1-1-2011

# Developing and Calibrating the Hydrodynamic and Water Quality Model CE-QUAL-W2 for Banks Lake Washington

Andrew John McCulloch
*Portland State University*

## Recommended Citation

McCulloch, Andrew John, "Developing and Calibrating the Hydrodynamic and Water Quality Model CE-QUAL-W2 for Banks Lake Washington" (2011). *Dissertations and Theses.* Paper 180.
https://doi.org/10.15760/etd.180

# Developing and Calibrating the Hydrodynamic and Water Quality Model CE-QUAL-W2 for Banks Lake Washington

By

Andrew John McCulloch

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science
in
Civil and Environmental Engineering

Thesis Committee:
Scott Wells, Chair
Chris Berger
Mark Sytsma

Portland State University

# ABSTRACT

Located in central Washington State, Banks Lake serves as an irrigation storage reservoir for the Columbia Basin Irrigation Project and is home to a diverse fisheries population. The current hydrologic management strategies used for Banks Lake have been chosen to serve two purposes: to adequately store and provide irrigation water for the Columbia Basin Irrigation Project and to maintain a healthy aquatic environment suitable for the growth and habitation of local flora and fauna. Increased needs for irrigation water within arid central Washington poses additional challenges to reservoir managers so that irrigation needs are met without damaging the present aquatic environment within Banks Lake. Future plans by the Washington Department of Ecology to use Banks Lake storage as an additional source of irrigation water in lieu of the depleted ground water reserves of the Odessa Subarea aquifer have required an investigation into how increased seasonal drawdown may affect fish growth, fish habitat and overall limnology of Banks Lake.

The goal of this project is to produce a hydrodynamic and water quality model of Banks Lake that can predict the impacts of management strategies on the lake’s water quality and the linkage of lake management to fish habitat.

# Acknowledgements

Funds for this project were provided by the Washington Department of Ecology. Andy Miller of the Spokane Tribe of Indians, Dr. Ross Black of Eastern Washington University, Jama Hamel of the US Bureau of Reclamation, Matt Polacek and Danny Didricksen of the Washington Department of Fish and Wildlife provided data water quality and meteorological data for Banks Lake and Lake Roosevelt. Patrick O'Callaghan, Cory Stolsig and David Cordner of the US Bureau of Reclamation provided bathymetric data for Banks Lake and helped with system interpretation. Dr. Scott Wells, Dr. Chris Berger and Vanessa Wells of the Portland State University Water Quality Research Group provided technical assistance and advice for the hydrodynamic and water quality model.

## Table of Contents

ABSTRACT ........ i
Acknowledgements ........ ii
List of Tables ........ vi
List of Figures ........ viii
Abbreviations ........ xiv
Project Overview ........ 1
  Banks Lake Overview ........ 2
  Lake Geometry ........ 6
  Hydraulic Structures ........ 8
    Feeder Canal & North Dam ........ 9
    Lake Roosevelt Pumping Plant ........ 10
    Main Canal & Dry Falls Dam ........ 12
  Work Impetus ........ 15
Overview of Models Used ........ 18
  CE-QUAL-W2 Overview ........ 18
Lake Roosevelt Fish Bioenergetics Model Review ........ 22
  Model Background ........ 23
Banks Lake Data Summary ........ 25
  Bathymetry Data & Grid Development ........ 26
  Hydraulic Boundary Conditions ........ 32
    Feeder Canal Inflow ........ 34
    Feeder Canal Return Flow ........ 36
    Main Canal Outflow ........ 38
  Water Surface Elevation ........ 40
  Boundary Condition Water Temperature Data ........ 42
  Meteorological Data ........ 47
  Topographical and Vegetative Shading ........ 51
  Water Quality Data ........ 53
    WDFW Water Quality Data ........ 56

    - EWU Water Quality Data ....59
    - EWU Nutrient Data Analysis ....61
  - Biological Data ....67
    - Algae ....67
    - Zooplankton ....71
- Banks Lake CE-QUAL-W2 Model Calibration ....75
  - Hydrodynamic Calibration ....76
  - Light Extinction ....79
  - Water Temperature Calibration ....81
  - Dissolved Oxygen Calibration ....86
  - pH Calibration ....91
  - Chlorophyll-a Calibration ....94
  - Algae Calibration ....98
    - Algae 1-Diatoms ....99
    - Algae 2-Cryptophyta ....102
    - Algae 3-Green & Blue Green Algae ....105
  - Zooplankton Calibration ....108
- Alternative Action Management Scenarios ....118
  - Alternative Action Management Scenario Background & Data ....118
  - Alternative Action Management Scenario Preparation ....124
  - Alternative Action Management Scenario Results and Discussion ....130
    - Effect of Alternative Action Management on Temperature Stratification ....131
    - Environmental Criteria: Annual Summary ....144
    - Environmental Criteria: Dissolved Oxygen Management Scenarios ....146
    - Fish Habitat Analysis ....149
    - Zooplankton Entrainment ....157
- Summary ....162
- References ....166
- Appendix A: CE-QUAL-W2 Control File ....171
- Appendix B: Water Temperature Calibration Profiles ....189
- Appendix C: Dissolved Oxygen Calibration Profiles ....221

Appendix D: pH Calibration Profiles ....................................................................251
Appendix E: Alternative Action Management Scenario Fish Habitat Percentages.........281
Appendix F: Lake Roosevelt Fish Bioenergetics FORTRAN Source Code Routine......289

## List of Tables

Table 1. Banks Lake dimensions ........ 7
Table 2. Lake Roosevelt pump summary ........ 11
Table 3. EIS action alternatives ........ 16
Table 4. CE-QUAL-W2 governing equations (Cole and Wells, 2010) ........ 22
Table 5. Summary of model grid layout and dimensions ........ 29
Table 6. Banks Lake flow gage summary ........ 33
Table 7. Feeder Canal inflow summary statistics ........ 34
Table 8. Feeder Canal return flow annual statistics ........ 36
Table 9. Main Canal annual flow annual statistics ........ 38
Table 10. Banks Lake annual water surface elevation summary statistics (m-NAVD88) 40
Table 11. Lake Roosevelt Dam forebay surface water temperature ($^o$C) annual summary statistics ........ 45
Table 12. Annual summary statistics for the calculated water temperature ($^o$C) at the intake to the Lake Roosevelt pumping plant ........ 45
Table 13. AGRIMET stations summary ........ 47
Table 14. Banks Lake air temperature ($^o$C) summary statistics 2002-2009 ........ 49
Table 15. Relative humidity (%) summary statistics ........ 50
Table 16. Calculated dew point temperature ($^o$C) summary statistics ........ 50
Table 17. Wind speed (m/s) statistics summary ........ 50
Table 18. Cloud cover data calculated from solar data (W/m$^2$) 2002-2009 ........ 50
Table 19. Short wave solar radiation (W/m$^2$) summary statistics 2002-2009 ........ 50
Table 20. Annual precipitation (cm) summary statistics ........ 50
Table 21. WDFW Banks Lake water quality sampling sites ........ 54
Table 22. Washington Fish and Wildlife phytoplankton summary statistics, average biovolume (mm$^3$/l) ........ 69
Table 23. Washington Fish and Wildlife zooplankton density summary statistics (organisms/l) ........ 73
Table 24. Water quality constituents and data types ........ 75
Table 25. Water surface elevation and distributed tributary flow statistics: 2002-2009 .. 77
Table 26. Comparison of secchi disk depths, theoretical light extinction coefficients and model predicted light extinction coefficients ........ 80
Table 27. Model–data error statistics for water temperature profile data for 2002, 2003, 2008 and 2009 ........ 84
Table 28. Model–data error statistics for dissolved oxygen profile data 2002, 2003, 2008 and 2009 ........ 89
Table 29. Model–data error statistics for pH profile data 2002, 2003, 2008 and 2009 .... 92

Table 30. Banks Lake 2007 and 2008 meteorological summary statistics and comparison ........ 122
Table 31. Odessa Subarea Special Study EIS reservoir draw downs for Banks Lake.... 123
Table 32. The mean difference for all action alternative temperatures compared with the no........ 133
Table 33. The mean difference for all action alternative temperatures compared with the no-action ........ 134
Table 34. Optimal growth habitat criteria for Banks Lake sport fish ........ 149
Table 35. Zooplankton group 1 monthly average mass flow rates through the Main Canal (g/s) ........ 160
Table 36. Zooplankton group 2 monthly average mass flow rates through the Main Canal (g/s) ........ 161

## List of Figures

Figure 1. Model study area and Washington State ........................................................ 3
Figure 2. Banks Lake with Grand Coulee Dam, North Dam and Dry Falls Dam ............ 4
Figure 3. Banks Lake sub-pools and Devil’s Lake ........................................................ 7
Figure 4. Map of hydraulic structures within the greater extent of the Banks Lake study area ........................................................................................................................ 8
Figure 5. Banks Lake Feeder canal, facing South ......................................................... 9
Figure 6. Side view of a generic pump/turbine from the Lake Roosevelt pumping plant (Hubbard, 1995) ........................................................................................................ 11
Figure 7. A side view schematic of the Dry Falls Dam powerhouse and the Main Canal headworks ................................................................................................................ 13
Figure 8. A top view schematic of Dry Falls Dam and the Main Canal headworks ........ 14
Figure 9. USGS aerial photograph of Devil’s Lake prior to the creation of Banks Lake. 28
Figure 10. Contour map of Devil’s Lake before and after correcting USBE bathymetry data ........................................................................................................................ 29
Figure 11. Close up view of the surface polygons with polygon numbers and direction of flow ........................................................................................................................ 30
Figure 12. Model grid side view of branch 7 ............................................................... 30
Figure 13. Model grid end view .................................................................................. 31
Figure 14. Banks Lake flow gage locations ................................................................. 32
Figure 15. Feeder Canal daily average inflow rates ($m^3/s$ & $ft^3/s$) 2008 ......................... 35
Figure 16. Feeder Canal daily average return flow rates ($m^3/s$ & $ft^3/s$) 2008 .................. 37
Figure 17. Main Canal daily average flow rates ($m^3/s$ & $ft^3/s$) 2008 ............................... 39
Figure 18. Banks Lake daily average water surface elevation 2002-2009 ..................... 41
Figure 19. Banks Lake daily average water surface elevation 2002-2004 ..................... 41
Figure 20. Linear regression used to predict feeder canal inflow temperatures where Y is Spring Canyon water temperature ($^oC$) at a depth of 30 meters and Y is the Grand Coulee Dam forebay daily average surface water temperature ($^oC$) ........................................ 44
Figure 21. Boundary condition temperature gages ...................................................... 45
Figure 22. Spring Canyon water temperature ($^oC$) isopleths 2002 ................................. 46
Figure 23. Surface water temperature ($^oC$) for hydromet station FDRW and calculated inflow temperatures ($^oC$) at the Lake Roosevelt Pumping Plant 2002 ............................ 46
Figure 24. AGRIMET weather station locations .......................................................... 49
Figure 25. CE-QUAL-W2 dynamic topographic shading angles diagram ..................... 52
Figure 26. Banks Lake maximum, minimum and average angles of inclination moving downstream from the Feeder Canal ............................................................................ 52
Figure 27. WDFW Banks Lake water quality sampling sites ........................................ 55
Figure 28. Banks Lake 2009 water temperature ($^oC$) isopleths: Lim site 1 ..................... 57

Figure 29. Banks Lake 2009 dissolved oxygen (mg/l) isopleths: Lim site 1 .................... 58
Figure 30. Banks Lake 2009 pH isopleths: Lim site 1 ...................................................... 58
Figure 31. Banks Lake 2005 chlorophyll-a (µg/l) isopleths: Lim site 1 ........................... 58
Figure 32. Banks Lake 2002-2003 chlorophyll-a concentrations (µg/l) measured at 5 meters ................................................................................................................ 60
Figure 33. Banks Lake 2003-2004 chlorophyll-a (µg/l) isopleths: Lim site 4 ................. 60
Figure 34. Orthophosphate data collected by EWU at Lim site 1: 2002-2004 ................. 63
Figure 35. Nitrate data collected by EWU at Lim site 1: 2002-2004 ............................... 64
Figure 36. Lake Roosevelt orthophosphorus and total phosphorus concentrations 2002-2008 ................................................................................................................ 64
Figure 37. Lake Roosevelt nitrite, nitrate and total nitrogen concentrations 2002-2008 . 64
Figure 38. Historical orthophosphate concentrations for 1974-1976 (Stober et al., 1976) ................................................................................................................ 65
Figure 39. Theoretical total phosphorus concentrations based on observed chlorophyll-a data and ortho-phosphorus data collected by EWU for Lim site 1 .................................. 66
Figure 40. Banks Lake phytoplankton biovolume concentrations (mm$^3$/l): Lim sites 1 .. 69
Figure 41. Banks Lake phytoplankton mass concentrations (mg/l) converted from biovolume (mm$^3$/l): Lim site 1 ......................................................................... 70
Figure 42. Algae biovolume to mass conversion curve and equation where X is algae biovolume (mm$^3$) and Y is algae mass (pg) (Reynolds, 1984). ...................................... 70
Figure 43. Banks Lake zooplankton densities (organisms/l): Lim 1 ............................... 73
Figure 44. Banks Lake zooplankton concentrations (mg/m$^3$) converted from density: Lim 1 ................................................................................................................ 73
Figure 45. Correlation between Lake Roosevelt monthly averaged Daphnia biomass and monthly averaged densities, where Y is Daphnia biomass (mg/m$^3$) and X is Daphnia density (#/m$^3$) ................................................................................................ 74
Figure 46. Correlation between Lake Roosevelt monthly averaged Copepoda biomass and monthly averaged densities, where Y is Copepoda biomass (mg/m$^3$) and X is copepoda density (#/m$^3$) ................................................................................................ 74
Figure 47. Model predicted water surface elevation with observed data from Banks Lake, 2002 ................................................................................................................ 77
Figure 48. Outflow discharge from the Main Canal at Dry Falls Dam with water balance flows, 2002 ................................................................................................................ 78
Figure 49. Model predicted water surface elevation (red) with observed data (black) and distributed tributary flow (blue), 2002-2009 ................................................................ 78
Figure 50. Secchi depths (m), model predicted light extinction coefficients and theoretical light extinction coefficients for Lim 2 during 2008-2009 (Williams 1980) (Poole & Atkins 1929) ................................................................................................ 80

Figure 51. Effect of wind on predicted water temperature profile for Lim site 9 on 7/2/2008 with a wsc=0.8 and wsc=1.5 .......... 83
Figure 52. Wind sheltering coefficients used for model temperature calibration .......... 83
Figure 53. A regression plot of model predicted water temperature profile data and water temperature profile data collected by WDFW .......... 85
Figure 54. A flow chart of dissolved oxygen sources and sinks (Cole and Wells, 2010) 88
Figure 55. Effects of SOD on dissolved oxygen profile predictions for Lim site 6 on 7/30/2008 with a SOD=0.3 and SOD=0.50 .......... 88
Figure 56. A regression plot of model predicted dissolved oxygen profile data and dissolved oxygen profile data collected by WDFW .......... 90
Figure 57. A regression plot of model predicted pH profile data and pH profile data collected by WDFW .......... 93
Figure 58. A regression plot of model predicted chlorophyll-a data and chlorophyll-a data collected by WDFW and EWU at a depth of 5 meters .......... 95
Figure 59. Chlorophyll-a model predictions compared against data collect by EWU and WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4 .......... 96
Figure 60. Chlorophyll-a model predictions compared against data collect by EWU and WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8 .......... 97
Figure 61. A regression plot of model predicted Algae 1(diatoms) (mg/l) and Algae 1 data (mg/l) collected by the WDFW at a depth of 5 meters .......... 99
Figure 62. Algal group 1 (Diatoms) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4 .......... 100
Figure 63. Algal group 1 (Diatoms) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8 .......... 101
Figure 64. A regression plot of model predicted Algae 2 (Cryptophyta) (mg/l) and Algae 2 data (mg/l) collected by the WDFW at a depth of 5 meters .......... 102
Figure 65. Algal group 2 (Cryptophyta) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4 .......... 103
Figure 66. Algal group 2 (Cryptophyta) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8 .......... 104
Figure 67. A regression plot of model predicted Algae 3(Green & Bluegreen) (mg/l) and Algae 3 data (mg/l) collected by the WDFW at a depth of 5 meters .......... 105
Figure 68. Algal group 3 (Green and Bluegreen) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4 .......... 106
Figure 69. Algal group 3 (Green and Bluegreen) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8 .......... 107
Figure 70. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 1, 2 and 3 .......... 110

Figure 71. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 4, 5 and 6 ........ 111
Figure 72. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 7, 8 and 9 ........ 112
Figure 73. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 10 and 11 ........ 113
Figure 74. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 1, 2 and 3............ 114
Figure 75. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 4, 5 and 6............ 115
Figure 76. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 7, 8 and 9............ 116
Figure 77. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 10 and 11............ 117
Figure 78. Banks Lake Feeder Canal flow annual totals ........ 121
Figure 79. Banks Lake water surface elevation: 2008 ........ 121
Figure 80. Prepared water surface elevations and flows rates for the no-action alternative ........ 125
Figure 81. Prepared water surface elevations and flows rates for management scenario Average 2A ........ 126
Figure 82. Prepared water surface elevations and flows rates for management scenario Average 3A ........ 126
Figure 83. Prepared water surface elevations and flows rates for management scenario Dry 2A ........ 127
Figure 84. Prepared water surface elevations and flows rates for management scenario Dry 3A ........ 127
Figure 85. Prepared water surface elevations and flows rates for management scenario Drought 2A ........ 128
Figure 86. Prepared water surface elevations and flows rates for management scenario Drought 3A ........ 128
Figure 87. Prepared water surface elevations and flows rates for management scenario Wet 2A ........ 129
Figure 88. Prepared water surface elevations and flows rates for management scenario Wet 3A ........ 129
Figure 89. Water temperature profiles at Lim 3 under action alternative Average 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31th and November 15th ... 135

Figure 90. Water temperature profiles at Lim 3 under action alternative Drought 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31th and November 15th ... 135
Figure 91. Water temperature profiles at Lim 3 under action alternative Wet 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31th and November 15th ......... 136
Figure 92. Water temperature profiles at Lim 3 under action alternative Dry 2A, 2B, 2C 2D and the no-action alternative on Aptil15th, August 31th and November 15th .......... 136
Figure 93. Water temperature profiles at Lim 3 under action alternative Average 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th ... 137
Figure 94. Water temperature profiles at Lim 3 under action alternative Drought 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th ... 137
Figure 95. Water temperature profiles at Lim 3 under action alternative Dry 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th ......... 138
Figure 96. Water temperature profiles at Lim 3 under action alternative Wet 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th ......... 138
Figure 97. Water temperature profiles at Lim 4 under action alternative Wet 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th .......... 139
Figure 98. Water temperature profiles at Lim 4 under action alternative Drought 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th .... 139
Figure 99. Water temperature profiles at Lim 4 under action alternative Dry 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th .......... 140
Figure 100. Water temperature profiles at Lim 4 under action alternative Average 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th ........................................................................................................................ 140
Figure 101. Water temperature profiles at Lim 4 under action alternative Average 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th ........................................................................................................................ 141
Figure 102. Water temperature profiles at Lim 4 under action alternative Drought 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th .... 141
Figure 103. Water temperature profiles at Lim 4 under action alternative Dry 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th .......... 142
Figure 104. Water temperature profiles at Lim 4 under action alternative Wet 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th .......... 142
Figure 105. Discharge from the Dry Falls dam under the no-action alternative and alternative action scenario 3A......................................................................................... 143
Figure 106. Temporal and volume weighted average water temperature for each one year management scenario run. ............................................................................................ 145
Figure 107. Temporal and volume weighted average dissolved oxygen concentration for each one year management scenario run. ...................................................................... 145

Figure 108. Average flow year time averaged volume fraction of dissolved oxygen for all scenarios ........ 147
Figure 109. Drought flow year time averaged volume fraction of dissolved oxygen for all scenarios ........ 147
Figure 110. Dry flow year time averaged volume fraction of dissolved oxygen for all scenarios ........ 148
Figure 111. Wet flow year time averaged volume fraction of dissolved oxygen for all scenarios ........ 148
Figure 112. Percent of reservoir volume that is optimal fish habitat for scenario Average-2A ........ 152
Figure 113. Percent of reservoir volume that is optimal fish habitat for scenario Drought-2A ........ 152
Figure 114. Percent of reservoir volume that is optimal fish habitat for scenario Dry-2A ........ 153
Figure 115. Percent of reservoir volume that is optimal fish habitat for scenario Wet-2A ........ 153
Figure 116. Percent of reservoir volume that is optimal fish habitat for the no-action alternative ........ 154
Figure 117. Annual average percent of reservoir volume that is optimal fish habitat for kokanee ........ 155
Figure 118. Annual average percent of reservoir volume that is optimal fish habitat for rainbow trout ........ 155
Figure 119. Annual average percent of reservoir volume that is optimal fish habitat for walleye ........ 156
Figure 120. Annual average percent of reservoir volume that is optimal fish habitat for smallmouth bass ........ 156
Figure 121. Zooplankton concentrations (mg/l) and mass flow rates (g/s) into the Main Canal for the ........ 158
Figure 122. Annual average mass flow rate of zooplankton group 1 through the Main Canal (g/s) ........ 159
Figure 123. Annual average mass flow rate of zooplankton group 2 through the Main Canal (g/s) ........ 159

## Abbreviations

| | |
|---|---|
| BLFEP | Banks Lake Fisheries Evaluation Program |
| cfs | Cubic Feet Per Second ($ft^3/s$) |
| DEM | Digital Elevation Model |
| DRYW | Dry Falls Dam, Washington AGRIMET Weather Station |
| EWU | Eastern Washington University |
| FDRW | Grand Coulee Dam Forebay Hydromet Water Gage |
| GCDW | Grand Coulee Dam, Washington AGRIMET Weather Station |
| GIS | Geographical Information System |
| hp | Horsepower |
| LRFEP | Lake Roosevelt Fisheries Evaluation Program |
| MASW | Manson, Washington AGRIMET weather station |
| MW | Megawatt |
| NAVD88 | North American Vertical Datum 1988 |
| ODSW | Odessa, Washington AGRIMET Weather Station |
| rad | Radians |
| RH | Relative Humidity |
| RM | River Mile |
| STOI | Spokane Tribe of Indians |
| Tair | Air Temperature |
| TDS | Total Dissolved Solids |
| Tdew | Dew Temperature |

| | |
|---|---|
| USBR | United States Bureau of Reclamation |
| USGS | United States Geological Survey |
| UTM | Universal Transverse Mercator |
| WDFW | Washington Department of Fish and Wildlife |

## Project Overview

The current hydrologic management strategies used for Banks Lake have been chosen to serve two purposes: to adequately store and provide irrigation water for the Columbia Basin Irrigation Project and to maintain a healthy aquatic environment suitable for the growth and habitation of local flora and fauna. Increased needs for irrigation water within arid central Washington poses additional challenges to reservoir managers so that irrigation needs are met without damaging the present aquatic environment within Banks Lake. Future plans by the Washington Department of Ecology (WDOE) to use Banks Lake storage to irrigate land located in the Odessa Subarea have required an investigation into how increased seasonal drawdown may affect fish growth, fish habitat and overall limnology of Banks Lake.

The following steps will be taken

1. Set up a CE-QUAL-W2 (Cole and Wells, 2010) model for Banks Lake
2. Calibrate the model for hydrodynamics, temperature, water quality, algae and zooplankton
3. Use the model to evaluate potential management scenarios for fish habitat and water quality

## Banks Lake Overview

Banks Lake was created in 1951 by the US Bureau of Reclamation as an equalizing reservoir for the Columbia Basin Irrigation Project. Water from Lake Roosevelt was pumped into the adjacent upper Grand Coulee and retained by two earthen dams. The Grand Coulee was created when the Columbia River was diverted south of its current path by an ancient ice dam and scoured deep into the basalt bedrock.

Banks Lake resides within the central Washington State, on the border between Grant and Douglas County (Figure 1). Banks Lake is located approximately 134 km (83 mi) west of Spokane, Washington, 132 km (82 mi) South of the US-Canada border and 220 km (137 mi) East of Seattle, Washington. The cities of Grand Coulee and Electric City border the lake on its northeast banks and Coulee City on the lake's southeast bank. Surrounding land cover classifications include agriculture, scrub/shrub and urban developed land.

**Figure 1. Model study area and Washington State**
**(Image taken from**
**http://www.washingtonstatesearch.com/Washington_maps/Washington_State_map.html)**

.

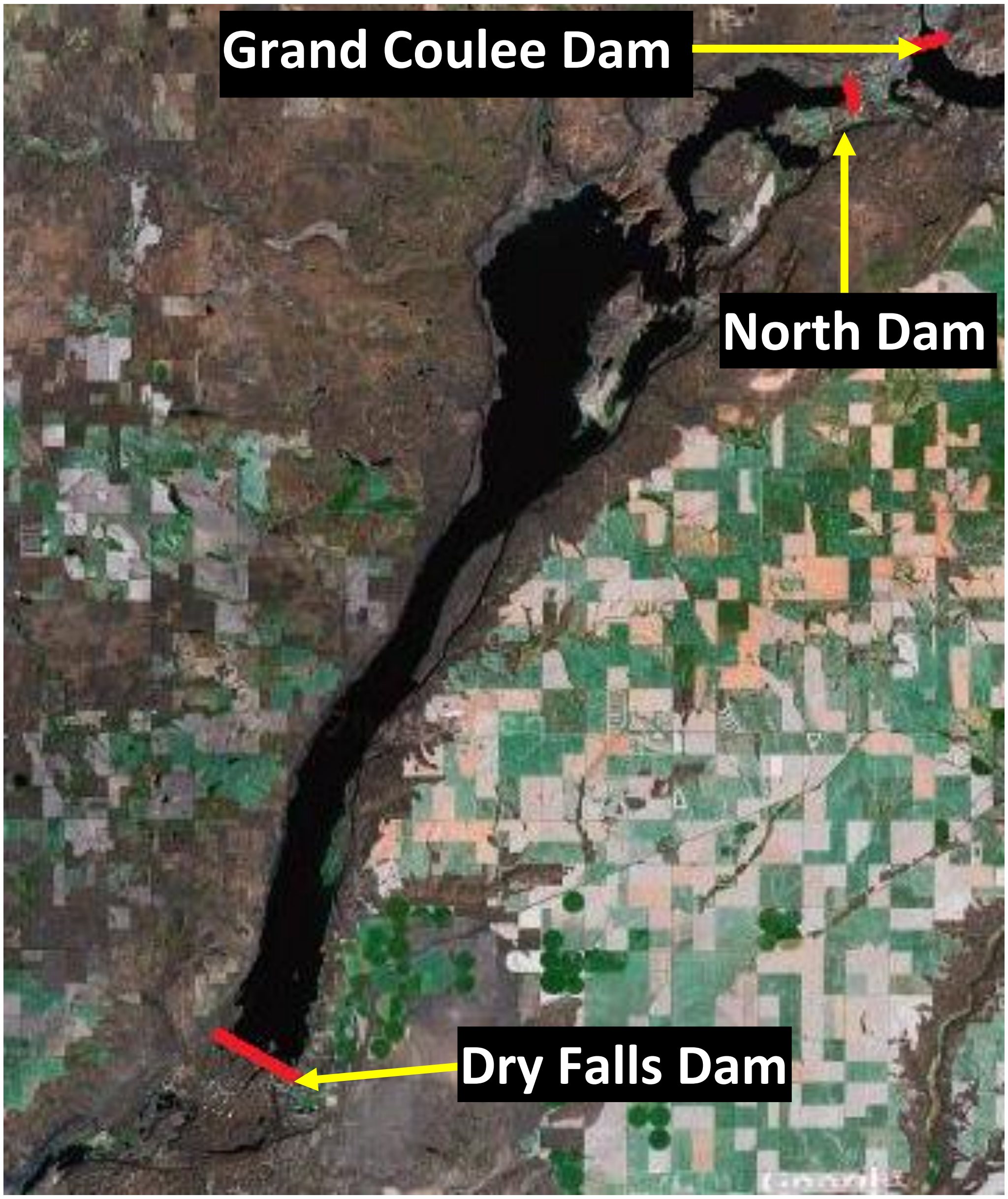


**Figure 2. Banks Lake with Grand Coulee Dam, North Dam and Dry Falls Dam**

Banks Lake is bordered by North Dam to the north and Dry Falls Dam to the south. Figure 2 shows the location of both dams relative to the main body of water. Banks Lake provides irrigation water storage/distribution, hydroelectric power generation and outdoor/aquatic tourism opportunities. Source water is pumped from Lake Roosevelt to Banks Lake and then is disturbed to the greater central Washington State area for agriculture. Waters from Lake Roosevelt and Banks Lake irrigate roughly 2200 $km^2$ (550,000 acres) of agricultural land within the Columbia Irrigation Project. Since Banks Lake is an off stream reservoir and has a relatively small watershed, it is not used for flood control. Banks Lake hydroelectric power generation is operated by returning flow to Lake Roosevelt through turbines and by allowing outflow to run through a low head generator located at Dry Falls Dam.

## Lake Geometry

Figure 3 shows how Banks Lake can be characterized into three sub-pools: the North Pool, the Middle Pool and the South Pool. The North Pool is characterized by the area south of North Dam to the southern tip of Steamboat Rock. The North Pool is surrounded by steep cliffs and contains a large pool area on the western border of Steamboat Rock. The Middle Pool contains the area south of Steamboat Rock to where the cliffs on the East bank subside to a gentle slope. The South Pool consists of the area North of Dry Falls Dam meeting the Middle Pool at the beginning of the East Bank cliffs.

In relation to the NAVD88 vertical datum, Banks Lake full pool elevation is measured at 479 m (1570 ft). At full pool Banks Lake has a volume of approximately 1.6 x $10^9$ $m^3$. While the mean depth at full pool is14 m, several deep pools exist, mostly in the southern half of the North Pool, the southern tip of the Middle Pool and most of the Southern Pool. At full pool a maximum depth of 54 meters occurs at Devils Lake, a cove located northwest of Steamboat Rock in the Middle Pool. Table 1 shows a summary of Banks Lake dimensions.

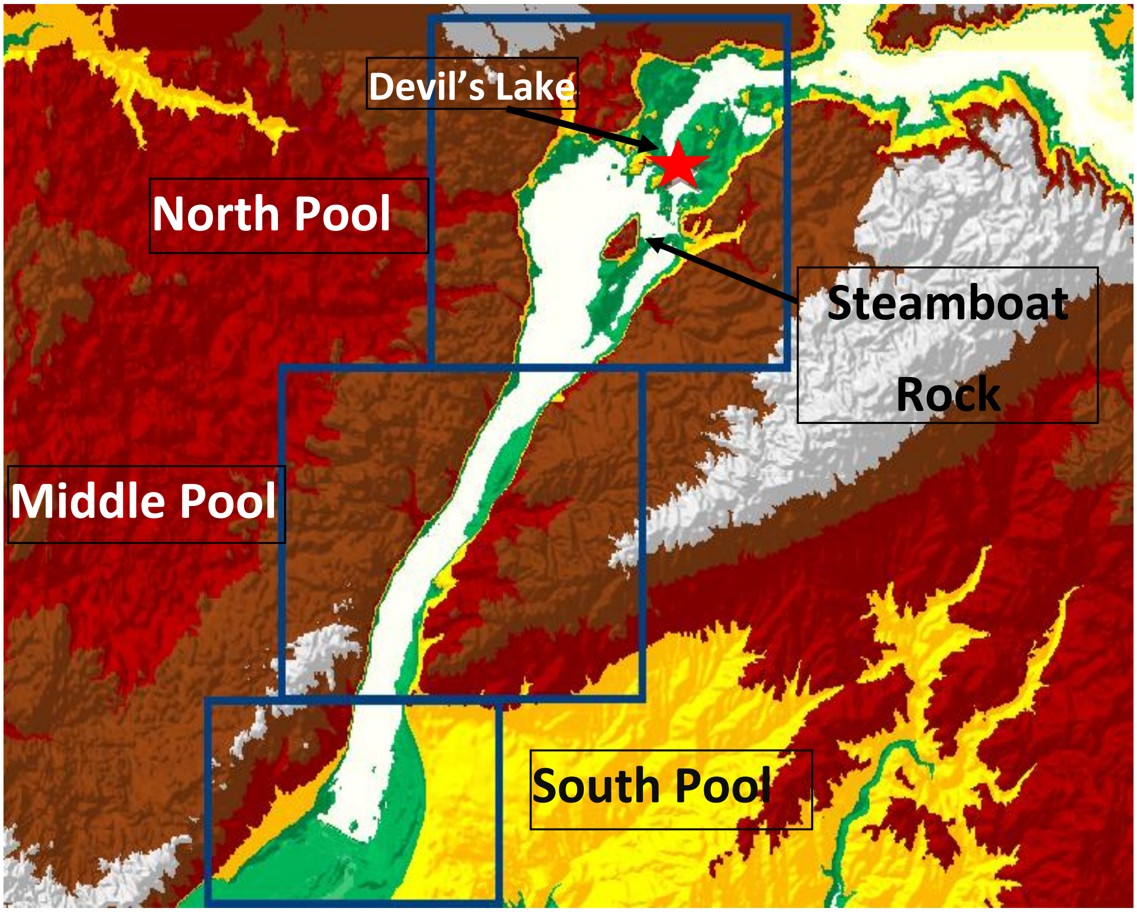


**Figure 3. Banks Lake sub-pools and Devil's Lake**

**Table 1. Banks Lake dimensions**

| | | |
|---|---|---|
| **Surface Area** | 108.81 km$^2$ | 10881 ha |
| **Shoreline Length** | 218 km | 135.5 mi |
| **Max Depth** | 54 m | 177 ft |
| **Mean Depth** | 14 m | 46 ft |
| **Max Volume** | 1.65 x 10$^9$ m$^3$ | 56.3 x10$^9$ ft$^3$ |
| **Length** | 43 km | 27 mi |

## Hydraulic Structures

Figure 4 shows a map of upper Columbia Basin Irrigation project with bodies of water and hydraulic structures of interest labeled.

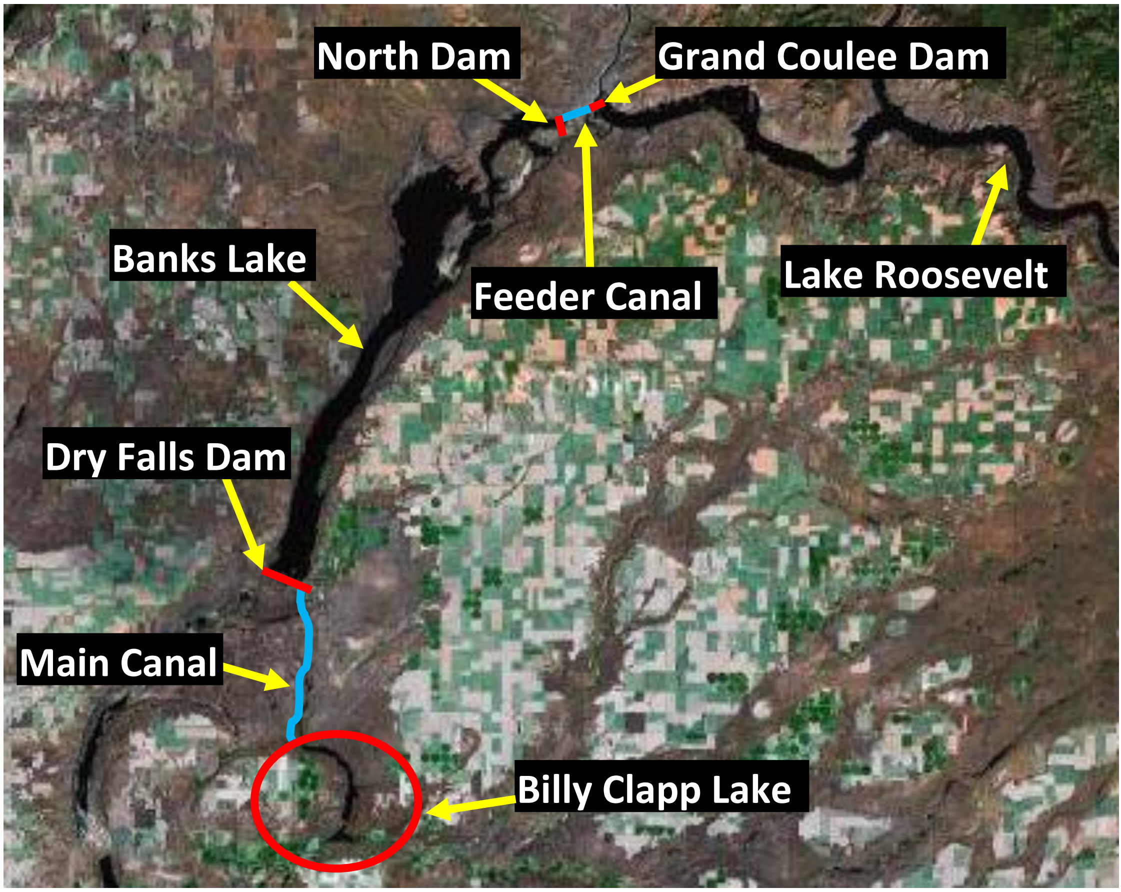


**Figure 4. Map of hydraulic structures within the greater extent of the Banks Lake study area**

## Feeder Canal & North Dam

Figure 5 shows the south end of the Feeder Canal draining into Banks Lake. The 24.4 m (80.1 ft) wide and 7.6 m (25 ft) deep concrete lined Feeder Canal spans the 2.9 km (1.8 mi) distance from the end of the pumping pipes to the head works of the North Dam. The Feeder Canal can operate at a maximum flow rate of 736.24 $m^3/s$ (26,000 cfs). The North dam is 442 m (1450 ft) long and has a crest height of 44.2 m (145 ft) at an elevation of 481.6 m (1580 ft) (NAVD88).

**Figure 5. Banks Lake Feeder canal, facing South**
**(Photo by Dr. Chris Berger)**

## Lake Roosevelt Pumping Plant

Water is drawn from Lake Roosevelt via 4.26 m (14 ft) diameter intake pipes and pumped uphill 83.5 m (274 ft) via twelve 3.66 m (12 ft) diameter pipes to the Banks Lake Feeder Canal. The center line of each pump's intake pipe is located at 363.74 m (1193.27 ft) (NAVD 88), providing 29.48 m (96.73 ft) of head when Lake Roosevelt is at full pool. Figure 6 shows a side view schematic of a generic pump/generator found at the pumping plant. Pumps one through six were installed at the beginning of operations in 1951, each rated at 65,000 horsepower and 45.31 $m^3/s$ (1600 cfs). Construction began in 1961 on what would become six additional pumps also capable of power generation through return flow to Lake Roosevelt. Pumps seven through nine were installed in 1973, pumps ten and eleven were installed in 1983 and pump twelve was installed in 1984. Pumps seven and eight are rated at 67,500 horsepower, 45.31 $m^3/s$ and are capable of producing 50 MW of electrical power. Pumps nine through twelve are rated at 70,000 horsepower, 45.45 $m^3/s$ and are able to produce 53.5 MW of electrical power. Table 2 shows the power rate, pumping rate, power generation potential and year of installation for all pumps. The total capacity for power generation at the Grand Coulee Pump Generating Plant is 314 MW.

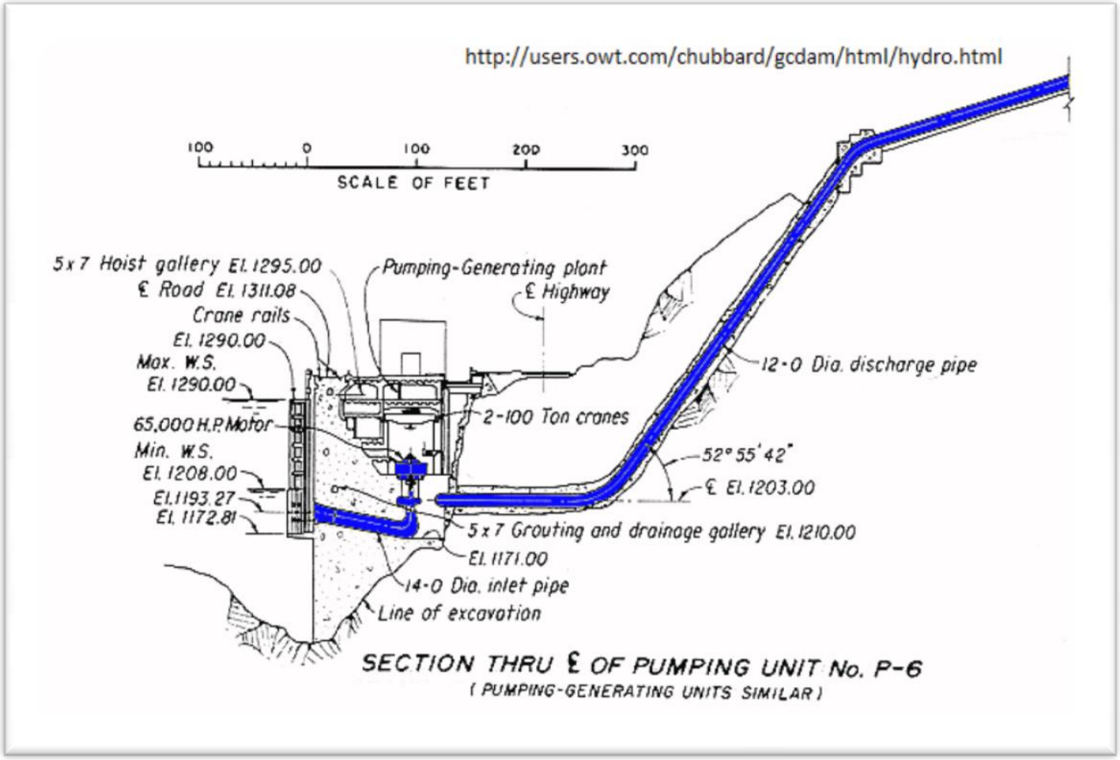

http://users.owt.com/chubbard/gcdam/html/hydro.html

**Figure 6. Side view of a generic pump/turbine from the Lake Roosevelt pumping plant (Hubbard, 1995)**

**Table 2. Lake Roosevelt pump summary**

| Pump # | Power Rating (hp) | Maximum Flow Rate ($m^3/s$) | Power Generation Potential (MW) | Year of Installation |
|---|---|---|---|---|
| 1 | 65,000 | 45.31 | 0 | 1951 |
| 2 | 65,000 | 45.31 | 0 | 1951 |
| 3 | 65,000 | 45.31 | 0 | 1951 |
| 4 | 65,000 | 45.31 | 0 | 1951 |
| 5 | 65,000 | 45.31 | 0 | 1951 |
| 6 | 65,000 | 45.31 | 0 | 1951 |
| 7 | 67,500 | 45.45 | 50 | 1973 |
| 8 | 67,500 | 45.45 | 50 | 1973 |
| 9 | 70,000 | 48.14 | 53.5 | 1973 |
| 10 | 70,000 | 48.14 | 53.5 | 1983 |
| 11 | 70,000 | 48.14 | 53.5 | 1983 |
| 12 | 70,000 | 48.14 | 53.5 | 1984 |

## Main Canal & Dry Falls Dam

Water used for irrigation exits the lake through Dry Falls Dam via the Main Canal at the southern end of the lake. During times of peak energy consumption flow can be diverted through the Dry Falls Dam spillway turbine for energy production. Dry Falls Dam is 2,987 m (9800 ft) long, has a crest height of 37.5 m (123 ft) at an elevation of 481.6 m (1580 ft) (NAVD 88) and supports a two lane highway. The unlined and concrete lined Main Canal is 29,612 m (18.4 miles) long and can support a maximum flow rate of 46.52 $m^3/s$ (19,300 cfs). Water leaving Banks Lake travels 2,896 m (1.8) down the Main Canal before entering the Bacon Siphon. The Bacon Siphon consists of two 1000 ft long siphons and two tunnels each two miles long which lead irrigation water underground to the Billy Clap Lake storage reservoir. Figure 7 and Figure 8 show a top view and a side view schematic of Dry Falls Dam and the headworks of the Main Canal.

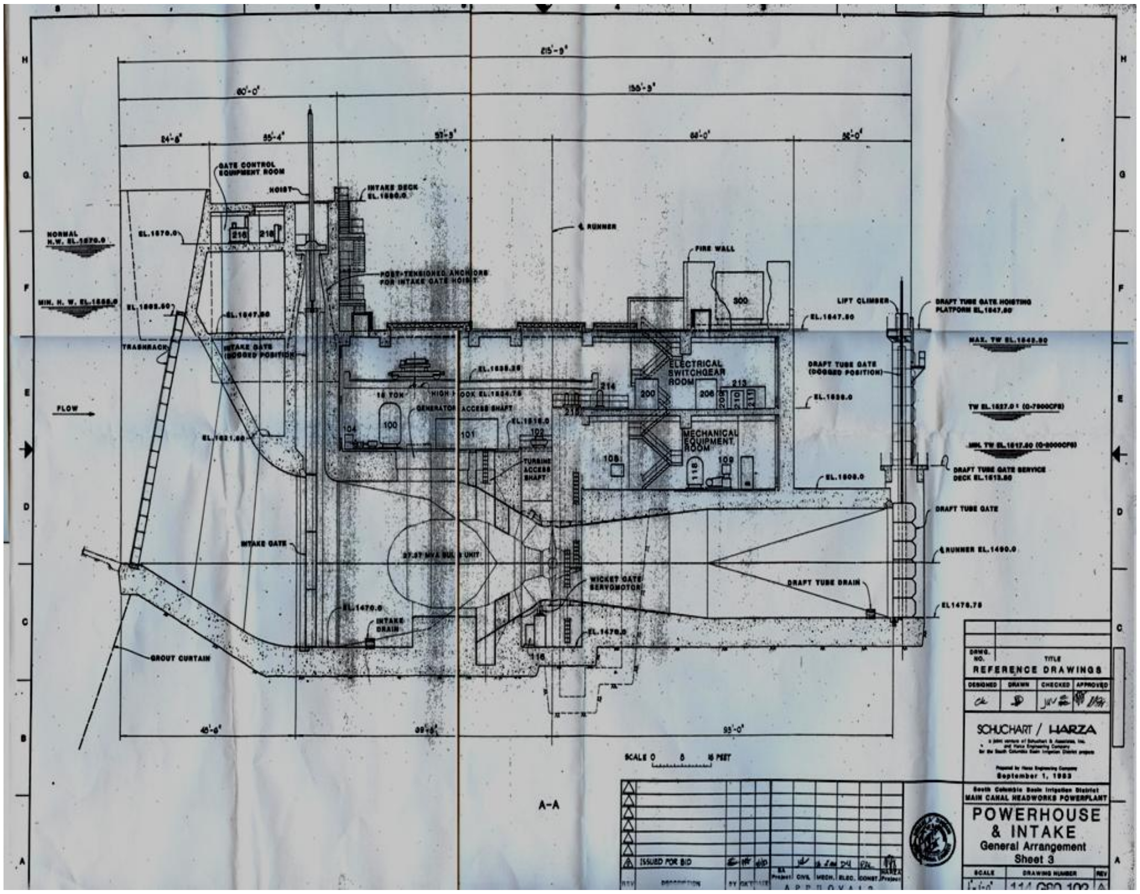


Figure 7. A side view schematic of the Dry Falls Dam powerhouse and the Main Canal headworks

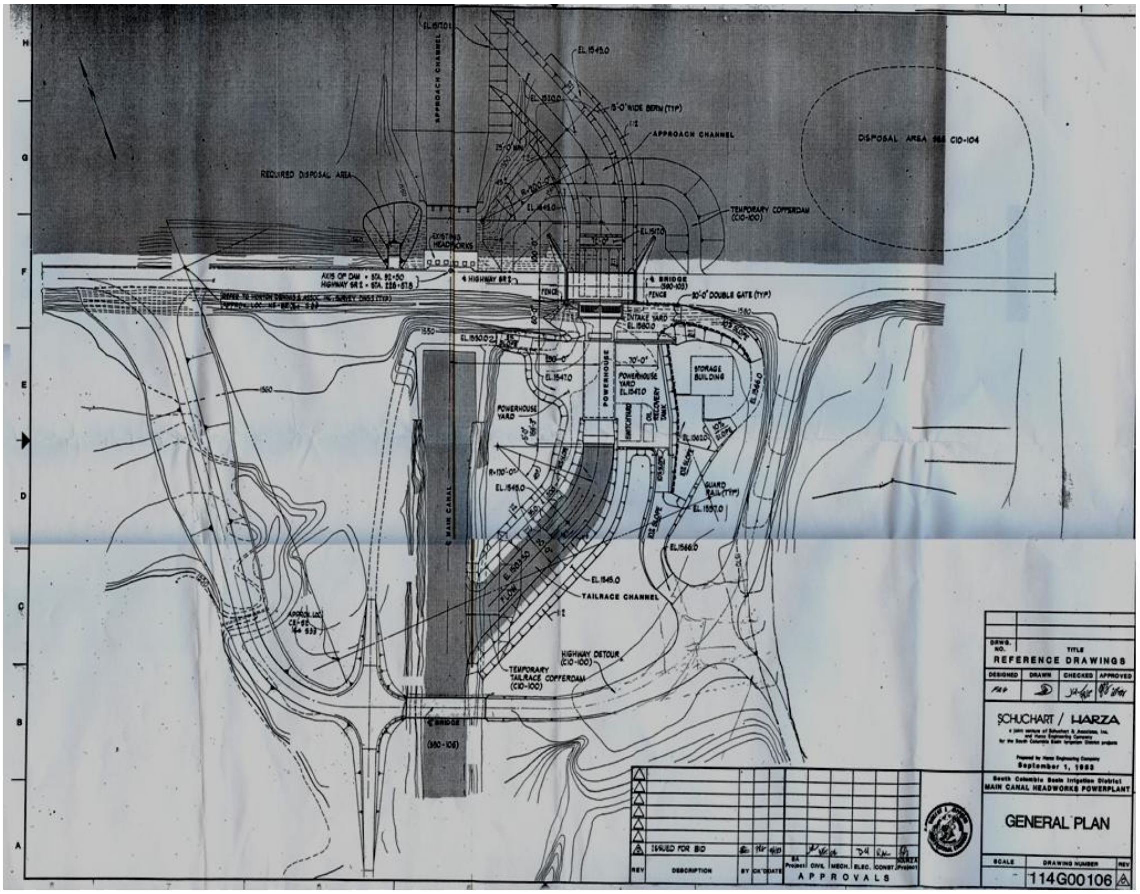


**Figure 8. A top view schematic of Dry Falls Dam and the Main Canal headworks**

## Work Impetus

The Odessa Subarea is located approximately 90 miles west of Spokane, Washington and is considered to be within the eastern boundary of Columbia Basin Project (CBP). The Washington State legislature officially recognized in 1967 that over pumping had led to significant declines of water table elevation and subsequently designated the Odessa Subarea as a groundwater management area. Continued irrigation pumping within the area has resulted in an overall decrease in the water table elevation and an increase in the surface extent of the affected land. Recent direction from the Washington State Legislature to the Washington State Department of Ecology (WDOE) to direct attention towards developing alternative water sources for users in the Odessa Subarea has prompted the development of a draft environmental impact statement (EIS) (USBR and WDOE, 2010). The EIS aims to evaluate the impact and feasibility of potential alternatives that would supply surface water for irrigation within the Odessa Subarea.

The draft EIS outlines eight potential action alternatives and one no-action alternative. The action alternatives are split into two groups: partial and complete irrigation of the Odessa Subarea. The partial alternatives (group 2) are estimated to irrigate 57,000 acres of land and the complete alternatives (group 3) to irrigate 102,600 acres of land. Groups 2 and 3 are further divided into 4 water source combinations, listed as water source A, B, C, and D. Table 3 shows the action alternatives and their water sources. Water source A uses only Banks Lake, source B uses a combination of Banks Lake and Lake Roosevelt water, source C involves Banks Lake and the use of a yet to be constructed retention reservoir named Rocky Coulee Reservoir and source D would use a combination of all three water bodies. Each action alternative is additionally mandated by the draft EIS to be evaluated under 4 flow years. The draft EIS outlines 1995 as an average flow year, 1982 as a wet flow year, 1998 as a dry flow year and 1931 as a drought flow year.

**Table 3. EIS action alternatives**

| | |
|---|---|
| Alternative 1 | No-Action Alternative |
| Alternative 2A | Partial-Banks |
| Alternative 2B | Partial-Banks+FDR |
| Alternative 2C | Partial-Banks+Rocky |
| Alternative 2D | Partial-Combined |
| Alternative 3A | Full-Banks |
| Alternative 3B | Full-Banks+FDR |
| Alternative 3C | Full-Banks+Rocky |
| Alternative 3D | Full-Combined |

This project will evaluate each of the 8 action alternatives under 4 flow years and the no-action alternative, for a total of 33 model runs. The CE-QUAL-W2 model will be used to assess the suitability of each management alternative for providing fish habitat and water quality.

The management scenarios will be assessed through evaluating the following:

1.) Percent of total reservoir volume that meets dissolved oxygen and temperature levels that agree with the optimal growth conditions for selected sport fish species

2.) Mass flow rate of zooplankton entrainment from Dry Falls Dam

3.) Effects of changing water surface elevations on temperature stratification

4.) Effects of management scenarios on the abundance of dissolved oxygen in the reservoir system

5.) Use of a fish bioenergetics model to evaluate output from CE-QUAL-W2 to predict fish growth in kokanee salmon (*Oncorhynchus nerka).*

## Overview of Models Used

### CE-QUAL-W2 Overview

CE-QUAL-W2 (Cole and Wells, 2010) is a two dimensional laterally averaged hydrodynamic and water quality model. Originally developed in 1975 as the LARM (Laterally Averaged Reservoir Model) by Edinger and Buchak (1975), the model's source code has steadily improved under the development of researchers, such as T. Cole and S. Wells, into a commonly used, powerful and open source hydrodynamic and water quality model. Modifications to the model have included improvements to computational efficiency and accuracy, transport and mixing schemes, as well as additional water quality algorithms, hydraulic structures and the ability to connect multiple water bodies. Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow water bodies exhibiting longitudinal and vertical water quality gradients such as Banks Lake.

•The application of CE-QUAL-W2 requires knowledge in the following areas according to Cole and Wells (2010):

1. Hydrodynamics
2. Aquatic biology
3. Aquatic chemistry
4. Numerical methods

5. Computers and FORTRAN coding
6. Statistics
7. Data assembly and reconstruction

•CE-QUAL-W2 includes the following state variables according to Cole and Wells (2010):

1. Water Temperature
2. any number of generic constituents defined by a 0th and/or a 1st order decay rate and/or a settling velocity and/or an Arrhenius temperature rate multiplier that can be used to define any number of the following:
a. conservative tracer(s)
b. water age or hydraulic residence time
c. coliform bacteria(s)
d. contaminant(s)
3. any number of inorganic suspended solids groups
4. any number of phytoplankton groups
5. any number of epiphyton groups
6. any number of CBOD groups
7. ammonium
8. bioavailable phosphorus (commonly represented by orthophosphate or soluble reactive phosphorus)
9. labile dissolved organic matter

10. refractory dissolved organic matter

11. labile particulate organic matter

12. refractory particulate organic matter

13. total inorganic carbon

14. alkalinity

15. total iron

16. dissolved oxygen

17. organic sediments

18. zooplankton

19.macrophytes

## Hydrodynamic & Water Quality Governing Equations

The governing equations are listed in Table 4.  Assumptions made are:

1. Incompressible fluid
2. Centripetal acceleration is a minor correction to gravity
3. Boussinesq approximation
4. Lateral homogeneity

**Table 4. CE-QUAL-W2 governing equations (Cole and Wells, 2010)**

| Equation | Governing Equation |
|---|---|
| x-momentum | $\frac{\partial UB}{\partial t}+\frac{\partial UUB}{\partial x}+\frac{\partial WUB}{\partial z}=gB\sin\alpha$<br>$+g\cos\alpha B\frac{\partial\eta}{\partial x}-\frac{g\cos\alpha B}{\rho}\int_{\eta}^{z}\frac{\partial\rho}{\partial x}dz+$<br>$\frac{1}{\rho}\frac{\partial B\tau_{xx}}{\partial x}+\frac{1}{\rho}\frac{\partial B\tau_{xz}}{\partial z}+qBU_{x}$ |
| z-momentum | $0=g\cos\alpha-\frac{1}{\rho}\frac{\partial P}{\partial z}$ |
| continuity | $\frac{\partial \mathrm{UB}}{\partial \mathrm{x}}+\frac{\partial \mathrm{WB}}{\partial \mathrm{z}}=\mathrm{qB}$ |
| state | $\rho=\mathrm{f}(\mathrm{T_w},\Phi_{\mathrm{TDS}},\Phi_{\mathrm{ss}})$ |
| free surface | $B_{\eta}\frac{\partial\eta}{\partial t}=\frac{\partial}{\partial x}\int_{\eta}^{h}UBdz-\int_{\eta}^{h}qBdz$ |
| Mass(heat) | $\frac{\partial\bar{c}}{\partial t}+\bar{u}\frac{\partial\bar{c}}{\partial x}+\bar{v}\frac{\partial\bar{c}}{\partial y}+\bar{w}\frac{\partial\bar{c}}{\partial z}=D\left[\frac{\partial^2\bar{c}}{\partial x^2}+\frac{\partial^2\bar{c}}{\partial y^2}+\frac{\partial^2\bar{c}}{\partial z^2}\right]$<br>$-\frac{\partial}{\partial x}\left(\overline{u'c'}\right)-\frac{\partial}{\partial y}\left(\overline{v'c'}\right)-\frac{\partial}{\partial z}\left(\overline{w'c'}\right)+\bar{S}$ |
| U = horizontal velocity m/s<br>W = vertical velocity m/s<br>B = channel width<br>p = pressure | Tx = x-direction lateral average shear stress<br>Ty = y-direction lateral average shear stress<br>ρ = density<br>η = water surface |

## Lake Roosevelt Fish Bioenergetics Model Review

This project desires to use the Lake Roosevelt fish bioenergetics model developed by McKillip (2008) to model fish growth in association with the CE-QUAL-W2 model output. The following covers a brief background of the bioenergetics model (Bevelhimer and Adams, 1993).

## Model Background

The overall goal of bioenergetics models is to adequately trace energy within an organism, from metabolism to growth to waste. In many ways, bioenergetics is treated like a mass balance equation. Equation 1 outlines the energy budget used in the Lake Roosevelt bioenergetics model (Kitchell, et al., 1977):

$$\mathbf{G = C-(R+F+U)} \qquad \textbf{Eq. 1}$$

where G ($g \cdot g^{-1} \cdot day^{-1}$) is the specific growth rate, C ($cal \cdot g^{-1} \cdot day^{-1}$) is the specific rate of consumption, R is the specific rate of respiration ($g \cdot g^{-1} \cdot day^{-1}$), F is the specific rate of egestion ($g \cdot g^{-1} \cdot day^{-1}$) and U is the specific rate of excretion ($g \cdot g^{-1} \cdot day^{-1}$). Most bioenergetics models either use known consumption rates to measure growth, or they use known growth rates to predict metabolism. Additional complications arise as use of bioenergetics models advance in complexity. Variability among typical species size, weight and metabolic costs are not factored into most bioenergetics models. Therefore the potential for large errors in predicting population growth does exist. In most situations, a bioenergetics model is considered successful if it is able to predict data values within a 50% error margin.

## Banks Lake Data Summary

This section summarizes available data used to develop the Banks Lake CE-QUAL-W2 model. Data used for this model focused on the calibration time period of 2002-2009. A more detailed description of the model data can be accessed from the report "Banks Lake Model: Boundary Conditions and Model Set-up (McCulloch, Berger and Wells, 2011) which contains:

- Physical Lake Description and Background
- Bathymetry Data and Grid Set-Up
- Hydraulic Boundary Conditions
- Water Temperature Boundary Conditions
- Water Quality Boundary Conditions
- Meteorological Data
- Dynamic Topographical Shading
- Abiotic Water Quality Data
- In-Lake nutrient Analysis
- Algae data
- Zooplankton Data
- Fish Data

## Bathymetry Data & Grid Development

The primary bathymetric data used to create the model grid was a USBR generated DEM file with a 5 meter resolution. Data used to develop the DEM was collected by the USBR prior to inundation during the 1940's via surface surveying methods. Original data was collected to develop five foot contours from the elevation of 1490 ft to 1530 ft and two foot contours from the elevation of 1530 ft to 1580 ft based on the NAVD 29 datum.

Processing the DEM file included converting the DEM raster file to a contour map using ArcGIS. The developed contour map was arranged in alignment with the UTM ZONE 11 N spatial coordinate projection (WGS84 datum) and NAVD 88 vertical datum.

The preliminary contour map displayed some irregularly shallow areas within the bathymetry data. Prior to the inundation of Banks Lake in 1951, several small lakes existed in the coulee. Figure 9 shows an aerial photograph of Devil's Lake and an adjacent lake prior to inundation. When surveyors collected the surface elevation data of the coulee used to develop the USBR DEM file in the 1940's, the land covered by these small lakes where assigned the surface elevation of their corresponding lake's shoreline. This assumption led to data loss in some areas of the DEM. The data loss was not significant in most areas, but all of Devil's Lake was found to be shallow. Additional 1-foot resolution bathymetric data were acquired via NAVIONICS HOT MAPS, an independent company that produces high resolution fishing maps. Using the NAVIONICS HOT MAPS as a guide, the Devil's lake bathymetry was repaired by hand digitizing correct bathymetry elevations. Figure 10 shows contour maps of Devil's Lake before and after the bathymetry data correction.

The updated bathymetry data was then used to develop the two-dimensional grid. The bathymetry contour map was delineated into one main branch extending the length of the lake from the Feeder Canal to the Main Canal. Nine complimentary branches that extend from the main branch through a cove to the shoreline were also delineated. Branch delineation was performed by hand digitizing the most likely path of flow through the thalweg. Using the branch delineation data and by specifying the direction of flow, the two-dimensional grid surface layer was created with 182 segments. Table 5 shows a summary of branch lengths and geometry. The surface grid laterally and longitudinally divides the two dimensional bathymetry data into individual and workable pieces. Figure 11 shows the model grid segments and the direction of flow covering part of branch 1 and all of branch 7 near Steamboat Rock. Each segment is a surface representation of the lake's bathymetry and represents an area which CE-QUAL-W2 assumes water quality constituents to be laterally and longitudinal homogenous.

The three dimensional grid was then created by adding depth to the newly developed two dimensional gird. Through selecting a maximum water surface elevation of 470 m (NAVD88) , minimum bathymetry elevation of 425 m(NAVD88) and using the bathymetry data contained within the two dimensional grid, a series of layers were added to each segment independent of other segments. Figure 12 and Figure 13 show a lateral view of branch 7 and the end view of the three dimensional grid, respectively. The final model grid consists of one meter deep cells that extend to the maximum depth of each segment as dictated by the bathymetry over laid by the two dimensional grid surface layer, resulting in a three dimensional representation of the Banks Lake bathymetry.

**Figure 9. USGS aerial photograph of Devil’s Lake prior to the creation of Banks Lake (Image taken from http://edcsns17.cr.usgs.gov/EarthExplorer/)**

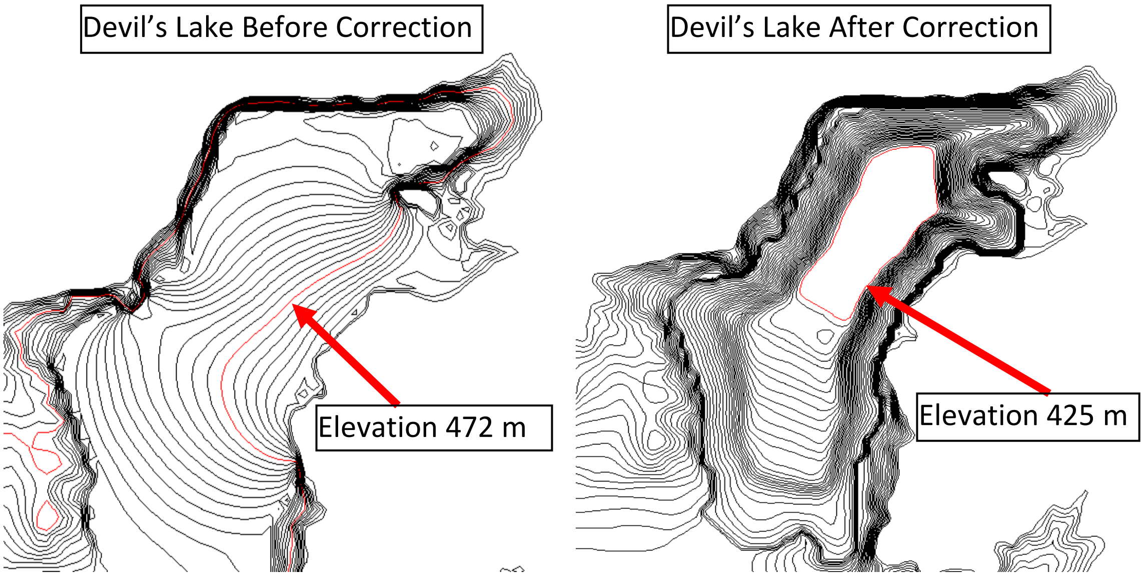


**Figure 10. Contour map of Devil’s Lake before and after correcting USBE bathymetry data**

**Table 5. Summary of model grid layout and dimensions**

| Branch # | Starting Segment | Ending Segment | Segment Length (m) | Branch Length (m) |
|---|---|---|---|---|
| 1 | 2 | 107 | 503.3 | 52850.7 |
| 2 | 110 | 117 | 536.2 | 3753.4 |
| 3 | 120 | 124 | 596.6 | 2386.4 |
| 4 | 127 | 131 | 536.0 | 2144.1 |
| 5 | 134 | 138 | 571.8 | 2287.2 |
| 6 | 141 | 144 | 441.0 | 1323.0 |
| 7 | 147 | 156 | 500.9 | 4507.8 |
| 8 | 159 | 162 | 259.9 | 779.6 |
| 9 | 165 | 169 | 295.6 | 1182.2 |
| 10 | 172 | 177 | 572.2 | 2861.1 |

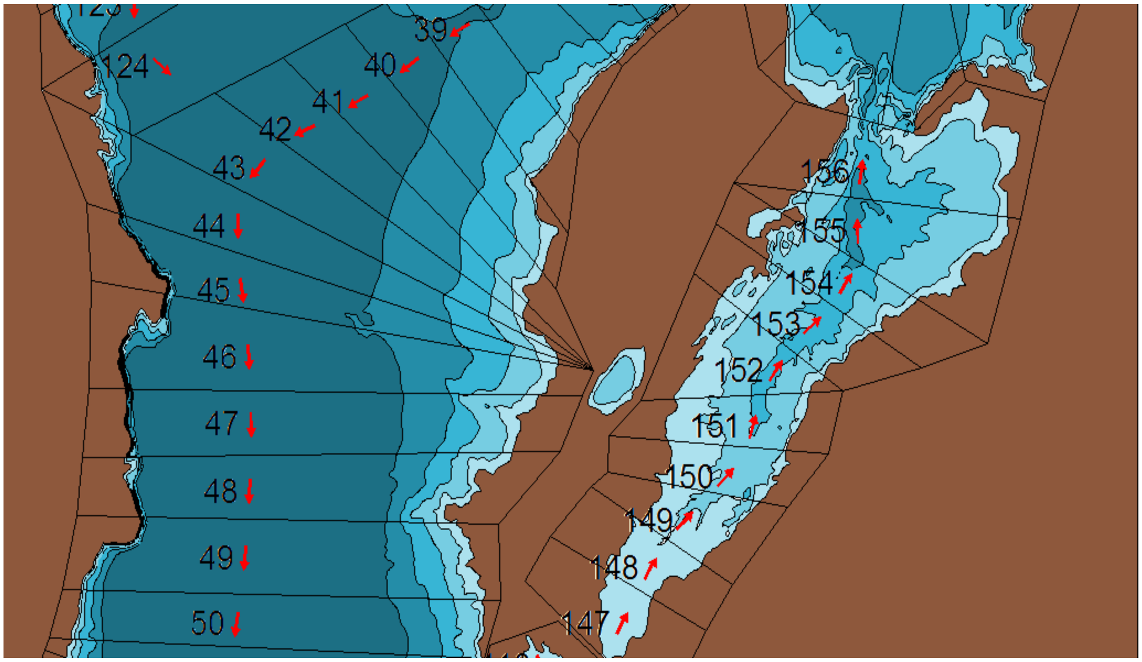


Figure 11. Close up view of the surface polygons with polygon numbers and direction of flow

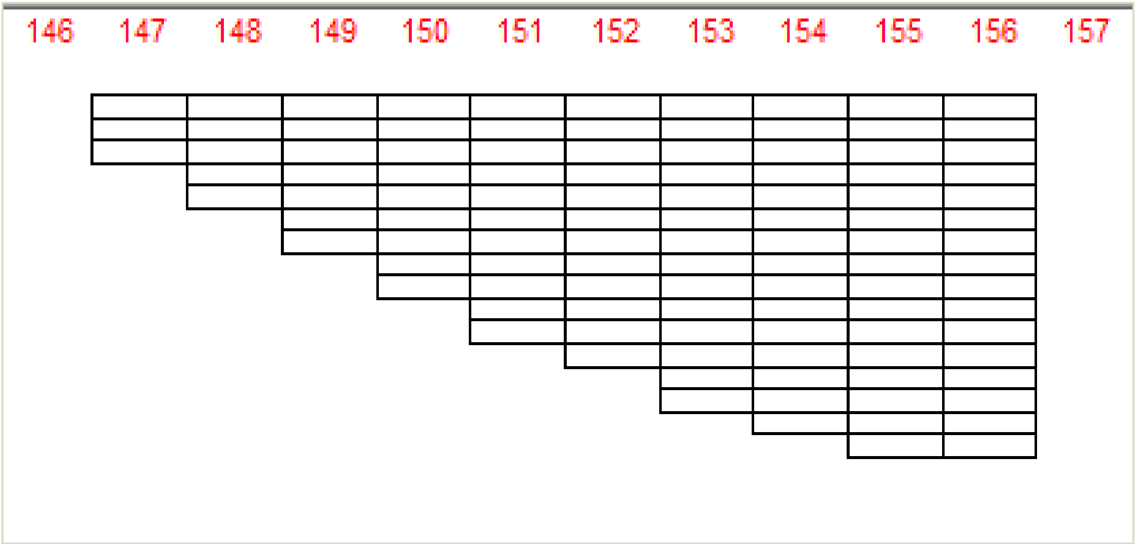


Figure 12. Model grid side view of branch 7

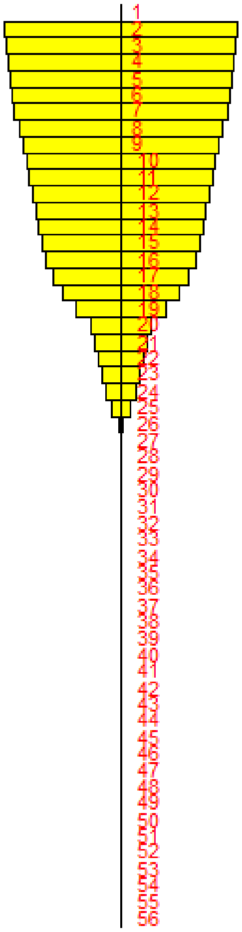


**Figure 13. Model grid end view**

### Hydraulic Boundary Conditions

Figure 14 shows the locations of flow gages on the boundary of Banks Lake. Table 6 lists the name, station ID, management agency, coordinates, data frequency and data range from each boundary condition flow gage.

Figure 14. Banks Lake flow gage locations

**Table 6. Banks Lake flow gage summary**

| Station Name | Station ID | Agency | Latitude | Longitude | Data Frequency | Data Range |
|---|---|---|---|---|---|---|
| **Feeder Canal** | 12435500 | *USGS | $47^o$ 57' 05" | $118^o$ 59' 40" | Daily | 1/1/2002-12/31/2009 |
| **Main Canal** | Main Canal | USBR | $47^o$ 37' 02" | $119^o$ 18' 00" | Sub-Hourly & Daily | 1/1/2002-12/31/2009 |

*Gage is registered as a USGS gage but data is collected by USBR

## Feeder Canal Inflow

Feeder Canal inflow data was collected as daily average flow ($m^3/s$). Source water for the Feeder Canal is withdrawn from Lake Roosevelt via the Lake Roosevelt Pumping Plant. Pumping is continuous from late March to late October with some rare days of zero flow. Occasionally pumping will occur during winter months. Pumping was most active in 2008 with 260 days of pumping. The highest volume of water was pumped in 2007 and 2008, both years having the highest annual average flow rate of 122 $m^3/s$. Peak flows took place mostly from late March to mid-July and ranged from 481.4 – 574.2 $m^3/s$. The average flow for days when flow was measured was highest in 2004 with 184.8 $m^3/s$ and lowest in 2006 with 168.4 $m^3/s$. Table 7 summarizes Feeder Canal flow rates and pumping time periods. Figure 15 shows Feeder Canal flow for 2008.

**Table 7. Feeder Canal inflow summary statistics**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| **Number of Days With Flow** | 237 | 236 | 223 | 235 | 237 | 241 | 260 | 237 |
| **Begin Flow Date** | 20-Mar | 14-Mar | 4-Apr | 27-Mar | 14-Mar | 7-Apr | 25-Mar | 14-Mar |
| **End Flow Date** | 23-Oct | 22-Oct | 3-Oct | 23-Oct | 18-Oct | 26-Oct | 5-Nov | 23-Oct |
| **Max Flow ($m^3/s$)** | 455.9 | 458.7 | 574.8 | 481.4 | 523.9 | 521 | 556.1 | 574.2 |
| **Annual Average Flow ($m^3/s$)** | 111.6 | 112.1 | 113.1 | 109.8 | 109.3 | 122 | 122 | 119.7 |
| **Average Flow When Flow Was Measured ($m^3/s$)** | 171.8 | 173.3 | 184.8 | 170.5 | 168.4 | 183.3 | 171.7 | 183.6 |

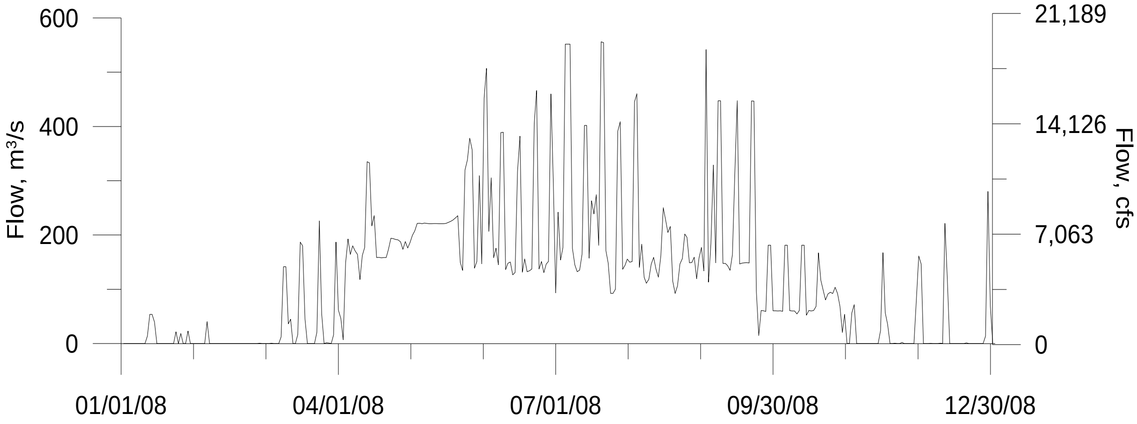


**Figure 15. Feeder Canal daily average inflow rates ($m^3/s$ & $ft^3/s$) 2008**

## Feeder Canal Return Flow

Feeder Canal return flow data was collected as daily average flow ($m^3/s$). Most of the return flow at the Feeder Canal took place during winter months with the exception of 2009 which had most of its flow between May and August. Continuous pumping normally lasted no more than one day, but occasionally reached up to four days. Return flow was most active in 2008 with 52 days of flow. The highest volume of water was pumped back to Lake Roosevelt in 2007 which had an annual average flow rate of 7.9 $m^3/s$. The average flow of days when flow was measured was highest in 2004 with 127.2 $m^3/s$ and lowest in 2008 with 10.9 $m^3/s$. Table 8 summarizes Feeder Canal return flow rates and days when return flow occurred. Figure 16 shows Feeder Canal return flow for 2008.

**Table 8. Feeder Canal return flow annual statistics**

| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
|---|---|---|---|---|---|---|---|---|
| **Number of Days With Flow** | 20 | 23 | 9 | 12 | 19 | 37 | 52 | 53 |
| **Max Flow ($m^3/s$)** | 148.1 | 199.4 | 229.4 | 129.1 | 202.2 | 243 | 108.5 | 166 |
| **Annual Average Flow ($m^3/s$)** | 3.1 | 4.6 | 3.1 | 1.2 | 4.1 | 7.9 | 1.5 | 6.8 |
| **Average of Days Flow Was Measured ($m^3/s$)** | 55.7 | 72.3 | 127.2 | 36.5 | 77.9 | 78 | 10.9 | 46.7 |

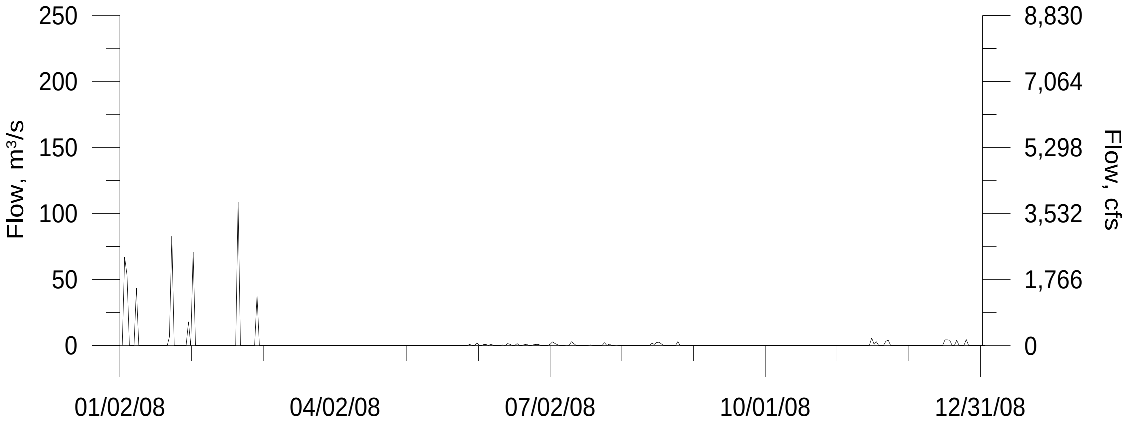


**Figure 16. Feeder Canal daily average return flow rates ($m^3/s$ & $ft^3/s$) 2008**

## Main Canal Outflow

Flow at the Main Canal is continuous from mid March to late October and was measured at a sub hourly time interval. Peak flows took place from mid-May to mid-August and ranged from 242.1 – 317.7 $m^3$/s. Average flow of days when flow was measured was highest in 2007 with 171.9 $m^3$/s and lowest in 2006 with 162.4 $m^3$/s. Table 9 summarizes Main Canal outflow rates and days when outflow occurred. Figure 17 shows Feeder Canal return flow for 2008.

**Table 9. Main Canal annual flow annual statistics**

| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
|---|---|---|---|---|---|---|---|---|
| **Number of Days With Flow** | 223 | 220 | 138 | 227 | 223 | 226 | 231 | 234 |
| **Flow Begin Date** | 15-Mar | 17-Mar | 13-Mar | 14-Mar | 17-Mar | 14-Mar | 12-Mar | 12-Mar |
| **Flow End Date** | 23-Oct | 23-Oct | 26-Oct | 26-Oct | 25-Oct | 25-Oct | 28-Oct | 31-Oct |
| **Max ($m^3$/s)** | 242.1 | 243.8 | 257.2 | 242.9 | 244.9 | 317.7 | 262.1 | 246.5 |
| **Annual Average ($m^3$/s)** | 165.2 | 169.8 | 170.4 | 161.8 | 161.6 | 171.1 | 168.2 | 165.5 |
| **Average of Days Flow Was Measured ($m^3$/s)** | 166.8 | 171.4 | 171.8 | 162.5 | 162.4 | 171.9 | 168.9 | 166.1 |

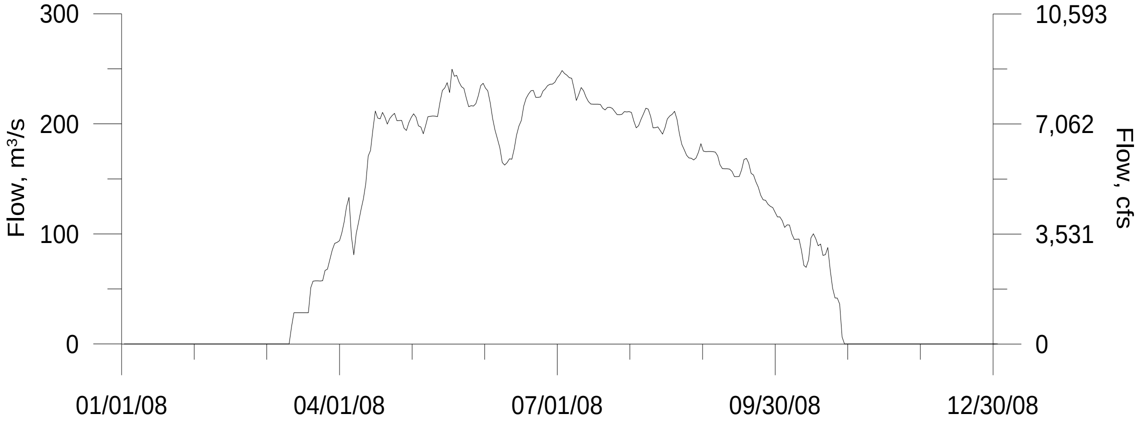


**Figure 17. Main Canal daily average flow rates ($m^3/s$ & $ft^3/s$) 2008**

## Water Surface Elevation

Water surface elevation data was collected daily by the USBR at the North Dam. Average annual water surface elevation was consistent around 478.0 meters (NAVD88) and daily data ranged from 476.7 – 478.5 meters (NAVD88). Table 10 summarizes the maximum, minimum and average water surface elevation for 2002-2009. Figure 18 shows daily water surface elevation for 2002-2009. Figure 19 shows daily water surface elevation for 2002 with the only water surface elevation data gap, which was filled by linear interpolation. Water surface elevation was steady during the first half of most years followed by a late summer drawdown beginning around August.

**Table 10. Banks Lake annual water surface elevation summary statistics (m-NAVD88)**

| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
|---|---|---|---|---|---|---|---|---|
| **Max** | 478.3 | 478.5 | 478.5 | 478.5 | 478.5 | 478.5 | 478.5 | 478.5 |
| **Min** | 477 | 477 | 476.7 | 476.9 | 477 | 477 | 477 | 476.5 |
| **Average** | 477.9 | 478 | 477.8 | 477.9 | 478 | 478 | 478 | 477.9 |

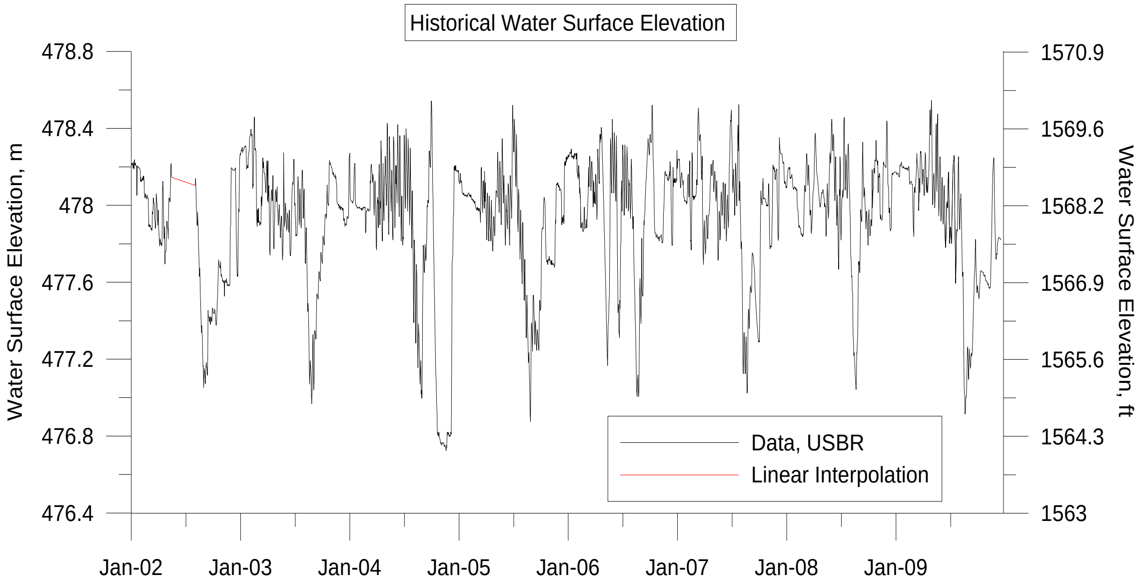


**Figure 18. Banks Lake daily average water surface elevation 2002-2009**

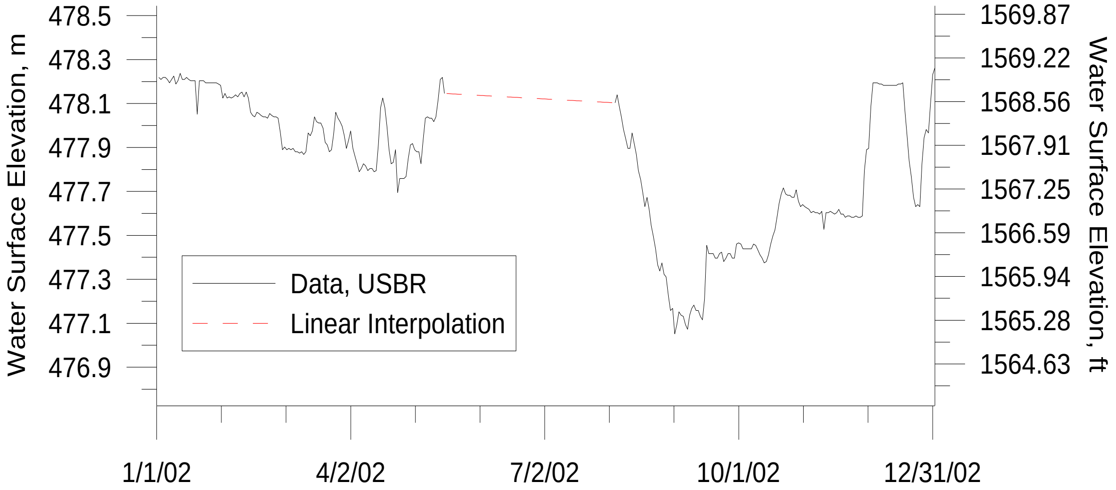


**Figure 19. Banks Lake daily average water surface elevation 2002-2004**

## Boundary Condition Water Temperature Data

Inflow water temperature was not available at the Feeder Canal, so water temperature at the Lake Roosevelt Pumping Plant intake pipes was estimated. To approximate water temperature at the depth from which the Lake Roosevelt Pumping Plant withdrawals water (29.6 m) (97.1 ft), a linear regression was fit between daily average surface water temperature data at hydromet station FDRW and water temperature profile data measured at the Spring Canyon Boat Ramp. Figure 20 shows the regression relationship between the surface water temperature at the Grand Coulee Dam forebay (FDRW) and water temperature measured from a depth of 30 meters at Spring Canyon. The regression between Lake Roosevelt forebay surface water temperature (FDRW) and Spring Canyon water temperature profile data was limited by the number of profile samples collected between 2002 and 2009. The regression used 81 points and yielded a goodness of fit of 0.98. From the regression equation a time series of daily average water temperatures at a depth of 30 m at the Grand Coulee dam was calculated.

This approach assumes that stratification/mixing processes are consistent longitudinally from hydromet station FDRW to Spring Canyon and laterally from the Lake Roosevelt Pumping Plant to the hydromet station FDRW. This approach also assumes that heat attenuation/cooling while the waters of Lake Roosevelt are in transit to the Banks Lake Feeder Canal is negligible

Lake Roosevelt surface water temperature was available from the hydromet station FDRW. Hydromet station FDRW is located at the forebay of Grand Coulee Dam, approximately 0.9 km (0.6 mi) east of the Lake Roosevelt Pumping Plant (Figure 21). Surface water temperature was measured at hourly time intervals for the entire 1/1/02 – 12/31/09 time period without data gaps. Table 11 shows the maximum, minimum and average surface water temperature at the Grand Coulee Dam forebay (FDRW).

The Spring Canyon boat ramp is located in a cove of Lake Roosevelt, approximately 4.2 km (2.6 mi) upstream from Grand Coulee Dam (Figure 21). Profile data were collected by the Spokane Tribes of Indians (STOI) on a monthly basis from 1/16/02 – 10/10/07. Figure 22 shows an isopleths plot of water temperature taken from Spring Canyon for 2002. Spring Canyon water temperature profile data show that the lower pool of Lake Roosevelt is typically isothermal from January to March and warms slowly until stratification begins to set in around mid June. Stratification temperatures of up to 20 $^{o}$C extended to depths of 80 meters in most years with temps of 22-24 $^{o}$C present within the upper 10 meters of the epilimnion. The stratification process was less pronounced in 2007.

Table 12 shows the maximum, minimum, average and average deviation of the calculated water temperature values from the measured surface water temperature data collected at the Grand Coulee Dam forebay. Figure 23 shows the Grand Coulee Dam forebay surface water temperature with the calculated water temperature at the intake to the Lake Roosevelt Pumping Plant for 2002. Grand Coulee Dam forebay surface water temperatures ranged from 1.5 – 25 °C.  Temperatures calculated at the Lake Roosevelt Pumping Station intake pipes were typically 0.5°C cooler and followed a similar annual trend to the forebay temperature data.  Annual average forebay water temperature ranged from 11-11.5 °C, except for 2002 which had a cooler average temperature of 10.4 °C. The regression equation accurately shows this drop in annual average water temperature in the calculated annual average water temperature for 2002.

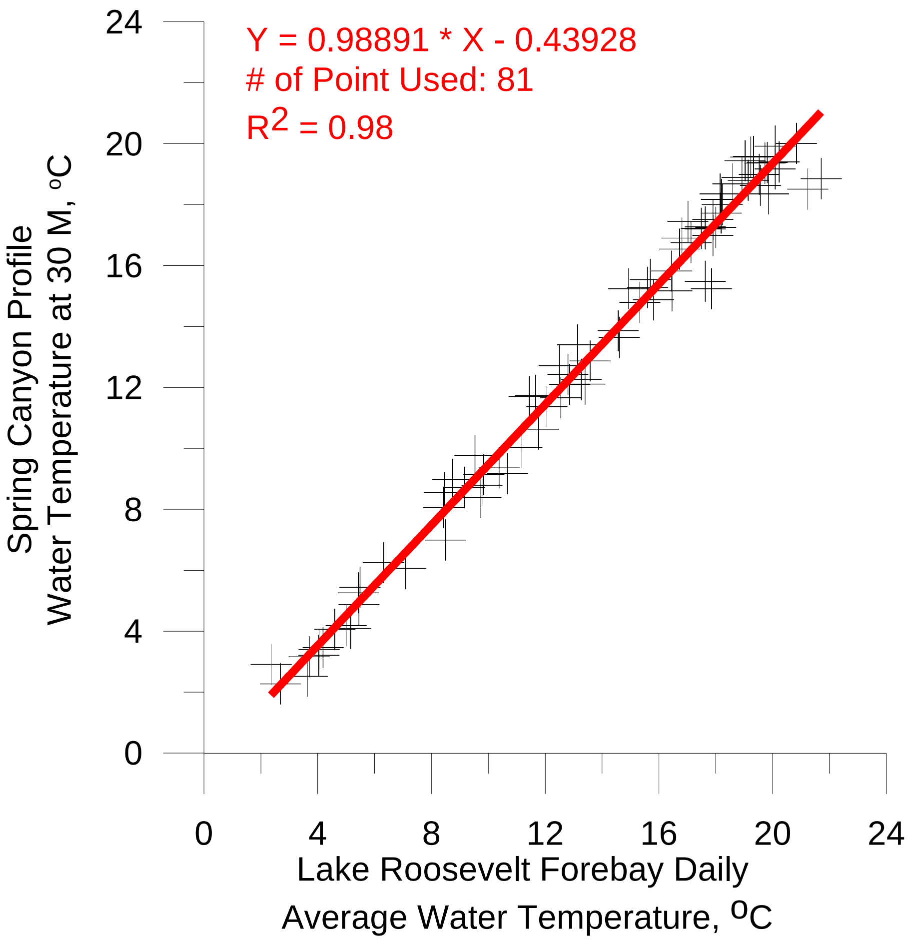


**Figure 20. Linear regression used to predict feeder canal inflow temperatures where Y is Spring Canyon water temperature (°C) at a depth of 30 meters and Y is the Grand Coulee Dam forebay daily average surface water temperature (°C)**

**Table 11. Lake Roosevelt Dam forebay surface water temperature ($^oC$) annual summary statistics**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 18.8 | 24 | 25 | 23.5 | 21.7 | 21.2 | 21.8 | 22.8 |
| Min | 2.5 | 3.3 | 2.2 | 2.8 | 3.4 | 2.1 | 2.1 | 1.5 |
| Average | 10.4 | 11.6 | 11.9 | 11.5 | 11.7 | 11.3 | 11.1 | 11.2 |

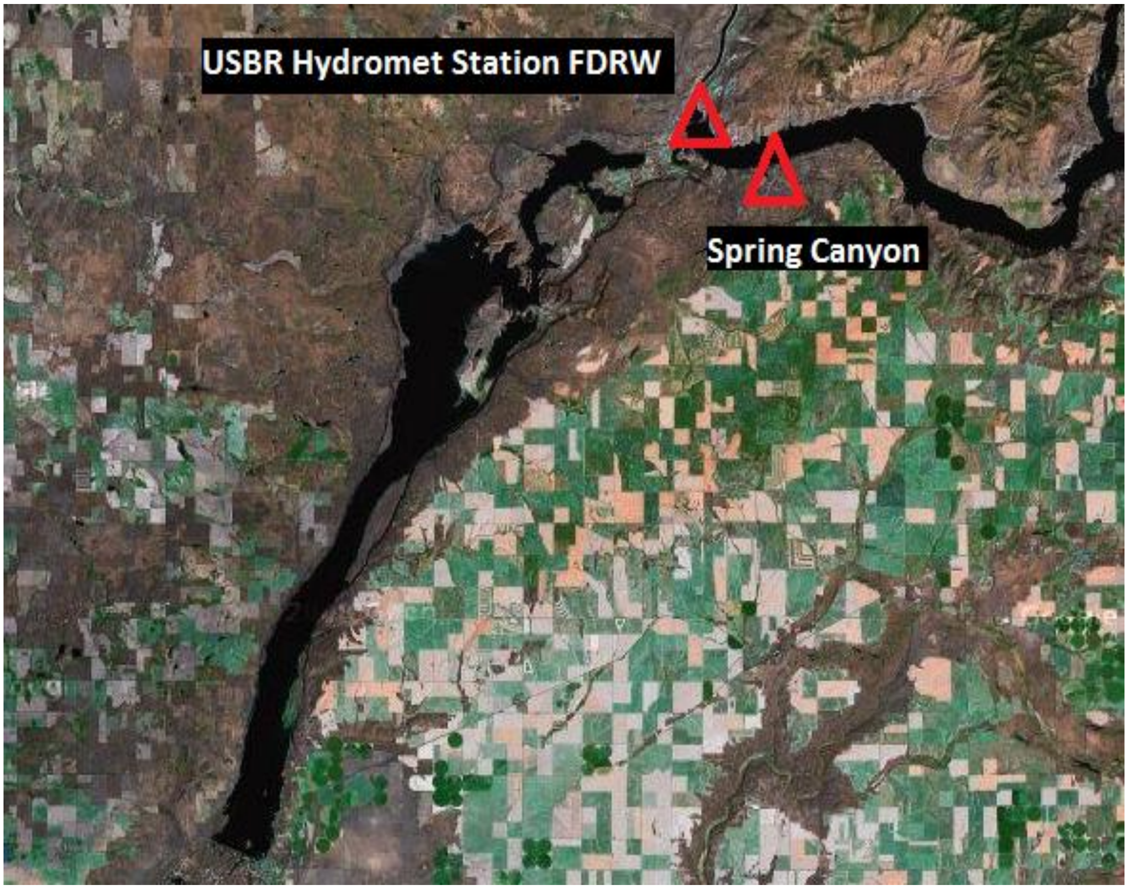


**Figure 21. Boundary condition temperature gages**

**Table 12. Annual summary statistics for the calculated water temperature ($^oC$) at the intake to the Lake Roosevelt pumping plant**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 18.2 | 23.3 | 24.3 | 22.8 | 21 | 20.5 | 21.1 | 22.1 |
| Min | 2 | 2.8 | 1.7 | 2.3 | 2.9 | 1.6 | 1.6 | 1 |
| Average | 9.9 | 11.1 | 11.3 | 11 | 11.1 | 10.8 | 10.6 | 10.6 |
| Average Difference from Observed Forebay Temperature | -0.55 | -0.57 | -0.57 | -0.57 | -0.57 | -0.57 | -0.56 | -0.56 |

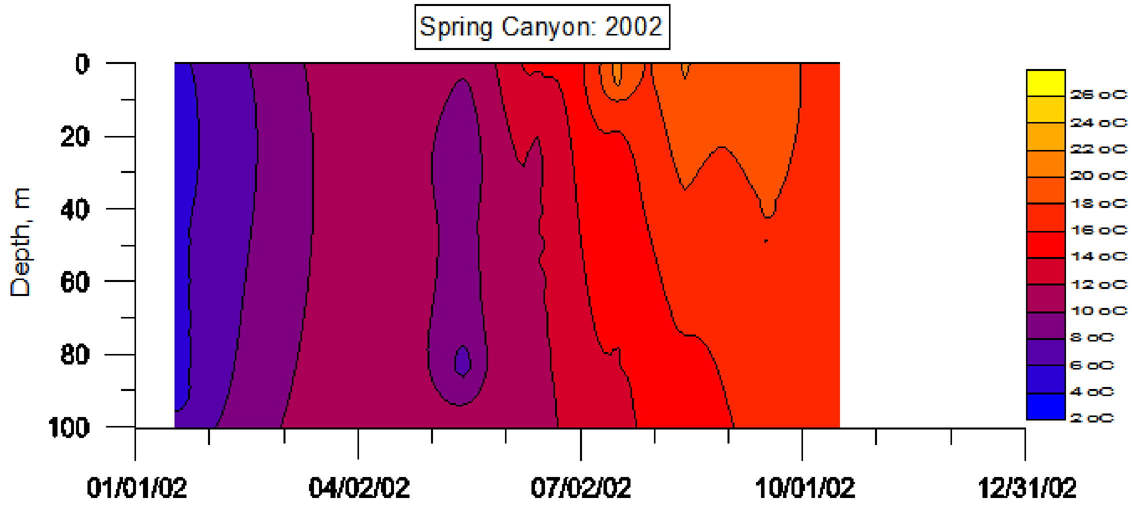


**Figure 22. Spring Canyon water temperature (°C) isopleths 2002**

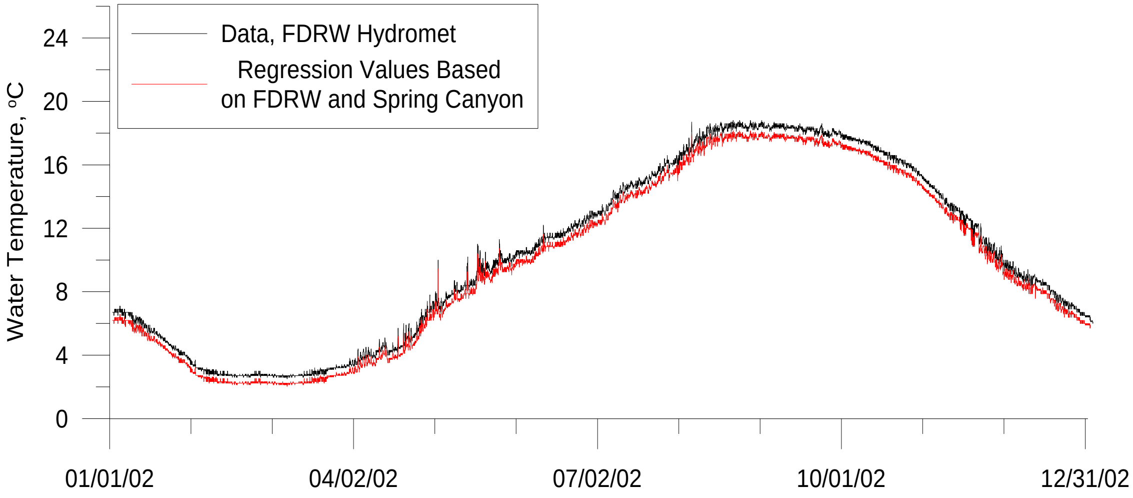


**Figure 23. Surface water temperature (°C) for hydromet station FDRW and calculated inflow temperatures (°C) at the Lake Roosevelt Pumping Plant 2002**

## Meteorological Data

Meteorological data were gathered from four AGRIMET weather stations: Grand Coulee Dam (GCDW), Odessa (ODSW) Dry Falls Dam (DRYW) and Manson (MASW) (Table 13). AGRIMET is a satellite based network of automated weather stations operated and maintained by the U.S. Bureau of Reclamation. Figure 24 shows the proximity of these AGRIMET stations to Banks Lake. The Odessa, Manson and Grand Coulee Dam AGRIMET stations are 56.8 km (35.3 mi), 69.6 km (43.2 mi) and 44.5 km (27.6 mi) from the Dry Falls Dam AGRIMET station, respectively.

**Table 13. AGRIMET stations summary**

| Station Location | Station ID | Agency | Elevation, m (NAVD88) | Latitude | Longitude | Meteorological Parameters |
|---|---|---|---|---|---|---|
| Grand Coulee Dam, WA | GCDW | AGRIMET (Bureau Of Reclamation) | 402.3 | 47.945278 | 118.95361 | Air Temperature, Humidity, Wind Speed, Wind Direction, Precipitation, Solar Radiation |
| Dry Falls Dam | DRYW | AGRIMET (Bureau Of Reclamation) | 376.4 | 47.614167 | 119.29917 | Air Temperature, Wind Speed, Wind Direction, Precipitation |
| Odessa, WA | ODSW | AGRIMET (Bureau Of Reclamation) | 502.9 | 47.312778 | 118.8725 | Air Temperature, Humidity, Solar Radiation, Wind Speed, Wind Direction |
| Manson, WA | MASW | AGRIMET (Bureau Of Reclamation) | 601.1 | 47.917222 | 120.13167 | Humidity |

The majority of meteorological data were gathered as hourly data from the Grand Coulee Dam AGRIMET station from 4/16/02 through 12/31/09. The GCDW station had the most complete record of hourly data of all AGRIMET stations located near Banks Lake. Limited meteorological data was available at DRYW from 4/1/07 to 7/9/2009. Meteorological data gathered from DRYW superseded the use of data collected at GCDW due to the proximity of the DRYW AGRIMET station to the main body of Banks Lake. Small data gaps were filled using linear interpolation. Larger gaps were filled with data generated by linear regressions between GCDW and the ODSW AGRIMET station or the MASW AGRIMET station; other substantial data gaps where linear regressions were not appropriate were filled by direct data substitution from other AGRIMET stations.

Statistical summaries of complete meteorological data records are provided for air temperature (Table 14), relative humidity (Table 15), dew point temperature (Table 16), wind speed (Table 17), cloud cover ( Table 18), shortwave solar radiation (Table 19) and cumulative annual precipitation (Table 20).

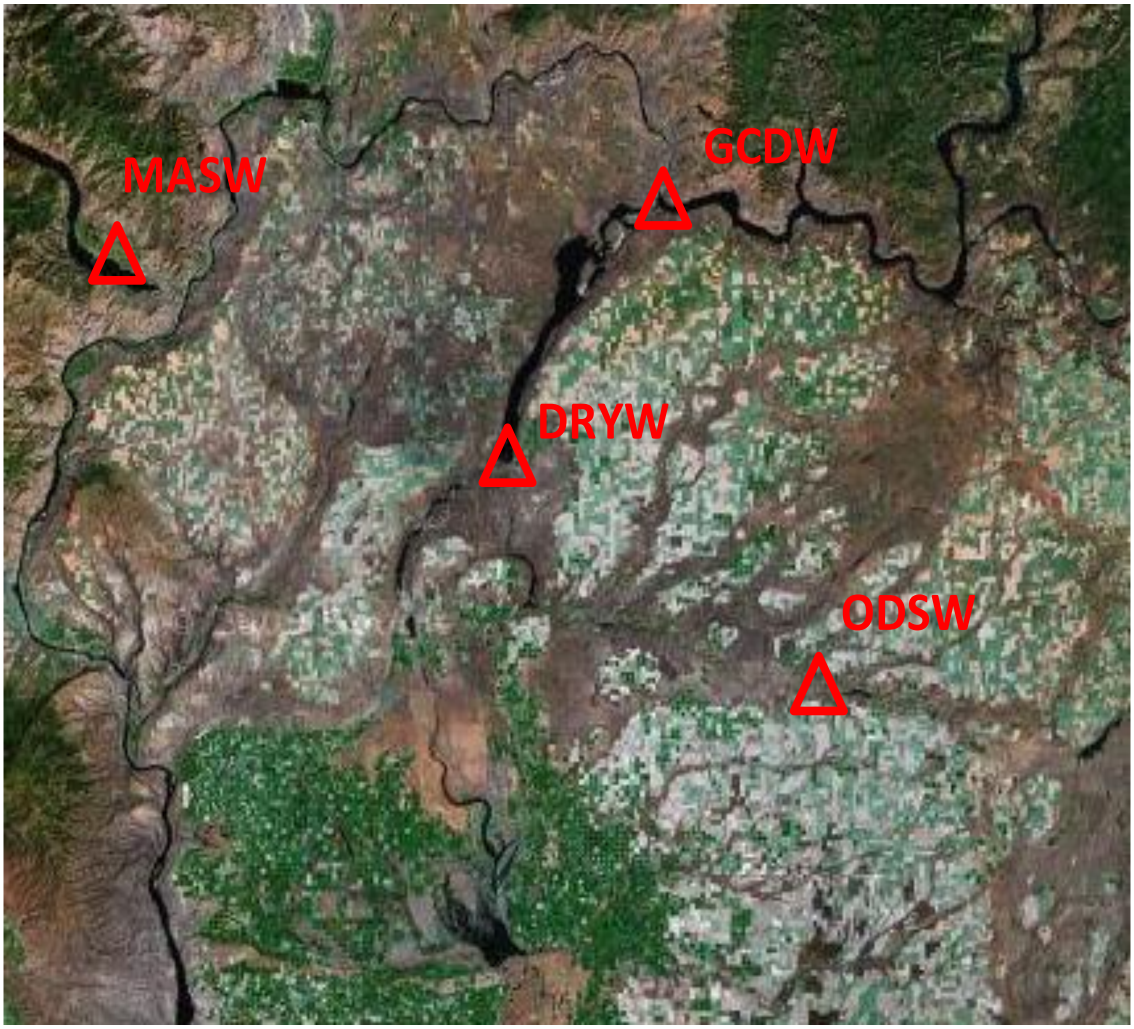


**Figure 24. AGRIMET weather station locations**

**Table 14. Banks Lake air temperature ($^{o}$C) summary statistics 2002-2009**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 40.5 | 39.5 | 39.3 | 37.2 | 41.5 | 39.8 | 41 | 38.6 |
| Min | -5.2 | -8.1 | -24 | -16.1 | -14.3 | -12 | -17.3 | -12.8 |
| Median | 10.8 | 11 | 11.6 | 11.1 | 10.6 | 10.8 | 10.1 | 9.7 |
| Average | 12.19 | 12.05 | 12.04 | 11.21 | 11.79 | 11.41 | 10.67 | 10.86 |

**Table 15. Relative humidity (%) summary statistics**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.7 |
| Min | 10.1 | 9.4 | 11.8 | 9.5 | 8.7 | 9.1 | 9.3 | 7.2 |
| Median | 65 | 63.6 | 65.8 | 67.5 | 67.1 | 61.5 | 59.3 | 60.2 |
| Average | 63.8 | 62.7 | 63.7 | 65 | 64.2 | 60.4 | 58.9 | 59.1 |

**Table 16. Calculated dew point temperature ($^o$C) summary statistics**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 17.9 | 19.9 | 22.5 | 5.58 | 18.1 | 17.6 | 16.9 | 16.2 |
| Min | -4.6 | -7.4 | -18.7 | -14.1 | -9.6 | -10.6 | -12.2 | -10.3 |
| Median | 5.7 | 5.6 | 5.9 | 5.8 | 5.7 | 5.2 | 4.6 | 4.6 |
| Average | 5.88 | 5.52 | 5.83 | 5.58 | 5.65 | 4.81 | 4.3 | 4.37 |

**Table 17. Wind speed (m/s) statistics summary**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 38.45 | 10.28 | 9.52 | 1.8 | 8.69 | 19.84 | 10.53 | 12.19 |
| Min | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 | 0 |
| Median | 1.79 | 1.51 | 1.44 | 1.53 | 1.51 | 0.8 | 1.62 | 1.76 |
| Average | 2.17 | 1.82 | 1.75 | 1.8 | 1.82 | 1.29 | 1.97 | 2.06 |

**Table 18. Cloud cover data calculated from solar data (W/m$^2$) 2002-2009**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 10 | 10 | 10 | 4.56 | 10 | 10 | 10 | 10 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 3.62 | 4.43 | 4.19 | 3.91 | 3.86 | 2.37 | 2.39 | 1.47 |
| Average | 4.35 | 4.69 | 4.51 | 4.56 | 4.56 | 4.28 | 4.16 | 4.1 |

**Table 19. Short wave solar radiation (W/m$^2$) summary statistics 2002-2009**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Max | 984.6 | 984.6 | 1017 | 169.1 | 1057 | 1019 | 1068 | 1003 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 10.6 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.6 | 8.6 |
| Average | 169.6 | 166.2 | 165.8 | 169.1 | 169.5 | 170.6 | 170.9 | 173 |

**Table 20. Annual precipitation (cm) summary statistics**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| Rainfall | 13.71 | 16.78 | 17.7 | 29.74 | 31.03 | 14.88 | 11.43 | 17.62 |

### Topographical and Vegetative Shading

CE-QUAL-W2 is able to calculate the amount of topographic and vegetative shading that takes place on Banks Lake. Referencing Figure 25, when the angle of solar inclination ($\alpha$) is less than that of the angle of topographical or vegetative inclination ($\alpha_t$) the model will reduce short wave solar radiation intensity by 90%, leaving 10% to account for diffuse radiation. Figure 26 shows the maximum, minimum and average angles of inclination of Banks Lake while traveling downstream from the Feeder Canal. This feature is useful for water bodies surrounded by mountains or water bodies located within deep canyons, such as Banks Lake. Due to the lack of shoreline vegetation surrounding Banks Lake, vegetative shading was not considered in the model. Further discussion on CE-QUAL-W2 topographical shading is available in Cole and Wells (2010).

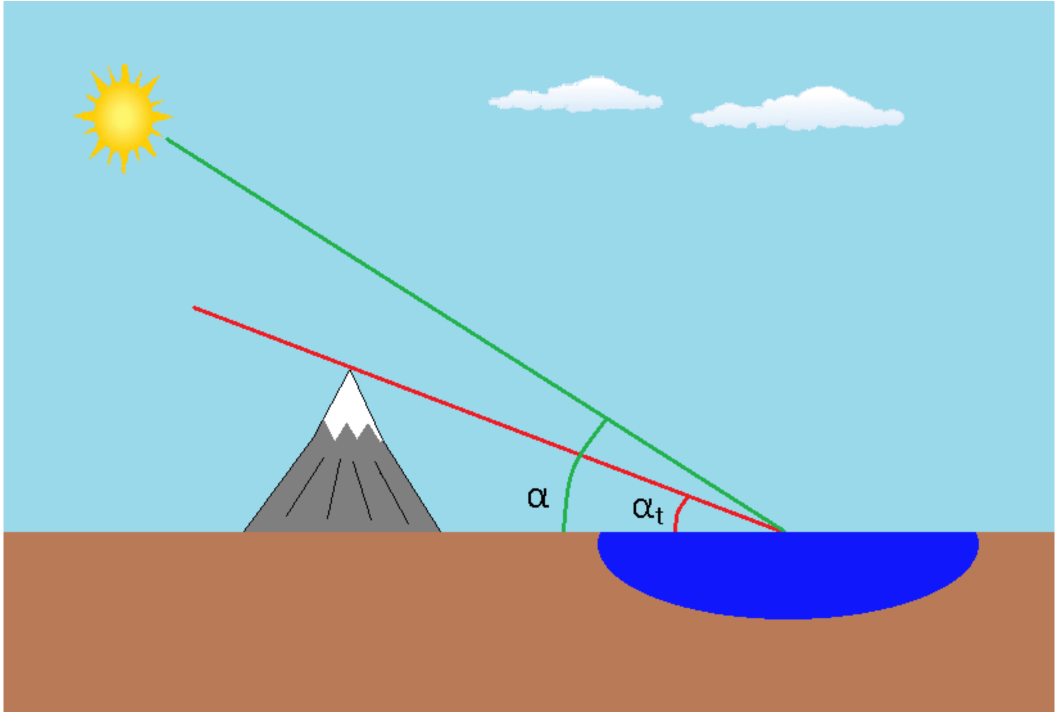


Figure 25. CE-QUAL-W2 dynamic topographic shading angles diagram

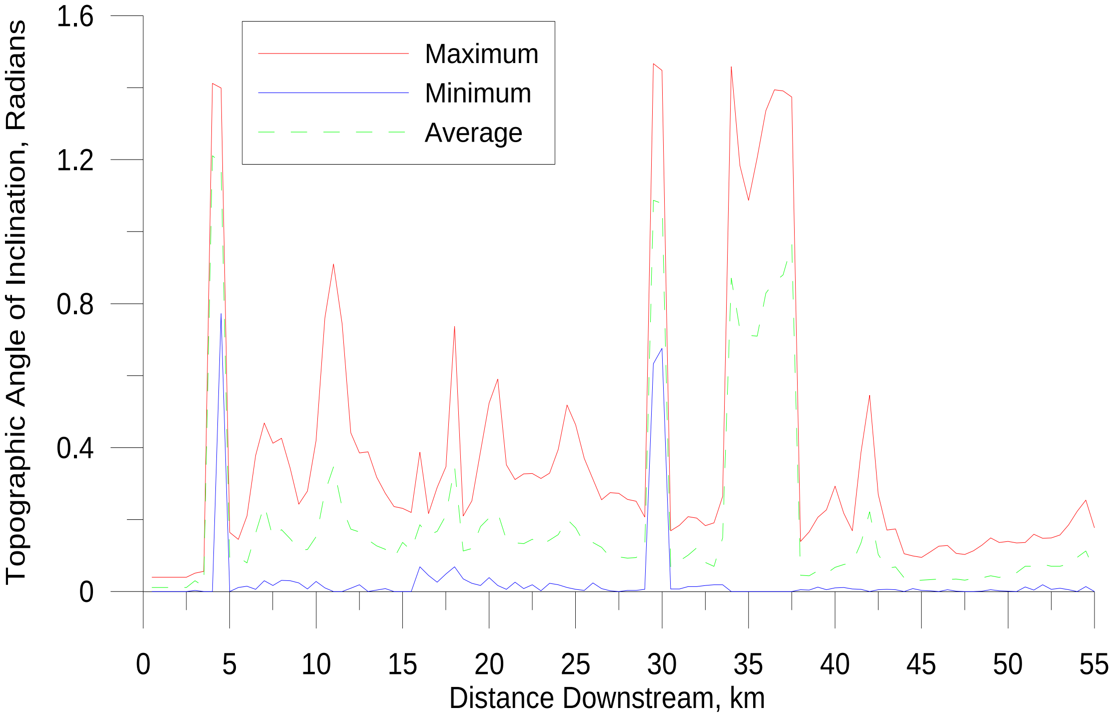


Figure 26. Banks Lake maximum, minimum and average angles of inclination moving downstream from the Feeder Canal

## Water Quality Data

Water quality data that were relevant to the development and evaluation of the Banks Lake CE-QUAL-W2 model were shown in McCulloch, Berger and Wells (2011).

In-reservoir water quality profile data and chlorophyll-a data were collected by the WDFW during 2002, 2003, 2008 and 2009. Profile data were measured on a monthly to bimonthly basis from April to December with occasional profiles taken in January. Profile data were gathered from eleven sample sites throughout Banks Lake. Table 21 and Figure 27 show the location of the WDFW sample sites.

In-reservoir orthophosphorus, nitrate and chlorophyll-a data were collected by Dr. Ross Black of Eastern Washington University (EWU) from 2002 through 2004 (Black et al., 2008). Sampling frequency was site specific, but most sites were sampled on a monthly to bi-monthly basis during spring, summer and fall months. In-reservoir nitrate, orthophosphorus and chlorophyll-a data were sampled from the same sites used by the WDFW, so for the purpose of this report these sample sites will be referred to as Lim sites 1-11.

**Table 21. WDFW Banks Lake water quality sampling sites**

<table>
<tr><th colspan="6">In-Reservoir Sampling Sites</th></tr>
<tr><th colspan="6">Washington State Department of Fish and Wildlife</th></tr>
<tr><th>Station</th><th>Site Name</th><th>Latitude</th><th>Longitude</th><th>Start</th><th>End</th></tr>
<tr><td>Lim 1</td><td>North Basin</td><td>47.935036</td><td>-119.067857</td><td>2/21/2002</td><td>12/3/2009</td></tr>
<tr><td>Lim 2</td><td>Kruk's Bay</td><td>47.897731</td><td>-119.089652</td><td>6/4/2003</td><td>11/5/2009</td></tr>
<tr><td>Lim 3</td><td>Mid-Reservoir</td><td>47.884251</td><td>-119.138469</td><td>2/21/2002</td><td>12/3/2009</td></tr>
<tr><td>Lim 4</td><td>Devil's Punch Bowl</td><td>47.858729</td><td>-119.112952</td><td>6/4/2003</td><td>12/3/2009</td></tr>
<tr><td>Lim 5</td><td>Million Dollar Mile North</td><td>47.729784</td><td>-119.261919</td><td>2/21/2002</td><td>12/3/2009</td></tr>
<tr><td>Lim 6</td><td>Goose Island-Southwest</td><td>47.664420</td><td>-119.301624</td><td>6/4/2003</td><td>12/3/2009</td></tr>
<tr><td>Lim 7</td><td>Devil's Lake</td><td>47.896469</td><td>-119.115290</td><td>5/8/2008</td><td>12/3/2009</td></tr>
<tr><td>Lim 8</td><td>Osborne Bay</td><td>47.928174</td><td>-119.060059</td><td>4/24/2008</td><td>12/3/2009</td></tr>
<tr><td>Lim 9</td><td>Million Dollar Mile South</td><td>47.831916</td><td>-119.179253</td><td>5/8/2008</td><td>12/3/2009</td></tr>
<tr><td>Lim 10</td><td>Middle Barrier Net</td><td>47.621845</td><td>-119.298556</td><td>4/24/2008</td><td>12/3/2009</td></tr>
<tr><td>Lim 11</td><td>S. Tern Island on Barrier</td><td>47.621667</td><td>-119.306959</td><td>5/8/2008</td><td>12/3/2009</td></tr>
<tr><th colspan="6">Eastern Washington State University</th></tr>
<tr><td>Lim 1</td><td>North Basin</td><td>47.935036</td><td>-119.067857</td><td>4/23/2002</td><td>8/19/2004</td></tr>
<tr><td>Lim 2</td><td>Kruk's Bay</td><td>47.897731</td><td>-119.089652</td><td>6/4/2003</td><td>8/19/2004</td></tr>
<tr><td>Lim 3</td><td>Mid-Reservoir</td><td>47.884251</td><td>-119.138469</td><td>4/23/2002</td><td>8/19/2004</td></tr>
<tr><td>Lim 4</td><td>Devil's Punch Bowl</td><td>47.858729</td><td>-119.112952</td><td>6/4/2003</td><td>8/19/2004</td></tr>
<tr><td>Lim 5</td><td>Million Dollar Mile North</td><td>47.729784</td><td>-119.261919</td><td>4/23/2002</td><td>8/19/2004</td></tr>
<tr><td>Lim 6</td><td>Goose Island-Southwest</td><td>47.664420</td><td>-119.301624</td><td>6/4/2003</td><td>8/19/2004</td></tr>
<tr><td>Lim 7</td><td>Devil's Lake</td><td>47.896469</td><td>-119.115290</td><td>5/12/2009</td><td>11/27/2009</td></tr>
<tr><td>Lim 8</td><td>Osborne Bay</td><td>47.928174</td><td>-119.060059</td><td>5/12/2009</td><td>11/27/2009</td></tr>
</table>

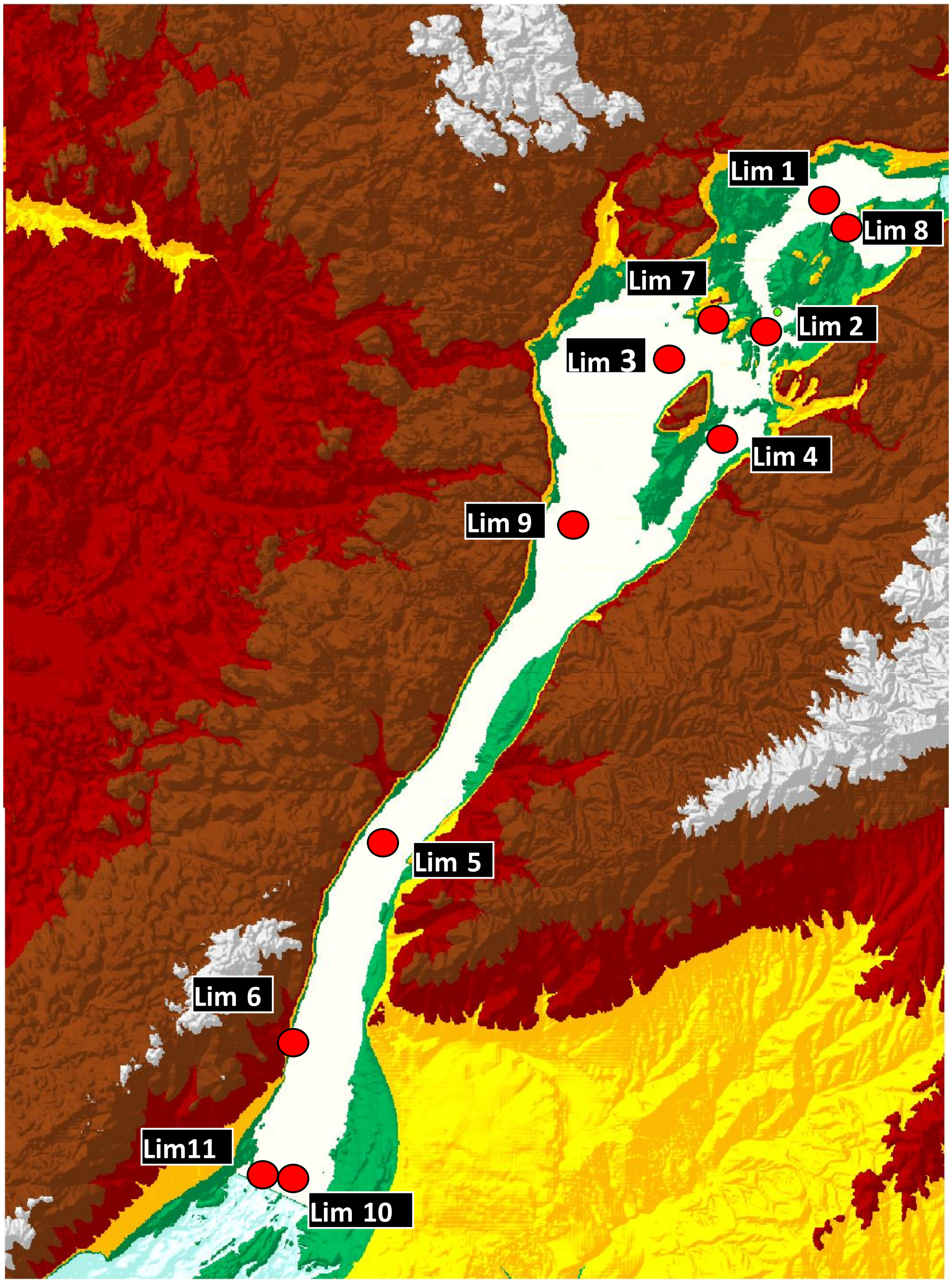


Figure 27. WDFW Banks Lake water quality sampling sites

## WDFW Water Quality Data

Figure 28 shows Banks Lake 2009 water temperature profile data for Lim site 1. Water temperature profile data were available for Lim sites 1, 3 and 5 in 2002, Lim sites 1-6 in 2003 and Lim sites 1-11 for 2008 and 2009. Summer highs often reached 20$^{o}$C, sometimes as high as 28$^{o}$C, and annual lows ranged 0-5$^{o}$C. Most summer heating trends showed the onset of stratification from late June to mid July and lasting through September. Warming of upstream Lim sites 1, 2 and 8 showed less prominent summer stratification, most likely due to the seasonal pumping and mixing from Lake Roosevelt water coming into the system. Available winter water temperature data showed no winter stratification.

Figure 29 shows Banks Lake 2009 dissolved oxygen profile data for Lim site 1. Dissolved oxygen profile data were available for Lim sites 1, 3 and 5 in 2002, Lim site 1-6 in 2003 and Lim sites 1-11 for 2008 and 2009. Annual highs were measured during late winter/early spring months or during mid-summer algal blooms and ranged from 10 to 15 mg/l. Most Lim sites experienced some hypolimnetic dissolved oxygen depletion beginning around July and lasting throughout September with concentrations ranging 0.5-4 mg/l. Lim site 7 showed oxygen depletion in both the hypolimnion and at the thermocline during summer and fall months.

Figure 30 shows Banks Lake 2009 pH profile data for Lim site 1. pH profile data were available for Lim sites 1, 3 and 5 in 2002, Lim sites 1-6 in 2003 and Lim sites 1-11 for

2008 and 2009. pH extrema ranged from 5.1-9.0 but most values fell between 7.5-8.5. Annual trends show a general drop in pH values during summer months in the hypolimnion and occasionally in the lower epilimnion. Data show these summer drops in pH to be more pronounced during 2008, reaching values as low as 6.38 at Lim site 7.

Figure 31 shows Banks Lake chlorophyll-a profile data. Chlorophyll-a profile data were available for Lim sites 1-8 in 2004 and Lim sites 1-7 in 2005. Limited chlorophyll-a data was available for 2003 with most sites sampled only two or three times annually, during the late summer or early fall. Maximum and minimum concentrations for 2003 ranged from 0.1 to 5.7 µg/l, but most values measured between 2-3 µg/l. Data from 2004 covered May through October and showed most sites had high algae growth during late spring months followed by intermediate growth through October. Maximum and minimum values for 2005 ranged from 0.4-10.3 µg/l with most values measured between 2-3 µg/l. Most sites showed algal production was highest at depths of 6-12 meters. Consistently Lim site 4 was the most productive site sampled.

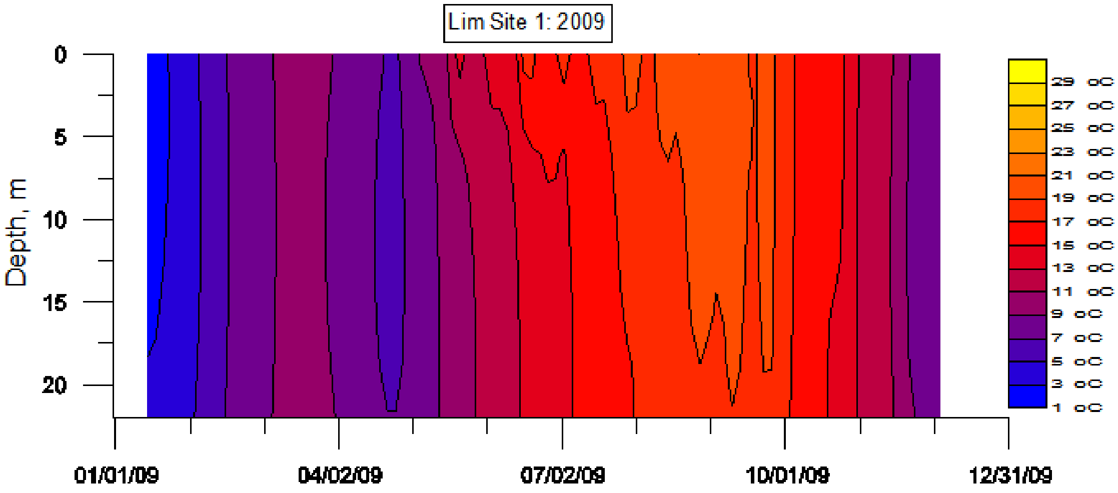


**Figure 28. Banks Lake 2009 water temperature ($^{o}$C) isopleths: Lim site 1**

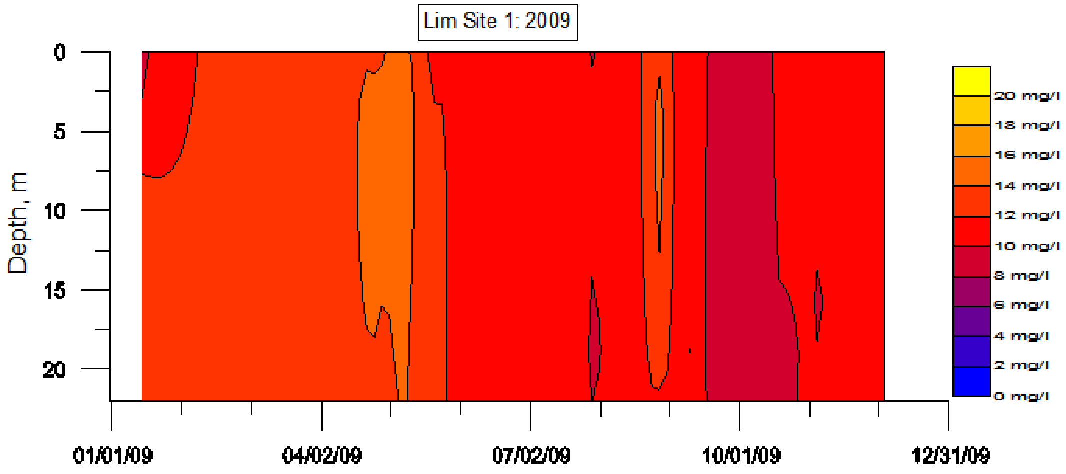


Figure 29. Banks Lake 2009 dissolved oxygen (mg/l) isopleths: Lim site 1

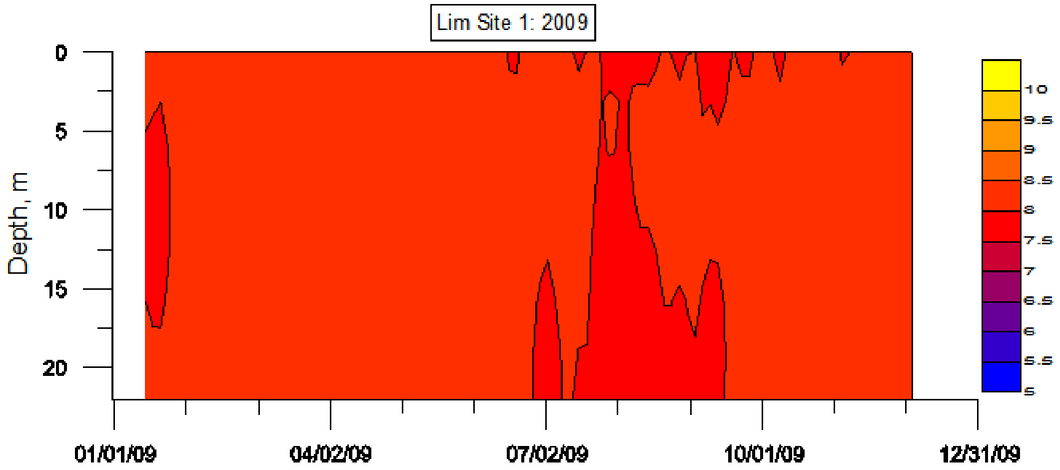


Figure 30. Banks Lake 2009 pH isopleths: Lim site 1

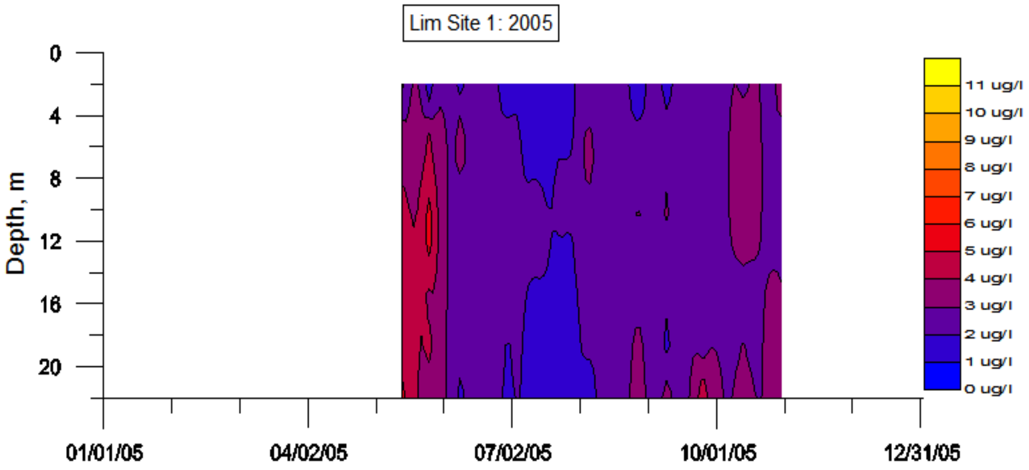


Figure 31. Banks Lake 2005 chlorophyll-a (µg/l) isopleths: Lim site 1

## EWU Water Quality Data

Eastern Washington University (EWU) sampled Lim sites 1-8 from 2002 through 2004. Most sites were only sampled during the summer months of 2003 and 2004, but Lim sites 1, 3 and 5 were also samples throughout the fall and winter months of 2002. Chlorophyll-a samples were collected in triplicate at a depth of 5 meters from Lim sites 1, 3 and 5 from 9/2002-6/2003. Chlorophyll-a profile data were collected from 6/2003-8/2004 and 5/2004-8/2004 for Lim sites 1-6 and Lim sites 7-8, respectfully. All orthophosphate and nitrate samples were collected in triplicate at a depth of 5 meters. Continued discussion of EWU nutrient data continues in the following section: EWU Nutrient Data Analysis

Figure 32 shows chlorophyll-a grab samples data from 2002-2003 for Lim sites 1, 3 and 5. Figure 33 shows chlorophyll-a profile data from 2003-2004 for Lim 4. Chlorophyll-a samples taken from 5 meters ranged from 0.88-5.14 µg/l. Lim site 1 chlorophyll-a concentrations peaked during the winter and spring months of 2003, Lim site 3 peaked during 10/2002, 12/2002 and 6/2003, and Lim site 5 concentrations peaked during 11/2002. Profile chlorophyll-a data normally ranged between 0-4 µg/l for all dates sampled, with short peak concentrations exceeding 4 µg/l occurring during the summer of 2004 for Lim sites 1, 5 and 6. Lim site 4 showed higher chlorophyll-a production from 2/2004-6/2004 with concentrations increasing from 4 µg/l to 7 µg/l. Limited profile data collected at Lim site 8 also showed high concentrations ranging from 2-8.5 µg/l during the summer of 2004. Lim site 4 and 8 were shown to have the highest productivity.

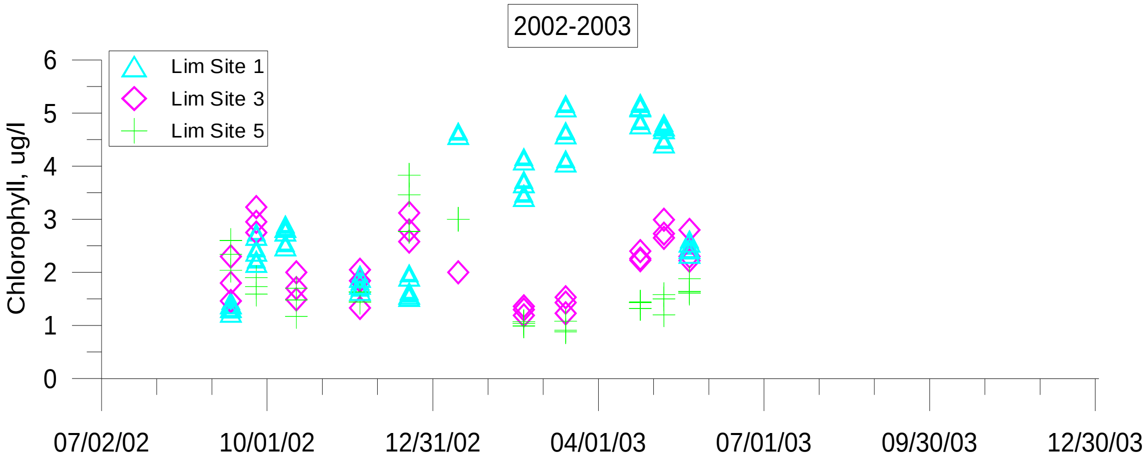


**Figure 32. Banks Lake 2002-2003 chlorophyll-a concentrations (µg/l) measured at 5 meters**

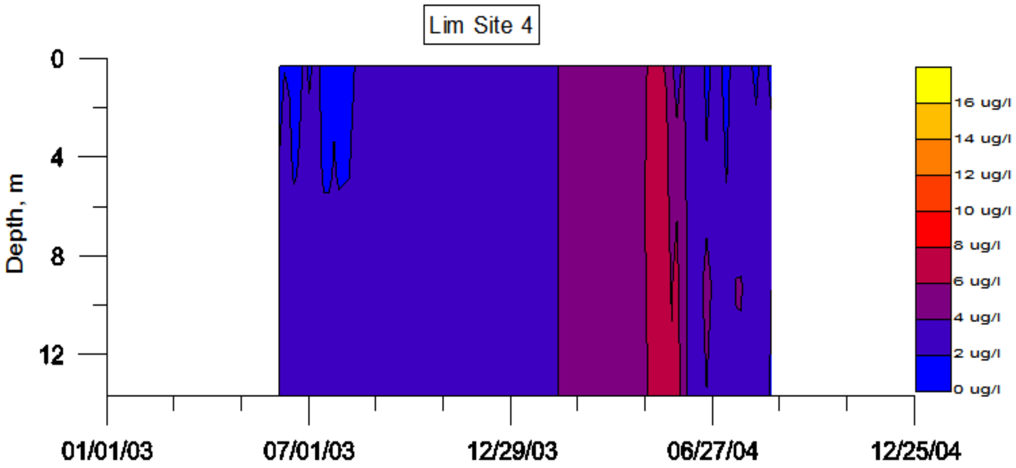


**Figure 33. Banks Lake 2003-2004 chlorophyll-a (µg/l) isopleths: Lim site 4**

## EWU Nutrient Data Analysis

Orthophosphate and nitrate grab samples were collected by EWU at Lim sites 1-8 over 9/2002-8/2004 from a depth of 5 meters. EWU orthophosphate and nitrate concentrations ranged from 0-400 µg/l and 0-3.5 mg/l, respectively. Figure 34 and Figure 35 show orthophosphate and nitrate concentrations collected by EWU at Lim site 1. While these were the only Banks Lake nutrient data available during the calibration time period, the legitimacy of the magnitude of the EWU nutrient data required some further investigation. Ultimately, the EWU nutrient data were discarded and nutrient calibration for Banks Lake was not attempted. The following explains how the nutrient data was examined and also shows why the nutrient data collected by EWU was not used.

- The orthophosphate and nitrate concentrations of Banks Lake's source water in Lake Roosevelt ranged from 1-7 µg/l and 0.02-0.15 mg/l over the same time period the EWU data was collected, respectively. Figure 36 and Figure 37 show scatter plots of Lake Roosevelt phosphorus and nitrate concentrations from 2002-2008. This comparison suggests that either a large nutrient source exists within the Banks Lake watershed or the EWU nutrient data were incorrect. Further investigation found that both major municipalities within the Banks Lake watershed (Coulee City and Electric City) have waste water treatment sites, neither of which discharge into Banks Lake. Also, a significant portion of the Banks Lake watershed has been developed for agricultural production and would pose a high risk for non-point source nutrient discharge into the lake, but scant precipitation records would suggest that not a likely possibility (McCulloch et al., 2011).

•Historical records from 1974-1976 produced by the U.S. Bureau of Reclamation (USBR) show orthophosphate concentrations ranging from 0-25 µg/l (Stober et al., 1976). Figure 38 shows a scanned image of the orthophosphate graph published by the USBR.

•The orthophosphate field samples were processed colorimetrically within 8 hours of sampling using a HACH DR/850colorimeter (Black et al., 2003). Analysis with the HACH DR/850 involved using the HACH Phosver 3 method (Black et al., 2003). According to the Hach website, using the HACH DR/850 with the HACH Phosver 3 method yields an estimated detection limit of 70µg/l. This instrument would allow the researchers at EWU to accurately detect, at best, nutrient levels that would be considered highly eutrophic (>> 20 µg/l) and nothing less than that (Chapra, 1997).

•The EWU orthophosphate data would classify Banks Lake as highly eutrophic (>> 20 µg/l TP) while the chlorophyll-a data collected by both EWU and WDFW would classify Banks Lake as mesotrophic (4-10 µg/l CHLA) (Chapra, 1997). To better show this lack of nutrient agreement, EWU orthophosphate data was compared against theoretical total phosphorus concentrations that were calculated from in-lake chlorophyll-a data.

Equation 2 was taken from Dillion and Rigler (1974), equation 3 was taken from Rast and Lee (1978) and equation 4 was taken from Bartsch and Gakstatter (1978), where TP is total phosphorus in µg/l and Chlα is chlorophyll-a in µg/l.

$$\mathbf{log(TP) = 0.69log(Chl}\boldsymbol{a}\mathbf{) + 0.783} \qquad \textbf{Eq. 2}$$

$$\mathbf{log(TP) = 1.315log(Chl}\boldsymbol{a}\mathbf{) + 0.341} \qquad \textbf{Eq. 3}$$

$$\mathbf{log(TP) = 1.239log(Chl}\boldsymbol{a}\mathbf{) + 0.24} \qquad \textbf{Eq. 4}$$

Figure 39 shows a scatter plot of the EWU orthophosphate data plotted with the theoretically calculated total phosphorus concentrations for Lim site 1.

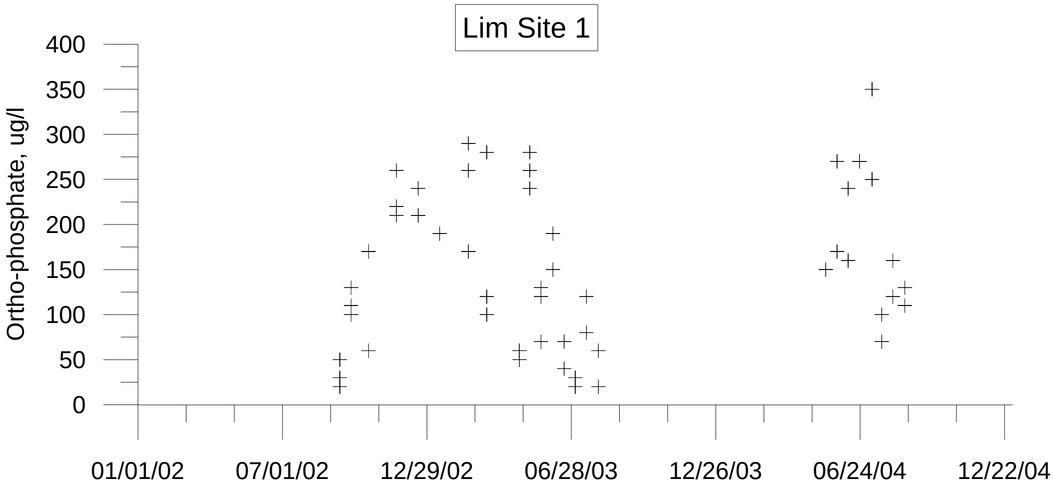


**Figure 34. Orthophosphate data collected by EWU at Lim site 1: 2002-2004**

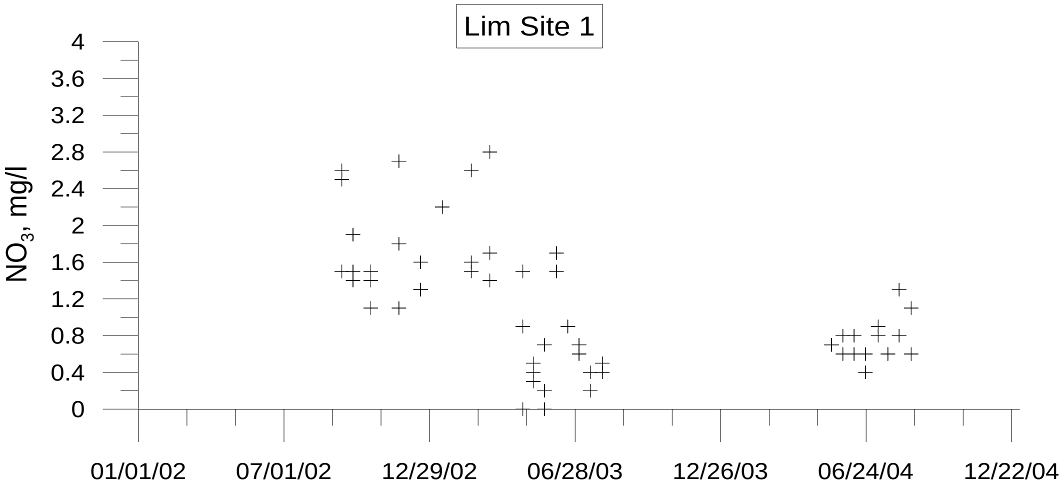


Figure 35. Nitrate data collected by EWU at Lim site 1: 2002-2004

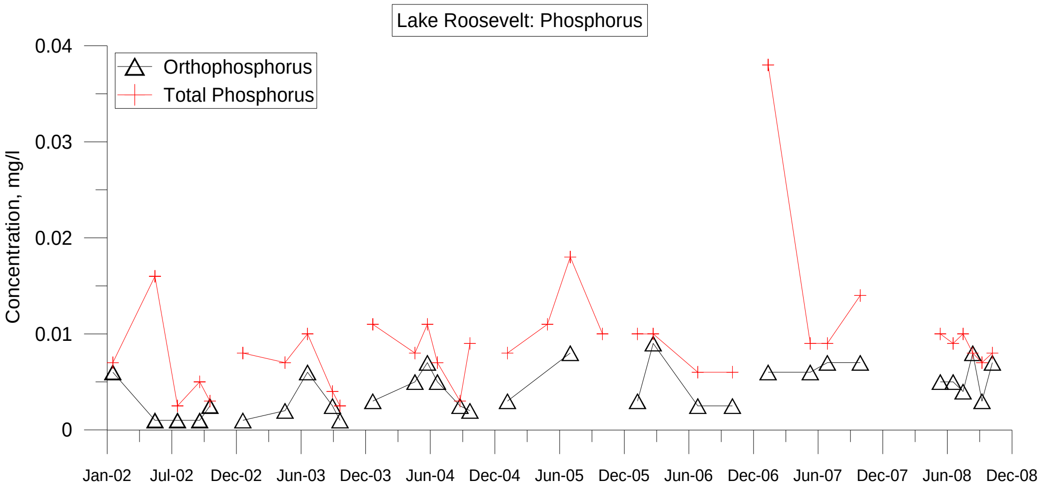


Figure 36. Lake Roosevelt orthophosphorus and total phosphorus concentrations 2002-2008

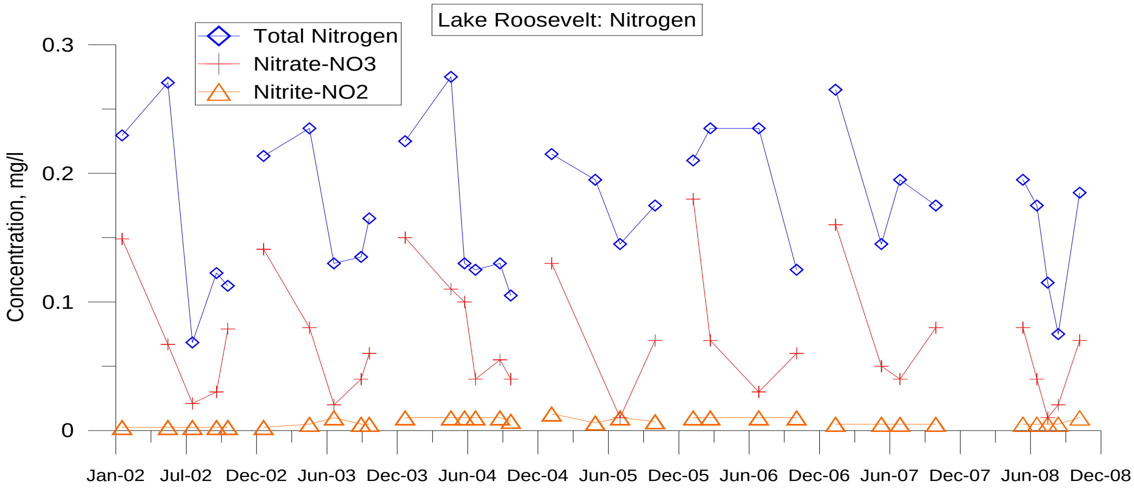


Figure 37. Lake Roosevelt nitrite, nitrate and total nitrogen concentrations 2002-2008

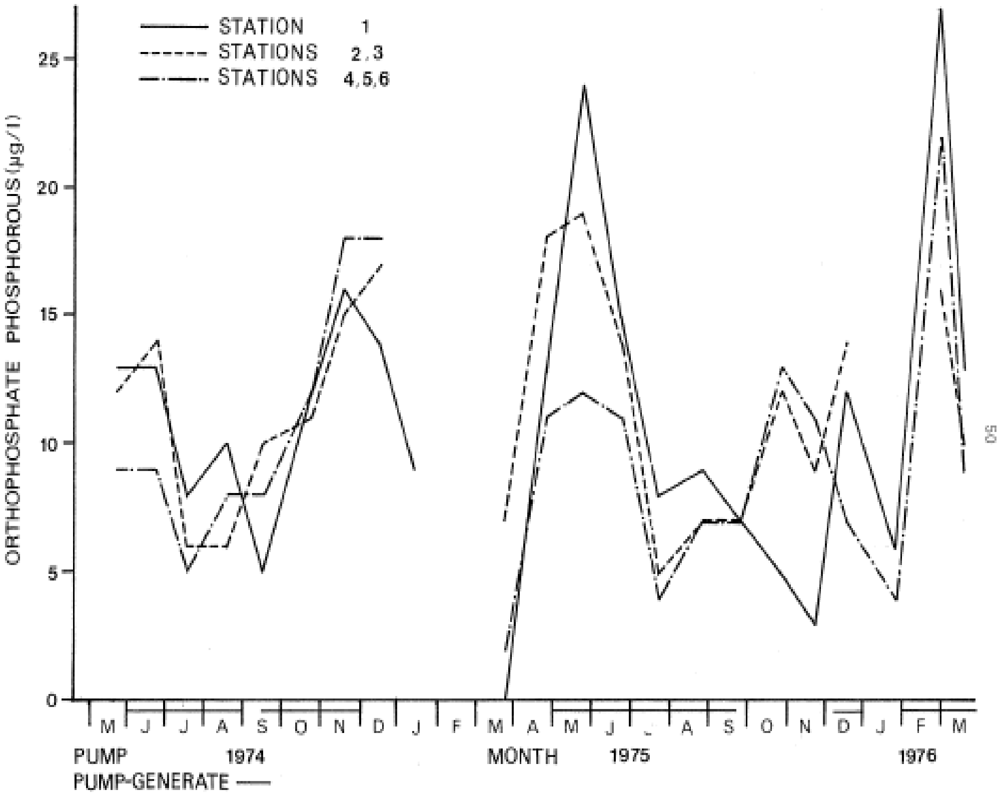


Figure 4.13 Mean monthly orthophosphate concentrations for Station 1, Stations 2 and 3 combined, and Stations 4, 5, and 6 combined; with the occurrence of feeder canal pumping or pump-generation from May 1974 to March 1976.

