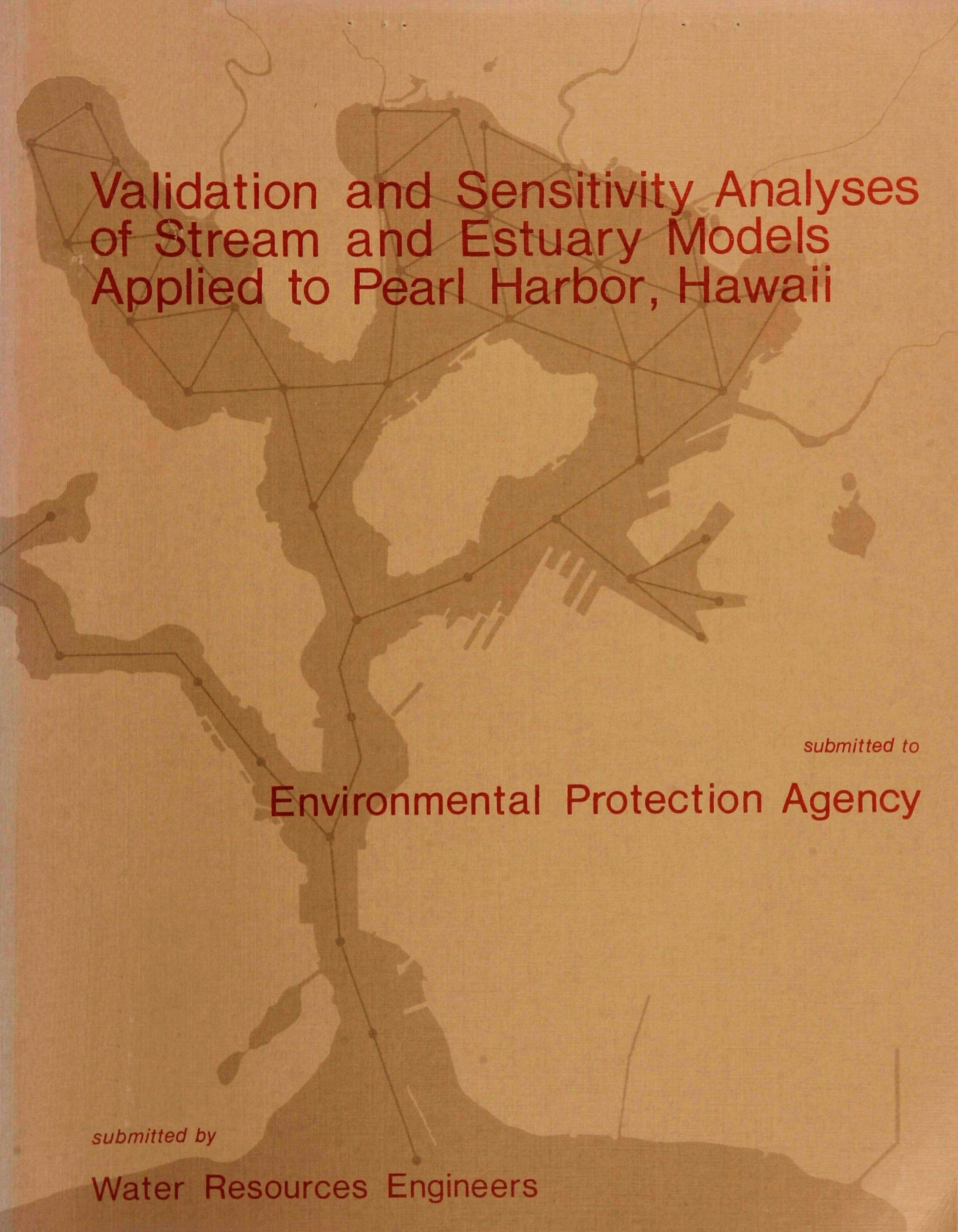
Validation and Sensitivity Analyses of Stream and Estuary Models Applied to Pearl Harbor, Hawaii



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Validation and Sensitivity Analyses of Stream and Estuary Models Applied to Pearl Harbor, Hawaii

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I. INTRODUCTION

BACKGROUND

On February 20, 1973, a contract was signed between the Environmental Protection Agency (EPA) of the United States of America and Water Resources Engineers (WRE) of Walnut Creek, California, under which WRE was to modify, document, and validate mathematical models of both Pearl Harbor and one of its tributaries on the Island of Oahu, State of Hawaii.

The work performed under that contract (No. 68-01-1800) was divided into four phases. Phase I involved four tasks: 1) segmentation of both Pearl Harbor and Waikele Stream into node-link networks to be used for mathematical modeling purposes, 2) specification of available hydrologic, water quality, and meteorologic data points, 3) assembly and coordination of these data with the model networks, and 4) preparation of a report enumerating types and quantity of data available on a point by point basis for the entire network. Moreover, the contractor identified data deficiencies by type and location throughout the network.

Phase II entailed the modification of existing mathematical models (computer programs) to include consideration of more quality constituents than the programs previously treated. The modification of the models was followed in Phase III by their application to historical periods of record to assure their correct functioning.

Phase III, the subject of this report, consisted of validating the models and then performing sensitivity analyses to determine the relative importance of individual model parameters to the accuracy of model predictions. The findings of the sensitivity analyses are summarized in this Sensitivity Analysis Report. The models, as modified in Phase II, will be fully documented and explained in detail for the benefit of future users in a Documentation Report.

Finally, Phase IV entails a training session for EPA, State, U.S. Navy, and local personnel on the use of the models. Following this seminar a final report will be prepared summarizing the three interim reports and the training seminar.

This report is the second in a series and describes the Phase III validation and sensitivity analyses results. Two models were applied in this task, an estuary model for Pearl Harbor and a stream model for Waikele Stream. Each model is described in the following section.

WATER QUALITY MODEL DESCRIPTIONS

The Stream Model

The contract specified that a stream model known as DOSAG would be modified and applied to Waikele Stream, a tributary of Pearl Harbor. This model is a steady-state model used for predicting dissolved oxygen levels in a stream under specified hydraulic and wasteload conditions.

For a number of reasons WRE requested that another model known as QUAL-II be substituted for DOSAG. This substitution of models was approved on June 12, 1973 [5]*. Although both DOSAG and QUAL-II are stream models, QUAL-II provides the following advantages over DOSAG: 1) it can operate in a dynamic mode as well as a steady-state mode, 2) it includes the ability to consider more constitutents than DOSAG, and, 3) it has some technical operational advantages over DOSAG. Although QUAL-II has the ability to treat numerous constituents [11], it was to be applied in this project to model only dissolved oxygen, biochemical oxygen demand, and coliform organisms. However, the full model with all its other capabilities will be supplied at the end of the project.

Simply stated, QUAL-II numerically solves mathematical expressions for advection and dispersion, as well as individual constituent changes such as decay or dieaway, for each of the physical computational elements into which the stream has been divided. These computations can be repeated through a series of small time steps (such as one-half hour) to approximate the dynamic character of the stream. Alternatively, the model can be operated to progress through a series of numerical iterations to attain the integrated, final, steady-state concentrations in each reach along the stream without conscious attention given to, or need for, a specific time step or duration.

In either mode, however, it is worth noting that the model uses constant values of tributary or waste discharge inflows with respect to both water quantity and constituent concentrations. So even in the dynamic mode, the model marches through time that is essentially the same day simulated over and over again. The result is that the model eventually attains a set of concentrations for each reach of the stream that would be attained during a real-time period when inflows from tributaries and waste discharges were constant.

The parameters that can be changed to give the solution its dynamic character are: 1) the sunlight energy for daylight and dark periods, and 2) the reaction rates for various constituents that are

*Numbers in brackets indicate references listed at the end of this report.

temperature dependent. To summarize, the solution in the dynamic mode is the set of simulated conditions over a diurnal cycle in each reach of the stream, which is presumed to be operating in real time in a steady-state hydrologic condition.

QUAL-II was applied to Waikele Stream from the outfall of the Schofield Barracks waste treatment plant to the stream's mouth at Pearl Harbor. Chapters II and III describe the validation and sensitivity analyses, respectively.

The Estuary Model

The contract for this project specified that two existing models be modified and applied to Pearl Harbor. These were: 1) a Dynamic Estuary Model (DEM), which is a quasi-two-dimensional mathematical model that operates on a network of interconnected links to simulate the tidally dynamic behavior of an estuary, and 2) a Tidal Temperature Model (TTM), which performs necessary heat budget calculations to predict water temperatures throughout the day and night and throughout the network.

During the modification stage WRE transformed the TTM into a subroutine of the DEM, therefore, the DEM now includes the TTM. The DEM is operated in two stages, the hydraulics submodel followed by the quality submodel. Although the hydraulics submodel remains essentially unchanged from the initial version, the quality submodel now incorporates many additional features. Whereas, previously the quality submodel only simulated dissolved oxygen, biochemical oxygen demand and a conservative constituent, it now treats all of the following parameters as a result of this project:

Temperature
Dissolved Oxygen
Biochemical Oxygen Demand
Chlorophyll-a
Ammonia
Nitrite
Nitrate
Phosphorus
Coliforms
Salinity (conservative)
Total nitrogen (conservative)
Two heavy metals
Two pesticides

The modifications and additions to the model will all be described in the Documentation Report.

The DEM can accept the 24.5-hour tide for Pearl Harbor (or any other tidal period) and constant tributary and wasteflow inputs to simulate a quasi-dynamic set of conditions in an estuary. In normal operation the model solves advection, dispersion, and constituent alteration equations for small time steps over a tidal cycle and then repeats these solutions for the following cycle over and over until a "dynamic equilibrium" is attained. Theoretically, this means that the concentrations at each point in the system become the same for the last cycle as they were in the cycle before that. The solution is similar in concept, then, though different in numerical technique, to the solution produced by QUAL-II: it is an approximation of what would occur in an estuary over a period of tidal cycles during which the estuary was receiving the same tributary runoff and waste discharges day after day.

It should be noted that attainment of "dynamic equilibrium" is a possibility only for the conservative constituents simulated by the model when the tidal period is different from the 24.0-hour solar day. Other constituents are related to the heat budget and cannot attain equilibrium unless the tidal period is 24.0 hours. The tide at Pearl Harbor, which has a 24.5-hour period, caused the dynamic equilibrium aspects of the contract to become rather academic for all but a few constituents; therefore, all simulations were performed for the reasonable alternative of 30 days of solar time.

VALIDATION APPROACH

The normal approach when applying mathematical models to streams and estuaries is to calibrate the models first through a comparison process, checking the model results against historical data and, in turn, adjusting model rate "constants" and similar parameters until the models reasonably simulate the historical measurements. Having calibrated a model successfully, one may then use it for projecting various possible future impacts on water bodies, taking into account both quantity and quality effects.

This validation approach was applied for both the stream model and the estuary model. The models of Waikele Stream and Pearl Harbor were validated against April and September 1972 conditions, which allowed examination of both a dry and a rainy season. The validation results for the stream and estuary models are described in Chapters II and IV, respectively.

SENSITIVITY ANALYSIS APPROACH

The validation procedure previously described resulted in a defined set of parameters and quality results representing the "base case."

Sensitivity analyses were then performed to determine the relative importance of individual model parameters to the accuracy of model predictions. Eight sensitivity runs were made for the stream model by independently varying either the deoxygenation rate constant, the reaeration rate constant, the coliform dieaway rate constant, or the tributary stream inflow quantities. The results demonstrate that rather large changes in assumptions for rate constants and input flows have little effect on the model results. These sensitivity analyses are described further in Chapter III.

Fifteen sensitivity analyses were made for the estuary model, wherein variations were made for either the deoxygenation rate constant, the reaeration rate constant, the coliform dieaway rate constant, the time step of computation, Manning's roughness coefficient, or the stream inflow quantities. The results of the sensitivity analyses for this model are presented in Chapter V.

SUMMARY OF FINDINGS

Stream Model

Validation

Although very few stream quality data were available for validation purposes, the model has simulated the dissolved oxygen, BOD, and coliform concentrations in a reasonable manner for periods of both low and high flows. However, due to the characteristics of Waikele Stream, the expressions for calculating the reaeration rate coefficient needed to be reformulated. Evidently none of the expressions originally programmed in the model are applicable to rapidly flowing, shallow streams.

Additionally, the model results demonstrated that the springs near the mouth of the stream may in fact have higher levels of dissolved oxygen than the values assumed for input to the model. These springs contribute a substantial portion of the flow and may warrant further investigation.

Sensitivity Analyses

The sensitivity analyses demonstrated that rather large changes in rate coefficients and input flows have only slight effects on the model results. Increasing the rates and flows by as much as 100 percent rarely altered the simulated results by more than 5 percent. Decreasing the rates and flows by 50 percent had even less effect.

Estuary Model

Validation

Several difficulties ensued from modeling Pearl Harbor with a horizontally quasi-two-dimensional model since the harbor is partially stratified in the vertical for much of the year. Even so, the simulated values corresponded quite reasonably with values measured in the field, falling midway between what was measured near the surface and at depth. This averaged result indicates the model's utility for long-term, large scale planning activities even for a partially stratified estuary.

The data were excellent for many parameters such as salinity, temperature, and dissolved oxygen but scarce to nonexistent for others such as BOD and chlorophyll a. Occasionally, data for time periods that did not coincide with the simulated time periods were needed for comparative purposes, but on the whole the data were quite sufficient for model validation.

Sensitivity Analyses

The sensitivity analyses demonstrated that the estuary model for Pearl Harbor was very insensitive to the deoxygenation rate, Manning's roughness coefficient, and the time step used in the quality model. However, results were quite dependent on accurate selection of the reaeration rate, coliform dieaway rate, and freshwater inflows.

The reaeration rate constant was difficult to choose due to the stratified nature of the harbor. It was possible to model dissolved oxygen for either the surface zone, the middle zone, or at depth. We elected to simulate the middle zone and the results may, therefore, be taken as indicative of the overall average concentration of dissolved oxygen in the harbor.

The model results were sensitive to the coliform dieaway rate constant primarily because the coefficient is a relatively large number on the order of 25 to 75 percent dieaway per day. This problem was compounded in this study by insufficient knowledge of contributions from unknown point or nonpoint waste sources. Therefore, the coliform simulation results remain suspect except in the vicinity of a large, point discharger for which input data were available.

The estuary model illustrated the sensitive nature of the West Loch to total stream inflow as well. Given the conditions of a relatively large stream flow into a shallow loch with low velocity currents, it was found that the specific quantity of inflow significantly affected the quality response of the loch. Smaller streams flowing into larger lochs had much smaller effects on the estuary's quality.

II. STREAM MODEL VALIDATION

GENERAL APPROACH

The drainage basin for Waikele Stream is illustrated in Figure 1. The portion of Waikele Stream that was modeled extends from the mouth to the point of discharge of the Schofield Barracks waste treatment plant. As shown in Figure 1 this distance is almost ten miles.

The validation of QUAL-II, which was operated as a steady-state water quality stream model, followed these six steps:

1) Major dischargers, tributaries, and monitoring stations were identified.

2) The stream was divided into reaches of similar hydraulic and topographic characteristics.

3) Reaches were subdivided into "elements" of equal length for further detail.

4) Validation periods were selected for two different hydrologic seasons of the stream. Unfortunately, no extensive data base existed for these periods, but they were used because they were the same periods used for the estuary model.

5) Tributary stream and waste discharger quantity and quality data were prepared from available records. Additionally, reasonable values for reaction rates were selected for simulation of dissolved oxygen, biochemical oxygen demand (BOD), and coliform organisms.

6) Simulations were made and compared against historical measurements.

Each of the six steps are described in the following sections of this chapter.

STREAM INPUTS AND MONITORING STATIONS

The Data Report for the Pearl Harbor System of Hawaii [12] contains detailed descriptions of the available hydrologic and water

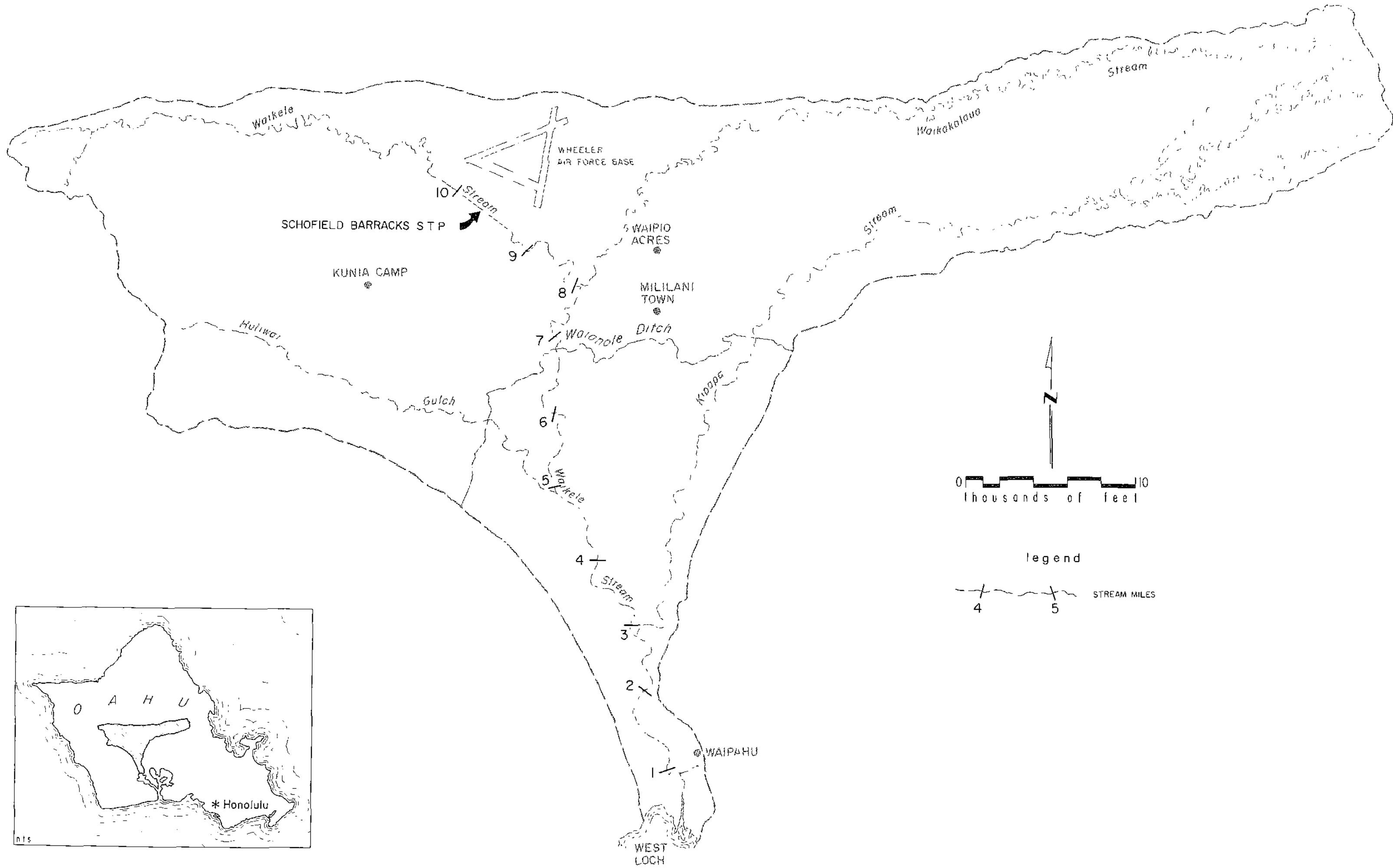


FIGURE 1
WAIKELE STREAM DRAINAGE BASIN

quality data to support this phase of the study. Therefore, a summary of the major dischargers, tributaries, and monitoring stations and a description of their relationships to the stream modeling task will suffice for the purposes of this report.

Major stream inputs for the period of stream simulation were identified to account volumetrically and spatially for increases or decreases in flow, dissolved oxygen, BOD, and coliforms resulting from such sources. The sources of inputs for which some data existed are shown in Figure 2. This figure also illustrates the stream profile, stream reaches and elements of reaches. The reaches and elements are each described in a later section of this chapter. It should be noted that data for the effluent from the waste treatment plant at Waipio Acres was used in part to estimate the quality of Waikakalaua Stream, for which no quality records exist. Further, data for the effluent at Mililani Town were used in part to estimate the quality of Kipapa Stream, for which quality records are sparse to nonexistent. These effluent quality data were graciously supplied from unpublished records by the City and County of Honolulu. It might also be noted that Waihole Ditch transports irrigation water from eastern to central Oahu during the dryer months of the year, drawing some supplemental water from Waikele Stream. It was assumed in this work that it was not in use during April 1972, or at least that the supplemental water was not being withdrawn.

Historical monitoring station data were used to validate the modeled results and were useful for adjusting stream constants during the calibration phase. Unfortunately, there were only two monitoring stations on Waikele Stream, both near the mouth. A U.S. Geological Survey station near Waipahu provided continuous records of flow and some quality data. Additional quality data were recorded at a U.S. Navy Sampling Station near the mouth for post-1971 periods. These were the only records available for validating the stream model.

STREAM REACHES AND ELEMENTS

The ten miles of Waikele Stream from the outfall of the Schofield Barracks waste treament plant to the stream's mouth at Pearl Harbor were divided into six reaches for modeling purposes. These model reaches were chosen as hydraulically and topographically similar sections of the stream.

The reaches were then subdivided into 39 one-quarter mile long elements for further detail. These elements, which the model's structure requires, serve primarily as points of input for waste discharges and inflows from tributaries. Figure 2 illustrates the reaches, elements, stream profile, major discharges and tributaries, and monitoring stations. Notice that each discharger, tributary, or monitoring station has been assigned to the particular element that corresponds most closely to its actual location along the stream profile.

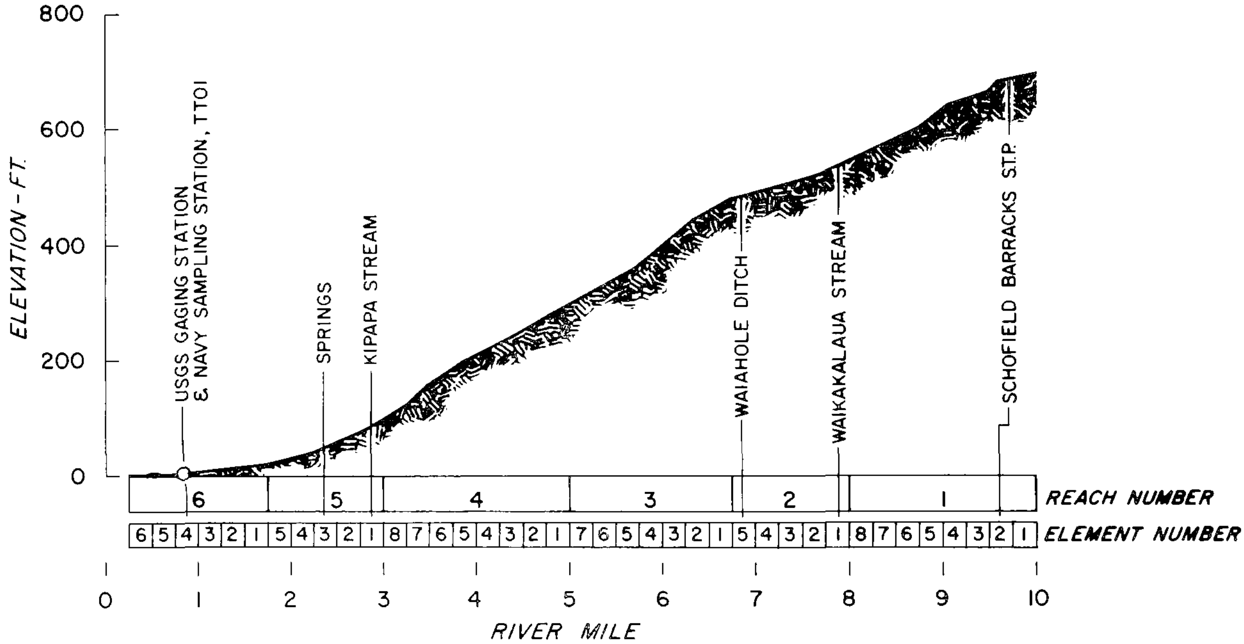


FIGURE 2

WAIKELE STREAM PROFILE AND MODEL REACHES

VALIDATION PERIODS

Two periods were selected for validating the stream model, April and September 1972. Since the available data were sparse for all months these two periods were selected merely to correspond to the estuary model validation periods, which in turn were based on data availability for Pearl Harbor. The calendar year 1972 was selected since the majority of the useful estuary data was collected by the U.S. Navy at that time. Two months were simulated as a means of checking both a wet month (April) and a dry month (September).

The quantities and qualities of inputs for these two periods are listed in Tables 1 and 2. In April a headwater flow of 1.5 cfs was assumed with a high dissolved oxygen level and low BOD and coliforms. Schofield Barracks produced an effluent of 2.5 cfs that was high in BOD and coliforms and with a dissolved oxygen content of 5.0 mg/l. Waikakalaua and Kipapa Streams supplied a major portion of the flow. Both of these were high in dissolved oxygen and relatively low in BOD and coliforms. No withdrawals were assumed for Waihole Ditch but substantial flow was included for underground springs in the vicinity of reach 5. Although quality input values for these springs were unknown, relatively low concentrations were assumed for dissolved oxygen, BOD, and coliforms.

In September the influent stream flows were all decreased. Headwater was assumed negligible, Waikakalaua Stream flow was halved, Kipapa Stream flow was only a tenth of the April flow, and the springs were decreased by 25 percent. The quality of the input generally diminished as well. The Schofield Barracks flow was the same as in April while the BOD and coliforms increased slightly. From the Waikele Stream flow, 3.5 cfs were diverted to Waihole Ditch for transportion to central Oahu. The water was withdrawn at the simulated quality level in element 5 of reach 2.

BASELINE SIMULATION

A baseline simulation was identified as the April 1972 set of rate coefficients and results. All subsequent sensitivity analyses were compared against this base case. The critical portion of this phase of work was identifying the three stream constants required for the model simulation of dissolved oxygen, BCD, and coliform organisms. These three stream constants are:

1) The biological deoxygenation rate constant, K_1.

2) The reaeration rate constant, K_2. (Although values were assigned in this simulation, a model option allows this constant to be calculated from one of five equations found in the environmental engineering literature).

3) The dieaway rate constant for coliforms, called K_5.

After several trial simulations with the model, a value of 0.2 per day was chosen for K_1 for all reaches; K_5 was assigned a value of 0.5 per day; and K_2 was assigned a value of 1.0 per day for all reaches except the most downstream reach where a value of 0.8 was assigned.

TABLE 1
Input Quantities and Qualities for April 1972

Discharge Identification	Flow, cfs	D.O., mg/l	5-day B.O.D, mg/l	Coliforms, MPN/100 ml
Headwater	1.5	9.2	0.5	1
Schofield Barracks	2.5	5.0	26.0	155,000
Waikakalaua Stream	5.2	8.2	1.6	3,300
Waihole Ditch	-0	---	---	---
Kipapa Stream	15.5	8.3	1.0	126
Springs	15.5	4.0	0.5	1

TABLE 2
Input Quantities and Qualities for September 1972

Discharge Indentification	Flow, cfs	D.O., mg/l	5-day B.O.D., mg/l	Coliforms MPN/100 ml
Headwater	0	---	---	---
Schofield Barracks	2.5	5.0	32.1	160,000
Waikakalaua Stream	2.6	8.0	2.3	366
Waihole Ditch	-3.4*	---	---	---
Kipapa Stream	1.5	5.3	8.9	1,365
Springs	11.6	4.0	0.5	1

*Removed at modeled quality of Waikele Stream at the point of withdrawal.

It was originally intended that be calculated from the Thackston and Krenkel expression:

$$K_2 = 10.8\ (1 + F^{0.5})\ \frac{u*}{D}\ X\ 2.31 \tag{1}$$

where F is the Froude Number,

$$F = \frac{u}{\sqrt{gD}} \tag{2}$$

u* is the shear velocity,

$$u* = \sqrt{gSD} = \frac{un\sqrt{g}}{1.49\ D^{1/6}} = \frac{5.675}{1.49}\ X\ \frac{un}{D^{1/6}} \tag{3}$$

D is the depth of flow, u is the average velocity in the stream, g is the acceleration of gravity, S is the slope of the energy grade line, and n is the Manning roughness coefficient. If one makes some reasonable assumptions and does some substitution of equations 2 and 3 into equation 1, the reaeration coefficient approximates

$$K_2 = 75\ \frac{un}{D^{1.167}} \tag{4}$$

In some reaches of Waikele Stream the velocity, u, approaches 2 feet per second, and the depth is as low as 0.2 feet. If n is taken as 0.04, K_2 will be calculated to be as high as 70 per day, clearly an unreasonable value. Therefore, this optional expression and others in the model for calculating K_2 were not deemed adequate for rapid, shallow streams; and more reasonable values of K_2 were assigned for these conditions.

VALIDATION RESULTS

Tables 3 and 4 present the modeled concentrations at the ends of each reach given the inputs in Tables 1 and 2, respectively. Figures 3 and 4 illustrate the results for April and September on an element by element basis. Major tributaries and waste dischargers are identified in their respective elements on the figures. Although complete computer results are presented in Appendices A and B, the results are summarized in the following sections.

April 1972 Validation

The quality profiles of Figure 3 demonstrate the effects of the major stream inputs listed in Table 1. The simulation begins at river mile number 10 where the quality is that of the headwaters. As the

TABLE 3
Concentrations of Modeled Constituents in Waikele Stream for April 1972*

Constituent	Lower End of Reach 1	2	3	4	5	6
Dissolved Oxygen, mg/l	6.41	7.35	7.26	7.17	6.40	6.46
Biochemical Oxygen Demand, mg/l	16.20	7.84	7.73	7.62	2.32	2.29
Coliform Organisms, MPN/100 ml	93,462	41,213	39,872	38,408	8,741	8,514

TABLE 4
Concentrations of Modeled Constituents in Waikele Stream for September 1972*

Constituent	Lower End of Reach 1	2	3	4	5	6
Dissolved Oxygen, mg/l	4.27	5.98	5.68	5.39	4.35	4.51
Biochemical Oxygen Demand, mg/l	31.40	16.41	16.04	16.62	3.10	3.05
Coliform Organisms, MPN/100 ml	151,414	71,400	68,302	63,963	7,490	7,178

*Deoxygenation Rate:
K_1 = 0.2 per day (all reaches)
Reaeration Rate:
K_2 = 1.0 per day (reaches 1-5); 0.8 per day (reach 6)
Coliform Dieaway Rate:
K_5 = 0.5 per day (all reaches)

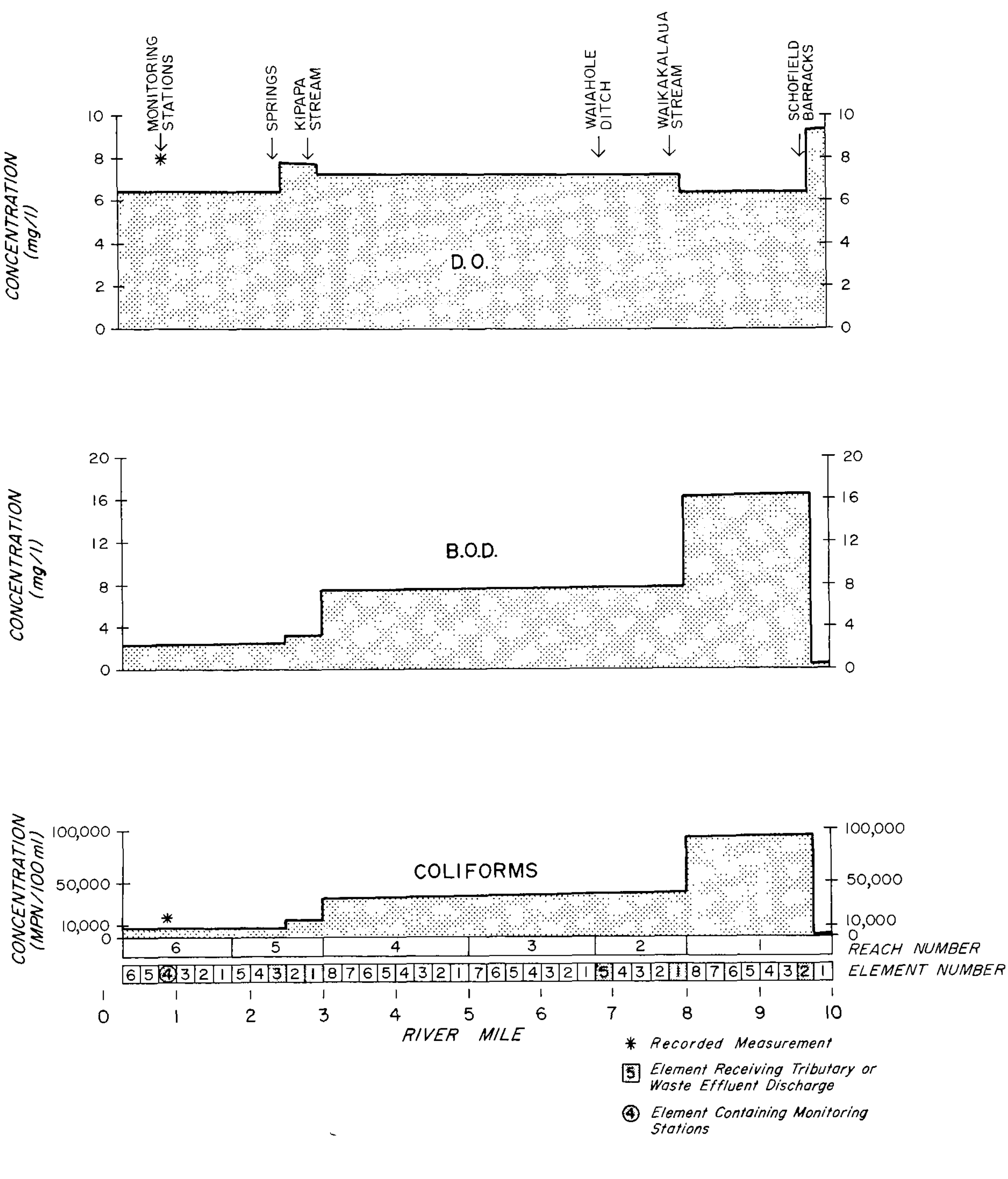


FIGURE 3
WAIKELE STREAM QUALITY PROFILES FOR APRIL 1972

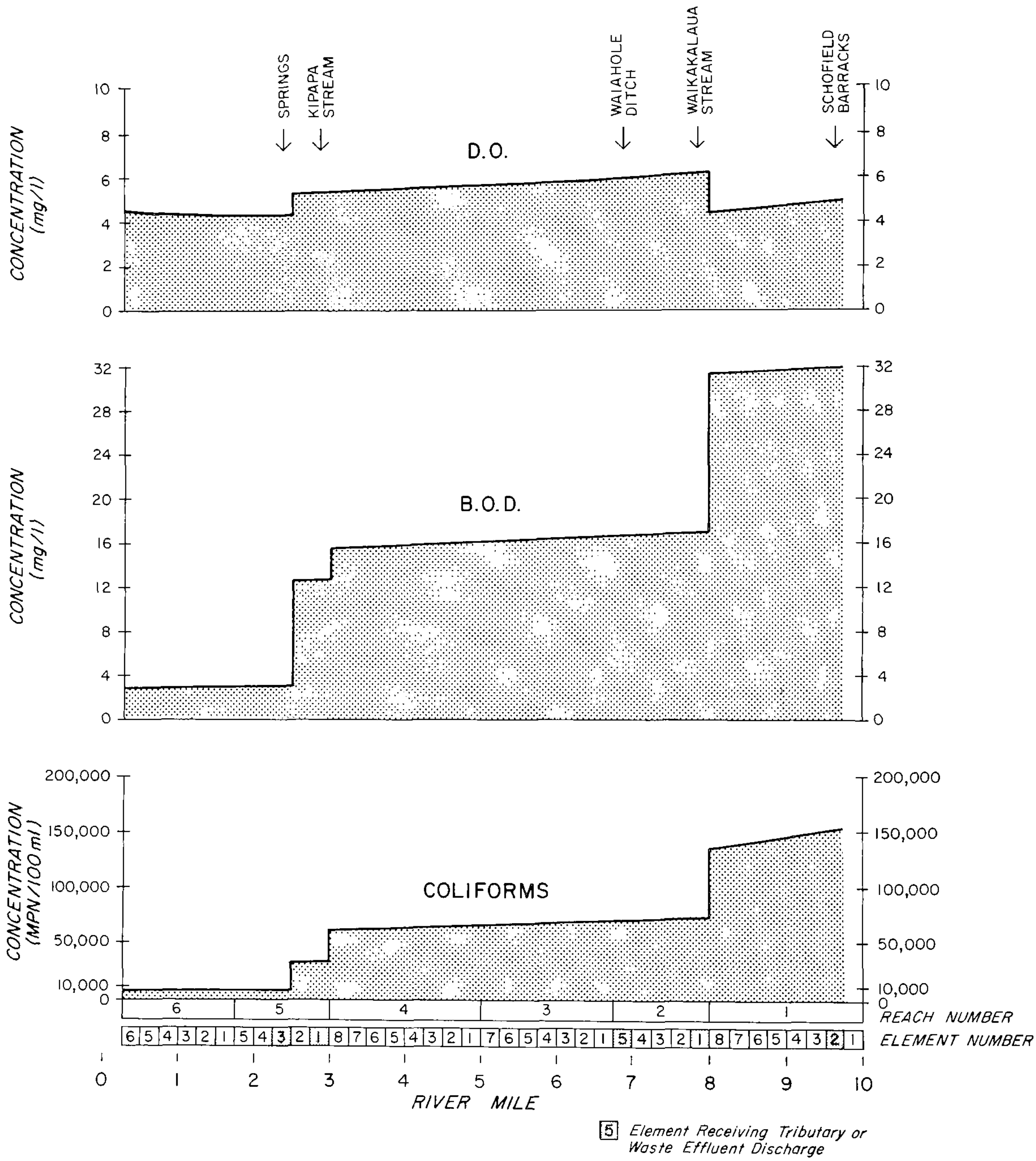


FIGURE 4
WAIKELE STREAM QUALITY PROFILES FOR SEPTEMBER 1972

effluent from Schofield Barracks enters the stream the quality deteriorates markedly. This effluent reduces the dissolved oxygen by 3 mg/l and increases both the BOD and coliforms by 16 mg/l and almost 100,000 MPN/100 ml, respectively.

