79

WATER RESOURCES STUDY

Metropolitan Spokane Region

APPENDIX J

Water Quality Simulation Model

JANUARY 1976

METROPOLITAN SPOKANE REGION
MSR WRS
WATER RESOURCES STUDY

LIST OF REPORTS AND APPENDICES

REPORTS

Summary Report

Technical Report

APPENDIX	TITLE
A	Surface Water
B	Geology and Groundwater
C	Water Use
D	Wastewater Generation and Treatment
E	Environment and Recreation
F	Demographic and Economic Characteristics
G	Planning Criteria
H (Volume 1)	Plan Formulation and Evaluation
H (Volume 2)	Plan Formulation and Evaluation
I	Institutional Analysis
J	**WATER QUALITY SIMULATION MODEL**

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METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY.

APPENDIX J.

WATER QUALITY SIMULATION MODEL.

(12) 284p.

(11) JANUARY 1976

Department of the Army
Corps of Engineers, Seattle District

Kennedy-Tudor Consulting Engineers

KENNEDY TUDOR

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The summary report was prepared by the Seattle District Corps of Engineers. The technical report and appendices were prepared for the Seattle District, Corps of Engineers by Kennedy-Tudor Consulting Engineers.

PREFACE

With the enactment of the Federal Water Pollution Control Act Amendment of 1972 (Public Law 92-500), new national goals have been established for the elimination of pollution discharges into our streams and lakes. This appendix is a part of the report prepared to assist local government in satisfying State and Federal Requirements relating to Public Law 92-500. The suggestions contained in this report are for implementation by local interests with available assistance from other local, State and Federal agencies. The study suggests a regional wastewater management plan for the metropolitan Spokane urban area and provides major input to Washington State Department of Ecology Section 303e plans for the Spokane River Basin in Washington State. Also included in the study are planning suggestions for urban runoff and flood control, and the protection of the area's water supply resources.

As listed on the inside front cover, documentation for this study consists of a Summary Report and a Technical Report with supporting Appendices A through J.

The Technical Report summarizes Appendices A through J, which contain 58 individual task section reports prepared during the study. These task sections are listed by title in Attachment I of the Technical Report. Generally, the numbering of appendix task sections reflects the following system:

Study Task Sections	Type of Study Activity
300's	Data Collection
400's	Data Evaluation and Projection
500's	Identification of Unmet Needs
600's	Development of Alternative Plans
700's	Evaluation Comparison and Selection of Plans
800's	Institutional Arrangements

Pages within each appendix are numbered by task section, as illustrated below:

701.2 - 45

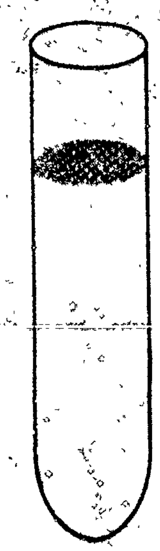
Task section identifier (701.2)

Identifies page number, numbered consecutively from beginning of task section (45)

APPENDIX J - WATER QUALITY SIMULATION MODEL

CONTENTS

A detailed index for each task section precedes the respective section text.



SECTION 607.1

SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 607.1

SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

1 April 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

INDEX (Continued)

INDEX TO TABLES

INDEX TO FIGURES

SECTION 607

SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

Scope and Objectives

This is to report the results of a water quality sampling and analysis program designed to provide data for quality calibration of the mathematical simulation model. The sampling and analysis program reported herein is based on samples collected in the period from noon on September 18, 1973 to noon on September 20, 1973.

The waters sampled in this program are the surface waters of the Spokane River from the Washington-Idaho border to Little Falls Dam and the tributaries Hangman Creek and Little Spokane River above their respective confluences with the Spokane River. The water quality parameters for which analyses are reported include all of the parameters to be simulated plus other parameters selected to augment the understanding of the chemical and biological processes.

The objective of the sampling and analysis program is to provide a unified body of water quality data in time sequence that will provide a calibration check of the dynamic simulation capability of the model. The data for calibration is not required to represent either typical conditions or extreme conditions or even stable conditions. The proposed calibration process will consist of starting a simulation run in June 1973 at water quality conditions existing then, and using historical meteorological, flow, and point source data from June to September 20, 1973 to simulate water quality conditions from June to and through the sampling period September 18 through September 20, 1973.

Complete meteorological data required for the calibration process extending from June through September 20, 1973 are not presented herein. These data are extremely voluminous and are typical of the data required for all simulation runs. Only data for the three day prior and the two day during the sampling period are summarized herein.

Likewise, streamflow data for the entire quality calibration period are not included herein. As for meteorological data, streamflow data are summarized herein for the three day prior and the two days during the sampling period. See the paragraph below for a description of hydrologic calibration of the model.

Unusual Circumstances

The use and interpretation of the data gathered in this sampling program should be tempered by the awareness that the sampling period was affected by four major events of an unusual nature:

1. The sampling period is at the close of one of the

dryest water years of record.

2. The Inland Empire Paper Company, the largest single industrial waste discharger on the Spokane River, had been closed by a strike from June 21, 1973 through the sampling period.

3. The first rains of the fall started approximately four hours after the sampling program began and resulted in (a) storm water overflows from the combined City of Spokane system and (b) both partial and 100 percent by-pass of the City of Spokane treatment plant for a time during the sampling period.

4. The controlled flow in the Spokane River at Post Falls was completely shut off, except for leakage, for a time during the sampling period by Washington Water Power Company.

Items 3 and 4 will be developed in detail where treatment flows and river flow data are presented below. The point source load of the Inland Empire Paper Company when in operation is presented in another section of this report under existing industrial waste sources.

Hydrologic Calibration

The simulation model contains two simulation processes. The first is a quantity simulation of streamflow, that is a hydrologic simulation. Superimposed on the hydrological simulation is the water quality simulation process.

The simulation model generates stream flow quantities from meteorological input data interacting with land associated parameters. A prerequisite to the calibration of the simulated water quality process is the calibration of the hydrologic simulation process. The calibration of the simulated hydrologic process consists of comparing streamflows simulated from meteorological data with those actually measured. This process will have been completed prior to the use of the water quality data developed herein for calibration of the quality process.

Overview of the Low Flow Sampling and Analysis Program

Ten locations on the Spokane River between the Washington-Idaho border and a point immediately downstream from Little Falls Dam, including a representative location in Long Lake, the two principal tributaries and the effluent of the City of Spokane sewage treatment plant are selected as the sampling points for the calibration program. In addition, samples were also taken at the sewage treatment plant bypass and at Fish Hatchery Springs on the Little Spokane River. These locations are shown in Figure A, are listed in Table 1 and are described in general below.

The fourteen sample locations are:

1. On the Spokane River at Harvard Bridge.
2. On the Spokane River at Trent Road Bridge.
3. On the Spokane River above Spokane Dam.
4. On the Spokane River at Green Street Bridge.
5. On the Spokane River above Hangman Creek confluence.
6. On Hangman Creek above the Spokane River confluence.
7. On the Spokane River above Nine Mile Dam.
8. On the Little Spokane River above the Spokane River confluence.
9. On the Spokane River in Long Lake approximately 4.5 miles upstream from the Dam.
10. On the Spokane River below Long Lake Dam at State Highway 231 Bridge.
11. On the Spokane River below Little Falls Dam.
12. Effluent of the Spokane Sewage Treatment Plant.

Special a. Fish Hatchery Spring

Special b. Spokane Sewage Treatment Plant By-Pass.

At all locations, except the special locations, the sampling interval is four hours. One sample only was taken at the special locations.

At the Long Lake location, Number 9, samples are taken at three depths.

The parameters selected for analysis and the number of analyses made are in accordance with Table 2. Note that the parameters which are to be simulated and hence used in the calibration process are so marked. The other parameters are included to complete the overall picture of chemical background.

Organization for the Sampling and Analysis Program

General. The entire sampling and analysis program was organized under the direction of Kennedy-Tudor Consulting Engineers, with the cooperation of client, affiliates and subconsultants. The complete team effort included input from the following:

1. Hydrocomp, Inc., subconsultant for the application of the simulation model, reviewed the selection of sampling locations, parameters to be analyzed and frequency and number of analyses.

2. Corps of Engineers in turn reviewed the proposed sampling locations, parameters and number of analyses.

3. Pacific Environmental Laboratory, an affiliate of Kennedy Engineers, Inc., was selected to coordinate the actual sample collection and analysis efforts, including some analytical work.

4. The Environmental Engineering Laboratories of Washington State University (EEL-WSU) were selected to perform the major part of the analytical work.

5. Dr. Raymond Soltero and two associates from Eastern Washington State College were selected to do sampling and analytical work on Long Lake where they were conducting an ongoing program of study.

The City of Spokane provided assistance by making their laboratory space at the sewage treatment plant available as headquarters during the sampling program for receipt and processing of samples for transshipment and some analytical work.

The selected overall program provided for making certain analyses in-situ by the sampling crews, analyzing other parameters in the field laboratory set up at the City sewage treatment plant and for making the majority of the analyses in samples shipped to EEL-WSU, with one minor exception. This breakdown by parameters is shown in Table 3.

The Sampling Team. Local coordination of the sampling program and transportation arrangements were under the supervision of Mr. Don Cooke, Kennedy-Tudor Spokane Manager. Field sampling and analyses were under the supervision of Mr. Robert Ryder, Director of the Pacific Environmental Laboratory. Five sampling crews were selected to man the twelve sampling stations over the 48 hour sampling period. One special crew consisted of Dr. Soltero and his associates, both with more than one year of experience at the Long Lake site. The other crews were each made up of one experienced Kennedy-Tudor employee assisted by one temporary student employee. Susan Degerstrom of Pacific Environmental Laboratory (in charge) and Dave La Chance, a student at Eastern Washington State College, sampled stations 1-4 from 1200 to 2400 both days. Samples from

0000 to 1200 at stations 1-4 were collected both days by Vern Threlkeld of Kennedy-Tudor (in charge) and Bill Current, a student at Eastern Washington State College. Robert Ryder of Pacific Environmental Laboratory (in charge) and La Nece Bryson, an Eastern Washington State University student, collected samples both days from 1200 to 2400 at stations 5-8 and 12. From 0000-1200 at station 5-8 and 12 samples were collected by Sandy MacDonald, a student at EWSC, Tetsuo Nakamura of Pacific Environmental Lab (in charge 9/19/73) and Richard Howell of Kennedy-Tudor (in charge 9/20/73). All samples at stations 9-11 were collected by Dr. Raymond Soltero of Eastern Washington State College (in charge) and two of his graduate students, Anthony Gasperino and William Graham. Composite preparation and shipping was handled by William Persich of Kennedy-Tudor. Sample transportation from Long Lake and to WSU was handled by Louis and Alex McGillioray.

Team Orientation. An orientation meeting was held on Monday, 9/18/73 for all sampling personnel. The meeting started with the introduction and a brief discussion of the purpose and objectives of the sampling program. Each person was assigned to a crew and given a sampling route and vehicle instructions. Mr. Cooke discussed the various safety procedures to be used, emphasizing the use of safety vests, flares, flashlights, and warning flashers on the cars. He also gave each crew a copy of letters to the Spokane and Lincoln Counties sheriffs and the Spokane City Police to be used as identification.

Following the general meeting, Dr. Soltero and Mr. Ryder discussed the specifics of the Long Lake sampling. Sample bottle requirements and sample transportation arrangements were completed, following which Dr. Soltero and his crew left for Long Lake.

The crews for stations 1 through 8 and 12 were taken to each sampling station and shown the exact sampling location which was marked with orange tape. Mr. Ryder demonstrated the general methods for collecting representative samples and emphasized the method for collecting uncontaminated samples in sterile bottles for bacteriological tests. He also demonstrated the use and operation of the dissolved oxygen sampler, dissolved oxygen meter and temperature probe. Water samples in sterile bottles were obtained at each station so that preliminary tests on the coliform level could be run.

The special padlock for the gate at Nine Mile Dam was put on at this time and any special safety or security precautions at other stations were pointed out to team members.

Detailed Description of Sampling Locations

The fourteen sampling stations enumerated in Table 1 and shown in Figure A were the product of a selection and evaluation process that involved the Kennedy-Tudor technical staff, the staff of Hydrocomp Inc., the Director of the Pacific Environment Laboratory (PEL) and the Office Manager of the Kennedy-Tudor Spokane office. All proposed sampling sites were visited by Robert Ryder, director of PEL, Dr. Norman Crawford and Henry Waggy of Hydrocomp and Donald

Cooke, Manager of K-T Spokane. Final sites as described below were mutually acceptable to these reviewing parties.

Station 1, on the Spokane River, is located on the Harvard Road Bridge at river mile 92.7. This station was selected to be representative of the waters of the Spokane River as they enter the study area at the Washington-Idaho boundary, river mile 96.5. The primary water quantity station for generation of the flow entering the study area is USGS gage #4195 which is at river mile 93.9. The Harvard Bridge was selected over a point near or at gage #4195 for two reasons; first, access to the center of the stream; and second, the presence of a construction project in the river at the border which was producing turbidity extending to the vicinity of gage 4195. From the middle of the Harvard Bridge there is access to free flowing homogeneous water approximately 3 to 4 feet in depth.

Station 2, on the Spokane River is located on the Trent Road Bridge at river mile 85.3. This is the most easterly of the three Trent Road or Avenue crossings. Water samples were obtained from the upstream side at the middle of the bridge. The rationale for establishing this station includes the proximity of a supplemental flow gaging station, a location below the industrial waste treatment plant, a location downstream of most of the irrigated farmland, and ready access to a relatively turbulent and homogeneous body of flowing water.

Station 3, on the Spokane River, is located at the Spokane Hydroelectric Plant at Water Works Road near the Spokane Dam at approximate river mile 81.1. Water samples were obtained from the upstream side of the bar rack at an opened gate near the middle of the intake structure. At low flow, the entire flow of the river passes through the turbines. Other locations in the impoundment are subject to eddy or deadwater conditions.

Station 4, on the Spokane River, is located on the Greene Street Bridge at river mile 78.0. Water samples were obtained from the upstream side at the middle of the bridge. This station is located approximately 2 miles below the Spokane Dam and is on the first bridge crossing the Spokane River below the Spokane Dam. This station was established to provide definitive water quality data between Spokane Dam and Upper Falls or Control Work Dam.

Station 5, on the Spokane River, is located immediately upstream from the confluence with Hangman Creek and is at approximate river mile 72.4. This is approximately one half mile below USGS gage # 4225. This section presents problems of both access and a succession of rapids. The final selected point is in non-eddying waters, relatively smooth flowing below one set of rapids and upstream from another. This location was chosen to provide quality data before the mixing of Hangman Creek.

Station 6, on the Hangman Creek, is located approximately 200 feet upstream of its confluence with the Spokane River. The extreme downstream location was selected over an upstream station near the USGS gage because several sewer overflows are known to exit between the gage and the mouth. The selected sampling site had approximately 10 to 18 inches of free flowing water at all times during the "low flow" sampling program. Extra care was exercised not to disturb the bottom sands and sediments while obtaining water samples. Flow was so low in Hangman Creek at the time of sampling that the USGS gage was not registering.

Station 7, on the Spokane River, is located at the Washington Water Power Co., Hydroelectric Plant at Nine Mile Dam at approximate river mile 58.2. Water samples were obtained from the upstream side of the bar rack in front of the opened gate at the middle of the structure. All river flow was being passed through the turbines. This station is located approximately 1 mile upstream of the Little Spokane River and nine miles downstream of the Spokane Sewage Treatment Plant, approximate river mile 67.2. During the site selection process, a DO survey was run in the vicinity of the dam to select the location representative of the flow leaving Nine Mile Dam.

Station 8, on the Little Spokane River, is located on the Highway Route 291 Bridge at river mile 1.1. Water samples were obtained from the middle of the bridge. Water samples at this station provided water quality data on this tributary to the Spokane River. Station 8 is in the backwater effect of Long Lake. It was desirable to sample as far downstream as possible, in order to measure the net quality entering Long Lake as a result of the surface flow which is measured at Dartford gage #4310, river mile 10.8, and the significant groundwater increment that reaches the Little Spokane below Dartford.

Station 9 is located approximately 4.5 miles upstream from

Long Lake Dam at a station corresponding to station number 1 of the biological sampling stations being monitored by Dr. Soltero and his associates in an ongoing program. This particular station was selected by Dr. Soltero as representative of midlake conditions. The location is at approximate river mile 38.4. The ongoing program by Dr. Soltero provides a year of data prior to the sampling period and will provide almost another year after. Hence, it was desirable to select a location that could be correlated with this extensive body of data.

The simulation model treats the Long Lake impoundment on the Spokane River as a lake in three horizontal strata. Therefore, samples are taken at three depths representative of these strata. Station 9 is subdivided into three vertical samples, 9a at surface (1 meter depth), 9b at mid-depth (15 meters depth) and 9c at lowest stratum (26 meters depth). The bottom depth at Soltero's station number 1, K-T number 9, is 27 meters as reported in Soltero (1973). Location on the lake was accomplished from reference points previously established by Dr. Soltero. Sampling was performed from a boat using a Van Dorn sampler and in-situ analyses were made with a Hydrolab unit.

Station 10, on the Spokane River, is located on the State Highway 231 Bridge at river mile 33.3, below Long Lake Dam. Water samples were obtained from the upstream side at the middle of the bridge. This station is located approximately 1/4 mile downstream from the Long Lake Dam and was established to provide water quality data below the Long Lake Dam.

Station 11, on the Spokane River, is located on the bridge below Little Falls Dam at river mile 29.2. Water samples were obtained from the downstream side at the middle of the bridge. This is the last downstream sampling station on the Spokane River. Although it is 29.2 miles from the confluence with the Columbia, it is within the backwater of Franklin D. Roosevelt Lake at full pool. This sample was taken to be representative of river flow as it enters FDR Lake and before it is modified by "lake" conditions.

Station 12 is located at the Spokane Sewage Treatment Plant. Effluent samples were obtained from the chlorine contact tank effluent weir.

Special Sampling Stations

a. Spokane Fish Hatchery Spring. A discrete sample was obtained on 9/19/73 at 1340 hours at the downstream side of the entrance road bridge.

b. Spokane Sewage Treatment Plant Bypass. A discrete sample of raw sewage being diverted during a heavy rainfall was obtained on 9/19/73 at 2300 hours. This sample was obtained from the diversion channel in the raw sewage pump building at the Spokane Sewage Treatment Plant.

Sampling Technique

Frequency. Samples were collected at 4 hour intervals at all stations except special stations a and b where only one sample was taken. It is not necessary to calibration of the simulation model that all sites be sampled simultaneously. It is necessary only to know the time of sampling to the nearest clock hour and preferable, but not necessary, to have the sampling intervals uniform. The basic collection times are 0400, 0800, 1200, 1600, 2000 and 2400. Each team began its sampling cycle at these times and covered their assigned stations in the same order each time resulting in approximately uniform frequency for all. The actual sample collection times are recorded for each station and will be compared with simulated values at these times.

General. At each river site for each collection time, certain parameters were measured *in situ* and samples collected for further processing or transshipment at the Field Laboratory. Refer to Table 3 and Figure B for the sampling and analysis plan.

Typically, at each site at each sampling time at least four sampling containers were filled from the sampling bucket as indicated in Figure B. The four containers used in every case are the two general samples, the nutrient sample and the sterile bottle sample. Where and when required, additional containers for biological sample and pesticide were also filled. Only at stations 1-4 was the dissolved oxygen sampler used and dissolved oxygen samples prepared.

Specific Collection Procedures. The samples at stations 1-8 were collected using plastic buckets with a rope attached to the handle for lowering and raising the bucket where collected from a bridge. A separate dissolved oxygen sampler was used at stations 1-4. The bucket was rinsed with river water before collecting the actual sample at each station. Immediately after the sample was collected, the bacteriological samples were poured into sterile plastic bottles, and the temperature and dissolved oxygen were measured in the bucket. At stations 1-4 only, the sample for dissolved oxygen was collected by a dissolved oxygen sampler in a dissolved oxygen bottle and measured at the Field Laboratory after each round. The remaining sample bottles, as required, were filled, usually requiring 1 1/2 to 2 bucketfuls of water.

At station 12, the Spokane STP, the samples were taken at four hour intervals at the chlorination tanks effluent weir. The plastic bucket was used to collect the sample, the appropriate sample bottles were filled, and the temperature and dissolved oxygen were measured in the bucket and recorded.

At station 9, Long Lake, the samples were taken from a boat by Dr. Soltero and his associates. The sample bottles were filled from a Van Dorn sampler. The field data measurements (pH, conductivity, dissolved oxygen and temperature) were made with a Hydrolab indicating meter which was frequently calibrated.

Samples for stations 10 and 11 were collected by Dr. Soltero and his associates with the same method as used for stations 1-8 with the exception that the <u>in situ</u> measurements were made with the Hydrolab instrument.

Special samples were collected at the Hatchery Springs and the STP Bypass. These samples were collected in the same manner as those at stations 1-8 and 12.

At the completion of each round of sampling, all sample bottles were brought back to the Field Laboratory at the Spokane

STP. There, the coliform samples were immediately filtered and incubated. The nutrient samples were preserved (0.8 ml. H_2SO_4 per quart sample). A general bottle was set aside for compositing and the other general bottle was stored for transshipment. Also at this time, the dissolved oxygens for stations 1-4 were measured from the D.O. bottles and the conductivity measurements were made from samples drawn from the compositing sample.

The composite samples were made as soon as the last sample for that composite came in. A nitric acid washed and distilled water rinsed graduated cylinder was used to measure the appropriate volumes. The 24 hour composite samples for river stations were prepared on an equal volume basis. The 12 hour composites for the Spokane Sewage Treatment Plant were flow-proportioned. The corresponding sample types, containers, preservatives, and analyses are listed in Table 4.

After each 24-hour sampling period, the appropriate sample bottles were delivered to the Environmental Engineering Laboratory at Washington State University, Pullman.

From the same general sample used for compositing, a sample was prepared for shipment to the Pacific Environmental Laboratory in San Francisco. This sample was used for pH measurement and hexane extractable analysis.

Analytical Methods

In-situ Analysis Techniques

Dissolved Oxygen. At stations 1-4, dissolved oxygen was not measured in-situ. The portable meter intended for use by this crew appeared to be unreliable when checked by calibration. Therefore, special D.O. samples were taken from these four stations for analysis at the Field Laboratory. Samples were collected at a depth of 6-12 inches below the surface in a D.O. bottle inserted into a D.O. sampler. The D.O. measurement was made within 2 hours of collection by a Weston-Stack D.O. meter at the Field Laboratory set up at the Spokane Sewage Treatment Plant.

At stations 5-8 and 12 samples were collected in a bucket, and the D.O. was read within 10 seconds by a Weston-Stack D.O. meter. Tests of this procedure, when compared to direct insertion of the probe into the stream indicated no difference in D.O. values. This method avoided the hazardous transport of the meter into locations where wading for samples or working from high bridges was required.

The accuracy of the Weston-Stack D.O. meter is ± 0.1 mg/l. The meter was calibrated in air prior to each analysis and by Winkler titration each day in the Field Laboratory.

At stations 9-11 the D.O. was measured in-situ by the Hydrolab dissolved oxygen probe lowered to the appropriate depth. The accuracy of this field meter is ± 0.1 mg/l.

Temperature. At stations 1-4 the temperature was measured by mercury thermometer within 2 minutes of sample collection in a bucket of water dipped from the river.

At stations 5-8 and 12 the temperature was measured by the Weston-Stack D.O. meter immediately following the D.O. measurement in the bucket of water.

At stations 9-11 the temperature was measured in situ by the Hydrolab precision thermistor temperature probe at the appropriate depth. The accuracy of all methods was ± 0.2°C.

Conductivity. At stations 9-11 the Hydrolab conductivity probe gave in-situ conductivity readings at the appropriate depth automatically corrected to 25°C. The accuracy of this probe is ± 2.5% of the conductivity reading. For all other stations, conductivity analyses were made in the Field Laboratory.

pH. At stations 9-11 in situ pH measurements were made by the Hydrolab high-pressure pH measuring and reference probes which are automatically temperature compensated. At all other stations where required, pH measurements were made on samples delivered to the Pacific Environmental Laboratories in San Francisco. These analyses were made with a Beckman expanded scale pH meter on September 24, 1973. The accuracy of both the Hydrolab and Beckman instruments is ± 0.05 pH units.

Field Laboratory Analysis Techniques

Fecal and Total Coliform. All water samples were poured from a bucket into sterilized bacteriological sample bottles in the field at the time of sampling. In the case of the Long Lake (station 9a only) samples, a Van Dorn sample bottle was used to collect the samples. The water was then poured into sterilized bacteriological sample bottles.

Coliform analyses were conducted by the Pacific Environmental

Laboratory staff at the Spokane Sewage Treatment Plant utilizing the membrane filter technique Standard Methods (1971). Membrane filters, culture dishes, and filter mechanism of Millipore Corporation were used.

Media for fecal coliform was DIFCO m FC Broth Base; for total coliform, DIFCO M Endo Broth.

Fecal coliform culture vessels were incubated for 24 hours in a water bath incubator, maintained at 44.5 ± 0.5°C.

Total coliform were incubated in a compartment incubator for 24 hours at 37 ± 0.5°C.

A number of distilled water controls were run along with the river samples, and were in all cases devoid of coliform or other bacterial or fungus colonies.

Dissolved Oxygen. Samples collected from stations 1-4 only, as described above, were analyzed within two hours of field collection at the Field Laboratory using a Weston-Stack D.O. meter. The accuracy and calibration for this meter is as described for in-situ analysis.

Conductivity. At stations 1-8 and 12, samples from the general sample bottles were analyzed within four hours of collection at the Field Laboratory at the Spokane Sewage Treatment Plant using a YSI Model 31 Conductivity Bridge and corrected to 25°C by calculation. The accuracy of this instrument is ± 2% of the conductivity readings.

Sample Preservation. The special samples for nutrient analysis and biological analysis had preservative added at the Field Laboratory as the samples arrived after each sampling cycle. Preservatives added were in accordance with Table 4 and Figure B.

Sample Compositing. At the conclusion of each composite period, 24 hours for river samples and 12 hours for treatment plant effluent samples, composites were prepared in the Field Laboratory from the gallon samples specifically reserved for this purpose. For compositing requirements see Table 1.

Transport of Samples. Samples gathered to the Field Laboratory for compositing, preservation and transshipment to the Environmental Engineering Laboratory of Washington State University (EEL-WSU) at Pullman, were shipped in accordance with the following schedule. Samples collected during the first 24-hour period were delivered to EEL-WSU on 19 September, 1973 by Mr. McGillioray in the mid-afternoon. On Thursday, 20 September, 1973, Susan Degerstrom of Pacific Environmental Laboratory, delivered the samples from the second 24-hour period to EEL-WSU. Miss Degerstrom met with Dr. S.K. Bhagat, Head of EEL-WSU, and Dr. Hindin, in charge of analysis, and delivered two tables of sample identification and analysis to be performed on each.

All samples were logged into EEL-WSU before Miss Degerstrom left to make sure that all sample identification was clearly understood.

Analysis Techniques Used by the Environmental Engineering Laboratory, WSU. The following techniques are reported for the analysis performed by the Environmental Engineering Laboratory of Washington State University at Pullman on samples collected and transported as described above:

1. Chlorophyll-a analyses were performed in accordance with the "Methods for Measuring Primary Production in Aquatic Environments," R.A. Vollenweider, International Biological Program Handbook No. 12, 1969.

2. Zooplankton: Available water (500 to 3500 ml) was filtered through a plankton net of 50 µ mesh. The concentrated organisms were rinsed into a 10 ml graduated cylinder and brought to 10 ml volume with distilled water. The 10 ml sample was placed in a petri dish marked with grid lines, let settle for 3-5 minutes, and counted microscopically under 60 magnifications. Rotifers, cope pods and cladocerans were counted and the number was divided by the volume of sample to obtain the concentration of organisms in the water.

3. Turbidity: Turbidity was measured by Hatch Turbidimeter Model 2100. Calibration was made with Formazin, Standard Methods (1971).

4. BOD, Total Dissolved Solids, Total Suspended Solids, Settleable Solids, Chloride and Sulfide: These were measured according to the procedures given in the Standard Methods (1971).

5. O-Phosphate, Total Phosphate, Total Kjeldahl, Nitrogen, Ammonia Nitrogen, Nitrite Nitrogen, Nitrate Nitrogen, and COD: Technicon Auto Analyzer II was used in making measurements for these parameters.

6. Sodium, Potassium, Calcium, Magnesium, Zinc, Lead, Copper, Silver, Cadmium, Iron, Manganese, Mercury, and Aluminum: Atomic absorption spectrophotometry using a Perkin-Elmer Model 303 Spectrophotometer was used in the analyses of these elements.

7. Arsenic was determined using the silver liethyldithiocarbonate method.

Laboratory Analysis Methods Used by Pacific Environmental Laboratory. Hexane extractables analyses were performed by the Pacific Environmental Laboratory at San Francisco Laboratory. Analytical method used was in accordance with the Standard Methods (1971) and Methods for Chemical Analysis (1971) using hexane as solvent.

pH measurements were made using a Beckman expanded scale pH meter, accuracy $\pm$ 0.05 pH units.

Special Sampling and Analyses by Dr. Soltero and Associates. In order to provide an accurate basis for correlation of results during this sample period with the long term ongoing program being carried out by Dr. Soltero and his two associates, Anthony Gasperino and William Graham, additional samplings and analyses were made at station 9 on Long Lake, duplicating the techniques used in the ongoing program. Refer to Soltero (1973). Note that this special work on chlorophyll, phytoplankton and zooplankton is supplemental to typical chlorophyll A and zooplankton analyses for station 9 which were performed by EEL-WSU.

The special sampling efforts consisted of the following performed at each 4-hour interval:

1. Measurement of the depth at which the light was one percent of the surface intensity, that is, the vertical extent of the euphotic zone. This depth was determined to be 5 meters.

2. Samples were taken at the surface, 1 meter, 3 meters and 5 meters, that is from the surface to the bottom of the euphotic zone, for compositing to make the special chlorophyll and phytoplankton counts described below.

3. Samples were taken from oblique tows from depths of 15 meters and 24 meters using a Clake-Bumpus sampler for zooplankton counts and identification.

The special analyses performed on the above described samples are as follows:

1. Concentrations of Chlorophyll a, b and c in $\mu g/l$ from composited samples from the euphotic zone.

2. Number and volume of phytoplankton as number per liter and volume mm per liter plus identification by taxon from composited samples from the euphotic zone.

3. Enumeration, number per liter, and identification by species of zooplankton from the 15 meter and 24 meter tow samples.

Laboratory methods for the above analyses are identical with those used in the ongoing program as reported in Soltero (1973) from which the following is quoted:

"Equal volumes of the euphotic zone samples were composited and the composite was used for chlorophyll determinations and phytoplankton volume-counts by species. A 250 ml sample of the euphotic zone composite was preserved with Lugol's solution. Cell volumes and counts per unit volume of water were determined for each taxon in the phytoplankton community utilizing the sedimentation method described by Schwoerbel (1970). Lund, Kipling, and LeCren (1958) have discussed the statistical validity of such direct count methods.

Chlorophyll a concentrations were determined by filtering (0.45 micron Millipore R filters) a known volume (usually 500 ml) of the euphotic zone composite water. Acetone (90%) was used as the extraction solvent and the concentrations (mg/m^3) of chlorophyll were determined as outlined by A.P.H.A. (1971)."

"Zooplankton were identified to species according to Edmondson (1959) and enumerated as outlined by Edmondson and Winberg (1971). Subsamples of 2 ml were placed in a modified rotary counting chamber (Ward, 1955) and to attain statistical validity a minimum of three subsamples was counted. Total numbers of each count were analyzed using a Chi square test to insure representative sampling within subsamples."

Analytical Results

Analytical results are summarized in three sets of tables, Tables 5, 6 and 7. Table 5 sets forth the results for parameters which are to be simulated. The units in which results are reported correspond to the units used in the simulation program and the format is the same as that in which simulation results will be printed out. Table 5 is the primary calibration tool.

Table 6 reports analytical results for all the other parameters measured which are not being simulated. These data provide a basis for correlation with existing quality records.

Table 7 reports results of the special analytical work done by Dr. Soltero and his associated to provide correlation with their previous and ongoing work. Table 7 is a summary only. The complete results of these special analyses including detailed breakdown by species is reported in Appendix I and Appendix II.

The analytical results for certain key parameters are also shown graphically in Figures C through F.

Anomalous Results

Certain anomalous results are noted. This is to report efforts made toward their resolution.

1. The 9/19/73 sample at 2000 hours for station 9c which gave atypical results for Total-P, NO_3, NH_3 and Total N, was found to be due to lack of preservative in the "nutrient" sample. It is recommended that these results be deleted.

2. For a number of samples, the ortho phosphate exceeds the total phosphate by a small amount. These results were checked and confirmed by EEL-WSU and it was concluded that there was no analytical error but that the difference was due to the fact that the two analyses were run from different components of the total sample, one preserved and the other not. Refer to Table 4 and Figure B. For the very unusual case exhibited by station 5 sample at 0800 on the 19th, it is recommended that the ortho-P result be deleted as unreliable for reasons unknown.

3. For samples at station 6, unusually high BOD's and COD's are reported for the following dates and times:

Date	Time
19	0400
19	1600
19	2400
20	0400

For the same station, total phosphorous is reported unusually high on the 20th at 0400.

These results were checked and confirmed by EEL-WSU. It is also noted that color and turbidity are correspondingly high. Considering the location of this station, on Hangman Creek, and the time of occurrance, after the rains began, the results are probably a true indication of water quality change caused by surface runoff being added to the very small flow which was predominantly groundwater. It is recommended that these values be retained as correct and representative of instantaneous conditions at this time and place.

4. The heavy metal sample was preserved with Ultrex hydrochloric acid due to the lack of availability of Ultrex grade nitric acid. This would precipitate all silver and lead, except lead in organic complexes. Therefore, the test results for silver and lead are invalid and should not be used.

Sewage Treatment Plant Flow

The City of Spokane Sewage Treatment Plant is located at river mile 67.2, approximately 9.0 miles upstream from Nine Mile Dam and 5.2 miles downstream from the Hangman Creek confluence. Refer to Figure A. The influent flow is measured and a continuous daily chart of instantaneous flows is kept together with total daily flow as indicated by a totalizer register on the recorder. The totalizer is read only at midnight when the charts are changed.

The treatment plant receives flows from combined sewers. There are overflows in the sewer system. The flows that can reach the treatment plant are, at times, greater than the hydraulic capacity of the treatment plant. Two bypasses are provided upstream from the sewage treatment plant influent meter. These bypasses are not metered. Therefore, when the treatment plant is being bypassed there is no measure of the total flow reaching the river. The recorded influent flow represents only that part of the total flow that is being sent through the treatment process.

Significant rainfall started at approximately 4 P.M. on September 18, four hours after the sampling run started. This rainfall is not indicated on any of the weather bureau gages, it apparently being highly localized in the eastern part of the city. This rainfall resulted between 5:00 P.M. and 5:45 P.M. in an instantaneous flow of 65 mgd rate which is the approximate hydraulic capacity of the plant.

The physical arrangement of the two bypasses is such that a partial bypass cannot be made for large flows in excess of plant capacity. Refer to Section 311. Total bypass was begun at 5:45 and continued to 7:45. It is our understanding that this particular total bypass was activated as a matter of operating policy which calls for total bypass of the first major flush after a prolonged dry period.

Rain continued intermittently throughout the remainder of the sampling period resulting in two additional partial bypasses and one more total bypass lasting 5 hours. The specific reason for this second total bypass is unknown.

The instantaneous flow at 15 minute intervals as taken from the recording charts is shown in Table 8. The instantaneous flow at each clock hour is plotted in Figure G.

Stream Flow Conditions

General. Four sources of stream flow data are reported herein. The primary sources are the U.S. Geological Survey permanent recording stream gages. Because of the unusually low flows which existed during the sampling period, some of which resulted in the USGS gages being inoperative, it is desirable to report the flows as estimated by Washington Water Power Company from their hydraulic turbine operations. At low flows, all river flow except structure leakage passes through the WWP turbines. In addition, Kennedy-Tudor measured the stage at several locations previously used by USGS for special low flow observations. USGS also made observations at several locations other than their permanent gages during the sampling period, some of which were at the same locations observed by K-T, but at different times. Refer to Figure [illegible] to location of USGS recording gages, Washington Water Power installations and supplemental stage observation station used by K-T and USGS.

USGS Stream Gages. Flows for the period September 15 through September 20 are reported herein for the following stream gages, locations of which are shown in Figure A.

Location	Gage Number
Spokane River above Liberty Bridge	4195
Spokane River at Spokane	4225
Little Spokane River at Dartford	4310
Hangman Creek at Spokane	4240

These data are shown in Table 9. The record for Hangman Creek throughout the period September 15 through 20 is from a special low stage recorder installed by USGS because the stage was so low that the regular gage intake tubes were out of water.

The USGS record for Spokane River at Long Lake, number 4330, is derived from Washington Water Power powerhouse records and therefore is redundant with the WWP data included below.

Washington Water Power Records. Records for the period September 15 through September 20 are shown in Table 10 for the following locations:

Post Falls Dam
Upper Falls Dam
Nine Mile Dam
Long Lake Dam
Little Falls Dam

The flow is controlled by Post Falls Dam. For two periods, all turbines were shut off and the flow shown in the tables is the estimated (by WWP) structure leakage. These periods of complete shutdown at Post Falls were:

Date	Hours
September 16	1 A.M. to 6 P.M.
September 18	12 Noon to 12 Midnight
September 19	12 Midnight to 9 A.M.

Hourly flow at Long Lake Power House and hourly stage levels of Long Lake are shown in Table 11.

Stage Observations by Kennedy-Tudor. The K-T sampling team made river stage elevation observations at the following locations during the sampling period:

Trent Road Bridge on the Spokane River	RM 85.3
Greene Street Bridge " " "	RM 78.0
Fort Wright Bridge " " "	RM 69.8
Riverside State Park Bridge " "	RM 66.1
Rutter Parkway Bridge near Dartford on the Little Spokane River	RM 3.91

USGS was also making stage measurements at some of these same locations at the same time. Where this situation was encountered, K-T did not make an observation. Refer to the USGS stage observations below for these data.

These stage measurements were made by a weighted tape hung next to a fixed reference point on the structure. For all locations except the Greene Street Bridge location it was subsequently possible to convert these stage measurements to flow from rating data in the possion of USGS. Stage measurements and flows are recorded in Table 12.

Stage and Flow Observations by USGS. During the sampling period USGS made stage observations at the following locations:

Trent Road Bridge on the Spokane River	RM 85.3
Fort Wright Bridge " " " "	RM 69.8
Riverside State Park Bridge " "	RM 66.1
Rutter Parkway Bridge near Dartford on the Little Spokane River	RM 3.91

These data are reported in Table 13.

Meteorological Conditions

The meteorological parameters required to drive the simulation model are as follows:

Parameter	Frequency	Units
Precipitation	hourly daily	inches/hr inches/day
Temperature	daily Maximum/Minimum	°F
Evaporation	Semi-monthly	inches/day
Solar Radiation	daily	langleys
Dew Point Temperature	daily mean	°F
Wind Velocity	daily	miles/day
Cloud Cover	daily	tenths

The recorded values for the above parameters at the Spokane Weather Bureau Airport Station for the period September 15 through September 20, 1973 are presented in Tables 14 and 15.

TABLE 1

SAMPLING LOCATIONS

Location Number	Description	Approximate River Mile
1	On the Spokane River at Harvard Road Bridge	92.7
2	On the Spokane River at Trent Road Bridge	85.3
3	On the Spokane River above Spokane Dam	81.1
4	On the Spokane River at Greene Street Bridge	78.0
5	On the Spokane River above Hangman Creek confluence	72.4
6	On Hangman Creek above Spokane River confluence	0.05*
7	On the Spokane River above Nine Mile Dam	58.2
8	On the Little Spokane River at Highway 291 Bridge	1.1**
9	On the Spokane River in Long Lake 4.5 miles upstream from Long ake Dam A Sample at 1 meter depth B Sample at 15 meters depth C Sample at 26 meters depth	38.4
10	On the Spokane River below Long Lake Dam at Highway 231 Bridge	33.3
11	On the Spokane River below Little Falls Dam	29.2
12	City of Spokane Sewage Treatment Plant Effluent	67.2
Special a	Fish Hatchery Springs	NA
Special b	City of Spokane Sewage Treatment Plant Bypass	67.2

* River Miles on Hangman Creek above mouth.
**River Miles on Little Spokane River.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLING LOCATIONS	TABLE 1

TABLE 2

PARAMETERS ANALYZED BY LOCATION AND FREQUENCY

PARAMETER	(1)	FREQUENCY OF ANALYSES BY LOCATION[3]: The Ten River Stations[4]	Long Lake Stations: Top Layer Sta. 9A	Long Lake Stations: Middle Layer Sta. 9B	Long Lake Stations: Bottom Layer Sta. 9C	Spokane STP Effluent Sta. 12	Special Stations: Hatchery Springs a	Special Stations: STP Bypass b
BOD	X	All[4]	All	All	All	All	1	1
Total Dissolved Solids	X	Daily Comp[5]	All	All	All	All	1	1
Chlorophyll A	X	See Note 7a	All	None[4]	All	None	--	--
Zooplankton	X	See Note 7b	All	None	All	None	--	--
Ortho-Phosphate	X	All	All	All	All	All	1	1
Total Phosphate	X	All	All	All	All	All	1	1
Nitrate	X	All	All	All	All	All	1	1
Nitrite	X	All	All	All	All	All	1	1
Ammonia	X	All	All	All	All	All	1	1
Total Nitrogen	X	All	All	All	All	All	1	1
Chlorides		Daily Comp	None	None	None	All	1	1
Zinc	X	Daily Comp	None	None	None	12 Hr Comp[6]	1	1
Lead	X	Daily Comp	None	None	None	" " "	1	1
Copper	X	Daily Comp	None	None	None	" " "	1	1
Silver		Daily Comp	None	None	None	None	1	--
Arsenic	X	Daily Comp	None	None	None	None	1	--
Cadmium	X	Daily Comp	None	None	None	None	1	--
Iron		Daily Comp	None	None	None	None	1	--
Turbidity		All	None	None	None	None	--	--
Total Suspended Solids		Daily Comp	All	None	None	All	--	1
Settleable Solids		Daily Comp	None	None	None	All	--	1
Sulfate		Daily Comp	None	None	None	None	--	--
COD		See Note 7c	None	None	None	All	1	1
Sodium		Daily Comp	None	None	None	None	1	--
Potassium		Daily Comp	None	None	None	None	1	--
Mercury		Daily Comp	None	None	None	None	1	--
Calcium		Daily Comp	None	None	None	None	1	--
Magnesium		Daily Comp	None	None	None	None	1	--
Manganese		Daily Comp	None	None	None	None	1	--
Aluminum		Daily Comp	None	None	None	12 Hr Comp	1	1
Pesticides		See Note 7d	None	None	None	See Note 7f	--	--
Total Coliform	X	See Note 7e	All	None	None	All	1	1
Fecal Coliform	X	All	All	None	None	All	1	1
Hexane Extractables		Daily Comp	None	None	None	12 Hr Comp	--	1
Dissolved Oxygen	X	All	All	All	All	None	1	--
Temperature	X	All	All	All	All	All	1	--
pH		All	All	All	All	All	1	--
Conductivity		All	All	All	All	All	1	--

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	PARAMETERS ANALYZED BY LOCATION AND FREQUENCY	TABLE 2

NOTES

[1]An X in this column indicates that the parameter is tentatively selected for simulation in the model.

[2]Does not include Long Lake Stations 9A, 9B or 9C.

[3]A sample is taken every 4 hours at all except special stations over the 48 hour period--that is, there are a total of 12 samples at each station. The number of analyses to be made for each parameter is as indicated in this table.

[4]"All" means that an analysis is made from each of the 12 samples at the location indicated. "None" means that no analysis is made for the particular parameter from any of the samples.

[5]"Daily Comp" means that an analysis is run on two composites of 6 samples each from each of the 24 hour periods, that is 2 analyses per location.

[6]"12 Hr Comp" means that an analysis is run on four composites of 3 samples each from each of the 12 hour periods, that is 4 analyses per location.

[7]Special designations of analyses:

a. Chlorophyll A analyses are made for all samples at locations 1, 3, 5, 7 and 8 and 9A. No chlorophyll A analyses are made for samples at locations 2, 4, 6, 10, 11, and 9B.

b. Zooplankton analyses are made for same locations as chlorophyll A per note 7a, except that frequency is for every other sample rather than for all samples at each station.

c. COD analyses are made on every other sample alternately at each location.

d. Pesticide analyses are made for two samples on river locations, the second day noon sample at locations 1 and 5.

e. Total coliform analyses are made for the noon sample only one each day at all river locations.

f. Pesticide analyses are made on noon sample for second day only on STP effluent.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	PARAMETERS ANALYZED BY LOCATION AND FREQUENCY	TABLE 2 (Con't)

TABLE 3

PLAN FOR ANALYSIS

Parameter	Analysis To Be Made: In-Situ	Field Laboratory	Env. Eng. Lab. of WSU	SF Laboratory of PEL	Dr. Soltero & Associates
Dissolved Oxygen	All except Sta. 1-4	Sta. 1-4			
Temperature	All				
pH	Sta. 9-11			Sta. 1-8	
Conductivity	Sta. 9-11	Sta. 1-8, 12			
Total Coliforms		All			
Fecal Coliforms		All			
Hexane Extractables				All	
Chlorophyll A			All		Sta. 9
Zooplankton			All		Sta. 9
All other			All		

TABLE 4

SAMPLE CONTAINERS, PRESERVATIVES AND ANALYSES

TYPE SAMPLE	SAMPLE CONTAINER	PRESERVATIVE	ANALYSES
General	Cubi-Container, 1 gal.	None	BOD, O-P, NO_2, Turbidity COD (Alternate Sample)
Composite General	Cubi-Container, 1 gal.	None	TDS, Cl, TSS, Settleable Solids, SO_4, Na, K, Ca, Mg
Nutrients	Cubi-Container, 1 qt.	0.8 ml conc. H_2SO_4*	T-P, NO_3, NH_3, T-N
Zoo	Polyethylene Bottle, Amber, 1 gal.	None	Chlorophyll and Zooplankton
Composite Heavy Metals	Cubi-Container, 1 qt.	4.5 ml Ultrex HCl**	Zn, Cu, As, Cd, Fe, Hg, Mn, Al
Pesticides	Glass Bottle, Jug, 1 gal.	None	Pesticides
Coliform	Polyethylene Bottle, 4 oz.	Sterilized, with $Na_2S_2O_3$	Total and Fecal Coliform

*J.T. Baker Analyzed Reagent grade Sulfuric Acid.
**J.T. Baker, "Ultrex" grade Hydrochloric Acid. Nitric Acid was not available at the time of sampling. A special instruction was given to Washington State University to this effect and recommended a separate sample be taken for silver and lead analyses from the general composite sample.

TABLE 5

ANALYTICAL RESULTS - SIMULATION PARAMETERS

Station	Date	Hour	Temperature °C	Dissolved Oxygen mg/l	Dissolved Oxygen percent saturation	BOD_5 mg/l	Total Dissolved Solids mg/l	Chlorophyll A µg/l	Zooplankton number/l	Ortho-Phosphates mg/l *	Total Phosphates mg/l *	Nitrates mg/l	Nitrites mg/l	Ammonia mg/l	Tot. Kjel. Nitrogen mg/l	T. Coliform number/100 ml	Fecal Coliform number/100 ml	Zinc µg/l	Lead µg/l	Copper µg/l	Arsenic µg/l	Cadmium µg/l
1	18	1200	18.0	8.0	91.5	0.7	38.00	1.74	4.1	0.026	0.090	0.010	0.0020	0.015	0.140	26	2	177	<5	<2	—	7
		1600	18.0	8.6	90.4	0.5	—	1.36	—	0.026	0.060	0.010	0.0020	0.015	0.150	—	4	—	—	—	—	—
		2000	17.0	8.8	89.6	0.5	—	1.74	5.6	0.021	0.090	0.010	0.0020	0.012	0.150	—	8	—	—	—	—	—
		2400	16.2	7.7	84.1	0.8	—	1.21	—	0.024	0.070	0.020	0.0020	0.105	0.470	—	21	—	—	—	—	—
	19	0355	16.0	7.5	81.5	0.6	—	0.80	2.3	0.021	0.070	0.070	0.0020	0.065	0.250	—	2	—	—	—	—	—
		0800	15.5	7.6	81.8	0.7	—	1.34	—	0.019	0.060	0.020	0.0020	0.027	0.190	—	8	—	—	—	—	—
		Comp	—	—	—	—	28.50	—	—	—	—	—	—	—	—	—	—	151	<5	<2	<29	6
		1200	16.0	8.3	90.2	0.5	52.65	1.07	6.0	0.084	0.100	0.012	<0.0020	0.010	0.180	28	14	—	—	—	—	—
		1600	16.5	8.1	89.4	0.0	—	3.22	—	0.031	0.050	0.012	<0.0020	0.015	0.200	—	36	—	—	—	—	—
		2000	16.5	7.9	87.2	0.0	—	2.68	7.2	0.032	0.070	0.003	<0.0020	0.013	0.193	—	36	—	—	—	—	—
	20	0005	16.8	7.3	81.4	0.0	—	3.48	—	0.023	0.050	0.003	<0.0020	0.015	0.163	—	15	—	—	—	—	—
		0405	16.8	7.3	81.4	1.3	—	0.38	11.1	0.022	0.050	0.010	<0.0020	0.037	0.230	—	19	—	—	—	—	—
		0805	16.4	8.0	87.8	0.0	—	1.88	—	0.026	0.040	0.009	<0.0020	0.025	0.198	—	8	—	—	—	—	—
		Comp	—	—	—	—	40.95	—	—	—	—	—	—	—	—	—	—	165	<5	<2	<29	5
2	18	1235	14.0	8.1	84.7	0.8	84.25	—	—	0.052	0.060	0.318	0.0070	0.110	0.210	88	1	128	<5	31	—	2
		1635	14.5	8.1	85.5	1.4	—	—	—	0.095	0.119	0.310	0.0075	0.130	0.240	—	5	—	—	—	—	—
		2035	14.0	7.4	77.3	1.1	—	—	—	0.078	0.080	0.330	0.0130	0.170	0.250	—	7	—	—	—	—	—
	19	0030	14.0	7.2	75.3	1.1	—	—	—	0.050	0.070	0.420	0.0125	0.225	0.410	—	7	—	—	—	—	—
		0425	12.7	7.0	71.4	1.0	—	—	—	0.049	0.070	0.510	0.0150	0.220	0.310	—	5	—	—	—	—	—
		0820	12.0	7.1	71.5	1.0	—	—	—	0.032	0.060	0.580	0.0126	0.320	0.470	—	4	—	—	—	—	—
		Comp	—	—	—	—	110.50	—	—	—	—	—	—	—	—	—	—	84	<5	10	<29	3
		1235	12.0	7.9	79.5	0.9	130.75	—	—	0.078	0.120	0.610	0.0100	0.295	0.400	108	14	—	—	—	—	—
		1635	11.5	7.7	76.4	0.6	—	—	—	0.080	0.060	0.650	0.0100	0.325	0.400	—	10	—	—	—	—	—
		2035	16.0	7.6	82.6	0.3	—	—	—	0.036	0.060	0.050	0.0030	0.065	0.230	—	54	—	—	—	—	—
	20	0030	16.0	7.5	81.5	0.4	—	—	—	0.030	0.060	0.070	0.0020	0.065	0.230	—	30	—	—	—	—	—
		0430	16.0	7.8	84.8	4.7	—	—	—	0.034	0.100	0.055	0.0020	0.073	0.250	—	34	—	—	—	—	—
		0825	16.0	7.8	84.8	0.5	—	—	—	0.017	0.040	0.060	0.0020	0.050	0.210	—	18	—	—	—	—	—
		Comp	—	—	—	—	78.50	—	—	—	—	—	—	—	—	—	—	122	<5	2	<29	3
3	18	1305	14.5	8.1	85.5	0.2	84.50	0.88	1.8	0.012	0.030	0.330	0.0040	0.145	0.238	66	2	113	<5	<2	—	<1
		1705	14.0	8.2	85.7	0.4	—	2.95	—	0.016	0.040	0.340	0.0040	0.153	0.250	—	<1	—	—	—	—	—
		2105	14.0	8.4	87.8	0.8	—	2.60	3.7	0.015	0.090	0.330	0.0040	0.140	0.230	—	28	—	—	—	—	—
	19	0100	14.0	8.3	86.7	0.3	—	1.88	—	0.011	0.040	0.330	0.0030	0.150	0.290	—	7	—	—	—	—	—
		0452	14.0	8.2	85.7	0.4	—	1.36	3.4	0.013	0.040	0.330	0.0030	0.143	0.160	—	2	—	—	—	—	—
		0850	14.0	8.1	84.7	0.8	—	1.61	—	0.021	0.040	0.330	0.0030	0.150	0.260	—	26	—	—	—	—	—
		Comp	—	—	—	—	100.00	—	—	—	—	—	—	—	—	—	—	80	<5	<2	<29	<1
		1305	14.5	8.6	90.8	0.3	92.20	2.01	9.8	0.020	0.040	0.320	0.0030	0.110	0.120	56	8	—	—	—	—	—
		1705	14.0	8.3	86.7	0.2	—	0.54	—	0.009	0.050	0.330	0.0030	0.105	0.120	—	<1	—	—	—	—	—
		2105	14.0	8.0	83.6	0.3	—	1.61	14.1	0.015	0.040	0.350	0.0040	0.096	0.110	—	20	—	—	—	—	—
	20	0100	13.9	8.4	87.8	0.5	—	1.21	—	0.026	0.030	0.360	0.0050	0.107	0.170	—	25	—	—	—	—	—
		0500	13.8	8.0	83.2	0.4	—	0.94	6.3	0.022	0.060	0.250	0.0050	0.102	0.100	—	7	—	—	—	—	—
		0850	13.8	8.0	83.2	0.0	—	1.07	—	0.023	0.050	0.390	0.0070	0.137	0.180	—	34	—	—	—	—	—
		Comp	—	—	—	—	97.35	—	—	—	—	—	—	—	—	—	—	91	<5	<2	<29	<1

* Expressed as PO_4. Multiply by 0.3262 to convert to concentration as P.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS SIMULATION PARAMETERS STATIONS 1, 2 AND 3	TABLE 1

TABLE 5 (Continued)

Station	Date	Hour	Temperature °C	Dissolved Oxygen mg/1	Dissolved Oxygen percent saturation	BOD_5 mg/1	Total Dissolved Solids mg/1	Chlorophyll A µg/l	Zooplankton number/1	Ortho-Phosphates mg/1 *	Total Phosphates mg/1 *	Nitrates mg/1	Nitrites mg/1	Ammonia mg/1	Kn. Kjd. Nitrogen mg/1	Total Coliform number/100 ml	Fecal Coliform number/100 ml	Zinc µg/1	Lead µg/1	Copper µg/1	Arsenic µg/1	Cadmium µg/1
4	18	1330	12.5	7.7	78.2	0	100.50	—	—	0.014	0.030	0.540	0.0025	0.082	0.130	20	4	73	<5	9	—	<1
		1730	12.0	7.6	76.5	0.8	—	—	—	0.027	0.050	0.620	0.0025	0.080	0.170	—	5	—	—	—	—	—
		2130	12.0	7.1	71.5	0.9	—	—	—	0.010	0.040	0.630	0.0025	0.073	0.130	—	8	—	—	—	—	—
	19	0120	12.0	7.2	72.5	0.6	—	—	—	0.009	0.030	0.610	0.0025	0.110	0.190	—	8	—	—	—	—	—
		0520	12.0	7.3	73.5	0.4	—	—	—	0.006	0.020	0.600	0.0030	0.082	0.170	—	2	—	—	—	—	—
		0920	12.0	7.1	71.5	0.8	—	—	—	0.006	0.010	0.660	0.0025	0.067	0.120	—	46	—	—	—	—	—
		Comp	—	—	—	—	118.50	—	—	—	—	—	—	—	—	—	—	60	<5	<3	<29	<1
		1330	12.0	7.9	79.5	0	133.05	—	—	0.015	0.030	0.660	0.0020	0.052	0.120	104	10	—	—	—	—	—
		1730	12.0	8.1	81.5	0.2	—	—	—	0.018	0.030	0.600	0.0020	0.057	0.120	—	26	—	—	—	—	—
		2130	13.5	7.8	80.7	1.4	—	—	—	0.023	0.050	0.430	0.0030	0.085	0.210	—	118	—	—	—	—	—
	20	0120	14.0	8.0	83.6	1.0	—	—	—	0.037	0.080	0.390	0.0040	0.107	0.260	—	363	—	—	—	—	—
		0515	13.2	7.6	78.3	0.4	—	—	—	0.014	0.040	0.420	0.0050	0.093	0.200	—	12	—	—	—	—	—
		0910	13.0	7.6	77.9	0.4	—	—	—	0.025	0.050	0.470	0.0060	0.119	0.230	—	29	—	—	—	—	—
		Comp	—	—	—	—	97.25	—	—	—	—	—	—	—	—	—	—	76	<5	<2	<29	<1
5	18	1210	13.5	10.5	100.0	0.2	109.25	1.61	0.8	0.004	0.010	0.480	0.0025	0.030	0.180	118	4	66	<5	<2	—	<1
		1610	14.0	11.0	100.0	0.6	—	1.61	—	0.003	0.010	0.440	0.0030	0.043	0.140	—	5	—	—	—	—	—
		2030	13.5	8.5	88.0	1.6	—	2.01	3.1	0.014	0.030	0.480	0.0050	0.057	0.220	—	52	—	—	—	—	—
		2400	14.5	9.0	95.0	1.3	—	1.61	—	0.005	0.020	0.470	0.0030	0.040	0.130	—	73	—	—	—	—	—
	19	0400	13.5	8.5	88.0	1.0	—	1.88	2.6	0.007	0.040	0.510	0.0040	0.045	0.140	—	252	—	—	—	—	—
		0806	13.0	8.4	86.1	0.7	—	1.07	—	0.243	0.040	0.550	0.0120	0.042	0.130	—	360	—	—	—	—	—
		Comp	—	—	—	—	117.50	—	—	—	—	—	—	—	—	—	—	60	<5	<2	<29	1
		1215	13.0	11.1	100.0	0.4	123.95	1.07	1.8	0.028	0.060	0.560	0.0040	0.034	0.140	230	214	—	—	—	—	—
		1630	13.0	10.5	100.0	0.2	—	1.61	—	0.007	0.040	0.440	0.0030	0.022	0.100	—	122	—	—	—	—	—
		2030	13.0	9.0	92.3	0.1	—	0.94	1.6	0.006	0.030	0.600	0.0040	0.035	0.130	—	174	—	—	—	—	—
	20	0005	13.0	7.8	80.0	0.3	—	0.94	—	0.005	0.020	0.630	0.0030	0.030	0.110	—	230	—	—	—	—	—
		0405	12.0	8.2	87.5	0.7	—	3.35	3.6	0.026	0.060	0.540	0.0050	0.060	0.190	—	620	—	—	—	—	—
		0755	13.5	8.6	89.0	0.7	—	2.14	—	0.020	0.100	0.410	0.0060	0.065	0.220	—	900	—	—	—	—	—
		Comp	—	—	—	—	129.25	—	—	—	—	—	—	—	—	—	—	64	<5	2	<29	<1
6	18	1225	16.0	10.8	100.0	0.7	223.00	—	—	0.008	0.030	1.240	0.0250	0.022	0.180	78	27	9	<5	<2	—	<1
		1630	17.0	10.8	100.0	1.1	—	—	—	0.006	0.030	1.280	0.0220	0.037	0.280	—	23	—	—	—	—	—
		2045	15.5	8.3	89.3	1.7	—	—	—	0.030	0.060	1.280	0.0200	0.030	0.280	—	33	—	—	—	—	—
	19	0012	16.0	6.6	71.7	7.0	—	—	—	0.010	0.070	1.320	0.0200	0.055	0.480	—	125	—	—	—	—	—
		0412	14.5	5.4	57.0	26.5	—	—	—	0.031	0.300	1.460	0.3030	0.129	1.420	—	98	—	—	—	—	—
		0815	14.0	5.4	56.4	30.0	—	—	—	0.016	0.170	1.280	0.0200	0.058	0.790	—	820	—	—	—	—	—
		Comp	—	—	—	—	246.00	—	—	—	—	—	—	—	—	—	—	24	<5	<2	<29	<1
		1230	15.3	11.3	100.0	4.7	264.35	—	—	0.019	0.090	1.440	0.0250	0.023	0.400	92	89	—	—	—	—	—
		1640	16.0	10.1	100.0	16.3	—	—	—	0.020	0.290	1.000	0.0120	0.055	0.600	—	2300	—	—	—	—	—
		2045	15.5	6.7	72.1	22.8	—	—	—	0.016	0.200	0.830	0.0180	0.062	0.600	—	2	—	—	—	—	—
	20	0020	15.0	5.8	61.8	23.0	—	—	—	0.013	0.160	0.960	0.0090	0.037	0.500	—	900	—	—	—	—	—
		0420	13.5	6.9	71.4	19.0	—	—	—	0.013	1.140	0.560	0.0110	0.041	1.020	—	1100	—	—	—	—	—
		0805	13.0	6.5	66.7	6.7	—	—	—	0.014	0.640	0.860	0.0080	0.046	0.600	—	1200	—	—	—	—	—
		Comp	—	—	—	—	185.00	—	—	—	—	—	—	—	—	—	—	26	9	<2	<29	<1

* Expressed as PO_4. Multiply by 0.3262 to convert to concentration as P.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy – Tudor Consulting Engineers	ANALYTICAL RESULTS SIMULATION PARAMETERS STATIONS 4, 5 AND 6	TABLE 5 (Cont.)

