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Temperature Simulation of the Snake River Above Lower Granite Dam Using Transect Measurements and the CE-QUAL-W2 Model

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EPA has developed this report as part of a multi-agency effort to improve our understanding of temperature regimes in the Columbia and Snake Rivers. For more information about this work, visit the EPA Region 10 website for the Total Maximum Daily Load for the Columbia and Snake River mainstems:

www.epa.gov/r10earth/columbiamainstemtmdl/htm

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Introduction

EPA has recently evaluated water temperature regimes of the mainstem Snake River using transect measurements and the RBM10 one-dimensional heat budget model (Cope, 2001). This work relied on detailed monitoring information collected by the Columbia River Inter-Tribal Fish Commission (CRITFC) and Fisheries and Aquatic Sciences in the early 1990s at 18 locations in the Snake River (Karr et al, 1998). This transect data can also be used to examine and simulate vertical temperature structures in the mainstem river. In this report, the two-dimensional CE-QUAL-W2 model framework developed by the U.S. Army Corps of Engineers (Cole and Buchak, 1995) is used to simulate temperature regimes in Lower Granite Pool, from the confluence of the Clearwater and Snake Rivers to Lower Granite Dam. The study period is July through October of 1992.

Transect Measurements

Long term monitoring of temperature has been conducted since the construction of the Snake River dams, but these temperature measurements have been collected at single, fixed depths in the vicinity of the dams (e.g, forebays, tailraces, and scroll cases). Evaluation of the performance of heat budget models has been hampered somewhat by the absence of transect data (Yearsley 2001, Cope 2001). The transect data from the CRITFC study offers an opportunity to evaluate model performance with a detailed sampling of cross-sectional average temperatures and vertical temperature gradients.

The data used for this evaluation was collected from July 1 to October 22, 1992. Transect measurements were collected at 14 stations in the lower Snake River and four stations in the Clearwater River (see Figure 1). The distance between each Snake River station is approximately 10 miles, with some adjusted distances based on dam locations. Measurements were collected at varying time intervals ranging from one day to several days between samples.

At each transect, temperature was measured at three locations (1/4, 1/2, and 3/4 river width) and at four depths (surface, 1/3 river depth, 2/3 river depth, and near bottom). Because of the varying depth to the bottom at the three sampling locations of a particular transect, the sampling depths can vary widely between the monitoring locations of a given transect. CE-QUAL-W2 is a two-dimensional modeling framework that simulates laterally-averaged temperatures for a waterbody. In this evaluation, all of the discrete temperature measurements are included in the vertical profiles for comparison to CE-QUAL-W2 estimates. For this reason, the vertical plots of temperature at a given transect location may have duplicate measurements at or near the same depth. In some cases, the variation in duplicate samples at a given depth indicates that there can be significant lateral variation in water temperature. These variations are not simulated by a two-dimensional model framework.

In addition to comparisons between measured and simulated vertical profiles within the impoundment, the simulated outflow temperature from Lower Granite Dam was compared to the transect measurements at the site downstream of the dam. This was accomplished by calculating the area-weighted average temperature at this transect site (Station 6) over time and then comparing it to the single-value outflow temperature from the CE-QUAL-W2 simulation.

Dworshak Operations

The release pattern from Dworshak Dam over the study period can be divided into three flow augmentation periods. The first period began July 5th, when outflow was increased from approximately 1,600 cfs to 11,000 cfs and held at that level until July 11th. After dropping back to approximately 2,000 cfs for three days, the second augmentation period began on July 15th, with outflows of approximately 20,000 cfs for three days (and 10,000 cfs on the fourth day). After this second augmentation period ended, the period from July 19th to September 9th was characterized by low outflows ranging from approximately 1,500 cfs to 3,000 cfs. A third augmentation period began on September 10, with outflows increased to approximately 12,000 cfs for eleven days, after which outflows were reduced to 1,600 cfs. A graphical depiction of the outflows from Dworshak is included in Figure 4.

CE-QUAL-W2 Model Representation

Waterbody Segmentation for CE-QUAL-W2

The Snake River from the confluence of the Clearwater River to Lower Granite Dam is represented by 34 longitudinal segments with a uniform length of one mile. In the vertical dimension, the river is divided into cells with a uniform layer thickness of 6 feet. At its deepest point, the river is represented by 22 vertical layers. A graphic of the model grid is provided in Figure 2.

Impoundment Bathymetry

Cross-sectional profiles of the river bottom were measured at approximately 40 locations in 1995 and 1996, but the measurements are not uniformly segmented as is the model representation of the system. In order to provide width/depth relationships for CE-QUAL-W2 grid cells with uniform lengths equal to one mile, the available cross-sections were interpolated to provide uniformly spaced cross-sections using the HEC-RAS model (U.S. Army Corps of Engineers, 2001).

The width/depth relationships were estimated by iteratively running HEC-RAS with the water elevation fixed at the depths of each model layer (i.e., from the maximum pool elevation to the bottom in 6 foot increments). Very low flows were used to provide a flat water surface. The resulting top-width outputs from these HEC-RAS runs provide the desired widths associated with each vertical layer of the CE-QUAL-W2 model. The bathymetry and control files with the pertinent geometry information are included in Appendix C of this report.

The elevation/pool volume relationship for the geometric grid representation of Lower Granite Pool in CE-QUAL-W2 was compared to the elevation/pool volume relationship used in HEC-5Q modeling assessments in the Columbia River System Operation Review (USACE, BPA, BOR, 1994). This comparison is shown in Figure 3.

Boundary Characteristics

The upstream boundary segment of the model represents the Snake River immediately downstream of the confluence of the Snake River and the Clearwater River. Each river is treated as a distinct input. In CE-QUAL-W2 terminology, the Snake River is a branch boundary, and the Clearwater River is a tributary input.

River Flows

Daily average river flows for the upstream boundary were obtained from the National Water Information System website maintained by the U.S. Geological Survey (USGS). Snake River flows into the upstream model segment are represented by daily flows for 1992 from the USGS station at Anatone, Washington. The daily flows recorded at the USGS station at Spalding, Idaho, were used as inputs from Clearwater River. Figure 4 depicts the outflow from Dworshak Dam during the study period, and Figure 5 depicts the boundary input flows for the Clearwater and Snake Rivers.

For the downstream boundary, powerhouse flows and spill flows from Lower Granite Dam are recorded by the U.S. Army Corps of Engineers (Corps) and shared with the public on a University of Washington website (DART - Data Access in Real Time, http://www.cqs.washington.edu/dart/river.html).

The Corps also records the water surface elevation at the dam. This information can be used in conjunction with river flows and geometry information from a pre-processing module of CE-QUAL-W2 to perform a water balance on the model system. The pre-processor outputs elevation/volume relationships for the model system. In order to match the simulated water surface elevation to the measured elevation, the measured inflows and outflows were adjusted. When the volume was too high, the powerhouse outflow was increased by the necessary amount to match the daily average elevation. When the volume was too low, the Snake and Clearwater flows were increased by the necessary amount to match the elevation.

Another option, simply adjusting the outflow to match the elevation, was evaluated. The model runs using these alternate outflows did not substantially alter the simulated temperatures of the outlet, so the flows from the first adjustment method above were used for the simulations reported in this document.

River Temperatures

The CRITFC study (Karr et al, 1998) included temperature sampling in the Snake River above the Clearwater confluence (RM 140.5) and in the Clearwater River near its mouth (RM 0.8). As discussed above, at each transect, temperature was measured at three locations (1/4, 1/2, and 3/4 river width) and at four depths (surface, 1/3 river depth, 2/3 river depth, and near bottom). In order to calculate a cross-sectional average temperature for the CE-QUAL-W2 boundary representation, rectangular cross sections around each sampling point were assumed and the area-weighted average temperature was calculated for the transect. The resulting discrete sample values were input into CE-QUAL-W2 as daily average temperatures (Figure 6).

CE-QUAL-W2 has two options for placement of boundary inflows to the model layers. Inflows can be placed evenly from top to bottom in the boundary cell layers of the model, or they can be placed according to their relative density. Both options were evaluated, and even distribution (top-to-bottom) resulted in slightly better agreement between simulated and measured temperatures below the dam. The only notable difference between the two options was a pattern of colder outlet temperatures during flow augmentation in the model runs using density-based placement.

As discussed above, transect measurements were collected at varying time intervals ranging from one day to several days between samples. Gaps in the measurement record were filled by linear interpolation between sample points.

CRITFC also sampled temperatures below Lower Granite Dam (RM 101). Based on an assumption that temperatures do not change significantly between the dam tailrace (RM107) and this location six miles downstream, these measurements can be compared against the dam outlet temperatures simulated in CE-QUAL-W2 to evaluate model performance. They were area-weighted in the same manner as the measurements upstream.

Dam Structures

The releases at Lower Granite Dam are represented using the Selective Withdrawal option in CE-QUAL-W2. Two structures are defined: powerhouse outflows and spill outflows. Powerhouse withdrawals are drawn from bays that extend 75 feet vertically from the bottom of the dam. For the model, the outlet structure is set between the bottom and top of the powerhouse bays, with no constraints on the elevation from which water can be drawn. The spill withdrawal elevation is set at a point near the pool elevation and withdrawals are constrained to the top half of the water column. It should be noted that the effect of spill is not a factor in the evaluation of model performance in this report, because spills in 1992 occurred in the early spring and measurements were not collect until mid-summer.

Meteorology

There are a limited number of meteorological stations in the Northwest where all of the parameters of the heat budget (air temperature, relative humidity, wind speed, cloud cover, and barometric pressure) are reported. Hourly average observations in 1992 from the closest Surface Airways (SAMSON) station, which is located at the Lewiston airport, were used in this analysis. Figure 7 depicts the hourly air temperature for the simulation timeframe.

Comparison of Model Simulations and Transect Measurements

The initial model evaluation involves an evaluation of simulated and measured outlet temperatures. As shown in Figure 8, the simulated outlet temperature is consistent with the timing and trajectory of the measured temperatures during periods of flow augmentation. This similarity in the temporal response to flow augmentation contrasts with previous simulations using a one-dimensional model (RBM10) that employs continuity-based hydrodynamics (EPA, 2001). In that analysis, the model predicted arrival of cold water fronts later than the measured arrival time. It was surmised that higher velocities of the cold water density underflow through the bottom of the impoundment may account for the earlier arrival time. The results using CE-QUAL-W2, which accounts for effects of vertical density gradients on velocities, support this hypothesis.

While the simulations capture the timing and pattern of measured temperature change over time, the simulated temperatures are generally lower than the measured temperatures. CE-QUAL-W2 includes an option for adjusting the heat budget terms associated with wind speed, which is relatively uncertain at the river location and has a bearing on river temperatures. Even after adjusting the wind sheltering coefficient to zero (which would result in less evaporation and higher water temperatures), the simulated temperatures were lower than the measured temperatures. The mean difference between simulated and measured temperatures (measured - simulated) for the 29 sampling days was 0.7 °C with a standard deviation of 0.6 °C. The root mean square difference was 0.2 °C.

Some of the under-prediction could be due to the direct comparison of outlet temperatures with measurements from a transect location six miles downstream from the dam. In order to determine the potential heating occurring between the dam and the transect location, particularly during flow augmentation, RBM10 model outputs from a previous report (Cope, 2001) were examined. On average, during the July augmentation periods, the cross-sectional average river temperature is predicted to warm by approximately 0.2 °C between River Miles 107 and 101. This result, for the period of highest heat transfer, indicates that the location of the measurement station in relation to the dam outlet does not explain the under-prediction in outlet temperatures.

Graphical presentations of measured and simulated vertical temperature profiles at the three transect sampling locations within Lower Granite pool are shown in Figures 9 through 11. The first profile on each page includes a graphic of the Dworshak outflow for 1992 (see Figure 4) and a vertical line on the date of the first profile. An overview of all of the graphical comparisons indicates that the model generally captures the observed temperature patterns in the pool. However, some of the profiles show a consistent deviation from the measured temperatures. For example, the profiles for River Mile 110 from July 28 to August 11 show colder simulated temperatures than measured temperatures below a depth of 40 feet.

The vertical profiles offers insights into the effect of Dworshak releases on temperature stratification, and the profiles also indicate some uncertainties in both model and measurement estimates of temperature. As described in the previous analysis of the effects of flow augmentation (Cope, 2001), the releases of cold water increase the thermal stratification within the pool. For example, large cold water releases (over 20,000 cfs) from July 15 to July 17 resulted in a measured vertical temperature gradient (surface/bottom difference) of 9.5 °C on August 1 at River Mile 120. In contrast, on August 29, after the cold water had moved through the pool, the measured gradient was only 2.5 °C. The simulation results were consistent with this change, with the vertical temperature gradient diminishing over this period from 6.9 °C on August 1 to 1.5 °C on August 29.

As noted above, the transect measurements on each graph include measurements from three monitoring stations along the transect. Since the sampling depths at each station were non-uniform, the graphs include duplicate data at certain depths. In some cases (e.g., RM130, 7/13/92), the duplicates vary substantially, suggesting that there are lateral temperature variations in the river. At the same time, the scale of the temperature difference at a given depth and/or the departure from the simulated temperature in some cases (e.g., RM120, 7/23/92) could be the result of measurement or recording errors.

Contour Plots of Simulated Temperatures

The dynamic changes in river temperature regime caused by flow augmentation from Dworshak Dam can also be examined using contour plots. One advantage of simulation estimates is that they can be obtained for each day during the period of interest; as noted above, the measurement record is more sporadic. Daily contour plots were generated using outputs from CE-QUAL-W2 for the augmentation period during July; August and September plots were generated in 4-day increments. The plots are constructed using CE-QUAL-W2 outputs for every 5 miles of river length. These plots are provided in Appendix A.