Beneficial effects are evident from Waikakalaua and Kipapa Streams in reaches 2 and 5. Between the two streams dissolved oxygen is increased by almost 1.5 mg/l, BOD is decreased by about 12.5 mg/l, and the coliform concentration drops by almost 80,000 MPN/100 ml. The springs near the lower end of the stream also decrease BOD and coliforms but have the detrimental effect of decreasing dissolved oxygen by almost 1.5 mg/l based on the assumed input DO concentration of 4.0 mg/l. At the mouth of Waikele Stream the simulated concentrations for dissolved oxygen, BOD, and coliforms were 6.5 mg/l, 2.3 mg/l, and 8,500 MPN/100 ml, respectively,

Unfortunately, these results may not be compared against historical results since only one measurement was taken in April 1972. However, there were several measurements for months other than April at both the USGS gaging station and the U.S. Navy sampling station in Element 4 of Reach 6. The complete record of these measurements is presented in Table 5.

TABLE 5
Water Quality Data for Waikele Stream

Constituent	Date	Samples	Concentration, mg/l or MPN/100 ml Minimum	Maximum	Average
Navy Sampling Station TT01					
Dissolved Oxygen	1/72	8	7.0	8.8	7.6
Dissolved Oxygen	2/72	5	8.0	8.7	8.3
Dissolved Oxygen	3/72	2	7.7	8.9	8.3
Total Coliform	3/72	2	8,700	12,300	10,500
Total Coliform	4/72	1	--	--	19,000
U.S.G.S. Station 2130					
Dissolved Oxygen	6/72	1	--	--	8.0

The measurements presented in Table 5 allow several conclusions to be drawn if they are accepted as indicative of the April 1972 input conditions. First, the model simulated coliforms reasonably well from the known Schofield Barracks effluent concentration to the known value at Element 4 of Reach 6. Second, the modeled dissolved oxygen value at the mouth of the stream does not correspond to the measured values for previous months. Upon examination of the data in Table 1, it is evident that the assumed dissolved oxygen level for the springs (4.0 mg/l) may very well have been too low. Since no data are available for this constituent perhaps further investigation should be made into this very important source, especially given the fairly significant effect that the model simulated. If the input quality is actually close to 8.0 mg/l, or if the spring flow is substantially less than the long-term average flow used herein, then the model results for dissolved oxygen would have been much more accurate. The results are reasonable as it is. Finally, no conclusions regarding validation may be drawn from the BOD results since no measurements were recorded. However, the modeled BOD was consumed in an appropriate fashion downstream, and the model appears to have represented this phenomenon correctly.

September 1972 Validation

A second stream validation was made for the low flow period of September 1972. The quality profiles of Figure 4 demonstrate the effects of the major stream inputs listed in Table 2. Since no headwater flow was assumed for this dry period the simulation begins with the Schofield Barracks effluent. The dissolved oxygen, BOD, and coliform concentrations all decreased appropriately until Waikakalaua Stream joined Waikele Stream. Having essentially the same flow as the Schofield Barracks effluent and being substantially better in quality, the Waikakalaua flow resulted in the beneficial effects of increasing dissolved oxygen by 1.9 mg/l while decreasing BOD and coliforms by 14.8 mg/l and 77,000 MPN/100 ml, respectively.

The Waihole Ditch diversion of approximately two-thirds of the Waikele Stream flow for irrigation purposes had no effect on the constituent concentrations in the stream. Following the diversion, the addition of Kipapa Stream approximately doubled the total flow. In addition, it had little effect on dissolved oxygen since it was added at about the simulated level of 5.4 mg/l. However, both BOD and coliforms were reduced to some extent.

The springs near the mouth of Waikele Stream reduced the dissolved oxygen by 1.0 mg/l and BOD and coliforms to about one-fourth of their previous values. The resultant simulated concentrations at the mouth of Waikele Stream for dissolved oxygen, BOD, and coliforms were 4.5 mg/l, 3.1 mg/l, and 7,200 MPN/100 ml, respectively. Although no measurements were taken during September 1972, the model appears to have simulated the concentrations in a reasonable manner.

Comparing Figures 3 and 4 it is evident that the average dissolved oxygen concentrations are almost 2.0 mg/l less in the low flow month of September. BOD levels are generally double those of April except at the mouth of the stream where they are about equal. Coliform concentrations in September range from equal to double those of April.

It should be noted that QUAL II has been previously validated for a number of streams on which more measurements have been taken [8, 9, 10, 13, 15, 16]. Those results demonstrated the model is a most useful and satisfactorily accurate tool for stream simulations. A network now exits for the Waikele Stream situation and the model is operational for it. It would seem that the model could be used most effectively to guide future planning and data collection efforts for this stream, as well as for other Hawaiian streams.

III. STREAM MODEL SENSITIVITY ANALYSES

GENERAL APPROACH

The purpose of the sensitivity analyses was to demonstrate the effects of varying stream rate constants by significant amounts from those used in the base case to determine the sensitivity of modeled results to the use of specific constants. Eight sensitivity analyses were made for the model by independently varying either the deoxygenation rate constant, reaeration rate constant, coliform dieaway rate constant, or inflow quantities. The baseline simulation values of these four constants were increased by 100 percent or decreased by 50 percent one at a time to produce the eight analyses.

SENSITIVITY ANALYSES RESULTS

Table 6 summarizes the results of the sensitivity analyses for the stream model. The table first presents the April 1972 concentrations for dissolved oxygen, BOD, and coliforms for the downstream element in each of the six stream reaches. The effects on the constituent concentrations of altering the biochemical deoxygenation rate, reaeration rate, coliform dieaway rate, and stream flows are then shown as a positive or negative percentage of the original value.

These results generally demonstrate that the model simulation for Waikele Stream will not vary much with rather large changes in assumptions related to rate constants and input flows. A description of the results is provided below.

An increase in the biochemical deoxygenation rate, K_1, of 100 percent (from 0.2 to 0.4 per day) decreased the dissolved oxygen and BOD concentations by 2.0 to 7.0 percent and 1.4 to 5.2 percent, respectively. Conversely, a decrease of 50 percent in the rate (from 0.2 to 0.1 per day) resulted in 1.1 to 3.6 percent increases in dissolved oxygen and 0.7 to 3.1 percent increases in BOD. Coliforms were not affected by the deoxygenation rate.

An increase in the reaeration rate, K_2, of 100 percent (from 1.0 to 2.0 per day for all but the most downstream reach where the value was increased from 0.8 to 1.6 per day) increased the dissolved oxygen by 1.5 to 2.9 percent. A 50 percent decrease in the rate reduced the dissolved oxygen by 0.8 to 1.8 percent. BOD and coliforms were not affected by the reaeration rate.

TABLE 6
Percentage Effects on Modeled Constituents in Waikele Stream
Caused by Specified Percentage Changes in Several Model Parameters

Reach	Constituent Modeled	April Base Value	Parameter Modified: Deoxygenation K_1		Reaeration K_2		Coliform Decay K_5		Streamflow Q	
			+100	-50	+100	-50	+100	-50	+100	-50
1	DO	6.41	-4.99	+2.65	+2.65	-1.40	0	0	+0.62	-0.60
	BOD	16.20	-1.42	+0.74	0	0	0	0	+0.31	-0.37
	Coliforms	93,462	0	0	0	0	-3.49	+1.80	+0.74	-0.94
2	DO	7.35	-3.40	+1.77	+1.50	-0.82	0	0	+0.41	-0.54
	BOD	7.84	-2.30	+1.15	0	0	0	0	+0.51	-0.64
	Coliforms	41,213	0	0	0	0	-6.12	+3.10	+1.23	-1.58
3	DO	7.26	-5.10	+2.62	+2.20	-1.24	0	0	+0.55	-0.69
	BOD	7.73	-3.49	+1.94	0	0	0	0	+0.78	-0.91
	Coliforms	39,872	0	0	0	0	-8.94	+4.81	+1.96	-2.42
4	DO	7.17	-6.97	+3.63	+2.93	-1.81	0	0	+0.84	-0.98
	BOD	7.62	-4.99	+2.62	0	0	0	0	+1.05	-0.31
	Coliforms	38,408	0	0	0	0	-12.25	+6.78	+2.73	-3.34
5	DO	6.40	-2.03	+1.09	+1.25	-0.78	0	0	+0.15	-0.16
	BOD	2.32	-4.74	+2.16	0	0	0	0	+0.86	-1.29
	Coliforms	8,741	0	0	0	0	-13.59	+7.62	+3.09	-3.75
6	DO	6.46	-2.01	+1.70	+2.63	-1.39	0	0	0	+0.15
	BOD	2.29	-5.24	+3.06	0	0	0	0	+2.18	-1.31
	Coliforms	8,514	0	0	0	0	-15.82	+9.04	+3.69	-4.46

When the coliform dieaway rate constant, K_5, was increased by 100 percent (from 0.5 to 1.0 per day) the coliform concentration decreased by 3.5 to 15.8 percent. A 50 percent decrease in the rate increased the coliform concentrations by 1.8 to 9.0 percent. The percentage effects became more pronounced in both cases as the base concentrations decreased. Dissolved oxygen and BOD were not affected by the changes to the coliform dieaway rate constant.

An increase of all stream inflows by 100 percent resulted in increases of less than one percent for dissolved oxygen and BOD and a maximum of 3.7 percent for coliforms, all essentially negligible changes. A decrease of 50 percent in the flow had a similar negligible effect on the three constituents. One may conclude that the model of Waikele Stream is relatively insensitive to the selection of stream constants and flows.

IV. ESTUARY MODEL VALIDATION

GENERAL APPROACH

The validation of the estuary model followed these five steps:

(1) Major dischargers, tributaries, and monitoring stations were identified.
(2) A network of nodes and channels was developed to represent Pearl Harbor.
(3) Validation periods were selected.
(4) Baseline simulation conditions were established by selecting reaction rates and other model constants.
(5) The baseline simulation was compared with historical measurements and the reaction rates were adjusted until a satisfactory simulation of the prototype was obtained.

Each of these five steps are described in the following sections of this chapter.

ESTUARY INPUTS AND MONITORING STATIONS

Since the Data Report for the Pearl Harbor System of Hawaii [12] presents detailed descriptions of the data gathering phase of the study, a data summary will suffice for the purposes of this report. Major dischargers, tributaries, and monitoring station locations each influenced the locations selected for nodes in the model network. Nodes were required near the dischargers and tributaries for the model to accept waste loads correctly, and they were also necessary near monitoring stations to facilitate validation of the model.

Figure 5 shows the locations of point waste dischargers and major tributaries included in the model simulation. Some stream inputs were not included due to insufficient data. The model network, which is described in the following section of this chapter, is also reproduced in the figure to make evident the nodes at which the tributaries and waste dischargers enter the network. Table 7 presents the inflow quantities and qualities for each of these point waste dischargers for April 1972 conditions.

Water quality and biological samples have been collected by the U.S. Navy's Environmental Protection Data Base Program since at least September 1971. Some 90 to 100 stations have been monitored

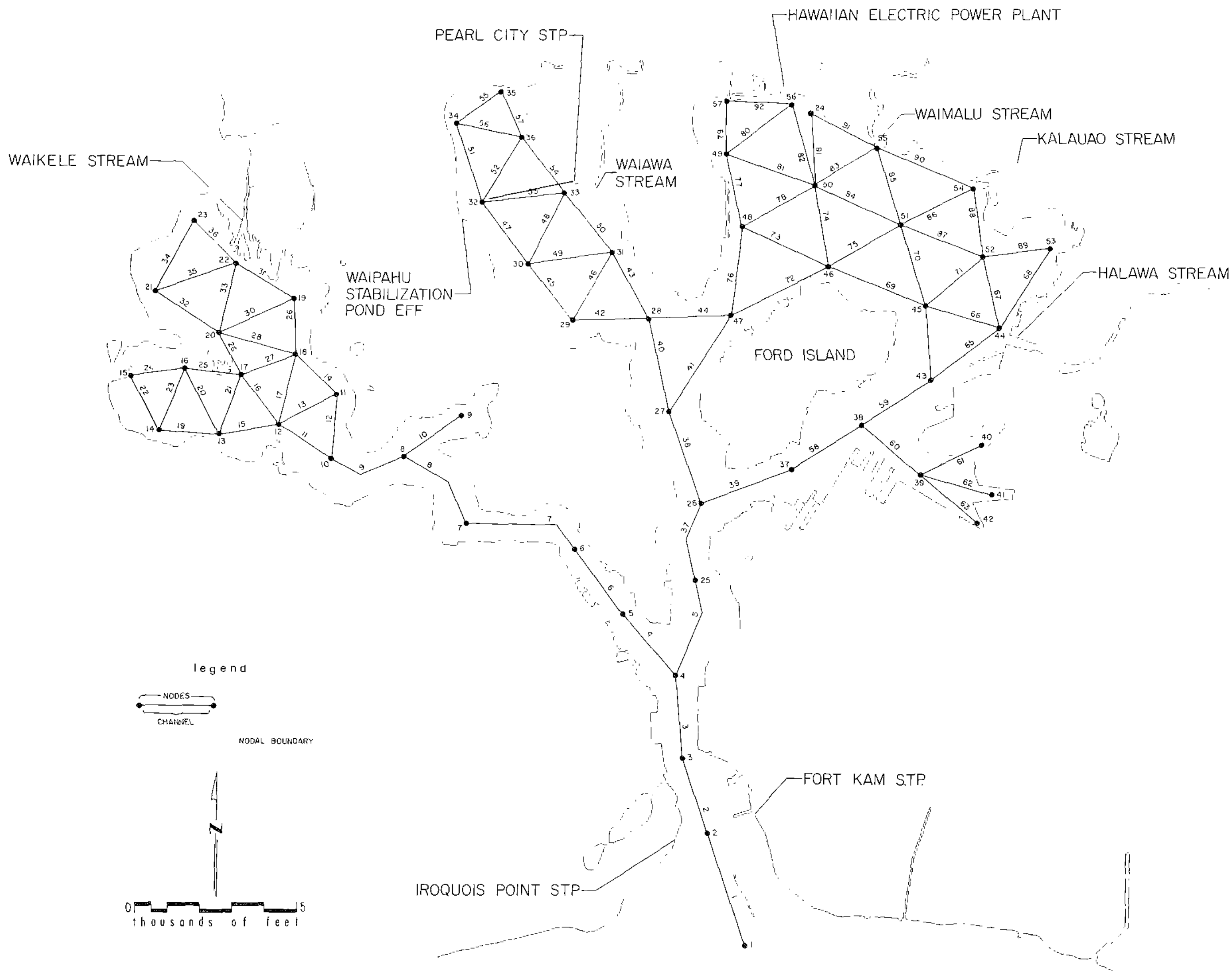


FIGURE 5

MODEL NETWORK AND SIMULATED POINT DISCHARGERS AND TRIBUTARIES TO PEARL HARBOR

TABLE 7
April 1972 Flow and Quality Input Data for Point Waste Discharges and Tributary Streams

Node		Inflow (cfs)	Inflow Quality (mg/l except as noted) Temp (C)	Oxy	BOD	Chlor A	NH3	NO2	NO3	PO4	Colif (MPN)	TDS	TOT N	Heavy Metals 1 & 2		Pesticides 1 & 2	
22	Waikele Stream	77.80	24.2	8.3	.3	.010	1.00	.017	1.20	.60	.19+05	300.	3.00	.10-01	.10-01	.50-02	.50-02
55	Waimalu Stream	7.30	26.0	8.3	.3	.010	1.00	.017	1.20	.01	.11+06	1100.	3.00	.10-01	.10-01	.50-02	.50-02
54	Kalauao Stream	2.60	26.2	9.9	.3	.010	1.00	.011	.79	.09	.22+05	11800.	3.00	.10-01	.10-01	.50-02	.50-02
44	Halawa Stream	9.60	29.3	10.0	.3	.010	1.00	.013	.23	.05	.52+05	900.	3.00	.10-01	.10-01	.50-02	.50-02
33	Waiawa Stream	27.80	24.5	6.0	.2	.010	1.00	.015	.20	.24	.15+06	2000.	3.00	.20+00	.10+00	.50-02	.50-02
32	Waipahu STP	2.39	25.7	.1	93.0	.000	15.00	.000	10.00	28.00	.53+07	830.	30.00	.10-01	.10-01	.10-01	.10-01
32	Pearl City STP	5.00	25.1	2.1	186.0	.000	15.00	.000	10.00	14.00	.18+05	573.	33.00	.10-01	.10-01	.10-01	.10-01
56	Hawaiian Electric Withdrawal	-570.80	.0	.0	.0	.000	.00	.000	.00	.00	.00	0.	.00	.00	.00	.00	.00
24	Hawaiian Electric	570.80	.0	.0	.0	.000	.00	.000	.00	.00	.00	0.	.00	.00	.00	.00	.00
2	Fort Kamehameha STP	6.10	26.0	2.0	15.6	.000	5.00	.000	20.00	15.00	.50+03	500.	30.00	.10-01	.10-01	.10-01	.10-01
2	Iroquois Point STP	.59	26.6	1.0	125.0	.000	15.00	.000	10.00	10.00	.50+04	500.	30.00	.10-01	.10-01	.10-01	.10-01
38	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
39	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
40	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
42	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
43	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
45	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
50	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00
51	Navy Ships (approximated)	.02	27.0	5.0	200.0	.000	50.00	.000	.00	20.00	.30+09	350.	70.00	.10-01	.10-01	.00	.00

within Pearl Harbor in addition to stations near the mouths of major tributaries. Figure 6 illustrates the water quality stations, and Figure 7 shows the biological and tributary stations. These stations provide data for the estuary model validation process. The actual data available at each station are referenced in the Data Report [12].

ESTUARY MODEL NETWORK

The network of nodes and channels for the Pearl Harbor system, including the West, Middle, and East Lochs, was constructed using the following guidelines:

(1) Nodes were located where:
  (a) a major tributary or waste discharge enters the harbor,
  (b) a water quality monitoring station exists,
  (c) a significant change in harbor geometry occurs, or
  (d) no particularly significant event occurs, but a node is needed within a reasonable travel time or distance from adjacent nodes.

(2) Channels, or "links", were formed almost automatically as interconnections between or among nodes.

The resulting model network consisting of 57 nodes and 92 channels has been shown in Figure 5. The correspondence between nodes and point dischargers is given in Table 7 while that between nodes and monitoring stations has been presented in the Data Report.

The nodes are associated with a surface area, volume, and depth of water at mean tide. Channels are defined by a length, width, cross-sectional area, and depth at mean tide at their midpoints. During a model execution, masses of water as well as quality and biological constituents are mathematically moved along channels from node to node until equilibrium occurs. The complete description of mathematical computations is contained in the Documentation Report [14], a further product of this study.

VALIDATION PERIODS

The calendar year 1972 was selected as the validation period since the majority of useful data was collected by the U.S. Navy at that time. Baseline simulations of Pearl Harbor were made for April and

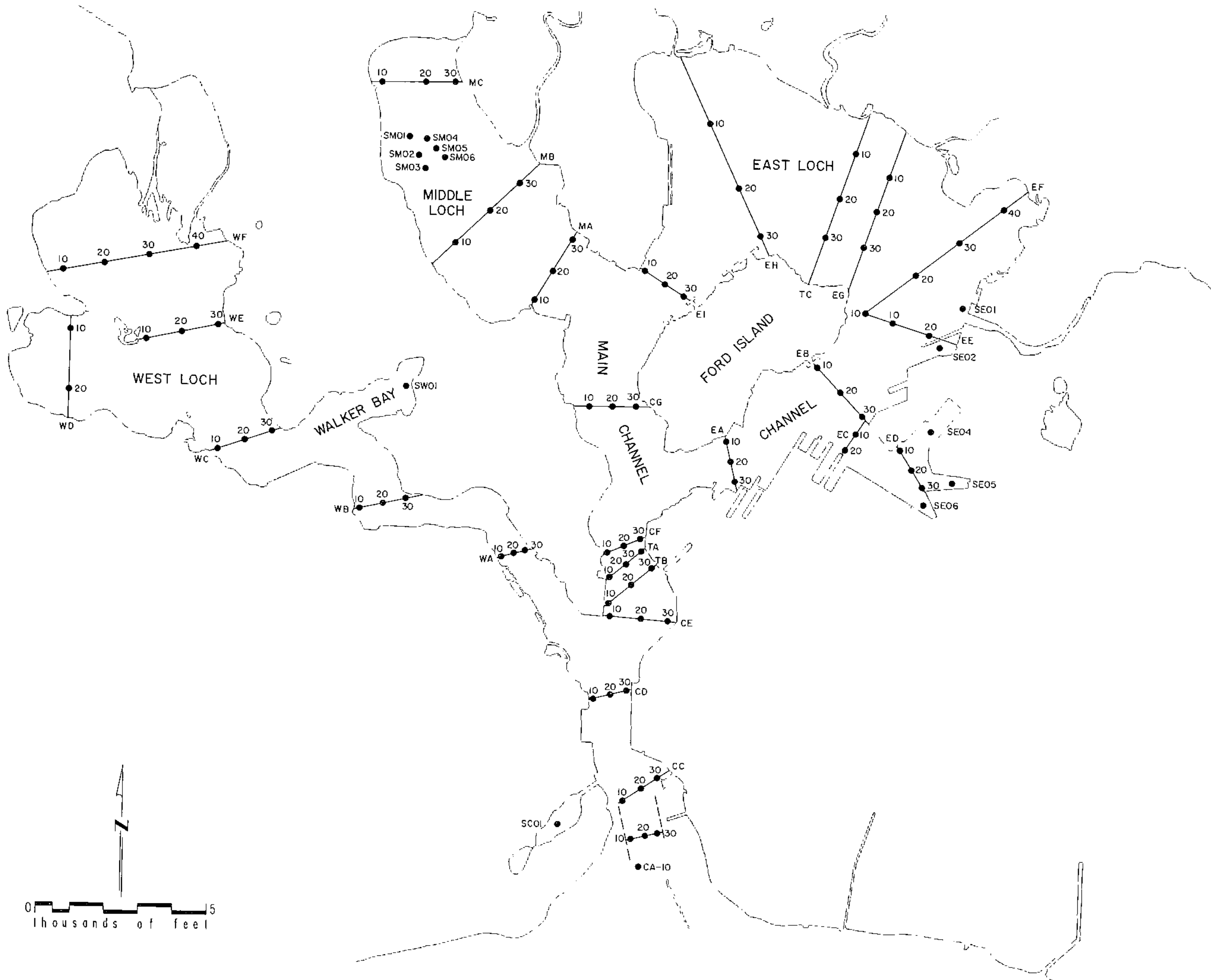


FIGURE 6
U. S. NAVY SAMPLING STATIONS FOR WATER QUALITY IN PEARL HARBOR

FIGURE 7
BIOLOGICAL AND TRIBUTARY SAMPLING STATIONS IN PEARL HARBOR

September 1972 conditions, permitting examination of the effects of wet and dry months and varying meteorologic seasons. The April simulation represents the average conditions for April 1972, a wet month with relatively high winds. The September simulation corresponds to a dry month with winds lower than those in April.

The complete results for the thirtieth day of each period are presented in Appendix C. The results for April are described in some detail in the remainder of this chapter.

BASELINE SIMULATION

The baseline simulation for the estuary model was taken as the April 1972 validation case. All sensitivity analyses were compared against the April simulation and are described in Chapter V. The results for the following constituents are listed in Appendix C:

Temperature
Dissolved Oxygen
Carbonaceous BOD
Chlorophyll a
Ammonia Nitrogen
Nitrite Nitrogen
Nitrate Nitrogen
Phosphate Phosphorus
Coliform Bacteria
Salinity
Total Nitrogen
Heavy Metal No. 1
Heavy Metal No. 2
Pesticide No. 1
Pesticide No. 2

All results in Appendix C represent the constituent levels at the fourteenth hour of the thirtieth day. It should be noted that the dynamic equilibrium conditions had not been attained at that time, and were not to be, since a 24 hour solar cycle and a 24 1/2 hour tidal cycle operated together cause inherent disequilibria that can never be overcome. Although many results tend to be reproduced from the twenty-ninth day to the thirtieth, the equilibrium condition was never quite obtained. Figure 8 illustrates the simulation of salinity and dissolved oxygen at several nodes over the 30-day period.

The reaction rates and other model constants used to obtain the final results are presented in Appendix D. Several of these coefficients were modified in the sensitivity analyses, as discussed in Chapter V. Those coefficients modified included the biological

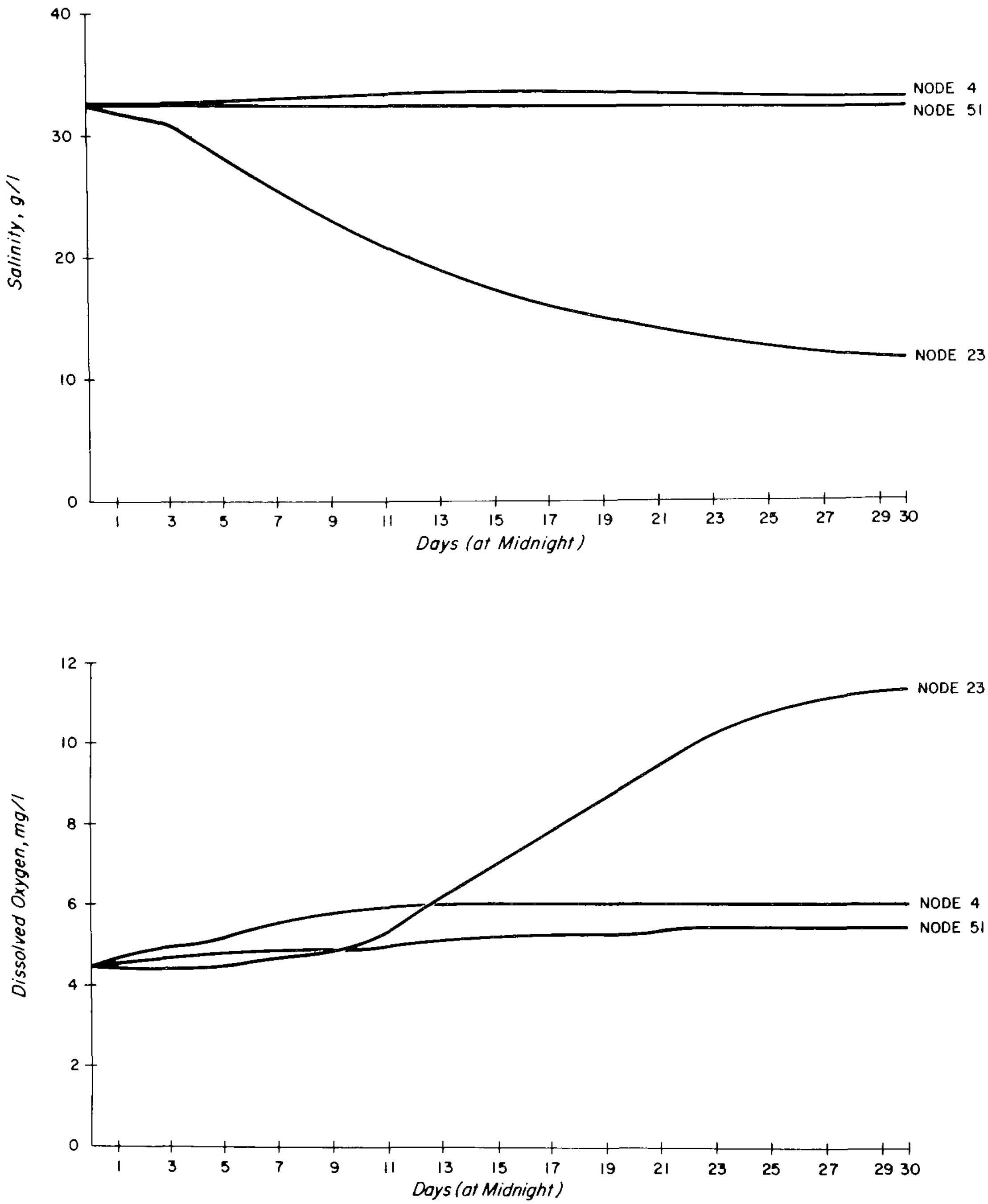


FIGURE 8
SIMULATED SALINITY AND DISSOLVED OXYGEN CONCENTRATIONS AT SEVERAL NODES FOR A 30-DAY PERIOD

deoxygenation rate, reaeration rate, coliform dieaway rate, quality time step, Manning's roughness coefficient, and the tributary stream inflows. A modeling problem resulted with the reaeration rate selection and is discussed in the remainder of this section.

At one point it was believed that the estuary model was as close to being validated as it was likely to get. There was a disturbing problem, however, with very low dissolved oxygen levels (0-4 mg/l) over much of the harbor and quite high values (up to 1.5 times saturation) at several nodes.

This was a manifestation of the problems, once again, of selecting a proper value for the reaeration rate, K_2. In the estuary model K_2 was computed for each junction from the expression

$$K_2 = \frac{(D_M V)^{0.5}}{D^{1.5}} X\ 86,400 \qquad (5)$$

where

K_2	=	reaeration coefficient, per day;
D_M	=	molecular diffusion coefficient ($2.25 X 10^{-8}$) ft /sec;
V	=	velocity in the channel(s) entering each junction, ft/sec;
D	=	depth of the junction, ft;
86,400	=	number of seconds per day.

Removing both constants leaves

$$K_2 = 13 \frac{V^{0.5}}{D^{1.5}} \qquad (6)$$

The velocities and depths of the channels entering each junction give values for K_2 that range roughly from 0.04 to 0.1 per day. This value is used in an expression for the change in oxygen concentration during each time step:

$$\frac{\Delta C}{\Delta t} = K_2 (C_s - C) \qquad (7)$$

where

ΔC = change in oxygen concentration due to reaeration, mg/l;

Δt = time, days;

K_2 = reaeration coefficient per day;

C_s = saturation concentration of oxygen (temperature and salinity dependent), mg/l;

C = concentration of oxygen at the last time step, mg/l.

