 | -0.017 | 0.0000 |
| 25 TULSA | 274 NEWT GRAHAM | 500.0 | 550.0 | 487.2 | -2.21 | 4.03 | -0.343 | 0.034 | 0.0000 |
| 25 TULSA | 275 OOLOGAH | 592.0 | 661.0 | 586.3 | 12.02 | -4.06 | 1.611 | -0.128 | 0.0000 |
| 25 TULSA | 276 PINE CREEK | 384.0 | 480.0 | 384.0 | -36.97 | 48.65 | -20.999 | 4.136 | -0.2945 |
| 25 TULSA | 277 ROBERT S KERR | 412.0 | 472.0 | 412.0 | 19.21 | -12.96 | 4.418 | -0.382 | 0.0000 |
| 25 TULSA | 278 TENKILLER FERRY | 594.0 | 667.0 | 483.7 | -2.11 | 4.04 | -0.331 | 0.029 | 0.0000 |
| 25 TULSA | 279 W D MAYO | 390.0 | 414.0 | 390.0 | 4.32 | -0.67 | 1.890 | -0.540 | 0.0566 |
| 25 TULSA | 280 WEBBERS FALLS | 438.0 | 520.0 | 438.0 | -13.79 | 15.19 | -3.596 | 0.355 | 0.0000 |
| 25 TULSA | 281 WISTER | 436.0 | 510.0 | 436.0 | 56.89 | -48.44 | 14.765 | -1.362 | 0.0000 |
| 25 TULSA | 282 CLAYTON | 530.0 | 611.0 | 530.0 | 58.68 | -72.41 | 33.744 | -6.433 | 0.4477 |
| 25 TULSA | 283 KAW | 931.0 | 1070.0 | 931.0 | 4.86 | -5.30 | 4.077 | -0.807 | 0.0569 |
| 25 TULSA | 284 COPAN | 670.0 | 732.0 | 670.0 | 175.79 | -206.25 | 89.505 | -16.551 | 1.1262 |
| 25 TULSA | 285 HUGO | 360.0 | 438.0 | 360.0 | 11.68 | -14.64 | 7.871 | -1.343 | 0.0765 |
| 25 TULSA | 286 OPTIMA | 2703.0 | 2779.0 | 2703.0 | -9.81 | 11.49 | -2.368 | 0.207 | 0.0000 |
| 25 TULSA | 287 WAURIKA | 890.0 | 970.0 | 890.0 | 30.29 | -41.85 | 22.048 | -4.525 | 0.3350 |
| 25 TULSA | 348 TEXOMA (DENNISO | 520.0 | 643.2 | 520.0 | 31.13 | -33.18 | 15.434 | -2.817 | 0.1877 |
| 25 TULSA | 357 PAT MAYSE | 393.0 | 477.0 | 393.0 | 62.67 | -78.96 | 37.845 | -7.478 | 0.5385 |
| 25 TULSA | 370 KEMP | 1090.0 | 1160.0 | 1079.1 | -24.30 | 29.44 | -10.172 | 1.632 | -0.0908 |
| 25 TULSA | 402 GILLHAM | 430.0 | 586.0 | 430.0 | 11.25 | -11.96 | 5.980 | -1.036 | 0.0657 |
| 26 FORT WORTH | 344 BARDWELL | 380.0 | 439.0 | 380.0 | -5.60 | 6.43 | -0.633 | 0.025 | 0.0000 |
| 26 FORT WORTH | 345 BELTON(BELL) | 480.0 | 631.0 | 480.0 | -6.10 | 8.95 | -3.185 | 0.723 | -0.0569 |
| 26 FORT WORTH | 346 BENBROOK | 620.0 | 741.0 | 618.7 | 0.13 | 3.00 | -1.478 | 0.571 | -0.0580 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 26 FORT WORTH | 347 CANYON | 750.0 | 970.0 | 750.0 | -41.33 | 37.04 | -11.999 | 1.933 | -0.1167 |
| 26 FORT WORTH | 349 GRAPEVINE | 470.0 | 581.0 | 470.0 | 9.67 | -10.47 | 6.352 | -1.259 | 0.0891 |
| 26 FORT WORTH | 351 HORDS CREEK | 1854.0 | 1920.0 | 1854.0 | -1.40 | 4.23 | -1.081 | 0.246 | -0.0174 |
| 26 FORT WORTH | 354 LAVON | 443.0 | 503.5 | 440.1 | -2.04 | 5.24 | 0.134 | -0.256 | 0.0331 |
| 26 FORT WORTH | 355 LEWISVILLE(GARZ | 455.0 | 535.6 | 455.0 | 18.48 | -22.74 | 13.047 | -2.792 | 0.2155 |
| 26 FORT WORTH | 356 NAVARRO MILLS | 390.0 | 452.0 | 390.0 | 4.03 | -2.71 | 2.956 | -0.638 | 0.0497 |
| 26 FORT WORTH | 358 PROCTOR | 1120.0 | 1201.0 | 1120.0 | -52.45 | 56.85 | -20.814 | 3.572 | -0.2293 |
| 26 FORT WORTH | 359 SAM RAYBURN (MC | 80.0 | 183.0 | 80.0 | 67.90 | -75.96 | 32.968 | -5.883 | 0.3842 |
| 26 FORT WORTH | 360 O C FISHER (SAN | 1840.0 | 1958.0 | 1837.0 | -6.01 | 5.85 | -0.395 | -0.045 | 0.0104 |
| 26 FORT WORTH | 361 SOMERVILLE | 200.0 | 275.0 | 200.0 | 15.91 | -22.26 | 13.915 | -3.134 | 0.2501 |
| 26 FORT WORTH | 362 STILLHOUSE HOLL | 498.0 | 693.0 | 498.0 | 3.41 | 1.65 | -0.936 | 0.353 | -0.0311 |
| 26 FORT WORTH | 363 WACO | 400.0 | 470.9 | 322.9 | -174.63 | 69.63 | -6.436 | 0.000 | 0.0000 |
| 26 FORT WORTH | 364 WHITNEY | 429.0 | 571.0 | 429.0 | -18.27 | 26.13 | -10.429 | 1.946 | -0.1285 |
| 26 FORT WORTH | 371 B A STEINHAGEN | 50.0 | 90.0 | 40.0 | 6.47 | -3.51 | 1.285 | 0.000 | 0.0000 |
| 28 ALBUQUERQUE | 065 JOHN MARTIN (HA | 3765.0 | 3870.0 | 3765.0 | 36.93 | -50.42 | 25.334 | -4.985 | 0.3515 |
| 28 ALBUQUERQUE | 218 ABIQUIU | 6060.0 | 6362.0 | 6060.0 | -9.49 | 1.10 | 1.944 | -0.359 | 0.0197 |
| 28 ALBUQUERQUE | 219 CONCHAS | 4071.0 | 4235.0 | 4071.0 | 73.77 | -101.18 | 45.649 | -8.212 | 0.5289 |
| 28 ALBUQUERQUE | 407 TRINIDAD | 6081.0 | 6281.0 | 6081.0 | 1.64 | -3.08 | 2.482 | -0.450 | 0.0305 |
| 29 KANSAS CITY | 100 RATHBUN | 855.0 | 946.0 | 855.0 | 4.69 | -1.77 | 2.307 | -0.497 | 0.0384 |
| 29 KANSAS CITY | 106 KANOPOLIS | 1430.0 | 1537.0 | 1430.0 | -2.31 | 12.46 | -5.489 | 1.153 | -0.0837 |
| 29 KANSAS CITY | 108 MILFORD | 1141.2 | 1176.2 | 1067.0 | 0.12 | 2.65 | 0.156 | -0.028 | 0.0018 |
| 29 KANSAS CITY | 109 MELVERN | 958.0 | 1073.0 | 958.0 | 4.42 | -2.86 | 1.637 | -0.134 | 0.0000 |
| 29 KANSAS CITY | 110 PERRY | 820.0 | 922.0 | 820.0 | 79.06 | -83.49 | 33.075 | -5.389 | 0.3197 |
| 29 KANSAS CITY | 111 POMONA | 942.0 | 1006.0 | 928.7 | 2.19 | 2.03 | 0.121 | -0.010 | 0.0000 |
| 29 KANSAS CITY | 113 TUTTLE CREEK | 1010.0 | 1140.0 | 973.0 | 131.64 | -144.99 | 56.837 | -9.231 | 0.5451 |
| 29 KANSAS CITY | 114 WILSON | 1430.0 | 1582.0 | 1425.0 | -9.24 | 6.11 | -0.291 | 0.000 | 0.0000 |
| 29 KANSAS CITY | 194 POMME DE TERRE | 750.0 | 874.0 | 750.0 | 9.51 | -7.41 | 3.870 | -0.639 | 0.0393 |
| 29 KANSAS CITY | 195 STOCKTON | 760.0 | 892.0 | 760.0 | 35.71 | -48.01 | 22.723 | -4.132 | 0.2679 |
| 29 KANSAS CITY | 207 HARLAN COUNTY | 1880.0 | 1982.0 | 1880.0 | -10.97 | 11.34 | -2.020 | 0.157 | 0.0000 |
| 30 OMAHA | 064 CHERRY CREEK | 5523.0 | 5640.0 | 5523.0 | -4.99 | 12.21 | -4.524 | 0.834 | -0.0548 |
| 30 OMAHA | 203 FORT PECK | 2033.0 | 2251.6 | 2033.0 | 3.49 | 0.28 | 1.022 | -0.162 | 0.0089 |
| 30 OMAHA | 208 OLIVE CREEK | 1310.0 | 1357.0 | 1310.0 | 4.67 | -7.99 | 6.050 | -1.405 | 0.1169 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 30 OMAHA | 209 BLUESTEM | 1276.0 | 1332.0 | 1276.0 | 52.84 | -69.06 | 34.114 | -7.009 | 0.5308 |
| 30 OMAHA | 210 WAGON TRAIN | 1256.0 | 1309.0 | 1256.0 | -20.30 | 31.42 | -16.223 | 3.911 | -0.3376 |
| 30 OMAHA | 211 STAGECOACH | 1248.0 | 1291.0 | 1248.0 | -14.23 | 22.27 | -10.062 | 2.201 | -0.1752 |
| 30 OMAHA | 212 YANKEE HILL | 1219.0 | 1267.0 | 1219.0 | 12.42 | -16.99 | 10.203 | -2.272 | 0.1848 |
| 30 OMAHA | 213 CONESTOGA | 1197.0 | 1258.0 | 1197.0 | -17.31 | 21.34 | -8.665 | 1.787 | -0.1350 |
| 30 OMAHA | 214 TWIN | 1306.0 | 1361.0 | 1306.0 | 10.68 | -11.47 | 5.619 | -0.933 | 0.0559 |
| 30 OMAHA | 215 PAWNEE | 1206.0 | 1269.0 | 1206.0 | 31.11 | -41.80 | 21.170 | -4.245 | 0.3094 |
| 30 OMAHA | 216 HOLMES PARK | 1216.0 | 1269.0 | 1216.0 | 14.92 | -14.48 | 5.776 | -0.731 | 0.0250 |
| 30 OMAHA | 217 BRANCHED OAK | 1250.0 | 1317.0 | 1250.0 | 21.50 | -21.49 | 10.626 | -2.065 | 0.1477 |
| 30 OMAHA | 234 BOWMAN HALEY | 2715.0 | 2781.0 | 2715.0 | -2.45 | 3.72 | -0.181 | 0.023 | 0.0000 |
| 30 OMAHA | 235 SAKAKAWEA(GARRI | 1668.0 | 1860.0 | 1668.0 | 21.36 | -24.75 | 12.162 | -2.169 | 0.1373 |
| 30 OMAHA | 331 SHARPE (BIG BEN | 1340.0 | 1430.0 | 1340.0 | -19.41 | 19.20 | -4.085 | 0.334 | 0.0000 |
| 30 OMAHA | 332 COLD BROOK | 3578.0 | 3666.0 | 3544.6 | -1.64 | 1.59 | 0.142 | 0.000 | 0.0000 |
| 30 OMAHA | 334 FRANCIS CASE (F | 1227.0 | 1390.0 | 1240.0 | -12.50 | 14.45 | -2.931 | 0.234 | 0.0000 |
| 30 OMAHA | 335 LEWIS AND CLARK | 1160.0 | 1230.0 | 1160.0 | 10.11 | -5.34 | 2.527 | -0.246 | 0.0000 |
| 30 OMAHA | 336 OAHE | 1420.0 | 1620.0 | 1420.0 | 0.10 | 5.82 | -0.938 | 0.083 | 0.0000 |
| 30 OMAHA | 415 CHATFIELD | 5380.0 | 5530.0 | 5380.0 | -14.10 | 11.50 | -1.859 | 0.128 | 0.0000 |
| 31 WALLA WALLA | 077 DWORSHAK | 970.0 | 1640.0 | 970.0 | -0.19 | 2.60 | -0.184 | 0.023 | 0.0000 |
| 31 WALLA WALLA | 078 LUCKY PEAK | 2822.0 | 3080.0 | 2827.0 | 14.92 | -17.44 | 8.272 | -1.405 | 0.0845 |
| 31 WALLA WALLA | 079 RIRIE | 5023.0 | 5119.0 | 4922.0 | -6.13 | 3.01 | 0.107 | -0.008 | 0.0000 |
| 31 WALLA WALLA | 379 ICE HARBOR | 375.0 | 440.0 | 375.0 | 7.31 | 1.34 | 0.000 | 0.000 | 0.0000 |
| 32 SEATTLE | 080 ALBENI FALLS (P | 2048.1 | 2062.5 | 1951.7 | 7.08 | 1.81 | 0.000 | 0.000 | 0.0000 |
| 32 SEATTLE | 204 KOOKANUSA(LIBBY | 2110.0 | 2459.1 | 2110.0 | 9.85 | -11.24 | 5.503 | -0.863 | 0.0477 |
| 32 SEATTLE | 377 RUFUS WOODS (CH | 785.0 | 956.0 | 780.0 | -1.29 | 7.80 | -2.658 | 0.477 | -0.0289 |
| 32 SEATTLE | 384 MUD MOUNTAIN | 910.0 | 1241.0 | 895.0 | 10.02 | -6.23 | 1.801 | -0.117 | 0.0000 |
| 32 SEATTLE | 385 WYNOOCHEE | 640.0 | 800.0 | 640.0 | -18.04 | 20.53 | -7.646 | 1.420 | -0.0960 |
| 32 SEATTLE | 386 HOWARD A HANSON | 1035.0 | 1222.4 | 1035.0 | -0.20 | 5.91 | -2.667 | 0.605 | -0.0434 |
| 33 PORTLAND | 288 BLUE RIVER | 1102.0 | 1357.0 | 1102.0 | -3.12 | 4.19 | -0.707 | 0.092 | -0.0029 |
| 33 PORTLAND | 290 COTTAGE GROVE | 719.0 | 802.6 | 719.0 | -7.36 | 5.85 | -0.412 | 0.003 | 0.0000 |
| 33 PORTLAND | 291 COUGAR | 1274.0 | 1699.0 | 1274.0 | -6.27 | 5.55 | -1.159 | 0.199 | -0.0125 |
| 33 PORTLAND | 292 CELILO (DALLES) | 155.0 | 160.0 | 103.6 | 5.26 | 1.85 | 0.000 | 0.000 | 0.0000 |
| 33 PORTLAND | 293 DETROIT | 1200.0 | 1569.0 | 1200.0 | -2.38 | 0.99 | 0.528 | -0.043 | 0.0000 |

MORPHOMETRIC CURVE PARAMETERS

| DIS | RES | EMIN | EMAX | EZERO | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|---|---|
| 33 PORTLAND | 294 DEXTER | 690.0 | 695.0 | 654.1 | 4.69 | 1.49 | 0.000 | 0.000 | 0.0000 |
| 33 PORTLAND | 295 DORENA | 735.0 | 850.0 | 735.0 | -13.94 | 13.07 | -2.638 | 0.215 | 0.0000 |
| 33 PORTLAND | 296 FALL CREEK | 673.0 | 839.0 | 673.0 | -2.33 | 5.69 | -1.626 | 0.319 | -0.0222 |
| 33 PORTLAND | 297 FERN RIDGE | 339.0 | 375.1 | 339.0 | -4.96 | 9.05 | -2.031 | 0.222 | 0.0000 |
| 33 PORTLAND | 298 FOSTER | 525.0 | 640.0 | 525.0 | 37.77 | -26.40 | 7.094 | -0.573 | 0.0000 |
| 33 PORTLAND | 299 GREEN PETER | 700.0 | 1015.0 | 700.0 | -2.19 | -0.39 | 1.052 | -0.092 | 0.0000 |
| 33 PORTLAND | 300 HILLS CREEK | 1245.0 | 1544.0 | 1245.0 | 3.57 | -0.86 | 1.144 | -0.190 | 0.0116 |
| 33 PORTLAND | 302 LOOKOUT POINT | 688.0 | 934.0 | 688.0 | -14.20 | 19.74 | -6.603 | 1.017 | -0.0554 |
| 33 PORTLAND | 304 LOST CREEK | 1550.0 | 1850.0 | 1550.0 | 16.94 | -8.34 | 2.145 | -0.141 | 0.0000 |
| 33 PORTLAND | 305 BIG CLIFF | 1193.0 | 1206.0 | 1121.0 | 0.01 | 1.97 | 0.000 | 0.000 | 0.0000 |
| 34 SACRAMENTO | 024 BLACK BUTTE | 381.0 | 490.0 | 381.0 | 0.36 | 5.43 | -2.296 | 0.593 | -0.0498 |
| 34 SACRAMENTO | 026 ENGLEBRIGHT | 295.0 | 550.0 | 295.0 | 5.16 | -5.29 | 3.083 | -0.538 | 0.0344 |
| 34 SACRAMENTO | 028 ISABELLA | 2455.0 | 2620.0 | 2455.0 | 28.92 | -21.60 | 6.160 | -0.494 | 0.0000 |
| 34 SACRAMENTO | 030 MARTIS CREEK | 5745.0 | 5853.0 | 5745.0 | -7.14 | 4.30 | -0.117 | 0.000 | 0.0000 |
| 34 SACRAMENTO | 032 NEW HOGAN | 535.0 | 720.0 | 535.0 | 4.15 | 0.97 | -0.304 | 0.169 | -0.0164 |
| 34 SACRAMENTO | 033 PINE FLAT | 565.5 | 960.0 | 565.5 | -23.46 | 14.21 | -2.002 | 0.112 | 0.0000 |
| 34 SACRAMENTO | 036 SUCCESS | 538.0 | 690.0 | 538.0 | 9.23 | -10.63 | 5.915 | -1.133 | 0.0797 |
| 34 SACRAMENTO | 037 KAWEAH (TERMINU | 507.0 | 720.0 | 507.0 | -5.82 | 8.61 | -2.888 | 0.565 | -0.0389 |
| 34 SACRAMENTO | 041 FOLSOM | 240.0 | 466.0 | 240.0 | -17.27 | 24.04 | -8.395 | 1.329 | -0.0744 |
| 34 SACRAMENTO | 043 NEW BULLARDS BA | 1600.0 | 1960.0 | 1344.7 | -7.16 | 4.41 | -0.426 | 0.052 | -0.0021 |
| 34 SACRAMENTO | 044 CAMANCHE | 104.0 | 234.8 | 89.5 | 9.41 | -10.12 | 5.594 | -1.022 | 0.0674 |
| 34 SACRAMENTO | 047 CHERRY VALLEY | 4430.0 | 4700.0 | 4430.0 | 65.89 | -68.46 | 25.686 | -3.898 | 0.2125 |
| 34 SACRAMENTO | 048 NEW DON PEDRO | 550.0 | 830.0 | 355.6 | 0.78 | -1.42 | 1.499 | -0.214 | 0.0109 |
| 34 SACRAMENTO | 051 MCCLURE (NEW EX | 440.0 | 870.0 | 410.5 | 2.88 | -4.33 | 2.631 | -0.403 | 0.0223 |
| 34 SACRAMENTO | 054 MILLERTON (FRIA | 375.0 | 580.0 | 285.4 | -0.12 | -0.87 | 1.486 | -0.241 | 0.0140 |
| 35 SAN FRANCISCO | 029 MENDOCINO | 637.0 | 800.0 | 640.0 | 1.26 | 3.85 | -1.536 | 0.423 | -0.0368 |
| 35 SAN FRANCISCO | 039 SANTA MARGARITA | 1190.0 | 1320.0 | 1190.0 | -8.99 | 9.27 | -2.815 | 0.520 | -0.0335 |
| 36 LOS ANGELES | 009 ALAMO | 1040.0 | 1259.0 | 960.0 | -71.20 | 37.94 | -6.027 | 0.351 | 0.0000 |
| 36 LOS ANGELES | 027 HANSEN | 990.0 | 1087.0 | 990.0 | 19.61 | -18.61 | 8.395 | -1.469 | 0.0943 |

# APPENDIX B

## Data Listings

This appendix summarizes the mass balance terms by reservoir and nutrient for each of 108 reservoirs sampled by the U. S. Environmental Protection Agency's National Eutrophication Survey, and high- and low-priority water quality data by station-year and reservoir-year.

Table B1: Nutrient Budget Summaries

Table B2: Water Balances and Inflow Concentrations by Period

Table B3: Water Quality Data Summary by Station-Year

Table B4: Water Quality Data Summary by Reservoir-Year

Table B1

Nutrient Budget Summaries

| Symbol | Meaning |
|---|---|
| DIS | CE District code |
| RES | CE reservoir code |
| PARAM | Total P, Ortho P, Total N, Inorg N in metric tons/yr; Flow in million $m^3$/yr) |
| LGAUG | gauged tributary loading |
| LUNGD | ungauged tributary loading |
| LPOINT | point-source loading |
| LOTHER | septic tank/wildfowl loading |
| LPREC | precipitation loading |
| LTOTAL | total loading |
| LEVAP | evaporation (FLOW only) |
| LOUT | outflow |
| LDSTOR | change in storage |
| LNET | net loading |
| CVI | coefficient of variation of total loading estimate |
| CVO | coefficient of variation of total outflow estimate |

Note: Hydrologic conditions refer to year of tributary monitoring by EPA National Eutrophication Survey, as identified in Table 4, Part III of the main text.

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | TOTAL P | 4.67 | 2.20 | 0.00 | 0.00 | 0.10 | 6.97 | . | 5.30 | 0.20 | 1.48 | 0.18 | 0.21 |
| 02 | 176 | ORTHO P | 1.40 | 0.59 | 0.00 | 0.00 | 0.05 | 2.04 | . | 1.70 | 0.06 | 0.28 | 0.09 | 0.13 |
| 02 | 176 | TOTAL N | 202.32 | 70.40 | 0.00 | 0.00 | 3.25 | 275.97 | . | 177.71 | 6.56 | 91.69 | 0.21 | 0.06 |
| 02 | 176 | INORG N | 101.40 | 47.33 | 0.00 | 0.00 | 1.62 | 150.36 | . | 116.32 | 4.30 | 29.74 | 0.11 | 0.09 |
| 02 | 176 | FLOW | 181.92 | 115.01 | . | . | 3.84 | 300.76 | 2.07 | 294.73 | 10.81 | -4.77 | . | . |
| 03 | 307 | TOTAL P | 2.41 | 0.27 | 0.00 | 0.00 | 0.11 | 2.79 | . | 2.26 | -0.02 | 0.55 | 0.10 | 0.13 |
| 03 | 307 | ORTHO P | 1.15 | 0.18 | 0.00 | 0.00 | 0.06 | 1.39 | . | 1.40 | -0.01 | -0.00 | 0.06 | 0.11 |
| 03 | 307 | TOTAL N | 219.45 | 17.50 | 0.00 | 0.00 | 3.77 | 240.72 | . | 239.08 | -2.14 | 3.78 | 0.08 | 0.13 |
| 03 | 307 | INORG N | 141.45 | 2.78 | 0.00 | 0.00 | 1.88 | 146.11 | . | 153.73 | -1.37 | -6.24 | 0.04 | 0.04 |
| 03 | 307 | FLOW | 180.25 | 24.76 | . | . | 5.44 | 210.45 | 3.07 | 211.01 | -1.86 | 1.31 | . | . |
| 04 | 312 | TOTAL P | 79.29 | 0.46 | 0.00 | 0.00 | 0.14 | 79.90 | . | 38.19 | -0.63 | 42.33 | 0.27 | 0.25 |
| 04 | 312 | ORTHO P | 50.44 | 0.19 | 0.00 | 0.00 | 0.07 | 50.70 | . | 19.17 | -0.31 | 31.85 | 0.22 | 0.19 |
| 04 | 312 | TOTAL N | 1237.63 | 35.71 | 0.00 | 0.00 | 4.70 | 1278.05 | . | 936.66 | -15.34 | 356.73 | 0.18 | 0.09 |
| 04 | 312 | INORG N | 829.73 | 24.61 | 0.00 | 0.00 | 2.35 | 856.69 | . | 569.79 | -9.33 | 296.23 | 0.14 | 0.10 |
| 04 | 312 | FLOW | 457.91 | 16.12 | . | . | 4.38 | 478.41 | 3.47 | 464.17 | -7.54 | 21.78 | . | . |
| 06 | 372 | TOTAL P | 911.22 | 16.07 | 21.70 | 0.13 | 5.78 | 954.91 | . | 188.35 | -2.04 | 768.60 | 0.08 | 0.25 |
| 06 | 372 | ORTHO P | 234.25 | 4.67 | 21.70 | 0.13 | 2.89 | 263.65 | . | 97.00 | -1.05 | 167.69 | 0.05 | 0.31 |
| 06 | 372 | TOTAL N | 9141.73 | 277.03 | 127.96 | 5.07 | 192.58 | 9744.38 | . | 8894.00 | -96.10 | 946.47 | 0.12 | 0.19 |
| 06 | 372 | INORG N | 2349.56 | 43.30 | 127.96 | 5.07 | 96.29 | 2622.18 | . | 2194.51 | -23.71 | 451.39 | 0.08 | 0.09 |
| 06 | 372 | FLOW | 6854.18 | 316.67 | . | . | 238.95 | 7409.80 | 196.10 | 7455.71 | -78.44 | 32.52 | . | . |
| 08 | 074 | TOTAL P | 620.02 | 26.64 | 0.00 | 0.07 | 8.43 | 655.17 | . | 278.79 | 2.73 | 373.65 | 0.17 | 0.14 |
| 08 | 074 | ORTHO P | 174.29 | 8.75 | 0.00 | 0.07 | 4.22 | 187.33 | . | 100.13 | 0.98 | 86.22 | 0.14 | 0.13 |
| 08 | 074 | TOTAL N | 7369.71 | 544.22 | 0.00 | 2.90 | 281.11 | 8197.94 | . | 10244.91 | 100.42 | -2147.39 | 0.14 | 0.30 |
| 08 | 074 | INORG N | 2983.32 | 98.25 | 0.00 | 2.90 | 140.55 | 3225.02 | . | 2582.20 | 25.31 | 617.51 | 0.10 | 0.07 |
| 08 | 074 | FLOW | 11126.09 | 516.23 | . | . | 417.81 | 12060.14 | 300.55 | 11779.20 | 112.52 | 168.42 | . | . |
| 08 | 330 | TOTAL P | 258.79 | 20.43 | 13.82 | 1.54 | 6.74 | 301.32 | . | 53.20 | 1.13 | 247.00 | 0.07 | 0.21 |
| 08 | 330 | ORTHO P | 90.85 | 8.21 | 13.82 | 1.54 | 3.37 | 117.78 | . | 33.30 | 0.71 | 83.78 | 0.05 | 0.13 |
| 08 | 330 | TOTAL N | 2899.53 | 663.37 | 30.75 | 54.44 | 224.67 | 3872.76 | . | 5824.66 | 123.40 | -2075.29 | 0.05 | 0.48 |
| 08 | 330 | INORG N | 1041.33 | 198.33 | 30.75 | 54.44 | 112.33 | 1437.18 | . | 1206.58 | 25.56 | 205.04 | 0.17 | 0.16 |
| 08 | 330 | FLOW | 4231.70 | 1175.38 | . | . | 372.65 | 5779.73 | 228.77 | 6028.37 | 122.86 | -371.51 | . | . |
| 10 | 003 | TOTAL P | 382.86 | 5.51 | 0.00 | 0.01 | 0.40 | 388.78 | . | 355.49 | -0.01 | 33.30 | 0.13 | 0.12 |
| 10 | 003 | ORTHO P | 110.82 | 1.22 | 0.00 | 0.01 | 0.20 | 112.25 | . | 108.41 | -0.00 | 3.84 | 0.13 | 0.16 |
| 10 | 003 | TOTAL N | 12607.88 | 197.19 | 0.00 | 0.10 | 13.30 | 12818.48 | . | 17388.39 | -0.68 | -4569.22 | 0.12 | 0.14 |
| 10 | 003 | INORG N | 6212.88 | 50.37 | 0.00 | 0.10 | 6.65 | 6270.02 | . | 8549.06 | -0.33 | -2278.71 | 0.05 | 0.08 |
| 10 | 003 | FLOW | 9834.54 | 216.67 | . | . | 22.77 | 10073.98 | 14.22 | 10382.79 | -0.41 | -308.41 | . | . |
| 10 | 069 | TOTAL P | 158.15 | 18.27 | 5.66 | 0.06 | 1.27 | 183.42 | . | 63.84 | 0.58 | 118.99 | 0.12 | 0.17 |
| 10 | 069 | ORTHO P | 31.26 | 2.92 | 5.66 | 0.06 | 0.64 | 40.53 | . | 21.38 | 0.20 | 18.95 | 0.08 | 0.10 |
| 10 | 069 | TOTAL N | 1525.93 | 194.12 | 8.75 | 2.20 | 42.38 | 1773.39 | . | 1393.04 | 12.74 | 367.61 | 0.07 | 0.17 |
| 10 | 069 | INORG N | 631.51 | 66.76 | 8.75 | 2.20 | 21.19 | 730.41 | . | 545.16 | 4.99 | 180.27 | 0.08 | 0.13 |
| 10 | 069 | FLOW | 2180.71 | 211.93 | . | . | 61.25 | 2453.90 | 42.08 | 2521.23 | 22.67 | -90.00 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 071 | TOTAL P | 2422.25 | 56.78 | 6.57 | 0.00 | 4.61 | 2490.21 | . | 2032.16 | 0.51 | 457.54 | 0.05 | 0.23 |
| 10 | 071 | ORTHO P | 772.93 | 22.19 | 6.57 | 0.00 | 2.31 | 804.00 | . | 611.16 | 0.15 | 192.68 | 0.04 | 0.16 |
| 10 | 071 | TOTAL N | 36414.34 | 418.50 | 8.42 | 0.00 | 153.81 | 36995.08 | . | 35764.79 | 8.93 | 1221.36 | 0.12 | 0.22 |
| 10 | 071 | INORG N | 11565.10 | 57.74 | 8.42 | 0.00 | 76.91 | 11708.17 | . | 8426.54 | 2.10 | 3279.53 | 0.10 | 0.14 |
| 10 | 071 | FLOW | 25614.89 | 526.55 | . | . | 332.06 | 26473.50 | 180.12 | 26977.91 | 6.69 | -511.09 | . | . |
| 10 | 072 | TOTAL P | 1179.01 | 8.64 | 7.26 | 0.04 | 5.26 | 1200.21 | . | 1129.43 | -1.05 | 71.84 | 0.05 | 0.12 |
| 10 | 072 | ORTHO P | 404.78 | 2.85 | 7.26 | 0.04 | 2.63 | 417.56 | . | 417.34 | -0.39 | 0.61 | 0.08 | 0.12 |
| 10 | 072 | TOTAL N | 12628.58 | 235.12 | 21.76 | 1.44 | 175.35 | 13062.25 | . | 14327.75 | -13.38 | -1252.11 | 0.09 | 0.16 |
| 10 | 072 | INORG N | 5276.80 | 48.59 | 21.76 | 1.44 | 87.68 | 5436.26 | . | 5782.92 | -5.40 | -341.25 | 0.10 | 0.08 |
| 10 | 072 | FLOW | 12201.20 | 305.57 | . | . | 331.45 | 12838.23 | 191.95 | 12705.19 | -11.69 | 144.72 | . | . |
| 10 | 076 | TOTAL P | 190.37 | 37.24 | 21.05 | 0.41 | 4.64 | 253.71 | . | 49.14 | 1.49 | 203.08 | 0.16 | 0.45 |
| 10 | 076 | ORTHO P | 64.29 | 12.97 | 21.05 | 0.41 | 2.32 | 101.04 | . | 13.82 | 0.42 | 86.80 | 0.13 | 0.03 |
| 10 | 076 | TOTAL N | 2362.66 | 800.54 | 43.08 | 15.27 | 154.64 | 3376.19 | . | 2121.15 | 64.28 | 1190.76 | 0.09 | 0.17 |
| 10 | 076 | INORG N | 1009.50 | 380.17 | 43.08 | 15.27 | 77.32 | 1525.35 | . | 1090.56 | 33.05 | 401.74 | 0.05 | 0.09 |
| 10 | 076 | FLOW | 2531.34 | 611.42 | . | . | 290.13 | 3432.90 | 161.41 | 2806.88 | 80.17 | 545.85 | . | . |
| 10 | 411 | TOTAL P | 583.76 | 6.53 | 0.00 | 0.02 | 1.16 | 591.48 | . | 500.67 | 0.31 | 90.50 | 0.14 | 0.26 |
| 10 | 411 | ORTHO P | 135.59 | 2.63 | 0.00 | 0.02 | 0.58 | 138.82 | . | 109.48 | 0.07 | 29.27 | 0.10 | 0.16 |
| 10 | 411 | TOTAL N | 15083.55 | 377.60 | 0.00 | 0.80 | 38.74 | 15500.70 | . | 14823.99 | 9.21 | 667.50 | 0.08 | 0.17 |
| 10 | 411 | INORG N | 8201.82 | 226.61 | 0.00 | 0.80 | 19.37 | 8448.60 | . | 6934.16 | 4.31 | 1510.13 | 0.09 | 0.06 |
| 10 | 411 | FLOW | 8935.34 | 268.25 | . | . | 65.18 | 9268.77 | 41.42 | 9560.48 | 5.91 | -297.63 | . | . |
| 14 | 099 | TOTAL P | 2968.73 | 34.79 | 4.93 | 0.00 | 1.54 | 3009.99 | . | 1081.88 | -44.01 | 1972.12 | 0.17 | 0.09 |
| 14 | 099 | ORTHO P | 878.24 | 6.19 | 4.93 | 0.00 | 0.77 | 890.13 | . | 599.07 | -24.37 | 315.43 | 0.07 | 0.14 |
| 14 | 099 | TOTAL N | 46139.88 | 333.60 | 14.79 | 0.00 | 51.48 | 46539.76 | . | 36354.27 | -1478.85 | 11664.33 | 0.10 | 0.06 |
| 14 | 099 | INORG N | 34912.38 | 89.80 | 14.79 | 0.00 | 25.74 | 35042.71 | . | 29650.63 | -1206.15 | 6598.24 | 0.12 | 0.07 |
| 14 | 099 | FLOW | 4830.95 | 95.12 | . | . | 36.48 | 4962.55 | 48.49 | 5027.89 | -202.56 | 137.22 | . | . |
| 15 | 178 | TOTAL P | 3.15 | 0.10 | 0.00 | 0.15 | 1.57 | 4.97 | . | 2.81 | 0.03 | 2.13 | 0.14 | 0.05 |
| 15 | 178 | ORTHO P | 0.74 | 0.04 | 0.00 | 0.15 | 0.79 | 1.72 | . | 1.13 | 0.01 | 0.57 | 0.19 | 0.19 |
| 15 | 178 | TOTAL N | 102.05 | 5.22 | 0.00 | 5.71 | 52.47 | 165.46 | . | 96.31 | 1.15 | 68.00 | 0.14 | 0.11 |
| 15 | 178 | INORG N | 10.86 | 0.21 | 0.00 | 5.71 | 26.24 | 43.03 | . | 7.77 | 0.09 | 35.16 | 0.25 | 0.23 |
| 15 | 178 | FLOW | 125.45 | 7.04 | . | . | 43.70 | 176.20 | 37.40 | 186.19 | 1.77 | -11.76 | . | . |
| 15 | 181 | TOTAL P | 8.25 | 1.26 | 1.75 | 0.00 | 13.59 | 24.87 | . | 8.19 | -1.30 | 17.97 | 0.22 | 0.27 |
| 15 | 181 | ORTHO P | 3.15 | 0.45 | 1.75 | 0.00 | 6.80 | 12.16 | . | 3.24 | -0.51 | 9.43 | 0.23 | 0.21 |
| 15 | 181 | TOTAL N | 636.76 | 82.23 | 5.27 | 0.18 | 453.09 | 1177.53 | . | 418.13 | -66.13 | 825.53 | 0.16 | 0.30 |
| 15 | 181 | INORG N | 36.68 | 6.09 | 5.27 | 0.18 | 226.55 | 274.77 | . | 160.68 | -25.41 | 139.50 | 0.33 | 0.75 |
| 15 | 181 | FLOW | 386.28 | 57.05 | . | . | 307.88 | 751.21 | 299.89 | 668.33 | -58.27 | 141.15 | . | . |
| 15 | 237 | TOTAL P | 43.62 | 3.44 | 1.68 | 0.03 | 0.63 | 49.40 | . | 36.73 | 0.29 | 12.38 | 0.22 | 0.14 |
| 15 | 237 | ORTHO P | 22.61 | 1.43 | 1.68 | 0.03 | 0.31 | 26.07 | . | 28.45 | 0.23 | -2.61 | 0.28 | 0.11 |
| 15 | 237 | TOTAL N | 418.09 | 38.22 | 5.05 | 1.06 | 20.98 | 483.39 | . | 361.21 | 2.88 | 119.30 | 0.20 | 0.07 |
| 15 | 237 | INORG N | 103.29 | 10.31 | 5.05 | 1.06 | 10.49 | 130.20 | . | 83.59 | 0.67 | 45.94 | 0.45 | 0.83 |
| 15 | 237 | FLOW | 159.44 | 13.01 | . | . | 11.50 | 183.95 | 16.02 | 179.35 | 1.30 | 3.30 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LOSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 243 | TOTAL P | 30.68 | 9.70 | 29.37 | 0.18 | 0.36 | 70.29 | . | 16.15 | -0.53 | 54.66 | 0.09 | 0.21 |
| 16 | 243 | ORTHO P | 8.75 | 2.45 | 29.37 | 0.18 | 0.18 | 40.92 | . | 5.88 | -0.19 | 35.24 | 0.08 | 0.23 |
| 16 | 243 | TOTAL N | 515.91 | 176.06 | 67.01 | 6.68 | 12.06 | 777.73 | . | 590.92 | -19.28 | 206.09 | 0.05 | 0.11 |
| 16 | 243 | INORG N | 294.58 | 107.10 | 67.01 | 6.68 | 6.03 | 481.41 | . | 326.58 | -10.66 | 165.49 | 0.07 | 0.12 |
| 16 | 243 | FLOW | 197.14 | 67.74 | . | . | 11.65 | 276.53 | 9.52 | 289.65 | -9.14 | -3.98 | . | . |
| 16 | 254 | TOTAL P | 5.42 | 7.28 | 3.62 | 0.00 | 0.89 | 17.22 | . | 5.58 | -0.09 | 11.73 | 0.60 | 0.15 |
| 16 | 254 | ORTHO P | 1.16 | 2.16 | 3.62 | 0.00 | 0.45 | 7.39 | . | 1.38 | -0.02 | 6.03 | 0.28 | 0.52 |
| 16 | 254 | TOTAL N | 73.11 | 105.88 | 7.71 | 0.00 | 29.76 | 216.47 | . | 165.69 | -2.74 | 53.52 | 0.27 | 0.21 |
| 16 | 254 | INORG N | 32.85 | 51.70 | 7.71 | 0.00 | 14.88 | 107.14 | . | 35.10 | -0.58 | 72.63 | 0.46 | 0.32 |
| 16 | 254 | FLOW | 37.18 | 51.07 | . | . | 27.98 | 116.23 | 22.73 | 117.52 | -1.57 | 0.27 | . | . |
| 16 | 317 | TOTAL P | 62.11 | 0.98 | 0.00 | 0.07 | 0.40 | 63.57 | . | 56.84 | -0.49 | 7.21 | 0.11 | 0.13 |
| 16 | 317 | ORTHO P | 22.50 | 0.39 | 0.00 | 0.07 | 0.20 | 23.16 | . | 10.81 | -0.09 | 12.44 | 0.11 | 0.14 |
| 16 | 317 | TOTAL N | 950.67 | 31.55 | 0.00 | 0.22 | 13.29 | 995.74 | . | 1210.77 | -10.36 | -204.68 | 0.06 | 0.08 |
| 16 | 317 | INORG N | 442.12 | 15.44 | 0.00 | 0.22 | 6.64 | 464.44 | . | 532.98 | -4.56 | -63.98 | 0.08 | 0.15 |
| 16 | 317 | FLOW | 633.26 | 19.73 | . | . | 11.93 | 664.92 | 10.15 | 821.84 | -6.94 | -149.97 | . | . |
| 16 | 328 | TOTAL P | 169.88 | 5.40 | 0.00 | 0.13 | 1.37 | 176.78 | . | 113.83 | -1.87 | 64.82 | 0.20 | 0.16 |
| 16 | 328 | ORTHO P | 44.71 | 1.97 | 0.00 | 0.13 | 0.69 | 47.50 | . | 32.79 | -0.54 | 15.25 | 0.14 | 0.31 |
| 16 | 328 | TOTAL N | 2335.95 | 273.44 | 0.00 | 0.67 | 45.69 | 2655.75 | . | 4744.08 | -78.01 | -2010.32 | 0.15 | 0.15 |
| 16 | 328 | INORG N | 1300.15 | 121.70 | 0.00 | 0.67 | 22.85 | 1445.37 | . | 2335.05 | -38.40 | -851.28 | 0.17 | 0.20 |
| 16 | 328 | FLOW | 3526.38 | 316.33 | . | . | 49.64 | 3892.35 | 31.41 | 3677.86 | -59.96 | 274.46 | . | . |
| 16 | 393 | TOTAL P | 51.12 | 7.50 | 0.00 | 0.01 | 0.18 | 58.81 | . | 93.13 | 0.02 | -34.35 | 0.11 | 0.41 |
| 16 | 393 | ORTHO P | 15.31 | 3.08 | 0.00 | 0.01 | 0.09 | 18.50 | . | 25.25 | 0.01 | -6.76 | 0.07 | 0.22 |
| 16 | 393 | TOTAL N | 1498.56 | 268.66 | 0.00 | 0.65 | 5.92 | 1773.79 | . | 1970.27 | 0.50 | -196.98 | 0.06 | 0.13 |
| 16 | 393 | INORG N | 1142.17 | 180.22 | 0.00 | 0.65 | 2.96 | 1326.00 | . | 1448.27 | 0.37 | -122.65 | 0.04 | 0.08 |
| 16 | 393 | FLOW | 2466.54 | 462.30 | . | . | 8.03 | 2936.87 | 4.52 | 2916.33 | 0.74 | 19.80 | . | . |
| 17 | 241 | TOTAL P | 7.63 | 1.18 | 0.00 | 0.05 | 0.19 | 9.05 | . | 2.46 | -0.05 | 6.64 | 0.11 | 0.07 |
| 17 | 241 | ORTHO P | 1.65 | 0.36 | 0.00 | 0.05 | 0.09 | 2.17 | . | 0.85 | -0.02 | 1.34 | 0.10 | 0.14 |
| 17 | 241 | TOTAL N | 155.71 | 79.47 | 0.00 | 6.25 | 6.24 | 247.67 | . | 84.80 | -1.89 | 164.76 | 0.05 | 0.10 |
| 17 | 241 | INORG N | 86.03 | 63.71 | 0.00 | 6.25 | 3.12 | 159.11 | . | 32.38 | -0.72 | 127.44 | 0.06 | 0.17 |
| 17 | 241 | FLOW | 58.64 | 43.62 | . | . | 6.03 | 108.29 | 4.92 | 94.37 | -1.99 | 15.90 | . | . |
| 17 | 242 | TOTAL P | 64.44 | 11.93 | 2.29 | 0.56 | 0.07 | 79.30 | . | 60.61 | -0.09 | 18.77 | 0.21 | 0.37 |
| 17 | 242 | ORTHO P | 11.86 | 1.45 | 2.29 | 0.56 | 0.04 | 16.20 | . | 10.25 | -0.01 | 5.96 | 0.09 | 0.12 |
| 17 | 242 | TOTAL N | 1009.32 | 226.94 | 6.87 | 20.97 | 2.46 | 1266.56 | . | 1098.64 | -1.55 | 169.47 | 0.08 | 0.12 |
| 17 | 242 | INORG N | 728.87 | 165.90 | 6.87 | 20.97 | 1.23 | 923.83 | . | 739.38 | -1.04 | 185.49 | 0.16 | 0.33 |
| 17 | 242 | FLOW | 244.32 | 63.68 | . | . | 2.62 | 310.62 | 2.00 | 290.19 | -0.41 | 20.83 | . | . |
| 17 | 245 | TOTAL P | 46.07 | 1.94 | 0.00 | 0.05 | 0.18 | 48.24 | . | 43.77 | -0.34 | 4.81 | 0.19 | 0.21 |
| 17 | 245 | ORTHO P | 12.32 | 1.49 | 0.00 | 0.05 | 0.09 | 13.95 | . | 7.39 | -0.06 | 6.62 | 0.10 | 0.16 |
| 17 | 245 | TOTAL N | 796.01 | 100.31 | 0.00 | 1.89 | 5.96 | 904.18 | . | 818.02 | -6.39 | 92.55 | 0.09 | 0.03 |
| 17 | 245 | INORG N | 457.44 | 58.10 | 0.00 | 1.89 | 2.98 | 520.42 | . | 395.20 | -3.09 | 128.31 | 0.11 | 0.31 |
| 17 | 245 | FLOW | 218.48 | 54.48 | . | . | 6.43 | 279.38 | 4.86 | 284.92 | -2.19 | -3.34 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 247 | TOTAL P | 33.27 | 0.92 | 0.14 | 0.00 | 0.14 | 34.47 | . | 47.00 | -0.02 | -12.51 | 0.14 | 0.10 |
| 17 | 247 | ORTHO P | 12.60 | 0.45 | 0.14 | 0.00 | 0.07 | 13.26 | . | 21.76 | -0.01 | -8.49 | 0.12 | 0.26 |
| 17 | 247 | TOTAL N | 1146.35 | 54.78 | 0.42 | 0.00 | 4.60 | 1206.15 | . | 1442.74 | -0.69 | -235.90 | 0.22 | 0.12 |
| 17 | 247 | INORG N | 844.11 | 41.56 | 0.42 | 0.00 | 2.30 | 888.39 | . | 1145.88 | -0.55 | -256.94 | 0.28 | 0.12 |
| 17 | 247 | FLOW | 353.54 | 20.50 | . | . | 5.11 | 379.15 | 3.86 | 371.78 | -0.18 | 7.54 | . | . |
| 17 | 248 | TOTAL P | 96.56 | 15.52 | 0.08 | 0.12 | 0.14 | 112.43 | . | 74.55 | -0.02 | 37.90 | 0.12 | 0.25 |
| 17 | 248 | ORTHO P | 32.36 | 7.32 | 0.08 | 0.12 | 0.07 | 39.96 | . | 30.61 | -0.01 | 9.35 | 0.06 | 0.18 |
| 17 | 248 | TOTAL N | 1523.54 | 361.38 | 0.25 | 4.49 | 4.79 | 1894.46 | . | 1703.95 | -0.38 | 190.90 | 0.03 | 0.08 |
| 17 | 248 | INORG N | 1066.77 | 291.21 | 0.25 | 4.49 | 2.40 | 1365.13 | . | 1221.34 | -0.28 | 144.06 | 0.07 | 0.10 |
| 17 | 248 | FLOW | 347.26 | 71.87 | . | . | 5.41 | 424.54 | 4.03 | 429.75 | -0.10 | -5.11 | . | . |
| 17 | 249 | TOTAL P | 168.59 | 2.42 | 0.34 | 0.03 | 0.21 | 171.60 | . | 132.94 | -0.22 | 38.89 | 0.17 | 0.08 |
| 17 | 249 | ORTHO P | 91.57 | 0.73 | 0.34 | 0.03 | 0.11 | 92.78 | . | 50.27 | -0.08 | 42.60 | 0.28 | 0.13 |
| 17 | 249 | TOTAL N | 2469.49 | 143.09 | 1.01 | 1.10 | 7.16 | 2621.86 | . | 2641.65 | -4.46 | -15.34 | 0.04 | 0.04 |
| 17 | 249 | INORG N | 1589.38 | 104.39 | 1.01 | 1.10 | 3.58 | 1699.47 | . | 1786.40 | -3.01 | -83.92 | 0.05 | 0.04 |
| 17 | 249 | FLOW | 918.10 | 97.20 | . | . | 7.63 | 1022.93 | 5.84 | 1026.14 | -1.72 | -1.49 | . | . |
| 17 | 256 | TOTAL P | 10.31 | 0.59 | 1.19 | 0.00 | 0.09 | 12.18 | . | 11.41 | -0.06 | 0.84 | 0.11 | 0.10 |
| 17 | 256 | ORTHO P | 3.90 | 0.21 | 1.19 | 0.00 | 0.04 | 5.35 | . | 5.67 | -0.03 | -0.29 | 0.08 | 0.23 |
| 17 | 256 | TOTAL N | 392.71 | 49.13 | 3.58 | 0.00 | 2.98 | 448.40 | . | 320.24 | -1.67 | 129.83 | 0.05 | 0.09 |
| 17 | 256 | INORG N | 262.56 | 42.05 | 3.58 | 0.00 | 1.49 | 309.68 | . | 206.46 | -1.08 | 104.30 | 0.05 | 0.11 |
| 17 | 256 | FLOW | 195.27 | 23.22 | . | . | 3.22 | 221.70 | 2.43 | 207.61 | -1.07 | 15.16 | . | . |
| 17 | 258 | TOTAL P | 0.94 | 0.70 | 0.00 | 0.03 | 0.64 | 2.32 | . | 1.84 | -0.20 | 0.68 | 0.13 | 0.29 |
| 17 | 258 | ORTHO P | 0.25 | 0.19 | 0.00 | 0.03 | 0.32 | 0.80 | . | 0.58 | -0.06 | 0.28 | 0.17 | 0.19 |
| 17 | 258 | TOTAL N | 32.18 | 23.87 | 0.00 | 1.26 | 21.48 | 78.79 | . | 67.09 | -7.27 | 18.98 | 0.13 | 0.18 |
| 17 | 258 | INORG N | 21.39 | 15.87 | 0.00 | 1.26 | 10.74 | 49.27 | . | 8.57 | -0.93 | 41.63 | 0.14 | 0.35 |
| 17 | 258 | FLOW | 32.35 | 24.00 | . | . | 22.86 | 79.21 | 17.50 | 79.11 | -6.68 | 6.78 | . | . |
| 17 | 373 | TOTAL P | 25.84 | 6.58 | 0.00 | 0.00 | 0.19 | 32.61 | . | 4.88 | 0.04 | 27.70 | 0.16 | 0.13 |
| 17 | 373 | ORTHO P | 2.50 | 0.48 | 0.00 | 0.00 | 0.10 | 3.08 | . | 2.10 | 0.02 | 0.97 | 0.06 | 0.03 |
| 17 | 373 | TOTAL N | 425.81 | 115.18 | 0.00 | 0.00 | 6.48 | 547.48 | . | 533.03 | 3.91 | 10.54 | 0.19 | 0.10 |
| 17 | 373 | INORG N | 141.45 | 37.90 | 0.00 | 0.00 | 3.24 | 182.59 | . | 151.69 | 1.11 | 29.78 | 0.08 | 0.03 |
| 17 | 373 | FLOW | 326.41 | 89.38 | . | . | 8.06 | 423.85 | 5.45 | 402.82 | 2.91 | 18.11 | . | . |
| 17 | 389 | TOTAL P | 310.12 | 5.60 | 4.22 | 0.02 | 0.43 | 320.39 | . | 302.07 | 6.05 | 12.27 | 0.07 | 0.09 |
| 17 | 389 | ORTHO P | 121.17 | 1.58 | 4.22 | 0.02 | 0.21 | 127.20 | . | 126.78 | 2.54 | -2.12 | 0.06 | 0.10 |
| 17 | 389 | TOTAL N | 9483.46 | 186.37 | 12.67 | 0.69 | 14.31 | 9697.50 | . | 9376.22 | 187.90 | 133.38 | 0.04 | 0.07 |
| 17 | 389 | INORG N | 6940.29 | 118.87 | 12.67 | 0.69 | 7.15 | 7079.67 | . | 7018.70 | 140.66 | -79.69 | 0.04 | 0.07 |
| 17 | 389 | FLOW | 6772.09 | 198.50 | . | . | 17.84 | 6988.42 | 12.02 | 6621.18 | 132.45 | 234.79 | . | . |
| 17 | 391 | TOTAL P | 52.47 | 2.77 | 0.00 | 0.00 | 0.21 | 55.46 | . | 35.60 | -0.01 | 19.87 | 0.13 | 0.19 |
| 17 | 391 | ORTHO P | 14.89 | 0.64 | 0.00 | 0.00 | 0.11 | 15.63 | . | 15.95 | -0.01 | -0.31 | 0.06 | 0.13 |
| 17 | 391 | TOTAL N | 2012.51 | 92.88 | 0.00 | 0.00 | 7.11 | 2112.51 | . | 2018.55 | -0.84 | 94.80 | 0.03 | 0.05 |
| 17 | 391 | INORG N | 1544.23 | 66.26 | 0.00 | 0.00 | 3.56 | 1614.05 | . | 1650.89 | -0.69 | -36.16 | 0.05 | 0.05 |
| 17 | 391 | FLOW | 2188.92 | 111.97 | . | . | 9.47 | 2310.35 | 5.43 | 2358.24 | -0.98 | -46.91 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 092 | TOTAL P | 326.28 | 12.41 | 0.59 | 0.02 | 0.39 | 339.69 | . | 136.09 | 0.00 | 203.60 | 0.25 | 0.40 |
| 18 | 092 | ORTHO P | 103.16 | 4.49 | 0.59 | 0.02 | 0.19 | 108.45 | . | 63.27 | 0.00 | 45.18 | 0.10 | 0.43 |
| 18 | 092 | TOTAL N | 5415.74 | 323.29 | 3.54 | 1.19 | 12.93 | 5756.70 | . | 4083.27 | 0.00 | 1673.43 | 0.08 | 0.14 |
| 18 | 092 | INORG N | 3233.72 | 223.21 | 3.54 | 1.19 | 6.47 | 3468.13 | . | 3002.94 | 0.00 | 465.18 | 0.12 | 0.16 |
| 18 | 092 | FLOW | 947.31 | 57.38 | . | . | 15.72 | 1020.42 | 10.54 | 1042.70 | 0.00 | -22.28 | . | . |
| 18 | 093 | TOTAL P | 11.57 | 1.84 | 0.66 | 0.02 | 1.36 | 15.45 | . | 6.58 | -0.20 | 9.06 | 0.09 | 0.31 |
| 18 | 093 | ORTHO P | 2.67 | 0.43 | 0.66 | 0.02 | 0.68 | 4.47 | . | 2.88 | -0.09 | 1.67 | 0.07 | 0.09 |
| 18 | 093 | TOTAL N | 360.59 | 63.85 | 4.08 | 1.44 | 45.33 | 475.29 | . | 361.68 | -10.74 | 124.36 | 0.06 | 0.06 |
| 18 | 093 | INORG N | 230.50 | 43.46 | 4.08 | 1.44 | 22.67 | 302.14 | . | 180.83 | -5.37 | 126.68 | 0.05 | 0.07 |
| 18 | 093 | FLOW | 422.76 | 71.96 | . | . | 51.80 | 546.51 | 39.24 | 554.86 | -15.32 | 6.96 | . | . |
| 18 | 120 | TOTAL P | 84.75 | 8.34 | 26.92 | 0.02 | 1.07 | 121.10 | . | 84.94 | 5.85 | 30.32 | 0.04 | 0.16 |
| 18 | 120 | ORTHO P | 64.41 | 6.60 | 26.92 | 0.02 | 0.54 | 98.49 | . | 32.83 | 2.26 | 63.40 | 0.28 | 0.28 |
| 18 | 120 | TOTAL N | 3708.05 | 774.35 | 67.29 | 0.69 | 35.75 | 4586.14 | . | 2226.41 | 153.23 | 2206.50 | 0.37 | 0.07 |
| 18 | 120 | INORG N | 1828.12 | 542.31 | 67.29 | 0.69 | 17.88 | 2456.29 | . | 1576.95 | 108.53 | 770.80 | 0.18 | 0.06 |
| 18 | 120 | FLOW | 1780.28 | 488.23 | . | . | 44.75 | 2313.26 | 33.67 | 1830.56 | 123.67 | 359.04 | . | . |
| 19 | 119 | TOTAL P | 6284.43 | 42.95 | 38.81 | 0.08 | 7.00 | 6373.28 | . | 6238.30 | 5.92 | 129.06 | 0.09 | 0.08 |
| 19 | 119 | ORTHO P | 2259.82 | 13.95 | 38.81 | 0.08 | 3.50 | 2316.16 | . | 2118.89 | 2.01 | 195.25 | 0.11 | 0.07 |
| 19 | 119 | TOTAL N | 55003.32 | 1463.83 | 110.08 | 3.19 | 233.36 | 56813.79 | . | 57970.25 | 55.05 | -1211.51 | 0.14 | 0.13 |
| 19 | 119 | INORG N | 29346.48 | 916.60 | 110.08 | 3.19 | 116.68 | 30493.03 | . | 25722.30 | 24.43 | 4746.29 | 0.10 | 0.06 |
| 19 | 119 | FLOW | 46731.71 | 992.78 | . | . | 318.55 | 48043.04 | 219.81 | 51141.86 | 48.36 | -3147.18 | . | . |
| 19 | 122 | TOTAL P | 744.28 | 96.92 | 0.00 | 0.02 | 5.92 | 847.14 | . | 512.91 | -27.94 | 362.18 | 0.17 | 0.18 |
| 19 | 122 | ORTHO P | 163.86 | 15.23 | 0.00 | 0.02 | 2.96 | 182.07 | . | 120.05 | -6.54 | 68.56 | 0.10 | 0.14 |
| 19 | 122 | TOTAL N | 13200.64 | 1724.12 | 0.00 | 0.78 | 197.49 | 15123.03 | . | 13734.33 | -748.17 | 2136.87 | 0.25 | 0.38 |
| 19 | 122 | INORG N | 4819.21 | 580.68 | 0.00 | 0.78 | 98.74 | 5499.42 | . | 9233.74 | -503.00 | -3231.31 | 0.04 | 0.53 |
| 19 | 122 | FLOW | 12882.20 | 1561.41 | . | . | 296.89 | 14740.50 | 170.93 | 15339.80 | -826.31 | 227.02 | . | . |
| 19 | 338 | TOTAL P | 5309.00 | 265.71 | 277.60 | 0.06 | 0.92 | 5853.29 | . | 9113.68 | 4.27 | -3264.66 | 0.15 | 0.19 |
| 19 | 338 | ORTHO P | 1656.64 | 155.87 | 277.60 | 0.06 | 0.46 | 2090.63 | . | 2680.21 | 1.26 | -590.84 | 0.14 | 0.18 |
| 19 | 338 | TOTAL N | 37145.91 | 1406.16 | 818.62 | 2.28 | 30.63 | 39403.59 | . | 34624.34 | 16.21 | 4763.04 | 0.15 | 0.19 |
| 19 | 338 | INORG N | 15187.02 | 715.03 | 818.62 | 2.28 | 15.31 | 16738.27 | . | 16047.63 | 7.51 | 683.12 | 0.10 | 0.06 |
| 19 | 338 | FLOW | 33382.59 | 877.95 | . | . | 42.08 | 34302.63 | 28.85 | 35741.58 | 16.72 | -1455.68 | . | . |
| 19 | 340 | TOTAL P | 272.57 | 32.87 | 21.27 | 0.03 | 1.66 | 328.40 | . | 225.42 | -8.12 | 111.11 | 0.10 | 0.15 |
| 19 | 340 | ORTHO P | 175.74 | 19.08 | 21.27 | 0.03 | 0.83 | 216.95 | . | 122.95 | -4.43 | 98.43 | 0.11 | 0.20 |
| 19 | 340 | TOTAL N | 1720.06 | 251.20 | 50.22 | 1.17 | 55.33 | 2077.99 | . | 1941.35 | -69.97 | 206.61 | 0.04 | 0.09 |
| 19 | 340 | INORG N | 1362.32 | 208.79 | 50.22 | 1.17 | 27.67 | 1650.17 | . | 1142.75 | -41.19 | 548.60 | 0.04 | 0.14 |
| 19 | 340 | FLOW | 2001.06 | 346.37 | . | . | 78.97 | 2426.40 | 52.12 | 2242.00 | -78.92 | 263.33 | . | . |
| 19 | 342 | TOTAL P | 2577.41 | 317.15 | 10.10 | 0.08 | 2.64 | 2907.38 | . | 2670.04 | -1.02 | 238.35 | 0.17 | 0.13 |
| 19 | 342 | ORTHO P | 742.61 | 131.66 | 10.10 | 0.08 | 1.32 | 885.77 | . | 744.14 | -0.28 | 141.92 | 0.15 | 0.13 |
| 19 | 342 | TOTAL N | 26559.03 | 1003.78 | 16.87 | 2.92 | 87.89 | 27670.50 | . | 26312.50 | -10.01 | 1368.01 | 0.14 | 0.15 |
| 19 | 342 | INORG N | 11918.92 | 442.25 | 16.87 | 2.92 | 43.95 | 12424.91 | . | 11747.81 | -4.47 | 681.57 | 0.11 | 0.05 |
| 19 | 342 | FLOW | 26631.64 | 736.29 | . | . | 125.44 | 27493.37 | 82.79 | 28446.82 | -10.79 | -942.67 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 343 | TOTAL P | 43.69 | 2.80 | 0.00 | 0.01 | 3.29 | 49.79 | . | 19.46 | -0.56 | 30.90 | 0.05 | 0.13 |
| 19 | 343 | ORTHO P | 18.71 | 1.16 | 0.00 | 0.01 | 1.64 | 21.53 | . | 13.05 | -0.38 | 8.85 | 0.04 | 0.08 |
| 19 | 343 | TOTAL N | 1668.11 | 117.83 | 0.00 | 0.31 | 109.63 | 1895.87 | . | 3486.76 | -101.07 | -1489.81 | 0.06 | 0.27 |
| 19 | 343 | INORG N | 952.18 | 72.69 | 0.00 | 0.31 | 54.81 | 1079.99 | . | 1920.84 | -55.68 | -785.17 | 0.04 | 0.43 |
| 19 | 343 | FLOW | 2607.19 | 171.60 | . | . | 206.78 | 2985.56 | 97.68 | 2445.19 | -68.05 | 608.42 | . | . |
| 20 | 081 | TOTAL P | 696.43 | 34.30 | 0.36 | 0.02 | 3.94 | 735.04 | . | 478.02 | -25.45 | 282.48 | 0.09 | 0.16 |
| 20 | 081 | ORTHO P | 218.16 | 8.93 | 0.36 | 0.02 | 1.97 | 229.43 | . | 223.83 | -11.92 | 17.52 | 0.13 | 0.17 |
| 20 | 081 | TOTAL N | 14900.18 | 554.99 | 1.15 | 0.71 | 131.25 | 15588.27 | . | 14237.59 | -758.05 | 2108.73 | 0.05 | 0.11 |
| 20 | 081 | INORG N | 10728.24 | 188.03 | 1.15 | 0.71 | 65.62 | 10983.76 | . | 8306.87 | -442.28 | 3119.17 | 0.05 | 0.20 |
| 20 | 081 | FLOW | 3416.54 | 241.32 | . | . | 163.38 | 3821.24 | 116.94 | 4071.65 | -210.56 | -39.85 | . | . |
| 20 | 087 | TOTAL P | 256.78 | 28.40 | 0.86 | 0.01 | 1.59 | 287.65 | . | 167.82 | 13.60 | 106.22 | 0.12 | 0.33 |
| 20 | 087 | ORTHO P | 147.97 | 12.10 | 0.86 | 0.01 | 0.79 | 161.75 | . | 85.57 | 6.94 | 69.24 | 0.12 | 0.32 |
| 20 | 087 | TOTAL N | 11647.37 | 1865.89 | 2.63 | 0.64 | 52.96 | 13569.49 | . | 9847.29 | 798.28 | 2923.92 | 0.03 | 0.16 |
| 20 | 087 | INORG N | 10513.97 | 1868.40 | 2.63 | 0.64 | 26.48 | 12412.13 | . | 7612.13 | 617.08 | 4182.91 | 0.05 | 0.21 |
| 20 | 087 | FLOW | 1405.99 | 205.15 | . | . | 82.65 | 1693.79 | 47.19 | 1636.33 | 128.83 | -71.37 | . | . |
| 20 | 088 | TOTAL P | 111.81 | 19.60 | 0.00 | 0.00 | 2.48 | 133.90 | . | 39.86 | -4.40 | 98.45 | 0.18 | 0.17 |
| 20 | 088 | ORTHO P | 18.94 | 4.11 | 0.00 | 0.00 | 1.24 | 24.30 | . | 10.79 | -1.19 | 14.70 | 0.22 | 0.14 |
| 20 | 088 | TOTAL N | 758.67 | 338.68 | 0.01 | 0.00 | 82.67 | 1180.03 | . | 656.36 | -72.49 | 596.16 | 0.09 | 0.19 |
| 20 | 088 | INORG N | 223.12 | 139.78 | 0.01 | 0.00 | 41.33 | 404.25 | . | 171.80 | -18.97 | 251.42 | 0.11 | 0.15 |
| 20 | 088 | FLOW | 292.84 | 132.54 | . | . | 92.21 | 517.59 | 75.76 | 538.47 | -51.11 | 30.23 | . | . |
| 21 | 196 | TOTAL P | 142.72 | 10.27 | 0.00 | 0.07 | 0.78 | 153.84 | . | 96.47 | -1.04 | 58.41 | 0.90 | 0.14 |
| 21 | 196 | ORTHO P | 25.18 | 3.45 | 0.00 | 0.07 | 0.39 | 29.09 | . | 20.50 | -0.22 | 8.82 | 0.46 | 0.16 |
| 21 | 196 | TOTAL N | 2139.64 | 519.11 | 0.00 | 2.83 | 25.97 | 2687.55 | . | 2690.16 | -29.01 | 26.40 | 0.27 | 0.12 |
| 21 | 196 | INORG N | 478.23 | 129.81 | 0.00 | 2.83 | 12.99 | 623.86 | . | 650.43 | -7.01 | -19.55 | 0.21 | 0.20 |
| 21 | 196 | FLOW | 1321.24 | 439.02 | . | . | 29.26 | 1789.52 | 25.12 | 2006.65 | -21.37 | -195.76 | . | . |
| 22 | 014 | TOTAL P | 14.81 | 4.97 | 0.00 | 0.03 | 1.58 | 21.39 | . | 27.38 | -0.84 | -5.15 | 0.06 | 0.19 |
| 22 | 014 | ORTHO P | 6.09 | 1.63 | 0.00 | 0.03 | 0.79 | 8.54 | . | 7.77 | -0.24 | 1.02 | 0.07 | 0.10 |
| 22 | 014 | TOTAL N | 138.61 | 68.81 | 0.00 | 1.13 | 52.77 | 261.32 | . | 745.35 | -22.86 | -461.16 | 0.10 | 0.41 |
| 22 | 014 | INORG N | 47.64 | 24.92 | 0.00 | 1.13 | 26.38 | 100.07 | . | 116.00 | -3.56 | -12.37 | 0.12 | 0.15 |
| 22 | 014 | FLOW | 941.67 | 341.31 | . | . | 89.64 | 1372.61 | 60.45 | 1405.63 | -41.25 | 8.23 | . | . |
| 22 | 019 | TOTAL P | 38.63 | 15.33 | 0.58 | 0.01 | 4.79 | 59.34 | . | 42.58 | -0.82 | 17.59 | 0.09 | 0.33 |
| 22 | 019 | ORTHO P | 23.20 | 7.54 | 0.58 | 0.01 | 2.39 | 33.73 | . | 18.21 | -0.35 | 15.87 | 0.22 | 0.19 |
| 22 | 019 | TOTAL N | 1416.40 | 359.22 | 2.53 | 0.43 | 159.57 | 1938.16 | . | 1232.35 | -23.65 | 729.46 | 0.20 | 0.24 |
| 22 | 019 | INORG N | 339.54 | 46.61 | 2.53 | 0.43 | 79.79 | 468.90 | . | 454.00 | -8.71 | 23.62 | 0.10 | 0.20 |
| 22 | 019 | FLOW | 1829.45 | 758.38 | . | . | 298.75 | 2886.58 | 170.61 | 2866.88 | -51.75 | 71.46 | . | . |
| 22 | 188 | TOTAL P | 283.00 | 22.75 | 16.06 | 0.02 | 1.90 | 323.73 | . | 451.61 | -7.28 | -120.60 | 0.05 | 0.12 |
| 22 | 188 | ORTHO P | 108.91 | 8.76 | 16.06 | 0.02 | 0.95 | 134.70 | . | 123.09 | -1.98 | 13.59 | 0.05 | 0.18 |
| 22 | 188 | TOTAL N | 2766.50 | 222.40 | 25.51 | 1.01 | 63.29 | 3078.71 | . | 2050.65 | -33.04 | 1061.10 | 0.07 | 0.24 |
| 22 | 188 | INORG N | 2290.48 | 184.13 | 25.51 | 1.01 | 31.65 | 2532.77 | . | 786.39 | -12.67 | 1759.06 | 0.10 | 0.24 |
| 22 | 188 | FLOW | 2883.02 | 231.76 | . | . | 93.25 | 3208.03 | 66.06 | 1683.34 | -26.06 | 1550.75 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 189 | TOTAL P | 414.83 | 3.20 | 0.00 | 0.01 | 2.16 | 420.21 | . | 84.89 | 8.84 | 326.47 | 0.23 | 0.55 |
| 22 | 189 | ORTHO P | 119.43 | 0.65 | 0.00 | 0.01 | 1.08 | 121.18 | . | 30.39 | 3.17 | 87.63 | 0.30 | 0.65 |
| 22 | 189 | TOTAL N | 2311.74 | 46.41 | 0.00 | 0.62 | 72.07 | 2430.84 | . | 1145.09 | 119.30 | 1166.46 | 0.24 | 0.19 |
| 22 | 189 | INORG N | 658.87 | 8.82 | 0.00 | 0.62 | 36.03 | 704.35 | . | 486.30 | 50.66 | 167.38 | 0.26 | 0.34 |
| 22 | 189 | FLOW | 1365.12 | 34.26 | . | . | 148.07 | 1547.45 | 75.22 | 1382.86 | 136.23 | 28.36 | . | . |
| 22 | 190 | TOTAL P | 453.12 | 0.31 | 0.00 | 0.01 | 5.19 | 458.64 | . | 301.88 | -15.97 | 172.72 | 0.04 | 0.23 |
| 22 | 190 | ORTHO P | 125.30 | 0.06 | 0.00 | 0.01 | 2.60 | 127.97 | . | 71.92 | -3.80 | 59.86 | 0.05 | 0.13 |
| 22 | 190 | TOTAL N | 2682.18 | 1.91 | 0.00 | 0.28 | 173.09 | 2857.46 | . | 2680.29 | -141.76 | 318.94 | 0.04 | 0.14 |
| 22 | 190 | INORG N | 713.47 | 0.45 | 0.00 | 0.28 | 86.54 | 800.76 | . | 595.97 | -31.52 | 236.31 | 0.06 | 0.14 |
| 22 | 190 | FLOW | 3662.05 | 2.84 | . | . | 334.81 | 3999.70 | 180.66 | 3034.29 | -150.93 | 1116.34 | . | . |
| 22 | 192 | TOTAL P | 263.57 | 11.76 | 0.00 | 0.00 | 5.32 | 280.66 | . | 66.99 | -4.33 | 218.00 | 0.04 | 0.58 |
| 22 | 192 | ORTHO P | 49.11 | 2.06 | 0.00 | 0.00 | 2.66 | 53.84 | . | 35.31 | -2.28 | 20.81 | 0.10 | 0.82 |
| 22 | 192 | TOTAL N | 2099.90 | 96.97 | 0.00 | 0.00 | 177.50 | 2374.37 | . | 2500.17 | -161.64 | 35.83 | 0.04 | 0.89 |
| 22 | 192 | INORG N | 842.55 | 37.58 | 0.00 | 0.00 | 88.75 | 968.88 | . | 272.99 | -17.65 | 713.53 | 0.07 | 0.49 |
| 22 | 192 | FLOW | 3181.15 | 159.44 | . | . | 354.54 | 3695.13 | 185.26 | 3820.75 | -235.04 | 109.41 | . | . |
| 23 | 352 | TOTAL P | 110.94 | 38.14 | 6.13 | 0.09 | 2.61 | 157.91 | . | 42.31 | -0.32 | 115.93 | 0.14 | 0.14 |
| 23 | 352 | ORTHO P | 59.58 | 16.29 | 6.13 | 0.09 | 1.30 | 83.40 | . | 12.13 | -0.09 | 71.36 | 0.19 | 0.19 |
| 23 | 352 | TOTAL N | 1055.05 | 378.62 | 18.10 | 3.52 | 86.85 | 1542.14 | . | 1164.38 | -8.79 | 386.55 | 0.09 | 0.14 |
| 23 | 352 | INORG N | 206.06 | 48.18 | 18.10 | 3.52 | 43.42 | 319.29 | . | 113.92 | -0.86 | 206.23 | 0.09 | 0.21 |
| 23 | 352 | FLOW | 1048.64 | 500.42 | . | . | 128.91 | 1677.97 | 110.55 | 1704.84 | -12.03 | -14.84 | . | . |
| 23 | 353 | TOTAL P | 504.36 | 193.70 | 0.73 | 0.00 | 4.05 | 702.85 | . | 656.85 | -1.17 | 47.17 | 0.16 | 0.13 |
| 23 | 353 | ORTHO P | 211.85 | 98.99 | 0.73 | 0.00 | 2.02 | 313.60 | . | 287.09 | -0.51 | 27.01 | 0.28 | 0.18 |
| 23 | 353 | TOTAL N | 3573.53 | 1638.78 | 0.90 | 0.00 | 134.94 | 5348.16 | . | 4416.76 | -7.88 | 939.28 | 0.09 | 0.08 |
| 23 | 353 | INORG N | 875.32 | 363.79 | 0.90 | 0.00 | 67.47 | 1307.49 | . | 1056.44 | -1.89 | 252.93 | 0.24 | 0.17 |
| 23 | 353 | FLOW | 3814.09 | 2015.68 | . | . | 211.66 | 6041.42 | 171.76 | 5279.63 | -9.12 | 770.91 | . | . |
| 23 | 413 | TOTAL P | 201.54 | 9.69 | 0.48 | 0.26 | 3.96 | 215.94 | . | 213.47 | . | 2.47 | 0.11 | 0.11 |
| 23 | 413 | ORTHO P | 73.42 | 3.01 | 0.48 | 0.26 | 1.98 | 79.16 | . | 71.07 | . | 8.09 | 0.11 | 0.23 |
| 23 | 413 | TOTAL N | 2716.96 | 128.98 | 1.50 | 9.79 | 132.04 | 2989.27 | . | 3872.48 | . | -883.20 | 0.10 | 0.24 |
| 23 | 413 | INORG N | 270.44 | 10.65 | 1.50 | 9.79 | 66.02 | 358.41 | . | 204.74 | . | 153.67 | 0.15 | 0.11 |
| 23 | 413 | FLOW | 3941.94 | 202.75 | . | . | 206.58 | 4351.27 | 164.71 | 4800.36 | . | -449.08 | . | . |
| 24 | 011 | TOTAL P | 114.18 | 18.37 | 0.00 | 0.01 | 3.56 | 136.11 | . | 36.11 | -2.19 | 102.20 | 0.20 | 0.19 |
| 24 | 011 | ORTHO P | 27.36 | 7.60 | 0.00 | 0.01 | 1.78 | 36.76 | . | 13.32 | -0.81 | 24.24 | 0.15 | 0.09 |
| 24 | 011 | TOTAL N | 1567.02 | 524.77 | 0.00 | 0.38 | 118.55 | 2210.73 | . | 1716.13 | -104.14 | 598.74 | 0.06 | 0.27 |
| 24 | 011 | INORG N | 693.19 | 298.30 | 0.00 | 0.38 | 59.27 | 1051.16 | . | 619.48 | -37.59 | 469.27 | 0.05 | 0.19 |
| 24 | 011 | FLOW | 1671.58 | 469.97 | . | . | 175.96 | 2317.51 | 129.76 | 2348.17 | -134.63 | 103.96 | . | . |
| 24 | 012 | TOTAL P | 17.41 | 1.22 | 0.00 | 0.00 | 0.53 | 19.16 | . | 54.82 | 0.17 | -35.83 | 0.17 | 0.28 |
| 24 | 012 | ORTHO P | 7.93 | 0.69 | 0.00 | 0.00 | 0.26 | 8.89 | . | 16.53 | 0.05 | -7.69 | 0.12 | 0.45 |
| 24 | 012 | TOTAL N | 550.95 | 49.52 | 0.00 | 0.25 | 17.61 | 618.34 | . | 585.26 | 1.80 | 31.28 | 0.18 | 0.16 |
| 24 | 012 | INORG N | 55.01 | 4.81 | 0.00 | 0.25 | 8.81 | 68.88 | . | 136.16 | 0.42 | -67.70 | 0.09 | 0.59 |
| 24 | 012 | FLOW | 666.64 | 80.19 | . | . | 20.28 | 767.11 | 19.73 | 761.98 | 2.28 | 2.85 | . | . |

## NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 013 | TOTAL P | 150.41 | 13.67 | 0.00 | 0.03 | 6.14 | 170.26 | . | 122.59 | -7.56 | 55.22 | 0.14 | 0.18 |
| 24 | 013 | ORTHO P | 61.74 | 5.91 | 0.00 | 0.03 | 3.07 | 70.76 | . | 56.16 | -3.46 | 18.05 | 0.08 | 0.10 |
| 24 | 013 | TOTAL N | 6235.18 | 726.60 | 0.00 | 1.22 | 204.53 | 7167.54 | . | 7673.72 | -473.04 | -33.15 | 0.11 | 0.21 |
| 24 | 013 | INORG N | 4017.78 | 311.89 | 0.00 | 1.22 | 102.27 | 4433.15 | . | 3651.39 | -225.08 | 1006.85 | 0.17 | 0.27 |
| 24 | 013 | FLOW | 8249.41 | 1014.86 | . | . | 309.33 | 9573.60 | 213.47 | 10091.29 | -608.90 | 91.22 | . | . |
| 24 | 016 | TOTAL P | 38.55 | 27.39 | 4.02 | 0.02 | 3.90 | 73'.89 | . | 24.25 | -0.34 | 49.98 | 0.42 | 0.07 |
| 24 | 016 | ORTHO P | 9.63 | 7.83 | 4.02 | 0.02 | 1.95 | 23.45 | . | 11.71 | -0.16 | 11.90 | 0.11 | 0.05 |
| 24 | 016 | TOTAL N | 532.11 | 370.31 | 21.28 | 0.97 | 129.96 | 1054.63 | . | 2284.04 | -31.72 | -1197.69 | 0.18 | 0.35 |
| 24 | 016 | INORG N | 124.74 | 83.39 | 21.28 | 0.97 | 64.98 | 295.36 | . | 341.87 | -4.75 | -41.76 | 0.17 | 0.11 |
| 24 | 016 | FLOW | 1174.77 | 918.79 | . | . | 198.24 | 2291.79 | 138.95 | 2273.23 | -29.64 | 48.21 | . | . |
| 24 | 021 | TOTAL P | 35.68 | 4.50 | 0.00 | 0.01 | 0.79 | 40.98 | . | 51.17 | 0.52 | -10.71 | 0.11 | 0.18 |
| 24 | 021 | ORTHO P | 13.71 | 2.46 | 0.00 | 0.01 | 0.39 | 16.58 | . | 14.64 | 0.15 | 1.79 | 0.13 | 0.18 |
| 24 | 021 | TOTAL N | 1064.05 | 340.68 | 0.00 | 0.61 | 26.29 | 1431.63 | . | 836.92 | 8.58 | 586.12 | 0.24 | 0.20 |
| 24 | 021 | INORG N | 268.92 | 23.05 | 0.00 | 0.61 | 13.14 | 305.73 | . | 116.46 | 1.19 | 188.07 | 0.39 | 0.16 |
| 24 | 021 | FLOW | 1031.43 | 301.98 | . | . | 28.07 | 1361.47 | 16.31 | 1317.94 | 13.35 | 30.18 | . | . |
| 24 | 022 | TOTAL P | 29.26 | 3.80 | 0.00 | 0.03 | 2.84 | 35.93 | . | 49.35 | -5.82 | -7.60 | 0.10 | 0.25 |
| 24 | 022 | ORTHO P | 15.46 | 2.05 | 0.00 | 0.03 | 1.42 | 18.95 | . | 27.45 | -3.24 | -5.26 | 0.14 | 0.16 |
| 24 | 022 | TOTAL N | 1991.38 | 387.02 | 0.00 | 1.13 | 94.71 | 2474.24 | . | 2665.10 | -314.19 | 123.32 | 0.06 | 0.16 |
| 24 | 022 | INORG N | 1360.78 | 195.69 | 0.00 | 1.13 | 47.35 | 1604.95 | . | 883.99 | -104.21 | 825.18 | 0.08 | 0.20 |
| 24 | 022 | FLOW | 1957.03 | 329.77 | . | . | 143.22 | 2430.01 | 92.89 | 2649.23 | -301.36 | 82.15 | . | . |
| 24 | 193 | TOTAL P | 11.66 | 1.70 | 0.38 | 0.01 | 0.26 | 14.02 | . | 36.68 | -0.16 | -22.51 | 0.13 | 0.39 |
| 24 | 193 | ORTHO P | 6.10 | 1.16 | 0.38 | 0.01 | 0.13 | 7.79 | . | 7.69 | -0.03 | 0.13 | 0.05 | 0.14 |
| 24 | 193 | TOTAL N | 1223.94 | 215.26 | 1.14 | 0.56 | 8.75 | 1449.65 | . | 1455.92 | -6.20 | -0.07 | 0.27 | 0.24 |
| 24 | 193 | INORG N | 289.85 | 74.25 | 1.14 | 0.56 | 4.38 | 370.17 | . | 208.75 | -0.89 | 162.30 | 0.08 | 0.20 |
| 24 | 193 | FLOW | 841.90 | 177.29 | . | . | 9.66 | 1028.84 | 6.38 | 1079.93 | -4.57 | -46.52 | . | . |
| 24 | 200 | TOTAL P | 233.62 | 13.80 | 1.15 | 0.03 | 5.19 | 253.79 | . | 103.17 | -5.36 | 155.99 | 0.09 | 0.08 |
| 24 | 200 | ORTHO P | 227.39 | 10.65 | 1.15 | 0.03 | 2.59 | 241.82 | . | 73.22 | -3.81 | 172.40 | 0.25 | 0.14 |
| 24 | 200 | TOTAL N | 9512.57 | 1247.01 | 3.55 | 1.28 | 172.86 | 10937.28 | . | 8087.13 | -420.50 | 3270.66 | 0.09 | 0.10 |
| 24 | 200 | INORG N | 4112.74 | 639.88 | 3.55 | 1.28 | 86.43 | 4843.89 | . | 3170.74 | -164.87 | 1838.02 | 0.08 | 0.12 |
| 24 | 200 | FLOW | 4466.98 | 687.35 | . | . | 223.32 | 5377.65 | 180.42 | 5881.34 | -296.42 | -207.27 | . | . |
| 25 | 020 | TOTAL P | 504.51 | 137.86 | 7.37 | 0.00 | 3.49 | 653.23 | . | 506.81 | 0.00 | 146.41 | 0.14 | 0.14 |
| 25 | 020 | ORTHO P | 113.94 | 56.90 | 7.37 | 0.00 | 1.74 | 179.95 | . | 129.14 | 0.00 | 50.81 | 0.19 | 0.10 |
| 25 | 020 | TOTAL N | 6153.79 | 1278.74 | 26.85 | 0.00 | 116.19 | 7575.59 | . | 4819.66 | 0.00 | 2755.92 | 0.13 | 0.08 |
| 25 | 020 | INORG N | 1521.62 | 489.82 | 26.85 | 0.00 | 58.10 | 2096.39 | . | 1240.51 | 0.00 | 855.87 | 0.14 | 0.16 |
| 25 | 020 | FLOW | 8614.15 | 1807.43 | . | . | 193.90 | 10615.47 | 141.98 | 10639.36 | 0.00 | -23.89 | . | . |
| 25 | 102 | TOTAL P | 29.40 | 15.99 | 0.00 | 0.00 | 0.39 | 45.77 | . | 10.60 | 0.12 | 35.06 | 0.46 | 0.24 |
| 25 | 102 | ORTHO P | 5.03 | 4.78 | 0.00 | 0.00 | 0.19 | 10.00 | . | 4.39 | 0.05 | 5.56 | 1.70 | 0.31 |
| 25 | 102 | TOTAL N | 291.98 | 414.71 | 0.00 | 0.00 | 12.84 | 719.53 | . | 176.34 | 1.98 | 541.20 | 0.81 | 0.08 |
| 25 | 102 | INORG N | 110.36 | 224.87 | 0.00 | 0.00 | 6.42 | 341.65 | . | 57.55 | 0.65 | 283.45 | 1.26 | 0.22 |
| 25 | 102 | FLOW | 50.42 | 72.70 | . | . | 10.59 | 133.71 | 18.31 | 125.31 | 1.20 | 7.21 | . | . |

## NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 103 | TOTAL P | 56.40 | 19.08 | 0.54 | 0.00 | 0.48 | 76.51 | . | 118.32 | -1.29 | -40.52 | 0.05 | 0.17 |
| 25 | 103 | ORTHO P | 13.06 | 4.42 | 0.54 | 0.00 | 0.24 | 18.26 | . | 24.16 | -0.26 | -5.63 | 0.04 | 0.22 |
| 25 | 103 | TOTAL N | 1176.25 | 397.98 | 1.63 | 0.00 | 16.04 | 1591.91 | . | 1246.46 | -13.60 | 359.04 | 0.03 | 0.16 |
| 25 | 103 | INORG N | 534.30 | 180.78 | 1.63 | 0.00 | 8.02 | 724.73 | . | 420.46 | -4.59 | 308.86 | 0.03 | 0.13 |
| 25 | 103 | FLOW | 705.82 | 238.81 | . | . | 18.41 | 963.04 | 21.24 | 832.83 | -8.85 | 139.06 | . | . |
| 25 | 104 | TOTAL P | 20.65 | 7.74 | 0.00 | 0.00 | 0.34 | 28.73 | . | 58.76 | -0.29 | -29.74 | 0.07 | 0.31 |
| 25 | 104 | ORTHO P | 7.75 | 2.02 | 0.00 | 0.00 | 0.17 | 9.94 | . | 10.93 | -0.05 | -0.93 | 0.08 | 0.15 |
| 25 | 104 | TOTAL N | 617.68 | 268.25 | 0.00 | 0.21 | 11.41 | 897.56 | . | 742.15 | -3.68 | 159.08 | 0.08 | 0.06 |
| 25 | 104 | INORG N | 170.37 | 60.43 | 0.00 | 0.21 | 5.70 | 236.71 | . | 233.82 | -1.16 | 4.05 | 0.08 | 0.11 |
| 25 | 104 | FLOW | 424.25 | 163.65 | . | . | 13.09 | 600.99 | 15.10 | 563.88 | -2.72 | 39.83 | . | . |
| 25 | 105 | TOTAL P | 603.56 | 65.67 | 1.65 | 0.00 | 1.15 | 672.04 | . | 312.10 | 0.10 | 359.84 | 0.11 | 0.19 |
| 25 | 105 | ORTHO P | 172.28 | 14.23 | 1.65 | 0.00 | 0.57 | 188.74 | . | 125.09 | 0.04 | 63.61 | 0.06 | 0.15 |
| 25 | 105 | TOTAL N | 5444.34 | 680.75 | 4.96 | 0.00 | 38.32 | 6168.38 | . | 3463.53 | 1.14 | 2703.72 | 0.07 | 0.13 |
| 25 | 105 | INORG N | 2205.65 | 228.16 | 4.96 | 0.00 | 19.16 | 2457.93 | . | 1299.76 | 0.43 | 1157.75 | 0.07 | 0.14 |
| 25 | 105 | FLOW | 1590.60 | 202.19 | . | . | 43.97 | 1836.77 | 48.77 | 1801.11 | 0.58 | 35.08 | . | . |
| 25 | 107 | TOTAL P | 9.37 | 4.58 | 0.00 | 0.00 | 0.73 | 14.68 | . | 2.95 | 0.18 | 11.54 | 0.39 | 0.08 |
| 25 | 107 | ORTHO P | 3.05 | 1.12 | 0.00 | 0.00 | 0.37 | 4.54 | . | 0.88 | 0.05 | 3.60 | 0.38 | 0.13 |
| 25 | 107 | TOTAL N | 128.12 | 66.49 | 0.00 | 0.00 | 24.43 | 219.04 | . | 60.44 | 3.70 | 154.89 | 0.37 | 0.19 |
| 25 | 107 | INORG N | 31.84 | 23.99 | 0.00 | 0.00 | 12.22 | 68.05 | . | 7.94 | 0.49 | 59.62 | 0.32 | 0.17 |
| 25 | 107 | FLOW | 36.11 | 36.18 | . | . | 19.79 | 92.08 | 34.83 | 83.97 | 3.01 | 5.10 | . | . |
| 25 | 112 | TOTAL P | 22.16 | 7.04 | 0.52 | 0.01 | 0.34 | 30.08 | . | 63.10 | -0.15 | -32.87 | 0.06 | 0.17 |
| 25 | 112 | ORTHO P | 5.17 | 2.01 | 0.52 | 0.01 | 0.17 | 7.88 | . | 12.74 | -0.03 | -4.83 | 0.09 | 0.24 |
| 25 | 112 | TOTAL N | 529.80 | 171.60 | 1.56 | 0.56 | 11.49 | 715.02 | . | 1068.46 | -2.53 | -350.90 | 0.06 | 0.12 |
| 25 | 112 | INORG N | 153.07 | 40.94 | 1.56 | 0.56 | 5.75 | 201.88 | . | 290.68 | -0.69 | -88.11 | 0.08 | 0.08 |
| 25 | 112 | FLOW | 419.31 | 143.74 | . | . | 13.19 | 576.24 | 16.09 | 734.96 | -1.70 | -157.02 | . | . |
| 25 | 267 | TOTAL P | 2884.45 | 188.91 | 27.30 | 0.01 | 12.16 | 3112.82 | . | 1832.51 | -144.67 | 1424.99 | 0.06 | 0.26 |
| 25 | 267 | ORTHO P | 641.84 | 42.65 | 27.30 | 0.01 | 6.08 | 717.87 | . | 568.00 | -44.84 | 194.72 | 0.08 | 0.25 |
| 25 | 267 | TOTAL N | 14205.09 | 2032.84 | 80.39 | 0.27 | 405.25 | 16723.84 | . | 14148.17 | -1116.95 | 3692.62 | 0.08 | 0.13 |
| 25 | 267 | INORG N | 1947.01 | 210.30 | 80.39 | 0.27 | 202.63 | 2440.60 | . | 4639.05 | -366.24 | -1832.22 | 0.31 | 0.24 |
| 25 | 267 | FLOW | 5564.10 | 3021.59 | . | . | 575.53 | 9161.23 | 536.46 | 10126.69 | -757.12 | -208.35 | . | . |
| 25 | 269 | TOTAL P | 1.10 | 0.04 | 0.00 | 0.00 | 0.22 | 1.36 | . | 1.23 | -0.29 | 0.42 | 0.23 | 0.11 |
| 25 | 269 | ORTHO P | 0.25 | 0.01 | 0.00 | 0.00 | 0.11 | 0.38 | . | 0.36 | -0.08 | 0.10 | 0.18 | 0.09 |
| 25 | 269 | TOTAL N | 19.43 | 0.77 | 0.00 | 0.10 | 7.41 | 27.71 | . | 21.35 | -4.94 | 11.30 | 0.14 | 0.28 |
| 25 | 269 | INORG N | 4.37 | 0.20 | 0.00 | 0.10 | 3.70 | 8.38 | . | 1.85 | -0.43 | 6.96 | 0.20 | 0.50 |
| 25 | 269 | FLOW | 25.95 | 0.45 | . | . | 4.36 | 30.76 | 12.07 | 36.00 | -5.53 | 0.30 | . | . |
| 25 | 273 | TOTAL P | 4779.82 | 213.61 | 19.93 | 0.01 | 3.42 | 5016.78 | . | 1513.53 | -47.73 | 3550.98 | 0.15 | 0.04 |
| 25 | 273 | ORTHO P | 1556.80 | 31.45 | 19.93 | 0.01 | 1.71 | 1609.90 | . | 1191.93 | -37.59 | 455.55 | 0.07 | 0.10 |
| 25 | 273 | TOTAL N | 37469.40 | 2962.24 | 55.45 | 0.39 | 113.96 | 40601.45 | . | 20297.25 | -640.04 | 20944.24 | 0.10 | 0.10 |
| 25 | 273 | INORG N | 10609.82 | 629.82 | 55.45 | 0.39 | 56.98 | 11352.47 | . | 10693.29 | -337.20 | 996.38 | 0.21 | 0.33 |
| 25 | 273 | FLOW | 11395.79 | 1572.04 | . | . | 144.36 | 13112.19 | 153.75 | 14019.16 | -437.23 | -469.75 | . | . |

## NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 275 | TOTAL P | 935.19 | 21.53 | 8.33 | 0.01 | 3.88 | 968.94 | . | 413.56 | -11.57 | 566.95 | 0.62 | 0.16 |
| 25 | 275 | ORTHO P | 168.58 | 20.56 | 8.33 | 0.01 | 1.94 | 199.42 | . | 157.17 | -4.40 | 46.64 | 0.21 | 0.25 |
| 25 | 275 | TOTAL N | 7474.54 | 767.25 | 19.89 | 0.51 | 129.23 | 8391.43 | . | 8804.53 | -246.29 | -166.81 | 0.21 | 0.03 |
| 25 | 275 | INORG N | 1824.39 | 73.51 | 19.89 | 0.51 | 64.62 | 1982.93 | . | 2319.57 | -64.88 | -271.75 | 0.25 | 0.05 |
| 25 | 275 | FLOW | 3742.81 | 489.55 | . | . | 167.60 | 4399.96 | 174.36 | 4995.95 | -134.87 | -461.12 | . | . |
| 25 | 278 | TOTAL P | 195.85 | 14.37 | 15.83 | 0.02 | 1.60 | 227.68 | . | 120.19 | -2.29 | 109.77 | 0.14 | 0.14 |
| 25 | 278 | ORTHO P | 109.22 | 8.01 | 15.83 | 0.02 | 0.80 | 133.88 | . | 76.76 | -1.46 | 58.58 | 0.10 | 0.17 |
| 25 | 278 | TOTAL N | 4170.26 | 520.63 | 31.01 | 0.70 | 53.34 | 4775.94 | . | 4629.23 | -88.14 | 234.85 | 0.09 | 0.16 |
| 25 | 278 | INORG N | 1751.25 | 94.22 | 31.01 | 0.70 | 26.67 | 1903.85 | . | 1583.81 | -30.16 | 350.20 | 0.15 | 0.18 |
| 25 | 278 | FLOW | 1969.30 | 462.30 | . | . | 73.40 | 2504.99 | 66.53 | 2576.93 | -47.80 | -24.14 | . | . |
| 25 | 281 | TOTAL P | 100.92 | 11.25 | 0.00 | 0.00 | 1.08 | 113.25 | . | 112.90 | -3.03 | 3.39 | 0.12 | 0.11 |
| 25 | 281 | ORTHO P | 31.82 | 2.32 | 0.00 | 0.00 | 0.54 | 34.68 | . | 42.19 | -1.13 | -6.37 | 0.12 | 0.32 |
| 25 | 281 | TOTAL N | 1358.55 | 124.81 | 0.00 | 0.14 | 35.85 | 1519.34 | . | 1440.40 | -38.71 | 117.66 | 0.23 | 0.14 |
| 25 | 281 | INORG N | 169.11 | 24.16 | 0.00 | 0.14 | 17.92 | 211.33 | . | 264.49 | -7.11 | -46.05 | 0.20 | 0.24 |
| 25 | 281 | FLOW | 1352.13 | 238.35 | . | . | 43.97 | 1634.46 | 44.71 | 1638.48 | -42.83 | 38.80 | . | . |
| 25 | 348 | TOTAL P | 2998.32 | 40.02 | 8.79 | 0.22 | 10.67 | 3058.02 | . | 780.87 | -59.89 | 2337.03 | 0.31 | 0.33 |
| 25 | 348 | ORTHO P | 617.65 | 14.71 | 8.79 | 0.22 | 5.33 | 646.70 | . | 394.10 | -30.22 | 282.82 | 0.20 | 0.44 |
| 25 | 348 | TOTAL N | 19356.74 | 806.31 | 23.16 | 8.44 | 355.51 | 20550.17 | . | 10090.86 | -773.88 | 11233.18 | 0.14 | 0.29 |
| 25 | 348 | INORG N | 2825.92 | 387.80 | 23.16 | 8.44 | 177.76 | 3423.09 | . | 2077.64 | -159.34 | 1504.79 | 0.15 | 0.18 |
| 25 | 348 | FLOW | 6863.75 | 856.10 | . | . | 416.88 | 8136.74 | 561.11 | 9048.39 | -650.90 | -260.75 | . | . |
| 25 | 370 | TOTAL P | 7.15 | 0.76 | 0.00 | 0.21 | 1.03 | 9.16 | . | 1.94 | 4.06 | 3.16 | 0.49 | 0.23 |
| 25 | 370 | ORTHO P | 1.90 | 0.20 | 0.00 | 0.21 | 0.52 | 2.83 | . | 0.38 | 0.79 | 1.66 | 0.11 | 0.15 |
| 25 | 370 | TOTAL N | 127.95 | 13.57 | 0.00 | 8.14 | 34.35 | 184.01 | . | 45.87 | 95.90 | 42.24 | 0.49 | 0.14 |
| 25 | 370 | INORG N | 72.80 | 7.72 | 0.00 | 8.14 | 17.18 | 105.84 | . | 5.16 | 10.78 | 89.91 | 0.21 | 0.37 |
| 25 | 370 | FLOW | 171.24 | 18.16 | . | . | 24.31 | 213.71 | 55.96 | 124.28 | 142.83 | -53.40 | . | . |
| 26 | 345 | TOTAL P | 216.62 | 60.25 | 9.72 | 0.05 | 1.62 | 288.26 | . | 24.44 | 0.27 | 263.55 | 0.06 | 0.15 |
| 26 | 345 | ORTHO P | 168.07 | 54.93 | 9.72 | 0.05 | 0.81 | 233.58 | . | 9.06 | 0.10 | 224.41 | 0.06 | 0.16 |
| 26 | 345 | TOTAL N | 878.66 | 168.73 | 42.60 | 1.94 | 54.14 | 1146.07 | . | 905.21 | 9.94 | 230.91 | 0.05 | 0.06 |
| 26 | 345 | INORG N | 463.71 | 117.83 | 42.60 | 1.94 | 27.07 | 653.16 | . | 326.55 | 3.59 | 323.03 | 0.05 | 0.13 |
| 26 | 345 | FLOW | 599.87 | 87.49 | . | . | 48.35 | 735.71 | 77.18 | 1156.90 | 11.86 | -433.04 | . | . |
| 26 | 347 | TOTAL P | 13.79 | 0.60 | 0.00 | 0.02 | 1.05 | 15.46 | . | 9.35 | -0.43 | 6.53 | 0.19 | 0.06 |
| 26 | 347 | ORTHO P | 5.97 | 0.34 | 0.00 | 0.02 | 0.52 | 6.85 | . | 4.73 | -0.22 | 2.34 | 0.14 | 0.10 |
| 26 | 347 | TOTAL N | 1110.66 | 22.92 | 0.00 | 0.83 | 34.91 | 1169.33 | . | 602.94 | -27.66 | 594.04 | 0.04 | 0.05 |
| 26 | 347 | INORG N | 770.82 | 8.69 | 0.00 | 0.83 | 17.46 | 797.80 | . | 352.28 | -16.16 | 461.68 | 0.04 | 0.11 |
| 26 | 347 | FLOW | 797.83 | 57.71 | . | . | 29.95 | 885.49 | 49.77 | 878.91 | -38.04 | 44.62 | . | . |
| 26 | 354 | TOTAL P | 227.81 | 2.77 | 6.47 | 0.08 | 1.68 | 238.81 | . | 46.89 | -1.40 | 193.32 | 0.32 | 0.24 |
| 26 | 354 | ORTHO P | 68.72 | 3.07 | 6.47 | 0.08 | 0.84 | 79.19 | . | 22.77 | -0.68 | 57.10 | 0.68 | 0.35 |
| 26 | 354 | TOTAL N | 2014.64 | 185.81 | 11.51 | 3.10 | 55.96 | 2271.02 | . | 849.69 | -25.34 | 1446.67 | 0.50 | 0.15 |
| 26 | 354 | INORG N | 576.77 | 92.23 | 11.51 | 3.10 | 27.98 | 711.60 | . | 193.94 | -5.78 | 523.44 | 0.36 | 0.25 |
| 26 | 354 | FLOW | 991.64 | 97.23 | . | . | 65.67 | 1154.54 | 91.17 | 1047.74 | -28.53 | 135.34 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 355 | TOTAL P | 288.41 | 37.89 | 30.72 | 0.00 | 2.89 | 359.91 | . | 112.36 | 0.02 | 247.54 | 0.30 | 0.09 |
| 26 | 355 | ORTHO P | 79.35 | 15.94 | 30.72 | 0.00 | 1.45 | 127.46 | . | 63.83 | 0.01 | 63.62 | 0.13 | 0.15 |
| 26 | 355 | TOTAL N | 1837.96 | 667.37 | 166.34 | 0.00 | 96.49 | 2768.15 | . | 1394.08 | 0.24 | 1373.84 | 0.19 | 0.09 |
| 26 | 355 | INORG N | 406.12 | 164.73 | 166.34 | 0.00 | 48.25 | 785.44 | . | 654.69 | 0.11 | 130.63 | 0.12 | 0.14 |
| 26 | 355 | FLOW | 914.06 | 516.83 | . | . | 106.57 | 1537.46 | 157.21 | 1615.24 | 0.25 | -78.03 | . | . |
| 26 | 359 | TOTAL P | 253.23 | 107.33 | 1.06 | 0.03 | 13.29 | 374.95 | . | 98.03 | 4.11 | 272.81 | 0.06 | 0.20 |
| 26 | 359 | ORTHO P | 89.74 | 35.94 | 1.06 | 0.03 | 6.64 | 133.43 | . | 37.83 | 1.58 | 94.02 | 0.07 | 0.37 |
| 26 | 359 | TOTAL N | 2493.22 | 1125.15 | 3.12 | 1.30 | 442.94 | 4065.73 | . | 2754.41 | 115.39 | 1195.94 | 0.06 | 0.28 |
| 26 | 359 | INORG N | 452.48 | 215.87 | 3.12 | 1.30 | 221.47 | 894.25 | . | 618.93 | 25.93 | 249.39 | 0.13 | 0.17 |
| 26 | 359 | FLOW | 2745.81 | 1079.03 | . | . | 707.18 | 4532.03 | 586.35 | 4212.73 | 151.92 | 167.38 | . | . |
| 26 | 360 | TOTAL P | 3.71 | 0.70 | 0.00 | 0.00 | 0.30 | 4.71 | . | 1.17 | 5.49 | -1.95 | 0.05 | 0.00 |
| 26 | 360 | ORTHO P | 1.49 | 0.28 | 0.00 | 0.00 | 0.15 | 1.92 | . | 0.23 | 1.06 | 0.64 | 0.06 | 0.00 |
| 26 | 360 | TOTAL N | 289.34 | 54.46 | 0.00 | 0.00 | 10.09 | 353.89 | . | 19.05 | 89.48 | 245.37 | 0.03 | 0.00 |
| 26 | 360 | INORG N | 757.26 | 142.54 | 0.00 | 0.00 | 5.04 | 904.84 | . | 0.23 | 1.10 | 903.51 | 0.05 | 0.00 |
| 26 | 360 | FLOW | 68.89 | 12.97 | . | . | 6.45 | 88.31 | 19.00 | 28.01 | 42.33 | 17.97 | . | . |
| 26 | 361 | TOTAL P | 65.71 | 11.81 | 2.17 | 0.00 | 1.51 | 81.21 | . | 49.08 | 0.00 | 32.12 | 0.09 | 0.15 |
| 26 | 361 | ORTHO P | 25.57 | 4.53 | 2.17 | 0.00 | 0.76 | 33.02 | . | 14.99 | 0.00 | 18.03 | 0.12 | 0.33 |
| 26 | 361 | TOTAL N | 977.67 | 194.18 | 6.49 | 0.21 | 50.34 | 1228.89 | . | 915.05 | 0.00 | 313.84 | 0.04 | 0.10 |
| 26 | 361 | INORG N | 125.19 | 26.06 | 6.49 | 0.21 | 25.17 | 183.12 | . | 67.20 | 0.00 | 115.92 | 0.13 | 0.25 |
| 26 | 361 | FLOW | 564.14 | 107.22 | . | . | 60.04 | 731.40 | 69.20 | 815.88 | 0.00 | -84.48 | . | . |
| 26 | 362 | TOTAL P | 29.85 | 0.93 | 0.68 | 0.00 | 0.81 | 32.28 | . | 12.25 | -0.45 | 20.48 | 0.34 | 0.12 |
| 26 | 362 | ORTHO P | 8.10 | 0.30 | 0.68 | 0.00 | 0.41 | 9.49 | . | 4.33 | -0.16 | 5.32 | 0.19 | 0.11 |
| 26 | 362 | TOTAL N | 835.51 | 35.50 | 2.04 | 0.00 | 27.17 | 900.22 | . | 463.71 | -16.93 | 453.43 | 0.25 | 0.08 |
| 26 | 362 | INORG N | 263.34 | 15.54 | 2.04 | 0.00 | 13.58 | 294.50 | . | 184.25 | -6.73 | 116.98 | 0.13 | 0.09 |
| 26 | 362 | FLOW | 615.01 | 55.66 | . | . | 24.26 | 694.93 | 38.04 | 751.90 | -26.06 | -30.91 | . | . |
| 26 | 364 | TOTAL P | 608.55 | 1.02 | 1.53 | 0.25 | 2.60 | 613.95 | . | 28.54 | 2.78 | 582.62 | 1.32 | 0.30 |
| 26 | 364 | ORTHO P | 92.81 | 0.56 | 1.53 | 0.25 | 1.30 | 96.45 | . | 20.07 | 1.96 | 74.43 | 1.04 | 0.18 |
| 26 | 364 | TOTAL N | 3340.26 | 77.76 | 4.59 | 9.42 | 86.68 | 3518.71 | . | 2419.96 | 236.04 | 862.71 | 0.63 | 0.35 |
| 26 | 364 | INORG N | 688.10 | 37.80 | 4.59 | 9.42 | 43.34 | 783.26 | . | 1623.92 | 158.40 | -999.06 | 0.41 | 0.73 |
| 26 | 364 | FLOW | 1989.82 | 84.17 | . | . | 79.41 | 2153.39 | 121.37 | 2105.59 | 193.54 | -145.74 | . | . |
| 28 | 219 | TOTAL P | 0.89 | 0.11 | 0.00 | 0.04 | 0.52 | 1.56 | . | 1.98 | -2.20 | 1.79 | 0.56 | 2.37 |
| 28 | 219 | ORTHO P | 0.23 | 0.02 | 0.00 | 0.04 | 0.26 | 0.55 | . | 0.33 | -0.37 | 0.58 | 0.22 | 1.10 |
| 28 | 219 | TOTAL N | 10.38 | 1.34 | 0.00 | 1.52 | 17.30 | 30.54 | . | 81.70 | -91.10 | 39.95 | 0.37 | 1.97 |
| 28 | 219 | INORG N | 1.51 | 0.12 | 0.00 | 1.52 | 8.65 | 11.80 | . | 3.14 | -3.51 | 12.17 | 0.29 | 1.28 |
| 28 | 219 | FLOW | 11.87 | 1.53 | . | . | 4.82 | 18.22 | 28.18 | 81.37 | -59.31 | -3.85 | . | . |
| 29 | 100 | TOTAL P | 63.41 | 32.92 | 0.56 | 0.16 | 1.35 | 98.41 | . | 9.29 | -0.20 | 89.31 | 0.06 | 0.13 |
| 29 | 100 | ORTHO P | 19.53 | 10.14 | 0.56 | 0.16 | 0.67 | 31.07 | . | 1.69 | -0.04 | 29.41 | 0.14 | 0.14 |
| 29 | 100 | TOTAL N | 442.29 | 229.59 | 1.70 | 0.92 | 44.85 | 719.35 | . | 303.81 | -6.43 | 421.97 | 0.16 | 0.07 |
| 29 | 100 | INORG N | 294.82 | 153.04 | 1.70 | 0.92 | 22.43 | 472.90 | . | 145.66 | -3.08 | 330.32 | 0.12 | 0.06 |
| 29 | 100 | FLOW | 145.95 | 75.76 | . | . | 34.52 | 256.24 | 42.25 | 217.38 | -3.71 | 42.56 | . | . |

## NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 106 | TOTAL P | 133.14 | 10.91 | 0.81 | 0.01 | 0.38 | 145.27 | . | 17.38 | 3.40 | 124.49 | 0.15 | 0.43 |
| 29 | 106 | ORTHO P | 29.90 | 3.37 | 0.81 | 0.01 | 0.19 | 34.29 | . | 5.64 | 1.10 | 27.55 | 0.07 | 0.17 |
| 29 | 106 | TOTAL N | 510.74 | 137.33 | 1.05 | 0.49 | 12.77 | 662.38 | . | 306.89 | 60.00 | 295.49 | 0.11 | 0.16 |
| 29 | 106 | INORG N | 75.97 | 68.31 | 1.05 | 0.49 | 6.39 | 152.21 | . | 84.53 | 16.53 | 51.16 | 0.15 | 0.19 |
| 29 | 106 | FLOW | 195.72 | 64.30 | . | . | 7.56 | 267.59 | 18.86 | 212.56 | 37.87 | 17.16 | . | . |
| 29 | 108 | TOTAL P | 235.91 | 18.88 | 0.83 | 0.00 | 1.94 | 257.57 | . | 27.22 | 1.81 | 228.54 | 0.08 | 0.24 |
| 29 | 108 | ORTHO P | 91.72 | 8.74 | 0.83 | 0.00 | 0.97 | 102.26 | . | 12.95 | 0.86 | 88.45 | 0.10 | 0.27 |
| 29 | 108 | TOTAL N | 1086.80 | 189.12 | 2.48 | 0.00 | 64.79 | 1343.20 | . | 681.05 | 45.34 | 616.81 | 0.19 | 0.41 |
| 29 | 108 | INORG N | 386.02 | 57.04 | 2.48 | 0.00 | 32.40 | 477.94 | . | 108.37 | 7.21 | 362.35 | 0.28 | 0.45 |
| 29 | 108 | FLOW | 476.06 | 54.98 | . | . | 42.92 | 573.96 | 89.07 | 545.60 | 30.39 | -2.03 | . | . |
| 29 | 109 | TOTAL P | 27.77 | 23.46 | 0.31 | 0.00 | 0.83 | 52.37 | . | 7.54 | 1.14 | 43.69 | 0.26 | 0.15 |
| 29 | 109 | ORTHO P | 5.24 | 4.43 | 0.31 | 0.00 | 0.41 | 10.39 | . | 2.66 | 0.40 | 7.34 | 0.09 | 0.31 |
| 29 | 109 | TOTAL N | 502.52 | 424.40 | 0.93 | 0.00 | 27.66 | 955.51 | . | 364.64 | 55.00 | 535.88 | 0.11 | 0.17 |
| 29 | 109 | INORG N | 113.15 | 95.56 | 0.93 | 0.00 | 13.83 | 223.48 | . | 81.20 | 12.25 | 130.03 | 1.62 | 0.33 |
| 29 | 109 | FLOW | 129.85 | 109.67 | . | . | 23.04 | 262.55 | 36.61 | 246.86 | 31.71 | -16.03 | . | . |
| 29 | 110 | TOTAL P | 145.87 | 6.62 | 1.78 | 0.00 | 1.48 | 155.74 | . | 23.11 | -0.57 | 133.20 | 0.06 | 0.38 |
| 29 | 110 | ORTHO P | 40.37 | 1.62 | 1.78 | 0.00 | 0.74 | 44.51 | . | 7.28 | -0.18 | 37.41 | 0.03 | 0.51 |
| 29 | 110 | TOTAL N | 921.12 | 103.15 | 5.33 | 0.00 | 49.30 | 1078.91 | . | 440.34 | -10.77 | 649.34 | 0.06 | 0.19 |
| 29 | 110 | INORG N | 484.94 | 40.89 | 5.33 | 0.00 | 24.65 | 555.82 | . | 248.80 | -6.09 | 313.11 | 0.10 | 0.33 |
| 29 | 110 | FLOW | 268.71 | 73.09 | . | . | 37.21 | 379.01 | 60.25 | 430.90 | -9.07 | -42.82 | . | . |
| 29 | 111 | TOTAL P | 22.10 | 4.54 | 0.68 | 0.00 | 0.49 | 27.81 | . | 14.48 | -0.30 | 13.63 | 0.27 | 0.12 |
| 29 | 111 | ORTHO P | 7.25 | 2.65 | 0.68 | 0.00 | 0.24 | 10.82 | . | 3.60 | -0.08 | 7.29 | 0.31 | 0.16 |
| 29 | 111 | TOTAL N | 479.61 | 149.96 | 2.04 | 0.00 | 16.30 | 647.92 | . | 555.03 | -11.58 | 104.47 | 0.34 | 0.09 |
| 29 | 111 | INORG N | 163.08 | 40.21 | 2.04 | 0.00 | 8.15 | 213.47 | . | 175.78 | -3.67 | 41.36 | 0.29 | 0.02 |
| 29 | 111 | FLOW | 126.28 | 77.12 | . | . | 13.58 | 216.98 | 20.75 | 264.13 | -5.08 | -42.07 | . | . |
| 29 | 113 | TOTAL P | 1464.46 | 34.08 | 7.49 | 0.00 | 2.06 | 1508.10 | . | 203.02 | 8.91 | 1296.17 | 0.07 | 0.23 |
| 29 | 113 | ORTHO P | 368.28 | 13.08 | 7.49 | 0.00 | 1.03 | 389.89 | . | 115.05 | 5.05 | 269.78 | 0.03 | 0.33 |
| 29 | 113 | TOTAL N | 6467.39 | 447.62 | 26.74 | 0.00 | 68.82 | 7010.57 | . | 3427.27 | 150.44 | 3432.86 | 0.11 | 0.07 |
| 29 | 113 | INORG N | 2409.53 | 201.52 | 26.74 | 0.00 | 34.41 | 2672.20 | . | 1785.62 | 78.38 | 808.20 | 0.19 | 0.24 |
| 29 | 113 | FLOW | 1267.33 | 202.40 | . | . | 52.01 | 1521.73 | 94.61 | 1585.73 | 65.45 | -129.45 | . | . |
| 29 | 114 | TOTAL P | 18.32 | 0.12 | 0.27 | 0.00 | 1.12 | 19.84 | . | 3.14 | -0.31 | 17.01 | 0.18 | 0.14 |
| 29 | 114 | ORTHO P | 2.99 | 0.02 | 0.27 | 0.00 | 0.56 | 3.84 | . | 0.98 | -0.10 | 2.95 | 0.14 | 0.33 |
| 29 | 114 | TOTAL N | 121.04 | 14.65 | 0.81 | 0.00 | 37.47 | 173.97 | . | 90.41 | -9.02 | 92.57 | 0.10 | 0.08 |
| 29 | 114 | INORG N | 21.53 | 7.94 | 0.81 | 0.00 | 18.73 | 49.02 | . | 19.77 | -1.97 | 31.22 | 0.17 | 0.08 |
| 29 | 114 | FLOW | 74.06 | 7.46 | . | . | 15.28 | 96.80 | 53.41 | 136.84 | -8.32 | -31.71 | . | . |
| 29 | 194 | TOTAL P | 24.00 | 2.52 | 0.00 | 0.02 | 0.99 | 27.53 | . | 43.74 | -0.24 | -15.97 | 0.25 | 0.15 |
| 29 | 194 | ORTHO P | 26.64 | 1.44 | 0.00 | 0.02 | 0.50 | 28.60 | . | 20.66 | -0.11 | 8.05 | 0.51 | 0.18 |
| 29 | 194 | TOTAL N | 803.31 | 355.91 | 0.00 | 0.99 | 33.03 | 1193.24 | . | 1202.33 | -6.58 | -2.50 | 0.26 | 0.06 |
| 29 | 194 | INORG N | 257.07 | 52.54 | 0.00 | 0.99 | 16.52 | 327.11 | . | 278.39 | -1.52 | 50.24 | 1.09 | 0.22 |
| 29 | 194 | FLOW | 448.52 | 193.09 | . | . | 36.68 | 678.30 | 35.32 | 711.97 | -[illegible].71 | -29.97 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 195 | TOTAL P | 56.11 | 36.51 | 0.38 | 0.00 | 3.14 | 96.14 | . | 27.72 | 0.30 | 68.12 | 0.22 | 0.05 |
| 29 | 195 | ORTHO P | 28.47 | 11.81 | 0.38 | 0.00 | 1.57 | 42.24 | . | 9.86 | 0.11 | 32.27 | 0.14 | 0.06 |
| 29 | 195 | TOTAL N | 2092.22 | 1229.91 | 0.97 | 0.21 | 104.56 | 3427.87 | . | 3790.59 | 40.83 | -403.55 | 0.05 | 0.06 |
| 29 | 195 | INORG N | 1111.50 | 762.41 | 0.97 | 0.21 | 52.28 | 1927.37 | . | 800.56 | 8.62 | 1118.18 | 0.04 | 0.08 |
| 29 | 195 | FLOW | 741.51 | 508.81 | . | . | 116.11 | 1366.43 | 111.79 | 1487.64 | 14.82 | -136.03 | . | . |
| 29 | 207 | TOTAL P | 72.19 | 1.14 | 1.92 | 0.04 | 1.43 | 76.72 | . | 21.05 | -3.02 | 58.69 | 0.09 | 0.09 |
| 29 | 207 | ORTHO P | 62.50 | 0.45 | 1.92 | 0.04 | 0.71 | 65.63 | . | 11.42 | -1.64 | 55.85 | 0.18 | 0.16 |
| 29 | 207 | TOTAL N | 1253.35 | 3.48 | 5.59 | 1.60 | 47.55 | 1311.57 | . | 213.28 | -30.57 | 1128.86 | 0.13 | 0.08 |
| 29 | 207 | INORG N | 142.40 | 0.80 | 5.59 | 1.60 | 23.77 | 174.17 | . | 30.66 | -[illegible].39 | 147.90 | 1.79 | 0.27 |
| 29 | 207 | FLOW | 223.10 | 1.13 | . | . | 29.02 | 253.26 | 65.36 | 237.97 | -24.74 | 40.03 | . | . |
| 30 | 064 | TOTAL P | 0.46 | 0.03 | 0.00 | 0.00 | 0.10 | 0.60 | . | 0.38 | 0.01 | 0.21 | 0.96 | 0.31 |
| 30 | 064 | ORTHO P | 0.19 | 0.01 | 0.00 | 0.00 | 0.05 | 0.26 | . | 0.20 | 0.00 | 0.06 | 0.50 | 0.56 |
| 30 | 064 | TOTAL N | 2.99 | 0.22 | 0.00 | 0.24 | 3.37 | 6.83 | . | 3.54 | 0.05 | 3.23 | 0.54 | 0.21 |
| 30 | 064 | INORG N | 1.26 | 0.09 | 0.00 | 0.24 | 1.69 | 3.28 | . | 0.87 | 0.01 | 2.39 | 0.66 | 0.37 |
| 30 | 064 | FLOW | 0.92 | 0.07 | . | . | 1.43 | 2.42 | 4.12 | 6.51 | 0.04 | -4.13 | . | . |
| 30 | 215 | TOTAL P | 1.56 | 0.57 | 0.00 | 0.00 | 0.09 | 2.22 | . | 0.75 | 0.06 | 1.41 | 0.08 | 0.40 |
| 30 | 215 | ORTHO P | 0.92 | 0.34 | 0.00 | 0.00 | 0.04 | 1.30 | . | 0.23 | 0.02 | 1.06 | 0.13 | 0.69 |
| 30 | 215 | TOTAL N | 8.95 | 3.26 | 0.00 | 0.00 | 2.92 | 15.13 | . | 5.05 | 0.38 | 9.70 | 0.09 | 0.28 |
| 30 | 215 | INORG N | 2.81 | 1.02 | 0.00 | 0.00 | 1.46 | 5.30 | . | 2.05 | 0.15 | 3.09 | 0.13 | 0.57 |
| 30 | 215 | FLOW | 4.54 | 1.65 | . | . | 1.77 | 7.97 | 3.27 | 6.26 | 0.22 | 1.48 | . | . |
| 30 | 217 | TOTAL P | 3.89 | 2.12 | 0.00 | 0.00 | 0.22 | 6.23 | . | 2.40 | 0.26 | 3.56 | 0.11 | 0.29 |
| 30 | 217 | ORTHO P | 2.37 | 1.29 | 0.00 | 0.00 | 0.11 | 3.76 | . | 1.78 | 0.19 | 1.78 | 0.11 | 0.30 |
| 30 | 217 | TOTAL N | 36.71 | 19.97 | 0.00 | 0.00 | 7.18 | 63.85 | . | 13.87 | 1.50 | 48.49 | 0.08 | 0.21 |
| 30 | 217 | INORG N | 14.15 | 7.70 | 0.00 | 0.00 | 3.59 | 25.44 | . | 6.74 | 0.73 | 17.97 | 0.11 | 0.33 |
| 30 | 217 | FLOW | 11.05 | 6.01 | . | . | 4.34 | 21.41 | 8.04 | 17.47 | 1.02 | 2.92 | . | . |
| 30 | 235 | TOTAL P | 10887.86 | 314.25 | 17.65 | 0.01 | 42.72 | 11262.50 | . | 779.57 | 41.24 | 10441.69 | 0.24 | 0.38 |
| 30 | 235 | ORTHO P | 567.45 | 94.08 | 17.65 | 0.01 | 21.36 | 700.55 | . | 345.58 | 18.28 | 336.69 | 0.18 | 0.46 |
| 30 | 235 | TOTAL N | 41805.09 | 1889.53 | 52.94 | 0.45 | 1424.15 | 45172.17 | . | 15676.70 | 829.28 | 28666.19 | 0.12 | 0.21 |
| 30 | 235 | INORG N | 4683.45 | 167.10 | 52.94 | 0.45 | 712.08 | 5616.02 | . | 4792.39 | 253.51 | 570.12 | 0.29 | 0.20 |
| 30 | 235 | FLOW | 31337.46 | 1030.59 | . | . | 609.47 | 32977.53 | 1341.41 | 29981.41 | 1515.02 | 1481.10 | . | . |
| 31 | 077 | TOTAL P | 88.12 | 22.26 | 0.00 | 0.00 | 1.71 | 112.09 | . | 91.73 | -3.19 | 23.55 | 0.21 | 0.19 |
| 31 | 077 | ORTHO P | 37.06 | 8.54 | 0.00 | 0.00 | 0.85 | 46.46 | . | 42.76 | -1.49 | 5.19 | 0.30 | 0.17 |
| 31 | 077 | TOTAL N | 3093.39 | 876.93 | 0.00 | 0.00 | 56.99 | 4027.31 | . | 2135.39 | -74.17 | 1966.10 | 0.18 | 0.23 |
| 31 | 077 | INORG N | 136.34 | 37.20 | 0.00 | 0.00 | 28.50 | 202.04 | . | 429.64 | -14.92 | -212.68 | 0.11 | 0.13 |
| 31 | 077 | FLOW | 4578.89 | 1229.44 | . | . | 37.07 | 5845.40 | 39.17 | 5550.58 | -191.44 | 486.26 | . | . |
| 32 | 204 | TOTAL P | 24.04 | 84.67 | 0.00 | 0.00 | 3.86 | 112.57 | . | 233.29 | -0.01 | -120.70 | 0.07 | 0.10 |
| 32 | 204 | ORTHO P | 12.88 | 24.94 | 0.00 | 0.00 | 1.93 | 39.75 | . | 198.06 | -0.01 | -158.30 | 0.13 | 0.13 |
| 32 | 204 | TOTAL N | 144.41 | 979.56 | 0.00 | 0.00 | 128.77 | 1252.75 | . | 4194.20 | -0.24 | -2941.21 | 0.22 | 0.30 |
| 32 | 204 | INORG N | 18.09 | 97.27 | 0.00 | 0.00 | 64.39 | 179.75 | . | 828.34 | -0.05 | -648.54 | 0.21 | 0.11 |
| 32 | 204 | FLOW | 332.19 | 4569.96 | . | . | 58.72 | 4960.87 | 85.23 | 9751.90 | -0.56 | -4790.47 | . | . |

NUTRIENT BUDGET SUMMARIES

| DIS | RES | PARAM | LGAUG | LUNGD | LPOINT | LOTHER | LPREC | LTOTAL | LEVAP | LOUT | LDSTOR | LNET | CVI | CVO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 300 | TOTAL P | 36.50 | 8.80 | 0.00 | 0.00 | 0.27 | 45.57 | . | 40.32 | -0.89 | 6.14 | 0.12 | 0.20 |
| 33 | 300 | ORTHO P | 28.26 | 6.81 | 0.00 | 0.00 | 0.13 | 35.21 | . | 27.05 | -0.60 | 8.76 | 0.12 | 0.28 |
| 33 | 300 | TOTAL N | 166.59 | 40.15 | 0.00 | 0.03 | 8.88 | 215.65 | . | 276.91 | -6.12 | -55.13 | 0.18 | 0.36 |
| 33 | 300 | INORG N | 26.08 | 6.29 | 0.00 | 0.03 | 4.44 | 36.83 | . | 53.69 | -1.19 | -15.67 | 0.14 | 0.20 |
| 33 | 300 | FLOW | 908.65 | 219.00 | . | . | 10.98 | 1138.63 | 5.42 | 1132.75 | -24.93 | 30.81 | . | . |
| 34 | 048 | TOTAL P | 26.75 | 31.77 | 10.62 | 0.00 | 1.21 | 70.36 | . | 32.98 | 2.63 | 34.76 | 0.23 | 0.19 |
| 34 | 048 | ORTHO P | 12.50 | 14.50 | 10.62 | 0.00 | 0.61 | 38.23 | . | 17.26 | 1.38 | 19.58 | 0.50 | 0.09 |
| 34 | 048 | TOTAL N | 873.95 | 752.11 | 23.56 | 0.19 | 40.37 | 1690.19 | . | 2183.03 | 174.29 | -667.13 | 0.16 | 0.12 |
| 34 | 048 | INORG N | 49.88 | 88.09 | 23.56 | 0.19 | 20.18 | 181.91 | . | 250.08 | 19.97 | -88.13 | 0.22 | 0.03 |
| 34 | 048 | FLOW | 1248.40 | 786.08 | . | . | 36.29 | 2070.77 | 61.68 | 2103.77 | 163.03 | -196.03 | . | . |
| 35 | 029 | TOTAL P | 46.61 | 5.16 | 0.00 | 0.00 | 0.20 | 51.97 | . | 22.88 | 1.14 | 27.95 | 0.35 | 0.15 |
| 35 | 029 | ORTHO P | 9.50 | 1.05 | 0.00 | 0.00 | 0.10 | 10.66 | . | 9.26 | 0.46 | 0.93 | 0.15 | 0.11 |
| 35 | 029 | TOTAL N | 335.72 | 37.19 | 0.00 | 0.00 | 6.73 | 379.64 | . | 274.54 | 13.72 | 91.37 | 0.21 | 0.12 |
| 35 | 029 | INORG N | 51.52 | 5.71 | 0.00 | 0.00 | 3.36 | 60.59 | . | 43.15 | 2.16 | 15.28 | 0.22 | 0.15 |
| 35 | 029 | FLOW | 357.78 | 39.63 | . | . | 10.13 | 407.54 | 6.51 | 372.26 | 18.28 | 16.99 | . | . |
| 35 | 039 | TOTAL P | 0.43 | 0.17 | 0.00 | 0.00 | 0.08 | 0.69 | . | 0.13 | -0.10 | 0.66 | 0.39 | 0.17 |
| 35 | 039 | ORTHO P | 0.20 | 0.08 | 0.00 | 0.00 | 0.04 | 0.32 | . | 0.04 | -0.03 | 0.31 | 0.25 | 0.22 |
| 35 | 039 | TOTAL N | 1.24 | 0.48 | 0.00 | 0.21 | 2.74 | 4.67 | . | 2.28 | -1.77 | 4.16 | 0.26 | 0.42 |
| 35 | 039 | INORG N | 0.88 | 0.34 | 0.00 | 0.21 | 1.37 | 2.81 | . | 0.15 | -0.11 | 2.78 | 0.36 | 0.12 |
| 35 | 039 | FLOW | 5.57 | 2.17 | . | . | 2.31 | 10.05 | 3.77 | 8.69 | -3.83 | 5.19 | . | . |

Table B2

Water Balances and Inflow Concentrations by Period

| Symbol | Meaning |
|---|---|
| DIS | CE District code |
| RES | CE reservoir code |
| GP | data screening code (A = high accuracy, B = low accuracy) |
| PD | period (N = normal hydrologic year, P = year of pool monitoring by EPA/NES, T = period of tributary monitoring by EPA/NES) |
| QINC | corrected total inflow (hm3/yr) = (cubic hectometre/yr) |
| QOUT | total outflow (hm3/yr) |
| QEVAP | evaporation (hm3/yr) |
| QSTOR | change in storage (hm3/yr) |
| ELEV | mean elevation (ft,msl) |
| AREA | mean surface area (km2) |
| VOLUME | mean volume (hm3) |
| ZMAX | maximum depth (m) |
| ZMEAN | mean depth (m) |
| QS | surface overflow rate (m/yr) |
| THYD | hydraulic residence time (yr) |
| IPTL | inflow total P concentration (mg/m3) |
| IPDS | inflow ortho P concentration (mg/m3) |
| INTL | inflow total N concentration (mg/m3) |
| ININ | inflow inorganic N concentration (mg/m3) |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | B | N | 210.1 | 208.1 | 2.1 | 0.0 | 580.0 | 3.4 | 33.1 | 24.0 | 9.6 | 60.5 | 0.159 | 22.8 | 7.2 | 906.5 | 462.7 |
| 02 | 176 | B | P | . | . | 2.1 | -2.0 | 583.6 | 3.1 | 37.7 | 25.1 | 12.3 | . | . | . | . | . | . |
| 02 | 176 | B | T | 305.7 | 292.8 | 2.1 | 10.8 | 587.9 | 3.3 | 41.0 | 26.4 | 12.6 | 90.0 | 0.140 | 23.2 | 6.8 | 917.2 | 499.7 |
| 03 | 307 | A | N | 195.1 | 192.0 | 3.1 | 0.0 | 628.0 | 3.8 | 50.9 | 38.7 | 13.3 | 50.1 | 0.265 | 13.7 | 6.6 | 1137.2 | 693.6 |
| 03 | 307 | A | P | 212.5 | 207.5 | 3.1 | 1.9 | 628.2 | 3.8 | 51.3 | 38.8 | 13.5 | 54.5 | 0.247 | 13.2 | 6.6 | 1144.8 | 694.1 |
| 03 | 307 | A | T | 209.2 | 208.0 | 3.1 | -1.9 | 627.6 | 3.8 | 50.6 | 38.6 | 13.4 | 55.1 | 0.243 | 13.3 | 6.6 | 1143.4 | 694.0 |
| 04 | 312 | A | N | 387.0 | 383.5 | 3.5 | 0.0 | 630.0 | 7.0 | 35.5 | 15.2 | 5.1 | 54.8 | 0.093 | 174.3 | 113.6 | 2695.6 | 1847.7 |
| 04 | 312 | A | P | 477.1 | 476.5 | 3.5 | -2.9 | 621.6 | 4.8 | 22.7 | 12.7 | 4.7 | 99.1 | 0.048 | 165.1 | 104.0 | 2663.9 | 1775.2 |
| 04 | 312 | A | T | 456.8 | 460.9 | 3.5 | -7.5 | 620.6 | 4.7 | 21.4 | 12.4 | 4.5 | 98.0 | 0.046 | 166.9 | 105.9 | 2670.4 | 1790.0 |
| 06 | 372 | A | N | 6825.6 | 6629.4 | 196.2 | 0.0 | 302.0 | 215.0 | 1888.6 | 33.2 | 8.8 | 30.8 | 0.285 | 128.1 | 36.2 | 1301.0 | 350.8 |
| 06 | 372 | A | P | 10868.3 | 10621.3 | 196.2 | 50.8 | 300.8 | 199.6 | 1865.8 | 32.9 | 9.3 | 53.2 | 0.176 | 133.0 | 33.0 | 1386.1 | 371.3 |
| 06 | 372 | A | T | 7380.1 | 7262.4 | 196.2 | -78.5 | 299.6 | 192.8 | 1787.3 | 32.5 | 9.3 | 37.7 | 0.246 | 128.8 | 35.6 | 1314.6 | 353.8 |
| 08 | 074 | A | N | 7770.1 | 7469.4 | 300.7 | 0.0 | 330.0 | 287.9 | 3098.3 | 42.7 | 10.8 | 25.9 | 0.415 | 54.8 | 15.8 | 643.6 | 237.6 |
| 08 | 074 | A | P | 12520.8 | 11864.2 | 300.7 | 356.0 | 328.5 | 277.7 | 2967.8 | 42.2 | 10.7 | 42.7 | 0.250 | 54.2 | 15.5 | 684.0 | 271.1 |
| 08 | 074 | A | T | 11896.3 | 11483.1 | 300.7 | 112.6 | 329.2 | 281.4 | 3021.5 | 42.4 | 10.7 | 40.8 | 0.263 | 54.3 | 15.5 | 679.5 | 267.3 |
| 08 | 330 | A | N | 3950.5 | 3721.6 | 228.9 | 0.0 | 660.0 | 227.1 | 3147.2 | 56.4 | 13.9 | 16.4 | 0.846 | 51.4 | 22.2 | 673.9 | 239.4 |
| 08 | 330 | A | P | 5756.5 | 5317.1 | 228.9 | 210.5 | 659.4 | 223.1 | 3098.4 | 56.2 | 13.9 | 23.8 | 0.583 | 51.8 | 20.5 | 669.5 | 246.1 |
| 08 | 330 | A | T | 6153.6 | 5801.8 | 228.9 | 122.9 | 660.0 | 224.9 | 3138.2 | 56.4 | 14.0 | 25.8 | 0.541 | 52.0 | 20.2 | 668.9 | 247.7 |
| 10 | 003 | A | N | 6532.3 | 6518.1 | 14.2 | 0.0 | 187.0 | 13.3 | 145.6 | 21.9 | 10.9 | 488.2 | 0.022 | 35.3 | 10.5 | 1314.3 | 665.2 |
| 10 | 003 | A | P | 9539.8 | 9524.6 | 14.2 | 1.0 | 186.8 | 13.3 | 145.0 | 21.9 | 10.9 | 715.3 | 0.015 | 38.0 | 11.0 | 1279.6 | 629.8 |
| 10 | 003 | A | T | 10386.4 | 10372.6 | 14.2 | -0.4 | 186.8 | 13.3 | 145.0 | 21.9 | 10.9 | 779.1 | 0.014 | 38.6 | 11.1 | 1271.9 | 622.2 |
| 10 | 069 | A | N | 1726.4 | 1684.3 | 42.1 | 0.0 | 848.0 | 57.7 | 582.1 | 45.1 | 10.1 | 29.2 | 0.346 | 61.8 | 16.7 | 661.5 | 283.1 |
| 10 | 069 | A | P | 2643.5 | 2539.1 | 42.1 | 62.3 | 835.5 | 42.3 | 380.0 | 41.3 | 9.0 | 60.0 | 0.150 | 76.1 | 16.4 | 728.5 | 298.9 |
| 10 | 069 | A | T | 2544.9 | 2480.1 | 42.1 | 22.7 | 836.3 | 42.4 | 388.8 | 41.5 | 9.2 | 58.5 | 0.157 | 74.6 | 16.4 | 722.2 | 297.4 |
| 10 | 071 | A | N | 20248.6 | 20068.4 | 180.2 | 0.0 | 77.0 | 151.8 | 453.4 | 10.1 | 3.0 | 132.2 | 0.023 | 85.3 | 29.6 | 1298.0 | 442.4 |
| 10 | 071 | A | P | 29270.6 | 29040.4 | 180.2 | 50.1 | 77.2 | 153.0 | 463.0 | 10.1 | 3.0 | 189.8 | 0.016 | 96.6 | 30.6 | 1426.1 | 442.0 |
| 10 | 071 | A | T | 26995.0 | 26808.1 | 180.2 | 6.7 | 77.3 | 154.0 | 465.9 | 10.1 | 3.0 | 174.1 | 0.017 | 94.0 | 30.4 | 1396.9 | 442.1 |
| 10 | 072 | A | N | 9990.5 | 9798.5 | 192.0 | 0.0 | 190.0 | 182.9 | 1153.4 | 28.4 | 6.3 | 53.6 | 0.118 | 93.2 | 33.7 | 1023.2 | 433.8 |
| 10 | 072 | A | P | 13087.5 | 12806.3 | 192.0 | 89.2 | 187.4 | 173.1 | 1017.9 | 27.6 | 5.9 | 74.0 | 0.079 | 93.5 | 32.4 | 1016.3 | 422.0 |
| 10 | 072 | A | T | 12698.4 | 12518.1 | 192.0 | -11.7 | 187.7 | 175.5 | 1033.0 | 27.7 | 5.9 | 71.3 | 0.083 | 93.5 | 32.5 | 1017.1 | 423.3 |
| 10 | 076 | A | N | 2095.2 | 1933.7 | 161.5 | 0.0 | 1070.0 | 154.0 | 2366.3 | 45.7 | 15.4 | 12.6 | 1.224 | 72.9 | 34.0 | 840.2 | 399.1 |
| 10 | 076 | A | P | 3003.2 | 2443.9 | 161.5 | 397.8 | 1068.0 | 150.9 | 2278.6 | 45.1 | 15.1 | 16.2 | 0.932 | 75.4 | 30.2 | 1006.1 | 453.9 |
| 10 | 076 | A | T | 2888.2 | 2646.5 | 161.5 | 80.2 | 1069.9 | 154.8 | 2364.7 | 45.7 | 15.3 | 17.1 | 0.894 | 75.1 | 30.6 | 986.3 | 447.4 |
| 10 | 411 | A | N | 6079.5 | 6038.0 | 41.4 | 0.0 | 241.5 | 28.2 | 221.3 | 20.3 | 7.8 | 213.8 | 0.037 | 65.5 | 15.5 | 1682.4 | 903.3 |
| 10 | 411 | A | P | 8822.6 | 8782.4 | 41.4 | -1.2 | 254.7 | 38.7 | 364.2 | 24.3 | 9.4 | 226.7 | 0.041 | 64.1 | 15.1 | 1673.6 | 909.7 |
| 10 | 411 | A | T | 9570.1 | 9522.7 | 41.4 | 5.9 | 254.7 | 38.8 | 364.7 | 24.3 | 9.4 | 245.6 | 0.038 | 63.8 | 15.0 | 1671.7 | 911.2 |
| 14 | 099 | A | N | 4128.0 | 4079.5 | 48.5 | 0.0 | 730.0 | 46.2 | 135.7 | 12.2 | 2.9 | 88.4 | 0.033 | 601.4 | 183.3 | 8960.8 | 6591.4 |
| 14 | 099 | A | P | 9330.1 | 9670.8 | 48.5 | -389.2 | 736.8 | 64.4 | 320.8 | 14.3 | 5.0 | 150.3 | 0.033 | 627.8 | 163.7 | 11339.6 | 9421.6 |
| 14 | 099 | A | T | 4827.2 | 4981.3 | 48.5 | -202.6 | 731.8 | 51.5 | 181.6 | 12.7 | 3.5 | 96.7 | 0.036 | 606.3 | 179.3 | 9374.7 | 7058.8 |
| 15 | 178 | B | N | 144.7 | 107.3 | 37.4 | 0.0 | 1193.8 | 52.8 | 671.0 | 21.9 | 12.7 | 2.0 | 6.254 | 28.1 | 10.4 | 927.3 | 248.0 |
| 15 | 178 | B | P | 242.0 | 204.0 | 37.4 | 0.6 | 1193.5 | 52.5 | 663.8 | 21.9 | 12.6 | 3.9 | 3.254 | 28.3 | 9.0 | 948.1 | 238.4 |
| 15 | 178 | B | T | 188.0 | 148.8 | 37.4 | 1.8 | 1193.5 | 52.5 | 663.3 | 21.9 | 12.6 | 2.8 | 4.457 | 28.2 | 9.7 | 936.7 | 242.1 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 181 | B | N | 691.6 | 391.6 | 300.0 | 0.0 | 1294.5 | 481.9 | 2170.1 | 45.6 | 4.5 | 0.8 | 5.542 | 33.7 | 16.6 | 1637.1 | 380.2 |
| 15 | 181 | B | P | 886.3 | 502.4 | 300.0 | 83.9 | 1294.5 | 482.0 | 2171.0 | 45.6 | 4.5 | 1.0 | 4.321 | 34.0 | 16.6 | 1782.7 | 407.7 |
| 15 | 181 | B | T | 610.3 | 368.6 | 300.0 | -58.3 | 1294.1 | 482.0 | 2171.0 | 45.5 | 4.5 | 0.8 | 5.890 | 33.6 | 16.7 | 1568.6 | 367.3 |
| 15 | 237 | A | N | 119.7 | 103.7 | 16.0 | 0.0 | 1266.0 | 22.0 | 87.1 | 13.2 | 4.0 | 4.7 | 0.840 | 254.8 | 138.5 | 2496.9 | 614.5 |
| 15 | 237 | A | P | 228.5 | 211.4 | 16.0 | 1.1 | 1264.1 | 20.0 | 74.2 | 12.6 | 3.7 | 10.6 | 0.351 | 278.0 | 144.8 | 2708.5 | 773.7 |
| 15 | 237 | A | T | 180.7 | 163.4 | 16.0 | 1.3 | 1264.9 | 21.0 | 79.2 | 12.9 | 3.8 | 7.8 | 0.485 | 268.6 | 141.8 | 2627.4 | 708.1 |
| 16 | 243 | A | N | 214.2 | 204.7 | 9.5 | 0.0 | 1019.0 | 10.5 | 50.7 | 21.3 | 4.8 | 19.4 | 0.248 | 280.1 | 180.9 | 2832.2 | 1676.1 |
| 16 | 243 | A | P | 319.8 | 303.9 | 9.5 | 6.4 | 1020.7 | 11.4 | 59.6 | 21.9 | 5.2 | 26.6 | 0.196 | 242.2 | 132.6 | 2803.3 | 1778.2 |
| 16 | 243 | A | T | 280.6 | 280.2 | 9.5 | -9.1 | 1021.7 | 12.1 | 62.3 | 22.2 | 5.2 | 23.2 | 0.222 | 252.6 | 146.4 | 2807.5 | 1736.4 |
| 16 | 254 | B | N | 99.7 | 77.0 | 22.7 | 0.0 | 901.4 | 31.8 | 101.7 | 9.9 | 3.2 | 2.4 | 1.321 | 152.2 | 68.8 | 1870.2 | 917.5 |
| 16 | 254 | B | P | 124.2 | 111.7 | 22.7 | -10.2 | 900.3 | 30.0 | 91.8 | 9.6 | 3.1 | 3.7 | 0.822 | 146.6 | 61.5 | 1858.6 | 924.1 |
| 16 | 254 | B | T | 116.0 | 94.8 | 22.7 | -1.6 | 900.1 | 29.8 | 89.9 | 9.5 | 3.0 | 3.2 | 0.948 | 148.2 | 63.6 | 1861.9 | 921.6 |
| 16 | 317 | A | N | 656.3 | 646.1 | 10.2 | 0.0 | 896.0 | 14.4 | 50.6 | 6.8 | 3.5 | 44.8 | 0.078 | 104.0 | 39.6 | 1424.8 | 624.4 |
| 16 | 317 | A | P | 819.8 | 807.2 | 10.2 | 2.4 | 893.6 | 13.0 | 41.2 | 6.1 | 3.2 | 62.1 | 0.051 | 95.3 | 34.7 | 1498.8 | 700.2 |
| 16 | 317 | A | T | 815.2 | 812.0 | 10.2 | -6.9 | 893.6 | 13.3 | 41.6 | 6.1 | 3.1 | 61.0 | 0.051 | 95.5 | 34.8 | 1496.9 | 698.2 |
| 16 | 328 | A | N | 3446.5 | 3415.1 | 31.4 | 0.0 | 1328.0 | 48.9 | 706.8 | 40.6 | 14.5 | 69.8 | 0.207 | 46.1 | 12.4 | 694.4 | 379.3 |
| 16 | 328 | A | P | 3726.1 | 3629.9 | 31.4 | 64.8 | 1322.3 | 47.7 | 638.7 | 38.8 | 13.4 | 76.1 | 0.176 | 45.0 | 12.1 | 674.8 | 366.5 |
| 16 | 328 | A | T | 3619.3 | 3647.9 | 31.4 | -60.0 | 1319.0 | 45.7 | 600.3 | 37.8 | 13.1 | 79.8 | 0.165 | 45.4 | 12.2 | 682.0 | 371.2 |
| 16 | 393 | B | N | 2074.1 | 2069.6 | 4.5 | 0.0 | 1088.0 | 6.8 | 122.8 | 39.0 | 18.1 | 304.4 | 0.059 | 19.6 | 6.6 | 591.0 | 422.5 |
| 16 | 393 | B | P | 2578.9 | 2548.8 | 4.5 | 25.6 | 1069.7 | 5.8 | 97.7 | 33.4 | 16.8 | 437.2 | 0.038 | 19.9 | 6.4 | 599.1 | 440.7 |
| 16 | 393 | B | T | 2918.2 | 2912.9 | 4.5 | 0.7 | 1069.7 | 5.9 | 95.3 | 33.4 | 16.1 | 491.5 | 0.033 | 20.0 | 6.3 | 603.7 | 451.3 |
| 17 | 241 | A | N | 69.6 | 64.6 | 4.9 | 0.0 | 928.0 | 6.2 | 29.1 | 12.4 | 4.7 | 10.4 | 0.451 | 93.0 | 23.2 | 2253.8 | 1413.4 |
| 17 | 241 | A | P | 81.3 | 76.4 | 4.9 | -0.1 | 928.0 | 6.5 | 29.2 | 12.5 | 4.5 | 11.8 | 0.382 | 87.7 | 21.4 | 2276.0 | 1447.7 |
| 17 | 241 | A | T | 92.4 | 89.5 | 4.9 | -2.0 | 926.9 | 6.2 | 27.2 | 12.1 | 4.4 | 14.3 | 0.304 | 83.6 | 20.1 | 2296.2 | 1478.7 |
| 17 | 242 | A | N | 238.0 | 236.0 | 2.0 | 0.0 | 948.0 | 1.7 | 2.1 | 3.6 | 1.3 | 138.8 | 0.009 | 255.1 | 55.6 | 3926.8 | 2811.4 |
| 17 | 242 | A | P | 382.1 | 380.6 | 2.0 | -0.5 | 949.6 | 2.2 | 3.1 | 4.1 | 1.4 | 175.7 | 0.008 | 257.6 | 49.4 | 4320.5 | 3243.6 |
| 17 | 242 | A | T | 289.9 | 288.3 | 2.0 | -0.4 | 950.4 | 2.5 | 3.8 | 4.3 | 1.5 | 117.1 | 0.013 | 255.8 | 52.8 | 4082.4 | 2979.5 |
| 17 | 245 | A | N | 176.7 | 171.8 | 4.9 | 0.0 | 997.0 | 5.5 | 7.4 | 3.7 | 1.4 | 31.4 | 0.043 | 166.7 | 48.9 | 2962.6 | 1574.3 |
| 17 | 245 | A | P | 316.9 | 314.3 | 4.9 | -2.2 | 998.0 | 5.6 | 9.0 | 4.0 | 1.6 | 56.0 | 0.029 | 174.1 | 50.2 | 3305.0 | 1939.6 |
| 17 | 245 | A | T | 282.8 | 280.2 | 4.9 | -2.2 | 998.5 | 6.0 | 9.9 | 4.1 | 1.7 | 47.0 | 0.035 | 172.6 | 49.9 | 3235.0 | 1861.9 |
| 17 | 247 | B | N | 230.0 | 226.2 | 3.9 | 0.0 | 805.0 | 4.5 | 18.6 | 12.2 | 4.1 | 49.8 | 0.082 | 103.7 | 40.1 | 2970.8 | 2114.4 |
| 17 | 247 | B | P | 398.1 | 394.9 | 3.9 | -0.7 | 805.6 | 4.5 | 19.9 | 12.4 | 4.4 | 88.0 | 0.050 | 89.2 | 34.3 | 3211.0 | 2376.7 |
| 17 | 247 | B | T | 371.8 | 368.1 | 3.9 | -0.2 | 805.9 | 4.6 | 21.0 | 12.5 | 4.6 | 79.9 | 0.057 | 90.9 | 35.0 | 3180.0 | 2342.2 |
| 17 | 248 | A | N | 306.1 | 302.1 | 4.0 | 0.0 | 915.0 | 5.3 | 15.9 | 10.7 | 3.0 | 57.0 | 0.053 | 263.4 | 98.6 | 4117.4 | 2800.8 |
| 17 | 248 | A | P | 532.2 | 532.5 | 4.0 | -4.3 | 913.4 | 4.7 | 14.3 | 10.2 | 3.1 | 113.8 | 0.027 | 265.6 | 91.4 | 4692.1 | 3506.6 |
| 17 | 248 | A | T | 429.8 | 425.9 | 4.0 | -0.1 | 913.9 | 4.8 | 15.0 | 10.3 | 3.1 | 88.8 | 0.035 | 264.7 | 94.1 | 4460.5 | 3214.2 |
| 17 | 249 | A | N | 706.7 | 700.9 | 5.8 | 0.0 | 737.0 | 6.1 | 19.9 | 11.3 | 3.3 | 115.5 | 0.028 | 195.9 | 115.9 | 2853.3 | 1785.7 |
| 17 | 249 | A | P | 1088.1 | 1083.5 | 5.8 | -1.3 | 736.1 | 6.0 | 18.3 | 11.0 | 3.0 | 180.0 | 0.017 | 163.5 | 87.1 | 2518.0 | 1641.4 |
| 17 | 249 | A | T | 1024.8 | 1020.7 | 5.8 | -1.7 | 739.0 | 7.2 | 24.9 | 11.9 | 3.5 | 142.3 | 0.024 | 167.7 | 90.7 | 2562.1 | 1660.7 |
| 17 | 256 | A | N | 174.1 | 171.7 | 2.4 | 0.0 | 1020.0 | 3.4 | 16.7 | 14.6 | 4.8 | 49.9 | 0.097 | 59.8 | 27.1 | 1948.3 | 1322.8 |
| 17 | 256 | A | P | 254.1 | 248.5 | 2.4 | 3.2 | 1014.4 | 2.5 | 13.2 | 12.9 | 5.3 | 99.5 | 0.053 | 50.5 | 21.8 | 2118.0 | 1494.6 |
| 17 | 256 | A | T | 206.6 | 205.3 | 2.4 | -1.1 | 1019.8 | 3.0 | 17.1 | 14.6 | 5.7 | 68.8 | 0.083 | 55.3 | 24.5 | 2023.0 | 1397.5 |

## WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 258 | B | N | 73.9 | 65.9 | 8.0 | 0.0 | 899.0 | 9.5 | 42.6 | 12.9 | 4.5 | 6.9 | 0.647 | 28.5 | 9.8 | 989.4 | 635.1 |
| 17 | 258 | B | P | 90.5 | 78.5 | 8.0 | 4.1 | 897.3 | 8.7 | 37.8 | 12.4 | 4.3 | 9.0 | 0.482 | 27.5 | 9.4 | 981.4 | 651.4 |
| 17 | 258 | B | T | 61.8 | 61.6 | 8.0 | 0.0 | 899.0 | 9.5 | 42.6 | 12.9 | 4.5 | 6.5 | 0.691 | 29.3 | 10.1 | 995.9 | 623.3 |
| 17 | 373 | A | N | 252.2 | 246.7 | 5.4 | 0.0 | 1396.0 | 4.6 | 82.7 | 56.7 | 17.9 | 53.3 | 0.335 | 64.7 | 7.9 | 1276.9 | 413.5 |
| 17 | 373 | A | P | 326.0 | 299.7 | 5.4 | 20.9 | 1420.5 | 6.3 | 123.6 | 64.2 | 19.6 | 47.4 | 0.413 | 71.0 | 7.6 | 1284.6 | 422.6 |
| 17 | 373 | A | T | 405.9 | 397.5 | 5.4 | 2.9 | 1421.4 | 6.4 | 125.1 | 64.4 | 19.5 | 62.0 | 0.315 | 76.9 | 7.3 | 1291.2 | 430.6 |
| 17 | 389 | A | N | 4924.4 | 4912.3 | 12.0 | 0.0 | 1410.0 | 8.0 | 41.7 | 12.8 | 5.2 | 612.5 | 0.008 | 46.5 | 18.7 | 1412.1 | 1022.4 |
| 17 | 389 | A | P | 6588.6 | 6578.2 | 12.0 | -1.6 | 1411.6 | 8.1 | 49.1 | 13.3 | 6.1 | 812.1 | 0.007 | 45.9 | 18.3 | 1389.1 | 1013.5 |
| 17 | 389 | A | T | 6756.2 | 6611.7 | 12.0 | 132.5 | 1437.5 | 14.5 | 142.6 | 21.2 | 9.8 | 455.2 | 0.022 | 45.8 | 18.2 | 1387.2 | 1012.7 |
| 17 | 391 | A | N | 1932.3 | 1926.8 | 5.4 | 0.0 | 1652.0 | 10.6 | 239.8 | 84.4 | 22.6 | 181.4 | 0.124 | 23.6 | 6.9 | 884.2 | 678.6 |
| 17 | 391 | A | P | 2582.4 | 2514.4 | 5.4 | 62.6 | 1599.8 | 6.7 | 140.4 | 68.5 | 21.0 | 376.3 | 0.056 | 24.2 | 6.7 | 927.9 | 707.5 |
| 17 | 391 | A | T | 2358.2 | 2353.7 | 5.4 | -1.0 | 1604.2 | 7.1 | 142.8 | 69.9 | 20.1 | 330.6 | 0.061 | 24.0 | 6.8 | 914.0 | 698.3 |
| 18 | 092 | A | N | 625.7 | 615.2 | 10.5 | 0.0 | 737.0 | 12.9 | 92.8 | 22.0 | 7.2 | 47.8 | 0.151 | 314.4 | 102.9 | 5195.2 | 3105.4 |
| 18 | 092 | A | P | 1092.6 | 1073.3 | 10.5 | 8.7 | 731.5 | 11.4 | 84.6 | 20.3 | 7.4 | 93.9 | 0.079 | 334.5 | 106.5 | 5681.4 | 3425.2 |
| 18 | 092 | A | T | 1043.1 | 1032.6 | 10.5 | 0.0 | 736.2 | 12.9 | 95.0 | 21.7 | 7.3 | 79.8 | 0.092 | 332.8 | 106.2 | 5639.2 | 3397.3 |
| 18 | 093 | A | N | 459.4 | 420.2 | 39.3 | 0.0 | 538.0 | 43.5 | 225.0 | 14.6 | 5.2 | 9.7 | 0.535 | 29.0 | 8.6 | 869.9 | 525.6 |
| 18 | 093 | A | P | 686.8 | 649.4 | 39.3 | -1.9 | 540.6 | 47.3 | 264.4 | 15.4 | 5.6 | 13.7 | 0.407 | 27.2 | 7.7 | 869.4 | 597.0 |
| 18 | 093 | A | T | 539.8 | 515.8 | 39.3 | -15.3 | 538.8 | 45.4 | 236.8 | 14.9 | 5.2 | 11.4 | 0.459 | 28.3 | 8.2 | 869.5 | 552.8 |
| 18 | 120 | A | N | 1330.9 | 1297.2 | 33.7 | 0.0 | 552.0 | 40.5 | 316.4 | 20.6 | 7.8 | 32.0 | 0.244 | 64.0 | 50.9 | 1974.9 | 975.0 |
| 18 | 120 | A | P | 1858.5 | 1790.2 | 33.7 | 34.6 | 546.6 | 35.4 | 270.4 | 18.9 | 7.6 | 50.6 | 0.151 | 55.6 | 45.4 | 1985.2 | 1053.7 |
| 18 | 120 | A | T | 1955.0 | 1797.6 | 33.7 | 123.7 | 548.5 | 35.8 | 286.4 | 19.5 | 8.0 | 50.2 | 0.159 | 54.5 | 44.7 | 1987.2 | 1066.8 |
| 19 | 119 | A | N | 34871.2 | 34651.3 | 219.9 | 0.0 | 354.0 | 183.1 | 753.0 | 22.6 | 4.1 | 189.3 | 0.022 | 136.5 | 54.1 | 1149.8 | 641.9 |
| 19 | 119 | A | P | 50980.1 | 50716.0 | 219.9 | 44.2 | 358.3 | 230.2 | 1115.2 | 23.9 | 4.8 | 220.3 | 0.022 | 132.6 | 48.2 | 1181.6 | 634.4 |
| 19 | 119 | A | T | 51210.0 | 50941.7 | 219.9 | 48.4 | 358.9 | 233.6 | 1168.6 | 24.0 | 5.0 | 218.1 | 0.023 | 132.6 | 48.1 | 1182.0 | 634.3 |
| 19 | 122 | A | N | 8281.7 | 8110.7 | 171.0 | 0.0 | 690.0 | 166.0 | 3097.3 | 44.2 | 18.7 | 48.8 | 0.382 | 56.2 | 12.8 | 1061.6 | 354.6 |
| 19 | 122 | A | P | 12456.0 | 12008.6 | 171.0 | 276.5 | 716.0 | 201.8 | 4589.0 | 52.1 | 22.7 | 59.5 | 0.382 | 57.1 | 12.5 | 1035.3 | 367.8 |
| 19 | 122 | A | T | 14519.1 | 15174.7 | 171.0 | -826.6 | 712.5 | 197.7 | 4385.7 | 51.1 | 22.2 | 76.8 | 0.289 | 57.4 | 12.3 | 1025.6 | 372.9 |
| 19 | 338 | B | N | 21076.5 | 21047.6 | 28.9 | 0.0 | 385.0 | 30.2 | 128.4 | 12.2 | 4.3 | 697.6 | 0.006 | 168.1 | 68.5 | 1080.1 | 475.9 |
| 19 | 338 | B | P | 32387.7 | 32354.7 | 28.9 | 4.1 | 385.2 | 30.8 | 133.1 | 12.3 | 4.3 | 1049.4 | 0.004 | 169.6 | 61.9 | 1133.6 | 484.0 |
| 19 | 338 | B | T | 35772.1 | 35726.5 | 28.9 | 16.7 | 385.2 | 30.7 | 132.6 | 12.2 | 4.3 | 1165.5 | 0.004 | 170.2 | 60.6 | 1147.3 | 486.8 |
| 19 | 340 | A | N | 1275.1 | 1223.0 | 52.1 | 0.0 | 480.0 | 42.8 | 330.8 | 24.5 | 7.7 | 28.6 | 0.271 | 164.0 | 111.3 | 1012.7 | 710.5 |
| 19 | 340 | A | P | 2155.6 | 2093.5 | 52.1 | 10.0 | 488.5 | 55.7 | 460.1 | 27.1 | 8.3 | 37.6 | 0.220 | 136.5 | 90.6 | 859.7 | 682.6 |
| 19 | 340 | A | T | 2163.9 | 2190.7 | 52.1 | -79.0 | 488.3 | 55.4 | 456.4 | 27.0 | 8.2 | 39.6 | 0.208 | 136.4 | 90.4 | 858.7 | 682.4 |
| 19 | 342 | A | N | 16907.9 | 16825.0 | 82.8 | 0.0 | 445.0 | 91.1 | 518.4 | 18.3 | 5.7 | 184.7 | 0.031 | 93.6 | 29.3 | 1057.9 | 420.8 |
| 19 | 342 | A | P | 24640.1 | 24558.9 | 82.8 | -1.6 | 444.6 | 87.5 | 508.2 | 18.2 | 5.8 | 280.6 | 0.021 | 102.2 | 31.4 | 1020.1 | 442.9 |
| 19 | 342 | A | T | 28447.0 | 28375.0 | 82.8 | -10.8 | 444.7 | 88.0 | 511.4 | 18.2 | 5.8 | 322.5 | 0.018 | 105.7 | 32.2 | 1006.0 | 451.7 |
| 19 | 343 | A | N | 1477.1 | 1379.4 | 97.7 | 0.0 | 645.0 | 105.7 | 1492.5 | 41.8 | 14.1 | 13.0 | 1.082 | 17.2 | 7.8 | 686.2 | 364.7 |
| 19 | 343 | A | P | 2175.1 | 2053.0 | 97.7 | 24.3 | 647.9 | 109.2 | 1570.1 | 42.7 | 14.4 | 18.8 | 0.765 | 16.8 | 7.3 | 644.1 | 362.2 |
| 19 | 343 | A | T | 2378.1 | 2348.4 | 97.7 | -68.1 | 648.4 | 109.7 | 1586.1 | 42.8 | 14.5 | 21.4 | 0.675 | 16.7 | 7.2 | 634.8 | 361.6 |
| 20 | 081 | A | N | 2207.4 | 2090.4 | 117.0 | 0.0 | 445.0 | 105.3 | 349.3 | 11.9 | 3.3 | 19.9 | 0.167 | 188.9 | 56.0 | 3527.4 | 2383.9 |
| 20 | 081 | A | P | 3899.7 | 3793.7 | 117.0 | -10.9 | 448.3 | 124.5 | 462.2 | 12.9 | 3.7 | 30.5 | 0.122 | 192.3 | 60.1 | 4087.9 | 2882.5 |
| 20 | 081 | A | T | 3862.6 | 3956.2 | 117.0 | -210.6 | 448.9 | 131.4 | 481.8 | 13.1 | 3.7 | 30.1 | 0.122 | 192.3 | 60.0 | 4077.8 | 2873.3 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | OEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 087 | A | N | 924.2 | 877.0 | 47.2 | 0.0 | 599.7 | 44.9 | 259.2 | 16.4 | 5.8 | 19.5 | 0.296 | 210.1 | 119.8 | 6790.8 | 5610.6 |
| 20 | 087 | A | P | 1725.4 | 1683.7 | 47.2 | -5.5 | 605.7 | 55.8 | 351.9 | 18.2 | 6.3 | 30.2 | 0.209 | 171.0 | 96.2 | 7961.0 | 7255.5 |
| 20 | 087 | A | T | 1765.8 | 1589.8 | 47.2 | 128.9 | 603.7 | 53.0 | 320.0 | 17.6 | 6.0 | 30.0 | 0.201 | 169.7 | 95.4 | 8008.1 | 7325.1 |
| 20 | 088 | A | N | 436.4 | 360.6 | 75.8 | 0.0 | 405.0 | 76.9 | 222.8 | 7.9 | 2.9 | 4.7 | 0.618 | 258.1 | 47.1 | 2276.1 | 771.8 |
| 20 | 088 | A | P | 458.0 | 336.7 | 75.8 | 45.5 | 405.3 | 76.1 | 234.5 | 8.0 | 3.1 | 4.4 | 0.696 | 258.3 | 47.0 | 2277.3 | 775.7 |
| 20 | 088 | A | T | 487.6 | 462.9 | 75.8 | -51.1 | 406.8 | 82.7 | 268.0 | 8.5 | 3.2 | 5.6 | 0.579 | 258.6 | 46.9 | 2279.0 | 780.7 |
| 21 | 196 | B | N | 1390.1 | 1365.0 | 25.1 | 0.0 | 355.0 | 21.0 | 47.6 | 13.6 | 2.3 | 64.8 | 0.035 | 77.6 | 15.5 | 1380.7 | 327.4 |
| 21 | 196 | B | P | 2283.7 | 2257.7 | 25.1 | 0.9 | 361.7 | 28.3 | 95.9 | 15.6 | 3.4 | 79.9 | 0.042 | 89.4 | 16.6 | 1551.1 | 356.9 |
| 21 | 196 | B | T | 1986.1 | 1982.3 | 25.1 | -21.4 | 360.6 | 26.0 | 83.2 | 15.3 | 3.2 | 76.3 | 0.042 | 85.9 | 16.2 | 1501.1 | 348.3 |
| 22 | 014 | B | N | 775.9 | 715.5 | 60.5 | 0.0 | 408.0 | 54.3 | 808.2 | 60.4 | 14.9 | 13.2 | 1.130 | 16.6 | 7.0 | 210.8 | 72.0 |
| 22 | 014 | B | P | 490.4 | 280.4 | 60.5 | 149.5 | 403.6 | 50.1 | 729.1 | 59.0 | 14.5 | 5.6 | 2.600 | 17.5 | 7.7 | 229.3 | 71.6 |
| 22 | 014 | B | T | 1364.9 | 1345.7 | 60.5 | -41.3 | 406.5 | 52.8 | 772.0 | 59.9 | 14.6 | 25.5 | 0.574 | 15.6 | 6.2 | 190.3 | 72.9 |
| 22 | 019 | B | N | 1492.0 | 1321.3 | 170.7 | 0.0 | 578.0 | 162.2 | 2654.4 | 60.4 | 16.4 | 8.1 | 2.009 | 20.5 | 11.5 | 575.7 | 134.5 |
| 22 | 019 | B | P | 2615.5 | 2341.0 | 170.7 | 103.8 | 576.2 | 158.7 | 2579.0 | 59.8 | 16.2 | 14.7 | 1.102 | 20.5 | 11.7 | 659.3 | 158.8 |
| 22 | 019 | B | T | 2816.2 | 2697.3 | 170.7 | -51.8 | 576.6 | 159.7 | 2596.9 | 59.9 | 16.3 | 16.9 | 0.963 | 20.6 | 11.7 | 671.2 | 162.4 |
| 22 | 188 | B | N | 1225.6 | 1159.5 | 66.1 | 0.0 | 220.0 | 51.6 | 155.3 | 9.4 | 3.0 | 22.5 | 0.134 | 105.5 | 49.1 | 937.0 | 731.3 |
| 22 | 188 | B | P | 2364.5 | 2302.7 | 66.1 | -4.3 | 229.8 | 91.4 | 399.0 | 12.5 | 4.4 | 25.2 | 0.173 | 106.9 | 45.0 | 1006.0 | 885.1 |
| 22 | 188 | B | T | 1657.9 | 1617.9 | 66.1 | -26.1 | 221.9 | 63.3 | 207.7 | 10.0 | 3.3 | 25.5 | 0.128 | 105.6 | 46.7 | 967.0 | 796.9 |
| 22 | 189 | A | N | 918.3 | 843.0 | 75.2 | 0.0 | 257.0 | 81.2 | 490.3 | 19.2 | 6.0 | 10.4 | 0.582 | 271.4 | 78.3 | 1570.5 | 455.3 |
| 22 | 189 | A | P | 1633.0 | 1469.6 | 75.2 | 88.2 | 254.9 | 78.3 | 485.7 | 18.6 | 6.2 | 18.8 | 0.331 | 271.4 | 78.3 | 1570.2 | 455.0 |
| 22 | 189 | A | T | 1519.7 | 1308.1 | 75.2 | 136.3 | 252.2 | 72.1 | 405.7 | 17.8 | 5.6 | 18.1 | 0.310 | 271.4 | 78.3 | 1570.3 | 455.0 |
| 22 | 190 | B | N | 1911.5 | 1730.8 | 180.7 | 0.0 | 221.0 | 182.7 | 977.1 | 18.6 | 5.3 | 9.5 | 0.565 | 111.5 | 29.4 | 717.8 | 190.1 |
| 22 | 190 | B | P | 3034.3 | 2328.3 | 180.7 | 525.2 | 220.2 | 180.9 | 1064.0 | 18.4 | 5.9 | 12.9 | 0.457 | 115.0 | 32.3 | 713.7 | 201.4 |
| 22 | 190 | B | T | 2884.5 | 2854.7 | 180.7 | -151.0 | 219.3 | 173.2 | 929.2 | 18.1 | 5.4 | 16.5 | 0.326 | 114.6 | 32.0 | 714.2 | 200.2 |
| 22 | 192 | B | N | 2299.6 | 2114.3 | 185.3 | 0.0 | 268.0 | 167.2 | 1138.1 | 19.5 | 6.8 | 12.6 | 0.538 | 74.8 | 14.2 | 678.0 | 249.0 |
| 22 | 192 | B | P | 4060.6 | 3261.6 | 185.3 | 613.6 | 271.5 | 185.9 | 1401.5 | 20.6 | 7.5 | 17.5 | 0.430 | 76.2 | 14.7 | 632.7 | 265.9 |
| 22 | 192 | B | T | 3587.1 | 3636.9 | 185.3 | -235.1 | 269.8 | 177.7 | 1248.9 | 20.1 | 7.0 | 20.5 | 0.343 | 75.9 | 14.6 | 642.3 | 262.1 |
| 23 | 352 | B | N | 730.1 | 619.5 | 110.6 | 0.0 | 229.0 | 75.7 | 314.6 | 14.9 | 4.2 | 8.2 | 0.508 | 110.3 | 59.4 | 1035.0 | 263.9 |
| 23 | 352 | B | P | . | . | 110.6 | 52.2 | 229.9 | 84.9 | 342.6 | 15.2 | 4.0 | . | . | . | . | . | . |
| 23 | 352 | B | T | 1693.5 | 1594.9 | 110.6 | -12.0 | 230.5 | 86.9 | 358.6 | 15.3 | 4.1 | 18.3 | 0.225 | 94.0 | 49.7 | 918.6 | 190.1 |
| 23 | 353 | B | N | 2724.9 | 2553.1 | 171.8 | 0.0 | 220.0 | 82.2 | 179.4 | 12.2 | 2.2 | 31.1 | 0.070 | 112.5 | 48.7 | 885.6 | 225.6 |
| 23 | 353 | B | P | . | . | 171.8 | 72.6 | 226.7 | 125.8 | 387.0 | 14.2 | 3.1 | . | . | . | . | . | . |
| 23 | 353 | B | T | 5272.5 | 5109.8 | 171.8 | -9.1 | 227.9 | 135.1 | 431.1 | 14.6 | 3.2 | 37.8 | 0.084 | 116.3 | 51.9 | 884.9 | 216.4 |
| 23 | 413 | B | N | 2202.8 | 2038.0 | 164.8 | 0.0 | 170.0 | 121.5 | 209.8 | 3.0 | 1.7 | 16.8 | 0.103 | 51.3 | 16.5 | 694.4 | 73.6 |
| 23 | 413 | B | P | . | 3898.3 | 164.8 | . | . | . | . | . | . | . | . | . | . | . | . |
| 23 | 413 | B | T | 4802.2 | 4637.4 | 164.8 | . | . | . | . | . | . | . | . | 49.6 | 18.2 | 686.5 | 82.1 |
| 24 | 011 | A | N | 1372.5 | 1242.7 | 129.8 | 0.0 | 1120.0 | 114.3 | 2039.1 | 62.8 | 17.8 | 10.9 | 1.641 | 53.6 | 14.5 | 919.9 | 431.8 |
| 24 | 011 | A | P | 2246.1 | 2051.5 | 129.8 | 64.8 | 1122.0 | 118.6 | 2103.0 | 63.4 | 17.7 | 17.3 | 1.025 | 58.9 | 15.9 | 954.6 | 454.1 |
| 24 | 011 | A | T | 2214.4 | 2219.3 | 129.8 | -134.7 | 1121.9 | 118.7 | 2100.1 | 63.4 | 17.7 | 18.7 | 0.946 | 58.7 | 15.9 | 953.6 | 453.4 |
| 24 | 012 | B | N | 472.9 | 453.2 | 19.7 | 0.0 | 387.0 | 13.8 | 42.1 | 11.7 | 3.1 | 32.9 | 0.093 | 25.8 | 11.8 | 786.7 | 86.3 |
| 24 | 012 | B | P | 574.3 | 557.2 | 19.7 | -2.6 | 388.6 | 14.3 | 47.1 | 12.2 | 3.3 | 38.8 | 0.084 | 25.5 | 11.7 | 794.3 | 87.7 |
| 24 | 012 | B | T | 764.6 | 742.5 | 19.7 | 2.3 | 391.8 | 17.6 | 63.5 | 13.1 | 3.6 | 42.1 | 0.086 | 25.0 | 11.6 | 805.7 | 89.8 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYO | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 013 | A | N | 5633.8 | 5420.2 | 213.6 | 0.0 | 654.0 | 184.0 | 3762.4 | 61.6 | 20.4 | 29.5 | 0.694 | 16.7 | 7.4 | 698.4 | 440.2 |
| 24 | 013 | A | P | 9331.0 | 8702.7 | 213.6 | 414.7 | 663.7 | 205.1 | 4369.4 | 64.5 | 21.3 | 42.4 | 0.502 | 17.7 | 7.4 | 746.8 | 462.1 |
| 24 | 013 | A | T | 9486.0 | 9881.6 | 213.6 | -609.1 | 663.8 | 204.7 | 4315.8 | 64.6 | 21.1 | 48.3 | 0.437 | 17.8 | 7.4 | 748.4 | 462.9 |
| 24 | 016 | B | N | 1713.3 | 1574.3 | 139.0 | 0.0 | 461.0 | 127.4 | 2356.9 | 57.6 | 18.5 | 12.4 | 1.497 | 32.6 | 10.8 | 459.3 | 127.3 |
| 24 | 016 | B | P | 2188.8 | 2114.3 | 139.0 | -64.6 | 462.6 | 131.0 | 2447.6 | 58.1 | 18.7 | 16.1 | 1.158 | 32.3 | 10.3 | 460.1 | 128.8 |
| 24 | 016 | B | T | 2244.4 | 2135.1 | 139.0 | -29.7 | 461.8 | 130.1 | 2414.6 | 57.9 | 18.6 | 16.4 | 1.131 | 32.3 | 10.3 | 460.2 | 129.0 |
| 24 | 021 | B | N | 770.0 | 753.7 | 16.3 | 0.0 | 345.0 | 18.6 | 51.1 | 13.7 | 2.8 | 40.6 | 0.068 | 28.5 | 11.6 | 898.2 | 190.0 |
| 24 | 021 | B | P | 999.1 | 1027.1 | 16.3 | -44.4 | 348.9 | 23.5 | 82.5 | 14.9 | 3.5 | 43.7 | 0.080 | 29.2 | 11.9 | 967.9 | 205.7 |
| 24 | 021 | B | T | 1331.8 | 1302.1 | 16.3 | 13.4 | 350.9 | 26.3 | 97.7 | 15.5 | 3.7 | 49.5 | 0.075 | 30.1 | 12.2 | 1051.1 | 224.5 |
| 24 | 022 | B | N | 1750.4 | 1657.5 | 92.9 | 0.0 | 552.0 | 89.0 | 1544.5 | 57.5 | 17.3 | 18.6 | 0.932 | 13.4 | 7.1 | 982.6 | 567.3 |
| 24 | 022 | B | P | 2891.2 | 2790.4 | 92.9 | 7.8 | 559.5 | 97.6 | 1751.9 | 59.8 | 18.0 | 28.6 | 0.628 | 15.8 | 8.3 | 1043.5 | 735.0 |
| 24 | 022 | B | T | 2348.8 | 2557.3 | 92.9 | -301.5 | 556.9 | 94.8 | 1676.3 | 59.0 | 17.7 | 27.0 | 0.655 | 14.8 | 7.8 | 1017.8 | 660.2 |
| 24 | 193 | B | N | 800.8 | 794.4 | 6.4 | 0.0 | 498.0 | 7.6 | 35.6 | 11.6 | 4.7 | 104.9 | 0.045 | 13.2 | 7.4 | 1246.7 | 329.4 |
| 24 | 193 | B | P | 1431.9 | 1430.3 | 6.4 | -4.8 | 505.6 | 10.8 | 64.5 | 13.9 | 5.9 | 131.8 | 0.045 | 14.1 | 7.7 | 1585.3 | 391.7 |
| 24 | 193 | B | T | 1075.8 | 1074.0 | 6.4 | -4.6 | 500.3 | 8.8 | 42.5 | 12.3 | 4.8 | 122.5 | 0.040 | 13.6 | 7.5 | 1408.4 | 359.6 |
| 24 | 200 | A | N | 3351.5 | 3171.0 | 180.5 | 0.0 | 915.0 | 174.4 | 3334.3 | 67.1 | 19.1 | 18.2 | 1.051 | 52.6 | 47.3 | 1975.4 | 903.5 |
| 24 | 200 | A | P | 6103.4 | 5879.9 | 180.5 | 43.0 | 917.2 | 175.8 | 3456.2 | 67.7 | 19.7 | 33.4 | 0.588 | 46.3 | 44.6 | 2043.2 | 899.9 |
| 24 | 200 | A | T | 5587.1 | 5703.1 | 180.5 | -296.5 | 915.7 | 173.0 | 3377.9 | 67.3 | 19.5 | 33.0 | 0.592 | 47.2 | 44.9 | 2033.0 | 900.4 |
| 25 | 020 | A | N | 6035.3 | 5893.2 | 142.0 | 0.0 | 258.0 | 108.1 | 212.3 | 13.7 | 2.0 | 54.5 | 0.036 | 61.4 | 18.7 | 695.6 | 189.4 |
| 25 | 020 | A | P | 8952.3 | 8787.1 | 142.0 | 23.1 | 260.4 | 121.4 | 280.9 | 14.5 | 2.3 | 72.4 | 0.032 | 61.4 | 17.4 | 707.8 | 194.8 |
| 25 | 020 | A | T | 10643.5 | 10501.4 | 142.0 | 0.0 | 259.9 | 116.3 | 264.7 | 14.3 | 2.3 | 90.3 | 0.025 | 61.5 | 16.9 | 713.4 | 197.4 |
| 25 | 102 | B | N | 126.5 | 108.2 | 18.3 | 0.0 | 1274.0 | 13.1 | 59.9 | 15.2 | 4.6 | 8.3 | 0.553 | 342.1 | 74.7 | 5378.4 | 2553.8 |
| 25 | 102 | B | P | 228.8 | 250.6 | 18.3 | -40.1 | 1271.9 | 12.8 | 54.4 | 14.6 | 4.2 | 19.5 | 0.217 | 411.5 | 81.9 | 6720.7 | 3240.5 |
| 25 | 102 | B | T | 126.6 | 107.0 | 18.3 | 1.2 | 1272.1 | 12.9 | 54.8 | 14.7 | 4.3 | 8.3 | 0.512 | 342.2 | 74.7 | 5379.0 | 2554.1 |
| 25 | 103 | B | N | 411.0 | 389.8 | 21.2 | 0.0 | 790.0 | 12.1 | 32.1 | 9.1 | 2.6 | 32.1 | 0.082 | 78.7 | 18.3 | 1505.8 | 589.6 |
| 25 | 103 | B | P | 799.8 | 780.7 | 21.2 | -2.2 | 796.1 | 17.5 | 61.3 | 11.0 | 3.5 | 44.5 | 0.079 | 79.5 | 19.0 | 1646.0 | 744.6 |
| 25 | 103 | B | T | 824.3 | 811.9 | 21.2 | -8.9 | 794.4 | 16.1 | 57.5 | 10.5 | 3.6 | 50.6 | 0.071 | 79.5 | 19.1 | 1652.6 | 752.5 |
| 25 | 104 | B | N | 319.1 | 304.0 | 15.1 | 0.0 | 948.0 | 9.5 | 27.0 | 9.4 | 2.8 | 31.9 | 0.089 | 53.9 | 18.5 | 1474.9 | 408.6 |
| 25 | 104 | B | P | 610.0 | 620.8 | 15.1 | -25.9 | 951.0 | 11.7 | 37.1 | 10.4 | 3.2 | 52.9 | 0.060 | 47.0 | 16.3 | 1495.6 | 391.6 |
| 25 | 104 | B | T | 561.4 | 549.0 | 15.1 | -2.7 | 950.4 | 11.4 | 35.6 | 10.2 | 3.1 | 48.1 | 0.065 | 47.8 | 16.5 | 1492.9 | 393.7 |
| 25 | 105 | A | N | 1446.1 | 1397.3 | 48.8 | 0.0 | 1036.0 | 31.5 | 66.7 | 8.2 | 2.1 | 44.4 | 0.048 | 360.4 | 104.9 | 3315.5 | 1275.1 |
| 25 | 105 | A | P | 2581.2 | 2968.2 | 48.8 | -435.8 | 1041.0 | 42.9 | 130.6 | 9.8 | 3.0 | 69.1 | 0.044 | 374.7 | 99.4 | 3426.2 | 1447.0 |
| 25 | 105 | A | T | 1802.4 | 1753.0 | 48.8 | 0.6 | 1039.1 | 38.4 | 95.4 | 9.2 | 2.5 | 45.7 | 0.054 | 365.8 | 102.7 | 3357.0 | 1337.7 |
| 25 | 107 | B | N | 109.0 | 74.2 | 34.8 | 0.0 | 1351.0 | 24.9 | 106.2 | 13.1 | 4.3 | 3.0 | 1.431 | 162.5 | 50.3 | 2426.7 | 752.1 |
| 25 | 107 | B | P | 175.8 | 188.0 | 34.8 | -47.1 | 1351.0 | 25.3 | 108.4 | 13.1 | 4.3 | 7.4 | 0.577 | 169.3 | 52.6 | 2533.5 | 781.3 |
| 25 | 107 | B | T | 87.0 | 49.2 | 34.8 | 3.0 | 1350.4 | 24.5 | 103.4 | 12.9 | 4.2 | 2.0 | 2.104 | 159.3 | 49.2 | 2377.8 | 738.7 |
| 25 | 112 | B | N | 453.8 | 437.7 | 16.1 | 0.0 | 902.0 | 11.0 | 27.0 | 12.2 | 2.5 | 39.8 | 0.062 | 52.7 | 13.9 | 1208.0 | 323.4 |
| 25 | 112 | B | P | 904.2 | 944.2 | 16.1 | -56.2 | 905.2 | 12.0 | 37.3 | 13.2 | 3.1 | 78.8 | 0.040 | 51.8 | 13.4 | 1253.8 | 361.7 |
| 25 | 112 | B | T | 733.5 | 719.1 | 16.1 | -1.7 | 904.3 | 11.5 | 35.2 | 12.9 | 3.1 | 62.5 | 0.049 | 52.0 | 13.5 | 1239.6 | 349.4 |
| 25 | 267 | A | N | 5694.5 | 5157.9 | 536.7 | 0.0 | 565.0 | 189.9 | 1067.5 | 21.4 | 5.6 | 27.2 | 0.207 | 326.8 | 85.6 | 1809.3 | 261.9 |
| 25 | 267 | A | P | 7161.8 | 6637.2 | 536.7 | -12.0 | 586.5 | 404.2 | 2992.7 | 27.9 | 7.4 | 16.4 | 0.451 | 332.5 | 82.0 | 1815.9 | 263.5 |
| 25 | 267 | A | T | 9373.2 | 9593.9 | 536.7 | -757.4 | 586.7 | 405.6 | 3019.7 | 28.0 | 7.4 | 23.7 | 0.315 | 339.6 | 78.3 | 1824.6 | 266.1 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 269 | A | N | 64.1 | 52.0 | 12.1 | 0.0 | 2004.0 | 7.4 | 17.1 | 4.9 | 2.3 | 7.1 | 0.330 | 42.7 | 10.1 | 757.4 | 207.4 |
| 25 | 269 | A | P | 33.3 | 18.6 | 12.1 | 2.6 | 2003.9 | 7.4 | 17.0 | 4.9 | 2.3 | 2.5 | 0.913 | 44.1 | 12.0 | 882.1 | 263.7 |
| 25 | 269 | A | T | 30.5 | 23.9 | 12.1 | -5.5 | 2003.8 | 7.4 | 16.8 | 4.8 | 2.3 | 3.2 | 0.704 | 44.3 | 12.2 | 900.5 | 272.4 |
| 25 | 273 | A | N | 6529.8 | 6376.0 | 153.8 | 0.0 | 714.0 | 81.6 | 560.7 | 18.3 | 6.9 | 78.1 | 0.088 | 358.9 | 127.7 | 2575.0 | 455.1 |
| 25 | 273 | A | P | 13546.6 | 14059.2 | 153.8 | -666.5 | 727.6 | 118.4 | 957.8 | 22.4 | 8.1 | 118.7 | 0.068 | 382.3 | 122.7 | 3092.8 | 863.0 |
| 25 | 273 | A | T | 13587.2 | 13870.8 | 153.8 | -437.4 | 726.4 | 114.1 | 920.9 | 22.1 | 8.1 | 121.6 | 0.066 | 382.4 | 122.7 | 3095.1 | 865.3 |
| 25 | 275 | B | N | 2804.6 | 2630.1 | 174.4 | 0.0 | 638.0 | 121.5 | 683.1 | 15.8 | 5.6 | 21.7 | 0.260 | 186.4 | 42.0 | 1817.1 | 462.7 |
| 25 | 275 | B | P | 5180.4 | 5289.4 | 174.4 | -283.5 | 641.7 | 132.5 | 840.2 | 16.9 | 6.3 | 39.9 | 0.159 | 224.2 | 45.6 | 1916.6 | 448.7 |
| 25 | 275 | B | T | 4862.9 | 4823.4 | 174.4 | -134.9 | 641.1 | 129.3 | 818.2 | 16.7 | 6.3 | 37.3 | 0.170 | 220.0 | 45.1 | 1906.0 | 450.1 |
| 25 | 278 | A | N | 1437.7 | 1371.2 | 66.6 | 0.0 | 595.0 | 29.8 | 357.1 | 33.9 | 12.0 | 46.0 | 0.260 | 90.1 | 54.7 | 1804.0 | 714.5 |
| 25 | 278 | A | P | 2712.4 | 2649.9 | 66.6 | -4.1 | 634.8 | 53.7 | 857.8 | 46.1 | 16.0 | 49.3 | 0.324 | 91.1 | 53.4 | 1919.0 | 765.8 |
| 25 | 278 | A | T | 2530.1 | 2511.4 | 66.6 | -47.8 | 634.6 | 53.4 | 855.0 | 46.0 | 16.0 | 47.0 | 0.340 | 90.8 | 53.4 | 1905.7 | 759.6 |
| 25 | 281 | A | N | 987.0 | 942.3 | 44.7 | 0.0 | 472.0 | 16.2 | 33.4 | 11.0 | 2.1 | 58.2 | 0.035 | 67.2 | 19.6 | 888.1 | 116.8 |
| 25 | 281 | A | P | 1479.4 | 1401.9 | 44.7 | 32.8 | 479.5 | 32.6 | 98.0 | 13.3 | 3.0 | 43.0 | 0.070 | 68.9 | 21.0 | 922.6 | 127.2 |
| 25 | 281 | A | T | 1596.3 | 1594.4 | 44.7 | -42.8 | 481.0 | 35.9 | 111.4 | 13.7 | 3.1 | 44.4 | 0.070 | 69.3 | 21.2 | 929.2 | 129.3 |
| 25 | 348 | A | N | 4485.9 | 3924.5 | 561.3 | 0.0 | 590.0 | 178.6 | 1295.1 | 21.3 | 7.3 | 22.0 | 0.330 | 364.3 | 88.2 | 2242.9 | 387.0 |
| 25 | 348 | A | P | 5107.2 | 4578.9 | 561.3 | -33.0 | 616.6 | 351.1 | 3394.3 | 29.4 | 9.7 | 13.0 | 0.741 | 366.6 | 86.3 | 2298.1 | 393.5 |
| 25 | 348 | A | T | 8400.7 | 8490.5 | 561.3 | -651.1 | 617.2 | 355.8 | 3458.1 | 29.6 | 9.7 | 23.9 | 0.407 | 375.6 | 79.4 | 2524.5 | 420.4 |
| 25 | 370 | B | N | 191.9 | 135.9 | 56.0 | 0.0 | 1144.0 | 57.3 | 330.8 | 19.8 | 5.8 | 2.4 | 2.435 | 41.4 | 13.2 | 792.8 | 440.6 |
| 25 | 370 | B | P | 143.8 | 118.5 | 56.0 | -30.7 | 1132.0 | 33.1 | 171.0 | 16.1 | 5.2 | 3.6 | 1.443 | 40.4 | 13.4 | 749.3 | 409.8 |
| 25 | 370 | B | T | 267.2 | 68.3 | 56.0 | 142.9 | 1133.1 | 34.4 | 183.5 | 16.5 | 5.3 | 2.0 | 2.685 | 42.6 | 13.0 | 853.1 | 487.5 |
| 26 | 345 | B | N | 592.3 | 515.1 | 77.2 | 0.0 | 569.0 | 28.3 | 242.7 | 27.1 | 8.6 | 18.2 | 0.471 | 392.9 | 324.9 | 1551.4 | 873.0 |
| 26 | 345 | B | P | 289.3 | 150.9 | 77.2 | 61.1 | 593.2 | 51.6 | 546.3 | 34.5 | 10.6 | 2.9 | 3.620 | 408.2 | 346.9 | 1609.0 | 922.2 |
| 26 | 345 | B | T | 1169.2 | 1080.1 | 77.2 | 11.9 | 596.7 | 54.2 | 604.4 | 35.6 | 11.2 | 19.9 | 0.560 | 386.7 | 312.4 | 1534.7 | 865.0 |
| 26 | 347 | A | N | 376.1 | 326.3 | 49.8 | 0.0 | 906.0 | 32.0 | 441.7 | 47.6 | 13.8 | 10.2 | 1.354 | 15.6 | 7.0 | 1522.8 | 979.9 |
| 26 | 347 | A | P | 484.8 | 461.3 | 49.8 | -26.3 | 908.3 | 34.5 | 461.9 | 48.3 | 13.4 | 13.4 | 1.001 | 16.1 | 7.2 | 1455.6 | 954.1 |
| 26 | 347 | A | T | 841.2 | 829.5 | 49.8 | -38.1 | 909.5 | 34.9 | 473.7 | 48.6 | 13.6 | 23.7 | 0.571 | 17.5 | 7.7 | 1320.1 | 900.7 |
| 26 | 354 | A | N | 418.0 | 326.8 | 91.2 | 0.0 | 492.0 | 86.5 | 563.5 | 15.8 | 6.5 | 3.8 | 1.724 | 190.8 | 67.3 | 1866.1 | 589.2 |
| 26 | 354 | A | P | 611.0 | 480.8 | 91.2 | 39.0 | 474.7 | 48.4 | 209.7 | 10.6 | 4.3 | 9.9 | 0.436 | 196.4 | 66.9 | 1906.2 | 598.6 |
| 26 | 354 | A | T | 1019.6 | 956.9 | 91.2 | -28.5 | 478.8 | 56.0 | 278.7 | 11.8 | 5.0 | 17.1 | 0.291 | 207.5 | 69.3 | 1967.9 | 617.8 |
| 26 | 355 | A | N | 688.6 | 531.3 | 157.3 | 0.0 | 515.0 | 94.0 | 564.9 | 18.3 | 6.0 | 5.7 | 1.063 | 243.3 | 102.5 | 1837.2 | 623.8 |
| 26 | 355 | A | P | 672.0 | 554.0 | 157.3 | -39.3 | 515.7 | 90.4 | 581.1 | 18.5 | 6.4 | 6.1 | 1.049 | 243.9 | 103.4 | 1840.5 | 629.2 |
| 26 | 355 | A | T | 1616.1 | 1458.6 | 157.3 | 0.2 | 517.5 | 96.6 | 641.0 | 19.1 | 6.6 | 15.1 | 0.439 | 233.0 | 81.9 | 1794.6 | 505.4 |
| 26 | 359 | B | N | 1910.7 | 1324.1 | 586.6 | 0.0 | 164.0 | 459.2 | 3521.3 | 25.6 | 7.7 | 2.9 | 2.659 | 89.4 | 31.8 | 942.7 | 271.2 |
| 26 | 359 | B | P | . | . | 586.6 | -604.8 | 163.8 | 459.2 | 3512.7 | 25.6 | 7.7 | . | . | . | .. | . | . |
| 26 | 359 | B | T | 4366.3 | 3627.8 | 586.6 | 152.0 | 163.0 | 443.3 | 3379.0 | 25.3 | 7.6 | 8.2 | 0.931 | 82.7 | 29.4 | 896.8 | 197.3 |
| 26 | 360 | B | N | 33.8 | 14.8 | 19.0 | 0.0 | 1908.0 | 22.0 | 142.9 | 21.7 | 6.5 | 0.7 | 9.634 | 54.4 | 21.5 | 3426.9 | 6102.5 |
| 26 | 360 | B | P | 70.9 | 7.6 | 19.0 | 44.3 | 1866.4 | 3.2 | 9.3 | 9.0 | 2.9 | 2.4 | 1.222 | 53.3 | 21.8 | 4012.5 | 10298.5 |
| 26 | 360 | B | T | 70.4 | 9.0 | 19.0 | 42.3 | 1888.6 | 10.1 | 53.7 | 15.7 | 5.3 | 0.9 | 5.952 | 53.3 | 21.8 | 4005.9 | 10242.3 |
| 26 | 361 | A | N | 360.1 | 290.9 | 69.2 | 0.0 | 238.0 | 46.4 | 197.6 | 11.6 | 4.3 | 6.3 | 0.679 | 110.0 | 44.8 | 1554.4 | 255.2 |
| 26 | 361 | A | P | 456.4 | 356.8 | 69.2 | 30.4 | 238.7 | 48.2 | 210.8 | 11.8 | 4.4 | 7.4 | 0.591 | 109.9 | 44.5 | 1588.3 | 252.6 |
| 26 | 361 | A | T | 816.2 | 747.0 | 69.2 | 0.0 | 240.1 | 50.4 | 232.5 | 12.2 | 4.6 | 14.8 | 0.311 | 110.7 | 44.8 | 1678.6 | 249.3 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 362 | A | N | 294.8 | 256.8 | 38.1 | 0.0 | 622.0 | 26.0 | 290.9 | 37.8 | 11.2 | 9.9 | 1.133 | 44.0 | 11.9 | 1073.8 | 343.9 |
| 26 | 362 | A | P | 262.3 | 192.8 | 38.1 | 31.5 | 622.1 | 25.7 | 293.1 | 37.8 | 11.4 | 7.5 | 1.520 | 43.8 | 11.9 | 1048.5 | 335.2 |
| 26 | 362 | A | T | 726.1 | 714.1 | 38.1 | -26.1 | 625.7 | 27.2 | 323.8 | 38.9 | 11.9 | 26.3 | 0.453 | 46.4 | 13.6 | 1294.8 | 423.5 |
| 26 | 364 | B | N | 1534.6 | 1413.2 | 121.4 | 0.0 | 533.0 | 95.4 | 774.1 | 31.7 | 8.1 | 14.8 | 0.548 | 261.2 | 43.0 | 1570.7 | 343.7 |
| 26 | 364 | B | P | 516.0 | 558.4 | 121.4 | -163.8 | 528.7 | 80.4 | 659.2 | 30.4 | 8.2 | 6.9 | 1.181 | 208.2 | 40.0 | 1425.6 | 308.0 |
| 26 | 364 | B | T | 2300.0 | 1985.0 | 121.4 | 193.6 | 532.2 | 86.8 | 747.6 | 31.5 | 8.6 | 22.9 | 0.377 | 284.9 | 44.7 | 1633.0 | 363.2 |
| 28 | 219 | B | N | 270.2 | 242.0 | 28.2 | 0.0 | 4201.0 | 39.2 | 407.5 | 39.6 | 10.4 | 6.2 | 1.684 | 88.6 | 31.6 | 1600.8 | 605.1 |
| 28 | 219 | B | P | 139.2 | 160.4 | 28.2 | -49.4 | 4168.7 | 17.9 | 149.3 | 29.8 | 8.3 | 9.0 | 0.931 | 87.3 | 30.7 | 1605.4 | 600.8 |
| 28 | 219 | B | T | 22.1 | 53.2 | 28.2 | -59.3 | 4166.8 | 17.3 | 139.6 | 29.2 | 8.1 | 3.1 | 2.624 | 85.2 | 29.6 | 1661.5 | 633.2 |
| 29 | 100 | B | N | 198.7 | 156.4 | 42.3 | 0.0 | 904.0 | 44.6 | 253.5 | 14.9 | 5.7 | 3.5 | 1.620 | 382.4 | 121.2 | 2785.7 | 1803.0 |
| 29 | 100 | B | P | 479.1 | 557.5 | 42.3 | -120.7 | 906.1 | 48.2 | 284.4 | 15.6 | 5.9 | 11.6 | 0.510 | 409.3 | 129.5 | 3075.5 | 2415.9 |
| 29 | 100 | B | T | 213.8 | 175.2 | 42.3 | -3.7 | 903.7 | 44.9 | 250.1 | 14.9 | 5.6 | 3.9 | 1.427 | 384.5 | 121.8 | 2808.3 | 1846.9 |
| 29 | 106 | A | N | 323.7 | 304.9 | 18.9 | 0.0 | 1463.0 | 14.2 | 68.2 | 10.1 | 4.8 | 21.5 | 0.224 | 628.7 | 131.7 | 2570.4 | 488.8 |
| 29 | 106 | A | P | 612.2 | 789.6 | 18.9 | -196.3 | 1467.9 | 18.0 | 99.5 | 11.6 | 5.5 | 44.0 | 0.126 | 907.9 | 141.5 | 2826.1 | 335.2 |
| 29 | 106 | A | T | 250.5 | 193.8 | 18.9 | 37.9 | 1460.5 | 12.8 | 61.3 | 9.3 | 4.8 | 15.2 | 0.316 | 542.9 | 128.3 | 2474.8 | 569.0 |
| 29 | 108 | A | N | 838.9 | 749.8 | 89.1 | 0.0 | 1144.0 | 64.8 | 504.6 | 23.5 | 7.8 | 11.6 | 0.673 | 511.5 | 180.4 | 2305.5 | 977.3 |
| 29 | 108 | A | P | 1421.6 | 1883.9 | 89.1 | -551.5 | 1147.0 | 70.4 | 574.9 | 24.4 | 8.2 | 26.8 | 0.305 | 615.7 | 183.9 | 2259.5 | 1226.2 |
| 29 | 108 | A | T | 576.2 | 456.7 | 89.1 | 30.4 | 1144.1 | 64.9 | 506.5 | 23.5 | 7.8 | 7.0 | 1.109 | 448.6 | 178.1 | 2339.3 | 832.4 |
| 29 | 109 | B | N | 210.9 | 174.2 | 36.6 | 0.0 | 1036.0 | 28.0 | 190.5 | 23.8 | 6.8 | 6.2 | 1.094 | 196.9 | 38.3 | 3462.9 | 751.6 |
| 29 | 109 | B | P | . | . | 36.6 | 2.4 | 1027.9 | 22.3 | 125.8 | 21.3 | 5.6 | . | . | . | . | . | . |
| 29 | 109 | B | T | 278.7 | 210.3 | 36.6 | 31.7 | 1033.9 | 27.7 | 171.6 | 23.1 | 6.2 | 7.6 | 0.816 | 199.3 | 39.5 | 3637.7 | 850.7 |
| 29 | 110 | B | N | 664.6 | 604.3 | 60.3 | 0.0 | 892.0 | 50.1 | 307.8 | 21.9 | 6.1 | 12.1 | 0.509 | 442.7 | 120.4 | 3195.9 | 1745.7 |
| 29 | 110 | B | P | 866.8 | 1229.2 | 60.3 | -422.7 | 893.8 | 54.3 | 335.4 | 22.5 | 6.2 | 22.6 | 0.273 | 463.2 | 122.8 | 3422.9 | 1936.4 |
| 29 | 110 | B | T | 422.0 | 370.8 | 60.3 | -9.1 | 890.8 | 49.3 | 281.7 | 21.6 | 5.7 | 7.5 | 0.760 | 410.3 | 116.9 | 2844.1 | 1464.5 |
| 29 | 111 | A | N | 176.3 | 155.6 | 20.8 | 0.0 | 974.0 | 16.2 | 87.1 | 13.8 | 5.4 | 9.6 | 0.560 | 124.2 | 46.3 | 2875.5 | 931.5 |
| 29 | 111 | A | P | 269.2 | 305.3 | 20.8 | -56.8 | 975.6 | 17.0 | 96.0 | 14.3 | 5.7 | 18.0 | 0.314 | 128.0 | 49.7 | 2994.3 | 987.1 |
| 29 | 111 | A | T | 259.2 | 243.5 | 20.8 | -5.1 | 974.5 | 16.3 | 90.0 | 14.0 | 5.5 | 14.9 | 0.370 | 127.6 | 49.3 | 2983.4 | 981.9 |
| 29 | 113 | A | N | 1818.8 | 1724.2 | 94.6 | 0.0 | 1075.0 | 64.1 | 525.0 | 31.1 | 8.2 | 26.9 | 0.304 | 1027.1 | 257.5 | 4726.7 | 1822.1 |
| 29 | 113 | A | P | 2654.2 | 3968.4 | 94.6 | -1408.8 | 1080.9 | 80.6 | 708.4 | 32.9 | 8.8 | 49.3 | 0.179 | 1186.3 | 265.2 | 5243.6 | 2118.9 |
| 29 | 113 | A | T | 1651.8 | 1491.7 | 94.6 | 65.5 | 1075.0 | 68.9 | 531.5 | 31.1 | 7.7 | 21.7 | 0.356 | 990.3 | 255.7 | 4603.8 | 1754.0 |
| 29 | 114 | B | N | 99.0 | 45.6 | 53.4 | 0.0 | 1516.0 | 36.6 | 305.9 | 27.8 | 8.4 | 1.2 | 6.710 | 182.5 | 35.8 | 1745.9 | 513.3 |
| 29 | 114 | B | P | 225.2 | 235.0 | 53.4 | -63.3 | 1517.8 | 39.6 | 323.0 | 28.3 | 8.1 | 5.9 | 1.374 | 261.0 | 47.7 | 1904.6 | 485.9 |
| 29 | 114 | B | T | 128.6 | 83.5 | 53.4 | -8.3 | 1515.6 | 37.5 | 296.9 | 27.6 | 7.9 | 2.2 | 3.557 | 204.2 | 38.9 | 1794.3 | 504.1 |
| 29 | 194 | B | N | 440.3 | 405.0 | 35.3 | 0.0 | 839.0 | 31.9 | 298.2 | 27.1 | 9.3 | 12.7 | 0.736 | 44.7 | 41.0 | 1698.0 | 407.3 |
| 29 | 194 | B. | P | 651.9 | 610.6 | 35.3 | 6.0 | 840.5 | 33.4 | 314.2 | 27.6 | 9.4 | 18.3 | 0.515 | 41.3 | 41.9 | 1747.7 | 467.9 |
| 29 | 194 | B | T | 708.5 | 676.9 | 35.3 | -3.7 | 840.2 | 33.1 | 311.1 | 27.5 | 9.4 | 20.5 | 0.460 | 40.6 | 42.2 | 1758.4 | 482.0 |
| 29 | 195 | B | N | 982.6 | 870.8 | 111.8 | 0.0 | 867.0 | 100.3 | 1095.0 | 32.6 | 10.9 | 8.7 | 1.258 | 71.4 | 32.5 | 2437.2 | 1404.4 |
| 29 | 195 | B | P | 1618.7 | 1450.1 | 111.8 | 56.8 | 868.0 | 106.7 | 1148.2 | 32.9 | 10.8 | 13.6 | 0.792 | 70.1 | 30.6 | 2520.1 | 1410.9 |
| 29 | 195 | B | T | 1503.0 | 1376.4 | 111.8 | 14.8 | 867.2 | 104.6 | 1121.5 | 32.7 | 10.7 | 13.2 | 0.815 | 70.3 | 30.9 | 2507.6 | 1409.9 |
| 29 | 207 | A | N | 322.7 | 257.3 | 65.4 | 0.0 | 1946.0 | 54.0 | 394.7 | 20.1 | 7.3 | 4.8 | 1.534 | 306.0 | 280.3 | 5969.1 | 811.3 |
| 29 | 207 | A | P | 272.3 | 281.6 | 65.4 | -74.7 | 1946.4 | 53.8 | 403.3 | 20.3 | 7.5 | 5.2 | 1.432 | 305.1 | 271.8 | 5631.4 | 759.2 |
| 29 | 207 | A | T | 213.3 | 172.7 | 65.4 | -24.7 | 1941.4 | 47.6 | 325.7 | 18.7 | 6.8 | 3.6 | 1.886 | 304.3 | 260.5 | 5182.1 | 692.8 |