The contour plots for the July flow augmentation period indicate that the cold water front from Dworshak remains well-mixed from the upstream boundary (where the Clearwater and Snake are assumed to be completely mixed) to point approximately 15 miles downstream of Lewiston (River Mile 125). The contour plots for July 6th and July 16th show the arrival of the cold water front between miles 5 and 15, and the temperature contours in this stretch are vertical. In subsequent plots, the surface layer downstream of mile 15 remains relatively stable, while the cold water plunges underneath this stable layer. There is little change in the surface layer temperatures during the period of flow augmentation. In addition, stratification lingers for some time after cessation of flow augmentation.

Another set of contour plots reflects the effects of changes in weather on pool temperatures. After a period of warm temperatures and no flow augmentaion in early August, the weather changes in late August (See Figure 7 for drop in air temperatures). The plots for August 26th and August 30th show the effects of this change on the river. The pattern of change is similar to the changes during to flow augmentation, with a stable surface layer developing in the pool. This time the stable surface layer extends from mile 5 below Lewiston (River mile 135). This pattern may be explained by the more rapid effects of weather changes on the upstream rivers than on the pool. The faster cooling upstream waters plunge under the warmer pool similar to the pattern seen during the flow augmentation periods.

Simulation of Spill Releases

Water quality models can be used to predict the water quality effects of alternate river management. For this report, a simple alternate management plan was simulated to illustrate the potential predictive use of the CE-QUAL-W2 model. The assumption for this simulation was that all flows would be sent over the spillway instead of the powerhouse. This scenario was chosen to investigate the possible effects of release through the spillway on the stable surface layer that occupies the lower half of the pool during flow augmentation.

For this experiment, all model parameters and boundary inputs were identical to the simulations of powerhouse releases (i.e., actual conditions in 1992), and only the release structure was altered. Contour maps for selected days during the augmentation period, presented side-by-side with the simulations of actual conditions, are included in Appendix B. The effect of releasing water from the spillway on the surface layer is apparent, particularly during the first augmentation period, when the stratification and maximum temperatures are reduced in the surface waters of the lower portion of the pool. It is more difficult to discern differences during the second, more pronounced, flow augmentation episode.

In the future, the CE-QUAL-W2 framework or other available model frameworks can be used to evaluate the effects of alternative operations at Dworshak Dam, the Hells

Canyon Complex dams, and Lower Granite Dam on water temperature regimes within Lower Granite Pool.

Summary

Based on the measurements and simulation outputs using CE-QUAL-W2, the following observations are offered:

(1) The CE-QUAL-W2 model framework captures most of the observed patterns of stratification occurring in the pool in 1992. The model also predicts the time-of-arrival of cold water underflows at the dam after commencement of flow augmentation from Dworshak Dam to within approximately one day of the observed time-of-arrival.

(2) Using the model domain geometry, boundaries and inputs described herein, the predicted outlet temperature was generally lower than the measured temperature, even with the wind sheltering coefficient set to zero.

(3) During flow augmentation, measurements and simulations indicate that a stable surface layer sets up beginning at approximately River Mile 125 to 135 and extends to downstream to the dam at River Mile 107. Flow augmentation appears to have little effect on temperatures within this surface layer; in fact, augmentation may cause temperature increases at the surface.

(4) The temperature regime in the pool after the passing of a cold air mass resembled the pattern observed during flow augmentation, with cooler input waters at the upstream boundary plunging beneath a warmer surface layer within the pool.

(5) An exploratory simulation assuming the release of all water over the spillway (instead of the powerhouse) resulted in slightly lower surface temperatures at the downstream end of the pool during the first augmentation period in July 1992, when compared to the simulation of actual conditions (releases through the powerhouse). Differences between the two simulations were harder to discern during the other augmentation episodes.

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U.S. EPA Region 10. Application of a 1-D Heat Budget Model to the Columbia River System. May, 2001.

Maps and Figures

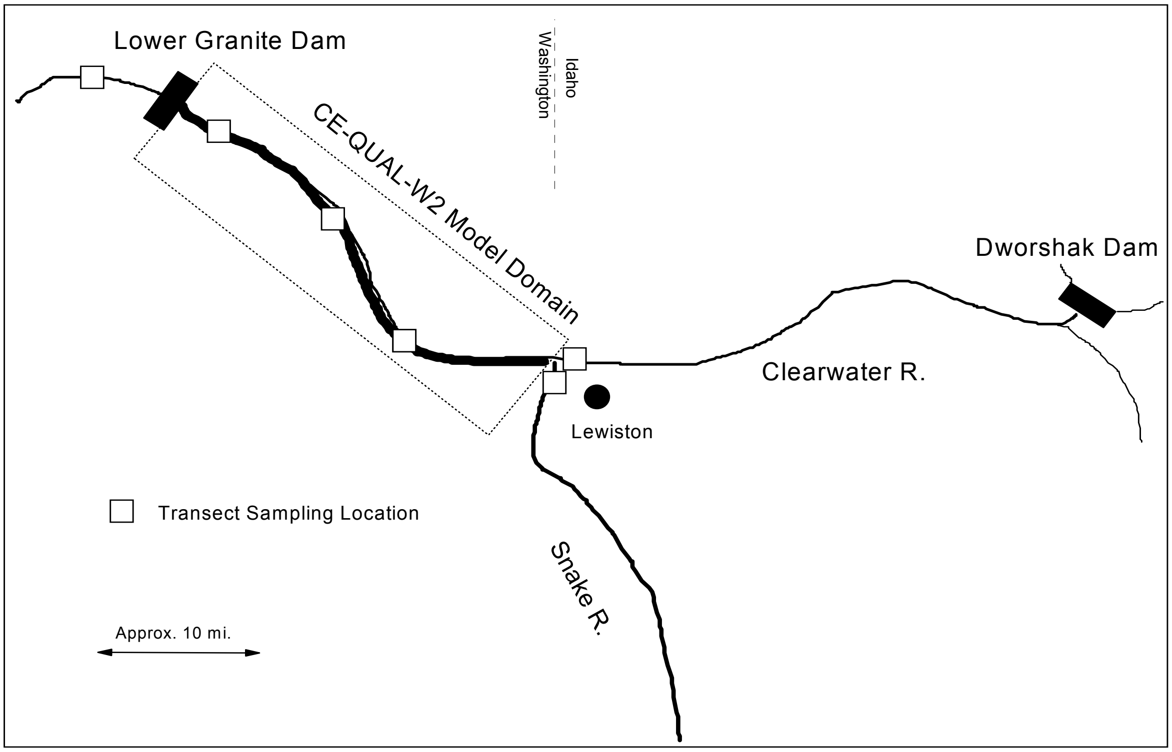


Figure 1: Study Area

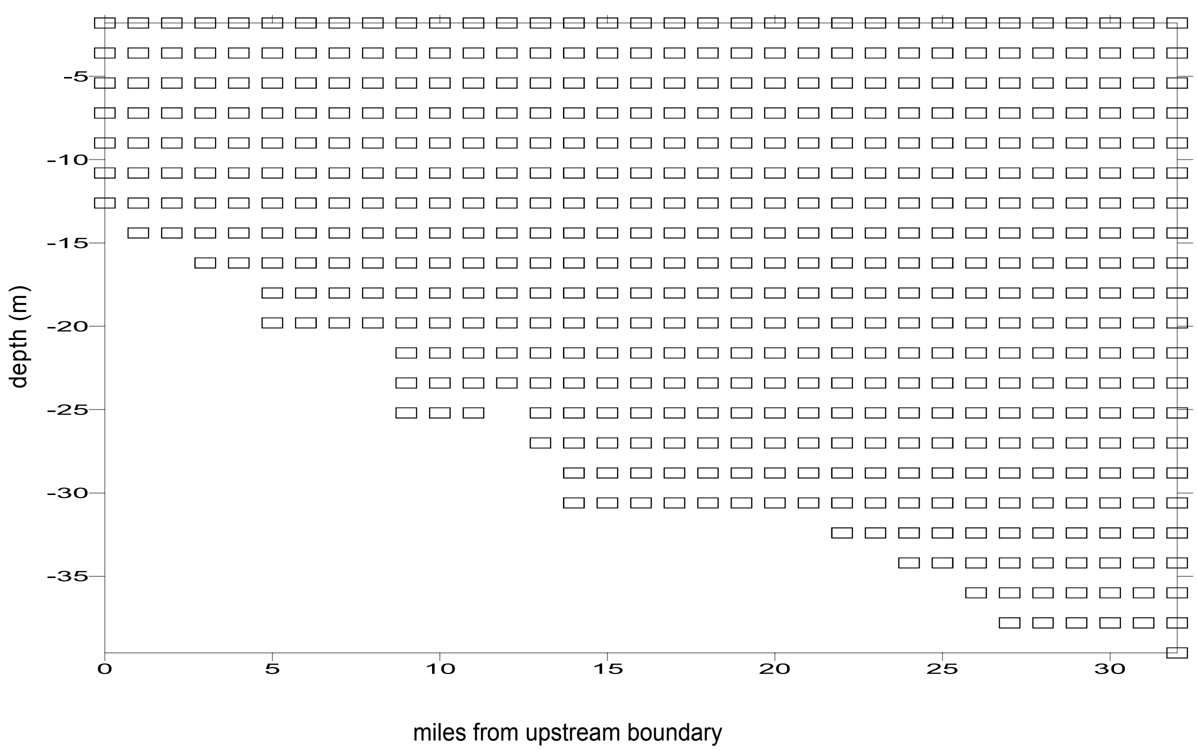


Figure 2: Spatial Resolution for Lower Granite Pool Model

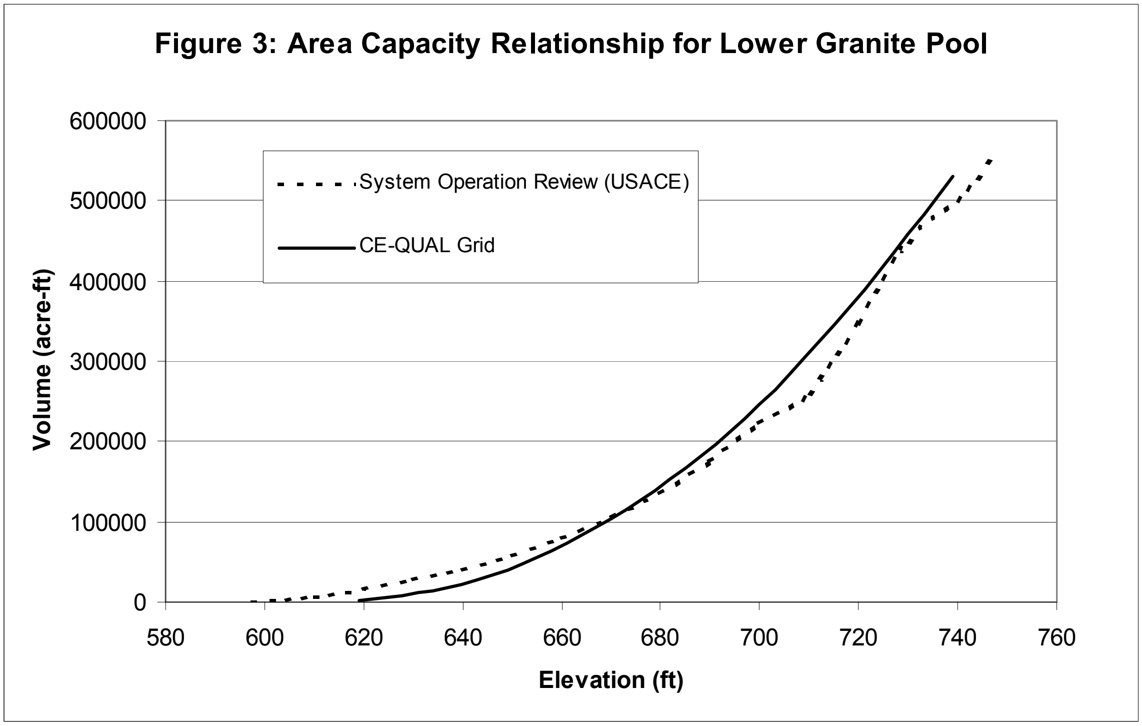


Figure 3: Area Capacity Relationship for Lower Granite Pool
System Operation Review (USACE)
CE-QUAL Grid
Volume (acre-ft)
600000
500000
400000
300000
200000
100000
0
580
600
620
640
660
680
700
720
740
760
Elevation (ft)

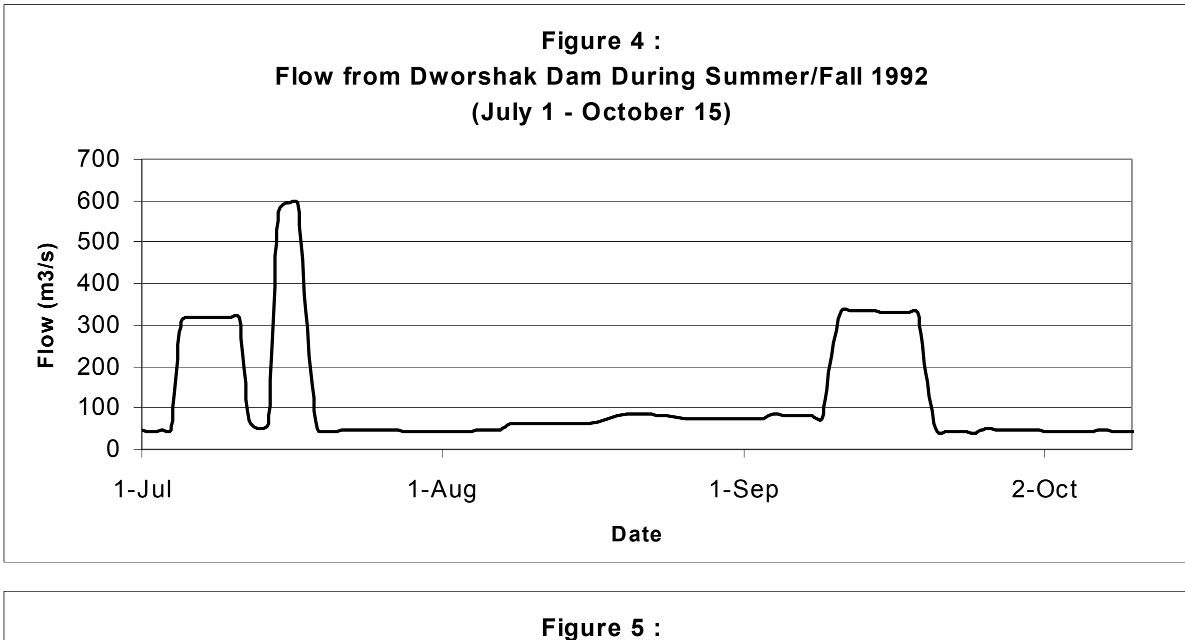


Figure 4 :
Flow from Dworshak Dam During Summer/Fall 1992
(July 1 - October 15)
700
600
500
400
300
200
100
0
Flow (m3/s)
1-Jul
1-Aug
1-Sep
2-Oct
Date