It can be seen that a low value of K_2 will allow only a small amount of oxygen to be added to a junction by reaeration during a time step. When supersaturation occurs caused by algal photosynthesis, a low value of K_2 will not allow much oxygen to escape to the atmosphere (i.e., when C_s-C is negative). Consequently, in the model, where BOD is present in the water, the dissolved oxygen will get lower and lower, because reaeration cannot keep up with bacterial deoxygenation. But at the same time where algae are growing rapidly (particularly in shallow, quiet areas of the harbor such as upper West Loch) the oxygen produced by photosynthesis will build up to supersaturation conditions which cannot be relieved by escape to the atmosphere. The result is low dissolved oxygen where BOD persists and algae do not proliferate, and high dissolved oxygen where conditions are ideal for algal growth.

The solution to this set of problems is not straightforward, and indeed may not exist. The crux of this problem is not with the algebraic expression for K_2 ; it lies in the fact that we are attempting to model a three-dimensional state of affairs with a quasi-two-dimensional model. Pearl Harbor is stratified much of the year in the vertical. Data indicate that while all the harbor was not stratified in April 1972, much of it was [1]. Data also show that the average dissolved oxygen level in the water less than 5 feet from the surface was between 5 and 7 mg/l, while water at depth averaged 1-4 mg/l.

The model assumes, regardless of the value of K_2 or how it is estimated, that oxygen enters or leaves the entire water column in each time step depending on the sign of $C_s - C$. Indeed it assumes that the water is fully mixed in the vertical for all purposes with the exception that algae "grow" only in the zone where significant light penetrates, but then the algae so grown are mixed throughout the entire junction volume.

The only alternative worthy of consideration was to try other values of K_2 arbitrarily to attempt to find a value that would yield oxygen levels between those measured at the surface and those measured at depth. The four values tried were: 1) a calculated K_2, 2) an assigned value of 1.0 for all junctions, 3) 0.2, and 4) 0.1. The results indicate that when K_2 was calculated (the lowest values used), the oxygen levels approximated what has been found to occur in the lower layer of the harbor (0-4 mg/l). When K_2 was set equal to 1.0, the harbor became very nearly saturated throughout, regardless of algae, BOD, or other influences. The value of $K_2 = 0.1$ yielded dissolved oxygen values about midway between measured values at the surface and at depth, with the exception of the upper West Loch junctions which become and remained supersaturated. Therefore, the value of $K_2 = 0.1$ was used in the baseline simulation.

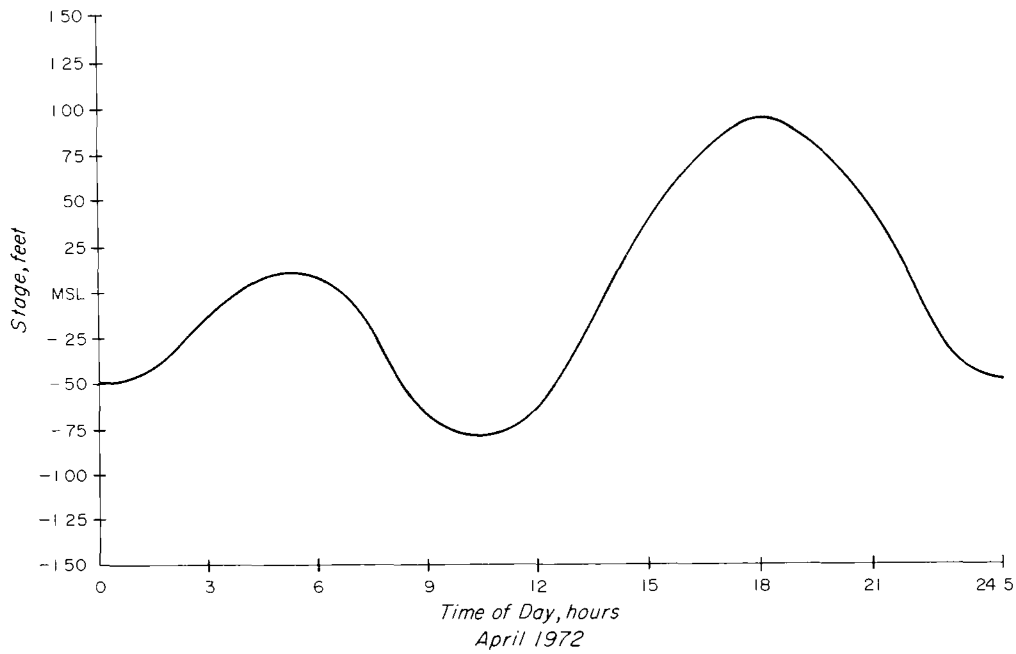
VALIDATION RESULTS

As stated in the contract's description of the Dynamic Estuary Model, it is applicable "to any estuary wherein vertical stratification is either absent or is limited to relatively small areas within the estuary." Although conditions in Pearl Harbor do not fit this description, WRE was able to obtain very reasonable results which demonstrated that even in the stratified condition the model is capable of producing results that may be viewed as the average representation of quality factors between the upper and lower layers (where they exist). Model results should prove especially useful in identifying the total net effects of waste discharges on the quality of Pearl Harbor. The model should also be directly applicable to other, nonstratified estuaries.

Hydraulics

Since the hydraulics subprogram of the estuary model has previously been validated for San Francisco and San Diego Bays [3, 6, 7], no attempt was made to validate the hydraulics, especially in light of the lack of sufficient head and current data. However, all heads and currents were checked for reasonableness against the data that were available [1, 4].

The hydraulic solution is driven by the tides imposed on the system at the seaward node, the mouth of the harbor. For the model simulations, average tides were applied for the months of April and September 1972. That is, in each month the daily higher-high, lower-high, higher-low and lower-low tides were averaged and fit statistically to a six term sine-cosine function to represent an "average" condition for the month. These tides are shown in Figure 9. The range of tidal amplitudes in April was 1.7 feet with a mean of -0.055 feet. In September the range was 1.8 feet with a mean of 0.179 feet. Hydraulic results for April and September 1972, are provided in Appendix E.



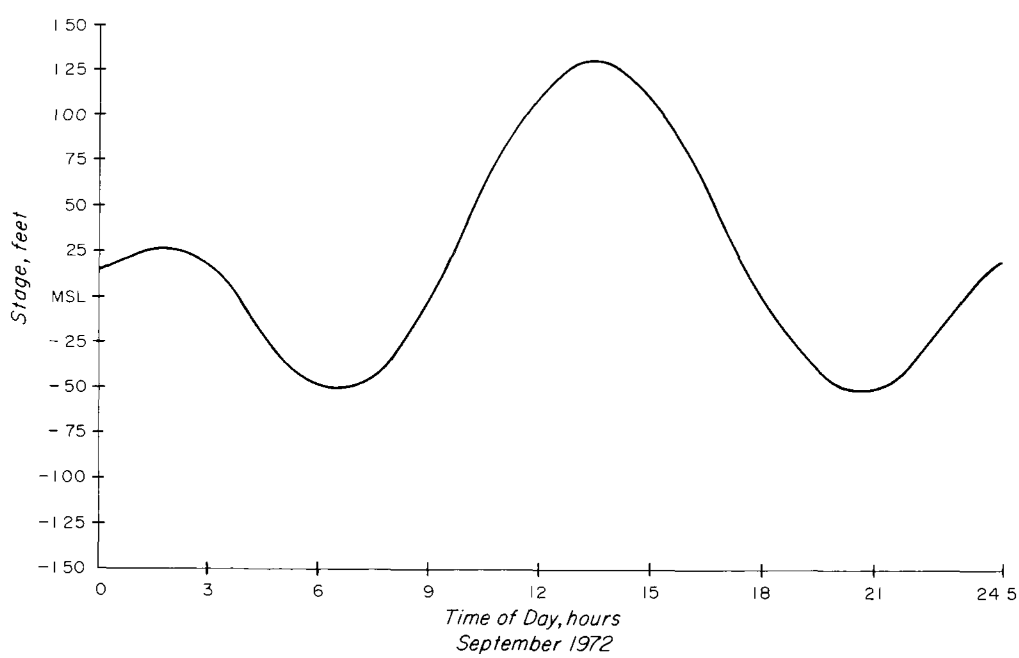


FIGURE 9
AVERAGE TIDES FOR APRIL AND SEPTEMBER 1972

Quality

Although certain features of the quality submodel have also been previously validated for San Francisco and San Diego Bays and the Columbia River [2, 3, 6, 7], significant additions have been made in this project. The baseline simulation output correspondence to measured Navy data are presented in this section. Direct comparisons should be avoided due to the previous caveat concerning stratified estuaries. Reasonableness should be expected, however.

Results for the April 1972 baseline simulation are presented in Figures 10, 11, 12 and 13. Each figure illustrates the measured and simulated quality levels for four constituents along one of five profiles, one from the harbor mouth up each of the three main lochs, a fourth north of Ford Island, and a fifth into the Southeast Loch. Figure 5 should be used in conjunction with these figures to determine the paths plotted. The four constituents shown on the figures are temperature, salinity, dissolved oxygen, and phosphorus.

The Navy data were recorded in two groups for each month: those measurements at less than five feet and those at greater than five feet. Ranges of values are plotted for each group since measurements were taken at different days, times, and depths. All values were obtained in April 1972 except as noted on the figures. Exceptions were used where a lack of data existed for April 1972. Values shown in these cases generally represent measurements for March or May 1972.

As shown in Figures 10 to 13, simulated qualities are generally bracketed by the measured ranges. Major discrepancies are explained later in this section in a discussion of results for each loch.

Although some Navy data for coliforms exist, the data are highly variable and seemingly related to coliform sources that were not modeled in this study. The modeled results correlate well with measured values near major dischargers, such as the Pearl City and Fort Kamehameha sewage treatment plants, but are generally low elsewhere. This may be attributed to any or all of three factors: 1) unidentified point source discharges, 2) unidentified nonpoint source discharges, and 3) possible phenomena, such as regrowth of coliforms in the bottom muds, that were not modeled.

The Navy sampling program was not very comprehensive for constituents such as chlorophyll _a_ and the nitrogen forms, and therefore, extensive comparisons were not possible. Complete model results for all constituents are presented in Appendix C, however. The discussions that follow relate to dissolved oxygen, salinity, temperature, and phosphorus in each loch.

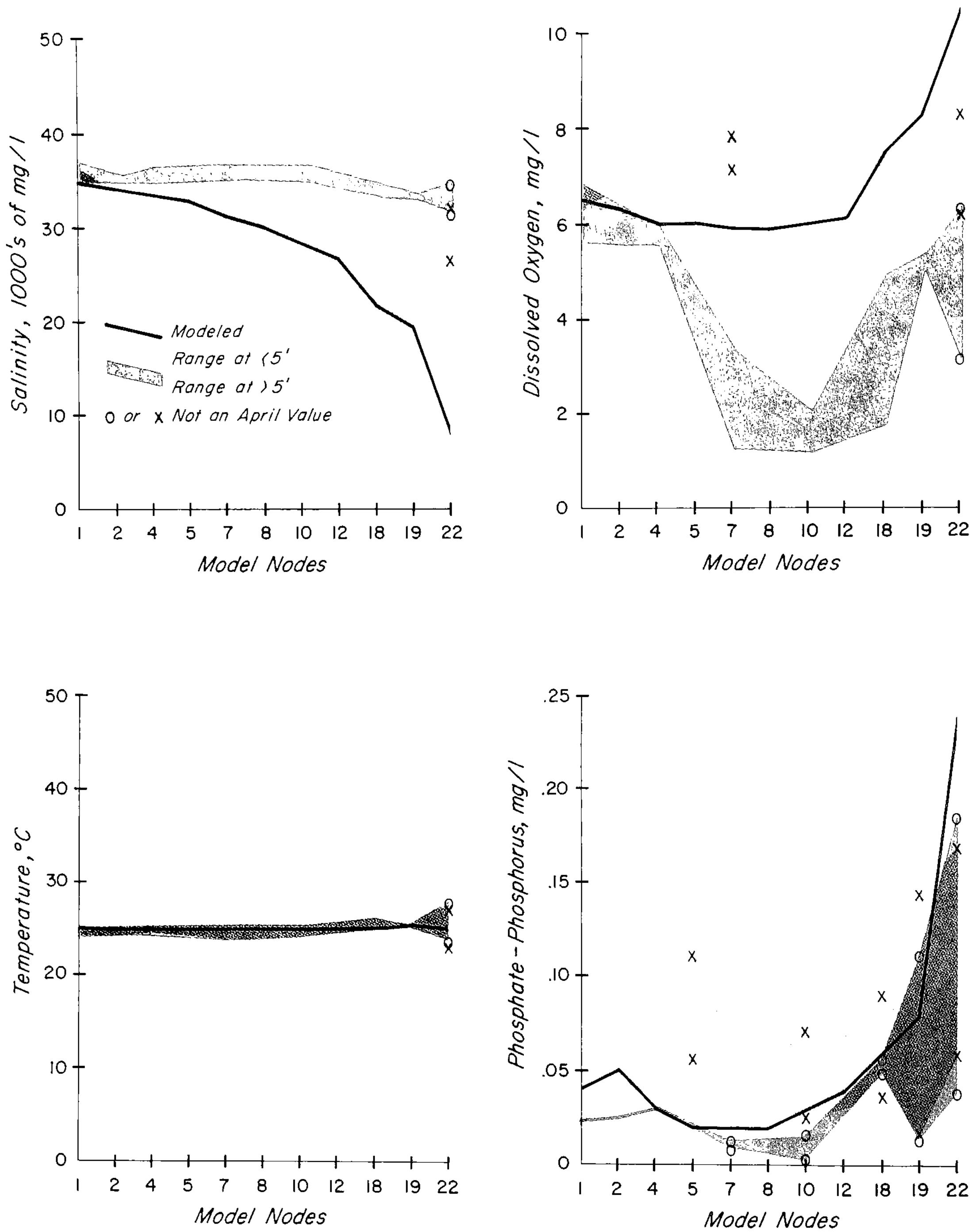


FIGURE 10
WEST LOCH VALIDATION RESULTS FOR APRIL 1972

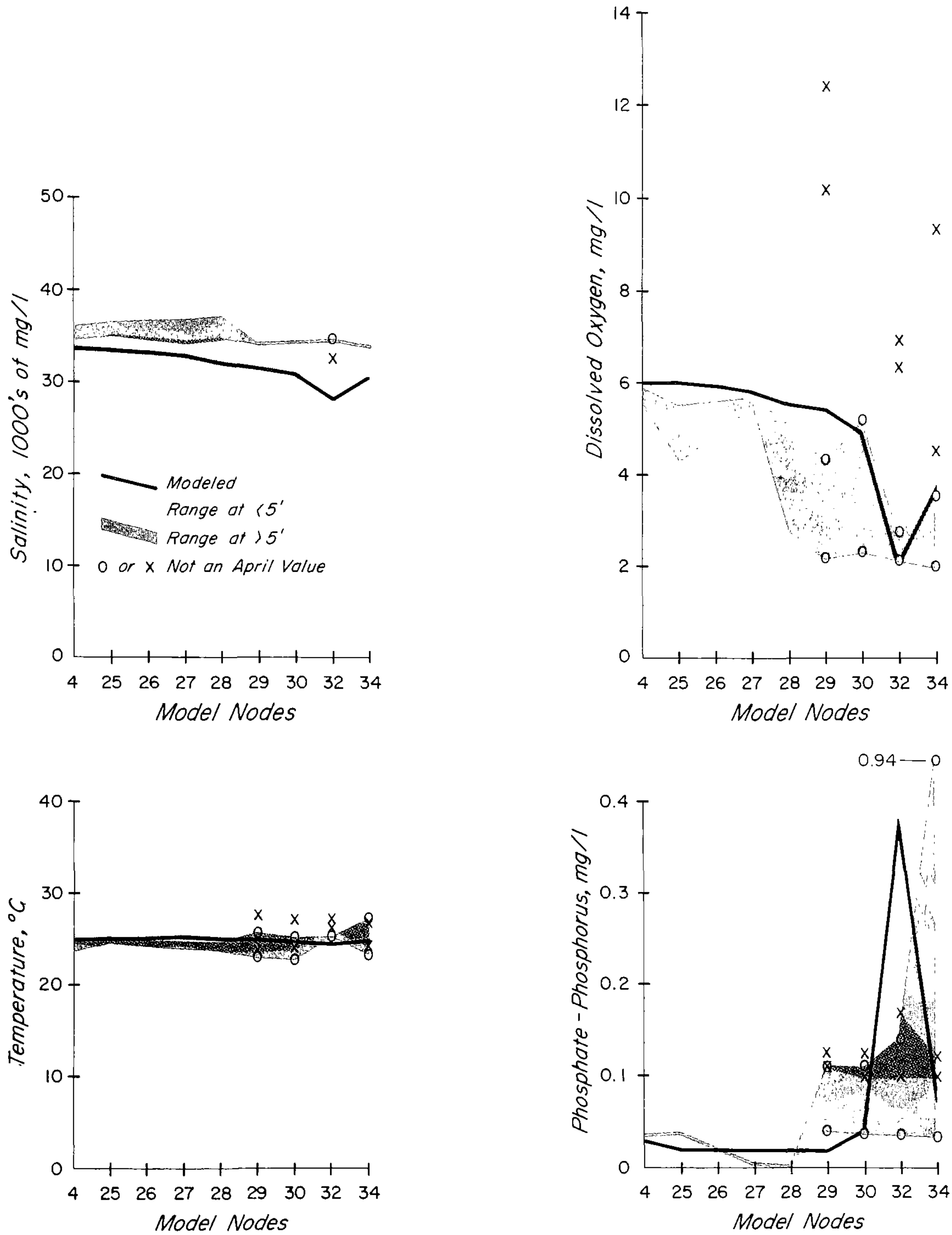


FIGURE 11
MIDDLE LOCH VALIDATION RESULTS FOR APRIL 1972

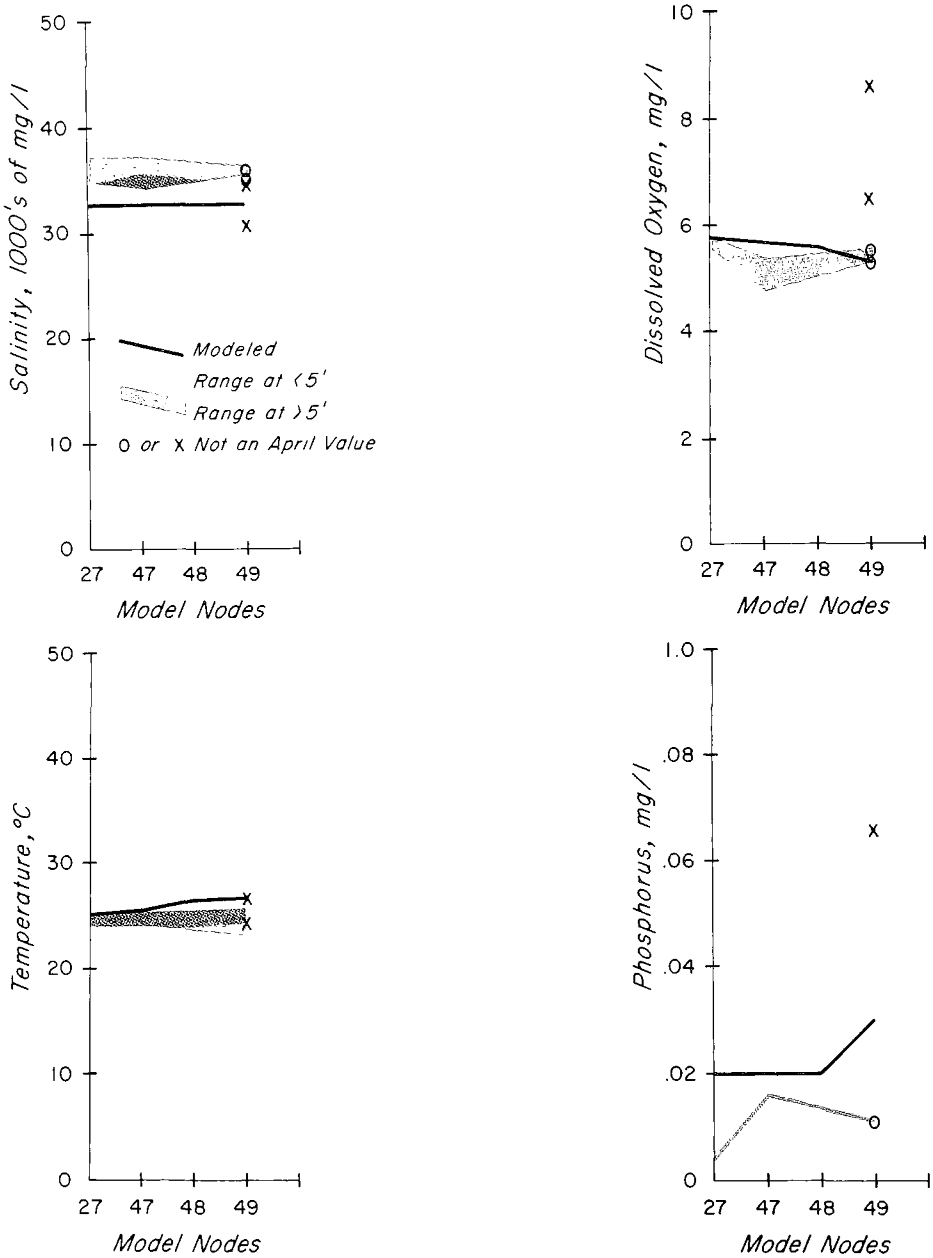


FIGURE 12
UPPER EAST LOCH VALIDATION RESULTS FOR APRIL 1972

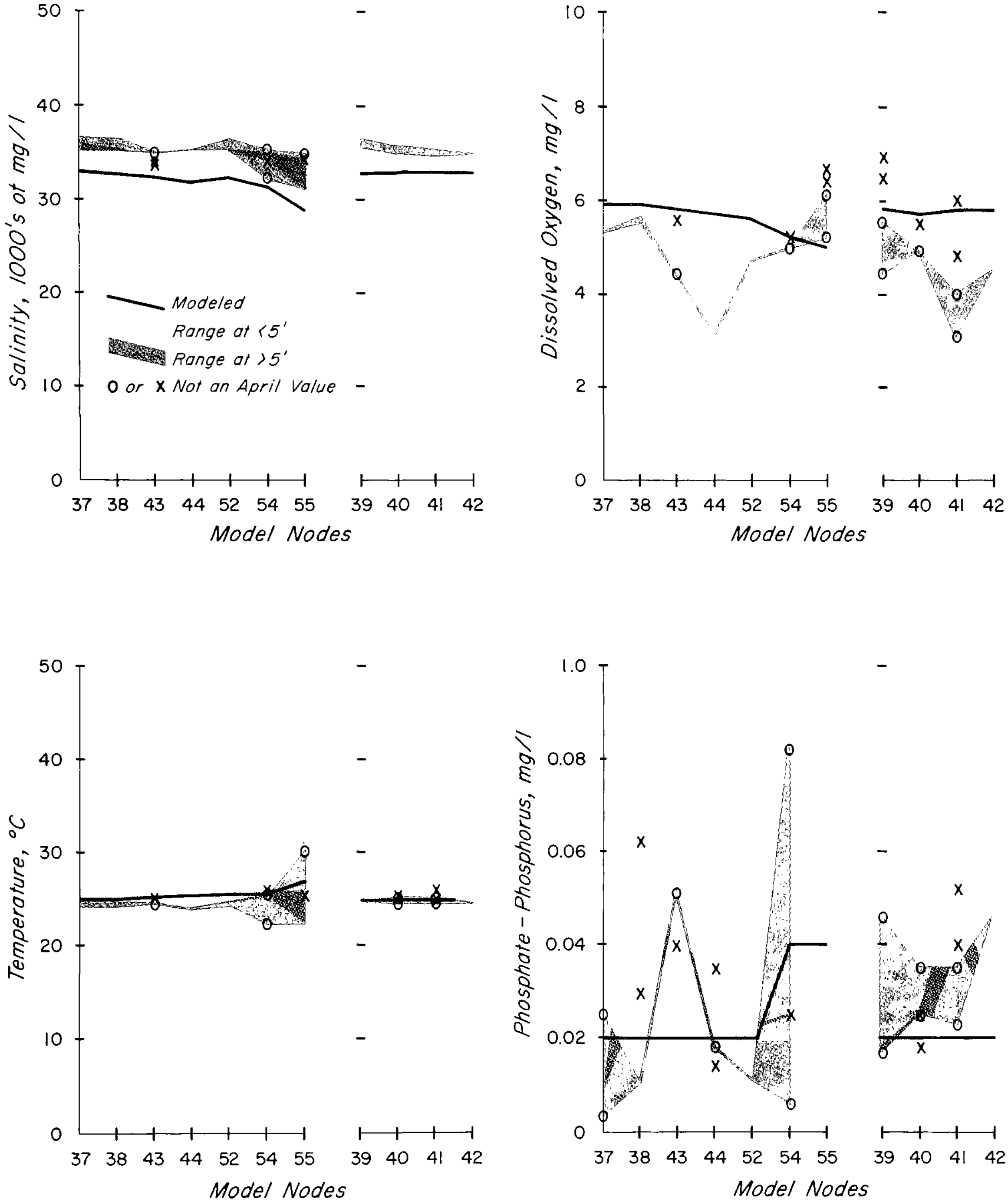


FIGURE 13
EAST AND SOUTHEAST LOCH VALIDATION RESULTS FOR APRIL 1972

West Loch

Dissolved Oxygen. As shown in Figure 10 the model simulation of dissolved oxygen corresponds to a value somewhere between the measurements at 5 feet and the bottom except at node 22 near the mouth of Waikele Stream. This area becomes supersaturated in the model due to the existence of ideal conditions for algal growth in the upper loch. These conditions include shallow, relatively stagnant water with an abundant supply of nitrate nitrogen and phosphorus. The reader is referred to the previous discussion of the model simulation of dissolved oxygen under these same conditions in the Baseline Simulation section of this chapter.

Salinity. Accurate results were again obtained for the salinity simulation. However, at node 22 the results were suspect and, unfortunately. no measurements had been taken in April. Upon examination of the input data it was apparent that the freshwater inflow originally prepared for Waikele Stream (77.8 cfs) as an average of the measured daily flows for April 1972 was biased on the high flow side, since most of the flow had occurred on four days of extremely high runoff. When a further simulation was made using a median of the daily flows for Waikele Stream (40.0 cfs) the modeled salinity at node 22 increased to the more realistic value of 17,000 mg/l.

Temperature. As illustrated in Figure 10 the temperature simulation is well within the range of mesured values at all nodes.

Phosphorus. From Figure 10 it is apparent that the model has simulated the phosphorus levels quite well. The peak value at the mouth of Waikele Stream (node 22) appears high even though no measurements were taken in April 1972. By reducing the stream inflow to 40.0 cfs (as discussed in the salinity section) the phosphorus level dropped to the more reasonable value of 0.13 mg/l. This is within the range indicated on the figure.

Middle Loch

In an attempt to understand the slightly anomalous behavior of temperature at node 32, WRE discovered that different tributary inflows at node 32 were used in the hydraulics and quality model runs. The hydraulics model used an inflow of 14.7 cfs rather than the more accurate 7.39 cfs of inflow used in the quality model. This discrepancy affected node 32 to the greatest extent and the adjacent nodes to a lesser degree. Specific effects are noted in the following descriptions.

Dissolved Oxygen. All simulated values of dissolved oxygen were contained within the range of measured values, as shown on Figure 11. It might be observed that the simulated level of 2.0 mg/l at node 32, opposite the Pearl City and Waipahu sewage treatment plants, was the lowest value at any node in the system. This value might have been slightly higher without the inflow discrepancy.

Salinity. The correlation of simulated salinity with measured values was accurate except in the vicintiy of nodes 32 and 34. Although no measurements were recorded in April 1972 for node 32 the simulated level is low due to the discrepant 7.3 cfs of inflow added at node 32 with a concentration of 0 mg/l. The simulated salinity at node 34 was also reduced by this error, as shown by Figure 11.

Temperature. All simulated values of temperature were contained within the range of measured values for April 1972. Although no April measurements were recorded at node 32, the anomalous decrease in temperature at node 32 in the presence of relatively high temperature inflows prompted the discovery of the additional inflow problem. In this case, an additional 7.3 cfs of inflow with a temperature of 0 degrees centigrade was essentially added at node 32, thereby reducing the simulated temperature by about 0.5 degrees centigrade.

Phosphorus. Although few of the simulated phosphorus levels for the Middle Loch were within the range of measurements, all are relatively close and demonstrate the general trend toward the high peak in the vicinity of nodes 32 and 34. The discrepant inflow problem at node 32 had the effect of diluting the phosphorus inflow concentration by half. Therefore, the simulated phosphorus levels shown on Figure 11 would tend to be higher without the additional 7.3 cfs inflow at a concentration of 0 mg/l phosphorus.

East Loch

Figures 12 and 13 illustrate three major areas of the East Loch: a path to the north of Ford Island, one to the south and east of Ford Island, and a third into the Southeast Loch.

Dissolved Oxygen. The dissolved oxygen correspondence to measured values is accurate in all cases except at node 42. Apparently a greater waste load should have been included in the input data approximation of waste load contributions.

Salinity. For the path from the mouth of the harbor up through the channel north of Ford Island and into the East Loch all simulated values of salinity were within the measured range. However, south of Ford Island the model simulation tended to be lower than actual measurements. Several factors were responsible for this condition. First, the range of measurements at nodes 43, 44, and 52 is extremely narrow compared to other locations. Second, the measurements are very high relative to the exchange concentration at node 1. And third, since evaporation for the purpose of concentrating dissolved salts is not included in the model, the maximum possible modeled value is the exchange concentration at node 1; namely, 35.6 g/l. Therefore, when the streams are added as freshwater inflows to the lochs the salinity concentrations naturally dropped below the maximum level.

Temperature. The temperature correlation was completely within the range for the path north of Ford Island. However, the path south of the island reflected an irregularity near Halawa Stream. Whereas the measured values at the mouth of the stream were on the order of 24 degrees centigrade, the modeled temperature remained high, reflecting the relatively high stream input data temperature of 29.3 degrees centigrade. Values at all other nodes were within the desired range.

Phosphorus. North of Ford Island the phosphorus correspondence was excellent. South of the island the correlation appears reasonable but comparisons are somewhat difficult due to insufficient data measurement for April 1972.

V. ESTUARY MODEL SENSITIVITY ANALYSES

GENERAL APPROACH

The purpose of the sensitivity analyses was to demonstrate the effects of varying several model rate coefficients and freshwater inflows by significant amounts from those used in the baseline simulation. Fifteen sensitivity analyses were made for the estuary model by varying one of the following:

1) Deoxygenation rate, K_1,
2) Reaeration rate, K_2,
3) Coliform dieaway rate, K_5,
4) Quality time step,
5) Manning's roughness coefficient, or
6) Freshwater inflow quantities.

The specific list of computer runs and parameters varied is given in Table 8. All changes were made independent of one another (except for the deoxygenation rate and coliform dieaway rate constants, which do not affect one another, and hence could be varied within a single analysis merely to save computer time).

Complete results for all sensitivity variations in Table 8 are presented in Appendix F. Effects of variations on the model simulations for dissolved oxygen, temperature, salinity, phosphate, chlorophyll a, nitrate nitrogen, and coliforms are described in this section.

SENSITIVITY ANALYSES RESULTS

Dissolved Oxygen

Table 9 gives a summary of the percentage effects on dissolved oxygen caused by changes in the deoxygenation rate, reaeration rate, stream flows, Manning's roughness coefficient, and the quality model time step. A variety of nodes in each loch are included in the analysis and the base value represents the dissolved oxygen level from the April 1972 baseline simulation.