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

| DIS | RES | GP | PD | QINC | QOUT | QEVAP | QSTOR | ELEV | AREA | VOLUME | ZMAX | ZMEAN | QS | THYD | IPTL | IPDS | INTL | ININ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 064 | B | N | 7.9 | 3.8 | 4.1 | 0.0 | 5550.0 | 3.4 | 16.3 | 8.2 | 4.7 | 1.1 | 4.329 | 263.6 | 108.3 | 2815.6 | 1280.2 |
| 30 | 064 | B | P | 6.5 | 2.4 | 4.1 | 0.0 | 5549.9 | 3.4 | 16.2 | 8.2 | 4.8 | 0.7 | 6.786 | 245.3 | 107.7 | 2755.9 | 1291.9 |
| 30 | 064 | B | T | 6.6 | 2.4 | 4.1 | 0.0 | 5549.9 | 3.4 | 16.2 | 8.2 | 4.8 | 0.7 | 6.777 | 245.9 | 107.8 | 2757.8 | 1291.5 |
| 30 | 215 | B | N | 7.4 | 4.1 | 3.3 | 0.0 | 1244.0 | 2.9 | 10.2 | 11.6 | 3.5 | 1.4 | 2.479 | 279.4 | 159.8 | 1909.4 | 634.8 |
| 30 | 215 | B | P | 15.8 | 13.6 | 3.3 | -1.1 | 1244.5 | 3.0 | 10.7 | 11.7 | 3.6 | 4.6 | 0.788 | 285.7 | 142.8 | 1973.2 | 487.8 |
| 30 | 215 | B | T | 6.5 | 3.0 | 3.3 | 0.2 | 1244.2 | 2.9 | 10.4 | 11.6 | 3.6 | 1.0 | 3.497 | 278.3 | 163.0 | 1898.4 | 664.9 |
| 30 | 217 | B | N | 23.2 | 15.2 | 8.0 | 0.0 | 1284.0 | 7.2 | 32.1 | 10.4 | 4.5 | 2.1 | 2.113 | 310.8 | 185.9 | 3274.9 | 1244.4 |
| 30 | 217 | B | P | 51.0 | 48.0 | 8.0 | -5.0 | 1284.4 | 7.4 | 33.0 | 10.5 | 4.5 | 6.5 | 0.687 | 391.5 | 226.5 | 4530.4 | 1462.2 |
| 30 | 217 | B | T | 18.5 | 9.4 | 8.0 | 1.0 | 1283.7 | 7.2 | 31.4 | 10.3 | 4.4 | 1.3 | 3.328 | 290.7 | 175.6 | 2981.3 | 1187.6 |
| 30 | 235 | A | N | 25238.4 | 23896.5 | 1341.9 | 0.0 | 1850.0 | 1490.6 | 27941.0 | 55.5 | 18.7 | 16.0 | 1.169 | 257.9 | 19.2 | 1282.7 | 147.1 |
| 30 | 235 | A | P | 21222.8 | 18961.9 | 1341.9 | 919.0 | 1843.5 | 1389.6 | 24966.7 | 53.5 | 18.0 | 13.6 | 1.317 | 207.2 | 17.8 | 1219.1 | 131.3 |
| 30 | 235 | A | T | 31508.6 | 28651.0 | 1341.9 | 1515.6 | 1845.1 | 1425.4 | 25674.9 | 54.0 | 18.0 | 20.1 | 0.896 | 341.4 | 21.3 | 1369.3 | 170.3 |
| 31 | 077 | A | N | 5130.5 | 5091.3 | 39.2 | 0.0 | 1545.0 | 55.1 | 3320.5 | 175.3 | 60.3 | 92.5 | 0.652 | 19.1 | 7.9 | 676.8 | 34.6 |
| 31 | 077 | A | P | 5414.1 | 5505.3 | 39.2 | -130.4 | 1545.2 | 56.7 | 3285.2 | 175.4 | 58.0 | 97.2 | 0.597 | 19.2 | 8.0 | 691.4 | 34.5 |
| 31 | 077 | A | T | 5361.2 | 5513.5 | 39.2 | -191.5 | 1543.2 | 57.0 | 3285.2 | 174.8 | 57.6 | 96.7 | 0.596 | 19.2 | 7.9 | 688.7 | 34.5 |
| 32 | 204 | B | N | 10768.5 | 10683.3 | 85.3 | 0.0 | 2405.0 | 139.4 | 4513.4 | 89.9 | 32.4 | 76.6 | 0.422 | 23.0 | 8.0 | 251.6 | 35.6 |
| 32 | 204 | B | P | 10433.7 | 9655.9 | 85.3 | 692.6 | 2380.0 | 124.0 | 3974.5 | 82.3 | 32.1 | 77.9 | 0.412 | 22.9 | 8.0 | 251.9 | 35.8 |
| 32 | 204 | B | T | 9755.1 | 9670.4 | 85.3 | -0.6 | 2380.0 | 128.9 | 3974.5 | 82.3 | 30.8 | 75.0 | 0.411 | 22.7 | 8.0 | 252.4 | 36.2 |
| 33 | 300 | A | N | 1023.9 | 1018.5 | 5.4 | 0.0 | 1541.0 | 10.4 | 431.6 | 90.3 | 41.3 | 97.5 | 0.424 | 40.4 | 31.1 | 189.4 | 32.0 |
| 33 | 300 | A | P | 1141.8 | 1126.1 | 5.4 | 10.3 | 1503.5 | 8.8 | 327.8 | 78.8 | 37.1 | 127.5 | 0.291 | 39.8 | 30.8 | 189.3 | 32.5 |
| 33 | 300 | A | T | 1108.2 | 1127.8 | 5.4 | -24.9 | 1503.5 | 8.9 | 327.8 | 78.8 | 36.9 | 126.9 | 0.291 | 40.0 | 30.9 | 189.3 | 32.3 |
| 34 | 048 | B | N | 1368.0 | 1306.3 | 61.7 | 0.0 | 650.0 | 20.3 | 638.7 | 89.8 | 31.5 | 64.4 | 0.489 | 39.2 | 15.0 | 846.9 | 86.1 |
| 34 | 048 | B | P | 2238.5 | 1969.8 | 61.7 | 207.0 | 784.7 | 40.3 | 1869.6 | 130.8 | 46.4 | 48.8 | 0.949 | 33.6 | 18.0 | 815.7 | 86.8 |
| 34 | 048 | B | T | 2267.7 | 2042.9 | 61.7 | 163.1 | 785.8 | 40.4 | 1883.4 | 131.2 | 46.6 | 50.6 | 0.922 | 33.5 | 18.0 | 814.9 | 86.8 |
| 35 | 029 | A | N | 312.3 | 305.7 | 6.5 | 0.0 | 737.5 | 7.0 | 86.4 | 29.7 | 12.3 | 43.6 | 0.283 | 111.6 | 24.1 | 916.6 | 145.9 |
| 35 | 029 | A | P | 393.8 | 369.8 | 6.5 | 17.5 | 738.1 | 6.8 | 89.4 | 29.9 | 13.2 | 54.7 | 0.242 | 128.1 | 26.2 | 931.7 | 148.7 |
| 35 | 029 | A | T | 390.7 | 365.9 | 6.5 | 18.3 | 738.8 | 6.7 | 90.7 | 30.1 | 13.5 | 54.3 | 0.248 | 127.5 | 26.1 | 931.2 | 148.6 |
| 35 | 039 | B | N | 21.2 | 17.4 | 3.8 | 0.0 | 1300.7 | 2.9 | 28.9 | 33.8 | 9.8 | 5.9 | 1.657 | 62.8 | 27.8 | 260.7 | 419.5 |
| 35 | 039 | B | P | 7.0 | 3.8 | 3.8 | -0.5 | 1298.2 | 2.8 | 27.2 | 33.0 | 9.8 | 1.4 | 7.220 | 67.3 | 31.2 | 414.3 | 319.9 |
| 35 | 039 | B | T | 4.9 | 4.9 | 3.8 | -3.8 | 1297.8 | 2.7 | 26.9 | 32.9 | 9.8 | 1.8 | 5.454 | 69.0 | 32.5 | 486.6 | 301.6 |

Table B3

Water Quality Data Summary by Station-Year

| Symbol | Meaning |
|---|---|
| DIS | CE District code |
| RES | CE reservoir code |
| STA | CE water quality station code |
| TYPE | station type code (D=near-dam, M=mid-pool, U=upper-pool) |
| YEAR | year of sample |

Note: Data listed by screen code (A or B) and in 2 parameter groups; screen codes reflect data reliability(see Part III of the main text); District and reservoir codes are defined in Appendix A.

WATER QUALITY SUMMARY BY STATION-YEAR
POOL DATA SCREEN CODE=A

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CDEP | STATION DEPTH (M) | 227 | 21.25 | 27.38 | 1.22 | 175.38 |
| CPHF | PH (STANDARD UNITS) | 258 | 7.85 | 0.47 | 6.27 | 8.70 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 258 | 493.30 | 548.24 | 22.50 | 4948.16 |
| CALK | ALKALINITY (MG/L) | 255 | 96.61 | 57.36 | 10.00 | 309.28 |
| CTMP | TEMPERATURE (DEG-C) | 258 | 20.69 | 2.96 | 13.18 | 27.89 |
| CTRJ | TURDIBITY (JTU) | 3 | 17.89 | 2.59 | 16.37 | 20.88 |
| CTRH | HACH TURBIDITY (NTU) | 46 | 10.16 | 11.31 | 1.60 | 40.00 |
| CTRN | -LOG(% TRANS./100) | 209 | 0.35 | 0.43 | 0.02 | 2.48 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 17 | 56.49 | 37.62 | 15.00 | 105.00 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 258 | 0.87 | 0.79 | 0.08 | 6.02 |
| CRTL | TOTAL SOLIDS (MG/L) | 24 | 159.25 | 78.42 | 5.00 | 389.58 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 33 | 115.46 | 51.34 | 44.80 | 208.50 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 41 | 11.60 | 10.18 | 1.00 | 39.33 |
| CALG | ALGAL COUNT (NO/LITER) | 2 | 178350.00 | 157614.10 | 66900.00 | 289800.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 2 | 0.04 | 0.01 | 0.04 | 0.05 |

POOL DATA SCREEN CODE=B

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CDEP | STATION DEPTH (M) | 205 | 15.82 | 12.72 | 1.32 | 82.32 |
| CPHF | PH (STANDARD UNITS) | 264 | 7.70 | 0.56 | 6.26 | 8.74 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 260 | 455.93 | 524.79 | 34.33 | 3999.11 |
| CALK | ALKALINITY (MG/L) | 250 | 85.67 | 71.31 | 10.00 | 324.33 |
| CTMP | TEMPERATURE (DEG-C) | 265 | 22.19 | 4.46 | 10.00 | 29.74 |
| CTRJ | TURDIBITY (JTU) | 9 | 63.83 | 83.87 | 2.50 | 280.00 |
| CTRH | HACH TURBIDITY (NTU) | 30 | 3.29 | 2.84 | 0.67 | 13.77 |
| CTRN | -LOG(% TRANS./100) | 207 | 0.49 | 0.72 | 0.04 | 4.61 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 6 | 67.96 | 114.06 | 10.00 | 300.00 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 267 | 1.01 | 1.14 | 0.08 | 6.40 |
| CRTL | TOTAL SOLIDS (MG/L) | 22 | 184.14 | 117.59 | 10.00 | 465.93 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 21 | 119.96 | 133.06 | 8.80 | 500.00 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 40 | 25.21 | 88.73 | 0.00 | 566.67 |
| CALG | ALGAL COUNT (NO/LITER) | 13 | 192065.38 | 197137.09 | 61500.00 | 738500.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 12 | 0.08 | 0.11 | 0.01 | 0.30 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 | 305 | D | 73 | 37.0 | 7.15 | 46 | 12 | 17.5 | . | . | 0.10 | . | 0.15 | . | . | . | . | . |
| 03 | 307 | 306 | M | 73 | 22.7 | 7.06 | 47 | 11 | 18.2 | . | . | 0.11 | . | 0.15 | . | . | . | . | . |
| 03 | 307 | 307 | U | 73 | 11.9 | 7.13 | 131 | 10 | 18.8 | . | . | 0.16 | . | 0.20 | . | . | . | . | . |
| 04 | 312 | 311 | D | 73 | 9.0 | 7.92 | 273 | 106 | 17.6 | . | . | 0.16 | . | 0.49 | . | . | . | . | . |
| 06 | 372 | 322 | D | 73 | 30.5 | 7.60 | 504 | 29 | 22.5 | . | . | 0.11 | . | 0.36 | . | . | . | . | . |
| 06 | 372 | 323 | M | 73 | 15.5 | 7.57 | 550 | 29 | 22.3 | . | . | 0.12 | . | 0.39 | . | . | . | . | . |
| 06 | 372 | 324 | M | 73 | 24.3 | 7.66 | 513 | 31 | 22.8 | . | . | 0.15 | . | 0.57 | . | . | . | . | . |
| 06 | 372 | 326 | U | 73 | 4.9 | 7.30 | 466 | 32 | 21.9 | . | . | 0.48 | . | 2.07 | . | . | . | . | . |
| 06 | 372 | 327 | U | 73 | 4.8 | 7.28 | 482 | 43 | 20.0 | . | . | 0.75 | . | 2.16 | . | . | . | . | . |
| 10 | 001 | 011 | U | 77 | . | 7.12 | 156 | 52 | 21.0 | . | 34.0 | . | 101 | 1.22 | . | 87 | . | . | . |
| 10 | 001 | 015 | M | 77 | . | 7.30 | 145 | 44 | 17.0 | . | 36.7 | . | 102 | 1.02 | . | 81 | . | . | . |
| 10 | 001 | 016 | D | 77 | . | 7.20 | 145 | 43 | 21.0 | . | 33.8 | . | 90 | 1.09 | . | 78 | . | . | . |
| 10 | 003 | 311 | D | 73 | 22.7 | 6.74 | 784 | 19 | 25.0 | . | . | 0.16 | . | 0.75 | . | . | . | . | . |
| 10 | 004 | 018 | M | 77 | . | 7.12 | 123 | 42 | 23.8 | . | 24.0 | . | 64 | 1.06 | . | 72 | . | . | . |
| 10 | 008 | 007 | D | 77 | . | 7.07 | 135 | 39 | 22.5 | . | 23.8 | . | 100 | 0.94 | . | 76 | . | . | . |
| 10 | 008 | 016 | D | 77 | . | 7.17 | 153 | 42 | 23.3 | . | 26.0 | . | 91 | 0.96 | . | 88 | . | . | . |
| 10 | 008 | 017 | D | 77 | . | 7.20 | 155 | 43 | 23.6 | . | 40.0 | . | 98 | 1.18 | . | 85 | . | . | . |
| 10 | 008 | 018 | D | 77 | . | 7.20 | 149 | 42 | 23.3 | . | 35.0 | . | 105 | 1.16 | . | 88 | . | . | . |
| 10 | 072 | 005 | D | 78 | . | 6.87 | 62 | 17 | 26.4 | . | 7.4 | . | 21 | 0.66 | . | 65 | 4 | . | . |
| 10 | 072 | 006 | D | 78 | . | 7.90 | 57 | 16 | 26.5 | . | 6.6 | . | 19 | 0.60 | . | 52 | 5 | . | . |
| 10 | 072 | 007 | M | 78 | . | 7.52 | 63 | 17 | 27.2 | . | 7.6 | . | 22 | 1.27 | . | 55 | 5 | . | . |
| 10 | 072 | 009 | M | 78 | . | 7.12 | 62 | 16 | 27.0 | . | 8.0 | . | 21 | 0.70 | . | 55 | 6 | . | . |
| 10 | 072 | 010 | M | 78 | . | 7.37 | 72 | 17 | 26.2 | . | 12.6 | . | 20 | 0.91 | . | 49 | 10 | . | . |
| 10 | 073 | 118 | M | 75 | . | 6.68 | 58 | 18 | 22.3 | 16.4 | . | . | 30 | 1.77 | 56 | 45 | 11 | . | . |
| 10 | 073 | 121 | M | 75 | . | 6.72 | 53 | 16 | 21.3 | 20.9 | . | . | 34 | 1.76 | 67 | 55 | 13 | . | . |
| 10 | 073 | 124 | M | 75 | . | 6.85 | 58 | 16 | 22.5 | 16.4 | . | . | 26 | 1.90 | 60 | 45 | 15 | . | . |
| 10 | 411 | 314 | M | 73 | 17.3 | 6.80 | 938 | 30 | 25.2 | . | . | 0.17 | . | 0.62 | . | . | . | . | . |
| 10 | 411 | 316 | U | 73 | 10.4 | 6.46 | 621 | 18 | 26.5 | . | . | 0.32 | . | 1.24 | . | . | . | . | . |
| 15 | 178 | 005 | M | 77 | 19.2 | 8.00 | 223 | 113 | 18.5 | . | 2.1 | . | 15 | 0.23 | . | . | 3 | . | . |
| 15 | 237 | 305 | D | 74 | 8.3 | 8.26 | 625 | 277 | 14.8 | . | . | 0.13 | . | 0.72 | . | . | . | . | . |
| 15 | 237 | 306 | M | 74 | 4.6 | 8.44 | 595 | 265 | 17.0 | . | . | 0.16 | . | 0.56 | . | . | . | . | . |
| 15 | 237 | 307 | M | 74 | 6.6 | 8.48 | 690 | 309 | 16.9 | . | . | 0.15 | . | 0.08 | . | . | . | . | . |
| 16 | 243 | 309 | D | 73 | 7.2 | 7.80 | 398 | 73 | 19.1 | . | . | 0.15 | . | 0.75 | . | . | . | . | . |
| 16 | 243 | 310 | M | 73 | 12.0 | 7.89 | 401 | 71 | 19.0 | . | . | 0.16 | . | 0.85 | . | . | . | . | . |
| 16 | 243 | 313 | U | 73 | 5.2 | 7.86 | 465 | 85 | 19.5 | . | . | 0.35 | . | 0.64 | . | . | . | . | . |
| 16 | 254 | 305 | M | 73 | 3.9 | 7.70 | 211 | 43 | 18.4 | . | . | 0.42 | . | 0.11 | . | . | . | . | . |
| 16 | 254 | 306 | D | 73 | 6.9 | 7.73 | 228 | 44 | 17.9 | . | . | 0.23 | . | 0.35 | . | . | . | . | . |
| 16 | 317 | 319 | M | 73 | 5.3 | 8.08 | 199 | 50 | 19.0 | . | . | 0.24 | . | 0.44 | . | . | . | . | . |
| 16 | 317 | 320 | D | 73 | 8.8 | 7.48 | 215 | 52 | 17.9 | . | . | 0.16 | . | 0.61 | . | . | . | . | . |
| 16 | 317 | 321 | M | 73 | 4.4 | 8.45 | 210 | 57 | 18.5 | . | . | 0.19 | . | 0.25 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

------------------------------------------- POOL DATA SCREEN CODE=A -------------------------------------------

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 328 | 337 | D | 73 | 30.3 | 7.67 | 118 | 25 | 15.5 | . | . | 0.08 | . | 0.30 | . | . | . | . | . |
| 16 | 328 | 338 | M | 73 | 26.8 | 7.62 | 120 | 23 | 16.1 | . | . | 0.09 | . | 0.31 | . | . | . | . | . |
| 16 | 328 | 339 | U | 73 | 2.4 | 7.31 | 181 | 19 | 16.3 | . | . | 0.42 | . | 1.08 | . | . | . | . | . |
| 16 | 328 | 340 | M | 73 | 20.5 | 7.65 | 133 | 27 | 17.4 | . | . | 0.09 | . | 0.26 | . | . | . | . | . |
| 16 | 393 | 312 | D | 73 | 35.8 | 6.61 | 487 | 13 | 22.4 | . | . | 0.17 | . | 0.32 | . | . | . | . | . |
| 16 | 393 | 313 | M | 73 | 27.7 | 6.60 | 510 | 10 | 22.0 | . | . | 0.13 | . | 0.31 | . | . | . | . | . |
| 16 | 393 | 314 | U | 73 | 22.9 | 6.33 | 565 | 10 | 22.6 | . | . | 0.04 | . | 0.26 | . | . | . | . | . |
| 17 | 241 | 306 | M | 73 | 8.5 | 7.88 | 262 | 46 | 18.8 | . | . | 0.25 | . | 0.50 | . | . | . | . | . |
| 17 | 241 | 307 | M | 73 | 5.5 | 8.11 | 265 | 46 | 19.1 | . | . | 0.34 | . | 0.61 | . | . | . | . | . |
| 17 | 241 | 308 | U | 73 | 3.2 | 8.30 | 371 | 50 | 19.2 | . | . | 0.60 | . | 0.87 | . | . | . | . | . |
| 17 | 241 | 309 | U | 73 | 1.4 | 8.70 | 279 | 52 | 19.9 | . | . | 0.53 | . | 1.29 | . | . | . | . | . |
| 17 | 242 | 312 | D | 73 | 2.3 | 7.56 | 559 | 72 | 19.1 | . | . | 2.15 | . | 3.31 | . | . | . | . | . |
| 17 | 245 | 306 | U | 73 | 1.5 | 8.23 | 444 | 151 | 19.4 | . | . | 2.48 | . | 0.73 | . | . | . | . | . |
| 17 | 245 | 307 | M | 73 | 6.3 | 8.07 | 373 | 126 | 19.1 | . | . | 1.03 | . | 0.38 | . | . | . | . | . |
| 17 | 245 | 308 | D | 73 | 2.0 | 8.45 | 374 | 126 | 19.4 | . | . | 1.63 | . | 0.89 | . | . | . | . | . |
| 17 | 247 | 306 | D | 73 | 10.6 | 8.17 | 466 | 188 | 20.1 | . | . | 0.62 | . | 0.91 | . | . | . | . | . |
| 17 | 247 | 307 | M | 73 | 4.5 | 8.39 | 480 | 195 | 20.0 | . | . | 0.78 | . | 0.89 | . | . | . | . | . |
| 17 | 248 | 309 | D | 73 | 9.1 | 8.04 | 456 | 145 | 19.6 | . | . | 0.58 | . | 1.74 | . | . | . | . | . |
| 17 | 248 | 310 | M | 73 | 2.2 | 8.05 | 510 | 160 | 19.9 | . | . | 1.12 | . | 2.23 | . | . | . | . | . |
| 17 | 248 | 311 | U | 73 | 1.2 | 8.23 | 514 | 169 | 19.6 | . | . | 2.06 | . | 3.04 | . | . | . | . | . |
| 17 | 249 | 311 | D | 73 | 8.3 | 7.89 | 412 | 126 | 20.6 | . | . | 0.60 | . | 1.18 | . | . | . | . | . |
| 17 | 249 | 312 | M | 73 | 2.8 | 8.18 | 434 | 133 | 20.1 | . | . | 1.52 | . | 1.21 | . | . | . | . | . |
| 17 | 256 | 309 | M | 73 | 3.3 | 8.36 | 323 | 129 | 18.9 | . | . | 0.28 | . | 0.48 | . | . | . | . | . |
| 17 | 256 | 310 | D | 73 | 8.5 | 8.13 | 324 | 127 | 18.3 | . | . | 0.24 | . | 0.25 | . | . | . | . | . |
| 17 | 258 | 305 | D | 73 | 7.8 | 8.34 | 603 | 75 | 19.0 | . | . | 0.24 | . | 0.26 | . | . | . | . | . |
| 17 | 258 | 306 | M | 73 | 5.9 | 8.04 | 631 | 76 | 19.0 | . | . | 0.31 | . | 0.33 | . | . | . | . | . |
| 17 | 258 | 307 | U | 73 | 2.9 | 8.38 | 772 | 77 | 19.6 | . | . | 0.73 | . | 0.26 | . | . | . | . | . |
| 17 | 373 | 308 | D | 73 | 39.8 | 7.59 | 1073 | 19 | 21.6 | . | . | 0.32 | . | 0.23 | . | . | . | . | . |
| 17 | 391 | 313 | U | 73 | 14.7 | 7.28 | 343 | 11 | 20.1 | . | . | 0.10 | . | 0.28 | . | . | . | . | . |
| 18 | 090 | 502 | D | 75 | . | 8.01 | 341 | 158 | 21.1 | . | 5.5 | . | . | 0.79 | 195 | . | 6 | 66900 | 0.035 |
| 18 | 090 | 502 | D | 77 | . | 8.19 | 341 | 96 | 22.5 | . | 4.0 | . | . | 0.76 | . | . | 3 | . | . |
| 18 | 091 | 502 | D | 75 | . | 8.05 | 517 | 155 | 21.5 | . | 19.5 | . | . | 1.93 | 390 | . | 21 | 289800 | 0.047 |
| 18 | 092 | 316 | U | 73 | 5.1 | 8.13 | 1998 | 204 | 19.2 | . | . | 1.24 | . | 2.10 | . | . | . | . | . |
| 18 | 092 | 317 | M | 73 | 14.2 | 7.93 | 1820 | 167 | 20.0 | . | . | 0.24 | . | 1.16 | . | . | . | . | . |
| 18 | 092 | 318 | D | 73 | 19.4 | 7.99 | 1730 | 164 | 19.6 | . | . | 0.17 | . | 0.81 | . | . | . | . | . |
| 18 | 093 | 312 | D | 73 | 17.0 | 7.46 | 575 | 32 | 22.0 | . | . | 0.10 | . | 0.16 | . | . | . | . | . |
| 18 | 093 | 313 | M | 73 | 14.9 | 7.58 | 577 | 28 | 22.3 | . | . | 0.09 | . | 0.24 | . | . | . | . | . |
| 18 | 093 | 314 | M | 73 | 12.8 | 7.61 | 557 | 30 | 22.2 | . | . | 0.10 | . | 0.38 | . | . | . | . | . |
| 18 | 093 | 315 | U | 73 | 7.5 | 7.34 | 541 | 30 | 21.9 | . | . | 0.36 | . | 0.85 | . | . | . | . | . |
| 18 | 093 | 502 | D | 77 | . | 7.65 | 139 | 25 | 21.2 | . | 2.7 | . | . | 0.41 | . | . | 2 | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 095 | 502 | D | 77 | . | 8.28 | 381 | 120 | 22.0 | . | 3.0 | . | . | 0.73 | . | . | 3 | . | . |
| 18 | 097 | 502 | D | 77 | . | 8.15 | 402 | 133 | 21.7 | . | 2.4 | . | . | 0.65 | 5 | . | 3 | . | . |
| 18 | 097 | 503 | M | 77 | . | 8.25 | 400 | 131 | 21.3 | . | 2.4 | . | . | 0.66 | 14 | . | 3 | . | . |
| 18 | 120 | 313 | D | 73 | 17.7 | 7.76 | 861 | 74 | 23.3 | . | . | 0.02 | . | 0.42 | . | . | . | . | . |
| 18 | 120 | 314 | M | 73 | 14.4 | 7.88 | 841 | 76 | 23.3 | . | . | 0.03 | . | 0.46 | . | . | . | . | . |
| 18 | 120 | 315 | M | 73 | 14.0 | 8.12 | 668 | 77 | 23.2 | . | . | 0.08 | . | 0.53 | . | . | . | . | . |
| 18 | 120 | 316 | M | 73 | 14.0 | 7.96 | 595 | 80 | 24.1 | . | . | 0..14 | . | 0.56 | . | . | . | . | . |
| 18 | 120 | 317 | M | 73 | 9.6 | 8.19 | 624 | 81 | 24.0 | . | . | 0.17 | . | 0.71 | . | . | . | . | . |
| 18 | 120 | 320 | M | 73 | 6.3 | 8.21 | 1032 | 81 | 26.0 | . | . | 0.16 | . | 0.60 | . | . | . | . | . |
| 18 | 120 | 321 | M | 73 | 13.2 | 8.05 | 592 | 74 | 23.7 | . | . | 0.15 | . | 0.60 | . | . | . | . | . |
| 18 | 120 | 322 | M | 73 | 10.5 | 7.95 | 1063 | 77 | 25.5 | . | . | 0.22 | . | 0.67 | . | . | . | . | . |
| 18 | 120 | 323 | M | 73 | 5.1 | 8.00 | 1089 | 88 | 25.4 | . | . | 0.44 | . | 1.22 | . | . | . | . | . |
| 18 | 120 | 502 | D | 77 | . | 8.35 | 194 | 72 | 24.8 | . | 2.3 | . | . | 0.44 | . | . | 1 | . | . |
| 18 | 121 | 502 | D | 77 | . | 7.62 | 161 | . | 22.0 | . | 3.7 | . | . | 0.62 | . | . | 7 | . | . |
| 18 | 126 | 502 | D | 77 | . | 7.68 | 137 | 43 | 22.9 | . | 3.2 | . | . | 0.54 | . | . | 2 | . | . |
| 18 | 128 | 502 | D | 77 | . | 8.27 | 227 | . | 24.3 | . | 2.4 | . | . | 0.46 | . | . | 2 | . | . |
| 18 | 129 | 502 | D | 77 | . | 7.67 | 205 | 80 | 22.6 | . | 2.3 | . | . | 0.49 | . | . | 2 | . | . |
| 18 | 260 | 505 | M | 77 | . | 7.55 | 321 | . | 19.9 | . | 29.9 | . | . | 2.34 | . | . | 39 | . | . |
| 18 | 263 | 502 | D | 77 | . | 8.36 | 434 | 182 | 19.7 | . | 3.6 | . | . | 0.70 | . | . | 4 | . | . |
| 18 | 263 | 504 | M | 77 | . | 8.30 | 440 | 173 | 19.2 | . | 5.3 | . | . | 1.26 | . | . | 8 | . | . |
| 19 | 119 | 324 | D | 73 | 20.9 | 7.86 | 751 | 71 | 22.9 | . | . | 0.44 | . | 0.82 | . | . | . | . | . |
| 19 | 122 | 325 | D | 73 | 52.3 | 7.40 | 633 | 36 | 21.7 | . | . | 0.10 | . | 0.32 | . | . | . | . | . |
| 19 | 122 | 326 | M | 73 | 38.0 | 7.49 | 603 | 40 | 22.6 | . | . | 0.11 | . | 0.39 | . | . | . | . | . |
| 19 | 122 | 327 | M | 73 | 27.0 | 7.47 | 603 | 41 | 22.9 | . | . | 0.14 | . | 0.39 | . | . | . | . | . |
| 19 | 122 | 328 | M | 73 | 36.3 | 7.50 | 607 | 35 | 23.0 | . | . | 0.24 | . | 0.54 | . | . | . | . | . |
| 19 | 122 | 330 | U | 73 | 31.6 | 7.80 | 652 | 40 | 22.2 | . | . | 0.31 | . | 0.58 | . | . | . | . | . |
| 19 | 122 | 331 | U | 73 | 20.0 | 7.64 | 679 | 38 | 22.3 | . | . | 1.17 | . | 1.10 | . | . | . | . | . |
| 19 | 338 | 322 | D | 73 | 11.3 | 7.55 | 873 | 58 | 24.2 | . | . | 0.39 | . | 1.21 | . | . | . | . | . |
| 19 | 340 | 315 | D | 73 | 22.1 | 7.92 | 965 | 109 | 23.2 | . | . | 0.07 | . | 0.26 | . | . | . | . | . |
| 19 | 340 | 316 | M | 73 | 18.4 | 8.01 | 1002 | 108 | 23.6 | . | . | 0.09 | . | 0.25 | . | . | . | . | . |
| 19 | 340 | 317 | M | 73 | 20.4 | 8.20 | 961 | 118 | 23.1 | . | . | 0.12 | . | 0.26 | . | . | . | . | . |
| 19 | 340 | 318 | M | 73 | 12.1 | 8.00 | 1008 | 125 | 22.7 | . | . | 0.18 | . | 0.48 | . | . | . | . | . |
| 19 | 340 | 319 | U | 73 | 12.0 | 8.08 | 1070 | 134 | 22.3 | . | . | 0.28 | . | 0.74 | . | . | . | . | . |
| 19 | 340 | 504 | M | 76 | 6.1 | 7.63 | 272 | 145 | 24.6 | . | 5.8 | . | . | 0.76 | 180 | 168 | 12 | . | . |
| 19 | 340 | 504 | M | 78 | 5.7 | 7.35 | 289 | 167 | 24.4 | . | 3.7 | . | . | 1.17 | 195 | 157 | 39 | . | . |
| 19 | 340 | 505 | U | 75 | 10.7 | 8.00 | 304 | 146 | 27.9 | . | 5.6 | . | . | 0.93 | 168 | 156 | 12 | . | . |
| 19 | 340 | 505 | U | 76 | 10.2 | 7.95 | 276 | 152 | 23.5 | . | 6.5 | . | . | 0.53 | 176 | 162 | 14 | . | . |
| 19 | 340 | 505 | U | 78 | 10.0 | 7.50 | 292 | 170 | 23.9 | . | 6.3 | . | . | 1.22 | 199 | 177 | 23 | . | . |
| 19 | 340 | 506 | U | 75 | 6.6 | 8.19 | 296 | 144 | 27.4 | . | 5.7 | . | . | 0.95 | 169 | 140 | 29 | . | . |
| 19 | 340 | 506 | U | 76 | 6.6 | 7.67 | 321 | 172 | 23.9 | . | 5.7 | . | . | 0.50 | 217 | 204 | 13 | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 340 | 506 | U | 78 | 6.4 | 7.61 | 345 | 175 | 25.3 | . | 2.7 | . | . | 0.73 | 217 | 209 | 9 | . | . |
| 19 | 340 | 507 | U | 75 | 7.7 | 7.90 | 363 | 156 | 27.7 | . | 7.5 | . | . | 0.67 | 176 | 137 | 39 | . | . |
| 19 | 340 | 507 | U | 76 | 6.8 | 7.72 | 286 | 158 | 24.0 | . | 6.3 | . | . | 0.40 | 184 | 171 | 13 | . | . |
| 19 | 340 | 507 | U | 78 | 7.0 | 7.49 | 314 | 176 | 25.6 | . | 3.8 | . | . | 0.97 | 194 | 176 | 18 | . | . |
| 19 | 340 | 508 | M | 75 | 16.8 | 7.96 | 294 | 134 | 27.8 | . | 2.1 | . | . | 0.45 | 174 | 158 | 16 | . | . |
| 19 | 340 | 508 | M | 76 | 16.8 | 7.70 | 260 | 141 | 23.4 | . | 3.6 | . | . | 0.55 | 169 | 158 | 11 | . | . |
| 19 | 340 | 508 | M | 78 | 16.1 | 7.66 | 268 | 144 | 24.2 | . | 2.3 | . | . | 0.61 | 162 | 140 | 22 | . | . |
| 19 | 340 | 509 | M | 76 | 4.3 | 7.72 | 260 | 138 | 23.3 | . | 5.7 | . | . | 0.70 | 161 | 151 | 11 | . | . |
| 19 | 340 | 510 | M | 75 | 9.3 | 8.21 | 193 | 105 | 27.6 | . | 1.6 | . | . | 0.50 | 139 | 123 | 16 | . | . |
| 19 | 340 | 510 | M | 76 | 9.6 | 7.70 | 257 | 133 | 23.1 | . | 2.9 | . | . | 0.33 | 158 | 153 | 5 | . | . |
| 19 | 342 | 319 | D | 73 | 18.5 | 8.15 | 612 | 45 | 21.4 | . | . | 0.27 | . | 0.79 | . | . | . | . | . |
| 19 | 342 | 321 | M | 73 | 18.1 | 7.89 | 552 | 53 | 20.8 | . | . | 0.27 | . | 1.10 | . | . | . | . | . |
| 19 | 342 | 323 | U | 73 | 13.6 | 7.37 | 565 | 49 | 20.5 | . | . | 0.26 | . | 1.28 | . | . | . | . | . |
| 19 | 343 | 312 | D | 73 | 34.5 | 7.78 | 784 | 62 | 22.5 | . | . | 0.03 | . | 0.11 | . | . | . | . | . |
| 19 | 343 | 313 | M | 73 | 33.5 | 7.62 | 806 | 59 | 22.9 | . | . | 0.03 | . | 0.11 | . | . | . | . | . |
| 19 | 343 | 314 | M | 73 | 29.9 | 7.58 | 818 | 59 | 22.8 | . | . | 0.04 | . | 0.17 | . | . | . | . | . |
| 19 | 343 | 316 | U | 73 | 19.1 | 7.63 | 809 | 58 | 22.9 | . | . | 0.10 | . | 0.22 | . | . | . | . | . |
| 19 | 343 | 317 | U | 73 | 11.6 | 7.49 | 849 | 61 | 21.5 | . | . | 0.07 | . | 0.51 | . | . | . | . | . |
| 20 | 081 | 312 | M | 73 | 6.5 | 7.97 | 1517 | 136 | 20.3 | . | . | 0.74 | . | 1.45 | . | . | . | . | . |
| 20 | 081 | 313 | M | 73 | 10.3 | 7.91 | 1496 | 132 | 20.5 | . | . | 0.74 | . | 1.80 | . | . | . | . | . |
| 20 | 081 | 314 | D | 73 | 9.2 | 8.20 | 1524 | 131 | 20.7 | . | . | 0.52 | . | 1.05 | . | . | . | . | . |
| 20 | 087 | 313 | D | 73 | 10.1 | 7.89 | 1711 | 169 | 20.5 | . | . | 0.26 | . | 0.50 | . | . | . | . | . |
| 20 | 087 | 315 | M | 73 | 10.4 | 8.04 | 1688 | 166 | 20.8 | . | . | 0.29 | . | 0.57 | . | . | . | . | . |
| 20 | 087 | 316 | M | 73 | 10.9 | 8.11 | 1675 | 161 | 20.8 | . | . | 0.34 | . | 0.61 | . | . | . | . | . |
| 20 | 087 | 317 | U | 73 | 8.4 | 8.08 | 1690 | 161 | 20.8 | . | . | 0.37 | . | 0.68 | . | . | . | . | . |
| 20 | 087 | 318 | U | 73 | 6.3 | 8.08 | 1520 | 157 | 20.2 | . | . | 0.56 | . | 1.22 | . | . | . | . | . |
| 20 | 088 | 310 | D | 73 | 5.4 | 7.72 | 1314 | 62 | 21.2 | . | . | 0.26 | . | 0.75 | . | . | . | . | . |
| 20 | 088 | 311 | M | 73 | 5.5 | 7.88 | 1361 | 62 | 21.5 | . | . | 0.56 | . | 1.03 | . | . | . | . | . |
| 20 | 088 | 312 | U | 73 | 3.4 | 7.59 | 1342 | 62 | 21.5 | . | . | 0.78 | . | 0.82 | . | . | . | . | . |
| 20 | 088 | 313 | U | 73 | 3.0 | 7.53 | 525 | 65 | 21.2 | . | . | 0.63 | . | 0.79 | . | . | . | . | . |
| 21 | 196 | 308 | D | 74 | 6.9 | 8.05 | 168 | 75 | 18.3 | . | . | 0.19 | . | 0.51 | . | . | . | . | . |
| 21 | 196 | 309 | M | 74 | 10.9 | 7.83 | 178 | 78 | 17.6 | . | . | 0.21 | . | 0.76 | . | . | . | . | . |
| 21 | 196 | 310 | U | 74 | 6.3 | 7.75 | 124 | 55 | 17.4 | . | . | 0.26 | . | 0.80 | . | . | . | . | . |
| 21 | 196 | 311 | U | 74 | 9.6 | 7.71 | 186 | 87 | 16.8 | . | . | 0.18 | . | 0.92 | . | . | . | . | . |
| 24 | 011 | 312 | D | 74 | 58.3 | 8.00 | 122 | 53 | 20.5 | . | . | 0.06 | . | 0.17 | . | . | . | . | . |
| 24 | 011 | 313 | M | 74 | 49.2 | 7.90 | 122 | 54 | 20.0 | . | . | 0.07 | . | 0.26 | . | . | . | . | . |
| 24 | 011 | 314 | M | 74 | 34.5 | 7.80 | 119 | 50 | 20.2 | . | . | 0.08 | . | 0.35 | . | . | . | . | . |
| 24 | 011 | 315 | M | 74 | 29.6 | 7.50 | 117 | 43 | 20.1 | . | . | 0.10 | . | 0.56 | . | . | . | . | . |
| 24 | 011 | 316 | U | 74 | 18.4 | 7.24 | 106 | 43 | 20.3 | . | . | 0.17 | . | 0.85 | . | . | . | . | . |
| 24 | 011 | 317 | U | 74 | 13.7 | 7.40 | 110 | 41 | 19.7 | . | . | 0.18 | . | 1.21 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 013 | 321 | D | 74 | 59.6 | 8.30 | 210 | 126 | 19.9 | . | . | 0.06 | . | 0.15 | . | . | . | . | . |
| 24 | 013 | 322 | M | 74 | 57.2 | 8.30 | 205 | 128 | 20.1 | . | . | 0.05 | . | 0.15 | . | . | . | . | . |
| 24 | 013 | 323 | M | 74 | 47.3 | 8.26 | 202 | 127 | 20.3 | . | . | 0.06 | . | 0.17 | . | . | . | . | . |
| 24 | 013 | 324 | U | 74 | 30.3 | 8.22 | 213 | 141 | 20.3 | . | . | 0.06 | . | 0.18 | . | . | . | . | . |
| 24 | 013 | 325 | M | 74 | 46.8 | 8.30 | 195 | 125 | 20.3 | . | . | 0.08 | . | 0.15 | . | . | . | . | . |
| 24 | 013 | 326 | M | 74 | 34.6 | 8.48 | 184 | 126 | 20.5 | . | . | 0.08 | . | 0.11 | . | . | . | . | . |
| 24 | 013 | 327 | M | 74 | 25.5 | 8.40 | 182 | 123 | 20.0 | . | . | 0.07 | . | 0.16 | . | . | . | . | . |
| 24 | 013 | 328 | U | 74 | 19.6 | 8.45 | 194 | 117 | 19.6 | . | . | 0.07 | . | 0.26 | . | . | . | . | . |
| 24 | 016 | 310 | M | 74 | 55.5 | 7.22 | 43 | 18 | 23.2 | . | . | 0.04 | . | 0.15 | . | . | . | . | . |
| 24 | 016 | 311 | M | 74 | 37.0 | 7.06 | 46 | 19 | 23.2 | . | . | 0.05 | . | 0.17 | . | . | . | . | . |
| 24 | 016 | 312 | U | 74 | 30.0 | 6.97 | 47 | 20 | 23.9 | . | . | 0.05 | . | 0.19 | . | . | . | . | . |
| 24 | 016 | 313 | U | 74 | 16.3 | 6.79 | 39 | 17 | 23.3 | . | . | 0.06 | . | 0.35 | . | . | . | . | . |
| 24 | 022 | 318 | D | 74 | 54.0 | 8.17 | 237 | 157 | 20.1 | . | . | 0.07 | . | 0.16 | . | . | . | . | . |
| 24 | 022 | 319 | U | 74 | 34.0 | 8.22 | 230 | 152 | 20.7 | . | . | 0.05 | . | 0.18 | . | . | . | . | . |
| 24 | 022 | 320 | M | 74 | 48.2 | 8.22 | 250 | 158 | 20.7 | . | . | 0.04 | . | 0.17 | . | . | . | . | . |
| 24 | 022 | 321 | M | 74 | 37.4 | 8.27 | 257 | 160 | 20.7 | . | . | 0.08 | . | 0.20 | . | . | . | . | . |
| 24 | 022 | 323 | M | 74 | 29.5 | 8.36 | 247 | 161 | 20.7 | . | . | 0.06 | . | 0.31 | . | . | . | . | . |
| 24 | 022 | 324 | U | 74 | 11.4 | 8.39 | 245 | 158 | 20.8 | . | . | 0.10 | . | 0.39 | . | . | . | . | . |
| 24 | 193 | 307 | D | 74 | 12.1 | 8.08 | 214 | 97 | 17.3 | . | . | 0.16 | . | 0.55 | . | . | . | . | . |
| 24 | 193 | 308 | U | 74 | 4.4 | 7.98 | 222 | 105 | 16.1 | . | . | 0.10 | . | 0.57 | . | . | . | . | . |
| 24 | 193 | 309 | M | 74 | 6.6 | 8.01 | 219 | 106 | 17.1 | . | . | 0.27 | . | 0.87 | . | . | . | . | . |
| 24 | 200 | 317 | D | 74 | 56.8 | 8.40 | 194 | 95 | 19.6 | . | . | 0.09 | . | 0.12 | . | . | . | . | . |
| 24 | 200 | 318 | U | 74 | 34.6 | 8.37 | 203 | 96 | 19.9 | . | . | 0.09 | . | 0.19 | . | . | . | . | . |
| 24 | 200 | 319 | M | 74 | 53.5 | 8.18 | 193 | 95 | 19.8 | . | . | 0.14 | . | 0.22 | . | . | . | . | . |
| 24 | 200 | 320 | M | 74 | 38.0 | 8.03 | 189 | 92 | 19.9 | . | . | 0.13 | . | 0.24 | . | . | . | . | . |
| 24 | 200 | 321 | M | 74 | 32.7 | 8.07 | 187 | 86 | 19.9 | . | . | 0.12 | . | 0.23 | . | . | . | . | . |
| 24 | 200 | 322 | U | 74 | 19.0 | 8.12 | 179 | 84 | 19.6 | . | . | 0.07 | . | 0.29 | . | . | . | . | . |
| 24 | 200 | 323 | M | 74 | 23.5 | 8.23 | 207 | 104 | 20.3 | . | . | 0.08 | . | 0.21 | . | . | . | . | . |
| 24 | 200 | 324 | M | 74 | 42.8 | 8.35 | 214 | 110 | 20.2 | . | . | 0.10 | . | 0.23 | . | . | . | . | . |
| 24 | 200 | 325 | U | 74 | 22.1 | 8.27 | 264 | 121 | 20.3 | . | . | 0.17 | . | 0.59 | . | . | . | . | . |
| 25 | 105 | 312 | D | 74 | 3.0 | 8.12 | 404 | 180 | 16.7 | . | . | 1.28 | . | 6.02 | . | . | . | . | . |
| 25 | 107 | 308 | M | 74 | 4.0 | 8.43 | 526 | 131 | 16.8 | . | . | 1.76 | . | 2.74 | . | . | . | . | . |
| 25 | 267 | 315 | D | 74 | 24.6 | 7.73 | 399 | 83 | 20.8 | . | . | 0.21 | . | 1.28 | . | . | . | . | . |
| 25 | 267 | 316 | M | 74 | 21.0 | 7.93 | 395 | 84 | 25.3 | . | . | 0.26 | . | 1.64 | . | . | . | . | . |
| 25 | 267 | 317 | M | 74 | 18.9 | 7.91 | 339 | 75 | 21.3 | . | . | 0.21 | . | 1.43 | . | . | . | . | . |
| 25 | 267 | 318 | M | 74 | 20.1 | 7.52 | 168 | 41 | 22.3 | . | . | 0.71 | . | 3.35 | . | . | . | . | . |
| 25 | 267 | 319 | U | 74 | 12.3 | 7.33 | 83 | 22 | 20.9 | . | . | 1.08 | . | 3.98 | . | . | . | . | . |
| 25 | 267 | 321 | M | 74 | 18.2 | 7.98 | 490 | 94 | 20.9 | . | . | 0.37 | . | 2.25 | . | . | . | . | . |
| 25 | 267 | 322 | U | 74 | 10.7 | 8.08 | 642 | 110 | 21.5 | . | . | 0.92 | . | 2.20 | . | . | . | . | . |
| 25 | 267 | 323 | U | 74 | 15.0 | 7.76 | 448 | 101 | 20.8 | . | . | 0.87 | . | 3.06 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 273 | 319 | M | 74 | 16.8 | 8.12 | 1397 | 119 | 20.2 | . | . | 0.43 | . | 1.36 | . | . | . | . | . |
| 25 | 273 | 320 | M | 74 | 17.3 | 8.03 | 1270 | 114 | 20.0 | . | . | 0.64 | . | 1.55 | . | . | . | . | . |
| 25 | 273 | 324 | M | 74 | 16.7 | 7.79 | 865 | 110 | 19.7 | . | . | 0.87 | . | 2.60 | . | . | . | . | . |
| 25 | 275 | 312 | D | 74 | 21.8 | 7.74 | 282 | 111 | 19.6 | . | . | 0.46 | . | 1.90 | . | . | . | . | . |
| 25 | 275 | 313 | M | 74 | 11.7 | 7.79 | 298 | 112 | 19.6 | . | . | 0.45 | . | 1.61 | . | . | . | . | . |
| 25 | 275 | 318 | U | 74 | 10.5 | 8.09 | 335 | 113 | 22.7 | . | . | 0.20 | . | 1.37 | . | . | . | . | . |
| 25 | 275 | 319 | M | 74 | 9.3 | 7.50 | 326 | 111 | 21.6 | . | . | 0.50 | . | 2.15 | . | . | . | . | . |
| 25 | 275 | 320 | M | 74 | 9.0 | 7.69 | 308 | 108 | 21.5 | . | . | 1.30 | . | 2.34 | . | . | . | . | . |
| 25 | 278 | 306 | D | 74 | 42.9 | 7.94 | 157 | 73 | 20.7 | . | . | 0.09 | . | 0.39 | . | . | . | . | . |
| 25 | 278 | 307 | M | 74 | 34.0 | 8.10 | 161 | 76 | 20.9 | . | . | 0.09 | . | 0.39 | . | . | . | . | . |
| 25 | 278 | 308 | M | 74 | 27.1 | 8.15 | 164 | 75 | 21.3 | . | . | 0.11 | . | 0.43 | . | . | . | . | . |
| 25 | 278 | 309 | U | 74 | 13.8 | 8.17 | 169 | 78 | 21.2 | . | . | 0.23 | . | 0.91 | . | . | . | . | . |
| 25 | 281 | 307 | D | 74 | 11.8 | 6.46 | 62 | 23 | 22.8 | . | . | 0.31 | . | 1.66 | . | . | . | . | . |
| 25 | 281 | 308 | M | 74 | 10.3 | 6.27 | 60 | 20 | 22.6 | . | . | 0.64 | . | 1.52 | . | . | . | . | . |
| 25 | 370 | 303 | D | 74 | 10.2 | 8.24 | 4948 | 88 | 22.0 | . | . | 0.08 | . | 0.52 | . | . | . | . | . |
| 25 | 370 | 306 | M | 74 | 7.5 | 8.29 | 4852 | 84 | 22.7 | . | . | 0.11 | . | 0.90 | . | . | . | . | . |
| 26 | 354 | 317 | D | 74 | 7.7 | 8.25 | 317 | 134 | 23.8 | . | . | 0.39 | . | 2.27 | . | . | . | . | . |
| 26 | 354 | 318 | M | 74 | 3.7 | 8.29 | 321 | 136 | 23.9 | . | . | 0.72 | . | 2.38 | . | . | . | . | . |
| 26 | 354 | 319 | M | 74 | 5.7 | 8.27 | 315 | 135 | 24.6 | . | . | 0.92 | . | 2.63 | . | . | . | . | . |
| 26 | 355 | 318 | M | 74 | 9.5 | 8.26 | 356 | 115 | 23.7 | . | . | 0.23 | . | 0.78 | . | . | . | . | . |
| 26 | 355 | 320 | M | 74 | 8.4 | 8.21 | 357 | 114 | 24.1 | . | . | 0.40 | . | 1.14 | . | . | . | . | . |
| 26 | 355 | 322 | U | 74 | 3.0 | 8.14 | 332 | 106 | 24.0 | . | . | 1.77 | . | 3.65 | . | . | . | . | . |
| 28 | 219 | 307 | D | 75 | 19.3 | 8.28 | 826 | 154 | 18.6 | . | . | 0.06 | . | 0.80 | . | . | . | . | . |
| 28 | 219 | 308 | U | 75 | 14.2 | 8.29 | 808 | 154 | 19.0 | . | . | 0.06 | . | 0.65 | . | . | . | . | . |
| 28 | 219 | 309 | M | 75 | 17.9 | 8.27 | 820 | 157 | 18.6 | . | . | 0.06 | . | 0.64 | . | . | . | . | . |
| 28 | 219 | 310 | M | 75 | 14.3 | 8.33 | 816 | 152 | 18.0 | . | . | 0.09 | . | 0.96 | . | . | . | . | . |
| 29 | 106 | 311 | M | 74 | 4.8 | 8.11 | 1384 | 156 | 17.0 | . | . | 1.67 | . | 3.00 | . | . | . | . | . |
| 29 | 108 | 314 | M | 74 | 14.8 | 8.39 | 749 | 191 | 16.5 | . | . | 0.25 | . | 0.60 | . | . | . | . | . |
| 29 | 108 | 315 | M | 74 | 10.3 | 8.33 | 774 | 192 | 16.5 | . | . | 0.41 | . | 1.07 | . | . | . | . | . |
| 29 | 108 | 316 | M | 74 | 5.1 | 8.38 | 863 | 232 | 16.8 | . | . | 1.94 | . | 2.07 | . | . | . | . | . |
| 29 | 110 | 315 | D | 74 | 16.2 | 8.34 | 397 | 164 | 17.7 | . | . | 0.14 | . | 1.34 | . | . | . | . | . |
| 29 | 110 | 316 | U | 74 | 10.1 | 8.25 | 398 | 167 | 17.1 | . | . | 0.19 | . | 1.57 | . | . | . | . | . |
| 29 | 110 | 317 | M | 74 | 14.9 | 8.24 | 395 | 168 | 17.1 | . | . | 0.26 | . | 2.04 | . | . | . | . | . |
| 29 | 110 | 318 | M | 74 | 10.1 | 8.11 | 336 | 172 | 17.1 | . | . | 0.88 | . | 2.19 | . | . | . | . | . |
| 29 | 111 | 310 | D | 74 | 9.9 | 8.25 | 330 | 144 | 18.1 | . | . | 0.21 | . | 1.67 | . | . | . | . | . |
| 29 | 111 | 311 | M | 74 | 7.8 | 8.18 | 354 | 142 | 17.4 | . | . | 0.25 | . | 1.88 | . | . | . | . | . |
| 29 | 194 | 311 | D | 74 | 21.5 | 8.25 | 234 | 114 | 18.5 | . | . | 1.22 | . | 0.30 | . | . | . | . | . |
| 29 | 194 | 312 | M | 74 | 17.4 | 8.02 | 250 | 119 | 17.5 | . | . | 0.17 | . | 0.46 | . | . | . | . | . |
| 29 | 194 | 313 | U | 74 | 8.6 | 8.03 | 287 | 138 | 17.0 | . | . | 0.32 | . | 0.88 | . | . | . | . | . |
| 29 | 194 | 314 | M | 74 | 11.5 | 8.24 | 182 | 104 | 18.0 | . | . | 0.11 | . | 0.71 | . | . | . | . | . |

## WATER QUALITY SUMMARY BY STATION-YEAR

### POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 195 | 315 | D | 74 | 29.3 | 8.24 | 284 | 132 | 16.8 | . | . | 0.09 | . | 0.34 | . | . | . | . | . |
| 29 | 207 | 310 | D | 74 | 16.4 | 8.46 | 496 | 199 | 16.1 | . | . | 0.16 | . | 0.63 | . | . | . | . | . |
| 29 | 207 | 311 | M | 74 | 11.7 | 8.32 | 507 | 198 | 15.6 | . | . | 0.19 | . | 1.14 | . | . | . | . | . |
| 30 | 064 | 305 | D | 75 | 5.5 | 8.28 | 490 | 181 | 15.4 | . | . | 0.15 | . | 0.96 | . | . | . | . | . |
| 30 | 064 | 307 | M | 75 | 5.2 | 8.42 | 458 | 167 | 15.6 | . | . | 0.09 | . | 1.02 | . | . | . | . | . |
| 30 | 235 | 320 | D | 74 | 54.9 | 8.27 | 690 | 166 | 14.6 | . | . | 0.07 | . | 0.20 | . | . | . | . | . |
| 30 | 235 | 321 | M | 74 | 19.9 | 8.19 | 693 | 166 | 14.5 | . | . | 0.08 | . | 0.35 | . | . | . | . | . |
| 30 | 235 | 322 | M | 74 | 39.6 | 7.85 | 727 | 166 | 14.2 | . | . | 0.76 | . | 0.20 | . | . | . | . | . |
| 30 | 235 | 323 | M | 74 | 24.9 | 8.03 | 708 | 162 | 15.5 | . | . | 0.09 | . | 0.27 | . | . | . | . | . |
| 30 | 235 | 324 | M | 74 | 30.0 | 8.30 | 638 | 159 | 14.2 | . | . | 0.05 | . | 0.20 | . | . | . | . | . |
| 31 | 077 | 311 | D | 75 | 175.4 | 7.51 | 25 | 20 | 20.1 | . | . | 0.06 | . | 0.38 | . | . | . | . | . |
| 31 | 077 | 312 | M | 75 | 175.4 | 7.21 | 24 | 14 | 14.0 | . | . | 0.04 | . | 0.31 | . | . | . | . | . |
| 31 | 077 | 313 | M | 75 | 175.4 | 7.25 | 23 | 15 | 13.2 | . | . | 0.05 | . | 0.34 | . | . | . | . | . |
| 31 | 077 | 314 | M | 75 | 175.4 | 6.99 | 23 | 19 | 13.4 | . | . | 0.05 | . | 0.32 | . | . | . | . | . |
| 31 | 077 | 315 | M | 75 | 175.4 | 7.08 | 22 | 19 | 13.6 | . | . | 0.05 | . | 0.37 | . | . | . | . | . |
| 32 | 204 | 314 | M | 75 | 82.3 | 8.42 | 187 | 101 | 17.5 | . | . | 0.04 | . | 0.15 | . | . | . | . | . |
| 32 | 204 | 315 | D | 75 | 82.3 | 8.49 | 192 | 102 | 16.0 | . | . | 0.03 | . | 0.08 | . | . | . | . | . |
| 32 | 204 | 316 | M | 75 | 38.1 | 8.35 | 177 | 97 | 17.0 | . | . | 0.11 | . | 0.32 | . | . | . | . | . |

### POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | 301 | D | 72 | . | 7.02 | 95 | 16 | 18.4 | . | . | 0.07 | . | 0.34 | . | . | . | . | . |
| 02 | 176 | 302 | M | 72 | . | 7.11 | 124 | 16 | 19.6 | . | . | 0.07 | . | 0.25 | . | . | . | . | . |
| 04 | 312 | 312 | M | 73 | 4.8 | 8.20 | 273 | 105 | 17.1 | . | . | 0.24 | . | 0.42 | . | . | . | . | . |
| 04 | 320 | 005 | M | 74 | . | 7.57 | 212 | 69 | 20.1 | . | . | . | . | 0.49 | . | . | . | . | . |
| 04 | 320 | 006 | M | 74 | . | 7.57 | 197 | 59 | 21.0 | . | . | . | . | 0.28 | . | . | . | . | . |
| 04 | 320 | 007 | M | 74 | . | 7.33 | 174 | 51 | 21.0 | . | . | . | . | 0.16 | . | . | . | . | . |
| 08 | 074 | 320 | D | 73 | 42.5 | 6.98 | 225 | 16 | 28.4 | . | . | 0.09 | . | 0.16 | . | . | . | . | . |
| 08 | 074 | 321 | M | 73 | 34.0 | 7.10 | 213 | 13 | 28.0 | . | . | 0.07 | . | 0.31 | . | . | . | . | . |
| 08 | 074 | 323 | U | 73 | 26.5 | 7.58 | 227 | 17 | 28.9 | . | . | 0.09 | . | 0.41 | . | . | . | . | . |
| 08 | 074 | 324 | U | 73 | 14.3 | 7.00 | 272 | 23 | 28.6 | . | . | 0.11 | . | 0.34 | . | . | . | . | . |
| 08 | 074 | 325 | M | 73 | 22.0 | 7.73 | 250 | 20 | 28.8 | . | . | 0.09 | . | 0.25 | . | . | . | . | . |
| 08 | 074 | 326 | U | 73 | 14.2 | 7.60 | 284 | 23 | 28.9 | . | . | 0.14 | . | 0.30 | . | . | . | . | . |
| 08 | 074 | 327 | U | 73 | 7.8 | 7.33 | 288 | 19 | 28.4 | . | . | 0.22 | . | 0.54 | . | . | . | . | . |
| 08 | 074 | 328 | M | 73 | 14.6 | 7.80 | 241 | 18 | 28.3 | . | . | 0.13 | . | 0.39 | . | . | . | . | . |
| 08 | 074 | 329 | U | 73 | 11.7 | 7.56 | 276 | 19 | 27.8 | . | . | 0.33 | . | 1.00 | . | . | . | . | . |
| 08 | 074 | 330 | U | 73 | 13.0 | 7.63 | 225 | 18 | 26.9 | . | . | 0.15 | . | 0.64 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08 | 330 | 340 | D | 73 | 51.7 | 6.82 | 155 | 12 | 28.2 | . | . | 0.05 | . | 0.08 | . | . | . | . | . |
| 08 | 330 | 341 | U | 73 | 17.2 | 6.53 | 166 | 10 | 28.7 | . | . | 0.09 | . | 0.09 | . | . | . | . | . |
| 08 | 330 | 342 | M | 73 | 46.6 | 7.00 | 169 | 10 | 28.6 | . | . | 0.14 | . | 0.22 | . | . | . | . | . |
| 08 | 330 | 343 | M | 73 | 31.4 | 7.27 | 300 | 12 | 28.1 | . | . | 1.64 | . | 0.27 | . | . | . | . | . |
| 08 | 330 | 344 | U | 73 | 9.8 | 7.01 | 367 | 15 | 28.1 | . | . | 0.10 | . | 0.52 | . | . | . | . | . |
| 08 | 330 | 345 | U | 73 | 10.7 | 6.27 | 106 | 10 | 25.1 | . | . | 0.30 | . | 0.89 | . | . | . | . | . |
| 08 | 330 | 346 | M | 73 | 15.2 | 6.68 | 167 | 11 | 28.3 | . | . | 0.12 | . | 0.36 | . | . | . | . | . |
| 08 | 330 | 347 | M | 73 | 18.7 | 6.61 | 162 | 10 | 28.8 | . | . | 0.09 | . | 0.24 | . | . | . | . | . |
| 08 | 330 | 348 | M | 73 | 32.3 | 7.04 | 173 | 15 | 29.1 | . | . | 0.10 | . | 0.25 | . | . | . | . | . |
| 08 | 330 | 349 | M | 73 | 16.5 | 7.11 | 186 | 13 | 29.1 | . | . | 0.10 | . | 0.29 | . | . | . | . | . |
| 08 | 330 | 350 | M | 73 | 17.5 | 6.98 | 316 | 14 | 28.4 | . | . | 1.51 | . | 0.26 | . | . | . | . | . |
| 08 | 330 | 351 | U | 73 | 12.5 | 7.06 | 214 | 16 | 28.6 | . | . | 0.12 | . | 0.19 | . | . | . | . | . |
| 10 | 003 | 310 | U | 73 | 17.8 | 6.73 | 805 | 21 | 24.9 | . | . | 0.16 | . | 0.75 | . | . | . | . | . |
| 10 | 069 | 311 | D | 73 | 40.2 | 7.06 | 150 | 17 | 26.4 | . | . | 0.05 | . | 0.40 | . | . | . | . | . |
| 10 | 069 | 312 | M | 73 | 17.4 | 7.02 | 164 | 14 | 26.8 | . | . | 0.09 | . | 0.41 | . | . | . | . | . |
| 10 | 069 | 313 | U | 73 | 5.0 | 6.74 | 202 | 21 | 27.1 | . | . | 0.17 | . | 0.49 | . | . | . | . | . |
| 10 | 069 | 314 | M | 73 | 14.0 | 7.22 | 155 | 15 | 27.3 | . | . | 0.05 | . | 0.31 | . | . | . | . | . |
| 10 | 069 | 315 | U | 73 | 7.6 | 7.12 | 200 | 18 | 26.9 | . | . | 0.23 | . | 0.60 | . | . | . | . | . |
| 10 | 069 | 316 | U | 73 | 11.0 | 7.29 | 152 | 14 | 26.4 | . | . | 0.08 | . | 0.48 | . | . | . | . | . |
| 10 | 071 | 311 | U | 73 | 7.6 | 7.41 | 357 | 23 | 28.4 | . | . | 0.29 | . | 0.87 | . | . | . | . | . |
| 10 | 071 | 312 | D | 73 | 8.2 | 7.57 | 448 | 30 | 28.9 | . | . | 0.36 | . | 1.03 | . | . | . | . | . |
| 10 | 071 | 313 | M | 73 | 7.9 | 7.41 | 593 | 49 | 28.6 | . | . | 0.17 | . | 0.94 | . | . | . | . | . |
| 10 | 071 | 314 | M | 73 | 3.2 | 7.64 | 946 | 86 | 28.2 | . | . | 0.14 | . | 0.58 | . | . | . | . | . |
| 10 | 071 | 315 | U | 73 | 7.9 | 7.33 | 620 | 52 | 28.0 | . | . | 0.15 | . | 0.84 | . | . | . | . | . |
| 10 | 072 | 321 | D | 73 | 11.1 | 8.24 | 316 | 19 | 29.7 | . | . | 0.11 | . | 0.40 | . | . | . | . | . |
| 10 | 072 | 322 | M | 73 | 2.0 | 8.50 | 325 | 20 | 29.4 | . | . | 0.22 | . | 0.48 | . | . | . | . | . |
| 10 | 072 | 323 | M | 73 | 26.1 | 8.17 | 302 | 20 | 28.3 | . | . | 0.21 | . | 0.85 | . | . | . | . | . |
| 10 | 072 | 324 | M | 73 | 6.9 | 7.52 | 308 | 16 | 28.2 | . | . | 0.40 | . | 1.17 | . | . | . | . | . |
| 10 | 073 | 113 | M | 75 | . | 6.66 | 53 | 18 | 22.9 | 12.2 | . | . | 29 | 1.16 | 67 | 57 | 10 | . | . |
| 10 | 073 | 131 | M | 75 | . | 6.56 | 58 | 17 | 21.3 | 22.3 | . | . | 34 | 2.24 | 68 | 40 | 28 | . | . |
| 10 | 076 | 312 | D | 73 | 43.0 | 7.48 | 134 | 11 | 27.2 | . | . | 0.07 | . | 0.20 | . | . | . | . | . |
| 10 | 076 | 313 | U | 73 | 25.2 | 7.71 | 134 | 10 | 27.4 | . | . | 0.07 | . | 0.26 | . | . | . | . | . |
| 10 | 076 | 314 | U | 73 | 22.3 | 6.77 | 143 | 10 | 27.3 | . | . | 0.07 | . | 0.21 | . | . | . | . | . |
| 10 | 076 | 315 | M | 73 | 42.5 | 7.47 | 138 | 11 | 27.8 | . | . | 0.07 | . | 0.21 | . | . | . | . | . |
| 10 | 076 | 316 | M | 73 | 27.6 | 7.57 | 140 | 11 | 28.3 | . | . | 0.07 | . | 0.21 | . | . | . | . | . |
| 10 | 076 | 317 | M | 73 | 35.1 | 7.63 | 134 | 12 | 27.9 | . | . | 0.07 | . | 0.21 | . | . | . | . | . |
| 10 | 076 | 318 | U | 73 | 22.4 | 8.40 | 174 | 14 | 28.0 | . | . | 0.16 | . | 0.20 | . | . | . | . | . |
| 10 | 076 | 319 | M | 73 | 29.9 | 7.42 | 134 | 12 | 27.9 | . | . | 0.14 | . | 0.33 | . | . | . | . | . |
| 10 | 076 | 320 | U | 73 | 14.9 | 7.37 | 129 | 12 | 26.8 | . | . | 0.13 | . | 0.35 | . | . | . | . | . |
| 10 | 076 | 321 | M | 73 | 30.5 | 7.41 | 132 | 10 | 27.8 | . | . | 0.12 | . | 0.28 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 076 | 322 | M | 73 | 24.7 | 7.61 | 132 | 11 | 27.9 | . | . | 0.15 | . | 0.27 | . | . | . | . | . |
| 10 | 076 | 323 | U | 73 | 15.2 | 7.65 | 135 | 12 | 27.8 | . | . | 0.13 | . | 0.15 | . | . | . | . | . |
| 10 | 411 | 313 | D | 73 | 18.0 | 6.73 | 988 | 25 | 24.8 | . | . | 0.28 | . | 0.55 | . | . | . | . | . |
| 10 | 411 | 315 | U | 73 | 10.2 | 6.76 | 719 | 25 | 25.3 | . | . | 0.21 | . | 0.79 | . | . | . | . | . |
| 14 | 099 | 312 | D | 74 | 13.9 | 8.03 | 635 | 293 | 17.9 | . | . | 0.79 | . | 0.89 | . | . | . | . | . |
| 14 | 099 | 313 | M | 74 | 7.5 | 7.90 | 703 | 292 | 14.0 | . | . | 1.61 | . | 2.27 | . | . | . | . | . |
| 15 | 178 | 005 | M | 76 | . | 8.33 | 223 | 110 | 18.2 | . | 2.2 | . | 23 | 0.15 | . | . | . | . | . |
| 15 | 178 | 005 | M | 78 | 19.8 | 7.90 | 213 | 98 | . | . | 1.3 | . | 10 | 0.27 | . | . | 3 | . | . |
| 15 | 178 | 006 | D | 77 | 19.8 | 7.93 | 237 | 123 | 18.1 | . | 3.3 | . | 12 | 0.09 | . | . | 3 | . | . |
| 15 | 178 | 305 | M | 72 | . | 8.18 | 404 | 100 | 15.2 | . | . | 0.10 | . | 0.08 | . | . | . | . | . |
| 15 | 178 | 306 | M | 72 | . | 8.18 | 441 | 105 | 15.6 | . | . | 0.11 | . | 0.17 | . | . | . | . | . |
| 15 | 178 | 307 | D | 72 | . | 8.20 | 449 | 103 | 15.7 | . | . | 0.12 | . | 0.18 | . | . | . | . | . |
| 15 | 179 | 802 | M | 79 | . | 8.28 | 550 | 232 | 19.4 | . | . | . | . | 0.08 | . | 15 | . | . | . |
| 15 | 179 | 803 | M | 79 | . | 8.55 | . | 216 | 20.0 | . | . | . | . | 0.08 | . | 25 | . | . | . |
| 15 | 179 | 804 | M | 79 | . | 8.32 | 683 | 220 | 18.4 | . | . | . | . | 0.08 | . | 19 | . | . | . |
| 15 | 179 | 805 | M | 79 | . | 8.56 | . | 218 | 19.1 | . | . | . | . | 0.08 | . | 17 | . | . | . |
| 15 | 179 | 806 | M | 79 | . | 8.42 | 726 | 226 | 19.1 | . | . | . | . | 0.42 | . | 19 | . | . | . |
| 15 | 181 | 309 | M | 72 | . | 8.16 | 265 | 136 | 15.7 | . | . | 0.41 | . | 0.24 | . | . | . | . | . |
| 15 | 181 | 310 | M | 72 | . | 8.26 | 261 | 134 | 14.4 | . | . | 0.53 | . | 0.38 | . | . | . | . | . |
| 15 | 181 | 311 | D | 72 | . | 8.28 | 264 | 133 | 14.6 | . | . | 0.54 | . | 0.29 | . | . | . | . | . |
| 15 | 181 | 312 | M | 72 | . | 8.27 | 261 | 132 | 14.6 | . | . | 0.52 | . | 0.32 | . | . | . | . | . |
| 15 | 237 | 309 | M | 74 | 6.1 | 8.74 | 697 | 324 | 19.3 | . | . | 0.14 | . | 0.11 | . | . | . | . | . |
| 15 | 399 | 801 | M | 78 | . | 8.20 | . | 188 | 13.3 | . | . | . | . | 0.34 | . | . | . | . | . |
| 15 | 399 | 801 | M | 79 | . | 8.05 | 373 | 133 | 15.5 | . | . | . | . | 0.24 | . | 9 | . | . | . |
| 15 | 399 | 802 | U | 78 | . | 8.20 | . | 190 | 10.0 | . | . | . | . | 0.23 | . | . | . | . | . |
| 16 | 243 | 311 | U | 73 | 7.3 | 7.80 | 402 | 75 | 15.9 | . | . | 0.12 | . | 0.77 | . | . | . | . | . |
| 16 | 243 | 312 | U | 73 | 4.4 | 8.20 | 406 | 75 | 16.3 | . | . | 0.11 | . | 0.68 | . | . | . | . | . |
| 16 | 243 | 314 | M | 73 | 3.7 | 7.95 | 462 | 92 | 20.1 | . | . | 0.65 | . | 1.39 | . | . | . | . | . |
| 16 | 328 | 336 | M | 72 | . | 7.87 | 163 | 36 | 17.3 | . | . | 0.31 | . | 0.45 | . | . | . | . | . |
| 17 | 247 | 308 | U | 73 | 1.7 | 8.35 | 452 | 183 | 16.9 | . | . | 2.45 | . | 1.99 | . | . | . | . | . |
| 17 | 249 | 313 | U | 73 | 2.1 | 7.85 | 441 | 142 | 16.8 | . | . | 0.60 | . | 2.43 | . | . | . | . | . |
| 17 | 373 | 309 | M | 73 | 30.3 | 7.76 | 1910 | 26 | 25.6 | . | . | 0.08 | . | 0.14 | . | . | . | . | . |
| 17 | 373 | 310 | U | 73 | 14.5 | 7.22 | 1376 | 24 | 21.6 | . | . | 0.24 | . | 0.85 | . | . | . | . | . |
| 17 | 373 | 311 | M | 73 | 11.6 | 7.02 | 1040 | 26 | 18.3 | . | . | 0.15 | . | 0.57 | . | . | . | . | . |
| 17 | 389 | 328 | D | 73 | 11.7 | 8.20 | 752 | 55 | 20.7 | . | . | 0.54 | . | 0.80 | . | . | . | . | . |
| 17 | 389 | 329 | M | 73 | 4.8 | 7.83 | 675 | 54 | 20.2 | . | . | 0.64 | . | 1.43 | . | . | . | . | . |
| 17 | 389 | 330 | M | 73 | 2.4 | 8.27 | 774 | 54 | 18.5 | . | . | 0.62 | . | 1.17 | . | . | . | . | . |
| 17 | 389 | 331 | U | 73 | 2.4 | 7.95 | 689 | 52 | 24.1 | . | . | 0.17 | . | 1.18 | . | . | . | . | . |
| 17 | 391 | 310 | D | 73 | 64.0 | 7.08 | 296 | 11 | 20.6 | . | . | 0.12 | . | 0.08 | . | . | . | . | . |
| 17 | 391 | 311 | M | 73 | 12.1 | 7.04 | 276 | 10 | 20.9 | . | . | 0.20 | . | 0.15 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 391 | 312 | M | 73 | 31.9 | 6.98 | 313 | 11 | 21.0 | . | . | 0.16 | . | 0.08 | . | . | . | . | . |
| 18 | 090 | 502 | D | 73 | . | 7.91 | 369 | 135 | 21.3 | . | . | . | . | 0.63 | 208 | . | 5 | 113100 | 0.075 |
| 18 | 091 | 502 | D | 74 | . | 8.04 | 536 | 149 | 19.2 | . | 13.8 | . | . | 2.23 | 466 | . | 57 | 738500 | 0.262 |
| 18 | 091 | 502 | D | 77 | . | 8.04 | 690 | . | 19.8 | . | 2.8 | . | . | 0.72 | . | . | 17 | . | . |
| 18 | 092 | 502 | D | 74 | . | 8.03 | 542 | 152 | 22.5 | . | 0.7 | . | . | 0.95 | 308 | . | 4 | 83775 | 0.020 |
| 18 | 092 | 502 | D | 75 | . | 8.15 | 476 | 156 | 20.3 | . | 4.0 | . | . | 0.95 | 341 | . | 8 | 263700 | 0.022 |
| 18 | 092 | 502 | D | 77 | . | 8.20 | 529 | . | 21.3 | . | 4.5 | . | . | 0.82 | . | . | 6 | . | . |
| 18 | 093 | 317 | M | 73 | 5.8 | 6.86 | 608 | 30 | 23.3 | . | . | 0.48 | . | 1.74 | . | . | . | . | . |
| 18 | 094 | 502 | D | 75 | . | 8.13 | 420 | 139 | 20.9 | . | 3.2 | . | . | 0.80 | 321 | . | 6 | 81667 | 0.020 |
| 18 | 095 | 502 | D | 76 | . | 8.31 | 361 | 137 | 19.2 | . | 5.0 | . | . | 0.51 | 216 | . | 5 | 468000 | . |
| 18 | 097 | 503 | M | 75 | . | 8.20 | 424 | 176 | 21.2 | . | 4.1 | . | . | 0.69 | 285 | . | 5 | 139667 | 0.013 |
| 18 | 120 | 318 | U | 73 | 5.9 | 8.32 | 973 | 99 | 22.2 | . | . | 1.00 | . | 1.28 | . | . | . | . | . |
| 18 | 120 | 319 | U | 73 | 5.0 | 8.36 | 844 | 87 | 23.5 | . | . | 0.47 | . | 1.03 | . | . | . | . | . |
| 18 | 121 | 502 | D | 75 | . | 7.42 | 125 | 31 | 24.6 | . | 6.2 | . | . | 0.73 | 77 | . | 6 | 82333 | 0.302 |
| 18 | 126 | 502 | D | 74 | . | 7.69 | 131 | 44 | 20.6 | . | . | . | . | 0.51 | 76 | . | 6 | 61500 | 0.015 |
| 18 | 128 | 502 | D | 75 | . | 8.06 | 199 | 121 | 21.8 | . | 6.8 | . | . | 0.64 | 128 | . | 5 | 89333 | 0.020 |
| 18 | 129 | 502 | D | 74 | . | 7.91 | 254 | 94 | 19.3 | . | 2.5 | . | . | 0.66 | 139 | . | 4 | 113000 | 0.191 |
| 18 | 134 | 502 | D | 75 | . | 7.61 | 104 | 34 | 25.8 | . | 6.3 | . | . | 0.36 | 73 | . | 5 | 142975 | 0.011 |
| 18 | 134 | 502 | D | 77 | . | 7.61 | 119 | . | 22.2 | . | 2.5 | . | . | 0.58 | . | . | 2 | . | . |
| 18 | 263 | 502 | D | 75 | . | 8.16 | 540 | 256 | 18.4 | . | 8.8 | . | . | 0.75 | 367 | . | 17 | 119300 | 0.009 |
| 19 | 119 | 325 | M | 73 | 16.8 | 7.94 | 748 | 81 | 23.3 | . | . | 0.34 | . | 0.62 | . | . | . | . | . |
| 19 | 119 | 326 | M | 73 | 18.7 | 7.90 | 510 | 79 | 20.7 | . | . | 0.49 | . | 1.10 | . | . | . | . | . |
| 19 | 119 | 327 | M | 73 | 21.6 | 7.68 | 682 | 77 | 23.0 | . | . | 0.38 | . | 1.02 | . | . | . | . | . |
| 19 | 119 | 328 | M | 73 | 18.6 | 7.68 | 554 | 71 | 20.9 | . | . | 0.55 | . | 1.38 | . | . | . | . | . |
| 19 | 119 | 329 | M | 73 | 16.3 | 7.51 | 652 | 73 | 22.3 | . | . | 0.33 | . | 1.18 | . | . | . | . | . |
| 19 | 119 | 330 | M | 73 | 16.3 | 7.51 | 610 | 70 | 21.2 | . | . | 0.50 | . | 1.30 | . | . | . | . | . |
| 19 | 119 | 331 | U | 73 | 15.5 | 7.48 | 650 | 71 | 21.8 | . | . | 0.33 | . | 1.27 | . | . | . | . | . |
| 19 | 119 | 332 | U | 73 | 16.0 | 7.50 | 640 | 65 | 21.0 | . | . | 0.48 | . | 1.53 | . | . | . | . | . |
| 19 | 122 | 329 | M | 73 | 35.0 | 7.60 | 606 | 38 | 22.6 | . | . | 0.23 | . | 0.47 | . | . | . | . | . |
| 19 | 338 | 323 | M | 73 | 9.5 | 7.20 | 611 | 57 | 21.1 | . | . | 0.36 | . | 1.48 | . | . | . | . | . |
| 19 | 340 | 502 | D | 75 | 29.7 | 8.54 | 197 | 104 | 27.5 | . | 1.8 | . | . | 0.42 | 129 | 122 | 8 | . | . |
| 19 | 340 | 502 | D | 76 | 29.2 | 7.68 | 248 | 134 | 22.1 | . | 2.6 | . | . | 0.27 | 156 | 152 | 4 | . | . |
| 19 | 340 | 502 | D | 78 | 29.5 | 7.72 | 250 | 136 | 24.4 | . | 1.2 | . | . | 0.44 | 152 | 147 | 5 | . | . |
| 19 | 340 | 503 | M | 75 | 24.5 | 8.30 | 217 | 108 | 27.1 | . | 2.7 | . | . | 0.54 | 131 | 120 | 11 | . | . |
| 19 | 340 | 503 | M | 76 | 24.5 | 7.65 | 256 | 134 | 23.1 | . | 2.8 | . | . | 0.44 | 178 | 170 | 8 | . | . |
| 19 | 340 | 503 | M | 78 | 24.3 | 7.75 | 247 | 131 | 24.2 | . | 1.3 | . | . | 0.39 | 157 | 153 | 4 | . | . |
| 19 | 342 | 320 | M | 73 | 21.3 | 8.33 | 598 | 59 | 22.1 | . | . | 0.31 | . | 0.87 | . | . | . | . | . |
| 19 | 342 | 322 | M | 73 | 17.8 | 7.71 | 536 | 54 | 20.7 | . | . | 0.36 | . | 1.55 | . | . | . | . | . |
| 19 | 343 | 315 | U | 73 | 16.6 | 7.80 | 822 | 70 | 22.9 | . | . | 0.04 | . | 0.21 | . | . | . | . | . |
| 20 | 087 | 314 | M | 73 | 15.5 | 8.05 | 1773 | 168 | 21.0 | . | . | 0.26 | . | 0.29 | . | . | . | . | . |

## WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 014 | 309 | D | 74 | 51.5 | 6.88 | 57 | 23 | 22.5 | . | . | 0.08 | . | 0.08 | . | . | . | . | . |
| 22 | 014 | 310 | M | 74 | 34.9 | 7.45 | 46 | 21 | 23.0 | . | . | 0.13 | . | 0.08 | . | . | . | . | . |
| 22 | 014 | 311 | U | 74 | 10.7 | 6.70 | 63 | 22 | 22.7 | . | . | 0.11 | . | 0.20 | . | . | . | . | . |
| 22 | 014 | 312 | M | 74 | 15.5 | 7.03 | 68 | 25 | 22.8 | . | . | 0.10 | . | 0.08 | . | . | . | . | . |
| 22 | 014 | 313 | M | 74 | 13.3 | 7.36 | 75 | 27 | 23.5 | . | . | 0.11 | . | 0.19 | . | . | . | . | . |
| 22 | 019 | 313 | D | 74 | 42.7 | 7.30 | 79 | 25 | 22.2 | . | . | 0.06 | . | 0.17 | . | . | . | . | . |
| 22 | 019 | 314 | M | 74 | 39.9 | 7.34 | 76 | 25 | 22.6 | . | . | 0.07 | . | 0.17 | . | . | . | . | . |
| 22 | 019 | 315 | M | 74 | 33.4 | 6.96 | 80 | 23 | 22.2 | . | . | 0.06 | . | 0.21 | . | . | . | . | . |
| 22 | 019 | 316 | U | 74 | 18.7 | 6.97 | 98 | 32 | 22.4 | . | . | 0.08 | . | 0.60 | . | . | . | . | . |
| 22 | 019 | 317 | U | 74 | 23.0 | 6.75 | 75 | 18 | 22.5 | . | . | 0.08 | . | 0.30 | . | . | . | . | . |
| 22 | 019 | 318 | U | 74 | 21.8 | 6.87 | 80 | 20 | 22.4 | . | . | 0.08 | . | 0.20 | . | . | . | . | . |
| 22 | 188 | 311 | M | 73 | 8.7 | 7.18 | 212 | 19 | 26.4 | . | . | 0.53 | . | 2.05 | . | . | . | . | . |
| 22 | 188 | 312 | D | 73 | 11.1 | 7.27 | 61 | 21 | 27.4 | . | . | 0.49 | . | 1.78 | . | . | . | . | . |
| 22 | 188 | 313 | M | 73 | 5.5 | 7.05 | 64 | 22 | 27.3 | . | . | 0.54 | . | 2.92 | . | . | . | . | . |
| 22 | 189 | 307 | U | 73 | 6.6 | 6.65 | 49 | 15 | 27.8 | . | . | 0.22 | . | 0.94 | . | . | . | . | . |
| 22 | 189 | 308 | M | 73 | 13.9 | 6.75 | 47 | 15 | 28.2 | . | . | 0.15 | . | 0.80 | . | . | . | . | . |
| 22 | 189 | 309 | D | 73 | 12.8 | 7.06 | 48 | 17 | 29.2 | . | . | 0.15 | . | 0.78 | . | . | . | . | . |
| 22 | 190 | 310 | D | 73 | 15.4 | 6.75 | 54 | 15 | 26.6 | . | . | 0.29 | . | 1.50 | . | . | . | . | . |
| 22 | 190 | 311 | U | 73 | 9.8 | 6.92 | 54 | 15 | 27.5 | . | . | 0.30 | . | 1.54 | . | . | . | . | . |
| 22 | 190 | 312 | U | 73 | 13.4 | 6.88 | 54 | 17 | 26.9 | . | . | 0.26 | . | 1.42 | . | . | . | . | . |
| 22 | 192 | 311 | D | 73 | 16.6 | 7.20 | 60 | 16 | 27.2 | . | . | 0.16 | . | 0.65 | . | . | . | . | . |
| 22 | 192 | 312 | M | 73 | 14.3 | 7.28 | 59 | 16 | 27.8 | . | . | 0.16 | . | 0.52 | . | . | . | . | . |
| 22 | 192 | 313 | M | 73 | 14.3 | 7.31 | 58 | 17 | 27.3 | . | . | 0.15 | . | 0.57 | . | . | . | . | . |
| 22 | 192 | 314 | U | 73 | 12.7 | 7.07 | 59 | 17 | 28.1 | . | . | 0.19 | . | 0.57 | . | . | . | . | . |
| 24 | 012 | 308 | D | 74 | 9.5 | 6.61 | 73 | 21 | 20.2 | . | . | 0.44 | . | 1.66 | . | . | . | . | . |
| 24 | 012 | 309 | M | 74 | 2.7 | 6.65 | 78 | 22 | 20.4 | . | . | 0.61 | . | 2.32 | . | . | . | . | . |
| 24 | 021 | 308 | M | 74 | 2.6 | 6.29 | 34 | 13 | 20.9 | . | . | 0.23 | . | 0.74 | . | . | . | . | . |
| 24 | 021 | 309 | D | 74 | 11.4 | 6.26 | 34 | 12 | 21.4 | . | . | 0.19 | . | 0.58 | . | . | . | . | . |
| 24 | 022 | 322 | M | 74 | 30.2 | 8.21 | 256 | 160 | 20.9 | . | . | 0.04 | . | 0.10 | . | . | . | . | . |
| 25 | 020 | 323 | D | 74 | 10.4 | 6.95 | 50 | 17 | 22.7 | . | . | 0.15 | . | 0.35 | . | . | . | . | . |
| 25 | 020 | 324 | M | 74 | 9.1 | 6.45 | 62 | 20 | 22.5 | . | . | 0.29 | . | 1.29 | . | . | . | . | . |
| 25 | 020 | 325 | M | 74 | 3.8 | 8.65 | 161 | 70 | 22.4 | . | . | 0.19 | . | 0.42 | . | . | . | . | . |
| 25 | 102 | 312 | D | 74 | 12.8 | 8.13 | 328 | 155 | 16.7 | . | . | 0.60 | . | 2.44 | . | . | . | . | . |
| 25 | 102 | 313 | M | 74 | 2.9 | 8.23 | 336 | 162 | 17.1 | . | . | 2.13 | . | 3.27 | . | . | . | . | . |
| 25 | 102 | 314 | M | 74 | 5.5 | 8.18 | 330 | 154 | 16.6 | . | . | 0.86 | . | 2.17 | . | . | . | . | . |
| 25 | 103 | 307 | D | 74 | 13.7 | 7.87 | 304 | 122 | 18.3 | . | . | 2.45 | . | 4.16 | . | . | . | . | . |
| 25 | 104 | 305 | D | 74 | 10.6 | 8.07 | 417 | 155 | 18.0 | . | . | 1.03 | . | 3.07 | . | . | . | . | . |
| 25 | 104 | 306 | M | 74 | 3.8 | 8.03 | 382 | 162 | 18.0 | . | . | 1.18 | . | 3.52 | . | . | . | . | . |
| 25 | 105 | 313 | M | 74 | 1.3 | 8.20 | 380 | 173 | 18.7 | . | . | 2.39 | . | 4.46 | . | . | . | . | . |
| 25 | 107 | 307 | D | 74 | 10.6 | 8.36 | 521 | 130 | 16.3 | . | . | 0.71 | . | 1.72 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 112 | 308 | D | 74 | 7.0 | 8.00 | 375 | 140 | 17.7 | . | . | 1.80 | . | 3.33 | . | . | . | . | . |
| 25 | 112 | 309 | M | 74 | 3.8 | 8.01 | 310 | 153 | 17.8 | . | . | 2.64 | . | 3.19 | . | . | . | . | . |
| 25 | 267 | 320 | U | 74 | 5.9 | 8.01 | 623 | 122 | 21.5 | . | . | 1.69 | . | 2.55 | . | . | . | . | . |
| 25 | 269 | 309 | D | 74 | 3.8 | 8.38 | 1204 | 181 | 17.7 | . | . | 0.74 | . | 3.09 | . | . | . | . | . |
| 25 | 269 | 310 | M | 74 | 1.8 | 8.37 | 1214 | 183 | 17.6 | . | . | 0.55 | . | 2.46 | . | . | . | . | . |
| 25 | 273 | 316 | D | 74 | 8.8 | 8.19 | 1363 | 115 | 18.1 | . | . | 0.31 | . | 1.42 | . | . | . | . | . |
| 25 | 273 | 317 | U | 74 | 6.2 | 8.45 | 3700 | 166 | 18.9 | . | . | 2.49 | . | 4.33 | . | . | . | . | . |
| 25 | 273 | 321 | M | 74 | 12.0 | 8.18 | 1782 | 110 | 20.8 | . | . | 1.15 | . | 2.53 | . | . | . | . | . |
| 25 | 273 | 322 | U | 74 | 4.0 | 8.08 | 1273 | 160 | 18.4 | . | . | 3.12 | . | 5.59 | . | . | . | . | . |
| 25 | 273 | 323 | U | 74 | 7.6 | 8.05 | 1345 | 152 | 19.6 | . | . | 4.61 | . | 6.14 | . | . | . | . | . |
| 25 | 273 | 325 | D | 74 | 21.4 | 7.90 | 1157 | 107 | 22.8 | . | . | 0.77 | . | 1.91 | . | . | . | . | . |
| 25 | 273 | 326 | U | 74 | 8.1 | 8.02 | 1043 | 137 | 19.7 | . | . | 2.38 | . | 4.84 | . | . | . | . | . |
| 25 | 275 | 321 | U | 74 | 2.7 | 7.60 | 304 | 108 | 21.5 | . | . | 2.07 | . | 4.34 | . | . | . | . | . |
| 25 | 348 | 317 | D | 74 | 28.9 | 7.92 | 1436 | 126 | 22.4 | . | . | 0.09 | . | 0.37 | . | . | . | . | . |
| 25 | 348 | 318 | M | 74 | 23.6 | 8.32 | 1404 | 127 | 23.2 | . | . | 0.10 | . | 0.21 | . | . | . | . | . |
| 25 | 348 | 319 | M | 74 | 21.2 | 8.29 | 1115 | 136 | 23.5 | . | . | 0.11 | . | 0.38 | . | . | . | . | . |
| 25 | 348 | 320 | U | 74 | 4.9 | 8.13 | 729 | 141 | 24.0 | . | . | 2.13 | . | 2.79 | . | . | . | . | . |
| 25 | 348 | 321 | M | 74 | 17.5 | 8.20 | 1721 | 115 | 23.4 | . | . | 0.13 | . | 0.39 | . | . | . | . | . |
| 25 | 348 | 322 | M | 74 | 7.1 | 8.23 | 1656 | 112 | 23.6 | . | . | 0.20 | . | 0.58 | . | . | . | . | . |
| 25 | 348 | 323 | U | 74 | 3.3 | 8.32 | 2531 | 113 | 24.3 | . | . | 2.88 | . | 3.20 | . | . | . | . | . |
| 25 | 370 | 304 | M | 74 | 3.2 | 8.32 | 3999 | 83 | 22.6 | . | . | 2.98 | . | 1.93 | . | . | . | . | . |
| 26 | 354 | 101 | D | 74 | . | 8.17 | 341 | . | 25.1 | 40.0 | . | . | . | 1.57 | . | . | 15 | . | . |
| 26 | 354 | 101 | D | 75 | . | 7.82 | 325 | . | 26.6 | . | . | . | . | 2.94 | . | . | 16 | . | . |
| 26 | 354 | 101 | D | 77 | . | 8.06 | 311 | 139 | 22.7 | . | . | . | . | 0.81 | . | 198 | 567 | . | . |
| 26 | 354 | 101 | D | 78 | . | 8.05 | 317 | 122 | 27.9 | . | . | . | . | 0.79 | . | 185 | 5 | . | . |
| 26 | 354 | 102 | M | 74 | . | 8.16 | 341 | . | 25.8 | 47.5 | . | . | . | 3.18 | . | . | 24 | . | . |
| 26 | 354 | 102 | M | 75 | . | 7.92 | 338 | . | 27.3 | . | . | . | . | 6.40 | . | . | 58 | . | . |
| 26 | 354 | 103 | M | 74 | . | 8.20 | 340 | . | 26.2 | 52.5 | . | . | . | 4.05 | . | . | 25 | . | . |
| 26 | 354 | 103 | M | 75 | . | 7.16 | 308 | . | 26.8 | . | . | . | . | 5.47 | . | . | 25 | . | . |
| 26 | 355 | 317 | D | 74 | 15.1 | 8.10 | 356 | 113 | 23.0 | . | . | 0.20 | . | 0.61 | . | . | . | . | . |
| 26 | 355 | 319 | M | 74 | 9.3 | 8.20 | 307 | 105 | 23.6 | . | . | 0.20 | . | 1.17 | . | . | . | . | . |
| 26 | 355 | 321 | U | 74 | 7.3 | 8.13 | 344 | 103 | 24.2 | . | . | 1.01 | . | 2.62 | . | . | . | . | . |
| 26 | 359 | 109 | M | 75 | . | 6.87 | 144 | 21 | 24.7 | 2.5 | . | . | . | 0.45 | . | . | 4 | . | . |
| 26 | 359 | 110 | U | 75 | . | 6.75 | 260 | 47 | 24.6 | 45.0 | . | . | . | 1.58 | 10 | . | 17 | . | . |
| 26 | 359 | 110 | U | 76 | . | 6.77 | 282 | 32 | 27.5 | 72.5 | . | . | . | 1.48 | . | . | 11 | . | . |
| 26 | 359 | 110 | U | 78 | . | 6.95 | 638 | 44 | 28.7 | 280.0 | . | . | 300 | 1.48 | . | 441 | 6 | . | . |
| 26 | 359 | 319 | D | 74 | 16.2 | 7.86 | 139 | 17 | 27.5 | . | . | 0.04 | . | 0.44 | . | . | . | . | . |
| 26 | 359 | 320 | M | 74 | 11.7 | 7.98 | 135 | 20 | 28.3 | . | . | 0.04 | . | 0.45 | . | . | . | . | . |
| 26 | 359 | 321 | M | 74 | 13.9 | 8.15 | 140 | 20 | 28.3 | . | . | 0.04 | . | 0.24 | . | . | . | . | . |
| 26 | 359 | 322 | M | 74 | 16.6 | 7.89 | 150 | 22 | 28.5 | . | . | 0.04 | . | 0.19 | . | . | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 359 | 323 | U | 74 | 6.4 | 7.70 | 148 | 28 | 28.7 | . | . | 0.07 | . | 0.32 | . | . | . | . | . |
| 26 | 359 | 324 | U | 74 | 5.3 | 7.16 | 312 | 47 | 28.0 | . | . | 0.24 | . | 1.06 | . | . | . | . | . |
| 26 | 360 | 303 | D | 74 | 5.8 | 8.14 | 492 | 133 | 23.2 | . | . | 0.90 | . | 1.47 | . | . | . | . | . |
| 28 | 218 | 007 | D | 77 | . | . | . | . | 23.0 | . | . | . | . | 0.32 | . | . | . | . | . |
| 28 | 219 | 012 | D | 77 | . | . | . | . | 25.2 | . | . | . | . | 0.47 | . | . | . | . | . |
| 28 | 219 | 012 | D | 78 | . | . | . | . | . | . | . | . | . | 0.47 | . | . | . | . | . |
| 29 | 100 | 305 | D | 74 | 13.4 | 7.87 | 265 | 87 | 17.1 | . | . | 0.26 | . | 0.98 | . | . | . | . | . |
| 29 | 100 | 306 | M | 74 | 8.5 | 7.89 | 266 | 90 | 17.5 | . | . | 0.36 | . | 0.97 | . | . | . | . | . |
| 29 | 100 | 307 | M | 74 | 9.8 | 7.92 | 263 | 90 | 17.6 | . | . | 0.39 | . | 1.33 | . | . | . | . | . |
| 29 | 100 | 308 | M | 74 | 9.7 | 7.83 | 267 | 96 | 17.9 | . | . | 0.39 | . | 1.18 | . | . | . | . | . |
| 29 | 100 | 309 | U | 74 | 7.1 | 7.67 | 312 | 132 | 18.2 | . | . | 2.42 | . | 2.81 | . | . | . | . | . |
| 29 | 100 | 310 | U | 74 | 7.9 | 7.88 | 269 | 101 | 18.2 | . | . | 0.69 | . | 1.67 | . | . | . | . | . |
| 29 | 106 | 310 | D | 74 | 9.8 | 8.01 | 1307 | 155 | 16.3 | . | . | 0.70 | . | 2.24 | . | . | . | . | . |
| 29 | 108 | 313 | D | 74 | 15.3 | 8.32 | 753 | 196 | 16.4 | . | . | 0.19 | . | 0.45 | . | . | . | . | . |
| 29 | 109 | 307 | D | 74 | 17.6 | 8.29 | 546 | 148 | 17.4 | . | . | 0.10 | . | 0.28 | . | . | . | . | . |
| 29 | 109 | 308 | M | 74 | 14.5 | 8.45 | 545 | 147 | 17.5 | . | . | 0.12 | . | 0.08 | . | . | . | . | . |
| 29 | 109 | 309 | M | 74 | 5.7 | 8.28 | 635 | 157 | 17.7 | . | . | 0.16 | . | 0.54 | . | . | . | . | . |
| 29 | 110 | 319 | U | 74 | 9.1 | 8.26 | 398 | 163 | 20.5 | . | . | 0.27 | . | 1.62 | . | . | . | . | . |
| 29 | 111 | 312 | M | 74 | 4.8 | 8.18 | 370 | 147 | 17.5 | . | . | 0.56 | . | 2.22 | . | . | . | . | . |
| 29 | 113 | 327 | D | 74 | 19.7 | 8.22 | 550 | 195 | 17.1 | . | . | 0.13 | . | 0.70 | . | . | . | . | . |
| 29 | 113 | 328 | M | 74 | 10.9 | 8.26 | 551 | 195 | 16.6 | . | . | 0.18 | . | 1.09 | . | . | . | . | . |
| 29 | 113 | 329 | M | 74 | 8.1 | 8.23 | 632 | 231 | 17.0 | . | . | 1.00 | . | 3.01 | . | . | . | . | . |
| 29 | 114 | 307 | D | 74 | 17.5 | 8.13 | 2365 | 151 | 16.9 | . | . | 0.13 | . | 0.46 | . | . | . | . | . |
| 29 | 114 | 308 | M | 74 | 15.9 | 8.29 | 2372 | 149 | 16.5 | . | . | 0.12 | . | 0.47 | . | . | . | . | . |
| 29 | 114 | 309 | M | 74 | 12.3 | 8.19 | 2442 | 155 | 16.9 | . | . | 0.18 | . | 0.58 | . | . | . | . | . |
| 29 | 194 | 315 | U | 74 | 3.5 | 8.44 | 248 | 125 | 21.6 | . | . | 0.58 | . | 1.22 | . | . | . | . | . |
| 29 | 195 | 316 | M | 74 | 21.3 | 8.16 | 283 | 132 | 16.7 | . | . | 0.11 | . | 0.25 | . | . | . | . | . |
| 29 | 195 | 317 | U | 74 | 21.3 | 8.14 | 283 | 131 | 16.9 | . | . | 0.15 | . | 0.45 | . | . | . | . | . |
| 29 | 195 | 318 | M | 74 | 23.1 | 8.20 | 293 | 130 | 17.2 | . | . | 0.09 | . | 0.35 | . | . | . | . | . |
| 29 | 195 | 319 | U | 74 | 17.0 | 8.24 | 281 | 128 | 17.6 | . | . | 0.13 | . | 0.34 | . | . | . | . | . |
| 29 | 207 | 312 | U | 74 | 1.6 | 8.46 | 581 | 206 | 16.5 | . | . | 1.80 | . | 2.28 | . | . | . | . | . |
| 30 | 064 | 306 | M | 75 | 3.3 | 8.41 | 463 | 178 | 15.9 | . | . | 0.28 | . | 0.13 | . | . | . | . | . |
| 30 | 215 | 304 | D | 74 | 7.4 | 7.74 | 466 | 209 | 16.9 | . | . | 0.15 | . | 0.44 | . | . | . | . | . |
| 30 | 215 | 305 | M | 74 | 6.8 | 7.98 | 465 | 244 | 17.3 | . | . | 0.17 | . | 0.50 | . | . | . | . | . |
| 30 | 217 | 306 | D | 74 | 10.7 | 7.88 | 480 | 250 | 17.0 | . | . | 0.13 | . | 0.44 | . | . | . | . | . |
| 30 | 217 | 307 | M | 74 | 9.1 | 7.82 | 478 | 244 | 16.8 | . | . | 0.15 | . | 0.44 | . | . | . | . | . |
| 30 | 217 | 308 | M | 74 | 6.3 | 7.76 | 481 | 247 | 16.4 | . | . | 0.12 | . | 0.56 | . | . | . | . | . |
| 30 | 235 | 325 | M | 74 | 23.6 | 8.25 | 560 | 151 | 13.9 | . | . | 0.11 | . | 0.51 | . | . | . | . | . |
| 30 | 235 | 326 | M | 74 | 9.8 | 8.21 | 595 | 165 | 16.1 | . | . | 0.42 | . | 1.05 | . | . | . | . | . |
| 30 | 235 | 327 | U | 74 | 3.4 | 8.34 | 789 | 269 | 16.0 | . | . | 2.55 | . | 2.20 | . | . | . | . | . |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 235 | 325 | M | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | | |
| 30 | 235 | 326 | M | 74 | 9.8 | 8.21 | 595 | [illegible] | | | | 2.[illegible] |
| 30 | 235 | 327 | U | 74 | 3.4 | 8.34 | 789 | 269 | 16.0 | . | . | |

WATER QUALITY SUMMARY BY STATION-YEAR

---------------------------------------- POOL DATA SCREEN CODE=8 ----------------------------------------

| DIS | RES | STA | TYPE | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 235 | 328 | U | 74 | 2.0 | 8.12 | 678 | 173 | 16.8 | . | . | 2.31 | . | 4.61 | . | . | . | . | . |
| 32 | 204 | 313 | M | 75 | 35.5 | 8.08 | 161 | 99 | 13.5 | . | . | 0.41 | . | 0.34 | . | . | . | . | . |
| 32 | 204 | 317 | M | 75 | 82.3 | 8.38 | 179 | 98 | 16.7 | . | . | 0.21 | . | 0.18 | . | . | . | . | . |
| 33 | 300 | 306 | D | 75 | 78.8 | 8.21 | 40 | 28 | 16.2 | . | . | 0.04 | . | 0.49 | . | . | . | . | . |
| 34 | 041 | 112 | D | 71 | . | 7.36 | 56 | 24 | 19.4 | . | 1.0 | . | . | 0.15 | . | 40 | 0 | . | . |
| 34 | 041 | 112 | D | 72 | . | 7.54 | 57 | 21 | 20.3 | . | 0.9 | . | . | 0.12 | . | 44 | 0 | . | . |
| 34 | 041 | 112 | D | 73 | . | 7.30 | 60 | . | 19.8 | . | 1.1 | . | . | 0.16 | . | 49 | . | . | . |
| 34 | 041 | 112 | D | 74 | . | 6.91 | 54 | . | 21.2 | . | 1.1 | . | . | 0.12 | . | . | . | . | . |
| 34 | 041 | 112 | D | 75 | . | 7.55 | 65 | . | 18.2 | . | 1.9 | . | . | 0.21 | . | . | . | . | . |
| 34 | 041 | 112 | D | 76 | . | 7.83 | 57 | . | 19.1 | . | 1.4 | . | . | 0.28 | . | . | . | . | . |
| 34 | 041 | 112 | D | 78 | . | 7.48 | 67 | . | 20.2 | . | 0.9 | . | . | 0.27 | . | 500 | . | . | . |

WATER QUALITY SUMMARY BY STATION-YEAR
POOL DATA SCREEN CODE=A

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 258 | 56.63 | 52.23 | 4.89 | 293.19 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 223 | 18.82 | 25.92 | 2.83 | 220.91 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 35 | 25.44 | 28.98 | 10.00 | 155.00 |
| CNTL | TOTAL NITROGEN (MG/M3) | 258 | 981.94 | 857.06 | 236.45 | 6075.00 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 258 | 521.15 | 704.99 | 39.96 | 5064.16 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 218 | 10.61 | 11.77 | 0.97 | 83.41 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 40 | 13.85 | 7.91 | 2.68 | 31.25 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 218 | 16.11 | 16.67 | 1.30 | 97.00 |
| CSEC | SECCHI DEPTH (M) | 258 | 1.50 | 1.23 | 0.16 | 6.97 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 258 | 3.66 | 1.70 | 3.00 | 21.00 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 258 | 3.40 | 0.68 | 3.00 | 7.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 258 | 3.57 | 1.26 | 3.00 | 13.00 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 258 | 3.46 | 0.78 | 3.00 | 6.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 258 | 0.18 | 0.10 | 0.01 | 0.48 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 258 | 0.28 | 0.12 | 0.01 | 0.50 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 258 | 0.15 | 0.08 | 0.01 | 0.37 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 258 | 0.18 | 0.10 | 0.00 | 0.49 |

POOL DATA SCREEN CODE=B

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 267 | 65.82 | 70.93 | 6.33 | 469.52 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 225 | 22.36 | 28.98 | 0.00 | 196.13 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 44 | 29.70 | 31.74 | 3.94 | 129.07 |
| CNTL | TOTAL NITROGEN (MG/M3) | 234 | 1056.95 | 1190.19 | 114.99 | 9307.14 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 260 | 546.32 | 984.31 | 20.00 | 7434.28 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 230 | 12.28 | 13.43 | 0.63 | 92.70 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 40 | 8.85 | 8.92 | 1.60 | 45.49 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 230 | 20.01 | 24.37 | 1.24 | 181.00 |
| CSEC | SECCHI DEPTH (M) | 267 | 1.45 | 1.16 | 0.14 | 7.08 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 267 | 2.81 | 1.80 | 2.00 | 18.00 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 267 | 2.61 | 0.96 | 2.00 | 7.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 267 | 2.37 | 1.72 | 0.00 | 14.00 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 267 | 2.78 | 1.17 | 2.00 | 7.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 267 | 0.25 | 0.18 | 0.00 | 0.85 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 267 | 0.36 | 0.22 | 0.00 | 0.97 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 234 | 0.16 | 0.13 | 0.00 | 0.74 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 267 | 0.21 | 0.17 | 0.00 | 0.93 |

| | | | | |
|---|---|---|---|---|
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 267 | 0.21 | |
| ESEC | CV OF MEAN SECCHI ESTIMATE | | | |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 | 305 | D | 73 | 12 | 6 | . | 941 | 650 | 5.4 | . | 8.4 | 3.56 | 3 | 3 | 3 | 3 | 0.03 | 0.30 | 0.14 | 0.12 |
| 03 | 307 | 306 | M | 73 | 10 | 4 | . | 972 | 636 | 5.0 | . | 6.2 | 3.66 | 3 | 3 | 3 | 3 | 0.05 | 0.16 | 0.11 | 0.13 |
| 03 | 307 | 307 | U | 73 | 10 | 5 | . | 909 | 694 | 4.2 | . | 5.7 | 3.27 | 3 | 3 | 3 | 3 | 0.07 | 0.18 | 0.16 | 0.12 |
| 04 | 312 | 311 | D | 73 | 50 | 28 | . | 1525 | 1045 | 6.5 | . | 8.3 | 1.54 | 3 | 3 | 3 | 3 | 0.16 | 0.14 | 0.04 | 0.31 |
| 06 | 372 | 322 | D | 73 | 26 | 7 | . | 474 | 190 | 7.6 | . | 14.2 | 1.82 | 3 | 3 | 3 | 3 | 0.39 | 0.44 | 0.04 | 0.29 |
| 06 | 372 | 323 | M | 73 | 28 | 7 | . | 648 | 120 | 14.7 | . | 23.2 | 1.32 | 3 | 3 | 3 | 3 | 0.08 | 0.36 | 0.24 | 0.19 |
| 06 | 372 | 324 | M | 73 | 36 | 9 | . | 611 | 205 | 5.5 | . | 7.0 | 1.42 | 3 | 3 | 3 | 3 | 0.38 | 0.15 | 0.16 | 0.29 |
| 06 | 372 | 326 | U | 73 | 97 | 36 | . | 959 | 317 | 8.3 | . | 11.9 | 0.44 | 3 | 3 | 3 | 3 | 0.14 | 0.35 | 0.20 | 0.10 |
| 06 | 372 | 327 | U | 73 | 63 | 10 | . | 693 | 287 | 4.3 | . | 5.3 | 0.44 | 3 | 3 | 3 | 3 | 0.17 | 0.13 | 0.10 | 0.31 |
| 10 | 001 | 011 | U | 77 | 100 | 27 | . | 457 | 252 | . | 5.8 | . | 0.73 | 4 | 4 | 4 | 4 | 0.26 | 0.07 | 0.30 | 0.03 |
| 10 | 001 | 015 | M | 77 | 150 | 22 | . | 475 | 250 | . | 8.3 | . | 0.81 | 4 | 4 | 4 | 4 | 0.17 | 0.35 | 0.24 | 0.09 |
| 10 | 001 | 016 | D | 77 | 165 | 30 | . | 400 | 328 | . | 6.4 | . | 0.80 | 4 | 4 | 4 | 4 | 0.14 | 0.14 | 0.13 | 0.05 |
| 10 | 003 | 311 | D | 73 | 22 | 7 | . | 1043 | 803 | 2.7 | . | 3.7 | 1.22 | 3 | 3 | 3 | 3 | 0.45 | 0.33 | 0.04 | 0.31 |
| 10 | 004 | 018 | M | 77 | 195 | 47 | . | 495 | 197 | . | 6.0 | . | 0.82 | 4 | 4 | 4 | 4 | 0.38 | 0.14 | 0.07 | 0.12 |
| 10 | 008 | 007 | D | 77 | 277 | 17 | . | 470 | 258 | . | 6.7 | . | 0.90 | 4 | 4 | 4 | 4 | 0.36 | 0.18 | 0.22 | 0.05 |
| 10 | 008 | 016 | D | 77 | 130 | 22 | . | 510 | 218 | . | 16.9 | . | 0.72 | 4 | 4 | 4 | 3 | 0.35 | 0.38 | 0.31 | 0.07 |
| 10 | 008 | 017 | D | 77 | 132 | 32 | . | 552 | 293 | . | 11.5 | . | 0.68 | 4 | 4 | 4 | 3 | 0.26 | 0.24 | 0.30 | 0.09 |
| 10 | 008 | 018 | D | 77 | 170 | 15 | . | 531 | 268 | . | 12.0 | . | 0.68 | 4 | 3 | 4 | 3 | 0.17 | 0.29 | 0.27 | 0.06 |
| 10 | 072 | 005 | D | 78 | 31 | 4 | . | 580 | 136 | 10.1 | . | 18.0 | 1.10 | 5 | 5 | 3 | 5 | 0.43 | 0.35 | 0.11 | 0.19 |
| 10 | 072 | 006 | D | 78 | 57 | 4 | . | 413 | 294 | 11.6 | . | 21.0 | 1.13 | 5 | 5 | 3 | 5 | 0.46 | 0.33 | 0.37 | 0.09 |
| 10 | 072 | 007 | M | 78 | 52 | 5 | . | 457 | 146 | 10.4 | . | 21.0 | 0.65 | 5 | 5 | 3 | 5 | 0.17 | 0.33 | 0.33 | 0.40 |
| 10 | 072 | 009 | M | 78 | 78 | 5 | . | 437 | 180 | 15.3 | . | 33.0 | 0.93 | 5 | 5 | 3 | 5 | 0.26 | 0.41 | 0.14 | 0.18 |
| 10 | 072 | 010 | M | 78 | 72 | 6 | . | 663 | 224 | 14.8 | . | 25.0 | 0.78 | 5 | 5 | 3 | 5 | 0.31 | 0.27 | 0.18 | 0.13 |
| 10 | 073 | 118 | M | 75 | 44 | . | 25 | 520 | 345 | 9.9 | . | 16.4 | 0.50 | 16 | 5 | 13 | 4 | 0.13 | 0.26 | 0.04 | 0.15 |
| 10 | 073 | 121 | M | 75 | 68 | . | 32 | 595 | 377 | 17.2 | . | 32.4 | 0.46 | 13 | 5 | 10 | 4 | 0.10 | 0.31 | 0.09 | 0.19 |
| 10 | 073 | 124 | M | 75 | 74 | . | 33 | 725 | 442 | 11.5 | . | 29.5 | 0.46 | 21 | 6 | 13 | 5 | 0.07 | 0.33 | 0.08 | 0.21 |
| 10 | 411 | 314 | M | 73 | 26 | 6 | . | 1907 | 1307 | 4.9 | . | 7.2 | 1.35 | 3 | 3 | 3 | 3 | 0.23 | 0.24 | 0.14 | 0.17 |
| 10 | 411 | 316 | U | 73 | 39 | 12 | . | 945 | 569 | 2.8 | . | 3.6 | 0.76 | 3 | 3 | 3 | 3 | 0.15 | 0.30 | 0.02 | 0.20 |
| 15 | 178 | 005 | M | 77 | 23 | 7 | . | 650 | 253 | 4.8 | . | 6.1 | 2.87 | 3 | 3 | 3 | 3 | 0.29 | 0.16 | 0.13 | 0.05 |
| 15 | 237 | 305 | D | 74 | 270 | 221 | . | 1611 | 552 | 12.9 | . | 17.1 | 0.96 | 3 | 3 | 3 | 3 | 0.06 | 0.29 | 0.30 | 0.29 |
| 15 | 237 | 306 | M | 74 | 273 | 170 | . | 1795 | 300 | 45.2 | . | 61.4 | 0.59 | 3 | 3 | 3 | 3 | 0.14 | 0.27 | 0.11 | 0.28 |
| 15 | 237 | 307 | M | 74 | 293 | 163 | . | 2184 | 216 | 63.9 | . | 78.3 | 0.61 | 3 | 3 | 3 | 3 | 0.26 | 0.12 | 0.20 | 0.25 |
| 16 | 243 | 309 | D | 73 | 34 | 5 | . | 1122 | 561 | 8.3 | . | 13.2 | 1.04 | 3 | 3 | 3 | 3 | 0.11 | 0.30 | 0.26 | 0.11 |
| 16 | 243 | 310 | M | 73 | 33 | 5 | . | 1177 | 535 | 11.0 | . | 14.7 | 0.89 | 3 | 3 | 3 | 3 | 0.13 | 0.24 | 0.19 | 0.07 |
| 16 | 243 | 313 | U | 73 | 71 | 8 | . | 1683 | 574 | 26.3 | . | 52.5 | 0.77 | 3 | 3 | 3 | 3 | 0.39 | 0.50 | 0.27 | 0.17 |
| 16 | 254 | 305 | M | 73 | 77 | 9 | . | 1374 | 177 | 43.6 | . | 62.1 | 0.83 | 3 | 3 | 3 | 3 | 0.27 | 0.21 | 0.18 | 0.13 |
| 16 | 254 | 306 | D | 73 | 49 | 4 | . | 1064 | 162 | 28.8 | . | 40.2 | 0.93 | 3 | 3 | 3 | 3 | 0.26 | 0.20 | 0.11 | 0.06 |
| 16 | 317 | 319 | M | 73 | 77 | 10 | . | 1106 | 239 | 35.6 | . | 57.5 | 0.75 | 3 | 3 | 3 | 3 | 0.27 | 0.36 | 0.14 | 0.11 |
| 16 | 317 | 320 | D | 73 | 45 | 7 | . | 992 | 378 | 15.3 | . | 22.3 | 1.01 | 3 | 3 | 3 | 3 | 0.24 | 0.24 | 0.08 | 0.11 |
| 16 | 317 | 321 | M | 73 | 58 | 7 | . | 1028 | 280 | 29.6 | . | 55.3 | 1.02 | 3 | 3 | 3 | 3 | 0.07 | 0.44 | 0.10 | 0.10 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 328 | 337 | D | 73 | 18 | 6 | . | 899 | 406 | 2.7 | . | 3.6 | 2.69 | 3 | 3 | 3 | 3 | 0.16 | 0.31 | 0.11 | 0.39 |
| 16 | 328 | 338 | M | 73 | 13 | 5 | . | 757 | 373 | 2.7 | . | 4.6 | 2.66 | 3 | 3 | 3 | 3 | 0.20 | 0.46 | 0.07 | 0.28 |
| 16 | 328 | 339 | U | 73 | 33 | 9 | . | 646 | 318 | 4.0 | . | 5.8 | 0.85 | 3 | 3 | 3 | 3 | 0.44 | 0.39 | 0.10 | 0.23 |
| 16 | 328 | 340 | M | 73 | 19 | 5 | . | 636 | 365 | 5.5 | . | 7.7 | 2.51 | 3 | 3 | 3 | 3 | 0.23 | 0.24 | 0.15 | 0.30 |
| 16 | 393 | 312 | D | 73 | 6 | 6 | . | 659 | 404 | 1.4 | . | 2.0 | 2.79 | 3 | 3 | 3 | 3 | 0.09 | 0.23 | 0.10 | 0.34 |
| 16 | 393 | 313 | M | 73 | 5 | 4 | . | 644 | 394 | 1.0 | . | 1.6 | 2.96 | 3 | 3 | 3 | 3 | 0.06 | 0.31 | 0.22 | 0.16 |
| 16 | 393 | 314 | U | 73 | 6 | 5 | . | 550 | 370 | 1.1 | . | 1.6 | 3.49 | 3 | 3 | 3 | 3 | 0.06 | 0.29 | 0.08 | 0.05 |
| 17 | 241 | 306 | M | 73 | 25 | 5 | . | 719 | 442 | 9.5 | . | 10.3 | 1.35 | 3 | 3 | 3 | 3 | 0.15 | 0.07 | 0.33 | 0.12 |
| 17 | 241 | 307 | M | 73 | 30 | 6 | . | 899 | 436 | 9.8 | . | 13.4 | 1.17 | 3 | 3 | 3 | 3 | 0.30 | 0.18 | 0.23 | 0.16 |
| 17 | 241 | 308 | U | 73 | 32 | 4 | . | 911 | 350 | 10.6 | . | 20.4 | 0.88 | 3 | 3 | 3 | 3 | 0.24 | 0.47 | 0.11 | 0.16 |
| 17 | 241 | 309 | U | 73 | 78 | 7 | . | 1249 | 463 | 35.9 | . | 61.8 | 0.46 | 3 | 3 | 3 | 3 | 0.18 | 0.46 | 0.18 | 0.28 |
| 17 | 242 | 312 | D | 73 | 167 | 20 | . | 2887 | 2072 | 10.9 | . | 19.4 | 0.28 | 3 | 3 | 3 | 3 | 0.35 | 0.41 | 0.09 | 0.14 |
| 17 | 245 | 306 | U | 73 | 159 | 15 | . | 2091 | 623 | 83.4 | . | 91.2 | 0.36 | 3 | 3 | 3 | 3 | 0.34 | 0.07 | 0.02 | 0.14 |
| 17 | 245 | 307 | M | 73 | 104 | 12 | . | 1611 | 530 | 55.2 | . | 75.9 | 0.57 | 3 | 3 | 3 | 3 | 0.29 | 0.19 | 0.10 | 0.19 |
| 17 | 245 | 308 | D | 73 | 118 | 9 | . | 1593 | 356 | 62.8 | . | 85.5 | 0.41 | 3 | 3 | 3 | 3 | 0.29 | 0.20 | 0.09 | 0.25 |
| 17 | 247 | 306 | D | 73 | 67 | 27 | . | 3260 | 2588 | 9.7 | . | 14.4 | 0.87 | 3 | 3 | 3 | 3 | 0.26 | 0.29 | 0.24 | 0.26 |
| 17 | 247 | 307 | M | 73 | 74 | 22 | . | 3323 | 2691 | 11.5 | . | 14.2 | 0.85 | 3 | 3 | 3 | 3 | 0.31 | 0.16 | 0.25 | 0.28 |
| 17 | 248 | 309 | D | 73 | 79 | 24 | . | 3053 | 2237 | 7.9 | . | 14.9 | 0.52 | 3 | 3 | 3 | 3 | 0.08 | 0.44 | 0.19 | 0.09 |
| 17 | 248 | 310 | M | 73 | 99 | 28 | . | 2890 | 2015 | 11.4 | . | 16.8 | 0.40 | 3 | 3 | 3 | 3 | 0.04 | 0.26 | 0.19 | 0.13 |
| 17 | 248 | 311 | U | 73 | 130 | 50 | . | 3375 | 2073 | 13.3 | . | 15.6 | 0.30 | 3 | 3 | 3 | 3 | 0.17 | 0.14 | 0.18 | 0.22 |
| 17 | 249 | 311 | D | 73 | 125 | 25 | . | 2814 | 1436 | 20.2 | . | 25.9 | 0.59 | 3 | 3 | 3 | 3 | 0.04 | 0.16 | 0.12 | 0.08 |
| 17 | 249 | 312 | M | 73 | 219 | 43 | . | 3273 | 1548 | 42.5 | . | 60.3 | 0.44 | 3 | 3 | 3 | 3 | 0.10 | 0.35 | 0.16 | 0.20 |
| 17 | 256 | 309 | M | 73 | 47 | 11 | . | 979 | 465 | 24.2 | . | 32.3 | 0.92 | 3 | 3 | 3 | 3 | 0.20 | 0.20 | 0.11 | 0.06 |
| 17 | 256 | 310 | D | 73 | 34 | 9 | . | 921 | 495 | 21.5 | . | 41.7 | 1.27 | 3 | 3 | 3 | 3 | 0.23 | 0.47 | 0.13 | 0.08 |
| 17 | 258 | 305 | D | 73 | 40 | 9 | . | 1018 | 269 | 30.5 | . | 35.9 | 0.98 | 3 | 3 | 3 | 3 | 0.24 | 0.09 | 0.05 | 0.01 |
| 17 | 258 | 306 | M | 73 | 43 | 7 | . | 979 | 257 | 27.4 | . | 35.2 | 0.99 | 3 | 3 | 3 | 3 | 0.28 | 0.16 | 0.03 | 0.12 |
| 17 | 258 | 307 | U | 73 | 75 | 10 | . | 1159 | 203 | 55.2 | . | 97.0 | 0.61 | 3 | 3 | 3 | 3 | 0.38 | 0.40 | 0.15 | 0.25 |
| 17 | 373 | 308 | D | 73 | 11 | 5 | . | 485 | 209 | 4.8 | . | 8.3 | 2.85 | 3 | 3 | 3 | 3 | 0.17 | 0.36 | 0.13 | 0.34 |
| 17 | 391 | 313 | U | 73 | 15 | 5 | . | 715 | 556 | 3.1 | . | 4.9 | 2.83 | 3 | 3 | 3 | 3 | 0.14 | 0.44 | 0.21 | 0.37 |
| 18 | 090 | 502 | D | 75 | 55 | . | 18 | 2550 | 1822 | . | 3.5 | . | 1.14 | 6 | 3 | 6 | 6 | 0.20 | 0.43 | 0.07 | 0.19 |
| 18 | 090 | 502 | D | 77 | 28 | . | 12 | 2792 | 1722 | . | 12.3 | . | 0.94 | 6 | 3 | 6 | 6 | 0.05 | 0.37 | 0.22 | 0.22 |
| 18 | 091 | 502 | D | 75 | 118 | . | 43 | 6075 | 5064 | . | 12.6 | . | 0.44 | 6 | 4 | 6 | 6 | 0.22 | 0.29 | 0.24 | 0.21 |
| 18 | 092 | 316 | U | 73 | 173 | 51 | . | 2901 | 1879 | 28.4 | . | 46.7 | 0.36 | 3 | 3 | 3 | 3 | 0.09 | 0.42 | 0.04 | 0.15 |
| 18 | 092 | 317 | M | 73 | 75 | 33 | . | 3019 | 2341 | 8.6 | . | 10.1 | 0.73 | 3 | 3 | 3 | 3 | 0.30 | 0.09 | 0.16 | 0.08 |
| 18 | 092 | 318 | D | 73 | 64 | 25 | . | 3288 | 2614 | 10.3 | . | 14.2 | 0.94 | 3 | 3 | 3 | 3 | 0.34 | 0.27 | 0.14 | 0.04 |
| 18 | 093 | 312 | D | 73 | 16 | 8 | . | 709 | 233 | 9.5 | . | 17.2 | 2.51 | 3 | 3 | 3 | 3 | 0.11 | 0.43 | 0.07 | 0.09 |
| 18 | 093 | 313 | M | 73 | 21 | 6 | . | 595 | 207 | 6.9 | . | 11.4 | 2.40 | 3 | 3 | 3 | 3 | 0.14 | 0.35 | 0.10 | 0.13 |
| 18 | 093 | 314 | M | 73 | 23 | 8 | . | 658 | 232 | 7.1 | . | 10.0 | 1.78 | 3 | 3 | 3 | 3 | 0.20 | 0.29 | 0.09 | 0.22 |
| 18 | 093 | 315 | U | 73 | 37 | 6 | . | 680 | 187 | 7.0 | . | 10.6 | 0.97 | 3 | 3 | 3 | 3 | 0.22 | 0.28 | 0.17 | 0.29 |
| 18 | 093 | 502 | D | 77 | 20 | . | 10 | 492 | 217 | . | 5.0 | . | 1.89 | 6 | 4 | 6 | 5 | 0.40 | 0.15 | 0.14 | 0.06 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 093 | 312 | D | 73 | 16 | [illegible] | . | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 18 | 093 | 313 | M | 73 | 21 | 6 | . | 595 | 207 | 6.9 | . | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 18 | 093 | 314 | M | 73 | 23 | 8 | . | 658 | 232 | 7.1 | . | 10.0 | 1.78 | 3 | 3 | 3 | 3 | [illegible] | [illegible] | [illegible] | [illegible] |
| 18 | 093 | 315 | U | 73 | 37 | 6 | . | 680 | 187 | 7.0 | . | 10.6 | 0.97 | 3 | 3 | 3 | 3 | 0.22 | 0.28 | 0.17 | [illegible] |
| 18 | 093 | 502 | D | 77 | 20 | . | 10 | 492 | 217 | . | 5.0 | . | 1.89 | 6 | 4 | 6 | 5 | 0.40 | 0.15 | 0.14 | 0.06 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 095 | 502 | D | 77 | 27 | . | 14 | 2367 | 1555 | . | 9.4 | . | 1.04 | 6 | 4 | 6 | 6 | 0.15 | 0.27 | 0.11 | 0.13 |
| 18 | 097 | 502 | D | 77 | 16 | . | 10 | 1417 | 778 | . | 8.2 | . | 1.17 | 6 | 4 | 6 | 6 | 0.10 | 0.21 | 0.19 | 0.12 |
| 18 | 097 | 503 | M | 77 | 26 | . | 10 | 1580 | 840 | . | 14.9 | . | 0.97 | 5 | 4 | 5 | 6 | 0.07 | 0.23 | 0.20 | 0.07 |
| 18 | 120 | 313 | D | 73 | 19 | 7 | . | 753 | 378 | 4.9 | . | 9.2 | 1.83 | 3 | 3 | 3 | 3 | 0.16 | 0.44 | 0.21 | 0.10 |
| 18 | 120 | 314 | M | 73 | 24 | 5 | . | 640 | 354 | 5.6 | . | 9.8 | 1.66 | 3 | 3 | 3 | 3 | 0.19 | 0.37 | 0.30 | 0.16 |
| 18 | 120 | 315 | M | 73 | 24 | 5 | . | 683 | 277 | 6.8 | . | 10.1 | 1.43 | 3 | 3 | 3 | 3 | 0.02 | 0.26 | 0.29 | 0.14 |
| 18 | 120 | 316 | M | 73 | 25 | 7 | . | 901 | 357 | 7.2 | . | 10.4 | 1.35 | 3 | 3 | 3 | 3 | 0.01 | 0.22 | 0.21 | 0.18 |
| 18 | 120 | 317 | M | 73 | 35 | 8 | . | 704 | 330 | 10.8 | . | 10.9 | 1.02 | 3 | 3 | 3 | 3 | 0.08 | 0.01 | 0.30 | 0.15 |
| 18 | 120 | 320 | M | 73 | 30 | 6 | . | 616 | 303 | 8.4 | . | 9.8 | 1.23 | 3 | 3 | 3 | 3 | 0.09 | 0.10 | 0.34 | 0.14 |
| 18 | 120 | 321 | M | 73 | 25 | 6 | . | 579 | 244 | 7.5 | . | 8.5 | 1.27 | 3 | 3 | 3 | 3 | 0.04 | 0.07 | 0.31 | 0.05 |
| 18 | 120 | 322 | M | 73 | 27 | 5 | . | 594 | 290 | 7.4 | . | 10.6 | 1.18 | 3 | 3 | 3 | 3 | 0.06 | 0.30 | 0.32 | 0.11 |
| 18 | 120 | 323 | M | 73 | 44 | 5 | . | 678 | 330 | 10.5 | . | 12.9 | 0.68 | 3 | 3 | 3 | 3 | 0.22 | 0.13 | 0.31 | 0.25 |
| 18 | 120 | 502 | D | 77 | 15 | . | 11 | 600 | 462 | . | 5.1 | . | 1.78 | 5 | 3 | 5 | 6 | 0.15 | 0.06 | 0.28 | 0.15 |
| 18 | 121 | 502 | D | 77 | 19 | . | 11 | 470 | 239 | . | 2.8 | . | 1.45 | 5 | 3 | 5 | 4 | 0.34 | 0.07 | 0.13 | 0.42 |
| 18 | 126 | 502 | D | 77 | 25 | . | 15 | 543 | 330 | . | 2.7 | . | 1.64 | 7 | 6 | 7 | 4 | 0.25 | 0.21 | 0.15 | 0.36 |
| 18 | 128 | 502 | D | 77 | 18 | . | 10 | 683 | 485 | . | 5.6 | . | 1.68 | 6 | 5 | 6 | 6 | 0.27 | 0.14 | 0.27 | 0.10 |
| 18 | 129 | 502 | D | 77 | 17 | . | 14 | 642 | 448 | . | 3.7 | . | 1.72 | 6 | 4 | 6 | 6 | 0.15 | 0.14 | 0.26 | 0.12 |
| 18 | 260 | 505 | M | 77 | 234 | . | 79 | 1705 | 678 | . | 27.5 | . | 0.33 | 7 | 4 | 7 | 6 | 0.17 | 0.14 | 0.11 | 0.08 |
| 18 | 263 | 502 | D | 77 | 28 | . | 11 | 1471 | 709 | . | 9.5 | . | 1.07 | 7 | 4 | 7 | 6 | 0.21 | 0.43 | 0.06 | 0.16 |
| 18 | 263 | 504 | M | 77 | 50 | . | 12 | 1681 | 808 | . | 15.2 | . | 0.61 | 7 | 3 | 7 | 6 | 0.16 | 0.36 | 0.10 | 0.21 |
| 19 | 119 | 324 | D | 73 | 103 | 40 | . | 746 | 419 | 16.3 | . | 27.3 | 0.81 | 3 | 3 | 3 | 3 | 0.04 | 0.40 | 0.10 | 0.07 |
| 19 | 122 | 325 | D | 73 | 11 | 7 | . | 435 | 206 | 4.2 | . | 7.5 | 2.34 | 3 | 3 | 3 | 3 | 0.14 | 0.44 | 0.20 | 0.12 |
| 19 | 122 | 326 | M | 73 | 11 | 8 | . | 551 | 198 | 4.5 | . | 8.0 | 1.98 | 3 | 3 | 3 | 3 | 0.16 | 0.41 | 0.07 | 0.29 |
| 19 | 122 | 327 | M | 73 | 12 | 6 | . | 516 | 197 | 4.3 | . | 7.9 | 2.01 | 3 | 3 | 3 | 3 | 0.18 | 0.43 | 0.11 | 0.18 |
| 19 | 122 | 328 | M | 73 | 13 | 7 | . | 454 | 195 | 3.9 | . | 7.6 | 1.57 | 3 | 3 | 3 | 3 | 0.25 | 0.49 | 0.05 | 0.25 |
| 19 | 122 | 330 | U | 73 | 18 | 8 | . | 429 | 188 | 3.3 | . | 6.4 | 1.51 | 3 | 3 | 3 | 3 | 0.20 | 0.48 | 0.14 | 0.31 |
| 19 | 122 | 331 | U | 73 | 30 | 10 | . | 500 | 227 | 2.4 | . | 3.6 | 0.86 | 3 | 3 | 3 | 3 | 0.46 | 0.29 | 0.03 | 0.48 |
| 19 | 338 | 322 | D | 73 | 146 | 84 | . | 799 | 487 | 7.3 | . | 11.5 | 0.72 | 3 | 3 | 3 | 3 | 0.23 | 0.29 | 0.03 | 0.09 |
| 19 | 340 | 315 | D | 73 | 26 | 8 | . | 431 | 97 | 6.8 | . | 10.4 | 2.32 | 3 | 3 | 3 | 3 | 0.09 | 0.28 | 0.13 | 0.07 |
| 19 | 340 | 316 | M | 73 | 29 | 10 | . | 460 | 93 | 7.5 | . | 13.3 | 2.27 | 3 | 3 | 3 | 3 | 0.12 | 0.39 | 0.10 | 0.09 |
| 19 | 340 | 317 | M | 73 | 34 | 13 | . | 602 | 106 | 8.6 | . | 13.5 | 2.08 | 3 | 3 | 3 | 3 | 0.06 | 0.28 | 0.30 | 0.19 |
| 19 | 340 | 318 | M | 73 | 58 | 21 | . | 648 | 129 | 11.8 | . | 13.6 | 1.29 | 3 | 3 | 3 | 3 | 0.08 | 0.12 | 0.21 | 0.16 |
| 19 | 340 | 319 | U | 73 | 77 | 29 | . | 706 | 153 | 15.1 | . | 22.7 | 0.90 | 3 | 3 | 3 | 3 | 0.10 | 0.25 | 0.14 | 0.02 |
| 19 | 340 | 504 | M | 76 | 60 | . | 23 | 300 | 150 | . | 20.2 | . | 0.79 | 3 | 3 | 3 | 3 | 0.19 | 0.14 | 0.19 | 0.08 |
| 19 | 340 | 504 | M | 78 | 106 | . | 17 | 750 | 375 | . | 16.4 | . | 0.63 | 4 | 4 | 4 | 4 | 0.27 | 0.31 | 0.21 | 0.09 |
| 19 | 340 | 505 | U | 75 | 70 | . | 27 | 800 | 175 | . | 26.2 | . | 0.63 | 4 | 3 | 4 | 4 | 0.32 | 0.03 | 0.17 | 0.04 |
| 19 | 340 | 505 | U | 76 | 53 | . | 16 | 467 | 243 | . | 24.7 | . | 0.87 | 3 | 4 | 3 | 4 | 0.08 | 0.12 | 0.07 | 0.15 |
| 19 | 340 | 505 | U | 78 | 84 | . | 21 | 950 | 426 | . | 22.4 | . | 0.56 | 6 | 7 | 6 | 5 | 0.13 | 0.18 | 0.26 | 0.13 |
| 19 | 340 | 506 | U | 75 | 83 | . | 22 | 900 | 150 | . | 25.2 | . | 0.63 | 3 | 3 | 3 | 3 | 0.13 | 0.06 | 0.28 | 0.02 |
| 19 | 340 | 506 | U | 76 | 139 | . | 92 | 875 | 600 | . | 26.3 | . | 0.86 | 4 | 4 | 4 | 4 | 0.20 | 0.36 | 0.22 | 0.20 |

## WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 340 | 506 | U | 78 | 174 | . | 155 | 1160 | 800 | . | 22.8 | . | 0.77 | 4 | 5 | 5 | 4 | 0.25 | 0.27 | 0.19 | 0.09 |
| 19 | 340 | 507 | U | 75 | 38 | . | 10 | 533 | 150 | . | 21.2 | . | 0.83 | 3 | 3 | 3 | 3 | 0.12 | 0.05 | 0.06 | 0.08 |
| 19 | 340 | 507 | U | 76 | 45 | . | 20 | 425 | 175 | . | 31.2 | . | 0.84 | 4 | 4 | 4 | 3 | 0.08 | 0.27 | 0.22 | 0.16 |
| 19 | 340 | 507 | U | 78 | 90 | . | 38 | 700 | 432 | . | 16.8 | . | 0.72 | 5 | 6 | 5 | 4 | 0.17 | 0.16 | 0.12 | 0.08 |
| 19 | 340 | 508 | M | 75 | 27 | . | 15 | 600 | 150 | . | 18.3 | . | 1.10 | 4 | 3 | 4 | 3 | 0.41 | 0.19 | 0.07 | 0.06 |
| 19 | 340 | 508 | M | 76 | 27 | . | 10 | 400 | 150 | . | 14.4 | . | 1.10 | 5 | 5 | 5 | 5 | 0.19 | 0.09 | 0.11 | 0.05 |
| 19 | 340 | 508 | M | 78 | 46 | . | 16 | 600 | 207 | . | 21.3 | . | 0.88 | 6 | 6 | 6 | 4 | 0.20 | 0.24 | 0.12 | 0.15 |
| 19. | 340 | 509 | M | 76 | 45 | . | 15 | 350 | 175 | . | 11.8 | . | 1.01 | 4 | 4 | 4 | 4 | 0.20 | 0.20 | 0.18 | 0.10 |
| 19 | 340 | 510 | M | 75 | 17 | . | 10 | 433 | 150 | . | 12.7 | . | 1.22 | 3 | 3 | 3 | 3 | 0.40 | 0.03 | 0.08 | 0.00 |
| 19 | 340 | 510 | M | 76 | 24 | . | 10 | 325 | 150 | . | 10.2 | . | 1.71 | 4 | 4 | 4 | 4 | 0.26 | 0.19 | 0.19 | 0.32 |
| 19 | 342 | 319 | D | 73 | 69 | 23 | . | 578 | 270 | 16.3 | . | 24.0 | 0.84 | 3 | 3 | 3 | 3 | 0.22 | 0.28 | 0.18 | 0.16 |
| 19 | 342 | 321 | M | 73 | 55 | 15 | . | 610 | 249 | 6.6 | . | 8.4 | 0.79 | 3 | 3 | 3 | 3 | 0.04 | 0.13 | 0.22 | 0.21 |
| 19 | 342 | 323 | U | 73 | 54 | 19 | . | 574 | 348 | 3.6 | . | 5.7 | 0.73 | 3 | 3 | 3 | 3 | 0.10 | 0.30 | 0.09 | 0.16 |
| 19 | 343 | 312 | D | 73 | 11 | 7 | . | 410 | 150 | 1.8 | . | 3.3 | 6.40 | 3 | 3 | 3 | 3 | 0.20 | 0.42 | 0.19 | 0.36 |
| 19 | 343 | 313 | M | 73 | 8 | 6 | . | 392 | 205 | 1.5 | . | 2.5 | 6.97 | 3 | 3 | 3 | 3 | 0.19 | 0.37 | 0.16 | 0.17 |
| 19 | 343 | 314 | M | 73 | 9 | 7 | . | 441 | 224 | 1.4 | . | 2.6 | 4.98 | 3 | 3 | 3 | 3 | 0.15 | 0.41 | 0.16 | 0.24 |
| 19 | 343 | 316 | U | 73 | 9 | 5 | . | 492 | 179 | 4.7 | . | 7.7 | 2.96 | 3 | 3 | 3 | 3 | 0.26 | 0.45 | 0.25 | 0.27 |
| 19 | 343 | 317 | U | 73 | 12 | 5 | . | 414 | 199 | 7.9 | . | 13.2 | 1.41 | 3 | 3 | 3 | 3 | 0.18 | 0.40 | 0.04 | 0.13 |
| 20 | 081 | 312 | M | 73 | 101 | 31 | . | 2322 | 1316 | 27.9 | . | 38.8 | 0.47 | 3 | 3 | 3 | 3 | 0.07 | 0.27 | 0.11 | 0.16 |
| 20 | 081 | 313 | M | 73 | 79 | 33 | . | 2009 | 1372 | 12.6 | . | 17.8 | 0.47 | 3 | 3 | 3 | 3 | 0.01 | 0.21 | 0.03 | 0.04 |
| 20 | 081 | 314 | D | 73 | 73 | 29 | . | 1942 | 1276 | 11.6 | . | 15.0 | 0.74 | 3 | 3 | 3 | 3 | 0.08 | 0.16 | 0.07 | 0.10 |
| 20 | 087 | 313 | D | 73 | 41 | 13 | . | 4525 | 3904 | 11.5 | . | 19.7 | 1.27 | 3 | 3 | 3 | 3 | 0.30 | 0.36 | 0.26 | 0.33 |
| 20 | 087 | 315 | M | 73 | 50 | 19 | . | 4475 | 3867 | 19.0 | . | 27.7 | 0.96 | 3 | 3 | 3 | 3 | 0.31 | 0.28 | 0.29 | 0.39 |
| 20 | 087 | 316 | M | 73 | 71 | 36 | . | 4383 | 3795 | 15.8 | . | 22.6 | 1.00 | 3 | 3 | 3 | 3 | 0.29 | 0.22 | 0.27 | 0.31 |
| 20 | 087 | 317 | U | 73 | 112 | 61 | . | 3895 | 3200 | 24.2 | . | 39.5 | 0.78 | 3 | 3 | 3 | 3 | 0.36 | 0.39 | 0.23 | 0.41 |
| 20 | 087 | 318 | U | 73 | 97 | 52 | . | 4209 | 3435 | 11.2 | . | 18.8 | 0.67 | 3 | 3 | 3 | 3 | 0.32 | 0.41 | 0.23 | 0.42 |
| 20 | 088 | 310 | D | 73 | 44 | 14 | . | 1236 | 312 | 11.1 | . | 14.3 | 0.97 | 3 | 3 | 3 | 3 | 0.12 | 0.17 | 0.20 | 0.07 |
| 20 | 088 | 311 | M | 73 | 68 | 21 | . | 1209 | 240 | 26.4 | . | 35.2 | 0.59 | 3 | 3 | 3 | 3 | 0.06 | 0.31 | 0.23 | 0.19 |
| 20 | 088 | 312 | U | 73 | 85 | 12 | . | 1213 | 208 | 32.0 | . | 51.4 | 0.62 | 3 | 3 | 3 | 3 | 0.08 | 0.31 | 0.20 | 0.13 |
| 20 | 088 | 313 | U | 73 | 88 | 10 | . | 1186 | 185 | 24.6 | . | 27.2 | 0.71 | 3 | 3 | 3 | 3 | 0.06 | 0.06 | 0.17 | 0.07 |
| 21 | 196 | 308 | D | 74 | 31 | 5 | . | 357 | 103 | 12.3 | . | 14.4 | 1.22 | 3 | 3 | 3 | 3 | 0.03 | 0.10 | 0.05 | 0.27 |
| 21 | 196 | 309 | M | 74 | 36 | 6 | . | 375 | 97 | 10.2 | . | 12.8 | 0.99 | 3 | 3 | 3 | 3 | 0.05 | 0.17 | 0.07 | 0.27 |
| 21 | 196 | 310 | U | 74 | 37 | 4 | . | 401 | 93 | 7.6 | . | 9.9 | 1.01 | 3 | 3 | 3 | 3 | 0.05 | 0.30 | 0.06 | 0.41 |
| 21 | 196 | 311 | U | 74 | 34 | 4 | . | 409 | 143 | 8.5 | . | 13.1 | 0.88 | 3 | 3 | 3 | 3 | 0.21 | 0.32 | 0.05 | 0.24 |
| 24 | 011 | 312 | D | 74 | 11 | 4 | . | 351 | 137 | 2.7 | . | 3.5 | 4.19 | 4 | 4 | 4 | 4 | 0.07 | 0.15 | 0.07 | 0.17 |
| 24 | 011 | 313 | M | 74 | 12 | 4 | . | 403 | 156 | 2.6 | . | 3.4 | 3.10 | 4 | 4 | 4 | 4 | 0.13 | 0.14 | 0.22 | 0.22 |
| 24 | 011 | 314 | M | 74 | 22 | 6 | . | 559 | 250 | 3.6 | . | 6.5 | 2.27 | 4 | 4 | 4 | 4 | 0.25 | 0.32 | 0.19 | 0.21 |
| 24 | 011 | 315 | M | 74 | 28 | 7 | . | 616 | 297 | 3.7 | . | 6.0 | 1.53 | 4 | 4 | 4 | 4 | 0.13 | 0.22 | 0.11 | 0.28 |
| 24 | 011 | 316 | U | 74 | 52 | 10 | . | 652 | 283 | 5.5 | . | 7.6 | 1.02 | 4 | 4 | 4 | 4 | 0.22 | 0.24 | 0.13 | 0.33 |
| 24 | 011 | 317 | U | 74 | 59 | 17 | . | 702 | 315 | 5.3 | . | 12.4 | 0.74 | 4 | 4 | 4 | 4 | 0.11 | 0.44 | 0.04 | 0.21 |



WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 011 | 315 | M | 74 | 28 | 7 | . | 616 | 297 | 3.7 | . | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 24 | 011 | 316 | U | 74 | 52 | 10 | . | 652 | 283 | 5.5 | . | 7.6 | 1.02 | 4 | 4 | 4 | 4 | 0.22 | 0.24 | 0.13 | 0.33 |
| 24 | 011 | 317 | U | 74 | 59 | 17 | . | 702 | 315 | 5.3 | . | 12.4 | 0.74 | 4 | 4 | 4 | 4 | 0.11 | 0.44 | 0.04 | 0.21 |

## WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 013 | 321 | D | 74 | 13 | 5 | . | 556 | 194 | 2.3 | . | 3.4 | 4.77 | 4 | 4 | 4 | 4 | 0.18 | 0.20 | 0.08 | 0.20 |
| 24 | 013 | 322 | M | 74 | 14 | 4 | . | 533 | 176 | 2.8 | . | 3.4 | 4.55 | 4 | 4 | 4 | 4 | 0.24 | 0.13 | 0.13 | 0.15 |
| 24 | 013 | 323 | M | 74 | 13 | 3 | . | 440 | 180 | 2.3 | . | 3.2 | 4.41 | 4 | 4 | 4 | 4 | 0.13 | 0.18 | 0.26 | 0.17 |
| 24 | 013 | 324 | U | 74 | 16 | 4 | . | 512 | 169 | 2.6 | . | 3.3 | 4.07 | 4 | 4 | 4 | 4 | 0.14 | 0.15 | 0.13 | 0.15 |
| 24 | 013 | 325 | M | 74 | 14 | 3 | . | 526 | 198 | 3.2 | . | 5.0 | 4.31 | 4 | 4 | 4 | 4 | 0.12 | 0.26 | 0.16 | 0.18 |
| 24 | 013 | 326 | M | 74 | 15 | 4 | . | 502 | 208 | 5.4 | . | 10.6 | 4.09 | 4 | 4 | 4 | 4 | 0.12 | 0.34 | 0.24 | 0.21 |
| 24 | 013 | 327 | M | 74 | 16 | 4 | . | 549 | 220 | 6.3 | . | 12.7 | 3.19 | 4 | 4 | 4 | 4 | 0.08 | 0.34 | 0.20 | 0.14 |
| 24 | 013 | 328 | U | 74 | 25 | 6 | . | 602 | 221 | 7.0 | . | 10.0 | 2.31 | 4 | 4 | 4 | 4 | 0.13 | 0.16 | 0.29 | 0.16 |
| 24 | 016 | 310 | M | 74 | 11 | 5 | . | 389 | 64 | 2.5 | . | 2.9 | 4.67 | 3 | 3 | 3 | 3 | 0.11 | 0.11 | 0.12 | 0.17 |
| 24 | 016 | 311 | M | 74 | 11 | 3 | . | 285 | 73 | 3.4 | . | 5.2 | 3.86 | 3 | 3 | 3 | 3 | 0.06 | 0.29 | 0.15 | 0.09 |
| 24 | 016 | 312 | U | 74 | 14 | 4 | . | 280 | 63 | 4.5 | . | 5.3 | 3.35 | 3 | 3 | 3 | 3 | 0.17 | 0.13 | 0.03 | 0.09 |
| 24 | 016 | 313 | U | 74 | 16 | 3 | . | 366 | 73 | 6.7 | . | 8.4 | 1.93 | 3 | 3 | 3 | 3 | 0.11 | 0.14 | 0.13 | 0.14 |
| 24 | 022 | 318 | D | 74 | 15 | 8 | . | 504 | 212 | 2.2 | . | 3.6 | 4.65 | 4 | 4 | 4 | 4 | 0.10 | 0.32 | 0.19 | 0.16 |
| 24 | 022 | 319 | U | 74 | 14 | 5 | . | 391 | 170 | 2.3 | . | 2.9 | 4.27 | 4 | 4 | 4 | 4 | 0.22 | 0.15 | 0.09 | 0.11 |
| 24 | 022 | 320 | M | 74 | 15 | 5 | . | 421 | 200 | 2.1 | . | 3.6 | 4.43 | 4 | 4 | 4 | 4 | 0.20 | 0.31 | 0.17 | 0.22 |
| 24 | 022 | 321 | M | 74 | 15 | 5 | . | 545 | 219 | 2.7 | . | 3.9 | 3.81 | 4 | 4 | 4 | 4 | 0.18 | 0.23 | 0.22 | 0.19 |
| 24 | 022 | 323 | M | 74 | 16 | 4 | . | 448 | 224 | 3.5 | . | 5.1 | 2.53 | 4 | 4 | 4 | 4 | 0.08 | 0.17 | 0.23 | 0.26 |
| 24 | 022 | 324 | U | 74 | 23 | 6 | . | 495 | 213 | 4.8 | . | 7.7 | 1.97 | 4 | 4 | 4 | 4 | 0.17 | 0.33 | 0.21 | 0.23 |
| 24 | 193 | 307 | D | 74 | 15 | 4 | . | 321 | 145 | 4.8 | . | 6.6 | 1.50 | 3 | 3 | 3 | 3 | 0.08 | 0.20 | 0.18 | 0.37 |
| 24 | 193 | 308 | U | 74 | 14 | 4 | . | 377 | 159 | 1.2 | . | 2.2 | 1.68 | 3 | 3 | 3 | 3 | 0.15 | 0.48 | 0.17 | 0.34 |
| 24 | 193 | 309 | M | 74 | 27 | 4 | . | 312 | 150 | 4.7 | . | 6.1 | 1.02 | 3 | 3 | 3 | 3 | 0.22 | 0.23 | 0.22 | 0.41 |
| 24 | 200 | 317 | D | 74 | 18 | 6 | . | 688 | 224 | 12.3 | . | 22.6 | 2.31 | 4 | 4 | 4 | 4 | 0.20 | 0.30 | 0.12 | 0.13 |
| 24 | 200 | 318 | U | 74 | 20 | 5 | . | 608 | 219 | 13.3 | . | 30.9 | 1.91 | 4 | 4 | 4 | 4 | 0.13 | 0.46 | 0.06 | 0.10 |
| 24 | 200 | 319 | M | 74 | 23 | 7 | . | 548 | 246 | 6.5 | . | 9.5 | 2.60 | 4 | 4 | 4 | 4 | 0.21 | 0.23 | 0.21 | 0.19 |
| 24 | 200 | 320 | M | 74 | 17 | 6 | . | 485 | 180 | 4.4 | . | 6.6 | 2.82 | 4 | 4 | 4 | 4 | 0.07 | 0.20 | 0.06 | 0.17 |
| 24 | 200 | 321 | M | 74 | 17 | 4 | . | 413 | 133 | 4.0 | . | 6.0 | 3.06 | 4 | 4 | 4 | 4 | 0.12 | 0.27 | 0.15 | 0.12 |
| 24 | 200 | 322 | U | 74 | 21 | 5 | . | 478 | 192 | 6.3 | . | 15.2 | 2.23 | 4 | 4 | 4 | 4 | 0.11 | 0.47 | 0.10 | 0.15 |
| 24 | 200 | 323 | M | 74 | 28 | 4 | . | 411 | 139 | 11.9 | . | 28.9 | 1.97 | 4 | 4 | 4 | 4 | 0.19 | 0.48 | 0.25 | 0.08 |
| 24 | 200 | 324 | M | 74 | 31 | 12 | . | 747 | 401 | 7.3 | . | 9.3 | 2.46 | 4 | 4 | 4 | 4 | 0.32 | 0.21 | 0.35 | 0.19 |
| 24 | 200 | 325 | U | 74 | 90 | 44 | . | 1346 | 872 | 15.7 | . | 26.8 | 1.02 | 4 | 4 | 4 | 4 | 0.11 | 0.27 | 0.20 | 0.05 |
| 25 | 105 | 312 | D | 74 | 125 | 74 | . | 1712 | 1220 | 8.2 | . | 16.1 | 0.16 | 3 | 3 | 3 | 3 | 0.10 | 0.50 | 0.09 | 0.42 |
| 25 | 107 | 308 | M | 74 | 71 | 12 | . | 1191 | 595 | 14.7 | . | 24.0 | 0.32 | 3 | 3 | 3 | 3 | 0.17 | 0.45 | 0.30 | 0.21 |
| 25 | 267 | 315 | D | 74 | 49 | 27 | . | 742 | 346 | 2.6 | . | 4.2 | 0.74 | 4 | 4 | 4 | 4 | 0.11 | 0.21 | 0.02 | 0.17 |
| 25 | 267 | 316 | M | 74 | 53 | 25 | . | 715 | 346 | 3.0 | . | 4.7 | 0.58 | 4 | 4 | 4 | 4 | 0.10 | 0.23 | 0.12 | 0.14 |
| 25 | 267 | 317 | M | 74 | 42 | 12 | . | 705 | 245 | 4.4 | . | 7.5 | 0.65 | 4 | 4 | 4 | 4 | 0.12 | 0.26 | 0.06 | 0.14 |
| 25 | 267 | 318 | M | 74 | 106 | 31 | . | 841 | 450 | 1.8 | . | 2.3 | 0.29 | 5 | 4 | 5 | 5 | 0.13 | 0.14 | 0.05 | 0.06 |
| 25 | 267 | 319 | U | 74 | 129 | 36 | . | 898 | 422 | 2.2 | . | 4.2 | 0.25 | 4 | 4 | 4 | 4 | 0.16 | 0.32 | 0.06 | 0.11 |
| 25 | 267 | 321 | M | 74 | 83 | 46 | . | 862 | 424 | 3.9 | . | 5.2 | 0.43 | 4 | 4 | 4 | 4 | 0.07 | 0.23 | 0.01 | 0.20 |
| 25 | 267 | 322 | U | 74 | 133 | 87 | . | 1096 | 505 | 7.3 | . | 13.6 | 0.42 | 4 | 4 | 4 | 4 | 0.12 | 0.33 | 0.08 | 0.22 |
| 25 | 267 | 323 | U | 74 | 86 | 29 | . | 1001 | 425 | 3.4 | . | 7.5 | 0.32 | 4 | 4 | 4 | 4 | 0.23 | 0.40 | 0.06 | 0.23 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 273 | 319 | M | 74 | 105 | 68 | . | 1109 | 564 | 9.1 | . | 18.4 | 0.63 | 4 | 4 | 4 | 4 | 0.15 | 0.41 | 0.09 | 0.23 |
| 25 | 273 | 320 | M | 74 | 116 | 82 | . | 1060 | 593 | 6.7 | . | 12.4 | 0.58 | 4 | 4 | 4 | 4 | 0.17 | 0.45 | 0.12 | 0.23 |
| 25 | 273 | 324 | M | 74 | 151 | 102 | . | 1362 | 797 | 2.8 | . | 6.8 | 0.37 | 4 | 4 | 4 | 4 | 0.14 | 0.48 | 0.03 | 0.28 |
| 25 | 275 | 312 | D | 74 | 61 | 34 | . | 946 | 568 | 1.6 | . | 3.0 | 0.51 | 4 | 4 | 4 | 4 | 0.21 | 0.35 | 0.05 | 0.21 |
| 25 | 275 | 313 | M | 74 | 57 | 26 | . | 833 | 555 | 4.0 | . | 8.8 | 0.58 | 4 | 4 | 4 | 4 | 0.21 | 0.43 | 0.08 | 0.27 |
| 25 | 275 | 318 | U | 74 | 63 | 18 | . | 912 | 533 | 8.2 | . | 13.8 | 0.63 | 3 | 3 | 3 | 3 | 0.19 | 0.49 | 0.12 | 0.27 |
| 25 | 275 | 319 | M | 74 | 70 | 24 | . | 930 | 549 | 4.8 | . | 7.2 | 0.44 | 3 | 3 | 3 | 3 | 0.36 | 0.46 | 0.17 | 0.29 |
| 25 | 275 | 320 | M | 74 | 88 | 26 | . | 1014 | 563 | 5.0 | . | 7.4 | 0.41 | 3 | 3 | 3 | 3 | 0.39 | 0.46 | 0.10 | 0.30 |
| 25 | 278 | 306 | D | 74 | 35 | 20 | . | 933 | 479 | 3.9 | . | 6.6 | 2.07 | 4 | 4 | 4 | 4 | 0.15 | 0.39 | 0.10 | 0.26 |
| 25 | 278 | 307 | M | 74 | 29 | 15 | . | 711 | 432 | 4.5 | . | 7.1 | 2.00 | 4 | 4 | 4 | 4 | 0.14 | 0.33 | 0.21 | 0.21 |
| 25 | 278 | 308 | M | 74 | 32 | 14 | . | 736 | 448 | 7.1 | . | 14.4 | 1.64 | 4 | 4 | 4 | 4 | 0.13 | 0.41 | 0.20 | 0.11 |
| 25 | 278 | 309 | U | 74 | 55 | 21 | . | 968 | 518 | 11.1 | . | 24.6 | 0.84 | 4 | 4 | 4 | 4 | 0.17 | 0.46 | 0.14 | 0.15 |
| 25 | 281 | 307 | D | 74 | 91 | 32 | . | 702 | 279 | 5.2 | . | 6.5 | 0.56 | 3 | 3 | 3 | 3 | 0.18 | 0.13 | 0.04 | 0.33 |
| 25 | 281 | 308 | M | 74 | 103 | 31 | . | 670 | 211 | 5.0 | . | 8.4 | 0.61 | 3 | 3 | 3 | 3 | 0.18 | 0.35 | 0.09 | 0.25 |
| 25 | 370 | 303 | D | 74 | 22 | 10 | . | 570 | 92 | 11.5 | . | 18.7 | 1.24 | 3 | 3 | 3 | 3 | 0.12 | 0.39 | 0.06 | 0.08 |
| 25 | 370 | 306 | M | 74 | 25 | 10 | . | 566 | 105 | 12.3 | . | 18.0 | 0.83 | 3 | 3 | 3 | 3 | 0.02 | 0.35 | 0.19 | 0.25 |
| 26 | 354 | 317 | D | 74 | 62 | 18 | . | 654 | 328 | 7.8 | . | 15.0 | 0.41 | 3 | 3 | 3 | 3 | 0.05 | 0.47 | 0.27 | 0.10 |
| 26 | 354 | 318 | M | 74 | 69 | 22 | . | 698 | 324 | 5.5 | . | 8.1 | 0.40 | 3 | 3 | 3 | 3 | 0.06 | 0.25 | 0.27 | 0.24 |
| 26 | 354 | 319 | M | 74 | 63 | 21 | . | 613 | 315 | 7.3 | . | 9.1 | 0.36 | 3 | 3 | 3 | 3 | 0.04 | 0.13 | 0.31 | 0.15 |
| 26 | 355 | 318 | M | 74 | 34 | 9 | . | 692 | 238 | 17.9 | . | 29.3 | 0.81 | 3 | 3 | 3 | 3 | 0.19 | 0.32 | 0.17 | 0.13 |
| 26 | 355 | 320 | M | 74 | 70 | 29 | . | 808 | 335 | 19.9 | . | 32.9 | 0.61 | 3 | 3 | 3 | 3 | 0.25 | 0.33 | 0.15 | 0.29 |
| 26 | 355 | 322 | U | 74 | 246 | 59 | . | 986 | 431 | 22.9 | . | 25.8 | 0.24 | 3 | 3 | 3 | 3 | 0.38 | 0.08 | 0.19 | 0.34 |
| 28 | 219 | 307 | D | 75 | 19 | 4 | . | 386 | 40 | 2.6 | . | 3.9 | 1.16 | 3 | 3 | 3 | 3 | 0.13 | 0.29 | 0.09 | 0.03 |
| 28 | 219 | 308 | U | 75 | 18 | 6 | . | 368 | 52 | 3.0 | . | 5.0 | 1.38 | 3 | 3 | 3 | 3 | 0.16 | 0.40 | 0.07 | 0.11 |
| 28 | 219 | 309 | M | 75 | 18 | 6 | . | 331 | 42 | 2.4 | . | 4.1 | 1.43 | 3 | 3 | 3 | 3 | 0.15 | 0.35 | 0.20 | 0.05 |
| 28 | 219 | 310 | M | 75 | 26 | 6 | . | 290 | 44 | 5.1 | . | 8.9 | 0.92 | 3 | 3 | 3 | 3 | 0.15 | 0.39 | 0.06 | 0.11 |
| 29 | 106 | 311 | M | 74 | 88 | 7 | . | 1197 | 475 | 23.3 | . | 36.1 | 0.28 | 3 | 3 | 3 | 3 | 0.24 | 0.32 | 0.09 | 0.05 |
| 29 | 108 | 314 | M | 74 | 64 | 27 | . | 1198 | 652 | 15.2 | . | 24.4 | 1.02 | 3 | 3 | 3 | 3 | 0.48 | 0.39 | 0.21 | 0.39 |
| 29 | 108 | 315 | M | 74 | 72 | 30 | . | 1153 | 620 | 16.5 | . | 25.7 | 0.68 | 3 | 3 | 3 | 3 | 0.41 | 0.31 | 0.19 | 0.18 |
| 29 | 108 | 316 | M | 74 | 176 | 41 | . | 1112 | 467 | 32.6 | . | 51.1 | 0.35 | 3 | 3 | 3 | 3 | 0.27 | 0.31 | 0.21 | 0.06 |
| 29 | 110 | 315 | D | 74 | 43 | 23 | . | 1468 | 1108 | 4.1 | . | 5.1 | 0.69 | 3 | 3 | 3 | 3 | 0.18 | 0.15 | 0.10 | 0.09 |
| 29 | 110 | 316 | U | 74 | 54 | 15 | . | 1347 | 898 | 7.8 | . | 13.2 | 0.57 | 3 | 3 | 3 | 3 | 0.08 | 0.35 | 0.03 | 0.10 |
| 29 | 110 | 317 | M | 74 | 52 | 19 | . | 1644 | 1224 | 5.8 | . | 9.6 | 0.46 | 3 | 3 | 3 | 3 | 0.09 | 0.41 | 0.16 | 0.19 |
| 29 | 110 | 318 | M | 74 | 74 | 23 | . | 1603 | 1075 | 6.9 | . | 12.8 | 0.42 | 3 | 3 | 3 | 3 | 0.34 | 0.50 | 0.24 | 0.14 |
| 29 | 111 | 310 | D | 74 | 41 | 19 | . | 1558 | 1133 | 8.2 | . | 13.8 | 0.53 | 3 | 3 | 3 | 3 | 0.16 | 0.39 | 0.08 | 0.08 |
| 29 | 111 | 311 | M | 74 | 44 | 20 | . | 1444 | 1104 | 7.6 | . | 9.9 | 0.48 | 3 | 3 | 3 | 3 | 0.14 | 0.25 | 0.14 | 0.05 |
| 29 | 194 | 311 | D | 74 | 35 | 15 | . | 837 | 400 | 8.9 | . | 13.2 | 1.92 | 3 | 3 | 3 | 3 | 0.26 | 0.24 | 0.26 | 0.28 |
| 29 | 194 | 312 | M | 74 | 44 | 15 | . | 871 | 394 | 7.9 | . | 11.9 | 1.53 | 3 | 3 | 3 | 3 | 0.32 | 0.26 | 0.17 | 0.30 |
| 29 | 194 | 313 | U | 74 | 49 | 11 | . | 978 | 439 | 8.2 | . | 14.2 | 0.92 | 3 | 3 | 3 | 3 | 0.03 | 0.42 | 0.13 | 0.33 |
| 29 | 194 | 314 | M | 74 | 45 | 13 | . | 732 | 325 | 5.8 | . | 6.6 | 1.17 | 3 | 3 | 3 | 3 | 0.29 | 0.11 | 0.31 | 0.34 |



WATER QUALITY SUMMARY BY STATION-YEAR

29 194 312 M 74 . 978 439 8.2 .
29 194 313 U 74 49 11 . 732 325 5.8 . 6.6 1.17 3 3 3
29 194 314 M 74 45 13 .

