



CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 4.5

Part 3 Input and Output Files User Manual

Edited by

Scott A. Wells
Professor
Department of Civil and Environmental Engineering
Portland State University
Portland, OR 97207-0751

Department of Civil and Environmental Engineering
Portland State University
Portland, OR 97207-0751

June 2024

CONTENTS

Contents

Contents	ii
List of Figures	xi
List of Tables.....	xiii
Preface.....	xvi
1. Introduction	1
Input Files Overview	1
Output Files Overview	1
Command-line Working Directory Specification	2
2. Input and Output Files Data Description	3
Input Files	3
Control File: w2_con.npt.....	3
Control File: w2_con.csv	3
Description of Control File Parameters	7
Title (TITLE C).....	7
Grid Dimensions (GRID).....	8
Inflow/Outflow Dimensions (IN/OUTFLOW).....	9
Constituent Dimensions (CONSTITUENTS).....	10
Miscellaneous (MISCELL).....	11
Time Control (TIME CON).....	14
Timestep Control (DLT CON)	15
Timestep Date (DLT DATE).....	16
Maximum Timestep (DLT MAX).....	16
Timestep Fraction (DLT FRN)	17
Timestep Limitations (DLT LIMIT).....	18
Branch Geometry (BRANCH G).....	19
Waterbody Definition (LOCATION).....	22
Initial Conditions (INIT CND)	24
Calculations (CALCULAT)	26
Dead Sea (DEAD SEA)	28
Interpolation (INTERPOL)	29
Heat Exchange (HEAT EXCH).....	31
Ice Cover (ICE COVER)	33
Transport Scheme (TRANSPORT).....	36
Hydraulic Coefficients (HYD COEF).....	37
Vertical Eddy Viscosity (EDDY VISC)	39
Number of Structures (N STRUC)	42
Structure Interpolation (STR INT)	43
Structure Top Selective Withdrawal Limit (STR TOP)	44
Structure Bottom Selective Withdrawal Limit (STR BOT)	45
Sink Type (SINK TYPE)	47

CONTENTS

Structure Elevation (E STRUC).....	48
Structure Width (W STRUC).....	49
Pipes (PIPES)	51
Upstream Pipe (PIPE UP)	53
Downstream Pipe (PIPE DOWN).....	54
Spillways (SPILLWAYS).....	56
Upstream Spillways (SPILL UP)	58
Downstream Spillways (SPILL DOWN)	59
Spillway Dissolved Gas (SPILL GAS)	60
Gates (GATES).....	63
Gate Weir (GATE WEIR).....	66
Upstream Gate (GATE UP)	68
Downstream Gate (GATE DOWN)	69
Gate Dissolved Gas (GATE GAS)	70
Pumps 1 (PUMPS 1).....	73
Pumps 2 (PUMPS 2).....	76
Internal Weir Segment Location (WEIR SEG)	77
Internal Weir Top Layer (WEIR TOP).....	78
Internal Weir Bottom Layer (WEIR BOT).....	79
Withdrawal Interpolation (WD INT).....	80
Withdrawal Segment (WD SEG).....	81
Withdrawal Elevation (WD ELEV).....	81
Withdrawal Top Layer (WD TOP)	82
Withdrawal Bottom Layer (WD BOT)	83
Tributary Inflow Placement (TRIB PLACE)	84
Tributary Interpolation (TRIB INT).....	85
Tributary Segment (TRIB SEG)	86
Tributary Inflow Top Elevation (TRIB TOP)	87
Tributary Inflow Bottom Elevation (ELEV BOT)	88
Distributed Tributaries (DST TRIB).....	89
Hydrodynamic Output Control (HYD PRINT)	90
Snapshot Print (SNP PRINT)	92
Snapshot Dates (SNP DATE).....	93
Snapshot Frequency (SNP FREQ).....	94
Snapshot Segments (SNP SEG)	95
Screen Print (SCR PRNT).....	96
Screen Dates (SCR DATE).....	97
Screen Frequency (SCR FREQ).....	98
Profile Plot (PRF PLOT)	99
Profile Date (PRF DATE)	100
Profile Frequency (PRF FREQ).....	101
Profile Segment (PRF SEG)	102
Spreadsheet Profile Plot (SPR PLOT)	103
Spreadsheet Profile Date (SPR DATE)	104
Spreadsheet Profile Frequency (SPR FREQ).....	105
Spreadsheet Profile Segment (SPR SEG)	106

CONTENTS

W2 Linkage File Output – (Vector Plot) (VPL PLOT).....	107
Vector Plot Date (VPL DATE).....	108
Vector Plot Frequency (VPL FREQ).....	109
Contour Plot (CPL PLOT)	110
Contour Plot Dates (CPL DATE).....	112
Contour Plot Frequency (CPL FREQ).....	113
Kinetic Flux Output (FLUXES).....	114
Kinetic Flux Date (KFL DATE).....	115
Kinetic Flux Frequency (FLX FREQ).....	115
Time Series Plot (TSR PLOT)	117
Time Series Date (TSR DATE)	119
Time Series Frequency (TSR FREQ).....	119
Time Series Segment (TSR SEG)	120
Time Series Elevation (TSR ELEV).....	120
Water Level Output (WL OUT).....	122
Flow Balance Output (FB OUT)	122
N and P Mass Balance Output (NPB OUT).....	123
Withdrawal Output (WITH OUT)	123
Withdrawal Output Date (WDO DATE)	124
Withdrawal Output Frequency (WDO FREQ)	125
Withdrawal Output Segment (WITH SEG)	125
Restart (RESTART)	126
Restart Date (RSO DATE)	127
Restart Frequency (RSO FREQ)	128
Constituent Computations (CST COMP)	129
Atmospheric Deposition (ATMDEP)	134
Active Constituents (CST ACTIVE)	135
Derived Constituents (CST DERIVE)	137
Constituent Kinetic Fluxes (CST FLUX).....	142
Constituent Initial Concentration (CST ICON)	146
Constituent Output (CST PRINT).....	148
Inflow Active Constituent Control (CIN CON)	151
Tributary Active Constituent Control (CTR CON).....	152
Distributed Trib Active Constituent (CDT CON).....	153
Precipitation Active Constituent Control (CPR CON)	154
Extinction Coefficient (EX COEF)	160
Algal Extinction (ALG EX)	164
Zooplankton Extinction (ZOO EX).....	164
Macrophyte Extinction (MAC EX)	165
Generic Constituent (GENERIC).....	166
Suspended Solids (S SOLIDS)	168
Bacteria	169
H2S	170
CH4.....	171

CONTENTS

Fe(II) and FeOOH.....	171
Mn(II) and MnO ₂	172
Algal Rates (ALGAL RATE).....	174
Algal Temperature Rate Coefficients (ALG TEMP)	187
Algal Stoichiometry (ALG STOICH).....	189
Epiphyte/Periphyton Control (EPIPHYTE).....	192
Epiphyte/Periphyton Print (EPI PRINT)	192
Epiphyte/Periphyton Initial Density (EPIINI).....	193
Epiphyte/Periphyton Rate (EPI RATE).....	194
Epiphyte/Periphyton Half-Saturation (EPI HALF).....	195
Epiphyte/Periphyton Temperature Rate Coefficients (EPI TEMP)	197
Epiphyte/Periphyton Stoichiometry (EPI STOICH)	199
Zooplankton Rate (ZOOP RATE)	201
Zooplankton Algal Preference (ZOOP ALGP)	202
Zooplankton Zooplankton Preference (ZOOP ZOOP).....	202
Zooplankton Temperature Rate Coefficients (ZOOP TEMP)	203
Zooplankton Stoichiometry (ZOOP STOICH)	204
Macrophyte Control (MACROPHYT).....	206
Macrophyte Print (MAC PRINT).....	206
Macrophyte Initial Concentration (MACINI).....	207
Macrophyte Rate (MAC RATE).....	209
Macrophyte Sediments (MAC SED).....	211
Macrophyte Distribution (MAC DIST).....	211
Macrophyte Drag (MAC DRAG).....	212
Macrophyte Temperature Rate Coefficients (MAC TEMP).....	213
Macrophyte Stoichiometry (MAC STOICH)	214
Dissolved Organic Matter (DOM).....	216
Particulate Organic Matter (POM).....	217
Organic Matter Stoichiometry (OM STOICH).....	219
Organic Matter Temperature Rate Multipliers (OM RATE).....	221
Turbidity and Secchi Disk (TURBSEC)	223
Carbonaceous Biochemical Oxygen Demand (CBOD).....	223
CBOD Stoichiometry (CBOD STOICH)	225
Inorganic Phosphorus (PHOSPHOR)	226
Ammonium (AMMONIUM)	227
Ammonium Temperature Rate Multipliers (NH4 RATE).....	229
Nitrate (NITRATE)	230
Nitrate Temperature Rate Multipliers (NO3 RATE).....	231
Silica (SILICA).....	232
Sediment Carbon Dioxide Release (SED CO2)	234
Oxygen Stoichiometry 1 (STOICH 1)	235
Oxygen Stoichiometry 2 (STOICH 2)	236
Oxygen Stoichiometry 3 (STOICH 3)	237
Oxygen Stoichiometry 4 (STOICH 4)	238
Oxygen Stoichiometry 5 (STOICH 5)	238
Oxygen Limit (O2 LIMIT)	239

CONTENTS

Sediment Compartment (SEDIMENT)	240
SOD Temperature Rate Multipliers (SOD RATE)	242
Zero-Order Sediment Oxygen Demand (S DEMAND)	244
Reaeration (REAERAT)	246
Restart Input Filename (RSI FILE)	250
Withdrawal Filename (QWD FILE)	250
Gate Outflow Filename (QGT FILE)	250
Wind Sheltering Filename (WSC FILE)	251
Dynamic Shading Filename (SHD FILE)	251
Bathymetry Filename (BTH FILE)	252
Meteorology Filename (MET FILE)	252
Light Extinction Filename (EXT FILE)	253
Atmospheric Deposition Filename (ATD FILE)	253
Vertical Profile Filename (VPR FILE)	254
Longitudinal Profile Filename (LPR FILE)	254
Branch Inflow Filename (QIN FILE)	255
Branch Inflow Temperature Filename (TIN FILE)	256
Branch Inflow Constituent Filename (CIN FILE)	256
Branch Outflow Filename (QOT FILE)	257
Tributary Inflow Filename (QTR FILE)	257
Tributary Inflow Temperature Filename (TTR FILE)	258
Tributary Inflow Concentration Filename (CTR FILE)	258
Distributed Tributary Inflow Filename (QDT FILE)	259
Distributed Tributary Inflow Temperature Filename (TDT FILE)	259
Distributed Tributary Inflow Concentration Filename (CDT FILE)	260
Precipitation Filename (PRE FILE)	260
Precipitation Temperature Filename (TPR FILE)	261
Precipitation Concentration Filename (CPR FILE)	261
External Upstream Head Filename (EUH FILE)	262
External Upstream Head Temperature Filename (TUH FILE)	262
External Upstream Head Concentration Filename (CUH FILE)	263
External Downstream Head Filename (EDH FILE)	263
External Downstream Head Temperature Filename (TDH FILE)	264
External Downstream Head Concentration Filename (CDH FILE)	264
Time Series Plot Filename (TSR FILE)	266
Withdrawal Output Filename (WDO FILE)	266
Sample Control Input File	267
Bathymetry File	289
Fixed Format Bathymetry File	290
Comma Delimited Format Bathymetry File	292
Fish Habitat Volumes and Volume-Weighted Averages of Eutrophication State Variables	295
Automatic Port Selection and Reservoir Volumes at Specified Temperatures	298
SELECTC='ON'	298

CONTENTS

File headers and frequency of checking for change in port	299
Automatic selection of outlet port to control temperature.....	300
Volume of reservoir at a given temperature threshold.....	305
SELECTC=' USGS'	305
Environmental Performance Criteria	310
Hypolimnetic Aeration.....	317
Constriction Input File	320
Sediment Diagenesis Input File	321
W2_diagenesis.npt Sample Input File.....	322
W2_diagenesis.npt Input Descriptions.....	326
Line Comments.....	326
Global ON/OFF Switch	327
Fine Fluids Tailing (FFT) Layer	327
Bed Consolidation	327
Consolidation Output.....	327
Initial Conditions	328
Sediment Characteristics	328
Gas Bubble Formation Rates	328
Bubble Related Turbulence	329
Resuspension of Particulate Organic Matter.....	329
Switches for Iron, Mn, and Alkalinity/pH in sediments.....	329
Diagenesis Initial Conditions.....	329
Diagenesis Region Settings.....	330
Porewater Diffusion, Particle Mixing Velocity and Burial Velocity of Sediments	331
Bioturbation Mixing Velocity.....	331
Methane Calculation Setting.....	331
Diagenesis Rates Settings Part 1	331
Diagenesis Rates Settings Part 2	332
Diagenesis Rates Settings Part 3	332
Diagenesis Rates Settings Part 4	333
Sediment Flux Output Settings.....	334
Input/Output Control.....	334
Ionization Settings	336
Dissolution Settings.....	336
pH Buffering Input File	336
Bed Consolidation Rate Input File	337
Meteorology File	338
Dynamic Elevation for Structure Outflows	341
Dynamic Pump Input File	342
Dynamic Pipe Input File	344
Gate File	345
Light Extinction File	349
Wind Sheltering Coefficient File	350
SYSTDG Input Files.....	352
W2 SYSTDG Control File.....	352

CONTENTS

TDG Target Control File	356
Shade Input File.....	359
Vegetation Elevation	360
Centerline Distance.....	361
Shade reduction factor.....	361
Topographic Shading.....	362
Input File Examples.....	362
Atmospheric Deposition Input File	365
Branch Inflow File.....	368
Branch Inflow Temperature File	369
Branch Inflow Constituent Concentration File.....	370
Branch Outflow File.....	373
Withdrawal File	375
Tributary Inflow File.....	376
Tributary Inflow Temperature File	378
Tributary Inflow Concentration File	379
Branch Distributed Tributary Inflow File	380
Branch Distributed Tributary Inflow Temperature File	382
Branch Distributed Tributary Inflow Concentration File	383
Branch Precipitation File	384
Branch Precipitation Temperature File	385
Branch Precipitation Concentration File	386
Branch External Upstream Head Elevation File	387
Branch External Upstream Head Temperature File.....	388
Branch External Upstream Head Constituent Concentration File	390
Branch External Downstream Head Elevation File	392
Branch External Downstream Head Temperature File.....	393
Branch External Downstream Head Concentration File	395
Vertical Profile File	397
Longitudinal Profile File	399
Graph Input File	405
Tecplot Input File Specifying Which Branches to Output.....	407
Lake River Contour Plots Input File.....	407
Algae Vertical Migration Input File	410
Algae Toxin Input File	414
Output Files	416
Snapshot.....	416
Title Cards	416
Time Parameters	417
Meteoro logical Parameters	417
Selective Withdrawal and Inflow/Outflow Parameters	418
Balances	420
Geometry	422
Water Surface	422

CONTENTS

Temperature/Water Quality.....	422
Sediment Diagenesis Output Files	424
Time Series	428
Auto-Port Selection Output Files.....	429
Volume at specified temperatures, volume_wbX.opt.....	429
Temperature of outlet releases, wd_out.opt and str_brX.csv	429
Fish Habitat Output Files.....	430
Fish Habitat	430
Nutrients, Dissolved Oxygen and Chlorophyll a – Volume weighted and surface	432
Overall organic matter accumulation at the bottom of each layer and summed for each segment	432
Preprocessor.....	433
Command-line working directory specification	433
Output (pre.opt).....	433
Warning Messages (pre.wrn)	443
Error Messages (pre.err)	444
Spreadsheet Profile Plot.....	445
Profile Plot	447
Longitudinal Profile Plot.....	452
Vector Plot.....	452
Contour Plot	452
Kinetic Fluxes.....	456
Withdrawal Outflow	460
Mass Balance Output File	461
Flow Balance Output File	462
SYSTDG Output File.....	463
Lake River Contour Plots Output Files.....	463
Lake Contour File	463
River Contour File.....	465
Water Level Output File.....	466
Run-time Warnings	467
Run-time Errors	469
W2.err.....	469
W2ErrorDump.csv	470
3. Using Particle Transport in CE-QUAL-W2.....	472
Input file w2_particle.csv	472
Reference System for Particles in Grid.....	474
Output Files	474
BRANCHX.DAT	475
PARTX.NPT	475
Finalparticle.csv	475
Initialparticle.csv	477
Envrprf_v_particle.csv, envrprf_t_particle.csv,	477
and envrprf_depth_particle.csv	477
Diagnostics.out	477

CONTENTS

Using Tecplot to Plot Particle Movement.....	478
4. Using Multiple Processors for a Cascade of Waterbodies	479
How to Set up a Simulation	480
Input File w2_multiple_WB.npt.....	481
Output file WaitForRunLog.opt.....	483
6. References.....	483

List of Figures

Figure 1. An overview of the input files required for CE-QUAL-W2.....	1
Figure 2. CE-QUAL-W2 generated output files.....	2
Figure 3. Example of Excel control file, w2_con.xlsm, that is used to output the file w2_con.csv.....	4
Figure 4. Screen shot of w2_con.xlsm used to output the control file w2_con.csv showing INTERPOLATION (Columns B through I).	5
Figure 5. Screen shot of w2_con.xlsm used to output the control file w2_con.csv showing TRIB FILES.	5
Figure 6. Example branch layout.....	21
Figure 7. Layer numbers and segments for a sloping waterbody where segment 9 is the last active segment of the waterbody. EBOT is 268.82 m, which is the lowest elevation in the waterbody and is the bottom elevation of layer 13 or KMX-1 (where KMX=14).....	23
Figure 8. Layer numbers and segments for a branch with a zero slope where segment 37 is the last active segment of the branch. EBOT for this waterbody is 261.21 m and is the bottom elevation of layer 13 or KMX-1 (where KMX=14).	23
Figure 9. Example bathymetry input file with layer and elevation at the right-hand side. EBOT is 21.6 m and is the top of the inactive layer or the bottom elevation of the first active layer. The first branch included active segments 2-27 and the second branch had active segments 30-34. Layer heights were 2 m (we recommend 1 m as a maximum). Branch slope was zero.....	23
Figure 10. Cross-section of current rectangular grid system	25
Figure 11. Various solutions to fitting a cross-section –trapezoidal layers compared to multiple rectangular layers.....	25
Figure 12 Downstream pipe DOWN designation.....	52
Figure 13. Lateral pipe LAT designation.	52
Figure 14. Downstream spillway DOWN designation.....	57
Figure 15. Lateral spillway LAT designation.	57
Figure 16. Downstream gate DOWN designation.....	64
Figure 17. Lateral gate LAT designation.	65
Figure 18. Definition of pump EOFPUPU and EONPU if [IDPU] is positive.	73
Figure 19. Downstream pump DOWN designation.....	74
Figure 20. lateral pump LAT designation.	74
Figure 21. Definition of EOFPUPU and EONPU when [IDPU] is negative.	75
Figure 22. Description of internal weir in CE-QUAL-W2 at downstream side of segment.77	77
Figure 23. Growth rate as a function of temperature.....	188
Figure 24. Growth rate as a function of temperature.....	197
Figure 25. Growth rate as a function of temperature.....	203
Figure 26. Growth rate as a function of temperature.....	213
Figure 27. Organic matter decay as a function of temperature.	221
Figure 28. Ammonia decay as a function of temperature.	229
Figure 29. Denitrification as a function of temperature.	231
Figure 30. Variation of KDO on anoxia processes.....	239

LIST OF FIGURES

Figure 31. Illustration of sediment focusing rate.	241
Figure 32. SOD rate as a function of temperature.....	242
Figure 33. Illustration of segment angle orientation.....	290
Figure 34. New bathymetry file format in csv format within Excel.	294
Figure 35. Outlet temperature as a function of time illustrating selective withdrawal meeting temperature target of 15°C between Julian day 1 and 45.	304
Figure 36. Example of possible configurations with the USGS algorithm (Rounds and Buccola, 2015).	306
Figure 37. Environmental performance for 3 different scenario runs comparing dissolved oxygen in a eutrophic system Eucha Reservoir in OK.	317
Figure 38. Side view of DeGray Reservoir grid used for hypolimnetic aeration.....	319
Figure 39. Dissolved oxygen at probe location and cumulative oxygen added in kg over period of aeration (Julian day 1-125). Target dissolved oxygen at probe location was between 11 and 12.5 mg/l.....	320
Figure 40. Constriction between segment 10 and 11 in Dexter Reservoir, OR, USA. Note that a spillway or weir was used for the connection between segment 27 and 11. (Map from Bing Maps, 2019.)	321
Figure 41. Model predicted aerobic and anaerobic temperature in sediment layers as well as model predicted water temperature.	335
Figure 42. Wind direction angle in radians, Θ_1 , in meteorological file.....	339
Figure 43. Tree top elevation and vegetation offset from a river.	361
Figure 44. The influence of topographic shading along a river.....	363
Figure 45. Topographic slices at three segments along a river.	363
Figure 46. Small mouth bass habitat in DeGray reservoir for 1980.	431
Figure 47. Dissolved oxygen less than 1 mg/l comparison of model compared to field data for Brownlee Reservoir.....	431
Figure 48. Example of contour plot of fish habitat zones using Tecplot.	455
Figure 49. Lake Contour for Chester Morse Lake for 2015 (Cervarich, 2020).	465
Figure 50. Cedar River temperature versus model segment over time (Cervarich, 2020).	46
Figure 51. Diagram illustrating unstable water surface elevation solution.	468
Figure 52. Example of particle detention time histogram using the file fnalparticle.csv file. For this system the average particle detention time was 9.5 days.....	476
Figure 53. Example histograms of particles released for velocity and temperature for a particle release experiment.....	477
Figure 54. Branch temperature, velocity and particles in Tecplot frame.	478
Figure 55. Cascade of reservoirs or multiple waterbodies.	479
Figure 56. Concept of running multiple waterbodies simultaneously.....	480

List of Tables

Table 1. Vertical Eddy Viscosity Formulations	39
Table 2. Equations used in CRISP model for gas production	60
Table 3. Equations used in CRISP model for gas production at Columbia basin dams .	61
Table 4. Reaeration Effects of Spillways, Weirs, and Gates.....	61
Table 5. Equations used in CRISP model for gas production	70
Table 6. Equations used in CRISP model for gas production at Columbia basin dams .	70
Table 7. Reaeration effects of gates	71
Table 8. Hydraulic Print Parameters.	90
Table 9. List of active constituents and their proper order in the control file.	130
Table 10. Typical list of constituents given NGC=3, NSS=2, NBOD=2, NAL=3, and NZP=1.	131
Table 11. List of derived variables in CE-QUAL-W2.	C-137
Table 12. Extinction Coefficient Literature Values	161
Table 13. Values of BETA and light extinction (TVA, 1972).....	162
Table 14. Literature values for light extinction due to macrophyte plant tissue concentration.	165
Table 15. <i>In Situ</i> Coliform Decay Rates	169
Table 16. Gross Production Rates of Phytoplankton.	174
Table 17. Maximum growth rates (1/day) determined by Grover (1989).	177
Table 18. Phosphorus half-saturation coefficients ($\mu\text{mol/liter}$) determined by Grover (1989).	177
Table 19. Maximum growth rates and carbon half saturation constants of 3 marine diatoms (Riebesell et. al., 1993)	177
Table 20. Maximum growth rate of <i>Skeletonema costatum</i> (Samuel et. al., 1983)....	178
Table 21. Maximum growth rates and carbon half-saturation coefficients of the green algae <i>Selenastrum capricornutum</i> and <i>Scenedesmus quadricauda</i> (Goldman et. al., 1974).	178
Table 22. Nutrient saturated maximum growth rates of the marine algae <i>Pavlova lutheri</i> (Chalup and Laws, 1990).....	178
Table 23. Maximum growth rate of two clones of the marine diatom <i>Thallassiosira Pseudonana</i> (Guillard et. al., 1973).....	179
Table 24. Silicon half-saturation constant of two clones of the marine diatom <i>Thallassiosira Pseudonana</i> (Guillard et. al., 1973).....	179
Table 25. Maximum growth rate of the golden-brown algae <i>Synura Petersenii</i> (Guillard and Klaveness, 1975).....	179
Table 26. Silicon half-saturation constant of the golden-brown algae <i>Synura Petersenii</i> (Guillard and Klaveness, 1975).....	179
Table 27. Maximum growth rates for five species of marine diatoms (Paasche, 1973).180	
Table 28. The maximum growth rate of the marine diatom <i>Skeletonema costatum</i> (Sakshaug and Andresen, 1989).....	180
Table 29. Maximum growth rate of the three marine diatom species <i>Skeletonema costatum</i> , <i>Olisthodiscus luteus</i> and <i>Gonyaulax tamarensis</i> measured by Langdon (1987).....	180

Table 30. Dark respiration rate of the three marine diatom species <i>Skeletonema costatum</i> , <i>Olisthodiscus luteus</i> and <i>Gonyaulax tamarensis</i> measured by Langdon (1987)	181
Table 31. Light saturation of <i>Isochrysis galbana</i> (Falkowski et. al., 1985).....	181
Table 32. Maximum growth rate of <i>Thalassiosira fluviatilis</i> (Laws and Bannister, 1981). ¹⁸¹	
Table 33. Maximum growth rates and optimum growth temperatures for phytoplankton studied by Reay et al. (1999).	181
Table 34. Maximum growth rates and carbon half-saturation constants of marine phytoplankton studied by Clark and Flynn (2000).....	182
Table 35. Maximum growth rate, saturation intensity and respiration rate for 4 freshwater algae species (Litchman, 2000).....	182
Table 36. Maximum Algal Excretion Rate Literature Values	183
Table 37. Algal Dark Respiration Rate Literature Values	183
Table 38. Algal settling Velocity Literature Values.....	183
Table 39. Phosphorus Half-Saturation Constant Literature Values	184
Table 40. Nitrogen Half-Saturation Constant Literature Values.....	185
Table 41. Literature values for saturating light intensity.....	186
Table 42. Freshwater algae minimum and optimum elemental contents in percentages of dry-weight (Reynolds, 1984).....	190
Table 43. Coefficients used in CE-QUAL-R1 to simulate macrophytes (from Collins and Włosinski, 1989).	209
Table 44. Values for the ratio between dry weight to wet volume.....	212
Table 45. Literature values for the ratio of dry weight to surface area.	212
Table 46. Labile DOM Decay Rate Literature Values.	216
Table 47. Detritus Decay Rate Literature Values.....	217
Table 48. Detritus Settling Velocity Literature Values	217
Table 49. Ammonium Decay Rate Literature Values	227
Table 50. Nitrification rates measured by McCutcheon (1987).....	227
Table 51. Sediment Oxygen Demand Literature Values.....	244
Table 52. River Reaeration Equations at 20°C.	246
Table 53. Lake Reaeration Equations at 20°C.	247
Table 54. Estuarine Reaeration Equations at 20°C.....	248
Table 55. Fish temperature and dissolved oxygen criteria from Welch et al. (2011).	296
Table 56. General fish temperature criteria from Hondzo and Stefan (1996).....	297
Table 57. Rules for selective withdrawal when there are 2 outlets where flow is being split.	303
Table 58. Description of user-specified inputs in the w2_selective.npt file for blending when SELECTC='USGS' (Rounds and Buccola, 2015)	307
Table 59. Description of Dynamic Shading Input Variables	360
Table 60. Typical atmospheric deposition rates for Hg, P, N, and particles.	365
Table 61. Input file for atmospheric deposition in csv format. Note that the '\$' should be the first character in cell A1.	366
Table 62. Literature values for biological parameters of cyanobacteria used in models.	412
Table 63. Model parameter ranges.	415
Table 64. Output file names for sediment diagenesis model.	424
Table 65. Techniques for using CE-QUAL-W2 to simulate a cascade of waterbodies..	479
Table 66. Description of input file w2_multiple_WB.npt.....	482

LIST OF TABLES

Preface

This manual documents the two-dimensional, laterally averaged, hydrodynamic and water quality model CE-QUAL-W2. As in all complex models, there have been many contributors. This re-write of the User Manual was based on prior User Manuals: Environmental and Hydraulic Laboratories (1986), Cole and Buchak (1995) Version 2, and Cole and Wells (2000) Version 3.0 through Cole and Wells (2019) Version 4.1. Hence, one can think of the primary author as merely an editor of past documents, rather than reflecting one person's sole authorship. This updated User Manual contains numerous corrections, new figures, new sections, additional documentation, and improvements in organization and presentation of information compared to Cole and Wells (2019).

This section of the User Manual Part 3 documents the input files required for running the model and the output files generated by the model.

The other sections of the User Manual are divided into multiple sections for ease of updating and editing:

- User Manual Part 1: Introduction to CE-QUAL-W2, Model download package, how to run the model, model versions, changes between model versions
- User Manual Part 2: Theoretical basis for CE-QUAL-W2: hydrodynamics and water quality, particle transport and numerical scheme
- User Manual Part 3: Model input and output file descriptions and input/output file examples
- User Manual Part 4: Model examples
- User Manual Part 5: Release notes, bug fixes, differences in model versions, history of bug fixes, and other user manuals such as for the GUI interface, the Waterbalance algorithm, and other external codes.

This report should be cited as follows:

Wells, S. A., editor (2024) "CE-QUAL-W2: A two-dimensional, laterally averaged, hydrodynamic and water quality model, version 4.5, user manual part 3, model input and output files," Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

or for a specific section of the report:

Cole, T. and Wells, S. (2024) "Input and Output Files Data Description," in "CE-QUAL-W2: A two-dimensional, laterally averaged, hydrodynamic and water quality model, version 4.5, user manual part 3, model input and output files," ed. by S. Wells, Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

1. Introduction

Input Files Overview

An overview of the input files required for the CE-QUAL-W2 model is shown in Figure 1. The required files include the main control file, **w2_con.npt** (or since Version 4.21 **w2_con.csv**), and grid, shading and boundary condition files. There is also a long list of additional input files that turn ON special routines in CE-QUAL-W2. A description of all of these files is included in this part of the User Manual. Note that tributary and distributed tributary files can be either positive (inflow) or negative (outflow).

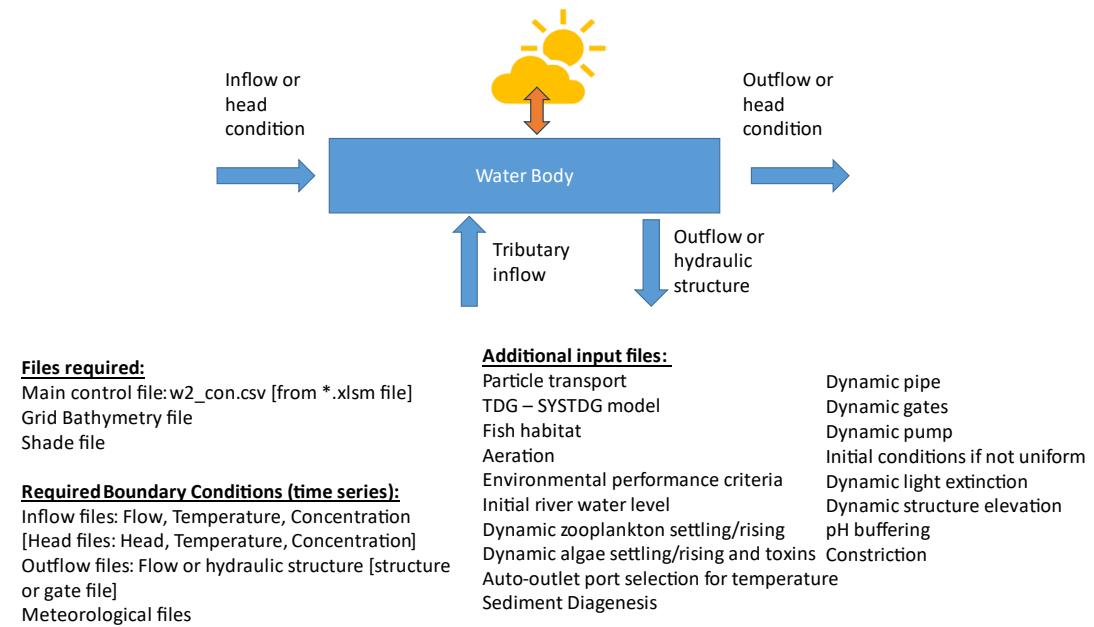
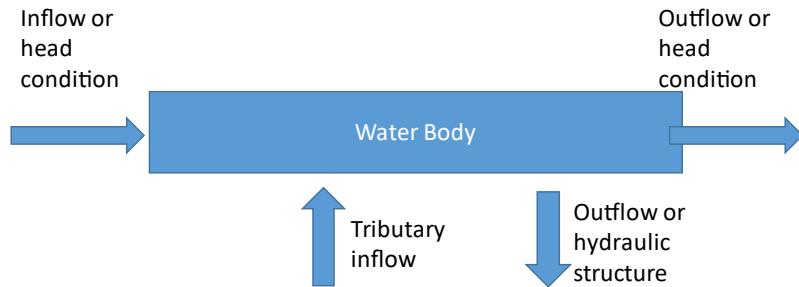


Figure 1. An overview of the input files required for CE-QUAL-W2.

Output Files Overview

The CE-QUAL-W2 model generates many different output files. The model user controls which files are output and at what frequency files are updated. Figure 2 shows the output files generated by the CE-QUAL-W2 model. Post-processing of model files is done by the model user. The program, **w2_post.exe**, uses the **w2** Linkage file (VPL) and provides many useful tools for post-processing model results.



Text output files related to preprocessor or model run Time series, contour, profile, and other output text files:

time:

Preprocessor: pre.opt, pre.wrn, pre.err
W2 Model: w2.wrn, w2.err, w2errordump.csv

Overview of model run (text file):

Snapshot output file (SNP)

Binary file for W2Post post-processing:

W2 Linkage file for w2_post.exe (VPL output file)

Profiles – Spreadsheet (SPR) and Longitudinal (PRF)
Contour – for Tecplot (CONTOUR)
Time series at points/segments (TSR) and at withdrawals (WDO)
Environmental performance criteria output
Initial river water level summary file; water level output file
Dynamic zooplankton/algae settling/rising output files
Auto-outlet port selection for temperature output file
Sediment diagenesis output files
Fish habitat output files
Flow balance file; nutrient mass balance file
Kinetic flux output files
Particle dynamics output files
W2Anim output files

Figure 2. CE-QUAL-W2 generated output files.

Command-line Working Directory Specification

In the windows version of the w2 model, the user can supply a command line argument that sets the working directory of the model executable – both the preprocessor and the W2 model executable. Hence, one does not need to copy the model executable into every directory with all the input files. In a batch file, for example, one can execute the following command:

```
preW2_v4_64.exe "C:\scott\waterqual\LakeLouise"
w2_v4_64.exe "C:\scott\waterqual\LakeLouise"
```

Hence, the model user needs to type the executable name, skip 1 space, then in double quotes include the working directory. The executable then uses the directory as the working directory for all the files. The working directory is displayed in the text box of the preprocessor and W2 dialog window during execution.

2. Input and Output Files Data Description

Primary Authors: Tom Cole and Scott Wells, Chris Berger, Rob Annear, Stewart Rounds, Annette Sullivan, S. Prakash, J. A. Vandenberg, E. M. Buchak, Zhang Zhong

This section is largely from the older User Manual (Cole and Wells, 2019) and was termed Appendix C in that report. This section contains descriptions of all model input and output files. The format of each file is based on either (1) text input with fixed formatting or (2) comma delimited text. Output files are usually in comma delimited format except for a few fixed format output text files.

For fixed format text file inputs, the input file begins with three lines used for file identification or user notes that are ignored by the program. The third line is often headers for the variables on the following line. The input file usually consists of groups of three lines - the first line is blank serving as a separator, the second line contains the card identification and the FORTRAN variable names associated with the input card, and the third line contains the input values. For fixed format files, the FORTRAN names are right justified according to the field widths associated with the input variable. There are 10 input fields associated with each card although the first field is not used in several of the input files. Each field has a length of eight characters.

For comma delimited input files, there are no restrictions on variable field size or in the number of columns or fields associated with an input variable.

Input Files

The model user can use either the fixed format text input control file or a comma delimited version derived from an Excel spreadsheet with macros. These files are described below.

Control File: w2_con.npt

The control file [CONFN] w2_con.npt is a fixed format text file that contains the variables used to run the model. There are no optional cards in the control file - each card is **required** although there may be either zero or no values associated with the card. The following pages contain a description of each card. **All character inputs must be capitalized except the TITLE cards and input/output filenames** or the variable will take on the default value. An example of a portion of a control file is given with each card description and a complete control file is given at the end of the control file description. Hyperlinks to related input cards are included at the bottom of each card description.

Note that the control file has an identifier card that is checked by the pre-processor code.

Control File: w2_con.csv

Starting with CE-QUAL-W2 Version 4.21, an Excel based input file was developed that is compatible with the preprocessor and model executable. The variables in the Excel based version are the same as those described in the section “**Control File: w2_con.npt**” except their order is somewhat changed from the order

in the fixed format text input file w2_con.npt. The Excel file, **w2_con.xls**, is provided in the download package for several example problems. Several screenshots of the Excel spreadsheet are shown in Figure 3, Figure 4, and Figure 5. This Excel spreadsheet has a built-in macro for writing out the file w2_con.csv. Advantages of this new format are as follows:

- Ease of file input and manipulation
 - Easier data entry since there is no spaces to worry about and no wrapping of lines
 - Easier cutting and pasting parts of the control file to other areas
- No need for the file **graph.npt** since this is incorporated into the control file
- Simplified input and output
 - Eliminated inputs that were not needed
 - Simplified inputs of input/output for SNP, TSR, SCR, CPL, PRF, and WDO files
- Even though the order of the inputs generally follows that of the file, w2_con.npt, some input order were changed to allow for a more logical setting up of a model simulation.
- A built-in macro writes out the Excel sheet in csv format – it is a button “Export to CSV file”
- Variable names and explanations are included in Column A and B and many notes and guidance points are included in these columns. These columns are not written out to the csv control file.
- There is only 1 place where the number of rows in the control file will be adjusted by the user and that is the constituents used in the model. Explanations and internal computations though make this easy to set up. Also, if there are more than 5 structures, epiphyton/periphyton groups, zooplankton or algae groups, then there will also need to be more rows added to the file. This is clearly annotated in the spreadsheet.

The screenshot shows the 'w2_con.csv file format' tab of the Excel spreadsheet. The spreadsheet is organized into several tabs, each containing specific configuration parameters and their descriptions. The tabs include:

- TITLE C:** Contains parameters like 'TITLE', 'Comment - this is written only to the SNP file', and 'Any comment - next 10 lines-ENCLOSE IN QUOTATIONS OR HAVE NO SPACES BETWEEN'.
- GRID/NPROC/CLOSE DIALOG BOX:** Contains parameters like 'NWB', 'NBR', 'IMX', 'KMX', 'NPROC', and 'CLOSEC'.
- CONSTITUENTS:** Contains parameters like 'NTR', 'NST', 'NIW', 'NWD', 'NGT', 'NSP', 'NPI', and 'NPU'.
- MISCELLANEOUS:** Contains parameters like 'NDAY', 'SELECTC', 'HABTAC', 'ENVIRPC', 'AERATEC', and 'INITUWL'.
- TIME CON:** Contains parameters like 'TMSTRT', 'TMEND', 'YEAR', and 'TIME CON'.

A large text block in the center of the spreadsheet provides detailed explanations for many of the parameters, such as 'Note COL A and B are not written out to w2_con.csv', 'Fixed length of file except when more than 5 algae, 5 zooplankton, 5 macrophytes, 5 structures, 5 periphyton groups.', and 'The # of rows though changes with the # of active water quality constituents.' A 'Export to CSV file' button is located in the middle-right area of the spreadsheet.

Figure 3. Example of Excel control file, w2_con.xls, that is used to output the file w2_con.csv.

	BR1	BR2	BR3	BR4	BR5	BR6	BR7
INTERPOLATION							
QINIC- interpolate inflows	ON						
DTRIC-interpolate distributed tributary inflows	ON						
HDIC-interpolate elevations for head boundary condition	ON						
HEAT EXCHANGE	WB1	WB2	WB3	WB4	WB5	WB6	WB7
H_SLHTC - Heat computations - Equilibrium (ET) or Termi	TERM						
SROC - Read in Short wave solar radiation	OFF						
RHEVAP - Use Ryan-Harleman Evap Model - for cooling po	OFF						
METIC - Interpolate meteorological data	ON						
FETCHC - Heinz Stefan Lake fetch correction - there is alre	OFF						
AFW - Evaporation coefficient	9.2						
BFW - Evaporation coefficient	0.46						
CFW - Evaporation coefficient	2						
WINDH - Wind height measurement above ground surfac	2						
ICE COVER ALGORITHM	WB1	WB2	WB3	WB4	WB5	WB6	WB7
ICEC - Turn ICE cover algorithm ON/OFF	OFF						
SLICEC - Use DETAIL for detailed model vs SIMPLE	DETAIL						
ALBEDO - Ratio of reflection to incident radiation of ice	0.25						
HWICE - Coefficient of water-ice heat exchange, W/m ² /o	10						
BICE-Fraction of solar radiation absorbed in the ice surfa	0.6						
GICE-Solar radiation extinction coefficient, m ⁻¹	0.07						
ICEMIN-Minimum ice thickness before ice formation is all	0.05						
ICET2-Temperature above which ice formation is not allo	3						
TRANSPORT SCHEME	WB1	WB2	WB3	WB4	WB5	WB6	WB7
SLTRC - UPWIND, QUICKEST, ULTIMATE - use ULTIMATE	ULTIMATE						
THETA - degree of implicitness - use 0.55	0.55						
HYD COEFFICIENTS	WB1	WB2	WB3	WB4	WB5	WB6	WB7
AX - Longitudinal eddy viscosity, m ² /s	1						
DX - Longitudinal eddy diffusivity/conductivity, m ² /s	1						
CBHE - Sediment heat transfer coefficient	0.3						
TSED - Temperature of sediment	11.5						
FI - Interfacial friction factor	0.01						
TSEDF - Sediment temperature coefficient	1						
FRICC - Friction factor type: CHEZY or MANN	MANN						
Z0 - wind roughness height, m	0.001						

Figure 4. Screen shot of w2_con.xlsx used to output the control file w2_con.csv showing INTERPOLATION (Columns B through I).

276	KBWD - Withdrawal selective withdrawal bottom, Bottom layer below which selective withdrawal will not occur							
277	TRIB PLACEMENT and TRIB FILES	TR1	TR2	TR3	TR4	TR5	TR6	TR7
278	PTRC - Tributary inflow placement	DISTR						
279	TRIC - Interpolation control	OFF						
280	ITR - Tributary inflow segment	3						
281	ELTRT - Top elevation if trib placement	0						
282	ELTRB - Bottom elevation if trib placement	0						
283	QTRPN - tributary flow file	lspkq00.csv						
284	TTTRFN - tributary temerature file	lspk100.csv						
285	CTIRFN - tributary concentration file	lspkc00.csv						
286								
287	DST TRIBUTARIES	BR 1	BR2	BR3	BR4	BR5	BR6	BR8
288	DTRC - Dist Trib Control	ON						
289	Note that all text fields cannot have spaces or '/' characters, unless you have the text in quotes							
290	HYD PRINT - Print in the SNP file	HNAME	FMTH	HMULT	HPRWBC1	HPRWBC2	HPRWBC3	HPRWBC4
291	HMULT is a multiplier of the output, usually it is 1, but if you want more significant digits	TimeStepViol(f10)	1	ON				
292	HPRWBC turns ON or OFF output for each waterbody	HorizontalVel(f10.3)	1	ON				
293	U	VerticalVel(f10.3)	1	ON				
294	FMTH is the FORTRAN output format for the SNP file F is real number 10.3 is 1	Temperature(f10.3)	1	ON				
295	HNAMES is fixed - it does not change	Density(Rho(f10.3)	1	OFF				
296	T	VerticalEddy(f10.3)	1	OFF				
297	RHO	VelocityShea(f10.3)	1	OFF				
298	AZ	InternalShear(f10.3)	1	OFF				
299	SHEAR	BottomShear(f10.3)	1	OFF				
300	ST	Longitudinal(f10.3)	1	OFF				
301	SB	Longitudinal(f10.3)	1	OFF				
302	ADMX	HorizontalDe(f10.3)	1	OFF				
303	DM							
	HOG							

Figure 5. Screen shot of w2_con.xlsx used to output the control file w2_con.csv showing TRIB FILES.

Note also that all of the ancillary input files described in this part of the User Manual are part of the xlsm file as separate tabs. There is an Index of Sheets for easy navigation, such as shown below:

	A	B	C	D	E	F	G	H	I	J
1										
2		Go to sheet:								
3		w2_con.csv A1								
4		Required Constituent Order A1								
5		w2_habitat.npt A1								
6		w2_aerate.npt A1								
7		w2_envirprf.npt A1								
8		w2_selective.npt A1								
9		w2_constriction.csv A1								
10		w2_particle.csv A1								
11		w2_multiple_WB.npt A1								
12		w2_tecplotbr.csv A1								
13		w2_systdg.npt A1								
14		atm_deposition_wb1.csv A1								
15		lake_river_contour.csv A1								
16		AlgaeMigration.csv A1								
17		Algae_Toxin.csv A1								
18										
19										
20		For tab w2_con.csv: This Excel macro writes out a csv file, w2_con.csv, for use in CE-QUAL-W2								
21		Columns A and B are not written out and contain information about variables.								
22		You can also write your own notes anywhere on the right hand side or perform computations as needed to insert formulae into vari								
23										
24		The # of rows will only be changed by the following:								
25		1. You will need to set the # of active constituents as the number of rows in the section								
26		shown on the right [close to row 385]. There is guidance in the tab 'Required' [REDACTED]								
27		Constituent Order' showing the expected # of rows (this must be adhered to). But you will have to adjust this list manually. Also ma								
28		2. No other changes are necessary to the # of rows unless you have the following:								
29		a. More than 5 outlet structures								
30		b. More than 5 zooplanton groups								

Description of Control File Parameters

This section describes the model parameters for both the control file, w2_con.npt, and the comma delimited file, w2_con.csv. Examples from each file are shown after each section. In some cases, the Excel input file version combines several model parameters compared to the text input file. In that case the Excel input file example will be included after all the variables have been reviewed.

Title (TITLE C)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TITLE	Character	Text for identification of simulation

There are 10 title lines for each a simulation that can be used to identify various types of output. Each line may contain up to 72 characters of text. Title cards appear in the SNP output file. Uses for the title cards include identifying the simulation, the simulation time frame, the date the simulation was run, and other information specific to the simulation. The Excel spreadsheet text must all have quotations around each text line.

This text only writes output to the SNP file and hence is limited in its usefulness even though it does force the user to document his run.

Example

```
TITLE C .....TITLE.....
Card 1 Version 4 Example Model
Card 2 PSU CE-QUAL-W2 Workshop Problem
Card 3 River with 2 branches
Card 4 Reservoir
Card 5 Estuary
Card 6 River Sloping Channels 2 Branches
Card 7 Temperature Mitigation Problem
Card 8 Temperature and residence time simulation
Card 9 Scott Wells - PSU
Card 10 Tom Cole - WES
```

TITLE C	Title comments: next 10 lines
Any comment - this is written only to the SNP file	"Degray Reservoir - March 4 through December 27, 1980"
	"Degray Reservoir - March 4 through December 27, 1980"
	"Density placed inflow point sink outflow"
	"Default hydraulic coefficients"
	"Default light absorption/extinction coefficients"
	"Testing sensitivity of temperature predictions to vertical resolution"
	"2 m layer heights"
	"Atmospheric Deposition Feature"
	""
	""

Grid Dimensions (GRID)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	NWB	Integer	Number of waterbodies in the computational grid
3	NBR	Integer	Number of branches in the computational grid
4	IMX	Integer	Number of segments in the computational grid
5	KMX	Integer	Number of layers in the computational grid
6	NPROC	Integer	Number of processors to use for computation
7	CLOSEC	ON or OFF	Close the W2 Windows dialog box at the end of simulation (ON) or keep it open (OFF)

This card defines the computational grid including the total number of waterbodies [**NWB**], branches [**NBR**], segments [**IMX**], and layers [**KMX**]. These values are used to define the array dimensions in the code since the code has been converted over to FORTRAN 90 and now takes advantage of dynamic array allocation. This eliminates the need to recompile the code for each application.

This sets the dimensions of the segments and layers and waterbodies and branches. We do not use NPROC currently. CLOSEC allows you to close the dialog box automatically after a simulation in case you are doing batch processing.

In Version 3.6, the code used OPENMP commands for parallelization achieving about an average of 20% improvement in speed by choosing 2 processors over 1 processor. Since using out-of-order arithmetic can lead to slight differences between model runs, we have disabled this feature. Hence, the code always now uses internally [**NPROC**]=1 regardless of what is used in the input file. There have been many code improvements in the current version to more than make up for the speed improvement used in Version 3.6.

[**CLOSEC**] is a control that allows the W2 windows dialog box to remain open at the end of a simulation (OFF) or to close at the end of a run (ON). Setting [**CLOSEC**]=OFF, at the end of a windows run, the windows dialog box waits for the user to press ‘close’ to exit the window. This allows the user to examine the final run parameters. When [**CLOSEC**] is set to ON, the dialog box will close once the run finishes. If it is set to OFF, then the dialog box will remain until the user clicks ‘close’.

Example

GRID	NWB	NBR	IMX	KMX	NPROC	CLOSEC
	3	4	43	24	2	OFF

GRID/NPROC/CLOSE DIALOG BOX	NWB	NBR	IMX	KMX	NPROC	CLOSEC
	1	1	32	36	1	OFF

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Constituent Dimensions](#)

[Miscellaneous Dimensions](#)

Inflow/Outflow Dimensions (IN/OUTFLOW)

FIELD	NAME	VALUE	DESCRIPTION
1			(ignored by code)
2	NTR	Integer	Number of tributaries
3	NST	Integer	Number of structures
4	NIW	Integer	Number of internal weirs
5	NWD	Integer	Number of withdrawals
6	NGT	Integer	Number of gates
7	NSP	Integer	Number of spillways
8	NPI	Integer	Number of pipes
9	NPU	Integer	Number of pumps

This card defines the variables used to dimension the arrays for tributaries, internal weirs, and inflow/outflow hydraulic structures including lateral withdrawals, outlet gates, spillways, pipes, and pumps. All variables should be set to zero if they are not used.

How many inflows and outflows do you have in your system? This is where you define the total number and their types.

Tributary: An inflow at a right angle to the model x-coordinate – prescribed flow (positive or negative)

Structure: An outflow at the end of a branch (longitudinal momentum is preserved) – prescribed flow

Withdrawal: An outflow at any segment assumed to be at right angles to the x-coordinate – prescribed flow

Gate, spillway, pump, pipe: At outflow or inflow at the end of a branch or at any segment at right-angles to the x-coordinate – model computed flow (or prescribed flow for the gate)

Example

```
IN/OUTFLOW    NTR      NST      NIW      NWD      NGT      NSP      NPI      NPU
          1        3        1        0        1        2        1        0        0
```

IN/OUTFLOW	NTR	NST	NIW	NWD	NGT	NSP	NPI	NPU
	0	1	0	0	1	0	0	0

Related Cards and Files

[Grid Dimensions](#)

[Constituent Dimensions](#)

[Miscellaneous Dimensions](#)

[Tributaries](#)

[Structures](#)

[Weirs](#)

[Withdrawals](#)

[Gates](#)

[Spillways](#)

[Pipes](#)

[Pumps](#)

Constituent Dimensions (CONSTITUENTS)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	NGC	Integer	Number of generic constituents
3	NSS	Integer	Number of inorganic suspended solids
4	NAL	Integer	Number of algal groups
5	NEP	Integer	Number of epiphyton/periphyton groups
6	NBOD	Integer	Number of CBOD groups
7	NMC	Integer	Number of macrophyte groups
8	NZP	Integer	Number of zooplankton groups

This card defines the array dimensions for the number of generic constituents, inorganic suspended solids groups, algal groups, CBOD groups, macrophyte groups and zooplankton groups. The user has complete freedom to include as many of these groups as data are available for and the application warrants.

The generic constituent allows the user the freedom to model any number of constituents that can be defined using any or all of the following: a 0-order decay rate, a 1st- order decay rate, a settling velocity, an Arhenius temperature rate multiplier, volatilization, or photo-degradation. Also, the sediment diagenesis model uses generic constituents for H₂S, CH₄, SO₄, turbidity, Fe²⁺, FeOOH(s), Mn²⁺, and MnO₂(s) even though they interact with other state variables.

The ability to model any number of CBOD groups now allows the model to characterize and track any number of point sources of CBOD. This should prove useful in determining which point source(s) is/are contributing to depressed dissolved oxygen levels or violations in a system and allow better understanding of what management strategies could be used to improve dissolved oxygen.

Care should be taken when including multiple algal, epiphyton, zooplankton, and macrophyte groups to ensure that the data are sufficient to describe their variation in the system. As a general rule, it is better to start with as simple a description of the kinetics in a system that still allows the model to capture the important temporal and spatial changes in water quality.

Example

CONSTITU	NGC	NSS	NAL	NEP	NBOD	NMC	NZP
	3	1	3	1	1	1	1

CONSTITUENTS	NGC	NSS	NAL	NEP	NBOD	NMC	NZP
	3	1	3	1	1	0	1

Related Cards and Files

[Grid Dimensions](#)

[Inflow/Outflow Dimensions](#)

[Miscellaneous Dimensions](#)

Miscellaneous (MISCELL)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	NDAY	Integer	Maximum number of output dates or timestep related changes
3	SELECTC	Character	Turn ON/OFF/USGS automatic port selection from a multiple outlet structure where level is chosen by model to reach temperature target
4	HABTATC	Character	Turn ON/OFF habitat analyses for fish and eutrophication variables
5	ENVIRPC	Character	Turn ON/OFF environmental performance criteria
6	AERATEC	Character	Turn ON/OFF aeration to waterbody with dissolved oxygen probe control
7	INITUWL	Character	Turn ON/OFF initial water surface slope and velocity calculation for a river system
8	ORCC	Character	Turn ON/OFF use of C for organic matter basis
9	SED_DIAG	Character	Turn ON/OFF sediment diagenesis processes
10	DZMAX	Real	Value of DZ when there is a density instability (m^2/s)

This card defines several variables that turn ON or OFF features of the code first implemented in Version 3.7. **NDAY** is the maximum number of output dates that will be used in the simulation. This should be the maximum of timestep, snapshot, screen, profile, vector, contour, time series, withdrawal, and restart number of dates that are used to define when output frequencies, or, in the case of the timestep related cards, when the maximum timestep or the fraction of the timestep change. This can easily be set to a value greater than any anticipated number of dates without any impact as the memory used by these variables is trivial. The user should use 100 as a default. There is often no reason to change this value.

Want to turn on Auto Port selection from a multi-port outlet structure to meet a downstream temperature?

Want to see if your system is good habitat for a fish species?

Want to add hypolimnetic aeration?

Want histogram output of water quality state variables?

Want your river model to run smoother at the beginning of the simulation?

SELECTC is a control that turns ON or OFF the use of the automatic port selection for a multiple outlet withdrawal structure at a downstream end of a branch. If this is ON, the model then reads the control file for this feature, “w2_selective.npt”. Another option new in Version 3.72 is to set **SELECTC**=’USGS’. Either of these options allows the user to let the model decide what outlet to use to meet temperature targets. Please see the section on the automatic port selection control file in Appendix C for a description of its features. If **SELECTC**=’OFF’, then this algorithm is not used.

HABTATC is a control that turns ON or OFF the fish habitat analysis and other useful analyses for eutrophication studies. If this is ON, the model then reads the control file for this feature, “w2_habitat.npt”. Please see the section on the habitat control file for a description of its features.

ARRAY DIMENSIONS

CONTROL FILE

ENVIRPC is a control that turns ON or OFF the environmental performance analysis for user-chosen model state variables. This feature allows for temporal and volume-weighted averages of and histograms of specified state variables. If this is ON, the model then reads the control file for this feature, “**w2_envirpc.npt**”. Please see the section on the environmental performance control file for a description of its features.

AERATEC is a control that turns ON or OFF aeration at specified segments and layers. If this is ON, the model then reads the control file for this feature, “**w2_aerate.npt**”. Please see the section on the aeration control file for a description of its features.

INITUWL is a control that turns ON or OFF a computation of the initial water level and the initial velocity of the river. A computation of the normal depth and initial velocity is made for any branch with a non-zero slope. This normal depth profile is used instead of the water surface profile given in the bathymetry file. The theory for this is described in Part 2 of the User Manual. A typical CE-QUAL-W2 application starts with velocity set to zero in the domain at the initial time. If **INITUWL** is ON, then the velocity at normal depth is computed and used as the initial velocity. This allows smoother running of the river models. When **INITUWL** is turned ON, the CE-QUAL-W2 model also writes out a file that shows the initial water surface elevations, normal depths, and velocities it computed for the first time step. These are found in an output file called, “**init_wl_u_check.dat**”.

ORGCC is an organic C control that turns ON or OFF the use of C as a basis for the organic matter compartments. When this is ON, the model uses LPOC, RPOC, LDOC, RDOC (L is for labile, R is for refractory, OC is for organic carbon, P is particulate, D is dissolved, C is for carbon) rather than LPOM, RPOM, LDOM, RDOM (where M is for matter on a dry weight basis).

SED_DIAG turns ON or OFF reading in the [sediment diagenesis input file](#). When the sediment diagenesis processes are turned ON within the input file **w2_diagenesis.npt**, both zero order and first order SOD are automatically turned OFF within the model.

DZMAX is the maximum value of vertical diffusion when there is a density instability or inversion. In the W2 model, the value of 1000 m²/s was hard-wired in the model. So to be compatible with legacy W2 models, the value would be 1000. There have been cases where this value may have instantly mixed the water over multiple vertical layers too quickly and led to excessive mixing or created a water quality instability. Hence, this value is now an input variable to the model. If the value DZMAX is positive, then that value is used as DZ during a density inversion. If the number is a negative value, then this is a multiplier of the computed DZ from the chosen turbulence closure model (such as TKE) to increase mixing during a density inversion. So if DZMAX=-100, then the value of DZ during an inversion would be the DZ(computed from let's say the TKE model) X 100. Using a value of 1000 m²/s, the mixing time if the layers are 1 m is 0.001 s. If DZMAX is 1 m²/s, the layers would mix in 1 s.

Example

MISCELL	NDAY	SELECTC	HABTATC	ENVIRPC	AERATEC	INITUWL	ORGCC	SEDIAG	DZMAX
	100	USGS	ON	ON	ON	OFF	OFF	OFF	1000.

NDAY	SELECTC	HABTATC	ENVIRPC	AERATEC	INITUWL	ORGCC	SED_DIAG	DZMAX
100	ON	ON	ON	ON	OFF	OFF	OFF	-100.

Related Cards and Files

[Grid Dimensions](#)

[Inflow/Outflow Dimensions](#)

[Constituent Dimensions](#)

[Control File for selective withdrawal](#)

[Control File for habitat](#)

CONTROL FILE

ARRAY DIMENSIONS

[Control File for environmental performance](#)

[Control File for aeration](#)

Time Control (TIME CON)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	TMSTRT	Real	Starting time, Julian day
3	TMEND	Real	Ending time, Julian day
4	YEAR	Integer	Starting or reference year

The simulation starting and ending times are specified with this card. When making a simulation extending into another year, the ending time is calculated as 365 (or 366 for a leap year) + Julian date of ending time. Midnight, January 1 starts at Julian day 1.0 in the model. Noon on January 1 is Julian day 1.5 for the reference year.

For the Excel spreadsheet there are formulae in Column A that compute the correct start and end date in Julian day based on the reference year.

Example

When does the model start and end? We use Julian days of the reference year for all inputs and internal model calculations. Yes, Julian days can go over 365 for multiple year simulations. It is useful in Excel to convert from a Julian decimal day to a date and vice-versa. In Excel if one has a date field, to convert to Julian day with a reference year of 1980, the formula '=<cell reference with date> -DATEVALUE("1/1/1980")+1' should work after converting the cell format to a number.

TIME CON	TMSTRT	TMEND	YEAR
	63.5	64.5	1980

TIME CON	TMSTRT	TMEND	YEAR
These are computed from formula in Column A-->	64.500	358.7	1980

Timestep Control (DLT CON)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	NDT	Integer	Number of timestep intervals
3	DLTMIN	Real	Minimum timestep, sec
4	DLTINTR	Character	Turn ON or OFF time step interpolation between DLTMAX time steps

The number of timestep intervals, minimum timestep, and whether interpolation is used between those time steps [**NDT**] are specified on this card.

The autostepping algorithm calculates a maximum timestep based on an estimate of hydrodynamic numerical stability requirements and then uses a fraction of this value for the actual timestep. The user can specify any number of intervals up to the value specified for [**NDAY**] on the [Miscellaneous Dimensions](#) card in which the maximum timestep and fraction of the timestep can vary. The values are specified on the next three cards.

This is the section where one can set the maximum time step and vary that over the simulation. Even though the model dynamically computes a “stable” timestep, this is not always possible, and the user must intervene to set a maximum time step.

The model automatically adjusts the timestep to ensure that it is never greater than the next time varying update. The minimum timestep is useful during periods of extremely high flows. In these instances, the timestep could become too small to economically run the model. Care should be taken when using this variable as the model may become numerically unstable if the minimum value is set too high. The default value of 1 sec should not be increased unless the user is absolutely certain that this will not affect numerical stability. Minimum values as low as 0.1 s have been used for river systems.

In Version 3.7 and forward, the option of interpolating the maximum time steps [**DLTMAX**] and [**DLTF**] by setting [**DLTINTR**] to ON is available. Turning interpolation on, **DLTINTR='ON'**, allows for a smoother transition between changes in **DLTMAX** and **DLTF**.

Example

```
DLT CON      NDLT    MINDLT   DLTINTR
          2        1.0       ON
```

DLT CON	NDLT	DLTMIN	DLTINTER
Time step control parameters	1	1	OFF

Related Cards and Files

- [Timestep Date](#)
- [Maximum Timestep](#)
- [Timestep Fraction](#)
- [Timestep Limitation](#)

Timestep Date (DLT DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	DLTD	Real	Beginning of timestep interval, Julian day

The intervals for the maximum timestep are specified on this card. Any number of intervals up to the value of [NDAY] on the [Miscellaneous Dimensions](#) card can be specified. If there are more intervals (>9) than can be specified on one line for input file, w2_con.npt, then they are continued on the next line without another **DLT DATE** card being specified. For the Excel version values of DLTD do not wrap values onto another row but continue along one row.

Example

DLT DATE	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD
	63.5	63.52						
DLT DATE	DLTD							
Date of time step change in JDAY	64.5							

Related Cards and Files

- [Timestep Control](#)
- [Maximum Timestep](#)
- [Timestep Fraction](#)
- [Timestep Limitation](#)

Maximum Timestep (DLT MAX)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	DLTMAX	Real	Maximum timestep, sec

The maximum timestep for intervals provided on the timestep interval card are specified with this card. For the w2_con.npt control file, if there are more intervals than can be specified on one line (>9), then they are continued on the next line without another **DLT MAX** card being specified. The Excel version does not wrap values onto another row but continue along one row.

Example

DLT MAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX
	30.0	100.0						
DLT MAX	DLTMAX							
Maximum time step in seconds	450							

Related Cards and Files

- [Timestep Control](#)
- [Timestep Date](#)
- [Timestep Fraction](#)
- [Timestep Limitation](#)

Timestep Fraction (DLT FRN)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	DLTF	Real	Fraction of calculated maximum timestep necessary for numerical stability

The fraction of the calculated maximum timestep for intervals given on the timestep interval card is specified here. For the w2_con.npt control file, if there are more intervals than can be specified on one line, then they are continued on the next line without another **DLT FRN** card being specified. There is no continuation onto another row for the Excel version of the control file. If the number of timestep violations exceeds 5%, either [\[DLTMAX\]](#) on the [Maximum Timestep](#) card or [\[DLTF\]](#) should be decreased.

Decreasing [\[DLTF\]](#) usually decreases the number of timestep violations without affecting the maximum timestep that the model can use. Thus, during times of low velocities, the model can still use the maximum timestep, but during periods of high velocities, the model will use a smaller timestep than if [\[DLTF\]](#) were set to a higher value.

Example

```
DLT FRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN      DLTFRN
          0.9          0.9          0.9          0.9          0.9          0.9          0.9          0.9          0.9          0.9
```

DLT FRN	DLTF						
Fraction of maximum theoretical time step	0.9						

Related Cards and Files

[Timestep Control](#)

[Timestep Date](#)

[Maximum Timestep](#)

[Timestep Limitation](#)

Timestep Limitations (DLT LIMIT)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	VISC	Character	Turns ON/OFF vertical eddy viscosity limitation on timestep calculated in autostepping algorithm
3	CELC	Character	Turns ON/OFF internal gravity wave limitation on timestep calculated in autostepping algorithm
4	DLTADD	Character	Turns ON/OFF an additional stability check that

This card specifies whether the effects of the vertical eddy viscosity and/or the internal gravity wave are included in the autostepping algorithm. Separate values are specified on a separate card for each waterbody.

No need to change these – just keep them ON

If the average timestep is very small, these can be turned OFF to decrease runtimes. However, care should be taken when using this option as experience has shown that, in certain applications, turning these OFF can affect the results. If either of these variables are turned OFF, the user should also make a run with them turned ON to see if this option affects the results. Results should never be a function of the timestep or grid spacing.

In practice, these values are always ON.

The DLTADD criterion adds a check as follows: when the absolute value of the change in water level between time steps over the surface layer thickness exceeds 0.35, then the time step is reduced by 50%. The purpose of this criterion is to lower the time step before another criterion is implemented causing the model to get too close to an instability.

Example

```
DLT LIMIT    VISC      CELC      DLTADD
Wb 1          ON        ON        OFF
Wb 2          ON        ON        OFF
Wb 3          ON        ON        OFF
```

DLT LIMIT	WB1	WB2	WB3	WB4	WB5
VISC - Viscosity time step limitation ON or OFF	ON				
CELC - Wave celerity time step limitation ON or OFF	ON				
DLTADD - additional stability check to lower time step ON or OFF	OFF				

Related Cards and Files

[Timestep Control](#)

[Timestep Date](#)

[Maximum Timestep](#)

[Timestep Fraction](#)

Branch Geometry (BRANCH G)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	US	Integer	Branch upstream segment
3	DS	Integer	Branch downstream segment
4	UHS	Integer	Upstream boundary condition
5	DHS	Integer	Downstream boundary condition
6	NLMIN	Integer	Minimum number of layers for a segment to be active
7	SLOPE	Real	Branch bottom slope (actual)
8	SLOPEC	Real	Hydraulic equivalent branch slope

It is critical to get the branch connectivity correct. The preprocessor will check for a logical connection of your system.

This card specifies the branch location in the grid and branch boundary conditions. No distinction is made between waterbodies. The mainstem of the first waterbody is always branch 1 and the mainstem of subsequent waterbodies is always the next branch after all branches have been numbered for the previous waterbody. Side branches for a given waterbody can be ordered in any fashion, but it is good practice to order the remaining branches starting with the most upstream branch and continuing downstream.

The branch upstream segment number [US] is the most upstream potentially active segment. For branch 1, this would always be segment 2. The branch downstream segment number [DS] is the most downstream active segment. The boundary segment is *never* included for either the upstream or downstream segment.

Four upstream and downstream boundary conditions can be specified. Boundary conditions along with the upstream head segment [UHS] and downstream head segment [DHS] values that specify these conditions are:

Boundary type [UHS] and/or [DHS]

External head	-1
External/internal flow	0
Internal head	>0

Dam flow-only for [UHS] <-1 [only for receiving a structure flow from another branch]

For internal head boundary conditions between branches or dam flow boundary conditions between waterbodies, [UHS] and/or [DHS] correspond to the branch segment the branch attaches to. In the following example, branch 1 consists of segments 2 through 6 and attaches to branch 2 at segment 9. Branch 2 consists of segments 9 through 14 and attaches at segment 6 in branch 1 and segment 17 at branch 3. See [Chapter 3](#) for additional information on the computational grid setup. The current version does not use the [UQB] and [DQB] variables – ignore these fields. A later version may use these to define internal flow boundary conditions. Any internal flow such as a structure flow will have a 0 value for [DHS]. For the receiving branch, a negative number corresponding to the structure segment number is specified for [UHS]. This is only when there is a structure flow specified as the downstream outflow of a corresponding branch, in other words you must specify the DS value of a corresponding branch. This allows that specified structure flow to go into the upstream segment of a downstream branch. If you use any hydraulic elements, such as spillways, pumps, pipes, gates, you would not use a negative value. You would use a flow boundary condition, i.e., zero for UHS or DHS. The spillways, pumps, pipes, and gates have their own specification for where the flow is directed.

GRID DEFINITION

CONTROL FILE

The following example is taken from the example [control file](#) of the Spokane River/Long Lake in Washington, USA. Branches one through four represent sloping river sections that are linked in series since the downstream head segment number [DHS=13 for branch one] is the upstream segment number [US=13 for branch 2] of the next branch and the upstream head segment number [UHS=10 for branch 2] is the downstream segment number [DS=10 for branch 1] of the preceding branch. Similar linkage occurs for branches two to three and three to four. Branch four, however, has a downstream head [DHS] set to 0, indicating either an internal (spillway or gate) or external (outlet structure) flow boundary condition. Branch 6 inflow is from the structure release from Branch 5; this structure outflow is a given, known flow rate, not one computed in the model.

In this example, branch four is connected to branch 5 via an internal flow from a spillway and the linkage is specified on the spillway card in the sample control file. Note though that branch 5 must be a separate waterbody with its own value of **EBOT** (see next card) since there is no way to define the elevations of the grid with another branch since it has no linkage specified.

SLOPEC is the hydraulic equivalent slope of the model branch. In many cases the actual slope of the channel (**SLOPE**) is not the correct equivalent hydraulic slope, since this may be punctuated by pools and riffles. **SLOPEC** is used in the momentum equation to determine the acceleration of a parcel of fluid for that branch rather than **SLOPE**. **SLOPE** is though critical for linking the model system together with correct elevations.

Example

BRANCH G	US	DS	UHS	DHS	NL	SLOPE	SLOPEC
Br 1	2	10	0	13	1	0.00181	0.00181
Br 2	13	24	10	27	1	0.00152	0.00100
Br 3	27	36	24	39	1	0.00328	0.00200
Br 4	39	48	36	0	1	0.00142	0.00142
Br 5	51	64	0	0	1	0.00000	0.00000
Br 6	67	73	-64	76	1	0.00000	0.00000
Br 7	76	86	73	0	1	0.00000	0.00000
Br 8	89	94	-86	97	1	0.00256	0.00150
Br 9	97	128	94	0	1	0.00208	0.00100
Br 10	131	135	0	138	1	0.00000	0.00000
Br 11	138	151	135	0	1	0.00000	0.00000
Br 12	154	188	-151	0	1	0.00000	0.00000

BRANCH GRID	BR1	BR2	BR3	BR4
US - upstream segment number of branch	2			
DS - downstream segment number of branch	31			
UHS- upstream boundary condition	0			
DHS - downstream boundary condition	0			
NLMIN # of layers	1			
SLOPE - actual slope	0			
SLOPEC - hydraulic equivalent slope (less than or equal to SLOPE)	0			

As an example, the layout in Figure 6 below would be set-up as shown in the table below.

CONTROL FILE

GRID DEFINITION

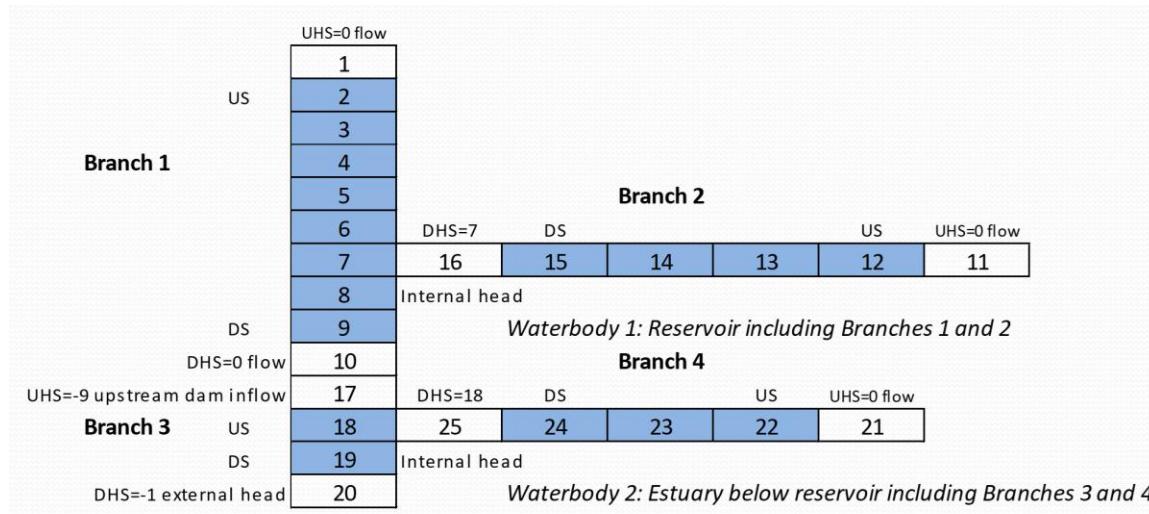


Figure 6. Example branch layout.

BRANCH GRID	BR1	BR2	BR3	BR4
US - upstream segment number of branch	2	12	18	22
DS - downstream segment number of branch	9	15	19	24
UHS- upstream boundary condition	0	0	-9	0
DHS - downstream boundary condition	0	7	-1	18
NLMIN # of layers	1	1	1	1
SLOPE - actual slope	0	0	0	0
SLOPEC - hydraulic equivalent slope (less than or equal to SLOPE)	0	0	0	0

Related Cards and Files

[Bathymetry File](#) [Branch Inflow File](#) [Branch Inflow Temperature File](#) [Branch Inflow Concentration File](#)
[Branch Outflow File](#) [Branch External Upstream Head Elevation File](#)
[Branch External Upstream Head Temperature File](#) [Branch External Upstream Head Concentration File](#)
[Branch External Downstream Head Elevation File](#) [Branch External Downstream Head Temperature File](#)
[Branch External Downstream Head Concentration File](#)

Waterbody Definition (LOCATION)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	LAT	Real	Latitude N, <i>degrees</i>
3	LONG	Real	Longitude W, <i>degrees</i>
4	EBOT	Real	Bottom elevation of waterbody, <i>m</i>
5	BS	Integer	Starting branch of waterbody
6	BE	Integer	Ending branch of waterbody
7	JBDN	Integer	Downstream branch of waterbody

This card specifies the waterbody latitude and longitude, bottom reference elevation, starting and ending branches of the waterbody, and the downstream most branch of the waterbody that connects to the next waterbody. The bottom elevation is used to tie computed water surface elevations to an external benchmark (e.g., *m* above sea level) and represents the elevation at the bottom of the bottommost active cell. This elevation is defined at the mid-point of a model cell.

Latitude and Longitude are critical for sunrise/sunset internal computation of short-wave solar radiation, shading, and for plotting xy coordinates of segments in the preprocessor. The reference bottom elevation is used to define the vertical datum.

The model was set up for LONG W and LAT N coordinates as being positive. Hence one would start at Greenwich as 0 and go 360 degrees toward the West or go negative toward the east - either approach is OK. Remember that this specification of **LONG** and **LAT** only affects internal shortwave solar calculation and shading calculations. Hence, if one reads in short wave solar radiation and does not have dynamic shading calculations, **LAT** and **LONG** will not be used.

JBDN specifies the downstream branch from which **[EBOT]** is referenced. In the case of a complicated grid, this is the starting elevation for tying the rest of the elevation of the grid together. **EBOT** is the elevation of the bottom of the bottommost active layer in the computational grid **[KMX]**. Figure 7, Figure 8, and Figure 9 show **[EBOT]** for a sloping river, a reservoir and another reservoir, respectively. For a sloping river, **[EBOT]** would generally be located at the most downstream segment in the section. **EBOT** is defined as the elevation of KMX-1 of DS(JBDN). **EBOT** would be defined at the segment center for a sloping domain.

Example

LOCATION	LAT	LONG	EBOT	BS	BE	JBDN
WB 1	45.44	122.18	36.00	1	2	2
WB 2	45.44	122.18	0.00	3	3	3
WB 3	45.44	122.18	-8.00	4	4	4

LOCATION	WB1	WB2	WB3	WB4
LAT, Latitude N	34.2			
LONG, Longitude W	93.3			
EBOT elevation of bottom of waterbody, m	66.35			
BS starting branch of waterbody	1			
BE ending branch of waterbody	1			
JBDN downstream branch of waterbody	1			

CONTROL FILE

GRID DEFINITION

Segment	4	5	6	7	8	9	10
DLX	33.49	149.18	108.37	196.35	306.19	87.04	87.04
ELWS	271	271	271	271	271	271	271
PHIO	3.5	3.5	4.71	4.71	3.14	3.14	3.14
Friction	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Layer	Width	Elev-top	Width	Elev-top	Width	Elev-top	Width
1	.00	276.83	.00	276.71	.00	276.55	.00
2	90.00	276.23	90.00	276.11	90.00	275.95	90.00
3	90.00	275.63	90.00	275.51	90.00	275.35	90.00
4	90.00	275.03	90.00	274.91	90.00	274.75	90.00
5	90.00	274.43	90.00	274.31	90.00	274.15	90.00
6	90.00	273.83	90.00	273.71	90.00	273.55	90.00
7	90.00	273.23	90.00	273.11	90.00	272.95	90.00
8	60.00	272.63	60.00	272.51	60.00	272.35	60.00
9	45.00	272.03	45.00	271.91	45.00	271.75	45.00
10	30.00	271.43	30.00	271.31	30.00	271.15	30.00
11	17.50	270.83	17.50	270.71	17.50	270.55	17.50
12	10.00	270.23	10.00	270.11	10.00	269.95	10.00
13	7.00	269.93	7.00	269.81	7.00	269.65	7.00
14	.00	269.88	.00	269.76	.00	269.6	.00

Figure 7. Layer numbers and segments for a sloping waterbody where segment 9 is the last active segment of the waterbody. EBOT is 268.82 m, which is the lowest elevation in the waterbody and is the bottom elevation of layer 13 or KMX-1 (where KMX=14).

Segment	29	30	31	32	33	34	35	36	37	38
DLX	117.988	28.3495	136.98	146.072	157.852	109.728	99.06	91.44	147.549	147.549
ELWS	264.5	264.5	264.5	264.5	264.5	264.5	264.5	264.5	264.5	264.5
PHI0	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	4.3	4.3
Friction	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Layer	Elev-top	Width	Elev-top	Width	Elev-top	Width	Elev-top	Width	Elev-top	Width
1	264.41	.00	264.41	.00	264.41	.00	264.41	.00	264.41	.00
2	264.16	33.00	264.16	32.00	264.16	25.00	264.16	38.00	264.16	161.00
3	263.91	20.00	263.91	30.00	263.91	20.00	263.91	90.00	263.91	120.00
4	263.66	20.00	263.66	20.00	263.66	12.00	263.66	70.00	263.66	80.00
5	263.41	.00	263.41	15.00	263.41	10.00	263.41	50.00	263.41	50.00
6	263.16	.00	263.16	10.00	263.16	10.00	263.16	30.00	263.16	18.00
7	262.91	.00	262.91	.00	262.91	10.00	262.91	20.00	262.91	15.00
8	262.66	.00	262.66	.00	262.66	.00	262.66	15.00	262.66	10.00
9	262.41	.00	262.41	.00	262.41	.00	262.41	10.00	262.41	10.00
10	262.16	.00	262.16	.00	262.16	.00	262.16	.00	262.16	9.00
11	261.91	.00	261.91	.00	261.91	.00	261.91	.00	261.91	8.00
12	261.66	.00	261.66	.00	261.66	.00	261.66	.00	261.66	7.00
13	261.41	.00	261.41	.00	261.41	.00	261.41	.00	261.41	6.00
14	261.21	.00	261.21	.00	261.21	.00	261.21	.00	261.21	5.00
15	261.00	.00	261.00	.00	261.00	.00	261.00	.00	261.00	4.00

Figure 8. Layer numbers and segments for a branch with a zero slope where segment 37 is the last active segment of the branch. EBOT for this waterbody is 261.21 m and is the bottom elevation of layer 13 or KMX-1 (where KMX=14).

Figure 9. Example bathymetry input file with layer and elevation at the right-hand side. EBOT is 21.6 m and is the top of the inactive layer or the bottom elevation of the first active layer. The first branch included active segments 2-27 and the second branch had active segments 30-34. Layer heights were 2 m (we recommend 1 m as a maximum). Branch slope was zero.

Initial Conditions (INIT CND)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	T2I	Real		Initial temperature, °C
3	ICETHI	Real		Initial ice thickness, m
4	WTYPEC	Character	FRESH	Waterbody type, FRESH or SALT
5	GRIDC	Character	RECT	Either 'RECT' or 'TRAP' specifying the interpretation of the bathymetry as either rectangular cells or trapezoidal cells

This card specifies the initial temperature and ice thickness, and waterbody type. Initial temperature can be specified as either a single value, a single vertical profile used to initialize every segment, or a vertical profile for each segment.

Initial condition	[T2I]
1. Isothermal	> or =0
2. Single vertical profile	-1.0
3. Vertical profile at each segment	-2.0

If option 2 or 3 is chosen, then the user must specify input files [**VPRFN**] or [**LPRFN**] containing the profile(s).

Initial ice thickness [**ICETHI**] is ignored if ice computations are turned off.

The waterbody type [**WTYPEC**] is either FRESH or SALT. If [**WTYPEC**] is set to SALT, then constituent computations [**CCC**] should be turned on and **salinity** should be included in the computations. This affects the equation of state used in the model and the units of TDS (if FRESH, g/m³ or mg/l) or SALINITY (if SALT, kg/m³). The equation of state for both **FRESH** and **SALT** is shown in the User Manual Part 2.

The following is not yet fully implemented in the model and hence only GRIDC=RECT is active.

The model user can specify that the grid can be interpreted as trapezoidal rather than rectangular. Trapezoidal cells have the advantage of smoother water level change especially in a river leading to faster run times and stability. The computational grid system traditionally used by CE-QUAL-W2 was a rectangular grid system, a basic cross-section of which is show in Figure 10. This grid system is ideal for waterbodies characterized by gradual changes in surface area with depth, such as lakes, reservoirs, and some larger rivers. In cases where small changes in water elevation result in large changes in surface area, however, the rectangular grid system can lead to numerical instability issues that require low maximum time steps and can impact processes on the air-water interface. Two possible solutions to make the layer change smoother is illustrated in Figure 11. The first approach involves decreasing layer thickness to create a more gradually sloping shoreline. This would entail increasing the number of layers which could considerably increase computational time. The second approach involves converting the rectangular grid to a trapezoidal grid. This solution not only results in increased stability and more realistic bank geometry, but it also allows for smooth changes in surface area while maintaining the same volume-elevation relationship in the channel as the original rectangular grid. (This approach makes it possible to "retrofit" older models without the necessity of recreating all the bathymetry and grid files.)

CONTROL FILE

INITIAL CONDITIONS

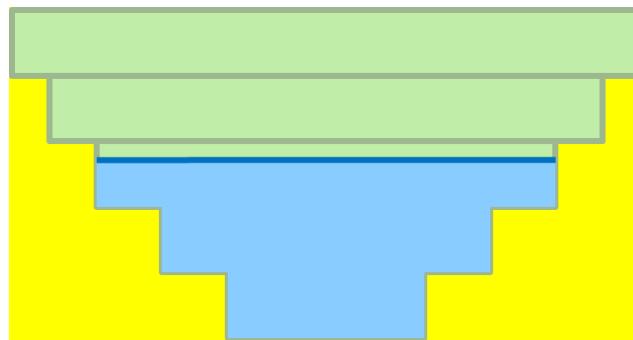


Figure 10. Cross-section of current rectangular grid system

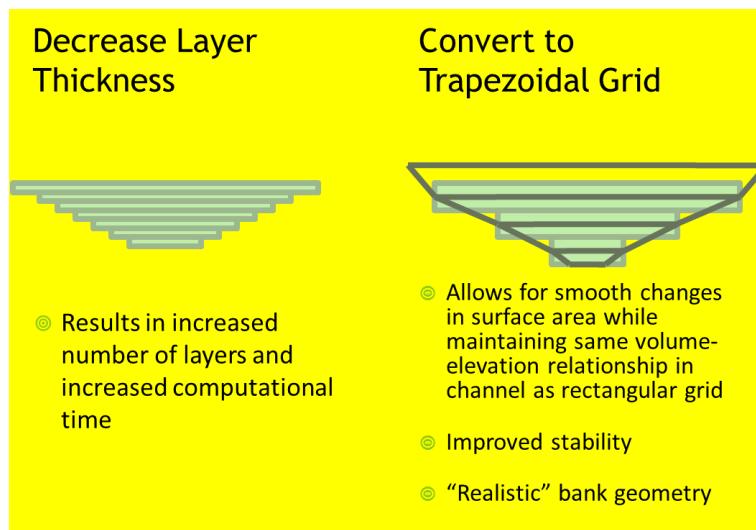


Figure 11. Various solutions to fitting a cross-section –trapezoidal layers compared to multiple rectangular layers.

Hence, the bathymetry will still be based on average widths at cell centers but will be interpreted as either rectangles or trapezoids.

Example

```
INIT CND      T2I    ICETHI   WTYPEC   GRIDC
Wb 1         -1.0     0.0     FRESH    RECT
Wb 2         -1.0     0.0     FRESH    RECT
Wb 3         -1.0     0.0     FRESH    RECT
```

INIT CND	WB1	WB2	WB3
T2I - initial temperature oC	-1		
ICEL - initial ice thickness, m	0		
WTYPEC - waterbody type FRESH or SALT	FRESH		
GRIDC - grid RECT or TRAP (not used at present)	RECT		

Related Cards and Files

[Constituent Computations](#) [Constituent Initial Concentration](#) [Vertical Profile File](#) [Longitudinal Profile File](#) [Ice Cover](#)

Calculations (CALCULAT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	VBC	Character	ON	Volume balance calculation, ON or OFF
3	EBC	Character	ON	Thermal energy balance calculation, ON or OFF
3	MBC	Character	ON	Mass balance calculation, ON or OFF
4	PQC	Character	OFF	Density placed inflows, ON or OFF
5	EVC	Character	ON	Evaporation included in water budget, ON or OFF
6	PRC	Character	OFF	Precipitation included, ON or OFF

This card specifies whether the model performs certain optional calculations. Calculations are turned on or off by right justifying ON or OFF in the input field.

Volume balance calculations are useful during initial runs as a check to ensure the model is preserving continuity and should always be used as a check if the user modifies the code. In order to reduce roundoff errors, the volume balance algorithm accumulates spatial and temporal changes in volume over time and uses these for comparison. Once the user is satisfied the model is running correctly, volume balance calculations may be turned off to reduce computational time. The volume balance output is written to the flowbalance output file ([Flow Balance Output \(FB OUT\)](#)) and to the Snapshot ([Snapshot Print \(SNP PRINT\)](#)) output file if those are ON.

Does the model conserve fluid mass, energy and constituent mass? This is where you can see if it is. The output is written to the SNP file and a flow balance file. Density placed inflows are only for branch inflow specification. Be careful using this since the model could try to put all the inflow into a small bottom layer and the time step for stability might be extremely small.

Thermal energy and mass balance calculations are similar in use to volume balance calculations. They should be used initially to ensure the model is running properly and turned off for further calculations. When this option is used, mass balances are performed for each constituent if constituent computations are turned on. Mass balances are not computed if only temperature is modeled. These balances are only written to the Snapshot [SNP] file.

There are two options for distributing mainstem and branch inflows. The default is inflows distributed evenly into each layer from top to bottom. If [PQC] is turned ON, then inflows are matched up with the layer(s) whose density most closely corresponds to inflow density. The model user should use this carefully since if you have a large inflow all the flow may be forced into the bottom-most small layer, causing the model to slow to a crawl to maintain stability or to go unstable.

If precipitation is specified [PRC=ON], then the user must supply input files for precipitation and precipitation temperature. If constituents are being modeled, then the user must supply an input file for constituent concentrations included in the simulation. The [Precipitation Active Constituent Control](#) card specifies which concentrations are included. If all precipitation constituents are turned OFF, then the precipitation constituent concentration input file is not required.

CONTROL FILE

INITIAL CONDITIONS

Evaporation rates are sometimes accounted for in estimating the inflow record, such as when net inflows are computed from outflows and water surface elevations. If so, then [EVC] should be set to OFF. Evaporation is always considered in the surface heat exchange calculations.

Example

CALCULAT	VBC	EBC	MBC	PQC	EVC	PRC
Wb 1	ON	ON	ON	OFF	OFF	OFF
Wb 2	ON	ON	ON	OFF	OFF	OFF
Wb 3	ON	ON	ON	OFF	OFF	OFF

CALCULATION	WB1	WB2	WB3
VBC - volume balance computation	ON		
EBC - energy balance computation	OFF		
MBC - mass balance computation	ON		
PQC - Turn ON or OFF placement of inflows by density	ON		
EVC - Turn ON or OFF evaporation water loss	OFF		
PRC - Turn ON or OFF precipitation on water surface	OFF		

Related Cards and Files

[Precipitation Active Constituent Control](#)

[Branch Inflow File](#)

[Tributary Inflow File](#)

[Precipitation File](#)

Dead Sea (DEAD SEA)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	WINDC	Character	ON	Turn ON/OFF wind
3	QINC	Character	ON	Turn ON/OFF all sources of water
4	QOUTC	Character	ON	Turn ON/OFF all sinks of water
5	HEATC	Character	ON	Turn ON/OFF heat exchange

This card has been used primarily during model development debugging. It is in the release version because it can be useful in evaluating relative effects of the hydrodynamic forcing functions. Occasionally in estuarine applications, temperature is treated conservatively with the initial and boundary conditions set at a constant temperature with bottom and surface heat exchange turned off, although it is not recommended.

This has nothing to do with THE Dead Sea in the Middle East! This allows the user to turn OFF different processes to debug where a problem may be occurring. These should all be ON for normal model runs.

Example

```
DEAD SEA    WINDC    QINC    QOUTC    HEATC
Wb 1        ON       ON       ON       ON
Wb 2        ON       ON       ON       ON
Wb 3        ON       ON       ON       ON
```

DEAD SEA - only for code testing	WB1	WB2	WB3
WINDC- turns ON or OFF all wind	ON		
QINC- turns ON or OFF all inflows	ON		
QOUTC-turns ON or OFF all outflows	ON		
HEATC-turns ON or OFF all surface heat transfer	ON		

Interpolation (INTERPOL)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	QINIC	Character	ON	Interpolate inflows, inflow temperatures, and inflow constituent concentrations, ON or OFF
3	DTRIC	Character	ON	Interpolate distributed tributary inflows and inflow temperatures and constituent concentrations, ON or OFF
4	HDIC	Character	ON	Interpolate head boundary elevations and boundary temperatures and constituent concentrations, ON or OFF

These options control whether time-varying data are input as a step function or linearly interpolated between data points. The model user can control interpolation for inflow, distributed tributary inflow, and external head boundary elevations for each branch. If interpolation is used, then the user must ensure it is appropriate and the input data supply correct information. Many reservoirs have periods of no releases. If outflow interpolation is turned on, then input data must be set up so no outflow occurs during these periods. This is accomplished by including extra dates in the outflow file with zero outflows to ensure the interpolation routine yields zero outflows. For example, given the following outflow time-series in the branch [outflow file \[QOTFN\]](#):

```
JDAY      QOT
100.00    50.0
110.00    0.0
120.00    50.0
```

If interpolation is not used, then outflow from Julian day 100 to 110 is $50 \text{ m}^3 \text{ sec}^{-1}$, from Julian day 110 to 120 is $0.0 \text{ m}^3 \text{ sec}^{-1}$, and $50 \text{ m}^3 \text{ sec}^{-1}$ thereafter. If interpolation is turned on, then outflow linearly decreases from Julian day 100 to 110 and then increases from Julian day 110 to 120. To ensure no outflow occurs between day 110 and 120 with interpolation on, the outflow file should be setup as follows:

```
JDAY      QOT
100.0000  50.0
109.9999  50.0
110.0000  0.0
119.9999  0.0
120.0000  50.0
```

Model boundary conditions can be at any time interval or at a variable time interval. This determines whether these should be linearly interpolated or viewed as a step function.

Example

INTERPOL	QINIC	DTRIC	HDIC
Br 1	ON	OFF	ON
Br 2	ON	OFF	ON
Br 3	ON	OFF	ON
Br 4	ON	OFF	ON

INITIAL CONDITIONS

CONTROL FILE

INTERPOLATION	BR1	BR2	BR3
QINIC- interpolate inflows	ON		
DTRIC-interpolate distributed tributary inflows	OFF		
HDIC-interpolate elevations for head boundary condition	OFF		

Related Cards and Files

[Branch Inflow File](#)

[Branch Distributed Tributary Inflow File](#)

[Branch Distributed Tributary Inflow Temperature File](#)

[Branch Distributed Tributary Inflow Concentration File](#)

[Branch External Upstream Head Elevation File](#)

[Branch External Upstream Head Temperature File](#)

[Branch External Upstream Head Concentration File](#)

[Branch External Downstream Head Elevation File](#)

[Branch External Downstream Head Temperature File](#)

[Branch External Downstream Head Concentration File](#)

Heat Exchange (HEAT EXCH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SLHTC	Character	TERM	Specify either term-by-term (TERM) or equilibrium temperature computations (ET) for surface heat exchange
3	SROC	Character	OFF	Read in observed short wave solar radiation, ON or OFF
4	RHEVAP	Character	OFF	Turns ON/OFF Ryan-Harleman evaporation formula only for TERM (ignored if ET is chosen)
5	METIC	Character	ON	Turns ON/OFF meteorological data interpolation
6	FETCHC	Character	OFF	Turns ON/OFF Fang and Stefan (1994) fetch calculation
7	AFW	Real	9.2	a coefficient in the wind speed formulation, $\text{Wm}^{-2} \text{mm Hg}^{-1}$
8	BFW	Real	0.46	b coefficient in the wind speed formulation, $\text{Wm}^{-2} \text{mm Hg}^{-1} (\text{ms}^{-1})^{-\text{cfw}}$
9	CFW	Real	2.0	c coefficient in the wind speed formulation, [-]
10	WINDH	Real		Wind speed measurement height, m

This card specifies various parameters affecting surface heat exchange. [SLHTC] allows the user to specify whether a term-by-term accounting or the equilibrium temperature approach is used in the computation of surface heat exchange. Although the term-by-term approach is more theoretically sound, some studies have used the equilibrium temperature successfully.

The [METIC] variable turns ON/OFF linear interpolation of meteorological input data. The [SROC] variable allows the user to specify whether or not short wave solar radiation data are computed from cloud cover (SROC=OFF), or whether the user specifies observed short wave solar radiation in the meteorological input file [METFN]. In the [meteorological data file](#), short wave solar radiation data are in units of W/m^2 and are the incident short-wave solar radiation on the water surface (in the code a reflection % of 6% is used to reflect a portion of this incident short wave solar if it is read in).

The [FETCHC] variable turns ON/OFF a technique of Fang and Stefan (1994) to compute fetch effects on wind. This should not be used for river sections and should be used with caution for reservoir/lake systems. A description is outlined in Part 2 of the User's Manual under Dissolved Oxygen and reaeration coefficients. Note that internal fetch calculations are always on, but that you can choose the Fang and Stefan approach if desired.

Meteorological inputs are critical to successfully modeling water temperature. The evaporation model (and wind speed sheltering coefficient) can significantly affect summer surface temperatures. Reading in known short wave solar radiation is best, but the model has a theoretical internal calculation. This theoretical internal calculation should be adjusted for high altitude lakes/reservoirs (see Annear and Wells, 2007).

INITIAL CONDITIONS

CONTROL FILE

The variables [AFW], [BFW], and [CFW] specify the coefficients to be used in the wind function used in computing surface heat exchange (for both term-by-term and equilibrium approaches) and evaporation (see Part 2 of the User Manual). The function has been generalized in the model to the following:

$$f(W_z) = a_{fw} + b_{fw} W_z^{cfw}$$

where a_{fw} is in units of $\text{Wm}^{-2} \text{mm Hg}^{-1}$, b_{fw} is in units of $\text{Wm}^{-2} \text{mm Hg}^{-1} (\text{ms}^{-1})^{-cfw}$, and cfw has no units. The default formulation is the recommended form of the function taken from Edinger, et. al. (1974), although there are several other forms that can be used. For systems that are thermally loaded such as cooling lakes, the Ryan-Harleman formulation that considers forced convection should be used with [RHEVAP] set to ON. This only affects the term-by-term model and not the equilibrium temperature model. All of the wind speed formulations are referenced to a height at which wind speeds were measured. The variable [WINDH] allows the user to specify the height at which wind speed measurements were taken, and the model converts them to the appropriate wind speed at the height that the wind speed formulation is based on.

Example

HEAT	EXCH	SLHTC	SROC	RHEVC	METIC	FETCHC	AFW	BFW	CFW	WINDH
Wb	1	TERM	OFF	OFF	ON	OFF	9.2	0.46	2.0	2.0
Wb	2	TERM	OFF	OFF	ON	OFF	9.2	0.46	2.0	2.0
Wb	3	TERM	OFF	OFF	ON	OFF	9.2	0.46	2.0	2.0

HEAT EXCHANGE	WB1	WB2	WB3
SLHTC - Heat computations - Equilibrium (ET) or Term-by-term (TERM)	TERM		
SROC - Read in Short wave solar radiation ON or OFF	OFF		
RHEVAP - Use Ryan-Harleman Evap Model - for cooling ponds ON or OFF	OFF		
METIC - Interpolate meteorological data ON or OFF	ON		
FETCHC - Heinz Stefan Lake fetch correction - there is already an internal fetch correction even if this is OFF	OFF		
AFW - Evaporation coefficient	9.2		
BFW - Evaporation coefficient	0.46		
CFW - Evaporation coefficient	2		
WINDH - Wind height measurement above ground surface, m	10		

Related Cards and Files

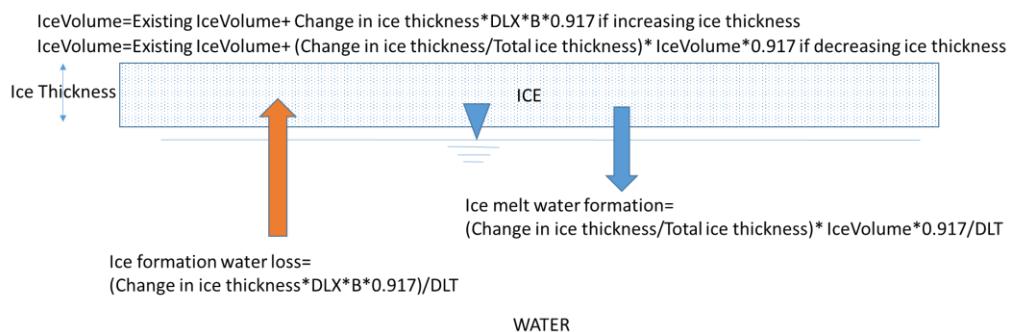
[Meteorology file](#)

Ice Cover (ICE COVER)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ICEC	Character	OFF	Allow ice calculations: ON, ONWB, OFF
3	SLICEC	Character	DETAIL	Specifies the method of ice cover calculations - either SIMPLE or DETAIL
4	ALBEDO	Real	0.25	Ratio of reflection to incident radiation (albedo of ice)
5	HWI	Real	10.0	Coefficient of water-ice heat exchange, $W m^{-2} ^\circ C^{-1}$
6	BETAI	Real	0.6	Fraction of solar radiation absorbed in the ice surface
7	GAMMAI	Real	0.07	Solar radiation extinction coefficient, m^{-1}
8	ICEMIN	Real	0.05	Minimum ice thickness before ice formation is allowed, m
9	ICET2	Real	3.0	Temperature above which ice formation is not allowed, $^\circ C$

Ice calculations are controlled with this card. The variable [ICEC] turns ON/OFF ice calculations or turns ice calculations ON with gains and losses of water occurring as water lets or freezes. When [ICEC]='ON', ice forms and melts but does not affect the waterbalance as was done in all model versions from 3.72 and earlier. When [ICEC]='ONWB' then ice calculations are made, but as ice is formed water is removed from the waterbody and as ice melts it is added back to the waterbody as shown below:

Currently snow accretion is not accounted for, nor is sublimation loss; ice is assumed to have no dissolved substances



Note: removal of 0.917 m3 of water for every 1 m3 of ice formed and vice versa

Two different methods for computing ice cover are available. The first method ([SLICEC] = SIMPLE) was included in version 1.0 and is available for backwards compatibility. The second method, DETAIL, is the preferred method.

The coefficient of water-ice heat exchange [HWI], $W m^{-2} C$, is a user specified calibration parameter that determines the rate of heat exchange between water and ice (see Appendix A). [BETAI] is the fraction of solar radiation absorbed at the ice surface and is similar to [BETA] in the surface heat exchange computations. [GAMMAI] is the solar radiation extinction coefficient through ice and is also similar to [GAMMA] in the surface heat exchange computations.

INITIAL CONDITIONS

CONTROL FILE

Albedo is the ratio of reflection to incident radiation. It is normally expressed by the albedo of a surface and varies widely depending on the solar altitude and the waterbody surface properties.

For free water surfaces, Anderson (1954), in his Lake Hefner studies, derived the following empirical formula for the water surface albedo, ALB_w , as a function of average solar altitude:

$$ALB_w = 1.18A_s^{-0.77}$$

where A_s is average solar altitude in degrees. Anderson found the coefficient 1.18 and the exponent -0.77 vary only slightly with cloud height and coverage.

For the ice surface, a functional representation of albedo has not been established. Reported values for ice surface albedo vary greatly from about 10% for clear lake ice (Bolsenga, 1969) to almost 70% for snow free Arctic sea ice (Kruckikh, et al., 1970). Kruckikh, et al. suggest ice albedo is more dependent on air temperature than on solar altitude. Based on their extensive Arctic Sea observations, ice surface albedo for solar radiation was determined as:

$$\begin{aligned} ALB_i &= \varepsilon \quad \text{for } T_a \leq 0^\circ\text{C} \\ ALB_i &= \xi + \omega \exp(\psi T_a) \quad \text{for } T_a > 0^\circ\text{C} \end{aligned}$$

where ε , ξ , ω , and ψ are empirical constants, and T_a is air temperature, $^\circ\text{C}$. This equation is an empirical fit to the observed data given by Kruckikh, et al. (1970) for Arctic ice.

Gao and Stefan (1998) report that they used the following in their empirical model of albedo based on field data on Ryan Lake in Minnesota:

$$\begin{aligned} ALB_{i-minimum} &= 0.38 \\ ALB_i &= 0.83 \text{ on snowfall days} \\ ALB_i &= -0.011d + 0.83 \text{ during nonmelt periods} \\ ALB_i &= -0.17 + ALB_{i-previous} \quad \text{for } T_a > 0^\circ\text{C} \\ ALB_i &= -0.013 + ALB_{i-previous} \quad \text{for } T_a \leq 0^\circ\text{C} \end{aligned}$$

where ALB_i is the daily ice albedo, $ALB_{i-minimum}$ is the minimum albedo, $ALB_{i-previous}$ is the previous days albedo, T_a is the average daily air temperature, and d is the number of days since the last snowfall.

The ice-water surface heat exchange coefficient for rivers was evaluated by Ashton (1979):

$$HWI = CWI \frac{U^{0.8}}{D^{0.2}}$$

Where U is the river velocity in m/s , D is the river depth in m , and CWI is an empirical coefficient ranging from 1622 to 2433 $\text{W s}^{0.8} \text{ m}^{-2.6} \text{ }^\circ\text{C}^{-1}$.

Note that the ice cover algorithm does not consider snow accumulation on the ice surface.

Example

ICE COVER	ICEC	SLICEC	ALBEDO	HWI	BETAI	GAMMAI	ICEMIN	ICET2
Wb 1	OFF	DETAIL	0.25	10.0	0.6	0.07	0.05	3.0
Wb 2	OFF	DETAIL	0.25	10.0	0.6	0.07	0.05	3.0
Wb 3	OFF	DETAIL	0.25	10.0	0.6	0.07	0.05	3.0

CONTROL FILE

INITIAL CONDITIONS

ICE COVER ALGORITHM	WB1	WB2	WB3
ICEC - Turn ICE cover algorithm ON/OFF	OFF		
SLICEC - Use DETAIL for detailed model vs SIMPLE	DETAIL		
ALBEDO - Ratio of reflection to incident radiation of ice	0.25		
HWICE - Coefficient of water-ice heat exchange, W/m ² /oC	10		
BICE-Fraction of solar radiation absorbed in the ice surface	0.6		
GICE-Solar radiation extinction coefficient, m ⁻¹	0.07		
ICEMIN-Minimum ice thickness before ice formation is allowed, m	0.05		
ICET2-Temperature above which ice formation is not allowed, oC	3		

Related Cards and Files

[Initial Conditions](#)

Transport Scheme (TRANSPORT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SLTRC	Character	ULTIMATE	Transport solution scheme, ULTIMATE, QUICKEST, or UPWIND
3	THETA	Real	0.55	Time-weighting for vertical advection scheme

This card specifies the transport solution scheme used by the model. There are three options for [SLTRC] – UPWIND, QUICKEST, or ULTIMATE with the latter being the recommended option. The older solution schemes are retained in this version of the model mainly as a means of comparing the different solution schemes. The QUICKEST option employs a higher-order solution scheme to reduce numerical diffusion present in the original UPWIND differencing scheme. The ULTIMATE option eliminates the physically unrealistic over/undershoots that QUICKEST generates near regions of sharp concentration gradients.

[THETA] specifies the amount of time weighting in the vertical advection scheme. A value of 0 specifies fully explicit vertical advection, 1 specifies fully implicit vertical advection, and 0.5 specifies a Crank-Nicholson scheme. The recommended value for [THETA] is 0.55. This ensures unconditional numerical stability for vertical transport. Vertical diffusion is always fully implicit.

While the addition of the ULTIMATE algorithm eliminates physically unrealistic over/undershoots due to longitudinal transport, the model can still generate over/undershoots when using implicit weighting for vertical transport. This is a result of phase errors generated when trying to resolve sharp vertical gradients over a few computational cells and can be eliminated completely by setting [THETA] to zero.

Example

```
TRANSPORT SLTRC THETA
Wb 1   ULTIMATE 0.55
Wb 2   ULTIMATE 0.55
Wb 3   ULTIMATE 0.55
```

TRANSPORT SCHEME	WB1	WB2	WB3
SLTRC - UPWIND, QUICKEST, ULTIMATE - use ULTIMATE	ULTIMATE		
THETA - degree of implicitness - use 0.55 - Time- weighting for vertical advection scheme	0.55		

Hydraulic Coefficients (HYD COEF)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	AX	Real	1.0	Longitudinal eddy viscosity, $m^2 sec^{-1}$
3	DX	Real	1.0	Longitudinal eddy diffusivity, $m^2 sec^{-1}$
4	CBHE	Real	0.3	Coefficient of bottom heat exchange, $W m^{-2} ^\circ C^{-1}$
5	TSED	Real	-	Sediment temperature, $^\circ C$
6	FI	Real	0.01	Interfacial friction factor
7	TSEDF	Real	1.0	Heat lost to sediments that is added back to water column
8	FRICC	Character	CHEZY	Bottom friction solution, MANN or CHEZY
9	Z0	Real	0.001	Water surface roughness height, m

This card specifies hydraulic and bottom heat exchange coefficients that can be varied during model calibration. The horizontal eddy viscosity [**AX**] specifies dispersion of momentum in the X-direction. Note that for estuaries the value of [**AX**] is often as high as 10-30 m^2/s . The horizontal eddy diffusivity [**DX**] specifies dispersion of heat and constituents in the X-direction. [**DX**] can vary significantly from the default value of 1 m^2/s in estuaries and rivers, with values as high as 10 to 100 m^2/s . Dye studies are often used to calibrate the value of [**DX**]. One approach by Okubo (1971) for estimating [**DX**] in units of m^2/s when the longitudinal grid spacing Δx is in m is:

$$D_x = 5.84 \times 10^{-4} \Delta x^{1.1}$$

Both values can be time and space invariant if they are entered as a positive number. Starting in Version 4.1, the user can also scale D_x and A_x as a function of the mean velocity. Hence, the model user can specify the following functional relationship:

$$\begin{aligned} A_x &= \alpha \bar{U} \Delta z \\ D_x &= \beta \bar{U} \Delta z \end{aligned}$$

where α and β are user input values, U with double bars are the time-averaged, lateral averaged longitudinal velocity at a segment and layer. The velocities are taken as absolute values in the model since negative velocities are possible. This computation is activated by replacing D_x and A_x with negative numbers which are then interpreted as the α and β input values. Hence, if A_x is negative, then α is equal to the absolute value of A_x , such that

$$A_x = |A_x| \bar{U} \Delta z$$

Similarly, if D_x is negative, then β is equal to the absolute value of D_x , such that

$$D_x = |D_x| \bar{U} \Delta z$$

The Chezy coefficient is used in calculating effects of bottom friction. The coefficient of bottom heat exchange [**CBHE**] and the sediment temperature [**TSED**] are used to compute heat exchange at the ground-water interface. Sediment temperature can be estimated from average annual air temperature at the site or the average annual overlying water temperature (See User Manual Part 2). The values of CBHE can range from 1 to 0.1 $W m^{-2} ^\circ C^{-1}$ depending on the value of the diffusion coefficient, density, specific heat, and vertical length scale as shown in User's Manual Part 2. Many have used 0.3 $W m^{-2} ^\circ C^{-1}$.

INITIAL CONDITIONS

CONTROL FILE

[TSEDF] is a coefficient that varies from 0 to 1. This regulates how short-wave solar radiation that penetrates to the bottom of the grid is handled in the code. A value of 1.0 specifies that 100% of the incident short wave solar impinging on the channel bottom is re-radiated as heat to the water column. A value of 0 means that 0% of the shortwave solar radiation is reradiated into the water column resulting in a loss of the solar radiation from the system.

Previous experience has shown recommended values produce remarkably accurate temperature predictions for a wide variety of systems. The horizontal eddy viscosities and diffusivities and Chezy or Manning's n coefficient may need additional tuning especially in modeling rivers or estuaries. The Chezy C or Manning's n coefficient is important in estuarine applications for calibrating tidal range and phase.

Typical values for the Chezy coefficient and Manning's friction factors have been 70 and 0.035, respectively. In estuaries and rivers, these values can vary widely, especially since often this friction factor incorporates errors in the bathymetry of the model. For Manning's friction factors, a range of values have been used in rivers and estuaries from 0.01 to 0.1 or higher. These are usually determined by calibrating the model to water surface elevation data.

Starting with Version 3.6, the user can specify the value of [Z0], the roughness height of the water. Typical values are less than 10% of the actual roughness height elements (often roughness height divided by 30 is used) and can range from 10^{-3} to 10^{-4} m.

Example

HYD COEF	AX	DX	CBHE	TSED	FI	TSEDF	FRICC	Z0
Wb 1	1.0	1.0	0.3	11.5	0.01	1.00	MANN	0.001
Wb 2	-0.1	-0.1	0.3	11.5	0.01	1.00	MANN	0.001
Wb 3	1.0	1.0	0.3	11.5	0.01	1.00	MANN	0.001

HYD COEFFICIENTS	WB1	WB2	WB3
AX - Longitudinal eddy viscosity, m ² /s	1		
DX - Longitudinal eddy diffusivity/conductivity, m ² /s	1		
CBHE - Coefficient of bottom heat exchange, W m ⁻² oC-1	0.3		
TSED - Temperature of sediment, C, average year round air temperature	14		
FI - Interfacial friction factor	0		
TSEDF - Sediment temperature coefficient (0-1) Heat lost to sediments that is added back to water column	0		
FRICC - Bottom friction factor type: CHEZY or MANN	CHEZY		
Z0 - water surface roughness height, m, for wind shear	0.001		

CONTROL FILE

INITIAL CONDITIONS

Vertical Eddy Viscosity (EDDY VISC)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	AZC	Character	TKE	Form of vertical turbulence closure algorithm, NICK, PARAB, RNG, W2, W2N, TKE, or TKE1
3	AZSLC	Character	IMP	Specifies either implicit, IMP, or explicit, EXP, treatment of the vertical eddy viscosity in the longitudinal momentum equation.
4	AZMAX	Real	1.0	Maximum value for vertical eddy viscosity, $m^2 s^{-1}$
5	FBC	Integer	3	Only active if AZC=TKE1; Choice of boundary condition: =1 Celik Rodi 1988, =2 Rodi 1983, =3 Original CE-QUAL-W2 boundary condition
6	E	Real	9.535	Only active if AZC=TKE1; roughness coefficient
7	ARODI	Real	0.431	Only active if AZC=TKE1; choose typical Values of 0.43 if FBC=1 and 0.07 if FBC=2. Not used if FBC=3.
8	STRCKLR	Real	24.0	Only active if AZC=TKE1; If this is =0.0, then the Strickler Nickuradse relationships are NOT used to calculate the roughness coefficient; if >0.0, then the Strickler Nickuradse relationships are used to calculate the roughness coefficient. The value of the coefficient sets the relationship between the surface roughness and the Manning's friction factor.
9	BOUNDFR	Real	10.0	Only active if AZC=TKE1; if =0.0, then Boundary production is OFF. If > 0.0, then boundary production is ON. The value of the boundary friction production constant is set by this constant.
10	TKECAL	Character	IMP	Only active if AZC=TKE1; select either the implicit or explicit vertical transport term formulation, options then are either IMP or EXP.

[AZC] specifies the vertical turbulence algorithm used in the horizontal momentum equation. Table 1 lists the options available for turbulence closure. For more information see Part 2 of the User Manual.

Table 1. Vertical Eddy Viscosity Formulations

Formulation	Formula	Reference
Nickuradse [NICK]	$v_t = \ell_m^2 \left \frac{\partial u}{\partial z} \right e^{-CRi}$ $\ell_m = H \left[0.14 - 0.08 \left(1 - \frac{z}{H} \right)^2 - 0.06 \left(1 - \frac{z}{H} \right)^4 \right]$	Rodi (1993)
Parabolic [PARAB]	$v_t = \kappa u_* z \left(1 - \frac{z}{H} \right) e^{-CRi}$	Engelund (1976)
[W2] (used in V2)	$v_t = K \left(\frac{l_m^2}{2} \right) \sqrt{\left(\frac{\partial U}{\partial z} \right)^2 + \left(\frac{\tau_{wy} e^{-2kz} + \tau_{y trib}}{\rho v_t} \right)^2} e^{(-CR_i)}$ $\ell_m = \Delta z_{max}$	Cole and Buchak (1995)

INITIAL CONDITIONS

CONTROL FILE

Formulation	Formula	Reference
W2 with mixing length of Nickuradse [W2N]	$\nu_t = K \left(\frac{l_m^2}{2} \right) \sqrt{\left(\frac{\partial U}{\partial z} \right)^2 + \left(\frac{\tau_{wy} e^{-2kz} + \tau_{y\text{trib}}}{\rho v_t} \right)^2} e^{(-CR_i)}$ $\theta_m = H \left[0.14 - 0.08 \left(1 - \frac{z}{H} \right)^2 - 0.06 \left(1 - \frac{z}{H} \right)^4 \right]$	Cole and Buchak (1995) and Rodi (1993)
[RNG] (renormalization group)	$v_t = v \left[1 + \Psi \left(3\kappa \left(\frac{zu_*}{v} \right)^3 \left(1 - \frac{z}{H} \right)^3 - C_1 \right) \right]^{1/3} e^{-CRL}$	Simoes (1998)
TKE (Turbulent kinetic energy) also TKE1 but with special conditions	$\nu_t = C_\mu \frac{k^2}{\varepsilon} \text{ where } k \text{ and } \varepsilon \text{ are defined from}$ $\frac{\partial kB}{\partial t} + \frac{\partial kB U}{\partial x} + \frac{\partial kB W}{\partial z} - \frac{\partial}{\partial z} \left(B \frac{\nu_t}{\sigma_k} \frac{\partial k}{\partial z} \right)$ $- \frac{\partial}{\partial x} \left(B \frac{\nu_t}{\sigma_k} \frac{\partial k}{\partial x} \right) = B(P + G - \varepsilon + P_k)$ $\frac{\partial \varepsilon B}{\partial t} + \frac{\partial \varepsilon BU}{\partial x} + \frac{\partial \varepsilon BW}{\partial z} - \frac{\partial}{\partial z} \left(B \frac{\nu_t}{\sigma_\varepsilon} \frac{\partial \varepsilon}{\partial z} \right)$ $- \frac{\partial}{\partial x} \left(B \frac{\nu_t}{\sigma_\varepsilon} \frac{\partial \varepsilon}{\partial x} \right) = B \left(C_\varepsilon \frac{\varepsilon}{k} P + C_{\varepsilon^2} \frac{\varepsilon^2}{k} + P_\varepsilon \right)$	Wells (2001), Gould (2006)

where:

ℓ_m = mixing length	C = constant (assumed 0.15)	k = wave number (in W2 models)
z = vertical coordinate	u^* = shear velocity	ρ = liquid density
H = depth	κ = von Karman constant	$\Psi(x)$ = $\max(0, x)$
u = horizontal velocity	τ_{wy} = cross-shear from wind	v = molecular viscosity
Ri = Richardson number	Δz_{\max} = maximum vertical grid spacing	C_1 = empirical constant, 100
$\tau_{y\text{trib}}$ = cross-shear from lateral tributaries		B = width
ν_t = turbulent viscosity	k = turbulent kinetic energy (in TKE model)	
ε = turbulent energy dissipation rate	P = turbulent energy production from boundary friction	
U = longitudinal velocity (laterally averaged)	W = vertical velocity (laterally averaged)	σ = turbulent Prandtl number
Production term: $P = \nu_t \left[\left(\frac{\partial U}{\partial z} \right)^2 \right]$	Buoyancy term: $G = - \frac{\nu_t}{\sigma_t} N^2$	Brunt–Vaisala frequency $N = \sqrt{-\frac{g d\rho}{\rho dz}}$

C_ε, C_μ = constants in the TKE model

The formulations PARAB, NICK, and RNG are appropriate for riverine/estuarine sections in which shear due to friction is dominant. The W2 is usually the choice for reservoirs and lakes where wind shear is dominant. The $k-\varepsilon$ turbulence formulation is though general to any waterbody and was added to W2 in order to eliminate the choice of turbulence scheme for the model user. The $k-\varepsilon$ model though is computationally expensive and similar results can often be obtained at less computational cost using another formulation.

To be backwards compatible with Version 2, set [AZC] to W2, [AZSLC] to EXP, and [AZMAX] to 1.0E-4 even though a value of 1.0E-3 is recommended as a minimum value of the maximum vertical eddy viscosity [AZ]. Note that for all model applications, we recommend using [AZC]=TKE, [AZSLC]=IMP and [AZMAX]= 1 $m^2 s^{-1}$. Setting [AZSLC] to EXP and [AZMAX] greater than 1.0E-2 will result in very low model time steps. In this case, setting [AZSLC] to IMP will remove the time step limitation allowing for much larger timesteps.

Only by choosing [AZC]=TKE1 are the other variables [FBC], [E], [ARODI], [STRCKLR], [BOUNDFR], and [TKECAL] active. These variables are described in detail in Gould (2006).

CONTROL FILE

INITIAL CONDITIONS

[FBC] sets the boundary condition for the model. The choices are [FBC]=1 Celik and Rodi (1988) model, [FBC]=2 Celik and Rodi (1984) model, [FBC]=3 Original TKE formulation found in CE-QUAL-W2. The user has the option of specifying the boundary roughness by setting the value of [E], the boundary roughness coefficient. [ARODI] sets the value of the coefficient used in the [FBC]=1 and [FBC]=2 models for computing boundary friction. [STRCKLR] gives a coefficient (typical is 24.0) used when Strickler Nickuradse relationships are used to calculate the roughness coefficient in the equation $k_s = (n \cdot 24.04)^6$. [BOUNDFR] sets the boundary condition for production, a typical value is 10.0 and is used in the production term as shown below:

$$P_\varepsilon = \frac{[BOUNDFR] C_f^{1.25} U^4}{(0.5B)^2}$$

[TKECAL] sets the implicit or explicit solution of the vertical transport terms in the k-ε model.

Example

EDDY VISC	AZC	AZSLC	AZMAX	FBC	E	ARODI	STRCKLR	BOUNDFR	TKECAL
WB 1	TKE	IMP	1.00	3	9.535	0.430	24.0	10.00	IMP
Wb 2	TKE	IMP	1.00	3	9.535	0.430	24.0	10.00	IMP
Wb 3	W2	IMP	1.00	3	9.535	0.430	24.0	10.00	IMP

EDDY VISCOSITY	WB1	WB2	WB3
AZC - Form of vertical turbulence closure algorithm, NICK, PARAB, RNG, W2, W2N, TKE, or TKE1	TKE		
AZSLC -Specifies either implicit, IMP, or explicit, EXP, treatment of the vertical eddy viscosity in the longitudinal momentum equation.	IMP		
AZMAX - Maximum value of eddy viscosity m2/s	1		
FBC Only active if AZC=TKE1; Choice of boundary condition: =1 Celik Rodi 1988, =2 Rodi 1983, =3 Original CE-QUAL-W2 boundary condition	3		
E Only active if AZC=TKE1; roughness coefficient	9.535		
ARODI Only active if AZC=TKE1; choose typical Values of 0.43 if FBC=1 and 0.07 if FBC=2. Not used if FBC=3.	0.43		
STRCKLR Only active if AZC=TKE1; If this is =0.0, then the Strickler Nickuradse relationships are NOT used to calculate the roughness coefficient; if >0.0, then the Strickler Nickuradse relationships are used to calculate the roughness coefficient. The value of the coefficient sets the relationship between the surface roughness and the Manning's friction factor.	24		
BOUNDFR Only active if AZC=TKE1; if =0.0, then Boundary production is OFF. If > 0.0, then boundary production is ON. The value of the boundary friction production constant is set by this constant.	10		
TKECAL Only active if AZC=TKE1; select either the implicit or explicit vertical transport term formulation, options then are either IMP or EXP.	IMP		

Related Cards and Files

[Timestep Limitations](#)

Number of Structures (N STRUC)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	NSTR	Integer	Number of branch outlet structures
3	DYNSTRUC	Character	ON or OFF. If this field is blank the model will assume this is OFF.

This card specifies the number of outlet structures for each branch. Outflows are computed based on a selective withdrawal algorithm. **DYNSTRUC** tells the model to use dynamic centerline elevation for the structure. Usually, the centerline elevation is fixed and specified with ESTR. If this is ON, the model will read a separate file for each branch called **dynselevX.npt** where X is the branch number. The format of this file is shown in the input file descriptions. If this file is supplied, the value of ESTR is ignored. Also, if the model user has activated auto-port selection in the file **w2_selective.npt**, DYNSTRUC will have precedence over port selection when a rule (as specified in **w2_selective.npt**) is inactive.

Example

```
N STRUC      NSTRDYNSTRUC
Br 1          0      OFF
Br 2          0      OFF
Br 3          3      ON
Br 4          0      OFF
```

STRUCTURES for each branch. These are known outflows at the end of a branch	BR1	BR2
NSTR - Number of branch outlet structures	1	
DYNSTRUC - Dynamic elevation of structure control ON or OFF - reads input file	OFF	

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Sink Type](#)
- [Structure Elevation](#)
- [Structure Width](#)
- [Structure Interpolation](#)
- [Structure Top Selective Withdrawal Limit](#)
- [Structure Bottom Selective Withdrawal Limit](#)
- [Outflow file](#)

Structure Interpolation (STR INT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	STRIC	Character	OFF	Turns ON/OFF interpolation of structure outflows

The outflows specified by the outflow file can either be assumed to be step functions with [STRIC] set to OFF, or the outflow file flows can be linearly interpolated between values with [STRIC] set to ON.

In the Excel version below, note that for the structure values, there are 5 fixed rows for structures 1-5. These rows stay in place even if you have less than 5 structures. If you have more than 5 structures at the end of a branch, then you need to add rows for each structure >5.

Example

```
STR INT      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC
Br 1
Br 2
Br 3          ON         ON         ON
Br 4
```

STRUCTURES for each branch. These are known outflows at the end of a branch	BR1	BR2
NSTR - Number of branch outlet structures	1	
DYNSTRUC - Dynamic elevation of structure control ON or OFF - reads input file	OFF	
STRIC1-Turns ON/OFF interpolation of structure outflows for structure 1	ON	
STRIC2-Turns ON/OFF interpolation of structure outflows for structure 2		
STRIC3-Turns ON/OFF interpolation of structure outflows for structure 3		
STRIC4-Turns ON/OFF interpolation of structure outflows for structure 4		
STRIC5-Turns ON/OFF interpolation of structure outflows for structure 5		

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Number of Structures](#)

[Sink Type](#)

[Structure Elevation](#)

[Structure Width](#)

[Structure Top Selective Withdrawal Limit](#)

[Structure Bottom Selective Withdrawal Limit](#)

[Outflow file](#)

Structure Top Selective Withdrawal Limit (STR TOP)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	KTSTR	Integer	Top layer above which selective withdrawal will not occur

The selective withdrawal algorithm calculates vertical withdrawal zone limits based on outlet geometry, outflows, and in-pool densities. The algorithm then assigns flows for each layer within the withdrawal zone. This card specifies the top elevation for which outflows are calculated in the selective withdrawal algorithm. This option can be used to mimic the effects of a curtain weir that limits the upper extent of the withdrawal zone. In the absence of any structure or topographic feature that limits the top of the selective withdrawal zone, the elevation should be set to the top elevation of the computational grid. If the structure centerline elevation is above **KTSTR**, then the value of **KTSTR** is raised to the centerline elevation.

As a default, the user should set this to layer 2 unless there is some reason to suspect that there is a restriction of the structure limiting withdrawal above the centerline of the outlet.

Example

```
STR TOP    KTSTR    KTSTR    KTSTR    KTSTR    KTSTR    KTSTR    KTSTR    KTSTR
Br 1
Br 2
Br 3        2        2        2
Br 4
```

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Number of Structures](#)
- [Sink Type](#)
- [Structure Elevation](#)
- [Structure Width](#)
- [Structure Interpolation](#)
- [Structure Bottom Selective Withdrawal Limit](#)
- [Outflow file](#)

Structure Bottom Selective Withdrawal Limit (STR BOT)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	KBSTR	Integer	Bottom layer below which selective withdrawal will not occur

The selective withdrawal algorithm calculates vertical withdrawal zone limits based on outlet geometry, outflows, and in-pool densities. The algorithm then assigns flows for each layer within the withdrawal zone. This card specifies the bottom elevation for which outflows are calculated in the selective withdrawal algorithm. This option can be used to simulate the effects of an upstream submerged weir, accumulation of debris at the trash racks, an upstream cofferdam, etc. In the absence of any structure or topographic feature limiting the bottom withdrawal layer, the value should be set to the bottommost active layer at the downstream segment. If the structure centerline elevation is below **KBSTR**, then the value of **KBSTR** is lowered to the centerline elevation.

As a default, the user should set this to layer KB (lowest active layer) at the location of the structure unless there is some reason to suspect that there is a restriction of the structure limiting its withdrawal below the centerline of the outlet.

In the Excel version below, note that for the structure values, there are 5 fixed rows for structures 1-5. These rows stay in place even if you have less than 5 structures. If you have more than 5 structures at the end of a branch, then you need to add rows for each structure >5.

Example

STR BOT	KBSTR								
Br 1									
Br 2									
Br 3	22	22	22						
Br 4									

STRUCTURES for each branch. These are known outflows at the end of a branch	BR1	BR2
NSTR - Number of branch outlet structures	1	
DYNSTRUC - Dynamic elevation of structure control ON or OFF - reads input file	OFF	
STRIC1-Turns ON/OFF interpolation of structure outflows for structure 1	ON	
STRIC2-Turns ON/OFF interpolation of structure outflows for structure 2		
STRIC3-Turns ON/OFF interpolation of structure outflows for structure 3		
STRIC4-Turns ON/OFF interpolation of structure outflows for structure 4		
STRIC5-Turns ON/OFF interpolation of structure outflows for structure 5		
KTSTR1-Top layer above which selective withdrawal will not occur for structure 1	2	
KTSTR2-Top layer above which selective withdrawal will not occur for structure 2		
KTSTR3-Top layer above which selective withdrawal will not occur for structure 3		
KTSTR4-Top layer above which selective withdrawal will not occur for structure 4		
KTSTR5-Top layer above which selective withdrawal will not occur for structure 5		
KBSTR1-Bottom layer below which selective withdrawal will not occur for structure 1	35	
KBSTR2-Bottom layer below which selective withdrawal will not occur for structure 2		
KBSTR3-Bottom layer below which selective withdrawal will not occur for structure 3		

OUTPUT CONTROL

CONTROL FILE

KBSTR4-Bottom layer below which selective withdrawal will not occur for structure 4		
KBSTR5-Bottom layer below which selective withdrawal will not occur for structure 5		

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Number of Structures](#)
[Sink Type](#)
[Structure Elevation](#)
[Structure Width](#)
[Structure Interpolation](#)
[Structure Top Selective Withdrawal Limit](#)
[Outflow file](#)

Sink Type (SINK TYPE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	SINKC	Character	POINT	Sink type used in the selective withdrawal algorithm, LINE or POINT

This card specifies the sink type for each withdrawal. The options are LINE or POINT each of which has different selective withdrawal characteristics.

Line sinks are usually structures that are wide relative to the dam width ($> 1/10$). Point sinks are usually structures that are narrow relative to dam width ($< 1/10$).

Example

```
SINK TYPE SINKC     SINKC     SINKC     SINKC     SINKC     SINKC     SINKC     SINKC     SINKC
Br 1
Br 2
Br 3      POINT    POINT    POINT
Br 4
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Number of Structures](#)

[Structure Elevation](#)

[Structure Width](#)

[Structure Interpolation](#)

[Structure Top Selective Withdrawal Limit](#)

[Structure Bottom Selective Withdrawal Limit](#)

[Outflow file](#)

Structure Elevation (E STRUC)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ESTR	Real	Centerline elevation of structure, <i>m</i>

This card specifies the centerline elevation for each withdrawal structure by branch.

Example

```
E STRUC      ESTR      ESTR      ESTR      ESTR      ESTR      ESTR      ESTR      WSTR
Br 1
Br 2
Br 3      45.0    25.00    15.00
Br 4
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Number of Structures](#)

[Sink Type](#)

[Structure Width](#)

[Structure Interpolation](#)

[Structure Top Selective Withdrawal Limit](#)

[Structure Bottom Selective Withdrawal Limit](#)

[Outflow file](#)

Structure Width (W STRUC)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	WSTR	Real	Width of structure (line sink), m

This card specifies the width of the structures by branch if a line sink is specified as the sink type [[SINKC](#)]. The values are ignored if a point sink is specified. If there are more outlet structures than will fit on a line, then the widths are continued on the next line starting in field 2.

In the Excel version below, note that for the structure values, there are 5 fixed rows for structures 1-5. These rows stay in place even if you have less than 5 structures. If you have more than 5 structures at the end of a branch, then you need to add rows for each structure >5.

Example

W STRUC	WSTR							
Br 1								
Br 2								
Br 3	10.0	10.0	10.0					
Br 4								

STRUCTURES for each branch. These are known outflows at the end of a branch	BR1	BR2
NSTR - Number of branch outlet structures	1	
DYNSTRUC - Dynamic elevation of structure control ON or OFF - reads input file	OFF	
STRIC1-Turns ON/OFF interpolation of structure outflows for structure 1	ON	
STRIC2-Turns ON/OFF interpolation of structure outflows for structure 2		
STRIC3-Turns ON/OFF interpolation of structure outflows for structure 3		
STRIC4-Turns ON/OFF interpolation of structure outflows for structure 4		
STRIC5-Turns ON/OFF interpolation of structure outflows for structure 5		
KTSTR1-Top layer above which selective withdrawal will not occur for structure 1	2	
KTSTR2-Top layer above which selective withdrawal will not occur for structure 2		
KTSTR3-Top layer above which selective withdrawal will not occur for structure 3		
KTSTR4-Top layer above which selective withdrawal will not occur for structure 4		
KTSTR5-Top layer above which selective withdrawal will not occur for structure 5		
KBSTR1-Bottom layer below which selective withdrawal will not occur for structure 1	35	
KBSTR2-Bottom layer below which selective withdrawal will not occur for structure 2		
KBSTR3-Bottom layer below which selective withdrawal will not occur for structure 3		
KBSTR4-Bottom layer below which selective withdrawal will not occur for structure 4		
KBSTR5-Bottom layer below which selective withdrawal will not occur for structure 5		
SINKC1 - Sink type used in the selective withdrawal algorithm, LINE or POINT, structure 1	POINT	
SINKC2 - Sink type used in the selective withdrawal algorithm, LINE or POINT, structure 2		
SINKC3 - Sink type used in the selective withdrawal algorithm, LINE or POINT, structure 3		
SINKC4 - Sink type used in the selective withdrawal algorithm, LINE or POINT, structure 4		
SINKC5 - Sink type used in the selective withdrawal algorithm, LINE or POINT, structure 5		
ESTR1-Centerline elevation of structure 1, m	115	
ESTR2-Centerline elevation of structure 2, m		
ESTR3-Centerline elevation of structure 3, m		
ESTR4-Centerline elevation of structure 4, m		
ESTR5-Centerline elevation of structure 5, m		
WSTR1 - Structure 1 width if "LINE" chosen, Width of structure (line sink), m	0	

OUTPUT CONTROL

CONTROL FILE

WSTR2- Structure 2 width if "LINE" chosen, Width of structure (line sink), m		
WSTR3- Structure 3 width if "LINE" chosen, Width of structure (line sink), m		
WSTR4- Structure 4 width if "LINE" chosen, Width of structure (line sink), m		
WSTR5- Structure 5 width if "LINE" chosen, Width of structure (line sink), m		

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Number of Structures](#)

[Sink Type](#)

[Structure Elevation](#)

[Structure Interpolation](#)

[Structure Top Selective Withdrawal Limit](#)

[Structure Bottom Selective Withdrawal Limit](#)

[Outflow file](#)

Pipes (PIPES)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	IUPI	Integer		Pipe upstream segment number
3	IDPI	Integer		Pipe downstream segment number
4	EUPI	Real		Upstream invert elevation, <i>m</i>
5	EDPI	Real		Downstream invert elevation, <i>m</i>
6	WPI	Real		Pipe diameter, <i>m</i>
7	DLXPI	Real		Pipe length, <i>m</i>
8	FPI	Real		Bottom roughness (Mannings' friction)
9	FMINPI	Real		Minor friction losses
10	LATPIC	Character		Downstream or lateral pipe withdrawal, DOWN or LAT
11	DYNPIPE	Character		Either ON or OFF. This turns OFF or ON the dynamic pipe switch

This card specifies the characteristics for each pipe included in the simulation. [IUSPI] and [IDPI] specify the upstream segment location and downstream segment location of the pipe, respectively. The user must also set an upstream [EUPI] and downstream [EDPI] invert elevation, diameter [WPI], and length [DLXPI] for each pipe. [FPI] sets the bottom roughness value (using a Manning's friction factor) and [FMINPI] specifies the minor friction losses.

Setting the pipe location [LATPIC] to DOWN specifies that the pipe is at the downstream end of the segment. In this case the water surface elevations are computed based on the right-hand side water surface elevation of the segment. The elevation of the right-hand side of the segment is estimated using the water surface slope of segment IUPI and IUPI-1. Also, momentum from the outflow is preserved as in a downstream structure withdrawal. If the pipe location [LATPIC] is set to LAT, it is assumed that the outflow is treated as a lateral withdrawal at the segment center elevation. In both cases selective withdrawal is used in the computations.

Note that for a downstream segment that is at the upstream end of a branch, this inflow is treated as an inflow. If it is input to a downstream segment that is not the upstream end, it is treated as a tributary inflow.

Figure 12 and Figure 13 show the layout of pipes set as a downstream [DOWN] and a lateral [LAT] withdrawal from the upstream segment, respectively.

When the **DYNPIPE** switch is ON, the CE-QUAL-W2 model reads a file called, **dynpipe.npt**. This file is in the same format as a time series file (see section on input files) with a time series of Julian day and a number usually from 0 to 1. The number is then multiplied by the flow rate computed for the pipe and has the effect of turning the pipe ON or OFF or reducing the flow for given periods of time. This input is treated as a step function, i.e., no linear interpolation between successive values. In many cases a gate valve is restricted to reduce the flow through the pipe over a certain time of year and later opened.

OUTPUT CONTROL

CONTROL FILE

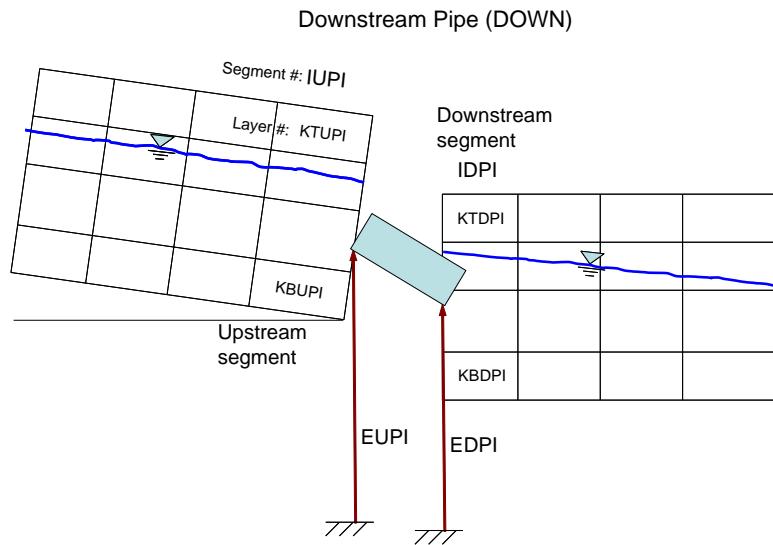


Figure 12 Downstream pipe DOWN designation.

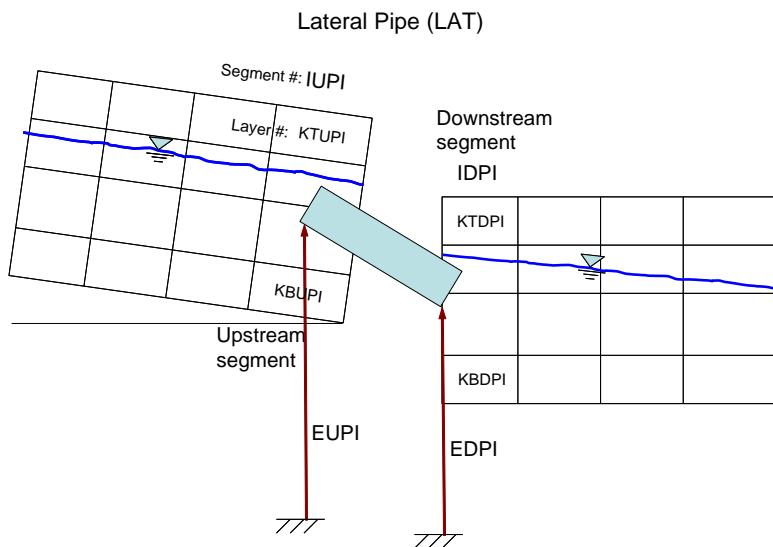


Figure 13. Lateral pipe LAT designation.

Example

PIPE	IUPI	IDPI	EUPI	EDPI	WPI	DLXPI	FPI	FMINPI	LATPIC	DYNPIPE
Pi 1	24	28	28.0	27.0	0.5	230.0	0.065	0.10	DOWN	ON

[For the Excel version see the next section.]

Related Cards and Files:

[Inflow/Outflow Dimensions](#)

[Upstream Pipe](#)

[Downstream Pipe](#)

Upstream Pipe (PIPE UP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PUPIC	Character	DISTR	Specifies how inflows enter into the upstream pipe segment, DISTR, DENSITY, or SPECIFY
3	ETUPI	Real		Top elevation pipe inflows enter when using SPECIFY option, <i>m</i>
4	EBUPI	Real		Bottom elevation pipe inflows enter when using SPECIFY option, <i>m</i>
5	KTUPI	Integer		Top layer above which selective withdrawal will not occur
6	KBUPI	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the upstream pipe location are handled. Setting [PUPIC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETUPI] and [EBUPI] are used to specify the top and bottom elevations that the inflows are distributed over.

[KTUPI] and [KBUPI] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
PIPE UP      PUPIC    ETUPI     EBUPI     KTUPI     KBUPI
Pi 1        DISTR          2         19
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Pipes](#)

[Downstream Pipe](#)

Downstream Pipe (PIPE DOWN)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PDPIC	Character	DISTR	How inflows enter into the downstream pipe segment, DISTR, DENSITY, or SPECIFY
3	ETDPI	Real		Top elevation pipe inflows enter using SPECIFY option, m
4	EBDPI	Real		Bottom elevation pipe inflows enter using SPECIFY option, m
5	KTDPI	Integer		Top layer above which selective withdrawal will not occur
6	KBDPI	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the downstream pipe location are handled. Setting [PDPIC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETDPI] and [EBDPI] are used to specify the top and bottom elevations that the inflows are distributed over.

[KTDPI] and [KBDPI] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
PIPE DOWN PDPIC ETDPI EBDPI KTDPI KBDPI
Pi 1      DISTR          2      23
```

PIPES	PIPE1	PIPE2
IUPI - Upstream segment number	24	
IDPI - Downstream segment number	28	
EUPI - Elevation upstream invert, m	28.1	
EDPI - Elevation downstream invert, m	27.2	
WPI - Pipe diameter, m	0.5	
DLXPI - Pipe length, m	52.5	
FPI - friction factor (Mannings)	0.035	
FMINPI - minor losses friction factor (Mannings)	0.065	
WTHLC - DOWN or LAT, withdrawal control for at end of segment or middle	LAT	
DYNPIPE - Dynamic pipe read input file, ON or OFF	OFF	
PUPIC - PipeUp inflow: DISTR, SPECIFY, DENSITY	DISTR	
ETUPI - PipeUp Elevation top in m if SPECIFY		
EBUPI - PipeUp Elevation bottom in m if SPECIFY		
KTUPI - PipeUp Selective withdrawal top layer, Top layer above which selective withdrawal will not occur	2	
KBUPI - PipeUp Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	19	
PDPIC - PipeDown inflow: DISTR, SPECIFY, DENSITY	DISTR	

CONTROL FILE

OUTPUT CONTROL

ETDPI - PipeDown Elevation top in m if SPECIFY		
EBDPI - PipeDown Elevation bottom in m if SPECIFY		
KTDPI- PipeDown Selective withdrawal top layer, Top layer above which selective withdrawal will not occur	2	
KBDPI- PipeDown Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	23	

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Pipes](#)

[Upstream Pipe](#)

Spillways (SPILLWAYS)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	IUSP	Integer		Spillway segment location
3	IDSP	Integer		Downstream segment spillway outflow enters
4	ESP	Real		Spillway elevation, m
5	A1SP	Real		α_1 , empirical coefficient for free-flowing conditions
6	B1SP	Real		β_1 , empirical coefficient for free-flowing conditions
7	A2SP	Real		α_2 , empirical coefficient for submerged conditions
8	B2SP	Real		β_2 , empirical coefficient for submerged conditions
9	LATSPC	Character		Downstream or lateral withdrawal, DOWN or LAT

This card specifies the spillway (or weir) characteristics. [IUSP] and [IDSP] specify the upstream and downstream segments for the spillway. Setting [IDSP] to 0 allows the user to spill water and have that water lost from the system. The model requires the user to specify a head (h , m) versus flow (Q , m^3/s) relationship in the following form for freely flowing conditions: $Q = \alpha_1 \Delta h^{\beta_1}$

where α_1 =empirical parameter, β_1 =empirical parameter, $\Delta h = Z_u - Z_{sp}$, m, Z_u =upstream head, m, Z_{sp} =the spillway crest elevation, m.

And for submerged conditions: $Q = \alpha_2 \Delta h^{\beta_2}$

where α_2 =empirical parameter, β_2 =empirical parameter, $\Delta h = Z_u - Z_d$, m, Z_u =upstream head, m, Z_d =downstream head, m.

Submerged conditions are defined when the tailwater depth over the upstream energy head (static head and velocity head) is greater than 0.67. Even though negative flow rates are possible using the second equation when the downstream head is greater than the upstream head, these results should be used with caution since rarely are rating curves done for reverse flow. The user should ensure a smooth transition between submerged and free flowing conditions by proper choice of model coefficients. See the User Manual Part 2 for further information since the A2SP coefficients may be about 5 times larger than the A1SP coefficients if the B1Sp and B2Sp coefficients are unchanged.

Setting the spillway location [LATSPC] to DOWN specifies that the spillway is at the downstream end of the segment. In this case the water surface elevations are computed based on the right hand side of segment IUSP. This water surface elevation is estimated based on the slope of the water surface at IUSP and IUSP-1. Also, momentum from the outflow is preserved as in a downstream structure withdrawal. If the spillway location [LATPIC] is set to LAT, it is assumed that the outflow is treated as a lateral withdrawal at the segment center elevation. In both cases selective withdrawal is used in the computations.

Figure 14 and Figure 15 show the layout of spillways set as a downstream [DOWN] and a lateral [LAT] withdrawal from the upstream segment, respectively.

CONTROL FILE

OUTPUT CONTROL

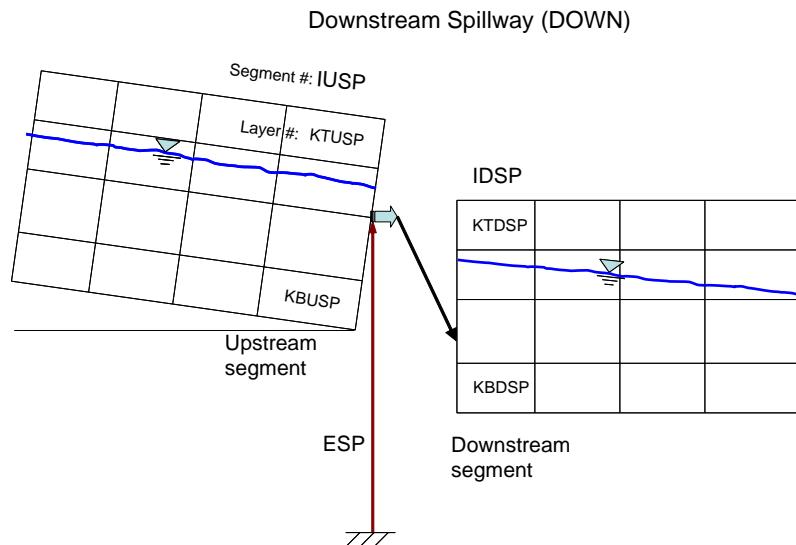


Figure 14. Downstream spillway DOWN designation.
Lateral Spillway (LAT)

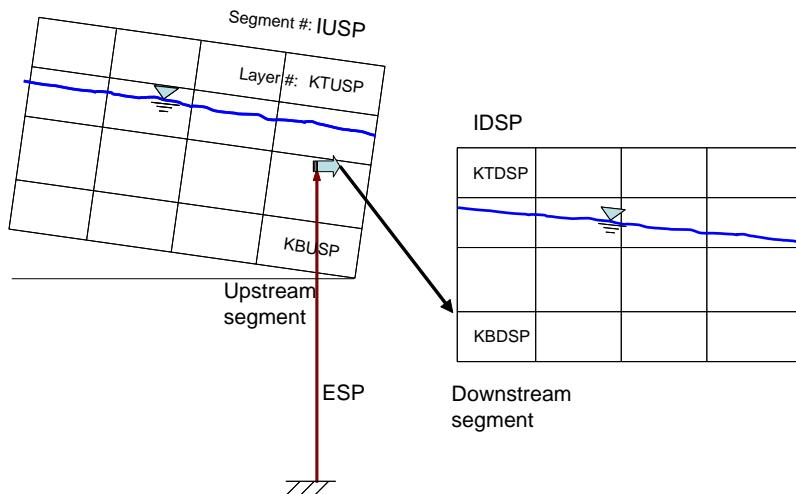


Figure 15. Lateral spillway LAT designation.

Example

SPILLWAYS	IUSP	IDSP	ESP	A1SP	B1SP	A2SP	B2SP	LATSPC
Sp 1	30	33	45.5	45.33	1.5	34.45	1.0	DOWN
Sp 2	28	33	40.0	10.00	1.5	20.00	1.0	LAT

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Upstream Spillways](#)

[Downstream Spillways](#)

[Spillway Dissolved Gas](#)

Upstream Spillways (SPILL UP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PUSPC	Character	DISTR	How inflows enter into the upstream spillway segment, DISTR, DENSITY, or SPECIFY
3	ETUSP	Real		Top elevation spillway inflows enter using SPECIFY option, m
4	EBUSP	Real		Bottom elevation spillway inflows enter using SPECIFY option, m
5	KTUSP	Integer		Top layer above which selective withdrawal will not occur
6	KBUSP	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the upstream spillway location are handled. Setting [PUSPC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETUSP] and [EBUSP] are used to specify the top and bottom elevations over which the inflows are distributed.

[KTUSP] and [KBUSP] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
SPILL UP  PUSPC  ETUSP  EBUSP  KTUSP  KBUSP
Sp 1      DISTR          2      23
Sp 2      DISTR          2      23
```

[For the Excel version see the next section.]