TABLE 5 (Continued)

Station	Date	Hour	Temperature °C	Dissolved Oxygen mg/l	Dissolved Oxygen percent saturation	BOD_5 mg/l	Total Dissolved Solids mg/l	Chlorophyll A µg/l	Zooplankton number/l	Ortho-Phosphates mg/l *	Total Phosphates mg/l *	Nitrates mg/l	Nitrites mg/l	Ammonia mg/l	Tot. Kjel. Nitrogen mg/l	Total Coliform number/50 ml	Fecal Coliform number/100 ml	Zinc µg/l	Lead µg/l	Copper µg/l	Arsenic µg/l	Cadmium µg/l
7	18	1300	15.5	6.5	70.0	1.0	94.50	0.80	5.4	0.685	0.760	0.410	0.0225	0.463	0.710	144	18	63	<5	<2	—	<1
		1700	15.5	6.1	65.6	1.4	—	0.80	—	0.672	0.760	0.440	0.0225	0.470	0.710	—	18	—	—	—	—	—
		2120	15.0	6.3	67.1	1.0	—	0.94	1.5	0.658	0.740	0.480	0.0210	0.487	0.720	—	10	—	—	—	—	—
	19	0050	15.5	6.7	72.1	1.1	—	0.80	—	0.656	0.590	0.450	0.0225	0.465	0.680	—	25	—	—	—	—	—
		0450	14.5	4.8	50.7	1.1	—	0.67	13.0	0.791	0.830	0.550	0.0230	0.617	0.860	—	24	—	—	—	—	—
		0650	15.0	5.9	62.9	1.3	—	1.74	—	0.712	0.680	0.470	0.0250	0.489	0.700	—	10	—	—	—	—	—
		Comp	—	—	—	—	110.00	—	—	—	—	—	—	—	—	—	—	38	<5	<2	<29	<1
		[illegible]105	15.5	6.1	65.6	1.0	118.80	0.40	1.4	0.795	0.850	0.530	0.0250	0.605	0.800	540	35	—	—	—	—	—
		1'15	15.0	6.0	63.9	0.8	—	0.67	—	0.825	0.870	0.550	0.0250	0.655	0.800	—	30	—	—	—	—	—
		2 20	14.5	5.7	60.2	1.3	—	0.27	6.6	0.932	0.980	0.590	0.0280	0.720	0.900	—	25	—	—	—	—	—
	20	0 05	16.0	5.8	63.0	1.1	—	0.04	—	0.885	0.960	0.570	0.0260	0.680	0.870	—	5	—	—	—	—	—
		0[illegible]00	12.0	5.2	52.3	1.1	—	1.34	5.8	1.025	1.090	0.640	0.0390	0.737	0.930	—	14	—	—	—	—	—
		0345	14.0	5.4	56.4	2.1	—	0.57	—	0.963	1.050	0.710	0.0390	0.720	0.960	—	890	—	—	—	—	—
		Comp	—	—	—	—	118.10	—	—	—	—	—	—	—	—	—	—	45	<5	<2	<29	<1
8	18	1320	12.0	8.9	89.6	0.5	204.30	0.67	0	0.036	0.060	1.010	0.0040	0.003	0.090	332	3	3	<5	<2	—	<1
		1720	12.5	8.4	85.3	0.0	—	0.27	—	0.034	0.040	[illegible].980	0.0050	0.005	0.100	—	5	—	—	—	—	—
		2135	12.5	7.9	80.3	0.0	—	0.27	0	0.046	0.040	1.010	0.0060	0.009	0.090	—	3	—	—	—	—	—
	19	0100	13.0	7.1	67.0	0.5	—	1.07	—	0.033	0.040	1.010	0.0050	0.010	0.080	—	28	—	—	—	—	—
		0500	11.5	7.3	72.5	0.4	—	0.67	0	0.033	0.060	1.000	0.0030	0.002	0.080	—	7	—	—	—	—	—
		0900	12.5	7.3	74.2	0.0	—	0.67	—	0.034	0.030	1.030	0.0030	0.017	0.090	—	31	—	—	—	—	—
		Comp	—	—	—	—	172.50	—	—	—	—	—	—	—	—	—	—	11	<5	<2	<29	<1
		1315	12.3	10.1	100.0	0.3	1[illegible].55	0.54	0.3	0.031	0.030	1.010	0.0030	0.005	0.070	425	15	—	—	—	—	—
		1730	12.5	8.0	81.3	0.0	—	0.96	—	0.029	0.040	1.000	0.0040	0.005	0.050	—	70	—	—	—	—	—
		2140	12.0	10.2	100.0	0.0	—	0.80	1.1	0.028	0.060	1.030	0.0040	0.005	0.060	—	45	—	—	—	—	—
	20	0120	15.0	7.1	75.7	2.1	—	1.07	—	0.027	0.070	1.020	0.0030	0.010	0.090	—	27	—	—	—	—	—
		0515	12.0	7.2	72.5	0.9	—	0.96	0	0.032	0.080	1.000	0.0030	0.006	0.060	—	62	—	—	—	—	—
		0900	14.0	7.1	74.2	0.5	—	1.07	—	0.035	0.040	1.000	0.0030	0.017	0.080	—	240	—	—	—	—	—
		Comp	—	—	—	—	175.75	—	—	—	—	—	—	—	—	—	—	14	<5	<2	<29	<1
Hatchery Springs	19	1340	11.3	7.4	73.1	0.0	166.50	—	—	0.015	0.010	2.100	0.0030	0.000	0.010	7	<1	5	<5	<2	<29	<1
STP Bypass	19	2300	—	—	—	93.0	204.40	—	—	7.500	16.300	0.040	0.0160	6.700	14.400	12500000	840000	364	25	9	—	—

* Expressed as PO_4. Multiply by 0.3262 to convert to concentration as P.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Bovay - Tudor Consulting Engineers	ANALYTICAL RESULTS SIMULATION PARAMETERS STATIONS 7, 8 AND SPECIAL	TABLE 5 (Cont.

TABLE 5 (Continued)

Station	Date	Hour	Temperature °C	Dissolved Oxygen mg/l	Dissolved Oxygen percent saturation	BOD_5 mg/l	Total Dissolved Solids mg/l	Chlorophyll A µg/l	Zooplankton number/l	Ortho-Phosphates mg/l *	Total Phosphates mg/l *
9A	18	1200	17.5	9.7	110.0	[illegible]	123.40	34.00	57.0	0.011	0.130
		1600	17.6	9.8	111.0	[illegible]	120.60	29.35	129.2	0.010	0.120
		2000	17.4	8.2	92.8	[illegible]	100.80	27.06	56.8	—	0.120
		2400	17.4	8.3	94.0	[illegible]	105.70	26.25	88.0	0.012	0.130
	19	0400	17.3	7.9	89.0	[illegible]	124.80	23.72	99.5	0.007	0.120
		0800	17.3	7.6	85.6	[illegible]	117.00	20.23	35.3	0.010	0.130
		Comp	—	—	—	—	—	—	—	—	—
		1200	[illegible]	7.9	[illegible]	[illegible]	128.80	23.85	88.0	0.009	0.130
		1600	17.3	8.6	96.9	[illegible]	127.00	28.94	90.4	0.013	0.130
		2000	[illegible]	[illegible]	94.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.110
		2400	16.9	8.3	93	1.0	124.00	27.74	86.0	0.007	0.110
	20	0400	17.1	8.1	[illegible]	[illegible]	124.00	27.60	97.4	0.006	0.190
		0800	17.0	8.2	[illegible]	[illegible]	122.80	26.40	90.0	0.012	0.140
		Comp	—	—		—	—	—	—	—	—
9B	18	1200	15.6	[illegible]	[illegible]	[illegible]	122.80	—	—	0.110	0.190
		1600	16.6	4.4	[illegible]	[illegible]	110.80	—	—	0.125	0.200
		2000	[illegible]	4.2	[illegible]	[illegible]	113.90	—	—	0.175	0.220
		2400	[illegible]	3.8	[illegible]	0.1	114.80	—	—	0.155	0.220
	19	0400	[illegible]	4.1	45.5	[illegible]	110.80	—	—	0.175	0.200
		0800	16.2	2.4	[illegible]	0.5	112.50	—	—	0.260	0.180
		Comp	—	—	—	—	—	—	—	—	—
		1200	16.3	2.8	[illegible]	[illegible]	119.30	—	—	0.205	0.220
		1600	[illegible]	2.1	22.9	[illegible]	119.00	—	—	0.217	0.220
		2000	[illegible]	2.3	25.3	[illegible]	123.10	—	—	0.228	0.270
		2400	16.0	2.1	22.8	1.4	112.60	—	—	0.205	0.200
	20	0400	16.2	2.2	24.0	[illegible]	110.30	—	—	0.273	0.260
		0800	16.2	1.8	19.6	[illegible]	121.00	—	—	0.045	0.180
		Comp	—	—	—	—	—	—	—	—	—
9C	18	1200	13.2	0.0	0.0	[illegible]	97.70	4.28	1.0	0.702	1.680
		1600	13.5	0.0	0.0	[illegible]	84.50	0.13	0.0	0.808	1.630
		2000	13.0	0.0	0.0	[illegible]	61.30	0.67	0.0	0.945	1.610
		2400	12.7	0.0	0.0	[illegible]	102.50	0.40	1.0	1.018	1.520
	19	0400	13.5	0.0	0.0	[illegible]	83.50	1.07	0.0	0.865	1.340
		0800	13.1	0.0	0.0	3.3	95.70	0.40	0.0	0.770	1.540
		Comp	—	—	—	—	—	—	—	—	—
		1200	12.9	0.0	0.0	3.0	74.30	0.94	0.0	0.739	1.520
		1600	13.4	0.0	0.0	5.7	99.80	3.09	0.0	0.720	1.400
		2000	13.1	0.0	0.0	6.6	88.80	0.67	0.0	0.884	0.990[#]
		2400	13.1	0.0	0.0	3.8	78.00	0.54	0.0	0.913	1.450
	20	0400	13.0	0.0	0.0	3.6	56.50	0.94	1.0	0.807	1.260
		0800	13.3	0.0	0.0	3.9	77.80	4.56	5.0	0.930	1.430
		Comp	—	—	—	—	—	—	—	—	—

Station	Date	Hour	Nitrates mg/l	Nitrites mg/l	Ammonia mg/l	Tot. Kjel. Nitrogen mg/l	Total Coliform number/100 ml	Fecal Coliform number/100 ml	Zinc µg/l	Lead µg/l	Copper µg/l	Arsenic µg/l	Cadmium µg/l
9A	18	1200	0.130	0.0420	0.030	0.370	294	<1	—	—	—	—	—
		1600	0.180	0.0390	0.012	0.270	264	2	—	—	—	—	—
		2000	0.220	0.0425	0.019	0.270	278	<1	—	—	—	—	—
		2400	0.240	[illegible]	0.020	0.240	174	16	—	—	—	—	—
	19	0400	0.250	[illegible]	0.030	0.220	98	1	—	—	—	—	—
		0800	0.250	[illegible]	0.020	0.190	30	15	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—
		1200	0.240	0.0375	0.020	0.230	260	18	—	—	—	—	—
		1600	0.240	0.0300	0.013	0.210	170	5	—	—	—	—	—
		2000	0.140	0.0500	[illegible]	0.300	400	<1	—	—	—	—	—
		2400	0.230	0.0600	0.020	0.210	420	2	—	—	—	—	—
	20	0400	0.230	0.0090	0.022	0.250	108	2	—	—	—	—	—
		0800	0.230	0.0320	0.020	0.260	5	4	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—
9B	18	1200	0.350	0.1150	0.102	0.310	—	—	—	—	—	—	—
		1600	0.360	0.0175	0.075	0.230	—	—	—	—	—	—	—
		2000	0.370	0.1050	0.125	0.300	—	—	—	—	—	—	—
		2400	0.380	0.0200	0.105	0.300	—	—	—	—	—	—	—
	19	0400	0.380	0.0550	0.110	0.350	—	—	—	—	—	—	—
		0800	0.350	0.0975	0.092	0.250	—	—	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—
		1200	0.370	0.1010	0.130	0.280	—	—	—	—	—	—	—
		1600	0.380	0.0800	0.127	0.270	—	—	—	—	—	—	—
		2000	0.510	0.0085	0.008	0.250	—	—	—	—	—	—	—
		2400	0.400	0.0050	0.130	0.250	—	—	—	—	—	—	—
	20	0400	0.420	0.0250	0.210	0.320	—	—	—	—	—	—	—
		0800	0.400	0.0250	0.122	0.290	—	—	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—
9C	18	1200	0.003	0.0270	1.220	1.470	—	—	—	—	—	—	—
		1600	0.003	0.0540	1.160	1.300	—	—	—	—	—	—	—
		2000	0.005	0.0120	1.300	1.320	—	—	—	—	—	—	—
		2400	0.005	0.0220	1.250	1.440	—	—	—	—	—	-	—
	19	0400	0.015	0.0460	1.030	1.260	—	—	—	—	—	—	—
		0800	0.006	0.0170	1.120	1.320	—	—	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—
		1200	0.007	0.0140	1.180	1.260	—	—	—	—	—	—	—
		1600	0.008	0.0300	1.060	1.210	—	—	—	—	—	—	—
		2000	0.040[#]	0.0300	0.000[#]	1.120	—	—	—	—	—	—	—
		2400	0.010	0.0090	1.080	1.200	—	—	—	—	—	—	—
	20	0400	0.008	0.0120	1.080	1.140	—	—	—	—	—	—	—
		0800	0.006	0.0120	1.070	1.200	—	—	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	<29	—

* Expressed as PO_4. Multiply by 0.3262 to convert to concentration as P.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS SIMULATION PARAMETERS STATIONS 9A, 9B AND 9C	TABLE 5 (Cont.)

TABLE 5 (Continued)

Station	Date	Hour	Temperature °C	Dissolved Oxygen mg/l	Dissolved Oxygen percent saturation	BOD$_5$ mg/l	Total Dissolved Solids mg/l	Chlorophyll A mg/l	Zooplankton number/l	Ortho-Phosphates mg/l*	Total Phosphates mg/l*	Nitrates mg/l	Nitrites mg/l	Ammonia mg/l	Org. Kjd. Nitrogen mg/l	Total Coliform number/100 ml	Fecal Coliform number/100 ml	Zinc µg/l	Lead µg/l	Copper µg/l	Arsenic µg/l	Cadmium µg/l
10	18	1330	17.5	3.9	44.2	0.9	127.20	—	—	0.213	0.240	0.450	0.0775	0.162	0.460	194	7	26	<5	<2	—	<1
		1730	17.0	4.6	51.5	1.7	—	—	—	0.209	0.290	0.430	0.0390	0.123	0.380	—	8	—	—	—	—	—
		2130	17.0	4.9	54.9	1.3	—	—	—	0.172	0.200	0.470	0.0440	0.120	0.420	—	8	—	—	—	—	—
	19	0130	16.1	5.1	55.4	1.0	—	—	—	0.186	0.200	0.420	0.0375	0.150	0.380	—	7	—	—	—	—	—
		0530	16.6	4.4	48.8	1.0	—	—	—	0.225	0.340	0.430	0.0575	0.180	0.430	—	4	—	—	—	—	—
		0930	16.5	3.7	40.8	1.6	—	—	—	0.282	0.300	0.460	0.0050	0.195	0.380	—	20	—	—	—	—	—
		Comp	—	—	—	—	127.20	—	—	—	—	—	—	—	—	—	—	14	<5	<2	<29	<1
		1330	16.8	3.8	39.0	2.3	129.50	—	—	0.215	0.200	0.470	0.0750	0.150	0.360	470	10	—	—	—	—	—
		1730	16.8	4.7	52.4	1.7	—	—	—	0.237	0.290	0.480	0.0350	0.125	0.330	—	10	—	—	—	—	—
		2130	16.7	4.6	52.1	1.6	—	—	—	0.198	0.200	0.450	0.0130	0.135	0.330	—	5	—	—	—	—	—
	20	0130	16.7	5.5	61.0	0.8	—	—	—	0.140	0.190	0.460	0.0150	0.062	0.270	—	2	—	—	—	—	—
		0530	16.5	4.9	54.1	1.5	—	—	—	0.119	0.190	0.460	0.0290	0.042	0.230	—	4	—	—	—	—	—
		0930	16.5	4.6	50.8	2.3	—	—	—	0.135	0.220	0.430	0.0400	0.095	0.260	—	4	—	—	—	—	—
		Comp	—	—	—	—	127.65	—	—	—	—	—	—	—	—	—	—	19	<5	<2	<29	<1
11	18	1345	17.2	4.9	54.9	1.9	121.00	—	—	0.170	0.300	0.390	0.1000	0.162	0.460	148	5	19	<5	<2	—	<1
		1745	16.8	5.6	57.4	2.2	—	—	—	0.164	0.200	0.410	0.0975	0.125	0.340	—	4	—	—	—	—	—
		2145	17.2	8.9	99.7	1.4	—	—	—	0.206	0.300	0.430	0.0490	0.155	0.440	—	2	—	—	—	—	—
	19	0145	16.1	9.1	98.9	1.3	—	—	—	0.223	0.200	0.440	0.0640	0.130	0.360	—	41	—	—	—	—	—
		0545	16.7	9.2	102.0	1.3	—	—	—	0.214	0.200	0.440	0.0440	0.132	0.340	—	8	—	—	—	—	—
		0945	16.4	5.0	55.7	2.4	—	—	—	0.200	0.290	0.420	0.1050	0.132	0.310	—	5	—	—	—	—	—
		Comp	—	—	—	—	134.00	—	—	—	—	—	—	—	—	—	—	14	<5	<2	<29	<1
		1345	[illegible].8	4.7	52.4	1.3	129.70	—	—	0.180	0.240	0.460	0.0500	0.109	0.310	230	1	—	—	—	—	—
		1745	16.7	5.3	58.8	1.0	—	—	—	0.225	0.250	0.450	0.0475	0.115	0.270	—	<1	—	—	—	—	—
		2145	16.5	4.8	53.0	0.7	—	—	—	0.243	0.260	0.470	0.0410	0.122	0.300	—	<1	—	—	—	—	—
	20	0145	16.7	4.3	52.1	0.9	—	—	—	0.260	0.220	0.490	0.0430	0.133	0.320	—	2	—	—	—	—	—
		0545	16.4	9.1	100.0	1.5	—	—	—	0.265	0.290	0.490	0.0250	0.130	0.280	—	<1	—	—	—	—	—
		0945	16.4	4.6	50.8	1.2	—	—	—	0.262	0.200	0.470	0.0150	0.130	0.290	—	1	—	—	—	—	—
		Comp	—	—	—	—	136.55	—	—	—	—	—	—	—	—	—	—	17	<5	<2	<29	<1
12	18	1350	19.5	2.7	31.6	81.0	391.80	—	—	13.900	20.200	0.060	0.0140	18.400	25.500	1900	1500	127	<5	18	—	—
		1755	20.0	2.5	29.5	102.0	410.60	—	—	17.000	20.200	0.090	0.0130	13.800	21.300	3200	2500	—	—	—	—	—
		2200	20.0	2.8	33.1	93.0	[illegible]5.40	—	—	12.200	21.600	0.120	0.0130	14.700	21.900	9400	4300	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	181	6	32	—	—
	19	0130	20.0	2.8	33.1	89.0	408.60	—	—	16.500	22.600	0.550	0.1950	17.700	21.000	4800	2100	—	—	—	—	—
		0530	19.0	3.0	34.7	82.0	333.80	—	—	24.000	19.200	0.210	0.1500	15.600	22.400	100	3	—	—	—	—	—
		0925	19.5	3.6	42.1	45.0	426.20	—	—	9.000	12.600	0.060	0.1670	13.660	19.900	350	120	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	115	3	30	—	—
		1440	18.8	4.5	52.0	66.0	418.00	—	—	6.000	14.300	0.930	0.1230	10.540	17.000	900	200	—	—	—	—	—
		1800	19.3	3.5	40.7	60.0	365.20	—	—	10.600	21.600	1.120	0.1380	10.100	18.700	300	100	—	—	—	—	—
		2255	19.5	3.0	35.1	96.0	369.00	—	—	14.000	24.000	0.440	0.2960	13.300	19.900	100	32	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	174	7	47	—	—
	20	0150	19.0	3.2	37.0	69.0	272.80	—	—	10.500	17.700	0.500	0.1830	9.780	16.500	38000	4200	—	—	—	—	—
		0550	18.0	3.4	38.9	60.0	318.60	—	—	11.000	19.200	0.390	0.1740	9.900	16.200	6000	1800	—	—	—	—	—
		0935	17.0	4.9	34.9	37.0	296.00	—	—	6.000	10.700	1.020	0.0890	9.250	15.700	3000	1200	—	—	—	—	—
		Comp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	117	4	23	—	—

* Expressed as PO_4. Multiply by 0.3262 to convert to concentration as P.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS SIMULATION PARAMETERS STATIONS 10, 11 AND 12	TABLE 5 (Cont.)

TABLE 6

ANALYTICAL RESULTS
OTHER PARAMETERS

Station	Date	Hour	pH	Conductivity µmhos/cm @ 25°C	Chlorides mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe µg/l	Mn µg/l	Ag µg/l
1*	18	1200	7.34	55	0.25	--	--	--	--	200	15	<1
		1600	7.24	54	--	--	--	--	--	--	--	--
		2000	7.11	58	--	--	--	--	--	--	--	--
		2400	6.84	57	--	--	--	--	--	--	--	--
	19	0355	6.81	54	--	--	--	--	--	--	--	--
		0800	7.32	54	--	--	--	--	--	--	--	--
		Comp	--	--	0.25	1.2	0.9	6.0	1.9	30	14	<1
		1200	7.28	57	--	--	--	--	--	--	--	--
		1600	7.31	56	--	--	--	--	--	--	--	--
		2000	7.39	58	--	--	--	--	--	--	--	--
	20	0005	7.22	56	--	--	--	--	--	--	--	--
		0405	6.95	56	--	--	--	--	--	--	--	--
		0805	7.09	54	--	--	--	--	--	--	--	--
		Comp	--	--	0.25	1.2	0.8	5.8	1.9	40	30	<1
2	18	1235	7.59	141	2.25	--	--	--	--	20	10	<1
		1635	7.39	145	--	--	--	--	--	--	--	--
		2035	7.51	148	--	--	--	--	--	--	--	--
	19	0030	7.37	170	--	--	--	--	--	--	--	--
		0425	8.05	188	--	--	--	--	--	--	--	--
		0820	7.68	205	--	--	--	--	--	--	--	--
		Comp	--	--	3.00	2.8	1.5	19.6	8.6	100	11	<1
		1235	7.61	230	--	--	--	--	--	--	--	--
		1635	7.62	237	--	--	--	--	--	--	--	--
		2035	7.12	68	--	--	--	--	--	--	--	--
	20	0030	7.13	69	--	--	--	--	--	--	--	--
		0430	7.06	67	--	--	--	--	--	--	--	--
		0825	7.26	69	--	--	--	--	--	--	--	--
		Comp	--	--	2.00	2.4	1.3	14.5	5.8	70	25	<1
3	18	1305	7.54	136	1.00	--	--	--	--	40	15	<1
		1705	7.50	143	--	--	--	--	--	--	--	--
		2105	7.41	139	--	--	--	--	--	--	--	--
		0100	7.50	138	--	--	--	--	--	--	--	--
	19	0452	7.70	134	--	--	--		--	--	--	--
		0850	7.79	139	--	--	--	--	--	--	--	--
		Comp	--	--	1.50	2.2	1.1	17.0	7.0	30	21	<1
		1305	7.51	142	--	--	--	--	--	--	--	--
		1705	7.47	144	--	--	--	--	--	--	--	--
		2105	7.39	151	--	--	--	--	--	--	--	--
	20	0100	7.40	150	--	--	--	--	--	--	--	--
		0500	7.50	154	--	--	--	--	--	--	--	--
		0850	7.41	152	--	--	--	--	--	--	--	--
		Comp	--	--	2.00	2.4	1.2	17.9	7.4	170	25	<1

WATI
METROP
Dept.
Kennedy

TABLE 6

ANALYTICAL RESULTS
OTHER PARAMETERS

Fe µg/l	Mn µg/l	Ag µg/l	Hg µg/l	Al µg/l	COD mg/l	Total Suspended Solids mg/l	Settleable Solids ml/l	Sulfate mg/l	Turbidity JTU	Hexane Extractables mg/l
200	15	<1	<0.1	<100	5.5	0.50	<0.01	7.6	0.54	6.4
--	--	--	--	--	--	--	--	--	0.62	--
--	--	--	--	--	5.1	--	--	--	0.63	--
--	--	--	--	--	--	--	--	--	0.84	--
--	--	--	--	--	5.2	--	--	--	0.70	--
--	--	--	--	--	--	--	--	--	0.66	--
30	14	<1	<0.1	<100	--	0.15	<0.01	7.5	--	2.1
--	--	--	--	--	5.5	1.70	<0.01	--	1.70	--
--	--	--	--	--	--	--	--	--	1.80	--
--	--	--	--	--	3.7	--	--	--	1.30	--
--	--	--	--	--	--	--	--	--	1.30	--
--	--	--	--	--	4.7	--	--	--	1.20	--
--	--	--	--	--	--	--	--	--	1.40	--
40	30	<1	<0.1	<100	--	8.70	<0.01	7.3	--	7.4
20	10	<1	<0.1	<100	4.3	0.50	<0.01	9.5	0.62	8.0
--	--	--	--	--	--	--	--	--	1.10	--
--	--	--	--	--	3.9	--	--	--	0.79	--
--	--	--	--	--	--	--	--	--	1.50	--
--	--	--	--	--	3.0	--	--	--	1.20	--
--	--	--	--	--	--	--	--	--	0.92	--
100	11	<1	<0.1	<100	--	1.10	<0.01	10.4	--	6.5
--	--	--	--	--	2.5	1.85	<0.01	--	2.20	
--	--	--	--	--	--	--	--	--	2.10	--
--	--	--	--	--	4.6	--	--	--	2.00	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	4.4	--	--	--	2.60	--
--	--	--	--	--	--	--	--	--	1.80	--
70	25	<1	<0.1	<100	--	10.50	<0.01	9.5	--	2.5
40	15	<1	<0.1	<100	4.3	0.50	<0.01	9.2	0.59	9.4
--	--	--	--	--	--	--	--	--	0.63	--
--	--	--	--	--	3.7	--	--	--	0.59	--
--	--	--	--	--	--	--	--	--	0.64	--
--	--	--	-	.	4.0	--	--	--	0.66	--
--	--	--	--	--	--	--	--	--	0.64	--
30	21	<1	<0.1	<100	--	0.95	<0.01	9.5	--	9.4
--	--	--	--	--	3.4	2.25	<0.01	--	0.60	--
--	--	--	--	--	--	--	--	--	0.50	--
--	--	--	--	--	3.9	--	--	--	0.60	--
--	--	--	--	--	--	--	--	--	1.00	--
--	--	--	--	--	3.3	--	--	--	0.70	--
--	--	--	--	--	--	--	--	--	0.90	--
170	25	<1	<0.1	<100	--	17.95	<0.01	9.7	--	9.1

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS STATIONS 1, 2 AND 3	TABLE 6

Station	Date	Hour	pH	Conductivity umhos/cm @ 25°C	Chlorides mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe µg/l	Mn µg/l	Ag µg/l
4	18	1330	7.79	174	.50	--	--	--	--	40	10	<1
		1730	7.67	196	--	--	--	--	--	--	--	--
		2130	7.57	198	--	--	--	--	--	--	--	--
	19	0120	7.63	187	--	--	--	--	--	--	--	--
		0520	7.55	197	--	--	--	--	--	--	--	--
		0920	7.67	194	--	--	--	--	--	--	--	--
		Comp	--	--	.00	2.4	1.4	24.0	10.4	370	11	<1
		1330	7.84	206	--	--	--	--	--	--	--	--
		1730	7.67	199	--	--	--	--	--	--	--	--
		2130	7.65	163	--	--	--	--	--	--	--	--
	20	0120	7.59	157	--	--	--	--	--	--	--	-
		0515	7.59	157	--	--	--	--	--	--	--	--
		0910	7.52	165	--	--	--	--	--	--	--	--
		Comp	--	--	1.50	2.4	1.3	21.4	9.2	70	21	<1
5*	18	1210	7.64	173	1.00	--	-		--	80	10	<1
		1610	7.84	168	--	--	--	--	-	--	--	--
		2030	7.59	173	--	--	-	-		--	--	--
		2400	7.88	166	--	--	-		--	--	-	--
	19	0400	7.55	177	--	--		-		-	--	--
		0806	7.73	179	--	--	-	-	--	-		--
		Comp	--	--	2.50	2.2	1.2	2 .2	9.0	30	14	<
		1215	8.05	198	--	--	-	--	--	-	--	--
		1630	7.63	199	-	--	--	--	--	--	--	--
		2030	7.86	204	-	--	-	-	-	--		-
	20	0005	7.73	190	-	--	-	--	-	-	-	
		0405	7.51	170	--	--	--	--	--	--	--	--
		0755	7.38	149	--	--	--	--	-	--	--	--
		Comp	--	--	2.00	2.5	1.3	22.7	9.8	100	21	<1
6	18	1225	7.70	350	12.0	--	--	--	--	30	35	<1
		1630	8.09	337	--	--	--	-	-	--	--	--
		2045	7.72	332	-	--	--	--	--	--	--	--
	19	0012	8.02	340	-	--	--	--	-	--		-
		0412	7.17	335	--	--	--	--	--	-	--	--
		0815	7.35	339	--	--	--	--	--	--	-	--
		Comp	--		13.0	13.0	4.9	40.3	14.5	270	40	<1
		1230	7.74	375	--	--	--	--	-	--	--	--
		1640	7.39	310	-	--	-	--	-			
		2045	7.29	360	-	--	-	-	-			
	20	0020	7.40	302	-	-	-	--	-	-	-	-
		0420	7.11	129	--	-		-		--		-
		0805	7.25	198	--	--		--	-	--	-	--
		Comp	-		9.5	9.6	5.0	33.3	10.0	390	40	<1

WA
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Kenne

TABLE 6 (Continued)

Fe µg/l	Mn µg/l	Ag ug/l	Hg ug/l	Al ug/l	COD mg/l	Total Suspended Solids mg/l	Settleable Solids ml/l	Sulfate mg/l	Turbidity JTU	Hexane Extractables mg/l
40	10	<1	<0.1	<100	2.8	0.50	<0.01	9.9	0.55	10.3
--	--	--	--	--	--	--	--	--	0.69	--
--	--	--	-	--	2.6	--	--	--	0.71	--
--	--	--	--	--	--	--	--	--	0.72	--
--	--	--	--	--	2.3	--	--	--	0.81	--
--	--	--	--	--	--	--	--	--	0.82	--
370	11	<1	<0.1	<100	--	1.10	<0.01	10.9	--	8.8
--	--	--	-	--	1.9	1.30	<0.01	--	0.60	--
--	--	--	--	--	--	--	--	--	0.40	--
--	--	--	--	--	3.0	--	--	--	1.70	--
--	--	--	--	--	--	--	--	--	2.60	--
--	--	--	--	--	2.6	--	--	--	0.80	--
--	--	--	--	--	--	--	--	--	9.90	--
70	21	<1	<0.1	<100	--	1.00	<0.01	10.3	--	3.1
80	10	<1	<0.1	<100	2.8	0.25	<0.01	9.6	0.51	6.3
--	--	--	--	--	--	--	--	--	0.64	--
--	--	--	--	--	4.4	--	--	--	1.30	--
--	--	--	--	--	--	--	--	--	0.67	--
--	--	--	-	--	3.7	--	--	--	1.70	--
-	--	--	-	--	--	--	--	--	1.70	--
10	14	<1	<0.1	<100	--	1.05	<0.01	10.4	--	2.1
-	--	--	--	--	2.2	1.90	<0.01	--	0.90	--
--	--	--	--	--	--	--	--	--	0.70	--
--	-	--	--	--	2.3	--	--	--	1.10	--
--	--	-	-	--	--	--	--	--	1.20	
--	--	--	--	--	3.0	--	--	--	3.50	--
--	--	--	--	--	--	--	--	--	5.00	--
100	21	<1	<0.1	<100	--	1.80	<0.01	10.6	--	8.0
30	35	<1	<0.1	<100	7.6	1.50	<0.01	20.4	1.70	5.4
--	--	--	--	--	7.9	--	--	--	2.60	--
--	--	--	--	--	10.6	--	--	--	2.70	--
--	--	--	-	--	--	--	--	--	4.80	--
--	--	--	-	--	118.3	--	--	--	17.00	--
--	--	--	--	--	--	--	--	--	9.60	--
270	40	<1	<0.1	<100	--	2.30	0.03	22.5	--	8.6
--	--	--	-	--	14.1	16.95	<0.01	--	7.80	--
-	--	--	-	-	49.0	--	--	--	14.00	--
	--	--	-	--	76.1	--	--	--	17.00	--
--	--	--	--	--	35.1	--	--	--	12.00	--
--	-	--	--	--	57.3	--	--	--	44.00	--
--	--	--	-	--	28.6	--	--	--	47.00	--
390	90	<1	<0.1	<100	--	44.65	<0.01	16.4	--	3.1

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS STATIONS 4, 5 AND 6	TABLE 6 (Cont.)

TABLE 6 (Continued)

Station	Date	Hour	pH	Conductivity µmhos/cm @ 25°C	Chlorides mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe µg/l	Mn ug/l	Ag ug/l
7	18	1300	7.27	154	3.00	--	--	--	--	70	45	<1
		1700	7.09	162	--	--	--	--	--	--	--	--
		2120	7.37	169	--	--	--	--	--	--	--	--
	19	0050	7.16	162	--	--	--	--	--	--	--	--
		0450	7.25	177	--	--	--	--	--	--	--	--
		0850	7.22	177	--	--	--	--	--	--	--	--
		Comp	--	--	4.00	3.8	1.3	19.4	7.4	420	44	<1
		1305	7.30	180	--	--	--	--	--	--	--	--
		1715	7.34	185	--	--	--	--	--	--	--	--
		2120	7.70	196	--	--	--	--	--	--	--	--
	20	0105	7.70	189	--	--	--	--	--	--	--	--
		0500	7.34	205	--	--	--	--	--	--	--	--
		0845	7.28	213	--	--	--	--	--	--	--	--
		Comp	--	--	4.00	5.0	1.5	23.1	8.9	60	45	<1
8	18	1320	7.65	253	3.00	--	--	--	--	50	11	<1
		1720	7.71	260	--	--	--	--	--	--	--	--
		2135	7.61	248	--	--	--	--	--	--	--	--
	19	0100	7.67	253	--	--	--	--	--	--	--	--
		0500	7.78	246	--	--	--	--	--	--	--	--
		0900	7.95	251	--	--	--	--	--	--	--	--
		Comp	--	--	3.50	3.8	1.7	32.3	13.5	60	14	<1
		1315	7.73	252	--	--	--	--	--	--	--	--
		1730	7.64	257	--	--	--	--	--	--	--	--
		2140	7.87	265	--	--	--	--	--	--	--	--
	20	0120	7.71	248	--	--	--	--	--	--	--	--
		0515	7.70	239	--	--	--	--	--	--	--	--
		0900	7.58	239	--	--	--	--	--	--	--	--
		Comp	--	--	2.50	4.0	1.8	32.0	13.5	50	20	<1
Hatchery Springs	19	1340	7.91	283	4.00	3.9	1.9	30.9	16.6	300	<10	<1
STP Bypass	19	2300	--	--	26.00	--	--	--	--	--	--	--

ABLE 6 (Continued)

l	Fe µg/l	Mn ug/l	Ag ug/l	Hg ug/l	Al ug/l	COD mg/l	Total Suspended Solids mg/l	Settleable Solids ml/l	Sulfate mg/l	Turbidity JTU	Hexane Extractables mg/l
	70	45	<1	<0.1	<100	7.3	2.00	<0.01	9.8	1.60	5.7
	--	--	--	--	--	--	--	--	--	1.50	--
	--	--	--	--	--	7.8	--	--	--	1.40	--
	--	--	--	--	--	--	--	--	--	1.30	--
	--	--	--	--	--	7.5	--	--	--	1.50	--
	--	--	--	--	--	--	--	--	--	1.90	--
4	420	44	<1	<0.1	<100	--	6.85	<0.01	9.9	--	6.3
	--	--	--	--	--	4.7	4.00	<0.01	--	2.00	--
	--	--	--	--	--	--	--	--	--	1.70	--
	--	--	--	--	--	6.5	--	--	--	1.90	--
	--	--	--	--	--	--	--	--	--	2.00	--
	--	--	--	--	--	6.3	--	--	--	2.30	--
	--	--	--	--	--	--	--	--	--	2.80	--
9	60	45	<1	<0.1	<100	--	1.15	<0.01	10.8	--	8.9
	50	11	<1	<0.1	<100	2.6	0.50	<0.01	11.6	0.57	5.1
	--	--	--	--	--	--	--	--	--	0.43	--
	--	--	--	--	--	2.2	--	--	--	0.83	--
	--	--	--	--	--	--	--	--	--	0.87	--
	--	--	--	--	--	2.4	--	--	--	0.85	--
	--	--	--	--	--	--	--	--	--	0.87	--
5	60	14	<1	<0.1	<100	--	1.30	<0.01	11.8	--	<0.5
	--	--	--	--	--	1.4	3.85	<0.01	--	1.10	--
	--	--	--	--	--	--	--	--	--	1.50	--
	--	--	--	--	--	1.2	--	--	--	1.60	--
	--	--	--	--	--	--	--	--	--	1.80	--
	--	--	--	--	--	1.4	--	--	--	1.90	--
	--	--	--	--	--	--	--	--	--	2.40	--
5	50	20	<1	<0.1	<100	--	4.25	<0.01	12.0	--	2.0
6	300	<10	<1	<0.1	300	0.5	--	--	--	--	--
	--	--	--	--	11400	237.0	153.6	6.00	--	--	18.1

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS STATIONS 7, 8 AND SPECIAL	TABLE 6 (Cont.)

TABLE 6 (Continued)

Station	Date	Hour	pH	Conductivity µmhos/cm @ 25°C	Chlorides mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe µg/l	Mn µg/l	Ag µg/l
9A	18	1200	8.61	190	--	--	--	--	--	--	--	--
		1600	8.72	189	--	--	--	--	--	--	--	--
		2000	8.50	205	--	--	--	--	--	--	--	--
		2400	8.51	189	--	--	--	--	--	--	--	-
	19	0400	8.38	188	--	--	--	--	--	--	--	--
		0800	8.31	189	--	--	--	--	--	--	--	--
		Comp	--	--	--	--	--	--	--	--	--	--
		1200	8.50	189	--	--	--	--	--	--	--	--
		1600	8.53	187	--	--	--	--	--	--	--	--
		2000	8.49	187	--	--	--		--	--	-	--
		2400	8.50	180	--	--			-	-	--	--
	20	0400	8.52	185	--	--	--	--	--	--	--	--
		0800	8.35	186	--	--	-	--	--	--	--	--
		Comp	--	-	--	--	-	--	--	--	--	--
9B	18	1200	7.43	185	--	--	--	--	--	--	--	--
		1600	7.55	186	--	--	--	--	--	--	--	--
		2000	7.40	200	--	--	--	--	--	--	--	--
		2400	7.32	181	--	--	--	--	--	--	--	--
	19	0400	7.40	180	-	--	--	--	--	--	--	--
		0800	7.25	180	--	--	--	--	--	--	--	--
		Comp	--	--	--	--	--	--	--	--	--	--
		1200	7.25	180	--	--	--	--	--	--	--	--
		1600	7.33	180	--	--	--	--	--	--	--	--
		2000	7.18	189	--	--	--	--	--	--	--	--
		2400	7.10	175	--	--	--	--	--	--	--	--
	20	0400	7.12	178	--	--	--	--	--	--	--	--
		0800	7.09	179	--	--	--	--	--	--	--	--
		Comp	--	--	--	--	--	--	--	--	--	-
9C	18	1200	7.05	155	--	--	--	--	--	--	-	--
		1600	7.05	159	--	--	--	--	-	--	--	--
		2000	6.93	165	--	--	--	--	--	--	-	--
		2400	7.15	140	--	--	--	--	--	--	-	-
	19	0400	7.03	155	--	--	--	--	--	--	-	-
		0800	6.98	144	--	--	--	--	--	-	--	--
		Comp	--	--	--	--	--	--	--	--	--	--
		1200	7.09	139	--	--	--	-	--	--	--	--
		1600	6.99	145	--	--	--	-			-	-
		2000	6.95	145	--	--	--			-	-	-
		2400	6.85	139	--	--	--	--		-	--	-
	20	0400	6.96	136	--	--	--	-	-	-		-
		0800	6.90	145	--	--	--	--		--		-
		Comp	--	--	--	--	-			-		-

E 6 (Continued)

Fe µg/l	Mn µg/l	Ag µg/l	Hg µg/l	Al µg/l	COD mg/l	Total Suspended Solids mg/l	Settleable Solids ml/l	Sulfate mg/l	Turbidity JTU	Hexane Extractables mg/l
--	--	--	--	--	--	8.30	--	--	2.10	--
--	--	--	--	--	--	7.60	--	--	2.20	--
--	--	--	--	-	--	13.20	--	--	1.70	--
--	--	-	--	--	--	56.60	--	--	1.70	--
--	--	--	--	--	--	15.30	--	--	1.70	--
--	--	--	--	--	--	17.50	--	--	1.70	--
--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	10.00	--	--	1.70	--
--	--	--	--	--	--	11.00	--	--	2.10	--
--	--	--	--	--	--	10.00	--	--	2.00	--
--	--	--	--	--	--	16.50	--	--	2.00	--
--	--	--	--	--	--	17.30	--	--	2.30	
--	--	--	--	--	--	19.80	--	--	2.30	--
--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	1.40	--
--	--	--	--	--	--	--	--	--	1.60	--
--	--	--	--	--	--	5.10	--	--	1.70	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	--	21.10	--	--	1.60	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	1.30	--
--	--	--	--	--	--	--	--	--	1.60	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	--	--	--	--	1.60	--
--	--	--	--	--	--	--	--	--	1.60	--
--	--	--	--	--	--	--	--	--	2.50	--
--	--	--	--	--	--	--	--	--	--	--
--	-	--	--	--	--	--	--	--	3.70	--
--	--	--	--	--	--	--	--	--	3.90	--
--	--	--	--	--	--	--	--	--	4.70	--
--	-	--	--	--	--	--	--	--	4.50	--
--	--	--	--	--	--	--	--	--	4.10	--
-	--	--	--	--	--	6.30	--	--	5.20	--
--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	4.20	--
	-	-	--	--	--	--	--	--	3.20	--
-	-	--	-	--	--	--	--	--	3.70	--
-	--	-	--	--	--	--	--	--	4.50	--
-	--	--	--	--	--	--	--	--	3.80	--
--	-	--	--	-	--	--	--	--	4.80	--
-	-	-	--	-	--	--	--	--	--	--

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS STATIONS 9A, 9B AND 9C	TABLE 6 (Cont.)

Station	Date	Hour	pH	Conductivity µmhos/cm @ 25°C	Chlorides mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe µg/l	Mn µg/l	Ag µg/l
10	18	1330	7.50	200	3.00	--	--	--	--	40	100	< 1
		1730	7.52	197	--	--	--	--	--	--	--	--
		2130	7.50	197	--	--	--	--	--	--	--	--
	19	0130	7.53	198	--	--	--	--	--	--	--	--
		0530	7.48	202	--	--	--	--	--	--	--	--
		0930	7.35	200	--	--	--	--	--	--	--	--
		Comp	--	--	3.50	4.4	1.5	23.5	9.6	60	85	< 1
		1330	7.45	202	--	--	--	--	--	--	--	--
		1730	7.42	200	--	--	--	--	--	--	--	--
		2130	7.50	198	--	--	--	--	--	--	--	--
	20	0130	7.55	198	--	--	--	--	--	--	--	--
		0530	7.61	197	--	--	--	--	--	--	--	--
		0930	7.52	194	--	--	--	--	--	--	--	--
		Comp	--	--	2.00	4.4	1.4	23.3	9.4	120	80	< 1
11	18	1345	7.60	205	4.00	--	--	--	--	50	100	< 1
		1745	7.62	205	--	--	--	--	--	--	--	--
		2145	8.00	202	--	--	--	--	--	--	--	--
	19	0145	7.95	205	--	--	--	--	--	--	--	--
		0545	7.80	210	--	--	--	--	--	--	--	--
		0945	7.58	208	--	--	--	--	--	--	--	--
		Comp	--	--	5.50	4.2	1.5	24.3	9.8	80	110	< 1
		1345	7.48	208	--	--	--	--	--	--	--	--
		1745	7.45	207	--	--	--	--	--	--	--	--
		2145	7.53	208	--	--	--	--	--	--	--	--
	20	0145	7.52	208	--	--	--	--	--	--	--	--
		0545	7.45	207	--	--	--	--	--	--	--	--
		0945	7.55	208	--	--	--	--	--	--	--	--
		Comp	--	--	4.50	4.6	1.5	24.2	9.8	90	110	< 1
12*	18	1350	--	645	68.00	--	--	--	--	--	--	--
		1755	--	700	80.50	--	--	--	--	--	--	--
		2200	--	624	65.50	--	--	--	--	--	--	--
		Comp	--	--		--	--	--	--	--	--	--
	19	0130	--	583	52.50	--	--	--	--	--	--	--
		0530	--	588	51.00	--	--	--	--	--	--	--
		0925	--	659	75.50	--	--	--	--	--	--	--
		Comp	--	--	--	--	--	--	--	--	--	--
		1440	--	595	59.00	--	--	--	--			--
		1800	--	584	64.30	--	--					--
		2255	--	610	60.40	--						--
		Comp	--	--		--					--	--
	20	0150	--	460	40.00	--	--	--	--		--	--
		0550	--	408	47.50	--	--	--	--	--	--	--
		0935	--	405	39.50	--	--	--	--	--	--	--
		Comp	--	--	--	--	--		--	--	--	--

Fe µg/l	Mn µg/l	Ag µg/l	Hg ug/l	Al µg/l	COD mg/l	Total Suspended Solids mg/l	Settleable Solids ml/l	Sulfate mg/l	Turbidity JTU	Hexane Extractables mg/l
40	100	< 1	< 0.1	<100	5.5	4.10	<0.01	11.6	1.10	6.0
--	--	--	--	--	--	--	--	--	1.10	--
--	--	--	--	--	6.4	--	--	--	1.40	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	6.9	--	--	--	2.20	--
--	--	--	--	--	--	--	--	--	2.20	--
60	85	<1	<0.1	<100	--	5.35	0.01	10.2	--	0.6
--	--	--	--	--	5.8	11.35	<0.01	--	2.70	--
--	--	--	--	-	--	--	--	--	1.70	--
--	--	--	--	--	6.0	--	--	--	1.90	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	6.4	--	--	--	1.90	--
--	--	--	--	-	--	--	--	--	2.00	--
120	80	<1	<0.1	<100	--	4.00	0.01	10.5	--	4.6
50	100	<1	<0.1	500	6.4	5.50	<0.01	10.3	1.50	5.2
--	--	--	--	--	--	--	--	--	1.80	--
--	--	--	--	--	6.5	--	--	--	1.80	--
--	--	--	--	--	--	--	--	--	1.70	--
--	--	--	--	--	6.2	--	--	--	2.00	--
--	--	--	--	--	--	--	--	--	1.40	--
80	110	<1	<0.1	100	--	3.85	<0.01	10.9	--	8.3
--	--	--	--	--	5.8	5.75	<0.01	--	1.60	--
--	--	--	--	--	--	--	--	--	1.30	--
--	--	--	--	--	5.4	--	--	--	1.80	--
--	--	--	--	--	--	--	--	--	1.80	--
--	--	--	--	--	6.9	--	--	--	1.60	--
--	--	--	--	--	--	--	--	--	2.00	--
90	110	<1	<0.1	100	--	4.65	<0.01	10.7	--	4.1
--	--	--	--	100	208.0	64.2	0.02	--	52.00	27.0
--	--	--	--	--	176.0	57.6	0.03	--	50.00	--
--	--	--	--	--	204.0	75.0	0.09	--	48.00	--
--	--	--	--	<100	--	--	--	--	--	15.0
--	--	--	--	--	136.0	18.2	<0.01	--	--	--
--	--	--	--	--	78.0	48.4	<0.01	--	37.00	--
--	--	--	--	--	110.0	35.2	<0.01	--	26.00	--
--	--	--	--	1700	--	--	--	--	--	9.3
--	--	--	--	--	150.0	85.4	0.02	--	--	--
	-	.	--	--	157.0	77.0	0.01	--	--	--
-		-		--	182.0	59.6	0.03	--	--	--
	--	-		400	--	--	--	--	--	17.5
--	--	--	--	--	110.0	37.4	<0.01	--	--	--
--	--	--	--	--	119.0	44.6	<0.01	--	--	--
--	--	--	--	--	67.0	38.2	<0.01	--	--	--
--	--	--	--	100	--	--	--	--	--	10.4

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS STATIONS 10, 11 AND 12	TABLE 6 (Cont.)

ANALYTICAL RESULTS--PESTICIDES

Station	Date	Hour	DDE µg/1	ppDDT µg/1	Lindane µg/1	Heptachlor µg/1	Aldrin µg/1	Heptachlor Epoxide µg/1	TDE(DDD) µg/1	Dieldri µg/1
1	19	1200	0.025 NC	0.025	ND	ND	ND	ND	ND	ND
5	19	1200	0.030 NC	0.010 NC	ND	ND	ND	ND	ND	ND
12	19	1200	0.020 NC	0.010 NC	ND	ND	ND	ND	ND	ND

NC = Not confirmed.
ND = Not detected (if present, the concentration was below 0.01 µg/1).

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ANALYTICAL RESULTS OTHER PARAMETERS PESTICIDES FOR STATIONS 1, 5 AND 12	TABLE 6 (Cont.)

TABLE 7

ANALYTICAL RESULTS
SPECIAL METHODS AT LONG LAKE

		CHLOROPHYLL[1] milligrams per cubic meter			PHYTOPLANKTON[1&2]		ZOOPLANKTON total numbers per liter	
DATE	TIME	a	b	c	Aver. Number per Liter x10^6	Tot. Avg. Vol. mm^3 per Liter	15 meter tow	24 meter tow
9/18	1200	19.93	11.52	7.30	19.47	13.167	328.66	161.09
9/18	1600	25.89	13.07	8.60	25.63	8.799	320.06	204.61
9/18	2000	22.50	11.58	9.18	14.11	3.415	267.70	189.21
9/18	2400	20.04	10.41	7.29	38.33	11.004	307.01	160.58
9/19	0400	21.13	10.85	8.03	51.93	83.732[3]	349.23	191.09
9/19	0800	19.88	9.79	8.38	13.59	5.767	330.61	190.44
9/19	1200	20.86	12.32	5.98	46.67	11.429	312.40	183.12
9/19	1600	24.60	13.89	8.16	25.72	5.839	309.69	184.98
9/19	2000	24.23	11.42	9.36	29.45	12.318	402.63	251.19
9/19	2400	23.07	11.36	8.95	13.96	4,445	479.85	273.80
9/20	0400	24.02	12.02	8.60	29.40	9.481	845.09[4]	368.27[4]
9/20	0800	23.62	11.81	7.68	35.02	9.284	475.10	416.15

[1] The euphotic zone depth for the chlorophyll determinations and the phytoplankton enumerations was established at 5 meters. Samples were composited from the surface, 1, 3, and 5 meter depths for the chlorophyll and phytoplankton parameters. Chlorophyll reported as a, b and c types.

[2] Microplankton exist in every sample. These are organisms of 5 microns or less in size possessing morphological distortions resulting from preservation with Lugol's solution.

[3] This large volume resulted primarily from an abnormally large colony of _Microcystis aeroginosa_.

[4] Suspected malfunction of volume measurement device.

TABLE 8

SPOKANE TREATMENT PLANT FLOWS
SEPTEMBER 18-20, 1973

Time	Flow, MGD Sept. 18	Sept. 19	Sept. 20
0000	30.7	30.0	36.0[3]
0015	29.5	29.5	36.0[3]
0030	29.0	29.0	39.0[3]
0045	28.5	28.4	52.0[3]
0100	27.3	27.5	00.0[1]
0115	26.5	26.5	00.0[1]
0130	24.0	25.5	00.0[1]
0145	23.5	24.5	00.0[1]
0200	23.0	23.5	00.0[1]
0215	22.5	23.5	00.0[1]
0230	22.0	22.5	00.0[1]
0245	21.5	22.5	00.0[1]
0300	21.5	22.0	00.0[1]
0315	20.5	21.5	00.0[1]
0330	20.5	21.0	00.0[1]
0345	20.0	21.0	00.0[1]
0400	20.0	20.5	00.0[1]
0415	19.5	20.0	00.0[1]
0430	19.0	20.0	00.0[1]
0445	19.0	20.0	00.0
0500	19.0	20.0	00.0[1]
0515	19.0	20.0	00.0[1]
0530	19.0	20.0	00.0[1]
0545	19.0	20.0	00.0[1]
0600	19.0	20.0	00.0[1]
0615	19.0	20.0	00.0[1]
0630	19.0	20.0	00.0[1]
0645	19.0	20.0	00.0[1]
0700	19.0	20.0	34.5
0715	19.0	20.0	32.5
0730	19.5	23.0	31.5
0745	21.0	28.5	31.5
0800	24.5	36.5	34.5
0815	26.5	42.5	35.0
0830	30.0	24.5[2]	36.5
0845	30.5	24.5[2]	38.5
0900	33.5	30.5[2]	39.0
0915	34.0	42.0[2]	39.0
0930	35.5	55.0[2]	41.5
0945	35.5	59.5[2]	41.5
1000	35.5	44.5[2]	40.5
1015	36.5	46.5[2]	40.5
1030	37.5	44.5[2]	40.0
1045	38.0	42.0[2]	40.0
1100	39.0	43.5[2]	40.5
1115	37.0	45.5[2]	40.5
1130	35.5	43.0[2]	39.5
1145	39.5	38.0[2]	39.5
1200	38.5	33.0[2]	42.5
1215	38.5	28.0[2]	
1230	39.5	24.5[2]	
1245	38.5	30.0[2]	
1300	37.0	52.5	
1315	38.5	48.5	
1330	36.0	45.0	
1345	35.5	42.5	
1400	35.2	39.5	
1415	36.5	37.0	
1430	34.5	38.0	
1445	34.5	36.0	
1500	36.0	35.0	
1515	34.5	36.5	
1530	34.0	33.0	
1545	33.5	32.5	
1600	33.5	35.5	
1615	34.5	36.5	
1630	34.5	36.0	
1645	40.0	36.5	
1700	57.0	35.0	
1715	64.5	35.5	
1730	60.0	34.5	
1745	00.0[1]	34.5	
1800	00.0[1]	35.0	
1815	00.0[1]	34.5	
1830	00.0[1]	34.0	
1845	00.0[1]	34.5	
1900	00.0[1]	34.5	
1915	00.0[1]	34.5	
1930	00.0[1]	35.5	
1945	00.0[1]	36.0	
2000	38.5	34.5	
2015	38.0	35.5	
2030	36.5	35.0	
2045	37.0	33.5	
2100	35.5	36.5	
2115	35.5	43.5	
2130	35.5	43.5	
2145	34.5	45.0	
2200	32.0	51.0[3]	
2215	32.7	39.0[3]	
2230	33.0	38.5[3]	
2245	33.0	38.5[3]	
2300	32.0	34.5[3]	
2315	32.3	31.5[3]	
2330	32.5	30.0[3]	
2345	31.0	33.5[3]	

[1] Bypass.

[2] Partial Bypass Periodically.