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 195 | 315 | D | 74 | 17 | 6 | . | 891 | 561 | 5.5 | . | 9.7 | 2.11 | 3 | 3 | 3 | 3 | 0.14 | 0.39 | 0.16 | 0.15 |
| 29 | 207 | 310 | D | 74 | 107 | 57 | . | 1112 | 317 | 20.5 | . | 22.1 | 0.87 | 3 | 3 | 3 | 3 | 0.13 | 0.06 | 0.21 | 0.38 |
| 29 | 207 | 311 | M | 74 | 106 | 60 | . | 1056 | 361 | 14.9 | . | 25.7 | 0.66 | 3 | 3 | 3 | 3 | 0.12 | 0.42 | 0.24 | 0.43 |
| 30 | 064 | 305 | D | 75 | 56 | 7 | . | 818 | 47 | 12.3 | . | 14.2 | 0.79 | 3 | 3 | 3 | 3 | 0.16 | 0.11 | 0.07 | 0.12 |
| 30 | 064 | 307 | M | 75 | 49 | 7 | . | 724 | 50 | 8.5 | . | 11.6 | 0.81 | 3 | 3 | 3 | 3 | 0.13 | 0.36 | 0.12 | 0.13 |
| 30 | 235 | 320 | D | 74 | 15 | 8 | . | 445 | 143 | 1.4 | . | 1.7 | 4.32 | 3 | 3 | 3 | 3 | 0.16 | 0.21 | 0.13 | 0.19 |
| 30 | 235 | 321 | M | 74 | 13 | 5 | . | 321 | 122 | 1.8 | . | 2.1 | 2.52 | 3 | 3 | 3 | 3 | 0.22 | 0.09 | 0.04 | 0.03 |
| 30 | 235 | 322 | M | 74 | 11 | 5 | . | 325 | 148 | 1.3 | . | 1.5 | 4.23 | 3 | 3 | 3 | 3 | 0.06 | 0.09 | 0.06 | 0.12 |
| 30 | 235 | 323 | M | 74 | 17 | 8 | . | 334 | 143 | 2.2 | . | 3.4 | 3.04 | 3 | 3 | 3 | 3 | 0.13 | 0.28 | 0.04 | 0.15 |
| 30 | 235 | 324 | M | 74 | 41 | 28 | . | 464 | 139 | 2.0 | . | 3.1 | 3.96 | 3 | 3 | 3 | 3 | 0.42 | 0.26 | 0.20 | 0.22 |
| 31 | 077 | 311 | D | 75 | 15 | 9 | . | 248 | 51 | 3.9 | . | 6.7 | 2.08 | 3 | 3 | 3 | 3 | 0.18 | 0.36 | 0.06 | 0.06 |
| 31 | 077 | 312 | M | 75 | 13 | 10 | . | 260 | 62 | 2.7 | . | 4.4 | 2.64 | 3 | 3 | 3 | 3 | 0.10 | 0.37 | 0.15 | 0.13 |
| 31 | 077 | 313 | M | 75 | 12 | 6 | . | 255 | 54 | 2.7 | . | 3.5 | 2.42 | 3 | 3 | 3 | 3 | 0.19 | 0.20 | 0.14 | 0.14 |
| 31 | 077 | 314 | M | 75 | 12 | 6 | . | 236 | 58 | 1.0 | . | 1.3 | 2.88 | 3 | 3 | 3 | 3 | 0.14 | 0.21 | 0.07 | 0.23 |
| 31 | 077 | 315 | M | 75 | 12 | 7 | . | 238 | 58 | 1.8 | . | 3.0 | 2.44 | 3 | 3 | 3 | 3 | 0.16 | 0.40 | 0.07 | 0.18 |
| 32 | 204 | 314 | M | 75 | 49 | 32 | . | 281 | 75 | 2.9 | . | 5.5 | 4.50 | 4 | 3 | 4 | 3 | 0.27 | 0.44 | 0.08 | 0.49 |
| 32 | 204 | 315 | D | 75 | 30 | 23 | . | 253 | 52 | 3.8 | . | 5.3 | 5.93 | 3 | 3 | 3 | 3 | 0.15 | 0.28 | 0.13 | 0.31 |
| 32 | 204 | 316 | M | 75 | 50 | 42 | . | 304 | 70 | 2.4 | . | 3.1 | 2.65 | 3 | 3 | 3 | 3 | 0.34 | 0.17 | 0.14 | 0.36 |

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | 301 | D | 72 | 6 | . | 4 | . | 270 | 3.3 | . | 5.8 | 2.34 | 3 | 2 | 0 | 3 | 0.23 | 0.73 | . | 0.12 |
| 02 | 176 | 302 | M | 72 | 7 | . | 4 | . | 233 | 6.5 | . | 7.5 | 2.45 | 3 | 3 | 0 | 3 | 0.16 | 0.10 | . | 0.25 |
| 04 | 312 | 312 | M | 73 | 142 | 81 | . | 1924 | 1266 | 29.6 | . | 76.2 | 0.86 | 3 | 3 | 3 | 3 | 0.58 | 0.79 | 0.31 | 0.24 |
| 04 | 320 | 005 | M | 74 | 58 | 17 | . | 1257 | 865 | . | 3.2 | . | 1.75 | 3 | 2 | 3 | 3 | 0.44 | 0.69 | 0.10 | 0.56 |
| 04 | 320 | 006 | M | 74 | 13 | 3 | . | 960 | 593 | . | 4.4 | . | 2.59 | 3 | 3 | 3 | 3 | 0.25 | 0.49 | 0.18 | 0.27 |
| 04 | 320 | 007 | M | 74 | 20 | 0 | . | 1017 | 647 | . | 2.3 | . | 4.58 | 2 | 3 | 3 | 3 | 0.00 | 0.57 | 0.20 | 0.19 |
| 08 | 074 | 320 | D | 73 | 16 | 7 | . | 491 | 100 | 6.8 | . | 7.8 | 3.00 | 2 | 2 | 2 | 2 | 0.37 | 0.14 | 0.28 | 0.32 |
| 08 | 074 | 321 | M | 73 | 15 | 6 | . | 461 | 111 | 6.0 | . | 9.1 | 2.16 | 2 | 2 | 2 | 2 | 0.38 | 0.50 | 0.29 | 0.15 |
| 08 | 074 | 323 | U | 73 | 16 | 7 | . | 298 | 110 | 9.3 | . | 12.1 | 1.56 | 2 | 2 | 2 | 2 | 0.13 | 0.30 | 0.10 | 0.19 |
| 08 | 074 | 324 | U | 73 | 21 | 5 | . | 423 | 102 | 8.2 | . | 8.9 | 1.84 | 2 | 2 | 2 | 2 | 0.27 | 0.09 | 0.23 | 0.01 |
| 08 | 074 | 325 | M | 73 | 17 | 7 | . | 410 | 98 | 9.8 | . | 12.5 | 2.02 | 2 | 2 | 2 | 2 | 0.22 | 0.28 | 0.04 | 0.06 |
| 08 | 074 | 326 | U | 73 | 29 | 6 | . | 480 | 103 | 11.0 | . | 12.8 | 1.73 | 2 | 2 | 2 | 2 | 0.38 | 0.16 | 0.26 | 0.12 |
| 08 | 074 | 327 | U | 73 | 23 | 6 | . | 522 | 105 | 5.7 | . | 7.2 | 1.47 | 2 | 2 | 2 | 2 | 0.24 | 0.25 | 0.12 | 0.03 |
| 08 | 074 | 328 | M | 73 | 20 | 7 | . | 488 | 110 | 7.6 | . | 8.7 | 1.73 | 2 | 2 | 2 | 2 | 0.07 | 0.14 | 0.22 | 0.03 |
| 08 | 074 | 329 | U | 73 | 33 | 5 | . | 601 | 220 | 5.7 | . | 6.6 | 0.88 | 2 | 2 | 2 | 2 | 0.20 | 0.15 | 0.14 | 0.04 |
| 08 | 074 | 330 | U | 73 | 25 | 4 | . | 553 | 155 | 7.2 | . | 9.9 | 1.22 | 2 | 2 | 2 | 2 | 0.18 | 0.37 | 0.17 | 0.25 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08 | 330 | 340 | D | 73 | 7 | 3 | . | 385 | 115 | 4.4 | . | 4.7 | 7.01 | 2 | 2 | 2 | 2 | 0.13 | 0.06 | 0.25 | 0.43 |
| 08 | 330 | 341 | U | 73 | 9 | 3 | . | 381 | 77 | 10.9 | . | 15.0 | 2.74 | 2 | 2 | 2 | 2 | 0.05 | 0.38 | 0.02 | 0.33 |
| 08 | 330 | 342 | M | 73 | 9 | 3 | . | 407 | 82 | 3.9 | . | 4.5 | 3.15 | 2 | 2 | 2 | 2 | 0.22 | 0.15 | 0.03 | 0.13 |
| 08 | 330 | 343 | M | 73 | 11 | 3 | . | 362 | 100 | 4.7 | . | 5.5 | 2.59 | 2 | 2 | 2 | 2 | 0.07 | 0.17 | 0.19 | 0.06 |
| 08 | 330 | 344 | U | 73 | 18 | 3 | . | 351 | 113 | 7.7 | . | 9.0 | 1.40 | 2 | 2 | 2 | 2 | 0.06 | 0.17 | 0.16 | 0.24 |
| 08 | 330 | 345 | U | 73 | 15 | 4 | . | 425 | 104 | 2.8 | . | 2.9 | 1.04 | 2 | 2 | 2 | 2 | 0.29 | 0.02 | 0.04 | 0.46 |
| 08 | 330 | 346 | M | 73 | 11 | 4 | . | 373 | 92 | 6.4 | . | 7.7 | 1.93 | 2 | 2 | 2 | 2 | 0.04 | 0.19 | 0.22 | 0.12 |
| 08 | 330 | 347 | M | 73 | 9 | 4 | . | 453 | 85 | 5.6 | . | 6.0 | 2.65 | 2 | 2 | 2 | 2 | 0.04 | 0.06 | 0.07 | 0.20 |
| 08 | 330 | 348 | M | 73 | 10 | 7 | . | 441 | 109 | 6.5 | . | 8.2 | 2.44 | 2 | 2 | 2 | 2 | 0.11 | 0.25 | 0.04 | 0.13 |
| 08 | 330 | 349 | M | 73 | 13 | 4 | . | 346 | 109 | 6.8 | . | 7.5 | 2.16 | 2 | 2 | 2 | 2 | 0.13 | 0.10 | 0.26 | 0.12 |
| 08 | 330 | 350 | M | 73 | 12 | 4 | . | 433 | 97 | 7.9 | . | 10.4 | 2.18 | 2 | 2 | 2 | 2 | 0.03 | 0.32 | 0.10 | 0.09 |
| 08 | 330 | 351 | U | 73 | 13 | 4 | . | 322 | 112 | 12.0 | . | 17.5 | 2.04 | 2 | 2 | 2 | 2 | 0.19 | 0.46 | 0.30 | 0.12 |
| 10 | 003 | 310 | U | 73 | 26 | 7 | . | 1262 | 883 | 2.5 | . | 3.6 | 1.24 | 3 | 3 | 3 | 3 | 0.51 | 0.26 | 0.10 | 0.23 |
| 10 | 069 | 311 | D | 73 | 18 | 7 | . | 989 | 141 | 4.6 | . | 4.6 | 1.94 | 2 | 2 | 2 | 2 | 0.14 | 0.00 | 0.45 | 0.07 |
| 10 | 069 | 312 | M | 73 | 17 | 5 | . | 916 | 155 | 8.7 | . | 11.2 | 1.60 | 2 | 2 | 2 | 2 | 0.27 | 0.28 | 0.12 | 0.14 |
| 10 | 069 | 313 | U | 73 | 18 | 4 | . | 727 | 124 | 8.1 | . | 10.1 | 1.45 | 2 | 2 | 2 | 2 | 0.24 | 0.25 | 0.01 | 0.05 |
| 10 | 069 | 314 | M | 73 | 12 | 5 | . | 665 | 92 | 8.3 | . | 9.9 | 1.92 | 2 | 2 | 2 | 2 | 0.08 | 0.19 | 0.08 | 0.05 |
| 10 | 069 | 315 | U | 73 | 27 | 5 | . | 630 | 168 | 8.8 | . | 13.5 | 1.22 | 2 | 2 | 2 | 2 | 0.20 | 0.54 | 0.30 | 0.13 |
| 10 | 069 | 316 | U | 73 | 24 | 5 | . | 677 | 124 | 7.0 | . | 9.3 | 1.52 | 2 | 2 | 2 | 2 | 0.15 | 0.33 | 0.55 | 0.20 |
| 10 | 071 | 311 | U | 73 | 40 | 8 | . | 814 | 307 | 10.4 | . | 15.3 | 0.89 | 2 | 2 | 2 | 2 | 0.36 | 0.47 | 0.03 | 0.14 |
| 10 | 071 | 312 | D | 73 | 43 | 4 | . | 730 | 262 | 9.6 | . | 10.2 | 0.79 | 2 | 2 | 2 | 2 | 0.31 | 0.06 | 0.05 | 0.16 |
| 10 | 071 | 313 | M | 73 | 40 | 9 | . | 773 | 455 | 6.1 | . | 7.2 | 0.91 | 2 | 2 | 2 | 2 | 0.43 | 0.18 | 0.07 | 0.06 |
| 10 | 071 | 314 | M | 73 | 25 | 9 | . | 704 | 288 | 4.5 | . | 6.1 | 1.45 | 2 | 2 | 2 | 2 | 0.37 | 0.34 | 0.23 | 0.26 |
| 10 | 071 | 315 | U | 73 | 44 | 20 | . | 1020 | 691 | 3.2 | . | 4.5 | 1.09 | 2 | 2 | 2 | 2 | 0.29 | 0.41 | 0.07 | 0.12 |
| 10 | 072 | 321 | D | 73 | 30 | 6 | . | 667 | 132 | 10.8 | . | 13.6 | 1.50 | 2 | 2 | 2 | 2 | 0.22 | 0.25 | 0.01 | 0.14 |
| 10 | 072 | 322 | M | 73 | 32 | 5 | . | 992 | 137 | 15.3 | . | 16.5 | 1.15 | 2 | 2 | 2 | 2 | 0.24 | 0.08 | 0.23 | 0.12 |
| 10 | 072 | 323 | M | 73 | 45 | 9 | . | 917 | 291 | 8.7 | . | 12.4 | 0.94 | 2 | 2 | 2 | 2 | 0.45 | 0.42 | 0.07 | 0.03 |
| 10 | 072 | 324 | M | 73 | 69 | 16 | . | 913 | 430 | 4.8 | . | 7.0 | 0.77 | 2 | 2 | 2 | 2 | 0.32 | 0.44 | 0.17 | 0.08 |
| 10 | 073 | 113 | M | 75 | 39 | . | 24 | 477 | 210 | 12.0 | . | 39.1 | 0.69 | 18 | 5 | 14 | 4 | 0.14 | 0.58 | 0.09 | 0.06 |
| 10 | 073 | 131 | M | 75 | 107 | . | 46 | 756 | 507 | 11.3 | . | 42.0 | 0.40 | 16 | 6 | 12 | 5 | 0.05 | 0.55 | 0.10 | 0.20 |
| 10 | 076 | 312 | D | 73 | 7 | 2 | . | 308 | 109 | 4.4 | . | 4.9 | 3.20 | 2 | 2 | 2 | 2 | 0.24 | 0.11 | 0.07 | 0.05 |
| 10 | 076 | 313 | U | 73 | 9 | 4 | . | 606 | 113 | 3.4 | . | 3.6 | 2.92 | 2 | 2 | 2 | 2 | 0.13 | 0.04 | 0.53 | 0.04 |
| 10 | 076 | 314 | U | 73 | 18 | 5 | . | 506 | 113 | 4.7 | . | 4.7 | 3.05 | 2 | 2 | 2 | 2 | 0.34 | 0.00 | 0.16 | 0.00 |
| 10 | 076 | 315 | M | 73 | 16 | 2 | . | 452 | 127 | 4.3 | . | 4.7 | 3.12 | 2 | 2 | 2 | 2 | 0.37 | 0.08 | 0.17 | 0.02 |
| 10 | 076 | 316 | M | 73 | 16 | 3 | . | 324 | 90 | 5.4 | . | 6.9 | 2.89 | 2 | 2 | 2 | 2 | 0.48 | 0.27 | 0.00 | 0.05 |
| 10 | 076 | 317 | M | 73 | 9 | 3 | . | 320 | 96 | 5.0 | . | 5.6 | 2.95 | 2 | 2 | 2 | 2 | 0.20 | 0.12 | 0.19 | 0.07 |
| 10 | 076 | 318 | U | 73 | 44 | 14 | . | 723 | 173 | 10.8 | . | 12.2 | 2.13 | 2 | 2 | 2 | 2 | 0.07 | 0.13 | 0.04 | 0.29 |
| 10 | 076 | 319 | M | 73 | 12 | 3 | . | 533 | 119 | 5.3 | . | 5.5 | 2.16 | 2 | 2 | 2 | 2 | 0.04 | 0.05 | 0.01 | 0.13 |
| 10 | 076 | 320 | U | 73 | 22 | 7 | . | 575 | 149 | 6.4 | . | 7.2 | 1.95 | 2 | 2 | 2 | 2 | 0.20 | 0.13 | 0.25 | 0.06 |
| 10 | 076 | 321 | M | 73 | 13 | 4 | . | 514 | 127 | 5.2 | . | 5.7 | 2.44 | 2 | 2 | 2 | 2 | 0.06 | 0.10 | 0.17 | 0.00 |



WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 076 | 318 | U | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 10 | 076 | 319 | M | 73 | 12 | 3 | . | 533 | 119 | 5.3 | . | 5.5 | 2.16 | 2 | 2 | 2 | 2 | [illegible] | [illegible] | [illegible] | [illegible] |
| 10 | 076 | 320 | U | 73 | 22 | 7 | . | 575 | 149 | 6.4 | . | 7.2 | 1.95 | 2 | 2 | 2 | 2 | 0.20 | 0.13 | 0.25 | 0.06 |
| 10 | 076 | 321 | M | 73 | 13 | 4 | . | 514 | 127 | 5.2 | . | 5.7 | 2.44 | 2 | 2 | 2 | 2 | 0.06 | 0.10 | 0.17 | 0.00 |

WATER QUALITY SUMMARY BY STATION-YEAR

------------------------------------------ POOL DATA SCREEN CODE=B ------------------------------------------

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 076 | 322 | M | 73 | 15 | 2 | . | 628 | 149 | 7.7 | . | 8.8 | 2.16 | 2 | 2 | 2 | 2 | 0.09 | 0.14 | 0.16 | 0.13 |
| 10 | 076 | 323 | U | 73 | 20 | 3 | . | 586 | 121 | 13.1 | . | 17.9 | 2.08 | 2 | 2 | 2 | 2 | 0.23 | 0.37 | 0.07 | 0.02 |
| 10 | 411 | 313 | D | 73 | 28 | 15 | . | 1695 | 1199 | 2.6 | . | 4.6 | 1.62 | 3 | 3 | 3 | 3 | 0.58 | 0.41 | 0.18 | 0.28 |
| 10 | 411 | 315 | U | 73 | 67 | 6 | . | 1089 | 595 | 5.8 | . | 7.2 | 1.07 | 3 | 3 | 3 | 3 | 0.57 | 0.12 | 0.07 | 0.14 |
| 14 | 099 | 312 | D | 74 | 179 | 91 | . | 5828 | 5120 | 13.5 | . | 25.4 | 0.81 | 2 | 3 | 2 | 3 | 0.02 | 0.51 | 0.58 | 0.45 |
| 14 | 099 | 313 | M | 74 | 187 | 104 | . | 6106 | 5537 | 14.3 | . | 17.5 | 0.38 | 2 | 2 | 2 | 2 | 0.11 | 0.22 | 0.63 | 0.20 |
| 15 | 178 | 005 | M | 76 | 23 | 5 | 13 | . | 140 | 8.6 | . | 9.6 | 2.75 | 3 | 3 | 0 | 3 | 0.18 | 0.06 | . | 0.05 |
| 15 | 178 | 005 | M | 78 | 16 | 3 | . | 710 | 233 | 7.1 | . | 7.9 | 2.23 | 3 | 3 | 3 | 3 | 0.33 | 0.09 | 0.06 | 0.20 |
| 15 | 178 | 006 | D | 77 | 19 | 8 | . | 747 | 257 | 9.7 | . | 19.7 | 2.97 | 3 | 3 | 3 | 3 | 0.04 | 0.52 | 0.07 | 0.02 |
| 15 | 178 | 305 | M | 72 | 22 | . | 13 | . | 114 | 15.0 | . | 19.1 | 2.58 | 3 | 3 | 0 | 3 | 0.25 | 0.23 | . | 0.13 |
| 15 | 178 | 306 | M | 72 | 21 | . | 12 | . | 110 | 11.4 | . | 16.3 | 2.18 | 3 | 3 | 0 | 3 | 0.16 | 0.30 | . | 0.06 |
| 15 | 178 | 307 | D | 72 | 21 | . | 14 | . | 122 | 11.0 | . | 14.0 | 2.18 | 3 | 3 | 0 | 3 | 0.21 | 0.14 | . | 0.06 |
| 15 | 179 | 802 | M | 79 | 157 | . | 129 | . | 254 | 30.5 | . | 54.3 | 1.58 | 4 | 3 | 0 | 3 | 0.30 | 0.39 | . | 0.31 |
| 15 | 179 | 803 | M | 79 | 272 | . | 97 | . | 109 | 83.0 | . | 118.0 | 0.69 | 4 | 3 | 0 | 4 | 0.31 | 0.40 | . | 0.41 |
| 15 | 179 | 804 | M | 79 | 186 | . | 108 | . | 50 | 74.6 | . | 99.9 | 0.79 | 4 | 3 | 0 | 4 | 0.24 | 0.31 | . | 0.15 |
| 15 | 179 | 805 | M | 79 | 188 | . | 93 | . | 23 | 74.1 | . | 106.0 | 0.71 | 4 | 3 | 0 | 4 | 0.18 | 0.32 | . | 0.19 |
| 15 | 179 | 806 | M | 79 | 245 | . | 116 | . | 78 | 72.2 | . | 108.3 | 0.45 | 4 | 3 | 0 | 3 | 0.26 | 0.42 | . | 0.33 |
| 15 | 181 | 309 | M | 72 | 22 | . | 17 | . | 124 | 5.9 | . | 7.5 | 2.61 | 3 | 3 | 0 | 3 | 0.31 | 0.14 | . | 0.12 |
| 15 | 181 | 310 | M | 72 | 16 | . | 9 | . | 139 | 5.2 | . | 6.9 | 1.95 | 3 | 3 | 0 | 3 | 0.01 | 0.21 | . | 0.13 |
| 15 | 181 | 311 | D | 72 | 17 | . | 12 | . | 137 | 7.3 | . | 8.4 | 2.13 | 3 | 3 | 0 | 3 | 0.19 | 0.11 | . | 0.08 |
| 15 | 181 | 312 | M | 72 | 20 | . | 13 | . | 133 | 6.5 | . | 8.7 | 2.06 | 3 | 3 | 0 | 2 | 0.24 | 0.21 | . | 0.11 |
| 15 | 237 | 309 | M | 74 | 272 | 196 | . | 1366 | 112 | 43.4 | . | 57.6 | 0.84 | 2 | 2 | 2 | 2 | 0.13 | 0.33 | 0.11 | 0.09 |
| 15 | 399 | 801 | M | 78 | 61 | . | 22 | . | . | 16.4 | . | 22.8 | 1.33 | 3 | 3 | 0 | 3 | 0.09 | 0.21 | . | 0.07 |
| 15 | 399 | 801 | M | 79 | 119 | . | 66 | . | 854 | 18.4 | . | 31.9 | 1.43 | 7 | 7 | 0 | 7 | 0.09 | 0.18 | . | 0.12 |
| 15 | 399 | 802 | U | 78 | 49 | . | 20 | . | . | 20.6 | . | 28.9 | 1.33 | 3 | 3 | 0 | 3 | 0.07 | 0.24 | . | 0.07 |
| 16 | 243 | 311 | U | 73 | 40 | 6 | . | 1273 | 605 | 9.7 | . | 11.7 | 0.99 | 2 | 2 | 2 | 2 | 0.36 | 0.20 | 0.19 | 0.03 |
| 16 | 243 | 312 | U | 73 | 50 | 6 | . | 1468 | 604 | 16.4 | . | 22.7 | 0.91 | 2 | 2 | 2 | 2 | 0.03 | 0.38 | 0.19 | 0.00 |
| 16 | 243 | 314 | M | 73 | 125 | 33 | . | 1842 | 991 | 15.8 | . | 15.9 | 0.56 | 2 | 2 | 2 | 2 | 0.11 | 0.01 | 0.00 | 0.09 |
| 16 | 328 | 336 | M | 72 | 35 | . | 16 | . | 399 | 12.6 | . | 16.7 | 1.30 | 3 | 3 | 0 | 3 | 0.33 | 0.16 | . | 0.32 |
| 17 | 247 | 308 | U | 73 | 202 | 36 | . | 3287 | 2284 | 7.7 | . | 11.7 | 0.46 | 2 | 2 | 2 | 2 | 0.54 | 0.51 | 0.43 | 0.78 |
| 17 | 249 | 313 | U | 73 | 216 | 76 | . | 3525 | 2119 | 15.5 | . | 20.2 | 0.36 | 2 | 2 | 2 | 2 | 0.38 | 0.30 | 0.27 | 0.14 |
| 17 | 373 | 309 | M | 73 | 7 | 5 | . | 471 | 140 | 5.4 | . | 7.0 | 3.66 | 2 | 2 | 2 | 2 | 0.16 | 0.28 | 0.02 | 0.00 |
| 17 | 373 | 310 | U | 73 | 14 | 4 | . | 589 | 203 | 8.6 | . | 16.4 | 0.94 | 3 | 3 | 3 | 2 | 0.09 | 0.46 | 0.07 | 0.35 |
| 17 | 373 | 311 | M | 73 | 11 | 4 | . | 545 | 242 | 3.6 | . | 6.4 | 1.52 | 2 | 2 | 2 | 2 | 0.14 | 0.75 | 0.01 | 0.60 |
| 17 | 389 | 328 | D | 73 | 65 | 17 | . | 1416 | 1153 | 23.1 | . | 41.9 | 0.73 | 3 | 3 | 3 | 3 | 0.06 | 0.51 | 0.09 | 0.26 |
| 17 | 389 | 329 | M | 73 | 78 | 20 | . | 1274 | 979 | 11.4 | . | 21.5 | 0.58 | 3 | 3 | 3 | 3 | 0.03 | 0.50 | 0.09 | 0.29 |
| 17 | 389 | 330 | M | 73 | 94 | 20 | . | 2316 | 1899 | 11.5 | . | 21.5 | 0.69 | 2 | 2 | 2 | 2 | 0.08 | 0.87 | 0.38 | 0.33 |
| 17 | 389 | 331 | U | 73 | 88 | 24 | . | 2069 | 1739 | 11.3 | . | 20.5 | 0.69 | 2 | 2 | 2 | 2 | 0.04 | 0.81 | 0.46 | 0.33 |
| 17 | 391 | 310 | D | 73 | 11 | 7 | . | 957 | 626 | 7.9 | . | 17.3 | 4.37 | 3 | 3 | 3 | 2 | 0.10 | 0.63 | 0.03 | 0.19 |
| 17 | 391 | 311 | M | 73 | 14 | 6 | . | 977 | 591 | 6.5 | . | 12.1 | 3.23 | 3 | 3 | 3 | 3 | 0.20 | 0.52 | 0.08 | 0.53 |

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPOS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 391 | 312 | M | 73 | 12 | 5 | . | 782 | 635 | 7.5 | . | 19.4 | 3.71 | 3 | 3 | 3 | 3 | 0.23 | 0.80 | 0.17 | 0.44 |
| 18 | 090 | 502 | D | 73 | 24 | . | 15 | 3087 | 2301 | . | 8.5 | . | 1.18 | 4 | 2 | 4 | 6 | 0.11 | 0.68 | 0.22 | 0.15 |
| 18 | 091 | 502 | D | 74 | 211 | . | 65 | 9307 | 7434 | . | 4.5 | . | 0.43 | 7 | 2 | 7 | 5 | 0.50 | 0.45 | 0.10 | 0.26 |
| 18 | 091 | 502 | D | 77 | 68 | . | 35 | 6767 | 4541 | . | 19.0 | . | 0.84 | 3 | 2 | 2 | 2 | 0.34 | 0.62 | 0.40 | 0.09 |
| 18 | 092 | 502 | D | 74 | 56 | . | 36 | 8180 | 7002 | . | 3.4 | . | 0.96 | 5 | 2 | 5 | 5 | 0.39 | 0.07 | 0.19 | 0.23 |
| 18 | 092 | 502 | D | 75 | 60 | . | 26 | 4025 | 3271 | . | 4.1 | . | 0.95 | 6 | 2 | 6 | 6 | 0.23 | 0.07 | 0.13 | 0.18 |
| 18 | 092 | 502 | D | 77 | 37 | . | 26 | 6212 | 5487 | . | 2.9 | . | 1.12 | 4 | 2 | 4 | 3 | 0.35 | 0.20 | 0.27 | 0.18 |
| 18 | 093 | 317 | M | 73 | 59 | 13 | . | 1173 | 370 | 5.5 | . | 6.4 | 0.53 | 2 | 2 | 2 | 2 | 0.07 | 0.16 | 0.02 | 0.33 |
| 18 | 094 | 502 | D | 75 | 38 | . | 22 | 3733 | 3090 | . | 5.4 | . | 1.07 | 6 | 3 | 6 | 6 | 0.27 | 0.58 | 0.07 | 0.12 |
| 18 | 095 | 502 | D | 76 | 32 | . | 12 | 2367 | 1702 | . | 13.6 | . | 1.17 | 6 | 2 | 6 | 7 | 0.34 | 0.36 | 0.13 | 0.18 |
| 18 | 097 | 503 | M | 75 | 37 | . | 22 | 2400 | 1812 | . | 14.6 | . | 0.95 | 6 | 2 | 6 | 5 | 0.16 | 0.72 | 0.16 | 0.09 |
| 18 | 120 | 318 | U | 73 | 186 | 66 | . | 2334 | 1796 | 14.2 | . | 19.6 | 0.61 | 2 | 2 | 2 | 2 | 0.07 | 0.38 | 0.18 | 0.00 |
| 18 | 120 | 319 | U | 73 | 47 | 9 | . | 732 | 320 | 9.5 | . | 10.6 | 0.79 | 3 | 2 | 3 | 3 | 0.21 | 0.11 | 0.25 | 0.15 |
| 18 | 121 | 502 | D | 75 | 24 | . | 16 | 540 | 150 | . | 1.6 | . | 1.29 | 7 | 2 | 5 | 6 | 0.38 | 0.69 | 0.16 | 0.17 |
| 18 | 126 | 502 | D | 74 | 17 | . | 11 | 971 | 566 | . | 6.5 | . | 1.48 | 6 | 2 | 7 | 7 | 0.34 | 0.08 | 0.18 | 0.16 |
| 18 | 128 | 502 | D | 75 | 41 | . | 25 | 1043 | 496 | . | 6.4 | . | 1.24 | 7 | 2 | 7 | 7 | 0.38 | 0.01 | 0.24 | 0.15 |
| 18 | 129 | 502 | D | 74 | 21 | . | 11 | 1257 | 759 | . | 3.9 | . | 1.33 | 7 | 2 | 7 | 7 | 0.18 | 0.41 | 0.13 | 0.13 |
| 18 | 134 | 502 | D | 75 | 21 | . | 15 | 760 | 620 | . | 3.5 | . | 2.23 | 7 | 3 | 5 | 5 | 0.24 | 0.18 | 0.35 | 0.09 |
| 18 | 134 | 502 | D | 77 | 14 | . | 11 | 636 | 361 | . | 3.2 | . | 1.52 | 7 | 4 | 7 | 2 | 0.19 | 0.15 | 0.22 | 0.60 |
| 18 | 263 | 502 | D | 75 | 48 | . | 16 | 2044 | 1245 | . | 5.0 | . | 1.14 | 8 | 3 | 8 | 7 | 0.21 | 0.53 | 0.14 | 0.09 |
| 19 | 119 | 325 | M | 73 | 114 | 37 | . | 724 | 340 | 26.2 | . | 29.1 | 0.79 | 2 | 2 | 2 | 2 | 0.00 | 0.11 | 0.04 | 0.10 |
| 19 | 119 | 326 | M | 73 | 107 | 43 | . | 720 | 428 | 19.0 | . | 28.4 | 0.63 | 2 | 2 | 2 | 2 | 0.05 | 0.49 | 0.02 | 0.20 |
| 19 | 119 | 327 | M | 73 | 131 | 50 | . | 731 | 451 | 13.4 | . | 13.9 | 0.74 | 2 | 2 | 2 | 2 | 0.03 | 0.03 | 0.04 | 0.17 |
| 19 | 119 | 328 | M | 73 | 130 | 61 | . | 716 | 461 | 12.0 | . | 18.5 | 0.60 | 2 | 2 | 2 | 2 | 0.01 | 0.54 | 0.02 | 0.23 |
| 19 | 119 | 329 | M | 73 | 136 | 63 | . | 726 | 533 | 11.1 | . | 17.0 | 0.69 | 2 | 2 | 2 | 2 | 0.13 | 0.53 | 0.03 | 0.07 |
| 19 | 119 | 330 | M | 73 | 139 | 69 | . | 760 | 506 | 7.6 | . | 12.4 | 0.67 | 2 | 2 | 2 | 2 | 0.10 | 0.63 | 0.07 | 0.09 |
| 19 | 119 | 331 | U | 73 | 117 | 54 | . | 815 | 543 | 6.6 | . | 10.0 | 0.70 | 2 | 2 | 2 | 2 | 0.01 | 0.52 | 0.03 | 0.09 |
| 19 | 119 | 332 | U | 73 | 145 | 69 | . | 810 | 496 | 7.2 | . | 9.4 | 0.58 | 2 | 2 | 2 | 2 | 0.03 | 0.31 | 0.21 | 0.13 |
| 19 | 122 | 329 | M | 73 | 14 | 6 | . | 454 | 187 | 4.2 | . | 8.5 | 1.74 | 3 | 3 | 3 | 3 | 0.15 | 0.52 | 0.18 | 0.30 |
| 19 | 338 | 323 | M | 73 | 138 | 57 | . | 721 | 443 | 9.4 | . | 10.2 | 0.58 | 2 | 2 | 2 | 2 | 0.28 | 0.08 | 0.13 | 0.22 |
| 19 | 340 | 502 | D | 75 | 15 | . | 10 | 450 | 150 | . | 8.1 | . | 1.61 | 4 | 2 | 4 | 3 | 0.24 | 0.35 | 0.14 | 0.12 |
| 19 | 340 | 502 | D | 76 | 13 | . | 10 | 320 | 150 | . | 6.0 | . | 2.38 | 5 | 6 | 5 | 5 | 0.15 | 0.10 | 0.06 | 0.10 |
| 19 | 340 | 502 | D | 78 | 14 | . | 14 | 440 | 150 | . | 6.9 | . | 1.63 | 5 | 6 | 5 | 5 | 0.29 | 0.20 | 0.20 | 0.10 |
| 19 | 340 | 503 | M | 75 | 16 | . | 10 | 475 | 150 | . | 10.8 | . | 1.23 | 4 | 3 | 4 | 4 | 0.29 | 0.10 | 0.05 | 0.05 |
| 19 | 340 | 503 | M | 76 | 14 | . | 10 | 367 | 150 | . | 9.4 | . | 1.49 | 3 | 4 | 3 | 4 | 0.30 | 0.12 | 0.09 | 0.12 |
| 19 | 340 | 503 | M | 78 | 20 | . | 12 | 533 | 221 | . | 17.3 | . | 1.22 | 6 | 6 | 6 | 5 | 0.25 | 0.20 | 0.08 | 0.08 |
| 19 | 342 | 320 | M | 73 | 53 | 12 | . | 736 | 224 | 10.2 | . | 11.1 | 0.89 | 2 | 2 | 2 | 2 | 0.17 | 0.08 | 0.33 | 0.14 |
| 19 | 342 | 322 | M | 73 | 57 | 19 | . | 648 | 316 | 8.0 | . | 12.7 | 0.57 | 2 | 2 | 2 | 2 | 0.25 | 0.59 | 0.19 | 0.16 |
| 19 | 343 | 315 | U | 73 | 13 | 5 | . | 508 | 176 | 4.1 | . | 9.1 | 3.18 | 3 | 3 | 3 | 3 | 0.13 | 0.60 | 0.23 | 0.22 |
| 20 | 087 | 314 | M | 73 | 45 | 10 | . | 4627 | 3921 | 21.2 | . | 43.5 | 1.22 | 3 | 3 | 3 | 3 | 0.28 | 0.54 | 0.27 | 0.21 |

19 343 315 U 73 13 5 .
20 087 314 M 73 45 10 . 4627 3921 21.2 . 43.5 1.22 3

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 014 | 309 | D | 74 | 18 | 6 | . | 455 | 78 | 13.8 | . | 23.3 | 2.36 | 2 | 2 | 2 | 2 | 0.07 | 0.68 | 0.14 | 0.31 |
| 22 | 014 | 310 | M | 74 | 21 | 3 | . | 372 | 50 | 16.3 | . | 29.0 | 2.29 | 2 | 2 | 2 | 2 | 0.11 | 0.78 | 0.28 | 0.07 |
| 22 | 014 | 311 | U | 74 | 24 | 3 | . | 361 | 107 | 11.3 | . | 18.9 | 2.08 | 2 | 2 | 2 | 2 | 0.06 | 0.67 | 0.16 | 0.02 |
| 22 | 014 | 312 | M | 74 | 18 | 4 | . | 321 | 73 | 15.6 | . | 25.3 | 2.36 | 2 | 2 | 2 | 2 | 0.21 | 0.62 | 0.01 | 0.03 |
| 22 | 014 | 313 | M | 74 | 22 | 3 | . | 356 | 93 | 15.9 | . | 22.1 | 1.70 | 2 | 2 | 2 | 2 | 0.27 | 0.39 | 0.04 | 0.01 |
| 22 | 019 | 313 | D | 74 | 23 | 6 | . | 390 | 60 | 3.1 | . | 3.7 | 4.04 | 2 | 2 | 2 | 2 | 0.32 | 0.17 | 0.08 | 0.06 |
| 22 | 019 | 314 | M | 74 | 12 | 7 | . | 285 | 62 | 3.3 | . | 3.4 | 3.91 | 2 | 2 | 2 | 2 | 0.00 | 0.03 | 0.05 | 0.09 |
| 22 | 019 | 315 | M | 74 | 15 | 5 | . | 397 | 80 | 5.4 | . | 7.9 | 2.89 | 2 | 2 | 2 | 2 | 0.08 | 0.45 | 0.38 | 0.05 |
| 22 | 019 | 316 | U | 74 | 18 | 3 | . | 266 | 81 | 6.9 | . | 9.5 | 1.29 | 2 | 2 | 2 | 2 | 0.07 | 0.37 | 0.18 | 0.89 |
| 22 | 019 | 317 | U | 74 | 20 | 3 | . | 301 | 103 | 5.6 | . | 7.8 | 2.26 | 2 | 2 | 2 | 2 | 0.04 | 0.38 | 0.27 | 0.28 |
| 22 | 019 | 318 | U | 74 | 13 | 2 | . | 281 | 81 | 7.8 | . | 12.3 | 2.51 | 2 | 2 | 2 | 2 | 0.06 | 0.57 | 0.04 | 0.15 |
| 22 | 188 | 311 | M | 73 | 140 | 17 | . | 1177 | 365 | 5.7 | . | 7.3 | 0.46 | 2 | 2 | 2 | 2 | 0.59 | 0.28 | 0.00 | 0.44 |
| 22 | 188 | 312 | D | 73 | 136 | 19 | . | 931 | 332 | 3.7 | . | 4.5 | 0.53 | 2 | 2 | 2 | 2 | 0.59 | 0.22 | 0.02 | 0.52 |
| 22 | 188 | 313 | M | 73 | 151 | 17 | . | 1139 | 407 | 4.3 | . | 6.0 | 0.33 | 2 | 2 | 2 | 2 | 0.61 | 0.38 | 0.09 | 0.38 |
| 22 | 189 | 307 | U | 73 | 63 | 18 | . | 678 | 203 | 4.0 | . | 5.9 | 0.97 | 2 | 2 | 2 | 2 | 0.48 | 0.46 | 0.13 | 0.26 |
| 22 | 189 | 308 | M | 73 | 42 | 7 | . | 734 | 170 | 4.9 | . | 6.1 | 1.08 | 2 | 2 | 2 | 2 | 0.52 | 0.23 | 0.01 | 0.29 |
| 22 | 189 | 309 | D | 73 | 43 | 6 | . | 809 | 183 | 5.5 | . | 6.8 | 1.09 | 2 | 2 | 2 | 2 | 0.47 | 0.24 | 0.06 | 0.30 |
| 22 | 190 | 310 | D | 73 | 61 | 10 | . | 896 | 345 | 4.1 | . | 4.7 | 0.62 | 2 | 2 | 2 | 2 | 0.38 | 0.13 | 0.19 | 0.51 |
| 22 | 190 | 311 | U | 73 | 62 | 9 | . | 841 | 310 | 5.3 | . | 6.6 | 0.60 | 2 | 2 | 2 | 2 | 0.40 | 0.25 | 0.20 | 0.49 |
| 22 | 190 | 312 | U | 73 | 59 | 7 | . | 746 | 335 | 6.3 | . | 9.3 | 0.63 | 2 | 2 | 2 | 2 | 0.48 | 0.48 | 0.13 | 0.52 |
| 22 | 192 | 311 | D | 73 | 45 | 23 | . | 646 | 204 | 6.6 | . | 7.0 | 1.22 | 2 | 2 | 2 | 2 | 0.58 | 0.05 | 0.00 | 0.63 |
| 22 | 192 | 312 | M | 73 | 40 | 6 | . | 586 | 152 | 8.4 | . | 12.7 | 1.37 | 2 | 2 | 2 | 2 | 0.64 | 0.50 | 0.06 | 0.67 |
| 22 | 192 | 313 | M | 73 | 30 | 7 | . | 531 | 148 | 5.8 | . | 7.5 | 1.40 | 2 | 2 | 2 | 2 | 0.47 | 0.28 | 0.10 | 0.67 |
| 22 | 192 | 314 | U | 73 | 41 | 7 | . | 613 | 156 | 7.7 | . | 10.4 | 1.31 | 2 | 2 | 2 | 2 | 0.62 | 0.35 | 0.02 | 0.65 |
| 24 | 012 | 308 | D | 74 | 62 | 8 | . | 481 | 153 | 8.6 | . | 9.4 | 0.53 | 2 | 2 | 2 | 2 | 0.21 | 0.09 | 0.20 | 0.33 |
| 24 | 012 | 309 | M | 74 | 82 | 8 | . | 597 | 127 | 12.0 | . | 14.1 | 0.38 | 2 | 2 | 2 | 2 | 0.29 | 0.17 | 0.09 | 0.20 |
| 24 | 021 | 308 | M | 74 | 47 | 9 | . | 441 | 163 | 19.7 | . | 35.9 | 0.81 | 2 | 2 | 2 | 2 | 0.13 | 0.82 | 0.03 | 0.13 |
| 24 | 021 | 309 | D | 74 | 38 | 5 | . | 446 | 204 | 19.4 | . | 36.5 | 0.94 | 2 | 2 | 2 | 2 | 0.06 | 0.88 | 0.04 | 0.03 |
| 24 | 022 | 322 | M | 74 | 16 | 5 | . | 491 | 215 | 6.3 | . | 16.4 | 3.90 | 4 | 4 | 4 | 4 | 0.11 | 0.53 | 0.14 | 0.18 |
| 25 | 020 | 323 | D | 74 | 39 | 5 | . | 561 | 74 | 18.7 | . | 29.6 | 1.22 | 2 | 2 | 2 | 2 | 0.09 | 0.58 | 0.06 | 0.25 |
| 25 | 020 | 324 | M | 74 | 49 | 7 | . | 640 | 188 | 7.9 | . | 9.8 | 0.67 | 2 | 2 | 2 | 2 | 0.14 | 0.23 | 0.13 | 0.13 |
| 25 | 020 | 325 | M | 74 | 67 | 7 | . | 745 | 57 | 34.1 | . | 50.6 | 0.79 | 2 | 2 | 2 | 2 | 0.02 | 0.48 | 0.17 | 0.16 |
| 25 | 102 | 312 | D | 74 | 61 | 26 | . | 1314 | 904 | 7.3 | . | 11.6 | 0.38 | 2 | 3 | 2 | 3 | 0.50 | 0.41 | 0.39 | 0.12 |
| 25 | 102 | 313 | M | 74 | 105 | 29 | . | 1356 | 809 | 12.3 | . | 20.0 | 0.28 | 2 | 3 | 2 | 3 | 0.64 | 0.40 | 0.43 | 0.05 |
| 25 | 102 | 314 | M | 74 | 62 | 27 | . | 1265 | 904 | 9.8 | . | 15.1 | 0.41 | 2 | 3 | 2 | 3 | 0.27 | 0.43 | 0.38 | 0.17 |
| 25 | 103 | 307 | D | 74 | 57 | 14 | . | 933 | 620 | 2.6 | . | 3.7 | 0.24 | 2 | 3 | 2 | 3 | 0.50 | 0.38 | 0.22 | 0.19 |
| 25 | 104 | 305 | D | 74 | 51 | 15 | . | 786 | 495 | 8.6 | . | 18.9 | 0.30 | 2 | 3 | 2 | 3 | 0.22 | 0.61 | 0.17 | 0.00 |
| 25 | 104 | 306 | M | 74 | 51 | 16 | . | 825 | 486 | 6.8 | . | 10.8 | 0.27 | 2 | 3 | 2 | 3 | 0.12 | 0.29 | 0.23 | 0.06 |
| 25 | 105 | 313 | M | 74 | 317 | 74 | . | 2004 | 1207 | 10.8 | . | 15.2 | 0.21 | 3 | 3 | 3 | 3 | 0.63 | 0.37 | 0.25 | 0.28 |
| 25 | 107 | 307 | D | 74 | 56 | 13 | . | 1053 | 607 | 10.1 | . | 21.5 | 0.51 | 3 | 3 | 3 | 3 | 0.40 | 0.59 | 0.29 | 0.29 |

## WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 112 | 308 | D | 74 | 64 | 10 | . | 665 | 468 | 5.9 | . | 12.0 | 0.29 | 2 | 3 | 2 | 3 | 0.02 | 0.51 | 0.14 | 0.06 |
| 25 | 112 | 309 | M | 74 | 77 | 11 | . | 825 | 447 | 7.2 | . | 13.5 | 0.30 | 2 | 3 | 2 | 3 | 0.12 | 0.46 | 0.18 | 0.03 |
| 25 | 267 | 320 | U | 74 | 129 | 35 | . | 825 | 308 | 10.6 | . | 25.4 | 0.36 | 4 | 4 | 4 | 4 | 0.14 | 0.51 | 0.08 | 0.10 |
| 25 | 269 | 309 | D | 74 | 73 | 16 | . | 752 | 161 | 7.5 | . | 10.8 | 0.30 | 2 | 2 | 2 | 2 | 0.06 | 0.43 | 0.08 | 0.00 |
| 25 | 269 | 310 | M | 74 | 66 | 14 | . | 677 | 135 | 6.6 | . | 10.5 | 0.38 | 2 | 2 | 2 | 2 | 0.08 | 0.58 | 0.13 | 0.20 |
| 25 | 273 | 316 | D | 74 | 97 | 60 | . | 1191 | 590 | 11.6 | . | 25.1 | 0.58 | 3 | 3 | 3 | 3 | 0.18 | 0.60 | 0.17 | 0.29 |
| 25 | 273 | 317 | U | 74 | 250 | 100 | . | 1109 | 378 | 23.7 | . | 45.6 | 0.20 | 3 | 3 | 3 | 3 | 0.10 | 0.53 | 0.10 | 0.47 |
| 25 | 273 | 321 | M | 74 | 130 | 76 | . | 1078 | 530 | 7.2 | . | 20.5 | 0.37 | 4 | 4 | 4 | 4 | 0.15 | 0.61 | 0.08 | 0.23 |
| 25 | 273 | 322 | U | 74 | 470 | 103 | . | 1294 | 357 | 71.8 | . | 154.7 | 0.14 | 3 | 3 | 3 | 3 | 0.20 | 0.62 | 0.21 | 0.35 |
| 25 | 273 | 323 | U | 74 | 371 | 123 | . | 1854 | 821 | 41.0 | . | 71.1 | 0.14 | 2 | 2 | 2 | 2 | 0.05 | 0.73 | 0.21 | 0.09 |
| 25 | 273 | 325 | D | 74 | 154 | 110 | . | 1419 | 805 | 3.8 | . | 9.6 | 0.50 | 2 | 3 | 2 | 3 | 0.26 | 0.77 | 0.09 | 0.38 |
| 25 | 273 | 326 | U | 74 | 273 | 122 | . | 1398 | 598 | 92.7 | . | 181.0 | 0.14 | 2 | 2 | 2 | 2 | 0.06 | 0.95 | 0.02 | 0.45 |
| 25 | 275 | 321 | U | 74 | 152 | 37 | . | 1199 | 550 | 8.0 | . | 15.5 | 0.22 | 3 | 3 | 3 | 3 | 0.18 | 0.54 | 0.05 | 0.23 |
| 25 | 348 | 317 | D | 74 | 38 | 19 | . | 588 | 185 | 7.7 | . | 11.8 | 1.78 | 2 | 3 | 2 | 3 | 0.12 | 0.39 | 0.04 | 0.17 |
| 25 | 348 | 318 | M | 74 | 37 | 14 | . | 573 | 138 | 11.3 | . | 16.5 | 2.03 | 2 | 3 | 2 | 3 | 0.07 | 0.28 | 0.01 | 0.18 |
| 25 | 348 | 319 | M | 74 | 40 | 16 | . | 650 | 188 | 10.2 | . | 12.7 | 1.57 | 2 | 3 | 2 | 3 | 0.02 | 0.21 | 0.14 | 0.23 |
| 25 | 348 | 320 | U | 74 | 176 | 40 | . | 1008 | 330 | 19.5 | . | 29.6 | 0.30 | 2 | 3 | 2 | 3 | 0.56 | 0.40 | 0.02 | 0.29 |
| 25 | 348 | 321 | M | 74 | 59 | 29 | . | 631 | 160 | 13.7 | . | 18.1 | 1.37 | 2 | 3 | 2 | 3 | 0.06 | 0.32 | 0.00 | 0.11 |
| 25 | 348 | 322 | M | 74 | 61 | 26 | . | 605 | 151 | 20.6 | . | 29.6 | 0.91 | 2 | 3 | 2 | 3 | 0.09 | 0.36 | 0.13 | 0.19 |
| 25 | 348 | 323 | U | 74 | 188 | 65 | . | 981 | 298 | 29.5 | . | 53.8 | 0.25 | 2 | 2 | 2 | 3 | 0.15 | 0.82 | 0.16 | 0.20 |
| 25 | 370 | 304 | M | 74 | 93 | 12 | . | 780 | 203 | 13.6 | . | 23.5 | 0.44 | 3 | 3 | 3 | 3 | 0.36 | 0.38 | 0.10 | 0.80 |
| 26 | 354 | 101 | D | 74 | 23 | 10 | . | . | 340 | . | 5.5 | . | 0.58 | 2 | 2 | 0 | 2 | 0.43 | 0.27 | . | 0.43 |
| 26 | 354 | 101 | D | 75 | 168 | 66 | . | . | 415 | . | 3.5 | . | 0.33 | 2 | 2 | 0 | 2 | 0.21 | 0.38 | . | 0.08 |
| 26 | 354 | 101 | D | 77 | 98 | 24 | . | . | 304 | . | 28.0 | . | 0.66 | 3 | 3 | 0 | 3 | 0.28 | 0.90 | . | 0.44 |
| 26 | 354 | 101 | D | 78 | 163 | 35 | . | . | 430 | . | 3.3 | . | 1.14 | 2 | 2 | 0 | 2 | 0.57 | 0.97 | . | 0.33 |
| 26 | 354 | 102 | M | 74 | 32 | 10 | . | . | 345 | . | 4.0 | . | 0.30 | 2 | 2 | 0 | 2 | 0.58 | 0.00 | . | 0.17 |
| 26 | 354 | 102 | M | 75 | 204 | 117 | . | . | 295 | . | 6.8 | . | 0.15 | 2 | 2 | 0 | 2 | 0.15 | 0.04 | . | 0.00 |
| 26 | 354 | 103 | M | 74 | 38 | 10 | . | . | 335 | . | 4.0 | . | 0.24 | 2 | 2 | 0 | 2 | 0.22 | 0.00 | . | 0.26 |
| 26 | 354 | 103 | M | 75 | 158 | 92 | . | . | 290 | . | 6.4 | . | 0.18 | 2 | 2 | 0 | 2 | 0.16 | 0.21 | . | 0.14 |
| 26 | 355 | 317 | D | 74 | 36 | 15 | . | 620 | 275 | 9.7 | . | 19.4 | 1.17 | 3 | 3 | 3 | 3 | 0.15 | 0.50 | 0.19 | 0.28 |
| 26 | 355 | 319 | M | 74 | 233 | 22 | . | 1104 | 343 | 17.3 | . | 31.7 | 0.63 | 3 | 3 | 3 | 3 | 0.85 | 0.42 | 0.37 | 0.46 |
| 26 | 355 | 321 | U | 74 | 167 | 31 | . | 915 | 448 | 16.5 | . | 20.7 | 0.33 | 3 | 3 | 3 | 3 | 0.56 | 0.14 | 0.26 | 0.47 |
| 26 | 359 | 109 | M | 75 | 17 | 10 | . | . | . | . | 15.5 | . | 1.19 | 2 | 2 | 0 | 2 | 0.40 | 0.03 | . | 0.09 |
| 26 | 359 | 110 | U | 75 | 82 | 43 | . | . | . | . | 45.5 | . | 0.37 | 2 | 2 | 0 | 2 | 0.27 | 0.47 | . | 0.10 |
| 26 | 359 | 110 | U | 76 | 76 | 17 | . | . | 295 | . | 31.0 | . | 0.44 | 2 | 2 | 0 | 2 | 0.74 | 0.10 | . | 0.37 |
| 26 | 359 | 110 | U | 78 | 248 | 62 | . | . | 400 | . | 14.0 | . | 0.55 | 2 | 2 | 0 | 2 | 0.68 | 0.29 | . | 0.77 |
| 26 | 359 | 319 | D | 74 | 58 | 42 | . | 486 | 97 | 2.5 | . | 2.6 | 1.99 | 2 | 2 | 2 | 2 | 0.61 | 0.02 | 0.45 | 0.30 |
| 26 | 359 | 320 | M | 74 | 62 | 48 | . | 548 | 87 | 3.8 | . | 4.5 | 1.83 | 2 | 2 | 2 | 2 | 0.67 | 0.18 | 0.05 | 0.25 |
| 26 | 359 | 321 | M | 74 | 53 | 41 | . | 446 | 121 | 7.5 | . | 12.0 | 2.35 | 2 | 2 | 2 | 2 | 0.59 | 0.59 | 0.15 | 0.30 |
| 26 | 359 | 322 | M | 74 | 59 | 46 | . | 396 | 86 | 11.1 | . | 17.3 | 2.13 | 2 | 2 | 2 | 2 | 0.58 | 0.55 | 0.19 | 0.29 |



WATER QUALITY SUMMARY BY STATION-YEAR

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 359 | 321 | M | 74 | 53 | 41 | . | 396 | 86 | 11.1 | . | 17.3 | 2.13 | 2 | 2 | 2 |
| 26 | 359 | 322 | M | 74 | 59 | 46 | . | | | | | | | | | |

WATER QUALITY SUMMARY BY STATION-YEAR

---------------------------------------------- POOL DATA SCREEN CODE=B ----------------------------------------------

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 359 | 323 | U | 74 | 66 | 51 | . | 470 | 91 | 11.4 | . | 13.1 | 1.65 | 2 | 2 | 2 | 2 | 0.61 | 0.15 | 0.11 | 0.08 |
| 26 | 359 | 324 | U | 74 | 95 | 51 | . | 715 | 112 | 3.8 | . | 4.8 | 0.86 | 2 | 2 | 2 | 2 | 0.48 | 0.25 | 0.08 | 0.06 |
| 26 | 360 | 303 | D | 74 | 110 | 29 | . | 1081 | 145 | 28.5 | . | 42.6 | 0.46 | 2 | 3 | 2 | 3 | 0.00 | 0.26 | 0.05 | 0.33 |
| 28 | 218 | 007 | D | 77 | 20 | 7 | . | 356 | . | 3.8 | 4.0 | 7.8 | 2.41 | 3 | 3 | 3 | 3 | 0.30 | 0.54 | 0.41 | 0.19 |
| 28 | 219 | 012 | D | 77 | 22 | 5 | . | 456 | . | 4.4 | 4.7 | 6.8 | 1.71 | 2 | 2 | 2 | 2 | 0.56 | 0.53 | 0.23 | 0.38 |
| 28 | 219 | 012 | D | 78 | 26 | 17 | 28 | 430 | . | 2.6 | 2.7 | 2.8 | 1.88 | 2 | 2 | 2 | 2 | 0.19 | 0.07 | 0.23 | 0.30 |
| 29 | 100 | 305 | D | 74 | 56 | 7 | . | 1794 | 1231 | 9.9 | . | 23.4 | 0.81 | 2 | 3 | 2 | 3 | 0.28 | 0.68 | 0.09 | 0.06 |
| 29 | 100 | 306 | M | 74 | 61 | 7 | . | 1605 | 1041 | 17.6 | . | 38.8 | 0.71 | 2 | 3 | 2 | 3 | 0.34 | 0.60 | 0.05 | 0.07 |
| 29 | 100 | 307 | M | 74 | 60 | 8 | . | 1745 | 1133 | 7.5 | . | 15.1 | 0.66 | 2 | 3 | 2 | 3 | 0.25 | 0.51 | 0.10 | 0.15 |
| 29 | 100 | 308 | M | 74 | 72 | 9 | . | 1854 | 1241 | 13.5 | . | 31.5 | 0.66 | 2 | 3 | 2 | 3 | 0.27 | 0.67 | 0.09 | 0.08 |
| 29 | 100 | 309 | U | 74 | 98 | 12 | . | 1764 | 971 | 11.8 | . | 25.3 | 0.32 | 2 | 3 | 2 | 3 | 0.12 | 0.59 | 0.14 | 0.50 |
| 29 | 100 | 310 | U | 74 | 73 | 9 | . | 1958 | 1152 | 11.9 | . | 28.8 | 0.51 | 2 | 3 | 2 | 3 | 0.21 | 0.73 | 0.09 | 0.20 |
| 29 | 106 | 310 | D | 74 | 48 | 12 | . | 1189 | 603 | 8.7 | . | 14.8 | 0.41 | 3 | 3 | 3 | 2 | 0.18 | 0.46 | 0.14 | 0.13 |
| 29 | 108 | 313 | D | 74 | 66 | 38 | . | 1214 | 755 | 11.3 | . | 24.6 | 1.37 | 3 | 3 | 3 | 3 | 0.40 | 0.62 | 0.19 | 0.50 |
| 29 | 109 | 307 | D | 74 | 37 | 10 | . | 811 | 334 | 24.5 | . | 58.6 | 1.12 | 3 | 3 | 3 | 3 | 0.22 | 0.71 | 0.25 | 0.39 |
| 29 | 109 | 308 | M | 74 | 36 | 4 | . | 932 | 302 | 36.3 | . | 74.7 | 1.23 | 3 | 3 | 3 | 3 | 0.27 | 0.55 | 0.17 | 0.37 |
| 29 | 109 | 309 | M | 74 | 34 | 12 | . | 889 | 339 | 30.4 | . | 60.7 | 0.77 | 3 | 3 | 3 | 3 | 0.08 | 0.53 | 0.17 | 0.10 |
| 29 | 110 | 319 | U | 74 | 57 | 21 | . | 1485 | 1056 | 2.4 | . | 2.9 | 0.60 | 2 | 2 | 2 | 2 | 0.15 | 0.21 | 0.22 | 0.02 |
| 29 | 111 | 312 | M | 74 | 50 | 22 | . | 1576 | 1090 | 9.5 | . | 11.3 | 0.41 | 3 | 2 | 3 | 2 | 0.19 | 0.18 | 0.10 | 0.13 |
| 29 | 113 | 327 | D | 74 | 134 | 105 | . | 1804 | 1417 | 5.1 | . | 7.5 | 1.20 | 2 | 3 | 2 | 3 | 0.37 | 0.26 | 0.20 | 0.45 |
| 29 | 113 | 328 | M | 74 | 153 | 106 | . | 1810 | 1404 | 10.1 | . | 14.4 | 0.74 | 2 | 3 | 2 | 3 | 0.25 | 0.23 | 0.23 | 0.45 |
| 29 | 113 | 329 | M | 74 | 197 | 75 | . | 1451 | 815 | 18.6 | . | 34.5 | 0.29 | 2 | 3 | 2 | 3 | 0.20 | 0.46 | 0.05 | 0.21 |
| 29 | 114 | 307 | D | 74 | 22 | 6 | . | 956 | 305 | 8.4 | . | 19.4 | 1.49 | 2 | 3 | 2 | 3 | 0.05 | 0.67 | 0.09 | 0.44 |
| 29 | 114 | 308 | M | 74 | 21 | 6 | . | 855 | 276 | 7.8 | . | 15.9 | 1.50 | 2 | 3 | 2 | 3 | 0.06 | 0.53 | 0.02 | 0.39 |
| 29 | 114 | 309 | M | 74 | 25 | 4 | . | 850 | 290 | 10.4 | . | 17.5 | 1.18 | 2 | 3 | 2 | 3 | 0.09 | 0.44 | 0.19 | 0.39 |
| 29 | 194 | 315 | U | 74 | 64 | 7 | . | 634 | 95 | 19.7 | . | 20.9 | 0.58 | 2 | 2 | 2 | 2 | 0.18 | 0.06 | 0.31 | 0.30 |
| 29 | 195 | 316 | M | 74 | 20 | 6 | . | 950 | 632 | 10.6 | . | 25.8 | 1.95 | 3 | 3 | 3 | 3 | 0.21 | 0.73 | 0.21 | 0.22 |
| 29 | 195 | 317 | U | 74 | 26 | 5 | . | 1026 | 688 | 12.3 | . | 29.2 | 1.31 | 3 | 3 | 3 | 3 | 0.17 | 0.70 | 0.24 | 0.21 |
| 29 | 195 | 318 | M | 74 | 19 | 7 | . | 815 | 534 | 5.8 | . | 13.0 | 2.03 | 3 | 3 | 3 | 3 | 0.06 | 0.63 | 0.15 | 0.18 |
| 29 | 195 | 319 | U | 74 | 28 | 8 | . | 865 | 556 | 10.7 | . | 21.8 | 1.64 | 3 | 3 | 3 | 3 | 0.13 | 0.53 | 0.22 | 0.24 |
| 29 | 207 | 312 | U | 74 | 164 | 71 | . | 929 | 275 | 47.9 | . | 101.6 | 0.29 | 3 | 3 | 3 | 3 | 0.45 | 0.57 | 0.36 | 0.06 |
| 30 | 064 | 306 | M | 75 | 66 | 12 | . | 903 | 47 | 49.2 | . | 124.5 | 0.74 | 3 | 3 | 3 | 3 | 0.17 | 0.77 | 0.15 | 0.14 |
| 30 | 215 | 304 | D | 74 | 57 | 20 | . | 1055 | 246 | 11.4 | . | 21.1 | 1.37 | 2 | 3 | 2 | 3 | 0.47 | 0.42 | 0.22 | 0.33 |
| 30 | 215 | 305 | M | 74 | 66 | 20 | . | 1101 | 155 | 19.3 | . | 34.5 | 1.02 | 2 | 3 | 2 | 3 | 0.56 | 0.43 | 0.26 | 0.26 |
| 30 | 217 | 306 | D | 74 | 60 | 18 | . | 983 | 177 | 20.0 | . | 27.5 | 1.07 | 2 | 3 | 2 | 3 | 0.43 | 0.25 | 0.24 | 0.14 |
| 30 | 217 | 307 | M | 74 | 53 | 18 | . | 946 | 68 | 17.6 | . | 32.1 | 1.13 | 2 | 3 | 2 | 3 | 0.45 | 0.41 | 0.12 | 0.13 |
| 30 | 217 | 308 | M | 74 | 52 | 15 | . | 813 | 68 | 13.5 | . | 21.1 | 1.12 | 2 | 3 | 2 | 3 | 0.38 | 0.32 | 0.07 | 0.12 |
| 30 | 235 | 325 | M | 74 | 27 | 13 | . | 316 | 158 | 7.6 | . | 10.8 | 1.42 | 2 | 3 | 2 | 3 | 0.01 | 0.32 | 0.06 | 0.26 |
| 30 | 235 | 326 | M | 74 | 37 | 12 | . | 356 | 162 | 7.2 | . | 8.1 | 0.81 | 2 | 3 | 2 | 3 | 0.48 | 0.08 | 0.38 | 0.25 |
| 30 | 235 | 327 | U | 74 | 109 | 14 | . | 732 | 100 | 30.3 | . | 35.5 | 0.34 | 2 | 3 | 2 | 3 | 0.44 | 0.10 | 0.56 | 0.18 |

## WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | STA | TYPE | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 235 | 328 | U | 74 | 386 | 15 | . | 845 | 305 | 12.7 | . | 14.8 | 0.20 | 2 | 3 | 2 | 3 | 0.82 | 0.16 | 0.74 | 0.25 |
| 32 | 204 | 313 | M | 75 | 62 | 51 | . | 286 | 92 | 3.4 | . | 5.9 | 2.37 | 2 | 2 | 2 | 2 | 0.27 | 0.74 | 0.23 | 0.80 |
| 32 | 204 | 317 | M | 75 | 44 | 34 | . | 280 | 83 | 1.3 | . | 1.9 | 4.74 | 3 | 3 | 3 | 2 | 0.45 | 0.21 | 0.14 | 0.93 |
| 33 | 300 | 306 | D | 75 | 20 | 10 | . | 288 | 57 | 3.2 | . | 3.8 | 1.75 | 2 | 2 | 2 | 2 | 0.09 | 0.17 | 0.24 | 0.13 |
| 34 | 041 | 112 | D | 71 | 45 | 9 | . | 262 | 41 | 1.0 | . | 1.8 | 5.68 | 8 | 5 | 6 | 7 | 0.17 | 0.23 | 0.14 | 0.06 |
| 34 | 041 | 112 | D | 72 | 16 | 7 | . | 264 | 21 | 1.3 | . | 2.5 | 6.50 | 7 | 7 | 7 | 6 | 0.15 | 0.21 | 0.23 | 0.12 |
| 34 | 041 | 112 | D | 73 | 10 | 10 | . | 115 | 25 | 0.9 | . | 1.5 | 5.44 | 6 | 6 | 6 | 5 | 0.00 | 0.19 | 0.04 | 0.14 |
| 34 | 041 | 112 | D | 74 | 10 | 10 | . | 186 | 24 | 0.8 | . | 1.8 | 7.08 | 7 | 7 | 7 | 7 | 0.00 | 0.23 | 0.22 | 0.09 |
| 34 | 041 | 112 | D | 75 | 13 | 10 | . | . | 34 | 1.5 | . | 3.3 | 3.95 | 7 | 7 | 0 | 6 | 0.14 | 0.24 | . | 0.19 |
| 34 | 041 | 112 | D | 76 | 10 | 10 | . | . | 20 | 0.6 | . | 1.2 | 3.44 | 6 | 7 | 0 | 5 | 0.00 | 0.20 | . | 0.24 |
| 34 | 041 | 112 | D | 78 | 12 | 10 | . | 205 | 47 | 1.0 | . | 1.6 | 3.39 | 4 | 4 | 4 | 3 | 0.20 | 0.25 | 0.35 | 0.49 |



Not

Table B4

Water Quality Data Summary by Reservoir-Year

| Symbol | Meaning |
|---|---|
| DIS | CE District code |
| RES | CE reservoir code |
| YEAR | year of sample |

Note: Data listed by screen code (A or B) and in 2 parameter groups; screen codes reflect data reliability (see Part III of the main text) District and reservoir codes are defined in Appendix A.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR
POOL DATA SCREEN CODE=A

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CDEP | STATION DEPTH (M) | 66 | 18.90 | 27.11 | 2.18 | 175.40 |
| CPHF | PH (STANDARD UNITS) | 85 | 7.84 | 0.49 | 6.37 | 8.48 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 85 | 512.29 | 589.18 | 23.50 | 4599.87 |
| CALK | ALKALINITY (MG/L) | 82 | 97.05 | 59.24 | 10.50 | 293.75 |
| CTMP | TEMPERATURE (DEG-C) | 85 | 20.46 | 2.80 | 14.85 | 27.56 |
| CTRJ | TURDIBITY (JTU) | 1 | 17.62 | . | 17.62 | 17.62 |
| CTRH | HACH TURBIDITY (NTU) | 22 | 9.29 | 10.76 | 2.25 | 34.81 |
| CTRN | -LOG(% TRANS./100) | 62 | 0.48 | 0.49 | 0.05 | 2.15 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 6 | 54.09 | 38.19 | 13.33 | 98.65 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 85 | 0.98 | 0.84 | 0.15 | 5.24 |
| CRTL | TOTAL SOLIDS (MG/L) | 8 | 155.36 | 115.94 | 9.50 | 389.58 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 8 | 101.02 | 47.64 | 48.42 | 165.32 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 20 | 8.52 | 9.32 | 1.00 | 38.56 |
| CALG | ALGAL COUNT (NO/LITER) | 3 | 166558.33 | 113305.93 | 66900.00 | 289800.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 3 | 0.03 | 0.02 | 0.01 | 0.05 |

------------------------------------- POOL DATA SCREEN CODE=B -------------------------------------

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CDEP | STATION DEPTH (M) | 33 | 14.27 | 13.46 | 2.82 | 78.80 |
| CPHF | PH (STANDARD UNITS) | 70 | 7.71 | 0.51 | 6.27 | 8.43 |
| CCNF | CONDUCTIVITY (UMHOS/CM) | 69 | 345.36 | 365.02 | 34.33 | 2393.00 |
| CALK | ALKALINITY (MG/L) | 61 | 96.82 | 74.20 | 11.35 | 292.83 |
| CTMP | TEMPERATURE (DEG-C) | 71 | 21.46 | 4.17 | 11.65 | 28.91 |
| CTRJ | TURDIBITY (JTU) | 4 | 105.73 | 117.87 | 23.75 | 280.00 |
| CTRH | HACH TURBIDITY (NTU) | 22 | 3.48 | 3.17 | 0.67 | 13.77 |
| CTRN | -LOG(% TRANS./100) | 36 | 0.50 | 0.56 | 0.04 | 2.45 |
| CTCO | TRUE COLOR (PT-CO UNITS) | 3 | 111.11 | 163.72 | 10.00 | 300.00 |
| CALPH | NON-ALGAL TURBIDITY (1/M) | 73 | 0.95 | 0.97 | 0.12 | 4.93 |
| CRTL | TOTAL SOLIDS (MG/L) | 13 | 226.27 | 135.16 | 10.00 | 465.93 |
| CRFL | DISSOLVED SOLIDS (MG/L) | 9 | 164.84 | 186.86 | 8.80 | 500.00 |
| CRNF | SUSPENDED SOLIDS (MG/L) | 25 | 32.25 | 112.00 | 0.00 | 566.67 |
| CALG | ALGAL COUNT (NO/LITER) | 12 | 196156.24 | 205325.84 | 61500.00 | 738500.00 |
| CBIO | ALGAL VOLUME (ML/LITER) | 11 | 0.09 | 0.11 | 0.01 | 0.30 |

## WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 | 73 | 23.8 | 7.11 | 74 | 11 | 18.2 | . | . | 0.12 | . | 0.17 | . | . | . | . | . |
| 04 | 312 | 73 | 6.9 | 8.06 | 273 | 105 | 17.3 | . | . | 0.20 | . | 0.45 | . | . | . | . | . |
| 06 | 372 | 73 | 16.0 | 7.48 | 503 | 33 | 21.9 | . | . | 0.32 | . | 1.11 | . | . | . | . | . |
| 10 | 001 | 77 | . | 7.21 | 148 | 46 | 19.7 | . | 34.8 | . | 98 | 1.11 | . | 82 | . | . | . |
| 10 | 003 | 73 | 20.2 | 6.74 | 795 | 20 | 24.9 | . | . | 0.16 | . | 0.75 | . | . | . | . | . |
| 10 | 004 | 77 | . | 7.12 | 123 | 42 | 23.8 | . | 24.0 | . | 64 | 1.06 | . | 72 | . | . | . |
| 10 | 008 | 77 | . | 7.16 | 148 | 41 | 23.2 | . | 31.2 | . | 99 | 1.06 | . | 84 | . | . | . |
| 10 | 072 | 78 | . | 7.36 | 63 | 17 | 26.7 | . | 8.4 | . | 21 | 0.83 | . | 55 | 6 | . | . |
| 10 | 073 | 75 | . | 6.69 | 56 | 17 | 22.1 | 17.6 | . | . | 31 | 1.77 | 64 | 48 | 15 | . | . |
| 10 | 411 | 73 | 13.9 | 6.69 | 816 | 25 | 25.4 | . | . | 0.25 | . | 0.80 | . | . | . | . | . |
| 15 | 178 | 77 | 19.5 | 7.97 | 230 | 118 | 18.3 | . | 2.7 | . | 13 | 0.16 | . | . | 3 | . | . |
| 15 | 237 | 74 | 6.4 | 8.48 | 652 | 294 | 17.0 | . | . | 0.15 | . | 0.37 | . | . | . | . | . |
| 16 | 243 | 73 | 6.6 | 7.92 | 422 | 79 | 18.3 | . | . | 0.26 | . | 0.85 | . | . | . | . | . |
| 16 | 254 | 73 | 5.4 | 7.71 | 220 | 44 | 18.2 | . | . | 0.33 | . | 0.23 | . | . | . | . | . |
| 16 | 317 | 73 | 6.2 | 8.00 | 208 | 53 | 18.5 | . | . | 0.20 | . | 0.43 | . | . | . | . | . |
| 16 | 328 | 73 | 20.0 | 7.57 | 138 | 23 | 16.3 | . | . | 0.17 | . | 0.49 | . | . | . | . | . |
| 16 | 393 | 73 | 28.8 | 6.51 | 521 | 11 | 22.3 | . | . | 0.11 | . | 0.30 | . | . | . | . | . |
| 17 | 241 | 73 | 4.6 | 8.25 | 294 | 48 | 19.2 | . | . | 0.43 | . | 0.82 | . | . | . | . | . |
| 17 | 242 | 73 | 2.3 | 7.56 | 559 | 72 | 19.1 | . | . | 2.15 | . | 3.31 | . | . | . | . | . |
| 17 | 245 | 73 | 3.3 | 8.25 | 397 | 134 | 19.3 | . | . | 1.71 | . | 0.67 | . | . | . | . | . |
| 17 | 247 | 73 | 5.6 | 8.30 | 466 | 188 | 19.0 | . | . | 1.28 | . | 1.26 | . | . | . | . | . |
| 17 | 248 | 73 | 4.2 | 8.11 | 493 | 158 | 19.7 | . | . | 1.25 | . | 2.34 | . | . | . | . | . |
| 17 | 249 | 73 | 4.4 | 7.97 | 429 | 134 | 19.2 | . | . | 0.91 | . | 1.61 | . | . | . | . | . |
| 17 | 256 | 73 | 5.9 | 8.24 | 323 | 128 | 18.6 | . | . | 0.26 | . | 0.37 | . | . | . | . | . |
| 17 | 258 | 73 | 5.6 | 8.26 | 669 | 76 | 19.2 | . | . | 0.43 | . | 0.28 | . | . | . | . | . |
| 17 | 373 | 73 | 24.1 | 7.40 | 1350 | 24 | 20.0 | . | . | 0.20 | . | 0.45 | . | . | . | . | . |
| 17 | 391 | 73 | 30.7 | 7.10 | 307 | 10 | 20.7 | . | . | 0.14 | . | 0.15 | . | . | . | . | . |
| 18 | 090 | 75 | . | 8.01 | 341 | 158 | 21.1 | . | 5.5 | . | . | 0.79 | 195 | . | 6 | 66900 | 0.035 |
| 18 | 090 | 77 | . | 8.19 | 341 | 96 | 22.5 | . | 4.0 | . | . | 0.76 | . | . | 3 | . | . |
| 18 | 091 | 75 | . | 8.05 | 517 | 155 | 21.5 | . | 19.5 | . | . | 1.93 | 390 | . | 21 | 289800 | 0.047 |
| 18 | 092 | 73 | 12.9 | 8.02 | 1849 | 178 | 19.6 | . | . | 0.55 | . | 1.36 | . | . | . | . | . |
| 18 | 093 | 73 | 11.6 | 7.37 | 572 | 30 | 22.3 | . | . | 0.23 | . | 0.68 | . | . | . | . | . |
| 18 | 093 | 77 | . | 7.65 | 139 | 25 | 21.2 | . | 2.7 | . | . | 0.41 | . | . | 2 | . | . |
| 18 | 095 | 77 | . | 8.28 | 381 | 120 | 22.0 | . | 3.0 | . | . | 0.73 | . | . | 3 | . | . |
| 18 | 097 | 77 | . | 8.20 | 401 | 132 | 21.5 | . | 2.4 | . | . | 0.66 | 10 | . | 3 | . | . |
| 18 | 120 | 73 | 10.5 | 8.07 | 835 | 81 | 24.0 | . | . | 0.26 | . | 0.74 | . | . | . | . | . |
| 18 | 120 | 77 | . | 8.35 | 194 | 72 | 24.8 | . | 2.3 | . | . | 0.44 | . | . | 1 | . | . |
| 18 | 121 | 77 | . | 7.62 | 161 | . | 22.0 | . | 3.7 | . | . | 0.62 | . | . | 7 | . | . |
| 18 | 126 | 77 | . | 7.68 | 137 | 43 | 22.9 | . | 3.2 | . | . | 0.54 | . | . | 2 | . | . |
| 18 | 128 | 77 | . | 8.27 | 227 | . | 24.3 | . | 2.4 | . | . | 0.46 | . | . | 2 | . | . |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 129 | 77 | . | 7.67 | 205 | 80 | 22.6 | . | 2.3 | . | . | 0.49 | . | . | 2 | . | . |
| 18 | 134 | 75 | . | 7.61 | 104 | 34 | 25.8 | . | 6.3 | . | . | 0.36 | 73 | . | 5 | 142975 | 0.011 |
| 18 | 260 | 77 | . | 7.55 | 321 | . | 19.9 | . | 29.9 | . | . | 2.34 | . | . | 39 | . | . |
| 18 | 263 | 77 | . | 8.33 | 437 | 178 | 19.5 | . | 4.5 | . | . | 0.98 | . | . | 6 | . | . |
| 19 | 119 | 73 | 17.9 | 7.67 | 644 | 73 | 21.9 | . | . | 0.43 | . | 1.13 | . | . | . | . | . |
| 19 | 122 | 73 | 34.3 | 7.56 | 626 | 38 | 22.5 | . | . | 0.33 | . | 0.54 | . | . | . | . | . |
| 19 | 338 | 73 | 10.4 | 7.38 | 742 | 58 | 22.6 | . | . | 0.37 | . | 1.34 | . | . | . | . | . |
| 19 | 340 | 73 | 17.0 | 8.04 | 1001 | 119 | 23.0 | . | . | 0.14 | . | 0.40 | . | . | . | . | . |
| 19 | 340 | 75 | 15.1 | 8.16 | 266 | 128 | 27.6 | . | 3.9 | . | . | 0.64 | 155 | 136 | 19 | . | . |
| 19 | 340 | 76 | 12.7 | 7.72 | 271 | 145 | 23.4 | . | 4.7 | . | . | 0.50 | 175 | 165 | 10 | . | . |
| 19 | 340 | 78 | 14.2 | 7.58 | 286 | 157 | 24.6 | . | 3.0 | . | . | 0.79 | 182 | 165 | 17 | . | . |
| 19 | 342 | 73 | 17.9 | 7.89 | 573 | 52 | 21.1 | . | . | 0.29 | . | 1.12 | . | . | . | . | . |
| 19 | 343 | 73 | 24.2 | 7.65 | 815 | 62 | 22.6 | . | . | 0.05 | . | 0.22 | . | . | . | . | . |
| 20 | 081 | 73 | 8.7 | 8.03 | 1512 | 133 | 20.5 | . | . | 0.67 | . | 1.43 | . | . | . | . | . |
| 20 | 087 | 73 | 10.3 | 8.04 | 1676 | 164 | 20.7 | . | . | 0.35 | . | 0.64 | . | . | . | . | . |
| 20 | 088 | 73 | 4.3 | 7.68 | 1136 | 63 | 21.4 | . | . | 0.56 | . | 0.85 | . | . | . | . | . |
| 21 | 196 | 74 | 8.4 | 7.83 | 164 | 74 | 17.5 | . | . | 0.21 | . | 0.75 | . | . | . | . | . |
| 24 | 011 | 74 | 34.0 | 7.64 | 116 | 47 | 20.1 | . | . | 0.11 | . | 0.57 | . | . | . | . | . |
| 24 | 013 | 74 | 40.1 | 8.34 | 198 | 127 | 20.1 | . | . | 0.07 | . | 0.17 | . | . | . | . | . |
| 24 | 016 | 74 | 34.7 | 7.01 | 44 | 18 | 23.4 | . | . | 0.05 | . | 0.22 | . | . | . | . | . |
| 24 | 022 | 74 | 35.0 | 8.26 | 246 | 158 | 20.7 | . | . | 0.06 | . | 0.21 | . | . | . | . | . |
| 24 | 193 | 74 | 7.7 | 8.02 | 218 | 103 | 16.9 | . | . | 0.18 | . | 0.66 | . | . | . | . | . |
| 24 | 200 | 74 | 35.9 | 8.22 | 203 | 98 | 19.9 | . | . | 0.11 | . | 0.26 | . | . | . | . | . |
| 25 | 105 | 74 | 2.2 | 8.16 | 392 | 176 | 17.7 | . | . | 1.84 | . | 5.24 | . | . | . | . | . |
| 25 | 107 | 74 | 7.3 | 8.39 | 524 | 130 | 16.5 | . | . | 1.24 | . | 2.23 | . | . | . | . | . |
| 25 | 267 | 74 | 16.3 | 7.81 | 399 | 81 | 21.7 | . | . | 0.70 | . | 2.42 | . | . | . | . | . |
| 25 | 273 | 74 | 11.9 | 8.08 | 1520 | 129 | 19.8 | . | . | 1.68 | . | 3.23 | . | . | . | . | . |
| 25 | 275 | 74 | 10.9 | 7.73 | 309 | 111 | 21.1 | . | . | 0.83 | . | 2.29 | . | . | . | . | . |
| 25 | 278 | 74 | 29.5 | 8.09 | 163 | 75 | 21.0 | . | . | 0.13 | . | 0.53 | . | . | . | . | . |
| 25 | 281 | 74 | 11.0 | 6.37 | 61 | 22 | 22.7 | . | . | 0.47 | . | 1.59 | . | . | . | . | . |
| 25 | 370 | 74 | 6.9 | 8.28 | 4600 | 85 | 22.4 | . | . | 1.06 | . | 1.12 | . | . | . | . | . |
| 26 | 355 | 74 | 8.8 | 8.17 | 342 | 109 | 23.8 | . | . | 0.63 | . | 1.66 | . | . | . | . | . |
| 28 | 219 | 75 | 16.4 | 8.29 | 817 | 154 | 18.5 | . | . | 0.07 | . | 0.76 | . | . | . | . | . |
| 29 | 106 | 74 | 7.3 | 8.06 | 1345 | 156 | 16.7 | . | . | 1.18 | . | 2.62 | . | . | . | . | . |
| 29 | 108 | 74 | 11.4 | 8.36 | 785 | 203 | 16.5 | . | . | 0.70 | . | 1.04 | . | . | . | . | . |
| 29 | 109 | 74 | 12.6 | 8.34 | 575 | 150 | 17.5 | . | . | 0.12 | . | 0.30 | . | . | . | . | . |
| 29 | 110 | 74 | 12.1 | 8.24 | 385 | 167 | 17.9 | . | . | 0.35 | . | 1.75 | . | . | . | . | . |
| 29 | 111 | 74 | 7.5 | 8.20 | 351 | 144 | 17.7 | . | . | 0.34 | . | 1.93 | . | . | . | . | . |
| 29 | 194 | 74 | 12.5 | 8.20 | 240 | 120 | 18.5 | . | . | 0.48 | . | 0.71 | . | . | . | . | . |
| 29 | 195 | 74 | 22.4 | 8.19 | 285 | 130 | 17.0 | . | . | 0.11 | . | 0.35 | . | . | . | . | . |