Deoxygenation Rate

Changes to the original deoxygenation rate (K_1 = 0.1 per day) of plus 100 percent and minus 50 percent generally had very little effect on dissolved oxygen levels. In fact, the changes were always less than 3 percent except at node 32 where a signficant change, on the

TABLE 8
Estuary Model Runs

No.	Month/Year	Parameter(s) Varied	Parameter Value	Submodel
Validation Runs				
1	April 1972	None Base Case	K1 = 0.1 K2 = 0.1 K5 = 0.5 Time Step = 1/2 hr. n = 0.018 to 0.030 Inflow = See Table 7	H & Q*
2	Sept. 1972	None	Same as April except for Stream Inflow	H & Q
Sensitivity Runs				
1	April 1972	Reaeration Rate	K2 = 0.2	Quality
2	April 1972	Reaeration Rate	K2 = 1.0	Quality
3	April 1972	Reaeration Rate	K2: See Eq. 5	Quality
4	April 1972	Deoxygenation and Coliform dieaway rates	K1 = 0.2 and K5 = 1.0	Quality
5	April 1972	Deoxygenation and Coliform dieaway rates	K1 - 0.05 and K5 = 0.25	Quality
6	April 1972	Quality Time Step	T = 1/4 hr.	Hydraulics
7	April 1972	Quality Time Step	T = 1/4 hr.	Quality
8	April 1972	Manning's 'n'	n = 0.8 x Base	Hydraulics
9	April 1972	Manning's 'n'	n = 0.8 x Base	Quality
10	April 1972	Manning's 'n'	n = 1.2 x Base	Hydraulics
11	April 1972	Manning's 'n'	n = 1.2 x Base	Quality
12	April 1972	Stream Flow	Q = 2.0 x Base	Hydraulics
13	April 1972	Stream Flow	Q = 2.0 x Base	Quality
14	April 1972	Stream Flow	Q = 0.5 x Base	Hydraulics
15	April 1972	Stream Flow	Q = 0.5 x Base	Quality

*H Hydraulics Model
Q Quality Model

TABLE 9
Percentage Effects on Dissolved Oxygen in Pearl Harbor Caused by Specified Changes in Several Model Parameters

Area	Node	Base DO Value, mg/l	Reaeration, K_2 (Base=0.1 day^{-1})			Deoxygenation, K_1 (Base=0.1 day^{-1})		Stream Inflows, Q		Manning's 'n'		Quality Model Time Step (1/2 hr.)
			10.0*Base	2.0*Base	Calc.[a]	2.0*Base	0.5*Base	2.0*Base	0.5*Base	1.20*Base	0.8*Base	0.5*Base
West Loch	7	5.9	+16.9	+10.2	-47.4	0	0	+6.8	-1.7	0	0	0
	12	6.1	+16.4	+9.8	-36.1	+1.6	0	+32.8	-11.5	+1.6	0	0
	15	4.1	+65.8	+31.7	-2.4	0	-2.4	+63.4	-22.0	+2.4	+2.4	+2.4
	17	6.6	+10.6	+7.6	-25.8	0	0	+42.4	-18.2	+3.0	+1.5	+1.5
	22	10.5	-14.3	-3.8	-0.1	0	+0.1	+2.9	-21.9	+0.9	0	0
	23	11.7	-23.9	-6.8	+0.1	0	0	+5.1	-24.8	0	0	0
Middle Loch	25	6.0	+13.3	+6.7	-45.0	0	0	0	0	0	0	0
	28	5.5	+23.6	+14.5	-70.1	+1.8	0	+1.8	+1.8	+1.8	+1.8	+1.8
	29	5.4	+25.9	+14.8	-81.5	0	0	0	0	-1.8	-1.8	-1.9
	31	4.9	+40.8	+22.4	-91.8	0	+2.0	+4.1	-4.1	+2.0	+2.0	+2.0
	32	2.0	+220.0	+100.0	-100.0	-45.0	+55.0	-5.0	-10.0	-15.0	-15.0	-15.0
	35	4.4	+54.5	+29.5	-100.0	+2.3	+2.3	+6.8	+4.3	+4.5	+4.5	+4.5
Southeast Loch	38	5.9	+15.2	+8.5	-64.4	0	-1.7	0	0	0	0	0
	39	5.8	+17.2	+13.8	-70.7	+1.7	0	0	0	0	0	0
	40	5.7	+19.3	+10.5	-61.4	0	0	0	0	0	0	0
	41	5.8	+17.2	+13.8	-56.9	+1.7	0	0	0	0	0	0
	42	5.8	+17.2	+13.8	-77.6	0	0	0	0	0	0	0
East Loch	24	4.9	+32.6	+16.3	-71.4	+2.0	0	0	0	0	0	0
	27	5.8	+17.2	+13.8	-60.3	0	0	0	0	0	0	0
	43	5.8	+17.2	+10.3	-69.0	0	0	+1.7	0	0	0	0
	44	5.7	+19.3	+10.5	-71.9	+1.8	0	+3.5	+1.8	+1.8	+1.8	+1.8
	47	5.7	+19.3	+10.5	-66.7	+1.8	0	0	0	0	0	0
	49	5.3	+24.5	+13.2	-73.6	0	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9
	50	5.1	+25.5	+13.7	-76.5	0	-2.0	0	0	0	0	0
	51	5.5	+21.8	+12.7	-80.0	0	0	+1.8	-1.8	0	0	0
	53	5.4	+25.9	+13.0	-81.5	0	-1.8	0	0	0	0	0
	56	5.0	+28.0	+16.0	-74.0	+2.0	0	0	0	0	0	0

[a] $K_2 = (D_M V)^{0.5}/D^{1.5}$; D_M = *diffusion coefficient*, V = *velocity*, D = *depth*

order of 50 percent, occurred. This may be related to the extremely low base value of 2.0 mg/l at node 32, whereas all other dissolved oxygen base values are greater than 4.0 mg/l.

Reaeration Rate

The three alternative reaeration rates described in Chapter IV were each tested for effects on dissolved oxygen. The base reaeration rate (= 0.1 per day) was increased by 100 percent, increased by 900 percent, and calculated by Equation 5. Increasing the rate by 100 percent increased the dissolved oxygen by 10 to 20 percent in most cases, and in the case of node 32 it doubled the base value (due again to the low original value). Multiplying the base reaeration rate by 10 effectively doubled the effects of the 100 percent rate increase on dissolved oxygen for most nodes. Permitting the model to calculate the reaeration rate according to Equation 5 resulted in a noticeable drop in the dissolved oxygen level. In the West Loch the decrease ranged from 0 to almost 50 percent, in the Middle Loch from 45 to 100 percent, and in the East and Southeast Lochs from about 55 to 80 percent. As previously described in Chapter IV, the base reaeration rate was selected with these results in mind since it provided the best overall representation of dissolved oxygen in view of the stratified nature of Pearl Harbor.

Stream Flows

Sensitivity runs for stream flows included altering the stream flows presented in Table 7 by plus 100 and minus 50 percent. Increases in the flow had a significant effect on dissolved oxygen in the West Loch due to the high level of dissolved oxygen in Waikele Stream and by promoting the growth of algae through the addition of further nitrate nitrogen. Only minor changes occurred throughout the other lochs. The decrease in stream flow had the adverse effect of decreasing dissolved oxygen levels in the West Loch by as much as 25 percent. Effects in the other lochs were again minor by comparison.

Manning's Roughness Coefficient

Manning's coefficients for the baseline simulation were increased and decreased by 20 percent in two sensitivity runs. The effects on dissolved oxygen reported in Table 9 are very small except at node 32, in which case the level was decreased by 15 percent in each alternative. Again, this may be attributed to the relatively low base value of 2.0 mg/l.

Quality Model Time Step

The decrease of the quality model time step from 1/2 hour to 1/4 hour resulted in minor changes to the dissolved oxygen levels, except again at node 32 where a decrease of 15 percent occurred.

Temperature

Table 10 provides a summary of the percentage effects on temperature caused by changes in the stream flows, Manning's n, and the quality model time step. Temperatures were not affected by changes in the deoxygenation rate, reaeration rate, or coliform dieaway rate.

Stream Flows

Temperature was essentially unaffected by both the 100 percent increase and 50 percent decrease in stream flows to the harbor. The greatest change amounted to 0.4 degrees centigrade increase at node 49.

Manning's Roughness Coefficient

Changes in Manning's n of plus and minus 20 percent had essentially no effect on the temperature simulations.

Quality Model Time Step

Reducing the quality model time step by one-half also had a negligible effect on the temperature.

Salinity

A summary of the percentage effects on salinity caused by changes in the stream flows, Manning's n, and the quality model time step is given in Table 11. Salinity was not affected by changes in the deoxygenation rate, reaeration rate, or coliform dieaway rate.

Stream Flows

Changes in stream flows can have a significant effect on salinity in some of the lochs. With a 100 percent increase in flow for Waikele Stream, the salinity in the upper west loch can drop by as much as 75 percent. Conversely, halving the stream flow increased the upper west loch salinity by as much as 100 percent. The lower and middle sections of the west loch were not affected as dramatically.

In the middle loch only those nodes adjacent to the Waiawa Stream outlet were significantly affected by stream flow changes, and then only by 5 to 10 percent. Similarly the salinities at only those nodes in the east loch that are adjacent to the mouths of Waimalu, Kalauao, and Halawa Streams were changed by even as much as 3 to 5 percent.

Manning's Roughness Coefficient

Changes in Manning's n of plus and minus 20 percent resulted in only minor salinity changes.

TABLE 10
Percentage Effects on Temperature in Pearl Harbor
Caused by Specified Changes in Several Model Parameters

Area	Node	Base Temp. Value, °C	Stream Inflow 2.0*Base	Stream Inflow 0.5*Base	Manning's n 1.2*Base	Manning's n 0.8*Base	Quality Model Time Step 0.5*Base
West Loch	7	24.9	0	0	0	0	0
	12	25.0	0	0	0	0	0
	15	25.6	0	0	0	0	-0.4
	17	25.1	0	0	0	0	0
	22	25.0	-0.4	+0.4	0	0	0
	23	25.2	0	+0.4	0	0	0
Middle Loch	25	25.0	0	0	0	0	0
	28	25.0	+0.4	+0.4	+0.4	+0.4	+0.4
	29	25.0	0	0	0	0	0
	31	24.9	0	0	0	0	0
	32	24.3	0	0	0	0	0
	35	24.9	+0.4	+0.4	+0.4	+0.4	+0.4
Southeast Loch	38	25.0	0	0	0	0	0
	39	24.9	+0.4	0	+0.4	+0.4	0
	40	24.9	+0.4	+0.4	+0.4	+0.4	+0.4
	41	24.9	0	0	0	0	0
	42	24.9	0	0	0	0	0
East Loch	24	35.3	0	0	+0.3	-0.3	0
	27	25.1	+0.4	+0.4	+0.4	+0.4	+0.4
	43	25.1	0	-0.4	-0.4	-0.4	-0.4
	44	25.2	0	-0.4	-0.4	-0.4	-0.4
	47	25.6	+0.4	+0.4	+0.4	+0.4	+0.4
	49	26.9	+1.5	+1.1	+1.1	+1.5	+1.1
	50	31.3	0	0	0	0	0
	51	25.9	-1.2	-1.2	-1.2	-1.2	-1.2
	53	25.1	0	0	0	0	0
	56	29.5	+0.3	+0.3	+0.3	0	0

TABLE 11
Percentage Effects on Salinity in Pearl Harbor
Caused by Specified Changes in Several Model Parameters

Area	Node	Base Salinity Value, g/l	Stream Inflows		Manning's n		Quality Model Time Step
			2.0*Base	0.5*Base	1.2*Base	0.8*Base	0.5*Base
West Loch	7	31.2	-10.6	+4.5	+0.6	+0.3	+0.6
	12	26.7	-25.8	+13.1	+0.4	+0.4	+0.4
	15	28.8	-16.3	+8.0	0	+0.3	+0.3
	17	24.5	-33.5	+17.1	-1.2	-0.8	-0.8
	22	8.5	-77.6	+100.4	+1.2	+2.4	+2.4
	23	11.9	-65.5	+68.9	+0.8	+1.7	+2.5
Middle Loch	25	33.3	-1.5	+0.9	+0.3	+0.3	+0.3
	28	31.9	-2.5	+2.2	+0.6	+0.6	+0.6
	29	31.3	-3.2	+2.9	+1.0	+1.0	+1.0
	31	30.1	-6.0	+4.3	+1.0	+1.0	+1.0
	32	28.0	-8.6	+0.7	-2.5	-2.5	-2.5
	35	30.5	-3.0	+3.3	+1.0	+1.0	+1.0
Southeast Loch	38	32.6	-0.9	+1.2	+0.6	+0.6	+0.6
	39	32.8	-0.3	+0.6	+0.3	+0.3	+0.3
	40	32.9	0	+0.3	+0.3	+0.3	+0.3
	41	32.9	0	+0.3	+0.3	+0.3	+0.3
	42	32.9	0	+0.3	+0.3	+0.3	+0.3
East Loch	24	32.5	-0.6	+1.2	+0.6	+0.6	+0.6
	27	32.7	-1.5	+1.2	+0.3	+0.3	+0.6
	43	32.2	-1.6	+1.9	+0.6	+0.6	+0.6
	44	31.8	-4.7	+1.9	-0.3	-0.3	-0.3
	47	32.7	-1.2	+0.9	+0.3	+0.3	+0.3
	49	32.7	-0.6	+0.6	+0.3	+0.3	+0.3
	50	32.3	-0.9	+1.5	+0.6	+0.6	+0.6
	51	32.1	-3.4	+1.2	-0.3	-0.3	-0.3
	53	32.2	-1.9	+1.2	+0.3	+0.3	+0.3
	56	32.5	-0.9	+0.9	+0.3	+0.3	+0.3

Quality Model Time Step

Reducing the quality model time step by one-half also had a negligible effect on the salinity conditions.

Phosphate Phosphorus

A summary of the percentage effects on phosphate phosphorus caused by changes in stream flows, Manning's n, and the quality model time step is given in Table 12. Phosphorus levels were not affected by changes in the deoxygenation rate, reaeration rate, or coliform dieaway rate.

Stream Flows

When Waikele Stream flow was doubled, enough additional phosphorus was added to the upper and middle sections of the West Loch to result in a general concentration increase of 25 to 55 percent. Only the upper West Loch was affected by the reduction in Waikele Stream inflow. When the inflow was halved the upper loch phosphous levels were decreased by 15 to 35 percent.

In the Middle Loch only node 29 was substantially affected by the increased flow from Waiawa Stream. This increase of 50 percent from 0.02 to 0.03 might be attributed to rounding of a number very close to 0.025. Similarly, round-off might account for the large percentage differences (but small in concentration) at nodes 29 and 31 when the stream flows were decreased.

Stream flows had no apparent effect on phosphorus levels in the East Loch, as indicated in Table 12.

Manning's Roughness Coefficient

Changes in Manning's n of plus and minus 20 percent resulted in only minor changes in the phosphorus concentrations.

Quality Model Time Step

Reducing the quality model time step by one-half also had a negligible effect on phosphorus concentrations.

Chlorophyll a

A summary of the percentage effects on chlorophyll a caused by changes in stream flows, Manning's n, and the quality model time step is given in Table 13. Chlorophyll a was not affected by changes in the deoxygenation rate, reaeration rate, or coliform dieaway rate.

TABLE 12
Percentage Effects on Phosphate Phosphorus in Pearl Harbor
Caused by Specified Changes in Several Model Parameters

Area	Node	Base PO_4 Value, mg/l	Stream Inflows 2.0*Base	Stream Inflows 0.5*Base	Manning's n 1.2*Base	Manning's n 0.8*Base	Quality Model Time Step 0.5*Base
West Loch	7	.02	0	0	0	0	0
	12	.04	+25.0	0	0	0	0
	15	.10	-10.0	0	0	0	0
	17	.06	+16.7	-16.7	0	0	0
	22	.24	+54.2	-33.3	0	0	0
	23	.11	+27.3	-18.2	0	0	0
Middle Loch	25	.02	0	0	0	0	0
	28	.02	0	0	0	0	0
	29	.02	+50.0	+50.0	+50.0	+50.0	+50.0
	31	.04	0	-25.0	0	0	0
	32	.38	+2.6	+2.6	+2.6	+2.6	+2.6
	35	.04	0	0	0	0	0
Southeast Loch	38	.02	0	0	0	0	0
	39	.02	0	0	0	0	0
	40	.02	0	0	0	0	0
	41	.02	0	0	0	0	0
	42	.02	0	0	0	0	0
East Loch	24	.04	0	0	0	0	0
	27	.02	0	0	0	0	0
	43	.02	0	0	0	0	0
	44	.02	0	0	0	0	0
	47	.02	0	0	0	0	0
	49	.03	0	0	0	0	0
	50	.03	0	0	0	0	0
	51	.02	0	0	0	0	0
	53	.03	0	0	0	0	0
	56	.03	0	0	0	0	0

TABLE 13
Percentage Effects on Chlorophyll a in Pearl Harbor
Caused by Specified Changes in Several Model Parameters

Area	Node	Base Chlor a Value, µg/l	Stream Flow		Manning's n		Quality Mode Time Step
			2.0*Base	0.5*Base	1.2*Base	0.8*Base	0.5*Base
West Loch	7	7	+114.3	-42.9	0	0	0
	12	19	+152.6	-52.6	0	0	0
	15	15	+166.7	-46.7	+13.3	+6.7	+6.7
	17	27	+140.7	-51.9	+11.1	+7.4	+7.4
	22	60	-6.7	-31.7	+1.7	+1.7	0
	23	84	+33.3	-33.3	+1.2	+1.2	0
Middle Loch	25	4	+25.0	0	0	0	+25.0
	28	3	+33.3	+33.3	0	0	0
	29	3	+33.3	+33.3	0	0	0
	31	4	+25.0	+25.0	0	0	0
	32	9	+33.3	+33.3	+11.1	+11.1	+11.1
	35	5	0	0	-20.0	-20.0	-20.0
Southeast Loch	38	3	0	0	0	0	0
	39	3	0	0	0	0	0
	40	2	0	0	0	0	0
	41	2	0	0	0	0	0
	42	3	0	0	0	0	0
East Loch	24	3	0	0	0	0	0
	27	3	+33.3	+33.3	0	0	+33.3
	43	3	0	0	0	0	0
	44	3	0	0	0	0	0
	47	3	0	0	0	0	0
	49	3	0	0	0	0	0
	50	3	0	0	0	0	0
	51	3	0	0	0	0	0
	53	2	0	0	0	0	0
	56	3	0	0	0	0	0

Stream Flows

Chlorophyll a concentrations more than doubled at all nodes in the West Loch, except those adjacent to Waikele Stream, as a result of doubling the stream flow. This result may be attributed to the additional nutrients supplied by the stream. At node 22 the concentration actually decreased. This may be attributed to the flushing action of the stream. The increase at node 23 by only 33 percent will be explained in the final section of this chapter under the heading Constituent Interactions.

The concentration at most nodes in the Middle Loch increased by 25 to 33 percent when the stream flows were doubled. The East Loch was relatively unaffected.

Reducing the stream flows by 50 percent again affected the West Loch the most, then the Middle Loch, and the East Loch only negligibly. In the West Loch, chlorophyll a concentrations were decreased by 32 to 53 percent while in the Middle Loch they were increased by 25 to 33 percent.

Manning's Roughness Coefficient

Changes in Manning's roughness coefficient of plus and minus 20 percent had little effect on chlorophyll a except at nodes 15, 17, 32 and 35. These effects are given in Table 13.

Quality Model Time Step

Reducing the quality model time step by one-half had no effect except at nodes 15, 17, 25, 32, 35, and 27. These changes were never greater than 1 g/l.

Nitrate Nitrogen

Table 14 presents a summary of the percentage effects on nitrate nitrogen caused by changes in stream flows, Manning's n, and the quality model time step. Nitrate nitrogen was not affected by changes in the deoxygenation rate, reaeration rate, or coliform dieaway rate.

Stream Flows

Changes in nitrate concentrations from doubling the stream flows were greatest in the West Loch where values were altered by -24 to +39 percent, or -0.08 to +0.23 mg/l. Concentrations in the Middle Loch and East Loch generally increased by 4 to 12 percent.

When the flows were decreased by half, the nitrate levels usually decreased. Percentage changes were as follows: the West Loch

TABLE 14
Percentage Effects on Nitrate Nitrogen in Pearl Harbor
Caused by Specified Changes in Several Model Parameters

Area	Node	Base Nitrate Value, mg/l	Stream Flow 2.0*Base	Stream Flow 0.5*Base	Manning's n 1.2*Base	Manning's n 0.8*Base	Quality Model Time Step 0.5*Base
West Loch	7	.25	+24.0	-16.0	-4.0	-4.0	-4.0
	12	.34	+5.9	-11.8	0	0	0
	15	.33	-24.2	0	0	0	0
	17	.35	0	-2.9	0	0	0
	22	.59	+39.0	-13.6	0	0	0
	23	.20	-20.0	+50.0	0	0	0
Middle Loch	25	.16	+12.5	0	0	0	0
	28	.22	+4.5	-4.5	-4.5	0	-4.5
	29	.25	+4.0	-4.0	0	0	0
	31	.32	0	-9.4	-6.3	-6.3	-6.3
	32	.76	+9.2	+6.6	+7.9	+7.9	+7.9
	35	.40	-7.5	-12.5	-10.0	-10.0	-10.0
Southeast Loch	38	.16	0	-6.3	0	0	-6.3
	39	.15	0	-6.7	0	0	0
	40	.15	0	0	0	0	0
	41	.14	0	0	0	0	0
	42	.14	0	0	0	0	0
East Loch	24	.20	+10.0	0	0	0	0
	27	.18	+5.6	-5.6	0	0	0
	43	.16	+6.3	-6.3	0	0	0
	44	.17	+5.9	-5.9	0	0	0
	47	.18	+5.6	-5.6	0	0	0
	49	.19	+5.3	0	0	0	0
	50	.22	+4.5	-4.5	-4.5	-4.5	-4.5
	51	.21	+14.3	-4.8	0	0	0
	53	.18	+5.6	0	0	0	0
	56	.21	+4.8	-4.8	0	0	0

varied from -14 to +50 percent, the Middle Loch by -13 to +7 percent, and the East Loch by 0 to 6 percent.

Manning's Roughness Coefficient

Sensitivity analyses for alternative Manning's coefficients had very little effect except in the Middle Loch where concentrations changed by as much as 10 percent.

Quality Model Time Step

Reducing the quality model time step similarly had little effect on the nitrate concentration except in the Middle Loch where values were decreased by as much as 10 percent or increased by as much 8 percent.

Coliforms

Table 15 presents a summary of the percentage effects on coliforms caused by changes in stream flows, the coliform dieaway rate, Manning's n, and the quality model time step. Coliform levels were not affected by changes in the reaeration rate or deoxygenation rate.

Stream Flows

Although the greatest changes in coliform concentrations due to stream flow changes occurred in the West Loch, significant changes were also indicated in the Middle and East Lochs. The Southeast Loch underwent only minor changes since no streams flow directly into this loch. When the stream flows were doubled, the coliform concentrations were modified in the West Loch by 75 to 190 percent, in the Middle Loch by -8 to 60 percent and in the East Loch by -5 to 26 percent. Conversely, when the stream flows were decreased by 50 percent, coliform levels were altered in the West, Middle, and East Loch by -43 to -60 percent, 0 to -47 percent, and -45 to 26 percent, respectively. The greatest percentage changes normally occurred in areas with relatively low base coliform levels.

Coliform Dieaway Rate

When the coliform dieaway rate, K_5, was doubled the coliform concentrations decreased quite significantly, by -23 to -93 percent. As indicated in Table 15 the average decrease was somewhere between 70 and 80 percent. When the dieaway rate was halved, coliform values increased by 43 to 1,233 percent. Even the nodes with the largest base values underwent changes on the order of 100 percent. Therefore, it may be concluded that the model results are extremely sensitive to the coliform dieaway rate.

TABLE 15
Percentage Effects on Coliform Organisms in Pearl Harbor Caused by Specified Changes in Several Model Parameters

Area	Node	Base Coliform Value, MPN/100ml	Stream Inflows		Coliform Dieaway, K (Base=0.5 day)		Manning's n		Quality Model Time Step
			2.10*Base	0.5*Base	2.0*Base	0.5*Base	0.2*Base	0.8*Base	0.5*Base
West Loch	7	2.1	+138	-42.9	-69.3	+1,233	-9.6	-4.8	+4.8
	12	45	+167	-60.0	-81.8	+322	-4.5	-2.3	0
	15	3.1	+190	-54.8	-92.9	+932	+6.4	+6.4	+12.9
	17	150	+160	-56.0	-72.0	+187	0	+6.6	+6.7
	22	4,400	+75.0	-47.7	-38.6	+43.2	0	-2.3	0
	23	710	+83.1	-47.9	-69.0	+154	0	0	0
Middle Loch	25	78	-7.7	-14.1	-80.8	+336	-11.6	-11.6	-6.4
	28	96	+45.8	-44.8	-82.3	+400	-17.8	-16.7	-14.6
	29	100	+60.0	-23.0	-83.0	+430	0	0	+10.0
	31	660	+51.5	-47.0	-68.2	+203	-15.2	-13.7	-13.6
	32	15,000	+6.7	0	-45.3	+73.3	0	0	0
	35	130	0	-36.9	-85.4	+500	-26.2	-25.4	-23.8
Southeast Loch	38	3,000	0	-3.3	-50.0	+86.7	-3.4	-3.4	0
	39	7,200	0	0	-50.0	+94.4	0	0	0
	40	21,000	0	0	-52.4	+90.5	0	0	0
	41	380	-2.6	-2.6	-77.4	+295	-2.7	-2.7	0
	42	32,000	0	0	-50.0	+93.8	0	0	0
East Loch	24	650	-4.6	-3.1	-80.0	+192	-1.6	-7.7	-3.1
	27	49	+8.2	-18.4	-88.0	+492	-14.3	-12.3	-10.2
	43	3,400	+5.9	+2.94	-47.1	+79.4	+5.8	+2.9	+5.9
	44	960	+14.6	-25.0	-63.5	+171	-10.5	-10.5	-10.4
	47	41	+24.4	+12.2	-82.9	+461	+14.6	+14.6	+19.5
	49	190	+26.3	+26.3	-71.6	+221	+26.3	+26.3	+26.3
	50	2,600	+3.8	0	-46.2	+84.6	0	0	+3.8
	51	3,900	+2.6	0	-23.1	+84.6	0	0	0
	53	84	-2.4	-44.8	-83.3	+424	-22.7	-21.5	-20.2
	56	1,300	0	0	-60.8	+115	0	-7.7	0

This is not to say, however, that a great deal of time and money should be spent identifying this rate since the coliform concentrations in both the model and the prototype are very sensitive to several other unknowns as well. These include unknown point and nonpoint waste sources and the possibility of mechanisms that may stimulate regrowth of coliforms. (It could be argued that it is probably better not to attempt to model total coliforms at all unless one is modeling a very controlled system.)

Manning's Roughness Coefficient

Altering the base values for Manning's roughness coefficient changes some coliform concentrations by -26 to 26 percent. However, nodes with relatively large original values were generally unchanged.

Quality Model Time Step

Decreasing the quality model time step by one-half generally affected only the concentrations at nodes with relatively small base coliform levels. For these nodes, the levels changed by anywhere from -24 to 26 percent.

Constituent Interactions

It is fairly simple to explain why the concentrations of individual constituents change from predicted values in the base case to those in the sensitivity analyses where some input parameter was purposely changed. It is more difficult to interpret why changes in several constituents occurred in the directions and magnitudes that they did. But if we can work our way through such an explanation, perhaps it will become a bit more obvious that 1) the model provides an instructional base for understanding at least part of the complex behavior of the prototype and 2) that the model has considerable worth as a tool for performing arithmetic calculations and keeping a large number of easily forgettable interrelationships continually in "mind."

Let us consider some of the results for the West Loch where most of the larger changes occurred. Let us also consider only the changes that resulted from doubling the stream inflows. How, we ask ourselves about node 22 at the mouth of Waikele Stream, could temperature drop slightly, nitrate and phosphate increase significantly, dissolved oxygen increase slightly and chlorophyll *a* *decrease*, all as a result of merely doubling the inflow? How could the nutrients and oxygen show increases anywhere for any reason when the algae are dropping? As if that were not strange enough, consider what happened just next door at node 23: temperature remained unchanged, nitrate dropped, phosphate increased, dissolved oxygen remained unchanged, but chlorophyll *a* increased more than 30 percent. How can one nutrient increase while the other decreases, and how can algae increase without increasing the oxygen produced? Perhaps more poignantly stated, how can these seemingly anomalous circumstances result and the model be "right"?

To settle that question, first the model is not "right" in the absolute; it does not contain provision for dealing with some phenomena that occur, such as use of CO_2 by algae and the production of CO_2 by biological oxidation. It has to "assume", because no other provision is there, that sufficient CO_2 exists in the water from biological oxidation of organic matter, or from any other source, not to limit the algae. This is just one "assumption" it has to make about the prototype. It is also not right in the absolute because it solves its many equations of interrelationships in a certain order, rather than truly simultaneously. They are solved simultaneously only in the sense that all of them are solved in each time step (each 30 minutes in the Pearl Harbor case), but they are solved in a certain order. Temperature is first, then coliforms, nitrate, nitrite, ammonia, phosphorus, algae, heavy metals, and pesticides. BOD and dissolved oxygen are last. Importantly, the concentrations of the earlier constituents that are related to the later constituents are calculated from the concentrations of the others that occurred in the previous time step, not the current one. The current value simply is not known yet since the model has not gotten there yet. Now, using a value that is 30 minutes old out of 30 days is not a major crime, but it is one source of possibly anomalous arithmetic. There are others, equally insignificant, but they are there just the same to remind us that the model is not the prototype. It is merely what it purports to be, a model of the prototype, an approximator, a facsimile, a simplification, not a duplicate.

So what are the physical conditions from the prototype that could explain the model's behavior at nodes 22 and 23? The input quality data for Waikele Stream are shown in Table 7 for the base case and for the increased stream flow condition.

Node 22 is right at the mouth of Waikele Stream. It is less than 3 feet deep, and is at the upper end of the West Loch, about as far removed from the harbor's mouth as it could be. Node 23 is about 8 feet deep, still further from the tidally influenced harbor mouth, and sheltered from the inrushing influence of Waikele Stream. The flow of Waikele Stream was increased from 77.8 cfs to 155.6 cfs, while it continued to flow into the loch with 1.2 mg/l of nitrate nitrogen, 0.6 mg/l of phosphate, 0.3 mg/l of BOD, and 8.3 mg/l of oxygen, at a temperature of 24.2°C. The rise in nitrogen, phosphate, and BOD at node 22 can be explained merely by the hydraulic situation wherein the increased Waikele Strem inflow brought in more water at higher concentrations than the background levels in the harbor water. The decrease in chlorophyll *a* can be explained by the same phenomenon. Waikele Stream contained virtually no chlorophyll *a*, so the node was simply diluted of algal cells; hence at the higher flow the chlorophyll *a* concentration at the node was lower than in the base case. An interesting point is that the dissolved oxygen increased very slightly even though BOD was higher and algae were lower. The answer is partly hydraulic again. During this hour, water was entering node 22 from Waikele Stream at 8.3 mg/l, but as much or more was entering the node from nodes 21 and 23 at concentrations of 12.2 and 12.3 mg/l, respectively. In the base case moreover, the salinities had been much higher than in the increased stream flow case. Oxygen is much less soluble at high salinities than at low salinities. Consequently, in the base case dissolved oxygen had been stopped at 1.5 times the solubility which yielded a DO level of 11.7 mg/l. In the lower salinity case, this "trap" in the model was never needed because the solubility was so much higher, and it had not been invoked even when the DO levels exceeded 12 mg/l. So this apparent anomaly can be explained in part by quite plausible behavior in the prototype and in part by a wrinkle in the model.

The most inexplicable anomaly occurred at node 23. Almost all conditons were met for greater algal growth in the greater stream flow case. Waikele Stream had brought more nutrients into the area, both more nitrate and more phosphate. The algae did indeed grow to a 30 percent greater biomass. But the resulting phosphate concentration was higher, and the resulting nitrate concentration was lower. This is a little difficult to understand. It appears, however, that the phosphate was much higher than that required by the growing algae, while the nitrogen became somewhat limiting (less than the half-saturation value) in both cases. Consequently, the phosphate appears to have increased by the influx from the stream alone; while the nitrate, even the additional nitrate from the stream, was depleted by the algae to a lower concentration than in the base case. The algae appear to have been limited by this as well, since they reached their peak biomass several days prior to the 30th day and were decreasing day by day at the end of the period.

If reading about these interrelationships has seemed tedious, it is not altogether a fault of the language, though apologies are tendered for that. But it does seem tedious because the data and the interrelationships are numerous and they fall on one another like dominoes, rapidly and each affecting the next. While there is a tendency simply to believe a model after a while, rather than to wade through what it suggests about a prototype, that tendency has to be avoided, even after considerable validation and testing has occurred. The anomalies uncovered in this study have all been explained, but there will be more in the next application; and the model user, the environmental planner wanting to depend on the model, will have to sort through the mass of modeled evidence to satisfy himself that either the model or the data are not quite correct or that the prototype could indeed be behaving in such a strange unexpected way. The insights gained about the prototype are almost bound to be of greater significance than the insights gained about modeling. This is the singular beauty of models; their computational efficiencies are merely advantages.

REFERENCES

1. Bathen, Karl H., Current Measurements in Pearl Harbor, Oahu, Hawaii, James K. Look Laboratory of Oceanographic Engineering, University of Hawaii, September 1972.

2. Callaway, R.J., et al., Mathematical Model of the Columbia River From the Pacific Ocean to the Bonneville Dam, Parts I and II, Federal Water Pollution Control Administration, Corvallis, Oregon.

3. Feigner, K.D., and H.S. Harris, Documentation Report FWQA Dynamic Estuary Model, Federal Water Quality Administration, July 1970.

4. Laevastu, Taivo, Don E. Avery, and Doak C. Cox, Coastal Currents and Sewage Disposal in the Hawaiian Islands, Final Report, Prepared for the Department of Planning and Economic Development, State of Hawaii.

5. Somers, William P., Project Officer, U.S. Environmental Protection Agency, Washington D.C., Private communication, June 12, 1973.

6. State of California Water Resources Control Board, San Francisco Bay-Delta Water Quality Control Program, Final Report - Abridged Preliminary Edition, March 1969.

7. Water Resources Engineers, Inc., A Hydraulic Water Quality Model of Suisan and San Pablo Bays, Report to the Federal Water Pollution Control Administration, Southwest Region, March 1966.

8. Water Resources Engineers, An Assessment of the Assimilative Capacity of Badfish Creek by Mathematical Simulation, Prepared for the Department of Natural Resources, State of Wisconsin, April 1974.

9. Water Resources Engineers, Application of QUAL-II to the Dan-Roanoke River Basin, Contract No. 68-01-0787 with the U.S. Environmental Protection Agency, report not yet completed.

10. Water Resources Engineers, Application of QUAL-II to the Upper Mississippi River Basin, Contract No. 68-01-0713 with the U.S. Environmental Protection Agency, report not yet completed.

11. Water Resources Engineers, Inc., Computer Program Documentation for the Stream Quality Model QUAL-II, Prepared for the Environmental Protection Agency, Systems Development Branch, Washington, D.C., May 1973.

12. Water Resources Engineers, Data Report for the Pearl Harbor System of Hawaii, Prepared for the Environmental Protection Agency, Systems Development Branch, Washington, D.C., July 20, 1973.

13. Water Resources Engineers, Dissolved Oxygen Modeling Report for the Chattahochee-Flint River Basin Mathematical Model Project, Contract No. 68-01-0708 with the Environmental Protection Agency.

14. Water Resources Engineers, Documentation Report for an Estuary Model Applied to the Pearl Harbor System of Hawaii, in press.

15. Water Resources Engineers, QUAL-II Model Validation Runs and Sensitivity Testing for the Iowa-Cedar River Basins, Contract No. 68-01-0742 with the U.S. Environmental Protection Agency, May 1973.

16. Water Resources Engineers, Santee River Basin Model Project, Draft Final Report, Contract No. 68-01-0739 with the U.S. Environmental Protection Agency, August 1973.

Appendix A

QUAL -II Input Data and Results
for Waikele Stream based on April 1972 Conditions

TEXAS WATER DEVELOPMENT BOARD/WATER RESOURCES ENGINEERS, INC.