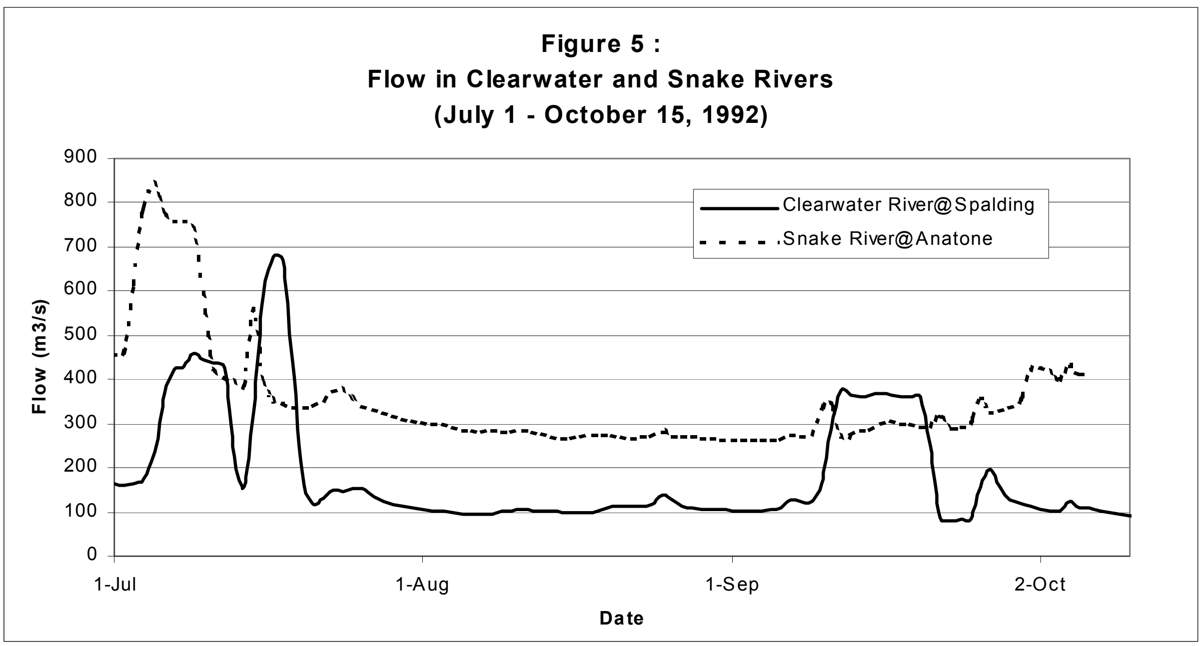


Figure 5 :
Flow in Clearwater and Snake Rivers
(July 1 - October 15, 1992)
900
800
700
600
500
400
300
200
100
0
Flow (m3/s)
Clearwater River@Spalding
Snake River@Anatone
1-Jul
1-Aug
1-Sep
2-Oct
Date

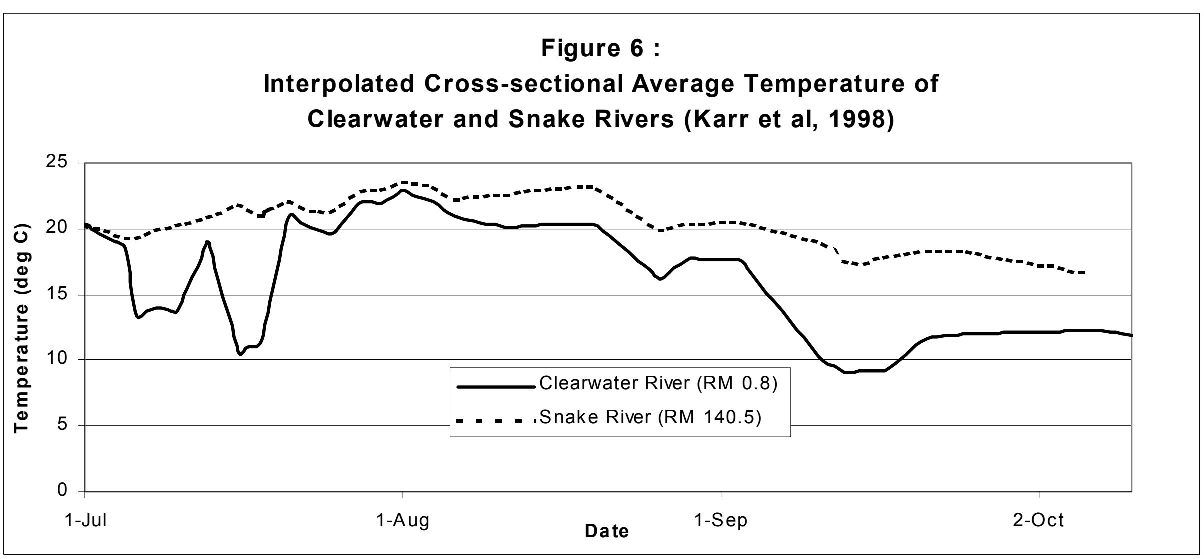


Figure 6 :
Interpolated Cross-sectional Average Temperature of
Clearwater and Snake Rivers (Karr et al, 1998)
25
20
15
10
5
0
Temperature (deg C)
Clearwater River (RM 0.8)
Snake River (RM 140.5)
1-Jul
1-Aug
1-Sep
2-Oct
Date

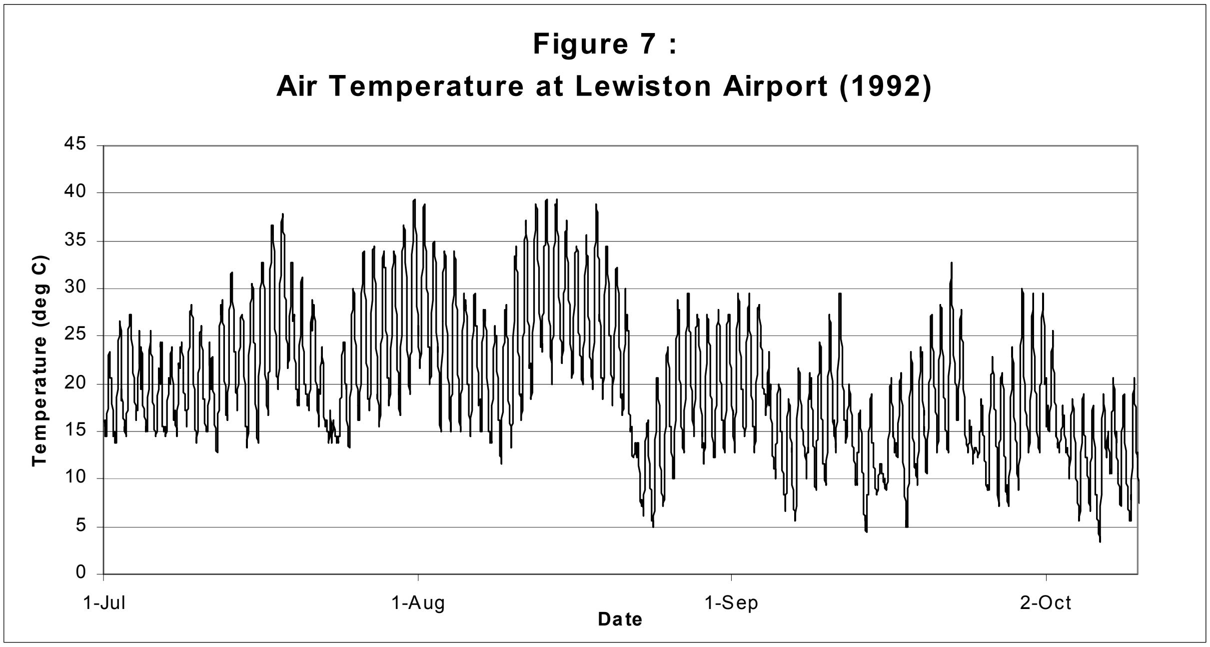


Figure 7 :
Air Temperature at Lewiston Airport (1992)
Temperature (deg C)
45
40
35
30
25
20
15
10
5
0
1-Jul
1-Aug
1-Sep
2-Oct
Date

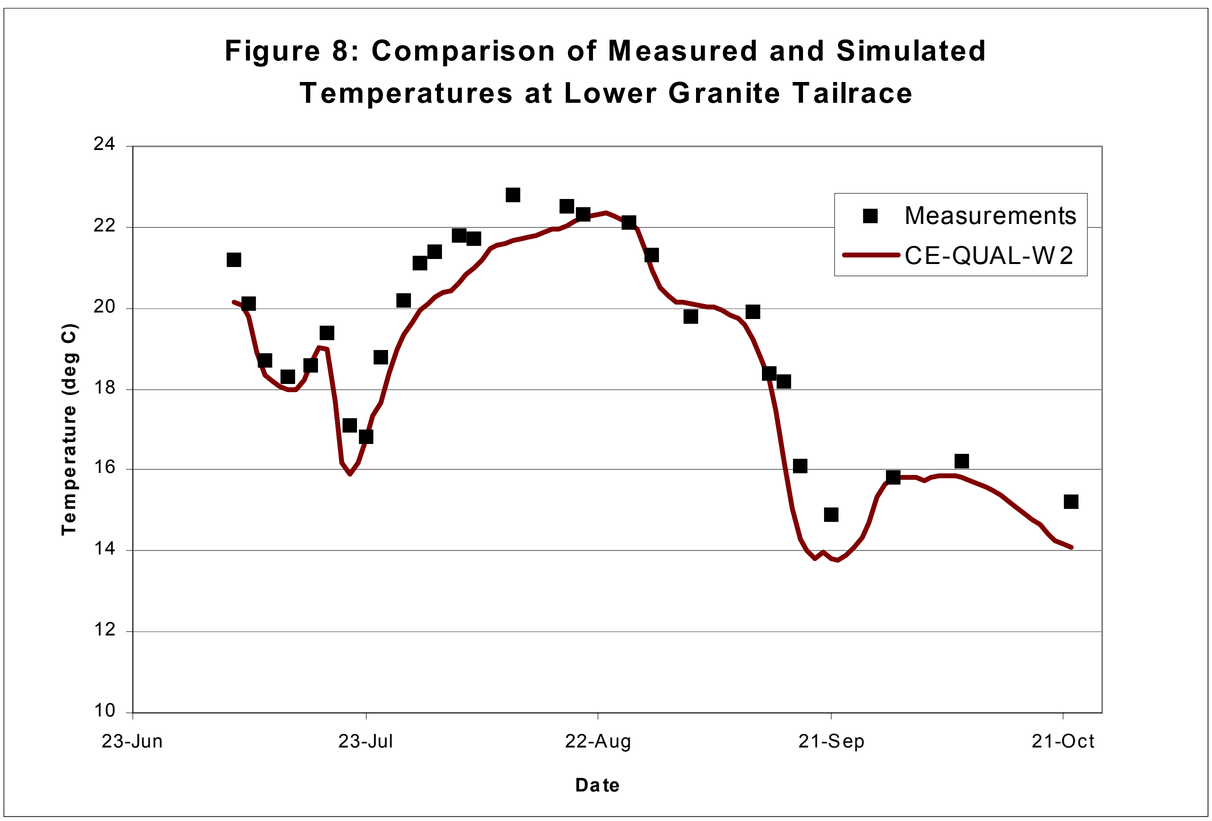
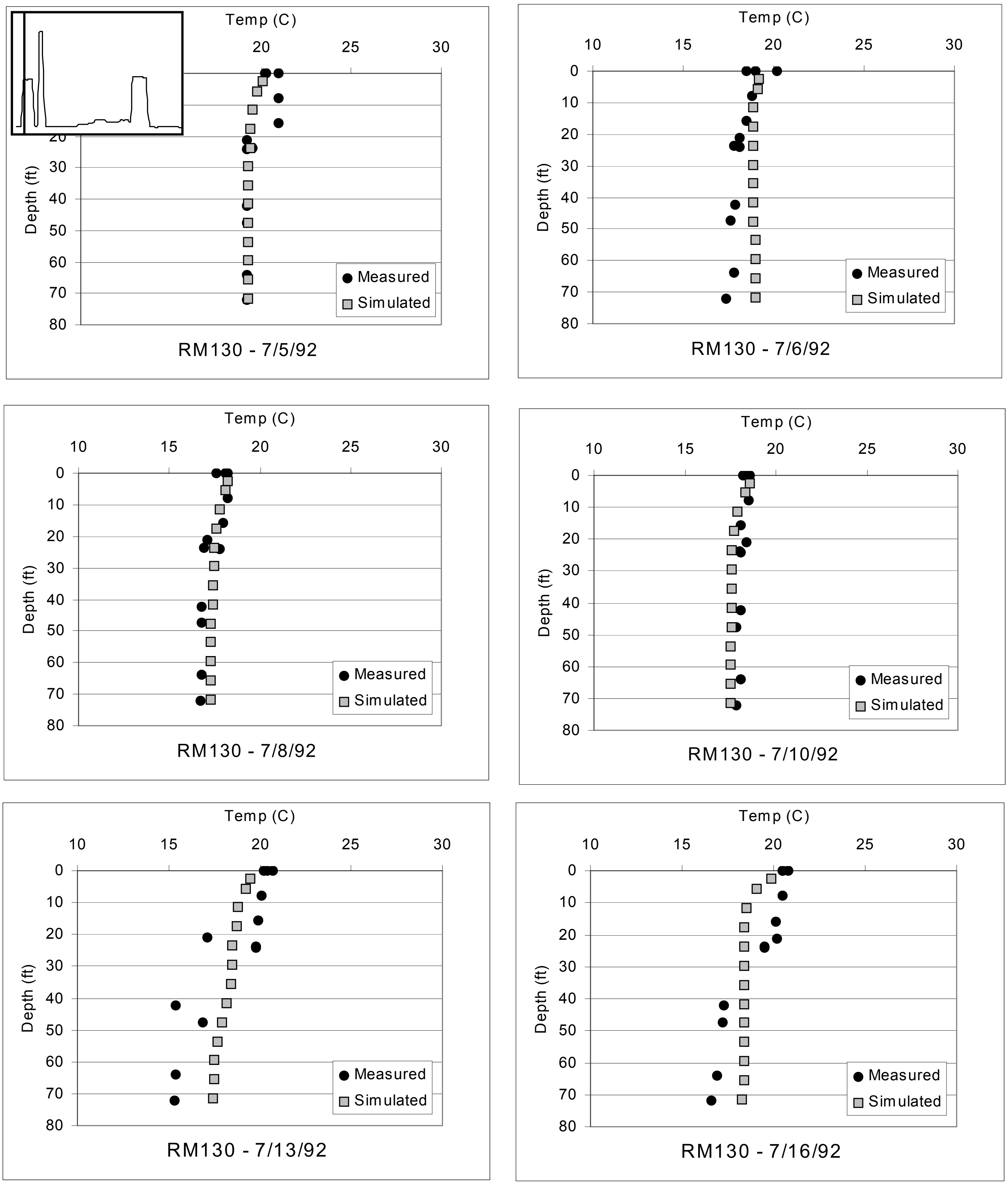
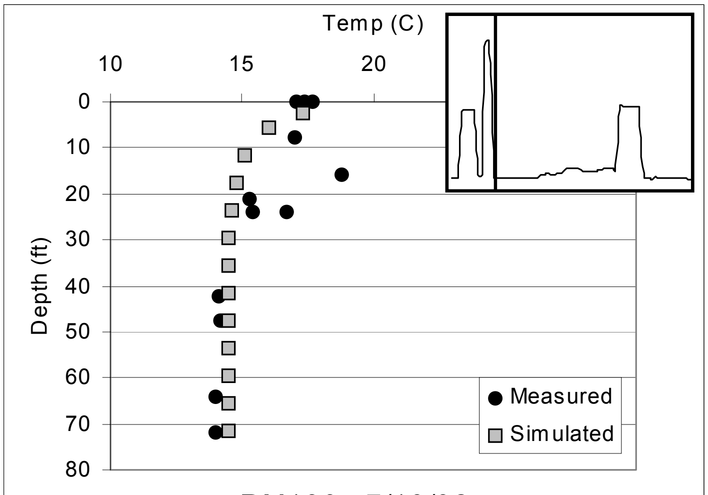