**Figure 38. Historical orthophosphate concentrations for 1974-1976 (Stober et al., 1976)**

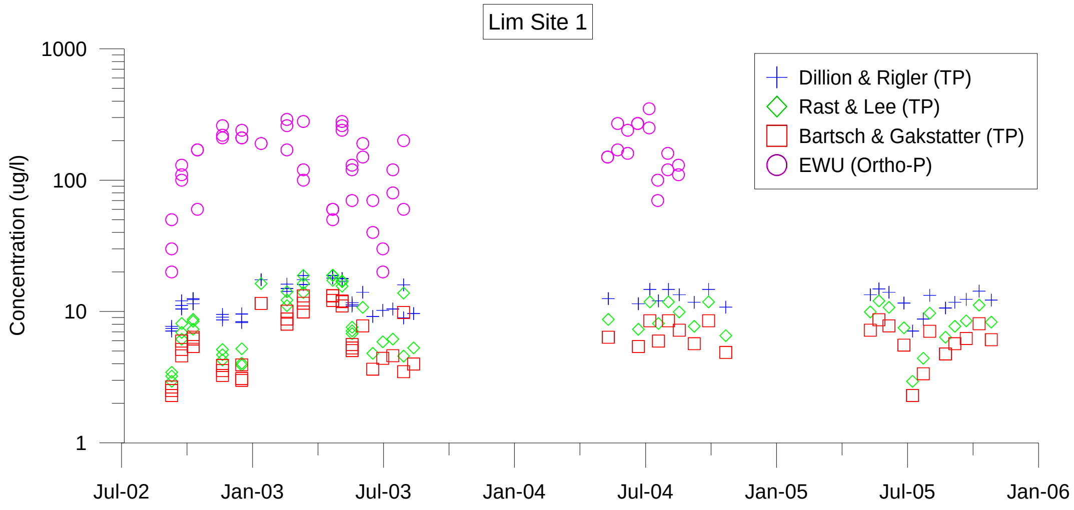


**Figure 39. Theoretical total phosphorus concentrations based on observed chlorophyll-a data and ortho-phosphorus data collected by EWU for Lim site 1**

## Biological Data

### Algae

Algae data were collected by the Washington Department of Fish and Wildlife (WDFW) on roughly a monthly basis from 9/2002-8/2004. Lim sites 1, 3 and 5 were sampled monthly from 9/2002-12/2002, Lim sites 1-6 were sampled monthly during all of 2003 and Lim sites 1-8 were sampled monthly from 3/2004-8/2004. Algae samples were collected in triplicate at a depth of 5 meters. Samples were classified and separated by phylum, then measured as biovolume ($mm^3/l$). Table 22 shows the total annual biovolume and the percent of total annual algae biovolume for each algae group. Figure 40 shows algae biovolume data at Lim site 1 from 2002-2004.

Chrysophytes (diatoms) were the dominate group for all years with 70%, 79% and 59% of the total biovolume for 2002, 2003 and 2004 respectively. The cryptophytes were the second most abundant phyla with 16%, 12% and 24% of the total biovolume for 2002, 2003 and 2004 respectively. Chlorophyta were the third most frequently sampled algal group with an annual percentage of the total biovolume ranging from 3-7%. Chrysophytes populations were highest during late winter/early spring months and would typically begin to decrease during mid to late summer. Pyrrophyta showed little presence for all years and euglenaopyta were measured only four times at Lim 2 and Lim 4 during late summer months. Eubacteria (bluegreen) would typically bloom during mid to late summer months. Eubacteria made up at least 10% of the total sample abundance at Lim site 5 and 6 for all years.

Since CE-QUAL-W2 reads and outputs algae data as mass per volume concentrations, algae data collected by the WDFW were converted from biovolume ($mm^3/l$) to mass concentration (mg/l). The two most dominant algal groups, including the chrysophytes and cryptophytes, were converted to mass concentrations and used in the CE-QUAL-W2 model. Although the eubacteria and the chlorophyta did not make up a large percentage of the total sampled algal biovolume, their biovolumes were combined and converted to mass concentrations to make the third algal group used in the CE-QUAL-W2 model. Figure 41 shows the converted algae mass concentrations for Lim 1. Figure 42 shows the exponential curve equation developed by Reynolds (1984) that was used to convert algal biovolume to mass. The Reynolds biovolunme to mass equation (equation 5) was developed using algae mass to biovolume relationships among multiple taxonomic groups, where Y is mass in pictograms and X is biovolume in cubic millimeters.

$$\mathbf{Y = 0.47 \cdot X^{0.99}} \qquad \textbf{Eq. 5}$$

Thus, within certain biovolume ranges the conversion from biovolume to mass will be more accurate for some algal groups over others. The conversion equation was not published with any error statistics, so it should be noted that although using equation 5 is assumed to be reliable, some leeway should be also assumed in its conversion accuracy.

The alternative of using an empirically based conversion equation did not present itself, as there were no available algal mass data to accompany the algal biovolume data.

**Table 22. Washington Fish and Wildlife phytoplankton summary statistics, average biovolume ($mm^3$/l)**

| | 2002 | | 2003 | | 2004 | |
|---|---|---|---|---|---|---|
| | **Total** | **Ratio** | **Total** | **Ratio** | **Total** | **Ratio** |
| **Chlorophyta** | 0.44 | 0.03 | 2.26 | 0.04 | 2.26 | 0.07 |
| **Chrysophyta** | 11.58 | 0.7 | 39.79 | 0.75 | 18.81 | 0.59 |
| **Cryptophyta** | 2.69 | 0.16 | 6.48 | 0.12 | 7.58 | 0.24 |
| **Pyrrophyta** | 0.04 | 0 | 0.82 | 0.02 | 0.66 | 0.02 |
| **Euglenophyta** | 0 | 0 | 0.01 | 0 | 0 | 0 |
| **Eubacteria** | 1.78 | 0.11 | 3.97 | 0.07 | 2.37 | 0.07 |

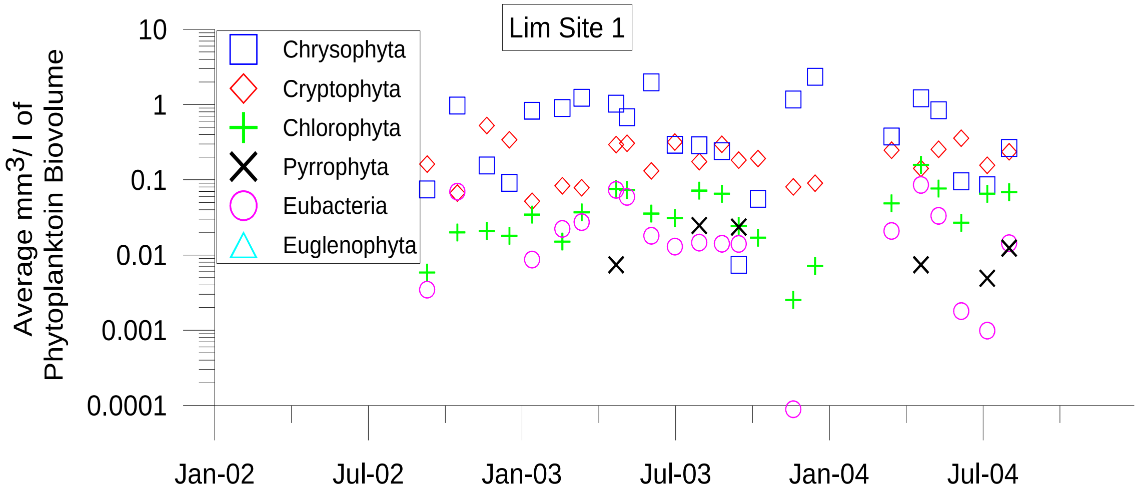


Figure 40. Banks Lake phytoplankton biovolume concentrations ($mm^3$/l): Lim sites 1

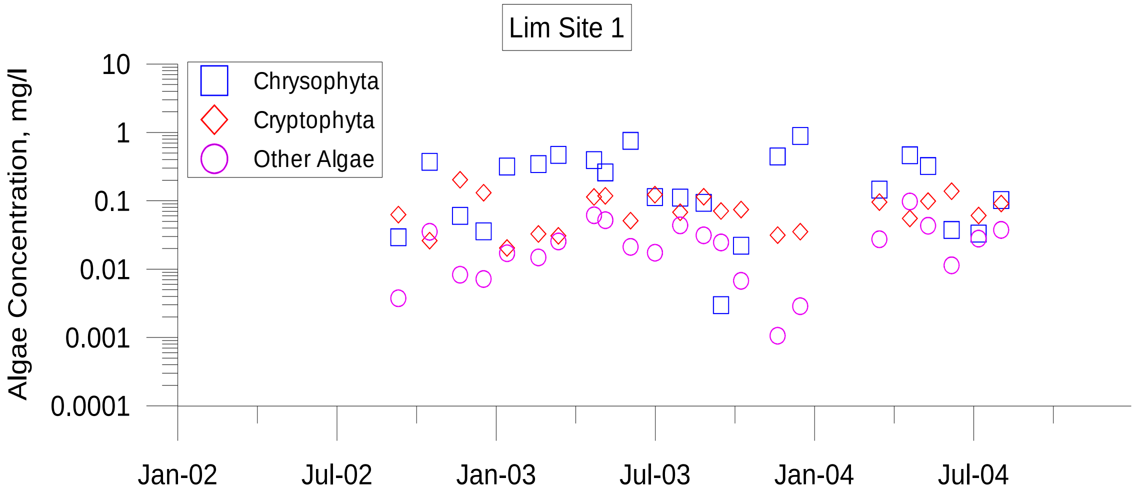


**Figure 41. Banks Lake phytoplankton mass concentrations (mg/l) converted from biovolume ($mm^3$/l): Lim site 1**

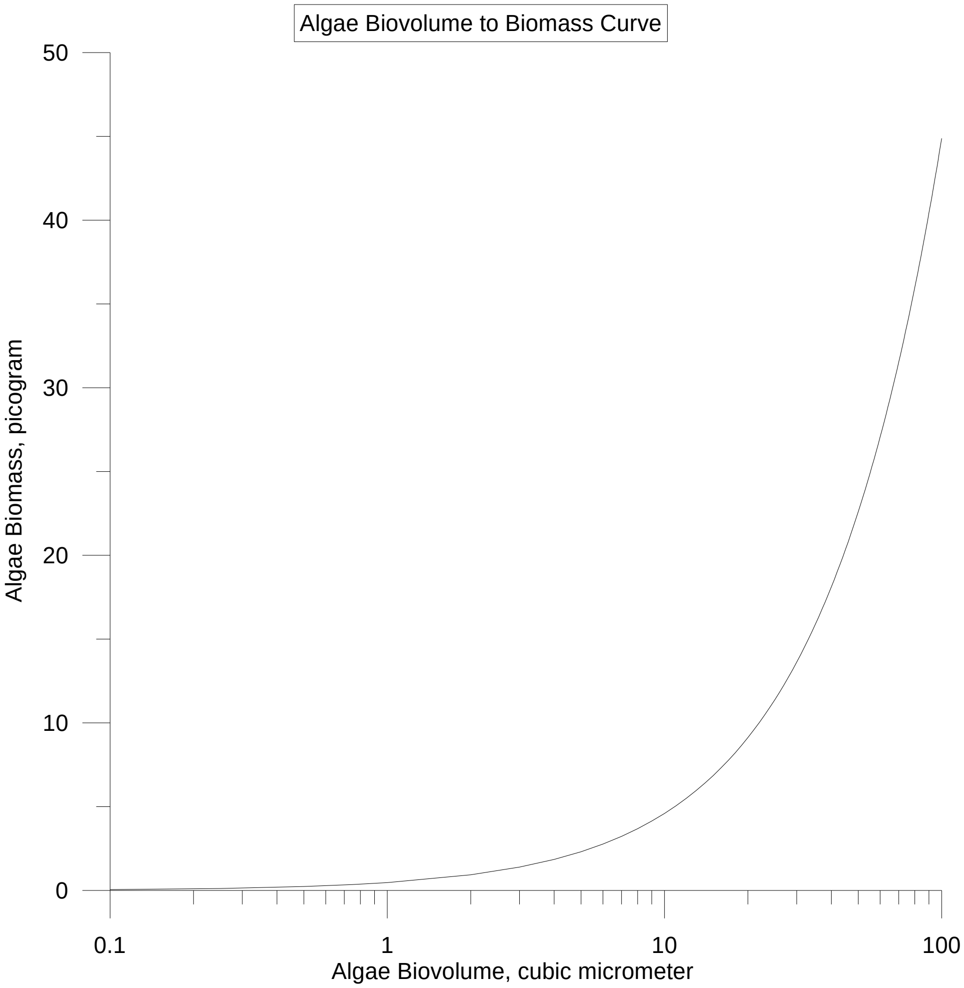


**Figure 42. Algae biovolume to mass conversion curve and equation where X is algae biovolume ($mm^3$) and Y is algae mass (pg) (Reynolds, 1984).**

## Zooplankton

Zooplankton data were collected by the Washington Department of Fish and Wildlife from Lim sites 1-11 on a mostly bi-monthly basis from 4/2008-11/2008 and 4/2009-11/2009. All Lim sites were sampled three times for each day sampled via a 0.15 meter radius zooplankton tow net. Samples were sorted by genus and counted. To achieve an accurate representation of zooplankton abundance in the water column the total number of zooplankton counted were then divided by the volume of water sampled by each tow, resulting in a zooplankton density of organisms per liter (organisms/l).

Copepodas were the dominate group for both years with 58% and 57% of the total density for 2008 and 2009 respectively. The rotoiferas were the second most abundant zooplankton group with 25% and 26% of the total density for 2008 and 2009 respectively. Copepoda populations peaked either in late spring or late fall depending on the Lim site. Rotoifera populations peaked during late spring and dropped to annual lows during late summer and early fall. Daphnia populations consistently made up 10-20% of the total zooplankton density for all Lim sites, except for Lim 2 where daphnia made up 26 % and 29% of the total zooplankton population for 2008 and 2009 respectively. Table 23 shows Banks Lake annual zooplankton density summaries. Figure 43 shows Banks Lake zooplankton densities for Lim site 1.

While the CE-QUAL-W2 modeling software reads and outputs zooplankton data in mass per volume concentrations, zooplankton density data collected by the WDFW were converted to mass using regression equations developed with the monthly average zooplankton mass concentrations and densities from Lake Roosevelt collected by the Lake Roosevelt Fisheries Evaluation Program (LRFEP). Since the LRFEP collected mass and density data for only copepoda and daphnia groups, they were the groups that were converted to mass concentration values for Banks Lake. Figure 44 shows the converted zooplankton mass concentrations for Lim 1. Figure 45 and Figure 46 show the linear regressions used to convert zooplankton density data for daphnia and copepoda into mass concentration values. It should be noted that although the regression conversion equations are assumed to be accurate and have relatively high $R^2$ values, there is the potential for high levels of error in these conversions since density data does not provide any information into the size or length of the individual zooplankton organisms counted in each sample.

**Table 23. Washington Fish and Wildlife zooplankton density summary statistics (organisms/l)**

| | | Copepoda | Rotoifera | Daphnia | Other Cladocera |
|---|---|---|---|---|---|
| **2008** | **Total Count** | 9078.87 | 3961.92 | 2248.90 | 415.73 |
| | **Ratio** | 0.58 | 0.25 | 0.14 | 0.03 |
| **2009** | **Total Count** | 6699.45 | 3016.53 | 1764.41 | 267.88 |
| | **Ratio** | 0.57 | 0.26 | 0.15 | 0.02 |

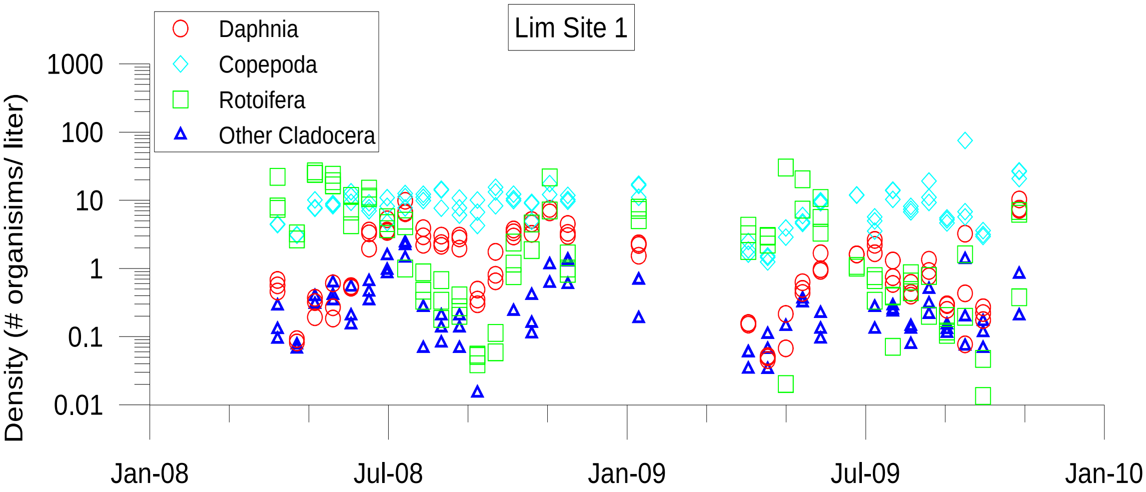


**Figure 43. Banks Lake zooplankton densities (organisms/l): Lim 1**

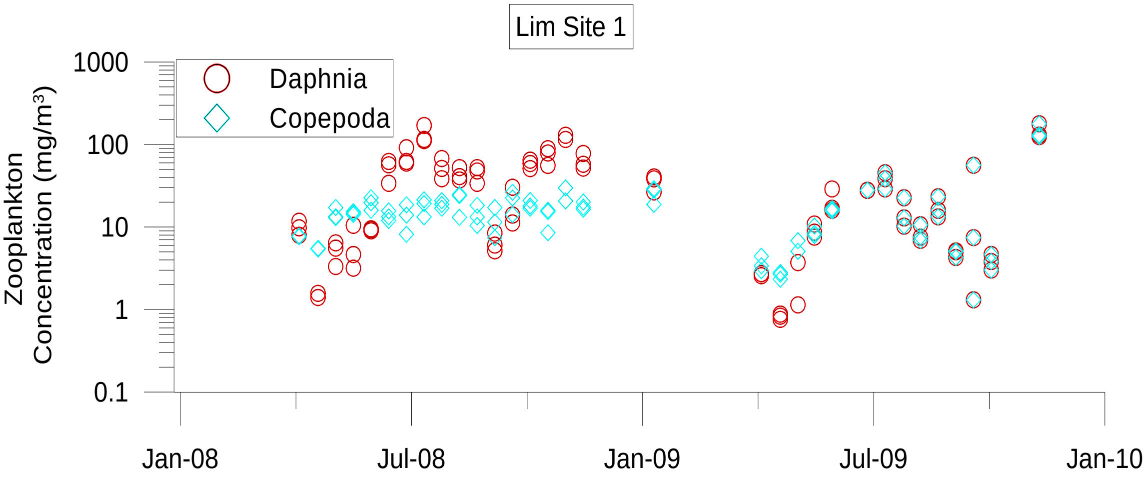


**Figure 44. Banks Lake zooplankton concentrations (mg/m$^3$) converted from density: Lim 1**

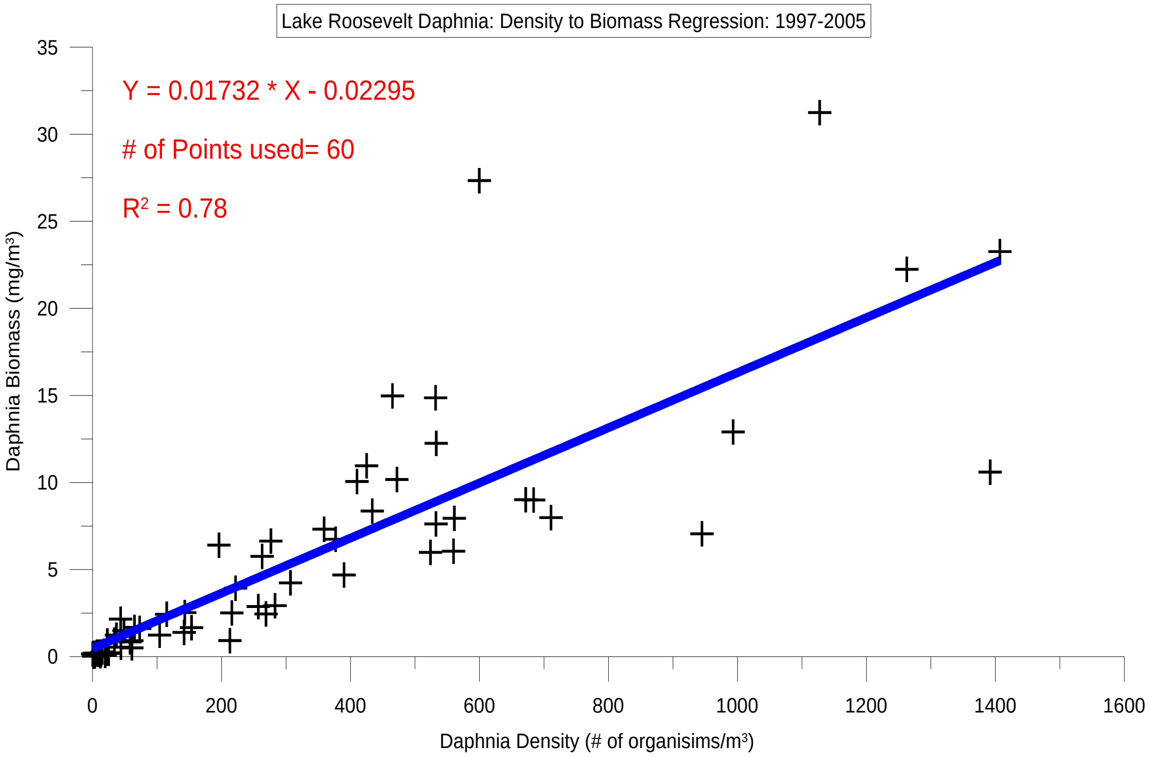


**Figure 45.** Correlation between Lake Roosevelt monthly averaged Daphnia biomass and monthly averaged densities, where Y is Daphnia biomass (mg/m$^3$) and X is Daphnia density (#/m$^3$)

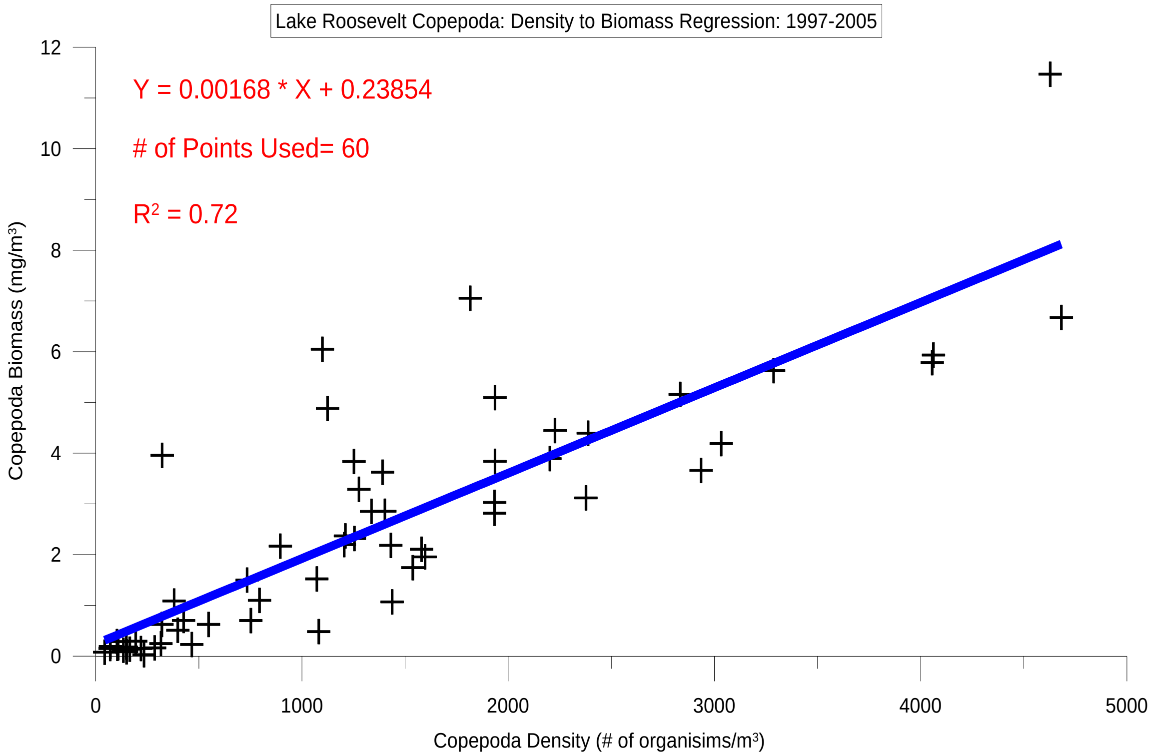


**Figure 46.** Correlation between Lake Roosevelt monthly averaged Copepoda biomass and monthly averaged densities, where Y is Copepoda biomass (mg/m$^3$) and X is copepoda density (#/m$^3$)

### Banks Lake CE-QUAL-W2 Model Calibration

The Banks Lake model calibration period lasted from January 1st, 2002 to December 31st, 2009. The calibration time period was determined by data availability and data frequency. Model calibration consisted of first evaluating reservoir hydrodynamics, followed by water temperature, abiotic water quality constituents and then biotic water quality constituents. Table 24 shows the water quality constituents used for calibration and their data types. Calibration coefficients and setup are shown as the model control file in Appendix A.

**Table 24. Water quality constituents and data types**

| Calibration Constituent | Data Type |
|---|---|
| Water Surface Elevation | Daily Time series, meters |
| Water Temperature | Vertical Profiles, °C |
| Dissolved Oxygen | Vertical Profiles, mg/l |
| pH | Vertical Profiles |
| Chlorophyll-a | Grab Sample, µg/l |
| Algae | Grab Sample, mg/l |
| Zooplankton | Net Tows, mg/l |

## Hydrodynamic Calibration

Hydrodynamic calibration was achieved by balancing inflow rates with outflow discharges while reproducing the corresponding water surface elevations for the given calibration period. Inaccurate flow gages, ground water seepage and evaporation act as sinks to the flow regime, and are accounted for in the calibration process by adding a user created distributed tributary. The distributed tributary is capable of adding or subtracting water from the system when needed, thus allowing for accurate water surface elevation predictions. Further discussion on hydrodynamic boundary conditions is available in McCulloch, Berger and Wells (2011).

Water surface elevation error statistics and average distributed tributary flows are shown in Table 25. Model predicted water surface elevations and observed water surface elevations for 2002 are plotted in Figure 47. Outflows from the Main Canal at Dry Falls Dam and distributed tributary flows for 2002 are plotted in Figure 48. Figure 49 shows model predicted and observed water surface elevations with distributed tributary flows for the entire 2002-2009 calibration period.

Table 25. Water surface elevation and distributed tributary flow statistics: 2002-2009

| Year | Mean Error, m | Absolute Mean Error, m | Root Mean Square Error, m | Average Annual Distributed Tributary Flow, $m^3/s$ |
|---|---|---|---|---|
| 2002 | 0.005 | 0.03 | 0.051 | -4.92 |
| 2003 | 0.014 | 0.035 | 0.052 | -4.41 |
| 2004 | 0.01 | 0.024 | 0.037 | -4.22 |
| 2005 | 0.028 | 0.048 | 0.075 | -4.9 |
| 2006 | 0.028 | 0.051 | 0.078 | -5.72 |
| 2007 | 0.026 | 0.043 | 0.058 | -5.74 |
| 2008 | 0.036 | 0.045 | 0.061 | -11.85 |
| 2009 | 0.035 | 0.051 | 0.064 | -4.95 |
| **Average** | **0.023** | **0.041** | **0.06** | **-5.84** |

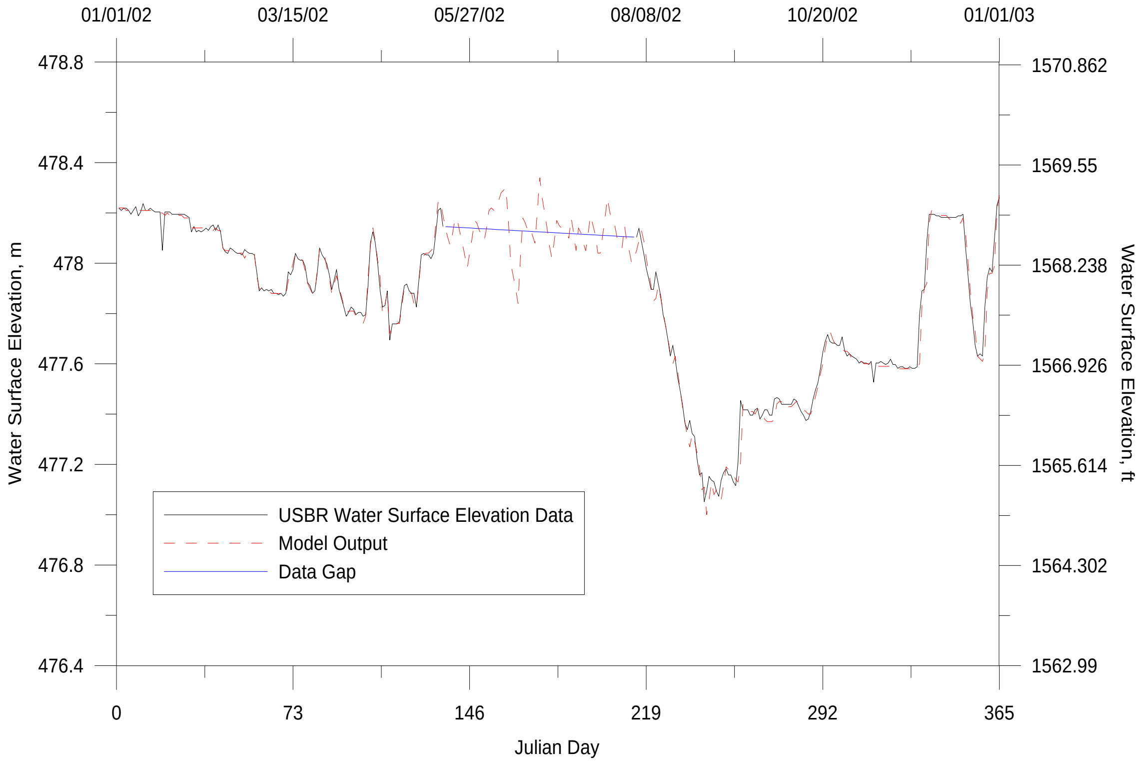


Figure 47. Model predicted water surface elevation with observed data from Banks Lake, 2002

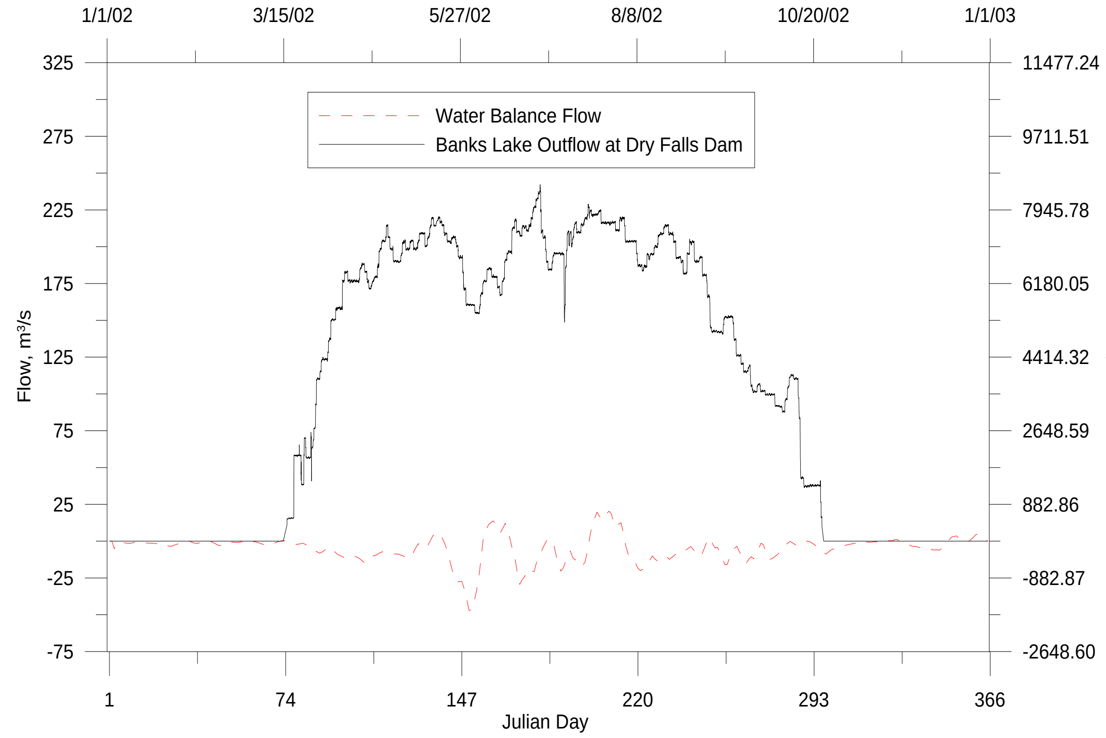


**Figure 48. Outflow discharge from the Main Canal at Dry Falls Dam with water balance flows, 2002**

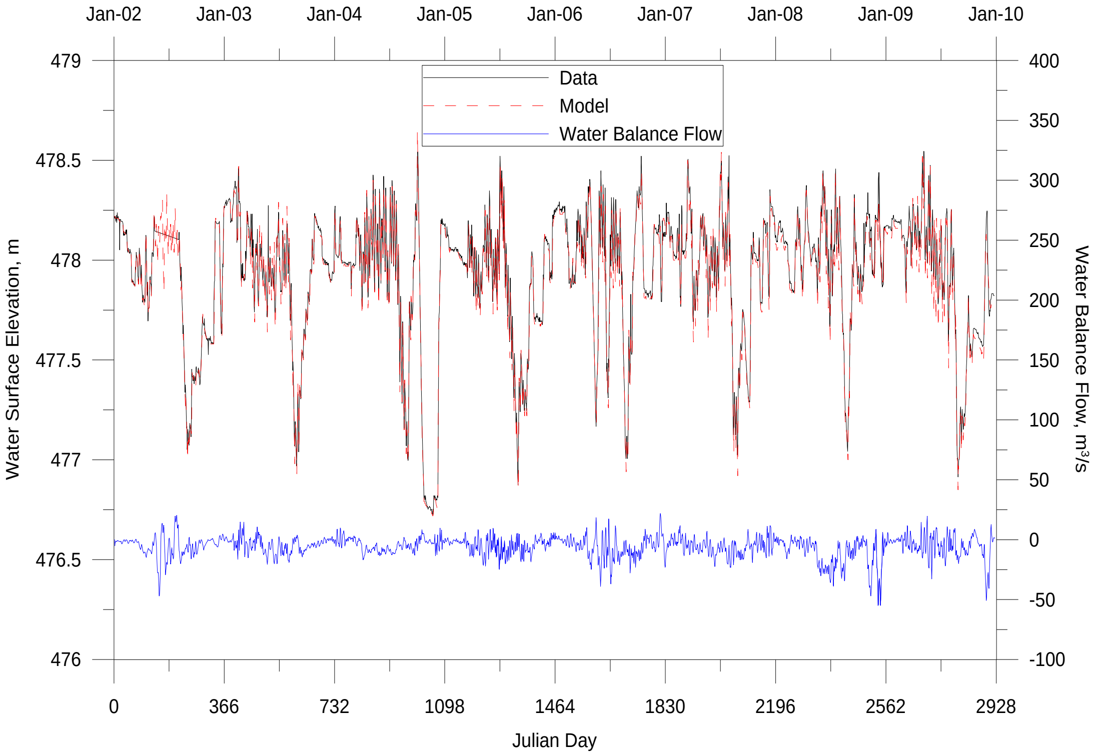


**Figure 49. Model predicted water surface elevation (red) with observed data (black) and distributed tributary flow (blue), 2002-2009**

## Light Extinction

Light extinction data were collected as secchi depths at all 11 Lim sites from 2008-2009. The secchi depths can be converted to light extinction coefficients by using two theoretical equations from the literature. The Poole and Atkins (1929) equation is $\lambda = 1.7/S_d$ where $\lambda$ is the light extinction coefficient in meters$^{-1}$ and $S_d$ is the secchi depth in meters. The Williams et al. (1980) equation is $\lambda = 1.11S_d^{-0.73}$. Both equations were used to convert the secchi depths to light extinction coefficient values and then compared against light extinction coefficient data calculated by CE-QUAL-W2 on the same day that secchi depths were measured. Table 26 shows the average secchi depth, the average model predicted light extinction coefficients and the theoretically calculated light extinction coefficients for Lim Sites 1-11 during 2008-2009. Figure 50 shows the secchi depths, the model predicted light extinction coefficients and the light extinction coefficients theoretically calculated from Poole and Atkins (1929) and Williams et al. (1980) for Lim site 2 during 2008-2009. The model typically over calculated the light extinction coefficients with an average error of 0.08 m$^{-1}$ when compared to the Williams et al. (1980) light extinction coefficients and a mean error of 0.06 m$^{-1}$ when compared to the Poole and Atkins (1929) light extinction coefficients. Light extinction coefficients are shown in the control file located in Appendix A, under the subheading “EX COEF”.

Table 26. Comparison of secchi disk depths, theoretical light extinction coefficients and model predicted light extinction coefficients

| Lim Site | Average Secchi Depth, m | Average Model Predicted Light Extinction Coefficient, $m^{-1}$ | Average Light Extinction Coefficient (Williams, et al. 1980), $m^{-1}$ | Average Light Extinction Coefficient (Poole and Atkins, et al. 1980), $m^{-1}$ |
|---|---|---|---|---|
| **1** | 5.27 | 0.44 | 0.35 | 0.35 |
| **2** | 3.56 | 0.46 | 0.46 | 0.51 |
| **3** | 4.46 | 0.48 | 0.40 | 0.43 |
| **4** | 3.52 | 0.47 | 0.46 | 0.52 |
| **5** | 4.72 | 0.47 | 0.37 | 0.36 |
| **6** | 5.44 | 0.47 | 0.33 | 0.33 |
| **7** | 4.84 | 0.46 | 0.36 | 0.37 |
| **8** | 3.75 | 0.44 | 0.45 | 0.50 |
| **9** | 4.86 | 0.47 | 0.36 | 0.37 |
| **10** | 4.71 | 0.48 | 0.36 | 0.37 |
| **11** | 5.06 | 0.48 | 0.35 | 0.35 |

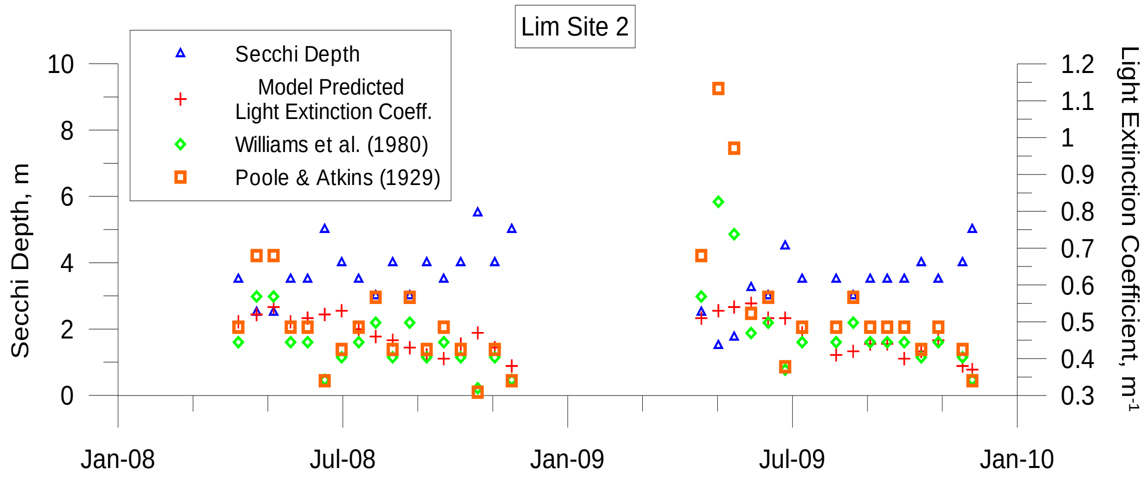


Figure 50. Secchi depths (m), model predicted light extinction coefficients and theoretical light extinction coefficients for Lim 2 during 2008-2009 (Williams 1980) (Poole & Atkins 1929).

## Water Temperature Calibration

Calibrating water temperature consisted of matching model profile predictions to water temperature profile data that was collected by the WDFW. Major drivers that dictate correct water temperature calibration include:

1.) Developing a correct bathymetry grid that is representative of the actual bathymetry and facilitates water and energy flow that is true to nature

2.) Accurately calibrating the hydrodynamics of the system through the use of distributed tributary flows and using correct boundary condition flows

3.) Using accurate and spatially relevant meteorological input data. Daily heating from short wave solar radiation and cooling from evaporation can have substantial effects on the energy budget of the lake

Further fine tuning of water temperature profile data was executed by altering the wind sheltering coefficients (WSC), which are used to increase or decrease the magnitude of wind driven mixing on a segment by segment basis through multiplying the current wind velocity by a user defined coefficient. The wind sheltering coefficient is vital in reproducing mixing characteristics for larger system such as Banks Lake since wind data are often measured offsite. Correct wind data will also provide for more correct evaporation rates. Figure 51 shows a comparison of the effects two different wind sheltering coefficients have on water temperature profiles predicted by the model. Figure 52 show the wind sheltering coefficients used in model calibration.

The calibrated model did well to match temperature data on days that were relatively isothermal.   On days when stratification was prominent the model would typically do well to match either or both the epilimnion and hypolimnion temperatures but then miss parts of the themocline.  This is most likely attributed to incorrect wind driven mixing. The majority of available wind data used in the model was collected from the Grand Coulee Dam AGRIMET station (GCDW), which has a predominant east-west wind direction, where the actual prominent wind direction at Banks Lake is South-North.

Table 27 shows model-data error statistics and the number of model-data comparisons for temperature.  Figure 53 shows a regression plot of model predicted water temperature profile data regressed against corresponding field data.  Temperature calibration model-data vertical profile plots are shown in Appendix B.

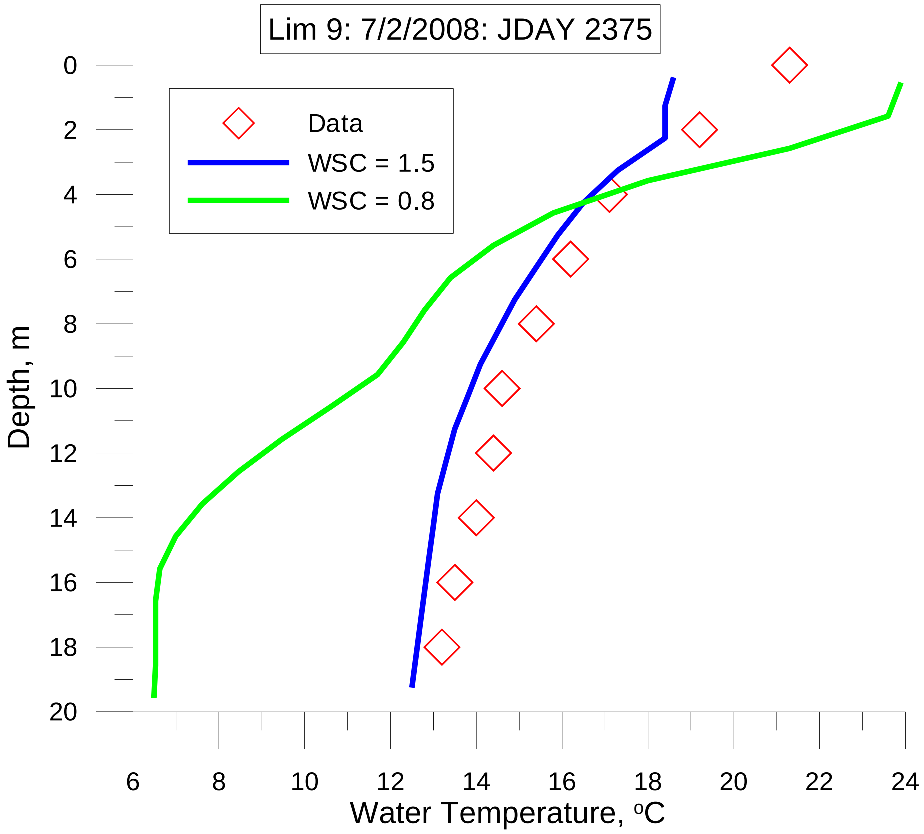


**Figure 51.** **Effect of wind on predicted water temperature profile for Lim site 9 on 7/2/2008 with a wsc=0.8 and wsc=1.5**

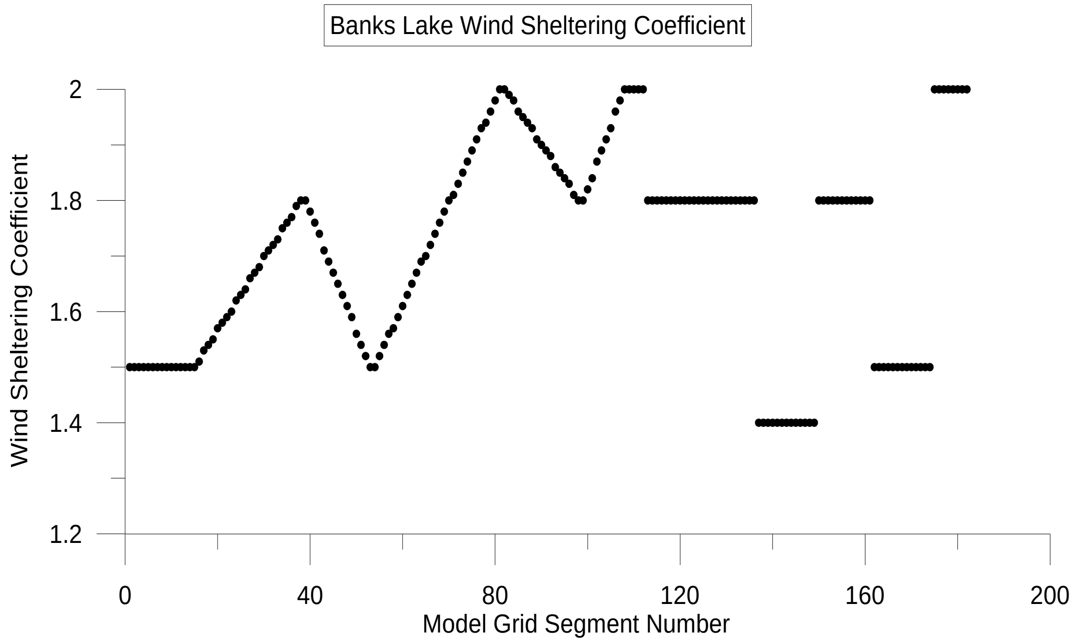


**Figure 52. Wind sheltering coefficients used for model temperature calibration**

**Table 27. Model–data error statistics for water temperature profile data for 2002, 2003, 2008 and 2009**

| Station | Model Segment | Number of Days with Data | Number of Comparisons | Mean Error, °C | Absolute Mean Error, °C | Root Mean Square Error, °C | Years |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 60 | 612 | -0.73 | 0.79 | 0.84 | 2002, 2003, 2008 & 2009 |
| 2 | 173 | 34 | 108 | -0.7 | 0.82 | 0.91 | 2003, 2008 & 2009 |
| 3 | 39 | 59 | 570 | -0.68 | 0.98 | 1.09 | 2002, 2003, 2008 & 2009 |
| 4 | 158 | 39 | 203 | -0.1 | 0.91 | 1.02 | 2003, 2008 & 2009 |
| 5 | 82 | 58 | 689 | 0.15 | 1.08 | 1.2 | 2002, 2003, 2008 & 2009 |
| 6 | 99 | 39 | 425 | 0.18 | 1.03 | 1.19 | 2003, 2008 & 2009 |
| 7 | 147 | 29 | 670 | 0.46 | 1.1 | 1.33 | 2008 &2009 |
| 8 | 181 | 33 | 124 | 0.05 | 0.73 | 0.86 | 2008 &2009 |
| 9 | 54 | 32 | 357 | 0.16 | 0.76 | 0.88 | 2008 &2009 |
| 10 | 109 | 31 | 115 | 0.84 | 0.99 | 1.02 | 2008 &2009 |
| 11 | 110 | 30 | 177 | 0.81 | 1.09 | 1.15 | 2008 &2009 |
| AVE |  |  |  | 0.04 | 0.94 | 1.04 |  |

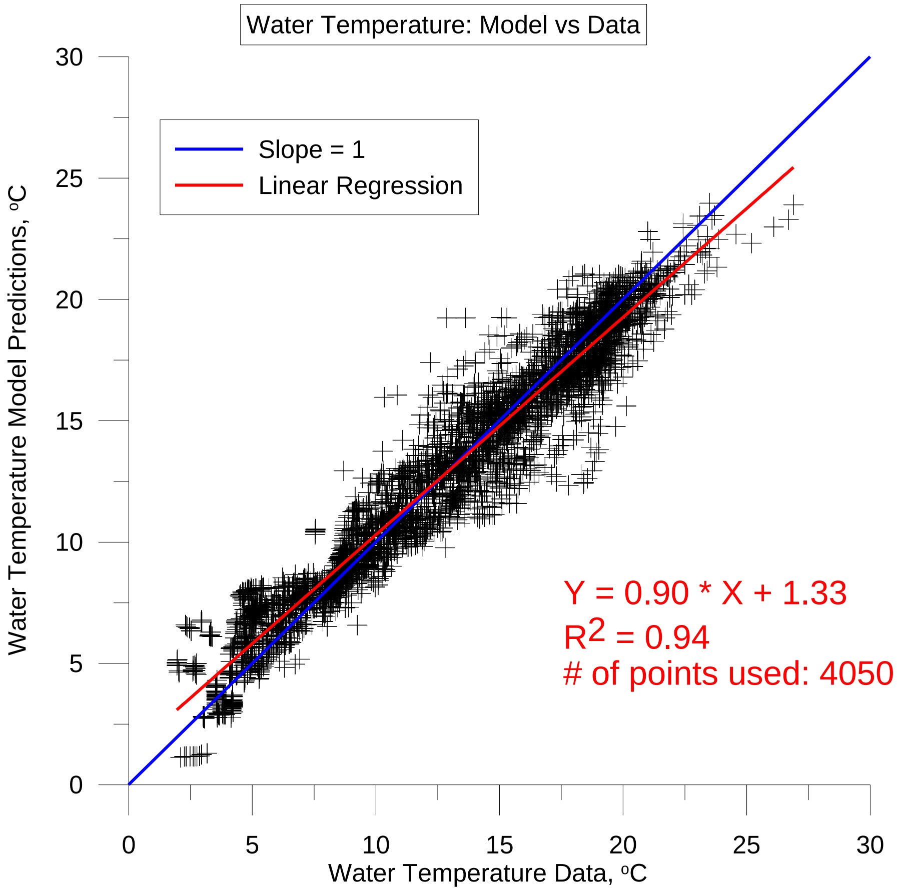


**Figure 53. A regression plot of model predicted water temperature profile data and water temperature profile data collected by WDFW**

## Dissolved Oxygen Calibration

Calibrating dissolved oxygen consisted of matching model profile predictions to dissolved oxygen profile data that were collected by the WDFW. Figure 54 shows a flow chart of dissolved oxygen sources and sinks which include:

<u>Source</u>

1.) Reaeration from the atmosphere through diffusion and turbulent mixing. Reaeration can be controlled in the CE-QUAL-W2 model by either selecting predetermined reaeration equations that are suited for different water systems, or there is the option of creating a user defined equation.

2.) Algal photosynthesis

<u>Sinks</u>

1.) Algal and zooplankton respiration

2.) Biological/sediment oxygen demand (BOD/SOD)

3.) Nitrification

4.) Diffusion into the atmosphere

Dissolved oxygen calibration proved to be challenging in that when in error, the model would most commonly produce too little dissolved oxygen and thus result in an overall negative mean error. More specifically, the model had a difficult time reproducing dissolved oxygen levels when the field data were shown to have been supersaturated. This under production of dissolved oxygen is most likely due to occurring algal blooms that were not reproduced by the model or perhaps changes in wind's effect on mixing that was not reproduced by the model. To help facilitate model oxygen production the model default reaeration equation for lakes was changed to a more conservative equation which would lose oxygen to the atmosphere less quickly. Also the oxygen production capacity of all algal groups was increased. Despite the need to increase overall dissolved oxygen concentrations, sediment oxygen demand (SOD) (g $O_2/m^2$ •day) was increased for some segments. An increase in SOD would result in a slight decrease in hypolimnetic dissolved oxygen and also help shape the model's dissolved oxygen profile to more resemble the field data. SOD and algal photosynthesis rates are shown in the model control file in Appendix A under sub heading "STOICH 2" and "S DEMAND" respectively. Figure 55 shows a comparison of the effects two different sediment oxygen demand coefficients have on predictions of dissolved oxygen.

Table 28 shows model-data error statistics and the number of model-data comparisons for dissolved oxygen. Figure 56 shows a regression plot of model predicted dissolved oxygen profile data regressed against corresponding field data. Dissolved oxygen model-data vertical profile plots are shown in Appendix C.

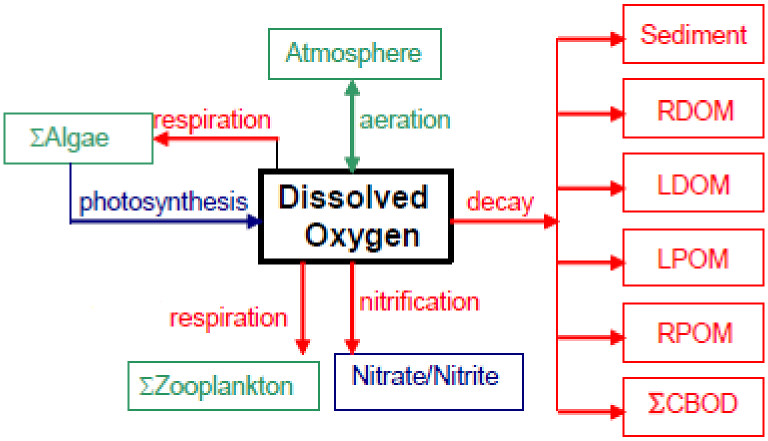


**Figure 54. A flow chart of dissolved oxygen sources and sinks (Cole and Wells, 2010)**

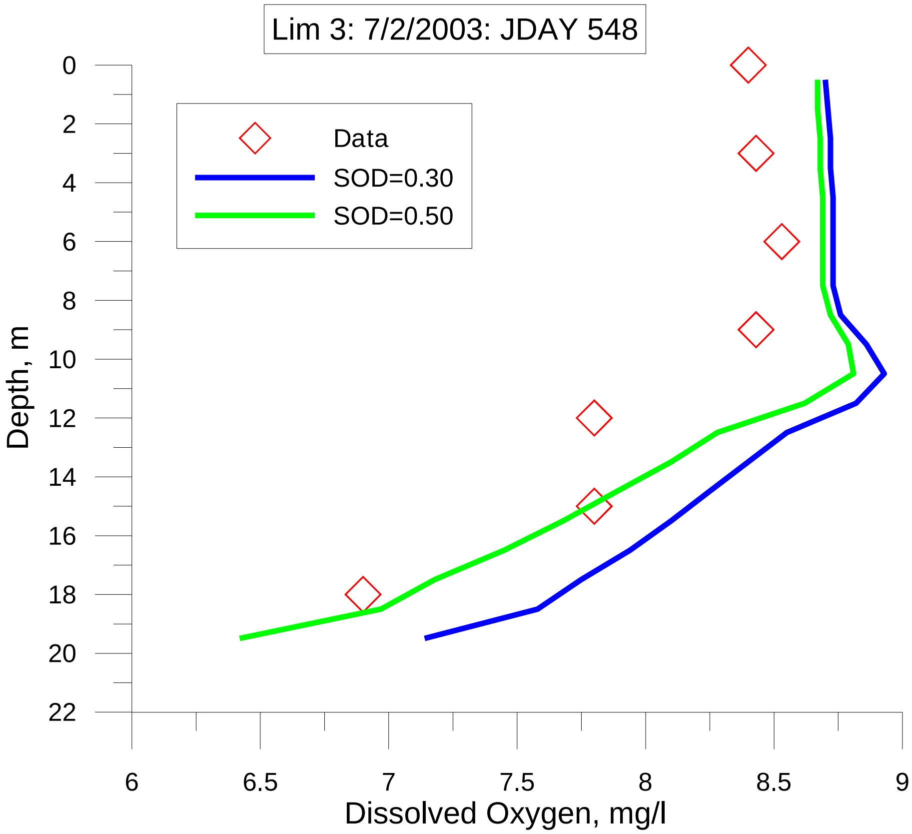


**Figure 55. Effects of SOD on dissolved oxygen profile predictions for Lim site 6 on 7/30/2008 with a SOD=0.3 and SOD=0.50**

**Table 28. Model–data error statistics for dissolved oxygen profile data 2002, 2003, 2008 and 2009**

| Station | Model Segment | Number of Days with Data | Number of Comparisons | Mean Error, mg/l | Absolute Mean Error, mg/l | Root Mean Square Error, mg/l | Years |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 55 | 551 | -1.34 | 1.45 | 1.50 | 2002, 2003, 2008 & 2009 |
| 2 | 173 | 34 | 109 | -0.71 | 1.24 | 1.24 | 2003, 2008 & 2009 |
| 3 | 39 | 55 | 522 | -0.69 | 1.16 | 1.16 | 2002, 2003, 2008 & 2009 |
| 4 | 158 | 39 | 201 | -0.40 | 1.13 | 1.13 | 2003, 2008 & 2009 |
| 5 | 82 | 53 | 622 | -0.58 | 1.06 | 1.06 | 2002, 2003, 2008 & 2009 |
| 6 | 99 | 38 | 413 | -0.39 | 1.02 | 1.02 | 2003, 2008 & 2009 |
| 7 | 147 | 29 | 669 | -0.17 | 1.37 | 1.37 | 2008 &2009 |
| 8 | 181 | 32 | 120 | -1.51 | 1.65 | 1.65 | 2008 &2009 |
| 9 | 54 | 32 | 357 | -0.71 | 1.24 | 1.24 | 2008 &2009 |

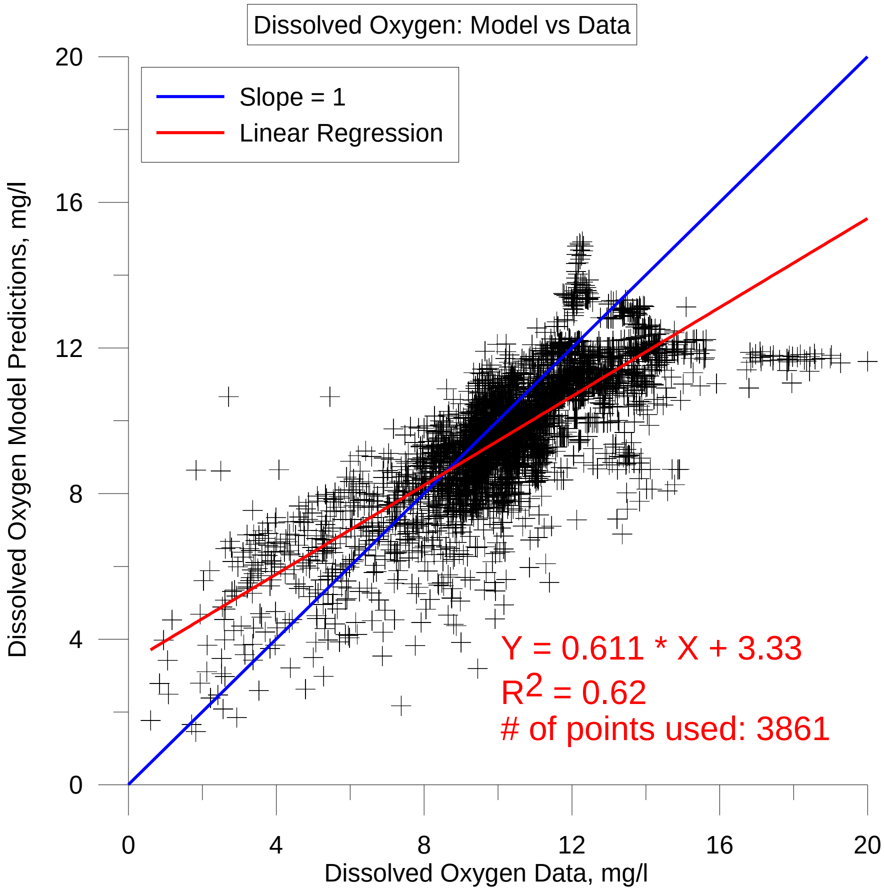


**Figure 56. A regression plot of model predicted dissolved oxygen profile data and dissolved oxygen profile data collected by WDFW**

## pH Calibration

Calibrating for pH consisted of matching model profile predictions to pH profile data that were collected by the WDFW.  While pH levels are primarily controlled by carbonate chemistry, pH calibration consisted of little more than providing good boundary condition data.  Alkalinity, pH and back calculated total inorganic carbon data were gathered as boundary condition data from the Lake Roosevelt Fisheries Evaluation Program (LRFEP).  In addition to correct boundary condition data, side effects of other calibration process such as increasing the respiration rate of algae and zooplankton or changing the reaeration equation would allow for more diffusion of $CO_2$ into the water thus resulting in a lower pH.

Table 29 shows model-data error statistics and the number of model-data comparisons for pH.  Figure 57 shows a regression plot of model predicted pH profile data regressed against corresponding field data.  pH model-data vertical profile plots are shown in Appendix D.

**Table 29. Model–data error statistics for pH profile data 2002, 2003, 2008 and 2009**

| Station | Model Segment | Number of Days with Data | Number of Comparisons | Mean Error | Absolute Mean Error | Root Mean Square Error | Years |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 55 | 578 | -0.3 | 0.55 | 0.56 | |
| 2 | 173 | 30 | 82 | -0.08 | 0.46 | 0.47 | 2008 & 2009 |
| 3 | 39 | 54 | 539 | -0.27 | 0.44 | 0.46 | 2002, 2003, 2008 & 2009 |
| 4 | 158 | 34 | 173 | -0.08 | 0.31 | 0.34 | 2008 & 2009 |
| 5 | 82 | 53 | 654 | -0.09 | 0.34 | 0.37 | 2002, 2003, 2008 & 2009 |
| 6 | 99 | 34 | 386 | 0.06 | 0.26 | 0.27 | 2008 & 2009 |
| 7 | 147 | 29 | 670 | 0.01 | 0.24 | 0.3 | 2008 &2009 |
| 8 | 181 | 33 | 124 | -0.09 | 0.43 | 0.44 | 2008 &2009 |
| 9 | 54 | 32 | 357 | -0.08 | 0.32 | 0.36 | 2008 &2009 |
| 10 | 109 | 32 | 118 | 0.16 | 0.24 | 0.24 | 2008 &2009 |
| 11 | 110 | 31 | 180 | 0.14 | 0.23 | 0.24 | 2008 &2009 |
| AVE | | | | -0.05 | 0.35 | 0.37 | |

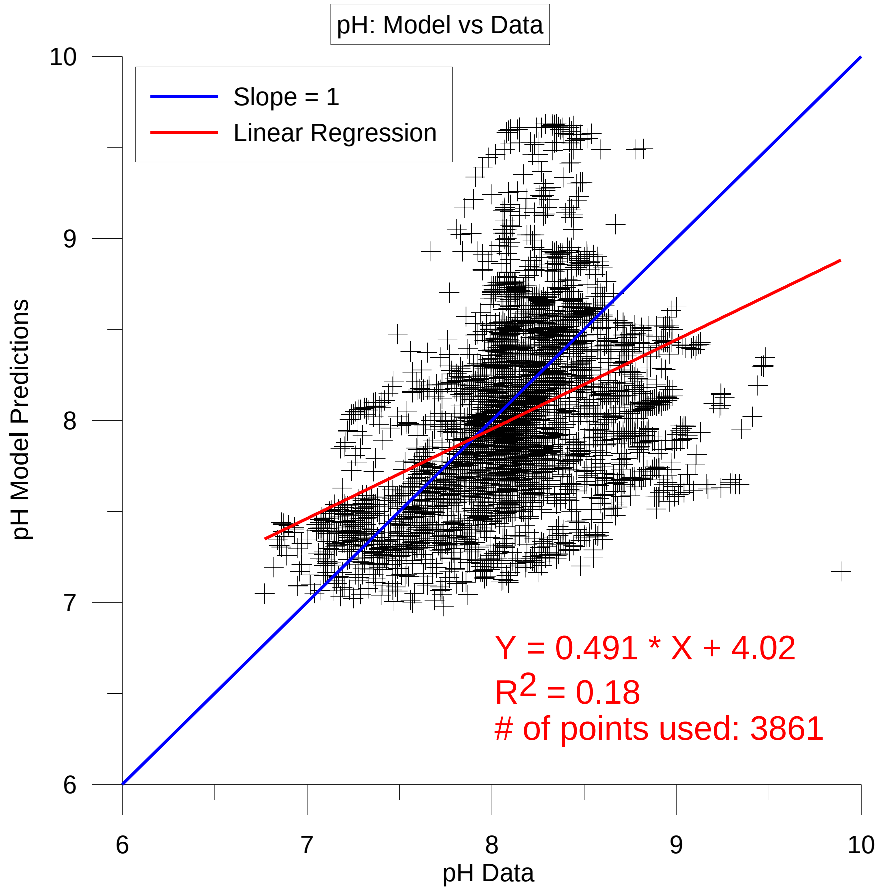


**Figure 57. A regression plot of model predicted pH profile data and pH profile data collected by WDFW**

## Chlorophyll-a Calibration

Chlorophyll-a calibration consisted of matching chlorophyll-a model prediction time series to chlorophyll-a data that was collected by the WDFW and Eastern Washington University (EWU). Chlorophyll-a data was collected at Lim sites 1-8 by EWU from 9/02-9/04 and by WDFW from 9/04-11/05. Although some of the chlorophyll-a data was collected as profile data, all data collected in 2002 and part of 2003 were single grab samples from a depth of 5 meters. Therefore, calibration used model output from a depth of 5 meters to compare against either field grab samples or profile data measured at a depth of 5 meters.

CE-QUAL-W2 calculates chlorophyll-a as a fixed ratio of predicted algal mass (mg algae/µg Chla). Calibration for chlorophyll-a consisted of fine tuning the algal mass to chlorophyll-a ratios for each algal group so that field data concentrations could be met. Algal group 1 had a ratio of 0.22 (mg algae/µg Chla), algal group 2 had a ratio of 0.11 (mg algae/µg Chla) and algal group 3 had a ratio of 0.14 (mg algae/µg Chla). The model did well to match seasonal fluxes in chlorophyll-a concentration across all Lim sites. Winter 2002-03 field data from Lim sites 1, 3 and 5 showed a summer-like algal bloom that was not captured by the model. This miss by the model is a result of it not capturing the correct algal production for winter 2002-03.

Figure 58 shows a regression plot of model predicted chlorophyll-a data regressed against corresponding field data. Figure 59 and Figure 60 show a comparison of model predicted time series of chlorophyll-a data and field data collected by WDFW and EWU at a depth of 5 meters at Lim site 1-8 during 2002-2005.

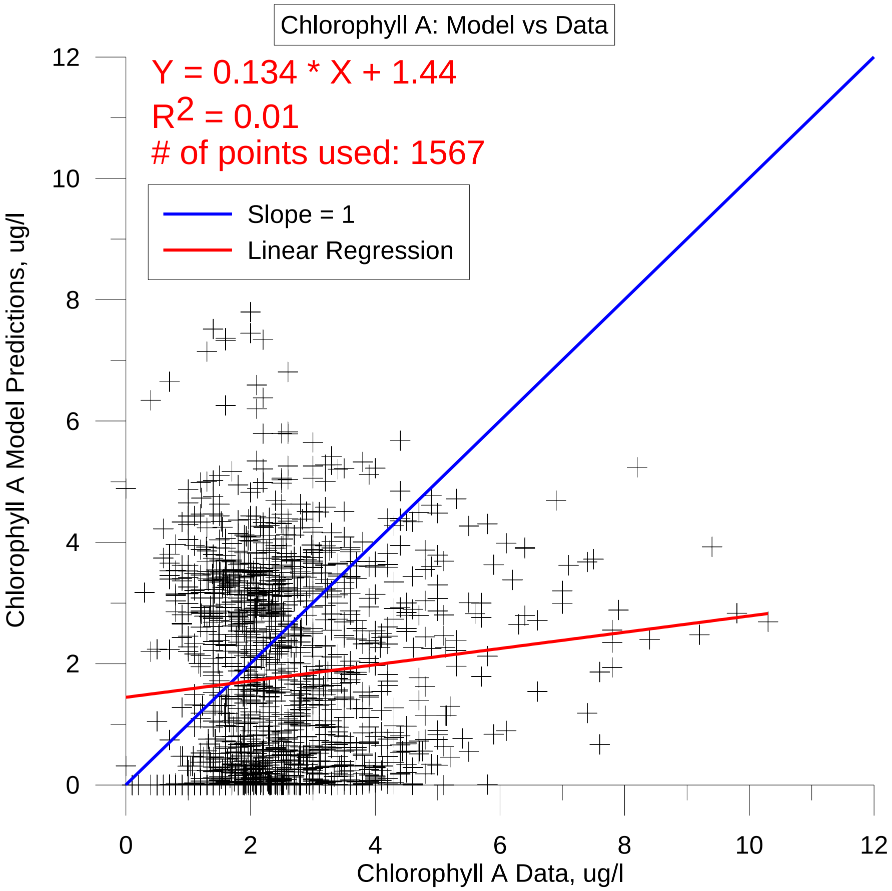


**Figure 58. A regression plot of model predicted chlorophyll-a data and chlorophyll-a data collected by WDFW and EWU at a depth of 5 meters**

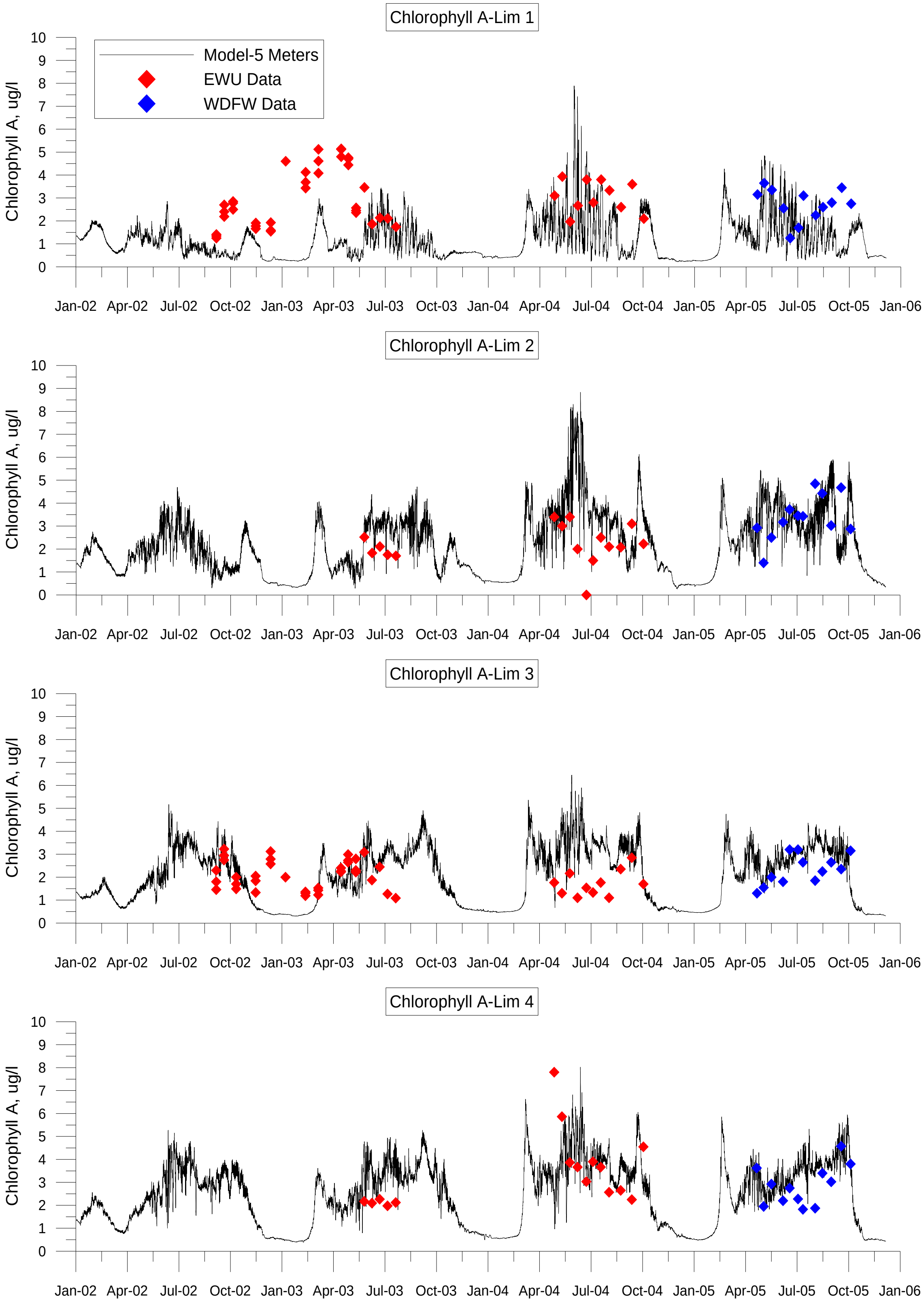


**Figure 59. Chlorophyll-a model predictions compared against data collect by EWU and WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4**

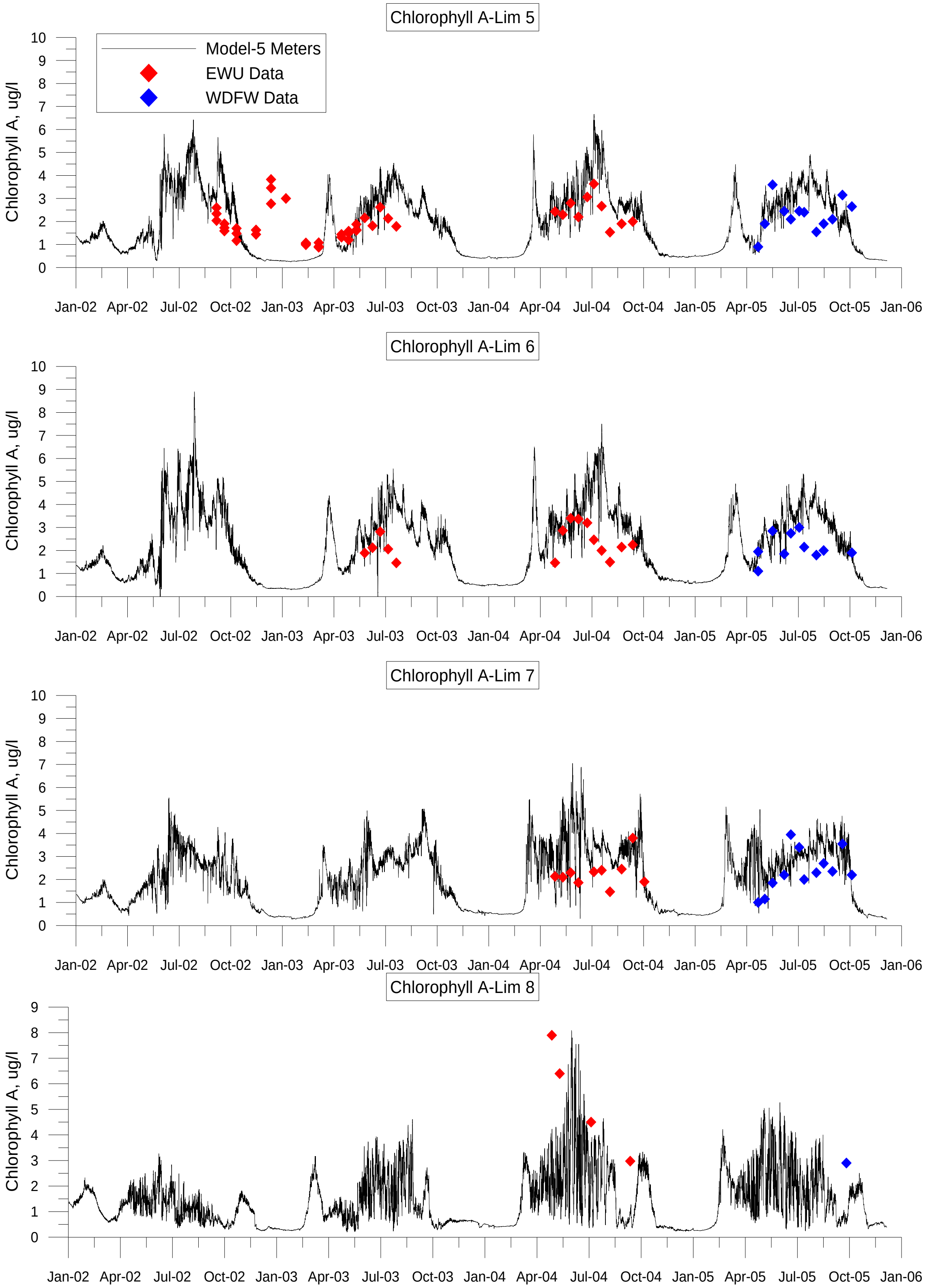


**Figure 60. Chlorophyll-a model predictions compared against data collect by EWU and WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8**

## Algae Calibration

The Banks Lake CE-QUAL-W2 model used three algal groups:

Algae 1: Diatoms
Algae 2: Cryptophyta
Algae 3: Other (Green/Blue Green Algae)

The first two algal groups represent the most dominant algal groups taken from the data and the third algal group includes all other algal groups of interest. Calibrating for algae used 5 main parameters which allowed to custom fit different algal groups within the model to match the life characteristics of their natural algal taxonomy group. Each group was assigned a specific maximum daily growth rate, a temperature range within which each group would grow at their maximum growth rate, a daily sinking rate, a daily mortality rate, and specific algal nutrient stoiciometry. These calibration parameters are shown in the control file located in Appendix A under subheading ”ALGAL RATE” “ALGAL TEMP” and “ALGAL STOI”. Proper use of these parameters allows for each algal group to bloom during the appropriate time of year, compete with each other for available nutrients, remain in the water column long enough to provide additional oxygen production or die and contribute to the nutrient cycle or add to the biological oxygen demand. Default values were used first for the algal parameters, and then as calibration progressed each parameter value was altered to achieve the best results.

## Algae 1-Diatoms

Figure 61 shows a regression plot of model predicted algae 1 mass concentrations against field data collected at a depth of 5 meters by the WDFW. Model-data comparisons of algae 1 mass concentrations measured at a depth of 5 meters are shown in Figure 62 and Figure 63 for Lim sites 1-8.

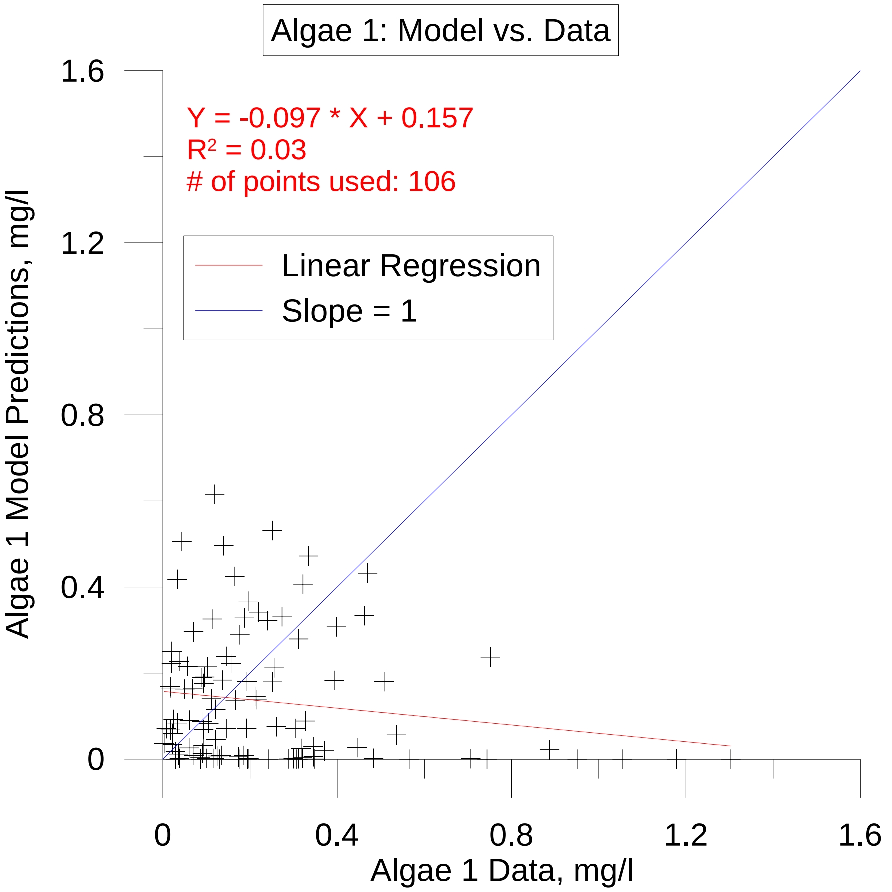


**Figure 61. A regression plot of model predicted Algae 1(diatoms) (mg/l) and Algae 1 data (mg/l) collected by the WDFW at a depth of 5 meters**

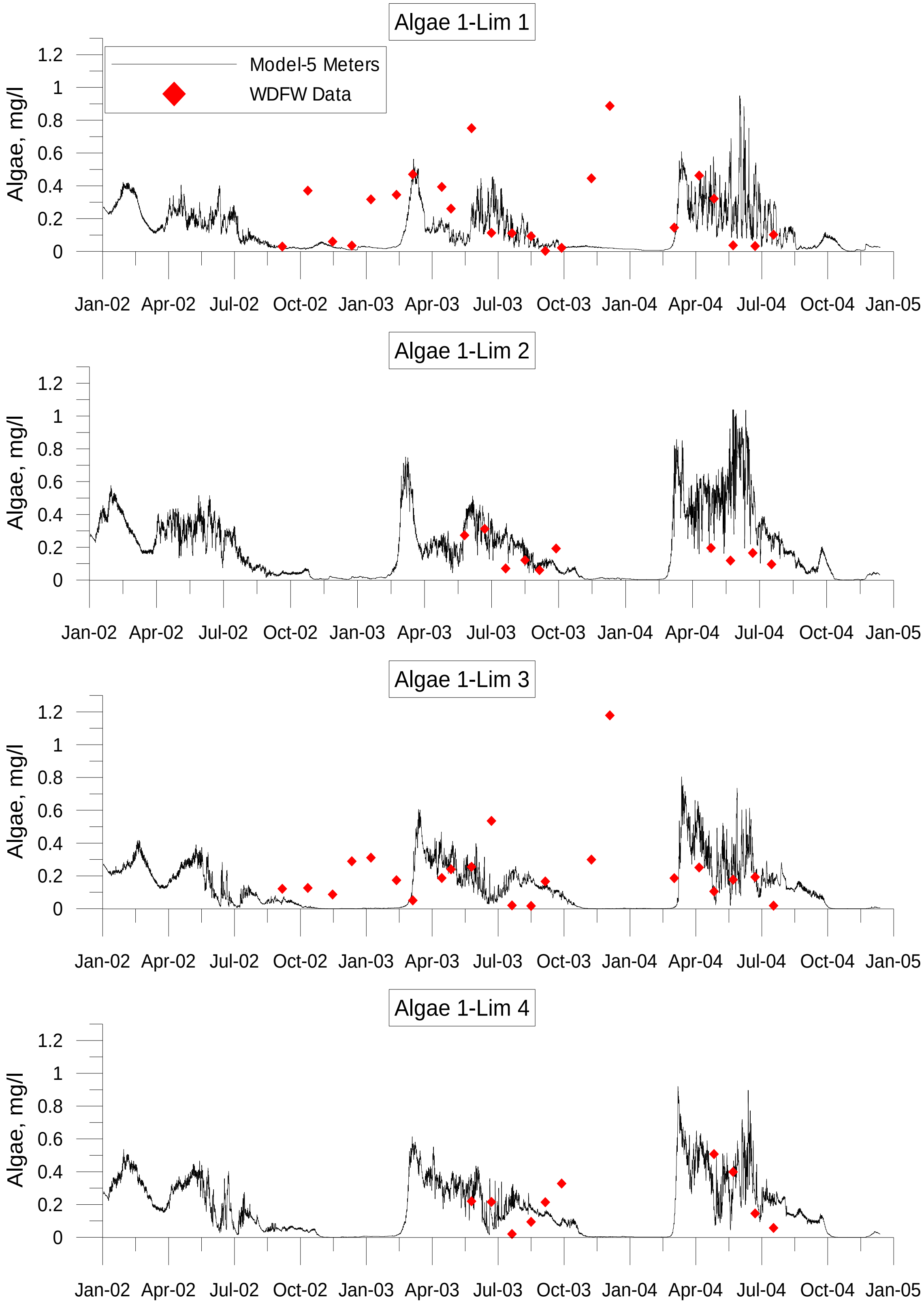
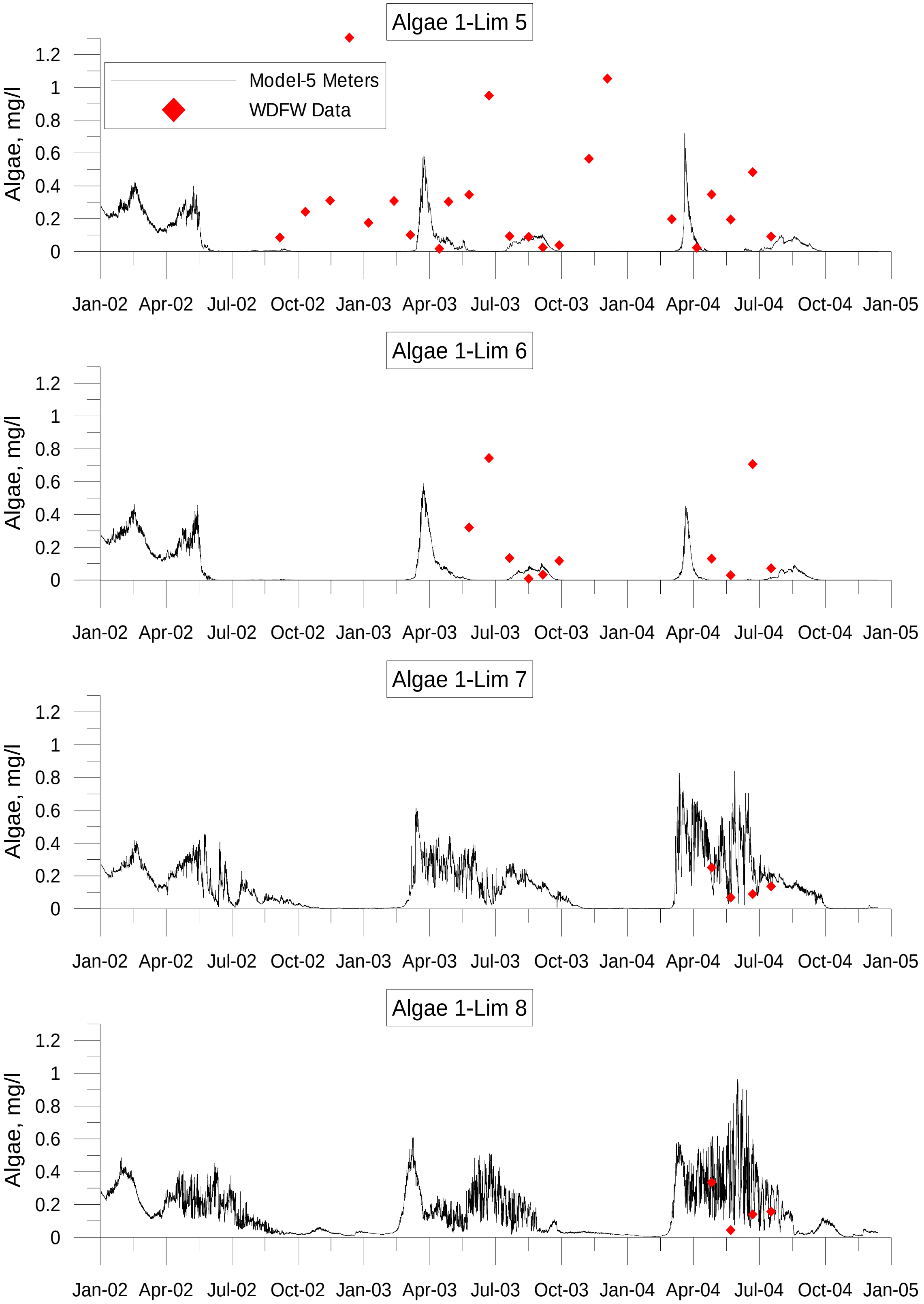


**Figure 62. Algal group 1 (Diatoms) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4**


Algae 1-Lim 5

Algae 1-Lim 6

Algae 1-Lim 7

Algae 1-Lim 8

**Figure 63. Algal group 1 (Diatoms) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8**

## Algae 2-Cryptophyta

Figure 64 shows a regression plot of model predicted algae 2 mass concentrations against field data collected at a depth of 5 meters by the WDFW. Model-data comparisons of algae 2 mass concentrations measured at a depth of 5 meters are shown in Figure 65 and Figure 66 for Lim sites 1-8.

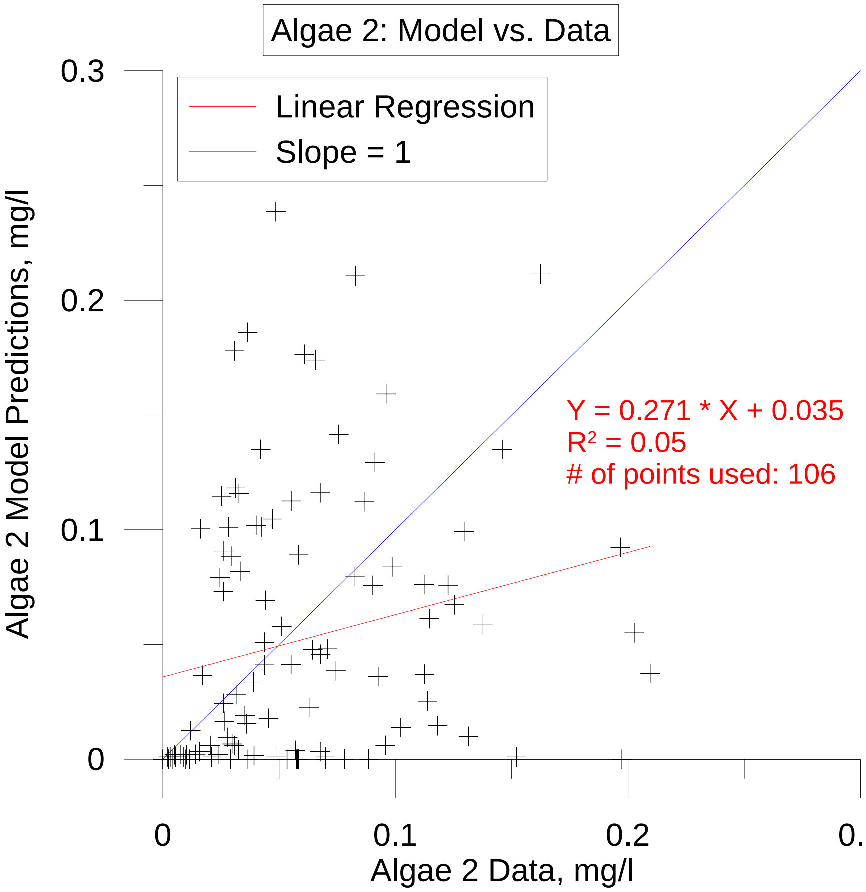


**Figure 64. A regression plot of model predicted Algae 2 (Cryptophyta) (mg/l) and Algae 2 data (mg/l) collected by the WDFW at a depth of 5 meters**

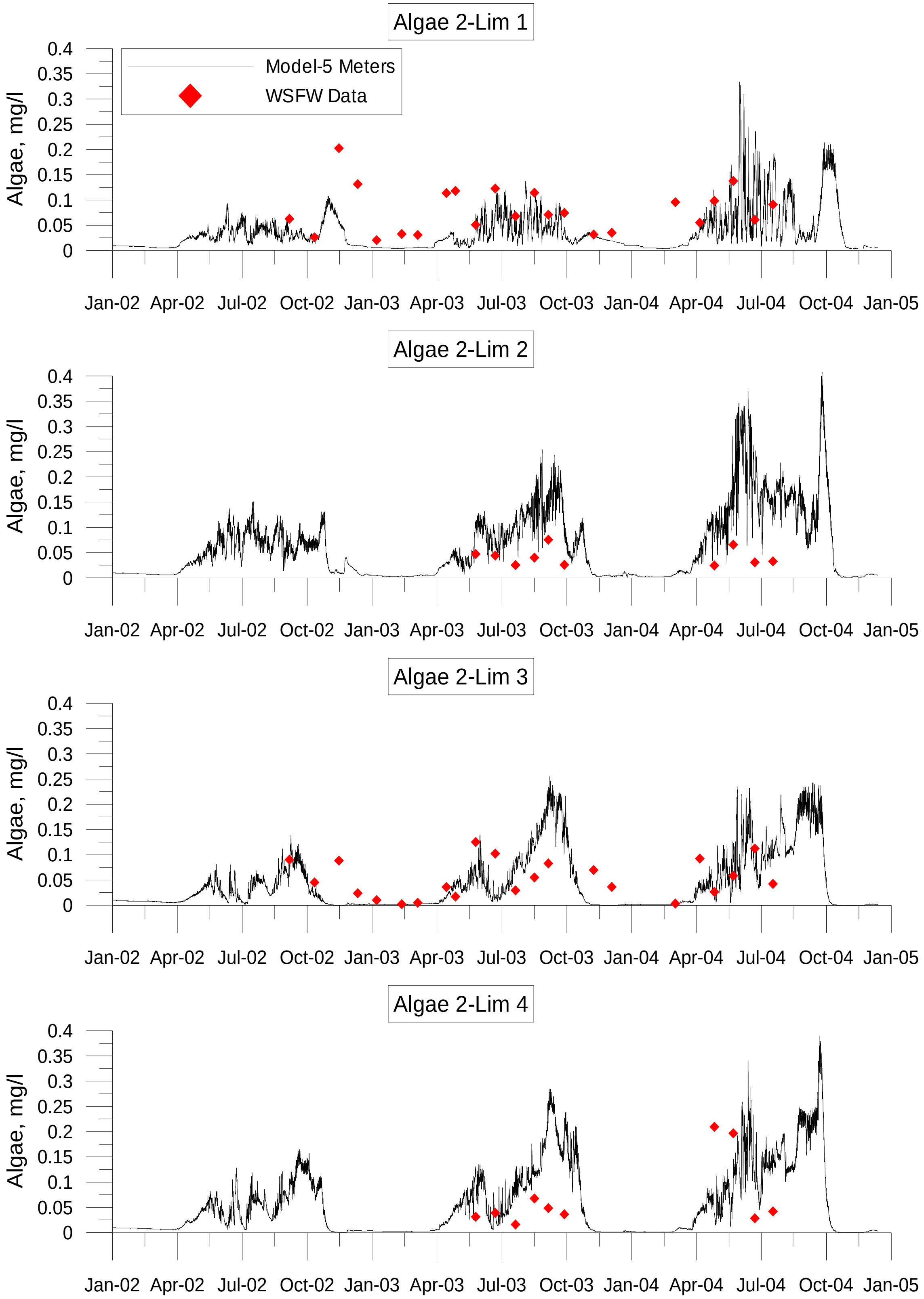


**Figure 65. Algal group 2 (Cryptophyta) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4**

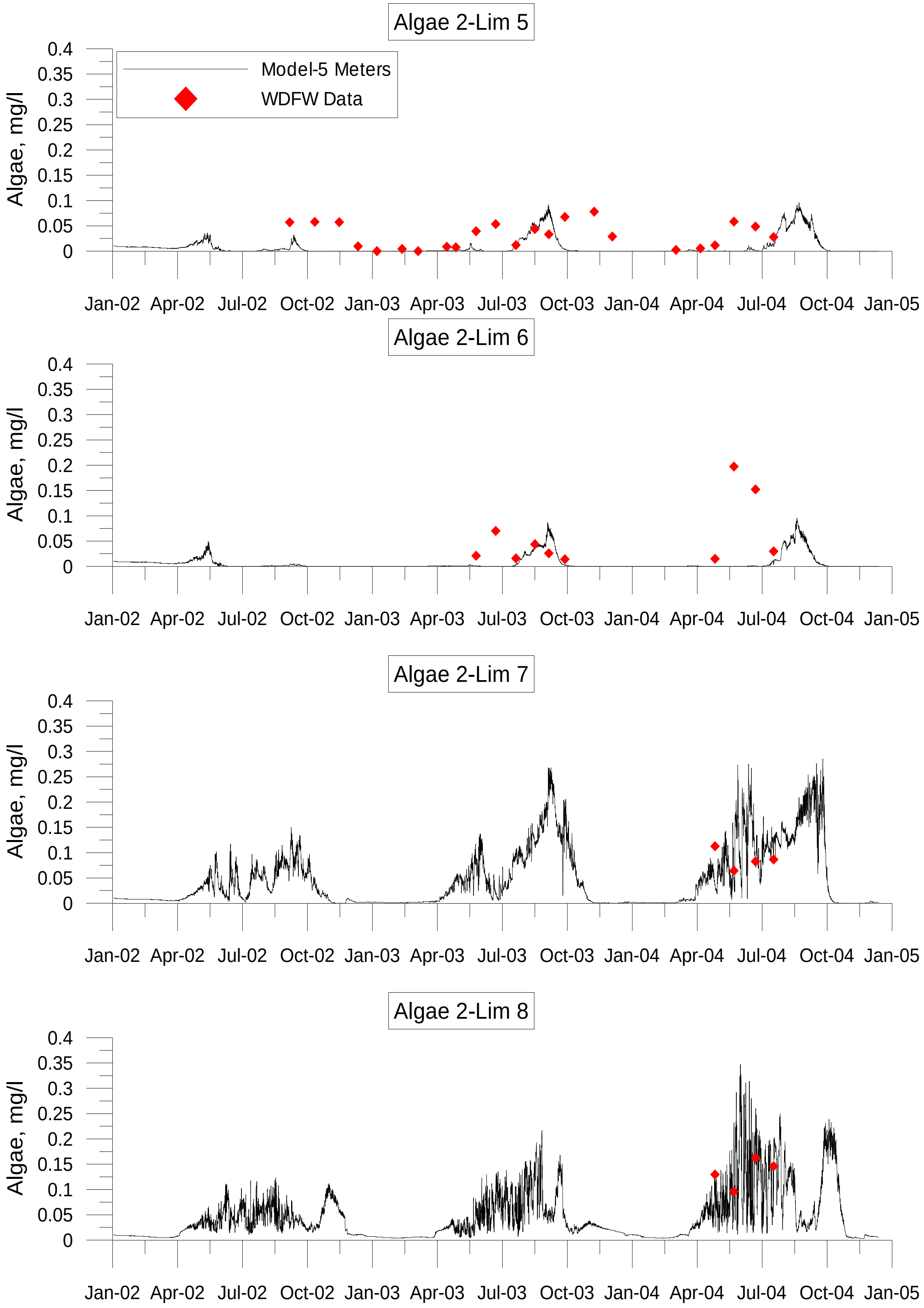


**Figure 66. Algal group 2 (Cryptophyta) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8**

## Algae 3-Green & Blue Green Algae

Figure 67 shows a regression plot of model predicted algae 3 mass concentrations against field data collected at a depth of 5 meters by the WDFW. Model-data comparisons of algae 3 mass concentrations measured at a depth of 5 meters are shown in Figure 68 and Figure 69 for Lim sites 1-8.

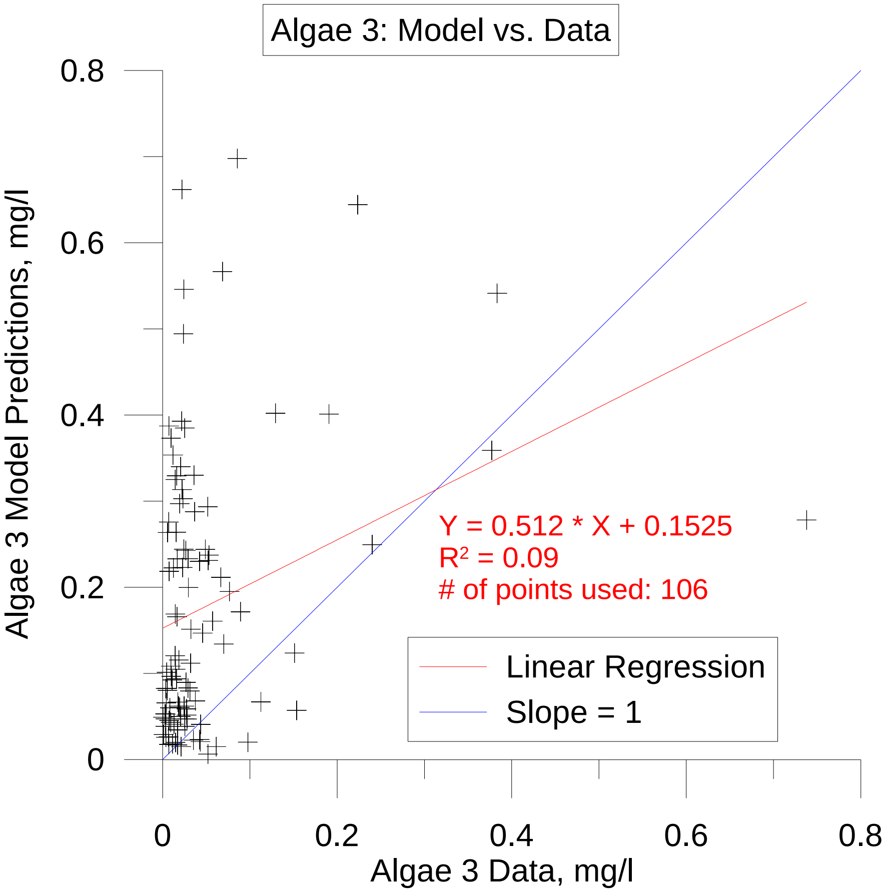


**Figure 67. A regression plot of model predicted Algae 3(Green & Bluegreen) (mg/l) and Algae 3 data (mg/l) collected by the WDFW at a depth of 5 meters**

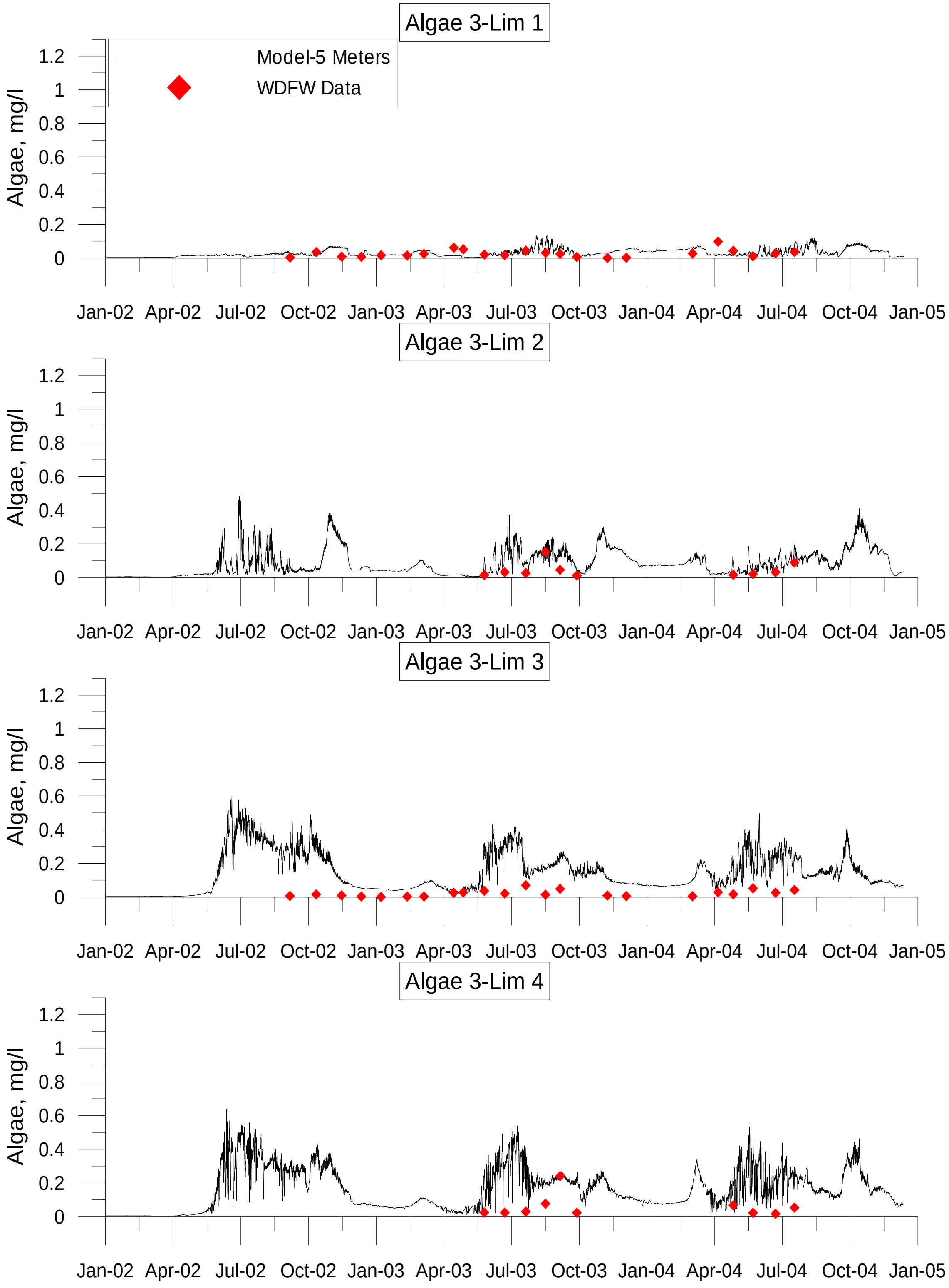


**Figure 68. Algal group 3 (Green and Bluegreen) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 1, 2, 3 and 4**

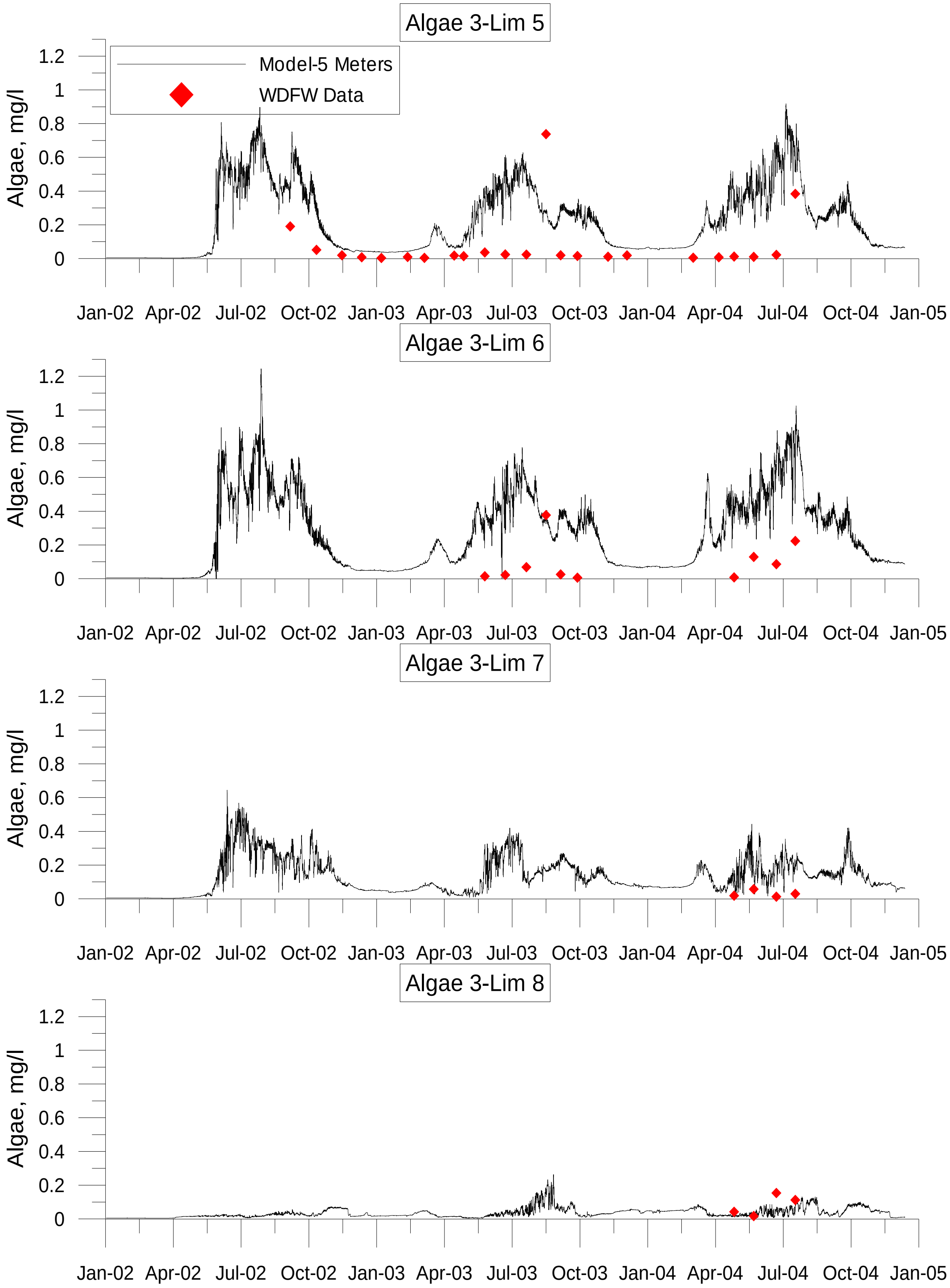


**Figure 69. Algal group 3 (Green and Bluegreen) model predictions compared against data that was collected by the WDFW at a depth of 5 meters for Lim sites 5, 6, 7 and 8**

## Zooplankton Calibration

The Banks Lake CE-QUAL-W2 model used two zooplankton groups:

Zooplankton 1: Copepod
Zooplankton 2: Daphnia

Zooplankton samples collection took place at all 11 Lim sites over 2008-2009. Samples were collected with a mesh tow net and the depth of tows among each Lim site would often vary throughout the year. For each tow the total number of individual zooplankton organisms were counted and then averaged over the total volume of water sampled by the tow net, resulting in a volume weighted density. Evaluating zooplankton abundance this way has the potential to dilute a sample's density if the tow was taken from a depth beyond the epilimnion where fewer zooplankton reside.

Zooplankton calibration, like algae calibration, involved multiple parameters that are used to fine tune zooplankton groups within the model to mimic the behavior and propagation of real zooplankton. The main calibration tools used included, a maximum daily growth rate, a temperature range within which each group would grow at their maximum growth rate, specific zooplankton nutrient stoichiometry, a daily mortality rate, algal prey feeding preference, zooplankton prey feeding preference, and a feeding assimilation efficiency coefficient. The algal and zooplankton feeding preference parameter allows the user to control each zooplankton group's like and dislike for certain prey items (i.e., diatoms vs blue green algae). The feeding assimilation efficiency parameter allows the user to determine the proportion of food assimilated to food consumed for each zooplankton group. These zooplankton calibration coefficients are listed within the control file in Appendix A under subheadings “ZOOP RATE”, “ZOOP ALGP”, “ZOOP ZOOP”, “ZOOP TEMP” and “ZOOP STOI”.

Zooplankton densities are often spotty in distribution within natural systems and concentrations can vary multiple orders of magnitude within a 24 hour period. When modeling zooplankton, it is often the goal of the modeler to produce model predictions within an order of magnitude of the field data. The following zooplankton plots intend to show the model’s ability to reproduce measured zooplankton concentrations and show how zooplankton concentrations vary with depth.

Figure 70, Figure 71, Figure 72 and Figure 73 show a range of model predicted zooplankton time series beginning at a depth of 5 meters and extending to a depth comparable to the tow depths used to collect zooplankton data at that particular Lim site, with the volume weighted mass concentrations field data of zooplankton group 1.

Figure 74, Figure 75, Figure 76 and Figure 77 show a range of model predicted zooplankton time series beginning at a depth of 5 meters and extending to a depth comparable to the tow depths used to collect zooplankton data at that particular Lim site, with the volume weighted mass concentrations field data of zooplankton group 2.

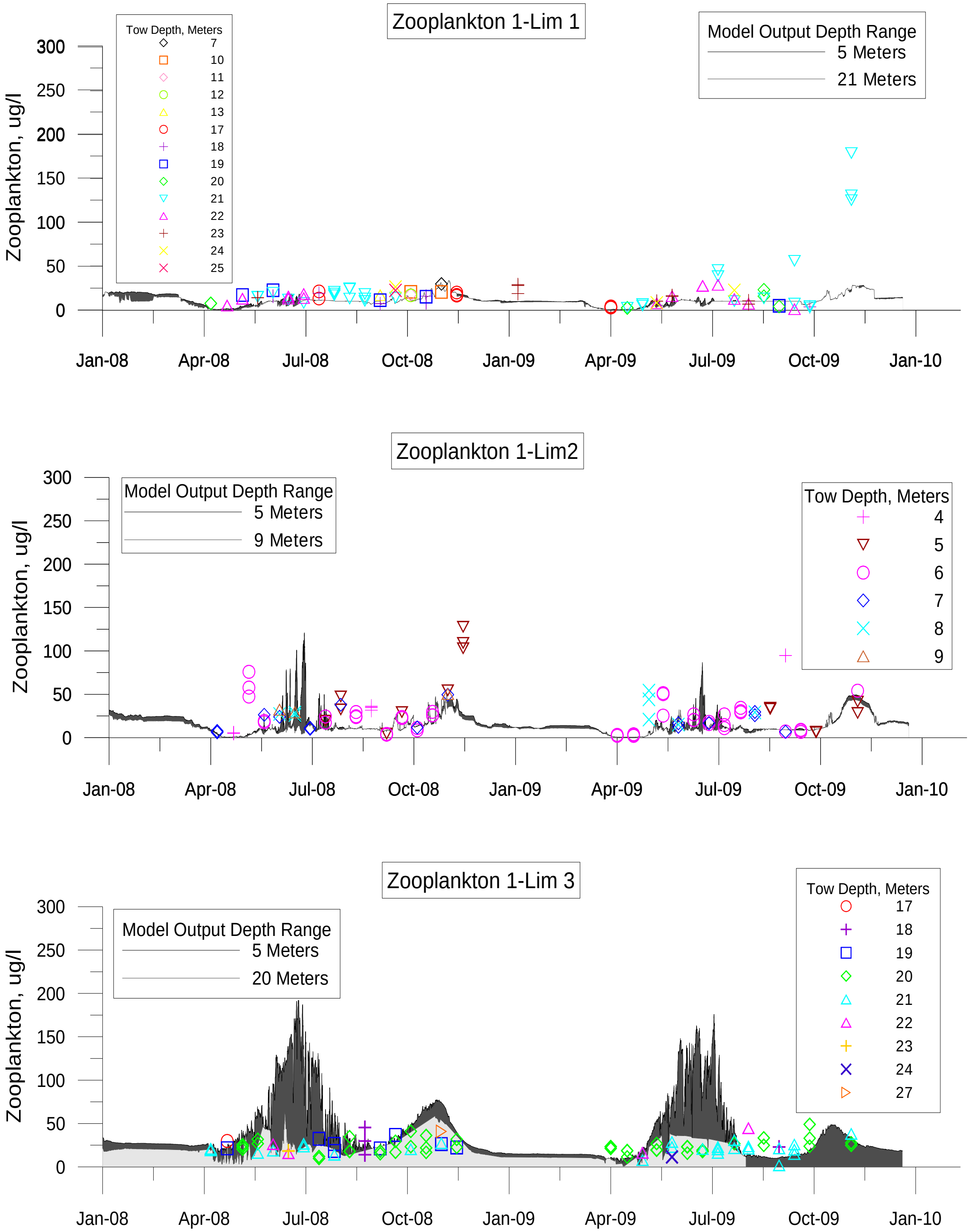


**Figure 70. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 1, 2 and 3**

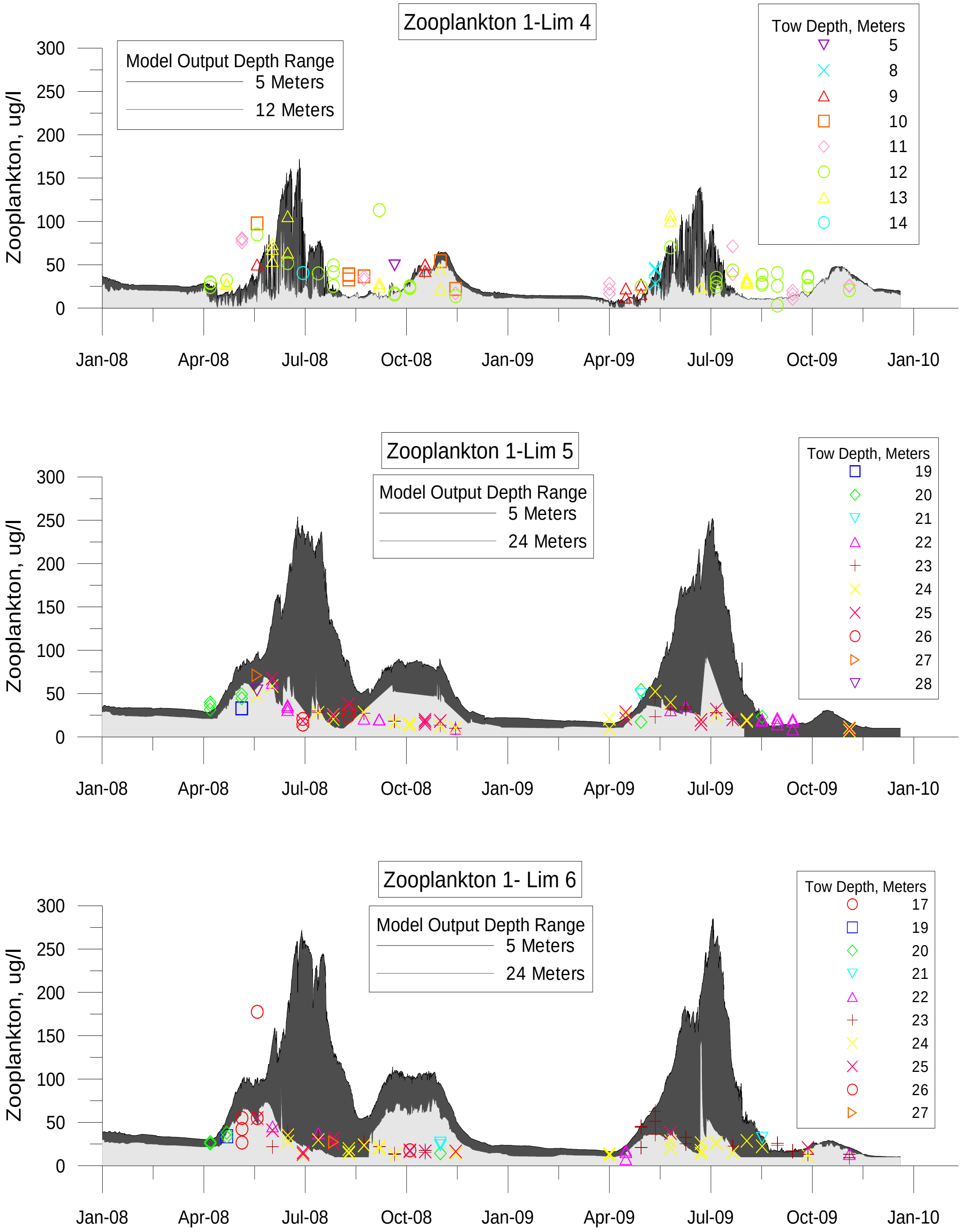


**Figure 71. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 4, 5 and 6**

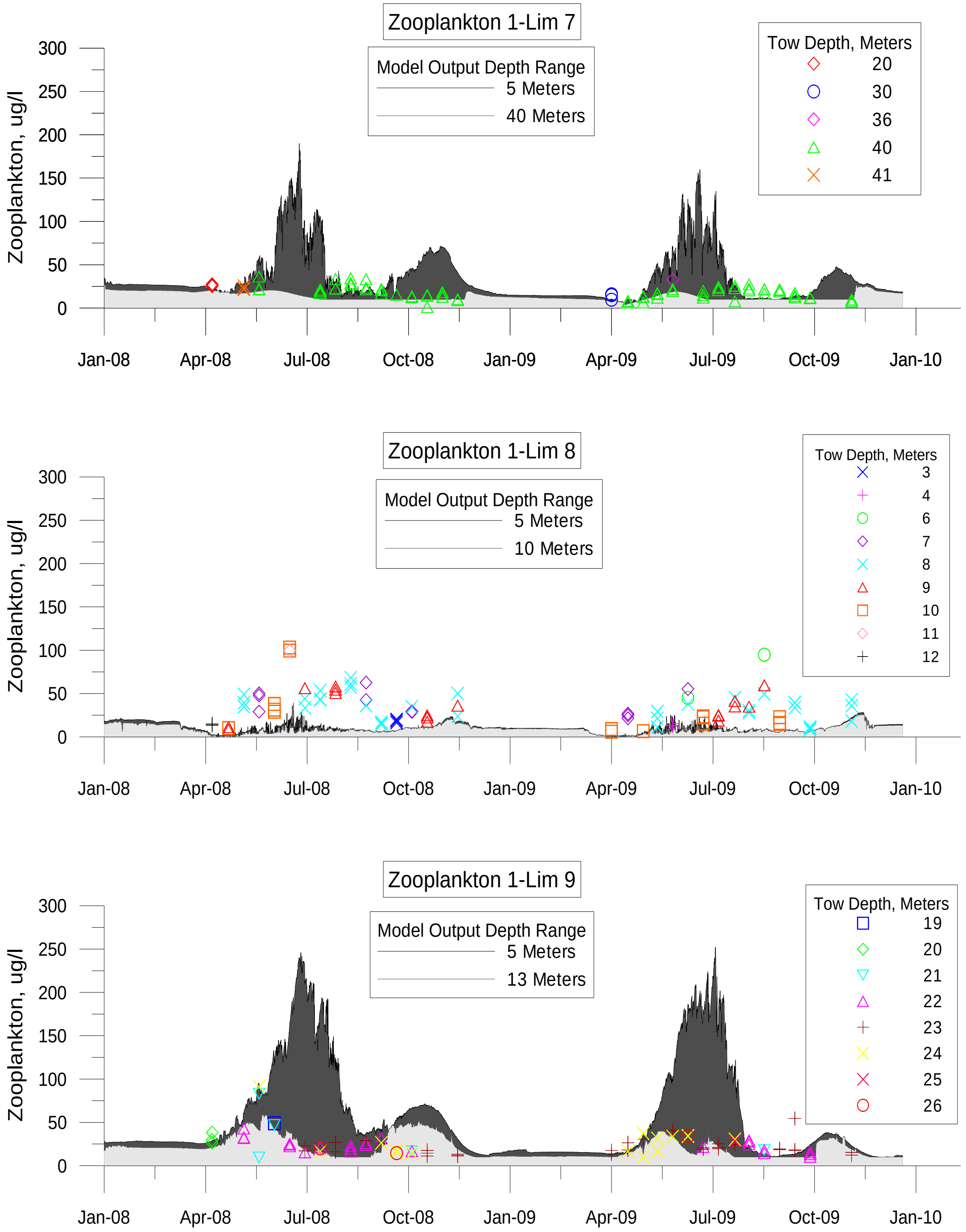


**Figure 72. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 7, 8 and 9**

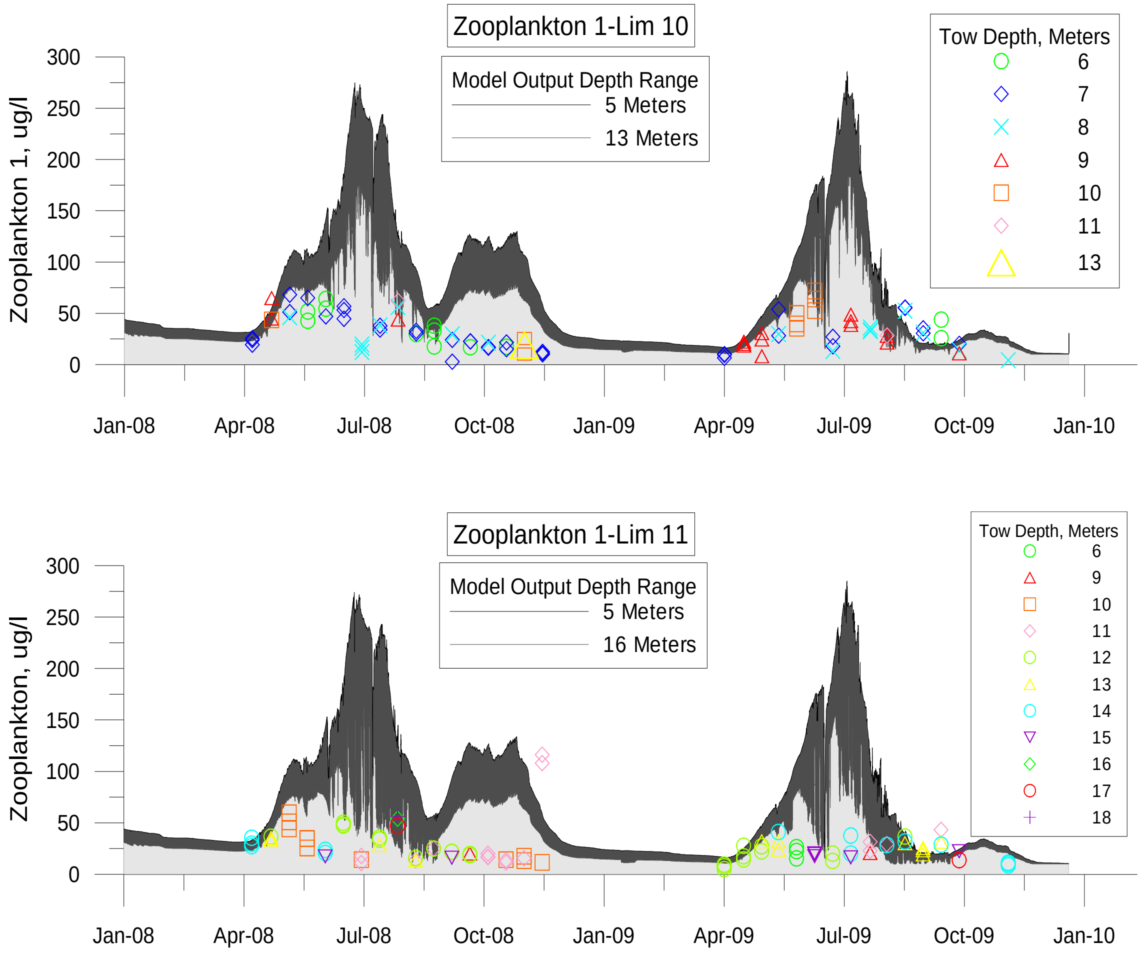


**Figure 73. Zooplankton group 1 (copepods) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 10 and 11**

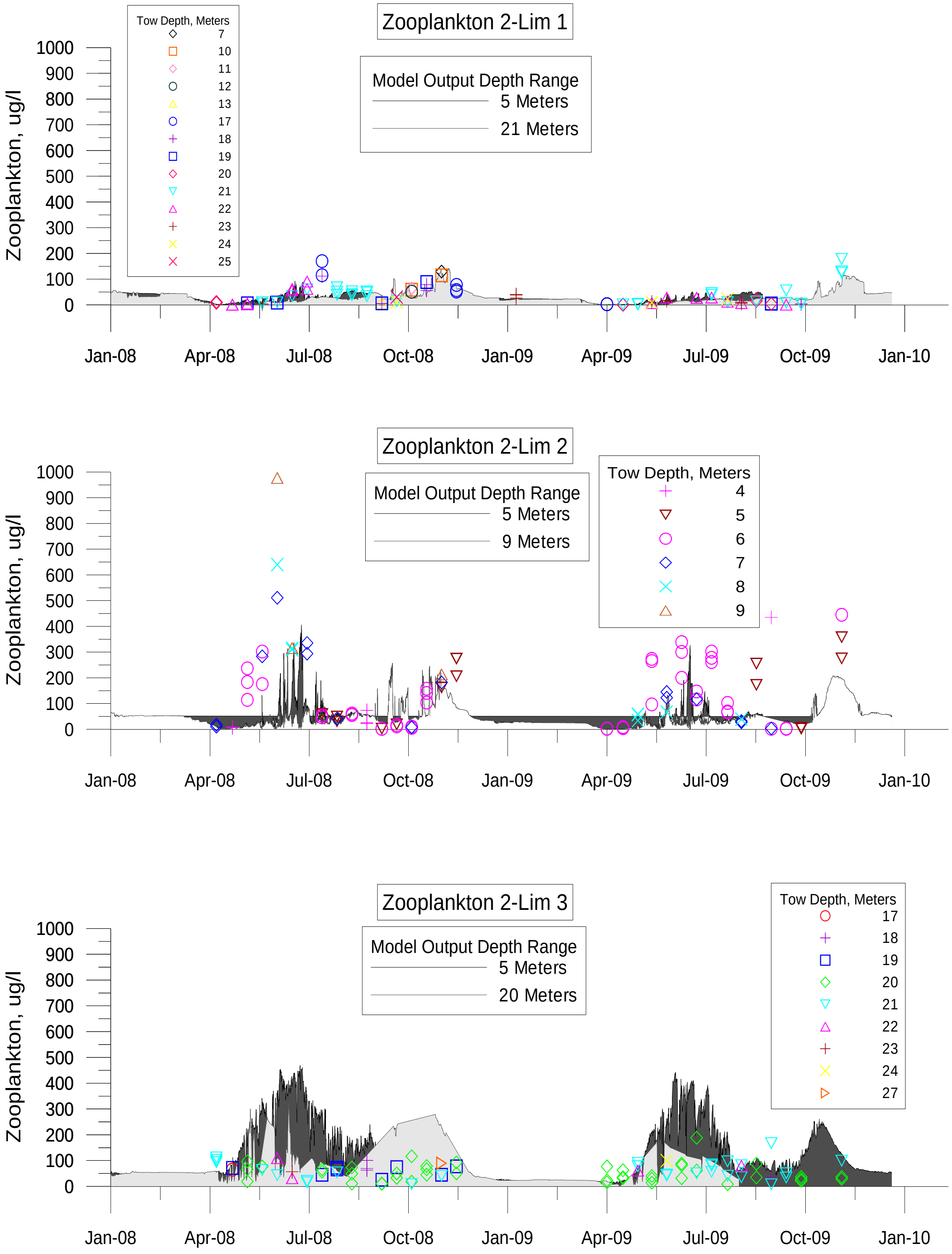


**Figure 74. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 1, 2 and 3**

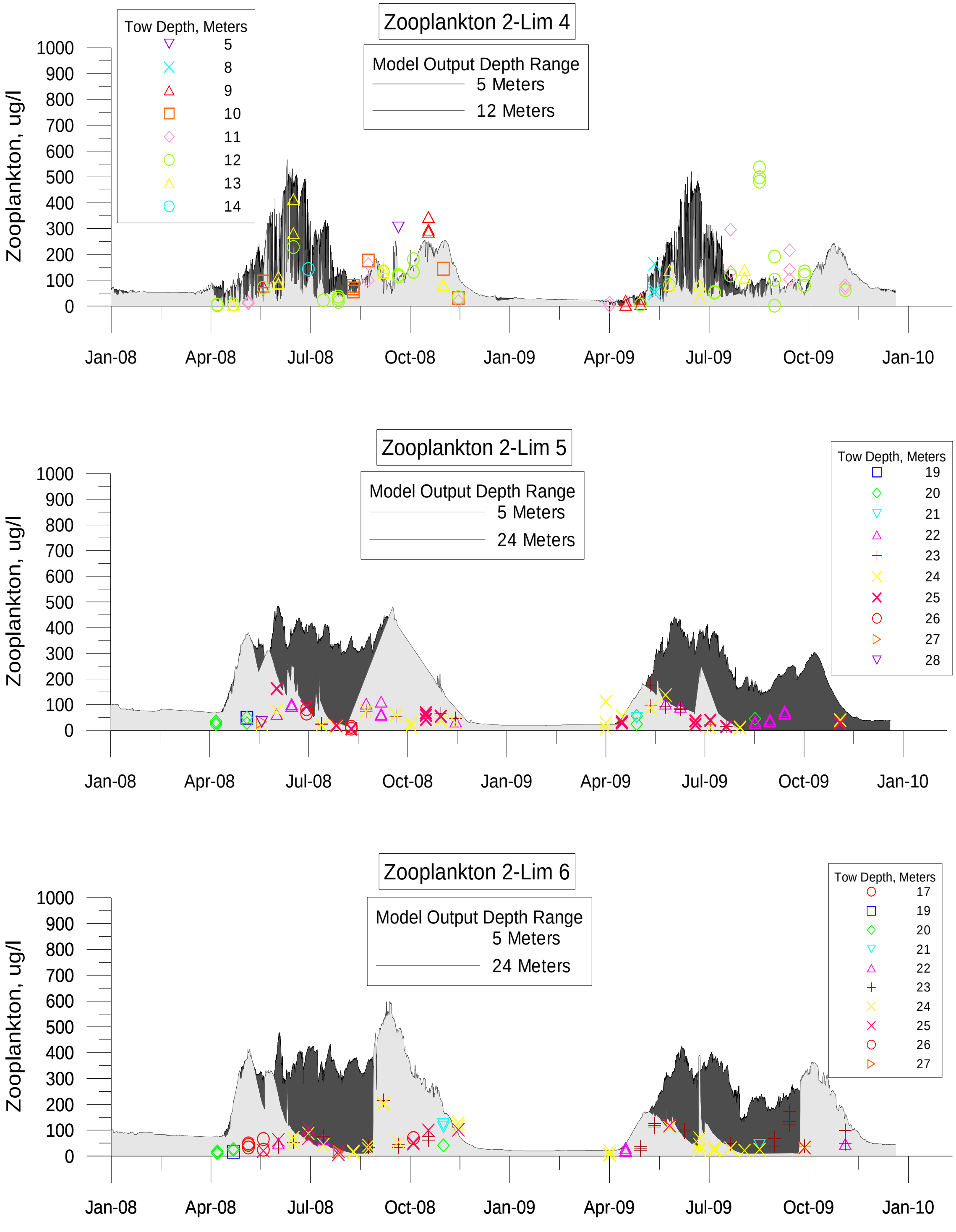


**Figure 75. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 4, 5 and 6**

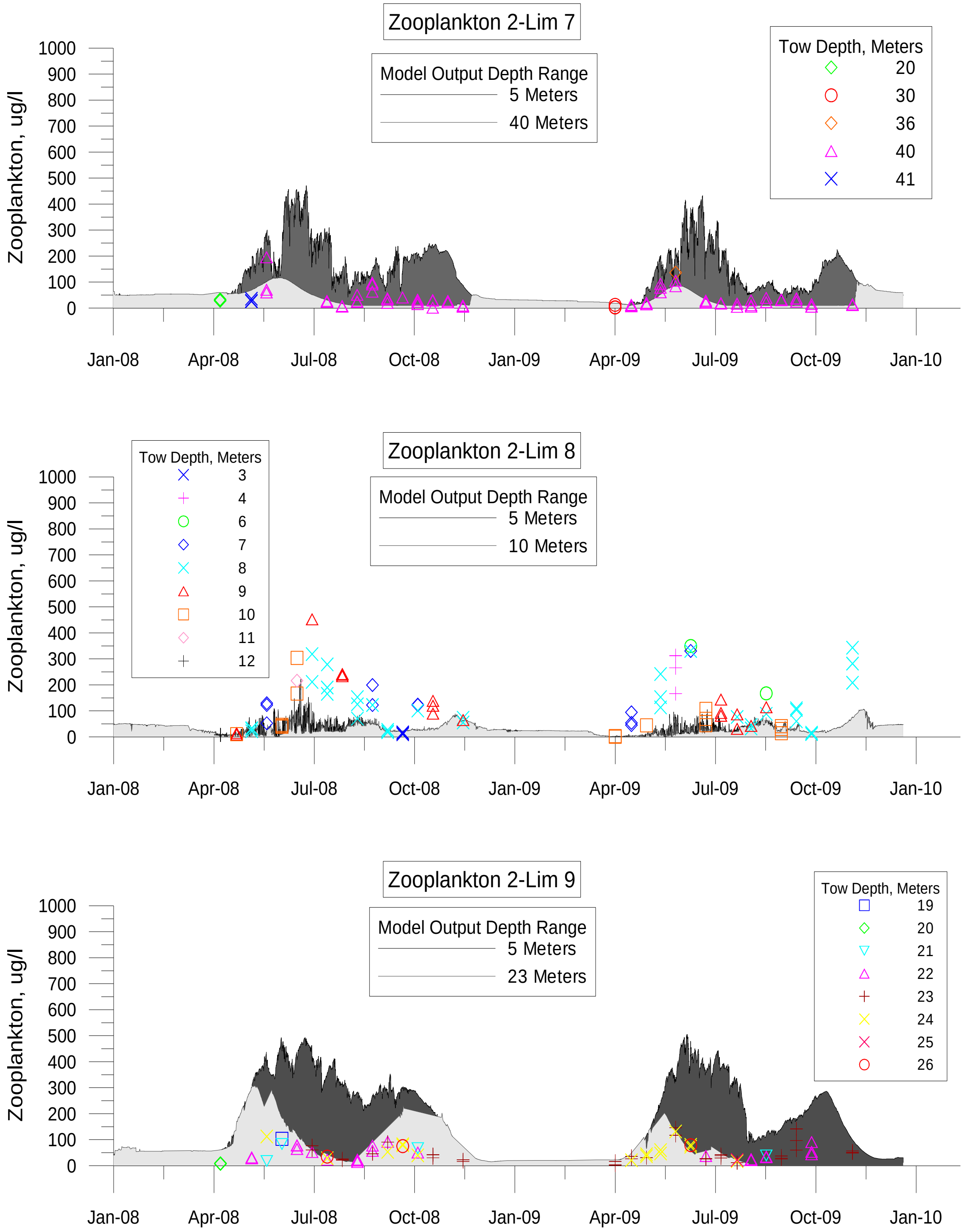
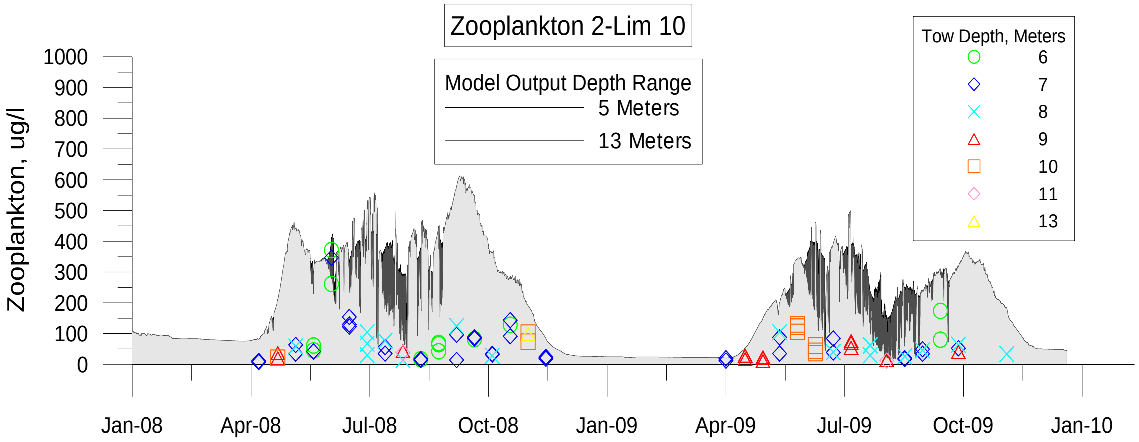


**Figure 76. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 7, 8 and 9**



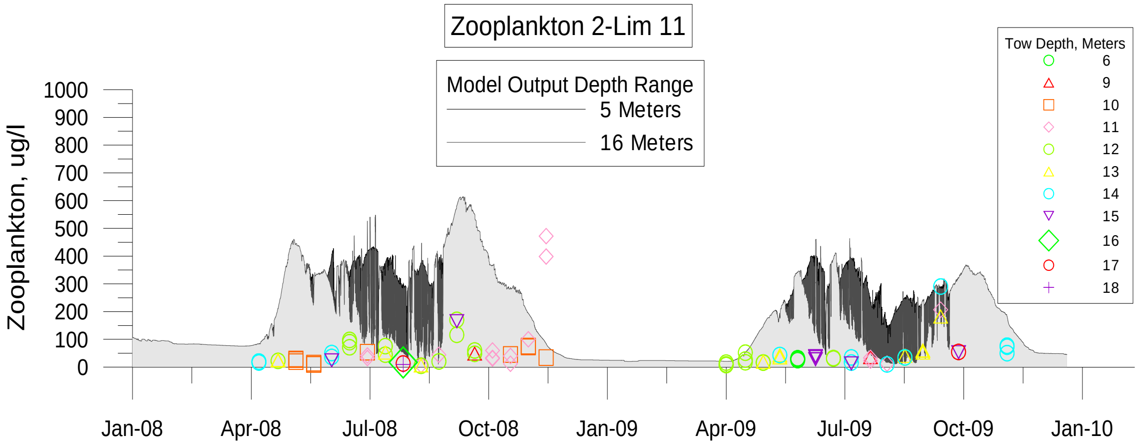


**Figure 77. Zooplankton group 1 (daphnia) model predictions at multiple depths compared against zooplankton tow data collected by the WDFW for Lim sites 10 and 11**

## Alternative Action Management Scenarios

### Alternative Action Management Scenario Background & Data

The Odessa Subarea Special Study draft EIS outlines eight action alternative management scenarios and one no-action alternative that involve altering the monthly drawdown schedule of Banks Lake. To anticipate the effects of various flow years on the proposed action alternative management scenarios, four previous flow years were selected to represent a range of conditions:

| | |
|---|---|
| Wet: | 1982 |
| Average: | 1995 |
| Dry: | 1998 |
| Drought: | 1931 |

To determine the effect of each alternative scenario on Banks Lake, the Banks Lake CE-QUAL-W2 model was run for one year (January 1 through December 31) under the drawdown guidelines of each action alternative outlined in the Banks Lake Draft EIS. This approach involved using the appropriate daily averaged Feeder Canal inflow for each wet, average, dry and drought run (see Table 31). All action alternatives were run using meteorological data from 2007 since meteorological data for all 1931, 1982, 1995 and 1998 were not available. Comparing annual meteorological data within the 2002-2009 model simulation showed that 2007 meteorological data were neither high nor low in any category, rather all max, min and average annual meteorological values from 2007 were near the overall average value for the entire eight year model simulation (Table 30). Since the dry flow reference year (1931) preceded the inundation of Banks Lake, flow records were not available from the Feeder Canal and flow from the drought flow reference year (1998) was used instead.

Feeder canal flow records show a gradual increase in total annual flow entering Banks Lake from 1982 to 2009, but there is little correlation between feeder canal flow rates and the type of flow reference year (see Figure 78). Therefore, the no-action alternative model run was based on 2008 flow records, since the 2008 water elevation records follow an August drawdown similar to the no-action alternative guidelines (see Figure 79).

Each model run began with its prescribed initial water surface elevation (mostly 1570 ft, 478.536 m) and followed the feeder canal flow regime as outlined in Table 31.
Water level draw-downs were controlled primarily through the use of the dynamic weir application. The dynamic weir application accesses a user defined time series of desired water surface elevations, which raises or lowers a weir at the lake's outlet over time. This method allows for altering the water surface elevation of the lake through controlling the outflow at Dry Falls Dam while maintaining the specific Feeder Canal flow rates for the given hydraulic year. CE-QUAL-W2 calculates the discharge spilling over the weir with a weir flow rating curve, where Q is flow leaving via the weir, $\Delta H$ is the head difference between the water level of the segment upstream of the weir and the weir crest elevation, $\alpha$ is a user defined variable and $\beta$ is a user defined variable.

$$\boldsymbol{Q = \alpha \Delta H^{\beta}} \quad \textbf{Eq. 6}$$

Using the weir equation allows for control of how quickly the water surface elevation responds to changes in the weir crest height as well as provide that the water discharge at the weir never exceeds the maximum flow rate of the Main Canal (546 $m^3/s$). Rather than simulate water spilling over the dynamic weir whenever there is a positive head difference at the weir crest, the creation of unwanted currents was avoided by instead pulling water from the system at a fixed elevation of 471 m (NAVD88). In addition to the dynamic weir outlet, the original outlet structure at Dry Falls dam was used to constantly discharge a flow rate 90% that of the daily average inflow at the Feeder Canal. By releasing 90% of the Feeder Canal inflow through the Main Canal in combination with the dynamic weir, outflow leaving the Dry Falls Dam was less subject to occasional spikes which happen when large volumes of water are released during periods of high inflow or during periods of substantial draining from the lake.

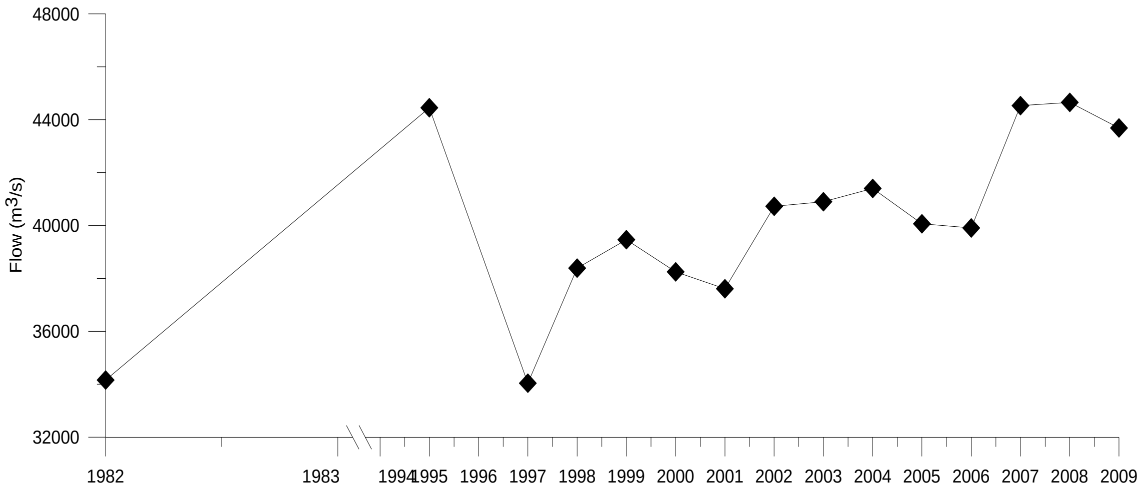


**Figure 78. Banks Lake Feeder Canal flow annual totals**

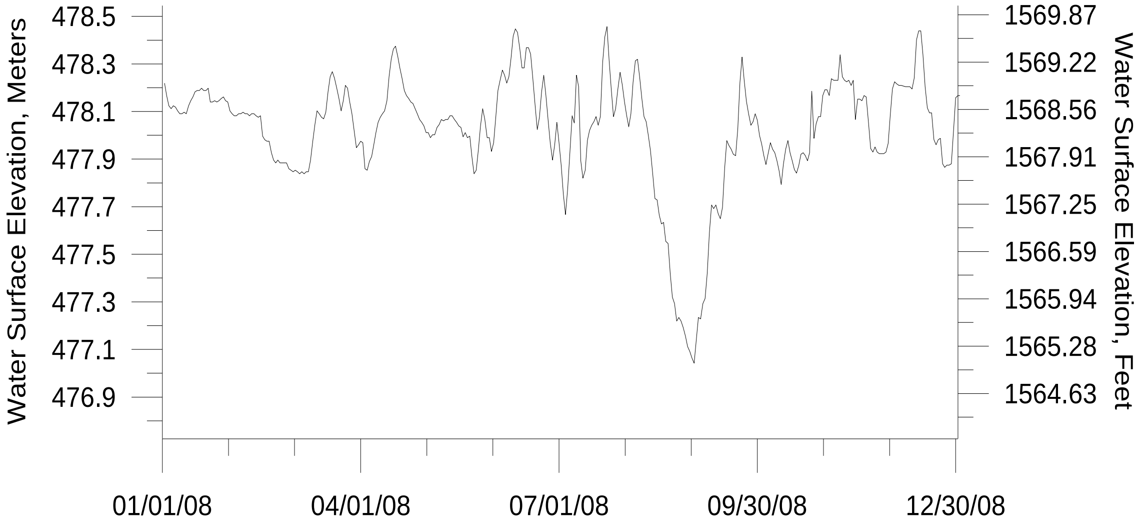


**Figure 79. Banks Lake water surface elevation: 2008**

### Table 30. Banks Lake 2007 and 2008 meteorological summary statistics and comparison

| Air Temp | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 Max | 41 | 37.2 | 39.675 |
| 2002-09 Min | -5.2 | -24 | -13.725 |
| 2002-09 Ave | 12.2 | 10.7 | 11.525 |
| 2007 | 39.8 | -12 | 11.4 |
| 2008 | 41 | -17.3 | 10.7 |

| Humidity | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 Max | 100 | 99.7 | 99.9625 |
| 2002-09 Min | 11.8 | 7.2 | 9.3875 |
| 2002-09 Ave | 65 | 58.9 | 62.225 |
| 2007 | 100 | 9.1 | 60.4 |
| 2008 | 100 | 9.3 | 58.9 |

| Dew Point | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 Max | 30 | 16.2 | 19.8875 |
| 2002-09 Min | -4.6 | -18.7 | -10.9375 |
| 2002-09 Ave | 5.9 | 4.6 | 5.3875 |
| 2007 | 17.6 | -10.6 | 4.8 |
| 2008 | 16.9 | -12.2 | 4.3 |

| Short Wave Solar | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 Max | 1067.9 | 984.6 | 1017.475 |
| 2002-09 Ave | 173 | 165.8 | 169.3375 |
| 2007 | 1018.6 | 0 | 170.6 |
| 2008 | 1067.9 | 0 | 170.9 |

| Wind Speed | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 Max | 38.4 | 7.4 | 12.675 |
| 2002-09 Ave | 2.2 | 1.8 | 1.5625 |
| 2007 | 10.6 | 0 | 1.9 |
| 2008 | 8.9 | 0 | 1.9 |

| Rainfall | | | |
|---|---|---|---|
| | Max | Min | Ave |
| 2002-09 | 31.03 | 11.43 | 19.11 |
| 2007* | 14.88 | | |
| 2008* | 11.43 | | |
| * cumulative annual values only | | | |

### Table 31. Odessa Subarea Special Study EIS reservoir draw downs for Banks Lake

| Run Number | Mgmt. Alternati | Flow Year | Flow Year | Management Scenario Drawdown Schedule (meters) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **June** | **July** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
| 1 | No Action | 2008 | NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -1.52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 2A | 1995 | Average | 0.00 | 0.00 | 0.00 | -0.06 | 0.00 | -0.30 | -0.67 | -2.56 | -0.49 | 0.00 | 0.00 | 0.00 |
| 3 | 2B | 1995 | Average | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -0.91 | -2.44 | -0.91 | 0.00 | 0.00 | 0.00 |
| 4 | 2C | 1995 | Average | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -1.55 | -0.12 | 0.00 | 0.00 | 0.00 |
| 5 | 2D | 1995 | Average | 0.00 | 0.00 | 0.00 | 0.00 | -0.15 | -0.15 | -0.15 | -2.44 | -1.52 | 0.00 | 0.00 | 0.00 |
| 6 | 3A | 1995 | Average | 0.00 | 0.00 | 0.00 | -0.03 | 0.00 | -0.79 | -1.74 | -4.11 | -1.86 | -0.40 | 0.00 | 0.00 |
| 7 | 3B | 1995 | Average | 0.00 | 0.00 | 0.00 | -0.03 | -0.37 | -0.91 | -0.91 | -2.44 | -0.91 | -0.06 | 0.00 | 0.00 |
| 8 | 3C | 1995 | Average | -0.52 | 0.00 | 0.00 | 0.00 | 0.00 | -0.30 | -0.73 | -3.05 | -1.58 | -0.85 | 0.00 | 0.00 |
| 9 | 3D | 1995 | Average | 0.00 | 0.00 | 0.00 | 0.00 | -0.21 | -0.52 | -0.91 | -2.44 | -1.52 | -0.79 | 0.00 | 0.00 |
| 10 | 2A | 1998 | Dry | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -1.01 | -2.99 | -0.85 | 0.00 | 0.00 | 0.00 |
| 11 | 2B | 1998 | Dry | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -0.91 | -2.44 | -0.91 | 0.00 | 0.00 | 0.00 |
| 12 | 2C | 1998 | Dry | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -1.68 | -0.24 | 0.00 | 0.00 | 0.00 |
| 13 | 2D | 1998 | Dry | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -2.44 | -1.52 | 0.00 | 0.00 | 0.00 |
| 14 | 3A | 1998 | Dry | -0.58 | -0.58 | 0.00 | -0.09 | -0.43 | -1.22 | -2.16 | -4.57 | -2.23 | -0.64 | -0.64 | -0.64 |
| 15 | 3B | 1998 | Dry | 0.00 | 0.00 | 0.00 | -0.09 | -0.43 | -0.91 | -0.91 | -2.44 | -0.91 | -0.03 | 0.00 | 0.00 |
| 16 | 3C | 1998 | Dry | -1.19 | -1.19 | 0.00 | 0.00 | 0.00 | -0.34 | -1.25 | -3.60 | -2.01 | -1.16 | -1.16 | -1.16 |
| 17 | 3D | 1998 | Dry | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.34 | -0.91 | -2.44 | -1.52 | -0.73 | 0.00 | 0.00 |
| 18 | 2A | 1982 | Wet | 0.00 | 0.00 | 0.00 | -0.06 | 0.00 | 0.00 | -0.37 | -2.23 | -0.18 | 0.00 | 0.00 | 0.00 |
| 19 | 2B | 1982 | Wet | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -0.91 | -2.44 | -0.91 | 0.00 | 0.00 | 0.00 |
| 20 | 2C | 1982 | Wet | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -1.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 2D | 1982 | Wet | 0.00 | 0.00 | 0.00 | 0.00 | -0.15 | -0.30 | -0.30 | -2.44 | -1.52 | 0.00 | 0.00 | 0.00 |
| 22 | 3A | 1982 | Wet | 0.00 | 0.00 | 0.00 | -0.03 | 0.00 | 0.00 | -0.91 | -3.23 | -1.04 | 0.00 | 0.00 | 0.00 |
| 23 | 3B | 1982 | Wet | 0.00 | 0.00 | 0.00 | -0.03 | -0.34 | -0.91 | -0.91 | -2.44 | -0.91 | -0.06 | 0.00 | 0.00 |
| 24 | 3C | 1982 | Wet | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.40 | -2.26 | -0.85 | -0.12 | 0.00 | 0.00 |
| 25 | 3D | 1982 | Wet | 0.00 | 0.00 | 0.00 | 0.00 | -0.18 | -0.91 | -0.91 | -2.44 | -1.52 | -0.79 | 0.00 | 0.00 |
| 26 | 2A | 1998 | Drought | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -1.01 | -2.93 | -0.79 | 0.00 | 0.00 | 0.00 |
| 27 | 2B | 1998 | Drought | 0.00 | 0.00 | 0.00 | -0.12 | -0.34 | -0.64 | -0.91 | -2.44 | -0.91 | 0.00 | 0.00 | 0.00 |
| 28 | 2C | 1998 | Drought | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -1.68 | -0.24 | 0.00 | 0.00 | 0.00 |
| 29 | 2D | 1998 | Drought | -0.24 | -0.24 | -0.24 | -0.24 | -0.24 | -0.24 | -0.24 | -2.44 | -1.52 | 0.00 | 0.00 | 0.00 |
| 30 | 3A | 1998 | Drought | -0.82 | -0.82 | -0.79 | -0.88 | -1.25 | -2.10 | -3.08 | -5.58 | -3.20 | -1.65 | -1.65 | -1.65 |
| 31 | 3B | 1998 | Drought | -0.82 | -0.82 | -0.82 | -0.91 | -0.91 | -0.91 | -0.91 | -2.44 | -0.91 | -0.91 | -0.91 | -0.91 |
| 32 | 3C | 1998 | Drought | -1.77 | -1.77 | -1.77 | -1.49 | -1.31 | -1.68 | -2.62 | -5.06 | -3.51 | -2.68 | -2.68 | -2.68 |
| 33 | 3D | 1998 | Drought | -1.40 | -1.40 | -1.40 | -1.40 | -1.40 | -1.40 | -1.40 | -2.44 | -1.52 | -0.91 | 0.00 | 0.00 |

## Alternative Action Management Scenario Preparation

In preparation of evaluating the effects of the alternative management scenarios on the water quality and fisheries population of Banks Lake, all management scenarios were first prepared to produced the water level elevation changes outlined in the Odessa Subarea Special Study draft EIS. Preparing the model for each scenario was an iterative process, running the model then making changes to either the weir equation or weir crest elevation, then running the model again. Special care was taken to avoid exceeding the 546 $m^3/s$ maximum discharge rate allowed by the Main Canal and to achieve the desired water surface elevation on the appropriate date. Avoiding discharge rates in excess of 546 $m^3/s$ was sometimes difficult at the beginning of the summer drawdown when large volumes of water were being released by the dynamic weir, also in situations when a constant surface elevation needed to be maintained while inflow rates from the Feeder Canal exceeded 546 $m^3/s$. Figure 80, Figure 81, Figure 82, Figure 83, Figure 84, Figure 85, Figure 86, Figure 87 and Figure 88 show the prepared water surface elevation and flows of the no-action alternative and management scenarios Average-2A, Average-3B, Dry-2A, Dry-3A, Drought-2A, Drought-3A, Wet-2A and Wet-3B alternative action management scenarios.