Related Cards and Files

[Spillways](#)
[Downstream Spillways](#)
[Spillway Dissolved Gas](#)

Downstream Spillways (SPILL DOWN)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PDSPC	Character	DISTR	How inflows enter into the downstream spillway segment, DISTR, DENSITY, or SPECIFY
3	ETDSP	Real		Top elevation spillway inflows enter using SPECIFY option, m
3	EBDSP	Real		Bottom elevation spillway inflows enter using SPECIFY option, m
5	KTDSP	Integer		Top layer above which selective withdrawal will not occur
5	KBDSP	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the downstream spillway location are handled. Setting [PDSPC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETDSP] and [EBDSP] are used to specify the top and bottom elevations over which the inflows are distributed.

[KTDSP] and [KBDSP] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
SPILL DOWN PDSPC    ETDSP     EBUSP      KTDSP      KBDSP
Sp 1          DISTR           2        23
Sp 2          DISTR           2        23
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Spillways](#)
[Upstream Spillways](#)
[Spillway Dissolved Gas](#)

Spillway Dissolved Gas (SPILL GAS)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	GASSPC	Character	OFF	Dissolved gas computations, ON or OFF
3	EQSP	Integer		Equation number for computing dissolved gas
3	ASP	Real		a coefficient in dissolved gas equation
5	BSP	Real		b coefficient in dissolved gas equation
5	CSP	Real		c coefficient in dissolved gas equation

This card turns ON/OFF spillway gas computations [**GASSPC**] and specifies the parameters that define the dissolved gas relationship. If dissolved gas computations are turned ON, then an equation number must be supplied (1 to 3). Based on the equation number, two or three coefficients are required. These coefficients are *a*, *b*, and *c* as shown in [Table 2](#). Note that if [**IDSP**] is 0, even if [**GASSPC**] is ON, the model will not compute any effects of gas transfer since the water exiting the spillway or weir is not accounted for in the system. This algorithm computes gas effects for flow from upstream to downstream and there is no adjustment of dissolved oxygen for reverse flow.

The Corps of Engineers has been involved in gas abatement studies on the Columbia and Snake River system for many years (WES, 1996, 1997). Some of their research efforts have been focused on development of models of spillway gas generations. These empirical models have been called CriSP 1.6 (Columbia Basin Research, 2000). The gas production equations used in CriSP are empirical correlations between total dissolved gas (TDG), usually measured a mile downstream of the dam after turbulence from the spillway had subsided, and discharge, usually measured in kcfs. The form of these equations is shown in [Table 2](#).

Table 2. Equations used in CRiSP model for gas production

Equation type	Equation	Coefficient description
Linear function of total spill	$\%TDG = mQ_s + b$	$\%TDG$ = % total dissolved gas saturation Q_s = total spill, kcfs m = empirical coefficient b = empirical coefficient
Bounded exponential of total spill	$\%TDG = a + b^{cQ_s}$	Q_s = total spill, kcfs a = empirical coefficient b = empirical coefficient c = empirical coefficient
Bounded exponential of the spill on a per spillway basis	$\%TDG = a + b^{cq_s}$	q_s = individual spillway spill, kcfs a = empirical coefficient b = empirical coefficient c = empirical coefficient

Examples of some of these correlations are shown in [Table 3](#). In many cases the $\%TDG$ in these correlations was constrained to a maximum of 145% and when the flow reached only a few kcfs, there was assumed to be no change in TDG from the forebay to the tailrace. Also, the correlations in [Table 2](#) sometimes changed from year to year based on changes in operating conditions or structural changes in the spillway or deflectors.

CONTROL FILE

OUTPUT CONTROL

Table 3. Equations used in CRISP model for gas production at Columbia basin dams

Dam	Equation	Coefficients
Bonneville	$\%TDG = mQ_s + b$	$m = 0.12$ $b = 105.61$
Lower Granite	$\%TDG = a + b^{cQ_s}$	$a = 138.0$ $b = -35.8$ $c = -0.10$
Dworshak	$\%TDG = a + b^{cQ_s}$	$a = 135.9$ $b = -71.1$ $c = -0.4787$
Ice Harbor	$\%TDG = a + b^{cQ_s}$	$a = 136.8; b = -42.0; c = -0.0340 - 1995$ $a = 138.7; b = -79.0; c = -0.0591 - 1996$ $a = 130.9; b = -26.5; c = -0.0220 - 1997$ $a = 120.9; b = -20.5; c = -0.0230 - 1998$
Hell's Canyon	$\%TDG = a + b^{cQ_s}$	$a = 138$ $b = -36$ $c = -0.02$ [Assumed relationship - no data]

For each spillway, the user now has a choice of equations to use for computing the effects of each hydraulic structure on downstream dissolved oxygen. The equations chosen are shown in [Table 4](#). These equations are based on equations from [Table 2](#) and [Table 3](#).

Table 4. Reaeration Effects of Spillways, Weirs, and Gates

Equation #, EQSP	Equation	Coefficient description
1. Linear function of spill on a per spillway basis; 2 empirical coefficients a and b	$\%TDG = aq_s + b$ Once TDG is known below the spillway, the dissolved oxygen concentration, C_{O_2} , is determined from $C_{O_2} = \%TDG * C_{so_2}$	$\%TDG = \text{ % total dissolved gas saturation}$ $q_s = \text{ individual spillway spill, } kcfs$ $a = \text{ empirical coefficient}$ $b = \text{ empirical coefficient}$ $C_{so_2} = \text{ dissolved oxygen saturation, } g m^{-3}$
2. Bounded exponential of the spill on a per spillway basis; 3 empirical coefficients a , b , and c	$\%TDG = a + be^{cQ_s}$ Once TDG is known below the spillway, the dissolved oxygen concentration, C_{O_2} , is determined from $C_{O_2} = \%TDG * C_{so_2}$	$q_s = \text{ individual spillway spill, } kcfs$ $a = \text{ empirical coefficient}$ $b = \text{ empirical coefficient}$ $c = \text{ empirical coefficient}$ $C_{so_2} = \text{ dissolved oxygen saturation, } g m^{-3}$
3. Reaeration effect for a small height weir or dam (<10 m); 3 empirical coefficients a , b , and c (Butts and Evans, 1983)	D_a D_b $= 1 + 0.38ab(1 - 0.11c)$ $(1 + 0.046T)c$ C_{O_2} below the dam is computed from: $C_{O_2} = C_{so_2} - D_b$	$D_a = \text{ DO deficit above dam, } g m^{-3}$ $D_b = \text{ DO deficit below dam, } g m^{-3}$ $T = \text{ temperature, } ^\circ C$ $a = 1.8 \text{ for clean water to } 0.65 \text{ for gross polluted water}$ $b = 0.05 \text{ for sluice gates}$ $b = 1.0 \text{ for sharp crested straight-faced weir}$ $b = 0.45 \text{ for flat broad crested curved face weir}$ $b = 0.7 \text{ for flat broad crested weir with regular step}$ $b = 0.8 \text{ for sharp crested vertical face weir}$ $b = 0.6 \text{ for flat broad crested weir vertical face}$ $c = \text{ water fall height, } m$ $C_{so_2} = \text{ dissolved oxygen saturation, } g m^{-3}$

OUTPUT CONTROL

CONTROL FILE

Equation #, EQSP	Equation	Coefficient description
4. Reaeration is increased by a fraction of the input dissolved oxygen. In many cases dams have turbine venting or other processes that introduce air into the turbine discharge. The model user can specify when this occurs by submitting a time series file of fractions that are multiplied by the incoming dissolved oxygen concentrations.	$C_{O_2} \text{ below the dam} = FRAC * C_{\text{into turbine } O_2}$	<p><i>FRAC = fraction of incoming dissolved oxygen,</i> $C_{\text{into turbine } O_2}$=dissolved oxygen concentration coming into the turbine, g m^{-3} <i>a=FRAC (if static)</i> <i>b=0 no input file, a=FRAC is applied at all times</i> <i>b=1 input time series file for FRAC values over time:</i> $w2_spX_DO.csv$ (where X is the spillway number, see file description at Dissolved Gas Added to Turbine Input File) <i>c=0 (no limit on saturation)</i> <i>c=1 (saturation limited to 100%)</i></p>

Note that for equations 1 and 2, the maximum *TDG* allowed is 145%, and if *TDG* is computed to be less than 100%, there is no effect of the spillway or gate on reaeration.

Example

```

SPILL GAS GASSPC      EQSP      ASP      BSP      CSP
Sp 1          ON       2     110.0    -0.1    -0.1
Sp 2          ON       1      10.0     110.0   10.0
  
```

SPILLWAYS	SP1	SP2
IUSP- Upstream segment number, spillway segment location	30	
IDSP- Downstream segment number, Downstream segment spillway outflow enters	33	
ESP - spillway elevation (crest), m	125.75	
A1SP- α_1 , empirical coefficient for free-flowing conditions	45.25	
B1SP- β_1 , empirical coefficient for free-flowing conditions	1.5	
A2SP- α_2 , empirical coefficient for submerged conditions	150.25	
B2SP- β_2 , empirical coefficient for submerged conditions	1.5	
LATSPC-Downstream or lateral withdrawal, DOWN or LAT	LAT	
PUSPC-How inflows enter into the upstream spillway segment, DISTR, DENSITY, or SPECIFY	DISTR	
ETUSP-Top elevation spillway inflows enter using SPECIFY option, m		
EBUSP-Bottom elevation spillway inflows enter using SPECIFY option, m		
KTUSP-Top layer above which selective withdrawal will not occur	2	
KBUSP-Spillway Up Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	15	
PDSPC-How inflows enter into the downstream spillway segment, DISTR, DENSITY, or SPECIFY	DISTR	
ETUSP-Top elevation spillway inflows enter using SPECIFY option m		
EBUSP-Bottom elevation spillway inflows enter using SPECIFY option, m		
KTDSP-Top layer above which selective withdrawal will not occur	2	
KBDSP-Spillway Down Selective withdrawal bottom layer bottom layer below which selective withdrawal will not occur	32	
GASSPC Dissolved gas computations ON or OFF	ON	
EQSP Equation number for computing dissolved gas	2	
AGASSP a empirical coefficient	110.4	
BGASSP b empirical coefficient	-0.12	
CGASSP c empirical coefficient	-0.11	

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Spillways](#) [Upstream Spillways](#) [Downstream Spillways](#) [Spillway Dissolved Gas](#)

Gates (GATES)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	IUGT	Integer		Gate segment location
3	IDGT	Integer		Downstream segment gate outflow enters
4	EGT	Real		Gate elevation, m
5	A1GT	Real		α_1 coefficient in gate equation for free flowing conditions
6	B1GT	Real		β_1 coefficient in gate equation for free flowing conditions
7	G1GT	Real		γ_1 coefficient in gate equation for free flowing conditions
8	A2GT	Real		α_2 coefficient in gate equation for submerged conditions
9	B2GT	Real		β_2 coefficient in gate equation for submerged conditions
10	G2GT	Real		γ_2 coefficient in gate equation for submerged conditions
11	LATGTC	Character		Downstream or lateral withdrawal, DOWN or LAT

This card specifies the gate characteristics. [IUGT] and [IDGT] specify the upstream and downstream segments for the spillway. Setting the downstream spillway segment [IDSP] to 0 allows the user to spill water that is lost from the system. The following equation for the flow rate (Q , m^3/s) is used for freely flowing conditions:

$$Q = \alpha_1 \Delta h^{\beta_1} B^{\gamma_1}$$

where:

β_1 = empirical coefficient

γ_1 = empirical coefficient

$\Delta h = Z_u - Z_{sp}$, m

Z_u = upstream head, m

Z_{sp} = spillway crest elevation, m

B = gate opening, m

and the following equation is used for submerged flow: $Q = \alpha_2 \Delta h^{\beta_2} B^{\gamma_2}$

where

α_2 = empirical coefficient

β_2 = empirical coefficient

γ_2 = empirical coefficient

$\Delta h = Z_u - Z_d$, m

Z_d = downstream head, m

B = gate opening, m

In defining these parameters, the model user also has to generate a time series file of the gate openings [\[GATEFN\]](#). Whenever the gate opening, B , is equal to or greater than $0.8(Z_u - Z_{sp})$, a weir equation is used with no functional dependency on the gate width. In this case, the user must also supply a rating curve when the gate acts like a weir.

If a valve-rating curve is used as a “gate” and the outlet elevation to compute the head difference is not the same as the withdrawal elevation, the following changes need to be included in the input variables:

1. [EGT] is interpreted as the outlet level for the water being withdrawn
2. [A2GT] must be set to zero (no reverse flow equation is used)
3. [G2GT] is interpreted as the elevation used to compute the head on the outlet valve - whenever [A2GT] is set to zero and [G2GT] is non-zero, [G2GT] will be used to compute the head difference between the water level and the outlet rather than [EGT], but [EGT] will still determine the location of the withdrawal.

In some reservoirs, an outlet valve is connected to the reservoir and a head-discharge relationship is used based on the gate opening or number of turns of the gate. In this case, the outlet level is usually at a different elevation than the withdrawal elevation. The gate formulation can still be used if there is no reverse flow through the needle valve.

Setting the gate location [**LATGTC**] to DOWN specifies that the gate is located at the downstream end of the segment. In this case the water surface elevations are computed based on the right hand side of segment IUGT. This water surface elevation is estimated based on the slope of the water surface at IUGT and IUGT-1. Also, momentum from the outflow is preserved as in a downstream structure withdrawal. If [**LATGTC**] is set to LAT, it is assumed that the outflow is treated as a lateral withdrawal at the segment center elevation. In both cases selective withdrawal is used in the computations.

Figure 16 and Figure 17 show the layout of gates set as a downstream [DOWN] and a lateral [LAT] withdrawal from the upstream segment, respectively.

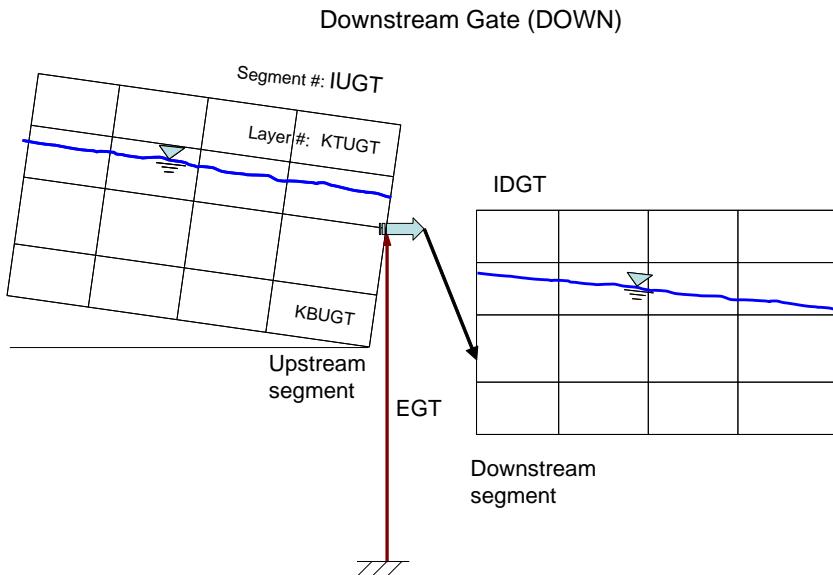


Figure 16. Downstream gate DOWN designation.

CONTROL FILE

OUTPUT CONTROL

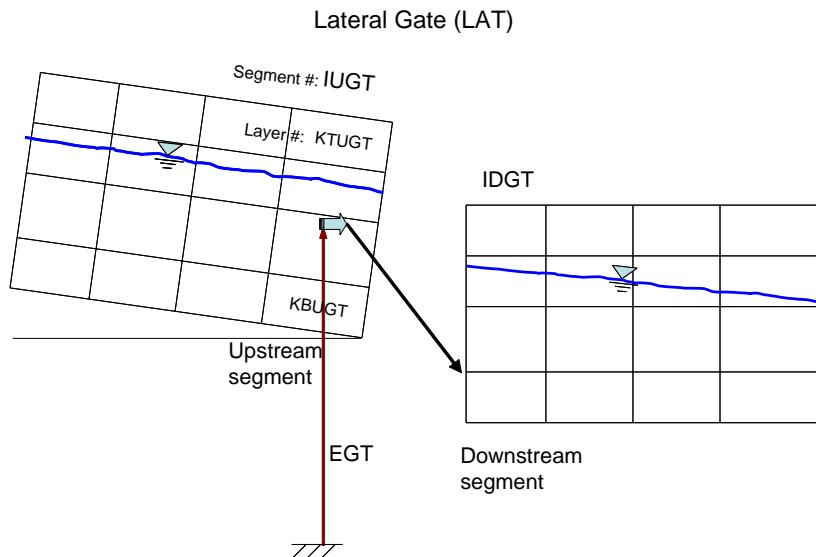


Figure 17. Lateral gate LAT designation.

Example

GATES	IUGT	IDGT	EGT	A1GT	B1GT	G1GT	A2GT	B2GT	G2GT	LATGTC
Gt 1	27	33	44.0	10.00	1.00	1.00	10.0	2.50	0.00	DOWN

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Gate Weir](#)

[Upstream Gate](#)

[Downstream Gate](#)

[Gate Dissolved Gas](#)

[Gate Filename](#)

[Gate Input File](#)

Gate Weir (GATE WEIR)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	GA1	Real	α_1 in gate equation for free flowing conditions
3	GB1	Real	β_1 in gate equation for free flowing conditions
4	GA2	Real	α_2 in gate equation for submerged conditions
5	GB2	Real	β_2 in gate equation for submerged conditions
6	DYNGTC	Character	Either 'B', 'ZGT', 'FLOW', or 'FLOW_ZGT'
7	GTIC	Character	Gate interpolation either 'ON' or 'OFF'

This card specifies the weir coefficients used when the gates are open and the open gate does not interfere with the flow (the gate opening, $B \geq 0.8\Delta h$). For [GA1] equal to zero, only the gated equations on the preceding card are used. For [GA2] equal to zero, only the freely flowing equation will be used even if submerged or reverse flow occurs.

The model requires the user to specify a head (h , m) versus flow (Q , m^3/s) relationship in the following form for freely flowing conditions:

$$Q = \alpha_1 \Delta h^{\beta_1}$$

where:

α_1 = empirical parameter [GA1]

β_1 = empirical parameter [GB1]

$\Delta h = Z_u - Z_{sp}$, m

Z_u = upstream head, m

Z_{sp} = the spillway crest elevation, m

And for submerged conditions:

$$Q = \alpha_2 \Delta h^{\beta_2}$$

where:

α_2 = empirical parameter [GA2]

β_2 = empirical parameter [GB2]

$\Delta h = Z_u - Z_d$, m

Z_u = upstream head, m

Z_d = downstream head, m

Submerged conditions are defined when the tailwater depth over the upstream energy head (static head and velocity head) is greater than 0.67. Even though negative flow rates are possible using the second equation when the downstream head is greater than the upstream head, these results should be used with caution since rarely are rating curves done for reverse flow. The user should ensure a smooth transition between submerged and free flowing conditions by proper choice of model coefficients. See [Appendix A](#) for further information.

[DYNGTC] is used to determine whether the gate inflow file represents dynamic gate opening heights (in that case, [DYNGTC] is set to "B"), dynamic weir crest elevations ([DYNGTC] is set to "ZGT"), known dynamic flow rates ([DYNGTC] is set to "FLOW"), or both dynamic flow and dynamic weir crest elevations defining the centerline of the flow out the gate ([DYNGTC] is set to "FLOW_ZGT"). Using the dynamic gate opening

CONTROL FILE

OUTPUT CONTROL

results in use of the rating curves for gates as already described. Using the dynamic weir crest setting uses the rating curve for gates, but **G1GT** and **G2GT** are set equal to 0 – effectively changing the rating curve to the same one as for a spillway or weir. In this case though the inflow file is used to change the crest elevation. Using the flow rate setting allows the user to ignore all the rating curves (A1GT, B1GT, G1GT, A2GT, B2GT, G2GT, GA1, GB1, GA2, GB2 are ignored). In this case dynamic flow rates are in the gate file and are used to move flow around the domain. For a pumped-storage project for example, the user can include one “gate” for flow out of Reservoir 1 to Reservoir 2 and another “gate” for flow from Reservoir 2 to Reservoir 1 (see descriptions of the GATE file).

With **DYNGTC=“ZGT”**, the model user can withdraw water using the dynamic weir crest (and weir rating curve) at the elevation of the dynamic weir crest or the user can withdraw water using the dynamic weir crest as before but specify a fixed elevation where that water is withdrawn. A description of this feature is shown in the GATE file description. With **DYNGTC=“FLOW_ZGT”**, it combines the “FLOW” and “ZGT” settings allowing the model user to specify flow and a dynamic centerline of withdrawal (similar to DYNSELEV for a structure). A description of the files for a gate are shown in the GATE file description.

The gate file (QGT) is defined in the section on file names. When **[DYNGTC]=“FLOW_ZGT”** the gate file is the dynamic flow rate, and there is another file for the dynamic centerline elevation called **“dynselevGT.npt”**. This file is the same format as the dynamic elevation for structural outflows. This input file is described in the section on the gate elevation file.

[GTIC] determines if the **[DYNGTC]** variable is to be interpolated or treated as a step function input. When **[GTIC]** is ‘ON’, then interpolation of the **[DYNGTC]** variable is ON and linear interpolation is used between data points in the input GATE file.

Example

GATE WEIR	GA1	GB1	GA2	GB2	DYNGTC	GTIC
Gt 1	10.0	1.5	10.0	1.5	B	ON

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Gates](#)

[Upstream Gate](#)

[Downstream Gate](#)

[Gate Dissolved Gas](#)

[Gate Filename](#)

[Gate Input File](#)

Upstream Gate (GATE UP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PUGTC	Character	DISTR	Specifies how inflows enter the upstream gate segment, DISTR, DENSITY, or SPECIFY
3	ETUGT	Real		Top elevation gate inflows enter using the SPECIFY option, m
4	EBUGT	Real		Bottom elevation gate inflows using the SPECIFY option, m
5	KTUGT	Integer		Top layer above which selective withdrawal will not occur
6	KBUGT	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the upstream gate location are handled. Setting [PUGTC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [KTUGT] and [KBUGT] are used to specify the top and bottom elevations over which the inflows are distributed.

[KTUGT] and [KBUGT] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
GATE UP      PUGTC      ETUGT      EBUGT      KTUGT      KBUGT
Gt 1        DISTR       2          23
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Gates](#)
[Gate Weir](#)
[Downstream Gate](#)
[Gate Dissolved Gas](#)
[Gate Filename](#)

Downstream Gate (GATE DOWN)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PDGTC	Character	DISTR	Specifies how inflows enter the downstream gate segment, DISTR, DENSITY, or SPECIFY
3	ETDGT	Real		Top elevation gate inflows enter using the SPECIFY option, m
4	EBDGT	Real		Bottom elevation gate inflows enter using the SPECIFY option, m
5	KTDGT	Integer		Top layer above which selective withdrawal will not occur
6	KBDGT	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the downstream gate location are handled. Setting [PDGTC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETDGT] and [EBDGT] are used to specify the top and bottom elevations over which the inflows are distributed.

[KTDGT] and [KBDGT] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm.

Example

```
GATE DOWN PDGTC ETDGT EBDGT KTDGT KBDGT
Gt 1      DISTR          2      23
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Gates](#)
[Gate Weir](#)
[Upstream Gate](#)
[Gate Dissolved Gas](#)
[Gate Filename](#)

Gate Dissolved Gas (GATE GAS)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	GASGTC	Character	OFF	Dissolved gas computations, ON or OFF
3	EQGT	Integer		Equation number for computing dissolved gas
3	AGASGT	Real		a coefficient in dissolved gas equation
5	BGASGT	Real		b coefficient in dissolved gas equation
5	CGASGT	Real		c coefficient in dissolved gas equation

For each gate, the model user activates or deactivates the computation by selecting ON or OFF for [GASGTC]. If the user activates this computation by choosing ON, then an equation number must be supplied (1 to 3). Based on the equation number, two or three coefficients are required. These coefficients are a , b , and c as shown in [Table 5](#). Note that if [IDGT] is 0, even if [GASGTC] is ON, the model will not compute any effects of gas transfer since the water exiting the spillway or weir is not accounted for in the system. This algorithm only computes gas effects for upstream to downstream flow and there is no adjustment of dissolved oxygen for reverse flow.

The Corps of Engineers has been involved in Gas Abatement Studies on the Columbia and Snake River system for many years (WES, 1996, 1997). Some of their research efforts have been focused on development of models of gas generation from spillways. These empirical models have been called CriSP 1.6 (Columbia Basin Research, 2000). The gas production equations used in CriSP are empirical correlations between total dissolved gas (TDG), usually measured a mile downstream of the dam after turbulence from the spillway had subsided, and discharge, usually measured in kcfs. The form of these equations is shown in [Table 5](#).

Table 5. Equations used in CRiSP model for gas production

Equation type	Equation	Coefficient Description
Linear function of total spill	$\%TDG = mQ_s + b$	$\%TDG$ = % total dissolved gas saturation Q_s = total spill, kcfs m, b = empirical coefficients
Bounded exponential of total spill	$\%TDG = a + be^{cQ_s}$	Q_s = total spill, kcfs a, b, c = empirical coefficients
Bounded exponential of the spill on a per spillway basis	$\%TDG = a + be^{cq_s}$	q_s = spill through individual spillway, kcfs a, b, c = empirical coefficients

Examples of some of these correlations are shown in [Table 6](#). In many cases the $\%TDG$ in these correlations was constrained to a maximum of 145% and when the flow reached only a few thousand cfs, no change in TDG was assumed from the forebay to the tailrace. Also, the correlations in [Table 6](#) sometimes changed from year to year based on changes in operating conditions or structural changes in the spillway or deflectors.

Table 6. Equations used in CRiSP model for gas production at Columbia basin dams

Dam	Equation	Coefficients
Bonneville	$\%TDG = mQ_s + b$	$m = 0.12$ $b = 105.61$
Lower Granite	$\%TDG = a + be^{cQ_s}$	$a = 138.0$ $b = -35.8$ $c = -0.10$
Dworshak	$\%TDG = a + be^{cq_s}$	$a = 135.9$ $b = -71.1$

CONTROL FILE

OUTPUT CONTROL

Dam	Equation	Coefficients
		$c = -0.4787$
Ice Harbor	$\%TDG = a + be^{cq_s}$	$a = 136.8; b = -42.0; c = -0.0340$ 1995; $a = 138.7; b = -79.0; c = -0.0591$ 1996; $a = 130.9; b = -26.5; c = -0.0220$ 1997; $a = 120.9; b = -20.5; c = -0.0230$ 1998
Hell's Canyon	$\%TDG = a + be^{cq_s}$	$a = 138; b = -36; c = -0.02$ [Assumed relationship - no data]

For each gate, the user now has the choice of equation to use for computing the effects of each hydraulic structure on downstream dissolved oxygen. The equations chosen are shown in [Table 7](#). These equations are based on equations from [Table 5](#) and [Table 6](#).

Table 7. Reaeration effects of gates

#, EQGT	Equation	Empirical Coefficient Description
1. Linear function of spill on a per spillway basis; 2 empirical coefficients: a and b	$\%TDG = aq_s + b$ Once $\%TDG$ is known below the spillway, the dissolved oxygen concentration, C_{O_2} , is determined from $C_{O_2} = \%TDG * C_{SO_2}$	$\%TDG$ = total dissolved gas saturation, % q_s = spill through an individual spillway, kcfs a = empirical coefficient b = empirical coefficient C_{SO_2} = dissolved oxygen saturation, g m ⁻³
2. Bounded exponential of the spill on a per spillway basis; 3 empirical coefficients: a, b, c	$\%TDG = a + be^{cq_s}$ Once $\%TDG$ is known below the spillway, the dissolved oxygen concentration, C_{O_2} , is determined from $C_{O_2} = \%TDG * C_{SO_2}$	q_s = spill through an individual spillway, kcfs a = empirical coefficient b = empirical coefficient c = empirical coefficient C_{SO_2} = dissolved oxygen saturation g m ⁻³
3. Reaeration effect for a small height weir or dam (<10 m); 3 empirical coefficients: a, b, c (Butts and Evans, 1983)	$\frac{D_a}{D_b} = 1 + 0.38ab(1 - 0.11c)$ $(1 + 0.046T)c$ C_{O_2} below the dam is computed from: $C_{O_2} = C_{SO_2} - D_b$	D_a = DO deficit above dam, g m ⁻³ D_b = DO deficit below dam, g m ⁻³ T = temperature, °C c = height of water fall, m a = 1.8 for clean water to 0.65 for gross polluted water b = 0.05 for sluice gates, 1.00 for sharp crested straight faced weir, 0.45 for flat broad crested curved face weir, 0.70 for flat broad crested weir with regular step, 0.8 for sharp crested vertical face weir, 0.60 for flat broad crested weir vertical face C_{SO_2} = dissolved oxygen saturation, g m ⁻³
4. Reaeration is increased by a fraction of the input dissolved oxygen. In many cases dams have turbine venting or other processes that introduce air into the turbine discharge. The model user can specify when this occurs by submitting a time series file of fractions that are multiplied by the incoming dissolved oxygen concentrations.	C_{O_2} below the dam is computed from: $C_{O_2} = FRAC * C_{into\ turbine\ O2}$	$FRAC$ = fraction of incoming dissolved oxygen, $C_{into\ turbine\ O2}$ = dissolved oxygen concentration coming into the turbine, g m ⁻³ $a=FRAC$ (if static) $b=0$ no input file, $a=FRAC$ is applied at all times $b=1$ input time series file for FRAC values over time: $w2_gtX_DO.csv$ (where X is the gate number, see file description at Dissolved Gas Added to Turbine Input File) $c=0$ (no limit on saturation) $c=1$ (saturation limited to 100%)

OUTPUT CONTROL

CONTROL FILE

Note that for equations 1 and 2, the maximum *TDG* allowed is 145%, and if *TDG* is computed to be less than 100%, there is no effect of the gate on reaeration.

Example

```
GATE GAS GASGTC   EQGT AGASGT BGASGT CGASGT
Gt 1      ON       1     10.0    120.0    1.0
```

GATES	GATE1	GATE2
IUGT- Upstream segment number	31	
IDGT- Downstream segment number	0	
EGT - Gate elevation m	120	
A1GT α_1 coefficient in gate equation for free-flowing conditions	5	
B1GT β_1 coefficient in gate equation for free-flowing conditions	1.5	
G1GT gamma1 coeff for free-flowing conditions	1	
A2GT α_2 coefficient in gate equation for submerged conditions	15	
B2GT β_2 coefficient in gate equation for submerged conditions	1.5	
G2GT gamma2 coeff for submerged conditions	1	
LATGTC downstream or lateral withdrawal LAT or DOWN	LAT	
GTA1 α_1 in gate equation for free-flowing conditions as a spillway	10	
GTB1 β_1 in gate equation for free-flowing conditions as a spillway	1.5	
GTA2 α_2 in gate equation for submerged conditions as a spillway	30	
GTB2 β_2 in gate equation for submerged conditions as a spillway	1.5	
DYNGTC Either 'B', 'ZGT', or 'FLOW'	FLOW	
GTIC Either ON or OFF interpolate gate file	ON	
PUGTC Specifies how inflows enter the upstream gate segment, DISTR, DENSITY, or SPECIFY	DISTR	
ETUGT Top elevation gate inflows enter using the SPECIFY option, m		
EBUGT Bottom elevation gate inflows using the SPECIFY option, m		
KTUGT Top layer above which selective withdrawal will not occur	2	
KBUGT-Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	30	
PDGTC Specifies how inflows enter the downstream gate segment, DISTR, DENSITY, or SPECIFY	DISTR	
ETDGT Top elevation gate inflows enter using the SPECIFY option, m		
EBDGT Bottom elevation gate inflows using the SPECIFY option, m		
KTDGT Top layer above which selective withdrawal will not occur	2	
KBDGT-Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	30	
GASGTC Dissolved gas computations ON or OFF	ON	
EQGT Equation number for computing dissolved gas	1	
AGASGT a empirical coefficient		
BGASGT b empirical coefficient		
CGASGT c empirical coefficient		

Related Cards and Files

[Inflow/Outflow Dimensions](#) [Gates](#) [Gate Weir](#)
[Upstream Gate](#) [Downstream Gate](#) [Gate Filename](#)

Pumps 1 (PUMPS 1)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	IUPU	Integer		Upstream segment number of pump where water is withdrawn
3	IDPU	Integer		Downstream segment number of pump where water enters (or negative downstream segment number)
4	EPU	Real		Elevation of pump, m
5	STRTPU	Real		Starting day of pumping, Julian day
6	ENDPU	Real		Ending day of pumping, Julian day
7	EONPU	Real		Pump starting elevation, m
8	EOFFPU	Real		Pump stopping elevations, m
9	QPU	Real		Pump flow rate, $m^3 sec^{-1}$
10	LATPUC	Character	DOWN	Downstream or lateral withdrawal, DOWN or LAT
11	DYNPUMP	Character	OFF	Dynamic pump control ON or OFF. This allows dynamic changes in pump characteristics over time if ON. An external time series file is read in by the program.

This card specifies the characteristics of the pumps in the system. [IUPU] and [IDPU] specify the segments from which water is withdrawn and added back to the system, respectively. If [IDPU] is zero, water is only withdrawn from the system. Note that [IDPU] can be specified as the negative of the downstream segment if the water level control for the pump is in [IDPU] rather than [IUPU]. The elevation of the pump [EPU] is used to specify the vertical location of the pump, the centerline of the output withdrawal. This withdrawal is in segment [IUPU]. The outflow of the pump uses the selective withdrawal algorithm to determine which vertical layers from which water is withdrawn. [STRTPU] and [ENDPU] specify the starting and ending times during which pumping occurs, [EONPU] and [EOFFPU] specify the elevations at which pumping is activated/deactivated, and [QPU] specifies the pumping rate.

Pumps can also be thought of as ‘water level control’ since the model user can use this to add a water level rule curve and have the model decide how much outflow is necessary to keep the water level within limits.

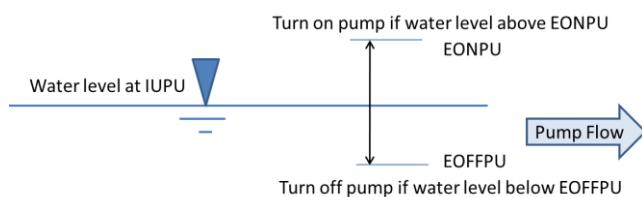


Figure 18. Definition of pump EOFPNU and EONPU if [IDPU] is positive.

Setting the pump location [LATPUC] to DOWN specifies that the pump is at the downstream end of the segment. In this case the water surface elevations are computed based on the right-hand side of segment

OUTPUT CONTROL

CONTROL FILE

[IUPU] This water surface elevation is estimated based on the slope of the water surface at [IUPU] and [IUPU]-1. Also, x-momentum from the outflow is preserved as in a downstream structure withdrawal. If [**LATPUC**] is set to **LAT**, it is assumed that the outflow is treated as a lateral withdrawal at the segment center elevation. In both cases selective withdrawal is used in the computations.

Figure 19 and Figure 20 show the layout of pumps set as a downstream [**DOWN**] and a lateral [**LAT**] withdrawal from the upstream segment, respectively.

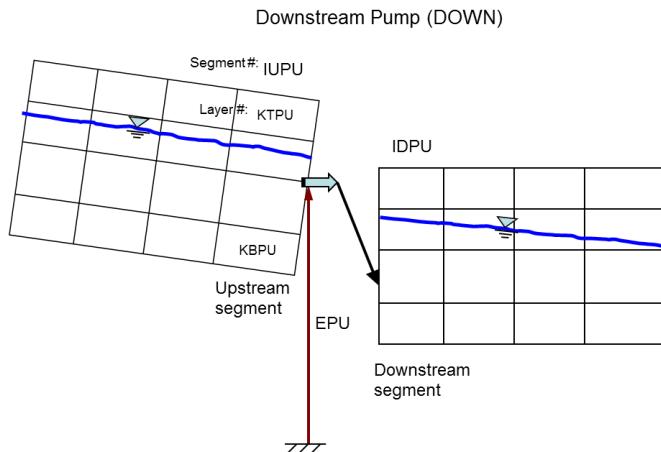


Figure 19. Downstream pump DOWN designation.

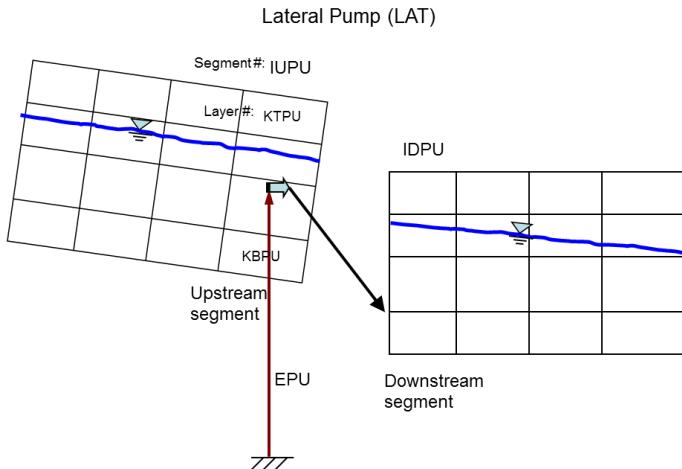


Figure 20. lateral pump LAT designation.

When the **DYNPUMP** control is ON, an input file is read that has the variables: **JDAY**, **EPU**, **EONPU**, and **EOFFPU** as a time series. The name of the file will be '**dynpumpX.npt**' where X is the Pump number. Hence, '**dynpump1.npt**' is expected if **DYNPUMP** is ON for Pump #1. An example file is shown in the section on INPUT files. When reading a **DYNPUMP** file, the values are treated as step functions, i.e., there is no interpolation between values. This allows the user to dynamically change the location of the outflow, or the elevation targets or the flow rate dynamically.

When [**IDPU**] is the negative of the downstream segment, then the water level of segment [**IDPU**] is used to determine the flow of the pump from segment [**IUPU**] to segment [**IDPU**] and the interpretation of **EONPU** and **EOFFPU** are changed.

CONTROL FILE

OUTPUT CONTROL

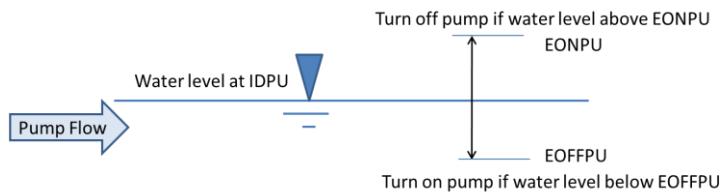


Figure 21. Definition of EOFFPU and EONPU when [IDPU] is negative.

Example

PUMPS 1	IUPU	IDPU	EPU	STRTPU	ENDPU	EONPU	EOFFPU	QPU	LATPUC	DYNPUMP
Pump1	34	57	465.430	290.	302.2	468.69	468.680	7.0	LAT	ON
Pump2	38	-60	465.125	2.5	356.1	460.00	458.000	1.0	DOWN	ON

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#) [Pumps 2](#)

Pumps 2 (PUMPS 2)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PPUC	Character	DISTR	How inflows enter into the downstream pump segment, DISTR, DENSITY, or SPECIFY
3	ETPU	Real		Top elevation inflow enters using SPECIFY option, m
4	EBPU	Real		Bottom elevation inflow enters using SPECIFY option, m
5	KTPU	Integer		Top layer above which selective withdrawal does not occur
6	KBPU	Integer		Bottom layer below which selective withdrawal will not occur

This card specifies how inflows/outflows for the water level controls are handled. Setting [PPUC] to DISTR distributes the inflows evenly from the water surface to the bottom active layer, setting it to DENSITY places the inflows into a layer with similar density, and setting it to SPECIFY allows the user to specify a top and bottom elevation into which inflows enter. If the SPECIFY option is used, then [ETPU] and [EBPU] are used to specify the top and bottom elevations over which the inflows are distributed.

[KTPU] and [KBPU] are used to set the upper and lower layers above and below which outflow does not occur in the selective withdrawal algorithm. For the pumps algorithm, in contrast to gates, spillways (weirs), and pipes, flow is only in 1-direction, i.e., only outflow is allowed from the upstream segment.

Example

```
PUMPS 2      PPUC     ETPU     EBPU     KTPU     KBPU
Pu 1        DISTR          4       23
```

PUMPS	Pump1	Pump2
IUPU- Upstream segment number where water is withdrawn	65	65
IDPU- Downstream segment number where water enters	103	103
EPU- elevation of pump, m	225.67	225.67
STRTPU - starting day of pumping Julian day	1	100.1
ENDPU - ending day of pumping Julian day	100	250.
EONPU pump starting elevation, m	245.25	252.2
EOFFPU - pump stopping elevation, m	245.15	251.5
QPU - pump flow rate, m ³ /s	10.5	12.5
LATPUC Downstream or lateral withdrawal, DOWN or LAT	DOWN	DOWN
DYNPUMP dynamic pump control ON or OFF	OFF	OFF
PPUC How inflows enter into the downstream pump segment, DISTR, DENSITY, or SPECIFY	DISTR	DISTR
ETPU Top elevation inflow enters using SPECIFY option, m		
EBPU Bottom elevation inflow enters using SPECIFY option, m		
KTPU Top layer above which selective withdrawal does not occur	4	4
KBPU-Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur	22	22

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Pumps 1](#)

Internal Weir Segment Location (WEIR SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	IWR	Integer	Weir segment location

This card specifies the segment location of the internal weir in the grid. If there are more internal weirs than can be specified on one line, then the segment locations are continued on the next line without another WEIR SEG card being specified.

Figure 22 illustrates the location of the internal weir. Note that the internal weir is always on the downstream side of a segment. The internal weir can simulate a skimmer (from the top down) or a curtain weir (from the bottom up). Also, the model can utilize a floating skimmer wall.

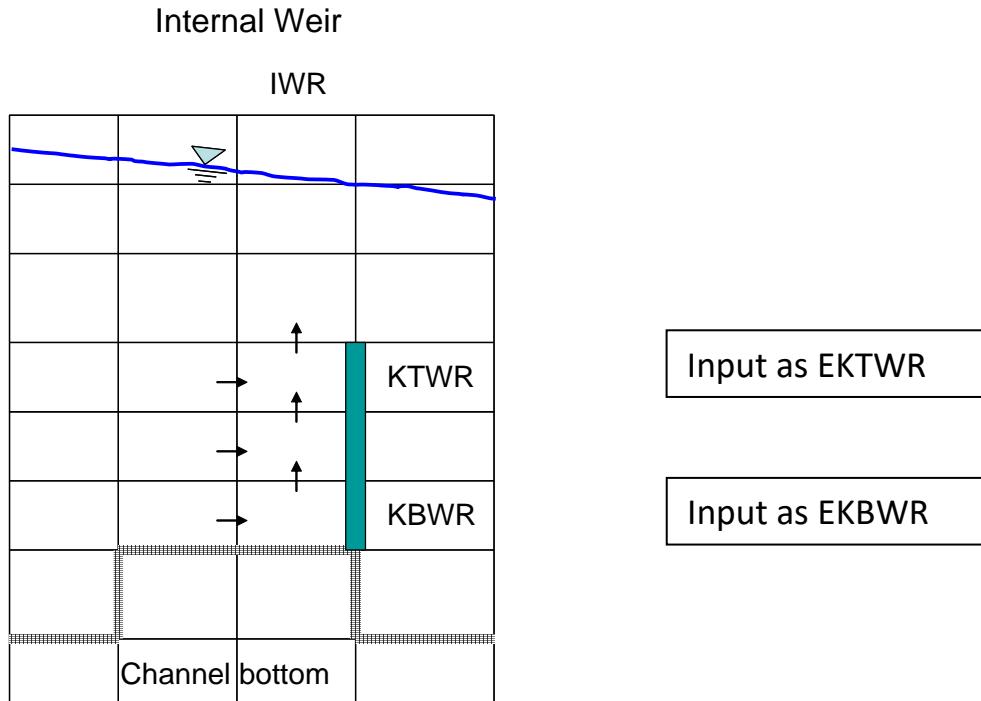


Figure 22. Description of internal weir in CE-QUAL-W2 at downstream side of segment.

Example

```
WEIR SEG      IWR      IWR      IWR      IWR      IWR      IWR      IWR      IWR
                  25
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

[Weir Top Layer](#)

[Weir Bottom Layer](#)

Internal Weir Top Layer (WEIR TOP)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EKTWR	Real	Weir top layer or for floating skimmer wall set equal to 0.0

This card specifies the top layer location of the internal weir. For a submerged weir, this should be set to the layer above which flow is allowed to occur between segments. For a floating skimmer wall, **EKTWR** is set equal to 0.0. In this case the skimmer wall always is at the water surface during the simulation. If there are more internal weirs than can be specified on one line, then the top layer locations are continued on the next line without another WEIR TOP card being specified.

Example

```
WEIR TOP    EKTWR    EKTWR    EKTWR    EKTWR    EKTWR    EKTWR    EKTWR    EKTWR    EKTWR  
          25        0.0
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)

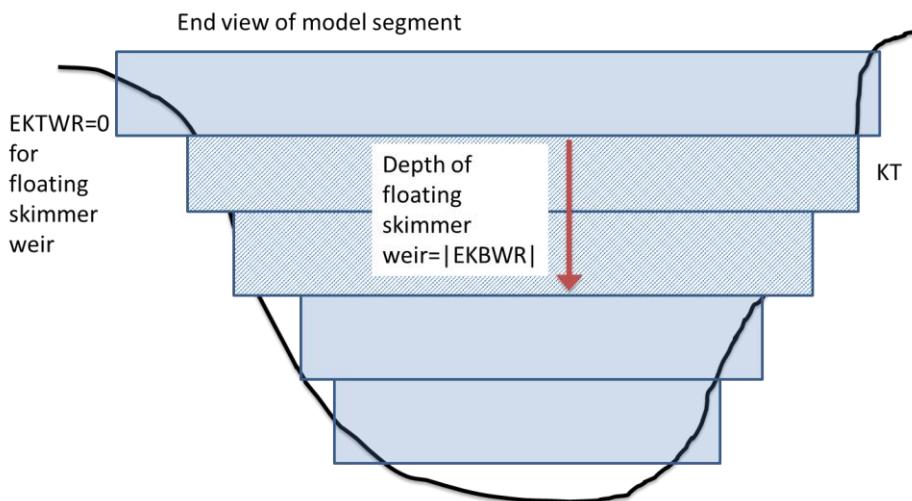
[Weir Segment Location](#)

[Weir Bottom Layer](#)

Internal Weir Bottom Layer (WEIR BOT)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EKBWR	Real	Weir bottom layer or if negative this is the absolute value of the depth of the floating skimmer weir

This card specifies the bottom layer location of the internal weir. For a curtain weir, [EKBWR] should be set to the bottommost layer above which flow between segments will not occur. For a submerged weir, [EKBWR] should be set to the bottommost active layer for the segment specified in the [WEIR SEG](#) card. For a floating skimmer weir [EKTWR=0.0], when [EKBWR] is set equal to a negative number, this number is the absolute value of the depth of the skimmer weir from the surface layer. If there are more internal weirs than can be specified on one line, then the top layer locations are continued on the next line without another WEIR BOT card being specified.

**Example**

```
WEIR BOT    EKBWR    EKBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR
      25        -25.0
```

INTERNAL WEIRS	IW1	IW2
IWR - Internal weir segment # (RHS)	35	
KTWR - Internal weir layer top	15	
KBWR - Internal weir layer bottom [EKBWR]	20	

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Weir Segment Location](#)
[Weir Top Layer](#)

Withdrawal Interpolation (WD INT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	WDIC		OFF	Withdrawal outflow interpolation, ON or OFF

This card specifies whether interpolation is turned on for lateral withdrawal outflow. If there are **more** withdrawal interpolations than can be specified on one line, then they are continued on the next line without another WD INT card being specified.

If [WDIC] is turned ON, then flows are linearly interpolated between updates. If interpolation is used, then the user must ensure it is appropriate and the input data supply correct information. Withdrawals can have periods of no releases. If withdrawal interpolation is turned on, then input data must be set up so no outflow occurs during these periods. This is accomplished by including extra dates in the withdrawal file with zero outflows to ensure the interpolation routine yields zero outflows. For example, given the following withdrawal time-series in the withdrawal file [QWDFN]:

JDAY	QWD
100.00	50.0
110.00	0.0
120.00	50.0

If interpolation is not used, then outflow from Julian day 100 to 110 is $50 \text{ m}^3 \text{ sec}^{-1}$, from Julian day 110 to 120 is $0.0 \text{ m}^3 \text{ sec}^{-1}$, and $50 \text{ m}^3 \text{ sec}^{-1}$ thereafter. If interpolation is turned on, then outflow linearly decreases from Julian day 100 to 110 and then increases from Julian day 110 to 120. To ensure no outflow occurs between day 110 and 120 with interpolation on, the withdrawal file should be setup as follows:

JDAY	QWD
109.9999	50.0
110.0000	0.0
119.9999	0.0
120.0000	50.0

Example

```
WD INT      WDIC      WDIC      WDIC      WDIC      WDIC      WDIC      WDIC      WDIC
          ON
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#)
[Withdrawal Segment](#)
[Withdrawal Elevation](#)
[Withdrawal Top Layer](#)
[Withdrawal Bottom Layer](#)
[Withdrawal File](#)
[Withdrawal Filename](#)

Withdrawal Segment (WD SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	IWD	Integer	Withdrawal segment number

This card specifies the withdrawal segment location. If there are more withdrawal segments than can be specified on one line, then they are continued on the next line without another WD SEG card being specified.

Example

W SEGMENT	IWD							
	4							

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Withdrawal Interpolation](#)
- [Withdrawal Elevation](#)
- [Withdrawal Top Layer](#)
- [Withdrawal Bottom Layer](#)
- [Withdrawal File](#)
- [Withdrawal Filename](#)

Withdrawal Elevation (WD ELEV)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EWD	Real	Withdrawal centerline elevation, <i>m</i>

This card specifies the centerline elevation of the withdrawal. If there are more withdrawal elevations than can be specified on one line, then they are continued on the next line without another WD ELEV card being specified.

Example

W EL	EWD	EWD	EWD	EWD	EWD	EWD	EWD	EWD
	40.0							

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Withdrawal Interpolation](#)
- [Withdrawal Segment](#)
- [Withdrawal Top Layer](#)
- [Withdrawal Bottom Layer](#)
- [Withdrawal File](#)
- [Withdrawal Filename](#)

Withdrawal Top Layer (WD TOP)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	KTWD	Integer	Top layer above which selective withdrawal will not occur

This card specifies the layer above which no flows will be computed in the selective withdrawal algorithm. For most situations, this should be set to layer 2, which ensures that water can be withdrawn all the way to the surface layer. It should be set to something greater than 2 if a structure is somehow limiting the withdrawal of water, such as a curtain weir. If there are more withdrawal elevations than can be specified on one line, then they are continued on the next line without another WD TOP card being specified. If the structure centerline elevation is above **KTWD**, then the value of **KTWD** is raised to the centerline elevation.

Example

```
WD TOP      KTWD      KTWD      KTWD      KTWD      KTWD      KTWD      KTWD      KTWD
          2
```

[For the Excel version see the next section.]

Related Cards and Files

[Inflow/Outflow Dimensions](#) [Withdrawal Interpolation](#) [Withdrawal Segment](#)
[Withdrawal Elevation](#) [Withdrawal Bottom Layer](#) [Withdrawal File](#) [Withdrawal Filename](#)

Withdrawal Bottom Layer (WD BOT)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	KBWD	Integer	Bottom layer below which selective withdrawal will not occur

This card specifies the layer below which no flows will be computed in the selective withdrawal algorithm. For most situations, this should be set to the bottommost active layer of the withdrawal segment, which ensures that water can be withdrawn all the way to the bottom layer. It should be set to something other than the bottommost active layer if a structure is somehow limiting the withdrawal of water, such as a submerged weir. If there are more bottom withdrawal layers than can be specified on one line, then they are continued on the next line without another WD BOT card being specified. If the structure centerline elevation is below **KBWD**, then the value of **KBWD** is lowered to the centerline elevation.

Example

```
WD BOT      KBWD      KBWD      KBWD      KBWD      KBWD      KBWD      KBWD      KBWD      KBWD
          10
```

WITHDRAWALS	WD1	WD2
WDIC - Withdrawal interpolation, ON or OFF		
IWD - Withdrawal outflow segment		
EWD - Withdrawal centerline elevation		
KTWD - Withdrawal selective withdrawal top, Top layer above which selective withdrawal will not occur		
KBWD - Withdrawal selective withdrawal bottom, Bottom layer below which selective withdrawal will not occur		

Related Cards and Files

[Inflow/Outflow Dimensions](#) [Withdrawal Interpolation](#) [Withdrawal Segment](#)
[Withdrawal Elevation](#) [Withdrawal Top Layer](#) [Withdrawal File](#) [Withdrawal Filename](#)

Tributary Inflow Placement (TRIB PLACE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TRC	Character	Tributary inflow placement, DISTR, DENSITY, SPECIFY

This card specifies how tributary inflows are distributed into the model layers. There are three options. Inflows can be distributed evenly from top to bottom ([PTRC] = DISTR), placed according to density ([PTRC] = DENSITY), or the user may specify a range of layer elevations in which the tributary inflows are distributed evenly ([PTRC] = SPECIFY). This is similar to the branch inflows, but with the additional option allowing the user to specify the range of layer elevations in which to distribute the inflows. This option is particularly useful when trying to model discharges from a pipe such as wastewater treatment effluent.

If there are more tributaries than can be specified on one line, then they are continued on the next line without another TRIB PLACE card being specified.

Even though tributary flows are usually inflows to a segment, they can also be negative, implying a withdrawal.

Example

```
TRIB PLACE PTRC      PTRC      PTRC      PTRC      PTRC      PTRC      PTRC      PTRC
        DENSITY    DISTR  SPECIFY  DENSITY  DENSITY  DENSITY  DENSITY  DENSITY
```

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Tributary Interpolation](#)
- [Tributary Segment](#)
- [Tributary Inflow Top Elevation](#)
- [Tributary Inflow Bottom Elevation](#)
- [Tributary Active Constituent Control](#)
- [Tributary Inflow File](#)
- [Tributary Temperature File](#)
- [Tributary Concentration File](#)
- [Tributary Inflow Filename](#)
- [Tributary Inflow Temperature Filename](#)
- [Tributary Inflow Concentration Filename](#)

Tributary Interpolation (TRIB INT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	TRIC	Character	ON	Turns ON/OFF interpolation of tributary inflows

The tributary inflow specified by the tributary files for flow, temperature, and concentration can either be assumed to be step functions, [TRIC] set to OFF, or can be linearly interpolated between values, [TRIC] set to ON.

Example

```
TRIB INT      TRIC      TRIC      TRIC      TRIC      TRIC      TRIC      TRIC      TRIC
          ON        ON        ON        ON        ON        ON        ON        ON        ON
```

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Tributary Inflow Placement](#)
- [Tributary Segment](#)
- [Tributary Inflow Top Elevation](#)
- [Tributary Inflow Bottom Elevation](#)
- [Tributary Active Constituent Control](#)
- [Tributary Inflow File](#)
- [Tributary Temperature File](#)
- [Tributary Concentration File](#)
- [Tributary Inflow Filename](#)
- [Tributary Inflow Temperature Filename](#)
- [Tributary Inflow Concentration Filename](#)

Tributary Segment (TRIB SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ITR	Integer	Segment tributary enters

This card specifies the segment that the tributary enters. Tributary flows are either placed into a layer whose density most closely corresponds to that of the tributary flows, are evenly distributed from top to bottom, or are specified to enter over a range of elevations (see [\[TRC\]](#)). Flows that enter segments upstream of the current upstream segment [\[CUS\]](#) for a branch are combined with the branch inflow.

If there are more tributary segments than can be specified on one line, then they are continued on the next line without another TRIB SEG card being specified.

Example

```
TRIB SEG      ITR      ITR      ITR      ITR      ITR      ITR      ITR      ITR      ITR
              2        3        4        3        4        5        6        7
```

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Tributary Inflow Placement](#)
- [Tributary Interpolation](#)
- [Tributary Inflow Top Elevation](#)
- [Tributary Inflow Bottom Elevation](#)
- [Tributary Active Constituent Control](#)
- [Tributary Inflow File](#)
- [Tributary Temperature File](#)
- [Tributary Concentration File](#)
- [Tributary Inflow Filename](#)
- [Tributary Inflow Temperature Filename](#)
- [Tributary Inflow Concentration Filename](#)

Tributary Inflow Top Elevation (TRIB TOP)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ETRT	Real	Tributary inflow top elevation, <i>m</i>

This card specifies the upper elevation for each tributary inflow in which the user has specified that inflows will be placed over a range of elevations. Only tributaries that are specified as SPECIFY on the [Tributary Inflow Placement](#) card need top elevations specified on this card.

If there are more tributary top elevations than can be specified on one line, then they are continued on the next line without another TRIB TOP card being specified.

Example

```
TRIB TOP    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT
                  116.0
```

[For the Excel version see the next section.]

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Tributary Inflow Placement](#)
- [Tributary Interpolation](#)
- [Tributary Segment](#)
- [Tributary Inflow Top Elevation](#)
- [Tributary Inflow Bottom Elevation](#)
- [Tributary Active Constituent Control](#)
- [Tributary Inflow File](#)
- [Tributary Temperature File](#)
- [Tributary Concentration File](#)
- [Tributary Inflow Filename](#)
- [Tributary Inflow Temperature Filename](#)
- [Tributary Inflow Concentration Filename](#)

Tributary Inflow Bottom Elevation (ELEV BOT)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ETRB	Real	Tributary inflow bottom elevation, <i>m</i>

This card specifies the bottom elevation for each tributary inflow in which the user has specified that inflows will be placed over a range of elevations. Only tributaries that are specified as SPECIFY on the [Tributary Inflow Placement](#) card need bottom elevations specified on this card.

If there are more tributary bottom elevations than can be specified on one line, then they are continued on the next line without another TRIB BOT card being specified.

Example

```
TRIB BOT      ETRB      ETRB      ETRB      ETRB      ETRB      ETRB      ETRB      ETRB
                  114.0
```

Note that for the Excel version the file names associated with the tributaries is included in this section to make sure the connections are correct. This section specifies the filename(s) for tributary inflows for flow (*q*), temperature (*t*), and concentration (*c*). There must be a separate file for each tributary. More information on data setup can be found at the description of the [tributary inflow file](#), [tributary inflow temperature file](#), and the [tributary inflow concentration file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

TRIB PLACEMENT and TRIB FILES	TR1	TR2
PTRC - Tributary inflow placement: DENSITY, SPECIFY, DISTR	SPECIFY	
TRIC - Interpolation control	ON	
ITR - Tributary inflow segment	27	
ELTRT - Top elevation if trib placement [ETRT]	125.5	
ELTRB - Bottom elevation if trib placement [ETRB]	120.0	
QTRFN - tributary flow file	qtr1_GreenRiver.csv	
TTRFN - tributary temperature file	ttr1_GreenRiver.csv	
CTRFN - tributary concentration file	ctr1_GreenRiver.csv	

Related Cards and Files

- [Inflow/Outflow Dimensions](#)
- [Tributary Inflow Placement](#)
- [Tributary Interpolation](#)
- [Tributary Segment](#)
- [Tributary Inflow Top Elevation](#)
- [Tributary Inflow Bottom Elevation](#)
- [Tributary Active Constituent Control](#)
- [Tributary Inflow File](#)
- [Tributary Temperature File](#)
- [Tributary Concentration File](#)
- [Tributary Inflow Filename](#)
- [Tributary Inflow Temperature Filename](#)
- [Tributary Inflow Concentration Filename](#)

Distributed Tributaries (DST TRIB)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	DTRC	Character	OFF	Distributed tributary option, ON or OFF

This card specifies whether or not a branch contains a distributed tributary inflow and whether or not the inflows, inflow temperatures, and inflow concentrations are linearly interpolated between input dates. A distributed tributary is equivalent to a non-point source loading. This option may be turned ON or OFF for each branch and is useful in accounting for ungaged flows for the water budget. The flow is distributed among the segments in each branch proportional to their surface areas. There is one value of [DTRC] for each branch. See the INTERPOL card for turning ON/OFF interpolation for distributed tributaries.

For each distributed tributary specified, the user must supply an inflow file [[QDTFN](#)], an inflow temperature file [[TDTFN](#)], and, if constituents are modeled, an inflow constituent concentration file [[CDTFN](#)].

If constituents are modeled, the user can select which constituents are included in the distributed tributary concentrations input file (see [Distributed Tributary Active Constituent Control](#) card).

Even though distributed tributary flows are usually inflows to the segments of a branch, they can also be negative, implying withdrawals from all active segments of a branch.

Example

```
DST TRIB      DTRC
Br 1          ON
Br 2          ON
Br 3          OFF
Br 4          OFF
```

DST TRIBUTARIES	BR1	BR2
DTRC - Dist Trib Control	OFF	

Related Cards and Files

- [Distributed Tributary Active Constituent Control](#)
- [Distributed Tributary Inflow File](#)
- [Distributed Tributary Temperature File](#)
- [Distributed Tributary Concentration File](#)
- [Distributed Tributary Inflow Filename](#)
- [Distributed Tributary Inflow Temperature Filename](#)
- [Distributed Tributary Inflow Concentration Filename](#)

Hydrodynamic Output Control (HYD PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	HPRWBC	Character	OFF	Output hydrodynamic terms to the snapshot file, ON or OFF

This card specifies whether or not certain hydrodynamic terms are included as output in the snapshot file [SNP]. The hydrodynamic terms include timestep violations, horizontal and vertical velocities, temperatures, and all the terms that comprise the horizontal momentum equation. The user can turn ON/OFF hydrodynamic output for each waterbody. The list of hydraulic print parameters is shown in Table 8.

Table 8. Hydraulic Print Parameters.

Term	Explanation
[NLIM]	Location and number of limiting time steps in the model grid
[U]	Longitudinal velocity in m/s
[W]	Vertical velocity in m/s
[T]	Temperature in °C
[RHO]	Density in kg/m ³
[AZ]	Vertical turbulent eddy viscosity in m ² /s
[SHEAR]	Velocity shear stress squared [VSH] in 1/s ²
[ST]	Total shear stress at top of model layer (see Equation A-150) X width of cell in m ³ /s ² , ST=bottom and side-wall shear+velocity shear+wind induced shear
[SB]	Shear stress at bottom of model layer (see Equation A-147) X width of cell in m ³ /s ²
[ADMX]	Longitudinal advection of momentum in m ³ /s ² [ADMX]~BH $\frac{\Delta U}{\Delta x}$
[DM]	Longitudinal momentum transport by eddy viscosity in m ³ /s ² where approximately [DM]~A _Z BH $\frac{\Delta U}{\Delta x^2}$
[HDG]	Horizontal density gradient in m ³ /s ² [HDG]~BH $\frac{\Delta P}{\rho \Delta x}$ *
[ADMZ]	Vertical advection of momentum in m ³ /s ² [ADMZ]~BWU
[HPG]	Horizontal pressure gradient in m ³ /s ² [HPG]~BH $\frac{\Delta P}{\rho \Delta x}$ *
[GRAV]	Gravity force term in m ³ /s ² [GRAV]~BHg
	g is acceleration due to gravity, B is cell width, H is average cell layer thickness, U is longitudinal velocity, W is vertical velocity, Δx is segment spacing, P is pressure, ρ is density. *Note HDG pressure is taken from horizontal elevation of layer KT and is used only in the water surface computation. HPG pressure is computed from actual water surface and is used in the velocity computation. The HDG pressure between the horizontal layer KT elevation and the water surface is already accounted for in the surface water layer computation for η.

For **w2_con.npt**: Values for each waterbody continue across the line. If there are more than nine waterbodies, then additional values continue on the next line starting in field two. Output formatting and animation of these variables can be specified in the **graph.npt** file.

Example

```

HYD PRINT HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC
NLIM      ON       ON       ON       ON       ON       ON       ON       ON       ON
U          ON       ON       ON       ON       ON       ON       ON       ON       ON
W          ON       ON       ON       ON       ON       ON       ON       ON       ON
T          ON       ON       ON       ON       ON       ON       ON       ON       ON
RHO        ON       ON       ON       ON       ON       ON       ON       ON       ON
AZ         ON       ON       ON       ON       ON       ON       ON       ON       ON
SHEAR      ON       ON       ON       ON       ON       ON       ON       ON       ON
ST         ON       ON       ON       ON       ON       ON       ON       ON       ON
SB         ON       ON       ON       ON       ON       ON       ON       ON       ON
ADMX      ON       ON       ON       ON       ON       ON       ON       ON       ON
DM         ON       ON       ON       ON       ON       ON       ON       ON       ON
HDG        ON       ON       ON       ON       ON       ON       ON       ON       ON
ADMZ      ON       ON       ON       ON       ON       ON       ON       ON       ON
HPG        ON       ON       ON       ON       ON       ON       ON       ON       ON
GRAV      ON       ON       ON       ON       ON       ON       ON       ON       ON

```

CONTROL FILE

OUTPUT CONTROL

For the Excel version, there is no **graph.npt** file and there is no wrapping of variables across multiple lines since they continue along a row for each waterbody. Also, there are several more variables:

HMULT is a multiplier of the output, usually it is 1, but if you want more significant digits, this can be increased
FMTH is the FORTRAN output format for the SNP file. Note: F10.3 = real number output of 10 digits and with the decimal point in the third position from the right. I10= integer number of 10 characters in length. These must be in parentheses.

HNAME is fixed name and does not change. It must be in double quotes.

Example:

HYD PRINT - Print in the SNP file	HNAME	FMTH	HMULT	HPRWBC1	HPRWBC2
NVIOL - Violations of time step	"Timestep violations [NVIOL] "	(I10)	1	ON	
U	"Horizontal velocity [U] m/s "	(f10.3)	1	ON	
W	"Vertical velocity [W] m/s "	(f10.3)	1	OFF	
T	"Temperature [T1] <o>C "	(f10.3)	1	ON	
RHO	"Density [RHO] g/m^3 "	(f10.3)	1	OFF	
AZ	"Vertical eddy viscosity [AZ] m^2/s "	(f10.3)	1	OFF	
SHEAR	"Velocity shear stress [SHEAR] 1/s^2 "	(f10.3)	1	OFF	
ST	"Internal shear [ST] m^3/s "	(f10.3)	1	OFF	
SB	"Bottom shear [SB] m^3/s "	(f10.3)	1	OFF	
ADMX	"Longitudinal momentum [ADMX] m^3/s "	(f10.3)	1	OFF	
DM	"Longitudinal momentum [DM] m^3/s "	(f10.3)	1	OFF	
HDG	"Horizontal density gradient [HDG] m^3/s "	(f10.3)	1	OFF	
ADMZ	"Vertical momentum [ADMZ] m^3/s "	(f10.3)	1	OFF	
HPG	"Horizontal pressure gradient [HPG] m^3/s "	(f10.3)	1	OFF	
GRAV	"Gravity term channel slope [GRAV] m^3/s "	(f10.3)	1	OFF	

Snapshot Print (SNP PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SNPC	Character	OFF	Specifies if information is written to snapshot file, ON or OFF
3	NSNP	Integer		Number of snapshot dates
4	NISNP	Integer		Number of segments output

This card specifies if information is output to the snapshot file [**SNPFN**], number of snapshot intervals for specifying output dates and frequencies, and the number of segments that will be output to each snapshot file. Each water body has separate controls so that the user can include/suppress snapshot output for each waterbody.

Snapshot file output provides the user with computed values for hydrodynamic and constituent variables for user assigned segments. Output from this file can be large if the frequency of output is small. This option is generally not used for post-processing since other files have these data in more graphing and processing friendly formats.

The number of snapshot dates [**NSNP**] refers to the option of writing information to the snapshot file for different dates and frequencies. For example, the user may specify output is to begin on Julian day 224.4 and output every 0.1 days until day 225.5. Information is then output every day until the end of the simulation. In this case, [**NSNP**] would be set to 2. Values for each waterbody start on a new line.

[**NISNP**] is only used in the w2_con.npt input file. This specifies the number of segments to write out. In the Excel version, all active segments are automatically included in the SNP file output.

Example

```
SNP PRINT    SNPC    NSNP    NISNP
Wb 1         ON      3        11
Wb 2         ON      1        14
Wb 3         ON      1        10
```

[For the Excel version see the next section.]

Related Cards and Files

[Snapshot Dates](#)
[Snapshot Frequency](#)
[Snapshot Segments](#)
[Snapshot Filename](#)
[Constituent Output](#)

Snapshot Dates (SNP DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SNPD	Real	Output dates, Julian day

This card specifies the dates that information is output to the snapshot file [SNPFN]. The total number of dates specified on this card must match [[NSNP](#)] on the [Snapshot Print](#) card.

If there are more dates than can be specified on one line, then the values for [SNPD] are continued on the next line without another SNP DATE card being specified. Values for each waterbody start on a new line.

Example

```
SNP DATE      SNPD      SNPD      SNPD      SNPD      SNPD      SNPD      SNPD      SNPD      SNPD
Wb 1          63.50    100.5    200.5
Wb 2          63.50
Wb 3          63.50
```

[For the Excel version see the next section.]

Related Cards and Files

- [Snapshot Print](#)
- [Snapshot Frequency](#)
- [Snapshot Segments](#)
- [Snapshot Filename](#)
- [Constituent Output](#)

Snapshot Frequency (SNP FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SNPF	Real	Output frequency, <i>days</i>

This card specifies the frequency information is output to the snapshot file [SNPFN]. Frequency can be changed at any time during the simulation by specifying appropriate dates on the [Snapshot Date](#) card and frequencies on the **Snapshot Frequency** card. If output is needed only for the date specified on the [Snapshot Date](#) card, then set the frequency to be greater than the number of days before the next output date.

If there are more frequencies than can be specified on one line, then they are continued on the next line without another SNP FREQ card being specified. Values for each waterbody start on a new line.

Example

SNP FREQ	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF
Wb 1	0.1	500.0	7.0						
Wb 2	0.1								
Wb 3	0.1								

SNP PRINT - Snapshot print	SNP		
SNPC, ON or OFF	ON		
NSNP, # of dates	3		
SNP DATE SNPD(NSNP) output days in Julian days	64.5	64.7	92.7
SNP FREQ SNPF(NSNP) Frequency of output in days	0.05	7	100

Related Cards and Files

[Snapshot Print](#)
[Snapshot Dates](#)
[Snapshot Segments](#)
[Snapshot Filename](#)
[Constituent Output](#)

Snapshot Segments (SNP SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ISNP	Integer	Output segments

This card and variable is only used in the w2_con.npt input file. The Excel version automatically includes all segments in a waterbody. ISNP specifies the segments to be included in the snapshot file for each waterbody. The user can include all segments in the computational grid. The user should omit boundary segments that are not part of the computational grid.

If there are more dates than can be specified on one line, then the values for [ISNP] are continued on the next line without another SNP SEG card being specified. Values for each waterbody start on a new line.

Example

SNP SEG	ISNP	ISN							
Wb 1	2	3	4	5	6	9	10	11	12
	13	14							
Wb 2	17	18	19	20	21	22	23	24	25
	26	27	28	29	30				
Wb 3	33	34	35	36	37	38	39	40	41
	42								

[The Excel version does not use this variable. See prior section for the Excel SNP file section.]

Related Cards and Files

[Snapshot Print](#)
[Snapshot Dates](#)
[Snapshot Frequency](#)
[Snapshot Filename](#)
[Constituent Output](#)

Screen Print (SCR PRNT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SCRC	Character	OFF	Specifies if information is written to the screen, ON or OFF
3	NSCR	Integer		Number of screen update intervals

This card specifies if information is output to the screen during the run and the number of intervals during which the frequency of updating the screen can change. Be careful of setting this so small that model run-time is affected by the output. Values for each waterbody start on a new line for the w2_con.npt control file. *In the Excel control file SCRC is only one value and is not a function of waterbody.*

Example

```
SCR PRINT    SCRC    NSCR
Wb 1        ON      1
Wb 2        ON      1
Wb 3        ON      1
```

[For the Excel version see the next section.]

Related Cards and Files

[Screen Dates](#)

[Screen Frequency](#)

Screen Dates (SCR DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SCRD	Real	Output dates, Julian day

This card specifies the dates information is output to the screen. The total number of dates specified on this card must match [**NSCR**] on the [Screen Print](#) card.

If there are more dates than can be specified on one line, then the values for [**SCRD**] are continued on the next line without another SCR DATE card being specified. Values for each waterbody start on a new line for the file w2_con.npt. . In the Excel control file SIRD is only one value and is not a function of waterbody

Example

SCR DATE	SCRD								
Wb 1	63.5								
Wb 2		63.5							
Wb 3			63.5						

[For the Excel version see the next section.]

Related Cards and Files

[Screen Print](#)

[Screen Frequency](#)

Screen Frequency (SCR FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SCRF	Real	Output frequency, days

This card specifies the frequency information is output to the screen. Frequency can be changed at any time during the simulation by specifying appropriate dates on the [Screen Date](#) card and frequencies on the **Screen Frequency** card. The frequency at which the screen is updated is typically be at least 0.1 days and more often 1.0 days. If output is needed only for the date specified on the [Screen Date](#) card, then set the frequency to be greater than the number of days before the next output date.

If there are more frequencies than can be specified on one line, then they are continued on the next line without another **Screen Frequency** card being specified. For the w2_con.npt control file, values for each waterbody start on a new line. *In the Excel control file SCRF is only one value and is not a function of waterbody.*

Example

```
SCR FREQ      SCRF      SCRF      SCRF      SCRF      SCRF      SCRF      SCRF      SCRF
Wb 1          0.15
Wb 2          0.15
Wb 3          0.15
```

SCR PRINT - Screen print	SCR
SCRC: ON or OFF, update screen output	ON
NSCR: # of dates	1
SCR DATE: SCRD(NSCR), output days in Julian days	64.5
SCR FREQ: SCRF(NSCR), frequency of output in days	4

Related Cards and Files

[Screen Print](#)
[Screen Dates](#)

Profile Plot (PRF PLOT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PRFC	Character	OFF	Specifies if information is written to the profile file, ON or OFF
3	NPRF	Integer		Number of profile dates
4	NIPRF	Integer		Number of segments output

This card specifies if information is output to the [profile output file \[PRFFN\]](#), the number of profile intervals for specifying output dates and frequencies, and the number of segments included in the output.

The [profile output file \[PRFFN\]](#) can be used to plot vertical profiles of temperature and constituents at a specified model segment comparing model predictions to observed data during calibration runs. This file is in a form suitable for FORTRAN postprocessing. The [spreadsheet profile output file \[SPRFN\]](#) is recommended for processing profile output data in a spreadsheet.

Alternately, this output file can be used to plot longitudinal profiles of water surface elevation, depth, flow rate, temperature and water quality at the surface layer. A volume weighted temperature is also output. This output is useful for evaluating longitudinal variation of river and estuary system dynamics. In all these cases, the model user will need to write code to prepare the output for graphics.

The [Constituent Output](#) card controls which constituents are output to the profile file. Temperature is always output to the profile file. Values for each waterbody start on a new line for the **w2_con.npt** control file. *In the Excel control file, the output is given for segments, not for waterbodies, hence PRFC, NPRF, and NIPRF are only value and are not a function of waterbody.*

Example

```
PRF PLOT    PRFC      NPRF      NIPRF
Wb 1        ON        1          1
Wb 2        OFF       0          0
Wb 3        ON        1          1
```

[For the Excel version see the next section.]

Related Cards and Files

[Profile Date](#)
[Profile Frequency](#)
[Profile Segment](#)
[Profile Filename](#)
[Constituent Output](#)

Profile Date (PRF DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	PRFD	Real	Output dates, Julian day

This card specifies the dates that information is output to the [profile output file \[PRFFN\]](#). If there are more dates than can be specified on one line, then they are continued on the next line without another PRF DATE card being specified. Values for each waterbody start on a new line for the control file w2_con.npt. *PRFD is only one value for all waterbodies in the Excel control file.*

Example

```
PRF DATE      PRFD      PRFD      PRFD      PRFD      PRFD      PRFD      PRFD      PRFD
Wb 1          63.5
Wb 2
Wb 3          63.5
```

[For the Excel version see the next section.]

Related Cards and Files

- [Profile Plot](#)
- [Profile Frequency](#)
- [Profile Segment](#)
- [Profile Filename](#)
- [Constituent Output](#)

Profile Frequency (PRF FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	PRFF	Real	Output frequency, days

This card specifies the frequency information is output to the [profile output file \[PRFFN\]](#). Frequency can be changed at any time during the simulation by specifying appropriate dates on the [Profile Date](#) card and frequencies on the **Profile Frequency** card. If output is needed only for the date specified on the [Profile Date](#) card, then set the frequency to be greater than the number of days before the next output date.

If there are more frequencies than can be specified on one line, then they are continued on the next line without another **PRF FREQ** card being specified. Values for each waterbody start on a new line for the w2_con.npt control file. *PRFF is only one value for all waterbodies in the Excel control file..*

Example

```
PRF FREQ      PRFF      PRFF      PRFF      PRFF      PRFF      PRFF      PRFF      PRFF
Wb 1          1.0
Wb 2
Wb 3          1.0
```

[For the Excel version see the next section.]

Related Cards and Files

[Profile Plot](#)
[Profile Date](#)
[Profile Segment](#)
[Profile Filename](#)
[Constituent Output](#)

Profile Segment (PRF SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	IPRF	Integer	Output segments

This card specifies model segments for which information is output to the [profile output file \[PRFFN\]](#). If there are more segments than can be specified on one line, then they are continued on the next line without another **PRF SEG** card being specified. Values for each waterbody start on a new line for the control file **w2_con.npt**. *IPRF is only one value for all waterbodies in the Excel control file.*

For printing out longitudinal profiles, the [**IPRF**] for the **first water body** is set to '**-1**'. No other water body information is used since the longitudinal profile output includes all waterbodies. Output files are named '**ProfLongJDXXX.csv**' where XXX is the Julian day of the output.

Example

```
PRF SEG      IPRF      IPRF      IPRF      IPRF      IPRF      IPRF      IPRF      IPRF      IPRF
Wb 1          -1
Wb 2
Wb 3          42
```

PRF PLOT - Profile output	PRFC		
PRFC- Specifies if information is written to the profile file, ON or OFF	ON		
NPRF- # of profile dates	1		
NIPRF- # of segments to output	3		
PRF DATE- PRFD(NPRF) output dates in Julian days	64.7		
PRF FREQ- PRFF(NPRF) frequency of output, days	1		
PRF SEG- IPRF(NIPRF) segment number	10	18	26

Related Cards and Files

- [Profile Plot](#)
- [Profile Date](#)
- [Profile Frequency](#)
- [Profile Filename](#)
- [Constituent Output](#)

Spreadsheet Profile Plot (SPR PLOT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SPRC	Character	OFF	Specifies if information is written to the spreadsheet profile file, ON, ONV, or OFF
3	NSPR	Integer		Number of spreadsheet dates
4	NISPR	Integer		Number of segments in output

This card specifies if information is output to the [spreadsheet profile output file \[SPRFN\]](#), the number of intervals for specifying output dates and frequencies, and the number of segments included in the output.

The [spreadsheet profile output file \[SPRFN\]](#) is used to plot vertical profiles of temperature, horizontal velocity, horizontal layer flow rate, and constituents at a specified model segment and is suitable as ASCII input into a spreadsheet when SPRC='ON'. The file is comma delimited and if the file name is specified as a '.csv' file it will open correctly in Excel. This file is used to compare observed data with simulated vertical profile data during calibration. For output to null layers, the default output is -99.

The user may also specify SPRC='ONV' which outputs an additional file with vertical, volume-weighted averages at each segment and time interval specified.

The [Constituent Output](#) card controls which constituents are output to the spreadsheet file. Temperature is always output to the spreadsheet file. For the control file **w2_con.npt**, values of [SPRC], [NSPR], and [NISPR] for each waterbody start on a new line. *For the Excel control file, [SPRC], [NSPR], and [NISPR] are set globally and are not a function of waterbody.*

Example

```
SPR PLOT    SPRC      NSPR     NISPR
Wb 1        OFF       0         0
Wb 2        OFF       1         1
Wb 3        OFF       1         1
```

[For the Excel version see the next section.]

Related Cards and Files

[Spreadsheet Date](#)
[Spreadsheet Frequency](#)
[Spreadsheet Segment](#)
[Spreadsheet Filename](#)
[Constituent Output](#)

Spreadsheet Profile Date (SPR DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SPRD	Real	Output dates, Julian Day

This card specifies the dates that information is output to the [spreadsheet profile output file \[SPRFN\]](#). If there are more dates than can be specified on one line, then they are continued on the next line without another **SPR DATE** card being specified. Values for each waterbody start on a new line for the control file w2_con.npt. *For the Excel control file, [SPRD] is set globally and is not a function of waterbody.*

Example

```
SPR DATE      SPRD      SPRD      SPRD      SPRD      SPRD      SPRD      SPRD      SPRD      SPRD
Wb 1
Wb 2          63.5
Wb 3          63.5
```

[For the Excel version see the next section.]

Related Cards and Files

[Spreadsheet Plot](#)
[Spreadsheet Frequency](#)
[Spreadsheet Segment](#)
[Spreadsheet Filename](#)
[Constituent Output](#)

Spreadsheet Profile Frequency (SPR FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SPRF	Real	Output frequency, days

This card specifies the frequency information is output to the [spreadsheet profile output file \[SPRFN\]](#). Frequency can be changed at any time during the simulation by specifying appropriate dates on the [Spreadsheet Date](#) card and frequencies on the **Spreadsheet Frequency** card. If output is needed only for the date specified on the [Spreadsheet Date](#) card, then set the frequency to be greater than the number of days before the next output date.

If there are more frequencies than can be specified on one line, then they are continued on the next line without another **SPR FREQ** card being specified. Values for each waterbody start on a new line for the control file w2_con.npt. *For the Excel control file, [SPRF] is set globally and is not a function of waterbody.*

Example

```
SPR FREQ     SPRF      SPRF      SPRF      SPRF      SPRF      SPRF      SPRF      SPRF      SPRF
Wb 1
Wb 2          7.0
Wb 3          7.0
```

[For the Excel version see the next section.]

Related Cards and Files

[Spreadsheet Plot](#)
[Spreadsheet Date](#)
[Spreadsheet Segment](#)
[Spreadsheet Filename](#)
[Constituent Output](#)

Spreadsheet Profile Segment (SPR SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ISPR	Integer	Output segments

This card specifies model segments for which information is output to the [spreadsheet output file \[SPRFN\]](#). For the control file, **w2_con.npt**, if there are more segments than can be specified on one line, then they are continued on the next line without another **SPR SEG** card being specified. *For the Excel control file, [ISPR] is not a function of waterbody and is set along one row.*

Example

```
SPR SEG      ISPR      ISPR      ISPR      ISPR      ISPR      ISPR      ISPR      ISPR      ISPR
Wb 1
Wb 2          14
Wb 3          42
```

SPR PLOT - spreadsheet output	SPR	
SPRC- Specifies if information is written to the spreadsheet profile file, ON, ONV, or OFF	ONV	
NSPR- # of dates	2	
NISPR- # of segments	2	
SPR DATE- SPRD(NSPR) - starting date of output in Julian days	100.7	150.5
SPR FREQ- SPRF(NSPR) - output frequency- days	10	30.
SPR SEG- ISPR(NISPR) - segment # of spreadsheet output	26	28

Related Cards and Files

[Spreadsheet Plot](#)
[Spreadsheet Date](#)
[Spreadsheet Frequency](#)
[Spreadsheet Filename](#)
[Constituent Output](#)

W2 Linkage File Output – (Vector Plot) (VPL PLOT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	VPLC	Character	OFF	Specifies if information is written to the W2 Linkage file (old vector file), ON or OFF
3	NVPL	Integer		Number of W2 Linkage Dates (vector plot) dates

This card specifies if information is output to the [vector plot file \[VPLFN\]](#) and the number of vector plot intervals for specifying output dates and frequencies. Starting in Version 3.71, the VPL card is no longer the ‘vector plot card’. This card will specify the frequency of output for the **W2_Post.exe** post-processor. Hence, when **VPLC** is ON, an output file will be created for the times and intervals specified in the vector plot frequency and the vector plot date. The vector plot filename specifies the binary file output. Be careful about high frequency output for a large system since the post-processor may not be able to process file sizes greater than 2 GB. For information on the **W2_Post.exe** post-processor, please consult the user manual for the w2tools program. Also, note that only 1 output file is used even for multiple waterbodies. Hence, the value of **VPLC** for the 1st waterbody must be ON for output. The values of **VPLC** for other waterbodies are ignored. *For the Excel control file, VPLC and NVPL are single values and are not a function of waterbody.*

Example

```
VPL PLOT      VPLC      NVPL
Wb 1          ON        7
Wb 2          ON        7    ←This is ignored
Wb 3          ON        7    ←This is ignored
```

[For the Excel version see the next section.]

Related Cards and Files

[Vector Plot Date](#)
[Vector Plot Frequency](#)
[Vector Plot Filename](#)

Vector Plot Date (VPL DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	VPLD	Real	Output dates, Julian day

This card specifies the dates that information is output to the [vector plot file \[VPLFN\]](#). If there are more dates than can be specified on one line, then they are continued on the next line without another **VPL DATE** card being specified. This is the frequency of data written to the post-processing tool, w2tools. Only the value for the 1st waterbody is used to write out information for all waterbodies used by the W2tool post-processing program. The values for other waterbodies are ignored. *For the Excel control file, VPLD is a single value and is not a function of waterbody.*

Example

```
VPL DATE      VPLD      VPLD      VPLD      VPLD      VPLD      VPLD      VPLD      VPLD      VPLD
Wb 1          224.5    225.5    226.5    227.5    228.5    229.5    230.5
Wb 2          224.5    225.5    226.5    227.5    228.5    229.5    230.5 ←This is ignored
Wb 3          224.5    225.5    226.5    227.5    228.5    229.5    230.5 ←This is ignored
```

[For the Excel version see the next section.]

Related Cards and Files

[Vector Plot](#)
[Vector Plot Frequency](#)
[Vector Plot Filename](#)

Vector Plot Frequency (VPL FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	VPLF	Real	Output frequency, days

This card specifies the frequency information is output to the [vector plot file \[VPLFN\]](#), the w2tools output file. Frequency can be changed at any time during the simulation by specifying the dates on the [Vector Plot Date](#) card and the frequencies on the **Vector Plot Frequency** card. If output is needed only for the date specified on the [Vector Plot Date](#) card, then set the frequency to be greater than the number of days before the next output date.

If there are more frequencies than can be specified on one line, then they are continued on the next line without another **VPL FREQ** card being specified.

Only the value for the 1st waterbody is used to write out information for all waterbodies used by the W2tool post-processing program. The values for other waterbodies are ignored. *For the Excel control file, VPLF is a single value and is not a function of waterbody.*

Example

```
VPL FREQ    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF
Wb 1        100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
Wb 2        100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0 ←This is ignored
Wb 3        100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0 ←This is ignored
```

DSI W2Linkage File for W2Post (used to be called VPL PLOT)	W2L
VPLC- ON or OFF Specifies if information is written to the W2 Linkage file, ON or OFF	ON
NVPL- # of dates	1
VPL DATE- VPLD(NVPL)- starting date of output in Julian days	1
VPL FREQ- VPLF(NVPL)- output frequency- days	0.5

Related Cards and Files

- [Vector Plot](#)
- [Vector Plot Date](#)
- [Vector Plot Filename](#)

Contour Plot (CPL PLOT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CPLC	Character	OFF	Specifies if information is output to the contour file, ON or OFF
3	NCPL	Integer		Number of contour plot dates
4	TECPLOT	Character	OFF	Turns ON or OFF TECPLOT output format

This card specifies if information is output to the [contour plot file \[CPLFN\]](#) and the number of contour plot intervals for specifying output dates and frequencies. The current version still requires the user to develop their own means of postprocessing data for contour plots. This also requires the user to “get under the hood” of the code to determine the data output and the format of the output to generate their own contour plots.

Turning ON TECPLOT output allows the user to quickly develop contour and vector animation of model output. TECPLOT output contains Elevation (m), Distance (m), U, W, T(C), RHO, HABITAT# (based on fish habitat criteria – see CPL file format) and all active constituents for the entire model grid at a frequency specified in CPL FREQ. See the description of the CPL file output in the section on output files.

Instructions for using TECPLOT360 and creating an animation are shown below:

1. In control file, turn on contour output (CPLC='ON') and tecplot option (TECPLOT='ON'). Also set output frequency CPLF to desired value.
2. Run model.
3. Start Tecplot, select ‘File|Load Data File’. Select ‘Teplot Data Loader’ and load contour output file (probably cpl.opt). It will probably take time for tecplot to convert the ascii file to binary. If the file is really big, this might take quite a while.
4. When the ‘Select Initial Plot’ window comes up, set initial plot time to “2D Cartesian” and select “Show First Zone Only”. A 2-D graph should be visible with Elevation being the y-axis and distance for the x-axis.
5. In the “Zone Surfaces Layers” box at the upper left, select “Contour” and “deselect anything else.”
6. Double Click on the y-axis, and a “Axis Details” box should come up. Select the Range tab and select “Independent” in the dependency box. Click on “Reset Range” and then select “reset to nice values” to reset the Min/Max values for the y-axis. The contour plot for the first day should be visible now.
7. Select Plot|Contour to select the parameter for which you want to make an animation. It will likely be set to ‘T’ or temperature initially.
8. To set the contour plot intervals, select Plot|Contour and click on the “>>” button. Then select “New Levels”. A typical setting for temperature would be Minimum Level =0, Maximum Level=30, and Number of Levels=25
9. To show a legend, click on the “Legend” tab and click “Show Contour Legend”
10. To blank out inactive cells, select Plot|Blanking|Value Blanking and click on “Include Value Blanking”. Then click on the “Active” box, and select “Blank when” temperature of ‘T’ is less than or equal to -0.1.

CONTROL FILE

OUTPUT CONTROL

11. To create animation, select Animate|Zones and click animate. You have the option of animating on screen, to an AVI file, or to a rastermetafile (RM).
12. One can also add velocity vectors by turning on the vector map and adjusting the vector properties on top of the temperature contour plot. Other contour movies of other state variables can be performed by following these same steps.
13. Before exiting tecplot, save your work by selecting File|Save Layout.

Also, if using TECPLOT output, the user can specify which model branches are output in the input file **w2_tecplotbr.csv**. This input file is described in the section on input files.

For the **w2_con.npt** control file, CPLC, NCPL, and TECPLOT are a function of waterbody. *In the Excel control file, CPLC, NCPL, and TECPLOT are single valued and apply to all waterbodies.*

Example

CPL PLOT	CPLC	NCPL	TECPLOT
Wb 1	ON	7	OFF
Wb 2	ON	7	OFF
Wb 3	ON	7	OFF

[For the Excel version see the next section.]

Related Cards and Files

[Contour Plot Date](#)
[Contour Plot Frequency](#)
[Contour Plot Filename](#)
[Constituent Output](#)

Contour Plot Dates (CPL DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CPLD	Real	Output dates, <i>Julian day</i>

This card specifies the dates that information is output to the [contour plot file \[CPLFN\]](#). For the **w2_con.npt** control file, if there are more dates than can be specified on one line, then CPLD, a function of waterbody, are continued on the next line without another **CPL DATE** card being specified.

In the Excel control file, CPLD is not a function of waterbody and applies to all waterbodies.

Example

```
CPL DATE    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD
Wb 1        224.5   225.5   226.5   227.5   228.5   229.5   230.5
Wb 2        224.5   225.5   226.5   227.5   228.5   229.5   230.5
Wb 3        224.5   225.5   226.5   227.5   228.5   229.5   230.5
```

[For the Excel version see the next section.]

Related Cards and Files

- [Contour Plot](#)
- [Contour Plot Frequency](#)
- [Contour Plot Filename](#)
- [Constituent Output](#)

Contour Plot Frequency (CPL FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CPLF	Real	Output frequency, days

This card specifies the frequency information is output to the [contour plot file \[CPLFN\]](#). Frequency can be changed at any time during the simulation by specifying appropriate dates on the [Contour Plot Date](#) card and frequencies on the **Contour Plot Frequency** card. If output is needed only for the date specified on the [Contour Plot Date](#) card, then set the frequency to be greater than the number of days before the next output date.

For the **w2_con.npt** control file, if there are more frequencies than can be specified on one line, then they are continued on the next line without another **CPL FREQ** card being specified.

In the Excel control file, CPLF is not a function of waterbody and applies to all waterbodies.

Example

```
CPL FREQ    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF
Wb 1        10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0
Wb 2        10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0
Wb 3        10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0
```

CPL PLOT - contour plot output	CPL		
CPLC Specifies if information is output to the contour file, ON or OFF	ON		
NCPL Number of contour plot dates	2		
TECPLOT Turns ON or OFF TECPLOT output format	ON		
CPL DATE- CPLD(NCPL)- starting date of output, output dates	1.5	120.5	
CPL FREQ- CPLF(NCPL)- output frequency-days	7	14	

Related Cards and Files

- [Contour Plot](#)
- [Contour Plot Date](#)
- [Contour Plot Filename](#)
- [Constituent Output](#)

Kinetic Flux Output (FLUXES)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	FLXC	Character	OFF	Specifies if information is sent to the kinetic flux output file, ON or OFF
3	NFLX	Integer		Number of kinetic flux dates

This card specifies if information is output to the [kinetic flux file \[KFLFN\]](#) and the number of kinetic flux intervals for specifying output dates and frequencies. Output of kinetic fluxes to the **TSR** file is dependent on the frequency of the **TSR** file. This file contains kinetic fluxes that allow the user to determine the dominant forcing function responsible for a given constituents increase/decrease in concentrations and is particularly useful during water quality calibration as the user can identify which kinetic processes are most responsible for the model behavior of a given constituent and adjust the rate coefficients correspondingly. The fluxes represent the average flux in kg/day over the time interval of flux output (FLX FREQ) and is in the same output format as the Snapshot [SNP] file. A summation of all active fluxes for each waterbody over all segments and layers is output to another file with a filename “**kflux_wb#.opt**” where # is the waterbody number. This file is also output at the frequency specified for flux output (FLX FREQ). Note that for the **w2_con.npt** control file, FLXC and NFLX are a function of waterbody. *For the Excel control file, FLXC and NFLX are not a function of waterbody and are set for all waterbodies automatically.*

Add Kinetic Flux Output – helps you understand what the model is predicting are the major water quality sources and sinks!

Is dissolved oxygen dominated by reaeration or by algae production or by nitrification?

Example

```
FLUXES      FLXC      NFLX
Wb 1        ON       1
Wb 2        OFF      0
Wb 3        OFF      0
```

[For the Excel version see the next section.]

Related Cards and Files

[Kinetic Flux Date](#)

[Kinetic Flux Frequency](#)

[Kinetic Flux Filename](#)

Kinetic Flux Date (KFL DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	KFLD	Real	Output dates, Julian day

This card specifies the dates that information is output to the [kinetic flux file \[KFLFN\]](#). For the w2_con.npt control file, if there are more dates than can be specified on one line, then they are continued on the next line without another **KFL DATE** card being specified. *For the Excel control file, KFLD is not a function of waterbody and is continued on one row.*

Example

```
FLX DATE      FLXD      FLXD      FLXD      FLXD      FLXD      FLXD      FLXD      FLXD
Wb 1          1.0
Wb 2
Wb 3
```

[For the Excel version see the next section.]

Related Cards and Files

[Kinetic Flux Output](#)

[Kinetic Flux Frequency](#)

[Kinetic Flux Filename](#)

Kinetic Flux Frequency (FLX FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	FLXF	Real	Output frequency, days

This card specifies the frequency information is output to the [kinetic flux file \[KFLFN\]](#). For the w2_con.npt control file, if there are more dates than can be specified on one line, then they are continued on the next line without another **KFL FREQ** card being specified. If output is needed only for the date specified on the [Kinetic Flux Date](#) card, then set the frequency to be greater than the number of days before the next output date. *For the Excel control file, KFLF is not a function of waterbody and is continued on one row.*

Example

```
FLX FREQ      FLXF      FLXF      FLXF      FLXF      FLXF      FLXF      FLXF      FLXF
Wb 1          7.0
Wb 2
Wb 3
```

OUTPUT CONTROL

CONTROL FILE

FLUXES- water quality kinetic flux output	FLUX		
FLXC Specifies if information is sent to the kinetic flux output file, ON or OFF	ON		
NFLX Number of kinetic flux dates	2		
FLX DATE- FLXD(NFLX)- starting date of output in Julian days	1.0	180.0	
FLX FREQ- FLXF(NFLX)- output frequency days	60	10.0	

Related Cards and Files

[Kinetic Flux Output](#)

[Kinetic Flux Date](#)

[Kinetic Flux Filename](#)

Time Series Plot (TSR PLOT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	TSRC	Character	OFF	Specifies if information is written to time series file, ON or OFF
3	NTSR	Integer		Number of time series dates
4	NITSR	Integer		Number of time series computational cells

This card specifies if information is output to the [times series file \[TSRFN\]](#) the number of time series intervals for specifying output dates and frequencies, and the number of time series computational cells for which information will be output.

Add Time Series Output – ‘super’ sensors in your water body and easily graph them in Excel.

Time series output consists of the Julian date, timestep, water surface elevation, temperature, flow rate (vertically integrated segment flow rate at the specified model segment), shortwave solar radiation (net) incident on the surface (i.e., it does not include the reflected solar), light extinction coefficient (m^{-1}), depth to bottom of channel (m), surface width (m), shade fraction (1.0 is no shade, 0.0 is 100% reduction in solar radiation), vertically volume-weighted temperature at the specified model segment, net radiation at surface of segment (W/m^2), short wave solar net coming into the water surface (W/m^2) (SRON accounts for cloud cover but not reflection, usually 6%, at the water surface; SWSolar[short-wave] accounts for cloud cover, reflection and shade effects and is the net entering the water body surface), long wave radiation in net at surface (W/m^2), back radiation at surface (W/m^2), evaporative heat flux at surface (W/m^2), conductive heat flux at surface (W/m^2), reaeration coefficient (day^{-1}) predicted by the model at the segment of the TSR file, active constituents, derived constituents, kinetic fluxes as specified in the CST flux card (fluxes are in units of kg/day), algae growth rate limitation fraction for P, N, and light [0 to 1] for each algal group if LIMC is turned on under the CST COMP card, and epiphyton growth rate limitation fraction for P, N, and light [0 to 1] for each epiphyton group. Note that the kinetic fluxes in the TSR file are instantaneous flux rates, whereas those fluxes shown in the kinetic flux file are averages over the time interval or frequency of output. The constituent concentrations output are the constituents specified for output on the [Constituent Output](#) card. The derived constituent concentrations output are the constituents specified on the [Derived Constituent](#) card.

Example

```
TSR PLOT      TSRC      NTSR      NITSR
          OFF           0           0
```

[For the Excel version see the next section.]

Related Cards and Files

- [Time Series Date](#)
- [Time Series Frequency](#)
- [Time Series Segment](#)
- [Time Series Elevation](#)

OUTPUT CONTROL

CONTROL FILE

[Constituent Output](#)

Time Series Date (TSR DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TSRD	Real	Output dates, Julian day

This card specifies the dates that information is output to the [times series file \[TSRFN\]](#). For the **w2_con.npt** control file, if there are more dates than can be specified on one line, then they are continued on the next line without another **TSR DATE** card being specified. *For the Excel control file, TRSD is not a function of waterbody and is continued on one row.*

Example

TSR DATE	TSRD							
	63.5							

[For the Excel version see the next section.]

Related Cards and Files

[Time Series Plot](#) [Time Series Frequency](#) [Time Series Segment](#)
[Time Series Elevation](#) [Constituent Output](#)

Time Series Frequency (TSR FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TSRF	Real	Output frequency, days

This card specifies the frequency information is output to the [times series file \[TSRFN\]](#). Frequency can be changed at any time during the simulation by specifying the dates on the [Time Series Date](#) card and the frequencies on the **Time Series Frequency** card. If output is needed only for the date specified on the [Time Series Date](#) card, then set the frequency to be greater than the number of days before the next output date.

For the control file **w2_con.npt**, if there are more frequencies than can be specified on one line, then they are continued on the next line without another **TSR FREQ** card being specified. *For the Excel control file, TRSF is not a function of waterbody and is continued on one row.*

Example

TSR FREQ	TSRF							
	1.00							

[For the Excel version see the next section.]

Related Cards and Files

[Time Series Plot](#) [Time Series Date](#)
[Time Series Segment](#) [Time Series Elevation](#)
[Constituent Output](#)

Time Series Segment (TSR SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ITSR	Integer	Output segments

This card, along with the [Time Series Elevation](#) card, defines which computational cells are output to the [times series file \[TSRFN\]](#). To specify multiple cells in a segment, the segment number must be duplicated for each computational cell to be output. For the control file **w2_con.npt**, if there are more segments than can be specified on one line, then they are continued on the next line without another **TSR SEG** card being specified. *For the Excel control file, ITSR is continued on one row.*

Example

```
TSR SEG      ITSR      ITSR      ITSR      ITSR      ITSR      ITSR      ITSR      ITSR
          20       23       26       30       30
```

[For the Excel version see the next section.]

Related Cards and Files

[Time Series Plot](#) [Time Series Date](#) [Time Series Frequency](#)
[Time Series Elevation](#) [Constituent Output](#)

Time Series Elevation (TSR ELEV)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ETSR	Real	Depth below water surface in m (if positive) or layer number (if negative) corresponding to time series segment

This card specifies the elevation from the water surface that corresponds to the segment [**ITSR**] specified on the [Time Series Segment](#) card. Specifying a negative number results in the layer number being used for the vertical location. For example, setting [ETSR] to -5.0 results in output from layer 5; setting [ESTR] to 0.0 is at the water surface; and setting [ESTR] to 1.5 is 1.5 m below the water surface. For the control file **w2_con.npt**, if there are more elevations than can be specified on one line, then they are continued on the next line without another **TSR ELEV** card being specified. *For the Excel control file, ETSR is continued on one row.*

Example

```
TSR ELEV      ETSR      ETSR      ETSR      ETSR      ETSR      ETSR      ETSR      ETSR
          1.0       5.0      10.0     -5.0     -8.0
```

The Excel control file also includes the variable, TSRFN, which is the file name of the TSR file providing the prefix and suffix for the model to write out the TSR files. The file prefix, 'tsr' is the file prefix for all tsr files. Also, the file type (in this example, 'csv') is used for all tsr files. The tsr file names include the number of

CONTROL FILE

OUTPUT CONTROL

the tsr file and the segment number. Note that in Windows one can use ‘.\Subdirectory\Filename’ to specify a model subdirectory in the working directory and a filename.

TSR PLOT- time series plot output	TSR	
TSRC- time series ON or OFF	ON	
NTSR- # of time series dates	1	
NITSR- # of locations for the time series output	2	
TSR FILE TSRFN time series output file name prefix and suffix	tsr.csv	
TSR DATE- TSRD(NTSR)- start date of output in Julian days	1	
TSR FREQ- TSRF(NTSR)- frequency of output in days	0.1	
TSR SEG- ITSR(NITSR)- segment number of time series output	31	39
TSR LAYER- ETSR(NITSR)- depth or layer# of time series output	0	-5

Related Cards and Files

[Time Series Plot](#)

[Time Series Date](#)

[Time Series Frequency](#)

[Time Series Segment](#)

[Constituent Output](#)

Water Level Output (WL OUT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	WLC	Character	OFF	Specifies if information is written to water level output file, ON or OFF
3	WLFREQ	Real		Frequency in days for writing out water level file.

This control specifies whether to write out a file with all segment water level at a given frequency. This file is useful for plotting water level dynamically for the model domain at every model segment. The output file format is described in the output file section.

Example:

```
WLOUT      WLC   WLFREQ
          ON     0.5
```

Or in spreadsheet format:

Water level output	WLEVEL
WLC- time series of water levels ON or OFF at all segments	ON
WL FREQ- WLF- frequency of output in days	0.1

Flow Balance Output (FB OUT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	FLOWBALC	Character	OFF	Specifies if information is written to flow balance output file, ON or OFF
3	FLOWBALF	Real		Frequency in days for writing out flow balance file.

This control specifies whether to write out a file with dynamic summation of water sources and sinks at a given frequency. The output file format is described in the output file section.

Example:

```
FLOWBAL    FLOWBC  FBFREQ
          ON     7.0
```

Or in spreadsheet format:

Flow balance output	FLOWBAL
FLOWBALC- time series of water levels ON or OFF at all segments	ON
FLOWBAL FREQ- FLOWBALF- frequency of output in days	7

N and P Mass Balance Output (NPB OUT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	NPBALC	Character	OFF	Specifies if information is written to N and P balance output file, ON or OFF
3	NPBALF	Real		Frequency in days for writing out flow balance file.

This control specifies whether to write out a file with dynamic summation of N and P sources and sinks at a given frequency. The output file format is described in the output file section. The Mass Balance control (MBC) must also be turned ON for this to be output (see [Calculations \(CALCULAT\)](#)).

Example:

```
NPBAL      NPBALC  NPBFRQ
          ON        7.0
```

Or in spreadsheet format:

N and P mass balance output	NPBAL
NPBALC- time series of water levels ON or OFF at all segments	ON
NP Balance FREQ- NPBALF- frequency of output in days	7

Withdrawal Output (WITH OUT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	WDOC	Character	OFF	Specifies if information is written to withdrawal output file, ON or ONH or ONS or OFF
3	NWDO	Integer		Number of withdrawal output dates
4	NIWDO	Integer		Number of withdrawal output segments
5	WDOFN	Character		This specifies the output file name embedded in the output file as well as the subdirectory and file suffix.

This card specifies if information is output to a separate [withdrawal outflow file \[WDOFN\]](#) for outflow, outflow temperature, outflow constituent concentrations, and outflow derived constituent concentrations. This option is useful for comparing time series results of these variables and for providing input files for downstream models that may be a separate model. The names of the outflow files are appended with the segment number to differentiate each of the files.

Withdrawal Output – finally you can see the mixed water quality and temperature of any withdrawal from the system. Since the model computes a withdrawal envelope for each withdrawal, you cannot predict the outlet conditions by just putting a probe at the centerline of the withdrawal.

The model user can specify for [WDOC] ON which implies using that the withdrawal frequency, **WDOF**, on following card is in days. If **ONH** is used, the **WDOF** is in hours. If **ONS** is used, **WDOF** is in seconds.

The information can also be used to link output from one waterbody to a downstream waterbody. The model uses the minimum timestep necessary to maintain numerical stability throughout the entire system. In many cases, breaking up a system of waterbodies into separate models can allow each waterbody to run at its own minimum rather than being restricted by a minimum in another waterbody. These output files can be used directly as input files for the downstream waterbodies. When using this option, the user should investigate if the frequency of output file from the upstream waterbody is the same as the integrated response, since the wdo output is instantaneous rather than an average between output. As a result, *WDO output files are not multiplied by CMULT or CDMULT, output multipliers, as is the case for the SNP and TSR output files.*

If there is one output located at the withdrawal output segment [**IWDO**], like a structure, the output files will be called **q_AAA_segXX.YYY**, **t_AAA_segXX.YYY**, **c_AAA_segXX.YYY**, and **d_AAA_segXX.YYY**, where XX is the segment number, q is for flow, t is for temperature, c is for concentration, d is for derived concentrations, AAA is the withdrawal output file name entered for **WDOFN**, and YYY is the filetype given for the wdo output file (if one chooses, **wdo.csv**, then YYY=csv). If there is a structure, withdrawal and a pump at this segment, the combined flows and flow-averaged temperature and concentrations will be written to these files. In addition, output files are written for each separate outlet. In this case there will also be written the following files (if WDO output is **wdo.csv**): **qwo_str1_segXX.csv**, **qwo_wd1_segXX.csv**, **qwo_pmp1_segXX.csv**, **two_str1_segXX.csv**, **two_wd1_segXX.csv**, **two_pmp1_segXX.csv**, **cwo_str1_segXX.csv**, **cwo_wd1_segXX.csv**, **cwo_pmp1_segXX.csv**, and similarly for the derived concentrations for the structure, withdrawal and pump withdrawals. Similarly named output files are provided for gates, spillways and pipes if they are located at the withdrawal output segment [**IWDO**].

Example

WITH OUT	WDOC	NWDO	NIWDO
	ON	1	2

The Excel version of these variables is shown in the next section.

Related Cards and Files

[Withdrawal Output Date](#) [Withdrawal Output Frequency](#) [Withdrawal Output Segment](#)

Withdrawal Output Date (WDO DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2	WDOD	Real	Output dates, Julian day

This card specifies the dates information is output to the [withdrawal outflow file \[WDOFN\]](#). For the **w2_con.npt** file, if there are more dates than can be specified on one line, then they are continued on the next line without another **WDO DATE** card being specified. This is not the case though for the Excel input file where values continue along a row.

Example

WDO DATE	WDOD							
	63.5							

The Excel version of these variables is shown in the next section.

Related Cards and Files

[Withdrawal Output](#)

[Withdrawal Output Frequency](#)
[Withdrawal Output Segment](#)

Withdrawal Output Frequency (WDO FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	WDOF	Real	Output frequency, days if WDOC=ON or hours if WDOC=ONH or seconds if WDOC=ONS

This card specifies the frequency information is output to the [withdrawal outflow file \[WDOFN\]](#). Frequency can be changed at any time during the simulation by specifying the dates on the [Withdrawal Output Date](#) card and the frequencies on the [Withdrawal Output Frequency](#) card. If output is needed only for the date specified on the [Withdrawal Output Date](#) card, then set the frequency to be greater than the number of days before the next output date.

For the control file, w2_con.npt, if there are more frequencies than can be specified on one line, then they are continued on the next line without another **WDO FREQ** card being specified. This is not the case though for the Excel input file where values continue along a row.

Example

```
WDO FREQ      WDOF      WDOF      WDOF      WDOF      WDOF      WDOF      WDOF      WDOF      WDOF
          0.2
```

The Excel version of these variables is shown in the next section.

Related Cards and Files

[Withdrawal Output](#)
[Withdrawal Output Date](#)
[Withdrawal Output Segment](#)

Withdrawal Output Segment (WITH SEG)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	IWDO	Integer	Output segments

This card specifies model segments for which information is output to the withdrawal output file [[WDOFN](#)]. If a downstream segment of a reservoir is specified, then information is output at the frequency specified in the [Withdrawal Output Frequency](#) card that can be used as input files to a waterbody downstream of the reservoir.

For the control file, w2_con.npt, if there are more segments than can be specified on one line, then they are continued on the next line without another **WITH SEG** card being specified. This is not the case though for the Excel input file where values continue along a row.

OUTPUT CONTROL

CONTROL FILE

Example

```
WITH SEG    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT    IWDOUT  
      30          32
```

The spreadsheet version of this series of cards for the withdrawal output is summarized below. Note that an extra variable, WDOFN is included in this section. WDOFN specifies the withdrawal output filename suffix and prefix. The file prefix, 'wdo_model1' is used in the output name for all wdo files for flow ('q'), temperature ('t'), concentration ('c') or derived concentrations ('d'). Whatever the file type specified below will be used as the file type for all wdo files. In the example below, all wdo files will have a csv filetype. Note that in Windows one can use for example '.\wdofiles\wdo_model1.csv' to specify a model subdirectory, 'wdofiles' in the working directory with a file suffix of 'csv'. These files will be named: q_wdo_model1.csv, t_wdo_model1.csv, etc.

WITH OUTPUT- withdrawal output	WDO	
WDOC- withdrawal output ON or OFF	ON	
NWDO- # of withdrawal output dates	2	
NIWDO- # of withdrawal output segments	2	
WDO FILE WDOFN withdrawal output file name prefix and suffix	.\\wdofiles\\wdo_model1.csv	
WITH DAT- WDOD(NWDO)- start date of output in Julian days	1	1
WITH FREQ- WDOF(NWDO)- frequency of output days	0.1	0.01
WITH SEG- IWDO(NIWDO)- segment number of withdrawal	31	48

Related Cards and Files

[Withdrawal Output](#)

[Withdrawal Output Date](#)

[Withdrawal Output Frequency](#)

Restart (RESTART)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	RSOC	Character	OFF	Specifies if information is output to a restart file, ON or OFF
3	NRSO	Integer		Number of restart dates
4	RSIC	Character	OFF	Specifies if information is input from a restart file, ON or OFF

This card specifies if information is output to the restart output file [[RSOFN](#)] or read into the model from a previously output restart file [[RSIFN](#)] and the number of restart dates.

Restart is a powerful tool if you have a long running simulation and you want to run it again without having to start at the beginning.

Example

```
RESTART      RSOC      NRSO      RSIC  
           ON          2        OFF
```

The Excel version of these variables is shown in the next section.

CONTROL FILE

OUTPUT CONTROL

Related Cards and Files

[Restart Date](#)

[Restart Frequency](#)

Restart Date (RSO DATE)

FIELD	NAME	VALUE	DESCRIPTION
1			(ignored by code)
2-10	RSOD	Real	Output dates, Julian day

This card specifies dates information is output to the restart file [[RSOFN](#)]. For the control file w2_con.npt, if there are more dates than can be specified on one line, then they are continued on the next line without another **RSO DATE** card being specified. This is not the case though for the Excel input file where values continue along a row.

Example

```
RSO DATE      RSOD      RSOD      RSOD      RSOD      RSOD      RSOD      RSOD      RSOD      RSOD
          224.5    230.5
```

Related Cards and Files

[Restart](#)

[Restart Frequency](#)

Restart Frequency (RSO FREQ)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	RSOF	Real	Output frequency, <i>days</i>

This card specifies the frequency information is output to the restart plot file [[RSOFN](#)]. Frequencies can be changed at any time during the simulation by specifying the appropriate dates on the [Restart Date](#) card and frequencies on the Restart Frequency card. If output is needed only for the date specified on the [Restart Date](#) card, then set the frequency to be greater than the number of days before the next output date.

For the control file w2_con.npt, if there are more frequencies than can be specified on one line, then they are continued on the next line without another **RSO FREQ** card being specified. This is not the case though for the Excel input file where values continue along a row.

Example

```
RSO FREQ      RSOF      RSOF      RSOF      RSOF      RSOF      RSOF      RSOF      RSOF
          100.0    100.0
```

The Excel version of all the restart parameters is shown below. The Excel version also includes the RSIFN, or the restart input file name (this can be any file name and is usually the name of the file that was written out previously). This file is read in if RSIC is ON. In this case the rso150.opt is a restart file written out previously on JDAY 150. Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename. If RSOC is ON, then RSO DATE is the first date that a restart file is written out (in this case it starts on JDAY 1), and RSO FREQ is the frequency that the output is written starting with RSO DATE (in this case a frequency of every 50 days).

RESTART	RESTART
RSOC- Restart control ON or OFF- for writing restart files	ON
NRSO- # of restart dates and frequencies of output	1
RSIC- Restart read in control- ON or OFF- read in a restart file	ON
RSI FILE RSIFN- restart in file name	rso150.opt
RSO DATE- RSOD(NRSO) - output dates in Julian days	1
RSO FREQ- RSOF(NRSO) - frequency of output in days	50

Related Cards and Files

[Restart](#)

[Restart Date](#)

Constituent Computations (CST COMP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CCC	Character	OFF	Specifies if constituents are computed, ON or OFF
3	LIMC	Character	OFF	Output algal growth limiting factor, ON or OFF
4	CUF	Real	2	Frequency which constituent kinetics are updated if > 0. If <0, this is the time between kinetics updates in JDAY.
5	CO2PPM	Real	415.	User input CO2 in ppm for gas concentration of CO2. The default value is dependent on the year of the simulation. In 2020 the average global CO2 gas concentration in ppm was over 415.
6	CO2YRLY	Character	ON	This variable turns ON or OFF the built-in regression equations to determine CO2PPM from global average data from NOAA between 1920 and 2019.

This card starts the specification of constituent computations. [CCC] determines if constituent computations are performed. If this variable is turned off, then constituent computations are not performed and all information specified on the remaining constituent control cards is ignored. Individual constituent computations are controlled on the [Active Constituents](#) card. During the initial calibration runs for freshwater systems, constituent computations are usually turned off until temperature, water surface elevations, and velocities are calibrated.

*Turn ON/OFF Water Quality Constituents
Limiting Nutrient in SNP and TSR files
Water Quality Kinetic Computation Frequency
CO2 Gas Atmospheric Concentration*

The [LIMC] variable specifies whether the factor limiting algal growth is output to the [snapshot file \[SNPFN\]](#) and to the [Time Series file \[TSRFN\]](#). The limiting factor (between 0 and 1) for N, P, and light is written to these files.

The model allows the user to update constituent kinetics at a different frequency than constituent transport. The constituent update frequency [CUF] specifies how many transport iterations are performed before constituent kinetics are updated if CUF is positive. This option is included primarily to reduce computation time. This variable should be set to one during initial calibration. If computation time is of concern, [CUF] can be increased until water quality results begin to deviate. Model results should not be a function of the timestep used during the simulation.

If [CUF] is negative, this is a more controlled method to reduce the update kinetics of a constituent. Hence, if [CUF] = -0.01, then this means that the constituents will be updated every 0.01 days or 14.4 min. Hence, if the hydrodynamics require a numerical stability of 10 s in a river model, then the model user may not need to update kinetics every 10 s. This as mentioned above can save computational time.

[CO2PPM] is the gas concentration of CO2 in the atmosphere in ppm. This is used to compute the partial pressure of CO2 gas in atm using relationships shown in User Manual Part 2. This value is ignored if [CO2YRLY] is ON. [CO2YRLY] turns ON or OFF using a regression equation for the global average CO2 in ppm

between 1920 and 2019. This regression equation is shown in the User Manual Part 2. These two variables only affect the computation of Total Inorganic C (TIC) and hence pH calculations. They have no impact on the model if TIC and pH are not active variables.

For the **w2_con.npt** and the Excel input file, active constituents must be in the following order as shown in Table 9. Only for the **w2_con.npt** file, the **graph.npt** file listing of constituents must be the same as that in the control file even if the constituents are not active. For the Excel file, there is no need for the **graph.npt** file. A typical example of a list of constituents is shown in Table 10. In the Excel control file, there is a separate tab that computes the required constituents for inclusion in the control file.

Table 9. List of active constituents and their proper order in the control file.

Required Constituent order	Constituent
	TDS (g/m3 or mg/l) or salinity (kg/m3) depending on variable waterbody type [WTYPEC]. If
1	[FRESH], then TDS, or if [SALT], salinity.
	Generic constituents, such as tracers or organics – user defined number of groups set by
2	[NGC]
3	Inorganic suspended solids, mg/l – user defined number of groups set by [NSS]
4	Water Age, days
5	Bacteria, col/100 ml
6	Dissolved Gas Pressure DGP, atm
7	N2 gas, mg/l
8	H2S, mg/l
9	CH4, mg/l
10	SO4, mg/l
11	FEII, mg/l
12	FEOOH, mg/l
13	MnII, mg/l
14	MnO2, mg/l
15	PO4-P, mg/l as P
16	NH4-N, mg/l as N
17	NO3-N + NO2-N, mg/l as N
18	Dissolved silica, mg/l as Si
19	Particulate silica, mg/l as Si
20	LDOM, mg/l as organic matter
21	RDOM, mg/l as organic matter
22	LPOM, mg/l as organic matter
23	RPOM, mg/l as organic matter
24	CBOD - user defined number of groups, mg/l as O2, set by [NBOD]
25	CBOD-P – user defined number of groups, mg/l as P, set by [NBOD]
26	CBOD-N – user defined number of groups, mg/l as N, set by [NBOD]
27	Algae - user defined number of groups, mg/l as dry weight organic matter, set by [NAL]
28	Dissolved oxygen, mg/l
29	TIC, mg/l as C
30	Alkalinity, mg/l as CaCO3

CONTROL FILE**CONSTITUENT CONTROL**

Required Constituent order	Constituent
31	Zooplankton - user defined number of groups, mg/l dry weight organic matter, set by [NZP]
32	LDOM-P, mg/l as P
33	RDOM-P, mg/l as P
34	LPOM-P, mg/l as P
35	RPOM-P, mg/l as P
36	LDOM-N, mg/l as N
37	RDOM-N, mg/l as N
38	LPOM-N, mg/l as N
39	RPOM-N, mg/l as N
40	MICROCYSTIN
41	CYLINDROSPERMOPSN
42	ANATOXIN-A
43	SAXITOXIN

Table 10. Typical list of constituents given NGC=3, NSS=2, NBOD=2, NAL=3, and NZP=1. Note that the short name has no spaces or commas. The long name must have a comma between the variable name and the units, but no other commas.

Required or optional constituent	Short name	Name of Constituent
Required	TDS	"TDS, g/m^3"
	Gen1	"Tracer, g/m^3"
	Gen2	"Conductivity, mhos"
	Gen3	"Chloride, mg/l"
	ISS1	"ISS, g/m^3"
	ISS2	"ISS, g/m^3"
Required	WaterAge	"Age, days"
Required	Bacteria	"Bacteria, col/100ml"
Required	DGP	"Dissolved Gas Pressure, atm"
Required	N2	"N2 dissolved gas, mg/l"
Required	H2S	"H2S dissolved gas, mg/l"
Required	CH4	"CH4 dissolved gas, mg/l"
Required	SO4	"SO4 dissolved, mg/l"
Required	FEII	"Reduced FE(II), mg/l"
Required	FEOOH	"Oxidized FeOOH, mg/l"
Required	MnII	"Reduced Mn(II), mg/l"
Required	MnO2	"Oxidized MnO2, mg/l"
Required	PO4	"Phosphate, g/m^3"
Required	NH4	"Ammonium, g/m^3"
Required	NO3	"Nitrate-Nitrite, g/m^3"

CONSTITUENT CONTROL

CONTROL FILE

Required or optional constituent	Short name	Name of Constituent
Required	DSI	"Dissolved silica, g/m^3"
Required	PSI	"Particulate silica, g/m^3"
Required	LDOM	"Labile DOM, g/m^3"
Required	RDOM	"Refractory DOM, g/m^3"
Required	LPOM	"Labile POM, g/m^3"
Required	RPOM	"Refractory POM, g/m^3"
	BOD1	"1CBOD, g/m^3"
	BOD2	"2CBOD, g/m^3"
	BODP1	"1CBODP, g/m^3"
	BODP2	"2CBODP, g/m^3"
	BODN1	"1CBODN, g/m^3"
	BODN2	"2CBODN, g/m^3"
	ALG1	"Algae1 Diatoms, g/m^3"
	ALG2	"Algae2 Greens, g/m^3"
	ALG3	"Algae3 Cyanobacteria, g/m^3"
Required	DO	"Dissolved oxygen, g/m^3"
Required	TIC	"Inorganic carbon, g/m^3"
Required	ALK	"Alkalinity, g/m^3"
	ZOO1	"Zooplankton1, g/m^3"
Required	LDOM-P	"LDOM P, g/m^3"
Required	RDOM-P	"RDOM P, g/m^3"
Required	LPOM-P	"LPOM P, g/m^3"
Required	RPOM-P	"RPOM P, g/m^3"
Required	LDOM-N	"LDOM N, g/m^3"
Required	RDOM-N	"RDOM N, g/m^3"
Required	LPOM-N	"LPOM N, g/m^3"
Required	RPOM-N	"RPOM N, g/m^3"
Required	MICROCYSTIN	"Microcystin, g/m^3"
Required	CYLINDRO-SPERMOPSIN	"Cylindrospermopsin, g/m^3"
Required	ANATOXIN-A	"Anatoxin-A, g/m^3"
Required	SAXITOXIN	"Saxitoxin, g/m^3"

Example

```
CST COMP      CCC      LIMC      CUF      CO2PPM CO2YRLY
          ON       OFF        10       415.      ON
```

CST COMP - Water quality computations	CCC	LIMC	CUF	CO2PPM	CO2YRLY
CCC: Turn ON or OFF water quality calculations, LIMC: Limiting nutrient computation ON or OFF, recalculate WQ kinetics every CUF hydrodynamic time steps;CO2PPM,CO2YRLY	ON	ON	1	400	ON

CONTROL FILE

CONSTITUENT CONTROL

Related Cards and Files

[Active Constituents](#)
[Constituent Initial Concentration](#)
[Constituent Output](#)
[Inflow Active Constituent Control](#)
[Tributary Active Constituent Control](#)
[Distributed Tributary Active Constituent Control](#)
[Precipitation Active Constituent Control](#)

Atmospheric Deposition (ATMDEP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ATMDPC	Character	OFF	Specifies if atmospheric deposition files are read in or not, ON or OFF
3	ATMDPIN	Character	ON	Turns on interpolation between values, ON or OFF

These variables turn ON or OFF atmospheric deposition input files [ATMDPC] and if they are read in whether interpolation is used between values in the input file [ATMDPIN]. These variables are a function of waterbody. The atmospheric deposition file accounts for dry deposition of state variables into the waterbody. The precipitation input files can account for wet deposition. If precipitation is not used as an input, this can be the total deposition rate to the waterbody. For a description of the atmospheric input file see [Atmospheric Deposition Input File](#).

Example

```
ATMDEP    ATMDPC  ATMDPIN
WB1        OFF      ON
WB2        ON       ON
```

ATMOSPHERIC DEPOSITION	WB1	WB2	WB3
Atm_DepositionC - turn ON/OFF mass loading for each water body	ON	OFF	
Atm_Deposition_Interpolation - Interpolate between values ON/OFF	ON	OFF	

Active Constituents (CST ACTIVE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CAC	Character	OFF	Specifies if calculations are to be performed for this constituent, ON or OFF

CAC specifies which constituents are included in water quality calculations. The user has the flexibility to include any number of generic, inorganic suspended solids, algal, periphyton/epiphyton groups, macrophyte, zooplankton and CBOD groups. The number of these groups is specified on the [Constituent Dimension](#) card. The generic constituent can be used to simulate any number of constituents that can be defined with any of the following: zero-order decay rate, a first order decay rate, a settling velocity, an Arhennius temperature rate multiplier, volatilization, and photo-degradation.

Active constituents listed here must agree with the graph.npt file list if you are using the fixed format w2_con.npt input file. The preprocessor will catch this error and give guidance on how to make the 2 lists agree. Using the Excel version of the control file eliminates this additional step.

The user has the flexibility of including/excluding any of the constituent state variables. The constituent kinetics are strongly coupled and failure to include one or more constituents can have far reaching effects that are hard to determine beforehand, so use this option carefully.

Note that if the user has CBOD groups and if BODP and BODN are OFF, the model uses the stoichiometric coefficients in the CBOD STOICH card to compute the fixed N and P content of each CBOD organic matter group.

The [Constituents Computation](#) section shows the required order of the active constituents. This order is the same order required for the **graph.npt** file if you use the fixed format **w2_con.npt** control file.

The Excel input control file includes CAC and other variables that are included in the sections below and parameters that were defined in the **graph.npt** file, which is no longer needed.

CONSTITUENT CONTROL

CONTROL FILE

Example

```
CST ACTIVE    CAC
TDS          ON
Gen1         ON
Gen2         ON
Gen3         ON
ISS1          ON
WATERAGE     OFF
BACTERIA     OFF
DGP           OFF
N2            OFF
H2S           OFF
CH4           OFF
SO4           OFF
FEII          OFF
FEOOH         OFF
MNII          OFF
MNO2          OFF
PO4           ON
NH4           ON
NO3           ON
DSI            OFF
PSI            OFF
FE             ON
LDOM          ON
RDOM          ON
LPOM          ON
RPOM          OFF
ALG1          ON
DO             ON
TIC            ON
ALK            ON
ZOO1          OFF
LDOM_P        OFF
RDOM_P        OFF
LPOM_P        OFF
RPOM_P        OFF
LDOM_N        OFF
RDOM_N        OFF
LPOM_N        OFF
RPOM_N        OFF
MICROCYNS    OFF
CYLINDRO     OFF
ANATOXIN     OFF
SAXITOZN     OFF
```

[The Excel version is shown in later sections.]

Related Cards and Files

[Constituent Computations](#)
[Constituent Initial Concentration](#)
[Constituent Output](#)
[Inflow Active Constituent Control](#)
[Tributary Active Constituent Control](#)
[Distributed Tributary Active Constituent Control](#)
[Precipitation Active Constituent Control](#)

Derived Constituents (CST DERIVE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1	CDNAME2	Character		At the beginning of each derived variable is the short name of the variable (8 characters)
2-10	CDWBC	Character	OFF	Specifies if derived variables are output for each waterbody, ON or OFF

This card allows the user to specify whether certain derived constituents are computed and output in order to compare with observed data. Derived constituents are constituents that are not state variables but are derived from the state variables. They are useful for comparing computed versus observed data for water quality parameters that are not state variables, but that are routinely monitored, such as total Kjeldahl nitrogen, Total N, and Total P.

TN, TP TKN, chlorophyll a, pH, TDG, and other variables can be active and written to output files.

pH computations are treated as derived variables as pH is computed from the total inorganic carbon and alkalinity state variables (as well as temperature). These derived variables are shown in Table 11.

Table 11. List of derived variables in CE-QUAL-W2.

#	Derived variable	Description
1	DOC	Dissolved organic carbon, mg/l as C
2	POC	Particulate organic carbon, mg/l as C
3	TOC	Total organic carbon, mg/l as C
4	DON	Dissolved organic nitrogen, mg/l as N
5	PON	Particulate organic nitrogen, mg/l N
6	TON	Total organic nitrogen, mg/l as N
7	TKN	Total Kjeldahl nitrogen, mg/l as N
8	TN	Total nitrogen, mg/l as N
9	NH3	Unionized ammonia, mg/l
10	DOP	Dissolved organic phosphorus, mg/l P
11	POP	Particulate organic phosphorus, mg/l P
12	TOP	Total organic phosphorus, mg/l as P

#	Derived variable	Description
13	TP	Total phosphorus, mg/l as P
14	APR	Algal production
15	CHLA	Chlorophyll a, µg/l chlorophyll a
16	ATOT	Total algal biomass, mg/l organic matter
17	%DO	Dissolved oxygen saturation, %
18	TDG	Total Dissolved Gas, %
19	Turbidity	Turbidity, NTU
20	TSS	Total suspended solids, mg/l
21	TISS	Total inorganic suspended solids, mg/l
22	CBODU	Total carbonaceous BOD (ultimate)
23	pH	pH
24	CO2	Carbon dioxide, mg/l as C
25	HCO3	Bicarbonate, mg/l as C
26	CO3	Carbonate, mg/l as C
27	Secchi Disk	Secchi disk depth, m

CONSTITUENT CONTROL

CONTROL FILE

Each of the derived variables is computed from parameters and the model state variables. Below is a detailed listing of each derived variable and how they are computed in CE-QUAL-W2.

Dissolved organic carbon: $\delta_C \Phi_{LDOM} + \delta_C \Phi_{RDOM} + \sum \delta_{C-CBOD} \Phi_{CBOD-dissolved}$

Particulate organic carbon: $\delta_C \Phi_{LPOM} + \delta_C \Phi_{RPOM} + \sum \delta_{C-alg ae} \Phi_{alg ae} + \sum \delta_{C-CBOD} \Phi_{CBOD-particulate} + \sum \delta_{C-zooplankton} \Phi_{zooplankton}$

Total organic carbon: $\delta_C \Phi_{LPOM} + \delta_C \Phi_{RPOM} + \sum \delta_{Ca lg ae} \Phi_{alg ae} + \delta_C \Phi_{LDOM} + \delta_C \Phi_{RDOM} + \sum \delta_{C-CBOD} \Phi_{CBOD} + \sum \delta_{C-zooplankton} \Phi_{zooplankton}$

Dissolved organic nitrogen: $\Phi_{LDOM-N} + \Phi_{RDOM-N} + \sum \delta_{N-CBOD} \Phi_{CBOD-dissolved}$

Particulate organic nitrogen: $\Phi_{LPOM-N} + \Phi_{RPOM-N} + \sum \delta_{N-CBOD} \Phi_{CBOD-particulate} + \sum \delta_{Na lg ae} \Phi_{alg ae} + \sum \delta_{N-zooplankton} \Phi_{zooplankton}$

Total organic nitrogen: $\Phi_{LDOM-N} + \Phi_{RDOM-N} + \Phi_{LPOM-N} + \Phi_{RPOM-N} + \sum \delta_{Na lg ae} \Phi_{alg ae} + \sum \delta_{N-CBOD} \Phi_{CBOD} + \sum \delta_{N-zooplankton} \Phi_{zooplankton}$

Total nitrogen: $\Phi_{LDOM-N} + \Phi_{RDOM-N} + \Phi_{LPOM-N} + \Phi_{RPOM-N} + \sum \delta_{Na lg ae} \Phi_{alg ae} + \sum \delta_{N-zooplankton} \Phi_{zooplankton} + \sum \delta_{N-CBOD} \Phi_{CBOD} + \Phi_{NH4} + \Phi_{NO3}$

Total Kheldahl Nitrogen (TKN): $\delta_N \Phi_{LDOM} + \delta_N \Phi_{RDOM} + \delta_N \Phi_{LPOM} + \delta_N \Phi_{RPOM} + \sum \delta_{Na lg ae} \Phi_{alg ae} + \sum \delta_{N-CBOD} \Phi_{CBOD} + \sum \delta_{N-zooplankton} \Phi_{zooplankton} + \Phi_{NH4}$

Dissolved organic phosphorus: $\Phi_{LDOM-P} + \Phi_{RDOM-P} + \sum \delta_{P-CBOD} \Phi_{CBOD-dissolved}$

Particulate organic phosphorus: $\Phi_{LPOM-P} + \Phi_{RPOM-P} + \sum \delta_{Pa lg ae} \Phi_{alg ae} + \sum \delta_{P-CBOD} \Phi_{CBOD-particulate} + \sum \delta_{P-zooplankton} \Phi_{zooplankton}$

Total organic phosphorus: $\Phi_{LDOM-P} + \Phi_{RDOM-P} + \Phi_{LPOM-P} + \Phi_{RPOM-P} + \sum \delta_{Pa lg ae} \Phi_{alg ae} + \sum \delta_{P-CBOD} \Phi_{CBOD} + \sum \delta_{P-zooplankton} \Phi_{zooplankton}$

Total phosphorus: $\Phi_{LDOM-P} + \Phi_{RDOM-P} + \Phi_{LPOM-P} + \Phi_{RPOM-P} + \sum \delta_{Pa lg ae} \Phi_{alg ae} + \sum \delta_{P-CBOD} \Phi_{CBOD} + \sum \delta_{P-zooplankton} \Phi_{zooplankton} + \Phi_{PO4} + [\delta_{PISS} \Phi_{ISS}]$

Carbonaceous BOD_{ultimate}, CBOD_u: $\delta_{OM} \Phi_{RDOM} + \delta_{OM} \Phi_{LDOM} + \sum \delta_{OM} \Phi_{alg ae} + \delta_{OM} \Phi_{LPOM} + \sum \delta_{OM} \Phi_{RPOM} + \sum \Phi_{CBOD} + \sum \delta_{OM} \Phi_{zooplankton}$

Nitrogenous BOD, NBOD: $\delta_{NH4} \Phi_{RDOM-N} + \delta_{NH4} \Phi_{LDOM-N} + \sum \delta_{N-alg ae} \delta_{NH4} \Phi_{alg ae} + \delta_{NH4} \Phi_{LPOM-N} + \delta_{NH4} \Phi_{RPOM-N} + \delta_{NH4} \Phi_{NH4} + \sum \delta_{N-zooplankton} \delta_{NH4} \Phi_{zooplankton} + \sum \delta_{N-CBOD} \delta_{NH4} \Phi_{CBOD}$

Total suspended solids:

$$TSS, \frac{mg}{l} = \sum_i InorganicSuspendedSolids_i + \sum_j AlgaeDryWeightBiomass_j + \sum_k ZooplanktonDryWeightBiomass_k + ParticulateOrganicMatter_labile + ParticulateOrganicMatter_refractory + \sum_m \delta_{CBOD_dryweight} CBOD_{m-particulate}$$

The computations for pH and the carbonate cycle are shown in the User Manual (see Part 2). The TDG is computed from the state variable, DGP (Total Dissolved Gas Pressure) as

$$TDG = 100 \frac{DGP}{PALT}$$

The turbidity is a correlation to Total Suspended Solids (inorganic and organic) and is computed from this relationship: $Turbidity = exp(A_{turbidity} * \ln(TOTSS)) + B_{turbidity}$

CONTROL FILE

CONSTITUENT CONTROL

Secchi disk is computed from the following equation:

$$Secchi = \frac{A_{Secchi}}{\lambda}$$

where:

δ_C : stoichiometric ratio of C to organic matter
 δ_N : stoichiometric ratio of N to organic matter
 δ_P : stoichiometric ratio of P to organic matter
 δ_{PISS} : stoichiometric ratio of P to inorganic matter
 δ_{NH4} : stoichiometric ratio of oxygen to NH4-N
 $\delta_{CBOD_dryweight}$: stoichiometric ratio of dry weight mass to oxygen for particulate CBOD
 Φ_{RDOM} : concentration of refractory dissolved organic matter
 Φ_{LDOM} : concentration of labile dissolved organic matter
 Φ_{algae} : concentration of algae biomass
 $\Phi_{zooplankton}$: concentration of zooplankton biomass
 Φ_{LPOM} : concentration of labile particulate organic matter
 Φ_{RPOM} : concentration of refractory particulate organic matter
 Φ_{PO4} : concentration of dissolved orthophosphorus as P
 Φ_{NO3} : concentration of nitrate and nitrite as N
 Φ_{NH4} : concentration of ammonia as N
 $\Phi_{CBOD-particulate}$: concentration of particulate CBOD. This is determined from any CBOD group that is given a settling velocity > 0.0 m/s.
 $\Phi_{CBOD-dissolved}$: concentration of dissolved CBOD. This is determined from any CBOD group that is given a settling velocity = 0.0 m/s.
 Φ_{CBOD} : concentration of CBOD both dissolved and particulate
 Φ_{ISS} : concentration of inorganic suspended solids
i,j,k,m: number of inorganic suspended solids groups, algae groups, zooplankton groups, and CBOD particulate groups, respectively
DGP: Total dissolved gas pressure, atm
PALT: Atmospheric pressure on water surface, atm
TOTSS: Total inorganic and organic SS, mg/l
 $A_{turbidity}$, $B_{turbidity}$: empirical coefficients for TOTSS and turbidity relationship
 A_{secchi} : Empirical coefficient (see section on light extinction)
 λ : light extinction coefficient, 1/m

Example

CST	DERIVE	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC
DOC	OFF	OFF	OFF			Dissolved organic carbon, mg/l as C			
POC	OFF	OFF	OFF			Particulate organic carbon, mg/l as C			
TOC	OFF	OFF	OFF			Total organic carbon, mg/l as C			
DON	OFF	OFF	OFF			Dissolved organic nitrogen, mg/l as N			
PON	OFF	OFF	OFF			Particulate organic nitrogen, mg/l N			
TON	OFF	OFF	OFF			Total organic nitrogen, mg/l as N			
TKN	OFF	OFF	OFF			Total Kjeldahl nitrogen, mg/l as N			
TN	OFF	OFF	OFF			Total nitrogen, mg/l as N			
NH3	OFF	OFF	OFF			Unionized ammonia, mg/l as N			
DOP	OFF	OFF	OFF			Dissolved organic phosphorus, mg/l P			
POP	OFF	OFF	OFF			Particulate organic phosphorus, mg/l P			
TOP	OFF	OFF	OFF			Total organic phosphorus, mg/l as P			
TP	OFF	OFF	OFF			Total phosphorus, mg/l as P			
APR	OFF	OFF	OFF			Algal production			
CHLA	OFF	OFF	OFF			Chlorophyll a, ug/l chlorophyll a			
ATOT	OFF	OFF	OFF			Total algal biomass, mg/l organic matter			
%DO	OFF	OFF	OFF			Dissolved oxygen saturation, %			

CONSTITUENT CONTROL

CONTROL FILE

TDG	OFF	OFF	OFF	Total dissolved gas, %
TURBIDITY	OFF	OFF	OFF	Turbidity, NTU
TSS	OFF	OFF	OFF	Total suspended solids, mg/l
TISS	OFF	OFF	OFF	Total inorganic suspended solids, mg/l
CBODU	OFF	OFF	OFF	Total carbonaceous BOD (ultimate)
pH	ON	OFF	OFF	pH
CO2	OFF	OFF	OFF	Carbon dioxide, mg/l as C
HCO3	OFF	OFF	OFF	Bicarbonate, mg/l as C
CO3	OFF	OFF	OFF	Carbonate, mg/l as C
Secchi	OFF	OFF	OFF	Secchi disk depth, m

The format for the Excel input file includes the variable, CDNAME, which is the long name of the derived variable, FMTCD, which is the format for output in Fortran output format, and CDMULT, which is a multiplier used to improve the numerical precision of the output only (not the input). The concentration multiplier [CDMULT] is a conversion factor and multiplies the output by the value specified. This is most useful when converting from $g\ m^{-3}$ to $mg\ m^{-3}$ for nutrient values. For the w2_con.npt control file, CDNAME, FMTCD, and CDMULT are in the **graph.npt** file.

CST DERI - Derived concentration state variables, number:27	CDNAME2	CDNAME	FMTCD	CDMULT	CDWBC1	CDWBC2
	DOC	"Dissolved organic carbon, g/m^3 "	(F10.3)	1	OFF	
	POC	"Particulate organic carbon, g/m^3 "	(F10.3)	1	OFF	
	TOC	"Total organic carbon, g/m^3 "	(F10.3)	1	OFF	
	DON	"Dissolved organic nitrogen, g/m^3 "	(F10.4)	1	OFF	
	PON	"Particulate organic nitrogen, g/m^3 "	(F10.4)	1	OFF	
	TON	"Total organic nitrogen, g/m^3 as N "	(F10.4)	1	OFF	
	TKN	"Total Kheldahl Nitrogen, g/m^3 as N "	(F10.4)	1	OFF	
	TN	"Total nitrogen, g/m^3 as N "	(F10.4)	1	ON	
New derived variable NH3, requires pH also	NH3	"Unionized ammonia, g/m3 as N"	(F10.4)	1	ON	
	DOP	"Dissolved organic phosphorus, mg/m^3 "	(F10.4)	1	OFF	
	POP	"Particulate organic phosphorus, mg/m^3 "	(F10.4)	1	OFF	
	TOP	"Total organic phosphorus, mg/m^3 "	(F10.4)	1	OFF	
	TP	"Total phosphorus, mg/m^3 "	(F10.4)	1	ON	
	APR	"Algal production, g/m^2/day "	(F10.3)	1	OFF	
	CHLA	"Chlorophyll a, mg/m^3 "	(F10.3)	1	OFF	

CONTROL FILE**CONSTITUENT CONTROL**

	ATOT	"Total algae, g/m^3 "	(F10.3)	1	OFF	
	%DO	"Oxygen % Gas Satura- tion "	(F10.3)	1	OFF	
Requires DGP being ac- tive	TDG	"Total dissolved gas, % "	(F10.3)	1	OFF	
Computed from correla- tion with SS	Turbidity	"Turbidity, NTU"	(F10.3)	1	ON	
	TSS	"Total suspended Solids, g/m^3 "	(F10.3)	1	ON	
	TISS	"Total Inorganic Sus- pended Solids,g/m^3 "	(F10.3)	1	OFF	
	CBOD	"Carbonaceous Ultimate BOD, g/m^3 "	(F10.3)	1	OFF	
	pH	"pH "	(F10.3)	1	ON	
	CO2	"CO2 "	(F10.3)	1	OFF	
	HCO3	"HCO3 "	(F10.3)	1	OFF	
	CO3	"CO3 "	(F10.3)	1	OFF	
Secchi disk computed from correlation with light extinction coeffi- cient	SECCHI	"Secchi disk depth, m "	(F10.3)	1	ON	

Related Cards and Files[Constituent Computations](#)[Active Constituents](#)

Constituent Kinetic Fluxes (CST FLUX)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CFWBC	Character	OFF	Specifies which kinetic fluxes are output for each waterbody, ON or OFF

The CFWBC allows the user to specify whether constituent kinetic fluxes are ON or OFF for each waterbody. For these to be output from the model, the model user must turn ON kinetic flux output (see [Kinetic Flux Output \(FLUXES\)](#)). This also controls whether the fluxes are output to other files (see [Kinetic Fluxes Output File](#)). For example, if all the fluxes associated with dissolved oxygen in the model are ON, then the user can determine the most important fluxes affecting DO and adjust the kinetic rate coefficients that are significant during calibration. This should greatly reduce the time required for water quality calibration and provide a greater understanding of the kinetic behavior in the model.

Besides the list below, when the user turns ON flux output and also has CH₄ ON as a state variable or sediment diagenesis ON, additional flux terms are automatically turned ON without the model user specifying them. For example, for methane, the flux variables that are turned on include methane decay in the water column, methane O₂ oxidation, methane flux from sediments, and methane gas release. These are described in [Kinetic Fluxes Output File](#).

Note that for the w2_con.npt control file, if the number of waterbodies is greater than 9, the line wraps around. This is not the case in the Excel control file where values (ON or OFF) for each waterbody are continued along one row.