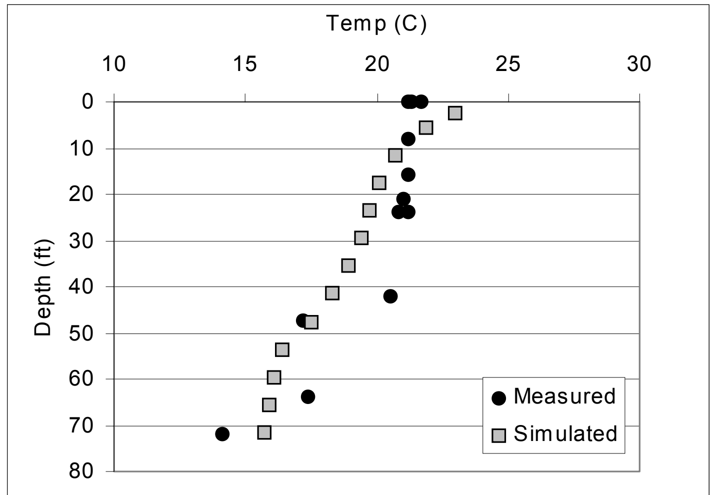
Figure 8: Comparison of Measured and Simulated Temperatures at Lower Granite Tailrace
Temperature (deg C)
24
22
20
18
16
14
12
10
Measurements
CE-QUAL-W2
23-Jun
23-Jul
22-Aug
21-Sep
21-Oct
Date

Figure 9 : Comparison of Summer 1992 Measured and Simulated Temperatures - River Mile 130

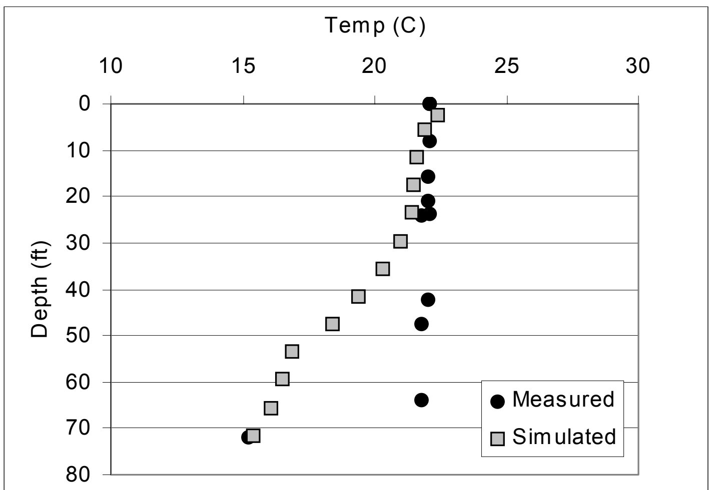




RM130 - 7/19/92



RM130 - 7/21/92



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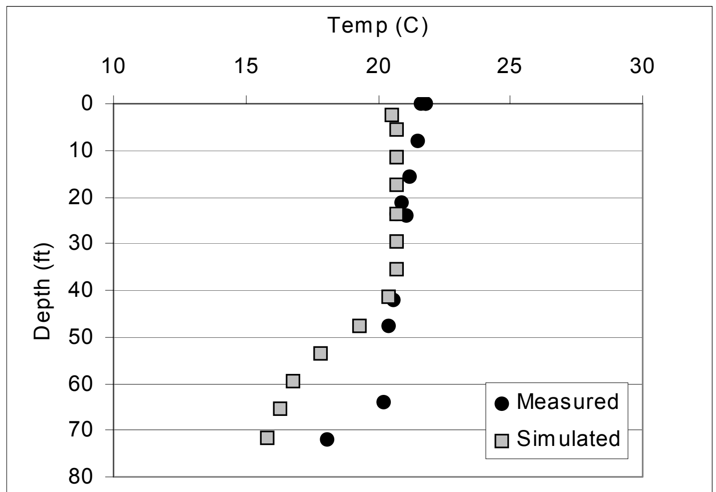

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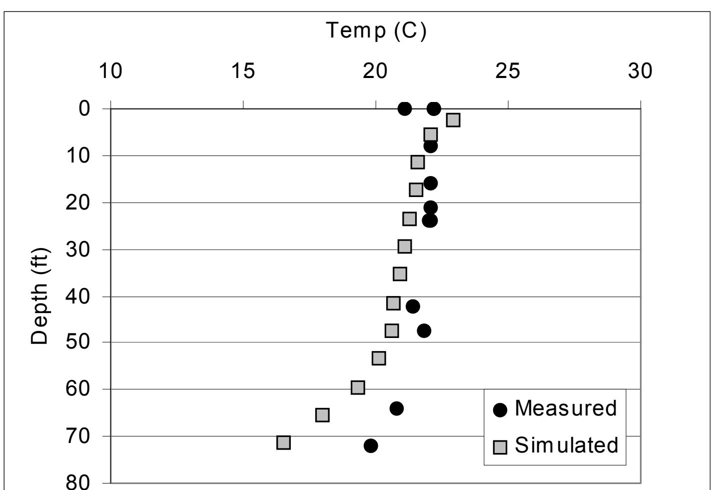

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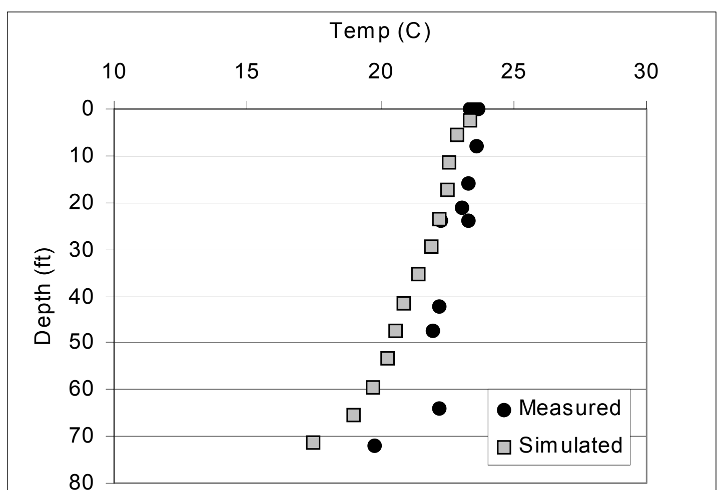
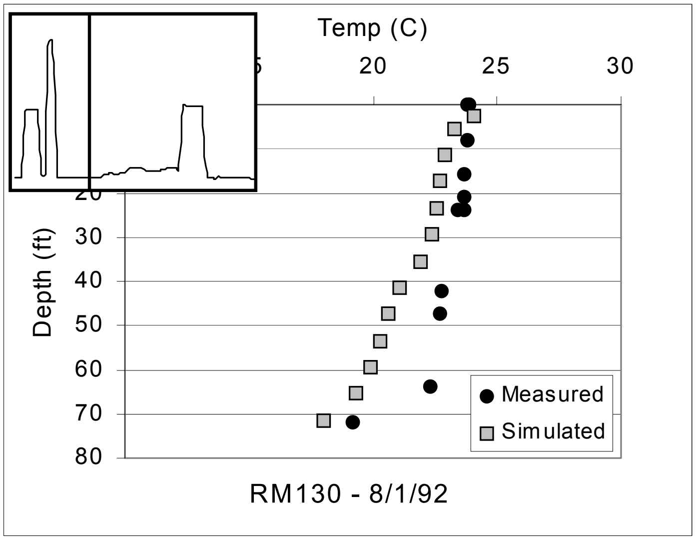
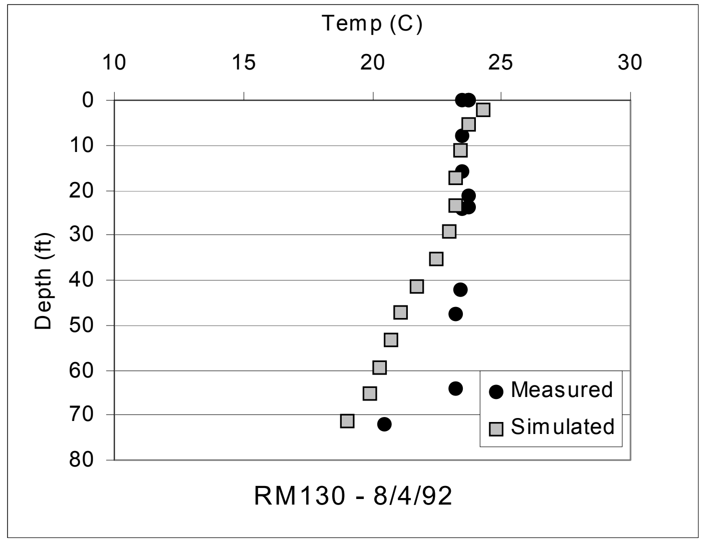