29 194 ... 22.4 8.19 ...
29 195 74

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 207 | 74 | 9.9 | 8.41 | 528 | 201 | 16.1 | . | . | 0.72 | . | 1.35 | . | . | . | . | . |
| 30 | 064 | 75 | 4.6 | 8.37 | 470 | 175 | 15.6 | . | . | 0.17 | . | 0.70 | . | . | . | . | . |
| 30 | 235 | 74 | 23.1 | 8.17 | 675 | 175 | 15.1 | . | . | 0.72 | . | 1.07 | . | . | . | . | . |
| 31 | 077 | 75 | 175.4 | 7.21 | 23 | 17 | 14.9 | . | . | 0.05 | . | 0.35 | . | . | . | . | . |
| 32 | 204 | 75 | 145.8 | 8.35 | 179 | 99 | 16.2 | . | . | 0.16 | . | 0.21 | . | . | . | . | . |

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | 72 | . | 7.07 | 110 | 16 | 19.0 | . | . | 0.07 | . | 0.30 | . | . | . | . | . |
| 04 | 320 | 74 | . | 7.49 | 194 | 59 | 20.7 | . | . | . | . | 0.31 | . | . | . | . | . |
| 08 | 074 | 73 | 20.1 | 7.43 | 250 | 19 | 28.3 | . | . | 0.14 | . | 0.43 | . | . | . | . | . |
| 08 | 330 | 73 | 23.3 | 6.87 | 207 | 12 | 28.3 | . | . | 0.36 | . | 0.30 | . | . | . | . | . |
| 10 | 069 | 73 | 15.9 | 7.07 | 170 | 16 | 26.8 | . | . | 0.11 | . | 0.45 | . | . | . | . | . |
| 10 | 071 | 73 | 7.0 | 7.47 | 593 | 48 | 28.4 | . | . | 0.22 | . | 0.85 | . | . | . | . | . |
| 10 | 072 | 73 | 11.5 | 8.11 | 312 | 19 | 28.9 | . | . | 0.24 | . | 0.72 | . | . | . | . | . |
| 10 | 076 | 73 | 27.8 | 7.54 | 138 | 11 | 27.7 | . | . | 0.10 | . | 0.24 | . | . | . | . | . |
| 14 | 099 | 74 | 10.7 | 7.97 | 669 | 293 | 15.9 | . | . | 1.20 | . | 1.58 | . | . | . | . | . |
| 15 | 178 | 72 | . | 8.19 | 431 | 103 | 15.5 | . | . | 0.11 | . | 0.15 | . | . | . | . | . |
| 15 | 178 | 76 | . | 8.33 | 223 | 110 | 18.2 | . | 2.2 | . | 23 | 0.15 | . | . | . | . | . |
| 15 | 178 | 78 | 19.8 | 7.90 | 213 | 98 | . | . | 1.3 | . | 10 | 0.27 | . | . | 3 | . | . |
| 15 | 179 | 79 | . | 8.43 | 653 | 222 | 19.2 | . | . | . | . | 0.15 | . | 19 | . | . | . |
| 15 | 181 | 72 | . | 8.24 | 263 | 134 | 14.8 | . | . | 0.50 | . | 0.31 | . | . | . | . | . |
| 15 | 399 | 78 | . | 8.20 | . | 189 | 11.6 | . | . | . | . | 0.29 | . | . | . | . | . |
| 15 | 399 | 79 | . | 8.05 | 373 | 133 | 15.5 | . | . | . | . | 0.24 | . | 9 | . | . | . |
| 16 | 328 | 72 | . | 7.87 | 163 | 36 | 17.3 | . | . | 0.31 | . | 0.45 | . | . | . | . | . |
| 17 | 389 | 73 | 5.3 | 8.06 | 723 | 54 | 20.9 | . | . | 0.49 | . | 1.14 | . | . | . | . | . |
| 18 | 090 | 73 | . | 7.91 | 369 | 135 | 21.3 | . | . | . | . | 0.63 | 208 | . | 5 | 113100 | 0.075 |
| 18 | 091 | 74 | . | 8.04 | 536 | 149 | 19.2 | . | 13.8 | . | . | 2.23 | 466 | . | 57 | 738500 | 0.262 |
| 18 | 091 | 77 | . | 8.04 | 690 | . | 19.8 | . | 2.8 | . | . | 0.72 | . | . | 17 | . | . |
| 18 | 092 | 74 | . | 8.03 | 542 | 152 | 22.5 | . | 0.7 | . | . | 0.95 | 308 | . | 4 | 83775 | 0.020 |
| 18 | 092 | 75 | . | 8.15 | 476 | 156 | 20.3 | . | 4.0 | . | . | 0.95 | 341 | . | 8 | 263700 | 0.022 |
| 18 | 092 | 77 | . | 8.20 | 529 | . | 21.3 | . | 4.5 | . | . | 0.82 | . | . | 6 | . | . |
| 18 | 094 | 75 | . | 8.13 | 420 | 139 | 20.9 | . | 3.2 | . | . | 0.80 | 321 | . | 6 | 81667 | 0.020 |
| 18 | 095 | 76 | . | 8.31 | 361 | 137 | 19.2 | . | 5.0 | . | . | 0.51 | 216 | . | 5 | 468000 | . |
| 18 | 097 | 75 | . | 8.20 | 424 | 176 | 21.2 | . | 4.1 | . | . | 0.69 | 285 | . | 5 | 139667 | 0.013 |
| 18 | 121 | 75 | . | 7.42 | 125 | 31 | 24.6 | . | 6.2 | . | . | 0.73 | 77 | . | 6 | 82333 | 0.302 |
| 18 | 126 | 74 | . | 7.69 | 131 | 44 | 20.6 | . | . | . | . | 0.51 | 76 | . | 6 | 61500 | 0.015 |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 128 | 75 | . | 8.06 | 199 | 121 | 21.8 | . | 6.8 | . | . | 0.64 | 128 | . | 5 | 89333 | 0.020 |
| 18 | 129 | 74 | . | 7.91 | 254 | 94 | 19.3 | . | 2.5 | . | . | 0.66 | 139 | . | 4 | 113000 | 0.191 |
| 18 | 134 | 77 | . | 7.61 | 119 | . | 22.2 | . | 2.5 | . | . | 0.58 | . | . | 2 | . | . |
| 18 | 263 | 75 | . | 8.16 | 540 | 256 | 18.4 | . | 8.8 | . | . | 0.75 | 367 | . | 17 | 119300 | 0.009 |
| 22 | 014 | 74 | 25.2 | 7.09 | 62 | 24 | 22.9 | . | . | 0.10 | . | 0.13 | . | . | . | . | . |
| 22 | 019 | 74 | 29.9 | 7.03 | 81 | 24 | 22.4 | . | . | 0.07 | . | 0.28 | . | . | . | . | . |
| 22 | 188 | 73 | 8.4 | 7.17 | 112 | 21 | 27.0 | . | . | 0.52 | . | 2.25 | . | . | . | . | . |
| 22 | 189 | 73 | 11.1 | 6.82 | 48 | 16 | 28.4 | . | . | 0.17 | . | 0.84 | . | . | . | . | . |
| 22 | 190 | 73 | 12.9 | 6.85 | 54 | 16 | 27.0 | . | . | 0.28 | . | 1.49 | . | . | . | . | . |
| 22 | 192 | 73 | 14.5 | 7.22 | 59 | 17 | 27.6 | . | . | 0.17 | . | 0.58 | . | . | . | . | . |
| 24 | 012 | 74 | 6.1 | 6.63 | 76 | 21 | 20.3 | . | . | 0.52 | . | 1.99 | . | . | . | . | . |
| 24 | 021 | 74 | 7.0 | 6.27 | 34 | 13 | 21.2 | . | . | 0.21 | . | 0.66 | . | . | . | . | . |
| 25 | 020 | 74 | 7.8 | 7.35 | 91 | 36 | 22.5 | . | . | 0.21 | . | 0.69 | . | . | . | . | . |
| 25 | 102 | 74 | 7.1 | 8.18 | 331 | 157 | 16.8 | . | . | 1.20 | . | 2.63 | . | . | . | . | . |
| 25 | 103 | 74 | 13.7 | 7.87 | 304 | 122 | 18.3 | . | . | 2.45 | . | 4.16 | . | . | . | . | . |
| 25 | 104 | 74 | 7.2 | 8.05 | 400 | 158 | 18.0 | . | . | 1.11 | . | 3.30 | . | . | . | . | . |
| 25 | 112 | 74 | 5.4 | 8.00 | 343 | 146 | 17.7 | . | . | 2.22 | . | 3.26 | . | . | . | . | . |
| 25 | 269 | 74 | 2.8 | 8.37 | 1209 | 182 | 17.7 | . | . | 0.65 | . | 2.78 | . | . | . | . | . |
| 25 | 348 | 74 | 15.2 | 8.20 | 1513 | 124 | 23.5 | . | . | 0.80 | . | 1.13 | . | . | . | . | . |
| 26 | 354 | 74 | 5.7 | 8.22 | 329 | 135 | 24.9 | 46.7 | . | 0.68 | . | 2.68 | . | . | 21 | . | . |
| 26 | 354 | 75 | . | 7.64 | 324 | . | 26.9 | . | . | . | . | 4.93 | . | . | 33 | . | . |
| 26 | 354 | 77 | . | 8.06 | 311 | 139 | 22.7 | . | . | . | . | 0.81 | . | 198 | 567 | . | . |
| 26 | 354 | 78 | . | 8.05 | 317 | 122 | 27.9 | . | . | . | . | 0.79 | . | 185 | 5 | . | . |
| 26 | 359 | 74 | 11.7 | 7.79 | 171 | 26 | 28.2 | . | . | 0.08 | . | 0.45 | . | . | . | . | . |
| 26 | 359 | 75 | . | 6.81 | 202 | 34 | 24.6 | 23.8 | . | . | . | 1.01 | 10 | . | 10 | . | . |
| 26 | 359 | 76 | . | 6.77 | 282 | 32 | 27.5 | 72.5 | . | . | . | 1.48 | . | . | 11 | . | . |
| 26 | 359 | 78 | . | 6.95 | 638 | 44 | 28.7 | 280.0 | . | . | 300 | 1.48 | . | 441 | 6 | . | . |
| 26 | 360 | 74 | 5.8 | 8.14 | 492 | 133 | 23.2 | . | . | 0.90 | . | 1.47 | . | . | . | . | . |
| 28 | 218 | 77 | . | . | . | . | 23.0 | . | . | . | . | 0.32 | . | . | . | . | . |
| 28 | 219 | 77 | . | . | . | . | 25.2 | . | . | . | . | 0.47 | . | . | . | . | . |
| 28 | 219 | 78 | . | . | . | . | . | . | . | . | . | 0.47 | . | . | . | . | . |
| 29 | 100 | 74 | 9.4 | 7.84 | 274 | 99 | 17.7 | . | . | 0.75 | . | 1.49 | . | . | . | . | . |
| 29 | 113 | 74 | 12.9 | 8.24 | 577 | 207 | 16.9 | . | . | 0.43 | . | 1.60 | . | . | . | . | . |
| 29 | 114 | 74 | 15.2 | 8.20 | 2393 | 152 | 16.8 | . | . | 0.14 | . | 0.51 | . | . | . | . | . |
| 30 | 215 | 74 | 7.1 | 7.86 | 466 | 227 | 17.1 | . | . | 0.16 | . | 0.47 | . | . | . | . | . |
| 30 | 217 | 74 | 8.7 | 7.82 | 480 | 247 | 16.7 | . | . | 0.13 | . | 0.48 | . | . | . | . | . |
| 33 | 300 | 75 | 78.8 | 8.21 | 40 | 28 | 16.2 | . | . | 0.04 | . | 0.49 | . | . | . | . | . |
| 34 | 041 | 71 | . | 7.36 | 56 | 24 | 19.4 | . | 1.0 | . | . | 0.15 | . | 40 | 0 | . | . |
| 34 | 041 | 72 | . | 7.54 | 57 | 21 | 20.3 | . | 0.9 | . | . | 0.12 | . | 44 | 0 | . | . |
| 34 | 041 | 73 | . | 7.30 | 60 | . | 19.8 | . | 1.1 | . | . | 0.16 | . | 49 | . | . | . |

34 041 72 . 7.30 60 .
34 041 73 .

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CDEP | CPHF | CCNF | CALK | CTMP | CTRJ | CTRH | CTRN | CTCO | CALPH | CRTL | CRFL | CRNF | CALG | CBIO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 041 | 74 | . | 6.91 | 54 | . | 21.2 | . | 1.1 | . | . | 0.12 | . | . | . | . | . |
| 34 | 041 | 75 | . | 7.55 | 65 | . | 18.2 | . | 1.9 | . | . | 0.21 | . | . | . | . | . |
| 34 | 041 | 76 | . | 7.83 | 57 | . | 19.1 | . | 1.4 | . | . | 0.28 | . | . | . | . | . |
| 34 | 041 | 78 | . | 7.48 | 67 | . | 20.2 | . | 0.9 | . | . | 0.27 | . | 500 | . | . | . |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 85 | 66.83 | 58.21 | 5.63 | 277.04 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 67 | 22.70 | 28.12 | 3.83 | 187.72 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 18 | 21.34 | 17.57 | 10.00 | 79.05 |
| CNTL | TOTAL NITROGEN (MG/M3) | 85 | 1159.05 | 973.24 | 247.34 | 6075.00 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 85 | 651.38 | 800.26 | 44.54 | 5064.16 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 65 | 13.04 | 11.52 | 1.18 | 67.13 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 20 | 9.73 | 6.56 | 2.68 | 27.47 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 65 | 20.97 | 17.48 | 1.73 | 84.19 |
| CSEC | SECCHI DEPTH (M) | 85 | 1.33 | 0.96 | 0.19 | 4.32 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 85 | 3.80 | 1.89 | 2.11 | 16.80 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 85 | 3.28 | 0.71 | 2.11 | 6.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 85 | 3.70 | 1.52 | 2.11 | 12.40 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 85 | 3.53 | 1.07 | 2.11 | 6.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 85 | 0.18 | 0.09 | 0.04 | 0.42 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 85 | 0.26 | 0.10 | 0.06 | 0.49 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 85 | 0.14 | 0.06 | 0.05 | 0.35 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 85 | 0.17 | 0.09 | 0.03 | 0.45 |

POOL DATA SCREEN CODE=B

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 73 | 57.49 | 52.99 | 6.55 | 248.29 |
| CPOT | ORTHO PHOSPHORUS (MG/M3) | 51 | 18.81 | 22.20 | 3.33 | 97.06 |
| CPDS | DISSOLVED PHOSPHORUS (MG/L) | 24 | 26.34 | 23.28 | 4.03 | 108.62 |
| CNTL | TOTAL NITROGEN (MG/M3) | 57 | 1541.61 | 2005.60 | 114.99 | 9307.14 |
| CNIN | INORGANIC NITROGEN (MG/M3) | 68 | 897.34 | 1606.22 | 20.00 | 7434.28 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 51 | 9.76 | 10.15 | 0.63 | 66.88 |
| CCFU | UNCORRECTED CHLOROPHYLL-A (MG/M3) | 25 | 9.20 | 8.93 | 1.60 | 30.99 |
| CCHAMX | MAXIMUM CHLOROPHYLL-A (MG/M3) | 51 | 14.83 | 15.48 | 1.24 | 97.29 |
| CSEC | SECCHI DEPTH (M) | 73 | 1.59 | 1.39 | 0.22 | 7.08 |
| NPTL | NUMBER OF TOTAL P SAMPLING DATES | 73 | 3.47 | 1.99 | 2.00 | 8.00 |
| NCHA | NUMBER OF CHL-A SAMPLING DATES | 73 | 2.83 | 1.35 | 2.00 | 7.00 |
| NNTL | NUMBER OF TOTAL N SAMPLING DATES | 73 | 2.66 | 2.28 | 0.00 | 8.00 |
| NSEC | NUMBER OF SECCHI SAMPLING DATES | 73 | 3.45 | 1.75 | 2.00 | 7.00 |
| EPTL | CV OF MEAN TOTAL P ESTIMATE | 73 | 0.24 | 0.16 | 0.00 | 0.74 |
| ECHA | CV OF MEAN CHL-A ESTIMATE | 73 | 0.32 | 0.20 | 0.01 | 0.97 |
| ENTL | CV OF MEAN TOTAL N ESTIMATE | 57 | 0.17 | 0.10 | 0.03 | 0.52 |
| ESEC | CV OF MEAN SECCHI ESTIMATE | 73 | 0.20 | 0.14 | 0.04 | 0.77 |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 | 73 | 11 | 5 | . | 941 | 660 | 4.9 | . | 6.8 | 3.49 | 3 | 3 | 3 | 3 | 0.04 | 0.18 | 0.11 | 0.10 |
| 04 | 312 | 73 | 96 | 54 | . | 1724 | 1156 | 18.0 | . | 42.2 | 1.20 | 3 | 3 | 3 | 3 | 0.37 | 0.49 | 0.19 | 0.24 |
| 06 | 372 | 73 | 50 | 14 | . | 677 | 224 | 8.1 | . | 12.3 | 1.09 | 3 | 3 | 3 | 3 | 0.20 | 0.24 | 0.13 | 0.19 |
| 10 | 001 | 77 | 138 | 27 | . | 444 | 277 | . | 6.8 | . | 0.78 | 4 | 4 | 4 | 4 | 0.16 | 0.18 | 0.19 | 0.05 |
| 10 | 003 | 73 | 24 | 7 | . | 1152 | 843 | 2.6 | . | 3.6 | 1.23 | 3 | 3 | 3 | 3 | 0.42 | 0.26 | 0.07 | 0.24 |
| 10 | 004 | 77 | 195 | 47 | . | 495 | 197 | . | 6.0 | . | 0.82 | 4 | 4 | 4 | 4 | 0.38 | 0.14 | 0.07 | 0.12 |
| 10 | 008 | 77 | 177 | 22 | . | 516 | 259 | . | 11.8 | . | 0.75 | 4 | 4 | 4 | 3 | 0.23 | 0.22 | 0.22 | 0.05 |
| 10 | 072 | 78 | 58 | 5 | . | 510 | 196 | 12.4 | . | 23.6 | 0.92 | 5 | 5 | 3 | 5 | 0.27 | 0.26 | 0.19 | 0.18 |
| 10 | 073 | 75 | 67 | . | 32 | 615 | 376 | 12.4 | . | 31.9 | 0.50 | 17 | 5 | 12 | 4 | 0.08 | 0.33 | 0.06 | 0.13 |
| 10 | 411 | 73 | 40 | 10 | . | 1409 | 917 | 4.0 | . | 5.6 | 1.20 | 3 | 3 | 3 | 3 | 0.34 | 0.23 | 0.09 | 0.16 |
| 15 | 178 | 77 | 21 | 7 | . | 698 | 255 | 7.2 | . | 12.9 | 2.92 | 3 | 3 | 3 | 3 | 0.18 | 0.33 | 0.09 | 0.03 |
| 15 | 237 | 74 | 277 | 188 | . | 1739 | 295 | 41.3 | . | 53.6 | 0.75 | 3 | 3 | 3 | 3 | 0.13 | 0.20 | 0.16 | 0.20 |
| 16 | 243 | 73 | 59 | 11 | . | 1428 | 645 | 14.6 | . | 21.8 | 0.86 | 3 | 3 | 3 | 3 | 0.18 | 0.25 | 0.16 | 0.08 |
| 16 | 254 | 73 | 63 | 7 | . | 1219 | 169 | 36.2 | . | 51.1 | 0.88 | 3 | 3 | 3 | 3 | 0.23 | 0.18 | 0.13 | 0.09 |
| 16 | 317 | 73 | 60 | 8 | . | 1042 | 299 | 26.8 | . | 45.0 | 0.93 | 3 | 3 | 3 | 3 | 0.17 | 0.29 | 0.09 | 0.09 |
| 16 | 328 | 73 | 21 | 6 | . | 735 | 366 | 3.7 | . | 5.4 | 2.18 | 3 | 3 | 3 | 3 | 0.22 | 0.28 | 0.09 | 0.24 |
| 16 | 393 | 73 | 6 | 5 | . | 618 | 390 | 1.2 | . | 1.7 | 3.08 | 3 | 3 | 3 | 3 | 0.06 | 0.23 | 0.12 | 0.18 |
| 17 | 241 | 73 | 41 | 6 | . | 945 | 423 | 16.4 | . | 26.5 | 0.96 | 3 | 3 | 3 | 3 | 0.18 | 0.27 | 0.18 | 0.15 |
| 17 | 242 | 73 | 167 | 20 | . | 2887 | 2072 | 10.9 | . | 19.4 | 0.28 | 3 | 3 | 3 | 3 | 0.35 | 0.41 | 0.09 | 0.14 |
| 17 | 245 | 73 | 127 | 12 | . | 1765 | 503 | 67.1 | . | 84.2 | 0.44 | 3 | 3 | 3 | 3 | 0.25 | 0.14 | 0.06 | 0.16 |
| 17 | 247 | 73 | 114 | 28 | . | 3290 | 2521 | 9.6 | . | 13.4 | 0.73 | 3 | 3 | 3 | 3 | 0.30 | 0.27 | 0.25 | 0.37 |
| 17 | 248 | 73 | 102 | 34 | . | 3106 | 2108 | 10.8 | . | 15.7 | 0.40 | 3 | 3 | 3 | 3 | 0.09 | 0.25 | 0.15 | 0.13 |
| 17 | 249 | 73 | 187 | 48 | . | 3204 | 1701 | 26.1 | . | 35.4 | 0.46 | 3 | 3 | 3 | 3 | 0.17 | 0.23 | 0.15 | 0.12 |
| 17 | 256 | 73 | 40 | 10 | . | 950 | 480 | 22.8 | . | 37.0 | 1.10 | 3 | 3 | 3 | 3 | 0.19 | 0.31 | 0.10 | 0.06 |
| 17 | 258 | 73 | 52 | 9 | . | 1052 | 243 | 37.7 | . | 56.0 | 0.86 | 3 | 3 | 3 | 3 | 0.25 | 0.21 | 0.08 | 0.13 |
| 17 | 373 | 73 | 11 | 4 | . | 523 | 198 | 5.6 | . | 9.5 | 2.24 | 3 | 3 | 3 | 2 | 0.11 | 0.38 | 0.07 | 0.30 |
| 17 | 391 | 73 | 13 | 6 | . | 858 | 602 | 6.2 | . | 13.4 | 3.53 | 3 | 3 | 3 | 3 | 0.14 | 0.49 | 0.11 | 0.33 |
| 18 | 090 | 75 | 55 | . | 18 | 2550 | 1822 | . | 3.5 | . | 1.14 | 6 | 3 | 6 | 6 | 0.20 | 0.43 | 0.07 | 0.19 |
| 18 | 090 | 77 | 28 | . | 12 | 2792 | 1722 | . | 12.3 | . | 0.94 | 6 | 3 | 6 | 6 | 0.05 | 0.37 | 0.22 | 0.22 |
| 18 | 091 | 75 | 118 | . | 43 | 6075 | 5064 | . | 12.6 | . | 0.44 | 6 | 4 | 6 | 6 | 0.22 | 0.29 | 0.24 | 0.21 |
| 18 | 092 | 73 | 104 | 36 | . | 3070 | 2278 | 15.8 | . | 23.6 | 0.67 | 3 | 3 | 3 | 3 | 0.22 | 0.24 | 0.10 | 0.08 |
| 18 | 093 | 73 | 31 | 8 | . | 763 | 246 | 7.2 | . | 11.1 | 1.64 | 3 | 3 | 3 | 3 | 0.13 | 0.25 | 0.08 | 0.17 |
| 18 | 093 | 77 | 20 | . | 10 | 492 | 217 | . | 5.0 | . | 1.89 | 6 | 4 | 6 | 5 | 0.40 | 0.15 | 0.14 | 0.06 |
| 18 | 095 | 77 | 27 | . | 14 | 2367 | 1555 | . | 9.4 | . | 1.04 | 6 | 4 | 6 | 6 | 0.15 | 0.27 | 0.11 | 0.13 |
| 18 | 097 | 77 | 21 | . | 10 | 1498 | 809 | . | 11.6 | . | 1.07 | 6 | 4 | 6 | 6 | 0.07 | 0.19 | 0.17 | 0.09 |
| 18 | 120 | 73 | 44 | 12 | . | 838 | 453 | 8.4 | . | 11.1 | 1.19 | 3 | 3 | 3 | 3 | 0.10 | 0.19 | 0.21 | 0.11 |
| 18 | 120 | 77 | 15 | . | 11 | 600 | 462 | . | 5.1 | . | 1.78 | 5 | 3 | 5 | 6 | 0.15 | 0.06 | 0.28 | 0.15 |
| 18 | 121 | 77 | 19 | . | 11 | 470 | 239 | . | 2.8 | . | 1.45 | 5 | 3 | 5 | 4 | 0.34 | 0.07 | 0.13 | 0.42 |
| 18 | 126 | 77 | 25 | . | 15 | 543 | 330 | . | 2.7 | . | 1.64 | 7 | 6 | 7 | 4 | 0.25 | 0.21 | 0.15 | 0.36 |
| 18 | 128 | 77 | 18 | . | 10 | 683 | 485 | . | 5.6 | . | 1.68 | 6 | 5 | 6 | 6 | 0.27 | 0.14 | 0.27 | 0.10 |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 129 | 77 | 17 | . | 14 | 642 | 448 | . | 3.7 | . | 1.72 | 6 | 4 | 6 | 6 | 0.15 | 0.14 | 0.26 | 0.12 |
| 18 | 134 | 75 | 21 | . | 15 | 760 | 620 | . | 3.5 | . | 2.23 | 7 | 3 | 5 | 5 | 0.24 | 0.18 | 0.35 | 0.09 |
| 18 | 260 | 77 | 234 | . | 79 | 1705 | 678 | . | 27.5 | . | 0.33 | 7 | 4 | 7 | 6 | 0.17 | 0.14 | 0.11 | 0.08 |
| 18 | 263 | 77 | 39 | . | 12 | 1576 | 759 | . | 12.4 | . | 0.84 | 7 | 4 | 7 | 6 | 0.16 | 0.35 | 0.07 | 0.17 |
| 19 | 119 | 73 | 125 | 54 | . | 750 | 464 | 13.3 | . | 18.4 | 0.69 | 2 | 2 | 2 | 2 | 0.05 | 0.33 | 0.06 | 0.10 |
| 19 | 122 | 73 | 16 | 7 | . | 477 | 200 | 3.8 | . | 7.1 | 1.72 | 3 | 3 | 3 | 3 | 0.18 | 0.33 | 0.10 | 0.22 |
| 19 | 338 | 73 | 142 | 71 | . | 760 | 465 | 8.4 | . | 10.8 | 0.65 | 3 | 3 | 3 | 3 | 0.22 | 0.20 | 0.07 | 0.13 |
| 19 | 340 | 73 | 45 | 16 | . | 569 | 116 | 10.0 | . | 14.7 | 1.77 | 3 | 3 | 3 | 3 | 0.07 | 0.22 | 0.15 | 0.10 |
| 19 | 340 | 75 | 38 | . | 15 | 599 | 154 | . | 17.5 | . | 1.04 | 4 | 3 | 4 | 3 | 0.22 | 0.11 | 0.11 | 0.05 |
| 19 | 340 | 76 | 47 | . | 23 | 425 | 216 | . | 17.2 | . | 1.23 | 4 | 4 | 4 | 4 | 0.15 | 0.14 | 0.12 | 0.12 |
| 19 | 340 | 78 | 76 | . | 39 | 733 | 373 | . | 17.7 | . | 0.92 | 5 | 6 | 5 | 4 | 0.17 | 0.17 | 0.13 | 0.08 |
| 19 | 342 | 73 | 58 | 18 | . | 629 | 281 | 8.9 | . | 12.4 | 0.76 | 3 | 3 | 3 | 3 | 0.13 | 0.24 | 0.16 | 0.13 |
| 19 | 343 | 73 | 10 | 6 | . | 443 | 189 | 3.6 | . | 6.4 | 4.32 | 3 | 3 | 3 | 3 | 0.14 | 0.34 | 0.14 | 0.19 |
| 20 | 081 | 73 | 84 | 31 | . | 2091 | 1322 | 17.4 | . | 23.9 | 0.56 | 3 | 3 | 3 | 3 | 0.05 | 0.18 | 0.06 | 0.09 |
| 20 | 087 | 73 | 69 | 32 | . | 4352 | 3687 | 17.1 | . | 28.6 | 0.98 | 3 | 3 | 3 | 3 | 0.24 | 0.29 | 0.20 | 0.27 |
| 20 | 088 | 73 | 71 | 14 | . | 1211 | 237 | 23.5 | . | 32.0 | 0.72 | 3 | 3 | 3 | 3 | 0.07 | 0.19 | 0.16 | 0.10 |
| 21 | 196 | 74 | 34 | 5 | . | 386 | 109 | 9.6 | . | 12.5 | 1.02 | 3 | 3 | 3 | 3 | 0.09 | 0.19 | 0.05 | 0.24 |
| 24 | 011 | 74 | 31 | 8 | . | 547 | 240 | 3.9 | . | 6.6 | 2.14 | 4 | 4 | 4 | 4 | 0.13 | 0.21 | 0.11 | 0.19 |
| 24 | 013 | 74 | 16 | 4 | . | 527 | 196 | 4.0 | . | 6.4 | 3.96 | 4 | 4 | 4 | 4 | 0.11 | 0.17 | 0.15 | 0.13 |
| 24 | 016 | 74 | 13 | 4 | . | 330 | 68 | 4.2 | . | 5.4 | 3.45 | 3 | 3 | 3 | 3 | 0.10 | 0.14 | 0.09 | 0.10 |
| 24 | 022 | 74 | 16 | 5 | . | 471 | 208 | 3.4 | . | 6.2 | 3.65 | 4 | 4 | 4 | 4 | 0.12 | 0.24 | 0.14 | 0.15 |
| 24 | 193 | 74 | 19 | 4 | . | 337 | 151 | 3.6 | . | 5.0 | 1.40 | 3 | 3 | 3 | 3 | 0.13 | 0.27 | 0.16 | 0.31 |
| 24 | 200 | 74 | 29 | 10 | . | 636 | 290 | 9.1 | . | 17.3 | 2.27 | 4 | 4 | 4 | 4 | 0.13 | 0.25 | 0.14 | 0.10 |
| 25 | 105 | 74 | 221 | 74 | . | 1858 | 1214 | 9.5 | . | 15.6 | 0.19 | 3 | 3 | 3 | 3 | 0.39 | 0.38 | 0.16 | 0.31 |
| 25 | 107 | 74 | 64 | 13 | . | 1122 | 601 | 12.4 | . | 22.8 | 0.41 | 3 | 3 | 3 | 3 | 0.27 | 0.45 | 0.26 | 0.22 |
| 25 | 267 | 74 | 90 | 36 | . | 854 | 386 | 4.4 | . | 8.3 | 0.45 | 4 | 4 | 4 | 4 | 0.10 | 0.23 | 0.05 | 0.12 |
| 25 | 273 | 74 | 212 | 95 | . | 1287 | 603 | 27.0 | . | 54.5 | 0.37 | 3 | 3 | 3 | 3 | 0.12 | 0.45 | 0.09 | 0.23 |
| 25 | 275 | 74 | 82 | 28 | . | 972 | 553 | 5.3 | . | 9.3 | 0.47 | 3 | 3 | 3 | 3 | 0.20 | 0.34 | 0.08 | 0.20 |
| 25 | 278 | 74 | 38 | 17 | . | 837 | 469 | 6.6 | . | 13.2 | 1.64 | 4 | 4 | 4 | 4 | 0.12 | 0.31 | 0.13 | 0.15 |
| 25 | 281 | 74 | 97 | 32 | . | 686 | 245 | 5.1 | . | 7.4 | 0.58 | 3 | 3 | 3 | 3 | 0.16 | 0.23 | 0.06 | 0.25 |
| 25 | 370 | 74 | 47 | 11 | . | 639 | 133 | 12.5 | . | 20.1 | 0.84 | 3 | 3 | 3 | 3 | 0.18 | 0.30 | 0.10 | 0.40 |
| 26 | 355 | 74 | 131 | 28 | . | 854 | 345 | 17.4 | . | 26.6 | 0.63 | 3 | 3 | 3 | 3 | 0.35 | 0.25 | 0.18 | 0.27 |
| 28 | 219 | 75 | 20 | 5 | . | 344 | 45 | 3.3 | . | 5.5 | 1.22 | 3 | 3 | 3 | 3 | 0.12 | 0.28 | 0.09 | 0.07 |
| 29 | 106 | 74 | 68 | 9 | . | 1193 | 539 | 16.0 | . | 25.4 | 0.34 | 3 | 3 | 3 | 3 | 0.18 | 0.34 | 0.10 | 0.08 |
| 29 | 108 | 74 | 94 | 34 | . | 1169 | 623 | 18.9 | . | 31.4 | 0.85 | 3 | 3 | 3 | 3 | 0.31 | 0.34 | 0.16 | 0.26 |
| 29 | 109 | 74 | 36 | 9 | . | 877 | 325 | 30.4 | . | 64.6 | 1.04 | 3 | 3 | 3 | 3 | 0.17 | 0.49 | 0.16 | 0.26 |
| 29 | 110 | 74 | 56 | 20 | . | 1510 | 1072 | 5.4 | . | 8.7 | 0.55 | 3 | 3 | 3 | 3 | 0.15 | 0.27 | 0.13 | 0.10 |
| 29 | 111 | 74 | 45 | 20 | . | 1526 | 1109 | 8.4 | . | 11.7 | 0.47 | 3 | 3 | 3 | 3 | 0.14 | 0.24 | 0.09 | 0.07 |
| 29 | 194 | 74 | 48 | 12 | . | 810 | 331 | 10.1 | . | 13.3 | 1.23 | 3 | 3 | 3 | 3 | 0.19 | 0.20 | 0.19 | 0.24 |
| 29 | 195 | 74 | 22 | 7 | . | 910 | 594 | 9.0 | . | 19.9 | 1.81 | 3 | 3 | 3 | 3 | 0.12 | 0.47 | 0.15 | 0.16 |

29 195 74 22 7 . 910 594 9.0 .

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

| DIS | RES | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 207 | 74 | 125 | 63 | . | 1033 | 318 | 27.8 | . | 49.8 | 0.61 | 3 | 3 | 3 | 3 | 0.23 | 0.33 | 0.23 | 0.27 |
| 30 | 064 | 75 | 57 | 8 | . | 815 | 48 | 23.3 | . | 50.1 | 0.78 | 3 | 3 | 3 | 3 | 0.13 | 0.40 | 0.10 | 0.10 |
| 30 | 235 | 74 | 73 | 12 | . | 460 | 158 | 7.4 | . | 9.0 | 2.32 | 3 | 3 | 3 | 3 | 0.27 | 0.15 | 0.23 | 0.15 |
| 31 | 077 | 75 | 13 | 8 | . | 247 | 57 | 2.4 | . | 3.8 | 2.49 | 3 | 3 | 3 | 3 | 0.12 | 0.25 | 0.08 | 0.12 |
| 32 | 204 | 75 | 47 | 37 | . | 281 | 74 | 2.8 | . | 4.3 | 4.04 | 3 | 3 | 3 | 3 | 0.24 | 0.30 | 0.11 | 0.45 |

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 | 176 | 72 | 7 | . | 4 | . | 251 | 4.9 | . | 6.6 | 2.39 | 3 | 3 | 0 | 3 | 0.17 | 0.41 | . | 0.17 |
| 04 | 320 | 74 | 31 | 7 | . | 1078 | 702 | . | 3.3 | . | 2.97 | 3 | 3 | 3 | 3 | 0.25 | 0.47 | 0.14 | 0.31 |
| 08 | 074 | 73 | 22 | 6 | . | 473 | 121 | 7.7 | . | 9.6 | 1.76 | 2 | 2 | 2 | 2 | 0.20 | 0.20 | 0.15 | 0.12 |
| 08 | 330 | 73 | 11 | 4 | . | 390 | 100 | 6.7 | . | 8.2 | 2.61 | 2 | 2 | 2 | 2 | 0.10 | 0.17 | 0.13 | 0.18 |
| 10 | 069 | 73 | 20 | 5 | . | 767 | 134 | 7.6 | . | 9.8 | 1.61 | 2 | 2 | 2 | 2 | 0.15 | 0.24 | 0.25 | 0.09 |
| 10 | 071 | 73 | 38 | 10 | . | 808 | 401 | 6.8 | . | 8.7 | 1.03 | 2 | 2 | 2 | 2 | 0.28 | 0.25 | 0.09 | 0.13 |
| 10 | 072 | 73 | 44 | 9 | . | 872 | 248 | 9.9 | . | 12.4 | 1.09 | 2 | 2 | 2 | 2 | 0.25 | 0.26 | 0.12 | 0.08 |
| 10 | 076 | 73 | 17 | 4 | . | 506 | 124 | 6.3 | . | 7.3 | 2.59 | 2 | 2 | 2 | 2 | 0.18 | 0.12 | 0.15 | 0.08 |
| 14 | 099 | 74 | 183 | 97 | . | 5967 | 5328 | 13.9 | . | 21.4 | 0.60 | 2 | 3 | 2 | 3 | 0.07 | 0.36 | 0.52 | 0.32 |
| 15 | 178 | 72 | 21 | . | 13 | . | 115 | 12.5 | . | 16.5 | 2.32 | 3 | 3 | 0 | 3 | 0.17 | 0.19 | . | 0.07 |
| 15 | 178 | 76 | 23 | 5 | 13 | . | 140 | 8.6 | . | 9.6 | 2.75 | 3 | 3 | 0 | 3 | 0.18 | 0.06 | . | 0.05 |
| 15 | 178 | 78 | 16 | 3 | . | 710 | 233 | 7.1 | . | 7.9 | 2.23 | 3 | 3 | 3 | 3 | 0.33 | 0.09 | 0.06 | 0.20 |
| 15 | 179 | 79 | 209 | . | 109 | . | 103 | 66.9 | . | 97.3 | 0.85 | 4 | 3 | 0 | 4 | 0.20 | 0.29 | . | 0.23 |
| 15 | 181 | 72 | 19 | . | 13 | . | 133 | 6.2 | . | 7.9 | 2.19 | 3 | 3 | 0 | 3 | 0.17 | 0.14 | . | 0.09 |
| 15 | 399 | 78 | 55 | . | 21 | . | . | 18.5 | . | 25.8 | 1.33 | 3 | 3 | 0 | 3 | 0.07 | 0.20 | . | 0.06 |
| 15 | 399 | 79 | 119 | . | 66 | . | 854 | 18.4 | . | 31.9 | 1.43 | 7 | 7 | 0 | 7 | 0.09 | 0.18 | . | 0.12 |
| 16 | 328 | 72 | 35 | . | 16 | . | 399 | 12.6 | . | 16.7 | 1.30 | 3 | 3 | 0 | 3 | 0.33 | 0.16 | . | 0.32 |
| 17 | 389 | 73 | 81 | 20 | . | 1769 | 1442 | 14.3 | . | 26.3 | 0.67 | 3 | 3 | 3 | 3 | 0.04 | 0.52 | 0.22 | 0.24 |
| 18 | 090 | 73 | 24 | . | 15 | 3087 | 2301 | . | 8.5 | . | 1.18 | 4 | 2 | 4 | 6 | 0.11 | 0.68 | 0.22 | 0.15 |
| 18 | 091 | 74 | 211 | . | 65 | 9307 | 7434 | . | 4.5 | . | 0.43 | 7 | 2 | 7 | 5 | 0.50 | 0.45 | 0.10 | 0.26 |
| 18 | 091 | 77 | 68 | . | 35 | 6767 | 4541 | . | 19.0 | . | 0.84 | 3 | 2 | 2 | 2 | 0.34 | 0.62 | 0.40 | 0.09 |
| 18 | 092 | 74 | 56 | . | 36 | 8180 | 7002 | . | 3.4 | . | 0.96 | 5 | 2 | 5 | 5 | 0.39 | 0.07 | 0.19 | 0.23 |
| 18 | 092 | 75 | 60 | . | 26 | 4025 | 3271 | . | 4.1 | . | 0.95 | 6 | 2 | 6 | 6 | 0.23 | 0.07 | 0.13 | 0.18 |
| 18 | 092 | 77 | 37 | . | 26 | 6212 | 5487 | . | 2.9 | . | 1.12 | 4 | 2 | 4 | 3 | 0.35 | 0.20 | 0.27 | 0.18 |
| 18 | 094 | 75 | 38 | . | 22 | 3733 | 3090 | . | 5.4 | . | 1.07 | 6 | 3 | 6 | 6 | 0.27 | 0.58 | 0.07 | 0.12 |
| 18 | 095 | 76 | 32 | . | 12 | 2367 | 1702 | . | 13.6 | . | 1.17 | 6 | 2 | 6 | 7 | 0.34 | 0.36 | 0.13 | 0.18 |
| 18 | 097 | 75 | 37 | . | 22 | 2400 | 1812 | . | 14.6 | . | 0.95 | 6 | 2 | 6 | 5 | 0.16 | 0.72 | 0.16 | 0.09 |
| 18 | 121 | 75 | 24 | . | 16 | 540 | 150 | . | 1.6 | . | 1.29 | 7 | 2 | 5 | 6 | 0.38 | 0.69 | 0.16 | 0.17 |
| 18 | 126 | 74 | 17 | . | 11 | 971 | 566 | . | 6.5 | . | 1.48 | 6 | 2 | 7 | 7 | 0.34 | 0.08 | 0.18 | 0.16 |

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CPTL | CPDT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 128 | 75. | 41 | . | 25 | 1043 | 496 | . | 6.4 | . | 1.24 | 7 | 2 | 7 | 7 | 0.38 | 0.01 | 0.24 | 0.15 |
| 18 | 129 | 74 | 21 | . | 11 | 1257 | 759 | . | 3.9 | . | 1.33 | 7 | 2 | 7 | 7 | 0.18 | 0.41 | 0.13 | 0.13 |
| 18 | 134 | 77 | 14 | . | 11 | 636 | 361 | . | 3.2 | . | 1.52 | 7 | 4 | 7 | 2 | 0.19 | 0.15 | 0.22 | 0.60 |
| 18 | 263 | 75 | 48 | . | 16 | 2044 | 1245 | . | 5.0 | . | 1.14 | 8 | 3 | 8 | 7 | 0.21 | 0.53 | 0.14 | 0.09 |
| 22 | 014 | 74 | 21 | 4 | . | 373 | 80 | 14.6 | . | 23.7 | 2.16 | 2 | 2 | 2 | 2 | 0.13 | 0.50 | 0.12 | 0.11 |
| 22 | 019 | 74 | 17 | 5 | . | 320 | 78 | 5.4 | . | 7.4 | 2.82 | 2 | 2 | 2 | 2 | 0.11 | 0.28 | 0.16 | 0.30 |
| 22 | 188 | 73 | 142 | 18 | . | 1082 | 368 | 4.6 | . | 5.9 | 0.44 | 2 | 2 | 2 | 2 | 0.49 | 0.24 | 0.04 | 0.37 |
| 22 | 189 | 73 | 49 | 10 | . | 740 | 185 | 4.8 | . | 6.3 | 1.05 | 2 | 2 | 2 | 2 | 0.40 | 0.27 | 0.07 | 0.23 |
| 22 | 190 | 73 | 61 | 9 | . | 828 | 330 | 5.2 | . | 6.9 | 0.62 | 2 | 2 | 2 | 2 | 0.34 | 0.26 | 0.14 | 0.41 |
| 22 | 192 | 73 | 39 | 11 | . | 594 | 165 | 7.2 | . | 9.4 | 1.32 | 2 | 2 | 2 | 2 | 0.46 | 0.27 | 0.05 | 0.52 |
| 24 | 012 | 74 | 72 | 8 | . | 539 | 140 | 10.3 | . | 11.7 | 0.46 | 2 | 2 | 2 | 2 | 0.22 | 0.12 | 0.13 | 0.24 |
| 24 | 021 | 74 | 43 | 7 | . | 444 | 184 | 19.6 | . | 36.2 | 0.88 | 2 | 2 | 2 | 2 | 0.09 | 0.74 | 0.03 | 0.08 |
| 25 | 020 | 74 | 51 | 6 | . | 649 | 106 | 20.3 | . | 30.0 | 0.89 | 2 | 2 | 2 | 2 | 0.08 | 0.37 | 0.10 | 0.15 |
| 25 | 102 | 74 | 76 | 28 | . | 1312 | 872 | 9.8 | . | 15.6 | 0.36 | 2 | 3 | 2 | 3 | 0.40 | 0.34 | 0.33 | 0.10 |
| 25 | 103 | 74 | 57 | 14 | . | 933 | 620 | 2.6 | . | 3.7 | 0.24 | 2 | 3 | 2 | 3 | 0.50 | 0.38 | 0.22 | 0.19 |
| 25 | 104 | 74 | 51 | 16 | . | 806 | 491 | 7.7 | . | 14.8 | 0.29 | 2 | 3 | 2 | 3 | 0.15 | 0.41 | 0.18 | 0.04 |
| 25 | 112 | 74 | 71 | 10 | . | 745 | 458 | 6.6 | . | 12.8 | 0.29 | 2 | 3 | 2 | 3 | 0.07 | 0.42 | 0.14 | 0.04 |
| 25 | 269 | 74 | 70 | 15 | . | 715 | 148 | 7.1 | . | 10.6 | 0.34 | 2 | 2 | 2 | 2 | 0.06 | 0.44 | 0.09 | 0.12 |
| 25 | 348 | 74 | 85 | 30 | . | 719 | 207 | 16.1 | . | 24.6 | 1.18 | 2 | 3 | 2 | 3 | 0.17 | 0.31 | 0.07 | 0.15 |
| 26 | 354 | 74 | 48 | 15 | . | 655 | 331 | 5.7 | . | 7.9 | 0.38 | 3 | 3 | 2 | 3 | 0.21 | 0.20 | 0.33 | 0.18 |
| 26 | 354 | 75 | 177 | 92 | . | . | 333 | . | 5.6 | . | 0.22 | 2 | 2 | 0 | 2 | 0.14 | 0.21 | . | 0.08 |
| 26 | 354 | 77 | 98 | 24 | . | . | 304 | . | 28.0 | . | 0.66 | 3 | 3 | 0 | 3 | 0.28 | 0.90 | . | 0.44 |
| 26 | 354 | 78 | 163 | 35 | . | . | 430 | . | 3.3 | . | 1.14 | 2 | 2 | 0 | 2 | 0.57 | 0.97 | . | 0.33 |
| 26 | 359 | 74 | 65 | 47 | . | 510 | 99 | 6.7 | . | 9.0 | 1.80 | 2 | 2 | 2 | 2 | 0.45 | 0.27 | 0.16 | 0.18 |
| 26 | 359 | 75 | 49 | 27 | . | . | . | . | 30.5 | . | 0.78 | 2 | 2 | 0 | 2 | 0.29 | 0.29 | | 0.08 |
| 26 | 359 | 76 | 76 | 17 | . | . | 295 | . | 31.0 | . | 0.44 | 2 | 2 | 0 | 2 | 0.74 | 0.10 | . | 0.37 |
| 26 | 359 | 78 | 248 | 62 | . | . | 400 | . | 14.0 | . | 0.55 | 2 | 2 | 0 | 2 | 0.68 | 0.29 | . | 0.77 |
| 26 | 360 | 74 | 110 | 29 | . | 1081 | 145 | 28.5 | . | 42.6 | 0.46 | 2 | 3 | 2 | 3 | 0.00 | 0.26 | 0.05 | 0.33 |
| 28 | 218 | 77 | 20 | 7 | . | 356 | . | 3.8 | 4.0 | 7.8 | 2.41 | 3 | 3 | 3 | 3 | 0.30 | 0.54 | 0.41 | 0.19 |
| 28 | 219 | 77 | 22 | 5 | . | 456 | . | 4.4 | 4.7 | 6.8 | 1.71 | 2 | 2 | 2 | 2 | 0.56 | 0.53 | 0.23 | 0.38 |
| 28 | 219 | 78 | 26 | 17 | 28 | 430 | . | 2.6 | 2.7 | 2.8 | 1.88 | 2 | 2 | 2 | 2 | 0.19 | 0.07 | 0.23 | 0.30 |
| 29 | 100 | 74 | 70 | 9 | . | 1787 | 1128 | 12.0 | . | 27.1 | 0.61 | 2 | 3 | 2 | 3 | 0.19 | 0.48 | 0.07 | 0.18 |
| 29 | .113 | 74 | 162 | 95 | . | 1688 | 1212 | 11.3 | . | 18.8 | 0.74 | 2 | 3 | 2 | 3 | 0.23 | 0.27 | 0.14 | 0.32 |
| 29 | 114 | 74 | 23 | 5 | . | 887 | 290 | 8.9 | . | 17.6 | 1.39 | 2 | 3 | 2 | 3 | 0.05 | 0.45 | 0.10 | 0.33 |
| 30 | 215 | 74 | 62 | 20 | . | 1078 | 200 | 15.4 | . | 27.8 | 1.19 | 2 | 3 | 2 | 3 | 0.45 | 0.37 | 0.21 | 0.26 |
| 30 | 217 | 74 | 55 | 17 | . | 914 | 104 | 17.0 | . | 26.9 | 1.11 | 2 | 3 | 2 | 3 | 0.34 | 0.27 | 0.13 | 0.11 |
| 33 | 300 | 75 | 20 | 10 | . | 288 | 57 | 3.2 | . | 3.8 | 1.75 | 2 | 2 | 2 | 2 | 0.09 | 0.17 | 0.24 | 0.13 |
| 34 | 041 | 71 | 45 | 9 | . | 262 | 41 | 1.0 | . | 1.8 | 5.68 | 8 | 5 | 6 | 7 | 0.17 | 0.23 | 0.14 | 0.06 |
| 34 | 041 | 72 | 16 | 7 | . | 264 | 21 | 1.3 | . | 2.5 | 6.50 | 7 | 7 | 7 | 6 | 0.15 | 0.21 | 0.23 | 0.12 |
| 34 | 041 | 73 | 10 | 10 | . | 115 | 25 | 0.9 | . | 1.5 | 5.44 | 6 | 6 | 6 | 6 | 0.00 | 0.19 | 0.04 | 0.14 |

## WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

| DIS | RES | YEAR | CPTL | CPOT | CPDS | CNTL | CNIN | CCHA | CCFU | CCHAMX | CSEC | NPTL | NCHA | NNTL | NSEC | EPTL | ECHA | ENTL | ESEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 041 | 74 | 10 | 10 | . | 186 | 24 | 0.8 | . | 1.8 | 7.08 | 7 | 7 | 7 | 7 | 0.00 | 0.23 | 0.22 | 0.09 |
| 34 | 041 | 75 | 13 | 10 | . | . | 34 | 1.5 | . | 3.3 | 3.95 | 7 | 7 | 0 | 6 | 0.14 | 0.24 | . | 0.19 |
| 34 | 041 | 76 | 10 | 10 | . | . | 20 | 0.6 | . | 1.2 | 3.44 | 6 | 7 | 0 | 5 | 0.00 | 0.20 | . | 0.24 |
| 34 | 041 | 78 | 12 | 10 | . | 205 | 47 | 1.0 | . | 1.6 | 3.39 | 4 | 4 | 4 | 3 | 0.20 | 0.25 | 0.35 | 0.49 |

# APPENDIX C

## U. S. Army Corps of Engineers Model Testing Data Sets

Table C1: Nutrient Input/Output Data Set
Table C2: Nutrient Loading/Water Quality Response Data Set
Table C3: Oxygen Status Data Set

Note: Data summaries precede listings; tables C1 and C2 include only data passing screening criteria described in Part III of the main text and listed in Table 14.

Table C1

Nutrient Input/Output Data Set

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| IPTL | INFLOW TOTAL P (MG/M3) | 62 | 179.13 | 185.85 | 13.46 | 1050.46 |
| OPTL | OUTFLOW TOTAL P (MG/M3) | 62 | 72.17 | 56.67 | 8.29 | 224.80 |
| IPDS | INFLOW DISSOLVED P (MG/M3) | 62 | 61.97 | 67.92 | 6.68 | 375.65 |
| OPDS | OUTFLOW DISSOLVED P (MG/M3) | 62 | 30.52 | 30.44 | 5.22 | 174.14 |
| INTL | INFLOW TOTAL N (MG/M3) | 62 | 2214.49 | 1824.22 | 190.25 | 9469.81 |
| ONTL | OUTFLOW TOTAL N (MG/M3) | 62 | 1596.49 | 1266.84 | 245.54 | 7298.11 |
| ININ | INFLOW INORGANIC N (MG/M3) | 62 | 1082.84 | 1378.57 | 32.50 | 7526.29 |
| ONIN | OUTFLOW INORGANIC N (MG/M3) | 62 | 812.55 | 1052.74 | 47.61 | 5952.35 |
| ZMEA | MEAN DEPTH (M) | 62 | 9.81 | 8.97 | 1.53 | 57.59 |
| THYD | RESIDENCE TIME (YR) | 62 | 0.32 | 0.33 | 0.01 | 1.89 |
| QSOV | OVERFLOW RATE (M/YR) | 62 | 81.59 | 123.88 | 3.23 | 779.14 |
| SEDM | SEDIMENTATION RATE (KG/M2-YR) | 17 | 35.79 | 39.80 | 3.97 | 142.10 |

NUTRIENT INPUT/OUTPUT DATA SET

| DIS | RES | IPTL | OPTL | IPDS | OPDS | INTL | ONTL | ININ | ONIN | ZMEA | THYD | QSOV | SEDM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 BELTZVILLE | 13.5 | 10.9 | 6.7 | 6.7 | 1160 | 1149 | 704 | 739 | 13.4 | 0.243 | 55.1 | . |
| 04 | 312 F J SAYERS (BLA | 168.2 | 82.9 | 106.7 | 41.6 | 2691 | 2032 | 1804 | 1236 | 4.5 | 0.046 | 98.0 | . |
| 06 | 372 JOHN H KERR | 132.4 | 25.9 | 36.6 | 13.4 | 1351 | 1225 | 363 | 302 | 9.3 | 0.246 | 37.7 | 23.56 |
| 08 | 074 CLARK HILL | 55.7 | 24.3 | 15.9 | 8.7 | 697 | 892 | 274 | 225 | 10.7 | 0.263 | 40.8 | . |
| 08 | 330 HARTWELL | 54.0 | 9.2 | 21.0 | 5.7 | 695 | 1004 | 257 | 208 | 14.0 | 0.541 | 25.8 | . |
| 10 | 003 HOLT | 38.6 | 34.3 | 11.2 | 10.5 | 1274 | 1676 | 623 | 824 | 10.9 | 0.014 | 779.1 | . |
| 10 | 069 ALLATOONA | 75.9 | 25.7 | 16.7 | 8.6 | 734 | 562 | 302 | 220 | 9.2 | 0.157 | 58.5 | . |
| 10 | 071 SEMINOLE (WOODR | 94.7 | 75.8 | 30.6 | 22.8 | 1406 | 1334 | 445 | 314 | 3.0 | 0.017 | 174.1 | . |
| 10 | 072 WALTER F GEORGE | 94.9 | 90.2 | 33.0 | 33.3 | 1033 | 1145 | 430 | 462 | 5.9 | 0.083 | 71.3 | . |
| 10 | 076 SIDNEY LANIER | 79.5 | 18.6 | 32.4 | 5.2 | 1045 | 801 | 474 | 412 | 15.3 | 0.894 | 17.1 | . |
| 10 | 411 BANKHEAD | 64.1 | 52.6 | 15.0 | 11.5 | 1679 | 1557 | 915 | 728 | 9.4 | 0.038 | 245.6 | . |
| 14 | 099 RED ROCK | 612.5 | 217.2 | 181.1 | 120.3 | 9470 | 7298 | 7130 | 5952 | 3.5 | 0.036 | 96.7 | . |
| 15 | 237 ASHTABULA (BALD | 294.8 | 224.8 | 155.6 | 174.1 | 2883 | 2211 | 777 | 512 | 3.8 | 0.485 | 7.8 | 8.18 |
| 16 | 243 BERLIN | 261.4 | 57.6 | 151.6 | 21.0 | 2906 | 2109 | 1797 | 1165 | 5.2 | 0.222 | 23.2 | . |
| 16 | 317 SHENANGO RIVER | 96.8 | 70.0 | 35.2 | 13.3 | 1516 | 1491 | 707 | 656 | 3.1 | 0.051 | 61.0 | . |
| 16 | 328 ALLEGHENY (KINZ | 45.8 | 31.2 | 12.3 | 9.0 | 688 | 1301 | 374 | 640 | 13.1 | 0.165 | 79.8 | . |
| 17 | 241 ATWOOD | 88.3 | 27.5 | 21.2 | 9.5 | 2426 | 948 | 1562 | 362 | 4.4 | 0.304 | 14.3 | . |
| 17 | 242 BEACH CITY | 257.6 | 210.2 | 53.1 | 35.6 | 4111 | 3811 | 3000 | 2565 | 1.5 | 0.013 | 117.1 | . |
| 17 | 245 CHARLES MILL | 175.6 | 156.2 | 50.8 | 26.4 | 3292 | 2920 | 1894 | 1411 | 1.7 | 0.035 | 47.0 | 12.31 |
| 17 | 248 DELAWARE | 267.2 | 175.0 | 95.0 | 71.9 | 4503 | 4001 | 3245 | 2868 | 3.1 | 0.035 | 88.8 | 9.75 |
| 17 | 249 DILLON | 168.7 | 130.2 | 91.2 | 49.3 | 2577 | 2588 | 1670 | 1750 | 3.5 | 0.024 | 142.3 | 24.18 |
| 17 | 256 PLEASANT HILL | 56.0 | 55.6 | 24.8 | 27.6 | 2047 | 1560 | 1414 | 1006 | 5.7 | 0.083 | 68.8 | . |
| 17 | 373 JOHN W FLANNAGA | 78.0 | 12.3 | 7.4 | 5.3 | 1309 | 1341 | 436 | 382 | 19.5 | 0.315 | 62.0 | . |
| 17 | 389 BLUESTONE | 45.9 | 45.7 | 18.2 | 19.2 | 1390 | 1418 | 1015 | 1062 | 9.8 | 0.022 | 455.2 | 45.31 |
| 17 | 391 SUMMERSVILLE | 24.1 | 15.1 | 6.8 | 6.8 | 916 | 858 | 700 | 701 | 20.1 | 0.061 | 330.6 | . |
| 18 | 092 MISSISSINEWA | 336.1 | 131.8 | 107.3 | 61.3 | 5697 | 3955 | 3432 | 2908 | 7.3 | 0.092 | 79.8 | . |
| 18 | 093 MONROE | 30.5 | 12.8 | 8.8 | 5.6 | 938 | 701 | 596 | 351 | 5.2 | 0.459 | 11.4 | . |
| 18 | 120 BARREN RIVER | 55.4 | 47.3 | 45.5 | 18.3 | 2022 | 1239 | 1086 | 877 | 8.0 | 0.159 | 50.2 | . |
| 19 | 119 BARKLEY | 133.1 | 122.5 | 48.3 | 41.6 | 1187 | 1138 | 637 | 505 | 5.0 | 0.023 | 218.1 | . |
| 19 | 122 CUMBERLAND (WOL | 58.1 | 33.8 | 12.5 | 7.9 | 1038 | 905 | 377 | 608 | 22.2 | 0.289 | 76.8 | . |
| 19 | 340 J PERCY PRIEST | 139.7 | 102.9 | 92.7 | 56.1 | 880 | 886 | 699 | 522 | 8.2 | 0.208 | 39.6 | . |
| 19 | 342 OLD HICKORY | 106.0 | 94.1 | 32.3 | 26.2 | 1009 | 927 | 453 | 414 | 5.8 | 0.018 | 322.5 | 16.36 |

NUTRIENT INPUT/OUTPUT DATA SET

| DIS | RES | IPTL | OPTL | IPDS | OPDS | INTL | ONTL | ININ | ONIN | ZMEA | THYD | QSOV | SEDM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 343 DALE HOLLOW | 17.4 | 8.3 | 7.5 | 5.6 | 662 | 1485 | 377 | 818 | 14.5 | 0.675 | 21.4 | . |
| 20 | 081 CARLYLE | 198.3 | 120.8 | 61.9 | 56.6 | 4205 | 3599 | 2963 | 2100 | 3.7 | 0.122 | 30.1 | 13.37 |
| 20 | 087 SHELBYVILLE | 174.4 | 105.6 | 98.1 | 53.8 | 8228 | 6194 | 7526 | 4788 | 6.0 | 0.201 | 30.0 | . |
| 20 | 088 REND | 306.2 | 86.1 | 55.6 | 23.3 | 2698 | 1418 | 924 | 371 | 3.2 | 0.579 | 5.6 | . |
| 22 | 189 ENID | 285.6 | 64.9 | 82.4 | 23.2 | 1652 | 875 | 479 | 372 | 5.6 | 0.310 | 18.1 | . |
| 24 | 011 BEAVER | 62.4 | 16.3 | 16.8 | 6.0 | 1013 | 773 | 482 | 279 | 17.7 | 0.946 | 18.7 | . |
| 24 | 013 BULL SHOALS | 18.2 | 12.4 | 7.6 | 5.7 | 766 | 777 | 474 | 370 | 21.1 | 0.437 | 48.3 | . |
| 24 | 200 TABLE ROCK | 48.7 | 18.1 | 46.4 | 12.8 | 2101 | 1418 | 930 | 556 | 19.5 | 0.592 | 33.0 | . |
| 25 | 020 MILLWOOD | 62.3 | 48.3 | 17.2 | 12.3 | 723 | 459 | 200 | 118 | 2.3 | 0.025 | 90.3 | . |
| 25 | 105 JOHN REDMOND | 375.9 | 178.0 | 105.6 | 71.4 | 3450 | 1976 | 1375 | 741 | 2.5 | 0.054 | 45.7 | 53.86 |
| 25 | 267 EUFAULA | 360.2 | 191.0 | 83.0 | 59.2 | 1935 | 1475 | 282 | 484 | 7.4 | 0.315 | 23.7 | 60.35 |
| 25 | 269 FORT SUPPLY | 73.4 | 51.5 | 20.2 | 14.9 | 1492 | 892 | 451 | 77 | 2.3 | 0.704 | 3.2 | 13.55 |
| 25 | 273 KEYSTONE | 386.8 | 109.1 | 124.1 | 85.9 | 3131 | 1463 | 875 | 771 | 8.1 | 0.066 | 121.6 | 122.73 |
| 25 | 278 TENKILLER FERRY | 93.2 | 47.9 | 54.8 | 30.6 | 1957 | 1843 | 780 | 631 | 16.0 | 0.340 | 47.0 | . |
| 25 | 281 WISTER | 71.3 | 70.8 | 21.8 | 26.5 | 956 | 903 | 133 | 166 | 3.1 | 0.070 | 44.4 | 3.97 |
| 25 | 348 TEXOMA (DENNISO | 402.5 | 92.0 | 85.1 | 46.4 | 2705 | 1188 | 451 | 245 | 9.7 | 0.407 | 23.9 | 142.10 |
| 26 | 347 CANYON | 18.5 | 11.3 | 8.2 | 5.7 | 1403 | 727 | 957 | 425 | 13.6 | 0.571 | 23.7 | . |
| 26 | 354 LAVON | 227.9 | 49.0 | 76.1 | 23.8 | 2161 | 888 | 678 | 203 | 5.0 | 0.291 | 17.1 | 19.18 |
| 26 | 355 LEWISVILLE(GARZ | 258.2 | 77.0 | 90.7 | 43.8 | 1988 | 956 | 560 | 449 | 6.6 | 0.439 | 15.1 | 16.84 |
| 26 | 361 SOMERVILLE | 120.9 | 65.7 | 49.0 | 20.1 | 1834 | 1225 | 272 | 90 | 4.6 | 0.311 | 14.8 | . |
| 26 | 362 STILLHOUSE HOLL | 49.0 | 17.2 | 14.4 | 6.1 | 1366 | 649 | 447 | 258 | 11.9 | 0.453 | 26.3 | . |
| 29 | 106 KANOPOLIS | 587.1 | 89.7 | 138.8 | 29.1 | 2676 | 1584 | 615 | 436 | 4.8 | 0.316 | 15.2 | . |
| 29 | 108 MILFORD | 530.6 | 59.6 | 210.7 | 28.4 | 2767 | 1491 | 985 | 237 | 7.8 | 1.109 | 7.0 | . |
| 29 | 111 POMONA | 138.7 | 59.5 | 53.6 | 14.8 | 3243 | 2280 | 1067 | 722 | 5.5 | 0.370 | 14.9 | . |
| 29 | 113 TUTTLE CREEK | 1050.5 | 136.1 | 271.3 | 77.1 | 4884 | 2298 | 1861 | 1197 | 7.7 | 0.356 | 21.7 | . |
| 29 | 207 HARLAN COUNTY | 438.8 | 121.9 | 375.6 | 66.1 | 7473 | 1235 | 999 | 178 | 6.8 | 1.886 | 3.6 | 22.80 |
| 30 | 235 SAKAKAWEA(GARRI | 356.6 | 27.2 | 22.2 | 12.1 | 1430 | 547 | 178 | 167 | 18.0 | 0.896 | 20.1 | . |
| 31 | 077 DWORSHAK | 19.3 | 16.6 | 8.0 | 7.8 | 694 | 387 | 35 | 78 | 57.6 | 0.596 | 96.7 | . |
| 33 | 300 HILLS CREEK | 40.2 | 35.7 | 31.1 | 24.0 | 190 | 246 | 32 | 48 | 36.9 | 0.291 | 126.9 | . |
| 35 | 029 MENDOCINO | 129.6 | 62.5 | 26.6 | 25.3 | 947 | 750 | 151 | 118 | 13.5 | 0.248 | 54.3 | . |

Table C2

Nutrient Loading/Water Quality Response Data Set

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 43 | 75.98 | 62.44 | 10.17 | 277.04 |
| OPTL | OUTFLOW TOTAL P (MG/M3) | 43 | 77.52 | 59.16 | 8.29 | 224.80 |
| CNTL | TOTAL NITROGEN (MG/M3) | 43 | 1255.61 | 887.27 | 247.34 | 4352.30 |
| CSEC | SECCHI DEPTH (M) | 43 | 1.32 | 1.03 | 0.19 | 4.32 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 43 | 13.65 | 12.06 | 2.42 | 67.13 |
| CALPH | NONALGAL TURBIDITY (1/M) | 43 | 1.12 | 1.02 | 0.15 | 5.24 |
| IPTL | INFLOW TOTAL P (MG/M3) | 43 | 183.45 | 182.74 | 13.36 | 936.81 |
| IPDS | INFLOW DISSOLVED P (MG/M3) | 43 | 65.09 | 66.97 | 6.68 | 357.65 |
| INTL | INFLOW TOTAL N (MG/M3) | 43 | 2380.67 | 1704.49 | 674.42 | 8184.93 |
| ININ | INFLOW INORGANIC N (MG/M3) | 43 | 1208.62 | 1308.16 | 34.80 | 7459.61 |
| ZMEA | MEAN DEPTH (M) | 43 | 9.95 | 9.61 | 1.42 | 57.98 |
| THYD | RESIDENCE TIME (YR) | 43 | 0.32 | 0.35 | 0.01 | 1.43 |
| QSOV | OVERFLOW RATE (M/YR) | 43 | 88.96 | 126.05 | 4.42 | 715.30 |
| SEDM | SEDIMENTATION RATE (KG/M2-YR) | 13 | 29.87 | 32.57 | 3.97 | 122.73 |

NUTRIENT LOADING/WATER QUALITY RESPONSE DATA SET

| DIS | RES | | YEAR | CPTL | OPTL | CNTL | CSEC | CCHA | CALPH | IPTL | IPOS | INTL | ININ | ZMEA | THYD | QSOV | SEDM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 | BELTZVILLE | 73 | 10.7 | 10.9 | 941 | 3.49 | 4.9 | 0.17 | 13.4 | 6.7 | 1162 | 704 | 13.5 | 0.247 | 54.5 | . |
| 04 | 312 | F J SAYERS (BLA | 73 | 96.5 | 82.9 | 1724 | 1.20 | 18.0 | 0.45 | 166.3 | 104.8 | 2683 | 1788 | 4.7 | 0.048 | 99.1 | . |
| 06 | 372 | JOHN H KERR | 73 | 50.0 | 25.9 | 677 | 1.09 | 8.1 | 1.11 | 135.5 | 33.6 | 1412 | 378 | 9.3 | 0.176 | 53.2 | 23.56 |
| 10 | 003 | HOLT | 73 | 24.2 | 34.3 | 1152 | 1.23 | 2.6 | 0.75 | 38.0 | 11.0 | 1282 | 631 | 10.9 | 0.015 | 715.3 | . |
| 10 | 411 | BANKHEAD | 73 | 40.1 | 52.6 | 1409 | 1.20 | 4.0 | 0.80 | 64.4 | 15.1 | 1682 | 914 | 9.4 | 0.041 | 226.7 | . |
| 15 | 237 | ASHTABULA (BALD | 74 | 277.0 | 224.8 | 1739 | 0.75 | 41.3 | 0.37 | 298.9 | 155.7 | 2913 | 832 | 3.7 | 0.351 | 10.6 | 8.18 |
| 16 | 243 | BERLIN | 73 | 58.8 | 57.6 | 1428 | 0.86 | 14.6 | 0.85 | 249.6 | 136.7 | 2889 | 1833 | 5.2 | 0.196 | 26.6 | . |
| 16 | 317 | SHENANGO RIVER | 73 | 59.8 | 70.0 | 1042 | 0.93 | 26.8 | 0.43 | 96.5 | 35.1 | 1518 | 709 | 3.2 | 0.051 | 62.1 | . |
| 16 | 328 | ALLEGHENY (KINZ | 73 | 20.9 | 31.2 | 735 | 2.18 | 3.7 | 0.49 | 45.4 | 12.2 | 681 | 370 | 13.4 | 0.176 | 76.1 | . |
| 17 | 241 | ATWOOD | 73 | 41.3 | 27.5 | 945 | 0.96 | 16.4 | 0.82 | 93.4 | 22.8 | 2423 | 1541 | 4.5 | 0.382 | 11.8 | . |
| 17 | 242 | BEACH CITY | 73 | 167.2 | 210.2 | 2887 | 0.28 | 10.9 | 3.31 | 258.9 | 49.7 | 4343 | 3261 | 1.4 | 0.008 | 175.7 | . |
| 17 | 245 | CHARLES MILL | 73 | 127.0 | 156.2 | 1765 | 0.44 | 67.1 | 0.67 | 176.8 | 50.9 | 3356 | 1970 | 1.6 | 0.029 | 56.0 | 12.31 |
| 17 | 248 | DELAWARE | 73 | 102.5 | 175.0 | 3106 | 0.40 | 10.8 | 2.34 | 267.6 | 92.1 | 4728 | 3533 | 3.1 | 0.027 | 113.8 | 9.75 |
| 17 | 249 | DILLON | 73 | 186.6 | 130.2 | 3204 | 0.46 | 26.1 | 1.61 | 164.4 | 87.6 | 2532 | 1650 | 3.0 | 0.017 | 180.0 | 24.18 |
| 17 | 256 | PLEASANT HILL | 73 | 40.4 | 55.6 | 950 | 1.10 | 22.8 | 0.37 | 50.9 | 22.0 | 2138 | 1509 | 5.3 | 0.053 | 99.5 | . |
| 17 | 373 | JOHN W FLANNAGA | 73 | 10.6 | 12.3 | 523 | 2.24 | 5.6 | 0.45 | 72.2 | 7.7 | 1306 | 430 | 19.6 | 0.413 | 47.4 | . |
| 17 | 391 | SUMMERSVILLE | 73 | 12.8 | 15.1 | 858 | 3.53 | 6.2 | 0.15 | 24.2 | 6.7 | 930 | 709 | 21.0 | 0.056 | 376.3 | . |
| 18 | 092 | MISSISSINEWA | 73 | 103.9 | 131.8 | 3070 | 0.67 | 15.8 | 1.36 | 337.7 | 107.6 | 5737 | 3459 | 7.4 | 0.079 | 93.9 | . |
| 18 | 093 | MONROE | 73 | 31.1 | 12.8 | 763 | 1.64 | 7.2 | 0.68 | 28.9 | 8.1 | 922 | 633 | 5.6 | 0.407 | 13.7 | . |
| 18 | 120 | BARREN RIVER | 73 | 44.2 | 47.3 | 838 | 1.19 | 8.4 | 0.74 | 56.6 | 46.2 | 2022 | 1073 | 7.6 | 0.151 | 50.6 | . |
| 19 | 119 | BARKLEY | 73 | 124.8 | 122.5 | 750 | 0.69 | 13.3 | 1.13 | 133.2 | 48.4 | 1187 | 637 | 4.8 | 0.022 | 220.3 | . |
| 19 | 122 | CUMBERLAND (WOL | 73 | 15.6 | 33.8 | 477 | 1.72 | 3.8 | 0.54 | 57.9 | 12.7 | 1050 | 373 | 22.7 | 0.382 | 59.5 | . |
| 19 | 340 | J PERCY PRIEST | 73 | 45.1 | 102.9 | 569 | 1.77 | 10.0 | 0.40 | 139.9 | 92.8 | 881 | 699 | 8.3 | 0.220 | 37.6 | . |
| 19 | 342 | OLD HICKORY | 73 | 57.8 | 94.1 | 629 | 0.76 | 8.9 | 1.12 | 102.5 | 31.5 | 1024 | 444 | 5.8 | 0.021 | 280.6 | 16.36 |
| 19 | 343 | DALE HOLLOW | 73 | 10.2 | 8.3 | 443 | 4.32 | 3.6 | 0.22 | 17.6 | 7.7 | 674 | 379 | 14.4 | 0.765 | 18.8 | . |
| 20 | 081 | CARLYLE | 73 | 84.4 | 120.8 | 2091 | 0.56 | 17.4 | 1.43 | 198.3 | 61.9 | 4214 | 2972 | 3.7 | 0.122 | 30.5 | 13.37 |
| 20 | 087 | SHELBYVILLE | 73 | 69.3 | 105.6 | 4352 | 0.98 | 17.1 | 0.64 | 175.9 | 98.9 | 8185 | 7460 | 6.3 | 0.209 | 30.2 | . |
| 20 | 088 | REND | 73 | 71.1 | 86.1 | 1211 | 0.72 | 23.5 | 0.85 | 309.6 | 56.4 | 2729 | 929 | 3.1 | 0.696 | 4.4 | . |
| 24 | 011 | BEAVER | 74 | 30.7 | 16.3 | 547 | 2.14 | 3.9 | 0.57 | 62.5 | 16.9 | 1013 | 482 | 17.7 | 1.025 | 17.3 | . |
| 24 | 013 | BULL SHOALS | 74 | 15.9 | 12.4 | 527 | 3.96 | 4.0 | 0.17 | 18.2 | 7.6 | 764 | 473 | 21.3 | 0.502 | 42.4 | . |
| 24 | 200 | TABLE ROCK | 74 | 29.4 | 18.1 | 636 | 2.27 | 9.1 | 0.26 | 47.7 | 45.9 | 2105 | 927 | 19.7 | 0.588 | 33.4 | . |
| 25 | 105 | JOHN REDMOND | 74 | 221.1 | 178.0 | 1858 | 0.19 | 9.5 | 5.24 | 381.9 | 101.3 | 3492 | 1475 | 3.0 | 0.044 | 69.1 | 53.86 |

NUTRIENT LOADING/WATER QUALITY RESPONSE DATA SET

| DIS | RES | | YEAR | CPTL | OPTL | CNTL | CSEC | CCHA | CALPH | IPTL | IPDS | INTL | ININ | ZMEA | THYD | OSOV | SEDM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 267 | EUFAULA | 74 | 90.0 | 191.0 | 854 | 0.45 | 4.4 | 2.42 | 359.4 | 88.7 | 1963 | 285 | 7.4 | 0.451 | 16.4 | 60.35 |
| 25 | 273 | KEYSTONE | 74 | 211.7 | 109.1 | 1287 | 0.37 | 27.0 | 3.23 | 386.7 | 124.1 | 3128 | 873 | 8.1 | 0.068 | 118.7 | 122.73 |
| 25 | 278 | TENKILLER FERRY | 74 | 37.7 | 47.9 | 837 | 1.64 | 6.6 | 0.53 | 93.4 | 54.7 | 1967 | 785 | 16.0 | 0.324 | 49.3 | . |
| 25 | 281 | WISTER | 74 | 96.9 | 70.8 | 686 | 0.58 | 5.1 | 1.59 | 71.1 | 21.6 | 951 | 131 | 3.0 | 0.070 | 43.0 | 3.97 |
| 26 | 355 | LEWISVILLE(GARZ | 74 | 131.0 | 77.0 | 854 | 0.63 | 17.4 | 1.66 | 318.5 | 135.0 | 2403 | 821 | 6.4 | 1.049 | 6.1 | 16.84 |
| 29 | 106 | KANOPOLIS | 74 | 68.1 | 89.7 | 1193 | 0.34 | 16.0 | 2.62 | 936.8 | 146.0 | 2916 | 346 | 5.5 | 0.126 | 44.0 | . |
| 29 | 108 | MILFORD | 74 | 94.5 | 59.6 | 1169 | 0.85 | 18.9 | 1.04 | 656.8 | 196.2 | 2411 | 1308 | 8.2 | 0.305 | 26.8 | . |
| 29 | 111 | POMONA | 74 | 45.2 | 59.5 | 1526 | 0.47 | 8.4 | 1.93 | 138.7 | 53.8 | 3245 | 1070 | 5.7 | 0.314 | 18.0 | . |
| 29 | 207 | HARLAN COUNTY | 74 | 125.3 | 121.9 | 1033 | 0.61 | 27.8 | 1.35 | 401.6 | 357.7 | 7411 | 999 | 7.5 | 1.432 | 5.2 | 22.80 |
| 30 | 235 | SAKAKAWEA(GARRI | 74 | 72.9 | 27.2 | 460 | 2.32 | 7.4 | 1.07 | 221.2 | 19.0 | 1301 | 140 | 18.0 | 1.317 | 13.6 | . |
| 31 | 077 | DWORSHAK | 75 | 13.0 | 16.6 | 247 | 2.49 | 2.4 | 0.35 | 19.3 | 8.0 | 696 | 35 | 58.0 | 0.597 | 97.2 | . |

Table C3

Oxygen Status Data Set

| VARIABLE | LABEL | N | MEAN | STANDARD DEVIATION | MINIMUM VALUE | MAXIMUM VALUE |
|---|---|---|---|---|---|---|
| DTMAX | TOP-TO-BOTTOM TEMP. DIFFERENCE (DEG-C) | 63 | 13.381 | 5.191 | 6.000 | 24.000 |
| ZTHERM | MID THERMOCLINE DEPTH (M) | 63 | 8.272 | 3.444 | 2.400 | 25.915 |
| PZMAX | MAXIMUM O2 PROFILE DEPTH (M) | 63 | 31.431 | 20.206 | 3.049 | 91.463 |
| PZDOM | MINIMUM DEPTH OF ANOXIC COND. (M) | 63 | 16.521 | 19.664 | 1.524 | 91.463 |
| TH | MEAN HYPOLIMNION TEMP. (DEG-G) | 63 | 14.452 | 4.437 | 7.500 | 22.500 |
| CPTL | TOTAL PHOSPHORUS (MG/M3) | 63 | 43.978 | 42.704 | 5.470 | 234.167 |
| CCHA | CHLOROPHYLL-A (MG/M3) | 51 | 9.092 | 9.497 | 1.036 | 58.983 |
| CSEC | SECCHI DEPTH (M) | 63 | 1.886 | 1.245 | 0.330 | 6.115 |
| IPTL | INFLOW TOTAL P (MG/M3) | 46 | 108.025 | 122.612 | 13.363 | 656.829 |
| OPTL | OUTFLOW TOTAL P (MG/M3) | 46 | 52.911 | 55.692 | 8.286 | 279.132 |
| THYD | RESIDENCE TIME (YR) | 62 | 0.533 | 0.745 | 0.007 | 4.321 |
| QSOV | OVERFLOW RATE (M/YR) | 62 | 66.436 | 122.062 | 1.042 | 812.107 |
| ZMEA | MEAN DEPTH (M) | 63 | 11.520 | 9.163 | 1.601 | 57.982 |
| ZH | MEAN HYPOLIMNION DEPTH (M) | 63 | 8.680 | 8.848 | 0.624 | 55.270 |

OXYGEN STATUS DATA SET

---------------------------------------- OXYGEN STATUS GROUP=OXIC ----------------------------------------

| DIS | RES | DTMAX | ZTHERM | PZMAX | PZDOM | TH | CPTL | CCHA | CSEC | IPTL | OPTL | THYD | QSOV | ZMEA | ZH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 235 SAKAKAWEA(GARRI | 15 | 25.9 | 57.9 | 57.9 | 10.5 | 22.9 | 3.3 | 2.90 | 221.2 | 27.2 | 1.317 | 13.6 | 18.0 | 9.2 |
| 31 | 077 DWORSHAK | 18 | 9.0 | 61.0 | 61.0 | 7.5 | 13.0 | 2.4 | 2.49 | 19.3 | 16.6 | 0.597 | 97.2 | 58.0 | 55.3 |
| 32 | 204 KOOKANUSA(LIBBY | 15 | 9.0 | 91.5 | 91.5 | 7.5 | 47.2 | 2.8 | 4.04 | 23.1 | 24.1 | 0.412 | 77.9 | 32.1 | 26.6 |
| 33 | 300 HILLS CREEK | 15 | 9.0 | 67.1 | 67.1 | 7.5 | 20.1 | 3.2 | 1.75 | 40.0 | 35.7 | 0.291 | 127.5 | 37.1 | 32.8 |
| 34 | 041 FOLSOM | 18 | 9.1 | 68.6 | 68.6 | 10.5 | 16.6 | 1.0 | 5.07 | . | . | 0.104 | 151.8 | 15.8 | 14.5 |

---------------------------------------- OXYGEN STATUS GROUP=INTERMEDIATE ----------------------------------------

| DIS | RES | DTMAX | ZTHERM | PZMAX | PZDOM | TH | CPTL | CCHA | CSEC | IPTL | OPTL | THYD | QSOV | ZMEA | ZH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 307 BELTZVILLE | 18 | 6.1 | 36.6 | 15.2 | 13.5 | 10.9 | 5.2 | 3.61 | 13.4 | 10.9 | 0.247 | 54.5 | 13.5 | 11.9 |
| 16 | 393 TYGART | 12 | 10.7 | 36.6 | 21.3 | 19.5 | 5.5 | 1.2 | 2.88 | 19.9 | 32.0 | 0.038 | 437.2 | 16.8 | 9.5 |
| 17 | 373 JOHN W FLANNAGA | 21 | 7.6 | 50.3 | 39.6 | 10.5 | 9.6 | 4.6 | 2.68 | 72.2 | 12.3 | 0.413 | 47.4 | 19.6 | 17.8 |
| 17 | 391 SUMMERSVILLE | 21 | 9.1 | 76.2 | 53.4 | 13.5 | 12.1 | 7.3 | 3.77 | 24.2 | 15.1 | 0.056 | 376.3 | 21.0 | 17.3 |
| 19 | 122 CUMBERLAND (WOL | 18 | 7.6 | 54.9 | 36.6 | 10.5 | 12.2 | 4.2 | 1.93 | 57.9 | 33.8 | 0.382 | 59.5 | 22.7 | 18.3 |
| 19 | 343 DALE HOLLOW | 21 | 9.1 | 42.7 | 18.3 | 10.5 | 9.1 | 1.6 | 6.11 | 17.6 | 8.3 | 0.765 | 18.8 | 14.4 | 10.2 |
| 22 | 014 DE GRAY | 24 | 6.7 | 51.8 | 30.5 | 7.5 | 19.9 | 15.4 | 2.18 | . | . | 1.130 | 13.2 | 14.9 | 13.7 |
| 22 | 019 OUACHITA (BLAKE | 24 | 7.6 | 53.4 | 36.0 | 7.5 | 16.5 | 4.0 | 3.61 | 22.0 | 15.8 | 1.102 | 14.7 | 16.2 | 14.0 |
| 24 | 011 BEAVER | 21 | 9.8 | 59.5 | 38.1 | 7.5 | 18.2 | 3.2 | 2.77 | 62.5 | 16.3 | 1.025 | 17.3 | 17.7 | 15.5 |
| 24 | 013 BULL SHOALS | 21 | 8.2 | 57.9 | 39.6 | 7.5 | 14.3 | 3.7 | 4.22 | 18.2 | 12.4 | 0.502 | 42.4 | 21.3 | 19.1 |
| 24 | 016 GREERS FERRY | 21 | 8.2 | 54.9 | 39.6 | 7.5 | 10.9 | 2.9 | 4.27 | 34.5 | 11.4 | 1.158 | 16.1 | 18.7 | 15.0 |
| 24 | 022 NORFOLK | 18 | 9.1 | 53.4 | 18.3 | 7.5 | 15.2 | 3.4 | 3.86 | 16.4 | 19.3 | 0.628 | 28.6 | 18.0 | 15.4 |

OXYGEN STATUS DATA SET

OXYGEN STATUS GROUP=ANOXIC

| DIS | RES | DTMAX | ZTHERM | PZMAX | PZDOM | TH | CPTL | CCHA | CSEC | IPTL | OPTL | THYD | QSOV | ZMEA | ZH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06 | 372 JOHN H KERR | 15 | 10.7 | 30.5 | 7.6 | 16.5 | 29.9 | 9.2 | 1.52 | 135.5 | 29.9 | 0.176 | 53.2 | 9.3 | 6.9 |
| 08 | 074 CLARK HILL | 15 | 6.1 | 42.7 | 6.1 | 16.5 | 17.1 | 7.6 | 2.22 | 55.6 | 24.3 | 0.250 | 42.7 | 10.7 | 9.6 |
| 08 | 330 HARTWELL | 15 | 7.6 | 51.8 | 10.7 | 16.5 | 10.2 | 5.8 | 3.01 | 54.0 | 9.2 | 0.583 | 23.8 | 13.9 | 12.8 |
| 10 | 073 WEST POINT | 9 | 6.7 | 22.9 | 5.2 | 22.5 | 66.7 | 12.4 | 0.50 | . | . | 0.152 | 46.8 | 7.1 | 5.2 |
| 10 | 076 SIDNEY LANIER | 18 | 6.1 | 44.2 | 10.7 | 13.5 | 12.7 | 5.3 | 2.70 | 79.7 | 18.6 | 0.932 | 16.2 | 15.1 | 13.1 |
| 15 | 178 GULL | 9 | 12.2 | 19.8 | 11.3 | 13.5 | 20.6 | 9.7 | 2.54 | 33.5 | 18.9 | 3.254 | 3.9 | 12.6 | 5.6 |
| 15 | 181 LEECH | 12 | 14.0 | 25.9 | 15.2 | 10.5 | 18.8 | 6.2 | 2.19 | 51.3 | 22.2 | 4.321 | 1.0 | 4.5 | 5.2 |
| 15 | 399 EAU GALLE | 6 | 2.4 | 3.0 | 2.4 | 13.5 | 90.0 | 17.4 | 1.38 | . | . | 0.069 | 45.5 | 3.1 | 2.7 |
| 16 | 243 BERLIN | 6 | 7.6 | 22.9 | 4.3 | 19.5 | 64.1 | 11.7 | 0.83 | 249.6 | 57.6 | 0.196 | 26.6 | 5.2 | 3.7 |
| 16 | 328 ALLEGHENY (KINZ | 12 | 9.1 | 30.5 | 10.7 | 13.5 | 21.4 | 5.8 | 2.29 | 45.4 | 31.2 | 0.176 | 76.1 | 13.4 | 10.3 |
| 17 | 241 ATWOOD | 9 | 6.1 | 10.7 | 4.3 | 16.5 | 27.3 | 9.7 | 1.26 | 93.4 | 27.5 | 0.382 | 11.8 | 4.5 | 2.1 |
| 17 | 245 CHARLES MILL | 9 | 3.7 | 7.6 | 2.4 | 13.5 | 111.2 | 59.0 | 0.49 | 176.8 | 156.2 | 0.029 | 56.0 | 1.6 | 0.6 |
| 17 | 247 DEER CREEK | 6 | 7.6 | 13.7 | 5.5 | 16.5 | 70.4 | 10.6 | 0.86 | 90.1 | 127.7 | 0.050 | 88.0 | 4.4 | 0.8 |
| 17 | 249 DILLON | 6 | 4.6 | 9.1 | 2.4 | 19.5 | 171.7 | 31.3 | 0.52 | 164.4 | 130.2 | 0.017 | 180.0 | 3.0 | 1.6 |
| 17 | 258 TAPPAN | 9 | 5.5 | 9.1 | 4.3 | 16.5 | 41.3 | 28.9 | 0.99 | 30.1 | 29.9 | 0.482 | 9.0 | 4.3 | 2.2 |
| 17 | 389 BLUESTONE | 6 | 9.1 | 13.7 | 9.1 | 19.5 | 78.9 | 15.3 | 0.67 | 46.0 | 45.7 | 0.007 | 812.1 | 6.1 | 1.5 |
| 18 | 090 CAGLES MILL | 15 | 6.1 | 15.2 | 2.4 | 13.5 | 35.8 | . | 1.09 | . | . | 0.130 | 45.4 | 5.9 | 3.5 |
| 18 | 091 HUNTINGTON | 6 | 4.6 | 9.1 | 4.0 | 19.5 | 132.3 | . | 0.57 | . | . | 0.029 | 146.7 | 4.2 | 2.0 |
| 18 | 092 MISSISSINEWA | 9 | 7.6 | 21.3 | 5.5 | 16.5 | 58.5 | 9.4 | 0.94 | 337.7 | 131.8 | 0.079 | 93.9 | 7.4 | 4.8 |
| 18 | 093 MONROE | 15 | 7.6 | 16.8 | 5.5 | 16.5 | 27.7 | 7.3 | 1.82 | 28.9 | 12.8 | 0.407 | 13.7 | 5.6 | 2.2 |
| 18 | 094 SALAMONIE | 12 | 7.6 | 21.3 | 3.7 | 16.5 | 38.3 | . | 1.07 | . | . | 0.167 | 38.6 | 6.5 | 4.2 |
| 18 | 095 C M HARDEN (MAN | 12 | 7.6 | 16.8 | 5.5 | 16.5 | 29.4 | . | 1.11 | . | . | 0.317 | 23.0 | 7.3 | 4.2 |
| 18 | 097 BROOKVILLE | 18 | 7.6 | 29.0 | 5.5 | 10.5 | 26.2 | . | 1.03 | . | . | 0.696 | 15.4 | 10.7 | 8.2 |
| 18 | 120 BARREN RIVER | 15 | 7.6 | 21.3 | 6.1 | 13.5 | 26.8 | 7.7 | 1.34 | 56.6 | 47.3 | 0.151 | 50.6 | 7.6 | 4.2 |
| 18 | 121 BUCKHORN | 12 | 7.6 | 18.3 | 8.2 | 16.5 | 21.9 | . | 1.37 | . | . | 0.077 | 99.6 | 7.7 | 6.2 |
| 18 | 126 GREEN RIVER | 18 | 6.7 | 24.4 | 5.5 | 13.5 | 20.8 | . | 1.56 | . | . | 0.331 | 27.4 | 9.1 | 6.0 |
| 18 | 128 NOLIN RIVER | 18 | 6.7 | 29.0 | 7.3 | 13.5 | 29.5 | . | 1.46 | . | . | 0.265 | 33.8 | 9.0 | 6.9 |
| 18 | 129 ROUGH RIVER | 15 | 7.6 | 19.8 | 4.6 | 13.5 | 18.7 | . | 1.53 | . | . | 0.241 | 29.2 | 7.0 | 4.0 |
| 18 | 134 CAVE RUN | 15 | 6.7 | 21.3 | 5.5 | 10.5 | 17.5 | . | 1.88 | . | . | 0.291 | 28.2 | 8.2 | 4.9 |
| 18 | 260 WEST FORK OF MI | 9 | 2.4 | 6.1 | 1.5 | 16.5 | 234.2 | . | 0.33 | . | . | 0.073 | 34.8 | 2.6 | 2.2 |

OXYGEN STATUS DATA SET

------------------------------------------- OXYGEN STATUS GROUP=ANOXIC -------------------------------------------

| DIS | RES | DTMAX | ZTHERM | PZMAX | PZDOM | TH | CPTL | CCHA | CSEC | IPTL | OPTL | THYO | QSOV | ZMEA | ZH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 263 CLARENCE J BROW | 12 | 6.7 | 13.7 | 4.5 | 13.5 | 42.1 | . | 0.94 | . | . | . | . | 5.3 | 2.4 |
| 19 | 340 J'PERCY PRIEST | 18 | 7.6 | 29.0 | 5.5 | 13.5 | 32.9 | 8.7 | 1.44 | 139.9 | 102.9 | 0.220 | 37.6 | 8.3 | 6.4 |
| 20 | 087 SHELBYVILLE | 9 | 6.1 | 15.2 | 6.1 | 19.5 | 51.7 | 16.9 | 1.11 | 175.9 | 105.6 | 0.209 | 30.2 | 6.3 | 4.5 |
| 22 | 188 ARKABUTLA | 9 | 4.6 | 12.2 | 4.6 | 19.5 | 142.5 | 4.6 | 0.44 | 110.0 | 279.1 | 0.173 | 25.2 | 4.4 | 2.4 |
| 22 | 189 ENID | 9 | 7.6 | 13.7 | 8.2 | 19.5 | 42.6 | 5.2 | 1.09 | 284.6 | 64.9 | 0.331 | 18.8 | 6.2 | 2.8 |
| 22 | 190 GRENADA | 9 | 9.1 | 15.2 | 6.7 | 19.5 | 60.6 | 4.1 | 0.62 | 122.3 | 105.7 | 0.457 | 12.9 | 5.9 | 2.1 |
| 22 | 192 SARDIS | 9 | 7.6 | 16.8 | 4.3 | 19.5 | 38.4 | 7.0 | 1.33 | 79.9 | 18.4 | 0.430 | 17.5 | 7.5 | 4.2 |
| 24 | 200 TABLE ROCK | 21 | 9.1 | 65.5 | 12.2 | 7.5 | 22.3 | 7.8 | 2.54 | 47.7 | 18.1 | 0.588 | 33.4 | 19.7 | 17.4 |
| 25 | 267 EUFAULA | 6 | 17.0 | 24.4 | 15.2 | 22.5 | 66.6 | 3.2 | 0.54 | 359.4 | 191.0 | 0.451 | 16.4 | 7.4 | 3.2 |
| 25 | 278 TENKILLER FERRY | 12 | 13.7 | 42.7 | 9.1 | 16.5 | 31.9 | 5.2 | 1.90 | 93.4 | 47.9 | 0.324 | 49.3 | 16.0 | 11.4 |
| 25 | 281 WISTER | 6 | 6.1 | 10.7 | 3.7 | 22.5 | 96.9 | 5.1 | 0.58 | 71.1 | 70.8 | 0.070 | 43.0 | 3.0 | 1.8 |
| 26 | 355 LEWISVILLE(GARZ | 6 | 9.1 | 16.8 | 9.1 | 19.5 | 93.3 | 16.2 | 0.80 | 318.5 | 77.0 | 1.049 | 6.1 | 6.4 | 3.1 |
| 26 | 359 SAM RAYBURN (MC | 12 | 10.7 | 25.9 | 7.6 | 19.5 | 49.7 | 6.3 | 1.90 | . | . | 2.659 | 2.9 | 7.7 | 3.8 |
| 29 | 108 MILFORD | 6 | 15.2 | 19.8 | 15.2 | 19.5 | 94.5 | 18.9 | 0.85 | 656.8 | 59.6 | 0.305 | 26.8 | 8.2 | 3.0 |
| 29 | 194 POMME DE TERRE | 15 | 7.6 | 25.9 | 4.6 | 10.5 | 41.4 | 7.5 | 1.54 | 43.6 | 64.6 | 0.515 | 18.3 | 9.4 | 6.8 |
| 29 | 195 STOCKTON | 12 | 7.6 | 30.5 | 8.5 | 16.5 | 18.9 | 7.3 | 2.03 | 75.3 | 20.1 | 0.792 | 13.6 | 10.8 | 7.8 |

# APPENDIX D

## Model Residual Summaries and Analyses

Table D1

Key to Appendix D Tables

| Model Category: | Internal | P Retention | Load/Response |
|---|---|---|---|
| Report Section: | V | VI | VI |
| | | Table | |
| Model Code and Data Set Definitions | 16,19* | 22* | 25,26,27* |
| Statistical Summaries: | | | |
| Original Parameters | D2 | D4 | D6 |
| Optimal Parameters | D3 | D5 | D7 |
| Regional Analyses | D8 | D9 | D10 |
| Correlation Matrices | D11 | D12 | D13 |
| Stepwise Regressions | D14 | D15 | D16 |

* In the main text.