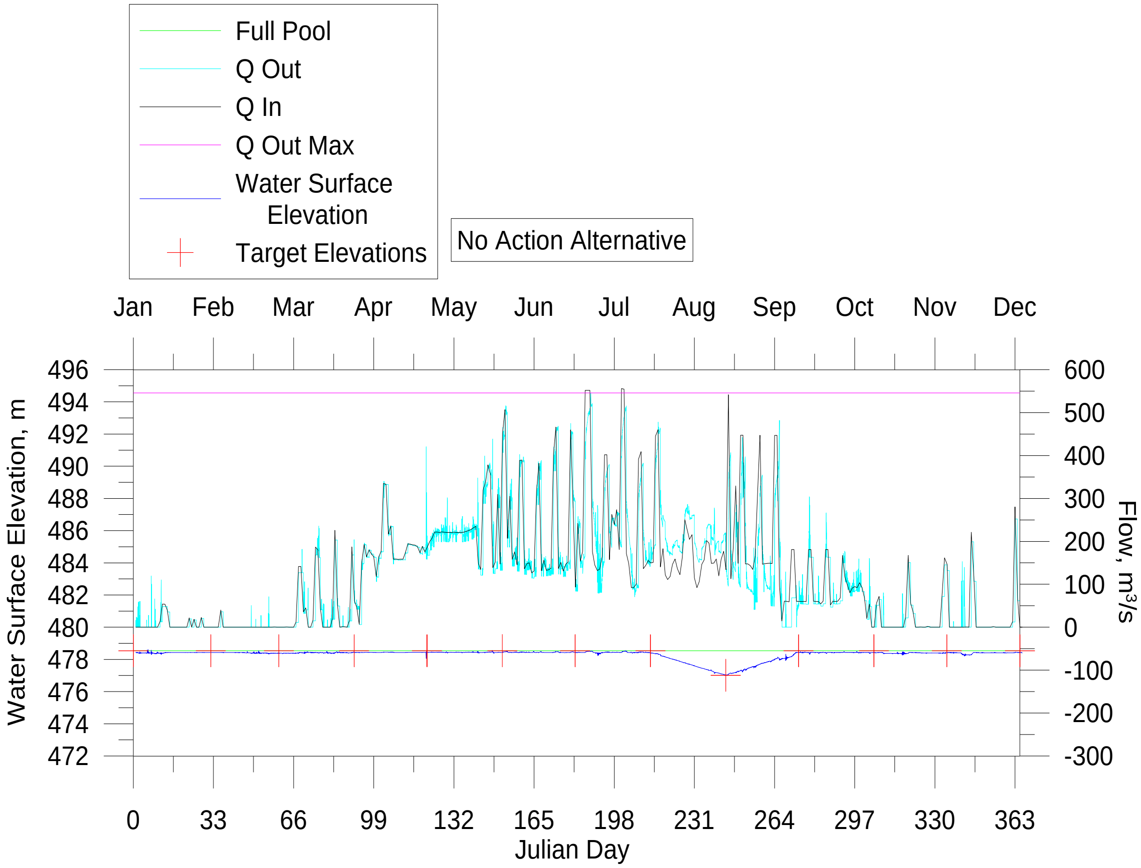


**Figure 80. Prepared water surface elevations and flows rates for the no-action alternative**

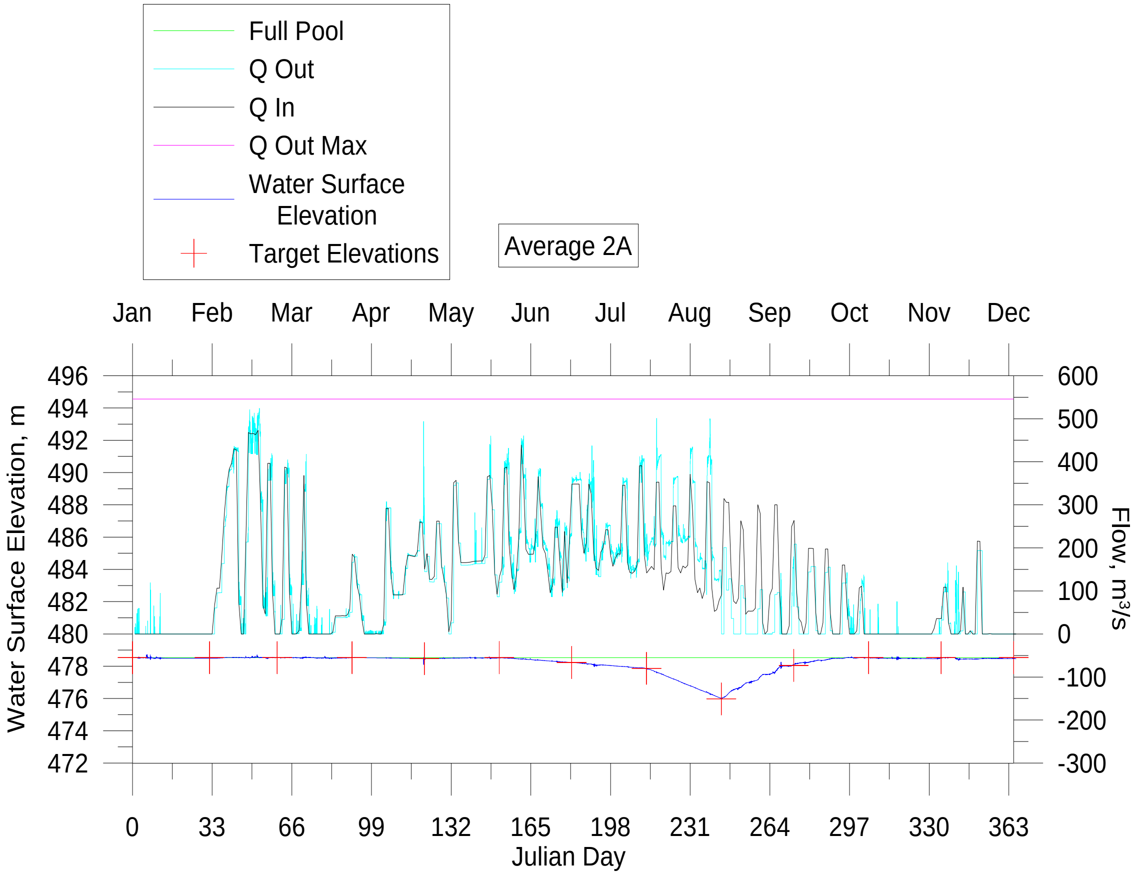


Figure 81. Prepared water surface elevations and flows rates for management scenario Average 2A

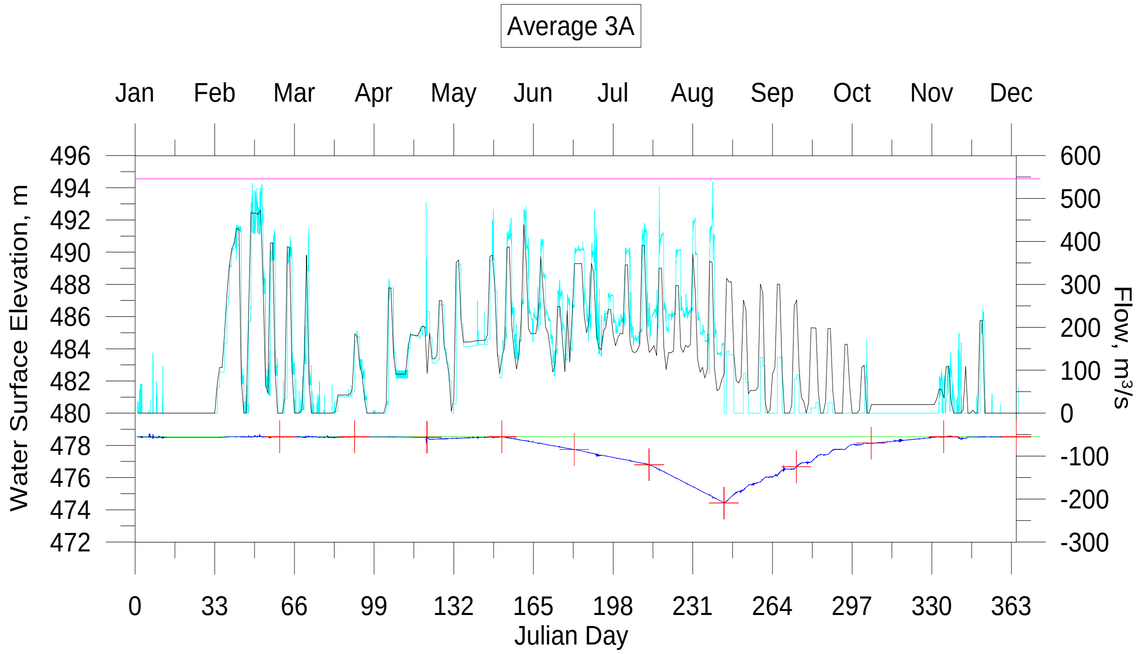


Figure 82. Prepared water surface elevations and flows rates for management scenario Average 3A

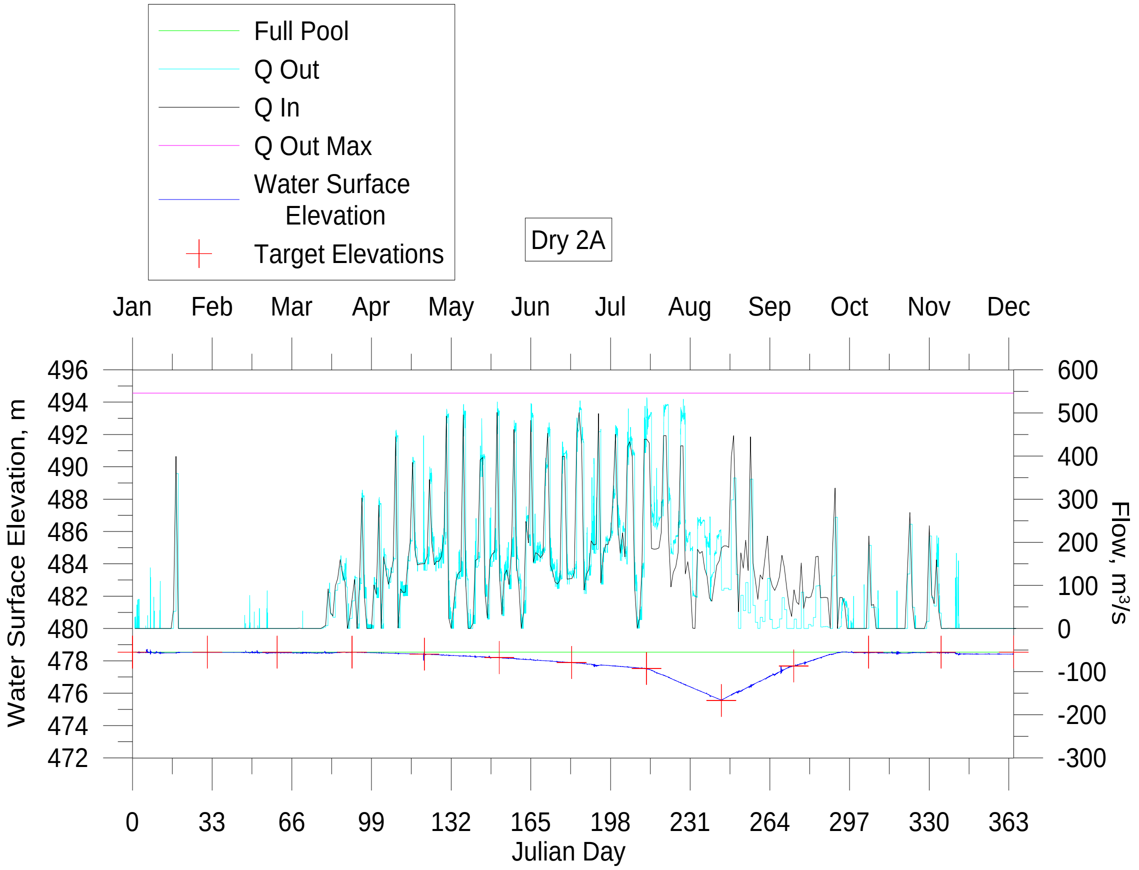


Figure 83. Prepared water surface elevations and flows rates for management scenario Dry 2A

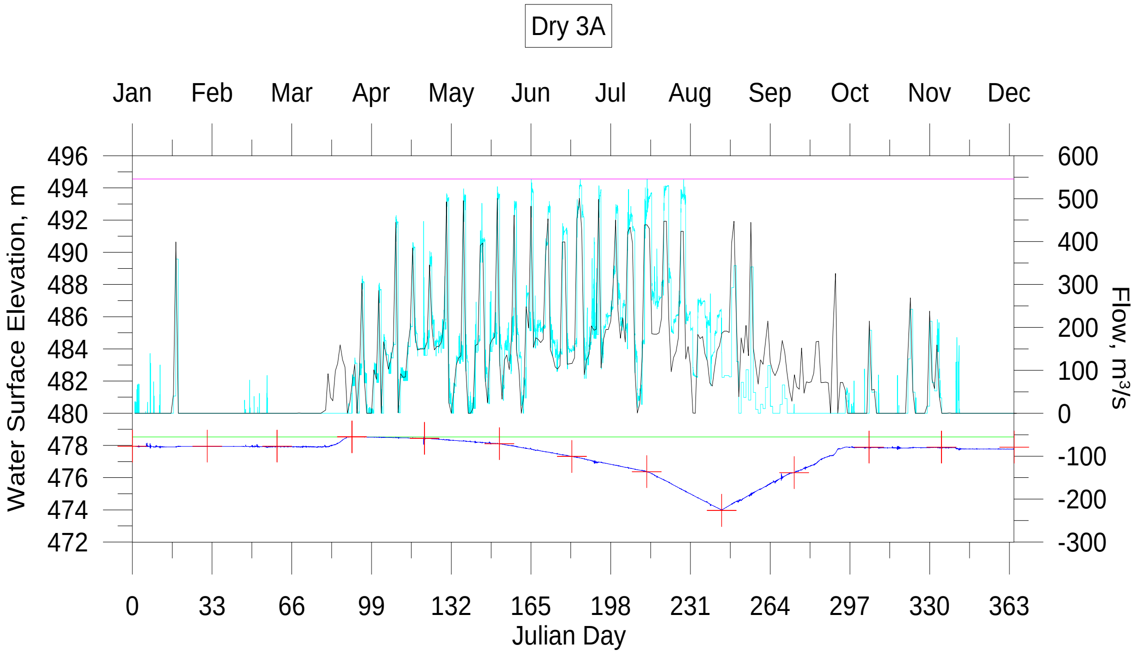


Figure 84. Prepared water surface elevations and flows rates for management scenario Dry 3A

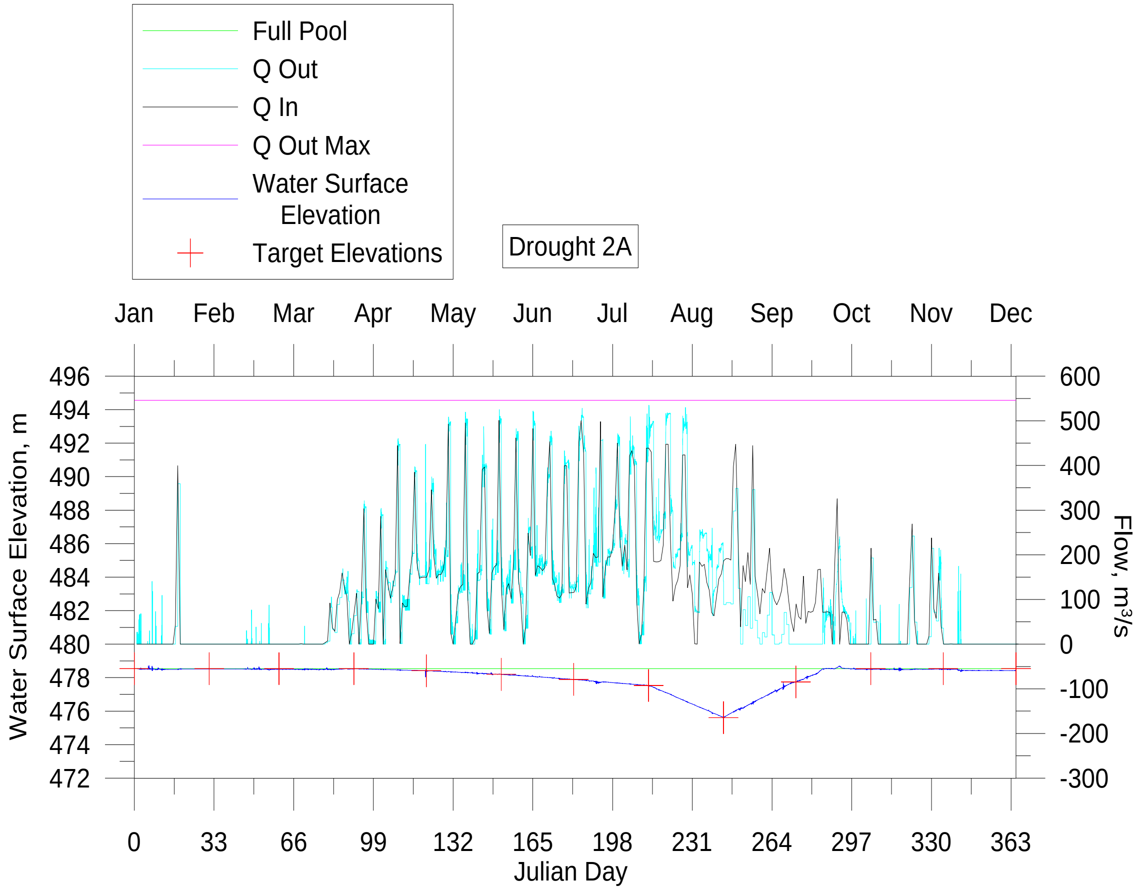


Figure 85. Prepared water surface elevations and flows rates for management scenario Drought 2A

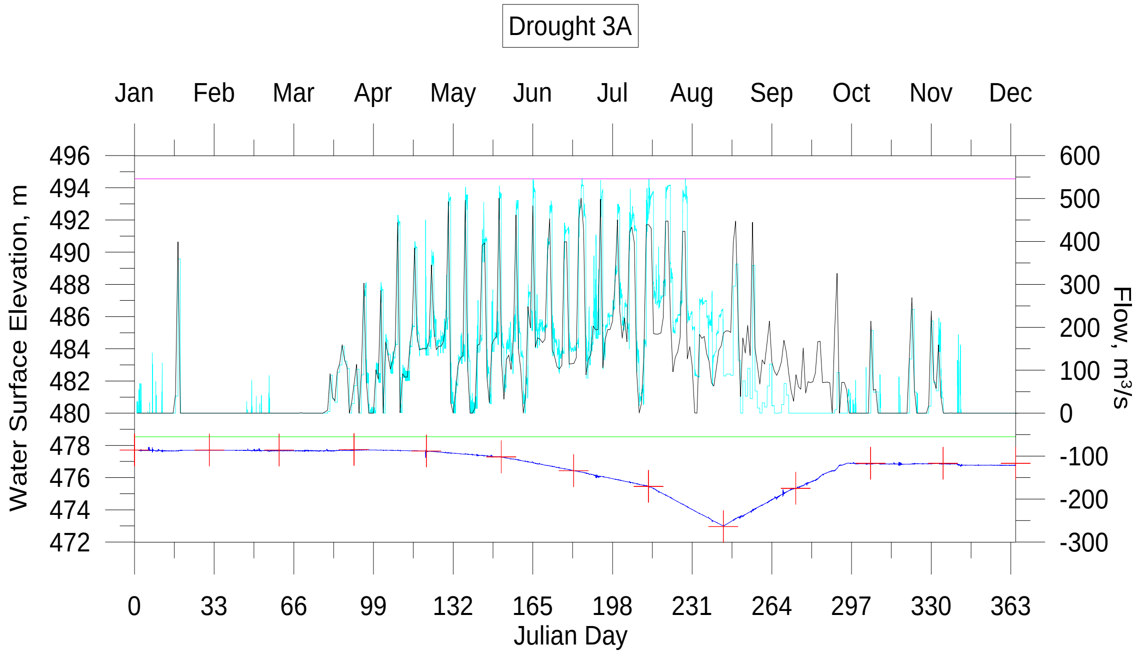


Figure 86. Prepared water surface elevations and flows rates for management scenario Drought 3A

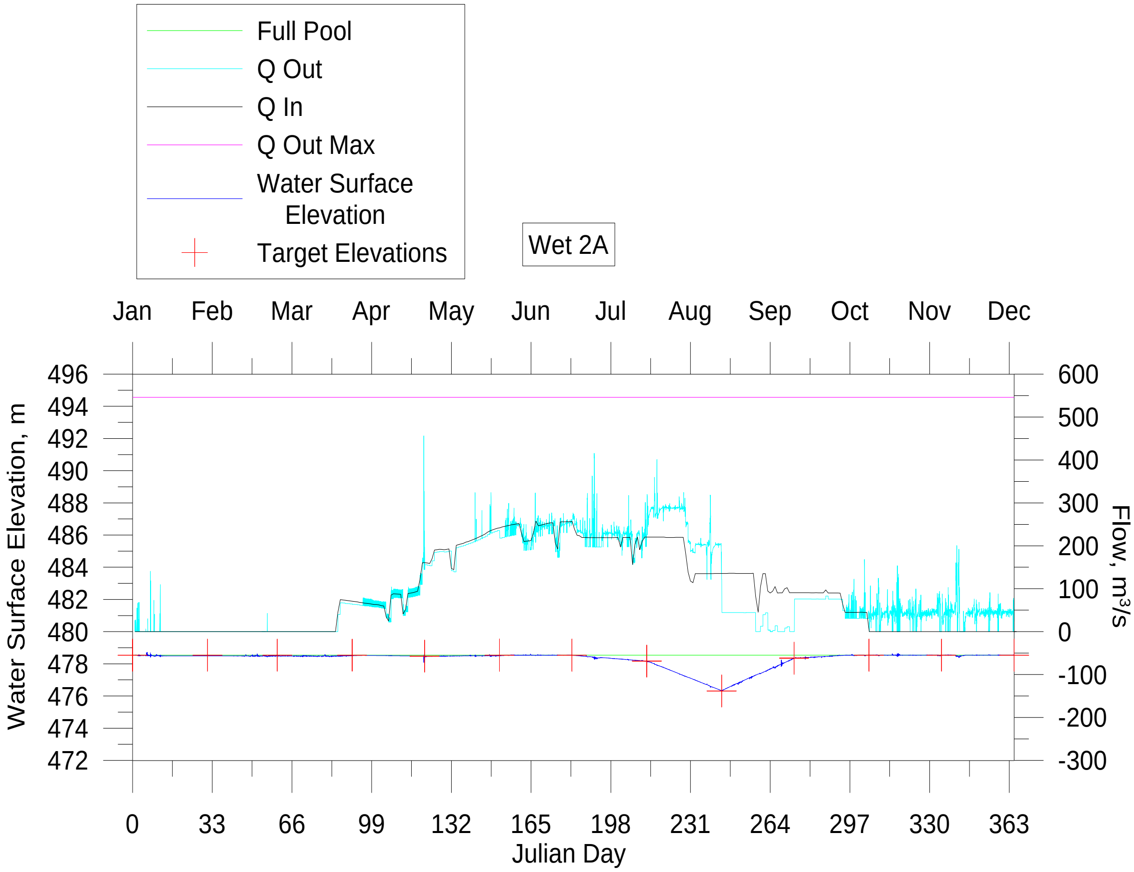


Figure 87. Prepared water surface elevations and flows rates for management scenario Wet 2A

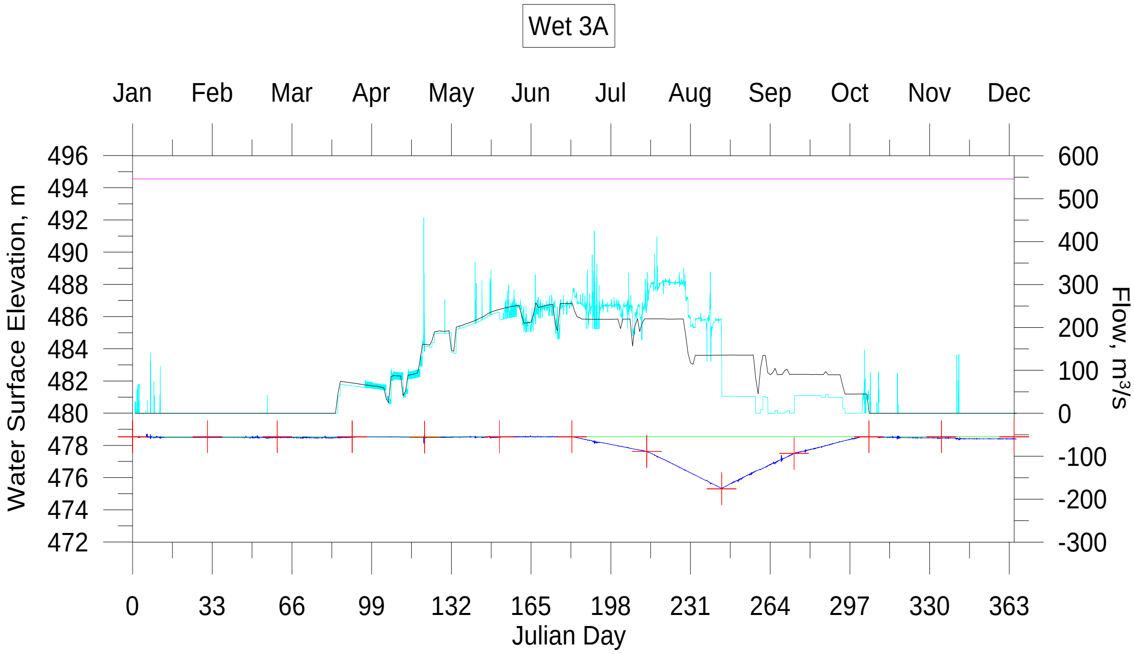


Figure 88. Prepared water surface elevations and flows rates for management scenario Wet 3A

### Alternative Action Management Scenario Results and Discussion

The next section will discuss the results and implications of the alternative action management scenarios as outlined in the Odessa Subarea Draft EIS. The management scenarios were evaluated by measuring the following:

1.) Effects of alternative action management scenarios on temperature stratification

2.) Change in the percent of total reservoir volume over time that meets both dissolved oxygen and temperature criteria which promote optimal growth habitat conditions for selected sport fish species

3.) Effects of management scenarios on dissolved oxygen concentrations in the reservoir

4.) Mass flow rate of zooplankton entrainment from Dry Falls Dam

5.) Use of a fish bioenergetics model to evaluate output from CE-QUAL-W2 to predict fish growth in kokanee

## Effect of Alternative Action Management on Temperature Stratification

The effects of alternative management scenarios on reservoir temperature characteristics were examined by plotting model predicted vertical temperature profiles from the Banks Lake CE-QUAL-W2 model. Lim site 3, located west of Steamboat Rock in the middle pool, was selected to represent a pelagic environment and Lim site 4, located within Devil's Punch Bowl due east of Steamboat Rock, was selected to represent the littoral zone. Model predicted water temperature data was recorded on April 15th, August 31st, and November 15th at both sites under all management scenarios. The temperature profiles were then compared with the no-action alternative and the mean difference between temperature profiles of the action alternative and the no-action alternative were calculated with equation 7.

$$\frac{\textit{Action Alternative temperature} - \textit{No Action Alternative Temperature}}{\#\ \textit{of comparisons}} = \textit{Mean Temp. Difference} \quad \textbf{Eq. 7}$$

Table 32 and Table 33 show the mean temperature difference for all action alternative temperatures compared with the no-action alternative for Lim site 3 and 4 respectively. Figure 89 through Figure 96 show water temperature profiles for Lim site 3 and Figure 97 through Figure 104 shows water temperature profiles for Lim site 4.

Results of the temperature profile comparisons showed that water temperature changed relatively little under the management scenarios vs. the no-action alternative. The average change in profile temperatures measured from the action alternatives compared to the no-action alternative exceeded 1°C. Trends in the profile comparisons showed that the action alternatives were consistently warmer than the no-action alternative at Lim sites 3 and 4 during April, colder during the November and mixed during the August water temperature measurements. Stand out scenarios include all average flow year scenarios run during April which were consistently 0.48-0.49 $^{o}$C and 0.74-0.76 $^{o}$C warmer than the no-action alternative at Lim site 3 and 4 respectively. Also, alternatives 3A and 3C consistently showed a negative mean difference when comparing August temperature profiles to the no-action alternative. Although unusual, the drop in temperature during the summer months was not a significant drop from the no-action alternative. Additionally, alternatives 3A and 3C contain the largest single month drops in water surface elevation among all management scenarios. A typical July to August decrease in water surface elevation for scenarios 3A and 3C range from 1.86 – 2.5 meters. Such a drop in water surface elevation would create turbulence in the reservoir system and thus mix the warmer epilimnetic waters with the colder waters of the hypolimnion. Figure 105 shows the predicted outflow discharge rates at Dry Falls Dam for the no-action alternative and the Drought-3A alternative from August 1st to August 31st.

**Table 32. The mean difference for all action alternative temperatures compared with the no action alternative at Lim 3 (Action Alternative temp. – No Action Alternative temp.)**

| **Lim Site 3** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| April 15th-JDAY 105 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | 0.49 | 0.49 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | ***0.48*** |
| Drought | 0.30 | 0.30 | 0.29 | 0.36 | 0.25 | 0.27 | 0.55 | 0.41 | ***0.34*** |
| Dry | 0.30 | 0.30 | 0.29 | 0.29 | 0.34 | 0.30 | 0.28 | 0.29 | ***0.30*** |
| Wet | 0.41 | 0.42 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | ***0.41*** |
| Mean | ***0.38*** | ***0.38*** | ***0.37*** | ***0.39*** | ***0.37*** | ***0.37*** | ***0.43*** | ***0.40*** | |
| August 31-JDAY 243 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | 0.18 | 0.24 | 0.40 | 0.01 | -0.43 | -0.15 | 0.20 | 0.21 | ***0.08*** |
| Drought | -0.32 | 0.19 | 0.40 | 0.03 | -0.93 | 0.29 | -0.58 | 0.46 | ***-0.06*** |
| Dry | 0.23 | 0.19 | 0.39 | -0.07 | -0.66 | -0.14 | -0.52 | 0.10 | ***-0.14*** |
| Wet | -0.05 | 0.13 | 0.40 | 0.03 | -0.43 | 0.17 | -0.03 | 0.15 | ***0.04*** |
| Mean | ***0.01*** | ***0.19*** | ***0.40*** | ***0.00*** | ***-0.61*** | ***0.04*** | ***-0.23*** | ***0.23*** | |
| November 15th-JDAY 319 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | -0.07 | -0.11 | -0.06 | -0.15 | -0.21 | -0.15 | -0.22 | -0.16 | ***-0.14*** |
| Drought | -0.05 | 0.11 | -0.06 | -0.15 | -0.29 | -0.17 | -0.39 | -0.14 | ***-0.14*** |
| Dry | -0.08 | -0.07 | -0.06 | -0.09 | -0.15 | -0.09 | -0.21 | -0.14 | ***-0.11*** |
| Wet | -0.07 | -0.11 | -0.05 | -0.10 | -0.09 | -0.14 | -0.10 | -0.13 | ***-0.10*** |
| Mean | ***-0.07*** | ***-0.05*** | ***-0.06*** | ***-0.12*** | ***-0.18*** | ***-0.14*** | ***-0.23*** | ***-0.14*** | |

**Table 33. The mean difference for all action alternative temperatures compared with the no-action alternative at Lim 4 (Action Alternative temp. – No Action Alternative temp.)**

| **Lim Site 4** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| April 15th-JDAY 105 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | 0.76 | 0.76 | 0.74 | 0.74 | 0.74 | 0.74 | 0.74 | 0.74 | ***0.74*** |
| Drought | 0.46 | 0.47 | 0.45 | 0.54 | 0.38 | 0.39 | 0.71 | 0.52 | ***0.49*** |
| Dry | 0.47 | 0.47 | 0.46 | 0.45 | 0.51 | 0.46 | 0.47 | 0.45 | ***0.47*** |
| Wet | 0.41 | 0.42 | 0.41 | 0.41 | 0.58 | 0.58 | 0.58 | 0.58 | ***0.50*** |
| Mean | ***0.52*** | ***0.53*** | ***0.51*** | ***0.54*** | ***0.55*** | ***0.54*** | ***0.63*** | ***0.57*** | |
| August 31-JDAY 243 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | 0.11 | 0.40 | 0.23 | -0.12 | -0.36 | 0.15 | 0.48 | 0.36 | ***0.16*** |
| Drought | 0.10 | 0.03 | 0.23 | -0.12 | -0.50 | 0.34 | -0.39 | 0.16 | ***-0.02*** |
| Dry | 0.43 | 0.03 | 0.23 | -0.19 | -0.47 | -0.15 | -0.44 | -0.05 | ***-0.08*** |
| Wet | -0.05 | 0.13 | 0.40 | 0.03 | -0.42 | 0.37 | -0.14 | -0.01 | ***0.04*** |
| Mean | ***0.15*** | ***0.15*** | ***0.27*** | ***-0.10*** | ***-0.44*** | ***0.18*** | ***-0.13*** | ***0.12*** | |
| November 15th-JDAY 319 | | | | | | | | | |
| | 2A | 2B | 2C | 2D | 3A | 3B | 3C | 3D | Mean |
| Average | -0.06 | -0.09 | -0.05 | -0.11 | -0.19 | -0.11 | -0.18 | -0.15 | ***-0.12*** |
| Drought | -0.05 | -0.10 | -0.06 | -0.11 | -0.36 | -0.26 | -0.78 | -0.19 | ***-0.24*** |
| Dry | -0.07 | -0.06 | -0.06 | -0.07 | -0.11 | -0.07 | -0.45 | -0.08 | ***-0.12*** |
| Wet | -0.07 | -0.11 | -0.05 | -0.10 | -0.07 | -0.10 | -0.09 | -0.12 | ***-0.09*** |
| Mean | ***-0.06*** | ***-0.09*** | ***-0.05*** | ***-0.10*** | ***-0.18*** | ***-0.13*** | ***-0.38*** | ***-0.14*** | |

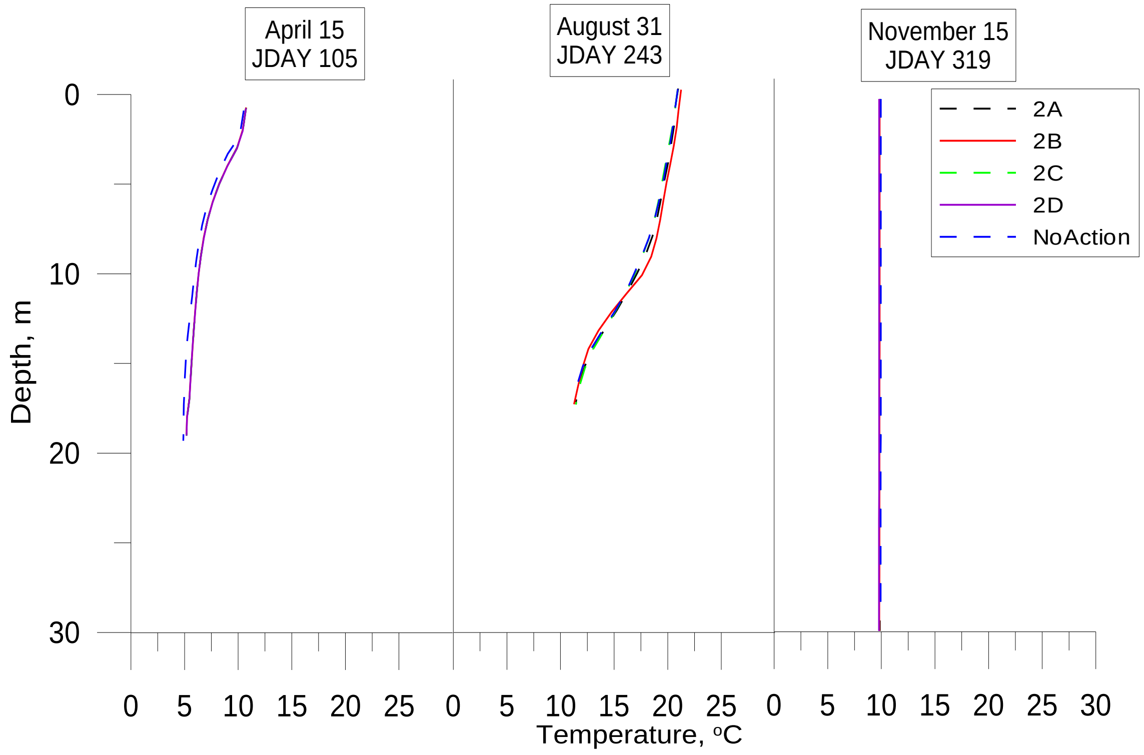


**Figure 89. Water temperature profiles at Lim 3 under action alternative Average 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31th and November 15th**

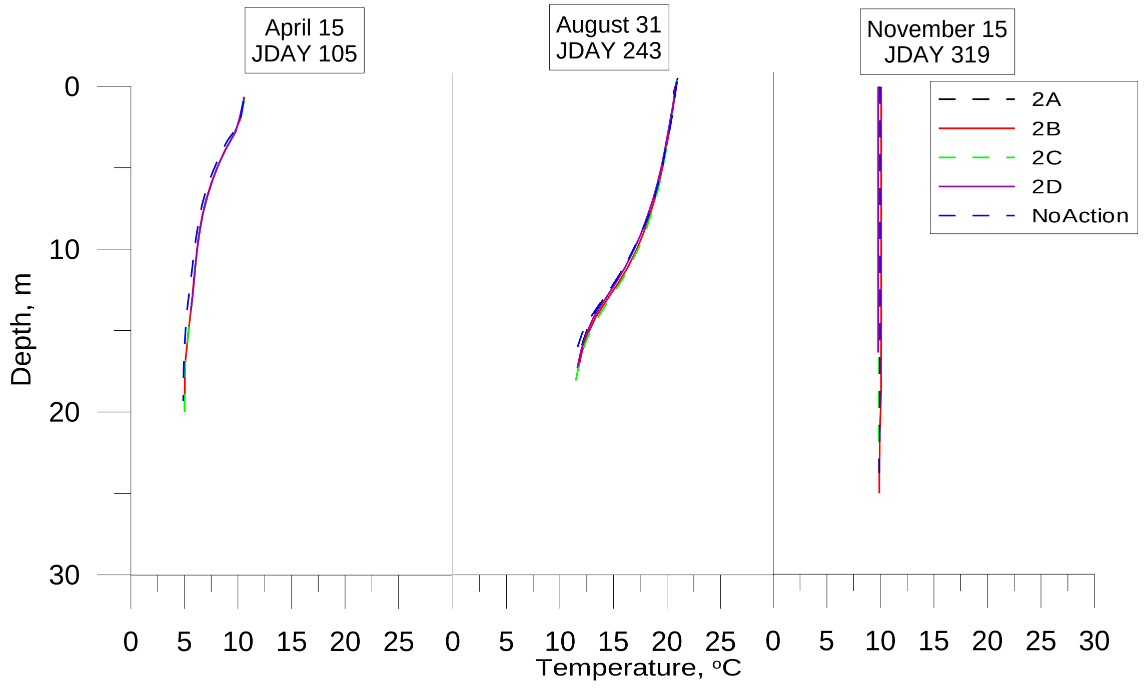


**Figure 90. Water temperature profiles at Lim 3 under action alternative Drought 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31th and November 15th**

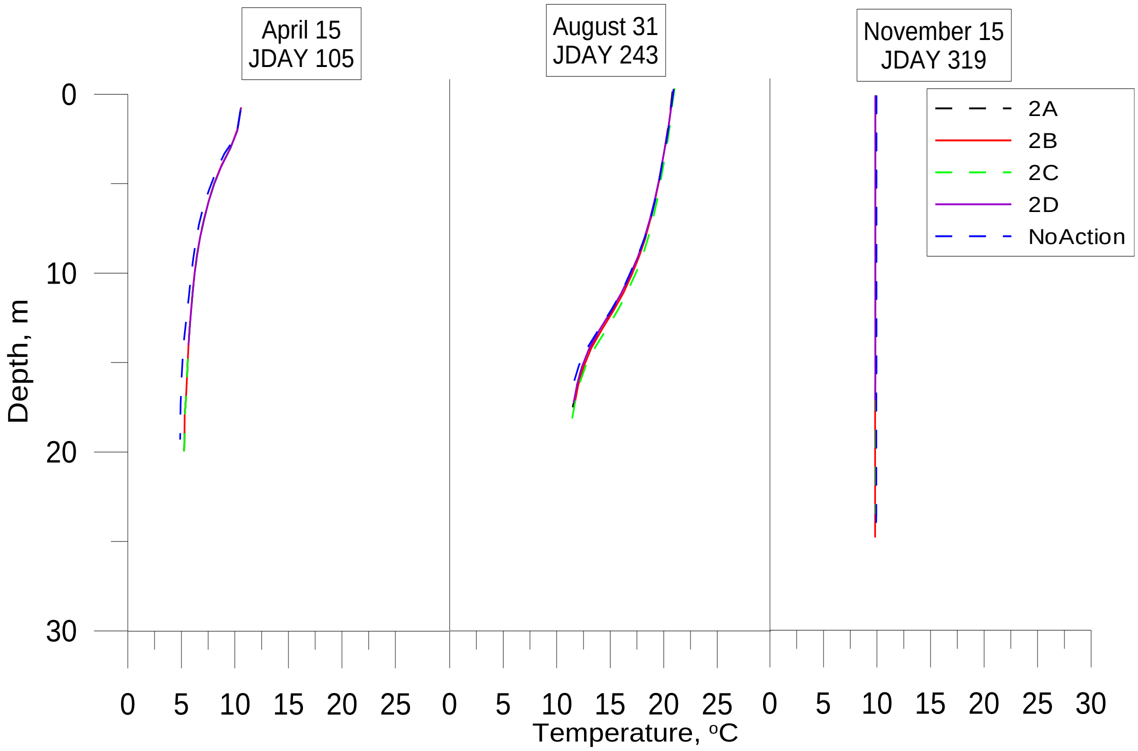


**Figure 91. Water temperature profiles at Lim 3 under action alternative Wet 2A, 2B, 2C 2D and the no-action alternative on April 15th, August 31$^{th}$ and November 15th**

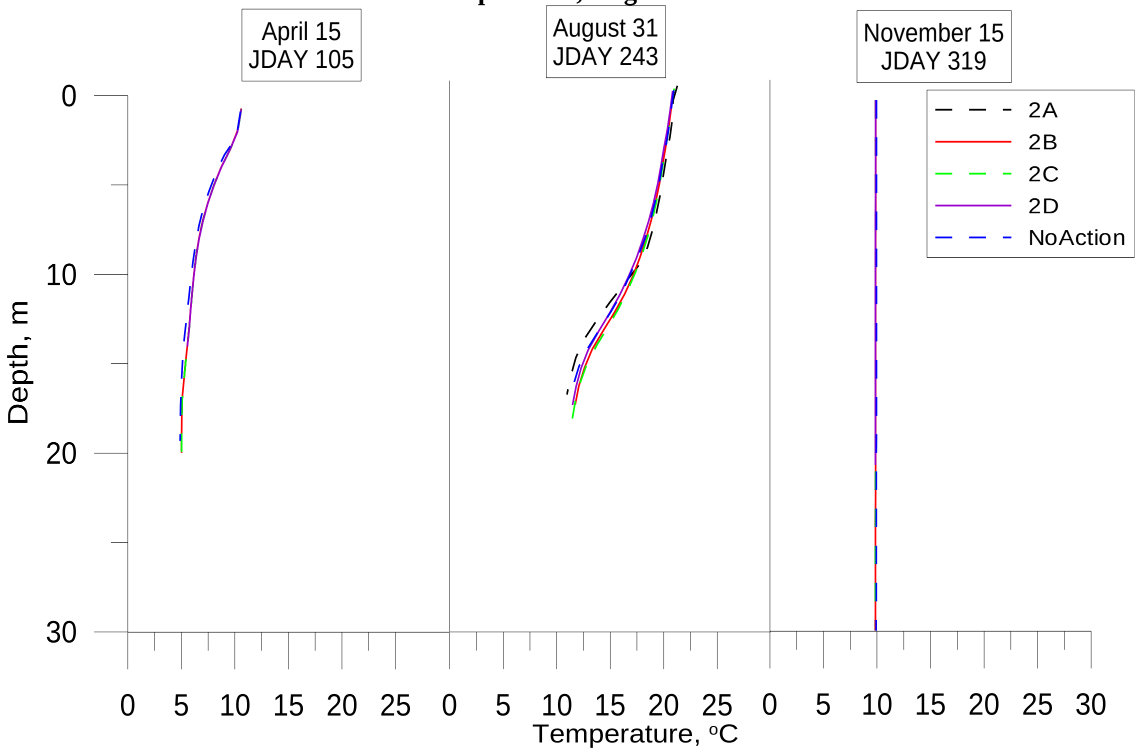


**Figure 92. Water temperature profiles at Lim 3 under action alternative Dry 2A, 2B, 2C 2D and the no-action alternative on Aptil15th, August 31$^{th}$ and November 15th**

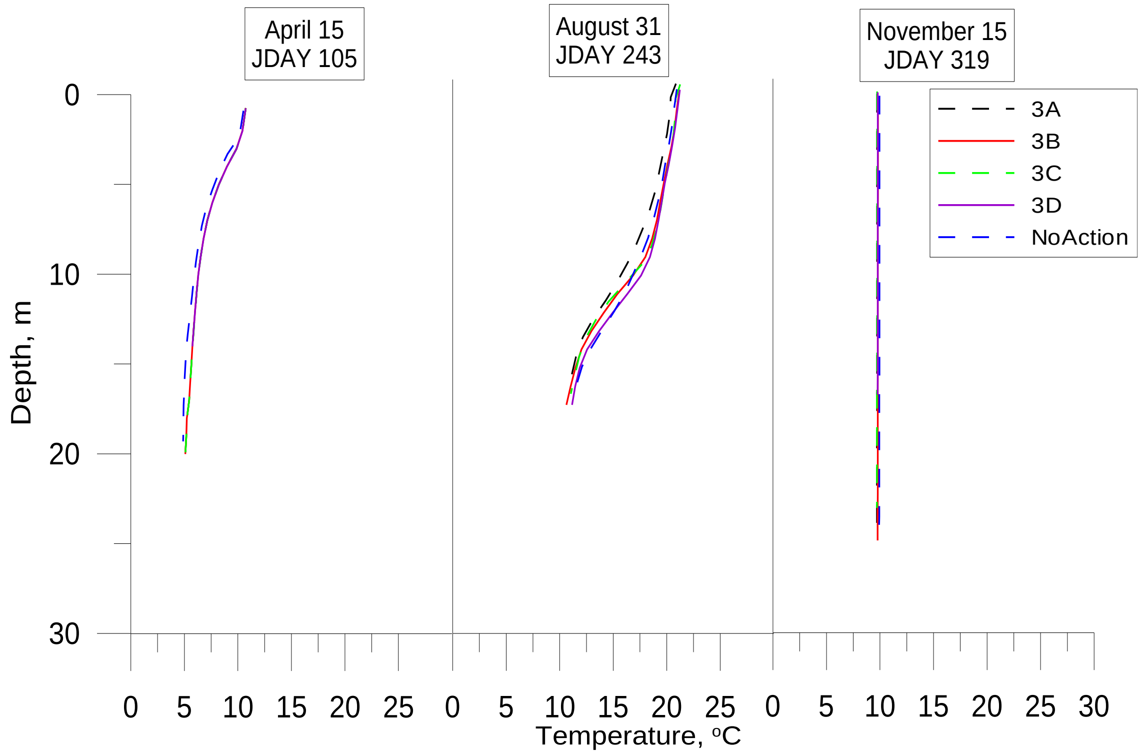


**Figure 93. Water temperature profiles at Lim 3 under action alternative Average 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31$^{th}$ and November 15th**

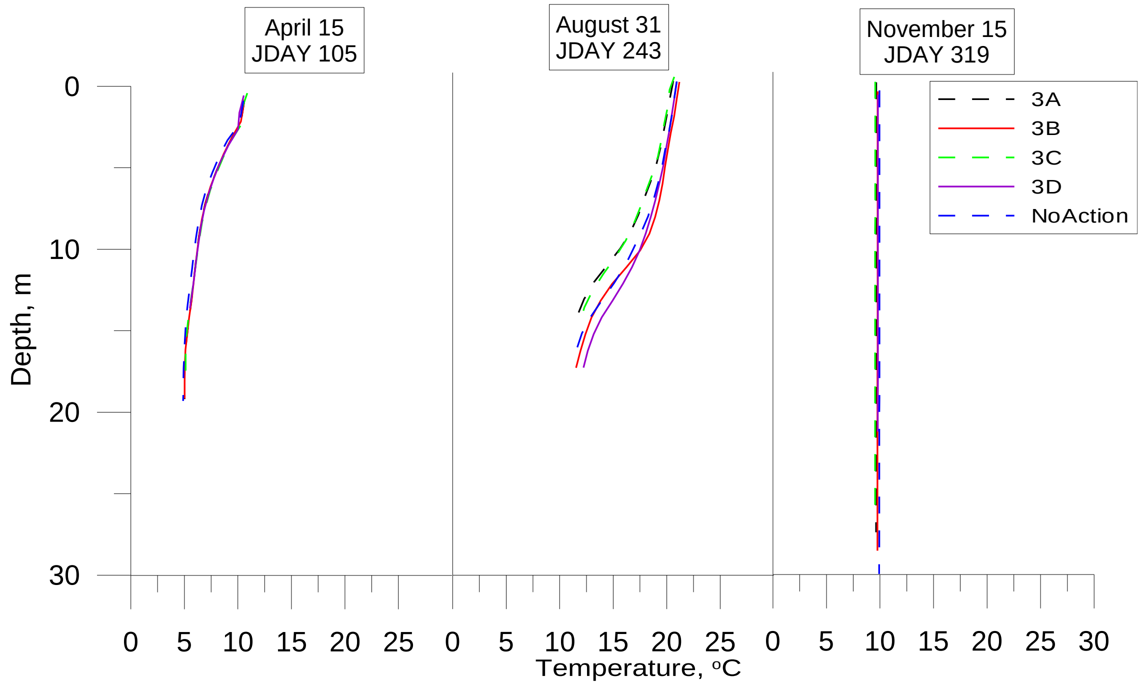


**Figure 94. Water temperature profiles at Lim 3 under action alternative Drought 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31$^{th}$ and November 15th**

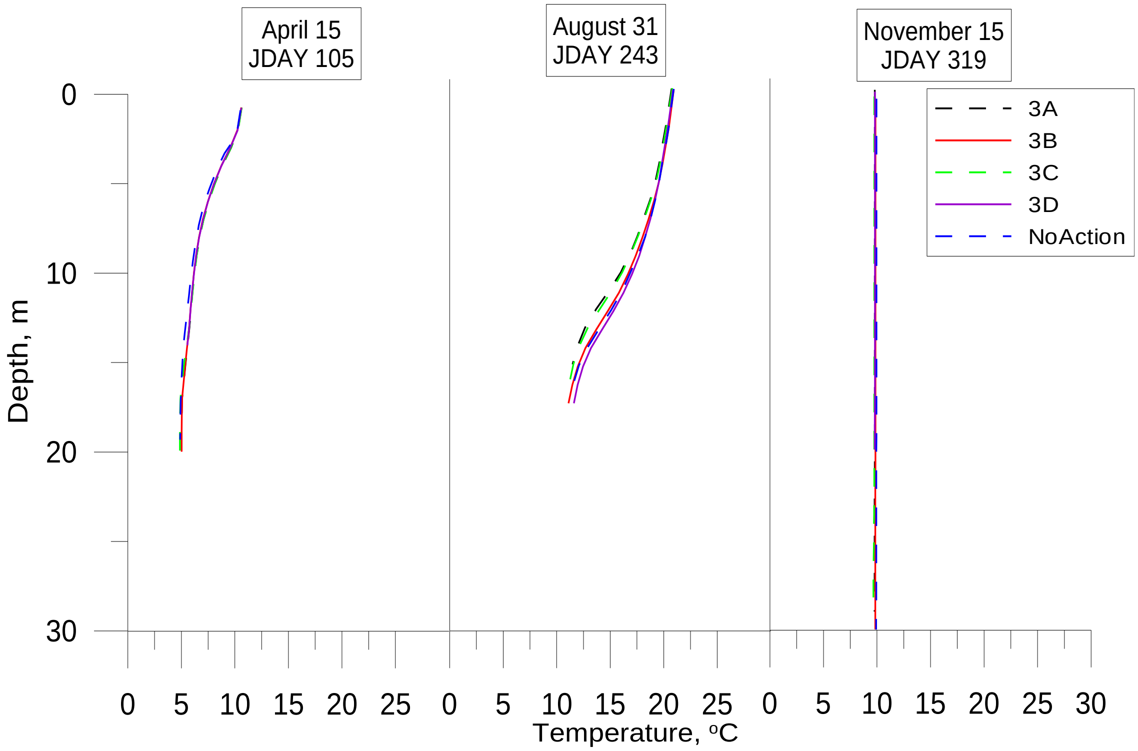


**Figure 95. Water temperature profiles at Lim 3 under action alternative Dry 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th**

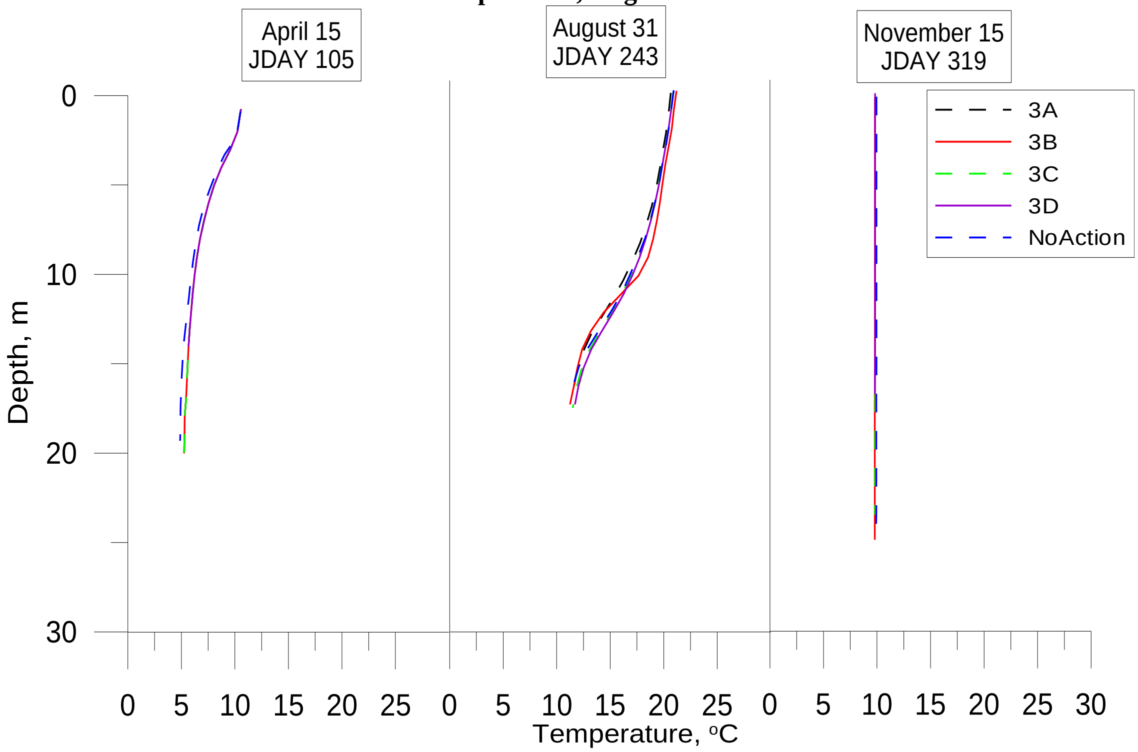


**Figure 96. Water temperature profiles at Lim 3 under action alternative Wet 3A, 3B, 3C 3D and the no-action alternative on April 15th, August 31th and November 15th**

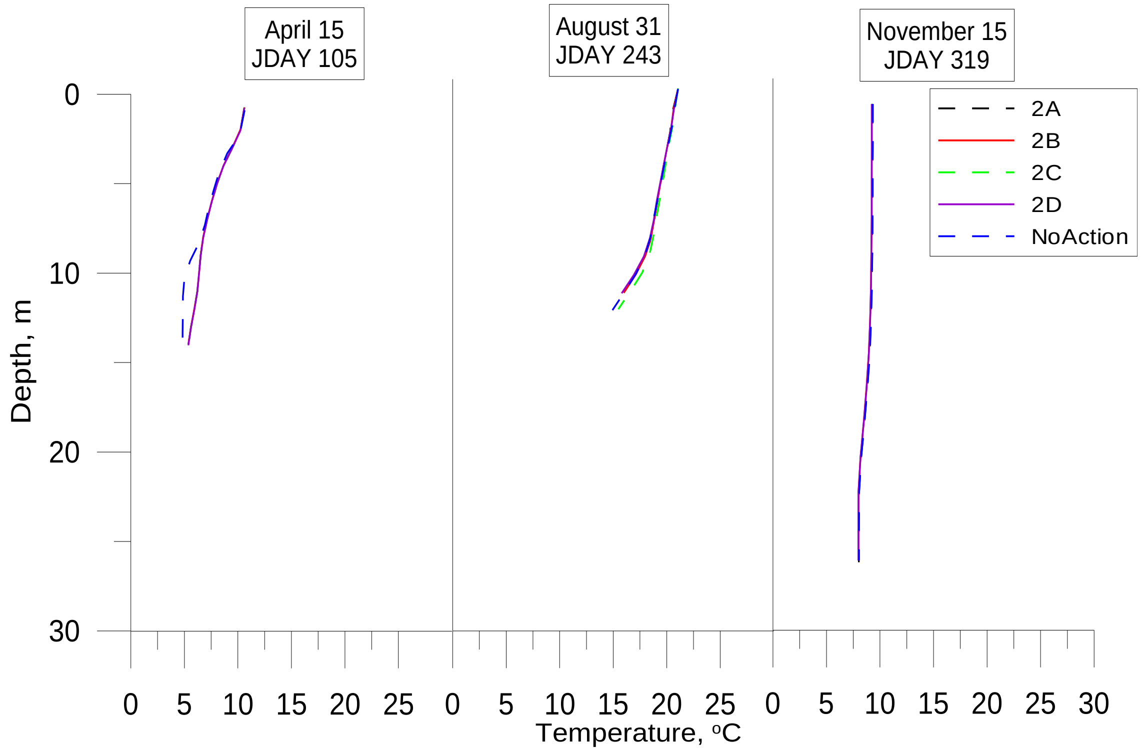


**Figure 97. Water temperature profiles at Lim 4 under action alternative Wet 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th**

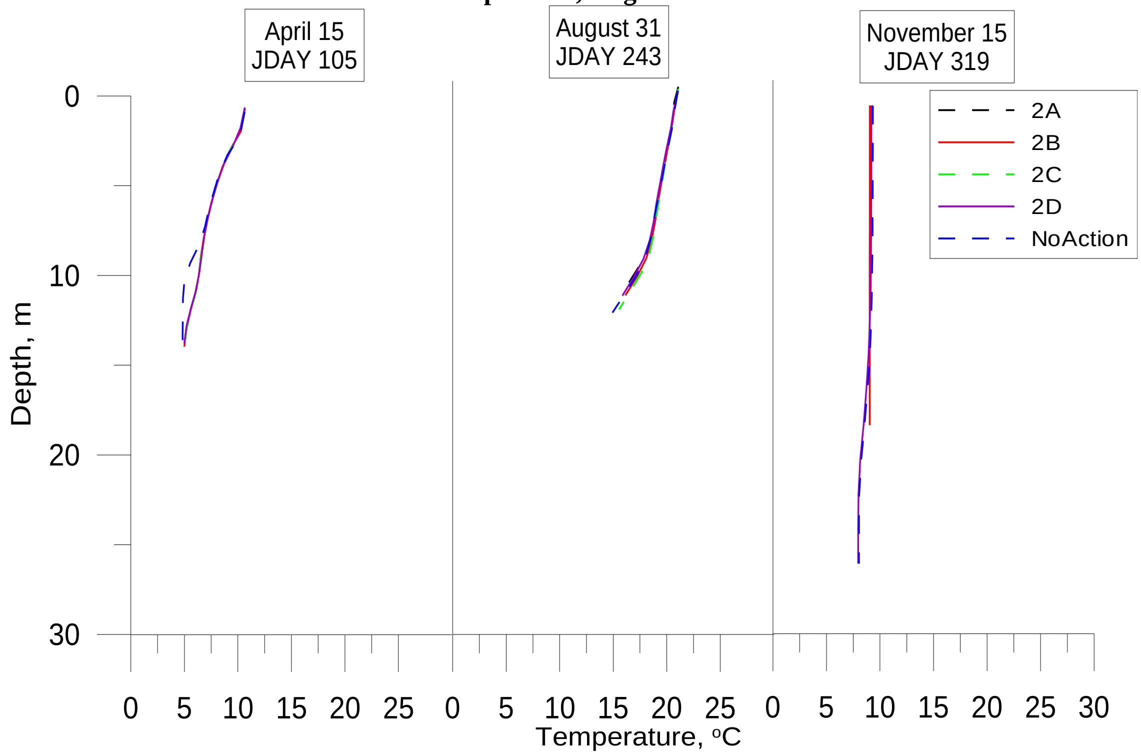


**Figure 98. Water temperature profiles at Lim 4 under action alternative Drought 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th**

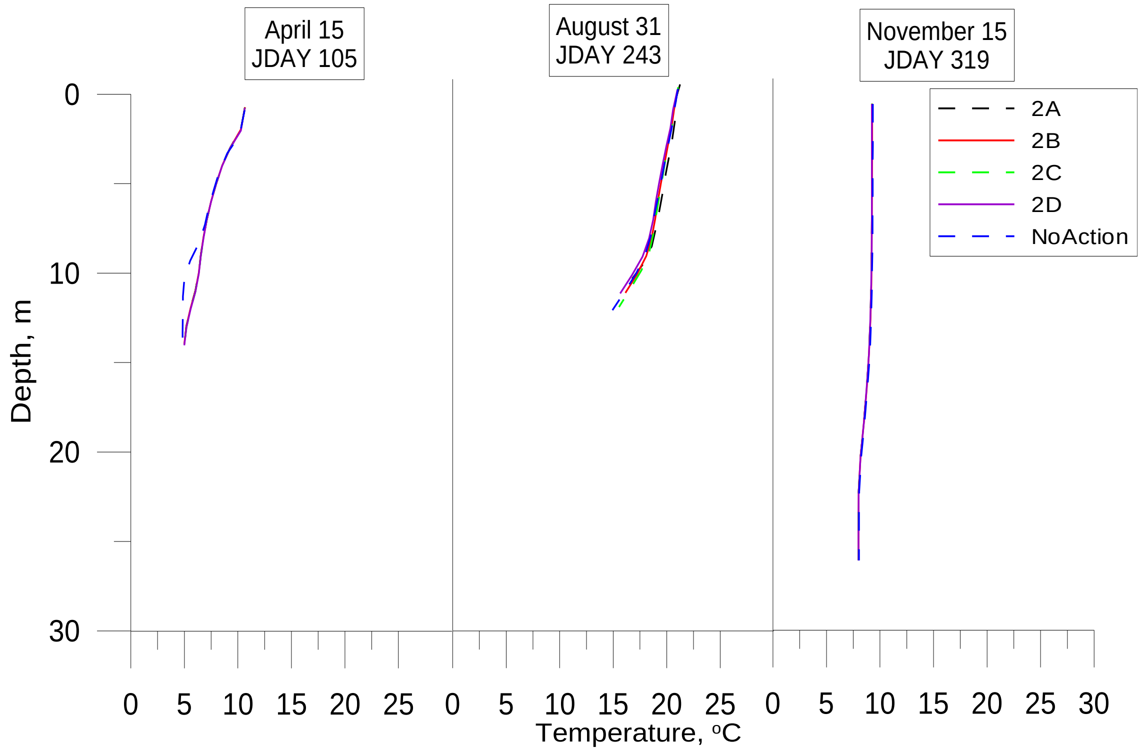


**Figure 99. Water temperature profiles at Lim 4 under action alternative Dry 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th**

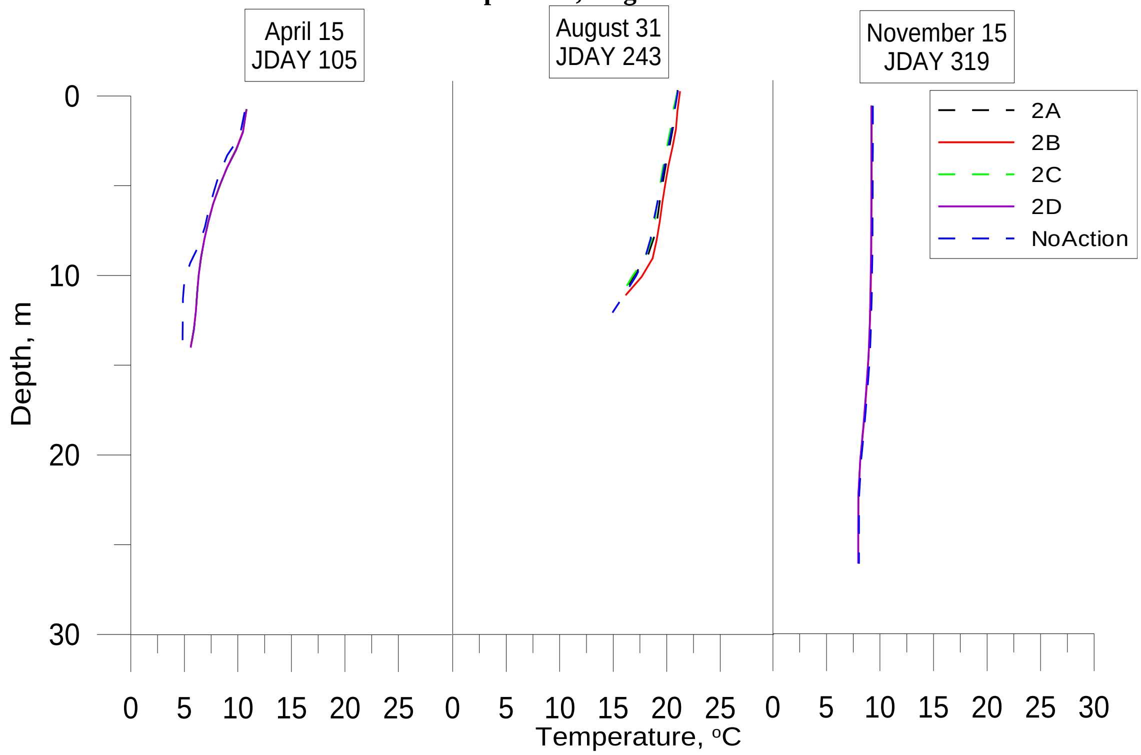


**Figure 100. Water temperature profiles at Lim 4 under action alternative Average 2A, 2B, 2C 2D and the no-action alternative on April15th, August 31th and November 15th**

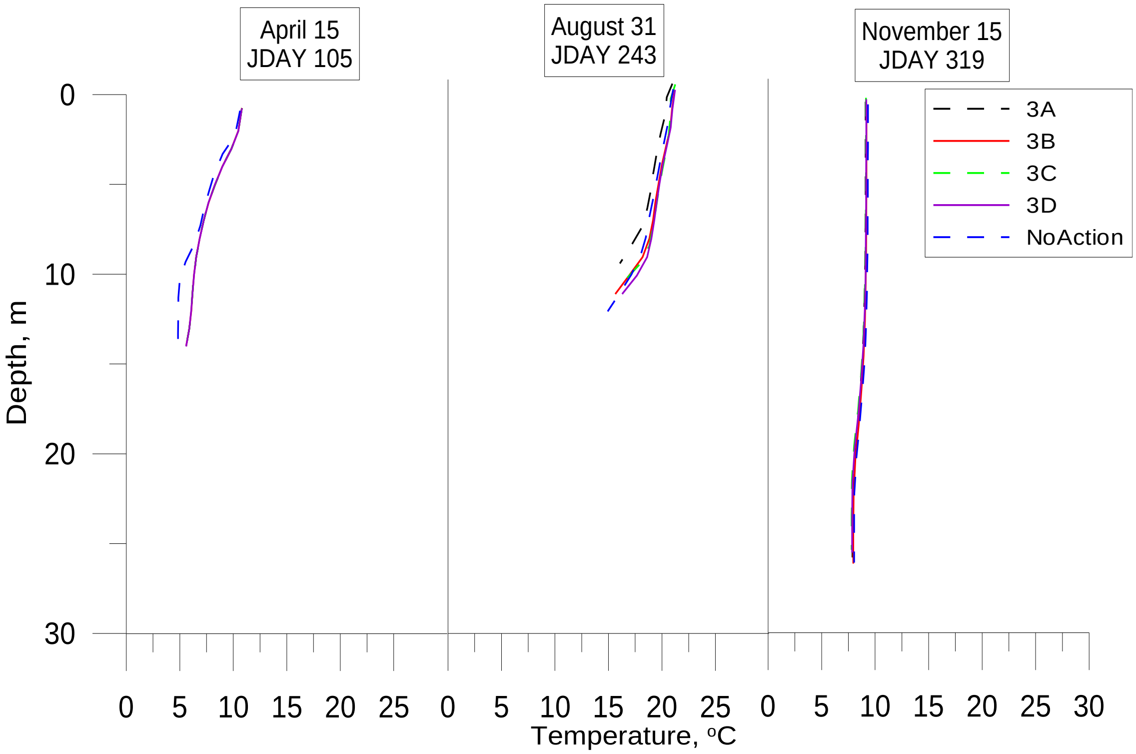


**Figure 101. Water temperature profiles at Lim 4 under action alternative Average 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th**

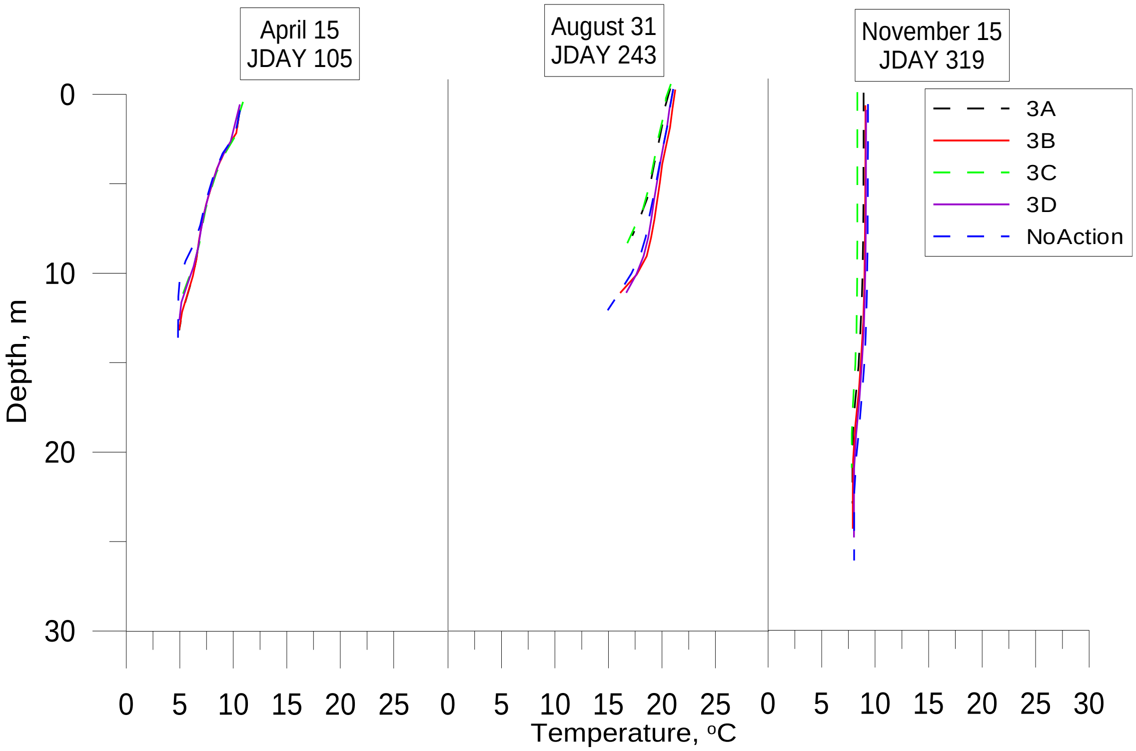


**Figure 102. Water temperature profiles at Lim 4 under action alternative Drought 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31th and November 15th**

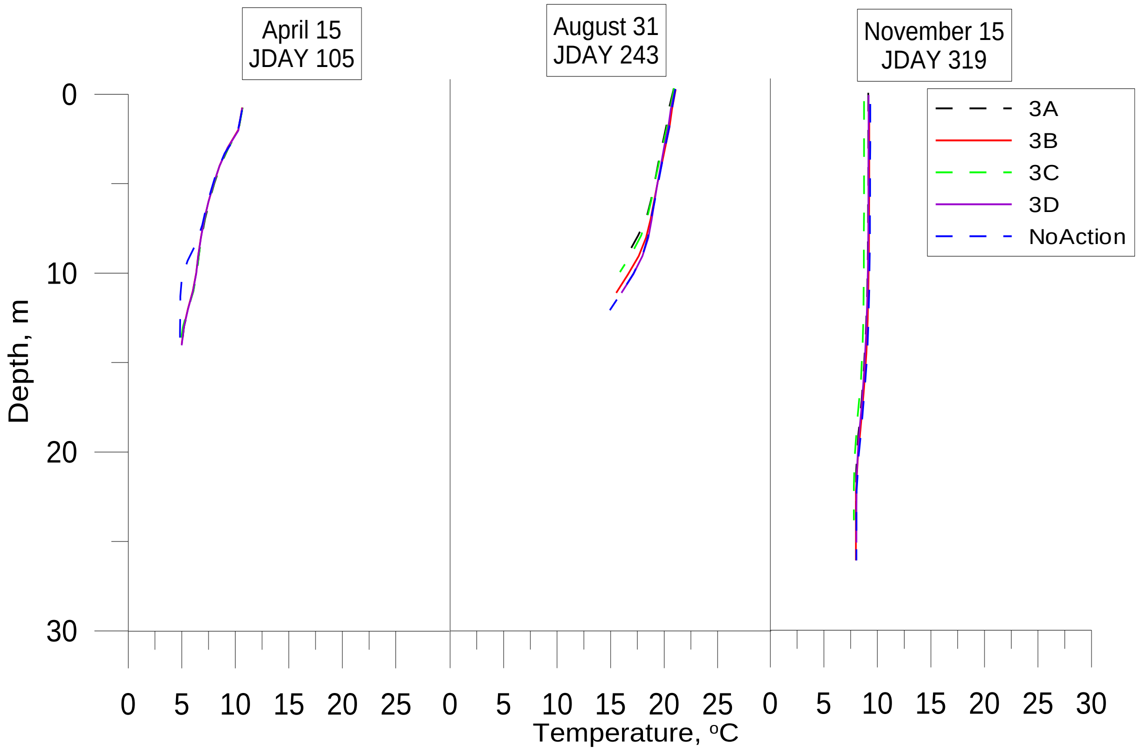


**Figure 103. Water temperature profiles at Lim 4 under action alternative Dry 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31$^{th}$ and November 15th**

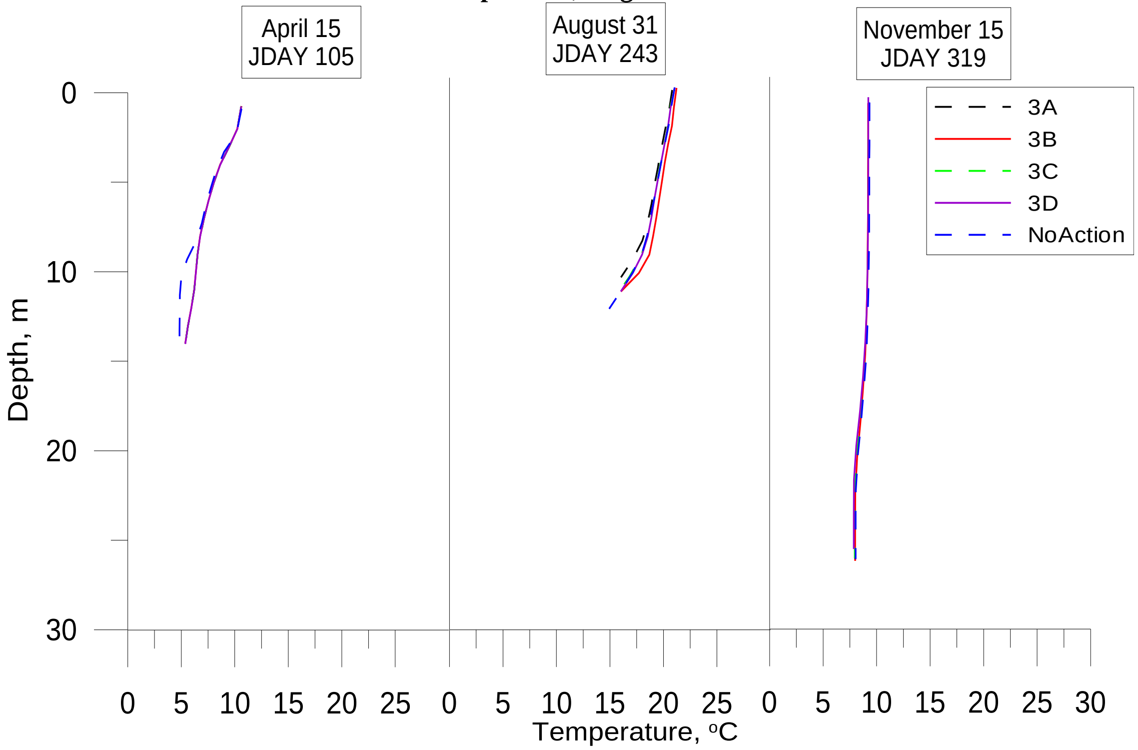


**Figure 104. Water temperature profiles at Lim 4 under action alternative Wet 3A, 3B, 3C 3D and the no-action alternative on April15th, August 31$^{th}$ and November 15th**

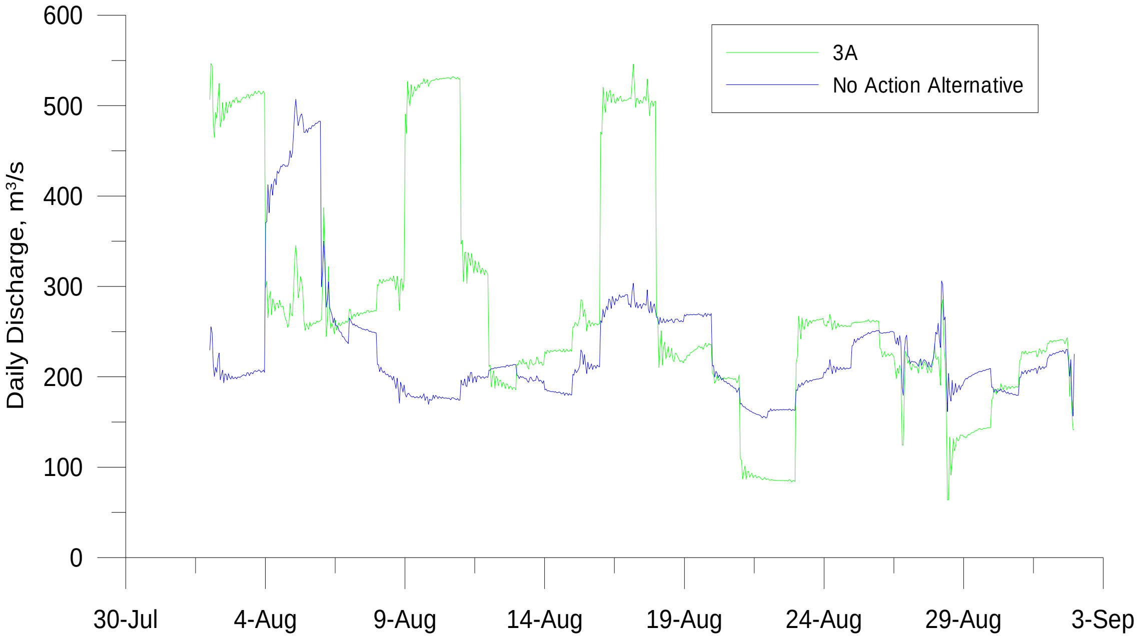


**Figure 105. Discharge from the Dry Falls dam under the no-action alternative and alternative action scenario 3A**

## Environmental Criteria: Annual Summary

Within the environmental performance criteria tool, CE-QUAL-W2 can calculate the temporal and volume weighted average of water quality constituents over the entire model domain and simulation time period (Cole and Wells, 2010). This tool allows for a macro comparison of water quality constituents among management scenario model runs for the whole lake system over the entire model run. Figure 106 shows the temporal and volume weighted water temperature for all management scenarios and the no-action alternative. Figure 106 shows that there is little overall variability in total average water temperature between management scenarios. Scenario 3A showed the lowest overall water temperature for all flow years, while scenario 2C showed all flow years to be the warmest at 10 $^{o}$C. Nonetheless, the difference in average water temperature between model scenarios and flow years is minimal and furthermore all management scenarios produced an average temperature comparable to the no-action alternative. Figure 107 shows the temporal and volume weighted dissolved oxygen for all management scenarios and the no-action alternative. Average dissolved oxygen concentrations showed slightly more variability between scenarios, but still relatively little overall change. Almost consistently the wet flow year had the highest overall dissolved oxygen concentration whereas the average flow year always produced the lowest average dissolved oxygen concentrations for all management scenarios.

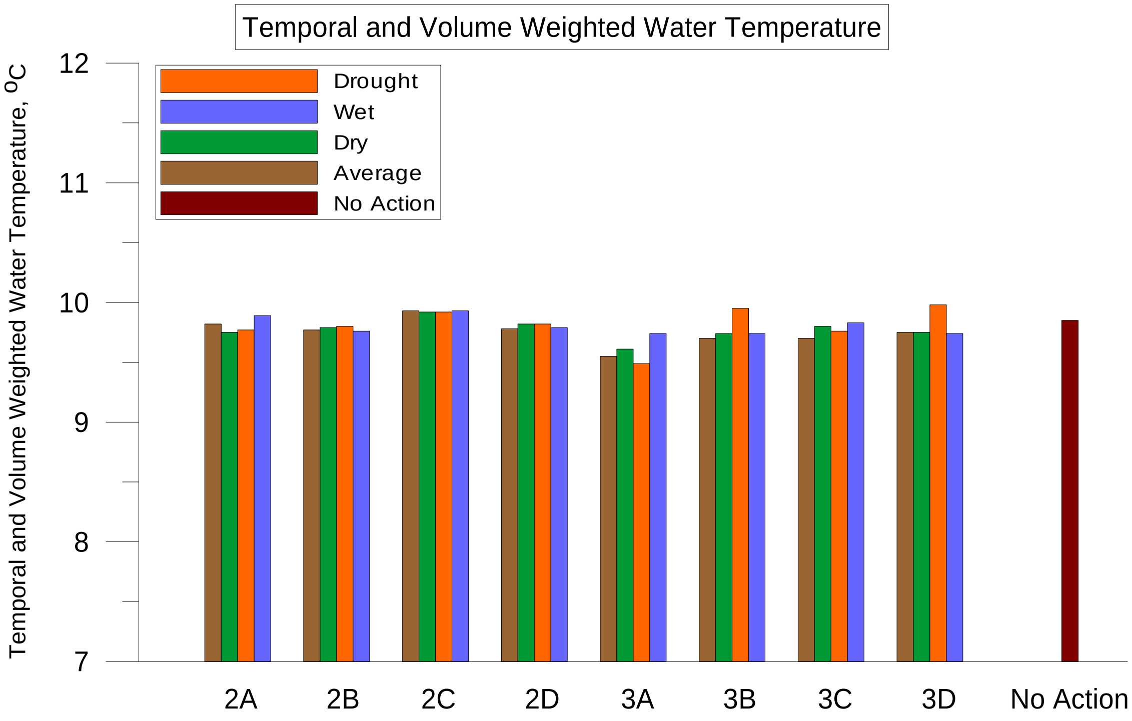


**Figure 106. Temporal and volume weighted average water temperature for each one year management scenario run.**

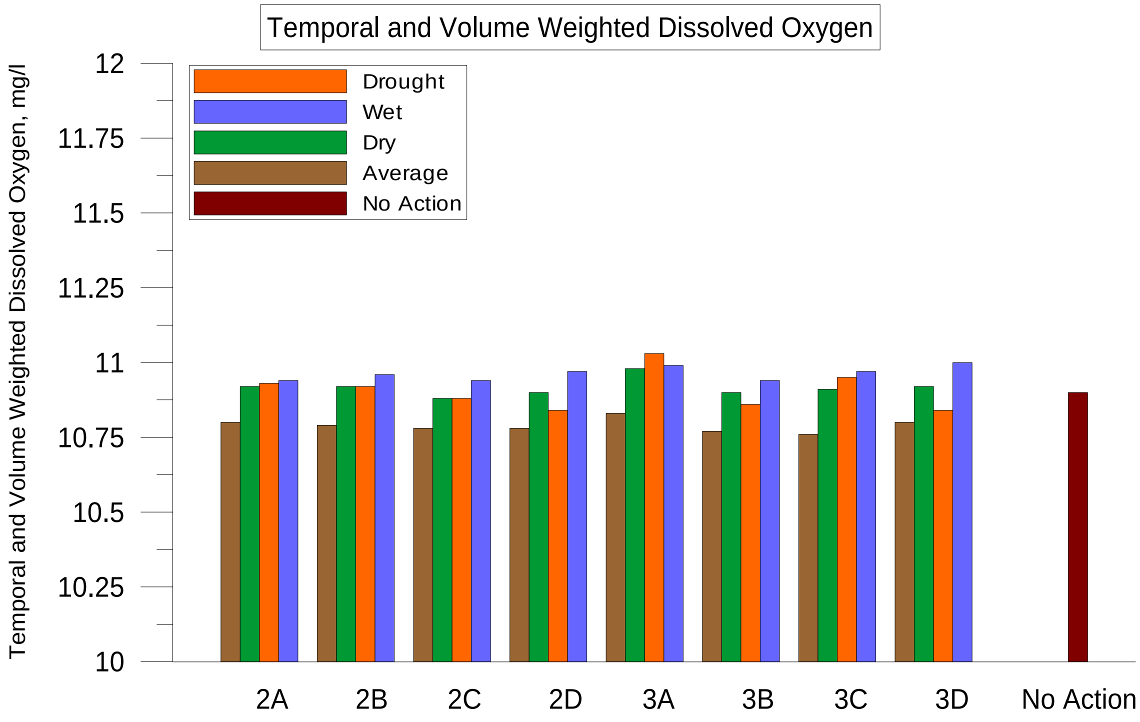


**Figure 107. Temporal and volume weighted average dissolved oxygen concentration for each one year management scenario run.**

## Environmental Criteria: Dissolved Oxygen Management Scenarios

Implementing new action alternative management plans and increasing summer water surface elevation draw downs in Banks Lake can have substantial effects on the limnology and available fish habitat within the lake. To evaluate the potential effects of these management scenarios on dissolved oxygen concentrations within the lake the CE-QUAL-W2 environmental performance criteria tool was used. The environmental performance criteria tool can output the time averaged volume fraction of any state variable used by CE-QUAL-W2 for the time period covered by the specific model run. Figure 108, Figure 109, Figure 110 and Figure 111 show histograms of the one year time averaged volume fraction of dissolved oxygen concentrations for Banks Lake average flow years, drought flow years, dry flow years and wet flow years.

The difference in the time averaged volume fraction of dissolved oxygen between management scenarios was found to be small. All management scenarios for all flow years showed the majority of dissolved oxygen concentrations to be either 9 mg/l or 13 mg/l. Among the lower dissolved oxygen concentrations (< 8 mg/l) all management scenarios for all flow years showed very little difference. The management scenario runs for the average flow year showed less over all dissolved oxygen within the 13 mg/l range but a higher distribution within the 12 mg/l range when compared to other flow years. The management scenarios run during the wet flow year had a higher distribution of dissolved oxygen concentrations with in the 13 mg/l range then all other flow years. Management scenarios 3A through 3D for the dry and drought flow years showed less dissolved oxygen within the 9 mg/l range than other management scenarios within the same flow years.

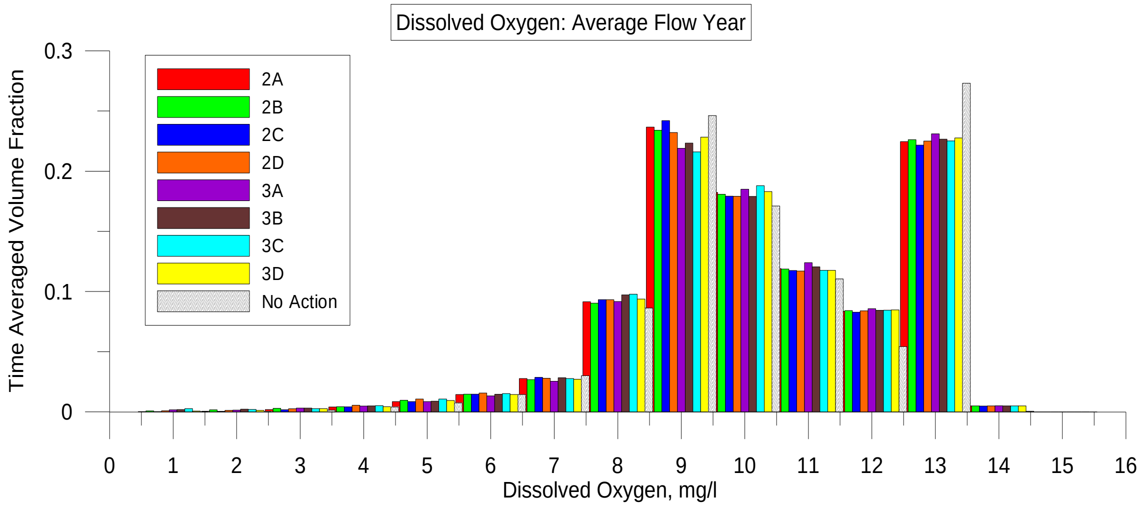


**Figure 108. Average flow year time averaged volume fraction of dissolved oxygen for all scenarios**

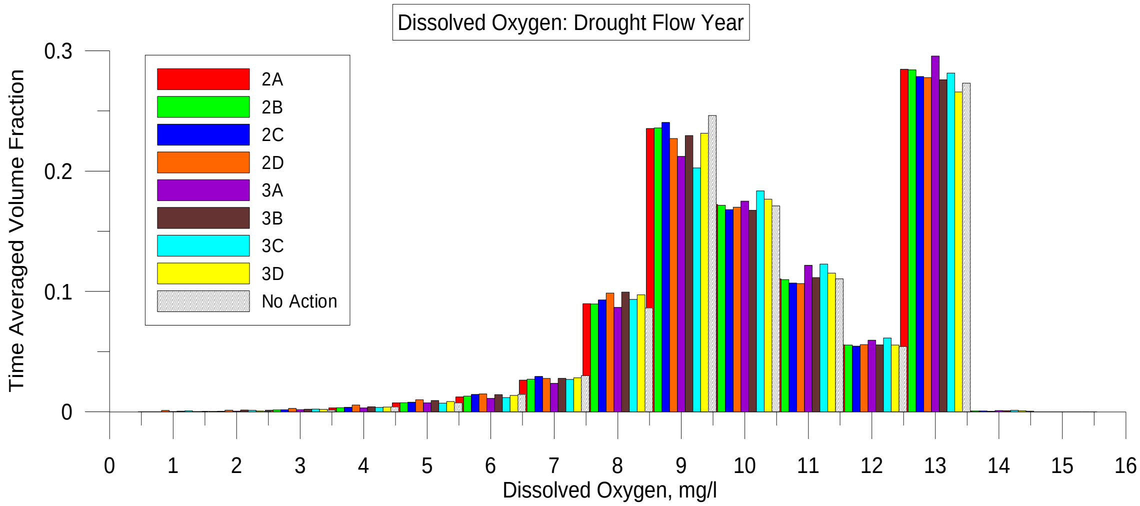


**Figure 109. Drought flow year time averaged volume fraction of dissolved oxygen for all scenarios**

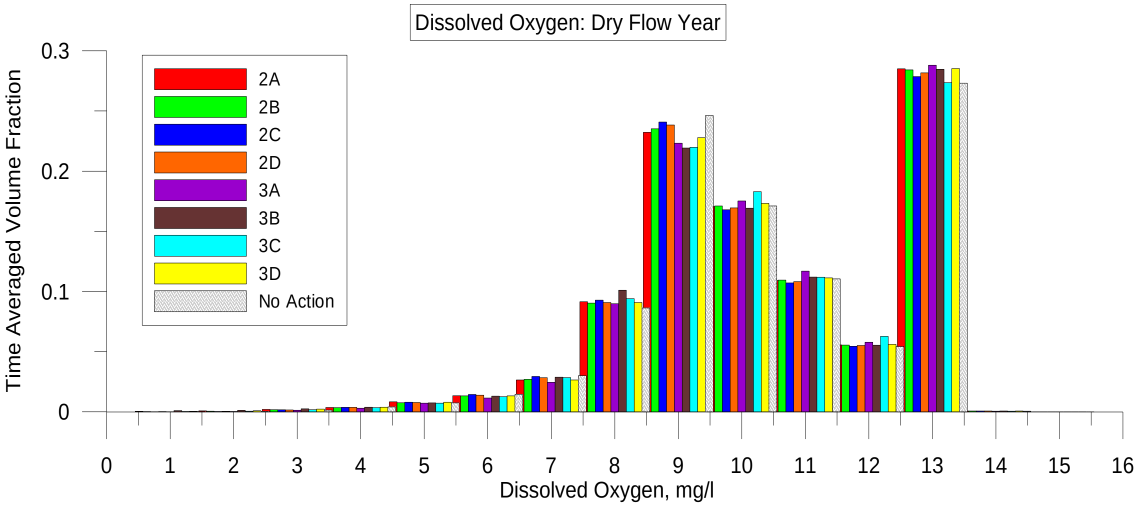


Figure 110. Dry flow year time averaged volume fraction of dissolved oxygen for all scenarios

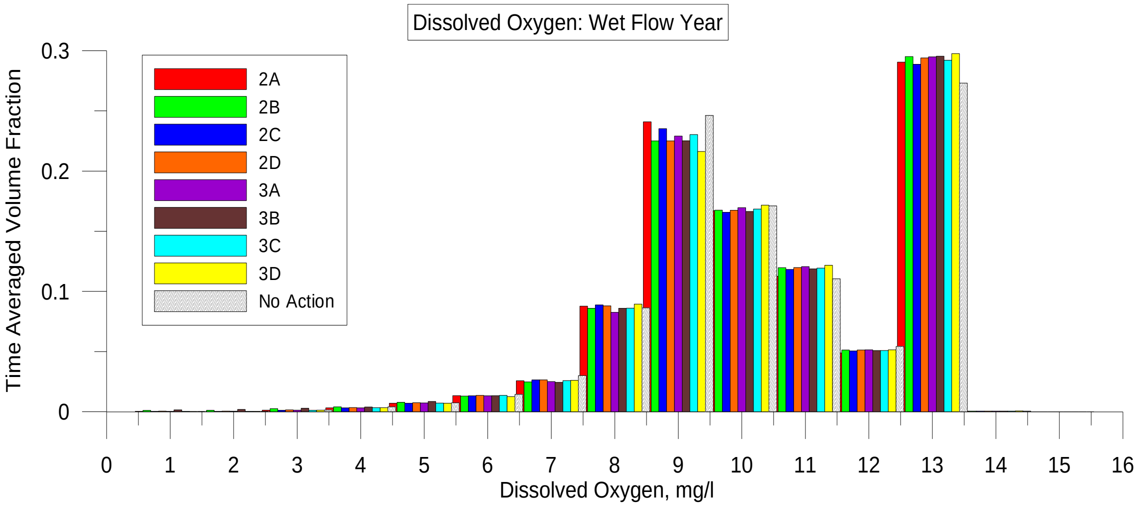


Figure 111. Wet flow year time averaged volume fraction of dissolved oxygen for all scenarios

## Fish Habitat Analysis

The effects of the proposed action alternative management scenarios on fish habitat availability were explored by using the fish habitat algorithm in CE-QUAL-W2. By specifying the preferred water temperature range and a desired dissolved oxygen concentration for any fish species or group of species, CE-QUAL-W2 calculates a time series of the percent of the total reservoir volume that meets the criteria. The Banks Lake model calculated optimal growth habitat for four popular sport fish found in Banks Lake: rainbow trout, kokanee, walleye and smallmouth bass. Table 34 shows the optimal growth temperatures and dissolved oxygen concentrations taken from literature.

**Table 34. Optimal growth habitat criteria for Banks Lake sport fish**

| | Temperature, oC | | | Dissolved Oxygen, mg/l | |
|---|---|---|---|---|---|
| | Temp-Low | Temp-High | Reference | Optimal DO, mg/l | Reference |
| Rainbow Trout | 14 | 16 | Piper, 1989 | >7 | Cooke and Welch, 2008 |
| Kokanee | 10 | 15 | Scott and Crossman, 1973 | >7 | Cooke and Welch, 2008 |
| Walleye | 20 | 25 | Koenst and Smith, 1976 | >5 | Cooke and Welch, 2008 |
| Smallmouth Bass | 21 | 28.5 | Koenst and Smith, 1976 | >6 | Cooke and Welch, 2008 |

Initial results did not show a definitive change in fish habitat among the different action alternative management scenarios. Figure 112, Figure 113, Figure 114, Figure 115 and Figure 116 show line plots of the initial results from the alternatives average-2A, drought-2A, dry-2A, wet-2A and the no-action alternative, respectively. Although finer details of how fish habitat volumes changed are not completely visible from the line plots, they do show the seasonal peaks and drop offs in available fish habitat. The cold water rainbow trout and kokanee have ample habitat though winter, spring and early summer while the warm water walleye and smallmouth have only a short window of optimal growth during midsummer. It should be noted that as a result of the narrowed optimal growth desired temperature ranges, the model did not calculate any available fish habitat prior to April 8th or after November 18th.

To better quantify available fish habitat in Banks Lake, the time series of the percent of the total reservoir volume that met fish habitat criteria were calculated into annual average percents. Figure 117, Figure 118, Figure 119 and Figure 120 show histograms of the annual average percent of the reservoir volume that were found to be optimal for kokanee, rainbow trout, walleye and smallmouth bass, respectively.

Kokanee were found to have the most optimal habitat with 21.5% to 24% of the reservoir found to be favorable. Kokanee habitat was consistently more available during wet flow years and was the least plentiful during drought years. Rainbow trout habitat was also most available during wet flow years with annual average percent volume values ranging from 8.5%-9.5% and at its lowest during drought years or any other management scenario that involved a large summer drawdown of the water surface elevation. The walleye and smallmouth bass habitat were generally more present during average flow years but also responded well to wet flow years.

It seems that management scenarios 2A, 2B and 2C produce consistent habitat percent results for each species, while management scenarios 2D, 3A, 3B, 3C and 3D have more variable effects within each species. The model results would suggest that kokanee habitat is affected the least by the changes in dissolved oxygen and water temperature that are attributed to the management scenarios, while their habitat percentages were never greatly impacted by the management scenarios that include a large summer drawdown. However, the rainbow trout, walleye and smallmouth bass habitat all responded relatively poorly to at least one management scenario, which would suggest that extra care be taken in the future during the implementation of any action alternative so that fisheries population are not affected.

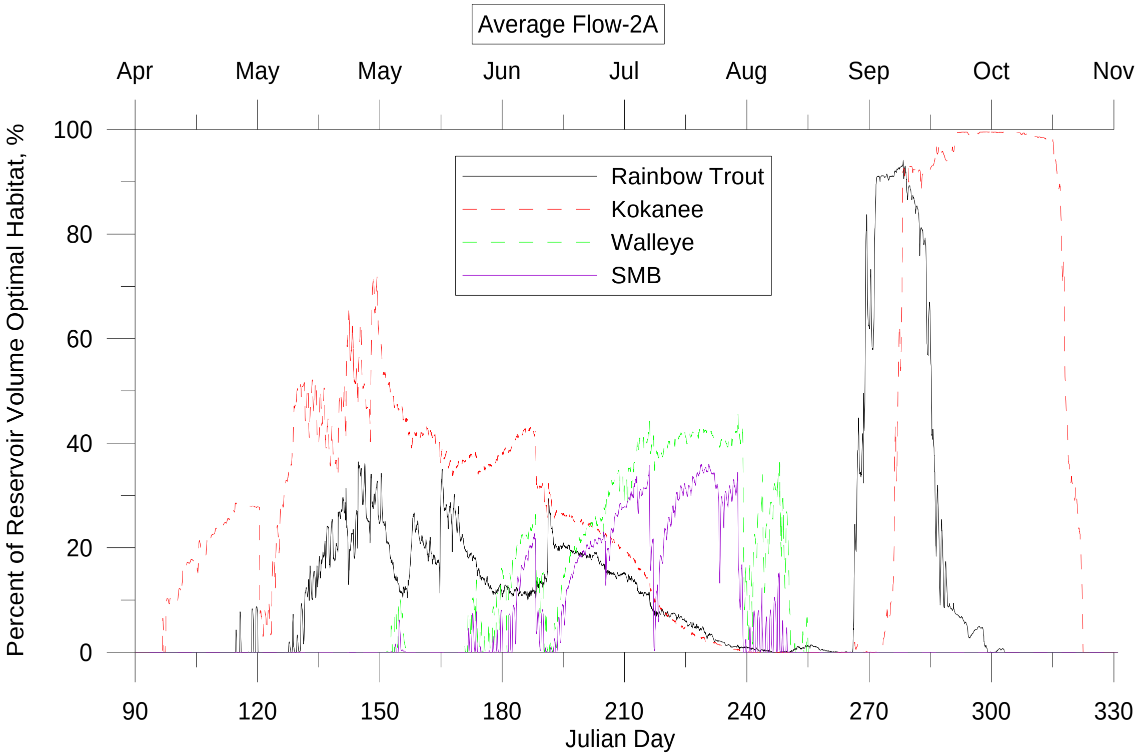


Figure 112. Percent of reservoir volume that is optimal fish habitat for scenario Average-2A

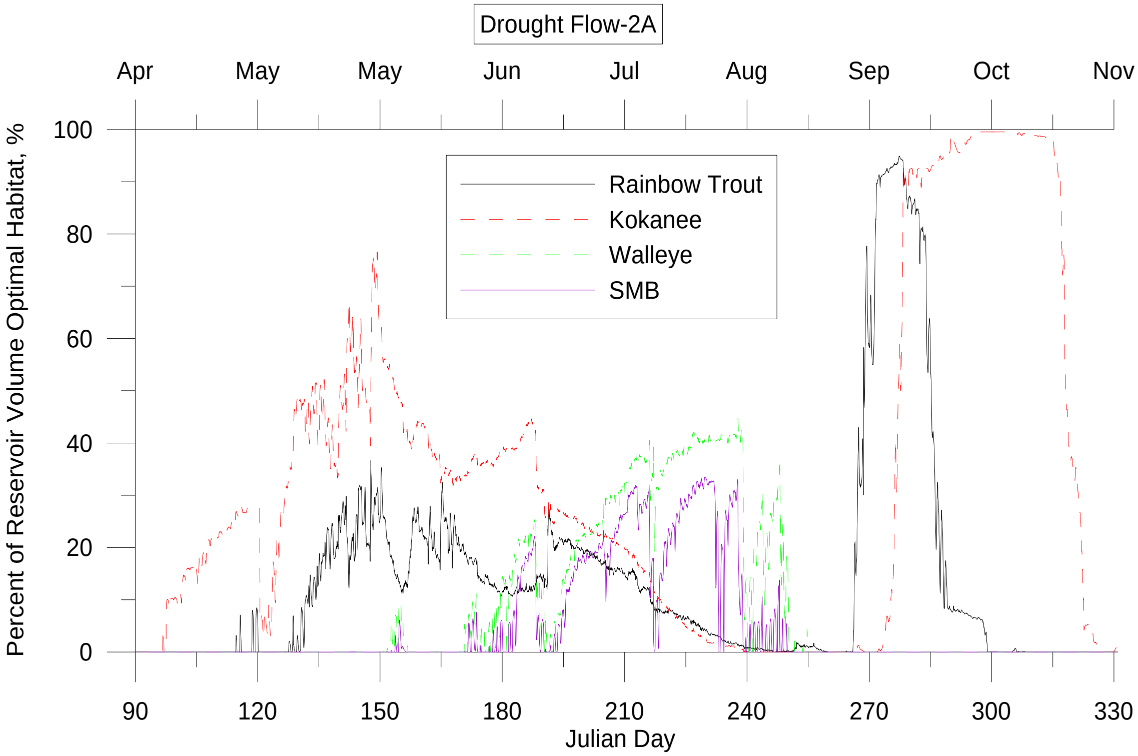


Figure 113. Percent of reservoir volume that is optimal fish habitat for scenario Drought-2A

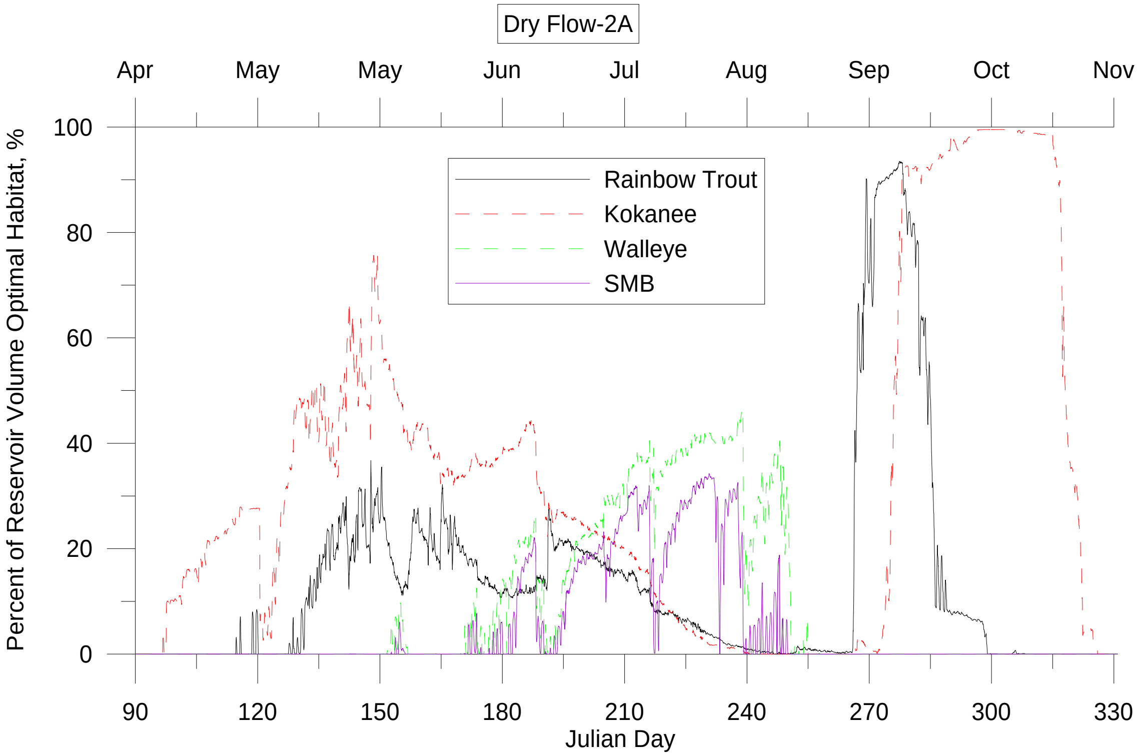


Figure 114. Percent of reservoir volume that is optimal fish habitat for scenario Dry-2A

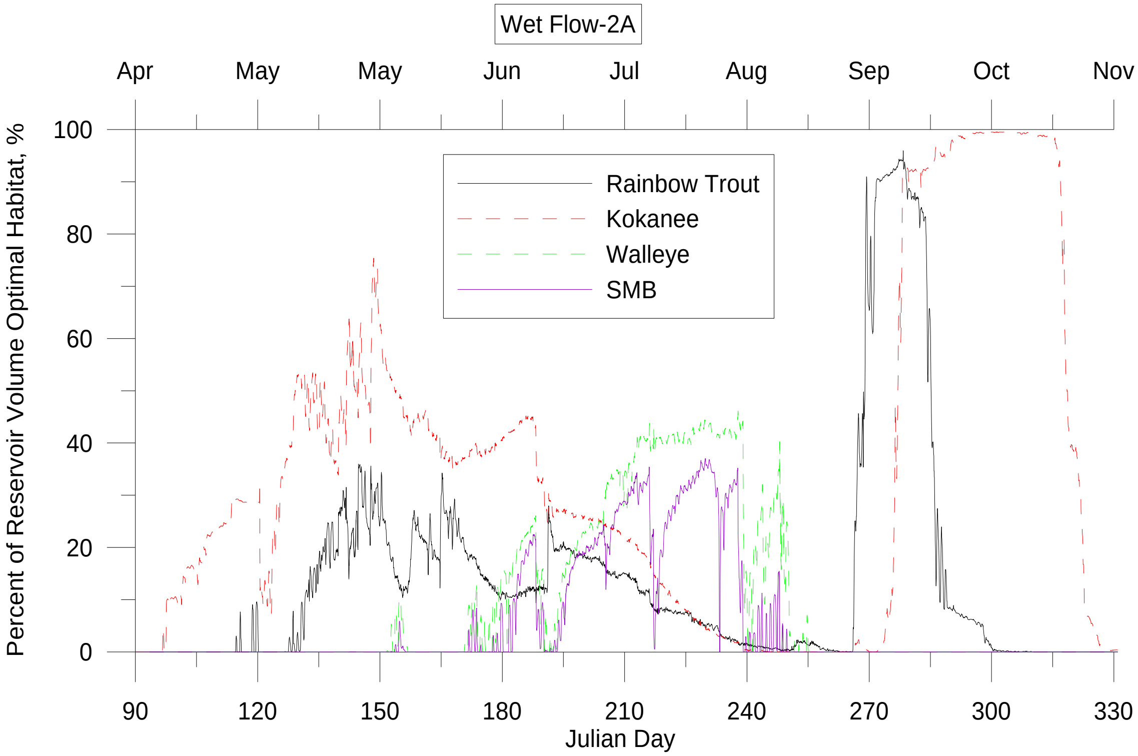


Figure 115. Percent of reservoir volume that is optimal fish habitat for scenario Wet-2A

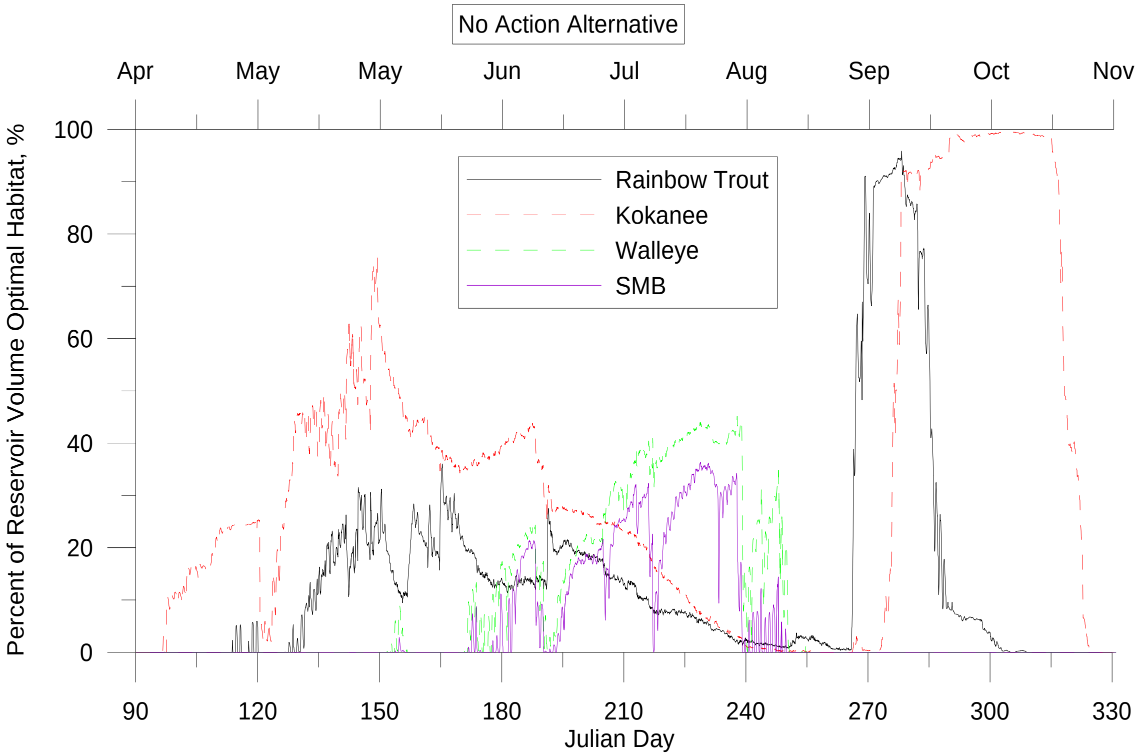


**Figure 116. Percent of reservoir volume that is optimal fish habitat for the no-action alternative**

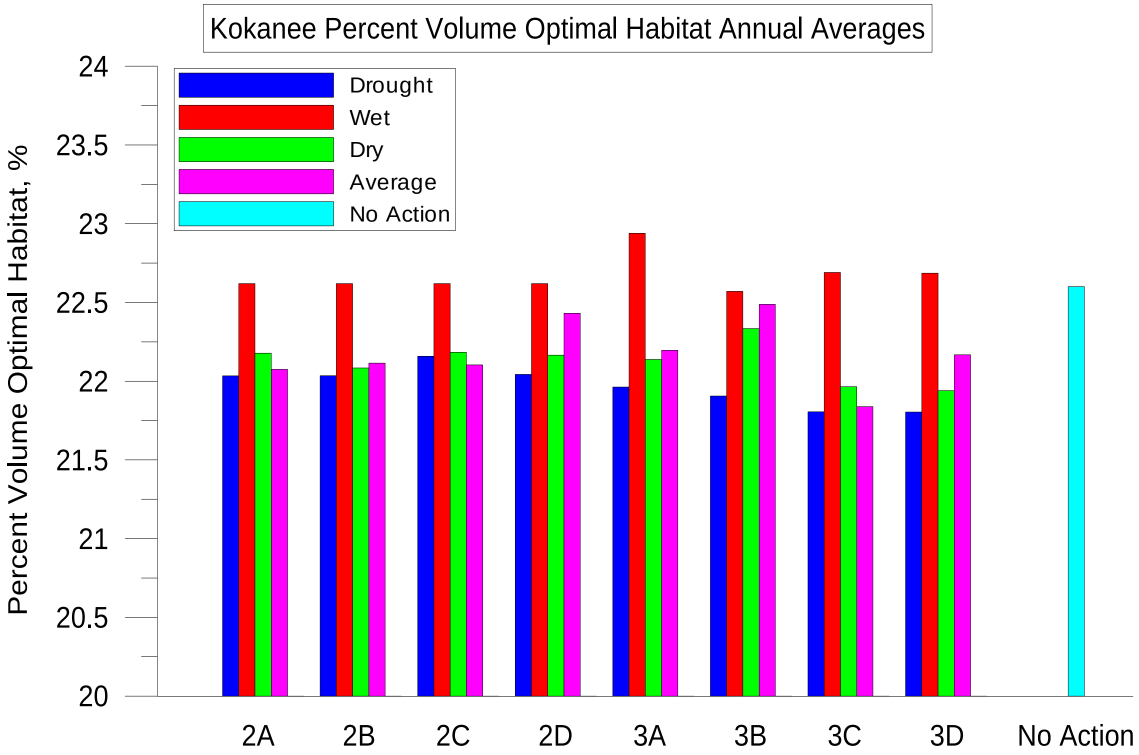


Figure 117. Annual average percent of reservoir volume that is optimal fish habitat for kokanee

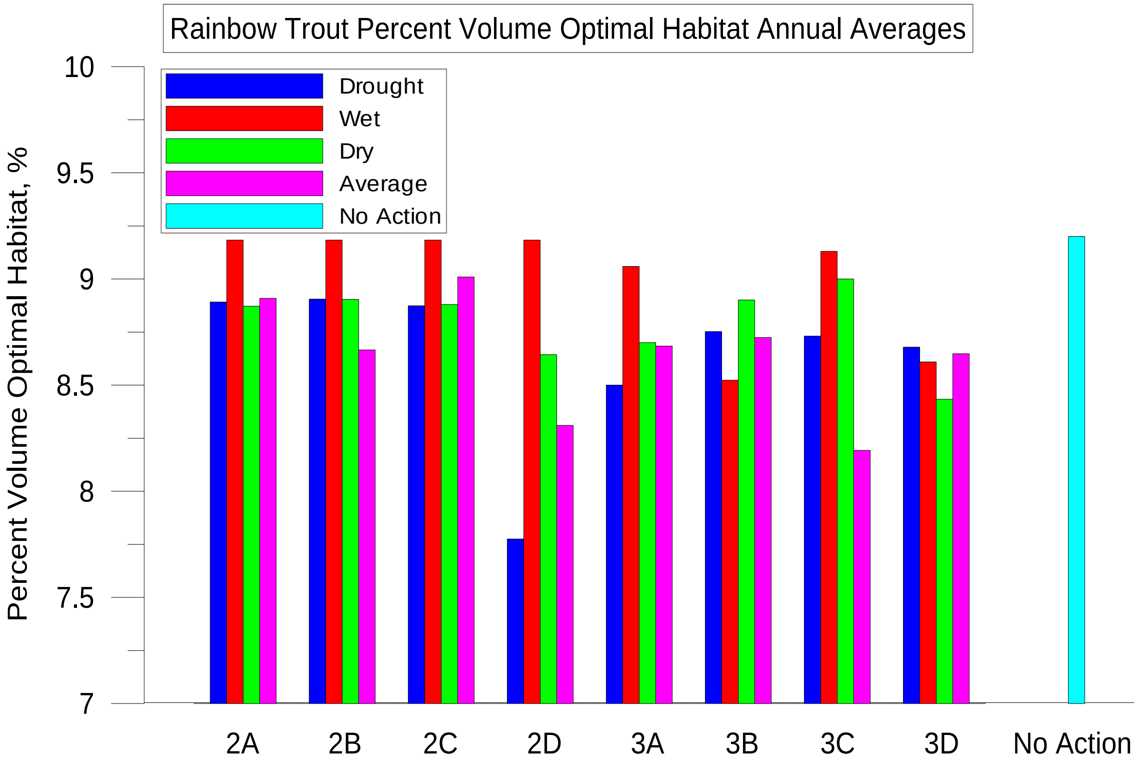


Figure 118. Annual average percent of reservoir volume that is optimal fish habitat for rainbow trout

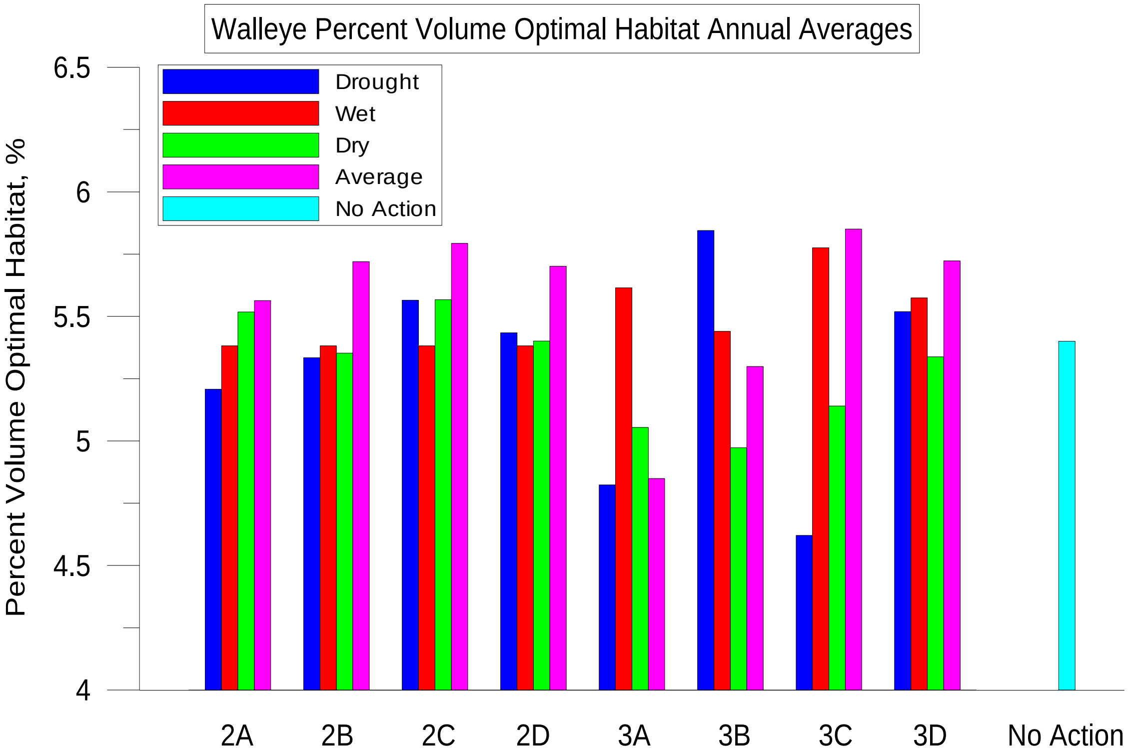


Figure 119. Annual average percent of reservoir volume that is optimal fish habitat for walleye

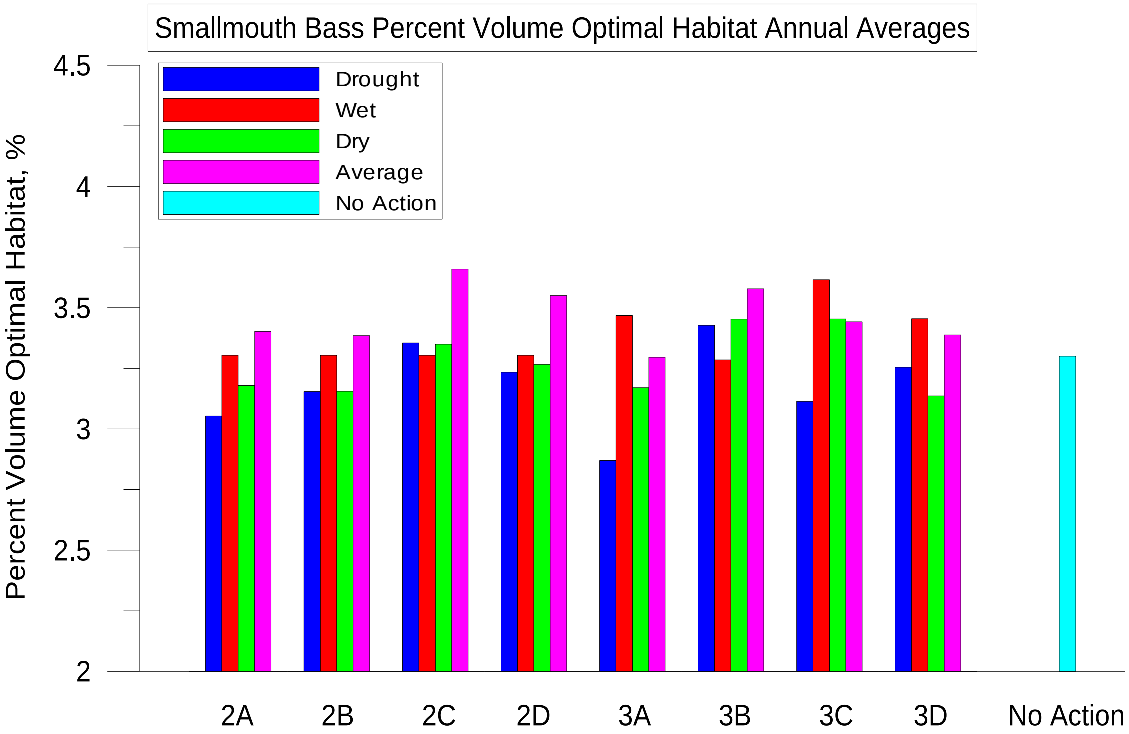


Figure 120. Annual average percent of reservoir volume that is optimal fish habitat for smallmouth bass

## Zooplankton Entrainment

The Banks Lake Fisheries Evaluation project currently collects zooplankton entrainment data from the tail waters of the Dry Falls Dam inside the Main Canal. During parts of the year when the Feeder Canal pumps are operational it is not uncommon for hydraulic residence time in the reservoir to drop below 50 days, thus posing a great risk of losing large zooplankton populations in a relatively short period of time. CE-QUAL-W2 has the capability to calculate the outflow discharge of water leaving the system at the Dry Falls dam as well as calculate multiple water quality constituents for the segment where the discharge structure is located. With this data a time series of zooplankton mass flow rates leaving Banks Lake can be calculated. Figure 121 shows a time series of model predicted mass concentrations of zooplankton group 1 and group 2 at Dry Falls Dam, and the calculated mass flow rate of zooplankton group 1 and group 2 leaving the Banks Lake system via the Main Canal. Figure 122 and Figure 123 show annual average mass discharge rates leaving via the Main Canal for zooplankton group 1 and group 2 respectively. Table 35 and Table 36 show monthly and annual averages zooplankton mass flow rates under all management scenarios for zooplankton group 1 and group 2.

Zooplankton group 1 had significant losses during the Dry-3A, Dry-3B, Dry-3C, Drought-3A and Drought-3C management scenarios. Conversely, zooplankton 1 was not lost at high levels during average and wet flow years. All management scenarios caused for zooplankton group 2 to lose less mass than the no-action alternative. Entrainment was at its lowest for zooplankton group 2 during average flow years and scenarios Dry-

2C, Dry-2D, Dry-3A and Dry-3B.  Zooplankton group 2 had its highest mass flow rate during Drought-3A, Wet-3B and Wet-3D.

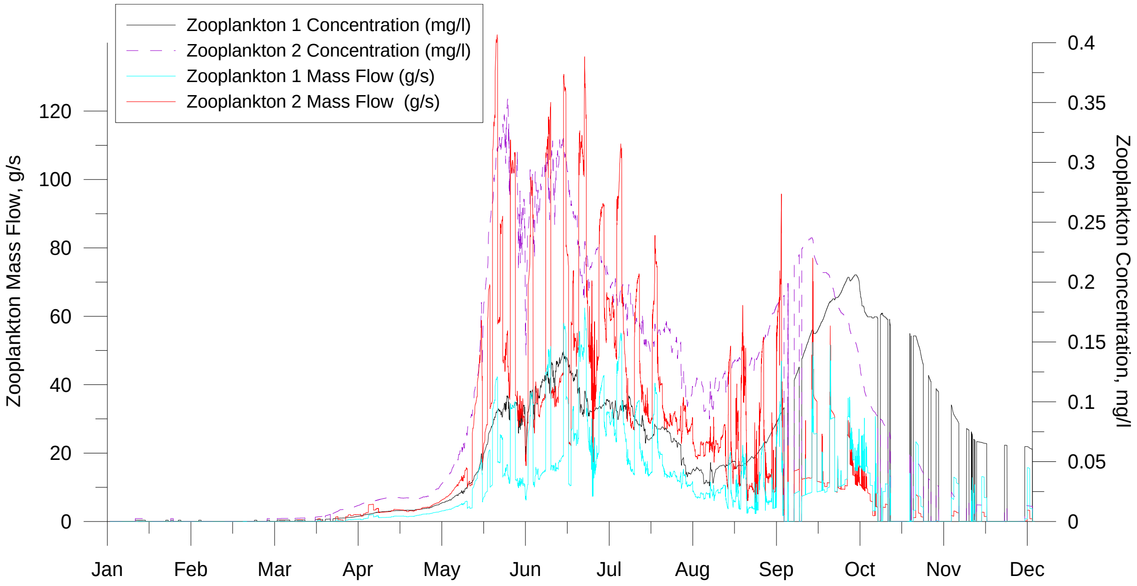


**Figure 121. Zooplankton concentrations (mg/l) and mass flow rates (g/s) into the Main Canal for the no-action alternative**

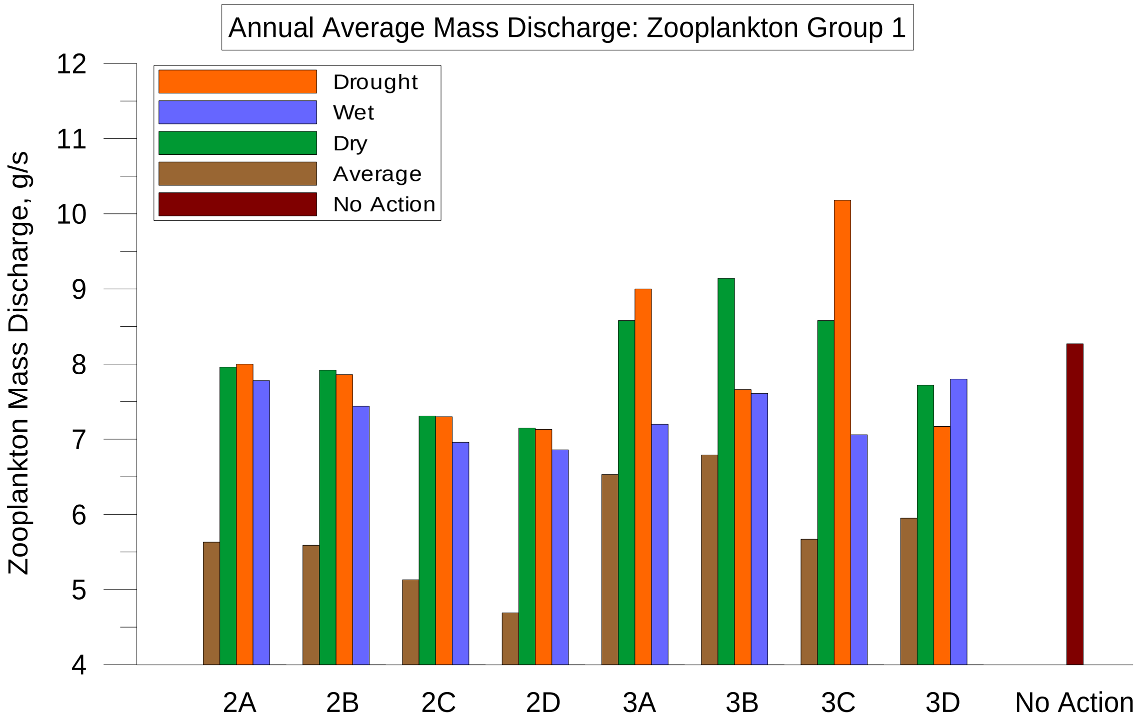


**Figure 122. Annual average mass flow rate of zooplankton group 1 through the Main Canal (g/s)**

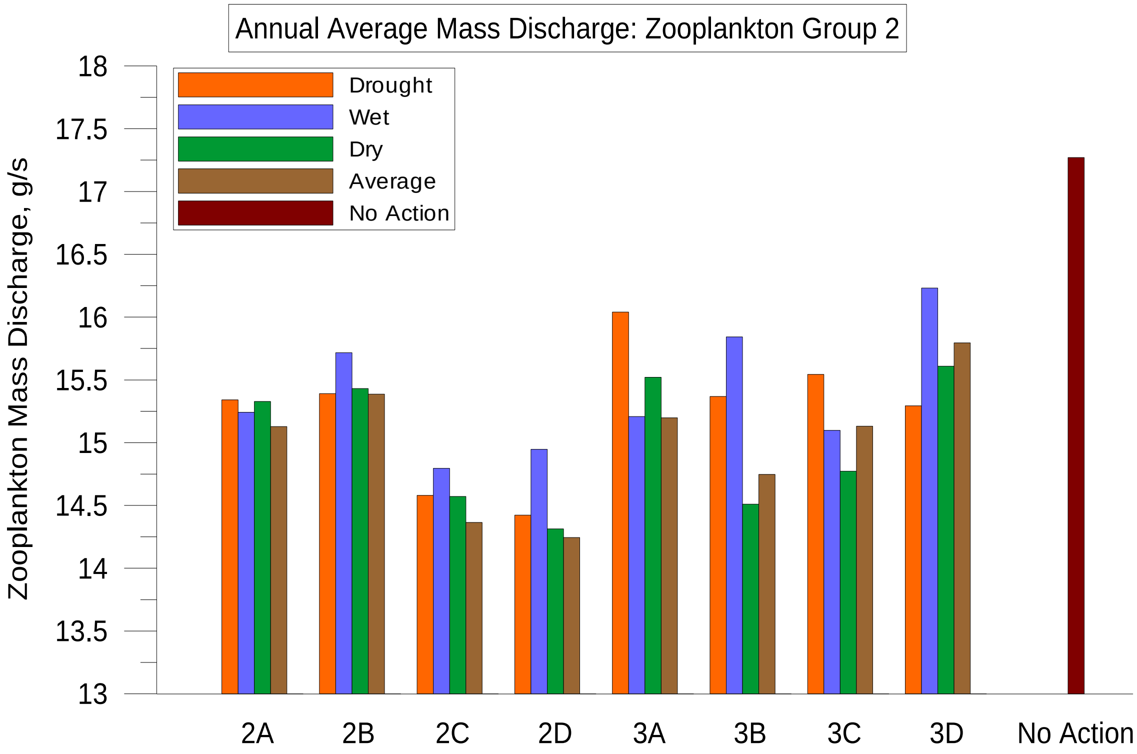


**Figure 123. Annual average mass flow rate of zooplankton group 2 through the Main Canal (g/s)**

**Table 35. Zooplankton group 1 monthly average mass flow rates through the Main Canal (g/s)**

| Average Mass Discharge: Zooplankton 1 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Ave. |
| No-Action Alt. | 0.01 | 0 | 0.06 | 1.08 | 5.62 | 22.7 | 29 | 12.9 | 8.7 | 14.7 | 2.7 | 1.84 | 8.27 |
| Average-2A | 0 | 0.27 | 0.77 | 0.94 | 5.61 | 14.8 | 19 | 13.4 | 2.77 | 7.78 | 0.12 | 2.03 | 5.63 |
| Average-2B | 0 | 0.27 | 0.07 | 0.91 | 5.81 | 15.4 | 20.1 | 13.5 | 4.42 | 4.49 | 0.38 | 1.7 | 5.59 |
| Average-2C | 0 | 0.27 | 0.08 | 0.88 | 5.61 | 13.9 | 17 | 9.99 | 3.2 | 8.55 | 0.32 | 1.79 | 5.13 |
| Average-2D | 0 | 0.26 | 0.07 | 0.88 | 5.74 | 14.1 | 17.5 | 11.9 | 5.89 | 1 | 0.41 | 1.68 | 4.96 |
| Average-3A | 0 | 0.27 | 0.77 | 0.89 | 5.4 | 16.5 | 25.4 | 20.7 | 3.74 | 2.1 | 0.36 | 2.25 | 6.53 |
| Average-3B | 0 | 0.26 | 0.07 | 0.89 | 5.9 | 16.4 | 22.4 | 21.6 | 4.58 | 6.7 | 0.57 | 2.23 | 6.79 |
| Average-3C | 0 | 0.24 | 0.07 | 0.88 | 5.58 | 14.9 | 19.4 | 14.7 | 3.77 | 6.13 | 0.36 | 1.99 | 5.67 |
| Average-3D | 0 | 0.26 | 0.07 | 0.88 | 5.79 | 15.3 | 20.2 | 13.5 | 6.3 | 6.3 | 0.74 | 2.05 | 5.95 |
| Dry-2A | 0.02 | 0 | 0.05 | 1.01 | 4.99 | 23.8 | 29.7 | 20.2 | 4.42 | 5.52 | 5.58 | 0.16 | 7.96 |
| Dry-2B | 0.02 | 0 | 0.05 | 1.01 | 4.98 | 23.8 | 29.2 | 18 | 6.52 | 5.48 | 5.68 | 0.17 | 7.92 |
| Dry-2C | 0.02 | 0 | 0.47 | 0.97 | 4.64 | 21.7 | 25 | 15.6 | 5.32 | 8.51 | 5.4 | 0.17 | 7.31 |
| Dry-2D | 0.02 | 0 | 0.47 | 0.97 | 4.66 | 21.7 | 25.2 | 17.5 | 7.87 | 1.3 | 5.95 | 0.16 | 7.15 |
| Dry-3A | 0.01 | 0 | 0.01 | 1.03 | 5.05 | 26.8 | 37.1 | 19.3 | 6.11 | 0.69 | 6.56 | 0.2 | 8.58 |
| Dry-3B | 0.02 | 0 | 0.04 | 1 | 5.12 | 25.1 | 34.6 | 24.5 | 6.99 | 6.06 | 6.07 | 0.24 | 9.14 |
| Dry-3C | 0.01 | 0 | 0.01 | 1.02 | 4.77 | 22.5 | 30.6 | 21.1 | 7.85 | 7.6 | 7.2 | 0.23 | 8.58 |
| Dry-3D | 0.01 | 0 | 0.04 | 0.97 | 4.67 | 23.5 | 29.5 | 17.1 | 8.4 | 6.79 | 1.41 | 0.31 | 7.72 |
| Drought-2A | 0.02 | 0 | 0.05 | 1.01 | 4.98 | 23.8 | 29.8 | 19.1 | 5.12 | 6.57 | 5.48 | 0.18 | 8 |
| Drought-2B | 0.02 | 0 | 0.05 | 1.01 | 4.98 | 23.8 | 29.2 | 18.1 | 6.26 | 5.18 | 5.59 | 0.17 | 7.86 |
| Drought-2C | 0.02 | 0 | 0.04 | 0.97 | 4.66 | 21.7 | 25.2 | 15.6 | 5.29 | 8.51 | 5.42 | 0.17 | 7.3 |
| Drought-2D | 0.02 | 0 | 0.47 | 0.99 | 4.69 | 21.8 | 25.7 | 17.4 | 7.51 | 0.79 | 6.03 | 0.16 | 7.13 |
| Drought-3A | 0.02 | 0 | 0.48 | 1.02 | 5.46 | 27 | 37.1 | 20.2 | 7.77 | 1.72 | 7.06 | 0.23 | 9 |
| Drought-3B | 0.01 | 0 | 0.48 | 1.03 | 4.99 | 21.9 | 25.5 | 15.5 | 6.25 | 10.5 | 5.52 | 0.19 | 7.66 |
| Drought-3C | 0.01 | 0 | 0.04 | 0.96 | 4.88 | 23.7 | 38 | 21.7 | 13.3 | 10.6 | 8.68 | 0.27 | 10.2 |
| Drought-3D | 0.01 | 0 | 0.04 | 1.03 | 5.1 | 22.1 | 26.7 | 15.4 | 7.76 | 7.14 | 0.41 | 0.33 | 7.17 |
| Wet-2A | 0 | 0 | 0.03 | 0.58 | 4.48 | 28 | 25.4 | 14.6 | 1.59 | 10.5 | 5.44 | 2.69 | 7.78 |
| Wet-2B | 0 | 0 | 0.26 | 0.59 | 4.73 | 30.8 | 27.2 | 15.3 | 3.65 | 6.34 | 0.31 | 0.09 | 7.44 |
| Wet-2C | 0 | 0 | 0.03 | 0.56 | 4.49 | 28.2 | 23.6 | 13.1 | 2.65 | 10.7 | 0.11 | 0.08 | 6.96 |
| Wet-2D | 0 | 0 | 0.02 | 0.56 | 4.64 | 29.5 | 24.6 | 15.4 | 5.23 | 1.94 | 0.34 | 0.08 | 6.86 |
| Wet-3A | 0 | 0 | 0.03 | 0.57 | 4.51 | 28.1 | 28.3 | 17.2 | 1.56 | 5.75 | 0.32 | 0.09 | 7.2 |
| Wet-3B | 0 | 0 | 0.03 | 0.57 | 4.8 | 32.5 | 26.1 | 15.1 | 3.66 | 7.12 | 1.27 | 0.29 | 7.61 |
| Wet-3C | 0 | 0 | 0.26 | 0.56 | 4.5 | 28.2 | 25.6 | 14.7 | 3.6 | 7.14 | 0 | 0.2 | 7.06 |
| Wet-3D | 0 | 0 | 0.02 | 0.56 | 4.68 | 32.9 | 25.9 | 15 | 5.74 | 8.06 | 0.52 | 0.3 | 7.8 |

### Table 36. Zooplankton group 2 monthly average mass flow rates through the Main Canal (g/s)

| Average Mass Discharge: Zooplankton 2 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Average |
| No-Action Alt. | 0.02 | 0 | 0.14 | 2.6 | 15.4 | 62.1 | 60.8 | 29.8 | 20.6 | 14.4 | 0.94 | 0.39 | 17.27 |
| Average-2A | 0 | 0.58 | 0.17 | 2.4 | 20.9 | 53.6 | 52.4 | 34.9 | 6.5 | 9.51 | 0.07 | 0.61 | 15.13 |
| Average-2B | 0 | 0.58 | 0.17 | 2.4 | 21.7 | 54.7 | 53.5 | 34.6 | 10.6 | 5.66 | 0.19 | 0.57 | 15.39 |
| Average-2C | 0 | 0.58 | 0.18 | 2.34 | 20.7 | 50.1 | 47.1 | 27.2 | 10 | 13.4 | 0.16 | 0.63 | 14.36 |
| Average-2D | 0 | 0.58 | 0.17 | 2.34 | 21.3 | 50.6 | 48 | 31.6 | 14.8 | 0.93 | 0.19 | 0.49 | 14.25 |
| Average-3A | 0 | 0.58 | 0.17 | 2.36 | 20.2 | 58.8 | 62.6 | 31.3 | 4.7 | 1.27 | 0.04 | 0.28 | 15.2 |
| Average-3B | 0 | 0.58 | 0.17 | 2.36 | 22 | 57.8 | 55.5 | 27.4 | 5.6 | 5.03 | 0.13 | 0.42 | 14.75 |
| Average-3C | 0 | 0.52 | 0.18 | 2.33 | 20.6 | 53.4 | 52.4 | 36.1 | 8.26 | 7.12 | 0.11 | 0.58 | 15.13 |
| Average-3D | 0 | 0.58 | 0.17 | 2.34 | 21.5 | 54.4 | 53.8 | 34.4 | 14.3 | 7.28 | 0.25 | 0.61 | 15.8 |
| Dry-2A | 0.4 | 0 | 0.13 | 2.42 | 13.6 | 59.6 | 54.1 | 38 | 8.58 | 5.13 | 2 | 0.04 | 15.33 |
| Dry-2B | 0.04 | 0 | 0.13 | 2.42 | 13.6 | 59.6 | 53.2 | 35 | 14.3 | 4.98 | 1.98 | 0.04 | 15.43 |
| Dry-2C | 0.04 | 0 | 0.13 | 2.36 | 12.4 | 55.2 | 47.8 | 31.5 | 13 | 10.2 | 2.24 | 0.04 | 14.57 |
| Dry-2D | 0.04 | 0 | 0.13 | 2.36 | 12.5 | 55.3 | 47.8 | 35 | 16 | 0.84 | 1.86 | 0.03 | 14.31 |
| Dry-3A | 0.31 | 0 | 0.02 | 2.5 | 13.8 | 66.3 | 61.3 | 31.9 | 8.6 | 0.27 | 1.27 | 0.03 | 15.52 |
| Dry-3B | 0.04 | 0 | 0.13 | 2.4 | 14 | 62.3 | 56.5 | 26.1 | 7.45 | 3.84 | 1.39 | 0.03 | 14.51 |
| Dry-3C | 0.03 | 0 | 0.02 | 2.52 | 13 | 58 | 57.8 | 30.7 | 9.37 | 4.34 | 1.47 | 0.02 | 14.77 |
| Dry-3D | 0.04 | 0 | 0.13 | 2.36 | 12.5 | 59.3 | 54.5 | 33.6 | 18.2 | 6.2 | 0.41 | 0.06 | 15.61 |
| Drought-2A | 0.04 | 0 | 0.13 | 2.4 | 13.6 | 59.6 | 54.1 | 36.5 | 10.8 | 5.12 | 1.81 | 0.03 | 15.34 |
| Drought-2B | 0.03 | 0 | 0.13 | 2.4 | 13.6 | 59.7 | 53.1 | 35.1 | 13.9 | 4.85 | 2 | 0.03 | 15.39 |
| Drought-2C | 0.04 | 0 | 0.13 | 2.36 | 12.5 | 55.3 | 47.9 | 31.4 | 12.9 | 10.2 | 2.24 | 0.04 | 14.58 |
| Drought-2D | 0.04 | 0 | 0.13 | 2.38 | 12.8 | 55.5 | 48.7 | 34.8 | 15.8 | 0.72 | 2.26 | 0.03 | 14.42 |
| Drought-3A | 0.03 | 0 | 0.13 | 2.4 | 15.7 | 67.8 | 63.7 | 31.2 | 10 | 0.56 | 0.96 | 0.03 | 16.04 |
| Drought-3B | 0.04 | 0 | 0.13 | 2.41 | 14.2 | 56.6 | 50 | 31.9 | 14.7 | 12.2 | 2.17 | 0.04 | 15.37 |
| Drought-3C | 0.04 | 0 | 0.13 | 2.24 | 14.5 | 61 | 66.7 | 24.3 | 12.9 | 3.85 | 0.91 | 0.03 | 15.54 |
| Drought-3D | 0.04 | 0 | 0.14 | 2.39 | 15 | 56.6 | 51.7 | 31.8 | 18.3 | 7.49 | 0.1 | 0.07 | 15.29 |
| Wet-2A | 0 | 0 | 0.08 | 1.55 | 11.6 | 72 | 47.1 | 30.3 | 4.38 | 12.8 | 2.46 | 0.69 | 15.24 |
| Wet-2B | 0 | 0 | 0.08 | 1.59 | 12.3 | 77.7 | 48.8 | 31.1 | 9.29 | 7.5 | 0.16 | 0.02 | 15.72 |
| Wet-2C | 0 | 0 | 0.08 | 1.51 | 11.6 | 71.4 | 43.8 | 27.2 | 7.4 | 14.5 | 0.06 | 0.02 | 14.8 |
| Wet-2D | 0 | 0 | 0.08 | 1.51 | 12.1 | 75 | 44.7 | 31.6 | 12.4 | 1.87 | 0.16 | 0.02 | 14.95 |
| Wet-3A | 0 | 0 | 0.08 | 1.53 | 11.7 | 72.1 | 52 | 34.9 | 3.97 | 6.12 | 0.14 | 0.02 | 15.21 |
| Wet-3B | 0 | 0 | 0.08 | 1.53 | 12.6 | 81.5 | 46.4 | 29.9 | 9.15 | 8.36 | 0.48 | 0.07 | 15.84 |
| Wet-3C | 0 | 0 | 0.08 | 1.51 | 11.6 | 72.2 | 47.3 | 30.6 | 9.21 | 8.59 | 0 | 0.05 | 15.1 |
| Wet-3D | 0 | 0 | 0.08 | 1.51 | 12.2 | 82.7 | 46.2 | 29.9 | 13.4 | 8.64 | 0.13 | 0.07 | 16.23 |

## Summary

The goal of this project was to produce a hydrodynamic and water quality model of Banks Lake that had the ability to predict the impacts of new management strategies on fish habitat and apply it to Banks Lake to determine whether certain proposed action alternatives would negatively impact the fish populations. This project has accomplished the following:

1.) Creation of a Banks Lake CE-QUAL-W2 model
2.) Calibration of the model for hydrodynamic, temperature, water quality, primary producers and secondary producers
3.) Documentation of model inputs and calibration
4.) Application of the model for the purpose of evaluating proposed management scenarios as outline in the Odessa Subarea Draft EIS.