RM130 - 7/30/92


Temp (C)
Depth (ft)
Measured
Simulated
RM130 - 8/1/92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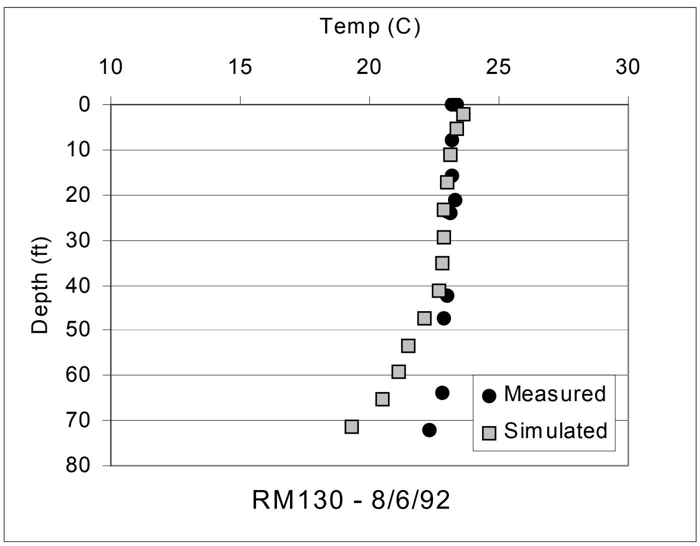
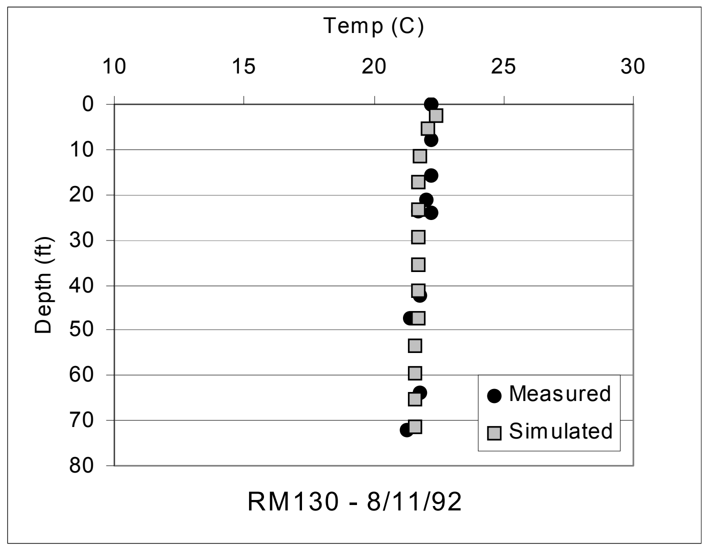
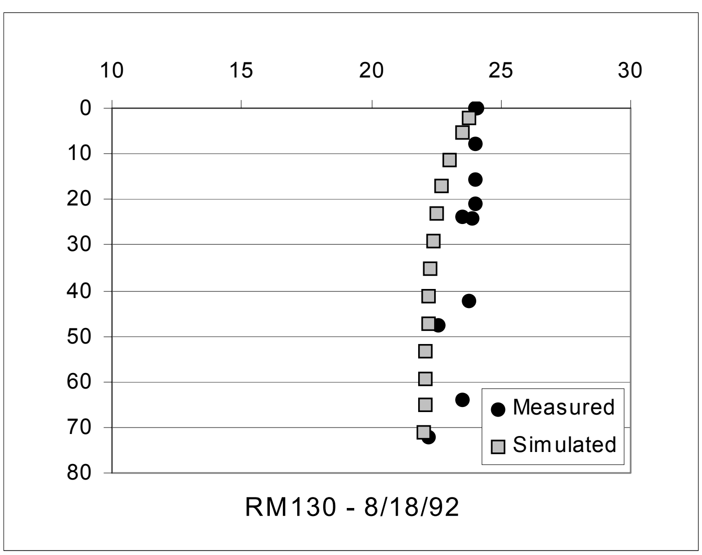
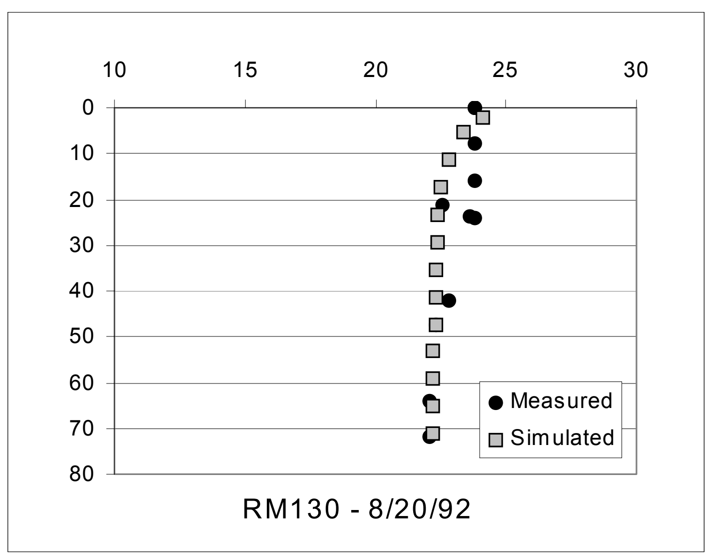
Depth (ft)
Measured
Simulated
RM130 - 8/4/92


Temp (C)
Depth (ft)
Measured
Simulated
RM130 - 8/6/92


Temp (C)
Depth (ft)
Measured
Simulated
RM130 - 8/11/92


Measured
Simulated
RM130 - 8/18/92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Simulated
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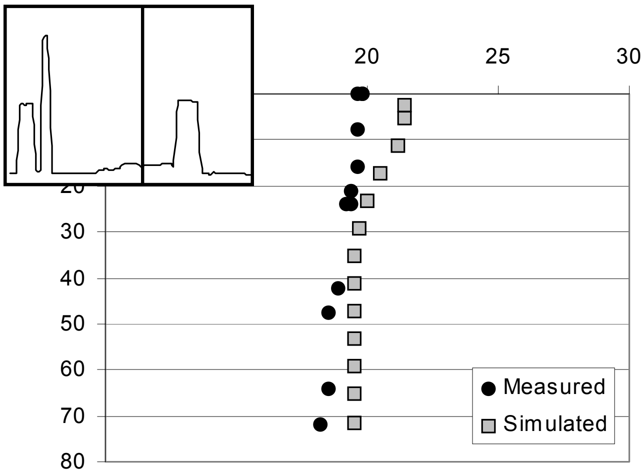
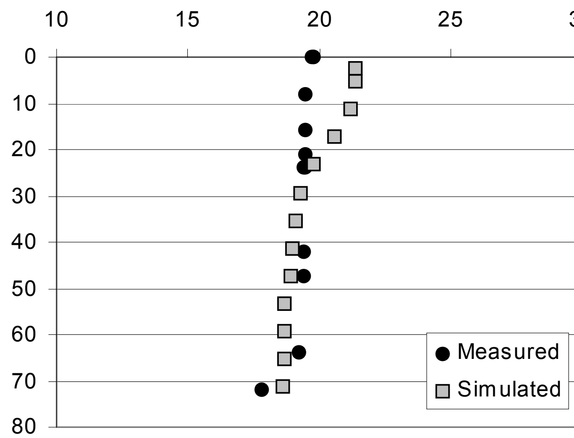
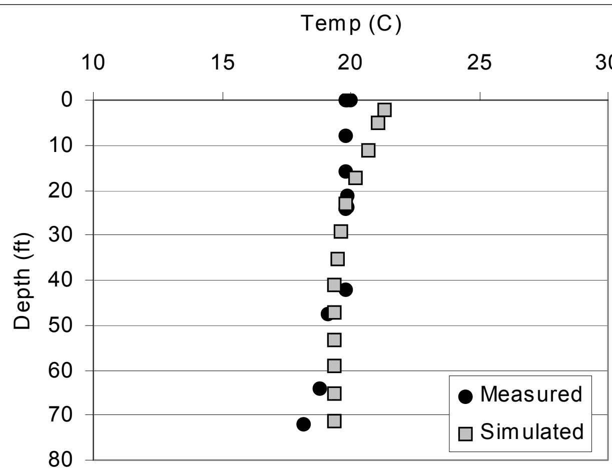