* * * DATA LIST FOR MODIFIED QUAL1 STREAM QUALITY ROUTING MODEL * * *

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-I PROGRAM TITLES
TITLE01		TWDB/WRE EXPANDED VERSION OF QUAL-I -- KNOWN AS QUAL II
TITLE02		WAIKELE STREAM -- OAHU AUGUST,1972
TITLE03	NO	
TITLE04	NO	
TITLE05	NO	
TITLE06	NO	
TITLE07	YES	5-DAY BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE08	NO	
TITLE09	NO	
TITLE10	NO	
TITLE11		
TITLE12		
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	YES	COLIFORMS AS MPN
TITLE15	NO	
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	.00000		.00000
WRITE FINAL SUMMARY	.00000		.00000
NO FLOW AUGMENTATION	.00000		.00000
STEADY STATE	.00000		.00000
NUMBER OF REACHES =	6.00000	NUMBER OF JUNCTIONS =	.00000
NUM OF HEADWATERS =	1.00000	NO OF TRIBS AND WASTES =	5.00000
TIME STEP (HOURS) =	.00000	LNTH. COMP. ELEMENT (MI)=	.25000
MAXIMUM ROUTE TIME (HRS)=	30.00000	TIME INC. FOR RPT2 (HRS)=	.00000
ENDATA1	.00000		.00000

$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)$$$

CARD TYPE		CARD TYPE	
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
ENDATA1A	.0000		.0000

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE	REACH ORDER AND IDENT			R. MILE		R. MILE
STREAM REACH	1.0	RCH= SCHOFIELD AREA	FROM	10.0	TO	8.0
STREAM REACH	2.0	RCH= WAIKAKA-WAIHOLE	FROM	8.0	TO	6.7
STREAM REACH	3.0	RCH= BELOW WAIHOLE	FROM	6.7	TO	5.0
STREAM REACH	4.0	RCH= HULIWAI - NAD S	FROM	5.0	TO	3.[illegible]
STREAM REACH	5.0	RCH= KIPAPA STREAM	FROM	[illegible].0	TO	1.7
STREAM REACH	6.0	RCH= USGS GAGE	FROM	1.7	TO	.3
ENDATA2	.0			.0		.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HDWS	TARGET	ORDER OF AVAIL SOURCES					
ENDATA3	0.	0.	.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	8.	1.6.2.2.2.2.2.2.************************
FLAG FIELD	2.	5.	6.2.2.2.7.******************************
FLAG FIELD	3.	7.	2.2.2.2.2.2.2.**************************
FLAG FIELD	4.	8.	2.2.2.2.2.2.2.2.************************
FLAG FIELD	5.	5.	6.2.6.2.2.******************************
FLAG FIELD	6.	6.	2.2.2.2.2.5.****************************
ENDATA4	0.	0.	**

$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEFQV	EXPOQV	COEFQH	EXPOQH	CMANN
HYDRAULICS	1.	.900	.340	.093	.580	.045
HYDRAULICS	2.	.770	.330	.087	.580	.045
HYDRAULICS	3.	.940	.330	.074	.580	.045
HYDRAULICS	4.	.940	.330	.074	.580	.045
HYDRAULICS	5.	.760	.350	.077	.590	.045
HYDRAULICS	6.	.470	.360	.095	.590	.030
ENDATA5	0.	.000	.000	.000	.000	.000

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	K2OPT	K2	COEQK2	EXPQK2
REACT COEF	1.	.20	.00	1.	1.00	.000	.000
REACT COEF	2.	.20	.00	1.	1.00	.000	.000
REACT COEF	3.	.20	.00	1.	1.00	.000	.000
REACT COEF	4.	.20	.00	1.	1.00	.000	.000
REACT COEF	5.	.20	.00	1.	1.00	.000	.000
REACT COEF	6.	.20	.00	1.	.80	.000	.000
ENDATA6	0.	.00	.00	0.	.00	.000	.000

$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHOROUS CONSTANTS) $$$

CARD TYPE	REACH	ALPHA0	ALGSET	CKNH3	CKNO2	SNH3	SPO4
ALGAE, N AND P COEF	1.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	2.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	3.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	4.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	5.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	6.	.0	.00	.00	.00	.0	.0
ENDATA6A	0.	.0	.00	.00	.00	.0	.0

$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CK4	CK5	EXCOEF	CK6
OTHER COEFFICIENTS	1.	.00	.50	.00	.00
OTHER COEFFICIENTS	2.	.00	.50	.00	.00
OTHER COEFFICIENTS	3.	.00	.50	.00	.00
OTHER COEFFICIENTS	4.	.00	.50	.00	.00
OTHER COEFFICIENTS	5.	.00	.50	.00	.00
OTHER COEFFICIENTS	6.	.00	.50	.00	.00
ENDATA6B	0.	.00	.00	.00	.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	68.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	2.	75.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	3.	75.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	4.	75.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	5.	75.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	6.	70.0	.0	.0	.0	.0	.0
ENDATA7	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
INITIAL COND-2	1.	.0	.00	.00	.00	.00	1.0	.00
INITIAL COND-2	2.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	3.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	4.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	5.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	6.	.0	.00	.00	.00	.00	1000.0	.00
ENDATA7A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	3.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	4.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	5.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	.0	.0	.0	.0	.0	.0
ENDATA8	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN,PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.0	.00
ENDATA8A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWATER ORDER AND IDENT		FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1.	HWD= ABOVE SCHOFIELD	1.5	68.0	9.2	.5	.0	.0	.0
ENDATA10	0.		.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	HDWATER	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN

HEADWATER-2	1.	.0	.00	.00	.00	.00	1.0	.00
ENDATA10A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT		EFF	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
WASTELOAD	1.	WSL=SCHOFIELD BARR.	.00	2.5	78.0	5.0	26.0	.0	.0	.0
WASTELOAD	2.	WSL=WAIKAKALAUA STR	.00	5.2	75.3	8.2	1.6	.0	.0	.0
WASTELOAD	3.	WSL=WAIHOLE DITCH	.00	.0	.0	.0	.0	.0	.0	.0
WASTELOAD	4.	WSL=KIPAPA STREAM	.00	15.5	75.2	8.3	1.0	.0	.0	.0
WASTELOAD	5.	WSL=SPRING INFLOWS	.00	15.5	65.0	4.0	.5	.0	.0	.0
ENDATA11	0.		.00	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE,NITROGEN,PHOSPHOROUS,
COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT		CHL. A	NH3	NO2	NO3	PO4	COLI	RADN
WASTELOAD-2	1.	WSL=SCHOFIELD BARR.	.00	.00	.00	.00	.00	155000.00	.00
WASTELOAD-2	2.	WSL=WAIKAKALAUA STR	.00	.00	.00	.00	.00	3300.00	.00
WASTELOAD-2	3.	WSL=WAIHOLE DITCH	.00	.00	.00	.00	.00	10.00	.00
WASTELOAD-2	4.	WSL=KIPAPA STREAM	.00	.00	.00	.00	.00	126.00	.00
WASTELOAD-2	5.	WSL=SPRING INFLOWS	.00	.00	.00	.00	.00	1.00	.00
ENDATA11A									

DISSOLVED OXYGEN IN MG/L ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	9.19	6.55	6.53	6.51	6.48	6.46	6.44	6.41												
2	7.41	7.40	7.38	7.36	7.35															
3	7.33	7.32	7.31	7.30	7.28	7.27	7.26													
4	7.25	7.24	7.22	7.21	7.20	7.19	7.18	7.17												
5	7.87	7.87	6.39	6.39	6.40															
6	6.41	6.42	6.43	6.44	6.45	6.46														

5-DAY BIOCHEMICAL OXYGEN DEMAND IN MG/L ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	.50	16.41	16.38	16.34	16.31	16.27	16.24	16.20												
2	7.91	7.89	7.87	7.85	7.84															
3	7.82	7.81	7.79	7.78	7.76	7.75	7.73													
4	7.72	7.71	7.69	7.68	7.66	7.65	7.63	7.62												
5	3.47	3.47	2.32	2.32	2.32															
6	2.31	2.31	2.30	2.30	2.30	2.29														

COLIFORMS AS MPN ITERATION 1

RCH/CL 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

```
 1 13.40******************************************
 2******************************
 3******************************************
 4************************************************
 5******************************
 6************************************
```

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 1.0 RCH= SCHOFIELD AREA
RIVER MILES 10.0 TO 8.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	1.500	4.000	4.000	1.500	3.687
VELOCITY (FPS)	=	1.033	1.442	1.442	1.033	1.403
DEPTH (FT)	=	.118	.208	.208	.118	.198

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	9.19	6.55	6.53	6.51	6.48	6.46	6.44	6.41												
BOD	.50	16.41	16.38	16.34	16.31	16.27	16.24	16.20												
COLI	13	96483	95975	95469	94966	94466	93968	93462												

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	1.000	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 2.0 RCH= WAIKAKA-WAIHOLE
RIVER MILES 8.0 TO 6.7

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	9.240	9.240	9.240	9.240	9.240
VELOCITY (FPS)	=	1.604	1.604	1.604	1.604	1.604
DEPTH (FT)	=	.316	.316	.316	.316	.316

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.41	7.40	7.38	7.36	7.35															
BOD	7.91	7.89	7.87	7.85	7.84															
COLI	42160	41921	41684	41448	41213															

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	1.000	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 3.0 RCH= BELOW WAIHOLE
RIVER MILES 6.7 TO 5.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	9.240	9.240	9.240	9.240	9.240
VELOCITY (FPS)	=	1.958	1.958	1.958	1.958	1.958
DEPTH (FT)	=	.269	.269	.269	.269	.269

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.33	7.32	7.31	7.30	7.28	7.27	7.26													
BOD	7.82	7.81	7.79	7.78	7.76	7.75	7.73													
COLI	41001	40810	40621	40432	40245	40058	39872													

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)	SETTLING RATES (1/DAY)	BENTHOS SOURCE RATES (MG/FT/DAY)	REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD = .20	BOD = .00	BOD = .00	K2 = 1.000	RATIO = .00
KNH3 = .00	ALGAE = .00	NH3 = .00		
KNO2 = .00		PO4 = .00		
KCOLI = .50				
KRDN = .00				

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 4.0 RCH= HULIWAI - NAD S
RIVER MILES 5.0 TO 3.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	9.240	9.240	9.240	9.240	9.240
VELOCITY (FPS)	=	1.958	1.958	1.958	1.958	1.958
DEPTH (FT)	=	.269	.269	.269	.269	.269

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.25	7.24	7.22	7.21	7.20	7.19	7.18	7.17												
BOD	7.72	7.71	7.69	7.68	7.66	7.65	7.63	7.62												
COLI	39686	39502	39319	39136	38954	38774	38594	38408												

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	1.000	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 5.0 RCH= KIPAPA STREAM
RIVER MILES 3.0 TO 1.7

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	24.710	40.180	40.180	24.710	33.992
VELOCITY (FPS)	=	2.335	2.768	2.768	2.335	2.611
DEPTH (FT)	=	.511	.681	.681	.511	.617

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.87	7.87	6.39	6.39	6.40															
BOD	3.47	3.47	2.32	2.32	2.32															
COLI	14404	14345	8799	8770	8741															

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)

- K1BOD = .20
- KNH3 = .00
- KNO2 = .00
- KCOLI = .50
- KRDN = .00

SETTLING RATES (1/DAY)

- BOD = .00
- ALGAE = .00

BENTHOS SOURCE RATES (MG/FT/DAY)

- BOD = .00
- NH3 = .00
- PO4 = .00

REAERATION RATE (1/DAY)

- K2 = 1.000

CHLOR A/ALGAE RATIO (UG/MG)

- RATIO = .00

* * * * * * F I N A L   R E P O R T * * * * * *

REACH NO. 6.0 RCH= USGS GAGE
RIVER MILES 1.7 TO .3

1. H Y D R A U L I C   P A R A M E T E R   V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	40.180	40.180	40.180	40.180	40.180
VELOCITY (FPS)	=	1.776	1.776	1.776	1.776	1.776
DEPTH (FT)	=	.840	.840	.840	.840	.840

2. W A T E R   Q U A L I T Y   P A R A M E T E R   V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	6.41	6.42	6.43	6.44	6.45	6.46														
BOD	2.31	2.31	2.30	2.30	2.30	2.29														
COLI	8709	8670	8631	8592	8553	8514														

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E   V A L U E S   O F   R E A C H   C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)

K1BOD = .20
KNH3 = .00
KNO2 = .00
KCOLI = .50
KRDN = .00

SETTLING RATES (1/DAY)

BOD = .00
ALGAE = .00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD = .00
NH3 = .00
PO4 = .00

REAERATION RATE (1/DAY)

K2 = .800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = .00

Appendix B

QUAL-II Input Data and Results
for Waikele Stream based on September 1972 Conditions

TEXAS WATER DEVELOPMENT BOARD/WATER RESOURCES ENGINEERS, INC.

* * * DATA LIST FOR MODIFIED QUAL1 STREAM QUALITY ROUTING MODEL * * *

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-I PROGRAM TITLES
TITLE01		TWDB/WRE EXPANDED VERSION OF QUAL-I -- KNOWN AS QUAL II
TITLE02		WAIKELE STREAM -- OAHU SEPTEMBER , 1972
TITLE03	NO	
TITLE04	NO	
TITLE05	NO	
TITLE06	NO	
TITLE07	YES	5-DAY BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE08	NO	
TITLE09	NO	
TITLE10	NO	
TITLE11		
TITLE12		
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	YES	COLIFORMS AS MPN
TITLE15	NO	
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	.00000		.00000
WRITE FINAL SUMMARY	.00000		.00000
NO FLOW AUGMENTATION	.00000		.00000
STEADY STATE	.00000		.00000
NUMBER OF REACHES =	6.00000	NUMBER OF JUNCTIONS =	.00000
NUM OF HEADWATERS =	1.00000	NO OF TRIBS AND WASTES =	5.00000
TIME STEP (HOURS) =	.00000	LNTH. COMP. ELEMENT (MI)=	.25000
MAXIMUM ROUTE TIME (HRS)=	30.00000	TIME INC. FOR RPT2 (HRS)=	.00000
ENDATA1	.00000		.00000

$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)$$$

CARD TYPE		CARD TYPE	
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
	.0000		.0000
ENDATA1A	.0000		.0000

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE	REACH ORDER AND IDENT			R. MILE		R. MILE
STREAM REACH	1.0	RCH= SCHOFIELD AREA	FROM	10.0	TO	8.0
STREAM REACH	2.0	RCH= KAIKAKA-WAIHOLE	FROM	8.0	TO	6.7
STREAM REACH	3.0	RCH= BELOW WAIHOLE	FROM	6.7	TO	5.0
STREAM REACH	4.0	RCH= HULIWAI - NAD S	FROM	5.0	TO	3.0
STREAM REACH	5.0	RCH= KIPAPA STREAM	FROM	3.0	TO	1.7
STREAM REACH	6.0	RCH= USGS GAGE	FROM	1.7	TO	.3
ENDATA2	.0			.0		.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HDWS	TARGET	ORDER OF AVAIL SOURCES					
ENDATA3	0.	0.	.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	8.	1.6.2.2.2.2.2.2.**************************
FLAG FIELD	2.	5.	6.2.2.2.7.********************************
FLAG FIELD	3.	7.	2.2.2.2.2.2.2.****************************
FLAG FIELD	4.	8.	2.2.2.2.2.2.2.2.**************************
FLAG FIELD	5.	5.	6.2.6.2.2.********************************
FLAG FIELD	6.	6.	2.2.2.2.2.5.******************************
ENDATA4	0.	0.	**

$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEFQV	EXPOQV	COEFQH	EXPOQH	CMANN
HYDRAULICS	1.	.900	.340	.093	.580	.045
HYDRAULICS	2.	.770	.330	.087	.580	.045
HYDRAULICS	3.	.940	.330	.074	.580	.045
HYDRAULICS	4.	.940	.330	.074	.580	.045
HYDRAULICS	5.	.760	.350	.077	.590	.045
HYDRAULICS	6.	.470	.360	.095	.590	.030
ENDATA5	0.	.000	.000	.000	.000	.000

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	K2OPT	K2	COEQK2	EXPQK2
REACT COEF	1.	.20	.00	1.	1.00	.000	.000
REACT COEF	2.	.20	.00	1.	1.00	.000	.000
REACT COEF	3.	.20	.00	1.	1.00	.000	.000
REACT COEF	4.	.20	.00	1.	1.00	.000	.000
REACT COEF	5.	.20	.00	1.	1.00	.000	.000
REACT COEF	6.	.20	.00	1.	.80	.000	.000
ENDATA6	0.	.00	.00	0.	.00	.000	.000

$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHOROUS CONSTANTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	CKNH3	CKNO2	SNH3	SPO4
ALGAE, N AND P COEF	1.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	2.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	3.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	4.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	5.	.0	.00	.00	.00	.0	.0
ALGAE, N AND P COEF	6.	.0	.00	.00	.00	.0	.0
ENDATA6A	0.	.0	.00	.00	.00	.0	.0

$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CK4	CK5	EXCOEF	CK6
OTHER COEFFICIENTS	1.	.00	.50	.00	.00
OTHER COEFFICIENTS	2.	.00	.50	.00	.00
OTHER COEFFICIENTS	3.	.00	.50	.00	.00
OTHER COEFFICIENTS	4.	.00	.50	.00	.00
OTHER COEFFICIENTS	5.	.00	.50	.00	.00
OTHER COEFFICIENTS	6.	.00	.50	.00	.00
ENDATA6B	0.	.00	.00	.00	.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	80.5	.0	.0	.0	.0	.0
INITIAL CONDITIONS	2.	75.8	.0	.0	.0	.0	.0
INITIAL CONDITIONS	3.	75.8	.0	.0	.0	.0	.0
INITIAL CONDITIONS	4.	75.8	.0	.0	.0	.0	.0
INITIAL CONDITIONS	5.	79.2	.0	.0	.0	.0	.0
INITIAL CONDITIONS	6.	75.0	.0	.0	.0	.0	.0
ENDATA7	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
INITIAL COND-2	1.	.0	.00	.00	.00	.00	1.0	.00
INITIAL COND-2	2.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	3.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	4.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	5.	.0	.00	.00	.00	.00	1000.0	.00
INITIAL COND-2	6.	.0	.00	.00	.00	.00	1000.0	.00
ENDATA7A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	3.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	4.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	5.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	.0	.0	.0	.0	.0	.0
ENDATA8	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN,PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.0	.00
ENDATA8A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWATER ORDER AND IDENT	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1. HWD= ABOVE SCHOFIELD	.0	.0	.0	.0	.0	.0	.0
ENDATA10	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	HDWATER	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN

HEADWATER-2	1.	.0	.00	.00	.00	.00	.0	.00
ENDATA10A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE	WASTE	LOAD ORDER AND IDENT	EFF	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
WASTELOAD	1.	WSL=SCHOFIELD BARR.	.00	2.5	80.5	5.0	32.1	.0	.0	.0
WASTELOAD	2.	WSL=WAIKAKALAUA STR	.00	2.6	75.8	8.0	2.3	.0	.0	.0
WASTELOAD	3.	WSL=WAIHOLE DITCH	.00	-3.4	.0	.0	.0	.0	.0	.0
WASTELOAD	4.	WSL=KIPAPA STREAM	.00	1.5	79.2	5.3	8.9	.0	.0	.0
WASTELOAD	5.	WSL=SPRING INFLOWS	.00	11.6	65.0	4.0	.5	.0	.0	.0
ENDATA11	0.		.00	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE,NITROGEN,PHOSPHOROUS,
COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT	CHL. A	NH3	NO2	NO3	PO4	COLI	RADN
WASTELOAD-2	1. WSL=SCHOFIELD BARR.	.00	.00	.00	.00	.00	160000.00	.00
WASTELOAD-2	2. WSL=WAIKAKALAUA STR	.00	.00	.00	.00	.00	366.00	.00
WASTELOAD-2	3. WSL=WAIHOLE DITCH	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	4. WSL=KIPAPA STREAM	.00	.00	.00	.00	.00	1365.00	.00
WASTELOAD-2	5. WSL=SPRING INFLOWS	.00	.00	.00	.00	.00	1.00	.00
ENDATA11A								

DISSOLVED OXYGEN IN MG/L ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	7.87	4.94	4.82	4.71	4.60	4.49	4.38	4.27												
2	6.13	6.09	6.05	6.01	5.98															
3	5.93	5.89	5.84	5.80	5.76	5.72	5.68													
4	5.64	5.60	5.57	5.53	5.49	5.46	5.42	5.39												
5	5.33	5.30	4.30	4.32	4.35															
6	4.37	4.40	4.43	4.46	4.48	4.51														

5-DAY BIOCHEMICAL OXYGEN DEMAND IN MG/L ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	.00	32.05	31.94	31.83	31.72	31.61	31.51	31.40												
2	16.59	16.54	16.50	16.45	16.41															
3	16.36	16.30	16.25	16.19	16.14	16.09	16.04													
4	15.98	15.93	15.88	15.83	15.77	15.72	15.67	15.62												
5	12.49	12.45	3.12	3.11	3.10															
6	3.10	3.09	3.08	3.07	3.06	3.05														

COLIFORMS AS MPN ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	.00	*********	*********	*********	*********	*********	*********	*********												
2	*********	*********	*********	*********	*********															
3	*********	*********	*********	*********	*********	*********	*********													
4	*********	*********	*********	*********	*********	*********	*********	*********												
5	*********	*********	*********	*********	*********															
6	*********	*********	*********	*********	*********	*********														

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 1.0 RCH= SCHOFIELD AREA
RIVER MILES 10.0 TO 8.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	.000	2.540	2.540	.000	2.222
VELOCITY (FPS)	=	.000	1.236	1.236	.000	1.181
DEPTH (FT)	=	.000	.160	.160	.000	.148

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.87	4.94	4.82	4.71	4.60	4.49	4.38	4.27												
BOD	.00	32.05	31.94	31.83	31.72	31.61	31.51	31.40												
COLI	0159322157978156645155324154014152715151414																			

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)

KIBOD = .20
KNH3 = .00
KNO2 = .00
KCOLI = .50
KRDN = .00

SETTLING RATES (1/DAY)

BOD = .00
ALGAE = .00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD = .00
NH3 = .00
PO4 = .00

REAERATION RATE (1/DAY)

K2 = 1.000

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = .00

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 2.0 RCH= WAIKAKA-WAIHOLE
RIVER MILES 8.0 TO 6.7

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	5.160	1.760	5.160	1.760	4.480
VELOCITY (FPS)	=	1.323	.928	1.323	.928	1.263
DEPTH (FT)	=	.225	.121	.225	.121	.208

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	6.13	6.09	6.05	6.01	5.98															
BOD	16.59	16.54	16.50	16.45	16.41															
COLI	74328	73808	73292	72779	72400															

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	1.000	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 3.0 RCH= BELOW WAIHOLE
RIVER MILES 6.7 TO 5.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	1.760	1.760	1.760	1.760	1.760
VELOCITY (FPS)	=	1.133	1.133	1.133	1.133	1.133
DEPTH (FT)	=	.103	.103	.103	.103	.103

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	5.93	5.89	5.84	5.80	5.76	5.72	5.68													
BOD	16.36	16.30	16.25	16.19	16.14	16.09	16.04													
COLI	71744	71159	70578	70002	69430	68864	68302													

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	1.000	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 4.0 RCH= HULIWAI - NAD S
RIVER MILES 5.0 TO 3.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	1.760	1.760	1.760	1.760	1.760
VELOCITY (FPS)	=	1.133	1.133	1.133	1.133	1.133
DEPTH (FT)	=	.103	.103	.103	.103	.103

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	5.64	5.60	5.57	5.53	5.49	5.46	5.42	5.39												
BOD	15.98	15.93	15.88	15.83	15.77	15.72	15.67	15.62												
COLI	67744	67191	66643	66099	65559	65024	64493	63963												

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)

KIBOD = .20
KNH3 = .00
KNO2 = .00
KCOLI = .50
KRDN = .00

SETTLING RATES (1/DAY)

BOD = .00
ALGAE = .00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD = .00
NH3 = .00
PO4 = .00

REAERATION RATE (1/DAY)

K2 = 1.000

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = .00

* * * * * * FINAL REPORT * * * * * *

REACH NO. 5.0 RCH= KIPAPA STREAM
RIVER MILES 3.0 TO 1.7

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	3.260	14.860	14.860	3.260	10.220
VELOCITY (FPS)	=	1.149	1.954	1.954	1.149	1.714
DEPTH (FT)	=	.155	.378	.378	.155	.303

2. WATER QUALITY PARAMETER VALUES * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	5.33	5.30	4.30	4.32	4.35															
BOD	12.49	12.45	3.12	3.11	3.10															
COLI	34924	34613	7569	7529	7490															

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

- K1BOD = .20
- KNH3 = .00
- KNO2 = .00
- KCOLI = .50
- KRDN = .00

SETTLING RATES (1/DAY)

- BOD = .00
- ALGAE = .00

BENTHOS SOURCE RATES (MG/FT/DAY)

- BOD = .00
- NH3 = .00
- PO4 = .00

REAERATION RATE (1/DAY)

- K2 = 1.000

CHLOR A/ALGAE RATIO (UG/MG)

- RATIO = .00

* * * * * * FINAL REPORT * * * * * *

REACH NO. 6.0 RCH= USGS GAGE
RIVER MILES 1.7 TO .3

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	14.860	14.860	14.860	14.860	14.860
VELOCITY (FPS)	=	1.242	1.242	1.242	1.242	1.242
DEPTH (FT)	=	.467	.467	.467	.467	.467

2. WATER QUALITY PARAMETER VALUES * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.37	4.40	4.43	4.46	4.48	4.51														
BOD	3.10	3.09	3.08	3.07	3.06	3.05														
COLI	7446	7391	7337	7284	7231	7178														

* NOTE: UNITS ARE MG/L, EXCEPT FOR
AND COLIFORMS AS MPN

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.20	BOD =	.00	BOD =	.00	K2 =	.800	RATIO =	.00
KNH3 =	.00	ALGAE =	.00	NH3 =	.00				
KNO2 =	.00			PO4 =	.00				
KCOLI =	.50								
KRDN =	.00								

Appendix C

Estuary Model Results on the 30th Day of Simulation for April and September 1972

APRIL 1972

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.13	.026	.10	.04	.18+02	34.9	.13	.78-03	.16-02	.41-03	.28-03
2	24.9	6.3	.1	7.	.21	.043	.15	.05	.12+02	34.2	.20	.63-03	.13-02	.16-03	.16-03
4	24.9	6.0	.1	5.	.27	.066	.17	.03	.29+02	33.5	.20	.53-03	.94-03	.32-04	.50-04
5	24.9	6.0	.0	5.	.31	.081	.19	.02	.62+01	32.8	.22	.40-03	.79-03	.14-04	.27-04
7	24.9	5.9	.0	7.	.42	.116	.25	.02	.21+01	31.2	.31	.37-03	.71-03	.88-06	.43-05
8	24.9	5.9	.0	9.	.52	.139	.28	.02	.49+01	30.0	.40	.47-03	.84-03	.11-05	.75-05
9	25.1	5.1	.0	5.	.67	.155	.26	.04	.52+00	31.3	.26	.24-03	.46-03	.00	.00
10	24.9	6.0	.0	13.	.63	.165	.32	.03	.16+02	28.4	.53	.67-03	.11-02	.41-05	.23-04
11	25.0	6.4	.0	21.	.76	.190	.35	.04	.59+02	25.9	.73	.11-02	.16-02	.17-04	.73-04
12	25.0	6.1	.0	19.	.78	.194	.34	.04	.45+02	26.7	.66	.92-03	.14-02	.13-04	.54-04
14	25.3	4.7	.0	16.	1.21	.263	.33	.07	.35+01	28.6	.47	.50-03	.86-03	.00	.00
15	25.6	4.1	.0	15.	1.47	.295	.33	.10	.31+01	28.8	.44	.46-03	.80-03	.00	.00
17	25.1	6.6	.0	27.	.94	.219	.35	.06	.15+03	24.5	.84	.13-02	.19-02	.43-04	.13-03
18	25.0	7.5	.0	37.	.96	.220	.36	.06	.26+03	21.7	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	8.3	.1	47.	1.08	.228	.36	.08	.51+03	19.5	1.28	.23-02	.31-02	.15-03	.35-03
20	25.1	9.1	.1	55.	1.14	.233	.38	.10	.90+03	16.8	1.52	.30-02	.39-02	.26-03	.55-03
21	25.2	10.2	.1	71.	1.32	.278	.25	.08	.37+03	16.0	1.58	.27-02	.38-02	.97-04	.29-03
22	25.0	10.5	.1	60.	1.20	.176	.59	.24	.44+04	8.5	2.26	.57-02	.65-02	.12-02	.18-02
23	25.2	11.7	.1	84.	1.47	.285	.20	.11	.71+03	11.9	1.95	.37-02	.48-02	.19-03	.50-03
24	35.3	4.9	.0	3.	.56	.125	.20	.04	.65+03	32.5	.15	.22-03	.27-03	.00	.00
25	25.0	6.0	.1	4.	.28	.070	.16	.02	.78+02	33.3	.19	.59-03	.89-03	.15-04	.29-04
26	25.0	5.9	.0	4.	.30	.077	.17	.02	.18+03	33.0	.19	.70-03	.87-03	.51-05	.13-04
27	25.1	5.8	.1	3.	.33	.085	.18	.02	.49+02	32.7	.23	.12-02	.12-02	.16-05	.58-05
28	25.0	5.5	.1	3.	.38	.100	.22	.02	.96+02	31.9	.35	.30-02	.24-02	.25-05	.10-04
29	25.0	5.4	.1	3.	.42	.110	.25	.02	.10+03	31.3	.44	.41-02	.33-02	.26-05	.11-04
30	24.9	4.9	.4	4.	.51	.129	.30	.04	.63+03	30.6	.61	.56-02	.42-02	.11-04	.31-04
31	24.9	4.9	.4	4.	.51	.132	.32	.04	.66+03	30.1	.69	.79-02	.56-02	.19-04	.52-04
32	24.3	2.0	4.1	9.	1.09	.207	.76	.38	.15+05	28.0	2.06	.42-02	.35-02	.99-04	.19-03
33	24.7	3.8	1.1	5.	.74	.171	.47	.10	.51+04	27.0	1.30	.20-01	.12-01	.14-03	.26-03
34	24.8	3.6	1.0	8.	.76	.193	.51	.08	.96+03	30.4	1.06	.18-02	.17-02	.57-05	.20-04
35	24.9	4.4	.4	5.	.67	.174	.40	.04	.13+03	30.5	.75	.37-02	.31-02	.95-06	.43-05
37	25.0	5.9	.0	3.	.30	.079	.16	.02	.92+03	32.9	.17	.37-03	.53-03	.13-05	.44-05
38	25.0	5.9	.0	3.	.32	.084	.16	.02	.30+04	32.6	.17	.25-03	.36-03	.13-05	.44-05
39	24.9	5.8	.0	3.	.32	.082	.15	.02	.72+04	32.8	.15	.10-03	.16-03	.00	.00
40	24.9	5.7	.1	2.	.38	.093	.15	.02	.21+05	32.9	.17	.51-04	.73-04	.00	.00
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.38+03	32.9	.12	.44-04	.64-04	.00	.00
42	24.9	5.8	.1	3.	.34	.085	.14	.02	.32+05	32.9	.21	.50-04	.70-04	.00	.00
43	25.1	5.8	.0	3.	.36	.091	.16	.02	.34+04	32.2	.19	.22-03	.32-03	.70-05	.17-04
44	25.2	5.7	.0	3.	.40	.099	.17	.02	.96+03	31.8	.22	.29-03	.38-03	.32-04	.56-04
47	25.6	5.7	.0	3.	.34	.090	.18	.02	.41+02	32.7	.19	.88-03	.88-03	.12-07	.61-07
48	26.6	5.6	.0	3.	.38	.099	.18	.02	.21+03	32.7	.16	.48-03	.53-03	.00	.00
49	26.9	5.3	.0	3.	.47	.115	.19	.03	.19+03	32.7	.14	.26-03	.30-03	.00	.00
50	31.3	5.1	.0	3.	.52	.127	.22	.03	.26+04	32.3	.17	.24-03	.30-03	.23-05	.59-05
51	25.9	5.5	.0	3.	.45	.115	.21	.02	.39+04	32.1	.20	.25-03	.34-03	.42-05	.13-04
52	25.3	5.6	.0	2.	.42	.107	.18	.02	.66+03	32.4	.17	.14-03	.20-03	.24-06	.70-06
53	25.1	5.4	.0	2.	.51	.120	.18	.03	.84+02	32.2	.17	.14-03	.21-03	.24-05	.74-05
54	25.3	5.2	.0	3.	.63	.135	.23	.04	.39+03	31.4	.30	.47-03	.59-03	.51-04	.99-04
55	26.7	5.0	.0	5.	.74	.154	.34	.04	.24+04	26.7	.49	.98-03	.12-02	.12-03	.23-03
56	29.5	5.0	.0	3.	.53	.124	.21	.03	.13+04	32.5	.16	.23-03	.29-03	.75-06	.23-05
57	26.5	3.8	.0	2.	.92	.147	.19	.09	.10+03	32.6	.14	.20-03	.24-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1422