During the development of this project, a substantial amount of water quality data, boundary condition data and meteorological data were gathered, processed, observed and ultimately used to develop/calibrate the Banks Lake CE-QUAL-W2 water quality model. Pertinent data that were missing or unavailable were obtained by either interpolating from existing data or through the development of regression analyses with multiple existing data sets.  The data collection/modification processes are discussed in McCulloch, Berger and Wells (2010).

Calibration of the CE-QUAL-W2 model for all relevant water quality constituents was carried out in order to reduce error in model predictions and to produce as accurate a representation of the natural system as possible. While no model can predict the responses of a natural system 100% of the time, the Banks Lake CE-QUAL-W2 model has been calibrated to within a tolerable range of error that is consistent with current modeling calibration standards. Furthermore, adequate calibration of the hydrodynamics and other abiotic constituents allowed for additional model calibration of biological constituents such as algae and zooplankton. The Banks Lake CE-QUAL-W2 model calibration process may review in McCulloch, Berger and Wells (2011).

Model application to the action alternatives outlined by the draft EIS for the Odessa Subarea did not show a substantial negative effect on water quality nor fish habitat. Water temperature profiles did reveal that under some scenarios, such as 3A, a slight cooling of the water column may take place during summer months. Conversely, water temperature profile analysis showed that most management scenarios exhibited slight warming during spring months and some cooling of the water column during fall months. Regardless, most heating and cooling of the water column was found to be minimal when compared to data collected from the no-action alternative.

Additional analysis of the distribution of dissolved oxygen concentrations throughout the reservoir over time did not show much change between management scenarios and the no-action alternative. Some selected cases, such as scenarios run during wet years, tended to have a higher ratio of dissolved oxygen at higher concentrations more frequently throughout the year, but similar to the water temperature profile analysis, the differences that existed were not significant. Additionally, the temporal/spatial average temperature and dissolved oxygen concentrations from each management scenario did not yield definitive results.

Zooplankton entrainment analysis did offer some variability in results among management scenarios. Zooplankton group 1 was not affected by scenarios 2A, 2B, 2C or 2D, however scenarios 3A, 3B and 3C run during dry and drought flow years were found to discharge 0.5-1.0 g/s more of zooplankton group 1 than the no-action alternative. Zooplankton group 2 was affected the most by scenarios 3A and 3D for all flow years, but in general when compared to the no-action alternative; zooplankton group 2 was not negatively affected by any scenario.

Fish habitat analysis showed that kokanee habitat was relatively abundant for most management scenarios especially all scenarios run during the wet flow year. Moderate negative impacts to the kokanee habitat occurred only on scenarios 3A, 3B, 3C and 3D during drought, dry and average flow years. The rainbow trout habitat decreased the most during scenarios drought/average 2-D and average 3-C while benefiting the most during wet flow years. Walleye habitat was favored by average flow years for all scenarios except 3A. Conversely, walleye habitat plummeted with scenario 3A for all flow years except the wet flow year. The smallmouth bass habitat was also the most plentiful for management scenarios run with the average flow year and was significantly affected only by scenarios 3A and 3C run with a drought flow year. In summary it seems that fish habitat is affected the least by management scenarios which require less drawdown of the water surface elevation such as scenarios 2A, 2B, 2C, 2D, and are run on either a wet or average flow year.

Future work could include evaluating the available fish habitat for more species, or perhaps instead of using optimal growth conditions to evaluate fish habitat, use acute and/or chronic temperature and dissolved oxygen criteria.  Also, utilizing the Lake Roosevelt fish bioenergetics model to predict fish growth would also be a realistic goal for further understanding how the management scenarios affect fish behavior and growth. The FORTRAN source code routine for the Lake Roosevelt fish bioenergetics model is show in Appendix F (McKillip, 2008).

## References

Annear, R., Berger, C., and Wells, S. (2008). "Lower Clackamas River Model Enhancements and Expansion: Part 1, Model Development." Technical Report EWR-04-08, Department of Civil Engineering, Portland State University, Portland, Oregon.

Banks Lake: Feeder Canal. Personal photograph by Dr. Chris Berger.

Bartsch, A. F., and Gakstatter, J. H. (1978). "Management Decisions for Lake Systems on a Survey of Trophic Status, Limiting Nutrients, and Nutrient Loadings in American-Soviet Symposium on Use of Mathematical Models to Optimize Water Quality Management." EPA-600/9-78-024, USEPA Agency Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, Florida.

Beck, J., King, C., Pearson, D., Shapiro, T., Steele, S., Kuchera, L., DeLeone, M., Haley, D., Sept, L., Kaumheimer, D., and Blanchard, J. (2001). "Banks Lake Resources Management Plan, Grant County Washington, July 2001." United States Bureau of Reclamation. Ephrata, Washington.

Berger, C., Wells, S., and Annear, R. (2008) "South Fork Tolt Reservoir Model: Model Calibration." Technical Report EWR-06-07, Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon.

Boisclair, D., and Leggett, W. C. (1989). "The importance of activity in bioenergetics models applied to actively foraging fishes." *Canadian Journal of Fisheries and Aquatic Sciences,* 46, 1859-1867.

Black, A. R., Smith, J., and Stegen, J. (2003). "A limnological survey and stable isotope food web analysis of Banks Lake, Washington, 2002 and 2003." Department of Biology,Eastern Washington University, Cheney, Washington.

Carlander, K. D. (1977) *Handbook of Freshwater Fishery Biology (volume 2).* The Iowa State University Press. Ames, Iowa

Chapra, S. (1997) *Surface water quality modeling.* McGraw-Hill, Boston, Massachusetts

Cole, T.M., and Wells, S. A. (2010). "CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.7," Department of Civil and Environmental Engineering. Portland State University, Portland, OR.

"Devil's Lake 1946." Online image. 1946. USGS: Earth Explorer. USGS. Feb. 2010. <http://edcsns17.cr.usgs.gov/EarthExplorer/>

Dillon, P. J., and Rigler, F. H. (1974). “The phosphorus-chlorophyll relationship for lakes.” Limnology and Oceanography. 19:767-773.

Buchak, E.M., and Edinger, J.E. (1982). "Hydrothermal Simulation of Quabbin Reservoir Using Longitudinal-Vertical Hydrodynamics, Interim Report." prepared for Wallace, Floyd Associates, Inc., Cambridge, MA.

Fields, K., Scofield, B., Lee, C., and Pavlik, D. (2005). “Lake Roosevelt Fisheries Evaluation Program, 2002 Annual Report.” Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington.

Hubbard, C. “Grand Coulee Dam: Pumping Plant Cross Section.” Online image. 1995. Hydroelectric Power Generation. Feb. 2010. <http://users.owt.com/chubbard/gcdam/html/hydro.html>

Kitchell, J. F., Stewart, D. J., and Weininger, D. (1977). “Applications of a bioenergetics model to yellow perch (Percaflavescens) and walleye (Stizostedion vitreum vitreum).” *Journal of the Fisheries Research Board of Canada*, 34, 1922-1935.

Koenst, W.M., and L.L. Smith Jr. (1976) Thermal Requirements of the Early Life History Stages of Walleye, *Stizostedion vitteum*, and Sauger, *Stizostedion canadense.* Journal of the Fisheries Research Board of Canada. 33: 1130-1138.

Kumar, R., (2003) “Effects of Mesocyclops thermocyclopoides (Copepoda: Cyclopoida) predation on the population growth patterns of different prey species.” Ecology Laboratory, Department of Zoology, University of Delhi, Delhi,India.

Lee, C., Pavlik-Kunkel, D., Fields, K., and Scofield, B. (2006). “Lake Roosevelt Fisheries Evaluation Program, 2004 Annual Report.” Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington.

Lee, C., Scofield, B., Pavlik, D., and Fields, K. (2003). “Lake Roosevelt Fisheries Evaluation Program, 2000 Annual Report.” Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington.

McCulloch, A., Berger, C., and Well, S. (2011) “Banks Lake Model: Boundary Conditions and Model Set-up.” Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon.

McCulloch, A., Berger, C., and Well, S. (2011) “Banks Lake Model: Model Calibration.” Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon.

McKillip, M. L. (2008). "Coupling the hydrodynamic and water quality model CE-QUAL-W2 with a multi-trophic fish bio-energetics model for Lake Roosevelt, Washington." Phd Thesis, Portland State University, Portland, Oregon.

McKillip, M. L., Annear, R., and Wells, S. (2006). "Lake Roosevelt Model: Boundary Conditions and Model Set-up." Technical Report EWR-01-05, Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon.

McKillip, M., and Wells, S. (2007). "Lake Roosevelt Water Quality and Hydrodynamic Model Calibration with Fish Bioenergetics." Technical Report EWR-03-06, Department of Civil and Environmental Engineering, Portland State University, Portland, Oregon.

McLellan, H., Lee, C., Scofield, B., and Pavlik, D. (2003). "Lake Roosevelt Fisheries Evaluation Program, 1999 Annual Report." Department of Natural Resources, Spokane Tribe of Indians. Wellpinit, Washington.

Pavlik-Kunkel, D., Fields, K., Scofield, B., and Lee, C. (2005). "Lake Roosevelt Fisheries Evaluation Program, 2003 Annual Report." Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington

Polacek, M. (2005). "Banks Lake Fishery Evaluation Project Draft Annual Report FY2005 (September 1, 2004 to August 31, 2005)." Washington Department of Fish and Wildlife. Ephrata, Washington.

Polacek, M. (2009). "Banks Lake Fishery Evaluation Project Annual Report FY2008 (March 1,2008 to February 1, 2009)." Washington Department of Fish and Wildlife. Ellensburg, Washington.

Polacek, M., Knuttgen, K., Baldwin, C., and Woller, H. (2003). "Banks Lake Fishery Evaluation Project Annual Report: Fiscal Year 2001 (September 1, 2001 to August 31, 2002)." Washington Department of Fish and Wildlife. Ephrata, Washington.

Polacek, M., Knuttgen, K., and Shipley, R. (2003). "Banks Lake Fishery Evaluation Project Annual Report: Fiscal Year 2002 (September 1, 2002 to August 31, 2003)." Washington Department of Fish and Wildlife. Ephrata, Washington.

Polacek, M., and Shipley, R. (2007). "Banks Lake Fishery Evaluation Project, Annual Report FY2006 (September 1, 2005 to August 31, 2006." Washington Department of Fish and Wildlife. Ellensburg, Washington.

Poole, H.H., and W.R.G. Atkins. (1929) "Photo-electric measurements of submarine illumination throughout the year." Journal of Marine Biological Association, U.K. v. 16, pp 297-324.

Reynolds, C. S., (1984) *The Ecology of Freshwater Phytoplankton.* Cambridge University Press, Melbourne, Australia.

Scofield, B., Lee, C., Pavlik, D., and Fields, K. (2004). "Lake Roosevelt Fisheries Evaluation Program, 2001 Annual Report." Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington.

Scofield, B., Lee, C., Pavlik-Kunkel, D., and Fields, K. (2007). "Lake Roosevelt Fisheries Evaluation Program, 2005 Annual Report." Department of Natural Resources Spokane Tribe of Indians. Wellpinit, Washington.

Scott, W.B., and Crossman, E.J. (1973) Freshwater Fisheries of Canada. Bulletin 184. Fisheries Research Board of Canada. Ottawa.

Stober, Q. J., Tyler, R.W., Thomas, G.L., Jensen, L., Knutzen, J. A., Smith, D. L., and Nakatani, R. E. (1976). "Operational effects of irrigation and pumped storage on the ecology of Banks Lake, Washington" U.S. Bureau of Reclamation Pacific Northwest Regional Office. Boise, Idaho.

Stober, Q. J., Tyler, R. W., Thomas, G. L., Karp, W. A., and Nakatani, R. E. (1975). "Preliminary assessment of the effects of Grand Coulee pumped/storage development of the ecology of Banks Lake, Washington." U.S. Bureau of Reclamation. Boise, Idaho.

Rast, W., and Lee, G. F. (1978). "Summary Analysis of the North American Project OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State Indices." EPA-600/3-78-008, USEPA Corvalis Environmental Research Laboratory, Corvalis, Oregon.

Reynolds, C. S., (1984) *The Ecology of Freshwater Phytoplankton.* Cambridge University Press, Melbourne, Australia.

United States Environmental Protection Agency (EPA) National Eutrophication Survey. (1977). "Report on Banks Lake Grant and Douglas Counties Washington EPA region X working paper No. 865." Office of Research and Development U.S. Environmental Protection Agency.

U.S. Department of Interior, Bureau of Reclamation (USBR). (1952) "Rating table for Banks Lake, USBR drawing # 222-117-12770."

U.S. Department of Interior, Bureau of Reclamation (USBR) and State of Washington Department of Ecology (WDOE). (2010). “Draft Environmental Impact Statement, Odessa Subarea Special Study, Columbia Basin Project, Washington..” Pacific Northwest Region, Columbia Cascades Office, Yakima, Washington.

“Washington State Map.” Online image. Washington State Search. Feb. 2010.

<http://www.washingtonstatesearch.com/Washington_maps/Washington_State_map.html>

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.

Winberg, G.G. (1956) “Rate of metabolism and food requirements of fishes.” Belorussian University, Minsk. Translated from Russian, 1960: Fisheries Research Board of Canada Translation Series 194, Ottawa.

Woller, H., Baldwin, C., Polacek, M., Knuttgen, K., Caromile, S., and Jackson, C. (2004). “Banks Lake Fish Survey, 2000” Washington Department of Fish and Wildlife. Spokane, Washington.

# Appendix A: CE-QUAL-W2 Control File

```
  W2 Model Version 3.7


TITLE C ...............................TITLE....................................
        Banks Lake - Janurary 1, 2002 through December 31, 2009



GRID         NWB     NBR     IMX     KMX   NPROC  CLOSEC
               1      10     182      56       2     OFF

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

CONSTITU     NGC     NSS     NAL     NEP    NBOD     NMC     NZP
               3       1       3       0       0       0       2

MISCELL     NDAY SELECTC HABTATC ENVIRPC AERATEC INITUWL
           12500     OFF     OFF     OFF     OFF     OFF

TIME CON  TMSTRT   TMEND    YEAR
         1.00000 2923.00    2002

DLT CON      NDT  DLTMIN DLTINTR
              11 1.00000     OFF

DLT DATE    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD
         1.00000  344.00  359.00  728.00  742.00 1503.00 1517.00 2087.00 2101.00
         2163.00 2177.00

DLT MAX   DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
          115.00    30.0   115.0    30.0   115.0    30.0   115.0    30.0   115.0
            30.0   115.0

DLT FRN     DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF
         0.70000 0.70000 0.70000 0.70000 0.70000 0.70000 0.70000 0.70000 0.70000
         0.70000 0.70000

DLT LIMI    VISC    CELC
WB 1          ON      ON

BRANCH G      US      DS     UHS     DHS     UQB     DQB   NLMIN   SLOPE  SLOPEC
BR1            2     111       0       0       0       0       1 0.00000   0.000
BR2          114     121       0      60       0       0       1 0.00000   0.000
BR3          124     128       0      47       0       0       1 0.00000   0.000
BR4          131     135       0      40       0       0       1 0.00000   0.000
BR5          138     142       0     134       0       0       1 0.00000   0.000
BR6          145     148       0      37       0       0       1 0.00000   0.000
BR7          151     160       0      34       0       0       1 0.00000   0.000
BR8          163     166       0      29       0       0       1 0.00000   0.000
BR9          169     173       0      28       0       0       1 0.00000   0.000
BR10         176     181       0      14       0       0       1 0.00000   0.000

LOCATION     LAT    LONG    EBOT      BS      BE    JBDN
WB 1     47.8000 119.200 425.000       1      10       1

INIT CND   TEMPI    ICEI  WTYPEC   GRIDC
WB 1      2.5000 0.00000   FRESH    RECT

CALCULAT     VBC     EBC     MBC     PQC     EVC     PRC
WB 1          ON      ON      ON     OFF      ON      ON

DEAD SEA   WINDC    QINC   QOUTC   HEATC
WB 1          ON      ON      ON      ON
```

```
INTERPOL   QINIC   DTRIC    HDIC
BR1          OFF     OFF     OFF
BR2           ON      ON      ON
BR3           ON      ON      ON
BR4           ON      ON      ON
BR5           ON      ON      ON
BR6           ON      ON      ON
BR7           ON      ON      ON
BR8           ON      ON      ON
BR9           ON      ON      ON
BR10          ON      ON      ON

HEAT EXCH  SLHTC    SROC  RHEVAP   METIC  FETCHC     AFW     BFW     CFW   WINDH
WB 1        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000  2.0000

ICE COVE    ICEC  SLICEC  ALBEDO   HWICE    BICE    GICE  ICEMIN   ICET2
WB 1          ON  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 0.30000  5.0000 0.00000 0.00000    MANN 0.00100

EDDY VISC    AZC   AZSLC   AZMAX     FBC       E   ARODI STRCKLR BOUNDFR  TKECAL
WB 1          W2     IMP 1.00000       3 9.53500 0.43000 24.0000 10.0000     IMP

N STRUC     NSTR
BR1            1
BR2            0
BR3            0
BR4            0
BR5            0
BR6            0
BR7            0
BR8            0
BR9            0
BR10           0

STR INT    STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC
BR 1         OFF
BR 2
BR 3
BR 4
BR 5
BR 6
BR 7
BR 8
BR 9
BR 10

STR TOP    KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR
BR1            2
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10

STR BOT    KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR
BR1           17
BR2
BR3
BR4
BR5
```

```
BR6
BR7
BR8
BR9
BR10

STR SINK   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC
BR1        POINT
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10

STR ELEV    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR
BR1      471.000
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10

STR WIDT    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR
BR1      28.0000
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10

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

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
             OFF

WD SEG       IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD
               2

WD ELEV      EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD
           476.5

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

WD BOT      KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD
               6

TRIB PLA    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC

TRIB INT    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC
             OFF

TRIB SEG     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR

TRIB TOP   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT

TRIB BOT   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB

DST TRIB    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC
BR 1          ON
BR 2         OFF
BR 3         OFF
BR 4         OFF
BR 5         OFF
BR 6         OFF
BR 7         OFF
BR 8         OFF
BR 9         OFF
BR 10        OFF

HYD PRIN  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC
NVIOL        OFF
U            OFF
```

```
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   SNPC    NSNP   NISNP
WB 1         OFF       1      26

SNP DATE    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD
WB 1         1.0

SNP FREQ    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF
WB 1         7.5

SNP SEG     ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP
WB 1           2      12      23      27      32      37      42      52      60
              70      80      90     100     110     115     120     125     134
             140     147     153     158     164     171     177     181

SCR PRINT   SCRC    NSCR
WB 1          ON       1

SCR DATE    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD
WB 1      1.0000

SCR FREQ    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF
WB 1     0.20000

PRF PLOT    PRFC    NPRF   NIPRF
WB 1          ON       1      11

PRF DATE    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD
WB 1         1.5

PRF FREQ    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF
WB 1     1.00000

PRF SEG     IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF
WB 1          15     173      39     158      82      99     147     181      54
             109     110

SPR PLOT    SPRC    NSPR   NISPR
WB 1         OFF       1      11

SPR DATE    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD
WB 1         1.5

SPR FREQ    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF
WB 1     1.00000

SPR SEG     ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR
WB 1          15     173      39     158      82      99     147     181      54
             109     110

VPL PLOT    VPLC    NVPL
WB 1         OFF       0

VPL DATE    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD
WB 1
```

```
VPL FREQ    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF
WB 1

CPL PLOT    CPLC    NCPL TECPLOT
WB 1         OFF       1      ON

CPL DATE    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD
WB 1         1.0

CPL FREQ    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF
WB 1     1.00000

FLUXES      FLXC    NFLX
WB 1         OFF       1

FLX DATE    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD
WB 1           1

FLX FREQ    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF
WB 1     0.50000

TSR PLOT    TSRC    NTSR   NITSR
              ON       1      11

TSR DATE    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD
               1

TSR FREQ    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF
         0.04166

TSR SEG     ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR
              15     173      39     158      82      99     147     181      54
             109     110

TSR LAYE    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR
         5.00000 5.00000 5.00000 5.00000 5.00000 5.00000 5.00000 5.00000 5.00000
         5.00000 5.00000

WITH OUT    WDOC    NWDO   NIWDO
             OFF       0       0

WITH DAT    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD


WITH FRE    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF


WITH SEG    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO


RESTART     RSOC    NRSO    RSIC
              ON       1     OFF

RSO DATE    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD
            99.0

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

CST COMP     CCC    LIMC     CUF
              ON      ON       3

CST ACTIVE   CAC
TDS           ON
Gen1         OFF
Gen2          ON
Gen3         OFF
ISS1         OFF
PO4           ON
```

```
NH4           ON
NO3           ON
DSI          OFF
PSI          OFF
FE           OFF
LDOM          ON
RDOM          ON
LPOM          ON
RPOM          ON
ALG1          ON
ALG2          ON
ALG3          ON
DO            ON
TIC           ON
ALK           ON
ZOO1          ON
ZOO2          ON
LDOM-P        ON
RDOM-P        ON
LPOM-P        ON
RPOM-P        ON
LDOM-N        ON
RDOM-N        ON
LPOM-N        ON
RPOM-N        ON

CST DERI   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC
DOC          OFF
POC          OFF
TOC          OFF
DON          OFF
PON          OFF
TON          OFF
TKN          OFF
TN            ON
DOP          OFF
POP          OFF
TOP          OFF
TP            ON
APR          OFF
CHLA          ON
ATOT         OFF
%DO           ON
TSS           ON
TISS         OFF
CBOD         OFF
pH            ON
CO2          OFF
HCO3         OFF
CO3          OFF

CST FLUX   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC
TISSIN       OFF
TISSOUT      OFF
PO4AR         ON
PO4AG         ON
PO4AP         ON
PO4ER         ON
PO4EG         ON
PO4EP         ON
PO4POM        ON
PO4DOM        ON
PO4OM         ON
PO4SED        ON
PO4SOD        ON
PO4SET        ON
NH4NITR       ON
NH4AR         ON
NH4AG         ON
```

```
NH4AP         ON
NH4ER         ON
NH4EG         ON
NH4EP         ON
NH4POM        ON
NH4DOM        ON
NH4OM         ON
NH4SED        ON
NH4SOD        ON
NO3DEN        ON
NO3AG         ON
NO3EG         ON
NO3SED        ON
DSIAG         ON
DSIEG         ON
DSIPIS       OFF
DSISED       OFF
DSISOD       OFF
DSISET       OFF
PSIAM        OFF
PSINET       OFF
PSIDK        OFF
FESET        OFF
FESED        OFF
LDOMDK       OFF
LRDOM        OFF
RDOMDK       OFF
LDOMAP       OFF
LDOMEP       OFF
LPOMDK       OFF
LRPOM        OFF
RPOMDK       OFF
LPOMAP       OFF
LPOMEP       OFF
LPOMSET      OFF
RPOMSET      OFF
CBODDK       OFF
DOAP          ON
DOAR          ON
DOEP          ON
DOER          ON
DOPOM         ON
DODOM         ON
DOOM          ON
DONITR        ON
DOCBOD        ON
DOREAR        ON
DOSED         ON
DOSOD         ON
TICAG        OFF
TICEG        OFF
SEDDK        OFF
SEDAS        OFF
SEDLPOM      OFF
SEDSET       OFF
SODDK        OFF

CST ICON   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB
TDS      87.7000
Gen1     100.000
Gen2     0.00000
Gen3     10.0000
ISS1     2.00000
PO4      0.00600
NH4      0.00500
NO3      0.14900
DSI      0.00000
PSI      0.00000
FE       0.10000
```

```
LDOM     0.22813
RDOM     0.22813
LPOM     0.22813
RPOM     0.22813
ALG1     0.27000
ALG2     0.01000
ALG3     0.00500
DO       13.6000
TIC      15.4200
ALK      60.8000
ZOO1     0.00109
ZOO2     0.00243
LDOM-P   0.00019
RDOM-P   0.00019
LPOM-P   0.00019
RPOM-P   0.00019
LDOM-N   0.01725
RDOM-N   0.01725
LPOM-N   0.01725
RPOM-N   0.01725

CST PRIN  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC
TDS           ON
Gen1         OFF
Gen2          ON
Gen3         OFF
ISS1         OFF
PO4           ON
NH4           ON
NO3           ON
DSI          OFF
PSI          OFF
FE           OFF
LDOM         OFF
RDOM         OFF
LPOM         OFF
RPOM         OFF
ALG1          ON
ALG2          ON
ALG3          ON
DO            ON
TIC           ON
ALK           ON
ZOO1          ON
ZOO2          ON
LDOM-P       OFF
RDOM-P       OFF
LPOM-P       OFF
RPOM-P       OFF
LDOM-N       OFF
RDOM-N       OFF
LPOM-N       OFF
RPOM-N       OFF

CIN CON   CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC
TDS           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ISS1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PO4           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
NH4           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
```

```
NO3           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG1          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG3          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DO            ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
TIC           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALK           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO1          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF

CTR CON   CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC
TDS          OFF
Gen1         OFF
Gen2         OFF
Gen3         OFF
ISS1         OFF
PO4          OFF
NH4          OFF
NO3          OFF
DSI          OFF
PSI          OFF
FE           OFF
LDOM         OFF
RDOM         OFF
LPOM         OFF
RPOM         OFF
ALG1         OFF
ALG2         OFF
ALG3         OFF
DO           OFF
```

```
TIC          OFF
ALK          OFF
ZOO1         OFF
ZOO2         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

CDT CON   CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC
TDS           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ISS1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PO4           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
NH4           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
NO3           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG1          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG3          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DO            ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
TIC           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALK           ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO1          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM-P        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
```

```
             OFF
RDOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM-N        ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF

CPR CON   CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
Gen3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ISS1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALG3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
DO            ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
ZOO2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-P       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM-P       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-P       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RPOM-P       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LDOM-N       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
RDOM-N       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
LPOM-N       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF
```

```
RPOM-N       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF

EX COEF    EXH2O    EXSS    EXOM    BETA     EXC    EXIC
WB 1     0.30000 0.01000 0.20000 0.45000     OFF     OFF

ALG EX       EXA     EXA     EXA     EXA     EXA     EXA
         0.15000 0.15000 0.15000

ZOO EX       EXZ     EXZ     EXZ     EXZ     EXZ     EXZ
         0.20000 0.20000

MACRO EX     EXM     EXM     EXM     EXM     EXM     EXM
         0.01000

GENERIC    CGQ10   CG0DK   CG1DK     CGS
CG 1     0.00000 0.00000 0.00000 0.00000
CG 2     0.00000 -1.0000 0.00000 0.00000
CG 3     1.04000 0.00000 1.40000 0.00000

S SOLIDS     SSS   SEDRC   TAUCR
SS# 1    1.00000     OFF 0.00000

ALGAL RATE    AG      AR      AE      AM      AS    AHSP    AHSN   AHSSI    ASAT
ALG1     2.50000 0.04000 0.04000 0.10000 0.12000 0.00240 0.01400 0.00000  90.000
ALG2     2.70000 0.04000 0.04000 0.10000 0.12000 0.00220 0.01400 0.00000  90.000
ALG3     2.50000 0.04000 0.04000 0.10000 0.00900 0.00320 0.01400 0.00000  90.000

ALGAL TEMP   AT1     AT2     AT3     AT4     AK1     AK2     AK3     AK4
ALG1     1.50000 7.00000 24.0000 30.0000 0.10000 0.99000 0.99000 0.10000
ALG2     3.00000 15.0000 26.0000 30.0000 0.10000 0.99000 0.99000 0.10000
ALG3     3.00000 20.0000 28.0000 30.0000 0.10000 0.99000 0.99000 0.10000

ALG STOI    ALGP    ALGN    ALGC   ALGSI   ACHLA   ALPOM   ANEQN    ANPR
ALG1     0.00500  0.0800 0.55000 0.00000 0.22000 0.80000       2 0.00100
ALG2     0.00500  0.0800 0.55000 0.00000 0.11000 0.80000       2 0.00100
ALG3     0.00500  0.0800 0.55000 0.00000 0.14000 0.80000       2 0.00100

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     10.0000

EPI RATE      EG      ER      EE      EM      EB    EHSP    EHSN   EHSSI
EPI1     2.00000 0.04000 0.04000 0.10000 0.00100 0.00300 0.01400 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   ECHLA    EPOM
EPI1     0.00500 0.08000 0.45000 0.00000 0.05000 0.80000

ZOOP RATE     ZG      ZR      ZM    ZEFF   PREFP  ZOOMIN    ZS2P
Zoo1     0.76950 0.10000 0.04000 0.48000 0.50000 0.01000 0.30000
Zoo2     0.75000 0.10000 0.01000 0.50000 0.50000 0.01000 0.30000

ZOOP ALGP  PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA
Zoo1     0.60000 0.60000 0.20000
Zoo2     0.75000 0.75000 0.20000

ZOOP ZOOP  PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ
Zoo1     0.00000 0.10000
```

```
Zoo2     0.00000 0.00000

ZOOP TEMP    ZT1     ZT2     ZT3     ZT4     ZK1     ZK2     ZK3     ZK4
Zoo1     5.00000 10.0000 17.0000 23.0000 0.10000 0.90000 0.98000 0.10000
Zoo2     5.00000  8.0000 20.0000 22.0000 0.10000 0.90000 0.98000 0.10000

ZOOP STOI     ZP      ZN      ZC
Zoo1     0.01500 0.08000 0.45000
Zoo2     0.01500 0.08000 0.45000

MACROPHYT MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC
Mac1          ON

MAC PRINT MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC
Mac1          ON

MAC INI  MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI
Mac1     0.00000

MAC RATE       MG      MR      MM    MSAT    MHSP    MHSN    MHSC    MPOM  LRPMAC
Mac1     0.30000 0.05000 0.05000 30.0000 0.00000 0.00000 0.00000 0.90000 0.20000

MAC SED     PSED    NSED
Mac1     0.50000 0.50000

MAC DIST    MBMP    MMAX
Mac1     40.0000 500.000

MAC DRAG  CDDRAG     DMV    DWSA   ANORM
Mac1     3.00000 70000.0 8.00000 0.30000

MAC TEMP     MT1     MT2     MT3     MT4     MK1     MK2     MK3     MK4
Mac1     7.00000 15.0000 24.0000 34.0000 0.10000 0.99000 0.99000 0.01000

MAC STOICH    MP      MN      MC
Mac1     0.00500 0.08000 0.45000

DOM       LDOMDK  RDOMDK   LRDDK
WB 1     0.08000 0.00100 0.01000

POM       LPOMDK  RPOMDK   LRPDK    POMS
WB 1     0.08000 0.00100 0.00100 0.50000

OM STOIC    ORGP    ORGN    ORGC   ORGSI
WB 1     0.00500 0.08000 0.45000 0.18000

OM RATE     OMT1    OMT2    OMK1    OMK2
WB 1     4.00000 30.0000 0.10000 0.99000

CBOD        KBOD    TBOD    RBOD   CBODS
BOD 1    0.25000 1.01500 1.85000 0.00000

CBOD STOIC  BODP    BODN    BODC
BOD 1    0.00500 0.08000 0.45000

PHOSPHOR    PO4R   PARTP
WB 1     0.01500 0.00000

AMMONIUM    NH4R   NH4DK
WB 1     0.15000 0.05000

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 0.37000

NO3 RATE   NO3T1   NO3T2   NO3K1   NO3K2
WB 1     5.00000 25.0000 0.10000 0.99000
```

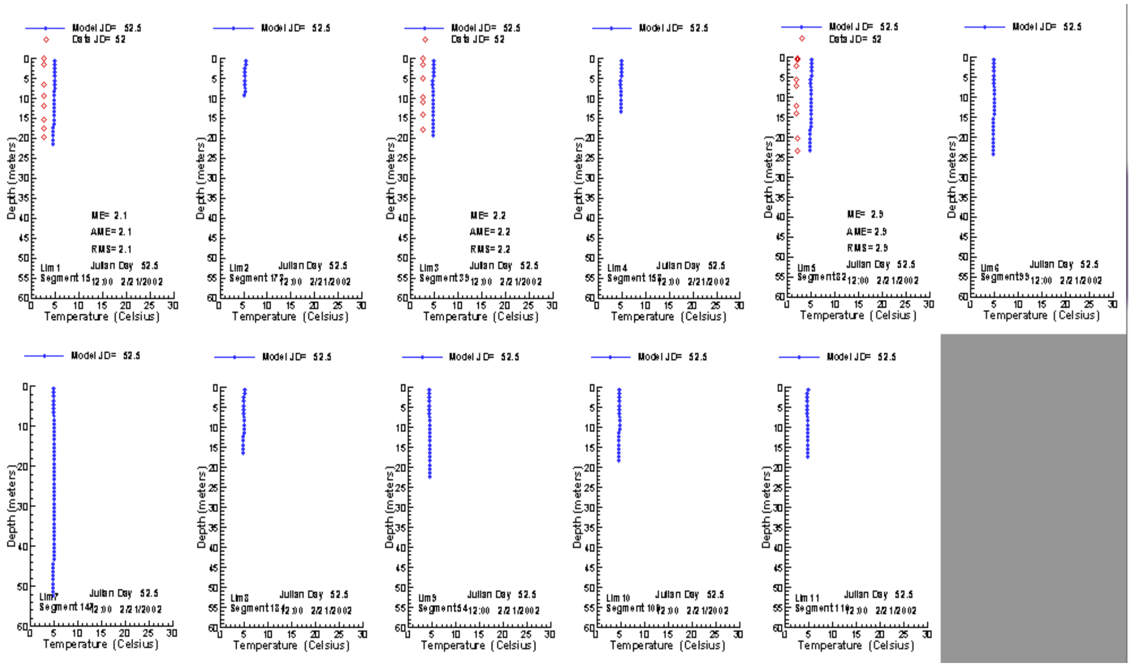
```
SILICA      DSIR    PSIS   PSIDK  PARTSI
WB 1     0.10000 0.10000 0.30000 0.20000

IRON         FER     FES
WB 1     0.50000 2.00000

SED CO2     CO2R
WB 1     0.50000

STOICH 1   O2NH4    O2OM
WB 1     4.57000 1.40000

STOICH 2    O2AR    O2AG
ALG1     0.95000 1.80000
ALG2     0.95000 1.80000
ALG3     0.95000 1.80000

STOICH 3    O2ER    O2EG
EPI1     1.10000 1.40000

STOICH 4    O2ZR
ZOO1     1.10000
ZOO2     1.10000

STOICH 5    O2MR    O2MG
Mac1     1.10000 1.40000

O2 LIMIT   O2LIM
         0.10000

SEDIMENT    SEDC  SEDPRC   SEDCI    SEDS    SEDK    FSOD    FSED   SEDBR DYNSEDK
WB 1          ON      ON 0.00000 0.08000 0.06000 1.00000 1.00000 0.01000     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     SOD
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.35000 0.40000 0.45000
         0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.40000 0.35000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.50000 0.50000 0.50000 0.50000
         0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000
         0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000 0.50000
         0.50000 0.50000 0.50000 0.50000 0.50000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000 0.30000
         0.30000 0.30000

REAERATION  TYPE    EQN#   COEF1   COEF2   COEF3   COEF4
WB 1        LAKE       9 0.00000 0.00000 0.00000 0.00000

RSI FILE.................................RSIFN................................
        rsi.npt

QWD FILE.................................QWDFN................................
        qwd_br1.npt
```

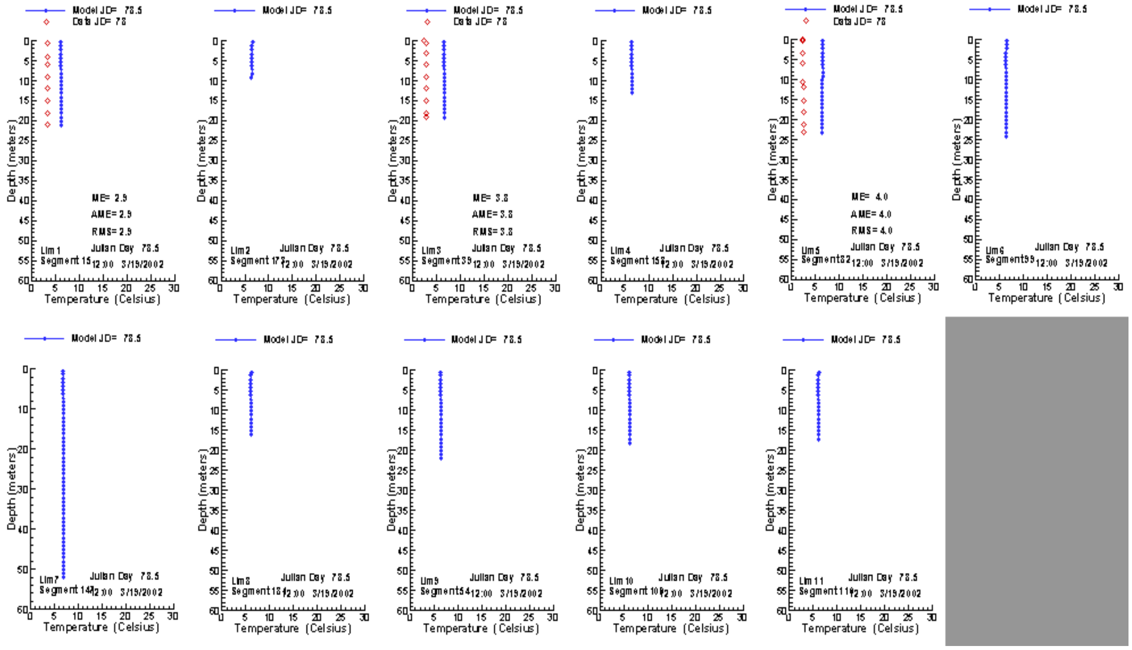
```
QGT FILE..................................QGTFN.................................
        qgt.npt - not used

WSC FILE..................................WSCFN.................................
        wsc.npt

SHD FILE..................................SHDFN.................................
        shade.npt

BTH FILE..................................BTHFN.................................
WB 1    bth.npt

MET FILE..................................METFN.................................
WB 1    met.npt

EXT FILE..................................EXTFN.................................
WB 1    ext_1.npt - not used

VPR FILE..................................VPRFN.................................
WB 1    vpr.npt – not used

LPR FILE..................................LPRFN.................................
WB 1    lpr.npt - not used

QIN FILE..................................QINFN.................................
BR1     qin_br1.npt
BR2     qin_br2.npt
BR3     qin_br3.npt
BR4     qin_br4.npt
BR5     qin_br5.npt
BR6     qin_br6.npt
BR7     qin_br7.npt
BR8     qin_br8.npt
BR9     qin_br9.npt
BR10    qin_br10.npt

TIN FILE..................................TINFN.................................
BR1     tin_br1.npt
BR2     tin_br2.npt
BR3     tin_br3.npt
BR4     tin_br4.npt
BR5     tin_br5.npt
BR6     tin_br6.npt
BR7     tin_br7.npt
BR8     tin_br8.npt
BR9     tin_br9.npt
BR10    tin_br10.npt

CIN FILE..................................CINFN.................................
BR1     cin_br1.npt
BR2     cin_br2.npt
BR3     cin_br3.npt
BR4     cin_br4.npt
BR5     cin_br5.npt
BR6     cin_br6.npt
BR7     cin_br7.npt
BR8     cin_br8.npt
BR9     cin_br9.npt
BR10    cin_br10.npt

QOT FILE..................................QOTFN.................................
BR1     qot_br1.npt

QTR FILE..................................QTRFN.................................
TR1     qtr_tr1.npt – not used

TTR FILE..................................TTRFN.................................
TR1     ttr_tr1.npt – not used
```

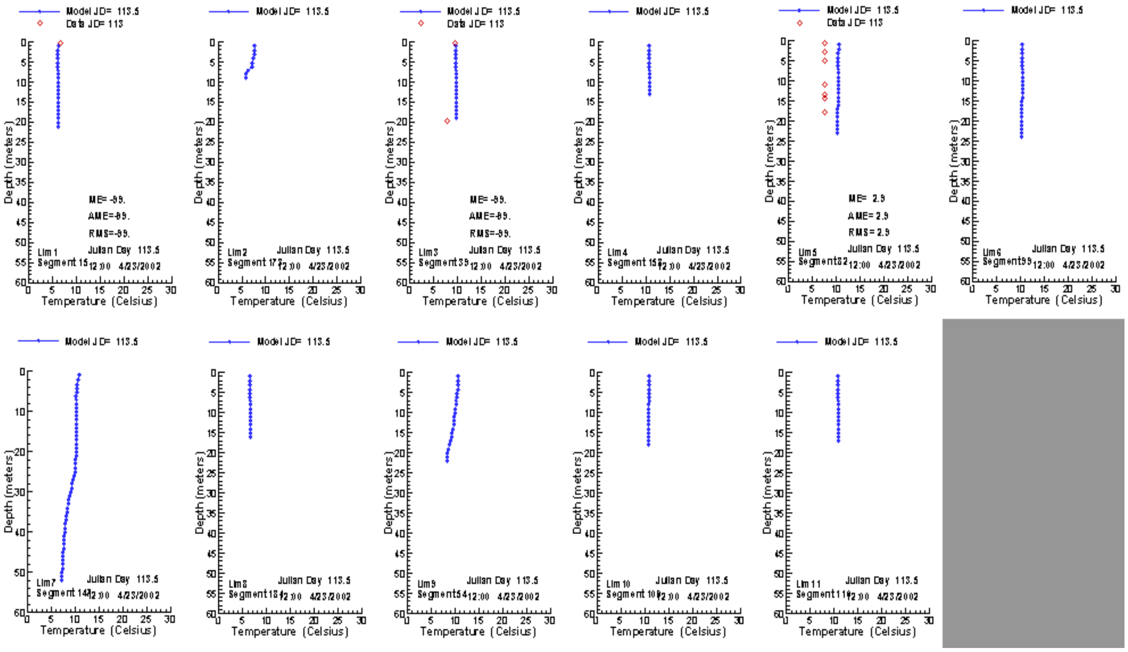
```
CTR FILE..................................CTRFN.................................
TR1     ctr_tr1.npt - not used

QDT FILE..................................QDTFN.................................
BR1     qdt_br1.npt

TDT FILE..................................TDTFN.................................
BR1     tdt_br1.npt

CDT FILE..................................CDTFN.................................
BR1     cdt_br1.npt

PRE FILE..................................PREFN.................................
BR1     pre_br1.npt
BR2     pre_br2.npt
BR3     pre_br3.npt
BR4     pre_br4.npt
BR5     pre_br5.npt
BR6     pre_br6.npt
BR7     pre_br7.npt
BR8     pre_br8.npt
BR9     pre_br9.npt
BR10    pre_br10.npt

TPR FILE..................................TPRFN.................................
BR1     tpr_br1.npt
BR2     tpr_br2.npt
BR3     tpr_br3.npt
BR4     tpr_br4.npt
BR5     tpr_br5.npt
BR6     tpr_br6.npt
BR7     tpr_br7.npt
BR8     tpr_br8.npt
BR9     tpr_br9.npt
BR10    tpr_br10.npt

CPR FILE..................................CPRFN.................................
BR1     cpr_br1.npt
BR2     cpr_br2.npt
BR3     cpr_br3.npt
BR4     cpr_br4.npt
BR5     cpr_br5.npt
BR6     cpr_br6.npt
BR7     cpr_br7.npt
BR8     cpr_br8.npt
BR9     cpr_br9.npt
BR10    cpr_br10.npt

EUH FILE..................................EUHFN.................................
BR1     euh_br1.npt - not used

TUH FILE..................................TUHFN.................................
BR1     tuh_br1.npt - not used
B

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

SNP FILE..................................SNPFN.................................
WB 1    snp.opt
```

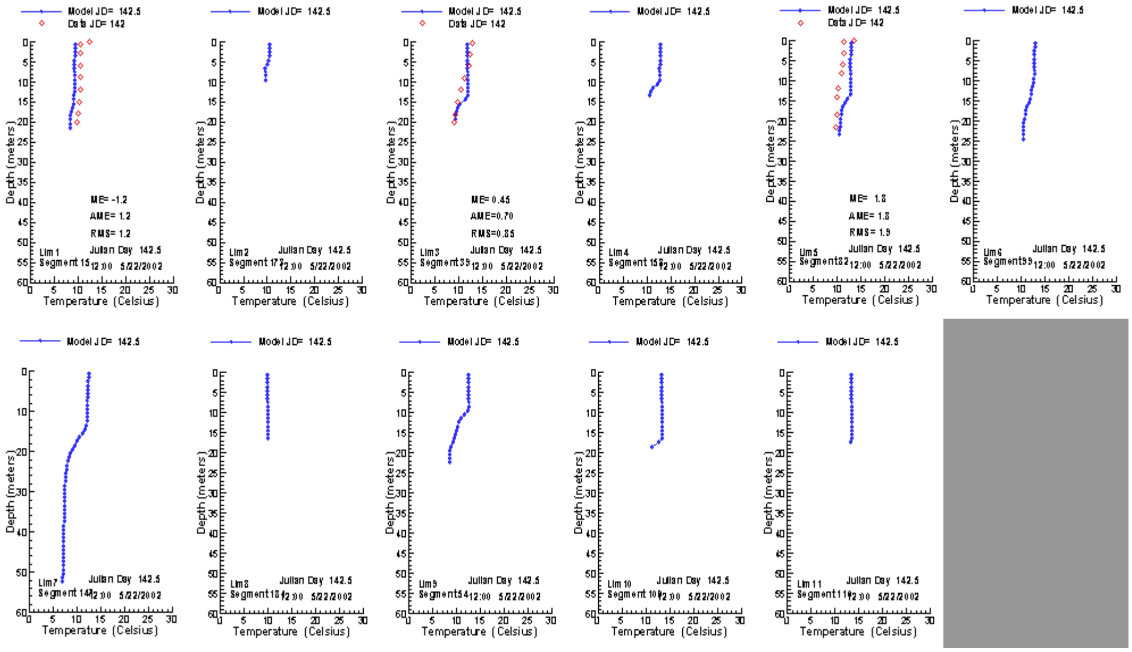
```
PRF FILE..................................PRFFN.................................
WB 1    prf.opt

VPL FILE..................................VPLFN.................................
WB 1    vpl.opt

CPL FILE..................................CPLFN.................................
WB 1    cpl.opt

SPR FILE..................................SPRFN.................................
WB 1    spr.opt

FLX FILE..................................FLXFN.................................
WB 1    flx.opt

TSR FILE..................................TSRFN.................................
        tsr.opt

WDO FILE..................................WDOFN.................................
        wdo.opt
```

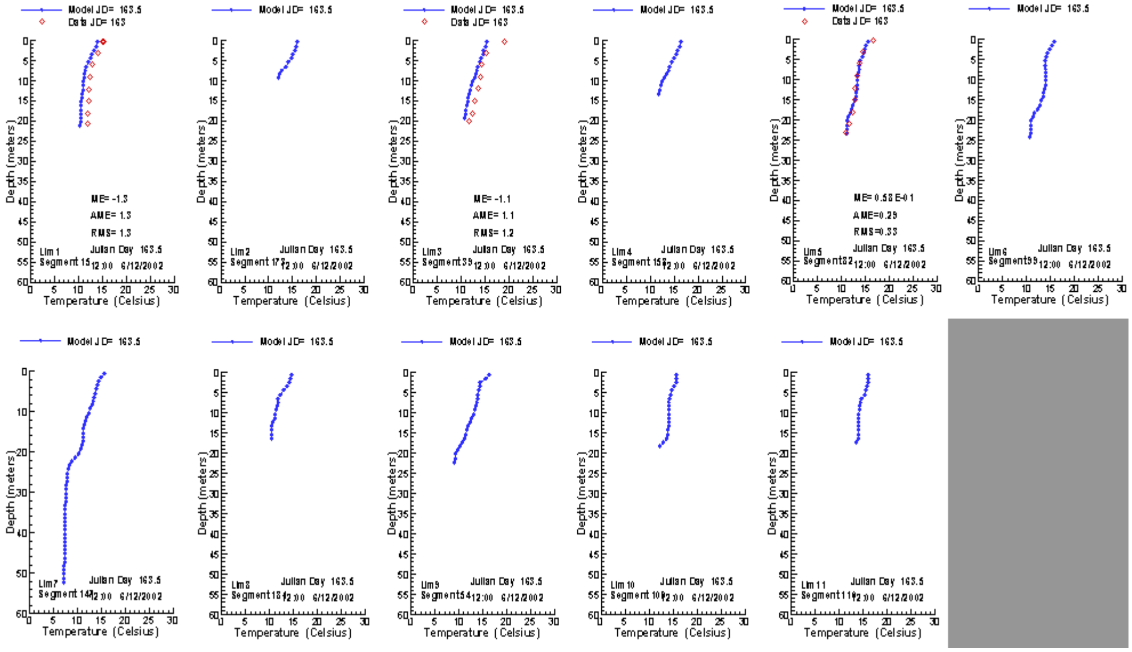
# Appendix B: Water Temperature Calibration Profiles



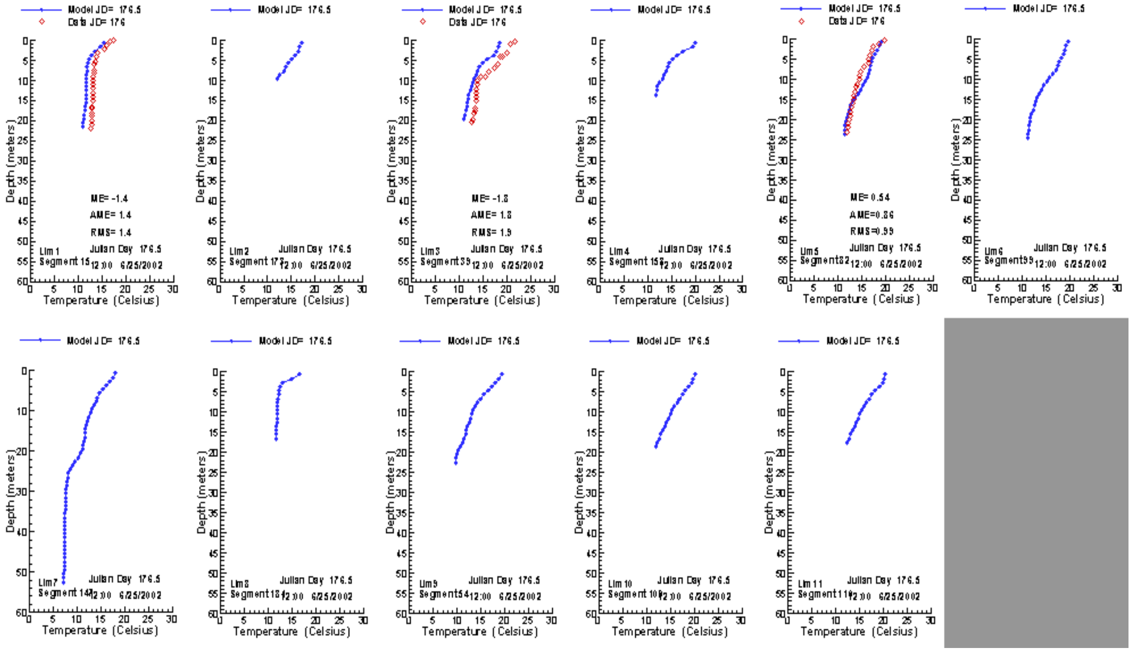



Model JD= 113.5
Data JD= 113
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -99.
AME=-99.
RMS=-99.
Lim 1
Segment 15
Julian Day 113.5
12:00 4/23/2002
Lim2
Segment 17
Lim3
Segment 39
Lim4
Segment 15
Lim5
Segment 82
ME= 2.9
AME= 2.9
RMS= 2.9
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

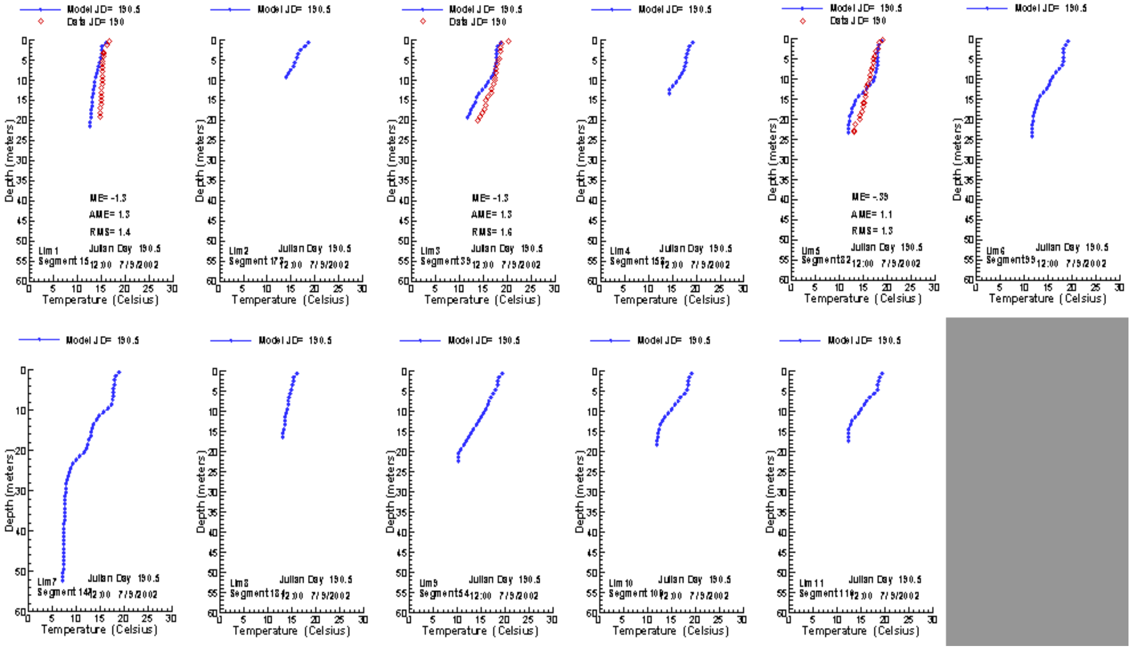

Model JD= 142.5
Data JD= 142
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60
Lim 1
Segment 15
ME= -1.2
AME= 1.2
RMS= 1.2
Julian Day 142.5
12:00 5/22/2002
Lim2
Segment 17
Lim3
Segment 39
ME= 0.45
AME=0.70
RMS=0.85
Lim4
Segment 15
Lim5
Segment 82
ME= 1.8
AME= 1.8
RMS= 1.9
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11



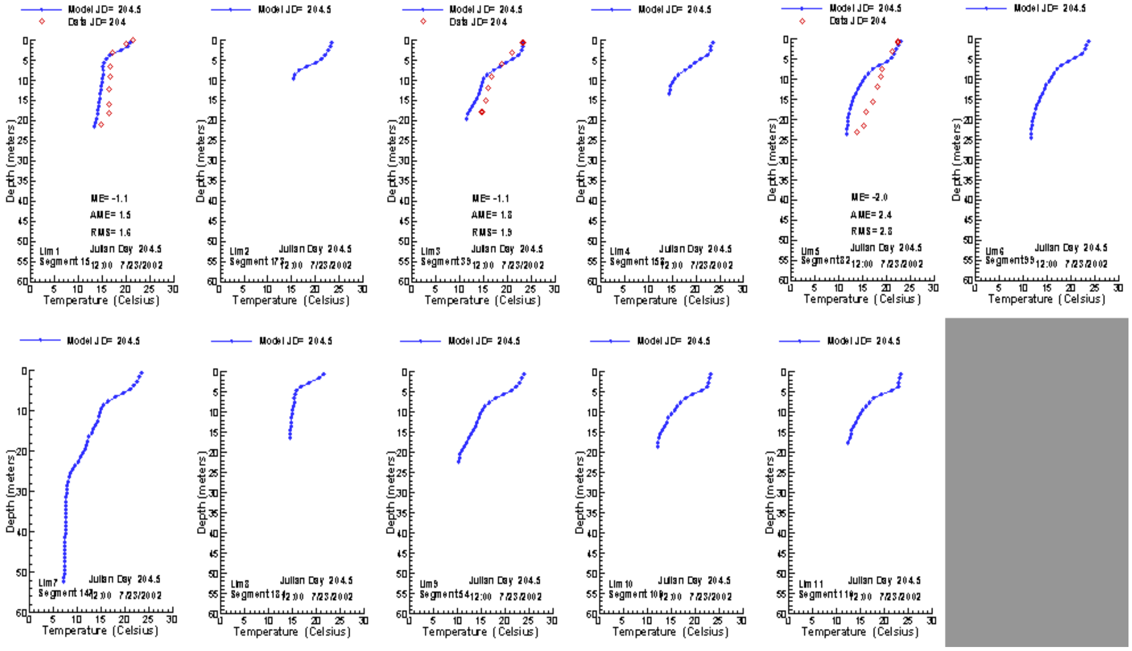
Model JD= 163.5
Data JD= 163
Depth (meters)
Temperature (Celsius)
ME= -1.3
AME= 1.3
RMS= 1.3
Lim1
Segment 15
Julian Day 163.5
12:00 6/12/2002
Lim2
Segment 17
Lim3
Segment 39
ME= -1.1
AME= 1.1
RMS= 1.2
Lim4
Segment 15
Lim5
Segment 32
ME= 0.58E-01
AME= 0.29
RMS= 0.33
Lim6
Segment 35
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11



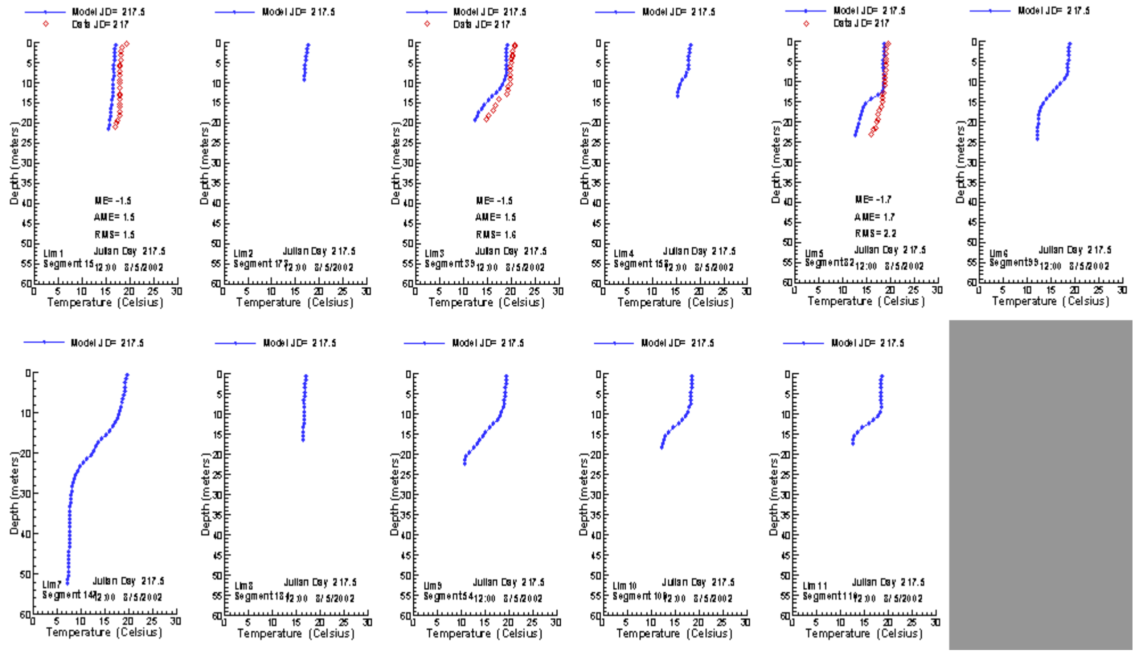
Model JD= 176.5
Data JD= 176
Depth (meters)
Temperature (Celsius)
ME= -1.4
AME= 1.4
RMS= 1.4
Lim1
Segment 15
Julian Day 176.5
12:00 6/25/2002
Lim2
Segment 17
Lim3
Segment 39
ME= -1.8
AME= 1.8
RMS= 1.9
Lim4
Segment 15
Lim5
Segment 32
ME= 0.54
AME= 0.86
RMS= 0.99
Lim6
Segment 35
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11



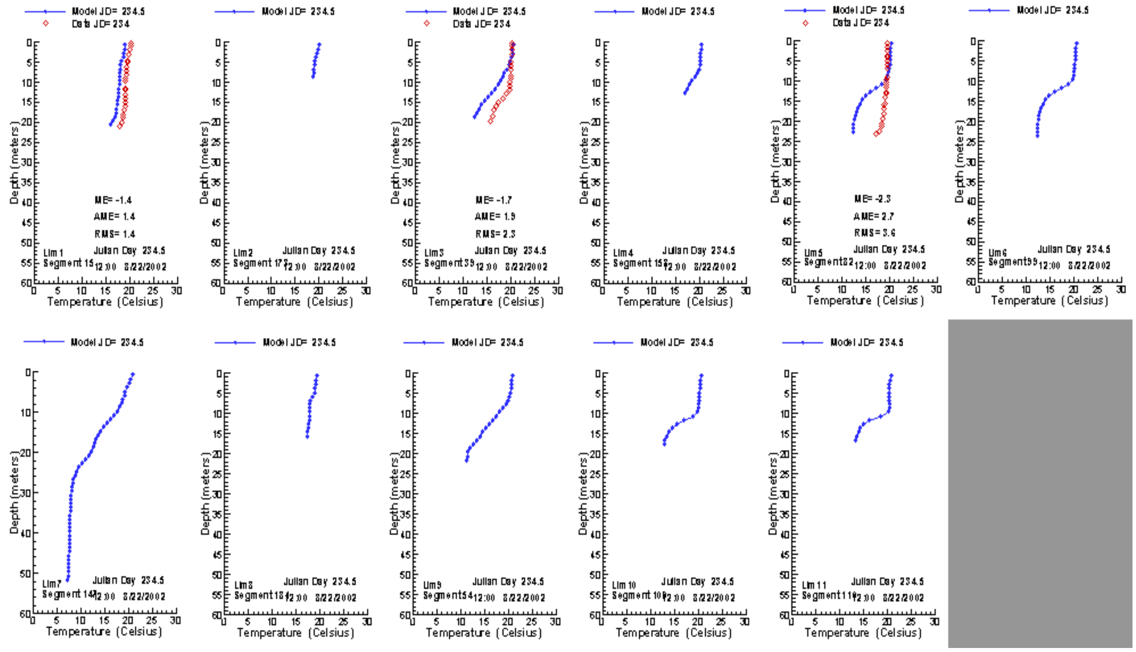
Model JD= 190.5
Data JD= 190
Depth (meters)
Temperature (Celsius)
ME= -1.3
AME= 1.3
RMS= 1.4
Lim1
Segment 15
Julian Day 190.5
12:00 7/9/2002
Lim2
Segment 17
Lim3
Segment39
ME= -1.3
AME= 1.3
RMS= 1.6
Lim4
Segment 15
Lim5
Segment82
ME= -.39
AME= 1.1
RMS= 1.3
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim10
Segment 10
Lim11
Segment11



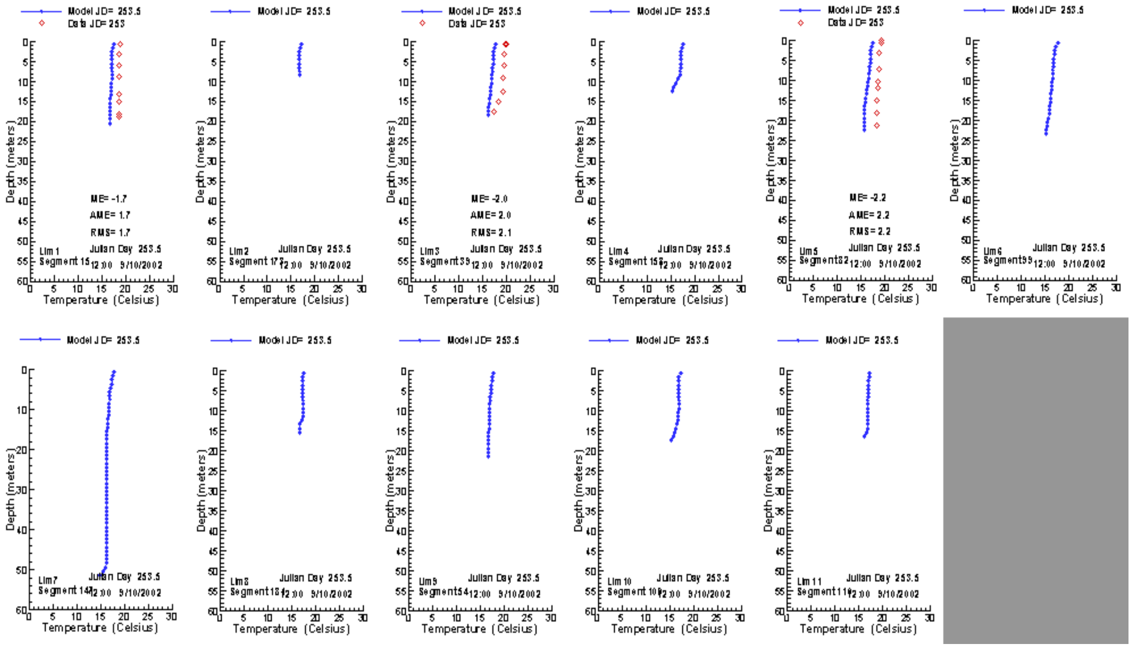
Model JD= 204.5
Data JD= 204
Depth (meters)
Temperature (Celsius)
ME= -1.1
AME= 1.5
RMS= 1.6
Lim1
Segment 15
Julian Day 204.5
12:00 7/23/2002
Lim2
Segment 17
Lim3
Segment39
ME= -1.1
AME= 1.8
RMS= 1.9
Lim4
Segment 15
Lim5
Segment82
ME= -2.0
AME= 2.4
RMS= 2.8
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim10
Segment 10
Lim11
Segment11

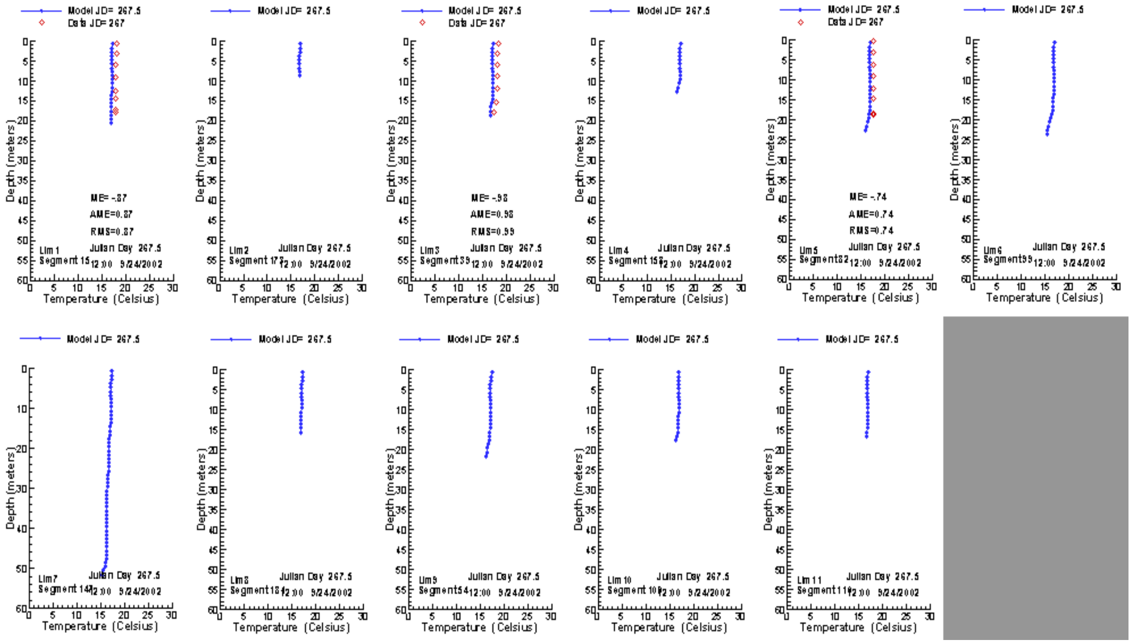


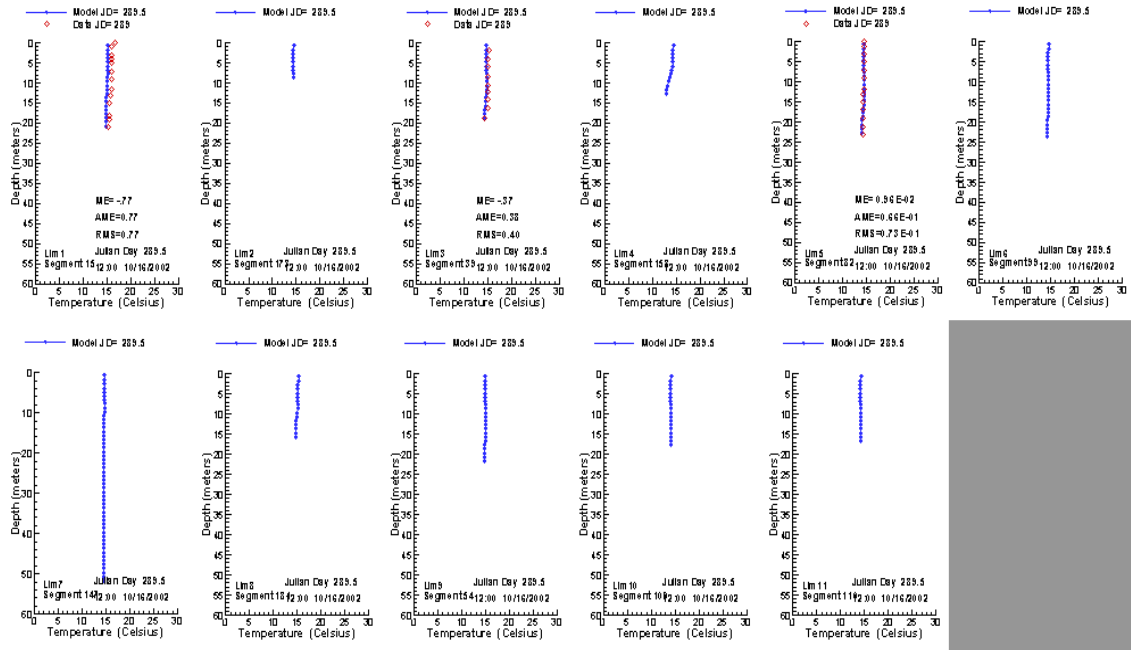
Model JD= 217.5
Data JD= 217
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
20
25
30
ME= -1.5
AME= 1.5
RMS= 1.5
Lim1
Segment 15
Julian Day 217.5
12:00 8/5/2002
Lim2
Segment 17
ME= -1.5
AME= 1.5
RMS= 1.6
Lim3
Segment39
Lim4
Segment 15
ME= -1.7
AME= 1.7
RMS= 2.2
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment11



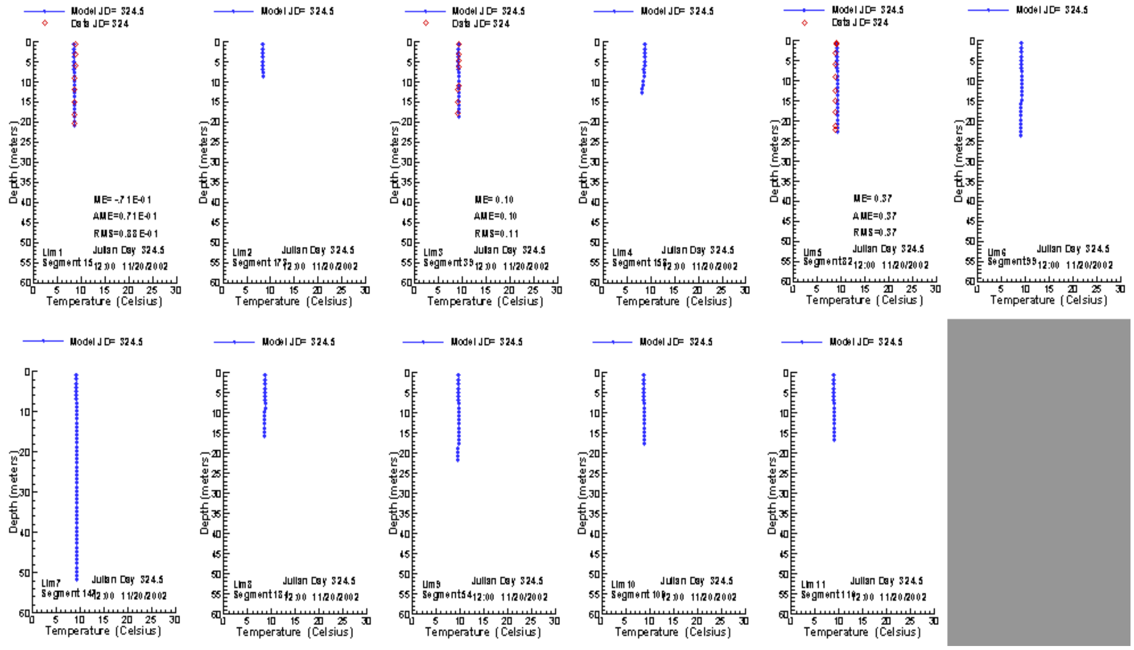
Model JD= 234.5
Data JD= 234
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
20
25
30
ME= -1.4
AME= 1.4
RMS= 1.4
Lim1
Segment 15
Julian Day 234.5
12:00 8/22/2002
Lim2
Segment 17
ME= -1.7
AME= 1.9
RMS= 2.3
Lim3
Segment39
Lim4
Segment 15
ME= -2.3
AME= 2.7
RMS= 3.6
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment11


Model JD= 253.5
Data JD= 253
Depth (meters)
Temperature (Celsius)
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 1
Segment 15
Julian Day 253.5
12:00 9/10/2002
Lim 2
Segment 17
ME= -2.0
AME= 2.0
RMS= 2.1
Lim3
Segment39
Lim4
Segment 15
ME= -2.2
AME= 2.2
RMS= 2.2
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11

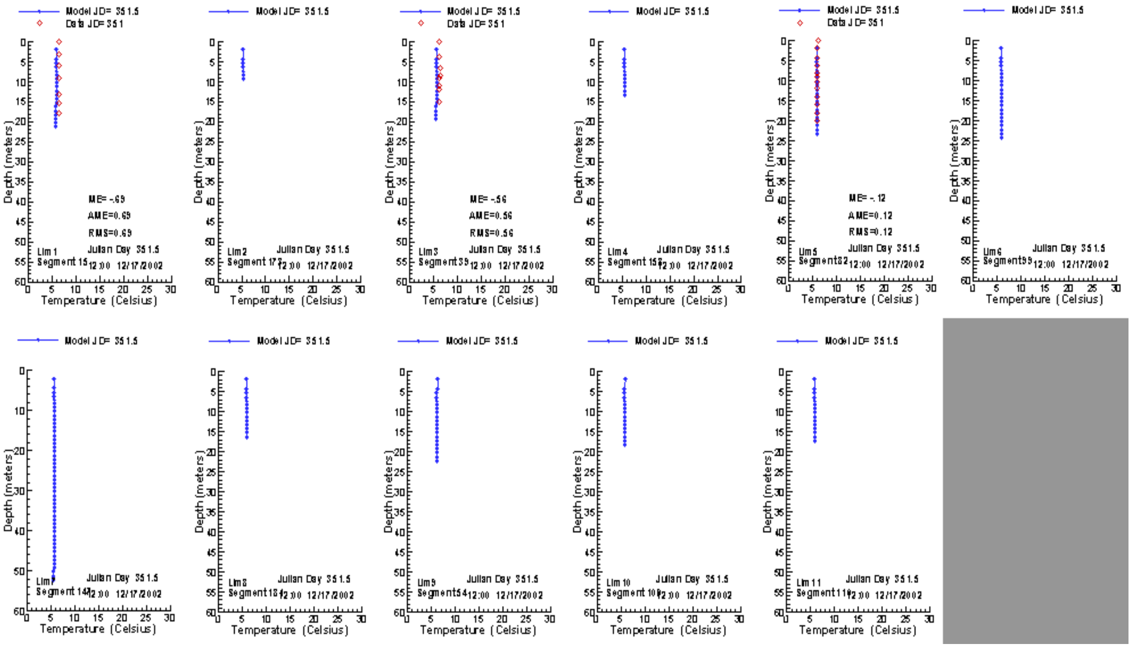

Model JD= 267.5
Data JD= 267
Depth (meters)
Temperature (Celsius)
ME= -.87
AME=0.87
RMS=0.87
Lim 1
Segment 15
Julian Day 267.5
12:00 9/24/2002
Lim 2
Segment 17
ME= -.98
AME=0.98
RMS=0.99
Lim3
Segment39
Lim4
Segment 15
ME= -.74
AME=0.74
RMS=0.74
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11



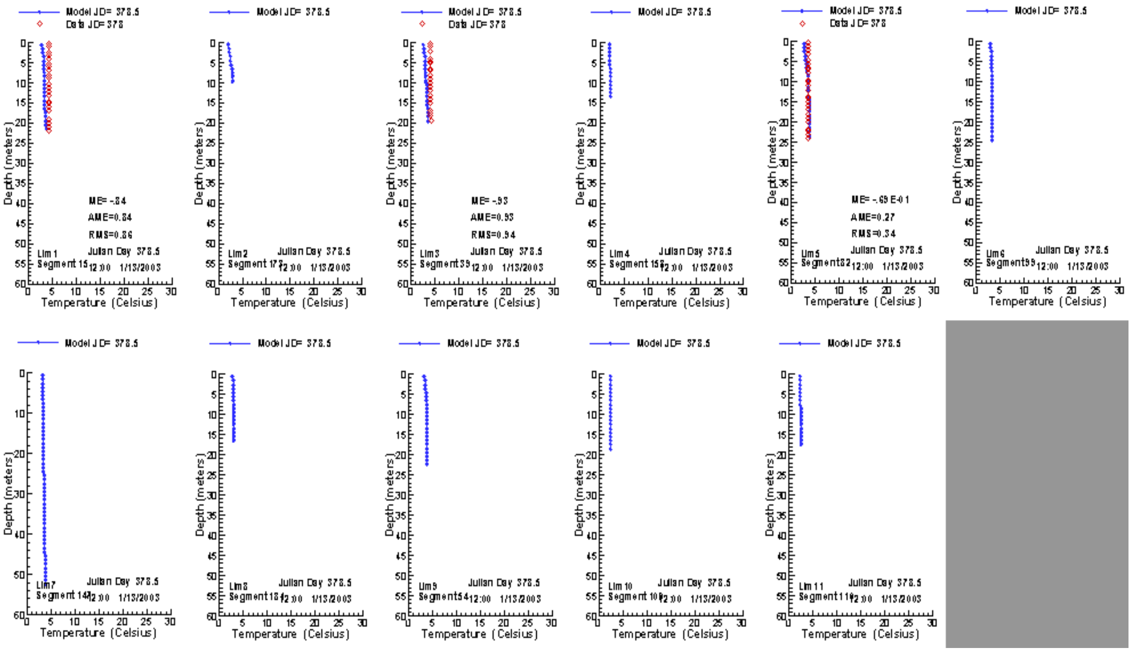
Model JD= 289.5
Data JD= 289
Depth (meters)
Temperature (Celsius)
ME= -.77
AME=0.77
RMS=0.77
Lim1
Segment 15
Julian Day 289.5
12:00 10/16/2002
Lim2
Segment 17
Lim3
Segment39
ME= -.37
AME=0.38
RMS=0.40
Lim4
Segment 15
Lim5
Segment82
ME= 0.96E-02
AME=0.66E-01
RMS=0.73E-01
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment11



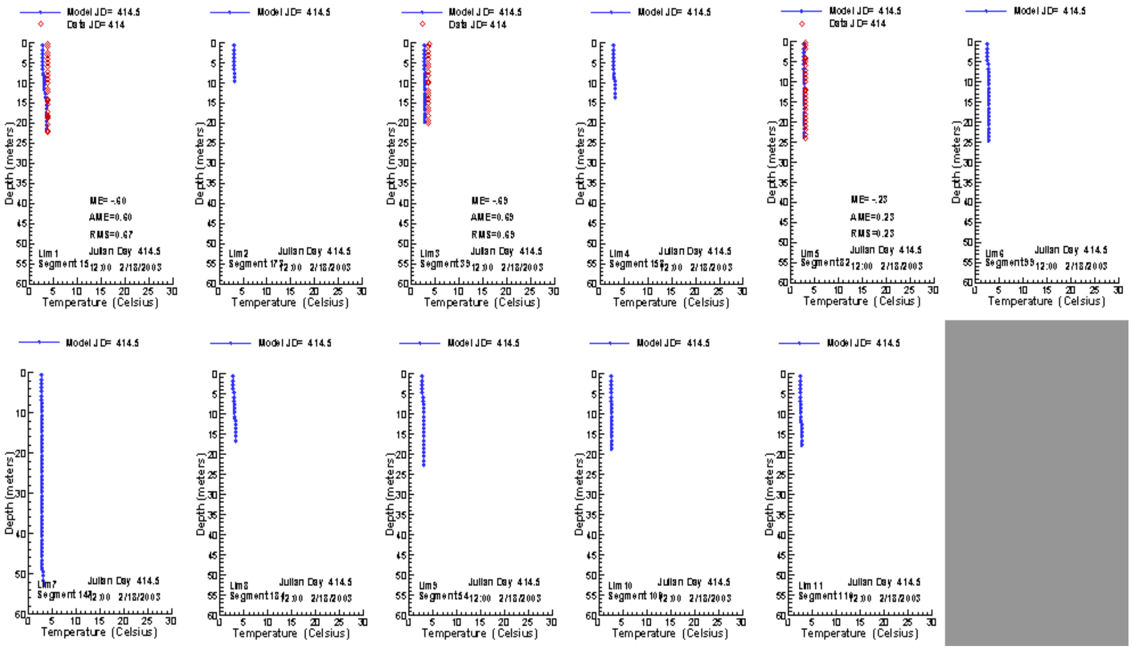
Model JD= 324.5
Data JD= 324
Depth (meters)
Temperature (Celsius)
ME= -.71E-01
AME=0.71E-01
RMS=0.88E-01
Lim1
Segment 15
Julian Day 324.5
12:00 11/20/2002
Lim2
Segment 17
Lim3
Segment39
ME= 0.10
AME=0.10
RMS=0.11
Lim4
Segment 15
Lim5
Segment82
ME= 0.37
AME=0.37
RMS=0.37
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment11

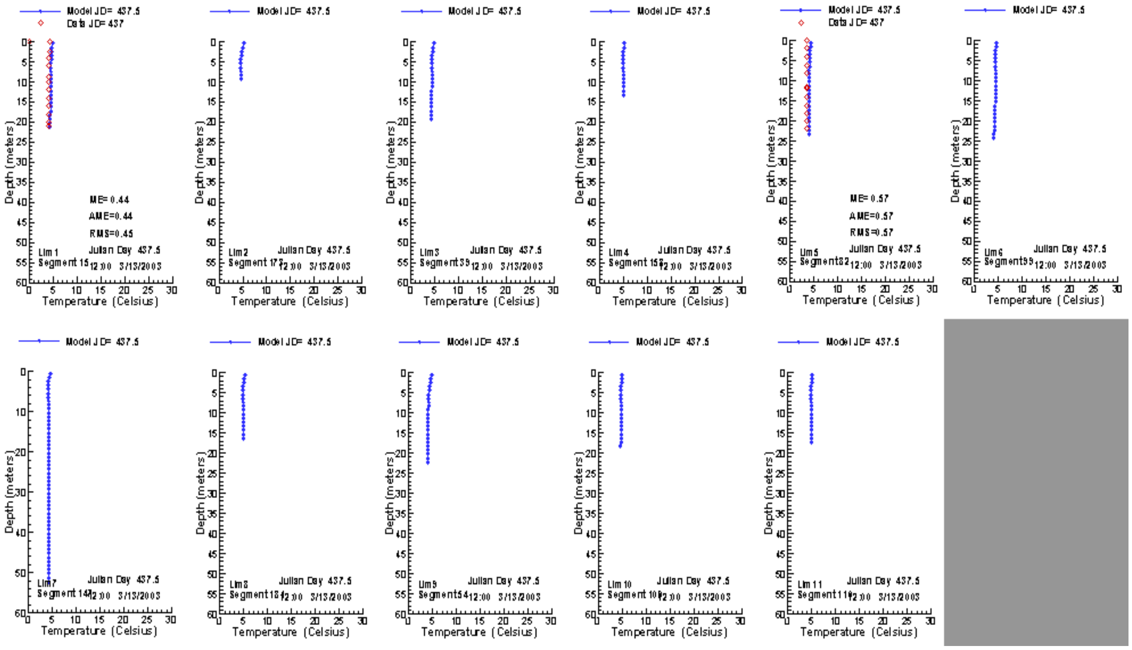


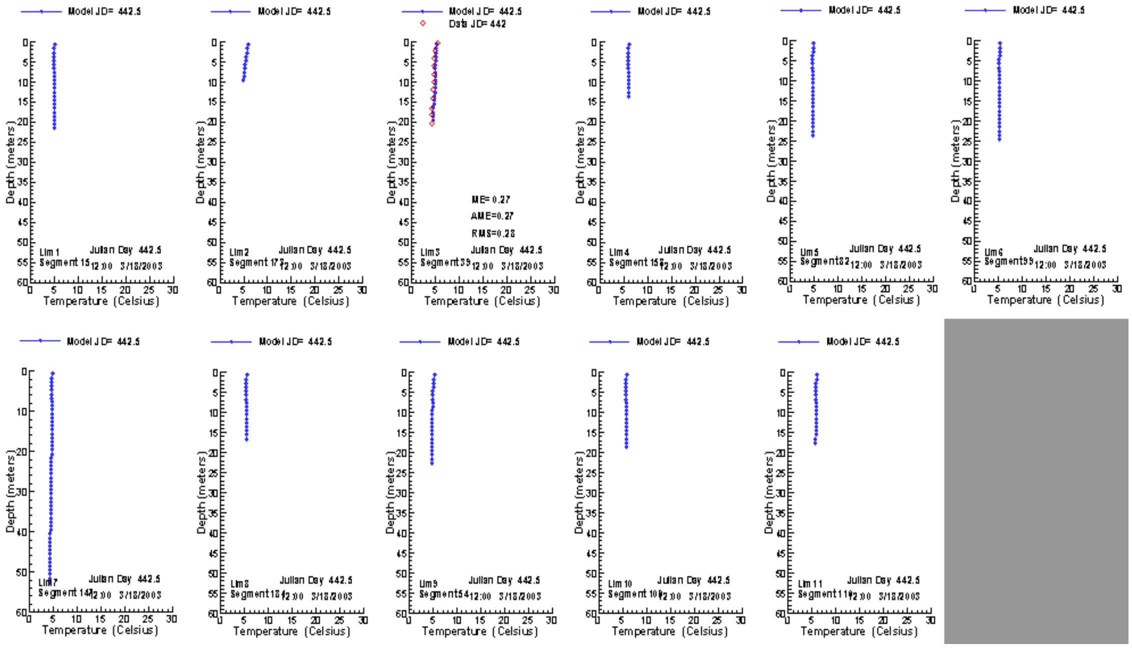
Model JD= 351.5
Data JD= 351
Depth (meters)
Temperature (Celsius)
ME= -.69
AME=0.69
RMS=0.69
Lim 1
Segment 15
Julian Day 351.5
12:00 12/17/2002
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.56
AME=0.56
RMS=0.56
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.12
AME=0.12
RMS=0.12
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11



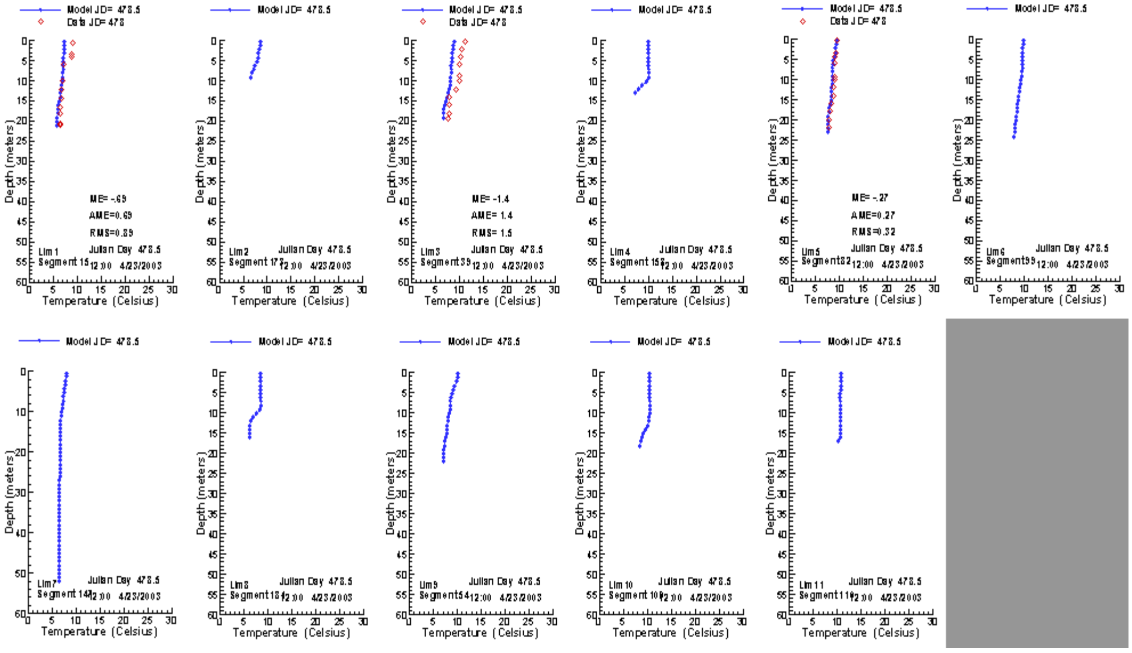
Model JD= 378.5
Data JD= 378
Depth (meters)
Temperature (Celsius)
ME= -.84
AME=0.84
RMS=0.86
Lim 1
Segment 15
Julian Day 378.5
12:00 1/13/2003
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.93
AME=0.93
RMS=0.94
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.69 E-01
AME=0.27
RMS=0.34
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11


Model JD= 414.5
Data JD= 414
Depth (meters)
Temperature (Celsius)
ME=-.60
AME=0.60
RMS=0.67
Lim1 Segment 15
Julian Day 414.5 12:00 2/18/2003
Lim2 Segment 17
ME=-.69
AME=0.69
RMS=0.69
Lim3 Segment39
Lim4 Segment 15
ME=-.23
AME=0.23
RMS=0.23
Lim5 Segment82
Lim6 Segment99
Lim7 Segment 14
Lim8 Segment18
Lim9 Segment54
Lim 10 Segment 10
Lim 11 Segment11

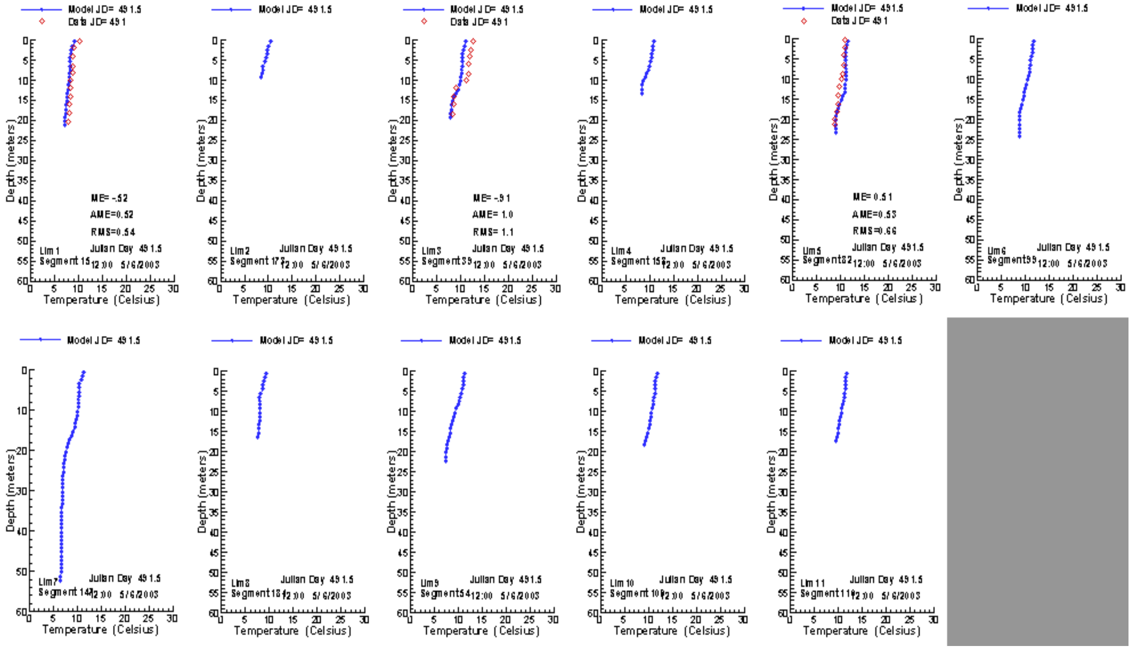

Model JD= 437.5
Data JD= 437
Depth (meters)
Temperature (Celsius)
ME=0.44
AME=0.44
RMS=0.45
Lim1 Segment 15
Julian Day 437.5 12:00 3/13/2003
Lim2 Segment 17
Lim3 Segment39
Lim4 Segment 15
ME=0.57
AME=0.57
RMS=0.57
Lim5 Segment82
Lim6 Segment99
Lim7 Segment 14
Lim8 Segment18
Lim9 Segment54
Lim 10 Segment 10
Lim 11 Segment11

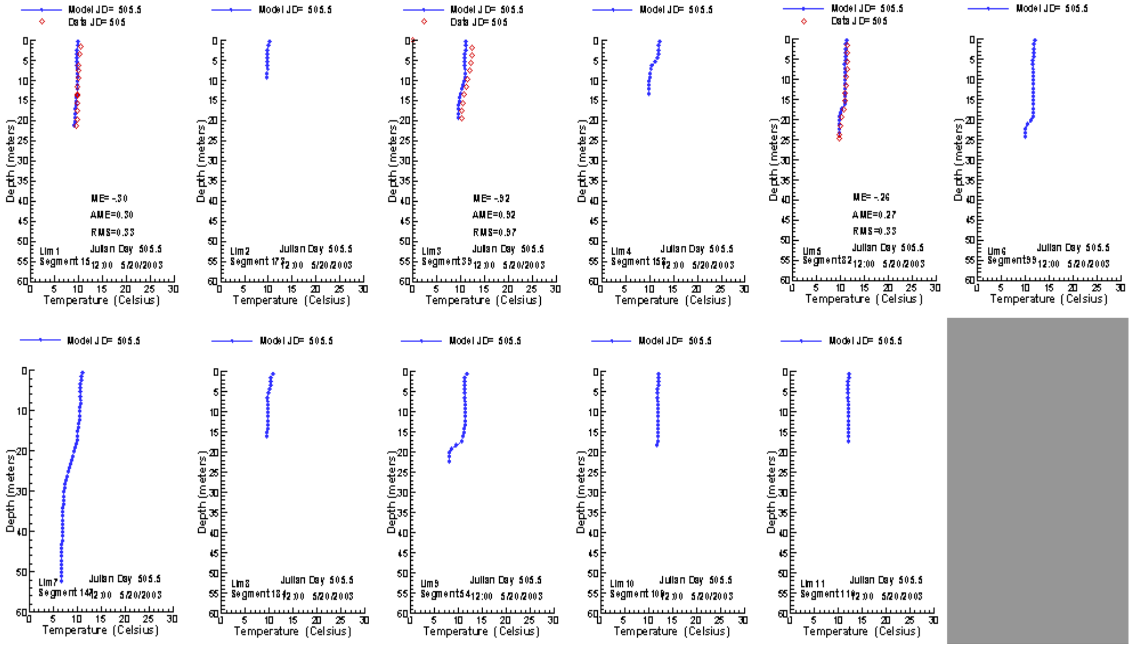


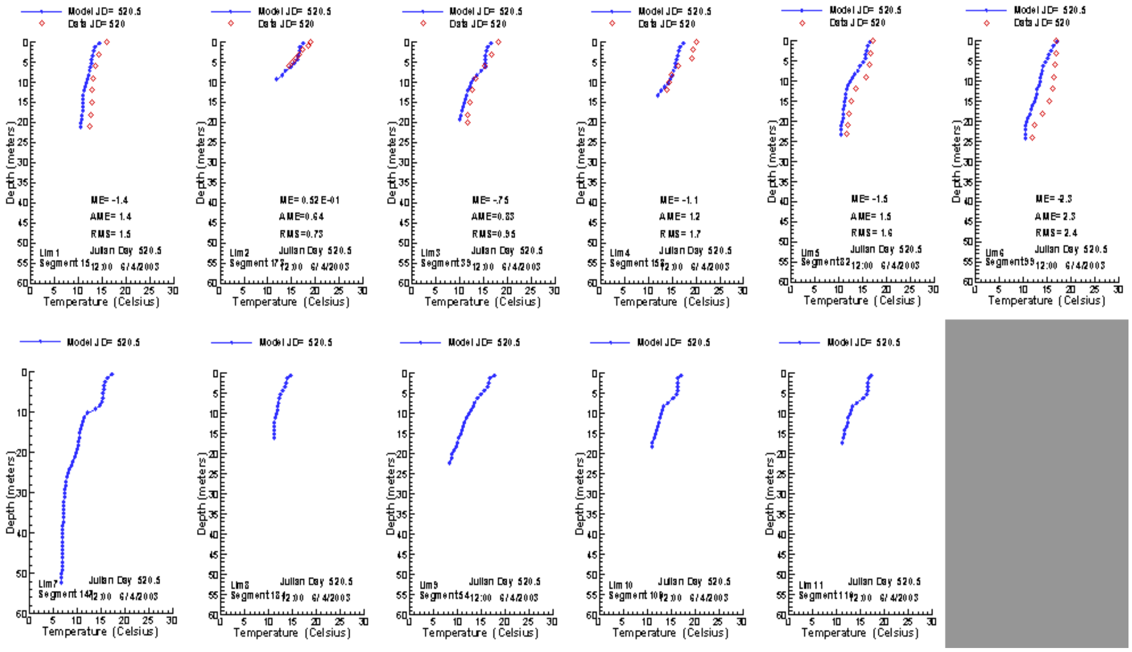
Model JD= 442.5
Data JD= 442
ME= 0.27
AME=0.27
RMS=0.28
Lim 1
Segment 15
Lim2
Segment 17
Lim3
Segment39
Lim4
Segment 15
Um5
Segment82
Um6
Segment99
Lim7
Segment 14
Lim8
Segment18
Um9
Segment54
Lim 10
Segment 10
Lim 11
Segment11
Julian Day 442.5
12:00 3/18/2003
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60

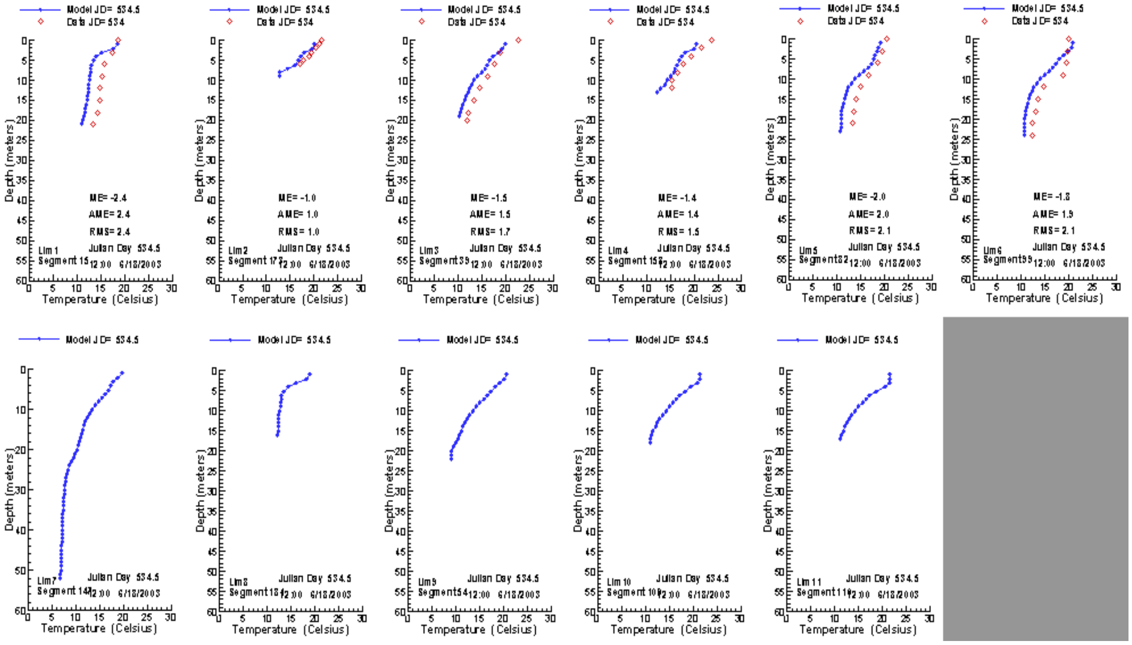


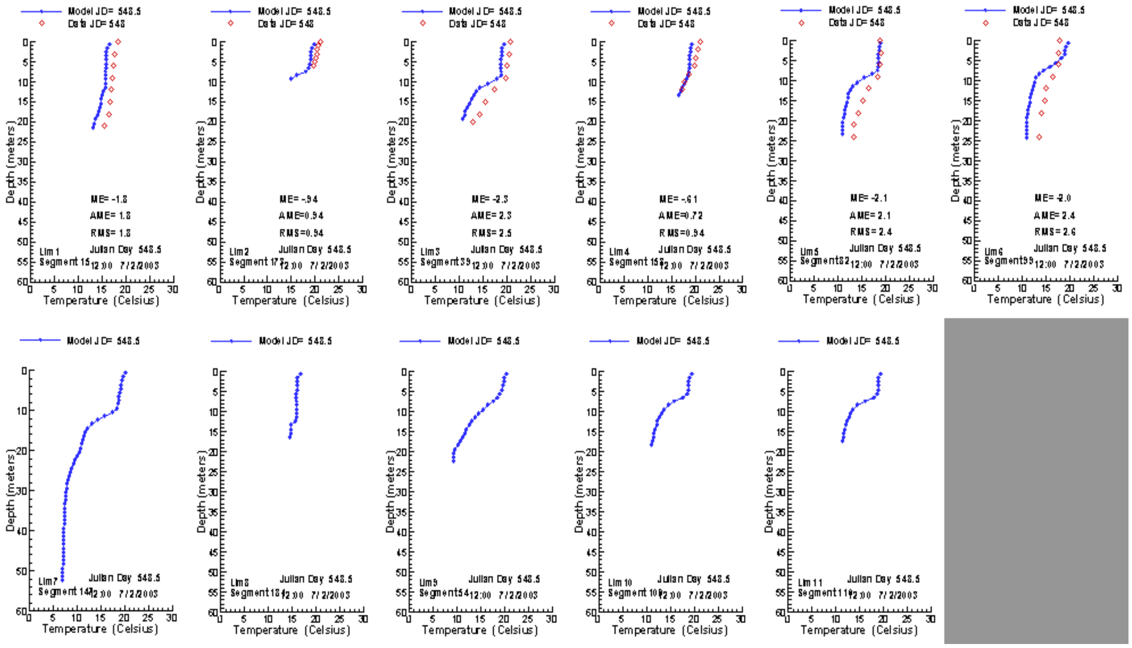
Model JD= 478.5
Data JD= 478
ME= -.69
AME=0.69
RMS=0.89
ME= -1.4
AME= 1.4
RMS= 1.5
ME= -.27
AME=0.27
RMS=0.32
Lim 1
Segment 15
Lim2
Segment 17
Lim3
Segment39
Lim4
Segment 15
Um5
Segment82
Um6
Segment99
Lim7
Segment 14
Lim8
Segment18
Um9
Segment54
Lim 10
Segment 10
Lim 11
Segment11
Julian Day 478.5
12:00 4/23/2003
Depth (meters)
Temperature (Celsius)
0
5
10
15
20
25
30
35
40
45
50
55
60

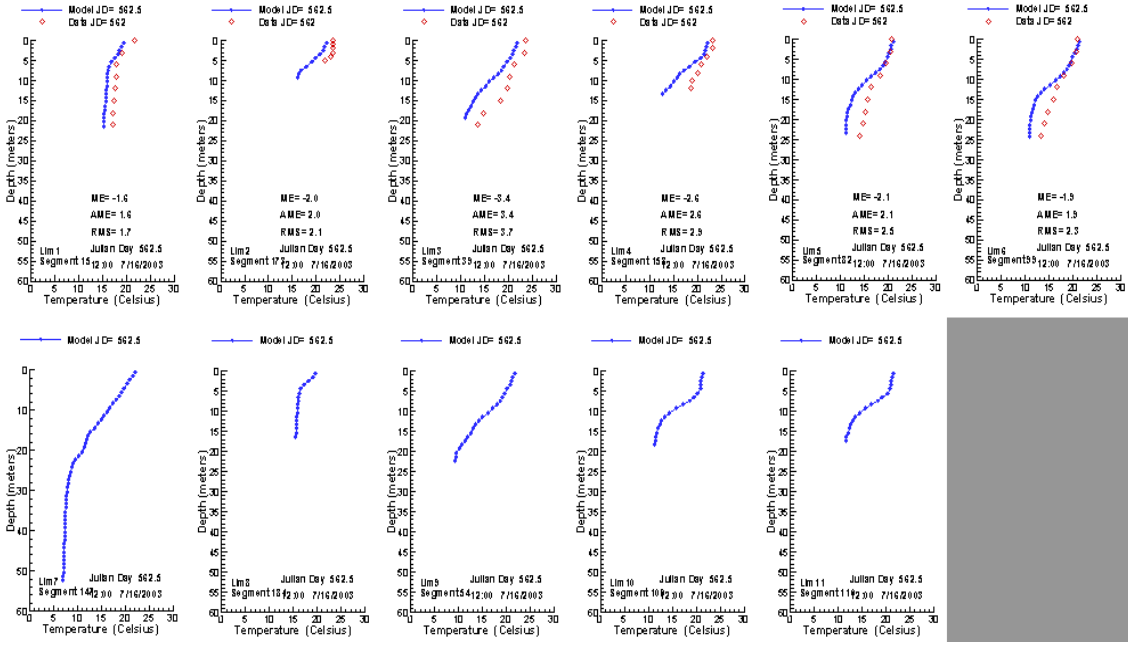

Model JD= 491.5
Data JD= 491
Depth (meters)
Temperature (Celsius)
ME=-.52
AME=0.52
RMS=0.54
Lim1 Segment 15
Julian Day 491.5
12:00 5/6/2003
Lim2 Segment 17
Lim3 Segment 33
ME=-.91
AME=1.0
RMS=1.1
Lim4 Segment 15
Lim5 Segment 32
ME=0.51
AME=0.53
RMS=0.66
Lim6 Segment 39
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11

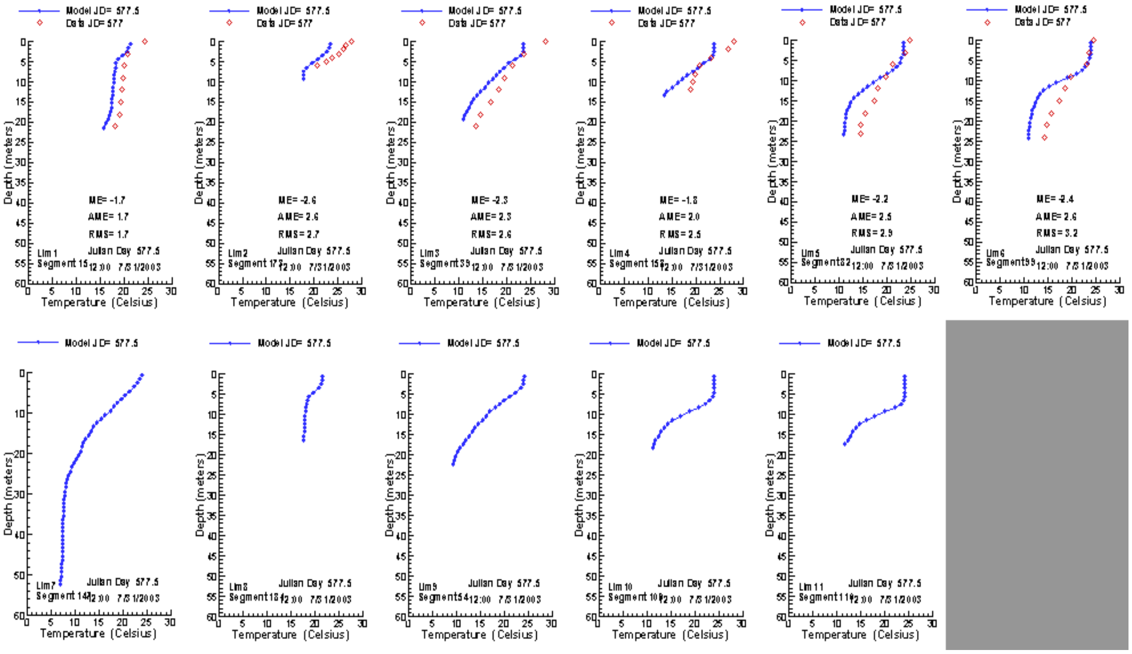

Model JD= 505.5
Data JD= 505
Depth (meters)
Temperature (Celsius)
ME=-.30
AME=0.30
RMS=0.33
Lim1 Segment 15
Julian Day 505.5
12:00 5/20/2003
Lim2 Segment 17
Lim3 Segment 33
ME=-.92
AME=0.92
RMS=0.97
Lim4 Segment 15
Lim5 Segment 32
ME=-.26
AME=0.27
RMS=0.33
Lim6 Segment 39
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11


Model JD= 520.5
Data JD= 520
Depth (meters)
Temperature (Celsius)
ME= -1.4
AME= 1.4
RMS= 1.5
Lim1
Segment 15
Julian Day 520.5
12:00 6/4/2003
ME= 0.52 E-01
AME=0.64
RMS=0.73
Lim2
Segment 173
ME= -.75
AME=0.83
RMS=0.95
Lim3
Segment39
ME= -1.1
AME= 1.2
RMS= 1.7
Lim4
Segment 158
ME= -1.5
AME= 1.5
RMS= 1.6
Lim5
Segment82
ME= -2.3
AME= 2.3
RMS= 2.4
Lim6
Segment99
Lim7
Segment 147
Lim8
Segment181
Lim9
Segment54
Lim 10
Segment 109
Lim 11
Segment119

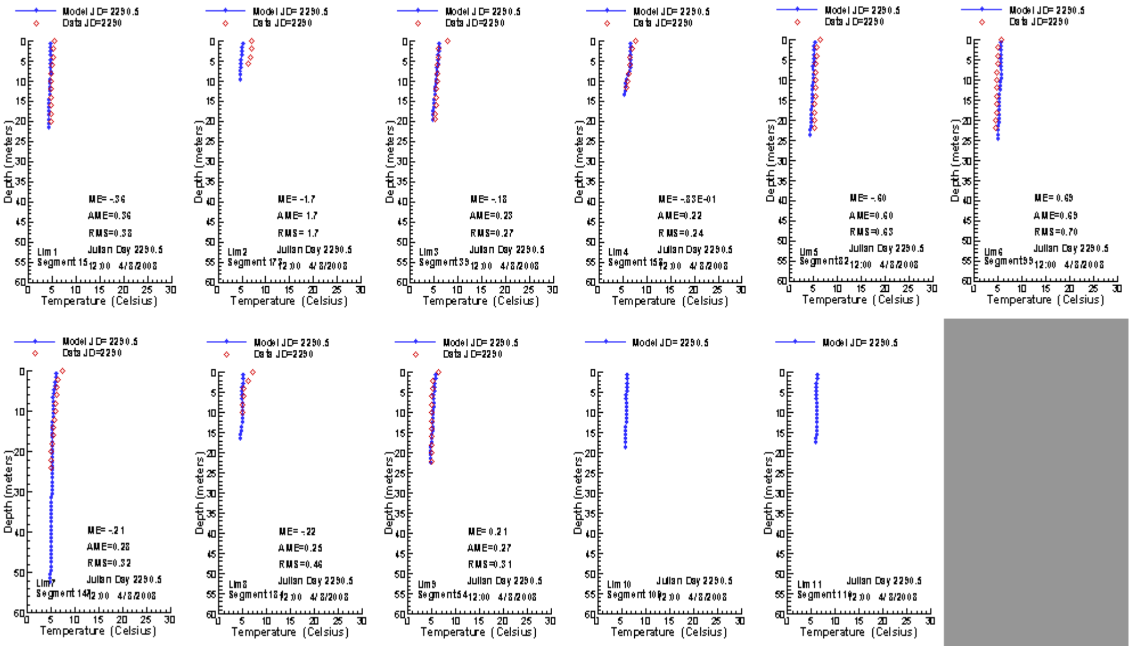

Model JD= 534.5
Data JD= 534
Depth (meters)
Temperature (Celsius)
ME= -2.4
AME= 2.4
RMS= 2.4
Lim1
Segment 15
Julian Day 534.5
12:00 6/18/2003
ME= -1.0
AME= 1.0
RMS= 1.0
Lim2
Segment 173
ME= -1.5
AME= 1.5
RMS= 1.7
Lim3
Segment39
ME= -1.4
AME= 1.4
RMS= 1.5
Lim4
Segment 158
ME= -2.0
AME= 2.0
RMS= 2.1
Lim5
Segment82
ME= -1.8
AME= 1.9
RMS= 2.1
Lim6
Segment99
Lim7
Segment 147
Lim8
Segment181
Lim9
Segment54
Lim 10
Segment 109
Lim 11
Segment119


Model JD= 548.5
Data JD= 548
Depth (meters)
Temperature (Celsius)
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 1
Segment 15
Julian Day 548.5
12:00 7/2/2003
ME= -.94
AME=0.94
RMS=0.94
Lim2
Segment 17
Julian Day 548.5
12:00 7/2/2003
ME= -2.3
AME= 2.3
RMS= 2.5
Lim3
Segment39
Julian Day 548.5
12:00 7/2/2003
ME= -.61
AME=0.72
RMS=0.94
Lim4
Segment 15
Julian Day 548.5
12:00 7/2/2003
ME= -2.1
AME= 2.1
RMS= 2.4
Lim5
Segment82
Julian Day 548.5
12:00 7/2/2003
ME= -2.0
AME= 2.4
RMS= 2.6
Lim6
Segment99
Julian Day 548.5
12:00 7/2/2003
Lim7
Segment 14
Julian Day 548.5
12:00 7/2/2003
Lim8
Segment18
Julian Day 548.5
12:00 7/2/2003
Lim9
Segment54
Julian Day 548.5
12:00 7/2/2003
Lim 10
Segment 10
Julian Day 548.5
12:00 7/2/2003
Lim 11
Segment11
Julian Day 548.5
12:00 7/2/2003

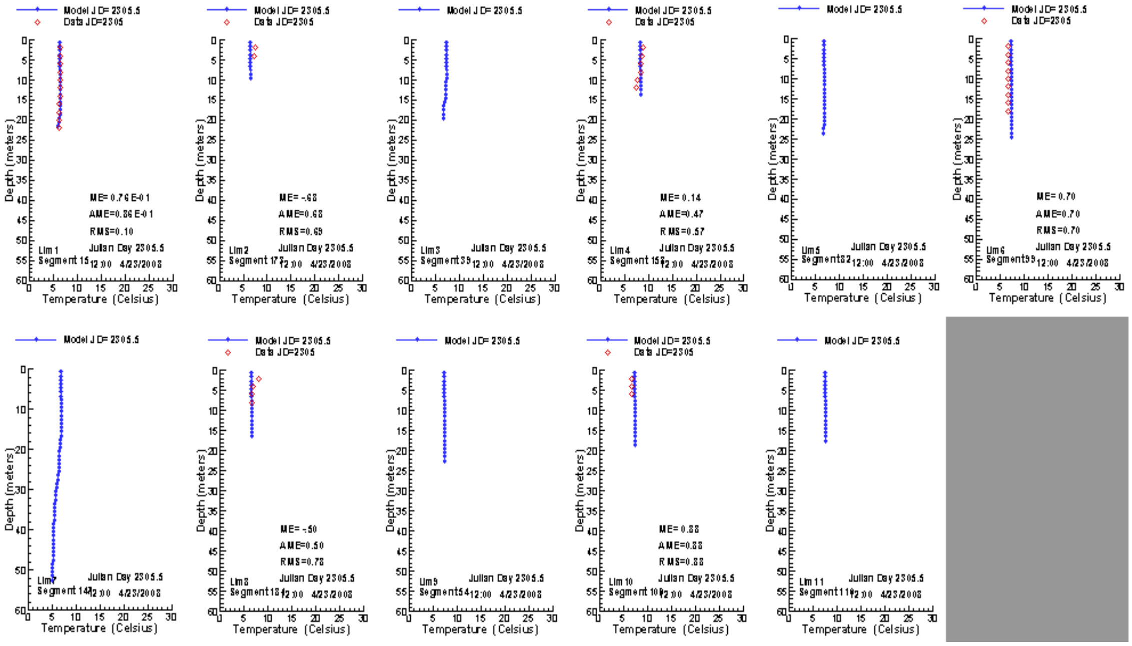

Model JD= 562.5
Data JD= 562
Depth (meters)
Temperature (Celsius)
ME= -1.6
AME= 1.6
RMS= 1.7
Lim1
Segment 15
Julian Day 562.5
12:00 7/16/2003
ME= -2.0
AME= 2.0
RMS= 2.1
Lim2
Segment 17
Julian Day 562.5
12:00 7/16/2003
ME= -3.4
AME= 3.4
RMS= 3.7
Lim3
Segment39
Julian Day 562.5
12:00 7/16/2003
ME= -2.6
AME= 2.6
RMS= 2.9
Lim4
Segment 15
Julian Day 562.5
12:00 7/16/2003
ME= -2.1
AME= 2.1
RMS= 2.5
Lim5
Segment82
Julian Day 562.5
12:00 7/16/2003
ME= -1.9
AME= 1.9
RMS= 2.3
Lim6
Segment99
Julian Day 562.5
12:00 7/16/2003
Lim7
Segment 14
Julian Day 562.5
12:00 7/16/2003
Lim8
Segment18
Julian Day 562.5
12:00 7/16/2003
Lim9
Segment54
Julian Day 562.5
12:00 7/16/2003
Lim 10
Segment 10
Julian Day 562.5
12:00 7/16/2003
Lim 11
Segment11
Julian Day 562.5
12:00 7/16/2003

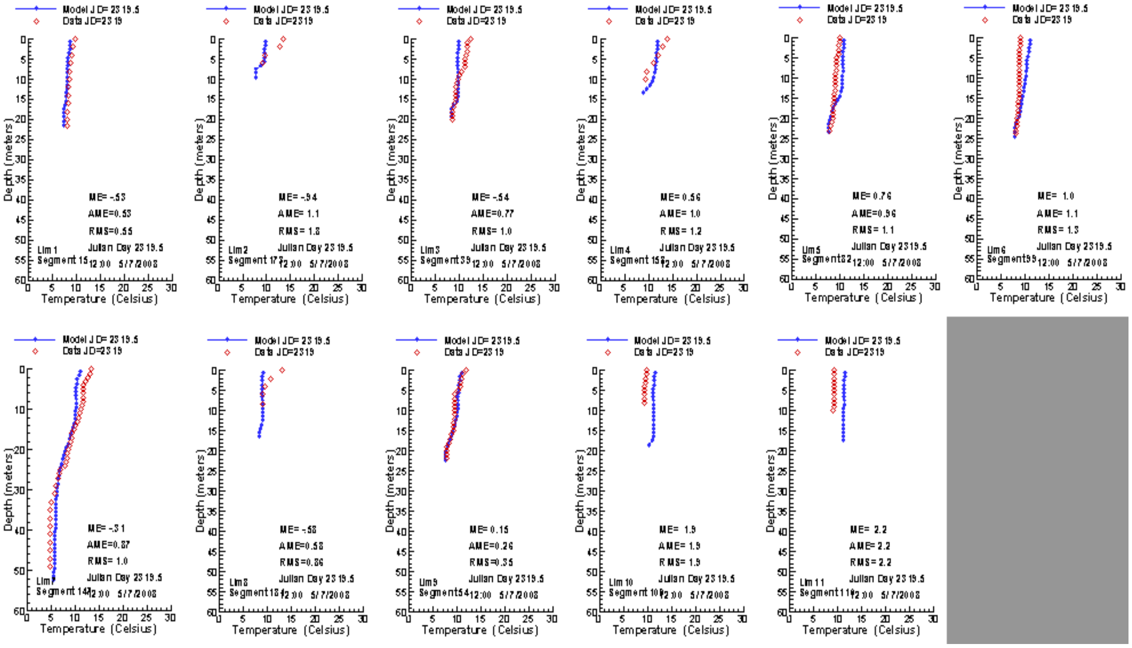


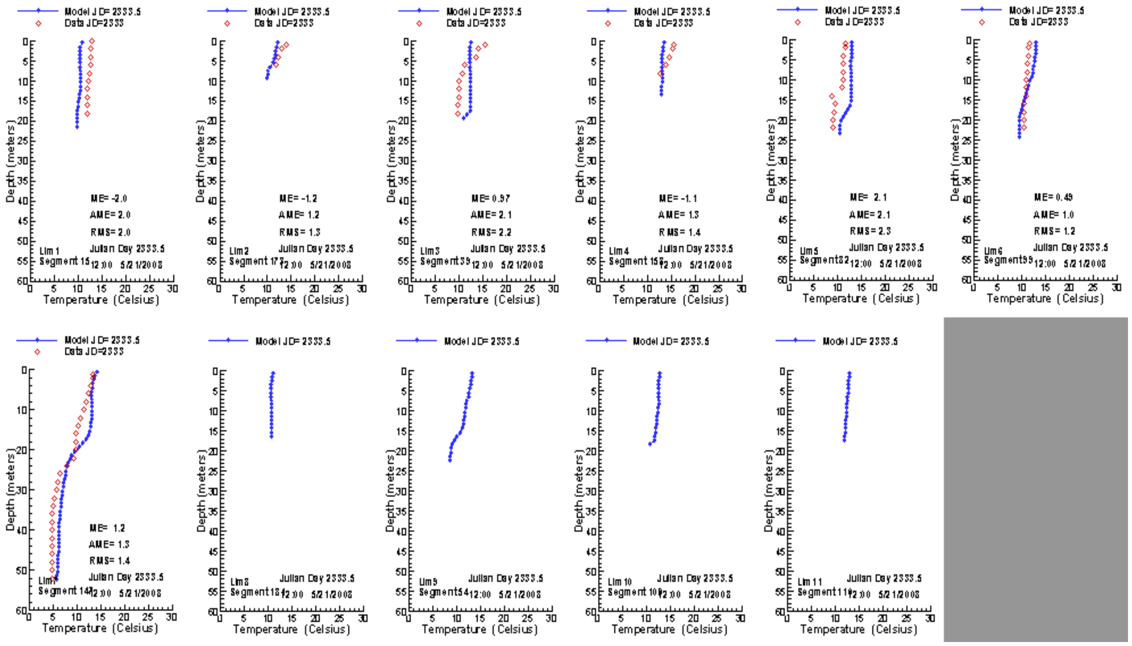
Model JD= 577.5
Data JD= 577
Depth (meters)
Temperature (Celsius)
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 1
Segment 15
Julian Day 577.5
12:00 7/31/2003
ME= -2.6
AME= 2.6
RMS= 2.7
Lim 2
Julian Day 577.5
12:00 7/31/2003
ME= -2.3
AME= 2.3
RMS= 2.6
Lim 3
Segment 39
Julian Day 577.5
12:00 7/31/2003
ME= -1.8
AME= 2.0
RMS= 2.5
Lim 4
Julian Day 577.5
12:00 7/31/2003
ME= -2.2
AME= 2.5
RMS= 2.9
Lim 5
Segment 82
Julian Day 577.5
12:00 7/31/2003
ME= -2.4
AME= 2.6
RMS= 3.2
Lim 6
Segment 99
Julian Day 577.5
12:00 7/31/2003
Lim 7
Lim 8
Lim 9
Segment 54
Lim 10
Lim 11



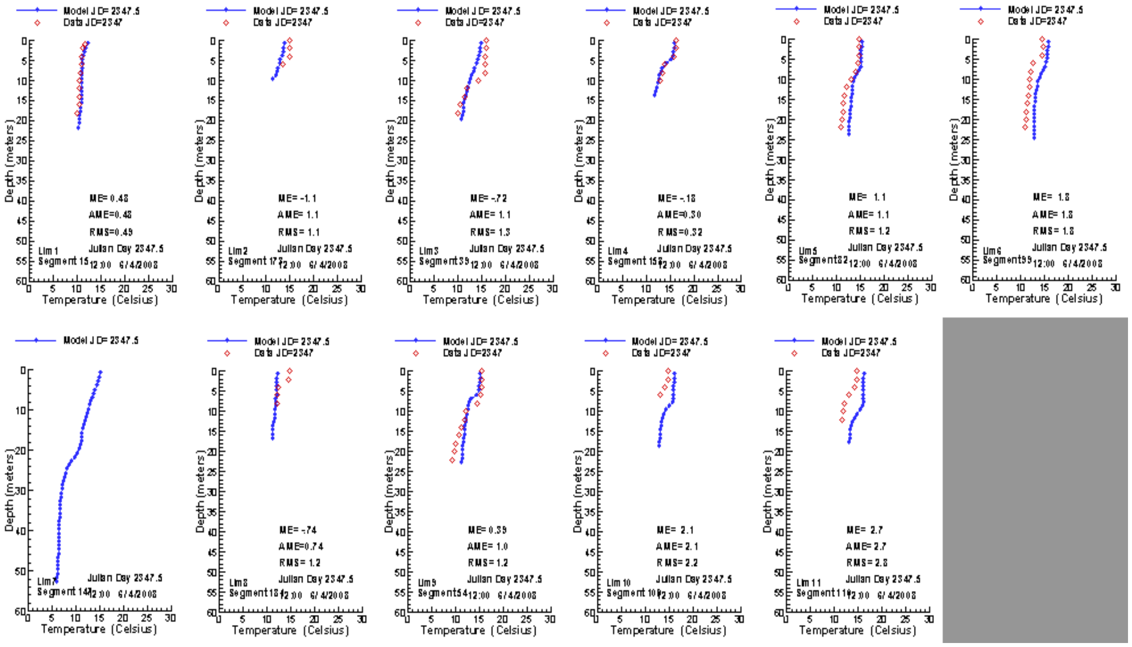
Model JD= 2290.5
Data JD=2290
Depth (meters)
Temperature (Celsius)
ME= -.36
AME=0.36
RMS=0.38
Lim 1
Segment 15
Julian Day 2290.5
12:00 4/8/2008
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 2
ME= -.18
AME=0.23
RMS=0.27
Lim 3
Segment 39
ME= -.83E-01
AME=0.22
RMS=0.24
Lim 4
ME= -.60
AME=0.60
RMS=0.63
Lim 5
Segment 82
ME= 0.69
AME=0.69
RMS=0.70
Lim 6
Segment 99
ME= -.21
AME=0.28
RMS=0.32
Lim 7
ME= -.22
AME=0.25
RMS=0.46
Lim 8
ME= 0.21
AME=0.27
RMS=0.31
Lim 9
Segment 54
Lim 10
Lim 11


Model JD= 2305.5
Data JD=2305
Depth (meters)
Temperature (Celsius)
ME= 0.76E-01
AME=0.86E-01
RMS=0.10
Lim 1
Segment 15
Julian Day 2305.5
12:00 4/23/2008
ME= -.68
AME=0.68
RMS=0.69
Lim 2
Segment 17
Julian Day 2305.5
12:00 4/23/2008
Lim 3
Segment 39
Julian Day 2305.5
12:00 4/23/2008
ME= 0.14
AME=0.47
RMS=0.57
Lim 4
Segment 15
Julian Day 2305.5
12:00 4/23/2008
Lim 5
Segment 82
Julian Day 2305.5
12:00 4/23/2008
ME= 0.70
AME=0.70
RMS=0.70
Lim 6
Segment 95
Julian Day 2305.5
12:00 4/23/2008
Lim 7
Segment 14
Julian Day 2305.5
12:00 4/23/2008
ME= -.50
AME=0.50
RMS=0.78
Lim 8
Segment 18
Julian Day 2305.5
12:00 4/23/2008
Lim 9
Segment 54
Julian Day 2305.5
12:00 4/23/2008
ME= 0.88
AME=0.88
RMS=0.88
Lim 10
Segment 10
Julian Day 2305.5
12:00 4/23/2008
Lim 11
Segment 11
Julian Day 2305.5
12:00 4/23/2008

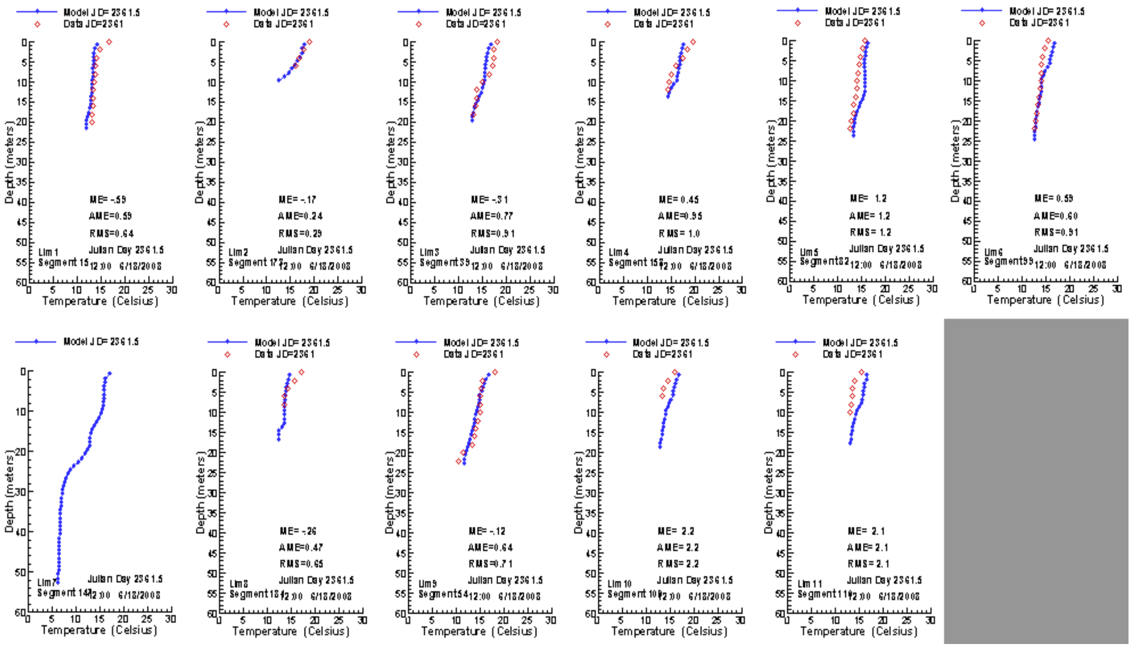

Model JD= 2319.5
Data JD=2319
Depth (meters)
Temperature (Celsius)
ME= -.53
AME=0.53
RMS=0.55
Lim 1
Segment 15
Julian Day 2319.5
12:00 5/7/2008
ME= -.94
AME= 1.1
RMS= 1.8
Lim 2
Segment 17
Julian Day 2319.5
12:00 5/7/2008
ME= -.54
AME=0.77
RMS= 1.0
Lim 3
Segment 39
Julian Day 2319.5
12:00 5/7/2008
ME= 0.56
AME= 1.0
RMS= 1.2
Lim 4
Segment 15
Julian Day 2319.5
12:00 5/7/2008
ME= 0.76
AME=0.96
RMS= 1.1
Lim 5
Segment 82
Julian Day 2319.5
12:00 5/7/2008
ME= 1.0
AME= 1.1
RMS= 1.3
Lim 6
Segment 95
Julian Day 2319.5
12:00 5/7/2008
ME= -.31
AME=0.87
RMS= 1.0
Lim 7
Segment 14
Julian Day 2319.5
12:00 5/7/2008
ME= -.58
AME=0.58
RMS=0.86
Lim 8
Segment 18
Julian Day 2319.5
12:00 5/7/2008
ME= 0.15
AME=0.26
RMS=0.35
Lim 9
Segment 54
Julian Day 2319.5
12:00 5/7/2008
ME= 1.9
AME= 1.9
RMS= 1.9
Lim 10
Segment 10
Julian Day 2319.5
12:00 5/7/2008
ME= 2.2
AME= 2.2
RMS= 2.2
Lim 11
Segment 11
Julian Day 2319.5
12:00 5/7/2008

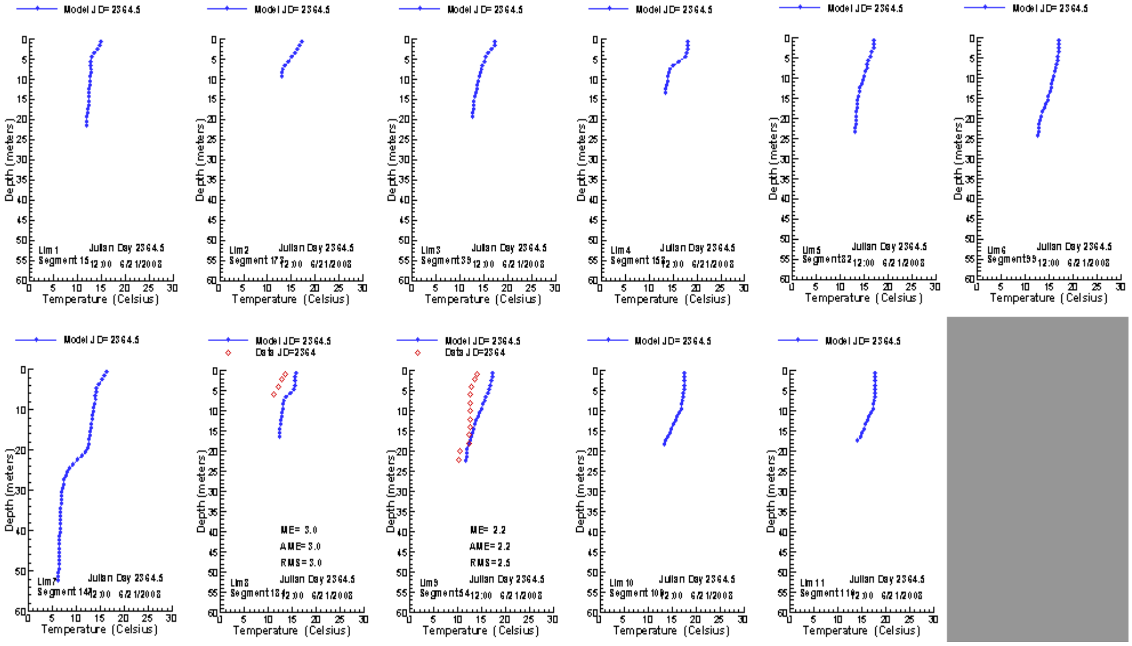


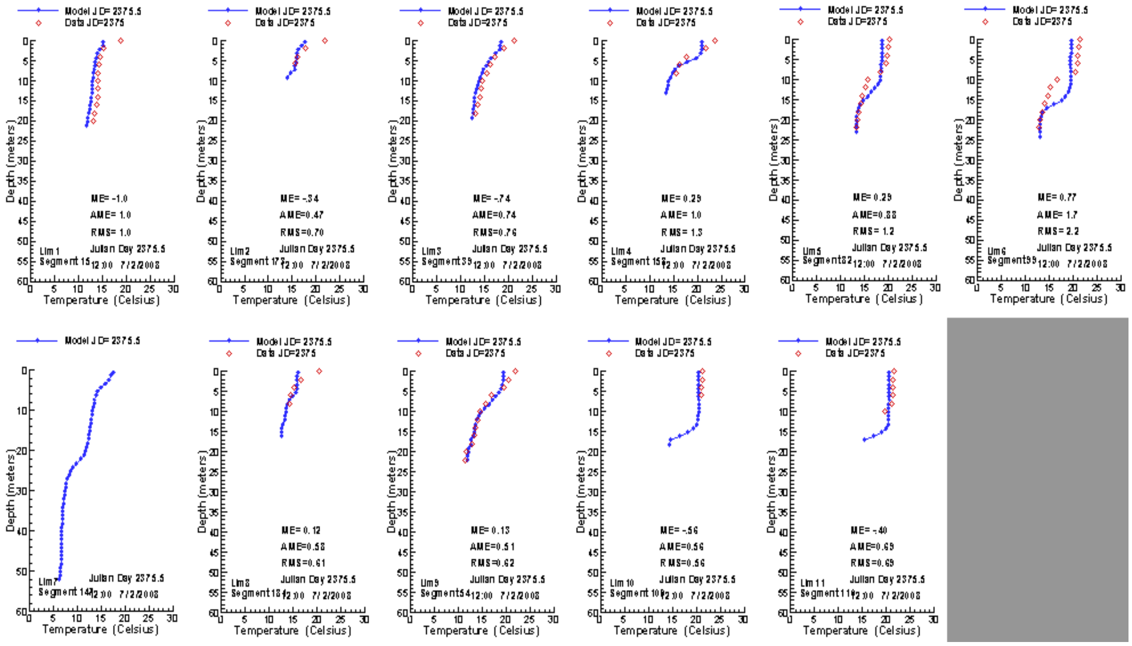
Model JD= 2333.5
Data JD=2333
Depth (meters)
Temperature (Celsius)
ME= -2.0
AME= 2.0
RMS= 2.0
Lim 1
Segment 15
Julian Day 2333.5
12:00 5/21/2008
ME= -1.2
AME= 1.2
RMS= 1.3
Lim2
Segment 17
Julian Day 2333.5
12:00 5/21/2008
ME= 0.97
AME= 2.1
RMS= 2.2
Lim3
Segment39
Julian Day 2333.5
12:00 5/21/2008
ME= -1.1
AME= 1.3
RMS= 1.4
Lim4
Segment 15
Julian Day 2333.5
12:00 5/21/2008
ME= 2.1
AME= 2.1
RMS= 2.3
Lim5
Segment82
Julian Day 2333.5
12:00 5/21/2008
ME= 0.49
AME= 1.0
RMS= 1.2
Lim6
Segment99
Julian Day 2333.5
12:00 5/21/2008
ME= 1.2
AME= 1.3
RMS= 1.4
Lim7
Segment 14
Julian Day 2333.5
12:00 5/21/2008
Lim8
Segment18
Julian Day 2333.5
12:00 5/21/2008
Lim9
Segment54
Julian Day 2333.5
12:00 5/21/2008
Lim 10
Segment 10
Julian Day 2333.5
12:00 5/21/2008
Lim 11
Segment 11
Julian Day 2333.5
12:00 5/21/2008

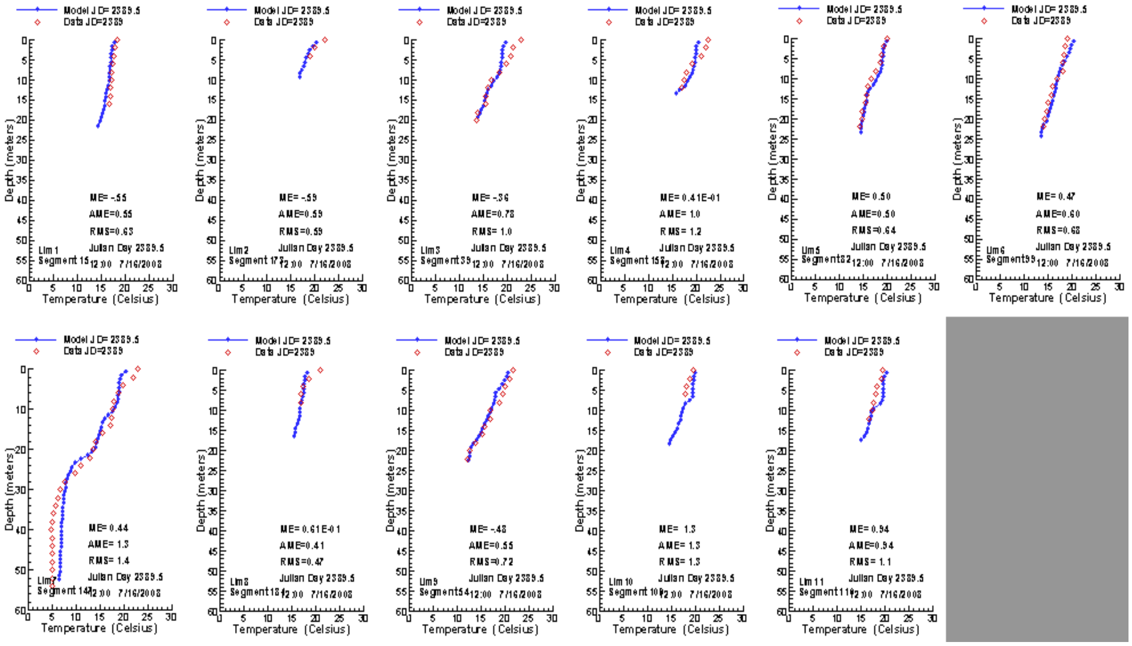


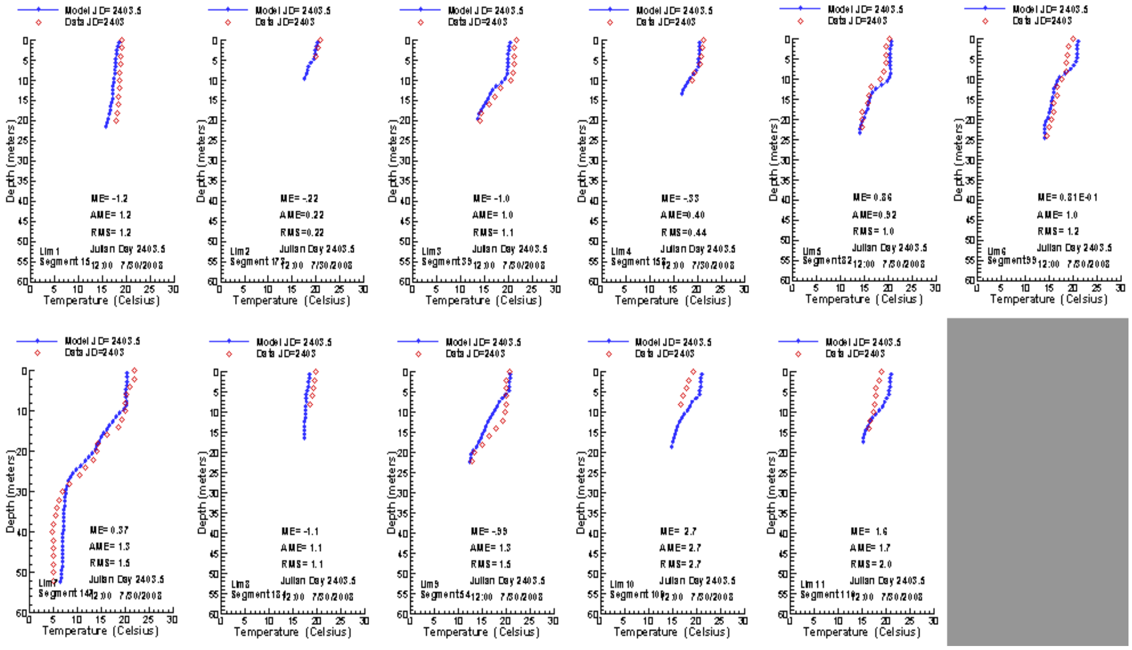
Model JD= 2347.5
Data JD=2347
Depth (meters)
Temperature (Celsius)
ME= 0.48
AME=0.48
RMS=0.49
Lim 1
Segment 15
Julian Day 2347.5
12:00 6/4/2008
ME= -1.1
AME= 1.1
RMS= 1.1
Lim2
Segment 17
Julian Day 2347.5
12:00 6/4/2008
ME= -.72
AME= 1.1
RMS= 1.3
Lim3
Segment39
Julian Day 2347.5
12:00 6/4/2008
ME= -.18
AME=0.30
RMS=0.32
Lim4
Segment 15
Julian Day 2347.5
12:00 6/4/2008
ME= 1.1
AME= 1.1
RMS= 1.2
Lim5
Segment82
Julian Day 2347.5
12:00 6/4/2008
ME= 1.8
AME= 1.8
RMS= 1.8
Lim6
Segment99
Julian Day 2347.5
12:00 6/4/2008
Lim7
Segment 14
Julian Day 2347.5
12:00 6/4/2008
ME= -.74
AME=0.74
RMS= 1.2
Lim8
Segment18
Julian Day 2347.5
12:00 6/4/2008
ME= 0.39
AME= 1.0
RMS= 1.2
Lim9
Segment54
Julian Day 2347.5
12:00 6/4/2008
ME= 2.1
AME= 2.1
RMS= 2.2
Lim 10
Segment 10
Julian Day 2347.5
12:00 6/4/2008
ME= 2.7
AME= 2.7
RMS= 2.8
Lim 11
Segment 11
Julian Day 2347.5
12:00 6/4/2008

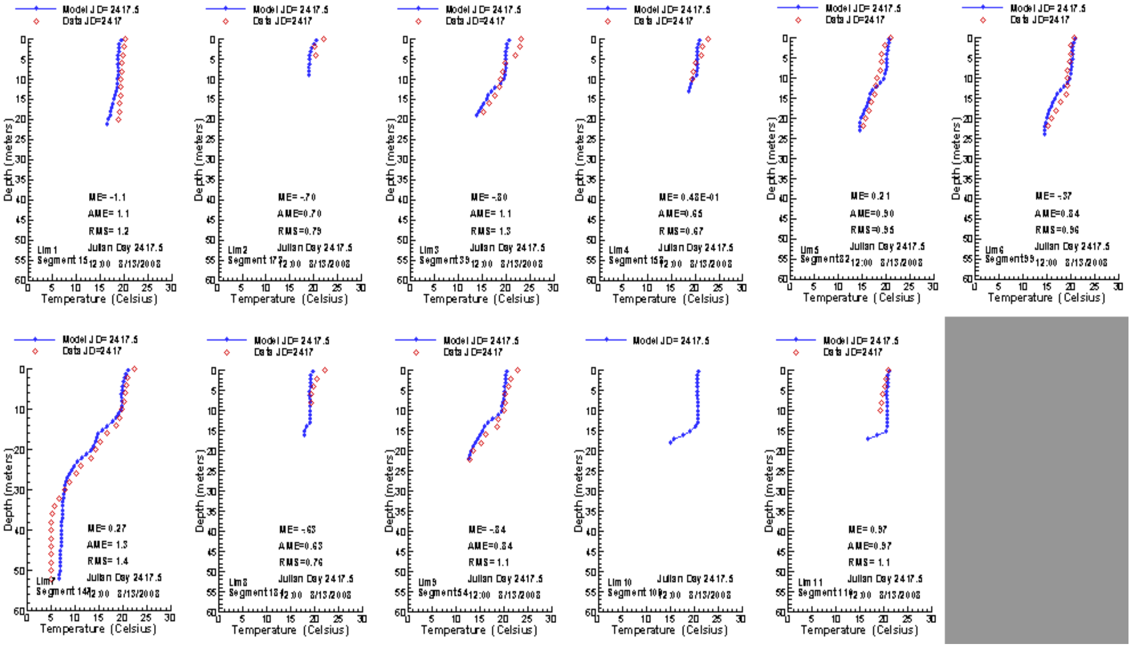

Model JD= 2361.5
Data JD=2361
Depth (meters)
Temperature (Celsius)
ME= -.59
AME=0.59
RMS=0.64
Lim 1
Segment 15
Julian Day 2361.5
12:00 6/18/2008
ME= -.17
AME=0.24
RMS=0.29
Lim 2
Segment 17
ME= -.31
AME=0.77
RMS=0.91
Lim 3
Segment 39
ME= 0.45
AME=0.95
RMS= 1.0
Lim 4
Segment 15
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 5
Segment 82
ME= 0.59
AME=0.60
RMS=0.91
Lim 6
Segment 99
Lim 7
Segment 14
ME= -.26
AME=0.47
RMS=0.65
Lim 8
Segment 18
ME= -.12
AME=0.64
RMS=0.71
Lim 9
Segment 54
ME= 2.2
AME= 2.2
RMS= 2.2
Lim 10
Segment 10
ME= 2.1
AME= 2.1
RMS= 2.1
Lim 11
Segment 11

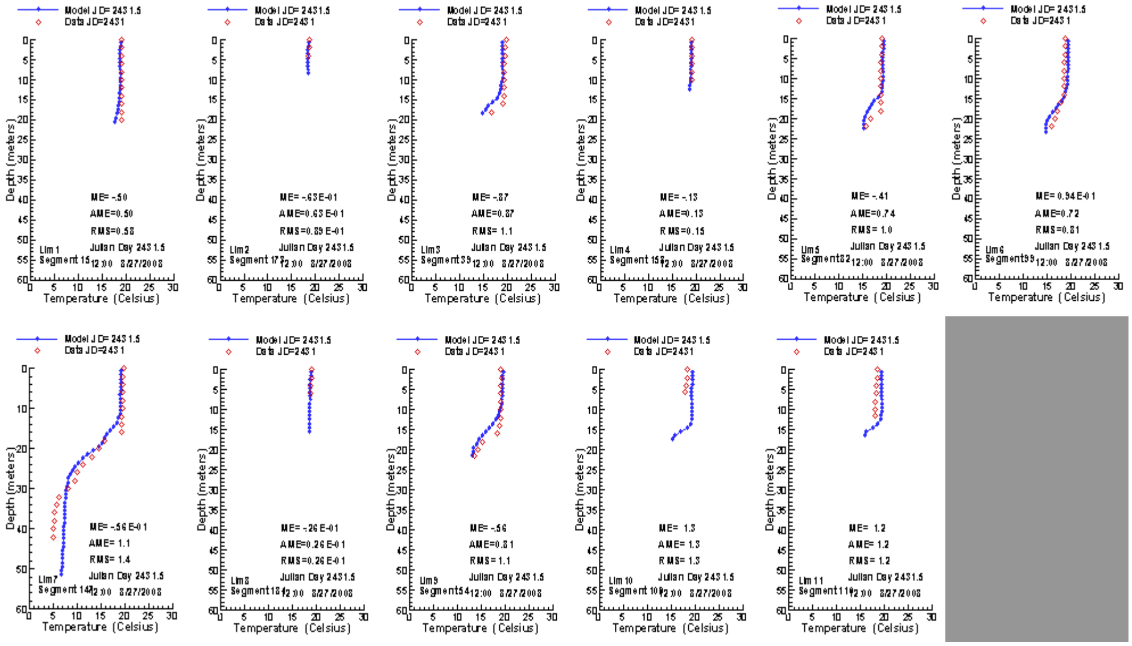

Model JD= 2364.5
Data JD=2364
Depth (meters)
Temperature (Celsius)
Lim 1
Segment 15
Julian Day 2364.5
12:00 6/21/2008
Lim 2
Segment 17
Lim 3
Segment 39
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
ME= 3.0
AME= 3.0
RMS= 3.0
Lim 8
Segment 18
ME= 2.2
AME= 2.2
RMS= 2.5
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