Example

CST FLUX	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC
TISSIN	OFF	OFF	OFF	Total inorganic suspended solids settling, source				
TISSOUT	OFF	OFF	OFF	Total inorganic suspended solids settling, sink				
PO4AR	OFF	OFF	OFF	PO4 from algal respiration, source				
PO4AG	OFF	OFF	OFF	PO4 from algal growth, sink				
PO4AP	OFF	OFF	OFF	Net PO4 algal uptake, source/sink				
PO4ER	OFF	OFF	OFF	PO4 from epiphyton respiration, source				
PO4EG	OFF	OFF	OFF	PO4 from epiphyton growth, sink				
PO4EP	OFF	OFF	OFF	Net PO4 epiphyton uptake, source/sink				
PO4POM	OFF	OFF	OFF	PO4 from particulate organic matter, source				
PO4DOM	OFF	OFF	OFF	PO4 from dissolved organic matter, source				
PO4OM	OFF	OFF	OFF	PO4 from organic matter, source				
PO4SED	OFF	OFF	OFF	PO4 from sediment compartment, source				
PO4SOD	OFF	OFF	OFF	PO4 from 0-order sediment release, source				
PO4SET	OFF	OFF	OFF	Sorbed PO4 from settling, source/sink				
NH4NITR	OFF	OFF	OFF	NH4 from nitrification, sink				
NH4AR	OFF	OFF	OFF	NH4 from algal respiration, source				
NH4AG	OFF	OFF	OFF	NH4 from algal growth, sink				
NH4AP	OFF	OFF	OFF	Net NH4 from algal growth, sink/source				
NH4ER	OFF	OFF	OFF	NH4 from epiphyton respiration, source				
NH4EG	OFF	OFF	OFF	NH4 from epiphyton growth, sink				
NH4EP	OFF	OFF	OFF	Net NH4 from epiphyton growth, sink/source				
NH4POM	OFF	OFF	OFF	NH4 from particulate organic matter, source				
NH4DOM	OFF	OFF	OFF	NH4 from dissolved organic matter, source				
NH4OM	OFF	OFF	OFF	NH4 from organic matter decay, source				
NH4SED	OFF	OFF	OFF	NH4 from sediment compartment, source				
NH4SOD	OFF	OFF	OFF	NH4 from 0-order sediment release, source				
NH3GAS	ON	ON	ON	NH3 volatilization gas loss, sink				
NO3DEN	OFF	OFF	OFF	NO3 from denitrification, sink				
NO3AG	OFF	OFF	OFF	NO3 from algal growth, sink				

CONTROL FILE

CONSTITUENT CONTROL

NO3EG	OFF	OFF	OFF NO3 from epiphyton growth, sink
NO3SED	OFF	OFF	OFF NO3 loss to sediment compartment, sink
DSIAG	OFF	OFF	OFF Dissolved Si from algal growth, sink
DSIEG	OFF	OFF	OFF Dissolved Si from epiphyton growth, sink
DSIPBSI	OFF	OFF	OFF Dissolved Si from particulate biogenic Si, source
DSISED	OFF	OFF	OFF Dissolved Si from sediment compartment, source
DSISOD	OFF	OFF	OFF Dissolved Si from 0-order sediment release, source
DSISET	OFF	OFF	OFF Dissolved Si from sorbed Si settling, source/sink
PBSIAM	OFF	OFF	OFF Particulate biogenic Si from algal mortality, source
PBSINET	OFF	OFF	OFF Particulate biogenic Si from settling, source/sink
PBSIDK	OFF	OFF	OFF Particulate biogenic Si decay, sink
FESET	OFF	OFF	OFF Fe from settling, source/sink
FESED	OFF	OFF	OFF Fe from sediment release, source
LDOMDK	OFF	OFF	OFF Labile DOM decay, sink
LRDOM	OFF	OFF	OFF Labile to refractory DOM decay, sink
RDOMDK	OFF	OFF	OFF Refractory DOM decay, sink
LDOMAP	OFF	OFF	OFF Labile DOM from algal mortality, source
LDOMEPE	OFF	OFF	OFF Labile DOM from epiphyton mortality, source
LPOMDK	OFF	OFF	OFF Labile POM decay, sink
LRPOM	OFF	OFF	OFF Labile to refractory POM decay, sink
RPOMDK	OFF	OFF	OFF Refractory POM decay, sink
LPOMAP	OFF	OFF	OFF Labile POM from algal mortality, source
LPOMSET	OFF	OFF	OFF Labile POM from settling, source/sink
RPOMSET	OFF	OFF	OFF Refractory POM from settling, source/sink
CBODDK	OFF	OFF	OFF CBOD decay, sink
DOAP	OFF	OFF	OFF DO from algal production, source
DOEP	OFF	OFF	OFF DO from epiphyton production, source
DOAR	OFF	OFF	OFF DO from algal respiration, sink
DOER	OFF	OFF	OFF DO from epiphyton respiration, sink
DOPOM	OFF	OFF	OFF DO from POM decay, sink
DODOM	OFF	OFF	OFF DO from DOM decay, sink
DOOM	OFF	OFF	OFF DO from OM decay, sink
DONITR	OFF	OFF	OFF DO from nitrification, sink
DOCBD	OFF	OFF	OFF DO from CBOD decay, sink
DOREAR	OFF	OFF	OFF DO from reaeration, source/sink
DOSED	OFF	OFF	OFF DO from sediment compartment decay, sink
DOSOD	OFF	OFF	OFF DO from 0-order sediment compartment, sink
TICAG	OFF	OFF	OFF Total inorganic carbon from algal growth, sink
TICEG	OFF	OFF	OFF Total inorganic carbon from epiphyton growth, sink
SEDDK	OFF	OFF	OFF Sediment compartment decay, sink
SEDAS	OFF	OFF	OFF Sediment compartment from algal settling, source
SEDLPOM	OFF	OFF	OFF Sediment compartment from LPOM settling, source
SEDSET	OFF	OFF	OFF Sediment compartment from net settling, source/sink
SODDK	OFF	OFF	OFF Sediment compartment from decay, sink

CST FLUX - Turn on fluxes in each waterbody, number:72	KFNAME2	CFWBC1	CFWB2
TISS settling in - source, kg/day	TISSIN	OFF	
TISS settling out - sink, kg/day	TISSOUT	OFF	
PO4 algal respiration - source, kg/day	PO4AR	OFF	
PO4 algal growth - sink, kg/day	PO4AG	OFF	
PO4 algal net- source/sink, kg/day	PO4AP	OFF	
PO4 epiphyton respiration - source, kg/day	PO4ER	OFF	
PO4 epiphyton growth - sink, kg/day	PO4EG	OFF	
PO4 epiphyton net- source/sink, kg/day	PO4EP	OFF	
PO4 POM decay - source, kg/day	PO4POM	OFF	
PO4 DOM decay - source, kg/day	PO4DOM	OFF	
PO4 OM decay - source, kg/day	PO4OM	OFF	
PO4 sediment decay - source, kg/day	PO4SED	OFF	
PO4 SOD release - source, kg/day	PO4SOD	OFF	
PO4 net settling - source/sink, kg/day	PO4SET	OFF	
NH4 nitrification - sink, kg/day	NH4NITR	ON	

CONSTITUENT CONTROL

CONTROL FILE

NH4 algal respiration - source, kg/day	NH4AR	ON
NH4 algal growth - sink, kg/day	NH4AG	ON
NH4 algal net - source/sink, kg/day	NH4AP	ON
NH4 epiphyton respiration - source, kg/day	NH4ER	ON
NH4 epiphyton growth - sink, kg/day	NH4EG	ON
NH4 epiphyton net - source/sink, kg/day	NH4EP	ON
NH4 POM decay - source, kg/day	NH4POM	ON
NH4 DOM decay - source, kg/day	NH4DOM	ON
NH4 OM decay - source, kg/day	NH4OM	ON
NH4 sediment decay - source, kg/day	NH4SED	ON
NH4 SOD release - source, kg/day	NH4SOD	ON
NH3 gas loss - sink, kg/day	NH3GAS	ON
NO3 denitrification - sink, kg/day	NO3DEN	ON
NO3 algal growth - sink, kg/day	NO3AG	ON
NO3 epiphyton growth - sink, kg/day	NO3EG	ON
NO3 sediment uptake - sink, kg/day	NO3SED	ON
DSi algal growth - sink, kg/day	DSIAG	OFF
DSi epiphyton growth - sink, kg/day	DSIEG	OFF
DSi PBSi decay - source, kg/day	DSIPIS	OFF
DSi sediment decay - source, kg/day	DSISED	OFF
DSi SOD release - source, kg/day	DSISOD	OFF
DSi net settling - source/sink, kg/day	DSISET	OFF
PBSi algal mortality - source, kg/day	PSIAM	OFF
PBSi net settling - source/sink, kg/day	PSINET	OFF
PBSi decay - sink, kg/day	PSIDK	OFF
LDOM decay - sink, kg/day	LDOMDK	ON
LDOM decay to RDOM - sink, kg/day	LRDOM	ON
RDOM decay - sink, kg/day	RDOMDK	OFF
LDOM algal mortality - source, kg/day	LDOMAP	OFF
LDOM epiphyton mortality - source, kg/day	LDOMEП	OFF
LPOM decay - sink, kg/day	LPOMDK	OFF
LPOM decay to RPOM - sink, kg/day	LRPOM	OFF
RPOM decay - sink, kg/day	RPOMDK	OFF
LPOM algal production - source, kg/day	LPOMAP	OFF
LPOM epiphyton production - source, kg/day	LPOMEП	OFF
LPOM net settling - source/sink, kg/day	LPOMSET	OFF
RPOM net settling - source/sink, kg/day	RPOMSET	OFF
CBOD decay - sink, kg/day	CBODDK	OFF
DO algal production - source, kg/day	DOAP	OFF
DO algal respiration - sink, kg/day	DOEP	OFF
DO epiphyton production - source, kg/day	DOAR	OFF
DO epiphyton respiration - sink, kg/day	DOER	OFF
DO POM decay - sink, kg/day	DOPOM	OFF
DO DOM decay - sink, kg/day	DODOM	OFF
DO OM decay - sink, kg/day	DOOM	OFF
DO nitrification - sink, kg/day	DONITR	OFF
DO CBOD uptake - sink, kg/day	DOCBOD	OFF
DO reaeration - source/sink, kg/day	DOREAR	ON

CONTROL FILE**CONSTITUENT CONTROL**

DO sediment uptake - sink, kg/day	DOSED	ON	
DO SOD uptake - sink, kg/day	DOSOD	OFF	
TIC algal uptake - sink, kg/day	TICAG	OFF	
TIC epiphyton uptake - sink, kg/day	TICEG	OFF	
Sediment decay - sink, kg/day	SEDDK	OFF	
Sediment algal settling - sink, kg/day	SEDAS	OFF	
Sediment LPOM settling - source,kg/day	SEDLPOM	OFF	
Sediment net settling - source/sink, kg/day	SEDSET	OFF	
SOD decay - sink, kg/day	SODDK	OFF	

Related Cards and Files[Kinetic Fluxes Output File](#)[Constituent Computations](#)[Active Constituents](#)

Constituent Initial Concentration (CST ICON)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	C2IWB	Real	Initializes entire grid to this concentration, or specifies a vertical and/or longitudinal profile be used to initialize grid, usually $g\ m^{-3}$

C2IWB is the initial concentration for each constituent as a function of waterbody. The user has three options. Initial concentrations can be specified as a single value, a single vertical profile which is used to initialize every segment, or a vertical profile for each segment.

Initial condition	[IC2]
Iso-concentration	>or =0.0
Single vertical profile	-1.0
Vertical profile at each segment	-2.0

The format of the **VPR** ([vertical profile file](#)) and the **LPR** ([longitudinal profile file](#)) are shown in the Input file section.

CONTROL FILE

CONSTITUENT CONTROL

Example

CST	ICON	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB
TDS		51.0000								
Gen1		100.000								
Gen2		0.00000								
Gen3		10.0000								
ISS1		2.00000								
WATERAGE		0.0								
BACTERIA		0.0								
DGP		0.0								
N2		0.0								
H2S		0.0								
CH4		0.0								
SO4		0.0								
FEII		0.0								
FEOOH		0.0								
MNII		0.0								
MNO2		0.0								
PO4		0.00100								
NH4		0.00200								
NO3		0.14000								
DSI		0.00000								
PSI		0.00000								
LDOM		0.70000								
RDOM		2.02200								
LPOM		0.10000								
RPOM		0.00000								
ALG1		-1.0000								
DO		-1.0000								
TIC		11.9100								
ALK		31.0000								
ZOO1		0.1000								
LDOM_P		0.0005								
RDOM_P		0.0005								
LPOM_P		0.0005								
RPOM_P		0.0005								
LDOM_N		0.0080								
RDOM_N		0.0080								
LPOM_N		0.0080								
RPOM_N		0.0080								
MICROCYS		0.0								
CYLINDRO		0.0								
ANATOXIN		0.0								
SAXITOXN		0.0								

[See below for Excel input file format for setting initial concentrations.]

Related Cards and Files

- [Constituent Computations](#)
- [Active Constituents](#)
- [Vertical Profile File](#)
- [Longitudinal Profile File](#)

Constituent Output (CST PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CPRWBC	Character	OFF	Specifies which constituents are printed to output files, ON or OFF

CPRWBC, a function of waterbody, specifies which constituents are printed to all the output files for water quality such as the [snapshot file \[SNPFN\]](#), [time series file \[TSRFN\]](#), [profile plot file \[PRFFN\]](#), spreadsheet plot file, withdrawal output, and [contour plot file \[CPLFN\]](#). The user does not have control over which constituents will be sent to an individual file. For the w2_con.npt input file, if there are more than 9 water-bodies the line wraps around. This does not occur in the Excel input file version.

CONTROL FILE

CONSTITUENT CONTROL

Example

CST PRIN	CPRWBC										
TDS	ON										
Gen1	ON										
Gen2	OFF										
Gen3	OFF										
ISS1	ON										
WATERAGE	OFF										
BACTERIA	OFF										
DGP	OFF										
N2	OFF										
H2S	OFF										
CH4	OFF										
SO4	OFF										
FEII	OFF										
FEOOH	OFF										
MNII	OFF										
MNO2	OFF										
PO4	ON										
NH4	ON										
NO3	ON										
DSI	OFF										
PSI	OFF										
LDOM	ON										
RDOM	ON										
LPOM	ON										
RPOM	OFF										
ALG1	ON										
DO	ON										
TIC	OFF										
ALK	OFF										
ZOO1	OFF										
LDOM_P	OFF										
RDOM_P	OFF										
LPOM_P	OFF										
RPOM_P	OFF										
LDOM_N	OFF										
RDOM_N	OFF										
LPOM_N	OFF										
RPOM_N	OFF										
MICROCY	OFF										
CYLINDR	OFF										
ANATOXIN	OFF										
SAXITOZN	OFF										

[See below for the Excel control file version.]

Related Cards and Files

[Snapshot Print](#) [Profile Plot](#) [Time Series Plot](#) [Spreadsheet Plot](#) [Contour Plot](#)

Constituent Atmospheric Loading (CST PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CATMD	Character	OFF	Specifies which constituents are read in the atmospheric deposition input file, ON or OFF

CATMD, a function of waterbody, specifies which constituents are read in for the atmospheric deposition input file. For the w2_con.npt input file, if there are more than 9 waterbodies the line wraps around. This does not occur in the Excel input file version.

Example

```

CST PRIN  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC
TDS          ON
Gen1         ON
Gen2         OFF
Gen3         OFF
ISS1         ON
WATERAGE    OFF
BACTERIA    OFF
DGP          OFF
N2           OFF
H2S          OFF
CH4          OFF
SO4          OFF
FEII         OFF
FEOOH        OFF
MNI_I        OFF
MNO2         OFF
PO4          ON
NH4          ON
NO3          ON
DSI           OFF
PSI           OFF
LDOM          ON
RDOM          ON
LPOM          ON
RPOM          OFF
ALG1          ON
DO            ON
TIC            OFF
ALK            OFF
ZOO1          OFF
LDOM_P        OFF
RDOM_P        OFF
LPOM_P        OFF
RPOM_P        OFF
LDOM_N        OFF
RDOM_N        OFF
LPOM_N        OFF
RPOM_N        OFF
MICROCY      OFF
CYLINDR      OFF
ANATOXIN     OFF
SAXITOXN     OFF

```

[See below for the Excel control file version.]

Inflow Active Constituent Control (CIN CON)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CINBRC	Character	OFF	Specifies which constituents are included in inflow constituent file, ON or OFF

For some applications, inflow concentrations for a particular constituent may not be available. This card allows the user to include in the [inflow concentration file \[CINFN\]](#) only those constituents for which there is a concentration. For those excluded (CINBRC=OFF), the model uses a zero concentration for the inflow.

Example

CIN CON	CINBRC								
TDS	ON								
Gen1	ON								
Gen2	OFF								
Gen3	ON								
ISS1	ON								
WATERAGE	OFF								
BACTERIA	OFF								
DGP	OFF								
N2	OFF								
H2S	OFF								
CH4	OFF								
SO4	OFF								
FEII	OFF								
FEOOH	OFF								
MNII	OFF								
MNO2	OFF								
PO4	ON								
NH4	ON								
NO3	ON								
DSI	OFF								
PSI	OFF								
LDOM	ON								
RDOM	ON								
LPOM	ON								
RPOM	OFF								
ALG1	ON								
DO	ON								
TIC	ON								
ALK	ON								
ZOO1	OFF								
LDOM_P	OFF								
RDOM_P	OFF								
LPOM_P	OFF								
RPOM_P	OFF								
LDOM_N	OFF								
RDOM_N	OFF								
LPOM_N	OFF								
RPOM_N	OFF								
MICROCY	OFF								
CYLINDR	OFF								
ANATOXIN	OFF								
SAXITOZN	OFF								

[The Excel input file example is shown in the next section.]

Related Cards and Files

[Branch Inflow Constituent File](#) [Branch Inflow Constituent Filename](#)

Tributary Active Constituent Control (CTR CON)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CTRTRC	Character	OFF	Specifies which constituents are included in tributary inflow constituent file for each tributary, ON or OFF

For some applications, tributary inflow concentrations for a particular constituent may not be available. This card allows the user to include in the [tributary inflow concentration file \[CTRFN\]](#) only those constituents for which there is a concentration.

Example

```

CTR CON   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC   CTRTRC
TDS        ON        OFF
Gen1       ON        OFF
Gen2       OFF       OFF
Gen3       ON        OFF
ISS1       ON        OFF
WATERAGE  OFF       OFF
BACTERIA  OFF       OFF
DGP        OFF       OFF
N2         OFF       OFF
H2S         OFF      OFF
CH4         OFF      OFF
SO4         OFF      OFF
FEII        OFF      OFF
FEOOH      OFF      OFF
MNI1I      OFF      OFF
MNO2       OFF      OFF
PO4         ON       OFF
NH4         ON       OFF
NO3         ON       OFF
DSI          OFF     OFF
PSI          OFF     OFF
LDOM        ON       OFF
RDOM        ON       OFF
LPOM        ON       OFF
RPOM        OFF      OFF
ALG1        ON       OFF
DO          ON       OFF
TIC          ON      OFF
ALK          ON      OFF
ZOO1        OFF      OFF
LDOM_P      OFF      OFF
RDOM_P      OFF      OFF
LPOM_P      OFF      OFF
RPOM_P      OFF      OFF
LDOM_N      OFF      OFF
RDOM_N      OFF      OFF
LPOM_N      OFF      OFF
RPOM_N      OFF      OFF
MICROCY    OFF      OFF
CYLINDR    OFF      OFF
ANATOXIN   OFF      OFF
SAXITOZN  OFF      OFF

```

[The Excel input file example is shown in the next section.]

Related Cards and Files

- [Tributary Inflow Concentration File](#)
- [Tributary Inflow Concentration Filename](#)

Distributed Trib Active Constituent (CDT CON)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CDTBRC	Character	OFF	Specifies which constituents are included in distributed tributary inflow constituent file for each branch, ON or OFF

For some applications, distributed tributary inflow concentrations for a particular constituent may not be available. This card allows the user to include in the [distributed tributary inflow concentration file \[CDTFN\]](#) only those constituents for which there is a concentration.

Example

CDT CON	CDTBRC									
TDS	ON	OFF								
Gen1	ON	OFF								
Gen2	OFF	OFF								
Gen3	ON	OFF								
ISS1	ON	OFF								
WATERAGE	OFF	OFF								
BACTERIA	OFF	OFF								
DGP	OFF	OFF								
N2	OFF	OFF								
H2S	OFF	OFF								
CH4	OFF	OFF								
SO4	OFF	OFF								
FEIII	OFF	OFF								
FEOOH	OFF	OFF								
MNII	OFF	OFF								
MNO2	OFF	OFF								
PO4	ON	OFF								
NH4	ON	OFF								
NO3	ON	OFF								
DSI	OFF	OFF								
PSI	OFF	OFF								
LDOM	ON	OFF								
RDOM	ON	OFF								
LPOM	ON	OFF								
RPOM	OFF	OFF								
ALG1	ON	OFF								
DO	ON	OFF								
TIC	ON	OFF								
ALK	ON	OFF								
ZOO1	OFF	OFF								
LDOM_P	OFF	OFF								
RDOM_P	OFF	OFF								
LPOM_P	OFF	OFF								
RPOM_P	OFF	OFF								
LDOM_N	OFF	OFF								
RDOM_N	OFF	OFF								
LPOM_N	OFF	OFF								
RPOM_N	OFF	OFF								
MICROCY	OFF	OFF								
CYLINDR	OFF	OFF								
ANATOXIN	OFF	OFF								
SAXITOZN	OFF	OFF								

[The Excel input file example is shown in the next section.]

Related Cards and Files

[Distributed Tributary Inflow Concentration File](#) [Distributed Tributary Inflow Concentration Filename](#)

Precipitation Active Constituent Control (CPR CON)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	CPRBRC	Character	OFF	Specifies which constituents are included in the precipitation inflow constituent file for each branch, ON or OFF

For some applications, precipitation concentrations for a particular constituent may not be available. This card allows the user to include in the [precipitation concentration file \[CPRFN\]](#) only those constituents for which there is a concentration.

Example

CPR CON	CPRBRC								
TDS	ON	ON							
Gen1	ON	OFF							
Gen2	OFF	OFF							
Gen3	ON	OFF							
ISS1	ON	OFF							
WATERAGE	OFF	OFF							
BACTERIA	OFF	OFF							
DGP	OFF	OFF							
N2	OFF	OFF							
H2S	OFF	OFF							
CH4	OFF	OFF							
SO4	OFF	OFF							
FEII	OFF	OFF							
FEOOH	OFF	OFF							
MNII	OFF	OFF							
MNO2	OFF	OFF							
PO4	ON	OFF							
NH4	ON	OFF							
NO3	ON	OFF							
DSI	OFF	OFF							
PSI	OFF	OFF							
LDOM	ON	OFF							
RDOM	ON	OFF							
LPOM	ON	OFF							
RPOM	OFF	OFF							
ALG1	ON	OFF							
DO	ON	OFF							
TIC	ON	OFF							
ALK	ON	OFF							
ZOO1	OFF	OFF							
LDOM_P	OFF	OFF							
RDOM_P	OFF	OFF							
LPOM_P	OFF	OFF							
RPOM_P	OFF	OFF							
LDOM_N	OFF	OFF							
RDOM_N	OFF	OFF							
LPOM_N	OFF	OFF							
RPOM_N	OFF	OFF							
MICROCY	OFF	OFF							
CYLINDR	OFF	OFF							
ANATOXIN	OFF	OFF							
SAXITOZN	OFF	OFF							

The Excel version includes the following parameters: **CNAME2**, the short name of the state variable name, **CNAME**, the long name of the state variable enclosed in double quotes, **CAC** (ON/OFF determining if constituent is active or not), **FMTC**, which is the FORTRAN format specification for output when printing,

CONTROL FILE

CONSTITUENT CONTROL

CMULT, which is a conversion factor and multiplies the output by the value specified (sometimes used when converting from g m⁻³ to mg m⁻³ for nutrient values), **C2IWB**, the initial concentration in each waterbody (this column is repeated for the number of waterbodies), **CPRWBC**, is ON/OFF and controls printing the state variable in the SNP file (this column is repeated for the number of waterbodies), **C_Atm_Deposition** is ON/OFF and specifies the input columns in the atmospheric deposition file that are read in (this column is repeated for the number of waterbodies), **CINBRC** is ON/OFF and specifies the input columns in the branch inflow file (this column is repeated for the number of branches), **CTRTRC** is ON/OFF and specifies the input columns in the tributary inflow file (this column is at least 1 even if there are no tributaries and is repeated for the number of tributaries), **CDTBRC** is ON/OFF and specifies the input columns in the distributed inflow file (this column is repeated for the number of branches), and **CPRBRC** is ON/OFF and specifies the input columns in the precipitation inflow file (this column is repeated for the number of branches).

In the Excel version, a formula specifies the number of columns of input required, as shown below in column A, and is a function of the number of branches, waterbodies and tributaries:

Note the order of these columns for this section:

CNAME2, CNAME, CAC, FMTC, CMULT,
C2IWB (repeat for each waterbody) Initial condition per WB
CPRWBC (repeat for each waterbody) Print output to SNP file
C_Atm_Deposition (repeat for each waterbody) Atmospheric deposition?
CINBRC (repeat for each branch) Inflow file ON or OFF
CTRTRC (repeat for each tributary - include at least 1 even if no trib) Trib file ON or OFF
CDTBRC (repeat for each branch) Distributed Tributary ON or OFF
CPRBRC (repeat for each branch) Precipitation file ON or OFF

Your last column should be in COLUMN:

N

12

Also, based on the specification of the required state variables and the user defined state variables, there should be 36 required state variables+NGC+NAL+NZP+3NBOD+NSS. This is computed in the Excel input file to verify that the required number have been specified.

An example of the Excel version of this section is shown below for the case where there are 42 required state variables.

CONSTITUENT CONTROL

CONTROL FILE

C S T	CNA ME2 Shor t nam e	CNAME Long name	CAC Ac- tive con- stit- uent	FMTC Fortran output format for SNP&SP R	CMU LT Out- put Mul- ti- plier	C2IWB 1 Initial con- cen- tra- tion in WB1	CPRW BC1 Print con- stitu- ent for Water Body 1	C Atm De- posi- ton	CINBRC 1 Inflow consti- tuent for Branch 1	CTRTRC 1 Tribu- tary consti- tuent for Trib 1	CDTBRC1 Distrib- uted consti- tuent for Branch 1	CPRBRC1 Precipi- ta- tion con- stitu- ent for Branch 1	
1	TDS	"TDS, g/m^3"	ON	(f10.3)	1	51	ON	OFF	ON	OFF	OFF	OFF	OFF
2	Gen 1	"GC1, g/m^3"	ON	(f10.3)	1	100	ON	OFF	ON	OFF	OFF	OFF	OFF
3	Gen 2	"Age, days"	ON	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
4	Gen 3	"GC3, g/m^3"	ON	(f10.3)	1	10	OFF	OFF	ON	OFF	OFF	OFF	OFF
5	ISS1	"ISS, g/m^3"	ON	(f10.3)	1	2	ON	OFF	ON	OFF	OFF	OFF	OFF
6	Wa- ter- Age	"Age, days"	OFF	(f10.3)	1	0	ON	OFF	OFF	OFF	OFF	OFF	OFF
7	Bac- teria	"Bacte- ria, col/100 ml"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
8	DGP	"Dis- olved Gas Pres- sure,atm"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
9	N2	"N2 dis- solved gas, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
10	H2S	"H2S, dissolved gas, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
11	CH4	"CH4 dis- solved gas, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
12	SO4	"SO4 dis- solved, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
13	FEII	"Re- duced FE(II), mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
14	FEO OH	"Oxi- dized FeOOH, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
15	MnII	"Re- duced"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF

CONTROL FILE

CONSTITUENT CONTROL

		Mn(II), mg/l"										
1 6	Mn O2	"Oxi- dized MnO2, mg/l"	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
1 7	PO4	"Phos- phate, g/m^3 "	ON	(f10.3)	1	0.01	ON	ON	ON	OFF	OFF	OFF
1 8	NH4	"Ammonium, g/m^3 as N - to- tal am- monia "	ON	(f10.3)	1	0.14	ON	ON	ON	OFF	OFF	OFF
1 9	NO3	"Nitrate- Nitrite, g/m^3 "	ON	(f10.3)	1	0.14	ON	ON	ON	OFF	OFF	OFF
2 0	DSI	"Dis- solved silica, g/m^3 "	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
2 1	PSI	"Particu- late sil- ica, g/m^3 "	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
2 2	LDO M	"Labile DOM, g/m^3 "	ON	(f10.3)	1	0.7	ON	OFF	ON	OFF	OFF	OFF
2 3	RDO M	"Refrac- tory DOM, g/m^3 "	ON	(f10.3)	1	2.022	ON	OFF	ON	OFF	OFF	OFF
2 4	LPO M	"Labile POM, g/m^3 "	ON	(f10.3)	1	0.1	ON	OFF	ON	OFF	OFF	OFF
2 5	RPO M	"Refrac- tory POM, g/m^3 "	OFF	(f10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
2 6	ALG 1	"Algae, g/m^3 "	ON	(f10.3)	1	-1	ON	OFF	ON	OFF	OFF	OFF
2 7	DO	"Dis- solved oxygen, g/m^3 "	ON	(f10.3)	1	-1	ON	OFF	ON	OFF	OFF	OFF
2 8	TIC	"Inor- ganic carbon, g/m^3 "	ON	(f10.3)	1	11.91	OFF	OFF	ON	OFF	OFF	OFF

CONSTITUENT CONTROL

CONTROL FILE

2 9	ALK	"Alkalinity, g/m^3"	ON	(f10.3)	1	31	OFF	OFF	ON	OFF	OFF	OFF
3 0 1	ZOO	"zoo-plankton1, mg/m^3"	OFF	(g10.3)	1	0.1	OFF	OFF	OFF	OFF	OFF	OFF
3 1	LDO M_P	"LDOM P, mg/m^3"	OFF	(g10.3)	1	0.0005	OFF	OFF	OFF	OFF	OFF	OFF
3 2	RDO M_P	"RDOM P, mg/m^3"	OFF	(g10.3)	1	0.0005	OFF	OFF	OFF	OFF	OFF	OFF
3 3	LPO M_P	"LPOM P, mg/m^3"	OFF	(g10.3)	1	0.0005	OFF	ON	OFF	OFF	OFF	OFF
3 4	RPO M_P	"RPOM P, mg/m^3"	OFF	(g10.3)	1	0.0005	OFF	ON	OFF	OFF	OFF	OFF
3 5	LDO M_N	"LDOM N, mg/m^3"	OFF	(g10.3)	1	0.008	OFF	OFF	OFF	OFF	OFF	OFF
3 6	RDO M_N	"RDOM N, mg/m^3"	OFF	(g10.3)	1	0.008	OFF	OFF	OFF	OFF	OFF	OFF
3 7	LPO M_N	"LPOM N, mg/m^3"	OFF	(g10.3)	1	0.008	OFF	OFF	OFF	OFF	OFF	OFF
3 8	RPO M_N	"RPOM N, mg/m^3"	OFF	(g10.3)	1	0.008	OFF	OFF	OFF	OFF	OFF	OFF
3 9	MIC ROC YSTI N	"Microcystin, g/m^3"	ON	(g10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
4 0	CYLI NDR O- SPER MO PSIN	"Cylindrospermopsin, g/m^3"	OFF	(g10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
4 1	ANA TOXI N-A	"Anatoxin-A, g/m^3"	OFF	(g10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF
4 2	SAXI TOXI N	"Saxitoxin, g/m^3"	OFF	(g10.3)	1	0	OFF	OFF	OFF	OFF	OFF	OFF

CONTROL FILE

CONSTITUENT CONTROL

Related Cards and Files

[Calculations](#) [Precipitation Concentration File](#) [Precipitation Concentration Filename](#)

Extinction Coefficient (EX COEF)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	EXH2O	Real	0.25 or 0.45	Extinction for pure water, m^{-1} [We recommend using 0.25 when water quality constituents such as algae and suspended solids are 'ON' and 0.45 when only temperature is being simulated as a start to a model calibration unless one has field data.]
3	EXSS	Real	0.1	ε_{ISS} : extinction due to inorganic suspended solids, $m^{-1}/(g/m^3)$
4	EXOM	Real	0.1	ε_{POM} : extinction due to organic suspended solids, $m^{-1}/(g/m^3)$
5	BETA	Real	0.45	β , fraction of incident solar radiation absorbed at the water surface (longwave components of short-wave solar)
6	EXC	Character	OFF	Read extinction coefficients, ON or OFF
7	EXIC	Character	OFF	Interpolate extinction coefficients, ON or OFF

This card specifies the short-wave solar radiation extinction coefficients and fraction of solar radiation, β , absorbed in the surface layer. Extinction coefficients are used to calculate a net extinction coefficient, λ , which is determined from the following equation:

Light extinction is critical for temperature and algae/periphyton/macrophyte growth.

$$\lambda = \lambda_{H2O} + \lambda_{ISS} + \lambda_{POM} + \lambda_a + \lambda_{macro} + \lambda_{zoo}$$

where:

$$\lambda_{ISS} = \varepsilon_{ISS} \sum \Phi_{ISS}$$

ε_{ISS} = extinction parameter for inorganic suspended solids, $m^{-1}/(g m^{-3})$ - user supplied parameter

Φ_{ISS} = inorganic suspended solids concentration for each size fraction

$$\lambda_{POM} = \varepsilon_{POM} \sum \Phi_{POM}$$

ε_{POM} = extinction parameter for particulate organic matter, $m^{-1}/g m^{-3}$ - user supplied parameter

Φ_{POM} = particulate organic matter concentration = particulate labile + particulate refractory organic matter concentration

$$\lambda_a = \sum \varepsilon_a \Phi_a \text{ algae extinction, } m^{-1}$$

$$\lambda_{zoo} = \sum \varepsilon_{zoo} \Phi_{zoo} \text{ zooplankton extinction, } m^{-1}$$

$$\lambda_{macro} = \sum \varepsilon_{macro} \Phi_{macro} \text{ macrophyte extinction, } m^{-1}$$

ε_a = extinction coefficient for each algal group, $m^{-1}/g m^{-3}$ - user supplied parameter

Φ_a = algal concentration for each algal group, $g m^{-3}$

ε_{zoo} = extinction coefficient for each zooplankton group, $m^{-1}/g m^{-3}$ - user supplied parameter

Φ_{zoo} = zooplankton concentration for each zooplankton group, $g m^{-3}$

ε_{macro} = extinction coefficient for each macrophyte group, $m^{-1}/g m^{-3}$ - user supplied parameter

Φ_{macro} = macrophyte concentration for each macrophyte group, $g m^{-3}$

CONTROL FILE

INPUT OUTPUT FILENAMES

λ_{H2O} = extinction coefficient for water (for a wavelength of between 0.5 and 0.6 μm , the absorption coefficient for *pure water* is about 0.1 m^{-1}).

λ_{H2O} varies greatly depending upon the dissolved substances in the water. [Table 12](#) gives values reported in the literature that can be used as rudimentary guidelines for selecting a value of λ_{H2O} .

Table 12. Extinction Coefficient Literature Values

Location	Description	λ, m^{-1}	Reference
Lake Tahoe, CA	Oligotrophic	0.2	Wetzel, 1975
Crystal Lake, WI	Oligotrophic	0.2	Wetzel, 1975
Crater Lake, OR	Oligotrophic	0.18	Spence, 1981
Lake Borralie, Scotland	Calcareous water	0.34	Spence, 1981
Wintergreen Lake, MI	Eutrophic	0.46-1.68	Wetzel, 1975
Lake Paajarvi, Finland	Brown-stained	0.7	Verduin, 1982
Loch Unagan, Scotland	Brown-stained	1.53	Spence, 1981
Loch Leven, Scotland	Turbid, eutrophic	2.58	Spence, 1981
Neusiedlersee, Austria	Turbid	3.31	Spence, 1981
Highly stained lakes	Average	4.0	Wetzel, 1975

Megard et al. (1980) and Smith and Baker (1978) determined each gram per cubic meter of chlorophyll increased ε_{POM} by 22 and 16 m^{-1} , respectively. Averaging the two values and assuming a carbon to algal biomass ratio of 0.45 and a carbon to chlorophyll ratio of 50, then each gram per cubic meter of algal biomass should increase ε_{POM} by about 0.17 m^{-1} . However, the carbon to chlorophyll ratios vary from 25 to 150. Values for ε_{ISS} should be of the same order of magnitude as ε_{POM} .

If any constituents included in the above equation are not included in the simulation, then the value for λ_{H2O} should be increased to account for the constituent left out.

In some cases Secchi disk data are available. The Secchi disk depth represents a quantitative measure of the transparency of that water body, or the visibility in the vertical direction (Duntley, 1952). SECCHI is calculated inversely proportional to the diffuse attenuation coefficient. There are different expressions for converting Secchi disk depth, z_{Secchi} in m, to a light extinction coefficient in m^{-1} , some of these include

$$\lambda = \frac{\alpha}{z_{Secchi}} \quad (\text{Chapra, 1997}) \text{ where } \alpha \text{ varies from 1.4 to 1.9 (typical value of 1.7; Koenings and Edmunson, 1991, suggest a median value in clear water of 1.9)}$$

$$\lambda = \frac{1.11}{z_{Secchi}^{0.73}} \quad (\text{Williams et al., 1980}) \text{ for lakes and reservoirs in the Ohio River basin the 1970's}$$

$$\lambda = \frac{1.36}{z_{Secchi}^{0.86}} \quad (\text{Armenglo et al., 2003}) \text{ for Sau Reservoir, Spain between 1995 and 2001}$$

$$\log \lambda = -0.96 \log(z_{Secchi}) + 0.30 \quad (\text{Caffrey et. al. 2006}) \text{ for 32 Florida, USA lakes}$$

$$\lambda = \frac{2.0}{z_{Secchi}} \quad (\text{Schmid and Koster, 2016}) \text{ for Lake Zurich, Switzerland}$$

where: λ =net extinction coefficient, m^{-1}

Caution should be used in transferring these results to reservoirs and lakes in other drainage basins.

The above equations converting Secchi disk depth to light extinction include the effects of ε_{ISS} and ε_{OSS} and should be used only when inorganic and organic suspended solids are not included in the simulation.

INPUT OUTPUT FILENAMES

CONTROL FILE

The fraction of incident solar radiation absorbed at the water surface, β , represents solar radiation absorbed in the surface layer. A study of 29 lakes and reservoirs in the Ohio River basin (USA) showed the following relationship between light extinction, λ in m^{-1} , and β (Williams et. al. 1980):

$$\beta = 0.265 \ln(\lambda) + 0.614$$

R²=0.69 Standard error (SE)=0.0992

Again caution should be used in using a relationship developed for a different waterbody than your application. A typical value for [BETA] is 0.45, implying that 45% of the incident radiation is absorbed in the upper layer of the water body, assumed to be the surface layer of the model. This represents the long wave components of the solar spectrum which are readily absorbed.

Table 13 shows values of [BETA] for a variety of systems. Note that in most cases these values assume that the water depth is between 0.5 to 2 m for the surface layer. The concept of using BETA in a shallow river system is not straightforward since the basic theory that we have a constant value of light extinction below the surface layer is probably not correct. The light extinction coefficient in a shallow system is constantly changing as a function of depth and light wavelength.

Table 13. Values of BETA and light extinction (TVA, 1972).

Location	β	λ in m^{-1}
Pure water	0.63	0.05
Clear oceanic water	0.64	0.08
Average oceanic water	0.68	0.12
Average coastal water	0.69	0.33
Turbid coastal water	0.69	0.43
Lake Mendota	0.58	0.72
Trout Lake	0.50	1.4
Big Ridge Lake, TVA	0.24	1.1
Fontana Lake, TVA	0.24	0.93

The model user can input a file of light extinction coefficients as a function of time for each water body if [EXC] is ON. Interpolation of this input file is performed when [EXIC] is ON. The extinction coefficients can be derived from Secchi disk or light photometer data. The input file is specified under the Extinction Coefficient file name. When the extinction coefficient is read in, all other calculations of light extinction are ignored.

Example

EX COEF	EXH2O	EXSS	EXOM	BETA	EXC	EXIC
WB 1	0.25	0.01	0.01	0.45	OFF	OFF
WB 2	0.25	0.01	0.01	0.45	OFF	OFF
WB 3	0.25	0.01	0.01	0.45	OFF	OFF

EX COEF	WB1	WB2
EXH2O - water light extinction- 1/m	0.45	
EXSS - suspended solids light extinction- 1/m	0.01	
EXOM - extinction organic matter- 1/(m mg/l)	0.2	
BETA - fraction short wave absorbed on surface	0.45	
EXC - Read in light extinction time series ON or OFF	OFF	
EXIC - Interpolation of light extinction time series ON or OFF	OFF	

Related Cards and Files

[Algal Extinction](#)

CONTROL FILE

[Light Extinction File](#)
[Light Extinction Filename](#)

INPUT OUTPUT FILENAMES

Algal Extinction (ALG EX)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	EXA	Real	0.2	ε_a : algal light extinction, m^{-1}/gm^{-3}

This card specifies the effect of algae on short wave solar radiation extinction in the water column. See the [Extinction Coefficient](#) card for a more complete description.

Example

```
ALG EX      EXA      EXA      EXA      EXA      EXA      EXA      EXA      EXA
          0.2      0.2      0.2
```

ALG EXTINCTION	EXA1	EXA2	EXA3
Algae light extinction- 1/(m mg/l)	0.2		

Related Cards and Files

[Extinction Coefficient](#)

Zooplankton Extinction (ZOO EX)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	EXZ	Real	0.2	ε_{zoo} : zooplankton light extinction, m^{-1}/gm^{-3}

This card specifies the effect of algae on short wave solar radiation extinction in the water column. See the [Extinction Coefficient](#) card for a more complete description.

Example

```
ZOO EX      EXZ      EXZ      EXZ      EXZ      EXZ
          0.2      0.2      0.2
```

ZOO EXTINCTION	EXZ1	EXZ2	EXZ3
Zooplankton light extinction- 1/(m mg/l)	0.2		

Related Cards and Files

[Extinction Coefficient](#)

CONTROL FILE**INPUT OUTPUT FILENAMES****Macrophyte Extinction (MAC EX)**

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	EXM	Real	0.01	ε_{macro} : macrophyte light extinction, m^{-1}/gm^{-3}

This card specifies the effect of macrophytes on short wave solar radiation extinction in the water column. See the [Extinction Coefficient](#) card for a more complete description.

Berger (2000) compiled the following literature values of light extinction for macrophytes in the following table.

Table 14. Literature values for light extinction due to macrophyte plant tissue concentration.

Species	Light extinction due to macrophyte concentration, $m^3m^{-1}g^{-1}$	Reference
<i>Myriophyllum spicatum</i> L.	0.01	Ikusima, 1970
<i>Myriophyllum spicatum</i> L.	0.006	Titus and Adams, 1979
<i>Vallisneria americana</i> Michx.	0.013 to 0.019	Titus and Adams, 1979
<i>Potamogeton pectinatus</i>	0.024	Van der Bijl et al., 1989

Example

```
MACRO EX      EXM      EXM      EXM      EXM      EXM      EXM
          0.0100
```

MACRO EXTINCTION	EXM1	EXM2	EXM3
Macrophyte light extinction- 1/(m mg/l)	0.01		

Related Cards and Files

[Extinction Coefficient](#)

Generic Constituent (GENERIC)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CGQ10	Real		Arrhenius temperature rate multiplier, theta
3	CG0DK	Real		0-order decay rate, <i>with mass concentration units: gm⁻³day⁻¹</i>
4	CG1DK	Real		1st -order decay rate, day ⁻¹
5	CGS	Real		Settling rate, m day ⁻¹
6	CGLDK	Real		Photodegradation parameter, m ² J ⁻¹
7	CGKLF	Real		Fraction of surface reaeration coefficient, K _L , for dissolved oxygen for gas transfer, [-]
8	CGCS	Real		Gas transfer saturation concentration, mg/l
9	CGR	Real		Sediment release rate from zero order sediment model, fraction of SOD, [-]

This card specifies the Arrhenius temperature rate multiplier, 0-order decay rate, 1st-order decay rate, settling rate, photodegradation parameter, fraction of dissolved oxygen reaeration rate for gas transfer, and gas saturation concentration for a generic constituent. The ability to model any number of generic constituents whose kinetics can be described by these parameters has been a part of CE-QUAL-W2 since Version 3.1. These constituents can include tracers, residence time or water age, coliform bacteria, N₂ gas (and %TDG), and others. For a tracer, all of the kinetic parameters should be set to zero. For residence time, the 0-order decay rate should be set to -1.0. In this case the units of [CG0DK] are [day/day] rather than [g/m³/day]. Since this is a decay rate, setting it to -1.0 specifies a growth rate of 1 day⁻¹.

Generic constituents can be used for modeling toxics. Be creative!

Unlike other state variables, the generic constituent uses an Arrhenius temperature rate multiplier (or Q₁₀) formulation to modify the generic constituent decay rate (for both zero order and first order rates) as a function of temperature: $k_T = k_{20}\theta^{T-20}$, where Θ=CGQ10 and k₂₀ is the decay rate (either CG0DK or CG1DK) at 20°C.

The photodegradation parameter, CGLDK, varies from 1E-5 to 1E-8 (see Part 2 of the User Manual).

The fraction of the gas transfer coefficient for dissolved oxygen, CGKLF, varies from 0.7 to 0.8 for many typical hydrocarbons with CGCS=0.0. See Part 2 of the User Manual.

CGR is the release rate from the sediments under anoxic conditions as a fraction of the zero-order sediment oxygen demand (SOD). Typical rates are variable depending on the state variable. Note how the variables CO2R, PO4R, and NH3R are used in a similar fashion for C, P, and N release from anoxic sediments.

Example

```
GENERIC    CGQ10    CG0DK    CG1DK      CGS     CGLDK    CGKLF      CGCS      CGR
CG 1        0.00     0.0       0.0       0.0     0.0       0.0       0.0       0.0   ! TRACER1
CG 2        0.00     1.0       0.0       0.0     0.0       0.0       0.0       0.0   ! TRACER2
```

CONTROL FILE**INPUT OUTPUT FILENAMES**

GENERIC CONSTITUENT	CG1	CG2	CG3
CGQ10, Arrhenius temperature rate multiplier, theta	0	0	1.04
CG0DK, 0-order decay rate, with mass concentration units: gm-3day-1	0	-1	0
CG1DK 1st -order decay rate, day-1	0	0	1.4
CGS Settling rate, m day-1	0	0	0
CGLDK Photodegradation parameter, m2J-1	0	0	0
CGKLF Fraction of surface reaeration coefficient, KL, for dissolved oxygen for gas transfer, [-]	0	0	0
CGS Gas transfer saturation concentration, mg/l	0	0	0
CGR, sediment release rate as a fraction of zero order SOD	0	0	0

Suspended Solids (S SOLIDS)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SSS	Real	1.0	Suspended solids settling rate, $m\ day^{-1}$
3	SEDRC	Real	OFF	Turns ON or OFF sediment resuspension
4	TAUCR	Real	1.0	Critical shear stress for sediment resuspension, dynes/cm^2
5	SSCS	Real	0.0	Flag that turns ON or OFF mature fine tailings for the sediment diagenesis model. When SSCS=-1, then this suspended solids group is identified in the sediment diagenesis model as mature fine tailings (a type of fine suspended solids)

This card specifies the suspended solids settling rates for each inorganic suspended solids state variable specified in the [Constituent Dimensions](#) card. Currently, phosphorus partitioning as specified on the [Inorganic Phosphorus](#) card is the same for all inorganic suspended solids. The resuspension of inorganic suspended solids due to wind shear and the resulting wind waves that cause sediment resuspension are based on the algorithm in Chapra (1997). The resuspension computations are included by setting [SEDRC] to ON. The critical shear stress is specified by [TAUCR]. Details of this computation for resuspension are found in Part 2 of the User Manual.

In the sediment diagenesis model for Version 4.22 and earlier, there was a group for Mature Fine Tailings that was added as a generic constituent. The current model now sets this state variable as a suspended solids group. Set SSCS to “-1.0”, and the mature fine tailing group will be active and parameters for this can be set in the sediment diagenesis input files.

The mature fine tailings from the sediment diagenesis model is set as a suspended solids group with a SSCS value of -1.

Example

```
S SOLIDS      SSS      SEDRC     TAUCR      SSCS
SSS 1        1.5       ON        1.500      0.0
SSS 2        0.5       ON        1.000      -1.0
```

S SOLIDS - Suspended solids (inorganic)	SS1	SS2	SS3
SSS - settling velocity- m/day	1		
SEDRC - Resuspension of suspended solids, ON or OFF	OFF		
TAUCR - Critical shear stress for sediment resuspension, dynes/cm ²	0		
SSCS - if = -1.0, this is mature fine tailings for the sediment diagenesis model	0		

Bacteria

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	BACTQ10	Real		Arhennius temperature rate multiplier, theta
3	BACT1DK	Real		1st -order decay rate, day^{-1}
4	BACTS	Real		Settling rate, $m day^{-1}$
5	BACTLDK	Real		Photodegradation parameter, $m^2 J^{-1}$

This card specifies the Arhennius temperature rate multiplier, 1st-order decay rate, settling rate, photodegradation parameter for bacteria.

Unlike other state variables, bacteria uses an Arhennius temperature rate multiplier (or Q₁₀) formulation to modify the first order decay rate as a function of temperature: $k_T = k_{20}\theta^{T-20}$, where Θ=BACTQ10 and k₂₀ is the decay rate (BACT1DK) at 20°C.

This is for only one bacterial group. If you have more than 1 group, use the generic constituent for other groups.

This decay as a function of temperature is what is most likely to be encountered in the literature, particularly for coliform bacteria. Care must be taken when using this formulation at low (< 6°C) temperatures. For coliform bacteria, the Q₁₀ coefficient (CGQ10) is usually 1.04. A range of values for coliform can be found in Zison et al. (1978).

Coliform decay rate is a function of sedimentation, solar radiation, nutrient availability, predation, algae, bacterial toxins, and physicochemical factors. For studies in which bacterial contamination is of important concern, efforts should be made to obtain *in situ* decay rate measurements. Methods for obtaining decay rates can be found in Frost and Streeter (1924), Marais (1974), and Zison et al. (1978). **Error! Reference source not found.** gives reported literature values for coliform decay rates.

Table 15. *In Situ* Coliform Decay Rates

Location	Season/ Temperature	Rate, day^{-1}	Reference
Ohio River	Summer, 20C	1.18	Frost and Streeter, 1924
Ohio River	Winter, 5C	1.08	Frost and Streeter, 1924
Upper Illinois River	June-September	2.04	Hoskins, et al, 1927
Upper Illinois River	October-May	2.52, 0.89	Hoskins, et al, 1927
Upper Illinois River	December-March	0.57, 0.62	Hoskins, et al, 1927
Upper Illinois River	April-November	1.03, 0.70	Hoskins, et al, 1927
Missouri River	Winter	0.48	Kittrell and Furfari, 1963
Tennessee River	Summer	1.03, 1.32	Kittrell and Furfari, 1963
Tennessee River	Summer	1.32	Kittrell and Furfari, 1963
Sacramento River	Summer	1.75	Kittrell and Furfari, 1963
Cumberland River	Summer	5.52	Kittrell and Furfari, 1963
Leaf River, MS		0.41	Mahloch, 1974
Wastewater lagoon	7.0-25.5C	0.20-0.70	Klock, 1971
Maturation ponds	19C	1.68	Marais, 1974
Oxidation ponds	20 C	2.59	Marais, 1974

INPUT OUTPUT FILENAMES

CONTROL FILE

The photodegradation parameter, **BACTLDK**, varies from 1E-5 to 1E-8 (see Part 2 of the User Manual).

These bacterial decay rates can be set differently in different water bodies.

Example

```
BACTERIA BACTQ10 BACT1DK    BACTS BACTLDK
WB1        1.04      0.5      0.1      0.1
WB2        1.04      0.5      0.1      0.1
```

BACTERIA	WB1	WB2	WB3
BACTQ10, Arrhenius temperature rate multiplier, theta	1.04		
BACT1DK 1st -order decay rate, day-1	1.4		
BACTS Settling rate, m day-1	0		
BACTLDK Photodegradation parameter, m2J-1	0		

H2S

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	H2SR	Real		Sediment release rate of H2S, a fraction of SOD for the zero order SOD model only [-]
3	H2SQ10	Real		Arrhenius temperature rate multiplier, theta
4	H2S1DK	Real		1st -order decay rate, day^{-1}
5	SO4R	Real		Sediment release rate of SO4, a fraction of SOD for the zero order SOD model only [-]. This is ignored if sediment diagenesis is ON.

These parameters are used for simulating H2S in the sediments and in the water column. The oxygen stoichiometry for H2S decay in the water column is fixed in the code as 1.88 g-O2/g-S.

Example

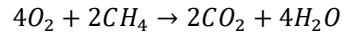
```
H2S      H2SR   H2SQ10   H2S1DK   SO4R
WB1      0.005   1.04     0.10     0.050
```

H2S	WB1	WB2	WB3
H2SR, sediment release rate, fraction of SOD (zero order), [-]	0.01		
H2SQ10, Arrhenius temperature rate multiplier, theta	1.04		
H2S1DK, first order decay rate, day-1	0.001		
SO4R, sediment release of SO4, source, fraction of SOD (zero order), [-]	0.001		

CH4

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CH4R	Real		Sediment release rate of CH ₄ , a fraction of SOD for the zero order SOD model only [-], This is ignored if sediment diagenesis is ON.
3	CH4Q10	Real		Arrhenius temperature rate multiplier, theta
4	CH41DK	Real		1st -order decay rate, day ⁻¹

These parameters are used for simulating CH₄ in the sediments and in the water column. CH₄ in the water column is in units of mg/l as CH₄. The oxygen stoichiometry for CH₄ decay in the water column is fixed in the code as 4 mg O₂/mg CH₄ (or 5.33 mg O₂/mg C) based on

**Example**

CH4	CH4R	CH4Q10	CH41DK
WB1	0.004	1.0400	0.05

CH4	WB1	WB2	WB3
CH4R, methane sediment release rate, fraction of SOD (zero order), [-]	0.01		
CH4Q10, Arrhenius temperature rate multiplier, theta	1.04		
CH41DK, first order decay rate, day-1	0.1		

Fe(II) and FeOOH

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	FEEIR	Real	0.0	Sediment release rate of reduced Fe, a fraction of SOD for the zero order SOD model only [-], This is ignored if sediment diagenesis is ON.
3	KFE_OXID	Real	1.0	Rate of Fe oxidation under oxic conditions, m ³ d ⁻¹ g ⁻¹
4	KFE_RED	Real	4.0	Rate of iron reduction under anaerobic conditions, day ⁻¹
5	KFEOOH_HalfSat	Real	0.2	Half-saturation constant for O ₂ for FeOOH reduction to Fe(II) g/m ³
6	FeSetVel	Real	2.0	Settling velocity of Fe oxide, m/day

INPUT OUTPUT FILENAMES

CONTROL FILE

These parameters are used for simulating Fe(II) and FeOOH in the sediments and in the water column. Iron is in units of mg/l or g/m³ as Fe. These parameters are used in the sediment model if Fe is activated in the sediments. The oxygen stoichiometry for Fe(II) decay is fixed in the code as 0.143 g-O/g-Fe.

DiToro (2001) used values of 10 day⁻¹ and 4 day⁻¹ for the reduction rate and oxidation rates, respectively, in lake examples. Using the oxidation rate of 4 day⁻¹, the W2 model rate in units of day⁻¹/(g/m³) then for a pH=7 and DO concentration of 5 mg/l would be 0.8 day⁻¹(g m⁻³)⁻¹ (see Part 2 of User's Manual).

Diez et al. (2007) reported on iron oxidation rates of between 0.0004-0.007 s⁻¹. This corresponds to rates of about 3-60 in units of day⁻¹(g m⁻³)⁻¹ for a dissolved oxygen concentration of 10 mg/l and neutral pH.

Settling rates of iron oxides have been recorded between 0.2-34 m/d (Jamieson, 1995).

Example

```
FE      FEIIR KFEOXID KFERED HalfSat SetVel
WB1     0.004  1.0000   4.00     0.20    2.001
```

Fe(II) and FeOOH	WB1	WB2	WB3
FEIIR Sediment release rate of reduced Fe, a fraction of SOD for the zero order SOD model only [-]	0.001		
KFE_OXID Rate of Fe oxidation under oxic conditions, day ⁻¹ (g m ⁻³) ⁻¹	1.0		
KFE_RED Rate of iron reduction under anaerobic conditions, day ⁻¹	4.0		
KFEOOH_HalfSat Half saturation constant for iron oxidation	0.2		
FeSetVel Settling velocity of Fe oxide, m/day	2		

Mn(II) and MnO₂

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	MNIIR	Real	0.0	Sediment release rate of reduced Mn, a fraction of SOD for the zero order SOD model only [-], This is ignored if sediment diagenesis is ON.
3	KMN_OXID	Real	1.0	Oxidation rate of manganese, day ⁻¹ (g m ⁻³) ⁻¹
4	KMN_RED	Real	4.0	Rate of Mn reduction under anaerobic conditions, day ⁻¹
5	KMNOH_HalfSat	Real	0.2	Half-saturation constant of oxygen for manganese dioxide reduction, g/m ³
6	MNSetVel	Real	2	Settling velocity of Mn oxide, m/day

These parameters are used for simulating Fe(II) and FeOOH in the sediments and in the water column. These parameters are used in the sediment model if Fe is activated in the sediments. The oxygen stoichiometry for Mn(II) decay is fixed in the code as 0.291 g-O/g-Mn.

CONTROL FILE

INPUT OUTPUT FILENAMES

DiToro (2001) used reduction and oxidation rates similar to Fe for Mn of 10 day⁻¹ and 4 day⁻¹, respectively. Using the oxidation rate of 4 day⁻¹, the W2 model rate in units of day⁻¹/(g/m³) then for a pH=7 and DO concentration of 5 mg/l would be 0.8 day⁻¹(g m⁻³)⁻¹(see Part 2 of User's Manual).

Example

```
MN      MNIIR  KMNOXID   KMNRED   HalfSat   SetVel  
WB1      0.004    1.000     4.000     0.20     2.001
```

Mn(II) MnO2	WB1	WB2	WB3
MNIIR Sediment release rate of reduced Mn, a fraction of SOD for the zero order SOD model only [-]	0.001		
KMN_OXID Rate of Mn oxidation under oxic conditions, day ⁻¹ (g m ⁻³) ⁻¹	1		
KMN_RED Rate of Mn reduction under anaerobic conditions, day ⁻¹	4		
KFMNOH_HalfSat Half saturation constant for Mn oxidation, g m ⁻³	0.2		
MNSetVel Settling velocity of Mn oxide, m/day	2		

Algal Rates (ALGAL RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	AG	Real	2.0	Maximum algal growth rate, day^{-1}
3	AR	Real	0.04	Maximum algal respiration rate, day^{-1}
4	AE	Real	0.04	Maximum algal excretion rate, day^{-1}
5	AM	Real	0.1	Maximum algal mortality rate, day^{-1}
6	AS	Real	0.1	Algal settling rate, $m day^{-1}$
7	AHSP	Real	0.003	Algal half-saturation for phosphorus limited growth, $g m^{-3}$
8	AHSN	Real	0.014	Algal half-saturation for nitrogen limited growth, $g m^{-3}$
9	AHSSI	Real	0.0	Algal half-saturation for silica limited growth, $g m^{-3}$
10	ASAT	Real	100.0	Light saturation intensity at maximum photosynthetic rate, $W m^{-2}$

Kinetic rates for algal growth, mortality, excretion, respiration, and settling are defined for each algae group. Values that affect the maximum algal growth rate including light and nutrient limited growth are also specified.

[AG] is the maximum gross production rate that is not corrected for respiration, mortality, excretion, or sinking. Most literature values report net production rates that take into account respiration so care must be taken when using reported literature values. The user must evaluate the experimental design to determine if reported values represent gross or net production rates. Also, [AG] is temperature dependent. If the expected temperature in the photic zone is 25°C, then the user should select rates measured near this temperature. The default value of 2 day^{-1} has given excellent results on previous studies. Table 16 shows growth rates of algae.

Algae growth, respiration, mortality, excretion, settling, half saturation constants for nutrients, and saturated light intensity vary by algal group if modeling multiple species and affect algal succession

Table 16. Gross Production Rates of Phytoplankton.

Species	[AG], day^{-1}	Temperature, °C	Reference
<i>Diatoms</i>			
<i>Asterionella formosa</i>	0.81	20	Holm and Armstrong, 1981
<i>Asterionella Formosa</i>	0.69	10	Hutchinson, 1957
<i>Asterionella Formosa</i>	1.38	20	Hutchinson, 1957
<i>Asterionella Formosa</i>	1.66	25	Hutchinson, 1957
<i>Asterionella Formosa</i>	1.71	20	Fogg, 1969
<i>Asterionella Formosa</i>	0.28	4	Talling 1955
<i>Asterionella Formosa</i>	0.69	10	Talling 1955
<i>Asterionella Formosa</i>	1.38	20	Talling 1955
<i>Asterionella Formosa</i>	2.2	20	Hoogenhout and Amesz, 1965
<i>Asterionella formosa</i>	1.9	18.5	Hoogenhout and Amesz, 1965
<i>Asterionella japonica</i>	1.19	22	Fogg, 1969
<i>Asterionella japonica</i>	1.3	18	Hoogenhout and Amesz, 1965
<i>Asterionella japonica</i>	1.7	25	Hoogenhout and Amesz, 1965
<i>Biddulphia</i> sp.	1.5	11	Castenholz, 1964
<i>Coscinodiscus</i> sp.	0.55	18	Fogg, 1969

CONTROL FILE

INPUT OUTPUT FILENAMES

Species	[AG], day ⁻¹	Temperature, °C	Reference
<i>Cyclotella meneghiniana</i>	0.34	16	Hoogenhout and Amesz, 1965
<i>Cyclotell nana</i>	3.4	20	Hoogenhout and Amesz, 1965
<i>Detonula confervacea</i>	0.62	2	Smayda, 1969
<i>Detonula confervacea</i>	1.4	10	Hoogenhout and Amesz, 1965
<i>Ditylum brightwellii</i>	2.1	20	Paasche, 1968
<i>Fragilaria</i> sp.	0.85	20	Rhee and Gotham, 1981b
<i>Fragilaria</i> sp.	1.7	11	Castenholz, 1964
<i>Melosira</i> sp.	0.7	11	Castenholz, 1964
<i>Navicula minima</i>	1.4	25	Hoogenhout and Amesz, 1965
<i>Navicula pelliculosa</i>	2.0	20	Hoogenhout and Amesz, 1965
<i>Nitzschia palea</i>	2.1	25	Hoogenhout and Amesz, 1965
<i>Nitzschia turgidula</i>	2.5	20	Paasche, 1968
<i>Phaeodactylum tricornutum</i>	1.66	25	Fogg, 1969
<i>Phaeodactylum tricornutum</i>	2.7	19	Hoogenhout and Amesz, 1965
<i>Rhizosolenia fragillissima</i>	1.2	21	Ignatiades and Smayda, 1970
<i>Skeletonema costatum</i>	1.26	18	Fogg, 1969
<i>Skeletonema costatum</i>	2.30	20	Jorgensen, 1968
<i>Skeletonema costatum</i>	1.52	20	Steemann-Nielsen and Jorgensen, 1968
<i>Skeletonema costatum</i>	1.23	20	Jitts, et al., 1964
<i>Synedra</i> sp.	1.2	11	Castenholz, 1964
<i>Thalassiosira nordenskioldii</i>	0.77	12	Jitts, et al., 1964
<i>Thalassiosira psuedonana</i>	2.85	20	Timmermans et al. 2004
<i>T. pseudonana</i>	1.8	20	Timmermans et al. 2004
<i>T. oceanica</i>	1.58	20	Timmermans et al. 2004
Natural diatom community	3.1	20	Verduin, 1952
Greens			
<i>Ankistrodesmus braunii</i>	2.33	25	Hoogenhout and Amesz, 1965
<i>Chlorella pyrenoidosa</i>	2.22	28	Shelef, 1968
<i>Chlorella ellipsoidea</i>	3.6	25	Hoogenhout and Amesz, 1965
<i>Chlorella luteoviridis</i>	0.56	22.4	Hoogenhout and Amesz, 1965
<i>Chlorella miniata</i>	0.87	25	Hoogenhout and Amesz, 1965
<i>Chlorella pyrenoidosa</i>	2.14	25	Fogg, 1969
<i>Chlorella pyrenoidosa</i>	1.95	25.5	Sorokin and Meyers, 1953
<i>Chlorella pyrenoidosa</i>	9.00	39	Castenholz, 1969
<i>Chlorella pyrenoidosa</i>	9.2	39	Hoogenhout and Amesz, 1965
<i>Chlorella seccharophilia</i>	1.2	25	Hoogenhout and Amesz, 1965
<i>Chlorella variegata</i>	0.86	25	Hoogenhout and Amesz, 1965
<i>Chlorella vulgaris</i>	2.9	25	Hoogenhout and Amesz, 1965
<i>Chlorella vulgaris</i>	1.59	20	Goldman and Graham, 1981
<i>Dunaliella tertiolecta</i>	1.0	16	Hoogenhout and Amesz, 1965
<i>Dunaliella tertiolecta</i>	0.77	36	Jitts, et al., 1964
<i>Haematococcus pluvialis</i>	1.2	23	Hoogenhout and Amesz, 1965
<i>Nanochloris atomus</i>	1.0	20	Hoogenhout and Amesz, 1965
<i>Platymonas subcordiformia</i>	1.5	16	Hoogenhout and Amesz, 1965
<i>Scenedesmus</i> sp.	1.34	20	Rhee and Gotham, 1981b
<i>Scenedesmus costulatus</i>	2.0	24.5	Hoogenhout and Amesz, 1965
<i>Scenedesmus obliquus</i>	2.11	20	Goldman and Graham, 1981
<i>Scenedesmus obliquus</i>	2.2	25	Hoogenhout and Amesz, 1965
<i>Scenedesmus quadridaula</i>	4.1	25	Hoogenhout and Amesz, 1965
<i>Scenedesmus quadridaula</i>	2.29	27	Goldman, et al., 1972
<i>Selenastrum capricornutum</i>	2.45	27	Goldman, et al., 1972
<i>Selenastrum westii</i>	1.0	25	Hoogenhout and Amesz, 1965
<i>Stichococcus</i> sp.	0.7	20	Hoogenhout and Amesz, 1965
Golden-Brown			
<i>Botrydiopsis intercedens</i>	1.5	25	Hoogenhout and Amesz, 1965
<i>Bumilleriopsis brevis</i>	2.9	25	Hoogenhout and Amesz, 1965
<i>Cricosphaera carterae</i>	0.82	18	Fogg, 1969
<i>Isochrysis galbana</i>	0.55	20	Fogg, 1969
<i>Isochrysis galbana</i>	0.8	25	Hoogenhout and Amesz, 1965

INPUT OUTPUT FILENAMES

CONTROL FILE

Species	[AG], day ⁻¹	Temperature, °C	Reference
<i>Monochrysis lutheri</i>	1.5	15	Hoogenhout and Amesz, 1965
<i>Monochrysis lutheri</i>	0.39	24	Jitts, et al., 1964
<i>Monodus subterraneus</i>	0.93	25	Hoogenhout and Amesz, 1965
<i>Monodus subterraneus</i>	0.39	30	Fogg, 1969
<i>Tribonema aequale</i>	0.7	25	Hoogenhout and Amesz, 1965
<i>Tribonema minus</i>	1.0	25	Hoogenhout and Amesz, 1965
<i>Vischera stellata</i>	0.7	25	Hoogenhout and Amesz, 1965
<i>Euglena gracilis</i>	2.2	25	Hoogenhout and Amesz, 1965
Dinoflagellate			
<i>Amphidinium carteri</i>	1.88	18	Fogg, 1969
<i>Amphidinium carteri</i>	0.32	32	Jitts, et al., 1964
<i>Ceratium tropos</i>	0.20	20	Fogg, 1969
<i>Gonyaulax polyedra</i>	2.1	21.5	Hoogenhout and Amesz, 1965
<i>Gymnodinium splendens</i>	0.92	20	Hoogenhout and Amesz, 1965
<i>Peridinium sp.</i>	0.9	18	Hoogenhout and Amesz, 1965
<i>Prorocentrum gracile</i>	0.83	18	Hoogenhout and Amesz, 1965
<i>Prorocentrum micans</i>	0.71	25	Hoogenhout and Amesz, 1965
<i>Prorocentrum micans</i>	0.3	20	Fogg, 1969
Cyanobacteria			
<i>Agmenellum quadriplatinum</i>	8.0	39	Hoogenhout and Amesz, 1965
<i>Anabaena cylindrical</i>	0.96	25	Hoogenhout and Amesz, 1965
<i>Anabaena variabilis</i>	3.9	34.5	Hoogenhout and Amesz, 1965
<i>Anacyclis nidulans</i>	2.9	25	Hoogenhout and Amesz, 1965
<i>Anacyclis nidulans</i>	11.0	40	Castenholz, 1969
<i>Chloropseudomonas ethylicum</i>	3.3	30	Hoogenhout and Amesz, 1965
<i>Cyanidium caldarium</i>	2.4	40	Hoogenhout and Amesz, 1965
<i>Cylindrospermum sphaericum</i>	0.17	25	Hoogenhout and Amesz, 1965
<i>Gloetrichia echinulata</i>	0.2	26.5	Hoogenhout and Amesz, 1965
<i>Microcystis aeruginosa</i>	0.25	20	Holm and Armstrong, 1981
<i>Microcystis aeruginosa</i>	1.6	23	Hoogenhout and Amesz, 1965
<i>Microcystis luminmosis</i>	1.5	40	Castenholz, 1969
<i>Nostoc muscorum</i>	2.9	32.5	Hoogenhout and Amesz, 1965
<i>Oscillatoria prinsips</i>	0.5	40	Castenholz, 1969
<i>Oscillatoria terebriformis</i>	3.36	40	Castenholz, 1969
<i>Oscillatoria rubescens</i>	5.04	30	Zimmerman, 1969
<i>Rhodopseudomonas sphaeroides</i>	10.8	34	Hoogenhout and Amesz, 1965
<i>Rhodospirillum rubrum</i>	4.85	25	Hoogenhout and Amesz, 1965
<i>Schizothrix calcicola</i>	3.4	30	Hoogenhout and Amesz, 1965
<i>Synechococcus lividus</i>	4.98	40	Castenholz, 1969
<i>Synechococcus</i> sp.	8.0	37	Hoogenhout and Amesz, 1965
<i>Tolyphothrix tenuis</i>	4.0	38	Hoogenhout and Amesz, 1965
<i>Leotocyclidruca danicus</i>	0.67-2.0	10-20	Verity, 1981
<i>Anabaena variabilis</i>	0.07-2.0	10-35	Collins and Boylen, 1982a

Grover (1989) rated the competitiveness of 11 algal species in P limiting environment. Maximum growth rates and P half saturation constants were measured and confidence intervals given.

Mixed species batch cultures were used to measure the kinetics. Algae density was determined by counting cells and the coefficients were estimated by fitting data to the Monod model. Three types of models were fitted: one with a common maximum growth rate and half saturation constant, one with a common half saturation constant but individual growth rates, and one with an individual growth rate and common half saturation constant.

Grover found it difficult to measure the half saturation constant because growth occurred at low concentrations of the nutrient even when it only existed as a contaminant. Half saturation constants were measured in units of micromoles/liter. Soluble reactive phosphorus was the form of P measured. Table 17 lists

CONTROL FILE

INPUT OUTPUT FILENAMES

the maximum growth rates, and Table 18 lists half-saturation constants. The source of the algae was Square Lake, Minnesota (Washington County). Temperature was maintained at 12°C, and the photon supply rate was ~60 µmoles/m²/s on a 14 hours light/10 hours dark cycle. The samples were grown over a period of 7 days. Table 17 and Table 18 show results from Grover (1989).

Table 17. Maximum growth rates (1/day) determined by Grover (1989).

Species	Group	Maximum Growth Rate (1/day)		
		Estimate	95% Confidence Limit	
			Lower	Upper
<i>Chlamydomonas</i> sp.	Green	0.79	0.61	0.96
<i>Chlorella</i> sp.	Green	0.81	0.62	1.05
<i>Cryptomonas</i> sp.		0.49	0.39	0.58
<i>Oocystis</i> sp.		0.52	0.43	0.61
<i>Scenedesmus quadricauda</i>		0.63	0.47	0.93
<i>Sphaerocystis schroeteri</i>		0.48	0.28	0.71
<i>Nitzschia acicularis</i>	Diatom	0.35	0.24	0.46
<i>Nitzschia linearis</i>	Diatom	0.56	0.45	0.68
<i>Nitzschia palea</i>	Diatom	0.88	0.77	1.03
<i>Synedra radians</i>	Diatom	0.60	0.39	0.85
<i>Synedra rumpens</i>	Diatom	0.73	0.59	0.88

Table 18. Phosphorus half-saturation coefficients (µmol/liter) determined by Grover (1989).

Species	Group	P-half saturation coefficients (µmol/liter)		
		Estimate	95% Confidence Limit	
			Lower	Upper
<i>Chlamydomonas</i> sp.	Green	0.0071	0.00097	0.038
<i>Chlorella</i> sp.	Green	0.022	0.0047	0.23
<i>Cryptomonas</i> sp.		0.014	0.0043	0.096
<i>Oocystis</i> sp.		0.012	0.0037	0.067
<i>Scenedesmus quadricauda</i>		0.035	0.0043	0.50
<i>Sphaerocystis schroeteri</i>		0.025	0.0011	0.34
<i>Nitzschia acicularis</i>	Diatom	0.0023	0	0.019
<i>Nitzschia linearis</i>	Diatom	0.019	0.0051	0.22
<i>Nitzschia palea</i>	Diatom	0.047	0.016	0.22
<i>Synedra radians</i>	Diatom	0.00014	0	0.012
<i>Synedra rumpens</i>	Diatom	0.0069	0.0014	0.026

Riebesell et. al. (1993) determined maximum growth rates and carbon half-saturation coefficients for 3 species of marine diatoms grown under optimal nutrient and light conditions (see Table 19). The carbon source of common marine diatoms was dissolved CO₂ although some microalgae could use bicarbonate. Temperatures were maintained at 17°C for *D. brightwellii* and *T. punctigera* and 5°C for *R. cf. alata*. Light intensity was 120 µE/m²/s.

Table 19. Maximum growth rates and carbon half saturation constants of 3 marine diatoms (Riebesell et. al., 1993)

Species	Group	Temperature (Celsius)	Light Intensity (µE/m ² /s)	Maximum Growth Rate (1/day)	Carbon half-saturation constant (µM)
<i>Ditylum brightwellii</i>	Marine diatom	17°	120	1.46	1.4
<i>Thalassiosira punctigera</i>	Marine diatom	17°	120	1.30	1.2
<i>Rhizoselina cf. alata</i>	Marine diatom	5°	120	0.93	2.1

INPUT OUTPUT FILENAMES

CONTROL FILE

The common diatom *Skeletonema costatum* was studied by Samuel et. al. (1983). In the East River *Skeletonema costatum* blooms during late winter early spring but does not do well in the summer months, perhaps because of pollution. The East River is saturated with NH₃-N, PO₄-P, and Silicon year-round. The source of water used in measuring growth rates was the East River. Salinity in laboratory was varied to simulate conditions found in East River. Temperature was 20°C and the photo period 14 hours light/10 hours dark at 2500 μW/m². Maximum growth rates measured were 1.2 to 1.8 day⁻¹ as shown in Table 20.

Table 20. Maximum growth rate of *Skeletonema costatum* (Samuel et. al., 1983).

Species	Group	Temperature (Celsius)	Light Intensity (μW/m ²)	Maximum growth rate (day ⁻¹)
<i>Skeletonema costatum</i>	diatom	20°	2500	1.2-1.8

Goldman et. al. (1974) determined the maximum growth rate and inorganic carbon half saturation coefficient for the freshwater algae *Selenastrum capricornutum* and *Scenedesmus quadricauda*. They are green algae of the order Chlorococcales. Algae were grown in continuously stirred reactors at a constant inflow and outflow and constant nutrient concentration. Algae growth was limited by inorganic carbon. The steady state concentration and carbon concentration were fitted to the Monod equation to determine maximum growth rate and half-saturation concentration. Cultures were grown at a constant temperature of 27° ± 1°C. Light was provided with “cool white” fluorescent tubes at an intensity of 4306 ± 431 lumens/meter². Concentrations were determined by counting algae cells. The algae dry weight carbon fraction was 44.7% for *Scenedesmus quadricauda* and 48.9% for *Selenastrum capricornutum*. Results from these tests are shown in Table 21.

Table 21. Maximum growth rates and carbon half-saturation coefficients of the green algae *Selenastrum capricornutum* and *Scenedesmus quadricauda* (Goldman et. al., 1974).

Species	Group	Temperature (Celsius)	Light Intensity (lumens/meter ²)	Maximum growth rate (day ⁻¹)	Carbon Half-saturation coefficient (mg/l)
<i>Selenastrum capricornutum</i>	Green algae	27°	4306 ± 431	2.45	0.4-1.49
<i>Scenedesmus quadricauda</i>	Green algae	27°	4306 ± 431	2.29	0.1-0.7

Chalup and Laws (1990) calculated the nutrient saturated growth rate of the marine phytoplankton *Pavlova lutheri* at different light intensities. Algae were grown in batch cultures at a temperature between 21.9°-22.1°C. Predicted growth rates of 0.625 and 1.14 1/day for light intensities of 5.44 and 16.3 moles quanta/m²-day, respectively. The nutrient saturated growth rate prediction was calculated based on the following regression:

$$\mu_s = \frac{1.95I}{I + 10.8} - 0.03$$

where μ_s and I have the dimensions day⁻¹ and moles quanta m⁻² d⁻¹, respectively. Table 22 shows the predicted growth rates.

Table 22. Nutrient saturated maximum growth rates of the marine algae *Pavlova lutheri* (Chalup and Laws, 1990).

Species	Group	Temperature (Celsius)	Light Intensity (moles quanta/m ² /day)	Growth rate (day ⁻¹)
<i>Pavlova lutheri</i>	marine	22°	5.44	0.625
<i>Pavlova lutheri</i>	marine	22°	16.3	1.14

CONTROL FILE

INPUT OUTPUT FILENAMES

The maximum growth rate (Table 23) and silicon half-saturation constant (Table 24) of two clones of the marine diatom *Thalassiosira Pseudonana* were calculated by Guillard et. al. (1973). One clone was from Saragossa Sea and the other was an estuarine clone from the Forge River, Moriches Bay, Long Island, New York. Batch cultures were grown at 20° Celsius and at 6500 lux. Growth was followed by counting cells.

Table 23. Maximum growth rate of two clones of the marine diatom *Thalassiosira Pseudonana* (Guillard et. al., 1973).

Species	Group	Source	Temperature (Celsius)	Light Intensity (lux)	Growth rate (doublings/day)	Confidence Interval, 95%
<i>Thalassiosira Pseudonana</i>	Marine diatom	Moriches Bay, Long Island, NY	20°	6500	3.64	2.9-4.4
<i>Thalassiosira Pseudonana</i>	Marine diatom	Saragossa Sea	20°	6500	2.13	2.0-2.3

Table 24. Silicon half-saturation constant of two clones of the marine diatom Thalassiosira Pseudonana (Guillard et. al., 1973).

Species	Group	Source	Temperature (Celsius)	Light Intensity (lux)	Half-Saturation Constant (μM)	Confidence Interval, 95%
<i>Thalassiosira Pseudonana</i>	Marine diatom	Moriches Bay, Long Island, NY	20°	6500	0.98	0.28-1.95
<i>Thalassiosira Pseudonana</i>	Marine diatom	Saragossa Sea	20°	6500	0.19	0.09-0.29

Diatoms are not the only alga which require silicon. Klaveness and Guillard (1975) determined the maximum growth rate (Table 25) and silicon half-saturation coefficient (Table 26) for the golden-brown (Chrysophyceae) algae *Synura Petersenii*. Golden brown algae are insignificant in the plankton of the sea but are abundant in freshwater lakes and ponds where they can form blooms. *Synura* spp. are known as an odor producing species. Batch cultures were used to measure growth rate and half-saturation constant. Steady-state conditions were attained by maintaining very low algae populations which did not initially affect nutrient concentrations. Cultures were grown at 20°C and light intensity was 9000 lux with 16 hour days. The algae were obtained from a freshwater pond near Woods Hole, Massachusetts.

Table 25. Maximum growth rate of the golden-brown algae *Synura Petersenii* (Guillard and Klaveness, 1975).

Species	Group	Source	Temperature (Celsius)	Light Intensity (lux)	Maximum growth rate (divisions/day)
<i>Synura Peterse-nii</i>	Golden-brown algae (Chrysophyceae)	Fresh water pond, Massachusetts	20°	9000	1.12

Table 26. Silicon half-saturation constant of the golden-brown algae *Synura Petersenii* (Guillard and Klaveness, 1975).

Species	Group	Source	Temperature (Celsius)	Light Intensity (lux)	Silicon half-saturation constant (μM)
<i>Synura Peterse-nii</i>	Golden-brown algae (Chrysophyceae)	Fresh water pond, Massachusetts	20°	9000	0.23

INPUT OUTPUT FILENAMES

CONTROL FILE

Paasche (1973) measured the maximum growth rates of the marine diatom species *Skeletonema costatum*, *Thalassiosira psuedonana*, *Thalassiosira decipiens*, *Ditylum brightwellii*, and *Licomophora* sp. (Table 27). Cultures of *Skeletonema costatum*, *Thalassiosira decipiens*, and *Licomophora* were isolated from the Oslo Fjord. Cultures were grown at 20°C at a light intensity of about 25000 erg/cm²-sec. An 18 hour day was used for *D. brightwellii* whereas the other cultures were lit continuously.

Table 27. Maximum growth rates for five species of marine diatoms (Paasche, 1973).

Species	Group	Source	Temperature (Celsius)	Light Intensity (erg/cm ² -second)	Maximum growth rate (doublings/day)
<i>Skeletonema costatum</i>	Marine Diatom	Oslo Fjord	20°	25000	2.4
<i>Thalassiosira psuedonana</i>	Marine Diatom		20°	25000	4.0
<i>Thalassiosira decipiens</i>	Marine Diatom	Oslo Fjord	20°	25000	1.4
<i>Ditylum brightwellii</i>	Marine Diatom		20°	25000	3.2
<i>Licomophora</i> sp.	Marine Diatom	Oslo Fjord	20°	25000	1.3

Table 28 shows the maximum growth rate determined for the marine diatom *Skeletonema Costatum costatum* (Sakshaug and Andresen, 1989). The culture temperature was 15°C. *Skeletonema Costatum* is a prominent species in most coastal waters and fjords. At the maximum growth rate of 1.4 day⁻¹ the light intensity was 4.33 PAR, moles/m²-hour (PAR=photosynthetically available radiation). The culture was lit continuously at this growth rate.

Table 28. The maximum growth rate of the marine diatom *Skeletonema costatum* (Sakshaug and Andresen, 1989).

Species	Group	Temperature (Celsius)	Light Intensity (PAR, moles/m ² -hour)	Maximum growth rate (day ⁻¹)
<i>Skeletonema costatum</i>	Marine Diatom	15°	4.33	1.4

Maximum growth rate and dark respiration rate of the three marine diatom species *Skeletonema costatum*, *Olisthodiscus luteus* and *Gonyaulax tamarensis* were measured by Langdon (1987) (see Table 29 and Table 30). Algae were grown using the batch culture method at 15°C with a 14-hour day. Langdon developed a interspecies growth-irradiance model consisting of three variables: cell carbon at maximum growth rate, carbon-chlorophyll a ratio, and dark respiration rate at zero growth rate. Cell growth was measured by counting cells.

Table 29. Maximum growth rate of the three marine diatom species *Skeletonema costatum*, *Olisthodiscus luteus* and *Gonyaulax tamarensis* measured by Langdon (1987).

Species	Group	Temperature (Celsius)	Maximum growth rate (divisions/day)	Standard error of Maximum growth rate (divisions/day)
<i>Skeletonema costatum</i>	Marine Diatom	15°	2.41	0.02
<i>Olisthodiscus luteus</i>	Marine Diatom	15°	0.87	0.03
<i>Gonyaulax tamarensis</i>	Marine Diatom	15°	0.56	0.02

CONTROL FILE**INPUT OUTPUT FILENAMES****Table 30. Dark respiration rate of the three marine diatom species *Skeletonema costatum*, *Olisthodiscus luteus* and *Gonyaulax tamarensis* measured by Langdon (1987).**

Species	Group	Temperature (Celsius)	Dark respiration at zero growth rate (divisions/day)	Standard error (divisions/day)
<i>Skeletonema costatum</i>	Marine Diatom	15°	0.04	0.03
<i>Olisthodiscus luteus</i>	Marine Diatom	15°	0.06	0.06
<i>Gonyaulax tamarensis</i>	Marine Diatom	15°	0.17	0.17

Falkowski et. al. (1985) calculated the steady-state growth rates of three species of marine phytoplankton but did not determine maximum growth rates. They did determine that the *Isochrysis galbana* becomes **light saturated** at 200 µmoles quanta/meter²-second. Phytoplankton were grown at 18°C. **Excretion** rates of less than 5% of gross photosynthesis were observed in *Isochrysis galbana*, *Thalassiosira weisflogii*, and *Prorecntrum micans*.

Table 31. Light saturation of *Isochrysis galbana* (Falkowski et. al., 1985).

Species	Group	Temperature (Celsius)	Light saturation (µmoles quanta/meter ² -second)
<i>Isochrysis galbana</i>	Marine Chrysophyte	18°	200

Laws and Bannister (1981) measured the maximum growth rate of the marine diatom Thalassiosira fluviatilis using the carbon 14 labeling method. A continuous culture system was used to grow the phytoplankton. Temperature was maintained at 20° Celsius with a 12 hour light/12 hour dark cycle. Maximum growth was measured to be 1.22 day⁻¹ as shown in Table 32.

Table 32. Maximum growth rate of Thalassiosira fluviatilis (Laws and Bannister, 1981).

Species	Group	Temperature (Celsius)	Maximum Growth Rate (day ⁻¹)
<i>Thalassiosira fluviatilis</i>	Marine Diatom	20°	1.22

Reay et al. (1999) measured maximum growth rates and optimal growth temperatures while studying the temperature effect of ammonia and nitrate uptake in algae and bacteria. The maximum growth rate and optimum growth temperatures for the algae are listed in Table 33. Also studied was dependence of ammonia and nitrate half-saturation coefficient on temperature. Algae cultures were grown in chemostat and batch cultures and were illuminated using fluorescent tubes emitting 200 µmol of quanta/m²/s.

Table 33. Maximum growth rates and optimum growth temperatures for phytoplankton studied by Reay et al. (1999).

Species	Group	Source	Optimum Growth Temperature (°C)	Maximum growth rate (day ⁻¹)
<i>Chaetoceros</i> sp.	Marine Diatom	Seawater Sample, Southern Ocean	6°	0.67
<i>Chaetoceros curvisetum</i>	Marine Diatom	Seawater Sample, North Sea	23°	0.48
<i>Dinialliella tertiolecta</i>	Flagellate alga	Seawater Sample, Oslo Fjord, Norway	24°	2.50

INPUT OUTPUT FILENAMES

CONTROL FILE

Clark and Flynn (2000) determined maximum growth rates and inorganic carbon half-saturation coefficients of marine phytoplankton while studying the kinetics of inorganic carbon and the influence of nitrogen source as shown in Table 34. Batch cultures were grown in a 16°C room under a photon intensity of 200 $\mu\text{mol m}^{-2} \text{s}^{-1}$ with a 12-hour light/ 12-hour dark cycle using cool-white fluorescent tubes. Half-saturation concentrations were estimated by fitting a growth curve to a rectangular hyperbolic (Michaelis-Menten type) function.

Table 34. Maximum growth rates and carbon half-saturation constants of marine phytoplankton studied by Clark and Flynn (2000).

Species	Group	Nitrogen Source	Carbon half-saturation constant (μM)	Maximum growth rate (day $^{-1}$)
Phaeodactylum tricornutum	Bacillariophyceae	NO ₂	30	0.80
Thalassiosira pseudonana	Bacillariophyceae	NO ₃	273	1.33
		NH ₄	233	1.75
Thalassiosira weissflogii	Bacillariophyceae	NO ₃	258	1.55
		NH ₄	135	1.52
Stichococcus Bacillaris	Chlorophyta	NO ₃	720	0.77
		NH ₄	568	0.83
Alexandrium fundyense	Dinophyta	NO ₃	468	0.36
Scrippsiella trochoidea	Dinophyta	NO ₃	280	0.40
Emiliana huxleyi	Prymnesiophyceae	NO ₃	150	1.19
		NH ₄	114	1.14
Isochrysis galbana	Prymnesiophyceae	NO ₂	81	0.48
Heterosigma carterae	Raphidophyceae	NO ₃	673	1.21
		NH ₄	663	1.62

Litchman (2000) compared the effect of constant light and fluctuating light on algae growth. Growth rate was shown to be species-specific and a diatom's *Nitzschia* sp. growth rate increased under fluctuating light at low average intensities. Maximum growth rates, metabolic loss rate (respiration) and light saturation intensity were measured for 4 freshwater species incubated in batch cultures at 20°C (Table 35). The growth rates of the blue-greens *Anabaena* and *Phormidium* decreased at higher light intensities, whereas the growth rates of *Nitzschia* and the green alga *Sphaerocystis* were not inhibited at higher light intensities.

Table 35. Maximum growth rate, saturation intensity and respiration rate for 4 freshwater algae species (Litchman, 2000).

Species	Group	Saturating Light Intensity ($\mu\text{moles photons/m}^2\text{-s}$)	Respiration rate (day $^{-1}$)	Maximum growth rate (day $^{-1}$)
<i>Nitzschia</i> sp.	Diatom	35	0.24	1.31
<i>Anabaena</i>	Blue-green	25	0.1	1.19
<i>Sphaerocystis</i>	green	19	0.6	1.44
<i>Phormidium</i>	Blue-green	17	0.001	1.4

Maximum algal mortality rate [AM] is also temperature dependent. A general rule of thumb is the maximum algal mortality rate [AM] should be less than 10% of the maximum algal growth rate [AG]. Values ranging from 0.03 to 0.3 have been used in previous modeling studies, with the default value of 0.1 day $^{-1}$ providing excellent results on a large number of systems.

CONTROL FILE

INPUT OUTPUT FILENAMES

[AE] is the maximum algal excretion (or photorespiration) rate that goes directly to the labile DOM compartment. The default value is 0.04 day^{-1} . [AR] is the maximum dark algal respiration rate. Respiration rates are often expressed as millilitres of oxygen consumed per milligram of organism dry weight per hour. To convert to model units ($\text{mg O}_2 \text{ mg}^{-1} \text{ organism dry weight day}^{-1}$), multiply dark respiration rates by $0.74 \text{ mg dry weight}/1 \text{ ml O}_2$. Literature values are reported in [Table 36](#) and [Table 37](#). The default value is 0.04 day^{-1} .

Table 36. Maximum Algal Excretion Rate Literature Values

Species	Excretion Rate, day^{-1}	Reference
Actinastrum hantzschii	0.044	Nalewajko, 1966
Ankistrodesmus falcatus	0.031	Nalewajko, 1966
Asterococcus superbus	0.036	Nalewajko, 1966
Chlorella pyrenoidosa	0.032	Nalewajko, 1966
Eudorina elegans	0.023	Nalewajko, 1966
Micractinium pusillum	0.014	Nalewajko, 1966

Table 37. Algal Dark Respiration Rate Literature Values

Species	Respiration Rate, day^{-1}	Reference
Anabaena variabilis	0.10-0.92	Collins and Boylen, 1978
Chlorella pyrenoidosa	0.01-0.03	Myers and Graham, 1961
Coscinodiscus excentricus	0.07-0.11	Riley and von Aux, 1949
Dunaliella teriolecta	0.12-0.16	Laws and Wong, 1978
Mesodinium rubrum	0.05	Smith, 1979
Monochrysis lutheri	0.15-0.32	Laws and Wong, 1978
Thalassiosira allenii	0.05-0.59	Laws and Wong, 1978

Literature value for algal settling velocities [AS] are given in [Table 38](#), but care must be taken in their use. Laboratory and *in situ* methods for determining settling velocities each have their drawbacks when attempting to measure net settling velocities. The settling velocity is very dependent upon the type of algae present, so a single default value is not recommended. Previous studies have used a settling velocity of 0.2 m day^{-1} for diatoms, 0.1 m day^{-1} for greens, and $0.0-0.05 \text{ m day}^{-1}$ for cyanobacteria. Also, for cyanobacteria or other floating phytoplankton, one can specify a negative settling velocity.

Table 38. Algal settling Velocity Literature Values

Species	Settling velocity, m day^{-1}	Reference
Diatoms		
Asterionella formosa	0.26-0.76	Smayda, 1974
Bacteriastrum hyalinum	0.39-1.27	Smayda & Boleyn, 1966
Chaetoceros didymus	0.85	Eppley Holmes, & Strickland, 1967b
Chaetoceros lauderi	0.46-1.54	Smayda & Boleyn, 1966
Chaetoceros spp.	0.85	Margalef, 1961
Chaetoceros spp.	4.00	Allen, 1932
Coscinodiscus wailesii	7.00-30.2	Eppley Holmes, & Strickland, 1967b
Coscinodiscus sp.	1.95-6.83	Eppley Holmes, & Strickland, 1967b
Cyclotella meneghiniana	0.08-0.24	Titman & Kilham, 1976
Cyclotella nana	0.16-0.76	Eppley Holmes, & Strickland, 1967b
Ditylum brightwellii	0.60-3.09	Eppley Holmes, & Strickland, 1967b
Fragilaria crotonensis	0.27	Burns & Rosa, 1980
Leptocylindrum danicus	0.08-0.42	Margalef, 1961
Melosira agassizii	0.67-1.87	Titman & Kilham, 1976
Nitzschia closterium	0.52	Margalef, 1961
Nitzschia seriata	0.35-0.50	Smayda & Boleyn, 1965
Phaeodactylum tricornutum	0.02-0.06	Riley, 1943

INPUT OUTPUT FILENAMES

CONTROL FILE

Species	Settling velocity, $m day^{-1}$	Reference
Rhizosolenia hebetata	0.22	Eppley, Holmes, & Strickland, 1967b
Rhizosolenia setigera	0.10-6.30	Smayda & Boleyn, 1974
Rhizosolenia stolterfothii	1.00-1.9	Eppley, Holmes, & Strickland, 1967b
Rhizosoleni sp.	0.00-0.72	Margalef, 1961
Skeletonema costatum	0.30-1.35	Smayda & Boleyn, 1974
Stephanopyxis turris	1.10	Eppley, Holmes, & Strickland, 1967b
Thalassionema nitzsiodes	0.35-0.78	Smayda (unpublished)
Thalassiosira fluviatilis	0.60-1.10	Eppley, Holmes, & Strickland, 1967b
Thalassiosira nana	0.10-0.28	Smayda & Boleyn, 1966
Thalassiosira rotula	0.39-2.10	Smayda & Boleyn, 1966
Dinoflagellates		
Gonyaulax polyedra	2.80-6.10	Bramlette, 1961
Coccolithophorids		
Coccolithus huxleyi	0.28, 1.2	Eppley, Holmes, & Strickland, 1967b
Cricospaera carterae	1.7	Eppley, Holmes, & Strickland, 1967b
Cricospaera elongata	0.25	Eppley, Holmes, & Strickland, 1967b
Cycloccolithus fragilis	10.3-13.2	Bernard, 1963
Microflagellates		
Cryptomonas reosa	0.31	Burns & Rosa, 1980

[AHSP] is the algal half-saturation constant for phosphorus and is defined as the phosphorus concentration at which the uptake rate is one-half the maximum rate (see Table 39). This represents the upper concentration at which algal growth is directly proportional to phosphorus concentrations.

Table 39. Phosphorus Half-Saturation Constant Literature Values

Species	Half-Saturation Constant, $mg l^{-1}$	Reference
Asterionella formosa	0.002	Holm & Armstrong, 1981
Asterionella japonica	0.014	Thomas & Dodson, 1968
Biddulphia sinensis	0.016	Quasim, et al., 1973
Cerataulina bergenii	0.003	Finenko & Krupatkina, 1974
Chaetoceros curvistus	0.074-0.105	Finenko & Krupatkina, 1974
Chaetoceros socialis	0.001	Finenko & Krupatkina, 1974
Chlorella pyrenoidosa	0.380-0.475	Jeanjean, 1969
Cyclotella nana	0.055	Fuhs, et al., 1972
Cyclotella nana	0.001	Fogg, 1973
Dinobryon cylindrium	0.076	Lehman (unpublished)
Dinobryon sociale	0.047	Lehman (unpublished)
Euglena gracilis	1.520	Dlum, 1966
Microcystis aeruginosa	0.006	Holm & Armstrong, 1981
Nitzschia actinastreoides	0.095	Von Muller, 1972
Pediastrum duplex	0.105	Lehman (unpublished)
Pithophora oedogonia	0.980	Spencer & Lembi, 1981
Scenedesmus obliquus	0.002	Fogg, 1973
Scenedesmus sp.	0.002-0.050	Rhee, 1973
Thalassiosira fluviatilis	0.163	Fogg, 1973

[AHSN] is the algal half-saturation constant for nitrogen and is defined as the nitrogen concentration (ammonium + nitrate/nitrite) at which the uptake rate is one-half the maximum rate. This represents the upper concentration at which algal growth is proportional to nitrogen. [Table 40](#) gives literature values for the nitrogen half-saturation constant. To simulate algal nitrogen fixation, set [AHSN] equal to 0.0.

Table 40. Nitrogen Half-Saturation Constant Literature Values

Species	Half saturation constant	N source	Reference
Diatoms			
<i>Biddulphia aurita</i>	0.056-0.197	NO3	Underhill, 1977
<i>Chaetoceros gracilis</i>	0.012	NO3	Eppley, Rogers, & McCarthy, 1969
	0.012	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Coscinodiscus lineatus</i>	0.012	NO3	Eppley, Rogers, & McCarthy, 1969
	0.012	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Cyclotella nana</i>	0.025-0.117	NO3	Carpenter & Guillard, 1971
	0.111		MacIsaac & Dugdale, 1969
	0.027		Caperon & Meyer, 1972
	0.031		Eppley, Rogers, & McCarthy, 1969
<i>Ditylum brightwellii</i>	0.037	NO3	Eppley, Rogers, & McCarthy, 1969
	0.020	NO3	Eppley, Rogers, & McCarthy, 1969
<i>Dunaliella teriolecta</i>	0.013	NO3	Caperon & Meyer, 1972
	0.013	NH4	Caperon & Meyer, 1972
	0.087	NO3	Eppley, Rogers, & McCarthy, 1969
<i>Fragilaria pinnata</i>	0.037-0.100	NO3	Carpenter & Guillard, 1971
<i>Leptocylindrus danicus</i>	0.078	NO3	Eppley, Rogers, & McCarthy, 1969
	0.013	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Navicula pelliculosa</i>	0.923	NO3	Wallen & Cartier, 1975
<i>Phaeodactylum tricornutum</i>	0.161	NO3	Ketchum, 1939
<i>Rhizosolenia robusta</i>	0.186	NO3	Eppley, Rogers, & McCarthy, 1969
	0.135	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Rhizosolenia stolterfothii</i>	0.105	NO3	Eppley, Rogers, & McCarthy, 1969
	0.009	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Skeletonema costatum</i>	0.027	NO3	Eppley, Rogers, & McCarthy, 1969
	0.014	NH4	Eppley, Rogers, & McCarthy, 1969
Bluegreens			
<i>Anabaena cylindrica</i>	4.34	NO3	Hattori, 1962
	2.48	NO3	Hattori, 1962
<i>Asterionella formosa</i>	0.074-0.093	NO3	Eppley & Thomas, 1969
	0.062	NH4	Eppley & Thomas, 1969
<i>Oscillatoria agardhii</i>	0.22	NO3	van Lierre, 1977
Microflagellates			
<i>Bellochia</i> sp.	0.001-0.16	NO3	Carpenter & Guillard, 1971
<i>Monochrysis lutheri</i>	0.026	NO3	Caperon & Meyer, 1972
	0.052	NH4	Caperon & Meyer, 1972
	0.037	NO3	Eppley, Rogers, & McCarthy, 1969
	0.007	NH4	Eppley, Rogers, & McCarthy, 1969
Coccolithophorids			
<i>Coccolithus huxleyi</i>	0.006	NO3	Eppley, Rogers, & McCarthy, 1969
	0.002	NH4	Eppley, Rogers, & McCarthy, 1969
Greens			
<i>Chlorella pyrenoidosa</i>	0.006-0.14		Pickett, 1975
	1.15	NO3	Knudsen, 1965
<i>Pithophora cedogonia</i>	1.236	NO3	Spencer & Lembi, 1981
Dinoflagellates			
<i>Gonyaulax polyedra</i>	0.589	NO3	Eppley, Rogers, & McCarthy, 1969
	0.099	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Gymnodinium splendens</i>	0.235	NO3	Eppley, Rogers, & McCarthy, 1969
	0.099	NH4	Eppley, Rogers, & McCarthy, 1969
<i>Gymnodinium wailesii</i>	0.223	NO3	Eppley, Rogers, & McCarthy, 1969
	0.088	NH4	Eppley, Rogers, & McCarthy, 1969

INPUT OUTPUT FILENAMES

CONTROL FILE

Species	Half saturation constant	N source	Reference
Chrysophytes			
Isochrysis galbana	0.006	NO3	Eppley, Rogers, & McCarthy, 1969

[AHSI] is the half-saturation constant for Silica for diatoms only. Nelson and Brzezinski (1990) report half-saturation values of 0.53 to 0.90 μM which is 0.015 to 0.025 mg/l Si for marine diatoms.

[ASAT] is the saturating light intensity at the maximum photosynthetic rate. Since phytoplankton adapt to low light regimes, saturation coefficients may be lower than those measured in the laboratory. [Table 41](#) gives literature values for [ASAT]. EPA (1985) gives as a guideline that [ASAT] for total phytoplankton range between 200-350 Langleys/day (about 100-170 W/m²).

Table 41. Literature values for saturating light intensity

Species	Saturation, W m^{-2}	Reference
<i>Cryptomonas ovata</i>	12-36	Cloern, 1977
<i>Oscillatoria agardhii</i>	10	van Lierre, et al., 1978
<i>Oscillatoria rubescens</i>	36-61	Konopka, 1983
<i>Scenedesmus protuberans</i>	24	van Lierre, et al., 1978
Mixed diatoms	86	Belay, 1981
Mixed phytoplankton	36	Belay, 1981
Shade-adapted phytoplankton	18-29	Belay, 1981

Example

ALGAL RATE	AG	AR	AE	AM	AS	AHSP	AHSN	AHSSI	ASAT
Alg 1	1.5	0.04	0.04	0.15	0.20	0.003	0.014	0.003	75.0
Alg 2	2.5	0.04	0.04	0.10	0.10	0.003	0.014	0.000	75.0
Alg 3	0.5	0.04	0.04	0.05	0.02	0.003	0.010	0.000	75.0

[Excel input file for algae is shown after ALG STOICH.]

Related Cards and Files

[Algal Extinction](#)

[Algal Temperature Rate Coefficients](#)

[Algal Stoichiometry](#)

Algal Temperature Rate Coefficients (ALG TEMP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	AT1	Real	5.0	Lower temperature for algal growth, °C
3	AT2	Real	25.0	Lower temperature for maximum algal growth, °C
4	AT3	Real	35.0	Upper temperature for maximum algal growth, °C
5	AT4	Real	40.0	Upper temperature for algal growth, °C
6	AK1	Real	0.1	Fraction of algal growth rate at AT1
7	AK2	Real	0.99	Fraction of maximum algal growth rate at AT2
8	AK3	Real	0.99	Fraction of maximum algal growth rate at AT3
9	AK4	Real	0.1	Fraction of algal growth rate at AT4

This card specifies the lower, maximum lower, upper, and maximum upper temperatures used in defining the curve that determines effects of temperature on algal rates. Also specified is the fraction of maximum algal rates that occurs at the specified temperature. The default values are ones for a single algal assemblage used in Version 2. When including multiple algal groups, the temperature rate coefficients are one of the most important parameters determining algal succession. Diatoms would have much lower temperatures for **AT1-AT4** than cyanobacteria. Hence, temperature ranges for algae vary by species. EPA (1985) reports maximum growth rates between 10°C and 27°C for diatoms depending on the species, between 20°C and 40°C (typical 20-25°C) for green algae depending on the species, and between 20°C and 40°C (typical 25°C) for blue-green (cyanobacteria) depending on the species.

Algae temperature preferences can determine algae succession when modeling multiple algae groups

How temperature affects algae growth is shown in Figure 23 for the default values of **AT1** through **AT4** and **AK1** through **AK4**. Note that the growth rate **AG** is specified as the maximum growth rate at the optimal temperature.

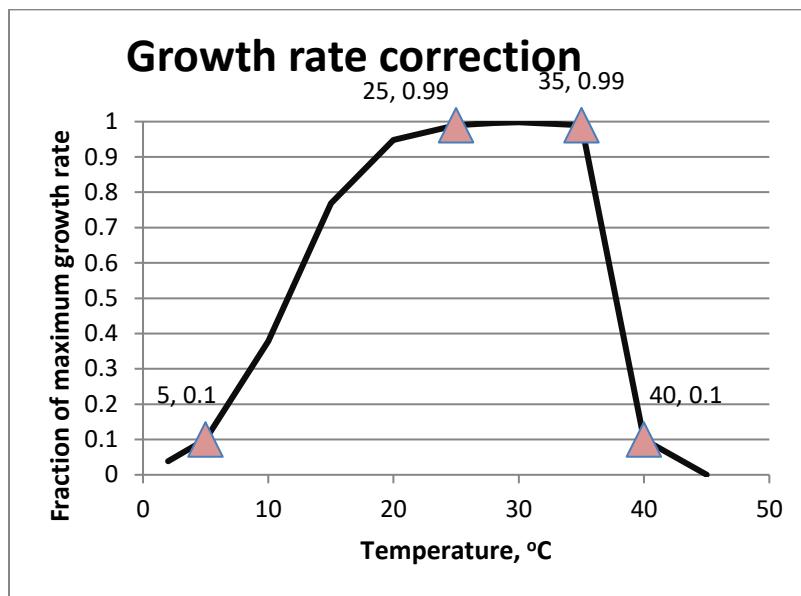


Figure 23. Growth rate as a function of temperature.

Example

ALGAL TEMP	AT1	AT2	AT3	AT4	AK1	AK2	AK3	AK4
Alg 1	5.0	18.0	20.0	24.0	0.1	0.99	0.99	0.01
Alg 2	10.0	30.0	35.0	40.0	0.1	0.99	0.99	0.01
Alg 3	10.0	35.0	40.0	50.0	0.1	0.99	0.99	0.01

[Excel input file for algae is shown after ALG STOICH.]

Related Cards and Files

[Algal Rates](#)
[Algal Extinction](#)
[Algal Stoichiometry](#)

CONTROL FILE**INPUT OUTPUT FILENAMES****Algal Stoichiometry (ALG STOICH)**

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	AP	Real	0.005	Stoichiometric equivalent between algal biomass and phosphorus, fraction
3	AN	Real	0.08	Stoichiometric equivalent between algal biomass and nitrogen, fraction
4	AC	Real	0.45	Stoichiometric equivalent between algal biomass and carbon, fraction
5	ASI	Real	0.18	Stoichiometric equivalent between algal biomass and silica, fraction
6	ACHLA	Real	0.05	Ratio between algal biomass and chlorophyll a in terms of mg algae/µg chl a
7	APOM	Real	0.8	Fraction of algal biomass that is converted to particulate organic matter when algae die
8	ANEQN	Integer	2	Equation number for algal ammonium preference (either 1 or 2)
9	ANPR	Real	0.001	Algal half saturation constant for ammonium preference
10	AVERTM	Character		ON or OFF. This turns ON/OFF vertical migration of algae

This card specifies the stoichiometric equivalences used for determining the amount of nutrients in algal biomass. Numerous researchers have noted that these ratios are not constant over time and vary by algal species. In addition, the algal to chlorophyll *a* ratio [**ACHLA**] is known to be different for different algal species and is known to vary over time for a given algal species.

Table 42 shows a summary of algal stoichiometry based on C, N, P, and Si percentages of dry-weight biomass from Reynolds (1984) for freshwater algae. EPA (1985) shows dry weight biomass fractions of C, N, and P ranging from 0.19-0.74 (typically 0.4-0.5), 0.006-0.16 (typically 0.08), and 0.0008 to 0.03 (typically 0.01), respectively, depending on algae type.

EPA(1985) reports percentages of chlorophyll *a* compared to dry weight algae biomass ranging from 0.25 to 3 for blue-green algae and from 2 to 10 for total phytoplankton. These correspond to a range in algae to chlorophyll *a* ratios (mg dry weight organic matter/µg chlorophyll *a*) [**ACHLA**] between 0.01 to 0.4. EPA(1985) also reports carbon:chlorophyll *a* ratios of from 10 to 100. Using a ratio of C:organic matter (OM) of about 1:2, this is approximately a range of 20-200 mg OM/mg chlorophyll *a*, or 0.02 to 0.2 mg OM/ µg chlorophyll *a*. Currently, the model does not include variable stoichiometry or a variable biomass to chlorophyll *a* ratio.

[**APOM**] is the fraction of algal biomass lost by mortality going into the detritus compartment with the remainder going to labile DOM. Otsuki and Hayna (1972) have reported a value of 0.8 for *Scenedesmus* sp. and this is the default value.

Certain algal groups are known to preferentially uptake ammonium over nitrate. If the equation number [**ANEQN**] for algal nitrogen uptake is set to 1, then the algal nitrogen preference factor for ammonium is computed using:

INPUT OUTPUT FILENAMES

CONTROL FILE

$$P_{NH4} = \frac{C_{NH4}}{(C_{NO3} + C_{NH4})}$$

and the preference for nitrate is:

$$P_{NO3} = \frac{C_{NO3}}{(C_{NO3} + C_{NH4})}.$$

If the equation number [ANEQN] is set to 2, then the phytoplankton nitrogen preference for ammonium is computed using the following equation (Thomann and Fitzpatrick, 1982):

$$P_{NH4} = C_{NH4} \frac{C_{NOx}}{(K_{mN} + C_{NH4})(K_{mN} + C_{NOx})} + C_{NH4} \frac{K_{mN}}{(C_{NH4} + C_{NOx})(K_{mN} + C_{NOx})}$$

P_{NH4} = ammonium preference factor

K_{mN} = N half-saturation coefficient, mg l⁻¹

C_{NH4} = ammonium nitrogen concentration. mg l⁻¹

C_{NOx} = nitrate-nitrite nitrogen concentration. mg l⁻¹

The nitrite-nitrate nitrogen preference factor is then calculated from:

$$P_{NOx} = 1 - P_{NH4}$$

Table 42. Freshwater algae minimum and optimum elemental contents in percentages of dry-weight (Reynolds, 1984).

Content ((percentages are ash-free dry weight)	C	N	P	Si
Minimum				
<i>Anabaena flos-aquae</i>	49.7 ⁽¹⁾		0.40 ⁽²⁾	
<i>Microcystis aeruginosa</i>	46.5 ⁽¹⁾	3.8 ⁽³⁾	0.34 ⁽³⁾	
Various cyanobacteria		4.5 ⁽⁴⁾		
<i>Asterionella formosa</i>				32 ⁽⁴⁾
<i>Stephanodiscus hantzschii</i>				20 ⁽⁴⁾
<i>Asterionella Formosa</i>		3.4 ⁽⁵⁾	0.03 ⁽⁶⁾	
<i>Scenedesmus obliquus</i>	54.6 ⁽¹⁾			
<i>Scenedesmus quadricauda</i>			0.59 ⁽⁷⁾	
<i>Scenedesmus sp.</i>			0.10 ⁽⁸⁾	
Optimum				
Cyanobacteria	46-49 ⁽¹⁾	8-11 ⁽⁹⁾	0.7-1.1 ^(1,9)	
Chrysophytes		3.3-5 ⁽⁹⁾	2.1 ⁽⁹⁾	
Chlorophytes	49-56 ⁽¹⁾	6.6-1.9 ⁽⁹⁾	1.2-2.9 ^(1,9)	
General population ⁽¹⁰⁾	51-56	8.0-10.4	0.8-1.45	

Original references in Reynolds(1984): (1) Anon (1968); (2) Healey (1973); (3) Gerloff & Skoog (1954); (4) Lund (1965); (5) Lund (1950); (6) Mackereth (1953); (7) Nalewajko & Lean (1978); (8) Rhee (1973); (9) Strickland (1965); (10) Reynolds (1984).

Example

ALG	STOICH	ALGP	ALGN	ALGC	ALGSI	ACHLA	APOM	ANEQN	ANPR	AVERTM
Alg 1		0.005	0.08	0.45	0.18	0.05	0.8	2	0.001	OFF
Alg 2		0.005	0.08	0.45	0.00	0.04	0.8	2	0.001	OFF
Alg 3		0.005	0.08	0.45	0.00	0.1000	0.8	2	0.001	OFF

CONTROL FILE**INPUT OUTPUT FILENAMES**

The Excel algae input section also includes O2AR and O2AG which are the stoichiometric equivalent of oxygen per algae dry weight biomass which are defined in [Oxygen Stoichiometry 2](#).

ALGAL RATES	ALG1	ALG2
AG - algae max growth rate- 1/day	2	
AR - algae respiration rate- 1/day	0.04	
AE - algae excretion rate	0.04	
AM - algae mortality rate	0.1	
AS - algae settling velocity- m/day	0.1	
AHSP - algae half-saturation rate for P- mg/l	0.003	
AHSN - algae half-saturation rate for N- mg/l	0.014	
AHSSI - algae half-saturation for Si- mg/l	0	
ASAT - algae light saturation- W/m ²	100	
AT1 - Temperature C for set point 1	5	
AT2 - Temperature C for set point 2	30	
AT3 - Temperature C for set point 3	35	
AT4 - Temperature C for set point 4	40	
AK1 - fraction of max growth rate at AT1	0.1	
AK2 - fraction of max growth rate at AT2	0.99	
AK3 - fraction of max growth rate at AT3	0.99	
AK4 - fraction of max growth rate at AT4	0.1	
AP ALGP Stoichiometric ratio of P to algae biomass	0.005	
AN ALGN Stoichiometric ratio of N to algae biomass	0.08	
AC ALGC Stoichiometric ratio of C to algae biomass	0.45	
ASI ALGSI Stoichiometric ratio of Si to algae biomass	0	
ACHLA Chlorophyll a to algae biomass ratio	0.065	
APOM ALPOM fraction of biomass going to POM at death	0.8	
ANEQN NH4-NO3 preference equation #	1	
ANPR Parameter for ANEQN#2	0.001	
O2AR Stoichiometric ratio of O ₂ to algae biomass, for algal respiration (mg O ₂ /mg algae organic matter)	1.1	
O2AG Stoichiometric ratio of O ₂ to algae biomass, for algal primary production (mg O ₂ /mg algae organic matter)	1.4	
Algae Vertical Migration, ON/OFF, AVERTM	OFF	

Related Cards and Files[Algal Rates](#)[Algal Extinction](#)[Algal Temperature Rate Coefficients](#)

Epiphyte/Periphyton Control (EPIPHYTE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	EPIWBC	Character	OFF	Waterbody epiphyte/periphyton computations, ON or OFF

This card allows the user to turn ON/OFF epiphyton/periphyton computations and their effects on water quality for a given waterbody. This flexibility allows the user to decrease model complexity and computation time for waterbodies where epiphyton/periphyton impacts are not considered important.

Example

```
EPIPHYTE EPIWB1C EPIWB2C EPIWB3C EPIWB4C EPIWB5C EPIWB6C EPIWB7C EPIWB8C
Epi 1      ON      ON      ON      ON
```

[Excel input file is shown in [Epiphyte/Periphyton Initial Density](#).]

Related Cards and Files

- [Epiphyte Print](#)
- [Epiphyte Initial Density](#)
- [Epiphyte Rate](#)
- [Epiphyte Half-Saturation](#)
- [Epiphyte Temperature Rate Coefficients](#)
- [Epiphyte Stoichiometry](#)

Epiphyte/Periphyton Print (EPI PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	EPRWBC	Character	OFF	epiphyte areal density output, ON or OFF

This card allows the user to turn ON/OFF epiphyton/periphyton biomass output in terms of areal density to the various output files for each waterbody.

Example

```
EPI PRINTEPRWB1C EPRWB2C EPRWB3C EPRWB4C EPRWB5C EPRWB6C EPRWB7C EPRWB8C
Epi 1      ON      ON      ON      ON
```

[Excel input file is shown in [Epiphyte/Periphyton Initial Density](#).]

Related Cards and Files

- [Epiphyte Control](#)
- [Epiphyte Initial Density](#)
- [Epiphyte Rate](#)
- [Epiphyte Half-Saturation](#)
- [Epiphyte Temperature Rate Coefficients](#)
- [Epiphyte Stoichiometry](#)

Epiphyte/Periphyton Initial Density (EPIINI)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EPIWBCI	Real	Initial areal density for each epiphyton//periphyton group, $g\ m^{-2}$

This card specifies the initial epiphyton/periphyton areal density for each waterbody. If the initial density is greater than or equal to zero, then this is the initial areal biomass for each waterbody. If the initial areal density is '-1', then the model will look for a VPR (vertical profile) file that specifies the initial areal density for each vertical layer in the waterbody. If the initial areal density is '-2', then the model will look for an LPR (longitudinal profile) file that specifies the initial areal density for each active model cell.

Initial condition	[EPIWBCI]
Isoconcentration	>or =0.0
Single vertical profile	-1.0
Vertical profile at each segment	-2.0

The format of the VPR (vertical profile file) and the LPR (longitudinal profile file) are shown in the Input File section.

Example

```
EPI INIT EPIWBCI EPIWBCI EPIWBCI EPIWBCI EPIWBCI EPIWBCI EPIWBCI EPIWBCI  
Epi 1      10.0    10.0    10.0    -2.0
```

The Excel input file is set up for a fixed 5 periphyton groups even if the user only has 0-4 groups. If more than 5 periphyton groups, one must add another row for each periphyton group >5.

EPIPHYTON	WB1	WB2
EPIC Turn ON/OFF Periphyton group 1	OFF	
EPRC Turn ON/OFF print for Periphyton group 1	OFF	
EPIC INIT Initial areal density Periphyton group 1 g/m ²	20	
EPIC Turn ON/OFF Periphyton group 2		
EPRC Turn ON/OFF print for Periphyton group 2		
EPIC INIT Initial areal density Periphyton group 2 g/m ²		
EPIC Turn ON/OFF Periphyton group 3		
EPRC Turn ON/OFF print for Periphyton group 3		
EPIC INIT Initial areal density Periphyton group 3 g/m ²		
EPIC Turn ON/OFF Periphyton group 4		
EPRC Turn ON/OFF print for Periphyton group 4		
EPIC INIT Initial areal density Periphyton group 4 g/m ²		
EPIC Turn ON/OFF Periphyton group 5		
EPRC Turn ON/OFF print for Periphyton group 5		
EPIC INIT Initial areal density Periphyton group 5 g/m ²		

Related Cards and Files

[Epiphyte Control](#)

[Epiphyte Temperature Rate Coefficients](#)

[Epiphyte Print](#)

[Epiphyte Stoichiometry](#)

[Epiphyte Rate](#)

[Vertical Profile File](#)

[Epiphyte Half-Saturation](#)

[Longitudinal Profile File](#)

Epiphyte/Periphyton Rate (EPI RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	EG	Real	2.0	maximum epiphyton/periphyton growth rate, day^{-1}
3	ER	Real	0.04	maximum epiphyton/periphyton respiration rate, day^{-1}
4	EE	Real	0.04	maximum epiphyton/periphyton excretion rate, day^{-1}
5	EM	Real	0.1	maximum epiphyton/periphyton mortality rate, day^{-1}
6	EB	Real	0.001	epiphyton/periphyton burial rate, day^{-1}
7	EHSP	Real	0.003	epiphyton half-saturation for phosphorus limited growth, $g m^{-3}$
8	EHSN	Real	0.014	epiphyton half-saturation for nitrogen limited growth, $g m^{-3}$
9	EHSSI	Real	-	epiphyton half-saturation for silica limited growth, $g m^{-3}$

This card specifies rates for epiphyton/periphyton growth, mortality, excretion, respiration, and burial. Additionally, values that affect the maximum epiphyton/periphyton growth rate including nutrient limited growth are also specified here. See the [Algal Rate](#) card for more detailed information, as the kinetic formulations are similar. Epiphyton/periphyton mortality becomes part of the LDOM and LPOM organic pool based on the variable EPOM (see EPI STOICH). The burial rate causes epiphyton/periphyton to be lost from the system and added to the first order sediment compartment.

Example

```
EPI RATE      EG      ER      EE      EM      EB      EHSP     EHSN    EHSSI
Epi 1        2.0     0.04    0.04    0.1     0.001   0.002   0.002   0.0
```

[Excel input file is shown in [Epiphyte/Periphyton Stoichiometry](#).]

Related Cards and Files

- [Epiphyte Control](#)
- [Epiphyte Print](#)
- [Epiphyte Initial Density](#)
- [Epiphyte Half-Saturation](#)
- [Epiphyte Temperature Rate Coefficients](#)
- [Epiphyte Stoichiometry](#)

Epiphyte/Periphyton Half-Saturation (EPI HALF)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ESAT	Real	75.0	light saturation intensity at maximum photosynthetic rate, $W\ m^{-2}$
3	EHS	Real	35.0	biomass limitation factor, $g\ m^{-2}$
4	ENEQN	Integer	2	ammonia preference factor equation for epiphyton/periphyton (1 or 2)
4	ENPR	Real	0.001	nitrogen half-saturation preference constant, mg/l - only used if ENEQN=2

This card specifies the light saturation intensity at maximum photosynthetic rate [ESAT], the half-saturation coefficient for epiphyton biomass limitation [EHS], and the nitrogen preference during epiphyton/periphyton growth [ENPR]. The ratio of nitrate-nitrite to ammonium taken up during epiphyton/periphyton growth increases as [ENPR] increases.

Field data during 2001 in the Spokane River have shown that biomass (dry weight) for epiphyton/periphyton can vary significantly from 13 to over 500 g/m², with median values of about 40 g/m² (Annear, et al., 2005). Field data of periphyton biomass needs though to be examined to ensure that it is representative of active epiphyton, which CE-QUAL-W2 computes. For example, in this model study, a value of **EHS** of 35 g/m² was used.

Certain epiphyton groups are known to preferentially uptake ammonium over nitrate. If the equation number [**ANEQN**] for algal nitrogen uptake is set to 1, then the epiphyton/periphyton nitrogen preference factor for ammonium is computed using:

$$P_{NH4} = \frac{C_{NH4}}{(C_{NO3} + C_{NH4})}$$

and the preference for nitrate is:

$$P_{NO3} = \frac{C_{NO3}}{(C_{NO3} + C_{NH4})}.$$

If the equation number [**ANEQN**] is set to 2, then the epiphyton/periphyton preference for ammonium is computed using the following equation (Thomann and Fitzpatrick, 1982):

$$P_{NH4} = C_{NH4} \frac{C_{NOx}}{(K_{mN} + C_{NH4})(K_{mN} + C_{NOx})} + C_{NH4} \frac{K_{mN}}{(C_{NH4} + C_{NOx})(K_{mN} + C_{NOx})}$$

P_{NH4} = ammonium preference factor

K_{mN} = N half-saturation coefficient, $mg\ l^{-1}$

C_{NH4} = ammonium nitrogen concentration. $mg\ l^{-1}$

C_{NOx} = nitrate-nitrite nitrogen concentration. $mg\ l^{-1}$

The nitrite-nitrate preference factor is then calculated from:

$$P_{NOx} = 1 - P_{NH4}$$

INPUT OUTPUT FILENAMES

CONTROL FILE

Example

```
EPI HALF     ESAT      EHS      ENEQN      ENPR  
Epi 1       150.00    35.0     2         0.001
```

[Excel input file is shown in [Epiphyte/Periphyton Stoichiometry](#).]

Related Cards and Files

[Epiphyte Control](#)

[Epiphyte Print](#)

[Epiphyte Initial Density](#)

[Epiphyte Rate](#)

[Epiphyte Temperature Rate Coefficients](#)

[Epiphyte Stoichiometry](#)

Epiphyte/Periphyton Temperature Rate Coefficients (EPI TEMP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ET1	Real	5.0	Lower temperature for epiphyton growth, °C
3	ET2	Real	25.0	Lower temperature for maximum epiphyton/periphyton growth, °C
4	ET3	Real	35.0	Upper temperature for maximum epiphyton/periphyton growth, °C
5	ET4	Real	40.0	Upper temperature for epiphyton/periphyton growth, °C
6	EK1	Real	0.1	Fraction of epiphyton/periphyton growth rate at ET1
7	EK2	Real	0.99	Fraction of maximum epiphyton/periphyton growth rate at ET2
8	EK3	Real	0.99	Fraction of maximum epiphyton/periphyton growth rate at ET3
9	EK4	Real	0.1	Fraction of epiphyton/periphyton growth rate at ET4

This card specifies the lower, maximum lower, upper, and maximum upper temperatures used in defining the curve that determines effects of temperature on epiphyton/periphyton rates. Also specified is the fraction of maximum epiphyton/periphyton rates that occurs at the specified temperature.

How temperature affects epiphyton/periphyton growth is shown Figure 24 for the default values of ET1 through ET4 and EK1 through EK4.

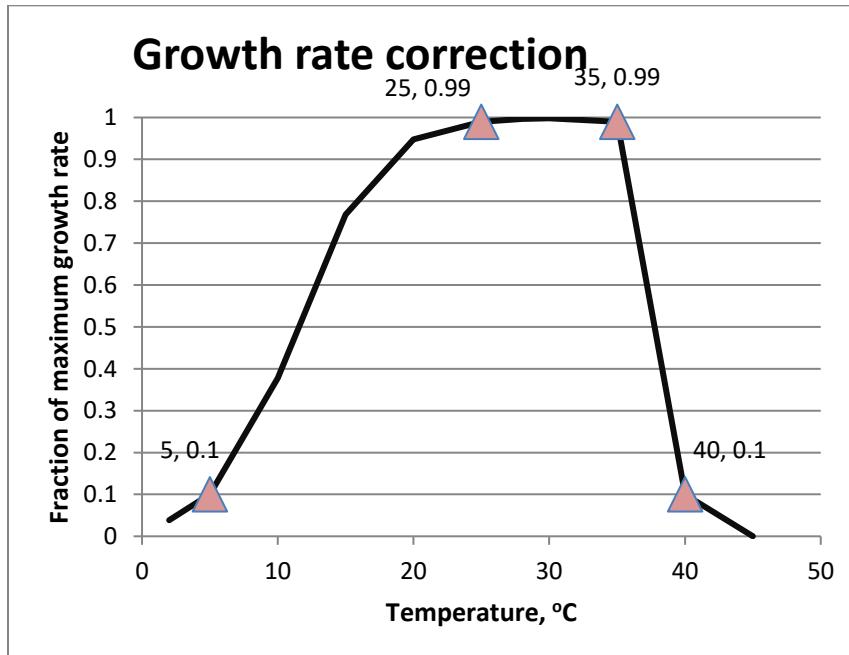


Figure 24. Growth rate as a function of temperature.

INPUT OUTPUT FILENAMES

CONTROL FILE

Example

EPI TEMP	ET1	ET2	ET3	ET4	EK1	EK2	EK3	EK4
Epi 1	5.0	18.0	20.0	24.0	0.1	0.99	0.99	0.01
Epi 2	10.0	30.0	35.0	40.0	0.1	0.99	0.99	0.01
Epi 3	10.0	35.0	40.0	50.0	0.1	0.99	0.99	0.01

[Excel input file is shown in [Epiphyte/Periphyton Stoichiometry](#).]

Related Cards and Files

[Epiphyte Control](#)

[Epiphyte Print](#)

[Epiphyte Initial Density](#)

[Epiphyte Rate](#)

[Epiphyte Half-Saturation](#)

[Epiphyte Stoichiometry](#)

Epiphyte/Periphyton Stoichiometry (EPI STOICH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	EP	Real	0.005	Stoichiometric equivalent between epiphyton/periphyton biomass and phosphorus
3	EN	Real	0.08	Stoichiometric equivalent between epiphyton/periphyton biomass and nitrogen
4	EC	Real	0.45	Stoichiometric equivalent between epiphyton/periphyton biomass and carbon
5	ESI	Real	0.18	Stoichiometric equivalent between epiphyton/periphyton biomass and silica
6	ECHLA	Real	0.05	Ratio between epiphyton/periphyton biomass and chlorophyll a [Not used at present], mg biomass/ μg chlorophyll a
7	EPOM	Real	0.8	Fraction of epiphyton/periphyton biomass that is converted to particulate organic matter when epiphyton/periphyton die

This card specifies the stoichiometric equivalences used for determining the amount of nutrients in epiphyton/periphyton biomass. These ratios are not constant over time and vary by epiphyton/periphyton species. The ratio of epiphyton biomass to chlorophyll a is currently not used in the model. This ratio will be used in the future to provide output in chlorophyll a rather than dry weight biomass. In addition, the epiphyton/periphyton to chlorophyll a ratio [ECHLA] is known to be different for different epiphyton/periphyton species and is known to vary over time for a given epiphyton/periphyton species. Currently, the model does not include variable stoichiometry or biomass to chlorophyll a ratios. This is an area that will be improved upon in the future. [EPOM] is the fraction of epiphyton/periphyton biomass lost by mortality going into the detritus compartment (labile POM) with the remainder going to labile DOM.

Example

```

EPI STOICH    EP      EN      EC      ESI      ECHLA     EPOM
Epi 1        0.005    0.08    0.45    0.18    0.05      0.8
Epi 2        0.005    0.08    0.45    0.00    0.05      0.8
Epi 3        0.005    0.08    0.45    0.00    0.05      0.8
  
```

The Excel file section also includes the variables O2ER and O2EG which are the stoichiometric equivalents of oxygen to organic matter for periphyton. These are described in [Oxygen Stoichiometry 3](#).

EPIPHYTON growth rate constants for each periphyton group		EP1	EP2
EG growth rate day-1		1.5	
ER respiration rate day-1		0.05	
EE excretion rate day-1		0.02	
EM mortality rate day-1		0.1	
EB burial rate day-1		0	
EHSP half saturation constant P- g/m^3		0.002	
EHSN half saturation constant N- g/m^3		0.002	
EHSSI half saturation constant Si- g/m^3		0	

INPUT OUTPUT FILENAMES**CONTROL FILE**

ESAT light saturation W/m2	150	
EHS biomass limitation factor, g m-2	15	
ENEQN ammonia preference factor equation for epiphyton/periphyton (1 or 2)	2	
ENPR nitrogen half-saturation preference constant, mg/l - only used if ENEQN=2	0.001	
ET1 Lower temperature for epiphyton growth, oC	1	
ET2 Lower temperature for maximum epiphyton/periphyton growth, oC	3	
ET3 Upper temperature for maximum epiphyton/periphyton growth, oC	20	
ET4 Upper temperature for epiphyton/periphyton growth, oC	30	
EK1 Fraction of epiphyton/periphyton growth rate at ET1	0.1	
EK2 Fraction of maximum epiphyton/periphyton growth rate at ET2	0.99	
EK3 Fraction of maximum epiphyton/periphyton growth rate at ET3	0.99	
EK4 Fraction of epiphyton/periphyton growth rate at ET4	0.1	
EP Stoichiometric equivalent between epiphyton/periphyton biomass and phosphorus	0.005	
EN Stoichiometric equivalent between epiphyton/periphyton biomass and nitrogen	0.08	
EC Stoichiometric equivalent between epiphyton/periphyton biomass and carbon	0.45	
ESI Stoichiometric equivalent between epiphyton/periphyton biomass and silica	0	
ECHLA Ratio between epiphyton/periphyton biomass and chlorophyll a [Not used at present], mg biomass/mg chlorophyll a	0.065	
EPOM Fraction of epiphyton/periphyton biomass that is converted to particulate organic matter when epiphyton/periphyton die	0.8	
O2ER Oxygen stoichiometry for epiphyton/periphyton respiration (mg O2/mg periphyton organic matter)	1.1	
O2EG Oxygen stoichiometry for epiphyton/periphyton primary production (mg O2/mg periphyton organic matter)	1.4	

Related Cards and Files

[Epiphyte Control](#)
[Epiphyte Print](#)
[Epiphyte Initial Density](#)
[Epiphyte Rate](#)
[Epiphyte Half-Saturation](#)
[Epiphyte Temperature Rate Coefficients](#)

CONTROL FILE**INPUT OUTPUT FILENAMES****Zooplankton Rate (ZOOP RATE)**

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ZG	Real	1.00	maximum zooplankton growth or ingestion rate, day^{-1}
3	ZR	Real	0.10	maximum zooplankton respiration rate, day^{-1}
4	ZM	Real	0.10	maximum zooplankton mortality (non-predatory) rate, day^{-1}
5	ZEFF	Real	0.50	Zooplankton assimilation efficiency or the proportion of food assimilated to food consumed (dimensionless), from 0 to 1.
6	PREFP	Real	0.50	Preference factor of zooplankton for detritus or LPOM (dimensionless), from 0 to 1.
7	ZOOMIN	Real	0.01	Threshold food concentration at which zooplankton feeding begins, $g m^{-3}$
8	ZS2P	Real	0.3	Zooplankton half-saturation constant for food (includes LPOM, algae, and zooplankton) ingestion, $g m^{-3}$
9	ZS	Real	0.0	Zooplankton settling velocity, m/day

This card specifies rates for zooplankton growth, mortality and respiration. Additionally, the zooplankton assimilation efficiency and the preference factor of zooplankton for detritus are specified along with the threshold food concentration at which zooplankton feeding begins and the zooplankton half-saturation constant for food ingestion.

Hopcroft et al. (1998) suggest growth rates between 1.5-2.7 day^{-1} for marine larvacean zooplankton, but lower growth rates for marine zooplankton in general. For marine copepods, growth rates vary for mixed copepods ($29.5^{\circ}C$) $0.544\ day^{-1}$, and for mixed zooplankton they can range from $0.053\ day^{-1}$ ($25^{\circ}C$) to $0.951\ day^{-1}$ ($29^{\circ}C$) (Huntley and Lopez, 1992). Pulsifer and Laws (2021) showed that zooplankton rates are usually less than phytoplankton growth rates and varied from 0.3 to 0.8 day^{-1} between $8^{\circ}C$ and $30^{\circ}C$.

Example

```
ZOOP RATE      ZG      ZR      ZM      ZEFFIC    PREFP   ZOOMIN     ZS2P      ZS
Zoo1        1.00    0.10    0.10     0.50      0.50    0.0100    0.30      0.0
```

[The Excel input example is shown in the [Zooplankton Stoichiometry](#) section.]

Zooplankton Algal Preference (ZOOP ALGP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	PREFA	Real	0.5	Preference factor of zooplankton for algae (dimensionless) from 0 to 1.

This card specifies the feeding preference of zooplankton for each algal group. For example, many zooplankton will avoid certain algae species as a food source, in that case the PREFA would be zero.

Zooplankton algae group food preferences are set here.

Note that the sum of the preference factors can be greater than 1 since the model normalizes them internally in the code.

Example

```
ZOOP ALGP  PREFA  PREFA  PREFA  PREFA  PREFA  PREFA  PREFA  PREFA  PREFA
Zoo1      1.00   0.50   0.50
```

[The Excel input example is shown in the [Zooplankton Stoichiometry](#) section.]

Zooplankton Zooplankton Preference (ZOOP ZOOP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	PREFZ	Real	0.0	Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.

This card specifies the feeding preference of zooplankton for each zooplankton group. The card below shows that for the one zooplankton group, it does not feed on itself. Note that the sum of the preference factors can be greater than 1 since the model normalizes them internally in the code.

Zooplankton can eat other zooplankton. This shows their preference for different groups of zooplankton.

Example

```
ZOOP ZOOP  PREFZ  PREFZ  PREFZ  PREFZ  PREFZ  PREFZ  PREFZ  PREFZ
Zoo1      0.00
```

[The Excel input example is shown in the [Zooplankton Stoichiometry](#) section.]

Zooplankton Temperature Rate Coefficients (ZOOP TEMP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ZT1	Real	5.0	Lower temperature for zooplankton growth, °C
3	ZT2	Real	25.0	Lower temperature for maximum zooplankton growth, °C
4	ZT3	Real	35.0	Upper temperature for maximum zooplankton growth, °C
5	ZT4	Real	40.0	Upper temperature for zooplankton growth, °C
6	ZK1	Real	0.1	Fraction of maximum zooplankton growth rate at ZT1
7	ZK2	Real	0.99	Fraction of maximum zooplankton growth rate at ZT2
8	ZK3	Real	0.99	Fraction of maximum zooplankton growth rate at ZT3
9	ZK4	Real	0.1	Fraction of maximum zooplankton growth rate at ZT4

This card specifies the lower, maximum lower, upper, and maximum upper temperatures used in defining the curve that determines effects of temperature on zooplankton rates. Also specified is the fraction of maximum zooplankton rates that occurs at the specified temperature.

How temperature affects zooplankton growth is shown in Figure 25 for the default values of ZT1 through ZT4 and ZK1 through ZK4.

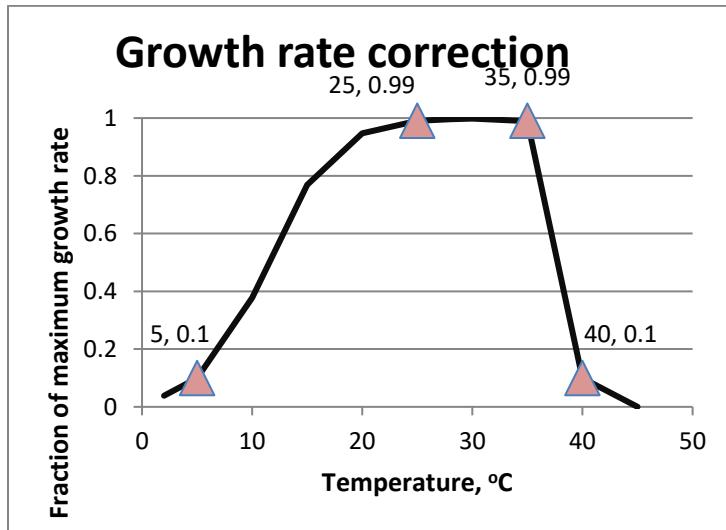


Figure 25. Growth rate as a function of temperature.

Example

ZOOP TEMP	ZT1	ZT2	ZT3	ZT4	ZK1	ZK2	ZK3	ZK4
Zoo1	0.0	15.0	20.0	36.0	0.1	0.9	0.98	0.100

[The Excel input example is shown in the [Zooplankton Stoichiometry](#) section.]

Zooplankton Stoichiometry (ZOOP STOICH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ZP	Real	0.005	Stoichiometric equivalent between zooplankton biomass and phosphorus
3	ZN	Real	0.08	Stoichiometric equivalent between zooplankton biomass and nitrogen
4	ZC	Real	0.45	Stoichiometric equivalent between zooplankton biomass and carbon

This card specifies the stoichiometric equivalences used for determining the amount of nutrients in zooplankton biomass. These ratios are not constant over time and vary by zooplankton species.

Example

```
ZOOP STOI      ZP      ZN      ZC
      0.01500 0.08000 0.45000
```

The Excel input file below is set for a maximum of 5 algae groups and 5 zooplankton groups in the food preference section. If there are more groups than 5, the user will need to add more rows.

ZOOPLANKTON RATES	Zoo1	Zoo2
ZG growth rate day-1	1.5	
ZR respiration rate day-1	0.1	
ZM mortality rate day-1	0.01	
ZEFF Zooplankton assimilation efficiency or the proportion of food assimilated to food consumed (dimensionless), from 0 to 1.	0.5	
PREFP Preference factor of zooplankton for detritus or LPOM (dimensionless), from 0 to 1.	0.5	
ZOOMIN Threshold food concentration at which zooplankton feed-ing begins, g m-3	0.01	
ZS2P Zooplankton half-saturation constant for food (includes LPOM, algae, and zooplankton) ingestion, g m-3	0.3	
ZS Zooplankton settling velocity in m/day	0	
ZT1 Lower temperature for zooplankton growth, oC	0	
ZT2 Lower temperature for maximum zooplankton growth, oC	15	
ZT3 Upper temperature for maximum zooplankton growth, oC	20	
ZT4 Upper temperature for zooplankton growth, oC	36	
ZK1 Fraction of maximum zooplankton growth rate at ZT1	0.1	
ZK2 Fraction of maximum zooplankton growth rate at ZT2	0.9	
ZK3 Fraction of maximum zooplankton growth rate at ZT3	0.98	
ZK4 Fraction of maximum zooplankton growth rate at ZT4	0.1	
ZP Stoichiometric equivalent between zooplankton biomass and phosphorus	0.015	

CONTROL FILE**INPUT OUTPUT FILENAMES**

ZN Stoichiometric equivalent between zooplankton bio-mass and nitrogen	0.08	
ZC Stoichiometric equivalent between zooplankton bio-mass and carbon	0.45	
O2ZR Oxygen stoichiometry for zooplankton respiration (mg O ₂ /mg zooplankton organic matter)	1.1	
PREFA-Algal Group 1 Preference factor of zooplankton for algae (dimensionless) from 0 to 1.	1	
PREFA-Algal Group 2 Preference factor of zooplankton for algae (dimensionless) from 0 to 1.		
PREFA-Algal Group 3 Preference factor of zooplankton for algae (dimensionless) from 0 to 1.		
PREFA-Algal Group 4 Preference factor of zooplankton for algae (dimensionless) from 0 to 1.		
PREFA-Algal Group 5 Preference factor of zooplankton for algae (dimensionless) from 0 to 1.		
PREFZ-Group 1 Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.	0	
PREFZ-Group2 Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.		
PREFZ-Group3 Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.		
PREFZ-Group4 Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.		
PREFZ-Group5 Preference factor of zooplankton for zooplankton (dimensionless) from 0 to 1.		

Macrophyte Control (MACROPHYT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	MACWBC	Character	OFF	Waterbody macrophyte computations, ON or OFF

This card allows the user to turn ON/OFF macrophyte computations and their effects on water quality for a given waterbody. This flexibility allows the user to decrease model complexity and computation time for waterbodies where macrophyte impacts are not considered important.

Example

```
MACROPHYT MACWBC MACWBC MACWBC MACWBC MACWBC MACWBC MACWBC MACWBC MACWBC
Mac1          ON      OFF      OFF
```

[The Excel input format file example is shown in the [Macrophyte Initial Concentration](#) section.]

Macrophyte Print (MAC PRINT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2-10	MPRWBC	Character	OFF	macrophyte concentration output, ON or OFF

This card allows the user to turn ON/OFF macrophyte biomass output to the SNP (snapshot) file and to the CPL file (only if TECPLOT='ON') for each waterbody.

Example

```
MAC PRINT MPRWBC MPRWBC MPRWBC MPRWBC MPRWBC MPRWBC MPRWBC MPRWBC MPRWBC
Mac1          ON      OFF      OFF
```

[The Excel input format file example is shown in the [Macrophyte Initial Concentration](#) section.]

Macrophyte Initial Concentration (MAC INI)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	MACWBCI	Real	Initial macrophyte concentration for each macrophyte group, gm^{-3}

This card specifies the initial macrophyte concentration for each waterbody. Without an initial concentration or seed, the macrophyte groups will not grow. The model currently does not have self-seeding of macrophytes.

You can set the initial density of macrophytes for each model cell.

If the initial concentration is greater than or equal to zero, then this is the initial concentration of biomass for each model cell in a waterbody. If the initial concentration is '-1', then the model will look for a VPR (vertical profile) file that specifies the initial concentration for each vertical layer in the waterbody. If the initial concentration is '-2', then the model will look for an LPR (longitudinal profile) file that specifies the initial concentration for each active model cell.

Initial condition	[MACWBCI]
Isoconcentration	>or =0.0
Single vertical profile	-1.0
Vertical profile at each segment	-2.0

The format of the VPR (vertical profile file) and the LPR (longitudinal profile file) are shown in the Input File section of this section of the User Manual.

Example

```
MAC INI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI
Mac1      0.10000    -2.0      0.5
```

The Excel input file format is set up for 5 macrophyte groups even if one only has 0-4 groups. If one has more than 5, additional rows must be added.

MACROPHYTES	WB1	WB2
MAC Waterbody macrophyte 1 computations, ON or OFF	OFF	
MAC Waterbody macrophyte 2 computations, ON or OFF		
MAC Waterbody macrophyte 3 computations, ON or OFF		
MAC Waterbody macrophyte 4 computations, ON or OFF		
MAC Waterbody macrophyte 5 computations, ON or OFF		
MPRWBC Macrophyte 1 concentration print output, ON or OFF	OFF	
MPRWBC Macrophyte 2 concentration print output, ON or OFF		
MPRWBC Macrophyte 3 concentration print output, ON or OFF		

INPUT OUTPUT FILENAMES**CONTROL FILE**

MPRWBC Macrophyte 4 concentration print output, ON or OFF		
MPRWBC Macrophyte 5 concentration print output, ON or OFF		
MACWBCI-Group1 Initial macrophyte concentration for each macrophyte group, gm-3	0	
MACWBCI-Group2 Initial macrophyte concentration for each macrophyte group, gm-3		
MACWBCI-Group3 Initial macrophyte concentration for each macrophyte group, gm-3		
MACWBCI-Group4 Initial macrophyte concentration for each macrophyte group, gm-3		
MACWBCI-Group5 Initial macrophyte concentration for each macrophyte group, gm-3		

Related Cards and Files[Vertical Profile File](#)[Longitudinal Profile File](#)

CONTROL FILE**INPUT OUTPUT FILENAMES****Macrophyte Rate (MAC RATE)**

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	MG	Real	0.3	maximum macrophyte growth rate, day^{-1}
3	MR	Real	0.05	maximum macrophyte respiration rate, day^{-1}
4	MM	Real	0.05	maximum macrophyte mortality rate, day^{-1}
5	MSAT	Real	30.0	light saturation intensity at maximum photosynthetic rate, $W m^{-2}$
6	MHSP	Real	0.0	macrophyte half-saturation for phosphorus limited growth, $g m^{-3}$
7	MHSN	Real	0.0	macrophyte half-saturation for nitrogen limited growth, $g m^{-3}$
8	MHSC	Real	0.0	macrophyte half-saturation for carbon limited growth, $g m^{-3}$
9	MPOM	Real	0.9	Fraction of macrophyte biomass that is converted to particulate organic matter when macrophytes die
10	LRPMAC	Real	0.2	Fraction of POM which originates as dead macrophytes becoming labile POM

This card specifies rates for macrophyte growth, mortality and respiration. Additionally, values that affect the maximum macrophyte growth rate including nutrient limited growth, light saturation, fraction of dead biomass converted to POM, and the fraction of POM originating from dead biomass becoming refractory POM are also specified here.

Light limitation was modeled with a hyperbolic equation which has the same form as the Michaelis-Menten function:

$$f(I) = \frac{I}{I+I_h}$$

where

I : solar radiation (W/m^2)

I_h : half-saturation coefficient for solar radiation (W/m^2)

The following table shows macrophyte coefficient values used in an application of CE-QUAL-R1 to Eau Galle Reservoir, Wisconsin (Collins and Wlosinski, 1989).

Table 43. Coefficients used in CE-QUAL-R1 to simulate macrophytes (from Collins and Wlosinski, 1989).

Description	Value	Reference
Carbon fraction of dry weight [MC] – see Macrophyte Stoichiometry	0.46	Soeder et al. (1969)
Maximum gross production rate [MG]	$0.42 day^{-1}$	Van et al. (1976)
Maximum dark respiration rate [MR]	$0.05 day^{-1}$	McGahee and Davis (1971)
Fraction of dead tissue to dissolved organic matter	0.2	Wetzel and Manny (1972)
Fraction of dead tissue to detritus [MPOM]	0.4	Godshalk and Wetzel (1978)

INPUT OUTPUT FILENAMES

CONTROL FILE

Description	Value	Reference
Fraction of dead tissue to sediments	0.4	Carpenter (1976)
Critical low temperature for metabolic processes [MT1] - See Macrophyte Temperature Rate Coefficients	7° C	Van et al. (1976)
Low optimum temperature for metabolic processes [MT2] - See Macrophyte Temperature Rate Coefficients	21° C	Barko et al. (1980)
High optimum temperature for metabolic processes [MT3] - See Macrophyte Temperature Rate Coefficients	24° C	Barko et al. (1980)
Critical high temperature [MT4] - See Macrophyte Temperature Rate Coefficients	34° C	Barko et al. (1980)
Volumetric density factor	40 g m ⁻³	Filbin and Barko (1985)

Example

```
MAC RATE      MG      MR      MM      MSAT     MHSP     MHSN     MHSC     MPOM    LRP MAC
Mac 1        0.30    0.05    0.05    30.0     0.0      0.0      0.0      0.9     0.2
```

[The Excel input format file example is shown in the [Macrophyte Stoichiometry](#) section.]

CONTROL FILE**INPUT OUTPUT FILENAMES****Macrophyte Sediments (MAC SED)**

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PSED	Real	1.0	Fraction of phosphorus uptake by macrophytes obtained from sediments
3	NSED	Real	1.0	Fraction of nitrogen uptake by macrophytes obtained from sediments

This card specifies the fraction of phosphorus and nitrogen uptake obtained from the sediments. The remaining fraction of uptake will be obtained from the water column. Depending on the macrophyte species, nitrogen and phosphorus may be obtained from the sediments or the water column. If they are obtained from the sediments, the sediments are assumed to be an infinite pool that cannot limit growth.

Example

```
MAC SED      PSED      NSED
MAC 1        0.5       0.5
```

[The Excel input format file example is shown in the [Macrophyte Stoichiometry](#) section.]

Macrophyte Distribution (MAC DIST)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	MBMP	Real	40.0	Threshold macrophyte concentration for which growth is moved to the above layer, $g m^{-3}$
3	MMAX	Real	500.0	Maximum macrophyte concentration, $g m^{-3}$

This card specifies the concentration at which macrophyte growth will be moved to the next layer above and the maximum macrophyte concentration allowed. Plants grow upwards from the sediment through model layers. Growth upward is accomplished by moving the growth of a layer to the layer above if the concentration in the layer is greater than a threshold concentration and the concentration in the upper layer is less than the same threshold concentration.

Example

```
MAC DIST      MBMP      MMAX
Mac 1        40.0     500.0
```

[The Excel input format file example is shown in the [Macrophyte Stoichiometry](#) section.]

Macrophyte Drag (MAC DRAG)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CDDRAG	Real	2.0	Macrophyte drag coefficient
3	DWV	Real	7.0e+04	Macrophyte dry weight to wet volume ratio, g m ⁻³
4	DWSA	Real	8.0	Macrophyte dry weight to surface area ratio, g m ⁻²
5	ANORM	Real	0.3	Fraction of macrophyte surface area normal to direction of flow

This card specifies the coefficients which simulate the frictional effects and areal blockage (through the porosity) of macrophytes. The macrophyte drag coefficient, dry weight to wet volume ratio, dry weight to surface area ratio, and the fraction of macrophyte surface area facing the direction of flow are specified. Measured values for the ratio of dry weight to wet volume are shown in Table 44, and literature values for the ration of dry weight to surface area are listed in Table 45.

Table 44. Values for the ratio between dry weight to wet volume.

Species	Dry wt. to wet volume g m ⁻³	Reference
<i>Elodea Canadensis</i>	7.3e+04	Berger (2000)
<i>Ceratophyllum demersum</i>	5.4e+04	Berger (2000)

Table 45. Literature values for the ratio of dry weight to surface area.

Species	Ratio of dry weight to wet surface area (g m ⁻²)	Reference
<i>Elodea canadensis</i>	7.97	Sher-Kaul et al. (1995)
<i>Myriophyllum spicatum</i>	8.30	Sher-Kaul et al. (1995)
<i>Nitelopsis obtuse</i>	17.86	Sher-Kaul et al. (1995)
<i>Potamogeton lucens</i>	15.75	Sher-Kaul et al. (1995)
<i>Potamogeton pectinatus</i>	20.00	Sher-Kaul et al. (1995)
<i>Potamogeton perfoliatus</i>	13.12	Sher-Kaul et al. (1995)

```
MAC DRAG CDDRAG DWV DWSA ANORM
Mac 1      3.0 7.0E+04   8.0    0.3
```

[The Excel input format file example is shown in the [Macrophyte Stoichiometry](#) section.]

Macrophyte Temperature Rate Coefficients (MAC TEMP)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	MT1	Real	5.0	Lower temperature for macrophyte growth, °C
3	MT2	Real	25.0	Lower temperature for maximum macrophyte growth, °C
4	MT3	Real	35.0	Upper temperature for maximum macrophyte growth, °C
5	MT4	Real	40.0	Upper temperature for macrophyte growth, °C
6	MK1	Real	0.1	Fraction of maximum macrophyte growth rate at MT1
7	MK2	Real	0.99	Fraction of maximum macrophyte growth rate at MT2
8	MK3	Real	0.99	Fraction of maximum macrophyte growth rate at MT3
9	MK4	Real	0.1	Fraction of maximum macrophyte growth rate at MT4

This card specifies the lower, maximum lower, upper, and maximum upper temperatures used in defining the curve that determines effects of temperature on macrophyte rates. Also specified is the fraction of maximum macrophyte rates that occurs at the specified temperature.

How temperature affects macrophyte growth is shown below for the default values of MT1 through MT4 and MK1 through MK4.