SEPTEMBER 1972

SYSTEM STATUS AFTER QUALITY CYCLE 1420 29 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	27.1	4.9	.4	5.	.05	.011	.04	.02	.27+02	35.6	.07	.89-01	.91-02	.74-02	.41-02
2	26.3	4.1	.3	4.	.14	.028	.07	.05	.15+02	35.2	.11	.66-01	.73-02	.35-02	.26-02
4	25.5	3.2	.1	3.	.23	.052	.12	.04	.15+02	35.0	.15	.40-01	.49-02	.88-03	.10-02
5	25.2	2.8	.1	3.	.27	.067	.16	.03	.15+02	34.9	.18	.26-01	.35-02	.31-03	.49-03
7	25.0	2.4	.0	3.	.36	.096	.21	.02	.22+01	34.8	.20	.12-01	.19-02	.34-04	.11-03
8	24.9	2.3	.0	3.	.43	.113	.24	.02	.11+01	34.7	.22	.85-02	.15-02	.12-04	.58-04
9	24.9	2.1	.0	4.	.62	.140	.25	.04	.22+00	34.9	.22	.44-02	.88-03	.15-05	.12-04
10	24.9	2.2	.0	4.	.51	.133	.26	.02	.17+01	34.5	.25	.58-02	.11-02	.45-05	.29-04
11	24.9	2.2	.0	6.	.61	.158	.29	.03	.60+01	34.2	.29	.39-02	.93-03	.29-05	.20-04
12	24.9	2.2	.0	5.	.62	.158	.29	.03	.50+01	34.3	.28	.39-02	.92-03	.27-05	.18-04
14	25.1	2.6	.0	8.	1.08	.230	.32	.07	.95+00	34.9	.27	.17-02	.51-03	.59-08	.43-07
15	25.4	3.3	.0	8.	1.32	.259	.32	.09	.88+00	35.0	.27	.13-02	.43-03	.00	.00
17	24.9	2.3	.0	7.	.76	.183	.31	.04	.11+02	34.1	.31	.28-02	.80-03	.34-05	.17-04
18	24.9	2.4	.0	8.	.76	.186	.32	.04	.24+02	33.6	.35	.28-02	.89-03	.77-05	.31-04
19	25.0	2.9	.0	11.	.91	.208	.34	.05	.60+02	32.9	.42	.21-02	.95-03	.18-04	.58-04
20	24.9	3.0	.0	12.	.95	.218	.35	.06	.92+02	32.5	.46	.20-02	.10-02	.28-04	.80-04
21	25.0	3.4	.0	17.	1.15	.257	.36	.07	.69+02	32.0	.51	.14-02	.10-02	.20-04	.64-04
22	25.0	4.0	.0	19.	1.11	.232	.43	.09	.90+03	28.8	.76	.23-02	.19-02	.26-03	.41-03
23	25.0	4.4	.0	25.	1.32	.282	.37	.08	.22+03	30.0	.68	.15-02	.15-02	.66-04	.16-03
24	32.9	1.4	.0	4.	.53	.119	.25	.03	.88+03	34.6	.26	.15-02	.40-03	.46-07	.31-06
25	25.2	2.7	.1	3.	.26	.064	.15	.03	.40+02	34.9	.18	.27-01	.36-02	.35-03	.53-03
26	25.1	2.4	.0	3.	.29	.073	.18	.02	.11+03	34.8	.22	.18-01	.26-02	.14-03	.28-03
27	25.0	1.9	.0	3.	.33	.086	.21	.02	.74+02	34.6	.28	.11-01	.18-02	.39-04	.12-03
28	24.9	1.3	.0	5.	.41	.110	.27	.03	.38+02	34.3	.44	.70-02	.13-02	.12-04	.54-04
29	24.9	.6	.1	6.	.51	.138	.34	.04	.38+02	33.9	.64	.41-02	.95-03	.47-05	.28-04
30	24.8	.4	.0	6.	.52	.144	.35	.02	.55+02	33.8	.64	.28-02	.78-03	.97-06	.13-04
31	24.8	.3	.1	8.	.61	.164	.40	.05	.12+03	33.4	.84	.30-02	.87-03	.97-05	.40-04
32	24.9	.0	3.0	13.	1.61	.270	.67	.67	.23+03	31.9	2.41	.20-02	.11-02	.16-03	.29-03
33	24.8	.0	.7	14.	1.03	.247	.59	.18	.11+04	31.9	1.63	.16-02	.10-02	.76-04	.16-03
34	24.8	.0	.5	16.	1.05	.266	.56	.15	.19+02	33.2	1.51	.59-03	.46-03	.12-04	.34-04
35	24.8	.0	.2	17.	.97	.262	.55	.09	.20+02	33.2	1.39	.47-03	.44-03	.18-05	.69-05
37	24.9	2.0	.0	3.	.31	.081	.20	.02	.61+03	34.6	.23	.94-02	.15-02	.31-04	.96-04
38	24.9	1.7	.0	3.	.33	.086	.21	.02	.27+04	34.4	.24	.46-02	.88-03	.75-05	.35-04
39	24.8	1.3	.0	3.	.33	.084	.21	.02	.69+04	34.6	.24	.17-02	.39-03	.38-06	.21-05
40	24.8	.9	.0	3.	.38	.093	.22	.02	.20+05	34.8	.27	.50-03	.15-03	.00	.00
41	24.8	1.1	.0	3.	.32	.082	.21	.02	.53+03	34.8	.22	.44-03	.14-03	.00	.00
42	24.8	.8	.0	3.	.34	.086	.21	.02	.32+05	34.7	.30	.41-03	.14-03	.00	.00
43	24.9	1.5	.0	4.	.36	.093	.23	.02	.33+04	34.1	.26	.21-02	.55-03	.82-05	.25-04
44	24.9	1.4	.0	4.	.39	.100	.25	.02	.11+04	33.8	.28	.85-03	.42-03	.30-04	.48-04
47	25.1	1.5	.0	4.	.35	.094	.23	.02	.35+02	34.6	.30	.63-02	.11-02	.77-05	.39-04
48	25.6	1.4	.0	3.	.37	.098	.24	.02	.14+03	34.6	.27	.37-02	.74-03	.15-05	.11-04
49	25.8	1.3	.0	4.	.45	.110	.24	.03	.24+03	34.7	.25	.20-02	.46-03	.77-07	.48-06
50	29.0	1.2	.0	4.	.49	.120	.26	.03	.28+04	34.4	.27	.14-02	.43-03	.20-05	.64-05
51	25.5	1.0	.0	4.	.44	.112	.26	.02	.38+04	34.2	.29	.12-02	.42-03	.27-05	.95-05
52	25.1	1.0	.0	4.	.42	.108	.25	.02	.93+03	34.4	.26	.71-03	.28-03	.14-06	.27-06
53	24.8	1.0	.0	4.	.49	.117	.25	.03	.14+03	34.3	.25	.34-03	.24-03	.30-05	.73-05
54	25.0	1.0	.0	4.	.60	.129	.29	.04	.53+03	33.7	.36	.74-03	.57-03	.49-04	.90-04
55	25.6	1.4	.0	6.	.69	.143	.36	.04	.26+04	31.3	.54	.13-02	.11-02	.11-03	.21-03
56	27.7	1.3	.0	4.	.50	.118	.26	.03	.15+04	34.5	.26	.15-02	.42-03	.11-05	.37-05
57	26.1	2.5	.0	3.	.79	.132	.24	.07	.19+03	34.8	.25	.16-02	.39-03	.00	.00

Appendix D

Estuary Model Input Quality Data
for April 1972

PEARL HARBOR HYDRAULICS - - 24 & 1/2 HOUR TIDE
APRIL 1972 -- SENSITIVITY ANALYSES
PEARL HARBOR QUALITY-- APRIL, 1972

FEDERAL WATER QUALITY ADMINISTRATION
DYNAMIC WATER QUALITY MODEL

******** FROM HYDRAULICS PROGRAM ********

START CYCLE	STOP CYCLE	TIME INTERVAL
2940	4410	60. SECONDS

STARTING CYCLE ON HYD. EXTRACT TAPE	INITIAL QUALITY CYCLE	TOTAL QUALITY CYCLES	*** OUTPUT INTERVALS *** CYCLES	HOURS	TIME INTERVAL IN QUALITY PROGRAM	CONSTANT FOR DIFFUSION COEFFICIENTS
2940	1	1440	96	2.00	.500 HOURS	2.500

THE FOLLOWING TAPE ASSIGNMENTS HAVE BEEN MADE

INTERNAL SCRATCH FILE	11
HYDRAULIC FILE FROM HYDRAULIC PROGRAM	12
RESTART FILE FOR ADDITIONAL SIMULATIONS	0
FILE CONTAINING RESTART DATA	0

PRINTOUT IS TO BEGIN AT CYCLE 1

QUALITY TAPE FOR EXTRACTING IS TO BEGIN AT CYCLE 96

THE FOLLOWING CONSTITUENTS ARE BEING CONSIDERED IN THIS RUN

CONSTITUENT NO.	CONSTITUENT
1	TEMPERATURE
2	DISSOLVED OXYGEN
3	CARBONACEOUS BOD
4	CHLOROPHYLL A
5	AMMONIA NITROGEN
6	NITRITE NITROGEN
7	NITRATE NITROGEN
8	PHOSPHATE PHOSPHORUS
9	COLIFORM BACTERIA
10	SALINITY
11	TOTAL NITROGEN
12	HEAVY METAL NO 1
13	HEAVY METAL NO 2
14	PESTICIDE NO 1
15	PESTICIDE NO 2

WEATHER DATA SUMMARY FOR WEATHER ZONE 1, JUNCTION 1 TO JUNCTION 57

LATITUDE 21.5

LONGITUDE 158.0

ATMOS TURBIDITY 2.0

DAY OF YEAR 105

CALCULATED NET RAD YES

EVAP A .000

EVAP B .154-08

INCOMING RADIATION (KCAL/M2/SEC)	WIND SPEED (M/SEC)	CLOUD COVER FRACTION	DRY BULB TEMPERATURE (C)	WET BULB TEMPERATURE (C)	ATMOSPHERIC PRESSURE (MB)	SHORT WAVE SOLAR(CALC) (KCAL/M2/SEC)	LONG WAVE SOLAR(CALC) (KCAL/M2/SEC)
.0826	2.1	.7	22.0	19.0	1010.	.0000	.0826
.0826	2.1	.7	21.0	19.0	1010.	.0000	.0826
.0950	2.2	.8	23.0	19.0	1010.	.0104	.0845
.1927	3.5	.8	26.0	20.0	1010.	.1064	.0863
.2499	3.5	.7	26.0	21.0	1010.	.1638	.0860
.1670	3.6	.8	25.0	21.0	1010.	.0789	.0881
.0863	2.8	.8	23.0	20.0	1010.	.0000	.0863
.0854	2.6	.8	22.0	19.5	1010.	.0000	.0854
.0826	2.6	.7	22.0	19.0	1010.	.0000	.0826

SPATIALLY VARYING COEFFICIENTS

JUNCTION	OXYGEN REAERATION 1/DAY	COLIFORM DECAY 1/DAY	BOD DECAY 1/DAY	AMMONIA DECAY 1/DAY	NITRITE DECAY 1/DAY	PESTICIDE DECAY NO 1 1/DAY	PESTICIDE DECAY NO 2 1/DAY	ALGAE GROWTH 1/DAY	ALGAE RESPIRATION 1/DAY	ALGAE SETTLING FT/DAY
1	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
2	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
3	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
4	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
5	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
6	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
7	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
8	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
9	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
10	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
11	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
12	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
13	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
14	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
15	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
16	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
17	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
18	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
19	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
20	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
21	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
22	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
23	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
24	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
25	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
26	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
27	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
28	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
29	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
30	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
31	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
32	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
33	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
34	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
35	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
36	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
37	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
38	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
39	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
40	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
41	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
42	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
43	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
44	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
45	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
46	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
47	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
48	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
49	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
50	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00

SPATIALLY VARYING COEFFICIENTS

JUNCTION	OXYGEN REAERATION 1/DAY	COLIFORM DECAY 1/DAY	BOD DECAY 1/DAY	AMMONIA DECAY 1/DAY	NITRITE DECAY 1/DAY	PESTICIDE DECAY NO 1 1/DAY	PESTICIDE DECAY NO 2 1/DAY	ALGAE GROWTH 1/DAY	ALGAE RESPIRATION 1/DAY	ALGAE SETTLING FT/DAY
51	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
52	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
53	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
54	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
55	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
56	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00
57	.10	.50	.10	.03	.09	.00	.00	2.00	.01	1.00

OTHER SPATIALLY VARYING COEFFICIENTS

JUNCTION	* * * * * HEAVY METALS NO 1 1/DAY	NO 2 1/DAY	SINK RATES * PESTICIDES NO 1 1/DAY	NO 2 1/DAY	* * * * PHOSPHATE 1/DAY	BENTHIC SOURCE RATES PHOSPHATE AS P MG/FT2	AMMONIA AS N MG/FT2	BENTHIC UPTAKE OF OXYGEN MG/FT2	SECHI DISC FT	RATIO OF CHLOROPHYLL A TO ALGAE
1	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
2	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
3	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
4	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
5	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
6	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
7	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
8	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
9	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
10	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
11	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
12	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
13	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
14	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
15	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
16	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
17	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
18	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
19	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
20	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
21	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
22	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
23	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
24	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
25	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
26	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
27	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
28	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
29	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
30	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
31	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
32	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
33	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
34	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
35	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
36	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
37	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
38	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
39	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
40	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
41	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
42	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
43	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
44	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
45	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
46	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
47	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
48	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
49	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
50	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020

OTHER SPATIALLY VARYING COEFFICIENTS

JUNCTION	* * * * * HEAVY METALS NO 1 1/DAY	NO 2 1/DAY	SINK RATES * PESTICIDES NO 1 1/DAY	NO 2 1/DAY	* * * * PHOSPHATE 1/DAY	BENTHIC SOURCE RATES PHOSPHATE AS P MG/FT2	AMMONIA AS N MG/FT2	BENTHIC UPTAKE OF OXYGEN MG/FT2	SECHI DISC FT	RATIO OF CHLOROPHYLL A TO ALGAE
51	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
52	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
53	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
54	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
55	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
56	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020
57	.500	.200	.050	.020	.200	.10	.50	2.00	2.5	.020

NON SPATIALLY VARYING SYSTEM COEFFICIENTS

Q10 TEMPERATURE COEFFICIENTS		
COLIFORM DIE OFF	1.047	
BOD DECAY	1.047	
AMMONIA DECAY	1.020	
NITRITE DECAY	1.020	
ORGANIC SEDIMENT DECAY	1.040	
PESTICIDE DECAY	1.047	
ALGAE GROWTH AND RESPIRATION	1.047	
STOICHIOMETRIC EQUIVALENCE BETWEEN OXYGEN AND		
NITRITE DECAY	1.200	
AMMONIA DECAY	3.500	
ALGAE RESPIRATION	2.100	
ALGAE GROWTH	1.600	
HALF-SATURATION CONSTANTS FOR ALGAE		
PHOSPHORUS, MG/L	.040	
NITROGEN, MG/L	.300	
LIGHT, KCAL/SQ METER/SEC	.005	
CHEMICAL COMPOSITION OF ALGAE		
PHOSPHORUS	.015	
NITROGEN	.090	
PESTICIDES	.001	
HEAVY METALS	.001	
PESTICIDE AND HEAVY METAL TOXICITY COEF		
K AND H FOR FIRST HEAVY METAL	1.000	.020
K AND H FOR SECOND HEAVY METAL	.500	.100
K AND H FOR FIRST PESTICIDE	2.000	.010
K AND H FOR SECOND PESTICIDE	5.000	.010
RATIO OF CHLOROPHYLL A TO ALGAE		
FOR ALL INFLOWS	.02	
FOR EXCHANGE	.02	

INITIAL CONDITIONS (MG/L EXCEPT AS NOTED)

JUNC	TEMP, C	OXY	BOD	CHLOR A	NH3	NO2	NO3	PO4	COLIF, MPN	TDS	TOT N	HEAVY MET 1 & 2		PEST 1 & 2	
1	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
2	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
3	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
4	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
5	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
6	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
7	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
8	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
9	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
10	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
11	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
12	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
13	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
14	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
15	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
16	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
17	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
18	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
19	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
20	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
21	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
22	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
23	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
24	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
25	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
26	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
27	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
28	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
29	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
30	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
31	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
32	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
33	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
34	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
35	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
36	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
37	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
38	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
39	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
40	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
41	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
42	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
43	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
44	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
45	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
46	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
47	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
48	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
49	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
50	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03

INITIAL CONDITIONS (MG/L EXCEPT AS NOTED)

JUNC	TEMP, C	OXY	BOD	CHLOR A	NH3	NO2	NO3	PO4	COLIF, MPN	TDS	TOT N	HEAVY MET 1 & 2		PEST 1 & 2	
51	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
52	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
53	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
54	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
55	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
56	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03
57	24.5	4.5	.5	.006	.03	.002	.03	.05	.20+05	33000.	.10	.20-03	.10-03	.20-03	.10-03

EXCHANGE WATER QUALITY

TEMPERATURE	24.80
DISSOLVED OXYGEN	7.000
CARBONACEOUS BOD	.2000
CHLOROPHYLL A	.1000-01
AMMONIA NITROGEN	.1000-01
NITRITE NITROGEN	.3000-02
NITRATE NITROGEN	.1600-01
PHOSPHATE PHOSPHORUS	.1600-01
COLIFORM BACTERIA	40.00
SALINITY	.3560+05
TOTAL NITROGEN	.2000-01
HEAVY METAL NO 1	.1000-02
HEAVY METAL NO 2	.2000-02
PESTICIDE NO 1	.1000-02
PESTICIDE NO 2	.5000-03

Appendix E

Estuary Model Hydraulic Results
for April and September 1972

APRIL 1972

***** SUMMARY OF HYDRAULIC INPUTS *****

** JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

*************************** CHANNEL DATA *****************************

CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS	
1	3540.	3330.	79116.	.020	-153.47	23.8	1	2
2	2500.	1460.	68120.	.020	-146.29	46.7	2	3
3	2550.	1250.	54332.	.020	-146.23	43.5	3	4
4	2500.	940.	39248.	.020	-79.82	41.8	4	5
5	3130.	1720.	74706.	.020	-66.32	43.4	4	25
6	2530.	830.	38755.	.020	-79.75	46.7	5	6
7	3750.	730.	36460.	.020	-79.67	49.9	6	7
8	2950.	1150.	48037.	.020	-79.56	41.8	7	8
9	2500.	1200.	44234.	.020	-79.35	36.9	8	10
10	2240.	630.	7665.	.025	-.07	12.2	8	9
11	1970.	1250.	33732.	.020	-16.88	27.0	10	12
12	2040.	940.	28449.	.025	-62.32	30.3	10	11
13	2040.	1200.	30435.	.020	-15.09	25.4	11	12
14	1740.	890.	18151.	.025	-47.16	20.4	11	18
15	1880.	1150.	17437.	.025	10.67	15.2	12	13
16	1950.	1140.	17737.	.020	21.66	15.6	12	17
17	2220.	1130.	21138.	.020	-64.17	18.7	12	18
18	2670.	780.	13357.	.022	552.31	17.1	24	50
19	1880.	730.	4160.	.025	7.28	5.7	13	14
20	2290.	1130.	11238.	.020	-7.37	9.9	13	16
21	1980.	1110.	13639.	.020	10.87	12.3	13	17
22	1950.	1040.	3443.	.025	.79	3.3	14	15
23	2080.	1100.	9839.	.020	6.57	8.9	14	16
24	1740.	1150.	4637.	.025	.87	4.0	15	16
25	1770.	520.	4672.	.030	.17	9.0	16	17
26	1490.	520.	4672.	.030	-1.29	9.0	17	20
27	1830.	1040.	16143.	.020	34.06	15.5	17	18
28	2500.	1040.	16143.	.020	-91.99	15.5	18	20
29	1790.	1040.	9343.	.025	14.83	9.0	18	19
30	2570.	1250.	11232.	.020	15.61	9.0	19	20
31	2140.	630.	2966.	.030	-.69	4.7	19	22
32	2390.	1350.	11125.	.025	-12.18	8.2	20	21
33	2240.	1350.	13426.	.020	-65.33	9.9	20	22
34	2520.	1150.	6637.	.025	1.16	5.7	21	23
35	2660.	1300.	10329.	.020	-13.17	7.9	21	22
36	1880.	1150.	7637.	.030	-1.26	6.6	22	23
37	2530.	1350.	58626.	.020	-66.20	13.4	25	26
38	3070.	1800.	69296.	.020	66.25	36.9	26	27
39	3010.	1040.	48542.	.020	-132.29	46.7	26	37
40	2950.	1460.	60920.	.020	39.48	41.7	27	28
41	3630.	1150.	48037.	.020	26.99	41.8	27	47
42	2340.	1250.	46032.	.020	24.78	36.8	28	29
43	2390.	1250.	46032.	.020	-68.22	36.8	28	31
44	2570.	1350.	56326.	.020	83.08	41.7	28	47
45	2250.	1770.	30336.	.020	250.00	17.1	29	30
46	2450.	1350.	51925.	.018	-225.09	38.5	29	31
47	2440.	1460.	25019.	.025	90.79	17.1	30	32
48	2530.	1460.	49019.	.018	-31.95	33.6	30	33

************** JUNCTION DATA ************

JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION						
1	.0	-.06	1	0	0	0	0	0	0
2	7.1	-.05	1	2	0	0	0	0	0
3	.0	-.05	2	3	0	0	0	0	0
4	.0	-.05	3	4	5	0	0	0	0
5	.0	-.05	4	6	0	0	0	0	0
6	.0	-.05	6	7	0	0	0	0	0
7	.0	-.05	7	8	0	0	0	0	0
8	.0	-.05	8	9	10	0	0	0	0
9	.0	-.05	10	0	0	0	0	0	0
10	.0	-.05	9	11	12	0	0	0	0
11	.0	-.05	12	13	14	0	0	0	0
12	.0	-.05	11	15	16	17	13	0	0
13	.0	-.05	15	19	20	21	0	0	0
14	.0	-.05	19	22	23	0	0	0	0
15	.0	-.05	22	24	0	0	0	0	0
16	.0	-.05	20	23	24	25	0	0	0
17	.0	-.05	16	21	25	26	27	0	0
18	.0	-.05	14	17	27	28	29	0	0
19	.0	-.05	29	30	31	0	0	0	0
20	.0	-.05	26	32	33	30	28	0	0
21	.0	-.05	32	34	35	0	0	0	0
22	77.8	-.05	31	33	35	36	0	0	0
23	.0	-.05	34	36	0	0	0	0	0
24	570.8	-.05	18	91	0	0	0	0	0
25	.0	-.05	5	37	0	0	0	0	0
26	.0	-.05	37	38	39	0	0	0	0
27	.0	-.05	38	40	41	0	0	0	0
28	.0	-.05	40	42	43	44	0	0	0
29	.0	-.05	42	45	46	0	0	0	0
30	.0	-.05	45	47	48	49	0	0	0
31	.0	-.05	43	46	49	50	0	0	0
32	14.7	-.05	47	51	52	53	0	0	0
33	27.8	-.05	48	53	54	50	0	0	0
34	.0	-.05	51	55	56	0	0	0	0
35	.0	-.05	55	57	0	0	0	0	0
36	.0	-.05	52	56	57	54	0	0	0
37	.0	-.05	39	58	0	0	0	0	0
38	.0	-.05	58	59	60	0	0	0	0
39	.0	-.05	60	61	62	63	0	0	0
40	.0	-.05	61	0	0	0	0	0	0
41	.0	-.05	62	0	0	0	0	0	0
42	.0	-.05	63	0	0	0	0	0	0
43	.0	-.05	59	64	65	0	0	0	0
44	9.6	-.05	65	66	67	68	0	0	0
45	.0	-.05	64	69	70	71	66	0	0
46	.0	-.05	69	72	73	74	75	0	0
47	.0	-.05	41	44	76	72	0	0	0
48	.0	-.05	73	76	77	78	0	0	0

REAERATION RATE CONSTANT = 0.10

49	2640.	1350.	47626.	.018	191.32	35.3	30	31
50	2390.	1300.	41528.	.020	-101.84	31.9	31	33
51	2640.	1040.	22942.	.025	15.93	22.1	32	34
52	2460.	1330.	31027.	.025	16.97	23.3	32	36
53	2650.	1430.	33921.	.025	72.75	23.7	32	33
54	2290.	1040.	23942.	.020	-33.11	23.0	33	36
55	1700.	1040.	24242.	.025	-25.14	23.3	34	35
56	2080.	1150.	26837.	.020	41.15	23.3	34	36
57	1520.	940.	16148.	.020	-25.10	17.2	35	36
58	2640.	1460.	68119.	.020	-132.15	46.7	37	38
59	2520.	2190.	91379.	.020	-131.78	41.7	38	43
60	2350.	1150.	48037.	.025	-.18	41.8	38	39
61	2160.	630.	19865.	.025	-.04	31.5	39	40
62	2400.	520.	18972.	.025	-.03	36.5	39	41
63	2380.	570.	23769.	.025	-.02	41.7	39	42
64	2330.	1560.	34414.	.020	245.66	22.1	43	45
65	2680.	1150.	48037.	.020	-377.26	41.8	43	44
66	2400.	1410.	56623.	.018	-259.34	40.2	44	45
67	2190.	1340.	49326.	.020	-135.01	36.8	44	52
68	2990.	940.	19249.	.025	26.85	24.5	44	53
69	3170.	1350.	27626.	.020	-2.92	20.5	45	46
70	2660.	1560.	57514.	.018	-38.18	36.9	45	51
71	2350.	1390.	55824.	.018	27.59	40.2	45	52
72	3400.	1040.	41743.	.020	-67.67	40.1	46	47
73	2980.	1610.	67211.	.018	10.59	41.7	46	48
74	2580.	1580.	65913.	.018	-39.88	41.7	46	50
75	2590.	1560.	57514.	.018	84.26	36.9	46	51
76	2730.	1350.	56325.	.020	52.60	41.7	47	48
77	2360.	940.	34649.	.020	79.65	36.9	48	49
78	2590.	1520.	58417.	.018	-16.33	38.4	48	50
79	1630.	1250.	4231.	.025	2.57	3.4	49	57
80	2550.	1300.	9528.	.020	176.37	7.3	49	56
81	2960.	1560.	57514.	.018	-99.17	36.9	49	50
82	2670.	780.	13357.	.022	391.74	17.1	50	56
83	2330.	1450.	24820.	.020	-29.02	17.1	50	55
84	2990.	1510.	55617.	.018	34.41	36.9	50	51
85	2500.	1460.	25019.	.020	-3.13	17.1	51	55
86	2550.	1470.	30020.	.020	-34.94	20.4	51	54
87	2770.	1460.	56119.	.018	118.75	38.4	51	52
88	2180.	890.	6551.	.025	38.43	7.4	52	54
89	2140.	1250.	21431.	.025	-26.98	17.1	52	53
90	3230.	990.	5546.	.025	6.19	5.6	54	55
91	2900.	830.	2254.	.025	18.54	2.7	55	24
92	2000.	630.	1466.	.025	-2.62	2.3	56	57

49	.0	-.05	77	79	80	81	0	0	0
50	.0	-.05	74	78	81	82	83	84	18
51	.0	-.05	70	75	84	85	86	87	0
52	.0	-.05	67	71	87	88	89	0	0
53	.0	-.05	68	89	0	0	0	0	0
54	2.6	-.05	86	90	88	0	0	0	0
55	7.3	-.05	83	91	90	85	0	0	0
56	-570.8	-.05	80	92	82	0	0	0	0
57	.0	-.05	79	92	0	0	0	0	0

SEPTEMBER 1972

***** SUMMARY OF HYDRAULIC INPUTS *****

** JUNCTION HEAD AND HYD. RADIUS AND X-SECTIONAL AREA OF CHANNELS ARE AT MEAN TIDE **

***************************** CHANNEL DATA *****************************

CHAN.	LENGTH	WIDTH	AREA	MANNING	NET FLOW	HYD. RADIUS	JUNC. AT ENDS	
1	3540.	3330.	78703.	.020	-35.95	23.6	1	2
2	2500.	1460.	67939.	.020	-27.05	46.5	2	3
3	2550.	1250.	54177.	.020	-27.35	43.3	3	4
4	2600.	940.	39132.	.020	-8.01	41.6	4	5
5	3130.	1720.	74492.	.020	-22.82	43.3	4	25
6	2530.	830.	38652.	.020	-5.33	46.6	5	6
7	3750.	730.	36369.	.020	-5.74	49.8	6	7
8	2950.	1150.	47895.	.020	-6.33	41.6	7	8
9	2500.	1200.	44085.	.020	-7.39	36.7	8	10
10	2240.	630.	7587.	.025	.38	12.0	8	9
11	1970.	1250.	33577.	.020	44.19	26.9	10	12
12	2040.	940.	28332.	.025	-52.32	30.1	10	11
13	2040.	1200.	30286.	.020	-27.85	25.2	11	12
14	1740.	890.	18041.	.025	-24.85	20.3	11	18
15	1880.	1150.	17295.	.025	41.05	15.0	12	13
16	1950.	1140.	17596.	.020	57.26	15.4	12	17
17	2220.	1130.	20998.	.020	-82.64	18.6	12	18
18	2670.	780.	13260.	.022	627.23	17.0	24	50
19	1880.	730.	4070.	.025	10.07	5.6	13	14
20	2290.	1130.	11098.	.020	-13.01	9.8	13	16
21	1980.	1110.	13502.	.020	43.47	12.2	13	17
22	1960.	1040.	3314.	.025	1.01	3.2	14	15
23	2080.	1100.	9703.	.020	8.68	8.8	14	16
24	1740.	1150.	4494.	.025	.60	3.9	15	16
25	1770.	520.	4607.	.030	-4.30	8.9	16	17
26	1490.	520.	4607.	.030	3.75	8.9	17	20
27	1830.	1040.	16014.	.020	92.34	15.4	17	18
28	2500.	1040.	16014.	.020	-55.51	15.4	18	20
29	1790.	1040.	9214.	.025	39.83	8.9	18	19
30	2570.	1250.	11077.	.020	41.37	8.9	19	20
31	2140.	630.	2888.	.030	-2.06	4.6	19	22
32	2390.	1350.	10958.	.025	10.75	8.1	20	21
33	2240.	1350.	13259.	.020	-21.96	9.8	20	22
34	2520.	1150.	6395.	.025	1.48	5.6	21	23
35	2660.	1300.	10168.	.020	8.38	7.8	21	22
36	1880.	1150.	7495.	.030	-.99	6.5	22	23
37	2530.	1350.	58459.	.020	-23.40	43.3	25	26
38	3070.	1880.	69064.	.020	193.52	36.7	26	27
39	3010.	1040.	48413.	.020	-217.73	46.6	26	37
40	2950.	1460.	60739.	.020	105.95	41.6	27	28
41	3630.	1150.	47894.	.020	86.48	41.6	27	47
42	2340.	1250.	45877.	.020	70.26	36.7	28	29
43	2390.	1250.	45877.	.020	-90.12	36.7	28	31
44	2570.	1350.	56159.	.020	125.01	41.6	28	47
45	2250.	1770.	30116.	.020	496.98	17.0	29	30
46	2450.	1350.	51/58.	.018	-427.36	38.3	29	31
47	2440.	1460.	24839.	.025	183.60	17.0	30	32
48	2530.	1460.	48838.	.018	-53.48	33.5	30	33

*************** JUNCTION DATA *************

JUNC.	INFLOW	HEAD	CHANNELS ENTERING JUNCTION						
1	.0	-.18	1	0	0	0	0	0	0
2	9.2	-.18	1	2	0	0	0	0	0
3	.0	-.18	2	3	0	0	0	0	0
4	.0	-.18	3	4	5	0	0	0	0
5	.0	-.18	4	6	0	0	0	0	0
6	.0	-.18	6	7	0	0	0	0	0
7	.0	-.18	7	8	0	0	0	0	0
8	.0	-.18	8	9	10	0	0	0	0
9	.0	-.18	10	0	0	0	0	0	0
10	.0	-.18	9	11	12	0	0	0	0
11	.0	-.18	12	13	14	0	0	0	0
12	.0	-.18	11	15	16	17	13	0	0
13	.0	-.18	15	19	20	21	0	0	0
14	.0	-.18	19	22	23	0	0	0	0
15	.0	-.18	22	24	0	0	0	0	0
16	.0	-.18	20	23	24	25	0	0	0
17	.0	-.18	16	21	25	26	27	0	0
18	.0	-.18	14	17	27	28	29	0	0
19	.0	-.18	29	30	31	0	0	0	0
20	.0	-.18	26	32	33	30	28	0	0
21	.0	-.18	32	34	35	0	0	0	0
22	15.3	-.18	31	33	35	36	0	0	0
23	.0	-.18	34	36	0	0	0	0	0
24	646.6	-.18	18	91	0	0	0	0	0
25	.0	-.18	5	37	0	0	0	0	0
26	.0	-.18	37	38	39	0	0	0	0
27	.0	-.18	38	40	41	0	0	0	0
28	.0	-.18	40	42	43	44	0	0	0
29	.0	-.18	42	45	46	0	0	0	0
30	.0	-.18	45	47	48	49	0	0	0
31	.0	-.18	43	46	49	50	0	0	0
32	12.5	-.18	47	51	52	53	0	0	0
33	12.0	-.18	48	53	54	50	0	0	0
34	.0	-.18	51	55	56	0	0	0	0
35	.0	-.18	55	57	0	0	0	0	0
36	.0	-.18	52	56	57	54	0	0	0
37	.0	-.18	39	58	0	0	0	0	0
38	.0	-.18	58	59	60	0	0	0	0
39	.0	-.18	60	61	62	63	0	0	0
40	.0	-.18	61	0	0	0	0	0	0
41	.0	-.18	62	0	0	0	0	0	0
42	.0	-.18	63	0	0	0	0	0	0
43	.0	-.18	59	64	65	0	0	0	0
44	9.8	-.18	65	66	67	68	0	0	0
45	.0	-.18	64	69	70	71	66	0	0
46	.0	-.18	69	72	73	74	75	0	0
47	.0	-.18	41	44	76	72	0	0	0
48	.0	-.18	73	76	77	78	0	0	0