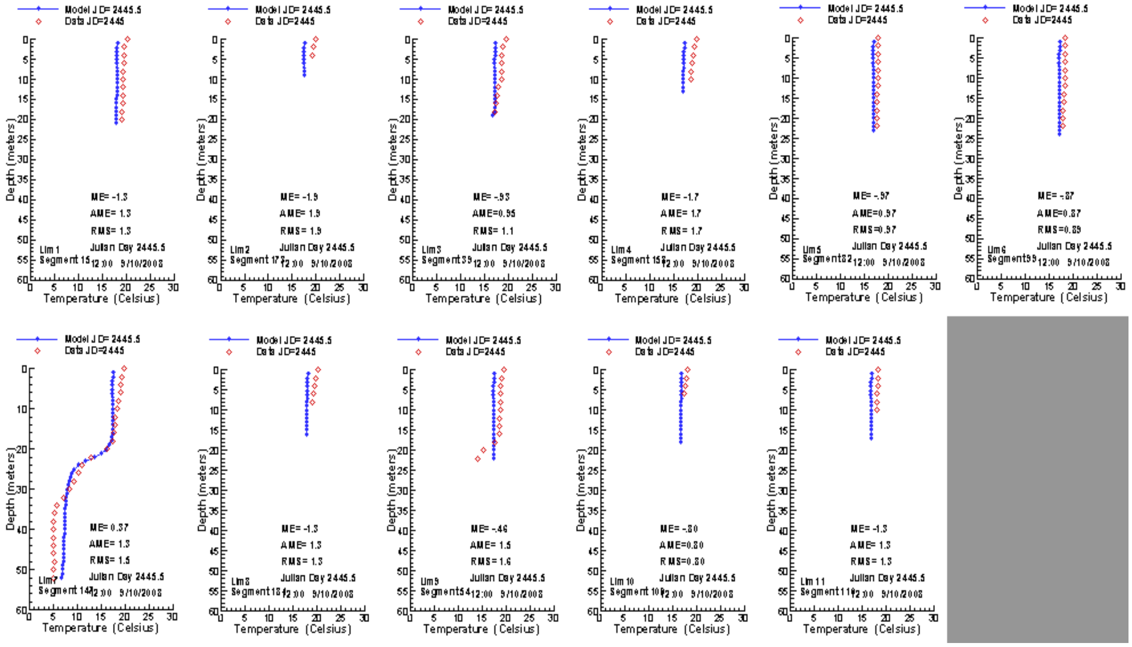

Model JD= 2375.5
Data JD=2375
Depth (meters)
Temperature (Celsius)
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 1
Segment 15
Julian Day 2375.5
12:00 7/2/2008
ME= -.34
AME=0.47
RMS=0.70
Lim 2
Segment 17
ME= -.74
AME=0.74
RMS=0.76
Lim 3
Segment 39
ME= 0.29
AME= 1.0
RMS= 1.3
Lim 4
Segment 15
ME= 0.29
AME=0.88
RMS= 1.2
Lim 5
Segment 82
ME= 0.77
AME= 1.7
RMS= 2.2
Lim 6
Segment 99
Lim 7
Segment 14
ME= 0.12
AME=0.58
RMS=0.61
Lim 8
Segment 18
ME= 0.13
AME=0.51
RMS=0.62
Lim 9
Segment 54
ME= -.56
AME=0.56
RMS=0.56
Lim 10
Segment 10
ME= -.40
AME=0.69
RMS=0.69
Lim 11
Segment 11

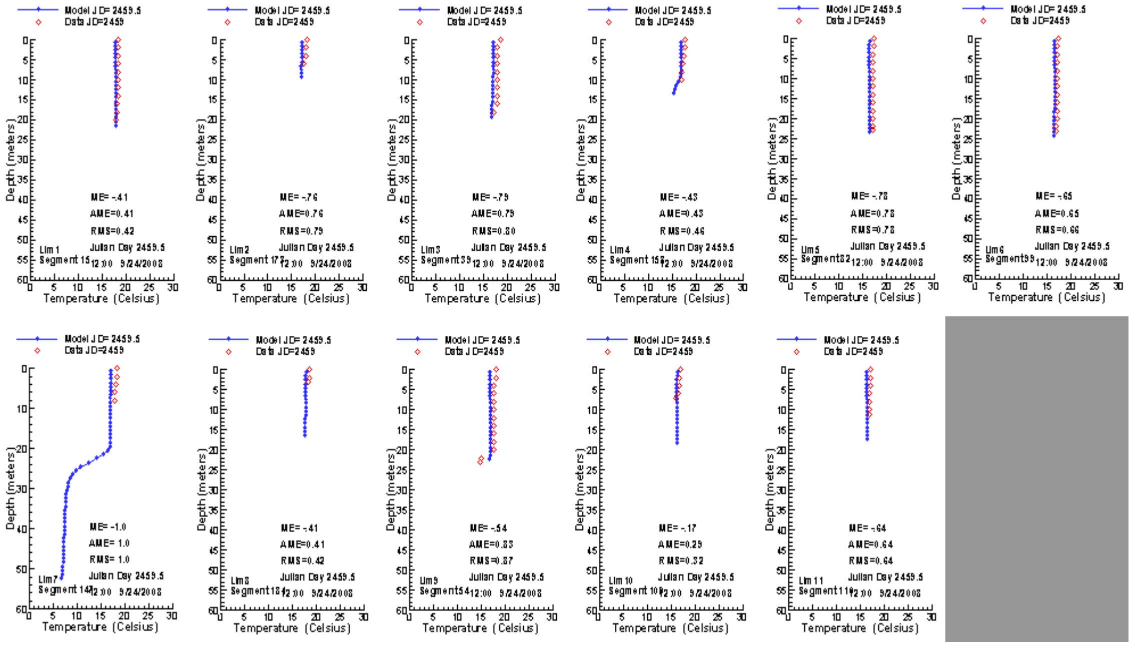

Model JD= 2389.5
Data JD=2389
Depth (meters)
Temperature (Celsius)
ME= -.55
AME=0.55
RMS=0.63
Lim 1
Segment 15
Julian Day 2389.5
12:00 7/16/2008
ME= -.59
AME=0.59
RMS=0.59
Lim 2
Segment 17
ME= -.36
AME=0.78
RMS= 1.0
Lim 3
Segment 39
ME= 0.41E-01
AME= 1.0
RMS= 1.2
Lim 4
Segment 15
ME= 0.50
AME=0.50
RMS=0.64
Lim 5
Segment 82
ME= 0.47
AME=0.60
RMS=0.68
Lim 6
Segment 99
ME= 0.44
AME= 1.3
RMS= 1.4
Lim 7
Segment 14
ME= 0.61E-01
AME=0.41
RMS=0.47
Lim 8
Segment 18
ME= -.48
AME=0.55
RMS=0.72
Lim 9
Segment 54
ME= 1.3
AME= 1.3
RMS= 1.3
Lim 10
Segment 10
ME= 0.94
AME=0.94
RMS= 1.1
Lim 11
Segment 11

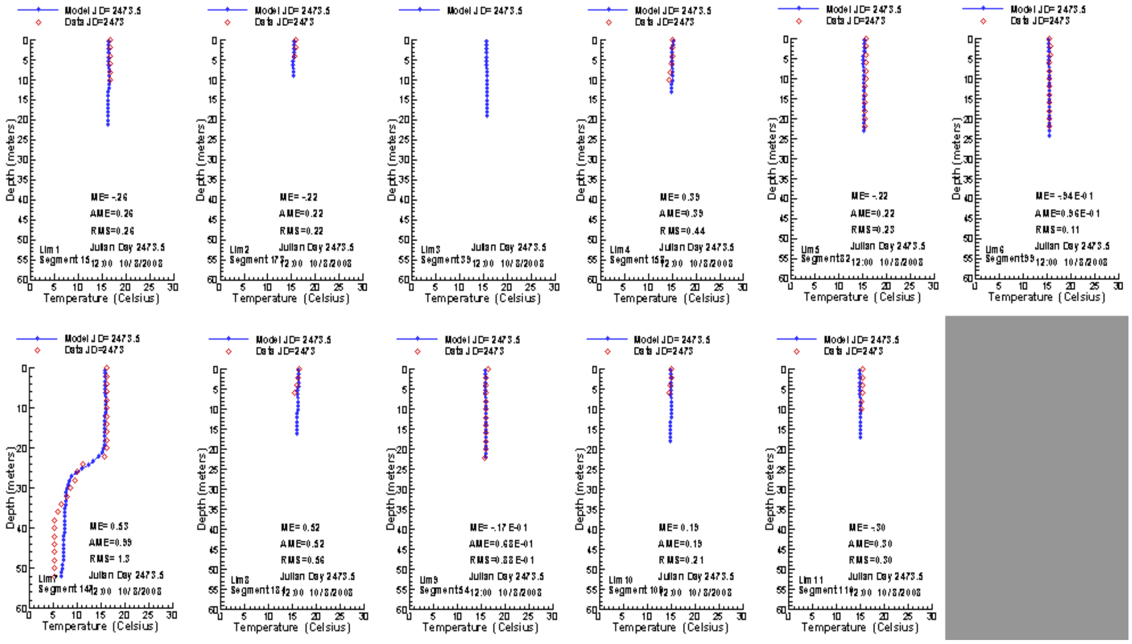

Model JD= 2403.5
Data JD=2403
Depth (meters)
Temperature (Celsius)
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 1
Segment 15
Julian Day 2403.5
12:00 7/30/2008
ME= -.22
AME=0.22
RMS=0.22
Lim 2
Segment 17
Julian Day 2403.5
12:00 7/30/2008
ME= -1.0
AME= 1.0
RMS= 1.1
Lim3
Segment39
Julian Day 2403.5
12:00 7/30/2008
ME= -.33
AME=0.40
RMS=0.44
Lim4
Segment 15
Julian Day 2403.5
12:00 7/30/2008
ME= 0.86
AME=0.92
RMS= 1.0
Lim5
Segment82
Julian Day 2403.5
12:00 7/30/2008
ME= 0.81E-01
AME= 1.0
RMS= 1.2
Lim6
Segment99
Julian Day 2403.5
12:00 7/30/2008
ME= 0.37
AME= 1.3
RMS= 1.5
Lim7
Segment 14
Julian Day 2403.5
12:00 7/30/2008
ME= -1.1
AME= 1.1
RMS= 1.1
Lim8
Segment18
Julian Day 2403.5
12:00 7/30/2008
ME= -.99
AME= 1.3
RMS= 1.5
Lim9
Segment54
Julian Day 2403.5
12:00 7/30/2008
ME= 2.7
AME= 2.7
RMS= 2.7
Lim 10
Segment 10
Julian Day 2403.5
12:00 7/30/2008
ME= 1.6
AME= 1.7
RMS= 2.0
Lim 11
Segment 11
Julian Day 2403.5
12:00 7/30/2008

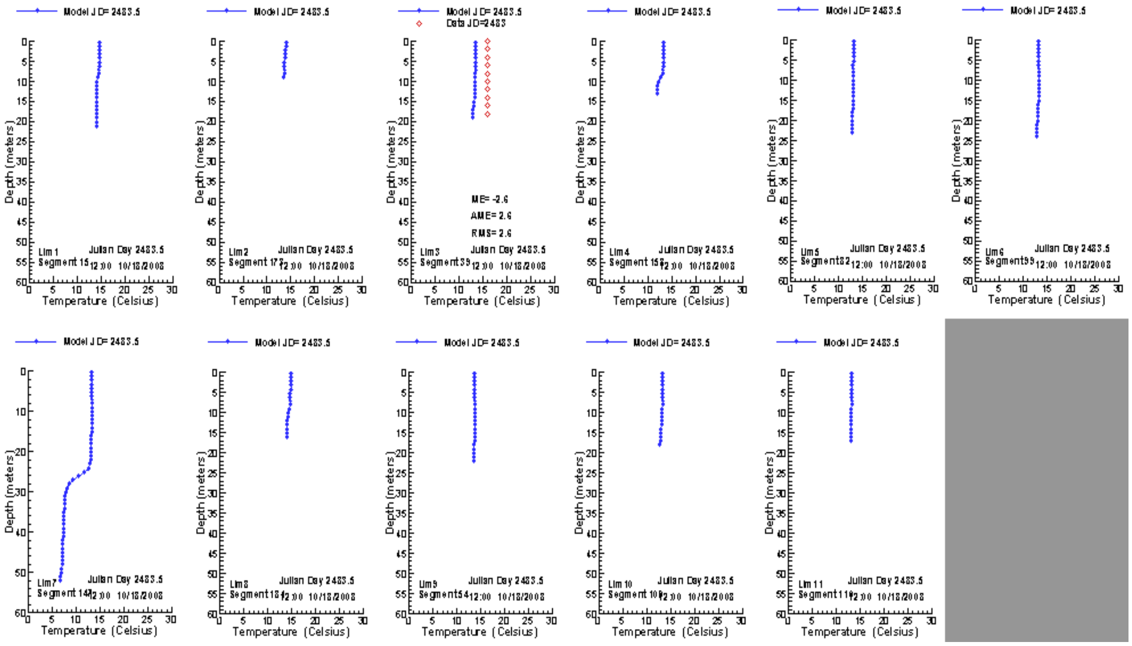

Model JD= 2417.5
Data JD=2417
Depth (meters)
Temperature (Celsius)
ME= -1.1
AME= 1.1
RMS= 1.2
Lim 1
Segment 15
Julian Day 2417.5
12:00 8/13/2008
ME= -.70
AME=0.70
RMS=0.79
Lim 2
Segment 17
Julian Day 2417.5
12:00 8/13/2008
ME= -.80
AME= 1.1
RMS= 1.3
Lim3
Segment39
Julian Day 2417.5
12:00 8/13/2008
ME= 0.48E-01
AME=0.65
RMS=0.67
Lim4
Segment 15
Julian Day 2417.5
12:00 8/13/2008
ME= 0.21
AME=0.90
RMS=0.95
Lim5
Segment82
Julian Day 2417.5
12:00 8/13/2008
ME= -.37
AME=0.84
RMS=0.96
Lim6
Segment99
Julian Day 2417.5
12:00 8/13/2008
ME= 0.27
AME= 1.3
RMS= 1.4
Lim7
Segment 14
Julian Day 2417.5
12:00 8/13/2008
ME= -.63
AME=0.63
RMS=0.76
Lim8
Segment18
Julian Day 2417.5
12:00 8/13/2008
ME= -.84
AME=0.84
RMS= 1.1
Lim9
Segment54
Julian Day 2417.5
12:00 8/13/2008
Lim 10
Segment 10
Julian Day 2417.5
12:00 8/13/2008
ME= 0.97
AME=0.97
RMS= 1.1
Lim 11
Segment 11
Julian Day 2417.5
12:00 8/13/2008


Model JD= 2431.5
Data JD=2431
Depth (meters)
Temperature (Celsius)
ME= -.50
AME=0.50
RMS=0.58
Lim1
Segment 15
Julian Day 2431.5
12:00 8/27/2008
ME= -.63E-01
AME=0.63E-01
RMS=0.89E-01
Lim2
Segment 17
ME= -.87
AME=0.87
RMS= 1.1
Lim3
Segment39
ME= -.13
AME=0.13
RMS=0.15
Lim4
Segment 15
ME= -.41
AME=0.74
RMS= 1.0
Lim5
Segment82
ME= 0.94E-01
AME=0.72
RMS=0.81
Lim6
Segment99
ME= -.56E-01
AME= 1.1
RMS= 1.4
Lim7
Segment 14
ME= -.26E-01
AME=0.26E-01
RMS=0.26E-01
Lim8
Segment18
ME= -.56
AME=0.81
RMS= 1.1
Lim9
Segment54
ME= 1.3
AME= 1.3
RMS= 1.3
Lim 10
Segment 10
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 11
Segment11

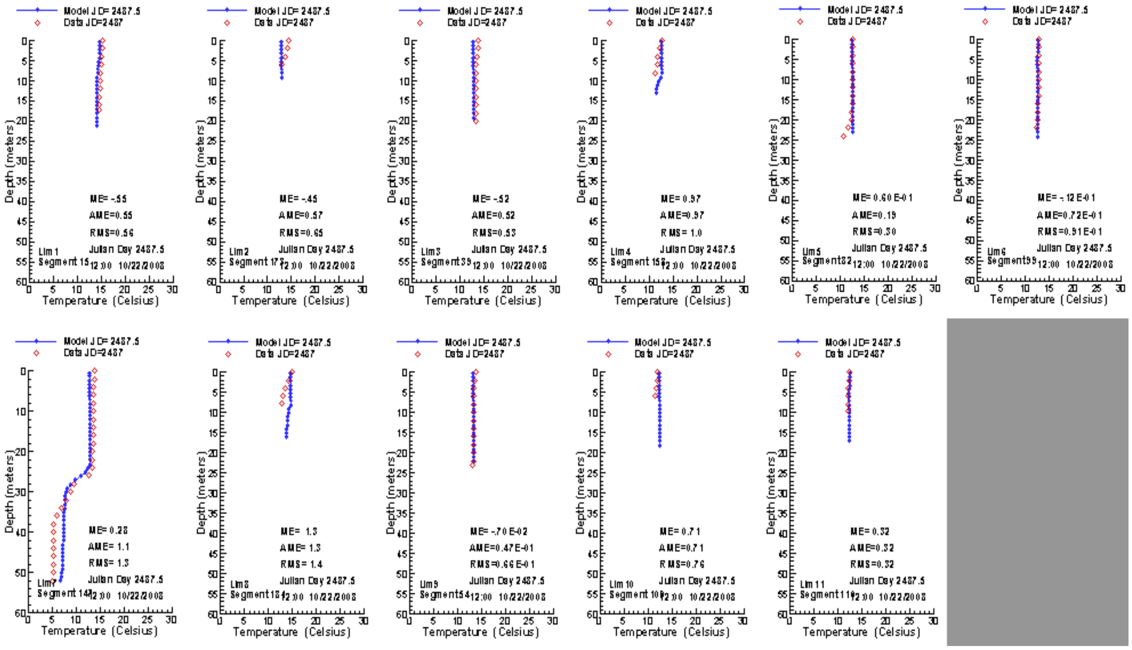

Model JD= 2445.5
Data JD=2445
Depth (meters)
Temperature (Celsius)
ME= -1.3
AME= 1.3
RMS= 1.3
Lim1
Segment 15
Julian Day 2445.5
12:00 9/10/2008
ME= -1.9
AME= 1.9
RMS= 1.9
Lim2
Segment 17
ME= -.93
AME=0.95
RMS= 1.1
Lim3
Segment39
ME= -1.7
AME= 1.7
RMS= 1.7
Lim4
Segment 15
ME= -.97
AME=0.97
RMS=0.97
Lim5
Segment82
ME= -.87
AME=0.87
RMS=0.89
Lim6
Segment99
ME= 0.37
AME= 1.3
RMS= 1.5
Lim7
Segment 14
ME= -1.3
AME= 1.3
RMS= 1.3
Lim8
Segment18
ME= -.46
AME= 1.5
RMS= 1.6
Lim9
Segment54
ME= -.80
AME=0.80
RMS=0.80
Lim 10
Segment 10
ME= -1.3
AME= 1.3
RMS= 1.3
Lim 11
Segment11


Model JD= 2459.5
Data JD=2459
Depth (meters)
Temperature (Celsius)
ME= -.41
AME=0.41
RMS=0.42
Lim 1
Segment 15
Julian Day 2459.5
12:00 9/24/2008
ME= -.76
AME=0.76
RMS=0.79
Lim2
Segment 17
Julian Day 2459.5
12:00 9/24/2008
ME= -.79
AME=0.79
RMS=0.80
Lim3
Segment39
Julian Day 2459.5
12:00 9/24/2008
ME= -.43
AME=0.43
RMS=0.46
Lim4
Segment 15
Julian Day 2459.5
12:00 9/24/2008
ME= -.78
AME=0.78
RMS=0.78
Lim5
Segment82
Julian Day 2459.5
12:00 9/24/2008
ME= -.65
AME=0.65
RMS=0.66
Lim6
Segment99
Julian Day 2459.5
12:00 9/24/2008
ME= -1.0
AME= 1.0
RMS= 1.0
Lim7
Segment 14
Julian Day 2459.5
12:00 9/24/2008
ME= -.41
AME=0.41
RMS=0.42
Lim8
Segment18
Julian Day 2459.5
12:00 9/24/2008
ME= -.54
AME=0.83
RMS=0.87
Lim9
Segment54
Julian Day 2459.5
12:00 9/24/2008
ME= -.17
AME=0.29
RMS=0.32
Lim 10
Segment 10
Julian Day 2459.5
12:00 9/24/2008
ME= -.64
AME=0.64
RMS=0.64
Lim 11
Segment11
Julian Day 2459.5
12:00 9/24/2008

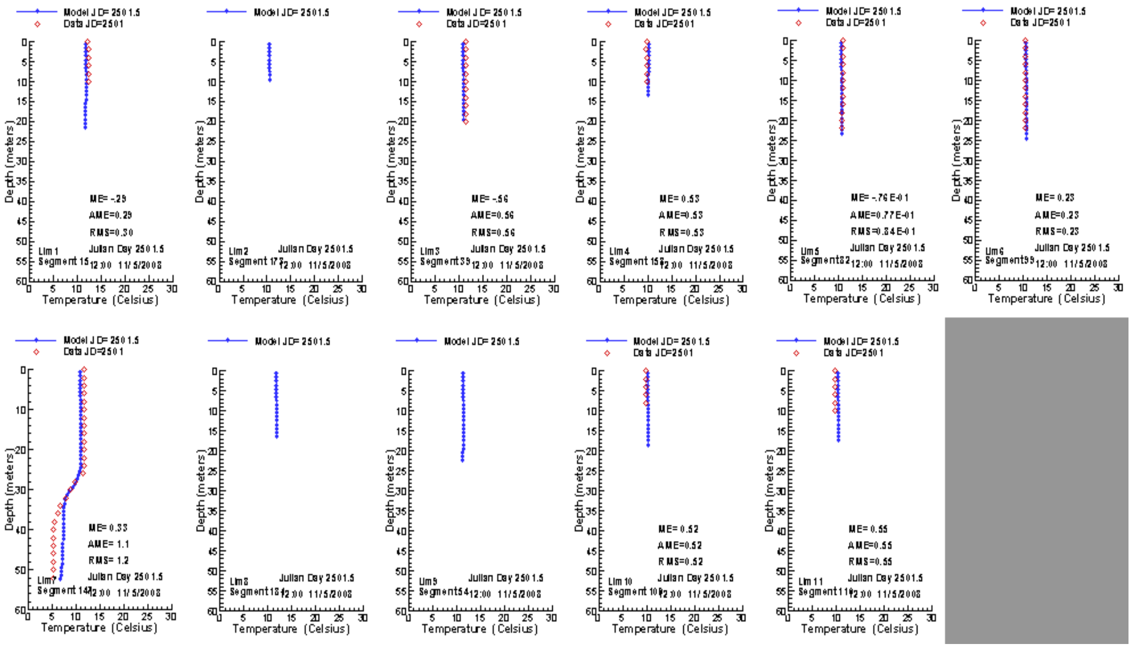

Model JD= 2473.5
Data JD=2473
Depth (meters)
Temperature (Celsius)
ME= -.26
AME=0.26
RMS=0.26
Lim 1
Segment 15
Julian Day 2473.5
12:00 10/8/2008
ME= -.22
AME=0.22
RMS=0.22
Lim2
Segment 17
Julian Day 2473.5
12:00 10/8/2008
Lim3
Segment39
Julian Day 2473.5
12:00 10/8/2008
ME= 0.39
AME=0.39
RMS=0.44
Lim4
Segment 15
Julian Day 2473.5
12:00 10/8/2008
ME= -.22
AME=0.22
RMS=0.23
Lim5
Segment82
Julian Day 2473.5
12:00 10/8/2008
ME= -.94E-01
AME=0.96E-01
RMS=0.11
Lim6
Segment99
Julian Day 2473.5
12:00 10/8/2008
ME= 0.53
AME=0.99
RMS= 1.3
Lim7
Segment 14
Julian Day 2473.5
12:00 10/8/2008
ME= 0.52
AME=0.52
RMS=0.56
Lim8
Segment18
Julian Day 2473.5
12:00 10/8/2008
ME= -.17E-01
AME=0.68E-01
RMS=0.88E-01
Lim9
Segment54
Julian Day 2473.5
12:00 10/8/2008
ME= 0.19
AME=0.19
RMS=0.21
Lim 10
Segment 10
Julian Day 2473.5
12:00 10/8/2008
ME= -.30
AME=0.30
RMS=0.30
Lim 11
Segment11
Julian Day 2473.5
12:00 10/8/2008

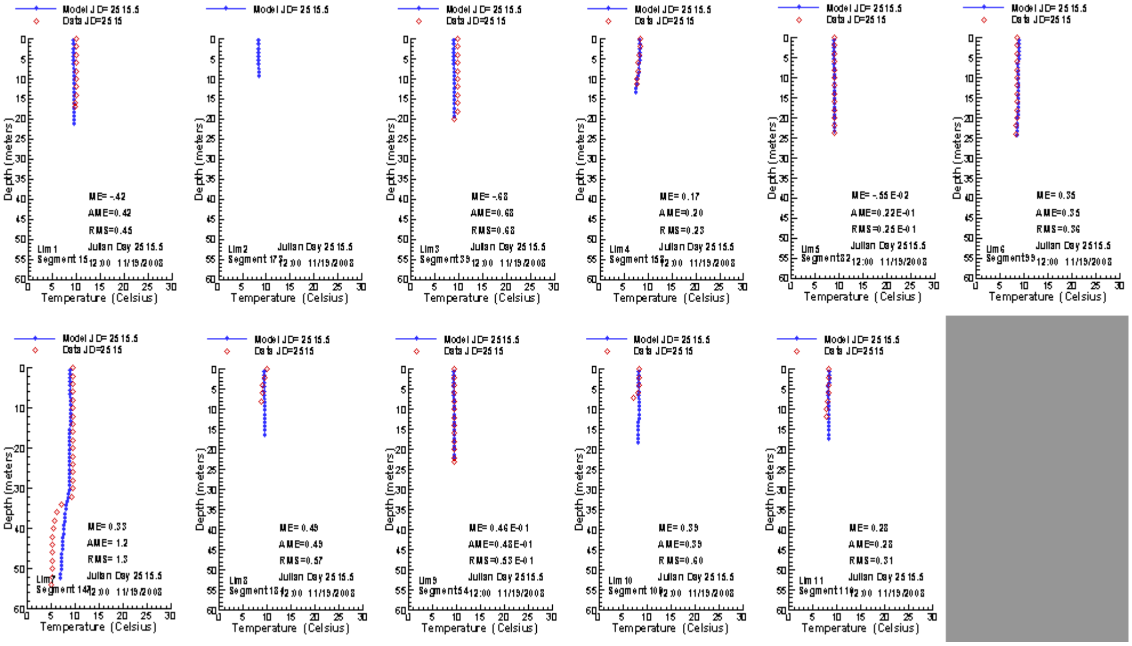


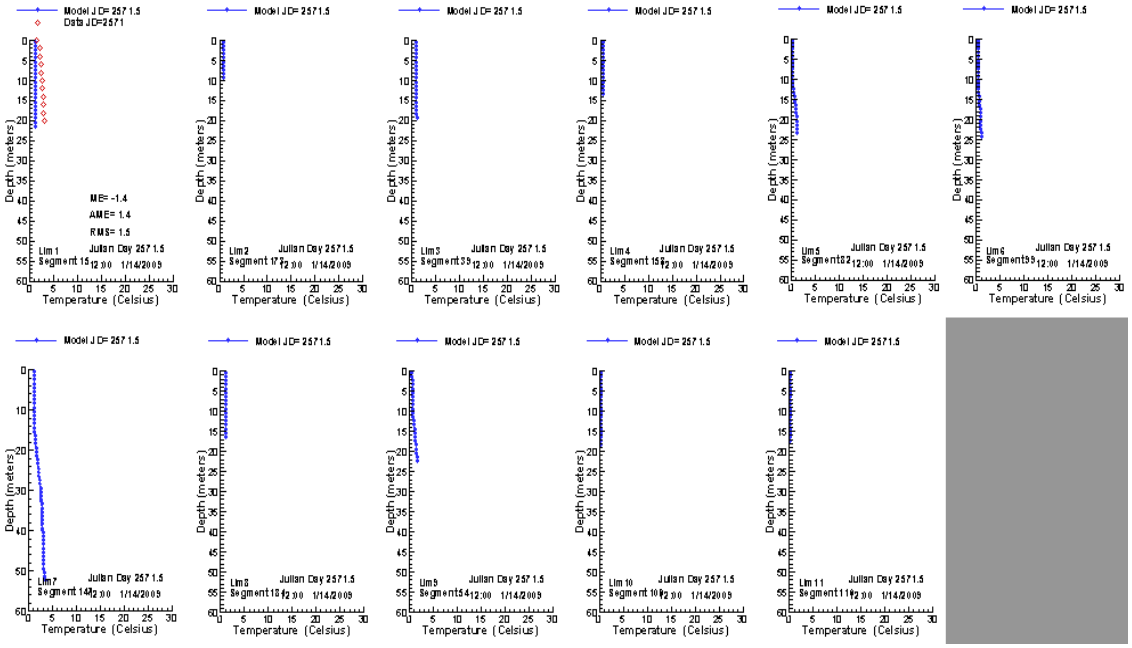
Model JD= 2483.5
Data JD=2483
Depth (meters)
Temperature (Celsius)
ME= -2.6
AME= 2.6
RMS= 2.6
Lim1 Segment 15
Lim2 Segment 17
Lim3 Segment 39
Lim4 Segment 15
Lim5 Segment 82
Lim6 Segment 99
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11
Julian Day 2483.5
12:00 10/18/2008

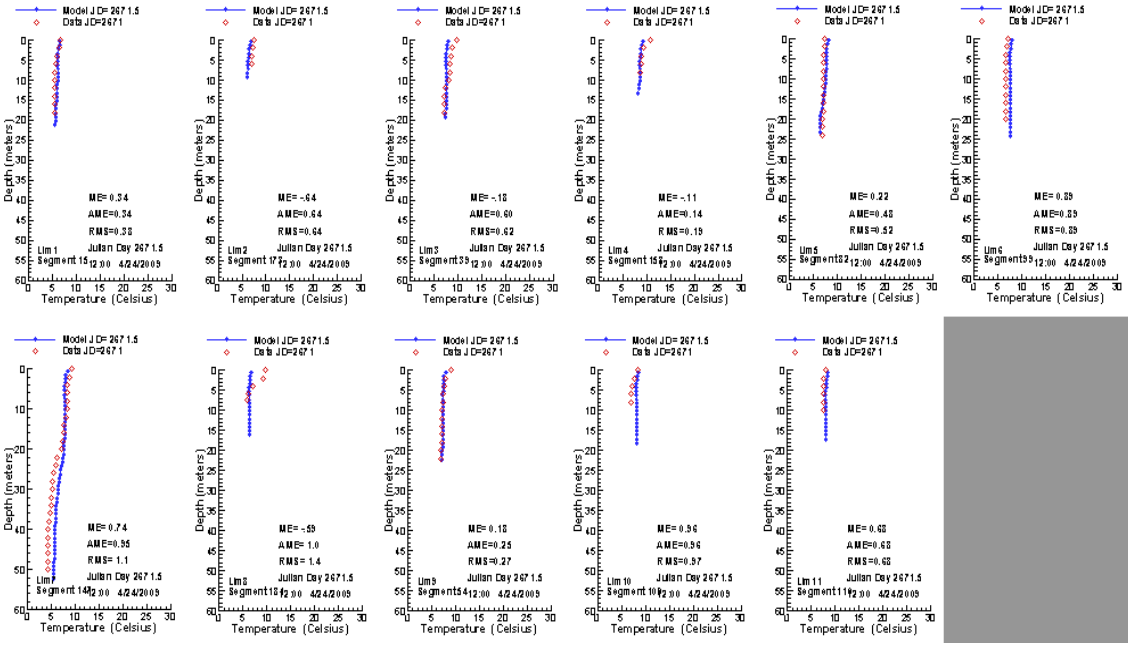


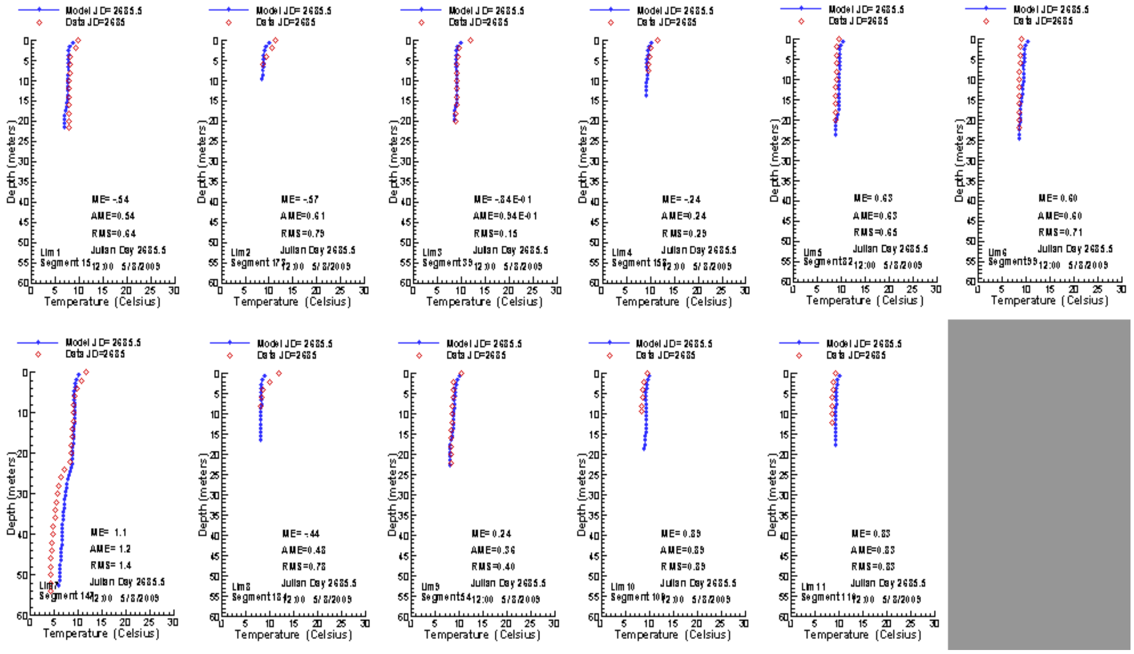
Model JD= 2487.5
Data JD=2487
Depth (meters)
Temperature (Celsius)
Lim1 Segment 15
ME= -.55
AME=0.55
RMS=0.56
Lim2 Segment 17
ME= -.45
AME=0.57
RMS=0.65
Lim3 Segment 39
ME= -.52
AME=0.52
RMS=0.53
Lim4 Segment 15
ME= 0.97
AME=0.97
RMS= 1.0
Lim5 Segment 82
ME= 0.60 E-01
AME=0.19
RMS=0.30
Lim6 Segment 99
ME= -.12 E-01
AME=0.72 E-01
RMS=0.91 E-01
Lim7 Segment 14
ME= 0.28
AME= 1.1
RMS= 1.3
Lim8 Segment 18
ME= 1.3
AME= 1.3
RMS= 1.4
Lim9 Segment 54
ME= -.70 E-02
AME=0.47 E-01
RMS=0.66 E-01
Lim10 Segment 10
ME= 0.71
AME=0.71
RMS=0.76
Lim11 Segment 11
ME= 0.32
AME=0.32
RMS=0.32
Julian Day 2487.5
12:00 10/22/2008

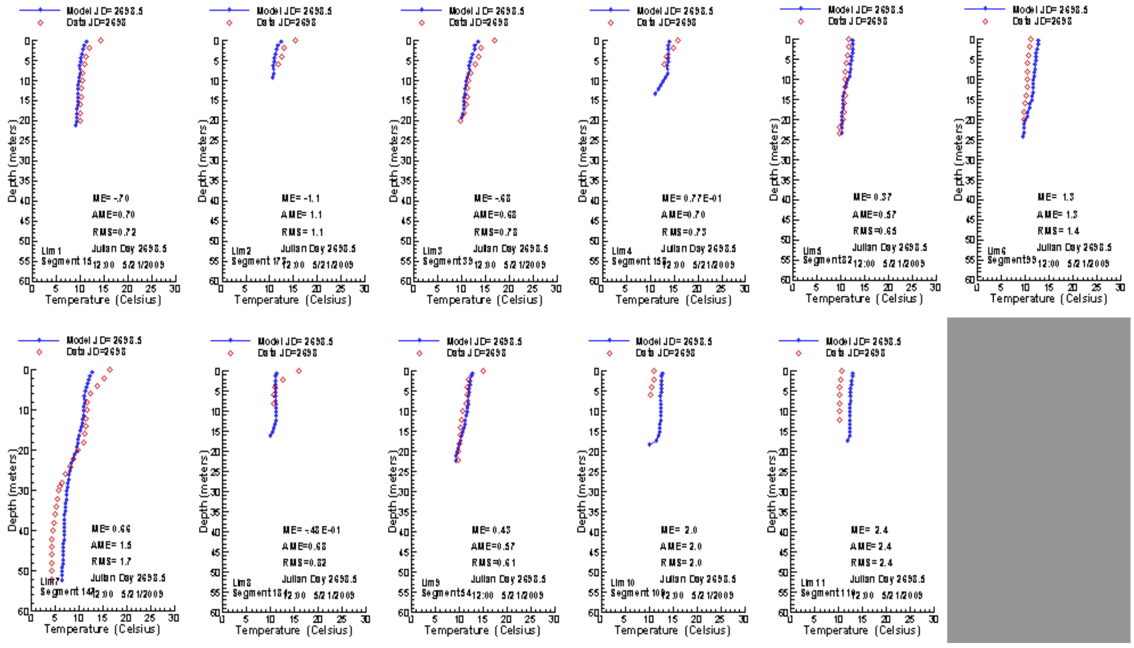

Model JD= 2501.5
Data JD=2501
Depth (meters)
Temperature (Celsius)
ME= -.29
AME=0.29
RMS=0.30
Lim1
Segment 15
Julian Day 2501.5
12:00 11/5/2008
Lim2
Segment 17
ME= -.56
AME=0.56
RMS=0.56
Lim3
Segment 39
ME= 0.53
AME=0.53
RMS=0.53
Lim4
Segment 15
ME= -.76E-01
AME=0.77E-01
RMS=0.84E-01
Lim5
Segment 82
ME= 0.23
AME=0.23
RMS=0.23
Lim6
Segment 99
ME= 0.33
AME= 1.1
RMS= 1.2
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
ME= 0.52
AME=0.52
RMS=0.52
Lim 10
Segment 10
ME= 0.55
AME=0.55
RMS=0.55
Lim 11
Segment 11

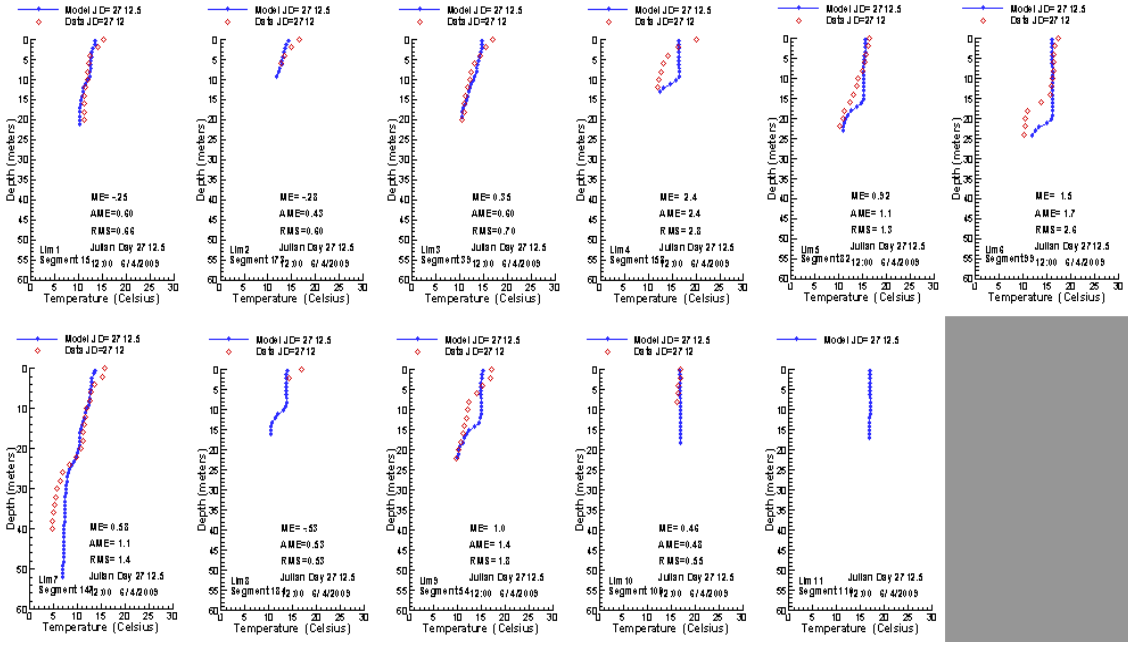

Model JD= 2515.5
Data JD=2515
Depth (meters)
Temperature (Celsius)
ME= -.42
AME=0.42
RMS=0.45
Lim1
Segment 15
Julian Day 2515.5
12:00 11/19/2008
Lim2
Segment 17
ME= -.68
AME=0.68
RMS=0.68
Lim3
Segment 39
ME= 0.17
AME=0.20
RMS=0.23
Lim4
Segment 15
ME= -.55E-02
AME=0.22E-01
RMS=0.25E-01
Lim5
Segment 82
ME= 0.35
AME=0.35
RMS=0.36
Lim6
Segment 99
ME= 0.33
AME= 1.2
RMS= 1.3
Lim7
Segment 14
ME= 0.49
AME=0.49
RMS=0.57
Lim8
Segment 18
ME= 0.46E-01
AME=0.48E-01
RMS=0.53E-01
Lim9
Segment 54
ME= 0.39
AME=0.39
RMS=0.60
Lim 10
Segment 10
ME= 0.28
AME=0.28
RMS=0.31
Lim 11
Segment 11

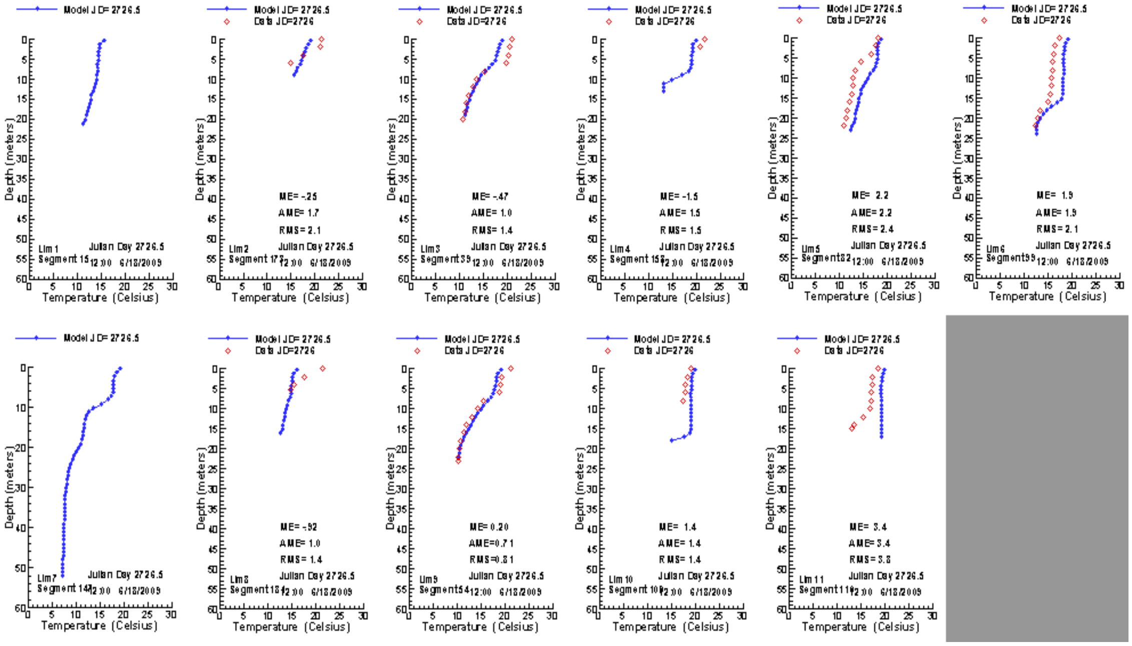

Model JD= 257 1.5
Data JD=2571
Depth (meters)
Temperature (Celsius)
ME= -1.4
AME= 1.4
RMS= 1.5
Lim 1
Segment 15
Julian Day 257 1.5
12:00 1/14/2009
Lim 2
Segment 17
Lim3
Segment 39
Lim 4
Segment 15
Lim5
Segment 82
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

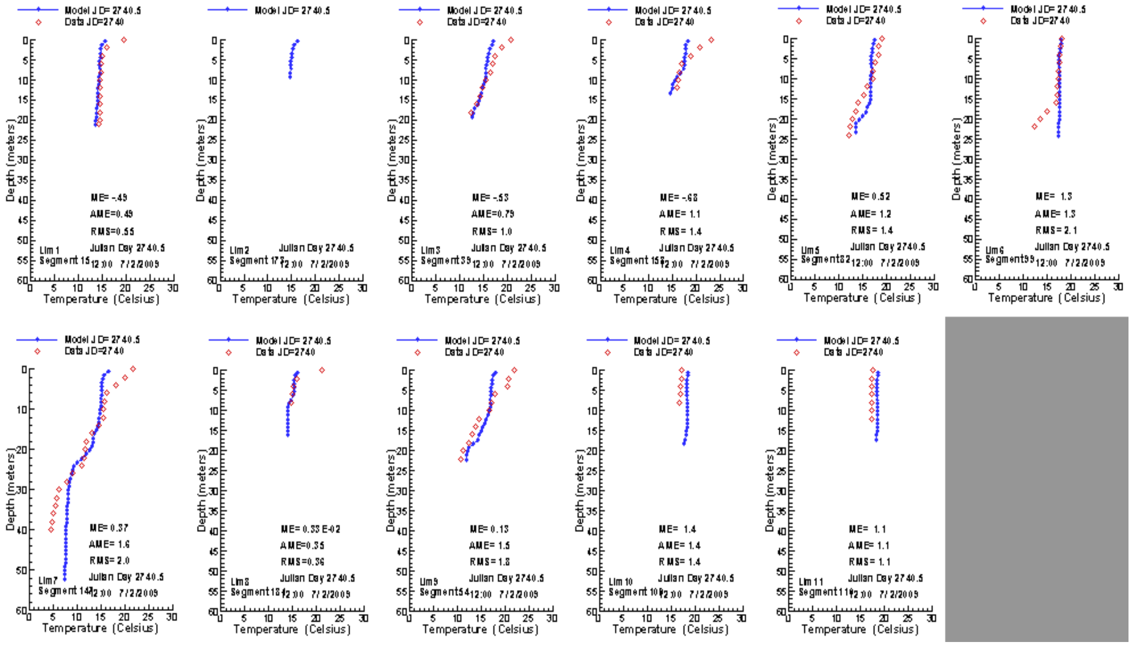

Model JD= 267 1.5
Data JD=2671
Depth (meters)
Temperature (Celsius)
Julian Day 267 1.5
12:00 4/24/2009
Lim 1
Segment 15
ME= 0.34
AME=0.34
RMS=0.38
Lim 2
Segment 17
ME= -.64
AME=0.64
RMS=0.64
Lim3
Segment 39
ME= -.18
AME=0.60
RMS=0.62
Lim 4
Segment 15
ME= -.11
AME=0.14
RMS=0.19
Lim5
Segment 82
ME= 0.22
AME=0.48
RMS=0.52
Lim6
Segment 99
ME= 0.89
AME=0.89
RMS=0.89
Lim7
Segment 14
ME= 0.74
AME=0.95
RMS= 1.1
Lim8
Segment 18
ME= -.59
AME= 1.0
RMS= 1.4
Lim9
Segment 54
ME= 0.18
AME=0.25
RMS=0.27
Lim 10
Segment 10
ME= 0.96
AME=0.96
RMS=0.97
Lim 11
Segment 11
ME= 0.68
AME=0.68
RMS=0.68

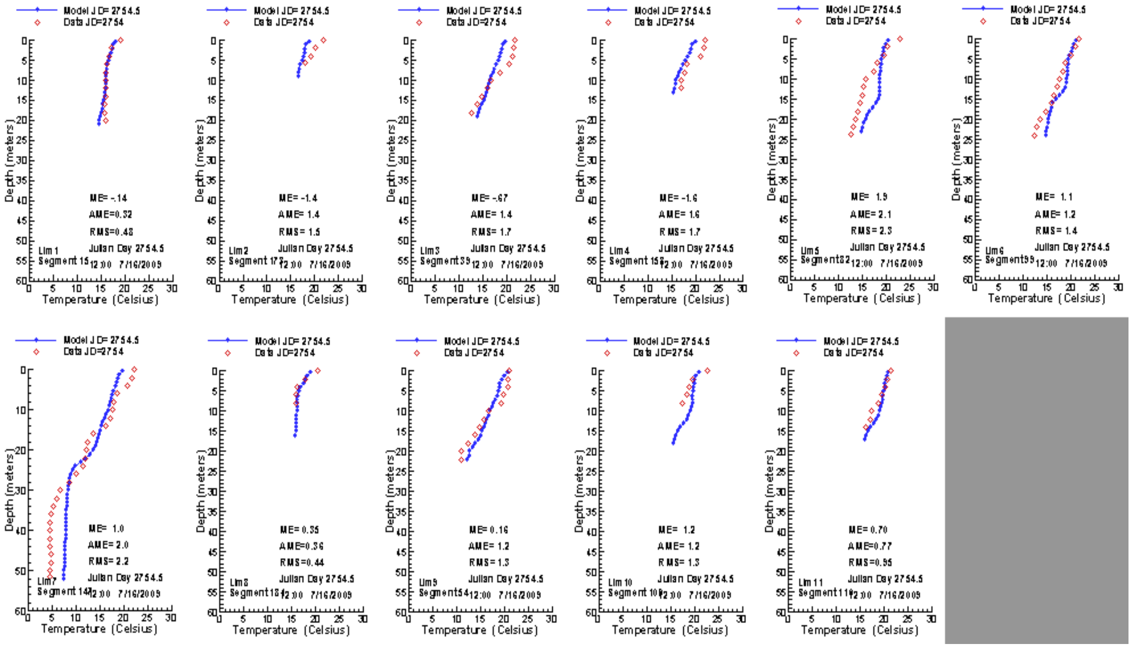

Model JD= 2685.5
Data JD=2685
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.54
AME=0.54
RMS=0.64
Julian Day 2685.5
12:00 5/8/2009
Lim 1
Segment 15
ME= -.57
AME=0.61
RMS=0.79
Julian Day 2685.5
12:00 5/8/2009
Lim 2
Segment 17
ME= -.84 E-01
AME=0.94 E-01
RMS=0.15
Julian Day 2685.5
12:00 5/8/2009
Lim 3
Segment 39
ME= -.24
AME=0.24
RMS=0.29
Julian Day 2685.5
12:00 5/8/2009
Lim 4
Segment 15
ME= 0.63
AME=0.63
RMS=0.65
Julian Day 2685.5
12:00 5/8/2009
Lim 5
Segment 82
ME= 0.60
AME=0.60
RMS=0.71
Julian Day 2685.5
12:00 5/8/2009
Lim 6
Segment 99
ME= 1.1
AME= 1.2
RMS= 1.4
Julian Day 2685.5
12:00 5/8/2009
Lim 7
Segment 14
ME= -.44
AME=0.48
RMS=0.78
Julian Day 2685.5
12:00 5/8/2009
Lim 8
Segment 18
ME= 0.24
AME=0.36
RMS=0.40
Julian Day 2685.5
12:00 5/8/2009
Lim 9
Segment 54
ME= 0.89
AME=0.89
RMS=0.89
Julian Day 2685.5
12:00 5/8/2009
Lim 10
Segment 10
ME= 0.83
AME=0.83
RMS=0.83
Julian Day 2685.5
12:00 5/8/2009
Lim 11
Segment 11

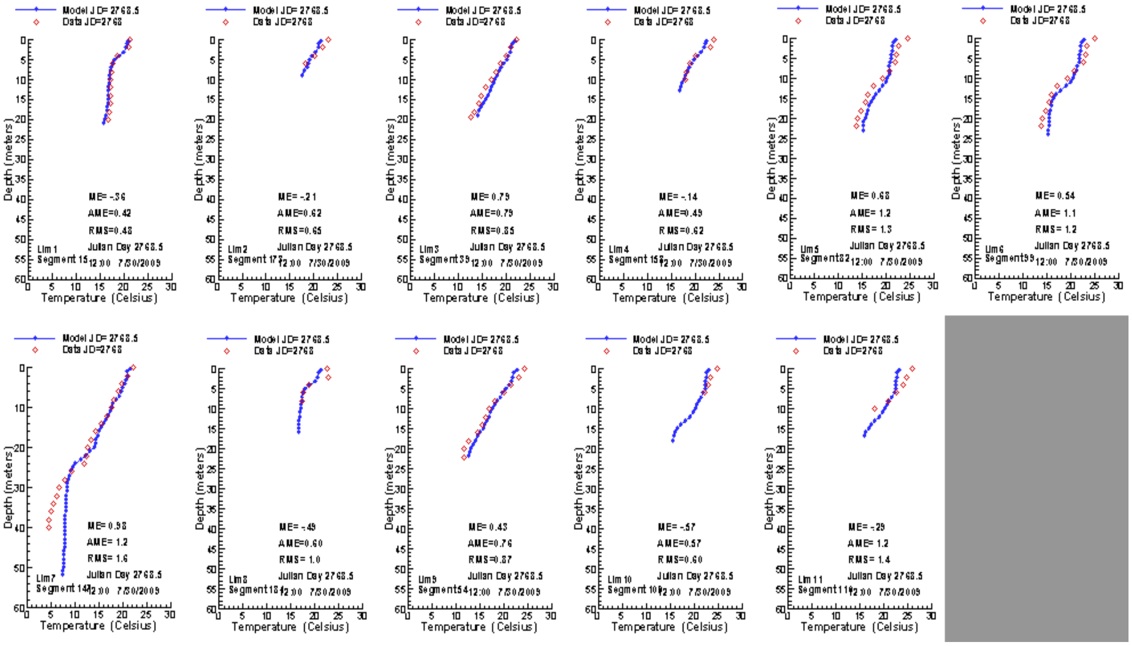

Model JD= 2698.5
Data JD=2698
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.70
AME=0.70
RMS=0.72
Julian Day 2698.5
12:00 5/21/2009
Lim 1
Segment 15
ME= -1.1
AME= 1.1
RMS= 1.1
Julian Day 2698.5
12:00 5/21/2009
Lim 2
Segment 17
ME= -.68
AME=0.68
RMS=0.78
Julian Day 2698.5
12:00 5/21/2009
Lim 3
Segment 39
ME= 0.77E-01
AME=0.70
RMS=0.73
Julian Day 2698.5
12:00 5/21/2009
Lim 4
Segment 15
ME= 0.37
AME=0.57
RMS=0.65
Julian Day 2698.5
12:00 5/21/2009
Lim 5
Segment 82
ME= 1.3
AME= 1.3
RMS= 1.4
Julian Day 2698.5
12:00 5/21/2009
Lim 6
Segment 99
ME= 0.66
AME= 1.5
RMS= 1.7
Julian Day 2698.5
12:00 5/21/2009
Lim 7
Segment 14
ME= -.48 E-01
AME=0.68
RMS=0.82
Julian Day 2698.5
12:00 5/21/2009
Lim 8
Segment 18
ME= 0.43
AME=0.57
RMS=0.61
Julian Day 2698.5
12:00 5/21/2009
Lim 9
Segment 54
ME= 2.0
AME= 2.0
RMS= 2.0
Julian Day 2698.5
12:00 5/21/2009
Lim 10
Segment 10
ME= 2.4
AME= 2.4
RMS= 2.4
Julian Day 2698.5
12:00 5/21/2009
Lim 11
Segment 11

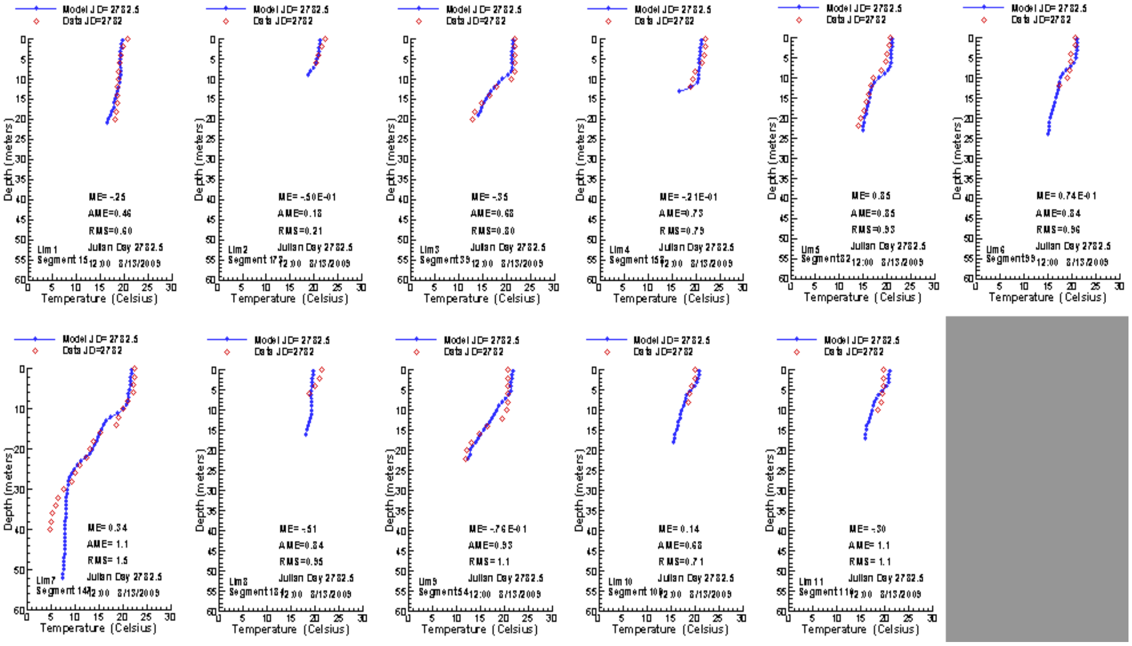

Model JD= 2712.5
Data JD=2712
Depth (meters)
Temperature (Celsius)
ME= -.25
AME=0.60
RMS=0.66
Lim 1
Segment 15
Julian Day 2712.5
12:00 6/4/2009
ME= -.28
AME=0.43
RMS=0.60
Lim2
Segment 17
ME= 0.35
AME=0.60
RMS=0.70
Lim3
Segment 39
ME= 2.4
AME= 2.4
RMS= 2.8
Lim4
Segment 15
ME= 0.92
AME= 1.1
RMS= 1.3
Lim5
Segment 82
ME= 1.5
AME= 1.7
RMS= 2.6
Lim6
Segment 99
ME= 0.58
AME= 1.1
RMS= 1.4
Lim7
Segment 14
ME= -.53
AME=0.53
RMS=0.53
Lim8
Segment 18
ME= 1.0
AME= 1.4
RMS= 1.8
Lim9
Segment 54
ME= 0.46
AME=0.48
RMS=0.55
Lim 10
Segment 10
Lim 11
Segment 11

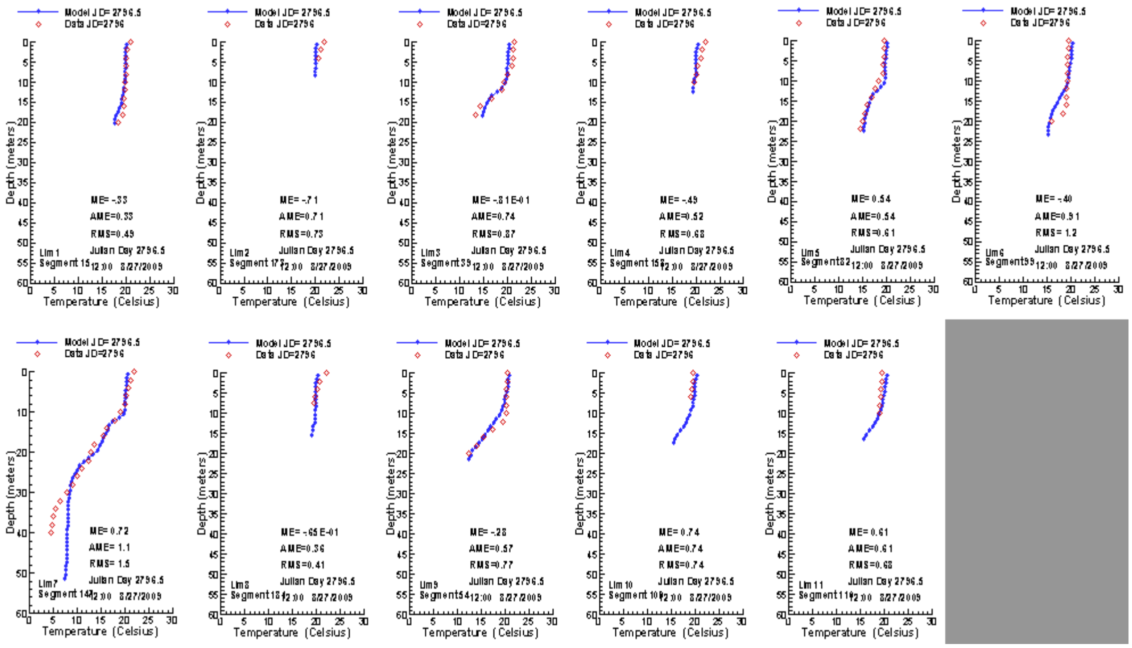

Model JD= 2726.5
Data JD=2726
Depth (meters)
Temperature (Celsius)
Lim 1
Segment 15
Julian Day 2726.5
12:00 6/18/2009
ME= -.25
AME= 1.7
RMS= 2.1
Lim2
Segment 17
ME= -.47
AME= 1.0
RMS= 1.4
Lim3
Segment 39
ME= -1.5
AME= 1.5
RMS= 1.5
Lim4
Segment 15
ME= 2.2
AME= 2.2
RMS= 2.4
Lim5
Segment 82
ME= 1.9
AME= 1.9
RMS= 2.1
Lim6
Segment 99
Lim7
Segment 14
ME= -.92
AME= 1.0
RMS= 1.4
Lim8
Segment 18
ME= 0.20
AME=0.71
RMS=0.81
Lim9
Segment 54
ME= 1.4
AME= 1.4
RMS= 1.4
Lim 10
Segment 10
ME= 3.4
AME= 3.4
RMS= 3.8
Lim 11
Segment 11

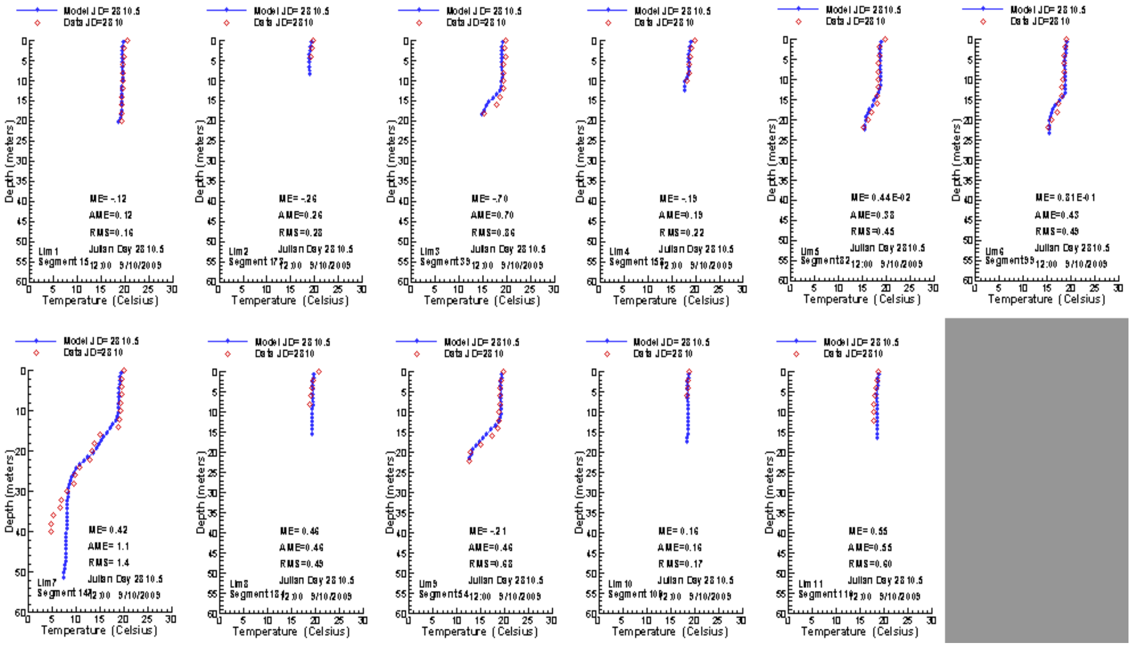

Model JD= 2740.5
Data JD=2740
Depth (meters)
Temperature (Celsius)
ME= -.49
AME=0.49
RMS=0.55
Lim1
Segment 15
Julian Day 2740.5
12:00 7/2/2009
Lim2
Segment 17
Julian Day 2740.5
12:00 7/2/2009
ME= -.53
AME=0.79
RMS= 1.0
Lim3
Segment39
Julian Day 2740.5
12:00 7/2/2009
ME= -.68
AME= 1.1
RMS= 1.4
Lim4
Segment 15
Julian Day 2740.5
12:00 7/2/2009
ME= 0.52
AME= 1.2
RMS= 1.4
Lim5
Segment82
Julian Day 2740.5
12:00 7/2/2009
ME= 1.3
AME= 1.3
RMS= 2.1
Lim6
Segment99
Julian Day 2740.5
12:00 7/2/2009
ME= 0.37
AME= 1.6
RMS= 2.0
Lim7
Segment 14
Julian Day 2740.5
12:00 7/2/2009
ME= 0.33 E-02
AME=0.35
RMS=0.36
Lim8
Segment 18
Julian Day 2740.5
12:00 7/2/2009
ME= 0.13
AME= 1.5
RMS= 1.8
Lim9
Segment54
Julian Day 2740.5
12:00 7/2/2009
ME= 1.4
AME= 1.4
RMS= 1.4
Lim 10
Segment 10
Julian Day 2740.5
12:00 7/2/2009
ME= 1.1
AME= 1.1
RMS= 1.1
Lim 11
Segment 11
Julian Day 2740.5
12:00 7/2/2009

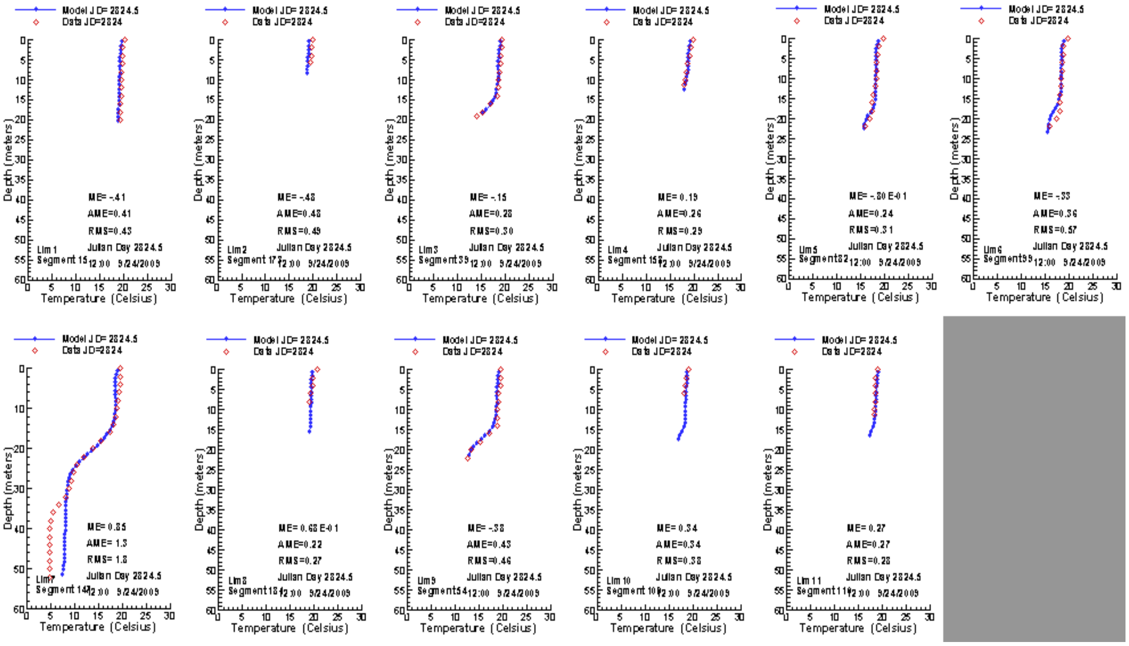

Model JD= 2754.5
Data JD=2754
Depth (meters)
Temperature (Celsius)
ME= -.14
AME=0.32
RMS=0.48
Lim1
Segment 15
Julian Day 2754.5
12:00 7/16/2009
ME= -1.4
AME= 1.4
RMS= 1.5
Lim2
Segment 17
Julian Day 2754.5
12:00 7/16/2009
ME= -.67
AME= 1.4
RMS= 1.7
Lim3
Segment39
Julian Day 2754.5
12:00 7/16/2009
ME= -1.6
AME= 1.6
RMS= 1.7
Lim4
Segment 15
Julian Day 2754.5
12:00 7/16/2009
ME= 1.9
AME= 2.1
RMS= 2.3
Lim5
Segment82
Julian Day 2754.5
12:00 7/16/2009
ME= 1.1
AME= 1.2
RMS= 1.4
Lim6
Segment99
Julian Day 2754.5
12:00 7/16/2009
ME= 1.0
AME= 2.0
RMS= 2.2
Lim7
Segment 14
Julian Day 2754.5
12:00 7/16/2009
ME= 0.35
AME=0.36
RMS=0.44
Lim8
Segment 18
Julian Day 2754.5
12:00 7/16/2009
ME= 0.16
AME= 1.2
RMS= 1.3
Lim9
Segment54
Julian Day 2754.5
12:00 7/16/2009
ME= 1.2
AME= 1.2
RMS= 1.3
Lim 10
Segment 10
Julian Day 2754.5
12:00 7/16/2009
ME= 0.70
AME=0.77
RMS=0.95
Lim 11
Segment 11
Julian Day 2754.5
12:00 7/16/2009

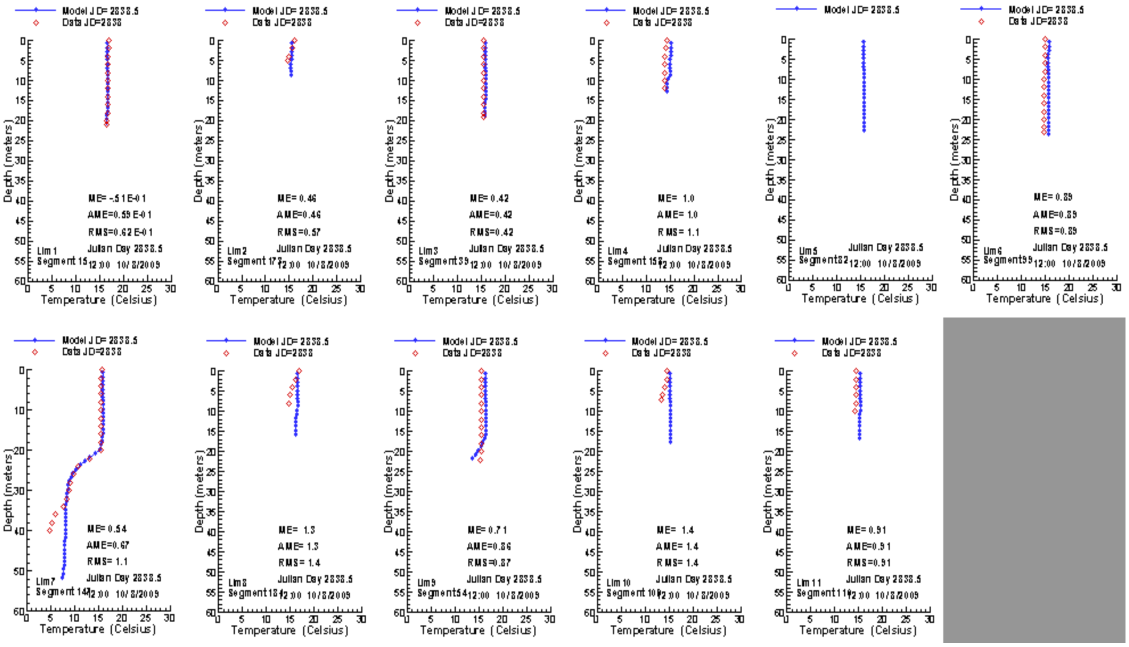

Model JD= 2768.5
Data JD=2768
Depth (meters)
Temperature (Celsius)
ME= -.36
AME=0.42
RMS=0.48
Lim1
Segment 15
Julian Day 2768.5
12:00 7/30/2009
ME= -.21
AME=0.62
RMS=0.65
Lim2
Segment 17
Julian Day 2768.5
12:00 7/30/2009
ME= 0.79
AME=0.79
RMS=0.85
Lim3
Segment39
Julian Day 2768.5
12:00 7/30/2009
ME= -.14
AME=0.49
RMS=0.62
Lim4
Segment 15
Julian Day 2768.5
12:00 7/30/2009
ME= 0.68
AME= 1.2
RMS= 1.3
Lim5
Segment82
Julian Day 2768.5
12:00 7/30/2009
ME= 0.54
AME= 1.1
RMS= 1.2
Lim6
Segment99
Julian Day 2768.5
12:00 7/30/2009
ME= 0.98
AME= 1.2
RMS= 1.6
Lim7
Segment 14
Julian Day 2768.5
12:00 7/30/2009
ME= -.49
AME=0.60
RMS= 1.0
Lim8
Segment18
Julian Day 2768.5
12:00 7/30/2009
ME= 0.43
AME=0.76
RMS=0.87
Lim9
Segment54
Julian Day 2768.5
12:00 7/30/2009
ME= -.57
AME=0.57
RMS=0.60
Lim 10
Segment 10
Julian Day 2768.5
12:00 7/30/2009
ME= -.29
AME= 1.2
RMS= 1.4
Lim 11
Segment 11
Julian Day 2768.5
12:00 7/30/2009

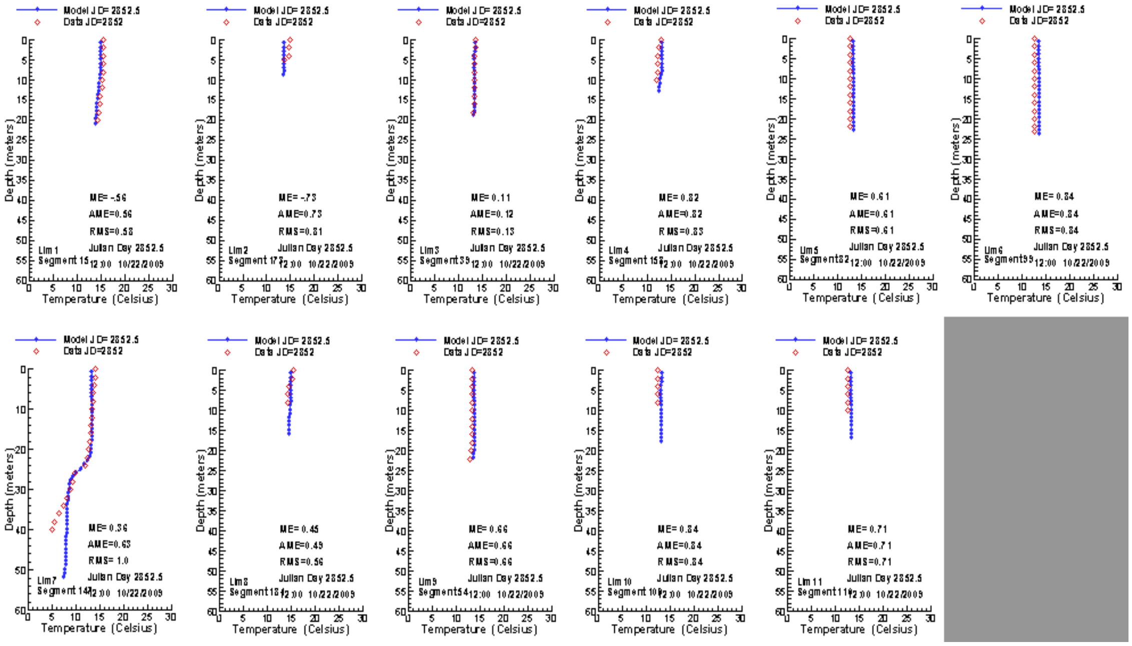

Model JD= 2782.5
Data JD=2782
Depth (meters)
Temperature (Celsius)
ME= -.25
AME=0.46
RMS=0.60
Lim1
Segment 15
Julian Day 2782.5
12:00 8/13/2009
ME= -.50E-01
AME=0.18
RMS=0.21
Lim2
Segment 17
Julian Day 2782.5
12:00 8/13/2009
ME= -.35
AME=0.68
RMS=0.80
Lim3
Segment39
Julian Day 2782.5
12:00 8/13/2009
ME= -.21E-01
AME=0.73
RMS=0.79
Lim4
Segment 15
Julian Day 2782.5
12:00 8/13/2009
ME= 0.85
AME=0.85
RMS=0.93
Lim5
Segment82
Julian Day 2782.5
12:00 8/13/2009
ME= 0.74E-01
AME=0.84
RMS=0.96
Lim6
Segment99
Julian Day 2782.5
12:00 8/13/2009
ME= 0.34
AME= 1.1
RMS= 1.5
Lim7
Segment 14
Julian Day 2782.5
12:00 8/13/2009
ME= -.51
AME=0.84
RMS=0.95
Lim8
Segment18
Julian Day 2782.5
12:00 8/13/2009
ME= -.76E-01
AME=0.93
RMS= 1.1
Lim9
Segment54
Julian Day 2782.5
12:00 8/13/2009
ME= 0.14
AME=0.68
RMS=0.71
Lim 10
Segment 10
Julian Day 2782.5
12:00 8/13/2009
ME= -.30
AME= 1.1
RMS= 1.1
Lim 11
Segment 11
Julian Day 2782.5
12:00 8/13/2009


Model JD= 2796.5
Data JD=2796
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.33
AME=0.33
RMS=0.49
Julian Day 2796.5
12:00 8/27/2009
Lim 1
Segment 15
ME= -.71
AME=0.71
RMS=0.73
Lim 2
Segment 173
ME= -.81E-01
AME=0.74
RMS=0.87
Lim3
Segment39
ME= -.49
AME=0.52
RMS=0.68
Lim 4
Segment 158
ME= 0.54
AME=0.54
RMS=0.61
Lim 5
Segment82
ME= -.40
AME=0.91
RMS= 1.2
Lim 6
Segment99
ME= 0.72
AME= 1.1
RMS= 1.5
Lim7
Segment 147
ME= -.65E-01
AME=0.36
RMS=0.41
Lim 8
Segment 184
ME= -.28
AME=0.57
RMS=0.77
Lim 9
Segment54
ME= 0.74
AME=0.74
RMS=0.74
Lim 10
Segment 109
ME= 0.61
AME=0.61
RMS=0.68
Lim 11
Segment 119

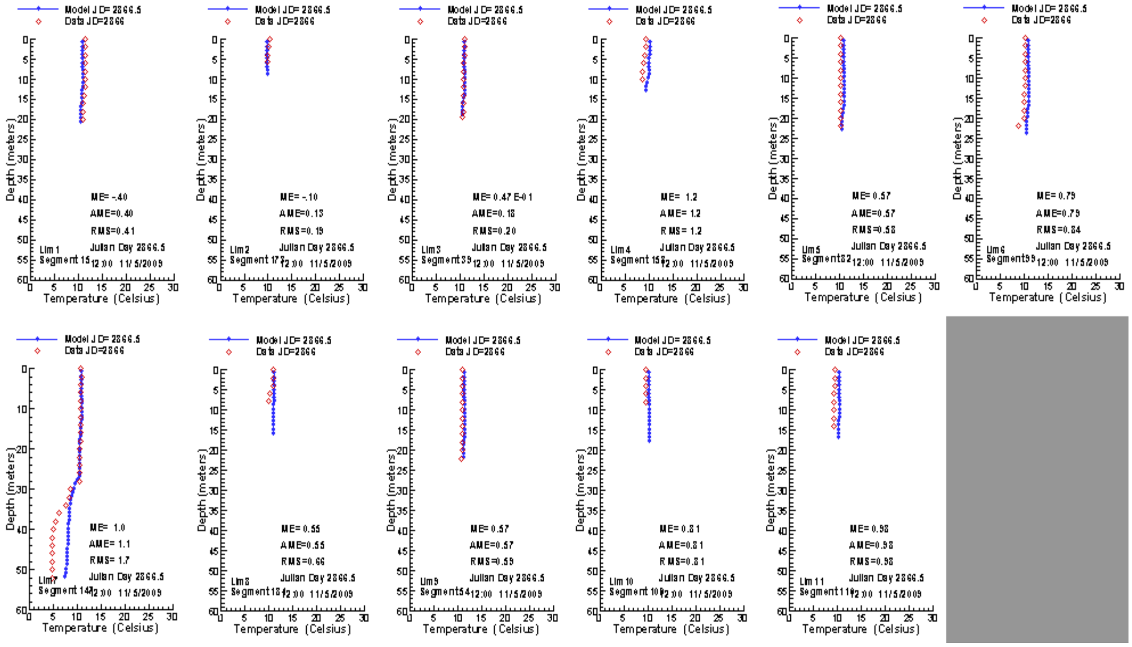

Model JD= 2810.5
Data JD=2810
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.12
AME=0.12
RMS=0.16
Julian Day 2810.5
12:00 9/10/2009
Lim 1
Segment 15
ME= -.26
AME=0.26
RMS=0.28
Lim 2
Segment 173
ME= -.70
AME=0.70
RMS=0.86
Lim3
Segment39
ME= -.19
AME=0.19
RMS=0.22
Lim 4
Segment 158
ME= 0.44E-02
AME=0.38
RMS=0.45
Lim 5
Segment82
ME= 0.81E-01
AME=0.43
RMS=0.49
Lim 6
Segment99
ME= 0.42
AME= 1.1
RMS= 1.4
Lim7
Segment 147
ME= 0.46
AME=0.46
RMS=0.49
Lim 8
Segment 184
ME= -.21
AME=0.46
RMS=0.68
Lim 9
Segment54
ME= 0.16
AME=0.16
RMS=0.17
Lim 10
Segment 109
ME= 0.55
AME=0.55
RMS=0.60
Lim 11
Segment 119


Model JD= 2824.5
Data JD=2824
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.41
AME=0.41
RMS=0.43
Lim 1
Segment 15
Julian Day 2824.5
12:00 9/24/2009
ME= -.48
AME=0.48
RMS=0.49
Lim2
Segment 173
Julian Day 2824.5
12:00 9/24/2009
ME= -.15
AME=0.28
RMS=0.30
Lim3
Segment39
Julian Day 2824.5
12:00 9/24/2009
ME= 0.19
AME=0.26
RMS=0.29
Lim4
Segment 158
Julian Day 2824.5
12:00 9/24/2009
ME= -.80 E-01
AME=0.24
RMS=0.31
Lim5
Segment82
Julian Day 2824.5
12:00 9/24/2009
ME= -.33
AME=0.36
RMS=0.57
Lim6
Segment99
Julian Day 2824.5
12:00 9/24/2009
ME= 0.85
AME= 1.3
RMS= 1.8
Lim7
Segment 147
Julian Day 2824.5
12:00 9/24/2009
ME= 0.68 E-01
AME=0.22
RMS=0.27
Lim8
Segment184
Julian Day 2824.5
12:00 9/24/2009
ME= -.38
AME=0.43
RMS=0.46
Lim9
Segment54
Julian Day 2824.5
12:00 9/24/2009
ME= 0.34
AME=0.34
RMS=0.38
Lim 10
Segment 109
Julian Day 2824.5
12:00 9/24/2009
ME= 0.27
AME=0.27
RMS=0.28
Lim 11
Segment119
Julian Day 2824.5
12:00 9/24/2009

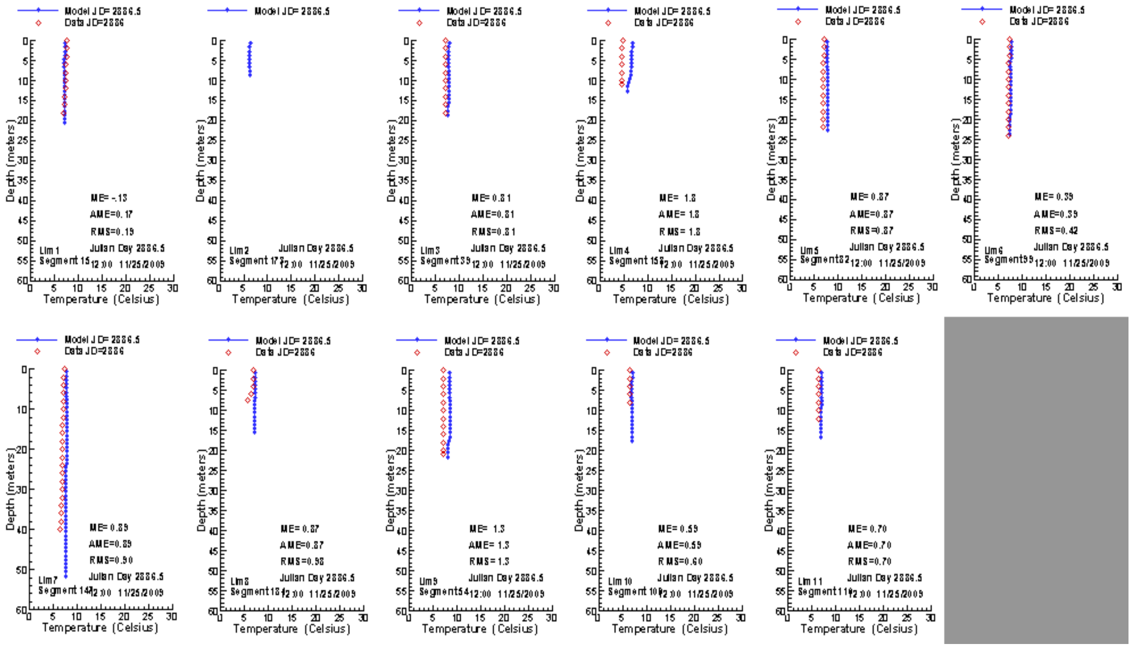

Model JD= 2838.5
Data JD=2838
Depth (meters)
Temperature (Celsius)
0 5 10 15 20 25 30
0 5 10 15 20 25 30 35 40 45 50 55 60
ME= -.51 E-01
AME=0.59 E-01
RMS=0.62 E-01
Lim 1
Segment 15
Julian Day 2838.5
12:00 10/8/2009
ME= 0.46
AME=0.46
RMS=0.57
Lim2
Segment 173
Julian Day 2838.5
12:00 10/8/2009
ME= 0.42
AME=0.42
RMS=0.42
Lim3
Segment39
Julian Day 2838.5
12:00 10/8/2009
ME= 1.0
AME= 1.0
RMS= 1.1
Lim4
Segment 158
Julian Day 2838.5
12:00 10/8/2009
Model JD= 2838.5
Lim5
Segment82
Julian Day 2838.5
12:00 10/8/2009
ME= 0.89
AME=0.89
RMS=0.89
Lim6
Segment99
Julian Day 2838.5
12:00 10/8/2009
ME= 0.54
AME=0.67
RMS= 1.1
Lim7
Segment 147
Julian Day 2838.5
12:00 10/8/2009
ME= 1.3
AME= 1.3
RMS= 1.4
Lim8
Segment184
Julian Day 2838.5
12:00 10/8/2009
ME= 0.71
AME=0.86
RMS=0.87
Lim9
Segment54
Julian Day 2838.5
12:00 10/8/2009
ME= 1.4
AME= 1.4
RMS= 1.4
Lim 10
Segment 109
Julian Day 2838.5
12:00 10/8/2009
ME= 0.91
AME=0.91
RMS=0.91
Lim 11
Segment119
Julian Day 2838.5
12:00 10/8/2009

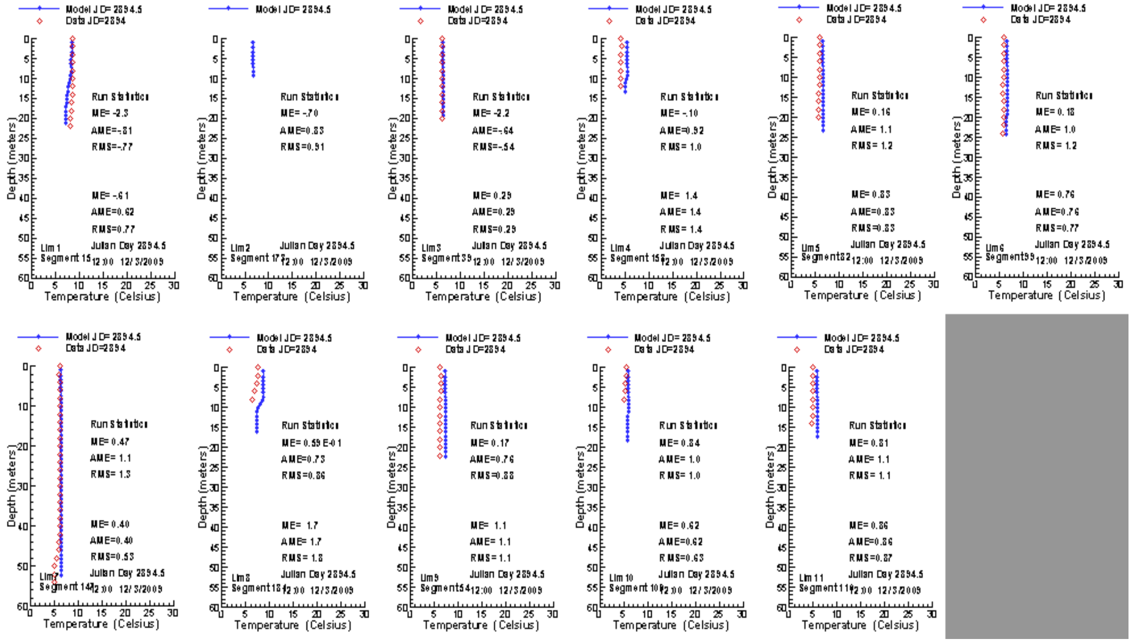


Model JD= 2852.5
Data JD=2852
Depth (meters)
Temperature (Celsius)
ME= -.56
AME=0.56
RMS=0.58
Lim 1
Segment 15
Julian Day 2852.5
12:00 10/22/2009
ME= -.73
AME=0.73
RMS=0.81
Lim 2
Segment 173
Julian Day 2852.5
12:00 10/22/2009
ME= 0.11
AME=0.12
RMS=0.13
Lim3
Segment39
Julian Day 2852.5
12:00 10/22/2009
ME= 0.82
AME=0.82
RMS=0.83
Lim 4
Segment 158
Julian Day 2852.5
12:00 10/22/2009
ME= 0.61
AME=0.61
RMS=0.61
Lim5
Segment82
Julian Day 2852.5
12:00 10/22/2009
ME= 0.84
AME=0.84
RMS=0.84
Lim6
Segment99
Julian Day 2852.5
12:00 10/22/2009
ME= 0.36
AME=0.63
RMS= 1.0
Lim7
Segment 147
Julian Day 2852.5
12:00 10/22/2009
ME= 0.45
AME=0.49
RMS=0.56
Lim8
Segment181
Julian Day 2852.5
12:00 10/22/2009
ME= 0.66
AME=0.66
RMS=0.66
Lim9
Segment54
Julian Day 2852.5
12:00 10/22/2009
ME= 0.84
AME=0.84
RMS=0.84
Lim 10
Segment 109
Julian Day 2852.5
12:00 10/22/2009
ME= 0.71
AME=0.71
RMS=0.71
Lim 11
Segment119
Julian Day 2852.5
12:00 10/22/2009

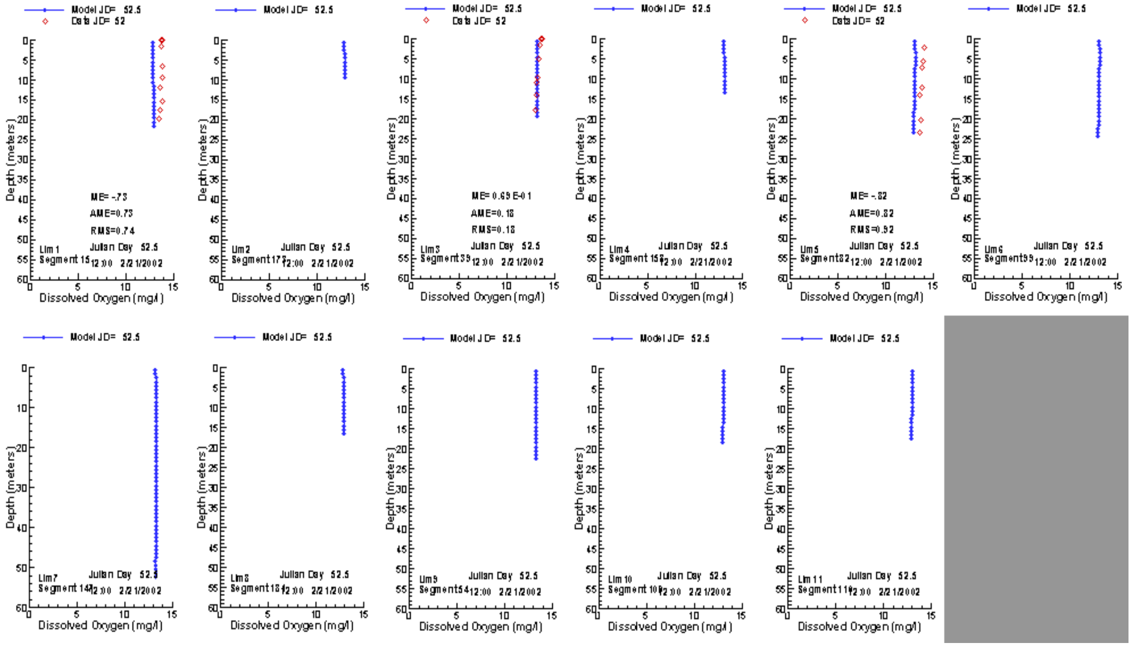


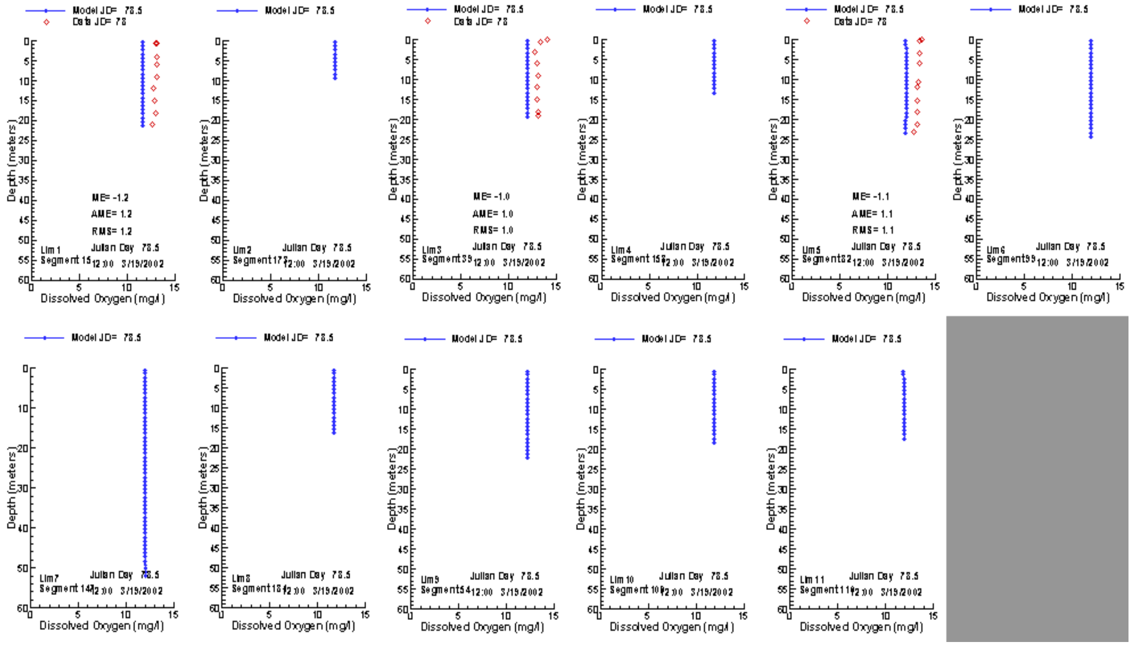
Model JD= 2866.5
Data JD=2866
Depth (meters)
Temperature (Celsius)
ME= -.40
AME=0.40
RMS=0.41
Lim 1
Segment 15
Julian Day 2866.5
12:00 11/5/2009
ME= -.10
AME=0.13
RMS=0.19
Lim 2
Segment 173
Julian Day 2866.5
12:00 11/5/2009
ME= 0.47 E-01
AME=0.18
RMS=0.20
Lim3
Segment39
Julian Day 2866.5
12:00 11/5/2009
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 4
Segment 158
Julian Day 2866.5
12:00 11/5/2009
ME= 0.57
AME=0.57
RMS=0.58
Lim5
Segment82
Julian Day 2866.5
12:00 11/5/2009
ME= 0.79
AME=0.79
RMS=0.84
Lim6
Segment99
Julian Day 2866.5
12:00 11/5/2009
ME= 1.0
AME= 1.1
RMS= 1.7
Lim7
Segment 147
Julian Day 2866.5
12:00 11/5/2009
ME= 0.55
AME=0.55
RMS=0.66
Lim8
Segment181
Julian Day 2866.5
12:00 11/5/2009
ME= 0.57
AME=0.57
RMS=0.59
Lim9
Segment54
Julian Day 2866.5
12:00 11/5/2009
ME= 0.81
AME=0.81
RMS=0.81
Lim 10
Segment 109
Julian Day 2866.5
12:00 11/5/2009
ME= 0.98
AME=0.98
RMS=0.98
Lim 11
Segment119
Julian Day 2866.5
12:00 11/5/2009

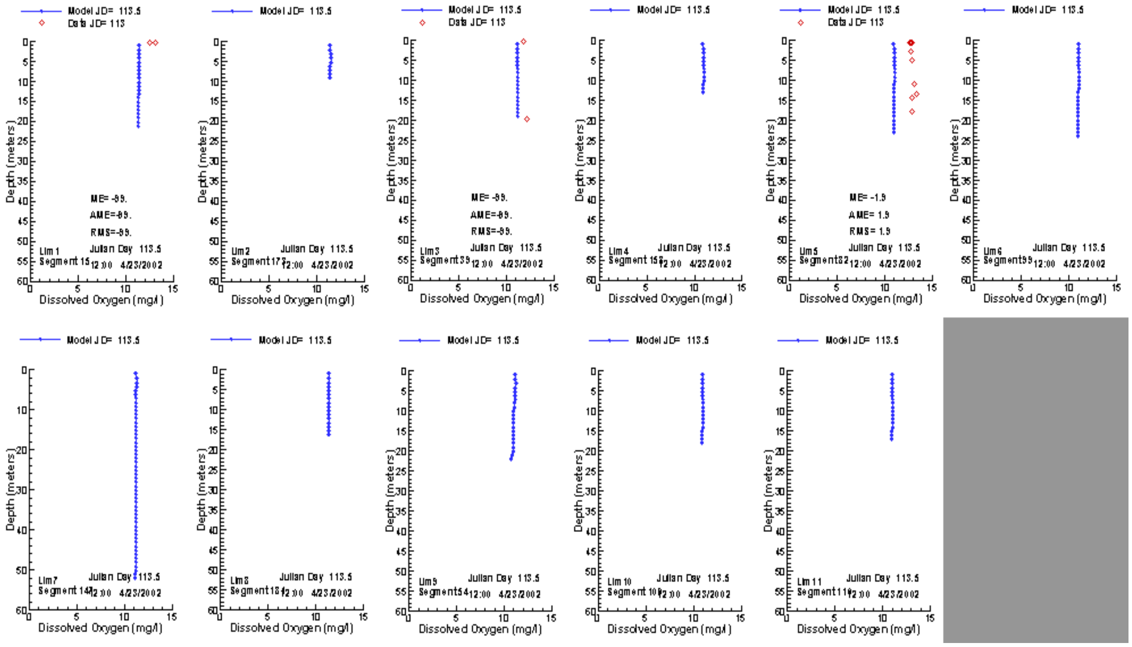

Model JD= 2886.5
Data JD=2886
Depth (meters)
Temperature (Celsius)
ME= -.13
AME=0.17
RMS=0.19
Lim1
Segment 15
Julian Day 2886.5
12:00 11/25/2009
ME= 0.81
AME=0.81
RMS=0.81
Lim2
Segment 17
Lim3
Segment39
ME= 1.8
AME= 1.8
RMS= 1.8
Lim4
Segment 15
ME= 0.87
AME=0.87
RMS=0.87
Lim5
Segment32
ME= 0.39
AME=0.39
RMS=0.42
Lim6
Segment99
ME= 0.89
AME=0.89
RMS=0.90
Lim7
Segment 14
ME= 0.87
AME=0.87
RMS=0.98
Lim8
Segment18
ME= 1.3
AME= 1.3
RMS= 1.3
Lim9
Segment54
ME= 0.59
AME=0.59
RMS=0.60
Lim 10
Segment 10
ME= 0.70
AME=0.70
RMS=0.70
Lim 11
Segment11

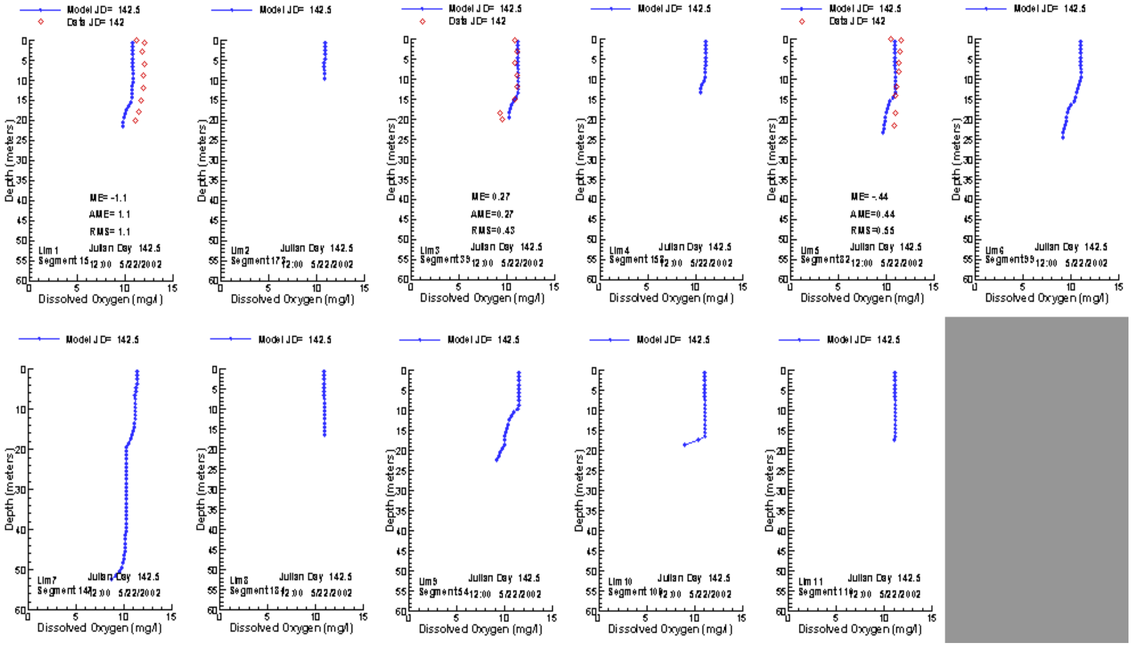

Model JD= 2894.5
Data JD=2894
Depth (meters)
Temperature (Celsius)
Run Statistics
Julian Day 2894.5
12:00 12/3/2009
Lim1
Segment 15
ME= -2.3
AME=-.81
RMS=-.77
ME= -.61
AME=0.62
RMS=0.77
Lim2
Segment 17
ME= -.70
AME=0.83
RMS=0.91
Lim3
Segment39
ME= -2.2
AME=-.64
RMS=-.54
ME= 0.29
AME=0.29
RMS=0.29
Lim4
Segment 15
ME= -.10
AME=0.92
RMS= 1.0
ME= 1.4
AME= 1.4
RMS= 1.4
Lim5
Segment32
ME= 0.16
AME= 1.1
RMS= 1.2
ME= 0.83
AME=0.83
RMS=0.83
Lim6
Segment99
ME= 0.18
AME= 1.0
RMS= 1.2
ME= 0.76
AME=0.76
RMS=0.77
Lim7
Segment 14
ME= 0.47
AME= 1.1
RMS= 1.3
ME= 0.40
AME=0.40
RMS=0.53
Lim8
Segment18
ME= 0.59 E-01
AME=0.73
RMS=0.86
ME= 1.7
AME= 1.7
RMS= 1.8
Lim9
Segment54
ME= 0.17
AME=0.76
RMS=0.88
ME= 1.1
AME= 1.1
RMS= 1.1
Lim 10
Segment 10
ME= 0.84
AME= 1.0
RMS= 1.0
ME= 0.62
AME=0.62
RMS=0.63
Lim 11
Segment11
ME= 0.81
AME= 1.1
RMS= 1.1
ME= 0.86
AME=0.86
RMS=0.87

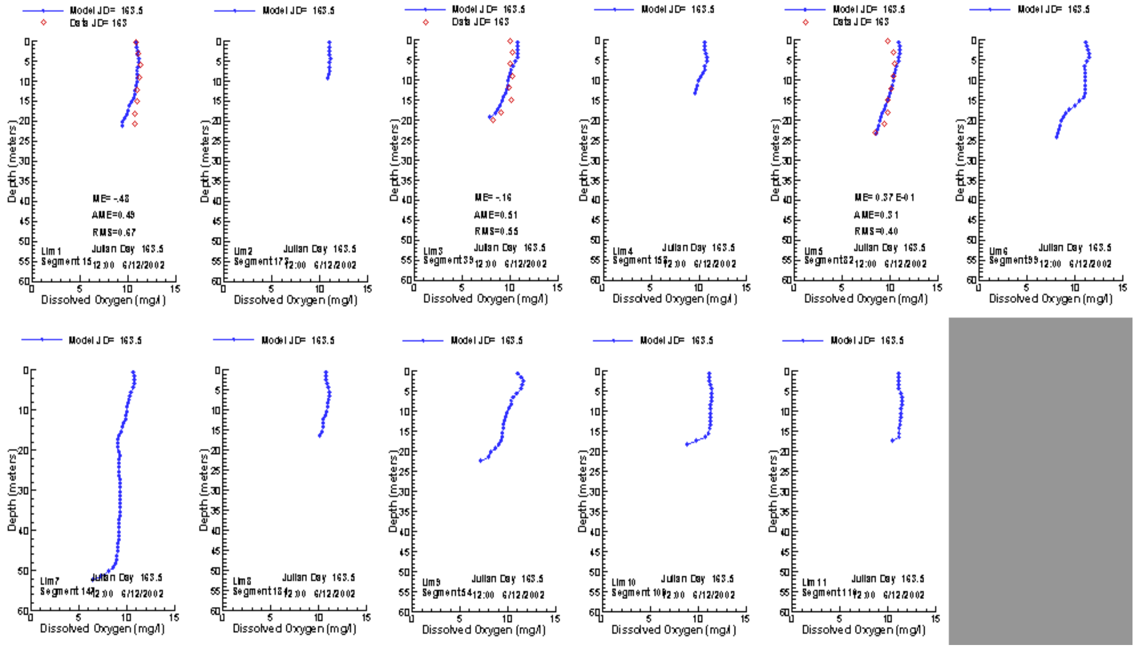
# Appendix C: Dissolved Oxygen Calibration Profiles

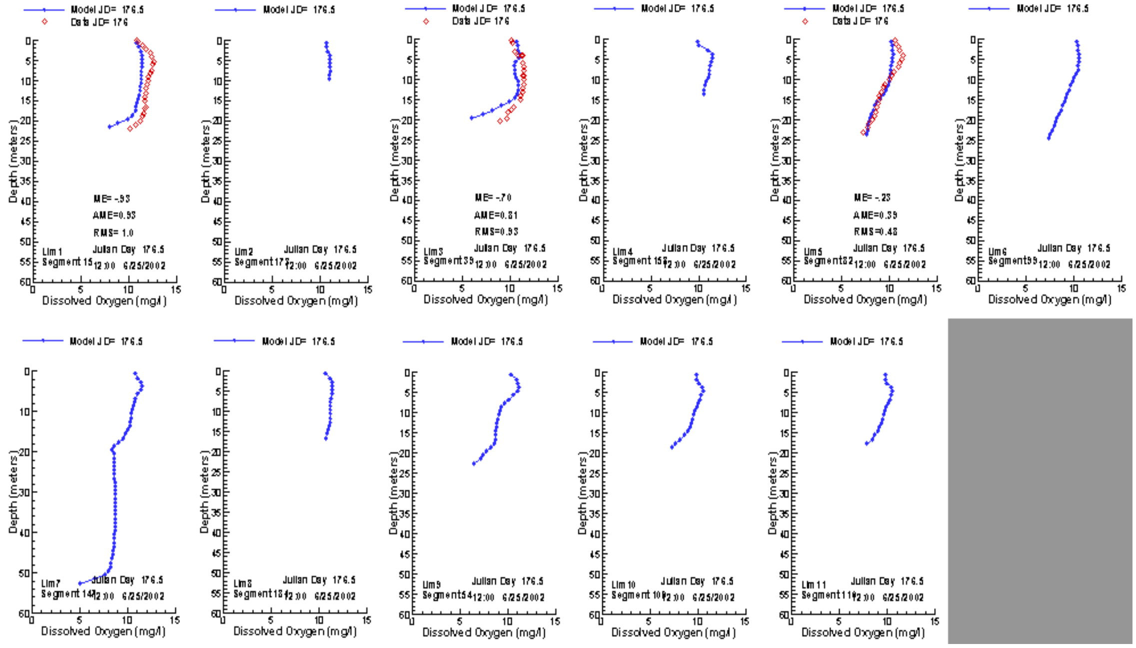


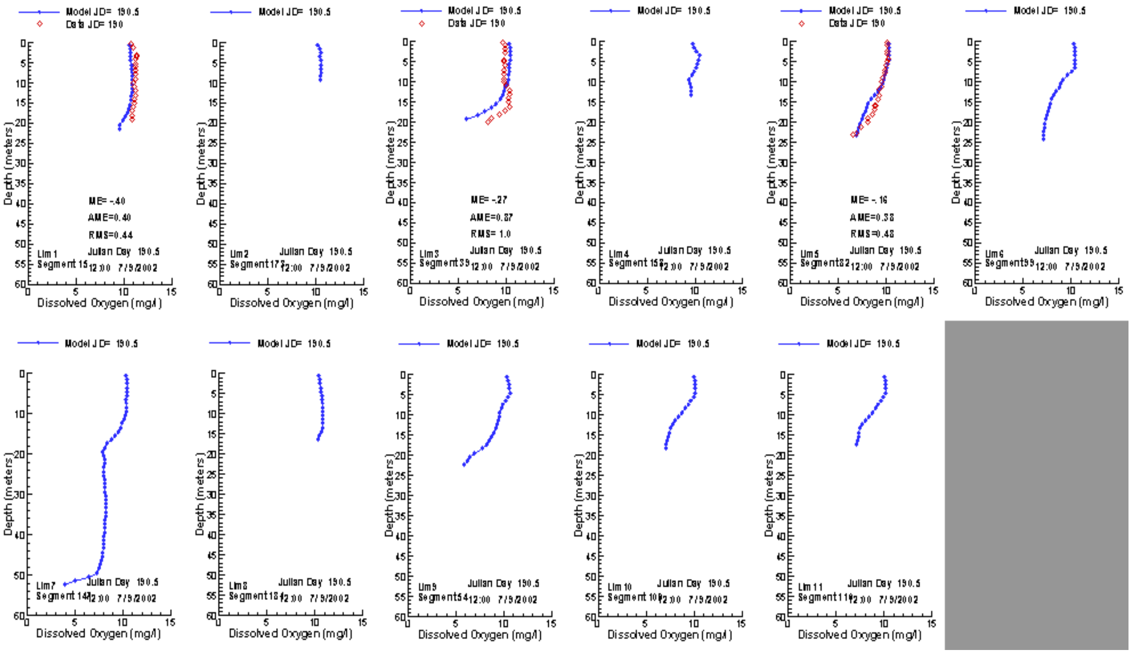


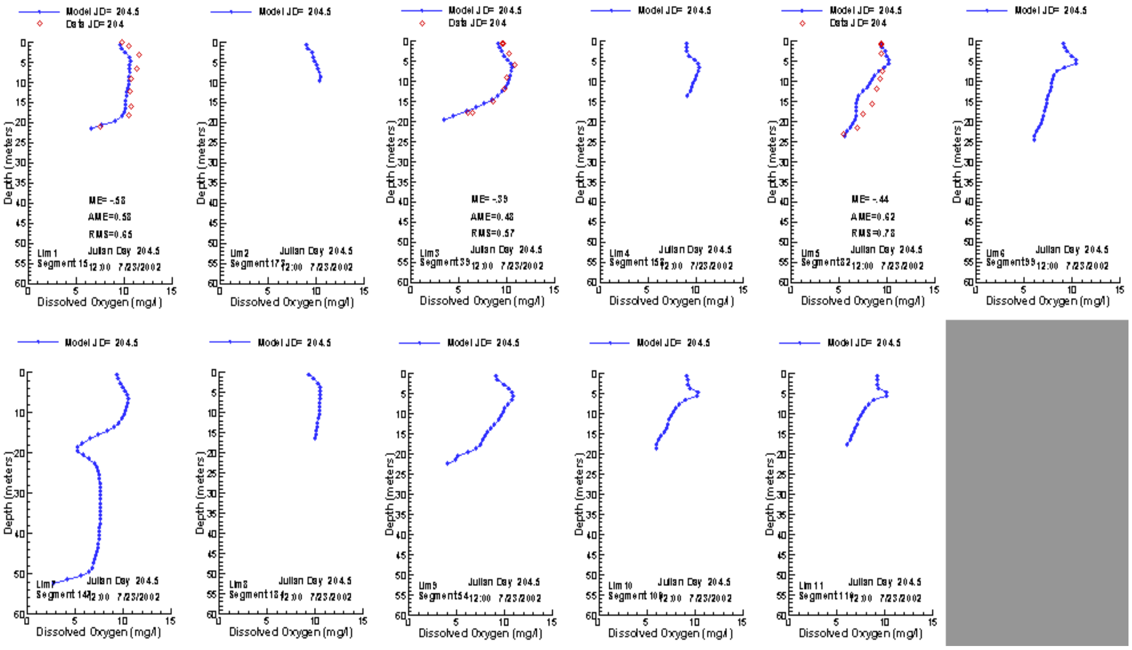

Model JD= 113.5
Data JD= 113
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -99.
AME=-99.
RMS=-99.
Lim1
Segment 15
Julian Day 113.5
12:00 4/23/2002
Lim2
Segment 17
Lim3
Segment39
Lim4
Segment 15
ME= -1.9
AME= 1.9
RMS= 1.9
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11

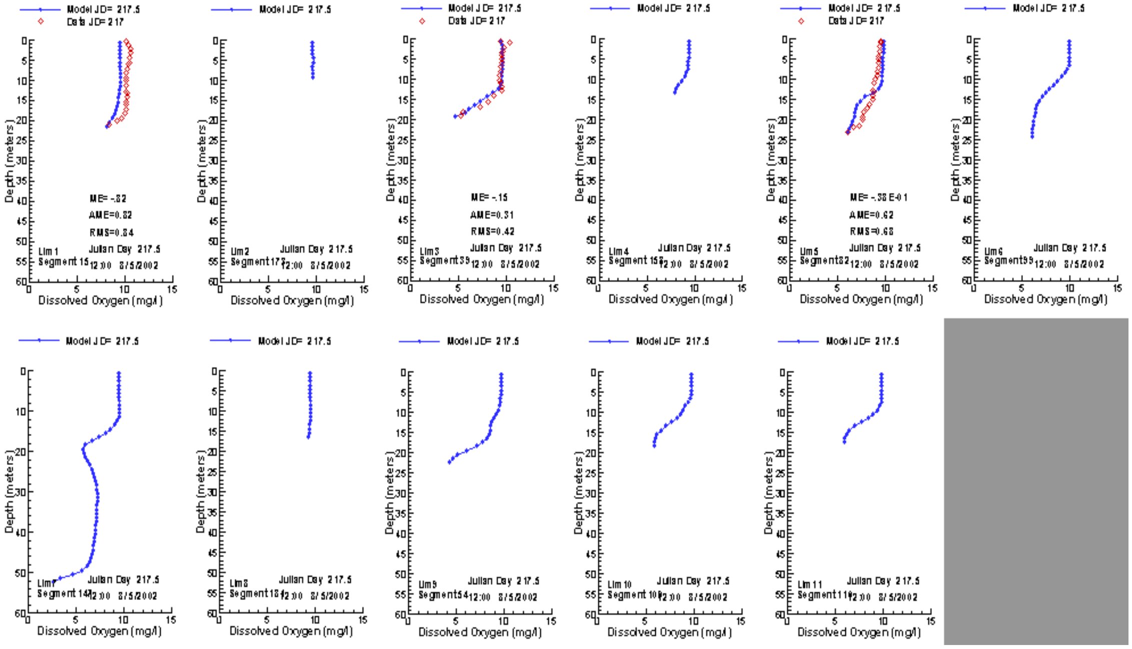

Model JD= 142.5
Data JD= 142
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -1.1
AME= 1.1
RMS= 1.1
Lim1
Segment 15
Julian Day 142.5
12:00 5/22/2002
Lim2
Segment 17
ME= 0.27
AME=0.27
RMS=0.43
Lim3
Segment39
Lim4
Segment 15
ME= -.44
AME=0.44
RMS=0.55
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11

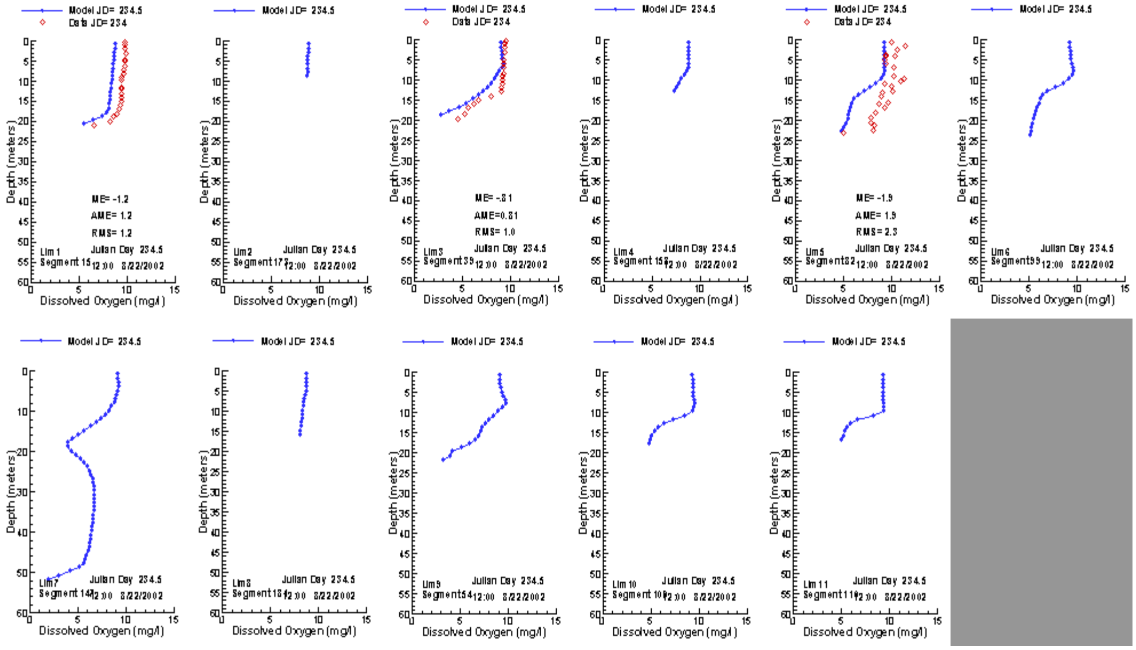

Model JD= 163.5
Data JD= 163
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.48
AME=0.49
RMS=0.67
Lim 1
Segment 15
Julian Day 163.5
12:00 6/12/2002
Lim2
Segment17
ME= -.16
AME=0.51
RMS=0.55
Lim3
Segment39
Lim4
Segment 15
ME= 0.37 E-01
AME=0.31
RMS=0.40
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11

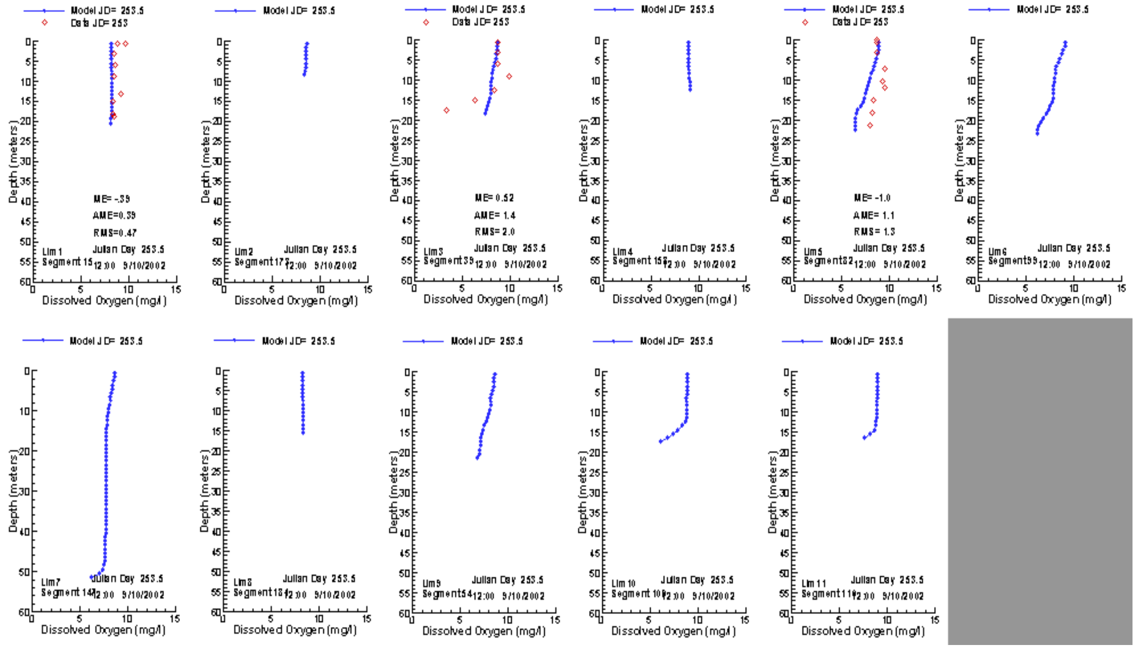

Model JD= 176.5
Data JD= 176
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.93
AME=0.93
RMS= 1.0
Lim 1
Segment 15
Julian Day 176.5
12:00 6/25/2002
Lim2
Segment17
ME= -.70
AME=0.81
RMS=0.93
Lim3
Segment39
Lim4
Segment 15
ME= -.23
AME=0.39
RMS=0.48
Lim5
Segment82
Lim6
Segment99
Lim7
Segment 14
Lim8
Segment18
Lim9
Segment54
Lim 10
Segment 10
Lim 11
Segment 11

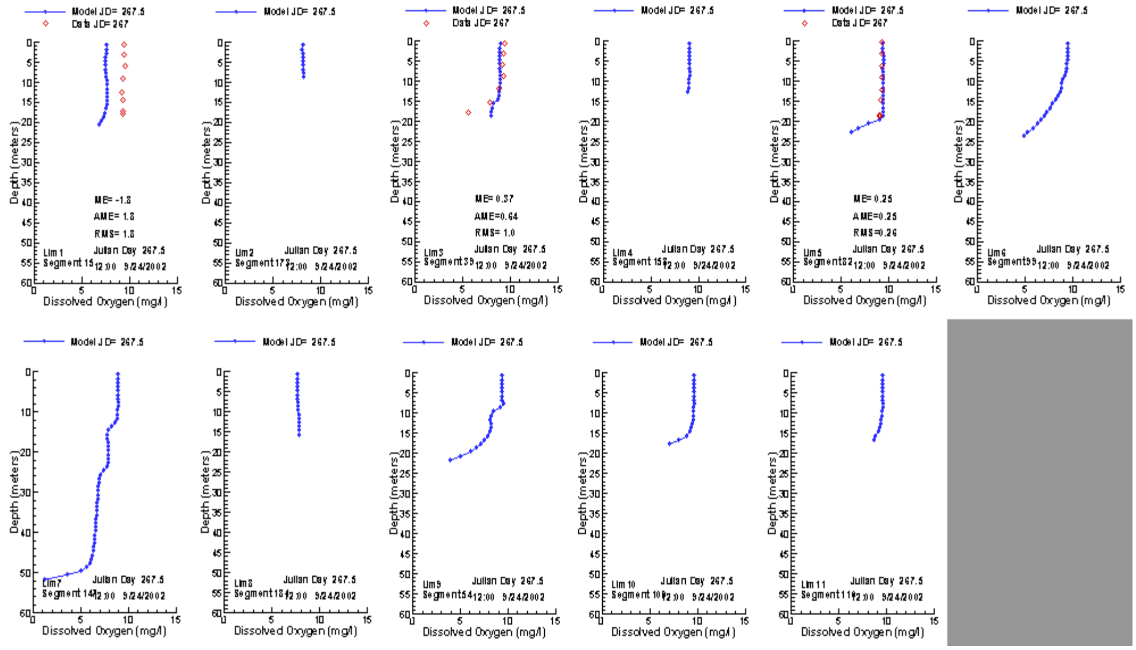

Model JD= 190.5
Data JD= 190
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -.40
AME=0.40
RMS=0.44
Lim 1
Segment 15
Julian Day 190.5
12:00 7/9/2002
Lim 2
Segment 17
ME= -.27
AME=0.87
RMS= 1.0
Lim 3
Segment 39
Lim 4
Segment 15
ME= -.16
AME=0.38
RMS=0.48
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

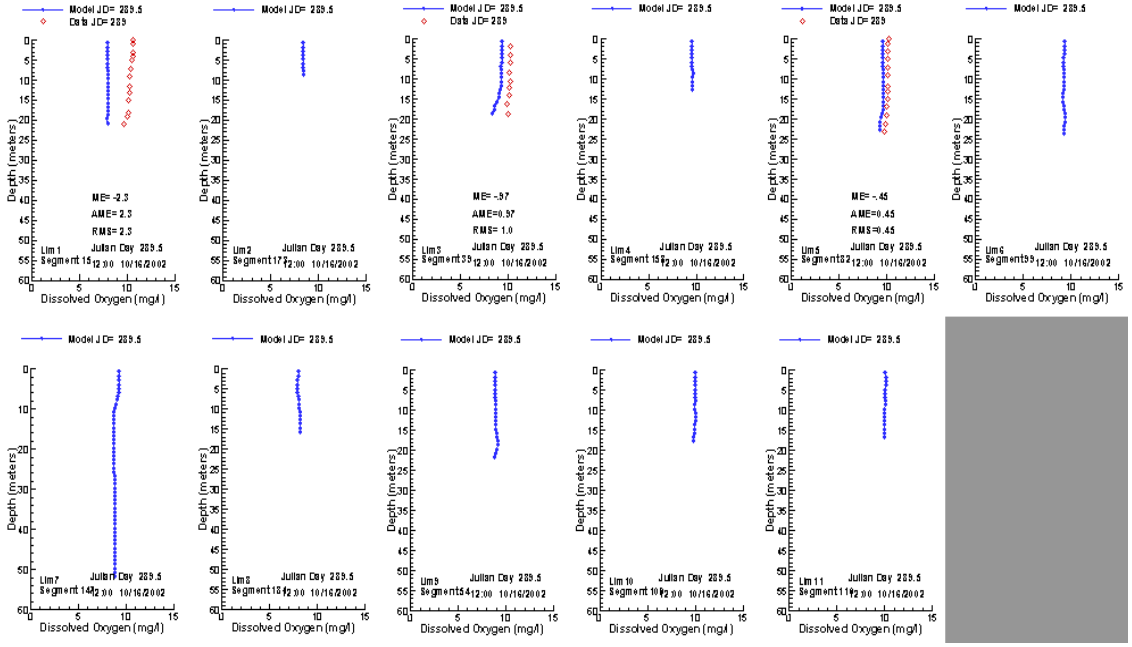

Model JD= 204.5
Data JD= 204
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -.58
AME=0.58
RMS=0.65
Lim 1
Segment 15
Julian Day 204.5
12:00 7/23/2002
Lim 2
Segment 17
ME= -.39
AME=0.48
RMS=0.57
Lim 3
Segment 39
Lim 4
Segment 15
ME= -.44
AME=0.62
RMS=0.78
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

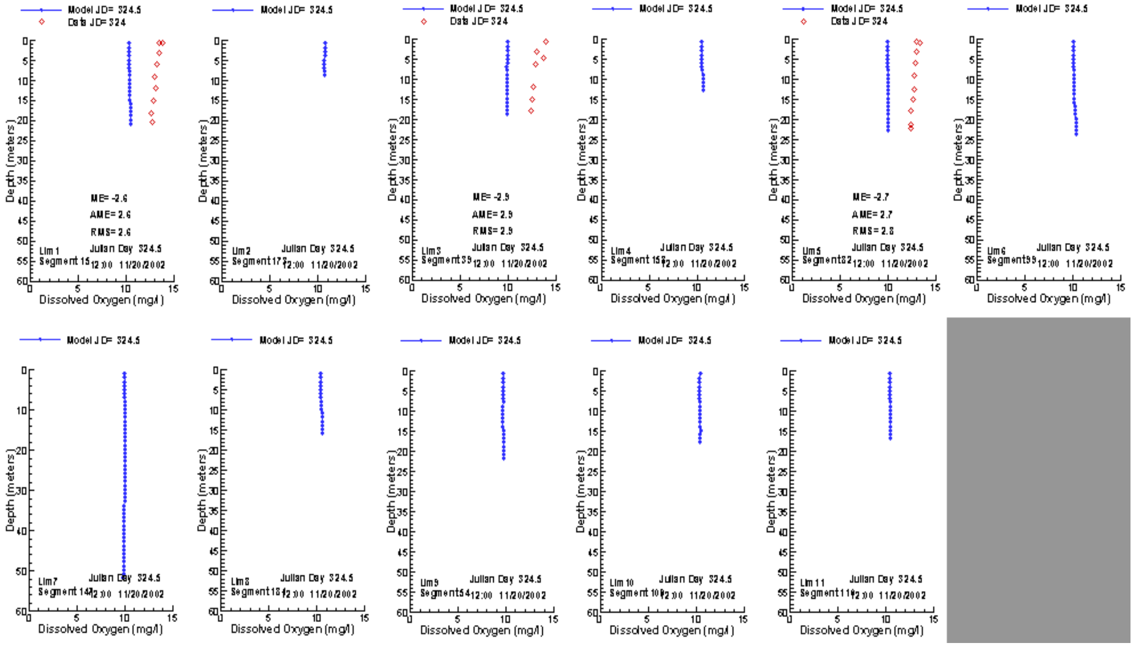

Model JD= 217.5
Data JD= 217
ME= -.82
AME=0.82
RMS=0.84
Lim1
Segment 15
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim2
Segment 17
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Data JD= 217
ME= -.15
AME=0.31
RMS=0.42
Lim3
Segment39
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim4
Segment 15
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Data JD= 217
ME= -.38E-01
AME=0.62
RMS=0.68
Lim5
Segment82
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim6
Segment99
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim7
Segment 14
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim8
Segment 18
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim9
Segment54
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim 10
Segment 10
Julian Day 217.5
12:00 8/5/2002
Model JD= 217.5
Lim 11
Segment 11
Julian Day 217.5
12:00 8/5/2002
Depth (meters)
0
5
10
15
20
25
30
35
40
45
50
55
60
Dissolved Oxygen (mg/l)
0
5
10
15

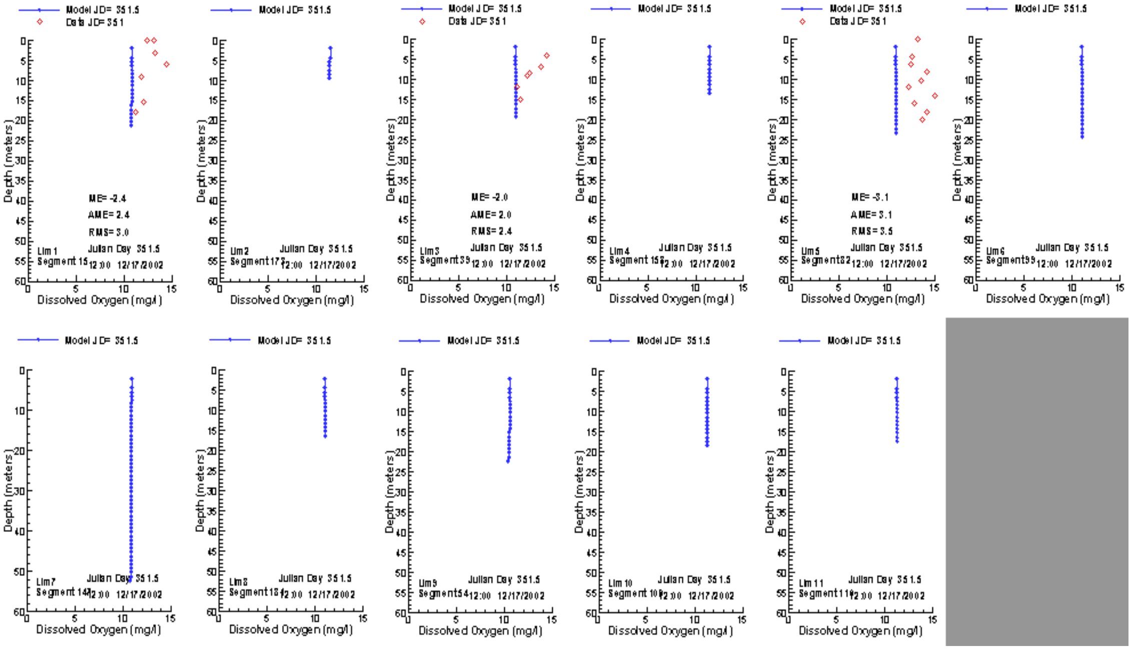

Model JD= 234.5
Data JD= 234
ME= -1.2
AME= 1.2
RMS= 1.2
Lim1
Segment 15
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim2
Segment 17
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Data JD= 234
ME= -.81
AME=0.81
RMS= 1.0
Lim3
Segment39
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim4
Segment 15
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Data JD= 234
ME= -1.9
AME= 1.9
RMS= 2.3
Lim5
Segment82
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim6
Segment99
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim7
Segment 14
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim8
Segment 18
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim9
Segment54
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim 10
Segment 10
Julian Day 234.5
12:00 8/22/2002
Model JD= 234.5
Lim 11
Segment 11
Julian Day 234.5
12:00 8/22/2002
Depth (meters)
0
5
10
15
20
25
30
35
40
45
50
55
60
Dissolved Oxygen (mg/l)
0
5
10
15


Model JD= 253.5
Data JD= 253
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.39
AME=0.39
RMS=0.47
Lim 1
Segment 15
Julian Day 253.5
12:00 9/10/2002
Lim2
Segment 17
ME= 0.52
AME= 1.4
RMS= 2.0
Lim3
Segment 39
Lim4
Segment 15
ME= -1.0
AME= 1.1
RMS= 1.3
Lim5
Segment 82
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11
0
5
10
15
20
25
30
35
40
45
50
55
60

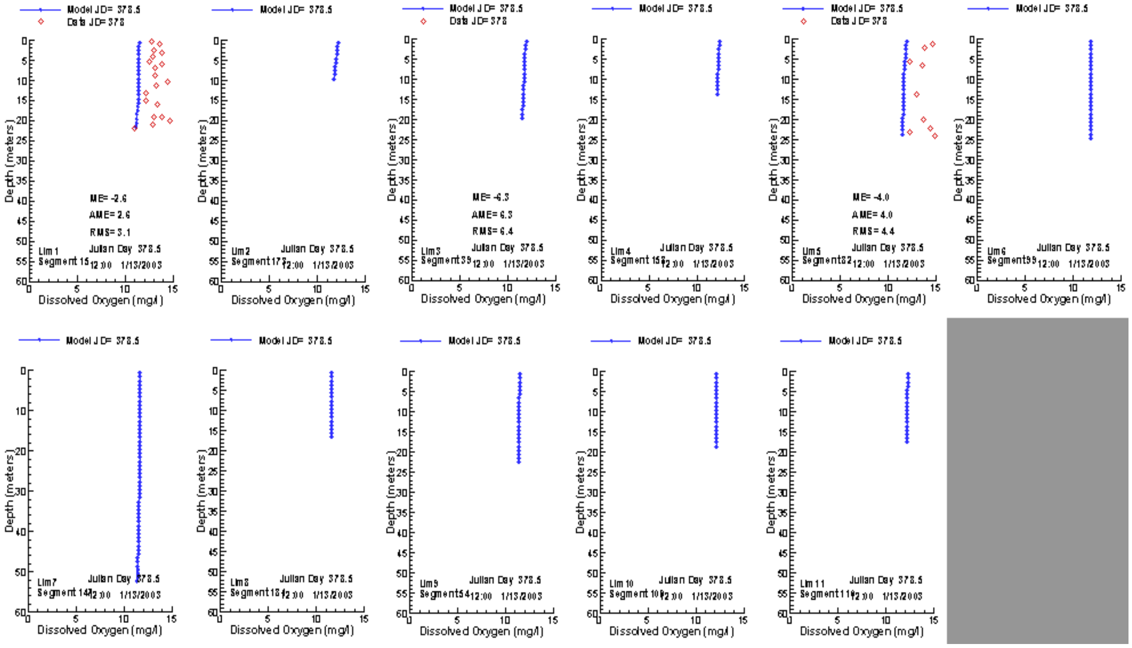

Model JD= 267.5
Data JD= 267
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 1
Segment 15
Julian Day 267.5
12:00 9/24/2002
Lim2
Segment 17
ME= 0.37
AME=0.64
RMS= 1.0
Lim3
Segment 39
Lim4
Segment 15
ME= 0.25
AME=0.25
RMS=0.26
Lim5
Segment 82
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11
0
5
10
15
20
25
30
35
40
45
50
55
60


Model JD= 289.5
Data JD= 289
ME= -2.3
AME= 2.3
RMS= 2.3
Lim 1
Segment 15
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 2
Segment 17
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Data JD= 289
ME= -.97
AME=0.97
RMS= 1.0
Lim 3
Segment 39
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 4
Segment 15
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Data JD= 289
ME= -.45
AME=0.45
RMS=0.45
Lim 5
Segment 82
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 6
Segment 99
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 7
Segment 14
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 8
Segment 18
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 9
Segment 54
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 10
Segment 10
Julian Day 289.5
12:00 10/16/2002
Model JD= 289.5
Lim 11
Segment 11
Julian Day 289.5
12:00 10/16/2002
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60

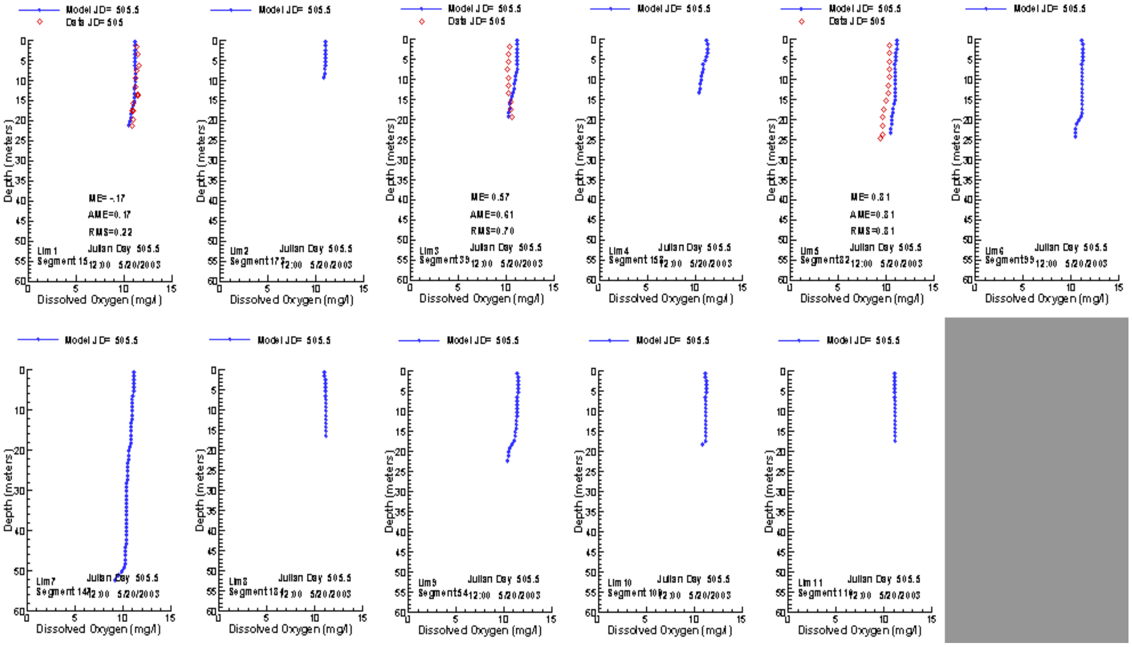

Model JD= 324.5
Data JD= 324
ME= -2.6
AME= 2.6
RMS= 2.6
Lim 1
Segment 15
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 2
Segment 17
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Data JD= 324
ME= -2.9
AME= 2.9
RMS= 2.9
Lim 3
Segment 39
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 4
Segment 15
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Data JD= 324
ME= -2.7
AME= 2.7
RMS= 2.8
Lim 5
Segment 82
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 6
Segment 99
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 7
Segment 14
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 8
Segment 18
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 9
Segment 54
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 10
Segment 10
Julian Day 324.5
12:00 11/20/2002
Model JD= 324.5
Lim 11
Segment 11
Julian Day 324.5
12:00 11/20/2002
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60

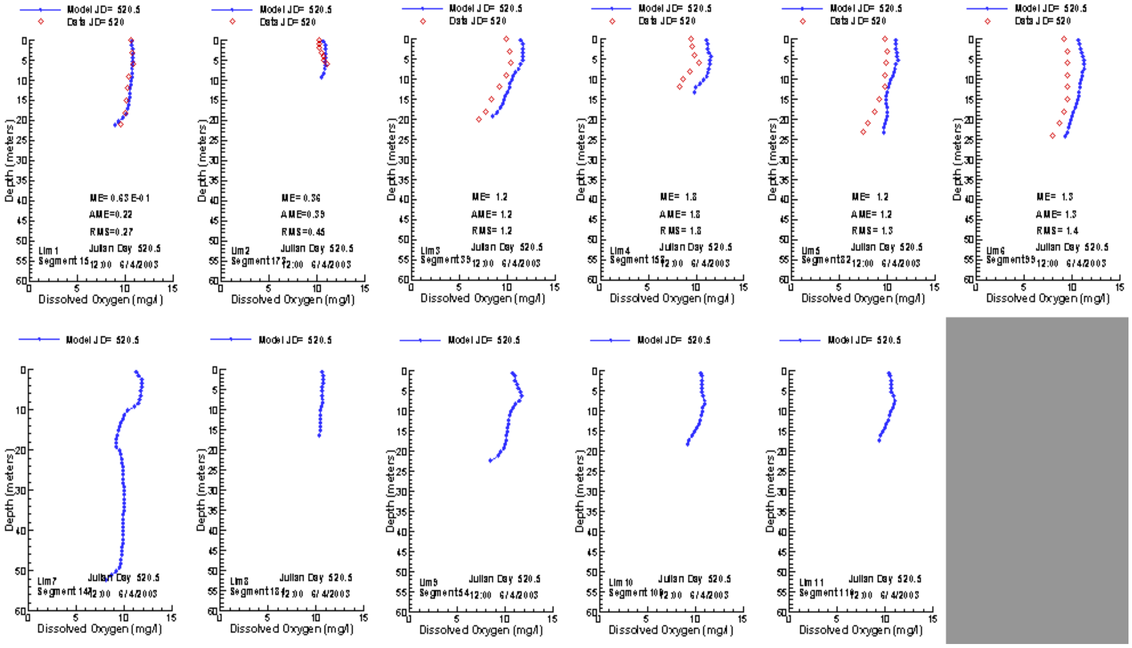


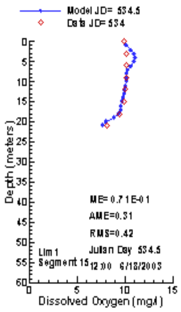
Model JD= 351.5
Data JD= 351
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -2.4
AME= 2.4
RMS= 3.0
Lim1 Segment 15
Julian Day 351.5 12:00 12/17/2002
Lim2 Segment 17
Lim3 Segment 33
ME= -2.0
AME= 2.0
RMS= 2.4
Lim4 Segment 15
Lim5 Segment 82
ME= -3.1
AME= 3.1
RMS= 3.5
Lim6 Segment 93
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11

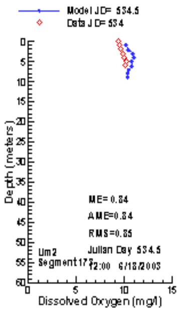


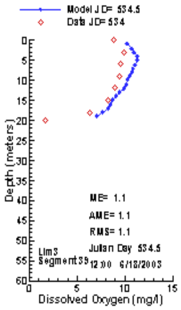
Model JD= 378.5
Data JD= 378
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -2.6
AME= 2.6
RMS= 3.1
Lim1 Segment 15
Julian Day 378.5 12:00 1/13/2003
Lim2 Segment 17
Lim3 Segment 33
ME= -6.3
AME= 6.3
RMS= 6.4
Lim4 Segment 15
Lim5 Segment 82
ME= -4.0
AME= 4.0
RMS= 4.4
Lim6 Segment 93
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11

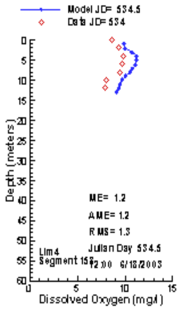

Model JD= 505.5
Data JD= 505
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.17
AME=0.17
RMS=0.22
Lim 1
Segment 15
Julian Day 505.5
12:00 5/20/2003
Lim 2
Segment 173
ME= 0.57
AME=0.61
RMS=0.70
Lim 3
Segment 39
Lim 4
Segment 158
ME= 0.81
AME=0.81
RMS=0.81
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 143
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

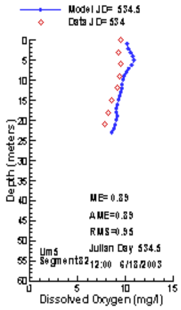

Model JD= 520.5
Data JD= 520
Depth (meters)
Dissolved Oxygen (mg/l)
ME= 0.63E-01
AME=0.22
RMS=0.27
Lim 1
Segment 15
Julian Day 520.5
12:00 6/4/2003
ME= 0.36
AME=0.39
RMS=0.45
Lim 2
Segment 173
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 3
Segment 39
ME= 1.8
AME= 1.8
RMS= 1.8
Lim 4
Segment 158
ME= 1.2
AME= 1.2
RMS= 1.3
Lim 5
Segment 82
ME= 1.3
AME= 1.3
RMS= 1.4
Lim 6
Segment 99
Lim 7
Segment 143
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

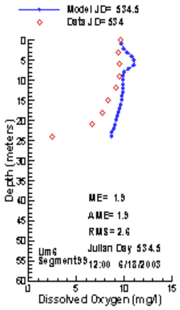

Model JD= 534.5
Data JD= 534
Depth (meters)
ME=0.71E-01
AME=0.31
RMS=0.42
Lim 1
Segment 15
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

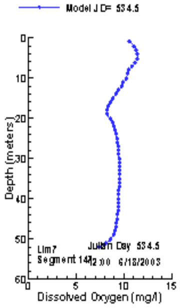

Model JD= 534.5
Data JD= 534
Depth (meters)
ME=0.84
AME=0.84
RMS=0.85
Lim2
Segment173
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

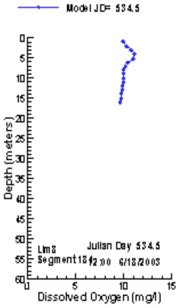

Model JD= 534.5
Data JD= 534
Depth (meters)
ME= 1.1
AME= 1.1
RMS= 1.1
Lim3
Segment39
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

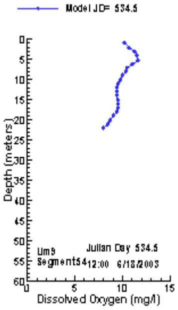

Model JD= 534.5
Data JD= 534
Depth (meters)
ME= 1.2
AME= 1.2
RMS= 1.3
Lim4
Segment 158
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

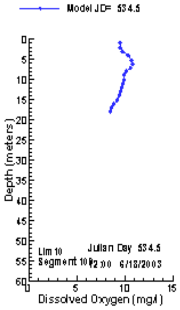

Model JD= 534.5
Data JD= 534
Depth (meters)
ME=0.89
AME=0.89
RMS=0.95
Lim5
Segment82
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

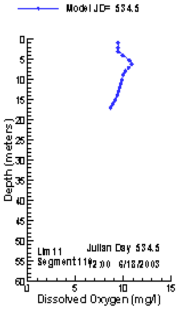

Model JD= 534.5
Data JD= 534
Depth (meters)
ME= 1.9
AME= 1.9
RMS= 2.6
Lim6
Segment99
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

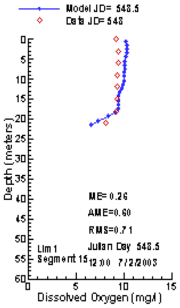

Model JD= 534.5
Depth (meters)
Lim7
Segment 147
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

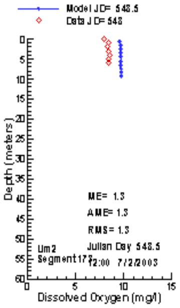

Model JD= 534.5
Depth (meters)
Lim8
Segment18
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

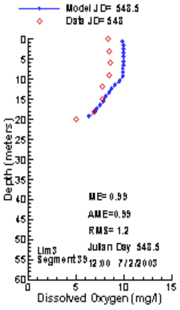

Model JD= 534.5
Depth (meters)
Lim9
Segment54
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

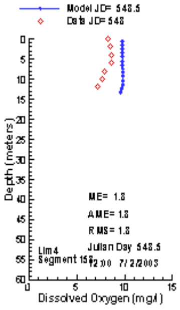

Model JD= 534.5
Depth (meters)
Lim 10
Segment 10
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

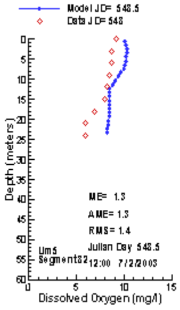

Model JD= 534.5
Depth (meters)
Lim 11
Segment11
Julian Day 534.5
12:00 6/18/2003
Dissolved Oxygen (mg/l)

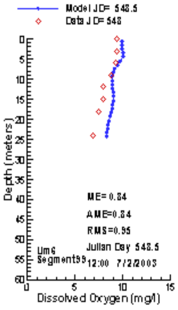

Model JD= 548.5
Data JD= 548
Depth (meters)
ME=0.26
AME=0.60
RMS=0.71
Lim 1
Segment 15
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

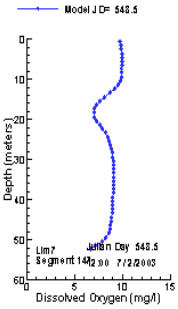

Model JD= 548.5
Data JD= 548
Depth (meters)
ME= 1.3
AME= 1.3
RMS= 1.3
Lim2
Segment173
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

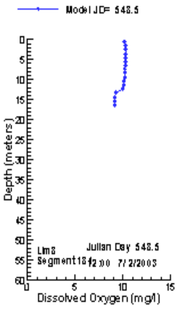

Model JD= 548.5
Data JD= 548
Depth (meters)
ME=0.99
AME=0.99
RMS= 1.2
Lim3
Segment39
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

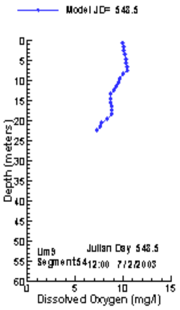

Model JD= 548.5
Data JD= 548
Depth (meters)
ME= 1.8
AME= 1.8
RMS= 1.8
Lim4
Segment 158
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

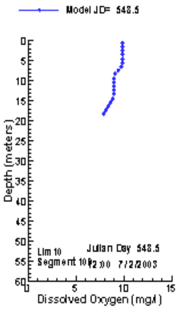

Model JD= 548.5
Data JD= 548
Depth (meters)
ME= 1.3
AME= 1.3
RMS= 1.4
Lim5
Segment82
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

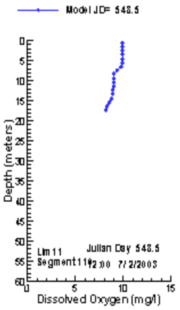

Model JD= 548.5
Data JD= 548
Depth (meters)
ME=0.84
AME=0.84
RMS=0.95
Lim6
Segment99
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

