Review of BATHTUB Calibration for Tainter Lake, Wisconsin

prepared for

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Introduction

This report reviews and revises BATHTUB calibrations for Tainter Lake developed by the USGS (1991a,b,c). Two versions of the model calibration to 1990 data were apparently developed. For purposes of discussion, calibrations are referenced as follows:

USGS1 - First USGS Calibration (USGS, 1991a)
USGS2 - Revised USGS Calibration (USGS, 1991c)

UNCALIB - Version 5.3, Uncalibrated

WWW - Version 5.3, Calibrated by WWW

Table 1 summarizes model options and calibration factors used in each USGS calibration and in the author's version. A diskette containing the current version of BATHTUB and the WWW calibration (TLWWW.BIN) is attached to this report. Tables 2, 3, and 4 lists input files for USGS2, UNCALIB, and WWW, respectively. Figures 1 and 2 show observed and predicted concentrations for UNCALIB and WWW, respectively. Observed and predicted diagnostic variables for WWW are listed in Table 5.

The USGS1 & USGS2 calibrations were developed using the early (batch) version of BATHTUB. An input file and calibrated coefficients were supplied only for USGS2. The latest (interactive) version (5.3) uses a different file format but includes a utility for translating input files generated for the batch version. In both versions, tributary TYPE = 2 codes are used to identify ungauged tributaries. Unlike the batch version, however, the interactive version automatically estimates flows

and concentrations based upon user-supplied land use data and non-point-source export coefficients. Directly specified flow and concentration values for TYPE = 2 tributaries are lost in translating files for use with the interactive version. To account for this, flow and concentration values specified for TYPE = 2 tributaries in USGS1 & USGS2 have been manually entered in the UNCALIB and WWW files and the TYPE codes have been reset to 1. Even though these are estimated values, they are treated the same as measured values in constructing reservoir flow and nutrient balances.

The UNCALIB version generates a-priori predictions using default coefficients. The only adjusted calibration coefficient in the case is the longitudinal dispersion coefficient for Segment 2, which has has been set to 0.0 to reflect impedence of longitudinal dispersion by the long and narrow river channel between Segments 2 and 3. The WWW version starts with UNCALIB and adjusts certain coefficients to match observed and predicted values for phosphorus, chlorophyll-a, and secchi depth within reasonable error bounds.

Specific comments on the calibrations are listed below:

- 1. USGS2 calibrates phosphorus, chlorophyll-a, and transparency separately for each segment. This involves adjusting 9 coefficients. While this approach is not neccessarily "wrong", the author prefers a more parsimonious approach to calibration (adjusting fewer coefficients). In WWW, only global calibration factors are adjusted using a least-squares criterion (3 coefficients). Given the uncertainty (CV) in the measured concentrations, exact calibration to each segment does not seem appropriate. If management decisions to be made using the model depend heavily upon water quality in a particular segment (vs. reservoir as a whole), the local calibration approach could be used.
- 2. All calibrations employ phosphorus model 1 (default). In USGS2, three calibration coefficients are adjusted to match observed concentrations in each segment. In WWW, the overall phosphorus sedimentation rate is adjusted slightly (from 1 to 1.13) to provide a least-squares fit of the observed concentrations.
- 3. USGS2 uses BATHTUB Chlorophyll-a Model 2, which was designed to account for algal growth limitation by phosphorus, light, and or flushing rate. Based upon the extremely high chlorophyll-a concentrations, shallow depth, bluegreen algal types found here, it is unlikely that light or flushing rate are controlling algal densities. Regional experience (primarily in Minnesota) suggests that chlorophyll-a Model 5 (Jones & Bachman regression) is appropriate. WWW uses

Model 5 with a global calibration factor of 0.83, well within the expected 0.5 to 2.0 range for calibration coefficients, based upon error magnitudes estimated from the CE reservoir data set.

4. Based on the memo on the Secchi/Phosphorus relationship (USGS,1991b), the USGS concluded that Secchi Model 3 (apparently used in USGS1) consisted of the following equation:

$$1/S = 0.082 + .022 P$$

As clearly stated in the program documentation (Walker, 1987, p. IV-10), the equation is:

$$S = 17.8 P^{-0.76}$$

It is puzzling that the USGS chose to guess the equation, instead of looking it up in the documentation. Since this equation was developed from reservoirs with a wide range of non-algal turbidities, the author suggests using Secchi Model 1, as adopted in the USGS1, UNCALIB, and WWW calibrations. Instead of adjusting Secchi calibration factors for each segment, the BETA coefficient (slope of inverse Secchi vs. Chl-a relationship) is adjusted downward from the default value (0.025 m²/mg) to 0.01 m²/mg. Based upon recent model applications in Minnesota and Oregon, this rather drastic adjustment is often necessary in reservoirs dominated by bluegreen algal types. Because of morphological features or mat-forming properties, light extinction per unit chlorophyll-a is lower in these situations.