Table D2

Error Statistics for Internal Models with Original Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B01A01 | 218 | -0.049 | .289 | .086 | -2.48 | .012 | -0.93 | 0.65 | 0.417 | 5.14 | .181 |
| B01A02 | 218 | -0.112 | .304 | .104 | -5.42 | <.001 | -1.14 | 0.50 | 0.291 | 5.92 | .184 |
| B01A03 | 218 | -0.358 | .400 | .287 | -13.21 | <.001 | -1.65 | 0.41 | -0.949 | 16.52 | .316 |
| B02A01 | 218 | -0.381 | .350 | .267 | -16.05 | <.001 | -1.51 | 0.41 | -0.811 | 15.65 | .360 |
| B03A01 | 218 | -0.346 | .351 | .242 | -14.56 | <.001 | -1.39 | 0.29 | -0.643 | 13.47 | .297 |
| B04A01 | 218 | -0.231 | .234 | .108 | -14.60 | <.001 | -1.01 | 0.33 | 0.267 | 7.10 | .264 |
| B05A01 | 218 | -0.093 | .253 | .072 | -5.40 | <.001 | -0.81 | 0.51 | 0.508 | 4.31 | .186 |
| S01A01 | 218 | -0.244 | .294 | .145 | -12.26 | <.001 | -1.26 | 0.27 | -0.391 | 8.29 | .175 |
| S01A02 | 218 | -0.274 | .286 | .156 | -14.16 | <.001 | -1.23 | 0.28 | -0.497 | 8.88 | .215 |
| S02A01 | 218 | -0.405 | .298 | .252 | -20.11 | <.001 | -1.28 | 0.21 | -1.417 | 14.59 | .379 |
| S03A01 | 218 | -0.395 | .289 | .239 | -20.22 | <.001 | -1.34 | 0.15 | -1.288 | 13.73 | .338 |
| S04A01 | 258 | -0.022 | .189 | .036 | -1.89 | .070 | -0.56 | 0.64 | 0.655 | 3.86 | .132 |
| S04A02 | 258 | -0.093 | .185 | .043 | -8.02 | <.001 | -0.56 | 0.58 | 0.591 | 4.91 | .148 |
| S05A01 | 258 | -0.027 | .212 | .045 | -2.03 | .050 | -0.52 | 0.73 | 0.565 | 4.88 | .132 |
| S05A02 | 258 | -0.173 | .212 | .075 | -13.11 | <.001 | -0.66 | 0.59 | 0.286 | 9.23 | .216 |
| S06A01 | 258 | -0.233 | .197 | .093 | -18.98 | <.001 | -0.64 | 0.46 | 0.112 | 11.50 | .262 |

Statistic Definitions

| | |
|---|---|
| N | number of observations |
| MEAN | mean residual (bias) |
| STD | standard deviation |
| MSE | mean squared error (uncorrected for degrees of freedom used in parameter estimation) |
| T | t-test for H0: mean=0 |
| PRT | probability if greater T, given H0 |
| MIN | minimum residual |
| MAX | maximum residual |
| R2 | R-Squared |
| CHI2 | Chi-Squared (see Part IV of main text) |
| MAD | median absolute deviation |

Table D3

Error Statistics for Internal Models with Optimized Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S01X01 | 218 | -0.005 | 0.285 | 0.081 | -0.25 | .201 | -0.929 | 0.565 | 0.308 | 4.85 | 0.192 |
| S02X01 | 218 | -0.001 | 0.294 | 0.086 | -0.06 | .239 | -0.887 | 0.555 | 0.264 | 5.22 | 0.206 |
| S03X01 | 218 | -0.010 | 0.285 | 0.081 | -0.50 | .154 | -0.934 | 0.560 | 0.307 | 4.84 | 0.189 |
| S04X01 | 258 | 0.004 | 0.185 | 0.034 | 0.31 | .190 | -0.484 | 0.673 | 0.675 | 3.45 | 0.124 |
| S04X02 | 212 | 0.001 | 0.153 | 0.023 | 0.12 | .226 | -0.370 | 0.311 | 0.774 | 2.86 | 0.117 |
| S05X01 | 258 | 0.010 | 0.194 | 0.038 | 0.82 | .103 | -0.432 | 0.662 | 0.641 | 3.81 | 0.125 |
| S05X02 | 212 | -0.001 | 0.154 | 0.024 | -0.09 | .233 | -0.342 | 0.333 | 0.773 | 2.90 | 0.125 |
| S06X01 | 258 | 0.003 | 0.185 | 0.034 | 0.25 | .201 | -0.485 | 0.673 | 0.675 | 3.45 | 0.124 |
| S06X02 | 212 | 0.000 | 0.153 | 0.023 | 0.03 | .243 | -0.363 | 0.314 | 0.774 | 2.86 | 0.120 |
| B01X01 | 218 | -0.003 | 0.289 | 0.083 | -0.15 | .220 | -0.914 | 0.681 | 0.437 | 4.96 | 0.184 |
| B01X02 | 189 | 0.005 | 0.266 | 0.070 | 0.26 | .199 | -0.845 | 0.624 | 0.507 | 4.10 | 0.175 |
| B01X03 | 161 | 0.006 | 0.237 | 0.056 | 0.31 | .189 | -0.630 | 0.515 | 0.637 | 3.40 | 0.156 |
| B01X04 | 137 | -0.006 | 0.211 | 0.044 | -0.31 | .189 | -0.487 | 0.435 | 0.717 | 2.60 | 0.148 |
| B01X05 | 62 | -0.006 | 0.197 | 0.038 | -0.23 | .204 | -0.461 | 0.411 | 0.759 | 2.89 | 0.135 |
| B02X01 | 218 | 0.007 | 0.294 | 0.086 | 0.33 | .186 | -0.935 | 0.687 | 0.414 | 5.26 | 0.178 |
| B02X02 | 62 | -0.005 | 0.212 | 0.044 | -0.20 | .210 | -0.490 | 0.370 | 0.719 | 3.36 | 0.155 |
| B03X01 | 218 | -0.005 | 0.285 | 0.081 | -0.25 | .202 | -0.887 | 0.686 | 0.450 | 4.91 | 0.179 |
| B03X02 | 73 | 0.016 | 0.239 | 0.057 | 0.57 | .570 | -0.630 | 0.445 | 0.661 | 2.83 | 0.153 |
| B04X01 | 218 | -0.005 | 0.219 | 0.048 | -0.32 | .187 | -0.659 | 0.596 | 0.674 | 2.58 | 0.136 |
| B04X02 | 189 | 0.007 | 0.201 | 0.040 | 0.45 | .163 | -0.673 | 0.590 | 0.718 | 2.22 | 0.129 |
| B05X01 | 218 | -0.023 | 0.251 | 0.063 | -1.33 | .046 | -0.772 | 0.543 | 0.572 | 3.68 | 0.169 |

in

Table D4

Error Statistics for Phosphorus Retention Models with Original Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R01A01 | 62 | -0.265 | 0.243 | 0.128 | -8.59 | <.001 | -0.918 | 0.077 | .135 | 10.97 | 0.190 |
| R01A02 | 62 | -0.155 | 0.227 | 0.074 | -5.37 | <.001 | -0.672 | 0.276 | .499 | 6.44 | 0.125 |
| R02A01 | 62 | -0.209 | 0.252 | 0.106 | -6.53 | <.001 | -0.942 | 0.459 | .287 | 8.89 | 0.150 |
| R02A02 | 62 | -0.178 | 0.252 | 0.094 | -5.56 | <.001 | -0.898 | 0.553 | .368 | 7.96 | 0.118 |
| R02A03 | 62 | -0.153 | 0.252 | 0.086 | -4.77 | <.001 | -0.863 | 0.621 | .420 | 7.43 | 0.142 |
| R02A04 | 62 | 0.213 | 0.299 | 0.133 | 5.60 | <.001 | -0.408 | 1.316 | .104 | 17.92 | 0.187 |
| R03A01 | 62 | -0.173 | 0.237 | 0.085 | -5.75 | <.001 | -0.828 | 0.184 | .426 | 7.12 | 0.124 |
| R03A02 | 62 | -0.190 | 0.242 | 0.094 | -6.21 | <.001 | -0.867 | 0.153 | .369 | 7.88 | 0.114 |
| R03A03 | 62 | -0.190 | 0.239 | 0.092 | -6.26 | <.001 | -0.852 | 0.161 | .379 | 7.72 | 0.118 |
| R03A04 | 62 | -0.123 | 0.225 | 0.065 | -4.29 | <.001 | -0.654 | 0.308 | .564 | 5.62 | 0.122 |
| R03A05 | 62 | -0.055 | 0.224 | 0.052 | -1.95 | .056 | -0.622 | 0.363 | .647 | 4.83 | 0.141 |
| R03A06 | 62 | -0.058 | 0.226 | 0.054 | -2.01 | .049 | -0.656 | 0.341 | .638 | 4.89 | 0.151 |
| R03A07 | 62 | 0.021 | 0.264 | 0.069 | 0.63 | .529 | -0.736 | 0.350 | .534 | 7.91 | 0.226 |
| R04A01 | 62 | -0.185 | 0.243 | 0.092 | -6.00 | <.001 | -0.838 | 0.157 | .377 | 7.67 | 0.119 |
| R04A02 | 62 | -0.268 | 0.263 | 0.140 | -8.02 | <.001 | -1.009 | 0.055 | .058 | 12.21 | 0.209 |
| R04A03 | 62 | -0.126 | 0.228 | 0.067 | -4.34 | <.001 | -0.673 | 0.284 | .547 | 5.77 | 0.111 |
| R05A01 | 62 | -0.133 | 0.252 | 0.080 | -4.16 | <.001 | -0.868 | 0.527 | .461 | 6.72 | 0.111 |
| R06A01 | 62 | -0.131 | 0.238 | 0.073 | -4.33 | <.001 | -0.837 | 0.422 | .508 | 6.18 | 0.125 |
| R06A02 | 62 | -0.095 | 0.229 | 0.060 | -3.26 | .002 | -0.761 | 0.418 | .593 | 5.40 | 0.121 |
| R06A03 | 62 | 0.010 | 0.230 | 0.052 | 0.34 | .736 | -0.669 | 0.444 | .647 | 5.57 | 0.160 |
| R07A01 | 62 | -0.210 | 0.247 | 0.104 | -6.68 | <.001 | -0.939 | 0.383 | .298 | 8.74 | 0.149 |
| R08A01 | 56 | 0.243 | 0.269 | 0.130 | 6.78 | <.001 | -0.376 | 0.977 | .114 | 18.39 | 0.226 |
| R09A01 | 62 | 0.743 | 1.407 | 2.500 | 4.16 | <.001 | -0.392 | 7.747 | -15.8 | 395.7 | 0.353 |
| R10A01 | 62 | -0.035 | 0.232 | 0.054 | -1.19 | .240 | -0.703 | 0.535 | .635 | 5.17 | 0.134 |
| R10A02 | 62 | -0.143 | 0.238 | 0.076 | -4.74 | <.001 | -0.788 | 0.521 | .486 | 6.66 | 0.120 |
| R11A01 | 62 | 0.077 | 0.248 | 0.066 | 2.44 | .018 | -0.625 | 0.396 | .554 | 8.45 | 0.223 |
| R11A02 | 62 | -0.019 | 0.276 | 0.075 | -0.55 | .582 | -0.803 | 0.324 | .494 | 8.04 | 0.220 |
| R11A03 | 62 | 0.083 | 0.252 | 0.069 | 2.60 | .012 | -0.634 | 0.398 | .533 | 8.92 | 0.224 |
| R12A01 | 62 | -0.026 | 0.194 | 0.038 | -1.07 | .289 | -0.501 | 0.372 | .747 | 4.08 | 0.121 |
| R13A01 | 62 | -0.100 | 0.219 | 0.057 | -3.60 | <.001 | -0.719 | 0.218 | .613 | 4.99 | 0.132 |
| R13A02 | 62 | 0.036 | 0.206 | 0.043 | 1.37 | .176 | -0.526 | 0.409 | .709 | 5.04 | 0.168 |
| R13A03 | 62 | -0.078 | 0.229 | 0.058 | -2.68 | .009 | -0.718 | 0.245 | .613 | 5.10 | 0.135 |
| R14A01 | 62 | -0.082 | 0.206 | 0.049 | -3.15 | .003 | -0.624 | 0.325 | .672 | 4.27 | 0.135 |
| R15A01 | 62 | -0.060 | 0.185 | 0.037 | -2.55 | .013 | -0.539 | 0.375 | .749 | 3.90 | 0.121 |
| R15A02 | 62 | -0.122 | 0.193 | 0.051 | -4.96 | <.001 | -0.605 | 0.277 | .653 | 4.83 | 0.114 |
| R15A03 | 62 | -0.033 | 0.184 | 0.034 | -1.42 | .161 | -0.519 | 0.415 | .768 | 3.82 | 0.118 |
| R16A01 | 17 | -0.031 | 0.243 | 0.056 | -0.53 | .601 | -0.526 | 0.444 | .099 | 5.25 | 0.156 |

Table D5

Error Statistics for Phosphorus Retention Models with Optimal Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Data | | | | | | | | | | | |
| R01X01 | 62 | -0.030 | 0.234 | 0.055 | -0.99 | .324 | -0.488 | 0.483 | 0.633 | 6.06 | 0.120 |
| R02X01 | 62 | -0.038 | 0.262 | 0.069 | -1.13 | .264 | -0.701 | 0.888 | 0.534 | 7.18 | 0.137 |
| R03X01 | 62 | 0.001 | 0.223 | 0.049 | 0.03 | .978 | -0.538 | 0.440 | 0.671 | 5.13 | 0.139 |
| R04X01 | 62 | -0.000 | 0.226 | 0.050 | -0.01 | .993 | -0.495 | 0.446 | 0.660 | 5.55 | 0.141 |
| R05X01 | 62 | 0.000 | 0.251 | 0.062 | 0.01 | .992 | -0.726 | 0.702 | 0.581 | 6.42 | 0.164 |
| R06X01 | 62 | -0.002 | 0.226 | 0.050 | -0.08 | .936 | -0.650 | 0.440 | 0.663 | 5.30 | 0.157 |
| R07X01 | 62 | 0.002 | 0.226 | 0.050 | 0.07 | .946 | -0.663 | 0.452 | 0.660 | 5.27 | 0.157 |
| R08X01 | 62 | -0.001 | 0.239 | 0.056 | -0.02 | .984 | -0.713 | 0.534 | 0.622 | 5.68 | 0.152 |
| R09X01 | 62 | -0.182 | 0.296 | 0.119 | -4.84 | <.001 | -0.931 | 1.005 | 0.199 | 10.97 | 0.167 |
| R10X01 | 62 | 0.002 | 0.222 | 0.048 | 0.06 | .951 | -0.559 | 0.447 | 0.675 | 5.11 | 0.130 |
| R11X01 | 62 | 0.000 | 0.239 | 0.056 | 0.01 | .992 | -0.625 | 0.361 | 0.622 | 6.38 | 0.189 |
| R12X01 | 62 | 0.014 | 0.189 | 0.035 | 0.57 | .568 | -0.434 | 0.441 | 0.763 | 4.48 | 0.109 |
| R13X01 | 62 | 0.001 | 0.206 | 0.042 | 0.04 | .969 | -0.554 | 0.380 | 0.718 | 4.56 | 0.165 |
| R14X01 | 62 | 0.001 | 0.169 | 0.028 | 0.04 | .969 | -0.376 | 0.427 | 0.810 | 3.17 | 0.108 |
| R15X01 | 62 | 0.005 | 0.168 | 0.028 | 0.21 | .833 | -0.402 | 0.398 | 0.813 | 3.54 | 0.100 |
| R16X01 | 17 | -0.065 | 0.232 | 0.055 | -1.16 | .261 | -0.552 | 0.347 | 0.123 | 4.70 | 0.155 |
| Restricted Data Set* | | | | | | | | | | | |
| R01X02 | 56 | -0.035 | 0.199 | 0.040 | -1.33 | .189 | -0.464 | 0.407 | 0.724 | 4.47 | 0.088 |
| R02X02 | 56 | -0.039 | 0.222 | 0.050 | -1.31 | .194 | -0.486 | 0.790 | 0.655 | 5.35 | 0.111 |
| R03X02 | 56 | 0.002 | 0.182 | 0.033 | 0.07 | .942 | -0.394 | 0.358 | 0.775 | 3.65 | 0.117 |
| R04X02 | 56 | -0.000 | 0.188 | 0.035 | -0.00 | .997 | -0.426 | 0.362 | 0.760 | 3.99 | 0.130 |
| R05X02 | 56 | -0.000 | 0.205 | 0.041 | -0.01 | .996 | -0.474 | 0.534 | 0.715 | 4.63 | 0.144 |
| R06X02 | 56 | -0.002 | 0.179 | 0.031 | -0.09 | .928 | -0.404 | 0.351 | 0.783 | 3.73 | 0.116 |
| R07X02 | 56 | 0.002 | 0.179 | 0.032 | 0.10 | .917 | -0.406 | 0.357 | 0.781 | 3.70 | 0.114 |
| R08X02 | 56 | 0.001 | 0.190 | 0.035 | 0.03 | .976 | -0.443 | 0.428 | 0.756 | 3.99 | 0.117 |
| R09X02 | 56 | -0.162 | 0.241 | 0.083 | -5.02 | .000 | -0.651 | 0.794 | 0.427 | 8.05 | 0.148 |
| R10X02 | 56 | 0.003 | 0.180 | 0.032 | 0.12 | .903 | -0.398 | 0.369 | 0.780 | 3.58 | 0.111 |
| R11X02 | 56 | 0.000 | 0.206 | 0.042 | 0.01 | .992 | -0.530 | 0.285 | 0.711 | 5.31 | 0.171 |
| R12X02 | 56 | 0.007 | 0.166 | 0.027 | 0.30 | .765 | -0.417 | 0.368 | 0.813 | 3.42 | 0.107 |
| R13X02 | 56 | 0.005 | 0.174 | 0.030 | 0.23 | .815 | -0.459 | 0.315 | 0.794 | 3.55 | 0.132 |
| R14X02 | 56 | 0.002 | 0.155 | 0.024 | 0.08 | .940 | -0.404 | 0.378 | 0.837 | 2.70 | 0.100 |
| R15X02 | 56 | 0.006 | 0.159 | 0.025 | 0.29 | .773 | -0.416 | 0.375 | 0.828 | 3.11 | 0.094 |

* Inflow Total P < 500 mg/m3, Inflow Ortho-P/Total P > .12

Table D6

Error Statistics for Phosphorus Loading Models with Original Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P01A01 | 43 | -0.255 | 0.249 | 0.126 | -6.70 | <.000 | -1.104 | 0.154 | 0.133 | 16.25 | 0.223 |
| P01A02 | 43 | -0.148 | 0.266 | 0.091 | -3.66 | <.001 | -1.041 | 0.291 | 0.373 | 11.44 | 0.198 |
| P02A01 | 43 | -0.206 | 0.255 | 0.106 | -5.31 | <.000 | -1.050 | 0.270 | 0.270 | 13.14 | 0.225 |
| P02A02 | 43 | -0.177 | 0.260 | 0.097 | -4.46 | <.000 | -1.025 | 0.325 | 0.329 | 11.88 | 0.189 |
| P02A03 | 43 | -0.154 | 0.265 | 0.092 | -3.80 | <.000 | -1.004 | 0.368 | 0.365 | 11.10 | 0.187 |
| P02A04 | 43 | 0.196 | 0.348 | 0.157 | 3.68 | .001 | -0.648 | 0.954 | -0.082 | 21.29 | 0.215 |
| P03A01 | 43 | -0.167 | 0.244 | 0.086 | -4.47 | <.000 | -1.007 | 0.247 | 0.406 | 10.94 | 0.169 |
| P03A02 | 43 | -0.183 | 0.244 | 0.092 | -4.92 | <.000 | -1.017 | 0.230 | 0.367 | 11.65 | 0.190 |
| P03A03 | 43 | -0.183 | 0.245 | 0.092 | -4.90 | <.000 | -1.022 | 0.227 | 0.367 | 11.66 | 0.176 |
| P03A04 | 43 | -0.118 | 0.262 | 0.081 | -2.96 | .005 | -1.001 | 0.331 | 0.443 | 10.21 | 0.189 |
| P03A05 | 43 | -0.053 | 0.254 | 0.066 | -1.37 | .179 | -0.915 | 0.402 | 0.547 | 8.71 | 0.154 |
| P03A06 | 43 | -0.055 | 0.248 | 0.063 | -1.44 | .157 | -0.906 | 0.390 | 0.564 | 8.47 | 0.155 |
| P03A07 | 43 | 0.031 | 0.251 | 0.062 | 0.82 | .416 | -0.781 | 0.485 | 0.570 | 9.39 | 0.139 |
| P04A01 | 43 | -0.175 | 0.249 | 0.091 | -4.60 | <.000 | -1.024 | 0.234 | 0.370 | 11.74 | 0.163 |
| P04A02 | 43 | -0.257 | 0.252 | 0.128 | -6.68 | <.000 | -1.077 | 0.192 | 0.119 | 16.38 | 0.204 |
| P04A03 | 43 | -0.119 | 0.260 | 0.080 | -2.99 | .005 | -1.002 | 0.308 | 0.449 | 10.17 | 0.172 |
| P05A01 | 43 | -0.130 | 0.254 | 0.080 | -3.36 | .002 | -0.973 | 0.343 | 0.448 | 9.89 | 0.155 |
| P06A01 | 43 | -0.132 | 0.245 | 0.076 | -3.52 | .001 | -0.932 | 0.346 | 0.476 | 9.27 | 0.168 |
| P06A02 | 43 | -0.098 | 0.256 | 0.074 | -2.50 | .016 | -0.910 | 0.448 | 0.492 | 8.92 | 0.140 |
| P06A03 | 43 | 0.007 | 0.248 | 0.060 | 0.19 | .847 | -0.768 | 0.508 | 0.586 | 8.47 | 0.150 |
| P07A01 | 43 | -0.207 | 0.252 | 0.105 | -5.37 | <.000 | -1.046 | 0.269 | 0.276 | 13.02 | 0.224 |
| P08A01 | 39 | 0.246 | 0.455 | 0.262 | 3.37 | .002 | -0.613 | 1.865 | -0.905 | 41.45 | 0.219 |
| P09A01 | 43 | 0.657 | 1.222 | 1.890 | 3.53 | .001 | -0.559 | 5.126 | -12.029 | 203.6 | 0.295 |
| P10A01 | 43 | -0.036 | 0.253 | 0.064 | -0.92 | .361 | -0.866 | 0.476 | 0.560 | 8.19 | 0.130 |
| P10A02 | 43 | -0.143 | 0.262 | 0.088 | -3.57 | .001 | -1.005 | 0.367 | 0.396 | 10.61 | 0.185 |
| P11A01 | 43 | 0.090 | 0.227 | 0.059 | 2.59 | .013 | -0.583 | 0.522 | 0.597 | 8.71 | 0.159 |
| P11A02 | 43 | -0.008 | 0.259 | 0.065 | -0.21 | .838 | -0.829 | 0.458 | 0.549 | 9.40 | 0.165 |
| P11A03 | 43 | 0.096 | 0.232 | 0.062 | 2.71 | .010 | -0.606 | 0.535 | 0.574 | 9.37 | 0.171 |
| P12A01 | 43 | -0.022 | 0.217 | 0.047 | -0.67 | .503 | -0.756 | 0.410 | 0.678 | 5.63 | 0.127 |
| P13A01 | 43 | -0.092 | 0.223 | 0.057 | -2.71 | .010 | -0.844 | 0.297 | 0.608 | 7.22 | 0.135 |
| P13A02 | 43 | 0.046 | 0.203 | 0.042 | 1.50 | .141 | -0.562 | 0.474 | 0.707 | 5.62 | 0.121 |
| P13A03 | 43 | -0.071 | 0.234 | 0.059 | -1.98 | .055 | -0.873 | 0.326 | 0.595 | 7.70 | 0.134 |
| P14A01 | 43 | -0.076 | 0.216 | 0.051 | -2.29 | .027 | -0.812 | 0.285 | 0.645 | 6.60 | 0.140 |
| P15A01 | 43 | -0.054 | 0.199 | 0.042 | -1.79 | .080 | -0.638 | 0.420 | 0.712 | 4.90 | 0.107 |
| P15A02 | 43 | -0.116 | 0.210 | 0.057 | -3.63 | .001 | -0.794 | 0.319 | 0.610 | 6.87 | 0.160 |
| P15A03 | 43 | -0.027 | 0.196 | 0.038 | -0.92 | .364 | -0.566 | 0.462 | 0.737 | 4.44 | 0.117 |
| P16A01 | 13 | -0.044 | 0.188 | 0.035 | -0.84 | .417 | -0.396 | 0.156 | 0.252 | 7.05 | 0.112 |

(continued)

Table D6 (continued)

Error Statistics for Phosphorus Loading Models with Original Parameters (ct)

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B10A01 | 43 | -0.691 | 0.511 | 0.733 | -8.88 | <.001 | -1.865 | 0.264 | -5.527 | 40.29 | 0.736 |
| B11A01 | 43 | -0.283 | 0.326 | 0.184 | -5.70 | <.001 | -1.041 | 0.327 | -0.636 | 10.66 | 0.325 |
| B11A02 | 43 | -0.179 | 0.288 | 0.113 | -4.09 | <.001 | -0.872 | 0.429 | -0.006 | 6.84 | 0.246 |
| B11A03 | 43 | -0.077 | 0.260 | 0.072 | -1.93 | .060 | -0.691 | 0.583 | 0.360 | 4.68 | 0.187 |
| B11A04 | 43 | -0.058 | 0.272 | 0.075 | -1.40 | .169 | -0.714 | 0.575 | 0.328 | 4.93 | 0.211 |
| B11A05 | 43 | -0.117 | 0.277 | 0.089 | -2.77 | .008 | -0.786 | 0.507 | 0.211 | 5.56 | 0.212 |
| B11A06 | 43 | -0.223 | 0.299 | 0.137 | -4.90 | <.001 | -0.938 | 0.371 | -0.221 | 8.14 | 0.294 |
| B11A07 | 43 | -0.093 | 0.356 | 0.133 | -1.71 | .095 | -0.894 | 0.546 | -0.182 | 8.26 | 0.259 |
| B12A01 | 43 | -0.191 | 0.292 | 0.120 | -4.28 | <.001 | -0.877 | 0.346 | -0.067 | 7.56 | 0.298 |
| B13A01 | 43 | -0.092 | 0.262 | 0.075 | -2.30 | .027 | -0.686 | 0.537 | 0.329 | 4.80 | 0.189 |
| B14A01 | 43 | -0.006 | 0.302 | 0.089 | -0.14 | .891 | -0.593 | 0.718 | 0.204 | 5.76 | 0.189 |
| | | | | | | | | | | | |
| S10A01 | 43 | -0.243 | 0.207 | 0.101 | -7.69 | <.001 | -0.758 | 0.163 | 0.044 | 12.95 | 0.264 |
| S10A02 | 43 | -0.151 | 0.180 | 0.054 | -5.53 | <.001 | -0.575 | 0.271 | 0.485 | 6.67 | 0.184 |
| S10A03 | 43 | -0.545 | 0.255 | 0.360 | -14.02 | <.001 | -1.155 | -0.095 | -2.410 | 49.01 | 0.543 |

Table D7

Error Statistics for Phosphorus Loading Models with Optimal Parameters

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Data | | | | | | | | | | | |
| P01X01 | 43 | -0.078 | 0.284 | 0.085 | -1.81 | .077 | -0.911 | 0.396 | 0.415 | 10.58 | 0.221 |
| P02X01 | 43 | -0.070 | 0.285 | 0.084 | -1.60 | .116 | -0.925 | 0.529 | 0.420 | 9.85 | 0.170 |
| P03X01 | 43 | 0.001 | 0.242 | 0.057 | 0.04 | .971 | -0.826 | 0.418 | 0.606 | 8.37 | 0.146 |
| P04X01 | 43 | 0.000 | 0.249 | 0.061 | 0.00 | .999 | -0.842 | 0.419 | 0.582 | 8.65 | 0.153 |
| P05X01 | 43 | -0.000 | 0.248 | 0.060 | -0.00 | 1.000 | -0.828 | 0.445 | 0.585 | 8.44 | 0.118 |
| P06X01 | 43 | -0.000 | 0.242 | 0.057 | -0.01 | .991 | -0.787 | 0.487 | 0.605 | 8.15 | 0.139 |
| P07X01 | 43 | -0.001 | 0.243 | 0.058 | -0.03 | .973 | -0.785 | 0.489 | 0.603 | 8.22 | 0.137 |
| P08X01 | 43 | -0.001 | 0.244 | 0.058 | -0.02 | .987 | -0.811 | 0.463 | 0.598 | 8.21 | 0.135 |
| P09X01 | 43 | -0.173 | 0.285 | 0.109 | -3.99 | <.001 | -1.047 | 0.348 | 0.245 | 13.27 | 0.234 |
| P10X01 | 43 | 0.001 | 0.242 | 0.057 | 0.03 | .976 | -0.822 | 0.430 | 0.607 | 8.25 | 0.147 |
| P11X01 | 43 | 0.001 | 0.217 | 0.046 | 0.02 | .981 | -0.563 | 0.431 | 0.682 | 6.07 | 0.127 |
| P12X01 | 43 | 0.015 | 0.207 | 0.042 | 0.47 | .643 | -0.670 | 0.433 | 0.711 | 5.54 | 0.105 |
| P13X01 | 43 | 0.000 | 0.202 | 0.040 | 0.01 | .992 | -0.561 | 0.447 | 0.726 | 4.97 | 0.110 |
| P14X01 | 43 | -0.001 | 0.169 | 0.028 | -0.03 | .980 | -0.433 | 0.389 | 0.807 | 3.64 | 0.110 |
| P15X01 | 43 | 0.005 | 0.170 | 0.028 | 0.21 | .836 | -0.432 | 0.359 | 0.804 | 3.79 | 0.107 |
| P16X01 | 13 | -0.063 | 0.180 | 0.034 | -1.27 | .226 | -0.401 | 0.121 | 0.264 | 7.34 | 0.096 |
| B10X01 | 43 | 0.001 | 0.274 | 0.074 | 0.02 | .982 | -0.543 | 0.711 | 0.345 | 4.89 | 0.182 |
| B11X01 | 43 | 0.001 | 0.256 | 0.064 | 0.02 | .982 | -0.569 | 0.689 | 0.432 | 4.33 | 0.178 |
| B12X01 | 43 | -0.027 | 0.259 | 0.066 | -0.69 | .494 | -0.578 | 0.615 | 0.408 | 4.65 | 0.202 |
| B13X01 | 43 | 0.002 | 0.256 | 0.064 | 0.06 | .952 | -0.546 | 0.670 | 0.431 | 4.29 | 0.172 |
| B14X01 | 43 | -0.000 | 0.302 | 0.089 | -0.00 | .997 | -0.587 | 0.730 | 0.205 | 5.77 | 0.185 |
| B15X01 | 43 | -0.003 | 0.231 | 0.052 | -0.08 | .934 | -0.533 | 0.548 | 0.536 | 3.35 | 0.165 |
| S10X01 | 43 | 0.009 | 0.175 | 0.030 | 0.35 | .726 | -0.360 | 0.443 | 0.717 | 3.08 | 0.109 |
| S11X01 | 43 | 0.006 | 0.149 | 0.022 | 0.27 | .788 | -0.312 | 0.301 | 0.795 | 2.48 | 0.091 |

(continued)

Table D7 (continued)

Error Statistics for Phosphorus Loading Models with Optimal Parameters (ct)

| MODEL | N | MEAN | STD | MSE | T | PRT | MIN | MAX | R2 | CHI2 | MAD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ---------- Restricted Data Set * ---------- | | | | | | | | | | | |
| P01X02 | 39 | -0.076 | 0.218 | 0.052 | -2.16 | .037 | -0.452 | 0.342 | 0.639 | 8.01 | 0.195 |
| P02X02 | 39 | -0.072 | 0.216 | 0.051 | -2.08 | .044 | -0.440 | 0.435 | 0.651 | 7.02 | 0.168 |
| P03X02 | 39 | 0.000 | 0.182 | 0.032 | 0.01 | .991 | -0.338 | 0.373 | 0.776 | 5.99 | 0.131 |
| P04X02 | 39 | -0.000 | 0.186 | 0.034 | -0.00 | .998 | -0.365 | 0.371 | 0.767 | 6.17 | 0.132 |
| P05X02 | 39 | -0.000 | 0.182 | 0.032 | -0.00 | .997 | -0.345 | 0.394 | 0.777 | 5.75 | 0.126 |
| P06X02 | 39 | 0.000 | 0.181 | 0.032 | 0.00 | .999 | -0.340 | 0.413 | 0.779 | 5.77 | 0.119 |
| P07X02 | 39 | -0.003 | 0.186 | 0.034 | -0.09 | .928 | -0.301 | 0.437 | 0.767 | 5.85 | 0.141 |
| P08X02 | 39 | 0.001 | 0.182 | 0.032 | 0.04 | .971 | -0.316 | 0.417 | 0.776 | 5.68 | 0.119 |
| P09X02 | 39 | -0.142 | 0.212 | 0.064 | -4.18 | <.001 | -0.510 | 0.301 | 0.558 | 9.60 | 0.192 |
| P10X02 | 39 | -0.000 | 0.181 | 0.032 | -0.00 | .997 | -0.326 | 0.391 | 0.780 | 5.75 | 0.120 |
| P11X02 | 39 | 0.001 | 0.175 | 0.030 | 0.02 | .982 | -0.341 | 0.381 | 0.793 | 4.65 | 0.123 |
| P12X02 | 39 | 0.007 | 0.157 | 0.024 | 0.26 | .792 | -0.276 | 0.375 | 0.834 | 3.80 | 0.096 |
| P13X02 | 39 | 0.001 | 0.158 | 0.024 | 0.06 | .953 | -0.302 | 0.380 | 0.833 | 3.59 | 0.105 |
| P14X02 | 39 | -0.000 | 0.140 | 0.019 | -0.01 | .990 | -0.240 | 0.361 | 0.869 | 2.79 | 0.100 |
| P15X02 | 39 | 0.005 | 0.145 | 0.020 | 0.20 | .839 | -0.252 | 0.353 | 0.859 | 3.01 | 0.105 |
| P15X03 | 39 | -0.003 | 0.154 | 0.023 | -0.12 | .902 | -0.338 | 0.369 | 0.841 | 3.42 | 0.100 |
| B10X02 | 39 | 0.002 | 0.281 | 0.077 | 0.03 | .973 | -0.581 | 0.681 | 0.352 | 5.18 | 0.206 |
| B11X02 | 39 | -0.001 | 0.261 | 0.067 | -0.02 | .987 | -0.607 | 0.658 | 0.439 | 4.58 | 0.177 |
| B12X02 | 39 | 0.000 | 0.268 | 0.070 | 0.01 | .991 | -0.562 | 0.631 | 0.410 | 4.97 | 0.199 |
| B13X02 | 39 | 0.001 | 0.263 | 0.067 | 0.03 | .975 | -0.576 | 0.642 | 0.432 | 4.58 | 0.186 |
| B14X02 | 39 | 0.002 | 0.315 | 0.096 | 0.04 | .971 | -0.594 | 0.722 | 0.187 | 6.27 | 0.190 |
| B15X02 | 39 | -0.010 | 0.241 | 0.057 | -0.25 | .803 | -0.543 | 0.538 | 0.521 | 3.67 | 0.169 |
| S10X02 | 39 | 0.004 | 0.151 | 0.022 | 0.17 | .862 | -0.306 | 0.335 | 0.788 | 2.71 | 0.109 |
| S11X02 | 39 | 0.000 | 0.145 | 0.021 | 0.01 | .991 | -0.317 | 0.305 | 0.803 | 2.48 | 0.084 |
| ---------- Low-Turbidity Data Set ** ---------- | | | | | | | | | | | |
| B11X03 | 29 | -0.008 | 0.244 | 0.057 | -0.18 | .857 | -0.445 | 0.538 | 0.582 | 3.85 | 0.187 |
| B15X03 | 29 | -0.005 | 0.203 | 0.040 | -0.14 | .890 | -0.378 | 0.411 | 0.709 | 2.71 | 0.168 |
| S10X03 | 29 | 0.002 | 0.112 | 0.012 | 0.09 | .928 | -0.213 | 0.196 | 0.828 | 1.66 | 0.101 |
| S11X03 | 29 | -0.009 | 0.106 | 0.011 | -0.43 | .667 | -0.201 | 0.179 | 0.845 | 1.37 | 0.086 |

* Inflow Total P < 500 mg/m3, Inflow Ortho-P/Total P > .12

** Above constraints, plus turbidity < 1.58 1/m, inflow N/P > 8

Table D8

Regional Analysis of Internal Model Residuals

| Model | B01X01 | | | B01X03 | | | B01X05 | | |
|---|---|---|---|---|---|---|---|---|---|
| Region | N | Mean | Gr. | N | Mean | Gr. | N | Mean | Gr.* |
| 02 NAD | 4 | .13 | ABCD | 4 | .14 | AB | 3 | .29 | A |
| 03 SAD | 16 | .00 | BCDE | 9 | -.07 | BC | 1 | -.08 | BC |
| 04A ORD-Pitts. | 15 | .13 | ABC | 15 | .09 | AB | 9 | -.00 | B |
| 04B ORD-Hunt. | 22 | .25 | A | 18 | .21 | A | 6 | .16 | AB |
| 04C ORD-Louis. | 16 | .11 | ABCD | 15 | .05 | AB | 2 | .18 | AB |
| 04D ORD-Nash. | 21 | -.01 | CDE | 17 | -.01 | BC | 6 | .04 | AB |
| 05 NCD | 4 | .04 | ABCDE | 1 | -.05 | BC | 1 | -.19 | BC |
| 06 LMVD | 16 | .18 | AB | 15 | .05 | AB | 0 | | |
| 07A SWD-L.Rock | 36 | -.01 | CDE | 36 | -.02 | BC | 28 | -.04 | B |
| 07B SWD-Other | 36 | -.25 | E | 15 | -.11 | BC | 0 | | |
| 08 MRD | 24 | -.06 | DE | 13 | -.16 | C | 6 | -.24 | C |
| 09 NPD | 8 | -.27 | E | 3 | -.24 | C | 0 | | |
| Among Regions | | | | | | | | | |
| Sum of Squares | | 5.437 | | | 1.795 | | | .911 | |
| Deg. of Freedom | | 11 | | | 11 | | | 8 | |
| Mean Square | | .494 | | | .163 | | | .114 | |
| Within Regions | | | | | | | | | |
| Sum of Squares | | 12.642 | | | 7.210 | | | 1.448 | |
| Deg. of Freedom | | 206 | | | 149 | | | 53 | |
| Mean Square | | .061 | | | .048 | | | .027 | |
| F Ratio | | 8.05 | | | 3.37 | | | 4.17 | |
| Prob > F | | <.001 | | | <.001 | | | <.001 | |
| R-Squared ** | | .301 | | | .199 | | | .387 | |

* means followed by the same letter are not significantly different at p<.05, Duncan's multiple range test

** percent of total residual variance explained by regional effects

(continued)

Regional Analysis of Internal Model Residuals (ct)

| Model | B04X02 | | | B05X01 | | | S05X02 | | |
|---|---|---|---|---|---|---|---|---|---|
| Region | N | Mean | Gr. | N | Mean | Gr. | N | Mean | Gr.* |
| 02 NAD | 4 | .06 | AB | 4 | .04 | ABCDE | 4 | .10 | A |
| 03 SAD | 14 | .06 | AB | 16 | .01 | BCDE | 14 | -.07 | AB |
| 04A ORD-Pitts. | 15 | .04 | AB | 15 | .07 | ABC | 15 | -.01 | A |
| 04B ORD-Hunt. | 22 | .10 | A | 22 | .19 | A | 22 | .03 | A |
| 04C ORD-Louis. | 16 | .02 | AB | 16 | .05 | ABCD | 30 | -.05 | AB |
| 04D ORD-Nash. | 17 | .03 | AB | 21 | -.02 | BCDE | 26 | -.02 | A |
| 05 NCD | 1 | -.11 | B | 4 | .06 | ABCD | 1 | .23 | A |
| 06 LMVD | 16 | -.01 | AB | 16 | .13 | AB | 16 | .05 | A |
| 07A SWD-L.Rock | 36 | .01 | AB | 36 | -.08 | CDE | 36 | .12 | A |
| 07B SWD-Other | 27 | -.07 | B | 36 | -.19 | DE | 27 | -.11 | B |
| 08 MRD | 18 | -.05 | B | 24 | -.06 | CDE | 18 | -.01 | A |
| 09 NPD | 3 | .05 | AB | 8 | -.26 | E | 3 | -.05 | AB |

| | B04X02 | B05X01 | S05X02 |
|---|---|---|---|
| Among Regions | | | |
| Sum of Squares | 0.490 | 5.242 | 1.167 |
| Deg. of Freedom | 11 | 11 | 11 |
| Mean Square | .045 | .295 | .106 |
| Within Regions | | | |
| Sum of Squares | 7.100 | 10.383 | 3.819 |
| Deg. of Freedom | 177 | 206 | 200 |
| Mean Square | .040 | .050 | .019 |
| F Ratio | 1.11 | 5.85 | 5.55 |
| Prob > F | .356 | <.001 | <.001 |
| R-Squared ** | .065 | .234 | .234 |

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test

** percent of total residual variance explained by regional effects

Table D9

Regional Analysis of Phosphorus Retention Model Residuals

| Model | | R03X02 | | R12X02 | | R13X02 | | R14X02 | | R15X02 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | N | Mean | Gr. | Mean | Gr. | Mean | Gr. | Mean | Gr. | Mean | Gr. |
| 02 NAD | 2 | .04 | AB | -.00 | AB | .01 | A | -.03 | C | -.02 | B |
| 03 SAD | 9 | -.09 | B | -.10 | B | -.10 | A | -.12 | C | -.11 | B |
| 04A ORD-Pitts. | 3 | -.07 | B | -.06 | AB | -.05 | A | -.06 | C | -.06 | B |
| 04B ORD-Hunt. | 8 | .03 | AB | .04 | AB | .09 | A | .00 | C | .02 | AB |
| 04C ORD-Louis. | 3 | .01 | AB | -.01 | AB | -.01 | A | -.00 | C | -.02 | B |
| 04D ORD-Nash. | 5 | .10 | AB | .08 | AB | .10 | A | .08 | ABC | .08 | AB |
| 05 NCD | 1 | .28 | AB | .37 | A | .32 | A | .38 | A | .37 | A |
| 06 LMVD | 4 | -.08 | B | -.02 | AB | -.03 | A | .01 | BC | -.01 | B |
| 07A SWD-L.Rock | 3 | .04 | AB | -.05 | AB | -.10 | A | -.04 | C | -.04 | B |
| 07B SWD-Other | 13 | -.03 | B | -.01 | AB | -.02 | A | .00 | C | -.00 | B |
| 08 MRD | 2 | .02 | AB | .13 | AB | .01 | A | .09 | ABC | .13 | AB |
| 09 NPD | 2 | .32 | A | .21 | A | .18 | A | .26 | AB | .25 | A |
| 10 SPD | 1 | -.00 | AB | .02 | AB | .01 | A | .08 | ABC | .06 | AB |
| Among Regions | | | | | | | | | | | |
| Sum of Squares | | .484 | | .417 | | .413 | | .482 | | .462 | |
| Deg. of Freedom | | 12 | | 12 | | 12 | | 12 | | 12 | |
| Mean Square | | .040 | | .035 | | .034 | | .040 | | .038 | |
| Within Regions | | | | | | | | | | | |
| Sum of Squares | | 1.338 | | 1.096 | | 1.254 | | .836 | | .929 | |
| Deg. of Freedom | | 43 | | 43 | | 43 | | 43 | | 43 | |
| Mean Square | | .031 | | .026 | | .029 | | .019 | | .022 | |
| F Ratio | | 1.30 | | 1.36 | | 1.18 | | 2.07 | | 1.76 | |
| Prob > F | | .255 | | .221 | | .327 | | .041 | | .082 | |
| R-Squared ** | | .267 | | .275 | | .248 | | .367 | | .332 | |

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test

** percent of total residual variance explained by regional effects

Table D10

Regional Analysis of Phosphorus Loading Model Residuals

| | | Model | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predicted Var. | | Phosphorus | | | | Chlorophyll | | | | Transparency | | | |
| Model Code | | P13X02 | | P15X02 | | B11X03 | | B15X03 | | S10X03 | | S11X03 | |
| Region | N | Mean | Gr. | Mean | Gr. | Mean | Gr. | Mean | Gr. | Mean | Gr. | Mean | Gr.* |
| 02 NAD | 2 | .03 | AB | -.00 | ABC | .11 | ABC | .11 | AB | .09 | A | .10 | A |
| 03 SAD | 3 | -.09 | B | -.04 | BC | -.35 | C | -.30 | C | -.04 | A | -.08 | A |
| 04A ORD-Pitts. | 3 | -.07 | B | -.16 | C | -.03 | BC | -.05 | BC | .05 | A | .06 | A |
| 04B ORD-Hunt. | 4 | -.00 | B | -.08 | BC | .33 | A | .28 | A | -.07 | A | -.03 | A |
| 04C ORD-Louis. | 3 | .07 | AB | .06 | ABC | -.01 | ABC | .00 | ABC | -.06 | A | -.07 | A |
| 04D ORD-Nash. | 4 | -.04 | B | -.05 | BC | -.12 | BC | -.10 | BC | -.02 | A | -.02 | A |
| 05 NCD | 1 | .40 | A | .29 | A | .28 | AB | .19 | AB | .07 | A | .11 | A |
| 06 LMVD | 3 | -.08 | B | -.19 | C | .02 | ABC | -.07 | BC | -.01 | A | .04 | A |
| 07A SWD-L.Rock | 3 | .08 | AB | .06 | ABC | .01 | ABC | .02 | AB | .08 | A | .09 | A |
| 07B SWD-Other | 1 | -.08 | B | .00 | ABC | -.19 | BC | -.09 | BC | .13 | A | .05 | A |
| 08 MRD | 1 | .07 | AB | .10 | ABC | .11 | ABC | .15 | AB | -.03 | A | -.09 | A |
| 09 NPD | 1 | .02 | AB | .15 | AB | -.14 | BC | .01 | ABC | -.10 | A | -.20 | A |
| Among Regions | | | | | | | | | | | | | |
| Sum of Squares | | .290 | | .343 | | 1.030 | | .738 | | .112 | | .158 | |
| Deg. of Freedom | | 11 | | 11 | | 11 | | 11 | | 11 | | 11 | |
| Mean Square | | .026 | | .031 | | .094 | | .067 | | .010 | | .014 | |
| Within Regions | | | | | | | | | | | | | |
| Sum of Squares | | .315 | | .178 | | .635 | | .419 | | .240 | | .156 | |
| Deg. of Freedom | | 17 | | 17 | | 17 | | 17 | | 17 | | 17 | |
| Mean Square | | .019 | | .010 | | .037 | | .025 | | .014 | | .009 | |
| F Ratio | | 1.43 | | 2.97 | | 2.51 | | 2.72 | | 0.72 | | 1.56 | |
| Prob > F | | .247 | | .021 | | .043 | | .031 | | .705 | | .198 | |
| R-Squared ** | | .480 | | .658 | | .619 | | .637 | | .318 | | .503 | |

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test
** percent of total residual variance explained by regional effects

Table D11

Correlation of Internal Model Residuals with Various Reservoir Characteristics

| Factor | Model S05X02 | B01X01 | B01X03 | B01X05 | B04X02 | B05X01 |
|---|---|---|---|---|---|---|
| Number of Sta-Yrs | 212 | 218 | 161 | 62 | 189 | 218 |
| Year Impounded | .016 | -.159* | -.164* | .108 | -.068 | -.119* |
| Shoreline Dev. Ratio | .296* | -.197* | -.176* | -.305* | -.118 | -.193* |
| Length/Width | .183* | -.197* | -.247* | -.097 | -.008 | -.218* |
| Drainage A./Surf. A | -.113 | -.433* | -.433* | -.246* | -.179* | -.333* |
| Surface Area | .144* | -.373* | -.290* | -.521* | -.209* | -.354* |
| Volume | .178* | -.395* | -.330* | -.505* | -.160* | -.403* |
| Mean Depth | .180* | -.289* | -.291* | -.258* | -.011 | -.346* |
| Maximum Depth | .199* | -.310* | -.307* | -.267* | -.039 | -.353* |
| Station Total Depth | .266* | -.327* | -.300* | -.301* | -.174* | -.409* |
| Residence Time | .092 | .001 | .062 | -.238* | .000 | -.055 |
| Overflow Rate | .013 | -.190* | -.270* | .084 | -.008 | -.163* |
| Alkalinity | .139* | .008 | -.088 | -.448* | -.180* | .000* |
| pH | .184* | .212* | .141* | -.296* | .006 | .168* |
| Conductivity | -.067 | .118* | .043 | -.103 | -.020 | .141* |
| Temperature | -.132* | .067 | .121 | .318* | .085 | .104 |
| Non-Algal Turb. | -.534* | -.285* | -.300* | -.086 | -.055 | -.106 |
| Turb.*Mean Depth | -.446* | -.587* | -.600* | -.289* | -.074 | -.436* |
| Total P | .030 | -.001 | .005 | -.003 | .017 | .149* |
| Total N | .092 | .182* | .077 | .336* | .063 | .242* |
| Ortho-P | .002 | -.277* | -.264* | -.141 | -.122* | -.114* |
| Inorganic N | .041 | -.004 | -.102 | .189 | -.008 | .063 |
| Total N/P | .065 | .184* | .083 | .264* | .049 | .047 |
| Inorganic N/P | .051 | .266* | .121 | .269* | .120* | .176* |

* correlation coefficient significant ($p < .10$)

Table D12

Correlation of Phosphorus Retention Model Residuals with Various Reservoir Characteristics

| Factor | Model R03X02 | R12X02 | R13X02 | R14X02 | R15X02 |
|---|---|---|---|---|---|
| Year Impounded | .013 | -.026 | -.035 | .029 | .005 |
| Shoreline Dev. Ratio | -.186 | -.274* | -.275* | -.236* | -.248* |
| Length/Width | .111 | .061 | .183 | .075 | .092 |
| Drainage A./Surf. A. | .204 | .359* | .448* | .294* | .382* |
| Surface Area | -.204 | -.226* | -.301* | -.149 | -.159 |
| Volume | -.103 | -.225* | -.342* | -.119 | -.131 |
| Mean Depth | .298* | .072 | -.027 | .166 | .153 |
| Maximum Depth | .230* | -.010 | -.107 | .077 | .062 |
| Residence Time | .016 | .007 | -.273* | .017 | .031 |
| Overflow Rate | .127 | .130 | .237* | -.030 | .105 |
| Inflow Total P | -.488* | -.123 | -.066 | .001 | -.038 |
| Inflow Total N | -.266* | -.002 | .034 | .043 | .024 |
| Inflow Ortho-P | -.355* | -.009 | .009 | .121 | .078 |
| Inflow Inorganic N | -.219 | -.071 | .027 | -.086 | -.101 |
| Inflow Ortho-P/Total P | .285* | .266* | .182 | .292* | .283* |
| Sedimentation Rate (n=17) | -.563* | -.492* | -.502* | -.401* | -.367 |

* correlation coefficient significant at $p < .10$
based upon 56 observations, except sedimentation rate

Table D13

Correlation of Loading Model Residuals with Various Reservoir Characteristics

| Predicted Variable: | Model | | | | | |
|---|---|---|---|---|---|---|
| | Phosphorus | | Chlorophyll | | Transparency | |
| Factor | P13X02 | P15X02 | B11X03 | B15X03 | S10X03 | S11X03 |
| Year Impounded | -.020 | .050 | -.062 | -.030 | .115 | .064 |
| Shoreline Dev. Ratio | .137 | .232 | -.292 | -.306 | .197 | .177 |
| Length/Width | .153 | .379* | -.383* | -.319* | -.057 | -.212 |
| Drainage Area/Surf. A. | .074 | .418* | -.267 | -.128 | -.105 | -.443* |
| Surface Area | -.014 | .076 | -.430* | -.457* | .098 | .035 |
| Volume | -.137 | .127 | -.530* | -.455* | .232 | .052 |
| Mean Depth | -.288 | .158 | -.461* | -.243 | .359* | .058 |
| Maximum Depth | -.239 | .198 | -.470* | -.263 | .409* | .113 |
| Residence Time | .012 | -.021 | .074 | .080 | .291 | .375 |
| Overflow Rate | -.198 | .124 | -.374* | -.241 | -.075 | -.358* |
| Alkalinity | .383* | .242 | .337* | .275 | .039 | .111 |
| Conductivity | -.073 | -.214 | -.101 | -.225 | -.074 | -.033 |
| Ph | .348* | .155 | .532* | .488* | .055 | .195 |
| Temperature | -.150 | -.188 | -.362* | -.444* | -.170 | -.142 |
| Non-Algal Turbidity | -.097 | -.129 | -.346* | -.461* | -.362* | -.460* |
| Turb.*Mean Depth | -.396* | .054 | -.805* | -.673* | .061 | -.348* |
| Total N/P | -.512* | -.406* | -.148 | -.067 | .244 | .200 |
| Inorganic N/P | -.503* | -.503* | -.117 | -.105 | .024 | .030 |
| Inflow N/P | .030 | .110 | .237 | .361* | -.082 | -.063 |
| Inflow Total P | .008 | -.093 | .011 | -.088 | .044 | .006 |
| Inflow Total N | .036 | -.036 | .217 | .181 | -.008 | -.044 |
| Inflow Ortho-P | .144 | .095 | .115 | .065 | .116 | .058 |
| Inflow Inorganic N | -.014 | -.208 | .256 | .166 | .065 | .161 |
| Inflow Ortho-P/Total P | .343* | .448* | .263 | .362* | .192 | .131 |
| Sedimentation Rate(n=6) | -.801* | -.494 | -.591 | -.460 | .108 | -.386 |

* correlation coefficient significant at p < .10
  based upon data from 29 reservoirs

Table D14

Results of Stepwise Regressions of Internal Model Residuals Against Various Reservoir Characteristics

| Factor | Model S05X02 | B01X01 | B01X03 | B01X05 | B04X02 | B05X01 |
|---|---|---|---|---|---|---|
| Number of Station-Yrs With Complete Factor Data | 170 | 185 | 117 | 59 | 161 | 185 |
| Intercept | -2.11* | -3.20 | .69 | -7.87 | .28 | .22 |
| Year Impounded | | | | .004 | | |
| Surface Area | | | -.07 | -.13(1) | -.42(1) | -.09 |
| Volume | | | | | .33 | |
| Mean Depth | | | | | | |
| Maximum Depth | | | | | | |
| Station Total Depth | .20 | | | | -.21 | -.22 |
| Drainage A./Surface A. | -.11 | -.17 | -.14 | | -.09 | -.11 |
| Length/Width | | | | | | |
| Shoreline Dev. Ratio | .14(1) | | | | | |
| Residence Time | | | | | | |
| Surface Overflow Rate | .11 | .13 | | | | |
| pH | .11 | .33 | | | | |
| Temperature | | | | .025 | | |
| Alkalinity | | -.33 | | | | |
| Conductivity | | | | | | |
| Total Phosphorus | | | | | | .19 |
| Ortho Phosphorus | | -.18 | -.11 | | | |
| Total Nitrogen | .53 | .96 | | | | |
| Inorganic Nitrogen | -.25 | -.45 | | | | |
| Total N/P | | | | | | |
| Inorganic N/P | | | | | | |
| Non-Algal Turbidity | - | | | | | -.34(1) |
| Turbidity*Mean Depth | - | -.24(1) | -.31(1) | | | |
| R-Squared | .389 | .610 | .435 | .355 | .179 | .402 |
| Mean Squared Residual | .016 | .034 | .033 | .026 | .034 | .038 |

(1) variable entered first in stepwise regression

* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$

** all independent variables transformed to base-10 logarithms except pH, temperature, and year impounded

Table D15

Results of Stepwise Regressions of P Retention Model Residuals Against Various Reservoir Characteristics

| Factor** | Model R03X02 | R12X02 | R13X02 | R14X02 | R15X02 |
|---|---|---|---|---|---|
| Number of Reservoir With Complete Factor Data | 51 | 51 | 51 | 51 | 51 |
| Intercept | .28* | -.24 | -.30 | *** | -.14 |
| Year Impounded | | | | | |
| Surface Area | | | | | |
| Volume | | | | | |
| Mean Depth | | | | | |
| Maximum Depth | | | | | |
| Drainage A./Surface A. | .11 | .12(1) | .15(1) | | .13(1) |
| Length/Width | | | | | |
| Shoreline Dev. Ratio | | | | | |
| Residence Time | | | | | |
| Surface Overflow Rate | | | | | |
| Inflow Total P | -.25(1) | | | | |
| Inflow Ortho P | | | | | |
| Inflow Total N | | | | | |
| Inflow Inorganic N | | | | | |
| Inflow Ortho P/Total P | | | | | .28 |
| R-Squared | .329 | .117 | .165 | .000 | .208 |
| Mean Squared Residual | .026 | .025 | .025 | - | .021 |

(1) variable entered first in stepwise regression

* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$

** all independent variables transformed to base-10 logarithms

*** no factors met .05 significance level

Table D16

Results of Stepwise Regressions of Loading Model Residuals Against Various Reservoir Characteristics

| | Model | | | | | |
|---|---|---|---|---|---|---|
| Predicted Var: | Phosphorus | | Chlorophyll | | Transparency | |
| Model Code | P13X02 | P15X02 | B11X03 | B15X03 | S10X03 | S11X03 |
| Number of Reservoirs with Complete Factor Data | 27 | 27 | 27 | 27 | 27 | 27 |
| Intercept | .14 | *** | .58 | .54 | -.77 | .23 |
| Year Impounded | | | | | | |
| Surface Area | | | | | | |
| Volume | | | | | | |
| Mean Depth | | | | | | |
| Maximum Depth | | | | | .32(1) | |
| Station Total Depth | | | | | | |
| Drainage A./Surface A. | | | | | | -.11(1) |
| Length/Width | | | | | | |
| Shoreline Dev. Ratio | | | | | | |
| Residence Time | | | .14 | | | |
| Surface Overflow Rate | | | | | | |
| pH | | | | | | |
| Temperature | | | | -.032 | | |
| Alkalinity | | | | | | |
| Conductivity | | | | | | |
| Inflow Total P | | | | | | |
| Inflow Ortho P | | | | | | |
| Inflow Total N | | | | | | |
| Inflow Inorganic N | | | | | .19 | |
| Inflow N/P | | | | .26 | -.16 | |
| Inflow Ortho P/Total P | | | | | | |
| Non-Algal Turbidity | | | | | | |
| Turbidity*Mean Depth | -.21(1) | | -.70(1) | -.42(1) | | |
| R-Squared | .204 | .000 | .741 | .702 | .500 | .176 |
| Mean Squared Residual | .018 | - | .018 | .015 | .007 | .010 |

(1) variable entered first in stepwise regression

* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$

** all independent variables transformed to base-10 logarithms except pH, temperature, and year impounded

*** no variables met .05 significance level

# Appendix E

## Compilation of Empirical Eutrophication Models

This appendix summarizes the results of a literature review on empirical eutrophication models. Models have been classified into the following general categories:

- PART I: Internal Relationships--Chlorophyll
- PART II: Internal Relationships--Transparency
- PART III: Nutrient Load/Response Relationships
- PART IV: Hypolimnetic Oxygen Depletion Models
- PART V: Trophic State Discriminant Functions

The review does not cover ranking schemes, index systems, or any of the various methods of defining "trophic state". Since in-depth discussion of each model is not feasible within this context, the following aspects are summarized:

- author(s) and date*
- data set characteristics
    - number of lakes or reservoirs
    - region
    - averaging periods
    - other characteristics which may restrict model applicability
- model equation(s) and parameter value(s)
- statistics
    - percent of variance explained
    - mean squared error

Models have been converted to consistent sets of units and symbols, as summarized in Table E1. Descriptions are arranged chronologically within each of the above categories.

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* See References section on page 222 of main text for complete listing.

Table E1

Variable, Subscript, and Statistic Definitions

Variable Definitions

P = total phosphorus (mg/m3)
N = total nitrogen (mg/m3)
S = Secchi depth (m)
B = chlorophyll-a (mg/m3)
Qs = surface overflow rate (m/yr)
T = hydraulic residence time (yr)
Z = mean depth (m)
Zmx = maximum depth (m)
Zm = mixed depth (m)
Lp = phosphorus loading (mg/m2-yr)
Pi = average inflow phosphorus concentration (mg/m3) = Lp/Qs
Pv = Vollenweider normalized P loading = Pi/(1 + sqrt(T))
HOD = hypolimnetic oxygen depletion rate (g/m2-day)
HODv = volumetric HOD (g/m3-day)
R = retention coefficient
I = trophic state index
U = first-order settling velocity (m/yr)
K = first-order sedimentation rate (1/yr)
D = discriminant function

Subscript Definitions

an = annual
eu = euphotic zone
sp = spring
su = summer
wn = winter
gs = growing season
mx = maximum value
o = outflow
i = inflow
p = phosphorus
n = nitrogen

Statistic Definitions

n = number of lakes or reservoirs in data set
S2 = mean squared error (base-10 logorithms)
R2 = percent of variance explained
log = base-10 logarithm
ln = base-e logarithm

Sakamoto, 1966: (as calculated by Dillon and Rigler, 1974)
28 lakes , excluding "very low" N/P values

$$\log(Bsu) = -1.13 + 1.58 \log(Psp) \qquad (R2=.96)$$

Edmondson, 1972: Lake Washington ($18 < P < 66$)

$$\log(Ban) = -0.73 + 1.25 \log(Pan)$$

Dillon & Rigler, 1974: 46 natural lakes, $N/P > 12$

$$\log(Bsu) = -1.14 + 1.45 \log(Psp) \qquad (R2=.90, S2=.047)$$

Norvell & Frink, 1975: 23 Connecticut lakes ($7 < Psp < 70$)

$$\log(Bsu) = -1.52 + 1.80 \log(Psp) \qquad (R2=.68)$$

$$\log(Bsu) = -1.28 + 1.62 \log(Psu) \qquad (R2=.79)$$

$$Bsu = .99\, Psp - 10.1 \qquad (R2=.74)$$

$$Bsu = .86\, Psu - 8.2 \qquad (R2=.88)$$

Jones & Bachman, 1976: 143 northern lakes

$$\log(Bsu) = - 1.09 + 1.46 \log(Psu) \qquad (R2=.90)$$

Carlson, 1977: 43 northern temperate lakes

$$\log(Bsu) = 1.45 \log(Psu) - 1.06 \qquad (R2=.72)$$

Williams et al., 1977: eastern EPA/NES lakes

$$\log(Bgs) = -.05 + .64 \log(Pgs) \qquad \text{(all 418 eastern lakes)}$$

$$\log(Bgs) = -.11 + .70 \log(Pgs) \qquad \text{(318 lakes with } T > 14 \text{ days)}$$

Lee, Rast, & Jones, 1977: US portion of OECD North American Project

$$Bmx = 1.6\, Bsu + 3.74 \qquad (R2=.92, \text{ for } Bsu > 5 \text{ ug/l})$$

Schindler, 1978 : approx. 60 lakes, mostly northern glacial
$Ni/Pi > 5$

$$\log(Ban) = -0.85 + 1.21 \log(Pan) \qquad (R2=.77)$$

Oglesby & Schaffner, 1978: 16 New York lakes

$$Bsu = -2.90 + .574\ Pwn \qquad (R2=.82)$$

Walker & Kuhner, 1978: EPA/NES data from midwestern impoundments
22 lakes and 23 reservoirs
none N-limited

$$a = \text{non-algal turbidity} = 1./Sgs - .02\ Bgs$$

$$\log(Bgs) = -.256 + 1.103 \log(Pgs) - .055\ a - .219 \log(Z) - .0049\ Qs$$
(22 lakes, R2=.925, S2=.018)

$$\log(Bgs) = .490 + .875 \log(Pgs) - .231\ a - .586 \log(Z) - .0007\ Qs$$
(26 reservoirs, R2=.742, S2=.022)

Oskam, 1973: light-limited chlorophyll (theoretical)

$$BL = (27/Zm - Ew)/Eb$$

$Zm$ = mixed depth (m)
$Ew$ = non-algal extinction coef (1/m)
$Eb$ = algal extinction coef (m2/mg)

Meta Systems, 1979: EPA/NES data from midwestern impoundments
22 lakes and 23 reservoirs; none N-limited

Light-limited chlorophyll:

$BL = F/Zm - a/.02$ , (minimum=20 mg/m3)
$F$ = light integral = 440
$a$ = non-algal turbidity = $1/Sgs - .02\ Bgs$
$Zm$ = mixed depth (m)

P-Limited chlorophyll : $BP = Pgs - 2.2$

N-Limited chlorophyll : $BN = (Ngs-2.2)/7$

regression : $1/Bgs = 1.866/BP + 1.363/BL$ (R2=.82,S2=.023)

general model : $1/Bgs = KP/BP + KN/BN + KL/BL$
KP,KN,KL = empirical parameters

Vermont Department of Water Resources, 1979 : 29 Vermont Lakes

$$\log(Bgs) = -0.27 + .898 \log(Psp) \qquad (R2=.82, S2=.022)$$

$$\log(Bsu) = -0.30 + .895 \log(Psp) \qquad (R2=.79, S2=.026)$$

$$\log(Bmx) = -0.15 + 1.09 \log(Psp) \qquad (R2=.83, S2=.029)$$

Walker, 1979: 45 northern temperate lakes

$$\log(Bsu) = -1.07 + 1.39 \log(Psu) \qquad (R2=.81, S2=.058)$$

Placke & Bruggink, 1980: TVA reservoirs

30 stations, tributary reservoirs ($10 < P < 30$)

$$\log(Bgs) = 1.56 \log(Pgs) - 1.04$$

22 stations, tributary reservoirs ($N/P > 10$)

$$\log(Bgs) = 1.90 \log(Pgs) - 1.38$$

19 stations, mainstem reservoirs ($20 < P < 30$)

$$\log(B) = 0.73 \log(Pgs) - 0.55$$

Smith, 1980: 56 northern lakes "variable yield model"

$$\log(Bsu) = 1.55 \log(Psu) - 1.55 \log[6.026/(.0204(Nsu/Psu)+.334)]$$

| N/P : | 25 | 17 | 10 | 7 |
|---|---|---|---|---|
| intercept: | -1.36 | -1.51 | -1.67 | -1.75 |

equivalent to:

$$\log(Bsu) = -3.71 + 1.55 \log(Nsu + 16.4\ Psu)$$

for 21 lakes with $N/P > 32.6$:

$$\log(Bsu) = 1.55 \log(Psu) - 1.25 \qquad (R2=.97)$$

Clasen, 1980: OECD Reservoir and Shallow Lakes Project, 46 water bodies
excluded 3 "turbid" reservoirs from regressions;
all but 2 have $N/P > 15$

$$\log(Ban) = -.37 + 0.88 \log(Pan) \qquad (S2=.055)$$

$$\log(Bmx) = 0.74\ Pan \qquad (S2=.060)$$

$$\log(Bmx) = -.24 + 1.07 \log(Pan) \qquad (S2=.059)$$

Fricker, 1980: OECD Alpine Lakes Project , 25 lakes
1 with N/P < 11

$\log(Ban) = -.080 + .596 \log(Pan)$ (R2=.35,S2=.097)

$\log(Ban) = -.152 + .604 \log(Psp)$ (R2=.36,S2=.096)

Ryding, 1980: OECD Nordic Project, 10 lakes

$Bmx = 1.96\ Bsu - .24$

$Bmx = 2.06\ Ban + 1.96$

$Bsu = -5.0 + 0.61\ Psu$

$\log(Bsu) = -0.54 + 1.093 \log(Psp)$

Hern et al., 1981: 757 EPA/NES lakes and reservoirs

$\log(Bsu) = -0.11 + 0.64 \log(Psu)$ (R2=.36)

Kerekes, 1981: OECD Summary Analysis
approx. 60 lakes

$\log(Bgs) = -.55 + .96 \log(Pan)$ (R2=.77,S2=.063)

$\log(Bmx) = -.19 + 1.05 \log(Pan)$ (R2=.81,S2=.066)

## PART II: INTERNAL RELATIONSHIPS -- TRANSPARENCY

### Transparency vs. Chlorophyll

Norvell, Frink, & Hill, 1979: 23 Connecticut lakes

$1/Ssu = .137 + .0167\ Bsu$ (R2=.80)

$\log(Ssu) = .857 - .383 \log(Bsu)$ (R2=.69)

$1/Ssu = .078 + .0066\ Color + .0171\ Bsu$ (R2=.89)

Carlson, 1977: 147 northern lakes

$\log(Ssu) = 0.89 - 0.68 \log(Bsu)$ (R2=.86)

Rast & Lee, 1978 : OECD North American Project

$\log(Ssu) = 0.803 - .473 \log(Bsu)$ (R2=.72)

Jones & Bachman, 1978: > 100 lakes

$$\log(Ssu) = .807 - .549 \log(Bsu + .03)$$

Brezonik, 1978: 55 Florida lakes , 4 < Color < 550 Pt Co Units

$$\log(San) = .63 - .55 \log(Ban) \qquad (R2=.75)$$

$$1/San = .48 + .032\ Ban \qquad (R2=.59)$$

$$1/San = .106 + .128\ Turb,FTU + .0025\ Color \qquad (R2=.89)$$

Oglesby & Schaffner, 1978: 16 New York lakes

$$\log(Ssu) = .961 - .606 \log(Bsu) \qquad (R2=.85)$$

Theoretical model:

$$1/S = a + b\ B$$

a = non-algal turbidity and color (1/m)

b = .020 (Walker & Kuhner, 1978)
b = .014 (Lorenzen, 1980)
b = .014, a=.214 ( Clasen, 1980): fit of OECD reservoirs
b = .032, a=.48 (Brezonik, 1978): fit of Florida lakes
b = .008-.054 (Carlson, 1980): literature range

Walker, 1979: 45 northern lakes

$$\log(1/Ssu - a) = 0.74 \log(Bsu) - 1.23 \qquad (R2=.80, S2=.063)$$

a = non-algal turbidity (1/m)

a = .04 + .003 Color , averaged .08 1/m in 45 lakes

Placke & Bruggink, 1980: TVA tributary reservoirs

$$\log(Sgs) = 0.596 - .315 \log(Bgs)$$

Hern et al., 1981: 757 EPA/NES lakes and reservoirs

$$\log(Ssu) = 1.09 - .86 \log(Bsu) \qquad (R2=.31)$$

## Transparency vs. Phosphorus

Carlson, 1977: northern lakes

$\log(Ssu) = 1.68 - \log(Psu)$ , or $Ssu = 48/Psu$

$\log(Sgs) = 1.81 - \log(Pgs)$ , or $Ssu = 64/Psu$ $(R2=.79)$

Oglesby & Schaffner, 1978: 16 New York lakes

$\log(Ssu) = 1.36 - .764 \log(Pwn)$

Walker, 1979: 45 northern lakes

$\log(1/Ssu - .08) = 1.03 \log(Psu) - 2.03$

Placke & Bruggink, 1980: 11 TVA tributary reservoirs

$\log(Sgs) = 1.05 - .608 \log(Pgs)$

Verduin et al., 1976:

SS = suspended solids (g/m3)

$1/S = .06\ SS$

## PART III: NUTRIENT LOAD RESPONSE RELATIONSHIPS

Vollenweider, 1969: K = phosphorus sedimentation rate (1/yr)

$$P = Pi / (1 + Kp\ T)$$

$$Kp = 10 / Z$$

or,

$$Kp = 5.5\ Z^{-.85}$$

Kirchner & Dillon, 1975: 15 So. Ontario lakes, Rp estimated from Psp

$$Rp = .426 \exp(-.271\ Qs) + .574 \exp(-.00949\ Qs) \qquad (R2=.88)$$

Chapra, 1975: 15 southern Ontario lakes

$$Psp = Pi\ Qs/(Qs + Up)\ ,\ Up = 16\ m/yr$$

Dillon & Kirchner, 1975: northern lakes

$$Up = 13.2\ m/yr$$

Jones & Bachman, 1976: 51 northern lakes

$$Psu = .84\ Pi / (1 + .65\ T) \qquad (R2=.85)$$

$$\log (Bsu) = -1.09 + 1.46 \log[.84\ Pi / (1 + .65\ T)] \qquad (R2=.79)$$

Chapra & Tarapchak, 1976: composite model, N/P > 12

$$Up = 12.4\ m/yr$$

$$Pan = .9\ Psp \qquad (20\ lakes)$$

$$\log(Bsu) = -1.08 + 1.449 \log[Pi\ Qs / (Qs+Up)]$$

Larsen & Mercier, 1976: 20 EPA/NES northeastern/northcentral lakes

$$Po = Pi/(1 + .89\ T^{.51}) \qquad (R2=.88)$$

Vollenweider, 1976: 60 northern lakes

$$Pv = Pi/(1+T^{.5})$$

$$\log(Ban) = -.44 + .91 \log(Pv) \qquad (R2=.75)$$

Walker, 1977a: 105 northern temperate lakes and reservoirs

model: $Po/Pi = 1/(1+K\,T)$, $K = a\,(1/T)^b$

| data set | number | a | b | R2 | S2(Po/Pi) |
|---|---|---|---|---|---|
| all | 105 | .912 | .492 | .723 | .023 |
| oligotrophic | 22 | .817 | .489 | .849 | .013 |
| mesotrophic | 23 | .778 | .517 | .704 | .025 |
| eutrophic | 60 | 1.050 | .434 | .693 | .027 |
| Pi < 100 mg/m3 | 71 | .824 | .546 | .727 | .018* |

* S2 for log(Po) = .029

multivariate model: 105 northern lakes and reservoirs

$$\log(Po) = 1.029 \log(Pi) - .145 \log(Lp) - .310 \log(T) - .023$$
(R2=.901, S2=.032)

Walker, 1977b: 71 eastern/central EPA/NES lakes and reservoirs

$$\log(Bgs) = -.27 + .77 \log(Px) \qquad (R2=.71,\ S2=.068)$$

$$Px = Pi/(1.+.82\ T^{.45})$$

$P_x$ = P concentration at location x

Reckhow, 1977; 1979a, b: 95 northern temperate lakes and reservoirs

95 lakes, "quasi-general":

$$Pgs = Pi\ Qs\ /\ (11.6 + 1.2\ Qs) \qquad (R2=.915, S2=.016)$$

33 oxic lakes, Qs < 50 m/yr:

$$Pgs = Pi\ Qs\ /\ [18\ Z/(10+Z) + 1.05\ Qs\ \exp(.012\ Qs)]$$
(R2=.876, S2=.015)

28 lakes Qs > 50 m/yr:

$$Pgs = Pi\ Qs\ /\ [2.77\ Z + 1.05\ Qs\ \exp(.0011\ Qs)]$$
(R2=.949, S2=.013)

21 anoxic lakes:

$$Pgs = Pi\ Qs\ /\ (.17\ Z + 1.13\ Qs) \qquad (R2=.948, S2=.011)$$

Ostrofski, 1978: northern lakes

$$Rp = .201 \exp(-.0425\ Qs) + .574 \exp(-.00949\ Qs)$$

Oglesby & Schaffner, 1978: 16 New York Lakes
$T > .5$ year

LPAV = bio-available P load per volume of mixed layer (mg/m3-yr)
BAP = total soluble P + labile P
labile P < 5% total particuate P exported from watershed

$$Pwn = .992 + .338\ LPAV \quad (R2 = .83)$$

$$Bsu = -4.05 + .24\ LPAV \quad (R2 = .78)$$

$$Bsu = -2.90 + .574\ Pwn \quad (R2 = .82)$$

$$\log(Ssu) = 1.36 - .764 \log(Pwn) \quad (R2 = .81)$$

$$\log(Ssu) = .961 - .606 \log(Bsu) \quad (R2 = .85)$$

Rast & Lee, 1978: US portion of OECD North American Project
54 lakes and reservoirs

$$\log(B) = -.259 + .76 \log(Pv)$$

$$\log(S) = .925 - .359 \log(Pv)$$

$$\log(HOD) = -1.07 + .467 \log(Pv)$$

Walker & Kuhner, 1978: midwestern impoundments, 12 reservoirs, 4 lakes

Sr = sedimentation rate (kg/m2-yr), est. from sediment surveys

$$Po/Pi = Qs/(Qs + Up) \quad (n=16, R2=.73, S2=.014)$$

$$Up = Sr - 4$$

$$Pgs = .78\ Po \quad (n=50, R2=.88, S2=.020)$$

Schindler, 1978: approx. 60 lakes, mostly northern glacial
$Ni/Pi > 5$

$$\log(Ban) = .968 \log(Pi^*) - 0.620 \quad (R2=.58)$$

$$\log(Pan) = .779 \log(Pi^*) + .214 \quad (R2=.77)$$

$$Pi^* = (Pst\ T + Pi)/(1 + T)$$

Pst = mean lake total P conc. at start of monitoring period

Schindler, Fee, & Ruszczynski , 1978: 15 Canadian experimental lakes

mean annual regressions

| | |
|---|---|
| Pan = 8.11 + .194 Pv | n=31, R2=.76 |
| Pan = 8.46 + .081 Pi | n=31, R2=.83 |
| Pan = 5.50 + .25 Pi* | n=22, R2=.90 |
| Ban = 1.13 + .21 Pv | n=31, R2=.71 |
| Ban = 1.35 + .088 Pi | n=31, R2=.79 |
| Ban = -1.78 + 0.27 Pi* | n=22, R2=.79 |
| Ban = -5.26 + 0.98 Pan | n=42, R2=.85 |

growing season, epilimnetic regressions

| | |
|---|---|
| Pgs = 8.48 + .22 Pv | n=31, R2=.69 |
| Pgs = 9.12 + .09 Pi | n=31, R2=.73 |
| Pan = 5.54 + .27 Pi* | n=22, R2=.76 |
| Bgs = .03 + .27 Pv | n=31, R2=.64 |
| Bgs = .28 + .11 Pi | n=31, R2=.73 |
| Bgs = -3.56 + 0.33 Pi* | n=22, R2=.66 |
| Bgs = -7.29 + 1.19 Pgs | n=41, R2=.69 |

(Pi* defined in Shindler,1978 (see above))

Norvell, Frink, & Hill, 1979: 33 Connecticuit lakes and reservoirs

Psp = Pi (Qs + 1.2)/(Qs + 12)        (std error = 6.9 ppb)

Higgins & Kim, 1981: 10 TVA tributary reservoirs (Rp>0, Pi>25)

CSTR P retention models:

Up = 92 m/yr

Rp = 1 - Po/Pi = 1.54 - .22 ln(Qs)     (R2=.85)

plug flow P retention model:

Px = P concentration at location X
Tx = time-of-travel to X

Px/Pi = exp(-Kp Tx)

Kp = 61/Z  (or, Up = 61 m/yr)

Frick.