[3] Partial Bypass.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SPOKANE TREATMENT PLANT FLOWS SEPTEMBER 18-20, 1973	TABLE 8

TABLE 9

STREAM FLOW FROM USGS RECORDING GAGES

LOCATION	GAGE NUMBER	DATE	MEAN DAILY FLOW- CFS	BI-HOURLY FLOW—CUBIC FEET PER SECOND TIME 0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
Spokane River above Liberty Bridge	4195	9 15 73	483.[illegible]	571.0	576.0	578.0	578.0	585.0	557.0	484.0	420.0	375.0	360.0	360.0	355.0
		16	110.[illegible]	310.0	216.0	148.0	60.0*	60.0*	60.0*	60.0*	60.0*	60.0*	60.0*	60.0*	60.0*
		17	35[illegible]	330.0	360.0	365.0	370.0	365.0	355.0	345.0	345.0	345.0	350.0	360.0	360.0
		18	27[illegible]	363.0	365.0	365.0	365.0	365.0	365.0	320.0	220.0	162.0	60.0*	60.0*	60.0*
		19	220.[illegible]	60.0*	60.0*	60.0*	60.0*	60.0*	60.0*	1685.0	1707.0	1707.0	1740.0	1740.0	1729.0
		20	1739	1752.0	1752.0	1740.0	1740.0	1740.0	1740.0	1740.0	1740.0	1729.0	1740.0	1729.0	1729.0
Spokane River at Spokane	4225	9 15 73	945.[illegible]	715.0	691.0	741.0	1100.0	1100.0	881.0	818.0	827.0	930.0	827.0	872.0	1842.0
		16	782.[illegible]	1460.0	600.0	800.0	890.0	766.0	699.0	707.0	691.0	683.0	612.0	605.0	675.0
		17	558	620.0	568.0	546.0	546.0	546.0	553.0	546.0	553.0	553.0	553.0	553.0	560.0
		18	678.0	560.0	605.0	659.0	635.0	707.0	715.0	707.0	715.0	715.0	707.0	707.0	707.0
		19	865.0	683.0	612.0	635.0	715.0	1460.0	758.0	612.0	699.0	724.0	715.0	1166.0	1604.0
		20	1987.0	2010.0	1954.0	1940.0	2055.0	2025.0	2010.0	2010.0	2010.0	1996.0	1996.0	1926.0	1912.0
Little Spokane	4310	9 15 73	89.8	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	88.8	88.8	88.8
		16	[illegible]	88.8	88.8	88.8	88.8	88.8	88.8	88.8	87.4	87.4	87.4	87.4	87.4
		17	88.[illegible]	87.4	87.4	87.4	87.4	87.4	88.8	90.2	90.2	90.2	90.2	90.2	90.2
		18	103.[illegible]	90.2	90.2	90.2	90.2	109.0	109.0	109.0	109.0	109.0	110.5	110.5	110.5
		19	117.[illegible]	110.5	110.5	112.0	110.5	112.0	112.0	113.5	112.0	112.0	112.0	113.5	116.5
		20	128	127.0	134.8	127.0	125.5	124.0	124.0	124.0	125.5	130.0	131.6	131.6	131.6
Hangman Creek at Spokane**	4240	9 15 73	[illegible]	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
		16	[illegible]	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
		17	[illegible]	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
		18	2.2	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6#	3.2	2.0	2.0	2.0
		19	2.7	2.0	1.8	1.8	1.8	6.6	5.4	2.7	2.4	2.2	2.2	4.1	4.1
		20	4.1	20.0##	9.9	4.4	3.2	2.7	2.4	2.4	3.0	3.0	2.0	2.0	2.0

*Record estimated by USGS due to st ge so low that gage intakes were out of water.
**Record from special low stage recorder installed by USGS for period when regular gage intake tubes were out of water.
#Peak of 7.4 cfs occurred between 1600 and 1800.
##Peak of 63.0 cfs occurred between midnight and 0200.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	STREAM FLOW FROM USGS RECORDING GAGES	TABLE 9

TABLE 10

SPOKANE RIVER FLOWS FROM
WASHINGTON WATER POWER RECORDS

Date	Time	Average Flow - CFS Per Shift				
		Post Falls	Upper Falls	Nine Mile	Long Lake	Little Falls
15	12- 8am	630	826	228	210	158
	8- 4	479	992	1294	1610	1978
	4-12	340	1178	1832	210	160
16	12- 8	130	1174	1049	210	160
	8- 4	130	812	1331	210	160
	4-12	340	672	1654	1715	1795
17	12- 8	410	635	220	506	462
	8- 4	410	590	1301	2610	2600
	4-12	410	590	1039	1645	1722
18	12- 8	410	642	361	506	462
	8- 4	200	730	1274	2590	2660
	4-12	130	820	1281	210	160
19	12- 8	130	710	628	508	445
	8- 4	1502	930	1302	2620	2780
	4-12	1670	982	1304	2431	2579
20	12- 8	1670	1942	1787	662	599
	8- 4	1670	2024	2400	3788	3790
	4-12	1670	1910	2410	2438	2466

TABLE 11

LONG LAKE STAGE AND DISCHARGE

Hour	September 15, 197. Elev.**	September 15, 197. Disch.*	September 16, 1973 Elev.	September 16, 1973 Disch.	September 17, 1973 Elev.	September 17, 1973 Disch.	September 18, 1973 Elev.	September 18, 1973 Disch.	September 19, 1973 Elev.	September 19, 1973 Disch.	September 20, 1973 Elev.	September 20, 1973 Disch.	September 21, 1973 Elev.	September 21, 1973 Disch.
0100			35.54	210	35.83	210	35.66	210	35.73	210	35.62	210	35.68	210
0200			35.54	210	35.83	210	35.66	210	35.73	210	35.62	210	35.68	210
0300			35.55	210	35.84	210	35.67	210	35.74	210	35.65	210	35.76	210
0400			35.55	210	35.84	210	35.67	210	35.74	210	35.65	210	35.76	210
0500			35.56	210	35.85	210	35.68	210	35.75	210	35.74	210	35.79	210
0600			35.56	210	35.85	210	35.68	210	35.75	210	35.74	210	35.79	210
0700			35.62	210	35.86	210	35.70	210	35.80	210	35.83	210	35.87	210
0800			35.66	210	35.85	2580	35.69	2580	35.78	2590	35.80	3830	35.86	3640
0900			35.66	210	35.85	2590	35.69	2590	35.78	2590	35.80	3850	35.86	5060
1000			35.68	210	35.82	2590	35.66	2590	35.77	2670	35.74	3750	35.79	5010
1100			35.70	210	35.81	2590	35.66	2670	35.77	2510	35.75	3750	35.77	4940
1200	35.27	2590	35.70	210	35.81	2590	35.66	2590	35.77	2590	35.75	3850	35.77	3820
1300	35.25	1430	35.76	210	35.78	2590	35.63	2590	35.75	2670	35.71	3750		
1400	35.29	740	35.76	210	35.78	2590	35.63	2590	35.75	2670	35.71	3850		
1500	35.29	210	35.81	210	35.74	2670	35.61	2590	35.71	2590	35.67	3740		
1600	35.33	210	35.82	210	35.72	2670	35.57	2510	35.68	2670	35.62	3760		
1700	35.33	210	35.82	2670	35.71	2570	35.59	210	35.66	3760	35.63	3840		
1800	35.40	210	35.82	2670	35.70	2490	35.59	210	35.62	3680	35.60	3670		
1900	35.41	210	35.80	2670	35.69	2580	35.62	210	35.59	3940	35.60	3930		
2000	35.41	210	35.60	2590	35.69	2490	35.62	210	35.59	3680	35.60	3670		
2100	35.44	210	35.78	2490	35.65	2400	35.65	210	35.53	3760	35.57	3760		
2200	35.44	210	35.78	210	35.65	210	35.65	210	35.53	210	35.57	210		
2300	35.51	210	35.80	210	35.66	210	35.70	210	35.55	210	35.60	210		
2400	35.52	210	35.83	210	35.67	210	35.71	210	35.62	210	35.68	210		

*All discharges in cubic feet per second.
**All elevations are feet above 1500 feet elevation.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	LONG LAKE STAGE AND DISCHARGE	TABLE 11

TABLE 12

RIVER STAGE MEASUREMENTS
BY KENNEDY-TUDOR SAMPLING TEAM

Location	Day	Time	Reference Point to Water Surface Measurements, Feet			Flow, Cubic Feet/Second
Trent Road Bridge	9/18	1510	72.43	72.44	72.43	540
Greene St.	"	1545	1.70	1.71	1.71	
Ft. Wright Lt.*	"	1610	67.51	67.53	67.53	860
Ft. Wright Rt.	"	1615	62.55	62.57	62.51	
State Park #1**	"	1630	18.52	18.52	18.52	435
State Park #2	"	1635	18.90	18.91	18.91	
Nr. Dart-ford	"	2250	13.57	13.56	13.57	
State Park #1	"	2320	18.53	18.53	18.51	435
State Park #2	"	2330	18.93	18.92	18.92	
Ft. Wright Lt.	"	2350	Not Sufficient Visibility			
Ft. Wright Rt.	9/19	2405	"	"	"	
Trent Ave. Bridge	"	2445	72.89	72.78	72.79	418
Greene St.	"	0110	1.59	1.60	1.60	
Nr. Dart-ford	"	1355	13.42	13.42	13.42	
State Park #1	"	1415	18.48	18.49	18.48	490
State Park #2	"	1420	18.86	18.86	18.84	
Ft. Wright Lt.	"	1450	67.67	67.70	67.68	790
Greene St.	"	1610	1.65	1.65	1.65	

*River splits into two channels (island). Lt. refers to left channel looking downstream.

**USGS maintains two reference points on the Riverside State Park Foot Bridge. RP#1 is on the fifth cross member from the right bank, #2 is on the seventh.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	RIVER STAGE MEASUREMENTS BY KENNEDY-TUDOR SAMPLING TEAM	TABLE 12

TABLE 13

SUPPLEMENTAL STAGE AND FLOW OBSERVATION BY USGS

Location	Date	Time	Reference Point to Water Surface, Feet	Flow Cubic Feet per Second
Trent Road Bridge	9-19	0935-1010	73.07	335
Ft. Wright Bridge	9-19	1220-1435	67.34 left R.P. 62.52 right R.P.	942
Riverside State Park Bridge	9-20	1120-1340	17.44	2380
Rutter Parkway Bridge	9-20	?	13.23	387

TABLE 14

PRECIPITATION
SPOKANE WEATHER BUREAU AIRPORT STATION
SEPTEMBER 15-20, 1973

Precipitation, Inches

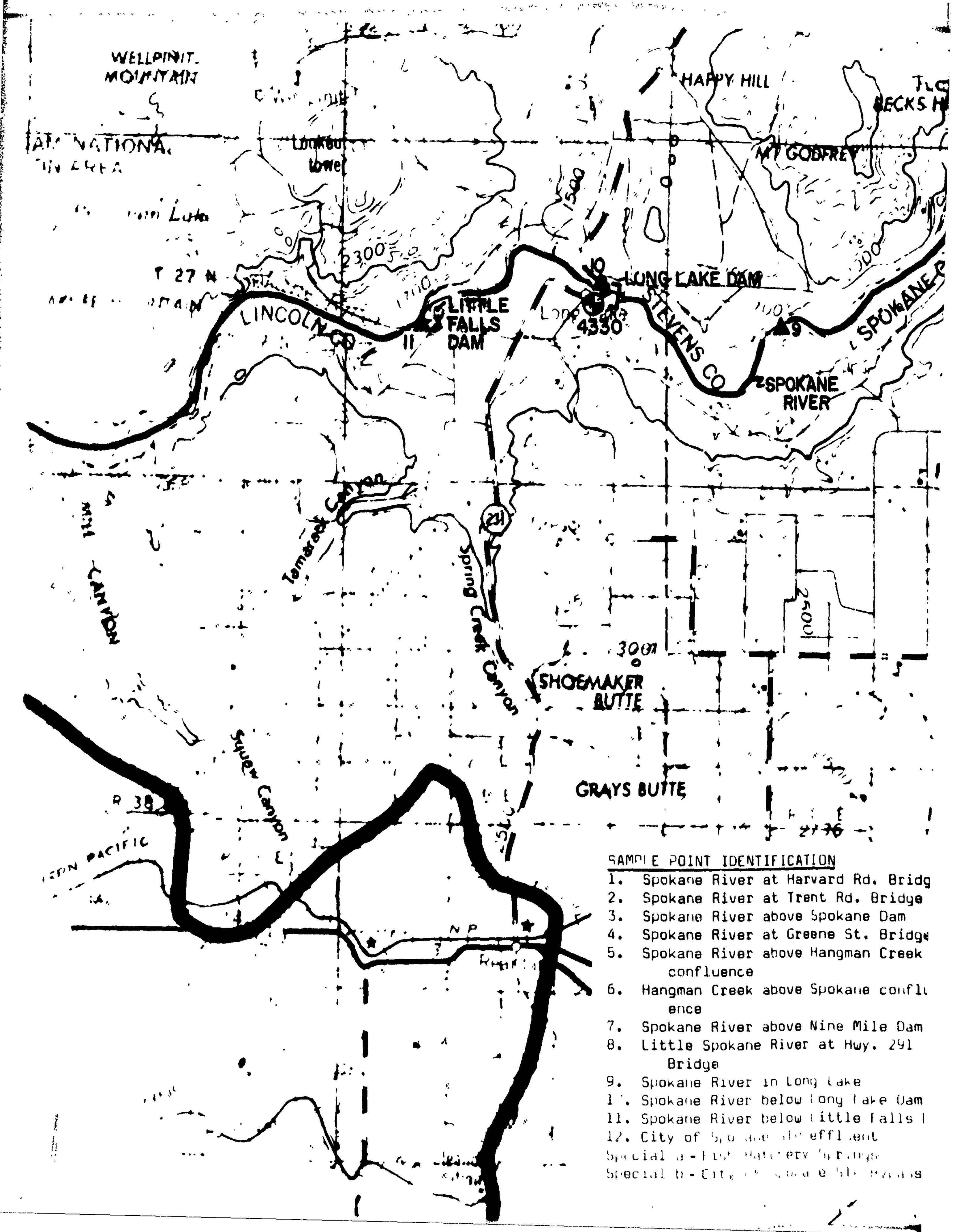
Hour	Sept. 15	Sept. 16	Sept. 17	Sept. 18	Sept. 19	Sept. 20
00-01	None	None	None	--	--	.03
01-02	"	"	"	--	--	.04
02-03	"	"	"	--	T	.01
03-04	"	"	"	--	T	T
04-05	"	"	"	--	T	--
05-06	"	"	"	--	.02	--
06-07	"	"	"	--	.09	--
07-08	"	"	"	--	.06	T
08-09	"	"	"	--	.04	T
09-10	"	"	"	T	.02	.03
10-11	"	"	"	--	T	T
11-12	"	"	"	T	T	--
12-13	"	"	"	--	T	.03
13-14	"	"	"	--	T	T
14-15	"	"	"	--	T	--
15-16	"	"	"	--	.01	--
16-17	"	"	"	--	.00	--
17-18	"	"	"	--	--	--
18-19	"	"	"	--	T	T
19-20	"	"	"	--	T	T
20-21	"	"	"	--	.03	--
21-22	"	"	"	--	T	--
22-23	"	"	"	--	.24	T
23-24	"	"	"	--	.53	--
Daily	None	None	None	Trace	1.04	0.14

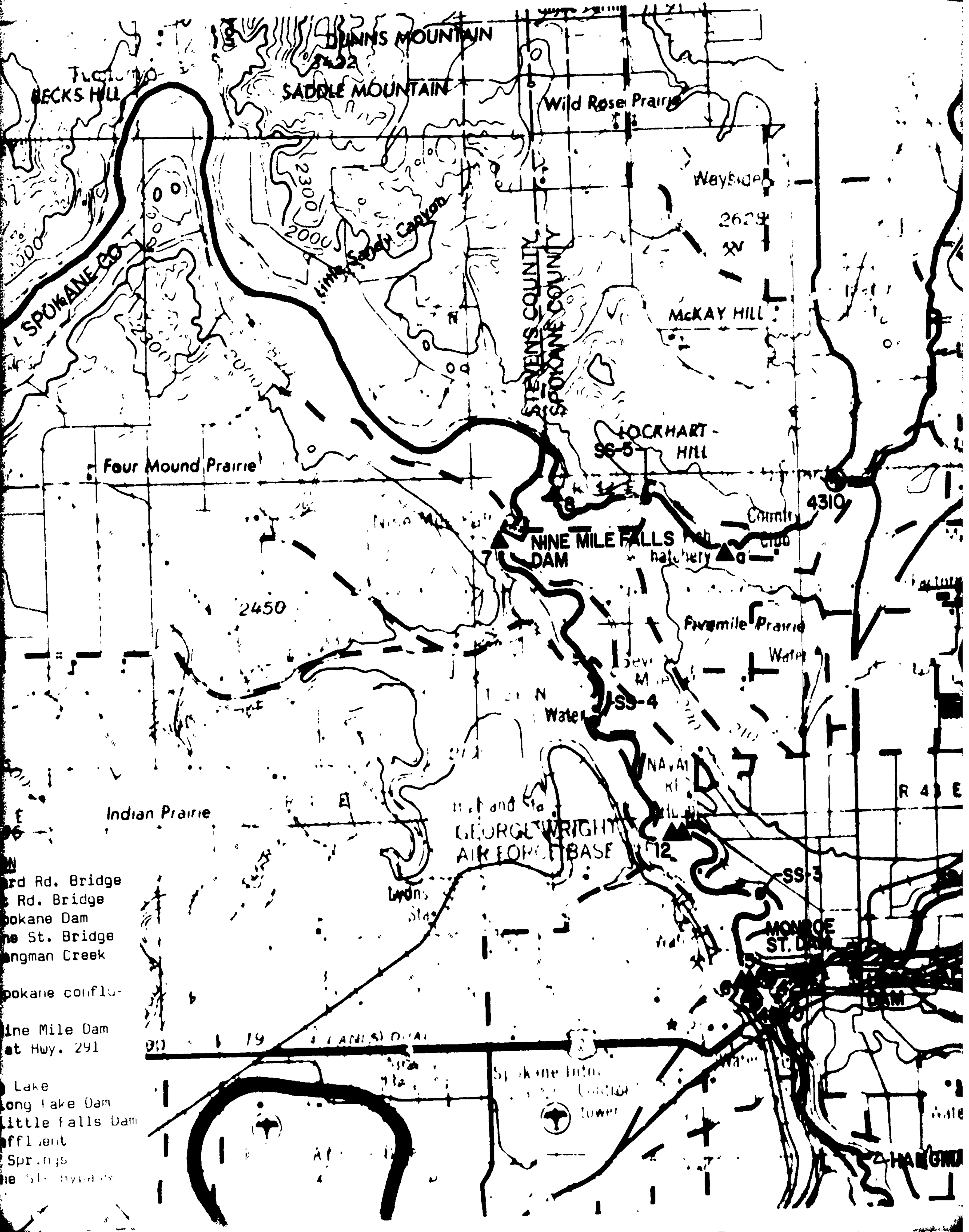
TABLE 15

TEMPERATURE, EVAPORATION, SOLAR RADIATION, DEW POINT
TEMPERATURE, WIND VELOCITY AND CLOUD COVER
SPOKANE WEATHER BUREAU AIRPORT STATION
SEPTEMBER 15-20, 1973

		September					
Parameter	Units	15	16	17	18	19	20
Temperature, Max.	°F	61	67	73	66	57	62
Min.	°F	37	35	39	54	51	51
Solar Radiation	Langleys	467	477	353	190	110	242
Dew Point Temperature, Mean	°F	26	25	29	44	50	48
Wind Velocity	Miles Per Day	262	158	182	264	204	353
Cloud Cover, Sunrise to Sunset	Tenths	0.0	0.0	0.9	1.0	1.0	0.9

Semi-monthly evaporation for the
Period September 15 to 30 .... 1.80 inches


WELLPINIT MOUNTAIN
HAPPY HILL
BECKS H
MT GODFREY
Lookout tower
2300
T 27 N
LONG LAKE DAM
LITTLE FALLS DAM
11
10
4330
LINCOLN CO
STEVENS CO
SPOKANE RIVER
9
Tamarack Canyon
231
Spring Creek Canyon
SHOEMAKER BUTTE
3001
2500
GRAYS BUTTE
R 38
Squaw Canyon
NP
SAMPLE POINT IDENTIFICATION
1. Spokane River at Harvard Rd. Bridg
2. Spokane River at Trent Rd. Bridge
3. Spokane River above Spokane Dam
4. Spokane River at Greene St. Bridge
5. Spokane River above Hangman Creek confluence
6. Hangman Creek above Spokane confluence
7. Spokane River above Nine Mile Dam
8. Little Spokane River at Hwy. 291 Bridge
9. Spokane River in Long Lake
10. Spokane River below Long Lake Dam
11. Spokane River below Little Falls
12. City of
Special a -
Special b -

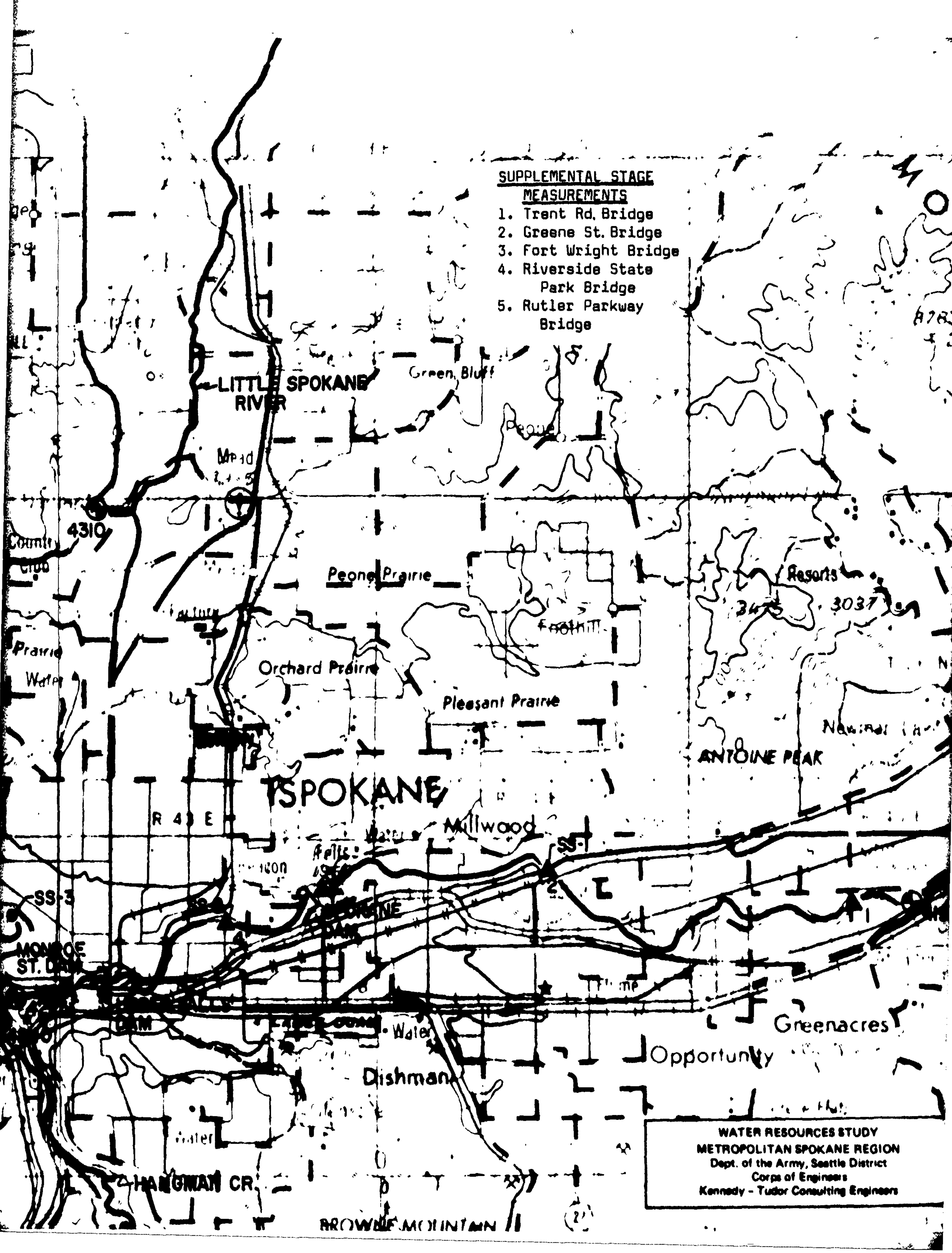


rd Rd. Bridge
Rd. Bridge
okane Dam
e St. Bridge
ngman Creek

pokane conflu-

ine Mile Dam
at Hwy. 291

Lake
ong Lake Dam
ittle Falls Dam
ffluent
Springs


SUPPLEMENTAL STAGE MEASUREMENTS
1. Trent Rd. Bridge
2. Greene St. Bridge
3. Fort Wright Bridge
4. Riverside State Park Bridge
5. Rutler Parkway Bridge
LITTLE SPOKANE RIVER
Green Bluff
Peone Prairie
Orchard Prairie
Pleasant Prairie
Resorts
3037
ANTOINE PEAK
SPOKANE
R 43 E
Millwood
SS-1
SS-3
MONROE ST. DAM
Greenacres
Opportunity
Dishman
HANGMAN CR.
BROWNE MOUNTAIN
4310
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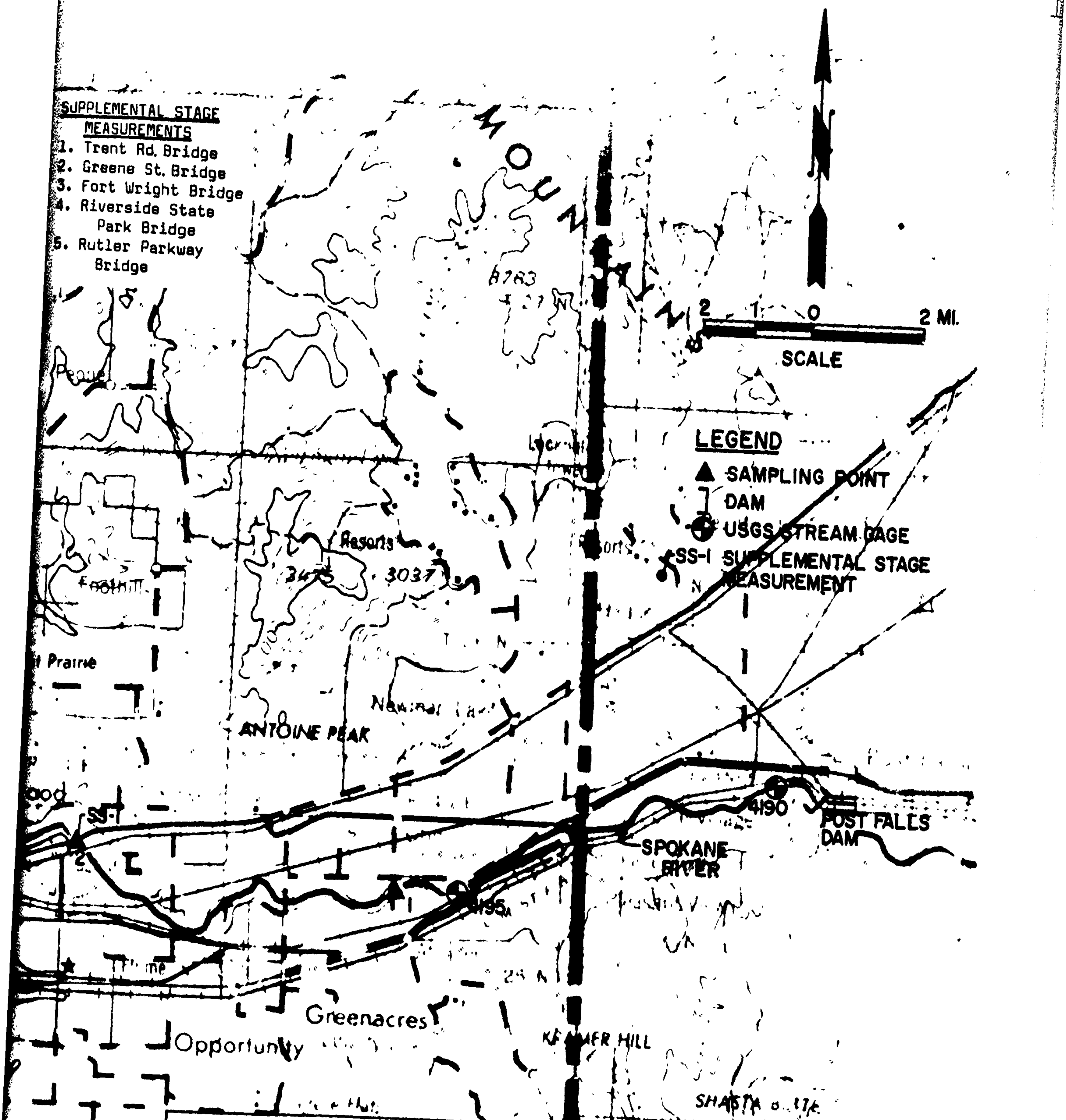

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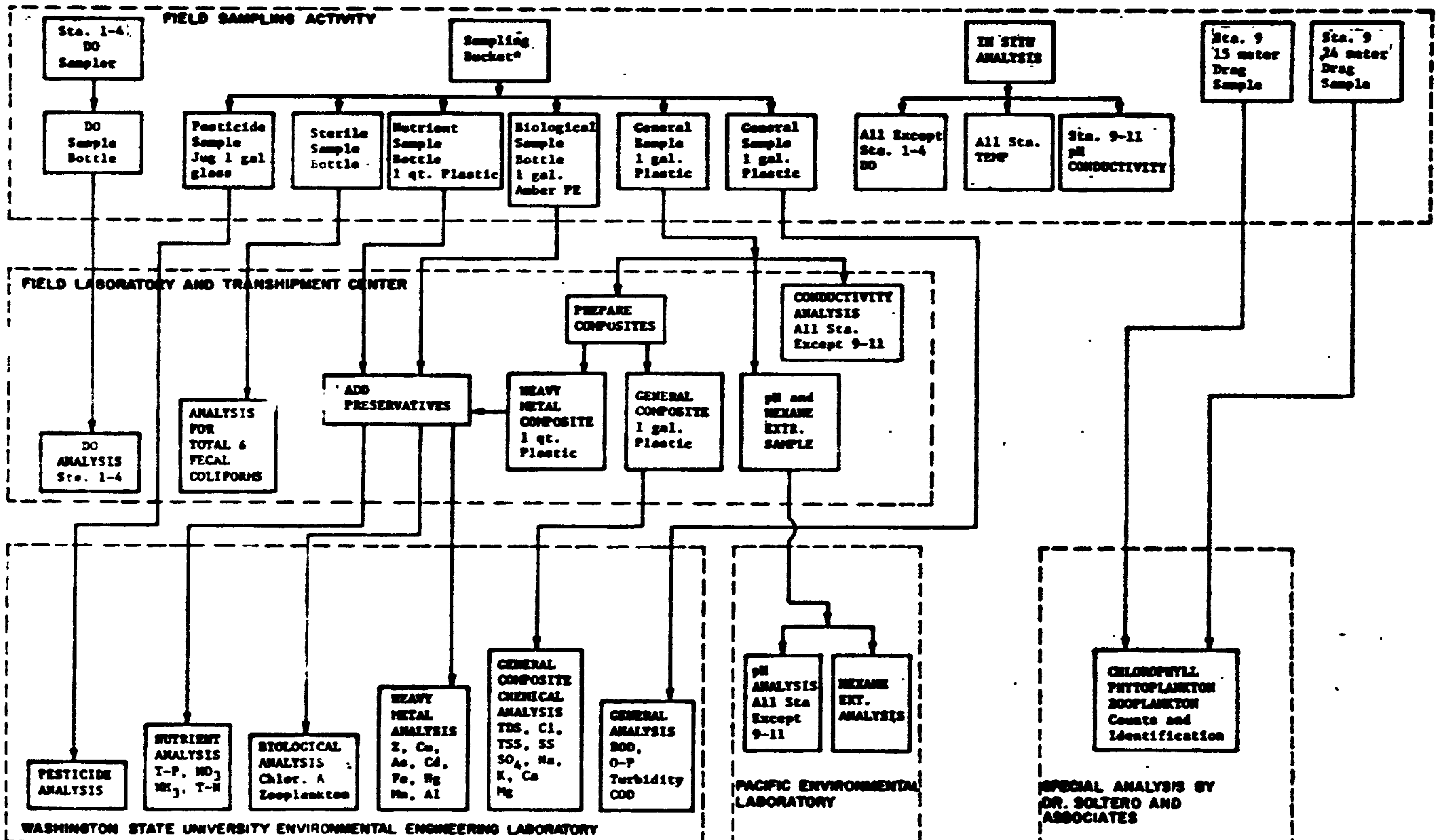
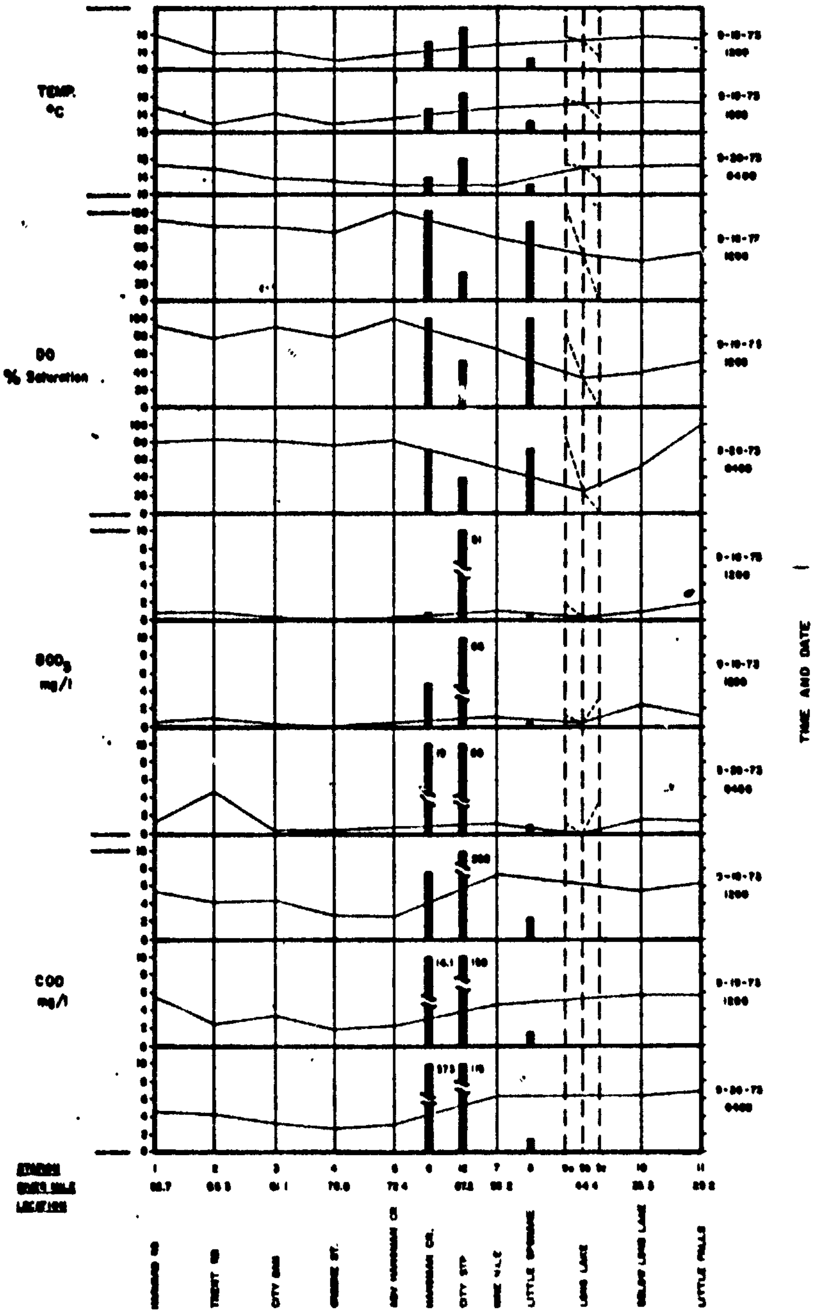
SAMPLING PROGRAM LOCATION MAP

FIG. A

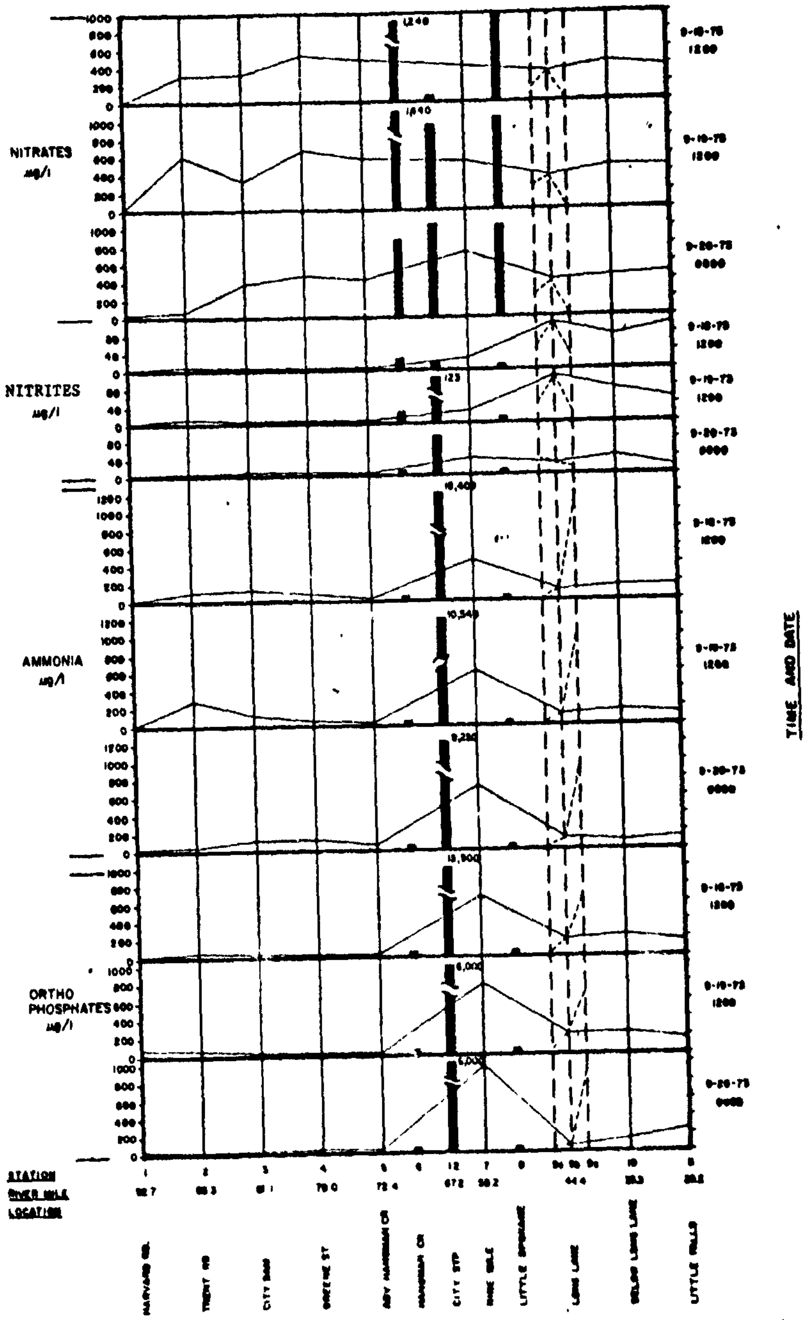


* FOR ALL STATIONS EXCEPT 9 WHERE A VAN DORN SAMPLER WAS USED.

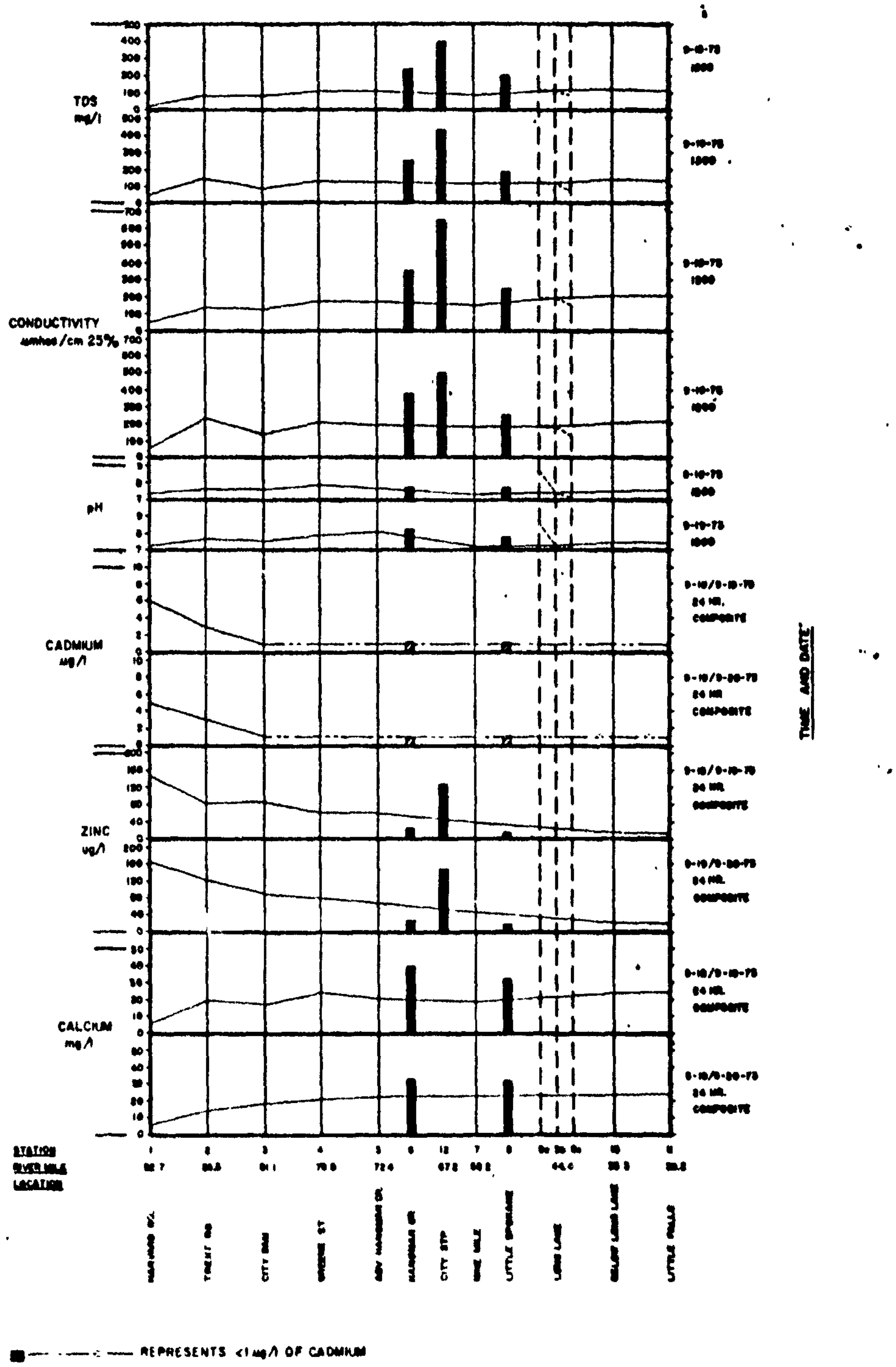
WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLING AND ANALSIS SCHEMATIC	FIG. 8



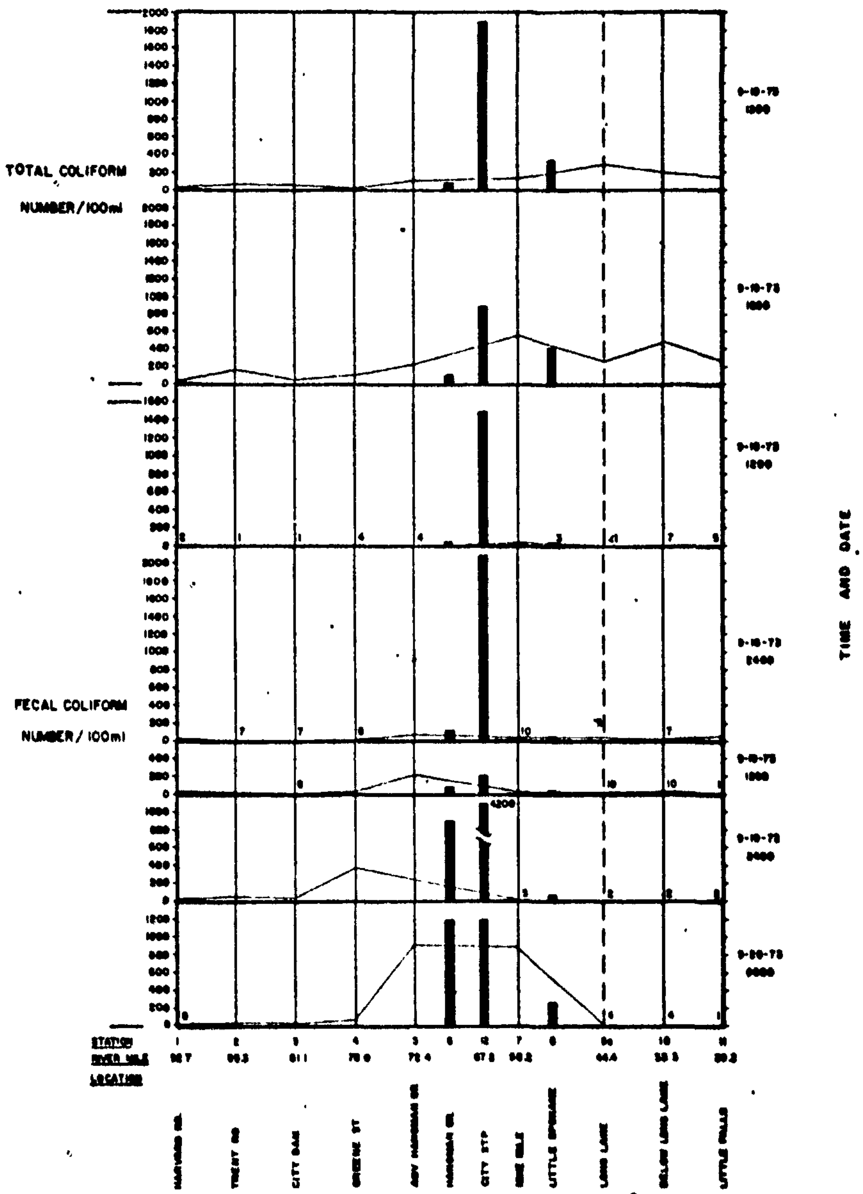
WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	OXYGEN BALANCE ANALYTICAL RESULTS TEMPERATURE, DISSOLVED OXYGEN (DO) BIOCHEMICAL OXYGEN DEMAND (BOD) AND CHEMICAL OXYGEN DEMAND (COD)	FIG C



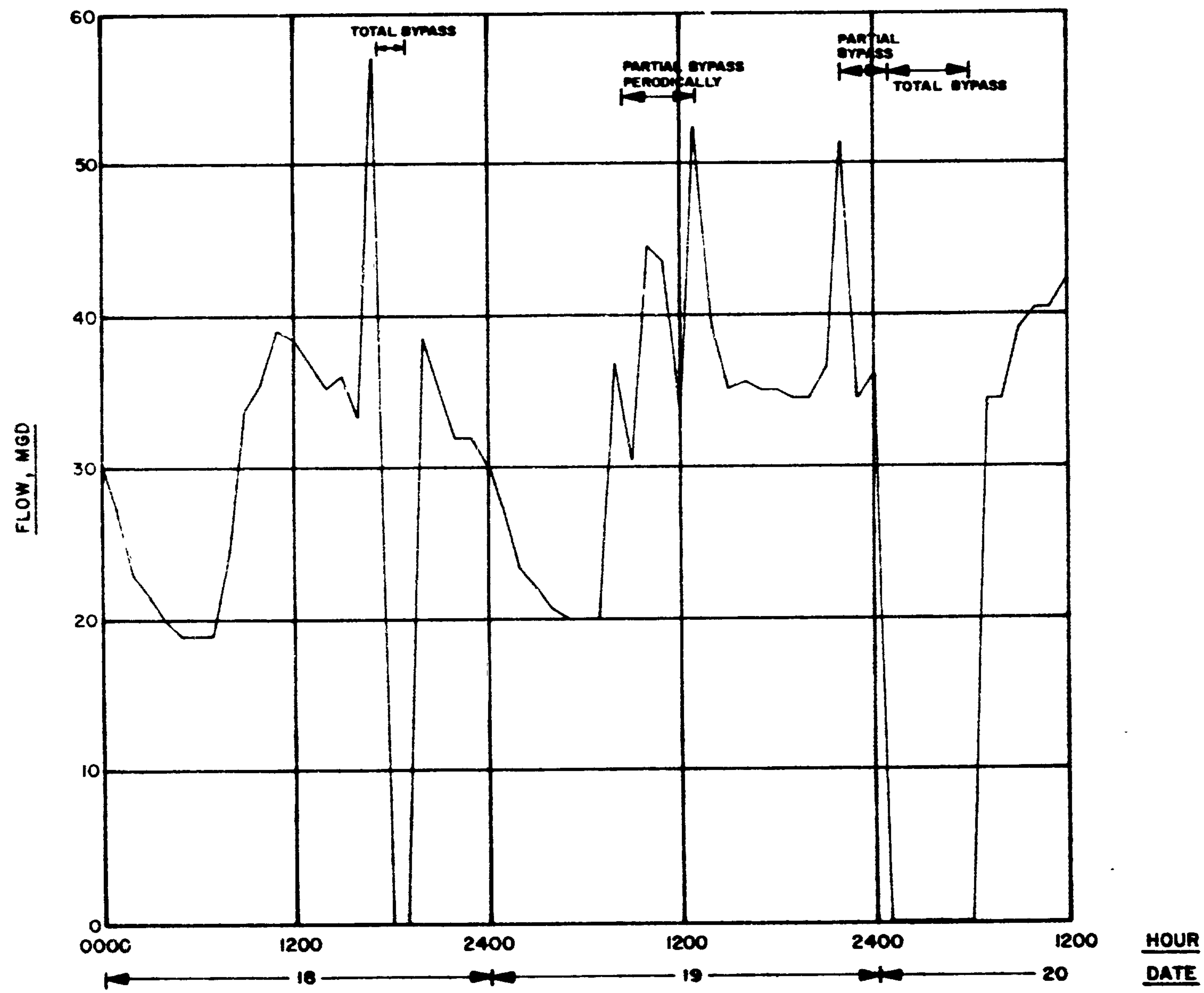
WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	NUTRIENTS ANALYTICAL RESULTS NITRATES, NITRITES, AMMONIA, AND ORTHO PHOSPHATES	FIG D



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SOLIDS AND CONSERVATIVES ANALYTICAL RESULTS TOTAL DISSOLVED SOLIDS (TDS), CONDUCTIVITY, pH, CADMIUM, ZINK AND CALCIUM	FIG E



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BACTERIOLOGICAL ANALYTICAL RESULTS TOTAL AND FECAL COLIFORMS	FIG F



WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
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SPOKANE TREATMENT PLANT FLOW : SEPT. 1973

FIG. G

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APPENDIX I

PHYTOPLANKTON BY CLASS FROM EUPHOTIC ZONE COMPOSITE AT STATION 9

VOLUME mm^3/liter

CLASS	Date 9-18-73 Hour 1200	9-18-73 1600	9-18-73 2000	9-18-73 2400	9-19-73 0400	9-19-73 0800	9-19-73 1200	9-19-73 1600	9-19-73 2000	9-15-73 2400	9-20-73 0400	9-20-73 0800
Bacillariophyceae	4.604	1.865	2.150	6.618	10.325	4.281	7.864	2.520	4.994	2.116	2.508	5.533
Chlorophyceae	1.992	3.025	.443	2.529	1.472	.450	2.320	1.396	1.962	.394	1.952	2.132
Cryptophyceae	6.489	3.891	.599	1.659	.489	.990	1.206	1.779	4.508	1.856	1.547	1.579
Cyanophyceae	.003	—	.194	.166	71.298	—	.007	—	.833	.014	—	—
Dinophyceae	—	—	—	—	—	—	—	.073	—	—	3.415	—
Microplankton	.079	.018	.029	.032	.258	.046	.032	.071	.021	.065	.059	.040
TOTAL	13.167	8.799	3.415	11.004	83.732	5.767	11.429	5.839	12.318	4.445	9.481	9.284

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	PHYTOPLANKTON BY CLASS FROM EUPHOTIC ZONE COMPOSITE AT STATION 9	APPENDIX I

APPENDIX II

ZOOPLANKTERS BY SPECIES FROM 15 AND 24 METER TOWS AT STATION 9

	NUMBERS PER LITER									
DATE / HOUR	9-18-73 1200		9-18-73 1600		9-18-73 2000		9-18-73 2400		9-19-73 0400	
SPECIES	15M TOW	24M TOW	15M TOW	24M TOW	15M TOW	24M TOW	15M TOW	24M TOW	15M TOW	24M TOW
Keratella cochlearis	71.58	44.60	85.64	44.81	63.32	53.79	89.81	50.31	85.29	39.67
Polyarthra vulgaris	11.77	3.06	7.32	4.12	4.32	2.42	9.13	2.87	6.91	3.97
Ascomorpha sp.	102.95	47.23	93.70	66.31	90.66	50.88	79.92	38.81	107.14	52.70
Kellicottia longispina	--	--	--	0.46	--	2.91	--	1.92	1.15	1.70
Lecane luna	--	--	0.73	--	--	--	--	--	--	--
TOTAL ROTIFERS	186.30	94.89	187.39	115.70	158.30	110.00	178.86	93.91	200.49	98.04
Diaphanosoma leuchtenbergianum	2.94	3.50	3.66	1.83	2.16	2.91	5.33	8.14	3.46	6.23
Daphnia retrocurva	36.28	13.56	37.33	22.41	21.58	13.57	26.64	16.29	18.43	19.83
Daphnia rosea	--	--	--	--	--	--	0.76	--	--	--
Bosmina longirostris	0.98	--	--	0.46	0.72	0.97	0.76	0.48	--	0.57
Chydorus sphaericus	1.96	--	0.73	0.46	0.72	0.48	--	--	--	0.57
Leptodora kindtii	0.15	0.16	0.19	0.18	0.24	0.22	0.29	0.08	0.14	0.12
TOTAL CLADOCERANS	42.35	17.22	41.91	25.34	25.42	16.15	33.78	24.99	22.03	27.32
Copepod nauplii	73.54	34.55	65.88	37.96	54.68	42.16	65.45	27.31	99.07	51.00
Mesocyclops edax	4.90	5.68	8.05	9.60	3.60	4.36	4.57	3.83	6.91	2.83
Cyclops vernalis	1.96	0.44	1.46	0.92	1.44	--	0.76	0.96	1.15	0.57
Diaptomus siciloides	19.61	8.31	15.37	15.09	24.46	14.54	23.59	9.58	19.58	11.33
TOTAL COPEPODS	100.01	48.98	90.76	63.57	83.98	61.06	94.37	41.68	126.71	65.73
TOTAL ZOOPLANKTERS	328.66	161.09	320.06	204.61	267.70	189.21	307.01	160.58	349.23	191.09

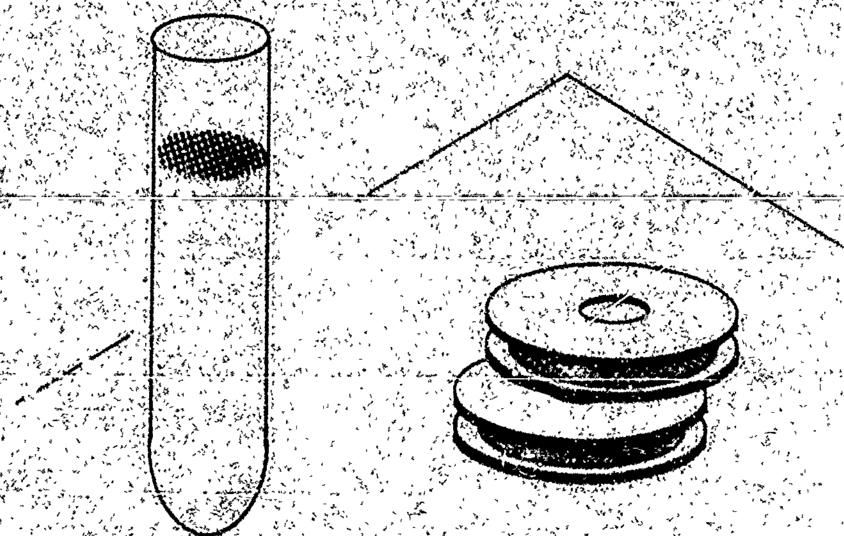
WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	ZOOPLANKTERS BY SPECIES FROM 15 AND 24 METER TOWS AT STATION 9	APPENDIX II

APPENDIX II (Continued)

SPECIES	9-19-73 1200 15M TOW	9-19-73 1200 24M TOW	9-19-73 1600 15M TOW	9-19-73 1600 24M TOW	9-19-73 2000 15M TOW	9-19-73 2000 24M TOW	9-19-73 2400 15M TOW	9-19-73 2400 24M TOW	9-20-73 0400 15M TOW	9-20-73 0400 24M TOW	9-20-73 0800 15M TOW	9-20-73 0800 24M TOW
	NUMBERS PER LITER											
Keratella cochlearis	93.31	54.27	90.35	54.55	93.70	75.24	101.82	67.00	193.10	87.57	129.41	105.98
Polvarthra vulgaris	10.38	4.26	12.55	5.63	10.04	4.54	7.10	4.64	18.77	7.75	6.86	9.22
Ascomorpha sp.	86.40	46.82	69.44	45.02	125.49	68.10	184.70	96.90	308.43	132.52	171.40	145.15
Kellicottia longispina	1.15	5.32	2.51	3.03	1.67	1.30	--	2.06	--	6.98	1.71	2.30
Lecane luna	--	--	--	--	--	--	--	--	--	1.55	--	--
TOTAL ROTIFERS	191.24	110.67	174.85	108.23	230.90	149.18	293.62	170.60	520.30	236.37	309.38	262.65
Diaphanosoma leuchtenbergianum	4.61	5.32	3.35	4.32	4.18	3.89	7.10	1.55	8.05	7.75	2.57	2.30
Daphnia retrocurva	25.34	13.83	30.95	10.82	20.08	8.43	20.13	11.34	42.91	9.30	26.57	17.28
Daphnia rosea	1.15	--	--	--	--	--	--	--	--	--	0.86	--
Bosmina longirostris	--	--	--	0.43	--	0.65	--	--	--	0.78	0.86	--
Chydorus sphaericus	--	--	--	--	--	--	--	--	5.36	--	--	2.30
Leptodora kindtii	0.21	0.09	0.15	0.14	0.23	0.17	0.33	0.11	0.27	0.14	0.31	0.30
TOTAL CLADOCERANS	31.31	19.24	34.45	15.71	24.49	13.14	27.56	13.00	56.59	17.97	31.17	22.18
Copepod nauplii	61.06	37.78	70.27	47.62	112.10	60.97	117.22	59.27	201.15	79.05	97.70	97.92
Mesocyclops edax	8.06	6.39	5.02	3.46	6.69	11.03	5.92	8.76	13.41	8.52	10.28	5.76
Cyclops vernalis	2.30	0.53	2.51	1.30	0.84	1.30	1.18	0.52	2.68	0.78	0.86	2.30
Diaptomus siciloides	18.43	8.51	22.59	8.66	27.61	15.57	34.35	21.65	50.96	25.58	25.71	25.34
TOTAL COPEPODS	89.85	53.21	100.39	61.04	147.24	88.87	158.67	90.20	268.20	113.98	134.55	131.32
TOTAL ZOOPLANKTERS	312.40	183.12	309.69	184.98	402.63	251.19	479.85	273.80	845.09	368.27	475.10	416.15

ZOOPLANKTERS BY SPECIES FROM 15 AND 24 METER TOWS AT STATION 9

APPENDIX II (Cont.)



SECTION 607.2

SUPPLEMENTARY SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 607.2

SUPPLEMENTARY SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

18 November 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

SECTION 607.2

SUPPLEMENTARY SAMPLING AND ANALYSIS OF WATER QUALITY FOR SIMULATION MODEL CALIBRATION

Purpose

The purpose of this section is to report results of a second sampling and analysis program for water quality to provide supplemental information for simulation model calibration. Three types of information not provided in the initial program are the goals of this sampling: (1) information on surface wash off quality from rural areas during precipitation and (2) quality information of locations which will permit identification of the effect of groundwater inflow and (3) quality associated with higher river flow rather than low. The program was not successful in meeting the first goal since its implementation was delayed beyond the end of the rainy season.

General Description of the Program

The supplemental program consists of sampling at each of five surface water locations for a twenty-four hour period at four hour intervals for a total of seven samples at each location. The five sampling points include one each on the Little Spokane and Hangman Creek and three on the Spokane River. Sampling of Long Lake is not included in this program. The parameter list for analysis is similar to that for the first sampling period except that no analysis for chlorophyl A or zooplankton are included since they are not expected to be significant at the higher stream flows.

The spring sampling period is chosen to be representative of higher river flows as contrasted with the minimal flows of late summer covered by the 1973 program. The high flows and low water temperatures in June prevent stratification of Long Lake. Since previous investigations indicate that quality is not significantly different than free flowing river at this time, sampling is not included in this program. Sampling dates are June 11 and 12, 1974 for the three locations on the Spokane River and June 19 and 20 on Hangman Creek and the Little Spokane River.

Reference is made throughout this section to the task report Section 607 dated 6 March 1974 which described the 1973 sampling program for detailed descriptions of techniques repeated herein. Reference is identified as "the 1973 program."

Detail Description of Sampling Locations

Little Spokane River. During the 1973 sampling program, the sampling point on the Little Spokane River was at the mouth to represent the total quality as its flow joins the Spokane River. The quality at the mouth includes the quality characteristics derived from the surface and groundwater flows generated entirely within the basin plus the characteristics of the groundwater from outside the basin which joins the Little Spokane in its lowest reach below Dartford. For this sampling, a sampling point near Dartford is selected to obtain data representing the in-basin component only and excluding the major groundwater inflow below Dartford. The actual point of sampling is the bridge at Dartford Drive, River Mile 10.6, approximately 1/4 mile downstream from USGS gage number 4310.

Hangman Creek. As for the Little Spokane River, the 1973 sampling point for Hangman Creek was at the mouth. Out-of-basin groundwater influence in the lower reach is present on Hangman Creek but is believed to be only minor and significant at very low flows. Of more significance are the urban drainage and overflow points in the lower reach. The sampling point selected in this program is upstream from the urban area at the Marshall Creek confluence in order to obtain data representative of the upstream rural segment. The actual point is selected approximately 50 yards downstream from the Marshall Creek confluence and just inside the City limits.

Spokane River. During the 1973 sampling, no samples were taken between the Hangman Creek confluence and Nine Mile Dam below the City sewage treatment plant discharge. There is a need to more closely bracket the reach of the river upstream and downstream from the City STP discharge. Points are so selected in this sampling program. A single point is selected between Hangman Creek confluence and the study area boundary as background for the two downstream points. The specific points selected are:

(1) At the Greene Street Bridge, River Mile 78.0, same point as Point Number 4 in the 1973 program.

(2) At the Fort Wright Bridge, River Mile 69.8, above the City STP discharge. This was one of the supplemental river stage observation points in the 1973 program.

(3) At the Bowl and Pitcher Bridge (Riverside State Park Bridge), River Mile 66.1, below the City STP discharge, also a

supplemental stage observation point in the 1973 program.

For a summary of sampling point locations see Table 1.

Sampling Techniques and Analytical Responsibility

Sample collection, compositing and field analyses were under the direction of Ms. Susan Degerstrom of Pacific Environmental Laboratory (PEL). Samples were collected at four hour intervals at each station following the general procedures described for the 1973 program. Field measurements were made at the time of collection of temperature and dissolved oxygen. Analyses were made in the temporary field laboratory set up at the City of Spokane sewage treatment plant of conductivity, pH, fecal and total coliforms. Samples for analysis of all other parameters except hexane extractables were prepared for and delivered to the Environmental Engineering Laboratory of Washington State University (EEL-WSU). Samples for metals analysis were preserved with ultra pure hydrochloric acid and all other samples were prepared and preserved as described for the 1973 program. Samples for hexane extractable analysis were prepared for and shipped to PEL, San Francisco.

Analytical Techniques

Field measurements of dissolved oxygen were made with an IBC Dissolved Oxygen and Temperature Monitor Field Unit using the deep water probe. Field laboratory measurements of conductivity were made with a YSI Model 31 Conductivity Bridge and pH with a Chemtrix Type 40.