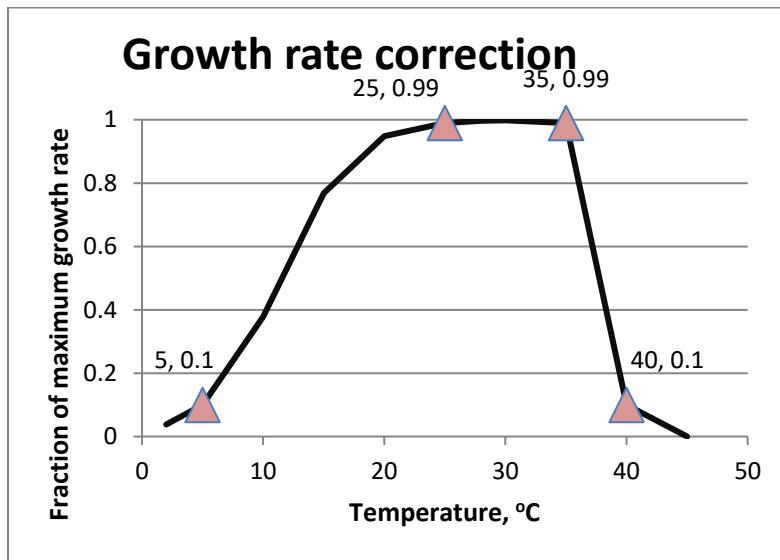


Figure 26. Growth rate as a function of temperature.

Example

MAC TEMP	MT1	MT2	MT3	MT4	MK1	MK2	MK3	MK4
Mac 1	7.0	15.0	24.0	34.0	0.1	0.99	0.99	0.01

[The Excel input format file example is shown in the [Macrophyte Stoichiometry](#) section.]

Macrophyte Stoichiometry (MAC STOICH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	MP	Real	0.005	Stoichiometric equivalent between macrophyte biomass and phosphorus
3	MN	Real	0.08	Stoichiometric equivalent between macrophyte biomass and nitrogen
4	MC	Real	0.45	Stoichiometric equivalent between macrophyte biomass and carbon

This card specifies the stoichiometric equivalences used for determining the amount of nutrients in macrophyte biomass.

Example

```
MAC STOICH      MP      MN      MC
Mac 1        0.005    0.08    0.45
```

The Excel input file also includes the parameters, O2MR and O2MG, which are the oxygen to macrophyte biomass stoichiometric coefficients for respiration and growth, respectively. These are discussed in the section on [Oxygen Stoichiometry 5](#).

MAC RATE	MacGroup1	MacGroup2
MG maximum macrophyte growth rate, day-1	0.3	
MR maximum macrophyte respiration rate, day-1	0.05	
MM maximum macrophyte mortality rate, day-1	0.05	
MSAT light saturation intensity at maximum photosynthetic rate, W m-2	30	
MHSP macrophyte half-saturation for phosphorus limited growth, g m-3	0	
MHSN macrophyte half-saturation for nitrogen limited growth, g m-3	0	
MHSC macrophyte half-saturation for carbon limited growth, g m-3	0	
MPOM Fraction of macrophyte biomass that is converted to particulate organic matter when macrophytes die	0.9	
LRPMAC Fraction of POM which originates as dead macrophytes becoming labile POM	0.2	
PSED Fraction of phosphorus uptake by macrophytes obtained from sediments	0.5	
NSED Fraction of nitrogen uptake by macrophytes obtained from sediments	0.5	
MBMP Threshold macrophyte concentration for which growth is moved to the above layer, g m-3	40	
MMAX Maximum macrophyte concentration, g m-3	500	
CDDRAG Macrophyte drag coefficient	3	
DMV Macrophyte dry weight to wet volume ratio, g m-3	70000	

CONTROL FILE**INPUT OUTPUT FILENAMES**

DWSA Macrophyte dry weight to surface area ratio, g m-2	8	
ANORM Fraction of macrophyte surface area normal to direction of flow	0.3	
MT1 Lower temperature for macrophyte growth, oC	7	
MT2 Lower temperature for maximum macrophyte growth, oC	15	
MT3 Upper temperature for maximum macrophyte growth, oC	24	
MT4 Upper temperature for macrophyte growth, oC	34	
MK1 Fraction of maximum macrophyte growth rate at MT1	0.1	
MK2 Fraction of maximum macrophyte growth rate at MT2	0.99	
MK3 Fraction of maximum macrophyte growth rate at MT3	0.99	
MK4 Fraction of maximum macrophyte growth rate at MT4	0.01	
MP Stoichiometric equivalent between macrophyte biomass and phosphorus	0.005	
MN Stoichiometric equivalent between macrophyte biomass and nitrogen	0.08	
MC Stoichiometric equivalent between macrophyte biomass and carbon	0.45	
O2MR Oxygen stoichiometry for macrophyte respiration (mg O2/mg macrophyte organic matter)	1.1	
O2MG Oxygen stoichiometry for macrophyte primary production (mg O2/mg macrophyte organic matter)	1.4	

Dissolved Organic Matter (DOM)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	LDOMDK	Real	0.1	Labile DOM decay rate, day-1
3	RDOMDK	Real	0.001	Refractory DOM decay rate, day-1
4	LRDDK	Real	0.01	Labile to refractory DOM decay rate, day-1

This card specifies decay rates associated with dissolved organic matter. Dissolved organic matter in the model is divided into labile and refractory partitions. The labile partition has a higher decay rate and generally consists of autochthonous inputs such as early products of algal decay. The refractory decay rate, [RDOMDK], is generally two orders of magnitude smaller than the labile decay rate [LDOMDK]. If BOD decay rates are available, then they should be used as a starting point for [LDOMDK].

Table 46. Labile DOM Decay Rate Literature Values.

Compound	Decay Rate, day ⁻¹	Reference
Acetate	0.20	Wright, 1975
Amino acids	0.64	Williams et al., 1976
Glucose	0.24	Williams et al., 1976
Glucose	0.32-0.50	Toerien and Cavari, 1982
Glucose	0.11	Wright, 1975
Glutamate	0.11-0.63	Carney and Colwell, 1976
Glycine	0.31-0.45	Vaccaro, 1969
Glycolate	0.01-0.43	Wright, 1975

Example

```
DOM      LDOMDK  RDOMDK  LRDDK
Wb 1      0.12    0.001   0.001
Wb 2      0.12    0.001   0.001
Wb 3      0.12    0.001   0.001
```

DOM Dissolved Organic Matter	WB1	WB2
LDOMDK, Labile DOM decay rate, day-1	0.3	
RDOMDK, Refractory DOM decay rate, day-1	0.001	
LRDDK Labile to refractory DOM decay rate, day-1	0.01	

Related Cards and Files

- [Particulate Organic Matter](#)
- [Organic Matter Stoichiometry](#)
- [Organic Matter Temperature Rate Multipliers](#)
- [Carbonaceous Biochemical Oxygen Demand](#)

Particulate Organic Matter (POM)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	LPOMDK	Real	0.08	Labile POM decay rate, day^{-1}
3	RPOMDK	Real	0.001	Refractory POM decay rate, day^{-1}
4	LRPDK	Real	0.01	Labile to refractory POM decay rate, day^{-1}
5	POMS	Real	0.1	POM settling rate, $m day^{-1}$

Detritus in the model consists of autochthonous and allochthonous particulate organic matter (POM). The model uses a single decay rate [LPOMDK], but detritus is really a heterogeneous mixture of organic matter in various stages of decay. Allochthonous inputs are usually dominated by the refractory component while autochthonous inputs are initially labile becoming more refractory over time. Literature values are given in the following tables.

Table 47. Detritus Decay Rate Literature Values

Detritus Source	Detritus Decay Rate, day^{-1}	Reference
Cladophora glomerata	0.007	Piecznska, 1972
Gloeotrichia echinulata	0.001-0.007	Piecznska, 1972
Isoetes lacustris	0.003-0.015	Hanlon, 1982
Potamogeton crispus	0.002-0.004	Rogers & Breen, 1982
Potamogeton perfoliatus	0.002-0.007	Hanlon, 1982
Beech litter	0.001-0.004	Hanlon, 1982
Green algae	0.016-0.076	Otsuki & Hayna, 1972
Mixed algae	0.007-0.111	Jewell & McCarty, 1971
Mixed algae	0.007-0.060	Fitzgerald, 1964
Leaf packs	0.005-0.017	Sedell, Triska, and Triska, 1975

Detrital settling velocities [POMS] vary over a large range (0.001 to $> 20 m day^{-1}$) depending upon the detritus. Again, the model allows for only a single value. Literature values are given in [Table 48](#).

Table 48. Detritus Settling Velocity Literature Values

Detritus Source	Settling Velocity, $m day^{-1}$	Reference
Ceratium balticum	9.0	Apstein, 1910
Chaetoceros borealis	9.0	Apstein, 1910
Chaetoceros didymus	0.85	Eppley, Holmes, & Strickland, 1967
Cricosphaera carterae	1.70	Eppley, Holmes, & Strickland, 1967
Ditylum brightwellii	2.0	Apstein, 1910
Phaeodactylum tricornutum	0.02-0.04	Riley, 1943
Rhizosolenia herbetata	0.22	Eppley, Holmes, & Strickland, 1967b
Stephanopyxis tunis	2.1	Eppley, Holmes, & Strickland, 1976b
Tabellaria flocculosa	0.46-1.5	Smayda, 1971
Thalassiosira pseudonana	0.85	Hecky & Kilham, 1974

Example

```

POM      LPOMDK   RPOMDK   LRPDK    POMS
WB 1      0.08     0.001    0.001    0.5
WB 2      0.08     0.001    0.001    0.5
WB 3      0.08     0.001    0.001    0.5

```

INPUT OUTPUT FILENAMES**CONTROL FILE**

POM, Particulate Organic Matter	WB1	WB2
LPOMDK Labile POM decay rate, day-1	0.08	
RPOMDK Refractory POM decay rate, day-1	0.01	
LRPDK Labile to refractory POM decay rate, day-1	0.001	
POMS POM settling rate, m day-1	0.5	

Related Cards and Files

[Dissolved Organic Matter](#) [Organic Matter Stoichiometry](#) [Organic Matter Temperature Rate Multipliers](#)
[Carbonaceous Biochemical Oxygen Demand](#)

Organic Matter Stoichiometry (OM STOICH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	ORGP	Real	0.005	Stoichiometric equivalent between organic matter and phosphorus [g P/g organic matter]
3	ORGN	Real	0.08	Stoichiometric equivalent between organic matter and nitrogen [g N/g organic matter]
4	ORGС	Real	0.45	Stoichiometric equivalent between organic matter and carbon [g C/g organic matter]
5	ORGSI	Real	0.18	Stoichiometric equivalent between organic matter and silica [g Si/g organic matter]

This card specifies the stoichiometric relationship between organic matter and inorganic nutrients in mass/mass ratios. The user has the ability to change the relationship between waterbodies, although this option is not recommended. If the variables: LDOM-P, RDOM-P, LPOM-P, and RPOM-P, are not active, the model does not track the dynamic stoichiometry of the organic P pool and uses the **ORGP** for the stoichiometric ratio between P and organic matter. If these variables are active, **ORGP** represents the initial P stoichiometry of organic matter set by the initial concentration of LDOM, RDOM, LPOM, and RPOM. Similarly, if the variables: LDOM-N, RDOM-N, LPOM-N, and RPOM-N, are not active, the model does not track the dynamic stoichiometry of the organic N pool and uses the **ORGН** for the stoichiometric ratio between N and organic matter. If these variables are active, **ORGН** represents the initial N stoichiometry of organic matter set by the initial concentration of LDOM, RDOM, LPOM, and RPOM.

Fixed or dynamic stoichiometry can be used for the organic matter groups.

EPA (1985) shows that organic matter from total phytoplankton can have the following stoichiometry: ORGC between 0.4-0.6, ORGN between 0.06-0.09, and ORGP between 0.0008 to 0.015. Hecky et al. (1993) show that marine particulates usually follow the Redfield molar ratio of 106:16:1 (C:N:P) but that inland lakes have much more variable composition than ocean particles and are usually higher than the Redfield ratio. The default values above have a molar ratio of C:N:P of 232:35:1. If ORGP is 0.01, the ratio is close to the Redfield ratio. They et al. (2017) also show that inland waters usually have higher C and N content when compared to oceanic particulate matter.

To summarize,

- if LDOM-P, RDOM-P, LPOM-P, and RPOM-P, are not active, the stoichiometry is determined by ORGP. Otherwise, it is determined by LDOM-P/LDOM, RDOM-P/RDOM, LPOM-P/LPOM, and RPOM-P/RPOM
- if LDOM-N, RDOM-N, LPOM-N, and RPOM-N, are not active, the stoichiometry is determined by ORGN. Otherwise, it is determined by LDOM-N/LDOM, RDOM-N/RDOM, LPOM-N/LPOM, and RPOM-N/RPOM
- ORGC always represents the C stoichiometry of LDOM, RDOM, LPOM, and RPOM
- ORGSI always represents the Si stoichiometry of LDOM, RDOM, LPOM, and RPOM

Example

OM STOICH	ORGP	ORGН	ORGС	ORGSI
Wb 1	0.005	0.08	0.45	0.18
Wb 2	0.005	0.08	0.45	0.18

INPUT OUTPUT FILENAMES

CONTROL FILE

Wb 3 0.005 0.08 0.45 0.18

[Excel input file example is shown in the next section.]

Related Cards and Files

[Dissolved Organic Matter](#)

[Particulate Organic Matter](#)

[Organic Matter Temperature Rate Multipliers](#)

[Carbonaceous Biochemical Oxygen Demand](#)

Organic Matter Temperature Rate Multipliers (OM RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	OMT1	Real	4.0	Lower temperature for organic matter decay, °C
3	OMT2	Real	25.0	Upper temperature for organic matter decay, °C
4	OMK1	Real	0.1	Fraction of organic matter decay rate at OMT1
5	OMK2	Real	0.99	Fraction of organic matter decay rate at OMT2

This card specifies the lower and maximum temperatures used in defining the curve that determines effects of temperature on organic matter decay. Recommended values are given in the example.

The decay rate correction as a function of temperature is shown in Figure 27 for **OMT1=5**, **OMK1=0.1**, **OMT2=25** and **OMK2=0.99**. Note that the organic matter decay rates, **LPOMDK**, **RPOMDK**, **LDOMDK**, **RDOMDK**, are maximum decay rates or when **OMK2** is 0.99 rather than at a standard temperature of 20°C. For the example shown in Figure 27, they would be the maximum decay rates at 25°C.

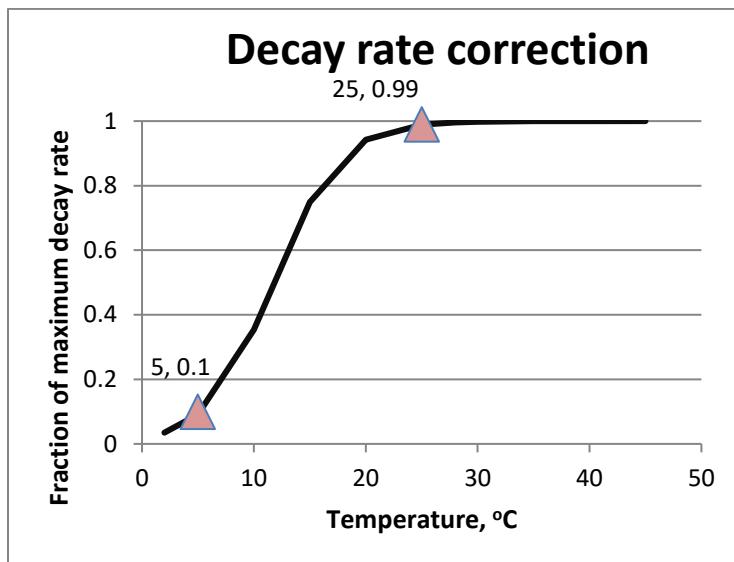


Figure 27. Organic matter decay as a function of temperature.

Example

```
OM RATE      OMT1      OMT2      OMK1      OMK2
Wb 1          4.0       25.0      0.1       0.99
Wb 2          4.0       25.0      0.1       0.99
Wb 3          4.0       25.0      0.1       0.99
```

OM STOIC Organic Matter Stoichiometry	WB1	WB2
ORGP Stoichiometric equivalent between organic matter and phosphorus	0.005	

INPUT OUTPUT FILENAMES**CONTROL FILE**

ORGN Stoichiometric equivalent between organic matter and nitrogen	0.08	
ORGС Stoichiometric equivalent between organic matter and carbon	0.45	
ORGSI Stoichiometric equivalent between organic matter and silica	0.18	
O2OM Stoichiometric equivalent between oxygen and organic matter	1.4	
OMT1 Lower temperature for organic matter decay, oC	4	
OMT2 Upper temperature for organic matter decay, oC	30	
OMK1 Fraction of organic matter decay rate at OMT1	0.1	
OMK2 Fraction of organic matter decay rate at OMT2	0.99	

Related Cards and Files[Dissolved Organic Matter](#)[Particulate Organic Matter](#)[Organic Matter Stoichiometry](#)[Carbonaceous Biochemical Oxygen Demand](#)

Turbidity and Secchi Disk (TURBSEC)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	COEFFA	Real		Empirical factor for correlation with TOTSS
3	COEFFB	Real		Empirical factor for correlation with TOTSS
4	SECC	Real		Empirical factor for relating light extinction coefficient,m ⁻¹ , to Secchi disk depth, m

Both turbidity and Secchi disk are derived variables in the section [Derived Constituents](#). In order to compute turbidity, the following equation is used with the empirical coefficients COEFFA and COEFFB:

$$\text{Turbidity} = \exp(COEFFA \ln(TOTSS) + COEFFB)$$

where TOTSS is the total suspended solids, including all particulate matter (see [Derived Constituents](#)).

To compute Secchi disk depth, z_{Secchi} , from the empirical factor SECC and internally computed light extinction coefficient λ , $z_{\text{Secchi}} = \frac{\lambda}{SECC}$. For typical values of SECC, see the section [Extinction Coefficient](#).

Example

TURBSEC	COEFFA	COEFFB	SECCHI
WB1	1.10	0.05	1.5

Turbidity and Secchi Disk (These are derived variables)	WB1	WB2
COEFFA_TURB, empirical factor for correlation with TOTSS	1.1	
COEFFB_TURB, empirical factor for correlation with TOTSS	0.05	
SECC_PAR,empirical factor for converting light extinction to Secchi Disk	1.5	

Carbonaceous Biochemical Oxygen Demand (CBOD)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	KBOD	Real	0.1	5-day decay rate @ 20°C, day ⁻¹
3	TBOD	Real	1.02	Arrhenius Temperature coefficient, theta
4	RBOD	Real	1.85	Ratio of CBOD5 to ultimate CBOD
5	CBODS	Real	0.0	CBOD settling rate, m day ⁻¹

The model allows the user to include any number of CBOD groups (see [Constituent Dimensions](#) card). This allows the user to specify multiple point source loadings of CBOD with different rates associated with them and track them in the model over space and time. The different CBOD groups can also be distinguished as dissolved or particulate or as labile or refractory groups.

INPUT OUTPUT FILENAMES

CONTROL FILE

[**KBOD**] is the first-order reaction rate for CBOD decay. [**TBOD**] is used to adjust the decay rate for temperature effects according to the following equation:

$$KBOD = KBOD_{20} * TBOD^{T-20}$$

where:

T = temperature, °C

$KBOD_{20}$ = decay rate at 20 °C

[**RBOD**] is used to convert 5-day CBOD values to ultimate CBOD. This formulation is included for applications that involve determining the effects of waste effluents on dissolved oxygen in which loadings are typically expressed in terms of CBOD. Note that if data are already in BOD-ultimate form, [**RBOD**]=1.0.

Settling rates for CBOD groups can be applied with [**CBODS**]. This allows for specification of particulate CBOD groups.

Example

CBOD	KBOD	TBOD	RBOD	CBODS
CBOD 1	0.25	1.0147	1.85	0.0
CBOD 2	0.25	1.0147	1.85	0.0
CBOD 3	0.25	1.0147	1.85	0.0

[The Excel input file is shown in the next section.]

Related Cards and Files

[CBOD Stoichiometry](#)

CBOD Stoichiometry (CBOD STOICH)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CBODP	Real	0.004	P stoichiometry for CBOD decay (mg P/mg O ₂)
3	CBODN	Real	0.06	N stoichiometry for CBOD decay (mg N/mg O ₂)
4	CBODC	Real	0.32	C stoichiometry for CBOD decay (mg C/mg O ₂)

The stoichiometric coefficients define the stoichiometry of BOD in terms of N, P, and C. Each coefficient expresses the fraction of N, P or C in terms of BOD. These are not the same as the organic matter stoichiometric coefficients defined in terms of N, P, or C in terms of organic matter. A typical conversion from organic matter to oxygen is about 1.4 (see [Oxygen Stoichiometry 1](#)).

Fixed or dynamic stoichiometry can be used for the CBOD groups. Dynamic stoichiometry is dependent on turning ON CBOD-N and CBOD-P as active constituents.

Note that if CBOD-P and CBOD-N are OFF in the CST ACTIVE card, **CBODN** and **CBODP** will represent the fixed stoichiometry of the CBOD group. If CBOD-P and CBOD-N are ON, then **CBODN** and **CBODP** are not used. The C stoichiometry for each CBOD group though is always fixed and is **CBODC**.

Example

```
CBOD STOIC CBODP    CBODN    CBODC
CBOD 1      0.004    0.06    0.32
CBOD 2      0.004    0.06    0.32
CBOD 3      0.004    0.06    0.32
```

CBOD	BOD1	BOD2
KBOD 5-day decay rate @ 20oC, day-1	0.15	
TBOD Theta Arrhenius Temperature coefficient	1.04	
RBOD Ratio of CBOD5 to ultimate CBOD	1.0	
CBODS CBOD settling rate, m day-1	0.1	
BODP P stoichiometry for CBOD decay (mg P/mg O ₂)	0.004	
BODN N stoichiometry for CBOD decay (mg N/mg O ₂)	0.06	
BODC C stoichiometry for CBOD decay (mg C/mg O ₂)	0.32	

Related Cards and Files

[Carbenaceous Biochemical Oxygen Demand](#)

Inorganic Phosphorus (PHOSPHOR)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	PO4R	Real	0.001	Sediment release rate of phosphorus, fraction of SOD
3	PARTP	Real	0.0	Phosphorus partitioning coefficient for suspended solids

[PO4R] is the sediment release rate of phosphorous under anaerobic conditions specified as a fraction of the sediment oxygen demand. *This is only used for the zero-order sediment oxygen demand model.* The PO4 release rate under anaerobic conditions is [PO4R]*[SOD] in units of g/m²/day modified by the temperature multiplier for SOD. Hence the rate chosen is dependent on the SOD rate. Often, P release rates are very site-specific. Sen et al. (2004) determined an average anaerobic P release rate of 0.57 mg/m²/day for Beaver Lake, Arkansas. Auer et al. (1993) found rates in a hypereutrophic lake from 9-21 mg/m²/day (mean 13 mg/m²/day). Kim et al. (2003) found rates in the summer between 20-24°C up to 16 mg/m²/day. Spears et al. (2007) showed that for a large shallow lake recovering from high nutrient that the maximum P release was 12 mg/m²/day. James et al. (1995) found that P release rates for Lake Pepin, an impoundment on the upper Mississippi River, were between 3.8 and 15 mg/m²/day.

[PARTP] is the phosphorous partitioning coefficient for sorption onto suspended solids. In the current model formulations, it is not recommended to allow phosphorus to sorb onto inorganic suspended solids unless clear evidence for this mechanism is known, so [PARTP] should be set to zero. Note that concentrations of PO₄ in the model are in units of PO₄ as P. Note that the model does not have a mechanism for desorption of P from the inorganic suspended solids to the water column.

Example

```
PHOSPHOR    PO4R    PARTP
Wb 1        0.015   0.0
Wb 2        0.015   0.0
Wb 3        0.015   0.0
```

[Excel input file example is shown in the section [Silica](#).]

Ammonium (AMMONIUM)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	NH4REL	Real	0.001	Sediment release rate of ammonium, fraction of SOD
3	NH4DK	Real	0.12	Ammonium decay rate, day ⁻¹
4	KGH2O	Real	168.0	Constant in calculation of Kg_H2O based on wind for volatilization of NH3.

[NH4REL] is the sediment release rate of ammonium anaerobic conditions specified as a fraction of the sediment oxygen demand. *This is only used for the zero order sediment oxygen demand model.* When there is anoxia, the rate of ammonia release is approximately the (SOD rate)*(NH4REL) in units of g NH₄-N/m²/day or if divided by the layer height in m in units of g NH₄-N/m³/day. These rates are modified by the temperature multiplier for SOD. Beutel (2006) showed that release rates of ammonia-N can vary from less than 5 to more than 15 mg NH₄-N/m²/day between oligotrophic to hypereutrophic lakes, respectively.

[NH4DK] is the rate at which ammonium is oxidized to nitrate-nitrite. Since the model considers nitrate-nitrite as one compartment, the rate specified should be the rate for conversion of ammonium to nitrate. Literature values are given in the following table.

Note that concentrations of ammonia in the model are in terms of NH₄ as N.

Table 49. Ammonium Decay Rate Literature Values

Site	Ammonium decay rate, day ⁻¹	Reference
Grand River, IL	0.80	Bansal, 1976
Grasmerer Lake, UK	0.001-0.013	Hall, 1982
Truckee River, NV	0.09-1.30	Bansal, 1976
Mohawk River, NY	0.23-0.40	Bansal, 1976
Ohio River	0.25	Bansal, 1976
Big Blue River, NB	0.17-0.25	Bansal, 1976
Flint River, MI	0.76-0.95	Bansal, 1976

McCutcheon (1987) measured the difference in BOD between samples with and without a nitrification inhibitor in order to estimate nitrification rates. The measured rates are shown in Table 50. The measured streams were relatively deep with low velocities and lacked well-developed periphyton communities.

Table 50. Nitrification rates measured by McCutcheon (1987).

Reaction	Source	Nitrification rate (d ⁻¹)
Nitrification	Chattahoochee River, Georgia	0.26
Nitrification	West Fork Trinity River, Texas	0.50

[NH3GAS] is a constant multiplied by the wind to determine the exchange coefficient for water vapor at the gas side of the air-water interface. This is used to compute the ammonia gas transfer coefficient (see User's Manual Part 2). A recommended value has been NH3GAS=168 (Mills et al., 1982; Chapra, 1997; Thomann and Mueller, 1987).

K_{NH_3} is the gas transfer coefficient for unionized ammonia and is controlled by the gas film. $K_{NH_3} = \left[\frac{K_g K_H}{RT_a} \right]$ where the overall volatilization flux rate in g/m³/day is $-\left[\frac{K_g K_H}{RT_a} \right] C_{NH_3} \frac{A_{surface}}{Volume_{surface\ layer}}$

INPUT OUTPUT FILENAMES

CONTROL FILE

where $K_g = K_{g-H_2O} \left(\frac{MW_{H_2O}}{MW_g} \right)^{0.25}$ and $K_{g-H_2O} = KGH2O \text{ Wind}$, R=8.206E-5 atm m³ °K⁻¹ mole⁻¹,

Wind is in m/s, Kg is in m/day, KH is is the Henry's Law constant for ammonia in units of atm m³ mole⁻¹. Within the model, the Wind is assumed to be at 2 m since no reference elevations were given in the primary references.

Example

AMMONIUM	NH4R	NH4DK	KGH2O
Wb 1	0.001	0.12	168.0
Wb 2	0.001	0.12	168.0
Wb 3	0.001	0.12	168.0

[Excel input file example is shown in the section [Silica.](#)]

Related Cards and Files

[Ammonium Temperature Rate Multipliers](#)

Ammonium Temperature Rate Multipliers (NH4 RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	NH4T1	Real	5.0	Lower temperature for ammonia decay, °C
3	NH4T2	Real	25.0	Lower temperature for maximum ammonia decay, °C
4	NH4K1	Real	0.1	Fraction of nitrification rate at NH4T1
5	NH4K2	Real	0.99	Fraction of nitrification rate at NH4T2

This card specifies the lower and maximum lower temperatures used in defining the curve that determines the effect of temperature on ammonia nitrification. See Part 2 of the User's Manual for more details on the mathematical formulation of the temperature coefficients.

The ammonia decay rate correction as a function of temperature is shown below for NH4T1=5, NH4K1=0.1, NH4T2=25 and NH4K2=0.99.

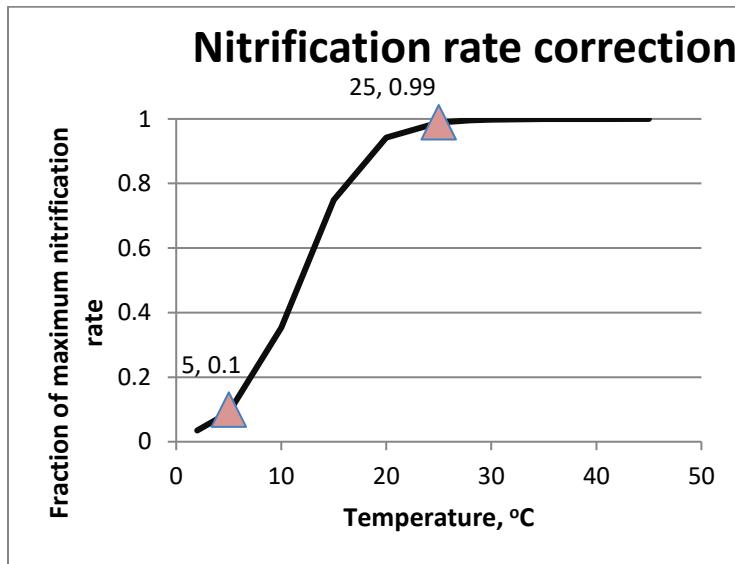


Figure 28. Ammonia decay as a function of temperature.

Example

```

NH4 RATE   NH4T1   NH4T2   NH4K1   NH4K2
Wb 1       5.0     25.0    0.1     0.99
Wb 2       5.0     25.0    0.1     0.99
Wb 3       5.0     25.0    0.1     0.99
  
```

[Excel input file example is shown in the section [Silica](#).]

Related Cards and Files

[Ammonium](#)

Nitrate (NITRATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	NO3DK	Real	0.03	Water column denitrification rate or nitrate decay rate, day^{-1}
3	NO3S	Real	0.001	Nitrate loss velocity to the sediments because of sediment denitrification, $m day^{-1}$
4	FNO3SED	Real	0.0	Fraction of NO ₃ -N diffused into the sediments that becomes part of organic N in the sediments (The rest is denitrified.)

This card specifies the denitrification rates in the water column (only under anoxic conditions) and from the water column to the sediments. Values used in previous modeling studies for the nitrate decay rate [NO3DK] have ranged from 0.05-0.15 day^{-1} . [NO3S] is analogous to a settling velocity and represents how fast nitrate is diffused into the sediments where it undergoes denitrification.

Of the NO₃-N that is diffused into the sediments, a fraction of that, f_{NO3-SED}, is incorporated into organic matter in the sediments. The rest, 1- f_{NO3-SED}, is denitrified into N₂. Wetzel (1975) shows that in one study 37% of the NO₃N of lake sediments was incorporated into bacterial organic matter. If 1st order sediments are not active, then all of the NO₃-N diffused into the sediments is assumed to be denitrified. Be careful in using this term in conjunction with [NO3S] since the stoichiometry of sediments (C:N:P ratios) can be changed by allowing this to occur.

Note that concentrations of nitrate in the model are in terms of NO₃ as N.

Example

```
NITRATE    NO3DK    NO3S  FNO3SED
Wb 1        0.05    0.001    0.00
Wb 2        0.05    0.001    0.37
Wb 3        0.05    0.001    0.37
```

[Excel input file example is shown in the section [Silica](#).]

Related Cards and Files

[Nitrate Temperature Rate Multipliers](#)

Nitrate Temperature Rate Multipliers (NO3 RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	NO3T1	Real	5.0	Lower temperature for nitrate decay, °C
3	NO3T2	Real	25.0	Lower temperature for maximum nitrate decay, °C
4	NO3K1	Real	0.1	Fraction of denitrification rate at NO3T1
5	NO3K2	Real	0.99	Fraction of denitrification rate at NO3T2

This card specifies the lower and maximum lower temperatures used in defining the curve that determines the effect of temperature on denitrification. See Part 2 of the User's Manual for more details on the mathematical formulation for the temperature coefficients.

The denitrification rate correction as a function of temperature is shown below for NO3T1=5, NO3K1=0.1, NO3T2=25 and NO3K2=0.99.

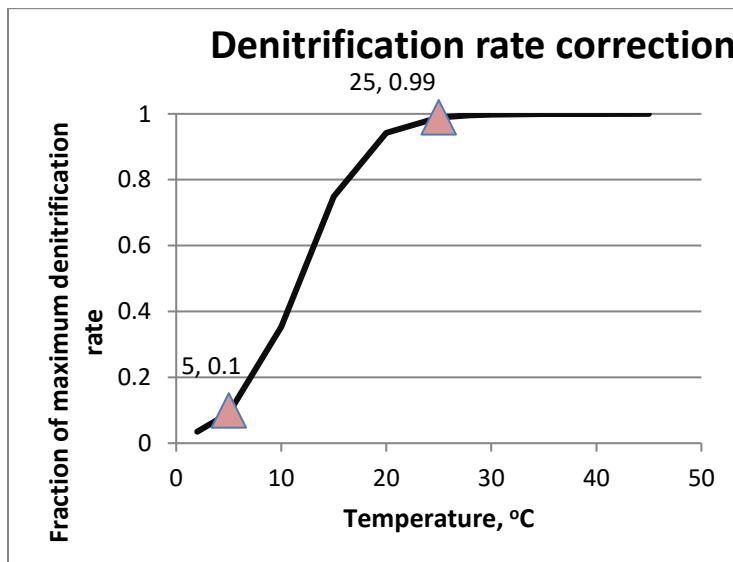


Figure 29. Denitrification as a function of temperature.

Example

```

NO3 RATE    NO3T1    NO3T2    NO3K1    NO3K2
Wb 1        5.0      25.0     0.1      0.99
Wb 2        5.0      25.0     0.1      0.99
Wb 3        5.0      25.0     0.1      0.99
  
```

[Excel input file example is shown in the section [Silica](#).]

Related Cards and Files

[Nitrate](#)

Silica (SILICA)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	DSIR	Real	0.1	Dissolved silica sediment release rate, fraction of SOD
3	PSIS	Real	1.0	Particulate biogenic settling rate, $m sec^{-1}$
4	PSIDK	Real	0.3	Particulate biogenic silica decay rate, day^{-1}
5	PARTSI	Real	0.0	Dissolved silica partitioning coefficient

This card specifies the relevant kinetic coefficient for silica kinetics. [DSIR] is the sediment release rate of dissolved silica from the zero-order sediment compartment. [PSIS] is the particulate biogenic settling rate and [PSIDK] is the particulate biogenic decay rate. Particulate biogenic silica represents the skeletal remains of diatoms. Dissolved silica is allowed to partition onto suspended solids and [PARTSI] is the value of the partitioning coefficient.

Example

```
SILICA      DSIR      PSIS      PSIDK      PARTSI
Wb 1        0.1       1.0       0.3       0.0
Wb 2        0.1       0.5       0.3       0.0
Wb 3        0.1       0.5       0.3       0.0
```

The Excel input file also includes the coefficient O2NH4 (this is described in [Stoichiometry 1](#)), which is the oxygen equivalent for the reaction from ammonia to nitrite to nitrate in mg O2/mg N.

NUTRIENTS - P N Si Si	WB1	WB2
PO4R Sediment release rate of phosphorus, fraction of SOD	0.015	
PARTP Phosphorus partitioning coefficient for suspended solids	1.2	
NH4R Sediment release rate of ammonium, fraction of SOD	0.15	
NH4DK Ammonium decay rate, day-1	0.05	
NH4T1 Lower temperature for ammonia decay, oC	5	
NH4T2 Lower temperature for maximum ammonia decay, oC	25	
NH4K1 Fraction of nitrification rate at NH4T1	0.1	
NH4K2 Fraction of nitrification rate at NH4T2	0.99	
NH3 gas transfer: Kg_H2O_Constant in calculation of Kg_H2O based on Wind	168	
O2NH4 Oxygen stoichiometry for nitrification (mg O2/mg N)	4.57	
NO3DK Water column denitrification rate or nitrate decay rate, day-1	0.05	
NO3S Nitrate loss velocity to the sediments because of sediment denitrification, m day-1	0	
FNO3SED Fraction of NO3-N diffused into the sediments that becomes part of organic N in the sediments (The rest is denitrified.)	0.37	
NO3T1 Lower temperature for nitrate decay, oC	5	
NO3T2 Lower temperature for maximum nitrate decay, oC	25	
NO3K1 Fraction of denitrification rate at NO3T1	0.1	

CONTROL FILE**INPUT OUTPUT FILENAMES**

NO3K2 Fraction of denitrification rate at NO3T2	0.99
DSIR Dissolved silica sediment release rate, fraction of SOD	0.1
PSIS Particulate biogenic settling rate, m sec-1	0.1
PSIDK Particulate biogenic silica decay rate, day-1	0.3
PARTSI Dissolved silica partitioning coefficient	0.2

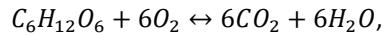
Related Cards and Files[Algal Stoichiometry](#)[Epiphyte Stoichiometry](#)[Zero-Order Sediment Oxygen Demand](#)

Sediment Carbon Dioxide Release (SED CO2)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	CO2REL	Real	1.2	Sediment carbon dioxide release rate, fraction of sediment oxygen demand

This card specifies the carbon dioxide release rate from the sediments as a fraction of the 0-order sediment oxygen demand. This is ignored if the zero-order sediment demand is zero.

Values as high as 1.4 have been used in earlier modeling studies. If one considers the CO₂ release as a fraction of O₂ uptake from



the stoichiometric ratio of O₂ to CO₂ is 32 g O₂/44 g CO₂ or 0.8 g O₂/g CO₂ for a CO2REL of 1/0.8 or 1.25.

Example

```
SED CO2    CO2REL
           1.0
```

SED CO2	WB1	WB2
CO2R Sediment carbon dioxide release rate, fraction of sediment oxygen demand	0.1	

Related Cards and Files

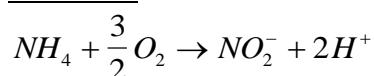
[Zero-Order Sediment Oxygen Demand](#)

Oxygen Stoichiometry 1 (STOICH 1)

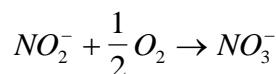
FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	O2NH4	Real	4.57	Oxygen stoichiometry for nitrification (mg O ₂ /mg N)
3	O2OM	Real	1.4	Oxygen stoichiometry for organic matter decay (mg O ₂ /mg organic matter)

This card specifies the stoichiometric equivalents of oxygen for nitrification, organic matter decay. The default values should not be changed unless the user has data to support the change.

Nitrification



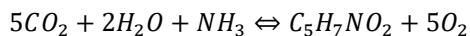
3.43 g O₂ required for 1 g N oxidized



1.14 g O₂ required for 1 g N oxidized for a total of 4.57 g O₂/g N. Gaudy and Gaudy (1980) recommend that the O₂ demand approaches 4.2 g O₂/g N because of cellular needs for N.

Organic matter

Assuming the organic matter represents average algal and bacterial composition (C₅H₇NO₂) (Golterman, 1975; Wang et al., 1978), the stoichiometric requirements are 1.4 g O₂/g organic matter from the following equation:



Example

```
STOICH 1    O2NH4    O2OM
Wb 1        4.57     1.4
Wb 2        4.57     1.4
Wb 3        4.57     1.4
```

[In the Excel version of the control file, these variables are included in the Nutrients and Organic matter sections of the input file.]

Related Cards and Files

[Oxygen Stoichiometry 2](#)
[Oxygen Stoichiometry 3](#)

Oxygen Stoichiometry 2 (STOICH 2)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	O2AR	Real	1.1	Oxygen stoichiometry for algal respiration (mg O ₂ /mg algae organic matter)
3	O2AG	Real	1.4	Oxygen stoichiometry for algal primary production (mg O ₂ /mg algae organic matter)

This card specifies the stoichiometric equivalents of oxygen for algal respiration and algal primary production.

The biological oxygen requirement for respiration is based on converting carbohydrate to carbon dioxide and water, such as



or 1.1 g O₂/g organic matter. EPA (1985) reports model applications where [O2AR] varied from 0.95 to 2.3 mg O₂/mg dry weight algae biomass.

[O2AG] rates reported in modeling studies have varied from 1.24 to 1.8 mg O₂/mg dry weight algae biomass (EPA, 1985). Ruane (2014) reported that values from 1.8-2.0 were often required to produce supersaturation.

Example

```
STOICH 2      O2AR      O2AG
Alg 1        1.1       1.4
Alg 2        1.1       1.4
Alg 3        1.1       1.4
```

[In the Excel version of the control file, these variables are included in the algae section of the input file.]

Related Cards and Files

[Oxygen Stoichiometry 1](#)

[Oxygen Stoichiometry 3](#)

Oxygen Stoichiometry 3 (STOICH 3)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	O2ER	Real	1.1	Oxygen stoichiometry for epiphyton/periphyton respiration (mg O ₂ /mg periphyton organic matter)
3	O2EG	Real	1.4	Oxygen stoichiometry for epiphyton/periphyton primary production (mg O ₂ /mg periphyton organic matter)

This card specifies the stoichiometric equivalents of oxygen for epiphyton/periphyton respiration and epiphyton/periphyton primary production. The default values should not be changed unless the user has data to support the change.

Example

```
STOICH 3      O2ER      O2EG
Ep 1          1.1       1.4
Ep 2          1.1       1.4
Ep 3          1.1       1.4
```

[In the Excel version of the control file, these variables are included in the periphyton section of the input file.]

Related Cards and Files

[Oxygen Stoichiometry 1](#)
[Oxygen Stoichiometry 2](#)

Oxygen Stoichiometry 4 (STOICH 4)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	O2ZR	Real	1.1	Oxygen stoichiometry for zooplankton respiration (mg O ₂ /mg zooplankton organic matter)

This card specifies the stoichiometric equivalents of oxygen for zooplankton respiration. The default values should not be changed unless the user has data to support the change.

Example

```
STOICH 4      O2ZR
ZOO1        1.1000
```

[In the Excel version of the control file, these variables are included in the zooplankton section of the input file.]

Related Cards and Files

[Oxygen Stoichiometry 1](#)
[Oxygen Stoichiometry 2](#)

Oxygen Stoichiometry 5 (STOICH 5)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	O2MR	Real	1.1	Oxygen stoichiometry for macrophyte respiration (mg O ₂ /mg macrophyte organic matter)
3	O2MG	Real	1.4	Oxygen stoichiometry for macrophyte primary production (mg O ₂ /mg macrophyte organic matter)

This card specifies the stoichiometric equivalents of oxygen for macrophyte respiration and macrophyte primary production. The default values should not be changed unless the user has data to support the change.

Example

```
STOICH 5      O2MR      O2MG
MAC1        1.1        1.4
```

[In the Excel version of the control file, these variables are included in the macrophyte section of the input file.]

Related Cards and Files

[Oxygen Stoichiometry 1](#)
[Oxygen Stoichiometry 2](#)

Oxygen Limit (O2 LIMIT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	KDO	Real	0.1	K _{DO} , Dissolved oxygen half-saturation constant or concentration at which aerobic processes are at 50% of their maximum, g m ⁻³

This card specifies the half-saturation constant or dissolved oxygen concentration at which oxic processes are at 50% of their normal oxic rates. Hence, sediment oxygen demand, nitrification, and other processes only occur when there is available oxygen. The change from oxic to anoxic (or vice versa) processes occurs gradually by means of a Monod type formulation.

This formulation is used to move gradually from oxic to anoxic conditions. This reduction of oxic reactions as dissolved oxygen levels approach zero is based on specification of a dissolved oxygen half-saturation constant in the following equation:

Rate Reduction = $\frac{\Phi_{DO}}{K_{DO} + \Phi_{DO}}$ where Φ_{DO} is the concentration of dissolved oxygen and K_{DO} is a half-saturation dissolved oxygen concentration when oxic reactions are half of their maximum without limitation of oxygen conditions. See Figure 30. Earlier versions of CE-QUAL-W2 used an ON-OFF oxygen limit for aerobic-anaerobic processes. Thomann and Mueller (1987) have used a value of $K_{DO}=0.7$ mg/l.

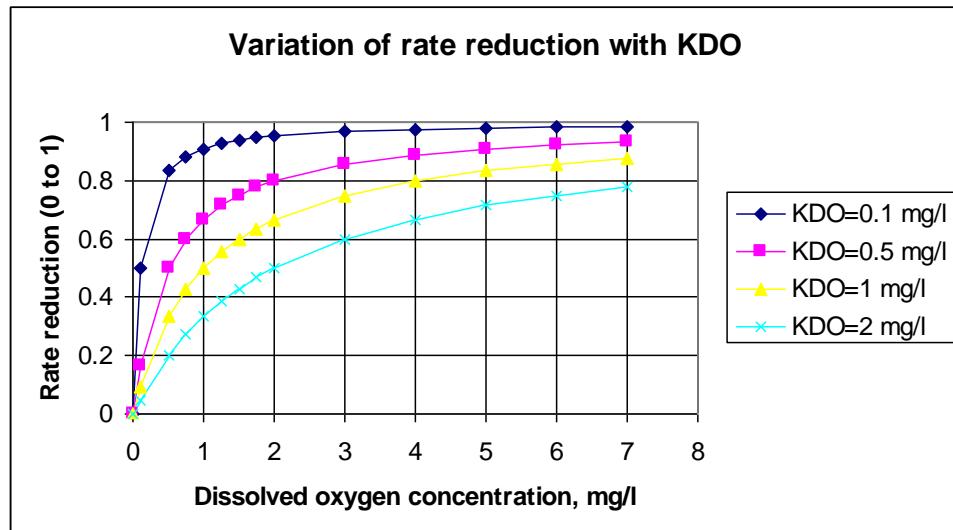


Figure 30. Variation of KDO on anoxia processes.

Example

```
O2 LIMIT      KDO
              0.7
```

OXYGEN Limit	O2LIMIT
O2 LIMIT KDO, Dissolved oxygen half-saturation constant or concentration at which aerobic processes are at 50% of their maximum, g m ⁻³	0.01

Sediment Compartment (SEDIMENT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SEDC	Character	OFF	Turns ON/OFF the first order sediment compartment
3	PRNSC	Character	OFF	Turns ON/OFF printing first order sediment organic matter concentrations to the snapshot file
4	SEDCI	Real	0.0	Initial first order sediment concentration, $g\ m^{-2}$
5	SEDK	Real	0.1	First order sediment decay rate, day^{-1}
6	SEDS	Real	0.1	First order sediment settling or focusing rate, $m\ day^{-1}$
7	FSOD	Real	1.0	Fraction of the zero-order SOD rate used
8	FSED	Real	1.0	Fraction of first-order sediment concentration initial condition
9	SEDBR	Real	0.01	First order sediment burial rate, day^{-1}
10	DYNSEDK	Character	OFF	Turns ON/OFF dynamic calculation of the first order sediment model decay rate

[SEDC] turns ON/OFF the 1st order sediment compartment. The 1st order sediment compartment is not a true sediment diagenesis compartment as it does not keep track of organic nutrient delivery to the sediments, their decay, and subsequent release back into the water column during hypoxic/anoxic conditions. However, it does keep track of organic matter delivery to the sediments via particulate organic matter and dead algal cells, and the subsequent water column oxygen demand that is exerted. The inclusion of the 1st order sediment compartment makes the model respond to an increase in organic matter delivery to the sediments affecting SOD. When sediment diagenesis is turned ON, this is automatically set to zero internally regardless of the values specified.

This information controls zero and first-order sediment oxygen demand. Another input file controls the sediment diagenesis model. In most cases, if sediment diagenesis is used, the zero-order model would be turned OFF by setting FSOD=0.0 or setting zero-order SOD to 0 g/m²/day.

[PRNSC] controls sediment organic matter concentrations that accumulate in the first-order SOD algorithm are output to the snapshot file. [SEDCI] specifies the initial “concentration(s)” for the 1st order sediment compartment and its behavior is the same as for setting the initial concentrations of any of the water column state variables, except that it is in units of mass per surface area or g/m². Just as the algae are modeled as a dry weight of organic matter, the sediment concentration is also a dry weight of organic matter per bottom surface area.

The initial concentrations of Sediment-P, Sediment-N, and Sediment-C are based on the initial sediment concentration multiplied by the appropriate initial stoichiometric coefficient, [ORG_P], [ORG_N], and [ORG_C], respectively. These nutrient ratios then are dynamically computed as organic matter accumulates and decays in the sediments. [SEDDK] specifies the sediment decay rate and should be somewhat less than the labile POM decay rate. [SEDS] is the velocity at which sediments that accumulate on each layer are settling or moving toward the bottom of the channel. In many systems turbulence tends to stir up and re-settle the sediments at lower and lower levels in the channel cross-section. In an earlier version (V3.2), the settling velocity of POM [POMS] was used to focus sediments toward the bottom. [FSOD] is multiplied by the SOD

CONTROL FILE

INPUT OUTPUT FILENAMES

rates for each segment to determine the actual SOD rate. This is an easy method to adjust all SOD values without changing them for each segment. [FSED] is multiplied by the initial sediment concentration given either through the LPR, VPR or w2_con.npt (or w2_con.csv) files. This allows the model user to adjust the initial condition of all model cells for the first order model. [SEDBR] is the sediment burial rate. This allows sediments to effectively be bound and unavailable for further decay.

[DYNSEDK] allows the user to compute dynamically the sediment decay rate in the first order sediment model based on the organics that are deposited into the 1st order sediment compartment. If [DYNSEDK] is OFF, then the value of the maximum decay rate is [SEDDK]. It is then adjusted according to temperature. If [DYNSEDK] is turned ON, then the maximum sediment decay rate is computed based on the weighted mass average of the decay rates of material which has settled and the amount that is already residing in the sediments every time step for which kinetics are computed or updated.

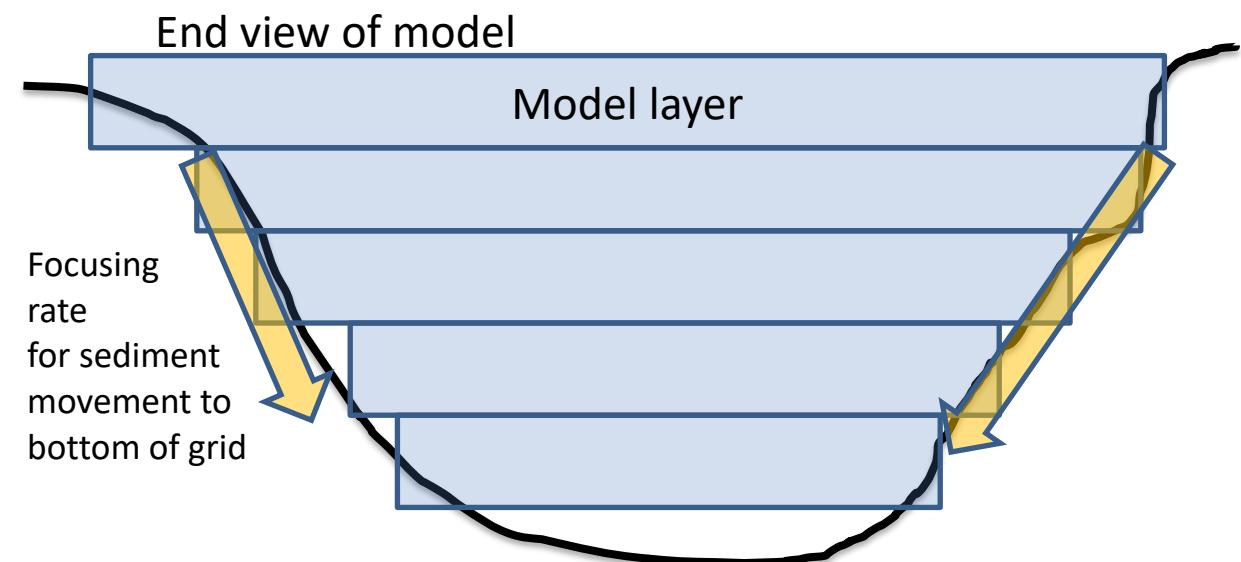


Figure 31. Illustration of sediment focusing rate.

Example

SEDIMENT	SEDC	PRNSC	SEDCI	SEDK	SEDS	FSOD	FSED	SEDBR	DYNSEDK
Wb 1	ON	ON	0.0	0.1	0.0	1.0	1.0	0.001	OFF
Wb 2	ON	ON	0.0	0.1	0.0	1.0	1.0	0.001	OFF
Wb 3	ON	ON	0.0	0.1	0.5	1.0	1.0	0.001	OFF

[For the Excel control file example, see the next section.]

Related Cards and Files

[Zero-Order Sediment Oxygen Demand](#)
[SOD Temperature Rate Multipliers](#)

SOD Temperature Rate Multipliers (SOD RATE)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	SODT1	Real	4.0	Lower temperature for zero-order SOD or first-order sediment decay, °C
3	SODT2	Real	25.0	Upper temperature for zero-order SOD or first-order sediment decay, °C
4	SODK1	Real	0.1	Fraction of SOD or sediment decay rate at lower temperature
5	SODK2	Real	0.99	Fraction of SOD or sediment decay rate at upper temperature

This card specifies the temperature rate multipliers that adjust the 0-order SOD or 1st-order decay rate. The model is very sensitive to these values and they are an important calibration parameter for accurately reproducing the timing of water column oxygen decreases early during stratified periods. The SOD rate correction as a function of temperature is shown below for **SODT1=5**, **SODK1=0.1**, **SODT2=25** and **SODK2=0.99**.

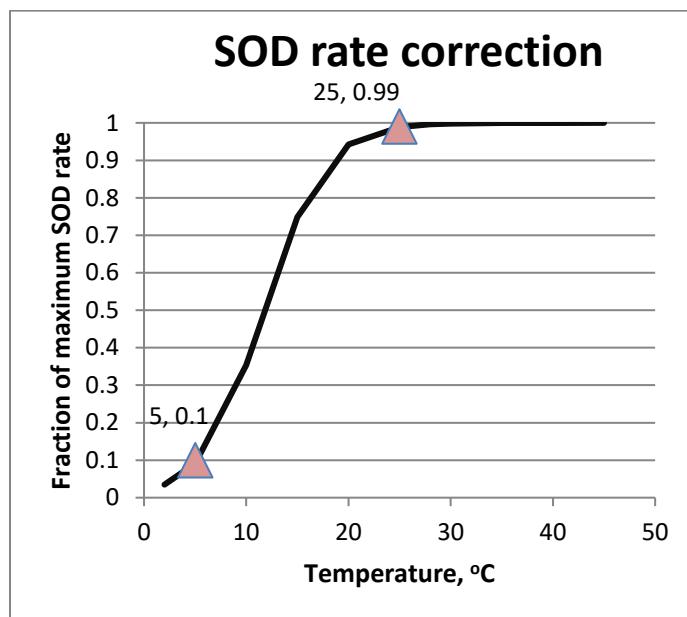


Figure 32. SOD rate as a function of temperature.

Example

```

SOD RATE   SODT1   SODT2   SODK1   SODK2
Wb 1        4.0     30.0    0.1     0.99
Wb 2        4.0     30.0    0.1     0.99
Wb 3        4.0     30.0    0.1     0.99
  
```

CONTROL FILE**INPUT OUTPUT FILENAMES**

SOD RATES	WB1	WB2
SEDC Turns ON/OFF the first order sediment compartment	OFF	
SEDPRC Turns ON/OFF printing first order sediment organic matter concentrations to the snapshot file	ON	
SEDCI Initial first order sediment concentration, g m-2	0	
SEDK First order sediment decay rate, day-1	0.08	
SEDS First order sediment settling or focusing rate, m day-1	0.1	
FSOD Fraction of the zero-order SOD rate used	1	
FSED Fraction of first-order sediment concentration initial condition	1	
SEDBR First order sediment burial rate, day-1	0	
DYNSEDK Turns ON/OFF dynamic calculation of the first order sediment model decay rate	OFF	
SODT1 Lower temperature for zero-order SOD or first-order sediment decay, oC	4	
SODT2 Upper temperature for zero-order SOD or first-order sediment decay, oC	30	
SODK1 Fraction of SOD or sediment decay rate at lower temperature	0.1	
SODK2 Fraction of SOD or sediment decay rate at upper temperature	0.99	

Related Cards and Files[Sediment Compartment](#)

Zero-Order Sediment Oxygen Demand (S DEMAND)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SOD	Real	Zero-order sediment oxygen demand for each segment, $g O_2 m^{-2} day^{-1}$

This card specifies the 0-order sediment oxygen demand for each segment (including boundary segments) in the computational grid.

These are fixed maximum rates of SOD for each model segment. They only vary as a function of temperature.

For the w2_con.npt control file, if there are *more* values than can be specified on one line, then they are continued on the next line without another **S DEMAND** card being specified. There are 9 8-character fields allowed per line. The inactive segments are also specified. Hence, the first value is for segment 1.

For the Excel input file, the values also include inactive segments but continue along one row and do not wrap around.

Sediment oxygen demand is known to vary spatially in reservoirs due to differences in sedimentation patterns and algal production (Cole and Hannan, 1989). In the model, the user can specify a separate value of sediment oxygen demand [**SOD**] for each model segment. Sediment oxygen demand typically ranges from 0.1 to 1.0 $gO_2 m^{-2} day^{-1}$, but can be higher (Newbold and Liggett, 1974). Additional information can be found in Gunnison, Chen, and Brannon (1983) and Chen, Brannon, and Gunnison (1984). Additional values are given in the following table.

Note that the values of SOD for the zero-order sediment oxygen demand are specified as maximum values at the optimal temperature rather than at a standard temperature of 20°C. If the SOD temperature rate multiplier is set so that **SODT2**=25 and **SODK2**=0.99, then the SOD values would be considered to be at 25°C. When sediment diagenesis is turned ON, this is automatically set to zero internally regardless of the values specified.

Table 51. Sediment Oxygen Demand Literature Values

Site	SOD, $g O_2 m^{-2} day^{-1}$	Reference
Cayuga Lake, NY	0.3-1.0	Newbold & Liggett, 1974
Lake Sammamish, WA	1.0	Bella, 1970
Lake Lyndon B. Johnson, TX	1.7-5.8	Schnoor & Fruh, 1979
Saginaw River, MI	0.1-5.3	Chiari & Burke, 1980

Example

S DEMAND	SOD							
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

CONTROL FILE**INPUT OUTPUT FILENAMES**

For the Excel input file, the segment number continues along one row.

SOD DEMAND ZERO ORDER: Segment #	1	2	3	4	5	6
SOD g/m ² /d Zero-order sediment oxygen demand for each segment	0.3	0.3	0.3	0.3	0.4	0.45

Related Cards and Files

[Sediment Compartment](#)

[SOD Temperature Rate Multipliers](#)

Reaeration (REAERAT)

FIELD	NAME	VALUE	DEFAULT	DESCRIPTION
1				(Ignored by code)
2	REARC	Character	LAKE	Type of waterbody, RIVER, LAKE, or ESTUARY
3	EQN#	Integer	6 (if LAKE)	Equation number used for determining reaeration
4	COEF1	Real		User defined parameter for custom definition of reaeration
5	COEF2	Real		User defined parameter for custom definition of reaeration
6	COEF3	Real		User defined parameter for custom definition of reaeration
7	COEF4	Real		User defined parameter for custom definition of reaeration
8	DGPO2	Real	1.027	This term is the fraction of oxygen transfer that is total gas transfer at the air-water interface. This term affects only the dissolved gas pressure state variables as it relates to computation of TDG.
9	MINKL	Real	0.0	This is the minimum gas transfer coefficient in units of m/d for LAKES and units of day ⁻¹ for RIVER/ESTUARY

This card allows the user to specify the appropriate reaeration formulation for the specific type of waterbody being simulated. [REARC] is used to specify the type of waterbody. [EQN#] is then used to specify the reaeration equation appropriate for the type of waterbody. To see the reaeration coefficient computed by the model, the value of reaeration is output to the [Time Series](#) output file (TSR). Some of these equations use COEF1 through COEF4 for setting a custom value of reaeration. For example, one can choose COEF1 as the constant reaeration coefficient by setting COEF2=COEF3=COEF4=0.0. DGPO2 is used when dissolved gas pressure is active. This is the fraction of the oxygen transfer that represents total gas transfer, composed of largely nitrogen and oxygen gases. A typical value would be 1.027. MINKL sets the minimum reaeration coefficient. Thomann and Mueller (1987) have suggested for lakes that this could be 0.6 m/d. The following table lists the equations for the RIVER waterbody type.

Table 52. River Reaeration Equations at 20°C.

#	Equation	Comments	Applicability	Reference
0	Either Eq 1, 2 or 4	<i>K_a</i> is determined based on applicability criteria of each of the 3 formulations		Covar (1976)
1	$K_a = \frac{K_L}{H} = \frac{(D_{O_2} U)^{1/2}}{H^{3/2}}$	D_{O_2} =water molecular diffusion coefficient at 20°C, $8.1 \times 10^{-5} \text{ ft}^2 \text{ hr}^{-1}$ or $2.09 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1}$ $D_{O_2}=1.91 \times 10^{-3} (1.037)^T \text{ ft}^2 \text{ day}^{-1}$ U= velocity, ft/day H=depth, ft	Depths between 1-30 ft and velocities between 0.5-1.6 fps	O'Connor and Dobbins (1958)
2	$K_a = \frac{K_L}{H} = \frac{11.6 U}{H^{1.67}}$	U=velocity, ft s ⁻¹ H=depth, ft <i>K_a</i> =reaeration rate, day ⁻¹	Depths between 2-11 ft and velocities between 1.8-5 fps	Churchill, Elmore and Buckingham (1962)

CONTROL FILE

INPUT OUTPUT FILENAMES

#	Equation	Comments	Applicability	Reference
3	$K_a = \frac{K_L}{H} = 1.8 \text{ US for } 1 \text{ cfs} < Q < 10 \text{ cfs}$ $K_a = \frac{K_L}{H} = 0.88 \text{ US for } 10 \text{ cfs} < Q < 300 \text{ cfs}$	$S=\text{slope, ft mile}^{-1}$ $U=\text{velocity, ft s}^{-1}$ $K_o=\text{reaeration rate, day}^{-1}$		Tsivoglou and Wallace (1972)
4	$K_a = \frac{K_L}{H} = \frac{21.6U^{0.67}}{H^{1.85}}$	$U=\text{velocity, ft s}^{-1}$ $H=\text{depth, ft}$	Depths between 0.4-2.4 ft and velocities between 0.1-1.8 fps	Owens et al. (1964)
5	$K_a = \frac{K_L}{H} = \frac{25u^*}{H}(1 + F^{0.5})$	$u^*=\text{shear velocity, (HSg)}^{0.5}$ $S=\text{energy grade line slope}$ $F=\text{Froude number, U/(gH)}^{0.5}$		Thackston and Krenkel (1966)
6	$K_a = \frac{K_L}{H} = \frac{7.62U}{H^{1.33}}$	$U = \text{velocity, ft s}^{-1}$ $H = \text{depth, ft}$		Langbien and Durum (1967)
7	$K_a = 517(\text{US})^{0.524}Q^{-0.242} \text{ for } Q < 0.556 \text{ m}^3\text{s}^{-1}$ $K_a = 596(\text{US})^{0.528}Q^{-0.136} \text{ for } Q > 0.556 \text{ m}^3\text{s}^{-1}$	$U=\text{velocity, m s}^{-1}$ $S=\text{slope, m m}^{-1}$ $Q=\text{flow, m}^3 \text{s}^{-1}$ $K_o=\text{reaeration rate, day}^{-1}$	For pool and riffle streams	Melching and Flores (1999)
8	$K_a = 88(\text{US})^{0.313}D^{-0.353} \text{ for } Q < 0.556 \text{ m}^3\text{s}^{-1}$ $K_a = 142(\text{US})^{0.333}D^{-0.66}W^{-0.243} \text{ for } Q > 0.556 \text{ m}^3\text{s}^{-1}$	$U = \text{velocity, m s}^{-1}$ $S = \text{slope, m m}^{-1}$ $W = \text{stream top width, m}$ $D = \text{average depth, m}$ $K_o = \text{reaeration rate, day}^{-1}$	For channel-control streams	Melching and Flores (1999)
9	$K_a = C_1 U^{C_2} H^{C_3} S^{C_4}$ and if no channel slope: $K_a = C_1 U^{C_2} H^{C_3}$	$U = \text{velocity, m s}^{-1}$ $H = \text{depth, m}$ $S = \text{slope [m/m or ft/ft]}$ $K_o = \text{reaeration rate, day}^{-1}$ $C_1 = \text{user defined}$ $C_2 = \text{user defined}$ $C_3 = \text{user defined}$ $C_4 = \text{user defined}$	User defined relationship	
10	$K_a = \frac{K_L}{H} = \frac{5.0u^*}{H}(1 + 9F^{0.25})$	$u^* = \text{shear velocity, (HSg)}^{0.5}$ $S = \text{slope of energy grade line}$ $F = \text{Froude number, U/(gH)}^{0.5}, K_o, \text{day}^{-1}$		Thackston and Dawson (2001)

[Table 53](#) lists the reaeration equations available for lakes, reservoirs, and estuaries in which it is assumed that wind is the dominant forcing function for reaeration.

Table 53. Lake Reraeration Equations at 20°C.

#	Equation	Comments	Reference
1	$K_a = \frac{K_L}{H} = \frac{0.864W}{H}$	$W = \text{wind speed at 10 m, m s}^{-1}$ $H = \text{depth, m}$ $K_L = \text{reaeration velocity, m day}^{-1}$	Broecker et al (1978)
2	$K_a = \frac{K_L}{H} = \frac{\alpha W^\beta}{H}$	$\alpha=0.2, \beta=1.0 \text{ for } W < 3.5 \text{ m s}^{-1}$ $\alpha=0.057, \beta=2.0 \text{ for } W > 3.5 \text{ m s}^{-1}$ $W = \text{daily average wind speed, m s}^{-1}$	Gelda et al (1996)
3	$K_a = \frac{K_L}{H} = \frac{0.728W^{0.5} - 0.317W + 0.0372W^2}{H}$	$W = \text{wind speed at 10 m, m s}^{-1}$ $K_L = \text{reaeration velocity, m day}^{-1}$	Banks and Herrera (1977)

INPUT OUTPUT FILENAMES

CONTROL FILE

#	Equation	Comments	Reference
4	$K_a = \frac{K_L}{H} = \frac{0.0986W^{1.64}}{H}$ at T=20°C or $K_a = \frac{K_L}{H} = \frac{0.0986W^{1.64}}{H} \left(\frac{600}{Sc} \right)^{0.5}$	W = wind speed at 10 m, $m s^{-1}$ Sc = Schmidt number, (v/D)=13750[0.10656 $\exp(-0.0627T)+0.00495]$ T = temperature, °C	Wanninkhof et al. (1991)
5	$K_a = \frac{K_L}{H} = \frac{\frac{D_{O_2}}{(200 - 60W^{0.5})10^{-6}}}{H}$	D_{O_2} = molecular diffusivity of oxygen, $m^2 s^{-1}$, 2.1E-9 $m^2 s^{-1}$ at 20°C W = wind speed, $m s^{-1}$ K_L = reaeration velocity, $m s^{-1}$	Kanwisher (1963)
6	$K_a = \frac{K_L}{H} = \frac{0.5 + 0.05W^2}{H}$		Cole and Buchak (1995)
7	$K_a = \frac{K_L}{H} = \frac{0.362\sqrt{W}}{H}$ $W < 5.5m/s$ $K_a = \frac{K_L}{H} = \frac{0.0277W^2}{H}$ $W > 5.5m/s$		Banks (1975)
8	$K_a = \frac{K_L}{H} = \frac{0.64 + 0.128W^2}{H}$	Recommended form for WQRSS reservoir model	Smith (1978)
9	$K_a = \frac{K_L}{H} = \frac{0.156W^{0.63}}{H}$ $W \leq 4.1ms^{-1}$ $K_a = \frac{K_L}{H} = \frac{0.0269W^{1.9}}{H}$ $W > 4.1ms^{-1}$		Liss (1973)
10	$K_a = \frac{K_L}{H} = \frac{0.0276W^2}{H}$		Downing and Truesdale (1955)
11	$K_a = \frac{K_L}{H} = \frac{0.0432W^2}{H}$		Kanwisher (1963)
12	$K_a = \frac{K_L}{H} = \frac{0.319W}{H}$		Yu et al (1977)
13	$K_a = \frac{K_L}{H} = \frac{0.398}{H}$ $W < 1.6ms^{-1}$ $K_a = \frac{K_L}{H} = \frac{0.155W^2}{H}$ $W \geq 1.6ms^{-1}$		Weiler (1974)
14	$K_a = \frac{K_L}{H} = \frac{C_1 + C_2W^{C_3}}{H}$	W = wind speed, $m s^{-1}$ at 10 m K_a = reaeration rate, day^{-1} C_1 = user defined, C_2 =user defined C_3 = user defined	User defined

For estuary systems, Thomann and Mueller (1987) and Chapra (1997) suggest using any of the wind formulations in [Table 53](#) or Equation 1 in [Table 52](#) (O'Connor-Dobbins formula) using the mean tidal velocity over a tidal cycle. [Table 54](#) shows an additional formulation from Thomann and Fitzpatrick (1982) for estuaries, as well as the approach of Covar (1976) for rivers. Since many texts suggest using the mean tidal velocity, caution should be used in using these equations since they are based on the instantaneous velocity.

Table 54. Estuarine Reaeration Equations at 20°C.

#	Equation	Comments	Reference
0	Either Eq 1, 2 or 4 from Table 52	K_a is determined based on applicability criteria of each of these 3 formulations	Covar (1976)
1	$K_a = \frac{K_L}{H} = \frac{0.728W^{0.5} - 0.317W + 0.0372W^2}{H} + 3.93 \frac{\sqrt{U}}{H^{1.5}}$	U = mean tidal velocity, $m s^{-1}$ W = wind speed, $m s^{-1}$ H = depth, m K_L = reaeration velocity, $m s^{-1}$ This formula combines the effect of wind from Banks and Herrera (1977) and estuary tidal flow	Thomann and Fitzpatrick (1982)

CONTROL FILE

INPUT OUTPUT FILENAMES

#	Equation	Comments	Reference
2	$K_a = C_1 U^{C_2} H^{C_3} + \frac{0.5 + C_4 W^2}{H}$	U = velocity, $m s^{-1}$, H =depth, m W = wind speed at 10 m K_a = reaeration rate, day^{-1} C_1 = user defined, C_2 =user defined C_3 = user defined, C_4 =user defined	User defined relationship

All reaeration coefficients are corrected by temperature using the Arrhenius formulation with a theta value of 1.024. For further information, see Part 2 of the User's Manual.

Example

```
REAERAT    REARC    EQN#    COEF1    COEF2    COEF3    COEF4    DGP02    MINKL
Wb 1        RIVER    7
Wb 2        LAKE    5
Wb 3        ESTUARY 1
```

REAERATION	WB1	WB2
TYPE: LAKE, RIVER, or ESTUARY	LAKE	
EQN#: Equation # (see User Manual)	2	
COEF1 User defined parameter	0	
COEF2 User defined parameter	0	
COEF3 User defined parameter	0	
COEF4 User defined parameter	0	
DGPO2, fraction of dissolved gas to reaeration coefficient, typical value 1.027	1.027	
MINKL (if LAKE, m/d) or MINKA (if RIVER/ESTUARY, day-1)	0.6	

Restart Input Filename (RSI FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	RSIFN	Character	Restart input data filename

This card specifies the filename used as input for restarts. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
RSI FILE.....RSIFN.....  
          rsi.npt
```

[This variable is in the [restart section](#) of the Excel control file.]

Withdrawal Filename (QWD FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QWDFN	Character	Withdrawal filename

This card specifies the filename for withdrawal outflows. See a description of the [withdrawal file](#) for more information on data setup. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
QWD FILE.....QWDFN.....  
          qwd.npt
```

[This variable is in the global filenames section of the Excel control file below.]

Gate Outflow Filename (QGT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QGTFN	Character	Gated outflow filename

This card specifies the filename(s) for branch outflows. See a description of the [gate outflow file](#) for more information on data setup. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

CONTROL FILE

INPUT OUTPUT FILENAMES

Example

QGT FILE..... QGTFN.....
qgt.csv

[This variable is in the global filenames section of the Excel control file below.]

Wind Sheltering Filename (WSC FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	WSCFN	Character	Wind sheltering Coefficient sheltering filename

This card specifies the filename containing the wind sheltering coefficients as a function of segment number and Julian date. One file contains all the wind sheltering coefficients for all waterbodies. See a description of the [wind-sheltering file](#) for more information on data setup. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

WSC FILE..... WSCFN.....
wsc.csv

[This variable is in the global filenames section of the Excel control file below.]

Dynamic Shading Filename (SHD FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	SHDFN	Character	Dynamic shading filename

This card specifies the filename containing the shading parameters as a function of segment number. This one file contains all the dynamic shading coefficients for all waterbodies. See a description of the [dynamic shading file](#) for more information on data setup. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

SHD FILE..... SHDFN.....
shade.csv

The Excel file includes the variable VPLNFN from the section [W2 Linkage Filename](#).

File names - global	FILE NAMES
QWD FILE QWDFN - withdrawals	qwd.csv
QGT FILE QGTFN - gate	qgt.csv
WSC FILE WSCFN - wind sheltering	wsc.csv
SHD FILE SHDFN - shading	shade.csv
VPLFN - W2 post output, DSI W2Post output file	degray.w2l

Bathymetry Filename (BTH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	BTHFN	Character	Bathymetry filename

This card specifies the filename(s) containing the waterbody bathymetry. See a description of the [bathymetry file](#) for more information on the data setup. Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
BTH FILE.....BTHFN.....  
Wb 1      bth_wb1.npt  
Wb 2      bth_wb2.npt  
Wb 3      bth_wb3.csv
```

[The Excel file summarizes all waterbody dependent file names below.]

Meteorology Filename (MET FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	METFN	Character	Meteorological input data filename

This card specifies the filename(s) for time-varying meteorological data. More information on data setup can be found in the description of the [meteorology input file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename. Usually the meteorological file is specified for each waterbody. There is an option to allow the meteorological file to vary by segment number rather than by waterbody – see [Meteorology File Varies by Segment Number Range](#).

Example

```
MET FILE.....METFN.....  
Wb 1      met_wb1.npt  
Wb 2      met_wb2.npt  
Wb 3      met_wb3.npt
```

[The Excel file summarizes all waterbody dependent file names below.]

Light Extinction Filename (EXT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EXTFN	Character	Light extinction input data filename

This card specifies the filename(s) for time-varying light extinction data in Julian day versus light extinction coefficient in m^{-1} . More information on data setup can be found in the description of the [light extinction file](#). Note that in Windows one can use ‘.\Subdirectory\Filename’ to specify a model subdirectory in the working directory and a filename.

Example

```
EXT FILE.....EXTFN.....  
Wb 1   ext_wb1.npt - not used  
Wb 2   ext_wb2.npt - not used  
Wb 3   ext_wb3.npt - not used
```

[The Excel file summarizes all waterbody dependent file names below.]

Atmospheric Deposition Filename (ATD FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	ATMDEPFN	Character	Atmospheric deposition file name

ATMDEPFN is the filename for the atmospheric deposition into each waterbody in rates of kg/km²/year. More information on data setup can be found in the description of the atmospheric deposition file. Note that in Windows one can use ‘.\Subdirectory\Filename’ to specify a model subdirectory in the working directory and a filename.

Example

```
EXT FILE.....EXTFN.....  
Wb 1   atm deposition wb1.csv  
Wb 2   atm_deposition_wb2.csv  
Wb 3   atm_deposition_wb3.csv
```

[The Excel file summarizes all waterbody dependent file names below.]

Vertical Profile Filename (VPR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	VPRFN	Character	Temperature and constituent vertical profile filename used for specifying initial conditions for the grid

This card specifies the filename(s) used to specify vertically varying initial temperatures and concentrations for the grid. More information on data setup can be found at the description of the [vertical profile file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
VPR FILE..... VPRFN.....  
Wb 1      vpr_wb1.npt  
Wb 2      vpr_wb2.npt  
Wb 3      vpr_wb3.npt
```

[The Excel file summarizes all waterbody dependent file names below.]

Longitudinal Profile Filename (LPR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	LPRFN	Character	Temperature and constituent longitudinal profile filename used for specifying initial conditions for the grid

This card specifies the filename(s) used to specify vertically and longitudinally varying initial temperatures and concentrations for the grid. More information on data setup can be found at the description of the [longitudinal profile file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
LPR FILE..... LPRFN.....  
Wb 1      lpr_wb1.npt  
Wb 2      lpr_wb2.npt  
Wb 3      lpr_wb3.npt
```

[The Excel file includes all waterbody dependent file names including SNPFN, PRFFN, CPLFN, SPRFN, and FLXFN which are described below.]

Waterbody Dependent File names	WB1	WB2
BTHFN bathymetry file	bth1.csv	
METFN meteorological file	met.npt	
EXTFN light extinction	ext_1.npt	

CONTROL FILE**INPUT OUTPUT FILENAMES**

CONTROL FILE	INPUT OUTPUT FILENAMES
ATMDEPFN atmospheric deposition file name	atm_deposition_wb1.csv
VPRFN vertical profile	vpr.npt
LPRFN longitudinal profile	lpr.npt
SNPFN snapshot	snp.opt
PRFFN profile output	prf.opt
CPLFN contour plot output	cpl.opt
SPRFN spreadsheet output	spr.csv
FLXFN flux output	flx.opt

Branch Inflow Filename (QIN FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QINFN	Character	Inflow filename

This card specifies the filename(s) for branch inflows. More information on data setup can be found at the description of the [branch inflow file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
QIN FILE.....QINFN.....  
Br 1  qin_br1.npt  
Br 2  qin_br2.npt  
Br 3  qin_br3.npt  
Br 4  qin_br4.npt
```

[The Excel file summarizes all branch dependent file names below.]

Branch Inflow Temperature Filename (TIN FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TINFN	Character	Inflow temperature filename

This card specifies the filename(s) for branch inflow temperatures. More information on data setup can be found at the description of the [branch inflow temperature file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TIN FILE.....TINFN.....  
Br 1   tin_br1.npt  
Br 2   tin_br2.npt  
Br 3   tin_br3.npt  
Br 4   tin_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Branch Inflow Constituent Filename (CIN FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CINFN	Character	Inflow constituent filename

This card specifies the filename(s) for branch inflow concentrations. More information on data setup can be found at the description of the [branch inflow concentration file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CIN FILE.....CINFN.....  
Br 1   cin_br1.npt  
Br 2   cin_br2.npt  
Br 3   cin_br3.npt  
Br 4   cin_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Branch Outflow Filename (QOT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QOTFN	Character	Outflow filename

This card specifies the filename(s) for branch outflows. More information on data setup can be found at the description of the [branch outflow file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
QOT FILE..... QOTFN.....
Br 1   qot_br1.npt
Br 2   qot_br2.npt
Br 3   qot_br3.npt
Br 4   qot_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Tributary Inflow Filename (QTR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QTRFN	Character	Tributary inflow filename

This card specifies the filename(s) for tributary inflows. There must be a separate file for each tributary. More information on data setup can be found at the description of the [tributary inflow file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
QTR FILE..... QTRFN.....
Tr 1   qtr_tr1.npt
```

[The Excel input file includes tributary names in the section on tributaries.]

Tributary Inflow Temperature Filename (TTR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TTRFN	Character	Tributary temperature filename

This card specifies the filename(s) for tributary inflow temperatures. There must be a separate file for each tributary. More information on data setup can be found at the description of the [tributary inflow temperature file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TTR FILE..... TTRFN.....  
Tr 1   ttr_tr1.npt
```

[The Excel input file includes tributary names in the section on tributaries.]

Tributary Inflow Concentration Filename (CTR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CTRFN	Character	Tributary inflow concentration filename

This card specifies the filename(s) for tributary inflow concentrations. There must be a separate file for each tributary. More information on data setup can be found at the description of the [tributary inflow concentration file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CTR FILE..... CTRFN.....  
Tr 1   ctr_tr1.npt
```

[The Excel input file includes tributary names in the section on tributaries.]

Distributed Tributary Inflow Filename (QDT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	QDTFN	Character	Distributed tributary inflow filename

This card specifies the filename(s) for distributed tributary inflow. There must be a separate file for each branch. More information on data setup can be found at the description of the [distributed tributary inflow file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
QDT FILE.....QDTFN.....  
Br 1    qdt_tr1.npt  
Br 2    qdt_tr2.npt  
Br 3    qdt_tr3.npt  
Br 4    qdt_tr4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Distributed Tributary Inflow Temperature Filename (TDT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TDTFN	Character	Distributed tributary temperature filename

This card specifies the filename(s) for distributed tributary inflow temperatures. There must be a separate file for each branch. More information on data setup can be found at the description of the [distributed tributary inflow temperature file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TDT FILE.....TDTFN.....  
Br 1    tdt_tr1.npt  
Br 2    tdt_tr2.npt  
Br 3    tdt_tr3.npt  
Br 4    tdt_tr4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Distributed Tributary Inflow Concentration Filename (CDT FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CDTFN	Character	Distributed tributary inflow concentration filename

This card specifies the filename(s) for distributed tributary inflow concentrations. There must be a separate file for each branch. More information on data setup can be found at the description of the [distributed tributary inflow concentration file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CDT FILE..... CDTFN.....  
Br 1      cdt_tr1.npt  
Br 2      cdt_tr2.npt  
Br 3      cdt_tr3.npt  
Br 4      cdt_tr4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Precipitation Filename (PRE FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	PREFN	Character	Precipitation filename

This card specifies the filename(s) for each branch precipitation. There must be a separate file for each branch. More information on data setup can be found at the description of the [precipitation file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
PRE FILE..... PREFN.....  
Br 1      pre_br1.npt  
Br 2      pre_br2.npt  
Br 3      pre_br3.npt  
Br 4      pre_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Precipitation Temperature Filename (TPR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TPRFN	Character	Precipitation temperature filename

This card specifies the filename(s) for branch precipitation temperatures. There must be a separate file for each branch. More information on data setup can be found at the description of the [precipitation temperature file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TPR FILE.....TPRFN.....
Br 1   tpr_br1.npt
Br 2   tpr_br2.npt
Br 3   tpr_br3.npt
Br 4   tpr_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

Precipitation Concentration Filename (CPR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CPRFN	Character	Precipitation concentration filename

This card specifies the filename(s) for branch precipitation constituent concentrations. There must be a separate file for each branch. More information on data setup can be found at the description of the [precipitation concentration file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CPR FILE.....CPRFN.....
Br 1   cpr_br1.npt
Br 2   cpr_br2.npt
Br 3   cpr_br3.npt
Br 4   cpr_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Upstream Head Filename (EUH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EUHFN	Character	External upstream head filename

This card specifies the filename(s) for branch external upstream heads. There must be a separate file for each branch. More information on data setup can be found at the description of the [upstream head file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
EUH FILE.....EUHFN.....
Br 1    euh_br1.npt
Br 2    euh_br2.npt
Br 3    euh_br3.npt
Br 4    euh_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Upstream Head Temperature Filename (TUH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TUHFN	Character	External upstream head temperature filename

This card specifies the filename(s) for branch external upstream head vertical temperatures. There must be a separate file for each branch. More information on data setup can be found at the description of the [upstream head temperature file](#). Note that in Windows one can use '\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TUH FILE.....TUHFN.....
Br 1    tuh_br1.npt
Br 2    tuh_br2.npt
Br 3    tuh_br3.npt
Br 4    tuh_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Upstream Head Concentration Filename (CUH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CUHFN	Character	External upstream head concentration filename

This card specifies the filename(s) for branch external upstream head constituent concentrations. There must be a separate file for each branch. More information on data setup can be found at the description of the [upstream head concentration file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CUH FILE.....CUHFN.....  
Br 1 cuh_br1.npt  
Br 2 cuh_br2.npt  
Br 3 cuh_br3.npt  
Br 4 cuh_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Downstream Head Filename (EDH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	EDHFN	Character	External downstream head filename

This card specifies the filename(s) for branch external downstream heads. There must be a separate file for each branch. More information on data setup can be found at the description of the [downstream head file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
EDH FILE.....EDHFN.....  
Br 1 edh_br1.npt  
Br 2 edh_br2.npt  
Br 3 edh_br3.npt  
Br 4 edh_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Downstream Head Temperature Filename (TDH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TDHFN	Character	External downstream head temperature filename

This card specifies the filename(s) for branch external downstream head vertical temperatures. There must be a separate file for each branch. More information on data setup can be found at the description of the [downstream head temperature file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TDH FILE..... TDHFN.....  
Br 1      tdh_br1.npt  
Br 2      tdh_br2.npt  
Br 3      tdh_br3.npt  
Br 4      tdh_br4.npt
```

[The Excel input file summarizes all branch dependent file names below.]

External Downstream Head Concentration Filename (CDH FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	CDHFN	Character	External downstream had concentration filename

This card specifies the filename(s) for branch external downstream head constituent concentrations. There must be a separate file for each branch. More information on data setup can be found at the description of the [downstream head concentration file](#). Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
CDH FILE..... CDHFN.....  
Br 1      cdh_br1.npt  
Br 2      cdh_br2.npt  
Br 3      cdh_br3.npt  
Br 4      cdh_br4.npt
```

Branch Dependent File Names	BR1	BR2
QINFN branch inflow	qin_br1_equal.npt	
TINFN branch temp inflow	tin_br1.npt	
CINFN branch conc inflow	cin_br1.csv	
QOTFN branch structure outflow	qot_br1_equal.npt	
QDTFN Distributed flow file	qin_br1.npt	
TDTFN Distributed temperature file	tdt_br1.npt	

CONTROL FILE**INPUT OUTPUT FILENAMES**

CDTFN Distributed concentration file	cdt_br1.npt	
PREFN Precipitation flow file	pre_br1.npt	
TPRFN Precipitation temperature file	tpr_br1.npt	
CPRFN Precipitation concentration file	cpr_br1.npt	
EUHFN Upstream head file	euh_br1.npt	
TUHFN Upstream temperature file	tuh_br1.npt	
CUHFN Upstream concentration file	cuh_br1.npt	
EDHFN Downstream head file	edh_br1.npt	
TDHFN Downstream temperature file	tdh_br1.npt	
CDHFN Downstream concentration file	cdh_br1.npt	

Time Series Plot Filename (TSR FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	TSRFN	Character	Time series plot filename

This card specifies the time series plot filename(s). The file prefix, 'tsr' is the file prefix for all tsr files. Also the file type ('csv') is used as the file type for all tsr files. The tsr file names include the number of the tsr file and the segment number. Note that in Windows one can use '.\Subdirectory\Filename' to specify a model subdirectory in the working directory and a filename.

Example

```
TSR FILE..... TSRFN.....  
          tsr.csv
```

[The Excel input filename includes this filename in the [TSR section](#) of the input file.]

Withdrawal Output Filename (WDO FILE)

FIELD	NAME	VALUE	DESCRIPTION
1			(Ignored by code)
2-10	WDOFN	Character	Withdrawal output filename

This card specifies the withdrawal output filename(s). The file prefix, 'wdo' is ignored for all wdo files as files are specified as flow ('q'), temperature ('t'), concentration ('c') or derived concentrations ('d') as the file prefix followed by the segment number. Whatever the file type specified below will be used as the file type for all wdo files. In the example below, all wdo files will have a csv filetype. Note that in Windows one can use for example '.\wdofiles\wdo.csv' to specify a model subdirectory, 'wdofiles' in the working directory with a file suffix of 'csv'.

Example

```
WDO FILE..... WDOFN.....  
          wdo.csv
```

[The Excel input filename includes this filename in the [WDO section](#) of the input file.]

INPUT FILES

Sample Control Input File

W2 Model Version 4.5

```

TITLE C .....TITLE.....
Degray Reservoir - March 4 through December 27, 1980
Degray Reservoir - March 4 through December 27, 1980
Density placed inflow, point sink outflow
Default hydraulic coefficients
Default light absorption/extinction coefficients
Testing sensitivity of temperature predictions to vertical resolution
2 m layer heights

```

GRID	NWB 1	NBR 1	IMX 32	KMX 36	NPROC 1	CLOSEC OFF			
IN/OUTFL	NTR 0	NST 1	NIW 0	NWD 0	NGT 0	NSP 0	NPI 0	NPU 0	
CONSTITU	NGC 3	NSS 1	NAL 1	NEP 1	NBOD 0	NMC 0	NZP 1		
MISCELL	NDAY 100	SELECTC OFF	HABTATC ON	ENVIRPC ON	AERATEC OFF	INITUWL OFF	ORGCC OFF	SEDDIAG OFF	
TIME CON	TMSTRT 64.5000	TMEND 358.700	YEAR 1980						
DLT CON	NDT 1	DLTMIN 1.00000	DLTINTR OFF						
DLT DATE	DLTD 64.50	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	
DLT MAX	DLTMAX 3600.00	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	
DLT FRN	DLTF 0.9	DLTF	DLTF	DLTF	DLTF	DLTF	DLTF	DLTF	
DLT LIMI	VISC WB 1	CEL ON	DLTADD OFF						
BRANCH G	US BR1 2	DS 31	UHS 0	DHS 0	NLMIN 2	SLOPE 0.00000	SLOPEC 0.000		
LOCATION	LAT WB 1 34.2000	LONG 93.3000	EBOT 66.3500	BS 1	BE 1	JBDN 1			
INIT CND	TEMPI WB 1 -1.0000	ICEI 0.00000	WTYPEC FRESH	GRIDC RECT					
CALCULAT	VBC WB 1 OFF	EBC OFF	MBC OFF	PQC ON	EVC OFF	PRC OFF			
DEAD SEA	WINDC WB 1 ON	QINC ON	QOUTC ON	HEATC ON					
INTERPOL	QINIC BR1 ON	DTRIC OFF	HDIC OFF						
HEAT EXCH	SLHTC WB 1 TERM	SROC OFF	RHEVAP OFF	METIC ON	FETCHC OFF	AFW 9.20000	BFW 0.46000	CFW 2.00000	WINDH 10.0000

INPUT FILES

ICE COVE	ICEC	SLICEC	ALBEDO	HWICE	BICE	GICE	ICEMIN	ICET2		
WB 1	OFF	DETAIL	0.25000	10.0000	0.60000	0.07000	0.05000	3.00000		
TRANSPOR	SLTRC	THETA								
WB 1	ULTIMATE	0.55000								
HYD COEF	AX	DX	CBHE	TSED	FI	TSEDF	FRICC	Z0		
WB 1	1.00000	1.00000	0.3	14.0000	0.00000	0.00000	CHEZY	0.001		
EDDY VISC	AZC	AZSLC	AZMAX	FBC	E	ARODI	STRCKLR	BOUNDFR	TKECAL	
WB 1	TKE	IMP	1.00000	3	9.535	0.430	24.0	10.0	IMP	
N STRUC	NSTR	DYNELEV								
BR1	1	OFF								
STR INT	STRIC	ON	STRIC	STRIC	STRIC	STRIC	STRIC	STRIC	STRIC	
BR1	KTSTR	2	KTSTR	KTSTR	KTSTR	KTSTR	KTSTR	KTSTR	KTSTR	
STR BOT	KBSTR	35	KBSTR	KBSTR	KBSTR	KBSTR	KBSTR	KBSTR	KBSTR	
STR SINK	SINKC	POINT	SINKC	SINKC	SINKC	SINKC	SINKC	SINKC	SINKC	
BR1	ESTR	115.000	ESTR	ESTR	ESTR	ESTR	ESTR	ESTR	ESTR	
STR WIDT	WSTR	0.00000	WSTR	WSTR	WSTR	WSTR	WSTR	WSTR	WSTR	
PIPES	IUPI	IDPI	EUPI	EDPI	WPI	DLXPI	FPI	FMINPI	WTHLC	
PIPE UP	PUPIC	ETUPI	EBUPI	KTUPI	KBUPI					
PIPE DOWN	PDPIC	ETDPI	EBDPI	KTDPI	KBDPI					
SPILLWAY	IUSP	IDSP	ESP	A1SP	B1SP	A2SP	B2SP	WTHLC		
SPILL UP	PUSPC	ETUSP	EBUSP	KTUSP	KBUSP					
SPILL DOWN	PDSPC	ETUSP	EBUSP	KTDSP	KBDSP					
SPILL GAS	GASSPC	EQSP	AGASSP	BGASSP	CGASSP					
GATES	IUGT	IDGT	EGT	A1GT	B1GT	G1GT	A2GT	B2GT	G2GT	WTHLC
GATE WEIR	GTA1	GTB1	GTA2	GTB2	DYNVAR	GTIC				
GATE UP	PUGTC	ETUGT	EBUGT	KTUGT	KBUGT					
GATE DOWN	PDGTC	ETDGT	EBDGT	KTDGT	KBDGT					
GATE GAS	GASGTC	EQGT	AGASGT	BGASGT	CGASGT					

INPUT FILES

PUMPS 1	IUPU	IDPU	EPU	STRTPU	ENDPU	EONPU	EOFFPU	QPU	WTHLC
PUMPS 2	PPUC	ETPU	EBPU	KTPU	KBPU				
WEIR SEG	IWR	IWR	IWR	IWR	IWR	IWR	IWR	IWR	IWR
WEIR TOP	KTWR	KTWR	KTWR	KTWR	KTWR	KTWR	KTWR	KTWR	KTWR
WEIR BOT	KBWR	KBWR	KBWR	KBWR	KBWR	KBWR	KBWR	KBWR	KBWR
WD INT	WDIC	WDIC	WDIC	WDIC	WDIC	WDIC	WDIC	WDIC	WDIC
WD SEG	IWD	IWD	IWD	IWD	IWD	IWD	IWD	IWD	IWD
WD ELEV	EWD	EWD	EWD	EWD	EWD	EWD	EWD	EWD	EWD
WD TOP	KTWD	KTWD	KTWD	KTWD	KTWD	KTWD	KTWD	KTWD	KTWD
WD BOT	KBWD	KBWD	KBWD	KBWD	KBWD	KBWD	KBWD	KBWD	KBWD
TRIB PLA	PTRC	PTRC	PTRC	PTRC	PTRC	PTRC	PTRC	PTRC	PTRC
TRIB INT	TRIC	TRIC	TRIC	TRIC	TRIC	TRIC	TRIC	TRIC	TRIC
TRIB SEG	ITR 0	ITR	ITR	ITR	ITR	ITR	ITR	ITR	ITR
TRIB TOP	ELTRT 0.00000	ELTRT	ELTRT	ELTRT	ELTRT	ELTRT	ELTRT	ELTRT	ELTRT
TRIB BOT	ELTRB 0.00000	ELTRB	ELTRB	ELTRB	ELTRB	ELTRB	ELTRB	ELTRB	ELTRB
DST TRIB BR 1	DTRC OFF	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC
HYD PRIN NVIOL	HPRWBC ON	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC
U	ON								
W	OFF								
T	ON								
RHO	OFF								
AZ	OFF								
SHEAR	OFF								
ST	OFF								
SB	OFF								
ADMX	OFF								
DM	OFF								
HDG	OFF								
ADMZ	OFF								
HPG	OFF								
GRAV	OFF								
SNP PRINT WB 1	SNPC ON	NSNP 21	NISNP 30						

INPUT FILES

SNP DATE	SNPD									
WB 1	64.5000	78.7000	92.7000	106.700	120.700	136.700	148.700	162.700	176.700	
	204.700	218.700	232.700	246.700	260.700	274.700	288.700	302.700	316.700	
	330.700	344.700	358.700							
SNP FREQ	SNPF									
WB 1	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
	100.000	100.000	100.000							
SNP SEG	ISNP									
WB 1	2	3	4	5	6	7	8	9	10	
	11	12	13	14	15	16	17	18	19	
	20	21	22	23	24	25	26	27	28	
	29	30	31							
SCR PRINT	SCRC	NSCR								
WB 1	ON	1								
SCR DATE	SCRD									
WB 1	64.5000									
SCR FREQ	SCRF									
WB 1	0.20000									
PRF PLOT	PRFC	NPRF	NIPRF							
WB 1	OFF	1	3							
PRF DATE	PRFD									
WB 1	64.7000									
PRF FREQ	PRFF									
WB 1	1.00000									
PRF SEG	IPRF									
WB 1	10	18	26							
SPR PLOT	SPRC	NSPR	NISPR							
WB 1	ON	1	1							
SPR DATE	SPRD									
WB 1	100.700									
SPR FREQ	SPRF									
WB 1	10.000									
SPR SEG	ISPR									
WB 1	26									
VPL PLOT	VPLC	NVPL								
WB 1	ON	1								
VPL DATE	VPLD									
WB 1	1.00									
VPL FREQ	VPLF									
WB 1	0.50									
CPL PLOT	CPLC	NCPL	TECPLOT							
WB 1	ON	1	ON							
CPL DATE	CPLD									
WB 1	64.7000									
CPL FREQ	CPLF									
WB 1	1.00000									

INPUT FILES

FLUXES WB 1	FLXC ON	NFLX 1							
FLX DATE WB 1	FLXD 1.00	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD
FLX FREQ WB 1	FLXF 60.0	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF
TSR PLOT	TSRC ON	NTSR 1	NITSR 1						
TSR DATE	TSRD 1.0	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD
TSR FREQ	TSRF 0.10	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF
TSR SEG	ITSR 31	ITSR	ITSR	ITSR	ITSR	ITSR	ITSR	ITSR	ITSR
TSR LAYE	ETSR 0.00000	ETSR	ETSR	ETSR	ETSR	ETSR	ETSR	ETSR	ETSR
WLOUT	WLC ON	WLFREQ 0.5							
FLOWBAL	FLOWBC ON	FBBREQ 7.0							
NPBAL	NPBALC	NPBFREQ ON 7.0							
WITH OUT	WDODC ON	NWDO 1	NIWDO 1						
WITH DAT	WDOD 1.00	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD
WITH FRE	WDOF 0.10	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF
WITH SEG	IWDO 31	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO
RESTART	RSOC OFF	NRSO 0	RSIC OFF						
RSO DATE	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD
RSO FREQ	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF
CST COMP	CCC ON	LIMC ON	CUF 3	CO2PPM 400.	CO2YRLY ON				
ATMDEP WB1	ATMDPC OFF	ATMDPIN ON							
CST ACTIVE	CAC								
TDS	ON								
Gen1	ON								
Gen2	ON								
Gen3	ON								
ISS1	ON								
WATERAGE	OFF								
BACTERIA	OFF								

INPUT FILES

DGP	OFF								
N2	OFF								
H2S	OFF								
CH4	OFF								
SO4	OFF								
FEII	OFF								
FEEOOH	OFF								
MNII	OFF								
MNO2	OFF								
PO4	ON								
NH4	ON								
NO3	ON								
DSI	OFF								
PSI	OFF								
FE	ON								
LDOM	ON								
RDOM	ON								
LPOM	ON								
RPOM	OFF								
ALG1	ON								
DO	ON								
TIC	ON								
ALK	ON								
ZOO1	OFF								
LDOM_P	OFF								
RDOM_P	OFF								
LPOM_P	OFF								
RPOM_P	OFF								
LDOM_N	OFF								
RDOM_N	OFF								
LPOM_N	OFF								
RPOM_N	OFF								
MICROCY	OFF								
CYLINDR	OFF								
ANATOXIN	OFF								
SAXITOZN	OFF								
CST DERI	CDWBC								
DOC	OFF								
POC	OFF								
TOC	ON								
DON	OFF								
PON	OFF								
TON	OFF								
TKN	OFF								
TN	ON								
NH3	ON								
DOP	OFF								
POP	OFF								
TOP	OFF								
TP	OFF								
APR	OFF								
CHLA	OFF								
ATOT	OFF								
%DO	OFF								
TDG	ON								
TURBIDITY	OFF								
TSS	OFF								
TISS	OFF								
CBOD	OFF								
pH	OFF								
CO2	OFF								
HCO3	OFF								
CO3	OFF								
SECCHI	OFF								
CST FLUX	CFWBC								
TISSIN	OFF								

INPUT FILES

TISSOUT	OFF
PO4AR	OFF
PO4AG	OFF
PO4AP	OFF
PO4ER	OFF
PO4EG	OFF
PO4EP	OFF
PO4POM	OFF
PO4DOM	OFF
PO4OM	OFF
PO4SED	OFF
PO4SOD	OFF
PO4SET	OFF
NH4NITR	OFF
NH4AR	OFF
NH4AG	OFF
NH4AP	OFF
NH4ER	OFF
NH4EG	OFF
NH4EP	OFF
NH4POM	OFF
NH4DOM	OFF
NH4OM	OFF
NH4SED	OFF
NH4SOD	OFF
NH3GAS	ON
NO3DEN	OFF
NO3AG	OFF
NO3EG	OFF
NO3SED	OFF
DSIAG	OFF
DSIEG	OFF
DSIPIS	OFF
DSISED	OFF
DSISOD	OFF
DSISET	OFF
PSIAM	OFF
PSINET	OFF
PSIDK	OFF
LDOMDK	OFF
LRDOM	OFF
RDOMDK	OFF
LDOMAP	OFF
LDOME ^P	OFF
LPOMDK	OFF
LRPOM	OFF
RPOMDK	OFF
LPOMAP	OFF
LPOME ^P	OFF
LPOMSET	OFF
RPOMSET	OFF
CBODDK	OFF
DOAP	OFF
DOEP	OFF
DOAR	OFF
DOER	OFF
DOPOM	OFF
DODOM	OFF
DOOM	OFF
DONITR	OFF
DOCBD	OFF
DOREAR	ON
DOSED	ON
DOSOD	OFF
TICAG	OFF
TICEG	OFF
SEDDK	OFF
SEDAS	OFF

INPUT FILES

SEDLPOM	OFF								
SEDSET	OFF								
SODDK	OFF								
CST	ICON	C2IW _B							
TDS		51.0000							
Gen1		100.000							
Gen2		0.00000							
Gen3		10.0000							
ISS1		2.00000							
WATERAGE		0.0							
BACTERIA		0.0							
DGP		0.0							
N2		0.0							
H2S		0.0							
CH4		0.0							
SO4		0.0							
FEII		0.0							
FEOOH		0.0							
MNII		0.0							
MNO2		0.0							
PO4		0.00100							
NH4		0.00200							
NO3		0.14000							
DSI		0.00000							
PSI		0.00000							
LDOM		0.70000							
RDOM		2.02200							
LPOM		0.10000							
RPOM		0.00000							
ALG1		-1.0000							
DO		-1.0000							
TIC		11.9100							
ALK		31.0000							
ZOO1		0.1000							
LDOM_P		0.0005							
RDOM_P		0.0005							
LPOM_P		0.0005							
RPOM_P		0.0005							
LDOM_N		0.0080							
RDOM_N		0.0080							
LPOM_N		0.0080							
RPOM_N		0.0080							
MICROCY		0.0							
CYLINDR		0.0							
ANATOXIN		0.0							
SAXITOZN		0.0							
CST	PRIN	CPRWBC							
TDS		ON							
Gen1		ON							
Gen2		OFF							
Gen3		OFF							
ISS1		ON							
WATERAGE		OFF							
BACTERIA		OFF							
DGP		OFF							
N2		OFF							
H2S		OFF							
CH4		OFF							
SO4		OFF							
FEII		OFF							
FEOOH		OFF							
MNII		OFF							
MNO2		OFF							
PO4		ON							
NH4		ON							
NO3		ON							

INPUT FILES

DSI	OFF										
PSI	OFF										
LDOM	ON										
RDOM	ON										
LPOM	ON										
RPOM	OFF										
ALG1	ON										
DO	ON										
TIC	OFF										
ALK	OFF										
ZOO1	OFF										
LDOM_P	OFF										
RDOM_P	OFF										
LPOM_P	OFF										
RPOM_P	OFF										
LDOM_N	OFF										
RDOM_N	OFF										
LPOM_N	OFF										
RPOM_N	OFF										
MICROCY	OFF										
CYLINDR	OFF										
ANATOXIN	OFF										
SAXITOZN	OFF										
CIN CON	CINBRC										
TDS	ON										
Gen1	ON										
Gen2	OFF										
Gen3	ON										
ISS1	ON										
WATERAGE	OFF										
BACTERIA	OFF										
DGP	OFF										
N2	OFF										
H2S	OFF										
CH4	OFF										
SO4	OFF										
FEII	OFF										
FEOOH	OFF										
MNII	OFF										
MNO2	OFF										
PO4	ON										
NH4	ON										
NO3	ON										
DSI	OFF										
PSI	OFF										
LDOM	ON										
RDOM	ON										
LPOM	ON										
RPOM	OFF										
ALG1	ON										
DO	ON										
TIC	ON										
ALK	ON										
ZOO1	OFF										
LDOM_P	OFF										
RDOM_P	OFF										
LPOM_P	OFF										
RPOM_P	OFF										
LDOM_N	OFF										
RDOM_N	OFF										
LPOM_N	OFF										
RPOM_N	OFF										
MICROCY	OFF										
CYLINDR	OFF										
ANATOXIN	OFF										
SAXITOZN	OFF										

INPUT FILES

CTR CON	CTRTRC									
TDS	ON	OFF								
Gen1	ON	OFF								
Gen2	OFF	OFF								
Gen3	ON	OFF								
ISS1	ON	OFF								
WATERAGE	OFF	OFF								
BACTERIA	OFF	OFF								
DGP	OFF	OFF								
N2	OFF	OFF								
H2S	OFF	OFF								
CH4	OFF	OFF								
SO4	OFF	OFF								
FEII	OFF	OFF								
FEOOH	OFF	OFF								
MNII	OFF	OFF								
MNO2	OFF	OFF								
PO4	ON	OFF								
NH4	ON	OFF								
NO3	ON	OFF								
DSI	OFF	OFF								
PSI	OFF	OFF								
LDOM	ON	OFF								
RDOM	ON	OFF								
LPOM	ON	OFF								
RPOM	OFF	OFF								
ALG1	ON	OFF								
DO	ON	OFF								
TIC	ON	OFF								
ALK	ON	OFF								
ZOO1	OFF	OFF								
LDOM_P	OFF	OFF								
RDOM_P	OFF	OFF								
LPOM_P	OFF	OFF								
RPOM_P	OFF	OFF								
LDOM_N	OFF	OFF								
RDOM_N	OFF	OFF								
LPOM_N	OFF	OFF								
RPOM_N	OFF	OFF								
MICROCY	OFF	OFF								
CYLINDR	OFF	OFF								
ANATOXIN	OFF	OFF								
SAXITOZN	OFF	OFF								

CDT CON	CDTBRC									
TDS	ON	OFF								
Gen1	ON	OFF								
Gen2	OFF	OFF								
Gen3	ON	OFF								
ISS1	ON	OFF								
WATERAGE	OFF	OFF								
BACTERIA	OFF	OFF								
DGP	OFF	OFF								
N2	OFF	OFF								
H2S	OFF	OFF								
CH4	OFF	OFF								
SO4	OFF	OFF								
FEII	OFF	OFF								
FEOOH	OFF	OFF								
MNII	OFF	OFF								
MNO2	OFF	OFF								
PO4	ON	OFF								
NH4	ON	OFF								
NO3	ON	OFF								
DSI	OFF	OFF								
PSI	OFF	OFF								
LDOM	ON	OFF								
RDOM	ON	OFF								

INPUT FILES

LPOM	ON	OFF							
RPOM	OFF	OFF							
ALG1	ON	OFF							
DO	ON	OFF							
TIC	ON	OFF							
ALK	ON	OFF							
ZOO1	OFF	OFF							
LDOM_P	OFF	OFF							
RDOM_P	OFF	OFF							
LPOM_P	OFF	OFF							
RPOM_P	OFF	OFF							
LDOM_N	OFF	OFF							
RDOM_N	OFF	OFF							
LPOM_N	OFF	OFF							
RPOM_N	OFF	OFF							
MICROCY	OFF	OFF							
CYLINDR	OFF	OFF							
ANATOXIN	OFF	OFF							
SAXITOZN	OFF	OFF							
CPR CON	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC
TDS	ON	ON							
Gen1	ON	OFF							
Gen2	OFF	OFF							
Gen3	ON	OFF							
ISS1	ON	OFF							
WATERAGE	OFF	OFF							
BACTERIA	OFF	OFF							
DGP	OFF	OFF							
N2	OFF	OFF							
H2S	OFF	OFF							
CH4	OFF	OFF							
SO4	OFF	OFF							
FEII	OFF	OFF							
FEOOH	OFF	OFF							
MNII	OFF	OFF							
MNO2	OFF	OFF							
PO4	ON	OFF							
NH4	ON	OFF							
NO3	ON	OFF							
DSI	OFF	OFF							
PSI	OFF	OFF							
LDOM	ON	OFF							
RDOM	ON	OFF							
LPOM	ON	OFF							
RPOM	OFF	OFF							
ALG1	ON	OFF							
DO	ON	OFF							
TIC	ON	OFF							
ALK	ON	OFF							
ZOO1	OFF	OFF							
LDOM_P	OFF	OFF							
RDOM_P	OFF	OFF							
LPOM_P	OFF	OFF							
RPOM_P	OFF	OFF							
LDOM_N	OFF	OFF							
RDOM_N	OFF	OFF							
LPOM_N	OFF	OFF							
RPOM_N	OFF	OFF							
MICROCY	OFF	OFF							
CYLINDR	OFF	OFF							
ANATOXIN	OFF	OFF							
SAXITOZN	OFF	OFF							
EX COEF	EXH2O	EXSS	EXOM	BETA	EXC	EXIC			
WB 1	0.45000	0.01000	0.20000	0.45000	OFF	OFF			
ALG EX	EXA	EXA	EXA	EXA	EXA	EXA			

INPUT FILES

```

0.20000

ZOO EX      EXZ      EXZ      EXZ      EXZ      EXZ      EXZ
          0.2      0.2      0.2

MACRO EX    EXM      EXM      EXM      EXM      EXM      EXM
          0.0100

GENERIC    CGQ10    CG0DK    CG1DK    CGS      CGLDK    CGKLF    CGCS     CGR
CG 1       0.00000  0.00000  0.00000  0.00000  0.0       0.0       0.0      0.0
CG 2       0.00000 -1.0000  0.00000  0.00000  0.0       0.0       0.0      0.0
CG 3       1.04000  0.00000  1.40000  0.00000  0.0       0.0       0.0      0.0

S SOLIDS   SSS      SEDRC    TAUCR    SSCS
SS# 1      1.00000  OFF      0.00000  0.0

BACTERIA  BACTQ10 BACT1DK  BACTS    BACTLDK
WB1        1.025    0.100    0.00     0.050

H2S         H2SR     H2SQ10   H2S1DK   SO4R
WB1        0.005    1.04     0.10     0.050

CH4         CH4R     CH4Q10   CH41DK
WB1        0.004    1.0400   0.05

FE          FEIIR    KFEOXID  KFERED   HalfSat  SetVel
WB1        0.004    1.0400   0.05     0.10     0.10

MN          MNIIIR   KMNOXID  KMNRED   HalfSat  SetVel
WB1        0.004    1.0400   0.05     0.10     0.10

ALGAL RATE  AG       AR       AE       AM       AS       AHSP     AHSN     AHSSI    ASAT
ALG1       2.00000  0.04000  0.04000  0.10000  0.10000  0.00300  0.01400  0.00000  100.000

ALGAL TEMP  AT1      AT2      AT3      AT4      AK1      AK2      AK3      AK4
ALG1       5.00000  30.0000  35.0000  40.0000  0.10000  0.99000  0.99000  0.10000

ALG STOI    ALGP     ALGN     ALGC     ALGSI    ACHILA   ALPOM    ANEQN    ANPR     AVERTM
ALG1       0.00500  0.08000  0.45000  0.00000  0.06500  0.80000  1 0.00100  OFF

EPIPHYTE   EPIC     EPIC     EPIC     EPIC     EPIC     EPIC     EPIC     EPIC     EPIC
EPI1        OFF

EPI PRIN    EPRC     EPRC     EPRC     EPRC     EPRC     EPRC     EPRC     EPRC     EPRC
EPI1        OFF

EPI INIT    EPICI    EPICI    EPICI    EPICI    EPICI    EPICI    EPICI    EPICI    EPICI
EPI1       20.0000

EPI RATE    EG       ER       EE       EM       EB       EHSP     EHSN     EHSSI
EPI1       1.50000  0.05000  0.02000  0.10000  0.00001  0.00200  0.00200  0.00000

EPI HALF    ESAT     EHS      ENEQN    ENPR
EPI1       150.000  15.0000  2 0.00100

EPI TEMP    ET1      ET2      ET3      ET4      EK1      EK2      EK3      EK4
EPI1       1.00000  3.00000  20.0000  30.0000  0.10000  0.99000  0.99000  0.10000

EPI STOI    EP       EN       EC       ESI      ECHILA   EPOM
EPI1       0.00500  0.08000  0.45000  0.00000  0.06500  0.80000

ZOOP RATE   ZG       ZR       ZM       ZEFF    PREFP    ZOOMIN   ZS2P     ZS
Zoo1       1.50     0.10     0.010   0.50     0.50     0.0100  0.30     0.0

ZOOP ALGP   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA
Zoo1       1.00     0.50     0.50

ZOOP ZOOP   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ

```

INPUT FILES

```

Zoo1      0.00    0.00    0.00

ZOOP TEMP   ZT1      ZT2      ZT3      ZT4      ZK1      ZK2      ZK3      ZK4
                  0.0     15.0     20.0     36.0     0.1      0.9     0.98     0.100

ZOOP STOI   ZP       ZN       ZC
                  0.01500  0.08000  0.45000

MACROPHYT MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC
Mac1        OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF

MAC PRINT  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC
Mac1        OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF

MACINI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI
Mac1        0.00000  0.1      0.5

MAC RATE   MG       MR       MM       MSAT     MHSP     MHSN     MHSC     MPOM     LRPMAC
Mac 1      0.30     0.05     0.05     30.0     0.0      0.0      0.0      0.9      0.2

MAC SED    PSED    NSED
Mac 1      0.5      0.5

MAC DIST   MBMP    MMAX
Mac 1      40.0     500.0

MAC DRAG   CDDRAG  DWV      DWSA     ANORM
Mac 1      3.0      7.0E+04  8.0      0.3

MAC TEMP   MT1      MT2      MT3      MT4      MK1      MK2      MK3      MK4
Mac 1      7.0      15.0     24.0     34.0     0.1      0.99     0.99     0.01

MAC STOICH MP       MN       MC
Mac 1      0.005    0.08     0.45

DOM       LDOMDK  RDOMDK  LRDCK
WB 1      0.30000  0.00100  0.01000

POM       LPOMDK  RPOMDK  LRPDK   POMS
WB 1      0.08000  0.01000  0.00100  0.50000

OM STOIC  ORGP     ORGN     ORGC     ORGSI    ATURB    BTURB    SECCHI
WB 1      0.00500  0.08000  0.45000  0.18000  0.00      0.00     1.20

OM RATE   OMT1     OMT2     OMK1     OMK2
WB 1      4.00000  30.0000  0.10000  0.99000

TURBSEC  COEFFA  COEFFB  SECCHI
WB1       1.10     0.05     1.5

CBOD      KBOD     TBOD     RBOD     CBODS
BOD 1     0.25000  1.01500  1.85000  0.0

CBOD STOIC BODP     BODN     BODC
BOD 1     0.00500  0.08000  0.45000

PHOSPHOR PO4R     PARTP
WB 1      0.01500  1.20000

AMMONIUM NH4R     NH4DK   KGH2O
WB 1      0.15000  0.05000  168.

NH4 RATE  NH4T1    NH4T2    NH4K1    NH4K2
WB 1      5.00000  25.0000  0.10000  0.99000

NITRATE  NO3DK    NO3S    FNO3SED
WB 1      0.05000  0.00000  0.37

```

INPUT FILES

```
NO3 RATE    NO3T1    NO3T2    NO3K1    NO3K2
WB 1        5.00000  25.0000  0.10000  0.99000

SILICA      DSIR     PSIS     PSIDK    PARTSI
WB 1        0.10000  0.10000  0.30000  0.20000

SED CO2      CO2R
WB 1        0.10000

STOICH 1    O2NH4    O2OM
WB 1        4.57000 1.40000

STOICH 2    O2AR     O2AG
ALG1       1.10000 1.40000

STOICH 3    O2ER     O2EG
EPI1       1.10000 1.40000

STOICH 4    O2ZR
ZOO1       1.10000

STOICH 5    O2MR     O2MG
MAC1        1.1      1.4

O2 LIMIT    O2LIM
              0.01000

SEDIMENT     SEDC     SEDPRC   SEDCI    SEDK    SEDS    FSOD    FSED    SEDB    DYNSEDK
WB 1          OFF      ON       0.00000  0.08000  0.1     1.00000 1.00000  0.0     OFF

SOD RATE    SODT1    SODT2    SODK1    SODK2
WB 1        4.00000 30.0000  0.10000  0.99000

S DEMAND     SOD      SOD      SOD      SOD      SOD      SOD      SOD      SOD
              0.30000 0.30000 0.30000 0.30000 0.30000 0.40000 0.50000 0.50000 0.50000
              0.70000 0.90000 1.10000 1.30000 1.50000 1.70000 1.90000 1.90000 1.90000
              1.70000 1.50000 1.40000 1.30000 1.20000 1.10000 1.00000 0.90000 0.80000
              0.60000 0.60000 0.50000 0.50000 0.50000

REAERATION   TYPE     EQN#     COEF1    COEF2    COEF3    COEF4    COEF5
WB 1          LAKE     2        0.00000 0.00000 0.00000 0.00000 0.00000