49	2640.	1350.	47458.	.018	366.05	35.2	30	31
50	2390.	1300.	41367.	.020	-152.15	31.8	31	33
51	2640.	1040.	22814.	.025	20.72	21.9	32	34
52	2460.	1330.	30862.	.025	41.18	23.2	32	36
53	2650.	1430.	33744.	.025	133.44	23.6	32	33
54	2290.	1040.	23814.	.020	-60.86	22.9	33	36
55	1700.	1040.	24114.	.025	-58.42	23.2	34	35
56	2080.	1150.	26695.	.020	78.72	23.2	34	36
57	1520.	940.	16031.	.020	-58.63	17.1	35	36
58	2640.	1460.	67939.	.020	-218.43	46.5	37	38
59	2520.	2190.	91108.	.020	-220.29	41.6	38	43
60	2350.	1150.	47894.	.025	.92	41.6	38	39
61	2160.	630.	19787.	.025	.20	31.4	39	40
62	2400.	520.	18907.	.025	.14	36.4	39	41
63	2380.	570.	23698.	.025	.10	41.6	39	42
64	2330.	1560.	34221.	.020	484.00	21.9	43	45
65	2680.	1150.	47894.	.020	-705.17	41.6	43	44
66	2400.	1410.	56448.	.018	-491.13	40.0	44	45
67	2190.	1340.	49160.	.020	-255.21	36.7	44	52
68	2990.	940.	19132.	.025	50.18	20.4	44	53
69	3170.	1350.	27458.	.020	34.20	20.3	45	46
70	2660.	1560.	57321.	.018	-79.90	36.7	45	51
71	2350.	1390.	55652.	.018	37.68	40.0	45	52
72	3400.	1040.	41614.	.020	-117.93	40.0	46	47
73	2980.	1610.	67012.	.018	34.25	41.6	46	48
74	2580.	1580.	65717.	.018	-70.29	41.6	46	50
75	2590.	1560.	57321.	.018	187.13	36.7	46	51
76	2730.	1350.	56158.	.020	92.60	41.6	47	48
77	2360.	940.	34532.	.020	108.96	36.7	48	49
78	2590.	1520.	58228.	.018	17.24	38.3	48	50
79	1630.	1250.	4076.	.025	1.18	3.3	49	57
80	2550.	1300.	9367.	.020	213.55	7.2	19	56
81	2960.	1560.	57321.	.018	-106.41	36.7	49	50
82	2670.	780.	13260.	.022	432.44	17.0	50	56
83	2330.	1450.	24641.	.020	-46.39	17.0	50	55
84	2990.	1510.	55430.	.018	80.73	36.7	50	51
85	2500.	1460.	24839.	.020	9.78	17.0	51	55
86	2550.	1470.	29837.	.020	-46.36	20.3	51	54
87	2770.	1460.	55938.	.018	223.56	38.3	51	52
88	2180.	890.	6441.	.025	55.00	7.2	52	54
89	2140.	1250.	21276.	.025	-49.56	17.0	52	53
90	3230.	990.	5423.	.025	10.88	5.5	54	55
91	2900.	830.	2151.	.025	19.12	2.6	55	24
92	2000.	630.	1388.	.025	-.95	2.2	56	57

49	.0	-.18	77	79	80	81	0	0	0
50	.0	-.18	74	78	81	82	83	84	18
51	.0	-.18	70	75	84	85	86	87	0
52	.0	-.18	67	71	87	88	89	0	0
53	.0	-.18	68	89	0	0	0	0	0
54	2.7	-.18	86	90	88	0	0	0	0
55	7.2	-.18	83	91	90	85	0	0	0
56	-646.6	-.18	80	92	82	0	0	0	0
57	.0	-.18	79	92	0	0	0	0	0

Appendix F

Estuary Model Sensitivity Analyses Results

1. Reaeration Rate Constant = 0.2
2. Reaeration Rate Constant = 1.0
3. Reaeration Rate Constant = $(D_M V)^{0.5}/D^{1.5}$
4. BOD Decay = 0.2 and Coliform Dieoff = 1.0
5. BOD Decay = 0.05 and Coliform Dieoff = 0.25
6. Quality Model Time Step = 1/4 hour
7. Manning's n = 0.8 X Base N
8. Manning's n = 1.2 X Base N
9. Stream Flow = 2.0 X Base Q
10. Stream Flow = 0.5 X Base Q

REAERATION RATE CONSTANT = 1.0

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.8	.2	8.	.13	.026	.10	.04	.18+02	34.9	.13	.78-03	.16-02	.41-03	.28-03
2	24.9	6.8	.1	7.	.21	.043	.15	.05	.12+02	34.2	.20	.63-03	.13-02	.16-03	.16-03
4	24.9	6.8	.1	5.	.27	.066	.17	.03	.29+02	33.5	.20	.53-03	.94-03	.32-04	.50-04
5	24.9	6.8	.0	5.	.31	.081	.19	.02	.62+01	32.8	.22	.40-03	.79-03	.14-04	.27-04
7	24.9	6.9	.0	7.	.42	.116	.25	.02	.21+01	31.2	.31	.37-03	.71-03	.88-06	.43-05
8	24.9	6.9	.0	9.	.52	.139	.28	.02	.49+01	30.0	.40	.47-03	.84-03	.11-05	.75-05
9	25.1	6.8	.0	5.	.67	.155	.26	.04	.52+00	31.3	.26	.24-03	.46-03	.00	.00
10	24.9	7.0	.0	13.	.63	.165	.32	.03	.16+02	28.4	.53	.67-03	.11-02	.41-05	.23-04
11	25.0	7.2	.0	21.	.76	.190	.35	.04	.59+02	25.9	.73	.11-02	.16-02	.17-04	.73-04
12	25.0	7.1	.0	19.	.78	.194	.34	.04	.45+02	26.7	.66	.92-03	.14-02	.13-04	.54-04
14	25.3	6.9	.0	16.	1.21	.263	.33	.07	.35+01	28.6	.47	.50-03	.86-03	.00	.00
15	25.6	6.8	.0	15.	1.47	.295	.33	.10	.31+01	28.8	.44	.46-03	.80-03	.00	.00
17	25.1	7.3	.0	27.	.94	.219	.35	.06	.15+03	24.5	.84	.13-02	.19-02	.43-04	.13-03
18	25.0	7.5	.0	37.	.96	.220	.36	.06	.26+03	21.7	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	7.9	.1	47.	1.08	.228	.36	.08	.51+03	19.5	1.28	.23-02	.31-02	.15-03	.35-03
20	25.1	8.1	.1	55.	1.14	.233	.38	.10	.90+03	16.8	1.52	.30-02	.39-02	.26-03	.55-03
21	25.2	8.4	.1	71.	1.32	.278	.25	.08	.37+03	16.0	1.58	.27-02	.38-02	.97-04	.29-03
22	25.0	9.0	.1	60.	1.20	.176	.59	.24	.44+04	8.5	2.26	.57-02	.65-02	.12-02	.18-02
23	25.2	8.9	.1	84.	1.47	.285	.20	.11	.71+03	11.9	1.95	.37-02	.48-02	.19-03	.50-03
24	35.3	6.3	.0	3.	.56	.125	.20	.04	.65+03	32.5	.15	.22-03	.27-03	.00	.00
25	25.0	6.8	.1	4.	.28	.070	.16	.02	.78+02	33.3	.19	.59-03	.89-03	.15-04	.29-04
26	25.0	6.8	.0	4.	.30	.077	.17	.02	.18+03	33.0	.19	.70-03	.87-03	.51-05	.13-04
27	25.1	6.8	.1	3.	.33	.085	.18	.02	.49+02	32.7	.23	.12-02	.12-02	.16-05	.58-05
28	25.0	6.8	.1	3.	.38	.100	.22	.02	.96+02	31.9	.35	.30-02	.24-02	.23-05	.10-04
29	25.0	6.8	.1	3.	.42	.110	.25	.02	.10+03	31.3	.44	.41-02	.33-02	.26-05	.11-04
30	24.9	6.8	.4	4.	.51	.129	.30	.04	.63+03	30.6	.61	.56-02	.42-02	.11-04	.31-04
31	24.9	6.9	.4	4.	.51	.132	.32	.04	.66+03	30.1	.69	.79-02	.56-02	.19-04	.52-04
32	24.3	6.4	4.1	9.	1.09	.207	.76	.38	.15+05	28.0	2.00	.42-02	.35-02	.99-04	.19-03
33	24.7	6.8	1.1	5.	.74	.171	.47	.10	.51+04	27.0	1.30	.20-01	.12-01	.14-03	.26-03
34	24.8	6.7	1.0	8.	.76	.193	.51	.08	.96+03	30.4	1.06	.18-02	.17-02	.57-05	.20-04
35	24.9	6.8	.4	5.	.67	.174	.40	.04	.13+03	30.5	.75	.37-02	.31-02	.95-06	.43-05
37	25.0	6.8	.0	3.	.30	.079	.16	.02	.92+03	32.9	.17	.37-03	.53-03	.13-05	.44-05
38	25.0	6.8	.0	3.	.32	.084	.16	.02	.30+04	32.6	.17	.25-03	.36-03	.13-05	.44-05
39	24.9	6.8	.0	3.	.32	.082	.15	.02	.72+04	32.8	.15	.10-03	.16-03	.00	.00
40	24.9	6.8	.1	2.	.38	.093	.15	.02	.21+05	32.9	.17	.51-04	.73-04	.00	.00
41	24.9	6.8	.0	2.	.32	.081	.14	.02	.38+03	32.9	.12	.44-04	.64-04	.00	.00
42	24.9	6.8	.1	3.	.34	.085	.14	.02	.32+05	32.9	.21	.50-04	.70-04	.00	.00
43	25.1	6.8	.0	3.	.36	.091	.16	.02	.34+04	32.2	.19	.22-03	.32-03	.70-05	.17-04
44	25.2	6.8	.0	3.	.40	.099	.17	.02	.96+03	31.8	.22	.29-03	.38-03	.32-04	.56-04
47	25.6	6.8	.0	3.	.34	.090	.18	.02	.41+02	32.7	.19	.88-03	.88-03	.12-07	.61-07
48	26.6	6.7	.0	3.	.38	.099	.18	.02	.21+03	32.7	.16	.48-03	.53-03	.00	.00
49	26.9	6.6	.0	3.	.47	.115	.19	.03	.19+03	32.7	.14	.26-03	.30-03	.00	.00
50	31.3	6.4	.0	3.	.52	.127	.22	.03	.26+04	32.3	.17	.24-03	.30-03	.23-05	.59-06
51	25.9	6.7	.0	3.	.45	.115	.21	.02	.39+04	32.1	.20	.25-03	.34-03	.42-05	.13-04
52	25.3	6.8	.0	2.	.42	.107	.18	.02	.66+03	32.4	.17	.14-03	.20-03	.24-06	.70-06
53	25.1	6.8	.0	2.	.51	.120	.18	.03	.84+02	32.2	.17	.14-03	.21-03	.24-05	.74-05
54	25.3	6.8	.0	3.	.63	.135	.23	.04	.39+03	31.4	.30	.47-03	.59-03	.51-04	.99-04
55	26.7	6.7	.0	5.	.74	.154	.34	.04	.24+04	28.7	.49	.98-03	.12-02	.12-03	.23-03
56	29.5	6.4	.0	3.	.53	.124	.21	.03	.13+04	32.5	.16	.23-03	.29-03	.75-06	.23-05
57	26.5	6.2	.0	2.	.92	.147	.19	.09	.10+03	32.6	.14	.20-03	.24-03	.00	.00

REAERATION RATE CONSTANT = $(D_M V)^{0.5}/D^{1.5}$

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	5.8	.2	8.	.13	.026	.10	.04	.18+02	34.9	.13	.78-03	.16-02	.41-03	.28-03
2	24.9	4.9	.1	7.	.21	.043	.15	.05	.12+02	34.2	.20	.63-03	.13-02	.16-03	.16-03
4	24.9	3.8	.1	5.	.27	.066	.17	.03	.29+02	33.5	.20	.53-03	.94-03	.32-04	.50-04
5	24.9	3.5	.0	5.	.31	.081	.19	.02	.62+01	32.8	.22	.40-03	.79-03	.14-04	.27-04
7	24.9	3.1	.0	7.	.42	.116	.25	.02	.21+01	31.2	.31	.37-03	.71-03	.88-06	.43-05
8	24.9	3.1	.0	9.	.52	.139	.28	.02	.49+01	30.0	.40	.47-03	.84-03	.11-05	.75-05
9	25.1	2.4	.0	5.	.67	.155	.26	.04	.52+00	31.3	.26	.24-03	.46-03	.00	.00
10	24.9	3.4	.0	13.	.63	.165	.32	.03	.16+02	28.4	.53	.67-03	.11-02	.41-05	.23-04
11	25.0	4.2	.0	21.	.76	.190	.35	.04	.59+02	25.9	.73	.11-02	.16-02	.17-04	.73-04
12	25.0	3.9	.0	19.	.78	.194	.34	.04	.45+02	26.7	.66	.92-03	.14-02	.13-04	.54-04
14	25.3	3.4	.0	16.	1.21	.263	.33	.07	.35+01	28.6	.47	.50-03	.86-03	.00	.00
15	25.6	4.0	.0	15.	1.47	.295	.33	.10	.31+01	28.8	.44	.46-03	.80-03	.00	.00
17	25.1	4.9	.0	27.	.94	.219	.35	.06	.15+03	24.5	.84	.13-02	.19-02	.43-04	.13-03
18	25.0	6.1	.0	37.	.96	.220	.36	.06	.26+03	21.7	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	7.3	.1	47.	1.08	.228	.36	.08	.51+03	19.5	1.28	.23-02	.31-02	.15-03	.35-03
20	25.1	8.4	.1	55.	1.14	.233	.38	.10	.90+03	16.8	1.52	.30-02	.39-02	.26-03	.55-03
21	25.2	10.0	.1	71.	1.32	.278	.25	.08	.37+03	16.0	1.58	.27-02	.38-02	.97-04	.29-03
22	25.0	10.4	.1	60.	1.20	.176	.59	.24	.44+04	8.5	2.26	.57-02	.65-02	.12-02	.18-02
23	25.2	11.8	.1	84.	1.47	.285	.20	.11	.71+03	11.9	1.95	.37-02	.48-02	.19-03	.50-03
24	35.3	1.4	.0	3.	.56	.125	.20	.04	.65+03	32.5	.15	.22-03	.27-03	.00	.00
25	25.0	3.3	.1	4.	.28	.070	.16	.02	.78+02	33.3	.19	.59-03	.89-03	.15-04	.29-04
26	25.0	2.8	.0	4.	.30	.077	.17	.02	.18+03	33.0	.19	.70-03	.87-03	.51-05	.13-04
27	25.1	2.3	.1	3.	.33	.085	.18	.02	.49+02	32.7	.23	.12-02	.12-02	.16-05	.58-05
28	25.0	1.6	.1	3.	.38	.100	.22	.02	.96+02	31.9	.35	.30-02	.24-02	.25-05	.10-04
29	25.0	1.0	.1	3.	.42	.110	.25	.02	.10+03	31.3	.44	.41-02	.33-02	.26-05	.11-04
30	24.9	.4	.4	4.	.51	.129	.30	.04	.63+03	30.6	.61	.56-02	.42-02	.11-04	.31-04
31	24.9	.4	.4	4.	.51	.132	.32	.04	.66+03	30.1	.69	.79-02	.56-02	.19-04	.52-04
32	24.3	.0	4.1	9.	1.09	.207	.76	.38	.15+05	28.0	2.00	.42-02	.35-02	.99-04	.19-03
33	24.7	.0	1.1	5.	.74	.171	.47	.10	.51+04	27.0	1.30	.20-01	.12-01	.14-03	.26-03
34	24.8	.0	1.0	8.	.76	.193	.51	.08	.96+03	30.4	1.06	.18-02	.17-02	.57-05	.20-04
35	24.9	.0	.4	6.	.67	.174	.40	.04	.13+03	30.5	.75	.37-02	.31-02	.95-06	.43-05
37	25.0	2.5	.0	3.	.30	.079	.16	.02	.92+03	32.9	.17	.37-03	.53-03	.13-05	.44-05
38	25.0	2.1	.0	3.	.32	.084	.16	.02	.30+04	32.6	.17	.25-03	.36-03	.13-05	.44-05
39	24.9	1.7	.0	3.	.32	.082	.15	.02	.72+04	32.8	.15	.10-03	.16-03	.00	.00
40	24.9	1.2	.1	2.	.38	.093	.15	.02	.21+05	32.9	.17	.51-04	.73-04	.00	.00
41	24.9	1.5	.0	2.	.32	.081	.14	.02	.38+03	32.9	.12	.44-04	.64-04	.00	.00
42	24.9	1.3	.1	3.	.34	.085	.14	.02	.32+05	32.9	.21	.50-04	.70-04	.00	.00
43	25.1	1.8	.0	3.	.36	.091	.16	.02	.34+04	32.2	.19	.22-03	.32-03	.70-05	.17-04
44	25.2	1.6	.0	3.	.40	.099	.17	.02	.96+03	31.8	.22	.29-03	.38-03	.32-04	.56-04
47	25.6	1.9	.0	3.	.34	.090	.18	.02	.41+02	32.7	.19	.88-03	.88-03	.12-07	.61-07
48	26.6	1.6	.0	3.	.38	.099	.18	.02	.21+03	32.7	.16	.48-03	.53-03	.00	.00
49	26.9	1.4	.0	3.	.47	.115	.19	.03	.19+03	32.7	.14	.26-03	.30-03	.00	.00
50	31.3	1.2	.0	3.	.52	.127	.22	.03	.26+04	32.3	.17	.24-03	.30-03	.23-05	.59-05
51	25.9	1.1	.0	3.	.45	.115	.21	.02	.39+04	32.1	.20	.25-03	.34-03	.42-05	.13-04
52	25.3	1.2	.0	2.	.42	.107	.18	.02	.66+03	32.4	.17	.14-03	.20-03	.24-06	.70-06
53	25.1	1.0	.0	2.	.51	.120	.18	.03	.84+02	32.2	.17	.14-03	.21-03	.24-05	.74-05
54	25.3	1.0	.0	3.	.63	.135	.23	.04	.39+03	31.4	.30	.47-03	.59-03	.51-04	.99-04
55	26.7	1.3	.0	5.	.74	.154	.34	.04	.24+04	28.7	.49	.98-03	.12-02	.12-03	.23-03
56	29.5	1.3	.0	3.	.53	.124	.21	.03	.13+04	32.5	.16	.23-03	.29-03	.75-06	.23-05
57	26.5	2.6	.0	2.	.92	.147	.19	.09	.10+03	32.6	.14	.20-03	.24-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1421

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.1	8.	.13	.026	.10	.04	.11+02	34.9	.13	.78-03	.16-02	.41-03	.28-03
2	24.9	6.2	.1	7.	.21	.043	.15	.05	.33+01	34.2	.20	.63-03	.13-02	.16-03	.16-03
4	24.9	6.0	.0	5.	.27	.066	.17	.03	.42+01	33.5	.20	.53-03	.94-03	.32-04	.50-04
5	24.9	6.0	.0	5.	.31	.081	.19	.02	.45+00	32.8	.22	.40-03	.79-03	.14-04	.27-04
7	24.9	5.9	.0	7.	.42	.116	.25	.02	.95-01	31.2	.31	.37-03	.71-03	.88-06	.43-05
8	24.9	5.9	.0	9.	.52	.139	.28	.02	.37+00	30.0	.40	.47-03	.84-03	.11-05	.75-05
9	25.1	5.2	.0	5.	.67	.155	.26	.04	.16-01	31.3	.26	.24-03	.46-03	.00	.00
10	24.9	6.0	.0	13.	.63	.165	.32	.03	.19+01	28.4	.53	.67-03	.11-02	.41-05	.23-04
11	25.0	6.4	.0	21.	.76	.190	.35	.04	.11+02	25.9	.73	.11-02	.16-02	.17-04	.73-04
12	25.0	6.2	.0	19.	.78	.194	.34	.04	.82+01	26.7	.66	.92-03	.14-02	.13-04	.54-04
14	25.3	4.8	.0	16.	1.21	.263	.33	.07	.22+00	28.6	.47	.59-03	.86-03	.00	.00
15	25.6	4.1	.0	15.	1.47	.295	.33	.10	.22+00	28.8	.44	.46-03	.86-03	.00	.00
17	25.1	6.6	.0	27.	.94	.219	.35	.06	.42+02	24.5	.84	.13-02	.19-02	.43-04	.13-03
18	25.0	7.5	.0	37.	.96	.220	.36	.06	.78+02	21.7	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	8.3	.0	47.	1.08	.228	.36	.08	.21+03	19.5	1.28	.23-02	.31-02	.15-03	.35-03
20	25.1	9.1	.0	55.	1.14	.233	.38	.10	.39+03	16.6	1.52	.30-02	.39-02	.26-03	.55-03
21	25.2	10.2	.0	71.	1.32	.278	.25	.08	.10+03	16.0	1.56	.27-02	.38-02	.97-04	.29-03
22	25.0	10.5	.1	60.	1.20	.176	.59	.24	.27+04	8.5	2.26	.57-02	.65-02	.12-02	.18-02
23	25.2	11.7	.0	84.	1.47	.285	.20	.11	.22+03	11.9	1.95	.37-02	.48-02	.19-03	.50-03
24	35.3	5.0	.0	3.	.56	.125	.20	.04	.13+03	32.5	.15	.22-03	.27-03	.00	.00
25	25.0	6.0	.0	4.	.28	.070	.16	.02	.15+02	33.3	.19	.59-03	.89-03	.15-04	.29-04
26	25.0	5.9	.0	4.	.30	.077	.17	.02	.48+02	33.0	.19	.70-03	.87-03	.51-05	.13-04
27	25.1	5.8	.0	3.	.33	.085	.18	.02	.59+01	32.7	.23	.12-02	.12-02	.16-05	.58-05
28	25.0	5.6	.0	3.	.38	.100	.22	.02	.17+02	31.9	.35	.30-02	.24-02	.25-05	.10-04
29	25.0	5.4	.0	3.	.42	.110	.25	.02	.17+02	31.3	.44	.41-02	.33-02	.26-05	.11-04
30	24.9	5.0	.1	4.	.51	.129	.30	.04	.23+03	30.6	.61	.56-02	.42-02	.11-04	.31-04
31	24.9	4.9	.1	4.	.51	.132	.32	.04	.21+03	30.1	.69	.79-02	.56-02	.19-04	.52-04
32	24.3	1.1	2.7	9.	1.09	.207	.76	.38	.82+04	28.0	2.00	.42-02	.35-02	.99-04	.19-03
33	24.7	3.7	.5	5.	.74	.171	.47	.10	.25+04	27.0	1.30	.20-01	.12-01	.14-03	.26-03
34	24.8	3.6	.4	8.	.76	.193	.51	.08	.25+03	30.4	1.06	.16-02	.17-02	.57-05	.20-04
35	24.9	4.5	.1	5.	.67	.174	.40	.04	.19+02	30.5	.75	.37-02	.31-02	.95-06	.43-05
37	25.0	5.9	.0	3.	.30	.079	.16	.02	.35+03	32.9	.17	.37-03	.53-03	.13-05	.44-05
38	25.0	5.9	.0	3.	.32	.084	.16	.02	.15+04	32.6	.17	.25-03	.36-03	.13-05	.44-05
39	24.9	5.9	.0	3.	.32	.082	.15	.02	.36+04	32.8	.15	.10-03	.16-03	.00	.00
40	24.9	5.7	.0	2.	.38	.093	.15	.02	.10+05	32.9	.17	.51-04	.73-04	.00	.00
41	24.9	5.9	.0	2.	.32	.081	.14	.02	.86+02	32.9	.12	.44-04	.64-04	.00	.00
42	24.9	5.8	.1	3.	.34	.085	.14	.02	.16+05	32.9	.21	.56-04	.72-04	.00	.00
43	25.1	5.8	.0	3.	.36	.091	.16	.02	.18+04	32.2	.19	.22-03	.32-03	.72-05	.17-04
44	25.2	5.8	.0	3.	.40	.099	.17	.02	.35+03	31.8	.22	.29-03	.38-03	.32-04	.56-04
47	25.6	5.8	.0	3.	.34	.090	.18	.02	.70+01	32.7	.19	.88-03	.88-03	.12-07	.61-07
48	26.6	5.6	.0	3.	.38	.099	.18	.02	.72+02	32.7	.16	.46-03	.53-03	.00	.00
49	26.9	5.3	.0	3.	.47	.115	.19	.03	.54+02	32.7	.14	.26-03	.36-03	.00	.00
50	31.3	5.1	.0	3.	.52	.127	.22	.03	.14+04	32.3	.17	.24-03	.36-03	.23-05	.59-05
51	25.9	5.5	.0	3.	.45	.115	.21	.02	.20+04	32.1	.20	.25-03	.34-03	.42-05	.13-04
52	25.3	5.6	.0	2.	.42	.107	.18	.02	.19+03	32.4	.17	.14-03	.20-03	.24-06	.70-06
53	25.1	5.4	.0	2.	.51	.120	.18	.03	.14+02	32.2	.17	.14-03	.21-03	.24-05	.74-05
54	25.3	5.2	.0	3.	.63	.135	.23	.04	.14+03	31.4	.30	.47-03	.59-03	.51-04	.99-04
55	26.7	5.1	.0	5.	.74	.154	.34	.04	.12+04	28.7	.49	.98-03	.12-02	.12-03	.23-03
56	29.5	5.1	.0	3.	.53	.124	.21	.03	.51+03	32.5	.16	.23-03	.29-03	.75-06	.23-05
57	26.5	3.8	.0	2.	.92	.147	.19	.09	.21+02	32.6	.14	.20-03	.24-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1422

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.13	.026	.10	.04	.45+02	34.9	.13	.78-03	.16-02	.41-03	.28-03
2	24.9	6.3	.2	7.	.21	.043	.15	.05	.63+02	34.2	.20	.63-03	.13-02	.16-03	.16-03
4	24.9	6.0	.2	5.	.27	.066	.17	.03	.16+03	33.5	.20	.53-03	.94-03	.32-04	.50-04
5	24.9	6.0	.1	5.	.31	.081	.19	.02	.56+02	32.8	.22	.40-03	.79-03	.14-04	.27-04
7	24.9	5.9	.1	7.	.42	.116	.25	.02	.28+02	31.2	.31	.37-03	.71-03	.88-06	.43-05
8	24.9	5.8	.1	9.	.52	.139	.28	.02	.43+02	30.0	.40	.47-03	.84-03	.11-05	.75-05
9	25.1	5.1	.1	5.	.67	.155	.26	.04	.11+02	31.3	.26	.24-03	.46-03	.00	.00
10	24.9	6.0	.1	13.	.63	.165	.32	.03	.91+02	28.4	.53	.67-03	.11-02	.41-05	.23-04
11	25.0	6.4	.1	21.	.76	.190	.35	.04	.24+03	25.9	.73	.11-02	.16-02	.17-04	.73-04
12	25.0	6.1	.1	19.	.78	.194	.34	.04	.19+03	26.7	.66	.92-03	.14-02	.13-04	.54-04
14	25.3	4.7	.1	16.	1.21	.263	.33	.07	.36+02	28.6	.47	.50-03	.86-03	.00	.00
15	25.6	4.0	.1	15.	1.47	.295	.33	.10	.31+02	28.8	.44	.46-03	.80-03	.00	.00
17	25.1	6.6	.1	27.	.94	.219	.35	.06	.43+03	24.5	.84	.13-02	.19-02	.43-04	.13-03
18	25.0	7.5	.1	37.	.96	.220	.36	.06	.72+03	21.7	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	8.3	.1	47.	1.08	.228	.36	.08	.11+04	19.5	1.28	.23-02	.31-02	.15-03	.35-03
20	25.1	9.1	.1	55.	1.14	.233	.38	.10	.18+04	16.8	1.52	.30-02	.39-02	.26-03	.55-03
21	25.2	10.2	.1	71.	1.32	.278	.25	.08	.10+04	16.0	1.58	.27-02	.38-02	.97-04	.29-03
22	25.0	10.6	.2	60.	1.20	.176	.59	.24	.63+04	8.5	2.26	.57-02	.65-02	.12-02	.18-02
23	25.2	11.7	.1	84.	1.47	.285	.20	.11	.18+04	11.9	1.95	.37-02	.48-02	.19-03	.50-03
24	35.3	4.9	.1	3.	.56	.125	.20	.04	.19+04	32.5	.15	.22-03	.27-03	.00	.00
25	25.0	6.0	.1	4.	.28	.070	.16	.02	.34+03	33.3	.19	.59-03	.89-03	.15-04	.29-04
26	25.0	5.9	.1	4.	.30	.077	.17	.02	.63+03	33.0	.19	.70-03	.87-03	.51-05	.13-04
27	25.1	5.8	.2	3.	.33	.085	.18	.02	.29+03	32.7	.23	.12-02	.12-02	.16-05	.58-05
28	25.0	5.5	.3	3.	.38	.100	.22	.02	.48+03	31.9	.35	.30-02	.24-02	.25-05	.10-04
29	25.0	5.4	.4	3.	.42	.110	.25	.02	.53+03	31.3	.44	.41-02	.33-02	.26-05	.11-04
30	24.9	5.0	.8	4.	.51	.129	.30	.04	.18+04	30.6	.61	.56-02	.42-02	.11-04	.31-04
31	24.9	5.0	.8	4.	.51	.132	.32	.04	.20+04	30.1	.69	.79-02	.56-02	.19-04	.52-04
32	24.3	3.1	5.7	9.	1.09	.207	.76	.38	.26+05	28.0	2.00	.42-02	.35-02	.99-04	.19-03
33	24.7	4.2	1.9	5.	.74	.171	.47	.10	.99+04	27.0	1.30	.20-01	.12-01	.14-03	.26-03
34	24.8	4.0	2.0	8.	.76	.193	.51	.08	.31+04	30.4	1.06	.18-02	.17-02	.57-05	.20-04
35	24.9	4.5	1.0	5.	.67	.174	.40	.04	.78+03	30.5	.75	.37-02	.31-02	.95-06	.43-05
37	25.0	5.9	.1	3.	.30	.079	.16	.02	.23+04	32.9	.17	.37-03	.53-03	.13-05	.44-05
38	25.0	5.8	.1	3.	.32	.084	.16	.02	.56+04	32.6	.17	.25-03	.36-03	.13-05	.44-05
39	24.9	5.8	.1	3.	.32	.082	.15	.02	.14+05	32.8	.15	.10-03	.16-03	.00	.00
40	24.9	5.7	.2	2.	.38	.093	.15	.02	.40+05	32.9	.17	.51-04	.73-04	.00	.00
41	24.9	5.8	.1	2.	.32	.081	.14	.02	.15+04	32.9	.12	.44-04	.64-04	.00	.00
42	24.9	5.8	.2	3.	.34	.085	.14	.02	.62+05	32.9	.21	.50-04	.70-04	.00	.00
43	25.1	5.8	.1	3.	.36	.091	.16	.02	.61+04	32.2	.19	.22-03	.32-03	.70-05	.17-04
44	25.2	5.7	.1	3.	.40	.099	.17	.02	.26+04	31.8	.22	.29-03	.38-03	.32-04	.56-04
47	25.6	5.7	.1	3.	.34	.090	.18	.02	.23+03	32.7	.19	.88-03	.88-03	.12-07	.61-07
48	26.6	5.5	.1	3.	.38	.099	.18	.02	.62+03	32.7	.16	.48-03	.53-03	.00	.00
49	26.9	5.2	.1	3.	.47	.115	.19	.03	.61+03	32.7	.14	.26-03	.30-03	.00	.00
50	31.3	5.0	.1	3.	.52	.127	.22	.03	.48+04	32.3	.17	.24-03	.30-03	.23-05	.59-05
51	25.9	5.5	.1	3.	.45	.115	.21	.02	.72+04	32.1	.20	.25-03	.34-03	.42-05	.13-04
52	25.3	5.6	.1	2.	.42	.107	.18	.02	.21+04	32.4	.17	.14-03	.20-03	.24-06	.70-06
53	25.1	5.3	.1	2.	.51	.120	.18	.03	.44+03	32.2	.17	.14-03	.21-03	.24-05	.74-05
54	25.3	5.1	.1	3.	.63	.135	.23	.04	.12+04	31.4	.30	.47-03	.59-03	.51-04	.99-04
55	26.7	5.0	.1	5.	.74	.154	.34	.04	.47+04	28.7	.49	.98-03	.12-02	.12-03	.23-03
56	29.5	5.0	.1	3.	.53	.124	.21	.03	.28+04	32.5	.16	.23-03	.29-03	.75-06	.23-05
57	26.5	3.7	.1	2.	.92	.147	.19	.09	.43+03	32.6	.14	.20-03	.24-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1422