The USGS2 calibration specifies no longitudinal dispersion (lateral 5. mixing between segments). This differs from the default option, which computes longitudinal dispersion using Fischer's equation. The specification of no dispersion between Segments 2 and 3 is justified based upon morphometric considerations (narrow river channel). Based upon the maps provided, however, considerable mixing would be expected between Segments 1 and 2. Accordingly the default dispersion option is specified in the UNCALIB version. As expected, this predicts high mixing rate and little difference in water quality between Segment 1 and 2 (Figure 1), which is contrary to the observed phosphorus, chlorophyll-a, and secchi data. The reason for this is unclear and is perhaps the most puzzling aspect of the calibration. Resetting the calibration factor for Segment 2 to 0.0 improves the predictions (Figure 2). This has the same effect has selecting dispersion Model 0, as in USGS2.

As discussed above, the most puzzling aspect of the calibration is the apparent presence of stronger longitudinal gradients than initially predicted. Data from other years should be examined to determine whether this pattern persists.

Maps suggest that another reservoir segment could be specified at the mouth of the Hay River. This has not been done, apparently because of the absence of observed water quality data for this area. Depending upon its area and volume relative to loads and flows from the Hay River, significant phosphorus retention may be occuring in this region. Exclusion of this segment would not have much effect on prediction of reservoir-average concentrations. If significant retention does occur in this segment, however, sensitivity of average main-lake concentrations to loads from the Hay River would be lower than predicted by the current model. Addition of this segment is suggested if sufficient data are available and if the relative sensitivity to loads from Hay vs. Red Cedar Rivers is important.

USGS (1991a) discusses the potential role of nitrogen limitation in Tainter Lake and reaches the conclusion that the system is primarily phosphorus limited, based upon Total N / Total P ratios. N/P ratios tend to be self-regulating in these highly eutrophic impoundments because of nitrogen fixation. Thus, modeling external nitrogen budgets would not be particuarly useful for predicting trophic response. The focus on phopshorus is appropriate.

Regarding the potential benefits of point-source P limits, the USGS (1991a) concludes that "if such limits are not adpoted, the water quality will continue to deteriorate". This conclusion implies a non-steady-state condition, which cannot be detected by calibrating the model to a single year. "Worsening" conditions would be expected only if point-source loads continue to increase over time.

References

Walker, W.W., "Empirical Methods for Predicting Eutrophication in Impoundments, Report 4,, Applications Manual", USAE Waterways Experiment Station, Tech. Report E-81-9, July 1987.

Walker, W.W., "Flux, Profile, & Bathtub Documentation", prepared for USAE Waterways Experiment Station", Draft May 1995.

US Geological Survey, "Summary of the Evaluation and Simulation of Water Quality in Tainter Lake, Dunn County, Wisconsin, June 1991a.

USGS, Memo, Secchi / Phosphorus Relationship, 1991b.

USGS, "Tainter Lake Model Revisions and Re-Calibration", July 9, 1991c.

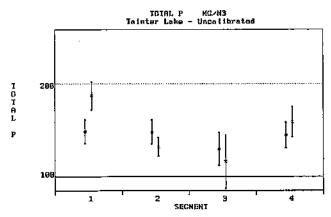
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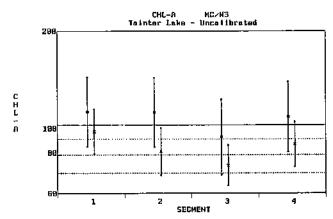
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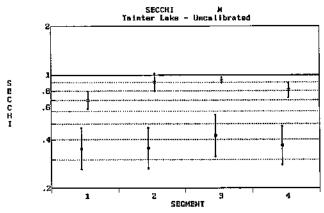
Figure 1
Observed & Predicted Values - Uncalibrated



■ ESTIMATE × OBSERVED

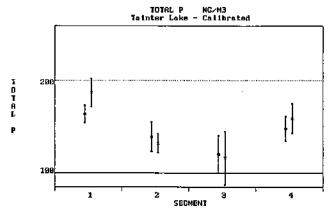


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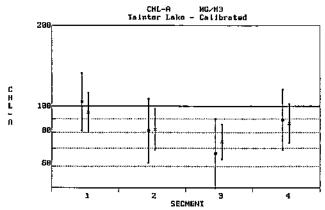


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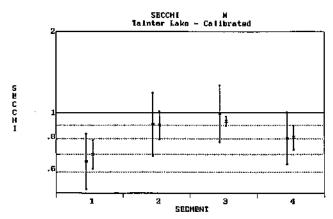
Figure 2
Observed & Predicted Values - Calibrated