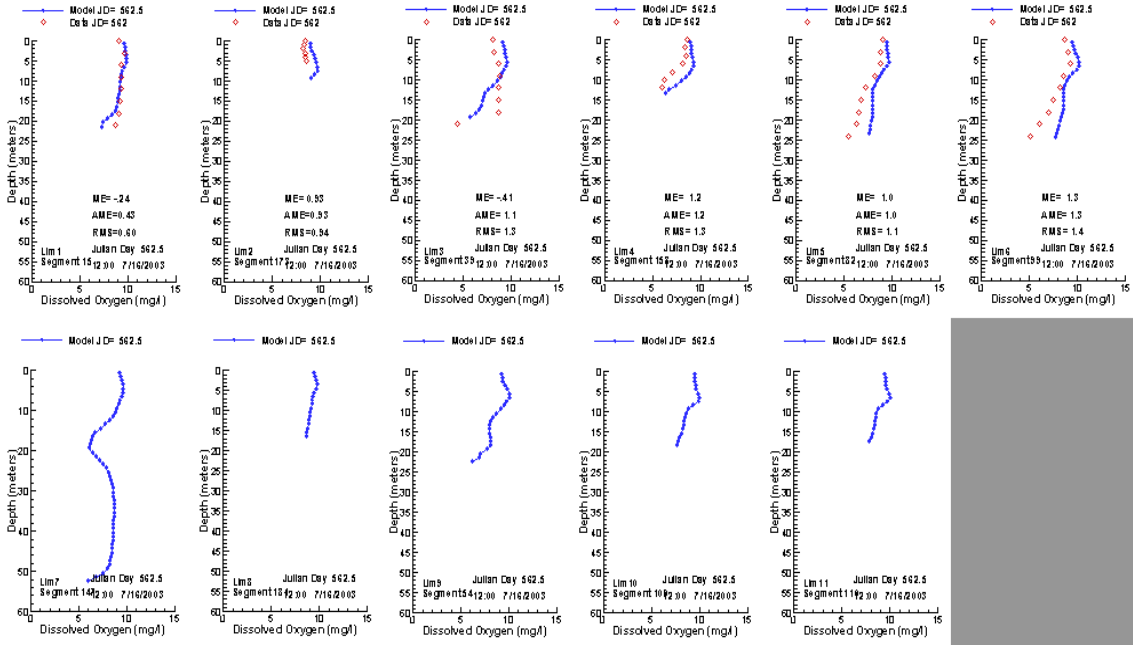

Model JD= 548.5
Depth (meters)
Lim7
Segment 147
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

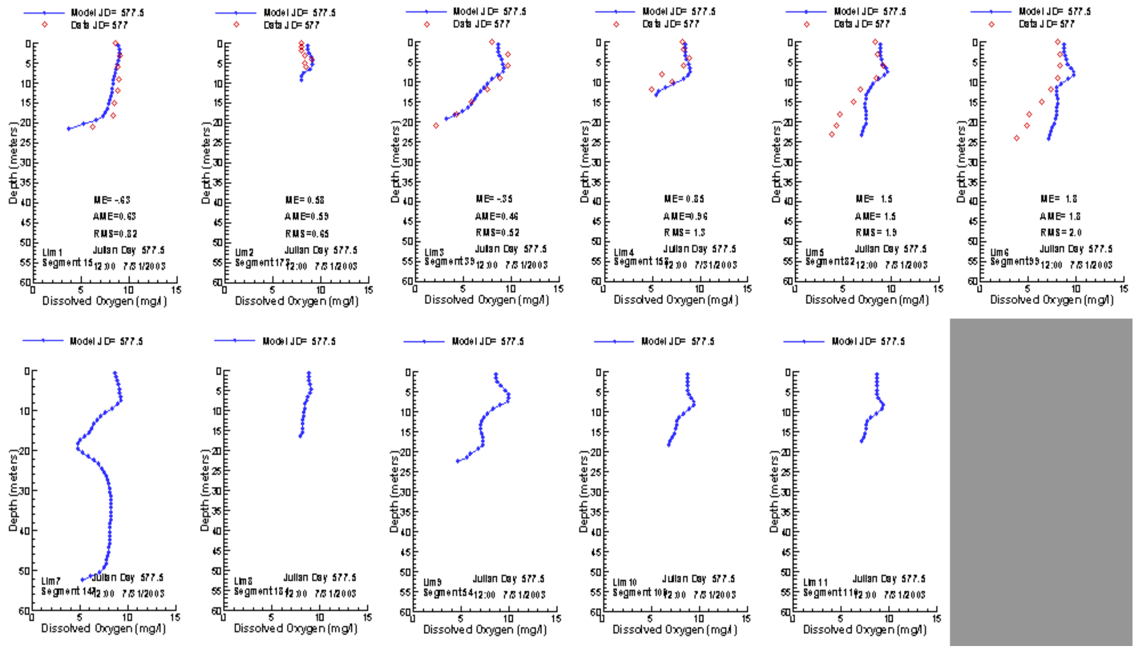

Model JD= 548.5
Depth (meters)
Lim8
Segment18
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

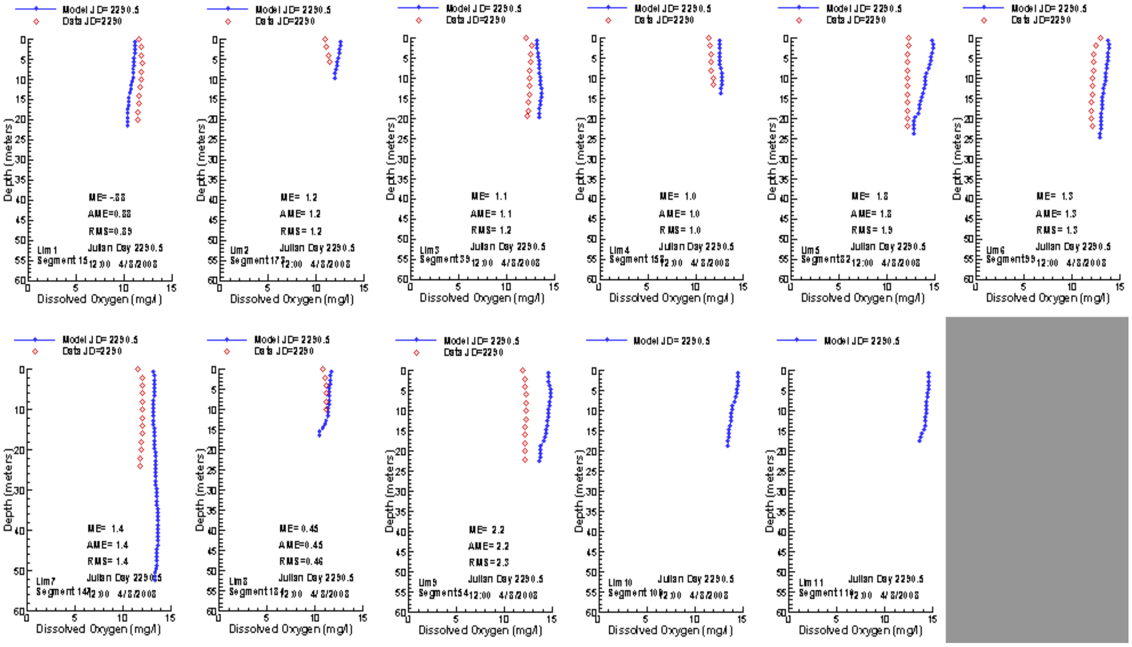

Model JD= 548.5
Depth (meters)
Lim9
Segment54
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

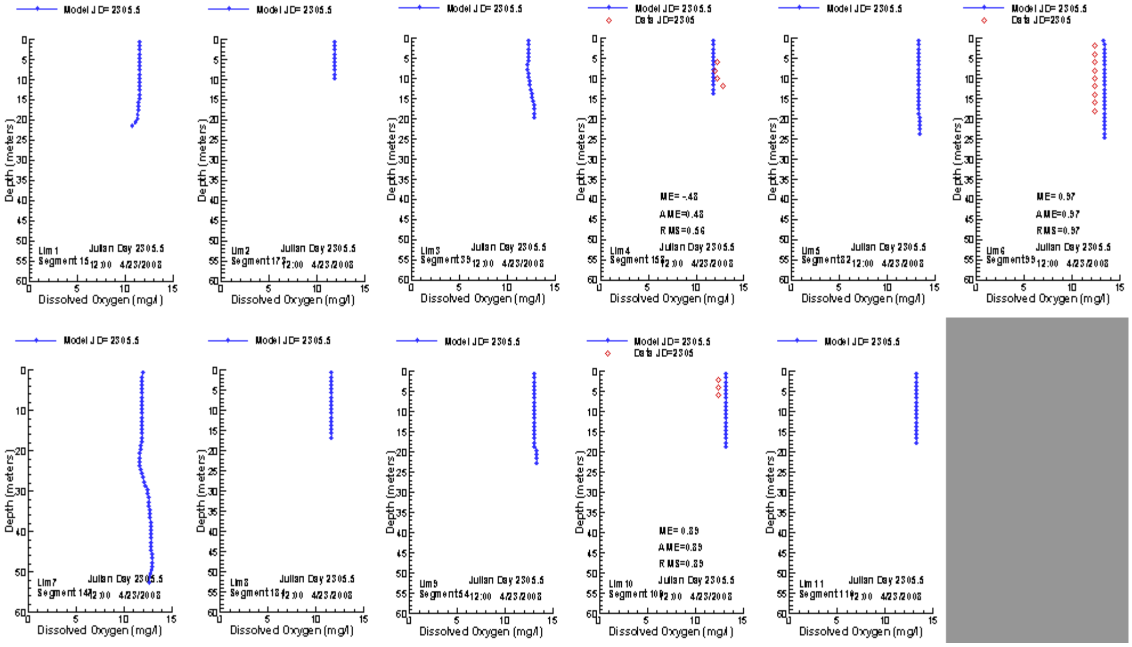

Model JD= 548.5
Depth (meters)
Lim 10
Segment 10
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

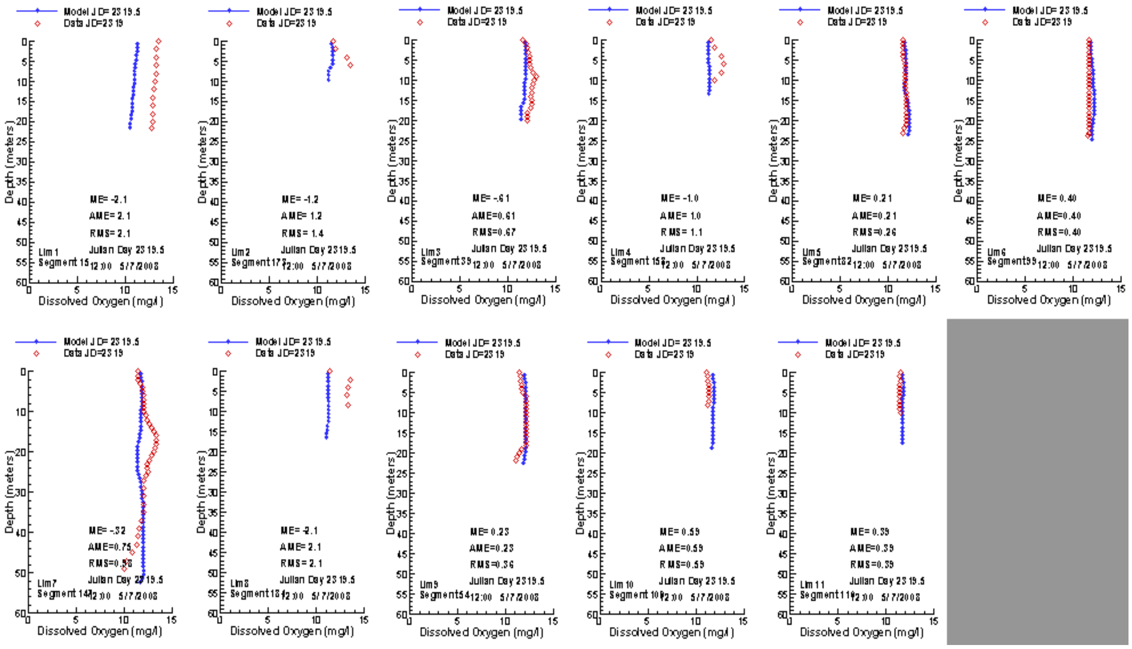

Model JD= 548.5
Depth (meters)
Lim 11
Segment11
Julian Day 548.5
12:00 7/2/2003
Dissolved Oxygen (mg/l)

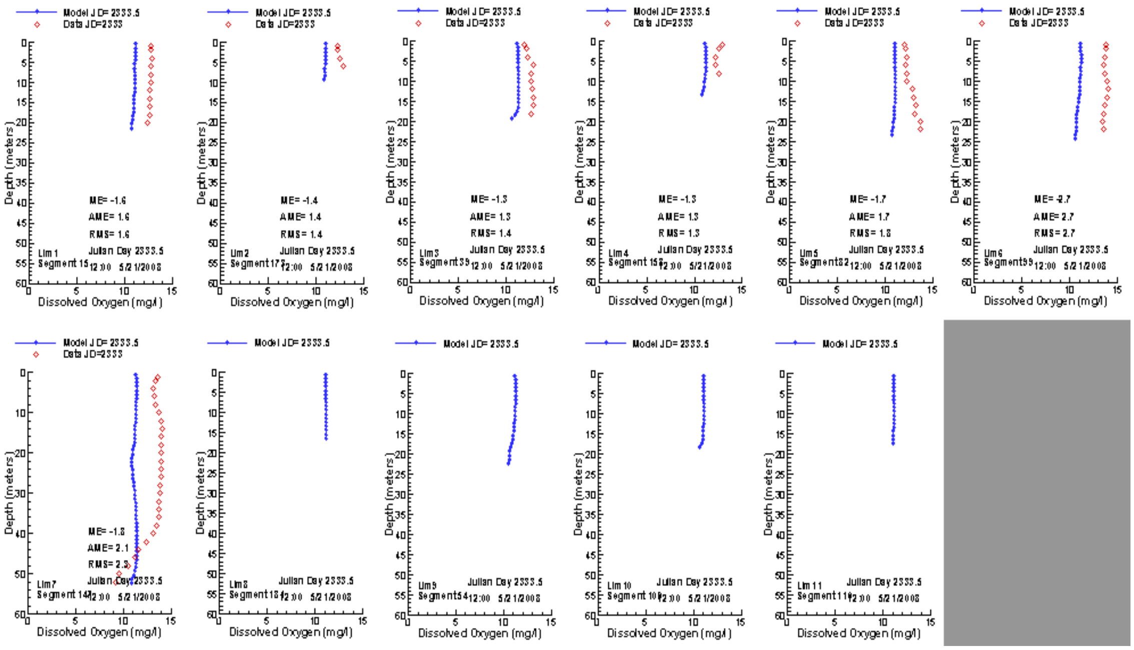

Model JD= 562.5
Data JD= 562
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.24
AME=0.43
RMS=0.60
Lim 1
Segment 15
Julian Day 562.5
12:00 7/16/2003
ME= 0.93
AME=0.93
RMS=0.94
Lim 2
Segment 17
Julian Day 562.5
12:00 7/16/2003
ME= -.41
AME= 1.1
RMS= 1.3
Lim 3
Segment 39
Julian Day 562.5
12:00 7/16/2003
ME= 1.2
AME= 1.2
RMS= 1.3
Lim 4
Segment 15
Julian Day 562.5
12:00 7/16/2003
ME= 1.0
AME= 1.0
RMS= 1.1
Lim 5
Segment 82
Julian Day 562.5
12:00 7/16/2003
ME= 1.3
AME= 1.3
RMS= 1.4
Lim 6
Segment 99
Julian Day 562.5
12:00 7/16/2003
Lim 7
Segment 14
Julian Day 562.5
12:00 7/16/2003
Lim 8
Segment 18
Julian Day 562.5
12:00 7/16/2003
Lim 9
Segment 54
Julian Day 562.5
12:00 7/16/2003
Lim 10
Segment 10
Julian Day 562.5
12:00 7/16/2003
Lim 11
Segment 11
Julian Day 562.5
12:00 7/16/2003

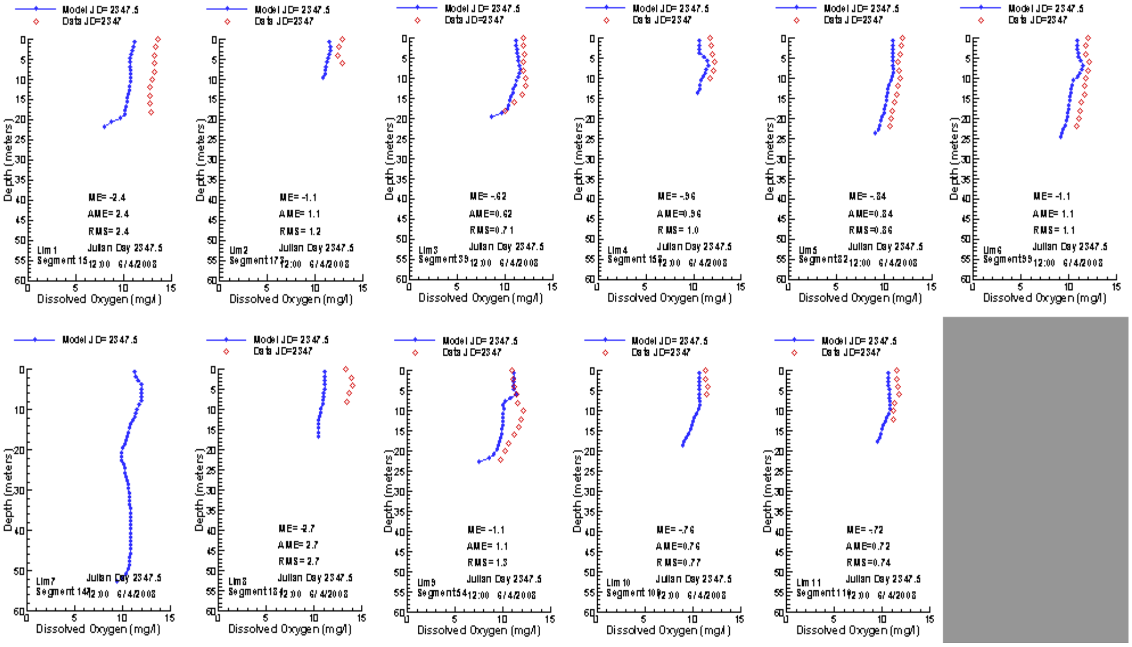

Model JD= 577.5
Data JD= 577
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.63
AME=0.63
RMS=0.82
Lim 1
Segment 15
Julian Day 577.5
12:00 7/31/2003
ME= 0.58
AME=0.59
RMS=0.65
Lim 2
Segment 17
Julian Day 577.5
12:00 7/31/2003
ME= -.35
AME=0.46
RMS=0.52
Lim 3
Segment 39
Julian Day 577.5
12:00 7/31/2003
ME= 0.85
AME=0.96
RMS= 1.3
Lim 4
Segment 15
Julian Day 577.5
12:00 7/31/2003
ME= 1.5
AME= 1.5
RMS= 1.9
Lim 5
Segment 82
Julian Day 577.5
12:00 7/31/2003
ME= 1.8
AME= 1.8
RMS= 2.0
Lim 6
Segment 99
Julian Day 577.5
12:00 7/31/2003
Lim 7
Segment 14
Julian Day 577.5
12:00 7/31/2003
Lim 8
Segment 18
Julian Day 577.5
12:00 7/31/2003
Lim 9
Segment 54
Julian Day 577.5
12:00 7/31/2003
Lim 10
Segment 10
Julian Day 577.5
12:00 7/31/2003
Lim 11
Segment 11
Julian Day 577.5
12:00 7/31/2003


Model JD= 2290.5
Data JD=2290
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.88
AME=0.88
RMS=0.89
Lim 1
Segment 15
Julian Day 2290.5
12:00 4/8/2008
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 2
Segment 17
Julian Day 2290.5
12:00 4/8/2008
ME= 1.1
AME= 1.1
RMS= 1.2
Lim 3
Segment 39
Julian Day 2290.5
12:00 4/8/2008
ME= 1.0
AME= 1.0
RMS= 1.0
Lim 4
Segment 15
Julian Day 2290.5
12:00 4/8/2008
ME= 1.8
AME= 1.8
RMS= 1.9
Lim 5
Segment 82
Julian Day 2290.5
12:00 4/8/2008
ME= 1.3
AME= 1.3
RMS= 1.3
Lim 6
Segment 99
Julian Day 2290.5
12:00 4/8/2008
ME= 1.4
AME= 1.4
RMS= 1.4
Lim 7
Segment 14
Julian Day 2290.5
12:00 4/8/2008
ME= 0.45
AME=0.45
RMS=0.46
Lim 8
Segment 18
Julian Day 2290.5
12:00 4/8/2008
ME= 2.2
AME= 2.2
RMS= 2.3
Lim 9
Segment 54
Julian Day 2290.5
12:00 4/8/2008
Lim 10
Segment 10
Julian Day 2290.5
12:00 4/8/2008
Lim 11
Segment 11
Julian Day 2290.5
12:00 4/8/2008

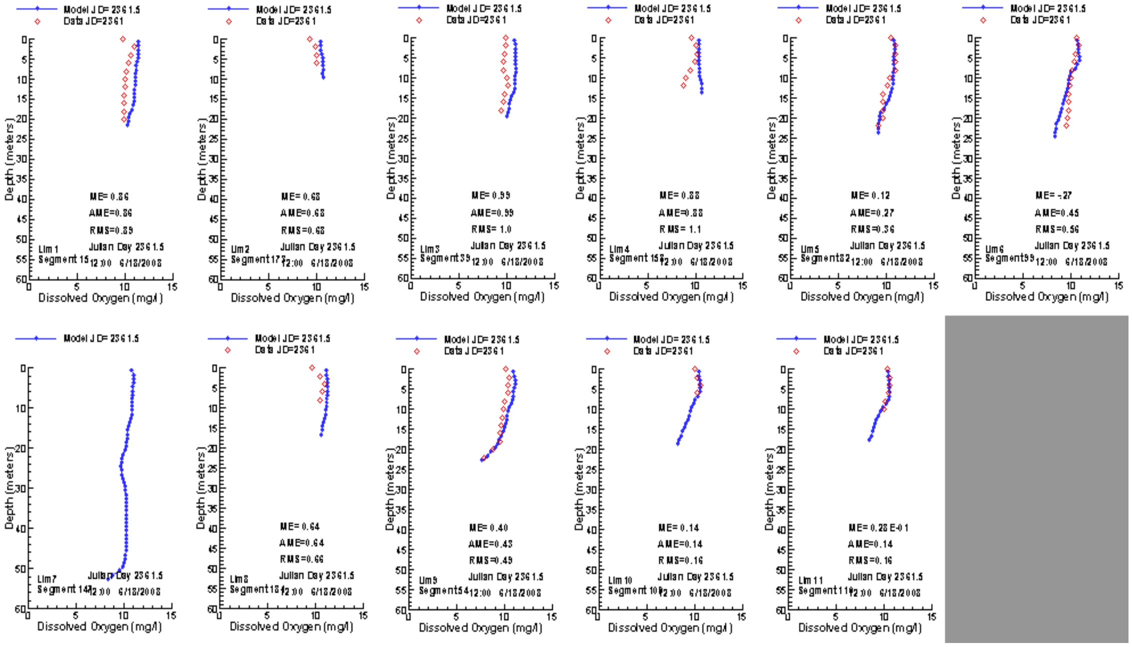

Model JD= 2305.5
Data JD=2305
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1
Segment 15
Julian Day 2305.5
12:00 4/23/2008
Lim 2
Segment 17
Julian Day 2305.5
12:00 4/23/2008
Lim 3
Segment 39
Julian Day 2305.5
12:00 4/23/2008
ME= -.48
AME=0.48
RMS=0.56
Lim 4
Segment 15
Julian Day 2305.5
12:00 4/23/2008
Lim 5
Segment 82
Julian Day 2305.5
12:00 4/23/2008
ME= 0.97
AME=0.97
RMS=0.97
Lim 6
Segment 99
Julian Day 2305.5
12:00 4/23/2008
Lim 7
Segment 14
Julian Day 2305.5
12:00 4/23/2008
Lim 8
Segment 18
Julian Day 2305.5
12:00 4/23/2008
Lim 9
Segment 54
Julian Day 2305.5
12:00 4/23/2008
ME= 0.89
AME=0.89
RMS=0.89
Lim 10
Segment 10
Julian Day 2305.5
12:00 4/23/2008
Lim 11
Segment 11
Julian Day 2305.5
12:00 4/23/2008


Model JD=2319.5
Data JD=2319
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1 Segment 15 ME=-2.1 AME=2.1 RMS=2.1 Julian Day 2319.5 12:00 5/7/2008
Lim2 Segment 17 ME=-1.2 AME=1.2 RMS=1.4 Julian Day 2319.5 12:00 5/7/2008
Lim3 Segment 39 ME=-.61 AME=0.61 RMS=0.67 Julian Day 2319.5 12:00 5/7/2008
Lim4 Segment 15 ME=-1.0 AME=1.0 RMS=1.1 Julian Day 2319.5 12:00 5/7/2008
Lim5 Segment 82 ME=0.21 AME=0.21 RMS=0.26 Julian Day 2319.5 12:00 5/7/2008
Lim6 Segment 99 ME=0.40 AME=0.40 RMS=0.40 Julian Day 2319.5 12:00 5/7/2008
Lim7 Segment 14 ME=-.32 AME=0.75 RMS=0.98 Julian Day 2319.5 12:00 5/7/2008
Lim8 Segment 18 ME=-2.1 AME=2.1 RMS=2.1 Julian Day 2319.5 12:00 5/7/2008
Lim9 Segment 54 ME=0.23 AME=0.23 RMS=0.36 Julian Day 2319.5 12:00 5/7/2008
Lim 10 Segment 10 ME=0.59 AME=0.59 RMS=0.59 Julian Day 2319.5 12:00 5/7/2008
Lim 11 Segment 11 ME=0.39 AME=0.39 RMS=0.39 Julian Day 2319.5 12:00 5/7/2008

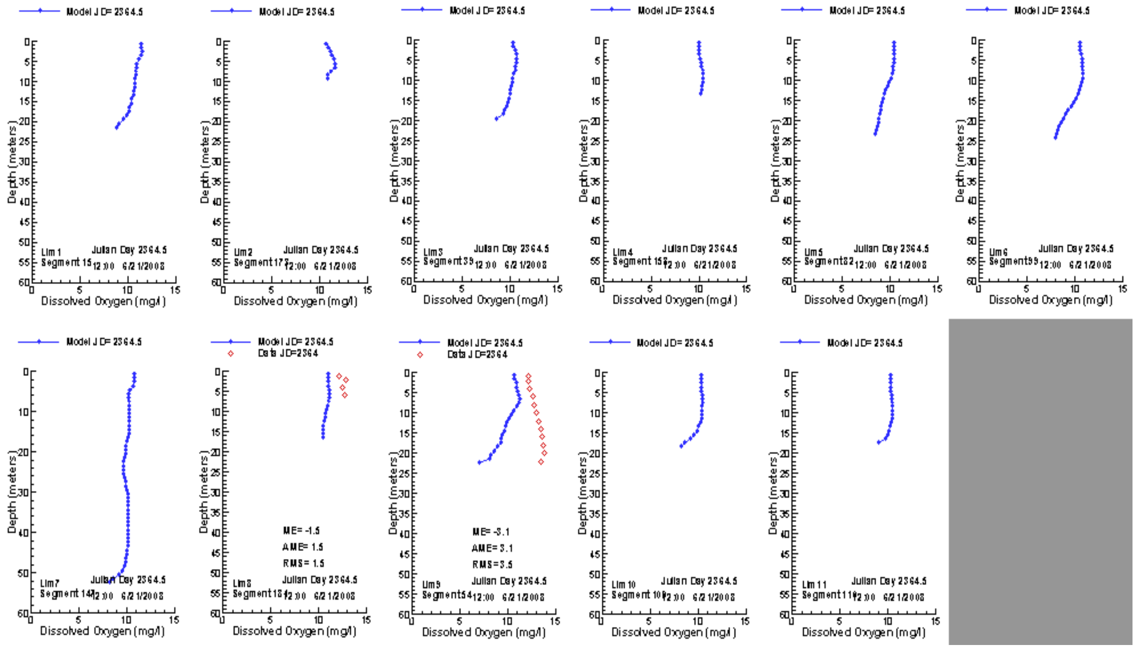

Model JD=2333.5
Data JD=2333
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1 Segment 15 ME=-1.6 AME=1.6 RMS=1.6 Julian Day 2333.5 12:00 5/21/2008
Lim2 Segment 17 ME=-1.4 AME=1.4 RMS=1.4 Julian Day 2333.5 12:00 5/21/2008
Lim3 Segment 39 ME=-1.3 AME=1.3 RMS=1.4 Julian Day 2333.5 12:00 5/21/2008
Lim4 Segment 15 ME=-1.3 AME=1.3 RMS=1.3 Julian Day 2333.5 12:00 5/21/2008
Lim5 Segment 82 ME=-1.7 AME=1.7 RMS=1.8 Julian Day 2333.5 12:00 5/21/2008
Lim6 Segment 99 ME=-2.7 AME=2.7 RMS=2.7 Julian Day 2333.5 12:00 5/21/2008
Lim7 Segment 14 ME=-1.8 AME=2.1 RMS=2.3 Julian Day 2333.5 12:00 5/21/2008
Lim8 Segment 18 Julian Day 2333.5 12:00 5/21/2008
Lim9 Segment 54 Julian Day 2333.5 12:00 5/21/2008
Lim 10 Segment 10 Julian Day 2333.5 12:00 5/21/2008
Lim 11 Segment 11 Julian Day 2333.5 12:00 5/21/2008

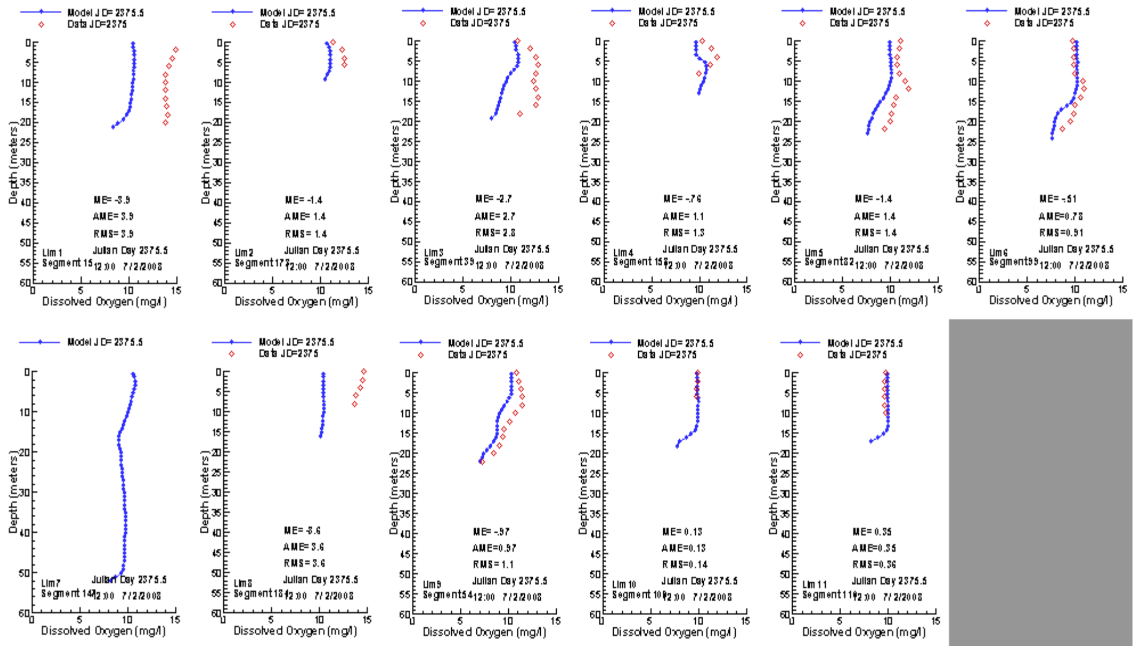


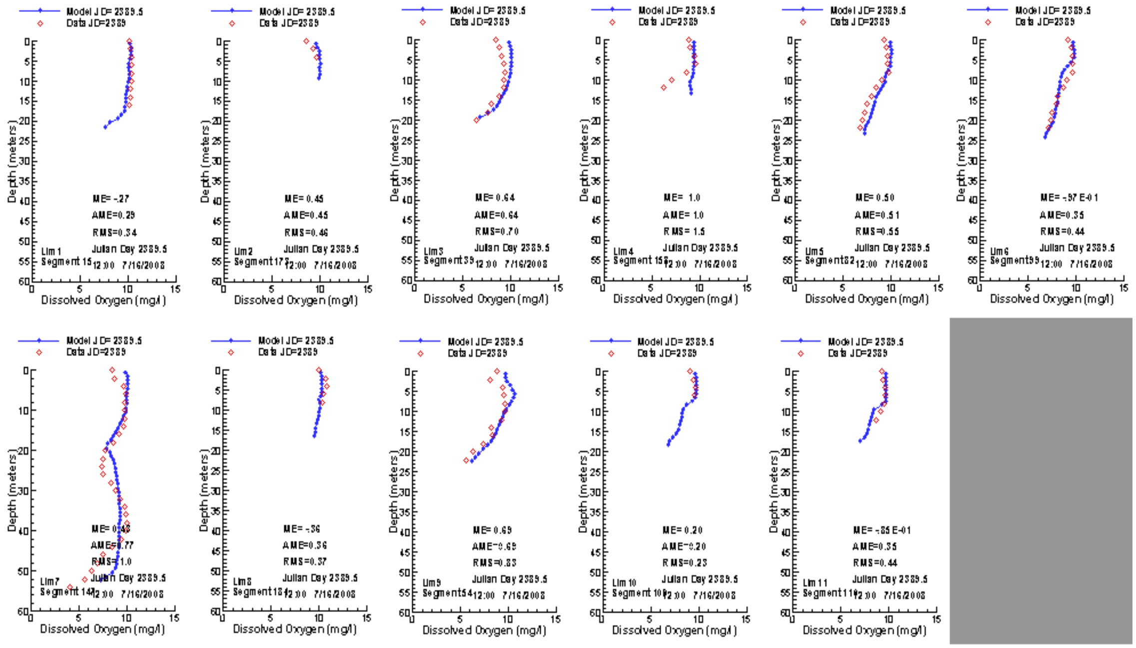
Model JD= 2347.5
Data JD=2347
Depth (meters)
Dissolved Oxygen (mg/l)
Lim1 Segment 15 ME=-2.4 AME=2.4 RMS=2.4 Julian Day 2347.5 12:00 6/4/2008
Lim2 Segment17 ME=-1.1 AME=1.1 RMS=1.2 Julian Day 2347.5 12:00 6/4/2008
Lim3 Segment39 ME=-.62 AME=0.62 RMS=0.71 Julian Day 2347.5 12:00 6/4/2008
Lim4 Segment 15 ME=-.96 AME=0.96 RMS=1.0 Julian Day 2347.5 12:00 6/4/2008
Lim5 Segment82 ME=-.84 AME=0.84 RMS=0.86 Julian Day 2347.5 12:00 6/4/2008
Lim6 Segment99 ME=-1.1 AME=1.1 RMS=1.1 Julian Day 2347.5 12:00 6/4/2008
Lim7 Segment 14 Julian Day 2347.5 12:00 6/4/2008
Lim8 Segment18 ME=-2.7 AME=2.7 RMS=2.7 Julian Day 2347.5 12:00 6/4/2008
Lim9 Segment54 ME=-1.1 AME=1.1 RMS=1.3 Julian Day 2347.5 12:00 6/4/2008
Lim10 Segment 10 ME=-.76 AME=0.76 RMS=0.77 Julian Day 2347.5 12:00 6/4/2008
Lim11 Segment11 ME=-.72 AME=0.72 RMS=0.74 Julian Day 2347.5 12:00 6/4/2008

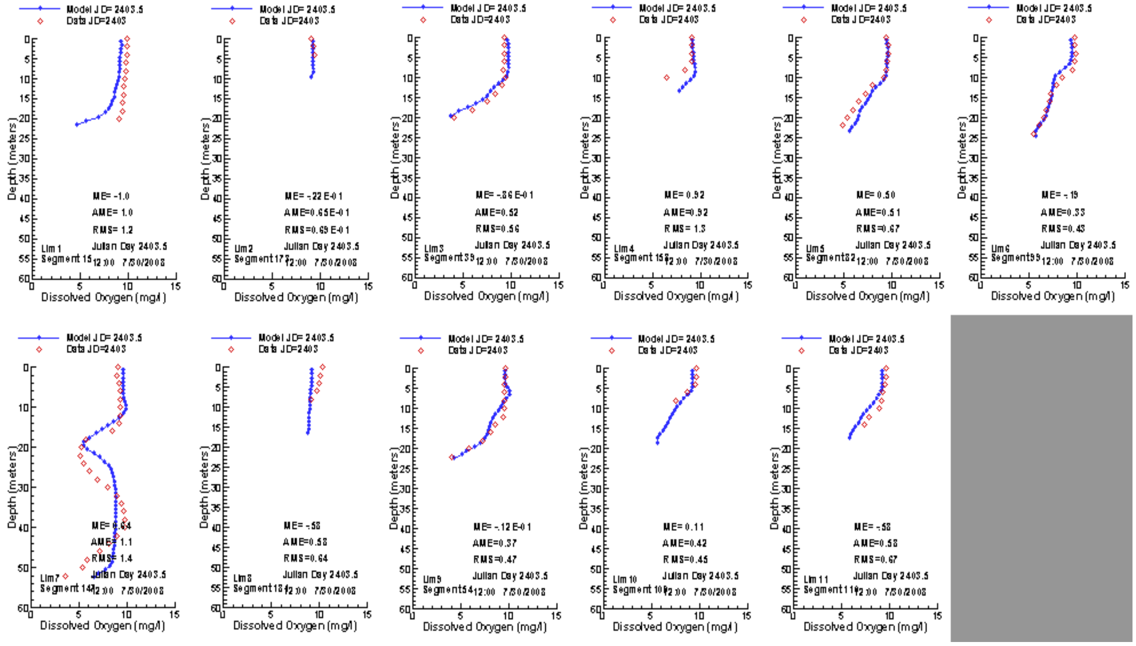


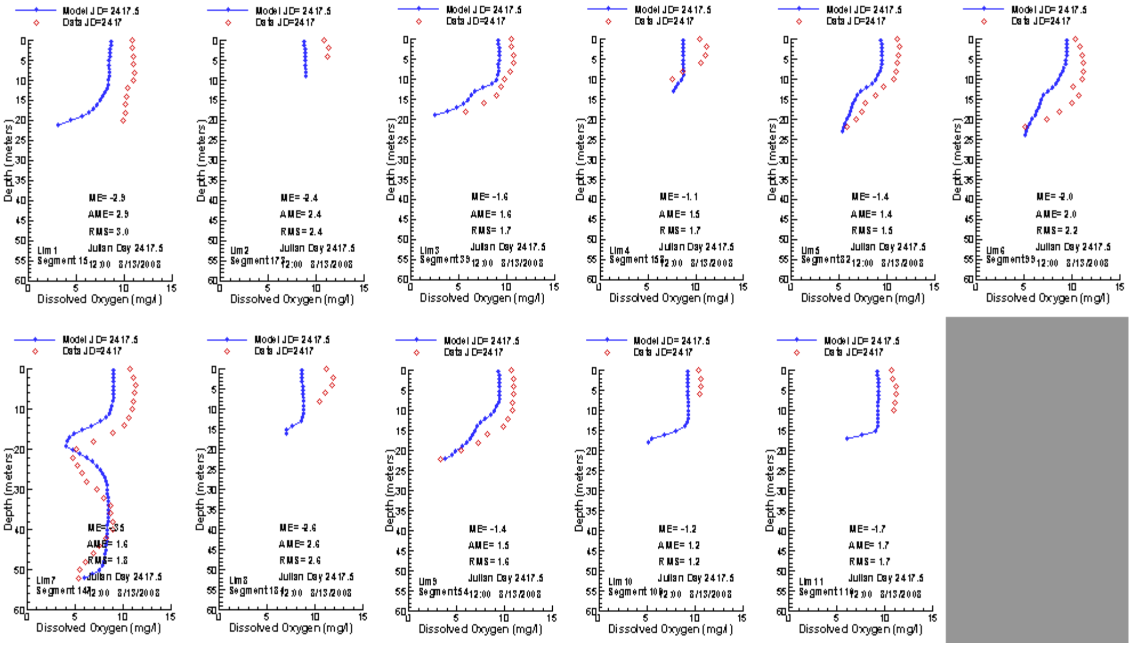
Model JD= 2361.5
Data JD=2361
Depth (meters)
Dissolved Oxygen (mg/l)
Lim1 Segment 15 ME=0.86 AME=0.86 RMS=0.89 Julian Day 2361.5 12:00 6/18/2008
Lim2 Segment17 ME=0.68 AME=0.68 RMS=0.68 Julian Day 2361.5 12:00 6/18/2008
Lim3 Segment39 ME=0.99 AME=0.99 RMS=1.0 Julian Day 2361.5 12:00 6/18/2008
Lim4 Segment 15 ME=0.88 AME=0.88 RMS=1.1 Julian Day 2361.5 12:00 6/18/2008
Lim5 Segment82 ME=0.12 AME=0.27 RMS=0.36 Julian Day 2361.5 12:00 6/18/2008
Lim6 Segment99 ME=-.27 AME=0.45 RMS=0.56 Julian Day 2361.5 12:00 6/18/2008
Lim7 Segment 14 Julian Day 2361.5 12:00 6/18/2008
Lim8 Segment18 ME=0.64 AME=0.64 RMS=0.66 Julian Day 2361.5 12:00 6/18/2008
Lim9 Segment54 ME=0.40 AME=0.43 RMS=0.49 Julian Day 2361.5 12:00 6/18/2008
Lim10 Segment 10 ME=0.14 AME=0.14 RMS=0.16 Julian Day 2361.5 12:00 6/18/2008
Lim11 Segment11 ME=0.28E-01 AME=0.14 RMS=0.16 Julian Day 2361.5 12:00 6/18/2008

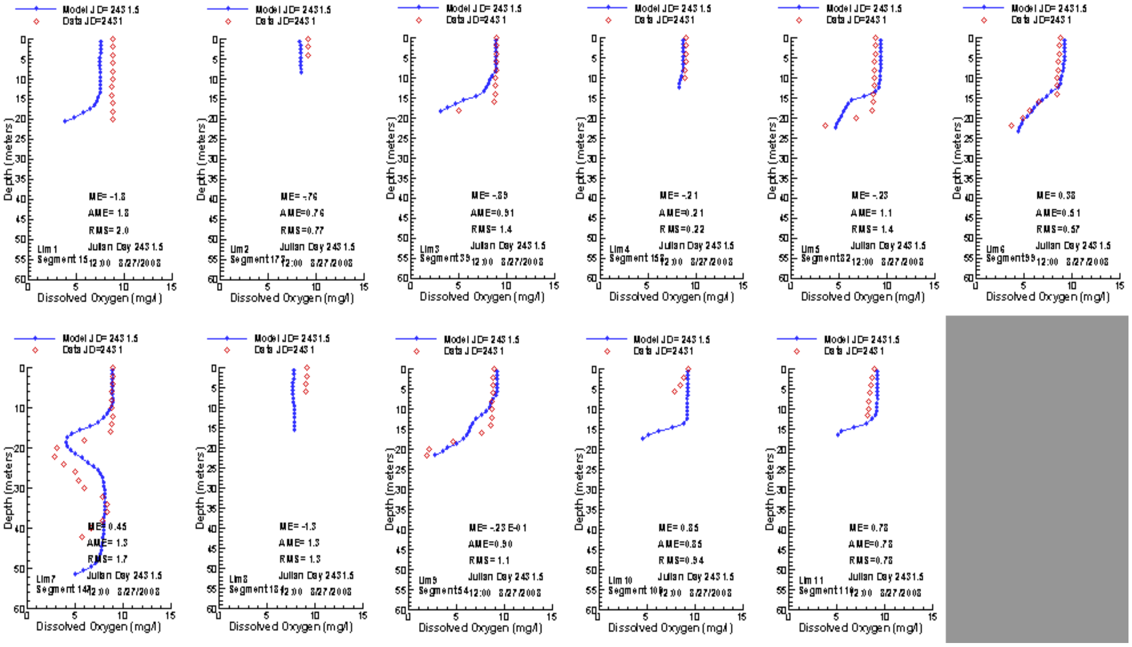

Model JD= 2364.5
Data JD=2364
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1
Segment 15
Lim 2
Segment 17
Lim 3
Segment 39
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
ME= -1.5
AME= 1.5
RMS= 1.5
Lim 9
Segment 54
ME= -3.1
AME= 3.1
RMS= 3.5
Lim 10
Segment 10
Lim 11
Segment 11
Julian Day 2364.5
12:00 6/21/2008

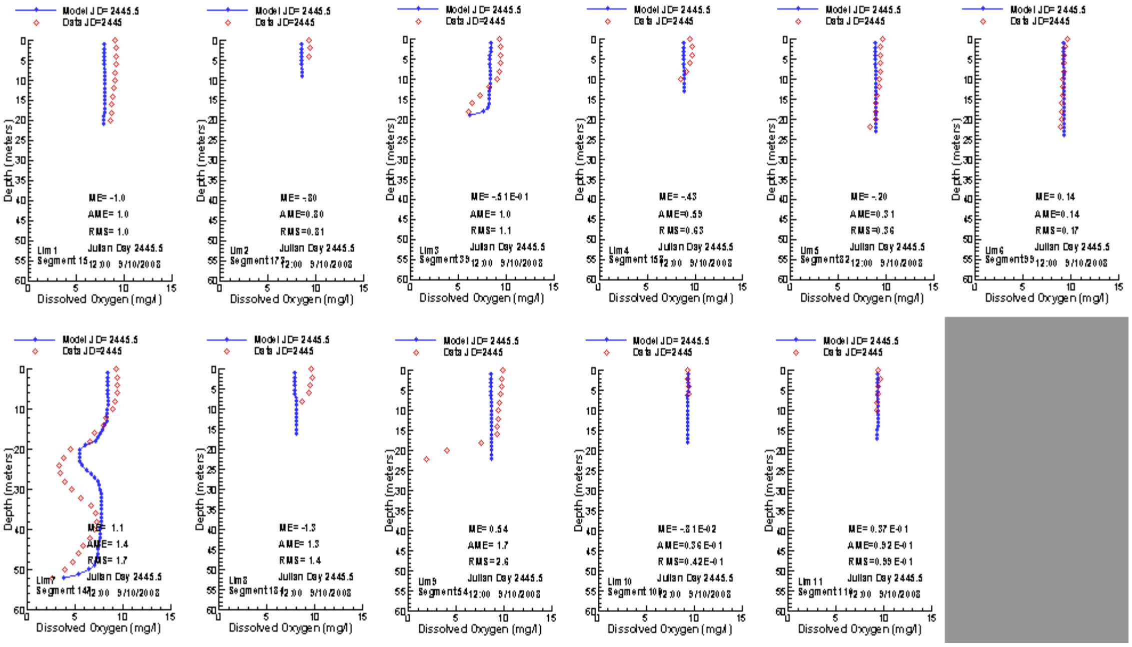

Model JD= 2375.5
Data JD=2375
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1
Segment 15
ME= -3.9
AME= 3.9
RMS= 3.9
Lim 2
Segment 17
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 3
Segment 39
ME= -2.7
AME= 2.7
RMS= 2.8
Lim 4
Segment 15
ME= -.76
AME= 1.1
RMS= 1.3
Lim 5
Segment 82
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 6
Segment 99
ME= -.51
AME=0.78
RMS=0.91
Lim 7
Segment 14
Lim 8
Segment 18
ME= -3.6
AME= 3.6
RMS= 3.6
Lim 9
Segment 54
ME= -.97
AME=0.97
RMS= 1.1
Lim 10
Segment 10
ME= 0.13
AME=0.13
RMS=0.14
Lim 11
Segment 11
ME= 0.35
AME=0.35
RMS=0.36
Julian Day 2375.5
12:00 7/2/2008

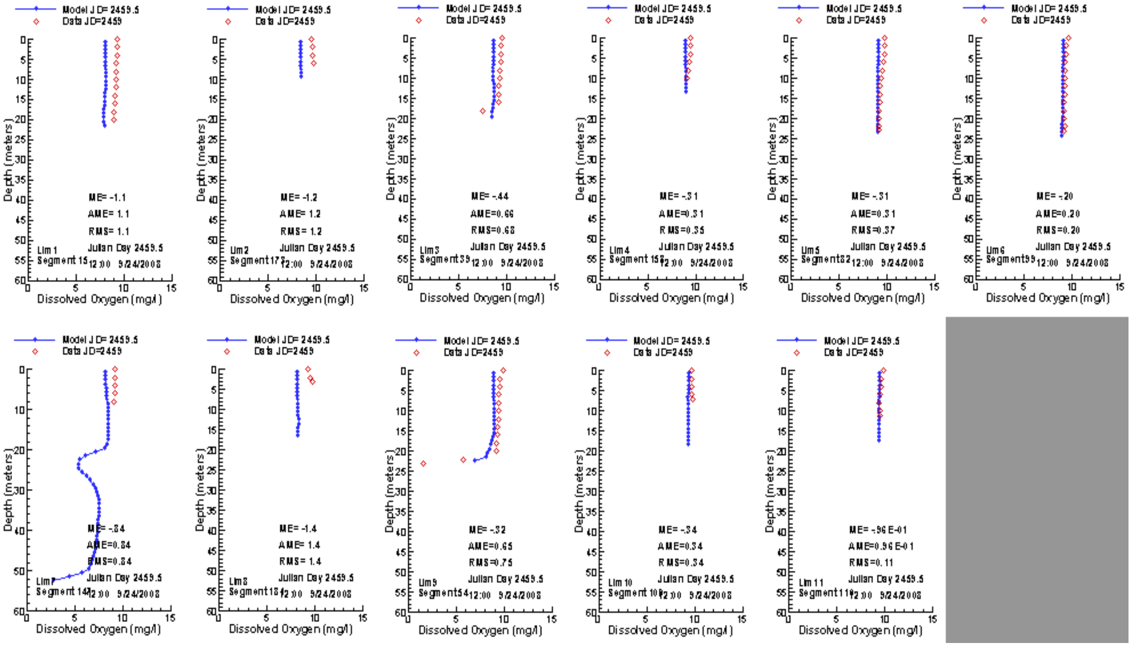

Model JD= 2389.5
Data JD=2389
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.27
AME=0.29
RMS=0.34
Lim 1
Segment 15
Julian Day 2389.5
12:00 7/16/2008
ME= 0.45
AME=0.45
RMS=0.46
Lim 2
Segment 17
Julian Day 2389.5
12:00 7/16/2008
ME= 0.64
AME=0.64
RMS=0.70
Lim 3
Segment 39
Julian Day 2389.5
12:00 7/16/2008
ME= 1.0
AME= 1.0
RMS= 1.5
Lim 4
Segment 15
Julian Day 2389.5
12:00 7/16/2008
ME= 0.50
AME=0.51
RMS=0.55
Lim 5
Segment 82
Julian Day 2389.5
12:00 7/16/2008
ME= -.97 E-01
AME=0.35
RMS=0.44
Lim 6
Segment 99
Julian Day 2389.5
12:00 7/16/2008
ME= 0.43
AME=0.77
RMS= 1.0
Lim 7
Segment 14
Julian Day 2389.5
12:00 7/16/2008
ME= -.36
AME=0.36
RMS=0.37
Lim 8
Segment 18
Julian Day 2389.5
12:00 7/16/2008
ME= 0.69
AME=0.69
RMS=0.83
Lim 9
Segment 54
Julian Day 2389.5
12:00 7/16/2008
ME= 0.20
AME=0.20
RMS=0.23
Lim 10
Segment 10
Julian Day 2389.5
12:00 7/16/2008
ME= -.85 E-01
AME=0.35
RMS=0.44
Lim 11
Segment 11
Julian Day 2389.5
12:00 7/16/2008

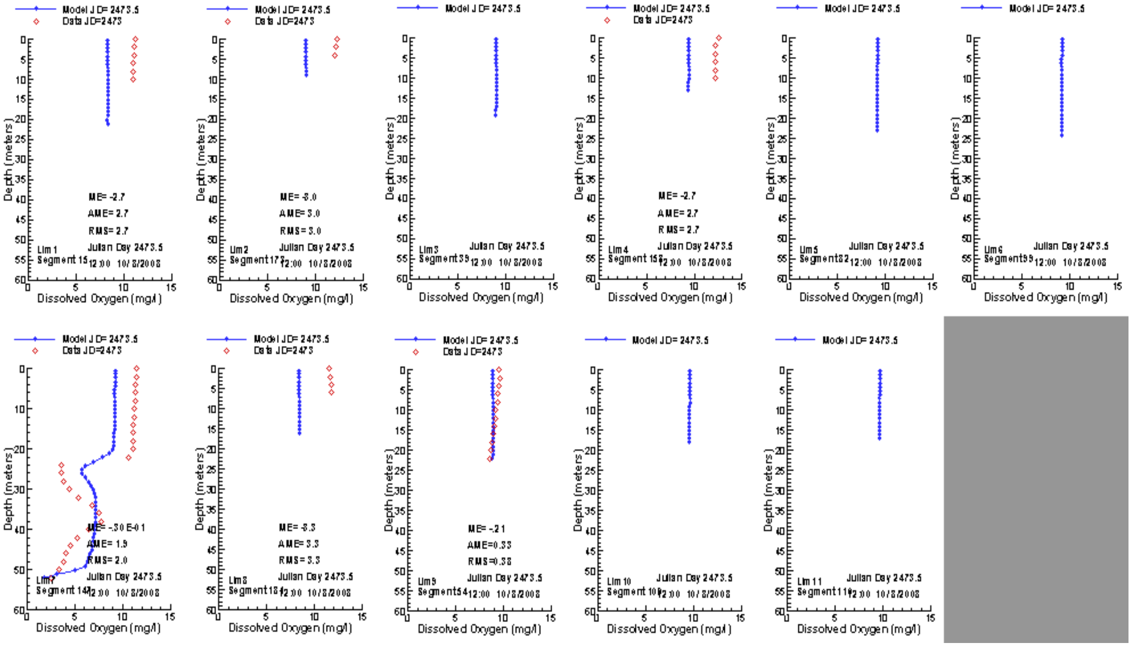

Model JD= 2403.5
Data JD=2403
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -1.0
AME= 1.0
RMS= 1.2
Lim 1
Segment 15
Julian Day 2403.5
12:00 7/30/2008
ME= -.22 E-01
AME=0.65 E-01
RMS=0.69 E-01
Lim 2
Segment 17
Julian Day 2403.5
12:00 7/30/2008
ME= -.86 E-01
AME=0.52
RMS=0.56
Lim 3
Segment 39
Julian Day 2403.5
12:00 7/30/2008
ME= 0.92
AME=0.92
RMS= 1.3
Lim 4
Segment 15
Julian Day 2403.5
12:00 7/30/2008
ME= 0.50
AME=0.51
RMS=0.67
Lim 5
Segment 82
Julian Day 2403.5
12:00 7/30/2008
ME= -.19
AME=0.33
RMS=0.43
Lim 6
Segment 99
Julian Day 2403.5
12:00 7/30/2008
ME= 0.64
AME= 1.1
RMS= 1.4
Lim 7
Segment 14
Julian Day 2403.5
12:00 7/30/2008
ME= -.58
AME=0.58
RMS=0.64
Lim 8
Segment 18
Julian Day 2403.5
12:00 7/30/2008
ME= -.12 E-01
AME=0.37
RMS=0.47
Lim 9
Segment 54
Julian Day 2403.5
12:00 7/30/2008
ME= 0.11
AME=0.42
RMS=0.45
Lim 10
Segment 10
Julian Day 2403.5
12:00 7/30/2008
ME= -.58
AME=0.58
RMS=0.67
Lim 11
Segment 11
Julian Day 2403.5
12:00 7/30/2008

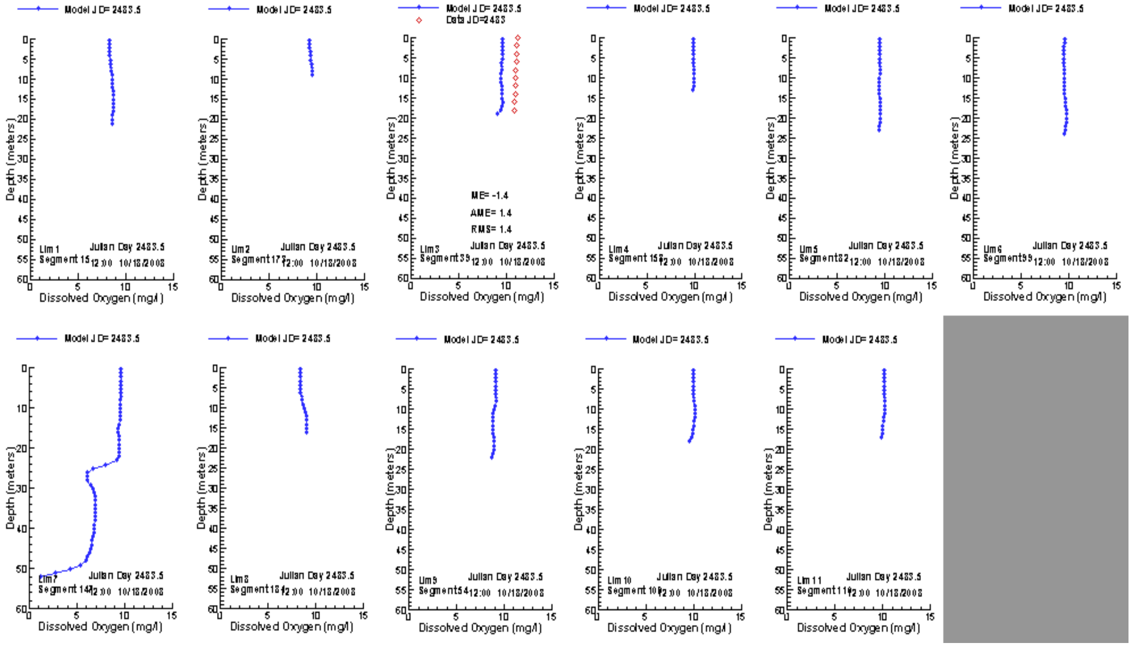

Model JD= 2417.5
Data JD=2417
Depth (meters)
Dissolved Oxygen (mg/l)
Lim1 Segment 15 ME= -2.9 AME= 2.9 RMS= 3.0 Julian Day 2417.5 12:00 8/13/2008
Lim2 Segment 17 ME= -2.4 AME= 2.4 RMS= 2.4 Julian Day 2417.5 12:00 8/13/2008
Lim3 Segment 39 ME= -1.6 AME= 1.6 RMS= 1.7 Julian Day 2417.5 12:00 8/13/2008
Lim4 Segment 15 ME= -1.1 AME= 1.5 RMS= 1.7 Julian Day 2417.5 12:00 8/13/2008
Lim5 Segment 82 ME= -1.4 AME= 1.4 RMS= 1.5 Julian Day 2417.5 12:00 8/13/2008
Lim6 Segment 99 ME= -2.0 AME= 2.0 RMS= 2.2 Julian Day 2417.5 12:00 8/13/2008
Lim7 Segment 14 ME= -.35 AME= 1.6 RMS= 1.8 Julian Day 2417.5 12:00 8/13/2008
Lim8 Segment 18 ME= -2.6 AME= 2.6 RMS= 2.6 Julian Day 2417.5 12:00 8/13/2008
Lim9 Segment 54 ME= -1.4 AME= 1.5 RMS= 1.6 Julian Day 2417.5 12:00 8/13/2008
Lim 10 Segment 10 ME= -1.2 AME= 1.2 RMS= 1.2 Julian Day 2417.5 12:00 8/13/2008
Lim 11 Segment 11 ME= -1.7 AME= 1.7 RMS= 1.7 Julian Day 2417.5 12:00 8/13/2008

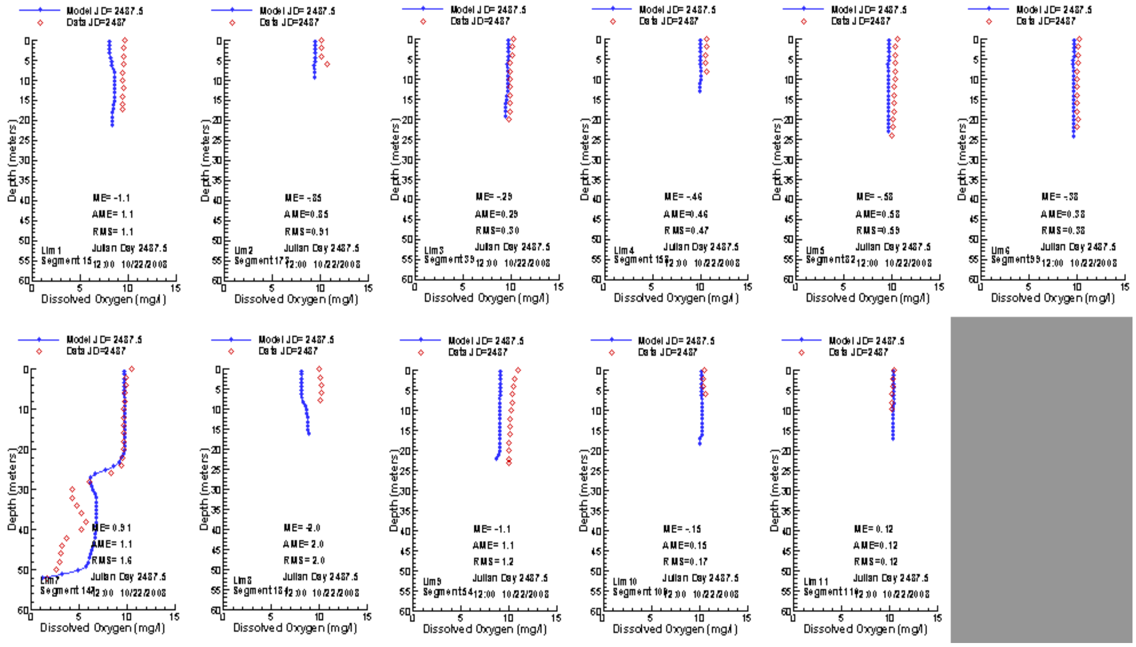

Model JD= 2431.5
Data JD=2431
Depth (meters)
Dissolved Oxygen (mg/l)
Lim1 Segment 15 ME= -1.8 AME= 1.8 RMS= 2.0 Julian Day 2431.5 12:00 8/27/2008
Lim2 Segment 17 ME= -.76 AME=0.76 RMS=0.77 Julian Day 2431.5 12:00 8/27/2008
Lim3 Segment 39 ME= -.89 AME=0.91 RMS= 1.4 Julian Day 2431.5 12:00 8/27/2008
Lim4 Segment 15 ME= -.21 AME=0.21 RMS=0.22 Julian Day 2431.5 12:00 8/27/2008
Lim5 Segment 82 ME= -.23 AME= 1.1 RMS= 1.4 Julian Day 2431.5 12:00 8/27/2008
Lim6 Segment 99 ME= 0.38 AME=0.51 RMS=0.57 Julian Day 2431.5 12:00 8/27/2008
Lim7 Segment 14 ME= 0.45 AME= 1.3 RMS= 1.7 Julian Day 2431.5 12:00 8/27/2008
Lim8 Segment 18 ME= -1.3 AME= 1.3 RMS= 1.3 Julian Day 2431.5 12:00 8/27/2008
Lim9 Segment 54 ME= -.23 E-01 AME=0.90 RMS= 1.1 Julian Day 2431.5 12:00 8/27/2008
Lim 10 Segment 10 ME= 0.85 AME=0.85 RMS=0.94 Julian Day 2431.5 12:00 8/27/2008
Lim 11 Segment 11 ME= 0.78 AME=0.78 RMS=0.78 Julian Day 2431.5 12:00 8/27/2008


Model J D= 2445.5
Data JD=2445
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 1
Segment 15
Julian Day 2445.5
12:00 9/10/2008
ME= -.80
AME=0.80
RMS=0.81
Lim 2
Segment 17
Julian Day 2445.5
12:00 9/10/2008
ME= -.51E-01
AME= 1.0
RMS= 1.1
Lim3
Segment 39
Julian Day 2445.5
12:00 9/10/2008
ME= -.43
AME=0.59
RMS=0.63
Lim 4
Segment 15
Julian Day 2445.5
12:00 9/10/2008
ME= -.20
AME=0.31
RMS=0.36
Lim5
Segment 82
Julian Day 2445.5
12:00 9/10/2008
ME= 0.14
AME=0.14
RMS=0.17
Lim6
Segment 99
Julian Day 2445.5
12:00 9/10/2008
ME= 1.1
AME= 1.4
RMS= 1.7
Lim7
Segment 14
Julian Day 2445.5
12:00 9/10/2008
ME= -1.3
AME= 1.3
RMS= 1.4
Lim8
Segment 18
Julian Day 2445.5
12:00 9/10/2008
ME= 0.54
AME= 1.7
RMS= 2.6
Lim9
Segment 54
Julian Day 2445.5
12:00 9/10/2008
ME= -.81E-02
AME=0.36E-01
RMS=0.42E-01
Lim 10
Segment 10
Julian Day 2445.5
12:00 9/10/2008
ME= 0.37E-01
AME=0.92E-01
RMS=0.99E-01
Lim 11
Segment 11
Julian Day 2445.5
12:00 9/10/2008

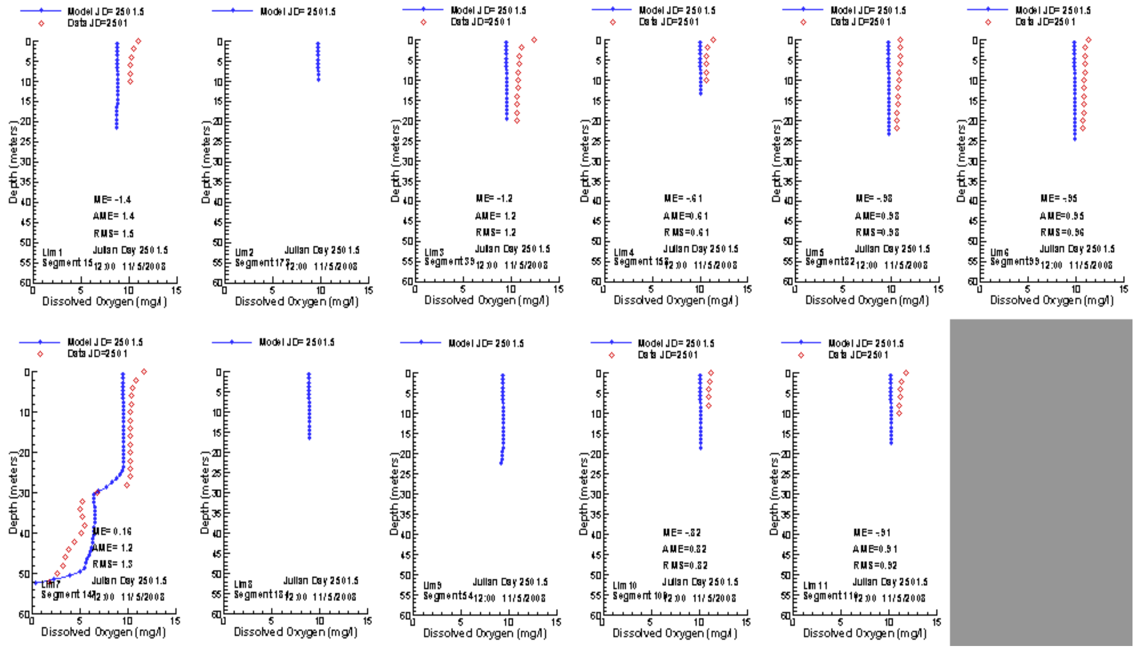

Model J D= 2459.5
Data JD=2459
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -1.1
AME= 1.1
RMS= 1.1
Lim 1
Segment 15
Julian Day 2459.5
12:00 9/24/2008
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 2
Segment 17
Julian Day 2459.5
12:00 9/24/2008
ME= -.44
AME=0.66
RMS=0.68
Lim3
Segment 39
Julian Day 2459.5
12:00 9/24/2008
ME= -.31
AME=0.31
RMS=0.35
Lim 4
Segment 15
Julian Day 2459.5
12:00 9/24/2008
ME= -.31
AME=0.31
RMS=0.37
Lim5
Segment 82
Julian Day 2459.5
12:00 9/24/2008
ME= -.20
AME=0.20
RMS=0.20
Lim6
Segment 99
Julian Day 2459.5
12:00 9/24/2008
ME= -.84
AME=0.84
RMS=0.84
Lim7
Segment 14
Julian Day 2459.5
12:00 9/24/2008
ME= -1.4
AME= 1.4
RMS= 1.4
Lim8
Segment 18
Julian Day 2459.5
12:00 9/24/2008
ME= -.32
AME=0.65
RMS=0.75
Lim9
Segment 54
Julian Day 2459.5
12:00 9/24/2008
ME= -.34
AME=0.34
RMS=0.34
Lim 10
Segment 10
Julian Day 2459.5
12:00 9/24/2008
ME= -.96E-01
AME=0.96E-01
RMS=0.11
Lim 11
Segment 11
Julian Day 2459.5
12:00 9/24/2008


Model J D= 2473.5
Data JD=2473
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -2.7
AME= 2.7
RMS= 2.7
Lim 1
Segment 15
Julian Day 2473.5
12:00 10/8/2008
ME= -3.0
AME= 3.0
RMS= 3.0
Lim 2
Segment 17
Lim 3
Segment 39
ME= -2.7
AME= 2.7
RMS= 2.7
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
ME= -.30 E-01
AME= 1.9
RMS= 2.0
Lim 7
Segment 14
ME= -3.3
AME= 3.3
RMS= 3.3
Lim 8
Segment 18
ME= -.21
AME= 0.33
RMS= 0.38
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

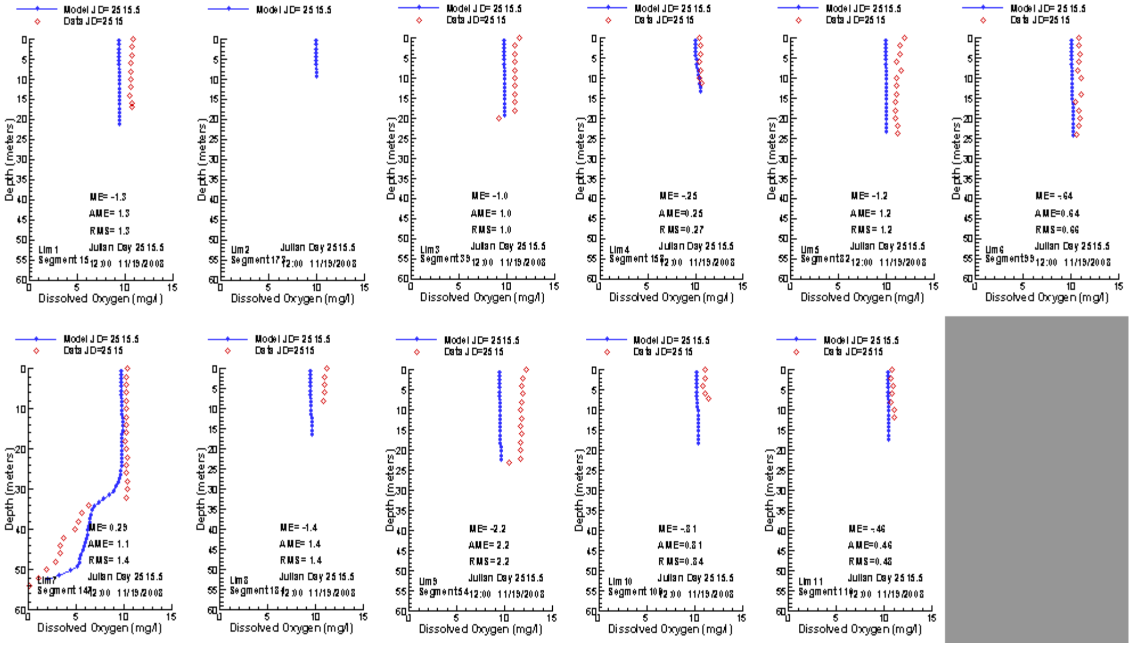

Model J D= 2483.5
Data JD=2483
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
Julian Day 2483.5
12:00 10/18/2008
Lim 1
Segment 15
Lim 2
Segment 17
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 3
Segment 39
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11



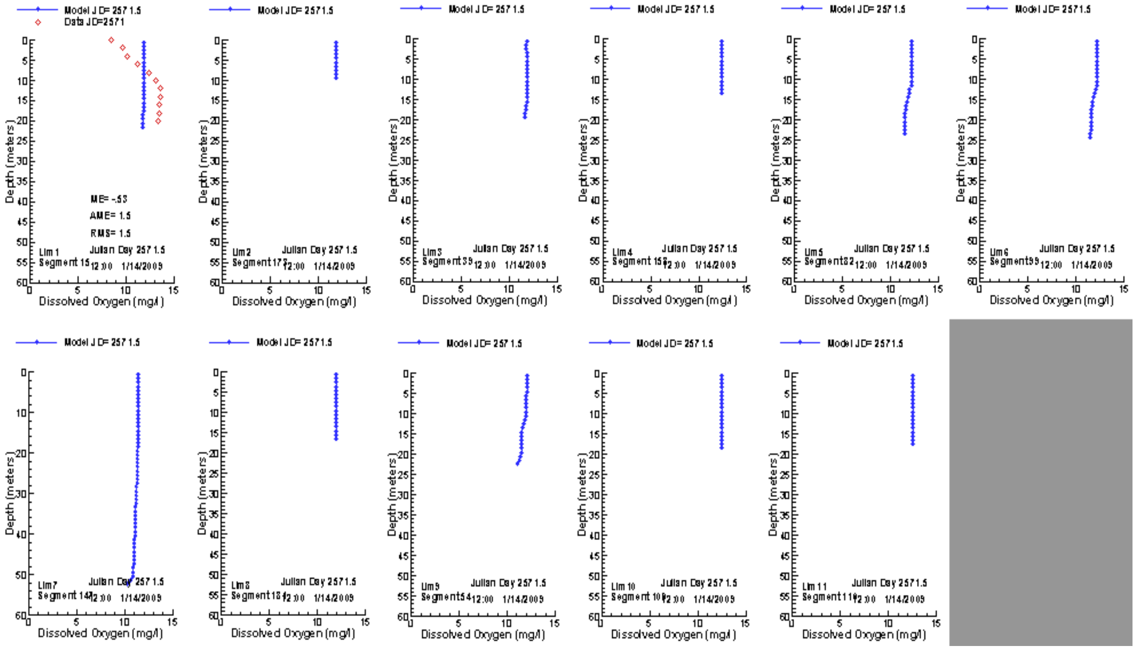
Model JD= 2487.5
Data JD=2487
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -1.1
AME= 1.1
RMS= 1.1
Lim 1
Segment 15
Julian Day 2487.5
12:00 10/22/2008
ME= -.85
AME=0.85
RMS=0.91
Lim 2
Segment 17
ME= -.29
AME=0.29
RMS=0.30
Lim 3
Segment 39
ME= -.46
AME=0.46
RMS=0.47
Lim 4
Segment 15
ME= -.58
AME=0.58
RMS=0.59
Lim 5
Segment 82
ME= -.38
AME=0.38
RMS=0.38
Lim 6
Segment 99
ME= 0.91
AME= 1.1
RMS= 1.6
Lim 7
Segment 14
ME= -2.0
AME= 2.0
RMS= 2.0
Lim 8
Segment 18
ME= -1.1
AME= 1.1
RMS= 1.2
Lim 9
Segment 54
ME= -.15
AME=0.15
RMS=0.17
Lim 10
Segment 10
ME= 0.12
AME=0.12
RMS=0.12
Lim 11
Segment 11



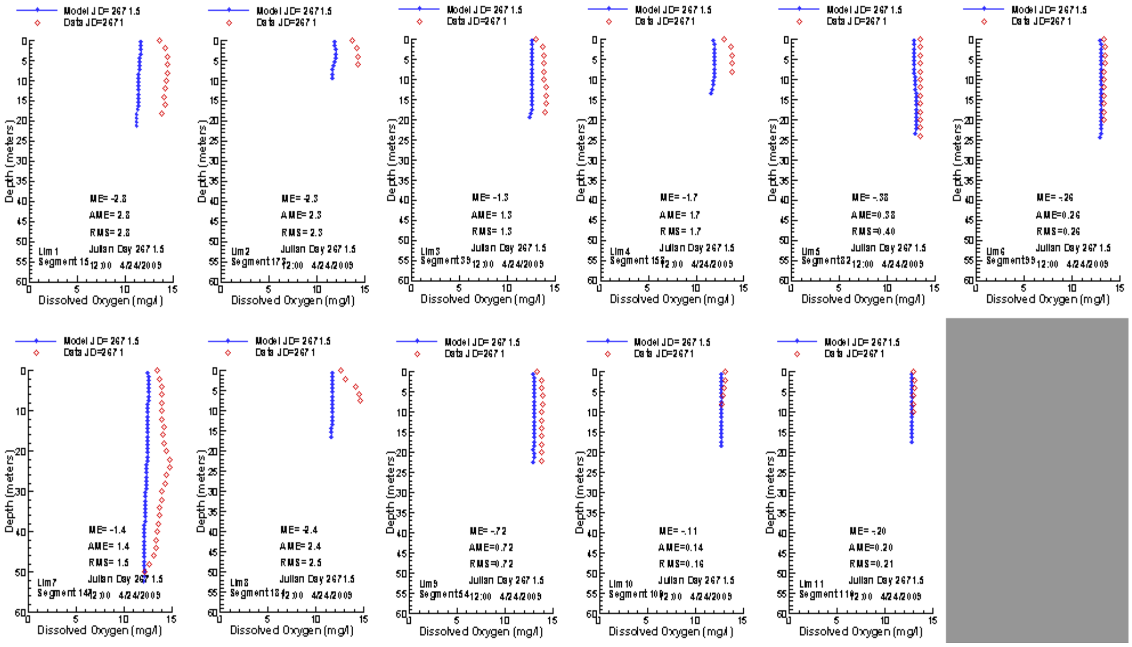
Model JD= 2501.5
Data JD=2501
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -1.4
AME= 1.4
RMS= 1.5
Lim 1
Segment 15
Julian Day 2501.5
12:00 11/5/2008
Lim 2
Segment 17
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 3
Segment 39
ME= -.61
AME=0.61
RMS=0.61
Lim 4
Segment 15
ME= -.98
AME=0.98
RMS=0.98
Lim 5
Segment 82
ME= -.95
AME=0.95
RMS=0.96
Lim 6
Segment 99
ME= 0.16
AME= 1.2
RMS= 1.3
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
ME= -.82
AME=0.82
RMS=0.82
Lim 10
Segment 10
ME= -.91
AME=0.91
RMS=0.92
Lim 11
Segment 11

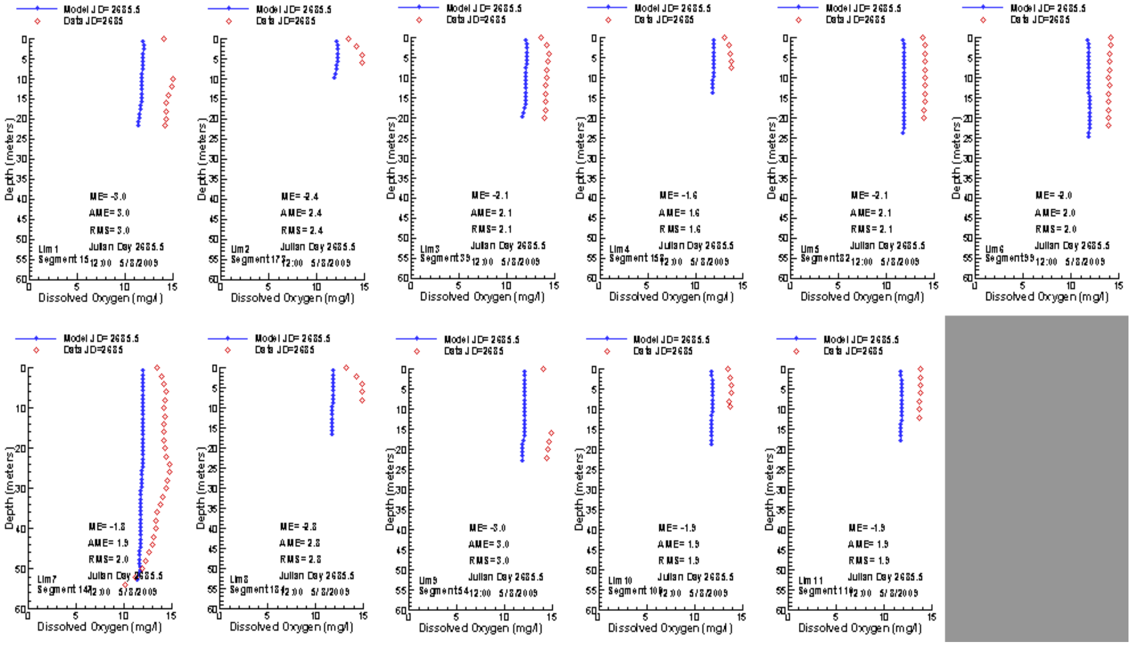


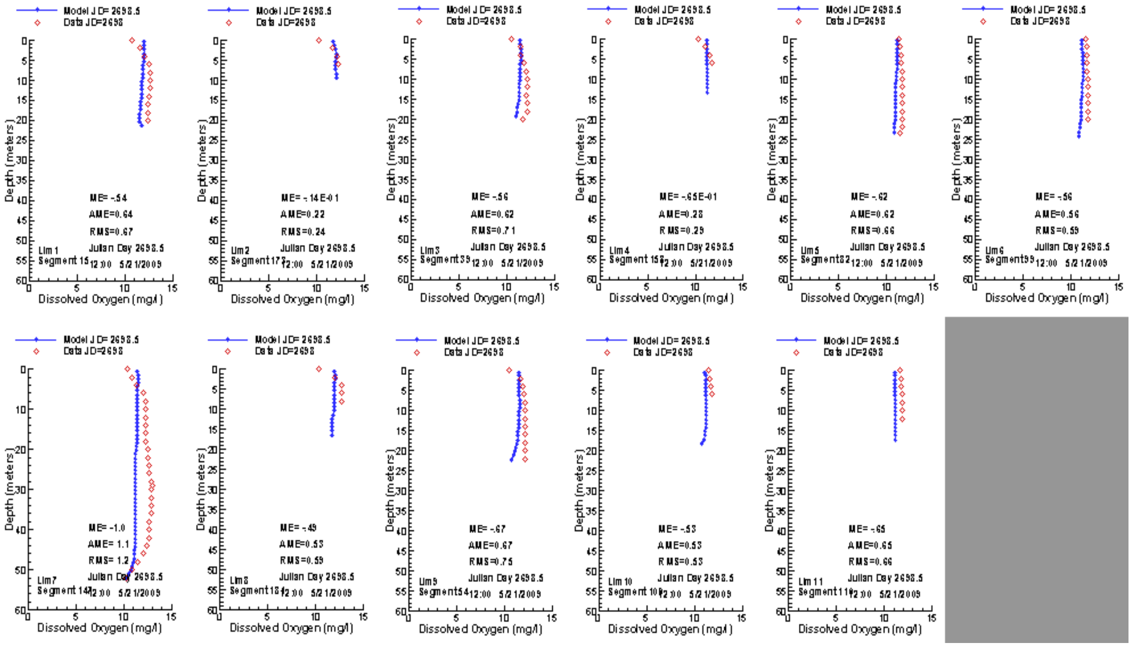
Model JD= 2515.5
Data JD=2515
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -1.3
AME= 1.3
RMS= 1.3
Lim1
Segment 15
Julian Day 2515.5
12:00 11/19/2008
Lim2
Segment 17
Julian Day 2515.5
12:00 11/19/2008
ME= -1.0
AME= 1.0
RMS= 1.0
Lim3
Segment 33
Julian Day 2515.5
12:00 11/19/2008
ME= -.25
AME=0.25
RMS=0.27
Lim4
Segment 15
Julian Day 2515.5
12:00 11/19/2008
ME= -1.2
AME= 1.2
RMS= 1.2
Lim5
Segment 32
Julian Day 2515.5
12:00 11/19/2008
ME= -.64
AME=0.64
RMS=0.66
Lim6
Segment 39
Julian Day 2515.5
12:00 11/19/2008
ME= 0.29
AME= 1.1
RMS= 1.4
Lim7
Segment 14
Julian Day 2515.5
12:00 11/19/2008
ME= -1.4
AME= 1.4
RMS= 1.4
Lim8
Segment 18
Julian Day 2515.5
12:00 11/19/2008
ME= -2.2
AME= 2.2
RMS= 2.2
Lim9
Segment 54
Julian Day 2515.5
12:00 11/19/2008
ME= -.81
AME=0.81
RMS=0.84
Lim10
Segment 10
Julian Day 2515.5
12:00 11/19/2008
ME= -.46
AME=0.46
RMS=0.48
Lim11
Segment 11
Julian Day 2515.5
12:00 11/19/2008

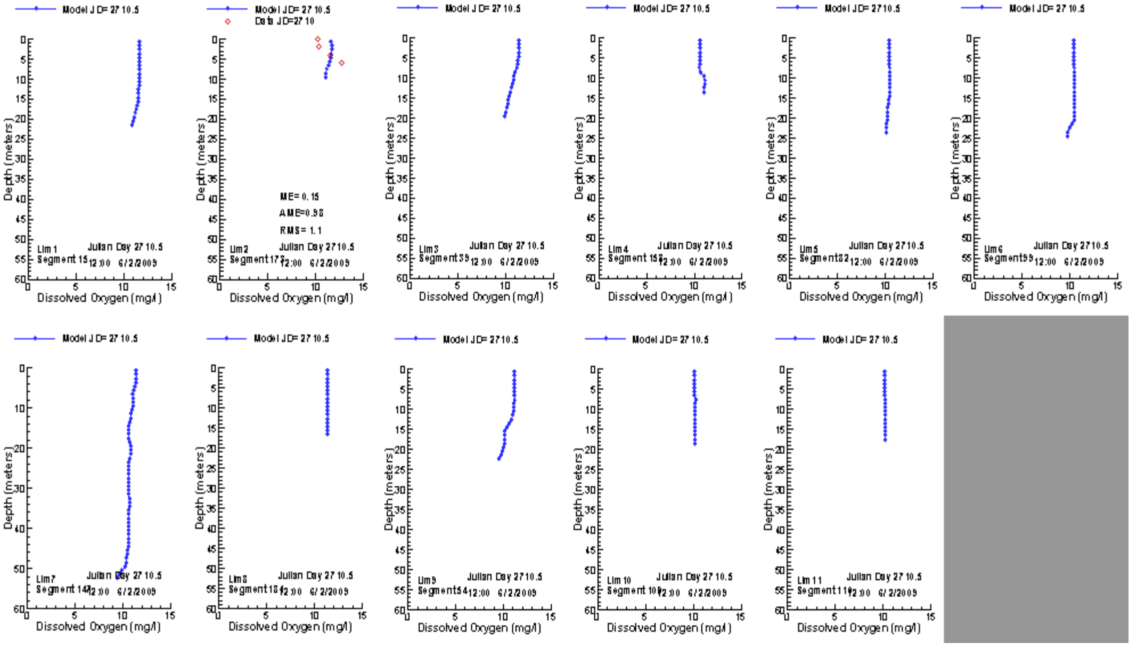


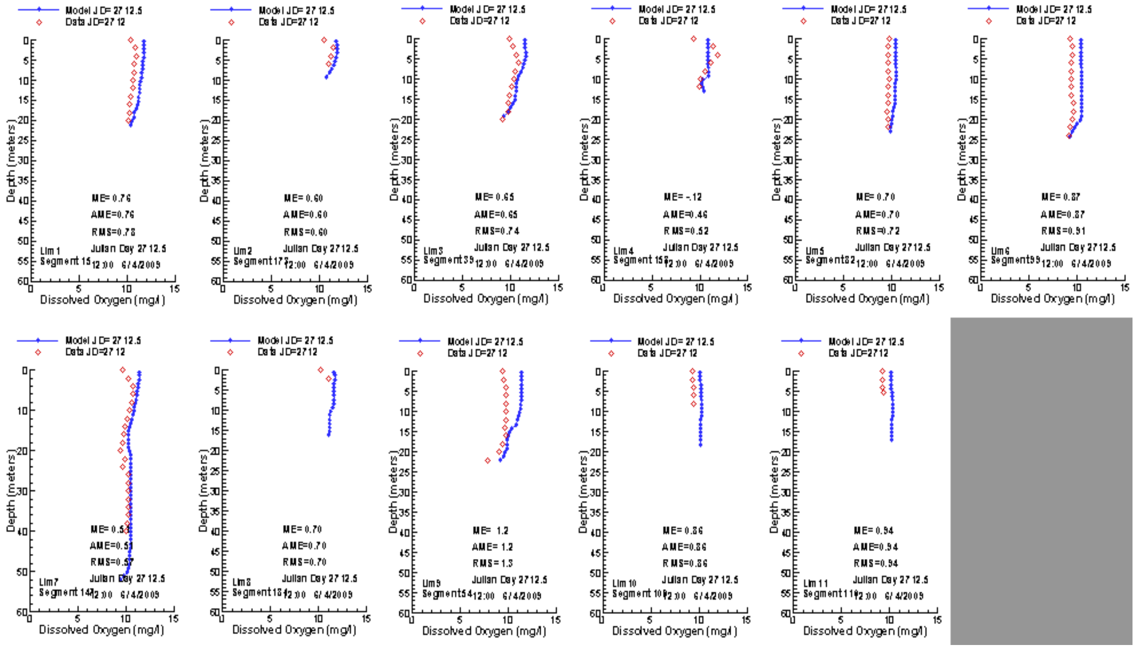
Model JD= 2571.5
Data JD=2571
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -.53
AME= 1.5
RMS= 1.5
Lim1
Segment 15
Julian Day 2571.5
12:00 1/14/2009
Lim2
Segment 17
Lim3
Segment 33
Lim4
Segment 15
Lim5
Segment 32
Lim6
Segment 39
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11


Model JD= 2671.5
Data JD=2671
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -2.8
AME= 2.8
RMS= 2.8
Lim 1
Segment 15
Julian Day 2671.5
12:00 4/24/2009
ME= -2.3
AME= 2.3
RMS= 2.3
Lim 2
Segment 17
Julian Day 2671.5
12:00 4/24/2009
ME= -1.3
AME= 1.3
RMS= 1.3
Lim 3
Segment 39
Julian Day 2671.5
12:00 4/24/2009
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 4
Segment 15
Julian Day 2671.5
12:00 4/24/2009
ME= -.38
AME=0.38
RMS=0.40
Lim 5
Segment 82
Julian Day 2671.5
12:00 4/24/2009
ME= -.26
AME=0.26
RMS=0.26
Lim 6
Segment 99
Julian Day 2671.5
12:00 4/24/2009
ME= -1.4
AME= 1.4
RMS= 1.5
Lim 7
Segment 14
Julian Day 2671.5
12:00 4/24/2009
ME= -2.4
AME= 2.4
RMS= 2.5
Lim 8
Segment 18
Julian Day 2671.5
12:00 4/24/2009
ME= -.72
AME=0.72
RMS=0.72
Lim 9
Segment 54
Julian Day 2671.5
12:00 4/24/2009
ME= -.11
AME=0.14
RMS=0.16
Lim 10
Segment 10
Julian Day 2671.5
12:00 4/24/2009
ME= -.20
AME=0.20
RMS=0.21
Lim 11
Segment 11
Julian Day 2671.5
12:00 4/24/2009

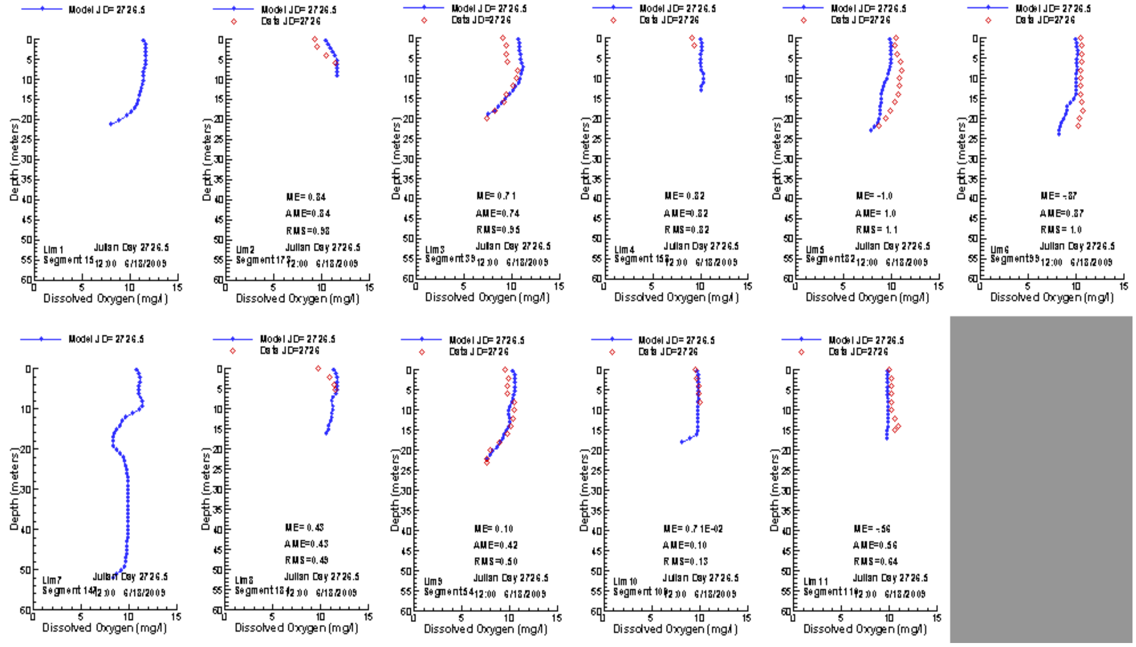

Model JD= 2685.5
Data JD=2685
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -3.0
AME= 3.0
RMS= 3.0
Lim 1
Segment 15
Julian Day 2685.5
12:00 5/8/2009
ME= -2.4
AME= 2.4
RMS= 2.4
Lim 2
Segment 17
Julian Day 2685.5
12:00 5/8/2009
ME= -2.1
AME= 2.1
RMS= 2.1
Lim 3
Segment 39
Julian Day 2685.5
12:00 5/8/2009
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 4
Segment 15
Julian Day 2685.5
12:00 5/8/2009
ME= -2.1
AME= 2.1
RMS= 2.1
Lim 5
Segment 82
Julian Day 2685.5
12:00 5/8/2009
ME= -2.0
AME= 2.0
RMS= 2.0
Lim 6
Segment 99
Julian Day 2685.5
12:00 5/8/2009
ME= -1.8
AME= 1.9
RMS= 2.0
Lim 7
Segment 14
Julian Day 2685.5
12:00 5/8/2009
ME= -2.8
AME= 2.8
RMS= 2.8
Lim 8
Segment 18
Julian Day 2685.5
12:00 5/8/2009
ME= -3.0
AME= 3.0
RMS= 3.0
Lim 9
Segment 54
Julian Day 2685.5
12:00 5/8/2009
ME= -1.9
AME= 1.9
RMS= 1.9
Lim 10
Segment 10
Julian Day 2685.5
12:00 5/8/2009
ME= -1.9
AME= 1.9
RMS= 1.9
Lim 11
Segment 11
Julian Day 2685.5
12:00 5/8/2009


Model JD= 2698.5
Data JD=2698
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.54
AME=0.64
RMS=0.67
Lim 1
Segment 15
Julian Day 2698.5
12:00 5/21/2009
ME= -.14E-01
AME=0.22
RMS=0.24
Lim 2
Segment 17
Julian Day 2698.5
12:00 5/21/2009
ME= -.56
AME=0.62
RMS=0.71
Lim 3
Segment 39
Julian Day 2698.5
12:00 5/21/2009
ME= -.65E-01
AME=0.28
RMS=0.29
Lim 4
Segment 15
Julian Day 2698.5
12:00 5/21/2009
ME= -.62
AME=0.62
RMS=0.66
Lim 5
Segment 82
Julian Day 2698.5
12:00 5/21/2009
ME= -.56
AME=0.56
RMS=0.59
Lim 6
Segment 95
Julian Day 2698.5
12:00 5/21/2009
ME= -1.0
AME= 1.1
RMS= 1.2
Lim 7
Segment 14
Julian Day 2698.5
12:00 5/21/2009
ME= -.49
AME=0.53
RMS=0.59
Lim 8
Segment 18
Julian Day 2698.5
12:00 5/21/2009
ME= -.67
AME=0.67
RMS=0.75
Lim 9
Segment 54
Julian Day 2698.5
12:00 5/21/2009
ME= -.53
AME=0.53
RMS=0.53
Lim 10
Segment 10
Julian Day 2698.5
12:00 5/21/2009
ME= -.65
AME=0.65
RMS=0.66
Lim 11
Segment 11
Julian Day 2698.5
12:00 5/21/2009

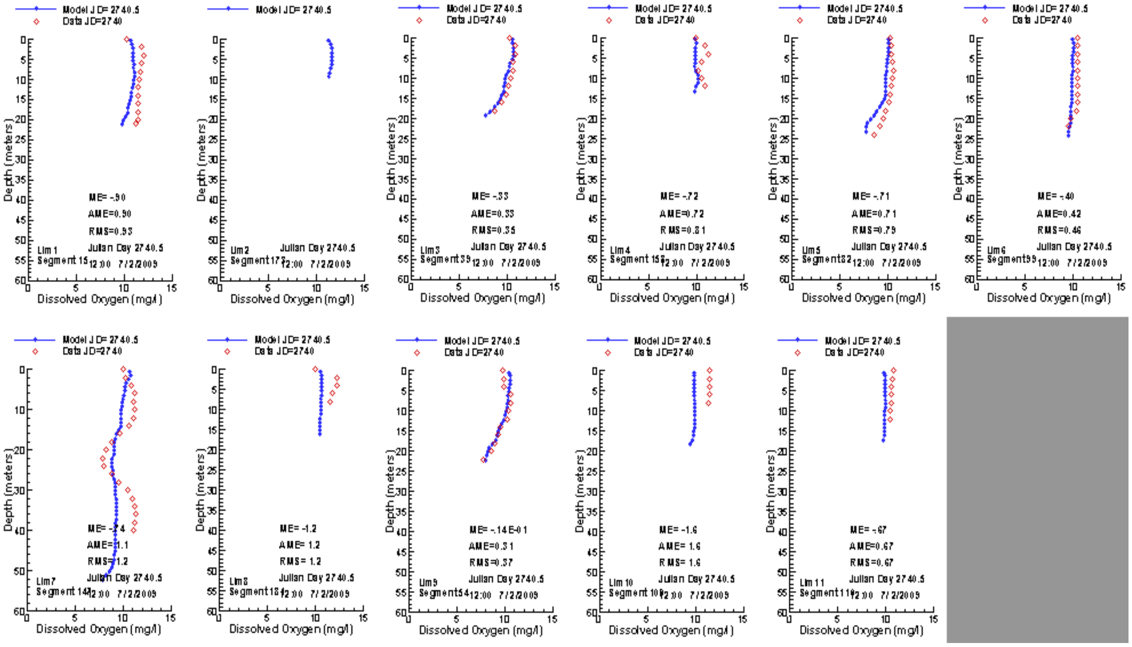

Model JD= 2710.5
Data JD=2710
Depth (meters)
Dissolved Oxygen (mg/l)
Lim 1
Segment 15
Julian Day 2710.5
12:00 6/2/2009
ME= 0.15
AME=0.98
RMS= 1.1
Lim 2
Segment 17
Julian Day 2710.5
12:00 6/2/2009
Lim 3
Segment 39
Julian Day 2710.5
12:00 6/2/2009
Lim 4
Segment 15
Julian Day 2710.5
12:00 6/2/2009
Lim 5
Segment 82
Julian Day 2710.5
12:00 6/2/2009
Lim 6
Segment 95
Julian Day 2710.5
12:00 6/2/2009
Lim 7
Segment 14
Julian Day 2710.5
12:00 6/2/2009
Lim 8
Segment 18
Julian Day 2710.5
12:00 6/2/2009
Lim 9
Segment 54
Julian Day 2710.5
12:00 6/2/2009
Lim 10
Segment 10
Julian Day 2710.5
12:00 6/2/2009
Lim 11
Segment 11
Julian Day 2710.5
12:00 6/2/2009

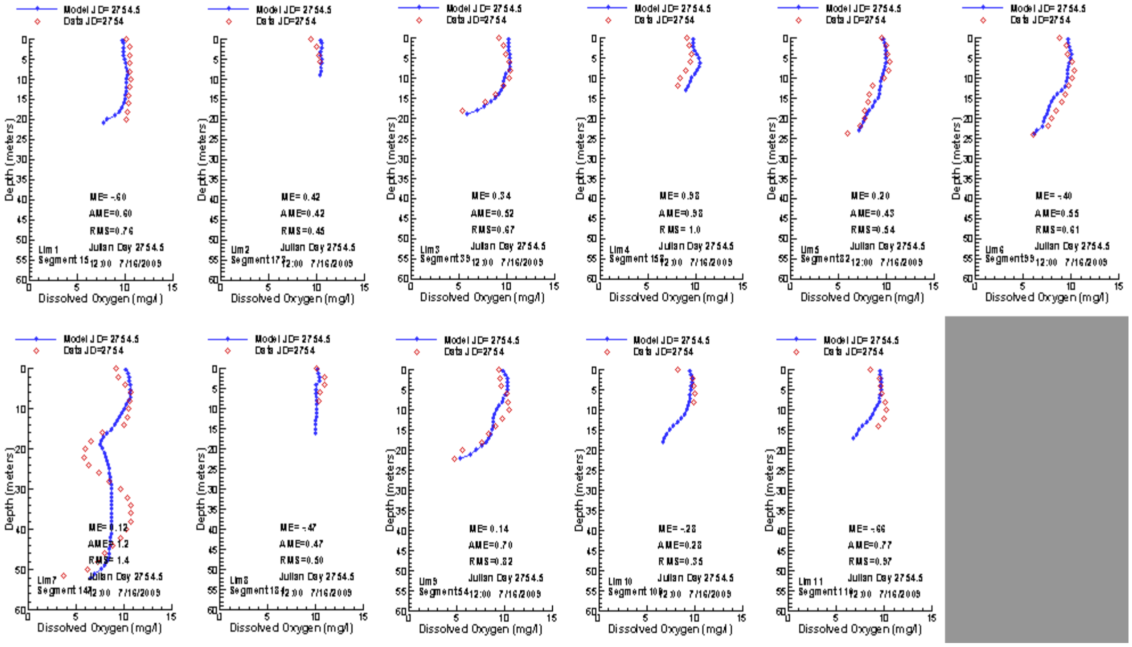


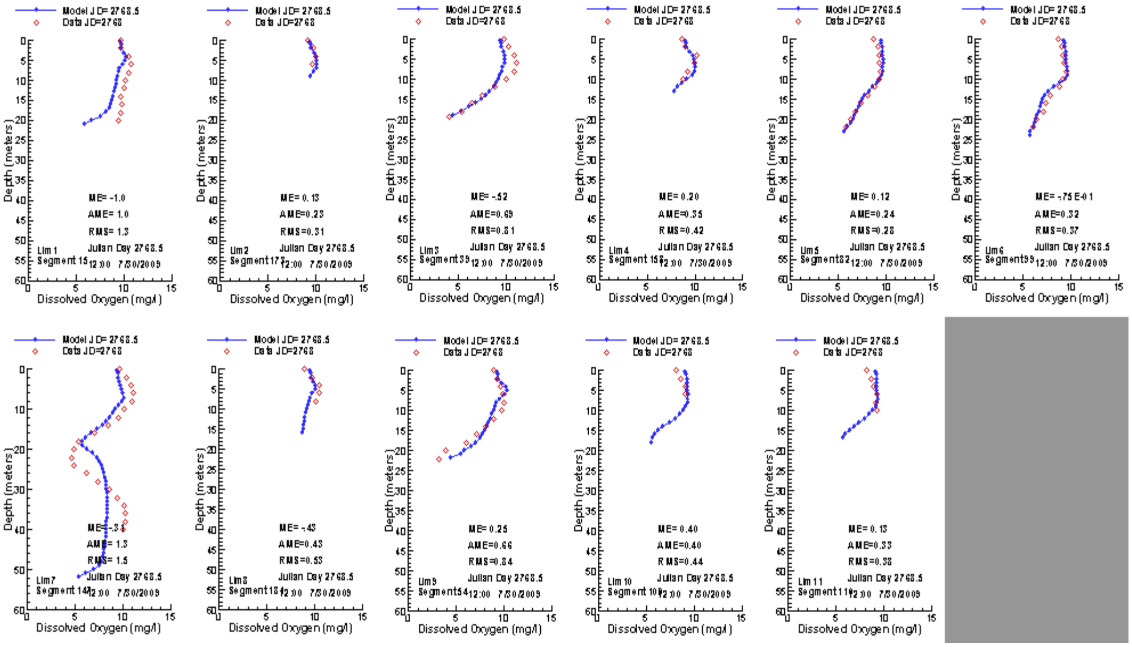
Model JD= 2712.5
Data JD=2712
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= 0.76
AME=0.76
RMS=0.78
Lim1
Segment 15
Julian Day 2712.5
12:00 6/4/2009
ME= 0.60
AME=0.60
RMS=0.60
Lim2
Segment 17
Julian Day 2712.5
12:00 6/4/2009
ME= 0.65
AME=0.65
RMS=0.74
Lim3
Segment 39
Julian Day 2712.5
12:00 6/4/2009
ME= -.12
AME=0.46
RMS=0.52
Lim4
Segment 15
Julian Day 2712.5
12:00 6/4/2009
ME= 0.70
AME=0.70
RMS=0.72
Lim5
Segment 82
Julian Day 2712.5
12:00 6/4/2009
ME= 0.87
AME=0.87
RMS=0.91
Lim6
Segment 99
Julian Day 2712.5
12:00 6/4/2009
ME= 0.51
AME=0.51
RMS=0.57
Lim7
Segment 14
Julian Day 2712.5
12:00 6/4/2009
ME= 0.70
AME=0.70
RMS=0.70
Lim8
Segment 18
Julian Day 2712.5
12:00 6/4/2009
ME= 1.2
AME= 1.2
RMS= 1.3
Lim9
Segment 54
Julian Day 2712.5
12:00 6/4/2009
ME= 0.86
AME=0.86
RMS=0.86
Lim10
Segment 10
Julian Day 2712.5
12:00 6/4/2009
ME= 0.94
AME=0.94
RMS=0.94
Lim11
Segment 11
Julian Day 2712.5
12:00 6/4/2009

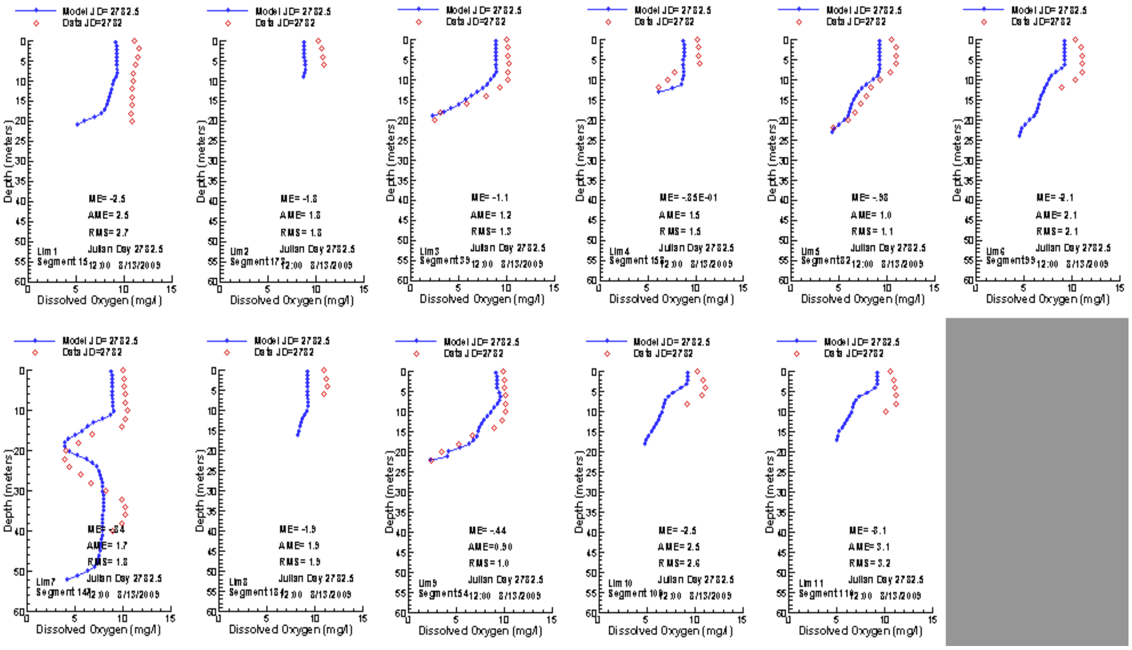


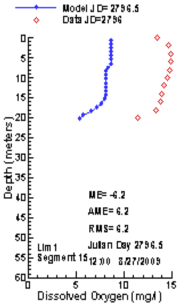
Model JD= 2726.5
Data JD=2726
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
Lim1
Segment 15
Julian Day 2726.5
12:00 6/18/2009
ME= 0.84
AME=0.84
RMS=0.98
Lim2
Segment 17
Julian Day 2726.5
12:00 6/18/2009
ME= 0.71
AME=0.74
RMS=0.95
Lim3
Segment 39
Julian Day 2726.5
12:00 6/18/2009
ME= 0.82
AME=0.82
RMS=0.82
Lim4
Segment 15
Julian Day 2726.5
12:00 6/18/2009
ME= -1.0
AME= 1.0
RMS= 1.1
Lim5
Segment 82
Julian Day 2726.5
12:00 6/18/2009
ME= -.87
AME=0.87
RMS= 1.0
Lim6
Segment 99
Julian Day 2726.5
12:00 6/18/2009
Lim7
Segment 14
Julian Day 2726.5
12:00 6/18/2009
ME= 0.43
AME=0.43
RMS=0.49
Lim8
Segment 18
Julian Day 2726.5
12:00 6/18/2009
ME= 0.10
AME=0.42
RMS=0.50
Lim9
Segment 54
Julian Day 2726.5
12:00 6/18/2009
ME= 0.71E-02
AME=0.10
RMS=0.13
Lim10
Segment 10
Julian Day 2726.5
12:00 6/18/2009
ME= -.56
AME=0.56
RMS=0.64
Lim11
Segment 11
Julian Day 2726.5
12:00 6/18/2009

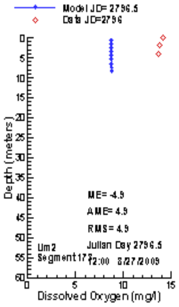

Model JD= 2740.5
Data JD=2740
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -.90
AME=0.90
RMS=0.93
Lim 1
Segment 15
Julian Day 2740.5
12:00 7/2/2009
Lim 2
Segment 17
Julian Day 2740.5
12:00 7/2/2009
ME= -.33
AME=0.33
RMS=0.35
Lim 3
Segment 39
Julian Day 2740.5
12:00 7/2/2009
ME= -.72
AME=0.72
RMS=0.81
Lim 4
Segment 15
Julian Day 2740.5
12:00 7/2/2009
ME= -.71
AME=0.71
RMS=0.79
Lim 5
Segment 82
Julian Day 2740.5
12:00 7/2/2009
ME= -.40
AME=0.42
RMS=0.46
Lim 6
Segment 99
Julian Day 2740.5
12:00 7/2/2009
ME= -.74
AME= 1.1
RMS= 1.2
Lim 7
Segment 14
Julian Day 2740.5
12:00 7/2/2009
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 8
Segment 18
Julian Day 2740.5
12:00 7/2/2009
ME= -.14E-01
AME=0.31
RMS=0.37
Lim 9
Segment 54
Julian Day 2740.5
12:00 7/2/2009
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 10
Segment 10
Julian Day 2740.5
12:00 7/2/2009
ME= -.67
AME=0.67
RMS=0.67
Lim 11
Segment 11
Julian Day 2740.5
12:00 7/2/2009

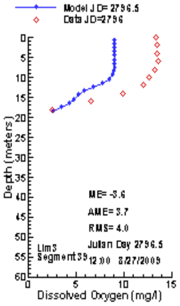

Model JD= 2754.5
Data JD=2754
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -.60
AME=0.60
RMS=0.76
Lim 1
Segment 15
Julian Day 2754.5
12:00 7/16/2009
ME= 0.42
AME=0.42
RMS=0.45
Lim 2
Segment 17
Julian Day 2754.5
12:00 7/16/2009
ME= 0.34
AME=0.52
RMS=0.67
Lim 3
Segment 39
Julian Day 2754.5
12:00 7/16/2009
ME= 0.98
AME=0.98
RMS= 1.0
Lim 4
Segment 15
Julian Day 2754.5
12:00 7/16/2009
ME= 0.20
AME=0.43
RMS=0.54
Lim 5
Segment 82
Julian Day 2754.5
12:00 7/16/2009
ME= -.40
AME=0.55
RMS=0.61
Lim 6
Segment 99
Julian Day 2754.5
12:00 7/16/2009
ME= 0.12
AME= 1.2
RMS= 1.4
Lim 7
Segment 14
Julian Day 2754.5
12:00 7/16/2009
ME= -.47
AME=0.47
RMS=0.50
Lim 8
Segment 18
Julian Day 2754.5
12:00 7/16/2009
ME= 0.14
AME=0.70
RMS=0.82
Lim 9
Segment 54
Julian Day 2754.5
12:00 7/16/2009
ME= -.28
AME=0.28
RMS=0.35
Lim 10
Segment 10
Julian Day 2754.5
12:00 7/16/2009
ME= -.66
AME=0.77
RMS=0.97
Lim 11
Segment 11
Julian Day 2754.5
12:00 7/16/2009

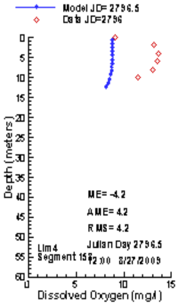

Model JD= 2768.5
Data JD=2768
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -1.0
AME= 1.0
RMS= 1.3
Lim 1
Segment 15
Julian Day 2768.5
12:00 7/30/2009
ME= 0.13
AME=0.23
RMS=0.31
Lim 2
Segment 17
Julian Day 2768.5
12:00 7/30/2009
ME= -.52
AME=0.69
RMS=0.81
Lim 3
Segment 39
Julian Day 2768.5
12:00 7/30/2009
ME= 0.20
AME=0.35
RMS=0.42
Lim 4
Segment 15
Julian Day 2768.5
12:00 7/30/2009
ME= 0.12
AME=0.24
RMS=0.28
Lim 5
Segment 82
Julian Day 2768.5
12:00 7/30/2009
ME= -.75E-01
AME=0.32
RMS=0.37
Lim 6
Segment 99
Julian Day 2768.5
12:00 7/30/2009
ME= -.31
AME= 1.3
RMS= 1.5
Lim 7
Segment 14
Julian Day 2768.5
12:00 7/30/2009
ME= -.43
AME=0.43
RMS=0.53
Lim 8
Segment 18
Julian Day 2768.5
12:00 7/30/2009
ME= 0.25
AME=0.66
RMS=0.84
Lim 9
Segment 54
Julian Day 2768.5
12:00 7/30/2009
ME= 0.40
AME=0.40
RMS=0.44
Lim 10
Segment 10
Julian Day 2768.5
12:00 7/30/2009
ME= 0.13
AME=0.33
RMS=0.38
Lim 11
Segment 11
Julian Day 2768.5
12:00 7/30/2009

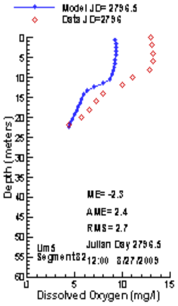

Model JD= 2782.5
Data JD=2782
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
ME= -2.5
AME= 2.5
RMS= 2.7
Lim 1
Segment 15
Julian Day 2782.5
12:00 8/13/2009
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 2
Segment 17
Julian Day 2782.5
12:00 8/13/2009
ME= -1.1
AME= 1.2
RMS= 1.3
Lim 3
Segment 39
Julian Day 2782.5
12:00 8/13/2009
ME= -.85E-01
AME= 1.5
RMS= 1.5
Lim 4
Segment 15
Julian Day 2782.5
12:00 8/13/2009
ME= -.98
AME= 1.0
RMS= 1.1
Lim 5
Segment 82
Julian Day 2782.5
12:00 8/13/2009
ME= -2.1
AME= 2.1
RMS= 2.1
Lim 6
Segment 99
Julian Day 2782.5
12:00 8/13/2009
ME= -.84
AME= 1.7
RMS= 1.8
Lim 7
Segment 14
Julian Day 2782.5
12:00 8/13/2009
ME= -1.9
AME= 1.9
RMS= 1.9
Lim 8
Segment 18
Julian Day 2782.5
12:00 8/13/2009
ME= -.44
AME=0.90
RMS= 1.0
Lim 9
Segment 54
Julian Day 2782.5
12:00 8/13/2009
ME= -2.5
AME= 2.5
RMS= 2.6
Lim 10
Segment 10
Julian Day 2782.5
12:00 8/13/2009
ME= -3.1
AME= 3.1
RMS= 3.2
Lim 11
Segment 11
Julian Day 2782.5
12:00 8/13/2009

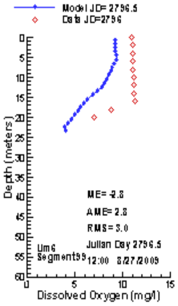

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -6.2
AME= 6.2
RMS= 6.2
Lim 1
Segment 15
Julian Day 2796.5
12:00 8/27/2009

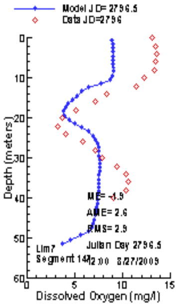

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -4.9
AME= 4.9
RMS= 4.9
Lim2
Segment 17
Julian Day 2796.5
12:00 8/27/2009

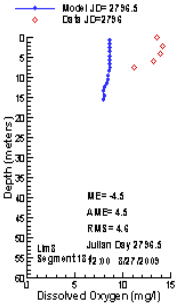

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -3.6
AME= 3.7
RMS= 4.0
Lim3
Segment 39
Julian Day 2796.5
12:00 8/27/2009

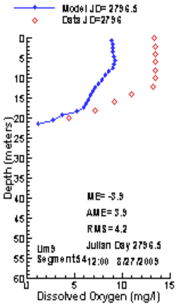

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -4.2
AME= 4.2
RMS= 4.2
Lim4
Segment 15
Julian Day 2796.5
12:00 8/27/2009

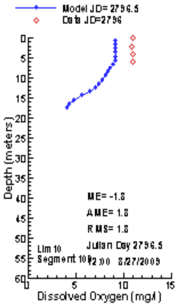

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.3
AME= 2.4
RMS= 2.7
Lim5
Segment82
Julian Day 2796.5
12:00 8/27/2009

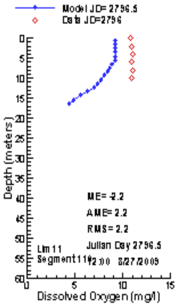

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.8
AME= 2.8
RMS= 3.0
Lim6
Segment99
Julian Day 2796.5
12:00 8/27/2009

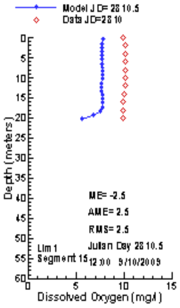

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 10 20 30 40 50 60
0 5 10 15
ME= -1.9
AME= 2.6
RMS= 2.9
Lim7
Segment 14
Julian Day 2796.5
12:00 8/27/2009

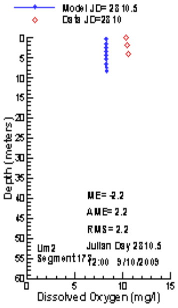

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -4.5
AME= 4.5
RMS= 4.6
Lim8
Segment 18
Julian Day 2796.5
12:00 8/27/2009

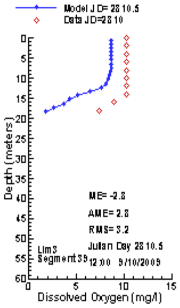

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -3.9
AME= 3.9
RMS= 4.2
Lim9
Segment54
Julian Day 2796.5
12:00 8/27/2009

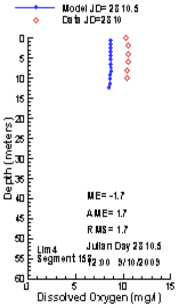

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 10
Segment 10
Julian Day 2796.5
12:00 8/27/2009

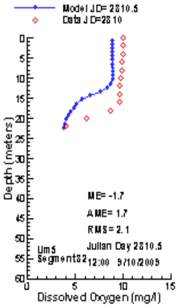

Model JD= 2796.5
Data JD=2796
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.2
AME= 2.2
RMS= 2.2
Lim 11
Segment 11
Julian Day 2796.5
12:00 8/27/2009

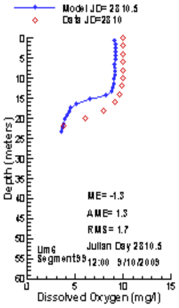

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.5
AME= 2.5
RMS= 2.5
Lim 1
Segment 15
Julian Day 2810.5
12:00 9/10/2009

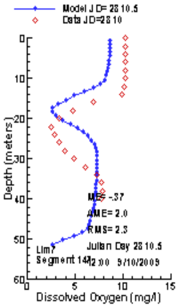

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.2
AME= 2.2
RMS= 2.2
Lim2
Segment 17
Julian Day 2810.5
12:00 9/10/2009

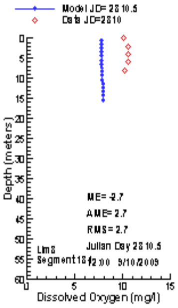

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.8
AME= 2.8
RMS= 3.2
Lim3
Segment 39
Julian Day 2810.5
12:00 9/10/2009

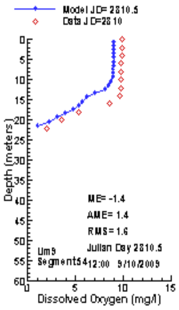

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.7
AME= 1.7
RMS= 1.7
Lim4
Segment 15
Julian Day 2810.5
12:00 9/10/2009

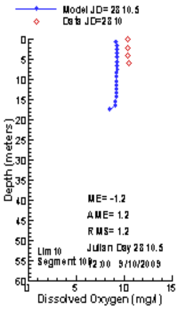

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.7
AME= 1.7
RMS= 2.1
Lim5
Segment82
Julian Day 2810.5
12:00 9/10/2009

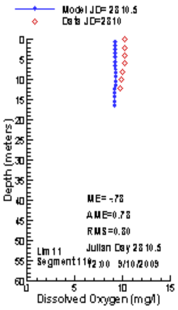

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.3
AME= 1.3
RMS= 1.7
Lim6
Segment99
Julian Day 2810.5
12:00 9/10/2009

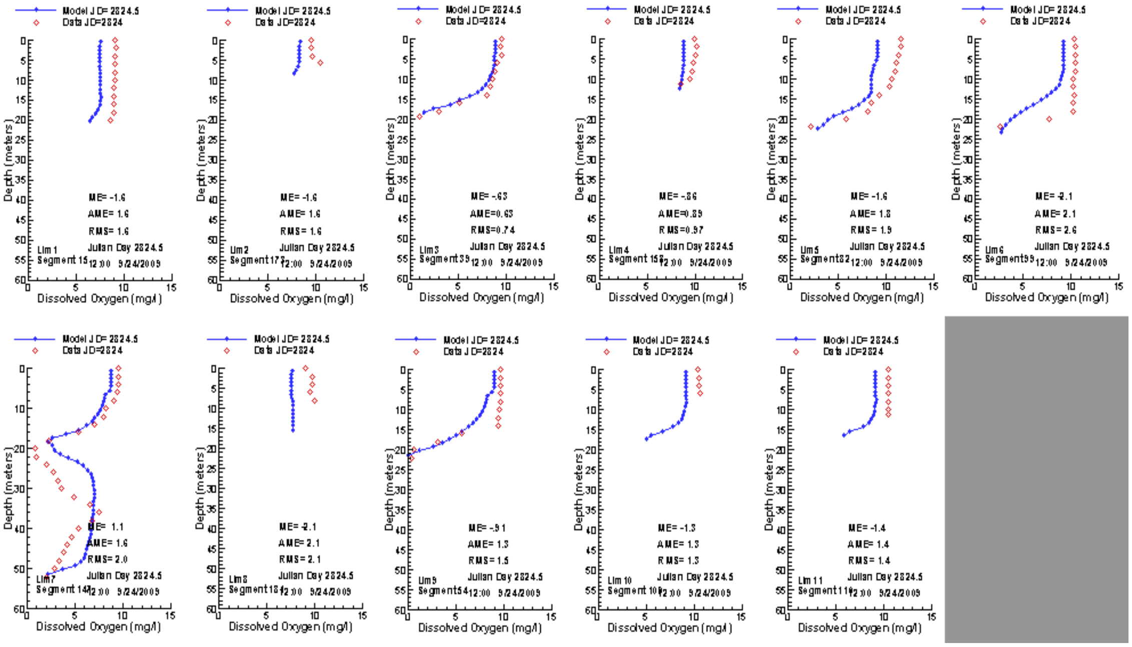

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 10 20 30 40 50 60
0 5 10 15
ME= -.37
AME= 2.0
RMS= 2.3
Lim7
Segment 14
Julian Day 2810.5
12:00 9/10/2009

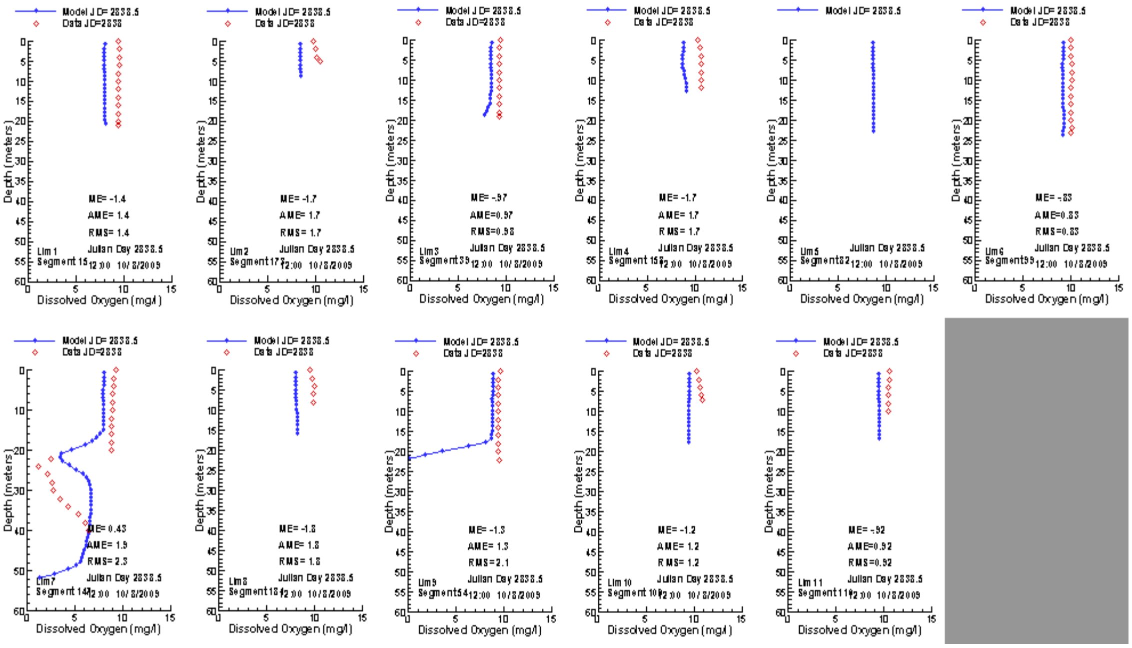

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -2.7
AME= 2.7
RMS= 2.7
Lim8
Segment 18
Julian Day 2810.5
12:00 9/10/2009

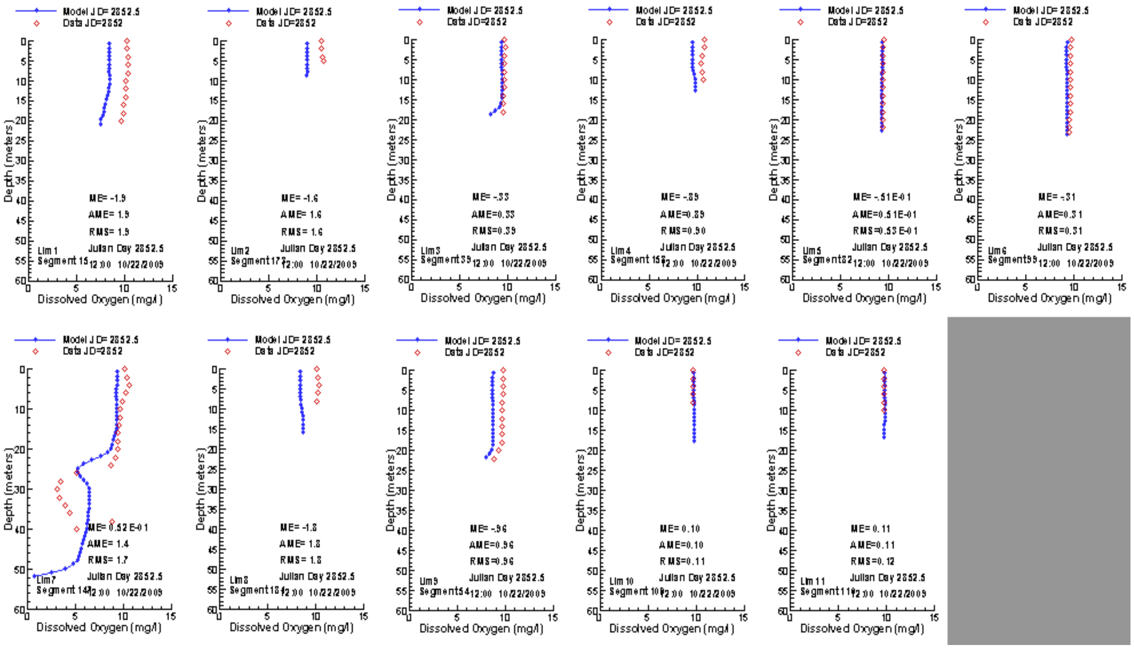

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.4
AME= 1.4
RMS= 1.6
Lim9
Segment54
Julian Day 2810.5
12:00 9/10/2009

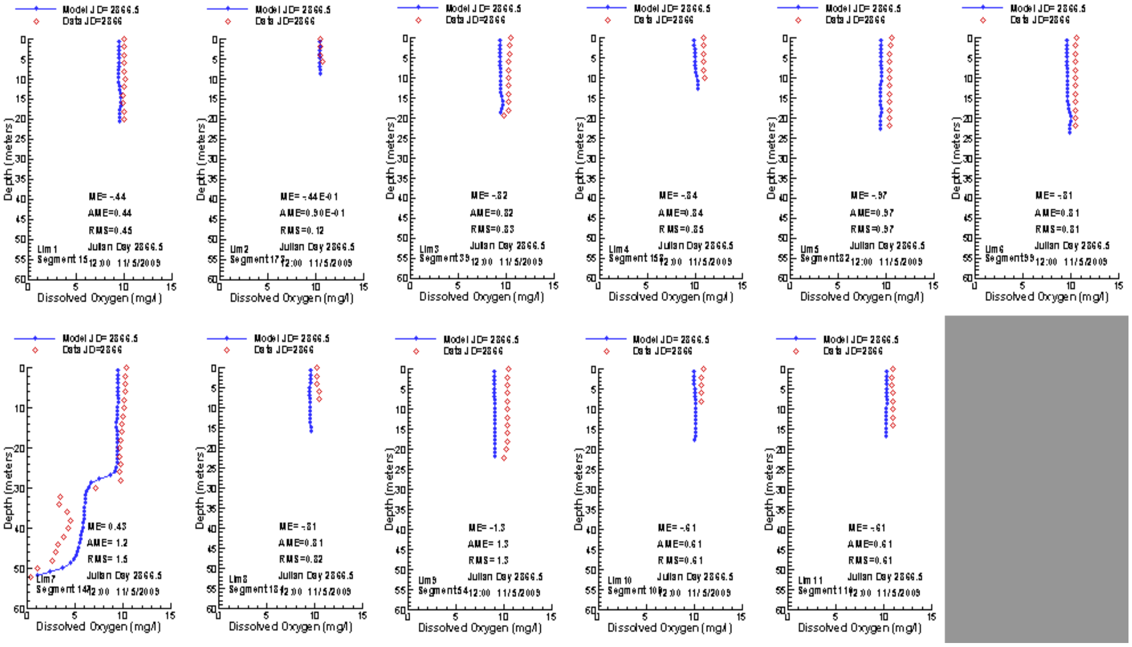

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 10
Segment 10
Julian Day 2810.5
12:00 9/10/2009

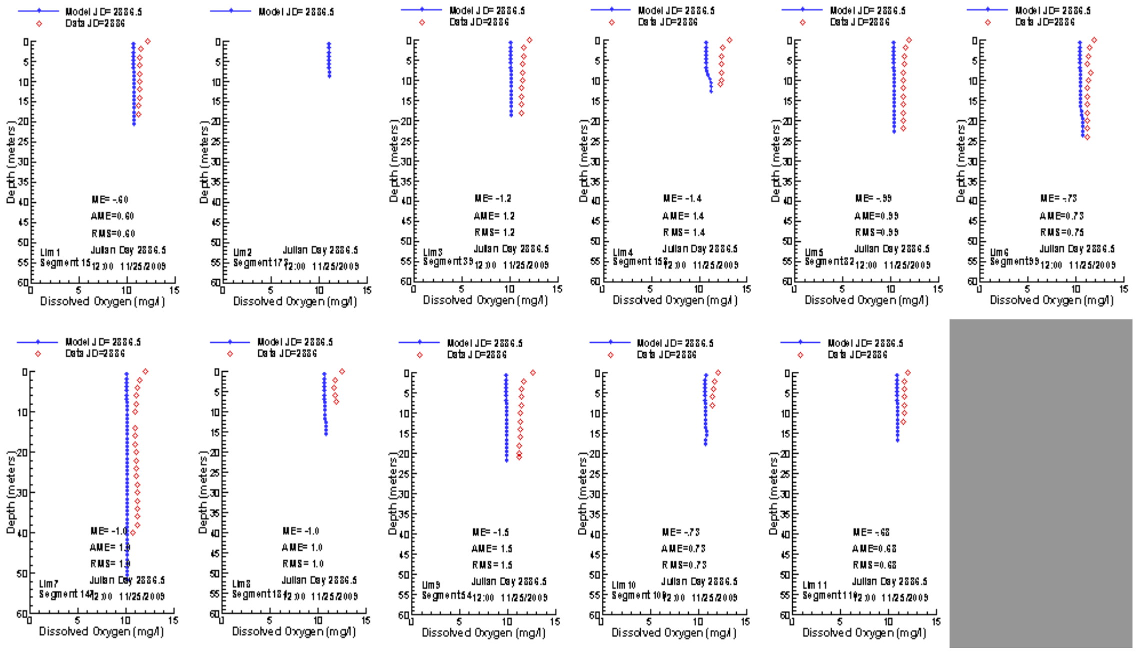

Model JD= 2810.5
Data JD=2810
Depth (meters)
Dissolved Oxygen (mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15
ME= -.78
AME=0.78
RMS=0.80
Lim 11
Segment 11
Julian Day 2810.5
12:00 9/10/2009

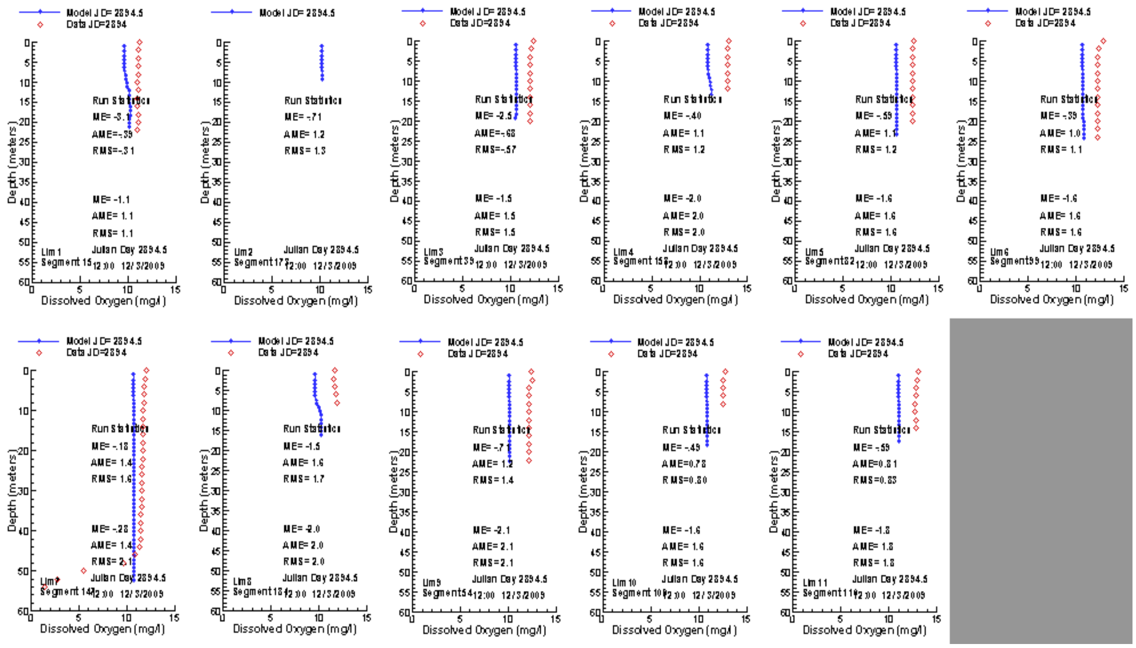

Model JD= 2824.5
Data JD=2824
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 1
Segment 15
Julian Day 2824.5
12:00 9/24/2009
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 2
Segment 17
Julian Day 2824.5
12:00 9/24/2009
ME= -.63
AME=0.63
RMS=0.74
Lim3
Segment 39
Julian Day 2824.5
12:00 9/24/2009
ME= -.86
AME=0.89
RMS=0.97
Lim 4
Segment 15
Julian Day 2824.5
12:00 9/24/2009
ME= -1.6
AME= 1.8
RMS= 1.9
Lim 5
Segment 82
Julian Day 2824.5
12:00 9/24/2009
ME= -2.1
AME= 2.1
RMS= 2.6
Lim 6
Segment 99
Julian Day 2824.5
12:00 9/24/2009
ME= 1.1
AME= 1.6
RMS= 2.0
Lim7
Segment 14
Julian Day 2824.5
12:00 9/24/2009
ME= -2.1
AME= 2.1
RMS= 2.1
Lim 8
Segment 18
Julian Day 2824.5
12:00 9/24/2009
ME= -.91
AME= 1.3
RMS= 1.5
Lim 9
Segment 54
Julian Day 2824.5
12:00 9/24/2009
ME= -1.3
AME= 1.3
RMS= 1.3
Lim 10
Segment 10
Julian Day 2824.5
12:00 9/24/2009
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 11
Segment 11
Julian Day 2824.5
12:00 9/24/2009


Model JD= 2838.5
Data JD=2838
Depth (meters)
Dissolved Oxygen (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 1
Segment 15
Julian Day 2838.5
12:00 10/8/2009
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 2
Segment 17
Julian Day 2838.5
12:00 10/8/2009
ME= -.97
AME=0.97
RMS=0.98
Lim3
Segment 39
Julian Day 2838.5
12:00 10/8/2009
ME= -1.7
AME= 1.7
RMS= 1.7
Lim 4
Segment 15
Julian Day 2838.5
12:00 10/8/2009
Lim 5
Segment 82
Julian Day 2838.5
12:00 10/8/2009
ME= -.83
AME=0.83
RMS=0.83
Lim 6
Segment 99
Julian Day 2838.5
12:00 10/8/2009
ME= 0.43
AME= 1.9
RMS= 2.3
Lim7
Segment 14
Julian Day 2838.5
12:00 10/8/2009
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 8
Segment 18
Julian Day 2838.5
12:00 10/8/2009
ME= -1.3
AME= 1.3
RMS= 2.1
Lim 9
Segment 54
Julian Day 2838.5
12:00 10/8/2009
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 10
Segment 10
Julian Day 2838.5
12:00 10/8/2009
ME= -.92
AME=0.92
RMS=0.92
Lim 11
Segment 11
Julian Day 2838.5
12:00 10/8/2009

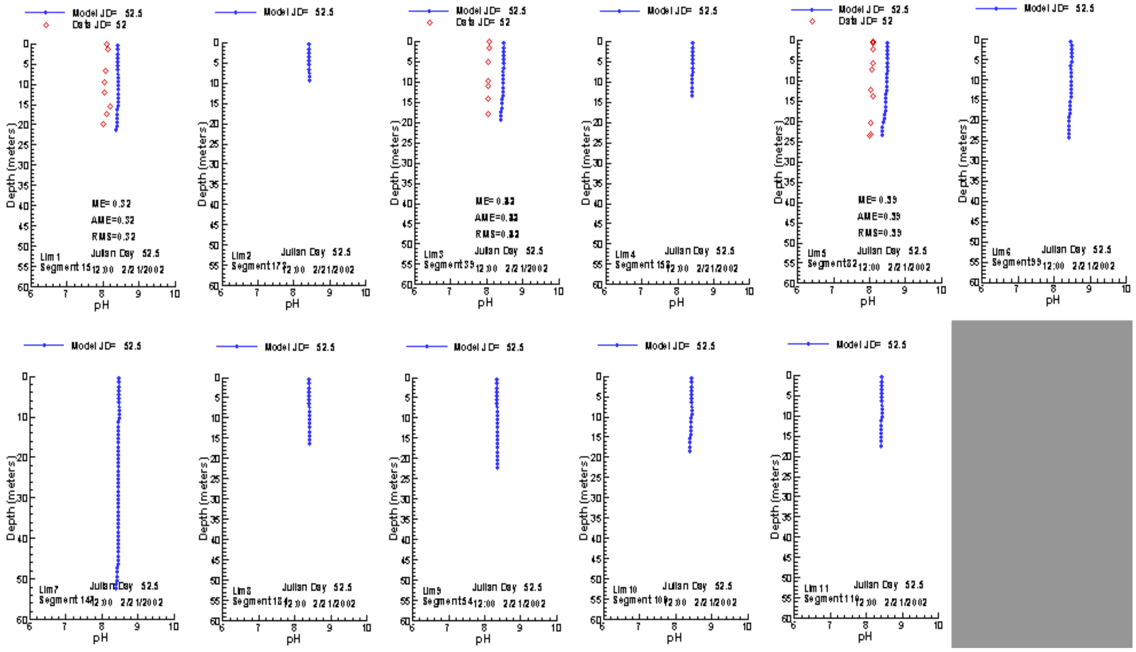

Model JD= 2852.5
Data JD=2852
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -1.9
AME= 1.9
RMS= 1.9
Lim 1
Segment 15
Julian Day 2852.5
12:00 10/22/2009
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 2
Segment 17
Julian Day 2852.5
12:00 10/22/2009
ME= -.33
AME=0.33
RMS=0.39
Lim 3
Segment 39
Julian Day 2852.5
12:00 10/22/2009
ME= -.89
AME=0.89
RMS=0.90
Lim 4
Segment 15
Julian Day 2852.5
12:00 10/22/2009
ME= -.51E-01
AME=0.51E-01
RMS=0.53E-01
Lim 5
Segment 82
Julian Day 2852.5
12:00 10/22/2009
ME= -.31
AME=0.31
RMS=0.31
Lim 6
Segment 99
Julian Day 2852.5
12:00 10/22/2009
ME= 0.52E-01
AME= 1.4
RMS= 1.7
Lim 7
Segment 14
Julian Day 2852.5
12:00 10/22/2009
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 8
Segment 18
Julian Day 2852.5
12:00 10/22/2009
ME= -.96
AME=0.96
RMS=0.96
Lim 9
Segment 54
Julian Day 2852.5
12:00 10/22/2009
ME= 0.10
AME=0.10
RMS=0.11
Lim 10
Segment 10
Julian Day 2852.5
12:00 10/22/2009
ME= 0.11
AME=0.11
RMS=0.12
Lim 11
Segment 11
Julian Day 2852.5
12:00 10/22/2009

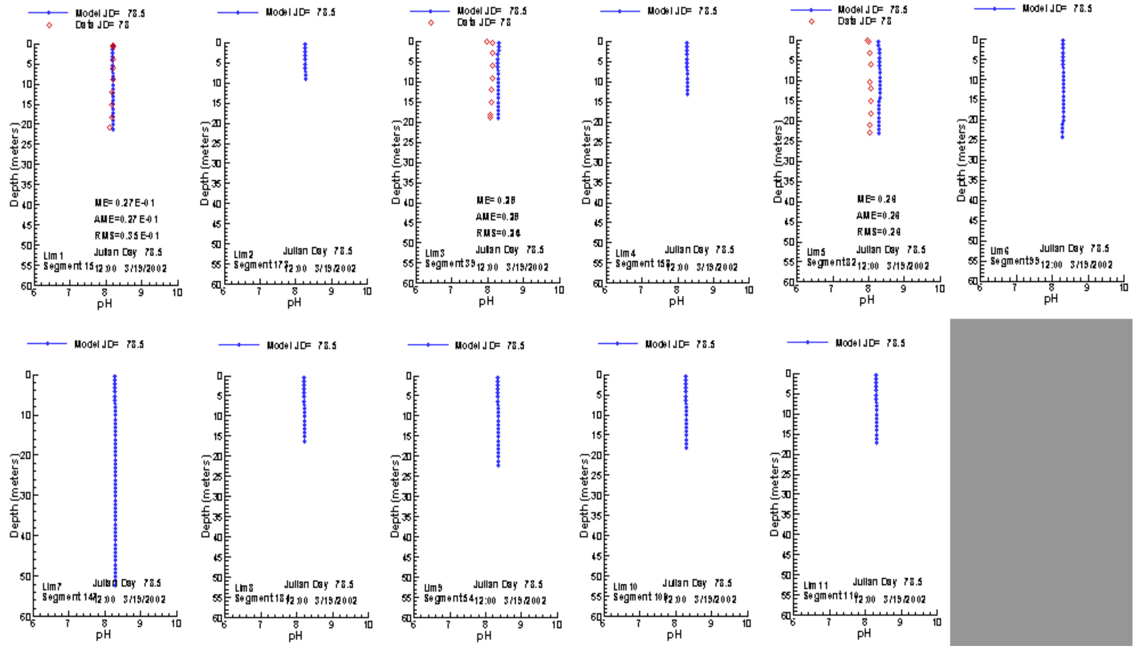

Model JD= 2866.5
Data JD=2866
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.44
AME=0.44
RMS=0.45
Lim 1
Segment 15
Julian Day 2866.5
12:00 11/5/2009
ME= -.44E-01
AME=0.90E-01
RMS=0.12
Lim 2
Segment 17
Julian Day 2866.5
12:00 11/5/2009
ME= -.82
AME=0.82
RMS=0.83
Lim 3
Segment 39
Julian Day 2866.5
12:00 11/5/2009
ME= -.84
AME=0.84
RMS=0.85
Lim 4
Segment 15
Julian Day 2866.5
12:00 11/5/2009
ME= -.97
AME=0.97
RMS=0.97
Lim 5
Segment 82
Julian Day 2866.5
12:00 11/5/2009
ME= -.81
AME=0.81
RMS=0.81
Lim 6
Segment 99
Julian Day 2866.5
12:00 11/5/2009
ME= 0.43
AME= 1.2
RMS= 1.5
Lim 7
Segment 14
Julian Day 2866.5
12:00 11/5/2009
ME= -.81
AME=0.81
RMS=0.82
Lim 8
Segment 18
Julian Day 2866.5
12:00 11/5/2009
ME= -1.3
AME= 1.3
RMS= 1.3
Lim 9
Segment 54
Julian Day 2866.5
12:00 11/5/2009
ME= -.61
AME=0.61
RMS=0.61
Lim 10
Segment 10
Julian Day 2866.5
12:00 11/5/2009
ME= -.61
AME=0.61
RMS=0.61
Lim 11
Segment 11
Julian Day 2866.5
12:00 11/5/2009

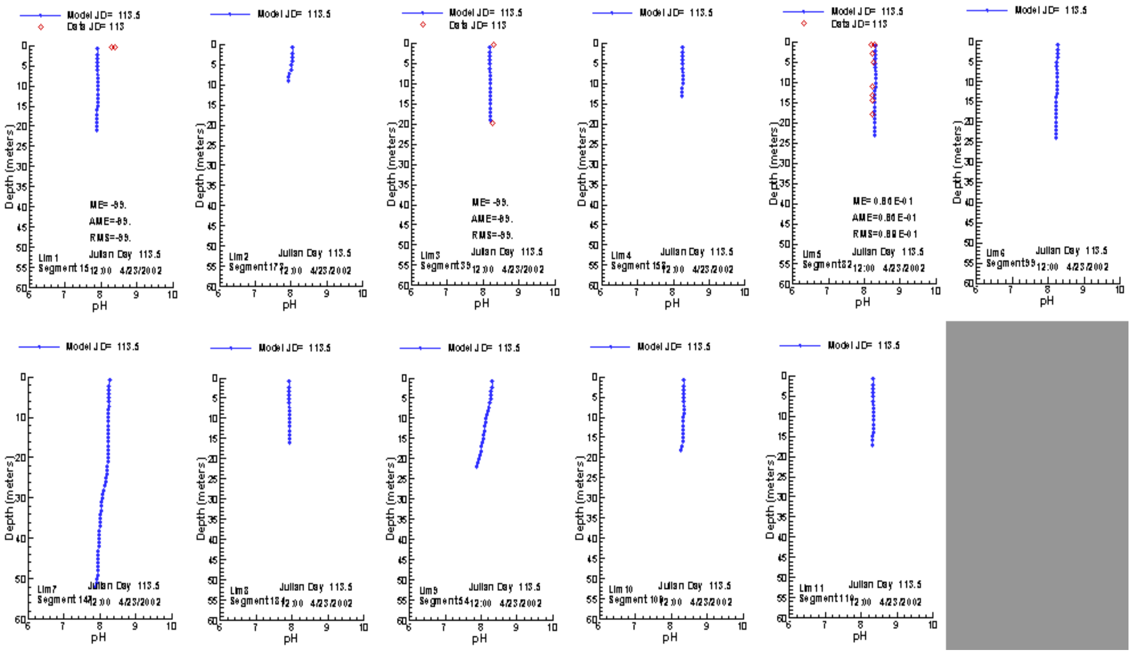

Model JD= 2886.5
Data JD=2886
Depth (meters)
Dissolved Oxygen (mg/l)
ME= -.60
AME=0.60
RMS=0.60
Lim 1
Segment 15
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Lim 2
Segment 17
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 3
Segment 39
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -1.4
AME= 1.4
RMS= 1.4
Lim 4
Segment 15
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -.99
AME=0.99
RMS=0.99
Lim 5
Segment 82
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -.73
AME=0.73
RMS=0.75
Lim 6
Segment 99
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 7
Segment 14
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 8
Segment 18
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -1.5
AME= 1.5
RMS= 1.5
Lim 9
Segment 54
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -.73
AME=0.73
RMS=0.73
Lim 10
Segment 10
Julian Day 2886.5
12:00 11/25/2009
Model JD= 2886.5
Data JD=2886
ME= -.68
AME=0.68
RMS=0.68
Lim 11
Segment 11
Julian Day 2886.5
12:00 11/25/2009
0
5
10
15
20
25
30
35
40
45
50
55
60


Model JD= 2894.5
Data JD=2894
Depth (meters)
Dissolved Oxygen (mg/l)
Run Statistics
ME= -3.1
AME=-.33
RMS=-.31
ME= -1.1
AME= 1.1
RMS= 1.1
Lim 1
Segment 15
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Run Statistics
ME= -.71
AME= 1.2
RMS= 1.3
Lim 2
Segment 17
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -2.5
AME=-.68
RMS=-.57
ME= -1.5
AME= 1.5
RMS= 1.5
Lim 3
Segment 39
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.40
AME= 1.1
RMS= 1.2
ME= -2.0
AME= 2.0
RMS= 2.0
Lim 4
Segment 15
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.59
AME= 1.1
RMS= 1.2
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 5
Segment 82
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.39
AME= 1.0
RMS= 1.1
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 6
Segment 99
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.18
AME= 1.4
RMS= 1.6
ME= -.28
AME= 1.4
RMS= 2.1
Lim 7
Segment 14
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -1.5
AME= 1.6
RMS= 1.7
ME= -2.0
AME= 2.0
RMS= 2.0
Lim 8
Segment 18
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.71
AME= 1.2
RMS= 1.4
ME= -2.1
AME= 2.1
RMS= 2.1
Lim 9
Segment 54
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.49
AME=0.78
RMS=0.80
ME= -1.6
AME= 1.6
RMS= 1.6
Lim 10
Segment 10
Julian Day 2894.5
12:00 12/3/2009
Model JD= 2894.5
Data JD=2894
Run Statistics
ME= -.59
AME=0.81
RMS=0.83
ME= -1.8
AME= 1.8
RMS= 1.8
Lim 11
Segment 11
Julian Day 2894.5
12:00 12/3/2009
0
5
10
15
20
25
30
35
40
45
50
55
60