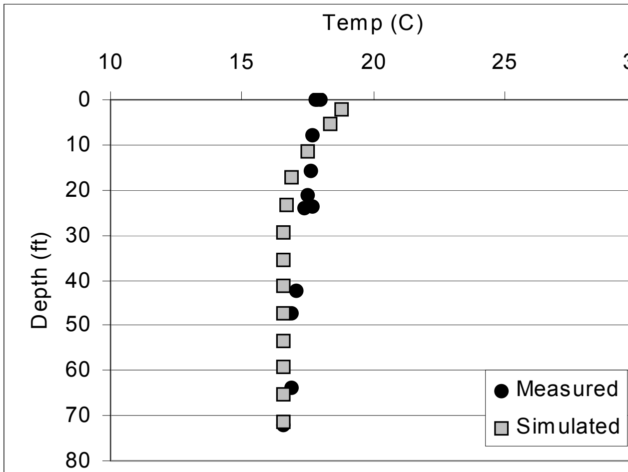
RM130 - 8/26/92



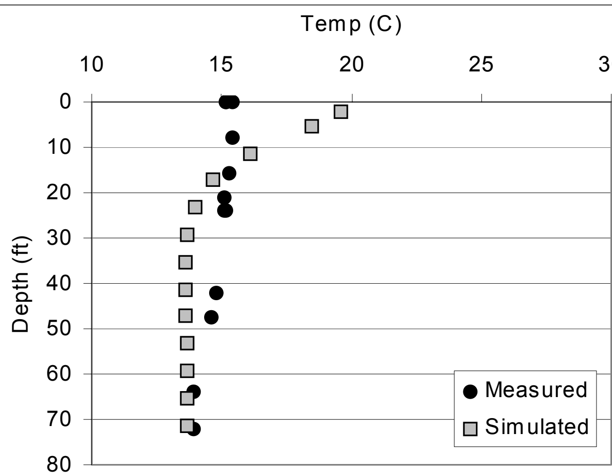
RM130 - 8/29/92



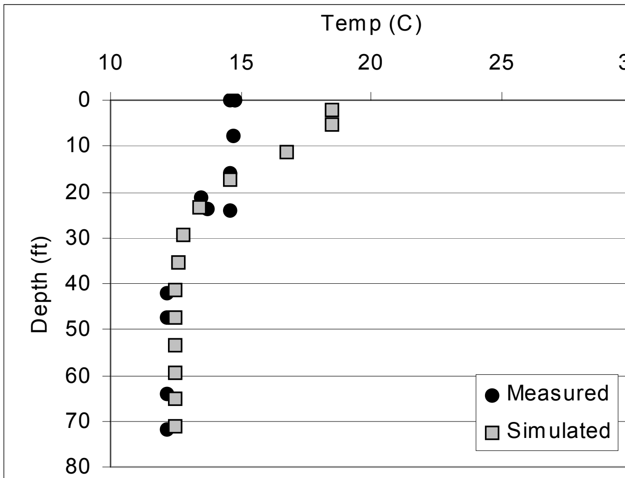
RM130 - 9/3/92



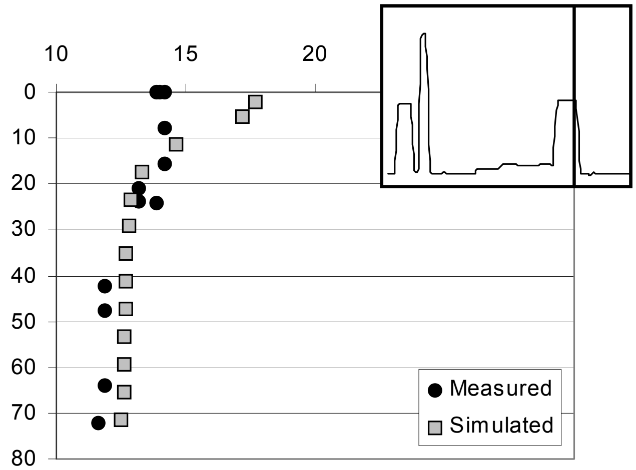
RM130 - 9/11/92



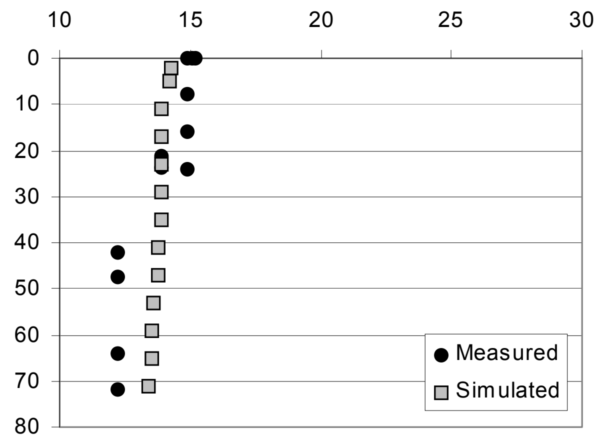
RM130 - 9/13/92



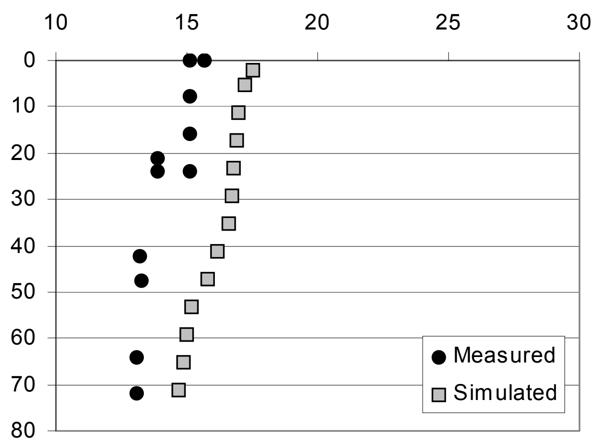
RM130 - 9/15/92



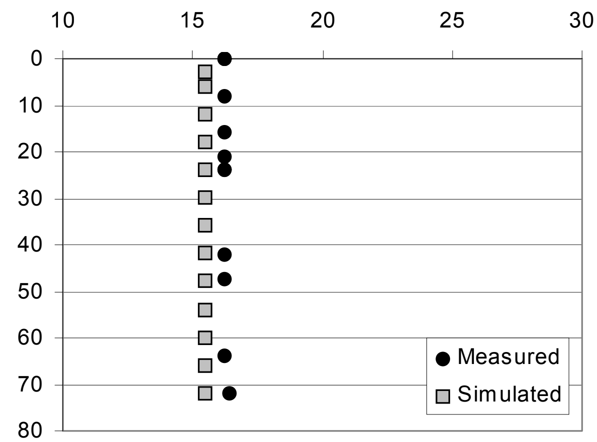
RM130 - 9/17/92



RM130 - 9/21/92

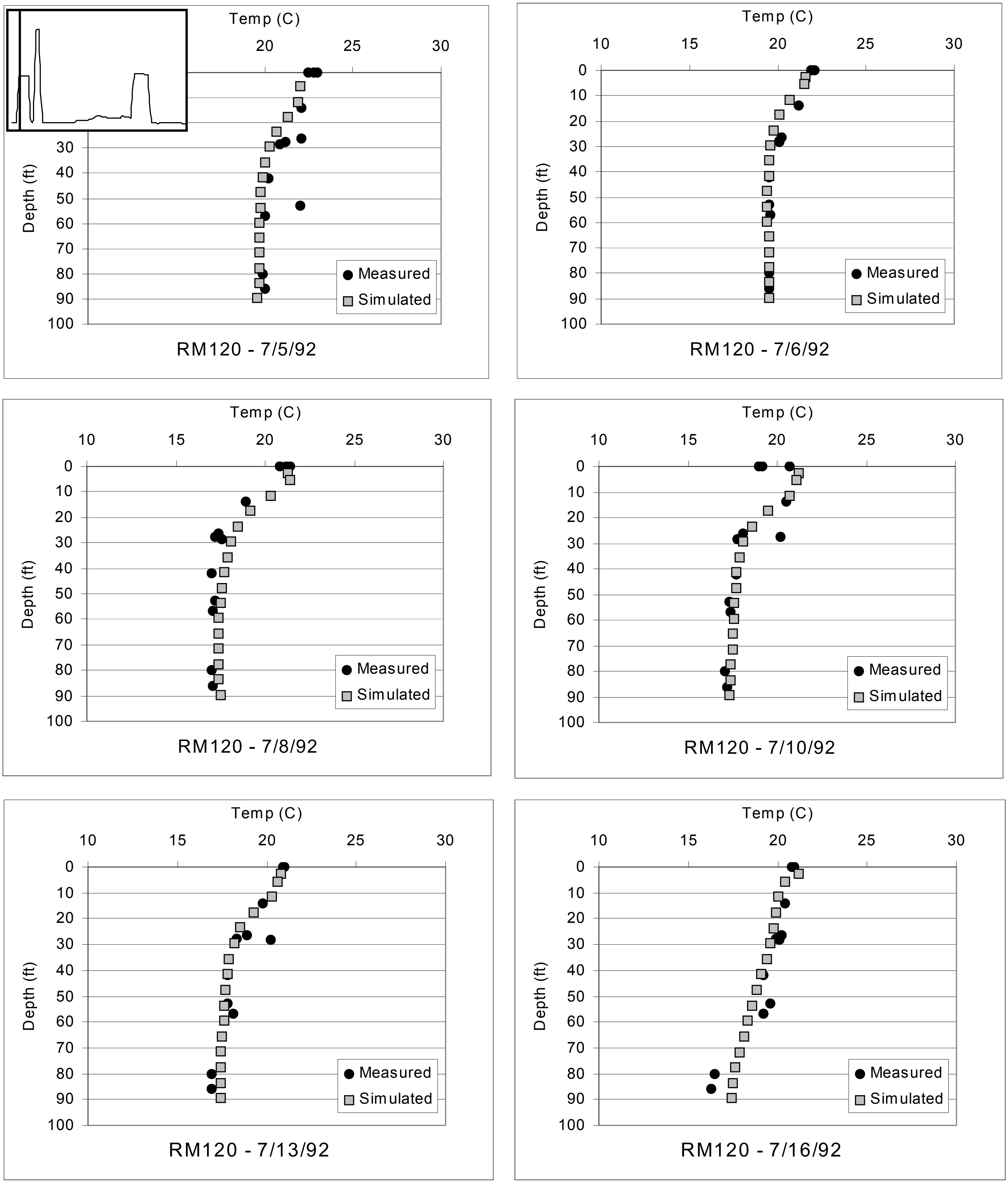


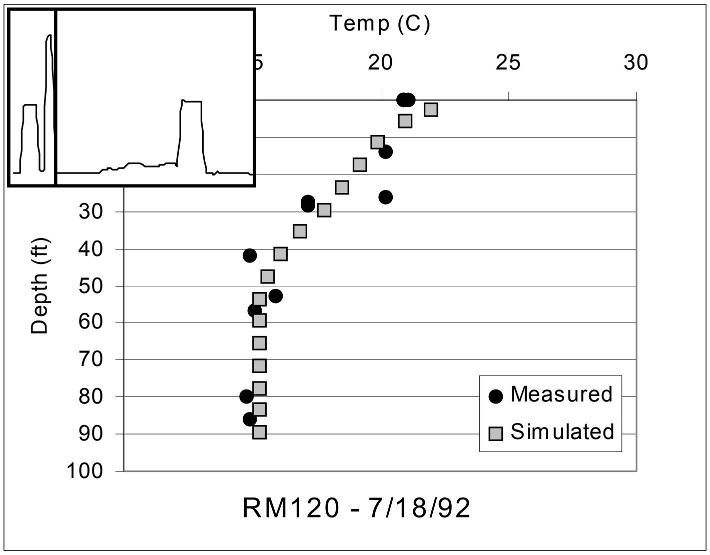
RM130 - 9/25/92

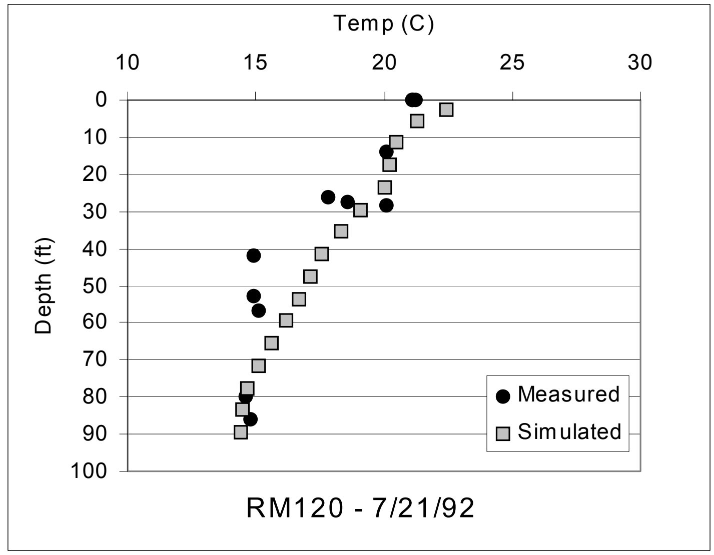


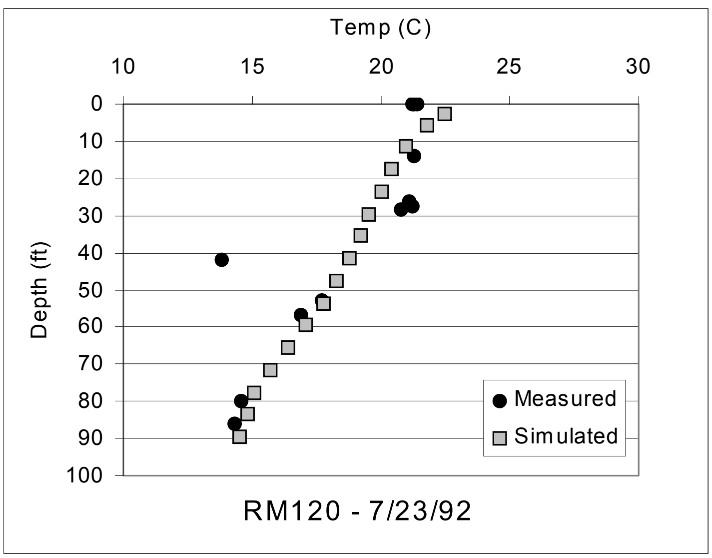
RM130 - 10/8/92

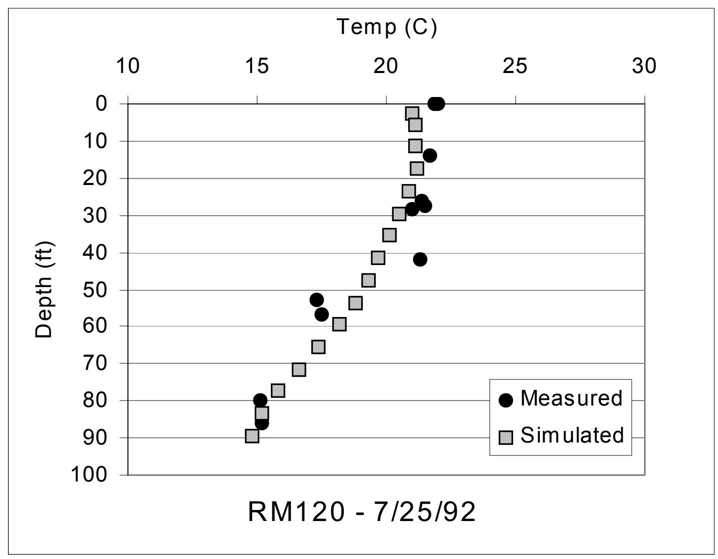
Figure 10 : Comparison of Summer 1992 Measured and Simulated Temperatures - River Mile 120

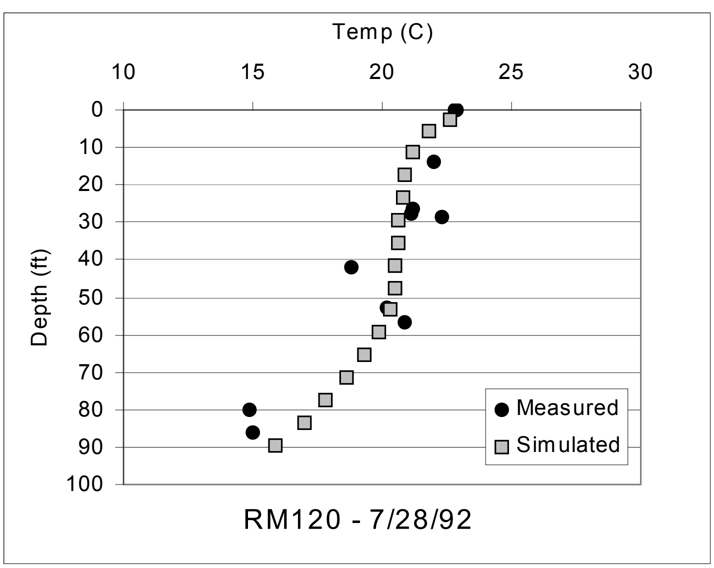


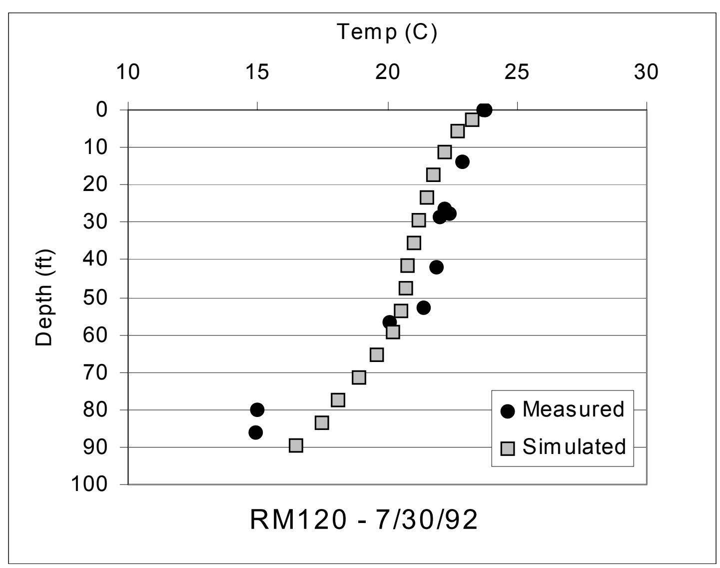

Temp (C)
5 20 25 30
Depth (ft)
30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/18/92