All other analytical procedures by PEL and EEL-WSU were as described for the 1973 program.

Analytical Results

Analytical results for the 24 hour programs on June 11 and 12 and June 19 and 20, 1974 are reported in Table 2.

TABLE 1

1974 RIVER QUALITY SAMPLING LOCATIONS

Station No.	Description	Approx. River Mile
1	Spokane River at Greene St.	78.0
2	Spokane River at Ft. Wright Bridge	69.8
3	Spokane River at Bowl & Pitcher	66.2
4	Hangman Creek at Marshall Creek (1)	4.2 (3)
5	Little Spokane River at Dartford (2)	10.6 (4)

(1) Located approx. 50 yds downstream from the confluence of Marshall Creek, just inside city limits. Approx. 1/3 of total flow appeared to be coming from Marshall Creek.

(2) Located off the bridge at Dartford Drive, approx. 1/4 mi. downstream of USGS Gage at Dartford.

(3) River miles on Hangman Creek above mouth.

(4) " " " Little Spokane River above mouth.

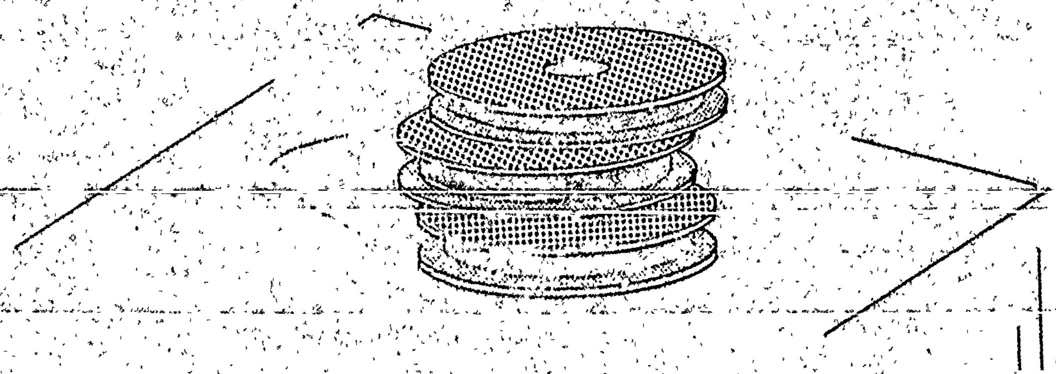
TABLE 2

ANALYTICAL RESULTS OF 1974 RIVER SAMPLING PROGRAM

Station	Date	Hour	Conduct. at 25°C umhos/cm	TDS mg/l	TSS mg/l	Sett. Solids mg/l	Turbid. JTU	pH	Temp. °C	D. O. mg/l	BOD₅ mg/l	COD mg/l	NH₃-N mg/l	NO₂-N mg/l	NO₃-N mg/l	Total Kjel. (N) mg/l	Total PO₄-P mg/l	Ortho PO₄-P mg/l	Cl mg/l
Greene St. (1)	6/11	2000	47.9	22.5	-(3)	-	0.9	7.10	14.5	9.2	0.7	3.8	0.085	0.003	0.025	0.075	0.023	0.003	-
	6/12	0000	46.3	34.0	-	-	1.3	7.30	15.0	8.9	0.4	3.8	0.009	<0.003	0.020	0.07	0.020	0.002	-
		0400	48.6	35.5	-	-	1.6	6.90	13.5	8.6	0.3	3.6	0.005	<0.003	0.020	0.095	0.013	0.002	-
		0800	45.7	27.5	-	-	1.2	6.90	13.5	9.1	0.4	3.9	0.037	<0.003	0.020	0.105	0.013	0.001	-
		1200	45.9	21.0	-	-	1.7	7.15	[illegible]	9.8	0.4	3.8	0.009	<0.003	0.019	0.105	0.010	0.001	-
		1600	44.5	34.5	-	-	1.4	7.15	14.8	10.2	0.3	3.5	0.009	<0.003	0.020	0.12	0.010	<0.001	-
		2000	45.0	33.0	7.0	Trace	1.1	6.95	14.8	9.0	0.4	3.5	0.009	<0.003	0.020	0.20	0.010	<0.001	1.0
Ft. Wright Bridge (2)	6/11	2000	49.4	26.0	-	-	1.4	7.05	14.5	9.7	0.5	3.5	0.012	<0.003	0.030	0.13	0.013	<0.001	-
	6/12	0000	46.2	33.0	-	-	0.9	7.10	14.0	9.6	0.4	3.8	0.010	<0.003	0.035	0.11	0.013	0.002	-
		0400	46.9	43.7	-	-	1.7	7.03	13.7	9.4	0.3	3.8	0.005	<0.003	0.030	0.08	0.010	0.002	-
		0800	48.2	26.0	-	-	1.4	6.95	14.0	9.8	0.4	3.8	0.025	<0.003	0.030	0.13	0.007	0.001	-
		1200	48.5	38.5	-	-	1.4	7.20	14.5	10.8	0.3	3.5	0.015	<0.003	0.028	0.10	0.007	<0.001	-
		1600	47.7	29.5	-	-	1.2	7.20	4.8	10.9	0.6	3.5	0.045	<0.003	0.031	0.09	0.007	<0.001	-
		[illegible]	48.0	14.5	6.0	Trace	1.3	6.95	15.0	9.9	0.6	3.5	0.013	<0.003	0.044	0.10	0.007	<0.001	0.5
Bowl & Pitcher (3)	6/11	2000	50.4	43.0	-	-	1.8	7.20	14.5	9.4	0.6	4.7	0.025	<0.003	0.037	0.15	0.013	0.004	-
	6/12	0000	45.2	23.0	-	-	2.1	7.13	13.0	8.6	0.7	4.7	0.025	<0.003	0.037	0.15	0.013	0.004	-
		0400	48.6	43.0	-	-	1.5	6.97	13.0	8.9	0.6	4.7	0.022	<0.003	0.040	0.17	0.013	0.003	-
		0800	50.3	37.5	-	-	1.2	7.00	14.0	10.2	0.9	5.1	0.095	<0.003	0.040	0.16	0.013	0.005	-
		1200	50.5	31.0	-	-	1.7	7.30	15.0	10.4	0.6	5.1	0.04	<0.003	0.036	0.17	0.016	0.007	-
		1600	48.8	44.0	-	-	1.6	7.05	14.8	10.1	0.5	4.7	0.025	<0.003	0.036	0.15	0.016	0.004	-
		2000	50.0	34.0	5.0	Trace	1.6	7.30	15.0	9.4	0.4	4.7	0.026	<0.003	0.039	0.15	0.010	0.005	0.5
Hangman Creek (4)	6/19	1600	216	114.0	-	-	2.4	8.65	[illegible]	9.0	0.9	12.3	0.06	0.005	0.66	0.5	0.091	0.062	-
		2000	243	165.0	-	-	3.2	8.75	23.5	7.6	0.3	9.5	0.07	0.003	0.51	0.5	0.088	0.062	-
	6/20	0000	245	161.0	-	-	2.9	7.90	19.5	7.4	0.5	11.7	0.09	0.003	0.52	0.55	0.091	0.065	-
		0400	209	135.5	-	-	5.4	7.55	18.5	6.8	0.45	14.1	0.13	0.006	0.83	0.56	0.114	0.072	-
		0800	239	178.0	-	-	3.5	7.95	19.0	6.3	1.1	10.6	0.11	0.005	0.57	0.50	0.091	0.065	-
		1200	245	154.5	-	-	1.9	8.35	20.0	7.6	1.05	9.0	0.07	0.004	0.52	0.51	0.098	0.065	-
		1600	200	130.0	8.0	Trace	4.2	7.80	17.0	8.2	0.5	11.0	0.095	0.005	2.84	0.49	0.104	0.073	2.5
Little Spokane (5)	6/19	1600	163	113.5	-	-	3.2	8.20	22.5	8.5	0.8	7.8	0.037	<0.003	0.40	0.28	0.042	0.025	-
		2000	165	101.7	-	-	2.3	7.95	22.0	7.8	0.35	7.0	0.042	0.003	0.41	0.29	0.046	0.027	-
	6/20	0000	159	95.5	-	-	1.7	7.65	20.5	6.8	0.35	9.0	0.040	<0.003	0.40	0.30	0.046	0.027	-
		0400	161	90.0	-	-	2.8	7.55	20.0	6.6	0.45	6.4	0.042	<0.003	0.40	0.31	0.046	0.026	-
		0800	163	113.0	-		3.0	7.85	19.8	6.7	0.3	9.1	0.042	<0.003	0.43	0.30	0.049	0.026	-
		1200	165	96.5	-	-	2.7	7.95	19.5	7.1	0.5	11.8	0.038	<0.003	0.40	0.25	0.046	0.025	-
		1600	163	99.5	8.0	Trace	2.0	7.82	20.0	7.6	0.25	7.0	0.043	<0.003	0.40	0.26	0.049	0.026	1.5

Station	Date	Hour	Na mg/l	K mg/l	Ca mg/l	Al mg/l	Al µg/l	Zn µg/l	Total Coliform #/100ml	Fecal Coliform #/100ml	Oil & Grease mg/l	Pesticides(1) µg/l	Hep. Epoxide µg/l
Greene St. (1)	6/11	2000							-	2	0.9		
	6/12	0000							358	5	1.4		
		0400							-	3	4.1		
		0800							496	3	4.8		
		1200							-	2	2.4		
		1600							188	4	4.3		
		2000	1.5c(2)	0.75c	4.9c	1.54c	310c	270c	-	6	<0.1	ND(4)	0.07c
Ft. Wright Bridge (2)	6/11	2000							-	332	3.3		
	6/12	0000							1488	175	14		
		0400							-	93	13		
		0800							1464	300	14		
		1200							-	500	8.0		
		1600							1960	232	13		
		[illegible]	1.0c	0.90c	5.0c	1.58c	450c	190c	-	270	13	ND	0.08c
Bowl & Pitcher (3)	6/11	2000							-	260	10		
	6/12	0000							2140	192	9.9		
		0400							-	113	7.8		
		0800							2740	232	7.0		
		1200							-	520	5.6		
		1600							2150	304	6.4		
		2000	1.5c	0.90c	5.2c	1.60c	80c	240	-	608	5.3	ND	0.09c
Hangman Creek (4)	6/19	1600							-	292	5.5		
		2000							870	178	9.8		
	6/20	0000							-	460	5.3		
		0400							1600	328	<0.1		
		0800							-	>5000	0.1		
		1200							7560	>1000	<0.1		
		1600	10.0c	3.75c	27.0c	6.7c	--	---	-	308	11	ND	0.11c
Little Spokane (5)	6/19	1600							-	388	4.9		
		2000							3030	328	18		
	6/20	0000							-	>3000	12		
		0400							2720	700	14		
		0800							-	>3000	12		
		1200							9000	>3000	13		
		1600	5.5c	1.70c	22.0c	5.8c	560c	850c	-	>3000	0.4	ND	0.11c

(1) Including heptachlor epoxide
(2) C = Overall composite sample
(3) - Indicates no sample
(4) ND = Not detected. Detection limits for lindane & heptachlor are high due to interfering substances.



SECTION 606.1

SIMULATION MODEL GOALS AND APPLICATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 606.1

SIMULATION MODEL GOALS AND APPLICATION

19 November 1974

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

PREFACE NOTE

This section was completed in draft form March 28, 1974. Its purpose was to describe the capabilities and application requirements of the selected software, Hydrocomp Simulation Programming, and to propose methodology for adaptation of this generalized simulation to the specific requirements and needs of the study area. Most of the actual application of the simulation process was accomplished after the draft date and is reported in subsequent task report sections and is documented in computer print outs and tapes. This section was revised for in-house review in November 1974 but no further revision was made to make it fully compatible with all subsequent developments which are reported and documented elsewhere. Refer to the following:

Section 606.3 Point Source Input Files for Year 2000 Simulation (Draft 15 July 1975)

Section 606.4 Simulation Model Calibration and Production Runs (Draft 24 September 1975)

Section 406.3 Criteria for Projection of Urban Runoff Flows and Pollution Loads by Simulation (11 Nov. 1974)

INDEX

INDEX (continued)

All plates are large drawings bound at the end of this section.

SECTION 606.1
SIMULATION MODEL GOALS
AND APPLICATION*

Introduction

The purpose of this section is to develop the goals of a water quality simulation and to show how it is proposed to meet those goals through application of a selected generalized simulation software. The general objective is the development of a water quality simulation tool specific to the requirements and needs of the study area. Water quality simulation is defined as a mathematical means for computing the water quality responses of a hydrologic system to a combination of natural meteorologic events and selected pollutional inputs.

The simulation of the flow in a river system from meteorological events interacting with the land surface and ground water aquifers is a complex process that has been studied and refined for some time by the science of hydrology. To superimpose on these hydrological events the chemical and biological processes that determine the quality of a flowing stream is an even more complex process. A number of generalized solutions to this problem are available, in various degrees of refinement and development, utilizing digital computers to manipulate the large masses of data. Prior to the inception of the study, a screening was made of available computer software which had the capability of providing hydrologic

* See Preface Note.

and water quality simulation for generalized watersheds. The Hydrocomp Simulation Programing was selected as the most appropriate base for developing a simulation specific to the watershed of the study area. The Hydrocomp Simulation Programing (HSP) is proprietary software which is the property of Hydrocomp, Inc., Palo Alto, California. HSP consists of algorithms for the calculation of the hydrologic cycle processes onto which other algorithms are super-imposed for the chemical and biological processes occuring on land surfaces and in streams and impoundments. The algorithms are general for any watershed. The simulation is made specific by the insertion of a data base specific to a watershed followed by a calibration process

HSP is divided into the following four load modules:

(1) LIBRARY - performs data management for hydrometeorologic data and quality data using direct access disk storage,

(2) LANDS - simulates snowpack and soil profile processes and calculates continuous soil moisture, evapotranspiration, groundwater accretion, and inflow to stream channels,

(3) CHANNEL - assembles and routes the channel inflow through the channel network and reservoirs,

(4) QUALITY - calculates water quality variables for flows at any location in streams/reservoirs. Data from LIBRARY, LANDS and CHANNEL is used and output summaries are stored by LIBRARY.

HSP is a dynamic simulation, that is, it assimilates data inputs representing external conditions that change with time and, in response, produces the dependent and corresponding time varying hydrological and water quality conditions. The basic time interval of the HSP simulation is one hour, as determined by the needs of the quality portion of the simulation. This means that both water quality and hydrologic processes are simulated in steps of one hour each.

The hardward selected for this study is provided by contract with McDonald Douglas Automation (McAUTO). The computer is located in St. Louis, Missouri. Access to the computer is by a Trendata terminal installed in the offices of Kennedy-Tudor Engineering, Seattle.

Load modules containing the HSP simulation program are loaded into the McAUTO computer by Hydrocomp to complete the working simulation facility accessible from the Trendata terminal.

Simulation Goals

General. An objective of the study as a whole is to analyze the existing and projected wastewater management needs of the study area and, through consideration of alternative solutions, to arrive at a recommended wastewater management plan. The role of the simulation model in meeting this goal is to provide factual data on the performance of the river system under various conditions that will aide in the decision making process of plan selection.

Steps in this decision making process that are to be addressed by the simulation model include:

1. Obtaining an understanding of "how and why" the observed undesirable pollution events are taking place.

2. Testing the reaction of the river system to various possible changes to the pollution load input.

3. Comparative evaluation of the performance of the river system to selected alternative wastewater management systems.

To meet the broad objectives listed above it is necessary to make specific simulation plans which recognize the unique characteristics of the study area. These specific plans include selection of the extent of the river system to be modeled, selection of the water quality parameters to be simulated and the locations at which quality and quantity readouts will be significant. The unique characteristics of the study area affecting these decisions include the following:

1. Approximately 85 percent of the water flowing through the study area originates outside the study area and enters carrying an almost negligible pollution load except for low concentrations of zinc and moderate coliform counts.

2. A significant proportion of the summer flow in both the Spokane and Little Spokane Rivers originates from groundwater, most of which also comes from outside the study area.

3. For both the present and the future, the major sources of pollution are within the Spokane urban planning area.

4. The only major quality degradation outside the urban planning area is the silt and associated pollutants from erosion in the Hangman Creek watershed.

5. The Long Lake impoundment is the focal point for present concern for water quality.

    a. The primary present concern is eutrophication.

    b. Long Lake exhibits stratification, turnover and other characteristics that indicate it must be modeled as a lake rather than a stream.

Extent of Model. The sources of water, sources of pollution and areas of quality concern indicate that the section of the river system to be modeled should include the Spokane River from its entrance into the study area to the outlet of Long Lake. To generate flow and quality of the Little Spokane River and Hangman Creek as they join the Spokane, these streams are included in the model.

The watershed of the Spokane River in Idaho is not simulated but treated as an input to the model. Representation of the Idaho portion of the watershed is discussed below, under Data Input.

Parameters to be Simulated. There is an indicated need to study biological activity in Long Lake and the presence of heavy metals in the waters entering the study area. Therefore, nutrients, algae, zooplankton and heavy metals are added to the usual pollution parameters of dissolved oxygen, biochemical oxygen demand and total dissolved solids. Fecal coliforms are selected as a simulation parameter in addition to total coliforms to give a more valid representation of bacterial contamination of human origin. Temperature is, of course, included not only for itself but for the fact that the rate of reaction of all nonconservative parameters is a function of temperature. Considering the foregoing, the complete list of water quality parameters selected for simulation is as follows:

a. Dissolved Oxygen
b. Biochemical Oxygen Demand
c. Temperature
d. Total Dissolved Solids
e. Total Coliform

f. Fecal Coliform
g. Algae-Chlorophyll A
h. Zooplankton
i. Ortho Phosphate
j. Total Phosphate
k. Nitrate
l. Nitrite
m. Ammonia
n. Total Nitrogen
o. Conservatives

The simulation model processes heavy metals as conservatives, that is, as nonreacting pollutants. Other constituents that could be included as conservatives are oil and grease, surfactants and chlorides. The above parameter list does not imply that all of these parameters will be simulated for every simulation run. Only those necessary to the objective of a simulation run will be processed. The list does imply that the model will be set up to run these parameters when required and that the sampling and calibration procedures will include these parameters.

Turbidity is not included in the parameter list since the present state of the art cannot represent its changing concentration or activity.

Locations at which Water Quality Data will be Simulated. The simulation model will be set up to make water quality data printouts available for the following kev locations:

a. Leaving Long Lake
b. At three depths in Long Lake for one location
c. The Spokane River above its confluence with the Little Spokane
d. The Little Spokane above its confluence with the Spokane
e. The Little Spokane above the confluence with Peone and Deadman Creeks
f. The Spokane River above its confluence with Hangman Creek

g. Hangman Creek above its confluence with the Spokane River
h. Hangman Creek below its confluence with California Creek
i. Spokane River at the present east city limit of Spokane
j. Spokane River at Liberty Bridge (near the Idaho-Washington state line)

Again, as stated for parameters, it is not implied that every run will develop data for all these locations. Data will be developed for locations as necessary to the objective of a particular run.

In addition to water quality data at the above locations, concurrent flow data will be available if required. Flow data will also be available, if required, at other smaller subdivisions of the study area as a consequence of the HSP hydrologic simulation process. Flow data from selected locations could be used to approximate hydrology for upstream portions of the two watersheds, Little Spokane and Hangman Creek. That is, runoff per square mile data would be available for selected subareas for which data are not presently available from gage records.

Hydrologic Simulation

The hydrologic simulation process uses meteorological data reacting with certain land parameters to generate runoffs which, in turn, are routed to produce flow hydrographs at desired locations.

The meteorological data categories used are: precipitation, temperature, evaporation, solar radiation, dew point temperature, cloud cover, and wind velocity. The specific meteorological data input files created for this specific study area are shown in Table 1. The length of proposed meteorological data files is twenty years. It is not intended that the entire data file be used for each or any run. The intent is to provide a wide range for selection and to provide a base for possible future statistical analysis.

The area subject to hydrologic simulation is delineated on Plate 606-1. The entire simulation area is first divided into major watersheds. These major areas correspond to portions of water resource inventory areas as follows:

1. Area 700, UPPER SPOKANE, is all of WRIA 57 downstream from USGS gage number 4195 at Liberty Bridge.
2. Area 500, LITTLE SPOKANE, is all of WRIA 55.
3. Area 600, HANGMAN, is all of WRIA 56 plus the rest of the natural tributary area in Idaho.
4. Area 400, LOWER SPOKANE, is all of WRIA 54 upstream from Long Lake Dam.

The basic land area for the accumulation of rainfall by the model is designated a "segment." Segments are selected to represent areas having common rainfall and elevation characteristics. The basic unit for routing of accumulated rainfall runoff and for making quality simulations is a length of channel designated as a "reach." The tributary area to a reach may include portions of not more than three segments for programming reasons within the quality module of the model. The length of channel in one reach is also subject to certain slope criteria limitations. Hydrologic data readout is available only at the downstream end of each reach and quality data readouts are available in terms of the entire reach length considered as a mixed body of uniform quality. Therefore, the selection of reaches is also tied to the requirements of desired data output.

The definition of segments need not be identical when going from one major drainage area to another. The definitions are selected to best categorize the topographic and precipitation regimes in each particular area.

The division of the major watershed into reaches is shown in Plate 606-1. An enlargement of the urban planning area is shown in Plate 606-2. Each reach and its associated tributary area are given the same identifying number. The reaches in which present and future urban development will exist are 590 in Area 500, 410 in Area 400, 660 in Area 600 and in all three reaches, 710, 720 and 730, of Area 700. The definition of segments for each area is shown in Table 2.

Having defined the reaches and segments, the input data from this mapping effort includes the following:

1. The total tributary area to each reach.
2. The fraction of the total tributary area to each reach represented by pervious and impervious component of each segment.
3. Mean segment slope.
4. Mean segment elevation.
5. Upstream and downstream reach elevation.
6. Length of channels in each reach.
7. Representative channel cross section and overbank slope for each reach.
8. Roughness coefficient for channel and overbank.
9. Roughness coefficient for overland (nonchannel) flow.
10. Mean overland flow length for each segment.
11. Fraction of each segment covered by forest.
12. Depth versus volume characteristics of lake.

Having established segments and reaches and developed land associated input data, the remaining input information required for

Hydrologic modeling is the assignment of meteorological data to segments.

The HSP program includes the ability to synthesize hourly data for precipitation stations with daily records by correlation with nearby stations having hourly records. Thus, although there are only three stations with hourly records, a total of nine become available by correlation. A particular gage is selected as applicable to each segment subject to an adjustment coefficient to recognize the difference in mean annual precipitation of the station and of the segment.

Temperature stations are selected for each segment based on location and elevation. The HSP program includes the capability of making further adjustments based on elevation.

Since only one meteorological station in the area provides data on solar radiation, dew point, temperature, wind velocity, cloud cover, and evaporation, this station is assigned to all segments for these parameters.

The flow of the Spokane River as it enters the study area is not developed by model simulation since a twenty-year record of flow is available for the same period as the meteorological data used within the study area. For this purpose, the daily flow record of USGS gage number 4195 at Liberty Bridge will create the necessary data file.

Groundwater provides a significant increment to the flow of both the Spokane River and the Little Spokane. Refer to the section of this report on Surface Waters for an approximate water balance. Since these groundwaters have their origin outside of the study area, a file of groundwater inflow must also be provided similar to the entering

Spokane River. Records of these flows do not exist. A synthetic file must be created based on the annual increment as indicated by the differential between stream gages, where available, and the measurements reported by Broom in 1951.

Hydrologic Calibration

There are sufficient USGS stream gage records at key locations with records that correspond to all or part of the twenty year meteorological record to provide adequate data for hydrological calibration of the simulation model. Before any water quality manipulations are tried, the hydrologic portion of the simulation model will be calibrated. The selected calibration runs are as follows, in the order to be performed:

Major Area	Reaches	At Downstream End of Reach No.	Against USGS Gage No.
Little Spokane (WRIA 55)	510 thru 580	550, 560, 580	4310
Hangman (WRIA 56)	610 thru 660	660	4240
Upper Spokane (WRIA 57)	710 thru 730	730	4225
Lower Spokane (WRIA 54)	410 thru 440 510 thru 590 610 thru 660 710 thru 730	440	4330

The first three areas can be calibrated independently, but the Lower Spokane must be calibrated including all of the tributary areas upstream. The length of proposed hydrologic calibration runs is two years.

The calibration process is primarily a trial and error fitting procedure. Parameters are assigned and the LANDS module run. The run results are plotted by LIBRARY together with recorded values. The closeness of the fit indicates how good the parameter selection was. By proper altering of parameters, the simulated results can be fit to the recorded data to achieve a best fit. There are a total of 37 parameters in 4 categories.

(1)	LANDS	16
(2)	SNOW	12
(3)	MOISTURE	7
(4)	SNOWPACK	2
	Total	37

Of this total, only about 6 parameters are expected to be manipulated to achieve satisfactory results.

The routing function is in the quality portion of the model. The usual hydrologic calibration procedure is to calibrate daily un-routed accumulations of runoff against daily stream flow records. The development of hydrographs in hourly steps is possible by extending the run to include that portion of the quality program which includes the routing function or to use the channels module.

Water Quality Simulation

The water quality simulation process combines point source and non-point source pollution inputs and manipulates the chemical and biological process in stream on a time step and flow progress basis, utilizing algorithms developed specifically for each parameter or parameter group.

The general methodology and the specific methodology for each parameter or parameter group is described in detail in a Hydrocomp publication by P.S. Lombardo and D.D. Franz titled Mathematical Model of Water Quality Indices in River and Impoundments, December 8, 1972. Chapters 1 and 2 of this publication are reproduced in Appendix I to make readily available the description of general methodology and limitations of the model.

Of particular concern in application of the model and selection of parameter groups for a particular run is the interdependence of these parameters in real life and as simulated. This interdependence is shown graphically in Figure 1.1 in Appendix I. The implication of these relationships for specifying the parameters required for a specific output are summarized in Table 3 which is also taken from Lombardo and Franz (1972).

One of the features of the HSP simulation of the lake reactions is the simulation of the rate of exchange of bottom layer nutrients with the benthal deposits as determined by calibration. The HSP simulation does not quantify the accumulation or the depletion of nutrients stored in the benthal deposits. HSP is not capable of simulating the gradual depletion of benthal accumulations following a reduction in nutrient input to the lake for the purpose of forecasting an improvement in lake quality which depends on substantial exhaustion of the deposits. Benthal deposits, if not sealed by sediment deposits, can release nutrients for a long period of time without being replenished. The simulation is incapable of evaluating this "long period of time". Refer to Chapter IX of Allen and Kramer (1972).

Meaning of Dy amic Simulation. Dynamic simulation means the simulation of water quality in a time sequence as the system responds to a time sequence of natural variables. The natural variables are the meteorological conditions and the consequent hydrologic events. The available description of the variability of natural events is historical. The goal of simulation modeling is to determine system response to present and forecast land use and pollutional input when reacting with natural events. It is assumed that historical meteorological events are a statistical representation of similar events that can occur in the future. Hence, the dynamic simulation process is one in which a fixed set of land use and pollutional inputs are reacted with an historical series of time variable natural events to produce a time variable series of resultant water quality. The output series of resultant water quality can be evaluated in terms of absolute values or can be subjected to statistical analysis for interpretation if the simulation runs are sufficiently long to be statistically valid.

The above reference to fixed pollution conditions does not mean that time variable pollutional events cannot be simulated. What it does mean is that the time variation must be a cycle that is completed within a year and that only one "pollution year" can be reacted at a time with an historical series of natural events in order for the output to have any statistical significance.

A typical simulation "run" would be for a fixed land use condition and for fixed pollution inputs, some of which may have a diurnal, seasonal or other variation in cyclical pattern of less than one years length, reacted with a selected number of years of natural variables. Each fixed land use and pollution input situation would represent the conditions at various levels of forecast growth or for various alternative wastewater management plans.

Data Inputs Required for Water Quality Simulation

Boundary Conditions. Water quality must be specified for boundary conditions which are for waters entering from outside the study area. Waters enter the study area as both surface and groundwaters. The surface flow for which quality must be specified is the Spokane River at Liberty Bridge, USGS gage 4195. The groundwater flow for which quality must be specified is the flow in the primary aquifer as it enters from Idaho. These boundary files, in so far as they reflect pollution added upstream as opposed to natural levels of constituents, should be for the pollution situation corresponding to the period for which the specific simulation run is to be representative.

The parameters which are to be included in the boundary files of water quality include all those which are to be simulated. See the listing above. Deletion can be made only for the reason that a particular parameter does not exist or does so only in negligible amounts in the boundary waters.

Temperature deserves special consideration for two reasons: (1) It is a reflection of the natural variables, and (2) It is critical to the rate of reaction of all the chemical and biological processes. Since temperature is a reflection of the natural variables, the file created must correspond to the file of other natural variables. That is, the temperature of the surface or groundwater should be that which corresponds to the meteorological events used as input data. If obtainable, the historical temperatures of the water should be used for the corresponding historical period of meteorological events.

For the Spokane River as it enters the study area, daily historical data are available only for January 1964 to September 1965. Beyond that period, only irregularly spaced observations are available. Study of the available record in 1964-65 indicates a wide range of annual variation and the need to develop a synthetic file for the full period of meteorological records. Such a synthetic file was prepared through development of a special simulation model. This model is described in Appendix II.

For the groundwater of the primary aquifer which augments the flow of both the Spokane and Little Spokane Rivers, the available data indicate a relatively stable year round temperature pattern. The magnitude of the groundwater augmentation of surface flows during the low surface flow season is such that the detail of the groundwater temperature file must be comparable to the surface water temperature file. The augmentation of the Spokane river is approximately one third to one half of the average summer surface flow. The augmentation of the Little Spokane is equal to or slightly in excess of the surface flow.

For the Spokane River as it enters the study area there are historical quality records in addition to data collected specifically for this project. These data indicate that negligible amounts are present for all except the following:

a. Dissolved Oxygen
b. BOD
c. Total Dissolved Solids
d. Total Coliforms
e. Fecal Coliforms
f. Nitrate
g. Ortho Phosphate
h. Zinc

Therefore, quality files for these parameters must be developed. Unlike temperature, these parameters, except for dissolved oxygen, are not associated with natural variables.

The HSP simulation requires the boundary dissolved oxygen (DO) to be expressed in terms of milligrams per liter (mg/l). The historical record indicates a significant variation of DO in terms of mg/l and an inverse correlation with water temperature. Due to the correlation with water temperature which in turn is correlated with natural variables, DO is dependent on the natural variable. This means that the DO file should correspond to the historical natural variable file. It is proposed to create this boundary DO file by a subroutine applied to the temperature file.

For the groundwater entering the study area through the primary aquifer, the ongoing sampling and analysis program under way by the U.S. Geological Survey (USGS) in cooperation with the Environmental Protection Agency (EPA) and other sources gives a picture of water quality. Examination of these data indicate that there are negligible amounts of all the simulation parameters except the following:

a. Temperature
b. Dissolved Oxygen
c. Total Dissolved Solids
d. Nitrate
e. Zinc

Therefore, quality files for these parameters must be developed. Due to the stable temperature condition in groundwater, DO is not dependent upon natural variables and the file created for this parameter need not develop such a relationship.

For all the surface water and groundwater boundary parameters, including DO, the currently observed levels and patterns of annual variation are a measure of the existing upstream land use and pollution situation. Simulation runs will consider the upstream conditions as they presently exist and the parameter files will be based on observed levels.

Point Sources. Although there are ninety-seven waste dischargers in the study area listed by the Department of Ecology, only the following nine are significant separate dischargers to surface waters. The remainder are either dischargers to the City of Spokane sewage treatment plant (City STP), Spokane Industrial Park sewage treatment plant (Ind. Pk. STP), or to land or leaching field disposal.

Name	Running Water
1. Hillyard Processing Co.	Spokane River
2. Inland Empire Paper Co.	Spokane River
3. Kaiser Aluminum, Trentwood	Spokane River
4. City STP	Spokane River
5. Spokane Industrial Park, STP	Spokane River
6. Culligan Soft Water	Spokane River
7. Deer Park STP	Dragoon Creek
8. Kaiser Aluminum	Peone Creek
9. Tekoa STP	Hangman Creek

The location of these existing point sources in the urban planning area is shown on Plate 606-2.

Quantity and quality files must be created for each of these point sources recognizing the conditions for each simulation run. The conditions to be recognized are whether the run is for existing or projected conditions and what degree or kind of treatment is operative.

For projected conditions and alternative wastewater management plans there will be additional point sources and some of the existing sources will be combined or relocated. These also will require generation of data input files of quantity and quality.

Combined Sewer Overflows. There are a large number of combined sewer overflows from the City of Spokane collection system. See Plate 606-2 for location. Pollutants of sanitary sewage and urban runoff origin are combined in these periodic overflows. Presumably, these overflows will exist in their present form only for simulation of present conditions. All projected conditions and alternative wastewater management plans will see either the elimination of these combined sewage overflows or their reduction and treatment. Therefore, there is no justification for development of an elaborate program to synthesize the quantity and quality of flows from the extremely complex existing conditions destined for significant change. Also, under existing conditions, there is bypassing of combined sewage at the City of Spokane STP concurrent with collection system overflows.

Simulation of existing conditions, including combined sewer overflows, is of interest only if there is extended rainfall concurrent with calibration. For existing conditions, it is proposed to develop a data file for the sanitary component separately, recognizing existing treatment. If necessary for calibration, untreated overflows will be estimated based on correlation with rainfall intensity durations known to cause overflow and bypass conditions.

For existing conditions the above assumptions will call for making the entire sanitary contribution at one point, namely the City STP in reach 420. This means that, for existing conditions, the quality module will not recognize the estimated sanitary component of overflows into reaches 730 and 660 which are lumped into reach 420.

Non-Point Sources. Both the developed and undeveloped land surface is the source of water quality constituents that are washed off by rainfall. The HSP simulation has the capability of quantifying these diffuse source or non-point source loads. The water quality constituents are assumed to accumulate on the land surfaces during period of no runoff. When runoff occurs, a portion of the accumulated constituents is washed off into the stream channel. The algorithms used to model these processes in the HSP simulation are detailed in Lombardo and Franz (1972).

In general, the processes are based on the following: (1) The water quality constituent accumulates at a rate directly proportional to time but with a limiting value, and (2) The wash off rate is proportional to the amount of accumulated constituent (logarithmic decrement). For each constituent or parameter to be simulated the following data must be developed, including different values for application in natural and urban areas:

Initial surface loading on impervious areas
Initial surface loading on pervious areas
Loading rate on impervious areas

Loading rate on pervious areas
Loading limit on impervious areas
Loading limit on pervious areas

A prerequisite to the above is the determination of the pervious and impervious areas in each segment.

There are limitations to the parameters that can and should be simulated from land wash off. The HSP program sets runoff water temperature equal to ambient air temperature and DO at saturation automatically. Hence, no additional data inputs are required for these parameters. Chlorophyll A, phytoplankton and zooplankton are assumed not to have existed on the dry surface before washoff and therefore are not programmed for washoff simulation. Most other parameters, as required, can be simulated for washoff including BOD, total dissolved solids, nutrients and coliforms.

A literature search has been made to provide a basis for the selection of the initial loading, loading rate and loading limit criteria for the parameters requiring simulation. These criteria selected from the literature will be the basis for simulation in the absence of specific field sampling for the study area.

The portion of the study area subject to urban development is proposed for special treatment regarding land surface runoff to facilitate consideration of stages of projected land use and alternative wastewater plans.* Significant existing and projected urban development are limited to reaches 590, 410, 660, 710, 720, and 730. It is proposed to make separate runs for these reaches considering various

* This method proposed in detail in Section 406.3 was not implemented.

projection levels and various structural alternatives. The output from these special "side" runs would be stored and used as input to be combined with output from the remainder of the basin which is unaffected by the urban variations.

The HSP simulation recognizes urban runoff that reaches the surface stream via sewers or other channels by designation of an appropriate fraction of the segment as "impervious." The impervious surfaces of urban areas that are not provided with sewers or channels but rather drain to "dry wells" or rely on area-wide percolation must be designated as "pervious." The overland flow time for areas designated "pervious" and "impervious" are simulated from input of average segment slope and average segment overland flow distance. Collection sewer or channel configuration within a reach are not recognized by the simulation.

It is not intended to use the HSP simulation as a tool for evaluation of storm drains or channels.

Return flows from agricultural irrigation are another potential non-point source. Data gathered thus far for this study area indicates that there is no significant return flow to surface waters. No data input for this source is planned.

Water Quality Calibration

A sampling and analysis program of water quality was conducted for the period noon September 18 to noon September 20, 1973 for the specific purpose of providing calibration data for the HSP simulation. The results of this sampling and analysis program are reported in Section 607 titled "Sampling and Analysis of Water Quality for Simulation Model Calibration." A second sampling period is proposed in the high flow and spring rain season of 1974.

Previous work, particularly by Soltero (1973), has shown that water quality conditions in Long Lake are the consequence of a summer long series of pollutional events and in-situ reactions. Therefore, the calibration period is selected to cover the period from the end of the high-runoff season through the low-flow period of summer to the sampling date, which was before the fall turnover ended lake stratification.

The water quality of Long Lake involves input from the entire study area. Before undertaking calibration at Long Lake, shorter calibration runs are planned for the upstream components which do not have the pollutional inertia of Long Lake. These runs can therefore be of shorter duration. The Little Spokane watershed is selected for calibration of a predominantly natural area first followed by Hangman Creek.

After calibration of the areas subject to non-point pollution from non-urban areas, the entire simulation area will be calibrated against the observed conditions in Long Lake during the September 1973 sampling period. These calibration runs will extend over the previous four months as described above.

Specific Model Application

Matching Goals to Model Capabilities. The most important characteristic of the HSP model is its ability to simulate dynamic changes with respect to reactions among many dependent variables and with respect to the cummulative effect over a long time period of these reactions. The dynamic characteristic makes this simulation model a most suitable tool for analysis of "how" and "why" certain undesirable pollution events take place. "How" and "why" analysis should be given higher priority in the use of this tool with respect to screening of alternatives over determination of absolute pollutional levels under extreme conditions. Concern for absolute pollution levels should be confined to final runs on selected alternatives.

For both the present and the future, the major sources of pollution are within the Spokane urban area. The Long Lake impoundment is the focal point of present concern for water quality. The storage volume is sufficiently large that the residence time for summer flows is of the order of two months. Available water quality data on Long Lake indicate that the pollutional events observed are the product of the cummulative effects of the entire season and are not significantly related to day by day changes in the river upstream.

How and why changes in the pollution load from the urban area affect the long term pollutional events in Long Lake should be the focus of specific simulation model application.

TABLE 1

METEOROLOGICAL DATA FILES
CREATED FOR SIMULATION MODELING

Parameter	Units	Frequency of Data	Station Records Available* Number	Name
Precipitation	inches	Hourly	101956	Coeur D'Alene R.S.
			107188	Plummber 3WSW
			457983	Spokane WBAS
Precipitation	inches	Daily	452066	Deer Park 2E
			455674	Mt. Spokane Summit
			455844	Newport
			457180	Rosalia
			458348	Tekoa
			459058	Wellpinit
Temperature	^{o}F	Semi-Daily	452066	Deer Park 2E
			455674	Mt. Spokane Summit
			455844	Newport
			457180	Rosalia
			457938	Spokane WBAS
			459058	Wellpinit
Solar Radiation	langleys	Daily	24157	Spokane WBAS
Dew Point Temp	^{o}F	Daily	24157	Spokane WBAS
Wind Velocity	Total miles	Daily	24157	Spokane WBAS
Evaporation	inches/ day	Semi-Monthly	24157	Spokane WBAS
Cloud Cover	tenths	Daily	24157	Spokane WBAS

*All records available are for the period January 1953 through September 1973.

TABLE 2

DEFINITION OF SEGMENTS

Area	Segment No.	Elevation Range, Feet From	To	Precipitation, Inches Mean Annual
400	41	1500	2000	18
(WRIA 54)	42	2000	2500	18
Lower Spokane	43	2500	+	18
500	51	1600	2500	22
(WRIA 55)	52	2500	3000	22
Little Spokane	53	3000	+	22
	54	2000	3000	26
	55	3000	+	40
600	61	1700	2500	20
(WRIA 56)	62	2500	3000	20
Hangman	63	2500	3000	24
	64	3000	+	24
700	71	1700	2500	20
(WRIA 57)	72	2500	3000	20
Upper Spokane	73	3000	+	20

TABLE 3

WATER QUALITY PARAMETER INTERDEPENDENCE

PARAMETER TO BE SIMULATED	OTHER PARAMETERS THAT MUST BE SIMULATED CONCURRENTLY
Temperature, Total Dissolved Solids, Turbidity and any Conservative Constituents	May be simulated without other constituents.
Coliforms (Total, Fecal, Fecal Streptococci)	Requires temperature simulation.
Dissolved Oxygen	Requires a minimum of temperature and BOD simulation, although BOD may be stated as being zero.
BOD	Requires temperature and dissolved oxygen simulation.
Algae - Benthic and Phytoplankton (Chlorophyll A)	Requires temperature, dissolved oxygen, BOD, nitrogen and phosphorus forms (minimum of NO3 and PO4), and zooplankton (phytoplankton only).
Zooplankton	Requires same indices as phytoplankton.
Nutrients (nitrogen and phosphorus forms)	Dependent upon processes in which these constituents are involved. For instance, to simulate nitrification temperature, dissolved oxygen and BOD are required.

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APPENDIX I

Chapters 1 and 2

of

MATHEMATICAL MODEL OF WATER QUALITY INDICES IN RIVERS AND IMPOUNDMENTS

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INTRODUCTION

In order to better protect our aquatic resources, water quality management plans are currently being emphasized. A major problem in designing management plans has been the method of evaluating the quality of a water body and the effects of the various influences on the aquatic system.

To accurately assess the quality of a water body, a number of water quality indices must be used jointly, including temperature, dissolved oxygen, total dissolved solids, coliforms and nutrients. Sporadic measurements of these indices are insufficient for water quality analysis as their values can fluctuate greatly over a short time interval. Data presented by O'Connor and DiToro (1970) showed fivefold diurnal fluctuations of dissolved oxygen in Flint River, Michigan. Also, the concentration of nutrients does not give an accurate indication of their potential effects (Shapiro, 1970). Knowledge of the dynamic behavior of the quality indices of a water body would allow one to have a better understanding of the aquatic system's expected behavior. Through mathematical formulations of the physical, biological and chemical processes occurring in the aquatic ecosystem, water quality models attempt to simulate the spatial and temporal variations of water quality indices.

Through input of water quality parameters, climatological and hydrological data, water quality modeling will provide information from which one can determine the probable causes of the changes in values of water quality indices. Simulation of water quality indices for a historic period provides a base for evaluating the probability of occurrence of critical quality conditions necessary for meaningful economic analysis of quality standards and quality control procedures.

Various management policies can be evaluated in terms of water quality indices through the use of modeling. The effect of location of treatment plants and levels of treatment on a stream's quality can be determined. The effects of development of a watershed on lake or river quality can be evaluated. Through the information generated by water quality modeling on the probable effects of alternative policies, optimization of the various alternatives can be achieved. The knowledge obtained through water quality modeling will provide a better understanding of the behavior of the aquatic system and assist in its proper management.

The hydrologic system greatly influences the quality of a water body. The assumption of steady-state hydrologic conditions may be justified for some water bodies during short time intervals, e.g. summer low flows. However, for long term analysis and sensitivity studies of various management policies, e.g. sewage treatment versus land disposal, it is necessary to model the dynamics of the hydrologic system t accurately analyze the water quality conditions of an aquatic system.

Hydrocomp's Water Quality Model simulates the dynamic behavior of most water quality indices. The model is deterministic in that cause and effect relationships are utilized to define the behavior of water quality indices. A numerical solution is used to solve the differential equations describing the dynamics of water quality behavior. The time interval used is one hour.

The Hydrocomp Water Quality Model may be used in combination with the Hydrocomp Hydrologic Simulation Program or alone with the user specifying the hydrologic flow conditions.

The water quality indices that can be simulated are:

Temperature	*Nitrate*
Total Dissolved Solids	*Nitrite*
Dissolved Oxygen	*Ammonia*
Carbonaceous Biochemical Oxygen Demand	*Total Nitrogen*
Coliforms (Total, Fecal, Fecal Streptococci)	*Phosphate*
Algae - Chlorophyll a	*Potential Phosphorous*
Zooplankton	*Conservative Constituents (Metals, Chloride, etc.)*

A flow chart of the Hydrocomp Water Quality Model is presented in Figure 1.1. The processes illustrated are analyzed for each time period and each stream segment or impoundment layer. The effects of advection have been omitted from Figure 1.1 to make it more readable. Advection effects are determined by a mass balance for each water quality index.

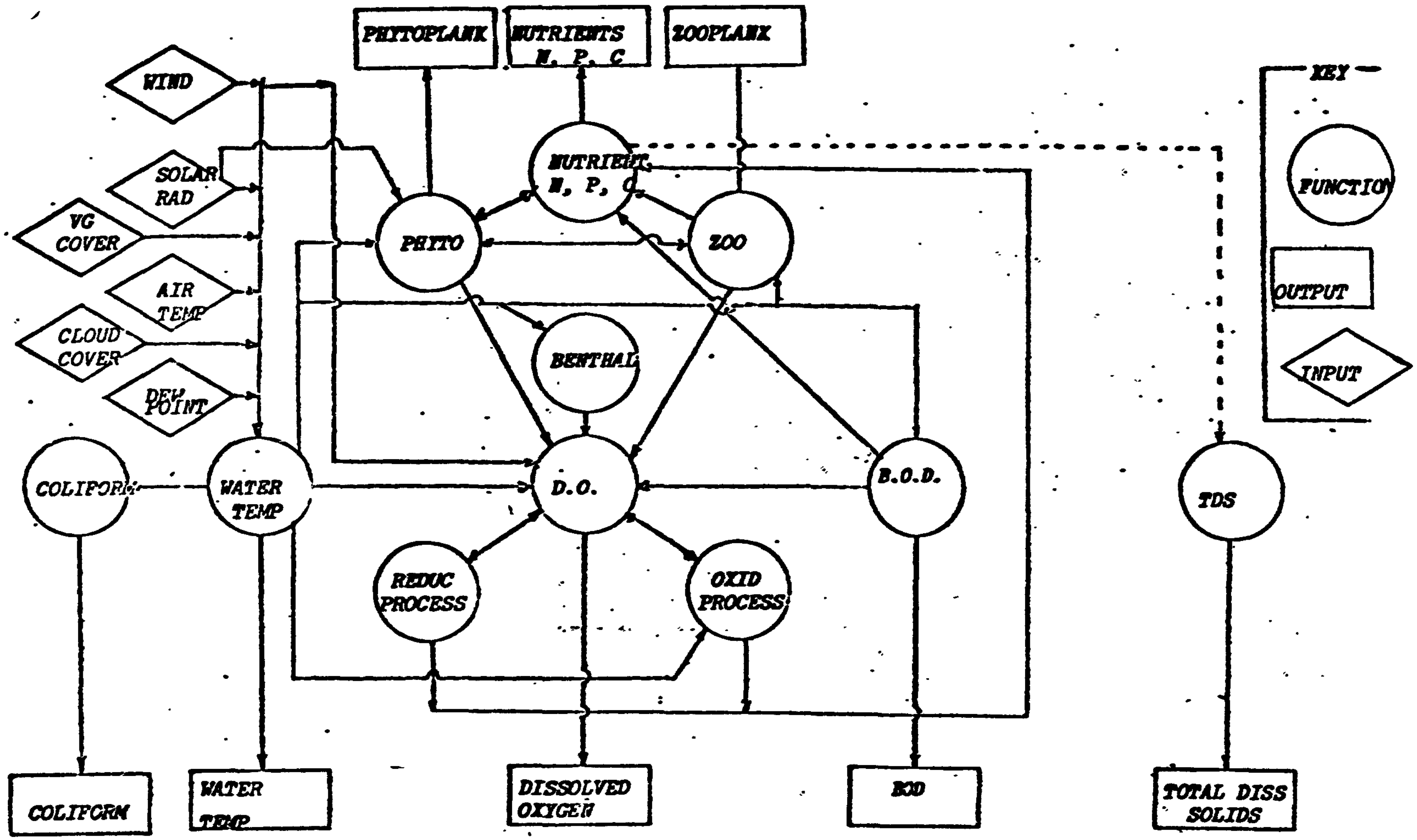


FIGURE 1.1 HYDROCOMP QUALITY FLOWCHART

There are many problems involved in applying mathematical formulations to the aquatic system. Presently, parts of the system do not lend themselves very nicely to mathematical analysis, due to the enormous interactions and complexities in the aquatic environment. Also we are dealing with the biological community of which we are members, so we should have a feeling for the limitations involved in using quantitative cause and effect relationships in describing the behavior of the aquatic system. Past history, adaptability and species changes can discount the utility of some of the mathematical formulations in the model. For this reason, the model has been constructed to allow the user considerable flexibility in determining how the model is to simulate the behavior of the aquatic system. For proper utilization of the model's potential as a planning tool requires knowledge of the specific aquatic system in question and of general aquatic systems.

The model is a tool which combines much of our quantitative knowledge of the aquatic environment. This quantification is the model's greatest asset and its limitation. The significance of this limitation will be determined by the system being simulated and the questions that are being asked. Observations and judgments on the condition of an aquatic system under question not only aid in the utilization of the model but more importantly lend veracity to model results. The model is a tool and as such can be valuable in decision making. However, for its proper utilization, its assets and limitations need to be considered.

METHODOLOGY

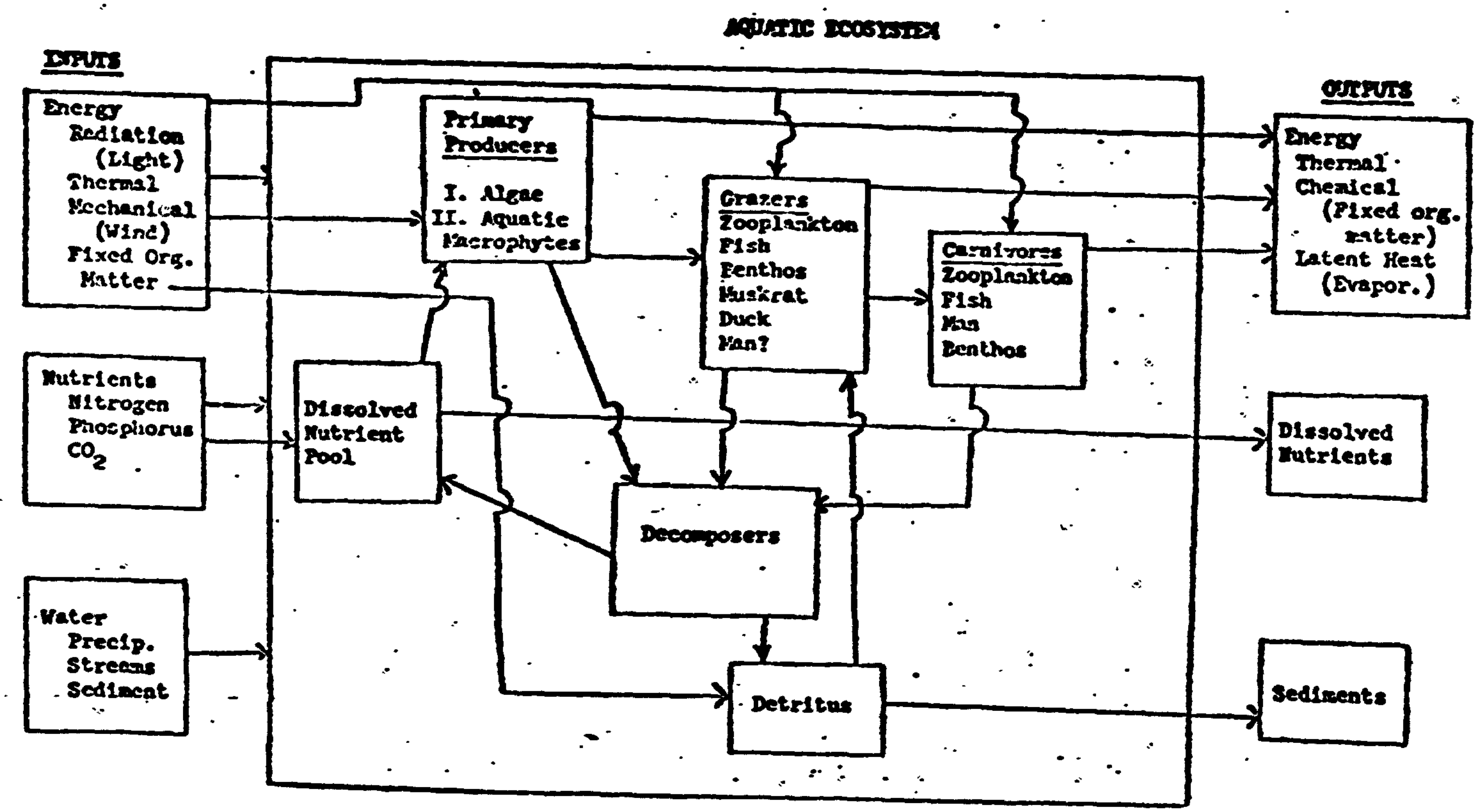
To describe mathematically the behavior of quality indices in the aquatic ecosystem, a method must be established to model the various processes occurring in the stream. The value of a water quality index at a particular time and place is dependent on the rate of the various processes influencing the index. As can be seen from Figure 2.1, there are numerous sources and sinks for the various compartments of the aquatic ecosystem.

The dynamics of a compartment, A , is represented by:

$$\frac{\partial A}{\partial t} = So_A - Si_A \qquad (2.1)$$

where So is the sum of the sources of A and Si is the sum of the sinks of A. The finite difference method is used to solve equation 2.1 by using a small time interval and determining the sources and sinks of A during that time interval. During each time interval, it is assumed that the rates of the various sources and sinks are constant. Thus, equation 2.1 can be rewritten as:

$$\frac{\Delta A}{\Delta t} = So_A - Si_A \qquad (2.2)$$



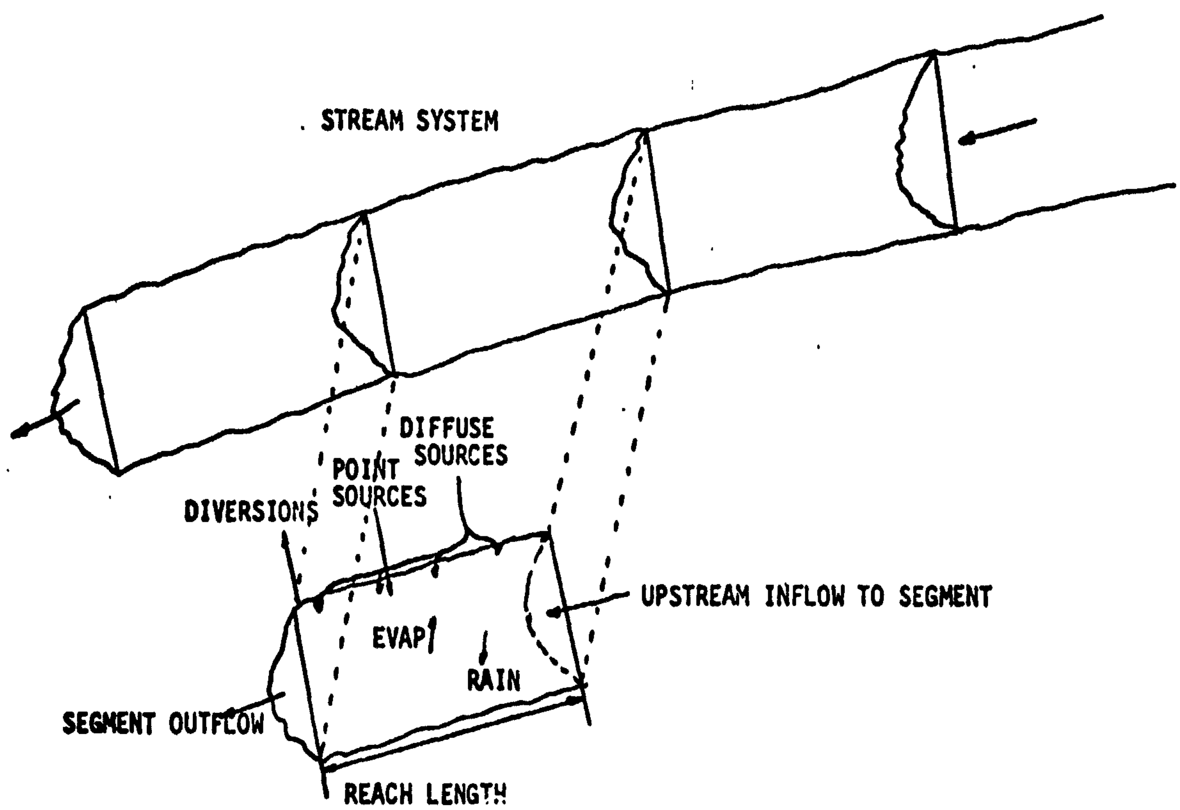
A compartment model showing (1) the major inputs, (2) the pools of plants, animals, dissolved nutrients and detritus, and (3) the major outputs of an aquatic ecosystem
From Watts and Loucks (1969)

Figure 2.1

In the aquatic ecosystem, many different processes are occurring simultaneously and influence one another. However, each process must be considered separately in the model and assumed to be constant for the time period. To minimize the error involved in this procedure, the time interval must be chosen such that the dynamic character of the aquatic ecosystem can be properly considered. Under nutrient limiting conditions for example, growth of algae depletes the nutrients available, which in turn decreases the growth rate. Other processes in the aquatic ecosystem are also contributing to and depleting the nutrients available. Simulation on an hourly basis has proven successful (Lombardo, 1971) and is thought to be valid (Dugdale, 1970).

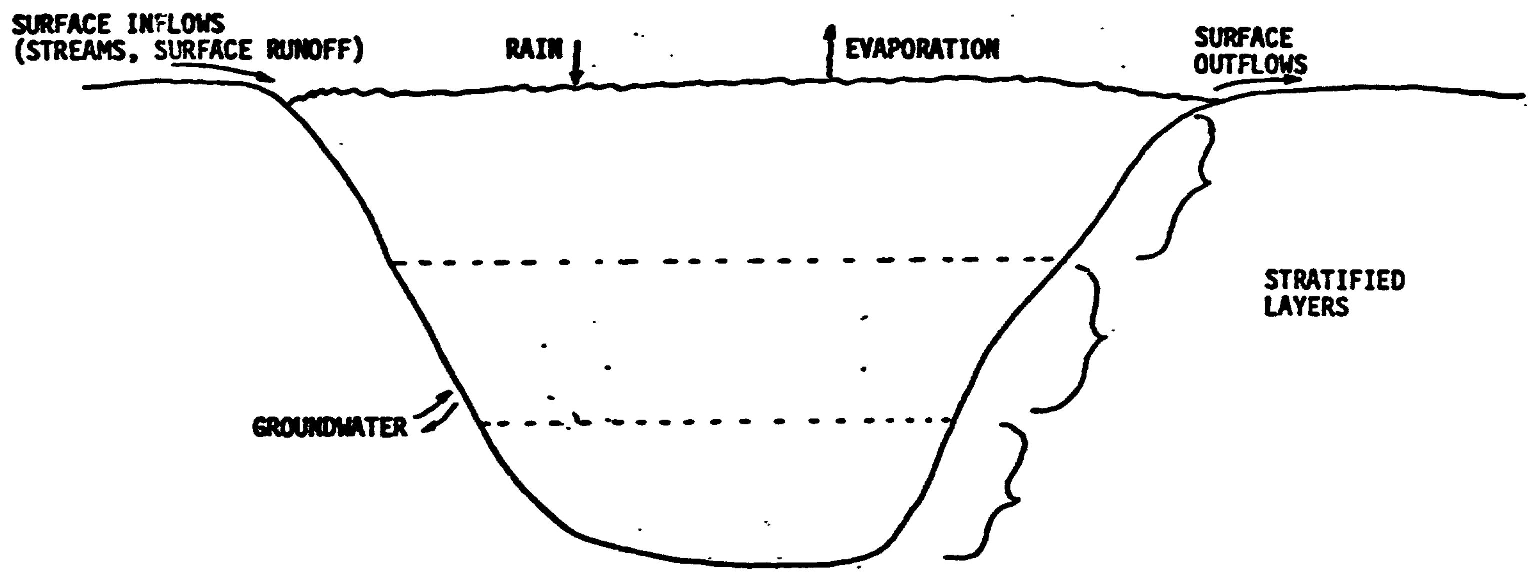
A stream system is divided into reaches (Figure 2.2) and it is assumed that there is complete mixing within each reach. During each time period, the transfer of water into and out of each reach is determined and the chemical and biological processes computed. An impoundment is considered similar to a stream reach except that there can be stratification in an impoundment (Figure 2.3). Stratification is analyzed by assuming that an impoundment consists of three layers and that there is mixing between the layers. The mixing coefficient, the fraction of a layer mixed with another layer, is assumed to be a function of the time of year to approximate the various mixing phenomena that occur in impoundments.