• ESTIMATE × OBSERVED



· ESTINATE · OBSERVED



■ ESTIMATE × OBSERVED

Table 1
Summary of Tainter Lake Calibrations

Version	USGS1	USGS2	UNCALIB	www
Phosphorus Sedimentation	Model 1 (?) Cal = ?	Model 1 Cal(1) = 1.16 Cal(2) = 0.92 Cal(3) = 0.93 Cal Option 2	Model 1 Cal Option 1*	Model 1 Cal Option 1 Cal = 1.13
Chlorophyll-a	Model 5 (?) Cal = ?	Model 2 Cal(1) = 4.08 Cal(2) = 6.34 Cal(3) = 11.9	Model 5	Model 5 Cal = 0.81
Secchi Depth	Model 3 Cal = ?	Model 1 Cal(1) = 1.7 Cal(2) = 2.0 Cal(3) = 1.8	Model 1 Beta = 0.025	Model 1 Beta = 0.01
Longitudinal Dispersion	Model 0 None	Model 0 None	Model 1 Cal(2) = 0.	Model 2 Cal(1) = 0. Cal(2) = 0.

Cal(n) - Calibration factor for Segment n

Cal - Calibration factor for entire system (Proc = 'Case Edit Mcoefs')

Default Cal(n) and Cal values = 1.0

Beta = Chl-a/Secchi Slope, Default = .025 m2/mg (Proc = "Case Edit Mcoefs')

* Calibration Options for Phosphorus

1 = Calibrate Decay Rates (default)

2 = Calibrate Concentrations

Table 2 Input File - Original (USGS2)

TAINTER LAKE BATHTUB MODEL, LOAD SCENARIO-1 SIMULATION

MODE 1 C 2 F 3 N 4 C 5 S 6 F 7 F 8 N 9 E 10 A	L OPT ONSER PHOSPH ITROG CHLORO SECCHI DISPER PHOSPH ITROG CROR VAILA MASS-B	ION VAT ORU EN DE SIO ORU EN ANA BIL	S: TIVE SUBSTANCE S BALANCE BALANCE LL-A PTH S CALIBRATION CALIBRATION LYSIS ITY FACTORS INCE TABLES		0 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	NOT C 2ND O NOT C P, LI VS. C NONE CONCE NONE NOT C USE F	COMPUTED PROPRIED COMPUTED COMPUTED COMPUTED COMPUTED COMPUTED COMPUTED COR MODEL 1 COSTIMATED CO	P DITY ONLY NCS		
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			ATMOSPHERIC-LO	DADS	AVAIL	ABILITY				
VARI	ONGED ONGED	7.7	NG/KMZ-XR	00	r,	.00				
2 7	COTAL	p	19.30	.10		1.00				
3 1	LATO	N	KG/KM2-YR .00 19.30 .00 .00	.00		.00				
4 0	RTHO	P	.00	.00		.00				
GT.OF	RAT. TN	ייו זיםי	TVALUES: TH YRS ON M M STORAGE M							
PARA	METER				MEAN	CV				
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EVAL	CORATI	ON.	M CTODACE M		000	000				
TRIE	BUTARY	DF	RAINAGE AREAS ANAME HAY RIVER GAGINAY RIVER STP: RED CEDAR GAGINED CEDAR STP: COLFAX STP IN: OTTER CREEK SINKING/8-MI LAMBS CREEK DIRECT RUNOFF CEDAR FALLS D	AND FL	OWS:			~~~ ~~		
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2	3	i	HAY RIVER STP	s S		.000	2.400		.000	
3	ı	1	RED CEDAR GAG	E	2852	.000	816.000		.100	
. 4	3	1	RED CEDAR STP	S		.000	2,400		.000	
5	3	1	COLFAX STP IN	FLO	01	.000	2.400		.250	
7	2	1	SINKING/8-MI	CBK	108	.000	.000		.000	
8	2	3	LAMBS CREEK		46	.900	.000		.000	
9	2	1	DIRECT RUNOFF		155	.000	.000		.000	
10	2	3	DIRECT RUNOFF		15	.500	.000		.000	
11	4	3	CEDAR FALLS D.	AM	4353	.000	1265.000		.100	
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000			CV:	.000	.000	.000	.000	.000	
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.000			٠,,	.000	,000	.000	.000	.000	
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			ARE	A ZMEA	AN.	ZMIX	ZH	ΥÞ	
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1 INFLOW POOL 2 MIDDLE POOL 3 LOWER DAM PO	:	1.80	2.900	0 2.8	3 2.8	3/ .12	.00	/ .00	
2 MIDDLE POOL	:	3.70	1.760	0 5.4	1 4.8	4/ .12	.00	/ .00	
3 LOWER DAM PO	OOL :	2.50	1.280	0 6.4	3 5.4	0/ .12	.00	/ .00	
								, , , , ,	
SEGMENT OBSERVE	ED WATER	QUALI'	TY:						
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MG/M3-D				•		•	•	ŕ	
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	. 00								
2 MN: .00	.0 :	125.0	.0	82.0	.9	.0	.0	.0	.0
2 MN: .00 CV: .13	.00	.07	.0 .00	82.0 .19	.9 .13	.0 .00	.0 .00	.0 .00	.0 00.
2 MN: .00 CV: .13 3 MN: .00 CV: .04	.00	.07 .12.0	.0 .00 .0	82.0 .19 74.0	.9 .13 .9	0. 00. 0.	.0 .00 .0	.0 .00 .0	0. 00. 0.