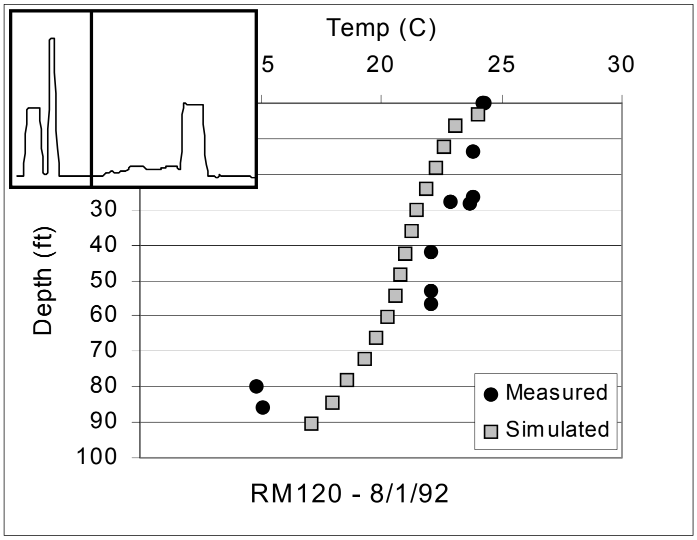

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/21/92

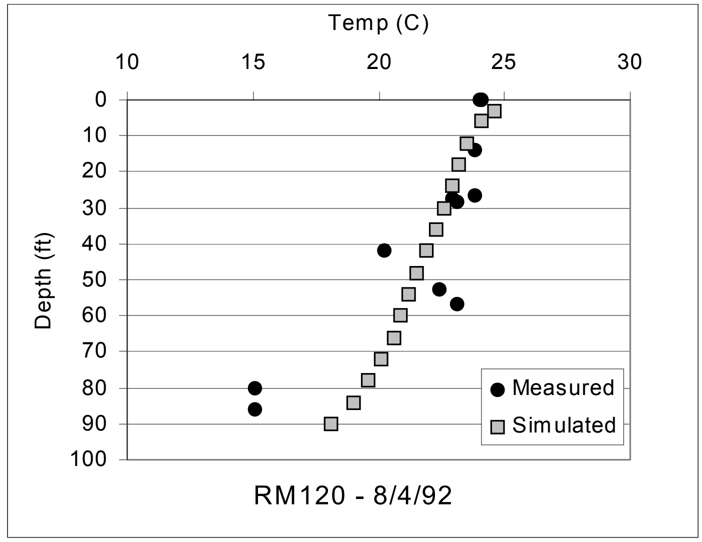

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/23/92

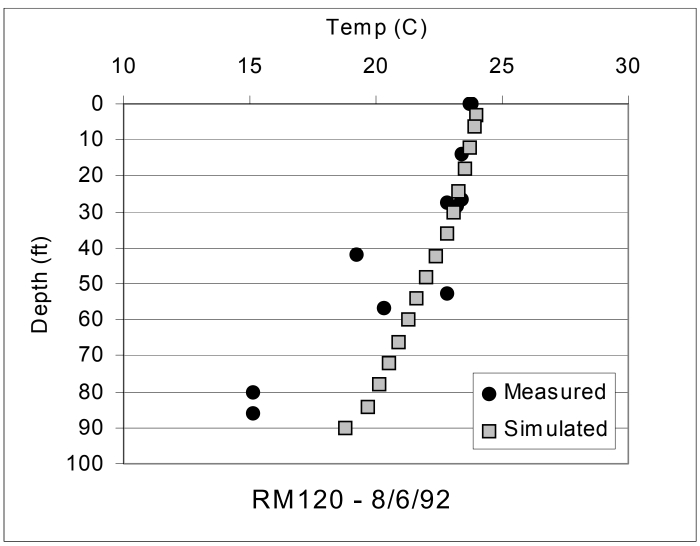

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/25/92

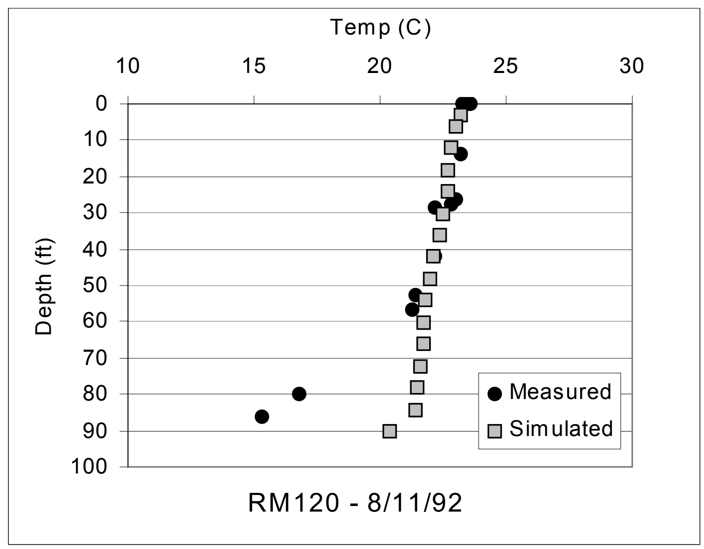

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/28/92

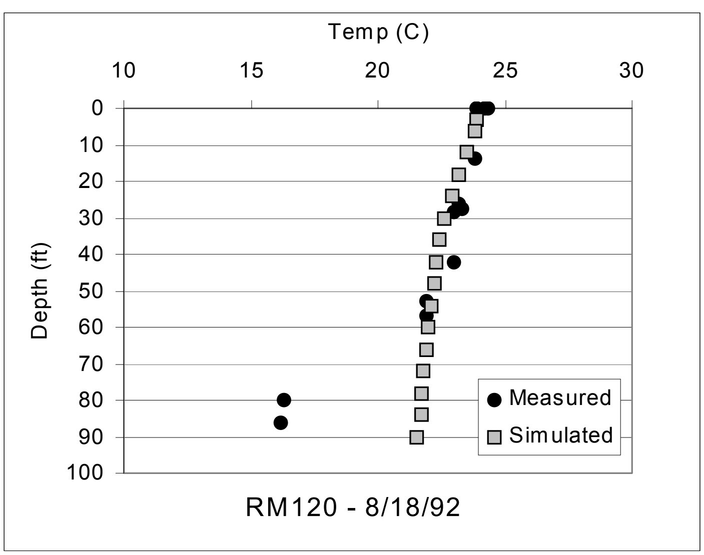

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 7/30/92

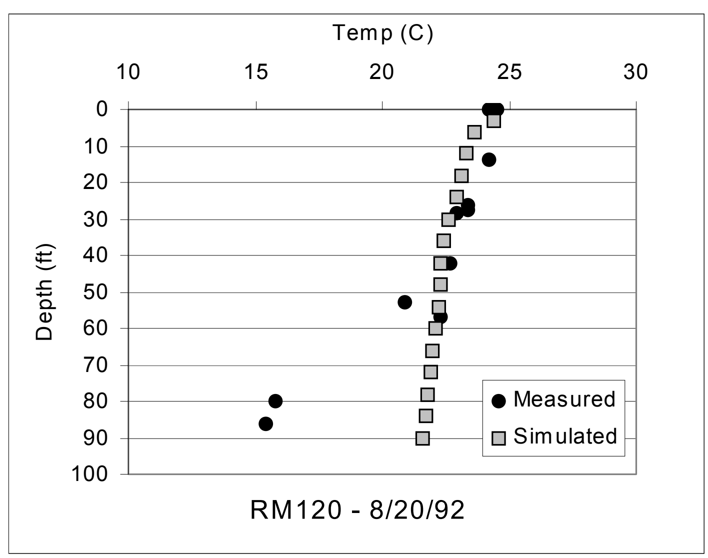

Temp (C)
5 20 25 30
Depth (ft)
30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/1/92

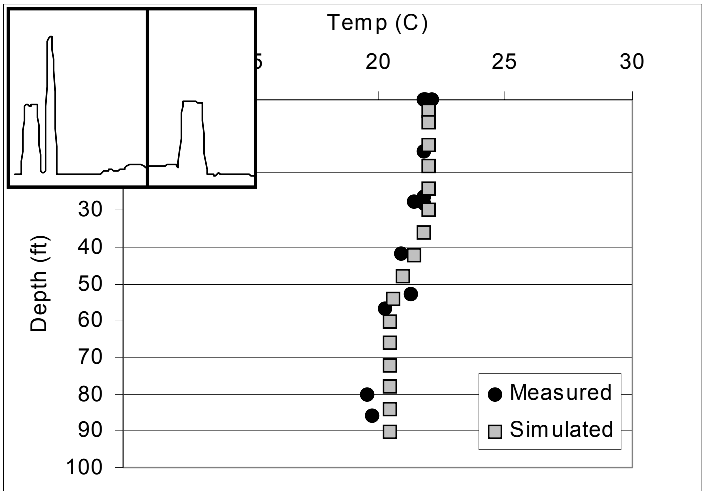

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/4/92


Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/6/92

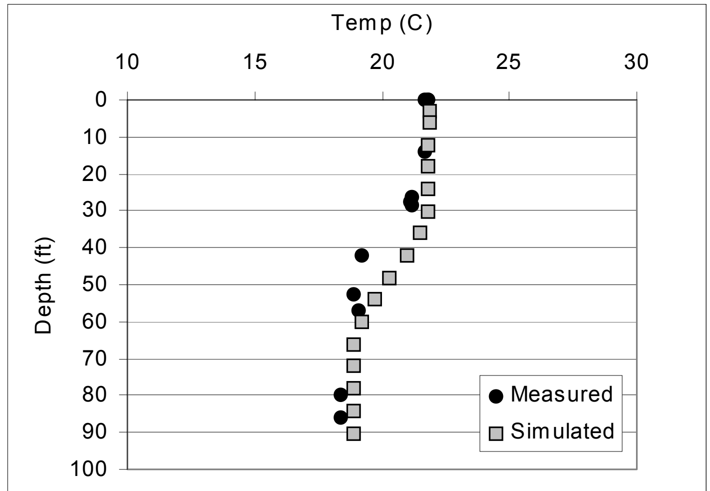

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/11/92


Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/18/92

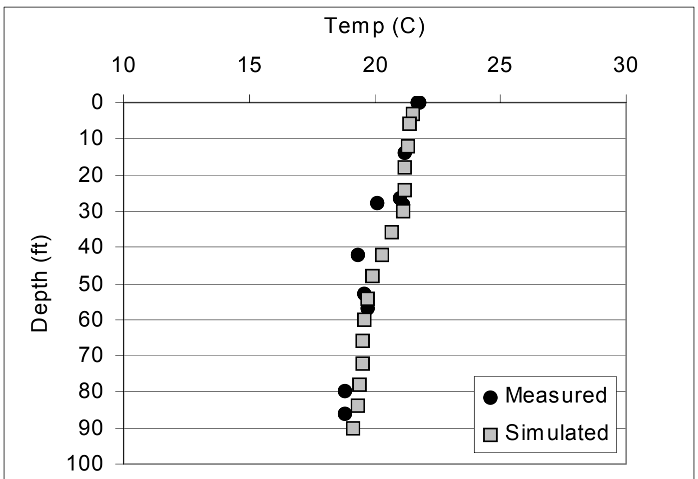

Temp (C)
10 15 20 25 30
Depth (ft)
0 10 20 30 40 50 60 70 80 90 100
Measured
Simulated
RM120 - 8/20/92



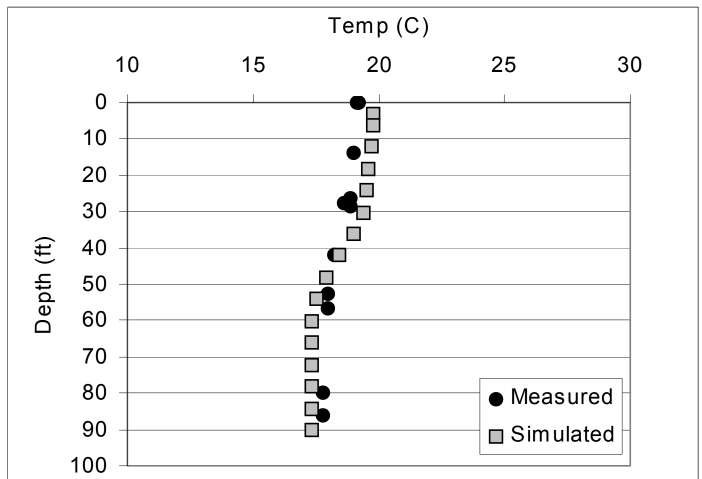
RM120 - 8/26/92



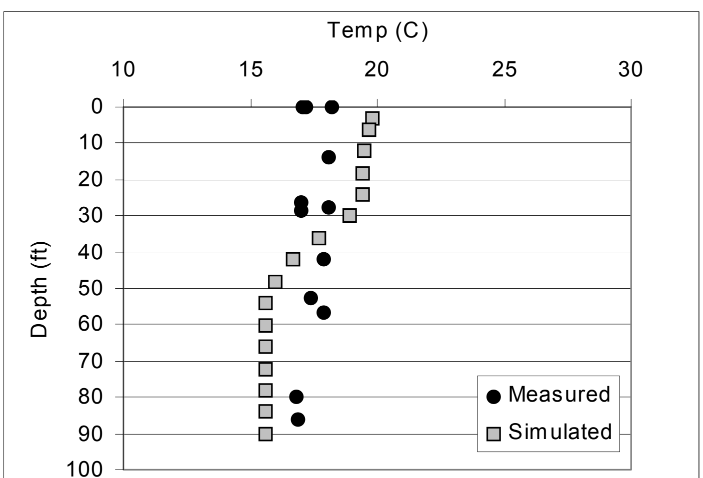
RM110 - 8/29/92



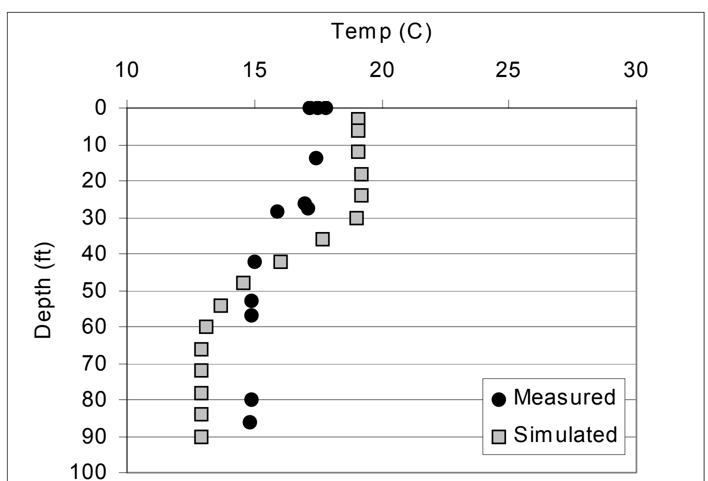
RM120 - 9/3/92



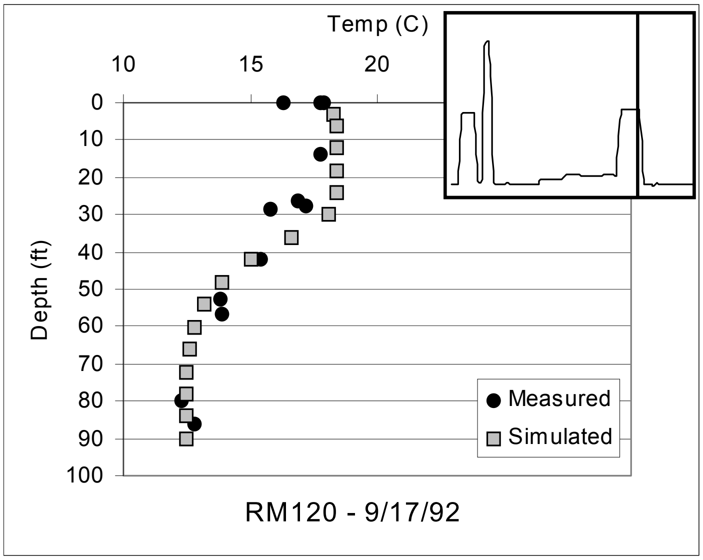
RM120 - 9/11/92



RM120 - 9/13/92



RM120 - 9/15/92


Temp (C)
10 15 20
0 10 20 30 40 50 60 70 80 90 100
Depth (ft)
Measured
Simulated
RM120 - 9/17/92