The transport of water quality consistuents in the channel system will be modeled by using the technique suggested by Bella and Dobbins (1968). This methodology applies the different transport effects sequentially. The experience of Goodman and Tucker (1969),



REPRESENTATION OF STREAM HYDROLOGIC SYSTEM

Figure 2.2



REPRESENTATION OF IMPOUNDMENT SYSTEM

Figure 2.3

Feigner and Harris (1970) and Metcalf & Eddy, et al (1971) has shown that eddy diffusion plays a very minor role in streams and estuaries. Hence eddy diffusion is not included in the Hydrocomp Water Quality Model.

Advection transports a constituent by movement of the parcel of water containing the constituent. Very simply, the mass Ma of a constituent transported out of the i-th reach and into the downstream reach in a time increment of Δt is:

$$M_a = Q_i \, C_i^* \quad \Delta t$$
$$C_i^* = ALPHA \; C_i^{(t)} + (1. - ALPHA) \; C_i^{(t+1)} \qquad (2.3)$$

where c* is a weighted average of the concentrations in the receiving and source reaches, ALPHA is the time weighing fraction, and Qi is the discharge out of the i-th reach during the time interval. The studies on numerical dispersion reported in Feigner and Harris (1970) show that a simple average of the concentrations is unstable although it gave good accuracy. The weights actually used by them are discussed in the review above. Longitudinal dispersion actually occurs in a stream because water in the central portion of a stream moves more rapidly than water near the banks. An injected constituent is dispersed along the length of the stream by these velocity differences. Although the simulation model uses a mean velocity, the unavoidable numerical dispersion in the computation serves to model the dispersion in the stream. However, care must be exercised to ensure that this dispersion effect is not excessive.

Harper (1972) concluded that simplification of his multi-parametric mathematical model by assuming the dispersion process to be negligible had no significant impact on model accuracy. He based this conclusion on results from sensitivity analysis and temperature verification.

APPENDIX II

CREATION OF A SYNTHETIC BOUNDARY WATER TEMPERATURE FILE

This is to outline a methodology for preparation of a file of mean daily water temperatures of the Spokane River as it enters the study area across the Washington-Idaho boundary. The temperature file is to synthesize the temperatures that occur under ambient meteorological conditions to supplement available recorded data. Those data are used as a check of the developed method.

The model boundary is at USGS stream gage number 4195 at RM 93.9. This is 8.2 miles downstream from Post Falls Dam, RM 102.1, and 17.2 miles downstream from the outlet of Coeur D'Alene Lake. The nine miles from the natural outlet to Post Falls Dam is essentially a narrow arm of the lake under normal operating conditions, whereas the reach below Post Falls Dam to RM 93.9 is a free flowing river with a slope of approximately six feet per mile. Available water temperature records indicate that the observed temperature at RM 93.9 is generally within one degree Fahrenheit, plus or minus , of the observed temperature in Coeur D'Alene Lake. This is taken as an indication that a simulation of lake temperature will satisfactorily represent river temperature and that it is unnecessary to simulate heat gain or loss in the intervening lake arm or free flowing river.

A simulation of lake temperature has been developed based on meteorological variables reacting with an element of lake water regarded as two variable depths for the epilimnion and hypolimnion layers. The meteorological parameters selected for the reaction are as follows, all expressed as mean daily values:

1. Solar radiation.
2. Maximum air temperature.
3. Minimum air temperature.
4. Dew point temperature.
5. Cloud cover.
6. Wind velocity.

These parameters are reacted with the element of lake water by the heat transfer relationships shown below which include three calibration coefficients. These three calibration coefficients involve empirical adjustment to (1) the quantity of evaporated water, (2) the heat of convection and (3) the heat transfer due to conduction between the epilimnion and the hypolimnion. A relationship between wind velocity and depth of the epilimnion is arrived at empirically and is regarded as a calibration constant. The best fit relationship is found to be a catinary with a fixed maximum of 40 feet depth for wind speeds in excess of 10 miles per hour.

The method of calibration consists of fitting the computed output to the available daily record extending from October 1964 to September 1965. The resultant fit achieves temperature matching within three degrees Fahrenheit generally, except that short term "real world" spikes of temperature rise and fall are not followed which may result in short term under or overstatement of up to eight degrees Fahrenheit. That is, the simulated temperature curve appears as a smoother damped version of the actual temperature pattern.

The creation of the synthesized water temperature file is not performed within the HSP simulation. The HSP simulation does not contain this program which is specially developed for this study by Kennedy-Tudor. The water temperature file is created in a separate computer and the results are loaded into the data storage of the HSP simulation. The temperature calculation is outlined below.

Temperature Calculations

Using the heat balance approach, the rate of change of temperature is computed by:

$$\frac{\partial T_w}{\partial t} = (Q_t \cdot A/c_p + M_i T_{wi} - M_o T_w)/M$$

where T_w is the water temperature, t is time, Q_t is the heat transfer between the water and the atmosphere, A is the surface area, M_i is the water mass of inflows with temperature T_{wi}, M_o is the water mass of the outflows, M is the mass of the water body and c_p is the heat capacity of water. In this specific problem, A and c_p are unity and $M_i = T_{wi} = M_o = c$. Thus the basic equation reduced to:

$$\frac{\partial T_w}{\partial t} = \frac{Q_t}{M}$$

The elements of Q_t are:

$$Q_t = Q_{sw} + Q_B - Q_e + Q_c$$

where

Q_{sw} = heat gain due to short wave solar radiation

Q_B = heat gain due to long wave radiation

Q_e = heat loss due to evaporation

Q_c = heat gain or loss due to convection by the air.

Each of these terms is evaluated as follows:

$$Q_{sw} = (1 - R)Q_{sr}$$

where Q_{sr} is the short wave solar radiation in langleys per day as measured by the Weather Bureau and R is the reflectivity of the water taken at 0.3 as suggested by P.S. Lombardo et al., 1972.

$$Q_B = Q_{at} - Q_w$$

where Q_{at} is the net atmospheric long wave radiation absorbed by water, Kcal/m^2/hr, represented by:

$$Q_{at} = 0.937 \cdot 10^5 \cdot \sigma \cdot T_a^{\ 6} (1 + 0.17c^2)(1 - RL)$$

where σ is the Stefan-Boltsman constant, 4.88 x 10^8 kcal/m^2/hr/°K^4, T_a is the air temperature in °Kelvin, c is the fraction of cloud cover, and RL is the reflectivity of the water for atmospheric radiation = 0.03. (P.S. Lombardo et al., 1970.)

The long wave radiation emitted by the water body, Q_w in Kcal/m^2/hr, is expressed by:

$$Q_w = 0.97 \sigma T_w^{\ 4}$$

where T_w = water temperature °K. Heat loss due to evaporation is:

$$Q_e = dL_wE$$

(TVA, 1970) where d is the water density in Kg/m^3, L_w is the latent heat of evaporation in Kcal/kg = 597.3 - 0.57 (T_w - 273) and E is the evaporated water in meters depth per hour given by:

$$E = EVAPK * 10^{-9} U(e_w - e_a)$$

where EVAPK is an empirical coefficient used for calibration ranging from 1 - 5/mb. U is the wind velocity, 2 meters above the water surface in m/hr, e_w is the vapor pressure of the water and e_a is the vapor pressure of the air in millibars.

The heat of convection, in $Kcal/m^2/hr$, is represented by:

$$Q_c = CONVK * 10^{-4} p/P_o U(T_a - T_w)$$

(TVA, 1970) where p is the barometric pressure at the site, P_o is the sea level pressure and CONVK is the calibration coefficient of convection, range 1-20. T_a and T_w are in °C here and below.

The heat transfer due to conduction between the epilimnion and hypolimnion in Kcal/day is:

$$Q_K = CONDK (T_a - T_w)$$

where CONDK is an empirical coefficient used in calibration, $Kcal/m^2$/°C/day. When turnover occurs, mixing of the epilimnion and hypolimnion is represented by:

$$T_w = T_h = (T_w D_e + T_n D)/(D_e + D)$$

where T_h is the temperature of the hypolimnion, D_e is the depth of the epilimnion and D is the lake depth in feet. Mixing occurs when the epilimnion temperature falls below the hypolimnion temperature except when the hypolimnion is at 4°C, the temperature of maximum density, then the conduction equation is used.

The depth of the epilimnion is a function of the wind velocity. The catinary relationship is selected empirically:

$$D = 2(2.9^{w/4} + 2.9^{-w/4})$$

where w = wind speed in mph and D = depth in feet.

The calibration constants selected for best fit are:

EVAPK = 0.06
CONVK = 18
CONDK = 5.

APPENDIX II -- REFERENCES

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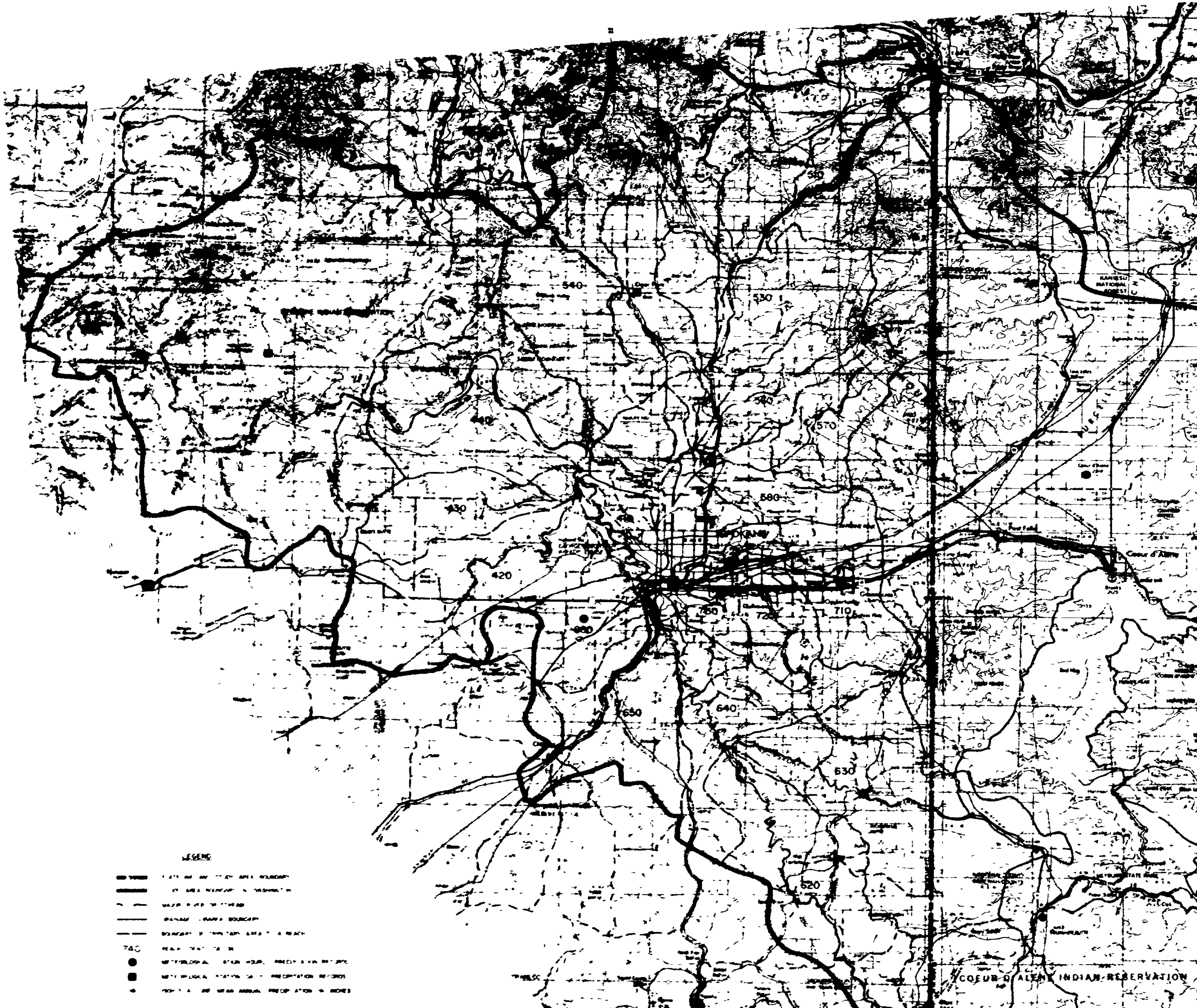
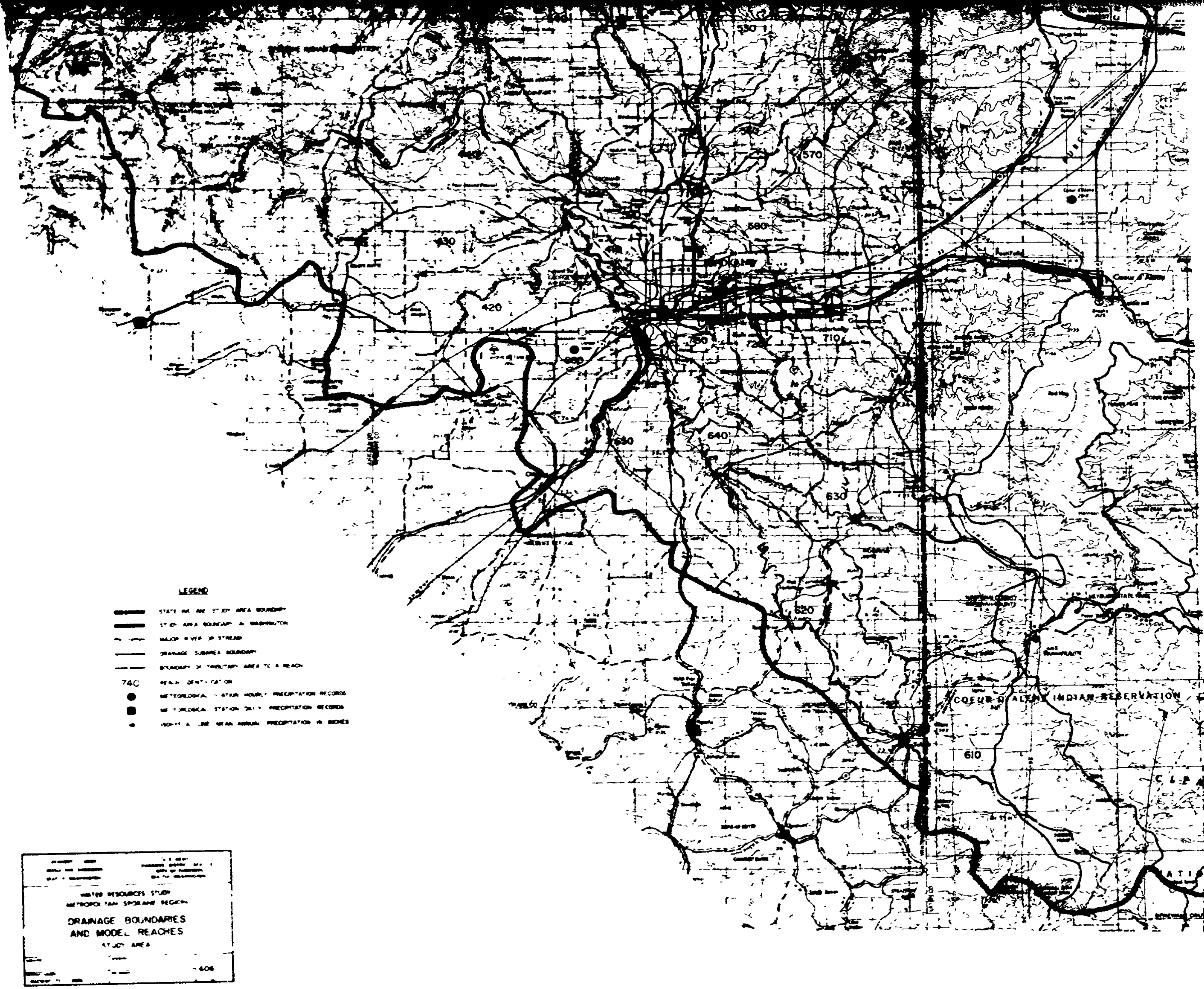
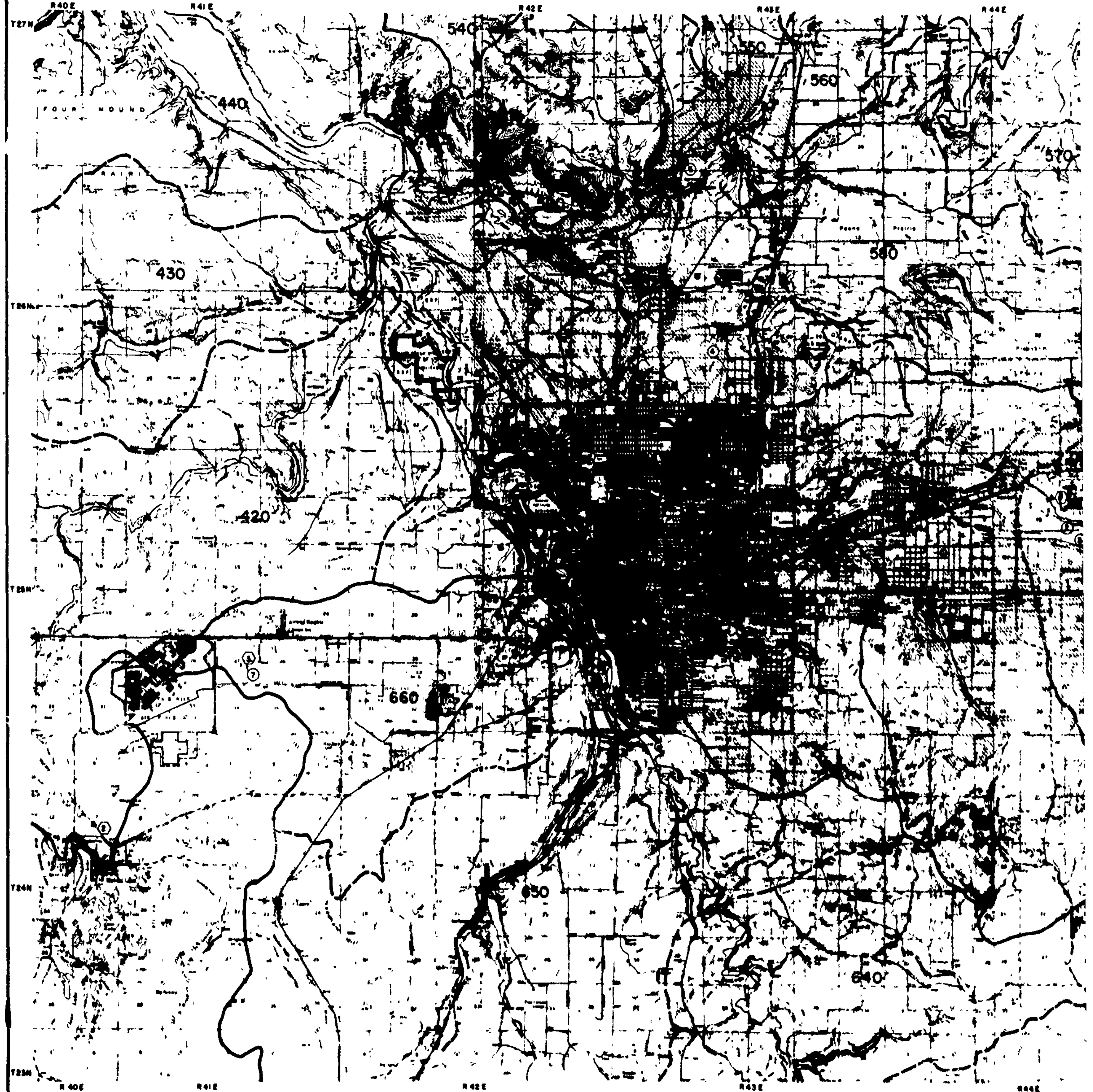

LEGEND
COEUR D'ALENE INDIAN RESERVATION



LEGEND
COEUR D'ALENE INDIAN RESERVATION
420
430
570
580
610
620
630
640
650
690
710
720
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
DRAINAGE BOUNDARIES
AND MODEL REACHES



MAP SOURCE USGS 15 MINUTE QUADRANGLE SERIES, CLAYTON WASH 1950, DEER PARK WASH 1940, MT SPOKANE WASH - IDAHO 1986
MEDICAL LAKE WASH 1964, SPOKANE WASH 1950, GREENACRES WASH - IDAHO 1949

1/2 0 1 2 3 4 MILES

3000 0 3000 9000 15000 21000 FEET

GRAPHIC SCALES

REVISIONS

SYMBOL	DESCRIPTION	DATE	BY

GENERAL LOCATION OF AREAS SERVED BY SPOKANE CO STORM RUNOFF COLLECTION SYSTEMS

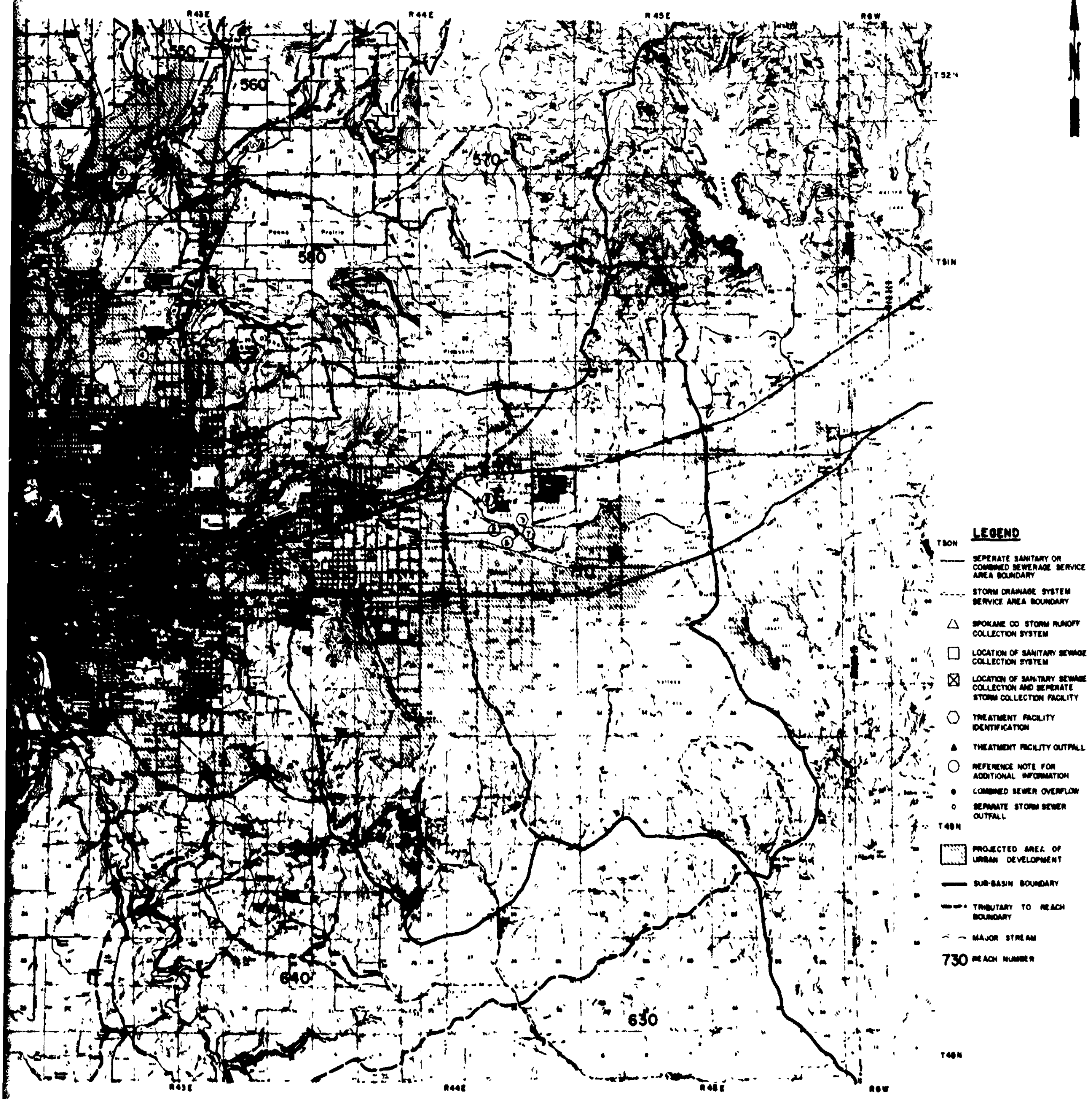
1. COUNTRY HOMES BLVD
2. HURWOOD PARK NO 1
3. HURWOOD CREST NO 1 & 2
4. WALL ST
5. WEDGEWOOD CT
6. DEARBORN DR

TREATMENT PLANT IDENTIFICATION

(1) CITY OF SPOKANE SEWAGE TREATMENT PLANT
(2) MEDICAL LAKE SEWAGE TREATMENT PLANT
(3) FAIRCHILD A F B SEWAGE TREATMENT PLANT
(4) MILLWOOD SEWAGE TREATMENT PLANT
(5) KAISER TRENTWOOD TREATMENT PLANT
(6) SPOKANE INDUSTRIAL PARK TREATMENT PLANT
(7) HILLYARD PROCESSING TREATMENT PLANT
(8) INLAND EMPIRE PAPER CO TREATMENT PLANT
(9) KAISER MEAD SOUTH TREATMENT PLANT
(10) KAISER MEAD TREATMENT PLANT

REFERENCE NOTES

(1) MILLWOOD COLLECTION SYSTEM SERVES ONLY PORTION OF TOWN
(2) SPOKANE INDUSTRIAL PARK TREATMENT PLANT OUTFALL
(3) HILLYARD PROCESSING TREATMENT PLANT OUTFALL
(4) TREATMENT FACILITY UTILIZES DRAINFIELDS
(5) DISCHARGE POINT OF KAISER MEAD TREATMENT PLANT
(6) DISCHARGE POINT FOR STORM DRAINS STATE HWY 395
(7) TREATMENT PLANT UTILIZES DRAINFIELDS OR POND



15 MINUTE QUADRANGLE SERIES, CLAYTON WASH 1950, DEER PARK WASH 1949, MT SPOKANE WASH-IDAHO 1950,
...CAL LAKE WASH 1964, SPOKANE WASH 1950, GREENACRES WASH-IDAHO 1949

...OD SEWAGE TREATMENT PLANT
...-TRENTWOOD TREATMENT PLANT
...E INDUSTRIAL PARK TREATMENT PLANT
...D PROCESSING TREATMENT PLANT
...D EMPIRE PAPER CO TREATMENT PLANT
...-MEAD SOUTH TREATMENT PLANT
...-MEAD TREATMENT PLANT

REFERENCE NOTES

1. MILLWOOD COLLECTION SYSTEM SERVES ONLY PORTION OF TOWN
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7. TREATMENT PLANT UTILIZES DRAINFIELDS OR POND

KENNEDY TUDOR
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SEATTLE WASHINGTON

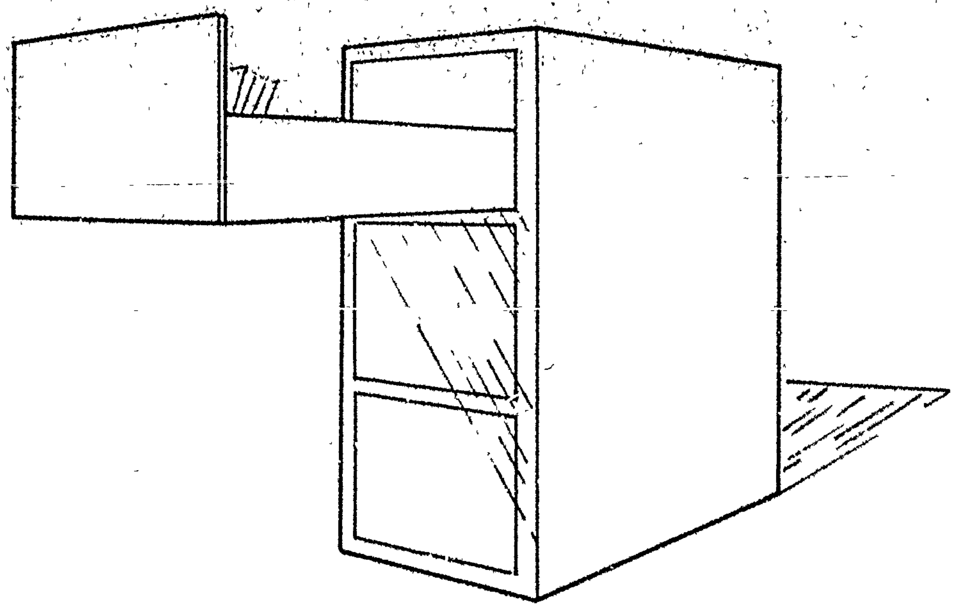
U S ARMY
ENGINEER DISTRICT SEATTLE
CORPS OF ENGINEERS
SEATTLE WASHINGTON

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

DRAINAGE BOUNDARIES AND MODEL REACHES

URBAN PLANNING AREA

PLATE 606-2



SECTION 606.3

POINT SOURCE INPUT FILES FOR YEAR 2000 SIMULATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 606.3

POINT SOURCE INPUT FILES FOR
YEAR 2000 SIMULATION

15 July 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

TABLE INDEX

APPENDICES INDEX

SECTION 606.3

POINT SOURCE INPUT FILES FOR YEAR 2000 SIMULATION

Objectives

The objectives of this section are to state the criteria for the year 2000 simulation condition and to develop the point source files corresponding to these conditions.

Criteria

Criteria for the year 2000 simulation are as follows:

1. The simulation will be for a 17 month period utilizing the meteorological and boundary streamflow files for the period May 1, 1968 through September 30, 1969, the identical period used for simulation of the zero point source condition.
2. The urban area wastewater management plan assumed to have been implemented and in operation at year 2000 is Plan A with North Spokane and the City served by the City STP and Spokane Valley served by a separate plant near Felts Field, both to surface water disposal.
3. It is assumed that the City of Spokane will have solved its combined sewer overflow problem in a manner equivalent to storm sewer separation; that is, it is assumed that all of the sanitary component receives the

equivalent of secondary treatment and all of the storm runoff receives no treatment.

4. Treatment of municipal wastes is to 1983 standards plus seasonal phosphorus removal in all plants with an average daily flow in excess of 0.5 mgd.

5. Treatment of industrial wastes discharged separately from municipal systems is assumed to result in pollutant discharges corresponding to controls provided by current waste discharge permits.

6. Point sources discharging to the Spokane River and tributaries at year 2000 are:

   a. Municipal Sources

      (1) City of Spokane (including North Spokane flow)

      (2) Spokane Valley

      (3) Deer Park

      (4) Tekoa

   b. Industrial Sources

      (1) Spokane Valley

      (2) North Spokane

   It is assumed that Spokane Valley has implemented a sewage collection system with separate sanitary sewers and that Spokane Valley urban runoff continues to be disposed of by infiltration-percolation. It is assumed that no effluent from West Plains communities reaches the the Spokane River.

The forecast of industrial growth in the City of Spokane concludes that there will continue to be no industries that would be of such character as to have waste discharges separate from the municipal system.

7. North Spokane will have a separate storm water collection system with a surface water discharge to the lower reach of the Little Spokane River.

8. The impact of City of Spokane and North Spokane urban runoff to surface waters is not represented by a point source file since it is included as a diffuse load in the simulation.

9. The Spokane River boundary water quality file is unchanged from that generated to represent current water quality except that it is assumed that the coliform content will have been brought to the standards for a Class A stream, namely 50 organisms per 100 ml of total coliforms.

City of Spokane STP

The point source file for the City of Spokane STP effluent at year 2000 as developed herein is shown in Table 1. The service population for the combined service areas of the City and North Spokane is forecast to be 233,909 as developed in Section 406.2. Under Plan A it is assumed that this population and the associated commercial and light industry components are served by the committed activated sludge secondary treatment plant of 40 mgd nominal capacity.

The committed treatment plant is expected to provide secondary treatment which will meet 1983 standards plus 85 percent phosphorus removal. Current Department of Ecology directives specify operation with year around phosphorus removal. The selected operation incorporated in the point source file is for phosphorus removal on a seasonal basis from May first to October fifteenth with no phosphorus removal except that incidental to secondary treatment for the remainder of the year. This mode of operation is selected to evaluate Long Lake performance under seasonal phosphorus removal conditions.

The mean annual forecast flow for the service population at year 2000 is 40.05 mgd, which is equal to 62 cfs. The historical annual flow pattern for the City shows a significant increase in summer but the mass pollutant load remains relatively constant. There is also a significant month-by-month variation in sewage temperature. It is assumed that the future flow conditions will reflect these historical conditions.

The simulation model can accept point source files expressed in terms of either flow and constituent concentration or as mass emissions of constituents. Since the City STP effluent has components expressed in both manners, the data for this one source are expressed in terms of two files. One file in terms of flow and constituent concentration expresses the variation throughout the year of flow, temperature, and dissolved oxygen (DO). Coliforms are also included in this file, not because a significant annual variation is expected, but to express this parameter in the same terms in which it is controlled, namely, concentration. The second file, in terms of mass emissions, includes those parameters which remain relatively constant while water use increases during summer months. (The advent of a significant food processing industry could reverse this condition and show greater strength in summer together with higher flows). Included in this group are BOD, phosphorus, nitrogen compounds and total dissolved solids (TDS). Table 1 shows the data for both files, actual separation taking place only in the details of entering the data.

Appendix I shows the data from which Table 1 is developed. The semi-monthly variation in temperature is taken directly from historical data, not shown in Appendix I, but added directly to Table 1. Historical DO data are for the existing primary plant and its particular effluent structure and are judged to be not representative of future conditions. In order to evaluate criticality of DO at year 2000 conditions it is conservatively assumed that there is no significant reaeration of effluent and that the effluent is typically at 30 percent of saturation (adjusted for an altitude of 2000 feet) for the wastewater temperature. (Any excessive DO sag revealed by the simulation will be the basis for recommending reaeration.)

Total dissolved solids (TDS) are based on a forecast that the incremental addition to water supply levels by municipal use will be the same as historical. The groundwater supply has an average TDS of 170 mg/l and the historical effluent averages 400 mg/l or greater when there is no dilution from storm runoff. Since there is expected to be a [illegible] infiltration [illegible] and separation of storm flows, the TDS is expected to be of the order 440 mg/l after these corrections take place.

The simulation requires that phosphorus be expressed in terms of both ortho phosphate and potential phosphate. The potential phosphorus is assumed to be organically combined and to be associated with the effluent BOD in the proportion of 0.007 for typical organic materials.

Fecal coliform content of the treated wastewater is assumed to be at the upper permissible limit established by BPWTT* for the 30-day mean 200 organisms/100 ml, at all times except two semi-monthly periods during the critical recreation season during which it is assumed that the level rises to the allowable maximum for the 7-day mean, 400 organisms/100 ml. These upper limits are selected to test the criticality of the control of this parameter at statutory limits and to evaluate the possible need for performance better than the statutory requirement. Total coliform are expected to be present in the ratio of 2 total to 1 fecal per historical experience.

The potential need for nitrification to reduce the threat of ammonia toxicity at critical low flow periods has been identified elsewhere in this study. It is desirable to confirm this need in the simulation. To test this need, nitrification is assumed for alternate semi-monthly periods through the period August 1 to November 30 to demonstrate conditions both with and without significant ammonia reduction. The assumed ammonia reduction is by nitrification rather than by ammonia

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*Best practicable waste treatment technology by reference to 40 CFR 133.102.

stripping so that there is no disturbance of the total nitrogen balance. The assumed treatment process is by shifting the alum coagulation for seasonal phosphorus removal from the secondary process to the primary to unload the activated sludge reactor to permit nitrification. A slight reduction in the efficiency of phosphorus removal is expected in this operational mode.

Spokane Valley Municipal

For simulation purposes, it is assumed that a community sanitary sewage collection system will have been implemented prior to the year 2000 for the urbanized area of Spokane Valley and that, in accordance with wastewater alternative Plan A, treatment will be provided in a separate facility near Felts Field for surface water disposal. The forecast Spokane Valley service population at year 2000 is 74,061 resulting in an average dry weather flow of 10.03 mgd which is equal to 15.52 cfs.

Treatment for surface water disposal is assumed to be the equal of activated sludge secondary treatment. Since the flow is in excess of 0.5 mgd, phosphorus removal is required in accordance with the DOE directive. Seasonal phosphorus removal is assumed, as for the City STP, beginning May 1 and ending October 15. Seasonal nitrification is not tested for this facility since preliminary calculations indicate that ammonia toxicity should not be a threat at the higher dilution experienced by this smaller flow. The developed file for the Spokane Valley STP effluent at year 2000 is shown in Table 2.

Since the Spokane Valley domestic water source is the same groundwater source as the City, the forecast temperature, DO and TDS, of the Spokane Valley STP effluent is assumed to be the same as the City STP. The Spokane Valley will probably experience a variation in flow throughout the year similar to the City. For a 10.03 mgd flow (15.52 cfs) a variation of plus or minus 10 percent from the average will have insignificant temperature impact on the receiving water. Therefore, the average flow is entered in the file without the refinement of semi-monthly variation.

Minor differences in raw sewage strength between the City and Spokane Valley are forecast, but the effluent quality from secondary treatment will be insignificantly different. Therefore, effluent quality with respect to BOD, phosphorus and nitrogen are forecast to be the same as forecast for the City STP. Coliform counts in the effluent are based on the same assumptions described above for the City STP including two semi-monthly periods in which the level is assumed to rise to the 7-day allowable maximum.

Deer Park and Tekoa Municipal

These communities with forecast service populations of 1824 and 900 respectively at year 2000 are assumed to continue surface water disposal but with secondary treatment complying with 1983 standards. The developed effluent quality files are shown in Table 3.

The per capita flows in these communities are based on criteria developed in Section 406.1 and result in forecast mean annual flow rates of 0.224 mgd (0.347 cfs) for Deer Park and 0.099 mgd (0.153 cfs) for Tekoa. Since both are less than 0.5 mgd, phosphorus removal is not required based on the current DOE directive. Appendix IV shows forecast raw sewage characteristics for these two communities. The sewage strengths are average and the expected secondary effluent from treating these flows is forecast to have the typical quality developed in Section 603.2 and shown in Table 3.

The water supply for Deer Park has TDS of approximately 126 mg/l. The incremental addition due to municipal use at 300 mg/l is expected to raise the effluent to 426 mg/l. The Tekoa water supply has a TDS of 147 mg/l which is forecast to yield an effluent of 447 mg/l.

Fecal coliform counts are forecast to be held at the 30-day maximum allowable level of 200 organisms per 100 ml with total coliform at a corresponding level of 400 org/100 ml.

Flows and all constituents are assumed to have average values throughout the year.

Industrial Point Sources

The existing industrial waste load condition was represented by individual files for each industry based on historical flow and pollutant load data. The forecast industrial waste load is not identified by specific industry but rather by a forecast total flow and pollutant load for an area. The forecast light industry load is incorporated into the municipal flow and load. The forecast municipal flows and pollutant loads as developed above include the light industrial component. It is assumed that the heavy industrial component will continue to receive separate treatment and disposal. Appendix V shows the basis for industrial flow and pollutant load forecasts as abstracted from Tables 12 and 13 of Section 406.1.

The City area is forecast to have no heavy industrial component going to separate treatment and disposal. The forecasts are in terms of process flow and its pollutant concentrations and cooling water flow, uncontaminated except for heat gain.

The pollutant concentrations are assumed to remain constant at the effluent levels currently set by waste discharge permits. Total dissolved solids (TDS) are assumed to be at well water concentration for the area plus 25 percent for process flows. For cooling water flows the TDS is taken at well water concentration for all except the present volume of surface water used by Kaiser Trentwood. Coliform content is assumed to be at 50 percent of that required for disinfected municipal effluent. The point source files developed on the above basis for Spokane Valley and North Spokane are shown in Tables 4 and 5 respectively.

Development of Spokane Valley Industrial Point Source File. From Table 12 of 406.1 the mass emission of pollutants in the forecast process flow of 11.43 mgd is as follows:

Parameter	Concentration mg/l in 11.43 mgd	Mass #/day in 11.43 mgd
BOD	16.34	1556
Suspended Solids (SS)	11.72	1116
Kjel Nitrogen	1.08	103
Phosphorus as P	0.81	77

Forecast cooling flow is 21.22 mgd including an element assumed equal to the Kaiser Trentwood surface water diversion of 17.5 mgd. The total process flow of 11.43 mgd plus 3.72 mgd of the cooling flow totaling 15.15 mgd are assumed to be from groundwater sources with initial dissolved solids content of groundwater. The groundwater typically has a total dissolved solids of 170 mg/l and contains negligible P and negligible Kjeldahl nitrogen but significant nitrate at 1.5 mg/l. It is desirable to express the point source file as one file for process water plus cooling water from groundwater sources. The cooling water from surface sources suffers no change in quality except for the temperature rise. The historical temperature rise of the 17.5 mgd of surface supplied cooling water is estimated to be less than 1.5 degrees C. Therefore, the surface source cooling water file consists of a mass input expressed as degrees centigrade times cubic feet per day for model requirements; specifically 1.5°C x 17.5 mgd x 1.5473 cfs/mgd x 86,400 seconds/day = 3.5×10^6.

The process and groundwater source cooling water point source file is as shown in Table 4 where the pollutant parameter concentrations are adjusted to a total flow of 15.15 mgd equal to 23.44 cfs. Available historical data on which projected values of Kjeldahl and Total P are based do not give a breakdown into the subconstituents handled by the model. The breakdown into organic nitrogen and ammonia and into ortho P and potential P are judgmental.

Development of North Spokane Industrial Point Source File. The basic data for year 2000 forecast flows and pollutant concentrations are taken from Table 13 of Section 406.1. All of both the process and cooling components are historically from groundwater supplies in the North Spokane area and are forecast to remain so. As for Spokane Valley, the coliform count is assumed at 50 percent of the allowable level for municipal discharges.

The cooling flow being entirely from groundwater, the TDS at 170 mg/l must be accounted for in discharge to surface water. The historical average temperature of the cooling water is 23°C or 73.4°F associated with a current flow of 3.14 mgd. The 7-day low flow in the Little Spokane River is 92 cfs and the forecast cooling flow is 6.7 cfs which means that each °F that cooling flow exceeds river temperature will cause a rise of .07°F. A flow of 6.7 cfs at 73.4°F into the river at 64.5°F would cause a river rise of 0.6°F which exceeds DOE criteria. It is assumed that future flows will be restricted to a temperature not to exceed 18°C equal 65°F.

Location of Point Sources

The simulation accepts point source files by reach and processes the data relative to time and mixing on the same basis. For this reason, a point source may be inserted in the next reach downstream if it is located near the lower end of a reach. Point source locations and the selected point for processing are as follows:

Point Source	Actual Location by Reach	Selected Location by Reach
City of Spokane STP	410	410
Spokane Valley Mun.	Edge 720	730
Deer Park Mun.	540	540
Tekoa Mun.	Edge 610	620
Spokane Valley Ind.	Edge 710 & 720	720
North Spokane Ind.	580	590

TABLE 1

MUNICIPAL POINT SOURCE FILES
CITY OF SPOKANE STP(1)

Semi-Monthly	Flow CFS	Temp. °C	D.O. mg/1	MASS EMISSIONS PER DAY in units mg x cf − liters − days for mean flow 61.96 cfs: BOD	TDS	Ortho P	Nitrate & Nitrite	Ammonia	Organic N	Pot P	COLIFORMS Organisms/100 ml: Fecal	Total
Jan 1	55.99	12	3.0	134×10^6	2356×10^6	41.9×10^6	3.7×10^6	78.2×10^6	20.9×10^6	1.0×10^6	200	400
Jan 2	55.99	12	"	"	"	"	"	"	"	"	"	"
Feb 1	55.99	12	"	"	"	"	"	"	"	"	"	"
Feb 2	55.99	13	2.9	"	"	"	"	"	"	"	"	"
Mar 1	55.99	14	"	"	"	"	"	"	"	"	"	"
Mar 2	55.99	14	"	"	"	"	"	"	"	"	"	"
Apr 1	62.64	15	2.8	"	"	"	"	"	"	"	"	"
Apr 2	62.64	16	2.7	"	"	"	"	"	"	"	"	"
May 1	65.97	16	"	112×10^6	"	6.7×10^6	"	"	"	0.8×10^6	"	"
May 2	65.97	17	"	"	"	"	"	"	"	"	"	"
June 1	68.72	18	2.6	"	"	"	"	"	"	"	"	"
June 2	68.72	19	"	"	"	"	"	"	"	"	"	"
July 1	68.72	19	"	"	"	"	"	"	"	"	"	"
July 2	68.72	21	2.5	"	"	"	"	"	"	"	400(3)	800(3)
Aug 1	68.72	21	"	"	"	7.8×10^6	78.7×10^6	3.2×10^6 (2)	"	"	200	400
Aug 2	68.72	21	"	"	"	6.7×10^6	3.7×10^6	78.2×10^6	"	"	400(3)	800(3)
Sept 1	65.97	20	"	"	"	7.8×10^6	78.7×10^6	3.2×10^6 (2)	"	"	200	400
Sept 2	65.97	19	2.6	"	"	6.7×10^6	3.7×10^6	78.2×10^6	"	"	"	"
Oct 1	62.64	18	"	"	"	6.7×10^6	"	"	"	"	"	"
Oct 2	62.64	18	"	134×10^6	"	41.9×10^6	"	"	"	1.0×10^6	"	"
Nov 1	55.99	16	2.7	"	"	"	"	"	"	"	"	"
Nov 2	55.99	14	2.9	"	"	"	"	"	"	"	"	"
Dec 1	55.99	13	"	"	"	"	"	"	"	"	"	"
Dec 2	55.99	13	"	"	"	"	"	"	"	"	"	"

(1) Year 2000 serving City and North Spokane, Secondary Treatment, Seasonal P removal May 1 to October 15.

(2) Nitrification in first half of August and September only.

(3) Assumed minimum control of coliforms to 7-day mean limit.

TABLE 2

MUNICIPAL POINT SOURCE FILES
SPOKANE VALLEY STP(1)

Semi-Monthly	Flow CFS	Temp. °C	DO mg/1	CONCENTRATION mg/1 BOD	TDS	Ortho-P	Pot-P	Nitrate & Nitrite	Ammonia	Organic N	COLIFORMS Organisms/100 ml Fecal	Total
Jan 1	15.52	12	3.0	25	440	7.82	.18	0.7	14.6	3.9	200	400
Jan 2	"	12	"	"	"	"	"	"	"	"	"	"
Feb 1	"	12	"	"	"	"	"	"	"	"	"	"
Feb 2	"	13	2.9	"	"	"	"	"	"	"	"	"
Mar 1	"	14	"	"	"	"	"	"	"	"	"	"
Mar 2	"	14	"	"	"	"	"	"	"	"	"	"
Apr 1	"	15	2.8	"	"	"	"	"	"	"	"	"
Apr 2	"	16	2.7	"	"	"	"	"	"	"	"	"
May 1	"	16	"	21	"	1.25	.15	"	"	"	"	"
May 2	"	17	"	"	"	"	"	"	"	"	"	"
June 1	"	18	2.6	"	"	"	"	"	"	"	"	"
June 2	"	19	"	"	"	"	"	"	"	"	"	"
July 1	"	19	"	"	"	"	"	"	"	"	"	"
July 2	"	21	2.5	"	"	"	"	"	"	"	400	800
Aug 1	"	21	"	"	"	"	"	"	"	"	200	400
Aug 2	"	21	"	"	"	"	"	"	"	"	400	800
Sept 1	"	20	"	"	"	"	"	"	"	"	200	400
Sept 2	"	19	2.6	"	"	"	"	"	"	"	"	"
Oct 1	"	18	"	"	"	"	"	"	"	"	"	"
Oct 2	"	18	"	25	"	7.82	.18	"	"	"	"	"
Nov 1	"	16	2.7	"	"	"	"	"	"	"	"	"
Nov 2	"	14	2.9	"	"	"	"	"	"	"	"	"
Dec 1	"	13	"	"	"	"	"	"	"	"	"	"
Dec 2	"	13	"	"	"	"	"	"	"	"	"	"

(1) Year 2000 serving 74,061 in Spokane Valley, Secondary Treatment, Seasonal P removal May 1 to October 15.

TABLE 3

MUNICIPAL POINT SOURCE FILES
DEER PARK AND TEKOA

Constituent	Units	Deer Park[1] Amount	Tekoa[2] Amount
Flow	cfs	0.347	0.153
Temperature	°C	16	16
Dissolved Oxygen	mg/l	2.7	2.7
BOD	mg/l	25	25
TDS	mg/l	426	447
Ortho P	mg/l	7.82	7.82
Pot P	mg/l	.18	.18
Nitrate & Nitrite	mg/l	0.7	0.7
Ammonia	mg/l	14.6	14.6
Organic N	mg/l	3.9	3.9
Fecal Coliform	org/100 ml	200	200
Total Coliform	org/100 ml	400	400

(1) At year 2000 for population of 1824 persons, secondary treatment, without phosphorus removal.

(2) At year 2000 for population of 900 persons, secondary treatment, without phosphorus removal.

TABLE 4

INDUSTRIAL POINT SOURCE FILE
SPOKANE VALLEY, YEAR 2000

PROCESS FLOW PLUS GROUNDWATER SOURCE COOLING WATER

Flow 15.15 mgd equal 23.44 cfs[1].

Constituent	Units	Value or Concentration
Temperature	°C	18
BOD	mg/1	12.3[3]
Dissolved Oxygen	mg/1	2.6[6]
TDS	mg/1	202[2]
Organic N	mg/1	0.41[3]
Ammonia	mg/1	0.41[3]
Nitrate N	mg/1	1.5[5]
Ortho P as P	mg/1	.52[3]
Pot P as P	mg/1	.09[3]
Total coliform	No./100 ml	200
Fecal coliform	No./100 ml	100

SURFACE WATER SOURCE COOLING WATER

Constituent	Units	Value
Heat content	°c x cf/day	3.5×10^6 [4]

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(1) 11.43 mgd process flow plus 3.72 mgd cooling water from wells.
(2) 11.43 mgd @ 1.25 x 170 mg/1 plus 3.72 mgd @ 170 mg/1.
(3) Forecast process flow concentration for 11.43 mgd adjusted to total flow 15.15 mgd.
(4) Mass units for 1.5°C rise in 17.5 mgd.
(5) From groundwater source.
(6) At 30 percent of saturation.

TABLE 5

INDUSTRIAL POINT SOURCE FILE
NORTH SPOKANE, YEAR 2000

PROCESS FLOW COMPONENT

Constituent	Units	Amount
Flow	cfs	0.743
Temperature	°C	18
BOD	mg/1	30
Dissolved Oxygen	mg/1	2.6 (1)
TDS	mg/1	213 (2)
Organic N	mg/1	1.5
Ammonia	mg/1	1.5
Nitrate	mg/1	1.5 (3)
Ortho P as P	mg/1	0.79
Pot P as P	mg/1	0.21
Total coliform	org/100 ml	200
Fecal coliform	org/100 ml	100

COOLING FLOW COMPONENT

Constituent	Units	Amount
Flow	cfs	6.70
Temperature	°C	18
TDS	mg/1	170
Dissolved Oxygen	mg/1	2
Nitrate	mg/1	1.5

(1) At 30 percent of saturation.
(2) At groundwater supply concentration plus 25 percent.
(3) From groundwater supply.

APPENDIX I

Development of City STP Effluent
Pollutant Loads, Year 2000

	Forecast Concentration in Raw Waste mg/1	Forecast Concentration in Treated Effluent, mg/1			Mass Emission Rate Per Day of Treated Effluent @ 40.05 mgd in Units of pounds per day			Mass Emission Rate Per Day of Treated Effluent @ 61.96 cfs = 5.3542 x 10^6 cf/day in Units of mg cf/liter - days x 10^6		
		Secondary w/o P Removal	Secondary w/P Removal	Secondary w/P Removal & Nitrification	Secondary w/o P Removal	Secondary w/P Removal	Secondary w/P Removal & Nitrification	Secondary w/o P Removal	Secondary w/P Removal	Secondary w/P Removal & Nitrification
BOD	212	25	21	21	8,340	7,006	7,006	134	112	112
Total P as P	11.5	8.0	1.4	1.6	2,669	467	534			
Ortho P as P	7.7	7.82	1.25	1.45	2,609	417	484	41.9	6.7	7.8
Pot P as P	3.8	.18	.15	.15	60	50	50	1.0	0.8	0.8
Total N	33.6	19.2	19.2	19.2	6,405	6,405	6,405			
NO_2+NO_3 as N	0.7	0.7	0.7	14.7	234	234	4,904	3.7	3.7	78.7
NH_3 as N	19.5	14.6	14.6	0.6	4,871	4,871	200	78.2	78.2	3.2
Org N as N	13.4	3.9	3.9	3.9	1,301	1,301	1,301	20.9	20.9	20.9
TDS	440	440	440	440	146,791	146,791	146,791	2356	2356	2356

APPENDIX II

Forecast Flow and Raw Sewage Characteristics
Year 2000, Spokane Valley Municipal

Forecast population: 90,585 gross Table 2, Section 406.2
74,061 service Table 2, Section 406.2

Flow: Average Dry Weather, 10.03 mgd, Table 7, Section 406.2
equal 15.52 cfs

Pollutant Loadings:

parameter	ppcd[1]	pounds per day[2]	concentration mg/1[3]
BOD	0.21	15,553	186
SS	0.21	15,553	186
Total N	0.035	2,592	31
Org N	0.014	1,037	12.4
Ammonia	0.021	1,555	18.6
Total P	0.012	889	10.6
Org P	0.008	592	7.1

(1) Pounds per capita per day, Table 9, Section 406.1.
(2) For 74,061 persons.
(3) In 10.03 mgd.

APPENDIX III

Forecast Flow and Raw Sewage Characteristics
Year 2000, Deer Park Municipal

Forecast population: 1824

Flow: 92 gpcd (Table 2 Section 406.1) sanitary
31 " (Table 4 Section 406.1) infiltration
123 gpcd x 1824 = 0.224 mgd = 0.347 cfs

Pollutant Loadings:

parameter	ppcd[1]	pounds[2] per day	concentration mg/1[3]
BOD	0.19	347	186
SS	0.19	347	186
Total N	0.032	58	31.3
Org. N	0.013	24	12.7
Ammonia	0.019	35	18.6
Total P	0.011	20	10.8
Ortho P	0.007	13	6.8

(1) Pounds per capita per day, Table 10, Section 406.1.
(2) For 1824 persons.
(3) In 0.224 mgd.

APPENDIX IV

Forecast Flow and Raw Sewage Characteristics
Year 2000, Tekoa Municipal

Forecast population: 900

Flow: 92 gpcd (Table 2 Section 406.1) sanitary
18 " (Table 4 Section 406.1) infiltration
110 gpcd x 900 = 0.099 mgd = 0.153 cfs

Pollutant Loadings:

parameter	ppcd[1]	pounds per day[2]	concentration mg/l[3]
BOD	0.19	171	207
SS	0.19	171	207
Total N	0.032	29	34.9
Org N	0.013	12	14.2
Ammonia	0.019	17	20.7
Total P	0.011	10	12.0
Ortho P	0.007	6	7.6

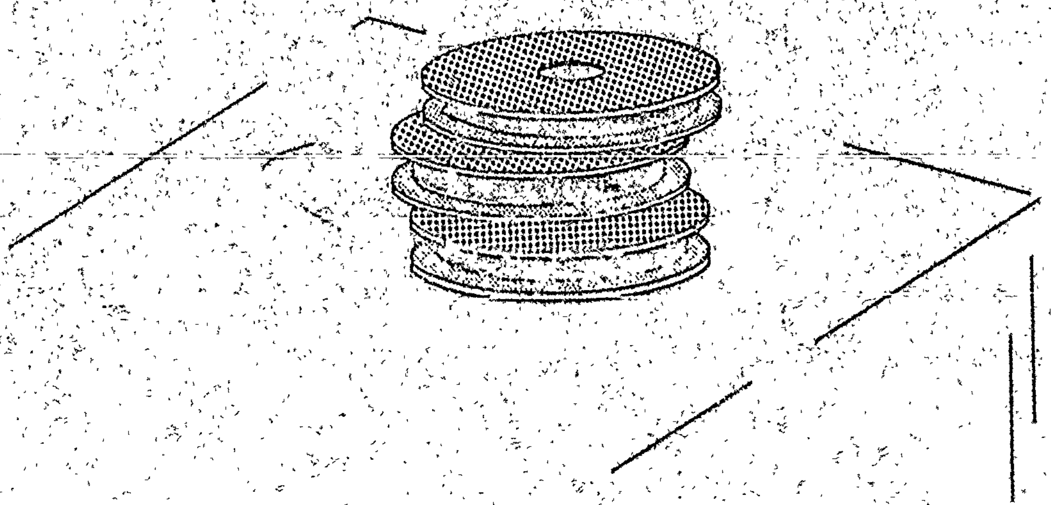
(1) Pounds per capita per day, Table 10, Section 406.1.
(2) For 900 persons.
(3) In 0.099 mgd.

APPENDIX V

Forecast Industrial Waste Flows and Effluent Pollution Loads, Year 2000

Constituent	Units	Heavy Component Amounts: Spokane Valley[1]	Heavy Component Amounts: North Spokane[2]
Process Flow	mgd	11.43	.48
Cooling Flow	mgd	21.22	4.33
BOD	mg/l	16.34	30
SS	mg/l	11.72	20
Total Kjel. N	mg/l	1.08	3
Total P as P	mg/l	0.81	1

(1) From Table 12 of Section 406.1.
(2) From Table 13 of Section 406.1.



SECTION 606.4

SIMULATION MODEL CALIBRATION AND PRODUCTION RUNS

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 606.4

SIMULATION MODEL

CALIBRATION AND PRODUCTION RUNS

24 September 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

TABLE INDEX

FIGURE INDEX

APPENDIX INDEX

SECTION 606.4

SIMULATION MODEL
CALIBRATION AND PRODUCTION RUNS

Introduction

The goals and general description of the simulation task are covered in Section 606. The objective of this section is to describe specifically the implementation of the simulation project and the results obtained. Included in the description of implementation are the basic data input and calibration processes. The water quality calibration is addressed in some detail for its usefulness in demonstrating both the strengths and weaknesses of the simulation process.

Simulation results in eight volumes of computer print out are furnished as appendices to this report. Interpretation and evaluation of these results is the primary objective of this section. Essential to interpretation are the bases for formulation of the production runs and input files used; facts which are included in this section.

The development of the simulation model as a tool for ongoing study ranks in importance with the uses in this study. Therefore, a final objective of this section is to describe the future access to the simulation model and to suggest areas for ongoing application. For the purpose of making this section a self-contained guide to future use, there is a repetition of certain data from prior task reports 606, 606.3 and 406.3.

water quality simulation specific to the input meteorological data and the corresponding hydrologic events. The HSP simulation is an iterative process working in one hour steps. The result is dynamic simulation in one hour steps of hydrologic and water quality events corresponding to input meteorological conditions.

HSP is divided into the following four load modules:

1. LIBRARY - performs data management for hydrometeorologic data and quality data using direct access disk storage.
2. LANDS - simulates snowpack and soil profile processes and calculates continuous soil moisture, evapotranspiration, groundwater accretion, and inflow to stream channels.
3. CHANNEL - assembles and routes the channel inflow through the channel network and reservoirs.
4. QUALITY - calculates water quality variables for flows at any location in streams/reservoirs. Data from LIBRARY, LANDS and CHANNEL is used and output summaries are stored by LIBRARY.

For a description of the water quality simulation process, refer to "Mathematical Model of Water Quality Indices in Rivers and Impoundments" by Lombardo and Franz. (Chapters 1 and 2 of this document are reproduced in the Appendix of Section 606.)

Basic to the utilization of this technique as a forecasting tool is the assumption that historical meteorological conditions are a statistical sample of future meteorological events. That is, forecast performance under selected conditions is judged against the background of those conditions applied to an appropriate statistical or specific sample of historical meteorological conditions. The response of the simulated watershed to changed point source pollution loads can be demonstrated as responses under a selected period of meteorological history, as for example a dry year.

An important characteristic of the Spokane River system is the significance of groundwater interflow to the hydrologic regime. There are large interflows involving waters originating outside the basin as well as from precipitation in the basin. The HSP simulation has the capability of incorporating these interflows.

The net result of the simulation process is a tool with the capability of producing as output for any period for which complete meteorological data is available an hour by hour response of hydrologic and water quality events to a given set of pollution conditions.