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MODEL COEFFICIENTS:		
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DISPERSION FACTO	1.000	.00
P DECAY RATE	1.000	.45
N DECAY RATE	1.000	.55
CHL-A MODEL	1.000	.26
SECCHI MODEL	1.000	.10
ORGANIC N MODEL	1.000	.12
TP-OP MODEL	1.000	.15
HODV MODEL	1.000	.15
MODV MODEL	1.000	.22
BETA M2/MG	.025	.00
MINIMUM QS	4.000	.00
FLUSHING EFFECT	1.000	.00
CHLOROPHYLL-A CV	.620	.00

CASE NOTES:

Table 3 Input File - Uncalibrated

Tainter Lake - Uncalibrated

MODEL OPTIONS: 1 CONSERVATIVE SUBSTANCE 2 PHOSPHORUS BALANCE 3 NITROGEN BALANCE 4 CHLOROPHYLL-A 5 SECCHI DEPTH 6 DISPERSION 7 PHOSPHORUS CALIBRATION 8 NITROGEN CALIBRATION 9 ERROR ANALYSIS 10 AVAILABILITY FACTORS 11 MASS-BALANCE TABLES	0 NOT COMPUTED 1 2ND ORDER, AVAIL P 0 NOT COMPUTED 5 P, JONES & BACHMAN 1 VS. CHLA & TURBIDITY 1 FISCHER-NUMERIC 1 DECAY RATES 0 NONE 1 MODEL & DATA 1 USE FOR MODEL 1 ONLY 1 USE ESTIMATED CONCS
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VARIABLE KG/KM2-YR CV	FACTOR
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3 TOTAL N .00 .00	.00
4 ORTHO P .00 .00	.00
VARIABLE KG/KM2-YR CV 1 CONSERV .00 .00 2 TOTAL P 19.30 .10 3 TOTAL N .00 .00 4 ORTHO P .00 .00 5 INORG N .00 .00	.00
GLOBAL INPUT VALUES: PARAMETER PERIOD LENGTH YRS PRECIPITATION M EVAPORATION M	MEAN
PARAMETER PERTOD LENGTH VRS	420 000
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EVAPORATION M	.560 .000
INCREASE IN STORAGE M	.000 .000
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1 1 1 HAY RIVER GAGE 2 3 1 HAY RIVER STPS 3 1 1 RED CEDAR GAGE 4 3 1 RED CEDAR STPS 5 3 1 COLFAX STP INFLO 6 1 1 OTTER CREEK 7 1 1 SINKING/8-MI CRK 8 1 3 LAMBS CREEK 9 1 1 DIRECT RUNOFF 10 1 3 DIRECT RUNOFF 11 4 3 CEDAR FALLS DAM TRIBUTARY CONCENTRATIONS (PPB) 1D CONSERV TOTAL P 1 .0/.00 150.0/.03 2 .0/.00 5240.0/.00 3 .0/.00 179.0/.04 4 .0/.00 3200.0/.00 5 .0/.00 174.0/.10	AINAGE AREA MEAN FLOW CV OF MEAN FLOW KM2 HM3/YR 1083.000 341.000 .100 .000 2.400 .000 2852.000 816.000 .100 .000 2.400 .000 .000 2.400 .250 91.900 27.600 .200 108.000 32.400 .200 108.000 32.400 .200 155.000 15.500 .200 155.000 15.500 .200 4353.000 1265.000 .100 **MEAN/CV TOTAL N ORTHO P INORG N .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00 .0/.00
1 1 1 HAY RIVER GAGE 2 3 1 HAY RIVER GAGE 3 1 1 RED CEDAR GAGE 4 3 1 RED CEDAR STPS 5 3 1 COLFAX STP INFLO 6 1 1 OTTER CREEK 7 1 1 SINKING/8-MI CRK 8 1 3 LAMBS CREEK 9 1 1 DIRECT RUNOFF 10 1 3 DIRECT RUNOFF 11 4 3 CEDAR FALLS DAM TRIBUTARY CONCENTRATIONS (PPB) 1D CONSERV TOTAL P 1 .0/.00 150.0/.03 2 .0/.00 179.0/.04 4 .0/.00 3200.0/.00 5 .0/.00 174.0/.10 6 .0/.00 150.0/.20	AINAGE AREA MEAN FLOW CV OF MEAN FLOW KM2 HM3/YR 1083.000 341.000 .100 .000 2.400 .000 2852.000 816.000 .100 .000 2.400 .000 .000 2.400 .250 91.900 27.600 .200 108.000 32.400 .200 168.000 32.400 .200 155.000 15.500 .200 155.000 15.500 .200 4353.000 1265.000 .100 * MEAN/CV TOTAL N ORTHO P INORG N .0/.00
1 1 1 HAY RIVER GAGE 2 3 1 HAY RIVER GAGE 3 1 HAY RIVER STPS 3 1 1 RED CEDAR GAGE 4 3 1 RED CEDAR STPS 5 3 1 COLFAX STP INFLO 6 1 1 OTTER CREEK 7 1 1 SINKING/8-MI CRK 8 1 3 LAMBS CREEK 9 1 1 DIRECT RUNOFF 10 1 3 DIRECT RUNOFF 11 4 3 CEDAR FALLS DAM TRIBUTARY CONCENTRATIONS (PPB) 1D CONSERV TOTAL P 1 .0/.00 150.0/.03 2 .0/.00 5240.0/.00 3 .0/.00 179.0/.04 4 .0/.00 3200.0/.00 5 .0/.00 174.0/.10 6 .0/.00 150.0/.20 7 .0/.00 150.0/.20	AINAGE AREA MEAN FLOW CV OF MEAN FLOW KM2 HM3/YR 1083.000 341.000 .100 .000 2.400 .000 2852.000 816.000 .100 .000 2.400 .000 .000 2.400 .250 91.900 27.600 .200 108.000 32.400 .200 108.000 32.400 .200 155.000 15.500 .200 155.000 15.500 .200 4353.000 1265.000 .100 **MEAN/CV TOTAL N ORTHO P INORG N .0/.00
1	MEAN FLOW CV OF MEAN FLOW KM2
1 1 1 HAY RIVER GAGE 2 3 1 HAY RIVER GAGE 3 1 HAY RIVER STPS 3 1 1 RED CEDAR GAGE 4 3 1 RED CEDAR STPS 5 3 1 COLFAX STP INFLO 6 1 1 OTTER CREEK 7 1 1 SINKING/8-MI CRK 8 1 3 LAMBS CREEK 9 1 1 DIRECT RUNOFF 10 1 3 DIRECT RUNOFF 11 4 3 CEDAR FALLS DAM TRIBUTARY CONCENTRATIONS (PPB) 1D CONSERV TOTAL P 1 .0/.00 150.0/.03 2 .0/.00 5240.0/.00 3 .0/.00 179.0/.04 4 .0/.00 3200.0/.00 5 .0/.00 174.0/.10 6 .0/.00 150.0/.20 7 .0/.00 150.0/.20	AINAGE AREA MEAN FLOW CV OF MEAN FLOW KM2 HM3/YR 1083.000 341.000 .100 .000 2.400 .000 2852.000 816.000 .100 .000 2.400 .000 .000 2.400 .250 91.900 27.600 .200 108.000 32.400 .200 108.000 32.400 .200 155.000 15.500 .200 155.000 15.500 .200 4353.000 1265.000 .100 **MEAN/CV TOTAL N ORTHO P INORG N .0/.00