RSI FILE.....RSIFN.....rsi.npt - not used

QWD FILE.....QWDFN.....qwd.npt - not used

QGT FILE.....QGTFN.....qgt.npt - not used

WSC FILE.....WSCFN.....wsc.npt

SHD FILE.....SHDFN.....shade.npt

BTH FILE.....BTHFN.....bth.npt

MET FILE.....METFN.....met.npt

EXT FILE.....EXTFN.....ext_1.npt

ATD FILE.....ATDFN.....atm_dep_wb1.csv
```

INPUT FILES

VPR FILE.....VPRFN.....
WB 1 vpr.npt

LPR FILE.....LPRFN.....
WB 1 lpr.npt

QIN FILE.....QINFN.....
BR1 qin_br1.npt

TIN FILE.....TINFN.....
BR1 tin_br1.npt

CIN FILE.....CINFN.....
BR1 cin_br1.npt

QOT FILE.....QOTFN.....
BR1 qot_br1.npt

QTR FILE.....QTRFN.....
TR1 qtr_tr1.npt

TTR FILE.....TTRFN.....
TR1 ttr_tr1.npt

CTR FILE.....CTRFN.....
TR1 ctr_tr1.npt

QDT FILE.....QDTFN.....
BR1 qin_br1.npt

TDT FILE.....TDTFN.....
BR1 tdt_br1.npt

CDT FILE.....CDTFN.....
BR1 cdt_br1.npt - not used

PRE FILE.....PREFN.....
BR1 pre_br1.npt - not used

TPR FILE.....TPRFN.....
BR1 tpr_br1.npt - not used

CPR FILE.....CPRFN.....
BR1 cpr_br1.npt - not used

EUH FILE.....EUHFN.....
BR1 euh_br1.npt - not used

TUH FILE.....TUHFN.....
BR1 tuh_br1.npt - not used

CUH FILE.....CUHFN.....
BR1 cuh_br1.npt - not used

EDH FILE.....EDHFN.....
BR1 edh_br1.npt - not used

TDH FILE.....TDHFN.....
BR1 tdh_br1.npt - not used

CDH FILE.....CDHFN.....
BR1 cdh_br1.npt - not used

TSR FILE.....TSRFN.....
tsr.csv

WDO FILE.....WDOFN.....

INPUT FILES

wdo . csv

A	B	C	D	E	F	G	H	I	J
1 Note COL A and B are not written out to w2_con.csv		CE-QUAL-W2 Version	4.5						
2		Control File version	4.5	w2_con.csv					
3 Fixed length of file except when more than 5 algae, 5 zooplankton,		Title comments: next 10 lines							
4 5 macrophytes, 5 structures, 5 periphyton groups.		"Degray Reservoir - March 4 through December 27, 1980"							
5 The # of rows though changes with the # of active water quality constituents.		"Degray Reservoir - March 4 through December 27, 1980"							
6 Do not change the file tab name for this sheet since the output file name is tied to the name of the tab		"Density placed inflow point sink outflow"							
7 NWB: number of water bodies		"Default hydraulic coefficients"							
8 NBR: number of branches		"Default light absorption/extinction coefficients"							
9 IMX: maximum number of segments including inactive segments		"Testing sensitivity of temperature predictions to vertical resolution"							
10 KMX: maximum number of vertical layers including inactive layers (top and bottom)		"2 m layer height"							
11 NPROC: # of processors (INACTIVE at this time)		"Atmospheric Deposition Feature"							
12 CLOSEC: close dialog box after executing if -ON		""							
13 NTR: number of tributaries		"**"							
14 NST: maximum # of structures in a branch									
15 NIW: # of internal weirs									
16 NWD: # of withdrawals									
17 NGT: # of gates									
18 NSP: # of spillways									
19 NPI: # of pipes									
20 NPU: # of pumps or water level control rules									
21 NGC: # of general water quality constituents									
22 Do not change the field names in Column A - they are checked by the program									
23 NDAY: maximum number of outlets for a timestep interval change									
24 SELECTC: turn ON/OFF USGS automatic port selection from a multiple outlet structure									
25 HABITATC: turn ON/OFF habitat analysis for fish and eutrophication variables									
26 ENVIRPC: turn ON/OFF environmental performance criteria									
27 AERATEC: turn ON/OFF aeration to waterbody with dissolved oxygen probe control									
28 INITWUL: turn ON/OFF initial water surface slope and velocity calculation for a river									
29 ORGCC: simulate organic matter as C rather than organic matter									
30 Fill in these with real dates and the Julian dates will be filled in automatically									
31 DLT CON	DLT CON	NDLT	DLTMIN	DLTINTER					
32 3/4/1980 12:00		1	1	OFF					
33 TMEND	DLT DATE	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD	DLTD
34 12/23/1980 16:48	Date of time step change in JDAY	64.5							
35 64.500									
36 358.700	DLT MAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX
37 Year		600							
38 1980									
39 Go to Index of Sheets:	DLT FRN	DLTF	DLTF	DLTF	DLTF	DLTF	DLTF	DLTF	DLTF
40 Index of Sheets:A1		0.9							
41									
42	DLT LIMIT	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
43	VISC - Viscosity time step limitation ON or OFF	ON							
44	CELC - Wave colority time step limitation ON or OFF	ON							
45 This is a new stability check in case water level rises or falls too quickly. It	DLTADD - additional stability check to lower time step ON or OFF	OFF							
46									
47	BRANCH GRID	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8
48	US - upstream segment number of branch	2							
49	DS - downstream segment number of branch	31							
50	UHS - upstream boundary condition	0							
51	DHS - downstream boundary condition	0							
52	NLNM: # of layers	1							
53	SLOPE - actual slope	0							
54	SLOPEC - hydraulic equivalent slope (less than or equal to SLOPE)	0							
55									
56	LOCATION	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
57	IAT, Latitude N	34.2							
58	LONG, Longitude W	93.3							
59	EBOT elevation of bottom of waterbody, m	66.35							
60	BS starting branch of waterbody	1							
61	BE ending branch of waterbody	1							
62	IBDN downstream branch of waterbody	1							
63									
64	INIT CND	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
65	T2I - initial temperature oC	-1							
66	ICEI - initial ice thickness, m	0							

INPUT FILES

A	B	C	D	E	F	G	H	I	J
		WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
64 INIT CND									
65 T2I - initial temperature oC		WB1	WB2						
66 ICEI - initial ice thickness, m		WB1	WB2						
67 WTYPEC - waterbody type FRESH or SALT		WB1	WB2						
68 GRIDC - grid ICE1 or ITRAP (not used at present)		WB1	WB2						
69									
70 CALCULATION		WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
71 VBC - volume balance computation	ON								
72 EBC - energy balance computation	OFF								
73 MBC - mass balance computation	ON								
74 PDE - Turn ON or OFF placement of inflows by density	ON								
75 FVC - Turn ON or OFF evaporation water loss	OFF								
76 PRC - Turn ON or OFF precipitation on water surface	OFF								
77									
78 DEAD SEA - only for code testing	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
79 WINUC-turns ON or OFF all wind	ON								
80 QINC-turns ON or OFF all inflows	ON								
81 QOUTC-turns ON or OFF all outflows	ON								
82 HEATC-turns ON or OFF all surface heat transfer	ON								
83									
84 INTERPOLATION	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
85 QINIC-interpolate inflows	ON								
86 DTINC-interpolate distributed tributary inflows	OFF								
87 HDIC-interpolate elevations for head boundary condition	OFF								
88									
89 HEAT EXCHANGE	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
90 M-SHCT - Heat computations - Equilibrium (ET) or Term-by-term (TERM)	TERM								
91 SRBC - Read in short wave solar radiation ON or OFF	OFF								
92 RHLVAP - Use Ryan-Harleman Lvap Model - for cooling ponds ON or OFF	OFF								
93 MI IK - Interpolate meteorological data ON or OFF	ON								
94 ETCHC - Heitz Stefan Lake fetch correction - there is already an internal fetch off									
95 ATW - Evaporation coefficient	9.2								
96 BEW - Evaporation coefficient	0.46								
97 CTW - Evaporation coefficient	3								
98 WINDH - Wind height measurement above ground surface, m	10								
99									
100 ICE COVER ALGORITHM	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
101 ICEC - Turn ICE cover algorithm ON/OFF	OFF								
102 SLICEC - Use DETAIL for all layers vs SIMPLE	DETAIL								
103 ALBEDO - Radiation coefficient for reflection of ice	0.25								
104 HAWKE - Coefficient of water ice heat exchange, W/m ² /oC	20								
105 BCLC-fraction of solar radiation absorbed in the ice surface	0.6								
106 GICL - Solar radiation extinction coefficient, m ⁻¹	0.07								
107 ICTMIN Minimum ice thickness before ice formation is allowed, m	0.05								
108 ICTT - Temperature above which ice formation is not allowed, oC	3								
109									
110 TRANSPORT SCHEME	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
111 SETC - UPWIND, CRICEST, ULTIMATE - use ULTIMATE	ULTIMATE								
112 THETA - degree of implicitness - use 0.55 - Time-weighting for vertical advection	0.55								
113									
114 HYD COEFFICIENTS	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
115 AX - Longitudinal eddy viscosity, m ² /s	1								
116 UX - Longitudinal eddy diffusivity/conductivity, m ² /s	1								
117 CBHE - Coefficient of bottom heat exchange, W/m ² oC ⁻¹	0.3								
118 TULL - Topographic parameter, t, average year round air temperature	10								
119 DI - Interfacial friction factor	0								
120 TSDF - Sediment temperature coefficient (0.1) heat lost to sediments that is ad	0								
121 FRBC - Bottom friction factor type: CHF7 or MANN	CHF7								
122 70 - water surface roughness height, m, for wind shear	0.001								
123									
124 EDDY VISCOSITY	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
125 AZC - Form of vertical turbulence closure algorithm, NICK, PARAB, RNG, W2, W21TRX									
126 AZSC - Specifies either implicit, IM, or explicit, EXP, treat-ment of the vertical c	IM								
127 AZMAX - Maximum value of eddy viscosity m ² /s	1								
128 HBC - Only active if AZC=IKL1; Choice of boundary condition - 1 Celik Hodl 1988,	3								
129									
130 STRUCTURES for each branch, These are known outflows at the end of a branch WB1	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	
131 NOTE - Number of structures per branch	1								
132 Usually the centerline elevation is fixed and specified with ESTR. If this is not the case, then the centerline elevation is fixed and specified with ESTR. If this is not the case, then the centerline elevation is fixed and specified with ESTR.	OFF								
133 The model will read a separate file for each branch called dymolek.knt with the same name as the branch	ON								
134 STIR1 - Turns ON/OFF interpolation of structure outflows for structure 1	ON								
135 STIR2 - Turns ON/OFF interpolation of structure outflows for structure 2	ON								
136 STIR3 - Turns ON/OFF interpolation of structure outflows for structure 3	ON								
137 STIR4 - Turns ON/OFF interpolation of structure outflows for structure 4	ON								
138 STIR5 - Turns ON/OFF interpolation of structure outflows for structure 5	ON								
139 KTS1 - Top layer above which selective withdrawal will not occur for structure 1	7								
140 KTS2 - Top layer above which selective withdrawal will not occur for structure 2	7								
141 KTS3 - Top layer above which selective withdrawal will not occur for structure 3	7								
142 KTS4 - Top layer above which selective withdrawal will not occur for structure 4	7								
143 KTS5 - Top layer above which selective withdrawal will not occur for structure 5	7								
144 KTS6 - Top layer above which selective withdrawal will not occur for structure 6	7								
145 KTS7 - Top layer above which selective withdrawal will not occur for structure 7	7								
146 KTS8 - Top layer above which selective withdrawal will not occur for structure 8	7								
147 KTS9 - Top layer above which selective withdrawal will not occur for structure 9	7								
148 KTS10 - Top layer above which selective withdrawal will not occur for structure 10	7								
149 KTS11 - Top layer above which selective withdrawal will not occur for structure 11	35								
150 KTS12 - Top layer above which selective withdrawal will not occur for structure 12	35								
151 KTS13 - Top layer above which selective withdrawal will not occur for structure 13	35								
152 KTS14 - Top layer above which selective withdrawal will not occur for structure 14	35								
153 KTS15 - Top layer above which selective withdrawal will not occur for structure 15	35								
154 KTS16 - Top layer above which selective withdrawal will not occur for structure 16	35								
155 KTS17 - Top layer above which selective withdrawal will not occur for structure 17	35								
156 KTS18 - Top layer above which selective withdrawal will not occur for structure 18	35								
157 KTS19 - Top layer above which selective withdrawal will not occur for structure 19	35								
158 KTS20 - Top layer above which selective withdrawal will not occur for structure 20	35								
159 KTS21 - Top layer above which selective withdrawal will not occur for structure 21	35								
160 KTS22 - Top layer above which selective withdrawal will not occur for structure 22	35								
161 KTS23 - Top layer above which selective withdrawal will not occur for structure 23	35								
162 KTS24 - Top layer above which selective withdrawal will not occur for structure 24	35								
163 KTS25 - Top layer above which selective withdrawal will not occur for structure 25	35								
164 KTS26 - Top layer above which selective withdrawal will not occur for structure 26	35								
165 KTS27 - Top layer above which selective withdrawal will not occur for structure 27	35								
166 KTS28 - Top layer above which selective withdrawal will not occur for structure 28	35								
167 KTS29 - Top layer above which selective withdrawal will not occur for structure 29	35								
168 KTS30 - Top layer above which selective withdrawal will not occur for structure 30	35								
169 KTS31 - Top layer above which selective withdrawal will not occur for structure 31	35								
170 KTS32 - Top layer above which selective withdrawal will not occur for structure 32	35								
171 KTS33 - Top layer above which selective withdrawal will not occur for structure 33	35								
172 KTS34 - Top layer above which selective withdrawal will not occur for structure 34	35								
173 KTS35 - Top layer above which selective withdrawal will not occur for structure 35	35								
174 KTS36 - Top layer above which selective withdrawal will not occur for structure 36	35								
175 KTS37 - Top layer above which selective withdrawal will not occur for structure 37	35								
176 KTS38 - Top layer above which selective withdrawal will not occur for structure 38	35								
177 KTS39 - Top layer above which selective withdrawal will not occur for structure 39	35								
178 KTS40 - Top layer above which selective withdrawal will not occur for structure 40	35								
179 KTS41 - Top layer above which selective withdrawal will not occur for structure 41	35								
180 KTS42 - Top layer above which selective withdrawal will not occur for structure 42	35								
181 KTS43 - Top layer above which selective withdrawal will not occur for structure 43	35								
182 KTS44 - Top layer above which selective withdrawal will not occur for structure 44	35								
183 KTS45 - Top layer above which selective withdrawal will not occur for structure 45	35								
184 KTS46 - Top layer above which selective withdrawal will not occur for structure 46	35								
185 KTS47 - Top layer above which selective withdrawal will not occur for structure 47	35								
186 KTS48 - Top layer above which selective withdrawal will not occur for structure 48	35								
187 KTS49 - Top layer above which selective withdrawal will not occur for structure 49	35								
188 KTS50 - Top layer above which selective withdrawal will not occur for structure 50	35								
189 PIPE1 - Upstream segment number	PIPE1	PIPE2	PIPE3	PIPE4	PIPES	PIPE6	PIPE7	PIPE8	
190 ID1 - Downstream segment number									
191 EUP1 - Elevation upstream invert, m									
192 ED1 - Elevation downstream invert, m									
193 WP1 - Pipe diameter, m									
194 DXP1 - Pipe length, m									
195 PIP1 - Friction factor (Manning)									
196 MM1 - Manning's roughness factor (Manning)									
197 WTH1 - DOWN or IAT, withdrawal control for at end of segment or middle									
198 DYNPIPE - Dynamic pipe read input file, ON or OFF									
199 PUP1 - PipeUp inflow, DSTR, SPECIFY, DENSITY									
200 E1UP1 - PipeUp Elevation top in m if SPECIFY									
201 K1UP1 - PipeUp Selective withdrawal top layer, Top layer above which selective withdrawal will not occur									
202 K1UP2 - PipeUp Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur									
203 PUP1C - PipeDown inflow, DSTR, SPECIFY, DENSITY									
204 E1DP1 - PipeDown Elevation top in m if SPECIFY									
205 L1DP1 - PipeDown Elevation bottom in m if SPECIFY									
206 K1DP1 - PipeDown Selective withdrawal top layer, Top layer above which selective withdrawal will not occur									
207 K1DP2 - PipeDown Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur									
208 w2.con.csv	w2.con.csv	Required Constituent Order	w2.habitat.npt	w2.aerote.npt	w2.envirp.npt	w2.selective.npt	w2.constric ...		

INPUT FILES

A	B	C	D	E	F	G	H	I	J	
184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311	KHUP - PipeUp Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur PPDIP - PipeDown inflow, DISTR, SPECIFY, DENSITY ETDP - PipeDown Elevation top in m of SPECIFY ELUP - PipeDown elevation bottom in m of SPECIFY KTDW - PipeDown Selective withdrawal top layer, Top layer above which selective withdrawal will not occur KBDW - PipeDown Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur SPILLWAYS IUSP - Upstream segment number, spillway segment location IDSP - Downstream segment number, downstream segment spillway outflow enters ESP - Elevation elevation AISP- α_1 empirical coefficient for free-flowing conditions BISP- β_1 empirical coefficient for free flowing conditions AISP- α_2 empirical coefficient for submerged conditions BISP- β_2 empirical coefficient for submerged conditions (AISP-Downstream or lateral withdrawal, DOWN or LAT) PUSP - How inflows enter into the upstream spillway segment, DISTR, DENSITY, or SPECIFY TUSP - How inflows enter into the upstream spillway segment, DISTR, DENSITY, or SPECIFY EISU - Bottom elevation spillway inflows entering SPECIFY option, m KUSP - Top layer above which selective withdrawal will not occur KUSP-Spillway Up Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur PDSU - How inflows enter into the downstream spillway segment, DISTR, DENSITY, or SPECIFY ETUSP - Top elevation spillway inflows enter using SPECIFY option m EBSU - Bottom elevation spillway inflows enter using SPECIFY option, m KDSU - Top layer above which selective withdrawal will not occur KDSU-Spillway Down Selective withdrawal bottom layer below which selective withdrawal will not occur GASSPC - Dissolved gas computations ON or OFF EGAS - Equation number for computing dissolved gas AGASSP - empirical coefficient BGASSP - empirical coefficient CGASSP - empirical coefficient GATES IGT - Upstream segment number IDGT - Downstream segment number EGT - Gate elevation m AIG1 - α_1 coefficient in gate equation for free flowing conditions BIG1 - β_1 coefficient in gate equation for free flowing conditions AIG2 - α_2 coefficient in gate equation for submerged conditions BIG2 - β_2 coefficient in gate equation for submerged conditions GZGT - gamma γ_2 coefficient for submerged conditions (ATGTC downstream or lateral withdrawal LAT or DOWN) GTA1 - α_1 in gate equation for free flowing conditions as a spillway GTL1 - β_1 in gate equation for free flowing conditions as a spillway GTL2 - β_2 in gate equation for submerged conditions as a spillway GTR2 - β_2 in gate equation for submerged conditions as a spillway DYNATC - Either '3', '2GT', or 'FLOW' GTK - EITHER ON or OFF interlock gate PIUG - Specifies how inflows enter the upstream gate segment, DISTR, DENSITY ETUGT - Top elevation gate inflows enter using the SPECIFY option, m EBUGT - Bottom elevation gate inflows using the SPECIFY option, m KUG1 - Top layer above which selective withdrawal will not occur KUG1-Selections withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur PUDG - Specifies how inflows enter the downstream gate segment, DISTR, DENSITY ETDGT - Top elevation gate inflows enter using the SPECIFY option, m EBDG - Bottom elevation gate inflows using the SPECIFY option, m KUDG1 - Top layer above which selective withdrawal will not occur KUDG1-Selections withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur GASGTC - Dissolved gas computations ON or OFF EGASGTC - Equation number for computing dissolved gas AGASGTC - empirical coefficient BGASGTC - empirical coefficient CGASGTC - empirical coefficient A <th>3</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> <th>H</th> <th>I</th> <th>J</th>	3	C	D	E	F	G	H	I	J
249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311	CGASGT - empirical coefficient PUMPS IUPU - Upstream segment number where water is withdrawn IDPU - Downstream segment number where water enters EPU - elevation of pump m SHPDU - starting day of pumping Julian day MSPDU - maximum day of pumping Julian day EOPNDU - pump starting elevation, m LOHPU - pump stopping elevation, m QPU - pump flow rate, m³/s (ATPDU - Downstream or lateral withdrawal, DOWN or LAT) PKW - How inflows enter into the downstream pump segment, DISTR, DENSITY, or SPECIFY ETPU - Top elevation inflow enters using SPECIFY option, m EBPU - Bottom elevation inflow enters using SPECIFY option, m KTPU - Top layer above which selective withdrawal does not occur KBU - Selective withdrawal bottom layer, Bottom layer below which selective withdrawal will not occur INTERNAL WEIRS INWR - Internal weir segment # (BWS) KINWR - Internal weir layer top KBINWR - Internal weir layer bottom WITHDRAWALS WDIC - Withdrawal interpolation, ON or OFF WDW - Withdrawal inflow KTWD - Withdrawal controlfile elevation KTWD - Withdrawal selective withdrawal top, Top layer above which selective withdrawal will not occur KBWD - Withdrawal selective withdrawal bottom, Bottom layer below which selective withdrawal will not occur TRIB PLACEMENT and TRIB FILES TRIC - Tributary inflow placement TRNC - Interpolation control TRI - Tributary inflow segment LUHI - Top elevation if trib placement EITR - Bottom elevation if trib placement QIRIN - tributary flow file TIRIN - tributary temperature file CTRIN - tributary concentration file DIST TRIBUTARIES DTRC - Dist Trib Control HYD PRINT - Print in the SDF file FMTFH - FMTFH format for the SDF file F is real number 10.3 HNAME - Name of variable HNAME1 - HNAME1 HNAME2 - HNAME2 HNAME3 - HNAME3 HNAME4 - HNAME4 HNAME5 - HNAME5 HNAME6 - HNAME6 HNAME7 - HNAME7 HNAME8 - HNAME8 HNAME9 - HNAME9 HNAME10 - HNAME10 HNAME11 - HNAME11 HNAME12 - HNAME12 HNAME13 - HNAME13 HNAME14 - HNAME14 HNAME15 - HNAME15 HNAME16 - HNAME16 HNAME17 - HNAME17 HNAME18 - HNAME18 HNAME19 - HNAME19 HNAME20 - HNAME20 HNAME21 - HNAME21 HNAME22 - HNAME22 HNAME23 - HNAME23 HNAME24 - HNAME24 HNAME25 - HNAME25 HNAME26 - HNAME26 HNAME27 - HNAME27 HNAME28 - HNAME28 HNAME29 - HNAME29 HNAME30 - HNAME30 HNAME31 - HNAME31 HNAME32 - HNAME32 HNAME33 - HNAME33 HNAME34 - HNAME34 HNAME35 - HNAME35 HNAME36 - HNAME36 HNAME37 - HNAME37 HNAME38 - HNAME38 HNAME39 - HNAME39 HNAME40 - HNAME40 HNAME41 - HNAME41 HNAME42 - HNAME42 HNAME43 - HNAME43 HNAME44 - HNAME44 HNAME45 - HNAME45 HNAME46 - HNAME46 HNAME47 - HNAME47 HNAME48 - HNAME48 HNAME49 - HNAME49 HNAME50 - HNAME50 HNAME51 - HNAME51 HNAME52 - HNAME52 HNAME53 - HNAME53 HNAME54 - HNAME54 HNAME55 - HNAME55 HNAME56 - HNAME56 HNAME57 - HNAME57 HNAME58 - HNAME58 HNAME59 - HNAME59 HNAME60 - HNAME60 HNAME61 - HNAME61 HNAME62 - HNAME62 HNAME63 - HNAME63 HNAME64 - HNAME64 HNAME65 - HNAME65 HNAME66 - HNAME66 HNAME67 - HNAME67 HNAME68 - HNAME68 HNAME69 - HNAME69 HNAME70 - HNAME70 HNAME71 - HNAME71 HNAME72 - HNAME72 HNAME73 - HNAME73 HNAME74 - HNAME74 HNAME75 - HNAME75 HNAME76 - HNAME76 HNAME77 - HNAME77 HNAME78 - HNAME78 HNAME79 - HNAME79 HNAME80 - HNAME80 HNAME81 - HNAME81 HNAME82 - HNAME82 HNAME83 - HNAME83 HNAME84 - HNAME84 HNAME85 - HNAME85 HNAME86 - HNAME86 HNAME87 - HNAME87 HNAME88 - HNAME88 HNAME89 - HNAME89 HNAME90 - HNAME90 HNAME91 - HNAME91 HNAME92 - HNAME92 HNAME93 - HNAME93 HNAME94 - HNAME94 HNAME95 - HNAME95 HNAME96 - HNAME96 HNAME97 - HNAME97 HNAME98 - HNAME98 HNAME99 - HNAME99 HNAME100 - HNAME100 HNAME101 - HNAME101 HNAME102 - HNAME102 HNAME103 - HNAME103 HNAME104 - HNAME104 HNAME105 - HNAME105 HNAME106 - HNAME106 HNAME107 - HNAME107 HNAME108 - HNAME108 HNAME109 - HNAME109 HNAME110 - HNAME110 HNAME111 - HNAME111 HNAME112 - HNAME112 HNAME113 - HNAME113 HNAME114 - HNAME114 HNAME115 - HNAME115 HNAME116 - HNAME116 HNAME117 - HNAME117 HNAME118 - HNAME118 HNAME119 - HNAME119 HNAME120 - HNAME120 HNAME121 - HNAME121 HNAME122 - HNAME122 HNAME123 - HNAME123 HNAME124 - HNAME124 HNAME125 - HNAME125 HNAME126 - HNAME126 HNAME127 - HNAME127 HNAME128 - HNAME128 HNAME129 - HNAME129 HNAME130 - HNAME130 HNAME131 - HNAME131 HNAME132 - HNAME132 HNAME133 - HNAME133 HNAME134 - HNAME134 HNAME135 - HNAME135 HNAME136 - HNAME136 HNAME137 - HNAME137 HNAME138 - HNAME138 HNAME139 - HNAME139 HNAME140 - HNAME140 HNAME141 - HNAME141 HNAME142 - HNAME142 HNAME143 - HNAME143 HNAME144 - HNAME144 HNAME145 - HNAME145 HNAME146 - HNAME146 HNAME147 - HNAME147 HNAME148 - HNAME148 HNAME149 - HNAME149 HNAME150 - HNAME150 HNAME151 - HNAME151 HNAME152 - HNAME152 HNAME153 - HNAME153 HNAME154 - HNAME154 HNAME155 - HNAME155 HNAME156 - HNAME156 HNAME157 - HNAME157 HNAME158 - HNAME158 HNAME159 - HNAME159 HNAME160 - HNAME160 HNAME161 - HNAME161 HNAME162 - HNAME162 HNAME163 - HNAME163 HNAME164 - HNAME164 HNAME165 - HNAME165 HNAME166 - HNAME166 HNAME167 - HNAME167 HNAME168 - HNAME168 HNAME169 - HNAME169 HNAME170 - HNAME170 HNAME171 - HNAME171 HNAME172 - HNAME172 HNAME173 - HNAME173 HNAME174 - HNAME174 HNAME175 - HNAME175 HNAME176 - HNAME176 HNAME177 - HNAME177 HNAME178 - HNAME178 HNAME179 - HNAME179 HNAME180 - HNAME180 HNAME181 - HNAME181 HNAME182 - HNAME182 HNAME183 - HNAME183 HNAME184 - HNAME184 HNAME185 - HNAME185 HNAME186 - HNAME186 HNAME187 - HNAME187 HNAME188 - HNAME188 HNAME189 - HNAME189 HNAME190 - HNAME190 HNAME191 - HNAME191 HNAME192 - HNAME192 HNAME193 - HNAME193 HNAME194 - HNAME194 HNAME195 - HNAME195 HNAME196 - HNAME196 HNAME197 - HNAME197 HNAME198 - HNAME198 HNAME199 - HNAME199 HNAME200 - HNAME200 HNAME201 - HNAME201 HNAME202 - HNAME202 HNAME203 - HNAME203 HNAME204 - HNAME204 HNAME205 - HNAME205 HNAME206 - HNAME206 HNAME207 - HNAME207 HNAME208 - HNAME208 HNAME209 - HNAME209 HNAME210 - HNAME210 HNAME211 - HNAME211 HNAME212 - HNAME212 HNAME213 - HNAME213 HNAME214 - HNAME214 HNAME215 - HNAME215 HNAME216 - HNAME216 HNAME217 - HNAME217 HNAME218 - HNAME218 HNAME219 - HNAME219 HNAME220 - HNAME220 HNAME221 - HNAME221 HNAME222 - HNAME222 HNAME223 - HNAME223 HNAME224 - HNAME224 HNAME225 - HNAME225 HNAME226 - HNAME226 HNAME227 - HNAME227 HNAME228 - HNAME228 HNAME229 - HNAME229 HNAME230 - HNAME230 HNAME231 - HNAME231 HNAME232 - HNAME232 HNAME233 - HNAME233 HNAME234 - HNAME234 HNAME235 - HNAME235 HNAME236 - HNAME236 HNAME237 - HNAME237 HNAME238 - HNAME238 HNAME239 - HNAME239 HNAME240 - HNAME240 HNAME241 - HNAME241 HNAME242 - HNAME242 HNAME243 - HNAME243 HNAME244 - HNAME244 HNAME245 - HNAME245 HNAME246 - HNAME246 HNAME247 - HNAME247 HNAME248 - HNAME248 HNAME249 - HNAME249 HNAME250 - HNAME250 HNAME251 - HNAME251 HNAME252 - HNAME252 HNAME253 - HNAME253 HNAME254 - HNAME254 HNAME255 - HNAME255 HNAME256 - HNAME256 HNAME257 - HNAME257 HNAME258 - HNAME258 HNAME259 - HNAME259 HNAME260 - HNAME260 HNAME261 - HNAME261 HNAME262 - HNAME262 HNAME263 - HNAME263 HNAME264 - HNAME264 HNAME265 - HNAME265 HNAME266 - HNAME266 HNAME267 - HNAME267 HNAME268 - HNAME268 HNAME269 - HNAME269 HNAME270 - HNAME270 HNAME271 - HNAME271 HNAME272 - HNAME272 HNAME273 - HNAME273 HNAME274 - HNAME274 HNAME275 - HNAME275 HNAME276 - HNAME276 HNAME277 - HNAME277 HNAME278 - HNAME278 HNAME279 - HNAME279 HNAME280 - HNAME280 HNAME281 - HNAME281 HNAME282 - HNAME282 HNAME283 - HNAME283 HNAME284 - HNAME284 HNAME285 - HNAME285 HNAME286 - HNAME286 HNAME287 - HNAME287 HNAME288 - HNAME288 HNAME289 - HNAME289 HNAME290 - HNAME290 HNAME291 - HNAME291 HNAME292 - HNAME292 HNAME293 - HNAME293 HNAME294 - HNAME294 HNAME295 - HNAME295 HNAME296 - HNAME296 HNAME297 - HNAME297 HNAME298 - HNAME298 HNAME299 - HNAME299 HNAME300 - HNAME300 HNAME301 - HNAME301 HNAME302 - HNAME302 HNAME303 - HNAME303 HNAME304 - HNAME304 HNAME305 - HNAME305 HNAME306 - HNAME306 HNAME307 - HNAME307 HNAME308 - HNAME308 HNAME309 - HNAME309 HNAME310 - HNAME310 HNAME311 - HNAME311	Pump1 Pump2 Pump3 Pump4 Pump5 Pump6 Pump7 Pump8 IW1 IW2 IW3 IW4 IW5 IW6 IW7 IW8 WD1 WD2 WD3 WD4 WD5 WD6 WD7 WD8 TR1 TR2 TR3 TR4 TR5 TR6 TR7 TR8 RR1 RR2 RR3 RR4 RR5 RR6 RR7 RR8 HNAME1 - HNAME1 HNAME2 - HNAME2 HNAME3 - HNAME3 HNAME4 - HNAME4 HNAME5 - HNAME5 HNAME6 - HNAME6 HNAME7 - HNAME7 HNAME8 - HNAME8 HNAME9 - HNAME9 HNAME10 - HNAME10 HNAME11 - HNAME11 HNAME12 - HNAME12 HNAME13 - HNAME13 HNAME14 - HNAME14 HNAME15 - HNAME15 HNAME16 - HNAME16 HNAME17 - HNAME17 HNAME18 - HNAME18 HNAME19 - HNAME19 HNAME20 - HNAME20 HNAME21 - HNAME21 HNAME22 - HNAME22 HNAME23 - HNAME23 HNAME24 - HNAME24 HNAME25 - HNAME25 HNAME26 - HNAME26 HNAME27 - HNAME27 HNAME28 - HNAME28 HNAME29 - HNAME29 HNAME30 - HNAME30 HNAME31 - HNAME31 HNAME32 - HNAME32 HNAME33 - HNAME33 HNAME34 - HNAME34 HNAME35 - HNAME35 HNAME36 - HNAME36 HNAME37 - HNAME37 HNAME38 - HNAME38 HNAME39 - HNAME39 HNAME40 - HNAME40 HNAME41 - HNAME41 HNAME42 - HNAME42 HNAME43 - HNAME43 HNAME44 - HNAME44 HNAME45 - HNAME45 HNAME46 - HNAME46 HNAME47 - HNAME47 HNAME48 - HNAME48 HNAME49 - HNAME49 HNAME50 - HNAME50 HNAME51 - HNAME51 HNAME52 - HNAME52 HNAME53 - HNAME53 HNAME54 - HNAME54 HNAME55 - HNAME55 HNAME56 - HNAME56 HNAME57 - HNAME57 HNAME58 - HNAME58 HNAME59 - HNAME59 HNAME60 - HNAME60 HNAME61 - HNAME61 HNAME62 - HNAME62 HNAME63 - HNAME63 HNAME64 - HNAME64 HNAME65 - HNAME65 HNAME66 - HNAME66 HNAME67 - HNAME67 HNAME68 - HNAME68 HNAME69 - HNAME69 HNAME70 - HNAME70 HNAME71 - HNAME71 HNAME72 - HNAME72 HNAME73 - HNAME73 HNAME74 - HNAME74 HNAME75 - HNAME75 HNAME76 - HNAME76 HNAME77 - HNAME77 HNAME78 - HNAME78 HNAME79 - HNAME79 HNAME80 - HNAME80 HNAME81 - HNAME81 HNAME82 - HNAME82 HNAME83 - HNAME83 HNAME84 - HNAME84 HNAME85 - HNAME85 HNAME86 - HNAME86 HNAME87 - HNAME87 HNAME88 - HNAME88 HNAME89 - HNAME89 HNAME90 - HNAME90 HNAME91 - HNAME91 HNAME92 - HNAME92 HNAME93 - HNAME93 HNAME94 - HNAME94 HNAME95 - HNAME95 HNAME96 - HNAME96 HNAME97 - HNAME97 HNAME98 - HNAME98 HNAME99 - HNAME99 HNAME100 - HNAME100 HNAME101 - HNAME101 HNAME102 - HNAME102 HNAME103 - HNAME103 HNAME104 - HNAME104 HNAME105 - HNAME105 HNAME106 - HNAME106 HNAME107 - HNAME107 HNAME108 - HNAME108 HNAME109 - HNAME109 HNAME110 - HNAME110 HNAME111 - HNAME111 HNAME112 - HNAME112 HNAME113 - HNAME113 HNAME114 - HNAME114 HNAME115 - HNAME115 HNAME116 - HNAME116 HNAME117 - HNAME117 HNAME118 - HNAME118 HNAME119 - HNAME119 HNAME120 - HNAME120 HNAME121 - HNAME121 HNAME122 - HNAME122 HNAME123 - HNAME123 HNAME124 - HNAME124 HNAME125 - HNAME125 HNAME126 - HNAME126 HNAME127 - HNAME127 HNAME128 - HNAME128 HNAME129 - HNAME129 HNAME130 - HNAME130 HNAME131 - HNAME131 HNAME132 - HNAME132 HNAME133 - HNAME133 HNAME134 - HNAME134 HNAME135 - HNAME135 HNAME136 - HNAME136 HNAME137 - HNAME137 HNAME138 - HNAME138 HNAME139 - HNAME139 HNAME140 - HNAME140 HNAME141 - HNAME141 HNAME142 - HNAME142 HNAME143 - HNAME143 HNAME144 - HNAME144 HNAME145 - HNAME145 HNAME146 - HNAME146 HNAME147 - HNAME147 HNAME148 - HNAME148 HNAME149 - HNAME149 HNAME150 - HNAME150 HNAME151 - HNAME151 HNAME152 - HNAME152 HNAME153 - HNAME153 HNAME154 - HNAME154 HNAME155 - HNAME155 HNAME156 - HNAME156 HNAME157 - HNAME157 HNAME158 - HNAME158 HNAME159 - HNAME159 HNAME160 - HNAME160 HNAME161 - HNAME161 HNAME162 - HNAME162 HNAME163 - HNAME163 HNAME164 - HNAME164 HNAME165 - HNAME165 HNAME166 - HNAME166 HNAME167 - HNAME167 HNAME168 - HNAME168 HNAME169 - HNAME169 HNAME170 - HNAME170 HNAME171 - HNAME171 HNAME172 - HNAME172 HNAME173 - HNAME173 HNAME174 - HNAME174 HNAME175 - HNAME175 HNAME176 - HNAME176 HNAME177 - HNAME177 HNAME178 - HNAME178 HNAME179 - HNAME179 HNAME180 - HNAME180 HNAME181 - HNAME181 HNAME182 - HNAME182 HNAME183 - HNAME183 HNAME184 - HNAME184 HNAME185 - HNAME185 HNAME186 - HNAME186 HNAME187 - HNAME187 HNAME188 - HNAME188 HNAME189 - HNAME189 HNAME190 - HNAME190 HNAME191 - HNAME191 HNAME192 - HNAME192 HNAME193 - HNAME193 HNAME194 - HNAME194 HNAME195 - HNAME195 HNAME196 - HNAME196 HNAME197 - HNAME197 HNAME198 - HNAME198 HNAME199 - HNAME199 HNAME200 - HNAME200 HNAME201 - HNAME201 HNAME202 - HNAME202 HNAME203 - HNAME203 HNAME204 - HNAME204 HNAME205 - HNAME205 HNAME206 - HNAME206 HNAME207 - HNAME207 HNAME208 - HNAME208 HNAME209 - HNAME209 HNAME210 - HNAME210 HNAME211 - HNAME211 HNAME212 - HNAME212 HNAME213 - HNAME213 HNAME214 - HNAME214 HNAME215 - HNAME215 HNAME216 - HNAME216 HNAME217 - HNAME217 HNAME218 - HNAME218 HNAME219 - HNAME219 HNAME220 - HNAME220 HNAME221 - HNAME221 HNAME222 - HNAME222 HNAME223 - HNAME223 HNAME224 - HNAME224 HNAME225 - HNAME225 HNAME226 - HNAME226 HNAME227 - HNAME227 HNAME228 - HNAME228 HNAME229 - HNAME229 HNAME230 - HNAME230 HNAME231 - HNAME231 HNAME232 - HNAME232 HNAME233 - HNAME233 HNAME234 - HNAME234 HNAME235 - HNAME235 HNAME236 - HNAME236 HNAME237 - HNAME237 HNAME238 - HNAME238 HNAME239 - HNAME239 HNAME240 - HNAME240 HNAME241 - HNAME241 HNAME242 - HNAME242 HNAME243 - HNAME243 HNAME244 - HNAME244 HNAME245 - HNAME245 HNAME246 - HNAME246 HNAME247 - HNAME247 HNAME248 - HNAME248 HNAME249 - HNAME249 HNAME250 - HNAME250 HNAME251 - HNAME251 HNAME252 - HNAME252 HNAME253 - HNAME253 HNAME254 - HNAME254 HNAME255 - HNAME255 HNAME256 - HNAME256 HNAME257 - HNAME257 HNAME258 - HNAME258 HNAME259 - HNAME259 HNAME260 - HNAME260 HNAME261 - HNAME261 HNAME262 - HNAME262 HNAME263 - HNAME263 HNAME264 - HNAME264 HNAME265 - HNAME265 HNAME266 - HNAME266 HNAME267 - HNAME267 HNAME268 - HNAME268 HNAME269 - HNAME269 HNAME270 - HNAME270 HNAME271 - HNAME271 HNAME272 - HNAME272 HNAME273 - HNAME273 HNAME274 - HNAME274 HNAME275 - HNAME275 HNAME276 - HNAME276 HNAME277 - HNAME277 HNAME278 - HNAME278 HNAME279 - HNAME279 HNAME280 - HNAME280 HNAME281 - HNAME281 HNAME282 - HNAME282 HNAME283 - HNAME283 HNAME284 - HNAME284 HNAME285 - HNAME285 HNAME286 - HNAME286 HNAME287 - HNAME287 HNAME288 - HNAME288 HNAME289 - HNAME289 HNAME290 - HNAME290 HNAME291 - HNAME291 HNAME292 - HNAME292 HNAME293 - HNAME293 HNAME294 - HNAME294 HNAME295 - HNAME295 HNAME296 - HNAME296 HNAME297 - HNAME297 HNAME298 - HNAME298 HNAME299 - HNAME299 HNAME300 - HNAME300 HNAME301 - HNAME301 HNAME302 - HNAME302 HNAME303 - HNAME303 HNAME304 - HNAME304 HNAME305 - HNAME305 HNAME306 - HNAME306 HNAME307 - HNAME307 HNAME308 - HNAME308 HNAME309 - HNAME309 HNAME310 - HNAME310 HNAME311 - HNAME311	SNP ON OFF NSNP # of dates SNP DATE SNP(NSNP) output days	64.5 64.7 93.7 106.7 170.7 136.7 148.7 162.7						

INPUT FILES

A	B	C	D	E	F	G	H	I	J
310	NSNP: # of dates	2							
311	SNP DATE: SNP(NSNP) output days in Julian days	64.5	64.7	93.7	106.7	120.7	136.7	148.7	162
312	SNP FREQ: SNP(NSNP) Frequency of output in days	0.05	7	100	100	100	100	100	100
313	SCR PRINT - Screen print	SCR							
314	SCR: On or Off; update screen output	ON							
315	NSCR: # of dates	1							
316	SCR DATE: SCR(NSCR), output days in Julian days	64.5							
317	SCR FREQ: SCR(NSCR), frequency of output in days	4							
318	This is different than the original file w2.con.npt file,								
319	since now it is only a function of segment number - not waterbody.								
320	Internally in the code it is rewritten based on each waterbody.								
321	PRF PLOT - Profile output	PRFC							
322	PRFC: Specifies if information is written to the profile file, ON or OFF	ON							
323	NPRH: # of profile dates	1							
324	NPRH: # of segments	1							
325	PRF DATE: PRF(NPRH) output dates in Julian days	64.7							
326	PRF FREQ: PRF(NPRH) frequency of output, days	1							
327	PRF SEG: PRF(NPRH) segment # of spreadsheet output	26							
328	This is different than the original file, since now it is based only on segments.								
329	SPR PLOT - spreadsheet output	SPH							
330	SPH: ON or OFF Specifies if information is written to the spreadsheet profile file, ON,ON/ONV								
331	NSPR: # of dates	1							
332	NSPR: # of segments	1							
333	SPR DATE: SPR(NSPR) - starting date of output in Julian days	100.7							
334	SPR FREQ: SPR(NSPR) - output frequency-days	10							
335	SPR SEG: SPR(NSPR) - segment # of spreadsheet output	26							
336	This used to be a Vector Plot, but is now the binary output driving								
337	DSI W2Linkage File for W2Post (used to be called VPL PLOT)	W2L							
338	DSI: ON or OFF Specifies if information is written to the W2 Linkage file, ON or ON								
339	NPCL: # of dates	1							
340	VPL DATE: VPL(NPCL) - starting date of output in Julian days	1							
341	VPL FREQ: VPL(NPCL) - output frequency days	0.5							
342	This is different than the original file, assumes all waterbodies are ON or CPL.PLOT - contour plot output	CPL							
343	CPL: ON or OFF Specifies if information is output to the contour file, ON or OFF								
344	NCPL: Number of contour plot dates	1							
345	TLCPLOT Turns ON or OFF TLCPLOT output format	ON							
346	CPL.DAT: CPL(NCPL) - starting date of output, output dates	1							
347	CPL.FREQ: CPL(NCPL) - output frequency days	2							
348	This is different than the original control file, assumes all waterbodies are ON or CPL.PLOT - contour plot output								
349	FUXKES: water quality kinetic flux output	FLUX							
350	Internally in the code it is rewritten based on each waterbody. But now ex CMC Specifies if information is sent to the kinetic flux output file, ON or OFF	ON							
351	NIKX: Number of kinetic flux dates	1							
352	FLX DATE: FLX(NIKX) - starting date of output in Julian days	1							
353	FLX FREQ: FLX(NIKX) - output frequency days	90							
354	TSR PLOT - time series plot output	TSR							
355	TSR: time series ON or OFF	ON							
356	NITSR: # of time series dates	1							
357	NITSR: # of locations for the time series output	1							
358	TSR FILE: TSR(NITSR) - output file name prefix and suffix	TSR.CSV							
359	TSR DATE: TSR(NITSR) - start date of output in Julian days	1							
360	TSR FREQ: TSR(NITSR) - frequency of output days	0.1							
361	TSR SEG: TSR(NITSR) - segment number of time series output	31							
362	TSR LAYER: TSR(NITSR) - depth or layer# of time series output	0							
363	Water level output	WLEVEL							
364	The water level file is for all segments in the model.								
365	Very useful for river and/or estuary water level comparisons at multiple w/TC. Time series of water levels ON or OFF at all segments	ON							
366	WL: FREQ: WLF: frequency of output in days	0.1							
367	Sum up all flows in and out of each waterbody. Must have VBC ON.								
368	Flow balance output	FLOWBAL							
369	FLOWBAL: summary of flows from all sources/sinks/volume balance check	ON							
370	FLOWBAL: FREQ: FLOWBAL: - frequency of output in days	1							
371	N and P mass balance output	NPBAL							
372	NPBAL: summary of all N and P sources/sinks	ON							
373	This applies to all waterbodies.								
374	W2.con.csv Required Constituent Order								
375	w2_habitat.npt Required Constituent Order								
376	w2_aerote.npt Required Constituent Order								
377	w2_envirpr.npt Required Constituent Order								
378	w2_selective.npt Required Constituent Order								
379	w2_constric.npt Required Constituent Order								

A	B	C	D	E	F	G	H	I	J
375	Cumulative N and P mass balance for all N/P sources/sinks.								
376	This applies to all waterbodies.								
377	Must have: MBC on and IP and TN as defined constituents.								
378	WITH OUTPUT - withdrawal output	WDO							
379	WDO: withdrawal output ON or OFF	ON							
380	NWDOD: # of withdrawal output dates	1							
381	NWDOD: # of withdrawal output constituents	1							
382	WDO: withdrawal output file name prefix and suffix	wdo.csv							
383	WDO DATE: WDO(NWDOD) - start date of output in Julian days	1							
384	WDO FREQ: WDO(NWDOD) - frequency of output days	0.1							
385	WDO SEG: WDO(NWDOD) - segment number of withdrawal	31							
386	RESTART	RESTART							
387	RSOC: Restart control ON or OFF - for writing restart files	OFF							
388	NRSD: # of restart dates and frequencies of output	0							
389	RSI: Restart read in control. ON or OFF - read in a restart file	OFF							
390	RSI1: RSI1: RSI: restart file name								
391	RSO: DATA: RSO(NRSO) - output dates in Julian days	1							
392	RSO FREQ: RSO(NRSO) - frequency of output in days	50							
393	C02PPM: CO2 in AtmospherePPM, CO2 atmospheric concentration in ppm	CST COMP - Water quality computations							
394	C02PPM: CO2 in AtmospherePPM, Turn ON or OFF water quality calculations, IMC: Limiting nutrient computation	ON	ON	1	400	ON			
395	CO2YR: CO2 YearlyGlobal average ON or OFF, use global yearly average	C02YR							
396	CO2YR: CO2 YearlyGlobal average ON or OFF, use global yearly average	ON							
397	ATMOSPHERIC DEPOSITION	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
398	Atm. Deposition_c - turn ON/OFF mass loading (kg/km2/year) for each water body	ON							
399	Atm. Deposition_Interpolation - Interpolate between values ON/OFF	ON							
400	Verify that you have this many constituent rows below:	38							
401	CST - Concentration State variables and initial conditions	CMATE2 Short	CMATE Long name	CM Active	CMU Fort CMU/CML Output	C2WBS Initial cond	CPRWBC	C Atm. DeCIP	
402	Must include text in quotes if there are spaces or other symbols like / for	1	100	100	100	100	100	100	
403	SEE TAB SHOWING REQUIRED CONSTITUENT ORDER	2	Gen1	100	100	100	100	100	
404	4. Note that epiphyton and macrophyte are turned ON below, otherwise	3	Gen2	100	100	100	100	100	
405	5. ISS	4	Gen3	100	100	100	100	100	
406	6. WaterAge	5	ISS1	100	100	100	100	100	
407	7. Turb	6	Turb1	100	100	100	100	100	
408	8. DGP	7	DGP1	100	100	100	100	100	
409	9. N2	8	N2 dissolved gas	100	100	100	100	100	
410	10. H2S	9	H2S dissolved	100	100	100	100	100	
411	11. CH4	10	CH4 dissolved	100	100	100	100	100	
412	12. CO2	11	CO2 dissolved	100	100	100	100	100	
413	13. FTO	12	Reduced FTOH	100	100	100	100	100	
414	14. FEOOH	13	OXidized FeOOH	100	100	100	100	100	
415	15. MuS2	14	OXidized MuS2	100	100	100	100	100	
416	16. MuS2	15	Reduced MuS2	100	100	100	100	100	
417	17. PO4	16	PO4	100	100	100	100	100	
418	18. NO3	17	NO3	100	100	100	100	100	
419	19. NO2	18	NO2	100	100	100	100	100	
420	20. DS9	19	NOx Nitrate	100	100	100	100	100	
421	21. PS9	20	Dissolved silica	100	100	100	100	100	
422	22. IODOM	21	Particulate silica	100	100	100	100	100	
423	23. HIXMAP	22	Iodine DOM	100	100	100	100	100	
424	24. HIXMAP	23	Iodine P	100	100	100	100	100	
425	25. IOPM	24	Iodine DOM	100	100	100	100	100	
426	26. IOPM	25	Iodine P	100	100	100	100	100	
427	27. AUS3	26	Iodine g/m3	100	100	100	100	100	
428	28. DO	27	Dissolved oxygen	100	100	100	100	100	
429	29. TIC	28	Total inorganic carbon	100	100	100	100	100	
430	30. TALK	29	2-hydroxy-3-ketone	100	100	100	100	100	
431	30. ZOO1	30	Zooplankton, 1,000g/m3	100	100	100	100	100	
432	31. IODOM_P	31	IODOM_P mg/m3/300F	100	100	100	100	100	
433	32. HIXMAP_P	32	HIXMAP_P mg/m3/100F	100	100	100	100	100	
434	33. PO4_P	33	PO4_P mg/m3/100F	100	100	100	100	100	
435	34. NO3_P	34	NO3_P mg/m3/100F	100	100	100	100	100	
436	35. DOM_N	35	DOM_N mg/m3/100F	100	100	100	100	100	
437	36. HIXMAP_N	36	HIXMAP_N mg/m3/100F	100	100	100	100	100	

INPUT FILES

INPUT FILES

A	B	C	D	E	F	G	H	I	J
542	CGOL, Arrhenius temperature rate multiplier, theta	0	0	1.04					
543	CGOK, Arrhenius decay rate, with mass concentration units: g/m3-day-1	0	-1						
544	CGOK, 1st-order decay rate, day-1	0	0	1.4					
545	COS_Setting_rate, m/day-1	0	0	0					
546	CGUD, Photodegradation parameter, m2-1	0	0	0					
547	CGMF, Fraction of surface reaeration coefficient, KI, for dis-solved oxygen for gas	0	0	0					
548	COS_Gas transfer saturation concentration, mg/l	0	0	0					
549	CGR, sediment release rate as a fraction of zero order SOD	0	0	0					
550	SOLIDS - Suspended solids (inorganic)	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8
551	SSS_settling velocity, m/day	1							
552	SSS_settling velocity of suspended solids, ON or OFF	OFF							
553	TAURC - Arrhenius temperature rate for sediment respiration, degrees/cm2	0							
554	SSCS_# -1.0, this is mature fine tailings for the sediment diagnosis model	0							
555	New								
556	BACTERIA	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
557	BACTD0, Arrhenius temperature rate multipliers, theta	1.04							
558	BACTD0, 1st-order decay rate, day-1	1.4							
559	BACTS_Setting_rate, m/day	0							
560	BACTD0, Photodegradation parameter, m2-1	0							
561	New								
562	H2S	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
563	H2SO4_sediment release rate, fraction of SOD (zero order), [-]	0.01							
564	H2SO4D, Arrhenius temperature rate multiplier, theta	1.04							
565	H2S1D0, first order decay rate, day-1	0.0001							
566	SO4R_sediment release of SO4, source, fraction of SOD (zero order), [-]	0.0001							
567	SO4R, sediment release of SO4, source, fraction of SOD (zero order), [-]	0.0001							
568	New								
569	CH4	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
570	CH4R_methane sediment release rate, fraction of SOD (zero order), [-]	0.01							
571	CH4D10, Arrhenius temperature rate multiplier, theta	1.04							
572	CH4D10, First order decay rate, day-1	0.0001							
573	CH4TS_Setting_rate, m/day	0							
574	CH4TD0, Photodegradation parameter, m2-1	0							
575	New								
576	Fe(II) Mn(IV)	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
577	ELB0_Sediment release rate of reduced Fe, a fraction of SOD for the zero order S	0.0001							
578	KfL_OXID_Rate of Fe oxidation underoxic conditions, day-1	0.01							
579	KfL_RLD_Rate of Fe reduction under anaerobic conditions, day-1	0.0001							
580	PEREON_HalfSat_Half saturation constant for Fe oxidation	0.01							
581	PEREON_Setting velocity of Mn oxide, m/day	0.1							
582	New								
583	Mn(II) Mn(IV)	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
584	Mn(II)_Mn(IV)_Reduction release rate of reduced Mn, a fraction of SOD for the zero order S	0.0001							
585	KMN_OXID_Rate of Mn oxidation underoxic conditions, day-1	0.01							
586	KMN_RED_Rate of Mn reduction under anaerobic conditions, day-1	0.0001							
587	KTMN0H1_HalfSat_Half saturation constant for Mn oxidation	0.01							
588	MNSatVel_Setting velocity of Mn oxide, m/day	0.1							
589	New								
590	ALG_RATES	ALG1	ALG2	ALG3	ALG4	ALG5	ALG6	ALG7	ALG8
591	AG - algae max growth rate, 1/day	2							
592	AR - algae respiration rate, 1/day	0.04							
593	AM - algae mortality rate	0.04							
594	AS - algae settling velocity, m/day	0.1							
595	AIHSP - algae half saturation rate for P, mg/l	0.1							
596	AIHSP - algae half saturation rate for N, mg/l	0.014							
597	AIHSP - algae half saturation rate for Si, mg/l	0							
598	AIHSP - algae half saturation rate for Mn, mg/l	100							
599	AI1 - Temperature C for set point 1	5							
600	AI2 - Temperature C for set point 2	20							
601	AI3 - Temperature C for set point 3	35							
602	AI4 - Temperature C for set point 4	45							
603	AK1 - fraction of max growth rate at A11	0.1							
604	AK2 - fraction of max growth rate at A12	0.99							
605	AK3 - fraction of max growth rate at A13	0.99							
606	AK4 - fraction of max growth rate at A14	0.1							
607	AP_ALGP_Stoichiometric ratio of P to algal biomass	0.005							
608	AN_ALGN_Stoichiometric ratio of N to algal biomass	0.08							
609	AC_ATCG_Stoichiometric ratio of C to algal biomass	0.45							
610	AS_ALGSI_Stoichiometric ratio of Si to algal biomass	0							
611	AL_ALGA_Stoichiometric ratio of algal biomass	0.005							
612	APMOM_ALPM_inflow biomass going to POM at death	0.06							
613	ANEDN_NH4-N03 preference equation #	1							
614	O2AR_Stoichiometric ratio of O2 to algal biomass, for algal respiration (mg O2/mg algal biomass)	1.1							
615	O2AG_Stoichiometric ratio of O2 to algal biomass, for algal primary production	1.4							
616	Algae Vertical Migration, ON/OFF, AVERTM	OFF							
617	EPHYTYPON	WB1	WB2	WB3	WB4				
618	EPHYTYPON group 5 as EPYC Turn ON/OFF Periphyton group 1	OFF							
619	EPYC Turn ON/OFF print for Periphyton group 1	OFF							
620	EPYC INIT initial areal density Periphyton group 1 g/m2	20							
621	EPYC Turn ON/OFF Periphyton group 2								
622	EPYC INIT initial areal density Periphyton group 2 g/m2								
623	EPYC Turn ON/OFF Periphyton group 3								
624	EPYC INIT initial areal density Periphyton group 3 g/m2								
625	EPYC Turn ON/OFF Periphyton group 4								
626	EPYC INIT initial areal density Periphyton group 4 g/m2								
627	EPYC INIT initial areal density Periphyton group 5								
628	EPYC INIT initial areal density Periphyton group 5 g/m2								
629	Increase # of rows if > 5 Periphyton groups								
630	EPHYTYPON growth rate constants for each periphyton group	EP1	EP2	EP3	EP4				
631	EG growth rate day-1	1.5							
632	ER respiration rate day-1	0.05							
633	EE excretion rate day-1	0.02							
634	FM mortality rate day-1	0.1							
635	FB burial rate day-1	0							
636	LHPS half saturation constant P, g/m3	0.0002							
637	LNHPS half saturation constant N, g/m3	0.0007							
638	LSAT1 light saturation W/m2	150							
639	FHS biomass limitation factor, g/m2	15							
640	LNQN ammonia preference factor equation for epiphyton-periphyton (1 or 2)	2							
641	TNP nitrogen half saturation preference constant, mg/l - only used if LNQN=2	0.001							
642	EL1_low temp temperature for maximum epiphyton-periphyton growth, oC	1							
643	ET1_Upper temperature for maximum epiphyton-periphyton growth, oC	30							
644	ET1_Upper temperature for epiphyton/periphyton growth, oC	30							
645	TK1_Fraction of epiphyton/periphyton growth rate at ET1	0.1							
646	EC2_Fraction of maximum epiphyton/periphyton growth rate at ET2	0.99							
647	LC3_Fraction of maximum epiphyton/periphyton growth rate at LT3	0.99							
648	TK4_Fraction of epiphyton/periphyton growth rate at ET4	0.1							
649	EPStoichiometry equivalent between epiphyton/periphyton biomass and photosynthesis	0.005							
650	LNStoichiometry equivalent between epiphyton/periphyton biomass and algal	0.08							
651	EC Stochiometric equivalent between epiphyton/periphyton biomass and carbo	0.45							
652	LSI Stochiometric equivalent between epiphyton/periphyton biomass and silica	0							
653	TC1HA Ratio between epiphyton/periphyton biomass and chlorophyll a (Not used)	0.065							
654	EPOM fraction of epiphyton/periphyton biomass that is converted to particulate	0.8							
655	O21H Oxygen stoichiometry for epiphyton/periphyton respiration (mg O2/mg)	1.1							
656	O22G Oxygen stoichiometry for epiphyton/periphyton primary production (mg O2/mg)	1.4							
657	ZOOPLANKTON_RATES	Zoo1	Zoo2	Zoo3	Zoo4				
658	ZG growth rate day-1	1.5							
659	ZK respiration rate day-1	0.1							
660	ZM mortality rate day-1	0.01							
661	ZEP_zooplankton assimilation efficiency or the proportion of food assimilated	0.5							
662	PHIP_Prefractionation factor of zooplankton for detritus or POM (dimensionless), fo	0.5							

INPUT FILES

A	B	C	D	E	F	G	H	I	J
688	ZEFF Zooplankton assimilation efficiency or the proportion of food assimilated	0.5							
689	PREFP Preference factor of zooplankton for detritus or IPOM (dimensionless)	0.5							
690	ZOOPMIN Threshold food concentration at which zooplankton feeding begins	0.01							
691	ZSP Zooplankton half-saturation constant for food (includes IPOM, algae, and zooplankton)	0.3							
692	Note that the option exists for variable settling rate where Zoop move up								
693	Z11 Lower temperature for zooplankton growth, oC	0							
694	Z12 Lower temperature for maximum zooplankton growth, oC	15							
695	Z13 Lower temperature for maximum zooplankton growth, oC	25							
696	Z14 Upper temperature for zooplankton growth, oC	36							
697	ZK1 Fraction of maximum zooplankton growth rate at Z11	0.1							
698	ZK2 Fraction of maximum zooplankton growth rate at Z12	0.9							
699	ZK3 Fraction of maximum zooplankton growth rate at Z13	0.98							
700	ZK4 Fraction of maximum zooplankton growth rate at Z14	0.1							
701	ZP Stoichiometric equivalent between zooplankton biomass and phosphorus	0.015							
702	ZN Stoichiometric equivalent between zooplankton biomass and nitrogen	0.06							
703	ZC Stoichiometric equivalent between zooplankton biomass and carbon	0.45							
704	ZD28 Oxygen stoichiometry for zooplankton respiration (mg O2/mg zooplankton)	1.1							
705	PREFA_Algal Group 1 Preference factor of zooplankton for algae (dimensionless)	1							
706	This is set for a maximum of 5 algae groups and 5 zooplankton groups - you must keep the 5 groups even if not used								
707	You must keep the 5 groups even if not used								
708	PREFA_Algal Group 2 Preference factor of zooplankton for algae (dimensionless)								
709	PREFA_Algal Group 3 Preference factor of zooplankton for algae (dimensionless)								
710	PREFA_Algal Group 4 Preference factor of zooplankton for algae (dimensionless)								
711	PREFA_Algal Group 5 Preference factor of zooplankton for algae (dimensionless)								
712	Increase # of rows if > 5 algal groups								
713	PREFZ_Group1 Preference factor of zooplankton for zooplankton (dimensionless)	0							
714	PREFZ_Group2 Preference factor of zooplankton for zooplankton (dimensionless)								
715	PREFZ_Group3 Preference factor of zooplankton for zooplankton (dimensionless)								
716	PREFZ_Group4 Preference factor of zooplankton for zooplankton (dimensionless)								
717	PREFZ_Group5 Preference factor of zooplankton for zooplankton (dimensionless)								
718	Increase # of rows if > 5 zooplankton groups								
719	MACROPHOTES	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
720	MMc Waterbody macrophyte 1 computations, ON or OFF	OFF							
721	MMc Waterbody macrophyte 2 computations, ON or OFF								
722	MMc Waterbody macrophyte 3 computations, ON or OFF								
723	MMc Waterbody macrophyte 4 computations, ON or OFF								
724	MMc Waterbody macrophyte 5 computations, ON or OFF								
725	MIPRWBC Macrophyte 1 concentration print output, ON or OFF	OFF							
726	MIPRWBC Macrophyte 2 concentration print output, ON or OFF								
727	MIPRWBC Macrophyte 3 concentration print output, ON or OFF								
728	MIPRWBC Macrophyte 4 concentration print output, ON or OFF								
729	MIPRWBC Macrophyte 5 concentration print output, ON or OFF								
730	MAC/CWBC1 Group1 Initial macrophyte concentration for each macrophyte group	0							
731	MAC/CWBC1 Group2 Initial macrophyte concentration for each macrophyte group								
732	MAC/CWBC1 Group3 Initial macrophyte concentration for each macrophyte group								
733	MAC/CWBC1 Group4 Initial macrophyte concentration for each macrophyte group								
734	MAC/CWBC1 Group5 Initial macrophyte concentration for each macrophyte group								
735	MAC RATE	MacGroup1	MacGroup2	MacGroup3	MacGroup4	MacGroup5	MacGroup6	MacGroup7	MacGroup8
736	MG maximum macrophyte growth rate, day-1	0.3							
737	MR maximum macrophyte respiration rate, day-1	0.05							
738	MM maximum macrophyte mortality rate, day-1	0.05							
739	MSAT light saturation intensity at maximum photosynthetic rate, W m-2	30							
740	MIP macrophyte half-saturation for phosphorus limited growth, g m-3	0							
741	MIP macrophyte half-saturation for nitrogen limited growth, g m-3	0							
742	MIP macrophyte half-saturation for carbon limited growth, g m-3	0							
743	MIPOM Fraction of macrophyte biomass that is converted to particulate organic	0.9							
744	LRPMAC Fraction of POM which originates as dead macro-phytes becoming labile	0.2							
745	PSD Fraction of phosphorus uptake by macrophytes obtained from sediments	0.5							
746	NSD Fraction of nitrogen uptake by macrophytes obtained from sediments	0.5							
747	MILMP Threshold macrophyte concentration for which growth is moved to the a	40							
748	MIMAC Maximum macrophyte concentration, g m-3	500							
749	LCBAG4 Macrophyte dry weight	2							
750	DMY Macrophyte dry weight to wet volume ratio, g m-3	70000							
751	DWSA Macrophyte dry weight to surface area ratio, g m2	8							
752	ANORM Fraction of macrophyte surface area normal to direction of flow	0.3							
753	MT1 Lower temperature for macrophyte growth, oC	7							
754	MT2 Lower temperature for maximum macrophyte growth, oC	15							
755	MT3 Upper temperature for maximum macrophyte growth, oC	24							
756	MKI Fraction of maximum macrophyte growth rate at MT1	0.1							
757	MK2 Fraction of maximum macrophyte growth rate at MT2	0.99							
758	MK3 Fraction of maximum macrophyte growth rate at MT3	0.99							
759	MP stoichiometric equivalent between macrophyte biomass and phosphorus	0.095							
760	MN Stoichiometric equivalent between macrophyte biomass and nitrogen	0.08							
761	MC Stoichiometric equivalent between macrophyte biomass and carbon	0.45							
762	O2M Oxygen stoichiometry for macrophyte respiration (mg O2/mg macrophyte)	1							
763	O2MG Oxygen stoichiometry for macrophyte primary production (mg O2/mg macrophyte)	1.4							
764									
765	DOM Standard Organic Matter	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
766	LURIMUK Labile DOM decay rate, day-1	0.2							
767	RDOMDK Refactory DOM decay rate, day-1	0.001							
768	LRDKL Labile to refractory DOM decay rate, day-1	0.01							
769									
770	POM Particulate Organic Matter	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
771	PDOMLK Labile POM decay rate, day-1	0.08							
772	RPDOMK Refactory POM decay rate, day-2	0.01							
773	LRPKL Labile to refractory POM decay rate, day-1	0.001							
774	POMS POM settling rate, m day-1	0.5							
775									
776	OM STOIC Organic Matter Stoichiometry	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
777	OMR1 Stoichiometric equivalent between organic matter and phosphorus	0.005							
778	ORG1 Stoichiometric equivalent between organic matter and nitrogen	0.05							
779	ORG2 Stoichiometric equivalent between organic matter and carbon	0.45							
780	ORG3 Stoichiometric equivalent between organic matter and silica	0.18							
781	OZOM Stoichiometric equivalent between oxygen and organic matter	3.4							
782	OMT1 Lower temperature for organic matter decay, oC	4							
783	OMT2 Upper temperature for organic matter decay, oC	30							
784	OMR1 Fraction of organic matter decay rate at OMT1	0.1							
785	OMR2 Fraction of organic matter decay rate at OMT2	0.99							
786									
787	Turbidity and Secchi Disk (These are derived variables)	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
788	COEFKA_Turb = EXP(CoefKA_Turb(W)) * LOG(TOTSS(K))) + CovKB_Turb(W)	1.1							
789	COEFB_Turb = (UBG(W) * empirical factor for correlation with TOTSS	0.05							
790	SECCCHI(DK,W) = SECC_PAR(W)/GAMMA(W)	1.5							
791									
792	CBOD	BO01	BO02	BO03	BO04	BO05	BO06	BO07	BO08
793	KBOD5_5 day decay rate @ 20oC, day-1								
794	TBD0 Theta Arhenius Temperature coefficient								
795	RBOD Ratio of CBOD0 to ultimate CBOD								
796	CBOD5 CBOD settling rate, m day-1								
797	BOBOD P stoichiometry for CBOD decay (mg P/mg O2)								
798	BOBON N stoichiometry for CBOD decay (mg N/mg O2)								
799	BOBC C stoichiometry for CBOD decay (mg C/mg O2)								
800									
801	NUTRIENTS - P N Si Si	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
802	PO4H Sediment release rate of phosphorus, fraction of SOD	0.015							
803	PARH Phosphorus partitioning coefficient for suspended solids	1.2							
804	NRH2 Nitrate release rate of nitrogen, fraction of SOD	0.15							
805	NH4NH3 Ammonium ion decay rate, day-1	0.05							
806	NH4T1 Lower temperature for ammonium decay, oC	5							
807	NH4T2 Lower temperature for maximum ammonium decay, oC	25							
808	NH4H1 Fraction of nitrification rate at NH4T1	0.1							
809	NH4H2 Fraction of nitrification rate at NH4T2	0.99							
810	NH3 Nitrate transfer: Kg H2O Constant in calculation of Kg H2O based on Wind	168							
811	UNH2 Unnitrified ammonia release rate, mg O2/mg NH3	4.57							
812	NO35 Nitrate loss velocity to the sediments because of sediment denitrification	0							
813	NO3SED Fraction of NO3-N diffused into the sediments that becomes part of o	0.37							
814	NO311 Lower temperature for nitrate decay, oC	5							
815									

INPUT FILES

A	B	C	D	E	F	G	H	I	J
814	INFO35ED Fraction of NO3-N diffused into the sediments that becomes part of organic matter, oC	0.37							
815	NO311 Lower temperature for nitrate decay, oC	5							
816	NO337 Lower temperature for maximum nitrate decay, oC	35							
817	NO33K1 Fraction of nitrate decay rate at NO311, day^-1	0.1							
818	NO33K2 Fraction of nitrate decay rate at NO337, day^-1	0.99							
819	PSD Dissolved silica sediment release rate, fraction of SOD	0.1							
820	PSG Particulate biogenic settling rate, m sec^-1	0.1							
821	PSIOK Particulate biogenic silica decay rate, day^-1	0.3							
822	PARIH Dissolved silica partitioning coefficient	0.2							
823	(see User Manual)								
824	SED CO2	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
825	CO2R Sediment carbon dioxide release rate, fraction of sediment oxygen demand	0.1							
826	OXYGEN Unit	01LIMIT							
827	O2 LIMIT IOD Dissolved oxygen half-saturation constant or concentration at wh	0.01							
828									
829	SOD RATES	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
830	OFF1 ON/OFF1 for first order sediment compartment	OFF							
831	SLDPPC Turns ON/OFF first order sediment organic matter concentration ON								
832	SLDPPC Initial first order sediment organic matter concentration, g/m^2	0							
833	SEOK First order sediment decay rate, day^-1	0.08							
834	SEOS First order sediment settling or focusing rate, m/day^-1	0.1							
835	FSOD Fraction of the zero-order SOD rate used	1							
836	FSOD1 First order sediment organic matter concentration initial condition	1							
837	SETB01 First order sediment hand rate, day^-1	0							
838	DPWSEOK Turns ON/OFF dynamic calculation of the first order sediment model off								
839	SOD11 Lower temperature for zero-order SOD or first order sediment decay, oC	4							
840	SOD12 Fraction of SOD or sediment decay rate at lower temperature	0.1							
841	SOD12K2 Fraction of SOD or sediment decay rate at upper temperature	0.99							
842									
843	SOD DEMAND ZERO ORDER: Segment #	1	2	3	4	5	6	7	8
844	SOD g/m^2/d zero-order sediment oxygen demand for each segment	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.3
845									
846	REAERATION	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
847	TYPE: LAKE, RIVER, OR ESTUARY	LAKE							
848	LAKE Lagoon # (see User Manual)	2							
849	COFF1 User defined parameter	0							
850	COFF2 User defined parameter	0							
851	COFF3 User defined parameter	0							
852	COFF4 User defined parameter	0							
853	COFF5 Only used when dissolved gas pressure is active state variable, fraction of	1							
854									
855	File names - global	FILE NAMES							
856	QWD FILE QWD1M withdrawal	qwdopt							
857	QST FILE QST1M - gpm	qstopt							
858	WSC FILE WSC1M - wind sheltering	wscopt							
859	SHD FILE SHD1N - shading	shdopt							
860	VFRN - W2 post output, DS1 W2Post output file	degsw21							
861									
862	Waterbody Dependent File Names	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
863	BTM1M bathymetry file	btm1.csv							
864	MTM1M meteorological file	metopt							
865	EXTN light extinction	ext1apt							
866	ATMDEP1M atmospheric deposition file name	atm_deposition_wb1.csv							
867	VFRN vertical profile	vfrapt							
868	LPFN longitudinal profile	lpfapt							
869	SHD1M shading	shdopt							
870	PIN1M profile output	pinopt							
871	CFRN contour plot output	cfnopt							
872	SPRN spreadsheet output	sprcav							
873	FLXN flux output	flxopt							
874									
875	Branch Dependent File Names	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8
876	QWD1M branch inflow	qwd_bt1_equalopt							
877	TIMN branch temp inflow	tim_bt1_opt							
878	CIMN branch conc inflow	cim_bt1cav							
879	QDTN branch structure outflow	qdt_bt1_equalpt							
880	QDTN branch structure inflow	qdt_bt1cav							
881	DTDN1M distributed temperature file	dtdn_bt1cav							
882	CDTN1M distributed concentration file	cdtn_bt1cav							
883	PREN1M Precipitation flow file	pres_bt1cav							
884	TPRN1M Precipitation temperature file	tpre_bt1cav							
885	CDRN1M distributed concentration file	cdrn_bt1cav							
886	UHM1M Upstream head file	uhm_bt1cav							
887	UHM1M Upstream temperature file	uhm_bt1cav							
888	CUHM1M Upstream concentration file	cuhm_bt1cav							
889	EDHM1M Downstream head file	edhm_bt1cav							
890	TDHM1M Downstream temperature file	tdhm_bt1cav							
891	CDHM1M Downstream concentration file	cdhm_bt1cav							
892									
893	END OF FILE								

Bathymetry File

The bathymetry file(s) contains information specifying the segment lengths, water surface elevations, segment orientations, bottom friction, and layer heights for each segment, and average widths for each grid cell. The following is a list of guidelines for file preparation are shown below.

1. It is recommended the user number the branches starting with the mainstem as branch 1. The remaining branch numbers should be numbered consecutively starting with the most upstream branch followed by the remaining branches as one moves downstream.

2. Each branch is surrounded by a segment of boundary cells (cells with zero widths) on both the upstream and downstream ends. Note this requirement results in two segments of zero widths between each branch.
3. Boundary cells must also be included at the top and bottom of each segment.
4. Cell widths start at layer 1 and continue to the maximum number of layers [[KMX](#)]. The number of layers specified in this file must match the value of [[KMX](#)] in the control file.
5. Only cells that are potentially active have non-zero widths. The first layer, boundary segment cells, and cells below the reservoir bottom elevation at a given segment have zero widths.
6. A separate bathymetry file is required for each waterbody.
7. The segment angles are relative to N. Figure 33 shows an example of segment orientation.

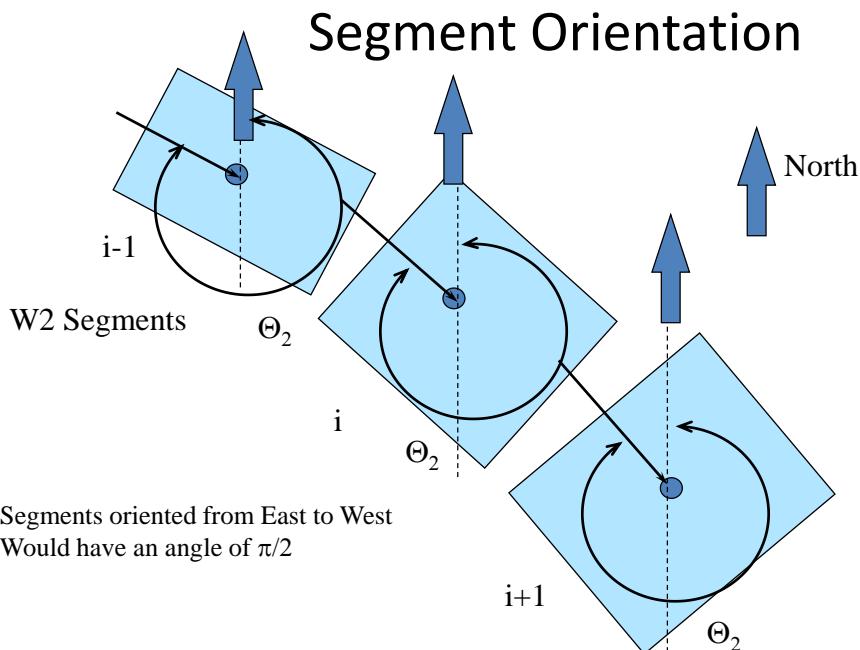


Figure 33. Illustration of segment angle orientation.

Fixed Format Bathymetry File

For the older bathymetry file format (the newer format is discussed below), the following additional guidelines must be followed:

1. The first three lines are ignored and can be used to comment the input file.
2. Segment lengths, water surface elevations, segment orientations, layer heights, and cell widths at each segment are preceded by two lines that are ignored. They can be used to comment each individual segment's bathymetry.
3. Input format for each cell width is F8.0 with 10 cell widths per line.
4. If there are more cell widths than can fit on one line, then they are continued immediately on the next line.

INPUT FILES

An alternate bathymetry input format has been available since Version 3.7. The next section describes this new format that can be more easily developed in a spreadsheet using a comma delimited file format.

Example bathymetry file for one waterbody. Note each waterbody has its own bathymetry file.

File bth_wb1.npt:

Waterbody 1 bathymetry

```
Segment lengths [DLX]
1200.00 1200.00 1200.00 1200.00 1200.00 1200.00 1200.00 1200.00 1200.00 1200.00
1200.00 1200.00 1200.00 1200.00 1200.00

Water surface elevation [WSEL]
49.80 49.20 48.00 46.80 45.60 44.40 43.20 44.40 43.20 42.96
42.72 42.48 42.24 42.00 41.80

Segment orientation [PHIO]
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

Bottom friction [FRICTC]
0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04
0.04 0.04 0.04 0.04 0.04

Layer heights [H]
2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00
2.00 2.00 2.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00

Segment 1 - branch 1
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0

Segment 2 - branch 1
0.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
250.0 200.0 050.0 0.0

Segment 3 - branch 1
0.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
250.0 200.0 050.0 0.0

Segment 4 - branch 1
0.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
250.0 200.0 050.0 0.0

Segment 5 - branch 1
0.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
250.0 200.0 050.0 0.0

Segment 6 - branch 1
0.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0 300.0
250.0 200.0 050.0 0.0

Segment 7 - branch 1
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0

Segment 8 - branch 2
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
```

INPUT FILES

```

0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0

Segment 9 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    200.0    050.0    0.0

Segment 10 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    200.0    075.0    0.0

Segment 11 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    200.0    075.0    0.0

Segment 12 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    200.0    100.0    0.0

Segment 13 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    200.0    150.0    0.0

Segment 14 - branch 2
0.0      300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0    300.0
300.0    250.0    200.0    0.0

Segment 15 - branch 2
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0

```

Comma Delimited Format Bathymetry File

Since Version 3.7, the model user can input the bathymetry as a comma delimited file (csv format). This allows the user to assemble the file in a spreadsheet, such as Excel. The new bathymetry format is shown below in Figure 34 using an Excel spreadsheet. For this new format to be used in the model, the model user has to insert the '\$' character as the first character of the first line.

1st line: Include the '\$' character as the first character in line 1, the rest of this line is ignored and can be used for comments

\$1981 Bluestone Reservoir Bathymetry

2nd line: Title:Seg, followed by a header for each model segment, this is ignored

SEG: I	1	2	3	4	5	6	7
--------	---	---	---	---	---	---	---

3rd line: Title: DLX, followed by DLX in m for each segment

DLX	1046.4	1046.4	1046.4	965.9	965.9	764.7	764.7
-----	--------	--------	--------	-------	-------	-------	-------

4th line: Title: ELWS, followed by ELWS in m for each segment (initial water surface elevation)

ELWS	430.1	430.1	430.1	430.1	430.1	430.1	430.1
------	-------	-------	-------	-------	-------	-------	-------

INPUT FILES

5th line: Title: PHIO, followed by PHIO for each segment (orientation angle in radians).

PHIO	3.142	3.142	3.142	3.142	3.142	3.142	3.142
------	-------	-------	-------	-------	-------	-------	-------

6th line: Title: FRICT, followed by FRICT for each segment (Mannings or Chezy friction factor). Typical values for Mannings friction factors are 0.035 and for Chezy are 70.

FRICT	70	70	70	70	70	70	70
-------	----	----	----	----	----	----	----

7th line: Titles that are ignored by the model

LAYERH		BR1						K
--------	--	-----	--	--	--	--	--	---

8th line to end of file: 1st column is layer height in m, 2nd column are segment widths in m for segment 1, 3rd column are segment widths in m for segment 2, etc. Note that the segment widths for the first segment and last segment are 0 and for the top layer K=1 and bottom layer are also 0. On the far right-hand side there, is a layer # specification.

0.5	0	0	0	0	0	0	0	1	
0.5	0	335	335	335	335	364	0	2	
0.5	0	231	231	231	231	254	0	3	
0.5	0	228	228	228	228	243	0	4	
0.5	0	224	224	224	224	231	0	5	
0.5	0	220	220	220	220	219	0	6	
0.5	0	215	215	215	215	206	0	7	

INPUT FILES

Figure 34. New bathymetry file format in csv format within Excel.

INPUT FILES

Fish Habitat Volumes, Volume below 1 mg/l Dissolved Oxygen, and Volume-Weighted Averages of Eutrophication State Variables

This section describes how the model allows for the computation of

- Volume of fish habitat based on temperature and dissolved oxygen targets for various fish species
- Volume of dissolved oxygen less than 1 mg/l
- Segment volume weighted averages of dissolved oxygen, NO₃-N, NH₄-N, PO₄-P, Total P, and chlorophyll a
- Surface volume weighted averages of dissolved oxygen, NO₃-N, NH₄-N, PO₄-P, Total P, and chlorophyll a

The input file, **w2_habitat.npt**, is read by the CE-QUAL-W2 model when ‘HABTATC’ is set to ‘ON’ in the control file. This file allows the model user to compute habitat volumes for various fish species and to evaluate volume-weighted averages of eutrophication parameters and examine first order sediment oxygen uptake as predicted by the model.

The file, **w2_habitat.npt**, is set up as a text file in free format with commas delimiting fields with titles between lines explaining the following lines. Each fish species is given a temperature target, both a low and a high target, and a dissolved oxygen target not to go below. In case the model user is not modeling dissolved oxygen, the oxygen limits are ignored. Note that the time of output of all these variables and volumes are at the frequency of the time series frequency output (TSR files).

An example file is shown below:

```
FISH HABITAT AND WQ AVERAGES INPUT FILE
#FISH CRITERIA, OUTPUTFILENAME,DOVOL
9,'habitat.csv',ON
NAMES OF FISH, TEMP-low, TEMP-high, DO limits [DO limits are ignored if no water quality constituents]
RainbowTrout,0.0,18.0,5.0
StripedBass,10.0,24.0,5.0
Walleye,12.0,24.0,5.0
WhiteBass,0.0,28.0,3.0
SmallmouthBass,0.0,29.0,4.0
SpottedBass,0.0,24.4,6.0
GizzardShad,10.0,26.7,6.0
LargemouthBass,10.0,30.0,5.0
ChannelCatfish,18.0,31.0,5.0
VOLUME WEIGHTED AVERAGES AT THE FOLLOWING # OF SEGMENTS: NSEG [These lines are ignored if no WQ constituents],Out.opt'putFileName for Vol Weighted Avgs
3,'volwgtavg.opt'
SEGMENT NUMBERS FOR VOL WEIGHTED AVERAGES
10,15,24
SURFACE WEIGHTED AVERAGES OVER THE FOLLOWING # OF SURFACE LAYERS,OutputFileName for surface averages
4,'surfvolwtavg.opt'
OutputFileName for 1st order SED at all time and all segments
'sodsed.opt'
```

In the Excel input file, this file is a separate tab as shown below:

INPUT FILES

A	B	C	D	E	F	G	H	I	J	K	L	M
1 FISH HABITAT AND WQ AVERAGES INPUT FILE												
2 #FISH CRITERIA	OUTPUTFILENAME	DOVOL										
3 9 'habitat.csv'	ON											
4 NAMES OF FISH	TEMP-low	TEMP-high	DO limits [DO limits are ignored if no water quality constituents]									
5 RainbowTrout	0	18	5									
6 StripedBass	10	24	5									
7 Walleye	12	24	5									
8 WhiteBass	0	28	3									
9 SmallmouthBass	0	29	4									
10 SpottedBass	0	24.4	6									
11 GizzardShad	10	26.7	6									
12 LargemouthBass	10	30	5									
13 ChannelCatfish	18	31	5									
14 VOLUME WEIGHTED AVERAGES AT THE FOLLOWING	Out.opt'putFileName for VOI Weighted Avgs											
15 3 'volwgtavg.opt'												
16 SEGMENT NUMBERS FOR VOL WEIGHTED AVERAGES												
17 10 15 24												
18 SURFACE WEIGHTED AVERAGES OVER THE FOLLOW	OutputFileName for surface averages											
19 4 'surfwvtavg.opt'												
20 OutputFileName for SOD+SED at all time and all segments												
21 'sodsed.opt'												

```
#FISH CRITERIA, OUTPUTFILENAME,DOVOL
9,'habitat.csv',ON
```

The first line is a title which is ignored by the model. This variable tells the code to expect 9 fish temperature and dissolved oxygen criteria and specifies the output filename which must be in quotations. The DOVOL is ON or OFF and specifies if the model will compute a time-series of reservoir volume less than 1 mg/l. This output filename is for the output of habitat volumes and volume less than 1 mg/l for the entire model grid. Other files are written out showing habitat volumes for each model branch and waterbody. Also, if TECPLOT is ON for CPL output, the habitat criteria can be animated – see CPL output file.

```
NAMES OF FISH, TEMP-low, TEMP-high, DO limits [DO limits ignored if water quality OFF]
RainbowTrout,0.0,18.0,5.0
StripedBass,10.0,24.0,5.0
Walleye,12.0,24.0,5.0
WhiteBass,0.0,28.0,3.0
SmallmouthBass,0.0,29.0,4.0
SpottedBass,0.0,24.4,6.0
GizzardShad,10.0,26.7,6.0
LargemouthBass,10.0,30.0,5.0
ChannelCatfish,18.0,31.0,5.0
```

The first line is ignored by the model. For each of the 9 species, a temperature in °C as a low and a high limit and a dissolved oxygen in mg/l target are used. These criteria can be selected for fish species in the reservoir or river system following the work of Welch et al. (2011) in Table 55 or Hondzo and Stefan (1996) in Table 56. Note that the habitat volume uses the following criteria for acceptable habitat:

Model temperature > TEMP-low and <= TEMP-high and dissolved oxygen >= DO limit.

Then based on these limits an output file for the entire waterbody is written out. The file is well-suited for importing into Excel or other graphics programs.

Table 55. Fish temperature and dissolved oxygen criteria from Welch et al. (2011).

INPUT FILES

TEMPERATURE AND DO REQUIREMENTS, SELECTED FISH SPECIES											
Species	Dissolved Oxygen (DO, mg/L)				Reference	Temperature (T, degrees C)					
	optimal DO ¹	Mean of optimal DO	Highest EC, DO	Effect		optimal T ¹	Mean of optimal T	Lowest EC, high T	Effect	Lowest Lethal T	Reference
rainbow trout	7.0 - 9.0	8.0	5.0	avoidance	USFWS HSI	12-18	15	18	avoidance	25	USFWS HSI
striped bass ²	6.0	6.0	5.0	ELS survival	USFWS HSI, USFWS SP (Optimal DO, juvenile)	20-21	20.5	24	avoidance	28	USFWS HSI, USFWS SP (Lethal T, larval)
walleye	>5.0	none reported (est. 7.0)	<5.0	adult abundance, fry survival	USFWS HSI	20-24	22	>24	avoidance	29	USFWS HSI
white bass	>5.0	none reported (est. 7.0)	3.0	stress (decreased activity, increased ventilation)	USFWS HSI	19-28	23.5	>28	growth	27 (based on closely related white perch, <i>Morone americana</i>), dependent on acclimation T.	USFWS SP
smallmouth bass	6.0	6.0	4.0	growth (20%)	USFWS HSI	21-27	24	29	growth	32.3	USFWS HSI
spotted bass	6.0	6.0	<6.0	growth	USFWS HSI	23.5-24.4	24	>24.4	reduced abundance	34	USFWS HSI
gizzard shad	6.0	6.0	6.0	other	USFWS HSI	22-29	25.5	26.7	repro. growth	36.5	USFWS HSI
largemouth bass	8.0	8.0	5.0	distress	USFWS HSI	24-30	27	30	embryo survival	35.0	Grant et al. 2003
channel catfish	7.0	7.0	5.0	reduced feeding	USFWS HSI	26-29	27.5	21	growth	33.5	USFWS HSI

EC - Effect Concentration (lowest of values of T=optimal and highest of values of DO <optimal)
¹ based on field data (in preference to lab data)
² except where indicated otherwise, data based on inland stocks (not coastal)

Reference	USFWS HSI - U.S. FWS Habitat Suitability Index(species specific)	Grant et al. 2003 - Effects of Temperature on the Susceptibility of Largemouth Bass to Largemouth Bass Virus	USFWS SP - Species Profile (Striped Bass, 1983)
-----------	--	--	---

Table 56. General fish temperature criteria from Hondzo and Stefan (1996).

Fish type	Lower temperature (°C) good growth limit	Upper temperature (°C) good growth limit	Upper temperature (°C) lethal limit
Coldwater (examples include brook trout, Chinook salmon, coho salmon, mountain whitefish, rainbow trout)	9.0	18.5	23.4
Coolwater (examples include black crappie, northern pike, walleye, white crappie, white sucker, yellow perch)	16.3	28.2	30.4
Warmwater (examples include bluegill, carp, channel catfish, freshwater drum, gizzard shad, green sunfish, largemouth bass, rock bass, smallmouth bass, white bass)	19.7	32.3	> 32.3

VOLUME WEIGHTED AVERAGES AT THE FOLLOWING # OF SEGMENTS: NSEG [These lines are ignored if no WQ constituents], Out.opt'putFileName for VOL Weighted Avgs 3, 'volwgtavg.opt'

The line with the title title is ignored in the model. The number of segments that the model will output volume weighted eutrophication variables (dissolved oxygen, nutrients and chlorophyll a) and the file name are the next fields. The file name must be in quotations.

SEGMENT NUMBERS FOR VOL WEIGHTED AVERAGES
10,15,24

The title line is ignored in the model. The segment numbers are given separated by commas.

SURFACE WEIGHTED AVERAGES OVER THE FOLLOWING # OF SURFACE LAYERS, OutputFileName for surface averages
4, 'surfvolwtavg.opt'

The title line is ignored in the model. The number 4 gives the model the number of active surface layers to volume average. In many cases the model user wants just a surface or epilimnetic average of the water quality variables. The code also takes all dissolved oxygen greater than saturation and assigns it a value of 100% saturation for purposes of the average. Note that the model also for the surface average outputs the layer average light extinction coefficient that can be compared with field data. The file name of the surface averages is the next field and it must be in quotations.

```
OutputFileName for SOD+SED at all time and all segments  
'sodsed.opt'
```

This output file prints the first order sediment organic matter accumulation at each segment as a function of time. It sums up all the sediment accumulated at all the vertical layers. The output is in grams of organic matter. This allows the model user to evaluate how changes in organic loading to the sediments affect the rate of accumulation of sediments and where they accumulate.

Automatic Port Selection and Reservoir Volumes at Specified Temperatures

The CE-QUAL-W2 model reads the file, 'w2_selective.npt', if the **SELECTC** control is 'ON' or set to 'USGS' in the w2_con.npt (or w2_con.csv) file. This input file allows the model user to

1. automatically choose a withdrawal port elevation based on meeting required temperature targets
2. print temperature of individual outlets rather than combining them together, and
3. print the volume of the reservoir at specified temperature targets.

Note that if DYNSTRUC is set to ON in the control file (w2_con.npt or w2_con.csv), the port selection in this file is ignored when there is not an active rule. Hence, when a rule is inactive, the input file of elevations (when DYNSTRUC=ON) will control the centerline of the structure.

SELECTC=' ON'

The input file is shown below for SELECTC='ON' and is named: 'w2_selective.npt'. A discussion of each line from the input file is included in the next sections. Note that there are 3 sections: (1) adjust an existing structure to meet a temperature target, (2) use 2 structures to blend water to meet a temperature target and (3) how to print out temperature volumes in reservoir at specified temperatures. Each section is independent of the other section.

```
Selective input control file  
Temperature outlet control - frequency of output for temperature  
OUT FREQ TFRQ TMP  
    0.02083  
Structure outlet control based on time and temperature and branch  
DYNSTR1 CONTROL      NUM      FREQ  
      ON        2      0.50  
  
DYNSTR2    WD/ST      JB      JS/NW      YEARLY      TSTR      TEND      TEMP      NELEV      ELEV1      ELEV2  
1          ST         1          1          ON       010.      045.      15.0       2       210.      190.  
2          ST         2          1          ON       180.      300.      20.0       1       95.0  
  
MONITOR LOC ISEG      ELEV      DYNSEL  
1            32          0          OFF  
2            43          1          OFF
```

INPUT FILES

```

AUTO ELEVCONTROL
1          ON
2          OFF

SPLIT1    CNTR      NUM
        ON       1

SPLIT2    ST/WD     JB   YEARLY   TSTR    TEND    TTARGET   NOUTS JS1/NW1 JS2/NW2 ELCONT DYNNSPLT
1          ST        2    ON       010.    045.    12.      2        2        3        OFF      ON

THRESH1   TEMPN
        2

THRESH2   TCRTWB1  TCRTWB2  TCRTWB3  TCRTWB4  TCRTWB5
1          10.0     10.0
2          12.5     12.5

```

Or from the Excel input file there is a tab, w2_selective.npt:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Selective input control file																							
2	Temperature outlet control - frequency of output for temperature																							
3	OUTREQ_TFRQTMP																							
4	0.125																							
5	Structure outlet control based on time and temperature and branch																							
6	DYNSTRI CONTROL NUM FREQ																							
7	ON 4 1																							
8																								
9	DYNSTR2 ST/WD JB IS/NW YEARLY TSTR TEND TEMP NELEV ELEV1 ELEV2 ELEV3 ELEV4 ELEV5 ELEV6 ELEV7 ELEV8 ELEV9 ELEV10																							
10	1 ST 1 0 100 4 051 5 2 215 400																							
11	2 ST 1 1 ON 151.1 101 17 2 115 100																							
12	3 ST 1 1 ON 181.1 273 16 2 115 95																							
13	4 ST 1 1 ON 275.1 365 10 2 115 92.5																							
14																								
15	MONITORSEG ELEV DYNCHL																							
16	1 0 -185 OFF																							
17	2 0 -185 OFF																							
18	3 0 -185 OFF																							
19	4 0 -185 OFF																							
20																								
21	AUTO ELEVCONTROL MINWL																							
22	1 OFF 0																							
23	2 OFF 0																							
24	3 OFF 0																							
25	4 OFF 0																							
26																								
27	SPLIT1 CNTR NUM																							
28	OFF 1																							
29																								
30	SPLIT2 ST/WD JB YEARLY TSTR TEND TTARGET NOUTS JS1/NW1 JS2/NW2 ELCONT DYNNSPLT																							
31	1 ST 1 ON 10 45 12 2 1 1 OFF OFF																							
32																								
33	THRESH1 TEMPN																							
34	2 0																							
35																								
36	THRESH2 TCRTWB1 TCRTWB2 TCRTWB3 TCRTWB4 TCRTWB5 TCRTWB6 TCRTWB7 TCRTWB8 TCRTWB9 TCRTWB10																							
37	1 11.11 11.11																							
38	2 15.55 15.55																							
39																								

ELEVCONTROL: lower a port if water level + MINWL does not have
MINWL: water level in m above the water level before lowering

These are for each waterbody, for a max of 10

File headers and frequency of checking for change in port

The first 2 lines are headers. The model output includes JDAY, the outlet temperature of each outlet in °C, the flow rate of each outlet in m³/s, and the elevation of each outlet in m. A '0' for temperature means that there was no outflow from that outlet. The frequency of the output of this file is determined from the input file called 'w2_selective.npt'. In this file, the variable TFRQTMP is the Julian day frequency of the output. For the example below (note that the value must be in columns 9-16 in Fortran F, fixed, format), the 0.02083 Julian day is every 30 minutes.

```

Selective input control file
Temperature outlet control - frequency of output for temperature
OUT FREQ TFRQTMP
0.02083

```

Out Freq

TFRQTMP: Real F8.0. This is the Julian day frequency of the output for the temperature for each structure outlet.

INPUT FILES

Automatic selection of outlet port to control temperature

The model code allows the user control over selective withdrawal structures and withdrawals. For each structure or withdrawal, the user can dynamically adjust the elevation of the discharge according to time and temperature of the outlet water or the temperature of another model cell somewhere downstream. Hence, the model user does not need to add any more structures or withdrawals to the model to allow for a selective withdrawal tower. The model user will specify a beginning upper elevation **ESTR** for a structure or **EWD** for a withdrawal (in the **w2_con.npt** or **w2_con.csv** file) and supply the correct time series of flows (such as in a specified input file for structure outflows or withdrawal outflows). The model will then dynamically lower or raise the elevation of the outlet using as a starting point the starting elevation defined for the structure or withdrawal in **w2_con.npt** (or **w2_con.csv**) before the rule starts. Information supplied to the model is found in the file '**w2_selective.npt**'. (*Note that the model user can also specify a structure with a dynamic outlet elevation if you do not want the model to decide when to move the outlet elevation.*) The relevant lines or card images from this file are shown below (note that fixed format is used; data are spaced every 8 columns; and there is no limit to the card length, i.e., the card images do not wrap around as in the other W2 files):

Dynstr1

DYNSTR1 CONTROL NUM FREQ

CONTROL: Character A8. This is set to 'ON' or 'OFF' (must be in all capitals) – this controls whether the algorithm is used. Turning it 'OFF' uses the normal W2 code.

NUM: Integer I8. This is the number of selective withdrawal structures. In the next set of lines, each line is for each selective withdrawal structure.

FREQ: Real F8.0. This is a real number that represents the Julian day frequency from the start time of the simulation to check the temperature criteria for the dynamic temperature control structure or the split temperature control. Hence, if one wanted to check the criteria every day and adjust the gates only once per day, FREQ=1.0. If every 12 hours, FREQ=0.5.

Dynstr2

DYNSTR2 ST/WD JB JS/NW YEARLY TSTR TEND TEMP NELEV ELEV1 ELEV2

ST/WD: Character A8. For a structure enter 'ST', for a withdrawal enter 'WD'. This specifies whether the dynamic withdrawal algorithm applies to a W2 'structure' or 'withdrawal' which are treated differently in the W2 model

JB: Integer I8. This is the branch number of the structure. This column is ignored for a withdrawal.

JS/NW: Integer I8. Outlet number of each selective withdrawal structure (if ST/WD='ST') or withdrawal number (if ST/WD='WD').

YEARLY: Character A8. This is a control that is ON or OFF. If it is ON, then the Julian days that follow TSTR and TEND are between 1 and 366 and are to be applied yearly during the simulation. If it is OFF, then TSTR and TEND are applied only once between the time period specified.

TSTR and TEND are the beginning Julian day and the ending Julian day for starting and ending selective withdrawal. The model will not lower the outlet until after TSTR. After TEND the outlet level will revert back to what was specified in the **w2_con.npt** (or **w2_con.csv**) file for the outlet elevation. Note that if YEARLY=ON, the Julian days must be between 1 and 366.

TEMP: Real F8.0. This is the temperature in C that is the criterion for lowering the structure elevation (or in practice – turning off one and opening up a lower one). If the TEMP is below the criterion and the temperature at the level of the outlet above the current outlet is also below the criterion, then the selective withdrawal structure will raise itself to a higher elevation until it reaches the top, or original elevation, as specified in the **w2_con.npt** (or **w2_con.csv**) file.

INPUT FILES

NELEV: Integer I8. This specifies model how many selective withdrawal elevations you will use in addition to the one supplied in the w2_con.npt (or w2_con.csv) file. Currently, this is limited to 100 values.

ELEV1, ELEV2...ELEV10: Real. These are the elevations in m of the selective withdrawal structures. Note that the model will use the value of the elevation in the control file as the initial elevation for the time before (<TSTR) and after (>TEND) the rule. It will raise the elevation if the temperature criterion, TEMP, is above the actual temperature; or it will lower the elevation if the actual temperature is above TEMP. There will be NELEV elevations specified. (The current limit on the number of elevations is set to 100 in the code.) These elevations must be ordered from a high to a low elevation.

Monitor

MONITOR LOC ISEG ELEV DYNSEL

ISEG: Integer I8. This can be <0 (use the summed flow weighted temperature of all structures and withdrawals at a withdrawal output segment defined in the WITH OUT card in the w2_con.npt, or w2_con.csv, file), =0 (use mixed outlet temperature of the particular structure or withdrawal defined in DYNSTR2), or >0 (use a model segment somewhere in the model domain as the monitoring point, such as a location downstream of a dam). If ISEG < 0, then the absolute value of ISEG must equal to the withdrawal number segment corresponding to IWDO(ABS(ISEG)) corresponding to the WITH OUT cards in the control file, w2_con.npt (or w2_con.csv). At this segment all withdrawals will be combined and evaluated for temperature. If ISEG < 0, then you must specify the withdrawal output as ON (WDOC=ON) and set up the withdrawal output to correspond to the monitor location. For example, if ISEG=-3", then all withdrawals, hydraulic structures, and structure outlets from withdrawal #3 will be summed together at a set frequency (as specified in the WDOF card). If IWDO(3)=24, then the mixed temperature from all water withdrawals at segment 24 will be used to decide on whether to lower the outlet elevation. For this case, the value of ELEV is ignored.

For example, if in **w2_con.npt**, the WITH OUT cards are defined as follows, then IWDO(3) is defined for segment 24.:

WITH OUT	WDOC ON	NWDO 1	NIWDO 7								
WITH DATE	WDOD 1.0	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	
WITH FREQ	WDOF 0.1	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	
WITH SEG	IWDO 64	IWDO 86	IWDO 24	IWDO 151	IWDO 188	IWDO 13	IWDO 97	IWDO	IWDO	IWDO	

and in **w2_selective.npt**,

MONITOR LOC ISEG ELEV
-5

then the model will use the combined withdrawals from segment 13 (IWDO(ABS(ISEG))) as a temperature monitoring location. Note that the WDOF is 0.1 days. Be careful that FREQ in card DYNSTR1 is greater than WDOF since the code uses the value of the last mixed temperature however frequently it is updated as defined by WDOF (not FREQ). Hence if WDOF was every 20 days and FREQ was every 5 days, this would not be appropriate since WDOF > FREQ.

INPUT FILES

If ISEG=0, the model will use the mixed temperature of the specified structure or withdrawal as the control temperature (as defined in DYNSTR2). IF ISEG > 0, the model uses this as the segment number for the temperature monitor location. This can be any active segment in the model domain. This would usually be used at a downstream location in a river below a dam structure.

ELEV: Real F8.0. This is the elevation of the temperature monitoring. Specifying a negative number results in the layer number being used for the vertical location. Hence, specifying '-5' results in specifying layer 5. Specifying '5.25' results in 5.25 m below the water surface. If ISEG=0 or ISEG<0, the elevation card is ignored.

DYNSEL: Character A8. This is either ON or OFF. This controls whether a time series file of temperature controls is read into the model. This allows the model user to use one selective withdrawal structure with a time varying temperature criterion. The file is named '**dynselectiveX.npt**', where X is the # in the list of dynamic structures (hence the first line defining a dynamic structure would be '1'). This file is a time series that skips the first 3 lines, then includes a column of Julian day (F8.0), temperature criterion in °C (F8.0). *This time series is treated as a step function input*, i.e., there is no linear interpolation between successive values. An example input file is shown below.

```
Dynamic selective input temperature input file 'dynselective1.npt'
```

JDAY	TEMP
1.000	10.0
50.000	12.0
150.000	15.0
200.000	20.0
265.000	15.0
365.000	10.0

If there is a '\$' character in the first line, first character, this file is comma delimited file with the following format (easily edited in Excel as a csv file):

```
$ dynselective1.npt,  
'  
JDAY,TTR,  
1, 4.420,  
2, 3.850,  
3, 3.719,  
4, 4.949,  
6, 5.056,
```

This card is repeated by the number of outlets (NUM in DYNSTR1 card).

Auto

```
AUTO ELEVCONTROL
```

ELEVCONTROL: Character A8. This is a switch that is either ON or OFF. This switch if 'ON' allows the elevation of the selective withdrawal structure to be reduced as the water level lowers. For example, if the water surface elevation is at an elevation of 259.9 m and the elevation of the withdrawal is at 260 m, the code then shifts the elevation of the outlet to the next lower elevation so that the water surface is always above the level of the outlet. If turned OFF, then W2 always takes water from the outlet at the surface if the elevation of the outlet is above the water surface elevation. This card is repeated by the number of outlets (NUM in DYNSTR1 card).

Split1

```
SPLIT1      CNTR      NUM
```

INPUT FILES

This card specifies which of 2 outlets (current limitation is 2 outlets) to direct flow. The outlet structure must have defined at least 2 outlets in the control file. This algorithm combines the specified flows from these outlets (from **qot.npt** file) and decides how to apportion those flows between the 2 outlets.

CNTR: Character A8. Either 'OFF' or 'ON'. This specifies whether this algorithm is active ('ON') or not ('OFF').

NUM: Integer I8. This specifies the number of outlet pairs to consider. These have to be from the same branch but can be any 2 already specified outlets in the **w2_con.npt** (or **w2_con.csv**) file.

Split2

SPLIT2	ST/WD	JB	YEARLY	TSTR	TEND	TTARGET	NOUTS	JS1/NW1	JS2/NW2	ELCONT	DYNNSPLT
--------	-------	----	--------	------	------	---------	-------	---------	---------	--------	----------

ST/WD: Character A8. For a structure enter ' ST', for a withdrawal enter ' WD'. This specifies whether the dynamic withdrawal algorithm applies to a W2 'structure' or 'withdrawal' which are treated differently in the W2 model

JB: Integer I8. This is the branch number of the structure. This column is ignored for a withdrawal.

YEARLY: Character A8. This is a control that is ON or OFF. If it is ON, then the Julian days that follow TSTR and TEND are between 1 and 366 and are to be applied yearly during the simulation. If it is OFF, then TSTR and TEND are applied only once between the time period specified.

TSTR: Real F8.0 and TEND: Real F8.0 are the beginning Julian day and the ending Julian day for starting and ending the splitting algorithm or rule. The model will not split the flow between outlets until after TSTR. After TEND the rule will end and there will be no more splitting. Note that if YEARLY=ON, the Julian days must be between 1 and 366.

TTARGET: Real F8.0. This is the temperature ($^{\circ}$ C) target for deciding where to apportion the flows. This is the temperature at the center line of the branch outlet, not the selective withdrawal mixed outlet temperature.

NOUTS: Integer I8. This is the number of outlets to apportion flows – **current limit is 2**. We may later increase this to more than 2 at a later date.

JS1/NW1: integer I8. Structure number (if ST/WD="ST") or withdrawal number (if ST/WD='WD') for upper outlet.

JS2/NW2: integer I8. Structure number (if ST/WD="ST") or withdrawal number (if ST/WD='WD') for lower outlet.

ELCONT: Character A8: Either ' ON' or ' OFF'. If this is ON, the top outlet elevation centerline will follow the water surface elevation if the centerline elevation of the outlet is below the existing water surface elevation. If OFF, the top outlet elevation is turned OFF when the water surface elevation is lowered below the centerline of the outlet level and all flow goes to the second outlet.

DYNNSPLT: Character A8: Either ' ON' or ' OFF'. If this is ON, an input file containing time varying values of the temperature target rather than a fixed value TTARGET. In this case TTARGET is ignored. This file is named **dynselectiveX_splt.npt** where X is the number of the split rule. It has the same input format as the file **dynselectiveX.npt** described above (see variable DYNSEL).

The decision rules for apportioning the flows between 2 outlets are shown in Table 57. Figure 35 illustrates the use of this new code feature.

Table 57. Rules for selective withdrawal when there are 2 outlets where flow is being split.

Rule #	Rule
1	If $T_{JS1} > T_{target}$ and $T_{JS2} > T_{target}$, take all flow from lower outlet (JS2)
2	If $T_{JS1} < T_{target}$ and $T_{JS2} < T_{target}$, take all flow from upper outlet (JS1)
3	If $T_{JS1} > T_{target}$ and $T_{JS2} < T_{target}$, take apportion flow based on flow balance equation: $Q_{JS1} = \frac{(Q_{sum}(T_{target} - T_{JS2}))}{(T_{JS1} - T_{JS2})} \text{ and}$ $Q_{JS2} = Q_{sum} - Q_{JS1}$

INPUT FILES

Rule # Rule

where Q_{sum} is the total flow from outlets at JS1 and JS2.

- 4 If water elevation is below outlet elevation for upper outlet (JS1), take all flow from lower outlet (JS2).

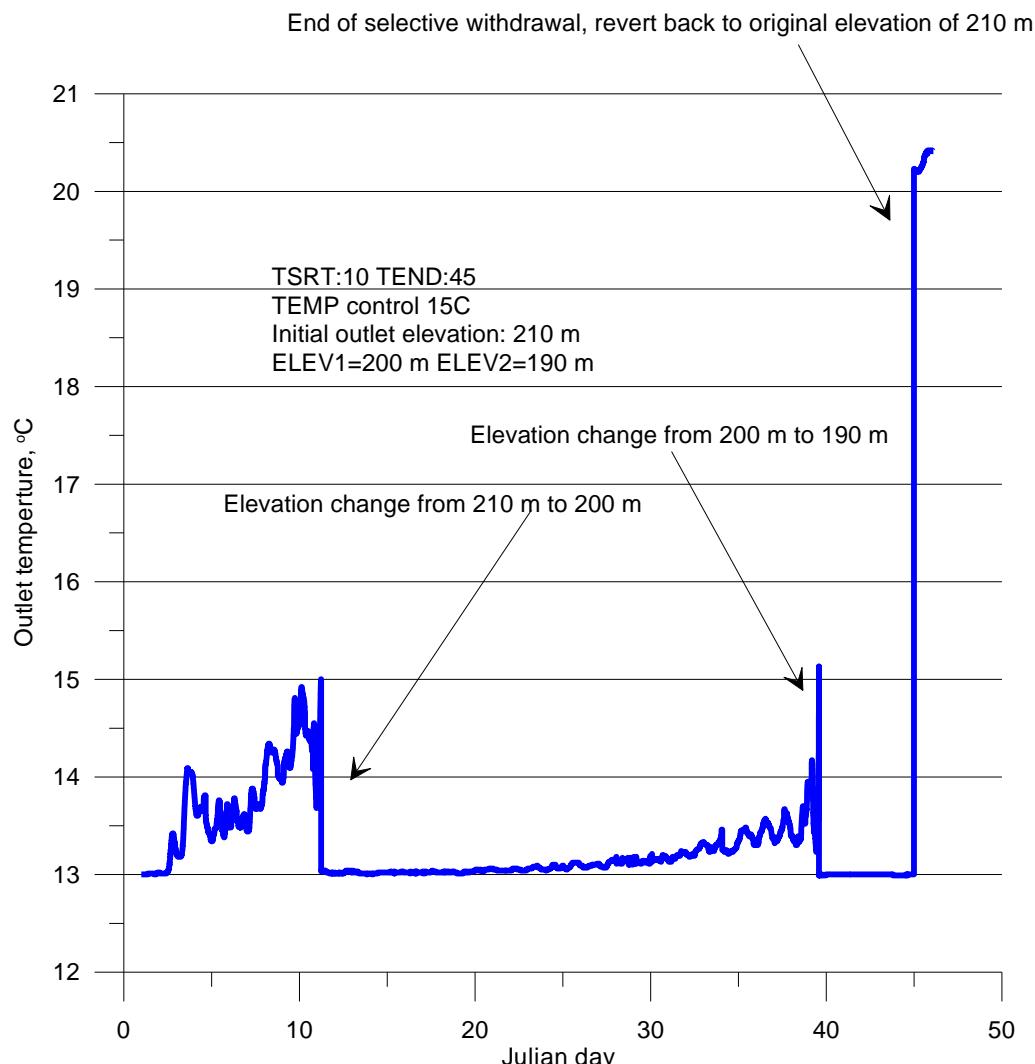


Figure 35. Outlet temperature as a function of time illustrating selective withdrawal meeting temperature target of 15°C between Julian day 1 and 45.

INPUT FILES

Volume of reservoir at a given temperature threshold

This feature is included in the file '**w2_selective.npt**' in the last few lines of the input file. The lines that control this feature are shown below:

```
THRESH1      TEMPN  
             2  
  
THRESH2  TCRTWB1  TCRTWB2  TCRTWB3  TCRTWB4  TCRTWB5  
1          10.0     10.0  
2          12.5     12.5
```

THRESH1

```
THRESH1      TEMPN  
             2
```

TEMPN: Integer I8. This is the number of temperature criteria for each water body

THRESH2

```
THRESH2  TCRTWB1  TCRTWB2  TCRTWB3  TCRTWB4  TCRTWB5  
       11.11    11.11      ! 52 deg. F  
       15.55    15.55      ! 60 deg. F
```

TCRTWBx: Real F8.0. This gives the temperature threshold for each waterbody for which to output the volume of the reservoir. In the example the first line corresponds to a temperature criterion of 11.11 degrees C for water bodies 1 and 2 (TCRTWB1, TCRTWB2), and the second line represents a second criterion of 15.55 degrees C for water bodies 1 and 2.

SELECTC=' USGS'

The input file is shown below for 'USGS' and is also named: '**w2_selective.npt**' but has a somewhat different format than for **SELECTC='ON'**. Please consult the USGS report, Rounds and Buccola (2015), for details on the algorithm and example problems.

Below is a section from Rounds and Buccola (2015) describing the new variables and features.

INPUT FILES

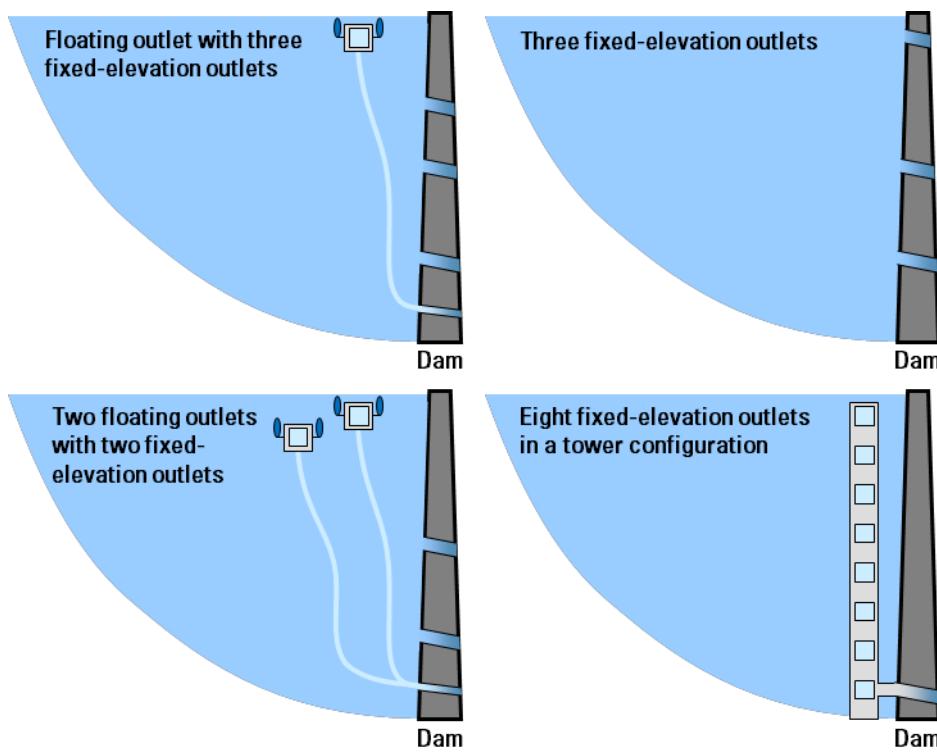


Figure 36. Example of possible configurations with the USGS algorithm (Rounds and Buccola, 2015).

In the `w2_selective.npt` file, two new inputs (**TSFREQ**, **TSCONV**) were added on the **SPLIT1** input card. **TSFREQ** specifies the update frequency for the blending groups that are specified on the **SPLIT2** input card, providing a means of separating the update frequency for blending groups and temperature control devices; previously, the update frequency was set for both algorithms with the **TCDFREQ** input. **TSCONV** specifies the convergence criterion for the blending calculations in units that correspond to the fraction of the total flow assigned to the first-priority outlets; therefore, **TSCONV** should be in the neighborhood of 0.1 or less, but nonzero. The default value for **TSCONV** is 0.005.

Additional new inputs were added to the `w2_selective.npt` file, requiring some reformatting of that input file to accommodate the new blending inputs. First, the maximum number of outlets in a blending group was increased from 2 to 10. With only two outlets, the blending solution is straightforward, but requires the user to determine which outlets should be blended at any time in the simulation prior to running the model. With up to 10 outlets specified, other constraints are used to select the outlets to be used and how flows in those outlets are balanced. The choice of outlets is controlled largely through the user-specified “priority” input. The following sections describe the new user-specified constraints, all of which are in the `w2_selective.npt` input file and summarized in **Table 58**.

Dynamic Temperature Target (TSDYN on SPLIT2 input card). Setting **TSDYN** to ON tells the model to override the temperature target (**TTARGET**) specified on the **SPLIT2** input card and instead use a user-specified time-series of temperature targets from an external file named

INPUT FILES

“**dynsplit_selectiveX.npt**” where X is the blending group number, starting at 1. This is implemented in much the same way that the original version 3.7 code allowed the user to set a time series of temperature targets for the single-structure temperature control device. This change simply allows a similar functionality to be applied for the blending of releases from two or more outlets.

Depth (DEPTHx on the DEPTH input card). Specifying a nonzero depth for a particular outlet results in that outlet being treated as a floating outlet with a centerline elevation at DEPTH meters below the current water surface. This condition allows some outlets to be treated as floating outlets, an alternative to the original code that allowed one outlet to be “lowered” with the water surface if the **ELCONT** input was ON.

Minimum Head (MINHDX on the MINHEAD input card). A nonzero minimum head criterion, specified for each blended outlet, is interpreted as the minimum depth in meters required for the outlet to be used. If the centerline outlet depth is shallower than this nonzero minimum head criterion, the outlet will not be used, regardless of any specified minimum flow criterion. This minimum head criterion is always honored. Inputs less than zero are changed to zero, which is interpreted as the absence of a minimum head criterion.

Maximum Head (MAXHDX on the MAXHEAD input card). A nonzero maximum head criterion, specified for each blended outlet, is interpreted as the maximum depth in meters under which the outlet can be used. If the centerline outlet depth is deeper than this nonzero maximum head criterion, the outlet will not be used, regardless of any specified minimum flow criterion. This maximum head criterion is always honored. Inputs less than zero are changed to zero, which is interpreted as the absence of a maximum head criterion. 6

Maximum Flow (MAXFLOx on the MAXFLOW input card). A nonzero maximum flow criterion, specified for each blended outlet in cubic meters per second, is honored regardless of its effect on temperature or any other minimum flow criterion. Inputs less than zero are changed to zero, which is interpreted as the absence of a maximum flow criterion.

Minimum Flow or Minimum Flow Fraction (MINFRCx on the MINFRAC input card). This input, specified for each outlet, can be used to specify a minimum flow rate or a minimum flow fraction. To specify a minimum flow rate, the input is negative and its absolute value is interpreted as a minimum flow rate in cubic meters per second. A minimum flow fraction is specified as a value between 0.0 and 1.0 and interpreted as the fraction of the total sum of all specified flows through outlets in the blending group. Values greater than 1.0 are set to 1.0. The blending algorithm attempts to honor all minimum flow criteria, but these criteria are subservient to the more important minimum head, maximum head, maximum flow, and priority inputs. If the priority is such that the outlet is not chosen to be used, the minimum flow criterion for that outlet is not honored. In addition, outlets that are high and dry (not under water) or that do not meet their minimum or maximum head criteria cannot have their minimum flows fulfilled.

Table 58. Description of user-specified inputs in the w2_selective.npt file for blending when SELECTC='USGS' (Rounds and Buccola, 2015)

INPUT FILES

[Input variable]	Card (name of input sec- tion)	Variable name in the code	Description
CNTR	SPLIT1	tspltc	Turns the blending calculations ON or OFF.
NUM	SPLIT1	numtsplt	Number of blending groups to specify, for different times of year or at different dams, etc.
TSFREQ	SPLIT1	tspltfreq	Frequency at which the blending calculations are updated, specified as a fraction of a day.
TSCONV	SPLIT1	tsconv	Convergence criterion for the iterative blending solution, constrained to be 0.1 or less, but nonzero.
ST/WD	SPLIT2	tspltcntr(j)	Specification of a group of either structures (ST) or withdrawals (WD) for blending.
JB	SPLIT2	tspltb(j)	Branch number for the structures being blended (ignored if using withdrawals).
YEARLY	SPLIT2	tsyearly(j)	Specifies that starting and ending dates for blending should be repeated (ON) each year, or not (OFF).
TSTR	SPLIT2	tstsrt(j)	Start date (Julian day) for blending calculations for that group (day 1 is the start of January 1).
TEND	SPLIT2	tstend(j)	End date (Julian day) for blending calculations for that group (day 1 is the start of January 1).
TTARGET	SPLIT2	tspltt(j)	Temperature target to try to meet for that period of dates, if not overridden by a time-series input.
TSDYN	SPLIT2	tsdynsel(j)	Specifies that a time-series of temperature targets is set (ON), with targets in the "dyncsplt_selectiveX.npt" file where X is the group number designation.
ELCONT	SPLIT2	elcontspl(j)	Specifies whether an outlet should decrease its elevation to follow the water surface (ON/OFF); this is independent of specifying a floating outlet with the DEPTH parameter.
NOUTS	SPLIT2	nouts(j)	Number of outlets in this particular blending group, between 2 and 10.
TSSHARE	SPLIT2	tsshare	Specifies whether releases among set-2 outlets should be shared (ON) or whether the best single outlet should be chosen (OFF)—see section, “Blending to the Temperature Target”.
JSx/NWx	SPLITOUT	jstsplt(j,n)	Structure or outlet number.
DEPTHx	DEPTH	tsdepth(j,n)	A nonzero value specifies that the outlet is a floating structure with this depth defining its centerline distance from the water surface.
MINFRCx	MINFRAC	tsminfrac(j,n)	A minimum flow fraction (between 0 and 1) specifying that at least that fraction of the total release should go through that outlet. When specified as a negative number, this input is interpreted as a minimum flow rate in cubic meters per second.
PRIORx	PRIORITY	tsprior(j,n)	An integer designation of the “priority” setting for the outlet. A “-1” means the outlet is not blended and the specified flow release rates are unchanged, but the temperature effect is accounted for by the blending calculations. Values of 0 or greater are interpreted as higher priorities for lower input values.

INPUT FILES

[Input variable]	Card (name of input sec- tion)	Variable name in the code	Description
MINHDx	MINHEAD	tsmin- head(j,n)	A minimum head designation, in meters. The outlet must be at least this deep to be used. A zero input means that no criterion is specified.
MAXHDx	MAXHEAD	tsmaxhead(j, n)	A maximum head designation, in meters. The outlet must be shallower than this depth to be used. A zero input means that no criterion is specified.
MAXFLOx	MAXFLOW	tsmaxflow(j, n)	A maximum flow designation, in cubic meters per second. A zero input means that no criterion is specified.

Priority (PRIORx on the PRIORITY input card). The priority input is an integer limited to values of -1 or greater. The priority input is used to distinguish among groups of both blended and nonblended outlets and to choose which outlets to use at any time. The details of how this input is used to select outlets for blending are provided later in section, “Using the Priority Input To Choose Outlets”.

Shared or Split Flows in Second Priority Group (TSSHARE on the SPLIT2 input card).

When at least two outlets are members of the same priority group and are being used in a blending scheme to meet a user-specified temperature target, by default the flow assigned to the priority groups is distributed among the members of the group equally, but while still fulfilling the minimum and maximum flow criteria set by the user. The TSSHARE input allows this default behavior to be modified for the second (lower) priority group. When turned OFF, the blending algorithm attempts to find the one preferred member of the second priority group that can best be used in conjunction with the first priority group to meet the user-specified temperature target. Minimum and maximum flow criteria are still honored.

An example of the ‘w2_selective.npt’ file is shown below for **SELECTC='USGS'**. Note that older variables for **SELECTC='ON'** were described in the prior section.

```
Selective input control file for SELECTC='USGS'
Temperature outlet control - frequency of output for temperature
OUT FREQ TFRQ TMP
    0.125
Structure outlet control based on time and temperature and branch
DYNSTR1 CONTROL      NUM TCDFREQ
    OFF          1   0.125

DYNSTR2     ST/WD      JB    JS/NW   YEARLY    TSTR    TEND    TEMP    NELEV   ELEV1   ELEV2
ELEV3     ELEV4      ELEV5    ELEV6    ELEV7    ELEV8    ELEV9    ELEV10
1           ST        1       1      ON       1.0    151.0    10.0      2      340.    330.

MONITOR LOC ISEG      ELEV    DYNCEL
1            0      -185      OFF

AUTO ELEVCONTROL
1            OFF

SPLIT1      CNTR      NUM   TSFREQ   TSCONV
ON          1      0.125    0.005

SPLIT2      ST/WD      JB    YEARLY    TSTR    TEND TTARGET    DYNSEL   ELCONT   NOUTS TSSHARE
1           ST        1      ON       1.    99999    12.      ON      OFF      8      OFF
```

INPUT FILES

```

SPLITOUT JS1/NW1 JS2/NW2 JS3/NW3 JS4/NW4 JS5/NW5 JS6/NW6 JS7/NW7 JS8/NW8 JS9/NW9
JS0/NW0
1          1      2      3      4      5      6      7      8

DEPTH      DEPTH1 DEPTH2 DEPTH3 DEPTH4 DEPTH5 DEPTH6 DEPTH7 DEPTH8 DEPTH9 DEPTH10
1          0      0      0      0      0      0      0      0      0      0

MINFRAC   MINFRC1 MINFRC2 MINFRC3 MINFRC4 MINFRC5 MINFRC6 MINFRC7 MINFRC8 MINFRC9 MNFRC10
1          0      0      0      0      0      0      0      0      0      0

PRIORITY  PRIOR1 PRIOR2 PRIOR3 PRIOR4 PRIOR5 PRIOR6 PRIOR7 PRIOR8 PRIOR9 PRIOR10
1          2      3      4      5      6      7      8      9      10     11

MINHEAD   MINHD1 MINHD2 MINHD3 MINHD4 MINHD5 MINHD6 MINHD7 MINHD8 MINHD9 MINHD10
1          2      2      2      2      2      2      2      2      2      2

MAXHEAD   MAXHD1 MAXHD2 MAXHD3 MAXHD4 MAXHD5 MAXHD6 MAXHD7 MAXHD8 MAXHD9 MAXHD10
1          0      0      0      0      0      0      0      0      0      0

MAXFLOW   MAXFLO1 MAXFLO2 MAXFLO3 MAXFLO4 MAXFLO5 MAXFLO6 MAXFLO7 MAXFLO8 MAXFLO9 MXFLO10
1          0      0      0      0      0      0      0      0      0      0

THRESH1   TEMPN
2

THRESH2   TCRTWB1 TCRTWB2 TCRTWB3 TCRTWB4 TCRTWB5
1          11.11  11.11
2          15.55  15.55

```

There are also 4 example problems from the USGS that are described in the Rounds and Buccola (2015) report that are part of the download package. Error trapping is also included in this routine and has also been added to the CE-QUAL-W2 preprocessor. Some of these errors include the following:

- “At least 2 and no more than 10 outlets must be specified for the NOUTS input in each blending group on the SPLIT2 input card.
- Any single outlet can only be specified once in each blending group (SPLITOUT input card).
- Any single outlet can only be specified in one blending group or temperature control device at a time. (Start and end dates for each group are checked.)
- Integer priority specifications must be -1 or greater (PRIORITY input card). ”

Environmental Performance Criteria

This section describes the environmental performance criteria which allow a model user to assess model predictions of state variables and how those can be affected by management changes to the waterbody system. This is a histogram of the fraction of time and volume during a model run where the selected water quality state variable falls between specified intervals. The model reads the file, **w2_envirprf.npt**, if the **ENVIRPC** control is ‘ON’ in the **w2_con.npt** (or **w2_con.csv**) file. This input file allows the model user to

1. Compute fraction of the reservoir volume and time associated with velocity, temperature, and depth levels
2. Compute fraction of the reservoir volume and time associated with model state variables for water quality

INPUT FILES

3. Compute fraction of the reservoir volume and time associated with model derived variables for water quality

These are very useful in assessing changes in water quality variables between model alternatives. This analysis creates the following files (if they are all turned ON): **envrprf_t.csv** (temperature), **envrprf_v.csv** (velocity), **envrprf_depth.csv** (depth), **envrprf_c.csv** (concentration for state variables), and **envrprf_cd.csv** (concentration for derived variables). The input file for these enhancements, **w2_en-virprf.npt**, is csv (comma delimited) text file and is shown below. A description of each line is shown below.

```

ENVIRONMENTAL PERFORMANCE CRITERIA CE-QUAL-W2 MODEL
IINTVLS    INTVLS SELECTC   JDAY1    JDAY2    ISTR1    IEND1    ISTR2    IEND2
1           20      OFF       100.     150.     5         25

TEMP/VEL VELOCITY  VINCR    VTOP     TEMPC    TINCR    TTOP     DEPTHC   DINCR    DTOP
OFF        0.050    0.50     ON       1.0      30.0     OFF      10.     120.

CST      ACTIVE  INTSCL  TOPLIMIT
TDS      OFF      1.00    20.00
WaterAge  ON      1.00    20.00
Gen2     ON      1.00    20.00
GEN3     ON      1.00    20.00
ISS1     ON      1.00    20.00
PO4      OFF      1.00    20.00
NH4      OFF      1.00    20.00
NO3      OFF      1.00    20.00
DSI      OFF      1.00    20.00
PSI      OFF      1.00    20.00
FE       OFF      1.00    20.00
LDOM     OFF      1.00    20.00
RDOM     OFF      1.00    20.00
LPOM     OFF      1.00    20.00
RPOM     OFF      1.00    20.00
ALG1     OFF      1.00    20.00
DO       ON       1.00    20.00
TIC      OFF      1.00    20.00
ALK      OFF      1.00    20.00
ZOO1     OFF      1.00    20.00
LDOM-P   OFF      1.00    20.00
RDOM-P   OFF      1.00    20.00
LPOM-P   OFF      1.00    20.00
RPOM-P   OFF      1.00    20.00
LDOM-N   OFF      1.00    20.00
RDOM-N   OFF      1.00    20.00
LPOM-N   OFF      1.00    20.00
RPOM-N   OFF      1.00    20.00

CST DERI  ACTIVE  INTSCL  TOPLIMIT
DOC      OFF      1.00    20.00
POC      OFF      1.00    20.00
TOC      OFF      1.00    20.00
DON      OFF      1.00    20.00
PON      OFF      1.00    20.00
TON      OFF      1.00    20.00
TKN      OFF      1.00    20.00
TN       OFF      1.00    20.00
DOP      OFF      1.00    20.00
POP      OFF      1.00    20.00
TOP      OFF      1.00    20.00
TP       OFF      1.00    20.00
APR      OFF      1.00    20.00
CHLA    OFF      1.00    20.00
ATOT    OFF      1.00    20.00
%DO     OFF      1.00    20.00
TSS     OFF      1.00    20.00

! 26
! 14

```

INPUT FILES

TISS	OFF	1.00	20.00
CBOD	OFF	1.00	20.00
pH	OFF	1.00	20.00
CO2	OFF	1.00	20.00
HCO3	OFF	1.00	20.00
CO3	OFF	1.00	20.00

In the Excel input file, the file **w2_envirprf.npt** is a tab in the spreadsheet as shown below and is written out as a comma delimited file. The model checks the input file if it is comma delimited or fixed format.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	ENVIRONMENTAL PERFORMANCE CRITERIA CE-QUAL-W2 MODEL																	
2	SEG INTERVALS	SELECTC	JDAY1	JDAY2	ISTR1	IEND1	ISTR2	IEND2	ISTR3	IEND3								
3	1	20	OFF	100	150	5	25											
4	TEMP/VEL/DEPTH																	
5	VELOCITY	VINCR	VTOP	TEMP	TINCR	TTOP	DEPTHC	DINCR	DTOP									
6	OFF		0.05	0.5	ON	1	30	OFF	10	120								
7																		
8	CST	ACTIVE	INTSCLE	TOPLIMIT														
9	TDS	OFF		1	20													
10	Gen1	ON		1	20													
11	Gen2	ON		1	20													
12	Gen3	ON		1	20													
13	ISS1	ON		1	20													
14	WaterAge	OFF		1	20													
15	Bacteria	OFF		1	20													
16	DGP	OFF		1	20													
17	N2	OFF		1	20													
18	H2S	OFF		1	20													
19	CH4	OFF		1	20													
20	SO4	OFF		1	20													
21	FEII	OFF		1	20													
22	FEEOOH	OFF		1	20													
23	MnII	OFF		1	20													
24	MnO2	OFF		1	20													
25	Po4	ON		1	20													
26	NH4	OFF		1	20													
27	NO3	OFF		1	20													
28	DSI	OFF		1	20													
29	PSI	OFF		1	20													
30	LDOM	OFF		1	20													
31	RDOM	OFF		1	20													
32	LPOM	OFF		1	20													
33	RPOM	OFF		1	20													
34	ALG1	OFF		1	20													
35	DO	ON	0.5	10														
36	TIC	OFF		1	20													
37	AUK	OFF		1	20													
38	ZOO1	OFF		1	20													
39	LDOM_P	OFF		1	20													
40	RDOM_P	OFF		1	20													
41	LPOM_P	OFF		1	20													
42	RPOM_P	OFF		1	20													
43	LDOM_N	OFF		1	20													
44	RDOM_N	OFF		1	20													
45	LPOM_N	OFF		1	20													
46	RPOM_N	OFF		1	20													
47																		
48	CST DERI	ACTIVE	INTSCLE	TOPLIMIT														
49	DOC	OFF		1	20													
50	POC	OFF		1	20													
51	TOC	OFF		1	20													
52	DON	OFF		1	20													
53	PON	OFF		1	20													
54	TON	OFF		1	20													
55	TKN	ON	0.05	1														
56	TN	ON	0.05	1														
57	NH3	ON	0.05	1														
58	DOP	OFF		1	20													
59	POP	OFF		1	20													
60	TOP	OFF		1	20													
61	TP	OFF		1	20													
62	APR	OFF		1	20													
63	CHLA	OFF		1	20													
64	ATOT	OFF		1	20													
65	%DO	OFF		1	20													
66	TDG	OFF		1	20													
67	Turbidity	OFF		1	20													
68	TSS	OFF		1	20													
69	TISS	OFF		1	20													
70	CBOD	OFF		1	20													
71	pH	OFF		1	20													
72	CO2	OFF		1	20													
73	HCO3	OFF		1	20													
74	CO3	OFF		1	20													
75	SECCHI	OFF		1	20													
76																		

◀ ▶ ... w2_habitat.npt w2_diagenesis.npt w2_aerate.npt **w2_envirprf.npt** w2_selective.

INPUT FILES

Description of each line of input file

```
ENVIRONMENTAL PERFORMANCE CRITERIA CE-QUAL-W2 MODEL
IINTVLS    IINTVLS SELECTC    JDAY1     JDAY2     ISTR1      IEND1     ISTR2      IEND2
1           20        OFF       100.      150.      5          25
```

ENVIRONMENTAL PERFORMANCE CRITERIA CE-QUAL-W2 MODEL										
SEG INTERVALS	#IINTVLS	SELECTC	JDAY1	JDAY2	ISTR1	IEND1	ISTR2	IEND2	ISTR3	IEND3
1	20	OFF	100	150	5	25				

The first 2 lines are ignored and are titles. The **IINTVLS**: Integer I1 is the number of segment intervals to run the histograms. Hence, one can specify more than one segment interval for computing histograms. This is limited to a maximum of 9 segment intervals. Setting this to '1' is the minimum, with a required pair of **ISTR** and **IEND** required for each interval. The **INTVLS**: Integer I8 are the number of intervals or bins on the histogram to use for the output file. **SELECTC** is character A3 and is either ON or OFF and either turns on the selective Julian day range and segment range. **JDAY1** (F8.0) and **JDAY2** (F8.0) are the range of Julian days. **ISTR1** is the first segment number and **IEND1** is the last segment number to perform the analysis. There can be up to 9 pairs of **ISTR** and **IEND** based on **IINTVLS**. If **SELECTC**='OFF', then all days of the simulation and all active model cells are used for this performance criterion. If **SELECTC**='ON', then **JDAY1** (F8.0) and **JDAY2** (F8.0) are the range of Julian days and **ISTR1** (I8) and **IEND1** (I8) are the range of model segments to evaluate the environmental performance criterion. Hence if **JDAY1**=100, **JDAY2**=150, **ISTR1**=5, and **IEND1**=25, then an environmental performance criterion is computed between JD 100 and 150 only for model segments between 5- 25. There is a blank line after this line. Note that **JDAY1** and **JDAY2** only apply to specific Julian days. If the model extends over multiple years and one wants to apply this Julian day range every year, let's say for the month of August each year, then the first Julian day will be negative, i.e., **JDAY1**=-213. And **JDAY2**=243. This means that every Julian day for every year between 213-243 the histogram will be developed.

```
VELOCITY   VINCR    VTOP     TEMPC     TINCR     TTOP     DEPTHc     DINCR     DTOP
ON         0.050    0.50     ON         1.0       30.0     ON         4.0       110.0
```

TEMP/VEL/DEPTH									
VELOCITY	VINCR	VTOP	TEMP	TINCR	TTOP	DEPTHc	DINCR	DTOP	
OFF	0.05	0.5	ON	1	30	OFF	10	120	

The title line is ignored but they help set the correct spacing for the variables on the following line for the fixed format file. **VELOCITY**: Character A8 is ON or OFF and allows a histogram of velocities. **VINCR**: Real F8.0 is the velocity increment in m/s and **VTOP**: Real F8.0 is the maximum velocity in the histogram. **TEMPC**: Character A8 is ON/OFF and allows a histogram of temperatures. **TINCR**: Real F8.0 is the increment of the histogram bins and **TTOP**: Real F8.0 is the maximum temperature in °C for the histogram output. **DEPTHc**: Character A8 is ON/OFF and allows a histogram of depths in m. **DINCR**: Real F8.0 is the increment of the histogram bins for depth and **DTOP**: Real F8.0 is the maximum depth in m for the histogram output.

```
CST          ACTIVE  INTSCLE  TOPLIMIT
TDS          OFF      1.00      20.00
WaterAge     ON       1.00      20.00
Gen2         ON       1.00      20.00
GEN3         ON       1.00      20.00
ISS1         ON       1.00      20.00
PO4          OFF      1.00      20.00
```

INPUT FILES

```

NH4      OFF    1.00   20.00
NO3      OFF    1.00   20.00
DSI      OFF    1.00   20.00
PSI      OFF    1.00   20.00
FE       OFF    1.00   20.00
LDOM     OFF    1.00   20.00
RDOM     OFF    1.00   20.00
LPOM     OFF    1.00   20.00
RPOM     OFF    1.00   20.00
ALG1     OFF    1.00   20.00
DO       ON     1.00   20.00
TIC      OFF    1.00   20.00
ALK      OFF    1.00   20.00
ZOO1     OFF    1.00   20.00
LDOM-P   OFF    1.00   20.00
RDOM-P   OFF    1.00   20.00
LPOM-P   OFF    1.00   20.00
RPOM-P   OFF    1.00   20.00
LDOM-N   OFF    1.00   20.00
RDOM-N   OFF    1.00   20.00
LPOM-N   OFF    1.00   20.00
RPOM-N   OFF    1.00   20.00
                                         ! 26

```

CST	ACTIVE	INTSCLE	TOPLMIT
TDS	OFF	1	20
Gen1	ON	1	20
Gen2	ON	1	20
Gen3	ON	1	20
ISS1	ON	1	20
WaterAge	OFF	1	20
Bacteria	OFF	1	20
DGP	OFF	1	20
N2	OFF	1	20
H2S	OFF	1	20
CH4	OFF	1	20
SO4	OFF	1	20
FEII	OFF	1	20
FEOOH	OFF	1	20
MnII	OFF	1	20
MnO2	OFF	1	20
PO4	ON	1	20
NH4	OFF	1	20
NO3	OFF	1	20
DSI	OFF	1	20
PSI	OFF	1	20
LDOM	OFF	1	20
RDOM	OFF	1	20
LPOM	OFF	1	20
RPOM	OFF	1	20
ALG1	OFF	1	20
DO	ON	0.5	10
TIC	OFF	1	20
ALK	OFF	1	20
ZOO1	OFF	1	20
LDOM_P	OFF	1	20
RDOM_P	OFF	1	20
LPOM_P	OFF	1	20
RPOM_P	OFF	1	20

INPUT FILES

LDOM_N	OFF	1	20
RDOM_N	OFF	1	20
LPOM_N	OFF	1	20
RPOM_N	OFF	1	20

The next line is a title line ignored by the code but the variable spacing format is shown. In the following lines, the same number of active constituents are required in this section as are in the w2_con.npt (or w2_con.csv) file under active constituents. The model user can decide which variables to output. The names of each state variable is ignored by the code. **ACTIVE: Character A8** is either OFF/ON and indicates whether to turn this output ON or OFF. **INTSCLE: Real F8.0** is the interval scale for the output state variable – it is the bin interval in the units of the state variable. **TOPLMIT: Real F8.0** is the upper limit of the histogram output.

```
CST DERI ACTIVE INTSCLE TOPLMIT
DOC      OFF    1.00   20.00
POC      OFF    1.00   20.00
TOC      OFF    1.00   20.00
DON      OFF    1.00   20.00
PON      OFF    1.00   20.00
TON      OFF    1.00   20.00
TKN      OFF    1.00   20.00
TN       OFF    1.00   20.00
DOP      OFF    1.00   20.00
POP      OFF    1.00   20.00
TOP      OFF    1.00   20.00
TP       OFF    1.00   20.00
APR      OFF    1.00   20.00
CHLA     OFF    1.00   20.00
ATOT     OFF    1.00   20.00
%DO      OFF    1.00   20.00
TSS      OFF    1.00   20.00
TISS     OFF    1.00   20.00
CBOD     OFF    1.00   20.00
pH       OFF    1.00   20.00
CO2      OFF    1.00   20.00
HCO3     OFF    1.00   20.00
CO3      OFF    1.00   20.00
                                         ! 14
```

CST DERI	ACTIVE	INTSCLE	TOPLMIT
DOC	OFF	1	20
POC	OFF	1	20
TOC	OFF	1	20
DON	OFF	1	20
PON	OFF	1	20
TON	OFF	1	20
TKN	ON	0.05	1
TN	ON	0.05	1
NH3	ON	0.05	1
DOP	OFF	1	20
POP	OFF	1	20
TOP	OFF	1	20
TP	OFF	1	20
APR	OFF	1	20
CHLA	OFF	1	20
ATOT	OFF	1	20
%DO	OFF	1	20
TDG	OFF	1	20
Turbidity	OFF	1	20

INPUT FILES

TSS	OFF	1	20
TISS	OFF	1	20
CBOD	OFF	1	20
pH	OFF	1	20
CO2	OFF	1	20
HCO3	OFF	1	20
CO3	OFF	1	20
SECCHI	OFF	1	20

The next line is a title line ignored by the code but the variable spacing format is shown. In the following lines, the same number of active derived constituents are required in this section as are in the w2_con.npt (or w2_con.csv) file under derived constituents (these though are not variable as are the active constituents). The model user can decide which variables to output. The names of each state variable is ignored by the code. **ACTIVE: Character A8** is either OFF/ON and indicates whether to turn this output ON or OFF. **INTSCLE: Real F8.0** is the interval scale for the output state variable – it is the bin interval in the units of the state variable. **TOPLIMIT: real F8.0** is the upper limit of the histogram output.

Typical output file is a comma delimited file and is easily opened directly in Excel. The first series of output lines are a histogram of the fraction of volume and time that the variable was in the specified interval. At the end of the column there is a sum of the fractions, which should sum to 1.0 and the last line is the temporal and volume weighted average over the entire model domain and simulation time period. An example is shown below.

An example of this type of analysis is shown comparing alternatives in watershed loading for Lake Tenkiller in OK, USA. Figure 37 shows the results for Total P histograms at one sampling station for different modeling scenarios.

TN_interval	Fraction_of_volume	TP_interval	Fraction_of_volume	CHLA_interval	Fraction_of_volume	%DO_interval	Fraction_of_volume
2	8.19E-01	0.15	9.09E-03	100	2.21E-03	20	8.24E-01
1.9	5.59E-02	0.1425	3.32E-03	95	7.99E-04	19	4.32E-03
1.8	4.34E-02	0.135	5.08E-03	90	1.06E-03	18	4.20E-03
1.7	3.49E-02	0.1275	8.23E-03	85	1.76E-03	17	4.24E-03
1.6	1.92E-02	0.12	1.45E-02	80	3.14E-03	16	4.31E-03
1.5	8.23E-03	0.1125	2.78E-02	75	5.37E-03	15	4.01E-03
1.4	4.39E-03	0.105	5.45E-02	70	8.85E-03	14	4.12E-03
1.3	3.20E-03	0.0975	8.73E-02	65	1.46E-02	13	4.06E-03
1.2	2.49E-03	0.09	1.07E-01	60	2.30E-02	12	4.09E-03
1.1	2.07E-03	0.0825	1.71E-01	55	3.42E-02	11	4.19E-03
1	1.73E-03	0.075	2.05E-01	50	4.61E-02	10	4.05E-03
0.9	1.47E-03	0.0675	1.07E-01	45	6.25E-02	9	4.15E-03
0.8	1.26E-03	0.06	1.46E-01	40	7.73E-02	8	4.02E-03
0.7	9.92E-04	0.0525	4.42E-02	35	9.02E-02	7	4.14E-03
0.6	1.44E-03	0.045	8.66E-03	30	1.10E-01	6	4.07E-03
0.5	3.95E-04	0.0375	1.50E-03	25	1.45E-01	5	4.17E-03
0.4	1.76E-04	0.03	1.13E-08	20	1.47E-01	4	4.14E-03
0.3	0.00E+00	0.0225	0.00E+00	15	1.17E-01	3	4.36E-03
0.2	1.13E-08	0.015	0.00E+00	10	7.83E-02	2	4.69E-03
0.1	4.94E-05	0.0075	4.94E-05	5	3.10E-02	1	1.01E-01
Sum_of_fractions		1 Sum_of_fractions		1 Sum_of_fractions		1 Sum_of_fractions	1
Average	2.38E+00	Average		8.45E-02	Average	3.25E+01	Average
							5.66E+01

INPUT FILES

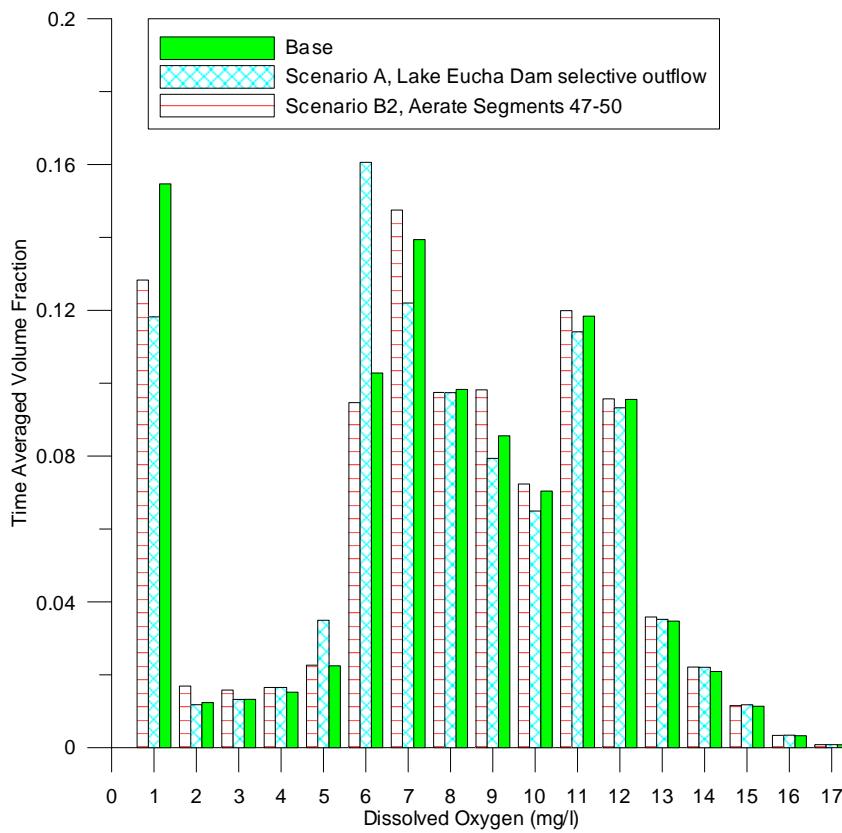


Figure 37. Environmental performance for 3 different scenario runs comparing dissolved oxygen in a eutrophic system Eucha Reservoir in OK.

Hypolimnetic Aeration

This section describes the hypolimnetic aeration algorithm which allows a model user to add oxygen and additional mixing to a section of a waterbody that is controlled by an oxygen probe at a specified location in the domain. The model reads the file, **w2_aerate.npt**, if the **AERATEC** control is '**ON**' in the **w2_con.npt** (or **w2_con.csv**) file. This input file allows the model user to

1. Add oxygen mass to specified model segments and layers
2. Control the oxygen mass added by using oxygen probes located anywhere in the model domain
3. Increase the mixing associated with the oxygen input

This algorithm does not model the dynamics of a bubble diffuser. It merely allows the user to experiment with delivering oxygen at given rates to parts of the reservoir domain. This is an excellent tool for planning since it does allow the model user to determine the amount of oxygen required to be delivered to meet a certain water quality target. The input file for hypolimnetic aeration, **w2_aerate.npt**, and a description of each line is shown below.

```
CONTROL FILE FOR Hypolimnetic aeration
NAER      OUTPUTFILE          # of aerators
1         aeration.opt
                           kg O2/d
```

INPUT FILES

SEG#	KTOP#	KBOT#	MASSRT	TIMON	TIMOFF	DZFACT	O2OFF	O2ON	iprb	kprb
31	25	30	1000.	1.0	125.0	5.	12.5	11.0	31	30

In the Excel input file, this input file is a separate tab as shown below:

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	CONTROL FILE FOR Hypolimnetic aeration												
2	NAER	OUTPUTFILE	# of aerators										
3	1	'aeration.opt'											
4	Layer top	Layer bottom	Rate of O2 mass	Start	End	Increase vertical mixing	mg/l O2	mg/l O2	Seg probe	Layer probe			
5	SEG#	KTOP#	KBOT#	MASSRT(kg O2/d)	TIMON	TIMOFF	DZFACT	O2OFF	O2ON	iprb	kprb		
6	31	25	30	12500	200	300	5	12.5	11	31	30		
7													
8													
9													
10													
11													
12													

An explanation of each term in the input file is shown in the table below:

Parameter	Values (typical)	Description
AERATION	ON/OFF	Turn on or off aeration/mixing
NAER	Integer from 1 to the maximum number of aerators	There is no limit to the number of aerators. These can also be thought of as 1 aerator turned ON/OFF at different time, so each aerator would be a different cycle of the aerator
OUTPUTFILE	Output file name	
SEG#	Integer segment #	Location of aerator
KTOP#	Top layer #	Location of aerator – 1 aerator can span more than 1 vertical layer
KBOT#	Bottom layer #	Location of aerator - 1 aerator can span more than 1 vertical layer
MASSRT	Rate of mass injection of air in kg O2/day	Rate of mass injection of O2
TIMON	Julian day	Start date for aerator
TIMOFF	Julian day	End date for aerator
DZFACT	Factor to multiply the vertical mixing coefficient: 1-100	A factor of 1 means to use the model predicted vertical mixing coefficient. A value of 100, means to increase the mixing value by 100X. If DZFACT=1, this assumes the aerator does not mix the water column. If DZFACT>1, then DZ is increased as a result of additional vertical mixing induced by the aerator. One should use this as a sensitivity analysis to see if an increase in vertical mixing will affect the efficiency of the aerator or whether it is desired or not.
O2OFF	Dissolved oxygen concentration in mg/l	Assuming we have a DO probe located at iprb and kprb, this tells the model when to turn off the aerator based on DO measurements at a user defined location
O2ON	Dissolved oxygen concentration in mg/l	Assuming we have a DO probe located at iprb and kprb, this tells the model when to turn on the aerator based on DO measurements at a user defined location
iprb	Integer segment #	Location of DO probe for turning ON/OFF the aerator

INPUT FILES

Parameter	Values (typical)	Description
kprb	Integer layer #	Location of DO probe for turning ON/OFF the aerator

As an example, a hypolimnetic aerator was inserted into DeGray Lake during 1980 at segment 31 over vertical layers 25 to 30 (see Figure 38). A dissolved oxygen probe was set at segment 31 and layer 30. This probe controlled aeration – aeration was turned ON when the dissolved oxygen was below 11 mg/l and was turned OFF when dissolved oxygen was at or above 12.5 mg/l. Figure 39 shows the results of the cumulative dissolved oxygen input in kg and the dissolved oxygen concentration at the probe location.

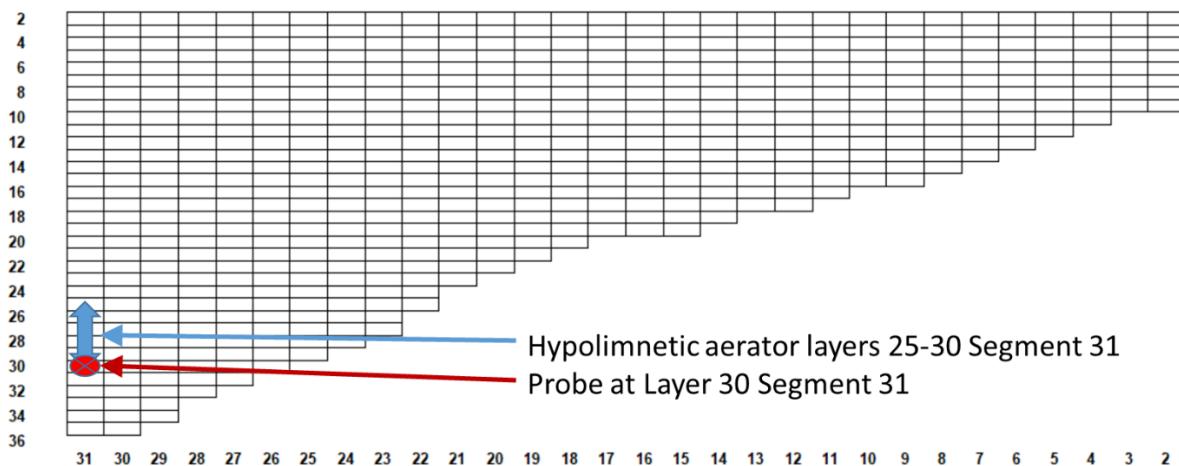


Figure 38. Side view of DeGray Reservoir grid used for hypolimnetic aeration.

INPUT FILES

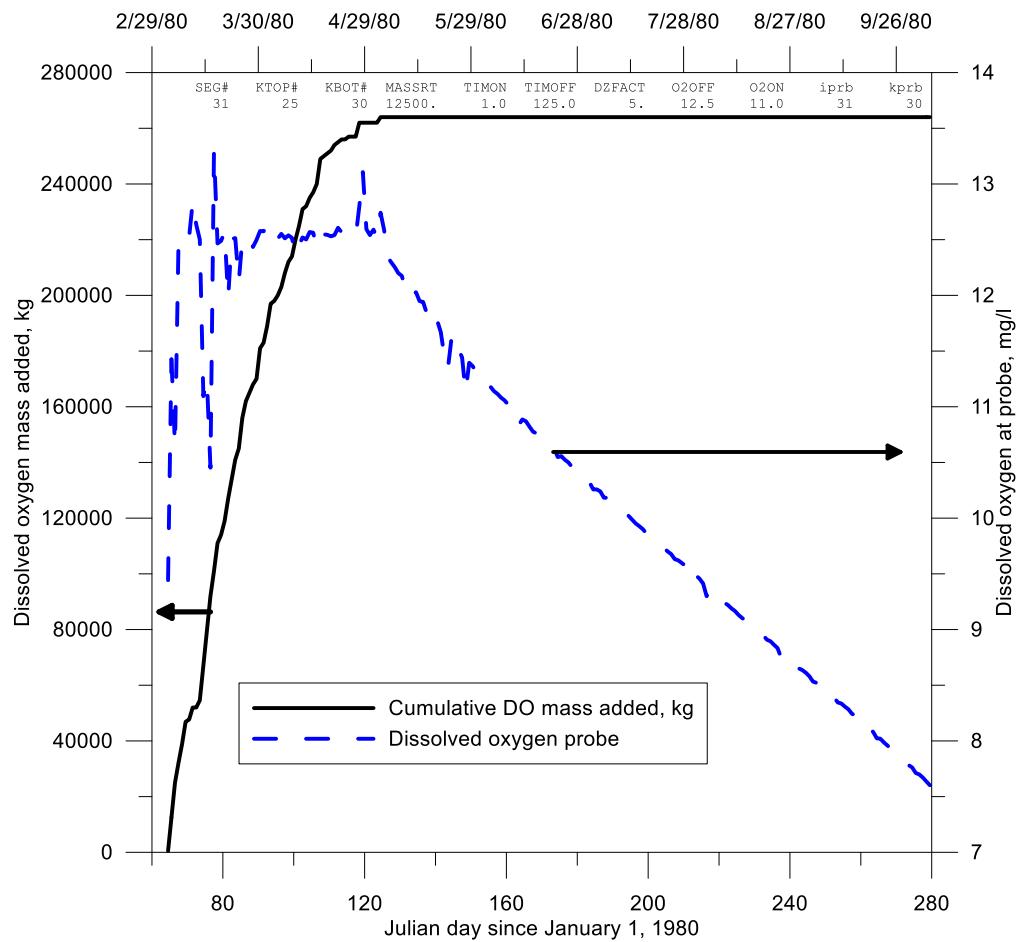


Figure 39. Dissolved oxygen at probe location and cumulative oxygen added in kg over period of aeration (Julian day 1-125). Target dissolved oxygen at probe location was between 11 and 12.5 mg/l.

Constriction Input File

The model user can specify a maximum width between segments by specifying that in an input file called '**w2_constriction.csv**'. This does not affect the width or volume of the segments – it only affects the right-hand side face width. Whereas an internal weir blocks all the flow, this allows for a reduced area and eliminates the need to insert a short segment of small width that can cause stability and a reduced time step for stability.

The input file '**w2_constriction.csv**' and has the following format:

Line 1: Comment

Line 2: ON or OFF, # of constrictions

Line 3: Comment

Line 4: [Repeated by # of constrictions] Segment # of constriction, Maximum width in m of constriction

INPUT FILES

A	B	C	D	E	F	G	H	I	J
1 Constriction ON/OFF	# of Constrictions								
2 OFF		1							
3 Seg #	Max width, m								
4 10	115								
5									
6	Export highlighted text to CSV file - no need for \$								
7	Go to Index of Sheets: Index of Sheets!A1								
8	Extend # of rows as # of constictions is increased.								
9									
10									
11									
	◀	▶	...	w2_aerate.npt	w2_envirprf.npt	w2_selective.npt	w2_constriction.csv	...	⊕

The W2 code looks for '**w2_constriction.csv**' and if it is found, the model reads the file and applies this to the right-hand side width between the specified 2 segments. This could be appropriate for bridge piers or other constrictions between 2 segments that might affect the flow between segments. An example is shown in Figure 40 for a bridge constriction between 2 segments.

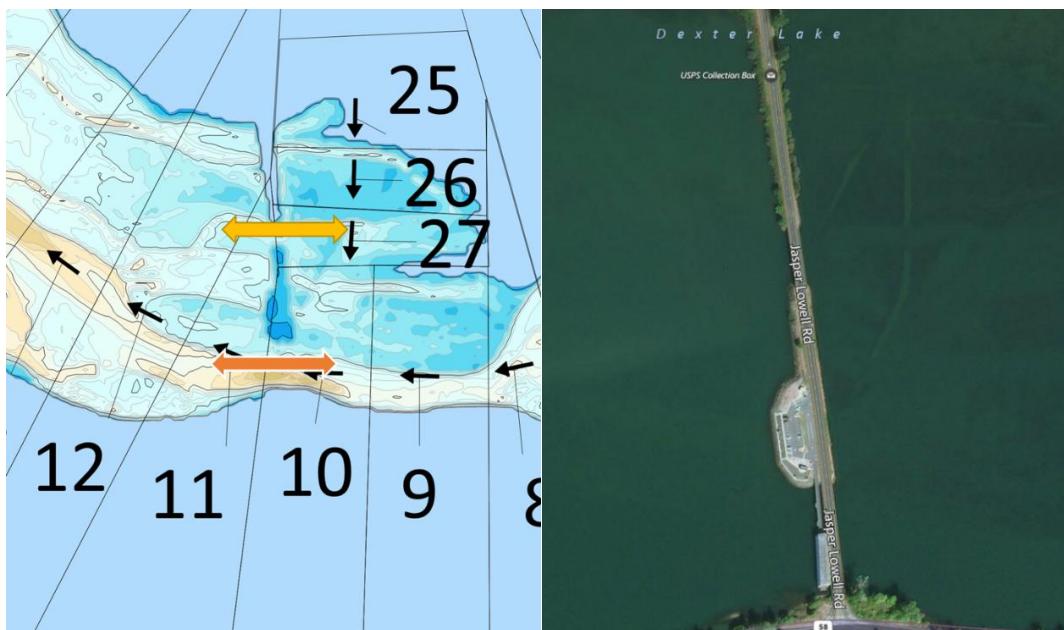


Figure 40. Constriction between segment 10 and 11 in Dexter Reservoir, OR, USA. Note that a spillway or weir was used for the connection between segment 27 and 11. (Map from Bing Maps, 2019.)

Sediment Diagenesis Input File

The control file for sediment diagenesis is called '**w2_diagenesis.npt**'. The control **SED_DIAG** in the main control file, **w2_con.npt** (or **w2_con.csv**), turns ON or OFF reading this input file. Note that '**w2_diagenesis.npt**' is the setup for the all the sediment diagenesis inputs except for those of the enhanced pH buffering and non-conservative alkalinity subroutines and bed consolidation which are in separate input files. In the Excel input file, there is a tab with the **w2_diagenesis.npt** title that can be used for writing out the diagenesis parameters.

Inputs for the '**W2_diagenesis.npt**' input file are described below following the sample input file. The descriptions have been adapted and expanded from those in ERM and Golder Associates (2011).

INPUT FILES

W2_diagenesis.npt Sample Input File

The sample below is the comma delimited input file written from the Excel input file and the Excel sheet.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1 \$ W2_diagenesis input file													
2 \$ All lines at top of file starting with \$ are comments and disregarded by the model													
3 \$ 08/29/2020 Additional inputs are required if a group switch is ON													
4 \$ Zhong Zhang													
5 "Global Switch for all sediment diagenesis features"	.TRUE.												
6 "Include FFT layer (Fine Fluids Tailing - for Pit Lakes)"	.FALSE.												
7 "FFT layer number of periods"	5												
8 "FFT layer start times"	1	65	125	200	300								
9 "FFT layer end times"	50	100	175	250	400								
10 "Initial tailings concentration in FFT (gm/m3)"	360000												
11 "Sediment settling velocity of FFT to MFT (m/d)"	0												
12 "Move FFT layer during consolidation"	.FALSE.												
13 "Include bed consolidation"	.FALSE.												
14 "Fraction of layer thickness at which water layer is added"	1												
15 "Number of bed consolidation regions"	6												
16 "Starting segment for regions"	1	14	36	54	67	82							
17 "Ending segment for regions"	13	35	51	66	81	90							
18 "Data type for bed consolidation for each region (0: Constant, 1: Time varying)"	1	1	1	1	1	1							
19 "Bed consolidation rate (m/d)"	0	0	0	0	0	0							
20 "Bed consolidation data file"	Regn.npt												
21 "Write bed elevation snapshot output"	.FALSE.												
22 "Write bed porosity snapshot output"	.FALSE.												
23 "Include sediment diagenesis simulation"	.TRUE.												
24 "Initial bed thickness in meters"	0.2												
25 "Initial sediment bed porosity"	0.8												
26 "Sediment bed particle size in microns"	100												
27 "Sediment type (1: Cohesive, 2: Non-cohesive)"	2												
28 "Sediment bulk density (kg/m3)"	2600												
29 "Sediment particle settling velocity (m/d)"	5												
30 "Include sediment resuspension and deposition processes"	.FALSE.												
31 "Include bubble release"	.FALSE.												
32 "Gas diffusion coefficient in sediment in m/s"	1.0d-9												
33 "Calibration parameter R1 in m"	0.0014												
34 "Young's modulus E in N/m2"	1.4d+9												
35 "Critical stress intensity factor for sediments K1c in N/m^3/2"	300												
36 "Bubbles release scale"	0												
37 "Fraction of critical pressure at which cracks close"	0.2												
38 "Switch to limit bubble size"	.TRUE.												
39 "Maximum bubble radius in mm"	80												
40 "Switch to use slow release of bubbles"	.TRUE.												
41 "Bubbles release fraction (sediments)"	0.001												
42 "Bubbles accumulation fraction"	0.1												
43 "Number of bubbles release array"	2000												
44 "Bubbles release fraction (atmosphere)"	0.001												
45 "Bubbles-water gas exchange rate (1/s)"	1.0e-7												
46 "Apply additional turbulence due to bubbles release"	.FALSE.												
47 "Turbulence scaling factor for bubbles release"	0.001												
48 "Include POM resuspension"	.FALSE.												
49 "Critical shear stress for POM resuspension dynes/cm^2"	0.001												
50 "Critical Shields parameter for POM"	10												
51 "Use Cao method to estimate critical Shields parameter (rather than using input value)"	.FALSE.												
52 "POM specific gravity"	1.5												
53 "POM particle diameter m"	0.0001												
54 "Include modeling of alkalinity/pH in sediments"	.FALSE.												
55 "Include modeling of iron (FeOII and FeIII) in sediments"	.FALSE.												
56 "Include modeling of Manganese (MnII and MnO2) in sediments"	.FALSE.												
57 "Number of regions for different initial sediment concentrations"	2												
58	Region1	Region2	Region3	Region4	Region5								
59 "Starting segment for regions"	2	14											
60 "Ending segment for regions"	33	31											
61 "Initial sediment temperature oC"	10	10											
62 "Initial sediment pH (only used if include modeling dynamic pH)"	7	7											
63 "Initial POC (total) concentration mgC/L"	2275.946	2275.946											
64 "Initial PON (total) concentration mgN/L"	326.003	326.003											
65 "Initial POP (total) concentration mgP/L"	25.766	25.766											

INPUT FILES

A	B	C	D	E	F	G	H	I	J	K	L	M	N
64 "Initial PON (total) concentration mgN/l"	326.003	326.003						6					
65 "Initial POP (total) concentration mgP/l"	25.266	25.266						7					
66 "Initial SO4 concentration mgS/l"	0	0						8					
67 "Initial dissolved NH4 concentration mgN/l"	0.05	0.05						9					
68 "Initial dissolved NO3 concentration mgN/l"	0	0						10					
69 "Initial total PO4 concentration mgP/l"	9.505	9.505						11					
70 "Initial dissolved H2S concentration mgS/l"	0	0						12					
71 "Initial CH4 concentration mgC/l"	0.092	0.092						13					
72 "Initial TIC concentration mgC/l"	4.011	4.011						14					
73 "Initial Alkalinity concentration for each region mg/l as CaCO3"	50	50						15					
74 "Initial Ferrous Iron concentration for each region mgFe/l"								16					
75 "Initial Iron Oxyhydroxide concentration for each region mgFe/l"								17					
76 "Initial Mn(II) concentration for each region mgMn/l"								18					
77 "Initial manganese dioxide concentration for each region mgMn/l,"								19					
78 "Number of regions for different diagenesis related rates"	2												
79	Region1	Region2	Region3	Region4	Region5								
80 "Starting segment for regions"	2	14						1					
81 "Ending segment for regions"	13	31						2					
82 "Fraction of labile POC"	0.1	0.1						3					
83 "Fraction of refractory POC"	0.89	0.89						4					
84 "Fraction of labile PON"	0.1	0.1						5					
85 "Fraction of refractory PON"	0.89	0.89						6					
86 "Fraction of labile POP"	0.1	0.1						7					
87 "Fraction of refractory POP"	0.89	0.89						8					
88 "Pore water diffusion coefficient m2/d"	0.0025	0.0025						9					
89 "Particle mixing velocity between aerobic and anaerobic layers m2/d"	0.00006	0.00006						10					
90 "Burial velocity m/d"	0.000274	0.000274						11					
91 "Reference POC G1 concentration for bioturbation mg C/g Calculation of final bent"	0.01	0.01						12					
92 "CH4 production calculation method (0: Analytical 1: Numerical)"	1	1						13					
93 "DO threshold for aerobic layer oxidation rates mgO2/L"	2	2						14					
94 "Nitritification rate in aerobic layer at DO below threshold m/d"	0.3	0.3						15					
95 "Nitritification rate in aerobic layer at DO above threshold m/d"	0.3	0.3						16					
96 "Denitrification rate in aerobic layer at DO below threshold m/d"	0.1	0.1						17					
97 "Denitrification rate in aerobic layer at DO above threshold m/d"	0.1	0.1						18					
98 "Denitrification rate in aerobic layer m/d"	0.1	0.1						19					
99 "CH4 oxidation rate in aerobic layer m/d"	0.7	0.7						20					
100 "Half-saturation oxygen constant for CH4 oxidation mg-O2/L"	0	0						21					
101 "Nitritification half-saturation constant for NH4 in aerobic layer mgN/l"	0.728	0.728						22					
102 "Nitritification half-saturation constant for O2 in aerobic layer mgO2/L"	0.37	0.37						23					
103 "Temperature coefficient for pore water diffusion between layers"	1.08	1.08						24					
104 "Temperature coefficient for particle mixing diffusion coefficient"	1	1						25					
105 "Temperature coefficient for infiltration"	1.123	1.123						26					
106 "Temperature coefficient for denitrification"	1.08	1.08						27					
107 "Temperature coefficient for methane oxidation"	1.079	1.079						28					
108 "SO4 concentration above which sulfide over methane is produced mgS/l"	20	20						29					
109 "H2S oxidation rate in aerobic layer m/d"	0.2	0.2						30					
110 "Temperature coefficient for H2S oxidation"	1.079	1.079						31					
111 "H2S oxidation normalization constant for O2 mgO2/L"	4	4						32					
112 "Diagenesis rate for labile POC (G1) 1/d"	0.035	0.035						33					
113 "Diagenesis rate for refractory POC (G2) 1/d"	0.0018	0.0018						34					
114 "Diagenesis rate for inert/slow refractory POC (G3) 1/d"	0	0						35					
115 "Diagenesis rate for labile PON (G1) 1/d"	0.035	0.035						36					
116 "Diagenesis rate for refractory PON (G2) 1/d"	0.0018	0.0018						37					
117 "Diagenesis rate for inert/slow refractory PON (G3) 1/d"	0	0						38					
118 "Diagenesis rate for labile POP (G1) 1/d"	0.035	0.035						39					
119 "Diagenesis rate for refractory POP (G2) 1/d"	0.0018	0.0018						40					
120 "Diagenesis rate for inert/slow refractory POP (G3) 1/d"	0	0						41					
121 "Temperature coefficient for labile POC"	1.1	1.1						42					
122 "Temperature coefficient for refractory POC"	1.15	1.15						43					
123 "Temperature coefficient for inert/slow refractory POC"	1	1						44					
124 "Temperature coefficient for labile PON"	1.1	1.1						45					
125 "Temperature coefficient for refractory PON"	1.15	1.15						46					
126 "Temperature coefficient for inert/slow refractory PON"	1	1						47					
127 "Temperature coefficient for labile POP"	1.1	1.1						48					
128 "Temperature coefficient for refractory POP"	1.15	1.15						49					
129 "Temperature coefficient for inert/slow refractory POP"	1	1						50					

These can be different regions than above
Rate constants

w2_con.csv | Required Constituent Order | w2_habitat.npt | w2_diagenesis.npt | w2_aerate.npt | w2_er ... + : |

INPUT FILES

A	B	C	D	E	F	G	H	I
123 "Temperature coefficient for inert/slow refractory POC"	1							44
124 "Temperature coefficient for labile PON"	1.1							45
125 "Temperature coefficient for refractory PON"	1.15							46
126 "Temperature coefficient for inert/slow refractory POP"	1							47
127 "Temperature coefficient for labile POP"	1.1							48
128 "Temperature coefficient for refractory POP"	1.15							49
129 "Temperature coefficient for inert/slow refractory POP"	1 Test 3	Test2	Test1					50
130 "PO4 sorption coefficient in anaerobic layer m^3/kg"	0.5	0.1	0	0.02				51
131 "Incremental PO4 partition coefficient"	0.02	0.3	0	0				52
132 "Critical oxygen concentration for incremental sorption mg-O2/L"	2	2	0.01	0.01				53
133 "NH4 sorption coefficient in aerobic layer m^3/kg"	0							54
134 "NH4 sorption coefficient in anaerobic layer m^3/kg"	0							55
135 "H2S sorption coefficient in aerobic layer m^3/kg"	0							56
136 "H2S sorption coefficient in anaerobic layer m^3/kg"	0							57
"Algorithm for POM resuspension (0: Wind induced resuspension, 1: Bottom scour resuspension) Only used if include POM resuspension is .TRUE."	1							58
138 "Fe(II) sorption coefficient in aerobic layer m^3/kg"	0.05	0.05						59
139 "Fe(II) sorption coefficient in anaerobic layer m^3/kg"	0.05	0.05						60
140 "Mn(II) sorption coefficient in aerobic layer m^3/kg"	0.05	0.05						61
141 "Mn(II) sorption coefficient in anaerobic layer m^3/kg"	0.05	0.05						62
142 "Write sediment fluxes"	.TRUE.							63
143 "Frequency of output days"	1							64
144 "Sediment Temperature Computations=1 (internal calcs or =2 neighboring water)"	2							65
145 "Subdirectory for Sediment Diagenesis Output (no quotes needed if no spaces in name)"	\SedDiagOutput							= if blank it writes to root directory
146								
147								

```

$ W2_diagenesis input file,,,
$ All lines at top of file starting with $ are comments and disregarded by the
model,,,
$ 08/29/2020 Additional inputs are required if a group switch is ON,,,
$ Zhong Zhang,,,
"Global Switch for all sediment diagenesis features", .TRUE.,,
"Include FFT layer (Fine Fluids Tailing - for Pit Lakes)", .FALSE.,,
"FFT layer number of periods",5,,,
"FFT layer start times",1,65,125,200,300,,,
"FFT layer end times",50,100,175,250,400,,,
"Initial tailings concentration in FFT (gm/m3)",360000,,,
"Sediment settling velocity of FFT to MFT (m/d)",0,,,
"Move FFT layer during consolidation",.FALSE.,,
"Include bed consolidation", .FALSE.,,
"Fraction of layer thickness at which water layer is added",1,,,
"Number of bed consolidation regions",6,,,
"Starting segment for regions",1,14,36,54,67,82,,,
"Ending segment for regions",13,35,51,66,81,90,,,
>Data type for bed consolidation for each region (0: Constant, 1: Time varying),1,1,1,1,1,,,
"Bed consolidation rate (m/d)",0,0,0,0,0,,,
"Bed consolidation data file",Regn.npt,,,
"Write bed elevation snapshot output",.FALSE.,,
"Write bed porosity snapshot output",.FALSE.,,
"Include sediment diagenesis simulation", .TRUE.,,
"Initial bed thickness in meters",0.2,,,
"Initial sediment bed porosity",0.8,,,
"Sediment bed particle size in microns",100,,,
"Sediment type (1: Cohesive, 2: Non-cohesive)",2,,,
"Sediment bulk density (kg/m3)",2600,,,
"Sediment particle settling velocity (m/d)",5,,,
"Include sediment resuspension and deposition processes",.FALSE.,,
"Include bubble release", .FALSE.,,
"Gas diffusion coefficient in sediment in m/s",1.0d-9,,,
"Calibration parameter R1 in m",0.0014,,,
"Young's modulus E in N/m^2",1.4d+9,,,
"Critical stress intensity factor for sediments K1c in N/m^3/2",300,,,
"Bubbles release scale",0,,,
"Fraction of critical pressure at which cracks close",0.2,,,
"Switch to limit bubble size",.TRUE.,,
"Maximum bubble radius in mm",80,,,
"Switch to use slow release of bubbles",.TRUE.,,
"Bubbles release fraction (sediments)",0.001,,,

```

INPUT FILES

```
"Bubbles accumulation fraction",0.1,,,,,
"Number of bubbles release array",2000,,,,,
"Bubbles release fraction (atmosphere)",0.001,,,,,
"Bubbles-water gas exchange rate (1/s)",1.0d-7,,,,,
"Apply additional turbulence due to bubbles release",.FALSE.,,,,
"Turbulence scaling factor for bubbles release",0.001,,,,,
"Include POM resuspension", .FALSE.,,,,
"Critical shear stress for POM resuspension dynes/cm^2",0.001,,,,,
"Critical Shields parameter for POM",10,,,,,
"Use Cao method to estimate critical Shields parameter (rather than using input
value)",.FALSE.,,,,
"POM specific gravity",1.5,,,,,
"POM particle diameter m",0.0001,,,,,
"Include modeling of alkalinity/pH in sediments", .FALSE.,,,,
"Include modeling of Iron (FeOOH and Fe(II)) in sediments", .FALSE.,,,,
"Include modeling of Manganese (Mn(II) and MnO2) in sediments", .FALSE.,,,,
"Number of regions for different initial sediment concentrations",2,,,,,
,Region1,Region2,Region3,Region4,Region5,,,
"Starting segment for regions",2,14,,,,,
"Ending segment for regions",13,31,,,,,
"Initial sediment temperature oC",10,10,,,,,
"Initial sediment pH (only used if include modeling dynamic pH)",7,7,,,,,
"Initial POC (total) concentration mgC/L",2275.946,2275.946,,,,,
"Initial PON (total) concentration mgN/L",326.003,326.003,,,,,
"Initial POP (total) concentration mgP/L",25.266,25.266,,,,,
"Initial SO4 concentration mgS/L",0,0,,,,,
"Initial dissolved NH4 concentration mgN/L",0.05,0.05,,,,,
"Initial dissolved NO3 concentration mgN/L",0,0,,,,,
"Initial total PO4 concentration mgP/L",9.505,9.505,,,,,
"Initial dissolved H2S concentration mgS/L",0,0,,,,,
"Initial CH4 concentration mgC/L",0.092,0.092,,,,,
"Initial TIC concentration mgC/L",4.011,4.011,,,,,
"Initial Alkalinity concentration for each region mg/l as CaCO3",50,50,,,,,
"Initial Ferrous Iron concentration for each region mgFe/l",,,,,,
"Initial Iron Oxyhydroxide concentration for each region mgFe/l",,,,,,
"Initial Mn(II) concentration for each region mgMn/l",,,,,,
"Initial manganese dioxide concentration for each region mgMn/l",,,,,,
"Number of regions for different diagenesis related rates",2,,,,,
,Region1,Region2,Region3,Region4,Region5,,,
"Starting segment for regions",2,14,,,,,
"Ending segment for regions",13,31,,,,,
"Fraction of labile POC",0.1,0.1,,,,,
"Fraction of refractory POC",0.89,0.89,,,,,
"Fraction of labile PON",0.1,0.1,,,,,
"Fraction of refractory PON",0.89,0.89,,,,,
"Fraction of labile POP",0.1,0.1,,,,,
"Fraction of refractory POP",0.89,0.89,,,,,
"Pore water diffusion coefficient m2/d",0.0025,0.0025,,,,,
"Particle mixing velocity between aerobic and anaerobic layers
m2/d",0.00006,0.00006,,,,,
"Burial velocity m/d",0.000273973,0.000273973,,,,,
"Reference POC G1 concentration for bioturbation mg-C/g Calculation of final benthic par-
ticle mixing velocity Equation 13.6 in DoToro (2001)",0.01,0.01,,,,,
"CH4 production calculation method (0: Analytical 1: Numerical)",1,1,,,,,
"DO threshold for aerobic layer oxidation rates mgO2/L",2,2,,,,,
"Nitrification rate in aerobic layer at DO below threshold m/d",0.3,0.3,,,,,
"Nitrification rate in aerobic layer at DO above threshold m/d",0.3,0.3,,,,,
"Denitrification rate in aerobic layer at DO below threshold m/d",0.1,0.1,,,,,
"Denitrification rate in aerobic layer at DO above threshold m/d",0.1,0.1,,,,,
"Denitrification rate in anerobic layer m/d",0.1,0.1,,,,,
"CH4 oxidation rate in aerobic layer m/d",0.7,0.7,,,,,
"Half-saturation oxygen constant for CH4 oxidation mg-O2/L",0,0,,,,,
"Nitrification half-saturation constant for NH4 in aerobic layer mgN/L",0.728,0.728,,,,,
"Nitrification half-saturation constant for O2 in aerobic layer mgO2/L",0.37,0.37,,,,,
"Temperature coefficient for pore water diffusion between layers",1.08,1.08,,,,,
"Temperature coefficient for particle mixing diffusion coefficient",1,1,,,,,
"Temperature coefficient for nitrification",1.123,1.123,,,,,
"Temperature coefficient for denitrification",1.08,1.08,,,,,
```

INPUT FILES