Specific Simulation Conditions. The selected extent of the simulation is defined by the watersheds tributary to the Spokane River from the Idaho boundary to Long Lake Dam including the Little Spokane River and Hangman Creek. The watershed of the Spokane River in Idaho is not included. Since the natural watershed in Idaho is not included in the simulation process, the entering flow and quality of the Spokane River must be supplied in another way. Stream flow records are available for periods corresponding to the periods for which meteorological data are available and are input as a data file. A special subroutine using meteorological input provides a temperature and dissolved oxygen file for the incoming river.

Another special condition of the watershed is the interchange of groundwater with the Spokane Valley aquifer. Since this groundwater stream originates outside the simulation boundary, it is not derived from meteorological data but must be provided as a separate input file. Available data from USGS studies make it possible to generate such a file for net additions to the Spokane and Little Spokane Rivers. The data describing the entering Spokane River and groundwater interchanges are designated "Boundary" files.

The points selected for water quality print-outs are as follows:

a. At the outlet of Long Lake
b. At three depths in Long Lake
c. Spokane River above the Little Spokane Confluence
d. Spokane River above the Hangman Creek Confluence
e. Spokane River at the east City limits
f. Little Spokane River at the mouth
g. Little Spokane River at Dartford
h. Hangman Creek at the mouth

Water quality parameters selected for simulation are listed below:

a. Dissolved oxygen
b. Biochemical oxygen demand
c. Temperature
d. Total dissolved solids
e. Total coliform
f. Fecal coliform
g. Algae-Chlorophyl A
h. Zooplankton
i. Ortho phosphate
j. Potential phosphate
k. Nitrate
l. Nitrite
m. Ammonia
n. Organic nitrogen
o. Conservatives

The simulation model processes heavy metals as conservatives, that is, as nonreacting pollutants. All the listed parameters are not selected for print out at all locations for all runs.

The study area is subdivided into four subareas corresponding approximately to Water Resource Inventory Areas (WRIA) as follows: (Refer to Plate 606-1.)

1. Area 700, UPPER SPOKANE, is all of WRIA 57 downstream from USGS gage number 4195 at Liberty Bridge.

2. Area 500, LITTLE SPOKANE, is all of WRIA 55.

3. Area 600, HANGMAN, is all of WRIA 56 plus the rest of the natural tributary area in Idaho.

4. Area 400, LOWER SPOKANE, is all of WRIA 54 upstream from Long Lake Dam.

The simulation process can be carried out separately and independently for areas 500, 600 and 700. The simulation output of these three independent subareas becomes input to the simulation process for subarea 400.

Basic Data

Introduction. Four general categories of data are necessary to combine with the HSP load module to create a simulation specific to the basin and to a period of meteorologic history. These categories are:

1. Land and channel characteristics
2. Meteolorogical data
3. Boundary conditions
4. Point sources of pollution
5. Miscellaneous

All categories except "boundary conditions" are typical requirements for any basin to be simulated. The boundary condition category is a unique requirement due to the fact that the entire natural watershed is not being simulated.

The miscellaneous category includes such items as man introduced controls on the hydrologic cycle exemplified by impoundments and controlled releases.

Following is a summary of the type of data contained in basic data categories.

Land and Channel Characteristics. As indicated above, the simulation area is first divided into natural drainage areas. The natural drainage areas are further subdivided into areas selected to characterize the accumulation of precipitation and runoff and to gather the runoff in existing natural channels.

The basic land area for the accumulation of rainfall by the model is designated a "segment." Segments are selected to represent areas having common rainfall and elevation characteristics. The basic unit for routing of accumulated rainfall runoff and for making quality simulations is a length of channel designated as a "reach." The tributary area to a reach may include portions of not more than three segments for programming reasons within the quality module of the model. The length of channel in one reach is also subject to certain slope criteria limitations. Hydrologic data readout is available only at the downstream end of each reach and quality data readouts are available in terms of the entire reach length considered as a mixed body of uniform quality. Therefore, the selection of reaches is also tied to the requirements of desired data output.

The definition of segments need not be identical when going from one major drainage area to another. The definitions are selected to best categorize the topographic and precipitation regimes in each particular area. It is desirable to minimize the number of both reaches and segments to reduce the computer time and storage requirements without significant loss in definition. A maximum of five segments is found to be satisfactory in any one major tributary area in this basin. Refer to Appendix 1.1 for segment identification. No generalization about reaches can be made since the number is determined by the branching, fall and readout requirements.

The division of the major watershed into reaches is shown in Plate 606-1. An enlargement of the urban planning area is shown in Plate 606-2. Each reach and its associated tributary area are given the same identifying number. The reaches in which present and future urban development will exist are 590 in Area 500, 410 in Area 400, 660 in Area 600 and in all three reaches, 710, 720 and 730, of Area 700.

Input data are required to define and describe each segment in each reach of the simulation area. The parameters required to accomplish this as listed below are developed as input to the model as basic data.

1. The total tributary area to each reach.

2. The fraction of the total tributary area to each reach represented by pervious and impervious component of each segment.

3. Mean segment slope.

4. Mean segment elevation.

5. Upstream and downstream reach elevation.

6. Length of channels in each reach.

7. Representative channel cross section and overbank slope for each reach.

8. Roughness coefficient for channel and overbank.

9. Roughness coefficient for overland (nonchannel) flow.

10. Mean overland flow length for each segment.

11. Fraction of each segment covered by forest.

Meteorological Data. The required categories of meteorological data are as follows:

Kind	Interval
Precipitation	Hourly and Daily
Evaporation	Semi-monthly*
Dew Point	Daily
Max-Min Temperature	Semi Daily
Solar Radiation	Daily
Wind	Daily
Cloud Cover	Daily

The available stations within or adjacent to the simulation area are listed in Appendix 2.1.

*Expressed as daily rate.

The basic goal was to collect a twenty year record including the calibration period June through September 1973 and to prepare in active form, the data for the period selected for production runs and the calibration period. A distinction is made between collecting the data in its raw available form and the necessary refinement to make it acceptable to the simulation process. The problem attendant to this refinement process depends upon the data and are discussed in Appendix 7.1.

Where possible meteorological data was obtained in magnetic tape form from the National Oceanic and Atmospheric Administration (NOAA). Appendix 7.1 lists these data. The taped data are not usable directly in the simulation for two reasons; first, the nature of the NOAA unlabeled tape format and secondly, the need to correct the data for missing or extraneous items.

The status of the available meteorological records is summarized as follows:

Category	Station	Status
Hourly Precip	Coeur d'Alene R.S. Plummer 3 WSW Spokane NWS	Complete Jan. 53 - Oct. 73 Double mass balance done for May 67 - Sept. 69 and June 73 - Sept. 73
Daily Precip	Deer Park 2E Mt. Spokane Smt Newport Rosalia Tekoa Wellpinit	Complete Jan. 53 - Oct. 73 Double mass balance done for May 67 - Sept. 69 and June 73 - Sept. 73
Evaporation	Spokane NWS	Complete Jan. 53 - Oct. 73 part from record and part synthesized

Category	Station	Status
Dew Point	Spokane NWS	Complete Jan. 53 - Oct. 73 from three sources
Max-Min Temp	Spokane NWS Mt. Spokane Smt Wellpinit Newport Deer Park Rosalia	Complete Jan. 53 - Oct. 73
Solar Radiation	Spokane NWS	Complete Jan. 53 - Oct. 73
Wind	Spokane NWS	Complete Jan. 53 - Oct. 73
Cloud Cover	Spokane NWS	Complete Jan. 53 - Oct. 73

As can be seen from the above summary, the 20 year data file is available in all respects except the completion of double mass balance test for consistency and the necessary adjustments arising from that test for both hourly and daily precipitation records.

Note that for the purpose of making a future simulation of urban runoff, which would use only the Spokane NWS station, the precipitation record is ready to use.

Boundary Conditions. A simulation of the Spokane River watershed in Idaho is not made. The flow of the Spokane River at the Idaho boundary is provided to the model as an input file derived from the records of USGS gage 4195 at Liberty Bridge. In addition to the surface water flow from outside the simulation area, there is a significant inflow of groundwater from Idaho which emerges into both the Spokane and Little Spokane Rivers. These flows also are necessarily entered into the model as input files and are based on the work of Broom (1951) as applied to other years of record.

The river temperature at the boundary is not available from records except from October 1964 to September 1965. Therefore it is necessary to develop a method for creating a temperature file for the calibration period and other simulation periods. This is accomplished through a subroutine simulation from meteorological data calibrated against the 1964-65 data as described in Appendix II of Section 606. A dissolved oxygen file is created from the temperature file based on correlation with recorded data.

To provide quantity and quality files for flows originating outside the area being simulated from meteorological data, boundary files are created for the following and are made available herein under the referenced Appendix:

File	Refer to Appendix
Spokane River Flow	3.1
Spokane River Temperature	3.2
Spokane River Dissolved Oxygen	3.3
Spokane River Quality	3.4
Groundwater Inflow to Upper Spokane, Quantity and Quality	3.5
Groundwater Inflow to Little Spokane, Quantity and Quality	3.6
Groundwater Inflow to Lower Spokane, Quantity and Quality	3.7

These files cover the periods October 1967 through September 1969 and June 1973 through September 1973.

<u>Point Source Files</u>. Files for point sources of pollution are not general for all simulations as are meteorological and boundary files but specific to the condition being simulated. Two sets of point source files are created, one representing conditions in the June through September period 1973 for calibration and one representing forecast year around conditions in year 2000 for Plan A. These specific files are described under Calibration and Production Run Formulation respectively.

<u>Miscellaneous Files</u>. Two important manmade controls influence the Spokane River regime, one is the regulation at Post Falls of the outlet of Coeur d'Alene Lake and the other at the outlet of Long Lake Dam. The effect of the Post Falls regulation is incorporated in the boundary file for the Spokane River.

The regulation at the outlet of Long Lake Dam is recorded as the record of USGS gage 4330 which is made up of the total of Washington Water Power releases through their turbines and dam spill, including leakage. The files for Long Lake spill are split into two parts, turbine releases and spill. These files in effect form an exit boundary file since these regulations determine the release from Long Lake. Refer to Appendix 3.8.

For discussion of the operating philosophy at both Post Falls and Long Lake refer to Section 308.

Calibration

Hydrologic. The model is calibrated in two steps, first for hydrologic simulation and then for water quality simulation output. The hydrologic calibration is itself broken down into elements corresponding to the subareas against the available USGS gage records as indicated below:

Major Area	Reaches	At Downstream End of Reach No.	Against USGS Gage No.
Little Spokane (WRIA 55)	510 thru 580	550, 560, 580	4310
Hangman (WRIA 56)	610 thru 660	660	4240
Upper Spokane (WRIA 57)	710 thru 730	730	4225
Lower Spokane (WRIA 54)	410 thru 440 510 thru 590 610 thru 660 710 thru 730	440	4330

The flow in area 700 is largely determined by input files rather than simulation within the study area thus masking the local contribution above USGS gage 4225. For this reason, the hydrologic calibration began and was concentrated in the two areas where flow is entirely from simulation, Area 500, the Little Spokane River, and Area 600, Hangman Creek. The refined calibration results from these watersheds are applied to parameter selection in Area 700 for the first iteration of the calibration process in that area thereby assuring a valid starting point.

The hydrologic calibration period selected is the two water years from October 1, 1967 to September 30, 1969 which provide examples of dry and wet years. That is, the meteorological input for this period is used by the model to create simulated runoffs which are tested against the USGS streamflow records for the same period.

The calibration process is primarily a trial and error fitting procedure. Parameters are assigned and the LANDS module run. The run results are plotted by LIBRARY together with recorded values. The closeness of the fit indicates appropriateness of the parameter selection. By proper altering of parameters the simulated results are adjusted to the recorded data to achieve a best fit. There are a total of 37 available adjustment parameters in 4 categories.

1.	LANDS	16
2.	SNOW	12
3.	MOISTURE	7
4.	SNOWPACK	2
	TOTAL	37

Of this total it proved necessary to manipulate only about 6 parameters to achieve satisfactory results. Some problems are encountered with certain rain-snow events, in which the model sees runoff when actually there is snow and also the opposite case where the model sees snow when there was actually rain. These problems are confined to minor storms under particular temperature conditions and have little or no effect on monthly runoff volumes.

After satisfactory completion of calibration of Areas 500, 6C0 and 700, the calibrated output from these areas becomes input to Area 400, Lower Spokane, to be combined with simulated local runoff for calibration against the recorded outflow from Long Lake Dam.

Quality. Water quality calibration builds on a previously completed hydrologic calibration. Section 607 describes and reports water quality sampling and analysis for the purpose of providing known synoptic quality data for calibration purposes covering a 48 hour period, noon September 18, 1973 to noon on September 20, 1973. Samples were taken at four hour intervals at ten river locations, at three depths in Long Lake and at the City STP effluent.

These data are the primary basis of calibration at all locations except Long Lake. The slow rate of response of Long Lake, compared with the river locations, indicated that the longest possible dynamic comparison period would provide superior calibration. For this purpose the work done by Dr. Raymond Soltero and associates over the entire summer of 1973 was utilized. The September 18-20 sampling in Long Lake corresponded to a location used by Dr. Soltero and was actually carried out under his direction to assure that the data were compatible with his long term studies.

The water quality calibration process is an iterative process in which simulation runs are made and the output compared with actual observed conditions. Quality calibration of flowing reaches where there is relatively little system inertia is made in runs starting September 1, 1973 and running through the special sampling dates of September 18-19-20, 1973. For Long Lake, the quality calibration runs are begun June 1, 1973 and run through September in recognition of the inertia of this impoundment. The simulation program has parameters that can be adjusted to make the simulation coverage on the observed conditions. In general, satisfactory agreement is achieved in 10 to 20 iterations. Thirty iterations were required for Long Lake. As for hydrologic calibration, the procedure is to calibrate each of the subareas that are independent of each other and finally, the dependent subarea for which the other three provide input.

Before water quality calibration is possible, specific point source pollution input data are required corresponding to the calibration period. For this purpose point source pollution files are created and input as follows to represent existing conditions:

1. Municipal Sources
   a. City of Spokane STP
   b. Deer Park STP
   c. Tekoa STP
2. Industrial Sources
   a. Hillyard Processing
   b. Kaiser Aluminum, Trentwood
   c. Spokane Industrial Park
   d. Culligan Soft Water
   e. Kaiser Aluminum, Mead

A major industrial point source, Inland Empire Paper, was closed by a strike for the period from the June prior to and through the calibration period and therefore is not included for calibration purposes. The load from this source is, however, included in future condition simulation runs. Point source files for calibration are shown in Appendices 4.1 through 4.3.

Discussion of Quality Calibration. Since Long Lake is both a focus of interest and the downstream consequence of all other basin calibration efforts, it is selected to discuss the quality calibration results. The strengths and limitations of the simulation process are particularly well demonstrated at this location.

The simulation sees Long Lake as a body of water consisting of three layers: a top layer 0 to 5.5 meters depth, a middle layer 5.5 to 13.4 meters depth, and a bottom layer 13.4 meters depth and below. The simulated quality for each layer is reported as the mean over the entire depth of the layer. At the sampling location, the lake is approximately 26 meters deep and the sampling depths are 1 meter, 15 meters and at the bottom. The simulation treats the entire extent of the lake in each horizontal stratum as a fully mixed homogeneous unit. Soltero's data for different locations on the lake show that this is a reasonable approximation for much of the year. Long Lake becomes strongly stratified as the summer progresses until a date late in September when turnover usually takes place after which the lake becomes relatively well mixed. The calibration period does not extend to the turnover date since the lake was still stratified September 18, 19 and 20 during the special sampling.

Before considering the calibration of individual parameters, it should be recognized that the parameters are inextricably interrelated by the simulation algorithms. That is, a change in simulation of one parameter is necessarily reflected by changes in other parameters. The interdependency of parameters is shown in Appendix 7.1. Hence, it is not always feasible in many cases to force a higher degree of compliance of one parameter with observed conditions without causing poorer correlation of another. There is a degree of compromise inherent in the calibration process.

In a similar manner, the dynamic nature of the simulation links successive events. This means that an adjustment to meet observed conditions at one instant is reflected in all other responses, but not necessarily in the same manner due to different combinations of conditions at other times. Here again compromise is required with more attention given to the matching of overall long range trends and responses rather than any particular instant. The importance of giving great weight to the long term trends from the Soltero data as compared with any one set of data is amply demonstrated below.

The parameters of primary interest in Long Lake are Temperature, Dissolved Oxygen, Chlorophyl A and Ortho Phosphate. The calibration significance of these four parameters and nitrogen compounds are discussed below, referencing Figures A through F.

Figures A through F show a comparison of Soltero's observations, in general a single daytime observation at intervals of one to two weeks and the simulated values for early afternoon (2 p.m.) at intervals of five days. Also plotted on these graphs are the range of observed values during the 48 hour special sampling period which were made at 4 hour intervals.

Temperature. Refer to Figure A. Simulation is good in all layers until the beginning of September. At that point the model starts cooling the top layer faster than nature whereas the middle and bottom layers are warmer. These deviations at their maxima are only of the order of 1-1/2 to 2 degrees centigrade but they are significant to the turnover mechanism. The tendency is for the simulation to be ready for turnover about two weeks early. A compromise has to be reached in the calibration process to retard the turnover process by control of the mixing coefficient between layers to achieve turnover at the correct time. It is inherent in the HSP simulation to input the stream entering the lake entirely in the top layer at all times. In nature for this impoundment this is not true and as fall approaches, the river cools tending to sink into the middle layer. This variation from nature is the probable cause of the temperature deviation. The mixing coefficients are adjustable monthly. The consequence of this is that turnover takes place on 1 October in the simulation when the mixing coefficient changes. Historically, turnover takes place in the last week of September to the first of October so that the result is a good approximation of fact.

Dissolved Oxygen. Refer to Figure B. The DO of the lower layers is of primary concern. Anaerobic conditions in the bottom layer particularly are of concern since that condition permits activity to release phosphorus from the bottom sediments into solution. The simulation correctly identifies the date of the onset of anaerobic conditions in the middle and bottom layers under present conditions. The simulation overshoots the anaerobic period in the bottom layer at the end of the season by two weeks due to the compromise setting of mixing coefficients noted above. Top layer DO simulation is approximately at saturation. This is lower than the supersaturated condition detected at 1 meter depth by sampling but probably correct for the mean over the top 5.5 meters being simulated.

Phosphate. Refer to Figure C. The surface layer is kept near ortho phosphate exhaustion by the algal activity after the June bloom comes into equilibrium with the incoming supply. This is shown by both the observed and simulated condition. The middle and bottom layers show steady increases in available ortho phosphate as the season progresses and becomes significant to algal growth only when some of this enriched water begins to reach the surface as the stratification weakens in the fall. The identification of the time of this upwelling is the most significant calibration consideration in the top layer which correctly identifies this time as the first of September.

The difference in concentration of phosphate in the light active zone and the middle layer is large so that the concentration gradient is likewise large. This makes the relation of the point of observation and point of simulation significant. The simulation of the middle layer matches observed conditions at the beginning and end of the stratification period but is low in mid season. This may be due in part to the middle simulation layer being above the middle layer observation point and hence reflects the concentration gradient that develops in mid season. Bottom layer simulation of amounts being released by anaerobic activity is good except that the cessation of activity is delayed by a couple of weeks, again by the compromise in mixing. Bottom simulation reaches the same levels as observed approaching 0.4 mg/1 toward mid September.

Chlorophyl A. Refer to Figure D. The simulation shows relatively little variation in level through the summer, but gives a level that is close to the mean of the wider swings observed in nature. There is an approximate two week cycle in the June-July period of wide variation in the observed level that is not reflected in the simulation. This cyclical phenomenon is observed in other years by Soltero so it probably represents a typical condition in Long Lake. The subsequent response of the simulation to the no-point-source and forecast conditions confirms that the simulation is properly responsive to the changing availability of nutrients and that the mean values developed have an appropriate relationship to the mean value developed for calibration conditions.

The observed available orthophosphate in the top and middle layers does not exhibit the two week cyclical behavior of the Chlorophyl A indicating that some other balance mechanism like relation to zooplankton predators may be responsible. Zooplankton activity was put at zero during the calibration. Zooplankton are not limiting in a bloom condition but tend to introduce strong instability in the process. It may be possible as a research effort to reintroduce the zooplankton constraint and achieve a simulation of the observed cyclical behavior without upsetting the entire process stability.

Nitrogen Compounds. Refer to Figures E and F. There are no published data for the ammonia form from Soltero's ongoing data, only for the nitrate form. In the surface layer where the nitrate form would be expected to dominate, this is no problem. In the middle and bottom layers which become anaerobic for significant periods in which the ammonia form would be expected to dominate, there is difficulty in checking simulation. The simulated nitrate and ammonia and their total are plotted for comparison with the observed nitrate data.

In the surface layer, the simulation of nitrate is higher than observed through the early part of the season and low through September. The simulated exhaustion of nitrate in September concurrent with the sudden simulated increase of Chlorophyl A indicates that the simulation sees nitrogen as a limiting factor at this point when both simulated and observed phosphorus rise above exhaustion levels.

In the middle layer, the observed and simulated nitrate level in mid season are highly divergent. The observed increase in nitrate in August in the face of observed anaerobic conditions in the middle layer is unexpected and an adequate explanation is not available. This may be due in part to the tendency of the influent river to seek the lower layers as the season advances. The simulated rise in ammonia at the expense of the nitrate is expected under the anaerobic conditions. Nevertheless, the total simulated nitrogen budget in the middle layer is significantly less than the observed nitrates. The total nitrates entering in the river are of the order .6 mg/l at summer flow but the observed levels reach 1.1 mg/l and the simulated .35 mg/l to .55 mg/l.

Lower layer simulation of nitrate is in general agreement with observed levels except that exhaustion is earlier and remains longer, but the offsetting ammonia increase tends to maintain the total budget.

Further model parameter manipulation to more closely match observed nitrate dynamics caused divergence in other areas.

Production Run Formulation

With the model loaded with meteorological data, land parameters and boundary files and with calibration satisfactorily completed, the model is ready to simulate selected forecast conditions. The first condition selected for simulation is the condition with all point sources of pollution removed, designated herein the no-point-source (NPS) run.

The purpose of the NPS run is to establish background conditions, that is, what is the best water quality condition that could be expected if the goal of zero pollution were achieved within the study area. The NPS run is a simulation under the selected sample meteorological conditions for the period May 1968 through September 1969 with all point sources removed. The water quality entering from Idaho both as surface water and as groundwater is assumed to be the same as presently observed, its primary deficiency being the bacteriological quality of the surface water.

The range of alternative wastewater management plans considered range from systems consisting entirely of surface water discharges to systems consisting entirely of land application to irrigation. Those plans consisting entirely of land application are substantially represented in simulation by the NPS run. The impact on surface waters through groundwater interchange from irrigation alternatives is judged to be negligibly small considering the application criteria. There would be a more significant impact through groundwater interchange for the rapid percolation alternatives, but limited to the soluble salts which, with the exception of nitrates, are not a pollution threat here. Phosphates would be removed by soil reactions and coliforms by filtration through the soil. Therefore, the rapid percolation alternatives are likewise substantially represented by the NPS run.

The surface water disposal alternatives are those which will impact the surface water quality. The recommended plan, Plan A, consists of two surface water disposals, one of which, for the City-North Spokane Subsystem, has strong probability of early implementation. Although the second surface water disposal for Spokane Valley probably will not be implemented early, it is prudent to include it in the evaluation of impact. Therefore, the second production run is selected to represent Plan A at year 2000 conditions meeting 1983 disposal criteria with both the City-North Spokane and Spokane Valley Subsystems active. This run is designated the year 2000 run. The two runs, NPS and year 2000, provide a bracketing of the best possible surface water quality condition and the most severe impact possible under 1983 standards.

Further considerations for the year 2000 run include selection of seasonal phosphorus removal for the purpose of evaluating its impact and determining if there is need for year around removal. The season selected for phosphorus removal is May first to October fifteenth. The potential for development of ammonia toxicity conditions and means for its alleviation is also investigated by providing two intervals of two weeks each of nitrification operation of the City STP, August 1-15 and September 1-15, for comparison. The importance of close control of bacterial levels in treated effluent is investigated by providing for comparison two other intervals of two weeks each, July 15-31 and August 15-31, in which quality is allowed to deteriorate to the 7-day maximum allowed by secondary treatment guidelines.

All of the foregoing considerations are recognized in the compilation of the point source input files for the year 2000 run. The following point source files comprise the year 2000 pollutant load.

1. Municipal sources, all assumed to be effluent from secondary treatment plant to 1983 standards.

    a. City of Spokane STP with seasonal phosphorus removal and nitrification and bacterial test periods. Flow 40 mgd equal 62 cfs.

    b. Spokane Valley STP with seasonal phosphorus removal and bacterial removal test period but without nitrification test. Flow 10 mgd equal 15.5 cfs.

    c. Deer Park STP, without phosphorus removal or tests. Flow .22 mgd equal .35 cfs.

    d. Tekoa STP, without phosphorus removal or tests. Flow .10 mgd equal .15 cfs.

2. Industrial sources, forecast

a. Spokane Valley process flows, 15.15 mgd equal 23.4 cfs.

b. Spokane Valley cooling flows, 17.5 mgd at 1.5°C rise, returned surface water.

c. North Spokane process flows, .48 mgd equal 0.74 cfs.

d. North Spokane cooling flows, 4.33 mgd equal 6.7 cfs at temperature 18°C, from groundwater source.

The development of these point source files is described in Section 606.3. The data are summarized in Appendices 5.1 through 5.5.

Production Run Results

Print outs of the NPS and year 2000 runs were made for the entire seventeen month simulation period at six hour intervals for the following locations: (Refer to Appendices 8.1-8.4 and 9.1-9.4.)

1. Upper Spokane, Subarea 700, WRIA 57

   a. Vicinity of University Road extended, about one mile east of Millwood

   b. At east City limits

   c. Above Hangman Creek confluence

2. Hangman Creek, Subarea 600, WRIA 56

   a. At Tekoa

   b. Above Rock Creek confluence

   c. Mouth of Rock Creek

   d. Vicinity of Gibbs Road extended

   e. At Minnie Creek confluence

   f. At mouth

3. Little Spokane, Subarea 500, WRIA 55

   a. Mouth of east branch above Milan

   b. Mouth of west branch above Milan

   c. Vicinity of Chattaroy on main stream

   d. Mouth of Dragoon Creek

   e. Mouth of Deep Creek

   f. Mouth of Peone Creek and mouth of Deadman Branch of Peone Creek

   g. Main stream at Deep Creek-Peone Creek confluence

   h. Mouth of main stream at the Spokane River

4. Lower Spokane, Subarea 400, WRIA 54

   a. Above the Deep Creek confluence, upstream from Nine Mile Reservoir

   b. Above the Little Spokane confluence at Nine Mile Dam

   c. In Long Lake at a point approximately 4 miles upstream from the dam

      (1) In the surface layer
      (2) In the middle layer
      (3) In the bottom layer

   d. Below Long Lake Dam

The quality parameters made available in the print out of each of the stream locations are as follows:

1. Dissolved oxygen
2. Temperature
3. BOD
4. Total dissolved solids
5. Total coliform
6. Fecal coliform
7. Ortho phosphate
8. Potential phosphate

9. Nitrate
10. Nitrite
11. Ammonia
12. Organic nitrogen
13. A conservative

For the Lower Spokane subarea only, which includes the City STP input and Long Lake, the index parameter for algal biomass, Chlorophyl A, is also provided.

Potential phosphate represents the phosphorus associated with the living biomass and with the BOD. It is the simulation program's parameter to maintain the phosphorus budget. Total phosphorus is the sum of Ortho phosphate and potential phosphate. The conservative is an index of proportionality that would show the concentration of a non-reacting parameter as it progressed through the system. Zinc is selected to represent conservatives since it is of interest in the flows from Coeur d'Alene Lake. The print out also provides the mean daily stream flow in cfs at each location listed above.

The simulation also recognizes and prints out the limiting factor in the biological activity at each period for which quality results are printed out. These limiting factors include light, temperature, phosphorus and nitrogen.

A key to symbols and abbreviations to reading the print outs is included in Appendix 6.1.

Evaluation of Results, Spokane River and Long Lake

The locations of primary interest are the Spokane River as it flows through the City of Spokane and the impoundment at Long Lake. The critical period is the season May through October. The following discussion focuses on these critical places and times.

Table 1 contrasts the NPS and year 2000 water quality conditions for significant locations on the Spokane River including Long Lake. Two specific dates are selected late in the summer season for the meteorological and flow conditions of 10 August 1968 and 25 August 1968. These dates are selected as representative of the most critical time of the year for both the river and Long Lake and for a year of low runoff. One date is selected in the first half of August to demonstrate the results of nitrification at the City STP and normal bacterial removal. The date in the second half of August is in the period when the City STP input file is without nitrification and for poorer bacterial control. It should be noted that the Spokane River flow on 10 August 1968 at 919 cfs (NPS conditions) is only 7 percent above the calculated 7-day 10-year low of 860 cfs.

The first two columns of data in Table 1 contrast performance on the Spokane River above the Hangman Creek confluence. This location shows the impact of the discharge from the Spokane Valley municipal treatment plant and the Spokane Valley industrial loads. Although phosphorus removal is taking place, there is significant biological activity at year 2000 conditions in response to the relatively small phosphorus additions. This activity affects the performance of the river with respect to DO. The simulation shows an increase in DO at year 2000 over NPS conditions, indicating that the impact of the biological activity in adding oxygen during daylight is greater than the effect of the added BOD is in depressing the oxygen supply. The data in Table 1 are for 1800 hours, 6 p.m., at the end of the strong daylight. The simulation six hours later at midnight shows that the DO by then has fallen to below NPS levels, demonstrating that the biological activity is indeed responsible. At midnight, however, the reduction in DO although measurable is not significant.

The high bacterial counts in the Spokane River at the boundary tend to mask the impact of the Spokane Valley STP effluent. Consideration of the dilution of the Spokane Valley STP effluent of 60 to 1 on 10 August and over 100 to 1 on 25 August explains the insignificant impact from effluent meeting 1983 discharge standards.

The amount of ammonia does not reach dangerous levels below the Spokane Valley STP without nitrification due to the high dilution ratio.

The impact of the industrial cooling water load is shown to be only 0.1°C. The impacts of sunlight and groundwater interchange are much more significant in this reach. There is an approximate 2 degree drop from the boundary condition due to groundwater interchange and a diurnal change of approximately 3 degrees due to sunlight.

In general it can be concluded from the simulation that the combined Spokane Valley STP and industrial loads would not degrade the river below Class A standards providing that the river meets these standards in all respects at the state boundary.

The second set of columns in Table 1 contrasts conditions in the Spokane River downstream from the City of Spokane STP. Here again, the DO is raised by the biological activity more than it is depressed by the added BOD. The biological activity as a result of added nutrients in combination with the high water temperatures is very large. The Chlor. A values at the low flow on August 10 reach 48.5 μg/l and the biomass has already utilized most of the added phosphorus as indicated by the drop of ortho P to .006 mg/l and increase of potential P to .069 mg/l.

With nitrification, the ammonia level is shown to be at a safe level of 0.048 mg/l but without nitrification at the higher dilutions which occur on 25 August, the ammonia level reaches 0.305 mg/l, a level of concern. The result would have been more critical on 10 August with much lower flow.

The dilution for the City of Spokane STP at year 2000 for the 10 August flow is approximately 17 to 1 and for 25 August 28 to 1. At these relatively low dilutions, the impact of bacterial pollution would be expected to be much greater than for the Spokane Valley STP. Again, however, the impact is masked by the high background levels. Purely on a dilution basis, the City STP additions should maintain the stream well within Class A standards even under less than optimum removal assumptions when background conditions from Idaho are corrected.

Immediately below the City STP at year 2000 it can be concluded that at summer low flow conditions there will be heavy biomass activity that will be visible, most prominently in Nine Mile Reservoir, and that there is a threat of ammonia toxicity without nitrification at very low flows.

The water quality in the three layers of Long Lake and after leaving Long Lake is contrasted in the remaining columns of Table 1. In addition, Tables 2 and 3 provide Long Lake results at 5 day intervals for the entire simulation period for NPS conditions and Tables 4 and 5 provide the corresponding data plus flow and temperature for year 2000 conditions. Figures G and H are graphical representations of flow, temperature and chlorophyl A for 1968 and 1969 respectively. Figures I and J show middle and bottom layer simulations of DO and Ortho P for 1968 and 1969 respectively.

Referring to Figures G through J the performance of Long Lake under NPS and year 2000 conditions can be observed. The first conclusion is that the temperature and stratification conditions are the same as presently observed. The point source flow increments have negligible effect on temperature. The wide range of temperature from 20°C at the surface to 10°C at the bottom in mid summer provides strong forces to prevent mixing and to maintain stratification. Even at NPS conditions, this strong stratification results in very low dissolved oxygen conditions at the bottom (less than 2 mg/l) leaving little reserve to prevent going anaerobic with the addition of small amounts of BOD. For NPS conditions, the biomass is negligible throughout the summer once the nutrients in the surface layer have been used up and the incoming supply decreases with the reduction in flow. There are still algal blooms, albeit at below nuisance levels, in the spring and at the fall turnover.

A note of caution is required with respect to interpreting the 1968 simulation of Ortho P for the NPS conditions. The simulation through two years demonstrates the great inertia in the lower layer even when flows are relatively high. The consequence is that the effect of assumed initial conditions persist throughout the summer to turnover. The assumed initial Ortho P for the lower layer was .05 mg/1 on 1 May 1968 for both NPS and YR 2000. This value did not fall during the high May and June flows. For NPS, Ortho P builds to about .09 mg/1 at turnover. The winter of 1968 brings Ortho P down to .03 mg/1 at 1 May 1969. The build is at about the same rate as 1968 resulting in a level of 0.075 mg/1 at turnover in 1969. The assumed initial condition appears to have had some effect on the maximum value at turnover in 1968. In the case of YR 2000 condition, the 1969 simulation indicates that the initial assumption was more valid and did not distort the 1968 values.

The simulated Ortho P levels in the middle layer indicate that YR 2000 conditions result in levels at 1 August of approximately twice the NPS levels. Hence, it is to be expected that as mixing increases and the middle layer waters start to reach the surface in late August and early September there will be a more significant growth of algal under YR 2000 conditions. Although the NPS levels are low, they do result in a biomass reaction.

In the bottom layer, the contrast in rate of build between the NPS condition where anaerobic levels are not reached and YR 2000 where they are is marked. At 1 August 1969, the NPS level is about .065 mg/l and YR 2000 at 0.10 mg/l, not a great difference. By the end of August, the NPS Ortho P level has risen to only .075 mg/l while the YR 2000 level has risen steeply to 0.23 mg/l. This emphasizes the importance of the oxygen level in preventing large releases of phosphate.

The addition of the phosphorus load forecast for year 2000, even with phosphorus removal, is of the order 690 pounds per day including Spokane Valley. The present estimated load from the City STP with primary treatment and no phosphorus removal is of the order 2500 pounds per day. The expected load after completion of the proposed expansion and upgrade but with the 1975 flows is of the order 350 pounds per day. Background level in the Spokane River at mean summer flows of 1500 cfs is 120 pounds per day. Thus the ratios of the NPS simulation condition to other conditions are as shown below.

Condition	Approximate Phosphate Loads Pounds Per Day			
	Background	Point Source	Total	Ratio
No point source simulation	120	-	120	1.00
Year 2000 simulation	120	690	810	6.75
Present conditions	120	2500	2620	21.83
Present flow with 85% removal	120	350	470	3.92

The observed level of biomass under present conditions reached levels of 15 to 30 μg/l in the calibration period. The simulated level in late summer under NPS conditions is less than 2 μg/l and is approximately 11 μg/l under year 2000 simulated conditions. The year 2000 simulation indicates that the reduction to a mean level of 11 μg/l for late summer would be a significant improvement over present conditions. The level is not reduced to the level generally accepted as satisfactory, namely, around 5 to 7 μg/l. The relation between phosphorus loading and biomass is obviously not linear from the NPS to present conditions. At the levels above the year 2000 loading, the utilization appears to be limited by other factors than phosphorus. If the relationship is close to linear below the year 2000 level, the expected performance in 1977 when the upgarded City STP is in service is around 7 μg/l. This would indicate that for average summer conditions quality would gradually decrease from around 7 to 11 μg/l as the total flows increased over the years.

Under year 2000 conditions the middle layer does not become anaerobic as it does at present but the DO at 1.8 mg/l is significantly below NPS conditions at 6.9 mg/l. The bottom layer does go anaerobic at year 2000 conditions during the first week in August. This is a significant improvement over present conditions in which the middle layer becomes anaerobic by the first of August and the bottom layer by mid July.

At year 2000, the simulated phosphate concentration in the middle and bottom layers is 0.064 and 0.076 mg/l respectively on the 10 August and 25 August dates. These levels are about twice the NPS levels. Under present conditions the bottom layer levels have reached over 0.2 mg/l by early August on their way to highs of 0.4 mg/l in September. At year 2000, the simulated phosphate tops at 0.25 mg/l prior to turnover. Since under NPS conditions, the bottom layer does not go anaerobic, the maximum phosphate level is only 0.085 which is about equal to the levels reached by year 2000 as the anaerobic period ends.

Since there are spring and post turnover blooms under NPS conditions, similar blooms are to be expected under year 2000 conditions. This is born out in the year 2000 simulations with the spring blooms not much higher than the NPS condition but with the post turnover blooms approaching present conditions. High values are reached, over 20 μg/l, in September when the nutrient supply in the surface layer is increased by a small amount of mixing from the middle layer.

Immediately after turnover at the first of October, there is another jump in activity corresponding to the bottom layer nutrients being made available at the surface but temperature and sunlight conditions are deteriorating so rapidly that the activity begins to decrease at a high rate. When October 15 is reached, the temperature and light conditions have become so overwhelmingly important that the cessation of phosphorus removal has no significant effect in checking the fall in activity. By the first weeks in November, the Chlor. A levels have fallen to NPS levels despite incoming phosphorus levels of the order 3500 pounds per day.

In spring, the critical temperature and sunlight conditions are seen to operate in a similar manner. In the year 2000 simulation, with no phosphorus removal throughout April, there is no algal activity. Only after phosphorus removal has begun on 1 May does activity start as water temperature begin to climb above 10°C. These results indicate that phosphorus removal between October 15 and May 1 would not affect the eutrophic condition of Long Lake.

Water quality of the reach below Long Lake is largely determined by the quality of the surface layer in Long Lake. This was evident from the calibration conditions and consequently reappears in the simulation. This result apparently derives from the construction of the outlet works of Long Lake Dam in which the penstock inlets are at a level corresponding to the upper part of the middle layer. (The top of the penstock is at 30 feet or less than 10 meters depth.)

Evaluation of Results, Little Spokane River and Hangman Creek

The primary function of the Little Spokane River and Hangman Creek simulations is to develop input to the main flow of the Spokane River. It should be kept in mind that both streams are calibrated to conditions at the mouth only and that upstream points may therefore differ from actual conditions.

The Little Spokane River NPS and year 2000 simulations show deficiencies in total coliforms and dissolved oxygen. The coliforms originate from non-point-sources and become a part of the background condition in the calibration process. The low dissolved oxygen conditions, between 7 and

8, occur only during part of the day and result from the nature of the simulation process of very low flows which does not recognize the sub-channel that exists in nature. These apparent low DO conditions are judged not to be "real" for upstream reaches. The DO levels in the range 7 to 8 in the reach just before the confluence are real and the result of the large volume of groundwater interchange. There appear to be no deficiencies that are the result of point source loads.

The NPS and year 2000 simulation show no significant deficiencies in the Hangman Creek data in the absence of precipitation. The same limitations to accuracy of DO results at low flow in upstream reaches also apply. The Hangman Creek quality, since the stream is so flashy, is heavily impacted by precipitation events and the accompanying washoff of non-point source pollutants. Under these conditions high coliform counts result. The simulation process is not capable of dealing with the silt load of Hangman Creek.

Access to the Model

Three elements are required for the simulation process, the data base, the load module and the input sequence. The data base, which contains the meteorological data, point source files and similar data, is preserved on three magnetic tapes, one each for the calibration, no-point-source and year 2000 simulation runs. The load module is the HSP program in machine language and is the property of Hydrocomp International and is preserved in their custody. The input sequence, which contains the calibration parameters, the physical description of the basin, data loading instructions and definition of run limits, is preserved on three sets of punched cards corresponding to the data base tapes.

The data base tapes were created from the disc packs used in the corresponding computer runs using IBM Utility Program IEHDASDR.

In addition to the tapes and card decks, print outs are available of the final calibration runs, the NPS runs and the year 2000 runs. There are also print outs of an index to each tape and of the input files. The LIBRARY portion of the HSP load module can be instructed to create additional print outs from the tapes of simulation results, index data and data files.

A fourth tape has stored on it the meteorological data for five parameters over a twenty year period, 1953 to 1973, from the Spokane Weather Bureau Airport Station. This file was created for possible use in side run simulations of urban runoff as described in Section 406.3.

In order to activate the simulation process for additonal runs under modified conditions the appropriate tape and the HSP load module must be reloaded into a compatible computer and driven by instructions from the corresponding card deck modified for the purpose intended in accordance with instructions in the Hydrocomp Simulation Programing Operations Manual. The proprietary nature of the HSP program requires that any additional simulations be performed only under appropriate contractual arrangements with Hydrocomp International, Incorporated. When these are completed, the load module is entered into the selected computer by Hydrocomp.

The information on the data base tapes is accessible only through reading and print out instructions from the LIBRARY portion of the load module. The tapes cannot be read by themselves.

The costs of computer operation for the simulation process may be estimated from the following experience in this project where an IBM 360/195 was used:

Simulation Area	Core	CPU's*	1.0. Wait*
Upper Spokane	446K	1.293	0.496
Hangman Creek	376K	2.014	0.389
Little Spokane	442K	3.025	0.409
Lower Spokane	654K	2.300	0.784

There are two alternatives for utilization of the HSP load module: one is for use of the simulation on a time-sharing computer utility, the other is for use in a client-owned computer. For use on time-sharing computer, the basis for compensation is a yearly fee plus a computer time surcharge. For use on a client-owned computer, a yearly charge basis is negotiated to recognize the proposed extent of use. Particulars should be obtained directly from Hydrocomp International, Inc. 1502 Page Mill Road, Palo Alto, California 94304; telephone (415) 493-5522.

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*CPU's and 1.0. Wait are in minutes per year of simulation.

Future Application of the Simulation Model

General. The calibration and production runs made under this study by no means exhaust the potential of this tool for planning, regulatory or research purposes. Some of the potential applications that are apparent at this time are explored briefly below. In addition there will be the unforseen or unanticipated changes in conditions or regulatory requirements that will provide other opportunities for use.

Since the Corps of Engineers does not have an ongoing authorization or responsibility for either planning or regulatory functions at this location, it is evident that a local agency with appropriate authority and responsibility should consider becoming custodian of the tool for ongoing use. In addition to the obvious usefulness to DOE, the City should find high interest, particularly as related to the forthcoming overflow abatement problem.

Statistical Evaluation. The trend in regulatory practice is to express requirements in statistical terms rather than a single fixed not-to-exceed value. As requirements become more stringent, statistical expression is expected to be utilized to achieve these ends economically. Also, when regulatory requirements are set for urban runoff, they can hardly be expressed in other than statistical terms.

The HSP simulation, with its capability of developing responsive quality data over periods as long as available meteorological records, can provide the raw materials for statistical analysis. The HSP simulation does not in itself contain statistical analysis programming but this is readily available from other software sources.

The raw meteorological data for a twenty year period are available. This is an adequate length of time for valid statistical results. Due to the very large volumes of data and the involved computations in the quality simulation process, these extended runs can be expensive in computer time. Refer to estimated computer storage and time requirements given above. Considering the cost treatement processes and alternatives this could be a wise investment despite the price.

Statistical application of water quality standards would permit deviation from the traditional definition of absolute requirements which do not necessarily relate to realistic objectives for cost-effective regulation of environmental impacts. The statistical analysis tool would permit a determination of such items as the percentage of time over any time base which a given parameter exceeds a given value. Or conversely, it can be used to determine what level of discharge parameter concentration is required to control receiving water quality to a given level r certain percentage of the time. This tool would aid in establishing discharge standards which could vary seasonally or with river flow conditions. For example, a specific parameter whose impact is not well defined and is very expensive to control is ammonia. The cost effective choice of treatment is highly dependent upon the percentage of time it would need to be operated.

Low Flow Augmentation. One of the most intriguing possibilities suggested by analysis of the initial production simulation runs, particularly evaluation of the NPS condition, concerns the possibility of controlling both quantity and temperature of flow. The quality simulation under these runs makes it very clear that phosphorus is not the sole limiting factor at all times in limiting biological activity within the rivers or Long Lake. Impoundment detention, temperature, lake stratification and radiation are more critical factors under certain conditions. The consideration of control of river flow and water temperature, which are discussed elsewhere as possible water quality management strategies, could be tested with the simulation model. It is possible to evaluate river flow operating policies to determine the optimum procedure accounting for both water quality and power generation, not just power generation alone.

Urban Runoff. Since the HSP simulation generates surface runoff and pollutant loads from meteorological events with full recognition of the time functions of build up and wash off of pollutants, it is ideal for evaluation of urban runoff impact. A simulation of urban runoff is included in both the NPS and YR 2000 runs. This specific application, however, does not take full advantage of the model capability for several reasons, the most important being lack of specific calibration data.

As presently incorporated in the model, urban runoff is the consequence of the amount of impervious area assigned to segments which include the presently sewered urban areas. Both the volume and the quality of runoff from the urban portion are inseparable from the remainder of the segment which is large compared with the urban area. Furthermore, the urban area falls in three different watersheds. The addition of more reaches was not justified when there was no way to calibrate, and urban runoff was not the primary object of the evaluation.

With the future advent of specific urban runoff criteria or in anticipation of same it would be justified to make a more refined approach. As proposed in Section 406.3, the urban area would be deleted from the natural reaches in which it occurs and a single separate reach would be created for the urban area. This separated reach could be processed separately from the remainder of the simulation area at greatly reduced cost and with output available for separate analysis or manipulation. The advantage of the separate side run to simulate urban runoff is that it can then be subject to various treatment alternatives before being entered into the basin simulation as a point source. This is not possible if the urban runoff simulation is an integral part of basin simulation as at present.

There are no urban runoff data specific to Spokane or to a Spokane sequence of rainfall events. Only isolated areas in Spokane are separately sewered to provide a test situation. It is not possible under present conditions of combined sewer overflow to estimate urban runoff quality from its impact on the receiving waters since the effect of the urban runoff component is masked by the combined overflows. In the absence of local calibration data it is possible to make an estimation of water quality impact by applying the HSP simulation with literature values as developed in Section 406.3.

The City program of correction of combined sewer overflow problems could make good use of the simulation process to evaluate the effectiveness of alternative plans. It would not be necessary to run the entire basin simulation for most considerations. These could be handled in a sub-routine variation of the urban run-off subroutine described above. Summarized results from selected subroutines could be used as point source inputs to the basin wide run for overall evaluation of selected plans. The HSP simulation of the runoff hydrograph would be particularly useful in evaluation of combined overflows.

Small Watershed Hydrology. Concentration on the water quality aspects of the HSP model almost leads to overlooking its earliest use, namely for hydrologic simulation. There are many branch streams like Rock Creek for which there are no long-term flow records. The HSP simulation could be utilized to synthesize these records.

The HSP model also provides a tool for evaluation of any proposed programs for alteration of the runoff from watersheds by either surface retention or storage.

Research. The complexities of model calibration for Long Lake illustrate that the model does not recognize many of the nuances of behavior but that it is a highly sensitive tool nonetheless. The very process of investigating the shortcomings of the simulation process are sure to lead to a better fundamental understanding of the processes in Long Lake.

There is an opportunity here for a cooperative effort between local regulatory agencies and the local academic interests which have made significant contributions to the understanding of Long Lake already.

Another research application would be in connection with urban runoff. Thus far, no urban runoff sampling program has been specifically designed and implemented to gather data in the form to fit the recognized build up - wash off algorithms such as those incorporated in HSP. With an available simulation, the data could be tested as developed.

TABLE 1
SIMULATED WATER QUALITY
SPOKANE RIVER AND LONG LAKE
NPS AND YR 2000

Meteorological Event				Reach 730 Spokane River Abv. Hangman Cr. Confluence		Reach 430 Spokane River Abv. Little Spk. Confluence		Long Lake-Reach 440						Reach 450 Leaving Long Lake	
								Top Layer		Middle Layer		Bottom Layer			
Date	Time	Parameter	Units	NPS(1)	YR 2000(2)	NPS	YR 2000	NPS	YR 2000	NPS	YR 2000	NPS	YR 2000	NPS	YR 2000
10 Aug 68	1800 (3)	Dissolved Oxygen	mg/l	8.8	9.9	8.2	9.1	8.1	8.8	6.9	1.8	2.8	0.0	8.2	8.5
		BOD	mg/l	0.6	2.1	1.1	9.1	0.1	1.7	0.0	0.6	0.1	0.4	0.3	2.0
		Temperature	°C	18.5	18.6	20.9	20.8	20.9	20.9	15.0	15.2	10.2	10.3	22.0	22.0
		Total Coliform	org/100 ml	299	297	257	256	42	43	0.0	0.0	0.0	0.0	35	36
		Fecal Coliform	org/100 ml	6	11	5	9	1	1	0.0	0.0	0.0	0.0	1	1
		Ortho Phosphate	mg/l	.001	.015	0.0	.006	0.0	.001	.031	.064	.082	.133	.001	.001
		Pot. Phosphate	mg/l	.009	.026	.008	.069	0.0	.013	0.0	.005	.001	.003	.002	.015
		Total Phosphate	mg/l	.010	.041	.008	.075	0.0	.014	.031	.069	.083	.136	.003	.016
		Ammonia	mg/l	.006	.123	.013	.048	0.0	.005	0.0	.011	.005	.228	.004	.008
		Total Nitrogen	mg/l	.554	.825	.65	2.69	.44	.98	.33	.59	.50	.62	.46	.99
		Chlorophyl a	µg/l			3.5	48.5	.30	11.3	.10	4.2	.10	.60	.90	12.2
		Flow	cfs	919	957	1065	1106							1107	1107
25 Aug 68	1800 (4)	Dissolved Oxygen	mg/l	9.5	10.1	8.9	9.7	8.5	9.2	6.8	.3	2.0	0.0	8.5	9.1
		BOD	mg/l	1.0	1.6	1.4	5.9	0.1	1.7	0.0	.6	.1	1.7	.2	1.8
		Temperature	°C	17.0	17.1	18.3	18.3	18.4	18.4	15.0	15.2	10.2	10.3	18.9	18.9
		Total Coliform	org/100 ml	468	467	412	412	87	87	0.0	0.0	0.0	0.0	77	77
		Fecal Coliform	org/100 ml	8	13	13	17	4	5	0.0	0.0	0.0	0.0	4	5
		Ortho Phosphate	mg/l	.003	.016	.001	.005	0.0	.001	.032	.076	.088	.198	.001	.001
		Pot. Phosphate	mg/l	.017	.023	.010	.045	.001	.013	0.0	.005	.001	.013	.001	.014
		Total Phosphate	mg/l	.020	.039	.011	.050	.001	.014	.032	.081	.089	.211	.002	.015
		Ammonia	mg/l	.010	.093	.012	.305	0.0	.013	0.0	.082	.007	.434	.003	.012
		Total Nitrogen	mg/l	.383	.566	.40	1.15	.41	.92	.32	.74	.53	.65	.42	.95
		Chlorophyl a	µg/l			4.6	29.5	.50	11.2	.10	4.1	.10	.60	.50	11.5
		Flow	cfs	1599	1638	1760	1801							1846	2109

NOTES:

(1) NPS = no point source simulation.
(2) YR 2000 = simulation of year 2000 conditions with Plan A point sources for urban area.
(3) Last precipitation prior to 10 Aug 68 was 0.2 in. on July 19. Simulation between 1 Aug. and 15 Aug. has nitrification treatment for City STP point source.
(4) Last precipitation prior to 25 Aug. 68 was 0.13 in. on Aug. 23. Simulation between 15 Aug. and 31 Aug. does not have nitrification treatment for City STP and has coliform at 800 org/100 ml.

TABLE 2

LONG LAKE SIMULATION - YR 2000 CONDITION

			Top Layer						Mid Layer			Bot Layer		
Yr	Mo	Day	Chl.a µg/l	Temp °C	DO mg/l	Ortho P mg/l	Pot P mg/l	Flow cfs	Temp °C	DO mg/l	Ortho P mg/l	Temp °C	DO mg/l	Ortho P mg/l
68	5	1	13.1	8.7	12.4	.036	.017	6,960	7.1	10.8	.051	7.0	10.0	.050
		5	15.9	9.9	12.2	.004	.020	6,860	7.6	10.4	.047	7.1	9.8	.052
		10	13.8	11.2	11.8	.001	.018	9,380	8.2	10.1	.039	7.5	9.5	.053
		15	12.9	12.6	11.4	.001	.017	10,160	9.1	9.7	.035	7.6	9.0	.053
		20	12.9	13.7	11.2	-	.017	11,030	10.0	9.3	.033	8.1	8.5	.053
		25	12.7	13.8	11.1	-	.016	9,380	10.6	8.9	.033	8.6	8.0	.053
	6	1	12.2	15.3	10.8	.001	.016	10,900	11.4	8.3	.033	9.3	7.2	.053
		5	11.7	17.3	10.3	.001	.015	8,000	11.6	7.9	.035	9.4	6.7	.056
		10	11.6	17.9	10.2	.001	.015	6,000	11.9	7.4	.037	9.6	6.1	.060
		15	11.4	17.7	10.2	.001	.014	7,850	12.2	7.0	.039	9.7	5.5	.063
		20	11.5	20.0	9.7	.001	.014	6,120	12.6	6.6	.041	9.8	5.0	.066
		25	11.6	20.9	9.6	.001	.014	5,720	13.1	6.2	.042	10.0	4.4	.069
	7	1	11.2	18.2	9.8	.001	.014	4,980	13.5	5.7	.044	10.2	3.8	.072
		5	11.4	22.5	9.3	.001	.013	3,700	13.7	5.4	.046	10.2	3.3	.076
		10	11.1	23.7	8.8	.001	.013	3,560	14.1	4.9	.048	10.2	2.7	.080
		15	11.1	19.5	8.9	.001	.013	2,300	14.4	4.4	.050	10.2	2.0	.084
		20	11.1	19.8	9.0	.001	.013	2,712	14.6	4.0	.052	10.2	1.5	.088
		25	11.2	22.2	8.9	.001	.013	2,520	14.8	3.6	.054	10.2	1.1	.093
	8	1	11.3	22.4	8.6	.001	.013	2,370	15.2	2.9	.057	10.3	0.4	.099
		5	11.3	21.2	8.7	.001	.013	2,180	15.2	2.4	.060	10.3	-	.106
		10	11.3	20.9	8.8	.001	.013	590	15.2	1.8	.064	10.3	-	.133
		15	11.6	19.3	8.9	.001	.014	1,720	15.2	1.3	.068	10.3	-	.158
		20	11.2	18.7	9.0	.001	.014	2,300	15.2	.8	.072	10.3	-	.179
		25	11.2	18.4	9.2	.001	.013	1,820	15.2	.3	.076	10.3	-	.198
	9	1	14.8	19.4	9.4	-	.017	1,750	15.7	.9	.076	10.3	-	.223
		5	21.9	19.1	9.9	-	.025	2,990	16.9	3.7	.052	10.6	-	.232
		10	22.2	19.7	9.7	.001	.026	1,830	17.8	5.2	.042	11.0	-	.244
		15	21.6	17.1	10.2	.001	.025	2,910	17.9	5.7	.039	11.3	-	.255
		20	20.3	15.3	10.5	.001	.025	2,600	16.7	6.2	.038	11.7	-	.266
		25	19.5	15.9	10.5	.001	.023	3,040	15.5	6.7	.037	11.9	-	.277

All values at 1800 hours.

TABLE 2 - Continued

Yr	Mo	Day	Chl.a µg/1	Top Layer Temp °C	DO mg/1	Ortho P mg/1	Pot P mg/1	Flow cfs	Mid Layer Temp °C	DO mg/1	Ortho P mg/1	Bot Layer Temp °C	DO mg/1	Ortho P mg/1
68	10	1	23.0	15.6	10.5	.003	.027	2,370	15.1	5.9	.072	12.7	-	.259
		5	27.1	13.8	10.0	.048	.032	3,320	13.9	4.5	.107	13.8	1.3	.170
		10	21.8	12.3	9.2	.068	.026	2,910	12.9	5.1	.102	13.4	2.3	.129
		15	19.1	11.1	9.7	.063	.023	5,100	12.1	6.0	.092	12.7	3.6	.112
		20	14.0	11.1	9.3	.086	.017	5,501	11.6	7.0	.093	11.9	5.0	.102
		25	15.5	10.9	10.6	.085	.019	5,290	11.1	7.7	.097	11.4	5.9	.103
	11	1	13.3	9.8	10.8	.090	.016	5,200	10.3	8.4	.099	10.7	7.4	.103
		5	8.2	9.1	9.6	.104	.011	4,800	9.7	8.4	.106	10.0	7.9	.106
		10	4.6	7.8	9.3	.114	.007	5,130	8.7	8.5	.113	9.0	8.1	.112
		15	2.6	6.9	9.4	.114	.005	6,700	7.7	8.7	.117	8.0	8.4	.118
		20	1.2	6.6	9.4	.113	.003	7,150	6.8	8.9	.116	7.0	8.6	.117
		25	0.6	6.3	9.7	.104	.003	10,660	6.6	9.1	.113	6.7	8.8	.116
	12	1	0.3	5.8	9.5	.107	.002	7,450	5.9	9.4	.107	5.9	9.3	.107
		5	0.2	5.2	9.8	.107	.002	8,730	5.4	9.7	.107	5.4	9.6	.108
		10	0.1	5.1	9.9	.106	.002	8,890	5.0	9.8	.107	5.0	9.8	.108
		15	-	4.7	10.1	.097	.002	10,880	4.7	9.9	.099	4.9	9.9	.100
		20	-	4.2	10.1	.095	.002	8,190	4.3	10.0	.095	4.3	10.0	.095
		25	-	4.0	10.2	.099	.002	7,040	3.9	10.1	.099	3.9	10.1	.099
69	1	1	-	1.8	10.5	.103	.002	6,980	1.9	10.4	.103	2.0	10.3	.103
		5	-	1.4	10.8	.106	.002	6,870	1.5	10.6	.106	1.5	10.6	.106
		10	-	.7	11.5	.090	.003	16,920	.8	11.2	.095	.8	11.1	.097
		15	-	.4	11.6	.080	.003	14,560	.5	11.5	.082	.5	11.4	.083
		20	-	.2	11.7	.078	.003	12,300	.2	11.6	.079	.2	11.5	.080
		25	-	-	11.7	.084	.003	7,440	.1	11.6	.083	.1	11.5	.083
	2	1	-	.1	11.8	.098	.003	6,720	.1	11.5	.095	.1	11.5	.095
		5	-	.7	11.7	.111	.002	4,230	.3	11.5	.103	.2	11.4	.101
		10	-	1.0	11.7	.107	.003	6,950	.5	11.4	.107	.4	11.4	.107
		15	-	1.5	11.4	.107	.003	7,710	1.0	11.2	.108	1.0	11.2	.108
		20	-	2.0	11.3	.110	.003	6,920	1.6	11.1	.110	1.5	11.0	.110
		25	-	2.4	11.2	.116	[illegible]	5,[illegible]8	1.8	11.0	.114	1.7	10.9	.114

All values at 1800 hours.