MODEL SEGMENTS & CALIBRATION FACTORS:

	SEGMENTS	5 & (.:ALL	.BRATIO	N FACTOR		C	ALIBRAT	TION FAC	CTORS	
SEG OUT		ROUP	SEG	MENT N	AME	P SED	n sed	CHL-A	SECCHI	HOD	
1	2	1,	INE	LOW POO)L	1.00	.00	1.00	1.00	.00	
.000					CV:	.000	.000	.000	.000	.000	
2 .000	3	1	MII	DLE POO	D.F.			1.00		.00	
.000						.000					
3 1.000	0	2	LOV	ier dam	POOL						
.000					CV:	.000	.000	.000	.000	.000	
SEGMENT	r MORPHO	OMET	RΥ:	MEAN/C	<i>J</i>		_				
			1	ENGTH	ARE	A ZMEAL	N	ZMIX	ZH	ΥP	
ID LABI	EL	_		KM	KM:	2 [ν 1	M		М	
1 INF	FOM BOOT	_		1.80	KM 2.900 1.760 1.280	0 2.8	3 2.8	3/ .12	.00,	, .00	
2 MIDI	DLE POOI	<u>. </u>		3.70	1.760	5.4	1 4.8	4/ .12	.00,	, .00	
3 POM	er dam i	POOL		2.50	1.280	0 6.43	3 5.4	0/ .12	.00,	/ .00	
											