```
"Temperature coefficient for methane oxidation",1.079,1.079,,,,,
"SO4 concentration above which sulfide over methane is produced mgS/L",20,20,,,,,
"H2S oxidation rate in aerobic layer m/d",0.2,0.2,,,,,
"Temperature coefficient for H2S oxidation",1.079,1.079,,,,,
"H2S oxidation normalization constant for O2 mgO2/L",4,4,,,,,
"Diagenesis rate for labile POC (G1) 1/d",0.035,0.035,,,,,
"Diagenesis rate for refractory POC (G2) 1/d",0.0018,0.0018,,,,,
"Diagenesis rate for inert/slow refractory POC (G3) 1/d",0,0,,,,,
"Diagenesis rate for labile PON (G1) 1/d",0.035,0.035,,,,,
"Diagenesis rate for refractory PON (G2) 1/d",0.0018,0.0018,,,,,
"Diagenesis rate for inert/slow refractory PON (G3) 1/d",0,0,,,,,
"Diagenesis rate for labile POP (G1) 1/d",0.035,0.035,,,,,
"Diagenesis rate for refractory POP (G2) 1/d",0.0018,0.0018,,,,,
"Diagenesis rate for inert/slow refractory POP (G3) 1/d",0,0,,,,,
"Temperature coefficient for labile POC",1.1,1.1,,,,,
"Temperature coefficient for refractory POC",1.15,1.15,,,,,
"Temperature coefficient for inert/slow refractory POC",1,1,,,,,
"Temperature coefficient for labile PON",1.1,1.1,,,,,
"Temperature coefficient for refractory PON",1.15,1.15,,,,,
"Temperature coefficient for inert/slow refractory PON",1,1,,,,,
"Temperature coefficient for labile POP",1.1,1.1,,,,,
"Temperature coefficient for refractory POP",1.15,1.15,,,,,
"Temperature coefficient for inert/slow refractory POP",1,1,,,,,
"PO4 sorption coefficient in anaerobic layer m^3/kg",0.02,0.02,,,,,
"Incremental PO4 partition coefficient",0,0,,,,,
"Critical oxygen concentration for incremental sorption mg-O2/L",0.01,0.01,,,,,
"NH4 sorption coefficient in aerobic layer m^3/kg",0.001,0.001,,,,,
"NH4 sorption coefficient in anaerobic layer m^3/kg",0.001,0.001,,,,,
"H2S sorption coefficient in aerobic layer m^3/kg",0.1,0.1,,,,,
"H2S sorption coefficient in anaerobic layer m^3/kg",0.1,0.1,,,,,
"Algorithm for POM resuspension (0: Wind induced resuspension, 1: Bottom scour resuspension) Only used if Include POM resuspension is .TRUE.",1,0,,,,,
"Fe(II) sorption coefficient in aerobic layer m^3/g",0.00005,0.00005,,,,,
"Fe(II) sorption coefficient in anaerobic layer m^3/g",0.01,0.01,,,,,
"Mn(II) sorption coefficient in aerobic layer m^3/g",0.00005,0.00005,,,,,
"Mn(II) sorption coefficient in anaerobic layer m^3/g",0.01,0.01,,,,,
"Write sediment fluxes", .TRUE.,,,,
"Frequency of output days",1,,,,,
"Sediment Temperature Computations=1 (internal calcs or =2 neighboring water)",2,,,,,
"Subdirectory for Sediment Diagenesis Output (no quotes needed if no spaces in name)",..\SedDiagOutput,,,if blank it writes to root directory,,
```

W2_diagenesis.npt Input Descriptions

Line Comments

Lines that begin with a dollar sign '\$' at the beginning of the file are skipped by the model when reading the input file. In the sample input file, the first 4 lines are skipped. The user can add any lines with the '\$' for comments.

Sample Line	Description
\$Additional CEMA related W2 input	Line Comment
\$Please see help file for input description	Line Comment
\$All lines starting with \$ are comments and disregarded by the model	Line Comment
\$Zhong Zhang	Line Comment: Zhong made these recent updates for V4.5

INPUT FILES

Global ON/OFF Switch

Sample Line	Description
"Global Switch for all sediment diagenesis features,", .TRUE.	Turns ON/OFF all features included in sediment diagenesis module. Note that the user must also turn the sediment diagenesis processes switch to '.TRUE.' also for the model to compute diagenesis (see 'Include Sediment Diagenesis Processes').

Fine Fluids Tailing (FFT) Layer

Sample Line	Description
"Include FFT Layer,", .FALSE.	Switch to include FFT Layer. '.TRUE.' or '.FALSE.' FFT: Fine Fluids Tailing
"FFT Layer Number of Periods,", 5	FFT Layer Number of Periods
"FFT Layer Start Times,", 1,65,125,200,300	FFT Layer Start Times (Julian Day)
"FFT Layer End Times,", 50,100,175,250,400	FFT Layer End Times (Julian Day)
"Initial tailings concentration in FFT (gm/m ³),", 360000	Initial tailings concentration in FFT (g/m ³)
"Settling velocity of FFT to MFT (m/d),", 0.d0	Settling velocity of FFT to MFT (m/d)
"Move FFT layer during consolidation,", .FALSE.	Switch to move FFT layer during consolidation. '.TRUE.' or '.FALSE.'

Bed Consolidation

Sample Line	Description
"Include bed consolidation,", .FALSE.	Switch to perform bed consolidation. '.TRUE.' or '.FALSE.'
"Fraction of layer thickness at which water layer is added,", 1.0	Fraction of layer thickness at which water layer is added
"Number of bed consolidation regions,", 1	Number of bed consolidation regions
"Starting segment for regions,", 2	Starting segment for regions
"Ending segment for regions,", 4	Ending segment for regions
"Data type for bed consolidation for each region (0: Constant, 1: Time varying),", 1	Data type for bed consolidation for each region
"Bed consolidation rate (m/d),", 0.02739726	Bed consolidation rate (m/d)
"Bed consolidation data file,", "Regnl.npt,"	Bed consolidation data file

Consolidation Output

Sample Line	Description
"Write bed elevation snapshot output,", .TRUE.	Switch to write bed elevation snapshot output. '.TRUE.' or '.FALSE.'
"Write bed porosity snapshot output,", .TRUE.	Switch to write bed porosity snapshot output. '.TRUE.' or '.FALSE.'

Include Sediment Diagenesis Processes

INPUT FILES

Sample Line	Description
"Include sediment diagenesis processes,", .TRUE.	Switch to include sediment diagenesis processes. '.TRUE.' or '.FALSE.' When this is TRUE, the first order and zero order sediment diagenesis processes are ignored in the model and only sediment diagenesis computations are performed.

Initial Conditions

Sample Line	Description
"Initial sediment bed thickness in meters,", 0.1	Thickness of sediment diagenesis bed (m)
"Initial sediment bed porosity,", 0.8	Initial sediment bed porosity

Sediment Characteristics

Sample Line	Description
"Sediment bed particle size in microns,", 100	Sediment bed particle size (microns)
"Sediment type 1: Cohesive, 2: Non-cohesive,", 2	Sediment type: '1'=Cohesive, '2'=Non-cohesive
"Sediment bulk density (kg/m³),", 2600	Sediment bulk density (kg/m³)
"Sediment particle settling velocity (m/d),", 5.0	Sediment particle settling velocity (m/d)
"Include sediment resuspension and deposition processes,", .TRUE.	Switch to include sediment resuspension and deposition processes. '.TRUE.' or '.FALSE.'

Gas Bubble Formation Rates

Sample Line	Description
"Gas Bubbles_Calculation", .FALSE.	Switch to activate gas bubble calculation in sediment diagenesis, 'TRUE.' Or 'FALSE'
"Gas diffusion coefficient in sediment in m²/s,", 1.0d-9	Gas diffusion coefficient in sediment (m²/s)
"Calibration parameter R1 in m,", 0.0014	Calibration parameter R1 (m)
"Young's modulus E in N/m²,", 1.4d+9	Young's modulus E (N/m²)
"Critical stress intensity factor for sediments K1c in N/m³/2,", 300	Critical stress intensity factor for sediments K1c (N/m³/2)
"Bubbles release scale,", 0.02	Bubbles release scale
"Fraction of critical pressure at which cracks close,", 0.20	Fraction of critical pressure at which cracks close
"Switch to limit bubble size,", .TRUE.	Switch to limit bubble size
"Maximum bubble radius in mm,", 80	Maximum bubble radius (mm)
"Switch to use slow release of bubbles,", .TRUE.	Switch to use slow release of bubbles
"Bubbles release fraction (sediments),", 0.005	Bubbles release fraction (sediments)
"Bubbles accumulation fraction,", 0.1	Bubbles accumulation fraction
"Number of bubbles release array,", 2000	Number of bubbles release array
"Bubbles release fraction (atmosphere),", 0.001	Bubbles release fraction (atmosphere)
"Bubbles-Water gas exchange rate (1/s),", 1.0d-7	Bubbles-Water gas exchange rate (1/s)

INPUT FILES

Bubble Related Turbulence

Sample Line	Description
"Apply additional turbulence due to bubbles release,", .TRUE.	Apply additional turbulence due to bubbles release, '.TRUE.' or '.FALSE.'
"Turbulence scaling factor for bubbles release,", 0.001	Scaling factor for bubbles related turbulence

Resuspension of Particulate Organic Matter

Sample Line	Description
"Include particulate organic matter resuspension processes,", .FALSE.	Turns ON/OFF resuspension of particulate organic matter in the sediments
"Critical shear stress for particulate organic matter resuspension dynes/cm^2", 0.001	Critical shear stress for particulate organic matter resuspension dynes/cm^2
"Critical Shields parameter for POM", 10.0	Critical Shields parameter for Particulate organic matter (POM)
"Use Cao method to estimate critical Shields parameter (rather than using input value)", .FALSE.	Turns ON/OFF option to use Cao method to estimate critical Shields parameter (rather than using input value)
"Specific gravity of particulate organic matter," 1.5	Specific gravity of particulate organic matter
"Particulate organic matter particle diameter m,", 0.0001	Particulate organic matter particle diameter m

Switches for Iron, Mn, and Alkalinity/pH in sediments

Sample Line	Description
"Include modeling of alkalinity/pH in sediments,", .FALSE.	Turns ON/OFF sediment calculations for alkalinity and pH, '.TRUE.' or '.FALSE.'
"Include modeling of Iron (FeOOH and Fe(II)) in sediments,", .FALSE.	Turns ON/OFF Iron (FeOOH and Fe(II)) in sediments, '.TRUE.' OR '.FALSE'
"Include modeling of Manganese (MnO2 and Mn(II)) in sediments,", .FALSE.	Turns ON/OFF Manganese (MnO2 and Mn(II)) in sediments, '.TRUE.' OR '.FALSE'

Diagenesis Initial Conditions

Note that the initial conditions for C, N, and P for the sediment are in mg/l. For example, if field data on sediment composition are in units of mass of an element per mass of sediment, then one can convert to mg/l as follows: Assuming we had mg P/g sediment, we would multiply mg P/g by 1 g/1000 mg giving the mass fraction of P (g P per g of sediment). Then, multiplying the P Fraction times the dry bulk density (in g sediment/m³) would give the P density in units of g/m³ or mg/L.

Sample Line	Description
"Number of regions for different initial sediment concentrations,", 1	Number of regions for different initial sediment concentrations
"Starting segment for regions,", 2	Starting segment for regions
"Ending segment for regions,", 4	Ending segment for regions

INPUT FILES

Sample Line	Description
"Initial temperature for each region C,", 20.0	
"Initial particulate organic carbon (total) concentration for each region mgC/l,", 0.0	Initial particulate organic carbon (total) concentration for each region (mgC/l)
"Initial particulate organic nitrogen (total) concentration for each region mgN/l,", 0.0	Initial particulate organic nitrogen (total) concentration for each region (mgN/l)
"Initial sulfate concentration for each region mgs/l,", 0.0	Initial sulfate concentration for each region (mg-S/l)
"Initial dissolved ammonia concentration for each region mgN/l,", 0.0	Initial dissolved ammonia concentration for each region (mg-N/l)
"Initial dissolved NO3-N concentration for each region mgN/l,", 0.0	Initial dissolved nitrate concentration for each region (mg-N/l)
"Initial total phosphate concentration for each region mgP/l,", 0.0	Initial dissolved PO4-P concentration for each region (mg-P/l)
"Initial dissolved sulfide concentration for each region mgS/l,", 0.0	Initial dissolved sulfide concentration for each region (mg-S/l)
"Initial dissolved methane concentration for each region mgC/l,", 0.0	Initial dissolved methane concentration for each region (mg-C/l)
"Initial total inorganic carbon concentration for each region mgC/l,", 11.9	Initial total inorganic carbon concentration for each region (mg-C/l)
"Initial alkalinity concentration for each region mg/l as CaCO3,", 40.0	Initial alkalinity concentration for each region (mg-CaCO3/l)
"Initial Ferrous Iron concentration for each region mgFe/l,", 1.0	Initial ferrous iron concentration for each region (mg-Fe/l)
"Initial Iron Oxyhydroxide concentration for each region mgFe/l,", 1.0	Initial iron oxyhydroxide concentration for each region (mg-Fe/l)
"Initial Mn(II) concentration for each region mgMn/l,", 1.0	Initial Mn(II) concentration for each region (mg-Mn/l)
"Initial manganese dioxide concentration for each region mgMn/l,", 1.0	Initial manganese dioxide concentration for each region (mg-Mn/l)

Diagenesis Region Settings

Sample Line	Description
"Number of regions for different diagenesis related rates,", 1	Number of regions for different diagenesis related rates
"Starting segment for regions,", 2	Starting segment for regions
"Ending segment for regions,", 4	Ending segment for regions
"Fraction of labile poc for each diagenesis region,", 0.65	Fraction of labile POC for each diagenesis region. Note if this value is negative, like -0.65, this implies that the ratio is dynamically computed over time based on the fraction of labile to refractory material settling into the sediment layer. If negative, then the 0.65 is treated as an initial ratio. Just setting this first variable (labile POC) to a minus value changes all the fractions below for N and P also. Typical values from DiToro(2001): 0.5-0.65
"Fraction of refractory poc for each diagenesis region,", 0.25	Fraction of refractory POC for each diagenesis region. Typical

INPUT FILES

Sample Line	Description
	values from DiToro(2001): 0.16-0.25
"Fraction of labile pon for each diagenesis region,",0.65	Fraction of labile PON for each diagenesis region
"Fraction of refractory pon for each diagenesis region,",0.25	Fraction of refractory PON for each diagenesis region
"Fraction of labile pop for each diagenesis region,",0.65	Fraction of labile POP for each diagenesis region
"Fraction of refractory pop for each diagenesis region,",0.25	Fraction of refractory POP for each diagenesis region

Typical values of fraction of labile POC range from 0.5-0.65 and of fraction of refractory POC from 0.16-0.25 (DiToro 2001). Similar fractions are often used for N and P fractions.

Porewater Diffusion, Particle Mixing Velocity and Burial Velocity of Sediments

Sample Line	Description
"Pore water diffusion coefficient m ² /d,",0.0005	Porewater diffusion coefficient (m ² /d)
"Particle Mixing Velocity between Aerobic and Anaerobic Layers m/d", 0.0012 (typical value from DiToro, 2001)	Particle Mixing Velocity between Aerobic and Anaerobic Layers m/d
"Burial Velocity m/d", 10 ⁻⁵ m/d (typical value from DiToro, 2001)	Burial Velocity of sediments, m/d

Typical values of pore water diffusion range from 5E-4 to 5E-3 m²/day; burial velocity ranges from 5.5E-6 to 2E-5 m/d; and particle mixing velocity ranges from 0.5E-3 to 3E-3 m/d. (DiToro, 2001).

Bioturbation Mixing Velocity

Sample Line	Description
"Reference POC G1 concentration for bioturbation mg-C/g, 0.1"	Reference POC G1 concentration for bioturbation mg-C/g Calculation of final benthic particle mixing velocity Equation 13.2 in DiToro (2001)

Methane Calculation Setting

Sample Line	Description
"Methane production calculation method (0: Analytical, 1: Numerical),", 1	Methane production calculation method (0: Analytical, 1: Numerical)

Diagenesis Rates Settings Part 1

Sample Line	Description
"DO Threshold for aerobic layer oxidation rates mgO2/l,",2.0	DO Threshold for aerobic layer oxidation rates (mgO2/l)
"Nitrification rate in aerobic layer (NH3->NO3) at DO below threshold m/d,",0.131	Nitrification rate in aerobic layer (NH3->NO3) at DO below threshold (m/d)
"Nitrification rate in aerobic layer (NH3->NO3) at DO above threshold m/d,",0.131	Nitrification rate in aerobic layer (NH3->NO3) at DO above threshold (m/d). Typical values from DiToro(2001): 0.14-0.2

INPUT FILES

Sample Line	Description
"Denitrification rate in aerobic layer (NO3->N2) at DO below threshold m/d,",0.1	Denitrification rate in aerobic layer (NO3->N2) at DO below threshold (m/d)
"Denitrification rate in aerobic layer (NO3->N2) at DO above threshold m/d,",0.25	Denitrification rate in aerobic layer (NO3->N2) at DO above threshold (m/d)
"Denitrification rate in anaerobic layer (NO3->N2) m/d,",0.25	Denitrification rate in anaerobic layer (NO3->N2) (m/d)
"Methane oxidation rate in aerobic layer m/d,",0.0	Methane oxidation rate in aerobic layer (m/d)
"Half-saturation oxygen constant for CH4 oxidation mg-O2/L, 0"	Half-saturation oxygen constant for CH4 oxidation mg-O2/L
"Nitrification half-saturation constant for NH4N in aerobic layer mgN/l,",0.728	Nitrification half-saturation constant for NH4N in aerobic layer (mgN/l)
"Nitrification half-saturation constant for O2 in aerobic layer mgO2/l,",0.37	Nitrification half-saturation constant for O2 in aerobic layer (mgO2/l)

Diagenesis Rates Settings Part 2

Sample Line	Description
"Temperature coefficient for pore water diffusion between layers,",1.08	Arrhenius temperature coefficient for porewater diffusion between layers
"Temperature coefficient for nitrification,",1.123	Arrhenius temperature coefficient for nitrification
"Temperature coefficient for denitrification,",1.08	Arrhenius temperature coefficient for denitrification
"Temperature coefficient for methane oxidation,",1.079	Arrhenius temperature coefficient for methane oxidation
"Sulfate concentration above which sulfide over methane is produced mgS/l,",20.0	Sulfate concentration above which sulfide over methane is produced (mgS/l)
"H2S oxidation rate in aerobic layer m/d,",0.2	Sulfide oxidation rate in aerobic layer m/d
"Temperature coefficient for sulfide (H2S) oxidation,",1.08	Arrhenius temperature coefficient for sulfide oxidation
"Sulfide oxidation normalization constant for O2 mgO2/l,",4.0	Sulfide oxidation normalization constant for O2 (mgO2/l)

Diagenesis Rates Settings Part 3

Sample Line	Description
"Mineralization or diagenesis rate for labile POC 1/d,",0.035 with a range between 0.019 to 0.07	Mineralization rate for labile POC (1/d)
"Mineralization or diagenesis rate for refractory POC 1/d,",0.0018 with a range between 0.0012-0.0088	Mineralization rate for refractory POC (1/d)
"Mineralization or diagenesis rate for inert/slow refractory POC 1/d,",0.0	Mineralization rate for inert/slow refractory POC (1/d)
"Mineralization or diagenesis rate for labile PON 1/d,",0.035	Mineralization rate for labile PON (1/d)
"Mineralization or diagenesis rate for refractory PON 1/d,",0.0018	Mineralization rate for refractory PON (1/d)

INPUT FILES

Sample Line	Description
"Mineralization or diagenesis rate for inert/slow refractory PON 1/d,",0.0	Mineralization rate for inert/slow refractory PON (1/d)
"Mineralization or diagenesis rate for labile POP 1/d,",0.035	Mineralization rate for labile POP (1/d)
"Mineralization or diagenesis rate for refractory POP 1/d,",0.0018	Mineralization rate for refractory POP (1/d)
"Mineralization or diagenesis rate for inert/slow refractory POP 1/d,",0.0	Mineralization rate for inert/slow refractory POP (1/d)
"Temperature coefficient labile POC,",1.1	Temperature coefficient labile POC
"Temperature coefficient refractory POC,",1.15	Temperature coefficient refractory POC
"Temperature coefficient for inert/slow refractory POC,",1.17	Temperature coefficient for inert/slow refractory POC
"Temperature coefficient for labile PON,",1.1	Temperature coefficient for labile PON
"Temperature coefficient refractory PON,",1.15	Temperature coefficient refractory PON
"Temperature coefficient inert/slow refractory PON,",1.17	Temperature coefficient inert/slow refractory PON
"Temperature coefficient labile POP,",1.1	Temperature coefficient labile POP
"Temperature coefficient refractory POP,",1.15	Temperature coefficient refractory POP
"Temperature coefficient for inert/slow refractory POP,",1.17	Temperature coefficient for inert/slow refractory POP

Diagenesis Rates Settings Part 4

Sample Line	Description
"Phosphorus Sorption Coefficient in Anaerobic Layer m^3/g",0.01	Phosphorus sorption coefficient in the anaerobic layer, $m^3 g^{-1}$
"Incremental PO4 partition coefficient," 0	This is incremental PO4 partitioning in the aerobic layer
"Critical oxygen concentration for incremental sorption mg-O2/L", 0.01	Critical oxygen level for incremental sorption in layer 1 or aerobic layer
"NH4 sorption coefficient in aerobic layer m^3/kg", 0.001	Ammonia sorption in aerobic layer
"NH4 sorption coefficient in anaerobic layer m^3/kg", 0.001	Ammonia sorption in anaerobic layer
"H2S sorption coefficient in aerobic layer m^3/kg", 0.1	Sulfide sorption in aerobic layer
"H2S sorption coefficient in anaerobic layer m^3/kg", 0.1	Sulfide sorption in anaerobic layer
Algorithm for resuspension of particulate organic matter for each region (0: Wind Induced Resuspension, 1: Bottom Scour Resuspension)," , 1	Choice of algorithm for resuspension of particulate organic matter for each region (0: Wind Induced Resuspension, 1: Bottom Scour Resuspension)
"Fe(II) Sorption Coefficient in Aerobic Layer m^3/kg",0.00005, in each region	Fe(II) sorption coefficient in aerobic Layer, m^3/kg .
"Fe(II) Sorption Coefficient in Anaerobic Layer m^3/kg",0.1, in each region	Fe(II) sorption coefficient in anaerobic Layer m^3/kg . DiToro (2001) used values of 100-3000

INPUT FILES

Sample Line	Description
	L/kg in an example calculation. These correspond to values of 0.1 to 3 m ³ /kg.
"Mn(II) Sorption Coefficient in Aerobic Layer m ³ /kg", 0.00005, in each region	Manganese sorption coefficient in aerobic layer, m ³ /kg
"Mn(II) Sorption Coefficient in Anaerobic Layer m ³ /kg", 0.1, in each region	Manganese sorption coefficient in anaerobic layer, m ³ /kg, DiToro (2001) used a value of 8000 L/kg in an example calculation. This corresponds to a value of 8 m ³ /kg.

Note that the Fe and Mn oxidation and reduction rates used in the sediment layers are the same values as specified in the main control file, w2_con.npt or w2_con.csv for Fe and Mn. A later version may consider adding separate kinetic rates for the sediment. The kinetic rates are adjusted by temperature using a theta value of 1.05 (see User Manual Part 2).

Sediment Flux Output Settings

Sample Line	Description
"Write sediment fluxes,", .TRUE.	Switch to write sediment fluxes, '.TRUE.' or '.FALSE.'

Input/Output Control

Sample Line	Description
"Frequency of Sediment Diagenesis Output in days,", 1.0	Adjusts the frequency that sediment diagenesis output is written to output files

Temperature Calculations Control

Sample Line	Description
"Sediment Temperature Computations=1 (internal calcs or =2 neighboring water)"	Adjusts the calculation of sediment temperature. If equal to "1", the sediment temperature uses the sediment temperature defined in the main control file and the adjacent water temperature to influence the temperature in the aerobic and anaerobic layers. If this is set to "2", the adjacent water temperature is used for the sediment temperature.

Output Subdirectory

Sample Line	Description
"Subdirectory for Sediment Diagenesis Output (no quotes needed if no spaces in name)"	If blank, the program writes all the sediment diagenesis output files to the root directory. Otherwise, if one writes '\SedDiagOutput' [no need for quotes if there is no space in the name] this instructs the model to write all output files to the root directory\SedDiagOutput. This eliminates file clutter since there are so many diagenesis output files.

INPUT FILES

Since these sediment processes are temperature dependent, the sediment temperature prediction should be reviewed (see [Sediment Diagenesis Output Files](#)). The initial temperature for both the aerobic and anaerobic layers is set in the diagenesis input file described above. The aerobic layer temperature after that will closely mimic the water temperature in that cell and the anaerobic layer temperature will approach the sediment temperature (TSED) using the sediment heat exchange coefficient (CBHE) described in [Hydraulic Coefficients \(HYD COEF\)](#). An example of a model simulation using an initial temperature of 4°C, CBHE=0.3 W m⁻² °C⁻¹ (default), and Tsed=13.5°C is shown in Figure 41. It takes about a year to approach the sediment temperature, hence the 4°C initial temperature was probably too low for the anaerobic layer. The connectivity between the heat transfer between the two layers is dependent on the pore water diffusion coefficient set in the diagenesis input file. When it is close to molecular, there is little connectivity for temperature between the two layers.

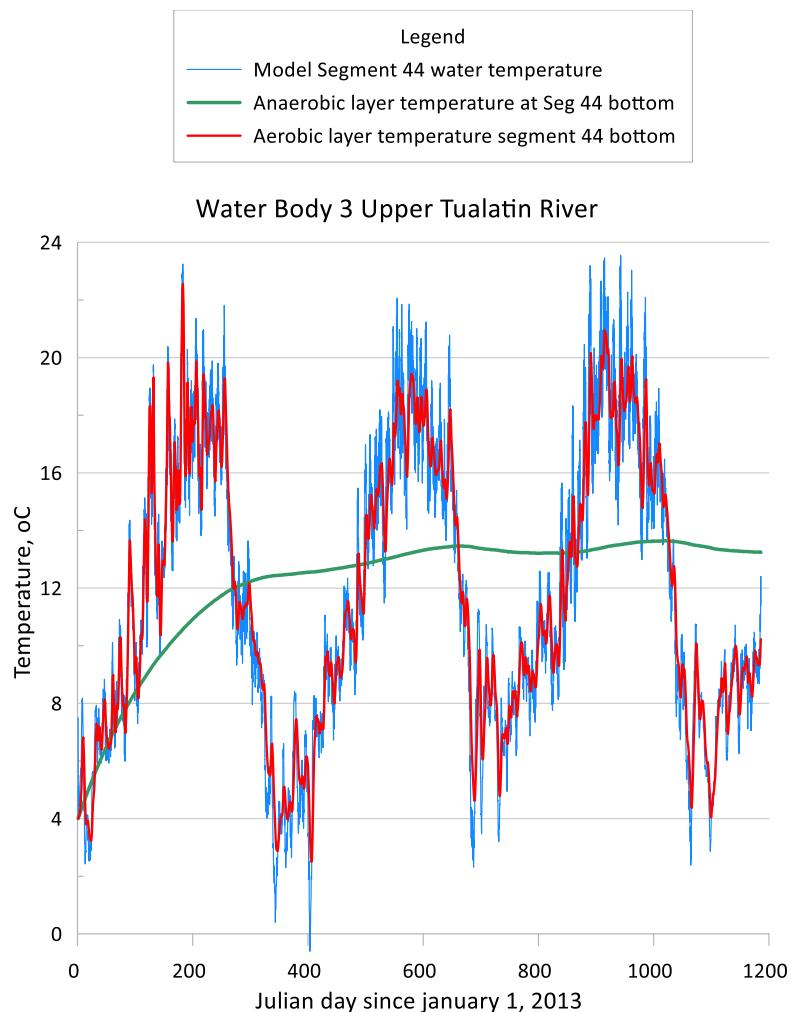


Figure 41. Model predicted aerobic and anaerobic temperature in sediment layers as well as model predicted water temperature.

Besides the input values to the sediment diagenesis model, there are many constants defined in the code. Those constants include the following:

Ionization Settings

Constants set in the Sediment Model	Constant
"Equilibrium constant for NH4+ <-> NH3 ionization. Provide as pK,"	9.1
"Equilibrium constant for HS- <-> H2S ionization. Provide as pK,"	9.0

Dissolution Settings

Constants set in the Sediment Model	Constant
"Henry's constant for NH3d <-> NH3g in atm/M,"	0.0179
"Henry's constant for CH4d <-> CH4g in atm/M,"	469
"Henry's constant for H2Sd <-> H2Sg in atm/M,"	10
"Henry's constant for CO2d <-> CO2g in atm/M,"	29

pH Buffering Input File

This describes the input file '**pH_buffering.npt**' which provides for dynamic computation of alkalinity. Description of file inputs for the pH and alkalinity routines have been adapted from Sullivan et al. (2013).

The variables **PHBUFC** turns ON/OFF the use of enhanced pH buffering and **NALKC** turns ON/OFF the use of non-conservative alkalinity.

An example **pH_buffering.npt** file is shown below.

Example:

```
Enhanced pH Buffering Input File for CE-QUAL-W2

DYNPHALK PHBUFC NCALKC
          ON

BUFTYPE NH4BUFC PO4BUFC OMBUFC
          ON

OM TYPE    OMTYPE      NAG POMBUFC
        DIST         2   OFF

DENSITY SDEN     SDEN     SDEN     SDEN     SDEN     SDEN     SDEN     SDEN
        SDEN       0.14    0.10

pK VALS      PK        PK        PK        PK        PK        PK        PK
        PK          4.5     9.6

STD DEV      PKSD      PDSD      PDSD      PDSD      PDSD      PDSD      PDSD
        PDSD
```

INPUT FILES

1.2 1.0

pH_buffering.npt variable descriptions (Sullivan et al., 2013):

PHBUFC:ON/OFF, specifies if enhanced pH buffering is used
NALKC: ON/OFF, specifies if non-conservative alkalinity is used
NH4BUFC: ON/OFF, specifies whether ammonia/ammonium is included in pH buffering
PO4BUFC: ON/OFF, specifies whether phosphoric acid is included in pH buffering
OMBUFC: ON/OFF, specifies whether organic matter is included in pH buffering
OMTYPE: DIST or MONO where DIST specifies one or more Gaussian distributions of pKa values, or MONO specifies a collection of discrete pKa values
NAG: number of acid/base groups to model, either as the means of Gaussian distributions of pKa values or as discrete monoprotic acids
POMBUFC: ON/OFF, specifies whether POM is included in OM buffering where ON indicates that OM buffering includes both DOM and POM. OFF indicates that OM buffering includes only DOM
SDEN: site density, in moles of acid/base sites per mole of carbon in OM
PK: the pKa values (negative log10 of the acid dissociation constant), specified either as the mean of a distribution or a discrete value
PKSD: the standard deviation for a Gaussian distribution of pKa values (ignored when specifying an OMTYPE of MONO)

Bed Consolidation Rate Input File

If desired, the user can specify the bed consolidation rate. Input file names are specified by the user in **w2_diagenesis.npt**. The bed consolidation rate input file is a time series input file with a column header line that is skipped. Additional comment lines can be added at the beginning of the file if they begin with a '\$'. This is a fixed format file at this time.

Example:

```
$Bed consolidation (m/d) rate
JDay     Consolidation
1.000 0.01370
2.000 0.01370
3.000 0.01370
4.000 0.01370
5.000 0.01370
6.000 0.01370
```

Meteorology File

The meteorological file can be input as a comma delimited free format text file or as a fixed-format text file. The meteorological input file contains the following data:

Variable Description	Name
Julian date	[JDAY]
Air temperature, °C	[TAIR]
Dewpoint temperature, °C	[TDEW]
Wind speed, $m\ sec^{-1}$	[WIND]
Wind direction, rad	[PHI]
Cloud cover (0 to 10)	[CLOUD]
Incident short wave solar radiation, $W\ m^{-2}$	[SRO]

The following is a list of guidelines for file preparation:

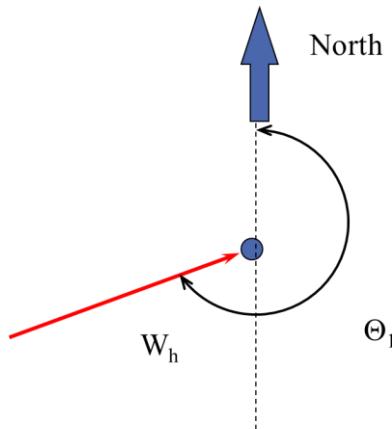
1. Data is read in according to the format of the input file in the order shown above. If the file is in fixed format a Fortran format of F8.0 is used. This implies the field is limited to 8 characters. For the free format input, the field width can vary as required by the user.
2. The first three lines are ignored in the model. The first two lines can be used to comment the file. The third line usually has the variable names of the columns.
4. Data can be input at any frequency and may vary during the simulation. The user need only specify the Julian date corresponding to the data.
5. Short wave solar radiation is required if the user has set [SROC] to ON in the [HEAT EXCH](#) card in the control file. Otherwise, this field is not required. This represents, not global radiation, but only the incident short-wave solar radiation component (*not including reflection*). A reflection % of 6% is applied to this time series to reduce the incident radiation in the model code.
6. Cloud cover is provided in tenths between 0 (no clouds) and 10 (fully cloudy).

Note: Cloud cover is required to compute long-wave atmospheric radiation and is always required even if short wave solar radiation data are used. Also, the internal short-wave solar radiation formulation within CE-QUAL-W2 is based on a formulation computed at sea level. See the paper by Annear and Wells (2007) on the existing correlation for short-wave solar and alternatives at elevations above sea level.

Wind direction is the direction as used typically by meteorological services. The wind direction is shown in Figure 42. The wind direction is always based on wind direction from true North with the wind vector arrow at the segment center. Hence, a wind from the north to the south has a radian value of 0; whereas a wind from the west to the east has a radian value of $3\pi/2$.

A sample fixed format text file is shown below:

INPUT FILES



Hence, a N wind would have an angle of 0;
an E wind would have an angle of $\pi/2$.

Figure 42. Wind direction angle in radians, Θ_1 , in meteorological file.

Example – Fixed Format, Space Delimited

Sample meteorological input file

JDAY	TAIR	TDEW	WIND	PHI	CLOUD	SRO
2.20833	-5.6111	-13.889	3.62102	3.14159	4.38	0.
2.25	-5.6111	-14.389	3.62102	3.14159	4.38	0.
2.29167	-4.3889	-13.278	3.08458	2.96706	7.5	0.
2.33333	2.22222	-13.278	2.05638	3.31613	7.5	22.3519
2.375	4.38889	-11.722	2.59283	4.18879	4.38	108.525
2.41667	6.72222	-12.222	4.11277	4.71239	4.38	324.073
2.45833	8.27778	-9.389	2.05638	4.88692	4.38	450.557
2.5	10.6111	-7.2222	6.7056	5.06145	4.38	514.012
2.54167	10.	-7.7778	8.22554	5.23599	4.38	513.528
2.58333	10.6111	-7.7778	6.7056	5.58505	4.38	437.301
2.625	8.88889	-7.7778	7.19734	5.06145	4.38	290.938
2.66667	6.72222	-7.7778	4.64922	5.23599	4.38	98.2427
2.70833	5.	-7.7778	1.56464	5.41052	4.38	24.0807
2.75	5.61111	-8.2778	4.11277	4.71239	1.88	0.
2.79167	2.22222	-7.7778	2.05638	3.49066	1.88	0.
2.83333	0.611	-7.7778	4.11277	4.01426	4.38	0.

Since Version 3.71, a free-format file rather than the fixed format shown above can be used. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below and the spreadsheet that was used to develop it.

Example – Free Format, Comma Delimited

```
$Spokane International Airport met data 1/1/2001
Solar is from Odessa
JDAY,TAIR,TDEW,WIND,PHI,CLOUD,Solar,
1,-2.2,-3.3,2.57,2.62,10,0,
1.039,-2.2,-3.3,2.57,2.62,10,0,
1.081,-2.2,-3.9,3.09,1.75,10,0,
1.122,-2.2,-3.3,0,0,10,0,
1.164,-2.2,-3.3,2.06,0.87,10,0,
```

INPUT FILES

```
1.206,-2.2,-3.3,3.09,0.35,10,0,  
1.247,-2.2,-2.8,3.09,0.35,10,0,  
1.289,-2.2,-2.8,3.09,1.05,10,0,  
1.331,-2.2,-2.8,3.09,1.05,10,0,  
1.372,-1.7,-2.2,2.57,0.87,10,13.01,  
1.414,-1.7,-1.7,0,0,10,64.47,  
1.456,-1.1,-1.7,2.57,6.28,10,113.6,  
1.497,-1.1,-1.1,2.57,0.7,10,152.29,  
1.539,-0.6,-1.1,0,0,10,144.5,  
1.581,-0.6,-1.1,0,0,10,100.71,  
1.622,-1.1,-1.1,3.09,3.32,10,54.13,  
1.664,-0.6,-1.1,0,0,10,20.68,  
1.706,-1.1,-1.1,2.06,5.24,10,0,
```

Or as viewed in Excel as a csv file:

\$Spokane	Internatio	Airport	met	data,	1/1/2001 to	12/31/2001
Solar	is	from	Odessa			
JDAY	TAIR	TDEW	WIND	PHI	CLOUD	Solar
1	-2.2	-3.3	2.57	2.62	10	0
1.039	-2.2	-3.3	2.57	2.62	10	0
1.081	-2.2	-3.9	3.09	1.75	10	0
1.122	-2.2	-3.3	0	0	10	0
1.164	-2.2	-3.3	2.06	0.87	10	0
1.206	-2.2	-3.3	3.09	0.35	10	0
1.247	-2.2	-2.8	3.09	0.35	10	0
1.289	-2.2	-2.8	3.09	1.05	10	0
1.331	-2.2	-2.8	3.09	1.05	10	0
1.372	-1.7	-2.2	2.57	0.87	10	13.01
1.414	-1.7	-1.7	0	0	10	64.47
1.456	-1.1	-1.7	2.57	6.28	10	113.6
1.497	-1.1	-1.1	2.57	0.7	10	152.29
1.539	-0.6	-1.1	0	0	10	144.5
1.581	-0.6	-1.1	0	0	10	100.71
1.622	-1.1	-1.1	3.09	3.32	10	54.13

Meteorology File Varies by Segment Number Range

In the main control file (w2_con.csv), the meteorological file is specified by waterbody [see [Meteorology Filename \(MET FILE\)](#)]. The model also allows the use of different meteorological files for ranges of segments within waterbodies. This can be used to allow several meteorological files within one waterbody or specify one meteorological file for multiple waterbodies. An input csv file named '**W2_MetRegions.csv**' specifies the parameters for the meteorological file varying by region. An example file is shown below:

```
Allow meteorological files to be read in by region rather than water body,,,,,  
ON,,,,,  
Number of regions,,,,,  
3,,,,  
Region number,Segment start,Segment end,Meteorological input file name,,  
1,1,5,met.csv,,  
2,6,20,met2.csv,,  
3,21,32,met3.csv,,
```

Or in Excel:

INPUT FILES

This tab is in the Excel master template. The selection must be highlighted before clicking the Export button. When this csv file is in the model directory and the first variable is set to ON, all references to the meteorological file as a function of waterbody in the w2_con.csv file are ignored. A summary of the regions and met files used are summarized in the pre.opt preprocessor output file. You can use the starting and ending segment the active segment or include the inactive segment as illustrated above.

Dynamic Elevation for Structure Outflows

Whenever **DYNSTRUC** is set to ON in the control file, **w2_con.npt** (or **w2_con.csv**), the model looks for the file, **dynselevX.npt**, where X is the model branch #. This file contains the variable outlet elevation of one or more structures for that branch.

First line: Ignored as header/title

Second line: Integer, **IJS**, # of structures (outlets) for this branch that have variable **ESTR**. The following line is repeated **IJS** times (any text after **IJS** is ignored)

Third line: Integer, **NJS**, Structure (Outlet) #, repeated **IJS** times showing the order of the structures to be read. (any text after **NJS** is ignored)

Fourth line Ignored as header/title

Fifth line **JDAY, ESTR(NJS1), ESTR(NJS2), ESTR(NJS3),...** This is the Julian day and the centerline elevation of each structure in m. These are not interpolated in the model but are treated as step function changes to the centerline elevation. There will be **IJS** columns of **ESTR** information provided.

An example input file is shown below.

INPUT FILES

Example – Free Format, Comma Delimited

```
$Dynamic structure withdrawal file for JB=1
2,# of outlets to for this branch that have a variable ESTR
17, Outlet number for this branch that has a variable ESTR, Repeat on different line.
18, Outlet number for this branch that has a variable ESTR
Jday since 2001,Elevation_m_17,Elev_m_18      Repeat columns for each JS
731.0,101.7129968,125.2
781.0,101.7129968,125.2
831.0,121.9214826,125.2
921.0,121.9214826,127.5
931.0,115.8254084,127.5
951.0,109.7293343,128.5
971.0,103.6332602,128.5
991.0,101.7129968,129.0
1096.0,101.7129968,129.0
```

The '\$' as the first character of the first line means that the JDAY and elevation values are in free format. Otherwise, the file is in fixed text format following the Fortran format specifier: 10f8.0:/(9f8.0).

Dynamic Pump Input File

Whenever DYNPUMP is set to ON in the control file, **w2_con.npt** (or **w2_con.csv**), the model looks for the file, **dynpumpX.npt**, where X is the pump #. This file is a time series that skips the first 3 lines, then includes a column of Julian day (F8.0), elevation of the centerline of the pump withdrawal in m (F8.0), elevation for turning the pump ON in m (F8.0), elevation for turning OFF the pump in m (F8.0), and the pump flow rate in m³/s (F8.0). This file is treated as a step function input, i.e., there is no linear interpolation between successive values. An example input file is shown below.

Example – Fixed Format, Space Delimited

Dynamic pump input file

JDAY	EPU	EONPU	EOFFPU	QPU
1.000	456.	460.0	459.0	1.0
60.000	456.	462.0	460.0	2.0
90.000	456.	463.0	461.0	3.0
160.000	457.5	464.0	462.0	5.0
365.000	458.	460.0	462.0	5.0

Also, the file can be in CSV or comma delimited format. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited

```
$$,,
Flow,,,
JDAY,EPU,EPON,EPOFF,QSum,
1,12.75,11.7,11.45,1.59673962537444E-03,
1.04166666666424,12.75,11.7,11.45,1.25754905174206E-03,
1.08333333333576,12.75,11.7,11.45,9.18358478109674E-04,
1.125,12.75,11.7,11.45,5.79167904477292E-04,
1.16666666666424,12.75,11.7,11.45,2.3997733084491E-04,
1.20833333333576,12.75,11.7,11.45,1.15558001161055E-04,
1.25,12.75,11.7,11.45,4.45567429160365E-04,
1.29166666666424,12.75,11.7,11.45,7.9030044978734E-04,
1.33333333333576,12.75,11.7,11.45,1.13503347041431E-03,
```

INPUT FILES

```
1.375,12.75,11.7,11.45,1.47976649104129E-03,  
1.41666666666424,12.75,11.7,11.45,1.82449951166826E-03,  
1.45833333333576,12.75,11.7,11.45,2.16923253229524E-03,  
1.5,12.75,11.7,11.45,2.51396555292221E-03,
```

Dynamic Pipe Input File

Whenever DYNPIPE is set to ON in the control file, **w2_con.npt** (or **w2_con.csv**), the model looks for the file, **dynpipe.npt**. This file is a time series that skips the first 3 lines, then includes a column of Julian day (F8.0), then every 8 columns it reads a number that is multiplied by the theoretical flow in the pipe. This allows for turning a pipe ON or OFF in case the number is 1 or 0, respectively. Or if the flow is throttled by closing a gate valve, the fraction of flow through the pipe can be given. This file is treated as a step function input, i.e., there is no linear interpolation between successive values. An example input file is shown below.

Chester Morse Lake Dynamic Pipe File. Pipe 1 = low level outlet, Pipe2 = Bypass valve

Jday	Pipe1	Pipe2
1.00	1.000	1
75.00	0.030	0
265.00	0.050	0
269.00	0.159	0
290.00	0.300	0
306.00	1.000	0
311.00	1.000	1
349.00	0.000	1
362.00	1.000	1
606.00	0.000	0
630.00	0.043	0
635.00	0.057	0
636.00	0.071	0
645.00	0.143	0
654.00	0.171	0
655.00	0.143	0
657.00	0.129	0
663.00	0.143	0
665.00	0.157	0
682.00	1.000	0
683.00	1.000	1
964.00	1.000	0
985.00	0.000	0
992.00	0.057	0
998.00	0.086	0
1002.00	0.286	0
1012.00	0.357	0
1063.00	1.000	0
1375.00	0.000	0
1382.00	0.129	0
1384.00	0.157	0
1390.00	0.143	0

INPUT FILES

Gate File

This file contains the dynamic gate height for each gate based on the rating curve supplied in the gates section in the control file if **DYNGTC=B** (see [Gate description](#) in control file). This file will be dynamic weir height elevations in m if **DYNGTC= ZGT**, the flow rates in m³/s if **DYNGTC=FLOW** or **DYNGTC=FLOW_ZGT**. One file is required for all the gates specified in the control file. For a fixed format file (see below for csv file format), the file contains the following data for n gates:

Variable Description	Name	Format
Julian day	[JDAY]	F8.0
Gate#1 opening, m <i>[or weir crest in m or flow in m³/s]</i>	[GATEH]	F8.0
Gate#2 opening, m	[GATEH]	F8.0
Gate#3 opening, m	[GATEH]	F8.0
Gate#4 opening, m	[GATEH]	F8.0
Gate#5 opening, m	[GATEH]	F8.0
....		
Gate#n opening, m	[GATEH]	F8.0

The following is a list of guidelines for file preparation for the fixed format space delimited file:

1. Data is read in according to an F8.0 format which allows the user to override the decimal point location according to the location specified in the input file. The field widths must be the same as specified above.
2. The first two lines are ignored and can be used to comment the file.
3. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
4. Data can be input at any frequency and may vary during the simulation. The user need only specify the Julian date corresponding to the data.
5. After the Julian day field, there are n columns of F8.0 format corresponding to each gate
6. The gate height is treated as a step function rather than interpolated between dates when **GTIC=OFF**. When **GTIC=ON**, the time series is interpolated linearly between values.

Example Gate Opening – Fixed Format, Space Delimited

Radial gate opening, m

JDAY	GATEH
1.00	1.2
200.30	0
204.65	1.25
209.50	2.50
368.00	0

In some cases, gate openings can be used to open or close a valve or gate dynamically. In the following example, the dynamic opening is either closed (0) or fully open (1). In either case, the model uses the rating curve for the gate as specified in the control file.

INPUT FILES

Example Open or Close a Weir – Fixed Format, Space Delimited

```
QGATE
simulating Willamette Falls 1999
Jday   Gate 1
1.00    1
200.30   0
204.65   1
209.50   0
368.00   0
```

Also, if the gate is specified as a dynamic weir (**[DYNGC]** is set to “ZGT”), then the weir crest elevation is included in this file rather than the gate opening. For example, if flashboards are raised, the weir equations will be used but with the dynamic weir crest elevation. The example below shows a dynamic flashback height.

Example Dynamic Weir Elevation – Fixed Format, Space Delimited

```
QGATE
Dynamic flashboards 1999
Jday   Gate 1
1.00    23.5
200.30   25.5
204.65   25.5
209.50   23.5
368.00   23.5
```

This file has also been used to predict the flow through needle valves where a rating curve based on the number of turns of the gate valve was developed. In this case, the dynamic height was interpreted as “turns” of a valve and is dependent on the supplied rating curve.

Also, if the gate is specified as a flow rate (**[DYNGC]** is set to “FLOW”), then the flow rate is included in this file rather than the gate opening. The example below shows a dynamic flow rate in m³/s.

Example Pumped Storage – Fixed Format, Space Delimited

```
QGATE
Flow rate for pumped storage between 2 reservoirs
Jday   GATE 1   GATE 2
1.00    23.5    0.0
1.50    0.0     23.5
2.00    12.5    0.0
2.50    0.0     12.5
3.00    20.0    0.0
```

The model user can also use the dynamic weir algorithm to achieve a target water level that changes over the year. When **DYNGTC**=ZGT, the elevation of the dynamic weir can be the target water level in the reservoir. The rating curve equations defining the gate describe the response of that weir/spillway. Under normal conditions, this would be a withdrawal at the vertical location of the dynamic weir elevation. In many cases it is desired that the target water level be achieved, but the flow is taken from a different target elevation. In that case the 2nd line in the gate file is not ignored. To turn this on, the model user must insert the following in the 2nd line:

Char 1-8: Title in all caps: **EGT2ELEV**

Char 9-16: Centerline elevation where the outflow will be removed in F8.0 format

INPUT FILES

This is repeated for the # of gates in F8.0 format. If you want to use the elevation specified in the dynamic weir elevations, just set the elevation above to 0.0. Note the example below for 2 gates both specified as dynamic weirs.

Example Weir Flow Rate at Target Elevation – Fixed Format, Space Delimited

```

QGATE
EGT2ELEV    110.0      00.0
      Jday   GATE 1   GATE 2
      1.00    123.5    122.5
      3.00    140.0    123.0

```

GATE1 would compute flow based on the dynamic weir elevation, but it would take the centerline of the withdrawal at 110.0 m. **GATE2** would compute the flow based on the dynamic weir elevation, and it would take the centerline of the withdrawal at elevation of the dynamic weir.

The gate file also uses the comma delimited file format if the first character in the first line is an '\$'. Hence for a gate file with 22 different flows, the free format file would have the following format:

Example Flow Rate Specified – Free Format, Comma Delimited

\$JDA_2014_BR1_LINKED_QGT.npt -Outflow file for System McNary model,.....
Structure flows based on proportional actual dam operations. Obtained from 'McNary-
Flows-Linked-2014.xls',.....
JDAY,POW,SPB1,SPB2,SPB3,SPB4,SPB5,SPB6,SPB7,SPB8,SPB9,SPB10,SPB11,SPB12,SPB13,SPB14,SPB15,
,SPB16,SPB17,SPB18,SPB19,SPB20,MISC,
1,3888.358,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,36.851,
2,4070.175,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,35.816,
3,3732.835,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,27.394,
4,2981.612,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,24.132,
5,2719.898,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,13.68,

In Excel the file would look like the following:

Dynamic Gate Elevation when DYNGETC="FLOW_ZGT"

If [DYNGC] is set to “FLOW_ZGT”, then the flow is read in from the gate file as shown above, but the dynamic elevation is read from another file called: ‘**dynselevGT.npt**’. This file contains the variable outlet elevation of one or more gates. It is a csv comma delimited file and only contains the elevation for those gates specified as ‘FLOW_ZGT’. The file structure is shown below:

- First line: Ignored as header/title
 - Second line: Integer, **JJG**, # of gates that have variable **EGT** (any text after JJG is ignored)
 - Third line: Integer, **NJG**, Gate #, repeated **JJG** times showing the order of the gates to be read (any text after **NJG** is ignored).

INPUT FILES

- Fourth line Ignored as header/title
- Fifth line **JDAY, EGT(NJG1), EGT(NJG2), EGT(NJG3),....** This is the Julian day and the centerline elevation of each gate in m. These are not interpolated in the model but are treated as step function changes to the centerline elevation. There will be **JJG** columns of **EGT** information provided.

An example input file is shown below.

Example – Free Format, Comma Delimited for ‘dynselevGT.npt’

```
Dynamic gate elevation when FLOW_ZGT
2,# of gates that have a variable EGT
2, gate number that has a variable EGT, Repeat on different line.
5, gate number that has a variable EGT
Jday since 2001,Elevation_m_Gt2,Elev_m_Gt5
731.0,101.7129968,125.2
781.0,101.7129968,125.2
831.0,121.9214826,125.2
921.0,121.9214826,127.5
931.0,115.8254084,127.5
951.0,109.7293343,128.5
971.0,103.6332602,128.5
991.0,101.7129968,129.0
1096.0,101.7129968,129.0
```

INPUT FILES

Light Extinction File

The light extinction input file contains the following data for each waterbody:

Variable Description	Name	Format
Julian date	[JDAY]	F8.0
Light extinction, m^{-1}	[EXH2O]	F8.0

These data are usually obtained by Secchi disk measurements. Due to inaccuracies in these measurements, a more appropriate method is the measurement of light extinction directly using a photometer. If dynamic light extinction is read in, all other internal calculations of light extinction are ignored. The following is a list of guidelines for file preparation:

1. Input format for each field is F8.0 that allows the user to specify the decimal point location.
2. The first two lines are ignored and can be used to comment the file.
3. The third line contains the variable name which is right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
4. The first field is the Julian date [JDAY], which can be entered at any frequency. The frequency between updates may vary during the simulation.
5. The second field contains values for observed light extinction, m^{-1} .

Values of [EXIC] determine if the values are linearly interpolated or not. The example below is the fixed format example.

Example – Fixed Format, Space Delimited

Observed light extinction

JDAY	EXH20
1.00	0.20
110.0	0.25
140.0	0.34
157.0	0.41
158.0	0.44
165.0	0.45
200.0	0.38
220.0	0.25
240.0	0.20
250.0	0.24

The model reads in a free format version of this file if the first character on the first line is '\$'. An example of this file type is shown below. The first 3 lines are ignored. Then each row starts with the Julian day followed by the extinction coefficient (for each waterbody).

Example – Free Format, Comma Delimited

```
$Dynamic light extinction coefficient input file,  
,  
JDAY,EXT(M-1)  
1.,0.25  
50.,0.45  
150.,0.35  
200.,0.35  
265.,0.4  
365.,0.45
```

Wind Sheltering Coefficient File

The wind sheltering input file contains the following data:

Variable Description	Name	Format
Julian date	[JDAY]	F8.0
Wind-sheltering coefficient	[WSC]	F8.0

This file contains the wind-sheltering as a function of segment and time. This is a representation of having segment-by-segment wind velocity data, which is preferable if the data exist based on only one meteorological station. **The wind sheltering coefficient is not interpolated in time and hence is treated as a step function in time.** The following is a list of guidelines for file preparation:

1. For the fixed format version only: Input format for each field is F8.0 that allows the user to specify the decimal point location. If more than 9 segments, the fields wrap to the next line. See example below.
2. The first two lines are ignored and can be used to comment the file.
3. The third line contains the variable name which is right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
4. The first field is the Julian date, which can be entered at any frequency. The frequency between updates may vary during the simulation.
5. The next fields are the wind-sheltering coefficients for all model segments including the boundary segments at the given Julian date.
6. The Julian date [JDAY] and wind-sheltering coefficient [WSC] are repeated as required to provide for dynamic wind sheltering.
7. Only one file is provided for all the model segments regardless of the number of waterbodies.

Example – Fixed Format, Space Delimited

Alum Creek wind sheltering coefficients

JDAY	WSC							
1.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
365.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

The model reads in a free format version of this file if the first character on the first line is '\$'. An example of this file type is shown below. The first 3 lines are ignored. Then each row starts with the Julian day followed by the WSC coefficient for each model segment including boundary/inactive segments.

INPUT FILES

Example - Free Format, Comma Delimited

```
$wsc file,,,
,Seg #s,,,
JDAY,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
1.0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1
365.0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1
```

An example viewed in Excel is shown below.

\$wsc file	Seg #s																				
JDAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
365	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

SYSTDG Input Files

SYSTDG is an empirical correlation for TDG at spillways at hydropower facilities. A detailed description of this algorithm is shown in the User Manual Part 2 under Dissolved Oxygen/Dam Reaeration.

W2 SYSTDG Control File

The SYSTDG control file, **w2_systdg.npt**, contains parameters that allow the user to configure the characteristics of spillways, powerhouses, and fish passage within the model. The control file is set up as a text file in fixed format with 8-digit numbers or characters. Each card is required although there may be either zero or no values associated with the card. An example of the SYSTDG control file is shown below:

```
CE-QUAL-W2 SYSTDG

TITLE C .....TITLE.....
1 SYSTDG input control file
2
3 MISCELL      SYSTDG  N2BND  DOBND  TDGTA
4
5
6 5 TDG production calculation equations
7 3 entrainment flow calculation equations
8
9 John Day Pool, Columbia River
10

SYSTDGC   SYSTDG   N2BND   DOBND   TDGTA
          ON       ON       ON       OFF

GATE GAS  GTTYPE   SPBC
SB1        SPB     1.0
SB2        SPB     1.0
RO1        RO      1.0
RO2        RO      1.0
POW1       POW     1.0
POW2       POW     1.0

GATE      FBE     TWCE    TWEMOD   TWE    TWETS   TDGLOC
SPB1     -1.0    135.0      0     160.0      ON      REL

GATE TDG  TDGEQ    P1      P2      P3      P4      P1      P2      P3      P4
SPB1      3       1.0     1.0    0.671    23.5    400.0    0.0    -0.020    0.0
RO        1       95.791  1.07193  178.852   -0.51

GATE ENT  ENTEQ    E1      E2      E1      E2
SPB1      1       0.150    0.0     0.0     0.0

TWETS FILE.....TWEFN.....
SPB1      TWE1.npt
```

Or in the Excel input file:

INPUT FILES

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1 CE-QUAL-W2 SYSTDG V4.3													
2													
3 TITLE C	TITLE.....												
4	"1 SYSTDG input control file for MCN 2011-2015 [TWCE & TWEFN NAVD88 H]"												
5	"2 NAVD88 TWCE and TWE file"												
6	"3 MISCELL NDAY SELECTC HABTATC ENVIRPC AERATEC INITUWL"												
7	"4 100 OFF OFF OFF OFF OFF"												
8	"5"												
9	"6 GATE GAS GASGTC = ON"												
10	"7 The model calculates N2 and DO concentrations based on their saturations"												
11	"8 for all inflow boundaries if N2BND and DOBND are set to ON"												
12	"9 4 TDG production calculation equations"												
13	"10 3 entrainment flow calculation equations"												
14													
15 SYSTDGC	SYSTDG	N2BND	DOBND	TDGTA									
16 OFF		OFF	OFF	OFF									
17													
18 GATE GAS	GTTYPE	SPBC											
19 POWER	RO		1										
20													
21 GATE	FBE	TWCE	TWEMO	TWE	TWETS	TDGLO	QSPILL	TDGSPMN					
22 SPB1		-1	231.3	0	269.1	ON	SPB	0	110				
23													
24 GATE TDG	TDGEQ	P1	P2	P3	P4	P1	P2	P3	P4				
25 SPB1		3	1	1	0.671	23.5	400	0	-0.02	0			
26 RO		1	95.791	1.0719	178.9	-0.51							
27													
28 GATE ENT	ENTEQ	E1	E2	E1	E2								
29 SPB1		1	0.0214	0.01									
30													
31 TWETS FILE.....	TWEFN.....												
32 SPB1	"MCNARY-DAM AT COLUMBIA RIVER TAILWATER_TWEELEV.csv"												
33													
34													
35	TDELOC is a character parameter (SPB/REL) to define TDG calculated for spillbay (SPB) or tailrace (REL)												

The code looks for the file, **w2_systdg.npt**. If it exists, then it reads the file. The first input is a title that is currently only used for this file.

CE-QUAL-W2 SYSTDG

```
TITLE C .....TITLE.....
1 SYSTDG input control file
2
3 MISCELL      SYSTDG  N2BND  DOBND  TDGTA
4
5
6 5 TDG production calculation equations
7 3 entrainment flow calculation equations
8
9 John Day Pool, Columbia River
10
```

There are 10 title cards for each simulation that can be used to identify various types of output. Each line may contain up to 72 characters of text.

Then the main code reads the four ON/OFF control parameters: SYSTDG, N2BND, DOBND, and TDGTA.

```
SYSTDGC SYSTDG  N2BND  DOBND  TDGTA
        ON      ON      ON      OFF
```

[SYSTDG] is an ON/OFF control used to allow or not allow calculation of tailrace TDG production using SYSTDG equations.

[N2BND] and [DOBND] are two ON/OFF controls to allow or not allow specifying boundary conditions of N2 and DO concentrations with percentage of their saturations. If [N2BND] and [DOBND] are "ON", N2 and DO concentrations included in boundary conditions must be specified with percentage of their saturations instead of their concentrations.

INPUT FILES

[TDGTA] is an ON/OFF control used to allow or not allow performing spillway operations set by TDG targets. If [TDGTA] is “ON”, then a TDG target control file, **w2_tdgtarget.npt**, must be provided to run the W2 model.

The next few lines describe the gates used. The number of gates (NGT) described in the **w2_con.npt** (or **w2_con.csv**) is used to determine the number of lines to read.

The next section in **w2_systdg.npt** defines each gate characteristic for the case of 6 gates (NGT=6):

GATE	GAS	GTTYPE	SPBC
SB1		SPB	1.0
SB2		SPB	1.0
RO1		RO	1.0
RO2		RO	1.0
POW1		POW	1.0
POW2		POW	1.0

Since a time series gate flow can be specified by the user, spillway TDG production calculated with SYSTDG is accomplished using “GATE” in W2V4.2. Each bay for the spillway can be defined with the individual gate. For the individual gate, [GASGTC] in the control file, **w2_con.npt** (or **w2_con.csv**), must be set to “ON” in order to calculate the TDG production using SYSTDG equations.

[GTTYPE] (SPB/POW/FLD/RO) control is a character value and is included for specifying the type of individual gate. The following four types of the gate are included:

- “SPB” represents a spillbay gate
- “POW” represent a powerhouse gate
- “FLD” represent a fish collector gate
- “RO” represent a regulating outlet gate.

[SPBC] is a real parameter (F8.3) to define the spill pattern specific coefficient in SYSTDG if the individual gate represents a spillbay. C values for 11 dams on the Columbia and Snake Rivers are listed in Table 3. These are only necessary if GTTYPE is specified as SPB.

Note that if [SYSTDG] is “ON” and [GASGTC] is “OFF”, the model will not compute TDG production using SYSTDG equations. Equation number (1 to 3) and associated parameters specified in this card are not necessary, all input parameters used in SYSTDG equations are specified in the SYSTDG control file if [SYSTDG] is “ON”.

GATE	FBE	TWCE	TWEMOD	TWE	TWETS	TDGLOC
SPB1	-1.0	135.0		0	160.0	ON REL

FBE is a real parameter (F8.3) to define the forebay elevation (feet). If FBE > 0, two sets of coefficients (P1, P2, P3, P4) used in the spillway TDG production equations must be defined for the TDG equation card; the spillway TDG is calculated based on two sets of coefficients.

TWCE is a real parameter (F8.3) to define the tailwater channel elevation (feet).

INPUT FILES

TWEMOD is an integer parameter (I8) to define whether TWE will be recalculated. If TWEMOD = 1, user-defined TWE will be updated based on the following equation. Otherwise, TWEMOD = 0.

$$twe = twe_{obs} * 0.934 + 4.94$$

TWE is a real parameter (F8.3) to define the averaged tailwater elevation (feet).

TWETSC is a logic parameter (ON/OFF) to define if a time series file with observed tailwater elevation is given. If TWETSC is “ON”, observed time series tailwater elevation must be included in the TWEFN file.

TDGLOC is a character parameter (SPB/REL) to define TDG calculated for spillbay (SPB) or tailrace (REL)

GATE	TDG	TDGEQ	P1	P2	P3	P4	P1	P2	P3	P4
SPB1		3	1.0	1.0	0.671	23.5	400.0	0.0	-0.020	0.0
RO		1	95.791	1.07193	178.852	-0.51				

TDGEQ (1 to 5) is an integer parameter (I8) to define the equation number for calculating spillway TDG production in SYSTDG (See User Manual Part 2 Systdg model description). Four spillway production coefficients (P1, P2, P3, P4) are real parameters (F8.3) and must be defined for each TDG equation. Either one or two sets of coefficients are required for the spillway TDG production equation depending on the FBE value. If FBE > 0, two sets of coefficients (P1, P2, P3, P4) are required in the spillway TDG production equation. Otherwise only first set of coefficients (P1, P2, P3, P4) are used for calculating the spillway TDG. P1, P2, P3, and P4 values for 11 dams on the Columbia and Snake Rivers are listed in the User Manual Part 2 in the Systdg model description section.

In SYSTDG, the TDG production through the regulating outlets (RO) is calculated differently compared to the spillway gates. A set of TDG equation numbers and coefficients (P1, P2, P3, P4) must be defined separately if the gate is a RO. Currently only one equation and one set of coefficients (P1, P2, P3, P4) is required for RO.

GATE	ENT	TDGENT	E1	E2	E1	E2
SPB1		1	0.150	0.0	0.0	0.0

TDGENT (0, 1, 2, 3) is an integer parameter (I8) to define the equation number for calculating powerhouse flow entrainment in SYSTDG (Table 2). Only spillway TDG is calculated if TDGENT is 0. Two coefficients (E1, E2) are real parameters (F8.3) and must be defined for the individual equation listed in Table 4. Either one or two sets of coefficients are required for the powerhouse flow entrainment equation depending on a FBE value. E1 and E2 values for 11 dams on the Columbia and Snake Rivers are listed in the User Manual Part 2 in the Systdg model description section.

TWETS FILE.....TWEFN.....
SPB1 TWE1.npt

TWEFN is a file name to define observed time series tailwater elevation (feet). If TWETSC is “ON”, time series tailwater elevation must be included in this file. This file format is consistent with other time series input files used in W2 model, either fixed format or csv, for example:

INPUT FILES

```

JDAY      TWE
1        18.91843867
2        17.41010533
3        19.976772
.....

```

TDG Target Control File

The TDG target control file is named **w2_TDGTtarget.csv**, which must include all inputs required for performing spillway operation set by a TDG target. It contains parameters that allow the user to allocate spill flows into the powerhouse to reduce spillway TDG and meet user-specified TDG targets. The control file is set up as a comma delimited format. Each row is required, although there may be either zero or no values associated with some parameters. An example of the TDG target control file is shown below and is included in the master spreadsheet:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	TDG TARGET OPERATION CONTROL FILE																	
2	w2_TDGTtarget.csv																	
3	TITLE C	Spillway flow allocation operation for																
4	1	Bonneville Dam																
5	2	W2 model is used to reallocate spillbay gate flow into powerhouses																
6	3	to meet downstream TDG target specified by the user.																
7	4	TDG target is specified as a constant or time series data																
8	5	DYNSEL= ON, read TDG target time series file 'TDGdyntarget.csv'																
9	6	SYSTDG TDGTA = ON																
10	7	TDG target location: 1) Spillway 2) Tailwater																
11	8	TDG target demo																
12	9	Zhong Zhang																
13	10	11-jul																
14																		
15	TDGTRGETTSFREQ	TSCONV																
16	1	1	0.1															
17																		
18	TDGTRGETYEARLY	TSTR	TEND	TTARGET	TSDFN	ITER	PRIDYN	DYNGRP										
19	1	OFF	40544	42369	115	ON	15	ON										
20																		
21	PRIORITY	BAY1	BAY2	BAY3	BAY4	BAY5	BAY6	BAY7	BAY8	BAY9	BAY10	BAY11	BAY12	BAY13	BAY14	BAY15	BAY16	BAY17
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23																		
24	MINFRACT MINFRC1	MINFRC2	MINFRC3	MINFRC4	MINFRC5	MINFRC6	MINFRC7	MINFRC8	MINFRC9	MINFRC10	MINFRC11	MINFRC2	MINFRC3	MINFRC4	MINFRC5	MINFRC6	MINFRC7	MINFRC8
25	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
26																		
27	MAXFLOW PHMAX1	PHMAX2	PHMAX3	PHMAX4														
28	1	20000																
29																		
30	TARGET FILE																	
31	1	TDGdyntarget.csv																
32																		
33																		
34																		
35																		
36		Export highlighted text to																
37		CSV file - no need for \$																
38																		

User inputs were added to specify the depth of floating outlets, optional constraints on minimum and maximum head and release rates for each outlet, and a priority ranking for each outlet, among others. An iterative solution technique was added to ensure that the TDG calculations were as accurate as possible.

The following description provides a description of each model parameter.

TITLE C	Spillway flow allocation operation for
1	Bonneville Dam
2	W2 model is used to reallocate spillbay gate flow into powerhouses
3	to meet downstream TDG target specified by the user.

INPUT FILES

4	TDG target is specified as a constant or time series data	
5	DYNSEL = ON, read TDG target time series file 'TDGdyntarget.csv'	
6	SYSTDG TDGTA = ON	
7	TDG target location: 1) Spillway 2) Tailwater	
8	TDG target demo	
9	Zhong Zhang	
10	11-Jul	

There are 10 title cards for each simulation that can be used to identify various types of output. Each line may contain up to 72 characters of text.

TDGTRGET	TSFREQ	TSCONV
1	1	0.1

The first field is ignored.

TSFREQ is a real parameter (F8.3) to define the frequency at which the spill flow allocation calculations for a TDG target are updated, specified as a fraction of a day.

TSCONV is a real parameter (F8.3) to define the convergence criterion for the iterative spill flow allocation solution, constrained to be 0.1 or less, but nonzero.

TDGTRGET	YEARLY	TSTR	TEND	TTARGET	TSDYN	ITER	PRIDYN	DYNGRP
1	OFF	40544	42369	115	ON	15	ON	1

The first field is ignored.

YEARLY is a logic parameter (ON/OFF) to define whether the starting and ending dates for spill flow allocation should be repeated (ON) each year, or not (OFF).

TSTR is a real parameter (F8.0) to define the start date (Julian day) for spill flow allocation calculations for that group (day 1 is the start of January 1).

TEND is a real parameter (F8.0) to define the end date (Julian day) for spill flow allocation calculations for that group (day 1 is the start of January 1).

TTARGET is a real parameter (%) to define a constant TDG target to meet for that period of dates.

TSDYN is a logic parameter (ON/OFF) to define if a time-series of TDG targets is used or not. If TSDYN is "ON", the model will override the TTARGET value and instead use a user-specified time-series of TDG targets from an external file. This file is specified at the end of this control file.

ITER is an integer parameter (I8) to define the maximum number of flow allocation iteration allowed for the numerical convergence.

PRIDYN is a logic parameter (ON/OFF) to define if "priority" of spill bays are dynamically set by their spill flow rates from the highest to the lowest.

INPUT FILES

DYNGRP is an integer parameter (I8) to define the number of priority groups to dynamically allocate spill flow.

PRIORITY	BAY1	BAY2	BAY3	BAY4	BAY5	BAY6	BAY7	BAY8
1	1	1	1	1	1	1	1	1

The first field is ignored.

BAY# is an integer parameter (I8) to define individual designation of the "priority" setting for the spill bay. A "-1" means the spill bay is not adjusted or allocated and the specified spill flow rates are unchanged, but the TDG effect is accounted for by the TDG calculations. Values of greater 1 (≥ 1) are interpreted as higher priorities than lower input values. If PRIDYN is "ON", priority defined here is not used by the model since priority of spill bays are dynamically determined by the spill flow rate.

MINFRACT	MINFRC1	MINFRC2	MINFRC3	MINFRC4	MINFRC5	MINFRC6	MINFRC7	MINFRC8
1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

The first field is ignored.

MINFRC# is a real parameter (F8.0) to define the minimum flow fraction (between 0 and 1) specifying that at least that fraction of the total spill flow should go through that bay. When specified as a negative number, this input is interpreted as a minimum flow rate (m^3/s).

MAXFLOW	PHMAX1	PHMAX2
1	20000	

The first field is ignored.

MAXFLOW is a real parameter (F8.0) to define individual maximum available powerhouse capacity for spill flow allocation (m^3/s). A zero means that no criterion is specified.

TARGET FILE	
1	TDGdyntarget.csv

If TSDYN is ON, then the final line of the input file is read. The first field is ignored. This file is the time series of TDG targets and the file format is consistent with other time series input files used in the W2 model, either fixed format or csv format , for example:

```

JDAY      TDG
 1.000  105.0
 90.000 105.0
 91.000 115.0
181.000 115.0
182.000 115.0
366.000 125.0
.....

```

Shade Input File

The shade input file contains the following data (if in fixed format):

Variable Description	Name	Format
Segment Number	[SEG]	I8
Dynamic shading (and static canopy) or static shading	[DYN SH]	F8.0
Vegetative elevation left bank, m	[VEL]	F8.0
Vegetative elevation right bank, m	[VER]	F8.0
Distance to vegetation left bank, m	[DL]	F8.0
Distance to vegetation right bank, m	[DR]	F8.0
Shade reduction factor #1, left bank	[SRFL1]	F8.0
Shade reduction factor #2, left bank	[SRFL2]	F8.0
Shade reduction factor #1, right bank	[SRFR1]	F8.0
Shade reduction factor #2, right bank	[SRFR2]	F8.0
Topographic angle #1 at 0°, radians	[TOPO1]	F8.0
Topographic angle #2 at 20°, radians	[TOPO2]	F8.0
Topographic angle #3 at 40°, radians	[TOPO3]	F8.0
Topographic angle #4 at 60°, radians	[TOPO4]	F8.0
Topographic angle #5 at 80°, radians	[TOPO5]	F8.0
Topographic angle #6 at 100°, radians	[TOPO6]	F8.0
Topographic angle #7 at 120°, radians	[TOPO7]	F8.0
Topographic angle #8 at 140°, radians	[TOPO8]	F8.0
Topographic angle #9 at 160°, radians	[TOPO9]	F8.0
Topographic angle #10 at 180°, radians	[TOPO10]	F8.0
Topographic angle #11 at 200°, radians	[TOPO11]	F8.0
Topographic angle #12 at 220°, radians	[TOPO12]	F8.0
Topographic angle #13 at 240°, radians	[TOPO13]	F8.0
Topographic angle #14 at 260°, radians	[TOPO14]	F8.0
Topographic angle #15 at 280°, radians	[TOPO15]	F8.0
Topographic angle #16 at 300°, radians	[TOPO16]	F8.0
Topographic angle #17 at 320°, radians	[TOPO17]	F8.0
Topographic angle #18 at 340°, radians	[TOPO18]	F8.0
Starting date for SRF#1, Julian day	[JDSRF1]	F8.0
Starting date for SRF#2, Julian day	[JDSRF2]	F8.0

The file can also be developed as a comma delimited input file rather than fixed format. When the first character in line 1 is '\$', the file format is in free, comma delimited format in the order listed above.

This file contains the shade information for computing the vegetative and topographic shading dynamically for a model segment. If the dynamic shading value [DYN SH] is set from 0 to 1, then static shading is used and the shade factor takes on the specified value. This means that a dynamic shading value [DYN SH] of 0.8 allows 80% of the incoming short-wave solar to reach the water surface of that segment – or 20% fully shaded. This would apply for all times. If dynamic shading [DYN SH] is set to -1, then the remaining columns are read for dynamic shading information and the shade percentage is computed dynamically. The absolute value of the negative value of [DYN SH] is used to compute a minimum canopy shade over the channel when used in conjunction with dynamic shading. Hence, if DYN SH=-1, then only dynamic shading is computed. If DYN SH=-0.8, then dynamic shading is computed using both vegetative and topographic shading and if the shading is more than 20%, then only dynamic shading is used in the model. If the dynamic shading computes

a value less than 20% shade, the model at that segment would always have 20% shade (1-absolute value of **DYN SH**) as if there was a permanent canopy cover.

The shade file consists of four types of vegetative information for each bank of the river, topographic information, and the time for leaf growth and leaf fall if the trees are deciduous. More detailed information on the shading model and data preparation is given in Part 2 of the User's Manual and Annear et al. (2001). [Table 59](#) provides a description of the input variables controlling dynamic shading.

Table 59. Description of Dynamic Shading Input Variables

Heading	Description
SEG	Segment number in the model – include all segment numbers and leave blank those that are inactive.
DYN SH	If between 0 and 1, this is a non-dynamic constant shade reduction similar to that used in Version 3.0 and the columns to the right are ignored. If this number is negative, this means that the rest of the columns to the right will be read and dynamic shading will be implemented. The absolute value of a negative number between -0.99 and -0.01 uses the dynamic shading algorithm but uses the absolute value of the negative number as the minimum shade value.
VEL	Tree top elevation on the left bank (m). The elevation of the left bank plus the height of the tree/vegetation are used to provide the tree top elevation. This is the absolute elevation that the entire model is referenced to. In most cases this is m, NGVD, or m MSL. This is not the elevation above the top of the bank.
VER	Tree top elevation on the right bank (m).
CDL	Distance from the centerline of the river segment to the shade controlling line of vegetation on the left bank (m).
CDR	Distance from the centerline of the river segment to the shade controlling line of vegetation on the right bank (m).
SRFL1	Shade reduction factor, left bank. This applies from SRFJD1 to SRFJD2 (and over multiple years for the same time period of the simulation goes over 360 days). It is based on the extent of vegetation along the length of the segment and the density of the vegetation (0 to 1).
SRFL2	Shade reduction factor, left bank (0 to 1). This applies from SRFJD2 to SRFJD1 (and over multiple years for the same time period of the simulation goes over 360 days). It is based on the extent of vegetation along the length of the segment and the density of the vegetation (0 to 1).
SRFR1	Shade reduction factor, right bank. This applies from SRFJD1 to SRFJD2 (and over multiple years for the same time period of the simulation goes over 360 days). It is based on the extent of vegetation along the length of the segment and the density of the vegetation (0 to 1).
SRFR2	Shade reduction factor, right bank (0 to 1). This applies from SRFJD2 to SRFJD1 (and over multiple years for the same time period if the simulation goes over 360 days). It is based on the extent of vegetation along the length of the segment and the density of the vegetation (0 to 1).
TOPO1 to TOPO18	Topographic inclination angle (radians) for every 20° around a segment starting with TOPO1 at 0° North and moving clockwise. The topographic angles are most easily computed using Digital Elevation Maps (DEMs) and using GIS or other programs to automatically compute controlling topographic angles from the DEM.
JDSRF1	Shading reduction factor Julian day for which SRF #1 starts to apply. This is typically thought of as "leaf-out" conditions for deciduous trees.
JDSRF2	Shading reduction factor Julian day for which SRF #2 starts to apply. This is typically thought of as when deciduous trees lose their leaves.

The following discussion provides an overview of data development for the dynamic shading file.

Vegetation Elevation

The algorithm uses elevations for the grid development so the vegetation's elevation is used instead of height. If shading is due to brush along side a river, the top elevation of the brush would be used in the model. The tree top elevation consists of the vegetation height and the bank surface elevation where the

vegetation is standing as shown in Figure 43. The vegetation height can be obtained from field surveys or from a GIS vegetation coverage. The surface elevation of the banks can be obtained from field surveys or from the U.S. Geological Survey digital elevation model (DEM). The frequency of tree top elevation measurements along a river bank depends on the variability of the controlling vegetation. The more comprehensive the elevation information, the more accurately the model will simulate shade. Tree top elevations should be collected for both river banks.

Centerline Distance

The centerline distance is the distance between the river centerline and the controlling vegetation on each bank. As shown in Figure 43, the information will vary for each bank depending on the location of the river centerline and the offset of the vegetation from the wetted edge. The frequency of the distances should match the tree top elevation data and reflect the variability of the vegetation. Less frequent data may be acceptable if there is not much variability in the controlling vegetation and the stream width does not change much.

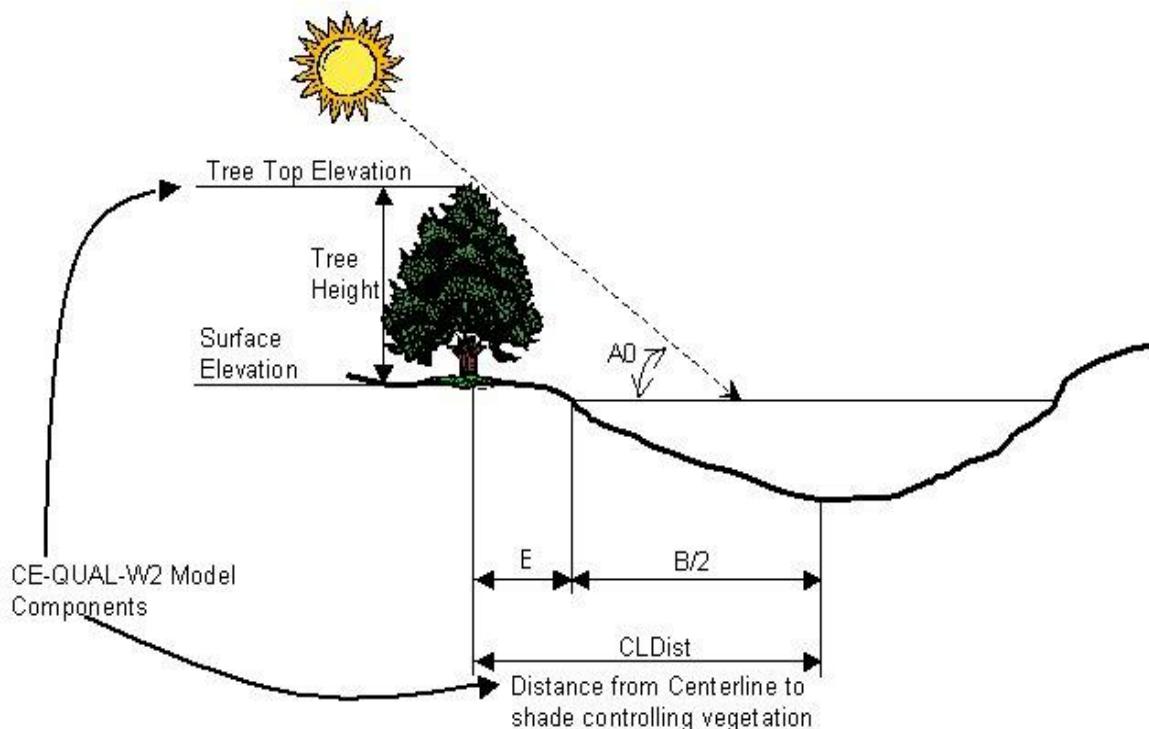


Figure 43. Tree top elevation and vegetation offset from a river.

Shade reduction factor

The shade reduction factor is based on the density and extent of the vegetation along the length of each model segment. If shade producing vegetation exists along only half the length of a segment and was 100% opaque, a shade reduction factor of 0.50 would be used. If shade was due to vegetation along only half of the segment with 80% density, then a shade reduction factor of 0.40 would be used. The shade reduction factors, [SRFR1] and [SRFR2], are expressed as a fraction from 0.0 to 1.0.

The extent of the vegetation along the segment length will depend on the grid discretization and the amount of vegetation. Vegetation density can be obtained from field surveys or from GIS vegetation information. The shade reduction factor is designed to attenuate the shade since some short-wave solar radiation penetrates the vegetation. The shade reduction factor should be developed for both banks and can be used as a calibration parameter if field data is uncertain or incomplete.

Topographic Shading

In addition to the vegetation near a river, the local topography can influence the amount of solar radiation reaching the water surface. [Figure 44](#) illustrates the influence of topographic shading on the water surface of a river.

The local topography around a river can be developed using survey information of the river channel or from a digital elevation map (DEM). To characterize the influence of the topography, inclination angles can be obtained every 20 degrees around each model segment center point as shown in [Figure 45](#). For each 20-degree increment around a model segment, an array of elevation points and their distances from the center point are obtained from the DEM. The elevations and distances are then used to calculate the highest inclination angle relative to the center point. The distance away from each segment center point that should be analyzed to obtain the controlling inclination angle will vary depending on the terrain surrounding the river. Wide open channels will require larger distances away from the channel to be analyzed than if the river channel is in a deep, narrow canyon. Inclination angles are then generated that control topographic shading for each of the 20-degree increments around a segment's center point. The inclination angles are converted to radians and specified in the dynamic shading input file [SHDFN]. The first column of the topographic inclination angles represents the inclination angle at 0° north with subsequent inclination angles obtained by moving clockwise to the east.

The shade algorithm can be used in both the northern and southern hemispheres, so inclination angles are provided for 360 degrees around each segment. If there is no topographic shading in a specific direction due to the latitude or the surrounding terrain, zero can be used as the inclination angle. The model uses all 18 topographic inclination angles. Based on the position of the sun, the algorithm will interpolate between the two nearest inclination angles to obtain the most appropriate inclination angle. The inclination angles are then used in the shading algorithm to determine if vegetative or topographic shading dominates at a specific time during the day.

Input File Examples

Example of the fixed format and free format files are shown below.

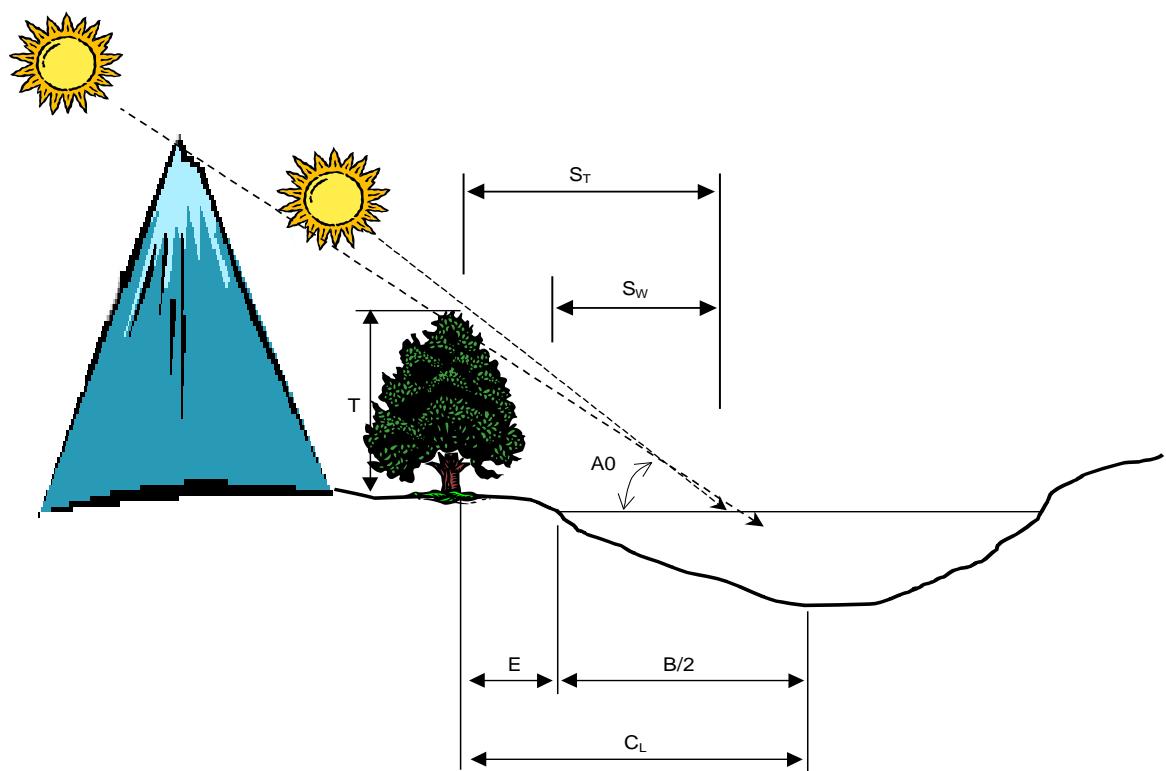
INPUT FILES**SHADE**

Figure 44. The influence of topographic shading along a river.

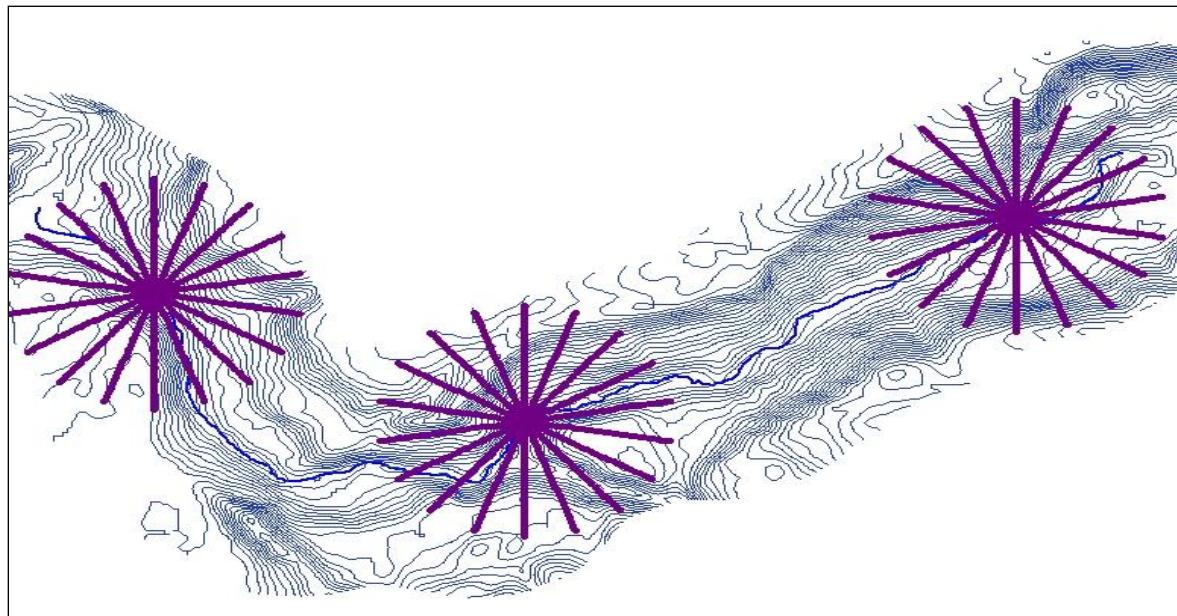


Figure 45. Topographic slices at three segments along a river.

Example – Fixed Format, Space Delimited

```

W2 Shading Input File, Vegetation and Topography, calibrated veg characteristics and corrected topography
SEGMENT  DYNSH TTE1ELB TTE1ERB C1DISLB C1DIRB SRFLB1 SRFLB2 SRFRB1 SRFRB2  TOPO1  TOPO2  TOPO3  TOPO4  TOPO5  TOPO6  TOPO7  TOPO8  TOPO9  TOPO10  TOPO11  TOPO12  TOPO13  TOPO14  TOPO15  TOPO16  TOPO17  TOPO18  SRFJD1  SRFJD2
1   -1.0 233.37 224.39 33.22 12.50 0.00 0.57 0.00 0.50 0.486 0.490 0.414 0.295 0.191 0.149 0.134 0.296 0.353 0.359 0.329 0.250 0.120 0.123 0.242 0.298 0.310 0.414 80.00 288.00
2   -1.0 233.37 224.39 33.22 12.50 0.00 0.57 0.00 0.50 0.501 0.505 0.476 0.383 0.201 0.121 0.122 0.231 0.257 0.221 0.136 0.083 0.101 0.166 0.258 0.318 0.361 0.427 80.00 288.00
3   -1.0 233.37 224.39 33.22 12.50 0.00 0.57 0.00 0.50 0.599 0.583 0.566 0.458 0.478 0.469 0.409 0.296 0.246 0.221 0.180 0.077 0.137 0.289 0.350 0.433 0.530 0.588 80.00 288.00
4   -1.0 233.37 224.39 33.22 12.50 0.00 0.57 0.00 0.50 0.599 0.583 0.566 0.458 0.478 0.469 0.409 0.296 0.246 0.221 0.180 0.077 0.137 0.289 0.350 0.433 0.530 0.588 80.00 288.00
5
6
7   -1.0 231.01 230.66 34.00 13.27 0.00 0.54 0.00 0.59 0.468 0.427 0.371 0.286 0.183 0.345 0.454 0.504 0.487 0.400 0.268 0.159 0.163 0.312 0.399 0.416 0.445 0.466 80.00 288.00
8   -1.0 227.30 240.49 35.22 14.49 0.00 0.55 0.00 0.53 0.468 0.418 0.332 0.251 0.127 0.185 0.230 0.255 0.247 0.197 0.102 0.134 0.253 0.427 0.522 0.536 0.534 0.500 80.00 288.00
9   -1.0 225.48 245.29 35.81 15.09 0.00 0.55 0.00 0.58 0.462 0.392 0.304 0.218 0.196 0.229 0.272 0.224 0.162 0.120 0.062 0.271 0.396 0.567 0.645 0.701 0.667 0.561 80.00 288.00
10
11
12   -1.0 225.00 237.01 28.08 15.14 0.00 0.51 0.00 0.58 0.393 0.310 0.236 0.216 0.228 0.228 0.250 0.222 0.169 0.119 0.282 0.558 0.736 0.809 0.770 0.699 0.668 0.564 80.00 288.00
13   -1.0 224.44 227.11 18.84 15.21 0.00 0.50 0.00 0.59 0.271 0.229 0.182 0.247 0.129 0.370 0.344 0.294 0.238 0.189 0.111 0.177 0.290 0.358 0.397 0.431 0.391 0.357 80.00 288.00
14   -1.0 225.46 222.71 16.11 16.02 0.00 0.59 0.00 0.58 0.243 0.190 0.215 0.346 0.394 0.425 0.428 0.405 0.372 0.287 0.162 0.068 0.210 0.288 0.297 0.308 0.302 80.00 288.00
15
16
17   -1.0 227.96 223.53 19.56 17.52 0.00 0.52 0.00 0.56 0.194 0.173 0.171 0.260 0.346 0.437 0.493 0.529 0.443 0.279 0.217 0.089 0.042 0.124 0.210 0.300 0.287 0.314 80.00 288.00
18   -1.0 230.47 224.35 23.00 19.02 0.00 0.55 0.00 0.54 0.184 0.162 0.103 0.187 0.280 0.392 0.365 0.271 0.299 0.311 0.246 0.128 0.051 0.155 0.197 0.300 0.281 0.285 80.00 288.00
19   -1.0 232.80 225.12 26.21 20.42 0.00 0.68 0.00 0.63 0.188 0.174 0.173 0.149 0.223 0.254 0.228 0.328 0.367 0.237 0.152 0.101 0.061 0.211 0.244 0.310 0.326 0.309 80.00 288.00
20
21

```

Example – Free Format, Comma Delimited

```

$W2 Shading InputFile Vegetation and Topography calibrated veg characteristics and corrected topography,,,,,,,,,,,
///////////
Segment, DynSh,TTE1LB,TTE1ERB,C1DisLB,C1DiRB,SRFLB1,SRFLB2,SRFRB1,SRFRB2,TOPO1,TOPO2,TOPO3,TOPO4,TOPO5,TOPO6,TOPO7,TOPO8,TOPO9,TOPO10,TOPO11,
TOPO12,TOPO13,TOPO14,TOPO15,TOPO16,TOPO17,TOPO18,SRFJD1,SRFJD2,
1/////////
2,-1,575,580,70,70,0,0.57,0,0.5,0.486,0.49,0.414,0.295,0.191,0.149,0.134,0.296,0.353,0.359,0.329,0.25,0.12,0.123,0.242,0.298,0.31,0.414,80,288,
3,-
1,568,566,70,70,0,0.57,0,0.5,0.501,0.505,0.476,0.383,0.201,0.121,0.122,0.231,0.257,0.221,0.136,0.083,0.101,0.166,0.258,0.318,0.361,0.427,80,288,
4,-1,562,565,70,70,0,0.57,0,0.5,0.599,0.583,0.566,0.458,0.478,0.469,0.409,0.296,0.246,0.221,0.18,0.077,0.137,0.289,0.35,0.433,0.53,0.588,80,288,
5,-1,568,565,70,70,0,0.57,0,0.5,0.599,0.583,0.566,0.458,0.478,0.469,0.409,0.296,0.246,0.221,0.18,0.077,0.137,0.289,0.35,0.433,0.53,0.588,80,288,
6,-1,544,546,70,70,0,0.57,0,0.5,0.599,0.583,0.566,0.458,0.478,0.469,0.409,0.296,0.246,0.221,0.18,0.077,0.137,0.289,0.35,0.433,0.53,0.588,80,288,
7,-
1,548,567,70,70,0,0.54,0,0.59,0.468,0.427,0.371,0.286,0.183,0.345,0.454,0.504,0.487,0.4,0.268,0.159,0.163,0.312,0.399,0.416,0.445,0.466,80,288,
8/////////

```

Atmospheric Deposition Input File

Atmospheric deposition is a process where either dry or wet deposition (rain or snow) of pollutants contribute to the mass loading of a pollutant. Dry deposition can include dust or particle transport associated with the pollutant. The processes of atmospheric deposition include Hg, P, and N and other state variables in CE-QUAL-W2. Typical values used in other studies are shown in Table 60.

Table 60. Typical atmospheric deposition rates for Hg, P, N, and particles.

Deposition State Variable	Location	Deposition Rate	Reference
Hg total deposition (95% of atmospheric deposition is elemental Hg)	Great Lakes, USA/Canada	5-17 g/km ² /year	Cohen (2003)
Hg total deposition (wet and dry)	Pullman, WA, USA	Dry deposition: $2.4 \pm 1.4 \text{ ng/m}^2 \cdot \text{h}$ Total Hg. Wet deposition: $7.0 \pm 4.8 \text{ ng/m}^2 \cdot \text{h}$ Total Hg.	Beutel et al. (2021)
Annual Total Hg deposition	Watershed model	$10 \mu\text{g Hg/m}^2 / \text{yr}$ with 98.5% HgII and 1.5% MeHg	Knightes et al., 2014
Wet deposition of Total Hg	Chongquin, China	$28.7 \pm 5.1 \mu\text{g/m}^2/\text{yr}$	Wang et al. (2014)
Dissolved Inorganic N (DIN) deposition (from dust from N. Africa)	Lake Redon, Pyrenees, Spain	6-18 kg/ha/year where 1 ha = 10000 m ²	Camarero et al. (2012)
Total P (from dust from N. Africa)	Lake Redon, Pyrenees, Spain	0.1-0.63 kg/ha/year where 1 ha = 10000 m ²	Camarero et al. (2012)
TSP (total suspended particles)	Lake Tahoe, CA/NV, USA	2.8×10^5 to $5.9 \times 10^5 \text{ kg/year}$ (Using area of Lake Tahoe of 490 km ² , this is a flux of 510 to 1204 kg/km ² /year)	Chien et al. (2019)
NO ₃ +NO ₂	Lake Tahoe, CA/NV, USA	21 to 39 kmol/year (Using area of Lake Tahoe of 490 km ² and a MW of NO ₃ of 62 g/mole, this is a flux of 2.7-4.9 kg/km ² /year)	Chien et al. (2019)
NH ₄	Lake Tahoe, CA/NV, USA	16 to 87 kmol/year (Using area of Lake Tahoe of 490 km ² and a MW of NH ₄ of 17 g/mole, this is a flux of 0.6-3.2 kg/km ² /year)	Chien et al. (2019)
P	Lake Tahoe, CA/NV, USA	11 to 67 kmol/year (Using area of Lake Tahoe of 490 km ² and MW of P of 30.97 g/mol, this is a flux of 0.7-4.2 kg/km ² /year)	Chien et al. (2019)

INPUT FILES

INFLOW

Deposition State Variable	Location	Deposition Rate	Reference
Total P	Lake Tahoe, CA/NV, USA	10^4 kg/year or using 490 km ² surface area, this is an areal loading of 20.4 kg/km ² /year	Sahoo et al. (2013)
Total N	Lake Tahoe, CA/NV, USA	2.2×10^5 kg/year or using 490 km ² surface area, this is an areal loading of 450 kg/km ² /year	Sahoo et al. (2013)
Total P	250 sites around the world to open land, lakes and marine coasts	0.027 g/m ² /year – geometric mean. (Varied from 0.005 to 0.3 g/m ² /year)	Tipping et al. (2014)
Filtered Total P	250 sites around the world to open land, lakes and marine coasts	0.019 g/m ² /year – geometric mean. (Varied from 0.004 to 0.03 g/m ² /year)	Tipping et al. (2014)
Inorganic P (PO4-P)	250 sites around the world to open land, lakes and marine coasts	0.014 g/m ² /year – geometric mean. (Varied from 0.0008 to 0.11 g/m ² /year) (Note that for paired field data of TP and PO4-P, the ratio of PO4-P to TP was about 40%.)	Tipping et al. (2014)

As shown in Table 60, there are many different units used in the publishing of atmospheric deposition rates. Even though a typical unit for mass flux would be in the SI system, g/m²/s, this leads to very small, reported numbers for the values in Table 60, such as between 10^{-13} to 10^{-17} g/m²/s. For the CE-QUAL-W2 model, the mass deposition rate is in units of kg/km²/year. This unit is often reported by researchers and is not mathematically such a small number as g/m²/s. Internally in the model, unit conversions will be applied such that the internal source/sink term units are g/s after multiplying by the area. For a variable with units of $\mu\text{g}/\text{m}^3$ (ng/l), the atmospheric deposition rates are in units of mg/km²/year.

The mass load will be applied to each waterbody, rather than to each branch, since one would expect the areal deposition to be inclusive of branches and segments making up a waterbody.

The input format for this file is similar to all other time series input files as shown below in csv format using Excel.

Table 61. Input file for atmospheric deposition in csv format. Note that the ‘\$’ should be the first character in cell A1.

\$atm_deposition_wb1.csv					
Atmospheric mass input, kg/km ² /year					
JDAY	PO4	NH4	NO3	LPOMP	RPOMP
1	14	0.6	2	1	1
100	16	0.7	2	1	1

INPUT FILES**INFLOW**

250	18	0.6	2	1	1
365	14	0.7	2	1	1
400	14	0.6	2	1	1

Branch Inflow File

This file contains the inflow for a branch with an [upstream flow boundary condition](#). The following is a list of guidelines for file preparation:

1. A separate file is required for each branch with an upstream flow boundary condition. This allows the user to update inflows for one branch independent of another branch.
2. Fixed text format file: Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow rate, $m^3 sec^{-1}$.
7. Note that the inflow file CANNOT handle negative inflows like the distributed inflow file or tributary inflows. The branch inflow cannot be a negative flow rate.

Note the following example takes advantage of the algorithm's capability to use data at varying frequencies.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample inflow file

```

JDAY      QIN
182.0000  0.0
182.5416  283.0
182.6250  566.0
182.6666  1699.0
182.7916  566.0
182.8333  283.0
182.9166  0.0
185.5416  283.0
185.6250  566.0
185.6666  1699.0
185.7916  566.0
185.8333  283.0
185.9166  0.0
186.5416  283.0

```

The model user can use a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited

```

$Flow data for 2012,,
"",
JDAY,q(m3/s),
1,9.12611182703854,
2,12.1179791828734,
3,4.2113553278442,
4,9.94341024175013E-03,
5,9.1933302008558E-03,
6,.011356298978275,
7,1.06203328212151E-02,

```

Branch Inflow Temperature File

This file contains the inflow temperatures for a branch with an [upstream flow boundary condition](#). The following is a list of guidelines for file preparation:

1. A separate file is required for each branch with an upstream flow boundary condition. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow temperature, °C.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample inflow temperature file

JDAY	TIN
1.00	6.80
2.00	6.70
3.00	7.00
4.00	6.30
5.00	6.40
6.00	6.10
7.00	6.60
8.00	5.70
9.00	5.20
10.00	5.40
11.00	7.10
12.00	6.60
13.00	5.50
14.00	5.60
15.00	7.30
16.00	9.50

The model user can also use a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited

```
$Temp data for 2012,
,
JDAY ,Temp,
1,15.04924,
1.125,13.61301,
1.25,16.16824,
1.375,20.82835,
1.5,23.3214,
1.625,22.30952,
1.75,20.3509,
```

Branch Inflow Constituent Concentration File

This file contains the inflow concentrations for a branch with an [upstream flow boundary condition](#). The following is a list of guidelines for file preparation:

1. *If* constituents are being modeled, a separate file is required for each branch with an upstream flow boundary condition. This allows the user to update constituent concentrations for one branch independent of another branch.
2. Input format for all fields is F8.0 that allows the user to specify the decimal point location. The number of fields is determined by (6) below and they are always located on one line.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the abbreviations for the constituent names that are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields contain the concentration for each constituent specified on the [Inflow Active Constituent Control](#) card. Only those constituents specified as active on the [Inflow Active Constituent Control](#) card are included in the constituent inflow concentration file.

Starting with Version 3.71, the model user can use a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

INPUT FILES

BRANCH INFLOW CONCENTRATION

Example – Fixed Format, Space Delimited

CE-QUAL-W2 constituent inflow concentration sample input file

JDAY	PO4	NH4	NOX	LDOM	RDOM	LPOM	RPOM	CBOD1	CBOD2	CBOD3	CBOD4	CBOD5	ALG1	DO
1.040	0.030	0.010	0.300	0.1000	0.1000	0.1000	0.1000	0.000	0.000	0.000	0.000	0.000	0.100	12.000
1.100	0.030	0.011	0.307	0.1040	0.0991	0.0989	0.0989	0.000	0.000	0.000	0.000	0.000	0.098	12.000
1.200	0.029	0.012	0.323	0.1100	0.0968	0.0963	0.0963	0.000	0.000	0.000	0.000	0.001	0.095	11.800
1.300	0.048	0.017	0.458	0.1250	0.0944	0.0935	0.0936	0.000	0.000	0.000	0.229	0.003	0.091	11.900
1.400	0.043	0.018	0.441	0.1360	0.0936	0.0924	0.0925	0.000	0.000	0.000	0.167	0.010	0.090	11.900
1.500	0.043	0.013	0.498	0.1430	0.0874	0.0861	0.0862	0.000	0.000	0.000	0.192	0.011	0.084	11.900
1.600	0.047	0.006	0.542	0.1530	0.0852	0.0837	0.0838	0.000	0.000	0.008	0.241	0.015	0.083	12.000
1.700	0.046	0.001	0.565	0.1690	0.0820	0.0804	0.0805	0.000	0.004	0.032	0.248	0.017	0.081	12.000
1.800	0.045	0.002	0.577	0.1730	0.0790	0.0773	0.0773	0.000	0.020	0.041	0.249	0.016	0.077	11.900

Example – Free Format, Comma Delimited [This is a partial view because of the number of variables]

In Excel part of the input file looks like this:

BRANCH INFLOW CONCENTRATION

INPUT FILES

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	\$Concentration file for segment 86															
2																
3	JDAY	TDS	Conduct	ISS1	PO4	NH4	NOx	LDOM	RDOM	LPOM	RPOM	1CBOD	2CBOD	3CBOD	4CBOD	5CBOD
4	1	0	0	0	3.00E-02	1.00E-02	0.3	0.1	0.1	0.1	0.1	0	0	0	0	0
5	1.01	0.118	0.208	.123-105	3.00E-02	1.02E-02	0.301	0.1	9.99E-02	0.102	9.99E-02	.330-233	.336-139	.389-104	0	0
6	1.02	0.235	0.413	3.18E-75	3.00E-02	1.03E-02	0.302	0.101	0.1	0.104	9.99E-02	.965-198	.279-107	1.01E-73	0	0
7	1.03	0.311	0.547	4.09E-64	3.00E-02	1.04E-02	0.303	0.101	0.1	0.106	9.99E-02	.412-185	2.38E-97	1.32E-62	0	0
8	1.04	0.383	0.674	5.12E-59	3.00E-02	1.05E-02	0.303	0.101	9.98E-02	0.106	9.97E-02	.203-176	2.82E-90	1.64E-57	0	0
9	1.05	0.484	0.851	5.59E-55	2.99E-02	1.06E-02	0.303	0.102	9.96E-02	0.108	9.95E-02	.379-170	4.02E-85	1.79E-53	0	0
10	1.06	0.619	1.09	5.58E-52	2.99E-02	1.08E-02	0.304	0.102	9.95E-02	0.112	9.94E-02	.407-164	2.29E-80	1.82E-50	0	0
11	1.07	0.812	1.42	2.28E-49	2.99E-02	1.11E-02	0.305	0.103	9.94E-02	0.115	9.92E-02	.353-156	6.05E-76	7.03E-48	0	0
12	1.08	1.24	2.15	3.82E-47	2.99E-02	1.14E-02	0.308	0.104	9.91E-02	0.119	9.89E-02	.342-143	3.52E-71	1.43E-45	0	0
13	1.09	1.98	3.41	8.16E-44	2.98E-02	1.21E-02	0.313	0.105	9.87E-02	0.123	9.85E-02	.841-129	1.37E-67	7.75E-42	0	0
14	1.1	3.54	6.06	9.85E-41	2.96E-02	1.31E-02	0.323	0.105	9.78E-02	0.126	9.75E-02	.381-117	7.12E-65	3.59E-39	0	0
15	1.11	5.38	9.16	1.00E-33	2.94E-02	1.42E-02	0.335	0.105	9.68E-02	0.13	9.65E-02	.656-104	4.67E-62	3.68E-32	0	0
16	1.12	7.25	12.3	7.49E-23	2.92E-02	1.53E-02	0.348	0.105	9.58E-02	0.133	9.55E-02	4.59E-94	5.22E-59	7.09E-23	0	0

Branch Outflow File

This file contains the outflow for a branch (a structure outflow) with a [downstream flow boundary condition](#). The following is a list of guidelines for file preparation:

1. A separate file is required for each branch with a downstream flow boundary condition. This allows the user to update outflows for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. There are a maximum of 10 fields to a line. If there are more outflows than can be specified on one line, then they are continued on the next line with blanks inserted in the Julian date field.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields are the outflow rate, $m^3 sec^{-1}$.
7. A separate column of outflow values must be specified for each outlet structure.

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also removes the restriction of an 8-column width of the flow value and line wrapping when one exceeds 9 outlets in a branch. An example is shown below.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample outflow file

JDAY	QOUT	QOUT	QOUT	QOUT	QOUT	QOUT	QOUT	QOUT	QOUT
1.00	8.13	8.13	8.13						
2.00	6.77	6.77	6.77						
3.00	18.60	18.60	18.60						
4.00	0.60	0.60	0.60						
5.00	7.50	7.50	7.50						
6.00	2.87	2.87	2.87						

Example - Free Format, Comma Delimited [*Note the file below is wrapped for viewing convenience since it has 17 outlets in the branch*]

```
$Penstock flows and spill,,,,% of lower leakage,,20,,,,,
,P1-O,P1-A,P1-U,P1-M,P1-L,P2-O,P2-A,P2-U,P2-M,P2-L,P3-O,P3-A,P3-U,P3-M,P3-L,,,
Julian
day,Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),
,Q(m3/s),Q(m3/s),Q(m3/s),Q(m3/s),QSPILL,QPP,
730.5,0.962772798,0,0,0,0,3.4093483788,0,0,0,13.6373935152,5.2839236502,0,0,0,21.13569460
08,0,2.69009789124642,
731.5,0.962772798,0,0,0,0,5.0007551802,0,20.0030207208,0,0,3.766140651,0,0,0,15.064562604
,0,2.63346425143071,
732.5,0.962772798,0,0,0,0,3.5735860914,0,14.2943443656,0,0,5.040398766,0,0,0,20.161595064
,0,2.69009789124642,
733.5,0.962772798,0,0,0,0,0.1925545596,0,0.7702182384,0,0,8.834856264,0,0,0,35.339425056,
0,2.7184147115428,
```

BRANCH OUTFLOW

INPUT FILES

734.5,0.962772798,0,0,0,0,4.1172695538,0,16.4690782152,0,0,6.0484785192,0,0,0,24.19391407
 68,0,2.54851379170714,
 735.5,0.962772798,0,0,0,0,10.0977876402,0,40.3911505608,0,0,1.189307574,0,0,0,0,0,2.57683
 061161499,

In Excel this looks like the following:

Julian day	\$Penstock flows and spill												% of lower leakage		25.00 %			
	P1-O	P1-A	P1-U	P1-M	P1-L	P2-O	P2-A	P2-U	P2-M	P2-L	P3-O	P3-A	P3-U	P3-M	P3-L	QSPILL	QPP	
730.50	0.96	0.00	0.00	0.00	0.00	4.26	0.00	0.00	0.00	12.79	6.60	0.00	0.00	0.00	19.81	0.00	2.69	
731.50	0.96	0.00	0.00	0.00	0.00	6.25	0.00	18.75	0.00	4.71	0.00	0.00	0.00	14.12	0.00	2.63		
732.50	0.96	0.00	0.00	0.00	0.00	4.47	0.00	13.40	0.00	0.00	6.30	0.00	0.00	0.00	18.90	0.00	2.69	
733.50	0.96	0.00	0.00	0.00	0.00	0.24	0.00	0.72	0.00	0.00	11.04	0.00	0.00	0.00	33.13	0.00	2.72	
734.50	0.96	0.00	0.00	0.00	0.00	5.15	0.00	15.44	0.00	0.00	7.56	0.00	0.00	0.00	22.68	0.00	2.55	
735.50	0.96	0.00	0.00	0.00	0.00	12.62	0.00	37.87	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.58	
736.50	0.96	0.00	0.00	0.00	0.00	11.31	0.00	33.94	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.46	
737.50	0.96	0.00	0.00	0.00	0.00	10.70	0.00	32.11	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.41	
738.50	0.96	0.00	0.00	0.00	0.00	11.47	0.00	34.40	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.46	
739.50	0.96	0.00	0.00	0.00	0.00	12.97	0.00	38.91	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.41	
740.50	0.96	0.00	0.00	0.00	0.00	13.95	0.00	41.86	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.41	
741.50	0.96	0.00	0.00	0.00	0.00	15.26	0.00	45.77	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.46	
742.50	0.96	0.00	0.00	0.00	0.00	19.28	0.00	57.85	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	2.61	
743.50	0.96	0.00	0.00	0.00	0.00	20.01	0.00	60.02	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	3.06	

Withdrawal File

This contains the outflow for each withdrawal specified on the [Inflow/Outflow Dimensions](#) card. The following is a list of guidelines for file preparation:

1. The order in which withdrawal outflows appear in the file **must** correspond with the order specified on the Withdrawal Segment and the [Withdrawal Elevation](#) cards.
2. Input format for each field is F8.0 with 10 fields to a line. The F8.0 input field allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields are the withdrawal outflow rate, $m^3 sec^{-1}$
7. Outflows from a single withdrawal structure spanning more than one layer in the computational grid can be divided up into several outflows and the total outflow apportioned among them.
8. If there are **more** withdrawals than can be specified on one line, then they are continued on the next line with blanks inserted under the JDAY field.

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also removes the restriction of an 8-column width of the flow value and line wrapping when one exceeds 9 outlets in a branch. Fixed and free format examples are shown below.

Example – Fixed Format, Space Delimited

```
CE-QUAL-W2 sample withdrawal outflow file

      JDAY    QWD    QWD    QWD    QWD    QWD    QWD    QWD    QWD    QWD
182.0000  51.    51.    51.    51.    51.    51.    51.    51.    51.
      51.
182.2500  0.     0.     0.     0.     0.     0.     0.     0.     0.
      0.
183.0000  51.    51.    51.    51.    51.    51.    51.    51.    0.
      51.
183.2500  0.     0.     0.     0.     0.     0.     0.     0.     0.
      0.
```

Example – Free Format, Comma Delimited

```
$Main outflows,,,,$CRLF
JDAY 1.0= 1/1/2000 12am,,,,$CRLF
JDAY,QWD1,QWD2,QWD3,QWD4,QWD5$CRLF
1,13.57,13.57,13.57,13.57,13.57$CRLF
2,15.17,15.17,15.17,15.17,15.17$CRLF
3,14.99,14.99,14.99,14.99,14.99$CRLF
4,13.57,13.57,13.57,13.57,13.57$CRLF
5,15.42,15.42,15.42,15.42,15.42$CRLF
6,14.32,14.32,14.32,14.32,14.32$CRLF
7,15.06,15.06,15.06,15.06,15.06$CRLF
8,8.98,8.98,8.98,8.98,8.98$CRLF
```

Tributary Inflow File

This file contains the inflows for a tributary specified on the [Tributary Segment](#) card. The following is a list of guidelines for file preparation:

1. A separate file is required for each tributary. This allows the user to update inflows for one tributary independent of another tributary.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow rate, $m^3 sec^{-1}$.
7. Flow rates can be negative or minus values, meaning withdrawals, or positive values implying inflows.

Example – Fixed Format, Space delimited

CE-QUAL-W2 sample tributary inflow file

```
JDAY      QTR
1.0       22.8
5.0       44.5
12.0      31.2
23.0      80.4
35.0      50.6
74.5      103.0
74.7      185.6
75.0      212.3
75.5      178.6
80.0      123.4
80.5      78.3
90.0      46.5
112.0     35.9
```

One can use a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited (in a text editor with hidden characters CRLF and in Excel)

```
$Inflow trib,CRLF
JDAY 1.0 = 1/1/2000 12 am,CRLF
JDAY,QTRCRLF
2358,6.93CRLF
2388,11.63CRLF
2419,13.45CRLF
2450,13.91CRLF
2480,27.92CRLF
2511,19.83CRLF
2541,6.04CRLF
2572,2.64CRLF
2603,1.51CRLF
2631,1.18CRLF
2662,2.14CRLF
```

	A	B	C
1	\$Inflow trib		
2	JDAY 1.0 = 1/1/2000 12 am		
3	JDAY	QTR	
4	2358	6.93	
5	2388	11.63	
6	2419	13.45	
7	2450	13.91	
8	2480	27.92	
9	2511	19.83	
10	2541	6.04	

INPUT FILES**TRIBUTARY INFLOW**

Tributary Inflow Temperature File

This file contains the inflow temperatures for a tributary specified on the [Tributary Segment](#) card. The following is a list of guidelines for file preparation:

1. A separate file is required for each tributary. This allows the user to update inflow temperatures for one tributary independent of another tributary.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow temperature, °C.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample tributary inflow temperature file

JDAY	TTR
1.0	10.3
5.0	9.5
12.0	10.1
23.0	8.6
35.0	11.2
74.5	13.9
74.7	13.1
75.0	12.8
75.5	12.5
80.0	12.6
80.5	12.7
90.0	15.4

The model user can specify a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited (text editor shows hidden characters such as CRLF)

```
$Branch 3 Inflow Temperature,CRLF
JDAY 1.0 = 1/1/2000 12 am,CRLF
JDAY,TIN,CRLF
1895,31.8,CRLF
1937,29.7,CRLF
1958,29,CRLF
2001,25.3,CRLF
2027,24.5,CRLF
2056,24.5,CRLF
2091.576389,27.5,CRLF
2119,22.5,CRLF
2147,22.4,CRLF
2160.541667,21,CRLF
```

Tributary Inflow Concentration File

This file contains the inflow constituent concentrations for each tributary specified on the [Tributary Segment](#) card. The following is a list of guidelines for file preparation:

1. *If* constituents are being modeled, a separate file is required for each tributary. This allows the user to update constituent inflow concentrations for one tributary independent of another tributary.
2. Input format for all fields is F8.0 that allows the user to specify the decimal point location. The number of fields is determined by (6) below and they are always located on one line.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the abbreviations for the constituent names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields contain the concentration for each constituent specified on the [Tributary Active Constituent Control](#) card. Only those constituents specified as *active* on the [Tributary Active Constituent Control](#) card may be included in the tributary inflow concentration file.

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format comma delimited rather than fixed format space delimited. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one to not be constrained by the 8-column width of the concentration value. An example is shown in the Inflow concentration file section above.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample tributary constituent inflow concentration file

JDAY	CLFORM	SSOLID	LDOM	RDOM	ALGAE	LPOM	PO4	NH4	NO3	O2	Fe
1.	17.	62.	7.333	17.111	0.0	0.9	0.02	0.10	0.42	13.9	0.4
8.	13.	0.0	8.000	18.667	0.0	0.4	0.01	0.03	0.37	14.0	0.2
15.	11.	17.	9.333	21.778	0.0	0.0	0.00	0.01	0.17	10.0	0.3
22.	14.	34.	10.000	23.333	0.0	0.0	0.05	0.00	0.20	10.4	1.6
29.	17.	38.	4.467	10.422	0.0	0.4	0.01	0.11	0.26	11.6	0.4
36.	101.	24.	3.867	9.022	0.0	0.2	0.01	0.00	0.23	12.2	0.3
43.	10.	11.	4.133	9.644	0.0	0.2	0.02	0.07	0.20	12.2	0.1

Example – Free Format, Comma Delimited [Not all fields or columns are shown]

```
$Tributary inflow concentration file,,,,,,,,,,,$
JDAY 1.0= 1/1/2000 12am,,,,,,,,,,,$
JDAY,TDS,CH4,S04,Tracer,Cond,TCol,ECol,ISS1,P04,NH4,NO3,LDOM,RDOM,LPOM,RPOM,ALG1,DO,TIC,ALK,LDOM-P,RDOM-P,LPOM-P,RPOM-P
4384,57.38,0,0,4.891,0,100.2,1342,219.2,23.06,0.1277,8.35E-02,0.4235,0.1183,0.1183,0.1183,0.1,7.9,7.507,22.35,5.92E-
4385,57.38,0,0,4.892,0,100.3,1342,219.2,23.04,0.1272,8.27E-02,0.419,0.1191,0.1191,0.1191,0.1,7.9,7.487,22.49,5.96E-0
4386,57.39,0,0,4.894,0,100.4,1342,219.2,23.03,0.1266,8.19E-02,0.4146,0.1199,0.1199,0.1199,0.1,7.9,7.469,22.62,6.00E-
4387,57.39,0,0,4.895,0,100.6,1342,219.2,23.02,0.1261,8.11E-02,0.4182,0.1207,0.1207,0.1207,0.1,7.9,7.451,22.76,6.04E-
4388,57.39,0,0,4.896,0,100.7,1342,219.2,23.01,0.1256,8.02E-02,0.4057,0.1215,0.1215,0.1215,0.1,7.9,7.435,22.89,6.08E-
4389,57.4,0,0,4.898,0,100.9,1342,219.2,22.99,0.1251,7.94E-02,0.4013,0.1223,0.1223,0.1223,0.1,7.9,7.42,23.03,6.12E-04,
4390,57.4,0,0,4.899,0,101,1342,219.2,22.98,0.1245,7.86E-02,0.3969,0.1232,0.1232,0.1232,0.1,7.9,7.406,23.16,6.16E-04,
4391,57.4,0,0,4.9,0.101.5,1342,219.2,22.97,0.124,7.77E-02,0.3924,0.124,0.124,0.1,7.9,7.392,23.3,6.20E-04,6.20E-
```

Branch Distributed Tributary Inflow File

This file contains the inflows for a distributed tributary specified on the [Distributed Tributary](#) card. The following is a list of guidelines for file preparation:

1. A separate file is required for each distributed tributary. This approach allows the user to update inflows for one distributed tributary independent of another distributed tributary.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow rate, $m^3 \text{ sec}^{-1}$.
7. Flow rates can be negative or minus values, meaning withdrawals, or positive values implying inflows.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample distributed tributary inflow file

JDAY	QDTR
1.0	22.8
5.0	44.5
12.0	31.2
23.0	80.4
35.0	50.6
74.5	103.0
74.7	185.6
75.0	212.3
75.5	178.6
80.0	123.4
80.5	78.3
90.0	46.5

The model user can also use a free-format file rather than the fixed format shown above. When the first character in the first line contains the ‘\$’ symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown below.

Example – Free Format, Comma Delimited

```
$Branch 6 Inflow,qin_br6.csvCRLF
JDAY 1.0 = 1/1/2000 12 am,CRLF
JDAY,QINCRLF
3913,21.4CRLF
3914,28.4CRLF
3915,25CRLF
3916,26.1CRLF
3917,36.2CRLF
3918,44.7CRLF
3919,35.3CRLF
3920,29.5CRLF
3921,31.6CRLF
3922,25.4CRLF
3923,26.1CRLF
3924,41.2CRLF
```

Branch Distributed Tributary Inflow Temperature File

This file contains the inflow temperatures for a distributed tributary specified on the [Distributed Tributary](#) card. The following is a list of guidelines for file preparation:

1. A separate file is required for each distributed tributary. This allows the user to update inflow temperatures for one distributed tributary independent of another distributed tributary.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the inflow temperature, °C.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample tributary inflow temperature file

JDAY	TDTR
1.0	10.3
5.0	9.5
12.0	10.1
23.0	8.6
35.0	11.2
74.5	13.9
74.7	13.1
75.0	12.8
75.5	12.5
80.0	12.6
80.5	12.7

The model user can also specify a free-format file rather than the fixed format shown above. When the first character in the first line contains the '\$' symbol, the model will treat the file as being in free format. As in the fixed format file, the first 3 lines are ignored and the data fields are in the same order as the fixed format file except that the user is no longer limited to 8 characters for each field. An example of a comma delimited file is shown in the Branch Temperature Inflow file description.

Branch Distributed Tributary Inflow Concentration File

This file contains the inflow concentrations for a distributed tributary specified on the [Distributed Tributary](#) card. The following is a list of guidelines for file preparation:

1. *If* constituents are being modeled, a separate file is required for each branch. This allows the user to update constituent inflow concentrations for one branch independent of another branch.
2. Input format for all fields is F8.0 that allows the user to specify the decimal point location. The number of fields is determined by (6) below and they are always located on one line.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the abbreviations for the constituent names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields contain the concentration for each constituent specified on the [Distributed Tributary Active Constituent Control](#) card. Only those constituents specified as *active* on the [Distributed Tributary Active Constituent Control](#) card may be included in the distributed tributary inflow concentration file.

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one to not be constrained by the 8-column width of the concentration value.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample distributed tributary constituent inflow concentration file

JDAY	CLFORM	ISS	LDOM	RDOM	ALGAE	DETTRIT	PO4	NH4	NO3	O2	Fe
1.	17.	62.	7.333	17.111	0.0	0.9	0.02	0.10	0.42	13.9	0.4
8.	13.	0.0	8.000	18.667	0.0	0.4	0.01	0.03	0.37	14.0	0.2
15.	11.	17.	9.333	21.778	0.0	0.0	0.00	0.01	0.17	10.0	0.3
22.	14.	34.	10.000	23.333	0.0	0.0	0.05	0.00	0.20	10.4	1.6
29.	17.	38.	4.467	10.422	0.0	0.4	0.01	0.11	0.26	11.6	0.4

Example – Free Format, Comma Delimited [not all columns are shown]

```
$Distributed Inflow Concentration,cdt_b1.csv,,,
JDAY 1.0= 1/1/2000 12am,,,
$Distributed Inflow Concentration,cdt_b1.csv,,,
JDAY,TDS,H2S,CH4,S04,Tracer,Cond,TCol,ECol,ISS1,PO4,NH4,NO3,LDOM,RDOM,LPM,RPOM,ALG1,D0,TIC,ALK,LDOM-P,RDOM-P,LPM-P,RPOM-P,LDO
4384,57.38,0,0,4.891,0,100.2,1342,219.2,23.06,0.1277,8.35E-02,0.4235,0.1183,0.1183,0.1183,0.1,7.9,7.507,22.35,5.92E-04,5
4385,57.38,0,0,4.892,0,100.3,1342,219.2,23.04,0.1272,8.27E-02,0.419,0.1191,0.1191,0.1191,0.1,7.9,7.487,22.49,5.96E-04,5
4386,57.39,0,0,4.894,0,100.4,1342,219.2,23.03,0.1266,8.19E-02,0.4146,0.1199,0.1199,0.1199,0.1,7.9,7.469,22.62,6.00E-04,6
4387,57.39,0,0,4.895,0,100.6,1342,219.2,23.02,0.1261,8.11E-02,0.4102,0.1287,0.1207,0.1287,0.1,7.9,7.451,22.76,6.04E-04,6
4388,57.39,0,0,4.896,0,100.7,1342,219.2,23.01,0.1256,8.02E-02,0.4057,0.1215,0.1215,0.1215,0.1,7.9,7.435,22.89,6.08E-04,6
4389,57.4,0,0,4.898,0,100.9,1342,219.2,22.99,0.1251,7.94E-02,0.4013,0.1223,0.1223,0.1223,0.1,7.9,7.42,23.03,6.12E-04,6.1
4390,57.4,0,0,4.899,0,101,1342,219.2,22.98,0.1245,7.86E-02,0.3969,0.1232,0.1232,0.1232,0.1,7.9,7.406,23.16,6.16E-04,6.16
4391,57.4,0,0,4.9,0,101.5,1342,219.2,22.97,0.124,7.77E-02,0.3924,0.124,0.124,0.124,0.1,7.9,7.392,23.3,6.20E-04,6.20E-04,6
4392,57.41,0,0,4.902,0,101.9,1342,219.2,22.95,0.1235,7.69E-02,0.388,0.1248,0.1248,0.1248,0.1,7.9,7.38,23.44,6.24E-04,6.2
4393,57.41,0,0,4.903,0,102.4,1342,219.2,22.94,0.123,7.61E-02,0.3835,0.1256,0.1256,0.1256,0.1,7.9,7.369,23.57,6.28E-04,6
4394,57.42,0,0,4.904,0,102.9,1342,219.2,22.93,0.1224,7.53E-02,0.3791,0.1264,0.1264,0.1264,0.1,7.9,7.358,23.71,6.32E-04,6
4395,57.42,0,0,4.906,0,103.4,1342,219.2,22.91,0.1219,7.44E-02,0.3747,0.1272,0.1272,0.1272,0.1,7.9,7.349,23.84,6.36E-04,6
4396,57.42,0,0,4.907,0,103.8,1342,219.2,22.9,0.1214,7.36E-02,0.3702,0.128,0.128,0.1,7.9,7.34,23.98,6.40E-04,6.40E-04
4397,57.43,0,0,4.908,0,104.3,1342,219.2,22.89,0.1209,7.28E-02,0.3658,0.1288,0.1288,0.1,7.9,7.333,24.11,6.44E-04,6
```

Branch Precipitation File

This file contains the precipitation values for a branch and is needed only if the precipitation option [[PRC](#)] is turned on. The following is a list of guidelines for file preparation:

1. A separate file is required for each branch. This allows the user to update precipitation for one branch independent of another branch if needed.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the precipitation rate, m sec⁻¹.

Note the following example takes advantage of the algorithm's capability to use data at varying frequencies.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample precipitation file where Pre is in m/s

JDAY	PRE
182.0000	0.000
182.5416	1.E-6
182.6250	2.E-6
182.6666	0.000
188.475	2.E-6
189.500	0.000

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one to not be constrained by the 8-column width of the Julian day or the precipitation rate.

Example – Free Format, Comma Delimited

\$CE-QUAL-W2 sample precipitation file where Pre is in m/s

JDAY, PRE
182.0000,0.000
182.5416,1.E-6
182.6250,2.E-6
182.6666,0.000
188.475,2.E-6
189.500,0.000

Branch Precipitation Temperature File

This file contains the precipitation temperatures for a branch and is needed only if the precipitation option [[PRC](#)] is turned on. The following is a list of guidelines for file preparation:

1. A separate file is required for each branch. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The second field is the precipitation temperature, °C.

Example – Fixed Format, Space Delimited

```
CE-QUAL-W2 sample precipitation temperature file
```

JDAY	TPR
1.00	6.80
2.00	6.70
3.00	7.00
4.00	6.30
5.00	6.40
6.00	6.10
7.00	6.60
8.00	5.70
9.00	5.20
10.00	5.40
11.00	7.10
12.00	6.60

There is also a free format option for this file. Whenever the first character on the first line is a '\$' character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one to not be constrained by the 8-column width of the Julian day or temperature value. As shown below:

Example – Free Format, Comma Delimited

```
$CE QUAL W2 sample precipitation temperature file
```

JDAY,TPR
1.00,6.80
2.00,6.70
3.00,7.00
4.00,6.30
5.00,6.40
6.00,6.10
7.00,6.60
8.00,5.70
9.00,5.20
10.00,5.40
11.00,7.10
12.00,6.60

Branch Precipitation Concentration File

This file contains the precipitation concentrations for a branch and is needed only if the precipitation option [[PRC](#)] is turned on. The following is a list of guidelines for file preparation:

1. **If** constituents are being modeled, a separate file is required for each branch. This allows the user to update constituent concentrations for one branch independent of another branch.
2. Input format for all fields is F8.0 that allows the user to specify the decimal point location. The number of fields is determined by (6) below and they are always located on one line.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the abbreviations for the constituent names that are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The remaining fields contain the concentration for each constituent specified on the [Precipitation Active Constituent Control](#) card. Only those constituents specified as **active** on the [Precipitation Active Constituent Control](#) card may be included in the constituent inflow concentration file. In the following example, only DO has been included.

An example is shown for the precipitation concentration below.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 constituent precipitation concentration sample input file

JDAY	DO
180.000	8.7
190.000	8.2
195.000	8.0
220.000	7.8

There is also a free format option for this file. Whenever the first character on the first line is a ‘\$’ character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one to not be constrained by the 8 column width of the Julian day or the concentration value. As shown below:

Example – Free Format, Comma Delimited

\$CE-QUAL-W2 constituent precipitation concentration sample input file

JDAY,DO
180.000,8.7
190.000,8.2
195.000,8.0
220.000,7.8

Branch External Upstream Head Elevation File

This file contains the elevations for a branch with an [external upstream head boundary condition](#). The following is a list of guidelines for file preparation:

1. A separate file is required for each branch with an external upstream head boundary condition. This allows the user to update elevations for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. If the first character in line 1 though is '\$', then this file is in CSV format and all fields are comma delimited and are not restricted to an 8-character field. An example is shown below.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next field is the external head elevation (m above datum specified on the [LOCATION](#) card).

Example – Fixed Format, Space Delimited

```
CE-QUAL-W2 sample external head elevation file
```

JDAY	ELUH
180.000	431.12
180.050	431.15
180.100	431.20
180.150	431.25
180.200	431.30

If the first character in line 1 is '\$', then the file is treated as a csv file format (comma delimited) and date formats can exceed 8 characters.

Example – Free Format, Comma Delimited

```
$ Head BC csv format
'
JDAY,Elevation (m)
311.01231,1.847
311.02156,1.844
311.03123,1.832
311.04234,1.807
311.05234,1.807
311.06345,1.786
```

Branch External Upstream Head Temperature File

This file contains the upstream temperature profiles for a branch with an [external upstream head boundary condition](#). Please note that there are 3 different input formats for this file. The following is a list of guidelines for file preparation for those files where the temperatures vary with depth at the upstream boundary:

1. A separate file is required for each branch. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. But if the first character on line 1 is a '\$', then the file is in a comma delimited format with no restriction on field length (csv file format).
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next fields are the upstream boundary temperatures, °C
7. Temperature values must be specified for each cell starting from layer two and extending to the bottom active layer at the upstream segment. For the fixed format input file: if the values do not all fit on one line, then they are continued on the next line with the first field (corresponding to the Julian date field) left blank. For the comma delimited file format, the temperatures do not wrap on the next line. The reason why the temperatures must start at layer two is the water surface may vary over many layers during the simulation and it is impossible to know beforehand exactly what time layers will be added or subtracted. When preparing the boundary temperature profiles, it is best to assign boundary temperatures starting from the bottom layer. Once the surface layer has been reached, then use this value to assign values up to layer two. In the following example, the surface layer [KT] starts out at layer six and the bottom is at layer 22. The first four values correspond to layers two through five and must be defined even if they are never used.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample external upstream boundary temperature file

JDAY	TUH							
180.500	19.3	19.3	19.3	19.3	19.3	19.0	18.8	18.7
	18.4	18.0	17.0	15.0	14.0	13.5	13.2	13.0
	12.8	12.8	12.8					12.8
187.500	20.3	20.3	20.3	20.3	20.3	20.0	19.8	19.7
	19.4	19.0	18.0	15.5	14.0	13.5	13.2	13.0
	12.8	12.8	12.8					12.8

Example – Free Format, Comma Delimited (viewed in Excel)

\$ Temperature BC	Layer																		
JDAY	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8				
80	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
200	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82
211	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82
225	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87
239	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18
253	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26

Another file format is available when the upstream boundary condition does not have any vertical stratification. In this case, the first 2 characters on line 1 of this file are '\$T'. The file format is similar to other comma delimited file formats such as the tributary temperature file.

Example No Stratification in Boundary – Free Format, Comma Delimited

```
$T Temperature BC,  
,  
JDAY,Temp (C)  
1.0,8.25  
80.05,12.345  
200.1,21.82  
211.4,21.82  
225.4,21.87  
239.2,21.18  
253.2,19.26  
271.1,17.61  
280.9,16.49  
293.1,14.5  
310.2,13.06  
323.25,11.01  
337.56,6.73
```

Branch External Upstream Head Constituent Concentration File

This file contains the upstream constituent concentration profiles for a branch with an [external upstream head boundary condition](#). Please note that there are 3 different input formats for this file. The following is a list of guidelines for file preparation for those files where the temperatures vary with depth at the upstream boundary:

1. **If** constituents are being modeled, then a separate file is required for each branch. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. But if the first character on line 1 is a '\$', then the file is in a comma delimited format with no restriction on field length (csv file format).
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next fields are the upstream boundary constituent concentrations.
7. Constituents must appear in the same order as they are turned on in the [Active Constituent](#) card. A boundary concentration is **required for each** active constituent.
8. Concentration values must be specified for each cell starting from layer two and extending to the bottom active layer at the upstream segment. For the fixed format file only: If the values do not all fit on one line, then they are continued on the next line with the first field (corresponding to the Julian date field) left blank. The reason why the concentrations must start at layer two is the water surface may vary over many layers during the simulation and it is impossible to know beforehand exactly what time layers will be added or subtracted. When preparing the boundary concentration profiles, it is best to assign concentrations starting from the bottom layer. Once the surface layer has been reached, then use this value to assign values up to layer two. In the following example, the surface layer [KT] starts out at layer six and the bottom is at layer 22. The first four values correspond to layers two through five and must be defined even if they are never used. Salinity and dissolved oxygen are the only values specified as active.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample external upstream boundary constituent concentration file									
JDAY	CUH								
180.000	23.5	23.5	23.5	23.5	23.5	23.9	24.5	25.0	26.0 !TDS
	27.0	28.0	29.0	29.5	30.0	30.2	30.4	30.6	30.6
	30.6	30.6	30.6	30.6					
180.000	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.8	8.7 !DO
	8.6	8.4	8.0	7.5	7.0	6.0	5.5	5.5	5.5
	5.5	5.5	5.5	5.5					
	5.5	5.5	5.5	5.5					
190.000	23.5	23.5	23.5	23.5	23.5	23.9	24.5	25.0	26.0 !TDS
	27.0	28.0	29.0	29.5	30.0	30.2	30.4	30.6	30.6
	30.6	30.6	30.6	30.6					
190.000	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.8	8.7 !DO
	8.6	8.4	8.0	7.0	6.0	5.0	5.0	5.0	5.0
	5.0	5.0	5.0	5.0					
	5.0	5.0	5.0	5.0					

UPSTREAM HEAD CONCENTRATION

INPUT FILES

Example – Free Format, Comma Delimited (viewed in Excel)

Another file format is available when the upstream boundary condition does not have any vertical variation in concentration. In this case, the first 2 characters on line 1 of this file are '\$T'. The file format is similar to other comma delimited file formats such as the tributary concentration file.

Example No Stratification– Free Format, Comma Delimited

```
$T Concentration BC,,,,,,,,,,  
//////////  
JDAY,TDS,TRACER,Age,COLIFRM,ISS,PO4,NH4,NO3,FE,LDOM,RDOM,LPOM,ALG1,DO,TIC,ALK  
1.25,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0  
80.5,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0  
200.24,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0  
211.45,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0  
225.4,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
```

Branch External Downstream Head Elevation File

This file contains the elevations for a branch with an [external downstream head boundary condition](#). The following is a list of guidelines for file preparation:

1. A separate file is required for each branch with an external downstream head boundary condition. This allows the user to update elevations for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. If the first character in line 1 though is '\$', then this file is in CSV format and all fields are comma delimited and are not restricted to an 8-character field. An example is shown below.
3. The first two lines are ignored and can be used to comment the file.
4. The next line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next field is the external head elevation (m above datum specified on the [Initial Condition](#) card).

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample external downstream head elevation file

JDAY	ELUH
180.000	431.12
180.050	431.15
180.100	431.20
180.150	431.25
180.200	431.30

If the first character in line 1 is '\$', then the file is treated as a csv file format (comma delimited) and date formats can exceed 8 characters.

Example – Free Format, Comma Delimited

```
$ Head BC csv format
,
JDAY,Elevation(m)
311.01231,1.847
311.02156,1.844
311.03123,1.832
311.04234,1.807
311.05234,1.807
311.06345,1.786
```

Branch External Downstream Head Temperature File

This file contains the downstream temperature profiles for a branch with an [external downstream head boundary condition](#). Please note that there are 3 different input formats for this file. The following is a list of guidelines for file preparation for those files where the temperatures vary with depth at the upstream boundary:

1. A separate file is required for each branch. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. But if the first character on line 1 is a '\$', then the file is in a comma delimited format with no restriction on field length (csv file format).
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next fields are the upstream boundary temperatures, °C, *starting from layer 2 to the bottom layer at that boundary location*.
7. Temperature values must be specified for each cell starting from layer two and extending to the bottom active layer at the upstream segment. For the fixed format input file: if the values do not all fit on one line, then they are continued on the next line with the first field (corresponding to the Julian date field) left blank. For the comma delimited file format, the temperatures do not wrap on the next line. The reason why the temperatures must start at layer two is the water surface may vary over many layers during the simulation and it is impossible to know beforehand exactly what time layers will be added or subtracted. When preparing the boundary temperature profiles, it is best to assign boundary temperatures starting from the bottom layer. Once the surface layer has been reached, then use this value to assign values up to layer two. In the following example, the surface layer [KT] starts out at layer six and the bottom is at layer 22. The first four values correspond to layers two through five and must be defined even if they are never used.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample external downstream boundary temperature file

	TUH							
180.500	19.3	19.3	19.3	19.3	19.3	19.0	18.8	18.7
	18.4	18.0	17.0	15.0	14.0	13.5	13.2	13.0
	12.8	12.8	12.8					12.8
187.500	20.3	20.3	20.3	20.3	20.3	20.0	19.8	19.7
	19.4	19.0	18.0	15.5	14.0	13.5	13.2	13.0
	12.8	12.8	12.8					12.8

INPUT FILES

DOWNSTREAM HEAD TEMPERATURE

Example – Free Format, Comma Delimited (viewed in Excel where bottom layer is K=16)

\$ Temperature BC	Layer																		
JDAY	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
80	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
200	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82
211	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82	21.82
225	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87	21.87
239	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18	21.18
253	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26	19.26

Another file format is available when the downstream boundary condition does not have any vertical stratification. In this case, the first 2 characters on line 1 of this file are '\$T'. The file format is similar to other comma delimited file formats such as the tributary temperature file.

Example – No Stratification, Free Format, Comma Delimited

```
$T Temperature BC,  
'  
JDAY,Temp (C)  
1.0,8.25  
80.05,12.345  
200.1,21.82  
211.4,21.82  
225.4,21.87  
239.2,21.18  
253.2,19.26  
271.1,17.61  
280.9,16.49  
293.1,14.5  
310.2,13.06  
323.25,11.01  
337.56,6.73
```

Branch External Downstream Head Concentration File

This file contains the downstream constituent concentration profiles for a branch with an [external downstream head boundary condition](#). Please note that there are 3 different input formats for this file. The following is a list of guidelines for file preparation for those files where the temperatures vary with depth at the upstream boundary:

1. **If** constituents are being modeled, then a separate file is required for each branch. This allows the user to update temperatures for one branch independent of another branch.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location. But if the first character on line 1 is a '\$', then the file is in a comma delimited format with no restriction on field length (csv file format).
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains the variable names which are right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is the Julian date that can be entered at any frequency. The frequency between updates may vary during the simulation.
6. The next fields are the upstream boundary constituent concentrations starting from layer K=2 to the bottom layer at the boundary.
7. Constituents must appear in the same order as they are turned on in the [Active Constituent](#) card. A boundary concentration is **required for each** active constituent.
8. Concentration values must be specified for each cell starting from layer two and extending to the bottom active layer at the upstream segment. For the fixed format file only: If the values do not all fit on one line, then they are continued on the next line with the first field (corresponding to the Julian date field) left blank. The reason why the concentrations must start at layer two is the water surface may vary over many layers during the simulation and it is impossible to know beforehand exactly what time layers will be added or subtracted. When preparing the boundary concentration profiles, it is best to assign concentrations starting from the bottom layer. Once the surface layer has been reached, then use this value to assign values up to layer two. In the following example, the surface layer [KT] starts out at layer six and the bottom is at layer 22. The first four values correspond to layers two through five and must be defined even if they are never used. Salinity and dissolved oxygen are the only values specified as active.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample external downstream boundary constituent concentration file

JDAY	CUH							
180.000	23.5	23.5	23.5	23.5	23.5	23.9	24.5	25.0
Salinity	27.0	28.0	29.0	29.5	30.0	30.2	30.4	30.6
	30.6	30.6	30.6	30.6				
180.000	9.0	9.0	9.0	9.0	9.0	9.0	8.8	8.7
DO	8.6	8.4	8.0	7.5	7.0	6.0	5.5	5.5
	5.5	5.5	5.5	5.5				
190.000	23.5	23.5	23.5	23.5	23.5	23.9	24.5	25.0
Salinity	27.0	28.0	29.0	29.5	30.0	30.2	30.4	30.6
	30.6	30.6	30.6	30.6				
190.000	9.0	9.0	9.0	9.0	9.0	9.0	8.8	8.7
DO	8.6	8.4	8.0	7.0	6.0	5.0	5.0	5.0
	5.0	5.0	5.0	5.0				

INPUT FILES

UPSTREAM HEAD CONCENTRATION

Example – Free Format, Comma Delimited (viewed in Excel where bottom layer is K=16)

\$ Concentration BC	Layer	Layer	16 Variable															
JDAY	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TDS	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TRACER	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 Age	
1	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300 COLIFRM	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 ISS	
1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05 PO4	
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1 NH4	
1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3 NO3	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 FE	
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5 LDOM	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 RDOM	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 LPOM	
1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06 ALG1	
1	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31 DO	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TIC	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 ALK	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TDS	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TRACER	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 Age	
120	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300 COLIFRM		
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 ISS	
120	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05 PO4	
120	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1 NH4	
120	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3 NO3	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 FE	
120	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5 LDOM	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 RDOM	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 LPOM	
120	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06 ALG1	
120	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31 DO	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 TIC	
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 ALK	

Another file format is available when the downstream boundary condition does not have any vertical variation in concentration. In this case, the first 2 characters on line 1 of this file are '\$T'. The file format is similar to other comma delimited file formats such as the tributary concentration file.

Example – No Stratification, Free Format, Comma Delimited