TABLE 2 - Continued

				Top Layer					Mid Layer			Bot Layer		
						Ortho	Pot				Ortho			Ortho
			Chl.a	Temp	DO	P	P	Flow	Temp	DO	P	Temp	DO	P
Yr	Mo	Day	µg/1	°C	mg/1	mg/1	mg/1	cfs	°C	mg/1	mg/1	°C	mg/1	mg/1
69	3	1	-	3.3	11.2	.119	.003	6,230	2.1	10.8	.117	2.0	10.8	.117
		5	-	4.4	10.9	.120	.003	6,230	2.5	10.6	.119	2.3	10.6	.119
		10	-	3.7	10.7	.112	.003	5,900	2.9	10.3	.119	2.7	10.3	.121
		15	-	3.9	10.7	.117	.003	6,900	3.2	10.2	.119	3.0	10.1	.121
		20	-	5.5	10.0	.092	.004	12,960	3.7	9.9	.115	3.4	9.9	.119
		25	-	6.0	10.2	.082	.004	12,030	4.1	9.7	.107	3.9	9.6	.112
	4	1	-	7.6	9.9	.052	.005	21,000	4.9	9.4	.099	4.6	9.3	.104
		5	-	7.9	9.9	.050	.005	22,080	5.3	9.3	.091	4.9	9.1	.101
		10	-	7.3	9.7	.050	.004	25,240	6.0	9.2	.079	5.4	9.0	.092
		15	.1	8.3	9.8	.051	.004	25,644	6.7	9.1	.071	6.0	8.9	.083
		20	.2	8.1	9.8	.049	.004	26,434	7.1	9.1	.065	6.6	8.8	.075
		25	.5	9.0	9.7	.045	.005	31,212	7.9	9.0	.061	7.2	8.7	.069
	5	1	.4	8.1	9.8	.035	.005	31,141	8.0	9.0	.056	7.7	8.6	.064
		5	1.5	10.3	10.0	.024	.006	26,860	8.1	8.9	.051	7.8	8.4	.064
		10	11.2	12.8	11.4	-	.016	25,161	9.0	9.1	.043	8.0	8.3	.062
		15	10.9	13.0	11.3	-	.016	29,563	9.9	9.0	.038	8.3	8.1	.059
		20	11.0	13.6	11.2	-	.016	26,700	10.6	8.8	.035	8.8	7.8	.057
		25	11.0	15.7	10.7	.001	.015	22,900	11.5	8.5	.034	9.3	7.5	.055
	6	1	10.8	16.2	10.5	.001	.015	20,150	12.2	8.1	.033	10.1	6.9	.054
		5	10.4	18.5	10.0	.001	.014	18,840	12.5	7.6	.035	10.2	6.4	.057
		10	10.4	18.6	10.0	.001	.014	14,850	12.9	7.2	.037	10.4	5.8	.061
		15	10.8	19.0	9.9	-	.013	4,950	13.3	6.8	.038	10.5	5.2	.064
		20	10.7	20.3	9.4	.001	.013	4,050	13.8	6.3	.040	10.7	4.7	.067
		25	10.8	17.4	9.6	.001	.013	5,388	14.1	5.9	.042	10.9	4.1	.069
	7	1	10.8	18.5	9.9	.001	.013	5,100	14.2	5.5	.044	11.0	3.5	.073
		5	10.7	19.4	9.7	.001	.013	5,090	14.3	5.1	.045	11.0	3.0	.076
		10	10.6	21.5	9.3	.001	.013	4,380	14.6	4.7	.047	11.1	2.3	.081
		15	10.8	19.6	9.3	.001	.013	3,090	14.8	4.3	.049	11.1	1.8	.085
		20	10.8	21.9	9.1	.001	.013	3,102	15.0	3.9	.051	11.1	1.3	.089
		25	10.7	21.8	8.9	.001	.013	2,490	15.2	3.5	.053	11.1	.8	.093

All values at 1800 hours.

TABLE 2 - Continued

				Top Layer					Mid Layer			Bot Layer		
						Ortho	Pot				Ortho			Ortho
			Chl.a	Temp	DO	P	P	Flow	Temp	DO	P	Temp	DO	P
Yr	Mo	Day	µg/l	°C	mg/l	mg/l	mg/l	cfs	°C	mg/l	mg/l	°C	mg/l	mg/l
69	8	1	10.8	22.3	8.7	.001	.013	2,210	15.6	2.9	.056	11.1	.1	.100
		5	10.9	19.8	8.8	.001	.013	1,830	15.6	2.4	.059	11.1	-	.118
		10	11.3	21.5	9.0	-	.013	1,972	15.6	1.8	.063	11.1	-	.144
		15	11.5	21.0	9.0	.001	.013	1,940	15.6	1.3	.067	11.1	-	.169
		20	11.1	20.8	8.9	.001	.013	1,880	15.6	.8	.071	11.1	-	.190
		25	10.8	21.4	8.8	.001	.013	2,921	15.6	.6	.075	11.1	-	.209
	9	1	14.1	20.1	9.3	.001	.016	2,500	16.0	.9	.075	11.2	-	.234
		5	20.7	15.8	10.1	.001	.024	2,501	16.3	3.9	.051	11.4	-	.243
		10	21.4	17.8	10.1	.001	.025	3,160	16.3	5.7	.041	11.6	-	.254
		15	20.9	15.9	10.5	.001	.024	3,091	16.4	6.3	.038	11.9	-	.265
		20	20.2	15.0	10.7	.001	.024	2,380	15.7	6.7	.037	12.1	-	.276
		25	19.7	14.1	10.9	.001	.023	2,620	14.8	7.0	.037	12.3	-	.286
		30	19.8	13.4	11.0	.001	.023	2,630	14.3	7.2	.037	12.4	-	.295

All values at 1800 hours.

TABLE 3

LONG LAKE SIMULATION - NO-POINT SOURCE CONDITION

Yr	Mo	Day	Top Layer Chl.a µg/l	Mid Layer DO mg/l	Mid Layer Ortho P mg/l	Bot Layer DO mg/l	Bot Layer Ortho P mg/l	Yr	Mo	Day	Top Layer Chl.a µg/l	Mid Layer DO mg/l	Mid Layer Ortho P mg/l	Bot Layer DO mg/l	Bot Layer Ortho P mg/l
68	5	1	6.3	10.7	.052	10.0	.050	68	10	1	6.4	7.9	.020	2.7	.073
		5	12.9	10.3	.047	9.8	.052			5	12.2	7.7	.024	5.5	.043
		10.	10.1	10.2	.038	7.3	.052			10	12.4	8.5	.018	7.0	.030
		15	9.3	9.9	.034	7.6	.052			15	11.1	9.0	.015	7.7	.024
		20	9.3	9.6	.031	8.1	.051			20	9.3	9.4	.012	8.3	.020
		25	8.9	9.3	.030	8.6	.049			25	8.9	9.7	.011	8.7	.017
	6	1	8.3	8.9	.030	7.9	.049		11	1	7.7	9.9	.010	9.3	.014
		5	7.3	8.6	.031	7.5	.051			5	5.6	9.9	.012	9.6	.013
		10	6.8	8.3	.032	7.0	.054			10	3.1	9.9	.014	9.7	.014
		15	6.7	8.0	.033	6.6	.056			15	1.8	10.0	.016	9.8	.016
		20	6.3	7.8	.034	6.2	.058			20	.8	10.0	.019	9.9	.019
		25	6.1	7.5	.034	5.8	.060			25	.4	10.1	.021	9.9	.021
	7	1	5.2	7.2	.035	5.4	.062		12	1	.2	10.2	.022	10.1	.023
		5	2.4	7.1	.035	5.0	.065			5	.1	10.4	.023	10.3	.023
		10	1.2	6.9	.035	4.6	.068			10	.1	10.4	.024	10.4	.024
		15	0.7	6.9	.034	4.3	.070			15	-	10.5	.024	10.5	.024
		20	0.6	6.9	.033	3.9	.073			20	-	10.5	.024	10.5	.024
		25	.6	6.9	.032	3.6	.075			25	-	10.6	.024	10.6	.025
	8	1	.4	6.9	.031	3.2	.078	69	1	1	-	10.9	.025	10.9	.025
		5	.4	6.9	.031	3.0	.079			5	-	11.2	.025	11.1	.025
		10	.3	6.9	.031	2.8	.082			10	-	11.6	.024	11.5	.024
		15	.3	6.9	.032	2.5	.084			15	-	11.8	.024	11.8	.024
		20	.4	6.8	.032	2.2	.086			20	-	11.9	.024	11.9	.024
		25	.5	6.8	.032	2.0	.088			25	-	11.9	.025	11.9	.025
	9	1	2.0	6.9	.029	1.7	.090		2	1	-	11.9	.025	11.9	.025
		5	5.6	7.7	.019	1.8	.089			5	-	11.9	.025	11.9	.026
		10	6.3	8.1	.014	1.8	.087			10	-	11.9	.025	11.9	.026
		15	5.8	8.3	.012	1.8	.087			15	-	11.7	.025	11.7	.026
		20	5.4	8.5	.011	1.8	.086			20	-	11.6	.026	11.6	.026
		25	5.4	8.7	.011	1.7	.086			25	-	11.5	.026	11.5	.026

All values at 1800 hours.

TABLE 3 - Continued

Yr	Mo	Day	Top Layer Chl.a µg/l	Mid Layer DO mg/l	Mid Layer Ortho P mg/l	Bot Layer DO mg/l	Bot Layer Ortho P mg/l
69	3	1	-	11.4	.026	11.4	.026
		5	-	11.3	.026	11.3	.027
		10	-	11.0	.026	11.0	.027
		15	-	11.0	.026	10.9	.027
		20	-	10.7	.026	10.7	.027
		25	-	10.4	.026	10.4	.028
	4	1	-	10.1	.027	10.1	.028
		5	-	10.0	.027	10.0	.029
		10	-	9.8	.027	9.7	.029
		15	.1	9.6	.026	9.5	.029
		20	.1	9.5	.026	9.3	.029
		25	.3	9.4	.026	9.2	.029
	5	1	.2	9.3	.026	9.0	.029
		5	.9	9.2	.026	8.9	.030
		10	8.5	9.4	.023	8.7	.031
		15	8.5	9.3	.021	8.6	.031
		20	8.5	9.2	.021	8.3	.032
		25	8.4	8.9	.021	8.1	.032
	6	1	8.4	8.6	.021	7.6	.034
		5	7.9	8.3	.023	7.2	.037
		10	7.5	7.9	.025	6.7	.040
		15	7.0	7.6	.026	6.3	.043
		20	4.9	7.3	.027	5.8	.045
		25	1.5	7.1	.027	5.5	.048
	7	1	1.0	7.0	.027	5.1	.050
		5	1.1	6.9	.026	4.8	.052
		10	1.0	6.9	.026	4.5	.055
		15	.7	6.9	.025	4.2	.057
		20	.6	6.9	.024	3.9	.059
		25	.6	7.0	.024	3.6	.061
69	8	1	.5	7.0	.026	3.3	.064
		5	.4	7.0	.023	3.1	.066
		10	.4	6.9	.023	2.8	068
		15	.3	6.9	.023	2.5	.070
		20	.3	6.9	.023	2.3	.072
		25	.4	6.9	.024	2.0	.074
	9	1	1.8	7.0	.022	1.8	.076
		5	4.7	7.6	.014	1.8	.075
		10	5.1	8.1	.011	1.9	.075
		15	4.7	8.3	.010	1.9	.074
		20	4.7	8.5	.009	1.8	.074
		25	4.7	8.7	.009	1.8	.074
		30	4.6	8.9	.009	1.8	.074

All values at 1800 hours.

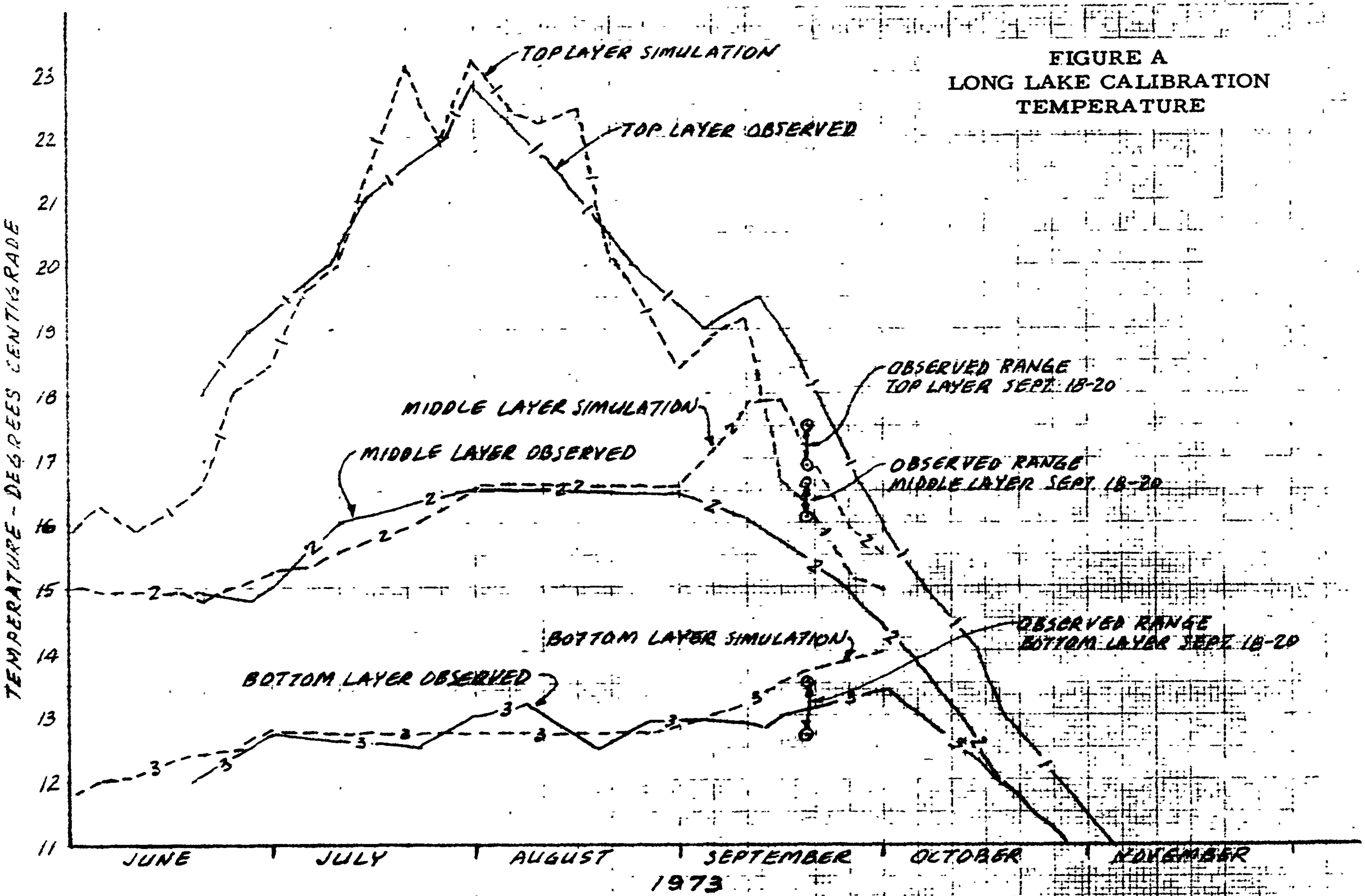
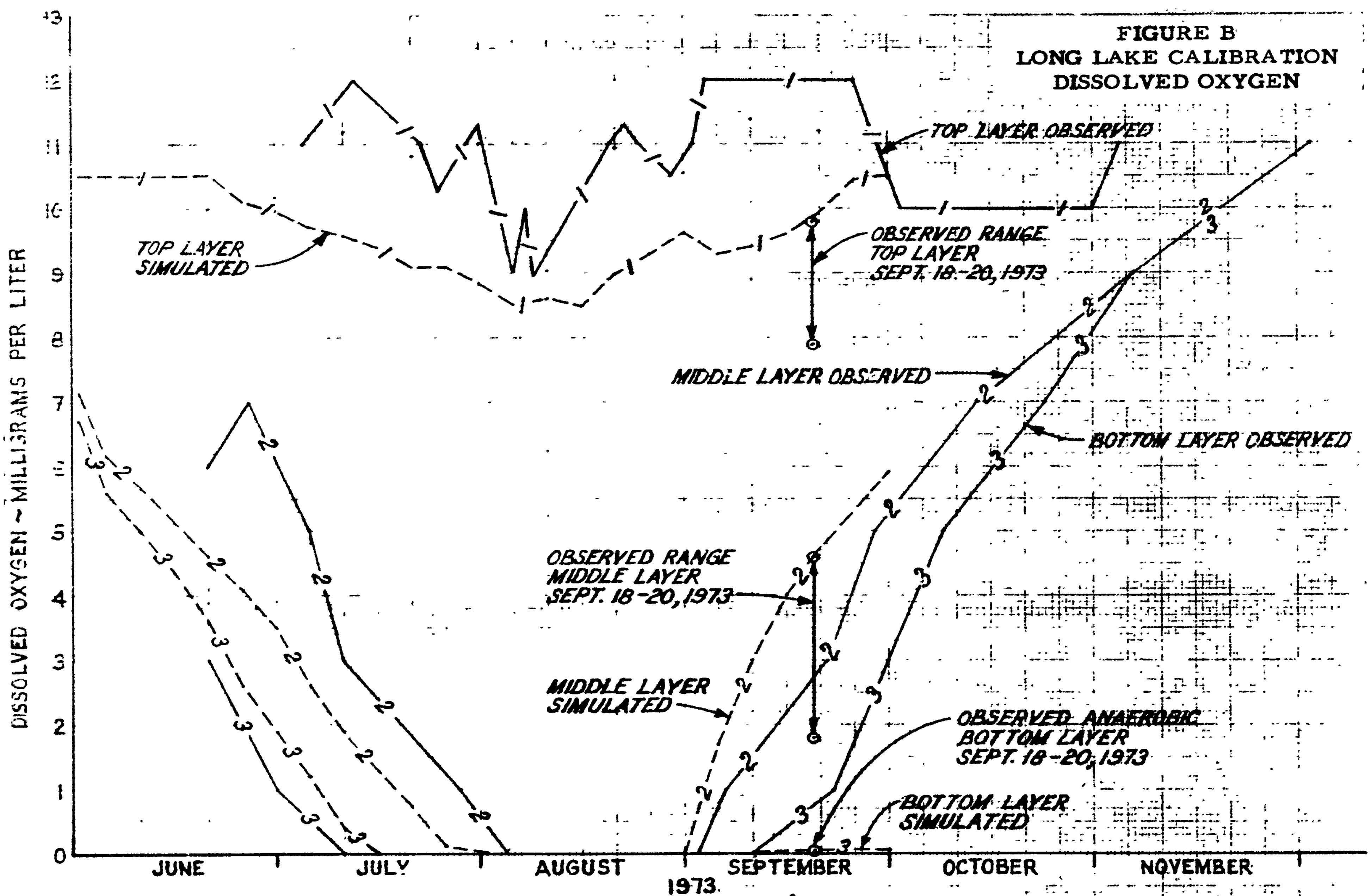


FIGURE A
LONG LAKE CALIBRATION
TEMPERATURE

FIGURE B
LONG LAKE CALIBRATION
DISSOLVED OXYGEN



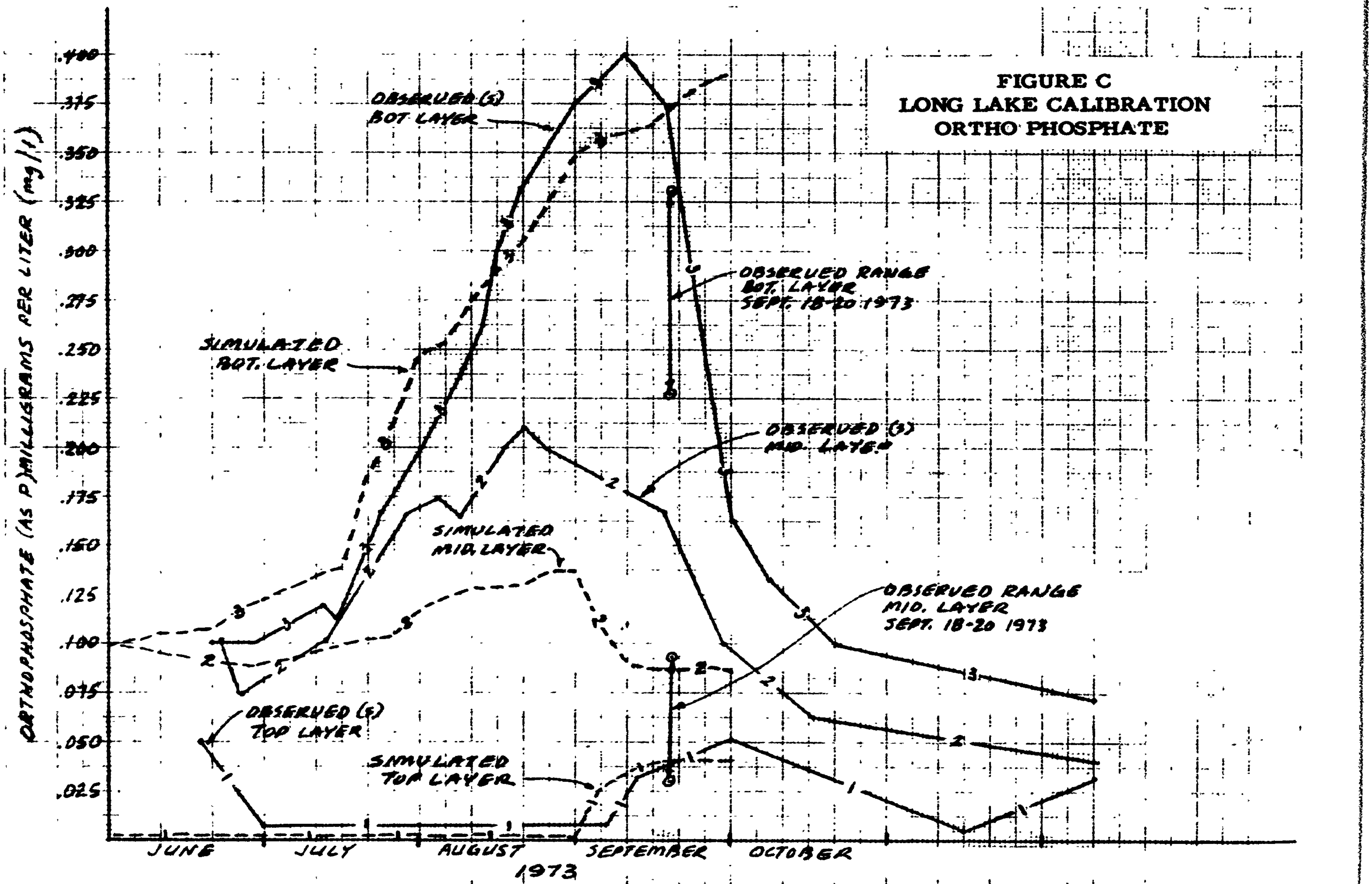


FIGURE C
LONG LAKE CALIBRATION
ORTHO PHOSPHATE

46 1323

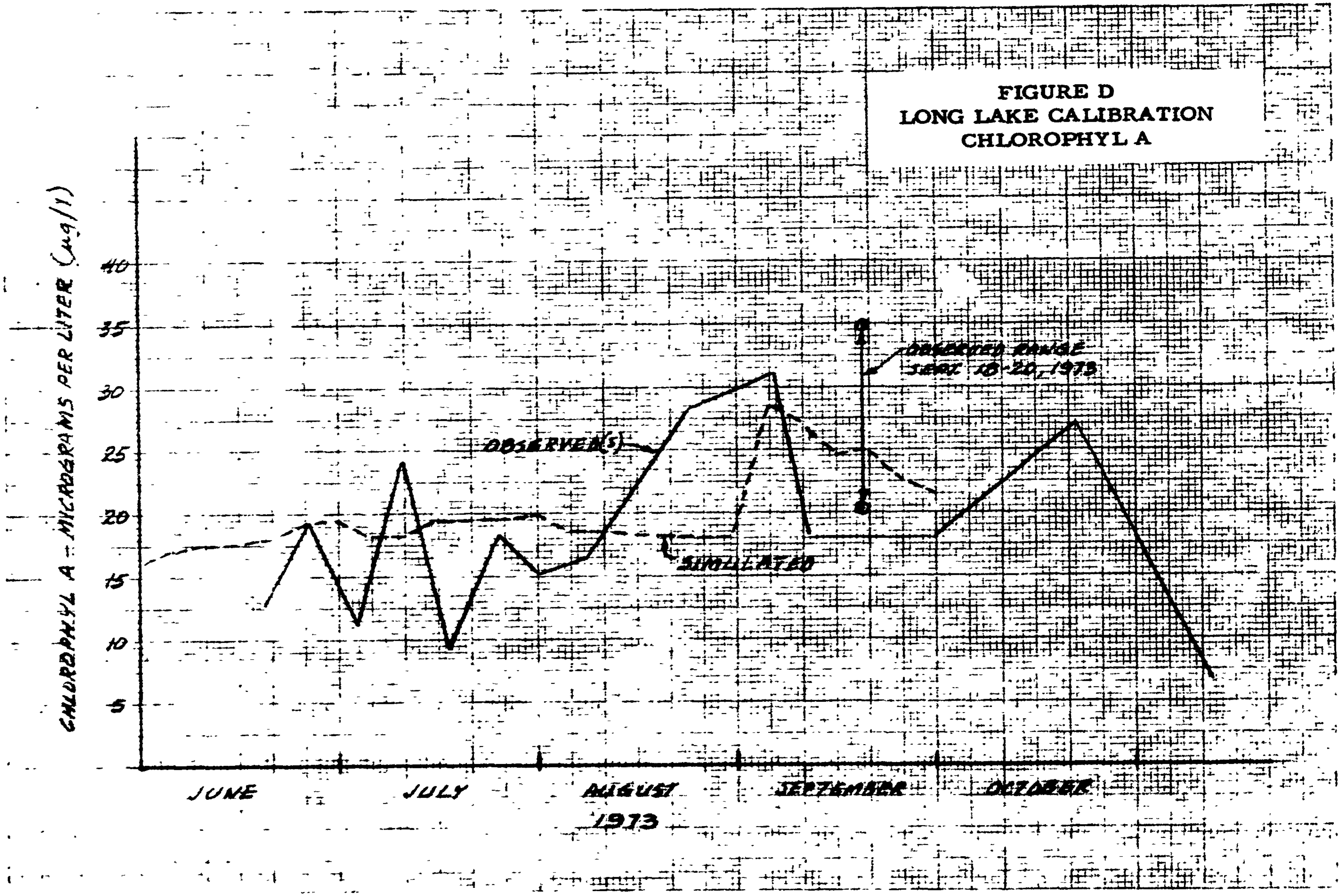


FIGURE D
LONG LAKE CALIBRATION
CHLOROPHYL A

FIG. E

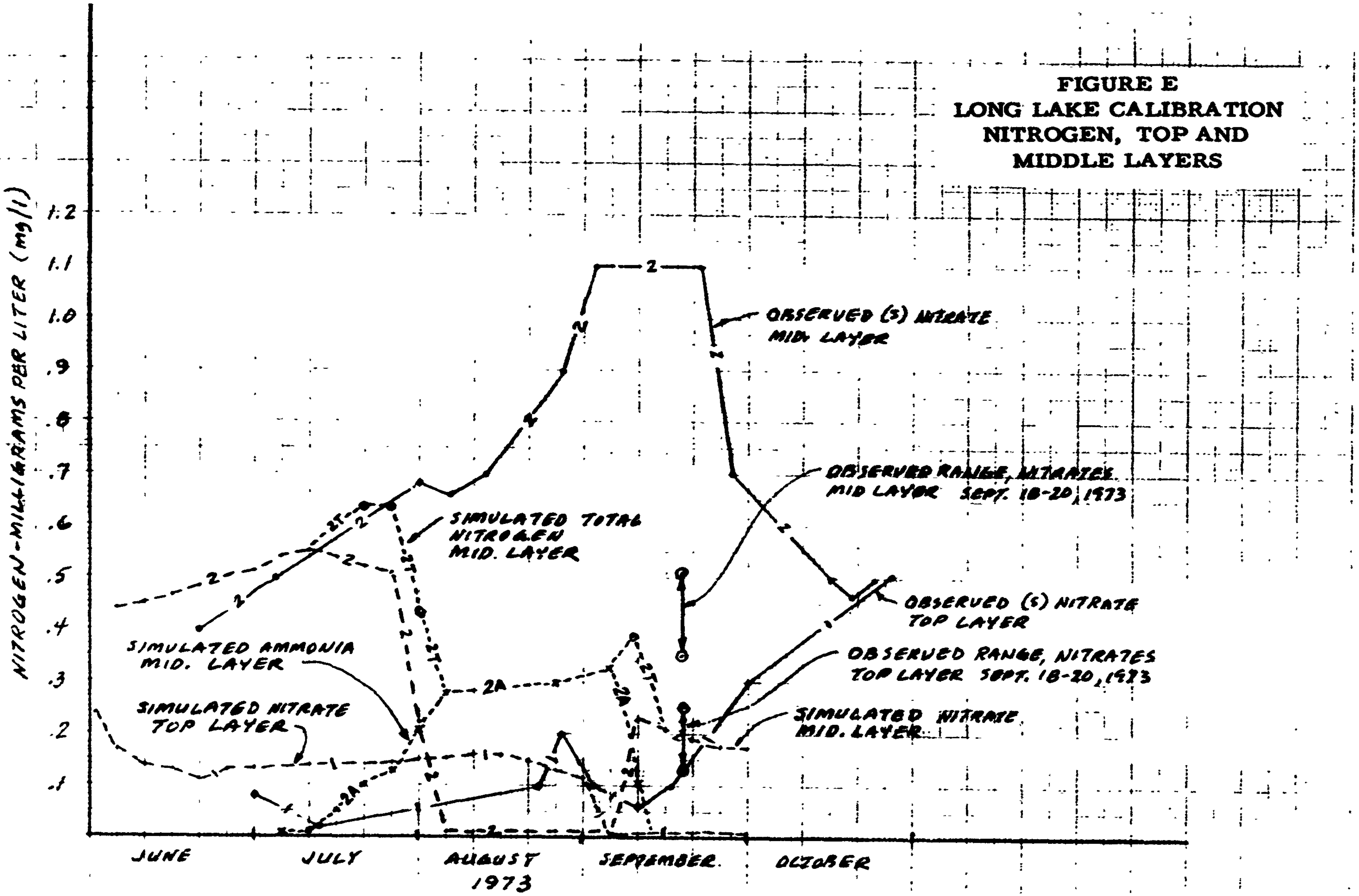


FIGURE E
LONG LAKE CALIBRATION
NITROGEN, TOP AND
MIDDLE LAYERS
NITROGEN-MILLIGRAMS PER LITER (mg/l)
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
JUNE
JULY
AUGUST
1973
SEPTEMBER
OCTOBER
OBSERVED (S) NITRATE
MID. LAYER
OBSERVED RANGE, NITRATES
MID LAYER SEPT. 18-20, 1973
SIMULATED TOTAL
NITROGEN
MID. LAYER
OBSERVED (S) NITRATE
TOP LAYER
SIMULATED AMMONIA
MID. LAYER
OBSERVED RANGE, NITRATES
TOP LAYER SEPT. 18-20, 1973
SIMULATED NITRATE
TOP LAYER
SIMULATED NITRATE
MID. LAYER

FIG. F

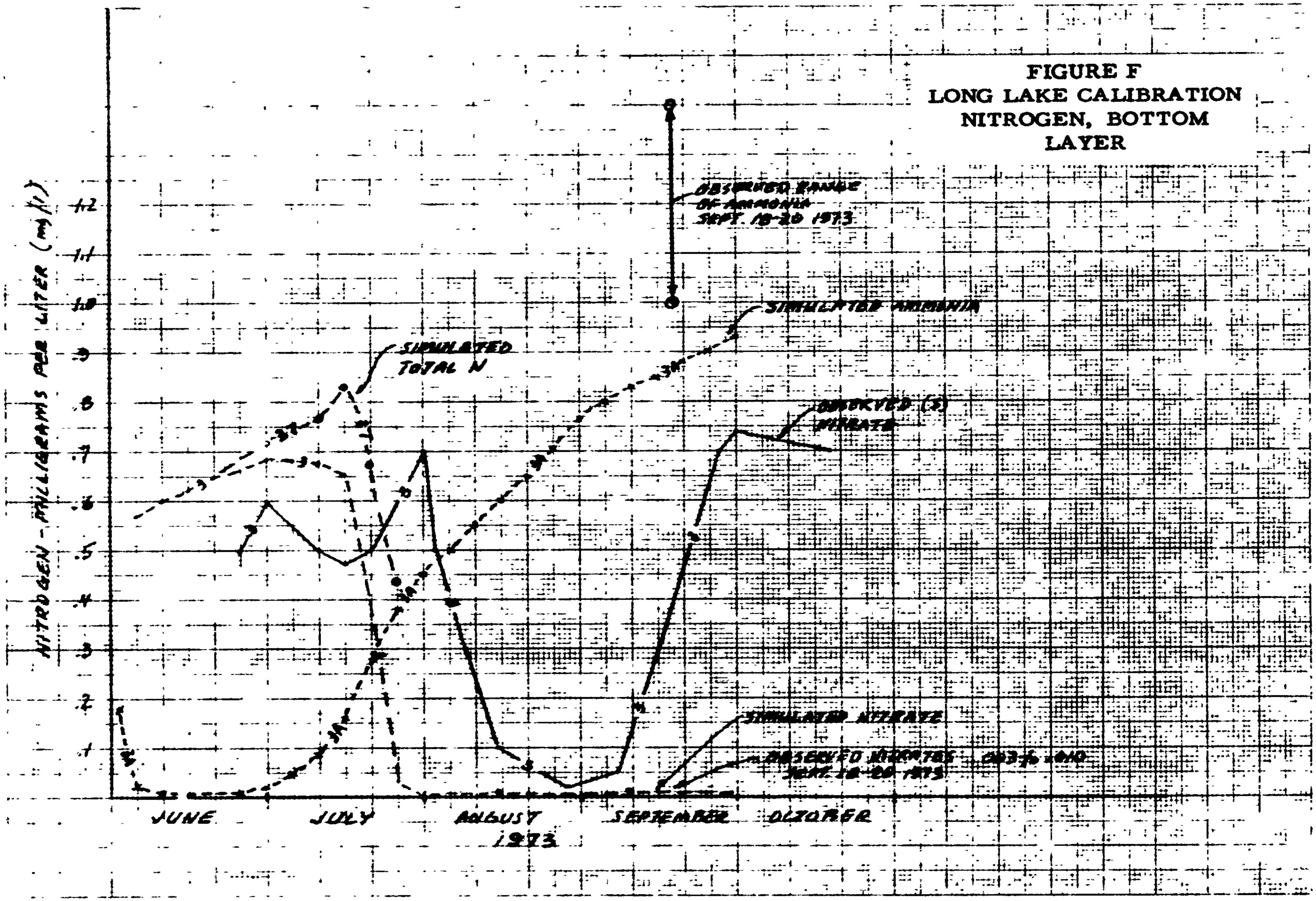


FIGURE F
LONG LAKE CALIBRATION
NITROGEN, BOTTOM LAYER

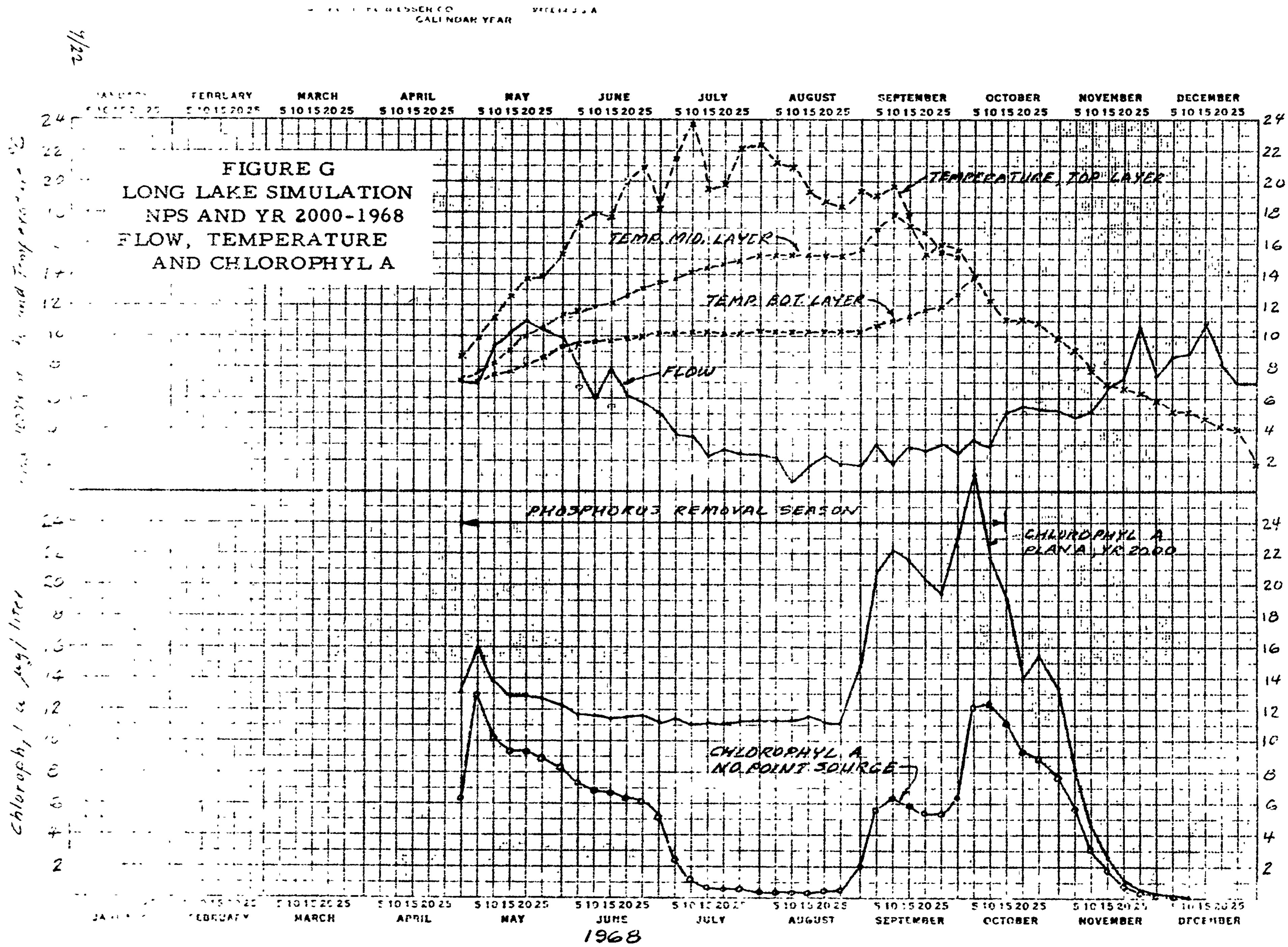


FIGURE G
LONG LAKE SIMULATION
NPS AND YR 2000-1968
FLOW, TEMPERATURE
AND CHLOROPHYL A

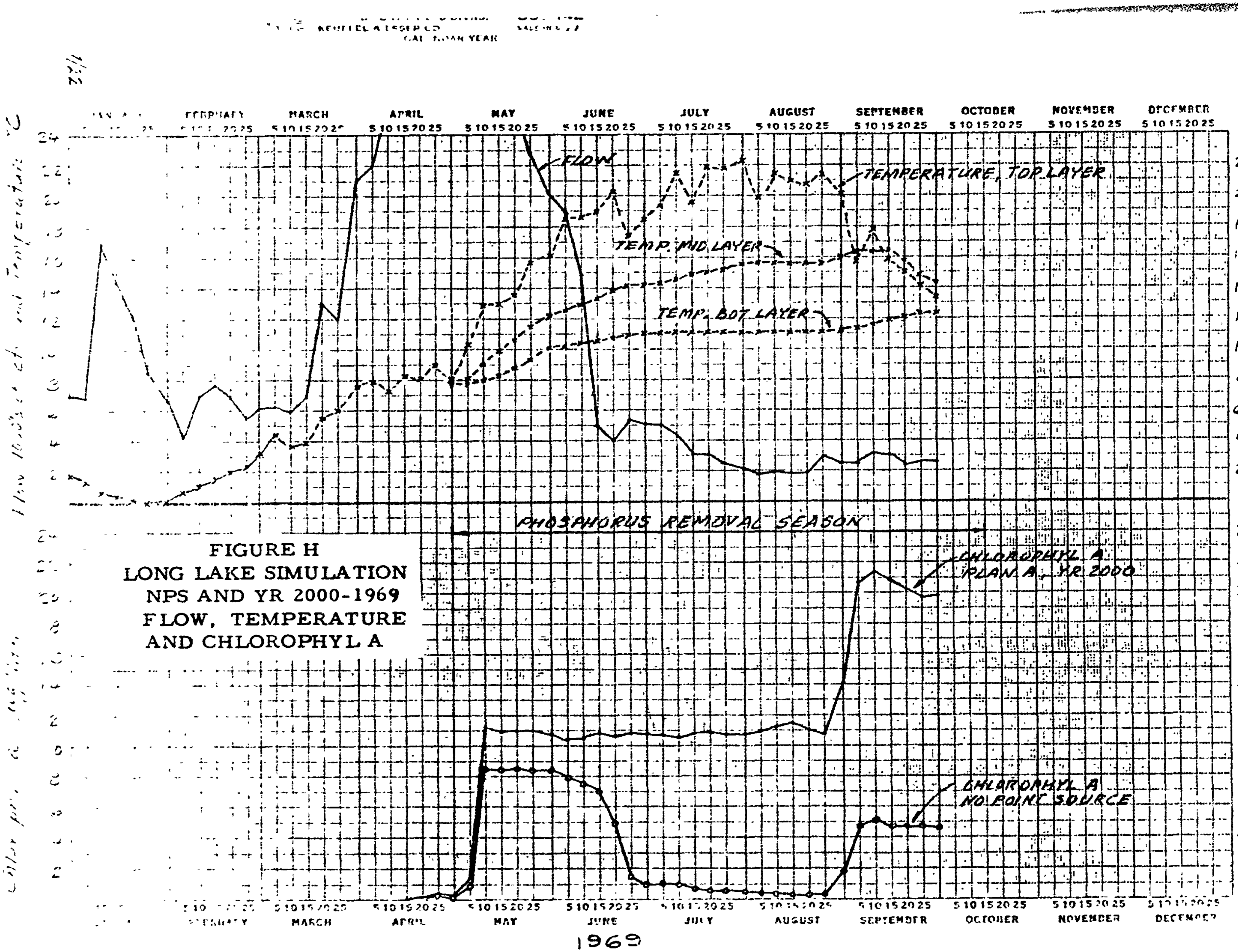


FIGURE H
LONG LAKE SIMULATION
NPS AND YR 2000-1969
FLOW, TEMPERATURE
AND CHLOROPHYL A

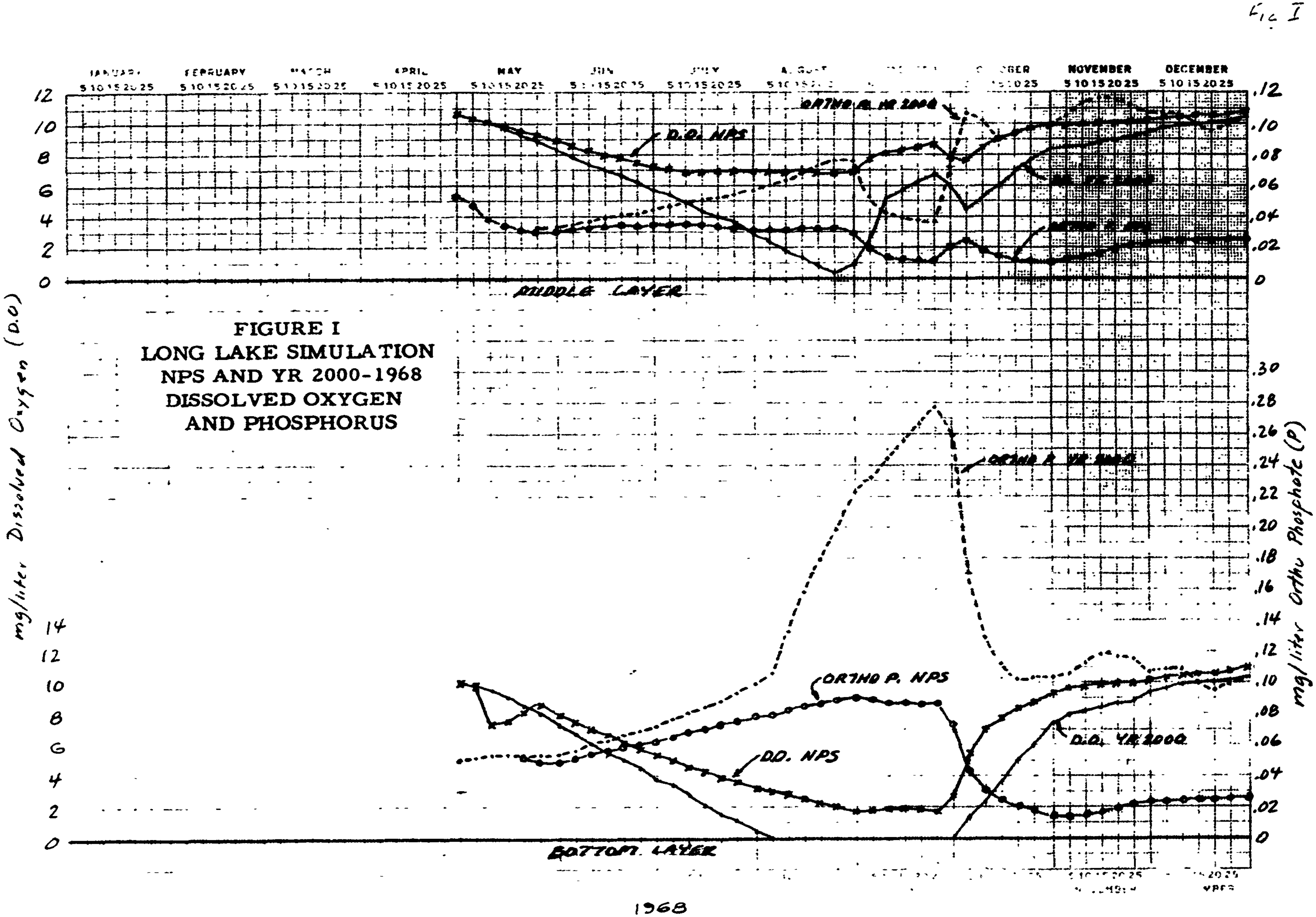


FIGURE I
LONG LAKE SIMULATION
NPS AND YR 2000-1968
DISSOLVED OXYGEN
AND PHOSPHORUS

Fig. J

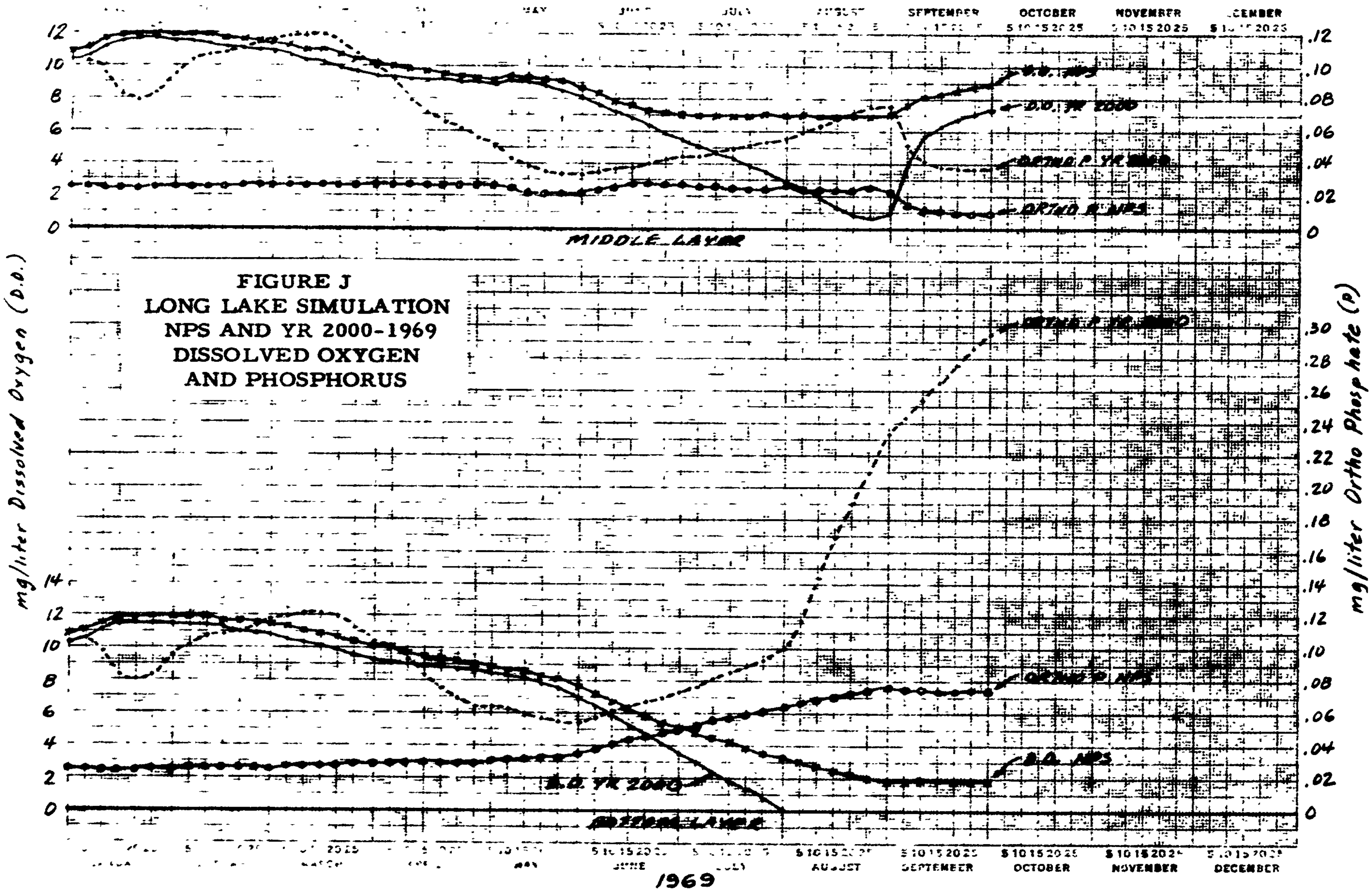


FIGURE J
LONG LAKE SIMULATION
NPS AND YR 2000-1969
DISSOLVED OXYGEN
AND PHOSPHORUS

LIST OF REFERENCES

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APPENDIX 1.1

DEFINITION OF SEGMENTS

Area	Segment No.	Elevation Range, Feet From	Elevation Range, Feet To	Precipitation, Inches Mean Annual
400	41	1500	2000	18
(WRIA 54)	42	2000	2500	18
Lower Spokane	43	2500	+	18
500	51	1600	2500	22
(WRIA 55)	52	2500	3000	22
Little Spokane	53	3000	+	22
	54	2000	3000	26
	55	3000	+	40
600	61	1700	2500	20
(WRIA 56)	62	2500	3000	20
Hangman	63	2500	3000	24
	64	3000	+	24
700	71	1700	2500	20
(WRIA 57)	72	2500	3000	20
Upper Spokane	73	3000	+	20

APPENDIX 2.1

METEOROLOGIC DATA
AVAILABILITY

Parameter	Units	Frequency of Data	Station Records Available Number	Name
Precipitation	inches	Hourly	101956	Coeur D'Alene R.S.
			107188	Plummber 3WSW
			457983	Spokane WBAS
Precipitation	inches	Daily	452066	Deer Park 2E
			455674	Mt. Spokane Summit
			455844	Newport
			457180	Rosalia
			458348	Tekoa
			459058	Wellpinit
Temperature	°F max-min	Daily	452066	Deer Park 2E
			455674	Mt. Spokane Summit
			455844	Newport
			457180	Rosalia
			457938	Spokane WBAS
			459058	Wellpinit
Solar Radiation	langleys	Daily	24157	Spokane WBAS
Dew Point Temp	mean	Daily	24157	Spokane WBAS
Wind Velocity	miles	Daily	24157	Spokane WBAS
Evaporation	inches/ day	Semi-Monthly	24157	Spokane WBAS
Cloud Cover	tenths	Daily	24157	Spokane WBAS

APPENDIX 3.1

SPOKANE RIVER BOUNDARY-FLOW*
October - December 1967

DATA 1967

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	5200	15200	6200	9160	10500	21700	1370	746	105	1410	1920	2670
2	5200	15300	6200	8960	10500	21000	1250	674	640	1410	1920	2780
3	5200	15000	6100	8710	10500	20700	519	669	761	1410	1920	2790
4	5140	14700	6200	8530	11000	20400	821	668	752	1400	1920	2790
5	5480	14300	6000	8470	11000	20000	811	676	629	1410	1960	2810
6	5880	12800	6000	8470	11000	19500	806	601	419	1400	2530	2940
7	6240	12400	6000	8410	11500	19200	1790	634	933	1400	2220	3430
8	6180	12200	6000	8430	12000	18800	2830	669	1170	1410	1880	3430
9	6270	11800	5900	8510	13000	18700	2540	509	1170	1410	1900	3430
10	6340	11400	5800	8470	14000	18300	1660	394	1180	1520	1900	3440
11	6350	11100	5600	8680	15000	17900	1440	673	1180	1600	1900	3440
12	6280	10700	5600	8980	16000	17400	1810	668	1290	1720	1880	3430
13	5980	9110	5500	9270	17000	17100	2090	672	1390	1910	2310	3430
14	5450	8350	5400	9670	18000	16200	2090	672	1390	1910	2690	3430
15	5230	8290	5300	10800	18000	15700	2090	667	890	1910	2720	3670
16	5330	8290	5200	11000	18000	15200	2090	661	100	1910	2700	4180
17	5430	8500	5200	10900	18000	14800	2030	663	440	1910	2720	4160
18	5900	8400	5300	10700	18000	14200	1630	657	1310	1920	2730	3790
19	6780	8200	5500	10600	19000	13900	1200	658	1400	1920	2730	3460
20	8870	8000	6000	10500	20000	13500	1210	460	1400	1920	2730	3330
21	9810	7700	6500	10400	21000	13400	1030	360	1400	1930	2720	3440
22	9910	7500	6800	10100	22000	12900	795	519	1410	1930	2720	3080
23	9790	7100	7200	9800	23000	12400	1020	135	1410	1930	2720	2760
24	9140	6800	7500	9550	24500	11900	1510	125	1410	1920	2730	3440
25	7690	6600	8500	9510	25600	11400	1560	125	1410	1920	2730	3440
26	6310	6400	9200	9600	25500	8000	1430	120	1410	1930	2730	2870
27	6730	6200	9600	10000	24900	5320	1280	120	1410	1930	2720	2610
28	7140	6000	9570	10500	24100	4060	789	115	1420	1930	2750	2780
29	9410		9630	10500	23500	2710	776	100	1410	1920	2780	3720
30	14500		9520	10500	23100	1680	1110	100	1410	1920	2790	3720
31	14900		9310		22400		1240	100		1930		3740
TOTALS	24060.00	78340.00	08630.00	87680.00	51600.00	37970.00	44617.00	14610.00	32649.00	54000.00	72570.00	02430.00

YEAR 2309156.00

* Cubic feet per second

APPENDIX 3.1

SPOKANE RIVER BOUNDARY-FLOW*
January - December 1968

DATA 1968

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	3720	3520	19800	9220	6100	9300	1740	740	727	1560	3980	6120
2	3910	3720	19000	9370	6320	9280	2060	720	727	1810	3980	6130
3	4130	3710	18300	9460	6540	8590	2300	690	1190	2130	3980	6110
4	4110	4160	17500	9460	6740	7500	2300	680	1620	2150	4230	6570
5	4090	4570	17000	9550	6930	6410	2300	680	1000	2140	4480	7100
6	4070	5050	16700	9550	7590	5890	2300	1010	757	2150	4390	6560
7	4050	5390	16400	9430	8010	5990	2290	370	1130	2170	4240	6110
8	4040	5900	16100	9100	8030	6410	2280	360	1140	2250	4090	6160
9	3280	5900	15700	8830	7930	6170	2280	586	865	2250	4030	6130
10	2970	5900	15200	8950	7930	5190	2160	435	607	2270	4010	7990
11	3890	5880	14500	8580	8010	6290	1620	442	607	2250	3920	9520
12	3670	5820	13800	8520	8190	6900	1200	471	745	2250	3760	9310
13	3490	5760	13300	8520	8700	6610	1170	620	1310	2870	5210	9110
14	3410	5670	12500	8460	8860	6790	1210	622	1700	2860	5760	9420
15	2490	5610	8640	8320	9030	5590	1210	712	1700	3670	6460	9300
16	2790	5510	12200	8190	916.	4990	1210	1170	1700	3780	6580	9280
17	3430	5410	11300	8190	8980	3880	1210	465	1700	3730	6190	9130
18	3440	5370	10800	8060	8860	3860	1210	561	1710	3990	6170	8590
19	3410	5760	10400	7680	8890	4520	1210	1140	1690	4200	6110	8180
20	3360	8800	9910	7670	90 0	5030	1210	1140	1700	4210	6100	6870
21	3360	13000	8740	7440	9390	5040	1290	1190	1890	3910	6120	5830
22	3520	15900	8520	7100	9260	4710	1290	1240	2540	3970	6140	5800
23	3710	18500	8300	6960	9200	4350	1470	1250	2330	4180	7810	5800
24	4040	20300	8110	6790	8370	4680	1210	1230	1880	4110	9630	5790
25	4070	21600	7950	6370	7560	3790	1160	1150	2000	4260	9720	5790
26	3810	22100	7930	6080	7600	3770	920	1060	2080	4860	10100	5790
27	4090	22000	7930	6040	7720	3760	830	732	1720	4320	9540	5760
28	4090	21500	7930	5990	7750	3600	830	729	1620	4250	7780	5730
29	3890	20700	8210	5930	8610	2830	830	725	1170	4510	6140	5700
30	4040		8600	5950	9340	2380	1180	727	1320	4400	6080	5700
31	3840		9010		9300		830	725		4260		5600
TOTALS	14210.00	83010.00	80530.00	39960.00	54120.00	64100.00	46310.00	24372.00	42875.00	01720.00	76770.00	16980.00

YEAR 2044957.00

* Cubic feet per second

APPENDIX 3.1

SPOKANE RIVER BOUNDARY-FLOW*
January - September 1969

DATA 1969

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	5600	5290	3980	15300	27000	17700	2760	649	1420	1590	1650	1600
2	5550	5230	4040	16600	26500	17300	3180	664	1430	1590	1650	1600
3	5500	3550	3890	17700	25400	15900	3520	654	1430	1580	1630	1600
4	5500	2330	3840	18500	24300	16400	3490	654	1430	1580	1640	1600
5	5520	4110	3220	19200	23100	15900	2830	652	1430	1580	1730	1550
6	6540	5600	1230	19900	22000	15400	1550	645	1420	1600	1910	1600
7	8510	5630	3120	20800	21300	14800	2390	650	1420	1620	1920	1600
8	12300	5510	4330	21400	21300	14200	2820	651	1410	1630	1920	1600
9	14500	5490	4330	21600	21700	13400	2820	649	1420	1630	1910	1600
10	15100	5610	4290	21800	22400	12500	2680	650	1410	1620	1910	1650
11	15100	5690	4220	21800	23400	12000	1970	667	1420	1610	1920	1650
12	14600	5670	4220	21800	24500	11400	1460	655	1430	1610	1940	1800
13	13100	5590	4200	21800	25600	10900	1450	641	1430	1610	1950	1950
14	12200	5490	4090	21900	26400	6800	1440	644	1430	1610	1800	1950
15	12100	5390	4070	21900	26800	2060	1670	652	1430	1630	1950	1950
16	11800	5350	4100	21700	26700	1720	1440	649	1430	1610	1950	1950
17	11500	5250	4160	21300	26300	1240	1460	642	1430	1630	1800	1950
18	11100	5130	4550	21500	25600	989	1440	655	1430	1630	1600	1980
19	10700	5010	5250	22100	25000	1400	1440	646	1430	1630	1550	1980
20	10300	4930	5820	22900	24300	1390	1440	649	1430	1630	1550	1980
21	9860	4710	5910	23500	23600	1390	1440	647	1430	1620	1600	1980
22	8700	4570	6140	23600	22700	1400	1430	1040	1420	1620	1600	3160
23	8000	4540	6540	24100	21800	2000	1330	1440	1420	1630	1600	3450
24	6800	4400	7080	25400	21200	2540	1190	1450	1420	1640	1600	3470
25	6000	4330	7490	27500	20600	3400	1190	1430	1420	1620	1600	3470
26	5950	4200	7810	28000	20100	4300	1090	1420	1440	1620	1600	3320
27	5900	4090	8390	28500	19700	3530	661	1460	1420	1620	1600	2750
28	5900	4000	9820	28500	19200	3500	814	1430	1420	1640	1600	2710
29	4800		11500	28000	18500	3500	1320	1410	1450	1630	1600	2730
30	3300		12300	27500	17900	3190	1090	1430	1590	1630	1600	2360
31	5300		13800		17700		650	1430		1630		2040
TOTALS	77630.00	36890.00	77730.00	76100.00	12600.00	33149.00	55455.00	27605.00	42940.00	50120.00	51880.00	66580.00