	r observ										
SEG					TOTALN						MODV
	1/M	-		MG/M3	MG/M3	MG/M3	М	MG/M3	MG/M3	MG/M3-D	
MG/M3-D											
1 MN:	.00		. 0	183.0	. 0	95.0	. 7	.0	.0	.0	.0
CV:	.13		.00	.11	.00	.18	.13	.00	.00	.00	.00
2 MN:	.00		.0	125.0	.0	82.0	. 9	.0	. 0	.0	.0
CV:	.13 .00		.00	.07	.00	.19	.13	.00	.00	.00	.00
	.00		.0	112.0	.0	74.0	. 9	.0	.0	.0	. 0
CV:	.04		.00	.22	.00	.16	.04	.00	.00	.0 .00 .00 .00	.00
MODEL 0	COEFFIC	IENT:	3:								
COEFFIC											
				MEAN	CV						
DISPERS		CTC		MEAN 1.000							
DISPERS	SION FAC	CTO		1.000	.00						
P DECA	SION FAC Y RATE			1.000	.00 .45						
P DECAY	SION FAC Y RATE Y RATE			1.000	.00 .45 .55						
P DECAY N DECAY CHL-A	SION FAC Y RATE Y RATE MODEL			1.000 1.000 1.000	.00 .45 .55 .26						
P DECAY N DECAY CHL-A	SION FAC Y RATE Y RATE MODEL			1.000 1.000 1.000	.00 .45 .55 .26 .10						
P DECAN N DECAN CHL-A M SECCHI ORGANIO	SION FAC Y RATE Y RATE MODEL MODEL C N MODI			1.000 1.000 1.000 1.000 1.000	.00 .45 .55 .26 .10						
P DECAN N DECAN CHL-A N SECCHI ORGANIC TP-OP N	SION FAC Y RATE MODEL MODEL C N MODI MODEL			1.000 1.000 1.000 1.000 1.000 1.000	.00 .45 .55 .26 .10 .12						
P DECAME NO DECA	SION FAC Y RATE Y RATE MODEL MODEL C N MODI MODEL ODEL			1.000 1.000 1.000 1.000 1.000 1.000	.00 .45 .55 .26 .10 .12 .15						
P DECAME NO DECA	SION FAC Y RATE Y RATE MODEL MODEL C N MODI MODEL ODEL ODEL	EL		1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	.00 .45 .55 .26 .10 .12 .15						
P DECAME NO DECA	SION FAC Y RATE Y RATE MODEL MODEL C N MODI MODEL ODEL ODEL	EL		1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	.00 .45 .55 .26 .10 .12 .15 .15						
P DECAME NO DECA	SION FAC Y RATE Y RATE MODEL MODEL O N MODI MODEL ODEL ODEL M2/MG	EL		1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 4.000	.00 .45 .55 .26 .10 .12 .15 .15 .22 .00						
P DECAME NO DECA	SION FAC Y RATE Y RATE MODEL MODEL C N MODI MODEL ODEL ODEL	EL		1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 4.000	.00 .45 .55 .26 .10 .12 .15 .15						

Table 4
Input File - Calibrated (WWW)

MODEL OPTIONS: 1 CONSERVATIVE 2 PHOSPHORUS BA 3 NITROGEN BALA: 4 CHLOROPHYLL-A 5 SECCHI DEPTH 6 DISPERSION 7 PHOSPHORUS CA: 8 NITROGEN CALI: 9 ERROR ANALYSI: 10 AVAILABILITY:	SUBSTANCE LANCE NCE LIBRATION BRATION S FACTORS TABLES		0 NOT (0 1 2ND (0 NOT (0 5 P, J0 1 VS. (0 1 PISCH 1 DECAY 0 NONE 1 MODEI 1 USE F	COMPUTED DRDER, AVAIL COMPUTED DNES & BACHN CHLA & TURBL HER-NUMERIC (RATES L & DATA FOR MODEL 1.	IAN IDITY ONLY ONCS
ATMO	SPHERIC-LOADS	AVAIL	ABILITY	<i>t</i>	
VARIABLE KG/I	KM2-YR CV	F	ACTOR		•
2 TOTAL P	19 30 10		.00		
3 TOTAL N	.00 .00		.00		
4 ORTHO P	.00 .00		.00		
VARIABLE KG/I 1 CONSERV 2 TOTAL P 3 TOTAL N 4 ORTHO P 5 INORG N	.00 .00		.00		
CIODAT TAINIUM MATI	TTPC .				
PARAMETER	JES:	MEAN	CV		
PERIOD LENGTH	YRS	.420	.000		
PRECIPITATION M		.570	.000		
EVAPORATION M		.560	.000		
GLOBAL INPUT VALUE PARAMETER PERIOD LENGTH PRECIPITATION M EVAPORATION M INCREASE IN STORA	AGE M	.000	.000		
TRIBUTARY DRAINAG	R AREAS AND FL	OWS.			
ID TYPE SEG NAME	DRA	INAGE :	AREA	MEAN FLOW	CV OF MEAN FLOW
			KM2	HM3/YR	ov or them them
1 1 1 HAY F	RIVER GAGE	1083	.000	341,000	.100
2 3 I HAY F	RIVER STPS	2052	.000	2.400	.000
4 3 1 RED (EDAR GAGE	2852	000	816.000	.100
5 3 1 COLF	AX STP INFLO		.000	2.400	.000 250
6 1 1 OTTER	R CREEK	91	.900	27,600	.200
7 1 1 SINK	ING/8-MI CRK	108	.000	32.400	.200
8 1 3 LAMBS	G CREEK	46	.900	14.100	.200
10 1 3 DIREC	T RUNOFF	155	.000	15.500	.200
11 4 3 CEDAR	REFALLS DAM	4353	.000	1265 000	.200
1 1 1 HAY F 2 3 1 HAY F 3 1 1 RED C 4 3 1 RED C 5 3 1 COLFF 6 1 1 OTTER 7 1 1 SINKI 8 1 3 LAMBS 9 1 1 DIREC 10 1 3 DIREC 11 4 3 CEDAR				2203.000	.100
TRIBUTARY CONCENT	TRATIONS (PPB):	MEAN/	CV		
ID CONSERV 1 .0/.00	TOTAL P		TAL N	ORTHO P	
2 .0/ .00	150.0/ .03 5240.0/ .00		.00 .00	.0/ .00	.0/ .00
	179.0/ .04		.00	.0/ .00 .0/ .00	.0/ .00 .0/ .00
4 .0/ .00	3200.0/ .00	0/		.0/ .00	.0/ .00
5 .0/ .00 6 .0/ .00	174.0/ .10	.0/	.00	.0/ .00	.0/ .00
•	150.0/ .20		.00	.0/ .00	.0/ .00
7 .0/.00 8 .0/.00	150.0/ .20 150.0/ .20		.00	.0/ .00	.0/ .00
9 .0/ .00	150.0/ .20		.00 .00	.0/ .00 .0/ .00	.0/ .00 .0/ .00
10 .0/ .00	150.0/ .20		.00	.0/ .00	.0/ .00
11 .0/ .00	.0/ .00		.00	.0/ .00	.0/ .00
MODEL SEGMENTS &	CALIBRATION FAC	CTORS:		CIT TIPE	TTOM TO STORE