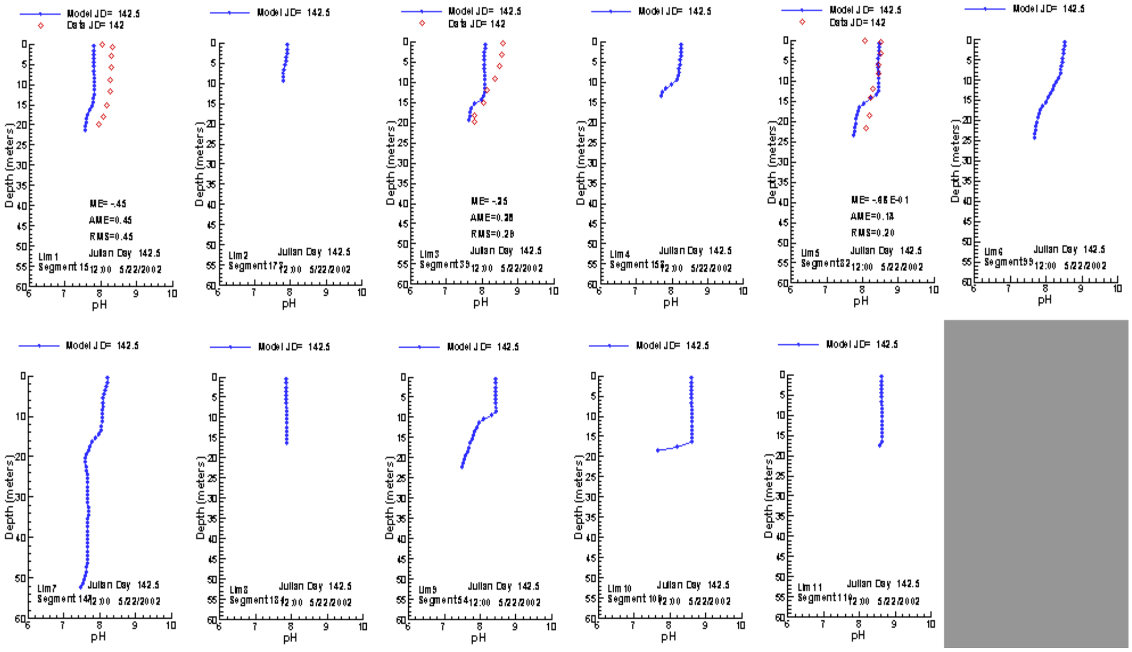
# Appendix D: pH Calibration Profiles



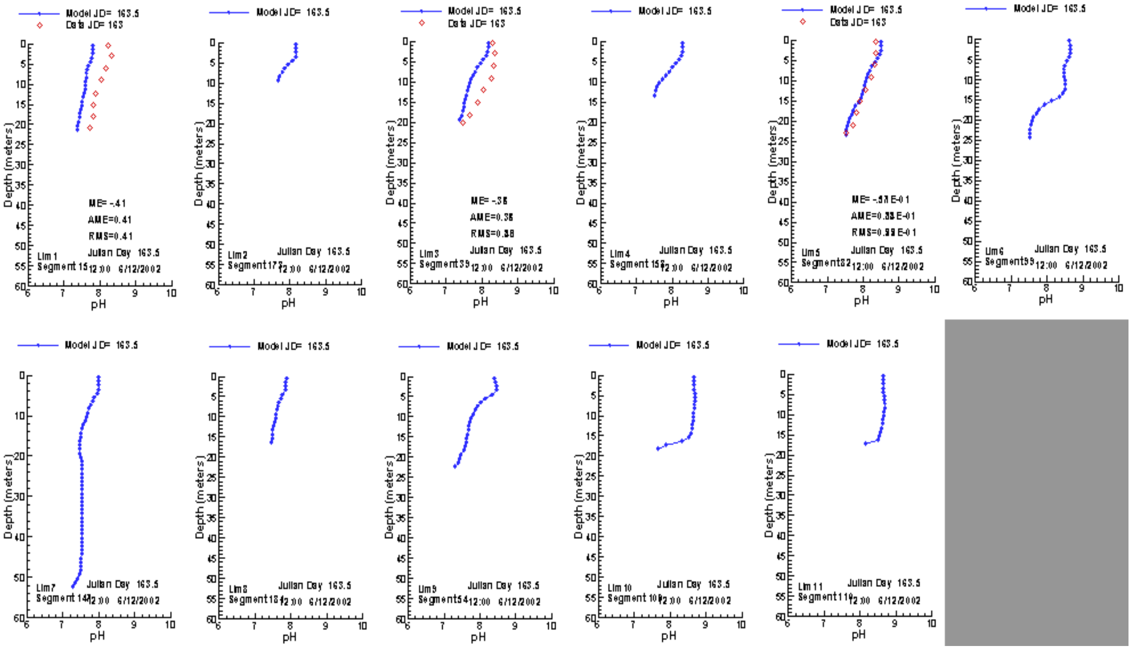


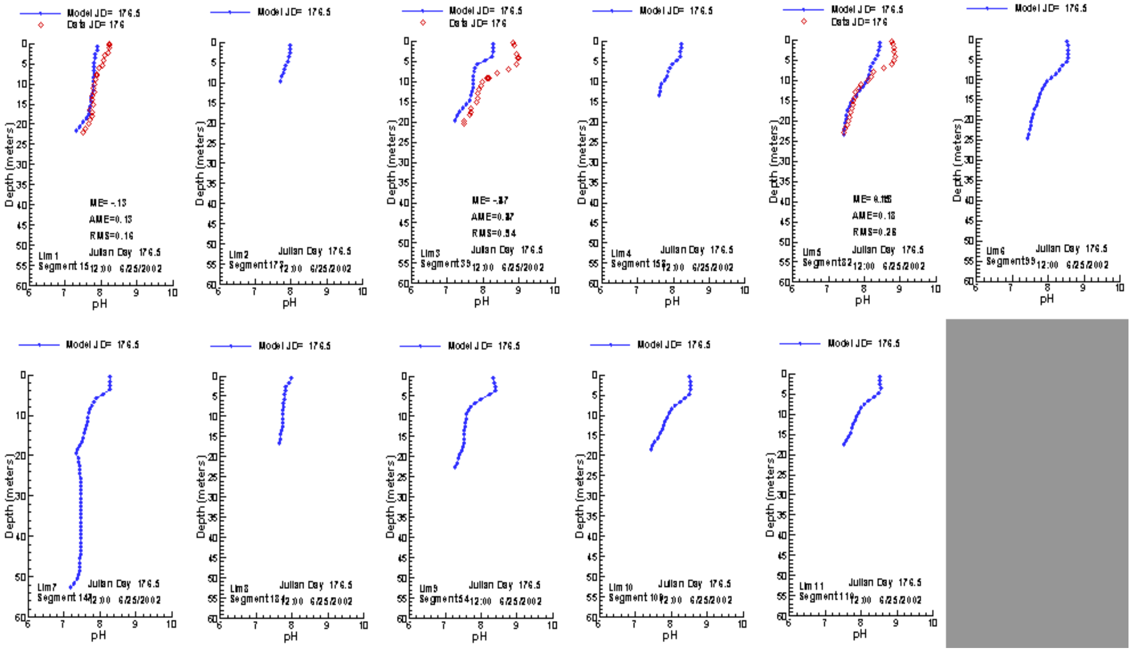


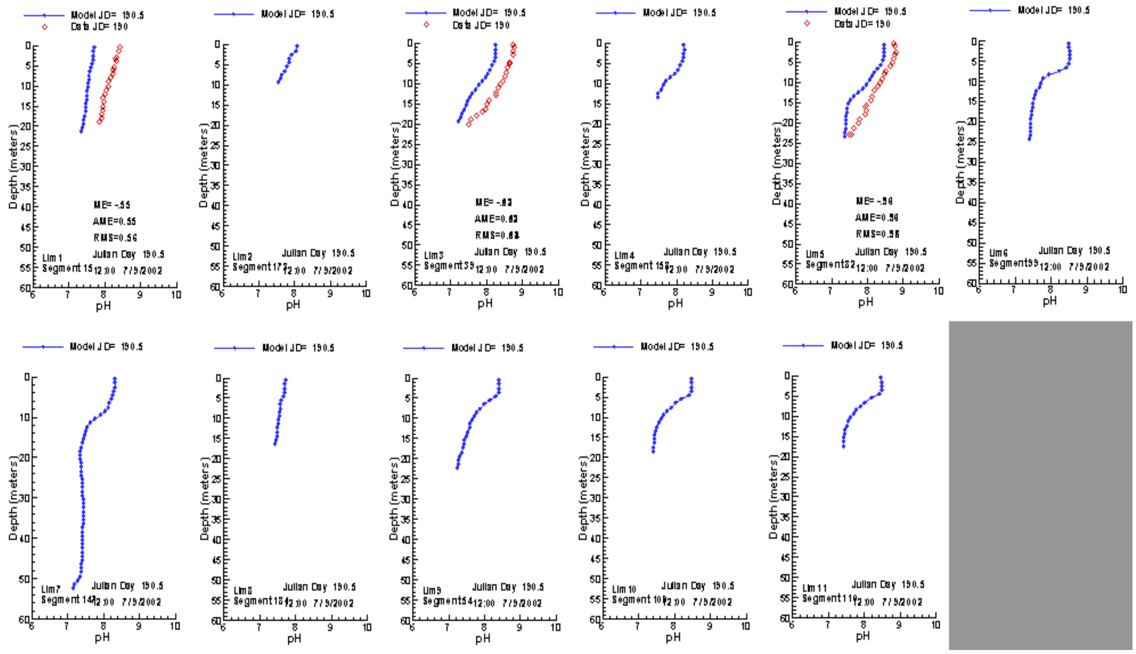
Model JD= 113.5
Data JD= 113
Depth (meters)
pH
ME=-99.
AME=-99.
RMS=-99.
Lim1
Segment 15
Julian Day 113.5
12:00 4/23/2002
Lim2
Segment 17
Lim3
Segment 39
Lim4
Segment 15
Lim5
Segment 82
ME= 0.86E-01
AME=0.86E-01
RMS=0.89E-01
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11

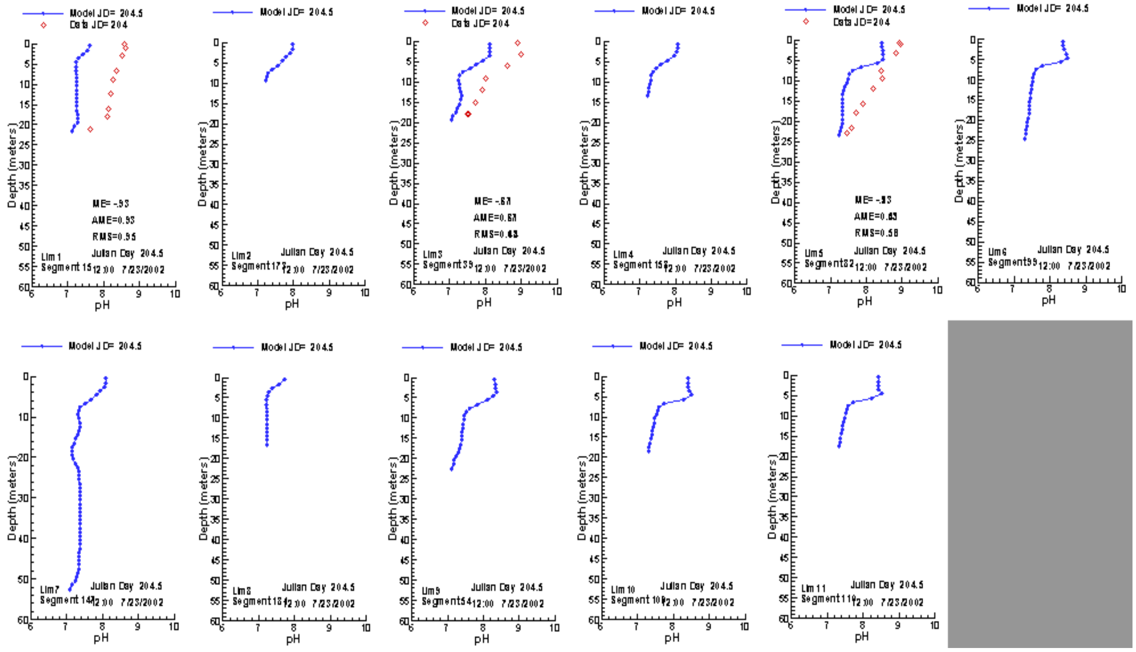


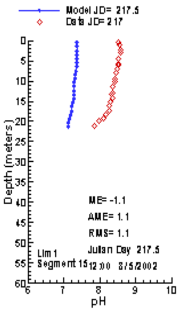
Model JD= 142.5
Data JD= 142
Depth (meters)
pH
ME=-.45
AME=0.45
RMS=0.45
Lim1
Segment 15
Julian Day 142.5
12:00 5/22/2002
Lim2
Segment 17
Lim3
Segment 39
ME=-.35
AME=0.38
RMS=0.28
Lim4
Segment 15
Lim5
Segment 82
ME=-.68E-01
AME=0.13
RMS=0.20
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11

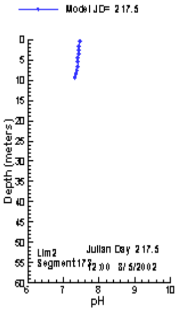

Model JD= 163.5
Data JD= 163
Depth (meters)
pH
ME= -.41
AME=0.41
RMS=0.41
Lim1
Segment 15
Julian Day 163.5
12:00 6/12/2002
Lim2
Segment 17
Lim3
Segment 39
ME= -.38
AME=0.38
RMS=0.38
Lim4
Segment 158
Lim5
Segment 82
ME= -.57E-01
AME=0.83E-01
RMS=0.99E-01
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11

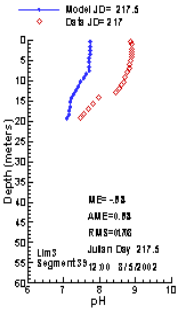

Model JD= 176.5
Data JD= 176
Depth (meters)
pH
ME= -.13
AME=0.13
RMS=0.16
Lim1
Segment 15
Julian Day 176.5
12:00 6/25/2002
Lim2
Segment 17
Lim3
Segment 39
ME= -.37
AME=0.37
RMS=0.54
Lim4
Segment 158
Lim5
Segment 82
ME= 0.15
AME=0.18
RMS=0.28
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11

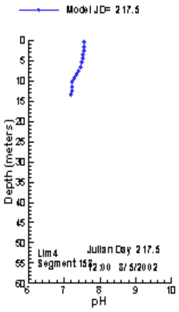

Model JD= 190.5
Data JD= 190
Depth (meters)
pH
ME= -.55
AME=0.55
RMS=0.56
Lim 1
Segment 15
Julian Day 190.5
12:00 7/9/2002
Lim 2
Segment 172
Lim 3
Segment 39
ME= -.62
AME=0.62
RMS=0.63
Lim 4
Segment 158
Lim 5
Segment 82
ME= -.59
AME=0.59
RMS=0.58
Lim 6
Segment 99
Lim 7
Segment 142
Lim 8
Segment 181
Lim 9
Segment 54
Lim 10
Segment 109
Lim 11
Segment 119

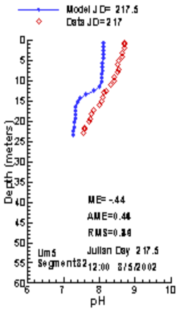

Model JD= 204.5
Data JD= 204
Depth (meters)
pH
ME= -.93
AME=0.93
RMS=0.95
Lim 1
Segment 15
Julian Day 204.5
12:00 7/23/2002
Lim 2
Segment 172
Lim 3
Segment 39
ME= -.67
AME=0.67
RMS=0.63
Lim 4
Segment 158
Lim 5
Segment 82
ME= -.53
AME=0.53
RMS=0.58
Lim 6
Segment 99
Lim 7
Segment 142
Lim 8
Segment 181
Lim 9
Segment 54
Lim 10
Segment 109
Lim 11
Segment 119

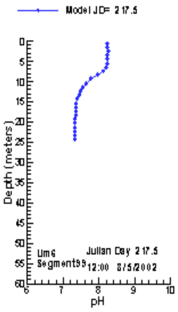

Model JD= 217.5
Data JD= 217
Depth (meters)
pH
ME= -1.1
AME= 1.1
RMS= 1.1
Lim 1
Segment 15
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

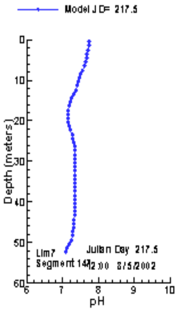

Model JD= 217.5
Depth (meters)
pH
Lim2
Segment172
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

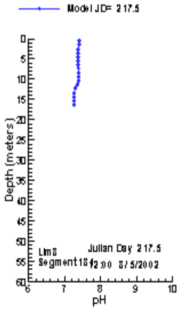

Model JD= 217.5
Data JD= 217
Depth (meters)
pH
ME= -.53
AME=0.53
RMS=0.76
Lim3
Segment39
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

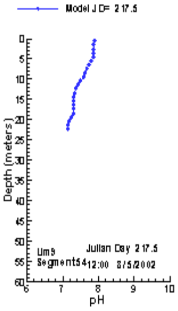

Model JD= 217.5
Depth (meters)
pH
Lim4
Segment 152
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

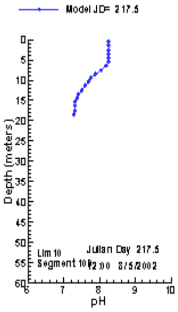

Model JD= 217.5
Data JD= 217
Depth (meters)
pH
ME= -.44
AME=0.44
RMS=0.36
Lim5
Segment82
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

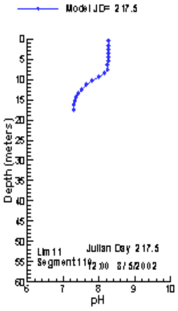

Model JD= 217.5
Depth (meters)
pH
Lim6
Segment99
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

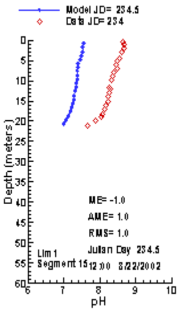

Model JD= 217.5
Depth (meters)
pH
Lim7
Segment 147
Julian Day 217.5
12:00 8/5/2002
0 10 20 30 40 50 60
6 7 8 9 10

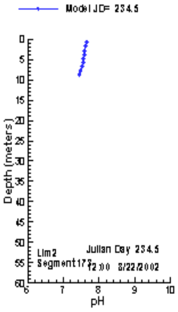

Model JD= 217.5
Depth (meters)
pH
Lim8
Segment181
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

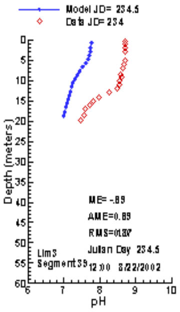

Model JD= 217.5
Depth (meters)
pH
Lim9
Segment54
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

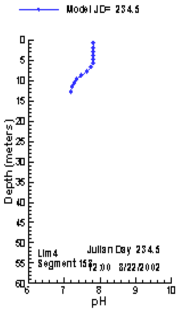

Model JD= 217.5
Depth (meters)
pH
Lim 10
Segment 109
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

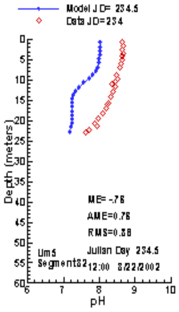

Model JD= 217.5
Depth (meters)
pH
Lim 11
Segment110
Julian Day 217.5
12:00 8/5/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

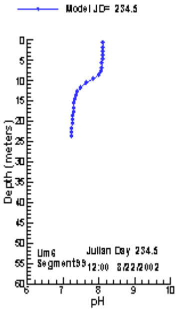

Model JD= 234.5
Data JD= 234
Depth (meters)
pH
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 1
Segment 15
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

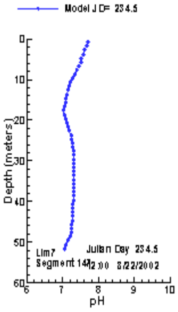

Model JD= 234.5
Depth (meters)
pH
Lim2
Segment172
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

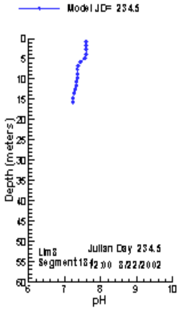

Model JD= 234.5
Data JD= 234
Depth (meters)
pH
ME= -.89
AME=0.89
RMS=0.97
Lim3
Segment39
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

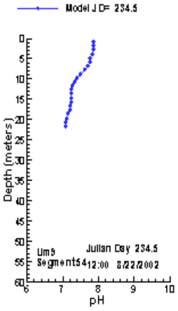

Model JD= 234.5
Depth (meters)
pH
Lim4
Segment 152
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

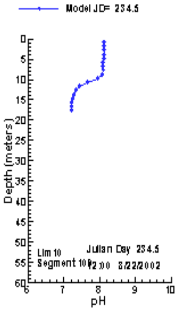

Model JD= 234.5
Data JD= 234
Depth (meters)
pH
ME= -.76
AME=0.76
RMS=0.88
Lim5
Segment82
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

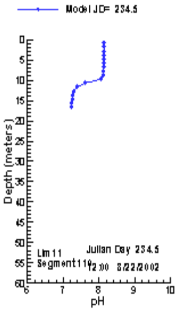

Model JD= 234.5
Depth (meters)
pH
Lim6
Segment99
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

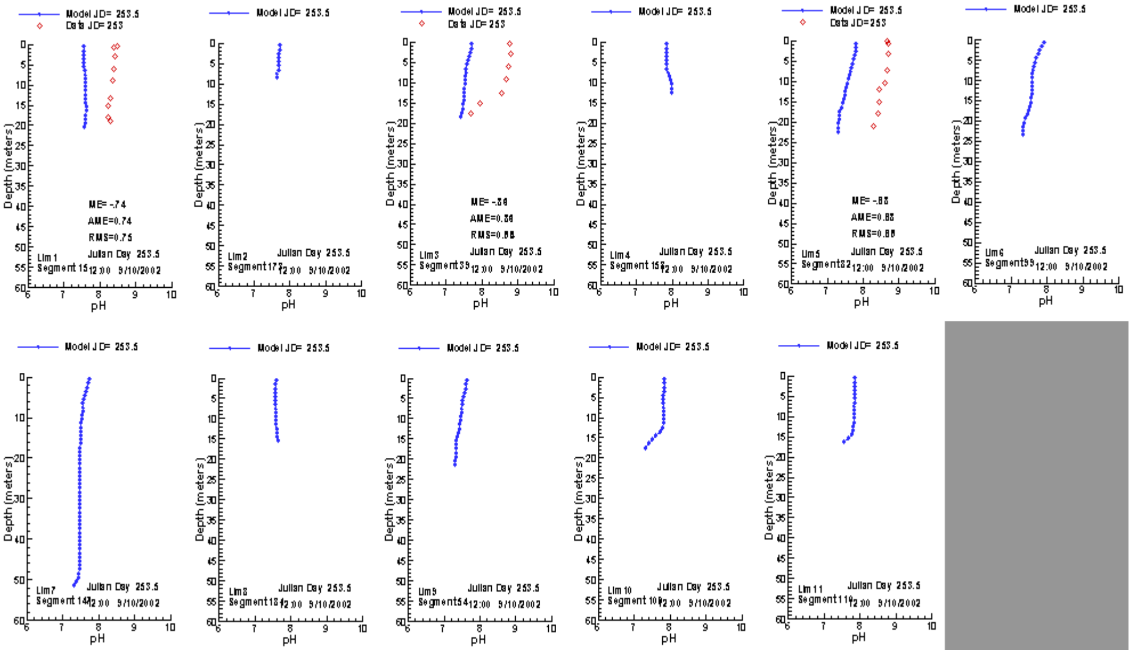

Model JD= 234.5
Depth (meters)
pH
Lim7
Segment 147
Julian Day 234.5
12:00 8/22/2002
0 10 20 30 40 50 60
6 7 8 9 10


Model JD= 234.5
Depth (meters)
pH
Lim8
Segment181
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

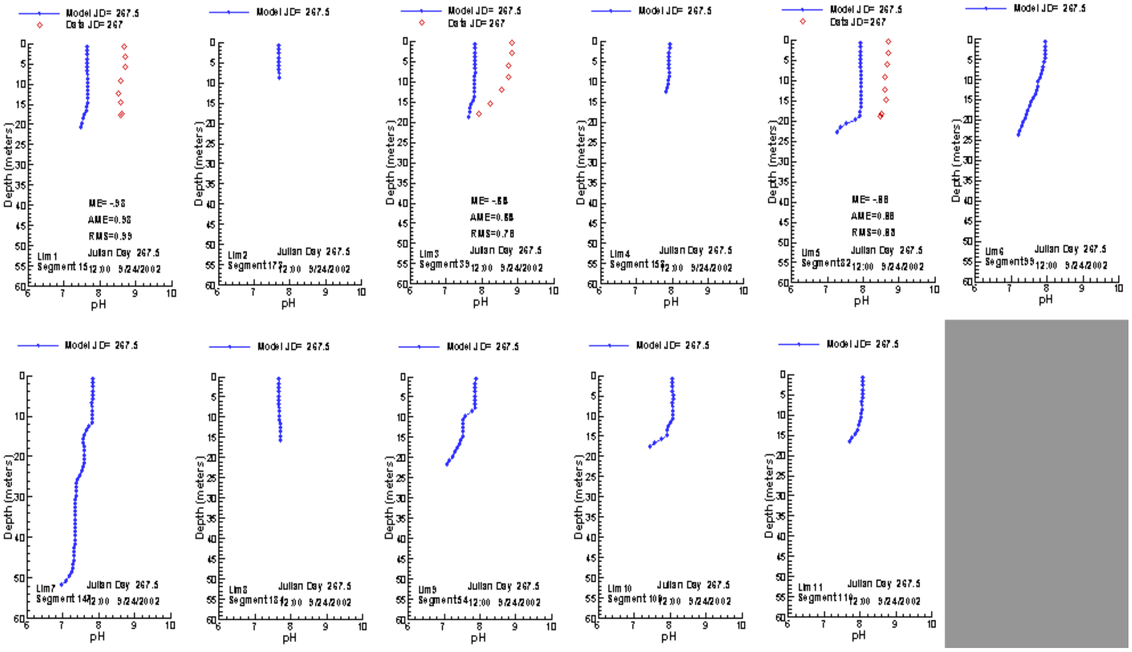

Model JD= 234.5
Depth (meters)
pH
Lim9
Segment54
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10


Model JD= 234.5
Depth (meters)
pH
Lim 10
Segment 109
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

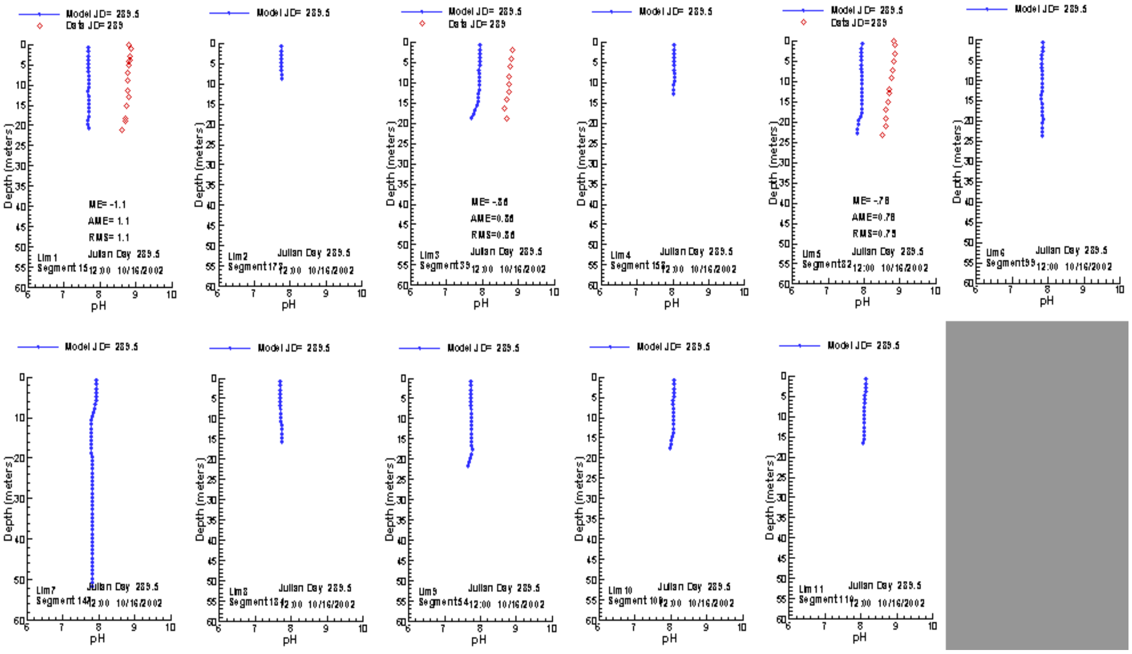

Model JD= 234.5
Depth (meters)
pH
Lim 11
Segment110
Julian Day 234.5
12:00 8/22/2002
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

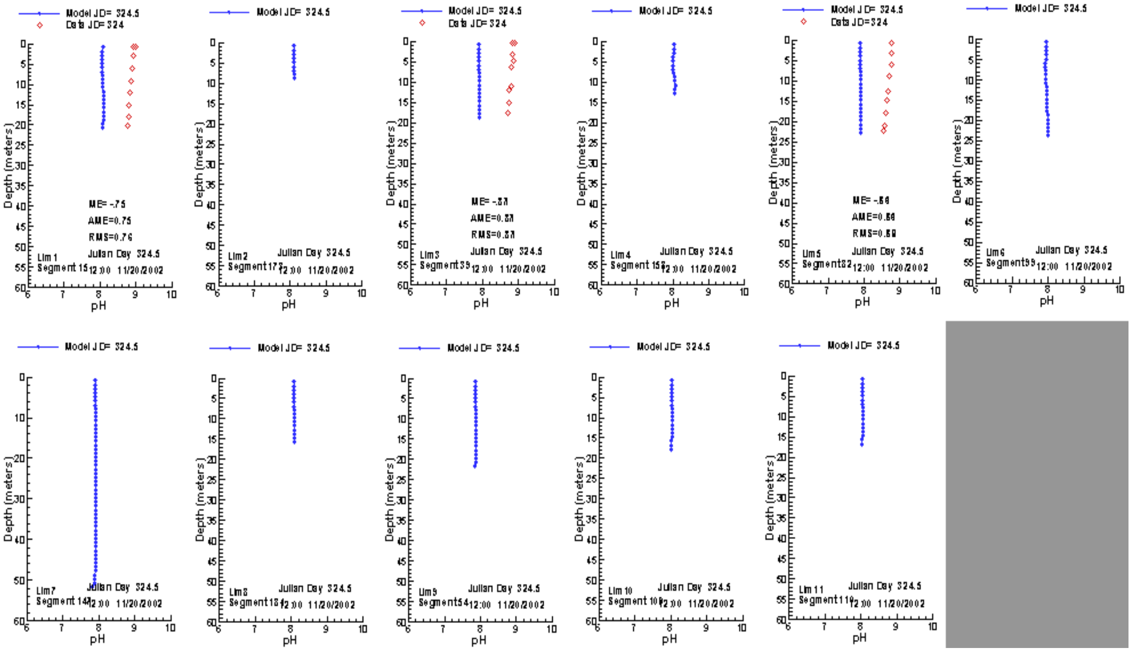


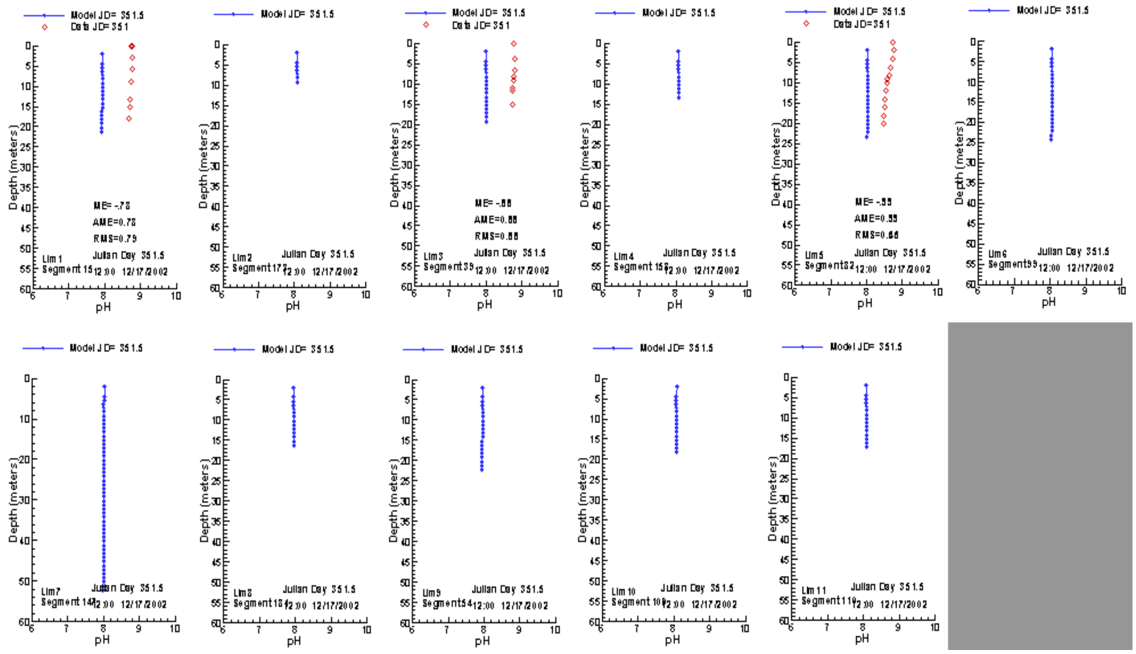
Model JD= 253.5
Data JD= 253
Depth (meters)
pH
ME= -.74
AME=0.74
RMS=0.75
Lim 1
Segment 15
Julian Day 253.5
12:00 9/10/2002
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.86
AME=0.86
RMS=0.88
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.88
AME=0.88
RMS=0.88
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11



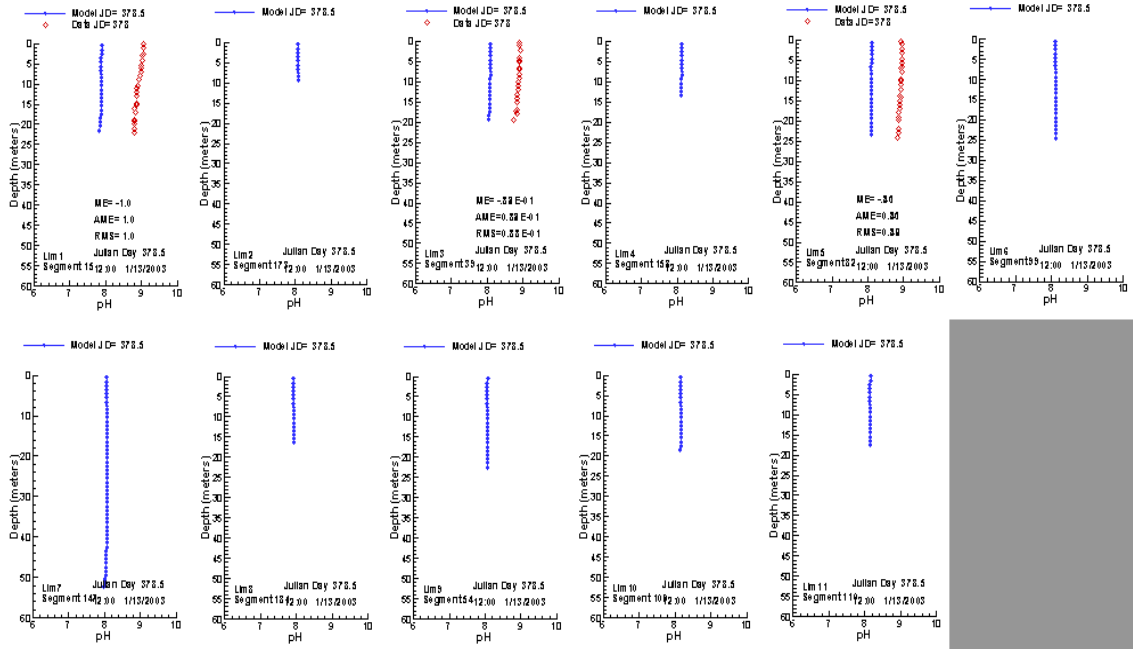
Model JD= 267.5
Data JD= 267
Depth (meters)
pH
ME= -.98
AME=0.98
RMS=0.99
Lim 1
Segment 15
Julian Day 267.5
12:00 9/24/2002
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.68
AME=0.68
RMS=0.78
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.88
AME=0.88
RMS=0.88
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11


Model JD= 289.5
Data JD= 289
Depth (meters)
pH
ME= -1.1
AME= 1.1
RMS= 1.1
Lim 1
Segment 15
Julian Day 289.5
12:00 10/16/2002
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.86
AME=0.86
RMS=0.86
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.78
AME=0.78
RMS=0.79
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10

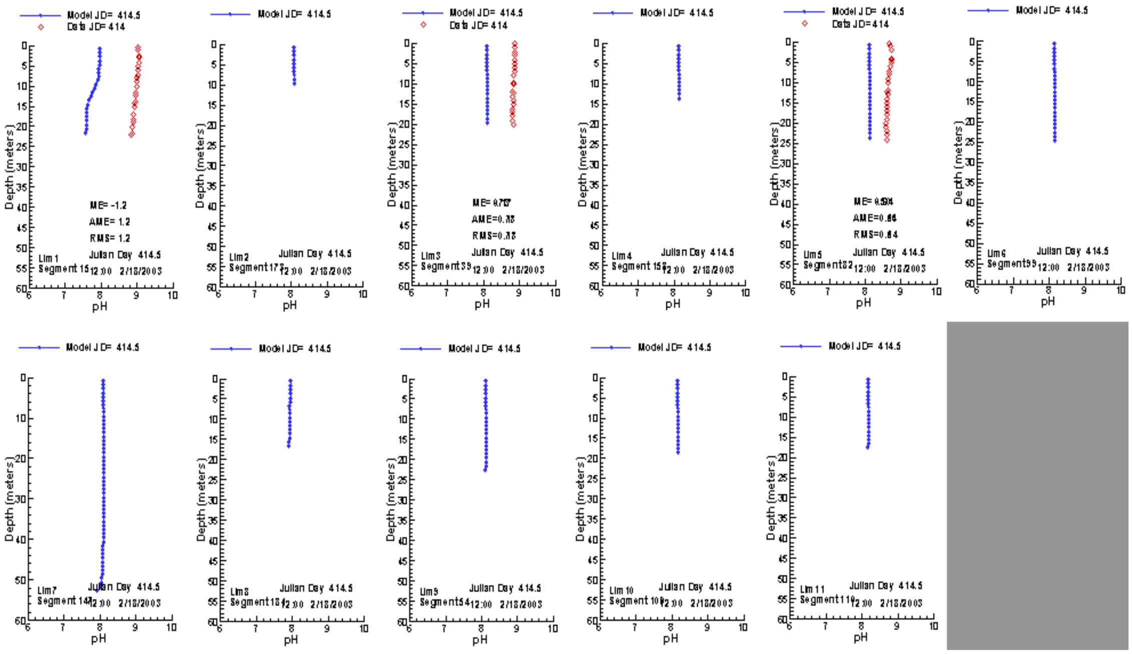

Model JD= 324.5
Data JD= 324
Depth (meters)
pH
ME= -.75
AME=0.75
RMS=0.76
Lim 1
Segment 15
Julian Day 324.5
12:00 11/20/2002
Lim 2
Segment 17
Lim 3
Segment 39
ME= -.87
AME=0.87
RMS=0.87
Lim 4
Segment 15
Lim 5
Segment 82
ME= -.66
AME=0.66
RMS=0.69
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10

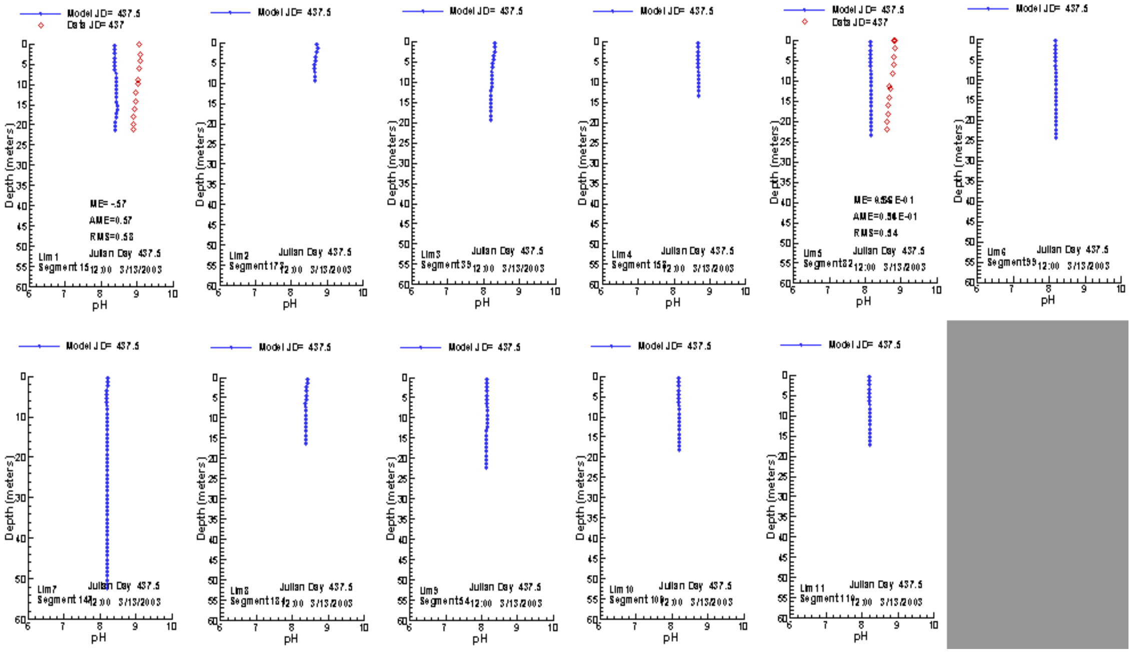


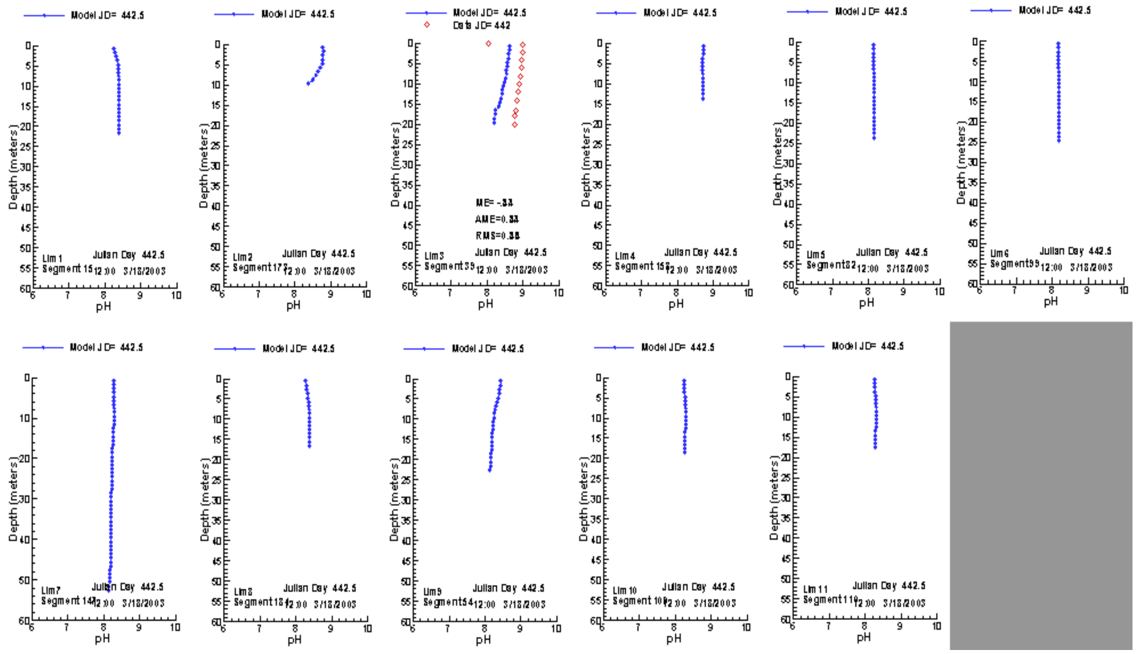
Model JD= 351.5
Data JD= 351
Depth (meters)
pH
ME= -.78
AME=0.78
RMS=0.79
Lim 1
Segment 15
Julian Day 351.5
12:00 12/17/2002
Lim2
Segment 17
Lim3
Segment 39
ME= -.88
AME=0.88
RMS=0.88
Lim4
Segment 15
Lim5
Segment 82
ME= -.55
AME=0.55
RMS=0.66
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

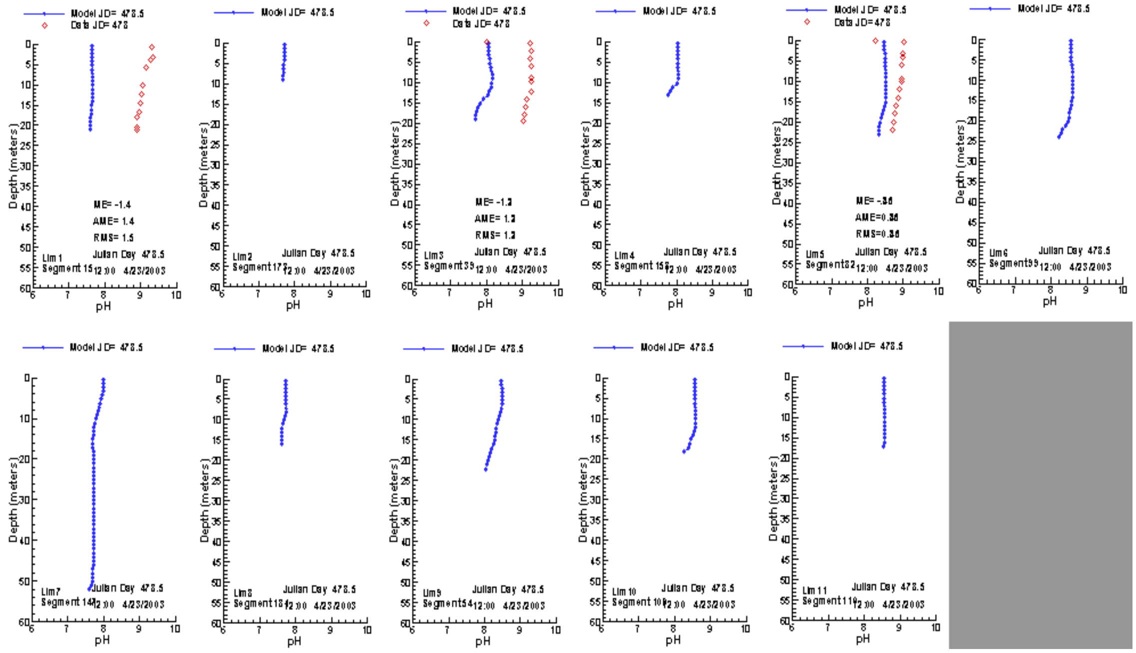


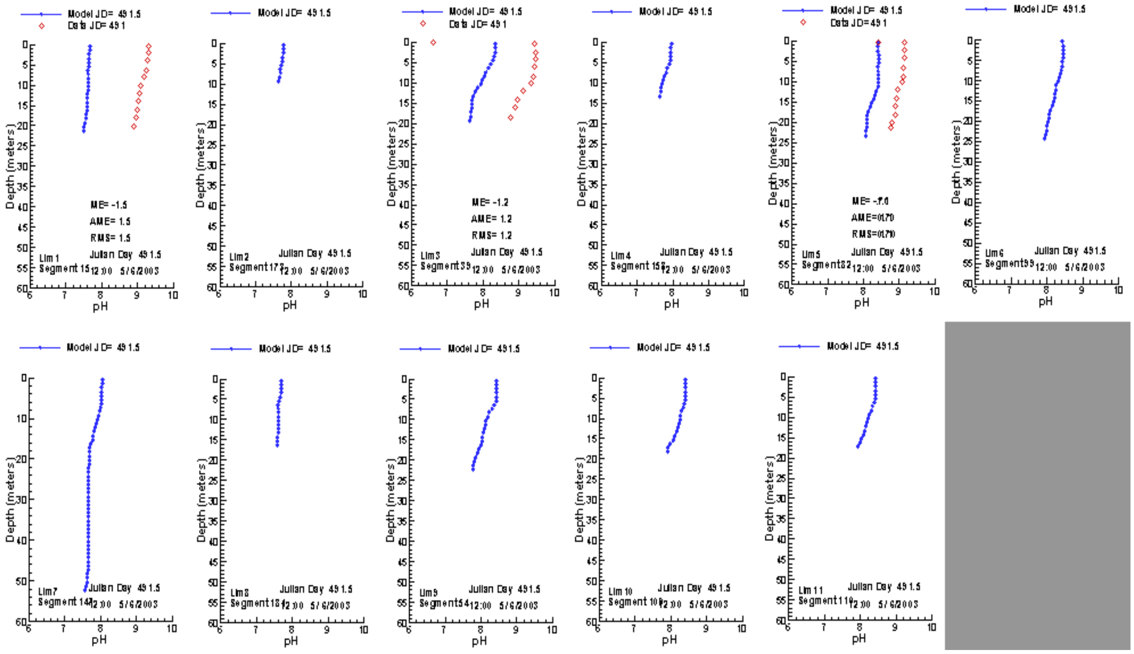
Model JD= 378.5
Data JD= 378
Depth (meters)
pH
ME= -1.0
AME= 1.0
RMS= 1.0
Lim 1
Segment 15
Julian Day 378.5
12:00 1/13/2003
Lim2
Segment 17
Lim3
Segment 39
ME= -.83 E-01
AME=0.83 E-01
RMS=0.88 E-01
Lim4
Segment 15
Lim5
Segment 82
ME= -.80
AME=0.80
RMS=0.80
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

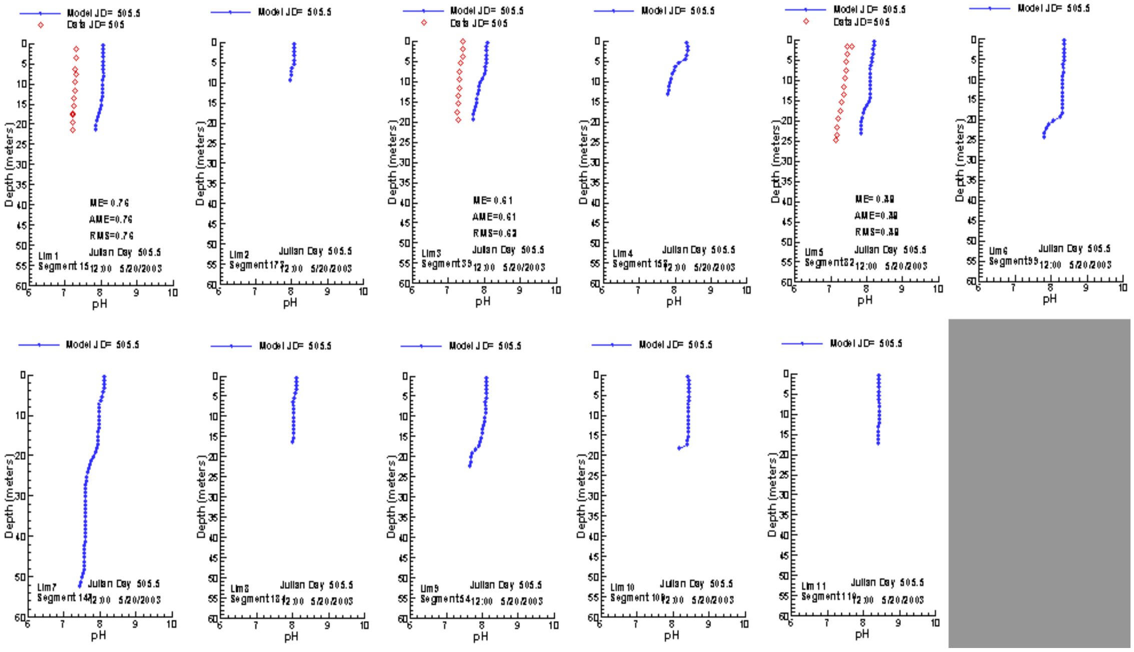

Model JD= 414.5
Data JD= 414
Depth (meters)
pH
ME= -1.2
AME= 1.2
RMS= 1.2
Lim1
Segment 15
Julian Day 414.5
12:00 2/18/2003
Lim2
Segment 173
Lim3
Segment 39
ME= 0.767
AME=0.78
RMS=0.78
Lim4
Segment 156
Lim5
Segment 82
ME= 0.594
AME=0.64
RMS=0.64
Lim6
Segment 99
Lim7
Segment 142
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 109
Lim11
Segment 116

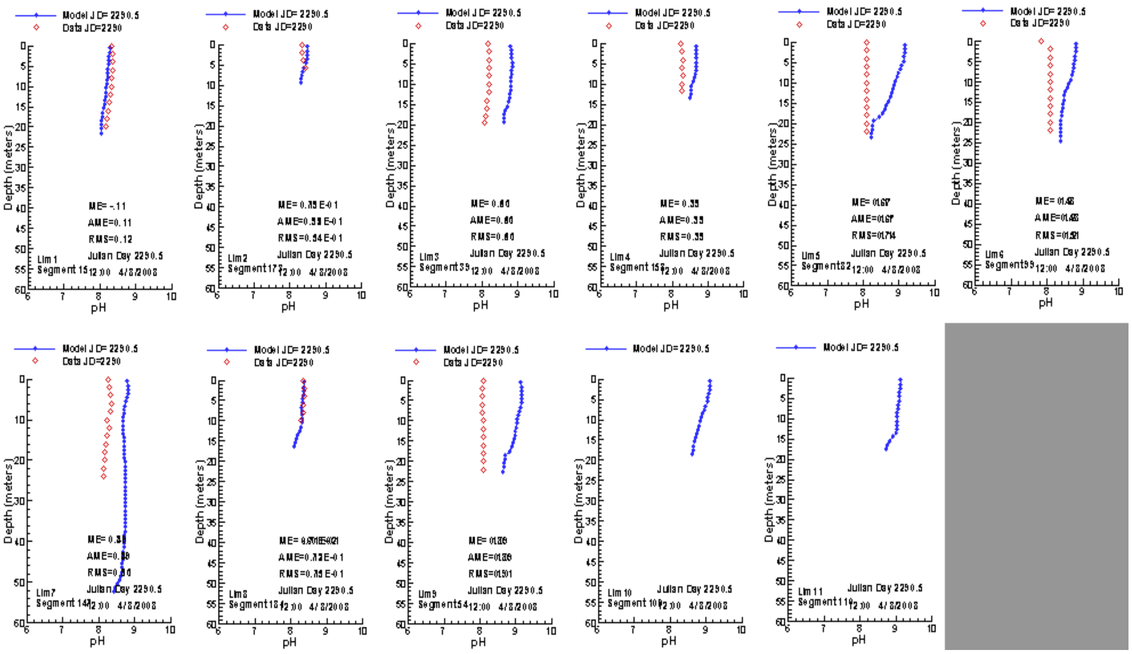

Model JD= 437.5
Data JD= 437
Depth (meters)
pH
ME= -.57
AME=0.57
RMS=0.58
Lim1
Segment 15
Julian Day 437.5
12:00 3/13/2003
Lim2
Segment 173
Lim3
Segment 39
Lim4
Segment 156
Lim5
Segment 82
ME= 0.556 E-01
AME=0.556 E-01
RMS=0.54
Lim6
Segment 99
Lim7
Segment 142
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 109
Lim11
Segment 116

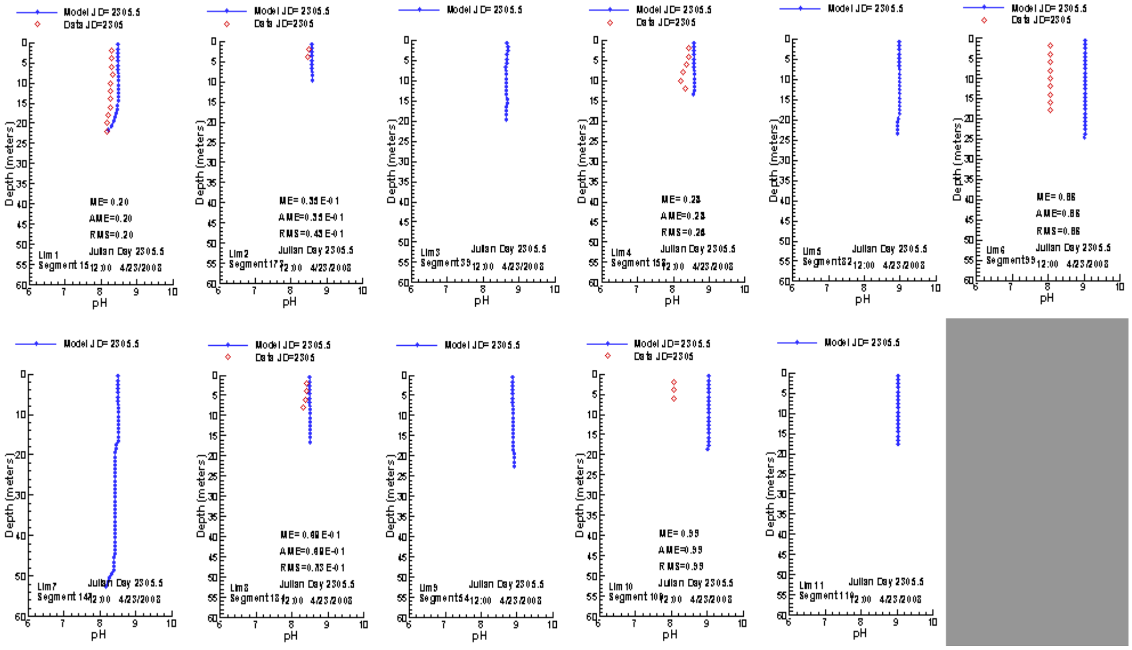

Model JD= 442.5
Data JD= 442
Depth (meters)
pH
ME= -.33
AME=0.33
RMS=0.38
Lim1 Segment 15
Lim2 Segment 17
Lim3 Segment 39
Lim4 Segment 15
Lim5 Segment 82
Lim6 Segment 99
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11
Julian Day 442.5
12:00 3/18/2003
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

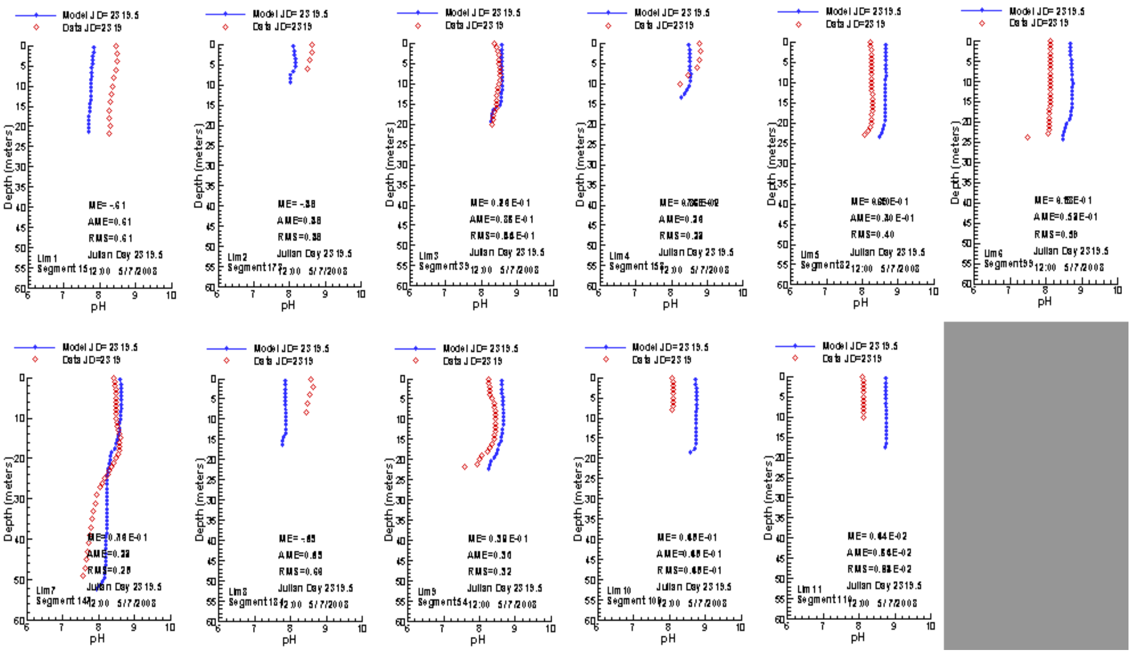

Model JD= 478.5
Data JD= 478
Depth (meters)
pH
ME= -1.4
AME= 1.4
RMS= 1.5
ME= -1.2
AME= 1.2
RMS= 1.2
ME= -.36
AME=0.36
RMS=0.36
Lim1 Segment 15
Lim2 Segment 17
Lim3 Segment 39
Lim4 Segment 15
Lim5 Segment 82
Lim6 Segment 99
Lim7 Segment 14
Lim8 Segment 18
Lim9 Segment 54
Lim10 Segment 10
Lim11 Segment 11
Julian Day 478.5
12:00 4/23/2003
0 5 10 15 20 25 30 35 40 45 50 55 60
6 7 8 9 10

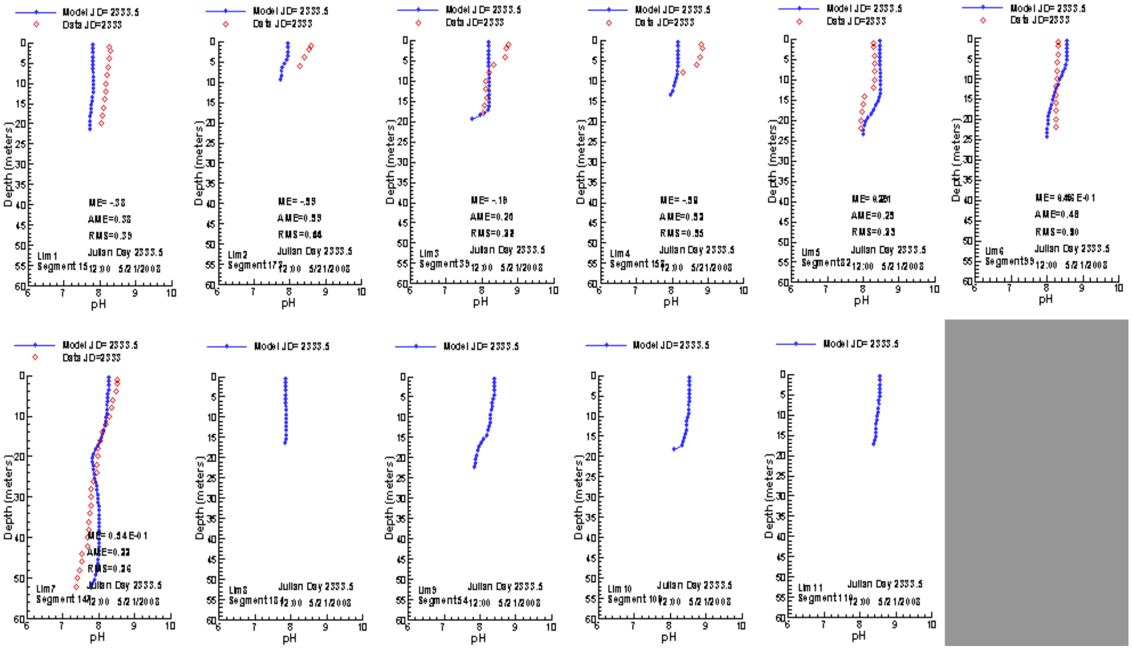

Model JD= 491.5
Data JD= 491
Depth (meters)
pH
ME= -1.5
AME= 1.5
RMS= 1.5
Lim 1
Segment 15
Julian Day 491.5
12:00 5/6/2003
Lim 2
Segment 17
Lim 3
Segment 39
ME= -1.2
AME= 1.2
RMS= 1.2
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

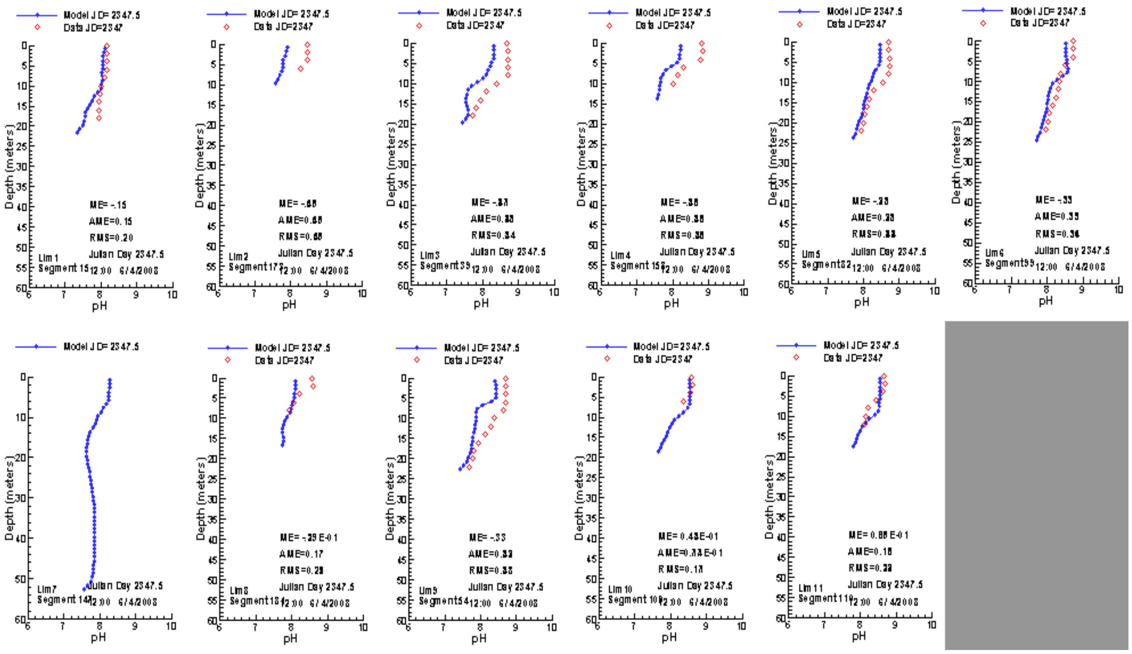

Model JD= 505.5
Data JD= 505
Depth (meters)
pH
ME= 0.76
AME=0.76
RMS=0.76
Lim 1
Segment 15
Julian Day 505.5
12:00 5/20/2003
Lim 2
Segment 17
Lim 3
Segment 39
ME= 0.61
AME=0.61
RMS=0.62
Lim 4
Segment 15
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

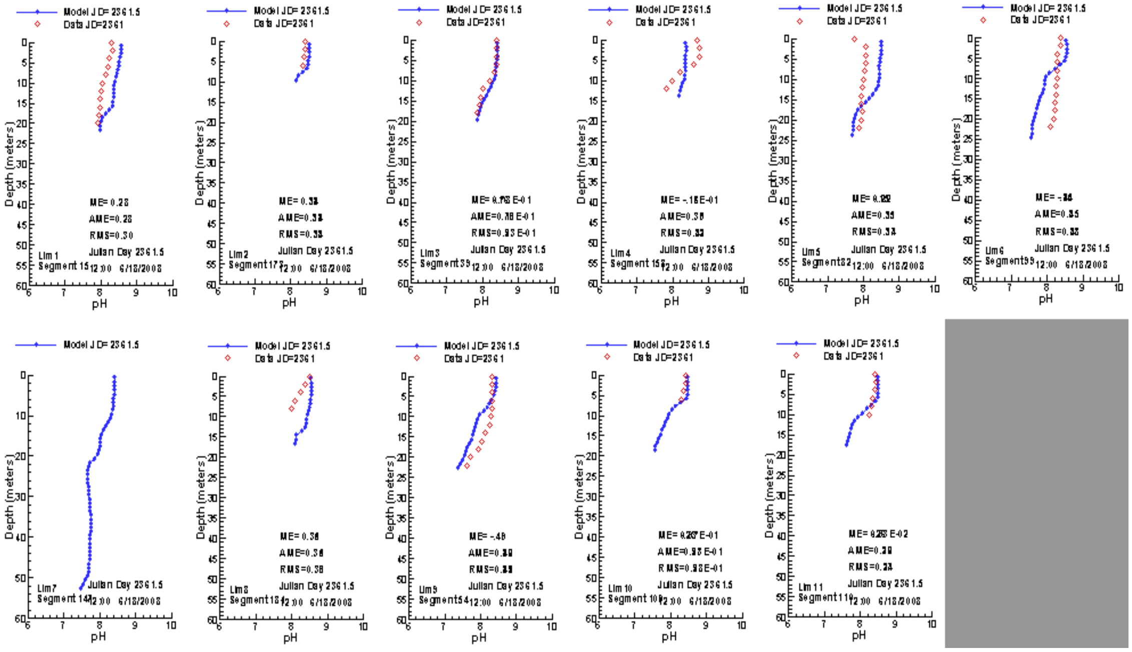

Model JD= 2290.5
Data JD=2290
Depth (meters)
pH
ME= -.11
AME=0.11
RMS=0.12
Lim 1
Segment 15
Julian Day 2290.5
12:00 4/8/2008
ME= 0.75 E-01
AME=0.59 E-01
RMS=0.54 E-01
Lim 2
Segment 173
Julian Day 2290.5
12:00 4/8/2008
ME= 0.60
AME=0.60
RMS=0.60
Lim 3
Segment 39
Julian Day 2290.5
12:00 4/8/2008
ME= 0.35
AME=0.35
RMS=0.35
Lim 4
Segment 158
Julian Day 2290.5
12:00 4/8/2008
ME= 0.67
AME=0.67
RMS=0.74
Lim 5
Segment 82
Julian Day 2290.5
12:00 4/8/2008
ME= 0.48
AME=0.48
RMS=0.51
Lim 6
Segment 99
Julian Day 2290.5
12:00 4/8/2008
ME= 0.38
AME=0.38
RMS=0.40
Lim 7
Segment 147
Julian Day 2290.5
12:00 4/8/2008
ME= 0.70 E-01
AME=0.72 E-01
RMS=0.75 E-01
Lim 8
Segment 184
Julian Day 2290.5
12:00 4/8/2008
ME= 0.89
AME=0.89
RMS=0.91
Lim 9
Segment 54
Julian Day 2290.5
12:00 4/8/2008
Lim 10
Segment 109
Julian Day 2290.5
12:00 4/8/2008
Lim 11
Segment 119
Julian Day 2290.5
12:00 4/8/2008

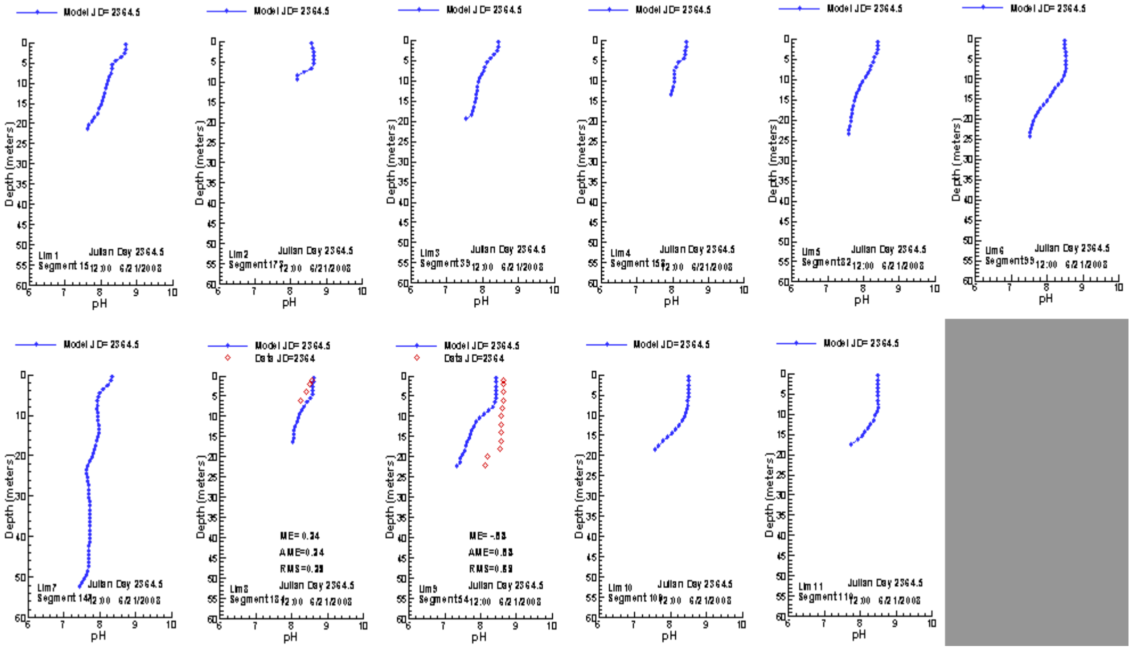

Model JD= 2305.5
Data JD=2305
Depth (meters)
pH
ME= 0.20
AME=0.20
RMS=0.20
Lim 1
Segment 15
Julian Day 2305.5
12:00 4/23/2008
ME= 0.35 E-01
AME=0.35 E-01
RMS=0.43 E-01
Lim 2
Segment 173
Julian Day 2305.5
12:00 4/23/2008
Lim 3
Segment 39
Julian Day 2305.5
12:00 4/23/2008
ME= 0.23
AME=0.23
RMS=0.26
Lim 4
Segment 158
Julian Day 2305.5
12:00 4/23/2008
Lim 5
Segment 82
Julian Day 2305.5
12:00 4/23/2008
ME= 0.86
AME=0.86
RMS=0.86
Lim 6
Segment 99
Julian Day 2305.5
12:00 4/23/2008
Lim 7
Segment 147
Julian Day 2305.5
12:00 4/23/2008
ME= 0.69 E-01
AME=0.69 E-01
RMS=0.73 E-01
Lim 8
Segment 184
Julian Day 2305.5
12:00 4/23/2008
Lim 9
Segment 54
Julian Day 2305.5
12:00 4/23/2008
ME= 0.99
AME=0.99
RMS=0.99
Lim 10
Segment 109
Julian Day 2305.5
12:00 4/23/2008
Lim 11
Segment 119
Julian Day 2305.5
12:00 4/23/2008

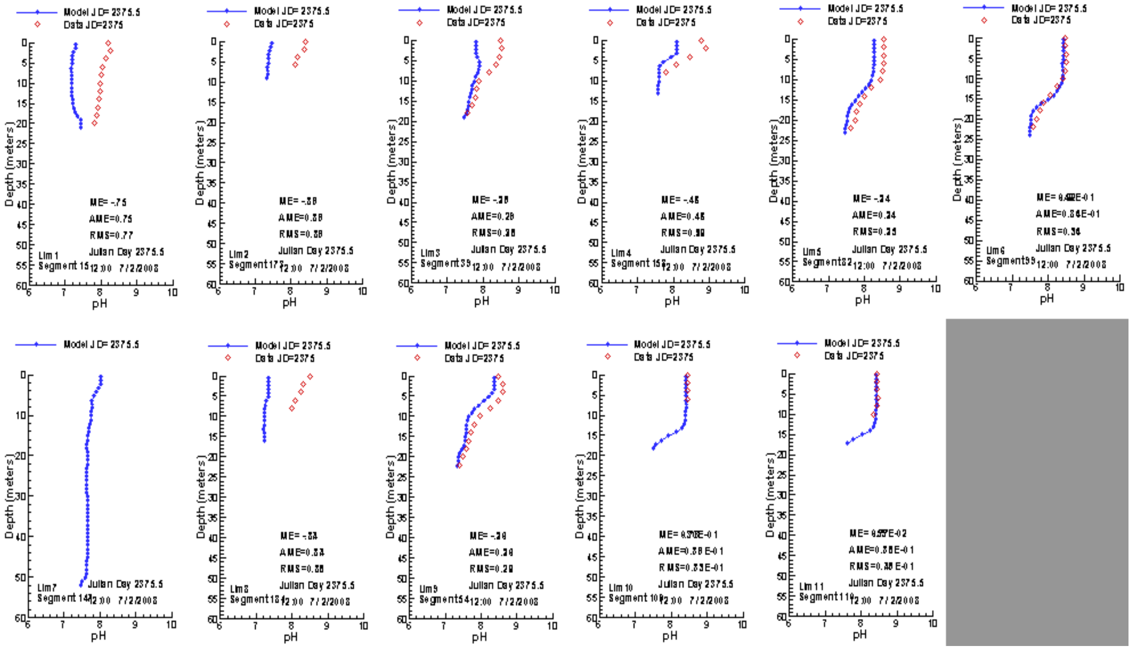

Model JD= 2319.5
Data JD=2319
Depth (meters)
pH
ME= -.61
AME=0.61
RMS=0.61
Lim 1
Segment 15
Julian Day 2319.5
12:00 5/7/2008
Lim 2
Segment 17
Lim 3
Segment 39
Lim 4
Segment 15
RMS=0.40
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

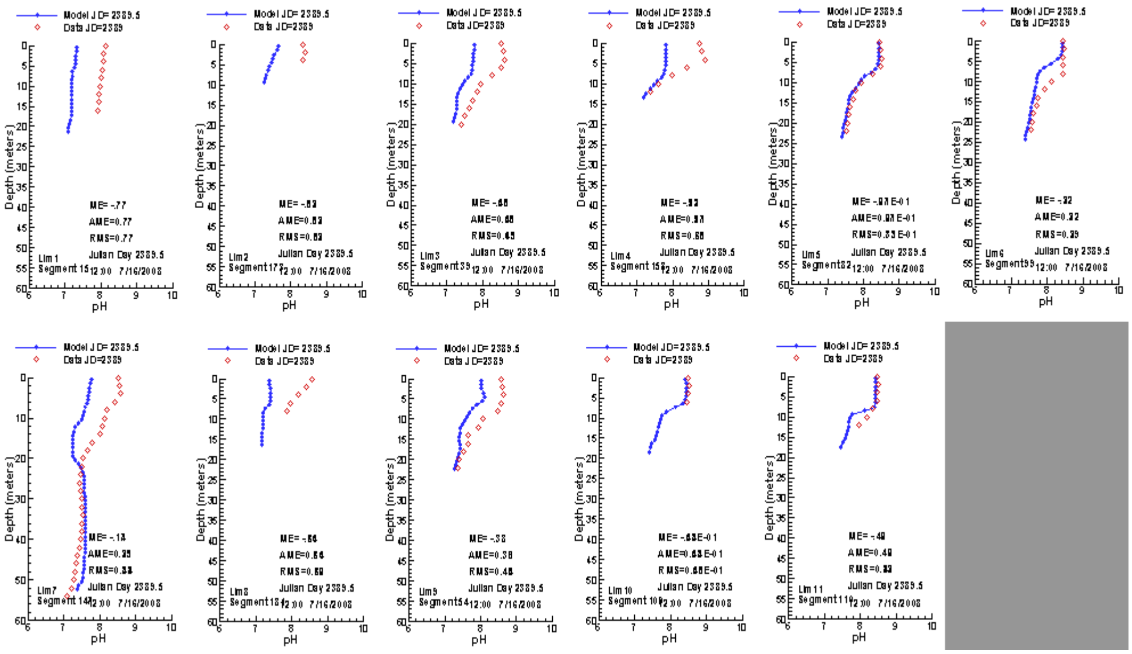

Model JD= 2333.5
Data JD=2333
Depth (meters)
pH
ME= -.38
AME=0.38
RMS=0.39
Lim 1
Segment 15
Julian Day 2333.5
12:00 5/21/2008
Lim 2
Segment 17
Lim 3
Segment 39
Lim 4
Segment 15
AME=0.25
Lim 5
Segment 82
Lim 6
Segment 99
ME= 0.54E-01
RMS=0.26
Lim 7
Segment 14
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

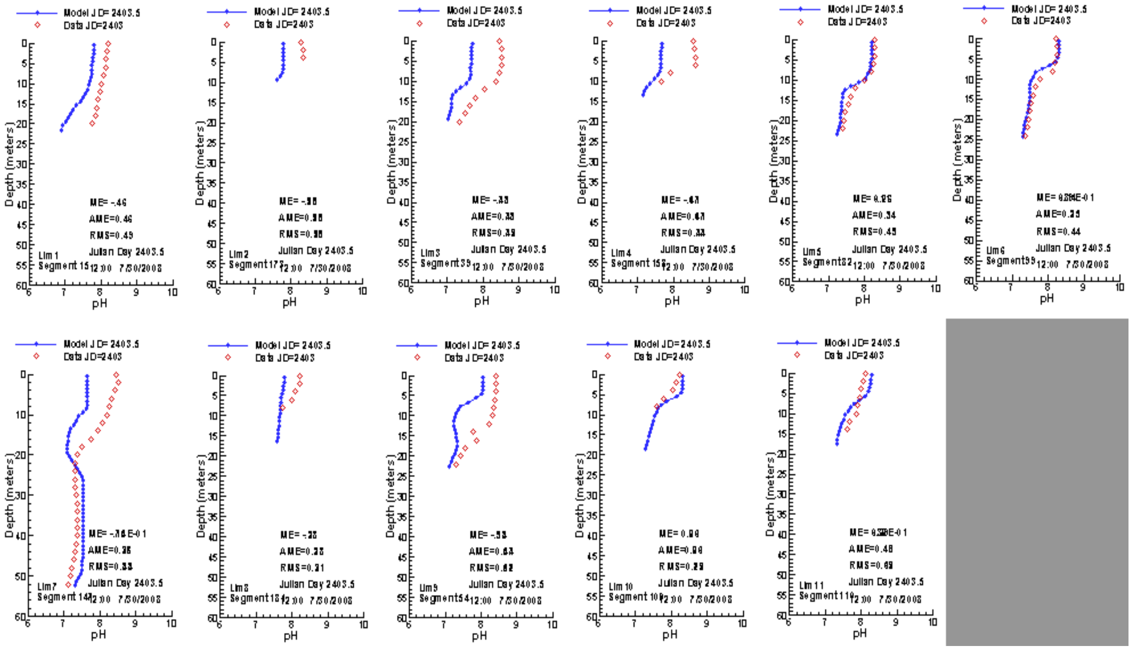

Model JD= 2347.5
Data JD=2347
Depth (meters)
pH
Lim 1
Segment 15
ME= -.15
AME=0.15
RMS=0.20
Julian Day 2347.5
12:00 6/4/2008
Lim 2
Segment 173
ME= -.68
AME=0.68
RMS=0.68
Lim 3
Segment 39
ME= -.37
AME=0.38
RMS=0.34
Lim 4
Segment 158
ME= -.38
AME=0.38
RMS=0.38
Lim 5
Segment 82
ME= -.33
AME=0.33
RMS=0.33
Lim 6
Segment 99
ME= -.33
AME=0.35
RMS=0.34
Lim 7
Segment 147
Lim 8
Segment 184
ME= -.29 E-01
AME=0.17
RMS=0.29
Lim 9
Segment 54
ME= -.33
AME=0.33
RMS=0.38
Lim 10
Segment 109
ME= 0.43E-01
AME=0.73E-01
RMS=0.17
Lim 11
Segment 119
ME= 0.88 E-01
AME=0.18
RMS=0.22

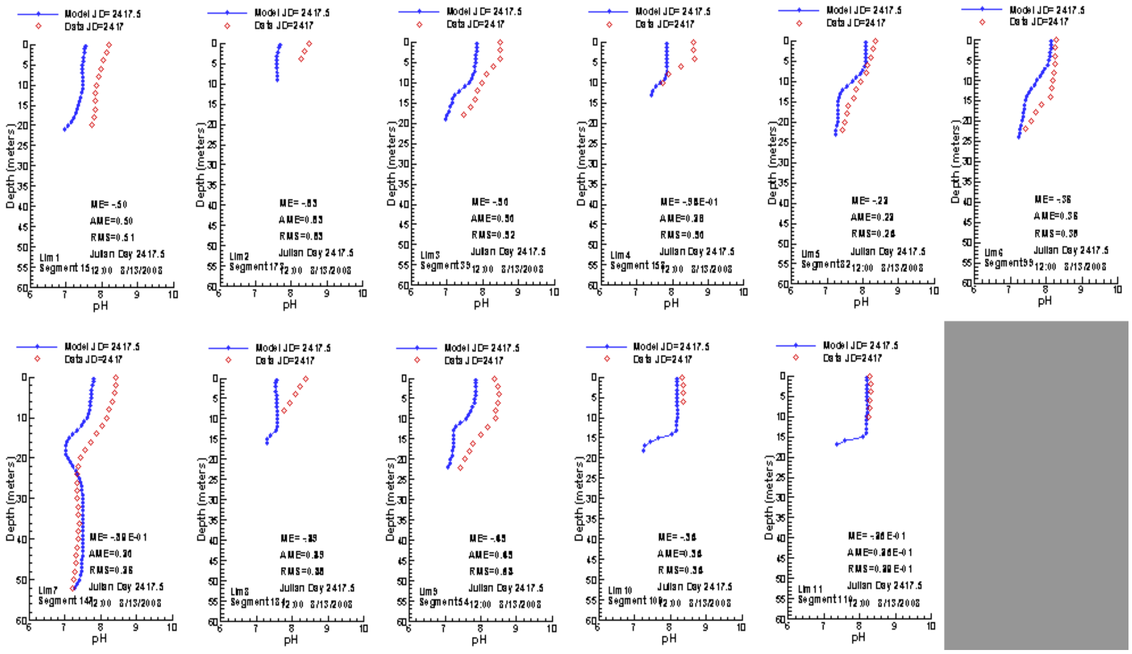

Model JD= 2361.5
Data JD=2361
Depth (meters)
pH
Lim 1
Segment 15
ME= 0.28
AME=0.28
RMS=0.30
Julian Day 2361.5
12:00 6/18/2008
Lim 2
Segment 173
ME= 0.33
AME=0.33
RMS=0.33
Lim 3
Segment 39
ME= 0.78 E-01
AME=0.78 E-01
RMS=0.93 E-01
Lim 4
Segment 158
ME= -.18E-01
AME=0.38
RMS=0.33
Lim 5
Segment 82
ME= 0.22
AME=0.35
RMS=0.37
Lim 6
Segment 99
ME= -.34
AME=0.35
RMS=0.38
Lim 7
Segment 147
Lim 8
Segment 184
ME= 0.38
AME=0.38
RMS=0.38
Lim 9
Segment 54
ME= -.49
AME=0.39
RMS=0.33
Lim 10
Segment 109
ME= 0.27E-01
AME=0.93 E-01
RMS=0.93E-01
Lim 11
Segment 119
ME= 0.28 E-02
AME=0.29
RMS=0.27

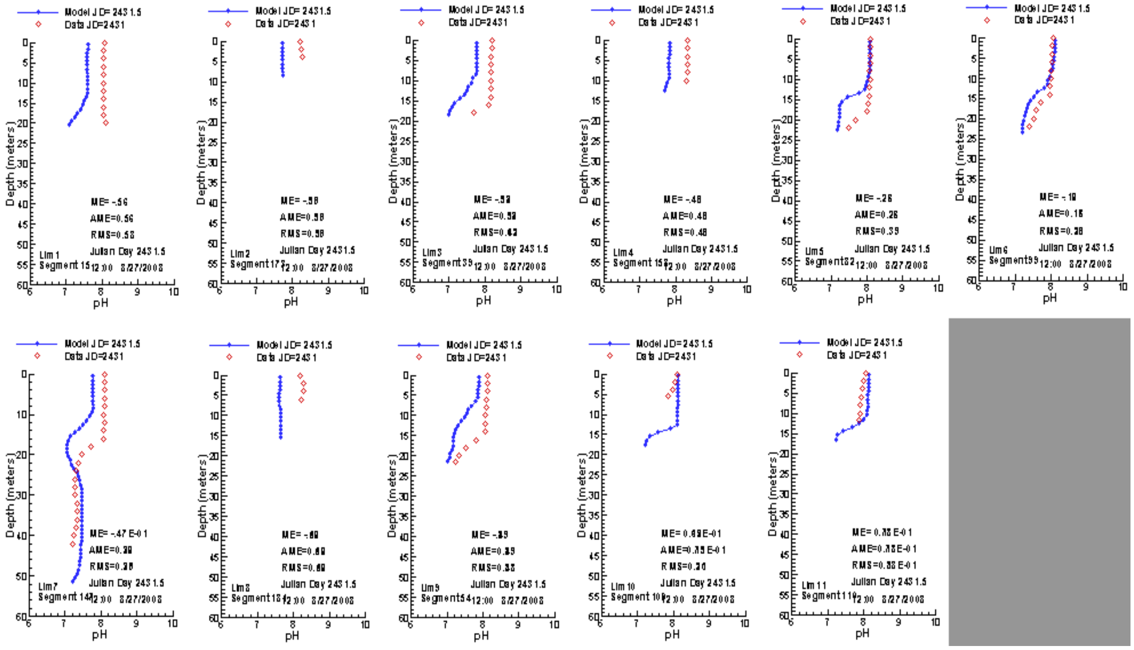

Model JD= 2364.5
Data JD=2364
Depth (meters)
pH
Lim1 Segment 15 Julian Day 2364.5 12:00 6/21/2008
Lim2 Segment 17 Julian Day 2364.5 12:00 6/21/2008
Lim3 Segment 39 Julian Day 2364.5 12:00 6/21/2008
Lim4 Segment 15 Julian Day 2364.5 12:00 6/21/2008
Lim5 Segment 82 Julian Day 2364.5 12:00 6/21/2008
Lim6 Segment 99 Julian Day 2364.5 12:00 6/21/2008
Lim7 Segment 14 Julian Day 2364.5 12:00 6/21/2008
ME= 0.34
AME=0.34
Lim8 Segment 18 Julian Day 2364.5 12:00 6/21/2008
ME= -.53
AME=0.53
Lim9 Segment 54 Julian Day 2364.5 12:00 6/21/2008
Lim 10 Segment 10 Julian Day 2364.5 12:00 6/21/2008
Lim 11 Segment 11 Julian Day 2364.5 12:00 6/21/2008

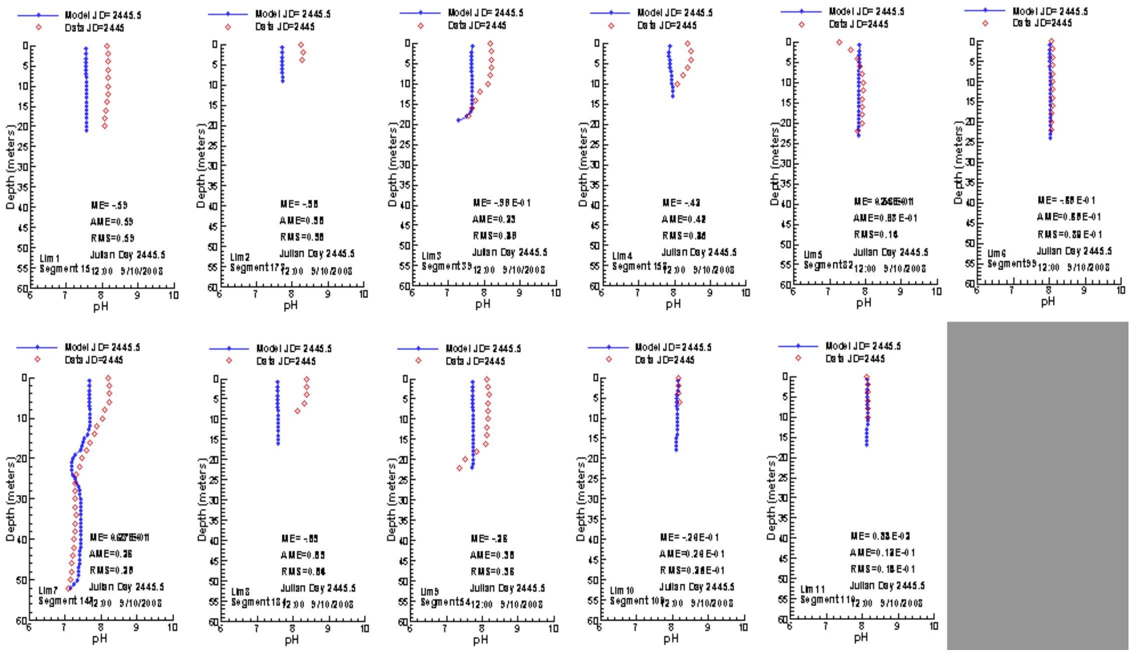

Model JD= 2375.5
Data JD=2375
Depth (meters)
pH
ME= -.75
AME=0.75
RMS=0.77
Lim1 Segment 15 Julian Day 2375.5 12:00 7/2/2008
ME= -.88
AME=0.88
RMS=0.88
Lim2 Segment 17 Julian Day 2375.5 12:00 7/2/2008
ME= -.28
AME=0.28
Lim3 Segment 39 Julian Day 2375.5 12:00 7/2/2008
ME= -.48
AME=0.48
Lim4 Segment 15 Julian Day 2375.5 12:00 7/2/2008
ME= -.24
AME=0.24
RMS=0.25
Lim5 Segment 82 Julian Day 2375.5 12:00 7/2/2008
RMS=0.34
Lim6 Segment 99 Julian Day 2375.5 12:00 7/2/2008
Lim7 Segment 14 Julian Day 2375.5 12:00 7/2/2008
Lim8 Segment 18 Julian Day 2375.5 12:00 7/2/2008
Lim9 Segment 54 Julian Day 2375.5 12:00 7/2/2008
Lim 10 Segment 10 Julian Day 2375.5 12:00 7/2/2008
Lim 11 Segment 11 Julian Day 2375.5 12:00 7/2/2008

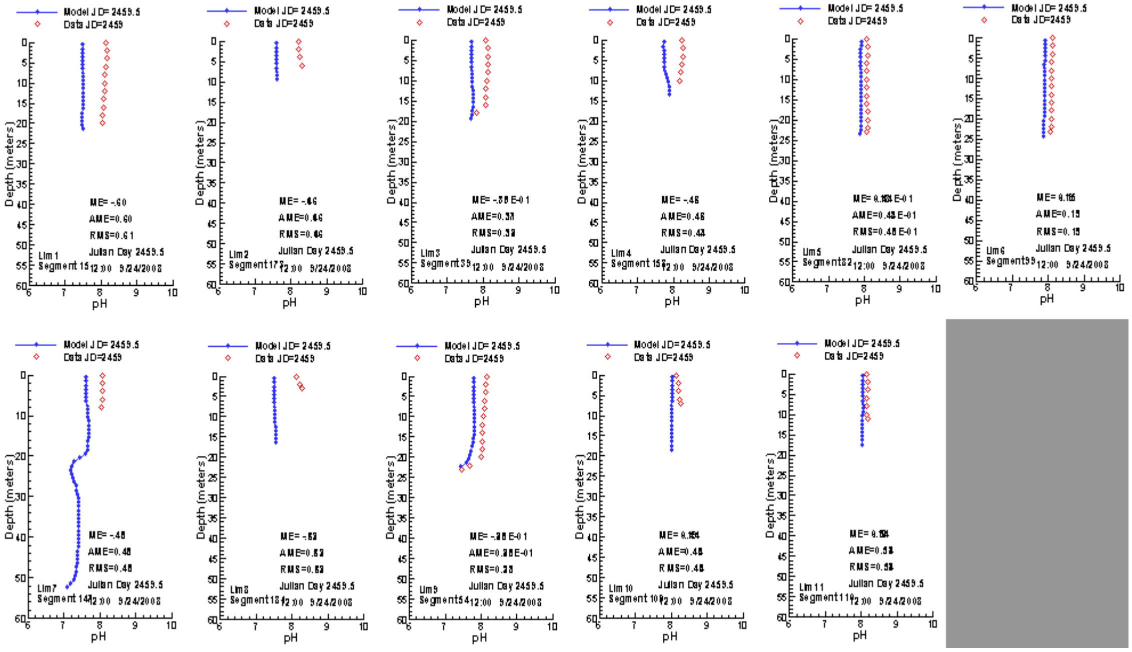

Model JD= 2389.5
Data JD=2389
Depth (meters)
pH
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10
Lim 1
Segment 15
ME= -.77
AME=0.77
RMS=0.77
Julian Day 2389.5
12:00 7/16/2008
Lim2
Segment 17
Lim3
Segment 39
Lim4
Segment 15
Lim5
Segment 82
Lim6
Segment 99
ME= -.32
Lim7
Segment 14
ME= -.17
Lim8
Segment 18
ME= -.56
Lim9
Segment 54
ME= -.38
AME=0.38
Lim 10
Segment 10
Lim 11
Segment 11
ME= -.49
AME=0.49

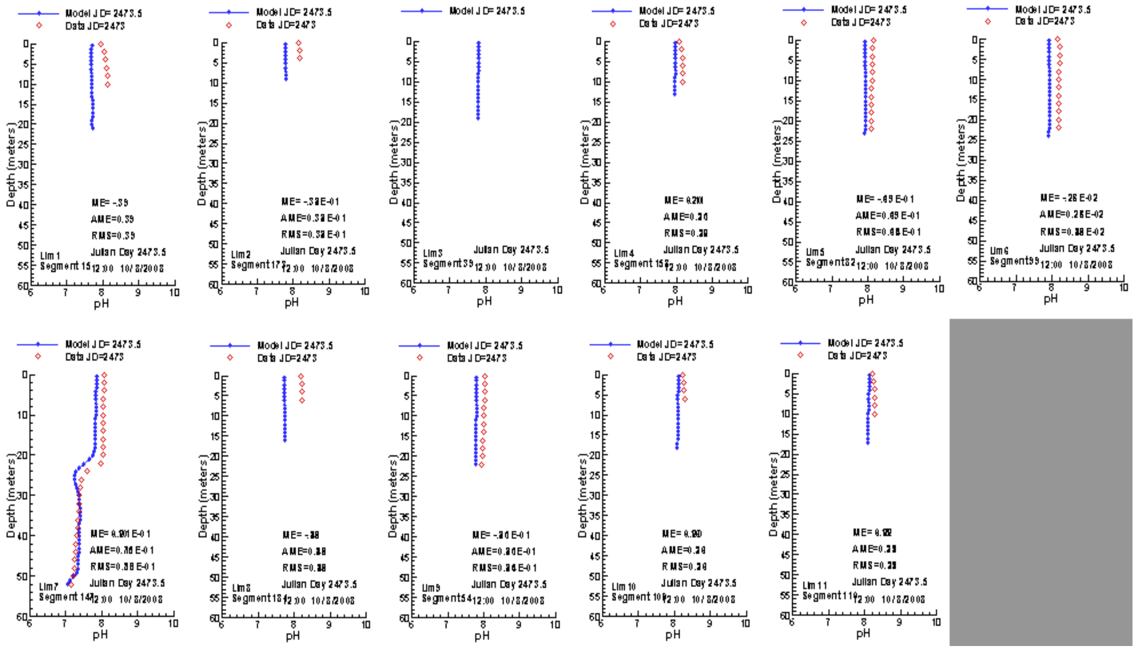

Model JD= 2403.5
Data JD=2403
Depth (meters)
pH
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10
Lim 1
Segment 15
ME= -.46
AME=0.46
RMS=0.49
Julian Day 2403.5
12:00 7/30/2008
Lim2
Segment 17
Lim3
Segment 39
Lim4
Segment 15
Lim5
Segment 82
AME=0.34
RMS=0.45
Lim6
Segment 99
RMS=0.44
Lim7
Segment 14
Lim8
Segment 18
RMS=0.21
Lim9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11
AME=0.48

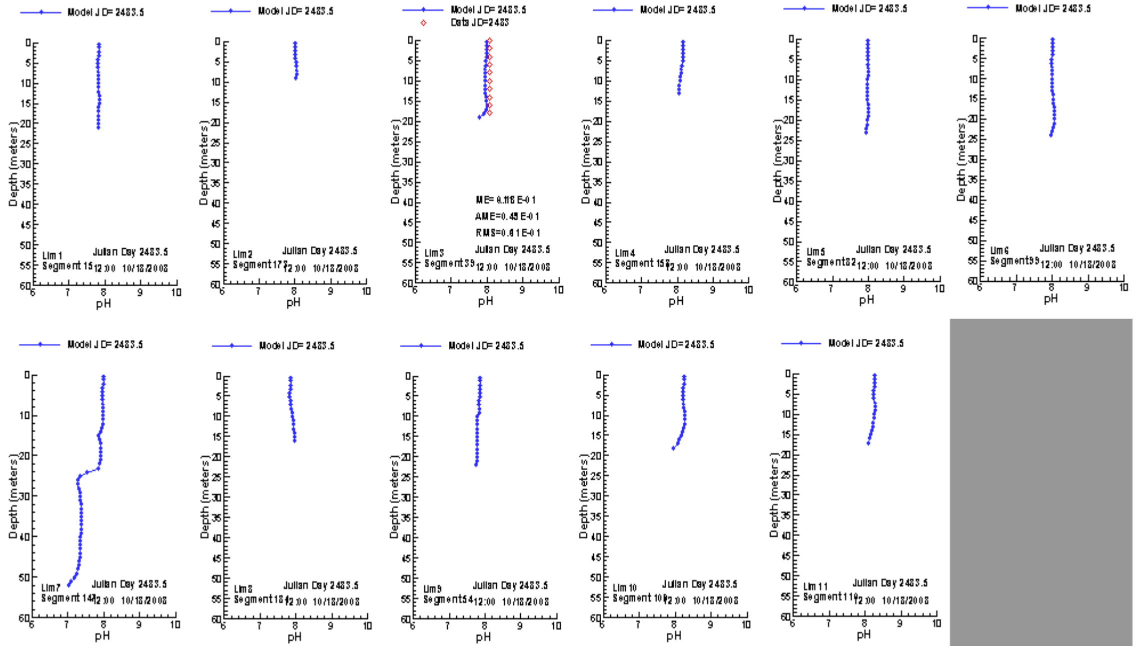

Model JD= 2417.5
Data JD=2417
Depth (meters)
pH
ME= -.50
AME=0.50
RMS=0.51
Lim 1
Segment 15
Julian Day 2417.5
12:00 8/13/2008
ME= -.83
AME=0.83
RMS=0.83
Lim 2
Segment 178
Julian Day 2417.5
12:00 8/13/2008
ME= -.50
AME=0.50
RMS=0.52
Lim 3
Segment 39
Julian Day 2417.5
12:00 8/13/2008
ME= -.98E-01
AME=0.28
RMS=0.30
Lim 4
Segment 158
Julian Day 2417.5
12:00 8/13/2008
ME= -.23
AME=0.23
RMS=0.24
Lim 5
Segment 82
Julian Day 2417.5
12:00 8/13/2008
ME= -.36
AME=0.36
RMS=0.38
Lim 6
Segment 99
Julian Day 2417.5
12:00 8/13/2008
ME= -.39E-01
AME=0.30
RMS=0.36
Lim 7
Segment 147
Julian Day 2417.5
12:00 8/13/2008
ME= -.39
AME=0.39
RMS=0.38
Lim 8
Segment 184
Julian Day 2417.5
12:00 8/13/2008
ME= -.65
AME=0.65
RMS=0.68
Lim 9
Segment 54
Julian Day 2417.5
12:00 8/13/2008
ME= -.34
AME=0.34
RMS=0.34
Lim 10
Segment 109
Julian Day 2417.5
12:00 8/13/2008
ME= -.26E-01
AME=0.26E-01
RMS=0.29E-01
Lim 11
Segment 119
Julian Day 2417.5
12:00 8/13/2008

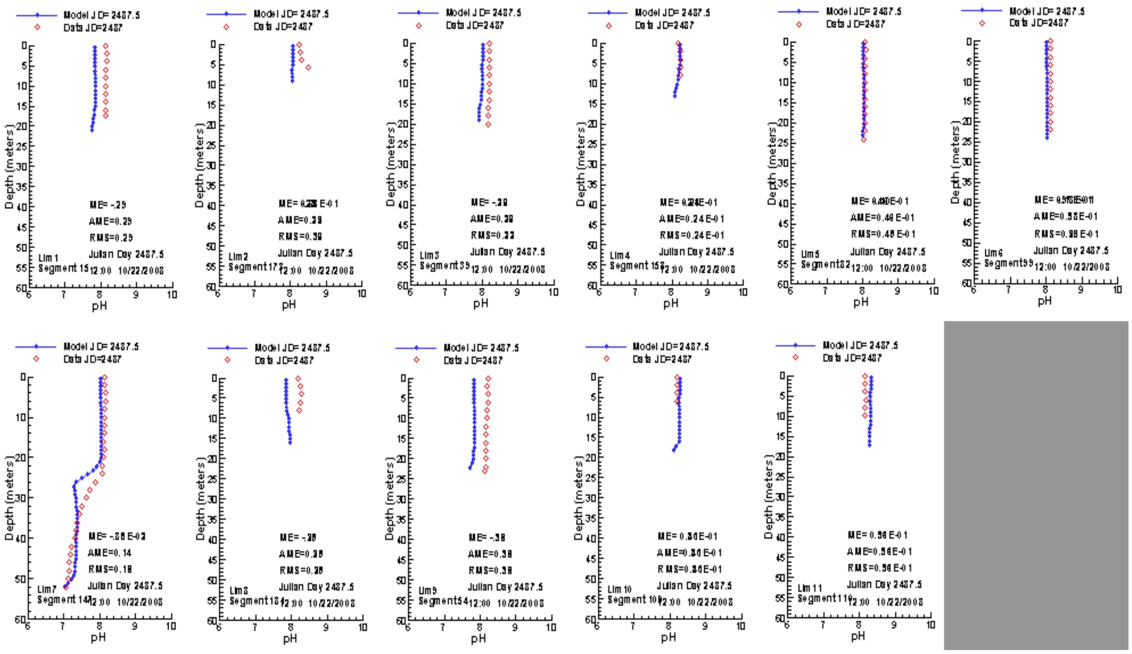

Model JD= 2431.5
Data JD=2431
Depth (meters)
pH
ME= -.56
AME=0.56
RMS=0.58
Lim 1
Segment 15
Julian Day 2431.5
12:00 8/27/2008
ME= -.58
AME=0.58
RMS=0.58
Lim 2
Segment 178
Julian Day 2431.5
12:00 8/27/2008
ME= -.53
AME=0.53
RMS=0.63
Lim 3
Segment 39
Julian Day 2431.5
12:00 8/27/2008
ME= -.48
AME=0.48
RMS=0.48
Lim 4
Segment 158
Julian Day 2431.5
12:00 8/27/2008
ME= -.26
AME=0.26
RMS=0.39
Lim 5
Segment 82
Julian Day 2431.5
12:00 8/27/2008
ME= -.19
AME=0.18
RMS=0.28
Lim 6
Segment 99
Julian Day 2431.5
12:00 8/27/2008
ME= -.47E-01
AME=0.29
RMS=0.28
Lim 7
Segment 147
Julian Day 2431.5
12:00 8/27/2008
ME= -.69
AME=0.69
RMS=0.69
Lim 8
Segment 184
Julian Day 2431.5
12:00 8/27/2008
ME= -.39
AME=0.39
RMS=0.38
Lim 9
Segment 54
Julian Day 2431.5
12:00 8/27/2008
ME= 0.69E-01
AME=0.75E-01
RMS=0.20
Lim 10
Segment 109
Julian Day 2431.5
12:00 8/27/2008
ME= 0.78E-01
AME=0.78E-01
RMS=0.88E-01
Lim 11
Segment 119
Julian Day 2431.5
12:00 8/27/2008

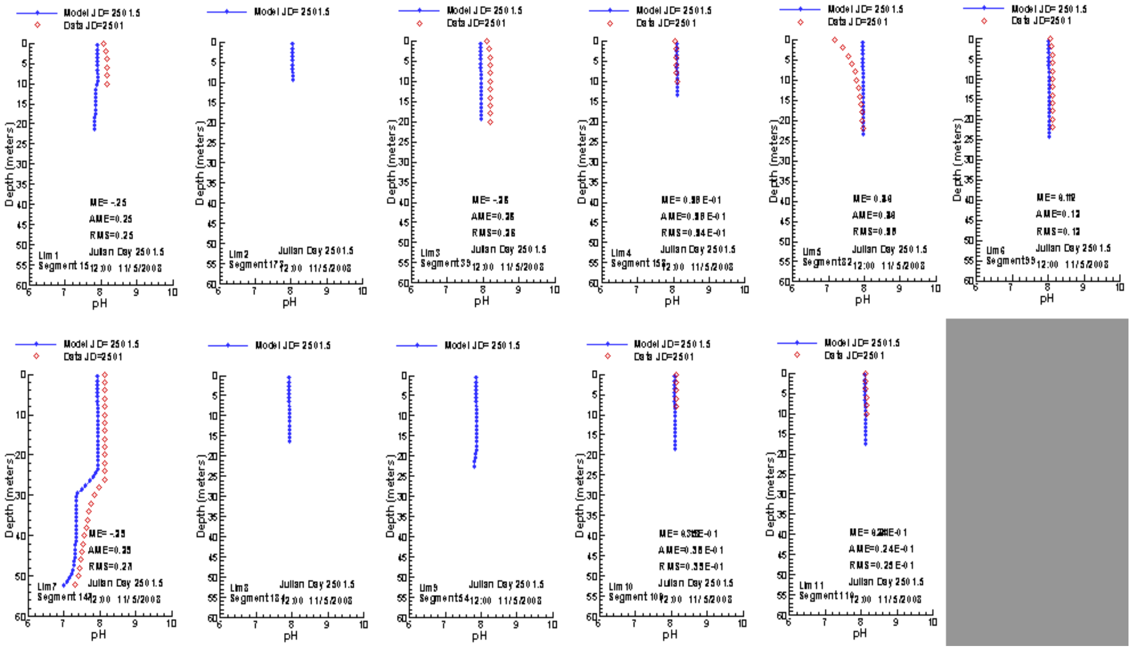

Model JD= 2445.5
Data JD=2445
Depth (meters)
pH
ME= -.59
AME=0.59
RMS=0.59
Julian Day 2445.5
Lim 1
Segment 15
12:00 9/10/2008
ME= -.58
AME=0.58
RMS=0.58
Julian Day 2445.5
Lim 2
Segment 173
12:00 9/10/2008
ME= -.98 E-01
AME=0.23
RMS=0.28
Julian Day 2445.5
Lim 3
Segment 39
12:00 9/10/2008
ME= -.42
AME=0.42
RMS=0.36
Julian Day 2445.5
Lim 4
Segment 158
12:00 9/10/2008
ME= 0.26E-01
AME=0.83 E-01
RMS=0.14
Julian Day 2445.5
Lim 5
Segment 82
12:00 9/10/2008
ME= -.55 E-01
AME=0.55E-01
RMS=0.59 E-01
Julian Day 2445.5
Lim 6
Segment 99
12:00 9/10/2008
ME= 0.27E-01
AME=0.26
RMS=0.28
Julian Day 2445.5
Lim 7
Segment 147
12:00 9/10/2008
ME= -.55
AME=0.55
RMS=0.54
Julian Day 2445.5
Lim 8
Segment 184
12:00 9/10/2008
ME= -.26
AME=0.38
RMS=0.36
Julian Day 2445.5
Lim 9
Segment 54
12:00 9/10/2008
ME= -.29E-01
AME=0.29 E-01
RMS=0.36E-01
Julian Day 2445.5
Lim 10
Segment 109
12:00 9/10/2008
ME= 0.33 E-02
AME=0.12E-01
RMS=0.18 E-01
Julian Day 2445.5
Lim 11
Segment 119
12:00 9/10/2008

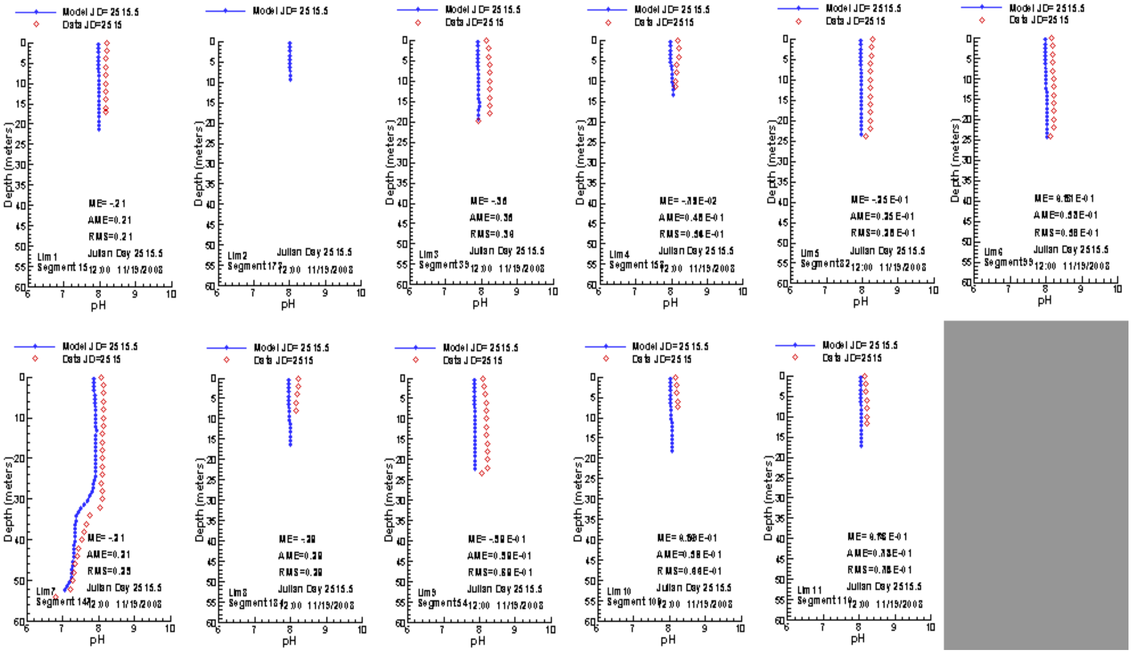

Model JD= 2459.5
Data JD=2459
Depth (meters)
pH
ME= -.60
AME=0.60
RMS=0.61
Julian Day 2459.5
Lim 1
Segment 15
12:00 9/24/2008
ME= -.66
AME=0.66
RMS=0.66
Julian Day 2459.5
Lim 2
Segment 173
12:00 9/24/2008
ME= -.38 E-01
AME=0.37
RMS=0.32
Julian Day 2459.5
Lim 3
Segment 39
12:00 9/24/2008
ME= -.46
AME=0.46
RMS=0.44
Julian Day 2459.5
Lim 4
Segment 158
12:00 9/24/2008
ME= 0.18 E-01
AME=0.43 E-01
RMS=0.48 E-01
Julian Day 2459.5
Lim 5
Segment 82
12:00 9/24/2008
ME= 0.15
AME=0.15
RMS=0.15
Julian Day 2459.5
Lim 6
Segment 99
12:00 9/24/2008
ME= -.46
AME=0.46
RMS=0.46
Julian Day 2459.5
Lim 7
Segment 147
12:00 9/24/2008
ME= -.52
AME=0.52
RMS=0.52
Julian Day 2459.5
Lim 8
Segment 184
12:00 9/24/2008
ME= -.28 E-01
AME=0.28E-01
RMS=0.23
Julian Day 2459.5
Lim 9
Segment 54
12:00 9/24/2008
ME= 0.14
AME=0.48
RMS=0.48
Julian Day 2459.5
Lim 10
Segment 109
12:00 9/24/2008
ME= 0.12
AME=0.52
RMS=0.52
Julian Day 2459.5
Lim 11
Segment 119
12:00 9/24/2008

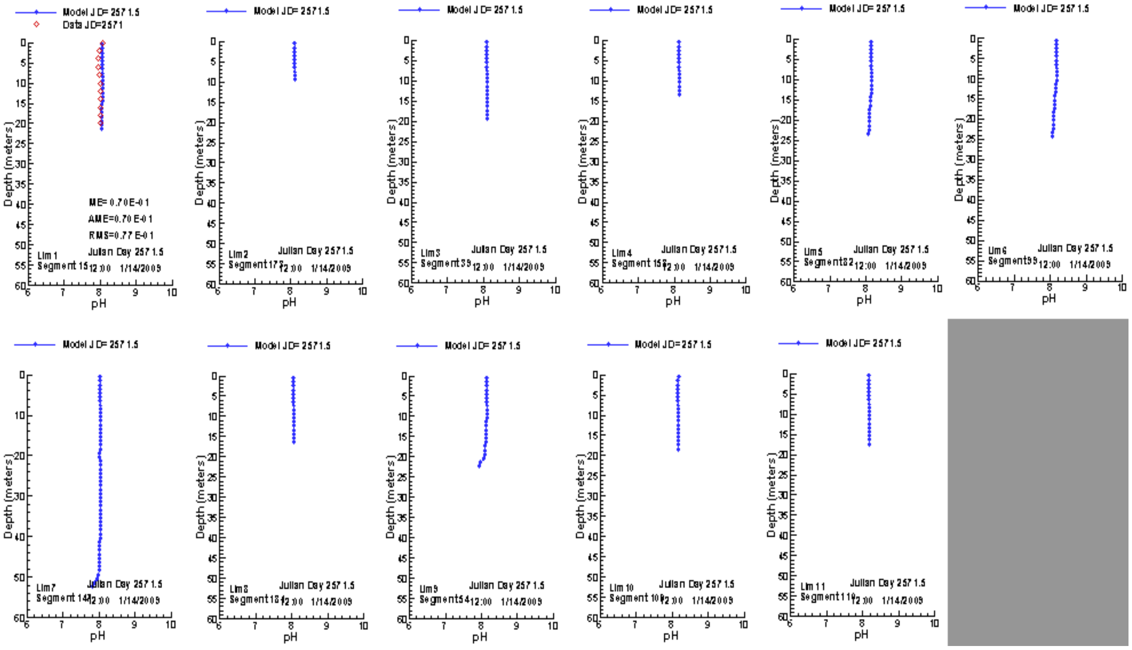

Model JD= 2473.5
Data JD=2473
Depth (meters)
pH
ME= -.39
AME=0.39
RMS=0.39
Lim1
Segment 15
Julian Day 2473.5
12:00 10/8/2008
ME= -.32E-01
AME=0.32E-01
RMS=0.32E-01
Lim2
Julian Day 2473.5
12:00 10/8/2008
Lim3
Segment39
Julian Day 2473.5
12:00 10/8/2008
Lim4
Julian Day 2473.5
12:00 10/8/2008
ME= -.69E-01
AME=0.69E-01
RMS=0.68E-01
Lim5
Segment82
Julian Day 2473.5
12:00 10/8/2008
ME= -.26E-02
AME=0.26E-02
RMS=0.38E-02
Lim6
Segment99
Julian Day 2473.5
12:00 10/8/2008
Lim7
Julian Day 2473.5
12:00 10/8/2008
Lim8
Julian Day 2473.5
12:00 10/8/2008
Lim9
Segment54
Julian Day 2473.5
12:00 10/8/2008
Lim10
Julian Day 2473.5
12:00 10/8/2008
Lim11
Julian Day 2473.5
12:00 10/8/2008

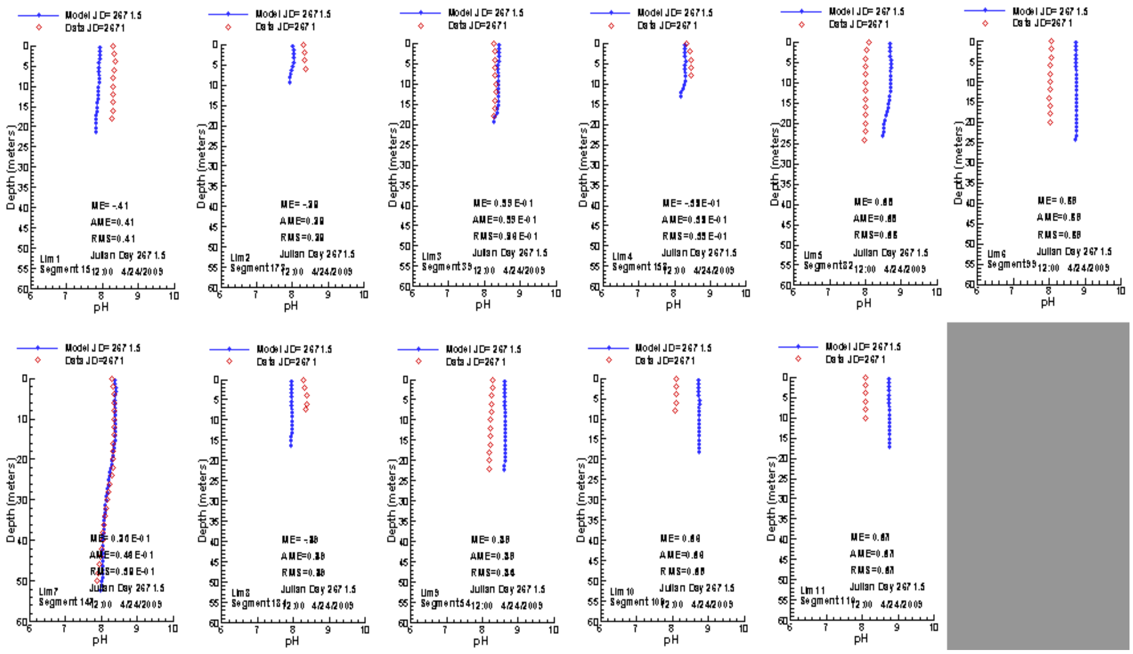

Model JD= 2483.5
Data JD=2483
Depth (meters)
pH
Lim1
Segment 15
Julian Day 2483.5
12:00 10/18/2008
Lim2
Julian Day 2483.5
12:00 10/18/2008
ME= 0.11E-01
AME=0.45E-01
RMS=0.61E-01
Lim3
Segment39
Julian Day 2483.5
12:00 10/18/2008
Lim4
Julian Day 2483.5
12:00 10/18/2008
Lim5
Segment82
Julian Day 2483.5
12:00 10/18/2008
Lim6
Segment99
Julian Day 2483.5
12:00 10/18/2008
Lim7
Julian Day 2483.5
12:00 10/18/2008
Lim8
Julian Day 2483.5
12:00 10/18/2008
Lim9
Segment54
Julian Day 2483.5
12:00 10/18/2008
Lim10
Julian Day 2483.5
12:00 10/18/2008
Lim11
Julian Day 2483.5
12:00 10/18/2008

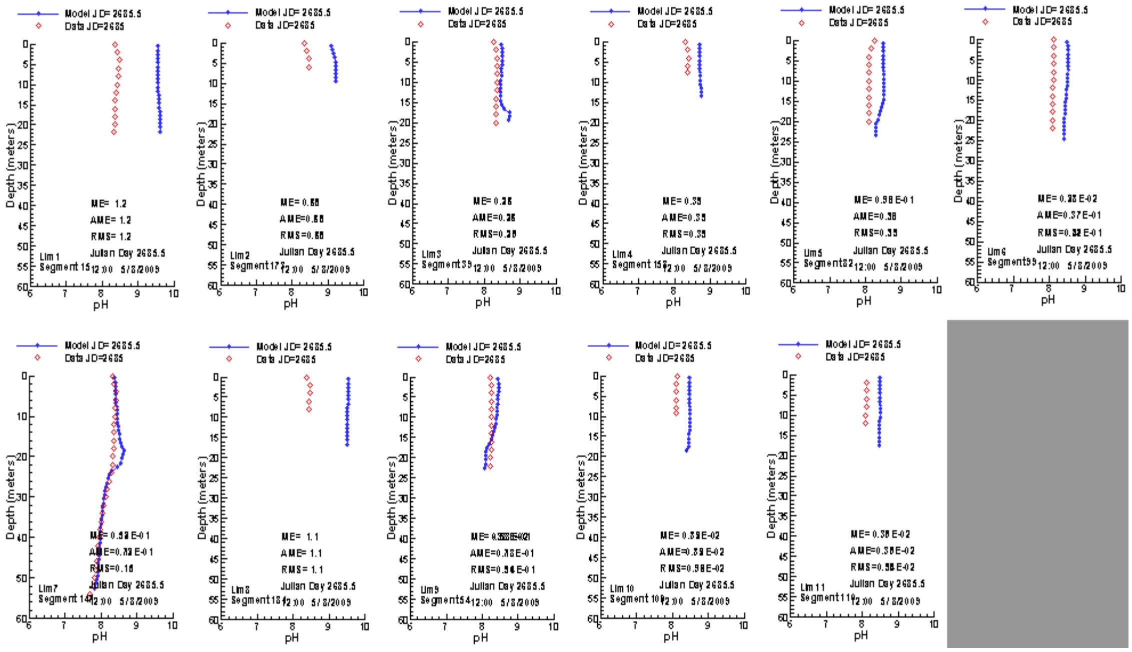

Model JD= 2487.5
Data JD=2487
Depth (meters)
pH
ME= -.29
AME=0.29
RMS=0.29
Julian Day 2487.5
Lim 1
Segment 15
12:00 10/22/2008
ME= 0.28E-01
AME=0.39
RMS=0.39
Lim 2
Segment 173
ME= -.29
AME=0.29
RMS=0.33
Lim 3
Segment 39
ME= 0.24E-01
AME=0.24 E-01
RMS=0.24 E-01
Lim 4
Segment 158
ME= 0.40E-01
AME=0.49 E-01
RMS=0.48 E-01
Lim 5
Segment 82
ME= 0.58E-01
AME=0.58 E-01
RMS=0.98 E-01
Lim 6
Segment 99
ME= -.88 E-02
AME=0.14
RMS=0.18
Lim 7
Segment 147
ME= -.28
AME=0.28
RMS=0.28
Lim 8
Segment 184
ME= -.38
AME=0.38
RMS=0.38
Lim 9
Segment 54
ME= 0.34E-01
AME=0.34 E-01
RMS=0.34 E-01
Lim 10
Segment 109
ME= 0.56 E-01
AME=0.56 E-01
RMS=0.56 E-01
Lim 11
Segment 119

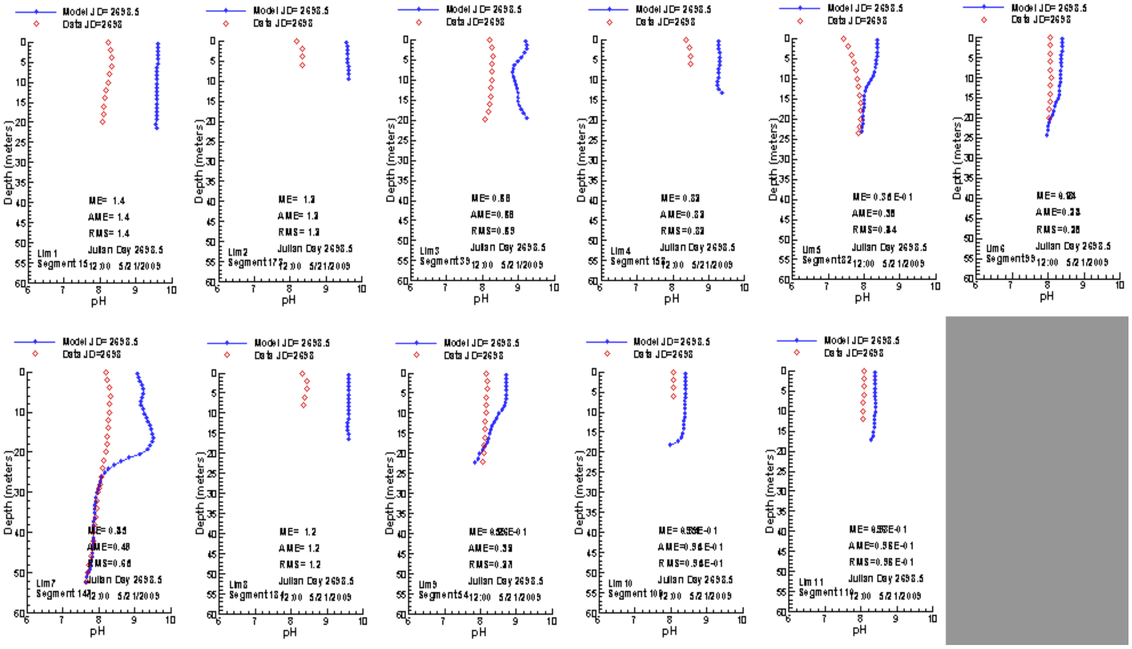

Model JD= 2501.5
Data JD=2501
Depth (meters)
pH
ME= -.25
AME=0.25
RMS=0.25
Julian Day 2501.5
Lim 1
Segment 15
12:00 11/5/2008
Lim 2
Segment 173
ME= -.26
AME=0.26
RMS=0.26
Lim 3
Segment 39
ME= 0.38 E-01
AME=0.38 E-01
RMS=0.34 E-01
Lim 4
Segment 158
ME= 0.38
AME=0.38
RMS=0.38
Lim 5
Segment 82
ME= 0.12
AME=0.13
RMS=0.13
Lim 6
Segment 99
ME= -.25
AME=0.25
RMS=0.27
Lim 7
Segment 147
Lim 8
Segment 184
Lim 9
Segment 54
ME= 0.35E-01
AME=0.38 E-01
RMS=0.35 E-01
Lim 10
Segment 109
ME= 0.24E-01
AME=0.24E-01
RMS=0.25 E-01
Lim 11
Segment 119


Model JD= 2515.5
Data JD=2515
Depth (meters)
pH
ME= -.21
AME=0.21
RMS=0.21
Lim 1
Segment 15
Julian Day 2515.5
12:00 11/19/2008
Lim 2
Segment 172
ME= -.36
AME=0.36
RMS=0.36
Lim 3
Segment 39
ME= -.79E-02
AME=0.48E-01
RMS=0.54E-01
Lim 4
Segment 158
ME= -.25E-01
AME=0.25E-01
RMS=0.28E-01
Lim 5
Segment 82
ME= 0.51E-01
AME=0.53E-01
RMS=0.58E-01
Lim 6
Segment 99
ME= -.31
AME=0.31
RMS=0.35
Lim 7
Segment 147
ME= -.29
AME=0.29
RMS=0.29
Lim 8
Segment 184
ME= -.59E-01
AME=0.59E-01
RMS=0.69E-01
Lim 9
Segment 54
ME= 0.59E-01
AME=0.58E-01
RMS=0.66E-01
Lim 10
Segment 109
ME= 0.78E-01
AME=0.78E-01
RMS=0.78E-01
Lim 11
Segment 119

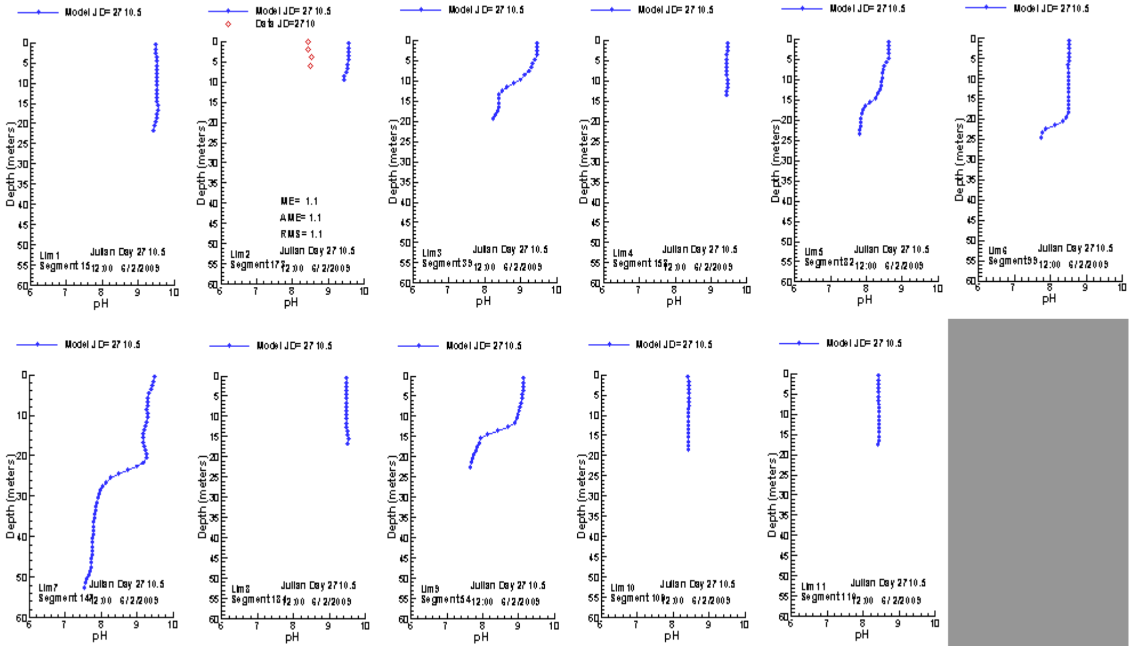

Model JD= 2571.5
Data JD=2571
Depth (meters)
pH
ME= 0.70E-01
AME=0.70E-01
RMS=0.77E-01
Lim 1
Segment 15
Julian Day 2571.5
12:00 1/14/2009
Lim 2
Segment 172
Lim 3
Segment 39
Lim 4
Segment 158
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 147
Lim 8
Segment 184
Lim 9
Segment 54
Lim 10
Segment 109
Lim 11
Segment 119


Model JD= 2671.5
Data JD=2671
Depth (meters)
pH
ME= -.41
AME=0.41
RMS=0.41
Lim 1
Segment 15
Julian Day 2671.5
12:00 4/24/2009
ME= -.39
AME=0.39
RMS=0.39
Lim 2
Segment 173
ME= 0.59E-01
AME=0.59E-01
RMS=0.86E-01
Lim 3
Segment 39
ME= -.55E-01
AME=0.55E-01
RMS=0.55E-01
Lim 4
Segment 152
ME= 0.66
AME=0.66
RMS=0.66
Lim 5
Segment 82
ME= 0.68
AME=0.68
RMS=0.68
Lim 6
Segment 99
ME= 0.20E-01
AME=0.46E-01
RMS=0.59E-01
Lim 7
Segment 147
ME= -.38
AME=0.38
RMS=0.38
Lim 8
Segment 181
ME= 0.38
AME=0.38
RMS=0.38
Lim 9
Segment 54
ME= 0.66
AME=0.66
RMS=0.66
Lim 10
Segment 109
ME= 0.67
AME=0.67
RMS=0.67
Lim 11
Segment 119

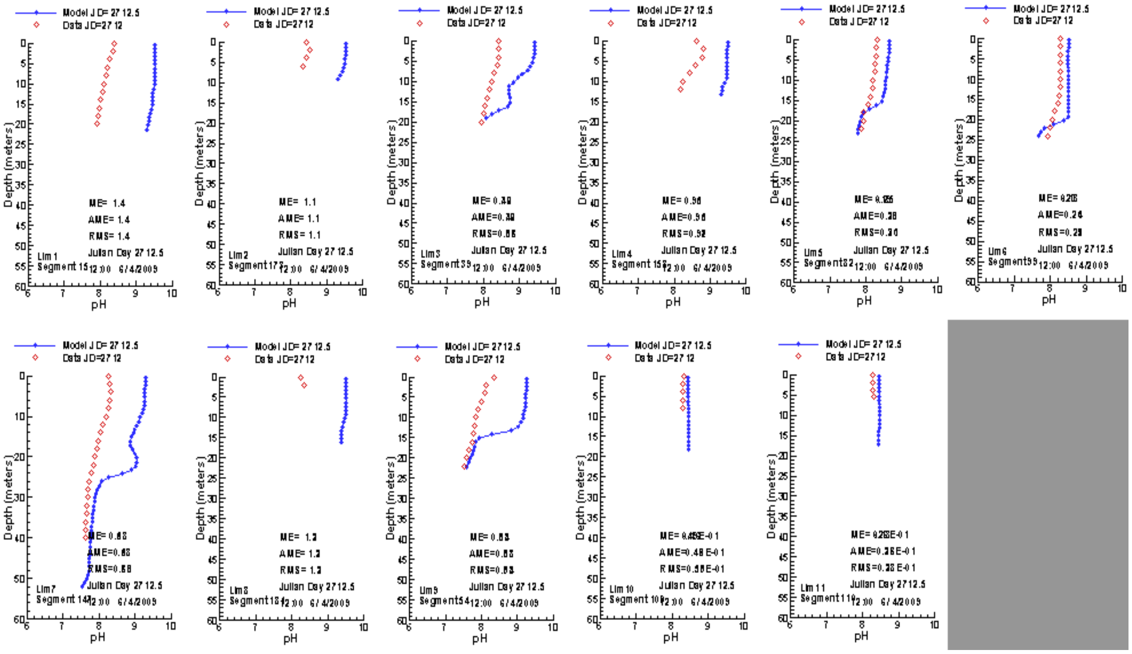

Model JD= 2685.5
Data JD=2685
Depth (meters)
pH
ME= 1.2
AME= 1.2
RMS= 1.2
Lim 1
Segment 15
Julian Day 2685.5
12:00 5/8/2009
ME= 0.68
AME=0.68
RMS=0.68
Lim 2
Segment 173
ME= 0.26
AME=0.26
RMS=0.26
Lim 3
Segment 39
ME= 0.35
AME=0.35
RMS=0.35
Lim 4
Segment 152
ME= 0.98E-01
AME=0.38
RMS=0.39
Lim 5
Segment 82
ME= 0.23E-02
AME=0.37E-01
RMS=0.32E-01
Lim 6
Segment 99
ME= 0.52E-01
AME=0.72E-01
RMS=0.16
Lim 7
Segment 147
ME= 1.1
AME= 1.1
RMS= 1.1
Lim 8
Segment 181
AME=0.78E-01
RMS=0.94E-01
Lim 9
Segment 54
ME= 0.39E-02
AME=0.39E-02
RMS=0.98E-02
Lim 10
Segment 109
ME= 0.38E-02
AME=0.38E-02
RMS=0.58E-02
Lim 11
Segment 119

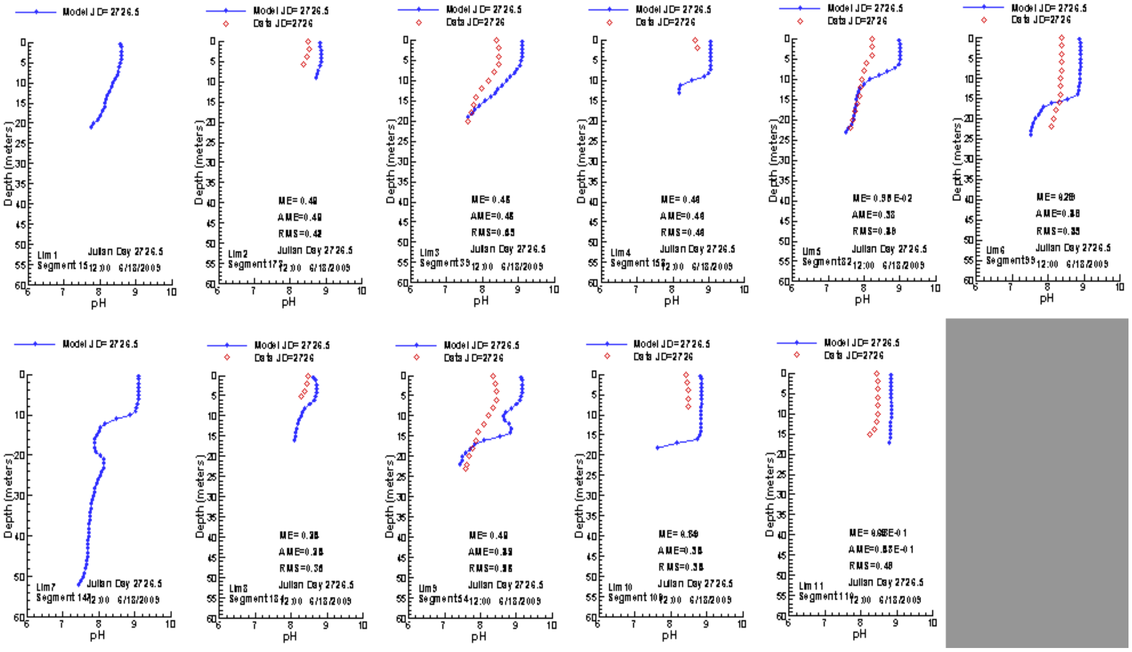


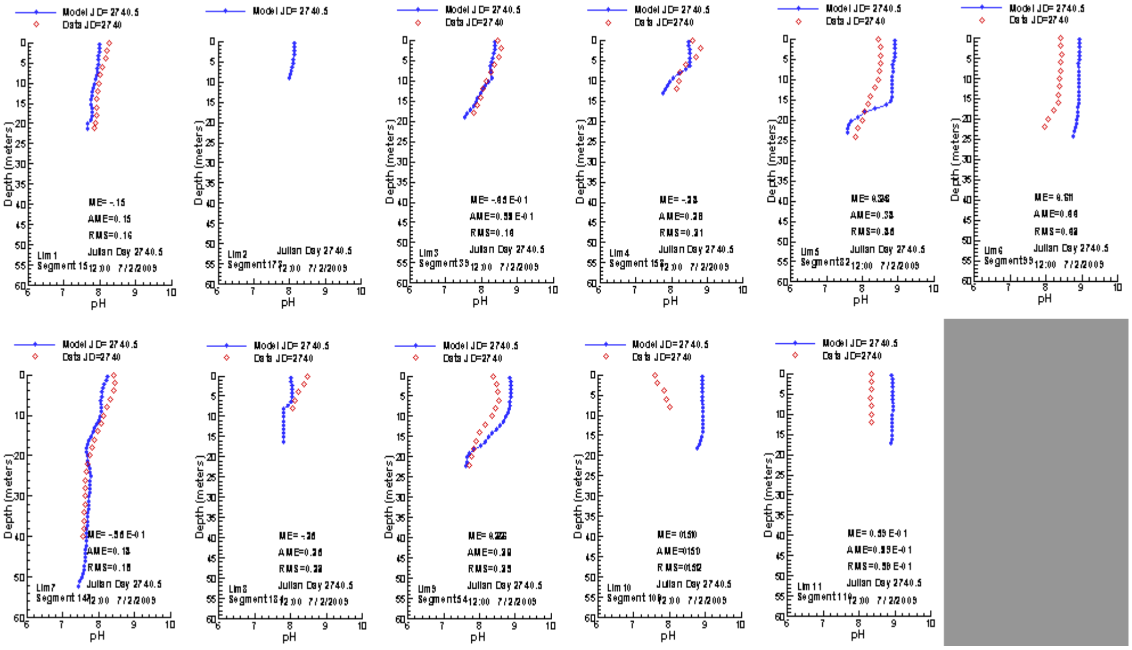
Model JD= 2698.5
Data JD=2698
Depth (meters)
pH
ME= 1.4
AME= 1.4
RMS= 1.4
Lim1
Segment 15
Julian Day 2698.5
12:00 5/21/2009
ME= 1.3
AME= 1.3
RMS= 1.3
Lim2
Segment 17
ME= 0.58
AME=0.58
RMS=0.59
Lim3
Segment 39
ME= 0.83
AME=0.83
RMS=0.83
Lim4
Segment 15
ME= 0.36E-01
AME=0.38
RMS=0.34
Lim5
Segment 82
ME= 0.24
AME=0.23
RMS=0.28
Lim6
Segment 99
ME= 0.35
AME=0.48
RMS=0.66
Lim7
Segment 14
ME= 1.2
AME= 1.2
RMS= 1.2
Lim8
Segment 18
ME= 0.52E-01
AME=0.39
RMS=0.37
Lim9
Segment 54
ME= 0.58E-01
AME=0.96E-01
RMS=0.96E-01
Lim10
Segment 10
ME= 0.58E-01
AME=0.96E-01
RMS=0.96E-01
Lim11
Segment 11

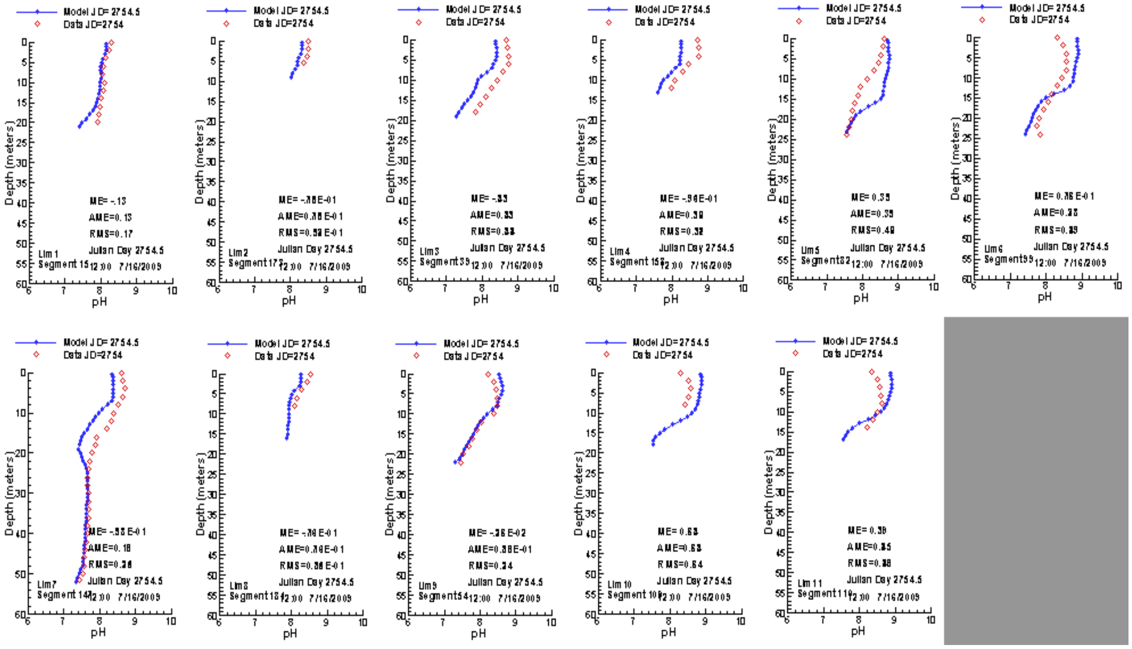


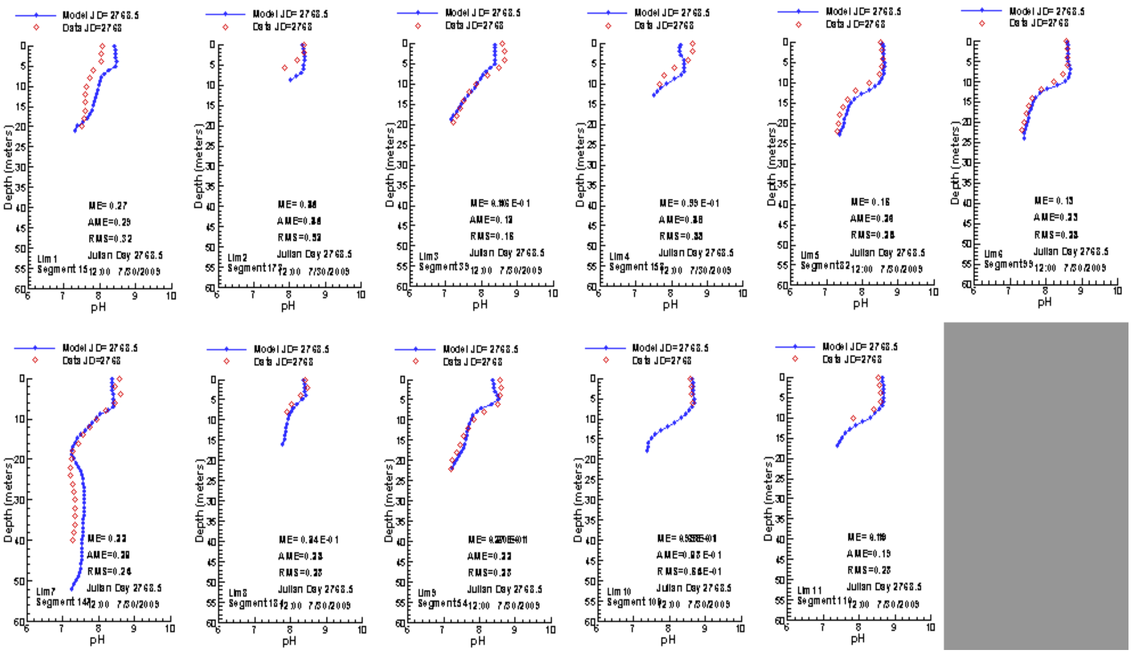
Model JD= 2710.5
Data JD=2710
Depth (meters)
pH
Lim1
Segment 15
Julian Day 2710.5
12:00 6/2/2009
ME= 1.1
AME= 1.1
RMS= 1.1
Lim2
Segment 17
Lim3
Segment 39
Lim4
Segment 15
Lim5
Segment 82
Lim6
Segment 99
Lim7
Segment 14
Lim8
Segment 18
Lim9
Segment 54
Lim10
Segment 10
Lim11
Segment 11

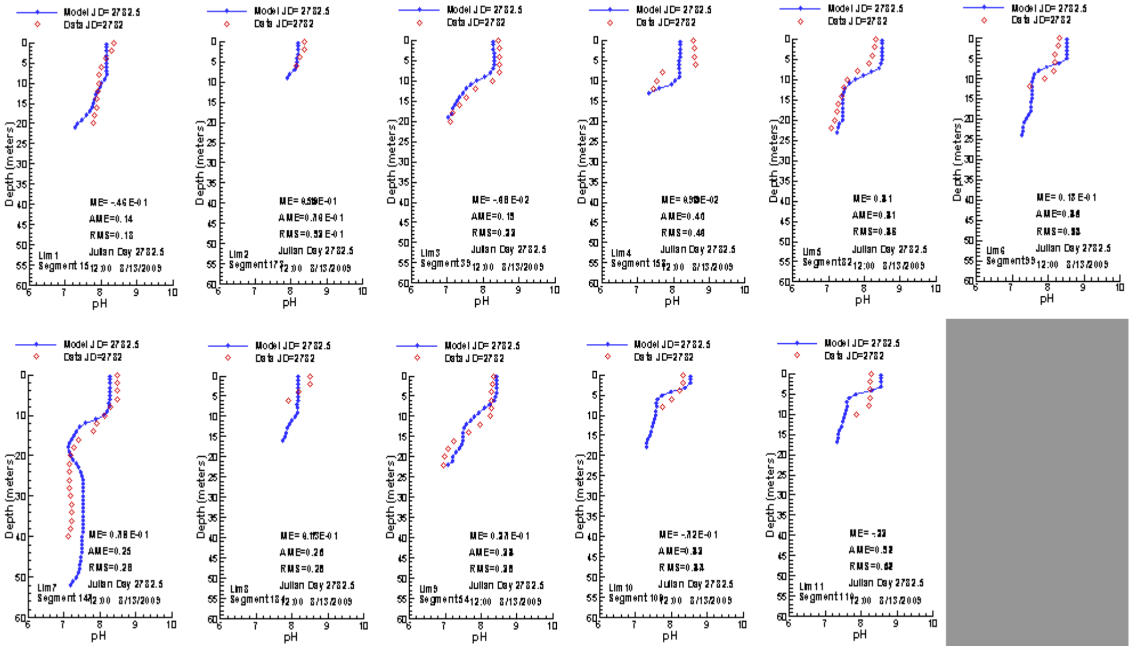

Model JD= 2712.5
Data JD=2712
Depth (meters)
pH
ME= 1.4
AME= 1.4
RMS= 1.4
Lim 1
Segment 15
Julian Day 2712.5
12:00 6/4/2009
ME= 1.1
AME= 1.1
RMS= 1.1
Lim 2
Segment 17
ME= 0.39
AME=0.39
RMS=0.55
Lim 3
Segment 39
ME= 0.96
AME=0.96
RMS=0.92
Lim 4
Segment 15
ME= 0.25
AME=0.28
RMS=0.30
Lim 5
Segment 82
ME= 0.26
AME=0.24
RMS=0.29
Lim 6
Segment 99
ME= 0.68
AME=0.68
RMS=0.68
Lim 7
Segment 14
ME= 1.3
AME= 1.3
RMS= 1.3
Lim 8
Segment 18
ME= 0.53
AME=0.53
RMS=0.53
Lim 9
Segment 54
ME= 0.45E-01
AME=0.48E-01
RMS=0.55E-01
Lim 10
Segment 10
ME= 0.26E-01
AME=0.26E-01
RMS=0.28E-01
Lim 11
Segment 11