Mueller, 1980: EPA/NES western reservoirs (Rp>0)
5 oligotrophic, 16 mesotrophic, 47 eutrophic

$Pgs = Pi/(16.4 + Qs)$ (R2=.27,S2=.17)

$Pgs = Pi\ (1-Rp)$

$Rp = .29 \exp(-.556\ Qs)+.71 \exp(-.00483\ Qs)$ (R2=.26,S2=.14)

*$Pgs = .882\ Pi\ /\ (1 + 1.61\ T)$ (R2=.45,S2=.11)

*$Pgs = Pi/(1 + 2.09\ T^{.832})$ (R2=.46.S2=.10)

*approximate form:

$Pgs = Pi\ /\ (\ 1 + 2\ T)$ (R2=.46,S2=.11)
(i.e., Kp = 2 1/yr)

$Pgs = Po$ (R2=.74,S2=.040)

Clasen, 1980: OECD Reservoir and Shallow Lakes Project ,
46 Waterbodies, 23% natural, 20% pumped storage,
47% "semi-artificial reservoirs"
70% eutrophic, 20% oligotrophic, 10% mesotrophic
$.6 < Qs < 773$, $1.7 < Z < 76$, $5 < Pi < 4900$

$Pan = Pi/(1 + 2.271\ T^{.586})$ (S2=.070)
[approx = $Pi/(1 + 2\ T^{.5})$] (S2=.071)

$Pan = Pi/(1 + 7.239\ T^{.608} Z^{-.500})$ (S2=.065)
[approx = $Pi/(1 + 7/(Qs^{.5})$] (S2=.065)

$\log(Pan) = -.11 + 0.85 \log(Pi)$ (R2=.89,S2=.063)

$\log(Pan) = (1 - .25\ T^{.32}) \log(Pi)$ (S2=.050)

$Pe = Pi/(1 + 2\ T^{.5})$

$Ban = 50\ (\ 1 - \exp(-.007\ Pe))$ (S2=.047)

$\log(Ban) = .06 + .58 \log(Pe)$ (S2=.077)

$\log(Ban) = -.02 + .58 \log(Pv)$ (S2=.079)

Fricker, 1980: OECD Alpine Project

$\log(Pan) = 1.013 \log(Pi) -.348$ (R2=.72, S2=.082)

$\log(Peu) = .882 \log(Pi) -.182$ (R2=.74, S2=.071) for lakes with T > 1 year , Rp > 0:

$$P/Pi = 1/(1 + 1.417\ T^{.0489})$$

$\log(Kp) = .971 - .692 \log(Z)$ (R2=.29,S2=.078)

$\log(Peu) = .906 \log(Pv) + .104$ (R2=.73,S2=.072)

excluding "non-fitting lakes":

$\log(Peu) = .754 \log(Pv) + .254$ (R2=.78,S2=.047)

$\log(Ban) = .675 \log(Pv) - .219$ (R2=.81,S2=.050)

$\log(Bsu) = .706 \log(Pv) - .219$ (R2=.75,S2=.083)

$\log(Bmx) = .837 \log(Pv) + .050$ (R2=.86,S2=.052)

$\log(Ssu) = -.200 \log(Pv) + .925$ (R2=.46,S2=.019)

Ryding, 1980 : OECD Nordic Project, 10 lakes

$\log(Pan) = -.02 + .96 \log(Pv)$ (R2=.72)

$\log(Nan) = -1.19 + .60 \log(Nv)$ (R2=.71)

$\log(Bsu) = -.31 + .81 \log(Pv)$ (R2=.67)

$\log(Nsu) = -2.18 + 1.12 \log(Nv)$ (R2=.58)

$\log(Ssu) = 1.12 - .51 \log(Pv)$ (R2=.62)

$Ban = 1.2 + 1.3\ Lp + .05\ Ln$

$Ban\ Zm = 46.9 + 7.4\ T - 12.2\ (Zmx/Z)$

$\log(Ban) = 1.01 \log(Pv) - .82$ (R2=.59)

$\log(Ban) = 1.26 \log(Nv) - 2.82$ (R2=.61)

$\log(Kp) = -.53 \log(Z) + .52$ (R2=.18)

Walker, 1980: EPA/NES data from 26 southeastern reservoirs with Sgs*Bgs > 10 (i.e., low nonalgal turbidity (3 < Bgs < 16 mg/m3)

$\log(Bgs) = 0.49 + .339 \log(Phk)$ (R2=.72,S2=.008)

Phk = Higgins & Kim (1981) normalized inflow P (mg/m3)

$= Pi\ Qs\ /\ (Qs + 92)$

* error statistics refer to predictions of log(Pgs)

Kerekes, 1981: OECD Summary Analysis, approx 87 waterbodies

$\log(Pan) = .19 + .82 \log(Pv)$ (R2=.85,S2=.037,n=87)

$\log(Po) = .13 + .92 \log(Pan)$ (R2=.90,S2=.030,n=62)

$\log(Po) = .07 + .98 \log(Peu)$ (R2=.92,S2=.023,n=59)

$\log(Ban) = -.43 + .79 \log(Pv)$ (R2=.77,S2=.066,n=67)

$\log(Bmx) = -.13 + .89 \log(Pv)$ (R2=.79,S2=.081,n=45)

Canfield and Bachman, 1981: 290 natural lakes, 433 reservoirs
626 from EPA National Eutrophication Survey

natural lakes:

$K = .162(L_P/Z)^{.458}$ (R2=.69,S2=.059)*

reservoirs:

$K = .114(L_P/Z)^{.589}$ (R2=.67,S2=.061)*

both:

$K = .129(L_P/Z)^{.549}$ (R2=.66,S2=.066)*

## PART IV: HYPOLIMNETIC OXYGEN DEPLETION MODELS

Lasenby, 1975: 21 natural lakes

$$\log(HOD) = .35 - 1.35 \log(Ssu) \qquad (R2=.72)$$

Rast & Lee, 1978: OECD North American Project, 32 lakes

$$\log(HOD) = -1.07 + .467 \log(Pv)$$

Reckhow, 1978: oxic vs. anoxic discriminant function
northern temperate lakes

$$D = -11.5 - 4.61 \log(Lp/1000) + 5.73 \log(Z) + 4.1 \log(Qs)$$

$$prob(oxic) = 1./(1+\exp(-D))$$

Cornett & Rigler, 1979: 20 lakes

$$1000\ HOD = -277 + .5\ Ap + 5\ Th^{1.74} + 150\ \ln(Zh) \qquad (R2=.75)$$

Ap = P accumulation rate (mgP/m2-yr)
Th = mean hypolimnion temperature (deg C)
Zh = mean hypolimnion thickness (m)

Walker, 1979: 30 natural lakes

$$I = \text{trophic index} = -15.6 + 46.1 \log(Psu)$$
$$= 20.0 + 33.2 \log(Bsu)$$
$$= 75.3 + 44.8 \log(1/Ssu - .08)$$

$$\log(HOD) = -3.58 + .0204\ I + 4.55 \log(Z) - 2.04\ [\log(Z)]^2$$

(Z < 20 meters, R2=.91, S2=.010)

Welch & Perkins, 1979: 26 lakes

$$\log(HOD) = -1.49 + 0.39 \log(Lp\ T) \qquad (R2=.53)$$

Ryding, 1980: OECD Nordic Project, 10 lakes

$$\log(HODv) = .67 \log(Pv) - 2.42 \qquad (R2=.40)$$

Vollenweider & Kerekes, 1980: 33 OECD study lakes

$$\log(HOD) = .585 \log(Pv) - 1.07 \qquad (R2=.52)$$

## PART V: TROPHIC STATE DISCRIMINANT FUNCTIONS

Vollenweider, 1968: northern lakes

$D = Lp\ Z^{-.6}$ , oligotrophic < 25 < mesotrophic < 50 < eutrophic

Vollenweider, 1975: northern lakes

$D = 0.1\ Lp\ Qs^{-.5}$, oligotrophic < 10 < mesotrophic < 20 < eutrophic

Vollenweider, 1976: northern lakes

$D = Pi/(1+T^{.5})$ , oligotrophic < 10 < mesotrophic < 20 < eutrophic

Walker, 1977a, b: 100 northern temperate lakes, EPA/NES classification
trophic state probabilities

$$Px = Pi/(1 + .82\ T^{.45})$$

$$D = .001\ Px^{.82} Lp^{.18} \quad , \quad Dt = -(D^{-.25})$$

$$xe = \exp(-18.51-20.49\ Dt)$$
$$xm = \exp(-36.77-29.33\ Dt)$$
$$xo = \exp(-53.80-35.65\ Dt)$$

$$xs = xe + xm + xo$$

$$prob(e) = xe/xs$$
$$prob(m) = xm/xs$$
$$prob(o) = xo/xs$$

Yeasted & Morel, 1978: trophic state
northern temperate lakes , mostly EPA/NES

$$De = -12.54 \log(Pi/1000) + 1.65 \log(T) - 5.89$$
$$Dm = -25.06 \log(Pi/1000) + 5.15 \log(T) - 18.87$$
$$Do = -31.48 \log(Pi/1000) + 9.13 \log(T) - 30.01$$

Ciecka, Fabian, & Merilatt, 1979 : midwestern lakes and reservoirs
D > 0 implies eutrophic

$$D = 1.68 + 1.77 \ln(Lp/1000) - .64 \ln(Qs) - .07 [\ln(Qs)]^2$$

# APPENDIX F

## Independent Data Sets

| | Data Sources | | | |
|---|---|---|---|---|
| | CE | EPA/NES | TVA | OECD/RSL |
| Data Tables | App. C | F-1 | F-2 | F-3,4 |
| Figures: | | | | |
| Internal Models | F-1 | F-4 | F-7 | F-10 |
| Loading Models - Pv* | F-2 | F-5 | F-8 | F-11 |
| Loading Models - Pn** | F-3 | F-6 | F-9 | F-12 |

CE = Corps of Engineers Data Set (See Appendices B,C)
EPA/NES = EPA National Eutrophication Survey (USEPA, 1978)
TVA = Tennesse Valley Authority Reservoirs (Higgins and Kim, 1981)
OECD/RSL = OECD Reservoir and Shallow Lakes Program (Clasen, 1980)

* Vollenweider normalized P loading
** Equation (61) (see Part VI, main text) P loading

Table F-1
EPA/NES Data on CE Reservoirs

| disres* | code | pi | ni | po | tp | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|---|---|
| 02176 | 1 | 24 | 851 | 18.2 | 6.9 | 5.2 | 2.4 | 12.6 | .230 |
| 03307 | 1 | 16 | 1174 | 11.5 | 10.0 | 4.9 | 3.5 | 12.9 | .380 |
| 04312 | 3 | 182 | 1071 | 95.5 | 64.6 | 15.1 | 1.2 | 1.6 | .030 |
| 06372 | 1 | 132 | 1288 | 24.5 | 43.7 | 8.7 | 1.0 | 10.7 | .338 |
| 08074 | 1 | 55 | 724 | 20.9 | 24.0 | 6.8 | 1.5 | 11.0 | .371 |
| 08330 | 1 | 50 | 776 | 8.9 | 12.9 | 6.2 | 2.0 | 13.8 | .831 |
| 10003 | 1 | 35 | 1513 | 22.4 | 18.2 | 2.2 | 1.3 | 7.9 | .015 |
| 10069 | 1 | 62 | 645 | 21.9 | 20.0 | 7.4 | 1.4 | 9.3 | .281 |
| 10076 | 1 | 81 | 891 | 8.5 | 15.8 | 5.4 | 2.6 | 19.5 | 1.584 |
| 10411 | 1 | 107 | 1096 | 36.3 | 28.8 | 4.0 | 1.2 | 3.1 | .019 |
| 14099 | 1 | 617 | 7413 | 245.5 | 177.8 | 14.8 | 0.7 | 3.0 | .026 |
| 15178 | 1 | 30 | 1174 | 18.6 | 21.9 | 12.6 | 2.3 | 9.1 | 2.884 |
| 15181 | 1 | 44 | 2570 | 20.0 | 15.1 | 6.2 | 2.2 | 4.7 | 5.248 |
| 15237 | 1 | 302 | 2884 | 245.5 | 257.0 | 40.7 | 0.7 | 4.0 | .831 |
| 16243 | 1 | 263 | 2691 | 64.6 | 41.7 | 15.5 | 0.9 | 4.9 | .223 |
| 16254 | 1 | 112 | 2187 | 61.7 | 57.5 | 36.3 | 0.9 | 2.7 | .955 |
| 16317 | 1 | 89 | 1202 | 66.1 | 57.5 | 26.9 | 0.9 | 2.5 | .057 |
| 16328 | 1 | 49 | 758 | 30.9 | 15.8 | 3.7 | 2.2 | 14.5 | .209 |
| 16393 | 1 | 21 | 631 | 19.5 | 6.0 | 1.2 | 3.1 | 17.4 | .055 |
| 17241 | 1 | 174 | 2290 | 60.3 | 30.9 | 16.2 | 1.0 | 4.7 | .489 |
| 17242 | 2 | 182 | 3388 | 151.4 | 123.0 | 11.0 | 0.3 | 1.2 | .008 |
| 17245 | 1 | 178 | 2884 | 147.9 | 125.9 | 67.6 | 0.4 | 1.7 | .055 |
| 17247 | 1 | 126 | 3311 | 102.3 | 97.7 | 10.0 | 0.8 | 5.0 | .114 |
| 17248 | 2 | 240 | 4265 | 138.0 | 85.1 | 11.0 | 0.4 | 3.3 | .063 |
| 17249 | 1 | 275 | 3890 | 134.9 | 162.2 | 27.5 | 0.5 | 3.0 | .025 |
| 17256 | 1 | 71 | 1778 | 55.0 | 36.3 | 22.9 | 1.1 | 4.8 | .095 |
| 17258 | 0 | 41 | 1318 | 83.2 | 39.8 | 38.0 | 0.9 | 4.6 | .660 |
| 17373 | 1 | 45 | 1174 | 13.2 | 11.0 | 6.0 | 2.1 | 18.2 | .323 |
| 17389 | 1 | 45 | 1288 | 39.8 | 74.1 | 14.8 | 0.7 | 5.8 | .008 |
| 17391 | 1 | 18 | 812 | 16.6 | 11.0 | 6.2 | 3.5 | 20.9 | .138 |
| 18092 | 1 | 246 | 4897 | 123.0 | 107.2 | 15.8 | 0.7 | 7.2 | .141 |
| 18093 | 1 | 35 | 1122 | 19.1 | 25.1 | 6.9 | 1.6 | 5.2 | .660 |
| 18120 | 1 | 72 | 1659 | 46.8 | 26.9 | 8.1 | 1.2 | 5.8 | .218 |
| 19119 | 3 | 166 | 1230 | 169.8 | 128.8 | 12.6 | 0.6 | 4.6 | .043 |
| 19122 | 1 | 50 | 1258 | 30.9 | 15.8 | 3.8 | 1.7 | 24.0 | .616 |
| 19338 | 0 | 123 | 851 | 173.8 | 141.3 | 8.1 | 0.7 | 4.3 | .005 |
| 19340 | 3 | 214 | 1230 | 190.5 | 56.2 | 10.0 | 1.8 | 8.5 | .380 |
| 19342 | 1 | 79 | 1000 | 87.1 | 57.5 | 8.9 | 0.8 | 5.6 | .030 |
| 19343 | 1 | 30 | 1000 | 10.0 | 10.0 | 3.6 | 4.3 | 14.5 | 1.202 |
| 20081 | 1 | 195 | 3090 | 120.2 | 83.2 | 17.4 | 0.6 | 2.7 | .173 |
| 20087 | 1 | 295 | 6165 | 102.3 | 61.7 | 17.4 | 1.0 | 5.0 | .363 |
| 20088 | 1 | 251 | 2570 | 125.9 | 70.8 | 23.4 | 0.7 | 4.7 | 1.202 |
| 21196 | 0 | 25 | 1047 | 39.8 | 33.1 | 9.5 | 1.0 | 3.0 | .038 |
| 22014 | 1 | 19 | 316 | 16.6 | 19.1 | 12.3 | 2.0 | 14.8 | 1.318 |
| 22019 | 1 | 20 | 524 | 16.6 | 15.1 | 4.3 | 2.8 | 16.2 | 1.862 |

* See page F-4 for key

(continued)

Table F-1 (continued)

| disres | code | pi | ni | po | tp | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|---|---|
| 22188 | 0 | 89 | 758 | 223.9 | 199.5 | 6.5 | 0.4 | 9.1 | .295 |
| 22189 | 3 | 288 | 1737 | 61.7 | 61.7 | 6.6 | 0.9 | 15.5 | 1.122 |
| 22190 | 1 | 105 | 1096 | 95.5 | 51.3 | 6.0 | 0.6 | 16.6 | 1.096 |
| 22192 | 1 | 74 | 955 | 61.7 | 40.7 | 6.5 | 1.3 | 16.6 | 1.096 |
| 23352 | 1 | 126 | 1412 | 33.1 | 30.9 | 12.9 | 1.5 | 4.1 | .602 |
| 23353 | 0 | 107 | 955 | 120.2 | 104.7 | 19.1 | 0.5 | 3.0 | .154 |
| 23413 | 1 | 47 | 691 | 50.1 | 51.3 | 18.2 | 0.9 | 1.8 | .114 |
| 24011 | 1 | 60 | 1174 | 13.8 | 21.9 | 3.9 | 2.1 | 17.8 | 1.513 |
| 24012 | 0 | 37 | 933 | 69.2 | 57.5 | 8.9 | 0.4 | 2.6 | .067 |
| 24013 | 1 | 20 | 1318 | 12.3 | 15.1 | 3.9 | 3.5 | 20.4 | .707 |
| 24016 | 1 | 25 | 588 | 13.2 | 12.0 | 3.8 | 3.3 | 21.4 | 2.238 |
| 24021 | 0 | 20 | 691 | 39.8 | 38.9 | 15.8 | 0.8 | 2.5 | .046 |
| 24022 | 0 | 14 | 1047 | 17.8 | 15.1 | 3.4 | 3.6 | 17.4 | .977 |
| 24193 | 0 | 10 | 1047 | 28.2 | 17.0 | 3.6 | 1.4 | 4.1 | .036 |
| 24200 | 1 | 71 | 1318 | 18.2 | 21.9 | 9.1 | 2.3 | 19.1 | .912 |
| 25020 | 1 | 49 | 676 | 52.5 | 39.8 | 15.1 | 0.8 | 2.2 | .049 |
| 25102 | 2 | 316 | 5248 | 104.7 | 69.2 | 9.8 | 0.4 | 3.9 | .602 |
| 25103 | 2 | 115 | 1584 | 63.1 | 30.2 | 3.2 | 0.2 | 2.4 | .123 |
| 25104 | 0 | 68 | 1737 | 85.1 | 52.5 | 7.8 | 0.3 | 3.0 | .109 |
| 25105 | 2 | 288 | 3235 | 166.0 | 117.5 | 9.5 | 0.2 | 2.0 | .063 |
| 25107 | 2 | 240 | 3715 | 67.6 | 52.5 | 12.3 | 0.4 | 4.1 | 2.398 |
| 25112 | 0 | 54 | 1349 | 75.9 | 67.6 | 6.6 | 0.3 | 2.5 | .060 |
| 25267 | 3 | 347 | 2238 | 218.8 | 81.3 | 4.4 | 0.4 | 10.0 | .851 |
| 25269 | 2 | 59 | 933 | 46.8 | 69.2 | 9.8 | 0.4 | 12.0 | 1.584 |
| 25273 | 2 | 324 | 2630 | 144.5 | 134.9 | 21.4 | 0.4 | 7.8 | .151 |
| 25275 | 2 | 182 | 1862 | 70.8 | 58.9 | 5.1 | 0.4 | 5.8 | .302 |
| 25278 | 1 | 91 | 2187 | 49.0 | 38.9 | 6.6 | 1.6 | 15.5 | .660 |
| 25281 | 0 | 55 | 776 | 69.2 | 79.4 | 4.8 | 0.5 | 2.3 | .043 |
| 25348 | 3 | 339 | 2511 | 134.9 | 41.7 | 12.6 | 1.2 | 5.8 | .478 |
| 25370 | 1 | 105 | 1862 | 31.6 | 22.9 | 10.2 | 1.1 | 5.2 | 2.818 |
| 26345 | 3 | 589 | 2818 | 51.3 | 15.8 | 7.9 | 3.1 | 10.7 | 1.584 |
| 26347 | 1 | 11 | 1047 | 6.6 | 10.0 | 2.5 | 3.0 | 14.1 | 1.000 |
| 26354 | 2 | 219 | 2138 | 50.1 | 63.1 | 5.4 | 0.4 | 6.5 | 1.412 |
| 26355 | 1 | 178 | 1584 | 56.2 | 44.7 | 14.1 | 0.6 | 6.0 | .851 |
| 26359 | 1 | 55 | 660 | 31.6 | 28.8 | 6.3 | 1.5 | 7.8 | 1.412 |
| 26360 | 1 | 107 | 5370 | 89.1 | 97.7 | 24.5 | 0.5 | 6.5 | 10.964 |
| 26361 | 1 | 76 | 1318 | 50.1 | 52.5 | 24.5 | 0.7 | 4.3 | .602 |
| 26362 | 1 | 32 | 933 | 12.0 | 18.2 | 3.9 | 2.4 | 11.2 | 1.000 |
| 26364 | 1 | 123 | 1737 | 29.5 | 28.2 | 6.9 | 1.8 | 8.1 | .794 |
| 28219 | 1 | 74 | 1174 | 4.5 | 20.0 | 3.3 | 1.2 | 11.7 | 3.020 |
| 29100 | 1 | 363 | 3020 | 64.6 | 70.8 | 12.0 | 0.6 | 6.8 | 1.000 |
| 29106 | 3 | 490 | 3235 | 107.2 | 56.2 | 15.8 | 0.3 | 4.5 | .331 |
| 29108 | 3 | 661 | 3630 | 74.1 | 79.4 | 19.1 | 0.9 | 7.8 | .776 |
| 29109 | 1 | 145 | 3311 | 55.0 | 33.9 | 30.2 | 1.0 | 6.0 | 1.096 |
| 29110 | 3 | 427 | 3235 | 104.7 | 55.0 | 5.6 | 0.5 | 3.7 | .776 |
| 29111 | 2 | 81 | 1905 | 67.6 | 39.8 | 8.3 | 0.5 | 6.5 | .524 |

(continued)

Table F-1 (continued)

| disres | code | pi | ni | po | tp | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|---|---|
| 29113 | 3 | 1023 | 5495 | 166.0 | 162.2 | 11.2 | 0.8 | 8.1 | .380 |
| 29114 | 1 | 155 | 2630 | 46.8 | 22.9 | 8.9 | 1.4 | 8.3 | 2.818 |
| 29194 | 1 | 59 | 1737 | 36.3 | 42.7 | 9.3 | 1.3 | 9.5 | .851 |
| 29195 | 1 | 71 | 2570 | 15.5 | 21.9 | 8.9 | 1.8 | 7.2 | 1.071 |
| 29207 | 1 | 398 | 3467 | 81.3 | 112.2 | 27.5 | 0.6 | 7.8 | 1.412 |
| 30064 | 3 | 1047 | 5623 | 158.5 | 53.7 | 23.4 | 0.8 | 5.2 | 3.630 |
| 30215 | 3 | 575 | 4466 | 144.5 | 60.3 | 15.5 | 1.2 | 3.7 | 2.884 |
| 30217 | 1 | 363 | 3890 | 72.4 | 43.7 | 17.0 | 1.1 | 5.5 | 2.818 |
| 30235 | 3 | 380 | 1584 | 26.3 | 15.8 | 6.9 | 2.3 | 19.1 | 1.584 |
| 31077 | 1 | 22 | 631 | 16.6 | 10.0 | 2.4 | 2.5 | 55.0 | .831 |
| 32204 | 0 | 3 | 42 | 23.4 | 44.7 | 2.7 | 4.1 | 38.0 | .741 |
| 33300 | 3 | 39 | 195 | 34.7 | 38.0 | 2.3 | 1.7 | 38.9 | .416 |
| 34048 | 1 | 37 | 912 | 18.2 | 12.9 | 3.6 | 3.0 | 47.9 | 1.698 |
| 35029 | 1 | 96 | 1202 | 58.9 | 20.0 | 3.1 | 1.6 | 19.1 | .457 |
| 35039 | 1 | 76 | 645 | 46.8 | 37.2 | 9.1 | 2.5 | 10.0 | 1.584 |

disres = CE district/reservoir code (see Table 1)
code: 0 = Rp < -.1 1 = used in error analysis
2 = turbidity > 1.58 1/m 3 = inflow N/P < 8
pi = inflow total p concentration (mg/m3)
ni = inflow total n concentration (mg/m3)
po = outflow total p concentration (mg/m3)
tp = median, reservoir total p concentration (mg/m3)
chla = mean chlorophyll-a (mg/m3)
secchi = mean secchi depth (m)
zmean = mean depth (m)
t = mean hydraulic residence time (yrs)
$R_p$ = retention coefficient of phosphorus
N/P = total nitrogen/phosphorus ratio

Table F-2
TVA Reservoir Data

| Reservoir | pi | ni | tp | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|
| ------------- Mainstem Tennessesee River --------------- | | | | | | | |
| Kentucky | 74 | 717 | 81 | 9.1 | 1.0 | 5.0 | .038 |
| Pickwick | 51 | 709 | 56 | 3.9 | 0.9 | 6.5 | .017 |
| Wilson | 56 | 685 | 53 | 5.9 | 1.4 | 12.3 | .013 |
| Wheeler | 35 | 618 | - | 4.4 | - | 5.3 | .021 |
| Guntersville | 38 | 654 | 44 | 4.8 | 1.1 | 4.2 | .024 |
| Nickajack | 36 | 623 | 51 | 2.8 | 1.1 | 6.8 | .007 |
| Chickamauga | 26 | 575 | 31 | 3.0 | 1.1 | 5.0 | .017 |
| Watts Bar | 40 | 739 | 32 | 6.2 | 1.0 | 7.3 | .035 |
| Ft Loudon | 44 | 1033 | 54 | 5.9 | 0.9 | 7.3 | .026 |
| -------------------- Tributary ---------------------- | | | | | | | |
| Chatuge | 21 | 360 | 14 | 5.5 | 2.7 | 9.5 | .435 |
| Cherokee | 155 | 1424 | 51 | 10.9 | 1.7 | 13.9 | .216 |
| Douglas | 67 | 722 | 26 | 6.3 | 1.6 | 10.7 | .117 |
| Fontana | 45 | 581 | 11 | 4.1 | 2.6 | 37.8 | .282 |
| Hiwasse | 21 | 343 | 15 | 5.0 | 2.4 | 20.2 | .153 |
| Normandy | 170 | 770 | - | 15.0 | 1.2 | 9.5 | .369 |
| Norris | 38 | 944 | - | 2.1 | 3.9 | 16.3 | .372 |
| So Holston | 34 | 732 | 14 | 6.5 | 2.6 | 23.4 | .550 |
| Tims Ford | 24 | 721 | 21 | 6.1 | 2.4 | 14.9 | .561 |
| Watauga | 51 | 724 | - | 2.9 | 2.7 | 24.5 | .687 |

pi = inflow total p (mg/m3)
ni = inflow total n (mg/m3)
tp = median total p (mg/m3) (EPA/NES)
chla = mean, summer chlorophyll-a (mg/m3)
secchi = mean, summer transparency (m)
zmean = mean depth (m)
t = mean hydraulic residence time (years)

Table F-3
Impoundments in the OECD/RSL Data Base

| # | Impoundment | Type | Country |
|---|---|---|---|
| 01 | De Grote Rug | p | Netherlands |
| 02 | Laugh Leane | l | Ireland |
| 03 | Louch Ennel | l | Ireland |
| 04 | Hundred dn Dertig | p | Netherlands |
| 05 | Petrusplaat | p | Netherlands |
| 06 | Braakmann II | p | Netherlands |
| 07 | Braakmann III | p | Netherlands |
| 08 | Biwa North | l | Japan |
| 09 | Biwa South | l | Japan |
| 10 | Kasamigaura West | l | Japan |
| 11 | Kasamigaura North | l | Japan |
| 12 | Nisramont | * | Belguim |
| 13 | Eupen | * | ? |
| 14 | Brielse Meer | r | Netherlands |
| 15 | El Burguillo | r | Spain |
| 16 | Lough Neagh | l | United Kingdom |
| 17 | Farmoor | p | United Kingdom |
| 18 | Grafham Water | r | United Kingdom |
| 19 | Loch Leven | l | United Kingdom |
| 20 | Queen Elizabeth II | p | United Kingdom |
| 21 | Mt. Bold | r | Australia |
| 22 | Wahnbach | r | Germany |
| 23 | Oleftal | r | Germany |
| 24 | Prospect | p | Australia |
| 25 | Sorpe | r | Germany |
| 26 | Mohne | r | Germany |
| 27 | Verse | r | Germany |
| 28 | Sose | r | Germany |
| 29 | Furwigge | r | Germany |
| 30 | Vechten | * | Netherlands |
| 31 | Tjeukemeer | * | Netherlands |
| 32 | Enneppe | * | Germany |
| 33 | Blackhawk | r | U.S. - Wisconsin |
| 34 | Twin Valley | r | U.S. - Wisconsin |
| 35 | Kerr Res. Roanoke | r | U.S. - Virginia |
| 36 | Isles | r | U.S. - Minnesota |
| 37 | Cox Hollow | r | U.S. - Wisconsin |
| 38 | Dutch Hollow | r | U.S. - Wisconsin |
| 39 | Kerr Res. Nutbush | r | U.S. - Virginia |
| 40 | Virginia | r | U.S. - Wisconsin |
| 41 | Redstone | r | U.S. - Wisconsin |
| 42 | Camelot Sherwood | r | U.S. - Wisconsin |
| 43 | Stewart | r | U.S. - Wisconsin |

# code number in OECD/RSL data base (Table F-4)
Type: l = natural lake, r = reservoir,
p = pumped storage impoundment
* = not specified in OECD/RSL report
(r assumed)

Table F-4
OECD Reservoir and Shallow Lakes Project Data

| resyr* | c | pi | ni | tp | tn | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|---|---|
| 1.74 | 3 | 529 | 5757 | 83 | 3700 | 16.0 | 1.1 | 5.3 | .457 |
| 1.75 | 3 | 514 | 4443 | 72 | 2700 | 13.0 | 1.5 | 5.5 | .471 |
| 1.76 | 3 | 629 | 5657 | 88 | 2670 | 23.0 | 1.3 | 4.5 | .385 |
| 2.73 | 2 | 26 | - | - | - | 4.6 | 2.8 | 13.7 | .363 |
| 2.74 | 2 | 22 | - | - | - | 5.7 | 2.6 | 13.7 | .304 |
| 3.75 | 2 | 328 | - | 70 | - | 26.0 | 1.4 | 7.5 | 2.100 |
| 3.76 | 2 | 151 | - | 38 | - | 27.0 | 1.3 | 7.5 | 1.680 |
| 4.74 | 3 | 486 | 5932 | 330 | 5600 | 5.0 | 2.8 | 14.7 | .218 |
| 4.75 | 3 | 455 | 5713 | 300 | 4900 | 6.0 | 3.4 | 14.7 | .225 |
| 4.76 | 3 | 558 | 6353 | 360 | 5500 | 6.0 | 3.4 | 14.7 | .219 |
| 5.74 | 3 | 331 | 5579 | 170 | 5400 | 4.0 | 3.5 | 12.4 | .097 |
| 5.75 | 3 | 293 | 4947 | 200 | 4700 | 6.0 | 3.6 | 12.4 | .097 |
| 5.76 | 3 | 357 | 5518 | 200 | 5200 | 8.0 | 2.9 | 12.4 | .094 |
| 6.74 | 3 | 550 | 13666 | 190 | 8100 | 32.0 | 2.0 | 9.3 | .850 |
| 6.75 | 3 | 644 | 11600 | 250 | 7000 | 71.0 | 1.7 | 8.4 | .760 |
| 6.76 | 3 | 300 | 10833 | 340 | 3200 | 47.0 | 2.0 | 6.2 | 1.170 |
| 7.74 | 3 | 232 | 6800 | 29 | 6600 | 17.0 | 3.0 | 9.3 | .560 |
| 7.75 | 3 | 311 | 7444 | 21 | 4500 | 20.0 | 3.5 | 8.0 | 1.330 |
| 7.76 | 3 | 125 | 4125 | 100 | 1800 | 44.0 | 3.0 | 7.3 | 1.380 |
| 8.74 | 2 | 39 | 566 | 8 | - | 2.1 | 7.8 | 6.5 | 5.990 |
| 8.75 | 2 | 41 | 592 | 7 | 381 | 1.8 | 8.1 | 6.5 | 6.170 |
| 8.76 | 2 | 40 | 568 | 8 | 363 | 2.1 | 7.9 | 6.5 | 5.820 |
| 9.74 | 2 | 23 | 453 | 24 | - | 5.1 | 2.5 | 0.8 | .034 |
| 9.75 | 2 | 22 | 509 | 15 | 441 | 3.5 | 3.0 | 0.8 | .035 |
| 9.76 | 2 | 23 | 495 | 21 | 459 | 5.5 | 2.0 | 3.8 | .033 |
| 10.74 | 2 | 232 | 3498 | 49 | 1260 | 35.2 | 1.2 | 3.9 | .608 |
| 10.75 | 2 | 232 | 3498 | 51 | 1357 | 19.1 | 1.2 | 3.4 | .608 |
| 10.76 | 2 | 232 | 3498 | 64 | 1143 | 35.7 | 1.4 | 3.9 | .608 |
| 11.74 | 2 | 183 | 2707 | 58 | 980 | 28.3 | 1.2 | 4.2 | .450 |
| 11.75 | 2 | 183 | 2707 | 53 | 1000 | 18.8 | 1.2 | 4.2 | .450 |
| 11.76 | 2 | 183 | 2707 | 59 | 906 | 30.5 | 1.1 | 4.2 | .450 |
| 12.74 | 1 | - | - | - | - | 8.4 | 2.8 | 6.4 | .008 |
| 12.75 | 1 | 82 | - | - | - | 34.6 | 2.2 | 6.4 | .016 |
| 12.76 | 1 | - | - | - | - | 11.6 | 2.1 | 6.4 | .022 |
| 13.74 | 1 | - | - | - | - | 0.7 | 3.0 | 18.5 | .370 |
| 13.75 | 1 | - | - | - | - | 2.1 | 4.0 | 17.5 | .340 |
| 13.76 | 1 | - | - | - | - | 1.4 | 4.3 | 16.8 | .300 |
| 14.74 | 1 | 1071 | 9611 | 230 | 5300 | 21.5 | 1.1 | 5.4 | .290 |
| 14.75 | 1 | 1056 | 9105 | 360 | 4100 | 27.8 | 1.4 | 5.4 | .430 |
| 15.74 | 1 | 55 | 889 | 27 | 889 | 8.0 | 2.5 | 20.3 | .410 |
| 15.75 | 1 | 70 | 976 | 40 | 1095 | 9.0 | 2.2 | 20.4 | .395 |
| 15.76 | 1 | 119 | 1444 | 42 | 988 | 16.0 | 2.3 | 17.7 | .287 |
| 16.74 | 2 | 179 | 2081 | 121 | 400 | 21.0 | 1.7 | 8.9 | 1.170 |
| 17.71 | 3 | 386 | - | - | - | 20.0 | 4.3 | 8.9 | .470 |
| 17.72 | 3 | 454 | - | - | - | 18.0 | 3.8 | 9.1 | .500 |
| 17.73 | 3 | 745 | - | - | - | 16.5 | 3.8 | 9.1 | .430 |
| 18.69 | 5 | - | - | - | 1830 | 9.9 | 3.4 | 9.5 | 5.800 |
| 18.73 | 5 | 4900 | - | - | 3990 | 8.0 | 4.2 | 9.5 | 5.800 |

* See page F-8 for key

(continued)

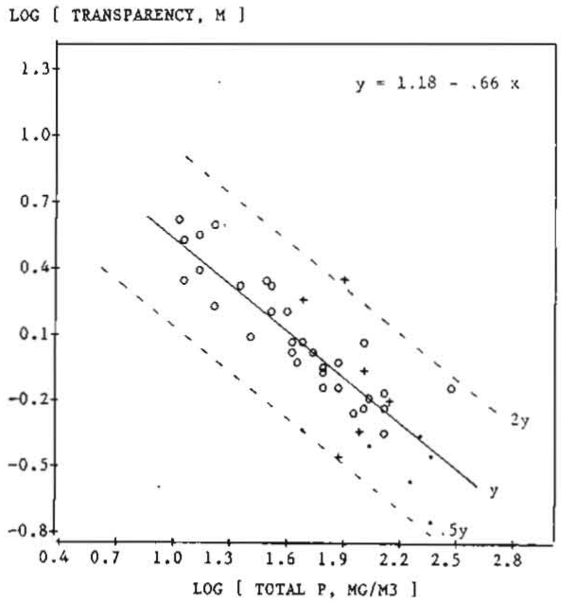
Table F-4 (continued)

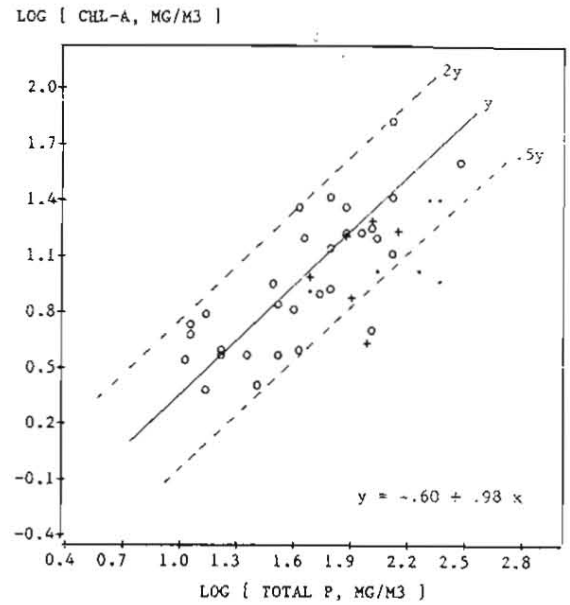
| resyr | c | pi | ni | tp | tn | chla | secchi | zmean | t |
|---|---|---|---|---|---|---|---|---|---|
| 19.74 | 2 | 146 | 3567 | 68 | 1520 | 39.0 | 1.4 | 3.9 | .588 |
| 20.69 | 3 | - | - | - | - | 2.0 | 3.0 | 15.3 | .147 |
| 21.73 | 5 | 231 | 1894 | 98 | 1330 | 3.0 | - | 13.4 | .400 |
| 21.75 | 5 | 150 | 1905 | 97 | 1420 | 3.0 | 1.0 | 13.3 | .330 |
| 21.76 | 5 | 153 | 1593 | 101 | 1500 | 4.0 | 1.4 | 12.7 | .480 |
| 22.74 | 1 | 82 | - | 25 | - | 4.7 | 4.0 | 17.8 | .740 |
| 22.75 | 1 | 85 | - | 22 | - | 6.0 | 4.0 | 17.7 | 1.370 |
| 22.76 | 1 | 100 | - | 16 | - | 5.1 | 4.0 | 17.3 | 1.270 |
| 23.75 | 1 | 9 | - | 12 | - | 1.7 | 6.1 | 15.5 | .610 |
| 23.76 | 1 | 6 | - | 8 | - | 5.6 | 5.7 | 13.7 | .430 |
| 24.75 | 3 | 14 | 359 | 11 | - | 3.0 | 3.2 | 9.7 | .115 |
| 24.76 | 3 | 12 | 402 | 10 | - | 3.1 | 2.1 | 9.7 | .119 |
| 25.74 | 1 | 198 | 3805 | 42 | 2190 | 8.6 | 4.0 | 20.4 | 1.140 |
| 26.73 | 1 | 366 | 4063 | 75 | - | 21.6 | 2.2 | 12.9 | .760 |
| 26.75 | 1 | 453 | 5463 | 77 | 3040 | 10.2 | 2.9 | 12.9 | .670 |
| 27.76 | 1 | 33 | 2894 | 12 | 1630 | 2.9 | 8.2 | 20.0 | 1.510 |
| 28.74 | 1 | 14 | - | 4 | - | - | 6.9 | 18.8 | .350 |
| 28.75 | 1 | 6 | - | 5 | - | 0.6 | 6.6 | 18.5 | .670 |
| 28.76 | 1 | 7 | - | 4 | - | 1.5 | 6.4 | 16.4 | .520 |
| 29.76 | 1 | 19 | 2781 | 8 | 1620 | 2.4 | 11.5 | 8.3 | .400 |
| 30.74 | 1 | - | - | - | - | 4.5 | - | 6.0 | 9.300 |
| 31.75 | 1 | - | - | - | - | 50.0 | - | 1.8 | - |
| 32.74 | 1 | 822 | 6628 | 168 | 4380 | - | 3.9 | 12.2 | .330 |
| 32.75 | 1 | 533 | 4363 | 208 | 4670 | - | 2.9 | 12.2 | .330 |
| 33.73 | 1 | 229 | 2396 | 85 | - | 15.0 | 3.6 | 4.9 | .500 |
| 34.73 | 1 | 223 | 2019 | 65 | - | 19.0 | 1.5 | 3.8 | .450 |
| 35.75 | 4 | 105 | 734 | - | - | 13.0 | 1.4 | 10.3 | .200 |
| 36.71 | 1 | 449 | - | - | - | 53.0 | 1.0 | 2.7 | .600 |
| 37.73 | 1 | 288 | 2972 | 80 | - | 27.0 | 1.5 | 3.8 | .592 |
| 38.73 | 1 | 600 | 6285 | 260 | - | 34.0 | 0.8 | 3.0 | 1.820 |
| 39.75 | 4 | 449 | 1517 | - | - | 21.1 | 1.2 | 8.0 | 4.980 |
| 40.73 | 1 | 1044 | 14711 | 85 | - | 29.0 | 1.7 | 1.7 | 1.370 |
| 41.73 | 1 | 519 | 6010 | 70 | - | 13.0 | 1.6 | 4.3 | 1.430 |
| 42.73 | 1 | 93 | 1278 | 35 | - | 6.3 | 2.0 | 3.0 | .110 |
| 43.73 | 4 | 2666 | 3083 | 60 | 1240 | 50.0 | 1.4 | 1.9 | .080 |

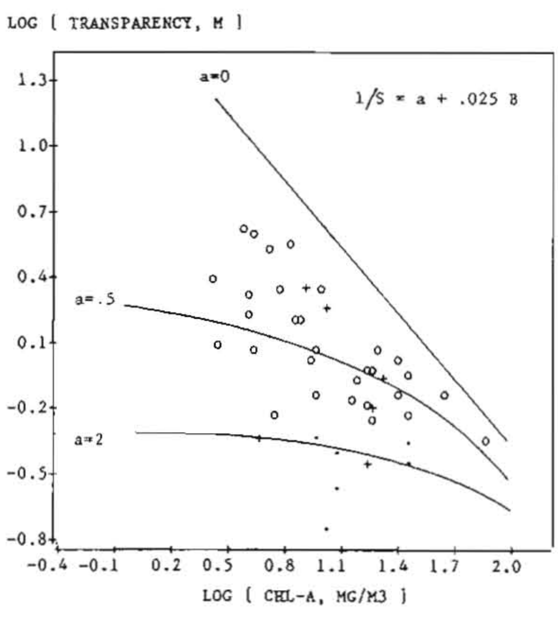
resyr = impoundment code (see Table F-3).year
c = code: 1 = reservoir 2 = natural lake
3 = pumped storage (artificial) reservoir
4 = inflow N/P < 8
5 = reservoir excluded from error analysis
pi = inflow total p (mg/m3)
ni = inflow total n (mg/m3)
tp = mean, annual, euphotic zone total p (mg/m3)
tn = mean, annual, euphotic zone total n (mg/m3)
chla = mean, annual, euphotic zone chlorophyll-a (mg/m3)
secchi = median, annual secchi depth (m)
zmean = mean depth (m)
t = hydraulic residence time (yrs)

Figure F-1

Internal Model Evaluations Using the CE Data Set



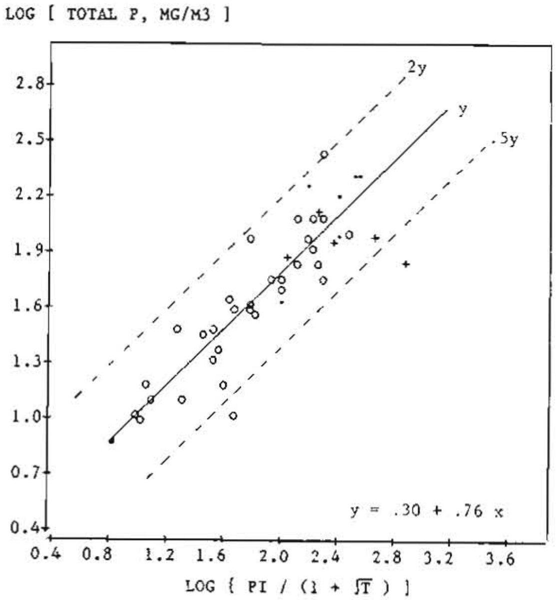

| Symbol | Meaning |
|---|---|
| o | CE Reservoir |
| + | Inflow Total N/P < 8 |
| . | Turbidity > 1.58 1/m |

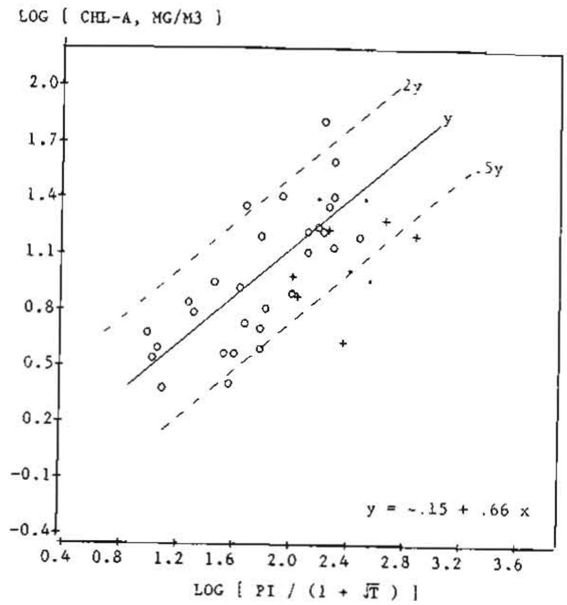
line = regression for CE reservoirs and CE data set

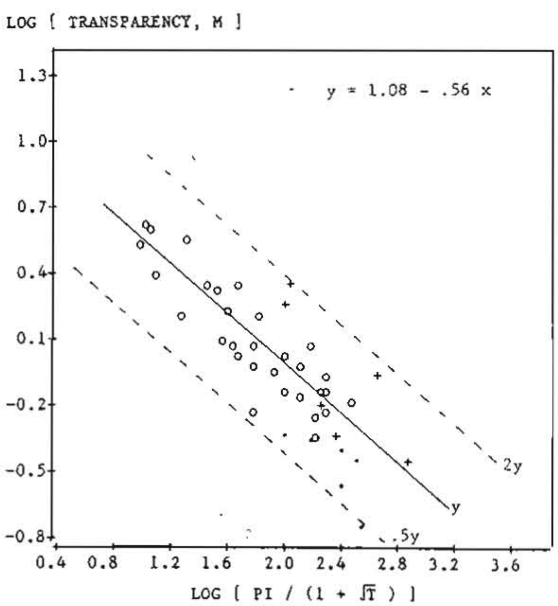
dashed line = 2-fold accuracy limits

Figure F-2

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the CE Data Set



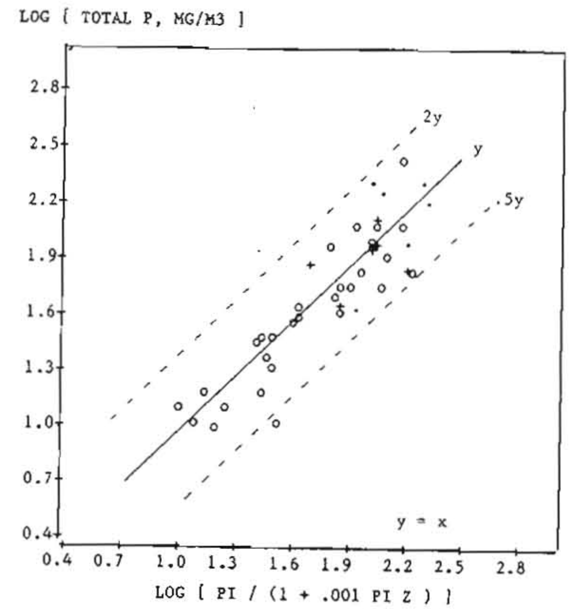

| Symbol | Meaning |
|---|---|
| o | CE Reservoir |
| + | Inflow Total N/P < 8 |
| . | Turbidity > 1.58 1/m |

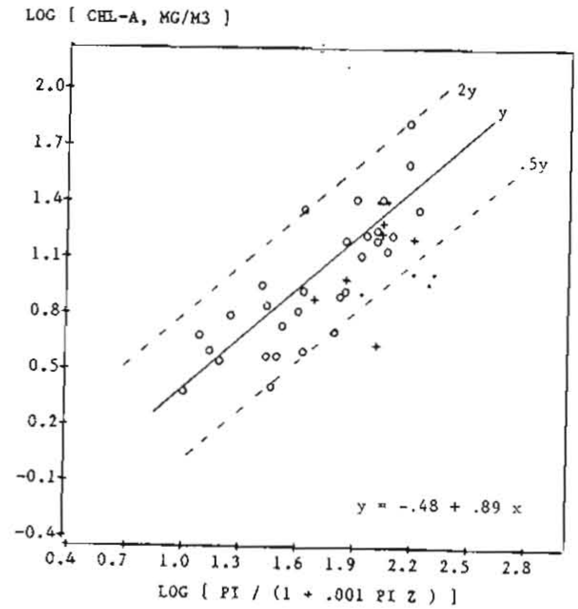
line = regression for CE reservoirs and CE data set

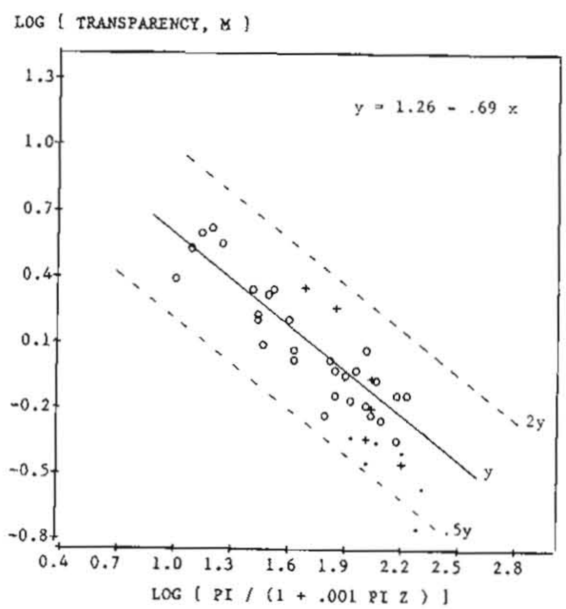
dashed line = 2-fold accuracy limits

Figure F-3

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the CE Data Set



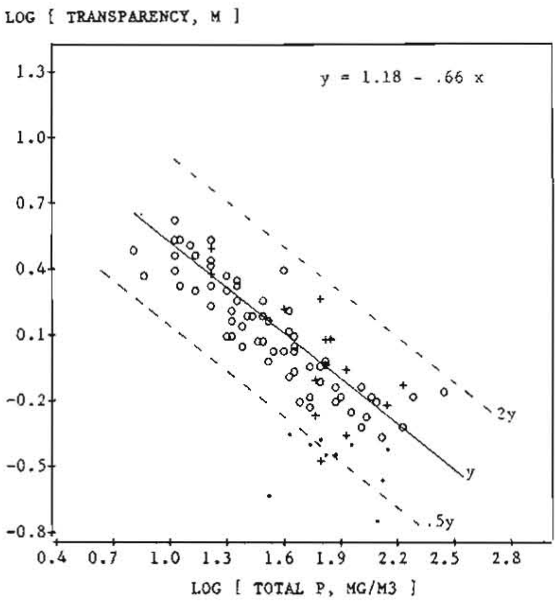



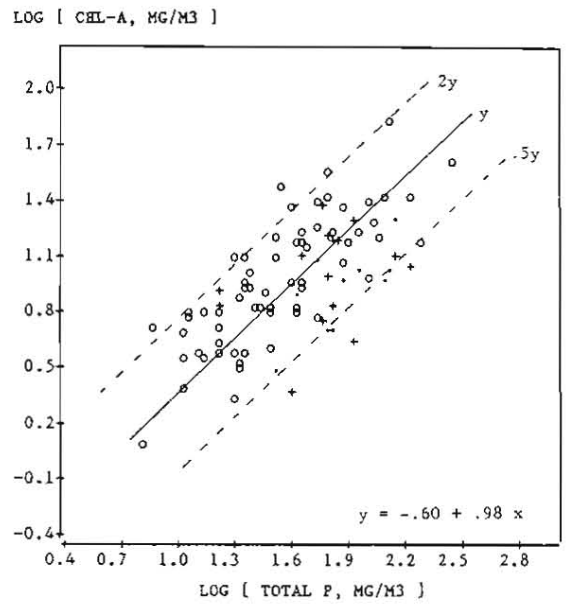

| Symbol | Meaning |
|---|---|
| o | CE Reservoir |
| + | Inflow Total N/P < 8 |
| . | Turbidity > 1.58 1/m |

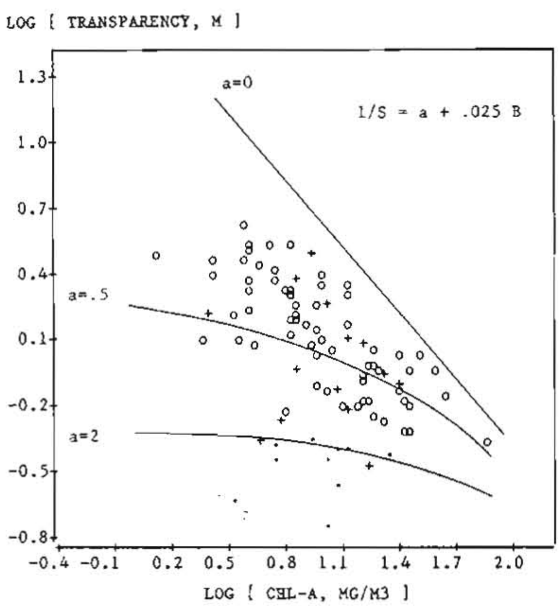
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3)
Z = mean depth (m)

Figure F-4

Internal Model Evaluations Using the EPA/NES Data Set




| Symbol | Meaning |
|---|---|
| o | CE Reservoir |
| + | Inflow Total N/P < 8 |
| . | Non-Algal Turbidity > 1.58 1/m |

line = regression for CE reservoirs and and CE data set

dashed line = 2-fold accuracy limits

## Figure F-5

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the EPA/NES Data Set

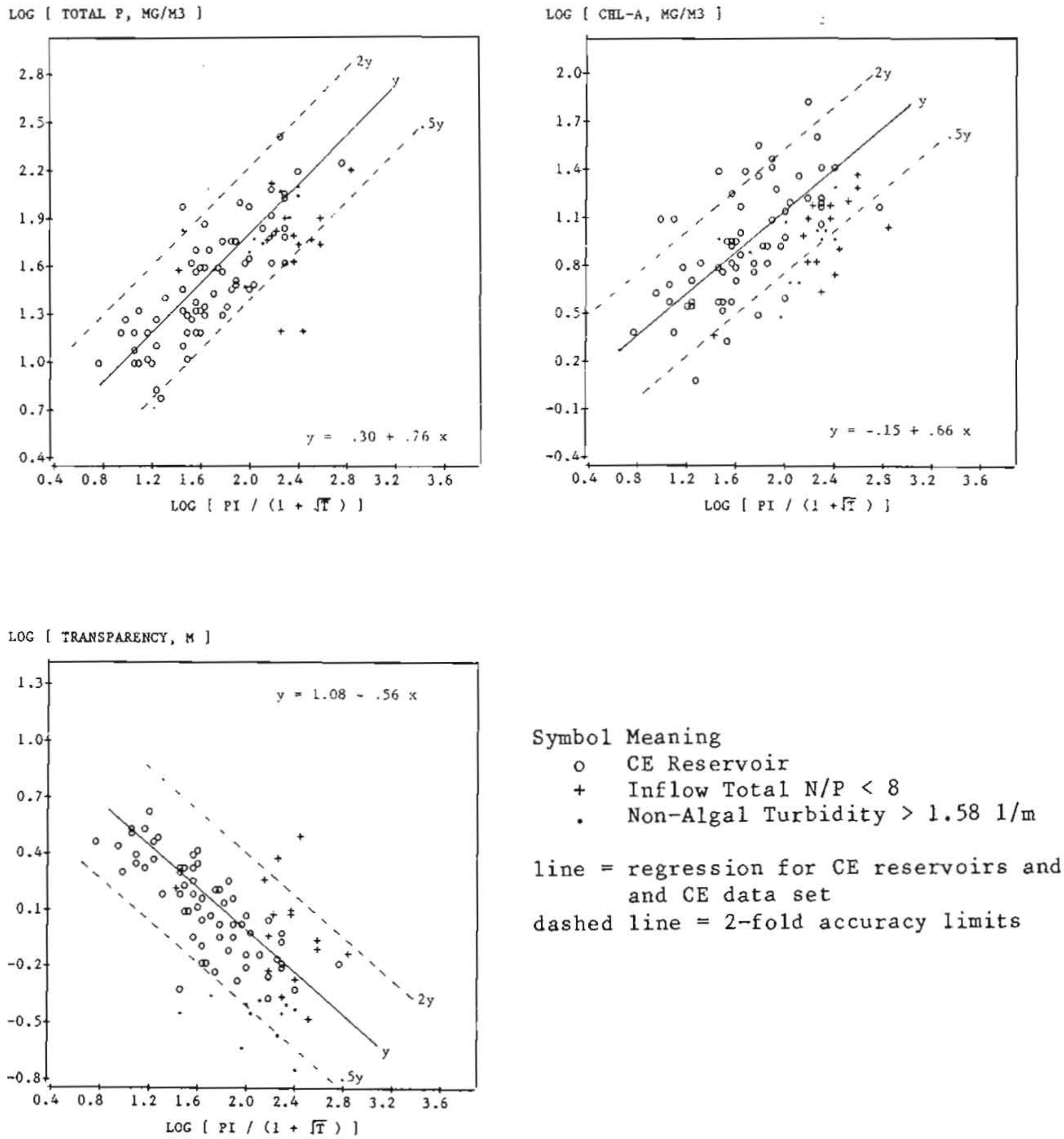
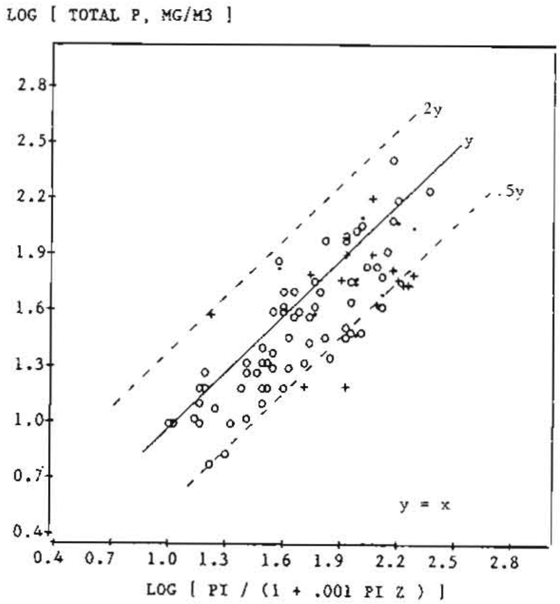
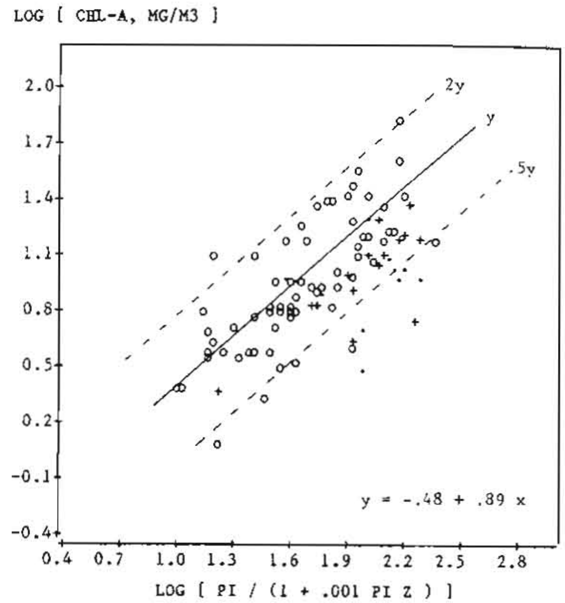
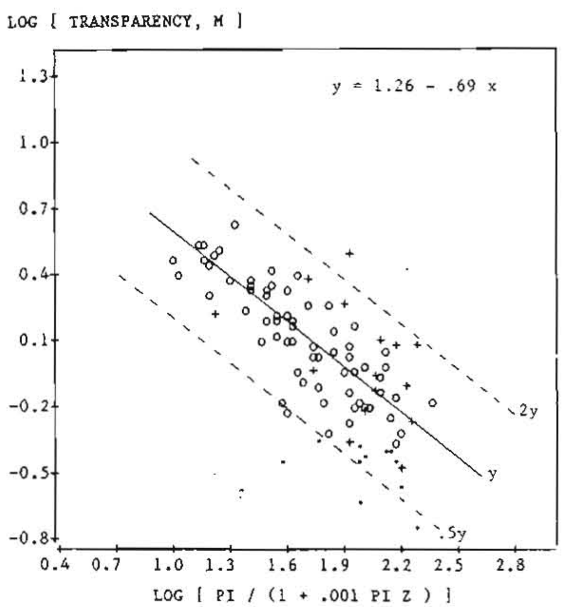


Figure F-6

Observed vs. Predicted Water Quality Using $P_n$ for Normalized Phosphorus Loading and the EPA/NES Data Set




| Symbol | Meaning |
|---|---|
| o | CE Reservoir |
| + | Inflow Total N/P < 8 |
| . | Non-Algal Turbidity > 1.58 1/m |

line = regression for CE reservoirs and CE data set

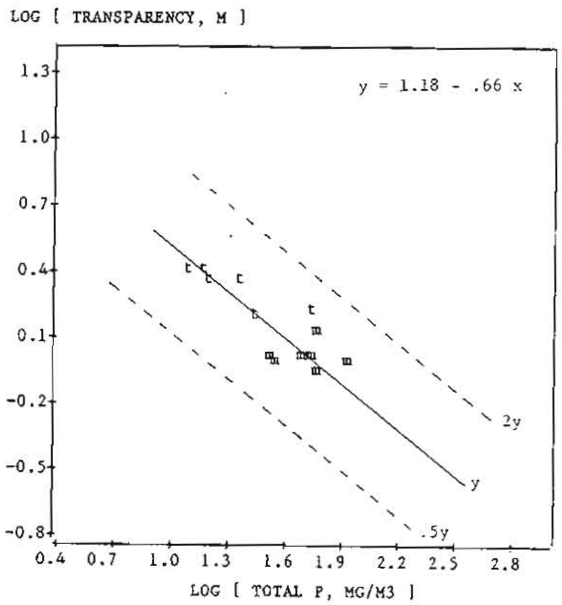
dashed line = 2-fold accuracy limits

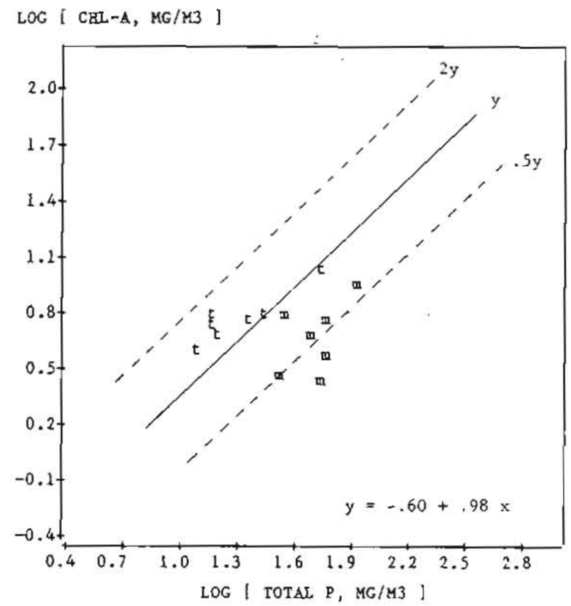
PI = average inflow phosphorus concentration (mg/m3)

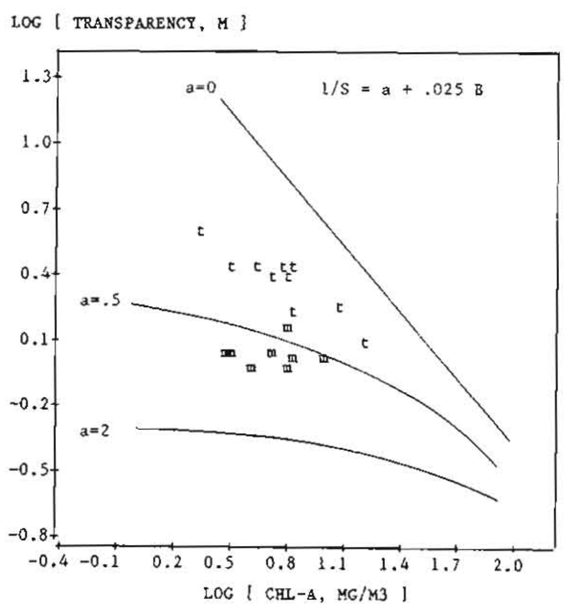
Z = mean depth (m)

Figure F-7

Internal Model Evaluations Using the TVA Data Set



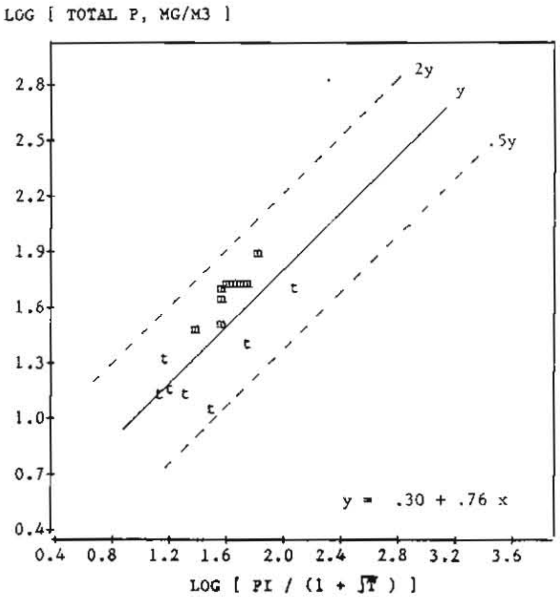



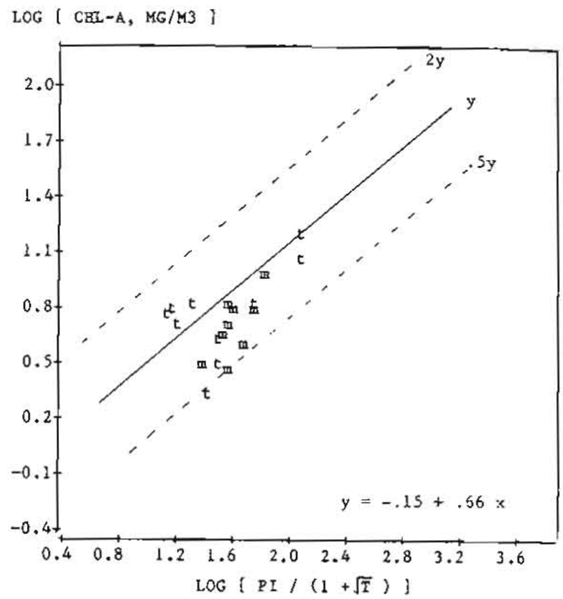

| Symbol | Meaning |
|---|---|
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |

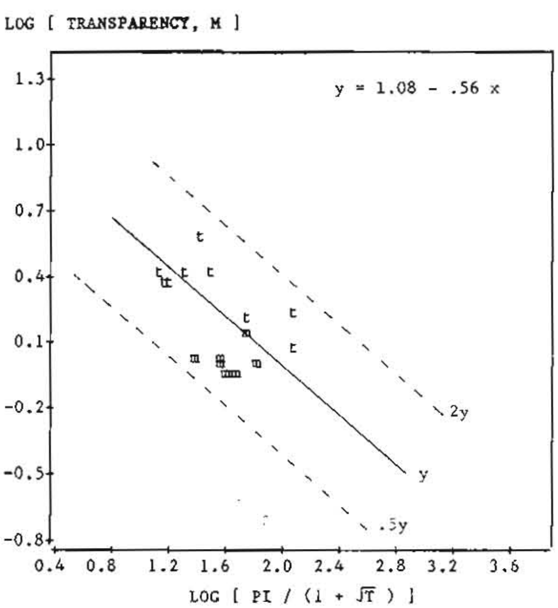
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits

Figure F-8

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the TVA Data Set



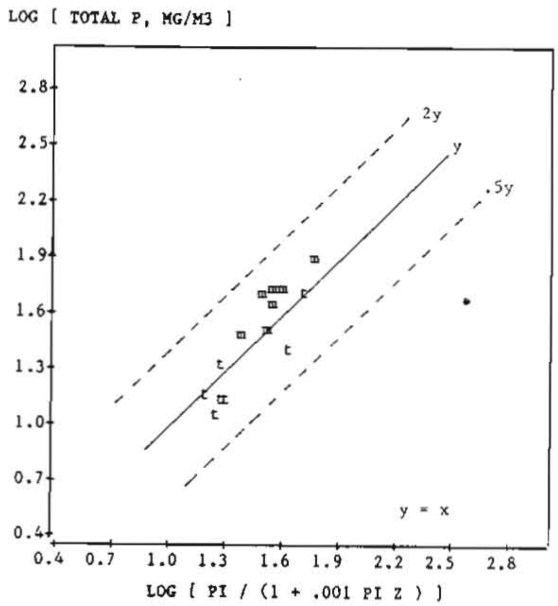

| Symbol | Meaning |
|---|---|
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |

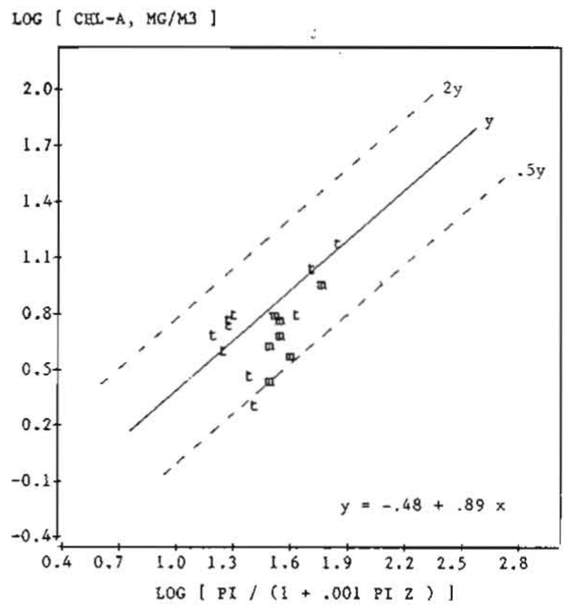
line = regression for CE reservoirs and CE data set

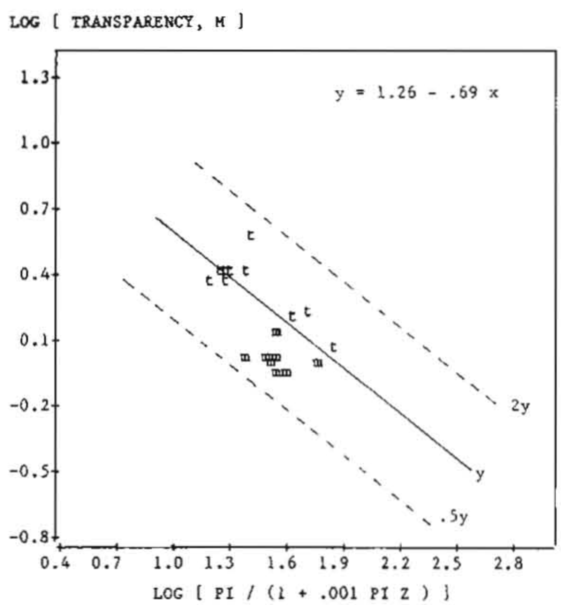
dashed line = 2-fold accuracy limits

Figure F-9

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the TVA Data Set




| Symbol | Meaning |
|---|---|
| t | TVA Tributary Reservoir |
| m | TVA Mainstem Reservoir |

line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3)
Z = mean depth (m)

Figure F-10

Internal Model Evaluations Using the OECD/RSL Data Set

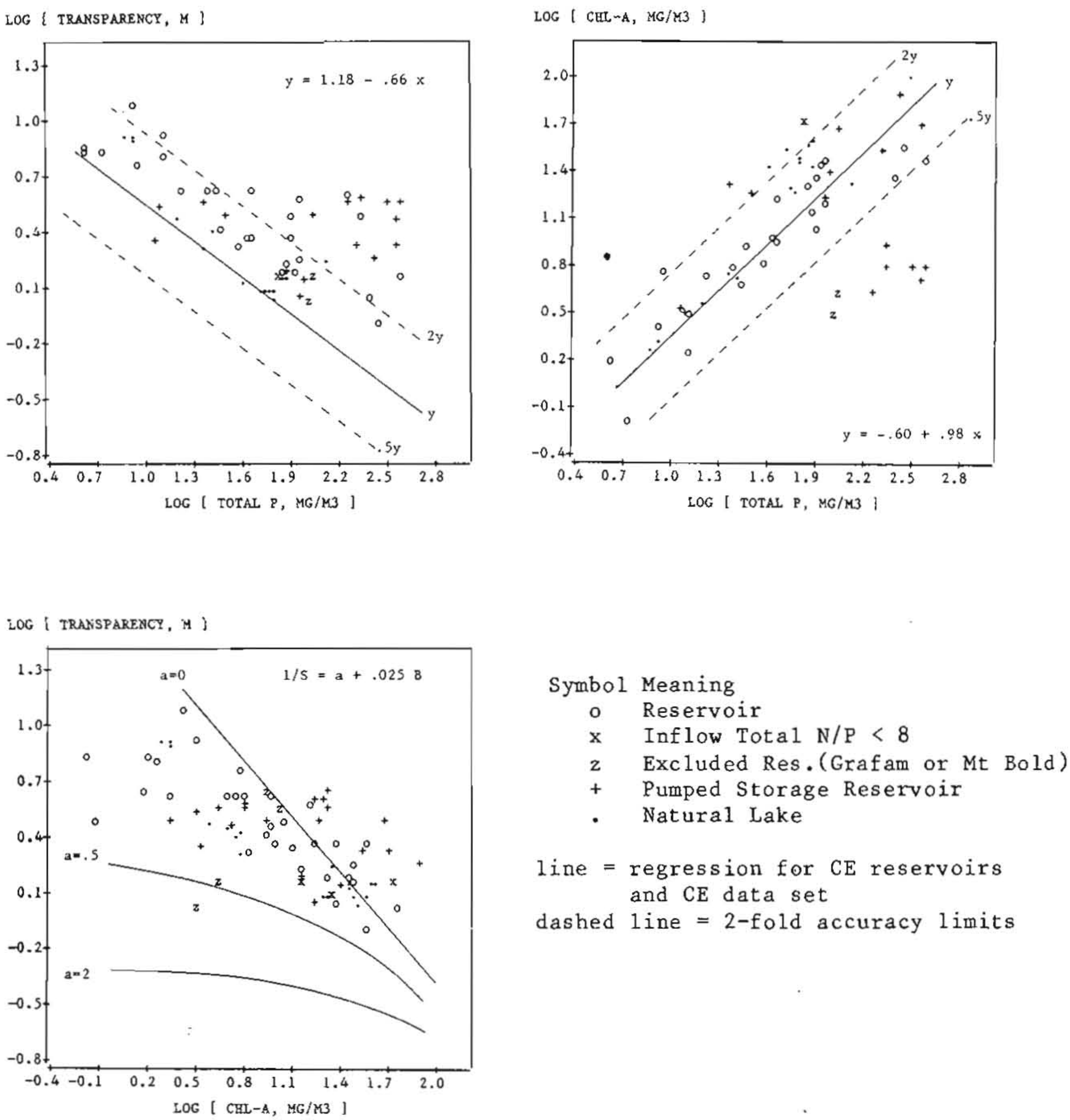
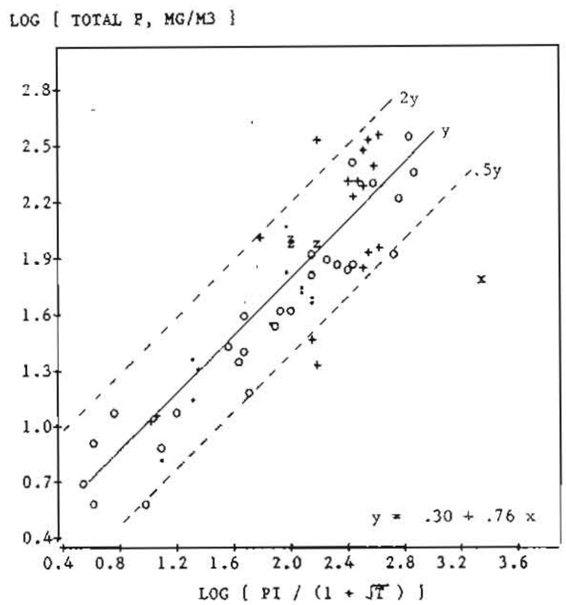
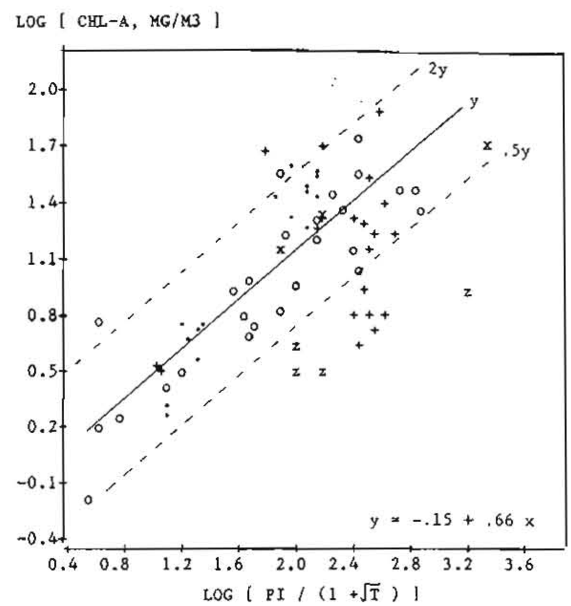
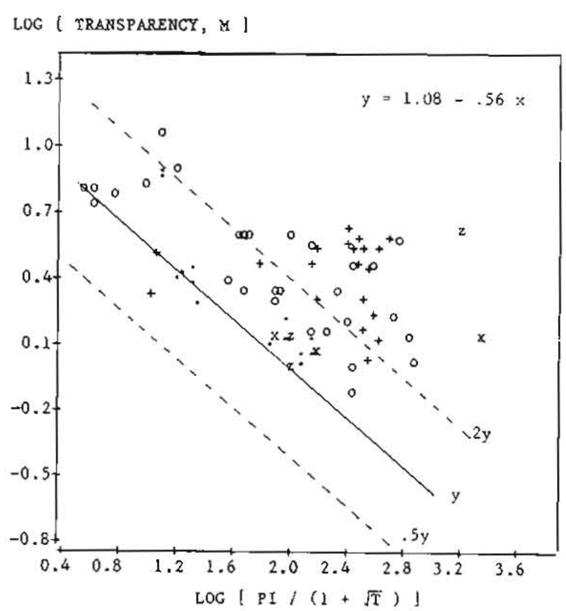


Figure F-11

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the OECD/RSL Data Set



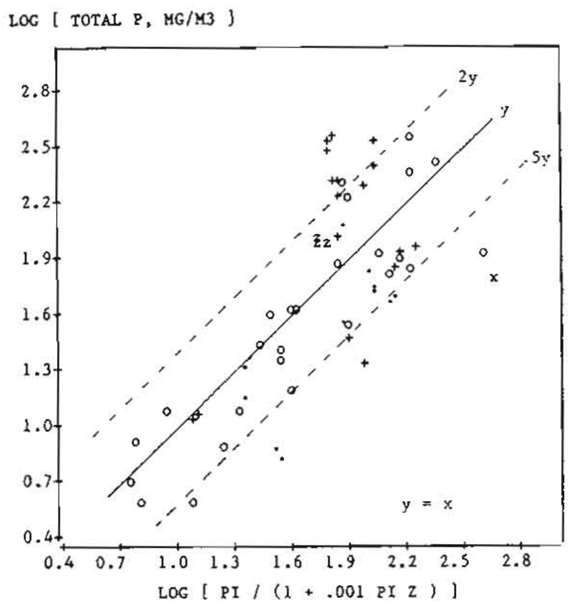

| Symbol | Meaning |
| --- | --- |
| o | Reservoir |
| x | Inflow Total N/P < 8 |
| z | Excluded Res. (Grafam or Mt. Bold) |
| + | Pumped Storage Reservoir |
| . | Natural Lake |

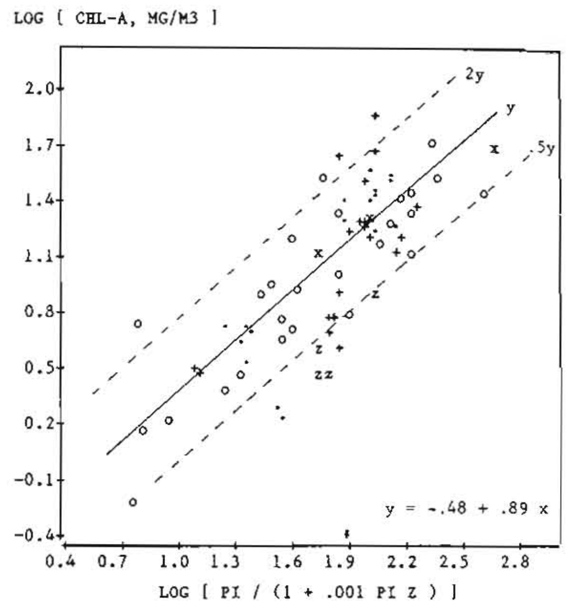
line = regression for CE reservoirs and CE data set

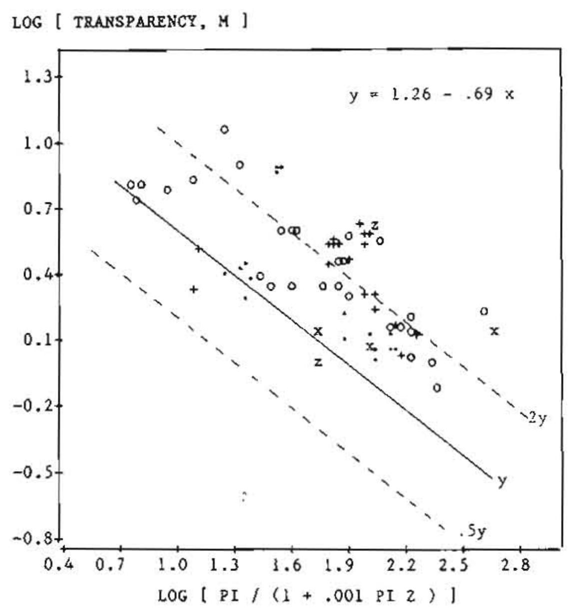
dashed line = 2-fold accuracy limits

Figure F-12

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the OECD/RSL Data Set




| Symbol | Meaning |
|---|---|
| o | Reservoir |
| x | Inflow Total N/P < 8 |
| z | Excluded Res.(Grafam or Mt Bold) |
| + | Pumped Storage Reservoir |
| . | Natural Lake |

line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3)
Z = mean depth (m)

# APPENDIX G: NOTATION

' = superscript denoting estimated value

= superscript denoting pool-monitoring year

an = annual (subscript)

A = effect of nonchlorophyll-related materials on S (turbidity) (1/m)

AE = average absolute error

AG = drainage area of gauged tributaries (km$^2$)

Ap = total phosphorus accumulation (trapping) rate (mg/m$^2$-yr)

AR = reservoir surface area (km$^2$)

As = surface area at elevation E (acres)

AT = drainage area at reservoir discharge (km$^2$)

AU = drainage area of ungaged tributaries (km$^2$)

b = sensitivity of inflow concentration to flow

= regression slope

B = chlorophyll-a (mg/m$^3$)

CI' = inflow concentration estimate at QI' (g/m$^3$)

CV = coefficient of variation of reservoir mean estimate

CGN = average nutrient concentration in sampled, but ungauged tributaries not under point source influence (g/m$^3$)

CIC = corrected inflow concentration (g/m$^3$)

Csi = depth-averaged value on date i

CVS$^2$ = mean squared within-station coefficient of variation

CV(X) = coefficient of variation for mean X

CICE = inflow concentration, adjusted for evaporation (g/m$^3$)

Csij = measurement for station s , date i , depth j

C1-C5 = polynominal coefficients

D = derivative of predicted Y with respect to X

= discriminant function

= discriminant score (oxic for D > 0)

DI = derivative of $\log(P_o)$ with respect to $\log(P_i)$

DK = derivative of $\log(P_o)$ with respect to $\log(K)$

dof = error degrees of freedom used in computing mean squared error and R-squared

DOsp = oxygen concentration at onset of stratification ($g/m^3$)

E = elevation (feet above mean sea level)

E0 = elevation at zero volume (feet above msl)

eu = euphotic zone (subscript)

E1,A1,V1 = elevation, area, and volume at first level

E2,A2,V2 = elevation, area, and volume at second level

F = fraction of loading attributed to point sources, septic tanks, and wildfowl

= F Statictic with p and n-p degrees of freedom

FE = evaporation/total inflow

Fm = morphometric factor

f(y) = normal frequency distribution function

gs = growing season (subscript)

Ho = the null hypothesis

HOD = hypolimnetic oxygen depletion rate ($g/m^2$-day)

HODa = estimated areal oxygen depletion rate ($g/m^2$-day)

HODv = volumetric HOD ($g/m^3$-day)

i = inflow (subscript)

I = trophic state index

K = first-order sedimentation rate (1/yr)

KE = effective rate constant for mixed model

K2 = slope parameter = 0.025 $m^2$/mg

ln = base-e logarithm

log = base-10 logarithm

Lp = total phosphorus loading ($mg/m^2$-yr)

M = total number of stations in the reservoir

mx = maximum value (subscript)

Med = median error

MSE = mean squared error

MSE* = minimum mean squared error

M1 = mean of group 1

M2 = mean of group 2

n = average number of sampling dates

= number of lakes or reservoirs in data set

= nitrogen (subscript)

= number of sampling dates/growing season

= number of impoundment-years

N = total N ($mg/m^3$)

No = organic nitrogen ($mg/m^3$)

Nsi = number of depths sampled in date i

o = outflow (subscript)

p = phosphorus (subscript)

= number of model parameters

P = total phosphorus ($mg/m^3$)

P* = probable classification error

Pi = average inflow phosphorus concentration ($mg/m^3$) = Lp/Qs

Pn = equation (61) normalized P loading = $P_i$/(1 + 0.001 PiZ)

Po = average outflow total P concentration

Pv = Vollenweider normalized P loading = $P_i$/(1 + sqrt(T))

PC1 = first principal component

PC2 = second principal component

QD = discharge from reservoir (cubic hectometres/yr)

QD' = total discharge (including withdrawals) (cubic hectometres/yr)

QE = evaporation (cubic hectometres/yr)

QG = gauged tributary input (cubic hectometres/yr)

QI = total water input (cubic hectometres/yr = $10^6$ $m^3$/yr)

QI' = total inflow (cubic hectometres/yr)

QN = net inflow (error, see equation (15)) (cubic hectometres/yr)

QO = total reservoir outflow (including evaporation) (cubic hectometres/yr)

QP = precipitation input (cubic hectometres/yr)

Qs = surface overflow rate (m/yr)

QU = estimated ungaged tributary input (cubic hectometres/yr)

QV = change in water storage (cubic hectometres/yr)

QV' = change-in-storage (cubic hectometres/yr)

QW = withdrawal from reservoir (cubic hectometres/yr)

QGN = inflow from gauged tributaries not under the influence of point sources (cubic hectometres/yr)

QIC = corrected total inflow (cubic hectometres/yr)

QIM = mean inflow over monitoring period, cubic hectometres/yr

QIS = mean inflow on tributary sampling days, cubic hectometres/yr

R = retention coefficient

R-squared = fraction of variance explained

R2 = percent of variance explained

sp = spring (subscript)

su = summer (subscript)

S = transparency (m)

$SE^2$ = mean squared error

$SE_m^2$ = model mean squared error

$SE_t^2$ = total mean squared error

Sr = sedimentation rate ($kg/m^2$-yr)

S1 = standard deviation of group 1

S2 = mean squared error (base-10 logarithms)

= standard deviation of group 2

T = length of monitoring period (yr)

= total hydraulic residence time (yr)

Th = mean hypolimnetic temperature (deg C)

TDO = days of oxygen supply at onset of stratification (days)

U = first-order settling velocity (m/yr)

V = total volume (acre-feet)

Var(X) = variance of estimated independent variable

Var(Y) = variance of estimated dependent variable

VD = dead storage (acre-feet)

VU1 = useable volume below first-listed elevation point (acre-ft)

VU2 = useable volume below second-listed elevation point (acre-ft)

$V_x$ = estimated data error variance of independent variable

$V_y$ = variance of dependent variable

= estimated data error variance of dependent variable

V1 = reservoir volume at beginning of period (cubic hectometres)

V2 = reservoir volume at end of period (cubic hectometres)

wn = winter (subscript)

W = weighting factor used for a given observation

WA = input from atmosphere (mt/yr)

WG = input from gauged tributaries (mt/yr)

WI = total input (metric tons/yr)

WO = total nutrient outflow (mt/yr)

WP = input from point source discharges (mt/yr)

WU = input from ungaged tributaries (mt/yr)

WV = change in nutrient storage (mt/yr)

WX = input from septic tanks and wildfowl (mt/yr)

WGN = nutrient input from gauged tributaries not under the influence of upstream point sources (mt/yr)

WIC = corrected total loading (mt/yr)

$|X-X'|$ = absolute value of X-X'

X* = critical value of discriminating variable

y = standard normal variable (mean = 0, standard deviation = 1)

Y = mean depth ratio

YA = atmospheric nutrient loading ($kg/km^2$-yr)

YE = average evaporation rate (m/yr)

YP = precipitation rate (m/yr)

Z = total depth (feet) (Part I, equation (1) only)

= mean depth (m)

Z* = normalized distance between groups 1 and 2

Zh = mean hypolimnetic depth = volume/area (m)

Zm = mixed depth (m)

Zmx = maximum depth (m)