SYSTEM STATUS AFTER QUALITY CYCLE 2840 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.13	.025	.09	.04	.18+02	34.9	.12	.78-03	.16-02	.42-03	.28-03
2	24.9	6.3	.1	7.	.20	.042	.15	.05	.13+02	34.3	.19	.64-03	.13-02	.17-03	.16-03
4	25.0	6.0	.1	5.	.26	.064	.16	.03	.28+02	33.6	.19	.53-03	.96-03	.39-04	.57-04
5	24.9	6.0	.1	5.	.31	.080	.19	.02	.59+01	32.9	.22	.41-03	.82-03	.17-04	.31-04
7	24.9	5.9	.0	7.	.42	.115	.24	.02	.22+01	31.4	.31	.38-03	.74-03	.14-05	.61-05
8	25.0	5.9	.0	9.	.52	.138	.28	.02	.52+01	30.2	.39	.48-03	.86-03	.13-05	.86-05
9	25.1	5.1	.0	5.	.67	.154	.26	.04	.55+00	31.5	.26	.25-03	.47-03	.00	.00
10	25.0	6.0	.0	13.	.62	.164	.31	.03	.16+02	28.6	.52	.67-03	.11-02	.42-05	.24-04
11	25.0	6.4	.0	21.	.75	.188	.34	.04	.59+02	26.2	.72	.10-02	.16-02	.17-04	.72-04
12	25.0	6.1	.0	19.	.78	.191	.34	.04	.45+02	26.8	.66	.92-03	.14-02	.13-04	.55-04
14	25.3	4.8	.0	16.	1.21	.264	.33	.07	.39+01	28.7	.48	.52-03	.90-03	.00	.00
15	25.5	4.2	.0	16.	1.47	.296	.33	.10	.35+01	28.9	.46	.49-03	.84-03	.00	.00
17	26.1	6.7	.0	29.	.94	.220	.35	.06	.16+03	24.3	.88	.14-02	.20-02	.46-04	.14-03
18	25.1	7.5	.0	37.	.95	.217	.36	.06	.26+03	22.1	1.08	.18-02	.26-02	.78-04	.23-03
19	25.2	8.3	.1	46.	1.07	.226	.36	.08	.51+03	19.8	1.28	.23-02	.31-02	.15-03	.36-03
20	25.1	9.0	.1	54.	1.13	.231	.38	.10	.89+03	17.1	1.52	.30-02	.38-02	.26-03	.55-03
21	25.2	10.2	.1	70.	1.32	.276	.26	.08	.38+03	16.2	1.58	.27-02	.38-02	.10-03	.29-03
22	25.0	10.5	.1	60.	1.20	.176	.59	.24	.44+04	8.7	2.25	.57-02	.65-02	.12-02	.18-02
23	25.2	11.7	.1	84.	1.47	.285	.20	.11	.71+03	12.2	1.94	.36-02	.48-02	.19-03	.50-03
24	35.3	4.9	.0	3.	.66	.125	.20	.04	.63+03	32.7	.14	.16-03	.21-03	.00	.00
25	25.0	6.0	.1	5.	.28	.068	.16	.02	.73+02	33.4	.18	.58-03	.90-03	.19-04	.33-04
26	25.0	5.9	.0	4.	.30	.075	.16	.02	.17+03	33.2	.19	.66-03	.87-03	.68-05	.15-04
27	25.2	5.8	.1	4.	.32	.084	.18	.02	.44+02	32.9	.22	.11-02	.11-02	.21-05	.66-05
28	25.1	5.6	.1	3.	.37	.098	.21	.02	.82+02	32.1	.33	.26-02	.21-02	.22-05	.87-05
29	25.0	5.3	.2	3.	.43	.110	.25	.03	.11+03	31.6	.42	.33-02	.27-02	.18-05	.78-05
30	24.9	4.5	.7	5.	.59	.146	.37	.06	.10+04	30.2	.81	.59-02	.45-02	.13-04	.39-04
31	24.9	5.0	.3	4.	.49	.127	.30	.04	.57+03	30.4	.63	.72-02	.52-02	.16-04	.46-04
32	24.3	1.7	4.3	10.	1.15	.224	.82	.39	.15+05	27.3	2.19	.60-02	.47-02	.10-03	.20-03
33	24.8	4.1	.9	5.	.70	.163	.44	.09	.48+04	27.1	1.21	.20-01	.13-01	.14-03	.25-03
34	24.8	3.7	.9	8.	.76	.195	.52	.08	.82+03	30.1	1.09	.29-02	.26-02	.49-05	.19-04
35	25.0	4.6	.3	4.	.64	.166	.36	.04	.99+02	30.8	.62	.36-02	.31-02	.71-06	.31-05
37	25.0	5.9	.0	3.	.30	.077	.16	.02	.88+03	33.1	.17	.37-03	.56-03	.18-05	.54-05
38	25.0	5.9	.0	3.	.31	.081	.15	.02	.30+04	32.8	.17	.25-03	.39-03	.87-06	.29-05
39	24.9	5.8	.0	3.	.32	.081	.15	.02	.72+04	32.9	.15	.10-03	.17-03	.00	.00
40	25.0	5.7	.1	2.	.38	.092	.15	.02	.21+05	33.0	.17	.51-04	.75-04	.00	.00
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.38+03	33.0	.12	.44-04	.66-04	.00	.00
42	24.9	5.8	.1	3.	.34	.084	.14	.02	.32+05	33.0	.20	.50-04	.72-04	.00	.00
43	25.0	5.8	.0	3.	.35	.088	.16	.02	.36+04	32.4	.18	.22-03	.33-03	.49-05	.12-04
44	25.1	5.8	.0	3.	.39	.095	.17	.02	.86+03	31.7	.24	.33-03	.44-03	.34-04	.63-04
47	25.7	5.7	.0	3.	.34	.090	.18	.02	.49+02	32.8	.18	.68-03	.72-03	.23-07	.96-07
48	26.8	5.6	.0	3.	.38	.101	.18	.02	.23+03	32.8	.15	.36-03	.42-03	.00	.00
49	27.2	5.2	.0	3.	.48	.118	.19	.03	.24+03	32.6	.14	.19-03	.24-03	.00	.00
50	31.3	5.1	.0	3.	.62	.127	.21	.03	.27+04	32.5	.16	.19-03	.25-03	.18-05	.44-05
51	25.6	5.5	.0	3.	.46	.117	.21	.02	.39+04	32.0	.21	.23-03	.33-03	.46-05	.15-04
52	25.1	5.6	.0	3.	.41	.104	.18	.02	.51+03	32.2	.18	.16-03	.24-03	.22-05	.70-05
53	25.1	5.4	.0	2.	.50	.119	.18	.03	.67+02	32.3	.17	.14-03	.21-03	.19-05	.60-05
54	25.3	5.2	.0	3.	.65	.139	.24	.04	.45+03	31.2	.33	.52-03	.66-03	.53-04	.10-03
55	27.0	5.0	.0	5.	.74	.155	.34	.04	.24+04	28.6	.49	.96-03	.12-02	.12-03	.23-03
56	29.5	5.0	.0	3.	.53	.125	.21	.03	.13+04	32.6	.15	.18-03	.23-03	.47-06	.14-05
57	26.6	3.7	.0	2.	.93	.149	.20	.09	.12+03	32.7	.13	.15-03	.20-03	.00	.00

SYSTEM STATUS AFTER QUALITY CYCLE 1420   30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.13	.026	.10	.04	.18+02	34.9	.13	.77-03	.16-02	.41-03	.20-03
2	24.9	6.3	.1	7.	.20	.043	.15	.05	.11+02	34.3	.19	.62-03	.13-02	.16-03	.16-03
4	25.0	6.0	.1	5.	.27	.066	.17	.03	.26+02	33.5	.19	.51-03	.92-03	.33-04	.51-04
5	24.9	6.0	.0	5.	.31	.081	.19	.02	.56+01	32.9	.22	.39-03	.78-03	.14-04	.27-04
7	24.9	5.9	.0	7.	.42	.116	.24	.02	.20+01	31.3	.31	.37-03	.71-03	.88-06	.42-05
8	25.0	5.9	.0	9.	.52	.139	.28	.02	.48+01	30.1	.39	.47-03	.84-03	.10-05	.72-05
9	25.1	5.1	.0	5.	.67	.155	.26	.04	.51+00	31.4	.26	.24-03	.46-03	.00	.00
10	25.0	6.0	.0	13.	.63	.165	.31	.03	.15+02	28.5	.52	.67-03	.11-02	.39-05	.23-04
11	25.0	6.4	.0	21.	.75	.190	.34	.04	.59+02	26.1	.73	.10-02	.16-02	.17-04	.72-04
12	25.0	6.1	.0	19.	.78	.195	.34	.04	.44+02	26.8	.66	.92-03	.14-02	.12-04	.54-04
14	25.3	4.8	.0	16.	1.21	.263	.33	.07	.37+01	28.7	.48	.52-03	.89-03	.00	.00
15	25.6	4.2	.0	16.	1.48	.298	.33	.10	.33+01	28.9	.46	.48-03	.83-03	.00	.00
17	25.1	6.7	.0	29.	.95	.221	.35	.06	.16+03	24.3	.87	.14-02	.20-02	.46-04	.14-03
18	25.1	7.5	.0	37.	.96	.219	.36	.06	.26+03	21.9	1.09	.19-02	.26-02	.77-04	.23-03
19	25.2	8.2	.0	46.	1.07	.228	.36	.08	.47+03	20.0	1.26	.23-02	.30-02	.14-03	.33-03
20	25.1	9.1	.1	56.	1.16	.233	.38	.10	.91+03	16.8	1.54	.30-02	.39-02	.26-03	.56-03
21	25.2	10.3	.1	71.	1.33	.279	.25	.08	.37+03	16.1	1.59	.28-02	.38-02	.98-04	.29-03
22	25.0	10.5	.1	61.	1.20	.177	.59	.24	.43+04	8.7	2.25	.57-02	.65-02	.12-02	.18-02
23	25.2	11.7	.1	85.	1.48	.286	.20	.11	.71+03	12.1	1.95	.37-02	.48-02	.19-03	.49-03
24	35.2	4.9	.0	3.	.56	.125	.20	.04	.60+03	32.7	.14	.16-03	.21-03	.00	.00
25	25.0	6.0	.1	4.	.28	.070	.16	.02	.69+02	33.4	.19	.56-03	.86-03	.15-04	.29-04
26	25.0	5.9	.0	4.	.30	.076	.17	.02	.16+03	33.1	.19	.65-03	.83-03	.51-05	.12-04
27	25.2	5.8	.1	3.	.33	.085	.18	.02	.43+02	32.8	.22	.11-02	.11-02	.15-06	.51-05
28	25.1	5.6	.1	3.	.36	.098	.22	.02	.60+02	32.1	.33	.26-02	.21-02	.20-05	.60-05
29	25.0	5.3	.2	3.	.43	.111	.25	.03	.10+03	31.6	.42	.33-02	.27-02	.17-05	.74-05
30	24.9	4.5	.6	5.	.59	.146	.37	.06	.10+04	30.2	.81	.59-02	.45-02	.13-04	.38-04
31	24.9	5.0	.3	4.	.49	.127	.30	.04	.57+03	30.4	.64	.73-02	.52-02	.16-04	.46-04
32	24.3	1.7	4.3	10.	1.15	.225	.82	.39	.15+05	27.3	2.19	.59-02	.47-02	.10-03	.20-03
33	24.8	4.1	.9	5.	.70	.164	.44	.09	.48+04	27.1	1.22	.20-01	.13-01	.14-03	.26-03
34	24.8	3.7	.9	8.	.76	.195	.52	.08	.82+03	30.1	1.09	.28-02	.25-02	.49-05	.10-04
35	25.0	4.6	.3	4.	.64	.167	.36	.04	.97+02	30.8	.63	.36-02	.30-02	.62-06	.27-05
37	25.0	5.9	.0	3.	.30	.077	.16	.02	.87+03	33.0	.17	.36-03	.53-03	.12-05	.38-05
38	25.0	5.9	.0	3.	.32	.081	.16	.02	.29+04	32.8	.17	.24-03	.37-03	.71-06	.23-05
39	25.0	5.8	.0	3.	.32	.081	.15	.02	.72+04	32.9	.15	.10-03	.16-03	.00	.00
40	25.0	5.7	.1	2.	.38	.092	.15	.02	.21+05	33.0	.17	.50-04	.72-04	.00	.00
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.37+03	33.0	.12	.43-04	.63-04	.00	.00
42	24.9	5.8	.1	3.	.34	.085	.14	.02	.32+05	33.0	.20	.49-04	.70-04	.00	.00
43	25.0	5.8	.0	3.	.35	.088	.16	.02	.35+04	32.4	.18	.22-03	.32-03	.49-05	.12-04
44	25.1	5.8	.0	3.	.39	.096	.17	.02	.86+03	31.7	.24	.33-03	.43-03	.34-04	.62-04
47	25.7	5.7	.0	3.	.35	.091	.18	.02	.47+02	32.8	.18	.68-03	.71-03	.00	.00
48	26.8	5.5	.0	3.	.39	.101	.18	.02	.23+03	32.8	.15	.36-03	.41-03	.00	.00
49	27.3	5.2	.0	3.	.48	.118	.19	.03	.24+03	32.8	.14	.19-03	.24-03	.00	.00
50	31.3	5.1	.0	3.	.52	.127	.21	.03	.26+04	32.5	.16	.19-03	.24-03	.18-05	.43-05
51	25.6	5.5	.0	3.	.46	.117	.21	.02	.39+04	32.0	.21	.23-03	.33-03	.46-05	.15-04
52	25.2	5.6	.0	3.	.41	.104	.18	.02	.62+03	32.2	.18	.16-03	.23-03	.19-05	.63-05
53	25.1	5.4	.0	2.	.51	.119	.18	.03	.66+02	32.3	.17	.14-03	.21-03	.18-05	.59-05
54	25.3	5.2	.0	3.	.64	.138	.24	.04	.42+03	31.3	.32	.51-03	.65-03	.53-04	.10-03
55	26.9	5.0	.0	5.	.75	.156	.34	.04	.24+04	28.8	.49	.97-03	.12-02	.12-03	.23-03
56	29.5	5.0	.0	3.	.53	.125	.21	.03	.12+04	32.6	.15	.18-03	.23-03	.42-06	.12-05
57	26.6	3.7	.0	2.	.93	.149	.20	.09	.11+03	32.7	.13	.15-03	.19-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1422

SYSTEM STATUS AFTER QUALITY CYCLE 1420 30 DAYS, 14.00 HOURS

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.13	.026	.10	.04	.18+02	34.9	.12	.77-03	.16-02	.41-03	.20-03
2	24.9	6.3	.1	7.	.20	.043	.15	.05	.11+02	34.3	.19	.62-03	.13-02	.16-03	.16-03
4	25.0	6.0	.1	5.	.27	.066	.17	.03	.26+02	33.5	.19	.50-03	.92-03	.33-04	.51-04
5	24.9	6.0	.0	5.	.31	.081	.19	.02	.55+01	32.9	.22	.39-03	.78-03	.14-04	.27-04
7	24.9	5.9	.0	7.	.42	.116	.24	.02	.19+01	31.4	.30	.37-03	.70-03	.84-06	.39-05
8	25.0	5.9	.0	9.	.52	.139	.28	.02	.46+01	30.2	.39	.46-03	.83-03	.94-06	.66-05
9	25.1	5.1	.0	5.	.67	.155	.26	.04	.49+00	31.5	.26	.24-03	.45-03	.00	.00
10	25.0	6.0	.0	13.	.63	.165	.31	.03	.15+02	28.5	.52	.66-03	.11-02	.37-05	.21-04
11	25.0	6.4	.0	21.	.75	.189	.34	.04	.55+02	26.2	.72	.10-02	.16-02	.16-04	.68-04
12	25.0	6.2	.0	19.	.78	.196	.34	.04	.43+02	26.8	.67	.92-03	.14-02	.12-04	.52-04
14	25.3	4.8	.0	17.	1.23	.269	.33	.07	.38+01	28.7	.48	.52-03	.90-03	.00	.00
15	25.6	4.2	.0	17.	1.49	.299	.33	.10	.33+01	28.8	.46	.49-03	.84-03	.00	.00
17	25.1	6.8	.0	30.	.95	.222	.35	.06	.15+03	24.2	.89	.14-02	.20-02	.44-04	.14-03
18	25.1	7.6	.0	38.	.95	.219	.36	.06	.26+03	22.0	1.09	.18-02	.26-02	.75-04	.22-03
19	25.2	8.5	.1	49.	1.08	.229	.35	.08	.52+03	19.4	1.31	.24-02	.32-02	.15-03	.36-03
20	25.1	9.2	.1	56.	1.14	.233	.38	.10	.88+03	16.9	1.53	.30-02	.39-02	.25-03	.54-03
21	25.2	10.3	.1	72.	1.33	.278	.25	.08	.39+03	15.9	1.61	.28-02	.38-02	.10-03	.30-03
22	25.0	10.6	.1	61.	1.20	.176	.59	.24	.44+04	6.6	2.27	.58-02	.65-02	.12-02	.18-02
23	25.2	11.7	.1	85.	1.48	.286	.20	.11	.71+03	12.0	1.96	.37-02	.48-02	.19-03	.49-03
24	35.4	4.9	.0	3.	.56	.126	.20	.04	.64+03	32.7	.14	.16-03	.21-03	.00	.00
25	25.0	6.0	.1	4.	.28	.070	.16	.02	.69+02	33.4	.19	.55-03	.86-03	.15-04	.29-04
26	25.0	5.9	.0	4.	.30	.076	.17	.02	.16+03	33.1	.19	.64-03	.83-03	.51-05	.12-04
27	25.2	5.8	.1	3.	.33	.085	.18	.02	.42+02	32.8	.22	.11-02	.11-02	.15-05	.80-05
28	25.1	5.6	.1	3.	.30	.393	.21	.02	.79+02	32.1	.33	.25-02	.21-02	.19-05	.78-05
29	25.0	5.3	.2	3.	.43	.111	.25	.03	.10+03	31.6	.42	.32-02	.27-02	.17-05	.74-05
30	24.9	4.5	.7	5.	.59	.147	.38	.06	.11+04	30.1	.82	.60-02	.45-02	.13-04	.39-04
31	24.9	5.0	.3	4.	.49	.127	.30	.04	.56+03	30.4	.63	.72-02	.52-02	.16-04	.45-04
32	24.3	1.7	4.3	10.	1.15	.225	.82	.39	.15+05	27.3	2.20	.61-02	.48-02	.10-03	.28-03
33	24.8	4.1	.8	5.	.70	.162	.43	.09	.47+04	27.1	1.20	.20-01	.13-01	.14-03	.25-03
34	24.8	3.7	.9	8.	.75	.195	.52	.08	.81+03	30.1	1.09	.29-02	.26-02	.48-05	.18-04
36	25.0	4.6	.3	4.	.64	.166	.36	.04	.96+02	30.8	.62	.36-02	.31-02	.63-06	.28-05
37	25.0	5.9	.0	3.	.30	.077	.16	.02	.87+03	33.0	.17	.36-03	.53-03	.12-05	.38-05
38	25.0	5.9	.0	3.	.31	.081	.16	.02	.29+04	32.8	.17	.24-03	.37-03	.67-06	.22-05
39	25.0	5.8	.0	3.	.32	.081	.15	.02	.72+04	32.9	.15	.10-03	.16-03	.00	.00
40	25.0	5.7	.1	2.	.38	.092	.15	.02	.21+05	33.0	.17	.50-04	.72-04	.00	.00
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.37+03	33.0	.12	.43-04	.63-04	.00	.00
42	24.9	5.8	.1	3.	.34	.085	.14	.02	.32+05	33.0	.20	.49-04	.69-04	.00	.00
43	25.0	5.8	.0	3.	.35	.088	.16	.02	.36+04	32.4	.18	.22-03	.32-03	.47-05	.12-04
44	25.1	5.8	.0	3.	.39	.096	.17	.02	.86+03	31.7	.24	.33-03	.44-03	.34-04	.63-04
47	25.7	5.7	.0	3.	.35	.091	.18	.02	.47+02	32.8	.18	.67-03	.70-03	.00	.00
48	26.8	5.5	.0	3.	.39	.101	.18	.02	.23+03	32.8	.15	.35-03	.40-03	.00	.00
49	27.2	5.2	.0	3.	.48	.118	.19	.03	.24+03	32.8	.14	.19-03	.23-03	.00	.00
50	31.3	5.1	.0	3.	.52	.127	.21	.03	.26+04	32.5	.16	.19-03	.24-03	.18-05	.44-05
51	25.6	5.5	.0	3.	.46	.117	.21	.02	.39+04	32.0	.21	.23-03	.32-03	.45-05	.14-04
52	25.1	5.6	.0	3.	.41	.104	.18	.02	.49+03	32.2	.18	.16-03	.24-03	.23-05	.76-05
53	25.1	5.4	.0	2.	.51	.120	.18	.03	.65+02	32.3	.17	.14-03	.21-03	.18-05	.60-05
54	25.3	5.2	.0	3.	.66	.141	.24	.04	.47+03	31.2	.33	.52-03	.67-03	.53-04	.11-03
55	27.0	5.0	.0	5.	.74	.156	.34	.04	.24+04	28.8	.49	.96-03	.12-02	.12-03	.23-03
56	29.6	5.0	.0	3.	.54	.125	.21	.03	.13+04	32.6	.15	.18-03	.23-03	.47-06	.14-05
57	26.6	3.7	.0	2.	.93	.150	.20	.09	.12+03	32.7	.13	.15-03	.19-03	.00	.00

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 23, CYCLE1422

SYSTEM STATUS AFTER QUALITY CYCLE 1420   DAY 30, HOUR 14.0

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.14	.029	.11	.04	.18+02	34.6	.15	.40-03	.11-02	.70-03	.42-03
2	24.9	6.2	.1	7.	.22	.049	.17	.05	.11+02	33.8	.23	.15-03	.55-03	.51-03	.36-03
4	25.0	6.0	.1	6.	.29	.074	.19	.03	.27+02	32.7	.26	.32-04	.20-03	.30-03	.28-03
5	24.9	6.1	.0	8.	.36	.096	.24	.02	.59+01	31.2	.36	.13-04	.11-03	.30-03	.36-03
7	24.9	6.3	.0	15.	.50	.139	.31	.02	.50+01	27.9	.59	.42-05	.57-04	.37-03	.57-03
8	24.9	6.6	.0	23.	.61	.166	.35	.03	.15+02	25.6	.78	.11-04	.99-04	.50-03	.78-03
9	25.1	5.5	.0	12.	.72	.173	.31	.04	.16+01	28.8	.49	.84-06	.15-04	.26-03	.44-03
10	25.0	7.2	.0	34.	.74	.194	.37	.03	.45+02	22.7	1.03	.32-04	.21-03	.70-03	.11-02
11	25.0	8.3	.0	51.	.87	.214	.37	.05	.16+03	18.8	1.37	.11-03	.48-03	.11-02	.15-02
12	25.0	8.1	.0	48.	.90	.221	.36	.05	.12+03	19.8	1.28	.86-04	.39-03	.94-03	.14-02
14	25.3	7.1	.0	42.	1.31	.292	.29	.06	.11+02	23.6	.93	.61-05	.62-04	.54-03	.89-03
15	25.6	6.7	.0	40.	1.56	.322	.25	.09	.90+01	24.1	.88	.45-05	.45-04	.49-03	.83-03
17	25.1	9.4	.1	65.	1.06	.236	.35	.07	.39+03	16.3	1.59	.26-03	.82-03	.13-02	.18-02
18	25.0	10.5	.1	78.	1.07	.226	.35	.09	.65+03	12.8	1.89	.43-03	.13-02	.17-02	.23-02
19	25.2	11.8	.1	92.	1.17	.228	.31	.11	.10+04	10.6	2.09	.64-03	.16-02	.20-02	.26-02
20	25.0	11.9	.1	91.	1.20	.211	.40	.16	.20+04	7.4	2.37	.12-02	.26-02	.26-02	.31-02
21	25.2	12.2	.1	111.	1.37	.262	.17	.11	.89+03	6.6	2.44	.59-03	.17-02	.23-02	.30-02
22	24.9	10.8	.2	56.	1.15	.110	.82	.37	.77+04	1.9	2.86	.44-02	.62-02	.40-02	.43-02
23	25.2	12.3	.1	112.	1.47	.257	.16	.14	.13+04	4.1	2.65	.84-03	.23-02	.27-02	.34-02
24	35.3	4.9	.0	3.	.57	.128	.22	.04	.62+03	32.3	.18	.00	.61-05	.75-04	.11-03
25	25.0	6.0	.1	5.	.36	.076	.18	.02	.72+02	32.8	.23	.19-04	.14-03	.23-03	.23-03
26	25.0	5.9	.0	4.	.31	.081	.18	.02	.17+03	32.5	.24	.16-04	.11-03	.18-03	.20-03
27	25.2	6.8	.1	4.	.34	.089	.19	.02	.53+02	32.2	.27	.40-04	.18-03	.16-03	.20-03
28	25.1	5.6	.1	4.	.39	.104	.23	.02	.14+03	31.1	.42	.21-03	.55-03	.21-03	.29-03
29	25.0	5.4	.2	4.	.45	.118	.26	.03	.16+03	30.3	.54	.20-03	.63-03	.24-03	.35-03
30	24.9	4.6	.7	6.	.62	.154	.39	.07	.13+04	28.3	1.00	.86-03	.16-02	.40-03	.58-03
31	24.9	5.1	.3	5.	.53	.134	.32	.04	.10+04	28.3	.83	.15-02	.24-02	.43-03	.60-03
32	24.3	1.9	4.3	12.	1.17	.231	.83	.39	.16+05	25.6	2.35	.72-03	.15-02	.68-03	.91-03
33	24.8	4.4	.8	6.	.75	.165	.43	.10	.83+04	23.2	1.53	.11-01	.10-01	.10-02	.13-02
34	24.8	3.8	.9	9.	.77	.199	.52	.08	.83+03	29.1	1.18	.89-04	.38-03	.28-03	.43-03
35	25.0	4.7	.3	5.	.66	.171	.37	.04	.13+03	29.6	.73	.13-03	.50-03	.24-03	.38-03
37	25.0	5.9	.0	3.	.31	.081	.17	.02	.88+03	32.5	.21	.46-05	.48-04	.14-03	.17-03
38	25.0	5.9	.0	3.	.33	.084	.16	.02	.30+04	32.3	.21	.61-05	.34-04	.12-03	.16-03
39	25.0	5.6	.0	3.	.32	.083	.15	.02	.72+04	32.7	.17	.34-06	.24-05	.62-04	.82-04
40	25.0	5.7	.1	2.	.38	.093	.15	.02	.21+05	32.9	.18	.00	.00	.37-04	.48-04
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.37+03	32.9	.12	.00	.00	.36-04	.46-04
42	24.9	5.8	.1	3.	.34	.085	.14	.02	.32+05	32.9	.21	.00	.00	.35-04	.44-04
43	25.1	5.9	.0	3.	.36	.092	.17	.02	.36+04	31.7	.25	.23-04	.70-04	.16-03	.21-03
44	25.2	5.9	.0	3.	.41	.099	.18	.02	.11+04	30.3	.36	.14-03	.27-03	.31-03	.39-03
47	25.7	5.7	.0	3.	.35	.094	.19	.02	.51+02	32.3	.22	.13-04	.79-04	.11-03	.14-03
48	26.6	5.6	.0	3.	.39	.103	.19	.02	.23+03	32.4	.19	.32-05	.28-04	.83-04	.11-03
49	27.3	5.2	.0	3.	.49	.120	.20	.03	.24+03	32.5	.17	.11-05	.90-05	.69-04	.98-04
50	31.3	5.1	.0	3.	.52	.129	.23	.03	.27+04	32.0	.21	.11-04	.36-04	.11-03	.15-03
51	25.6	5.6	.0	3.	.48	.121	.24	.02	.40+04	31.0	.31	.21-04	.80-04	.20-03	.28-03
52	25.2	5.7	.0	3.	.42	.108	.20	.02	.52+03	31.5	.26	.11-04	.46-04	.15-03	.21-03
53	25.1	5.4	.0	2.	.52	.123	.19	.03	.82+02	31.6	.24	.95-05	.40-04	.14-03	.20-03
54	25.3	5.4	.0	4.	.60	.144	.29	.04	.63+03	29.6	.53	.21-03	.43-03	.49-03	.63-03
55	26.9	5.4	.0	7.	.79	.157	.45	.04	.43+04	25.2	.83	.48-03	.92-03	.89-03	.11-02
56	29.6	5.0	.0	3.	.54	.127	.22	.03	.13+04	32.2	.19	.47-05	.21-04	.90-04	.13-03
57	26.5	5.7	.0	2.	.94	.151	.20	.09	.12+03	32.5	.16	.44-06	.40-05	.62-04	.89-04

DISSOLVED OXYGEN CONCENTRATION WAS REDUCED TO 1.5 TIMES SATURATION AT JUNCTION 19, CYCLE1421

SYSTEM STATUS AFTER QUALITY CYCLE 1420   DAY 30, HOUR 14.0

JUNC	TEMP C	OXY MG/L	BOD MG/L	CHLOR A UG/L	NH3 MG/L	NO2 MG/L	NO3 MG/L	PO4 MG/L	COLIF MPN/100ML	TDS G/L	TOT N MG/L	HEAVY MET 1 & 2 MG/L		PEST 1 & 2 MG/L	
1	25.0	6.5	.2	8.	.12	.024	.09	.04	.18+02	35.0	.12	.42-03	.11-02	.73-03	.41-03
2	24.9	6.3	.1	7.	.20	.041	.15	.05	.11+02	34.5	.18	.17-03	.60-03	.53-03	.34-03
4	25.0	6.0	.1	5.	.26	.062	.16	.03	.25+02	33.8	.17	.36-04	.21-03	.30-03	.23-03
5	24.9	6.0	.1	5.	.29	.075	.17	.02	.54+01	33.5	.17	.17-04	.12-03	.24-03	.20-03
7	24.9	5.8	.0	4.	.39	.145	.21	.02	.12+01	32.6	.20	.20-05	.31-04	.16-03	.18-03
8	25.0	5.6	.0	5.	.47	.126	.24	.02	.19+01	32.0	.24	.18-05	.24-04	.16-03	.21-03
9	25.1	5.0	.0	4.	.65	.147	.23	.04	.21+00	32.5	.17	.77-07	.15-05	.94-04	.13-03
10	25.0	5.5	.0	6.	.57	.150	.27	.03	.59+01	31.1	.30	.45-05	.36-04	.19-03	.27-03
11	25.0	5.6	.0	9.	.68	.173	.31	.03	.23+02	29.9	.40	.17-04	.87-04	.27-03	.40-03
12	25.0	5.4	.0	9.	.72	.179	.30	.04	.18+02	30.2	.37	.13-04	.68-04	.24-03	.36-03
14	25.3	4.0	.0	8.	1.18	.254	.32	.07	.15+01	31.0	.28	.83-06	.98-05	.14-03	.23-03
15	25.6	3.2	.0	8.	1.45	.287	.33	.10	.14+01	31.1	.27	.67-06	.73-05	.14-03	.22-03
17	25.1	5.4	.0	13.	.88	.208	.34	.05	.66+02	28.7	.49	.45-04	.16-03	.36-03	.51-03
18	25.1	5.8	.0	17.	.87	.206	.35	.05	.11+03	27.4	.60	.76-04	.26-03	.48-03	.66-03
19	25.2	6.1	.0	22.	1.00	.220	.37	.07	.25+03	25.7	.75	.16-03	.43-03	.65-03	.87-03
20	25.1	6.6	.0	28.	1.06	.232	.39	.08	.41+03	24.1	.89	.26-03	.63-03	.82-03	.11-02
21	25.2	7.0	.0	37.	1.24	.272	.34	.07	.17+03	23.6	.93	.11-03	.41-03	.76-03	.11-02
22	25.1	8.2	.1	41.	1.18	.214	.51	.16	.23+04	17.3	1.49	.14-02	.22-02	.18-02	.21-02
23	25.3	8.8	.0	56.	1.40	.291	.30	.09	.37+03	20.1	1.24	.25-03	.75-03	.11-02	.15-02
24	35.3	4.9	.0	3.	.56	.125	.20	.04	.63+03	32.9	.13	.00	.00	.43-04	.55-04
25	25.0	6.0	.1	4.	.27	.067	.16	.02	.67+02	33.6	.17	.18-04	.13-03	.23-03	.19-03
26	25.0	5.9	.0	4.	.29	.074	.16	.02	.16+03	33.4	.17	.86-05	.74-04	.17-03	.15-03
27	25.2	5.8	.1	4.	.32	.082	.17	.02	.38+02	33.1	.19	.10-04	.60-04	.13-03	.13-03
28	25.1	5.6	.1	4.	.36	.095	.21	.02	.53+02	32.6	.28	.47-04	.13-03	.12-03	.15-03
29	25.0	5.4	.2	4.	.42	.107	.24	.03	.77+02	32.2	.36	.44-04	.14-03	.12-03	.16-03
30	24.9	4.6	.6	6.	.57	.142	.36	.06	.91+03	31.1	.72	.20-03	.38-03	.19-03	.26-03
31	24.9	5.1	.3	5.	.47	.123	.29	.03	.35+03	31.4	.54	.36-03	.57-03	.18-03	.24-03
32	24.3	1.6	4.3	12.	1.13	.221	.81	.39	.15+05	28.2	2.12	.25-03	.51-03	.49-03	.62-03
33	24.8	4.2	.9	7.	.66	.160	.43	.08	.29+04	29.2	1.03	.29-02	.28-02	.39-03	.51-03
34	24.8	3.7	.9	9.	.75	.193	.51	.08	.80+03	30.6	1.05	.26-04	.11-03	.18-03	.27-03
35	25.0	4.6	.3	5.	.63	.164	.35	.04	.82+02	31.5	.57	.32-04	.13-03	.12-03	.18-03
37	25.0	5.9	.0	3.	.29	.076	.15	.02	.87+03	33.2	.15	.25-05	.31-04	.12-03	.12-03
38	25.0	5.9	.0	3.	.31	.080	.15	.02	.29+04	33.0	.15	.14-05	.12-04	.86-04	.94-04
39	24.9	5.8	.0	3.	.32	.081	.14	.02	.72+04	33.0	.14	.53-08	.10-07	.49-04	.57-04
40	25.0	5.7	.1	2.	.38	.092	.15	.02	.21+05	33.0	.17	.00	.00	.33-04	.40-04
41	24.9	5.8	.0	2.	.32	.081	.14	.02	.37+03	33.0	.11	.00	.00	.33-04	.40-04
42	24.9	5.8	.1	3.	.34	.084	.14	.02	.32+05	33.0	.20	.00	.00	.32-04	.38-04
43	25.0	5.8	.0	3.	.34	.086	.15	.02	.35+04	32.8	.15	.52-05	.16-04	.79-04	.95-04
44	25.1	5.8	.0	3.	.37	.094	.16	.02	.72+03	32.4	.17	.34-04	.64-04	.11-03	.13-03
47	25.7	5.7	.0	3.	.34	.089	.17	.02	.46+02	33.0	.16	.27-05	.20-04	.80-04	.90-04
48	26.5	5.5	.0	3.	.35	.100	.18	.02	.23+03	32.9	.14	.43-06	.36-05	.56-04	.68-04
49	27.2	5.2	.0	3.	.48	.117	.19	.03	.24+03	32.9	.13	.00	.00	.44-04	.56-04
50	31.3	5.1	.0	3.	.51	.126	.21	.03	.26+04	32.8	.14	.20-05	.49-05	.51-04	.65-04
51	25.5	5.5	.0	3.	.45	.115	.20	.02	.39+04	32.5	.16	.47-05	.15-04	.73-04	.99-04
52	25.1	5.5	.0	2.	.40	.102	.17	.02	.50+03	32.6	.15	.22-05	.75-05	.61-04	.82-04
53	25.1	5.1	.0	2.	.50	.118	.18	.03	.58+02	32.6	.14	.19-05	.63-05	.58-04	.78-04
54	25.3	5.1	.0	3.	.63	.138	.21	.04	.36+03	32.1	.22	.53-04	.11-03	.15-03	.19-03
55	27.0	4.3	.0	4.	.72	.155	.28	.04	.14+04	30.8	.31	.12-03	.23-03	.26-03	.32-03
56	29.6	5.0	.0	3.	.53	.124	.20	.03	.13+04	32.8	.13	.56-06	.17-05	.47-04	.60-04
57	25.5	5.7	.0	2.	.93	.140	.19	.09	.12+03	32.9	.12	.00	.00	.41-04	.52-04