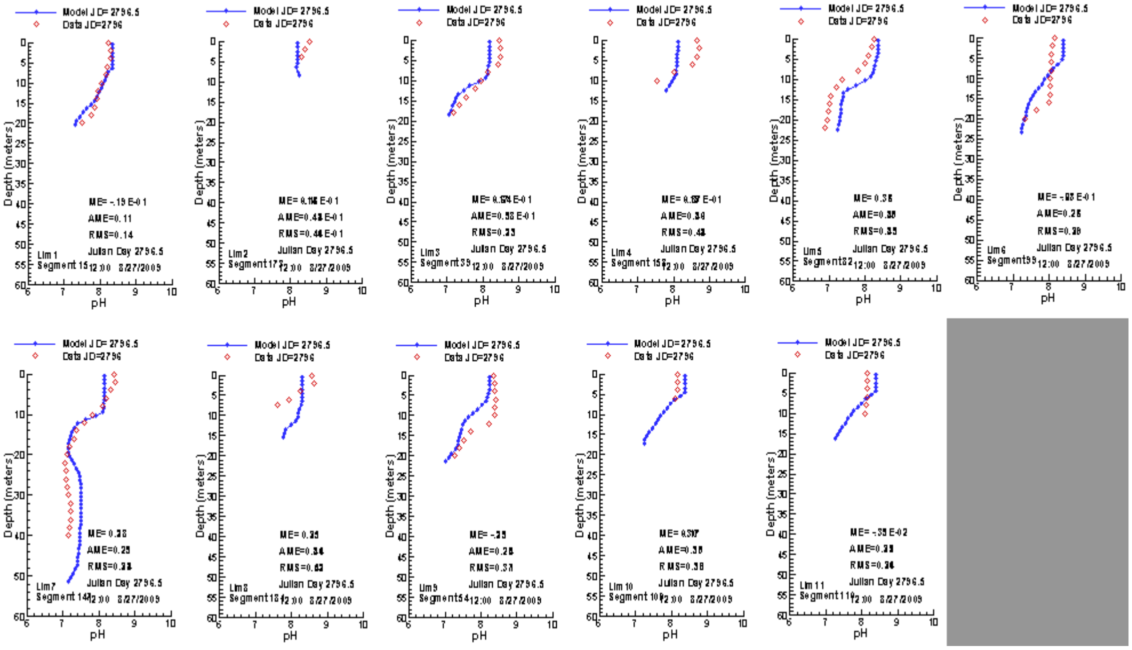

Model JD= 2726.5
Data JD=2726
Depth (meters)
pH
Lim 1
Segment 15
Julian Day 2726.5
12:00 6/18/2009
ME= 0.49
AME=0.49
RMS=0.42
Lim 2
Segment 17
ME= 0.45
AME=0.45
RMS=0.65
Lim 3
Segment 39
ME= 0.46
AME=0.46
RMS=0.46
Lim 4
Segment 15
ME= 0.95E-02
AME=0.38
RMS=0.39
Lim 5
Segment 82
ME= 0.29
AME=0.38
RMS=0.35
Lim 6
Segment 99
Lim 7
Segment 14
ME= 0.38
AME=0.38
RMS=0.36
Lim 8
Segment 18
ME= 0.49
AME=0.59
RMS=0.58
Lim 9
Segment 54
ME= 0.39
AME=0.38
RMS=0.38
Lim 10
Segment 10
ME= 0.69E-01
AME=0.83E-01
RMS=0.48
Lim 11
Segment 11

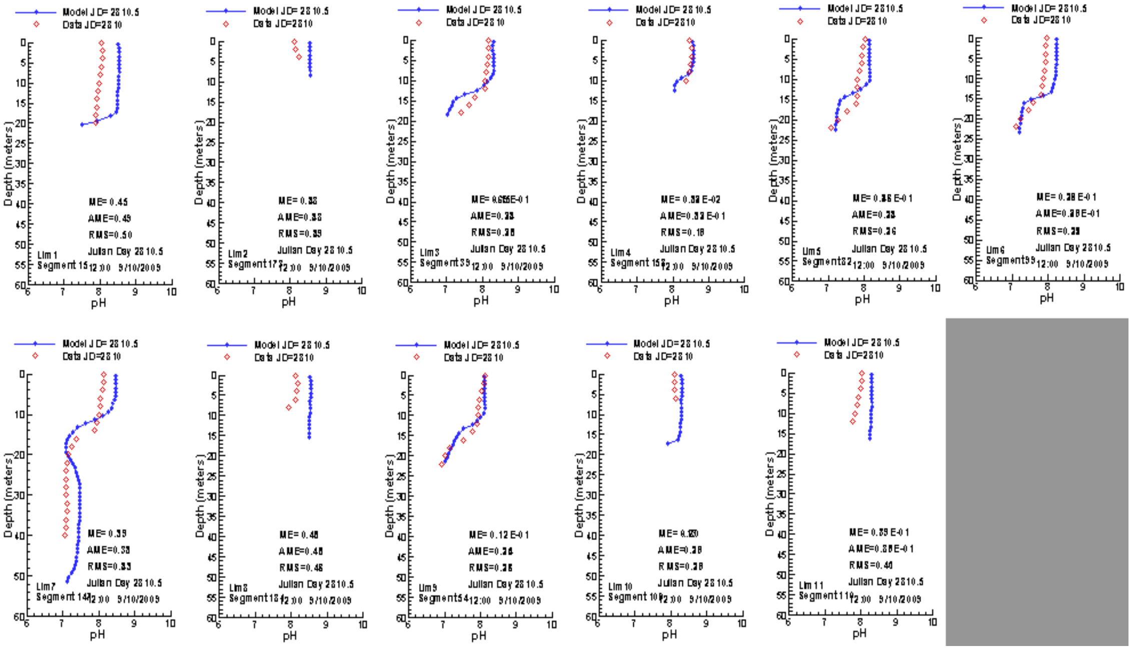

Model JD= 2740.5
Data JD=2740
Depth (meters)
pH
ME= -.15
AME=0.15
RMS=0.16
Julian Day 2740.5
Lim1
Segment 15
12:00 7/2/2009
Lim2
Segment 17
Lim3
Segment 33
ME= -.65 E-01
AME=0.59 E-01
RMS=0.16
Lim4
Segment 15
ME= -.23
AME=0.28
RMS=0.31
Lim5
Segment 32
ME= 0.26
AME=0.33
RMS=0.36
Lim6
Segment 35
ME= 0.61
AME=0.66
RMS=0.62
Lim7
Segment 14
ME= -.56 E-01
AME=0.13
RMS=0.18
Lim8
Segment 18
ME= -.26
AME=0.26
RMS=0.22
Lim9
Segment 54
ME= 0.26
AME=0.29
RMS=0.35
Lim10
Segment 10
ME= 0.51
AME=0.51
RMS=0.52
Lim11
Segment 11
ME= 0.59 E-01
AME=0.59 E-01
RMS=0.59 E-01

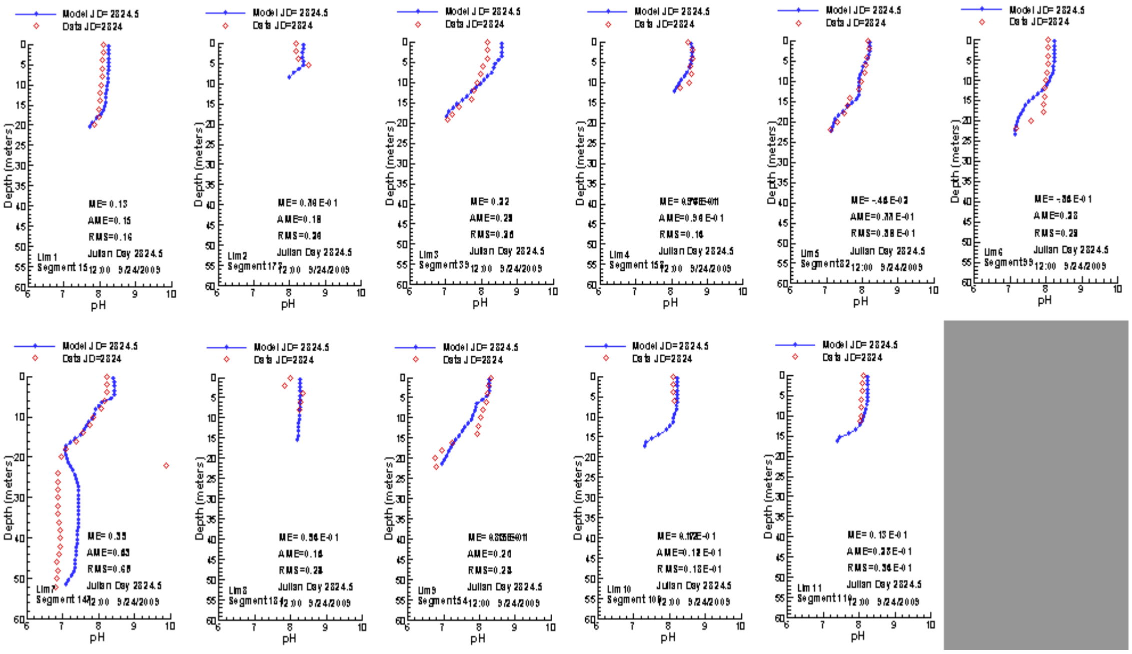

Model JD= 2754.5
Data JD=2754
Depth (meters)
pH
Julian Day 2754.5
12:00 7/16/2009
Lim1
Segment 15
ME= -.13
AME=0.13
RMS=0.17
Lim2
Segment 17
ME= -.78E-01
AME=0.78 E-01
RMS=0.52 E-01
Lim3
Segment 33
ME= -.33
AME=0.33
RMS=0.33
Lim4
Segment 15
ME= -.96E-01
AME=0.39
RMS=0.32
Lim5
Segment 32
ME= 0.35
AME=0.35
RMS=0.49
Lim6
Segment 35
ME= 0.76 E-01
AME=0.28
RMS=0.29
Lim7
Segment 14
ME= -.58 E-01
AME=0.18
RMS=0.26
Lim8
Segment 18
ME= -.76 E-01
AME=0.76E-01
RMS=0.86 E-01
Lim9
Segment 54
ME= -.26 E-02
AME=0.86E-01
RMS=0.24
Lim10
Segment 10
ME= 0.63
AME=0.63
RMS=0.64
Lim11
Segment 11
ME= 0.38
AME=0.35
RMS=0.38

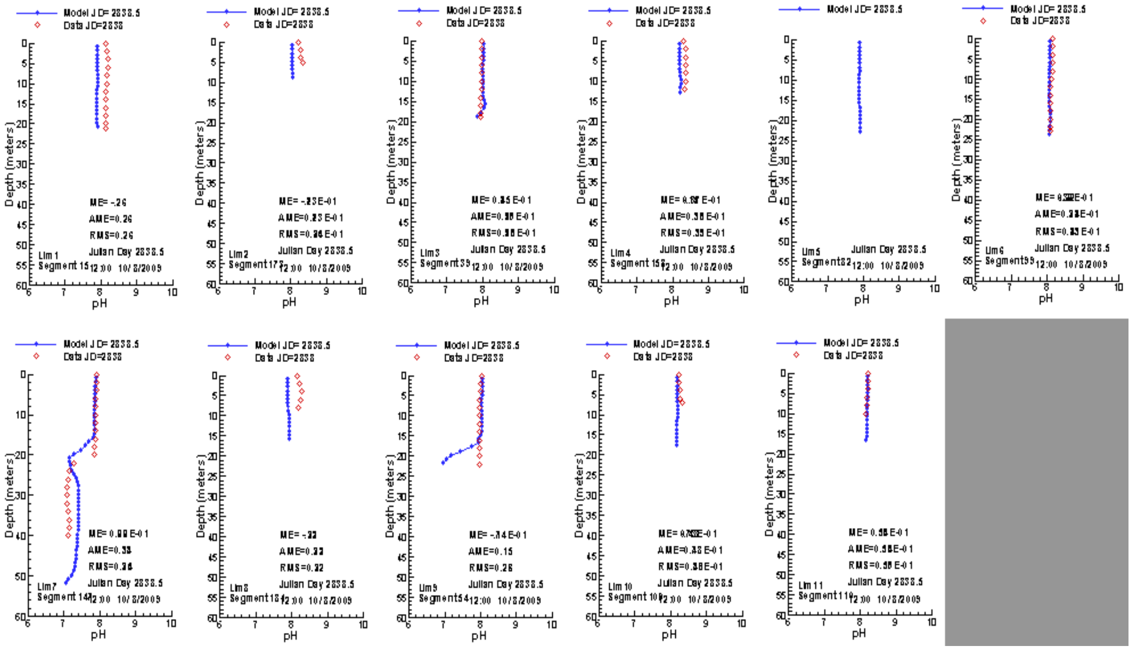

Model JD= 2768.5
Data JD=2768
Depth (meters)
pH
Lim 1
Segment 15
ME= 0.27
AME=0.29
RMS=0.32
Julian Day 2768.5
12:00 7/30/2009
Lim 2
Segment 17
ME= 0.36
AME=0.36
RMS=0.53
Lim 3
Segment 39
ME= 0.96 E-01
AME=0.13
RMS=0.16
Lim 4
Segment 15
ME= 0.99 E-01
AME=0.36
RMS=0.33
Lim 5
Segment 82
ME= 0.16
AME=0.26
RMS=0.28
Lim 6
Segment 99
ME= 0.13
AME=0.23
RMS=0.23
Lim 7
Segment 14
ME= 0.22
AME=0.29
RMS=0.24
Lim 8
Segment 18
ME= 0.24 E-01
AME=0.23
RMS=0.28
Lim 9
Segment 54
ME= 0.27 E-01
AME=0.22
RMS=0.28
Lim 10
Segment 10
ME= 0.58 E-01
AME=0.93 E-01
RMS=0.84 E-01
Lim 11
Segment 11
ME= 0.19
AME=0.19
RMS=0.23
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10

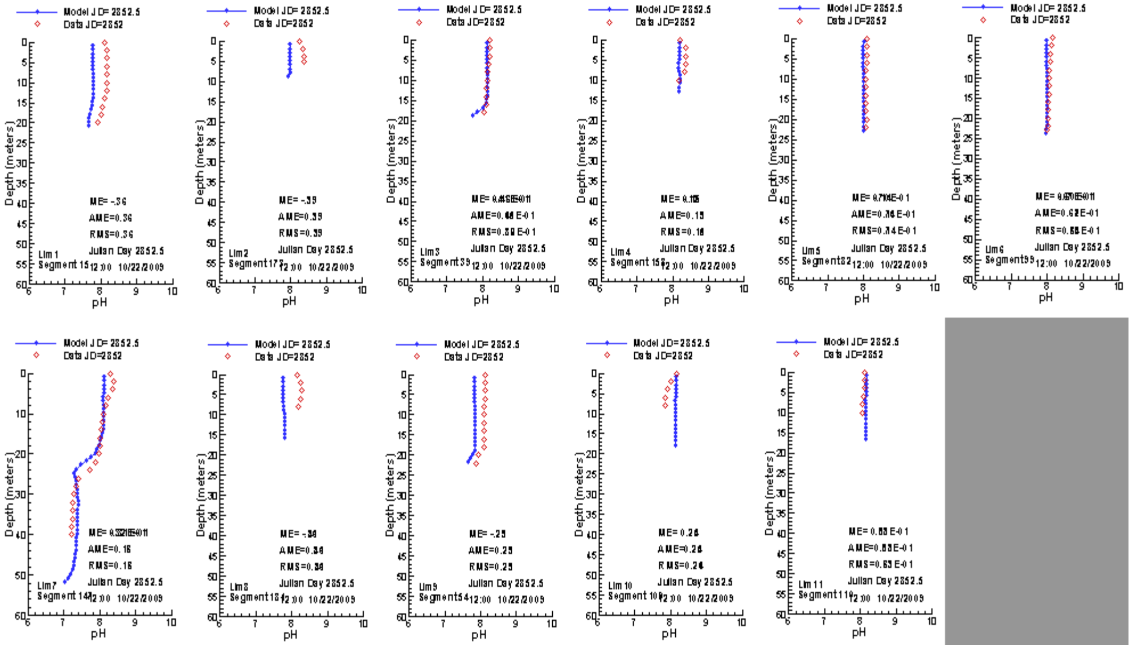

Model JD= 2782.5
Data JD=2782
Depth (meters)
pH
Lim 1
Segment 15
ME= -.46 E-01
AME=0.14
RMS=0.18
Julian Day 2782.5
12:00 8/13/2009
Lim 2
Segment 17
ME= 0.59 E-01
AME=0.79 E-01
RMS=0.53 E-01
Lim 3
Segment 39
ME= -.68 E-02
AME=0.15
RMS=0.22
Lim 4
Segment 15
ME= 0.59 E-02
AME=0.40
RMS=0.46
Lim 5
Segment 82
ME= 0.31
AME=0.31
RMS=0.36
Lim 6
Segment 99
ME= 0.18 E-01
AME=0.36
RMS=0.53
Lim 7
Segment 14
ME= 0.78 E-01
AME=0.25
RMS=0.28
Lim 8
Segment 18
ME= 0.13 E-01
AME=0.26
RMS=0.28
Lim 9
Segment 54
ME= 0.27 E-01
AME=0.33
RMS=0.38
Lim 10
Segment 10
ME= -.72 E-01
AME=0.33
RMS=0.33
Lim 11
Segment 11
ME= -.22
AME=0.52
RMS=0.62
0
5
10
15
20
25
30
35
40
45
50
55
60
6
7
8
9
10


Model JD= 2796.5
Data JD=2796
Depth (meters)
pH
Lim1
Segment 15
ME= -.19 E-01
AME=0.11
RMS=0.14
Julian Day 2796.5
12:00 8/27/2009
Lim2
Segment 17
ME= 0.14 E-01
AME=0.43 E-01
RMS=0.44 E-01
Julian Day 2796.5
12:00 8/27/2009
Lim3
Segment 39
ME= 0.74 E-01
AME=0.58 E-01
RMS=0.23
Julian Day 2796.5
12:00 8/27/2009
Lim4
Segment 15
ME= 0.37 E-01
AME=0.34
RMS=0.43
Julian Day 2796.5
12:00 8/27/2009
Lim5
Segment 82
ME= 0.35
AME=0.35
RMS=0.35
Julian Day 2796.5
12:00 8/27/2009
Lim6
Segment 99
ME= -.93 E-01
AME=0.25
RMS=0.29
Julian Day 2796.5
12:00 8/27/2009
Lim7
Segment 14
ME= 0.23
AME=0.25
RMS=0.23
Julian Day 2796.5
12:00 8/27/2009
Lim8
Segment 18
ME= 0.35
AME=0.34
RMS=0.63
Julian Day 2796.5
12:00 8/27/2009
Lim9
Segment 54
ME= -.25
AME=0.25
RMS=0.37
Julian Day 2796.5
12:00 8/27/2009
Lim 10
Segment 10
ME= 0.37
AME=0.36
RMS=0.38
Julian Day 2796.5
12:00 8/27/2009
Lim 11
Segment 11
ME= -.35 E-02
AME=0.23
RMS=0.24
Julian Day 2796.5
12:00 8/27/2009

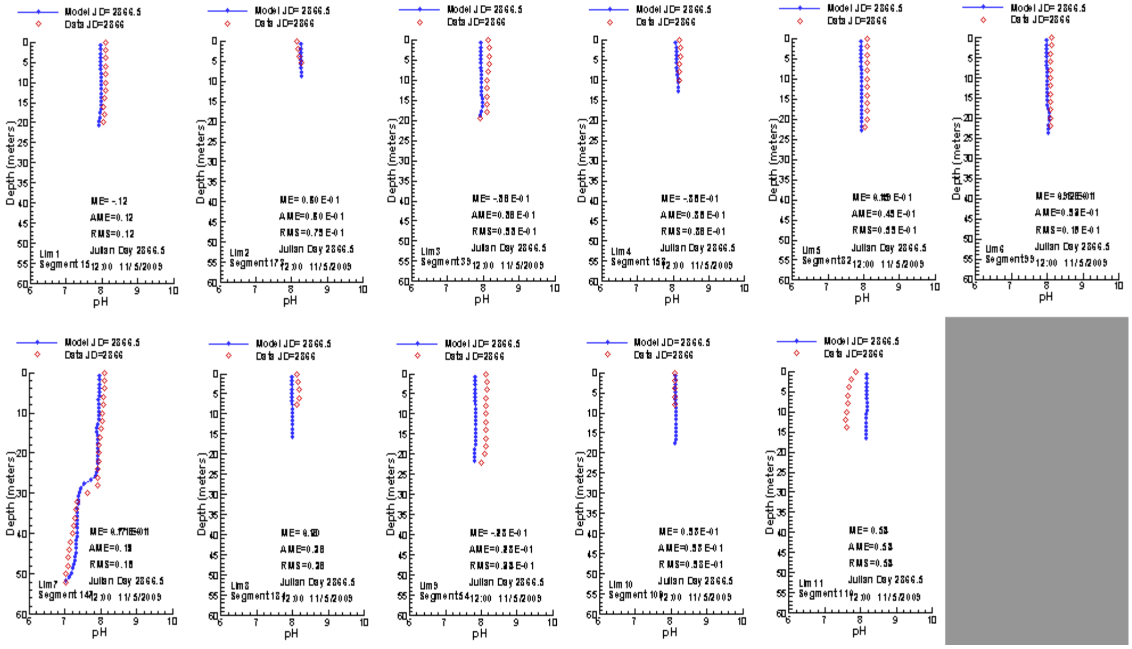

Model JD= 2810.5
Data JD=2810
Depth (meters)
pH
Lim1
Segment 15
ME= 0.45
AME=0.49
RMS=0.50
Julian Day 2810.5
12:00 9/10/2009
Lim2
Segment 17
ME= 0.38
AME=0.38
RMS=0.39
Julian Day 2810.5
12:00 9/10/2009
Lim3
Segment 39
ME= 0.65 E-01
AME=0.33
RMS=0.36
Julian Day 2810.5
12:00 9/10/2009
Lim4
Segment 15
ME= 0.33 E-02
AME=0.33 E-01
RMS=0.18
Julian Day 2810.5
12:00 9/10/2009
Lim5
Segment 82
ME= 0.36 E-01
AME=0.23
RMS=0.26
Julian Day 2810.5
12:00 9/10/2009
Lim6
Segment 99
ME= 0.28 E-01
AME=0.28 E-01
RMS=0.33
Julian Day 2810.5
12:00 9/10/2009
Lim7
Segment 14
ME= 0.39
AME=0.38
RMS=0.33
Julian Day 2810.5
12:00 9/10/2009
Lim8
Segment 18
ME= 0.48
AME=0.48
RMS=0.48
Julian Day 2810.5
12:00 9/10/2009
Lim9
Segment 54
ME= 0.12 E-01
AME=0.24
RMS=0.26
Julian Day 2810.5
12:00 9/10/2009
Lim 10
Segment 10
ME= 0.20
AME=0.28
RMS=0.28
Julian Day 2810.5
12:00 9/10/2009
Lim 11
Segment 11
ME= 0.39 E-01
AME=0.38 E-01
RMS=0.40
Julian Day 2810.5
12:00 9/10/2009


Model JD= 2824.5
Data JD=2824
Depth (meters)
pH
ME= 0.13
AME=0.15
RMS=0.16
Lim1
Segment 15
Julian Day 2824.5
12:00 9/24/2009
ME= 0.76E-01
AME=0.18
RMS=0.26
Lim2
Segment 17
ME= 0.22
AME=0.23
RMS=0.26
Lim3
Segment 33
ME= 0.97E-01
AME=0.96E-01
RMS=0.16
Lim4
Segment 15
ME= -.46E-02
AME=0.77E-01
RMS=0.98E-01
Lim5
Segment 32
ME= -.36E-01
AME=0.28
RMS=0.29
Lim6
Segment 35
ME= 0.35
AME=0.63
RMS=0.68
Lim7
Segment 14
ME= 0.56E-01
AME=0.16
RMS=0.28
Lim8
Segment 18
ME= 0.85E-01
AME=0.20
RMS=0.23
Lim9
Segment 54
ME= 0.17E-01
AME=0.12E-01
RMS=0.13E-01
Lim10
Segment 10
ME= 0.13E-01
AME=0.23E-01
RMS=0.36E-01
Lim11
Segment 11

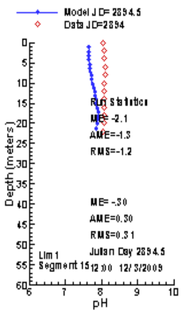

Model JD= 2838.5
Data JD=2838
Depth (meters)
pH
ME= -.26
AME=0.26
RMS=0.26
Lim1
Segment 15
Julian Day 2838.5
12:00 10/8/2009
ME= -.23E-01
AME=0.23E-01
RMS=0.26E-01
Lim2
Segment 17
ME= 0.15E-01
AME=0.95E-01
RMS=0.98E-01
Lim3
Segment 33
ME= 0.37E-01
AME=0.38E-01
RMS=0.35E-01
Lim4
Segment 15
Lim5
Segment 32
ME= 0.22E-01
AME=0.23E-01
RMS=0.33E-01
Lim6
Segment 35
ME= 0.99E-01
AME=0.33
RMS=0.34
Lim7
Segment 14
ME= -.32
AME=0.32
RMS=0.32
Lim8
Segment 18
ME= -.74E-01
AME=0.15
RMS=0.26
Lim9
Segment 54
ME= 0.76E-01
AME=0.38E-01
RMS=0.36E-01
Lim10
Segment 10
ME= 0.58E-01
AME=0.58E-01
RMS=0.56E-01
Lim11
Segment 11

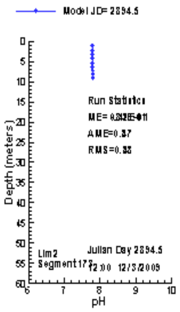


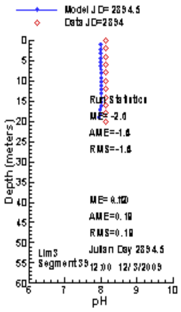
Model JD= 2852.5
Data JD=2852
Depth (meters)
pH
Lim 1
Segment 15
ME= -.36
AME=0.36
RMS=0.36
Julian Day 2852.5
12:00 10/22/2009
Lim 2
Segment 17
ME= -.39
AME=0.39
RMS=0.39
Lim 3
Segment 39
Lim 4
Segment 15
AME=0.15
RMS=0.16
Lim 5
Segment 82
Lim 6
Segment 99
Lim 7
Segment 14
AME=0.16
RMS=0.16
Lim 8
Segment 18
Lim 9
Segment 54
ME= -.25
AME=0.25
RMS=0.25
Lim 10
Segment 10
ME= 0.24
AME=0.24
RMS=0.24
Lim 11
Segment 11

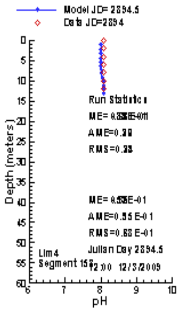


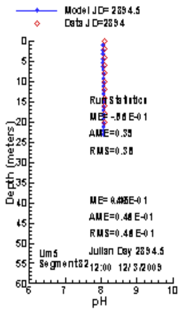
Model JD= 2866.5
Data JD=2866
Depth (meters)
pH
Lim 1
Segment 15
ME= -.12
AME=0.12
RMS=0.12
Julian Day 2866.5
12:00 11/5/2009
Lim 2
Segment 17
ME= 0.50E-01
AME=0.50E-01
RMS=0.75E-01
Lim 3
Segment 39
Lim 4
Segment 15
Lim 5
Segment 82
AME=0.45E-01
Lim 6
Segment 99
Lim 7
Segment 14
RMS=0.16
Lim 8
Segment 18
Lim 9
Segment 54
Lim 10
Segment 10
Lim 11
Segment 11

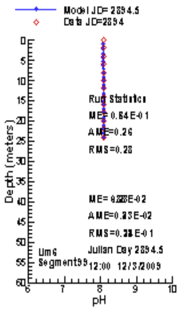

Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
ME=-2.1
AME=-1.3
RMS=-1.2
ME=-.30
AME=0.30
RMS=0.31
Lim1
Segment 15
Julian Day 2894.5
12:00 12/3/2009
pH

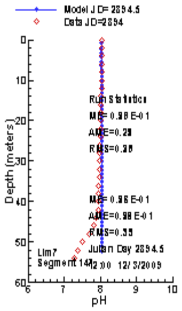

Model JD=2894.5
Depth (meters)
Run Statistics
AME=0.37
Lim2
Julian Day 2894.5
12:00 12/3/2009
pH

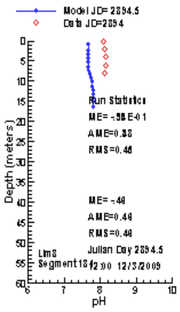

Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
ME=-2.0
AME=-1.6
RMS=-1.6
AME=0.19
RMS=0.19
Lim3
Julian Day 2894.5
12:00 12/3/2009
pH

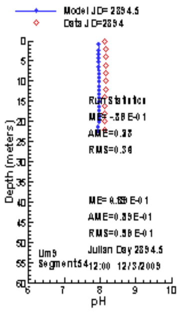

Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
Lim4
Julian Day 2894.5
12:00 12/3/2009
pH

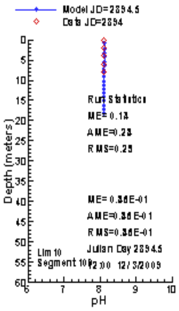

Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
AME=0.35
RMS=0.36
Lim5
Julian Day 2894.5
12:00 12/3/2009
pH

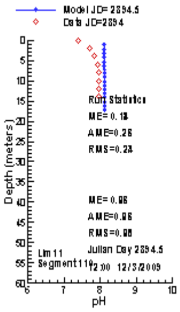

Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
AME=0.26
RMS=0.28
Lim6
Julian Day 2894.5
12:00 12/3/2009
pH


Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
Lim7
Julian Day 2894.5
12:00 12/3/2009
pH


Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
RMS=0.46
ME=-.46
AME=0.46
RMS=0.46
Lim8
Julian Day 2894.5
12:00 12/3/2009
pH


Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
Lim9
Julian Day 2894.5
12:00 12/3/2009
pH


Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
RMS=0.25
Lim10
Julian Day 2894.5
12:00 12/3/2009
pH


Model JD=2894.5
Data JD=2894
Depth (meters)
Run Statistics
AME=0.26
Lim11
Julian Day 2894.5
12:00 12/3/2009
pH

# Appendix E: Alternative Action Management Scenario Fish Habitat Percentages

| Percent Total Volume Optimal Fish Habitat-**No-Action Alternative** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| R. Trout | 0 | 0 | 0 | 0.3 | 12.9 | 18.9 | 16.3 | 5.7 | 20.1 | 36 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 14.5 | 41.4 | 40.4 | 29.7 | 9 | 0.4 | 88 | 48 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.1 | 20.3 | 36.5 | 4.6 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.1 | 23.4 | 0.6 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Average-2A** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 18.2 | 16.1 | 4.7 | 16.8 | 35.5 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 42.8 | 39.6 | 27.8 | 4.6 | 0.2 | 87.6 | 45.9 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.8 | 21.4 | 37.1 | 5.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16 | 23.5 | 0.7 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Average-2B** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.1 | 18.9 | 16.6 | 4.5 | 17.4 | 31.2 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.3 | 43.3 | 40.3 | 27.8 | 4.3 | 0.4 | 88.4 | 44.6 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.5 | 21 | 38 | 7.2 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.3 | 23.5 | 1.2 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Average-2C** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15.3 | 17.9 | 15.5 | 5 | 17.1 | 37 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.5 | 43 | 39.5 | 27.6 | 5.1 | 0.2 | 87.2 | 46.3 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3 | 22.2 | 39.1 | 5.2 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 17 | 25.7 | 0.7 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Average-2D** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15.2 | 18.3 | 15.8 | 4.9 | 19 | 26.1 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.5 | 43.1 | 39.7 | 27.6 | 4.9 | 1.6 | 92.5 | 43.3 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.9 | 22 | 37.8 | 5.8 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16.8 | 24.5 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Average-3A**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15.3 | 18.5 | 17.7 | 6.8 | 18.4 | 27.1 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 42.9 | 39.7 | 28.8 | 5.9 | 1.5 | 88.4 | 42.6 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.4 | 19.3 | 32.5 | 4 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.5 | 15.4 | 23.1 | 0.5 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Average-3B**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15 | 19.1 | 17.2 | 8.3 | 18.1 | 26.6 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 43.4 | 40.6 | 28.1 | 7.1 | 0.7 | 89.5 | 44 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.2 | 19.8 | 34.8 | 6.8 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.5 | 15.6 | 25.8 | 1 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Average-3C**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15.4 | 18.2 | 16.2 | 4.5 | 17.9 | 25.7 | 0.1 | 0 |
| Kokanee | 0 | 0 | 0 | 16.5 | 43 | 39.6 | 27.9 | 4.8 | 1.1 | 87.6 | 41.6 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.8 | 21.3 | 38.2 | 7.9 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16 | 23.8 | 0.9 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Average-3D**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.4 | 15.2 | 18.7 | 16.5 | 4.5 | 18 | 30.5 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.5 | 43.2 | 39.9 | 27.9 | 4.5 | 0.4 | 88.9 | 44.7 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.6 | 21.1 | 37.9 | 7.1 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.5 | 23.4 | 1.2 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Dry-2A**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.4 | 18 | 16.6 | 5.1 | 19.4 | 32.6 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.5 | 42.9 | 39 | 27.5 | 5.1 | 0.5 | 89.3 | 46.4 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.7 | 20.5 | 36.1 | 6.9 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15 | 21.6 | 0.9 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Dry-2B**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.4 | 18 | 16.6 | 5.1 | 17.7 | 34.7 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.5 | 42.9 | 39.1 | 27.5 | 5.1 | 0.3 | 87.8 | 46.8 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.7 | 20.6 | 35.7 | 5.2 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.2 | 21.4 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Dry-2C**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.6 | 17.4 | 15.6 | 5.6 | 18.5 | 34.5 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.6 | 42.5 | 38.3 | 27.6 | 6.5 | 0.3 | 88.5 | 46.9 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.3 | 22 | 36.3 | 5.3 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.6 | 22.2 | 0.6 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Dry-2D**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.6 | 17.4 | 15.5 | 5.6 | 19.2 | 31.1 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.6 | 42.5 | 38.3 | 27.4 | 6.4 | 0.6 | 89.2 | 46 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.3 | 21.9 | 35.1 | 4.6 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.6 | 21.3 | 0.6 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Dry-3A** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.5 | 18.5 | 16 | 5 | 18.8 | 31.4 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.7 | 43.2 | 39.7 | 27.6 | 5.4 | 0.5 | 88.8 | 44.8 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.3 | 20.9 | 33.9 | 3.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16.4 | 20.6 | 0.5 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Dry-3B** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.4 | 18.3 | 16.9 | 7.5 | 18.1 | 31.4 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.5 | 43 | 39.5 | 27.9 | 7.4 | 0.5 | 88.1 | 46.1 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.4 | 18.3 | 34.5 | 4.6 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 14.8 | 25.4 | 0.6 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Dry-3C** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.7 | 17.3 | 16.5 | 6.8 | 21.1 | 31 | 0.1 | 0 |
| Kokanee | 0 | 0 | 0 | 15.7 | 42.6 | 38.6 | 27.7 | 6.8 | 0.5 | 89.3 | 42.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3 | 20.4 | 34.6 | 3.7 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 15 | 25.2 | 0.5 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Dry-3D** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.6 | 17.4 | 16.3 | 5 | 16.9 | 30.6 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.6 | 42.5 | 38.4 | 27.8 | 5.6 | 0.2 | 88.3 | 44.8 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3 | 20.8 | 35.3 | 5.1 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 15.4 | 20.9 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Drought-2A**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.4 | 18 | 16.6 | 5.1 | 16.3 | 35.9 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.5 | 42.9 | 39.1 | 27.5 | 5 | 0.2 | 87 | 47.3 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.6 | 20.5 | 34.8 | 4.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15 | 20.4 | 0.6 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-Drought-**2B**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.4 | 18 | 16.6 | 5 | 16.8 | 35.7 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.5 | 42.9 | 39 | 27.4 | 5 | 0.2 | 87.3 | 47.1 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.7 | 20.6 | 35.8 | 5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.1 | 21.4 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Drought-2C**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.6 | 17.4 | 15.5 | 5.6 | 18.5 | 34.6 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.6 | 42.5 | 38.3 | 27.5 | 6.4 | 0.3 | 88.4 | 46.9 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.3 | 21.9 | 36.3 | 5.3 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.6 | 22.3 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Drought-2D**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 14.6 | 17.7 | 15.9 | 5.2 | 15.1 | 24.6 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.4 | 43 | 38.8 | 27.4 | 5.6 | 1.1 | 89 | 44.2 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3 | 21.4 | 35.2 | 5.6 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.3 | 21.1 | 0.7 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Drought-3A** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15 | 18 | 16.4 | 4.4 | 18.2 | 29.3 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.2 | 43.6 | 40.9 | 27.5 | 3.8 | 0.7 | 89.3 | 41.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.3 | 20.8 | 31.7 | 3.1 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16.3 | 17.2 | 0.4 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Drought-3B** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 17 | 16.2 | 4.8 | 17.9 | 33.5 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.3 | 43.3 | 39.5 | 26.8 | 3.8 | 0.3 | 88.4 | 44.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.4 | 22.3 | 37.4 | 7 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.8 | 22.5 | 1.1 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Drought-3C** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.6 | 17.7 | 17.8 | 5.9 | 19.4 | 28 | 0.1 | 0 |
| Kokanee | 0 | 0 | 0 | 16.6 | 44.7 | 40.9 | 27.1 | 4.1 | 0.9 | 89.5 | 37.8 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.7 | 18.7 | 31.6 | 2.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 14.9 | 21.5 | 0.3 | 0 | 0 | 0 |

| Percent Total Volume Optimal Fish Habitat-**Drought-3D** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 17.7 | 17 | 4.4 | 14.2 | 35.3 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 15.8 | 44.5 | 40.7 | 26.1 | 2.8 | 0.1 | 86.6 | 45.1 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.9 | 21.3 | 36.7 | 5.3 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.2 | 21.4 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-2A**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 18.1 | 15.8 | 5.6 | 17.6 | 36 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.3 | 44.5 | 41.5 | 29.3 | 7.1 | 0.2 | 87.9 | 48.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.1 | 21.5 | 37.6 | 5.2 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.5 | 23.8 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-2B**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.1 | 19.1 | 16.7 | 5.3 | 14.5 | 31.2 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.3 | 44.6 | 42.7 | 29.5 | 6.3 | 0.4 | 86.4 | 44.7 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.5 | 5.1 | 20.6 | 37.1 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 15.2 | 23 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-2C**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.4 | 18.1 | 15.5 | 5.7 | 17 | 37.5 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.4 | 41.4 | 29 | 7.2 | 0.2 | 87.1 | 46.6 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.1 | 21.9 | 38.9 | 5.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.7 | 25.3 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-2D**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 18.6 | 16 | 5.5 | 16.8 | 30.8 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.6 | 42 | 29 | 6.7 | 0.5 | 88.3 | 44.7 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.8 | 21.4 | 37.8 | 4.9 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.6 | 16.3 | 23.8 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-3A**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 18.1 | 16.2 | 5.4 | 19.3 | 32.3 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.6 | 41.7 | 29.5 | 6.8 | 0.5 | 89.2 | 45.2 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3.1 | 20.9 | 35.6 | 4.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 15.8 | 21.5 | 0.6 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-3B**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.2 | 19.3 | 17.1 | 5.4 | 15.5 | 29.3 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.7 | 42.9 | 29.9 | 6.3 | 0.5 | 86.7 | 44.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.2 | 21.1 | 38.7 | 7.5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.5 | 15.8 | 24.3 | 1.2 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-3C**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.4 | 18 | 15.8 | 5.5 | 17.5 | 34 | 0 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.4 | 41.4 | 29.3 | 7 | 0.4 | 88.2 | 45.4 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 3 | 21.5 | 37.7 | 5 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.7 | 16.4 | 23.7 | 0.7 | 0 | 0 | 0 |

Percent Total Volume Optimal Fish Habitat-**Wet-3D**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 0 | 0 | 0 | 0.3 | 15.3 | 19 | 17 | 5.3 | 16.4 | 33.3 | 0.1 | 0 |
| Kokanee | 0 | 0 | 0 | 16.4 | 44.7 | 42.6 | 29.9 | 6.4 | 0.4 | 87.2 | 45.5 | 0 |
| Walleye | 0 | 0 | 0 | 0 | 0 | 2.3 | 21.1 | 38.2 | 5.2 | 0 | 0 | 0 |
| S. Mouth Bass | 0 | 0 | 0 | 0 | 0 | 0.5 | 15.8 | 24.3 | 0.7 | 0 | 0 | 0 |

## Appendix F: Lake Roosevelt Fish Bioenergetics FORTRAN Source Code Routine

```
! PROGRAM BIOENERGETICS
! MIKE MCKILLIP (2006)
! STOCKWELL AND JOHNSON APPROACH, AS SUGGESTED BY MAZUR AND BEAUCHAMP
! STAND ALONE PROGRAM FOR TESTING MODULES TO BE INCORPORATED WITH THE W2 CODE

!**************************************
!   TASK B.1. MODULE DECLARATION
!**************************************
MODULE MAINW2 ! REPETIION OF W2-CODE VARIABLES
 REAL*8,             ALLOCATABLE, DIMENSION (:,:)    :: DEPTHM,T1,GAMMA,BH,EL
 REAL*8,             ALLOCATABLE, DIMENSION (:,:,:)  :: C2
 REAL JDAY,JEND !BIOF = FREQUENCY OF BIOEXP OUTPUT
 REAL FBIONXT ! NEXT DAY TO GET CALCULATION INPUTS
 INTEGER,            ALLOCATABLE, DIMENSION(:)       :: BIOINFN
 INTEGER,            ALLOCATABLE, DIMENSION(:)       :: KTI,KBI
 INTEGER KMX, IMX,NUNIT,NZP,K,I,DLT,JI,NWB
 INTEGER NCT,JZ,NZOOS,NZOOE,NOD
 CHARACTER*72,       ALLOCATABLE, DIMENSION(:)       :: BIOINNAME
 CHARACTER*72 FRED,SEGNUM
END MODULE MAINW2
MODULE ROOSEVELT !THIS MODULE TAKEN FROM W2-ROOSEVELT; ALLOWs THE W2_ANC_CON.NPT TO BE READ
  INTEGER,           ALLOCATABLE, DIMENSION(:)       :: IBIO,BIODP,BIOEXPFN
  REAL*8,            ALLOCATABLE, DIMENSION(:)       :: BIOD, BIOF
  INTEGER,           ALLOCATABLE, DIMENSION(:,:)     :: NVIOL_LOC
  CHARACTER*8 NVIOLC, BIOC
  LOGICAL BIOEXP
  INTEGER NBIO,NIBIO
  REAL*8 NXBIO,NXTBIO,GAMMAB
  CHARACTER*72 BIOFN,WEIGHTFN
END MODULE ROOSEVELT
MODULE FISH ! FOR FISH BIOENERGETICS ROUTINE (DIRECT INCLUSION)
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: EZOO,LZOO,MZOO,FTL,F1I
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: FCON,FVEL,FACT,GAMMAFDC,FVELAVE,FACTAVE
 REAL*8,             ALLOCATABLE, DIMENSION(:,:,:)   :: F1
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: F2,AVEC,MINC,MAXC
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: F_F,F_U,F_D,F_R,F_S,F_C,F_G,F_W ! UNITS OF J
(DAILY SCALE)
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: F_G2
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: F_DINI,F_DCON,F_DUNDIG
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DAYC,SRCHVOL,RDZ
 REAL*8,             ALLOCATABLE, DIMENSION(:,:,:)   :: C1Z
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: F_FC,F_UC,F_DC,F_RC,F_SC,F_CC ! UNITS OF J
(TIME-STEP SCALE)
  REAL*8,             ALLOCATABLE, DIMENSION(:)       :: ZAVAIL, ZAVAILNX,CEFF,Z1Z,L1Z,CELL_PER
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: T1Z
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: FCONMAXGG,FCONGG,FCONMAXJ,FCONJ,DAYCM,FCONP
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: T1BZ
 REAL NXTFISH,NXTFOPT,FG1,FG2,FKA,FKB,FL1,FL2,DIGK,JUNK, FDLTM,FDLTH,FOXYCAL
 REAL FISHT1,FISHT2,FISHT3,FISHT4,FISHK1,FISHK2,FISHK3,FISHK4 ! TEMPERATURE RATE TERMS
 REAL FJDAYNXT,HANDLE,FVELA,FVELB,FVELE,THRESHV,DAP_IN,JAVAIL,FGPD,FGPF
 REAL FBIODAYNXT,FBIOSUBNXT,FBIODAYLST,ZAVJD,ZAVNX
 REAL GIM, BIM, DIM, GALP, BALP, DALP, GTI, BTI, DTI
 REAL F1M,F1J,WILMA1,WILMA2
 INTEGER,            ALLOCATABLE, DIMENSION (:)      :: ZDEPTH,DATA_FILENUM,BIOOUTFN, CELL_POS,
CELL_NEG,FGPFN
 INTEGER,            ALLOCATABLE, DIMENSION (:,:)    :: FULLSTO
 INTEGER,            ALLOCATABLE, DIMENSION (:)      :: KBIP
 INTEGER CUR_FJDAY, FJDAYINT,ZHOLDNUM,DIAGLOGFN, JJZ,FOPTNUM,THRESHZ,ZAVFN,BIOCON,NUMSTEPS,FUF
 CHARACTER*72,       ALLOCATABLE, DIMENSION(:)       :: BIOOUTNAME,FGPFNAME
 INTEGER FXNFN(3)
 CHARACTER*72 ZAVFNAME
 CHARACTER*8 FHEAD(30),FUNIT(20),FCALC,FGPC,CMAXC
 CHARACTER*8 GENMTP,BESTMTP,DIELMTP
 CHARACTER*72 FXNFNAME(3)
 LOGICAL,            ALLOCATABLE, DIMENSION(:)       :: FIRST_BIO,THRESHFEED
 LOGICAL SAMEDAY,FIRSTLIGHT,FIRST_OUTPUT,DAILY_FISH_OPT,BIOSUB_CALC, BIODAY_CALC
 LOGICAL HAPPY, NEWDAY,FBIOCALC,FGPPLOT,FISHCALC,THRESHOLD,CMAXCALC
 LOGICAL
GMTPCELL,GMTPFXN,GMTPUSER,GMTPFIXED,BMTPSEG,BMTPFXN,BMTPUSER,BMTPFIXED,DMTPSEG,DMTPFXN,DMTPUSER,DMTPFI
XED
 LOGICAL GMTOK,BMTOK,DMTOK
END MODULE FISH
MODULE FISH2 ! FOR USE WITH THIS PROGRAM; WILL NEED TO BE ALTERED FOR INCORPORATION WITH W2-CODE
 REAL LUX, LUX1, LUX2 ! TEMPORARY LIGHT DATA TERMS
 REAL LJDAY1,LJDAY2
```

```
 INTEGER LIGHTNUM
END MODULE FISH2
MODULE BIOEXPDATATRANSFORM ! FOR CONVERTING THE BIOEXP DATA OUTPUT INTO W2 ARRAYS AND VARIABLES
 REAL ZDAY1,ZDAY2
 INTEGER FIRSTK,LASTK,SEGK,GRCT
 CHARACTER*20 GREGORY(1000)
 LOGICAL,            ALLOCATABLE, DIMENSION(:)       :: FIRSTREAD
END MODULE BIOEXPDATATRANSFORM
MODULE GROWTH_ANIMATION
 INTEGER ANIMFN,ANIMFN2,ZONECNT,ZONEFIRST,NNODE,NELEM
 CHARACTER*52 HEADER1,HEADER2
 REAL LEFT(999), RIGHT(999)
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: DISTL,DISTR,BOTTOME
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: GELEV,X1,X2,X3,X4,Y1,Y2,Y3,Y4
 REAL    VLL,VLR
 INTEGER,            ALLOCATABLE, DIMENSION(:)       :: BOTSEG
 LOGICAL,            ALLOCATABLE, DIMENSION(:)       :: ANIMEXP
END MODULE GROWTH_ANIMATION
MODULE DIAGNOSTIC
 REAL*8,             ALLOCATABLE, DIMENSION(:,:,:)   :: DIET
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: VISIBLE
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: MAXG,MAXM
 INTEGER BYSEGMFN,BYSEGGFN,BYSEGMFN2,BYSEGGFN2,BYSEGMFN3,BYSEGGFN3,SURFSEGMFN,SURFSEGGFN
 INTEGER TLCALCFN
 CHARACTER*8 FDIAGC,THRESHC,SURFC,TLC
 LOGICAL FDIAG,BYSEG,SURFDIAG
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: MF_GI,MF_RI,MF_DI,MF_CI,MF_WI,MF_SI
 CHARACTER*8 FISHC, BIOPARC, CONSC, DIGC, RESPC,SINGLEC
 LOGICAL FISHDIAG, BIOPARDIAG, CONSDIAG, DIGDIAG, RESPDIAG,SINGLEDIAG,TLCALC
 INTEGER SINGFN, SINIBIO
END MODULE DIAGNOSTIC
MODULE MOVEMENT
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BFCON,BFVEL,BFACT
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BFVELAVE,BFACTAVE
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DFCON,DFVEL,DFACT
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: DFVELAVE,DFACTAVE
 REAL*8,             ALLOCATABLE, DIMENSION(:,:,:)   :: BF1, DF1,BDIET, DDIET
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BF_F,BF_U,BF_D,BF_R,BF_S,BF_C,BF_G,BF_W
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DF_F,DF_U,DF_D,DF_R,DF_S,DF_C,DF_G,DF_W
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BF_FC,BF_UC,BF_DC,BF_RC,BF_SC,BF_CC
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DF_FC,DF_UC,DF_DC,DF_RC,DF_SC,DF_CC
 REAL*8,             ALLOCATABLE, DIMENSION(:)       ::
BF_GI,BF_RI,BF_DI,BF_CI,BF_WI,BF_SI,BF_UI,BF_FI
 REAL*8,             ALLOCATABLE, DIMENSION(:)       ::
DF_GI,DF_RI,DF_DI,DF_CI,DF_WI,DF_SI,DF_UI,DF_FI
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BDAYC,BSRCHVOL,BRDZ
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DDAYC,DSRCHVOL,DRDZ
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BCELL_PER,DCELL_PER
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BESTG,TEPI,THYPO
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     ::
BFCONMAXGG,BFCONGG,BFCONMAXJ,BFCONJ,BDAYCM,BFCONP
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     ::
DFCONMAXGG,DFCONGG,DFCONMAXJ,DFCONJ,DDAYCM,DFCONP
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BAVEC,BMINC,BMAXC
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: DAVEC,DMINC,DMAXC
 REAL*8,             ALLOCATABLE, DIMENSION(:)       ::
BFCONMAXJI,BFCONMAXGGI,BFCONI,BFCONPI,BFDAYCI,BFDAYCMI,BFCONJI,BFCONGGI
 REAL*8,             ALLOCATABLE, DIMENSION(:)       ::
DFCONMAXJI,DFCONMAXGGI,DFCONI,DFCONPI,DFDAYCI,DFDAYCMI,DFCONJI,DFCONGGI
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BDAYCI,BDAYCMI
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: DDAYCI,DDAYCMI
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BF_DC_EXT,BF_G_EXT
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: DF_DC_EXT,DF_G_EXT
 REAL GMAXG,DIELLUX,DIELG,DIELS,RMIN,CMAX
 INTEGER,            ALLOCATABLE, DIMENSION(:)       :: BCELL_POS,BCELL_NEG,BFULLSTOI
 INTEGER,            ALLOCATABLE, DIMENSION(:)       :: DCELL_POS,DCELL_NEG,DFULLSTOI
 INTEGER,            ALLOCATABLE, DIMENSION(:,:)     :: BESTK,DIELK,BFULLSTO,DFULLSTO
 INTEGER GMAXK, BESTSTEP,KDIEL,RMINK,CMAXK,KBEST
 CHARACTER*8 BESTC,DIELC,DEPTHC
 LOGICAL BESTCALC,DIELCALC,DIELDEEP,DAYLIGHT,DEPTHCALC
 REAL*8,             ALLOCATABLE, DIMENSION(:)       :: BVISIBLE,DVISIBLE
 REAL*8,             ALLOCATABLE, DIMENSION(:,:)     :: BDIETI,DDIETI
 INTEGER BESTDIAGFN
 LOGICAL,            ALLOCATABLE, DIMENSION(:)       :: FORAY
END MODULE MOVEMENT

!*************************************
!   TASK B.2.0 MAIN PROGRAM DECLARATIONS
!*************************************
```

```
PROGRAM BIOENERGETICS
USE MAINW2; USE FISH; USE FISH2;USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE DIAGNOSTIC; USE
ROOSEVELT; USE MOVEMENT
!****TEMPORARY FILES
OPEN(999,FILE='TEMP.DAT',STATUS='UNKNOWN')
OPEN(998,FILE='TEMP2.DAT',STATUS='UNKNOWN')

!****VARIABLE/ ARRAY ALLOCATION & INITIAL VALUES*****
NOD = 100
! ROOSEVELT
  OPEN (12,FILE='W2_CON_ANC.NPT',STATUS='OLD')
  DO II = 1,16
    READ(12,'(A8)') BIOC
  END DO
  ALLOCATE (BIOD(NOD), BIOF(NOD),BIODP(NOD))
  ! BIOENERGETICS OUTPUT CARDS
  READ(12,'(//(8X,A8,2I8))') BIOC,NBIO,NIBIO
  ALLOCATE (BIOEXPFN(NIBIO),IBIO(NIBIO))
  ROO2 = 0.0; C2W = 0.0
  READ(12,'(//(:8X,9F8.0))') (BIOD(II),II=1,NBIO)
  READ(12,'(//(:8X,9F8.0))') (BIOF(II),II=1,NBIO)
  READ(12,'(//(:8X,9I8))') (IBIO(II),II=1,NIBIO)
  READ(12,'(//(8X,A72))') BIOFN
  CLOSE(12)
! END ROOSEVELT
! MAINW2
IMX = 583; KMX = 76;NUNIT = 100; NWB = 1; FBIONXT = 366.5
JDAY = 366.0; JEND = 400.5; DLT = 1; NCT = 22; NZOOS = 20; NZOOE = 22; NZP = 3
ALLOCATE(DEPTHM(KMX,IMX),T1(KMX,IMX),GAMMA(KMX,IMX),BH(KMX,IMX),EL(KMX,IMX))
ALLOCATE(C2(KMX,IMX,NCT),KTI(IMX),KBI(IMX))
ALLOCATE(BIOINNAME(NIBIO), BIOINFN(NIBIO)) ! ULTIMATELY, IMX (& NEW VARIABLE)
! FISH
ALLOCATE (BIOOUTFN(NIBIO),EZOO(NZP),LZOO(NZP),MZOO(NZP))
ALLOCATE (BIOOUTNAME(NIBIO),FCON(KMX,IMX),FVEL(KMX,IMX),FACT(KMX,IMX),F1I(3))
ALLOCATE (F1(KMX,IMX,5)) ! 1 = MASS; 2 = LENGTH; 3 = STOMACH CONTENT; 4 = ENERGY DENSITY OF FISH; 5 =
STOMACH CAPACITY
ALLOCATE (FTL(KMX),SRCHVOL(KMX,IMX),RDZ(KMX,IMX),F2(KMX,IMX))
ALLOCATE (CELL_POS(IMX), CELL_NEG(IMX),CELL_PER(IMX),FULLSTO(KMX,IMX))
ALLOCATE (F_F(KMX,IMX),F_U(KMX,IMX),F_D(KMX,IMX),F_R(KMX,IMX),F_S(KMX,IMX),F_C(KMX,IMX))
ALLOCATE (F_G(KMX,IMX),F_W(KMX,IMX),DAYC(KMX,IMX))
ALLOCATE (F_FC(KMX,IMX),F_UC(KMX,IMX),F_DC(KMX,IMX),F_RC(KMX,IMX),F_SC(KMX,IMX),F_CC(KMX,IMX))
ALLOCATE (T1Z(KMX,IMX),C1Z(KMX,IMX,NZP),Z1Z(KMX),L1Z(KMX),ZDEPTH(KMX))
ALLOCATE (FIRST_BIO(NIBIO),GAMMAFDC(KMX,IMX))
ALLOCATE (ZAVAIL(NZP),ZAVAILNX(NZP),CEFF(KMX))
ALLOCATE (FGPFN(NWB),FGPFNAME(NWB),GELEV(KMX,IMX),DISTL(IMX),DISTR(IMX))
ALLOCATE (X1(KMX,IMX),X2(KMX,IMX),X3(KMX,IMX),X4(KMX,IMX))
ALLOCATE (Y1(KMX,IMX),Y2(KMX,IMX),Y3(KMX,IMX),Y4(KMX,IMX))
ALLOCATE (DIET(KMX,IMX,NZP),THRESHFEED(KMX),VISIBLE(KMX,IMX))
ALLOCATE (ANIMEXP(NIBIO),BOTSEG(IMX),BOTTOME(IMX))
ALLOCATE (MAXG(IMX),MAXM(IMX),KBIP(IMX))
ALLOCATE (FCONMAXGG(KMX,IMX),FCONGG(KMX,IMX),FCONMAXJ(KMX,IMX),FCONJ(KMX,IMX),FCONP(KMX,IMX))
ALLOCATE (F_DINI(KMX,IMX),F_DCON(KMX,IMX),F_DUNDIG(KMX,IMX),DAYCM(KMX,IMX))
ALLOCATE (FVELAVE(KMX,IMX),FACTAVE(KMX,IMX))
ALLOCATE (AVEC(KMX,IMX),MINC(KMX,IMX),MAXC(KMX,IMX))
ALLOCATE (F_G2(KMX,IMX))
!IF(SINGLEDIAG) THEN
  ALLOCATE (MF_GI(KMX),MF_RI(KMX),MF_DI(KMX),MF_CI(KMX),MF_WI(KMX),MF_SI(KMX))
  MF_GI = 0.0;MF_RI = 0.0;MF_DI = 0.0;MF_CI = 0.0;MF_WI = 0.0;MF_SI = 0.0
!END IF
TLCALC = .FALSE.
F1(:,:,4) = 5821.9*4.1868 ; F1(:,:,5) = 3.64 ; FCON = 0.0
F_R  = 0.0; F_D  = 0.0; F_C  = 0.0; F_F  = 0.0; F_U  = 0.0; F_S  = 0.0; F_G = 0.0; F_W = 0.0
F_RC = 0.0; F_DC = 0.0; F_CC = 0.0; F_FC = 0.0; F_UC = 0.0; F_SC = 0.0
F_DINI = 0.0; F_DCON = 0.0; F_DUNDIG = 0.0; DAYCM = 0.0
AVEC = 0.0; MINC = 0.0; MAXC = 0.0
FVELAVE = 0.0; FACTAVE = 0.0
KBIP = 1
FBIOSUBNXT = 366.0; FBIODAYNXT = 367.0; FBIODAYLST = 366.0
CELL_POS = 0; CELL_NEG = 0; DAYC = 0.0; CELL_PER = 0.0; FULLSTO = 0
DAP_IN = 0.0; RDZ = 0.08; GAMMAFDC = 0.0
FCONMAXGG = 0.0; FCONGG = 0.0; FCONMAXJ = 0.0; FCONJ = 0.0
BIOSUB_CALC  = .FALSE.; BIODAY_CALC    = .FALSE.;   HAPPY  = .TRUE. ; NEWDAY    = .TRUE.; FIRSTLIGHT =
.TRUE.
FIRST_OUTPUT = .TRUE. ; DAILY_FISH_OPT = .FALSE.; FBIOCALC = .FALSE.; FIRST_BIO = .TRUE.
GMTPCELL = .FALSE.;GMTPFXN   = .FALSE.;GMTPUSER = .FALSE.;GMTPFIXED = .FALSE.;BMTPSEG  =
.FALSE.;BMTPFXN   = .FALSE.
BMTPUSER = .FALSE.;BMTPFIXED = .FALSE.;DMTPSEG  = .FALSE.;DMTPFXN   = .FALSE.;DMTPUSER =
.FALSE.;DMTPFIXED = .FALSE.
GMTOK    = .FALSE.;BMTOK     = .FALSE.;DMTOK    = .FALSE.
```

```
SINGLEDIAG = .FALSE.;SURFDIAG = .FALSE.
FISHDIAG = .FALSE.; BIOPARDIAG = .FALSE.; CONSDIAG = .FALSE.; DIGDIAG = .FALSE.; RESPDIAG =
.FALSE.;SINGLEDIAG  = .FALSE.
 F_G2 = 0.0
! FISH2
LJDAY1 = 360.0; LJDAY2 = 361.0; LUX = 0.0 ! TEMPORARY SET UP VALUES
MAXG = -999.0; MAXM = -999.0; DIELDEEP = .TRUE.;CMAXCALC = .FALSE.
! BIOEXP
ALLOCATE (FIRSTREAD(NIBIO))
FIRSTREAD = .TRUE.
! GROWTH ANIMATION
 HEADER1 = 'TITLE ="Lake Roosevelt"'
 HEADER2 = 'VARIABLES = "Distance, km", "Elevation, m", "FGP"'
 GELEV = 0.0; DISTL = 0.0; DISTR = 0.0
 ZONECNT = 0 ; ZONEFIRST = INT(JDAY)
 DIET = 0.0 ; THRESHFEED = .FALSE.; VISIBLE = 0.0
OPEN(13,FILE='CHANNEL_BOT.OPT',STATUS='OLD')
READ(13,*) BESTC
DO I = 1,IMX
   READ(13,'(I10,50X,F10.0)',END=1199) BOTSEG(I),BOTTOME(I)
END DO
1199 CONTINUE
CALL GETFISHDATA
 FDLTM = FUF*1.0 ! IN MINUTES
 FDLTH = FDLTM/60.0; ZHOLDNUM = 4+NZP; NUMSTEPS = 1440/FUF
 GRCT = 1
 ANIMEXP = .TRUE.; ANIMEXP(12) = .FALSE.; ANIMEXP(21) = .FALSE.; ANIMEXP(24) = .FALSE.
! BYSEG
BYSEG = .TRUE.
! MOVEMENT
IF(BESTCALC) THEN
 ALLOCATE (BFCON(KMX,IMX),BFVEL(KMX,IMX),BFACT(KMX,IMX),BF1(KMX,IMX,5))
 ALLOCATE (BF_F(KMX,IMX),BF_U(KMX,IMX),BF_D(KMX,IMX),BF_R(KMX,IMX),BF_S(KMX,IMX),BF_C(KMX,IMX))
 ALLOCATE (BF_G(KMX,IMX),BF_W(KMX,IMX),BDAYC(KMX,IMX),BDAYCM(KMX,IMX))
 ALLOCATE (BF_FC(KMX,IMX),BF_UC(KMX,IMX),BF_DC(KMX,IMX),BF_RC(KMX,IMX),BF_SC(KMX,IMX),BF_CC(KMX,IMX))
 ALLOCATE (BSRCHVOL(KMX,IMX),BRDZ(KMX,IMX))
 ALLOCATE (BCELL_POS(IMX),BCELL_NEG(IMX),BCELL_PER(IMX))
 ALLOCATE (BESTK(IMX,NUMSTEPS+1),BESTG(IMX))
 ALLOCATE (BDIETI(IMX,NZP),BDIET(KMX,IMX,NZP))
 ALLOCATE (BF_GI(IMX),BF_RI(IMX),BF_DI(IMX),BF_CI(IMX),BF_WI(IMX),BF_SI(IMX),BF_UI(IMX),BF_FI(IMX))
 ALLOCATE (BFCONMAXGG(KMX,IMX),BFCONGG(KMX,IMX),BFCONMAXJ(KMX,IMX),BFCONJ(KMX,IMX),BFCONP(KMX,IMX))
 ALLOCATE (BFULLSTO(KMX,IMX),BFULLSTOI(IMX),BVISIBLE(IMX))
 ALLOCATE (BFVELAVE(IMX),BFACTAVE(IMX))
 ALLOCATE (BAVEC(IMX),BMINC(IMX),BMAXC(IMX))
 ALLOCATE
(BFCONMAXJI(IMX),BFCONMAXGGI(IMX),BFCONI(IMX),BFCONPI(IMX),BFDAYCI(IMX),BFDAYCMI(IMX),BFCONGGI(IMX),BF
CONJI(IMX))
 ALLOCATE (BDAYCI(IMX),BDAYCMI(IMX))
 ALLOCATE (BF_DC_EXT(KMX,IMX),BF_G_EXT(KMX,IMX))
 ALLOCATE (T1BZ(IMX))
 BFCON = 0.0  ;BF1 = F1; BDAYC = 0.0; BFULLSTO = 0; BFULLSTOI = 0
 BCELL_POS = 0; BCELL_POS = 0; BESTSTEP = 0
 BVISIBLE = 0.0; BDIET = 0.0; BESTK = 0
 BF_F = 0.0 ;BF_U = 0.0 ;BF_D = 0.0 ;BF_R = 0.0 ;BF_S = 0.0 ;BF_C = 0.0 ;BF_G = 0.0 ;BF_W = 0.0
 BF_FC = 0.0;BF_UC = 0.0;BF_DC = 0.0;BF_RC = 0.0;BF_SC = 0.0;BF_CC = 0.0
 BF_GI = 0.0;BF_RI = 0.0;BF_DI = 0.0;BF_CI = 0.0;BF_WI = 0.0;BF_SI = 0.0; BF_UI = 0.0; BF_FI = 0.0
 BFVELAVE = 0.0; BFACTAVE = 0.0
 BAVEC = 0.0; BMINC = 0.0; BMAXC = 0.0
 BFCONMAXJI = 0.0; BFCONMAXGGI = 0.0; BFCONI = 0.0; BDAYCI = 0.0; BDAYCMI = 0.0; BFCONPI = 0.0;
BFCONJI = 0.0; BFCONGGI = 0.0
 BF_DC_EXT = 0.0;BF_G_EXT =0.0
 T1BZ = 0.0
END IF
IF(DIELCALC) THEN
 ALLOCATE(DFCON(KMX,IMX),DFVEL(KMX,IMX),DFACT(KMX,IMX),DF1(KMX,IMX,5))
 ALLOCATE (DF_F(KMX,IMX),DF_U(KMX,IMX),DF_D(KMX,IMX),DF_R(KMX,IMX),DF_S(KMX,IMX),DF_C(KMX,IMX))
 ALLOCATE (DF_G(KMX,IMX),DF_W(KMX,IMX),DDAYC(KMX,IMX),DDAYCM(KMX,IMX))
 ALLOCATE (DF_FC(KMX,IMX),DF_UC(KMX,IMX),DF_DC(KMX,IMX),DF_RC(KMX,IMX),DF_SC(KMX,IMX),DF_CC(KMX,IMX))
 ALLOCATE (DSRCHVOL(KMX,IMX),DRDZ(KMX,IMX))
 ALLOCATE (DCELL_POS(IMX),DCELL_NEG(IMX),DCELL_PER(IMX))
 ALLOCATE (DIELK(IMX,NUMSTEPS+1),TEPI(IMX),THYPO(IMX))
 ALLOCATE (DF_GI(IMX),DF_RI(IMX),DF_DI(IMX),DF_CI(IMX),DF_WI(IMX),DF_SI(IMX),DF_UI(IMX),DF_FI(IMX))
 ALLOCATE (DFVELAVE(IMX),DFACTAVE(IMX),DVISIBLE(IMX))
 ALLOCATE (DAVEC(IMX),DMINC(IMX),DMAXC(IMX))
 ALLOCATE
(DFCONMAXJI(IMX),DFCONMAXGGI(IMX),DFCONI(IMX),DFCONPI(IMX),DFDAYCI(IMX),DFDAYCMI(IMX),DFCONGGI(IMX),DF
CONJI(IMX))
 ALLOCATE (DDAYCI(IMX),DDAYCMI(IMX))
 ALLOCATE (DF_DC_EXT(KMX,IMX),DF_G_EXT(KMX,IMX))
```

```
 ALLOCATE (DFCONMAXGG(KMX,IMX),DFCONGG(KMX,IMX),DFCONMAXJ(KMX,IMX),DFCONJ(KMX,IMX),DFCONP(KMX,IMX))
 ALLOCATE (DDIETI(IMX,NZP),DDIET(KMX,IMX,NZP),DFULLSTO(KMX,IMX),DFULLSTOI(IMX))
 ALLOCATE (FORAY(IMX))
 DFCON = 0.0  ;DF1 = F1; DDAYC = 0.0; DFULLSTO = 0; DFULLSTOI = 0
 DCELL_POS = 0; DCELL_POS = 0; DIELK = 0
 DF_F = 0.0 ;DF_U = 0.0 ;DF_D = 0.0 ;DF_R = 0.0 ;DF_S = 0.0 ;DF_C = 0.0 ;DF_G = 0.0 ;DF_W = 0.0
 DF_FC = 0.0;DF_UC = 0.0;DF_DC = 0.0;DF_RC = 0.0;DF_SC = 0.0;DF_CC = 0.0
 DF_GI = 0.0;DF_RI = 0.0;DF_DI = 0.0;DF_CI = 0.0;DF_WI = 0.0;DF_SI = 0.0; DF_UI = 0.0; DF_FI = 0.0
 DFVELAVE = 0.0; DFACTAVE = 0.0
 DAVEC = 0.0; DMINC = 0.0; DMAXC = 0.0;DVISIBLE = 0
 DFCONMAXJI = 0.0; DFCONMAXGGI = 0.0; DFCONI = 0.0; DDAYCI = 0.0; DDAYCMI = 0.0; DFCONPI = 0.0;
DFCONJI = 0.0; DFCONGGI = 0.0
 DF_DC_EXT = 0.0;DF_G_EXT =0.0
 FORAY = .FALSE.
END IF

! **************************************************************************************
! *                            TASK B.2.1 FILE SET UP                                   *
! **************************************************************************************
CALL INITIALFILESETUP
!**************************************
!   TASK B.2.1 PSEUDO W2-TIME CONTROL AND VARIABLE UPDATE
!**************************************
!   TASK B.2.1.1 PSEUDO W2 TIME ADVANCEMENT
2110 CONTINUE
GOTO 2111 ! BY PASS  FOR FIXED FISH TIMESTEPS
JDAY = JDAY + DLT/3600.0/24.0
! CHECK FOR END OF SIMULATION
IF(JDAY.GT.JEND) THEN
  GOTO 997
END IF
! CHECK FOR ROUTING TO SUB-DAILY CALCULATIONS
IF(JDAY.GE.FBIOSUBNXT) THEN
  FBIOSUBNXT = FBIOSUBNXT + 1.0/48.0
  BIOSUB_CALC = .TRUE.
  IF(JDAY.GE.FBIODAYNXT) THEN
    FBIODAYLST = FBIODAYNXT; FBIODAYNXT = FBIODAYNXT + 1.0
    BIODAY_CALC = .TRUE.
         NEWDAY = .TRUE.; GRCT = GRCT+1
  END IF
END IF
IF(BIOSUB_CALC) THEN
  CONTINUE
  ELSE
    GOTO 2110
END IF
2111 continue
JDAY = JDAY + 1.0/48.0
IF(JDAY.GT.JEND) THEN
  GOTO 997
END IF
IF(JDAY.GE.FBIOSUBNXT) THEN
  !JDAY = INT(JDAY)*1.0 +0.0
    FBIOSUBNXT = JDAY + 1.0/48.0
  !FBIOSUBNXT = INT(JDAY+1.0)*1.0 + 0.0
  BIOSUB_CALC = .TRUE.
  IF(JDAY.GE.FBIODAYNXT) THEN
    FBIODAYLST = FBIODAYNXT; FBIODAYNXT = FBIODAYNXT + 1.0
         JDAY = 1.0*INT(JDAY)
    BIODAY_CALC = .TRUE.
         NEWDAY = .TRUE.; GRCT = GRCT+1
  END IF
END IF

! ******ZOOPLANKTON AVAILABILITY UPDATE********
  IF(JDAY.GE.ZAVNX) THEN ! THIS UPDATE MUST OCCUR AFTER THE COMPUTATIONS IN W2 OR RISK AN END OF FILE
READ ERROR
    ZAVJD = ZAVNX; ZAVAIL = ZAVAILNX
         READ(ZAVFN,'(:F8.0,9F8.0)')  ZAVNX,(ZAVAILNX(II),II=1,NZP)
  END IF
!**************************************
!   TASK B.2.2 SUBDAILY CALCULATIONS
!**************************************
!   TASK B.2.2.1 GET UPDATED SOLAR INPUTS
IF(JDAY.LT.LJDAY1) LUX = LUX1
IF(JDAY.LE.LJDAY2) LUX = (LJDAY2-JDAY)/(LJDAY2-LJDAY1)*(LUX2-LUX1)

2200 CONTINUE
IF(JDAY.GE.LJDAY2) THEN
```

```
  CALL LIGHTOUT
  IF(JDAY.GE.LJDAY1.AND.JDAY.LE.LJDAY2) THEN
    LUX = LUX1 + (LJDAY2-JDAY)/(LJDAY2-LJDAY1)*(LUX2-LUX1)
  ELSE
    GOTO 2200
  END IF
END IF

LUX = MAX(LUX,0.0) ! REDUDANT CHECK
IF(LUX.GE.1.0) THEN !ARBITRARY; USED FOR VERTICAL MIGRATION
  DAYLIGHT = .TRUE.
ELSE
  DAYLIGHT = .FALSE.
END IF
!NOON CHECK ( FOR DEBUGGING )
IF(JDAY.GT.557.5) THEN
  IF(JDAY.LT.557.51) THEN
    CONTINUE
  END IF
END IF
! BESTCALC TIMESTEP COUNT
IF(BESTCALC) BESTSTEP = BESTSTEP + 1
!**************************************
!   TASK B.2.2.2 SUB-DAILY BIOENERGETICS
!**************************************
write (999,'(a12,f8.3)') 'JDAY ', jday
! NEED TO MATCH DEPTHS TO K-LAYERS FOR W2 APPLICATION; ! ITERATE BY SEGMENT, SO ONLY K DIMENSION IS
NEEDED
DO JI = 1,NIBIO ! THIS IS THE MAIN W2 LOOP SIMULATION
  I = IBIO(JI)
  KBIP = KTI
 ! GET BIOEXP DATA AND DETERMINE KTI,KBI
  IF(FIRST_BIO(JI)) THEN
    CALL BIOEXPTRANSFORM
  END IF
write(999,'(a12,2i4,f8.2)') "Loop JI, I ",JI,I,t1z(2,I)
! MAIN VERTICAL LOOP
 DO K = KTI(I),KBI(I)
   ! GROWTH ANIMATION NODE COUNT
   NELEM = NELEM+1
   ! CONVERT LIGHTOUT DATA AT SURFACE TO DEPTH CORRECTED VALUES
   !** UPDATE WHEN INTEGRATING WITH MAIN W2 CODE
   GAMMAFDC(K,I) = LUX*EXP(-1*DEPTHM(K,I)*0.36) ! ARBITRARY LIGHT EXTINCTION VALUE OF 0.36 /M
   ! DIAGNOSTIC
   IF(GAMMAFDC(K,I).GT.1) THEN
     VISIBLE(K,I) = VISIBLE(K,I) + FDLTM
   END IF
   ! UPDATE REACTION DISTANCE AND SEARCH VOLUME
   FVEL(K,I) = 0.01*9.9*EXP(0.0405*T1Z(K,I)) * F1(K,I,1)**0.13 ! PULLED FROM METABOLISM, NEEDED FOR
SEARCH VOLUME
   FVELAVE(K,I) = FVELAVE(K,I) + FVEL(K,I)*FDLTM/1440
   RDZ(K,I) = 0.01*4.9424*GAMMAFDC(K,I)**0.086 ! METERS
   SRCHVOL(K,I) = 3.141596*RDZ(K,I)*RDZ(K,I)*FVEL(K,I)
     IF(BESTCALC) THEN
      BFVEL(K,I) = 0.01*9.9*EXP(0.0405*T1Z(K,I)) * BF1(K,I,1)**0.13
      BRDZ(K,I) = 0.01*4.9424*GAMMAFDC(K,I)**0.086
      BSRCHVOL(K,I) = 3.141596*BRDZ(K,I)*BRDZ(K,I)*BFVEL(K,I)
     END IF
     IF(DIELCALC) THEN
      DFVEL(K,I) = 0.01*9.9*EXP(0.0405*T1Z(K,I)) * DF1(K,I,1)**0.13
      DRDZ(K,I) = 0.01*4.9424*GAMMAFDC(K,I)**0.086
      DSRCHVOL(K,I) = 3.141596*DRDZ(K,I)*DRDZ(K,I)*DFVEL(K,I)
     END IF

   !************************************** PUT THE TL TERM INTO THE CONSUMPTION TERM; DEVIATES FROM
COMMON FORMULATIONS *******
   ! *** THORNTON-LESSEM FUNCTION
   FL1 = EXP(FG1*(T1Z(K,I)-FISHT1)); FL2 = EXP(FG2*(FISHT4-T1Z(K,I)))
   FKA = (FISHK1*FL1)/(1+FISHK1*(FL1-1)); FKB = (FISHK4*FL2)/(1+FISHK4*(FL2-1)); FTL(K) = FKA*FKB
   ! CHECKING FUNCTION
   IF(SINGLEDIAG) THEN
     RJINT=JDAY-INT(JDAY)
     IF(RJINT.LT.0.1) THEN
       IF(K.EQ.KTI(I)) THEN
         WRITE(TLCALCFN,'(F8.2,F8.4)') T1Z(K,I),FTL(K)
       END IF
     END IF
   END IF
! *********************************************************************************
```

```
! *                              TASK ....  CONSUMPTION                                     *
! **************************************************************************************
 ! DETERMINE MAXIMUM PRACTICAL FEEDING RATES ! FROM BEAUCHAMP, ET AL 1989, CMAX
   FCONMAXJ(K,I) = (0.303*F1(K,I,1)**-0.275)*EZOO(3)*F1(K,I,1)*FTL(K) ! UNITS OF J/DAY
   FCONMAXGG(K,I) = (0.303*F1(K,I,1)**-0.275)*FTL(K) ! UNITS OF G/G/ DAY
 ! CHECK STOMACH CONTENT COMPARED TO CAPACITY
   IF(F1(K,I,3).GT.F1(K,I,5)) THEN ! FORAGING
    FCON(K,I) = 0.0 !STOMACH FULL
         FULLSTO(K,I) = FULLSTO(K,I) + 1
   ELSE ! FORAGING
     IF(CMAXCALC) THEN      ! PRACTICAL FEEDING LIMIT?
           ! FCON(K,I) = FCONMAXGG(K,I)*F1(K,I,1)/MZOO(3)/1440
            WILMA1 = FCONMAXGG(K,I)*F1(K,I,1)/MZOO(3)/1440
            WILMA2 = (SRCHVOL(K,I)*CEFF(K)/(1+SRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
       IF (WILMA2.GT.WILMA1) THEN
               FCON(K,I) = WILMA1
                 ELSE
                   FCON(K,I) = WILMA2
            END IF
     ELSE
       FCON(K,I) = (SRCHVOL(K,I)*CEFF(K)/(1+SRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
     END IF
     DAYC(K,I) = DAYC(K,I) + FCON(K,I)*FDLTM
          DAYCM(K,I) = DAYC(K,I)*MZOO(3)
     AVEC(K,I) = AVEC(K,I) + FCON(K,I)*FDLTM/1440
          MINC(K,I) = MIN(MINC(K,I),FCON(K,I))
          MAXC(K,I) = MAX(MAXC(K,I),FCON(K,I))
          IF(FDIAG) THEN ! DIET REPORTING
       IF(THRESHFEED(K)) THEN
              DIET(K,I,THRESHZ) = DIET(K,I,THRESHZ) +
FCON(K,I)*C1Z(K,I,THRESHZ)*ZAVAIL(THRESHZ)/CEFF(K)*FDLTM
            ELSE
              DO JJZ = 1,NZP
                DIET(K,I,JJZ) = DIET(K,I,JJZ) +  FCON(K,I)*C1Z(K,I,JJZ)*ZAVAIL(JJZ)/CEFF(K)*FDLTM
              END DO
            END IF
     END IF
   END IF ! FORAGING
   ! ACTUAL CONSUMPTION DIAGNOSTIC
   FCONJ(K,I)  = DAYC(K,I)*MZOO(3)*EZOO(3)
   FCONGG(K,I) = DAYC(K,I)*MZOO(3)/F1(K,I,1)
   FCONP(K,I)  = FCONGG(K,I)/FCONMAXGG(K,I)
! ***********  BESTCALC  *************
IF(BESTCALC) THEN
   BFCONMAXJ(K,I) = (0.303*BF1(K,I,1)**-0.275)*EZOO(3)*BF1(K,I,1)*FTL(K) ! UNITS OF J/DAY
   BFCONMAXGG(K,I) = (0.303*BF1(K,I,1)**-0.275)*FTL(K) ! UNITS OF G/G/ DAY
   IF(BF1(K,I,3).GT.BF1(K,I,5)) THEN ! FORAGING
    PRINT *,'FULL_STOMACH'
    BFCON(K,I) = 0.0 !STOMACH FULL
         BFULLSTO(K,I) =  1
   ELSE ! FORAGING
    BFULLSTO(K,I) = 0
     IF(CMAXCALC) THEN
       BFCON(K,I) = BFCONMAXGG(K,I)*BF1(K,I,1)/MZOO(3)/1440
            WILMA1 = BFCONMAXGG(K,I)*BF1(K,I,1)/MZOO(3)/1440
            WILMA2 = (SRCHVOL(K,I)*CEFF(K)/(1+SRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
       IF (WILMA2.GT.WILMA1) THEN
               BFCON(K,I) = WILMA1
                 ELSE
                   BFCON(K,I) = WILMA2
            END IF
      ELSE
       BFCON(K,I) = (BSRCHVOL(K,I)*CEFF(K)/(1+BSRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
     END IF
     BDAYC(K,I) = BFCON(K,I)*FDLTM ! DIFFERS FROM MAIN: ONLY ONE TIMESTEP
          BDAYCM(K,I) = BDAYC(K,I)*MZOO(3)
     IF(FDIAG) THEN ! DIET REPORTING ! DIFFERS FROM MAIN ROUTINE; THIS IS ONLY PER TIMESTEP; BDIETI IS
CUMMULATIVE
       IF(THRESHFEED(K)) THEN
              BDIET(K,I,THRESHZ) = BFCON(K,I)*C1Z(K,I,THRESHZ)*ZAVAIL(THRESHZ)/CEFF(K)*FDLTM
            ELSE
              DO JJZ = 1,NZP
                BDIET(K,I,JJZ) = BFCON(K,I)*C1Z(K,I,JJZ)*ZAVAIL(JJZ)/CEFF(K)*FDLTM
              END DO
            END IF
     END IF
   END IF ! FORAGING
   BFCONJ(K,I)  = BDAYC(K,I)*MZOO(3)*EZOO(3)
   BFCONGG(K,I) = BDAYC(K,I)*MZOO(3)/BF1(K,I,1)
```

```
   BFCONP(K,I)  = BFCONGG(K,I)/BFCONMAXGG(K,I)
END IF ! BESTCALC
! ***********  DIELCALC  *************
IF(DIELCALC) THEN
   DFCONMAXJ(K,I) = (0.303*DF1(K,I,1)**-0.275)*EZOO(3)*DF1(K,I,1)*FTL(K) ! UNITS OF J/DAY
   DFCONMAXGG(K,I) = (0.303*DF1(K,I,1)**-0.275)*FTL(K) ! UNITS OF G/G/ DAY
   IF(DF1(K,I,3).GT.DF1(K,I,5)) THEN ! FORAGING
    DFCON(K,I) = 0.0 !STOMACH FULL
         DFULLSTO(K,I) =  1
   ELSE ! FORAGING
    DFULLSTO(K,I) = 0
     IF(CMAXCALC) THEN
            WILMA1 = DFCONMAXGG(K,I)*DF1(K,I,1)/MZOO(3)/1440
            WILMA2 = (SRCHVOL(K,I)*CEFF(K)/(1+SRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
       IF (WILMA2.GT.WILMA1) THEN
               DFCON(K,I) = WILMA1
                 ELSE
                   DFCON(K,I) = WILMA2
            END IF
     ELSE
       DFCON(K,I) = (DSRCHVOL(K,I)*CEFF(K)/(1+DSRCHVOL(K,I)*CEFF(K)*HANDLE))*60*FTL(K)
     END IF
     DDAYC(K,I) = DFCON(K,I)*FDLTM ! DIFFERS FROM MAIN: ONLY ONE TIMESTEP
          DDAYCM(K,I) = DDAYC(K,I)*MZOO(3)
     IF(FDIAG) THEN ! DIET REPORTING ! DIFFERS FROM MAIN ROUTINE; THIS IS ONLY PER TIMESTEP; BDIETI IS
CUMMULATIVE
       IF(THRESHFEED(K)) THEN
              DDIET(K,I,THRESHZ) = DFCON(K,I)*C1Z(K,I,THRESHZ)*ZAVAIL(THRESHZ)/CEFF(K)*FDLTM
            ELSE
              DO JJZ = 1,NZP
                DDIET(K,I,JJZ) = DFCON(K,I)*C1Z(K,I,JJZ)*ZAVAIL(JJZ)/CEFF(K)*FDLTM
              END DO
            END IF
     END IF
   END IF ! FORAGING
   DFCONJ(K,I)  = DDAYC(K,I)*MZOO(3)*EZOO(3)
   DFCONGG(K,I) = DDAYC(K,I)*MZOO(3)/DF1(K,I,1)
   DFCONP(K,I)  = DFCONGG(K,I)/DFCONMAXGG(K,I)
END IF ! DIELCALC

! **************************************************************************************
! *                            TASK ....  NON-CONSUMPTION PARAMETERS                    *
! **************************************************************************************
   !****DIGESTION (SDA)
   DIGK = 0.014*T1Z(K,I)+0.1135
   !** MAZUR'S B&A
   F_DC(K,I) = (F1(K,I,3) + FCON(K,I)*MZOO(3)*FDLTM - (F1(K,I,3)*EXP(-1*DIGK*FDLTH) &
     + FCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH)) )) *EZOO(3)
   ! DIAGNOSTIC:  DIGENSTION BY PARTS
   F_DINI(K,I) = F1(K,I,3)*EZOO(3)
   F_DCON(K,I) = FCON(K,I)*MZOO(3)*FDLTM*EZOO(3)
   !F_DUNDIG(K,I) = ((F1(K,I,3)*EXP(-1*DIGK*FDLTH)+FCON(K,I)*MZLW(3)*60/DIGK*(1-EXP(-
1*DIGK*FDLTH))))*EZOO(3)
   F_DUNDIG(K,I) = ((F1(K,I,3)*EXP(-1*DIGK*FDLTH)+FCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-
1*DIGK*FDLTH))))*EZOO(3)
   !****EGESTION
   F_FC(K,I)    = 0.212*(T1Z(K,I)**-0.222)*F_DC(K,I)
   !****EXCRETION
   F_UC(K,I) = 0.0233*(T1Z(K,I)**-0.580)*(F_DC(K,I)-F_FC(K,I))
   !****METABOLISM/RESPIRATION (ACTIVITY)
   FACT(K,I) = EXP(0.02334*100.0*FVEL(K,I))
   FACTAVE(K,I) = FACTAVE(K,I) + FACT(K,I)*FDLTM/1440
   F_RC(K,I) = 0.00143*(F1(K,I,1)**-0.209)*EXP(0.086*T1Z(K,I))*FACT(K,I)*FOXYCAL*FDLTM/1440*F1(K,I,1)
   !****SPECIFIC DYNAMIC ACTION
   F_SC(K,I) = 0.172*(F_DC(K,I)-F_FC(K,I))
   !****FISH ENERGY DENSITY (IN J/G)
   IF(F1(K,I,1).LE.196.0) THEN
     F1(K,I,4) = (1.851*F1(K,I,1)+1250.0)*4.1868
   ELSE
     F1(K,I,4) = (0.1254*F1(K,I,1) + 1588.0)*4.1868
   END IF
   !****UPDATE STOMACH CONTENT ! THIS CAN PROBABLY BE MOVED INTO THE DIGESTION SECTION, BUT WILL KEEP
SEPARATE FOR CLARITY
   F_CC(K,I) = FCON(K,I)*MZOO(3)*FDLTM*EZOO(3)
   F1(K,I,3) = F1(K,I,3)*EXP(-1*DIGK*FDLTH)+FCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH))

! ***********  BESTCALC  *************
IF(BESTCALC) THEN
       BF_DC(K,I) = (BF1(K,I,3) + BFCON(K,I)*MZOO(3)*FDLTM - (BF1(K,I,3)*EXP(-1*DIGK*FDLTH) &
```

```
     + BFCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH)) )) *EZOO(3)
       BF_DC_EXT(K,I) = BF_DC(K,I) + 0.2*BFCONJ(K,I)
       BF_FC(K,I)    = 0.212*(T1Z(K,I)**-0.222)*BF_DC(K,I)
       BF_UC(K,I) = 0.0233*(T1Z(K,I)**-0.580)*(BF_DC(K,I)-BF_FC(K,I))
       BFACT(K,I) = EXP(0.02334*100.0*BFVEL(K,I))
       BF_RC(K,I) = 0.00143*(BF1(K,I,1)**-
0.209)*EXP(0.086*T1Z(K,I))*BFACT(K,I)*FOXYCAL*FDLTM/1440*BF1(K,I,1)
       BF_SC(K,I) = 0.172*(BF_DC(K,I)-BF_FC(K,I))
       IF(BF1(K,I,1).LE.196.0) THEN
         BF1(K,I,4) = (1.851*BF1(K,I,1)+1250.0)*4.1868
       ELSE
         BF1(K,I,4) = (0.1254*BF1(K,I,1) + 1588.0)*4.1868
       END IF
       BF_CC(K,I) = BFCON(K,I)*MZOO(3)*FDLTM*EZOO(3)
       BF1(K,I,3) = BF1(K,I,3)*EXP(-1*DIGK*FDLTH)+BFCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH))
END IF !BESTCALC

! ***********  DIELCALC  *************
IF(DIELCALC) THEN
       DF_DC(K,I) = (DF1(K,I,3) + DFCON(K,I)*MZOO(3)*FDLTM   -   (DF1(K,I,3)*EXP(-1*DIGK*FDLTH) &
         + DFCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH))    )) *EZOO(3)
       DF_DC_EXT(K,I) = DF_DC(K,I) + 0.2*DFCONJ(K,I)
       DF_FC(K,I)    = 0.212*(T1Z(K,I)**-0.222)*DF_DC(K,I)
       DF_UC(K,I) = 0.0233*(T1Z(K,I)**-0.580)*(DF_DC(K,I)-DF_FC(K,I))
       DFACT(K,I) = EXP(0.02334*100.0*DFVEL(K,I))
       DF_RC(K,I) = 0.00143*(DF1(K,I,1)**-
0.209)*EXP(0.086*T1Z(K,I))*DFACT(K,I)*FOXYCAL*FDLTM/1440*DF1(K,I,1)
       DF_SC(K,I) = 0.172*(DF_DC(K,I)-DF_FC(K,I))
       IF(DF1(K,I,1).LE.196.0) THEN
         DF1(K,I,4) = (1.851*DF1(K,I,1)+1250.0)*4.1868
       ELSE
         DF1(K,I,4) = (0.1254*DF1(K,I,1) + 1588.0)*4.1868
       END IF
       DF_CC(K,I) = DFCON(K,I)*MZOO(3)*FDLTM*EZOO(3)
       DF1(K,I,3) = DF1(K,I,3)*EXP(-1*DIGK*FDLTH)+DFCON(K,I)*MZOO(3)*60/DIGK*(1-EXP(-1*DIGK*FDLTH))
END IF !DIELCALC
END DO ! MAIN K LOOP

! ***************************************************************************************
! *                             TASK ....  DAILY PARAMETER UPDATES                      *
! ***************************************************************************************
 ! DAILY PARAMETER UPDATES
 CELL_POS(I) = 0; CELL_NEG(I) = 0
 DO K = KTI(I),KBI(I)
   F_R(K,I) = F_R(K,I) + F_RC(K,I)
   F_D(K,I) = F_D(K,I) + F_DC(K,I)
   F_C(K,I) = F_C(K,I) + F_CC(K,I)
   F_W(K,I) = F_W(K,I) + F_UC(K,I) + F_FC(K,I)
   F_S(K,I) = F_S(K,I) + F_SC(K,I)
   F_G(K,I) = F_G(K,I) + (F_DC(K,I) - (F_SC(K,I) + F_FC(K,I) + F_UC(K,I))- F_RC(K,I))/F1(K,I,4)
   F2(K,I) =F_G(K,I)/F1(K,I,1)
   IF(F_G(K,I).GT.0) CELL_POS(I) = CELL_POS(I) +1
   IF(F_G(K,I).LT.0) CELL_NEG(I) = CELL_NEG(I) +1
 END DO
 CELL_PER(I) = (CELL_POS(I)*1.0)/(CELL_POS(I)*1.0+CELL_NEG(I)*1.0)*100.0
! ***********  BESTCALC  *************
IF(BESTCALC) THEN
      BCELL_POS(I) = 0; BCELL_NEG(I) = 0
          GMAXG = -99999.0; GMAXK = 2
      DO K = KTI(I),KBI(I)
        BF_G(K,I) = (BF_DC(K,I) - (BF_SC(K,I) + BF_FC(K,I) + BF_UC(K,I))- BF_RC(K,I))/BF1(K,I,4)
        BF_G_EXT(K,I) = (BF_DC_EXT(K,I) - (BF_SC(K,I) + BF_FC(K,I) + BF_UC(K,I))-
BF_RC(K,I))/BF1(K,I,4)
           F_G2(K,I) = F_G2(K,I) + BF_G(K,I)
        IF(BF_G_EXT(K,I).GT.GMAXG) THEN ! FIND BEST LAYER
          GMAXG = BF_G_EXT(K,I); GMAXK = K
             END IF
       IF(BF_G(K,I).GT.0) BCELL_POS = BCELL_POS + 1
           IF(BF_G(K,I).LT.0) BCELL_NEG = BCELL_NEG + 1
      END DO
          ! APPLY BEST LAYER TO CUMMALATIVE TERMS
       BF_GI(I) = BF_GI(I) + BF_G(GMAXK,I)
            BESTK(I,BESTSTEP) = GMAXK
       BF_RI(I) = BF_RI(I) + BF_RC(GMAXK,I)
       BF_DI(I) = BF_DI(I) + BF_DC(GMAXK,I)
            BF_CI(I) = BF_CI(I) + BF_CC(GMAXK,I)
            BF_WI(I) = BF_WI(I) + BF_UC(GMAXK,I) + BF_FC(GMAXK,I)
            BF_UI(I) = BF_UI(I) + BF_UC(GMAXK,I)
            BF_FI(I) = BF_FI(I) + BF_FC(GMAXK,I)
```

```
            BF_SI(I) = BF_SI(I) + BF_SC(GMAXK,I)
                    T1BZ(I)  = T1BZ(I)  + T1Z(GMAXK,I)/48.0       ! average over a day
       ! UPDATE DIAGNOSTIC ACCOUNTING TERMS
       BFVELAVE(I) = BFVELAVE(I) + BFVEL(GMAXK,I)*FDLTM/1440
            BFACTAVE(I) = BFACTAVE(I) + BFACT(GMAXK,I)*FDLTM/1440
            BAVEC(I) = BAVEC(I) + BFCON(GMAXK,I)*FDLTM/1440
            BMINC(I) = MIN(BMINC(I),BFCON(GMAXK,I))
            BMAXC(I) = MAX(BMAXC(I),BFCON(GMAXK,I))
            BFULLSTOI(I) = BFULLSTOI(I) + BFULLSTO(GMAXK,I)
       BFCONI(I) = BFCONI(I) + BFCON(GMAXK,I)
            BDAYCI(I) = BDAYCI(I) + BDAYC(GMAXK,I)
            BDAYCMI(I) = BDAYCMI(I) + BDAYCM(GMAXK,I)
            BFCONMAXJI(I) = BFCONMAXJI(I) + BFCONMAXJ(GMAXK,I)/48.0     ! average over a day
            BFCONMAXGGI(I) = BFCONMAXGGI(I) + BFCONMAXGG(GMAXK,I)/48.0  ! average over a day
            BFCONJI(I) = BFCONJI(I) + BFCONJ(GMAXK,I)
            BFCONGGI(I) = BFCONGGI(I) + BFCONGG(GMAXK,I)
       BFCONPI(I) = BFCONGGI(I)/BFCONMAXGGI(I)
  IF(SINGLEDIAG.AND.DEPTHCALC) THEN
    IF(I.EQ.SINIBIO) THEN
             WRITE(BIOOUTFN(21),'(F8.3,3I8)') JDAY, I, BESTK(I,BESTSTEP),DIELK(I,BESTSTEP)
    END IF
  END IF
            ! TRANFER STOMACH CONTENTS
            BF1(:,I,3) = BF1(GMAXK,I,3)
       BCELL_PER(I) = (BCELL_POS(I)*1.0)/(BCELL_POS(I)*1.0+BCELL_NEG(I)*1.0)*100.0
       IF(GAMMAFDC(GMAXK,I).GT.1) THEN
         BVISIBLE(I) = BVISIBLE(I) + FDLTM
       END IF
            DO JJZ = 1,NZP
              BDIETI(I,JJZ) = BDIETI(I,JJZ) + BDIET(GMAXK,I,JJZ)
            END DO
       BDAYC(:,I) = BDAYC(GMAXK,I)
END IF !BESTCALC
! ***********  DIELCALC  *************
    IF(DIELCALC) THEN
      DCELL_POS(I) = 0; DCELL_NEG(I) = 0
           GMAXG = -99999.0; GMAXK = 2
           RMIN = -99999.0 ; RMINK = 2; CMAX = -99999.0 ; CMAXK = 2
      DO K = KTI(I),KBI(I)
        DF_G(K,I) = (DF_DC(K,I) - (DF_SC(K,I) + DF_FC(K,I) + DF_UC(K,I))- DF_RC(K,I))/DF1(K,I,4)
        DF_G_EXT(K,I) = (DF_DC_EXT(K,I) - (DF_SC(K,I) + DF_FC(K,I) + DF_UC(K,I))-
DF_RC(K,I))/DF1(K,I,4)
        IF(DF_G_EXT(K,I).GT.GMAXG) THEN ! FIND BEST LAYER
          GMAXG = DF_G_EXT(K,I); GMAXK = K
             END IF
        IF(DF_R(K,I).LT.RMIN) THEN ! FIND BEST LAYER
          RMIN = DF_R(K,I); RMINK = K
             END IF
        IF(DF_CC(K,I).GT.CMAX) THEN ! FIND BEST LAYER
          CMAX = DF_CC(K,I); CMAXK = K
             END IF
       IF(DF_G(K,I).GT.0) DCELL_POS = DCELL_POS + 1
            IF(DF_G(K,I).LT.0) DCELL_NEG = DCELL_NEG + 1
      END DO
! ***************************************************************
           ! APPLY BEST LAYER TO CUMMALATIVE TERMS
IF(DF_G(GMAXK,I).GT.0.0) THEN
  KBEST = GMAXK
ELSE
  IF(DAYLIGHT) THEN
    IF(DF_G(CMAXK,I).GE.0.0) THEN
           KBEST = CMAXK
         ELSE
           IF(FORAY(I)) THEN
             IF(T1Z(CMAXK,I).GT.20.0) THEN
                   DO KK = CMAXK,KBI(I)-1
                     IF(T1Z(KK,I).GT.20.0) THEN
                            CONTINUE
                          ELSE
                            KBEST = KK
                            EXIT
                          END IF
                   END DO
                 ELSE
                   KBEST = CMAXK
                 END IF
                 FORAY(I) = .FALSE.
           ELSE
             KBEST = RMINK
```

```
                 FORAY(I) = .TRUE.
           END IF
         END IF
  ELSE
    KBEST = RMINK
  END IF
END IF
       DF_GI(I) = DF_GI(I) + DF_G(KBEST,I)
            DIELK(I,BESTSTEP) = KBEST
       DF_RI(I) = DF_RI(I) + DF_RC(KBEST,I)
       DF_DI(I) = DF_DI(I) + DF_DC(KBEST,I)
            DF_CI(I) = DF_CI(I) + DF_CC(KBEST,I)
            DF_WI(I) = DF_WI(I) + DF_UC(KBEST,I) + DF_FC(KBEST,I)
            DF_UI(I) = DF_UI(I) + DF_UC(KBEST,I)
            DF_FI(I) = DF_FI(I) + DF_FC(KBEST,I)
            DF_SI(I) = DF_SI(I) + DF_SC(KBEST,I)
       ! UPDATE DIAGNOSTIC ACCOUNTING TERMS
       DFVELAVE(I) = DFVELAVE(I) + DFVEL(KBEST,I)*FDLTM/1440
            DFACTAVE(I) = DFACTAVE(I) + DFACT(KBEST,I)*FDLTM/1440
            DAVEC(I) = DAVEC(I) + DFCON(KBEST,I)*FDLTM/1440
            DMINC(I) = MIN(DMINC(I),DFCON(KBEST,I))
            DMAXC(I) = MAX(DMAXC(I),DFCON(KBEST,I))
            DFULLSTOI(I) = DFULLSTOI(I) + DFULLSTO(KBEST,I)
       DFCONI(I) = DFCONI(I) + DFCON(KBEST,I)
            DDAYCI(I) = DDAYCI(I) + DDAYC(KBEST,I)
            DDAYCMI(I) = DDAYCMI(I) + DDAYCM(KBEST,I)
            DFCONMAXJI(I) = DFCONMAXJI(I) + DFCONMAXJ(KBEST,I)/48.0     ! average over a day
            DFCONMAXGGI(I) = DFCONMAXGGI(I) + DFCONMAXGG(KBEST,I)/48.0  ! average over a day
            DFCONJI(I) = DFCONJI(I) + DFCONJ(KBEST,I)
            DFCONGGI(I) = DFCONGGI(I) + DFCONGG(KBEST,I)
       DFCONPI(I) = DFCONGGI(I)/DFCONMAXGGI(I)
            DF1(:,I,3) = DF1(KBEST,I,3)
       DCELL_PER(I) = (DCELL_POS(I)*1.0)/(DCELL_POS(I)*1.0+DCELL_NEG(I)*1.0)*100.0
       IF(GAMMAFDC(KBEST,I).GT.1) THEN
         DVISIBLE(I) = DVISIBLE(I) + FDLTM
       END IF
            DO JJZ = 1,NZP
              DDIETI(I,JJZ) = DDIETI(I,JJZ) + DDIET(KBEST,I,JJZ)
            END DO
       DDAYC(:,I) = DDAYC(KBEST,I)
    END IF !DIELCALC

! **************************************************************************************
! *                            TASK ....  DAILY CALCULATIONS AND UPDATES               *
! **************************************************************************************
 IF(BIODAY_CALC) THEN !BIODAY
  ! IF(KBI(I).GT.KTI(I)+1) F_G(KBI(I)-1,I) = F_G(KBI(I)-2,I)
  ! IF(KBI(I).GT.KTI(I)) F_G(KBI(I),I) = F_G(KBI(I)-1,I)
   IF(FDIAG) CALL FOUTPUT_DAILY
   IF(JI.EQ.NIBIO) then
      print *,'ji = ', ji
      CALL ANIMATION_DATA
           continue
   end if
   CALL DAILY_GROWTH
   IF(JI.EQ.NIBIO) CALL BY_SEG_OUTPUT
   IF(JI.EQ.NIBIO) PRINT *,JDAY,BF1(2,312,1),T1Z(2,I)
   KBIP(I) = KBI(I)
   CALL BIOEXPTRANSFORM
  ! CHECK FOR CHANGES IN KTI (LAYER ADDITION/SUBTRACTION REQUIRES INITIALIZING):  SHOWS UP IN
ANIMATIONS
  IF(KBI(I).GT.KBIP(I)) THEN
     ! WRITE(999,*)'INITIALIZING, JDAY, I ',INT(JDAY),I
    DO K = KBI(I),3,-1
           F1(KBI(I),I,:) = F1(KBI(I)-1,I,:)
      F_R(KBI(I),I) = F_R(KBI(I)-1,I)
      F_D(KBI(I),I) = F_D(KBI(I)-1,I)
      F_C(KBI(I),I) = F_C(KBI(I)-1,I)
      F_W(KBI(I),I) = F_W(KBI(I)-1,I)
      F_S(KBI(I),I) = F_S(KBI(I)-1,I)
      F_G(KBI(I),I) = F_G(KBI(I)-1,I)
    END DO
           F1(2,I,:) = F1(3,I,:)
      F_R(2,I) = F_R(3,I)
      F_D(2,I) = F_D(3,I)
      F_C(2,I) = F_C(3,I)
      F_W(2,I) = F_W(3,I)
      F_S(2,I) = F_S(3,I)
      F_G(2,I) = F_G(3,I)
```

```
   END IF
  IF(KBI(I).LT.KBIP(I)) THEN
       ! WRITE(999,*)'INITIALIZING, JDAY, I ',INT(JDAY),I
    DO K = KBI(I),2,-1
           F1(KBI(I),I,:) = F1(KBI(I)+1,I,:)
      F_R(KBI(I),I) = F_R(KBI(I)+1,I)
      F_D(KBI(I),I) = F_D(KBI(I)+1,I)
      F_C(KBI(I),I) = F_C(KBI(I)+1,I)
      F_W(KBI(I),I) = F_W(KBI(I)+1,I)
      F_S(KBI(I),I) = F_S(KBI(I)+1,I)
      F_G(KBI(I),I) = F_G(KBI(I)+1,I)
    END DO
   END IF
! ***********  ANIMATION  *************
   ! ANIMATION ELEVATION DETERMINATION (TEMPORARY APPROACH)
    ! FIND BOTTOM ELEVATION
   DO II = 1,IMX
     IF(I.EQ.BOTSEG(II)) THEN
            GELEV(KBI(I),I) = BOTTOME(II)
            EXIT
          END IF
   END DO
    ! ASSIGN ELEVATIONS
   DO K=KBI(I)-1,2,-1
     GELEV(K,I)=GELEV(K+1,I)+2.0
   END DO
  END IF !BIODAY
  FIRST_BIO(JI) = .FALSE.
 998 CONTINUE
END DO ! MAIN LOOP (SEGMENT ADVANCEMENT)
! ***************************************************************************************
! *                            TASK ....  REZERO CUMMULATIVE DAILY TERMS               *
! ***************************************************************************************
! REZERO CUMMULATIVE DAILY TERMS
NELEM = 0; NNODE = 0
IF(BIODAY_CALC) THEN
 F_R  = 0.0  ;F_D  = 0.0  ;F_C  = 0.0  ;F_F   = 0.0  ;F_U      = 0.0 ; VISIBLE = 0.0
 F_S  = 0.0  ;F_G  = 0.0  ;F_W  = 0.0  ;DAYC  = 0.0  ;FULLSTO  = 0   ; DIET    = 0.0
 FVELAVE = 0.0; FACTAVE = 0.0;AVEC = 0.0; MINC = 0.0; MAXC = 0.0
 MAXG = -999.0; MAXM = -999.0; F_G2 = 0.0
    ! ***********  BESTCALC  *************
 IF(BESTCALC) THEN
  BF_R  = 0.0 ;BF_D  = 0.0 ;BF_C  = 0.0 ;BF_F   = 0.0 ;BF_U    = 0.0
  BF_S  = 0.0 ;BF_G  = 0.0 ;BF_W  = 0.0 ;BDAYC  = 0.0 ;BDIET  = 0.0; BDIETI = 0.0
  BESTSTEP = 0
  BF_GI = 0.0 ;BF_RI = 0.0 ;BF_DI = 0.0 ;BF_CI  = 0.0 ;BF_WI   = 0.0  ; BF_SI = 0.0; BF_UI = 0.0;
BF_FI = 0.0
  BFVELAVE = 0.0; BFACTAVE = 0.0;  BAVEC = 0.0; BMINC = 0.0; BMAXC = 0.0; BVISIBLE = 0.0
  BFULLSTO = 0; BFULLSTOI = 0
  BFCONMAXJI = 0.0; BFCONMAXGGI = 0.0; BFCONI = 0.0; BDAYCI = 0.0; BDAYCMI = 0.0; BFCONPI = 0.0;
BFCONJI = 0.0; BFCONGGI = 0.0
  T1BZ = 0.0
 END IF
   ! ***********  DIELCALC  *************
 IF(DIELCALC) THEN
  DF_R  = 0.0 ;DF_D  = 0.0 ;DF_C  = 0.0 ;DF_F   = 0.0 ;DF_U    = 0.0
  DF_S  = 0.0 ;DF_G  = 0.0 ;DF_W  = 0.0 ;DDAYC  = 0.0 ;DDIET  = 0.0; DDIETI = 0.0
  DF_GI = 0.0 ;DF_RI = 0.0 ;DF_DI = 0.0 ;DF_CI  = 0.0 ;DF_WI   = 0.0  ; DF_SI = 0.0; DF_UI = 0.0;
DF_FI = 0.0
  DFVELAVE = 0.0; DFACTAVE = 0.0;  DAVEC = 0.0; DMINC = 0.0; DMAXC = 0.0; DVISIBLE = 0.0
  DFULLSTO = 0; DFULLSTOI = 0
  DFCONMAXJI = 0.0; DFCONMAXGGI = 0.0; DFCONI = 0.0; DDAYCI = 0.0; DDAYCMI = 0.0; DFCONPI = 0.0;
DFCONJI = 0.0; DFCONGGI = 0.0
 END IF
END IF
BIOSUB_CALC = .FALSE.;  BIODAY_CALC = .FALSE.

! ***************************************************************************************
! *                            TASK ....  END TIME-STEP                                *
! ***************************************************************************************
GOTO 2110 ! RETURN TO JDAY ADVANCEMENT
!*****************************************************************************************************
******************************
!**                                                     E N D   P R O G R A M
**
!*****************************************************************************************************
******************************
997 CONTINUE
! GROWTH ANIMATION DATE/TEXT
```

```
DO IZ = 1,ZONECNT
  IZZ = IZ+ZONEFIRST-1
  WRITE(ANIMFN,863) IZ,IZZ
  WRITE(ANIMFN,864) IZ,GREGORY(IZ)
END DO
863 FORMAT('TEXT X=0.2, y=0.15, H=3.0, ZN=',i4,',',' C=BLACK,','T= "Julian Day ',I6,'"')
864 FORMAT('TEXT X=0.2, y=0.20, H=3.0, ZN=',i4,',',' C=BLACK,','T= "',A20,'"')
DO II = 1,NIBIO
  CLOSE(BIOINFN(II))
END DO
CLOSE(LIGHTNUM)
STOP
END !PROGRAM END

!*****************************************************************************************************
******************************
!**                                              S U B R O U T I N E   L I G H T O U T
**
!*****************************************************************************************************
******************************

SUBROUTINE LIGHTOUT
 USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE DIAGNOSTIC; USE ROOSEVELT; USE MOVEMENT
    LJDAY1 = LJDAY2; LUX1 = LUX2
    READ(LIGHTNUM,'(10X,F10.0,20X,E10.2)') LJDAY2,LUX2
RETURN
END SUBROUTINE LIGHTOUT

!*****************************************************************************************************
******************************
!**                                            S U B R O U T I N E   D A I L Y   G R O W T H
**
!*****************************************************************************************************
******************************

SUBROUTINE DAILY_GROWTH
 USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE DIAGNOSTIC; USE ROOSEVELT; USE MOVEMENT
! UPDATE MASS & STOMACH CAPACITY
! GENERAL EQUATION
  IF(GMTPCELL) THEN
    DO K = KTI(I),KBI(I)
      F1(K,I,1) = F1(K,I,1) + F_G(K,I)
      IF(F1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        F1(K,I,5) = (14.1-4.95*LOG10(F1(K,I,1)))/100.0*F1(K,I,1)
      ELSE
        F1(K,I,5) = 0.0022*F1(K,I,1)
      END IF
      MAXM(I) = MAX(MAXM(I),F1(K,I,1))  ! MAXMASS
      MAXG(I) = MAX(MAXG(I),F_G(K,I))   ! MAXGROWTH
    END DO
  END IF
  IF(GMTPFXN) THEN
    DO K = KTI(I),KBI(I)
      F1(K,I,1) = GIM*EXP(GALP*(JDAY-GTI))
      IF(F1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        F1(K,I,5) = (14.1-4.95*LOG10(F1(K,I,1)))/100.0*F1(K,I,1)
      ELSE
        F1(K,I,5) = 0.0022*F1(K,I,1)
      END IF
      MAXM(I) = MAX(MAXM(I),F1(K,I,1))  ! MAXMASS
      MAXG(I) = MAX(MAXG(I),F_G(K,I))   ! MAXGROWTH
    END DO
  END IF
  IF(GMTPFIXED) THEN
    CONTINUE
  END IF
  IF(GMTPUSER) THEN
    READ(FXNFN(1),'(2F8.0)') F1J,F1M
         F1(:,I,1) = F1M
         IF(INT(JDAY).NE.INT(F1J)) THEN
      PRINT *,'POSSIBLE PRESCRIBED MASS ERROR :',F1J,JDAY
    END IF
  END IF
IF(BESTCALC) THEN
  IF(BMTPSEG) THEN
    DO K = KTI(I),KBI(I)
      BF1(K,I,1) = BF1(K,I,1) + BF_GI(I)
      IF(BF1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        BF1(K,I,5) = (14.1-4.95*LOG10(BF1(K,I,1)))/100.0*BF1(K,I,1)
```

```
      ELSE
        BF1(K,I,5) = 0.022*BF1(K,I,1)
      END IF
    END DO
  END IF
  IF(BMTPFXN) THEN
    DO K = KTI(I)-1,KBI(I)+1
      BF1(K,I,1) = BIM*EXP(BALP*(JDAY-BTI))
      IF(BF1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        BF1(K,I,5) = (14.1-4.95*LOG10(BF1(K,I,1)))/100.0*BF1(K,I,1)
      ELSE
        BF1(K,I,5) = 0.022*BF1(K,I,1)
      END IF
    END DO
  END IF
  IF(BMTPFIXED) THEN
    CONTINUE
  END IF
  IF(BMTPUSER) THEN
    READ(FXNFN(2),'(2F8.0)') F1J,F1M
         BF1(:,I,1) = F1M
         IF(INT(JDAY).NE.INT(F1J)) THEN
      PRINT *,'POSSIBLE PRESCRIBED MASS ERROR :',F1J,JDAY
    END IF
  END IF
END IF
IF(DIELCALC) THEN
  IF(DMTPSEG) THEN
    DO K = KTI(I),KBI(I)
      DF1(K,I,1) = DF1(K,I,1) + DF_GI(I)
      IF(DF1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        DF1(K,I,5) = (14.1-4.95*LOG10(DF1(K,I,1)))/100.0*DF1(K,I,1)
      ELSE
        DF1(K,I,5) = 0.022*DF1(K,I,1)
      END IF
    END DO
  END IF
  IF(DMTPFXN) THEN
    DO K = KTI(I),KBI(I)
      DF1(K,I,1) = DIM*EXP(DALP*(JDAY-DTI))
      IF(DF1(K,I,1).LE.253.5) THEN ! UPDATE STOMACH CAPACITY (BRETT, 1971)
        DF1(K,I,5) = (14.1-4.95*LOG10(DF1(K,I,1)))/100.0*DF1(K,I,1)
      ELSE
        DF1(K,I,5) = 0.022*DF1(K,I,1)
      END IF
    END DO
  END IF
  IF(DMTPFIXED) THEN
    CONTINUE
  END IF
  IF(DMTPUSER) THEN
    READ(FXNFN(3),'(2F8.0)') F1J,F1M
         DF1(:,I,1) = F1M
         IF(INT(JDAY).NE.INT(F1J)) THEN
      PRINT *,'POSSIBLE PRESCRIBED MASS ERROR :',F1J,JDAY
    END IF
  END IF
END IF
END SUBROUTINE DAILY_GROWTH

!****************************************************************************************************
******************************
!**                                       S U B R O U T I N E   F I S H O U T P U T  D A I L Y
**
!****************************************************************************************************
******************************

SUBROUTINE FOUTPUT_DAILY
USE MAINW2; USE FISH; USE FISH2;USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE DIAGNOSTIC; USE
ROOSEVELT; USE MOVEMENT

  IF(FISHDIAG) THEN
    DO K = KTI(I),KBI(I)
           WRITE(BIOOUTFN(1),77771)
JDAY,I,F_G(K,I),F1(K,I,1),CELL_PER(I),FULLSTO(K,I),VISIBLE(K,I),T1Z(K,I)
         END DO
         77771 FORMAT(F8.3,X,I8,X,F8.4,X,2(F8.2,X),I8,X,2(F8.2,X))
         77871 FORMAT(F8.3,X,I8,X,F8.4,X,2(F8.2,X),I8,X,2(F8.2,X),F8.5)
    IF(SURFDIAG) THEN
```

```
           K = KTI(I)
      WRITE(BIOOUTFN(16),77771)
JDAY,I,F_G(K,I),F1(K,I,1),CELL_PER(I),FULLSTO(K,I),VISIBLE(K,I),T1Z(K,I)
         END IF
         IF(BESTCALC) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(2),77871)
JDAY,I,BF_GI(I),BF1(K,I,1),BCELL_PER(I),BFULLSTOI(I),BVISIBLE(I),T1BZ(I),GAMMAFDC(K,I)
         END IF
         IF(DIELCALC) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(3),77771)
JDAY,I,DF_GI(I),DF1(K,I,1),DCELL_PER(I),DFULLSTOI(I),DVISIBLE(I),T1Z(K,I)
         END IF
  END IF ! FISHDIAG
  IF(BIOPARDIAG) THEN
    DO K = KTI(I),KBI(I)
           WRITE(BIOOUTFN(4),77772)
JDAY,I,F_G(K,I),F_D(K,I),F_R(K,I),F_S(K,I),F_W(K,I),F_U(K,I),F_F(K,I)
         END DO
         77772 FORMAT(F8.3,X,I8,X,7(F8.1,X))
    IF(SURFDIAG) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(17),77772) JDAY,I,F_G(K,I),F_D(K,I),F_R(K,I),F_S(K,I),F_W(K,I),F_U(K,I),F_F(K,I)
         END IF
         IF(BESTCALC) THEN
           K = KTI(I)
           WRITE(BIOOUTFN(5),77772)
JDAY,I,BF_GI(I),BF_DI(I),BF_RI(I),BF_SI(I),BF_WI(I),BF_UI(I),BF_FI(I)
         END IF
         IF(DIELCALC) THEN
           K = KTI(I)
           WRITE(BIOOUTFN(6),77772)
JDAY,I,DF_GI(I),DF_DI(I),DF_RI(I),DF_SI(I),DF_WI(I),DF_UI(I),DF_FI(I)
         END IF
  END IF ! BIOPARDIAG
  IF(CONSDIAG) THEN
    DO K = KTI(I),KBI(I)
           WRITE(BIOOUTFN(7),77773)
JDAY,I,CEFF(K),AVEC(K,I),MINC(K,I),MAXC(K,I),DAYC(K,I),DAYCM(K,I),DIET(K,I,1),DIET(K,I,2),&
             DIET(K,I,3),FCONMAXJ(K,I),FCONMAXGG(K,I),FCONJ(K,I),FCONGG(K,I),FCONP(K,I)
         END DO
         77773 FORMAT(F8.3,X,I8,X,5(F8.1,X),F8.2,X,3(F8.2,X),2(F8.1,X,F8.4,X),F8.3,X)
         77873 FORMAT(F8.3,X,I8,X,5(F8.1,X),F8.2,X,3(F8.2,X),2(F8.1,X,F8.4,X),2(F8.3,X))
    IF(SURFDIAG) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(18),77773)
JDAY,I,CEFF(K),AVEC(K,I),MINC(K,I),MAXC(K,I),DAYC(K,I),DAYCM(K,I),DIET(K,I,1),DIET(K,I,2),&
             DIET(K,I,3),FCONMAXJ(K,I),FCONMAXGG(K,I),FCONJ(K,I),FCONGG(K,I),FCONP(K,I)
         END IF
         IF(BESTCALC) THEN
           K = KTI(I)
           WRITE(BIOOUTFN(8),77873)
JDAY,I,CEFF(K),BAVEC(I),BMINC(I),BMAXC(I),BDAYCI(I),BDAYCMI(I),BDIETI(I,1),BDIETI(I,2),BDIETI(I,3),&
             BFCONMAXJI(I),BFCONMAXGGI(I),BFCONJI(I),BFCONGGI(I),BFCONPI(I),T1BZ(I)
         END IF
    IF(DIELCALC) THEN  ! NEED TO ADD TERMS
      K = KTI(I)
      WRITE(BIOOUTFN(9),77773)
JDAY,I,CEFF(K),DAVEC(I),DMINC(I),DMAXC(I),DDAYCI(I),DDAYCMI(I),DDIETI(I,1),DDIETI(I,2),DDIETI(I,3),&
        DFCONMAXJI(I),DFCONMAXGGI(I),DFCONJI(I),DFCONGGI(I),DFCONPI(I)
    END IF
  END IF ! CONSDIAG
  IF(DIGDIAG) THEN
    DO K = KTI(I),KBI(I)
           WRITE(BIOOUTFN(10),77774)
JDAY,I,F_D(K,I),F_DINI(K,I),F_DCON(K,I),F_DUNDIG(K,I),F1(K,I,3),F1(K,I,5),F1(K,I,4)
         END DO
         77774 FORMAT(F8.3,X,I8,X,4(F8.1X),3(F8.2,X))
    IF(SURFDIAG) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(19),77774)
JDAY,I,F_D(K,I),F_DINI(K,I),F_DCON(K,I),F_DUNDIG(K,I),F1(K,I,3),F1(K,I,5),F1(K,I,4)
         END IF
         IF(BESTCALC) THEN ! ADD THE DIGESTIVE DIAGNOSTIC TERMS TO THE CODE
           K = KTI(I)
           WRITE(BIOOUTFN(11),77774)
JDAY,I,BF_DI(I),F_DINI(K,I),F_DCON(K,I),F_DUNDIG(K,I),BF1(K,I,3),BF1(K,I,5),BF1(K,I,4)
         END IF
```

```
    IF(DIELCALC) THEN   ! NEED TO ADD TERMS
      K = KTI(I)
      WRITE(BIOOUTFN(12),77774)
JDAY,I,DF_DI(I),F_DINI(K,I),F_DCON(K,I),F_DUNDIG(K,I),DF1(K,I,3),DF1(K,I,5),DF1(K,I,4)
    END IF
  END IF ! DIGDIAG
  IF(RESPDIAG) THEN
    DO K = KTI(I),KBI(I)
           WRITE(BIOOUTFN(13),77775) JDAY,I,F_R(K,I),FACTAVE(K,I),FVELAVE(K,I)
         END DO
         77775 FORMAT(F8.3,X,I8,X,F8.1,X,2(F8.3,X))
    IF(SURFDIAG) THEN
           K = KTI(I)
      WRITE(BIOOUTFN(20),77775) JDAY,I,F_R(K,I),FACTAVE(K,I),FVELAVE(K,I)
         END IF
         IF(BESTCALC) THEN
           K = KTI(I)
           WRITE(BIOOUTFN(14),77775) JDAY,I,BF_RI(I),BFACTAVE(I),BFVELAVE(I)
         END IF
         IF(DIELCALC) THEN
           K = KTI(I)
           WRITE(BIOOUTFN(15),77775) JDAY,I,DF_RI(I),DFACTAVE(I),DFVELAVE(I)
         END IF
  END IF ! RESPDIAG
GOTO 2121
  IF(SINGLEDIAG.AND.DEPTHCALC) THEN
    IF(I.EQ.SINIBIO) THEN
      DO II = 1, BESTSTEP
             WRITE(BIOOUTFN(21),'(4I8)') INT(JDAY-0.5), I, BESTK(I,II),DIELK(I,II)
      END DO
    END IF
  END IF
2121 CONTINUE
RETURN
END SUBROUTINE FOUTPUT_DAILY

!******************************************************************************************************
******************************
!**                                          S U B R O U T I N E    B I O E X P T R A N S F O R M
**
!******************************************************************************************************
******************************

! KTI,KBI ARE NOT W2 VALUES; NEED TO UPDATE TO INCORPORATE INTO W2
SUBROUTINE BIOEXPTRANSFORM
USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE DIAGNOSTIC; USE
ROOSEVELT; USE MOVEMENT
GOTO 5001
REWIND(BIOINFN(JI))
READ(BIOINFN(JI),'(A72)') FRED
FIRSTK = -1; LASTK = -1
DO K = 1,10000000
  READ(BIOINFN(JI),'(F8.0)') ZDAY1
  IF(ZDAY1.LT.FBIODAYLST) FIRSTK = K
  IF(ZDAY1.LT.FBIODAYNXT) LASTK = K
  IF(ZDAY1.GE.FBIODAYNXT) EXIT
END DO
! POSITION CURSOR TO READ THE INTENDED DAY
REWIND(BIOINFN(JI))
READ(BIOINFN(JI),'(A72)') FRED
DO K = 1, FIRSTK
  READ(BIOINFN(JI),'(F8.0)') ZDAY1
END DO
KTI(I) = 2; KBI(I) = LASTK-FIRSTK
IF(KBI(I).LT.KTI(I)) KBI(I) = KTI(I)
5001 CONTINUE
IF(FIRSTREAD(JI)) THEN
 REWIND(BIOINFN(JI))
 READ(BIOINFN(JI),'(A72)') FRED
 FIRSTREAD(JI) = .FALSE.
END IF
 DO K = 2,10000000
   READ(BIOINFN(JI),'(F8.0)') ZDAY1
   IF(ZDAY1.LT.FBIODAYNXT) LASTK = K
   IF(ZDAY1.GE.FBIODAYNXT) EXIT
 END DO
 DO K = 2,LASTK+1
   BACKSPACE(BIOINFN(JI))
 END DO
```

```
KTI(I) = 2; KBI(I) = LASTK
DO K = KTI(I),KBI(I) ! WILL NEED TO CONVERT C2 (:,:,JZ) FROM NZP TO NZOOS,NZOOE FOR MAIN W2 PROGRAM
  READ(BIOINFN(JI),'(F8.0,8X,3F8.2,3F8.3,I8,2F8.0,A20)') ZDAY1,DEPTHM(K,I),T1(K,I),GAMMA(K,I),&
       (C2(K,I,JZ),JZ=1,NZP),SEGK,BH(K,I),EL(K,I),GREGORY(GRCT)
 ! T1Z(K,I) = T1Z(K,I) - 1.0 !temperature sensitivity
  T1Z(K,I) = MAX(T1(K,I)-1,0.01) ! TEMPERATURES BELOW FREEZING
  DO JJZ = 1,NZP
    C1Z(K,I,JJZ)=C2(K,I,JJZ)/MZOO(JJZ)/1000.0 !C1Z HAS UNITS OF ORGANISMS PER M3 ! CONVERT FROM MG TO
G
  END DO
  ! AVAILABILITY COMPUTATION (MAZUR)
  IF(THRESHOLD) THEN
    DAP_IN = C2(K,I,3)*1000.0
    IF(DAP_IN.GE.THRESHV) THEN
          THRESHFEED(K) = .TRUE.
      CEFF(K) = C1Z(K,I,3)*ZAVAIL(3)
    ELSE
          THRESHFEED(K) = .FALSE.
      CEFF(K) = (C1Z(K,I,1)*ZAVAIL(1)+C1Z(K,I,2)*ZAVAIL(2)+C1Z(K,I,3)*ZAVAIL(3))
    END IF
  ELSE
    CEFF(K) = (C1Z(K,I,1)*ZAVAIL(1)+C1Z(K,I,2)*ZAVAIL(2)+C1Z(K,I,3)*ZAVAIL(3))
  END IF !THRESHOLD
END DO
END SUBROUTINE BIOEXPTRANSFORM

!****************************************************************************************************
******************************
!**                                          S U B R O U T I N E   G E T   F I S H   D A T A
**
!****************************************************************************************************
******************************

SUBROUTINE GETFISHDATA
USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE DIAGNOSTIC; USE ROOSEVELT; USE MOVEMENT
  NUNIT = NUNIT+1; BIOCON = NUNIT
  OPEN(BIOCON,FILE='W2_BIO_CON.NPT',STATUS='OLD')
  DO II = 1,8
   READ(BIOCON,*)
  END DO
  READ(BIOCON,'(/(8X,A8,I8,4A8))') FCALC,FUF,FDIAGC,BESTC,DIELC,CMAXC
   FISHCALC = FCALC == '      ON'  ; FDIAG = FDIAGC == '      ON';BESTCALC = BESTC == '      ON'  ;
DIELCALC = DIELC == '      ON'
   CMAXCALC = CMAXC == '      ON'
  READ(BIOCON,'(//(8X,2F8.0))') JDAY, JEND
  READ(BIOCON,'(//(8X,8F8.0))') FISHT1,FISHT2,FISHT3,FISHT4,FISHK1,FISHK2,FISHK3,FISHK4
   FG1=(1/(FISHT2-FISHT1))*LOG((FISHK2*(1-FISHK1))/(FISHK1*(1-FISHK2)))
   FG2=(1/(FISHT4-FISHT3))*LOG((FISHK3*(1-FISHK4))/(FISHK4*(1-FISHK3)))
  READ(BIOCON,'(//(8X,F8.0))') FOXYCAL
  READ(BIOCON,'(//(8X,3F8.0))') (F1I(II),II=1,3)
   F1(:,:,1) = F1I(1); F1(:,:,2) = F1I(2); F1(:,:,3) = F1I(3)
  READ(BIOCON,'(/)')
  READ(BIOCON,'(:8X,9F8.0)') (LZOO(II),II = 1,3)
  READ(BIOCON,'(/)')
  READ(BIOCON,'(:8X,9F8.0)') (MZOO(II),II = 1,3)
  READ(BIOCON,'(/)')
  READ(BIOCON,'(:8X,9F8.0)') (EZOO(II),II = 1,3)
  READ(BIOCON,'(//(8X,4F8.0,A8,F8.0,I8,F8.0))')
HANDLE,FVELA,FVELB,FVELE,THRESHC,THRESHV,THRESHZ,DIELLUX
   THRESHOLD = THRESHC == '      ON'
  READ(BIOCON,'(//(8X,A8))') FGPC
   FGPPLOT = FGPC == '      ON'
  READ(BIOCON,'(//(8X,F8.0))') FGPD
  READ(BIOCON,'(//(8X,F8.0))') FGPF
  READ(BIOCON,'(//(8X,3A8))') GENMTP,BESTMTP,DIELMTP
   GMTPCELL = GENMTP  == '    CELL';GMTPFXN = GENMTP  == '     FXN';GMTPUSER = GENMTP  == '
USER';GMTPFIXED = GENMTP  == '   FIXED'
   BMTPSEG  = BESTMTP == '     SEG';BMTPFXN = BESTMTP == '     FXN';BMTPUSER = BESTMTP == '
USER';DMTPFIXED = BESTMTP == '   FIXED'
   DMTPSEG  = DIELMTP == '     SEG';DMTPFXN = DIELMTP == '     FXN';DMTPUSER = DIELMTP == '
USER';BMTPFIXED = DIELMTP == '   FIXED'
   IF(GMTPCELL.OR.GMTPFXN.OR.GMTPUSER.OR.GMTPFIXED) GMTOK = .TRUE.
   IF(BMTPSEG.OR.BMTPFXN.OR.BMTPUSER.OR.BMTPFIXED) BMTOK = .TRUE.
   IF(DMTPSEG.OR.DMTPFXN.OR.DMTPUSER.OR.DMTPFIXED) DMTOK = .TRUE.
   IF(.NOT.GMTOK) THEN
     PRINT *,'GENERAL FISH MASS TYPE NOT RECOGNIZED: ',GENMTP
         STOP
   END IF
   IF(.NOT.BMTOK) THEN
```

```
     PRINT *,'BEST FISH MASS TYPE NOT RECOGNIZED: ',BESTMTP
         STOP
   END IF
   IF(.NOT.DMTOK) THEN
     PRINT *,'FORAGING FISH MASS TYPE NOT RECOGNIZED: ',DIELMTP
         STOP
   END IF
  READ(BIOCON,'(//(8X,9F8.0))') GIM,BIM,DIM,GALP,BALP,DALP,GTI,BTI,DTI
  READ(BIOCON,'(//(8X,7A8))') FISHC, BIOPARC, CONSC, DIGC, RESPC, SURFC,DEPTHC
   FISHDIAG = FISHC  == '      ON'; BIOPARDIAG = BIOPARC  == '      ON'; CONSDIAG = CONSC   == '
ON'
   DIGDIAG  = DIGC   == '      ON'; RESPDIAG   = RESPC    == '      ON'; SURFDIAG = SURFC   == '
ON'
   DEPTHCALC= DEPTHC == '      ON'
  READ(BIOCON,'(//(8X,A8,2I8,A8))') SINGLEC, SINGFN, SINIBIO,TLC
   SINGLEDIAG   = SINGLEC    == '      ON'
   IF(SINGLEDIAG) TLCALC = TLC    == '      ON'
   IF(TLCALC) THEN
     NUNIT = NUNIT + 1; TLCALCFN = NUNIT
         OPEN(TLCALCFN,FILE='TLDIAG.DAT',STATUS='UNKNOWN')
         WRITE(TLCALCFN,'(2A8)') '    TEMP','      TL'
   END IF
  READ(BIOCON,'(//(8X,A72))') ZAVFNAME
   FRED = ADJUSTL(ZAVFNAME)
   L      = LEN_TRIM(FRED)
   ZAVFNAME = FRED(1:L)
   NUNIT = NUNIT+1; ZAVFN = NUNIT
  READ(BIOCON,'(/)')
   DO II = 1,NWB
     NUNIT = NUNIT+1; FGPFN = NUNIT
     READ(BIOCON,'(8X,A72)') FGPFNAME(II)
      FRED = ADJUSTL(FGPFNAME(II))
      L      = LEN_TRIM(FRED)
      FGPFNAME(II) = FRED(1:L)
   END DO
   READ(BIOCON,'(//(8X,A72))') FXNFNAME(1)
   READ(BIOCON,'((8X,A72))')   FXNFNAME(2)
   READ(BIOCON,'((8X,A72))')   FXNFNAME(3)
   DO II = 1,3
     FRED = ADJUSTL(FXNFNAME(II))
     L      = LEN_TRIM(FRED)
     FXNFNAME(II) = FRED(1:L)
     NUNIT = NUNIT+1; FXNFN(II) = NUNIT
   END DO
   IF(GMTPUSER) THEN
     OPEN(FXNFN(1),FILE=FXNFNAME(1),STATUS='OLD')
         READ(FXNFN(1),'(///)')
   END IF
   IF(BMTPUSER) THEN
     OPEN(FXNFN(2),FILE=FXNFNAME(2),STATUS='OLD')
         READ(FXNFN(2),'(///)')
   END IF
   IF(DMTPUSER) THEN
     OPEN(FXNFN(3),FILE=FXNFNAME(3),STATUS='OLD')
         READ(FXNFN(3),'(///)')
   END IF
CLOSE(BIOCON)
RETURN
END SUBROUTINE GETFISHDATA

!*****************************************************************************************************
******************************
!**                                         S U B R O U T I N E   A N I M A T I O N   D A T A
**
!*****************************************************************************************************
******************************

SUBROUTINE ANIMATION_DATA
USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE ROOSEVELT; USE
MOVEMENT

NELEM = 0
DO JJI = 1,NIBIO
 IF(ANIMEXP(JJI)) THEN
  II = IBIO(JJI)
  DO K = KTI(II),KBI(II)
   NELEM = NELEM+1
  END DO
 END IF
```

```
END DO
NNODE = NELEM*4
WRITE(ANIMFN,906) NNODE,NELEM
906 FORMAT('ZONE N=',i5,' E=',i6,', F=FEPOINT, ET=QUADRILATERAL')
LEFT = 0.0
DO JJI = 1,NIBIO
 IF(ANIMEXP(JJI)) THEN
  II = IBIO(JJI)
  DO K = KTI(II),KBI(II)
    IF(JJI.EQ.1) THEN
          X1(K,II) = 0.0; X4(K,II) = 0.0
    ELSE
          X1(K,II) = LEFT(1); X4(K,II) = LEFT(1)
         END IF
         X2(K,II) = DISTR(II)    ; X3(K,II) = DISTR(II)
   IF(K.EQ.KTI(I)) THEN
    Y1(K,II) = EL(K+1,II)+3  ; Y2(K,II) = EL(K+1,II)+3
    Y3(K,II) = EL(K+1,II)+1  ; Y4(K,II) = EL(K+1,II)+1
   ELSE
    Y1(K,II) = EL(K,II)+1  ; Y2(K,II) = EL(K,II)+1
    Y3(K,II) = EL(K,II)-1  ; Y4(K,II) = EL(K,II)-1
   END IF
    WRITE(ANIMFN,'(f8.1,X,f7.2,X,f7.3)') X1(K,II),Y1(K,II), F_G(K,II)
    WRITE(ANIMFN,'(f8.1,X,f7.2,X,f7.3)') X2(K,II),Y2(K,II), F_G(K,II)
         WRITE(ANIMFN,'(f8.1,X,f7.2,X,f7.3)') X3(K,II),Y3(K,II), F_G(K,II)
    WRITE(ANIMFN,'(f8.1,X,f7.2,X,f7.3)') X4(K,II),Y4(K,II), F_G(K,II)
  END DO
  LEFT(1) = DISTR(II)
 END IF
END DO
DO IM=1,NELEM
  MPOS=IM*4
  WRITE(ANIMFN,'(4I6)')MPOS-3,MPOS-2,MPOS-1,MPOS
END DO
ZONECNT=ZONECNT+1
END SUBROUTINE ANIMATION_DATA

!****************************************************************************************************
******************************
!**                                    S U B R O U T I N E   B Y   S E G M E N T   O U T P U T
**
!****************************************************************************************************
******************************

SUBROUTINE BY_SEG_OUTPUT
USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE ROOSEVELT; USE
MOVEMENT; USE DIAGNOSTIC

  WRITE(BYSEGMFN,'(F7.1,500(X,F6.2))') JDAY,(MAXM(IBIO(II)),II=1,NIBIO)
  WRITE(BYSEGGFN,'(F7.1,500(X,F6.2))') JDAY,(MAXG(IBIO(II)),II=1,NIBIO)
  IF(BESTCALC) THEN
    WRITE(BYSEGMFN2,'(F7.1,500(X,F6.2))') JDAY,(BF1(2,IBIO(II),1),II=1,NIBIO)
    WRITE(BYSEGGFN2,'(F7.1,500(X,F6.2))') JDAY,(BF_GI(IBIO(II)),II=1,NIBIO)
  END IF
  IF(DIELCALC) THEN
    WRITE(BYSEGMFN3,'(F7.1,500(X,F6.2))') JDAY,(DF1(2,IBIO(II),1),II=1,NIBIO)
    WRITE(BYSEGGFN3,'(F7.1,500(X,F6.2))') JDAY,(DF_GI(IBIO(II)),II=1,NIBIO)
  END IF
  WRITE(SURFSEGMFN,'(F7.1,500(X,F6.2))') JDAY,(F1(2,IBIO(II),1),II=1,NIBIO)
  WRITE(SURFSEGGFN,'(F7.1,500(X,F6.2))') JDAY,(F_G(2,IBIO(II)),II=1,NIBIO)
END SUBROUTINE BY_SEG_OUTPUT

!****************************************************************************************************
******************************
!**                                    S U B R O U T I N E   F I L E   S E T U P
**
!****************************************************************************************************
******************************

SUBROUTINE INITIALFILESETUP
USE MAINW2; USE FISH; USE FISH2; USE BIOEXPDATATRANSFORM; USE GROWTH_ANIMATION; USE ROOSEVELT; USE
MOVEMENT; USE DIAGNOSTIC

! *** ZOOPLANKTON AVAILABLITY ( REPLACE WITH INPUT FILE FORMAT (WILL NEED TIME CONTROL VARIABLES))
OPEN(ZAVFN,FILE=ZAVFNAME,STATUS='OLD')
READ(ZAVFN,'(//)')
ZAVJD = -9999.99
DO WHILE (ZAVJD.LT.JDAY)
  READ(ZAVFN,'(:F8.0,9F8.0)')  ZAVJD,(ZAVAIL(II),II=1,NZP)
```

```
END DO
  READ(ZAVFN,'(:F8.0,9F8.0)')  ZAVNX,(ZAVAILNX(II),II=1,NZP)
! *** ASSIGN BIOEXP DATA FILE NUMBERS AND FILENAMES
  DO JI = 1,NIBIO
   IF(FIRST_BIO(JI)) THEN
    NUNIT = NUNIT +1; BIOINFN(JI) = NUNIT
        WRITE (SEGNUM,'(I0)') JI
        SEGNUM = ADJUSTL(SEGNUM)
        L      = LEN_TRIM(SEGNUM)
        OPEN   (BIOINFN(JI),FILE='BIOEXP_'//SEGNUM(1:L)//'.opt',STATUS='OLD')
    END IF
  END DO
IF(SINGLEDIAG) THEN
  NIBIO = 1.0
  BIOINFN(1) = BIOINFN(SINGFN)
  IBIO(1) = SINIBIO
END IF

! *********   RESULTS AND DIAGNOSTIC OUTPUT FILES *******
IF(FDIAG) THEN
  IF(FISHDIAG) THEN
    NUNIT = NUNIT+1; BIOOUTFN(1) = NUNIT; OPEN(BIOOUTFN(1),FILE='BIO_FISH.DAT',STATUS='UNKNOWN')
    FHEAD(1) = 'JDAY'   ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'GROWTH'  ;FHEAD(4) = 'FMASS'   ;FHEAD(5) =
'%POS'    ;&
    FHEAD(6) = 'FULLSTO';FHEAD(7) = 'LIGHTMIN';FHEAD(8) = 'TEMP'
    WRITE(BIOOUTFN(1),'(8(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,8)
    IF(SURFDIAG) THEN
      NUNIT = NUNIT+1; BIOOUTFN(16) = NUNIT;
OPEN(BIOOUTFN(16),FILE='BIO_FISH_SURF.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(16),'(8(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,8)
         END IF
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(2) = NUNIT;
OPEN(BIOOUTFN(2),FILE='BIO_FISH_BEST.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(2),'(8(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,8)
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(3) = NUNIT;
OPEN(BIOOUTFN(3),FILE='BIO_FISH_DIEL.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(3),'(8(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,8)
         END IF
  END IF ! FISHDIAG
  IF(BIOPARDIAG) THEN
    NUNIT = NUNIT+1; BIOOUTFN(4) = NUNIT; OPEN(BIOOUTFN(4),FILE='BIO_PARA.DAT',STATUS='UNKNOWN')
    FHEAD(1) = 'JDAY'   ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'GROWTH'  ;FHEAD(4) = 'DIGEST'  ;FHEAD(5) =
'RESP'    ;&
    FHEAD(6) = 'SDA'    ;FHEAD(7) = 'WASTE'   ;FHEAD(8) = 'EXCRETE' ;FHEAD(9) = 'EGEST'
    WRITE(BIOOUTFN(4),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
    IF(SURFDIAG) THEN
      NUNIT = NUNIT+1; BIOOUTFN(17) = NUNIT;
OPEN(BIOOUTFN(17),FILE='BIO_PARA_SURF.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(17),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(5) = NUNIT;
OPEN(BIOOUTFN(5),FILE='BIO_PARA_BEST.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(5),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(6) = NUNIT;
OPEN(BIOOUTFN(6),FILE='BIO_PARA_DIEL.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(6),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
  END IF ! BIOPARDIAG
  IF(CONSDIAG) THEN
    NUNIT = NUNIT+1; BIOOUTFN(7) = NUNIT; OPEN(BIOOUTFN(7),FILE='BIO_CONS.DAT',STATUS='UNKNOWN')
    FHEAD(1) = 'JDAY'    ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'PREYDEN' ;FHEAD(4) = 'AVEC'    ;FHEAD(5) =
'MINC'    ;&
    FHEAD(6) = 'MAXC'    ;FHEAD(7) = '#CON'    ;FHEAD(8) = 'MASSCON' ;FHEAD(9) = 'DIET1'
;!FHEAD(10)= 'DIET1'   ;&
    FHEAD(10)= 'DIET2'   ;FHEAD(11)= 'DIET3'   ;FHEAD(12)= 'MAXC_J'  ;FHEAD(13)= 'MAXC_G/G';FHEAD(14)=
'ACTC_J'  ;&
         FHEAD(15)= 'ACTC_G/G';FHEAD(16)= 'P_VALUE'
         WRITE(BIOOUTFN(7),'(16(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,16)
    IF(SURFDIAG) THEN
      NUNIT = NUNIT+1; BIOOUTFN(18) = NUNIT;
OPEN(BIOOUTFN(18),FILE='BIO_CONS_SURF.DAT',STATUS='UNKNOWN')
          WRITE(BIOOUTFN(18),'(16(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,16)
         END IF
```

```
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(8) = NUNIT;
OPEN(BIOOUTFN(8),FILE='BIO_CONS_BEST.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(8),'(16(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,16)
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(9) = NUNIT;
OPEN(BIOOUTFN(9),FILE='BIO_CONS_DIEL.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(9),'(16(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,16)
         END IF
  END IF ! CONSDIAG
  IF(DIGDIAG) THEN
    NUNIT = NUNIT+1; BIOOUTFN(10) = NUNIT; OPEN(BIOOUTFN(10),FILE='BIO_DIG.DAT',STATUS='UNKNOWN')
    FHEAD(1) = 'JDAY'    ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'DIG_J'   ;FHEAD(4) = 'INITIAL' ;FHEAD(5) =
'CONSUMED';&
    FHEAD(6) = 'UNDIGEST';FHEAD(7) = 'STOMCON' ;FHEAD(8) = 'STOMCAP' ;FHEAD(9) = 'EDENSITY'
         FHEAD(16)= 'ACTC_G/G';FHEAD(17)= 'P_VALUE'
         WRITE(BIOOUTFN(10),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
    IF(SURFDIAG) THEN
      NUNIT = NUNIT+1; BIOOUTFN(19) = NUNIT;
OPEN(BIOOUTFN(19),FILE='BIO_DIG_SURF.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(19),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(11) = NUNIT;
OPEN(BIOOUTFN(11),FILE='BIO_DIG_BEST.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(11),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(12) = NUNIT;
OPEN(BIOOUTFN(12),FILE='BIO_DIG_DIEL.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(12),'(9(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,9)
         END IF
  END IF ! DIGDIAG
  IF(RESPDIAG) THEN
    NUNIT = NUNIT+1; BIOOUTFN(13) = NUNIT; OPEN(BIOOUTFN(13),FILE='BIO_RESP.DAT',STATUS='UNKNOWN')
    FHEAD(1) = 'JDAY'    ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'RESP_J'  ;FHEAD(4) = 'FACTAVE' ;FHEAD(5) =
'FVELAVE'
         WRITE(BIOOUTFN(13),'(5(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,5)
    IF(SURFDIAG) THEN
      NUNIT = NUNIT+1; BIOOUTFN(20) = NUNIT;
OPEN(BIOOUTFN(20),FILE='BIO_RESP_SURF.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(20),'(5(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,5)
         END IF
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(14) = NUNIT;
OPEN(BIOOUTFN(14),FILE='BIO_RESP_BEST.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(14),'(5(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,5)
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BIOOUTFN(15) = NUNIT;
OPEN(BIOOUTFN(15),FILE='BIO_RESP_DIEL.DAT',STATUS='UNKNOWN')
           WRITE(BIOOUTFN(15),'(5(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,5)
         END IF
  END IF ! RESPDIAG
  IF(SINGLEDIAG) THEN
    IF(DEPTHCALC) THEN
     NUNIT = NUNIT +1; BIOOUTFN(21) = NUNIT;
OPEN(BIOOUTFN(21),FILE='FORAGING_DEPTHS.DAT',STATUS='UNKNOWN')
     FHEAD(1) = 'JDAY'    ;FHEAD(2) = 'SEG'     ;FHEAD(3) = 'BESTDTH'  ;FHEAD(4) = 'DIELDTH'
          WRITE(BIOOUTFN(21),'(4(A8,1X))') (ADJUSTR(FHEAD(TT)), TT = 1,4)
    END IF
  END IF
END IF ! FDIAG

! ***********  GROWTH ANIMATION OUTPUT FILE  *************************
    NUNIT = NUNIT+1; ANIMFN = NUNIT
    OPEN(ANIMFN,FILE='FGP_ANIM.DAT',STATUS='UNKNOWN') ! BASIC OUTPUT
  WRITE(ANIMFN,'(A52)') HEADER1
  WRITE(ANIMFN,'(A52)') HEADER2
    IF(BESTCALC) THEN
      NUNIT = NUNIT+1; ANIMFN2 = NUNIT
      OPEN(ANIMFN2,FILE='FGP_ANIM_BEST.DAT',STATUS='UNKNOWN') ! BEST LOCATION OUTPUT
      WRITE(ANIMFN2,'(A52)') HEADER1
      WRITE(ANIMFN2,'(A52)') HEADER2
    END IF
  ! PREP DISTANCE VALUES (TEMPORARY APPROACH)
  NUNIT = NUNIT+1
  OPEN(NUNIT,FILE='DLX.PRN',STATUS='OLD')
```

```
  READ(NUNIT,*)
  DO J = 1,1000
    READ(NUNIT,'(I8,8X,2F8.0)',END=107) I,VLL,VLR
    DISTL(I) = VLL; DISTR(I) = VLR
  END DO
107 CONTINUE
  ! REMOVE ZEROS
  DO J = 2,IMX
    IF(DISTR(J).EQ.0.0) THEN
           DISTR(J) = DISTR(J-1)
         END IF
  END DO
  ! FIX ERRORS
  DO II = 2,NIBIO
    IF(DISTR(IBIO(II-1)).EQ.0.0) THEN
           PRINT *,'ZERO ', II-1, IBIO(II-1)
          ! DISTR(IBIO(II-1) = DISTR(IBIO(II
         END IF
    DISTL(IBIO(II)) = DISTR(IBIO(II-1))
         IF(DISTL(IBIO(II)).NE.DISTR(IBIO(II-1)) ) THEN
           PRINT *,'NE ', II, IBIO(II)
         END IF
  END DO
 CLOSE(NUNIT)

! *********** BYSEG FILE PREP  ******************
 IF(BYSEG) THEN
    NUNIT = NUNIT+1; BYSEGMFN = NUNIT
    OPEN(BYSEGMFN,FILE='MASS.DAT',STATUS='UNKNOWN')
    NUNIT = NUNIT+1; BYSEGGFN = NUNIT
    OPEN(BYSEGGFN,FILE='GROWTH.DAT',STATUS='UNKNOWN')
         WRITE(BYSEGMFN,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
    WRITE(BYSEGGFN,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
         IF(BESTCALC) THEN
      NUNIT = NUNIT+1; BYSEGMFN2 = NUNIT
      OPEN(BYSEGMFN2,FILE='MASS_BEST.DAT',STATUS='UNKNOWN')
      NUNIT = NUNIT+1; BYSEGGFN2 = NUNIT
      OPEN(BYSEGGFN2,FILE='GROWTH_BEST.DAT',STATUS='UNKNOWN')
           WRITE(BYSEGMFN2,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
      WRITE(BYSEGGFN2,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
      NUNIT = NUNIT+1; BESTDIAGFN = NUNIT
           OPEN(BESTDIAGFN,FILE='BESTDIAG.DAT',STATUS='UNKNOWN')
         END IF
         IF(DIELCALC) THEN
      NUNIT = NUNIT+1; BYSEGMFN3 = NUNIT
      OPEN(BYSEGMFN3,FILE='MASS_DIEL.DAT',STATUS='UNKNOWN')
      NUNIT = NUNIT+1; BYSEGGFN3 = NUNIT
      OPEN(BYSEGGFN3,FILE='GROWTH_DIEL.DAT',STATUS='UNKNOWN')
           WRITE(BYSEGMFN3,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
      WRITE(BYSEGGFN3,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
         END IF
    ! SURFACE SEGMENT
    NUNIT = NUNIT+1; SURFSEGMFN = NUNIT
    OPEN(SURFSEGMFN,FILE='MASS_SURF.DAT',STATUS='UNKNOWN')
         NUNIT = NUNIT+1; SURFSEGGFN = NUNIT
    OPEN(SURFSEGGFN,FILE='GROWTH_SURF.DAT',STATUS='UNKNOWN')
         WRITE(SURFSEGMFN,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
    WRITE(SURFSEGGFN,'(A7,500(I6,A))') '   JDAY',((IBIO(II),'S'),II = 1,NIBIO)
  END IF
! *** LIGHTOUT
    NUNIT = NUNIT+1; LIGHTNUM=NUNIT
         OPEN(LIGHTNUM,FILE='LIGHTOUT.PRN',STATUS='OLD')
         FIRSTLIGHT = .FALSE.
    READ(LIGHTNUM,'(10X,F10.0,20X,E10.2)') LJDAY1,LUX1
         READ(LIGHTNUM,'(10X,F10.0,20X,E10.2)') LJDAY2,LUX2

END SUBROUTINE INITIALFILESETUP
```