----- CALIBRATION FACTORS

SEC DISE	GOUT!	FLOW G	ROUP	SE	GMENT I	NAME	1	P SED	N SE	D CHL	-A :	SECCHI	HOD	
.000)	2	1	IN	FLOW P	DOL		1.00	. 04	0 1.0	00	1.00	.00	
.000)						CV:	.000	.000	0.00	00	.000	.000	
.000)	3	1	MI	DDLE P	OOL		1.00	.00	1.0	00	1.00	.00	
.000							CV:	.000	.000		00	.000	.000	
3 1.00		0	2	LO	WER DA	M PO	OL	1.00	. 00	1.0	00	1.00	.00	
.000)						CV;	.000	.000		00	.000	.000	
SEG	MENT	MORPHO	OMETI	RY:	MEAN/	ZV								
ID	LABEI			1	LENGTH KM		AREA KM2	A ZMEAL 2 1 0 2.8 0 5.4 0 6.4	N vr	ZMIX		ZH	YP M	
1	TNELC	וססם שו	٠.		1 80		2 9000			03/ 1			/	
÷	MITTATA	ישל הייט			1.00		2.5000	2.8	3 2.	.83/ .1	L 22	.00,	, .00	
2	TOMPI	JE POUI	7001		3.70		1.7600	5.4	14.	.84/ .1	L2	.00,	/ .00	
. 3	LOWER	C DAM I	COOL		2.50		1.2800	6.4	35.	40/ .1	L2	.00,	/ .00	
SEG	WENT.	OBSERV	/ED V	ITAV	er quai	LITY	;							
SEG	} 7	URBID	CONS	ER	TOTALI	OT ?	TALN	CHL-A	SECCHI	ORG-	-N	TP-OP	HODV	MODV
		1/M			MG/M3	3 M	G/M3	MG/M3	N	1 MG/M	13	MG/M3	MG/M3-D	
MG/M	13 - D													
1	MN:	.00		. 0	183.0)	.0	95.0	. 7	, .	. 0	. 0	. 0	٥
	CV:	.13		00	.13	L	.00	.18	. 13		00	00	00	.00
2	MN:	.00		.0	125.0)	. 0	82.0		·	'n		.00	.00
	CV:	.13		00	. 0	7	. 00	19	12	,	00	00	.0	.0
3	MN:	.00	•	. 0	112.0)		74 0		, , ,	^^	.00	.00	.00
_	CV.	04		00	22	Ó	00	74.0	0.4	, ,		.0	. 0	. 0
		.04	•	00	. 44	•	.00	.10	.04		, 0	.00	.00	.00
		EFFICI												
COE	FFICI	ENT			MEAN		CV							
DIS	PERSI	ON FAC RATE	TO		1.000		.00							
PD	ECAY	RATE			1.130		.45							
N D	ECAY	RATE DEL			1.000		.55							
CHL	-A MC	لكلالا			.810		.26							
SEC	CHI M	ODEL			1.000		.10							
ORG	ANIC	N MODE	EL		1.000		.12							
TP-	OP MO	DEL			1,000		.15							
HOD	V MOD	EL			1.000		.15							
MOD	V MOD	RI.			1.000		.22							
BET	A M2	/MG QS			010		.00							
MTN	TMTIM	OS.			4 000		.00							
TLIT	CHIMO	i proces	יקי		7 000									
ידנדין.	Ob∪bn	EFFEC	_T		1.000		.00							
Cal		тпп-А	CV		.620		.00							
										`				