```
$T Concentration BC,///////////
/////////////////////////////
JDAY,TDS,TRACER,Age,COLIFRM,ISS,PO4,NH4,NO3,FE,LDOM,RDOM,LPOM,ALG1,DO,TIC,ALK
1.25,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
80.5,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
200.24,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
211.45,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
225.4,0,0,0,3300,0,0.05,0.1,0.3,0,5,0,0,0.06,9.31,0,0
```

Vertical Profile File

This file contains a single vertical profile used to specify initial conditions for temperatures and/or constituent concentrations. The vertically varying profile is then used to initialize all segments in the computational grid. This file is most commonly used for vertically stratified waterbodies with no longitudinal gradients. The following is a list of guidelines for file preparation:

1. An initial vertical profile is specified by inputting -1.0 for the initial temperature on the [Initial Conditions](#) card or a constituent's initial concentration on the [Initial Concentration](#) card. If temperature is included, then it **must** be the first profile in the file. Constituent profiles **must** be input in the same order as they are specified on the [Initial Concentration](#) card.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains in the first field a constituent identifier name to aid in creating and editing the file. The remaining fields contain the variable name which is right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is left blank or can be used for comments since it is ignored on input. The remaining fields are used for specifying the temperature or concentration at a given layer. If there are **more** values than can be specified on one line, then they are continued on the next line leaving the first field blank or using it for comments.
6. Values for the vertical profile start at the water surface layer [KT] and stop at the bottom layer. Boundary segments are **not** included in the file.
7. The order of constituents in the VPR file are as follows:
 - Temperature
 - Constituents
 - Epiphyton/periphyton
 - Macrophytes

The following sample input file contains vertically varying initial temperature and dissolved oxygen profiles that correspond to the sample input bathymetry. The surface layer [KT] is located at layer five.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample vertical profile initial conditions file									
TEMP VPR	T1	T1	T1						
	15.2	15.0	14.7	14.5	14.3	14.2	11.7	8.5	6.7
	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	6.0	6.0							
DO VPR	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.7
	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	6.0	6.0							

There is also a free format option for this file. Whenever the first character on the first line is a ‘\$’ character, the model assumes the input is in free format rather than fixed format. Besides allowing the use of Excel and easy exporting to a csv file type, this also allows one not to be constrained by the 8-column width nor by wrapping temperature or concentration values.

INPUT FILES

VERTICAL PROFILE

Example – Free format, comma delimited

Example – Free format, comma delimited (as viewed in Excel)

Longitudinal Profile File

This file contains vertical profiles for each segment used to initialize temperature and/or constituent concentrations for each computational grid cell. It is useful when temperature or a constituent is both vertically and longitudinally stratified where a single value or profile is not representative of the initial conditions. There are two file types: (1) The older version described below and (2) an updated csv file format that is much easier to prepare.

The following is a list of guidelines for file preparation of the older input file format:

1. An initial longitudinal profile input is specified by inputting -2.0 for the initial temperature on the [Initial Conditions](#) card or a constituent's initial concentration on the [Initial Concentration](#) card. If temperature is included, then it **must** be the first series of profiles in the file. Constituent profiles **must** be input in the same order as they are specified on the [Initial Concentration](#) card.
2. Input format for each field is F8.0 that allows the user to specify the decimal point location.
3. The first two lines are ignored and can be used to comment the file.
4. The third line contains in the first field a constituent identifier name to aid in creating and editing the file. The remaining fields contain the variable name which is right justified according to the input field. This line is also ignored although the preprocessor checks to ensure the fields are aligned correctly.
5. The first field is left blank or can be used for comments since it is ignored on input. The remaining fields are used for specifying the temperature or concentration at a given layer. If there are **more** values than can be specified on one line, then they are continued on the next line leaving the first field blank or using it for comments.
6. Values for the vertical profile at each segment start at the water surface layer [KT] and stop at the bottom layer. Boundary segments are **not** included in the file. You must determine the correct surface layer KT to start your profile. This can be readily seen in the pre.opt file where the model geometry and initial conditions are reproduced.
7. Note that the order of constituents in the LPR file is as follows:
 - Temperature
 - Constituents
 - Epiphyton/periphyton
 - Macrophytes
 - Sediment

The following sample input file includes vertically and longitudinally varying initial conditions for temperature and dissolved oxygen that corresponds to the sample input bathymetry. The surface layer [KT] is located at layer five.

Example – Fixed Format, Space Delimited

CE-QUAL-W2 sample longitudinal profile file									
Segment 2									
Temperature	T1	T1	T1						
	15.0	14.8	14.5	14.3	14.2	14.1	11.5	8.2	6.5
	6.2	6.0	6.0						
Segment 3									
Temperature	T1	T1	T1						
	15.0	14.8	14.5	14.3	14.2	14.1	11.5	8.2	6.5
	6.2	6.0							
Segment 4									
Temperature	T1	T1	T1						

INPUT FILES

LONGITUDINAL PROFILE

	15.0 6.2	14.8	14.5	14.3	14.2	14.1	11.5	8.2	6.5
Segment 5									
Temperature	T1 15.0	T1 14.8	T1 14.5	T1 14.3	T1 14.2	T1 14.1	T1 11.5	T1 8.2	T1 6.5
Segment 6									
Temperature	T1 15.1 6.2	T1 14.9 6.0	T1 14.5 6.0	T1 14.4 6.0	T1 14.2 6.0	T1 14.2 6.0	T1 11.7 6.0	T1 8.5 6.0	T1 6.7
Segment 7									
Temperature	T1 15.1 6.2	T1 14.9 6.0	T1 14.6 6.0	T1 14.4 6.0	T1 14.2 6.0	T1 14.2 6.0	T1 11.7 6.0	T1 8.5 6.0	T1 6.7
Segment 8									
Temperature	T1 15.2 6.2	T1 15.0 6.0	T1 14.7 6.0	T1 14.5 6.0	T1 14.3 6.0	T1 14.2 6.0	T1 11.7 6.0	T1 8.5 6.0	T1 6.7
Segment 9									
Temperature	T1 15.2 6.2 6.0	T1 15.0 6.0 6.0	T1 14.7 6.0 6.0	T1 14.5 6.0 6.0	T1 14.3 6.0 6.0	T1 14.2 6.0 6.0	T1 11.7 6.0 6.0	T1 8.5 6.0 6.0	T1 6.7
Segment 12									
Temperature	T1 15.5	T1 15.3	T1 14.8	T1 14.5	T1 14.3	T1 14.2	T1 10.6	T1 7.2	T1
Segment 13									
Temperature	T1 15.4 6.2	T1 15.2 6.0	T1 14.8 6.0	T1 14.5 6.0	T1 14.3 6.0	T1 14.2 6.0	T1 10.6	T1 7.2	T1 6.8
Segment 14									
Temperature	T1 15.4 6.2	T1 15.2 6.0	T1 14.8 6.0	T1 14.5 6.0	T1 14.3 6.0	T1 14.2 6.0	T1 10.6	T1 7.2	T1 6.5
Segment 15									
Temperature	T1 15.5 6.2	T1 15.3 6.0	T1 14.8 6.0	T1 14.5 6.0	T1 14.3 6.0	T1 14.2 6.0	T1 10.6	T1 7.2	T1 6.4
Segment 18									
Temperature	T1 15.5 6.2	T1 15.3 6.0	T1 14.8 6.0	T1 14.5 6.0	T1 14.3 6.0	T1 14.2 6.0	T1 10.6	T1 7.2	T1 6.4
Segment 19									
Temperature	T1 15.5 6.2 6.0	T1 15.3 6.0 6.0	T1 14.8 6.0 6.0	T1 14.5 6.0 6.0	T1 14.3 6.0 6.0	T1 14.2 6.0 6.0	T1 10.6 6.0 6.0	T1 7.2 6.0 6.0	T1 6.4 6.0 6.0
Segment 2									
DO	C1 12.0 6.2	C1 12.0 6.0	C1 12.0 6.0	C1 12.0 6.0	C1 11.9	C1 11.9	C1 11.5	C1 8.2	C1 6.5
Segment 3									
DO	C1 12.0 6.2	C1 12.0 6.0	C1 12.0 6.0	C1 12.0 6.0	C1 11.9	C1 11.9	C1 11.5	C1 8.2	C1 6.5
Segment 4									
DO	C1 12.0 6.2	C1 12.0 6.0	C1 12.0 6.0	C1 12.0 6.0	C1 11.9	C1 11.9	C1 11.5	C1 8.2	C1 6.5
Segment 5									
DO	C1 12.0 6.2	C1 12.0 6.0	C1 12.0 6.0	C1 12.0 6.0	C1 11.9	C1 11.9	C1 11.5	C1 8.3	C1 6.5
Segment 6									
DO	C1 12.0 6.2	C1 12.0 6.0	C1 12.0 6.0	C1 12.0 6.0	C1 11.9	C1 11.9	C1 11.6	C1 8.4	C1 6.7
Segment 7									
DO	C1	C1	C1						

LONGITUDINAL PROFILE

INPUT FILES

	12.0	12.0	12.0	12.0	11.9	11.9	11.6	8.5	6.7
Segment 8	6.2	6.0	6.0	6.0	6.0	6.0	6.0		
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.6	8.5	6.7
	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Segment 9	6.0								
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.7
	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Segment 12	6.0								
DO	C1	C1	C1						
	12.0	15.3	14.8	14.5	14.3	14.2	11.7	8.5	
Segment 13									
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.8
Segment 14	6.2	6.0							
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.5
Segment 15	6.2	6.0	6.0	6.0	6.0				
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.4
Segment 18	6.2	6.0	6.0	6.0	6.0				
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.4
Segment 19	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
DO	C1	C1	C1						
	12.0	12.0	12.0	12.0	11.9	11.9	11.7	8.5	6.4
	6.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	6.0								

The following is a list of guidelines for file preparation of the newer csv input file format:

1. An initial longitudinal profile input is specified by inputting -2.0 for the initial temperature on the [Initial Conditions](#) card or a constituent's initial concentration on the [Initial Concentration](#) card. If temperature is included, then it **must** be the first series of profiles in the file. Constituent profiles **must** be input in the same order as they are specified on the [Initial Concentration](#) card.
2. The first character on the first line is a '\$' character. This will tell the model to use layers as columns and rows as model segments. One is not constrained by an 8-digit number format nor by wrapping temperature or concentration values across rows.
3. Other than the '\$' character, the first two lines are ignored and can be used to comment the file.
4. The third line contains in the first field a constituent identifier name to aid in creating and editing the file. The remaining columns contain the layer numbers starting with the surface layer KT to the maximum layer number KMX-1. These too are ignored in the model and can be used for the user as comments.
5. The next rows all contain the following information: the first field is the segment number (which is not read by the model) and the remaining fields are used for specifying the temperature or concentration at a given layer.
6. Values for the vertical profile at each segment start at the water surface layer [KT] and stop at the bottom layer. Boundary segments are **not** included in the file. You must determine the correct surface layer KT to start your profile. This can be readily seen in the pre.opt file where the model geometry and initial conditions are reproduced.
7. Note that the order of constituents in the LPR file is as follows:

INPUT FILES

LONGITUDINAL PROFILE

- Temperature
 - Constituents
 - Epiphyton/periphyton
 - Macrophytes
 - Sediment

Example – Free format, comma delimited

LONGITUDINAL PROFILE

INPUT FILES

```
19,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
20,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
21,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
22,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
23,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
24,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
25,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
26,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
27,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
28,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
29,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
30,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
31,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
32,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
33,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
34,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
35,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
36,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
37,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
38,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
39,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
40,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,  
41,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01,
```

INPUT FILES

LONGITUDINAL PROFILE

Example – Free format, comma delimited (as viewed in Excel)

Graph Input File

The file **graph.npt** is only required for all model simulations of CE-QUAL-W2 using the control file **w2_con.npt**. When the model user uses the Excel version of the control file based on **w2_con.csv**, the **graph.npt** file is not needed. Many of the variables in the **graph.npt** file are now included in the **csv** file format directly. This file controls output formats for the model output variables.

The first section contains hydraulic variables. The hydrodynamic format [**HFMT**] specifies the output variable format for the snapshot output file. The hydrodynamic minimum [**HMIN**], maximum [**HMAX**], and [**HPLTC**] are no longer used and are ignored by the model. In earlier versions of the code they specify the plotting limits when viewing the output using Array Viewer. The **HYD PR** card in the **w2_con.npt** control file defines which terms are printed and describes the output variables.

The second section of the file contains a line for each active constituent defined in the control file **w2_con.npt**. The concentration multiplier [**CMULT**] is a conversion factor and multiplies the output by the value specified. This is most useful when converting from $g\ m^{-3}$ to $mg\ m^{-3}$ for nutrient values. The concentration minimum [**CMIN**], maximum [**CMAX**], and plot control [**CPLTC**] are no longer used in Version 3.7 and later. For earlier versions they defined the limits of the Array Viewer animation scaling.

The model preprocessor provides detailed guidance on setting up the active model constituents in this file once they have been set in **w2_con.npt**. Hence, we recommend running the preprocessor first before spending time adjusting the **graph.npt** file.

The third section contains derived constituent variables. The derived constituent multiplier [**CDMULT**] can be used to convert the output to units other than $g\ m^{-3}$. The derived constituent minimum concentration [**CDMIN**], maximum concentration [**CDMAX**], and plot control [**CDPLTC**] are no longer used. In earlier versions of the code they specified the plotting limits when viewing the output using Array Viewer.

Example

Hydrodynamic, constituent, and derived constituent names, formats, multipliers, and array viewer controls

.....HNAME.....	FMTH	HMULT	HMIN	HMAX	HPLTC	#
Timestep violations [NVIOL]	(I10)	1.0	-1.0	1.0	OFF	1
Horizontal velocity [U], m/s	(g10.3)	1.0	-1.000	0.25	OFF	2
Vertical velocity [W], m/s	(g10.3)	1.0	-1E-6	-0.01	OFF	3
Temperature [T1], <math><math> <td>(g10.3)</td> <td>1.0</td> <td>-2.0</td> <td>-30.0</td> <td>ON</td> <td>4</td>	(g10.3)	1.0	-2.0	-30.0	ON	4
Density [RHO], kg/m ³	(g10.3)	1.0	997.0	1005.0	OFF	5
Vertical eddy viscosity [AZ], m ² /s	(g10.3)	1.0	-1E-08	0.01	OFF	6
Velocity shear stress [SHEAR], 1/s ²	(g10.3)	1.0	-1E-08	0.01	OFF	7
Internal shear [ST], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	8
Bottom shear [SB], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	9
Longitudinal momentum [ADMX], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	10
Longitudinal momentum [DM], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	11
Horizontal density gradient [HDG1], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	12
Vertical momentum [ADMZ], m ³ /s ²	(g10.3)	1.0	-1E-08	0.01	OFF	13
Horizontal pressure gradient [HPG], m ³ /s ²	(g10.3)	1.0	-1E-08	10.0	OFF	14
Gravity term channel slope [GRAV], m ³ /s ²	(g10.3)	1.0	0.0	0.0	OFF	15
.....CNAME.....	FMTC	CMULT	CMIN	CMAX	CPLTC	#
TDS, g/m ³	(g10.3)	1.0	-1.0	200.0	OFF	1
Tracer, g/m ³	(g10.3)	1.0	-1.0	200.0	OFF	2
Age, days	(g10.3)	1.0	-1.0	-20.0	OFF	3
Coliform, g/m ³	(g10.3)	1.0	-1.0	200.0	OFF	4
Conductivity, g/m ³	(g10.3)	1.0	-1.0	-300.0	OFF	5
Chloride, g/m ³	(g10.3)	1.0	-1.0	6.0	OFF	6

OUTPUT FILES

SNAPSHOT

ISS, g/m^3	(g10.3)	1.0	-20.000	15.0	OFF	7
Phosphate, mg/m^3	(g10.3)	1000.0	-1.0	-500.0	ON	8
Ammonium, mg/m^3	(g10.3)	1000.0	-0.1000	-300.0	OFF	9
Nitrate-Nitrite, g/m^3	(g10.3)	1.0	-0.1000	5.0	OFF	10
Dissolved silica, g/m^3	(g10.3)	1.0	-1.0	10.0	OFF	11
Particulate silica, g/m^3	(g10.3)	1.0	-0.2000	15.0	OFF	12
Total iron, g/m^3	(g10.3)	1.0	-0.1000	2.0	OFF	13
Labile DOM, g/m^3	(g10.3)	1.0	-0.1000	-3.0	OFF	14
Refractory DOM, g/m^3	(g10.3)	1.0	-0.1000	-4.0	OFF	15
Labile POM, g/m^3	(g10.3)	1.0	-0.1000	-3.0	OFF	16
Refractory POM, g/m^3	(g10.3)	1.0	-0.1000	-4.0	OFF	17
1CBOD, g/m^3	(g10.3)	1.0	-0.1	10.0	OFF	18
1CBODP, g/m^3	(g10.3)	1.0	-0.1	10.0	OFF	19
1CBODN, g/m^3	(g10.3)	1.0	-0.1	10.0	OFF	20
Algae1, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	21
Algae2, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	22
Algae3, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	23
Algae4, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	24
Dissolved oxygen, g/m^3	(g10.3)	1.0	-0.0100	-1.0	ON	25
Inorganic carbon, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	26
Alkalinity, g/m^3	(g10.3)	1.0	-0.0100	3.0	OFF	27
zooplankton1, mg/m^3	(g10.3)	1000.0	-0.0100	1.0	OFF	28
LDOM P, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	29
RDOM P, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	30
LPOM P, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	31
RPOM P, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	32
LDOM N, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	33
RDOM N, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	34
LPOM N, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	35
RPOM N, mg/m^3	(g10.3)	1000.0	0.0	1.0	OFF	36
MICROCYSTIN, g/m3	(g10.3)	1.0	0.0	1.0	OFF	37
CYLINDROSPERMOPSIIN, g/m3	(g10.3)	1.0	0.0	1.0	OFF	38
ANATOXIN-A, g/m3	(g10.3)	1.0	0.0	1.0	OFF	39
SAXITOXIN, g/m3	(g10.3)	1.0	0.0	1.0	OFF	40
.....CDNAME.....	FMTCD	CDMULT	CDMIN	CDMAX	CDPLTC	#
Dissolved organic carbon, g/m^3	(g10.3)	1.0	-1.0	25.0	OFF	1
Particulate organic carbon, g/m^3	(g10.3)	1.0	-1.0	50.0	OFF	2
Total organic carbon, g/m^3	(g10.3)	1.0	-1.0	25.0	OFF	3
Dissolved organic nitrogen, g/m^3	(g10.3)	1.0	-1.0	25.0	OFF	4
Particulate organic nitrogen, g/m^3	(g10.3)	1.0	-1.0	25.0	OFF	5
Total organic nitrogen, g/m^3	(g10.3)	1.0	-1.0	50.0	OFF	6
Total Kheldahl Nitrogen, g/m^3	(g10.3)	1.0	-1.0	15.0	OFF	7
Total nitrogen, g/m^3	(g10.3)	1.0	-1.0	15.0	OFF	8
Dissolved organic phosphorus, mg/m^3	(g10.3)	1000.0	-1.0	25.0	OFF	9
Particulate organic phosphorus, mg/m^3	(g10.3)	1000.0	-1.0	-1.0	OFF	10
Total organic phosphorus, mg/m^3	(g10.3)	1000.0	-1.0	5.0	OFF	11
Total phosphorus, mg/m^3	(g10.3)	1000.0	-1.0	20.0	OFF	12
Algal production, g/m^2/day	(g10.3)	1.0	-1.0	5.0	OFF	13
Chlorophyll a, mg/m^3	(g10.3)	1.0	-5.0	145.0	OFF	14
Total algae, g/m^3	(g10.3)	1.0	-1.0	60.0	OFF	15
Oxygen % Gas Saturation	(g10.3)	1.0	-1.0	50.0	OFF	16
Total suspended Solids, g/m^3	(g10.3)	1.0	-1.0	5.0	OFF	17
Total Inorganic Suspended Solids, g/m^3	(g10.3)	1.0	-1.0	20.0	OFF	18
Carbonaceous Ultimate BOD, g/m^3	(g10.3)	1.0	5.0	9.0	OFF	19
pH	(g10.3)	1.0	-1.0	10.0	OFF	20
CO2	(g10.3)	1.0	-1.0	10.0	OFF	21
HCO3	(g10.3)	1.0	-1.0	10.0	OFF	22
CO3	(g10.3)	1.0	-1.0	0.0	OFF	23

Tecplot Input File Specifying Which Branches to Output

If the model user specifies for the CPL output, CPLC=ON and TECPLOT=ON, then the model searches for a file named **w2_tecplotbr.csv**. This file contains information on how many branches of information to output to the output file. For example, if the user had a main branch and numerous side branches, the model user may want just to use the main branch in Tecplot rather than post-processing the output file further to isolate the main branch.

The file, **w2_tecplotbr.csv**, is shown below:

```
# of branches to output to TECPLOT
2
Put the branches you want to be output to TECPLOT on the next line separated by a comma
1,2
```

Or in the Excel input file:

A	B	C	D	E	F	G	H
1 # of branches to output to TECPLOT		This file allows the user to control which branches are output to Tecplot					
2							
3 Put the branches you want to be output to TECPLOT on the next line seperated by a comma							
4	1 2						
5							

The first line is a comment and is not read. The 2nd line shows the number of branches to output to the Tecplot CPL file within a waterbody. In the example above, only 2 branches are written out to the CPL output file. The 3rd line is a comment line. The 4th line is the branch number for each branch to output. In this example, branches 1 and 2 are written to the CPL output file, even though there may have been more branches in the waterbody.

Lake River Contour Plots Input File

In many limnological studies, a contour plot of elevation at one location versus time for the temperature or dissolved oxygen is useful in describing changes in the contour variable over time. Also, the evaluating change in temperature along a river's length as it varies with time for temperature or dissolved oxygen is useful in understanding the river system over time and space. The CE-QUAL-W2 model outputs data easily to provide such graphs. The output files are described in the [Lake River Contour Plots Output File](#).

There is no ON/OFF switch in the control file, just the presence or absence of an input file, **lake_river_contour.csv**. This file is located in the Excel master input file and has the following format as shown below:

OUTPUT FILES

SNAPSHOT

A	B	C	D	E	F	G	H	I	J
1 Specify output for lake river contours - specify ON or OFF for further processing "Hard wired for temperature DO only"									
2 ON									
3 #LakeContours[Max10]	OutputFormat[1:TimeElevTemp and DO;2:Contour]								
4 1	1								
5 Lake segment#	Startday	Frequency in days							
6 31	1.5	1							
7 #RiverContours[Max10]	OutputFormat[1:Time Elev Temp and DO;2:Contour]								
8 0	2								
9 BranchStart	BranchEnd	StartDay	FrequencyDays						
10 1		1	1.5	0.25					
11									
12									
13									
14									
15 Limnological plots for lakes/reservoirs									
16 This allows for easy plotting in lake/reservoirs the typical contour plots of elevation vs time with temperature and DO contoured;									
17 or in a river a contour of longitudinal distance and time with temperature and DO									

The variables and explanations are shown below:

Specify output for lake river contours - specify ON or OFF for further processing "Hard wired for temperature DO only"

ON

This turns ON or OFF the output file. The model senses the presence of this file and then checks to see if the value here is ON before proceeding.

#LakeContours[Max20]	OutputFormat[1:TimeElevTemp and DO;2:Contour]
1	1

The first number specifies how many segments does the model user want to output an elevation vs time vs temperature and dissolved oxygen. There are a maximum of 20 lake contours.

The second number is either 1 or 2 and has 2 different output format possibilities. Output format 1 outputs a file with JDAY, ELEVATION, and TEMPERATURE and another file with JDAY, ELEVATION, and DISSOLVED OXYGEN. There are -99 values when there is a channel bottom and no model value, such as shown partially below:

JDAY	ELEVATION(m)	TEMPERATURE(C)
64.5	123.9	-99
64.5	123.8	7.4
64.5	120.35	7.4
64.5	118.35	7.3
64.5	116.35	7.3
64.5	114.35	7.3
64.5	112.35	7.3

The output 2 format has values along the first row of elevation of the grid in m, then for each time (column 1), the values of temperature or dissolved oxygen are in columns 2 to the end for each depth at that time. This allows for direct contour plotting. A partial file example is shown below in Excel:

TIME	126.35	124.35	122.35	120.35	118.35	116.35
64.5	-99	-99	7.4	7.4	7.3	7.3
65.5	-99	-99	7.74	7.63	7.56	7.52
66.5	-99	-99	7.98	7.88	7.85	7.83
67.5	-99	-99	7.8	7.53	7.45	7.44
68.5	-99	-99	8.74	8.63	8.53	8.48

SNAPSHOT**OUTPUT FILES**

69.5	-99	-99	9.27	9.05	8.99	8.98
70.5	-99	-99	9.07	8.78	8.36	8.1
71.5	-99	-99	9.43	9.34	9.1	8.46
72.5	-99	-99	7.93	7.59	7.29	7.28
73.5	-99	-99	8.03	7.95	7.87	7.8
74.5	-99	-99	9.04	8.8	8.74	8.73
75.5	-99	-99	8.81	8.61	8.47	8.22
76.5	-99	-99	8.07	7.86	7.69	7.65
77.5	-99	-99	8.24	8.19	8.12	8.03
78.5	-99	-99	9.18	8.97	8.85	8.81
79.5	-99	-99	9.18	9.05	8.91	8.86
80.5	-99	-99	9.24	8.95	8.66	8.6
81.5	-99	-99	9.91	9.73	9.62	9.58

Lake segment#	Startday	Frequency in days
31	1.5	1

The next line shows the model segment and the start day and frequency of output in days. Include more rows for the number of LakeContours. If the # of lake contours is zero, delete this data input line.

#RiverContours[Max20]	OutputFormat[1:Time Elev Temp and DO;2:Contour]
1	2

This first field shows the number of river contours (a maximum of 20) and their output format (=1 or 2). The river contour is always time versus distance and the contour variable temperature or dissolved oxygen. The output format 1 has columns of JDAY, Distance along the river, and temperature or dissolved oxygen as shown below:

JDAY	DISTANCE(M)	TEMPERATURE(C)
64.5	500	7.4
64.5	1000	7.4
64.5	2000	7.4
64.5	3000	7.4
64.5	4000	7.4
64.5	5000	7.4
64.5	6000	7.4
64.5	7000	7.4
64.5	8000	7.4
64.5	9000	7.4
64.5	10000	7.4
64.5	11000	7.4

Output format 2 has in row 1 the river distance, in column 1 time and to fill out the rows is temperature or dissolved oxygen for each distance and time as shown partially below:

TIME	500	1000	2000	3000	4000	5000
64.5	7.4	7.4	7.4	7.4	7.4	7.4
64.75	6.68	7.43	7.65	7.67	7.63	7.59
65	6.17	6.96	7.64	7.76	7.72	7.66
65.25	5.87	6.31	7.35	7.55	7.56	7.53
65.5	6.27	6.35	7.33	7.77	7.78	7.74

OUTPUT FILES

SNAPSHOT

65.75	6.68	6.7	7.46	8.09	8.1	8.06
66	6.57	6.48	6.97	7.65	7.76	7.79
66.25	6.66	6.29	6.57	7.25	7.46	7.56

BranchStart	BranchEnd	StartDay	FrequencyDays
1	1	1.5	0.25

The Branch start specifies the beginning branch number and branch end specifies the ending branch number for the river contour. The start day and the frequency of output are also specified. This line is continued for each River Contour. Note that the branches must be in one waterbody! If not, just add multiple River Contours for each branch that is associated with one waterbody.

Algae Vertical Migration Input File

This input file describes parameters used for the vertical migration model of Overman (2019) and described in the User Manual Part 2. The file template is in the Excel input file as a tab named **w2_AlgaeMigration.csv**.

An example of the **w2_AlgaeMigration.csv** input file is shown below:

The parameter **AVERTM** is read in from the control file for each algae group. If this is ON for any group, then this input file **w2_AlgaeMigration.csv** is read.

A description of each line in the migration file is shown below:

AlgaeMigration: ON/OFF

SNAPSHOT

OUTPUT FILES

This turns algae migration ON or OFF for all algae groups. This supersedes the **AVERTM** control in the main control file.

NumAlgaeGroups# of algae groups that migrate	Debug Output(1-ON/0-OFF)
1	1

This shows how many of your algae groups will migrate vertically and whether the model user wants a debug log of all model decisions on algae movement.

NumMigrateIntervals - # of intervals for algal migration (Models 1 and 2 only)
2

This specifies how many time intervals will the algae use a time variable settling or sinking velocity.

JDAYStart - start of each migration interval		
100		465
JDAYend		
250		610

This specifies the Julian day for starting vertical migration and the Julian day for ending vertical migration for the number of intervals specified.

ContiuumModel: 1 - velocity time; 2 - velocity time and space; 3 - density growth; 4 - density growth (Visser)
1

This parameter specifies which vertical migration model to use: 1, 2, 3, or 4. These are described in the User Manual Part 2 and in Overman (2019).

The next few cards are input parameters for each method.

Ampli-tude(m)	PhaseShift(ra-dians)	Calibra-tionCoef-fi-cientEx-tinction	DepthCal-cOnOff(1-ON/0-OFF)	ExpDepth(m)	DepthLim-i-tOnOff(1-ON/0-OFF)	Depth-Limit(m)	LossFrac-tion
2	1.570796		0		1	25	0.05

This line contains the inputs for Models 1 and 2 only. If cyanobacteria colonies are assumed to migrate vertically on a daily cycle, an equation for colony velocity as a function of time can be used:

$$v_p(t) = A \frac{2\pi}{86,400 \text{ s}} \cos\left(\frac{2\pi}{86,400 \text{ s}} t + \phi\right)$$

where A is migration amplitude and the period is assumed to be one day (86,400 seconds). The value of the phase shift (ϕ) depends on the initial location of colonies. For example, if $t = 0$ in the simulation corresponds to midnight and colonies are assumed to be at the bottom at that time, the value is $\pi/2$ with positive velocity corresponding to downward movement. The Depth Calculation for this is OFF (=0), so this is Method 1. There is a depth limit imposed if the Depth Limit is ON (=1) on the migration. In this case the depth limit is 25 m (they stop once they reach that depth). The loss fraction is the fraction of biomass lost once they interact with the bottom of the system.

For Model 2, the velocity function is dependent on space as well as time, as in Belov and Giles (1997):

$$v_p(t, z) = \begin{cases} A \frac{2\pi}{86,400 \text{ s}} \cos\left(\frac{2\pi}{86,400 \text{ s}} t + \phi\right) e^{-\alpha(H-z)}, & I_0 > 0 \\ A \frac{2\pi}{86,400 \text{ s}} \cos\left(\frac{2\pi}{86,400 \text{ s}} t + \phi\right), & I_0 \leq 0 \end{cases}$$

where, α is the light attenuation coefficient (CalibrationCoefficientExtinction) and I_0 is solar irradiance at the water surface, H is the ExpDepth(m) and is a user supplied parameter. The addition of the exponential term gives colonies deeper in the water column higher speeds and responds to variations in water clarity

OUTPUT FILES

SNAPSHOT

when the light attenuation coefficient, α , is variable. The exponential term is only applied during the photoperiod so that the effects of water clarity are only included when there is sunlight present. During dark periods, the equation reduces to Model 1.

ColonyRadius(m)	Min-ColonyDen (kg m^-3)	Max-ColonyDen (kg m^-3)	In-itColonyDenSurf (kg m^-3)	InitColonyDenBot (kg m^-3)	Decay-Time-Constant (day^-1)	Decay-TimeStep s	Coeff-DenInc r (kg m^-3 s^-1)	Coeff-fDen-Decr (kg m^-3 s^-1)	Depth Limi-tOn-Off (1-ON/0-OFF)	Depth Limit (m)	Loss-Fraction
5.00E-05	920	1085	980	920	5	1000	0.0115	0.005	0	30	0.1

These parameters describe the inputs to the Model 3, the density migration model and are described in the User Manual Part 2. The Dynamic Velocity Models respond to changes in solar irradiance in a more direct manner. The settling velocity is computed dynamically from Stokes law based on the time-varying density of the algal cell:

$$v = \frac{2gr^2(\rho_c - \rho')}{9\phi n}$$

where g is acceleration due to gravity, r is colony radius, ρ_c is cyanobacteria density, ρ' is density of water, ϕ is form resistance, and n is viscosity of water. In the dynamic velocity model, colonies were assumed to have a minimum and maximum allowable density (ρ_{min} and ρ_{max} , respectively) as well as a constant radius based on values found in field studies (Table 62). When predicted densities were greater than the maximum or less than the minimum allowed values, the value was set to ρ_{max} or ρ_{min} , respectively. It was also necessary to define initial densities (ρ_0) for all colonies within a grid cell. Initial colony density, ρ_{0i} , was assumed to vary exponentially from the surface to the bed, following a similar pattern to light decay with depth, as:

$$\rho_{0i} = \rho_{0S} + (\rho_{0B} - \rho_{0S})(1 - e^{-z_i})$$

where ρ_{0S} is the initial colony density at the surface and ρ_{0B} is the initial colony density at the bed.

Table 62. Literature values for biological parameters of cyanobacteria used in models.

Study	Identifier	Minimum density, kg m^-3	Maximum density, kg m^-3	Colony radius, μm	Saturating light intensity, W m^-2
Reynolds (1984)	Cyanobacteria	-	-	25-1000	-
Reynolds et al. (1987)	<i>M. aeruginosa</i>	985	1005	120-3200	-
	<i>A. flos-aqua</i>	920	1030	28-100	-
	<i>P. agardhii</i>	985	1085	13.7-18.3	-
Nakamura et al. (1993)	<i>Microcystis</i> sp.	-	-	10-300	-
Visser et al. (1997)	<i>Microcystis</i> sp.	-	-	-	139
Long et al. (2001)	<i>M. aeruginosa</i>	-	-	-	-
Wu and Song (2008)	<i>M. aeruginosa</i>	-	-	-	119-244
Wu et al. (2009)	<i>M. aeruginosa</i>	-	-	-	65-119
Zhang et al. (2011)	<i>M. aeruginosa</i>	-	-	-	75-392
Zhu et al. (2014, 2018)	<i>Microcystis</i> sp.	967	997	10-350	-
Rowe et al. (2016)	<i>Microcystis</i> sp.	-	-	12.5-370, median: 58.5	-

density change was assumed to follow a response to light similar to algal growth kinetics, including photoinhibition:

$$\frac{\partial \rho_c}{\partial t} = c_1 F(I) - c_2$$

where c_1 and c_2 are calibration coefficients. In the absence of light, density decreases at a constant rate. The numerical solution for the above equation is:

$$\rho_{c_i}^{n+1} = (c_1 F(I_i^n) - c_2) \Delta t + \rho_{c_i}^n$$

where Δt is the model timestep.

The function of light, $F(I)$, must account for variations in light intensity over the depth of a model grid cell due to light attenuation with depth. The integral of light over the grid cell is (Chapra, 2008):

$$F(I) = \frac{e}{\alpha \Delta z} [e^{-\gamma_2} - e^{-\gamma_1}]$$

where

$$\begin{aligned} \gamma_1 &= \frac{(1 - \beta) I_0}{I_s} e^{-\alpha(i-1)\Delta z} \\ \gamma_2 &= \frac{(1 - \beta) I_0}{I_s} e^{-\alpha(i)\Delta z} \end{aligned}$$

where β is the fraction of solar irradiance absorbed at the water surface and α is the light attenuation coefficient (TVA, 1972). The height of the model grid cell is given by Δz , I_0 is irradiance at the water surface, and I_s is the saturating light intensity for the cyanobacteria species.

While the above equations account for changes in colony density due to instantaneous solar irradiance, they do not include information about past growth rates. To address this, an exponentially-decaying weighted average of past growth rates in each grid cell was applied as:

$$\rho_{c_i}^{n+1} = \frac{\sum_{q=-1}^Q \rho_{c_i}^{n-q} W^q}{\sum_{q=-1}^Q W^q}$$

where the past densities in the grid cell i are multiplied by a weight W and summed. The total number of timesteps over which to average past densities is given by Q . The weight decreases exponentially with time before the present, so that densities predicted at more recent timesteps have greater weights, i.e.:

$$W^q = e^{-k(t^{n+1} - t^{n-q})}$$

where k is the time decay constant for influence of past densities. This is similar to the approach taken by Serizawa et al. (2008).

	Mi nC ol on yD en (k m ^- 3)	M ax- Co lo ny De (kg m ^- 3)	In- itCo lony Den Surf (kg m^- 3)	In- itCol- o- nyDe nBot (kg m^- 3)	Co mp Ir- ra d (W m^ ^-2)	Coeff- DenIn cr_1 (s^- 2 m^- 3)	Coeff- DenIn cr_2 (kg m^- 3 s^- 1)	Co- eff- De nD ec_ 2 (kg m^ ^-3 s^- 1)	Co- eff- De nD ec_ 1 (kg m^- 3 s^- 1)	Co- eff- De nD ec_ -3 (kg m^- 3 s^- 1)	MinDen ecSurf (kg m^- 3 s^- 1)	MinDe nDec- Bot(kg m^- 3 s^- 1)	Dep thLi mi- tOn Off(1- ON/ 0- OFF)	Dep thLim it(m)	Lo ssF rac tio n
Col- o- nyR adiu s(m)															

This is the input parameters for the Model 4, or the Visser density migration model. The equations used in the Visser et al. (1997) model for density were based on

$$\begin{aligned} I_i^n \geq I_c, \quad \rho_{c_i}^{n+1} &= (c_1 I e^{-I/I_0} + c_2) \Delta t + \rho_{c_i}^n \\ I_i^n < I_c, \quad \rho_{c_i}^{n+1} &= \left(f_1 \left(\rho_{c_i}^n + \rho_* \right) + f_2 \right) \Delta t + \rho_{c_i}^n \end{aligned}$$

OUTPUT FILES

SNAPSHOT

It was assumed that ρ_i was the last density experienced by a particle or grid cell while the irradiance was greater than I_c , the compensation irradiance. The light intensity was averaged across a grid cell depth as

$$I_i = \frac{I_0(1-\beta)}{-k\Delta z} (e^{-\alpha z_i} - e^{-\alpha z_{i-1}})$$

The parameter values used in Visser et al. (1997) were converted from units of $\mu\text{mol photon s}^{-1}$ to *Watts* to align with the units used for solar irradiance in CE-QUAL-W2. A conversion factor of $2 \mu\text{mol photon s}^{-1}/\text{Watt}$ was used.

Converted parameter values from Visser et al. (1997)

Parameter	I_c , $W m^{-2}$	c_1 , $s^2 m^{-3}$	c_2 , $kg m^{-3}s^{-2}$	f_1 , s^{-1}	f_2 , $kg m^{-3} s^{-1}$
Converted Value	5.45	5.333×10^{-5}	-2.75×10^{-4}	-1.587×10^{-5}	0.0164

These set of parameters are repeated for each algae group that migrates vertically.

Algae Toxin Input File

This input file describes parameters for modeling algal toxin production from cyanobacteria. This file template is located in the master Excel file under the tab with the file name, **w2_Algae_Toxin.csv**. A description of the conceptual model for toxins is shown in Part 2 of the User Manual. This file is read in when any of the toxin state variables are active.

An example of this input file is shown below:

The screenshot shows a portion of the 'w2_Algae_Toxin.csv' Excel spreadsheet. Column A lists parameters, and columns B through P show their values for six algae groups (ALG1 to ALG6). The parameters include toxin type (e.g., CTP, CTR), concentration (e.g., MC, CYN, ATX), and various rates (e.g., release, decay). Some cells are highlighted in yellow, indicating specific conditions or notes. A note in cell A24 states 'Do not highlight Column A'. A note in cell A32 states 'ATOX_DEBUG: This turns on an output file that has the following information at the location of and frequency of TSR output files: jday,k,l,ex_toxin[k,l,j],j=1,numtoxins,in_toxin[k,l,j],j=1,numtoxins,ctess[k,l,j]=1,numtoxins,alg[k,l,j,j=1,nal]'. A tooltip in cell A26 says 'Export highlighted text to CSV file - no need for \$'. A button in cell A26 says 'Go to Index of Sheets: Index of Sheets!A1'.

The following is a description of each set of inputs to the model. Column A is not written to the **w2_Algae_Toxin.csv** input file.

Cyanotoxins Control File

ON/OFF DEBUG

SNAPSHOT

OUTPUT FILES

TOXINCONTROL: ATOX (turn ON/OFF all algae toxins),ATOX_DEBUG (turn on debugging output)	ON	ON
---	----	----

ATOX is ON or OFF and describes whether the toxin production is ON or OFF in the model. The ATOX_DEBUG turns ON or OFF debugging output writing output to the file **algae_toxin_debug.csv** and includes extracellular and intracellular toxin concentrations for each segment at the frequency of the tsr output file.

MICROCYSTIN	ALG1	ALG2	ALG3
CTP_MC, fraction of algae concentration producing MC	0.5	0.25	0.3
CTB_MC, ratio of intracellular toxin to dry weight biomass (mg toxin/mg DW)	0.1	0.2	0.2
CTR_MC, release rate, day-1	0.5		
CTD_MC, extracellular decay , day-1	0.1		

For each of the 4 toxin groups, the following variables are required: CTP, the fraction of algae in a group that produce the toxin, CTB, the ratio of intracellular toxin to algae biomass, CTR, the release rate of intracellular toxin to extracellular toxin, and the extracellular decay rate.

These values are repeated for each active toxin as shown below:

CYLINDROSPERMOPSIN	ALG1	ALG2	ALG3
CTP_CYN, fraction of algae concentration producing CYN	1	0	0
CTB_CYN, ratio of intracellular toxin to dry weight biomass (mg toxin/mg DW)	0.25	0.2	0.2
CTR_CYN, release rate, day-1	0.5		
CTD_CYN, extracellular decay , day-1	0.25		
ANATOXIN-A	ALG1	ALG2	ALG3
CTP_ATX, fraction of algae concentration producing ATX	0.5	0.25	0.3
CTB_ATX, ratio of intracellular toxin to dry weight biomass (mg toxin/mg DW)	0.1	0.2	0.2
CTR_ATX, release rate, day-1	0.5		
CTD_ATX, extracellular decay, day-1	0.1		
SAXITOXIN	ALG1	ALG2	ALG3
CTP_STX, fraction of algae concentration producing STX	0.5	0.25	0.3
CTB_STX, ratio of intracellular toxin to dry weight biomass (mg toxin/mg DW)	0.1	0.2	0.2
CTR_STX, release rate, day-1	0.5		
CTD_STX, extracellular decay , day-1	0.1		

Typical values of these parameters are shown in Table 63 from Garstecki (2021).

Table 63. Model parameter ranges.

Parameter	MC	CYN	ATX-A	STX
CTP, fraction of algae concentration producing toxin	Waterbody dependent, determined by species present			
CTB, ratio of intracellular toxin to dry weight biomass (mg-toxin mg-DW ⁻¹) where DW, dry weight	0.0005-0.024	0.0005-0.007	0.001-0.01	0.001-0.004
CTR, release rate day ⁻¹	Approx. equal to 0-1 times excretion rate	Approx. equal to 1-2 times excretion rate	Approx. equal to 0-1 times excretion rate	Approx. equal to 0-1 times excretion rate

OUTPUT FILES

SNAPSHOT

Parameter	MC	CYN	ATX-A	STX
CTD, extracellular decay rate, day ⁻¹	0.05-0.2	0.01-0.06	0.05-0.2	0.01-0.07

Dissolved Gas Added to Turbine Input File

This file is a time series file of Julian day and fraction multiplied by the incoming turbine dissolved oxygen. This file is assumed to be a step function input. The file is either for a spillway, **w2_spX_DO.csv** (where X is the spillway number), or for a gate, **w2_gtX_DO.csv** (where X is the gate number). Usually, the fraction will be greater than 1.0. If it is 1.0, the inflow oxygen is unchanged. If it is 1.1 then the inflow oxygen is increased by 10%. Other parameters for the spillway or gate dictate whether the outflow oxygen is limited or not by 100% saturation.

The file has the following format: The first 3 lines are ignored and then there is a time series of Julian day and Fraction.

Input fraction for gate1

Dynamic turbine venting

JDAY	FRAC
1	1
210.5	1.1
300	1
365	1

Output Files

Snapshot

The snapshot file was designed for output to a hard copy printer and contains useful information that can be utilized during model application. The file can read using any text editor. It is not recommended for using the snapshot file for plotting model predictions since other output files are easier to graph.

Title Cards

The first lines of output contain the information specified in the **Title Card** for identifying the run plus the date and time that the run occurred. This information will appear every time output is updated to the file based on the update dates [**SNPD**] and frequency [**SNPF**] specified in the control file. Following the title cards is information related to the progress of the run including the output date and timestep information.

EXAMPLE

CE-QUAL-W2 V3.1

SNAPSHOT

OUTPUT FILES

```
Burnsville Reservoir - March 15 through December 11, 1992
Density placed inflow, point sink outflows
Default hydraulic coefficients
Default light absorption/extinction coefficients
Default kinetic coefficients
Temperature and water quality simulation
Run 8
Testing sensitivity to wind
Wind sheltering set to 0.75
Jim Stiles and Vince Marchese, USACE Huntington District
Model run at 16:58:03 on 07/22/02
```

```
Time Parameters
Gregorian date      [GDAY] =            March 15, 1992
Julian date         [JDAY] =    75 days 12.00 hours
Elapsed time        [ELTMJD] =   0 days 12.00 hours
Timestep            [DLT] =      356 sec
at location [KLOC,ILOC] = (26,47)
Minimum timestep   [MINDLT] =   378 sec
at Julian day     [JDMIN] =    75 days 7.31 hours
at location [KMIN,IMIN] = (27,19)
Average timestep   [DLTAV] =    600 sec
Number of iterations [NIT] =    72
Number of violations [NV] =      5
```

Time Parameters

The time parameter information includes the date at which the information was output, the elapsed time of the simulation, and useful information about the timestep and its behavior. This includes the current timestep and where the computational cell is located that was used to determine the current timestep based on numerical stability criterion. The current minimum timestep that has occurred, the date at which it occurred, and the location is also given. The average timestep for the simulation up to this time, the total number of iterations, and the number of timestep violations that required restoring variables and recomputing the water surface elevations and velocities are also output.

The timestep information can be very useful in providing information that can be analyzed to see where violations are occurring and possibly altering inputs or the bathymetry to increase the average timestep without impacting the results. For example, the location of the minimum timestep can be checked to see if the width can be increased without impacting results. The number of violations provides information as to whether or not the fraction of the computed timestep used needs to be decreased. If the number of violations exceeds 5% of the number of iterations, the fraction of the timestep [[DLTF](#)] should be decreased 5-10%.

Meteorological Parameters

The next information includes meteorological parameters used at the current timestep. This can be useful when trying to better understand temperature simulations such as “why is the model overpredicting epilimnetic temperatures on a specified date?”. Running sensitivity analyses on meteorological forcing data during this time period can show that the model will reproduce observed data if the forcing data are more accurate.

EXAMPLE

```
Meteorological Parameters
Input
Air temperature      [TAIR] =      0.55 °C
Dewpoint temperature [TDEW] =    -8.59 °C
Wind direction       [PHI] =      4.65 rad
Cloud cover          [CLOUD] =     4.53
```

OUTPUT FILES

SNAPSHOT

```
Calculated
Equilibrium temperature [ET] =      0.00 °C
Surface heat exchange [CSHE] = 0.00E+00 m/sec
Short wave radiation [SRO] = 0.14E-03 °C m/sec
```

Selective Withdrawal and Inflow/Outflow Parameters

Inflows, inflow placement, and inflow temperatures are then output to provide information as to what the model is seeing at all inflow boundaries during the current timestep. This information can be very useful in debugging a model application.

All outflows are also printed out including individual structure outflows, the layer-by-layer outflow computed from the selective withdrawal algorithm, and the total outflow.

EXAMPLE

```
Inflows
Upstream inflows
Branch 1
Layer [KQIN] = 23-23
Inflow [QIN] = 7.13 m^3/sec
Temperature [TIN] = 3.59 °C
Branch 2
Layer [KQIN] = 29-29
Inflow [QIN] = 0.87 m^3/sec
Temperature [TIN] = 5.10 °C
Branch 3
Layer [KQIN] = 35-35
Inflow [QIN] = 0.18 m^3/sec
Temperature [TIN] = 5.10 °C
Branch 4
Layer [KQIN] = 28-28
Inflow [QIN] = 0.12 m^3/sec
Temperature [TIN] = 5.10 °C
Branch 5
Layer [KQIN] = 28-28
Inflow [QIN] = 0.06 m^3/sec
Temperature [TIN] = 5.10 °C
Branch 6
Layer [KQIN] = 24-24
Inflow [QIN] = 0.04 m^3/sec
Temperature [TIN] = 5.10 °C

Tributaries
Segment [ITR] = 24
Layer [KTWB] = 23-38
Inflow [QTR] = 0.09
Temperature [TTR] = 5.10

Outflows
Structure outflows [QSTR]
Branch 1 = 22.00

Total outflow [QOUT] = 22.00 m^3/s
Outlets
Layer[KOUT] =   8     9    10    11    12    13    14    15    16    17    18    19
              20    21    22    23    24    25    26    27    28    29    30    31
Outflow (m^3/sec) [QOUT]=3.27 1.83 2.20 2.15 2.11 2.05 1.97 1.84 1.60 1.28 1.24 0.47
              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

LAYER DEPTH(m) T(C) DENSITY(kg/m3) U(m/s) Q(m3/s)
  8      1.72    7.40    999.927    0.001    3.273
  9      4.45    7.40    999.927    0.001    1.832
 10     6.45    7.30    999.932    0.002    2.203
 11     8.45    7.30    999.932    0.002    2.155
 12    10.45    7.30    999.932    0.002    2.106
 13    12.45    7.30    999.932    0.002    2.046
 14    14.45    7.30    999.932    0.002    1.973
```

SNAPSHOT

OUTPUT FILES

15	16.45	7.20	999.937	0.001	1.836		
16	18.45	7.10	999.941	0.001	1.596		
17	20.45	7.00	999.946	0.001	1.278		
18	22.45	7.00	999.946	0.001	1.239		
19	24.45	6.80	999.955	0.000	0.468		
20	26.45	6.70	999.959	0.000	0.000		
21	28.45	6.70	999.959	0.000	0.000		
22	30.45	6.60	999.964	0.000	0.000		
23	32.45	6.60	999.964	0.000	0.000		
24	34.45	6.60	999.964	0.000	0.000		
25	36.45	6.60	999.964	0.000	0.000		
26	38.45	6.50	999.968	0.000	0.000		
27	40.45	6.50	999.968	0.000	0.000		
28	42.45	6.50	999.968	0.000	0.000		
29	44.45	6.50	999.968	0.000	0.000		
30	46.45	6.50	999.968	0.000	0.000		
31	48.45	6.50	999.968	0.000	0.000		
32	50.45	6.50	999.968	0.000	0.000		
33	52.45	6.50	999.968	0.000	0.000		
34	54.45	6.50	999.968	0.000	0.000		
35	56.45	6.50	999.968	0.000	0.000		
Withdrawals							
Segment		[IWD]	=	31			
Outflow (m^3/sec)		[QWD]	=	0.02			
Layer		[KWD]	=	8	9	10	11
Outflow (m^3/sec)		[QSW]	=	0.01	0.01	0.00	0.00
LAYER	DEPTH (m)	T (C)	DENSITY (kg/m3)	Q (m3/s)			
8	1.72	7.40	999.927	0.013			
9	4.45	7.40	999.927	0.007			
10	6.45	7.30	999.932	0.000			
11	8.45	7.30	999.932	0.000			
12	10.45	7.30	999.932	0.000			
13	12.45	7.30	999.932	0.000			
14	14.45	7.30	999.932	0.000			
15	16.45	7.20	999.937	0.000			
16	18.45	7.10	999.941	0.000			
17	20.45	7.00	999.946	0.000			
18	22.45	7.00	999.946	0.000			
19	24.45	6.80	999.955	0.000			
20	26.45	6.70	999.959	0.000			
21	28.45	6.70	999.959	0.000			
22	30.45	6.60	999.964	0.000			
23	32.45	6.60	999.964	0.000			
24	34.45	6.60	999.964	0.000			
25	36.45	6.60	999.964	0.000			
26	38.45	6.50	999.968	0.000			
27	40.45	6.50	999.968	0.000			
28	42.45	6.50	999.968	0.000			
29	44.45	6.50	999.968	0.000			
30	46.45	6.50	999.968	0.000			
31	48.45	6.50	999.968	0.000			
32	50.45	6.50	999.968	0.000			
33	52.45	6.50	999.968	0.000			
34	54.45	6.50	999.968	0.000			
35	56.45	6.50	999.968	0.000			

The final information regarding boundary forcing functions is output next and includes inflow constituent concentrations for all boundary inflows. A great deal of grief can be saved by checking to ensure that the concentrations are correct as it is very easy to get the inflow concentrations out of order.

EXAMPLE

Constituent Inflow Concentrations
Branch 1 [CIN]
Dissolved solids = 43.004 g/m^3
Suspended solids1 = 2.000 g/m^3

```

Phosphate      =    0.020 g/m^3
Ammonium       =    0.100 g/m^3
Nitrate nitrite =    0.200 g/m^3
Labile DOM     =    0.382 g/m^3
Refractory_DOM =    0.892 g/m^3
Labile POM     =    0.425 g/m^3
Algae          =    0.000 g/m^3
Dissolved oxygen = 12.000 g/m^3
Tributary 1 [CTR]
Dissolved solids = 161.196 g/m^3
Suspended solids1 = 2.000 g/m^3
Phosphate      =    0.020 g/m^3
Ammonium       =    0.100 g/m^3
Nitrate nitrite =    0.200 g/m^3
Labile DOM     =    0.405 g/m^3
Refractory_DOM =    0.945 g/m^3
Labile POM     =    0.450 g/m^3
Algae          =    0.000 g/m^3
Dissolved oxygen = 11.980 g/m^3

```

Balances

If volume, thermal, and/or constituent mass balances are turned on, then the balances are output next. They are computed for separately for each branch and summed for each waterbody. Information includes the spatially and temporally integrated change in volume since the start of the simulation, the total volume error between the two, and the percent error based on the total volume change. Using the change in volume rather than the total volume is important for preventing roundoff error from masking the results of the balance. The volume balance is computed as:

$$\underbrace{\Delta S}_{\text{spatially integrated volume}} = \sum_{\text{temporally integrated volume}} Q_{in} - \sum Q_{out}$$

where:

ΔS = change in volume, m^3

ΣQ_{in} = sum of all inflows, m^3

ΣQ_{out} = sum of all outflows, m^3

Energy and mass balances are computed similarly. Errors should be on the order of 10^{-6} to 10^{-13} percent, which means that the model is essentially conserving water to machine accuracy. This computation is routinely used to debug and find errors in the code.

EXAMPLE

```

Water Balance
Waterbody 1
  Spatial change [VOLSR] = -0.20089851E+06 m^3
  Temporal change [VOLTR] = -0.20089851E+06 m^3
  Volume error           =  0.10186341E-08 m^3
  Percent error          = -0.50703913E-12 %
Branch 1
  Spatial change [VOLSBR] = -0.13863158E+06 m^3
  Temporal change [VOLTBR] = -0.13863158E+06 m^3
  Volume error           =  0.10768417E-08 m^3
  Percent error          = -0.77676510E-12 %
Branch 2
  Spatial change [VOLSBR] = -0.28973777E+05 m^3
  Temporal change [VOLTBR] = -0.28973777E+05 m^3
  Volume error           = -0.76397555E-10 m^3
  Percent error          =  0.26367827E-12 %

Energy Balance

```

SNAPSHOT

OUTPUT FILES

Waterbody 1
 Spatially integrated energy [ESR] = 0.29332063E+12 kJ
 Temporally integrated energy [ETR] = 0.29332063E+12 kJ
 Energy error = -0.28701192E+01 kJ
 Percent error = -0.97849211E-09 %
Branch 1
 Spatially integrated energy [ESBR] = 0.20810993E+12 kJ
 Temporally integrated energy [ETBR] = 0.20812486E+12 kJ
 Energy error = 0.79701322E+01 kJ
 Percent error = 0.38294956E-08 %
Branch 2
 Spatially integrated energy [ESBR] = 0.46706347E+11 kJ
 Temporally integrated energy [ETBR] = 0.46709696E+11 kJ
 Energy error = -0.72348511E+01 kJ
 Percent error = -0.15488971E-07 %

Mass Balance

Branch 1
 Dissolved solids
 Spatially integrated mass [CMBRS] = 0.42683593E+09 g
 Temporally integrated mass [CMBRT] = 0.42683593E+09 g
 Mass error = -0.15495062E-01 g
 Percent error = -0.36302150E-08 %
 Residence time
 Spatially integrated mass [CMBRS] = 0.46090907E+07
 Temporally integrated mass [CMBRT] = 0.46090907E+07
 Mass error = -0.14215708E-04
 Percent error = -0.30842760E-09 %
 Suspended solids1
 Spatially integrated mass [CMBRS] = 0.10093689E+08 g
 Temporally integrated mass [CMBRT] = 0.10093689E+08 g
 Mass error = -0.31241588E-03 g
 Percent error = -0.30951605E-08 %
 Phosphate
 Spatially integrated mass [CMBRS] = 0.17123908E+06 g
 Temporally integrated mass [CMBRT] = 0.17123908E+06 g
 Mass error = -0.72119292E-05 g
 Percent error = -0.42116142E-08 %
 Ammonium
 Spatially integrated mass [CMBRS] = 0.48859061E+06 g
 Temporally integrated mass [CMBRT] = 0.48859061E+06 g
 Mass error = -0.20249572E-04 g
 Percent error = -0.41444865E-08 %
 Nitrate_nitrite
 Spatially integrated mass [CMBRS] = 0.18775938E+07 g
 Temporally integrated mass [CMBRT] = 0.18775938E+07 g
 Mass error = -0.75169839E-04 g
 Percent error = -0.40035198E-08 %
 Labile DOM
 Spatially integrated mass [CMBRS] = 0.61793186E+07 g
 Temporally integrated mass [CMBRT] = 0.61793186E+07 g
 Mass error = -0.24503283E-03 g
 Percent error = -0.39653698E-08 %
 Refractory_DOM
 Spatially integrated mass [CMBRS] = 0.14555086E+08 g
 Temporally integrated mass [CMBRT] = 0.14555086E+08 g
 Mass error = -0.57210773E-03 g
 Percent error = -0.39306379E-08 %
 Labile POM
 Spatially integrated mass [CMBRS] = 0.65861106E+07 g
 Temporally integrated mass [CMBRT] = 0.65861106E+07 g
 Mass error = -0.26675593E-03 g
 Percent error = -0.40502802E-08 %
 Algae
 Spatially integrated mass [CMBRS] = 0.57925594E+07 g
 Temporally integrated mass [CMBRT] = 0.57925594E+07 g
 Mass error = -0.22346061E-03 g

OUTPUT FILES

SNAPSHOT

```
Percent error = -0.38577180E-08 %
Dissolved oxygen
    Spatially integrated mass [CMBRS] = 0.10224093E+09 g
    Temporally integrated mass [CMBRT] = 0.10224093E+09 g
    Mass error = -0.40865839E-02 g
    Percent error = -0.39970136E-08 %
```

Geometry

The water surface layer number, elevation at the downstream segment, and the current upstream segment number for each branch are then output. Note that in the example, the current upstream segment is located at segment 8.

EXAMPLE

```
Geometry
    Surface layer [KT] = 23
    Elevation [ELKT] = 238.575 m

    Current upstream segment [CUS]
        Branch 1 =8
        Branch 2 =30
        Branch 3 =41
        Branch 4 =46
        Branch 5 =51
        Branch 6 =55
```

Water Surface

The water surface elevation and the water surface deviation from the top of the water surface layer number is output next. The water surface deviation uses the oceanographic convention in which the deviation downwards from the top of the surface layer is positive. The output includes information only for the segments specified on the [Snapshot Segments](#) card.

EXAMPLE

```
Water Surface, m
    8          9          10         11         12         13         14         15
238.574   238.573   238.574   238.573   238.574   238.574   238.574   238.574

    Water Surface Deviation (positive downwards), m
    8          9          10         11         12         13         14         15
-0.2136   -0.2135   -0.2135   -0.2135   -0.2136   -0.2139   -0.2138   -0.2137
```

Temperature/Water Quality

The last information available from the snapshot file is information related to hydrodynamics and water quality. The user has complete control of how much information is output including which hydrodynamic and water quality variables are included in the output. The file can rapidly become quite large, so only variables of interest should be output. This information is useful for quickly looking at the results of a run to gain a feel for how the variables of concern are behaving over time. Title cards are printed on each new page for ease in identifying the simulation. An example below shows the temperature snapshot output.

SNAPSHOT

OUTPUT FILES

Burnsville Reservoir - March 15 through December 11, 1992
Density placed inflow, point sink outflows
Default hydraulic coefficients
Default light absorption/extinction coefficients
Default kinetic coefficients
Temperature and water quality simulation
Run 8
Testing sensitivity to wind
Wind sheltering set to 0.75
Jim Stiles and Vince Marchese, USACE Huntington District
Model run at 08:25:31 on 07/23/02

		Temperature [T1], deg C											
Layer	Depth	8	9	10	11	12	13	14	15	16	17	18	
23	0.41	3.74	3.77	4.19	5.02	5.53	5.62	5.49	5.51	5.50	5.55	5.58	
24	1.13	3.81	3.77	4.19	4.96	5.32	5.43	5.26	5.34	5.29	5.34	5.35	
25	1.74	3.83	3.76	4.19	5.03	5.27	5.31	5.17	5.30	5.23	5.28	5.29	
26	2.35	3.81	3.76	4.19	5.07	5.26	5.22	5.11	5.25	5.19	5.24	5.30	
27	2.96		3.76	4.19	5.08	5.27	5.14	5.05	5.27	5.17	5.24	5.33	
28	3.57		3.76	4.19	5.08	5.26	5.14	5.01	5.29	5.20	5.26	5.31	
29	4.18			4.19	5.11	5.23	5.14	5.01	5.32	5.36	5.31	5.33	
30	4.79			4.19	5.21	5.22	5.14	5.19	5.31	5.35	5.34	5.33	
31	5.40				4.63	5.21	5.22	5.14	5.23	5.31	5.33	5.32	
32	6.01					5.06	5.32	5.24	5.14	5.31	5.31	5.31	
33	6.62						5.31	5.34	5.26	5.14	5.30	5.31	
34	7.23							5.32	5.22	5.30	5.31	5.30	
35	7.84									5.33	5.32	5.29	
36	8.45										5.30	5.29	

Sediment Diagenesis Output Files

Output files from the sediment diagenesis routine are shown in Table 64. Examples of these files are included in the sediment diagenesis example problem in the download package. Most of these are in csv format facilitating graphing.

Table 64. Output file names for sediment diagenesis model.

Sediment diagenesis output file name	Description
DiagenesisBubbleReleaseSummary.csv	Summary of bubble release model predictions
DiagenesisBubbles.csv	Time series including bubble radius, concentration of gas in bubbles (C_g), concentration of gas in porewater (C_O), net concentration of gas (dissolved+gas) in sediments (C_t), and if cracks are open or closed for each model segment.
DiagenesisBubblesAtmosphereRelease.csv	Time series of H ₂ S, CH ₄ , NH ₃ , and CO ₂ gas bubble release to atmosphere for each model segment.
DiagenesisAerobicLayer.csv	Time series containing thickness of sediment aerobic layer (m) at the bottom (KB) layer only for each segment.
Diagenesis_POCG1.csv	Time series containing sediment constituent concentrations of <i>labile</i> POC (g/m ³) in layer 2 (anaerobic) for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_POCG2.csv	Time series containing sediment constituent concentrations of <i>refractory</i> POC (g/m ³) in layer 2 (anaerobic) for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_PONG1.csv	Time series containing sediment constituent concentrations of <i>labile</i> PON (g/m ³) in anaerobic layer 2 for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_PONG2.csv	Time series containing sediment constituent concentrations of <i>refractory</i> PON (g/m ³) in anaerobic layer 2 for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_POPG1.csv	Time series containing sediment constituent concentrations of <i>labile</i> POP (g/m ³) in anaerobic layer 2 for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_POPG2.csv	Time series containing sediment constituent concentrations of <i>refractory</i> POP (g/m ³) in anaerobic layer 2 for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.

TIME SERIES

OUTPUT FILES

Sediment diagenesis output file name	Description
DiagenesisLogFile.opt	Contains information regarding layer addition when using bed consolidation feature
DiagenesisSedDissGasOutput.csv	Time series of sediment dissolved gas concentrations (H2S, CH4, NH3, and CO2) for each model segment
DiagenesisSedimentGasOutput.csv	Time series of gas concentrations in bubbles (H2S, CH4, NH3, and CO2) for each model segment
Diagenesis_SD_JCH4.csv	Time series of dissolved methane sediment fluxes for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JCH4 = flux of dissolved methane, fast reacting C, and CBODu between water and sediment in O2 equivalent units ($\text{gO}_2/\text{m}^2/\text{d}$); positive is source of CBOD to water column, note that $\text{gO}_2/\text{m}^2/\text{d} = \text{gC}/\text{m}^2/\text{d} * 2.67 \text{ gO}_2/\text{gC}$.
Diagenesis_SD_JNH4.csv	Time series of sediment flux of N for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JNH4 = flux of ammonia N between the water and sediment ($\text{gN}/\text{m}^2/\text{d}$), positive is source of NH4-N to water column.
Diagenesis_SD_JNO3.csv	Time series of sediment N flux for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JNO3 = flux of nitrate N between the water and sediment ($\text{gN}/\text{m}^2/\text{d}$), positive is source of NO3-N to water column.
Diagenesis_SD_JPO4.csv	Time series of sediment P flux for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JPO4 = flux of soluble reactive P between the water and sediment ($\text{gP}/\text{m}^2/\text{d}$), positive is source of PO4-P to water column.
Diagenesis_SOD.csv	Time series containing sediment oxygen demand ($\text{gO}_2/\text{m}^2/\text{d}$) (CSOD+NCSOD) for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_NSOD.csv	Time series containing sediment nitrogenous oxygen demand NSOD ($\text{gO}_2/\text{m}^2/\text{d}$) for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_CSOD.csv	Time series containing carbonaceous sediment oxygen demand (CSOD) ($\text{gO}_2/\text{m}^2/\text{d}$) for each model segment <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment.
Diagenesis_JC.csv	Time series of sediment C flux into each model segment from the water column <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JC = flux of C into the sediments from water column ($\text{gC}/\text{m}^2/\text{d}$).
Diagenesis_JN.csv	Time series of sediment N flux into each model segment from the water column <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each

OUTPUT FILES

SEDIMENT DIAGENESIS

Sediment diagenesis output file name	Description
	model segment. JN = flux of N into the sediments from water column (gN/m ² /d).
Diagenesis_JP.csv	Time series of sediment P flux into each model segment from the water column <i>for the bottom layer</i> . Then written out also is the average for all vertical layers for each model segment. JP = flux of P into the sediments from water column (gP/m ² /d).
Diagenesis_TemperatureAerobicLayer.csv	Time series of model temperature in the aerobic layer for each model segment for the bottom layer in each segment. This should closely mimic the water temperature at that cell.
Diagenesis_TemperatureAnaerobicLayer.csv	Time series of model temperature in the anaerobic layer for each model segment for the bottom layer in each segment. This should approach the sediment bottom temperature specified in the main control file.
Diagenesis_NO3AerobicLayer.csv	Time series of model porewater NO ₃ -N in the aerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_NO3AnaerobicLayer.csv	Time series of model porewater NO ₃ -N in the anaerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_NH3AerobicLayer.csv	Time series of model porewater ammonia-N in the aerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_NH3AnaerobicLayer.csv	Time series of model porewater ammonia-N in the anaerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_PO4AerobicLayer.csv	Time series of model porewater PO ₄ -P in the aerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_PO4AnaerobicLayer.csv	Time series of model porewater PO ₄ -P in the anaerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_SO4AerobicLayer.csv	Time series of model porewater SO ₄ -S in the aerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_SO4AnaerobicLayer.csv	Time series of model porewater SO ₄ -S in the anaerobic layer for each model segment for the bottom layer in each segment.
Diagenesis_FeIIAerobicLayer.csv	Time series of model porewater reduced Fe in the aerobic layer for each model segment for the bottom layer in each segment in units of mg Fe/l.
Diagenesis_FeIIClaraLayer.csv	Time series of model porewater reduced Fe in the anaerobic layer for each model segment for the bottom layer in each segment in units of mg Fe/l.
Diagenesis_MnIIClaraLayer.csv	Time series of model porewater reduced Mn in the aerobic layer for each model segment for the bottom layer in each segment in units of mg Mn/l.

TIME SERIES

OUTPUT FILES

Sediment diagenesis output file name	Description
Diagenesis_MnIIAnaerobicLayer.csv	Time series of model porewater reduced Mn in the anaerobic layer for each model segment for the bottom layer in each segment in units of mg Mn/l.
Diagenesis_CH4AerobicLayer.csv	Time series of model porewater CH4 in the aerobic layer for each model segment for the bottom layer in each segment in units of mg O2/l.
Diagenesis_CH4AnaerobicLayer.csv	Time series of model porewater CH4 in the anaerobic layer for each model segment for the bottom layer in each segment in units of mg O2/l.
Diagenesis_TransferVelocity_SD_KL12.csv	Time series of model predicted transfer velocity between aerobic layer and anaerobic layer for porewater diffusion (KL12) for each segment bottom layers in m/d.
Diagenesis_TransferVelocity_SD_W12.csv	Time series of model predicted transfer velocity between aerobic layer and anaerobic layer for particle mixing (W12) for each segment bottom layers in m/d.
Diagenesis_TransferVelocity_SD_S.csv	Time series of model predicted transfer velocity between water and aerobic layer for each segment bottom layers in m/d.
Diagenesis_Bubble1_BubRad_Cg.csv	If Bubble model is .TRUE., then this file is written and it outputs the bubble radius, concentration of gas, and whether a crack exists in the sediment for each segment and bottom layer as a function of time.
Diagenesis_Bubble2_GasConc_at_Bottom_Layer.csv	If Bubble model is .TRUE., then this file is written and it outputs the concentration of ammonia, methane, hydrogen sulfide and carbon dioxide in the water column for each segment and bottom layer as a function of time.
Diagenesis_Bubble3_BubbleGasReleaseToAtmosphereRate.csv	If Bubble model is .TRUE., then this file is written and it outputs the release rate (gm/s) for bubbles released into the atmosphere for ammonia, methane, hydrogen sulfide and carbon dioxide for each segment as a function of time.
Diagenesis_Bubble4_DissGasSediments_BottomLayer.csv	If Bubble model is .TRUE., then this file is written and it outputs the concentration of ammonia, methane, hydrogen sulfide and carbon dioxide in the sediments (aerobic) for each segment and bottom layer as a function of time.
Diagenesis_Bubble5_WaterBodySurfaceReleaseCumulative.csv	If Bubble model is .TRUE., then this file is written and it outputs the cumulative release (kg) for bubbles released into the atmosphere for ammonia, methane, hydrogen sulfide and carbon dioxide for each segment as a function of time. Also included is the non-bubble release rate cumulatively of methane.

Time Series

A time series history can be output for any number of cells in the computational grid with output for each cell written to a separate output file. Output is suitable for import into a spreadsheet program for analysis and plotting and is in comma delimited format. If the TSR filename is set to a file suffix 'csv', then all tsr files will have that suffix and will open in Excel automatically. The model takes the name of the time series file specified on the [TIME SERIES PLOT FILENAME](#) card and appends an “_x” to the filename where x is 1, 2, 3, etc., depending upon whether the cell is the first, second, third, etc. one specified on the [TIME SERIES SEGMENT](#) card. Information includes the Julian date, current time step (s), water surface elevation for the cell's segment location (m), temperature (°C) at the layer and segment specified, velocity (m/s) at the layer and segment specified, total flow rate through the entire segment (m³/s, vertically integrated flow through the segment), net short wave solar radiation incident on the water surface (W/m², reflection is not included, hence it would be the internally computed SRO which includes reflection X 1.06), light extinction coefficient in m⁻¹ at the layer and segment specified, depth from water surface to channel bottom (m), surface width (m), shade (shade factor multiplied by SRON, if SHADE =1, no shade, if shade =0, no short wave solar reaches the water surface), vertically volume-weighted temperature at the specified model segment, net radiation at surface of segment (W/m²), short wave solar net at surface (W/m²), long wave radiation in net at surface (W/m²), back radiation at surface (W/m²), evaporative heat flux at surface (W/m²), conductive heat flux at surface (W/m²), reaeration coefficient (day⁻¹) predicted by the model at the segment of the TSR file, and active constituent concentrations, derived constituent concentrations, instantaneous kinetic flux rates in kg/day, instantaneous algae growth rate limitation fractions for P, N, and light [0 to 1] for each algal group [if LIMC is turned on under the CST COMP card], and instantaneous epiphyton growth rate limitation fractions for P, N, and light [0 to 1] for each epiphyton group.

If the first order sediment model is ON, the TSR file will also output SED (total organic matter in g/m³), SEDN (Organic N in sediments in g/m³), SEDP (organic P in sediments in g/m³), and SEDC (organic C in sediments in g/m³). The mass of organic matter, N, P, and C is normalized by the volume of the model cell in contact with the sediment layer.

Note that if SLHTC is set to ‘ET’ for equilibrium temperature approach, then the radiation fluxes will all be set to zero.

Example (not all columns are shown)

JDAY	DLT(s)	ELWS(m)	T2(C)	U(ms ⁻¹)	Q(m ³ s ⁻¹)	SRON(Wm ⁻²)	EXT(m ⁻¹)	DEPTH(m)	WIDTH(m)	SHADE	Tvolavg(C)	NetRad(Wm ⁻²)	SWSolar(Wm ⁻²)	LWRad(Wm ⁻²)	BackRad(Wm ⁻²)	EvapF(Wm ⁻²)	ConducF(1
35.000,	45.407,	80.160,	20.000,	0.068,	0.000,	0.000,	0.408,	32.160,	3218.634,	1.000,	20.000,	31.632,	0.000,	367.669,	406		
35.250,	141.224,	79.601,	19.998,	0.063,	0.000,	0.000,	0.817,	31.601,	3113.656,	1.000,	19.998,	-13.918,	0.000,	347.485,	406		
35.500,	121.441,	79.045,	19.990,	0.066,	0.000,	0.000,	0.808,	31.045,	3113.656,	1.000,	19.990,	22.099,	0.000,	400.545,	406		
35.750,	100.198,	78.629,	20.229,	0.064,	0.000,	0.000,	0.761,	30.629,	3016.855,	1.000,	20.026,	68.504,	0.000,	408.465,	408		
36.000,	64.435,	78.526,	20.425,	0.064,	0.000,	0.000,	0.715,	30.526,	3016.855,	1.000,	20.069,	24.453,	0.000,	372.324,	409		
36.250,	99.578,	78.611,	20.535,	0.063,	0.000,	0.000,	0.688,	30.611,	3016.855,	1.000,	20.083,	31.816,	0.000,	375.458,	409		
36.500,	101.725,	78.783,	20.682,	0.061,	0.000,	0.000,	0.668,	30.783,	3016.855,	1.000,	20.115,	77.557,	0.000,	418.336,	410		
36.750,	95.694,	78.992,	20.896,	0.059,	0.000,	0.000,	0.650,	30.992,	3016.855,	1.000,	20.205,	77.991,	0.000,	419.624,	411		
37.000,	104.905,	79.203,	24.035,	0.056,	0.000,	0.000,	0.568,	31.203,	3113.656,	1.000,	22.102,	-26.856,	0.000,	403.467,	429		
37.250,	103.537,	79.427,	24.929,	0.055,	0.000,	0.000,	0.559,	31.427,	3113.656,	1.000,	23.037,	-47.313,	0.000,	403.412,	434		
37.500,	117.263,	79.643,	25.388,	0.055,	0.000,	0.000,	0.552,	31.643,	3113.656,	1.000,	23.876,	-43.192,	0.000,	411.524,	437		
37.750,	109.387,	79.846,	25.835,	0.055,	0.000,	0.000,	0.541,	31.846,	3113.656,	1.000,	24.542,	7.072,	0.000,	442.962,	440		
38.000,	107.058,	80.042,	26.173,	0.054,	0.000,	0.000,	0.531,	32.042,	3218.634,	1.000,	25.097,	-102.064,	0.000,	369.637,	442		
38.250,	131.730,	80.177,	26.217,	0.063,	0.000,	0.000,	0.537,	32.177,	3218.634,	1.000,	25.498,	-126.588,	0.000,	354.585,	442		
38.500,	129.778,	80.241,	26.227,	0.069,	0.000,	0.000,	0.539,	32.241,	3218.634,	1.000,	25.621,	-62.941,	0.000,	374.579,	442		
38.750,	107.211,	80.265,	26.328,	0.071,	0.000,	0.000,	0.531,	32.265,	3218.634,	1.000,	25.854,	-15.802,	0.000,	442.128,	443		
39.000,	137.803,	80.279,	26.433,	0.073,	0.000,	0.000,	0.533,	32.279,	3218.634,	1.000,	26.059,	-41.532,	0.000,	425.309,	443		
39.250,	120.966,	80.284,	26.582,	0.073,	0.000,	0.000,	0.529,	32.284,	3218.634,	1.000,	26.251,	-95.261,	0.000,	377.758,	444		
39.500,	129.444,	80.287,	26.608,	0.074,	0.000,	0.000,	0.529,	32.287,	3218.634,	1.000,	26.366,	-112.616,	0.000,	379.190,	444		
39.750,	133.411,	80.290,	26.649,	0.075,	0.000,	0.000,	0.529,	32.290,	3218.634,	1.000,	26.461,	26.894,	0.000,	481.286,	445		

Auto-Port Selection Output Files

The auto-port selection routine writes out 2 types of files: (1) the volume of water in the lake or reservoir at given temperatures over time and a file describing the outlet elevations and outlet temperatures chosen by the routine.

Volume at specified temperatures, **volume_wbX.opt**

The volume at specified temperature files are called '**Volume_wbX.opt**', where X is the water body number. This file shows a time series of time (Julian day), total volume, and the volumes below the temperature thresholds. The number of values of **TEMPCRIT** are based on the number of waterbodies in the model domain. For example, the file **Volume_wb1.opt** contains the following output for time, total volume (m^3), volume (m^3) under $11.11^\circ C$, and volume (m^3) under $15.55^\circ C$:

```
jday      Volume      Volcrit      Volcrit
22919.05  0.1650E+10  0.1565E+10  0.1650E+10
22919.09  0.1650E+10  0.1563E+10  0.1650E+10
22919.13  0.1650E+10  0.1561E+10  0.1650E+10
22919.17  0.1650E+10  0.1560E+10  0.1650E+10
22919.21  0.1650E+10  0.1557E+10  0.1650E+10
```

Temperature of outlet releases, **wd_out.opt** and **str_brX.csv**

In the control file, **w2_con.npt** (or **w2_con.csv**), the card '**WITH OUT**' allows the specification of outlet withdrawal files. This is also performed using the auto-port selection. When **SELECTC='ON'**, the model allows printing each branch structure as a separate time series of outlet temperatures and flows for each individual outlet, in addition to the existing CE-QUAL-W2 combined temperature time series. The outlet files are named '**str_brX.csv**' where X is the branch number. A similar file is written for withdrawals. The withdrawals are included in one file named: '**wd_out.opt**'. The format for the structure and withdrawal output files is as follows:

Branch:	1 # of structures:			3 outlet temperatures			ELEVCL	ELEVCL	ELEVCL
	JDAY	T (C)	T (C)	T (C)	Q (m ³ /s)	Q (m ³ /s)			
22920.000	0.00	9.52	7.20	0.00	69.27	17.91	300.23	280.42	173.74
22921.000	0.00	9.76	7.20	0.00	68.36	17.57	300.23	280.42	173.74
22922.000	0.00	9.81	7.20	0.00	67.46	17.23	300.23	280.42	173.74
22923.000	0.00	9.90	7.20	0.00	66.55	16.90	300.23	280.42	173.74

Fish Habitat Output Files

There are several output files defined in the fish habitat input file – one for fish habitat, volume weighted averages for an entire segment over all vertical layers, surface weighted averages over a fixed number of vertical layers, and accumulation of sediments in the first order sediment model.

Fish Habitat

The fish habitat zones are defined in the section on [Fish Habitat](#). A typical output file is shown below:

Fish habitat analysis: CE-QUAL-W2 model results

```

Species, Temperature minimum, Temperature maximum, Dissolved oxygen minimum
RainbowTrout,          0.00,    18.00,      5.00
StripedBass,           10.00,   24.00,      5.00
Walleye,               12.00,   24.00,      5.00
WhiteBass,              0.00,   28.00,      3.00
SmallmouthBass,         0.00,   29.00,      4.00
SpottedBass,            0.00,   24.40,      6.00
GizzardShad,           10.00,   26.70,      6.00
LargemouthBass,         10.00,   30.00,      5.00
ChannelCatfish,         18.00,   31.00,      5.00

JDAY, %VOL-RainbowTrout, HAB-VOL(m3)-RainbowTrout, %VOL-StripedBass, HAB-VOL(m3)-
StripedBass, %VOL-Walleye, HAB-VOL(m3)-Walleye, %VOL-WhiteBass, HAB-VOL(m3)-WhiteBass, %VOL-
SmallmouthBass, HAB-VOL(m3)-SmallmouthBass, %VOL-SpottedBass, HAB-VOL(m3)-SpottedBass, %VOL-
GizzardShad, HAB-VOL(m3)-GizzardShad, %VOL-LargemouthBass, HAB-VOL(m3)-LargemouthBass, %VOL-
ChannelCatfish, HAB-VOL(m3)-ChannelCatfish, , DO VOL(m3)<=1mg/L
  61.532, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00, 0.0000E+00, 100.00,
  0.1170E+09, 100.00, 0.1170E+09, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00,
  0.0000E+00, 0.00, 0.0000E+00, 0.0000E+00
  61.542, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00, 0.0000E+00, 100.00,
  0.1170E+09, 100.00, 0.1170E+09, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00,
  0.0000E+00, 0.00, 0.0000E+00, 0.0000E+00
  61.566, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00, 0.0000E+00, 100.00,
  0.1170E+09, 100.00, 0.1170E+09, 100.00, 0.1170E+09, 0.00, 0.0000E+00, 0.00,
  0.0000E+00, 0.00, 0.0000E+00, 0.0000E+00

```

The output code reprints the original criteria and then at the output of the TSR FREQ, outputs JDAY (Julian day), % habitat volume for species 1, actual habitat volume in m³ for species 1, and then this is repeated for each species.

An example of this is shown below for DeGray Reservoir for small mouth bass and gizzard shad between March and September 1980 in Figure 46. A comparison of reservoir volume less than 1 mg/l compared to estimated field data for 5 years on Brownlee Reservoir is shown in Figure 47.

The model also writes out output for each branch and waterbody if this feature [**HABITAC**] is ON. For each waterbody the model will write out ‘fish_habitat_wbX.csv’ where X is the waterbody #. Also, for each branch the model will write out ‘fish_habitat_brX.csv’ where X is the branch #. These files allow the model user to explore fish habitat in smaller sections of the waterbody as required for the study. These files follow the output described above for the habitat volume % and habitat volume in that particular waterbody or branch.

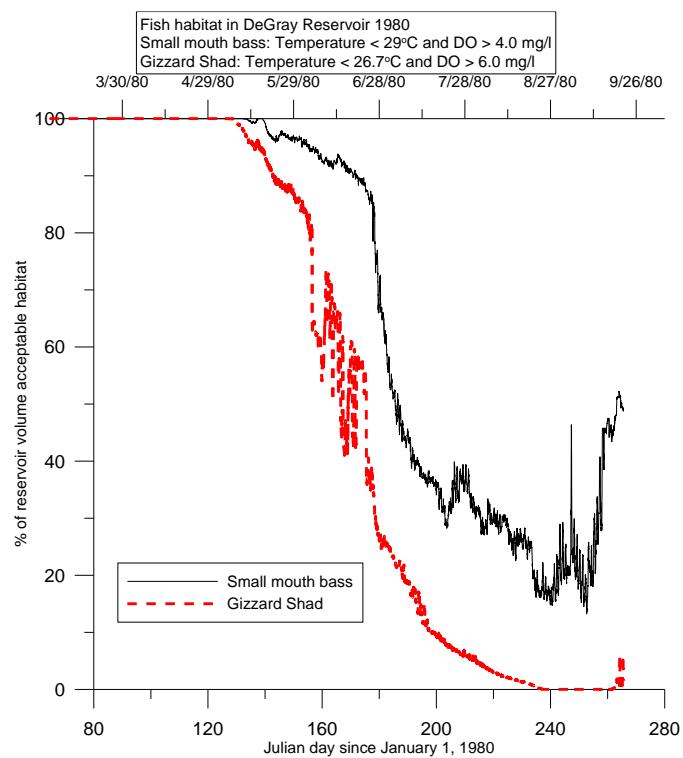


Figure 46. Small mouth bass habitat in DeGray reservoir for 1980.

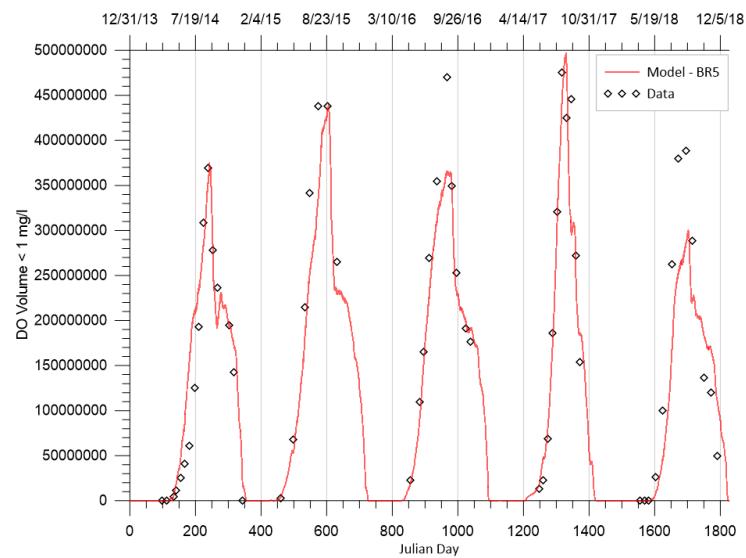


Figure 47. Dissolved oxygen less than 1 mg/l comparison of model compared to field data for Brownlee Reservoir.

Nutrients, Dissolved Oxygen and Chlorophyll a – Volume weighted and surface

Typical output file results are shown below for the volume weighted averages at the 3 segment numbers specified. Volume-weighted averages are computed at specified segments. There are a number of blank lines at the beginning of the file to match the format of the fish habitat output file.

```
Volume weighted WQ parameters at segments: 10 15 24
JDAY, PO4- 10, NH4- 10, NO3- 10, DO- 10, TP- 10, CHLA- 10, PO4- 15,
NH4- 15, NO3- 15, DO- 15, TP- 15, CHLA- 15, PO4- 24, NH4- 24, NO3- 24,
DO- 24, TP- 24, CHLA- 24,
64.542, 0.0010, 0.0022, 0.1400, 11.0935, 0.0000, 0.0000, 0.0010, 0.0022,
0.1400, 11.0284, 0.0000, 0.0000, 0.0010, 0.0022, 0.1400, 10.6507, 0.0000,
0.0000,
64.583, 0.0010, 0.0023, 0.1400, 11.0934, 0.0000, 0.0000, 0.0010, 0.0023,
0.1400, 11.0276, 0.0000, 0.0000, 0.0010, 0.0023, 0.1400, 10.6486, 0.0000,
0.0000,
64.625, 0.0010, 0.0025, 0.1400, 11.0932, 0.0000, 0.0000, 0.0010, 0.0025,
0.1400, 11.0269, 0.0000, 0.0000, 0.0010, 0.0025, 0.1400, 10.6462, 0.0000,
0.0000,
64.667, 0.0010, 0.0026, 0.1400, 11.0929, 0.0000, 0.0000, 0.0010, 0.0026,
0.1400, 11.0259, 0.0000, 0.0000, 0.0010, 0.0026, 0.1400, 10.6437, 0.0000,
0.0000,
64.708, 0.0010, 0.0028, 0.1400, 11.0927, 0.0000, 0.0000, 0.0010, 0.0028,
0.1400, 11.0249, 0.0000, 0.0000, 0.0010, 0.0028, 0.1400, 10.6410, 0.0000,
0.0000,
64.750, 0.0010, 0.0029, 0.1400, 11.0926, 0.0000, 0.0000, 0.0010, 0.0029,
0.1400, 11.0240, 0.0000, 0.0000, 0.0010, 0.0029, 0.1400, 10.6380, 0.0000,
0.0000,
```

Typical output file results are shown below for the surface (specified number of layers of the surface) volume weighted averages at the 3 segment numbers specified. There are a number of blank lines at the beginning of the file to match the format of the fish habitat output file.

```
Surface (upper 4 model layers) Volume weighted WQ parameters at segments: 10 15 24
JDAY, PO4- 10, NH4- 10, NO3- 10, DO- 10, TP- 10, CHLA- 10, Gamma(m-1)- 10,
PO4- 15, NH4- 15, NO3- 15, DO- 15, TP- 15, CHLA- 15, Gamma(m-1)- 15, PO4- 24,
NH4- 24, NO3- 24, DO- 24, TP- 24, CHLA- 24, Gamma(m-1)- 24,
64.542, 0.0010, 0.0022, 0.1400, 11.1004, 0.0000, 0.0000, 0.5100, 0.0010,
0.0022, 0.1400, 11.0998, 0.0000, 0.0000, 0.5100, 0.0010, 0.0022, 0.1400,
11.1001, 0.0000, 0.0000, 0.5100,
64.583, 0.0010, 0.0023, 0.1400, 11.1007, 0.0000, 0.0000, 0.5100, 0.0010,
0.0023, 0.1400, 11.0995, 0.0000, 0.0000, 0.5100, 0.0010, 0.0023, 0.1400,
11.1001, 0.0000, 0.0000, 0.5100,
64.625, 0.0010, 0.0025, 0.1400, 11.1012, 0.0000, 0.0000, 0.5100, 0.0010,
0.0025, 0.1400, 11.0992, 0.0000, 0.0000, 0.5100, 0.0010, 0.0025, 0.1400,
11.1000, 0.0000, 0.0000, 0.5100,
64.667, 0.0010, 0.0026, 0.1400, 11.1013, 0.0000, 0.0000, 0.5090, 0.0010,
0.0026, 0.1400, 11.0985, 0.0000, 0.0000, 0.5095, 0.0010, 0.0026, 0.1400,
11.0996, 0.0000, 0.0000, 0.5095,
64.708, 0.0010, 0.0028, 0.1400, 11.0998, 0.0000, 0.0000, 0.5090, 0.0010,
0.0028, 0.1400, 11.0977, 0.0000, 0.0000, 0.5095, 0.0010, 0.0028, 0.1400,
11.0991, 0.0000, 0.0000, 0.5095,
64.750, 0.0010, 0.0029, 0.1400, 11.1002, 0.0000, 0.0000, 0.5090, 0.0010,
0.0029, 0.1400, 11.0968, 0.0000, 0.0000, 0.5095, 0.0010, 0.0029, 0.1400,
11.0984, 0.0000, 0.0000, 0.5095,
```

Overall organic matter accumulation at the bottom of each layer and summed for each segment

The output file is shown below where all entries are comma delimited and are for each segment and time of output. The values for each segment are grams of organic matter. There are a number of blank lines at the beginning of the file to match the format of the fish habitat output file.

PREPROCESSOR

OUTPUT FILES

```
JDAY, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
23, 24, 25, 26, 27, 28, 29, 30, 31,
64.542, 0.2676E+03, 0.3751E+03, 0.5351E+03, 0.7376E+03, 0.1120E+04,
0.1630E+04, 0.1577E+04, 0.1288E+04, 0.1490E+04, 0.2253E+04, 0.2452E+04,
0.3120E+04, 0.4287E+04, 0.3824E+04, 0.2663E+04, 0.4700E+04, 0.5847E+04,
0.6447E+04, 0.1021E+05, 0.9486E+04, 0.1095E+05, 0.1289E+05, 0.7819E+04,
0.5235E+04, 0.5760E+04, 0.6320E+04, 0.6432E+04, 0.4698E+04, 0.2557E+04,
0.1682E+04,
64.583, 0.5577E+03, 0.7482E+03, 0.1067E+04, 0.1471E+04, 0.2236E+04,
0.3258E+04, 0.3150E+04, 0.2572E+04, 0.2976E+04, 0.4500E+04, 0.4898E+04,
0.6234E+04, 0.8565E+04, 0.7638E+04, 0.5316E+04, 0.9387E+04, 0.1168E+05,
0.1288E+05, 0.2039E+05, 0.1895E+05, 0.2189E+05, 0.2575E+05, 0.1562E+05,
0.1046E+05, 0.1150E+05, 0.1263E+05, 0.1285E+05, 0.9388E+04, 0.5109E+04,
0.3361E+04,
64.625, 0.8683E+03, 0.1121E+04, 0.1597E+04, 0.2201E+04, 0.3348E+04,
0.4886E+04, 0.4726E+04, 0.3853E+04, 0.4467E+04, 0.6745E+04, 0.7342E+04,
0.9346E+04, 0.1284E+05, 0.1145E+05, 0.7963E+04, 0.1407E+05, 0.1752E+05,
0.1931E+05, 0.3056E+05, 0.2841E+05, 0.3282E+05, 0.3860E+05, 0.2341E+05,
0.1567E+05, 0.1724E+05, 0.1892E+05, 0.1926E+05, 0.1407E+05, 0.7659E+04,
0.5037E+04,
64.667, 0.1194E+04, 0.1499E+04, 0.2125E+04, 0.2927E+04, 0.4458E+04,
0.6513E+04, 0.6300E+04, 0.5131E+04, 0.5956E+04, 0.8987E+04, 0.9782E+04,
0.1246E+05, 0.1711E+05, 0.1525E+05, 0.1060E+05, 0.1875E+05, 0.2334E+05,
0.2573E+05, 0.4072E+05, 0.3785E+05, 0.4375E+05, 0.5143E+05, 0.3119E+05,
0.2087E+05, 0.2296E+05, 0.2520E+05, 0.2567E+05, 0.1875E+05, 0.1021E+05,
0.6711E+04,
```

Preprocessor

The preprocessor produces several output files including a file that echoes all control file inputs along with additional information (**pre.opt**), a warning file that attempts to alert the user to potential problems with inputs (**pre.wrn**), and an error file (**pre.err**) that points out serious problems in the input data that may prevent the model from running or running correctly. It is important to run the preprocessor routinely before a model simulation.

Command-line working directory specification

In the windows version of the preprocessor, the user can now supply a command line argument that sets the working directory of the code. Hence, one does not need to copy the preprocessor into every directory. In a batch file, for example, one can execute the following command:

```
preW2_ivf.exe "C:\scott\w2workshop\2009 workshop\waterqual\problem3"
```

The preprocessor now uses the supplied directory (in double quotes) as the working directory for all the files. The command line argument has one blank space between the end of the executable and the first quote. The working directory is displayed at the top of the window for the preprocessor.

Output (pre.opt)

The title cards are echoed at the beginning of the output followed by a complete echoing of all control file input. A description of the input, the FORTRAN variable name used in the control file, and the value of the variable are then output. The sequence of output tries to closely follow the sequence of input in the control file, but in some cases it is different as certain types of output are more logically grouped together.

OUTPUT FILES

PREPROCESSOR

The first information includes variables affecting the time of simulation and the timestep for the simulation. Next is information that is used to set initial conditions and variables that are used to control certain calculations in the model.

EXAMPLE

```
Burnsville Reservoir - March 15 through December 11, 1992
Density placed inflow, point sink outflows
Default hydraulic coefficients
Default light absorption/extinction coefficients
Default kinetic coefficients
Temperature and water quality simulation
Run 8
Testing sensitivity to wind
Wind sheltering set to 0.75
Jim Stiles and Vince Marchese, USACE Huntington District

Time Control
Starting time (Julian day) [TMSTRT] = 75.00
Ending time (Julian day) [TMEND] = 320.00
Year [YEAR] = 1992
# Timestep intervals [NDLT] = 1
Minimum timestep (sec) [DLTMIN] = 1.0
Timestep day (Julian day) [DLTD] = 1.0
Maximum timestep (sec) [DLTMAX] = 1800.0
Fraction of timestep [DLTF] = 0.85
Timestep limitation
Waterbody 1
Vertical eddy viscosity [VISC] = ON
Internal gravity wave [CELC] = ON

Initial Conditions
Waterbody 1
Temperature [T2I] = Downstream vertical profile
Water type [WTYPEC] = FRESH water
Ice thickness [ICEI] = 0.000 m

Calculations
Waterbody 1
Evaporation [EVC] = OFF
Precipitation [PRC] = OFF
Volume balance [VBC] = ON
Energy balance [EBC] = ON
Mass balance [MBC] = ON
Place inflows [PQC] = ON
Wind [WINDC] = ON
Inflow [QINC] = ON
Outflow [QOUTC] = ON
Heat exchange [HEATC] = ON
Heat exchange [SLHTC] = TERM
Waterbody 1
read radiation [SROC] = OFF
wind function coefficient a [AFW] = 9.20
wind function coefficient b [BFW] = 0.46
wind function coefficient c [CFW] = 2.00
wind height [WINDH] = 10.00
Ryan-Harleman evaporation [RHEVC] = OFF
```

The next output includes controls for all input interpolation. These are then followed by meteorological parameters that affect wind and surface heat exchange as well as a summary of statistics of all meteorological variables in the meteorological input file.

EXAMPLE

```
Input Interpolations
Branch 1
```

PREPROCESSOR

OUTPUT FILES

```
Inflow [QINIC] = ON
Distributed tributary [DTRIC] = OFF
Head boundary [HDIC] = OFF
Branch 2
Inflow [QINIC] = ON
Distributed tributary [DTRIC] = OFF
Head boundary [HDIC] = OFF
Branch 3
Inflow [QINIC] = ON
Distributed tributary [DTRIC] = OFF
Head boundary [HDIC] = OFF
Waterbody 1
Meteorology [METIC] = ON
Tributary 1 [TRIC] = ON
Branch 1
Structure 1 [STRIC] = ON
Structure 2 [STRIC] = ON
Structure 3 [STRIC] = ON

Meteorological Parameters
Waterbody 1
Latitude [LAT] = 38.80
Longitude [LONG] = 80.60
Meteorological Data Input Summary
Parameter Waterbody Average Value Maximum Minimum
TAIR(C) 1 26.258 37.300 16.000
TDEW(C) 1 22.850 29.000 8.500
WIND(m/s) 1 0.592 11.490 0.000
PHI(rad) 1 1.871 6.280 0.000
CLOUD(0-10) 1 5.249 10.000 0.000
SRO(W/m2) 1 0.000 0.000 0.000
Axis orientation
Segment # 2 3 4 5 6 7 8 9 10 11 12 13 14 15
[PHIO] (rads) 1.22 5.22 4.62 0.65 5.67 3.84 5.08 6.27 0.19 5.58 5.32 0.44 0.35 4.54
Segment # 21 22 23 24 25 26 27 28 29 30 31 32 33 34
[PHIO] (rads) 4.82 0.24 6.16 0.04 0.00 0.00 5.24 5.18 4.14 5.01 4.35 4.00 3.30 5.15
Segment # 40 41 42 43 44 45 46 47 48 49 50 51 52 53
[PHIO] (rads) 6.13 0.35 0.33 0.00 0.00 0.35 6.20 5.64 0.00 0.00 3.51 3.77 3.40 0.00
```

Variables affecting the transport solution and hydraulics are output next along with variables affecting ice cover.

EXAMPLE

```
Transport Solution
Waterbody 1
Transport [SLTRC] = QUICKEST
Theta [THETA] = 0.55

Hydraulic coefficients
Waterbody 1
Longitudinal eddy viscosity [AX] = 1.00 m2/sec
Longitudinal eddy diffusivity [DX] = 1.00 m2/sec
Sediment temperature [TSED] = 11.80 °C
Coefficient of bottom heat exchange [CBHE] = 0.3 W/m2/°C

Ice cover
Waterbody 1
Ice calculations [ICEC] = OFF
Solution [SLICEC] = DETAIL
Albedo [ALBEDO] = 0.25
Ice-water heat exchange [HWI] = 10.00
Light absorption [BETAI] = 0.60
Light decay [GAMMAI] = 0.07
```

OUTPUT FILES

PREPROCESSOR

Output controls excluding constituents are output next.

EXAMPLE

```
Output Control
Waterbody 1
  Timestep violations [NVIOL] = OFF
  Horizontal velocity [U], m/s = OFF
  Vertical velocity [W], m/s = OFF
  Temperature [T1], deg C = ON
  Density [RHO], kg/m^3 = OFF
  Vertical eddy viscosity [AZ], m^2/s = OFF
  Velocity shear stress [SHEAR], 1/s^2 = OFF
  Internal shear [ST], m^3/s^2 = OFF
  Bottom shear [SB], m^3/s^2 = OFF
  Longitudinal momentum [ADMX], m^3/s^2 = OFF
  Longitudinal momentum [DM], m^3/s^2 = OFF
  Horizontal density gradient [HDG], m^3/s^2= OFF
  Vertical momentum [ADMZ], m^3/s^2 = OFF
  Horizontal pressure gradient [HPG], m^3/s^2= OFF
  Gravity term channel slope [GRAV], m^3/s^2= OFF
Waterbody 1
  Snapshot [SNPC] = ON
  Number of time intervals [NSNP] = 7
  Date (Julian day) [SNPD] = 75.50 139.50 153.50 167.50 195.50 223.60 252.60
  Frequency (days) [SNPF] = 100.00 100.00 100.00 100.00 100.00 100.00 100.00
  Screen [SCRC] = ON
  Number of time intervals [NSCR] = 1
  Date (Julian day) [SCRD] = 75.50
  Frequency (days) [SCRF] = 1.00
  Fluxes [FLXC] = ON
  Number of time intervals [NFLX] = 1
  Date (Julian day) [FLXD] = 77.70
  Frequency (days) [FLXF] = 100.00
  Vector plot [VPLC] = ON
  Number of time intervals [NVPL] = 1
  Date (Julian day) [VPLD] = 75.70
  Frequency (days) [VPLF] = 100.00
  Profile plot [PRFC] = ON
  Number of time intervals [NPRF] = 7
  Number of stations [NIPRF] = 1
  Segment location [IPRF] = 24
  Date (Julian day) [PRFD] = 75.70 139.50 153.50 167.50 195.50 223.60 252.60
  Frequency (days) [PRFF] = 100.00 100.00 100.00 100.00 100.00 100.00 100.00
  Spreadsheet plot [SPRC] = ON
  Number of time intervals [NSPR] = 7
  Number of stations [NISPR] = 1
  Segment location [ISPR] = 24
  Date (Julian day) [SPRD] = 75.70 139.50 153.50 167.50 195.50 223.60 252.60
  Frequency (days) [SPRF] = 100.00 100.00 100.00 100.00 100.00 100.00 100.00
  Contour plot [CPLC] = ON
  Number of time intervals [NCPL] = 1
  Date (Julian day) [CPLD] = 75.70
  Frequency (days) [CPLF] = 15.00
  Time series [TSRC] = ON
  Number of time intervals [NTSR] = 1
  Date (Julian day) [TSRD] = 75.70
  Frequency (days) [TSRF] = 1.00
Restart out [RSOC] = OFF
Restart in [RSIC] = OFF
```

Inflow/outflow information is output next.

EXAMPLE

```
Inflow/Outflow
Selective Withdrawal
Branch # of structures [NSTR]
```

PREPROCESSOR

OUTPUT FILES

```
1          3
2          0
3          0
Branch 1
Structure   Type    Width (m)   Elevation (m)   Bottom Layer
1           POINT   0.0        237.7        38
2           POINT   0.0        234.7        38
3           LINE    6.1        231.9        38
Number of withdrawals [NWD] = 0
Number of tributaries [NTR] = 1
segment number [ITR] = 24
Inflow placement [PTRC] = DISTR
Top elevation [ETTR] = 2.00
Bottom elevation [EBTR] = 38.00
Distributed tributaries [DTRC]
Branch 1 = OFF
Branch 2 = OFF
Branch 3 = OFF
Branch 4 = OFF
Branch 5 = OFF
Branch 6 = OFF
```

Input and output filenames are then output.

EXAMPLE

```
Input Filenames
Control      = w2_con.npt
Restart       = rsi.npt - not used
Withdrawal   = qwd.npt - not used
Waterbody 1
Bathymetry    = bth.npt
Meteorology   = met.npt
Vertical profile = vpr.npt
Longitudinal profile = lpr.npt - not used
Branch 1
Inflow          = qin_brl.npt
Inflow temperature = tin_brl.npt
Inflow concentrations = cin_brl.npt
Outflow          = qot_brl.npt
Distributed tributary inflows = qin_brl.npt - not used
Distributed tributary temperatures = tdt_brl.npt - not used
Distributed tributary concentrations = cdt_brl.npt - not used
Precipitation    = pre_brl.npt - not used
Precipitation temperatures = tpr_brl.npt - not used
Precipitation concentrations = cpr_brl.npt - not used
Upstream head    = euh_brl.npt - not used
Upstream head temperatures = tuh_brl.npt - not used
Upstream head concentrations = cuh_brl.npt - not used
Downstream head = edh_brl.npt - not used
Downstream head temperatures = tdh_brl.npt - not used
Downstream head concentrations = cdh_brl.npt - not used
Tributary 1
Inflow          = qtr_tr1.npt
Inflow temperature = ttr_tr1.npt
Inflow concentration = ctr_tr1.npt

Output Filenames
Error          = pre.err
Warning        = pre.wrn
Time series   = tsr.opt
Withdrawal    = wdo.opt
Waterbody 1
Snapshot       = smp.opt
Fluxes         = flx.opt
Profile        = prf.opt
Vector plot   = vpl.opt
```

OUTPUT FILES

PREPROCESSOR

Contour plot = cpl.opt

The next section includes all variables affecting water quality simulations including input/output controls, initial concentrations, active constituents, derived variables, kinetic fluxes, and kinetic rates constants.

EXAMPLE

```
Constituents [CCC] = ON
Algal limiting nutrient [LIMC] = OFF
Kinetics update frequency [CUF] = 2
```

```
Waterbody 1
State Variables
Constituent      Computation Initial Conc   Fluxes      Printout
[CNAME]           [CAC]       [C2IWB, g/m^3] [CFWBC]    [CPRWBC]
Dissolved solids ON          -1.000        OFF         ON
Residence time   ON          0.000        OFF         OFF
Suspended solids1 ON          -1.000        OFF         ON
Phosphate        ON          0.020        OFF         ON
Ammonium         ON          0.050        OFF         ON
Nitrate nitrite  ON          0.200        OFF         ON
Dissolved silica OFF         0.000        OFF         OFF
Particulate silica OFF        0.000        OFF         OFF
Total Iron       OFF         10.000       OFF         OFF
Labile DOM       ON          0.675        OFF         ON
Refractory_DOM   ON          1.575        OFF         ON
Labile POM       ON          0.750        OFF         ON
Refractory POM   OFF         0.000        OFF         OFF
Algae            ON          0.650        OFF         ON
Dissolved oxygen ON          -1.000       OFF         ON
Inorganic carbon OFF         11.910       OFF         OFF
Alkalinity       OFF         40.000       OFF         OFF
Sediments        OFF         0.000        OFF         OFF
Branch 1
State Variables
Constituent      Inflow      Distributed trib  Precipitation
[CNAME]           [CINBRC]   [CDTBRC]      [CPRBRC]
Dissolved solids ON          OFF          OFF
Residence time   OFF         OFF          OFF
Suspended solids1 ON          OFF          OFF
Phosphate        ON          OFF          OFF
Ammonium         ON          OFF          OFF
Nitrate nitrite  ON          OFF          OFF
Dissolved silica OFF         OFF          OFF
Particulate silica OFF        OFF          OFF
Total Iron       OFF         OFF          OFF
Labile DOM       ON          OFF          OFF
Refractory_DOM   ON          OFF          OFF
Labile POM       ON          OFF          OFF
Refractory POM   OFF         OFF          OFF
Algae            ON          OFF          OFF
Dissolved oxygen ON          OFF          OFF
Inorganic carbon OFF         OFF          OFF
Alkalinity       OFF         OFF          OFF
Branch 2
State Variables
Constituent      Inflow      Distributed trib  Precipitation
[CNAME]           [CINBRC]   [CDTBRC]      [CPRBRC]
Dissolved solids ON          OFF          OFF
Residence time   OFF         OFF          OFF
Suspended solids1 ON          OFF          OFF
Phosphate        ON          OFF          OFF
Ammonium         ON          OFF          OFF
Nitrate nitrite  ON          OFF          OFF
Dissolved silica OFF         OFF          OFF
Particulate silica OFF        OFF          OFF
Total Iron       OFF         OFF          OFF
```

PREPROCESSOR

OUTPUT FILES

Labile DOM	ON	OFF	OFF
Refractory_DOM	ON	OFF	OFF
Labile POM	ON	OFF	OFF
Refractory POM	OFF	OFF	OFF
Algae	ON	OFF	OFF
Dissolved oxygen	ON	OFF	OFF
Inorganic carbon	OFF	OFF	OFF
Alkalinity	OFF	OFF	OFF
Branch 3			
State Variables			
Constituent [CNAME]	Inflow [CINBRC]	Distributed trib [CDTBRC]	Precipitation [CPRBRC]
Dissolved solids	ON	OFF	OFF
Residence time	OFF	OFF	OFF
Suspended solids1	ON	OFF	OFF
Phosphate	ON	OFF	OFF
Ammonium	ON	OFF	OFF
Nitrate nitrite	ON	OFF	OFF
Dissolved silica	OFF	OFF	OFF
Particulate silica	OFF	OFF	OFF
Total Iron	OFF	OFF	OFF
Labile DOM	ON	OFF	OFF
Refractory_DOM	ON	OFF	OFF
Labile POM	ON	OFF	OFF
Refractory POM	OFF	OFF	OFF
Algae	ON	OFF	OFF
Dissolved oxygen	ON	OFF	OFF
Inorganic carbon	OFF	OFF	OFF
Alkalinity	OFF	OFF	OFF
Derived Variables			
Constituent [CDNAME]		Computation [CDWBC]	
Dissolved organic carbon, g/m^3		OFF	
Particulate organic carbon, g/m^3		OFF	
Total organic carbon, g/m^3		OFF	
Dissolved organic nitrogen, g/m^3		OFF	
Particulate organic nitrogen, g/m^3		OFF	
Total organic nitrogen, g/m^3		OFF	
Total nitrogen, g/m^3		OFF	
Dissolved organic phosphorus, mg/m^3		OFF	
Particulate organic phosphorus, mg/m^3		OFF	
Total organic phosphorus, mg/m^3		OFF	
Total phosphorus, mg/m^3		OFF	
Algal production, g/m^2/day		OFF	
Chlorophyll a, mg/m^3		OFF	
Total algae, g/m^3		OFF	
Oxygen gas saturation, %		OFF	
Total suspended solids, g/m^3		OFF	
Total inorganic suspended solids, g/m^3		OFF	
Total Kheldahl nitrogen, g/m^3		OFF	
Carbonaceous ultimate BOD, g/m^3		OFF	
pH		OFF	
Carbon dioxide, g/m^3		OFF	
Bicarbonate, g/m^3		OFF	
Carbonate, g/m^3		OFF	
Tributary 1			
State Variables			
Constituent [CNAME]	Inflow [CINTRC]		
Dissolved solids	ON		
Residence time	OFF		
Suspended solids1	ON		
Phosphate	ON		
Ammonium	ON		
Nitrate nitrite	ON		
Dissolved silica	OFF		
Particulate silica	OFF		
Total Iron	OFF		

OUTPUT FILES

PREPROCESSOR

```

Labile DOM          ON
Refractory_DOM     ON
Labile POM          ON
Refractory POM      OFF
Algae               ON
Dissolved oxygen    ON
Inorganic carbon    OFF
Alkalinity          OFF
Waterbody 1

Constituent Rates
  Constituent      Rate/Coefficient
  Residence time   Temperature mult [CGQ10] = 0.000
                    0-Order Decay   [CG0DK] = -1.000/day
                    1-Order Decay   [CG1DK] = 0.000/day
                    Settling        [CGS] = 0.000 m/day
  Suspended solids Settling        [SSS] = 1.000 m/day
  Labile DOM        Decay          [LDOMDK] = 0.120 /day
                    to refractory [LRDDK] = 0.001 /day
  Refractory DOM    Decay          [RDOMDK] = 0.001 /day
  Labile POM        Decay          [LPOMDK] = 0.060 /day
                    to refractory [LRPDK] = 0.001 /day
                    Settling        [POMS] = 0.350 m/day
  Refractory POM    Decay          [RPOMDK] = 0.010 /day
  Algal group 1    Growth         [AG] = 1.100 /day
                    Mortality       [AM] = 0.010 /day
                    Excretion       [AE] = 0.010 /day
                    Respiration     [AR] = 0.020 /day
                    Settling        [AS] = 0.140 m/day
                    Org-P           [ALGP] = 0.011
                    Org-N           [ALGN] = 0.080
                    Org-C           [ALGC] = 0.450
                    Org-Si          [ALGSI] = 0.000
                    Chl a/algae ratio [ACHLA] = 65.000 ug/mg
                    Fraction algae to POM [APOM] = 0.80

  Phosphorous       Release        [PO4R] = 0.015 g/m^2/day
  Ammonium          Decay          [NH4DK] = 0.120 /day
                    Release        [NH4R] = 0.080 g/m^2/day
  Nitrate-Nitrite  Decay          [NO3DK] = 0.102 /day
  Silica            Decay          [PSIDK] = 0.100 /day
                    Release        [DSIR] = 0.300 g/m^2/day
                    Settling        [PSIS] = 0.100 m/day
  Sediment          Decay          [SEDDK] = 0.080 /day
  Iron               Settling       [FES] = 2.000 m/day
                    Release        [FER] = 0.500 g/m^2/day
  Oxygen             Sediment demand [SOD] = 1.0 1.0 1.0 1.0 1.0 1.0 1.0
                           1.0 1.0 1.0 1.0 1.0 1.0 1.0
                           1.0 1.0 1.0 1.0 1.0 1.0 1.0
                           1.0 1.0 1.0 1.0 1.0 1.0 1.0
                           1.0 1.0 1.0 1.0 1.0 1.0 1.0
  SOD fraction      [FSOD] = 1.0
  Sediment fraction [FSED] = 1.0

Upper Temperature Bounds
  Constituent      Rate          Upper      Max Upper
  Ammonium          Decay         [NH4T1] = 5.0  [NH4T2] = 25.0
  Nitrate           Decay         [NO3T1] = 5.0  [NO3T2] = 25.0
  Organic            Decay         [OMT1] = 4.0  [OMT2] = 20.0
  Sediment           Decay         [SEDT1] = 4.0  [SEDT2] = 20.0
  Algal group 1    Growth        [AT1] = 10.0 [AT2] = 30.0

Lower Temperature Bounds
  Constituent      Rate          Lower      Max Lower
  Algal group 1    Growth        [AT3] = 35.0 [AT4] = 40.0

Stoichiometric Equivalence
  Oxygen
    Ammonium      [O2NH4] = 4.57
    Organic matter [O2OM] = 1.40
    Respiration    [O2AR] = 1.40
    Algal growth   [O2AG] = 1.40

```

PREPROCESSOR

OUTPUT FILES

```
Organic Matter
  Carbon      [BIOC] = 0.450
  Phosphorous [BIOP] = 0.011
  Nitrogen    [BION] = 0.080
  Silica      [BIOSI] = 0.180
Half Saturation
  Algal group 1
    Phosphorous [AHSP] = 0.009 g/m^3
    Nitrogen   [AHSN] = 0.014 g/m^3
    Silica     [AHSSI] = 0.000 g/m^3
Light
  Attenuation
    Surface layer [BETA] = 0.45
    Water        [EXH2O] = 0.55 /m
    Inorganic solids [EXSS] = 0.01 /m
    Organic solids [EXOM] = 0.01 /m
    Algal group 1 [EXA] = 0.20 /m
Saturation Intensity
  Algal group 1 [ASAT] = 150.0 W/m^2
Diffusion
  Oxygen       [DMO2] = 2.040E-09 m^2/g
  Carbon dioxide [DMCO2] = 1.630E-09 m^2/g
Partitioning Coefficients
  Phosphorous [PARTP] = 1.200 m^3/g
  Silica      [PARTSI] = 0.200 m^3/g
Miscellaneous Constants
  Aerobic half saturation coeff[KDO] = 0.20 g/m^3
  CO2 sediment release [CO2R] = 0.10 g/m^2/day
```

The next section contains summary statistics regarding inflows, temperatures, and inflow constituent concentrations. This is useful for screening time-varying input files for accuracy.

EXAMPLE

```
Inflow Constituent Statistics
Branch 1
  Constituent name      Average      Maximum      Minimum
  Dissolved solids       49.576      99.000      10.000
  Suspended solids1     4.467       156.000      2.000
  Phosphate              0.020       0.020       0.020
  Ammonium               0.100       0.100       0.100
  Nitrate nitrite         0.200       0.200       0.200
  Labile DOM              0.382       0.382       0.382
  Refractory_DOM          0.892       0.892       0.892
  Labile POM              0.425       0.425       0.425
  Algae                   0.000       0.000       0.000
  Dissolved oxygen         9.851      14.000      0.000

Water Balance Summary
Waterbody 1
  total inflows      total outflows
  average maximum    average maximum
  6.22   124.38      6.25    38.19

Branch 1
  Inflows
    total
    average maximum
    5.29   124.38
    upstream      tributaries      distributed tributaries      precipitation
    average maximum    average maximum    average maximum    average maximum
    5.22   124.38      0.07     1.60        0.00     0.00      0.00     0.00
  Outflows
    outlets      withdrawals
    average maximum    average maximum
    6.25    38.19      0.00     0.00
```

OUTPUT FILES

PREPROCESSOR

```
Branch Inflow Temperature Min/Max
Branch(JB)      Maximum Temp (C)      Minimum Temp (C)
    1           0.200E+02            0.187E+01

Tributary Inflow Temperature Min/Max
Tributary(JT)    Maximum Temp (C)    Minimum Temp (C)
    1           0.178E+02            0.320E+01
```

Geometric information follows including all information in the control and bathymetry file along with a computed area-volume-elevation table that also includes average width and depth. Theoretical hydraulic residence at each elevation is also included if the waterbody is a reservoir. The location of the surface layer is indicated by a [KT] next to the layer number. The computational grid showing cell widths is then output, at the top of which is the segment number and the distance to the end of the branch in m.

EXAMPLE

```
Geometry
Overall Grid
Total
    segments [IMX] = 58
    layers [KMX] = 39
    branches [NBR] = 6

Waterbody 1
    Segments          = 1-58
    Branches          = 1-6
    Bottom elevation [ELBOT] = 228.60 m
    Surface layer     [KT] = 23
    Vertical spacing  [H]
        Layer   1   2   3   4   5   6   7   8   9   10  11  12  13  14
        15   16  17  18  19
        Height (m) 0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6
        0.6  0.6  0.6  0.6  0.6
        Layer   20  21  22  23  24  25  26  27  28  29  30  31  32  33
        34   35  36  37  38
        Height (m) 0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6  0.6
        0.6  0.6  0.6  0.6
        Layer   39
        Height (m) 0.6

Branch 1
    Upstream segment [US] = 2      Downstream segment [DS] = 24
    Upstream head segment [UHS] = 0 Downstream head segment [DHS] = 0
Branch 2
    Upstream segment [US] = 27     Downstream segment [DS] = 36
    Upstream head segment [UHS] = 0 Downstream head segment [DHS] = 19
Branch 3
    Upstream segment [US] = 39     Downstream segment [DS] = 42
    Upstream head segment [UHS] = 0 Downstream head segment [DHS] = 17

Initial Branch Volume [VOLB] = 9495622.2 m^3
```

Branch 1 Volume-Area-Elevation Table

Layer	Elevation (m)	Area (1.0E6 m^2)	Volume (1.0E6 m^3)	Active Cells	Average depth (m)	Average width (m)
2	251.17	5.171	58.316	630	11.3	262.48
3	250.56	5.002	55.162	607	11.0	253.90
4	249.95	4.923	52.111	584	10.6	249.88
5	249.34	4.828	49.108	563	10.2	245.09
6	248.73	4.706	46.163	542	9.8	238.89
7	248.12	4.624	43.292	521	9.4	234.74
8	247.51	4.522	40.471	500	9.0	229.52
9	246.90	4.350	37.713	479	8.7	220.84
10	246.29	4.191	35.059	458	8.4	212.73

PREPROCESSOR

OUTPUT FILES

11	245.68	4.059	32.503	437	8.0	206.02
12	245.07	3.835	30.027	417	7.8	194.70
13	244.46	3.661	27.688	397	7.6	185.86
14	243.85	3.570	25.454	378	7.1	181.21
15	243.24	3.476	23.277	359	6.7	176.45
16	242.63	3.363	21.156	341	6.3	170.73
17	242.02	3.083	19.104	323	6.2	156.48
18	241.41	2.972	17.224	305	5.8	150.88
19	240.80	2.878	15.411	287	5.4	146.07
20	240.19	2.777	13.655	269	4.9	140.96
21	239.58	2.626	11.962	251	4.6	133.29
22	238.97	2.485	10.360	233	4.2	126.14
23 KT	238.36	2.413	8.844	216	3.7	122.50
24	237.75	2.282	7.372	199	3.2	115.85
25	237.14	1.927	5.980	182	3.1	97.83
26	236.53	1.716	4.804	165	2.8	87.12
27	235.92	1.290	3.757	148	2.9	65.48
28	235.31	1.150	2.970	132	2.6	58.38
29	234.70	0.995	2.269	116	2.3	50.52
30	234.09	0.839	1.662	101	2.0	42.61
31	233.48	0.595	1.150	86	1.9	30.19
32	232.87	0.410	0.787	71	1.9	20.84
33	232.26	0.306	0.536	56	1.8	15.51
34	231.65	0.225	0.350	41	1.6	11.41
35	231.04	0.145	0.213	28	1.5	7.34
36	230.43	0.106	0.125	17	1.2	5.39
37	229.82	0.074	0.060	8	0.8	3.76
38	229.21	0.024	0.015	3	0.6	1.23

Initial Branch Volume [VOLB] = 2111233.1 m³

Finally, initial conditions for the water surface deviation, temperature, and constituent concentrations are output. The user should check these to ensure that the initial concentrations are correct, particularly when using the vertical and/or longitudinal profile files to set initial conditions. Inactive segments are output to ensure the user realizes that the initial water surface has caused upstream segments to be subtracted. Open a **pre.opt** file from the Example problems to review this section of output.

Warning Messages (pre.wrn)

The preprocessor does an extensive check of inputs in order to determine if inputs “make sense”. For many cases, it is easy to determine if the input is valid or not. For these cases, information is written to the error output file (**pre.err**) if the information is invalid. For instance, an algal growth rate that is less than the respiration rate. However, because the model is so flexible, certain inputs are not necessarily errors, but should be flagged so that the user can check to ensure that what they have input is indeed what they intended. Additionally, when kinetic rates differ from valid ranges or a specific value that should not normally be changed, a warning message is also generated.

For example, the preprocessor warns the user that certain active constituents are given a zero initial concentration or are not included in branch inflows. This may be fine unless one had not intended for them to be zero. This is analogous to a compiler that will issue warning and error messages. Warning messages alert the user to potential problems. Error messages are meant to alert the user that they cannot continue until the problem is fixed.

All warning messages include a concise statement in English showing what the problem is. Also included is the FORTRAN variable name as it appears in the input file header along with its value where appropriate. This is illustrated in the following example.

EXAMPLE

```
Epiphyton excretion rate [EE=0.000] < 0.001 for epiphyton group 1
Oxygen to algal respiration stoichiometry [O2AR=1.400] /= 1.1 for waterbody 1
Phosphorus/organic matter stoichiometry [ORGP=0.011] /= 0.005 for waterbody 1
Water surface elevation is below bottom elevation at segment 1
Water surface elevation is below bottom elevation at segment 2
Water surface elevation is below bottom elevation at segment 3
Water surface elevation is below bottom elevation at segment 4
Water surface elevation is below bottom elevation at segment 5
Water surface elevation is below bottom elevation at segment 6
Water surface elevation is below bottom elevation at segment 7
Water surface elevation is below bottom elevation at segment 26
Water surface elevation is below bottom elevation at segment 27
Water surface elevation is below bottom elevation at segment 28
Water surface elevation is below bottom elevation at segment 44
Water surface elevation is below bottom elevation at segment 45
Water surface elevation is below bottom elevation at segment 49
Water surface elevation is below bottom elevation at segment 50
```

In the above example, the user is warned that the epiphyton excretion rate is less than the recommended minimum value. Likewise, the stoichiometric relationships are flagged as these should not be changed from their default values unless the user has data that indicates a different stoichiometry. The remaining warning messages inform the user that part of the system is dry based on the given initial water surface elevation.

A very important point – the user should not assume that because there are no warnings generated that there are no problems with inputs. It is not possible to check all possible combinations of inputs, so there may be problems that were not flagged.

Error Messages (pre.err)

Input errors that will prevent the model from running correctly or running at all are extensively screened and, when found, are included in the preprocessor error output file. All error messages include a concise statement in English what the problem is along with the FORTRAN variable name as it appears in the input file header and its input value where appropriate. This is illustrated in the following example.

EXAMPLE

```
Starting time [TMSTRT=75.000] < ending time [TMEND=-320.000]
Timestep fraction [DLTF(1)=-0.850] <= 0.0
Internal gravity wave limitation control [CELC= on] /= "ON" or "OFF" for waterbody 1
Heat exchange solution control [SLHTC= term] /= "TERM" or "ET" for waterbody 1
Vertical advection time weighting [THETA=-0.550] < 0.0 for waterbody 1
Selective withdrawal elevation [ESTR=137.700] < the bottom active cell elevation
```

Spreadsheet Profile Plot

The spreadsheet profile output was designed to be imported into a spreadsheet program for plotting vertical profiles of temperature, constituents, and derived constituents. Output consists of a comma delimited file with the variable name, Julian date, depth below water surface, elevation, and temperature, horizontal velocity, horizontal layer flow, and/or concentrations for the output segment. Additional segments each contain a depth, elevation, and temperature/concentration column and are continued to the right. Whenever a depth or vertical layer is part of the channel bottom, a value of -99 is placed in the cell.

EXAMPLE

```

Constituent,Julian_day,Depth,Elevation,Seg_9 ,Elevation,Seg_10 ,Elevation,Seg_11 ,Elevation,
Temperature(C), 1.500, 1.549, 439.649, 6.611, 439.649, 6.658, 439.649, 6.664,
Temperature(C), 1.500, 4.073, 437.125, 6.611, 437.125, 6.658, 437.125, 6.664,
Temperature(C), 1.500, 6.023, 435.175, 6.611, 435.175, 6.658, 435.175, 6.664,
Temperature(C), 1.500, 7.973, 433.225, 6.611, 433.225, 6.658, 433.225, 6.664,
Temperature(C), 1.500, 9.923, 431.275, 6.611, 431.275, 6.658, 431.275, 6.664,
Temperature(C), 1.500, 11.873, 429.325, 6.611, 429.325, 6.658, 429.325, 6.664,
Temperature(C), 1.500, 13.823, 427.375, 6.611, 427.375, 6.658, 427.375, 6.664,
Temperature(C), 1.500, 15.773, 425.425, 6.611, 425.425, 6.658, 425.425, 6.664,
Temperature(C), 1.500, 17.723, 423.475, 6.611, 423.475, 6.658, 423.475, 6.664,
Temperature(C), 1.500, 19.673, 421.525, 6.611, 421.525, 6.658, 421.525, 6.664,
Temperature(C), 1.500, 21.623, 419.575, 6.611, 419.575, 6.658, 419.575, 6.664,
Temperature(C), 1.500, 23.573, 417.625, 6.611, 417.625, 6.658, 417.625, 6.664,
Temperature(C), 1.500, 25.523, 415.675, 6.611, 415.675, 6.658, 415.675, 6.664,
Temperature(C), 1.500, 27.473, 413.725, 6.611, 413.725, 6.658, 413.725, 6.664,
Temperature(C), 1.500, 29.423, 411.775, 6.611, 411.775, 6.658, 411.775, 6.664,
Temperature(C), 1.500, 31.373, 409.825, 6.611, 409.825, 6.658, 409.825, 6.664,
Temperature(C), 1.500, 33.323, 407.875, 6.611, 407.875, 6.658, 407.875, 6.664,
Temperature(C), 1.500, 35.273, 405.925, -99.00 , 405.925, 6.658, 405.925, 6.664,
Temperature(C), 1.500, 37.223, 403.975, -99.00 , 403.975, 6.658, 403.975, 6.664,
Temperature(C), 1.500, 39.173, 402.025, -99.00 , 402.025, 6.658, 402.025, 6.664,
Temperature(C), 1.500, 41.123, 400.075, -99.00 , 400.075, 6.658, 400.075, 6.664,
Temperature(C), 1.500, 43.073, 398.125, -99.00 , 398.125, 6.658, 398.125, 6.664,
Temperature(C), 1.500, 45.023, 396.175, -99.00 , 396.175, 6.658, 396.175, 6.664,
Temperature(C), 1.500, 46.973, 394.225, -99.00 , 394.225, 6.658, 394.225, 6.664,
Temperature(C), 1.500, 48.923, 392.275, -99.00 , 392.275, 6.658, 392.275, 6.664,
Temperature(C), 1.500, 50.873, 390.325, -99.00 , 390.325, 6.658, 390.325, 6.664,
Temperature(C), 1.500, 52.823, 388.375, -99.00 , 388.375, 6.658, 388.375, 6.664,
Temperature(C), 1.500, 54.773, 386.425, -99.00 , 386.425, -99.00 , 386.425, 6.664,
Temperature(C), 1.500, 56.723, 384.475, -99.00 , 384.475, -99.00 , 384.475, 6.664,
Temperature(C), 1.500, 58.673, 382.525, -99.00 , 382.525, -99.00 , 382.525, 6.664,
Temperature(C), 1.500, 60.623, 380.575, -99.00 , 380.575, -99.00 , 380.575, 6.664,
Temperature(C), 1.500, 62.573, 378.625, -99.00 , 378.625, -99.00 , 378.625, 6.664,
Temperature(C), 1.500, 64.523, 376.675, -99.00 , 376.675, -99.00 , 376.675, 6.664,
Temperature(C), 1.500, 66.473, 374.725, -99.00 , 374.725, -99.00 , 374.725, 6.664,
HorizontalVelocity(ms-1), 1.500, 1.549, 439.649, -0.0001, 439.649, -0.0036, 439.649, 0.0007,
HorizontalVelocity(ms-1), 1.500, 4.073, 437.125, 0.0035, 437.125, 0.0021, 437.125, 0.0007,
HorizontalVelocity(ms-1), 1.500, 6.023, 435.175, 0.0056, 435.175, 0.0050, 435.175, 0.0007,
HorizontalVelocity(ms-1), 1.500, 7.973, 433.225, 0.0062, 433.225, 0.0062, 433.225, 0.0007,
HorizontalVelocity(ms-1), 1.500, 9.923, 431.275, 0.0046, 431.275, 0.0015, 431.275, 0.0007,
HorizontalVelocity(ms-1), 1.500, 11.873, 429.325, 0.0001, 429.325, 0.0014, 429.325, 0.0007,
HorizontalVelocity(ms-1), 1.500, 13.823, 427.375, 0.0005, 427.375, 0.0015, 427.375, 0.0007,
HorizontalVelocity(ms-1), 1.500, 15.773, 425.425, 0.0009, 425.425, 0.0015, 425.425, 0.0007,
HorizontalVelocity(ms-1), 1.500, 17.723, 423.475, 0.0014, 423.475, 0.0015, 423.475, 0.0007,
HorizontalVelocity(ms-1), 1.500, 19.673, 421.525, 0.0016, 421.525, 0.0016, 421.525, 0.0007,
HorizontalVelocity(ms-1), 1.500, 21.623, 419.575, 0.0016, 419.575, 0.0016, 419.575, 0.0007,
HorizontalVelocity(ms-1), 1.500, 23.573, 417.625, 0.0019, 417.625, 0.0017, 417.625, 0.0007,
HorizontalVelocity(ms-1), 1.500, 25.523, 415.675, 0.0022, 415.675, 0.0017, 415.675, 0.0007,
HorizontalVelocity(ms-1), 1.500, 27.473, 413.725, 0.0024, 413.725, 0.0018, 413.725, 0.0007,
HorizontalVelocity(ms-1), 1.500, 29.423, 411.775, 0.0027, 411.775, 0.0018, 411.775, 0.0007,
HorizontalVelocity(ms-1), 1.500, 31.373, 409.825, 0.0029, 409.825, 0.0018, 409.825, 0.0007,
HorizontalVelocity(ms-1), 1.500, 33.323, 407.875, 0.0032, 407.875, 0.0018, 407.875, 0.0007,
HorizontalVelocity(ms-1), 1.500, 35.273, 405.925, -99.00 , 405.925, 0.0018, 405.925, 0.0007,
HorizontalVelocity(ms-1), 1.500, 37.223, 403.975, -99.00 , 403.975, 0.0018, 403.975, 0.0007,
HorizontalVelocity(ms-1), 1.500, 39.173, 402.025, -99.00 , 402.025, 0.0018, 402.025, 0.0007,
HorizontalVelocity(ms-1), 1.500, 41.123, 400.075, -99.00 , 400.075, 0.0018, 400.075, 0.0007,
HorizontalVelocity(ms-1), 1.500, 43.073, 398.125, -99.00 , 398.125, 0.0019, 398.125, 0.0007,
```

OUTPUT FILES

PROFILE PLOT

HorizontalVelocity(ms-1), 1.500, 45.023, 396.175, -99.00 , 396.175, 0.0019, 396.175, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 46.973, 394.225, -99.00 , 394.225, 0.0019, 394.225, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 48.923, 392.275, -99.00 , 392.275, 0.0020, 392.275, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 50.873, 390.325, -99.00 , 390.325, 0.0019, 390.325, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 52.823, 388.375, -99.00 , 388.375, 0.0017, 388.375, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 54.773, 386.425, -99.00 , 386.425, -99.00 , 386.425, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 56.723, 384.475, -99.00 , 384.475, -99.00 , 384.475, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 58.673, 382.525, -99.00 , 382.525, -99.00 , 382.525, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 60.623, 380.575, -99.00 , 380.575, -99.00 , 380.575, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 62.573, 378.625, -99.00 , 378.625, -99.00 , 378.625, 0.0007,
 HorizontalVelocity(ms-1), 1.500, 64.523, 376.675, -99.00 , 376.675, -99.00 , 376.675, 0.0000,
 HorizontalVelocity(ms-1), 1.500, 66.473, 374.725, -99.00 , 374.725, -99.00 , 374.725, 0.0000,
 HorizontalLayerFlow(m3s-1), 1.500, 1.549, 439.649, -0.0936, 439.649, -4.1658, 439.649, 0.5209,
 HorizontalLayerFlow(m3s-1), 1.500, 4.073, 437.125, 5.3436, 437.125, 2.4416, 437.125, 0.5103,
 HorizontalLayerFlow(m3s-1), 1.500, 6.023, 435.175, 8.2063, 435.175, 5.6493, 435.175, 0.4993,
 HorizontalLayerFlow(m3s-1), 1.500, 7.973, 433.225, 8.8257, 433.225, 6.8659, 433.225, 0.4881,
 HorizontalLayerFlow(m3s-1), 1.500, 9.923, 431.275, 6.3341, 431.275, 1.6891, 431.275, 0.4771,
 HorizontalLayerFlow(m3s-1), 1.500, 11.873, 429.325, 0.1887, 429.325, 1.5178, 429.325, 0.4663,
 HorizontalLayerFlow(m3s-1), 1.500, 13.823, 427.375, 0.6163, 427.375, 1.5241, 427.375, 0.4559,
 HorizontalLayerFlow(m3s-1), 1.500, 15.773, 425.425, 1.1120, 425.425, 1.5279, 425.425, 0.4456,
 HorizontalLayerFlow(m3s-1), 1.500, 17.723, 423.475, 1.5472, 423.475, 1.5263, 423.475, 0.4356,
 HorizontalLayerFlow(m3s-1), 1.500, 19.673, 421.525, 1.6613, 421.525, 1.5277, 421.525, 0.4256,
 HorizontalLayerFlow(m3s-1), 1.500, 21.623, 419.575, 1.5036, 419.575, 1.5298, 419.575, 0.4157,
 HorizontalLayerFlow(m3s-1), 1.500, 23.573, 417.625, 1.5087, 417.625, 1.5398, 417.625, 0.4062,
 HorizontalLayerFlow(m3s-1), 1.500, 25.523, 415.675, 1.4054, 415.675, 1.5356, 415.675, 0.3967,
 HorizontalLayerFlow(m3s-1), 1.500, 27.473, 413.725, 1.3066, 413.725, 1.5222, 413.725, 0.3872,
 HorizontalLayerFlow(m3s-1), 1.500, 29.423, 411.775, 1.1801, 411.775, 1.4968, 411.775, 0.3774,
 HorizontalLayerFlow(m3s-1), 1.500, 31.373, 409.825, 0.9957, 409.825, 1.4556, 409.825, 0.3672,
 HorizontalLayerFlow(m3s-1), 1.500, 33.323, 407.875, 0.9760, 407.875, 1.3703, 407.875, 0.3567,
 HorizontalLayerFlow(m3s-1), 1.500, 35.273, 405.925, -99.00 , 405.925, 1.2763, 405.925, 0.3459,
 HorizontalLayerFlow(m3s-1), 1.500, 37.223, 403.975, -99.00 , 403.975, 1.2357, 403.975, 0.3345,
 HorizontalLayerFlow(m3s-1), 1.500, 39.173, 402.025, -99.00 , 402.025, 1.1864, 402.025, 0.3225,
 HorizontalLayerFlow(m3s-1), 1.500, 41.123, 400.075, -99.00 , 400.075, 1.1189, 400.075, 0.3095,
 HorizontalLayerFlow(m3s-1), 1.500, 43.073, 398.125, -99.00 , 398.125, 1.0292, 398.125, 0.2957,
 HorizontalLayerFlow(m3s-1), 1.500, 45.023, 396.175, -99.00 , 396.175, 0.9325, 396.175, 0.2811,
 HorizontalLayerFlow(m3s-1), 1.500, 46.973, 394.225, -99.00 , 394.225, 0.8409, 394.225, 0.2655,
 HorizontalLayerFlow(m3s-1), 1.500, 48.923, 392.275, -99.00 , 392.275, 0.7326, 392.275, 0.2489,
 HorizontalLayerFlow(m3s-1), 1.500, 50.873, 390.325, -99.00 , 390.325, 0.5786, 390.325, 0.2314,
 HorizontalLayerFlow(m3s-1), 1.500, 52.823, 388.375, -99.00 , 388.375, 0.3367, 388.375, 0.2131,
 HorizontalLayerFlow(m3s-1), 1.500, 54.773, 386.425, -99.00 , 386.425, -99.00 , 386.425, 0.1946,
 HorizontalLayerFlow(m3s-1), 1.500, 56.723, 384.475, -99.00 , 384.475, -99.00 , 384.475, 0.1753,
 HorizontalLayerFlow(m3s-1), 1.500, 58.673, 382.525, -99.00 , 382.525, -99.00 , 382.525, 0.1538,
 HorizontalLayerFlow(m3s-1), 1.500, 60.623, 380.575, -99.00 , 380.575, -99.00 , 380.575, 0.1269,
 HorizontalLayerFlow(m3s-1), 1.500, 62.573, 378.625, -99.00 , 378.625, -99.00 , 378.625, 0.0833,
 HorizontalLayerFlow(m3s-1), 1.500, 64.523, 376.675, -99.00 , 376.675, -99.00 , 376.675, 0.0000,
 HorizontalLayerFlow(m3s-1), 1.500, 66.473, 374.725, -99.00 , 374.725, -99.00 , 374.725, 0.0000,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 1.549, 439.649, 2.3025E+01, 439.649, 2.3006E+01, 439.649, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 4.073, 437.125, 2.3025E+01, 437.125, 2.3006E+01, 437.125, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 6.023, 435.175, 2.3025E+01, 435.175, 2.3006E+01, 435.175, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 7.973, 433.225, 2.3025E+01, 433.225, 2.3006E+01, 433.225, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 9.923, 431.275, 2.3025E+01, 431.275, 2.3006E+01, 431.275, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 11.873, 429.325, 2.3025E+01, 429.325, 2.3006E+01, 429.325, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 13.823, 427.375, 2.3025E+01, 427.375, 2.3006E+01, 427.375, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 15.773, 425.425, 2.3025E+01, 425.425, 2.3006E+01, 425.425, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 17.723, 423.475, 2.3025E+01, 423.475, 2.3006E+01, 423.475, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 19.673, 421.525, 2.3025E+01, 421.525, 2.3006E+01, 421.525, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 21.623, 419.575, 2.3025E+01, 419.575, 2.3006E+01, 419.575, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 23.573, 417.625, 2.3025E+01, 417.625, 2.3006E+01, 417.625, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 25.523, 415.675, 2.3025E+01, 415.675, 2.3006E+01, 415.675, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 27.473, 413.725, 2.3025E+01, 413.725, 2.3006E+01, 413.725, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 29.423, 411.775, 2.3025E+01, 411.775, 2.3006E+01, 411.775, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 31.373, 409.825, 2.3025E+01, 409.825, 2.3006E+01, 409.825, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 33.323, 407.875, 2.3025E+01, 407.875, 2.3006E+01, 407.875, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 35.273, 405.925, -99.00 , 405.925, 2.3006E+01, 405.925, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 37.223, 403.975, -99.00 , 403.975, 2.3006E+01, 403.975, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 39.173, 402.025, -99.00 , 402.025, 2.3006E+01, 402.025, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 41.123, 400.075, -99.00 , 400.075, 2.3006E+01, 400.075, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 43.073, 398.125, -99.00 , 398.125, 2.3006E+01, 398.125, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 45.023, 396.175, -99.00 , 396.175, 2.3006E+01, 396.175, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 46.973, 394.225, -99.00 , 394.225, 2.3006E+01, 394.225, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 48.923, 392.275, -99.00 , 392.275, 2.3006E+01, 392.275, 2.3005E+01,
 TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 50.873, 390.325, -99.00 , 390.325, 2.3006E+01, 390.325, 2.3005E+01,

PROFILE PLOT

OUTPUT FILES

```
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 52.823, 388.375, -99.00 , 388.375, 2.3005E+01, 388.375, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 54.773, 386.425, -99.00 , 386.425, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 56.723, 384.475, -99.00 , 384.475, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 58.673, 382.525, -99.00 , 382.525, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 60.623, 380.575, -99.00 , 380.575, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 62.573, 378.625, -99.00 , 378.625, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 64.523, 376.675, -99.00 , 376.675, 2.3005E+01,  
TDS_g/m3_or_Salinity_kg/m3_____, 1.500, 66.473, 374.725, -99.00 , 374.725, 2.3005E+01,
```

If the **SPRC** was set to 'ONV' rather than 'ON', an additional output file is written that contains the volume weighted temperature and water quality state and derived variables at the locations and times specified. This file has the suffix '**_volw.csv**' and is a comma delimited file. A typical output file for a simulation with the vertical, volume-weighted temperature and water age is shown below.

Constituent	Julian day	Seg_35	Seg_36
Temperature	1.04	4	8.986
Age	1.04	0	0
Temperature	31.041	3.998	3.999
Age	31.041	14.335	16.312
Temperature	61.041	3.908	3.906
Age	61.041	11.502	12.378
Temperature	91.04	5.649	5.65
Age	91.04	7.977	8.595
Temperature	121.04	8.183	8.186
Age	121.04	3.875	4.11

Profile Plot

The profile plot output file was originally developed to provide data for a plotting package from Computer Associates called DISSPLA. This was a popular set of FORTRAN callable subroutines developed back in the 1970's for visualizing scientific computing. If the user should decide to develop their own plotting program, then the following describes the information located in the [profile plot output file](#). Note that the new longitudinal profile plot output format is described in the next section.

As in most other output files, the card titles are included for identifying the run prior to plotting and also for including information about the run on the plot.

```
Burnsville Reservoir - March 15 through December 11, 1992  
Density placed inflow, point sink outflows  
Default hydraulic coefficients  
Default light absorption/extinction coefficients  
Default kinetic coefficients  
Temperature and water quality simulation  
Run 8  
Testing sensitivity to wind  
Wind sheltering set to 0.75  
Jim Stiles and Vince Marchese, USACE Huntington District  
Model run at 13:18:39 on 07/23/02
```

The next line reports:

1. maximum number of layers [KMX]
2. number of segments for which information is output [NIPRF]

OUTPUT FILES

PROFILE PLOT

3. total number of output dates [NDSP]
4. total number of constituents regardless of whether they are included in the simulations [NCT]
5. total number of derived constituents regardless of whether they are included in the output [NDC]
6. pointer to the profile date currently in effect [\[PRFDP\]](#)
7. waterbody surface layer [KTWB]
8. logical variable that is T if constituents are simulated, otherwise F

39 1 3 17 23 12 1 23 T

The next line reports the segment(s) output [\[IPRF\]](#):

18 24

The next three lines report which constituents are active:

ON ON OFF ON ON ON ON OFF OFF OFF ON ON ON OFF ON ON OFF OFF OFF OFF
OFF OFF
OFF

Constituent and derived constituent names are included in the next 21 lines:

Temperature, °C	Dissolved solids, g/m ³
Residence time, days	Suspended solids1, g/m ³
Phosphate, mg/m ³	Ammonium, mg/m ³
Nitrate nitrite, g/m ³	Dissolved silica, g/m ³
Particulate silica, g/m ³	Total Iron, g/m ³
Labile DOM, g/m ³	Refractory_DOM, g/m ³
Labile POM, g/m ³	Refractory POM, g/m ³
Algae, g/m ³	Dissolved oxygen, g/m ³
Inorganic carbon, g/m ³	Alkalinity, g/m ³
Dissolved organic carbon, g/m ³	Particulate organic carbon, g/m ³
Total organic carbon, g/m ³	Dissolved organic nitrogen, g/m ³
Particulate organic nitrogen, g/m ³	Total organic nitrogen, g/m ³
Total nitrogen, g/m ³	Dissolved organic phosphorus, mg/m ³
Particulate organic phosphorus, mg/m ³	Total organic phosphorus, mg/m ³
Total phosphorus, mg/m ³	Algal production, g/m ² /day
Chlorophyll a, mg/m ³	Total algae, g/m ³
Oxygen gas saturation, %	Total suspended solids, g/m ³
Total inorganic suspended solids, g/m ³	Total Kheldahl nitrogen, g/m ³
Carbonaceous ultimate BOD, g/m ³	pH
Carbon dioxide, g/m ³	Bicarbonate, g/m ³
Carbonate, g/m ³	

The constituent and derived constituent numbers follow on the next line. Temperature is always considered constituent 1 and derived constituents continue increasing from the last constituent number.

1 2 3 4 5 6 7 11 12 13 15 16

The bottom active layer for each output segment is given on the next line.

36 38

Layer heights for layers 1 through the maximum [KMX] are output next.

0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61

PROFILE PLOT

OUTPUT FILES

```
0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61  
0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61    0.61
```

Initial temperatures/constituent concentrations for each segment specified in the profile segment card are then output. Initial temperatures/constituent concentrations are always output in case the user wants to include these in their plot to show how much change has occurred over time. The first line contains the constituent abbreviation and the number of values corresponding to the number of active layers output. The next line(s) contain the temperatures/concentrations for a given segment.

```
TEMP      14  
      5.50      5.50      5.50      5.40      5.40      5.50      5.40      5.30  
      5.30      5.40      5.30      5.20      5.20      5.20  
TEMP      16  
      5.50      5.50      5.50      5.40      5.40      5.50      5.40      5.30  
      5.30      5.40      5.30      5.20      5.20      5.20      5.20      5.20  
TDS       14  
0.400E+02 0.400E+02 0.400E+02 0.400E+02 0.450E+02 0.500E+02 0.550E+02 0.680E+02  
0.700E+02 0.650E+02 0.600E+02 0.550E+02 0.500E+02 0.450E+02  
TDS       16  
0.400E+02 0.400E+02 0.400E+02 0.400E+02 0.450E+02 0.500E+02 0.550E+02 0.680E+02  
0.700E+02 0.650E+02 0.600E+02 0.550E+02 0.500E+02 0.450E+02 0.400E+02 0.340E+02  
ISS       14  
0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01  
0.100E+01 0.200E+01 0.200E+01 0.500E+01 0.500E+01 0.500E+01  
ISS       16  
0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01 0.100E+01  
0.100E+01 0.200E+01 0.200E+01 0.500E+01 0.500E+01 0.500E+01 0.150E+02 0.300E+02  
PO4       14  
0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01  
0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01  
PO4       16  
0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01  
0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01 0.200E-01  
NH4       14  
0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01  
0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01  
NH4       16  
0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01  
0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01 0.500E-01  
NO3       14  
0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
NO3       16  
0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
LDOM      14  
0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00  
0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00  
LDOM      16  
0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00  
0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00 0.675E+00  
RDOM      14  
0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01  
0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01  
RDOM      16  
0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01  
0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01  
LPOM      14  
0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00  
0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00  
LPOM      16  
0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00  
0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00 0.750E+00  
ALG1      14  
0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00
```

OUTPUT FILES

PROFILE PLOT

```
0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00  
ALG1      16  
0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00  
0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00 0.650E+00  
DO      14  
0.108E+02 0.107E+02 0.107E+02 0.108E+02 0.108E+02 0.109E+02 0.109E+02  
0.109E+02 0.110E+02 0.110E+02 0.110E+02 0.110E+02 0.110E+02  
DO      16  
0.108E+02 0.107E+02 0.107E+02 0.108E+02 0.108E+02 0.109E+02 0.109E+02  
0.109E+02 0.110E+02 0.110E+02 0.110E+02 0.110E+02 0.110E+02 0.110E+02
```

The next output grouping consists of temperature/constituent concentrations output over time for the [dates](#) and [frequencies](#) specified in the control file. The first line includes:

1. Julian date [JDAY]
2. Gregorian date [GDAY]
3. water surface layer number [KTWB]
4. deviation of the water surface [Z] from the top of the surface layer [KT]
5. how many dates information has been written to the file

The next line contains the abbreviated constituent name and the number of active layers at the segment. This is also the number of values that have to be read in the following cards.