YEAR 2508679.00

* Cubic feet per second

APPENDIX 3.1

SPOKANE RIVER BOUNDARY-FLOW*

June - September 1973

DATA 1973

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	4330	5710	3170	4870	6720	4150	2050	295	673	0	0	0
2	4330	6060	3390	4710	6340	3900	1750	295	670	0	0	0
3	4320	5950	3570	4630	5760	3900	1390	230	668	0	0	0
4	4310	5860	3790	4650	5470	3850	1400	343	698	0	0	0
5	4290	5480	3840	4520	6650	3650	1430	338	1490	0	0	0
6	4280	5130	3860	4500	6930	3530	1420	339	1700	0	0	0
7	4270	5070	3860	4330	5900	3690	1410	319	1700	0	0	0
8	4280	5010	3880	4250	5610	3880	1260	210	1670	0	0	0
9	4280	4920	3890	4270	5780	3890	1130	210	1670	0	0	0
10	4270	4840	4040	4400	5670	3880	1070	210	1680	0	0	0
11	4250	4790	4180	4370	5330	3800	613	250	1690	0	0	0
12	4240	4710	4370	4420	5010	3440	569	210	1690	0	0	0
13	4260	4630	4570	4630	4810	3310	578	210	1690	0	0	0
14	3950	4560	4570	4750	4870	3310	765	210	1130	0	0	0
15	4260	4460	4520	4970	5270	3690	628	190	486	0	0	0
16	4300	4250	4370	5150	5550	3640	815	359	110	0	0	0
17	4020	4090	4400	4570	6260	3320	1130	680	346	0	0	0
18	4050	3840	4400	5950	6450	3280	1120	768	270	0	0	0
19	4440	3710	4420	6410	6500	3220	845	774	820	0	0	0
20	5560	3570	4420	6450	6650	2790	581	656	1740	0	0	0
21	5990	3390	4440	6480	6260	2460	595	535	1710	0	0	0
22	5980	3250	4570	6450	5760	2000	584	604	1710	0	0	0
23	5950	3080	4690	6410	4970	2020	483	654	1720	0	0	0
24	5930	2970	4690	6390	5530	2060	60	651	1860	0	0	0
25	5580	2940	4570	6340	5590	2090	70	657	1960	0	0	0
26	5180	2910	4670	6040	5310	2060	441	657	1960	0	0	0
27	5430	2910	4630	5690	5250	2080	514	665	1950	0	0	0
28	5810	2900	4670	6500	5110	2050	342	665	1960	0	0	0
29	5750		4890	6040	4690	2050	240	665	1980	0	0	0
30	5700		4990	5820	3620	2070	200	671	1960	0	0	0
31	5630		4930		4020		170	678		0		0
TOTALS	49320.00	21010.00	33650.00	58960.00	73640.00	93100.00	25653.00	14198.00	41361.00	0.00	0.00	0.00

YEAR 910692.00

* Cubic feet per second

APPENDIX 3.2

SPOKANE RIVER BOUNDARY-TEMPERATURE*
October - December 1967

DATA 1967 DAILY VALUES FOR WATERTEMP

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	10.7	6.4
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.8	10.2	6.3
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6	9.7	6.3
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	9.1	6.3
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	8.7	6.2
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5	8.2	6.2
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	7.8	6.1
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	7.6	6.1
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8	7.6	6.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7	7.5	6.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	7.3	6.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	7.1	5.9
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	7.2	5.8
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	7.1	5.8
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	7.1	5.7
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4	7.0	5.6
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	7.0	5.5
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	7.0	5.5
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	6.9	5.4
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	6.9	5.3
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	6.8	5.3
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	6.8	5.2
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	6.8	5.2
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	6.7	5.2
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	6.7	5.2
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	6.6	5.1
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	6.5	5.1
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	6.5	5.1
29	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	6.4	5.0
30	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	6.4	5.0
31	0.0		0.0		0.0		0.0	0.0		10.9		5.0

* Degrees Centigrade

APPENDIX 3.2

SPOKANE RIVER BOUNDARY-TEMPERATURE*
January - December 1968

DATA 1968 DAILY VALUES FOR WATERTEMP

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	4.9	3.6	4.9	5.5	7.3	12.5	16.9	21.1	18.1	14.8	8.8	5.9
2	4.8	3.6	5.0	5.5	7.5	12.7	17.2	21.2	18.0	14.4	8.5	5.8
3	4.8	3.6	5.2	5.6	7.7	12.8	17.6	21.4	17.9	14.1	8.2	5.8
4	4.7	3.6	5.4	5.7	7.9	13.1	18.1	21.4	17.8	14.1	7.8	5.8
5	4.7	3.6	5.5	5.7	7.9	13.4	18.7	21.4	17.9	13.8	7.3	5.8
6	4.6	3.6	5.4	5.6	7.9	13.7	19.1	21.3	18.0	13.7	6.8	5.7
7	4.5	3.5	5.3	5.6	8.1	13.5	19.6	21.3	18.0	13.5	6.6	5.7
8	4.5	3.5	5.2	5.7	8.2	13.6	20.0	21.3	18.0	13.2	6.6	5.6
9	4.4	3.5	5.1	5.9	8.5	13.8	20.2	21.3	18.2	12.9	6.6	5.6
10	4.4	3.5	5.1	6.1	8.7	14.0	20.4	21.3	18.2	12.8	6.5	5.6
11	4.4	3.5	5.0	6.2	9.1	14.1	20.5	21.4	18.3	12.6	6.5	5.6
12	4.3	3.5	5.2	6.1	9.3	14.0	20.5	21.4	18.2	12.5	6.5	5.5
13	4.3	3.4	5.2	6.0	9.4	14.0	20.3	21.0	17.9	12.3	6.5	5.5
14	4.3	3.4	5.2	6.0	9.4	14.1	20.3	20.6	17.8	12.1	6.4	5.4
15	4.2	3.4	5.2	6.0	9.6	14.3	20.2	20.3	17.7	11.9	6.4	5.4
16	4.2	3.4	5.2	5.9	9.8	14.7	20.1	20.2	17.6	11.6	6.3	5.4
17	4.2	3.3	5.2	5.9	10.2	14.9	20.0	19.9	17.5	11.2	6.3	5.3
18	4.2	3.3	5.1	5.9	10.6	15.3	20.1	19.6	17.3	11.0	6.2	5.3
19	4.2	3.5	5.1	5.8	10.9	15.6	20.1	19.2	16.8	10.6	6.2	5.2
20	4.2	3.7	5.1	5.8	11.0	15.9	19.9	18.9	16.1	10.4	6.2	5.1
21	4.2	3.9	5.3	5.8	11.1	15.9	19.9	18.8	15.6	10.2	6.2	5.1
22	4.2	3.8	5.5	5.9	11.2	16.1	19.8	18.6	15.4	10.2	6.2	5.0
23	4.1	3.9	5.6	5.9	11.3	16.4	19.9	18.4	15.3	10.1	6.2	5.0
24	4.1	4.0	5.6	5.9	11.5	16.6	19.9	18.3	15.2	10.1	6.1	5.0
25	4.1	4.1	5.5	6.0	11.4	17.1	20.0	18.2	15.1	10.0	6.1	4.9
26	4.0	4.1	5.5	6.1	11.5	17.3	20.2	18.2	15.2	9.8	6.1	4.8
27	3.9	4.3	5.6	6.3	11.6	17.3	20.5	18.1	15.1	9.6	6.0	4.7
28	3.8	4.4	5.6	6.7	11.7	17.1	20.7	18.0	15.0	9.5	6.0	4.6
29	3.7	4.6	5.7	7.2	11.8	16.8	20.8	18.0	14.[illegible]	9.5	6.0	4.5
30	3.7		5.5	7.3	11.9	16.7	20.9	18.0	14.9	9.4	5.9	2.9
31	3.6		5.5		12.1		20.9	18.2		9.1		1.9

* Degrees Centigrade

APPENDIX 3.2

SPOKANE RIVER BOUNDARY-TEMPERATURE*
January - September 1969

DATA 1969 DAILY VALUES FOR WATERTEMP

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	1.2	0.0	0.2	4.5	7.3	14.6	17.1	20.1	19.9	0.0	0.0	0.0
2	0.6	0.0	0.3	4.9	7.2	14.9	17.3	20.2	19.9	0.0	0.0	0.0
3	0.3	0.0	0.3	4.9	7.4	15.4	17.3	20.3	19.7	0.0	0.0	0.0
4	0.1	0.0	0.3	5.1	7.6	15.9	17.3	20.3	19.5	0.0	0.0	0.0
5	0.1	0.0	0.4	5.5	8.0	16.2	17.3	20.1	19.1	0.0	0.0	0.0
6	0.2	0.1	0.5	5.5	8.5	16.6	17.3	19.9	18.8	0.0	0.0	0.0
7	0.1	0.1	0.5	5.6	8.8	16.7	17.4	19.8	18.7	0.0	0.0	0.0
8	0.0	0.1	0.4	5.9	9.2	16.8	17.7	19.8	18.8	0.0	0.0	0.0
9	0.0	0.1	0.3	6.1	9.9	17.1	18.0	20.0	18.6	0.0	0.0	0.0
10	0.0	0.1	0.2	6.1	10.4	17.1	18.2	20.2	18.6	0.0	0.0	0.0
11	0.0	0.3	0.1	6.2	10.8	17.2	18.2	20.2	18.6	0.0	0.0	0.0
12	0.0	0.3	0.1	6.4	11.2	17.2	18.2	20.1	18.8	0.0	0.0	0.0
13	0.1	0.2	0.1	6.4	11.4	17.2	18.1	20.1	18.6	0.0	0.0	0.0
14	0.0	0.1	0.2	6.5	11.5	17.3	18.1	20.3	18.3	0.0	0.0	0.0
15	0.1	0.1	0.3	6.6	11.6	17.4	17.9	20.3	17.7	0.0	0.0	0.0
16	0.0	0.1	0.5	6.8	11.8	17.5	18.0	20.2	17.4	0.0	0.0	0.0
17	0.0	0.1	0.6	6.8	12.0	17.9	18.2	20.1	17.3	0.0	0.0	0.0
18	0.1	0.1	0.8	6.9	12.2	18.2	18.3	20.2	17.1	0.0	0.0	0.0
19	0.1	0.1	0.9	6.9	12.2	18.4	18.6	20.2	16.8	0.0	0.0	0.0
20	0.1	0.1	1.1	6.9	12.3	18.6	18.8	20.3	16.2	0.0	0.0	0.0
21	0.0	0.1	1.3	7.3	12.7	18.6	19.0	20.4	15.9	0.0	0.0	0.0
22	0.1	0.1	1.3	7.6	13.2	18.6	19.1	20.7	15.5	0.0	0.0	0.0
23	0.1	0.1	1.4	7.6	13.7	18.4	19.5	21.0	15.4	0.0	0.0	0.0
24	0.1	0.1	1.5	7.6	13.9	18.3	19.7	21.1	15.2	0.0	0.0	0.0
25	0.0	0.1	1.8	7.6	14.1	18.1	19.6	20.9	15.1	0.0	0.0	0.0
26	0.0	0.1	2.1	7.7	14.2	17.6	19.5	20.9	14.8	0.0	0.0	0.0
27	0.1	0.1	2.4	7.9	14.1	17.2	19.6	20.7	14.7	0.0	0.0	0.0
28	0.1	0.2	2.8	7.9	14.2	17.1	19.7	20.5	14.6	0.0	0.0	0.0
29	0.1		3.9	7.8	14.1	17.0	19.8	20.1	14.6	0.0	0.0	0.0
30	0.0		4.3	7.6	14.1	17.0	19.9	20.1	14.5	0.0	0.0	0.0
31	0.0		4.4		14.2		20.0	19.9		0.0		0.0

* Degrees Centigrade

APPENDIX 3.2

SPOKANE RIVER BOUNDARY-TEMPERATURE*
June - September 1973

DATA 1973 DAILY VALUES FOR WATERTEMP

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.0	0.0	0.0	0.0	0.0	13.0	17.0	21.0	20.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	13.0	17.0	21.0	20.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	13.0	17.0	22.0	20.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	13.0	17.0	22.0	20.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	14.0	17.0	22.0	20.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	14.0	17.0	22.0	20.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	14.0	17.0	22.0	20.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	14.0	17.0	22.0	20.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	14.0	17.0	22.0	20.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	20.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	20.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	20.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	19.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	19.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	14.0	18.0	22.0	19.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	14.0	19.0	22.0	19.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	14.0	19.0	22.0	19.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	14.0	19.0	22.0	19.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	14.0	19.0	22.0	18.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	15.0	19.0	21.0	18.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	15.0	19.0	22.0	18.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	16.0	19.0	22.0	18.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	16.0	19.0	21.0	18.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	16.0	19.0	21.0	18.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	16.0	20.0	21.0	17.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	16.0	20.0	21.0	17.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	16.0	20.0	21.0	17.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	16.0	21.0	21.0	17.0	0.0	0.0	0.0
29	0.0		0.0	0.0	0.0	17.0	21.0	21.0	17.0	0.0	0.0	0.0
30	0.0		0.0	0.0	0.0	17.0	21.0	21.0	17.0	0.0	0.0	0.0
31	0.0		0.0		0.0		21.0	21.0		0.0		0.0

* Degrees Centigrade

APPENDIX 3.3

SPOKANE RIVER BOUNDARY-DISSOLVED OXYGEN*
October - December 1967

DATA 1967 DAILY VALUES FOR DO

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	9.8	10.9
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	10.9
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	10.1	11.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	10.2	11.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	10.3	11.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	10.4	11.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	10.5	11.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.6	11.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.6	11.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.6	11.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.7	11.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	10.7	11.1
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	10.7	11.1
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	10.7	11.1
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	10.7	11.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	10.8	11.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	10.8	11.2
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	10.8	11.2
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	10.8	11.2
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	10.8	11.2
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	10.8	11.3
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	10.8	11.3
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	10.8	11.3
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	10.8	11.3
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	10.8	11.3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	10.9	11.3
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	10.9	11.3
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	10.9	11.3
29	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	10.9	11.3
30	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	10.9	11.3
31	0.0		0.0		0.0		0.0	0.0		9.8		11.3

* Milligrams per liter

APPENDIX 3.3

SPOKANE RIVER BOUNDARY-DISSOLVED OXYGEN*
January - December 1968

DATA 1968 DAILY VALUES FOR DO

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	11.4	11.8	11.4	11.2	10.7	9.4	8.6	7.9	8.4	9.0	10.3	11.1
2	11.4	11.8	11.3	11.2	10.6	9.4	8.5	7.9	8.4	9.1	10.4	11.1
3	11.4	11.8	11.3	11.2	10.6	9.4	8.5	7.9	8.4	9.1	10.5	11.1
4	11.4	11.7	11.2	11.1	10.5	9.3	8.4	7.9	8.4	9.1	10.6	11.1
5	11.4	11.8	11.2	11.1	10.5	9.3	8.3	7.9	8.4	9.2	10.7	11.1
6	11.4	11.8	11.2	11.1	10.5	9.2	8.2	7.9	8.4	9.2	10.8	11.1
7	11.5	11.8	11.2	11.1	10.5	9.2	8.2	7.9	8.4	9.2	10.9	11.1
8	11.5	11.8	11.3	11.1	10.4	9.2	8.1	7.9	8.4	9.3	10.9	11.1
9	11.5	11.8	11.3	11.1	10.4	9.2	8.1	7.9	8.4	9.4	10.9	11.1
10	11.5	11.8	11.3	11.0	10.3	9.1	8.0	7.9	8.4	9.4	10.9	11.1
11	11.5	11.8	11.3	11.0	10.2	9.1	8.0	7.9	8.4	9.4	10.9	11.2
12	11.5	11.8	11.3	11.0	10.2	9.1	8.0	7.9	8.4	9.4	10.9	11.2
13	11.5	11.8	11.3	11.0	10.1	9.1	8.0	7.9	8.4	9.5	10.9	11.2
14	11.5	11.8	11.3	11.0	10.1	9.1	8.1	8.0	8.4	9.5	10.9	11.2
15	11.6	11.8	11.3	11.1	10.1	9.1	8.1	8.0	8.5	9.6	10.9	11.2
16	11.6	11.8	11.3	11.1	10.0	9.0	8.1	8.1	8.5	9.7	10.9	11.2
17	11.6	11.8	11.3	11.1	9.9	9.0	8.1	8.1	8.5	9.7	11.0	11.2
18	11.6	11.8	11.3	11.1	9.9	8.9	8.1	8.2	8.5	9.8	11.0	11.2
19	11.6	11.8	11.3	11.1	9.8	8.8	8.1	8.2	8.6	9.9	11.0	11.3
20	11.6	11.7	11.3	11.1	9.8	8.8	8.1	8.3	8.7	9.9	11.0	11.3
21	11.6	11.7	11.3	11.1	9.8	8.8	8.1	8.3	8.8	9.9	11.0	11.3
22	11.6	11.7	11.2	11.1	9.7	8.7	8.1	8.3	8.9	10.0	11.0	11.3
23	11.6	11.7	11.1	11.1	9.7	8.7	8.1	8.4	8.9	10.0	11.0	11.3
24	11.6	11.6	11.1	11.1	9.7	8.6	8.1	8.4	8.9	10.0	11.0	11.3
25	11.6	11.6	11.2	11.0	9.7	8.6	8.1	8.4	8.9	10.0	11.0	11.4
26	11.6	11.6	11.2	11.0	9.7	8.5	8.1	8.4	8.9	10.0	11.0	11.4
27	11.7	11.5	11.2	10.9	9.6	8.5	8.0	8.4	8.9	10.1	11.0	11.4
28	11.7	11.5	11.1	10.8	9.6	8.6	8.0	8.4	8.9	10.1	11.0	11.4
29	11.7	11.5	11.1	10.7	9.6	8.6	8.0	8.4	9.0	10.1	11.0	11.5
30	11.7		11.2	10.7	9.6	8.6	8.0	8.4	9.0	10.1	11.1	12.0
31	11.7		11.2		9.5		8.0	8.4		10.2		12.3

* Milligrams per liter

APPENDIX 3.3

SPOKANE RIVER BOUNDARY-DISSOLVED OXYGEN*

January - September 1969

DATA 1969 DAILY VAL 'ES FOR DO

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	12.5	13.0	12.9	11.5	10.7	9.0	8.6	8.1	8.1	0.0	0.0	0.0
2	12.7	13.0	12.9	11.4	10.7	9.0	8.5	8.1	8.1	0.0	0.0	0.0
3	12.9	13.0	12.9	11.3	10.7	8.9	8.5	8.1	8.1	0.0	0.0	0.0
4	12.9	13.0	12.8	11.3	10.6	8.8	8.5	8.1	8.2	0.0	0.0	0.0
5	12.9	13.0	12.8	11.2	10.5	8.7	8.5	8.1	8.2	0.0	0.0	0.0
6	12.9	12.9	12.8	11.2	10.4	8.7	8.5	8.1	8.3	0.0	0.0	0.0
7	12.9	12.9	12.8	11.2	10.3	8.6	8.5	8.1	8.3	0.0	0.0	0.0
8	13.0	12.9	12.8	11.1	10.2	8.6	8.5	8.1	8.3	0.0	0.0	0.0
9	13.0	12.9	12.8	11.0	10.0	8.6	8.4	8.1	8.3	0.0	0.0	0.0
10	13.0	12.9	12.9	11.0	9.9	8.6	8.4	8.1	8.3	0.0	0.0	0.0
11	13.0	12.9	12.9	11.0	9.8	8.5	8.4	8.1	8.3	0.0	0.0	0.0
12	13.0	12.9	12.9	10.9	9.7	8.5	8.4	8.1	8.3	0.0	0.0	0.0
13	12.9	12.9	12.9	10.9	9.7	8.5	8.4	8.1	8.3	0.0	0.0	0.0
14	13.0	12.9	12.9	10.9	9.7	8.5	8.4	8.1	8.4	0.0	0.0	0.0
15	12.9	12.9	12.8	10.9	9.6	8.5	8.4	8.0	8.5	0.0	0.0	0.0
16	13.0	12.9	12.8	10.8	9.6	8.5	8.4	8.1	8.5	0.0	0.0	0.0
17	13.0	12.9	12.7	10.8	9.6	8.4	8.4	8.1	8.5	0.0	0.0	0.0
18	12.9	12.9	12.7	10.8	9.5	8.4	8.4	8.1	8.6	0.0	0.0	0.0
19	12.9	12.9	12.7	10.8	9.5	8.3	8.3	8.1	8.6	0.0	0.0	0.0
20	12.9	12.9	12.6	10.8	9.5	8.3	8.3	8.1	8.7	0.0	0.0	0.0
21	13.0	12.9	12.5	10.7	9.4	8.3	8.2	8.0	8.8	0.0	0.0	0.0
22	12.9	12.9	12.5	10.6	9.3	8.3	8.2	8.0	8.8	0.0	0.0	0.0
23	12.9	12.9	12.5	10.6	9.2	8.4	8.2	7.9	8.9	0.0	0.0	0.0
24	12.9	12.9	12.4	10.6	9.2	8.4	8.1	7.9	8.9	0.0	0.0	0.0
25	13.0	12.9	12.3	10.6	9.1	8.4	8.2	8.0	8.9	0.0	0.0	0.0
26	13.0	12.9	12.2	10.6	9.1	8.5	8.2	8.0	9.0	0.0	0.0	0.0
27	12.9	12.9	12.1	10.5	9.1	8.6	8.2	8.0	9.0	0.0	0.0	0.0
28	12.9	12.9	12.0	10.5	9.1	9.6	8.1	8.0	9.0	0.0	0.0	0.0
29	12.9		11.7	10.6	9.1	8.6	8.1	8.1	9.0	0.0	0.0	0.0
30	13.0		11.5	10.6	9.1	8.6	8.1	8.1	9.0	0.0	0.0	0.0
31	13.0		11.5		9.1		8.1	8.1		0.0		0.0

* Milligrams per liter

APPENDIX 3.3

SPOKANE RIVER BOUNDARY-DISSOLVED OXYGEN*
June - September 1973

DATA 1973 DAILY VALUES FOR DO

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.0	0.0	0.0	0.0	0.0	9.2	8.6	7.8	8.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	9.2	8.6	7.8	8.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	9.2	8.6	7.7	8.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	9.2	8.6	7.7	8.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	9.1	8.5	7.7	8.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	9.1	8.5	7.7	8.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	9.1	8.5	7.7	8.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	9.1	8.5	7.7	8.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	9.1	8.5	7.7	8.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	9.1	8.4	7.7	8.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	9.1	8.4	7.7	8.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	9.0	8.4	7.6	8.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	9.0	8.4	7.6	8.1	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	9.0	8.3	7.6	8.1	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	9.0	8.3	7.6	8.1	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	9.0	8.2	7.6	8.2	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	9.0	8.2	7.7	8.2	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	9.0	8.1	7.7	8.2	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	9.0	8.1	7.7	8.3	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	8.9	8.1	7.8	8.3	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	8.9	8.1	7.7	8.3	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	8.8	8.1	7.8	8.4	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	8.8	8.1	7.8	8.4	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	8.8	8.1	7.8	8.4	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	8.8	8.0	7.9	8.5	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	8.7	8.0	7.9	8.5	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	8.7	8.0	7.9	8.5	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	8.7	7.9	7.9	8.5	0.0	0.0	0.0
29	0.0		0.0	0.0	0.0	8.6	7.9	7.9	8.6	0.0	0.0	0.0
30	0.0		0.0	0.0	0.0	8.6	7.8	7.9	8.6	0.0	0.0	0.0
31	0.0		0.0		0.0		7.8	7.9		0.0		0.0

* Milligrams per liter

APPENDIX 3.4

SPOKANE RIVER BOUNDARY QUALITY

Parameter	Index	Units	Jan-Mar	Apr-Jun	Jul-Dec	Jan-Dec
			Mean Daily Value			
BOD	375	mg/1	-	-	-	1.21
COLITOTAL	376	No./100 ml	518	251	872	-
COLIFECAL	377	No./100 ml	59	58	14	-
TDS	378	mg/1	-	-	-	41.0
ORGNIT	379	mg/1	-	-	-	0.166
NH_3	380	mg/1	0.037	0.086	0.030	-
NO_3	381	mg/1	0.067	0.123	0.049	-
PO4	382	mg/1	-	-	-	0.018
CHLA	383	μg/1	-	-	-	1.78
ZOO	384	No./1	-	-	-	6.1
CONI	385	μg /1	446	259	222	-
POTP	386	mg/1	-	-	-	0.029

APPENDIX 3.5

LITTLE SPOKANE GROUNDWATER INPUT, QUANTITY AND QUALITY

Parameter	Index	Units	Mean Daily Value Jan-Mar	Apr-Jun	Jul-Dec	Jan-Dec
TDS	298	mg/l	-	-	-	229
ORGNIT	299	mg/l	-	-	-	0.088
NH_3	300	mg/l	-	-	-	0.014
NO_3	301	mg/l	-	-	-	1.410
POTP	302	mg/l	-	-	-	0.003
PO_4	303	mg/l	-	-	-	0.007
CONI	304	μg	-	-	-	12
WATERTEMP	305	°C	10.0	11.4	10.9	-
DO	306	mg/l	-	-	-	7.4
FLOW	193	CFS	-	-	-	244
NO_3	370	mg/l	-	-	-	1.123

APPENDIX 3.6

UPPER SPOKANE GROUNDWATER INPUT, QUANTITY AND QUALITY

Parameter	Index	Units	Mean Daily Value Jan-Mar	Apr-Jun	Jul-Dec	Jan-Dec
TDS	366	mg/l	-	-	-	187
ORGNIT	367	mg/l	-	-	-	0.10
NH_3	368	mg/l	-	-	-	0.015
NO_2	369	mg/l	-	-	-	0.002
NO_3	370	mg/l	-	-	-	1.123
POTP	371	mg/l	-	-	-	0.003
PO_4	372	mg/l	-	-	-	0.011
CONI	373	μg	-	-	-	.25
WATERTEMP	374	°C	10.3	10.4	11.5	-
FLOW	194	See Below				

Years	1967	Mean Daily Flow - cfs 1968	1969	1972	1973
Jan	-	228	568	-	478
Feb	-	141	574	-	594
Mar	-	590	432	-	425
Apr	-	570	530	-	348
May	-	411	1100	-	382
Jun	-	372	1101	-	402
Jul	-	423	637	-	442
Aug	-	420	470	-	306
Sep	-	345	372	-	250
Oct	354	174	-	483	-
Nov	287	209	-	571	-
Dec	194	453	-	429	-

APPENDIX 3.7

LOWER SPOKANE GROUNDWATER INPUT, QUANTITY AND QUALITY

			Mean Daily Value			
Parameter	**Index**	**Units**	**Jan-Mar**	**Apr-Jun**	**Jul-Dec**	**Jan-Dec**
TDS	366	mg/1	-	-	-	187
ORGNIT	367	mg/1	-	-	-	0.10
NH_3	368	mg/1	-	-	-	0.015
NO_2	369	mg/1	-	-	-	0.002
NO_3	370	mg/1	-	-	-	1.123
POTP	371	mg/1	-	-	-	0.003
PO4	372	mg/1	-	-	-	0.011
CONI	373	μg	-	-	-	25
WATERTEMP	374	°C	10.3	10.4	11.5	-
FLOW	192	CFS	See Below			

Mean Daily Flow - cfs

Year	1967	1968	1969	1972	1973
Jan	-	936	197	-	115
Feb	-	455	133	-	324
Mar	-	766	293	-	240
Apr	-	168	0	-	0
May	-	254	12	-	0
Jun	-	519	235	-	86
Jul	-	316	322	-	102
Aug	-	108	174	-	206
Sep	-	195	200	-	99
Oct	281	316	-	150	-
Nov	313	270	-	180	-
Dec	440	227	-	78	-

APPENDIX 3.8

LONG LAKE RELEASES*-TURBINE
October - December 1967

DATA 1967 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0	0	0	0	0	0	0	0	0	1900	1830	3680
2	0	0	0	0	0	0	0	0	0	2920	3020	3890
3	0	0	0	0	0	0	0	0	0	2590	3440	3910
4	0	0	0	0	0	0	0	0	0	2130	2910	4170
5	0	0	0	0	0	0	0	0	0	2170	2950	4250
6	0	0	0	0	0	0	0	0	0	2580	3580	4360
7	0	0	0	0	0	0	0	0	0	2260	3910	4570
8	0	0	0	0	0	0	0	0	0	2340	3910	4580
9	0	0	0	0	0	0	0	0	0	2650	3350	4600
10	0	0	0	0	0	0	0	0	0	3010	2950	4610
11	0	0	0	0	0	0	0	0	0	2660	1930	4470
12	0	0	0	0	0	0	0	0	0	3520	2570	4430
13	0	0	0	0	0	0	0	0	0	3870	2770	4430
14	0	0	0	0	0	0	0	0	0	3760	3890	4400
15	0	0	0	0	0	0	0	0	0	470	3900	4420
16	0	0	0	0	0	0	0	0	0	2730	3900	4420
17	0	0	0	0	0	0	0	0	0	3470	3890	4440
18	0	0	0	0	0	0	0	0	0	3550	3870	4440
19	0	0	0	0	0	0	0	0	0	3170	2420	4430
20	0	0	0	0	0	0	0	0	0	3670	3850	4420
21	0	0	0	0	0	0	0	0	0	2500	3860	4420
22	0	0	0	0	0	0	0	0	0	1530	3850	4640
23	0	0	0	0	0	0	0	0	0	2860	3870	4740
24	0	0	0	0	0	0	0	0	0	3610	3880	4590
25	0	0	0	0	0	0	0	0	0	3210	3900	4610
26	0	0	0	0	0	0	0	0	0	3410	3890	4740
27	0	0	0	0	0	0	0	0	0	3450	3860	4180
28	0	0	0	0	0	0	0	0	0	2750	3870	4590
29	0		0	0	0	0	0	0	0	1570	3870	5200
30	0		0	0	0	0	0	0	0	3100	3900	5190
31	0		0		0		0	0		3780		5170

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-TURBINE
January - December 1968

DATA 1968 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	5190	6100	5870	5970	6260	6350	4960	2370	1750	2370	5200	6330
2	5160	6090	5890	5980	6260	6360	3540	1460	1680	2880	5100	6300
3	5150	6150	5930	4560	6250	6330	3440	1080	2560	2900	5140	6270
4	5150	6220	5910	5020	6260	6350	990	210	2860	3720	5100	6280
5	5140	6200	5890	5860	6290	6340	3700	2180	2990	3320	4800	6270
6	5140	6040	5900	5960	6250	6450	3520	1690	1690	3100	5020	6270
7	5150	6180	5880	5990	6270	6030	3920	1490	1520	3860	5160	6320
8	5140	6190	5900	5980	6260	6320	3440	1780	1100	2940	5570	6340
9	5120	6200	5910	6020	6270	6360	3800	1970	2180	2780	5160	6310
10	5160	6210	5930	6030	6260	5410	3560	590	1830	2910	5130	6250
11	5160	6270	5890	6050	6310	4730	2850	340	1720	2980	5110	6270
12	5160	6200	5800	6050	6310	4720	2380	1550	1710	3050	5590	6230
13	5170	6190	5920	6050	6290	4720	1620	1660	2040	4100	6320	6260
14	5190	6160	5930	6080	6270	4730	1720	1680	2200	4010	6230	6270
15	5590	6200	5930	6060	6270	4760	2300	1720	2910	5100	6270	6290
16	5970	6190	5910	6040	6310	4750	2200	2540	2940	3710	6250	6280
17	5960	6150	5960	6060	6300	3710	2280	880	2570	4410	6300	6230
18	5950	6200	5740	6030	6310	3630	2050	1690	2340	4640	6260	6250
19	5930	6180	5800	6110	6330	3790	2280	2430	2920	4990	6330	6260
20	5960	6060	5930	6150	6300	4130	2120	2300	2600	4910	6330	6280
21	5970	5990	5940	6190	6340	5160	2390	1840	2730	5590	6280	6300
22	5920	5980	5550	6160	6300	5740	2690	1890	2770	5240	6270	6300
23	5910	5980	5980	6170	6320	5500	2640	2270	3220	5260	6260	6250
24	5930	5960	5990	6170	6330	5520	2630	1870	3200	5180	6300	6270
25	5910	5910	6000	6170	6340	5700	2520	1820	3040	5290	6260	6310
26	5890	5960	5180	6200	6390	4780	2400	2740	2930	5180	6220	6220
27	5880	5930	6010	6240	6360	4760	2120	2130	2580	5220	6230	6270
28	5900	5880	5970	6300	6360	5040	2170	1650	3030	5120	6310	6230
29	5890	5870	5990	6250	6370	4180	2060	1380	2020	5040	6280	6240
30	5740		5990	6260	6350	4160	1800	1750	2360	5580	6290	6200
31	5940		6020		6390		1630	1740		5810		6190

* Cubic feet per second

APPENDIX 3.8
LONG LAKE RELEASES*-TURBINE
January - September 1969

DATA 1969 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	6280	6240	6220	5820	5890	4510	5090	2200	2490	0	0	0
2	6240	6270	6280	5850	5900	4490	5070	1930	1920	0	0	0
3	6220	6280	6190	5720	5920	4070	4590	1150	2500	0	0	0
4	6280	4690	6180	5860	5930	3950	4350	1660	2190	0	0	0
5	6280	4110	6220	5860	5930	4980	5080	1820	2500	0	0	0
6	6250	6190	6160	5880	5940	5500	3670	2130	2460	0	0	0
7	6200	5990	6120	5740	5980	5880	4140	2040	2360	0	0	0
8	6150	6230	6140	5800	5960	5800	4490	1770	2440	0	0	0
9	6160	6270	6180	5780	5970	5820	3850	1130	2300	0	0	0
10	6170	6230	5890	5800	5970	4900	4370	1370	3150	0	0	0
11	6170	6190	6150	5800	6000	5230	3870	2530	1830	0	0	0
12	6180	5280	6110	5820	5940	5810	1680	1640	2310	0	0	0
13	6150	7380	6010	5840	5940	5820	1830	2460	2290	0	0	0
14	6190	5640	600	4430	5910	5830	4200	1990	2230	0	0	0
15	6150	6260	6030	4350	5930	4600	3080	1930	2490	0	0	0
16	6170	6270	6040	4400	5920	4700	3120	1090	2610	0	0	0
17	6160	5890	6000	5060	5880	3560	2810	1690	2640	0	0	0
18	6180	5850	5930	5780	5920	3700	2650	1860	2800	0	0	0
19	6180	6230	5900	5800	5970	3820	2220	1720	2310	0	0	0
20	6180	6210	5920	5820	5900	4040	2500	1870	2370	0	0	0
21	6200	6250	5930	5810	5930	4150	2810	2410	2280	0	0	0
22	6170	6270	6310	5880	5960	2260	3020	1460	2530	0	0	0
23	6210	6310	5950	5850	5960	3450	2550	2310	2620	0	0	0
24	6210	6250	5890	5930	5970	3860	4030	2600	2600	0	0	0
25	6190	6230	5890	5930	6000	4490	2480	2320	2610	0	0	0
26	6270	6190	5920	5930	5330	5690	1510	2410	2570	0	0	0
27	6230	6190	5760	7000	4480	4770	2040	2250	2040	0	0	0
28	6210	6210	5830	5920	4470	5050	2170	2620	2800	0	0	0
29	6250		5790	5910	4500	5080	3000	2390	2560	0	0	0
30	5970		5810	5910	4500	5250	2240	1750	2620	0	0	0
31	5490		5280		4500		2510	2750		0		0

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-TURBINE
June - September 1973

DATE 1973 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0	0	0	0	0	4920	2340	1520	1380	0	0	0
2	0	0	0	0	0	4590	3020	1480	700	0	0	0
3	0	0	0	0	0	4760	3000	1670	1760	0	0	0
4	0	0	0	0	0	5080	2290	600	2050	0	0	0
5	0	0	0	0	0	4900	2310	210	2210	0	0	0
6	0	0	0	0	0	4690	2640	1580	2330	0	0	0
7	0	0	0	0	0	5080	1620	1490	2330	0	0	0
8	0	0	0	0	0	5060	2230	1490	1510	0	0	0
9	0	0	0	0	0	5070	2810	1480	1920	0	0	0
10	0	0	0	0	0	4800	3260	1510	3090	0	0	0
11	0	0	0	0	0	4050	3290	490	2940	0	0	0
12	0	0	0	0	0	4160	2140	210	2720	0	0	0
13	0	0	0	0	0	4530	2390	1660	3020	0	0	0
14	0	0	0	0	0	4530	800	1740	1890	0	0	0
15	0	0	0	0	0	4410	210	1770	680	0	0	0
16	0	0	0	0	0	4570	2520	1250	710	0	0	0
17	0	0	0	0	0	4430	2500	1480	1590	0	0	0
18	0	0	0	0	0	4319	2110	1390	1100	0	0	0
19	0	0	0	0	0	4920	1990	210	1850	0	0	0
20	0	0	0	0	[illegible]	4510	1160	1840	2260	0	0	0
21	0	0	0	0	0	4370	210	1820	2610	0	0	0
22	0	0	0	0	0	4030	210	1870	2590	0	0	0
23	0	0	0	0	0	2660	1350	1600	2590	0	0	0
24	0	0	0	0	0	1120	1260	1680	2680	0	0	0
25	0	0	0	0	0	2360	1460	1340	2600	0	0	0
26	0	0	0	0	0	2820	1950	210	2830	0	0	0
27	0	0	0	0	0	3000	1450	1870	2940	0	0	0
28	0	0	0	0	0	2920	1200	1500	2870	0	0	0
29	0		0	0	0	2980	210	1500	1810	0	0	0
30	0		0	0	0	2990	1990	1460	2820	0	0	0
31	0		0		0		1410	2100		0		0

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-SPILL
October - December 1967

DATA 1967 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0	0	0	0	0	0	0	0	0	10	10	10
2	0	0	0	0	0	0	0	0	0	10	10	10
3	0	0	0	0	0	0	0	0	0	10	10	10
4	0	0	0	0	0	0	0	0	0	10	10	10
5	0	0	0	0	0	0	0	0	0	10	10	10
6	0	0	0	0	0	0	0	0	0	10	10	10
7	0	0	0	0	0	0	0	0	0	10	10	10
8	0	0	0	0	0	0	0	0	0	10	10	10
9	0	0	0	0	0	0	0	0	0	10	10	10
10	0	0	0	0	0	0	0	0	0	10	10	10
11	0	0	0	0	0	0	0	0	0	10	10	10
12	0	0	0	0	0	0	0	0	0	10	10	10
13	0	0	0	0	0	0	0	0	0	10	10	10
14	0	0	0	0	0	0	0	0	0	10	10	10
15	0	0	0	0	0	0	0	0	0	10	10	10
16	0	0	0	0	0	0	0	0	0	10	10	10
17	0	0	0	0	0	0	0	0	0	10	10	10
18	0	0	0	0	0	0	0	0	0	10	10	10
19	0	0	0	0	0	0	0	0	0	10	10	10
20	0	0	0	0	0	0	0	0	0	10	10	10
21	0	0	0	0	0	0	0	0	0	10	10	10
22	0	0	0	0	0	0	0	0	0	10	10	10
23	0	0	0	0	0	0	0	0	0	10	10	10
24	0	0	0	0	0	0	0	0	0	10	10	10
25	0	0	0	0	0	0	0	0	0	10	10	10
26	0	0	0	0	0	0	0	0	0	10	10	10
27	0	0	0	0	0	0	0	0	0	10	10	10
28	0	0	0	0	0	0	0	0	0	10	10	10
29	0		0	0	0	0	0	0	0	10	10	10
30	0		0	0	0	0	0	0	0	10	10	10
31	0		0		0		0	0		10		10

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-SPILL
January - December 1968

DATA 1968 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	10	10	16700	5130	700	4550	20	0	0	0	0	1120
2	10	10	15380	5320	570	4280	20	0	0	0	0	740
3	10	10	14480	6470	530	4290	10	0	0	0	0	840
4	10	10	15910	6290	610	2340	0	0	0	0	0	1110
5	10	10	14440	5040	570	1660	0	0	0	0	0	2460
6	10	10	13120	5470	490	1010	0	0	0	0	0	2000
7	10	10	12680	5200	2280	450	0	0	0	0	0	1050
8	10	10	12330	3840	3220	1820	0	0	0	0	0	1010
9	10	10	11620	2940	2910	930	0	0	0	0	0	1050
10	10	10	11630	3010	3120	1490	0	0	0	0	0	2640
11	10	10	10700	3050	2910	2200	0	0	0	0	0	5110
12	10	440	10050	3840	3290	3660	0	0	0	0	0	4630
13	10	940	9660	3910	3440	3640	0	0	0	0	0	4540
14	10	890	8370	4070	4240	3740	0	0	0	0	670	4480
15	10	930	6960	3850	3890	3090	0	0	0	0	430	4590
16	10	890	6870	3890	4080	2360	0	0	0	0	930	4260
17	10	880	7480	3730	4280	1350	0	0	0	0	1090	4680
18	10	880	7450	3150	4270	1380	0	0	0	0	710	4510
19	10	1940	6630	1740	3670	820	0	0	0	0	1080	3570
20	10	9270	6340	640	4730	1990	0	0	0	0	820	1910
21	10	13570	5339	680	4200	810	0	0	0	0	710	1370
22	10	15250	4600	1640	4800	210	0	0	0	0	940	700
23	10	14880	4480	2070	4330	90	0	10	0	0	1330	710
24	10	17660	4230	2280	4350	20	0	0	0	0	4510	1750
25	10	18440	4240	1160	3040	20	0	0	0	0	4400	730
26	10	18710	4650	590	2990	20	0	0	0	0	4650	1980
27	10	19270	3990	610	3070	20	0	0	0	0	4780	970
28	10	18590	4060	550	3200	20	0	0	0	0	3840	830
29	10	0	4070	570	3260	20	0	0	0	0	1400	700
30	10		4390	580	4310	20	0	0	0	0	850	700
31	10		4670		4350		0	0		0		700

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-SPILL
January - September 1969

DATA 1969 DAILY VA!UES FOR FLOW

DATE	JAN.	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	700	480	10	15180	24660	15640	10	10	10	0	0	0
2	620	190	10	14610	23330	15050	10	10	10	0	0	0
3	210	400	10	15420	22340	15240	10	10	10	0	0	0
4	290	20	10	15970	21250	14760	10	10	10	0	0	0
5	590	120	10	16220	20930	13860	10	10	10	0	0	0
6	2410	230	10	16700	18770	11570	10	10	10	0	0	0
7	7520	1090	10	18860	17960	10980	10	10	10	0	0	0
8	9220	720	10	18470	17810	11110	10	10	10	0	0	0
9	10870	720	10	18480	17940	10330	10	10	10	0	0	0
10	10750	720	10	19440	18600	9950	10	10	10	0	0	0
11	10450	1320	270	19560	19460	9100	10	10	10	0	0	0
12	10160	2040	840	18960	20400	7890	10	10	10	0	0	0
13	9290	300	830	18840	21370	6430	10	10	10	0	0	0
14	7720	2150	830	19840	22190	6250	10	10	10	0	0	0
15	8410	1450	870	20110	22150	350	10	10	10	0	0	0
16	7690	1200	820	20110	22380	210	10	10	10	0	0	0
17	7250	1620	880	18980	22610	80	10	10	10	0	0	0
18	7150	1010	5590	18160	21980	10	10	10	10	0	0	0
19	6620	710	7300	18960	21140	10	10	10	10	0	0	0
20	6120	710	7040	19430	20800	10	10	10	10	0	0	0
21	5760	240	5730	17940	20080	10	10	10	10	0	0	0
22	4690	10	5530	16160	18810	10	10	10	10	0	0	0
23	3780	10	5480	17350	18190	10	10	10	10	0	0	0
24	3110	10	6610	18910	17530	10	10	10	10	0	0	0
25	1250	10	6140	21110	16900	10	10	10	10	0	0	0
26	1940	10	7140	25030	16990	10	10	10	10	0	0	0
27	1120	10	8600	24070	17550	10	10	10	10	0	0	0
28	1240	10	12890	24780	17290	10	10	10	10	0	0	0
29	1150		13280	24200	16330	10	10	10	10	0	0	0
30	20		12460	24510	15650	10	10	10	10	0	0	0
31	180		8990		15620		0	10		0		0

* Cubic feet per second

APPENDIX 3.8

LONG LAKE RELEASES*-SPILL
June - September 1973

DATA 1973 DAILY VALUES FOR FLOW

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0	0	0	0	0	20	0	0	0	0	0	0
2	0	0	0	0	0	20	0	0	0	0	0	0
3	0	0	0	0	0	20	0	0	0	0	0	0
4	0	0	0	0	0	20	0	0	0	0	0	0
5	0	0	0	0	0	20	0	0	0	0	0	0
6	0	0	0	0	0	20	0	0	0	0	0	0
7	0	0	0	0	0	20	0	0	0	0	0	0
8	0	0	0	0	0	20	0	0	0	0	0	0
9	0	0	0	0	0	20	0	0	0	0	0	0
10	0	0	0	0	0	20	0	0	0	0	0	0
11	0	0	0	0	0	20	0	0	0	0	0	0
12	0	0	0	0	0	20	0	0	0	0	0	0
13	0	0	0	0	0	20	0	0	0	0	0	0
14	0	0	0	0	0	20	0	0	0	0	0	0
15	0	0	0	0	0	20	0	0	0	0	0	0
16	0	0	0	0	0	20	0	0	0	0	0	0
17	0	0	0	0	0	20	0	0	0	0	0	0
18	0	0	0	0	0	11	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0
29	0		0	0	0	0	0	0	0	0	0	0
30	0		0	0	0	0	0	0	0	0	0	0
31	0		0		0		0	0		0		0

* Cubic feet per second

APPENDIX 4.1

CALIBRATION POINT SOURCE FILES
INDUSTRIAL

Industry	Flow cfs	BOD mg/l	TDS mg/l	COLITOT no/100 ml	COLIFEC no/100 ml	Daily Mean Values Ortho P mg/l	Pot. P mg/l	Ammonia mg/l	Nitrite mg/l	Nitrate mg/l	ORGANIC mg/l	CONI m/gl
Culligan	.042	9	16,600	-	-	-	4.1	-	-	-	-	-
Hillyard	.845	25	334	-	-	-	.02	8.0	-	.8	-	-
Inland Empire (2)	5.11	47.3	97	17	20	.56	.13	-	-	.1	1.21	.44
Kaiser Mead (1)	6.00	.74	164	5	3	.17	.08	.48	-	1.1	.21	.10
Kaiser Trentwood	37.2	3.5	31	34	19	.15	.15	1.8	-	.04	5.9	.35
Spokane Ind. Park	.845	5.3	250	2	2	4.8	1.1	3.4	.2	1.42	3.4	.165

NOTES:

(1) Water temp °C for Kaiser Mead by months: Jan. 24, Feb. 25, Mar. 26, Apr-Jul 23, Aug. 24, Sept. 23, Oct-Dec 24.
(2) Inland Empire file was not actually used for calibration since the plant was closed by strike from June through September 1973.

APPENDIX 4.2

CALIBRATION POINT SOURCE FILES
DEER PARK STP AND TEKOA STP

Constituent	Units	Deer Park Amount	Tekoa[1] Amount
Flow	cfs	.221	.103
BOD	mg/l	27.8	196
TDS	mg/l	236[2]	460
ORGANIT	mg/l	7.2	15.2
Ammonia	mg/l	10.5	22.1
Ortho P	mg/l	3.3	5.8
Potential P	mg/l	2.6	5.3
COLITOTAL	no/100 ml	300	30,000
COLIFECAL	no/100 ml	100	10,000

Annual temperature pattern same as City of Spokane STP.

(1) The Tekoa plant was essentially inoperative during the calibration period.
(2) Incorrectly input as 23.6.

APPENDIX 4.3

CALIBRATION POINT SOURCE FILE
CITY OF SPOKANE STP

Constituent (2)	Mass Emission (1)
BOD	440
TDS	1786
Ortho P	14.9
Nitrate and Nitrite	3.1
Ammonia	50.7
ORGANIT	25.6
COLITOTAL	148
COLIFECAL	111

(1) Units for all except COLIT and COLIF are millions of milligrams times cfs divided by liters times days. Units for COLIT and COLIF are 10^8 organisms times cubic feet divided by 100 ml times days.

(2) Constituents with constant rate of mass emission throughout the year. Flow temperature and DO vary with time as below.

Semi-Month	Flow cfs	Temp °C	DO mg/1
Jan 1	38.7	12	5.4
2	38.7	12	5.4
Feb 1	38.7	12	5.3
2	38.7	13	5.2
Mar 1	38.7	14	5.1
2	38.7	14	5.0
Apr 1	43.3	15	4.8
2	43.3	16	4.7
May 1	45.6	16	4.2
2	45.6	17	4.0
Jun 1	47.5	18	3.6
2	47.5	19	3.4
Jul 1	47.5	19	3.2
2	47.5	21	3.1
Aug 1	47.5	21	3.2
2	47.5	21	3.3
Sep 1	45.6	20	3.5
2	45.6	19	3.7
Oct 1	43.3	18	4.0
2	43.3	18	4.4
Nov 1	38.7	16	4.7
2	38.7	14	5.0
Dec 1	38.7	13	5.3
2	38.7	13	5.4

APPENDIX 5.1

YR 2000 POINT SOURCE FILES
CITY OF SPOKANE STP(1)

Semi-Monthly	Flow CFS	Temp. °C	D.O. mg/1	MASS EMISSIONS PER DAY in units mg x cf – liters – days for mean flow 61.96 cfs: BOD	TDS	Ortho P	Nitrate & Nitrite	Ammonia	Organic N	Pot P	COLIFORMS Organisms/100 ml: Fecal	Total
Jan 1	55.99	12	3.0	134×10^6	2356×10^6	41.9×10^6	3.7×10^6	78.2×10^6	40.9×10^6	1.0×10^6	200	400
Jan 2	55.99	12	"	"	"	"	"	"	"	"	"	"
Feb 1	55.99	12	"	"	"	"	"	"	"	"	"	"
Feb 2	55.99	13	2.9	"	"	"	"	"	"	"	"	"
Mar 1	55.99	14	"	"	"	"	"	"	"	"	"	"
Mar 2	55.99	14	"	"	"	"	"	"	"	"	"	"
Apr 1	62.64	15	2.8	"	"	"	"	"	"	"	"	"
Apr 2	62.64	16	2.7	"	"	"	"	"	"	"	"	"
May 1	65.97	16	"	112×10^6	"	6.7×10^6	"	"	"	0.8×10^6	"	"
May 2	65.97	17	"	"	"	"	"	"	"	"	"	"
June 1	68.72	18	2.6	"	"	"	"	"	"	"	"	"
June 2	68.72	19	"	"	"	"	"	"	"	"	"	"
July 1	68.72	19	"	"	"	"	"	"	"	"	"	"
July 2	68.72	21	2.5	"	"	"	"	"	"	"	400(3)	800(3)
Aug 1	68.72	21	"	"	"	7.8×10^6	78.7×10^6	3.2×10^6 (2)	"	"	200	400
Aug 2	68.72	21	"	"	"	6.7×10^6	3.7×10^6	78.2×10^6	"	"	400(3)	800(3)
Sept 1	65.97	20	"	"	"	7.8×10^6	78.7×10^6	3.2×10^6 (2)	"	"	200	400
Sept 2	65.97	19	2.6	"	"	6.7×10^6	3.7×10^6	78.2×10^6	"	"	"	"
Oct 1	62.64	18	"	"	"	6.7×10^6	"	"	"	"	"	"
Oct 2	62.64	18	"	134×10^6	"	41.9×10^6	"	"	"	1.0×10^6	"	"
Nov 1	55.99	16	2.7	"	"	"	"	"	"	"	"	"
Nov 2	55.99	14	2.9	"	"	"	"	"	"	"	"	"
Dec 1	55.99	13	"	"	"	"	"	"	"	"	"	"
Dec 2	55.99	13	"	"	"	"	"	"	"	"	"	"

(1) Year 2000 serving City and North Spokane, Secondary Treatment, Seasonal P removal May 1 to October 15.

(2) Nitrification in first half of August and September only.

(3) Assumed minimum control of coliforms to 7-day mean limit.

APPENDIX 5.2

YR 2000 POINT SOURCE FILES
SPOKANE VALLEY STP(1)

Semi-Monthly	Flow CFS	Temp. °C	DO mg/1	CONCENTRATION mg/1 BOD	TDS	Ortho-P	Pot-P	Nitrate & Nitrite	Ammonia	Organic N	COLIFORMS Organisms/100 ml Fecal	Total
Jan 1	15.52	12	3.0	25	440	7.82	.18	0.7	14.6	3.9	200	400
Jan 2	"	12	"	"	"	"	"	"	"	"	"	"
Feb 1	"	12	"	"	"	"	"	"	"	"	"	"
Feb 2	"	13	2.9	"	"	"	"	"	"	"	"	"
Mar 1	"	14	"	"	"	"	"	"	"	"	"	"
Mar 2	"	14	"	"	"	"	"	"	"	"	"	"
Apr 1	"	15	2.8	"	"	"	"	"	"	"	"	"
Apr 2	"	16	2.7	"	"	"	"	"	"	"	"	"
May 1	"	16	"	21	"	1.25	.15	"	"	"	"	"
May 2	"	17	"	"	"	"	"	"	"	"	"	"
June 1	"	18	2.6	"	"	"	"	"	"	"	"	"
June 2	"	19	"	"	"	"	"	"	"	"	"	"
July 1	"	19	"	"	"	"	"	"	"	"	"	"
July 2	"	21	2.5	"	"	"	"	"	"	"	400	800
Aug 1	"	21	"	"	"	"	"	"	"	"	200	400
Aug 2	"	21	"	"	"	"	"	"	"	"	400	800
Sept 1	"	20	"	"	"	"	"	"	"	"	200	400
Sept 2	"	19	2.6	"	"	"	"	"	"	"	"	"
Oct 1	"	18	"	"	"	"	"	"	"	"	"	"
Oct 2	"	13	"	25	"	7.82	.18	"	"	"	"	"
Nov 1	"	16	2.7	"	"	"	"	"	"	"	"	"
Nov 2	"	14	2.9	"	"	"	"	"	"	"	"	"
Dec 1	"	13	"	"	"	"	"	"	"	"	"	"
Dec 2	"	13	"	"	"	"	"	"	"	"	"	"

(1) Year 2000 serving 74,061 in Spokane Valley, Secondary Treatment, Seasonal P removal May 1 to October 15.

APPENDIX 5.3

YR 2000 POINT SOURCE FILES
DEER PARK AND TEKOA STP

Constituent	Units	Deer Park[1] Amount	Tekoa[2] Amount
Flow	cfs	0.347	0.153
Temperature	°C	16	16
Dissolved Oxygen	mg/l	2.7	2.7
BOD	mg/l	25	25
TDS	mg/l	426	447
Ortho P	mg/l	7.82	7.82
Pot P	mg/l	.18	.18
Nitrate & Nitrite	mg/l	0.7	0.7
Ammonia	mg/l	14.6	14.6
Organic N	mg/l	3.9	3.9
Fecal Coliform	org/100 ml	200	200
Total Coliform	org/100 ml	400	400

(1) At year 2000 for population of 1824 persons, secondary treatment, without phosphorus removal.

(2) At year 2000 for population of 900 persons, secondary treatment, without phosphorus removal.

APPENDIX 5.4

YR 2000 POINT SOURCE FILES
INDUSTRIAL, SPOKANE VALLEY

PROCESS FLOW PLUS GROUNDWATER SOURCE COOLING WATER

Flow 15.15 mgd equal 23.44 cfs[(1)].

Constituent	Units	Value or Concentration
Temperature	°C	18
BOD	mg/l	12.3[(3)]
Dissolved Oxygen	mg/l	2.6[(6)]
TDS	mg/l	202[(2)]
Organic N	mg/l	0.41[(3)]
Ammonia	mg/l	0.41[(3)]
Nitrate N	mg/l	1.5[(5)]
Ortho P as P	mg/l	.52[(3)]
Pot P as P	mg/l	.09[(3)]
Total coliform	No./100 ml	200
Fecal coliform	No./100 ml	100

SURFACE WATER SOURCE COOLING WATER

Constituent	Units	Value
Heat content	°c x cf/day	3.5×10^6 [(4)]

(1) 11.43 mgd process flow plus 3.72 mgd cooling water from wells.
(2) 11.43 mgd @ 1.25 x 170 mg/l plus 3.72 mgd @ 170 mg/l.
(3) Forecast process flow concentration for 11.43 mgd adjusted to total flow 15.15 mgd.
(4) Mass units for 1.5°C rise in 17.5 mgd.
(5) From groundwater source.
(6) At 30 percent of saturation.

APPENDIX 5.5

YR 2000 POINT SOURCE FILES
INDUSTRIAL, NORTH SPOKANE

PROCESS FLOW COMPONENT

Constituent	Units	Amount
Flow	cfs	0.743
Temperature	°C	18
BOD	mg/l	30
Dissolved Oxygen	mg/l	2.6 (1)
TDS	mg/l	213 (2)
Organic N	mg/l	1.5
Ammonia	mg/l	1.5
Nitrate	mg/l	1.5 (3)
Ortho P as P	mg/l	0.79
Pot P as P	mg/l	0.21
Total coliform	org/100 ml	200
Fecal coliform	org/100 ml	100

COOLING FLOW COMPONENT

Constituent	Units	Amount
Flow	cfs	6.70
Temperature	°C	18
TDS	mg/l	170
Dissolved Oxygen	mg/l	2
Nitrate	mg/l	1.5

(1) At 30 percent of saturation.
(2) At groundwater supply concentration plus 25 percent.
(3) From groundwater supply.

APPENDIX 6.1

KEY TO READING SIMULATION PRINTOUTS

1. Each page shows results for one day which is identified by the year month and day on the first line. This is the year, month and day of the meteorological and streamflow conditions under which the quality simulation is taking place.

2. Column heading abbreviations, and units:

Heading	Description	Units	Notes
HOUR	Hour of the day, 24 hour clock		
RCH	Stream reach identifier		(1)(2)
CHLA	Chlorophyl a	μg/l	
ZOO	Zooplankton	numbers/l	(3)
WATERT	Water temperature	°C	
DO	Dissolved Oxygen	mg/l	
BOD	Biochemical oxygen demand	mg/l	(4)
TDS	Total dissolved solids	mg/l	
COLIT	Total coliforms	number/100 ml	
COLIF	Fecal coliforms	number/100 ml	
PO4	Ortho phosphate	mg/l	(5)
POT	Potential phosphorus	mg/l	(6)
NO3	Nitrate	mg/l	(7)
NO2	Nitrite	mg/l	(7)
NH3	Ammonia	mg/l	(7)
ORGNIT	Organic nitrogen	mg/l	(8)
CONI	Conservative	μg/l	(9)
BENTH	Benthic algae	μg/l	(10)
BACDEN	Bacterial density	μg/l	(11)
(See Note)	Limiting substrate	none	(12)

3. The streamflow in cubic feet per second mean daily flow at each reach is shown by the numbers on one line below the last hour entry on each page. The first digit is the day of week, the following are in order of the reaches from left to right. That is if reach 710 is the first listed under RCH, the first number is the flow in Reach 710.

4. Limiting substrate abbreviations:

Abbreviations	Description
LIT	Darkness period
LIB	Light limited benthic algae growth
LIP	Light limited phytoplankton growth
NON	No growth due to insufficient nitrogen or phorphorus
PO4	Phosphate limited growth
NO3	Nitrate limited growth
TEMP	No growth due to excessively low temperature (less than 6°C)

NOTES:

1. Refer to Plate 606-1 for identification of reach number.
2. The three levels of Long Lake are identified by reach number 440. For each hour of the day, three results are printed, the first is the top layer, the second the middle layer and the third the bottom layer.
3. Zooplankton were not simulated.
4. Five day BOD.
5. Orthophosphate and potential phosphate are both expressed as P. (Note that Soltero data and data in Section 607 express phosphates as PO4.)
6. Phosphorus bound in chlorophyl a and BOD.
7. All nitrogen compound expressed as N.
8. Organic nitrogen is equal to Kjeldahl minus ammonia.
9. Zinc is carried as the conservative through all simulations.
10. Benthic algae simulated for free flowing reaches only. Lake depth precludes green plants.
11. Bacterial density is a measure of activity of denitrifying bacteria in anaerobic conditions.
12. The last unlabeled column on the right contains the coded indication of limiting substrate.

APPENDIX 7.1

WATER QUALITY PARAMETER INTERDEPENDENCE

PARAMETER TO BE SIMULATED	OTHER PARAMETERS THAT MUST BE SIMULATED CONCURRENTLY
Temperature, Total Dissolved Solids, Turbidity and any Conservative Constituents	May be simulated without other constituents.
Coliforms (Total, Fecal, Fecal Streptococci)	Requires temperature simulation.
Dissolved Oxygen	Requires a minimum of temperature and BOD simulation, although BOD may be stated as being zero.
BOD	Requires temperature and dissolved oxygen simulation.
Algae - Benthic and Phytoplankton (Chlorophyll A)	Requires temperature, dissolved oxygen, BOD, nitrogen and phosphorus forms (minimum of NO_3 and PO_4), and zooplankton (phytoplankton only).
Zooplankton	Requires same indices as phytoplankton.
Nutrients (nitrogen and phosphorus forms)	Dependent upon processes in which these constituents are involved. For instance, to simulate nitrification temperature, dissolved oxygen and BOD are required.