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Table 5 Listing of Observed & Predicted Values (WWW)

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS USING THE FOLLOWING ERROR TERMS:

- 1 = OBSERVED WATER QUALITY ERROR ONLY
- 2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET

3 = OBSER	OMA DEVI	PREDICT	ED ERR	OR					
SEGMENT:	1 INFLO	W POOL							
		OBSI	ERVED	ESTI	MATED		т	STATIS	rics
VARIABLE		MEAN	CV	MEAN	CV	RATIO	1	2	3
									
TOTAL P	MG/M3	183.0	.11	155.6	.07	1.18	1.47	.60	1.26
CHL-A	MG/M3	95.0	.18	104.1	.28	.91	51	26	28
SECCHI	M	. 7	.13	. 7	.27	1.06	.47	.22	.21
ORGANIC N	MG/M3	.0	.00	2565.8	.28	.00	.00	.00	.00
TOTAL P CHL-A SECCHI ORGANIC N TP-ORTHO-F	MG/M3	.0	.00	192.5	.31	.00	.00	.00	.00
SEGMENT:	2 MIDDLE	E POOL							
		OBSI	ERVED	ESTI	MATED		т	STATIST	rics
VARIABLE		MEAN	CV	MEAN	CV	RATIO	1	2	3
ΤΟΤΔΙ. Ρ	MG/M3	125 N	07	121 4	13			<u>-</u> -	
CHI-A	MG/M3	82 A	19	231.4	71	3 01	/2	18	37
SECCHI	M	9	13	01.3	.JI	1,01	.05	.03	, 02
ORGANIC N	MG/M3	. ,	. 10	2032.2	21	. 29	05	02	-,02
TP-ORTHO-P	MG/M3	,0	00	147 5	3.4 - 2 T	.00	.00	.00	.00
CHL-A SECCHI ORGANIC N TP-ORTHO-P								.00	.00
SEGMENT:	3 LOWER	DAM POOI	J						
		OBSE	RVED	ESTI	4ATED		T	STATIST	rics
SEGMENT: VARIABLE		MEAN	CV	MEAN	CA	RATIO	1	2	3
TOWN D	MG /MD								
CHI A		110 0							
	MC /MO	112.0	.22	115.1	.15	.97	13	10	10
CECCUT	MG/M3	112.0 74.0	.22	115.1 67.1	.15	.97 1.10	13 .62	10 .28	10 .26
SECCHI OPGANIC N	MG/M3 MG/M3	112.0 74.0 .9	.22 .16 .04	115.1 67.1 1.0	.15 .34 .28	.97 1.10 .94	13 .62 -1.67	10 .28 24	10 .26 24
SECCHI ORGANIC N	MG/M3 MG/M3 MG/M3	112.0 74.0 .9 .0	.22 .16 .04	115.1 67.1 1.0 1711.0	.15 .34 .28 .33	.97 1.10 .94 .00	13 .62 -1.67	10 .28 24	10 .26 24
SECCHI ORGANIC N TP-ORTHO-P	MG/M3 MG/M3 MG/M3 MG/M3	112.0 74.0 .9 .0	.22 .16 .04 .00	115.1 67.1 1.0 1711.0 123.2	.15 .34 .28 .33 .36	.97 1.10 .94 .00	13 .62 -1.67 .00	10 .28 24 .00	10 .26 24 .00
SECCHI ORGANIC N TP-ORTHO-P	MG/M3 MG/M3 MG/M3 MG/M3	112.0 74.0 .9 .0	.22 .16 .04 .00 .00	115.1 67.1 1.0 1711.0 123.2	.15 .34 .28 .33 .36	.97 1.10 .94 .00	13 .62 -1.67 .00	10 .28 24 .00	10 .26 24 .00
				115.1 67.1 1.0 1711.0 123.2	.15 .34 .28 .33 .36	.97 1.10 .94 .00	13 .62 -1.67 .00	10 .28 24 .00 .00	10 .26 24 .00
				115.1 67.1 1.0 1711.0 123.2	.15 .34 .28 .33 .36	.97 1.10 .94 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
SEGMENT:	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00
	4 AREA-W	TD MEAN OBSE MEAN	ERVED CV	115.1 67.1 1.0 1711.0 123.2 	.15 .34 .28 .33 .36	.97 1.10 .94 .00 .00	13 .62 -1.67 .00 .00	10 .28 24 .00 .00	10 .26 24 .00 .00