```
75.702 Mar 15, 1992 23 -0.1950 1  
TEMP      14  
  5.81      5.64      5.48      5.41      5.37      5.35      5.34      5.33  
  5.32      5.32      5.32      5.32      5.32      5.32  
TEMP      16  
  6.07      5.89      5.67      5.52      5.41      5.34      5.30      5.29  
  5.32      5.34      5.32      5.32      5.31      5.31      5.31  
ISS       14  
 0.674E+00 0.850E+00 0.991E+00 0.116E+01 0.136E+01 0.148E+01 0.166E+01 0.191E+01  
 0.208E+01 0.225E+01 0.239E+01 0.250E+01 0.255E+01 0.255E+01  
ISS       16  
 0.611E+00 0.771E+00 0.841E+00 0.873E+00 0.888E+00 0.893E+00 0.891E+00 0.870E+00  
 0.877E+00 0.130E+01 0.217E+01 0.279E+01 0.296E+01 0.307E+01 0.307E+01 0.307E+01  
PO4       14  
 0.157E-01 0.171E-01 0.182E-01 0.186E-01 0.188E-01 0.189E-01 0.191E-01 0.193E-01  
 0.195E-01 0.196E-01 0.197E-01 0.198E-01 0.198E-01 0.198E-01  
PO4       16  
 0.155E-01 0.166E-01 0.177E-01 0.182E-01 0.185E-01 0.187E-01 0.189E-01 0.191E-01  
 0.189E-01 0.181E-01 0.185E-01 0.193E-01 0.196E-01 0.199E-01 0.199E-01 0.199E-01  
NH4       14  
 0.507E-01 0.507E-01 0.507E-01 0.507E-01 0.507E-01 0.507E-01 0.507E-01 0.507E-01  
 0.507E-01 0.506E-01 0.506E-01 0.505E-01 0.503E-01 0.503E-01  
NH4       16  
 0.508E-01 0.508E-01 0.508E-01 0.508E-01 0.508E-01 0.508E-01 0.509E-01 0.509E-01  
 0.509E-01 0.510E-01 0.510E-01 0.510E-01 0.510E-01 0.510E-01 0.510E-01 0.510E-01  
NO3       14  
 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
NO3       16  
 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00 0.200E+00  
LDOM      14  
 0.665E+00 0.666E+00 0.666E+00 0.666E+00 0.666E+00 0.666E+00 0.666E+00 0.666E+00  
 0.666E+00 0.666E+00 0.667E+00 0.667E+00 0.668E+00 0.668E+00  
LDOM      16  
 0.664E+00 0.665E+00 0.665E+00 0.665E+00 0.665E+00 0.665E+00 0.665E+00 0.665E+00  
 0.665E+00 0.664E+00 0.664E+00 0.664E+00 0.664E+00 0.664E+00 0.664E+00 0.664E+00  
RDOM      14  
 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.158E+01 0.158E+01 0.158E+01  
 0.158E+01 0.158E+01 0.158E+01 0.158E+01 0.158E+01 0.158E+01 0.158E+01 0.158E+01
```

PROFILE PLOT

OUTPUT FILES

```
RDOM      16
 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01
 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01 0.157E+01
LPOM      14
 0.641E+00 0.697E+00 0.717E+00 0.727E+00 0.732E+00 0.734E+00 0.739E+00 0.742E+00
 0.743E+00 0.744E+00 0.745E+00 0.746E+00 0.747E+00 0.747E+00
LPOM      16
 0.624E+00 0.683E+00 0.703E+00 0.711E+00 0.715E+00 0.718E+00 0.719E+00 0.721E+00
 0.728E+00 0.736E+00 0.742E+00 0.743E+00 0.743E+00 0.743E+00 0.743E+00 0.743E+00
ALG1      14
 0.615E+00 0.636E+00 0.643E+00 0.646E+00 0.647E+00 0.648E+00 0.649E+00 0.650E+00
 0.650E+00 0.651E+00 0.652E+00 0.653E+00 0.655E+00 0.655E+00
ALG1      16
 0.607E+00 0.630E+00 0.637E+00 0.639E+00 0.640E+00 0.641E+00 0.641E+00 0.641E+00
 0.643E+00 0.645E+00 0.646E+00 0.646E+00 0.646E+00 0.646E+00 0.646E+00 0.646E+00
DO        14
 0.110E+02 0.109E+02 0.108E+02 0.108E+02 0.108E+02 0.108E+02 0.108E+02 0.108E+02
 0.109E+02 0.109E+02 0.109E+02 0.109E+02 0.108E+02 0.108E+02
DO        16
 0.110E+02 0.109E+02 0.109E+02 0.108E+02 0.108E+02 0.108E+02 0.108E+02 0.108E+02
 0.108E+02 0.109E+02 0.109E+02 0.109E+02 0.109E+02 0.109E+02 0.109E+02 0.109E+02
```

Longitudinal Profile Plot

An alternative output file for the profile plot is the longitudinal profile plot. This is set in the profile plot section of the control file. The output consists of files named as '**ProfLongJDXXX.csv**' where XXX is the Julian day of the profile. The output consists of model segment number, water surface elevation(m), flow rate (m^3/s), temperature($^{\circ}C$) of surface layer, depth (m), volume weighted temperature of the segment ($^{\circ}C$), concentrations of state variables and derived variables at the surface layer. The file is a comma delimited file format as shown below:

Seg#, ElevWaterSurf(m)	Q(m^3/s)	SurfaceTemp ($^{\circ}C$)	Depth (m)	Width (m)	VolWeighTemp ($^{\circ}C$)	TDS	Gen1,			
Gen2,	Gen3,	ISS1,	PO4,	NH4,	NO3,	FE,	LDOM,	RDOM,	LPOM,	ALG1,
DO,	TIC,	ALK,								
2,	122.335,	3.782,	28.740,	3.985,	79.000,	28.529,	25.161,			
100.000,	0.762,	51.823,	41.164,	6.043,	108.891,	0.014,	0.107,			
4.776,	14.229,	0.330,	0.002,	4.293,	14.829,	46.230,				
3,	122.335,	3.770,	29.246,	3.985,	100.000,	28.952,	31.416,			
100.000,	15.342,	25.373,	27.203,	8.209,	200.732,	0.041,	0.052,			
3.557,	14.254,	0.266,	0.103,	4.081,	14.742,	44.852,				
4,	122.335,	3.754,	31.198,	5.985,	125.000,	30.654,	50.331,			
100.000,	83.158,	2.435,	5.341,	3.305,	149.378,	0.125,	0.006,			
0.838,	10.788,	0.276,	0.599,	5.814,	13.979,	36.630,				
5,	122.335,	3.733,	31.629,	7.985,	183.000,	30.817,	54.273,			
100.000,	100.817,	0.160,	1.355,	1.416,	120.269,	0.148,	0.000,			
0.287,	9.539,	0.290,	0.718,	6.424,	13.633,	34.382,				
6,	122.335,	3.684,	31.647,	9.985,	353.000,	30.264,	53.966,			
100.000,	100.976,	0.188,	1.509,	1.568,	121.739,	0.149,	0.000,			
0.300,	9.547,	0.293,	0.694,	6.317,	13.596,	34.359,				
7,	122.335,	3.623,	31.658,	11.985,	603.000,	29.480,	53.990,			
100.000,	104.386,	0.090,	1.190,	1.384,	116.675,	0.156,	0.000,			
0.249,	9.305,	0.291,	0.675,	6.353,	13.439,	33.909,				
8,	122.335,	3.565,	31.675,	13.985,	624.000,	28.646,	53.749,			
100.000,	110.506,	0.043,	0.843,	1.073,	106.667,	0.167,	0.000,			
0.194,	8.853,	0.274,	0.627,	6.393,	13.151,	33.087,				
9,	122.335,	3.518,	31.659,	15.985,	492.000,	27.439,	53.400,			
100.000,	116.488,	0.018,	0.567,	0.839,	96.931,	0.179,	0.000,			
0.147,	8.405,	0.255,	0.577,	6.433,	12.863,	32.288,				
10,	122.335,	3.459,	31.604,	15.985,	574.000,	27.493,	52.901,			
100.000,	123.644,	0.004,	0.300,	0.616,	85.751,	0.192,	0.000,			
0.098,	7.864,	0.232,	0.517,	6.468,	12.511,	31.334,				
11,	122.335,	3.375,	31.568,	17.985,	857.000,	27.548,	52.150,			
100.000,	131.370,	0.000,	0.112,	0.473,	74.438,	0.207,	0.000,			
0.060,	7.288,	0.203,	0.451,	6.464,	12.118,	30.320,				

Vector Plot

The vector plot output writes a binary file that is used by the W2_POST post-processor developed by DSI, Inc. In order for the W2_Post.exe program to recognize the file natively, we recommend using the filetype '**w2L**' for W2 Linkage file. Only the first filename for the first waterbody is used for the output for all waterbodies.

Contour Plot

As in the profile and vector plot output, this output was originally included for developing DISSPLA contour plots of model output using FORTRAN callable subroutines. Output consists initially of:

1. title cards
2. number of branches [NBR]
3. grid dimensions [KMX] and [IMX]
4. branch upstream and downstream segments [US] and [DS]

CONTOUR PLOT

OUTPUT FILES

5. segment length [DLX]
6. layer heights [H]
7. number of active constituents
8. active constituent names

Each title card takes up a separate line in the output and each of the reaming item number is output on a single line. The user should refer to the code for the actual format of the output. The preceding information is time invariant and is used to set up the plotting grid. During simulations, the following information is output:

1. Julian date [JDAY] and Gregorian date [GDAY]
3. water surface layer [KTWB]
3. tributary inflows [QTR]
4. tributary inflow temperatures [TTR]
5. tributary inflow concentrations for each active constituent [CTR]
6. current upstream segment [CUS]
7. branch inflow [QIN] and the sum of the branch inflow [QSUM]
8. interfacial area (width times height) [BHRKT1] for all active segments in the surface layer [KT]
9. interfacial area [BHR] for all remaining active computational cells
10. horizontal velocities [U]
11. flows [QC]
12. water surface deviations [Z]
13. temperatures
14. constituent concentrations

Currently, the model user must develop their own plotting program to use this feature unless the TECPLOT option is chosen. The FORTRAN90 code for writing out the CPL file with TECPLOT=OFF is as follows:

```
      WRITE (CPL(JW),'(A,F12.4,5X,A9,5X,I2,5X,I4)') 'New date ',JDAY,MONTH,GDAY,YEAR
      WRITE (CPL(JW),'(9(I8,2X))')                                KTWB(JW)
      WRITE (CPL(JW),'(9(E13.6,2X))')                            (QTR(JT),JT=1,NTR)
      WRITE (CPL(JW),'(9(E13.6,2X))')                            (TTR(JT),JT=1,NTR)
      DO JT=1,NTR
        DO JAC=1,NACTR(JT)
          IF (PRINT_CONST(TRCN(JAC,JT),JW)) WRITE (CPL(JW),'(9(E13.6,2X))') CTR(TRCN(JAC,JT),JT)
        END DO
      END DO
      DO JB=BS(JW),BE(JW)
        IF(BR_INACTIVE(JB))CYCLE
        WRITE (CPL(JW),'(9(I8,2X))')                                CUS(JB)
        WRITE (CPL(JW),'(9(E13.6,2X))')                            QIN(JB), QSUM(JB)
        DO I=CUS(JB),DS(JB)
          WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') 'BHR', (BHR1(K,I),K=KTWB(JW)+1,KB(I))
        END DO
        DO I=CUS(JB),DS(JB)
          WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') 'U',   (U(K,I), K=KTWB(JW),KB(I))
        END DO
        WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') 'QC', (QC(I), I=CUS(JB),DS(JB))
        WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') 'Z',  (Z(I), I=CUS(JB),DS(JB))
        WRITE (CPL(JW),'(A38/(9(I8,2X)) )') 'KTI', (kti(I), I=CUS(JB),DS(JB))
        DO I=CUS(JB),DS(JB)
          WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') 'Temperature',(T2(K,I),K=KTWB(JW),KB(I))
        END DO
        DO JC=1,NAC
          IF (PRINT_CONST(CN(JC),JW)) THEN
            DO I=CUS(JB),DS(JB)
              WRITE (CPL(JW),'(A38/(9(E13.6,2X))))') CNAME(CN(JC)),(C2(K,I,CN(JC))*CMULT(CN(JC)),
K=KTWB(JW),KB(I))
            END DO
          END IF
        END DO
        DO JE=1,NEP
          DO I=CUS(JB),DS(JB)
```

```

      IF (PRINT_EPIPHYTON(JW,JE)) WRITE (CPL(JW),'(A38/(9(E13.6,2X)))') 'Epiphy-
ton',(EPD(K,I,JE),K=KTWB(JW),KB(I))
      END DO
    END DO
    IF(PRINT_SEDIMENT(JW))THEN
      DO I=CUS(JB),DS(JB)
        WRITE (CPL(Jw),'(A38/(9(E13.6,2X)))')'Sediment',(seD(K,I),K=KTWB(JW),KB(I))
      END DO
      DO I=CUS(JB),DS(JB)
        WRITE (CPL(Jw),'(A38/(9(E13.6,2X)))')'Sediment P',(seDp(K,I),K=KTWB(JW),KB(I))
      END DO
      DO I=CUS(JB),DS(JB)
        WRITE (CPL(Jw),'(A38/(9(E13.6,2X)))')'Sediment N',(seDn(K,I),K=KTWB(JW),KB(I))
      END DO
      DO I=CUS(JB),DS(JB)
        WRITE (CPL(Jw),'(A38/(9(E13.6,2X)))')'Sediment C',(seDc(K,I),K=KTWB(JW),KB(I))
      END DO
    END IF
  DO M=1,NMC
    IF (PRINT_MACROPHYTE(JW,M)) THEN
      DO I=CUS(JB),DS(JB)
        WRITE (CPL(Jw),'(A38/(9(E13.6,2X)))')'Macrophytes',((macrc(j,K,I,m),j=kti(i),kb(i)),
K=KTwb(Jw),KB(I))
      END DO
    END IF
  END DO
  IF (CONSTITUENTS) THEN
    DO JD=1,NACD(JW)
      IF (PRINT_DERIVED(CDN(JD,JW),JW)) THEN
        DO I=CUS(JB),DS(JB)
          WRITE (CPL(JW),'(A38/(9(F10.3,2X)))')CDNAME(CDN(JD,JW)),(CD(K,I,CDN(JD,JW))
*CDMULT(CDN(JD,JW)),K=KTWB(JW),KB(I))
        end do
      END IF
    END DO
  END IF
END DO

```

When the TECPLOT option is ON, the output consists of elevation (m), longitudinal distance (m), U (x-velocity, m/s), W (z-velocity, m/s), T ($^{\circ}$ C), RHO (kg/m³), Fish Habitat# (see below), and concentrations for all active constituents for the entire grid at the time interval specified in CPL FREQ. For those users of TECPLOT, TECPLOT can read the file directly and the user can create contour animations of any of the variables including superimposed velocity vector plots.

The Fish Habitat # is the fish criterion that is satisfied at that grid point (K,I). For example, consider defining fish criteria in the order of more restrictive to least restrictive. Consider 3 fish criteria defined as follows (See Fish Habitat input file):

```

OptimalFishX,12.0,18.0,5.0
SuboptimalFishX,10.0,22.0,5.0
NonOptimalFishX(Lethal),0.0,35.0,4.0

```

where the first 2 numbers are the lower and higher temperature criteria, and the last number is the minimum dissolved oxygen level.

The first fish is given a #1, second fish #2, and 3rd fish group #3. In the Tecplot output for each grid point, the fish habitat criteria 1, 2, 3, or 100 (if outside the last range) is written to the Tecplot output file. You can then produce a dynamic movie of habitat areas that are optimal (1), suboptimal (2), not optimal perhaps lethal (3 to 100). An example is shown Figure 48 for 5 criteria ranked from most favorable to least favorable.

CONTOUR PLOT

OUTPUT FILES

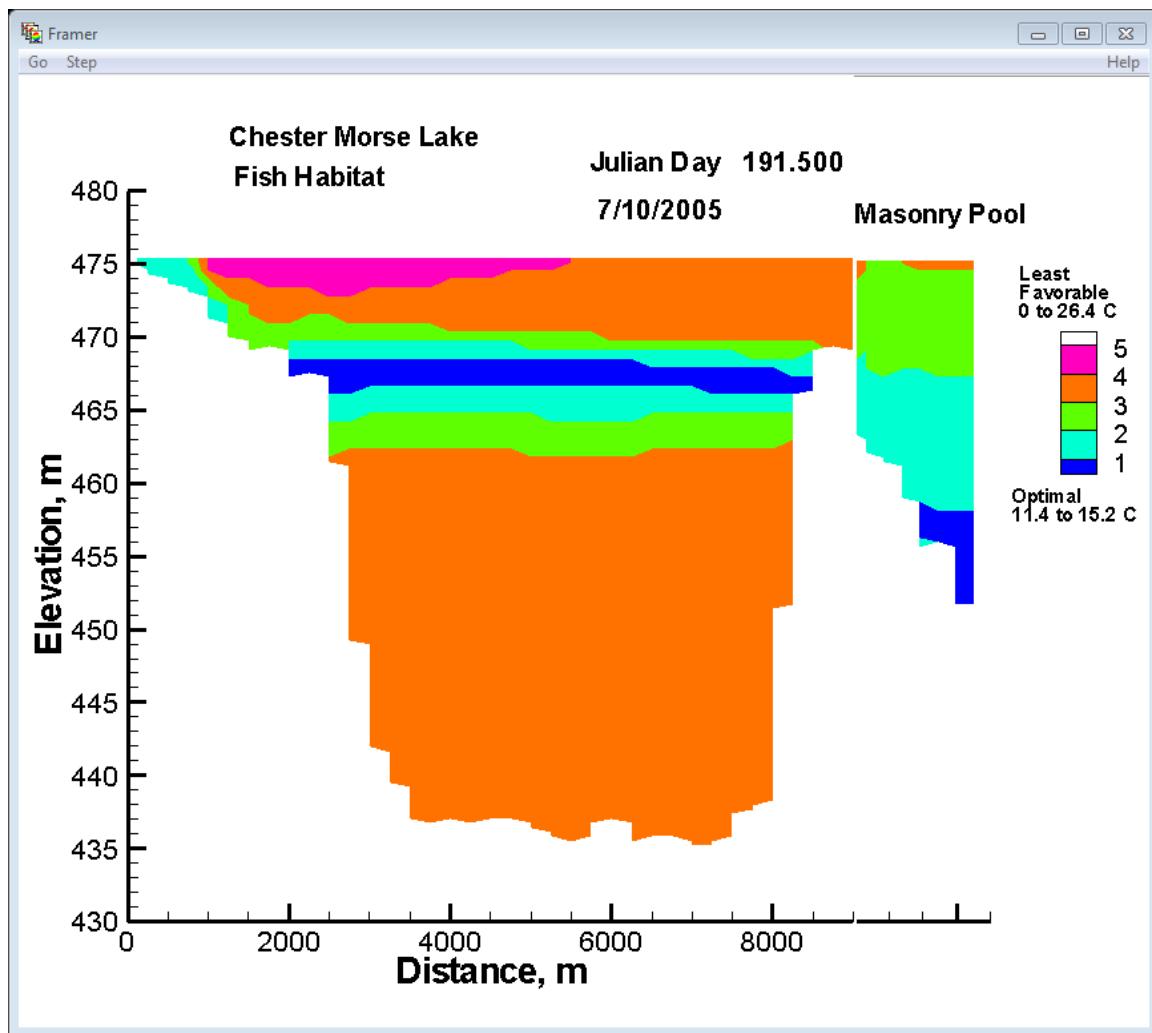


Figure 48. Example of contour plot of fish habitat zones using Tecplot.

The steps to making a useful contour animation in TECPLOT are as follows:

1. Import data (cpl.opt) file into Tecplot using the Tecplot Data Loader
2. Turn ON contours
3. Reset axes so that they are Independent (Tecplot default is dependent)
4. Turn on Value Blanking since any state variables outside the domain are set to -99. Set value blanking for temperature to any value less than 0.0.
5. Reset the contour intervals since Tecplot automatically uses the -99 as its minimum data value.
6. One can now go to the animation and view the zones (the model output frequency or time of output) to view the movie on screen or sent to an AVI or RM file.
7. Adding vectors is also easy. Turn on vectors and choose U and W as the vector variables. You will have to adjust the arrowhead size and length of the vector until the arrows appear correctly.

OUTPUT FILES

KINETIC FLUXES

Kinetic Fluxes

The ability to compute kinetic fluxes was introduced first in Version 3.2 and is specified by setting the kinetic flux control variable [FLXC] to ON. Two types of output are available. The first flux output file writes the fluxes at segments specified by the snapshot segments [SNP] in the control file, **w2_con.npt** (or **w2_con.csv**). The model user specifies the file name, but it is a formatted text file similar to the snapshot file.

EXAMPLE of formatted text output (similar to SNP file):

March 15, 1992 Julian Date = 75 days 16.86 hours							DO algal production - source, kg/day					
	2	3	4	5	6	7	8	9	10	11	12	13
23							0.232E-02	0.164E-01	0.558	1.34	7.22	8.22
24							0.296E-02	0.237E-01	0.375	0.980	4.52	4.99
25							0.195E-02	0.297E-01	0.316	0.898	4.21	4.38
26							0.509E-03	0.220E-01	0.267	0.821	3.82	3.85
27							0.259E-01	0.218	0.702	1.01	1.00	
28							0.201E-01	0.159	0.489	0.567	0.543	
29							0.944E-01	0.270	0.258	0.247		
30							0.569E-01	0.160	0.144	0.138		
31							0.746E-01	0.965E-01	0.770E-01	0.744E-01		
32							0.652E-01	0.583E-01	0.449E-01	0.434E-01		
33							0.431E-01	0.318E-01	0.254E-01	0.246E-01		
34							0.113E-01	0.139E-01				

In addition, another output file is written named internally in the model as “**kflux_wb#.csv**” where # is the waterbody number is output for each waterbody. This sums up all the kinetic fluxes for all active cells at the frequency specified for the kinetic flux file (FLX FREQ). Output format is JDAY, ELTM (elapsed time over which fluxes are summed in days), each active kinetic flux term in kg/day. Example output is shown below.

EXAMPLE of comma delimited csv text output:

JDAY	ELTM	DOAP (kg/d)	DOEP (kg/d)	DOPOM (kg/d)	DODOM (kg/d)	DOOM (kg/d)	DONITR (kg/d)	DOREAR (kg/d)	DOSED (kg/d)	DOSO5D (kg/d)	TICAG (kg/d)	C02GASX(kg/d)
4385.500	1.500	0.2537E+05	0.1073E+05	0.2123E+06	0.6981E+06	0.9104E+06	0.1015E+06	0.1245E+06	0.4999E+03	0.2836E+05	-0.2996E+04	-0.5258E+05
4387.000	1.500	0.3706E+05	0.1382E+05	0.1924E+06	0.8105E+06	0.8105E+06	0.1304E+06	0.1311E+06	0.1453E+04	0.2779E+05	-0.7281E+04	-0.5868E+05
4388.500	1.500	0.4905E+05	0.1573E+05	0.1776E+06	0.5585E+06	0.7362E+06	0.1510E+06	0.1193E+06	0.2343E+04	0.2780E+05	-0.1136E+05	-0.5285E+05
4390.000	1.500	0.8127E+05	0.1659E+05	0.5107E+06	0.6766E+06	0.1645E+06	0.7930E+05	0.3204E+04	0.2800E+05	-0.2139E+05	-0.3824E+05	
4391.501	1.501	0.1141E+06	0.1660E+05	0.1552E+06	0.4669E+06	0.6221E+06	0.1717E+06	0.5867E+05	0.4924E+04	0.2824E+05	-0.3129E+05	-0.3256E+05
4393.000	1.499	0.1746E+06	0.2312E+05	0.1449E+06	0.4242E+06	0.5693E+06	0.1714E+06	0.6151E+05	0.4786E+04	0.2851E+05	-0.4921E+05	-0.3755E+05
4394.500	1.500	0.2081E+06	0.2087E+05	0.1344E+06	0.3810E+06	0.5155E+06	0.1665E+06	0.2512E+05	0.5438E+04	0.2817E+05	-0.5653E+05	-0.2097E+05
4396.000	1.500	0.2868E+06	0.2363E+05	0.1278E+06	0.3476E+06	0.4754E+06	0.1612E+06	0.1657E+05	0.6111E+04	0.2827E+05	-0.8111E+05	-0.1616E+05
4397.501	1.501	0.2900E+06	0.2055E+05	0.1233E+06	0.3181E+06	0.4412E+06	0.1565E+06	0.3804E+05	0.6747E+04	0.2832E+05	-0.7984E+05	-0.7115E+04
4399.000	1.499	0.3167E+06	0.1942E+05	0.1187E+06	0.2884E+06	0.4071E+06	0.1484E+06	0.8515E+05	0.7197E+04	0.2780E+05	-0.8576E+05	-0.1859E+04
4400.501	1.501	0.3162E+06	0.1947E+05	0.1173E+06	0.2650E+06	0.3832E+06	0.1424E+06	0.7640E+05	0.7650E+04	0.2754E+05	-0.8382E+05	-0.7061E+03
4402.000	1.499	0.3231E+06	0.1876E+05	0.1157E+06	0.2429E+06	0.3586E+06	0.1330E+06	0.1158E+06	0.7969E+04	0.2679E+05	-0.8400E+05	0.1794E+04
4403.501	1.501	0.2808E+06	0.1714E+05	0.1140E+06	0.2206E+06	0.3346E+06	0.1232E+06	0.8381E+05	0.8096E+04	0.2568E+05	-0.6994E+05	0.2364E+04
4405.000	1.499	0.2994E+06	0.1872E+05	0.1140E+06	0.2029E+06	0.3169E+06	0.1130E+06	0.1326E+06	0.8142E+04	0.2455E+05	-0.7482E+05	0.5357E+04

Hence, the fluxes at JDAY=4387.0 above represent the sum of all fluxes between JD 4385.5 and JD 4387.0 over the ELTM of 1.5 days.

The list of available fluxes that can be specified are shown below. Some are automatically turned ON when different processes are active (for example 121-136 are turned ON when sediment diagenesis is ON and FLXC is ON). Currently, numbers 1-72 can be toggled ON/OFF by the model user.

#	Short name for output	Description (long name)
1	TISSIN	TISS settling in - source, kg/day
2	TISSOUT	TISS settling out - sink, kg/day
3	PO4AR	PO4 algal respiration - source, kg/day

4	PO4AG	PO4 algal growth - sink, kg/day
5	PO4AP	PO4 algal net- source/sink, kg/day
6	PO4ER	PO4 epiphyton respiration - source, kg/day
7	PO4EG	PO4 epiphyton growth - sink, kg/day

KINETIC FLUXES

8	PO4EP	PO4 epiphyton net-source/sink, kg/day
9	PO4POM	PO4 POM decay - source, kg/day
10	PO4DOM	PO4 DOM decay - source, kg/day
11	PO4OM	PO4 OM decay - source, kg/day
12	PO4SED	PO4 sediment decay - source, kg/day
13	PO4SOD	PO4 SOD release - source, kg/day
14	PO4SET	PO4 net settling - source/sink, kg/day
15	NH4NITR	NH4 nitrification - sink, kg/day
16	NH4AR	NH4 algal respiration - source, kg/day
17	NH4AG	NH4 algal growth - sink, kg/day
18	NH4AP	NH4 algal net - source/sink, kg/day
19	NH4ER	NH4 epiphyton respiration - source, kg/day
20	NH4EG	NH4 epiphyton growth - sink, kg/day
21	NH4EP	NH4 epiphyton net - source/sink, kg/day
22	NH4POM	NH4 POM decay - source, kg/day
23	NH4DOM	NH4 DOM decay - source, kg/day
24	NH4OM	NH4 OM decay - source, kg/day
25	NH4SED	NH4 sediment decay - source, kg/day
26	NH4SOD	NH4 SOD release - source, kg/day
27	NH3GAS	Volatilization of NH3, kg/day
28	NO3DEN	NO3 denitrification - sink, kg/day
29	NO3AG	NO3 algal growth - sink, kg/day
30	NO3EG	NO3 epiphyton growth - sink, kg/day
31	NO3SED	NO3 sediment uptake - sink, kg/day
32	DSIAG	DSi algal growth - sink, kg/day
33	DSIEG	DSi epiphyton growth - sink, kg/day
34	DSIPIS	DSi PBSi decay - source, kg/day
35	DSISED	DSi sediment decay - source, kg/day
36	DSISOD	DSi SOD release - source, kg/day
37	DSISET	DSi net settling - source/sink, kg/day
38	PSIAM	PBSi algal mortality - source, kg/day
39	PSINET	PBSi net settling - source/sink, kg/day
40	PSIDK	PBSi decay - sink, kg/day

OUTPUT FILES

41	LDOMD	LDOM decay - sink, kg/day
42	LRDOM	LDOM decay to RDOM - sink, kg/day
43	RDOMDK	RDOM decay - sink, kg/day
44	LDOMAP	LDOM algal mortality - source, kg/day
45	LDOMEPE	LDOM epiphyton mortality - source, kg/day
46	LPOMDK	LPOM decay - sink, kg/day
47	LRPOM	LPOM decay to RPOM - sink, kg/day
48	RPOMDK	RPOM decay - sink, kg/day
49	LPOMAP	LPOM algal production - source, kg/day
50	LPOMEPE	LPOM epiphyton production - source, kg/day
51	LPOMSET	LPOM net settling vertically in a layer - source/sink, kg/day; LPOM flux in minus LPOM flux out of a layer. This is not sedimentation loss; nor does it account for longitudinal transport.
52	RPOMSET	RPOM net settling vertically in a layer - source/sink, kg/day; RPOM flux in minus RPOM flux out of a layer. This is not sedimentation loss, nor does it account for longitudinal transport.
53	CBODDK	CBOD decay - sink, kg/day
54	DOAP	DO algal production - source, kg/day
55	DOEP	DO epiphyton production - source, kg/day
56	DOAR	DO algal respiration - sink, kg/day
57	DOER	DO epiphyton respiration - sink, kg/day
58	DOPOM	DO POM decay - sink, kg/day
59	DODOM	DO DOM decay - sink, kg/day
60	DOOM	DO OM decay - sink, kg/day
61	DONITR	DO nitrification - sink, kg/day
62	DOCBOD	DO CBOD uptake - sink, kg/day
63	DOREAR	DO reaeration - source/sink, kg/day
64	DOSED	DO sediment uptake - sink, kg/day
65	DOSOD	DO SOD uptake - sink, kg/day
66	TICAP	TIC algal uptake - sink, kg/day
67	TICEP	TIC epiphyton uptake - sink, kg/day
68	SEDD	Sediment decay - sink, kg/day
69	SEDAS	Sediment algal settling - sink, kg/day

OUTPUT FILES

KINETIC FLUXES

70	SEDOMS	Sediment LPOM settling - source, kg/day
71	SEDNS	Sediment net settling - source/sink, kg/day
72	SODD	SOD decay - sink, kg/day
73	LDOMPAP	LDOM P algal mortality - source, kg/day
74	LDOMPEP	LDOM P epiphyton mortality - source, kg/day
75	LPOMPAP	LPOM P algal production- source, kg/day
76	LPOMPNS	LPOM P net settling - source/sink, kg/day
77	RPOMPNS	RPOM P net settling - source/sink, kg/day
78	LDOMNAP	LDOM N algal mortality - source, kg/day
79	LDOMNEP	LDOM N epiphyton mortality - source, kg/day
80	LPOMNAP	LPOM N algal production- source, kg/day
81	LPOMNNS	LPOM N net settling - source/sink, kg/day
82	RPOMNNS	RPOM N net settling - source/sink, kg/day
83	SEDDP	Sediment P decay - sink, kg/day
84	SEDASP	Sediment algal P settling - source, kg/day
85	SEDOMSP	Sediment P LPOM settling - source, kg/day
86	SEDNSP	Sediment net P settling - source/sink, kg/day
87	LPOMEPP	Sediment epiphyton P settling - source, kg/day
88	SEDDN	Sediment N decay - sink, kg/day
89	SEDASN	Sediment algal N settling - source, kg/day
90	SEDOMSN	Sediment N LPOM settling - source, kg/day
91	SEDNSN	Sediment net N settling - source/sink, kg/day
92	LPOMEPN	Sediment epiphyton N settling - source, kg/day
93	SEDDC	Sediment C decay - sink, kg/day
94	SEDASC	Sediment algal C settling - source, kg/day
95	SEDOMSC	Sediment C LPOM settling - source, kg/day
96	SEDNSC	Sediment net C settling - source/sink, kg/day
97	LPOMEPC	Sediment epiphyton C settling - source, kg/day
98	SEDNO3	Sediment N denitrification - source, kg/day
99	PO4MR	PO4 macrophyte resp - source, kg/day
100	PO4MG	PO4 macrophyte growth - sink, kg/day
101	NH4MR	NH4 macrophyte resp - source, kg/day

102	NH4MG	NH4 macrophyte growth - sink, kg/day
103	LDOMMAC	LDOM macrophyte mort - source, kg/day
104	RDOMMAC	RDOM macrophyte mort - source, kg/day
105	LPOMMAC	LPOM macrophyte mort - source, kg/day
106	DOMP	DO macrophyte production - source, kg/day
107	DOMR	DO macrophyte respiration - sink, kg/day
108	TICMC	TIC macrophyte growth/resp - S/S, kg/day
109	CBODNS	CBOD settling - sink, kg/day
110	SEDCB	Sediment CBOD settling - source, kg/day
111	SEDCBP	Sediment CBOD P settling - source, kg/day
112	SEDCBN	Sediment CBOD N settling - source, kg/day
113	SEDCBC	Sediment CBOD C settling - source, kg/day
114	SEDBR	Sediment Burial - sink, kg/day
115	SEDBRP	Sediment P Burial - sink, kg/day
116	SEDBRN	Sediment N Burial - sink, kg/day
117	SEDBRC	Sediment C Burial - sink, kg/day
118	CBODNSP	CBOD P settling - sink, kg/day
119	CBODNSN	CBOD N settling - sink, kg/day
120	CO2REAER	CO2 gas exchange air/water interface, kg/day
121	DOH2S	DO H2S decay - sink, kg/day
122	H2SREAER	H2S gas exchange air/water interface, kg/day
123	H2SD	H2S decay - sink, kg/day
124	H2SSR	H2S sediment release, kg/d
125	DOCH4	DO CH4 decay - sink, kg/day
126	CH4REAER	CH4 gas exchange air/water interface, kg/day
127	CH4D	CH4 decay - sink, kg/day
128	CH4SR	CH4 sediment release, kg/d
129	Fe2D(kg/d)	Fe(II) oxidation water column - sink, kg/day
130	DOFe2(kg/d)	DO Fe(II) oxidation water col. - sink, kg/day
131	FEIISR	Fell sediment release, kg/d
132	SDIN-FeOOH(kg/d)	FeOOH settling from water col. - sink, kg/day
133	Mn2d(kg/d)	Mn(II) oxidation water column - sink, kg/day
134	DOMn2(kg/d)	DO Mn(II) oxidation water col. - sink, kg/day

KINETIC FLUXES

OUTPUT FILES

135	MNIISR	MnII sediment release, kg/d
136	SDINMnO2(kg/d)	MnO2 settling from water col. - sink, kg/day
137	SD_C_IN(kg/d)	C to Sed. Diagenesis module - source, kg/day
138	SD_N_IN(kg/d)	N to Sed. Diagenesis module - source, kg/day
139	SD_P_IN(kg/d)	P to Sed. Diagenesis module - source, kg/day
140	DOSEDIA	DO sediment diagenesis up-take - sink, kg/day
141	SEDD1	Labile standing biomass decay, sink, kg/day
142	SEDD2	Refract. stand. biomass decay-sink, kg/day

Note also that the TSR output file includes flux output on an instantaneous basis at a given cell location.

If Sediment Diagenesis is turned ON, then other flux terms will appear in the file “**kflux_wb#.csv**”. These include the following in kg/d: CO2GASX (CO2 exchange with atmosphere), DOH2S (oxygen demand for oxidation of H2S in water column), DOCH4 (oxygen demand for oxidation of methane in water column), H2SGASX (H2S gas flux to the atmosphere), CH4GASX (CH4 gas flux to the atmosphere), H2SDK (first order loss of H2S within water column), CH4DK (first order CH4 decay in water column), SD_C_IN (Flux rate of C to the sediments), SD_N_IN (Flux rate of N to the sediments), SD_P_IN (Flux rate of P to the sediments), DOSEDIA (sediment oxygen demand of sediment diagenesis model), Fe2D (oxidation rate of Fe in water column), DOFe2 (oxygen demand to oxidize reduced iron to oxidized iron in water column), SDINFeOO (Flux rate of oxidized Fe to the sediments), SDINMnO2 (Flux rate of oxidized Mn to the sediments), Mn2D (oxidation rate of Fe in water column).

Withdrawal Outflow

Whenever withdrawal output control [**WDOC**] is ON (see in **w2_con.npt**, or **w2_con.csv**, file), withdrawal outflow files contain information for plotting any release or withdrawal temperatures and/or constituent concentrations as a time series are output. The files can also be used to externally link upstream waterbodies to downstream waterbodies so that waterbasins can be broken up into multiple waterbodies. This is an important feature when runtimes for the entire waterbasin become excessive. With this option, calibration can start at the most upstream waterbody and proceed sequentially downstream. As a result, WDO output files are **not multiplied by CMULT or CDMULT, output multipliers, as is the case for the SNP and TSR output files.**

The model user can set any filetype for the WDO files and all output files will have that filetype. For example, if **WDOFN** is set to ‘**wdo.csv**’, then all output files will have the filetype ‘.csv’.

Integrated output

Output consists of up to four separate files for each segment [**IWDO**] specified in the control file. The files include an outflow, outflow temperature, constituent concentrations, and derived constituent concentrations. These files are for all the withdrawals specified at that segment lumped together if there are multiple withdrawals. The constituent concentration outflow file is only generated if constituent computations [**ICCC**] are turned on. The derived constituent concentration outflow file is generated only if constituent computations [**ICCC**] are turned on and one or more derived constituents [**CDWBC**] are turned on.

In addition, for the flow and temperature files, individual flows and outlet temperatures are provided to the right of the weighted average (temperature) or summed flow. All output files are in comma delimited format and are in the correct format for a downstream inflow or tributary file.

Individual Output

Also, a series of individual comma delimited files are also output for each structure at the withdrawal segment. For example, if there are 2 spillways (weirs), 1 gate and 1 pump at the withdrawal segment, all these withdrawal types are automatically output individually as separate files. They would be output with a fixed internally specified file name based on the hydraulic element and the segment number where it is located, such as: **qwo_sp1_seg23.csv**, **qwo_sp2_seg23.csv**, **qwo_gate1_seg23.csv**, and **qwo_pmp1_seg23.csv**. For further information, see the withdrawal output card description in **w2_con.npt** (or **w2_con.csv**). The files have the same format as the integrated output, but have only flow, temperature, and concentration for one outlet.

EXAMPLE – Integrated Output for flow rate

\$Withdrawal output flow file for segment 64

To the right of the sum of flows are individual flows starting with QWD then QSTR

JDAY,QWD(m3s-1),

4384.000,	20.016,	4.000,	4.000,	4.000,	4.000,	4.000,	0.016,
4384.103,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.203,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.301,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.401,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.501,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.602,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.701,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.802,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4384.901,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,
4385.000,	20.000,	4.000,	4.000,	4.000,	4.000,	4.000,	0.000,

EXAMPLE – Integrated Output for temperature

\$Temperature file for segment 64

To the right of the sum of temperatures are individual temperatures starting with QWD then QSTR

JDAY,T(C),

4384.000,	25.00,	25.00,	25.00,	25.00,	25.00,	25.00,	25.00,
4384.103,	24.99,	24.99,	24.99,	24.99,	24.99,	24.99,	-99.00,
4384.203,	24.99,	24.99,	24.99,	24.99,	24.99,	24.99,	-99.00,
4384.301,	24.98,	24.98,	24.98,	24.98,	24.98,	24.98,	24.98,
4384.401,	24.98,	24.98,	24.98,	24.98,	24.98,	25.00,	24.98,
4384.501,	25.01,	24.98,	24.98,	24.98,	24.98,	25.12,	24.98,
4384.602,	25.00,	24.98,	24.98,	24.98,	24.98,	25.06,	-99.00,
4384.701,	24.98,	24.98,	24.98,	24.98,	24.98,	24.98,	-99.00,
4384.802,	24.98,	24.98,	24.98,	24.98,	24.98,	24.98,	-99.00,
4384.901,	24.97,	24.97,	24.97,	24.97,	24.97,	24.97,	-99.00,
4385.000,	24.97,	24.97,	24.97,	24.97,	24.97,	24.97,	-99.00,
4385.102,	24.97,	24.97,	24.97,	24.97,	24.97,	24.97,	-99.00,
4385.202,	24.96,	24.96,	24.96,	24.96,	24.96,	24.96,	-99.00,
4385.302,	24.96,	24.96,	24.96,	24.96,	24.96,	24.96,	-99.00,

EXAMPLE – Integrated Output for concentration (partial listing of columns)

\$Concentration file for withdrawal |segment 64

JDAY,	TDS,	Gen1,	Gen2,	Gen3,	Gen4,	Gen5,	ISS2,	PO4,	NH4,	NO3,	LDOM,	RDOM,	LPOM,	RPOM,	ALG1,	DO,	TIC,	ALK,
4384.000,	57.0000,	0.0000,	0.0000,	0.0000,	6.0600,	0.0000,	7.7000,	0.0480,	0.0500,	0.1270,	2.8890,	2.8890,	2.8890,	0.8690,	0.8690,	0.8690,	0.8690,	
4384.103,	57.0000,	0.1000,	0.0000,	0.0000,	6.0600,	0.0000,	7.6832,	0.0480,	0.0518,	0.1276,	2.8699,	2.8915,	0.8642,	0.8681,	0.8681,	0.8681,	0.8681,	
4384.203,	57.0000,	0.1995,	0.0000,	0.0000,	6.0600,	0.0000,	7.6758,	0.0481,	0.0536,	0.1282,	2.8511,	2.8940,	0.8605,	0.8676,	0.8676,	0.8676,	0.8676,	
4384.301,	57.0000,	0.2992,	0.0000,	0.0000,	6.0600,	0.0000,	7.6638,	0.0481,	0.0553,	0.1288,	2.8324,	2.8964,	0.8566,	0.8670,	0.8670,	0.8670,	0.8670,	
4384.401,	57.0000,	0.3988,	0.0000,	0.0000,	6.0600,	0.0000,	7.6519,	0.0482,	0.0569,	0.1294,	2.8138,	2.8989,	0.8524,	0.8663,	0.8663,	0.8663,	0.8663,	
4384.501,	57.0000,	0.4998,	0.0000,	0.0000,	6.0600,	0.0000,	7.6372,	0.0482,	0.0584,	0.1301,	2.7952,	2.9013,	0.8481,	0.8655,	0.8655,	0.8655,	0.8655,	
4384.602,	57.0000,	0.6001,	0.0000,	0.0000,	6.0600,	0.0000,	7.6479,	0.0483,	0.0601,	0.1308,	2.7768,	2.9037,	0.8452,	0.8661,	0.8661,	0.8661,	0.8661,	
4384.701,	57.0000,	0.6989,	0.0000,	0.0000,	6.0600,	0.0000,	7.6598,	0.0483,	0.0619,	0.1315,	2.7586,	2.9061,	0.8424,	0.8667,	0.8667,	0.8667,	0.8667,	
4384.802,	57.0000,	0.7997,	0.0000,	0.0000,	6.0600,	0.0000,	7.6598,	0.0484,	0.0635,	0.1322,	2.7463,	2.9085,	0.8391,	0.8667,	0.8667,	0.8667,	0.8667,	
4384.901,	57.0000,	0.8994,	0.0000,	0.0000,	6.0600,	0.0000,	7.6374,	0.0484,	0.0650,	0.1329,	2.7222,	2.9108,	0.8344,	0.8654,	0.8654,	0.8654,	0.8654,	
4385.000,	57.0000,	0.9980,	0.0000,	0.0000,	6.0600,	0.0000,	7.6307,	0.0485,	0.0665,	0.1337,	2.7046,	2.9131,	0.8307,	0.8651,	0.8651,	0.8651,	0.8651,	
4385.102,	57.0000,	1.0987,	0.0000,	0.0000,	6.0600,	0.0000,	7.6182,	0.0485,	0.0680,	0.1344,	2.6866,	2.9155,	0.8267,	0.8644,	0.8644,	0.8644,	0.8644,	
4385.202,	57.0000,	1.1993,	0.0000,	0.0000,	6.0600,	0.0000,	7.6661,	0.0486,	0.0695,	0.1352,	2.6688,	2.9178,	0.8226,	0.8637,	0.8637,	0.8637,	0.8637,	
4385.302,	57.0000,	1.2988,	0.0000,	0.0000,	6.0600,	0.0000,	7.5940,	0.0486,	0.0709,	0.1360,	2.6512,	2.9201,	0.8185,	0.8630,	0.8630,	0.8630,	0.8630,	

Mass Balance Output File

When a Mass_Balance [**MBC**] is turned ON (see CALCULATIONS in control file), the model outputs a summary of the N and P mass balance for each waterbody based on the output interval for CPL output with the name '**massbal.csv**'. If CPL output is turned OFF, [**CPLC**]='OFF', or if [**MBC**] is OFF or if no derived variables were turned ON [TP, total phosphorus, and TN, total nitrogen, must be turned ON], then no file will be written. The file name is '**massbal.csv**'. This file is useful in looking at waterbody overall N and P balances. The output file consists of the following information in comma delimited format: Julian day, water body #, TP in the water column (kg) at that JDAY, TP in the sediments (kg) at that time, TP in plants (kg) including macrophytes and periphyton at that JDAY, cumulative TP in the outflow (kg), cumulative TP in the tributaries (kg), cumulative TP in the distributed tributaries (kg), cumulative TP in the withdrawals (kg), cumulative

TP in precipitation (kg), cumulative TP in the inflow (kg), cumulative TP release from zero order and first order sediment models (kg), cumulative TP flux to the sediments (kg), SedimentDiagenesisPFlux(kg), TN in the water column (kg) at that JDAY, TN in the sediments (kg) at that time, TN in plants (kg) including macrophytes and periphyton at that JDAY, cumulative TN in the outflow (kg), cumulative TN in the tributaries (kg), cumulative TN in the distributed tributaries (kg), cumulative TN in the withdrawals (kg), cumulative TN in precipitation (kg), cumulative TN in the inflow (kg), cumulative TN release from zero order and first order sediment models (kg), cumulative TN flux to the sediments (kg), SedimentDiagenesisNH4Flux(kg), and SedimentDiagenesisNO3Flux(kg). An example file is shown below:

EXAMPLE

```

JDAY,WB,TP-Waterbody(kg),TP-Sediment(kg),TP-
Plants(kg),OutflowTP(kg),TributaryTP(kg),DistributedTributaryTP(kg),WithdrawalTP(kg),Pre-
cipitationTP(kg),InflowTP(kg),SED+SOD_PRelease(kg),PFluxtoSediments(kg),TN-
Waterbody(kg),TN-Sediment(kg),TN-
Plants(kg),OutflowTN(kg),TributaryTN(kg),DistributedTributaryTN(kg),WithdrawalTN(kg),Pre-
cipitationTN(kg),InflowTN(kg),SED+SOD_NRelease(kg),NFluxtoSedi
    64.667,    1, 0.12679944E+05, 0.00000000E+00, 0.00000000E+00, 0.83834236E+00,
0.00000000E+00, 0.79200000E-01, 0.00000000E+00, 0.00000000E+00, 0.35644500E+00,
0.00000000E+00, 0.00000000E+00, 0.30836186E+06, 0.00000000E+00, 0.00000000E+00,
0.11709391E+03, 0.00000000E+00, 0.47520000E+00, 0.00000000E+00, 0.00000000E+00,
0.60953400E+01, 0.00000000E+00, 0.00000000E+00,
    65.664,    1, 0.12659822E+05, 0.00000000E+00, 0.00000000E+00, 0.45900878E+01,
0.00000000E+00, 0.21442880E+00, 0.00000000E+00, 0.00000000E+00, 0.16980436E+01,
0.00000000E+00, 0.00000000E+00, 0.30749935E+06, 0.00000000E+00, 0.00000000E+00,
0.59442605E+03, 0.00000000E+00, 0.17735488E+01, 0.00000000E+00, 0.00000000E+00,
0.34790680E+02, 0.00000000E+00, 0.00000000E+00,
    66.667,    1, 0.12585145E+05, 0.00000000E+00, 0.00000000E+00, 0.86632257E+01,
0.00000000E+00, 0.24912040E+00, 0.00000000E+00, 0.00000000E+00, 0.27638597E+01,
0.00000000E+00, 0.00000000E+00, 0.30663902E+06, 0.00000000E+00, 0.00000000E+00,
0.10567244E+04, 0.00000000E+00, 0.26755304E+01, 0.00000000E+00, 0.00000000E+00,
0.64705249E+02, 0.00000000E+00, 0.00000000E+00,
    67.667,    1, 0.12497461E+05, 0.00000000E+00, 0.00000000E+00, 0.13014066E+02,
0.00000000E+00, 0.28368040E+00, 0.00000000E+00, 0.00000000E+00, 0.35159535E+01,
0.00000000E+00, 0.00000000E+00, 0.30586699E+06, 0.00000000E+00, 0.00000000E+00,
0.14947647E+04, 0.00000000E+00, 0.35740904E+01, 0.00000000E+00, 0.00000000E+00,
0.94594627E+02, 0.00000000E+00, 0.00000000E+00,
    68.697,    1, 0.12414187E+05, 0.00000000E+00, 0.00000000E+00, 0.15884963E+02,
0.00000000E+00, 0.31902752E+00, 0.00000000E+00, 0.00000000E+00, 0.41401823E+01,
0.00000000E+00, 0.00000000E+00, 0.30551296E+06, 0.00000000E+00, 0.00000000E+00,
0.17768698E+04, 0.00000000E+00, 0.44931156E+01, 0.00000000E+00, 0.00000000E+00,
0.12793976E+03, 0.00000000E+00, 0.00000000E+00,
    69.665,    1, 0.12336782E+05, 0.00000000E+00, 0.00000000E+00, 0.18633801E+02,
0.00000000E+00, 0.35272419E+00, 0.00000000E+00, 0.00000000E+00, 0.47557015E+01,
0.00000000E+00, 0.00000000E+00, 0.30529501E+06, 0.00000000E+00, 0.00000000E+00,
0.20373899E+04, 0.00000000E+00, 0.53692290E+01, 0.00000000E+00, 0.00000000E+00,
0.16495905E+03, 0.00000000E+00, 0.00000000E+00,
    70.665,    1, 0.12260243E+05, 0.00000000E+00, 0.00000000E+00, 0.20302616E+02,
0.00000000E+00, 0.38715346E+00, 0.00000000E+00, 0.00000000E+00, 0.56108035E+01,
0.00000000E+00, 0.00000000E+00, 0.30537243E+06, 0.00000000E+00, 0.00000000E+00,
0.21865107E+04, 0.00000000E+00, 0.62643900E+01, 0.00000000E+00, 0.00000000E+00,
0.21075827E+03, 0.00000000E+00, 0.00000000E+00,

```

Flow Balance Output File

When a Volume_Balance is turned ON, [VBC]='ON' (see CALCULATIONS in control file), the model outputs a summary of the flow balance for each waterbody based on the output interval for Contour output or CPL output in a file of the name '**flowbalance.csv**'. If CPL output is turned OFF, [CPLC]='OFF', or Volume-Balance [VBC] is OFF, then no file will be written. This output file is useful in looking at waterbody overall flows. The output file consists of the following information: Julian day, water body #, inflow volume to waterbody from

Qin files in m³, inflow volume from precipitation in m³, outflow volume from outlet structures in m³, output volume from withdrawals in m³, output volume from evaporation in m³, input volume from distributed tributaries in m³, input volume from tributaries in m³, the volume of ice formation/ice melting in m³ (this is zero if [ICEC] is OFF), and the % error in computing the fluid mass balance. The volumes and % error between Julian days are cumulative, not instantaneous, and are negative for an outflow and positive for an inflow. Note that if one has ice formation removing water and later ice melting back into the waterbody, there should not be any net gain or loss of water.

EXAMPLE

```
        JDAY,WB,VOLIN(m3),VOLPR(m3),VOLOUT(m3),VOLWD(m3),VOLEV(m3),VOLDT(m3),VOLTRB(m3),VOLICE(m3),%VOLerror
4387.999, 1, 0.24151082e+08, 0.00000000e+00, -0.69120300e+07, -0.16976138e+08, 0.00000000e+00, -0.37091214e+07, 0.34455048e+07, 0.00000000e+00, 0.29166358E-09,
4391.999, 1, 0.47366154e+08, 0.00000000e+00, -0.13824930e+08, -0.33692832e+08, 0.00000000e+00, -0.64635273e+07, 0.66123003e+07, 0.00000000e+00, -0.21169441E-07,
4395.999, 1, 0.67535746e+08, 0.00000000e+00, -0.20736032e+08, -0.47716111e+08, 0.00000000e+00, -0.85854645e+07, 0.95003819e+07, 0.00000000e+00, -0.13750798E-06,
4399.998, 1, 0.85489085e+08, 0.00000000e+00, -0.27648832e+08, -0.60439033e+08, 0.00000000e+00, -0.95447497e+07, 0.12139541e+08, 0.00000000e+00, 0.36565686E-07,
4403.999, 1, 0.10159034e+09, 0.00000000e+00, -0.34560034e+08, -0.71820452e+08, 0.00000000e+00, -0.99198733e+07, 0.14708703e+08, 0.00000000e+00, 0.88815155E-07,
4407.997, 1, 0.11626645e+09, 0.00000000e+00, -0.41472834e+08, -0.82316254e+08, 0.00000000e+00, -0.97188439e+07, 0.17237730e+08, 0.00000000e+00, 0.10015483E-06,
```

SYSTDG Output File

TDG concentrations computed with the SYSTDG equations are written into the withdrawal output files. Withdrawal outflow files contain information with release or withdrawal TDG concentrations in the time series output files. The model output consists of up to four separate files for the individual segment [IWDO] specified in the W2 control file. The files include an outflow, outflow temperature, constituent concentrations, and derived constituent concentrations. These files are for all the withdrawals specified at that segment lumped together if there are multiple withdrawals. All output files are in comma delimited format. Also, whenever withdrawal output is ON, a series of individual files is also written in the output file for each structure at the withdrawal segment.

An additional TDG target output file, “**TDGTarget_output.opt**” is generated from the model if **TDGTA** is turned ON. This file contains information for outflow release or spillway TDG concentrations and outflows as a time series file. These files are for all the withdrawals specified at that segment lumped together if there are multiple withdrawals.

Lake River Contour Plots Output Files

When the model reads input file, **lake_river_contour.csv** file (described in the [Lake River Contour Input File](#)), several output files are produced, such as **LakeContour_DO_SegXX.csv**, **Lake_Contour_T_SegXX.csv**, **RiverContour_DO_BrYY.csv**, and **RiverContour_T_BrYY.csv** where XX is the model segment for the lake contour and YY is the Branch number for the river contour.

Lake Contour File

Output format 1 outputs a file with JDAY, ELEVATION, and TEMPERATURE and another file with JDAY, ELEVATION, and DISSOLVED OXYGEN. There are -99 values when there is a channel bottom and no model value, such as shown partially below:

JDAY	ELEVATION(m)	TEMPERATURE(C)
64.5	123.9	-99
64.5	123.8	7.4
64.5	120.35	7.4
64.5	118.35	7.3

64.5	116.35	7.3
64.5	114.35	7.3
64.5	112.35	7.3

The output 2 format has values along the first row of elevation of the grid in m, then for each time (column 1), the values of temperature or dissolved oxygen are in columns 2 to the end for each depth at that time. This allows for direct contour plotting. A partial file example is shown below in Excel:

TIME	128.35	126.35	124.35	122.35	120.35	118.35	116.35
64.5	-99	-99	-99	7.4	7.4	7.3	7.3
65.5	-99	-99	-99	7.74	7.63	7.56	7.52
66.5	-99	-99	-99	7.98	7.88	7.85	7.83
67.5	-99	-99	-99	7.8	7.53	7.45	7.44
68.5	-99	-99	-99	8.74	8.63	8.53	8.48
69.5	-99	-99	-99	9.27	9.05	8.99	8.98
70.5	-99	-99	-99	9.07	8.78	8.36	8.1
71.5	-99	-99	-99	9.43	9.34	9.1	8.46
72.5	-99	-99	-99	7.93	7.59	7.29	7.28
73.5	-99	-99	-99	8.03	7.95	7.87	7.8
74.5	-99	-99	-99	9.04	8.8	8.74	8.73
75.5	-99	-99	-99	8.81	8.61	8.47	8.22
76.5	-99	-99	-99	8.07	7.86	7.69	7.65
77.5	-99	-99	-99	8.24	8.19	8.12	8.03
78.5	-99	-99	-99	9.18	8.97	8.85	8.81
79.5	-99	-99	-99	9.18	9.05	8.91	8.86
80.5	-99	-99	-99	9.24	8.95	8.66	8.6
81.5	-99	-99	-99	9.91	9.73	9.62	9.58
82.5	-99	-99	-99	10.41	10.18	10.02	9.76
83.5	-99	-99	-99	9.67	9.36	9.12	9.12

This output allows the model user to produce graphics for lake contours as shown in Figure 49.

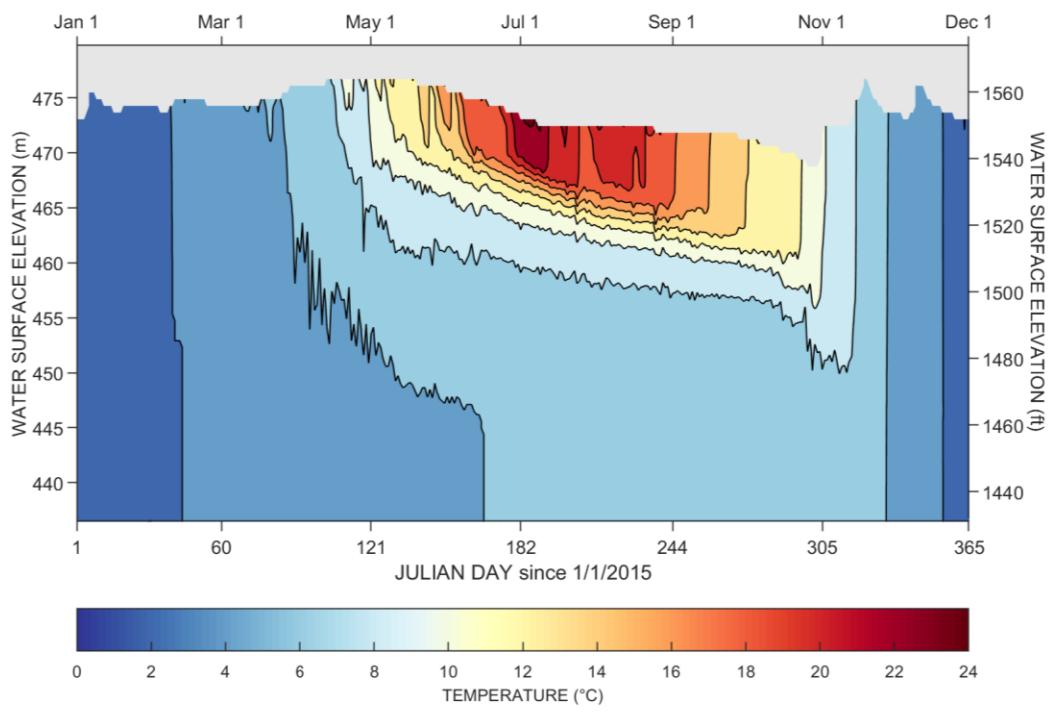


Figure 49. Lake Contour for Chester Morse Lake for 2015 (Cervarich, 2020).

River Contour File

The output format 1 has columns of JDAY, Distance along the river, and temperature or dissolved oxygen as shown below:

JDAY	DISTANCE(M)	TEMPERATURE(C)
64.5	500	7.4
64.5	1000	7.4
64.5	2000	7.4
64.5	3000	7.4
64.5	4000	7.4
64.5	5000	7.4
64.5	6000	7.4
64.5	7000	7.4
64.5	8000	7.4
64.5	9000	7.4
64.5	10000	7.4
64.5	11000	7.4
64.5	12000	7.4
64.5	13000	7.4
64.5	14000	7.4

Output format 2 has in row 1 the river distance, in column 1 time and to fill out the rows is temperature or dissolved oxygen for each distance and time as shown partially below:

TIME	500	1000	2000	3000	4000	5000
64.5	7.4	7.4	7.4	7.4	7.4	7.4
64.75	6.68	7.43	7.65	7.67	7.63	7.59
65	6.17	6.96	7.64	7.76	7.72	7.66
65.25	5.87	6.31	7.35	7.55	7.56	7.53
65.5	6.27	6.35	7.33	7.77	7.78	7.74
65.75	6.68	6.7	7.46	8.09	8.1	8.06
66	6.57	6.48	6.97	7.65	7.76	7.79
66.25	6.66	6.29	6.57	7.25	7.46	7.56

An example of a river contour plot is shown in Figure 50.

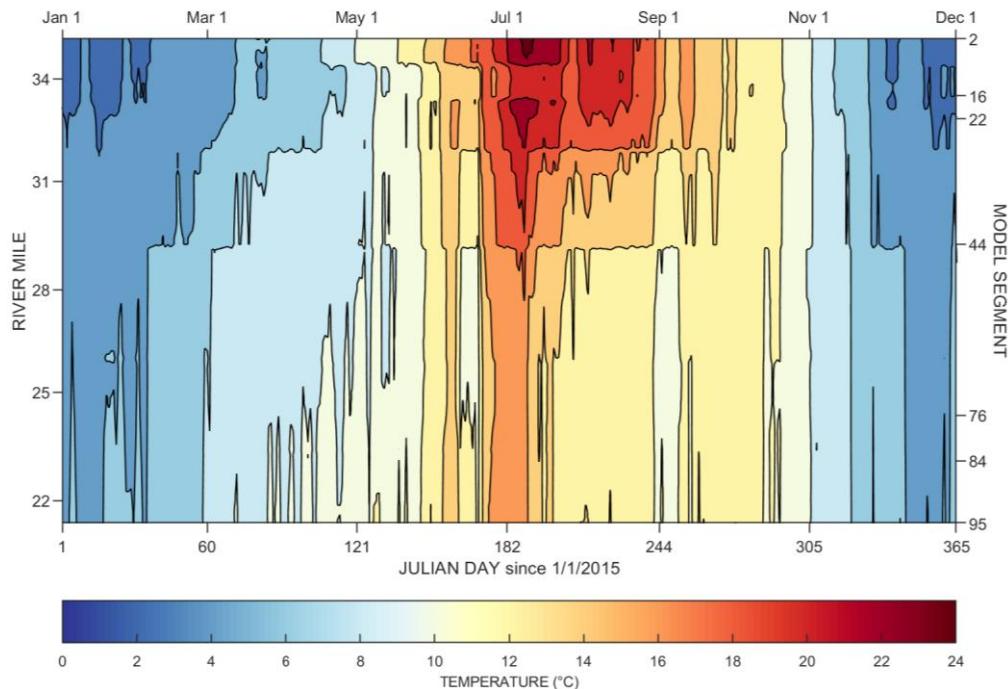


Figure 50. Cedar River temperature versus model segment over time (Cervarich, 2020).

Water Level Output File

A convenient file for plotting water level variations as a function of time and space is written out if the TIME_SERIES is ON. The water level at every model segment is written rather than those specified in the TIME_SERIES output. The output file name is '**wl.csv**'. The file consists of Julian day followed by the water surface elevation at each model segment in m. An example file is shown below:

84.700,1484.700,1484.700,1484.700,1484.699,1484.698,1484.696,1484.691,1484.691,1
 480.000,1480.044,1480.022,1480.019,1480.019,1480.000,1480.043,1480.036,1480.034,1480.034,
 1480.000,1480.009,1480.006,1480.005,1480.005,1480.000,1480.008,1480.005,1480.004,1480.004
 ,1473.700,1473.701,1473.700,1473.700,1473.700,1470.900,1470.900,1470.900,1470.900,1470.90
 0,1470.900,1466.500,1466.500,1466.500,1466.500,1466.500,1464.500,1464.500,1464.500,1464.5
 00,1464.500,1464.000,1464.000,1464.000,1464.000,
1.150,1484.700,1484.700,1484.700,1484.700,1484.320,1484.319,1484.319,14
 84.319,1484.700,1484.317,1484.317,1484.317,1484.317,1484.317,1484.317,1484.317,1484.317,1
 480.000,1480.658,1480.658,1480.658,1480.658,1480.658,1480.000,1480.644,1480.644,1480.644,
 1480.644,1480.644,1480.644,1480.644,1480.644,1480.644,1480.644,1480.644,1480.644,
 1480.000,1480.614,1480.614,1480.614,1480.614,1480.614,1480.000,1480.591,1480.591,1480.591,
 1480.591,1473.700,1474.226,1474.226,1474.226,1474.226,1470.900,1470.900,1470.900,1470.900,1470.90
 0,1470.900,1466.500,1466.500,1466.500,1466.500,1466.500,1464.500,1464.500,1464.500,1464.5
 00,1464.500,1464.000,1464.000,1464.000,1464.000,

W2Anim – Output File for Withdrawals and Structures

If one uses Stewart Rounds new post-processor W2Anim, <https://github.com/sarounds/w2anim/releases/latest>, one of the files used for viewing the flow, temperature and water quality of outlets is now automatically output. This file is used for viewing the outlet dynamics (flow, temperature and water quality) for any outflow. The output file is written out whenever there is a WDO (withdrawal output) specified.

The file is internally named based on the prefix and suffix specified for the WDO output file. The file name is “**qwo_layers_XX_wdo.csv**” if the prefix was ‘wdo’ and the suffix was ‘csv’ where XX is the segment number where the withdrawal occurs. The file format is shown below. The column D starts with the flow in layer 2, column E is the flow in layer 3, etc.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	
1	Flow layers file for segment 31																		
2	Output is JI total outlet WS elev																		
3	and layer outflows starting w/ layer 2																		
4																			
5	JDAY	Q(m3/s)	ELWS(m)	LayerFlows(m3/s)															
6	64.5	22.005	123.798							3.273	1.833	2.203	2.155	2.106	2.046	1.973	1.836	1.596	1.278
7	64.625	20.923	123.797							2.917	1.978	2.104	2.062	2.016	1.958	1.888	1.738	1.494	1.216
8	64.7083	19.84	123.795							2.678	1.905	2.022	1.985	1.94	1.884	1.814	1.647	1.404	1.16
9	64.8333	18.216	123.794							2.453	1.773	1.921	1.882	1.839	1.786	1.706	1.499	1.265	1.054
10	64.9167	17.134	123.793							2.291	1.68	1.828	1.791	1.751	1.7	1.612	1.399	1.183	0.992
11	65	16.051	123.792							2.151	1.493	1.619	1.688	1.65	1.602	1.523	1.33	1.126	0.946
12	65.125	15.575	123.792							2.106	1.342	1.405	1.632	1.591	1.543	1.473	1.321	1.115	0.919
13	65.2095	15.654	123.791							2.562	1.438	1.405	1.625	1.551	1.439	1.362	1.259	1.084	0.832
14	65.3163	15.74	123.789							2.707	1.524	1.49	1.457	1.424	1.383	1.33	1.231	1.109	0.964
15	65.419	15.82	123.788							2.173	1.366	1.376	1.35	1.32	1.281	1.236	1.189	1.143	1.091
16	65.5	15.889	123.787							1.902	1.359	1.392	1.372	1.335	1.278	1.216	1.169	1.125	1.085
17	65.6118	15.97	123.785							1.744	1.32	1.439	1.434	1.372	1.278	1.172	1.074	0.993	0.937
	65.7191	16.052	123.783							2.861	2.024	2.227	2.31	2.011	1.542	1.148	0.829	0.561	0.341
	65.8038	16.116	123.781							2.881	1.678	2.002	2.134	1.972	1.641	1.276	0.956	0.69	0.471

Run-time Warnings

The model generates the following run-time warnings that can be useful when setting up the model. These are output to the file: **w2.wrn**.

1. Water surface is above the top of layer 2 in segment 'x' at day 'y'

This message is output to inform the user that the water surface elevation has gone above the top of the computational grid. This may be okay or it might indicate that additional layers need to be added to the grid so that the surface layer does not become inappropriately thick. This is a common message when first

calibrating the water surface in a reservoir if either the inflows are overestimated or the outflows are underestimated. An application of the model to Lake Roosevelt did not include water pumped to another reservoir and the water surface ended up 70 m above the top of the grid.

2. *Computational warning at Julian day = 'x', at segment 'y' timestep = 'z'
water surface deviation [Z] = 'x' m layer thickness = 'y' m*

This message indicates that the water surface elevation solution is starting to go unstable and is generally a result of velocities approaching supercritical values. What is happening is that from one timestep to the next, the water surface elevation has gone from residing in layer [KT] to layer [KT]+1, which causes a negative surface layer thickness ([Figure 51](#)). The surface layer thickness, HKT1, is the layer thickness, H, minus the water surface deviation, z, from the top layer [KT]. As can be seen, this is negative when the solution begins to go unstable.

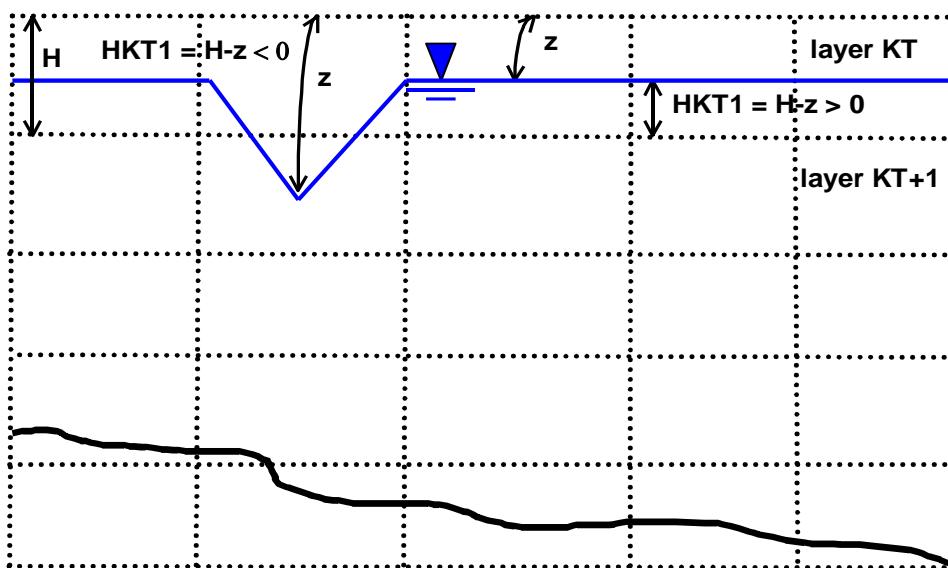


Figure 51. Diagram illustrating unstable water surface elevation solution.

Normally, when the water surface elevation approaches the bottom of layer [KT], the model would subtract a layer thus allowing the water surface level to decline smoothly over time. However, if the water surface elevation jumps below the bottom of layer [KT] in one timestep, the layer subtraction algorithm does not have a chance to adjust the water surface layer before solving for the velocities.

The model attempts to recover from the instability by decreasing the timestep by 90% and recomputing the water surface elevation. If the current timestep is greater than the minimum timestep [DLTMIN], then the following warning message is then generated.

3. *Unstable water surface elevation on day 'x',
negative surface layer thickness using minimum timestep at iteration 'y'*

If the current timestep is less than or equal to the minimum timestep [\[DLTMIN\]](#), then an error message is output and the run is stopped. However, all is not lost. Based on the Julian date in the warning messages, the user can reduce the maximum timestep [\[DLTMAX\]](#) and/or the fraction of the timestep [\[DLTF\]](#) just prior to the instability and then increase back to the original value(s) sometime later in the simulation. Often-times, this allows the model to get through the time period that was generating the instability. This may

need to be done for several time periods during the simulation in order to get the model to run to completion, especially for river applications.

If the instability is occurring during high inflow periods, the user also has the option of spreading inflows out over a greater time period in order to reduce the maximum velocities. Care must be taken to ensure that the total inflows remain the same, especially if inflow interpolation [\[QINIC\]](#) is turned on. Likewise, velocities can also be reduced through adjustments to the bathymetry such as making cells wider. If inflows are placed according to density [\[PQINC\]](#) and/or [\[PQTRC\]](#), velocities can also be reduced by using the “distribute evenly from top to bottom” option. Still another option is to increase the minimum number of layers [\[NLMIN\]](#) for a segment to remain active. This has a similar action as distributing the inflow evenly from top to bottom in that it provides more layers for the inflow to be distributed over thus reducing velocities.

Problems in model setup can also generate these warning messages. For instance, if an external head boundary condition is inadvertently set way off from the starting water surface elevation (or vice versa), then large velocities can be generated that result in a water surface instability. Extremely small widths (<1 m) can also cause the same problems.

4. Low water in segment 'x' water surface deviation ='y' at day 'z'

This warning message is to alert the user that water is drying up in a segment with only one active layer. This may mean that more friction is required to hold back water in downstream segments or the segment in question, or that segments upstream may need to have less friction.

5. Computational warning at Julian day = 'x' spatial change ='x' m^3 temporal change ='y' m^3 volume error ='z' m^3

This message is to let the user know that the volume error is more than 1000 m³. This should not normally happen unless the user has incorrectly modified the code or the water surface elevation solution has become unstable. The message is more informational and does not require the user to do anything as the volume error is arbitrarily set to 1000 m³.

- 6. Change of model surface layer by adding or subtracting layers*
- 7. Other diagnostic information*

Run-time Errors

When the model goes unstable and stops running the code generates 2 files: **w2.err** and **w2errordump.csv**. The model generates the run-time error messages and outputs them to the file, **w2.err**, and generates an error “dump” file of all the pertinent output data at the time of the model crash, **w2errordump.csv**. Both of these files are useful in debugging the cause of a model instability and “crash”.

W2.err

- 1. Unstable water surface elevation on day 'x' negative surface layer thickness using minimum timestep at iteration 'y'*

As discussed in the [RUN-TIME WARNINGS](#) section, this error message is generated by an unstable water surface elevation solution. Refer to that section on methods for eliminating the instability. Additional information is output to the error message file and includes the segment number, the water surface elevation

at that segment, the bottom elevation of that segment, and the elevation difference for all segments in the offending branch.

2. Fatal error - Insufficient segments in branch 'x' Julian day = 'y' water surface layer = 'z'

Currently in the model, if the number of segments in a branch becomes less than two due to drying out and subsequent subtraction of upstream segments from the active computational grid, then the model issues this error message and terminates. The reason why is that there must be at least two active segments in a branch for many of the computations to proceed. This error is most common in reservoir simulations. Future plans include bypassing this limitation so that the model runs using only active branches. However, this will involve major coding changes and will take some time to implement.

If this occurs during water surface calibration due to insufficient inflows or excessive outflows, then adjust the flows so that either more water comes in or less water flows out. The user will have to decide the appropriate inflow/outflow to adjust. If this problem occurs with a correct water balance, then one option is to remove the branch from the computational grid and include the branch inflows as a tributary. The missing branch volume should then be evenly distributed throughout the active computational grid cells to ensure that the project volume is conserved.

Another workaround is to add additional depth to the bottom of the branch so that water levels can drop without segments being subtracted. Similarly, the number of active layers required to prevent segment subtraction [[NLMIN](#)] can be set to one if it is not already set to that value, which may prevent the branch from going dry.

An example of the **w2.err** file is shown below:

```
Unstable water surface elevation on day 200.039
negative surface layer thickness using minimum timestep at iteration 295
Branch #:           1 in Waterbody:           1 Surface layer KT:      39
Segment, Surface layer thickness, m, Flow m3/s, U(KT,I) m/s, ELWS, m
 37            3.15          92.69        0.63        495.73
 38            3.09          95.95        0.76        494.66
 39            3.00         -12781.80       -0.30        493.54
 40           -88.37        3541556.07     -19427.77       401.16
 41            9.73           0.00        0.02        498.24
```

W2ErrorDump.csv

An example of the output in **w2errordump.csv** is shown below. The variable names shown in the dump file are as follows: JDAY: Julian day at time of model crash, QIN: inflow flow rates in m³/s for each model branch, QTR: tributary inflow flow rates in m³/s for each tributary, QDT: distributed inflow rates in m³/s for each branch, QWD: withdrawal flow rates in m³/s for each withdrawal, SEG: segment number (I), Branch: branch number, KT: surface layer, WSE: water surface elevation in m, SZ: the prior time step deviation of the surface layer water surface from KT, Z: the current time step deviation of the surface layer water surface from KT, Q: flow rate between model segments computed from horizontal momentum equation, QC: corrected flow rate between model segments computed from continuity balance (this is what is used in the model), QERR: differences in flow rate between Q and QC, H2KT: the prior time step surface layer depth, H1KT: the current time step surface layer depth, BHR1: the current time step right hand side area (depth times width) of the surface layer, BHR2: the prior time step right hand side area (depth times width) of the surface layer, T1: the current time step model temperature at the surface layer, T2: the prior time step model temperature at the surface layer, SUKT: the prior time step velocity of the surface layer at the right-hand side of the segment, UKT: the current time step velocity of the surface layer at the right-hand side of the segment.

JDAY =	200.000001157407																	
QIN:	38.15	-5119498																
QTR:	0.41	1.644			0	0												
QDT:	-1.428	2.133																
QWD:	0																	
SEG	BRANCH	KT	WSE	SZ	Z	Q	QC	QERR	H2KT	H1KT	BHR1	BHR2	T1	T2	SUKT	UKT		
1	1	39	530	-0.41566	-18.1497	38.15	38.15	0	0.915655	18.64971	561.611	7.183069	15.45	15.45	1.71978	0.066162		
2	1	39	546.7049	-0.41566	-18.1497	-2703471	-2703463	0.000274	0.915655	18.64971	774.9188	7.408601	16.99981	16.99981	9586.486	-1357.8		
3	1	39	551.9997	-0.46872	-24.6929	-7485014	-7485029	-0.00019	0.968721	25.19289	612.7469	12.81144	17	17	14227.43	-4576.28		
4	1	39	534.1757	-0.45984	-8.11713	-8554272	-8554274	-2.9E-05	0.959839	8.61713	139.5798	24.08919	16.99999	16.99999	13108.25	-21328.8		
5	1	39	525.6689	-0.5144	-0.8586	-8611410	-8611339	0.000818	1.014401	1.358597	-845.977	37.05462	16.99999	16.99999	11388.61	3509.393		
6	1	39	476.9492	-0.57031	46.61293	-7189387	57401.89	100.7984	1.070314	-46.1129	-2526.55	51.38547	16.99999	16.99999	9588.911	-1988.81		
7	1	39	452.228	-0.62375	70.08592	-5089877	16529692	424.7562	1.123752	-69.5859	-1474.56	70.56718	16.99999	16.99999	7687.993	-14011.2		
8	1	39	525.7412	-0.93458	-4.67575	0	0	0	1.434584	5.175748	370.1223	82.28301	17	17	0	0		
9	2	39	523	-0.55187	818.3901	16529692	16529692	0	1.051871	-817.89	-22486.9	212.458	16.99999	16.99999	2553.539	-918.776		
10	2	39	402.2994	-4.67795	118.7641	-289716	47509545	16498.68	5.177953	-118.264	-5105.13	222.3768	17	17	-2377.37	-9303.92		
11	2	39	426.9583	-0.90442	93.08724	2447290	68670029	-2705.96	1.404415	-92.5872	-2123.47	71.8197	17	17	-5778.64	-32056.1		
12	2	39	518.1301	-0.9158	0.897452	2839202	68994818	-2330.08	1.415796	-0.39745	5.940512	66.54133	16.99999	16.99999	-5836.59	1773617		
13	2	39	517.7559	-0.92671	0.253779	3107512	69263130	-2128.89	1.426714	0.246221	302.3853	57.60137	16.99999	16.99999	-4707.55	205426.2		
14	2	39	524.2843	-0.79906	-7.29246	443503.8	66599118	-14916.6	1.299062	7.792455	485.8254	48.32397	16.99999	16.99999	-1842.7	130029		
15	2	39	520.9208	-0.78968	-4.94688	-1174353	64981303	5633.369	1.289681	5.446877	1482.432	42.36815	16.99999	16.99999	2883.803	43445.04		
16	2	39	537.9271	-0.78166	-22.9711	-1.4E+07	52505212	484.6424	1.281656	23.47106	2488.67	36.42927	16.99999	16.99999	10005.53	22689.91		

3. Using Particle Transport in CE-QUAL-W2

There are no switches in the **w2_con.npt** (or **w2_con.csv**) input file to turn ON particle transport. Activating the particle transport algorithm in CE-QUAL-W2 is based on having the input file, **w2_particle.csv**, in the default model directory of the executable. The file **w2_particle.csv** and output files from the particle transport algorithm are described below.

Input file **w2_particle.csv**

The input file, **w2_particle.csv**, must be in the directory of the model files for the particle transport to be activated. A template for this file is included in the Excel input file under the tab **w2_particle.csv**. An example of the file opened directly in Excel is shown below:

Description of Input File for Particle Transport

1. The first 2 lines are headers and are skipped in the model. The model reads the 3rd line. Note that all model inputs are comma delimited.

Particle Input File S.Wells PSU based on Andy Goodwin Fish Migration Program										
PART CONTROL		NSEG	#PARTICLES SEGMENT	LINE	DXTHEORY	OUTFREQ (days)	ILINEAR	HTST BOTTOM	HTST SIDE	IDEBUG
ON		5		10	ON	ON	1	1	0	0

PART CONTROL: ON or OFF. Turns ON or OFF particle transport in the model.

NSEG: Number of segments to add particles

#PART/SEG: Number of particles added per segment. In this example, 5 particles are added per model cell.

LINE: distribute particles in a line from top to bottom at a segment (top and bottom are defined below for each segment)

DXTHEORY: This ignores the value of DX in the control file for longitudinal dispersion and uses a theoretically computed value based on the segment length, i.e., $DISPX=5.84e-4*DLX^{**}1.1$ where DLX is the segment length in m, and DISPX is the longitudinal dispersion coefficient in

m^2/s . The random movement in x is very sensitive to the value of DX. Hence, adjusting values of DX in the control file with DXTHEORY being OFF will affect the random component significantly.

OUTFREQ: output frequency of model files in days

ILINEAR: This turns on linear interpolation rather than 3rd order Newton interpolating polynomial for computing the velocity field for the particles. When ILINEAR=1, linear interpolation is used.

HTSTBOTTOM: If =0, particles are reflected off the bottom when in contact with the bottom. If =1, particles are lost from the system by contact to the bottom.

HTSTSIDE: If =0, particles are reflected off the side when in contact with the side. If =1, particles are lost from the system by contact to the side.

IDEBUG: If you want extensive debug information, set IDEBUG=1, it is OFF when =0.

2. The next section defines the segments where the particles are deposited. The first line are text headers ignored by the model. For the number of segments defined above in **NSEG**, there will be separate lines for each segment number where the particles will be deposited.

Part#	PARTSEG	TOPK	BOTTOMK	FXLOC(m)	FZLOC(m)	SEDVEL(m/d)	DATE
1	61	100	120	0	0	0	4384.5
2	62	100	120	0	0	0	4384.5
3	63	100	120	0	0	0	4384.5
4	61	100	120	0	0	0	4394.5
5	61	100	120	0	0	0	4394.5
6	61	100	120	0	0	0	4394.5
7	61	100	120	0	0	0	4400.5
8	61	100	120	0	0	0	4400.5
9	61	100	120	0	0	0	4400.5
10	61	177	177	0	0.5	0	4384.5

PARTSEG: The segment number where particles will be deposited.

TOPK: the top layer for the particles

BOTTOMK: the bottom layer for a particle.

FXLOC: x distance in m from upstream for location of particles

FZLOC: z distance in m from top of cell for location of particles. This is not used if the particles are distributed as a LINE in each layer.

SEDVEL: Sedimentation velocity of particles in m/d in case they are not neutrally buoyant.

DATE: The Julian day when to release the particles. If this is less than the start date, then the particles will be released at the first time step.

Looking at the example above for Part#1, Since **LINE** is ON above, this would mean that 5 particles would be added to each K layer from K=100 to K=120 at segment 61 evenly spaced in a line. If **LINE** were OFF, 5 particles would be starting at **FZLOC** of 0.0 for each layer from 100 to 120 rather than being distributed with a spacing of the layer height over the number of particles.

3. This section defines the histogram output for the particle time history. A time history of the temperature, velocity and depth of the particle are determined for every time step and particle released and output to 3 files: **envrprf_v_particle.csv**, **envrprf_t_particle.csv**, and **envrprf_depth_particle.csv**.

The first variable is the number of histogram bins for each variable. As shown below there are 30 bins or intervals specified.

NUMCLASS OR INTERVALS							
30							

The next section defines the histogram bins or intervals for velocity, temperature, and depth.

VINCR	VTOP	TINCR	TTOP	DINCR	DTOP
0.05	0.5	1	30	10	120

VINCR is the interval for velocity in m/s. **VTOP** is the maximum velocity in m/s. **TINCR** is the temperature increment in °C. **TTOP** is the maximum temperature in °C. **DINCR** is the depth interval in m. **DTOP** is the maximum depth in m.

The next set of parameters is for monitoring the particles as they pass different locations.

#MONITORING LOCATIONS	
2	
Monitoring segments	
30	60
Monitoring x shift in m within a segment starting from upstream edge	
10	5

The # of monitoring locations is the number of sensors in your system that will mark when a particle passes a point. The monitoring segments are the segment number where the sensors are located. The monitoring shift is the distance in m from the upstream edge of a segment locating the sensor within a segment.

Reference System for Particles in Grid

The location of the particles in the grid are identified by its segment (I) and layer (K) location as well as X, Y, and Z coordinates within each layer. These are shown in Part 2 of the User Manual where the particle algorithm is discussed.

Output Files

The model generates output files for viewing the particle transport in Tecplot. There are 2 types of files: **BranchX.dat** and **PartX.dat**, where X is the branch number. The **BranchX.dat** file has branch characteristics, such as velocity, temperature, dissolved oxygen; whereas the **PartX.dat** file has the particle location in each branch for those particles in that branch.

BRANCHX.DAT

This file has X, Z, Water(=1 if in the water and -1 if above water or in bottom), U(HorizVel), W(VertVel), Temperature, DissolvedOxygen, KLayer, and ISegment for each time interval of output. This file is often used as the background to overlay over the particle file.

```
TITLE = "GRID NODE INFO for Branch      1"
VARIABLES = "X", "Z", "WATER", "HorizVel", "VertVel", "Temp", "DO", "KLayer", "ISegment"
ZONE T="JDAY    4384.00", N=    9351, E=     9109, F=FEPOINT, ET=QUADRILATERAL
      0.0    300.04    -1    0.00E+00    0.00E+00   25.00    5.64    2    2
      503.3   300.02    -1    0.00E+00    0.00E+00   25.00    5.64    2    3
     1006.7   300.01    -1    0.00E+00    0.00E+00   25.00    5.64    2    4
     1510.0   300.01    -1    0.00E+00    0.00E+00   25.00    5.64    2    5
     2013.4   300.00    -1    0.00E+00    0.00E+00   25.00    5.64    2    6
     2516.7   300.00    -1    0.00E+00    0.00E+00   25.00    5.64    2    7
```

PARTX.NPT

This file has the location of all the particles as a function of time. Typical format is shown below:

```
TITLE = "FISH INFO for Branch      1"
VARIABLES = "X", "Z", "FSIZE", "FAGE", "WATER"
ZONE T="JDAY    4384.00", I=    631, F=POINT
      0.01    0.01    0.00    0.00    -1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29697.06   298.00    0.00    0.00    1
      29705.55   298.00    0.00    0.00    1
...
TEXT X=47, Y=90, F=HELV-BOLD, HU=FRAME, AN=MIDCENTER,C=RED, H=3, T=" January 1, 2012
12am (JDAY4384.000)", ZN= 1
TEXT X=30.0, Y=21.0, F=HELV-BOLD, HU=FRAME,AN=MIDRIGHT, C=BLACK, H=2.1, T=" 630", ZN=
1
TEXT X=25.0, Y=25.0, F=HELV-BOLD, HU=FRAME,AN=MIDCENTER, C=BLACK, H=2.1, T="# of Parti-
cles"
```

Finalparticle.csv

This file contains the final state of all particles released in the model. The header prints out the information for each particle as shown below:

Part#	Seg # I	X Location within Segment from Upstream Side(m)	Layer # K	Vertical Dist from Top (m)	Lateral Dist from Left Bank (m)	Bra nc h#	Particle In Model (=0)	JDAY left sys tem	Detention Time (days)	Removal Mechanism	Sed Velocity (m/d)	Date Start
1	99	155.32	111	1.194	22.498	3	0	0	0	0	0	438 4.5
2	123	64.456	114	0.325	249.169	5	0	0	0	0	0	438 4.5
3	123	43.971	133	0.291	138.361	5	0	0	0	0	0	438 4.5

4	64	503.855	115	0.579	245.313	1	1	4605. 509	221.509	5	0	438 4.5
5	52	64.271	140	0.492	362.113	1	0	0	0	0	0	438 4.5
6	56	397.945	145	0.611	59.894	1	0	0	0	0	0	438 4.5
7	64	503.61	113	1.109	201.792	1	1	4479. 505	95.505	5	0	438 4.5

This file also includes additional columns of time in Julian days when the particle passed a monitoring location.

The column removal mechanism shows why the particle left the system. The following codes are used for particle removal:

Removal #	Reason
1	Particle lateral removal by withdrawal
2	Particle hits bottom and sticks
3	Particle leaves at external head BC Upstream
4	Particle leaves at external head BC Downstream
5	Particle leaves at downstream structure/dam/hydraulic structure
6	Particle leaves by hitting side wall and sticking-LHS
7	Particle leaves by hitting side wall and sticking-RHS

The user can then plot a histogram of particle detention times in the system. Figure 52 shows an example of particle detention time histogram plotted using Excel from the 'finalparticle.csv' file.

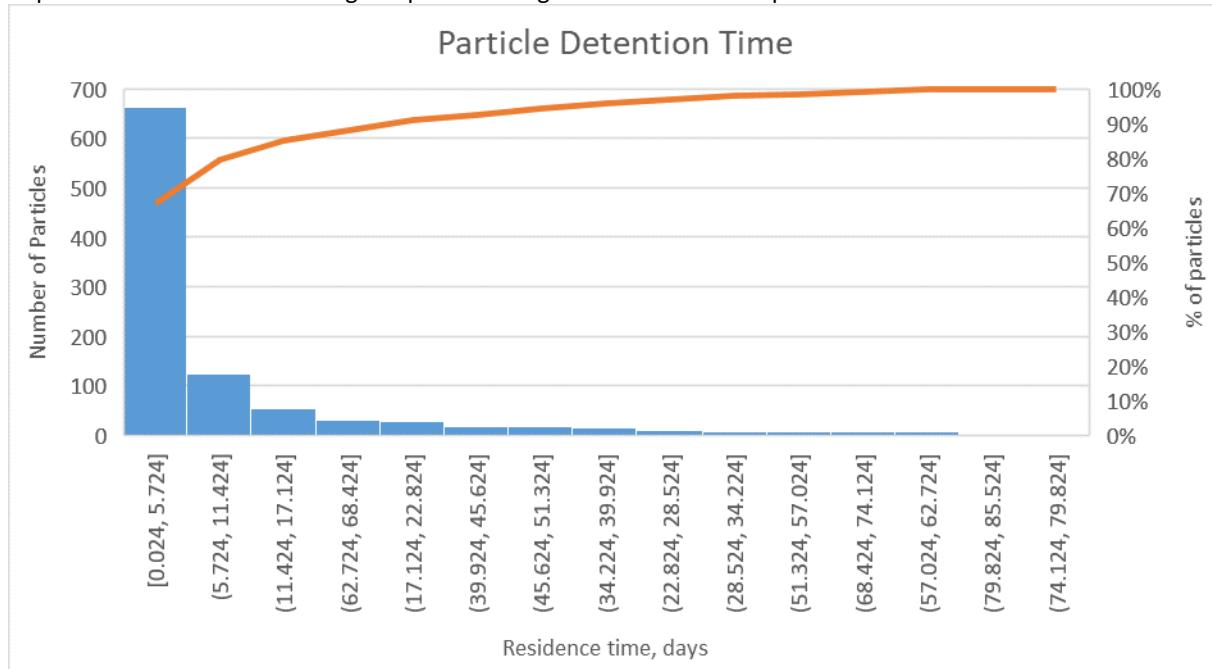


Figure 52. Example of particle detention time histogram using the file finalparticle.csv file. For this system the average particle detention time was 9.5 days.

Initialparticle.csv

This file contains the initial state of all particles added or to be added to the system. This is a valuable file in order to make sure the input file, **w2_particle.csv**, was interpreted properly. The file is of the same format as the **finalparticle.csv** file shown above.

Envrprf_v_particle.csv, envrprf_t_particle.csv, and envrprf_depth_particle.csv

These files contain the histograms of each particle released in the model domain for velocity, temperature and depth. They have the same format as the Environmental Performance Criteria files (see the section entitled ‘Environmental Performance Criteria’). These histograms can also be summed up for all the particles released. Figure 53 shows an example of velocity and temperature histograms for one particle experiment.

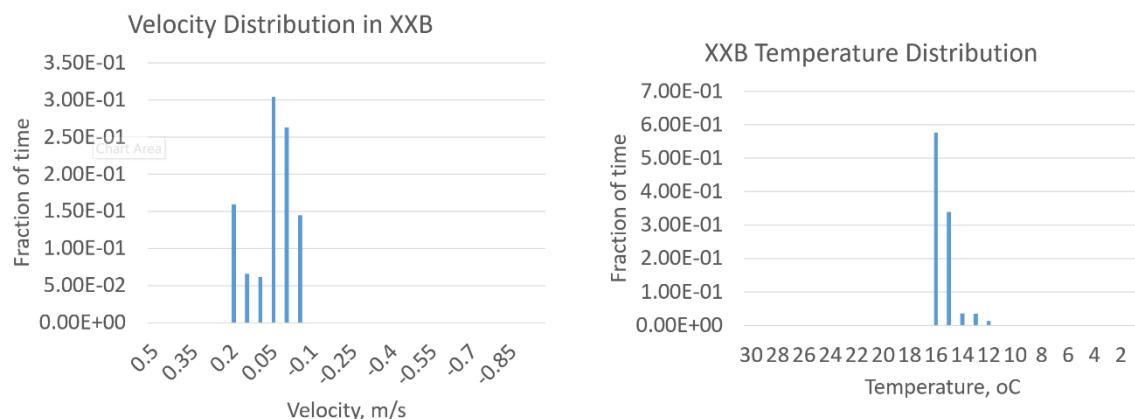


Figure 53. Example histograms of particles released for velocity and temperature for a particle release experiment.

Diagnostics.out

This file provides diagnostics of the initial state of all the particles and changes in branches or particles leaving the system.

Particle lost from the dam or from the end of a branch. The data is the array which contains all the information on each particle. This is the same as the header in the file **finalparticle.csv** described above.

At Dam: Particle Leaves System on JDAY:	4626.88896283064	Data:
64.0000000000000	503.327892820194	108.0000000000000
1.54366227122847	207.744214026401	1.000000000000000
0.000000000000000E+000	242.888962830642	0.000000000000000E+000
0.000000000000000E+000	1.000000000000000	
0.000000000000000E+000	4626.88896283064	242.888962830639
0.000000000000000E+000		

Particle lost by a withdrawal. The data is the array which contains all the information on each particle.

This is the same as the header in the file **finalparticle.csv** described above.

```
Withdrawal: Particle Leaves System on JDAY: 4629.66818200118 Data:
 84.0000000000000 62.4260124317897 103.0000000000000
 1.76838368998323 3.53317756466032 2.000000000000000
 0.000000000000000E+000 245.668182001177 0.000000000000000E+000
 0.000000000000000E+000 1.000000000000000 0.000000000000000E+000
 0.000000000000000E+000 4629.66818200118 245.668182001185
 1.000000000000000
```

Particle moves into a branch. There are several cases here – moving into a right-hand side branch, a left hand side branch, or into a downstream branch (DHS) as shown below:

```
LateralLEFT: Particle move to new branch on JDAY: 4629.70252382608 FYVEL=
 = -1.179162334446832E-002 OLD I: 43 NEW I: 94 OLD branch:
 1 NEW branch: 2

DHS: Particle move to new branch on JDAY: 4629.61918428981 FYVEL=
 4.945798728780737E-003 OLD I: 94 NEW I: 43 OLD branch:
 2

LateralRIGHT: Particle move to new branch on JDAY: 4629.64614344996
 FYVEL= 3.108536747846590E-002 OLD I: 43 NEW I: 112
 OLD branch: 1 NEW branch: 3
```

Using Tecplot to Plot Particle Movement

The basic idea is to load the data from **branchX.dat** (X is the branch number) file with temperature contours and velocity vectors. Once that is set then create another frame over the top of the original frame. The new frame (frame 2) will load the particle data. Load the data from **PartX.dat** into frame2 and activate a scatter plot. You probably should change the scatter graphic from its default rectangle to a circle (and reduce its size – I use 1). Also, link the frame styles between frame 1 and frame 2 and set the background of frame 2 to transparent. You can visualize the particle movement by just pressing animate the zones of the particles (but the temperature/velocity zones are not changed). Now, write a script in Tecplot where you activate a frame 1 with zone 1, then activate frame 2 with Zone 1 and then export the animation image. Include this in a loop where all the zones are activated and written out to a graphics animation file (mp4, avi, wmv). An example animation frame is shown in Figure 54.

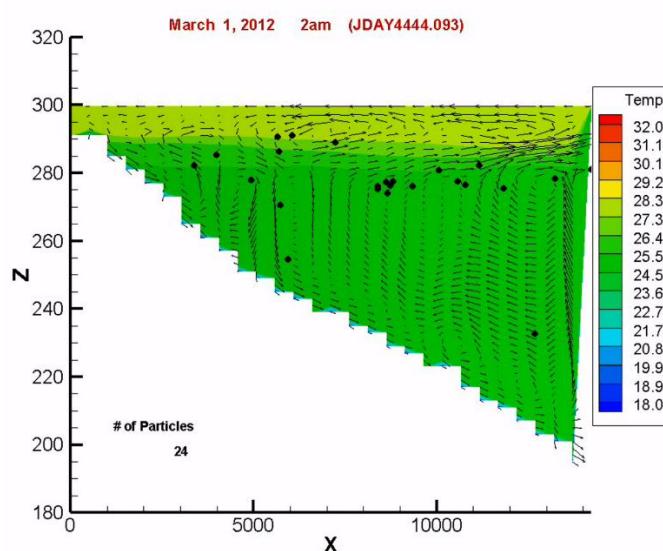


Figure 54. Branch temperature, velocity and particles in Tecplot frame.

4. Using Multiple Processors for a Cascade of Waterbodies

If the model user has a cascade of waterbodies (see Figure 55), such as reservoirs in series or even a river system with a cascade of reaches where the backwater from a downstream waterbody does not affect an upstream waterbody, then the model user can use a model feature to reduce overall model run time.

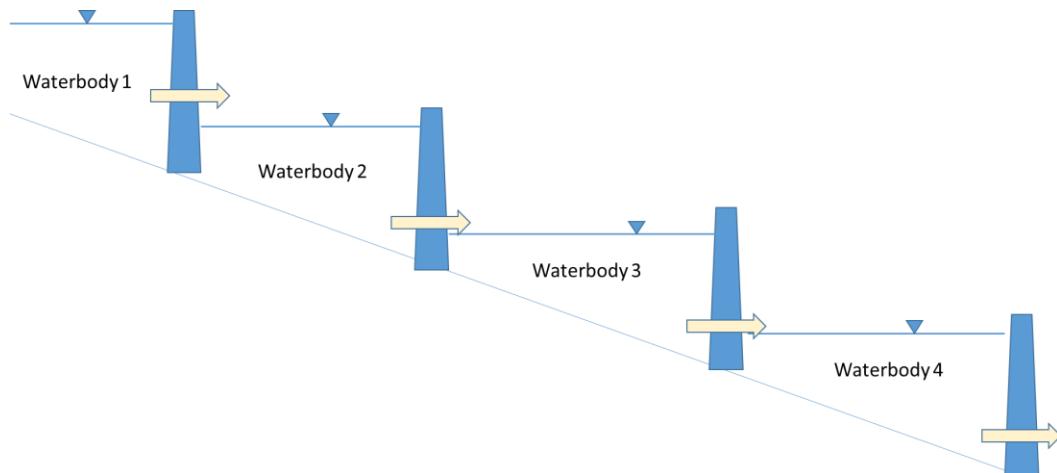


Figure 55. Cascade of reservoirs or multiple waterbodies.

There are 3 options now for simulating this series of waterbodies as shown in Table 65.

Table 65. Techniques for using CE-QUAL-W2 to simulate a cascade of waterbodies.

Option #	Option Description	Advantages	Disadvantages
1	Have one system model with multiple waterbodies and one control file	Entire model is under one control file, <code>w2_con.npt</code> (or <code>w2_con.csv</code>), simpler to manage	The time step for stability will be dictated by one of the waterbodies, causing other waterbodies to run at the lowest time step. Run times may be long.
2	Have separate waterbodies in separate directories, use a batch file to automatically transfer the output from one waterbody (withdrawal output files) as the input to the next waterbody	Each waterbody runs according to its own minimum time step and hence will result in faster simulation time compared to option 1. Also, the model user can tune for faster DLTMAX in some waterbodies.	Must break model into multiple models, one for each waterbody. Each waterbody must wait until the upper one is completed before starting.

Option #	Option Description	Advantages	Disadvantages
3	Have separate waterbodies in separate directories, use the input file (w2_multiple_WB.npt) for multiple waterbodies to point to inflow from upper waterbody	Each waterbody runs according to its own minimum time step and does not have to wait until the upper waterbody is complete before proceeding. Hence the model will run faster compared to option 1 and 2. Also, the model user can tune for faster DLTMAX in some waterbodies. Each model will usually be running on different cores of a multiple core processor.	Must break model into multiple models, one for each waterbody.

The third option shown above allows the downstream model to run even before the upstream model has completed. The downstream model, by means of the input file, '**w2_multiple_WB.npt**', which tells the downstream model where to obtain the upstream inflow boundary conditions. The downstream code can accept inflow from both branch inflows and tributaries from other waterbodies. How the CE-QUAL-W2 model proceeds during a computation is shown in Figure 56. In model tests with multiple waterbodies, speed improvements from 22-90% have been seen.

Concept

Caveat: This assumes that water level in downstream WB does not influence upstream WB

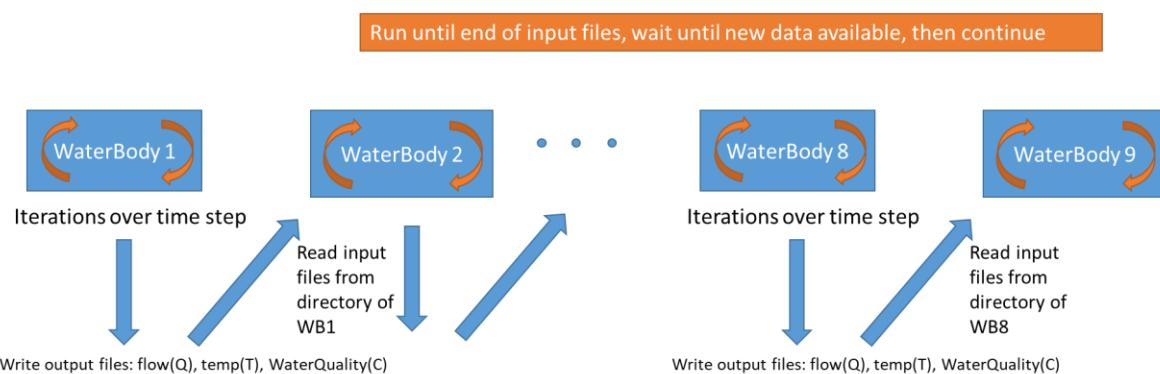


Figure 56. Concept of running multiple waterbodies simultaneously.

How to Set up a Simulation

The model user must set up a simulation with multiple waterbodies in separate directories. After this is complete, then the following steps are required:

1. The user must set for each upstream waterbody a Withdrawal outflow by setting the withdrawal output control [**WDOC**] to ON (see **w2_con.npt**, or **w2_con.csv**) and setting the outlet segment as a withdrawal outflow. These outflow files contain information for the withdrawal flows, temperatures and/or constituent concentrations as a time series. These files will be used as input to the

downstream waterbody. Make sure the output frequency is set to a short time since the model is writing out instantaneous flows, temperatures, and concentrations rather than integrated values between output times.

2. For the downstream waterbody, the user must set as the inflow or tributary flow rate, temperature and concentration, the name of the withdrawal outlet file in the upstream waterbody. Just the filenames are required since one does not set the directory path since these are copied into the directory of the downstream waterbody by the CE-QUAL-W2 model. Hence, if the upstream waterbody has set for the **WDOFN** ‘**wdo.csv**’, and the withdrawal output segment is 6, then the upstream model will write out files: qwo_6.csv, two_6.csv, and cwo_6.csv. The downstream model will then use these names as **QINFN**, **TINFN**, and **CINFN**, respectively, if these are a branch inflow. Note that the inflow file from the upstream model and an output file for the downstream model cannot have the same name. You can adjust that if necessary by changing the file suffix for the WDO file specification from let's say csv to npt.
3. The downstream model will also have a file called ‘**w2_multiple_WB.npt**’ that contains information on running the series of waterbodies. This is described below.
4. Then, the model user starts the upstream waterbody by double-clicking the executable. A dialog box for the first waterbody then starts. Then in the downstream waterbody directory, double click the executable in that directory. Then once, that waterbody starts to run, then start the next downstream W2 executable. You must wait to execute the downstream waterbody exe only after the upstream model starts generating output.
5. *Note that the files from upstream waterbodies must either be deleted in the downstream directory prior to starting a new simulation or one must start each waterbody sequentially allowing enough time for a new input file to be copied to the downstream waterbody.*

Input File **w2_multiple_WB.npt**

The input file, **w2_multiple_WB.npt**, is a text file with the following format:

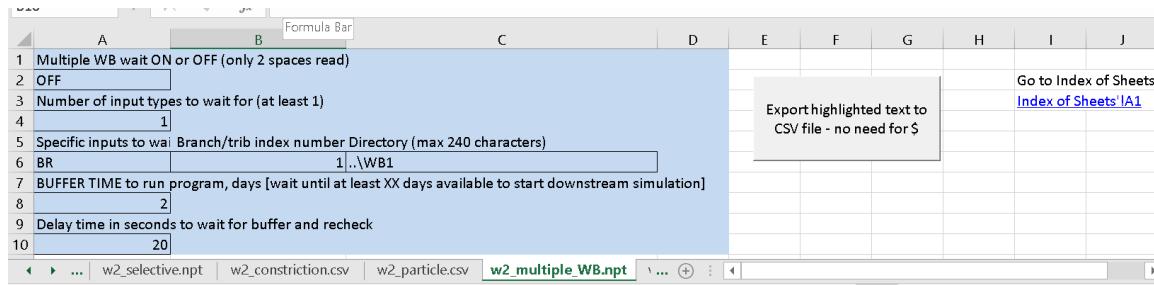
```
Multiple WB wait ON or OFF (only 2 spaces read)
ON
Number of input types to wait for (at least 1)
2
Specific inputs to wait for: branch inflow [BR] or trib [TR], branch/trib index number,
and directory (max 240 characters)
BR, 1, ..\WB2                                →Model_directory_where_QIN1_files_are_generated
TR, 3, ..\WB3                                →Model_directory_where_QTR3_files_are_generated
Buffer time to run program, days (wait until at least XX days available)
2
Delay time in seconds to wait for buffer and recheck
60
```

Each header between lines is used for comments and is ignored by the model. Each input field is described below in Table 66.

Table 66. Description of input file w2_multiple_WB.npt.

Variable	Description
Multiple WB wait ON or OFF	ON or OFF. This turns ON or OFF the multiple waterbody run.
Number of input types to wait for (at least 1)	Number of model inputs to the downstream waterbody – it must be at least 1, but can be multiple input files.
Specific inputs to wait for: branch inflow [BR] or trib [TR], branch/trib index number, and directory (max 240 characters)	This specifies the directory of the upstream waterbody, whether it is a branch inflow (BR) or a tributary inflow (TR), and the BR number and/or tributary number, followed by the directory of that file. In the example above, relative directory path was used. '..\WB2' means to go up one directory to a subdirectory WB2. One can also give an absolute directory path.
Buffer Time in days	How many days of output data from the upper waterbody is required before you start running the downstream waterbody.
Delay time in s to wait for checking upstream boundary	This is the time in s for the downstream waterbody to pause before checking to see if the buffer time is satisfied. If one chooses a 2-day buffer time, the downstream model would check at 'delay time' intervals to see if the required number of output days are complete before continuing to run.

Also, this file is part of the Excel input file under tab, w2_multiple_WB.npt. This file is shown below:



Once the highlighted section is selected in Excel, just push the export button to write out the csv file.

Output file WaitForRunLog.opt

An output file ‘**WaitForRunLog.opt**’ is produced showing how the downstream model copied files from the upstream waterbody. This is merely for debugging model errors. An example of this file is shown below:

```
1.0000 COPY ..\WB1\qwo_6.csv
1.0000 COPY ..\WB1\two_6.csv
Execution stopped at    10.900 WAITING FOR RESTART
10.9000 COPY ..\WB1\qwo_6.csv
10.9000 COPY ..\WB1\two_6.csv
Execution stopped at    22.350 WAITING FOR RESTART
22.3500 COPY ..\WB1\qwo_6.csv
22.3500 COPY ..\WB1\two_6.csv
Execution stopped at    32.850 WAITING FOR RESTART
32.8500 COPY ..\WB1\qwo_6.csv
32.8500 COPY ..\WB1\two_6.csv
Execution stopped at    43.080 WAITING FOR RESTART
43.0800 COPY ..\WB1\qwo_6.csv
43.0800 COPY ..\WB1\two_6.csv
Execution stopped at    53.000 WAITING FOR RESTART
53.0000 COPY ..\WB1\qwo_6.csv
53.0000 COPY ..\WB1\two_6.csv
```

6. References

- Allen, W.E. 1932. "Marine Plankton Diatom of Lower California in 1931", *Botanical Gazette*, Vol 95, pp 485-492.
- Anderson, E.R. 1954. Energy budget studies in Water-loss investigations, Lake Hefner Studies, Technical Report, USGS Prof. Paper, 269, 71-119.
- Annear, R. and Wells, S. A. 2007. A comparison of five models for estimating clear-sky solar radiation, *Water Resources Research*, 43, W10415, doi:10.1029/2006WR005055.
- Apstein, C. 1910. "Hat ein Organisms in der Tiefe Gelebt, in der er gefischt ist?", *Internat. Rev. Ges. Hydrobiol. Hydrograph.*, Vol 3, pp 17-33.
- Armenglo et al., 2003) for Sau Reservoir, Spain
- Ashton, G.D. 1979. "Suppression of River Ice by Thermal Effluents", *CRREL Rpt. 79-30*, US Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.
- Auer, M. T., M.T.; Johnson, N. A., Penn, M. R. and Effler, S. 1993. Measurement and verification of rates of sediment phosphorus release for a hypereutrophic urban lake. *Hydrobiologia*, Volume 253, Numbers 1-3 / March, 1993 DOI:10.1007/BF00050750.
- Banks, R.B. 1975. "Some Features of Wind Action on Shallow Lakes," *ASCE, J. Env. Engr. Div.*, 101(EE3), pp. 489-504.

- Banks, R. B. and Herrera, F. F. 1977. "Effect of Wind and Rain on Surface Reaeration", *J. Envir. Engr. Div. ASCE*, 101(EE5):813-827.
- Bansal, M.K. 1976. "Nitrification in Natural Streams", *Water Pollution Control Federation Journal*, Vol 48, pp 2380-2393.
- Belay, A. 1981. "An Experimental Investigation of Inhibition of Phytoplankton Photosynthesis at Lake Surfaces", *New Phytologist*, Vol 89, pp 61-74.
- Belov, A. P., and Giles, J. D. (1997). "Dynamical model of buoyant cyanobacteria." *Hydrobiologia*, (349), 11.
- Bella, D. 1970. "Dissolved Oxygen Variations in Stratified Lakes", *ASCE J. of the Sanitary Engineering Division*, Vol 96, No. SA5, pp 1129-1146.
- Berger, C. (2000). "Modeling Macrophytes of the Columbia Slough." PhD. dissertation, Portland State University, Department of Civil Engineering, Portland, Oregon.
- Bernard, F. 1963. "Vitesses de chute chez Cyclococcolithus fragilis Lohm", *Consequences Pour le Cycle Vital Des Mers Chaudes*.
- Beutel, M. 2006. "Inhibition of ammonia release from anoxic profundal sediments in lakes using hypolimnetic oxygenation", *J. Ecol. Eng.*, doi:10.1016/j.ecoleng.2006.05.009.
- Beutel, M.W.; DeSilva, L.; Amegbletor, L. 2021. Direct Measurement of Mercury Deposition at Rural and Suburban Sites in Washington State, USA. *Atmosphere* 2021, 12, 35. <https://doi.org/10.3390/atmos12010035>.
- Bolsenga, J. S. 1969. Total albedo of Great Lakes ice, *Water Resources Research*, Vol 5, Issue 5, 1132-1133, October 1969 <https://doi.org/10.1029/WR005i005p01132>.
- Bramlette, M.N. 1961. In. *Oceanography*, No. 67, M. Sears, ed., American Association of Science, Washington, DC., pp 345-366.
- Broecker, H. C., Petermann, J., and Siems, W. 1978. The Influence of Wind on CO₂ Exchange in a Wind-Wave Tunnel, *J. Marine Res.*, 36(4):595-610.
- Burns, N.M. 1976. "Nutrient Budgets for Lake Erie", *J. of the Fisheries Research Board of Canada*, Vol 33, pp 520-536.
- Burns, N.M., and Rosa, F. 1980. "In situ Measurement of Settling Velocity of Organic Carbon Particles and 10 Species of Phytoplankton", *Limnology and Oceanography*, Vol 25, pp 855-864.
- Butts, T.A. and Evans, R.L. (1983) "Small Stream Channel Dam Aeration Characteristics," *Journal Environmental Engineering Division*, ASCE, Vol 109, No 3, pp. 555-573, June 1983.
- Caffrey, A., Hoyer, M., and Canfield, D. 2006. Factors Affecting the Maximum Depth of Colonization by Submersed Macrophytes in Florida Lakes, Southwest Florida Water Management District, 46 pp.

Camarero, L., Catalan, J. 2012. Atmospheric phosphorus deposition may cause lakes to revert from phosphorus limitation back to nitrogen limitation. *Nat Commun* 3, 1118 (2012). <https://doi.org/10.1038/ncomms2125>

Carney, J.F., and Colwell, R.R. 1976. "Heterotrophic Utilization of Glucose and Glutamate in an Estuary: Effect of Season and Nutrient Load", *Applied and Environmental Microbiology*, Vol. 31, pp 227-233.

Carpenter, E.J., and Guillard, R.R.L. 1971. "Intraspecific Differences in Nitrate Half-Saturation Constants for Three Species of Marine Phytoplankton", *Ecology*, Vol 52, pp 183-185.

Castenholz, R.W. 1964. "The Effect of Daylength and Light Intensity on the Growth of Littoral Marine Diatoms in Culture", *Physiological Plant*, Vol 17, pp 951-963.

Castenholz, R.W. 1969. "The Thermophilic Cyanophytes of Iceland and the Upper Temperature Limit", *J. of Phycology*, Vol 5, pp 360-368.

Celik I., Rodi W. 1984. "Simulation of Free-Surface Effects in Turbulent Channel Flow", *PhysicoChemical Hydrodynamics*, Vol. 5, No 3 / 4, 1984, pp 217-227.

Celik I., Rodi W. 1988. "Modeling Suspended Sediment Transport in Nonequilibrium Situations", *Journal of Hydraulic Engineering*, Vol. 114, No. 10, October, 1988, pp 1157-1191.

Cervarich, A.2020. "CE-QUAL-W2 Hydrodynamic and Water Quality Model of the Cedar River Municipal Watershed," M.S. Thesis, Department of Civil and Environment Engineering, Portland State University, Portland, OR.

Chalup and Laws (1990) calculated the nutrient saturated growth rate of the marine phytoplankter *Pavlova lutheri* at different light intensities

Chapra, S. 1997. *Surface Water Quality Modeling*, McGraw-Hill, NY.

Chen, R.L., Brannon, J.M., and Gunnison, D. 1984. "Anaerobic and Aerobic Rate Coefficients for Use in CE-QUAL-RI", *Miscellaneous Paper E-84-5*, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chiari, P.S., and Burke, D.A. 1980. "Sediment Oxygen Demand and Nutrient Release", *ASCE J. Env. Engr.*, Vol 106, No. EEI, pp 177-195.

Chien, Chia-Te; Allen, Brant; Dimova, Natasha T.; Yang, Juan; Reuter, John; Schladow, Geoffrey; Paytan, Adina. 2019. "Evaluation of atmospheric dry deposition as a source of nutrients and trace metals to Lake Tahoe,", *Chemical Geology*, Volume 511, 20 April 2019, Pages 178-189.

Churchill, M.A., Elmore, H. L., and Buckingham, R.A. 1962. "Prediction of Stream Reaeration Rates," *J. San. Engr. Div., ASCE*, SA4:1, Proc. Paper 3199.

Cloern, J.E. 1977. "Effects of Light Intensity and Temperature on Cryptomonas Cryptophyceae. Growth and Nutrient Uptake Rates", *J. of Phycology*, Vol 13, pp 389-395.

Cohen, Mark. 2003. "The Atmospheric Deposition of Mercury to the Great Lakes," Presentation An Ecosystem Approach to the Health Effects of Mercury in the Great Lakes Basin February 26-27, 2003 Cleary International Conference Center Windsor, Ontario.

Cole, T. and Buchak, E. 1995. CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 2.0, Technical Report EI-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Collins, C.D., and Boylen, C.W. 1982a. "Physiological Responses of *Anabaena variabilis* Cyanophyceae. to Instantaneous Exposure to Various Combinations of Light Intensity and Temperature", *J. of Phycology*, Vol 18, pp 206-211.

_____. 1982b. "Ecological Consequences of Long-Term Exposure of *Anabaena variabilis* to Shifts in Environmental Conditions", *Applied and Environmental Microbiology*, Vol 44, pp 141-148.

Collins, C. D. and Wlosinski, J. H. 1989. "A macrophyte submodel for aquatic ecosystems", *Aquatic Botany*, Volume 33, Issues 3–4, June 1989, Pages 191-206. 10.1016/0304-3770(89)90037-5.

Columbia Basin Research. 2000. "Columbia River Salmon Passage Model, CRISP 1.6, Theory and Calibration", Technical Report, School of Aquatic and Fisheries Sciences, University of Washington, 238 pp.

Covar, A. P. 1976. "Selecting the Proper Reaeration Coefficient for Use in Water Quality Models," presented at the US EPA Conference on Environmental Simulation and Modeling, April 19-22, Cincinnati, OH.

Diez, S., Noonan, G., MacFarlane, J., and Gschwend, P. 2007. Ferrous iron oxidation rates in a pycnocline of a permanently stratified lake, *Chemosphere*, 66 (8): 1561-1570. doi: 10.1016/j.chemosphere.2006.08.017

DiToro, D.M. 2001. *Sediment Flux Modeling*. Wiley-Interscience. New York. 656pp.

Downing, A.L., and G.A. Truesdale. 1955. "Some factors affecting the rates of solution of oxygen in water", *J. Applied Chemistry*, Vol. 5, pp.570-581.

Duntley, S.Q. 1952. The visibility of submerged objects, Visibility Lab., Mass. Inst. Tech, Scripps Institution of Oceanography, San Diego, p. 74.

Engelund, F. 1978. Effect of Lateral Wind on Uniform Channel Flow. *Progress Report 45*, Inst. of Hydrodynamic and Hydraulic Engr., Tech. Univ. of Denmark.

EPA 1985. Rates, Constants and Kinetics in Surface Water Quality Modeling, Environmental Research Laboratory, EPA/600/3-85/040, Athens, Ga.

Eppley, R.W., Holmes, R.W., and Strickland, J.D.H. 1967b. "Sinking Rates of Marine Phytoplankton Measured with a Fluorometer", *J. of Experimental Marine Biology and Ecology*, Vol 1, pp 191-208.

Eppley, R.W., Rogers, J.N., and McCarthy, J.J. 1969. "Half-Saturation Constants for Uptake of Nitrate and Ammonia by Marine Phytoplankton", *Limnology and Oceanography*, Vol 14, pp. 912-920.

Eppley, R.W., and Sloan, P.R. 1966. "Growth Rates of Marine Phytoplankton: Correlation with Light Adsorption by Cell Chlorophyll-a", *Physiological Plant*, Vol 19, pp 47-59.

Eppley, R.W., and Thomas, W.H. 1969. "Comparison of Half-Saturation Constants for Growth and Nitrate Uptake of Marine Phytoplankton", *J. of Phycology*, Vol 5, pp 375-379.

ERM and Golder Associates .2001. "CEMA Oil Sands Pit Lake Model", Report 09-1336-1008, CEMA Reclamation Working Group, Alberta, CA.

Falkowski et. al. (1985) calculated the steady-state growth rates of three species of marine

Fang, X. and Stefan, H. G. 1994. "Modeling Dissolved Oxygen Stratification Dynamics in Minnesota Lakes under Different Climate Scenarios," *Project Report 339*, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis.

Finenko, Z.Z., and Krupatkina-Aki-Nina, D.K. 1974. "Effect of Inorganic Phosphorus on the Growth Rate of Diatoms", *Marine Biology*, Vol 26, pp. 193-201.

Fitzgerald, G.P. 1964. "The Effect of Algae on BOD Measurements", *National Pollution Control Federation J.*, Vol 36, pp 1524-1542.

Fogg, G.E. 1969. "The Physiology of an Algal Nuisance", *Proc. R. Soc.B.*, Vol 173, pp 175-189.

_____. 1973. "Phosphorus in Primary Aquatic Plants", *Water Research*, Vol 7, pp 77-91.

Frost, W.H., and Streeter, H.W. 1924. "Bacteriological Studies", *Public Health Bulletin 143*, US Public Health Service, Washington, DC.

Fuhs, G.W., Demmerle, S.D., Canelli, E., and Chen, M. 1972. "Characterization of Phosphorus-Limited Plankton Algae", *Limnol. Oceanogr. Special Symposia*, Vol 1, pp 113-133.

Gao, Shaobai and Stefan, Heinz G. 1998. "Observed and Simulated Ice Characteristics of Five Freshwater Lakes and Extrapolation to a Projected 2xCO₂ Climate Scenario", St. Anthony Falls Laboratory Project Report 411, University of Minnesota, 94 pp.

Garstecki, B. 2021. Modeling Algae Cyanotoxin Production, Fate and Transport in Surface Waterbodies, M.S. Thesis, Department of Civil and Environmental Engineering, Portland State University, 175 pp.

Gaudy, A. F. and Gaudy, E. T. (1980) Microbiology for Environmental Engineers and Scientists, Mc-Graw-Hill, N.Y.

Gelda, R. K., Auer, M. T., Effler, S. W., Chapra, S. C., and Storey, M. L. 1996. "Determination of Reaeration Coefficients: A Whole Lake Approach", *ASCE J. Envir. Engr.*, Vol. 122, Issue 4 (April 1996).

Goldman, J.C., and Graham, S.J. 1981. "Inorganic Carbon Limitation and Chemical Composition of Two Freshwater Green Microalgae", *Applied and Environmental Microbiology*, Vol 41, pp 60-70.

Goldman, J.C., Porcella, D.B., Middlebrooks, E.J., and Toerien, D.F. 1972. "The Effects of Carbon on Algal Growth--Its Relationship to Eutrophication", *Water Research*, Vol 6, pp 637-679.

Goldman et. al. (1974) maximum growth rate and inorganic carbon half saturation coefficient for the freshwater algae *Selenastrum capricornutum*

Golterman, H.L. 1975. *Physiological Limnology*, Elsevier, Amsterdam.

Goodwin, R. A., J. M. Nestler, D. P. Loucks, and R. S. Chapman. 2001. Simulating mobile populations in aquatic ecosystems. *ASCE Journal of Water Resources Planning and Management*, 127(6)386–393.

Gould, S. 2006. "k- ϵ Turbulence Model in CE-QUAL-W2", Research Project Report, Department of Civil and Environmental Engineering, Portland State University, Portland, OR, 53 pp.

Grover 1989 Algae species P

Guillard, R.R.L., and Ryther, J.H. 1962. "Studies on the Marine Planktonic Diatoms; I. *Cyclotella nana* Hustedt and *Detonula confervacea* Cleve)", *Canadian J. of Microbiology*, Vol 8, pp 229-239.

Guillard et. al., 1973. Maximum growth rate of two clones of the marine diatom *Thalassiosira Pseudonana*.

Gunnison, D., Chen, R.L., and Brannon, J.M. 1983. "Relationship of Materials in Flooded Soils and Sediments to the Water Quality of Reservoir; I. Oxygen Consumption Rates", *Water Research*, Vol 17, No. 11, pp 1609-1617.

Hall, G.H. 1982. "Apparent and Measured Rates of Nitrification in the Hypolimnion of a Mesotrophic Lake", *Applied and Environmental Microbiology*, Vol 43, pp 542-547.

Hanlon, R.D.G. 1982. "The Breakdown and Decomposition of Allochthonous and Autochthonous Plant Litter in an Oligotrophic Lake Llyn Frongoch)", *Hydrobiologia*, Vol 88, pp 281-288.

Hecky, R.E., and Kilham, P. 1974. "Environmental Control of Phytoplankton Cell Size", *Limnology and Oceanography*, Vol 19, No. 2, pp 361-365.

Hecky, R. E., Campbell, P., and Hendzel L. L. 1993. "The stoichiometry of carbon, nitrogen, and phosphorus in particulate matter of lakes and oceans," *Limnology and Oceanography*, 38(4), 709-724.

Holm, N.P., and Armstrong, D.E. 1981. "Role of Nutrient Limitation and Competition in Controlling the Populations of *Asterionella formosa* and *Microcystis aeruginosa* in Semicontinuous Culture", *Limnology and Oceanography*, Vol 26, pp 622-634.

Hondzo, M. and Stefan, H. G. 1996. "Dependence of water quality and fish habitat on lake morphometry and meteorology", *Journal of Water Resources Planning and Management*, Volume 122, Issue 5, September/October 1996, Pages 364-373.

Hopcroft, Russell R., Roff, John, and Bouman, Heather. 1998. Zooplankton growth rates: the larvaeans Appendicularia, Fritillaria and Oikopleura in tropical waters, *Journal of Plankton Research*, Vol.20 No.3, pp.539-555, 1998.

Hoogenhout, H., and Amesz, J. 1965. "Growth Rates of Photosynthetic Microorganisms in Laboratory Studies", *Archives of Microbiology*, Vol 50, pp 10-24.

Hoskins, J.K., Ruchhoft, C.C., and Williams, L.G. 1927. "A Study of the Pollution and Natural Purification of the Illinois River; I. Surveys and Laboratory Studies", *Public Health Bulletin No. 171*, Washington, DC.

Huntley, M. E. and Lopez, Mai. 1992. Temperature Dependent Production of Marine Copepods: A global synthesis, *The American Naturalist*, Vol 140, No. 2, (Aug 1992), pp. 201-242.

Hutchinson, G.E. 1957. *A Treatise on Limnology; I. Geography, Physics and Chemistry*, John Wiley and Sons, New York, NY.

Ignatiades, L., and Smayda, T.J. 1970. "Autecological Studies on the Marine Diatom *Rhizosolenia fragilis-sima* Bergon; I. The Influence of Light, Temperature, and Salinity", *J. of Phycology*, Vol 6, pp 332-229.

Ikusima, 1970 [Macrophytes]

James, William F., Berko, John W., Eakin, Harry L. 1995. Phosphorus Loading in Lake Pepin (Minnesota-Wisconsin). Final report ADA304855. Army Engineer Waterways Experiment Station, Vicksburg MS.

Jamieson, E. J. 1995. Precipitation and Characterization of Iron (III) Oxyhydroxides from Acid Liquors. Ph.D. Dissertation, School of Mathematical and Physical Sciences, Murdoch University, Perth Australia,

Jeanjean, R. 1969. "Influence de la Carence en Phosphore sur les Vitesses d'Absorption du Phosphate Par les Chlorelles", *Bull. Soc. Fr. Physiol. Veg.*, Vol 15, pp 159-171.

Jewell, W.J., and McCarty, P.L. 1971. "Aerobic Decomposition of Algae", *Environment Science and Technology*, Vol 5, pp 1023-1031.

Jitts, H.R., McAllister, C.D., Stephens, K., and Strickland, J.D.H. 1964. "The Cell Division Rates of Some Marine Phytoplankton as a Function of Light and Temperature", *J. of the Fisheries Research Board of Canada*, Vol 21, pp 139-157.

Jorgensen, E.G. 1968. "The Adaptation of Plankton Algae; II. Aspects of the Temperature and the Temperature Adaptation of *Skeletonema costatum*", *Physiological Plant*, Vol 21, pp 423-427.

Kanwisher, J. 1963. "On the Exchange of Gases Between the Atmosphere and the Sea", *Deepsea Research with Oceanography*, Vol 10, pp 195-207.

Kim, Lee-Hyung; Choi, Euiso; Gil, Kyung-Ik; and Stenstrom, M. K. 2003. Phosphorus release rates from sediments and pollutant characteristics in Han River, Seoul, Korea. doi:10.1016/j.scitotenv.2003.08.018.

Kittrell, F.W., and Furfari, S.A. 1963. "Observations of Coliform Bacteria in Streams", *J. of the Water Pollution Control Federation*, Vol 35, p 1361.

Klaveness and Guillard (1975) determined the maximum growth rate and silicon half-saturation coefficient for the golden-brown (Chrysophyceae) algae *Synura* *Petersenii*.

Klock, J.W. 1971. "Survival of Coliform Bacteria in Wastewater Treatment Lagoons", *J. of the Water Pollution Control Federation*, Vol 43, p 2071.

Knightes, C., Golden, H., Journey, C., Davis, G., Conrads, P., Marvin-DiPasquale, M., Brigham, M., Bradley, P. 2014. Mercury and methylmercury stream concentrations in a Coastal Plain watershed: A multi-scale simulation analysis, Environmental Pollution, Volume 187, 2014, Pages 182-192, <https://doi.org/10.1016/j.envpol.2013.12.026>.

Koenings, J., and Edmundson, J. 1991. "Secchi disk and photometer estimates of light regimes in Alaskan lakes: Effects of yellow color and turbidity," *Limnology and Oceanography*, 36(1), 91-105.

Konopka, A. 1983. "The Effect of Nutrient Limitation and Its Interaction with Light upon the Products of Photosynthesis in *Merismopedia tenuissima* Cyanophyceae)", *J. Phycology*, Vol 19, pp 403-409.

Krutsikh, et al., 1970

Langbien, W. B. and Durum, W. H. 1967. "The Aeration Capacity of Streams," USGS, Washington, D.C. Circ. 542.

Langdon 1987 rates for marine diatoms

Laws and Bannister (1981) measured the maximum growth rate of the marine diatom *Thalassiosira fluvialis*

Laws, E.A., and Wong, D.C. 1978. "Studies of Carbon and Nitrogen Metabolism by Three Marine Phytoplankton Species in Nitrate-Limited Continuous Culture", *J. of Phycology*, Vol 14, pp 406-416.

Liss, P.S. 1973. "Processes of gas exchange across an air-water interface", *Deep Sea Research*, Vol. 20, pp 221-238.

Litchman, Elena. 2000. "Growth rates of phytoplankton under fluctuating light", *Freshwater Biology*, Volume 44, pp. 223-235.

MacIsaac, J.H., and Dugdale, R.C. 1969. "The Kinetics of Nitrate and Ammonia Uptake by Natural Populations of Marine Phytoplankton," *Deepsea Research with Oceanography*, Vol 16, pp 16-27.

Mahloch, J.L. 1974. "Comparative Analysis of Modeling Techniques for Coliform Organisms in Streams", *Applied Microbiology*, Vol 27, p 340.

Marais, G.V.R. 1974. "Faecal Bacterial Kinetics in Stabilization Ponds", *ASCE J. of the Sanitation Engineering Division*, Vol 100, No. EE1, p 119.

Margalef, R. 1961. "Velocidad de Sedimentacion de Organismos Pasivos del Fitoplankton", *Investigacion Pesq.*, Vol 18, pp 3-8.

McCutcheon, Steve. 1987. "Laboratory and instream nitrification rates for selected streams." *Journal of Environmental Engineering*, Vol. 113, No. 3, pp. 628-646.

Melching, C. and Flores, H. 1999. "Reaeration Equations Derived from USGS Database," *J. Envir. Engr., ASCE*, 125(5), 407-414.

Megard, R. O., Comles, W.S., Smith, P.D., and Knoll, A.S. 1980. "Attenuation of Light and Daily Integral Rates of Photosynthesis Attained by Planktonic Algae", *Limnology and Oceanography*, Vol 24, pp 1038-1050.

Mills, W., Dean, J., Porcella, D., Gherini, A., Hudson, R., Frick, W., Rupp, G., Bowie, G. 1982. Water Quality Assessment: A Screening procedure for Toxic and Conventional Pollutants, part 1, Tetra Tech, Inc. Env. Res. Lab., Office of Res. And Develop., USEPA, Athens, G, 570 pp., EPA-600/6-82-004a.

Myers, J., and Graham, J. 1961. "On the Mass Culture of Algae; III. Light Diffusers: High vs. Low Temperature Chlorellas", *Plant Physiology*, Vol 36, pp 342-346.

- Nalewajko, C. 1966. "Photosynthesis and Excretion in Various Planktonic Algae", *Limnology and Oceanography*, Vol 11, pp 1-10.
- Nelson, D. M. and Brzezinski, M. A. 1990. "Kinetics of silicic acid uptake by natural diatom assemblages in two Gulf Stream warm-core rings," *Marine Ecology Progress Series*, Vol 62, 283-292.
- Newbold, J.D., and Liggett, D.S. 1974. "Oxygen Depletion Model for Cayuga Lake", *ASCE J. of the Environmental Engineering Division*, Vol 100, No. EEI, pp 41-59.
- O'Connor, D. J. and Dobbins, W.E. 1958. "Mechanism of Reaeration in Natural Streams," *ASCE Trans.*, 86(SA3):35-55.
- O'Connor, D.J. 1983. "Wind Effects on Gas-Liquid Transfer Coefficients" *J. Envir Engr ASCE*, Vol. 109, pp. 731-752.
- Okubo, A. 1971. "Oceanic Diffusion Diagrams", *Deep-Sea Research*, 18:789. [Revise]
- Otsuki, A., and Hanya, T. 1972. "Production of Dissolved Organic Matter from Dead Green Algal Cells; I. Aerobic Microbial Decomposition", *Limnology and Oceanography*, Vol 17, pp 248-257.
- Overman, C. 2019. Modeling Vertical Migration of Cyanobacteria and Zooplankton. M.S. Thesis Department of Civil and Environmental Engineering, Portland State University, 233 pp.
- Owens, M., Edwards, R., and Gibbs, J. 1964. "Some Reaeration Studies in Streams," *Int. J. Air Water Poll.*, 8:469-486.
- Paasche, E. 1968. "Marine Plankton Algae Grown with Light-Dark Cycles; II. *Ditylum brightwellii* and *Nitzschia turgidula*", *Physiological Plant*, Vol 21, pp 66-77.
- Paasche 1973 growth rates marine diatoms**
- Piecznska. 1972. *Wiadomosci Ekologiczne*, Vol 18, pp 131-140.
- Prakash, S., Vandenberg, J. A., E. M. Buchak. 2015. Sediment Diagenesis Module for CE-QUAL-W2. Part 2: Numerical Formulation. *Environmental Modeling & Assessment*. <http://dx.doi.org/10.1007/s10666-015-9459-1>. Springer International Publishing. April.
- Pulsifer, Jennifer, and Edward Laws. 2021. "Temperature Dependence of Freshwater Phytoplankton Growth Rates and Zooplankton Grazing Rates" *Water* 13, no. 11: 1591. <https://doi.org/10.3390/w13111591>
- Quasim, S.Z., Bhattachari, P.M.A., and Dovassoy, V.P. 1973. *Marine Biology*, Vol 21, pp 299-304.
- Reynolds, C. S. 1984. *The ecology of freshwater phytoplankton*. Cambridge University Press.
- Rhee, G-Yull. 1973. "A Continuous Culture Study of Phosphate Uptake, Growth Rate and Polyphosphate in *Scenedesmus sp.*", *J. of Phycology*, Vol 9, pp 495-506.
- Rhee, G-Yull, and Gotham, I.J. 1981a. "The Effects of Environmental Factors on Phytoplankton Growth: Temperature and the Interaction of Temperature with Nutrient Limitation", *Limnology and Oceanography*, Vol 26, pp 635-648.

_____. 1981b. "The Effects of Environmental Factors on Phytoplankton Growth: Light and the Interaction of Light with Nitrate Limitation", *Limnology and Oceanography*, Vol 26, pp 649-659.

Riebesell et. al., 1993 [algae growth rates marine diatoms]

Riley, G.A. 1943. *Bulletin of the Bingham Oceanography College*, Vol 8, Art. 4, p 53.

Riley, G.A., H. Stommel, and D.F. Bumpus. 1949. "Quantitative Ecology of the Plankton of the Western North Atlantic", *Bulletin of the Bingham Oceanography College*, Vol 12, pp 1-169.

Riley, G.A., and von Aux, R. 1949. In. *J. of Marine Research*, Vol 8, No. 11, pp 60-72.

Rodi, W. 1993. *Turbulence Models and Their Application in Hydraulics, 3rd edition*, IAHR, A.A. Balkema, Rotterdam.

Rogers, K.H., and C.M. Breen. 1982. "Decomposition of *Potamogeton crispus*; I. Effects of Drying on the Pattern of Mass and Nutrient Loss", *Aquatic Botany*, Vol 12, pp 1-12.

Rounds, S.A., and Buccola, N.L., 2015. "Improved algorithms in the CE-QUAL-W2 water-quality model for blending dam releases to meet downstream water-temperature targets", U.S. Geological Survey Open-File Report 2015-1027, 40 p., <http://dx.doi.org/10.3133/ofr20151027>.

Ruane, Jim (2014) Personal communication, Portland, OR.

Sahoo, G. B., Nover, D. M., Reuter, J. E., Heyvaert, A. C. Riverson, J., Schladow, S. G. 2013. "Nutrient and particle load estimates to Lake Tahoe (CA–NV, USA) for Total Maximum Daily Load Establishment," *Science of The Total Environment*, Volume 444, 1 February 2013, Pages 579-590.

Samuel et. al., 1983 growth rate of *Skeletonema costatum*.

Sakshaug and Andresen, 1989 The maximum growth rate of the marine diatom *Skeletonema costatum*

Schmid, M., and O. Koster. 2016. "Excess warming of a Central European lake driven by solar brightening", *Water Resour. Res.*, 52, 8103–8116, doi:10.1002/2016WR018651.

Schnoor, J.L., and Fruh, E.G. 1979. "Dissolved Oxygen Model of a Short Detention Time Reservoir with Anaerobic Hypolimnion", *Water Resources Bulletin*, Vol 15, No. 2, pp 506-518.

Sedell, J.R., Triska, F.J., and Triska, N.S. 1975. "The Processing of Conifer and Hardwood Leaves in Two Coniferous Forest Streams; I. Weight Loss and Associated Invertebrates", *Verh. Internat. Verein. Limnol.*, Vol 19, pp 1617-1627.

Shelef, G. 1968. "Kinetics of Algal Systems in Waste Treatment; Light Intensity and Nitrogen Concentration as Growth-Limiting Factors", Ph.D. Thesis, University of California, Berkeley, CA.

Sher-Kaul, S., Oertli, B., Castella, E. and J. Lachavanne (1995), "Relationship between biomass and surface area of six submerged aquatic plant species." *Aquatic Botany*, 51, 147-154.

Simoes, F. 1998. "An Eddy Viscosity Model for Shallow-Water Flows," *Water Resources Engineering* 98, ASCE, NY, 1858-1863.

- Smayda, T.J. 1969. "Experimental Observations on the Influence of Temperature, Light, and Salinity on Cell Division of the Marine Diatom *Detonula cofervacea* Cleve. Gran", *J. of Phycology*, Vol 5, pp 150-157.
- _____. 1971. "Normal and Accelerated Sinking of Phytoplankton in the Sea", *Marine Geology*, Vol 11, pp 105-122.
- _____. 1974. "Some Experiments on the Sinking Characteristics of Two Freshwater Diatoms", *Limnology and Oceanography*, Vol 19, No. 4, pp 628-635.
- Smith, R.C., and Baker, K.S. 1978. "The Bio-optical State of Ocean Waters and Remote Sensing", *Limnology and Oceanography*, Vol 23, pp 247-259.
- Smith, D.J. 1978. "WQRSS, Generalized computer program for River-Reservoir systems," *USACE Hydrologic Engineering Center HEC*, Davis, California, User's Manual 401-100, 100A, 210 pp.
- Smith, W.O. 1979. "A Budget for the Autotrophic Ciliate *Mesodinium rubrum*", *J. of Phycology*, Vol 15, pp 27-33.
- Spears, Bryan M.; Carvalho, Laurence; Perkins, Rupert; Kirika, Alex; Paterson, David M.. 2007. Sediment phosphorus cycling in a large shallow lake: spatio-temporal variation in phosphorus pools and release. *Hydrobiologia*, 584. 37-48. doi:10.1007/s10750-007-0610-0.
- Sorokin, C., and Krauss, R.W. 1962. "Effects of Temperature and Illumination on *Chorella* Growth Uncoupled from Cell Division", *Plant Physiology*, Vol 37, pp 37-42.
- Sorokin, C., and Meyers, J. 1953. "A High Temperature Strain of Chlorella", *Science*, Washington, D.C., Vol 117, pp 330-331.
- Spence, D.H.N. 1981. "Light Quality and Plant Responses Underwater", *Plants and the Daylight Spectrum*, H. Smith, ed., Academic Press, New York, NY, pp 245-276.
- Spencer, D.F., and Lembi, C.A. 1981. "Factors Regulating the Spatial Distribution of the Filamentous Alga *Pithophora oedoga* Chlorophyceae. in an Indiana Lake", *J. of Phycology*, Vol 17, pp 168-173.
- Steele, J.H. 1962. "Environmental Control of Photosynthesis in the Sea", *Limnology and Oceanography*, Vol 7, pp 137-150.
- Steemann-Nielsen, E. 1952. "On Detrimental Effects of High Light Intensities on the Photosynthetic Mechanism", *Physiological Plant*, Vol 5, pp 334-344.
- Steemann-Nielsen, E., and Jorgensen, E.G. 1968. "The Adaptation of Plankton Algae; I. General Part", *Physiological Plant*, Vol 21, pp 401-413.
- Talling, 1975 Algae growth rates**
- Tennessee Valley Authority (TVA) 1972. Heat and Mass Transfer between a water surface and the atmosphere, Water Resources Report 0-6803, Lab Report #14, Norris, TN.
- Thackston, E. L. and Krenkel, P. A. 1966. "Reaeration Predictions in Natural Streams," *J. San. Engr. Div., ASCE*, 89(SA5):1-30.

Thackston, E., L. and Dawson, J. W. 2001. "Recalibration of a Reaeration Equation," *J. Envir. Engr.*, ASCE, 127(4), 317-321.

They NH, Amado AM and Cotner JB. 2017. Redfield Ratios in Inland Waters: Higher Biological Control of C:N:P Ratios in Tropical Semi-arid High Water Residence Time Lakes. *Front. Microbiol.* 8:1505. doi: 10.3389/fmicb.2017.01505

Thomas, W.H., and Dodson, A.N. 1968. "Effects of Phosphate Concentration on Cell Division Rates and Yield of a Tropical Oceanic Diatom", *Biological Bulletin*, Vol 134, pp 199-208.

Thomann, R. V. and Mueller, J. A. 1987. *Principles of Surface Water Quality Modeling and Control*, Harper and Row, NY.

Timmermans, K., Wagt, B., and Baar, H. 2004. "Growth rates, half-saturation constants, and silicate, nitrate, and phosphate depletion in relation to iron availability of four large, open-ocean diatoms from the Southern Ocean," *Limnol. Oceanogr.*, 49(6), 2141-2151.

Tipping, E., S. Benham, J. F. Boyle, P. Crow, J. Davies, U. Fischer, H. Guyatt, R. Helliwell, L. Jackson-Blake, A. J. Lawlor, D. T. Monteith, E. C. Rowe and H. Toberman. 2014. Atmospheric deposition of phosphorus to land and freshwater," *Environmental Science: Processes & Impacts*, Issue 7, 2014.

Titman, D., and Kilham, P. 1976. "Sinking in Freshwater Phytoplankton: Some Ecological Implications of Cell Nutrient Status and Physical Mixing Processes", *Limnology and Oceanography*, Vol 21, No. 3, pp 109-117.

Titus and Adams, 1979[Macrophytes]

Toerien, D.F., and Cavari, B. 1982. "Effect of Temperature on Heterotrophic Glucose Uptake, Mineralization, and Turnover Rates in Lake Sediment", *Applied and Environmental Microbiology*, Vol 43, pp 1-5.

Tsivoglou, E. C. and Wallace, S. R. 1972. "Characterization of Stream Reaeration Capacity," *USEPA, Report No. EPA-R3-72-012*.

Turner, J.T. 1977. "Sinking Rates of Fecal Pellets from the Marine Copepod *Pontella meadii*", *Marine Biology*, Vol 40, No. 3, pp 249-259.

Underhill, P.A. 1977. "Nitrate Uptake Kinetics and Clonal Variability in the Neritic Diatom *Biddulphia aurita*", *J. of Phycology*, Vol 13, pp 170-176.

Vaccaro, R.F. 1969. "The Response of Natural Microbial Populations in Seawater to Organic Enrichment", *Limnology and Oceanography*, Vol 14, pp 726-735.

Vandenberg, J. A., S. Prakash, E. M. Buchak. 2014. Sediment Diagenesis Module for CE-QUAL-W2. Part 1: Conceptual Formulation. Environmental Modeling & Assessment. DOI 10.1007/s10666-014-9428-0. Print ISSN 1420-2026. Online ISSN 1573-2967. <http://link.springer.com/article/10.1007%2Fs10666-014-9428-0>. Springer International Publishing. November.

Van der Bijl et al., 1989 [Macrophytes]

van Lierre, L., Zevenboom, W., and Mur, L.R. 1977. "Nitrogen as a Limiting Factor for the Growth of the Blue Green Alga *Oscillatoria*", *Progressive Water Technology*, Vol 8, pp 301-312.

- Verduin, J. 1952. "Photosynthesis and Growth Rates of Live Diatom Communities in Western Lake Erie", *Ecology*, Vol 33, pp 163-169.
- _____. 1982. "Components Contributing to Light Extinction in Natural Waters: Methods of Isolation", *Archives of Hydrobiology*, Vol 93, pp 303-312.
- Verity, P.G. 1981. "Effects of Temperature, Irradiance and Daylength on the Marine Diatom *Leptocylindrus danicus* Cleve; I. Photosynthesis and Cellular Composition", *J. of Experimental Marine Biology and Ecology*, Vol 55, pp 79-91.
- Visser, P. M., Passarge, J., and Mur, L. R. 1997. "Modelling vertical migration of the cyanobacterium *Microcystis*." *Hydrobiologia*, 349, 99–109
- Von Muller, H. 1972. "Washstum and Phosphatbedarf von *Nitzschia octinastroides* Lemm.. V. Goor in Statischer und Homokontinuierlicher Kulter unter Phosphatlimitierung", *Arch. Hydrobiol. Suppl.*, Vol 38, pp 399-484.
- Wallen, D.G., and Cartier, L.D. 1975. "Molybdenum Dependence, Nitrate Uptake and Photosynthesis of Freshwater Plankton Algae", *J. of Phycology*, Vol 11, pp 345-349.
- Wang, L.K., Poon, C.P., Wang, M.H., and Bergenthal, J. 1978. "Chemistry of Nitrification-Denitrification Process", *J. of Environmental Sciences*, Vol 21, pp 23-28.
- Wang, Y., Peng, Y., Wang, D., Zhang, C. 2014. Wet deposition fluxes of total mercury and methylmercury in core urban areas, Chongqing, China, *Atmospheric Environment*, Volume 92, 2014, Pages 87-96.
- Wanninkhof, R., J. R. Ledwell, and J. Crucius. 1991. "Gas transfer velocities on lakes measured with sulfur hexafluoride", in Proceedings of the Second International Symposium on Gas Transfer at Water Surfaces, edited by S.C. Wilhelms and J. S. Gulliver, pp. 441-455, American Society of Civil Engineers, New York.
- Weiler, R.R. 1974. "Carbon dioxide exchange between water and atmosphere, "Journal of Fisheries Research, Board Committee, Vol. 31, pp. 329-332.
- Welch, E. B., Cooke, G. D., Jones, J. R. and Gendusa, T. C. 2011. "DO-Temperature habitat loss due to eutrophication in Tenkiller Reservoir, Oklahoma, USA", *Lake and Reservoir Management*, 27:3, 271-285, DOI: 10.1080/07438141.2011.607553
- Wells, S. 2001. "Turbulence Closure Modeling in CE-QUAL-W2", Research Report, Department of Civil and Environmental Engineering, Portland State University, 37 pp.
- WES. 1996. Evaluation and Analysis of Historical Dissolved Gas Data from the Snake and Columbia Rivers, Waterways Experiments Station, *ACOE Dissolved Gas Abatement Study Phase 1 Technical Report*, Vicksburg, MS.
- WES. 1997. "Total Dissolved Gas Production at Spillways on the Snake and Columbia Rivers, Memorandum for Record," Waterways Experiments Station, *ACOE Dissolved Gas Abatement Study Phase 1 Technical Report*, Vicksburg, MS.
- Wetzel, R.G. 1975. *Limnology*, W.B. Saunders, Philadelphia, PA.

Williams, P.J., Yentsch, L.B., and Yentsch, C.S. 1976. "An Examination of Photosynthetic Production, Excretion of Photosynthetic Products and Heterotrophic Utilization of Dissolved Organic Compounds with Reference to Results from a Coastal Subtropical Sea", *Marine Biology*, Vol 35, pp 31-40.

Williams, D.T.; Drummond, G.R.; Ford, D.E.; and Robey, D.L. 1980. "Determination of Light Extinction Coefficients in Lakes and Reservoirs", *Surface Water Impoundments, Proceedings of the Symposium on Surface Water Impoundments*, American Society of Civil Engineers, H.G. Stefan, ed.

Wright, R.T. 1975. "Studies on Glycolic Acid Metabolism by Freshwater Bacteria", *Limnology and Oceanography*, Vol 20, pp 626-633.

Yu, S.L., T.J. Tuffy, and D.S. Lee. 1977. "Atmosphere Reaeration in a lake," *Office of Water Resources and Technology*, U.S. Department of the Interior.

Zimmerman, U. 1969. "Okologische und Physiologische Untersuchungen an der Planktonischen Blauagle Oscillatoria Rubescens, D.C., unter Besonderer Berücksichtigung von Licht und Temperatur", *Schweiz. Z. Hydrol.*, Vol 31, pp 1-58.

Zison, S.W., Mills, W.B., Deimer, B., and Chen, C.W. 1978. "Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling", *EPA-600/3-68-105*, US Environmental Protection Agency, Washington, DC.