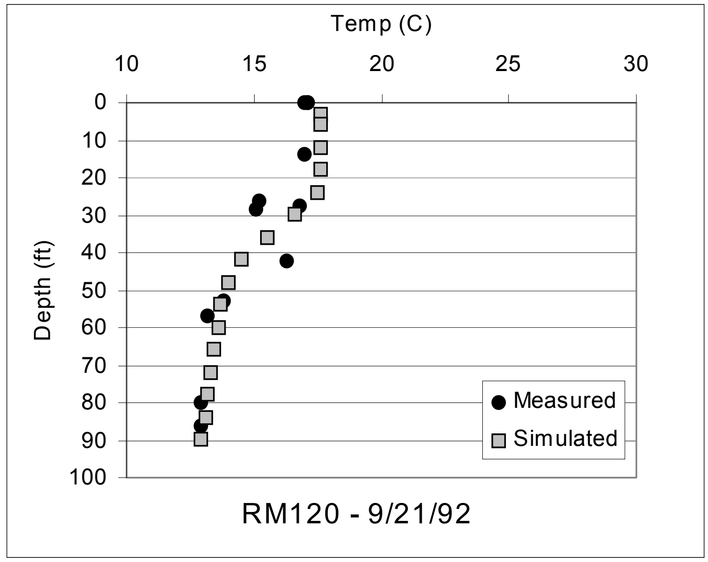
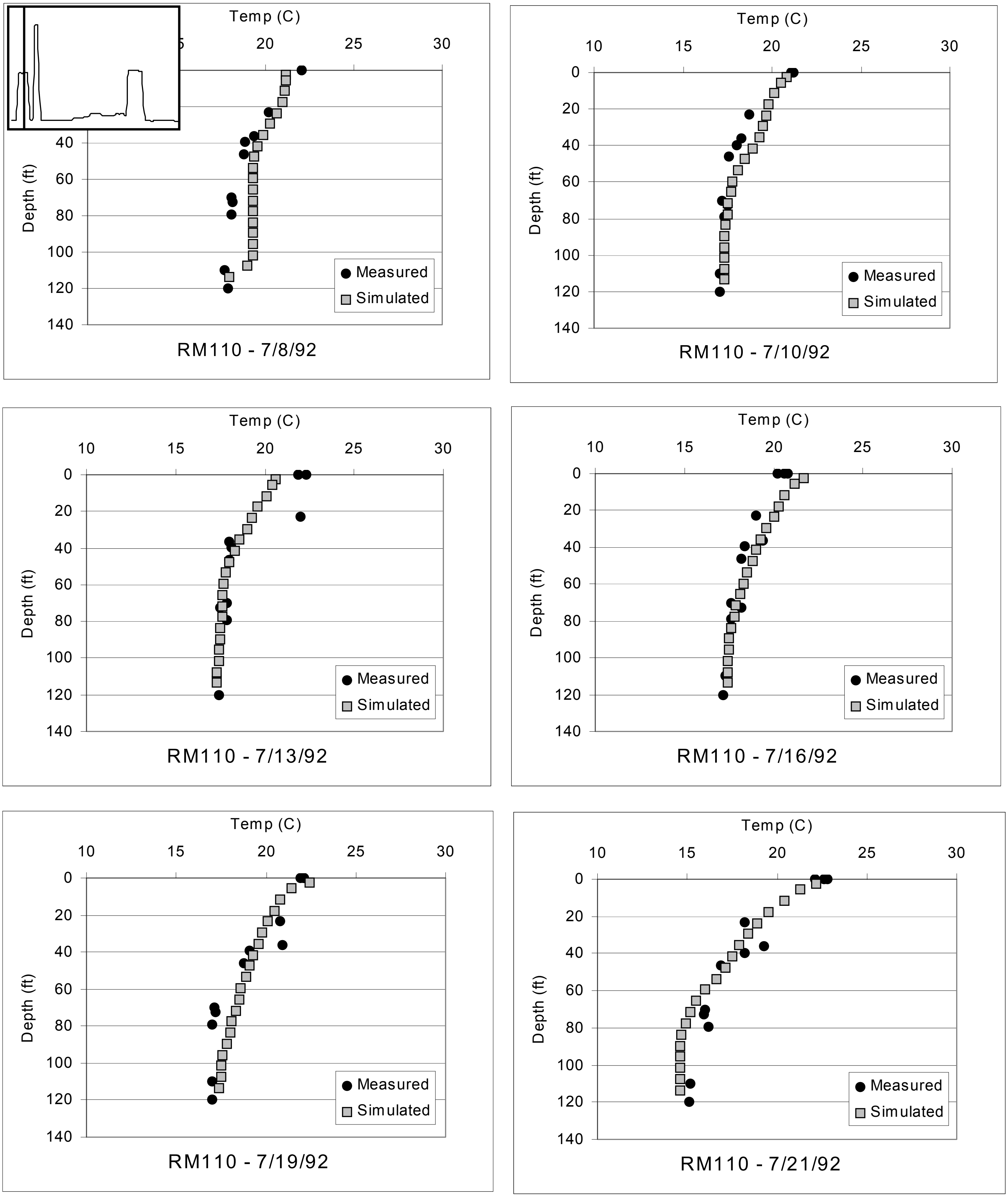
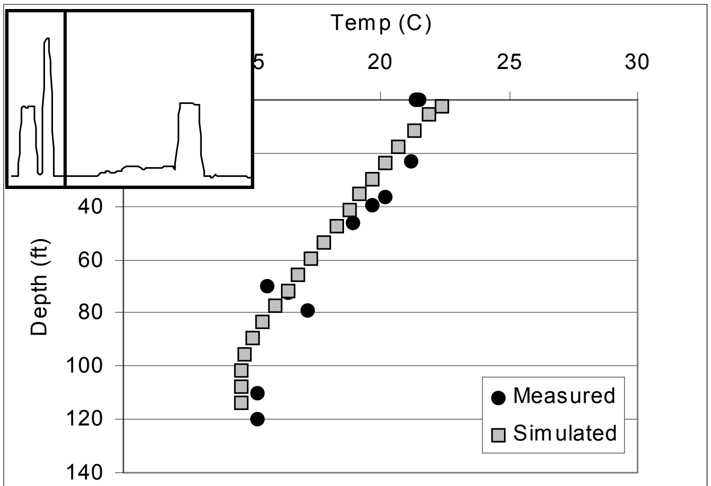
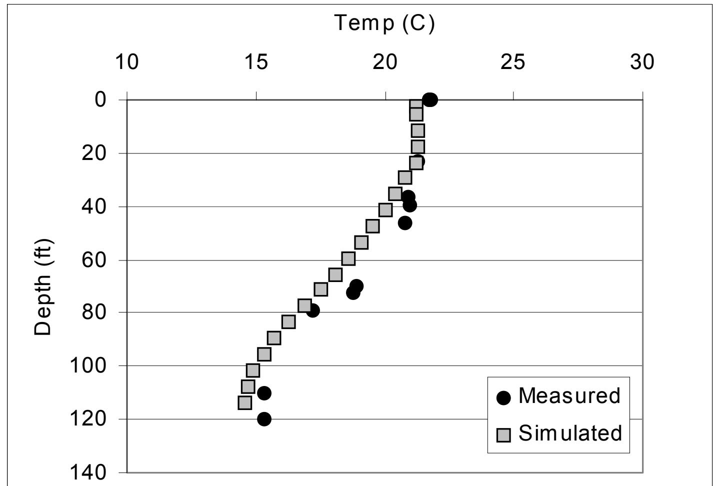

Temp (C)
10 15 20 25 30
0 10 20 30 40 50 60 70 80 90 100
Depth (ft)
Measured
Simulated
RM120 - 9/21/92

Figure 11 : Comparison of Summer 1992 Measured and Simulated Temperatures - River Mile 110

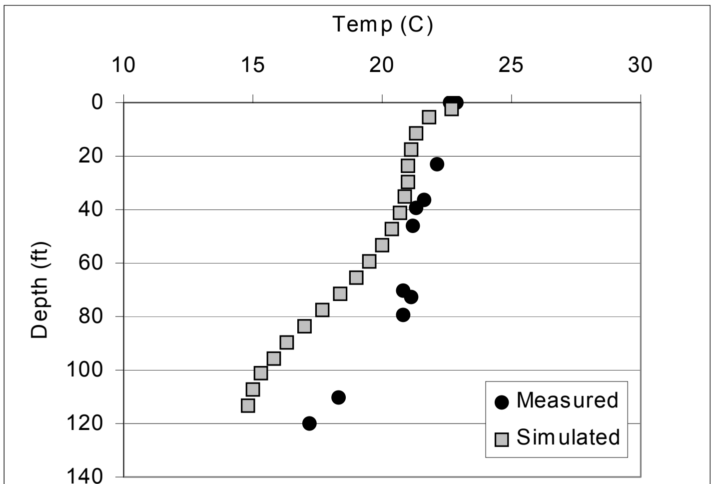




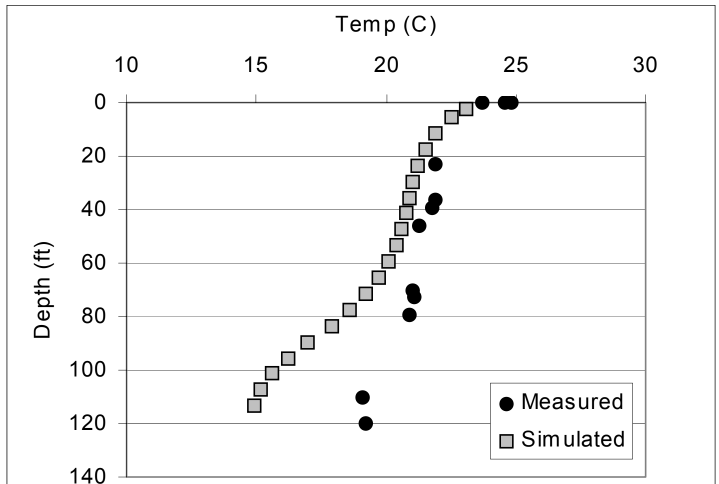
RM110 - 7/23/92



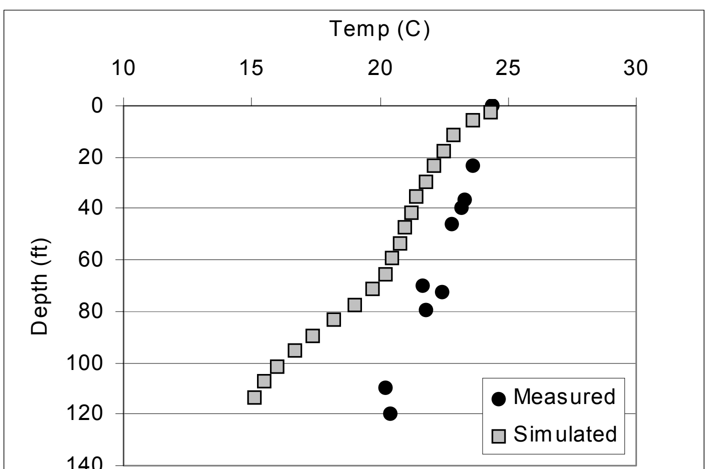
RM110 - 7/25/92



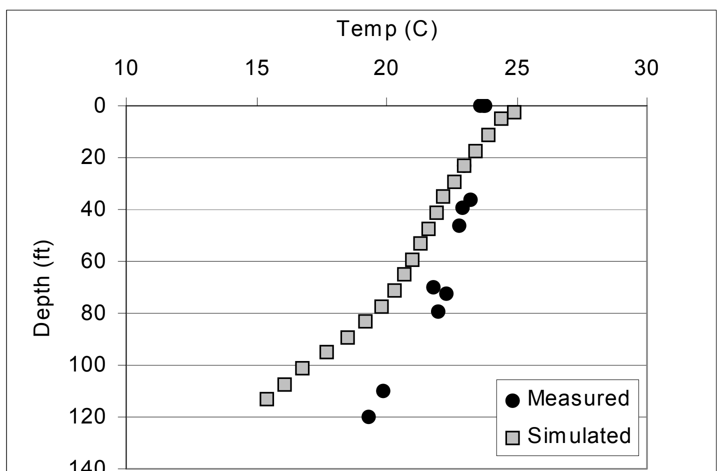
RM110 - 7/28/92



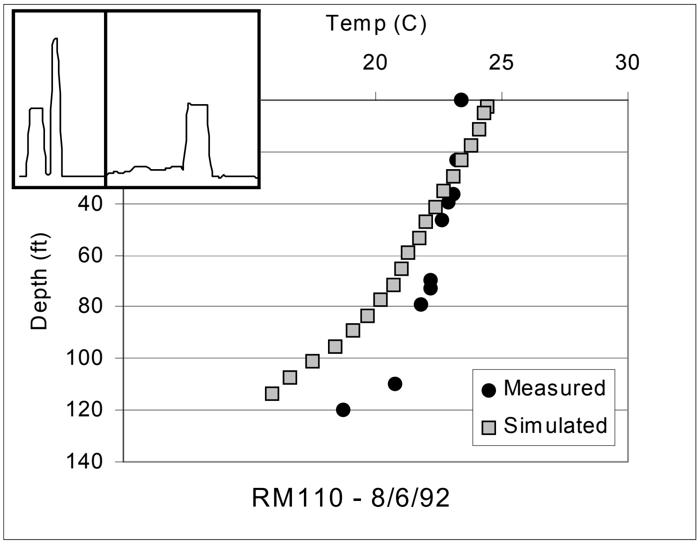
RM110 - 7/30/92

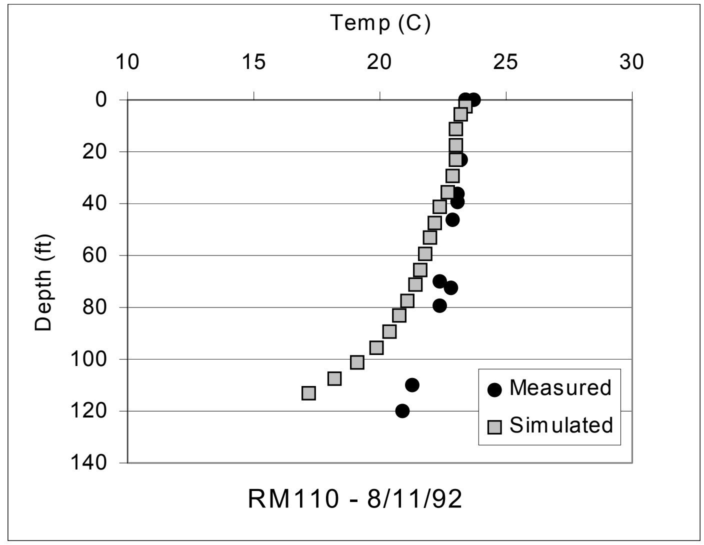


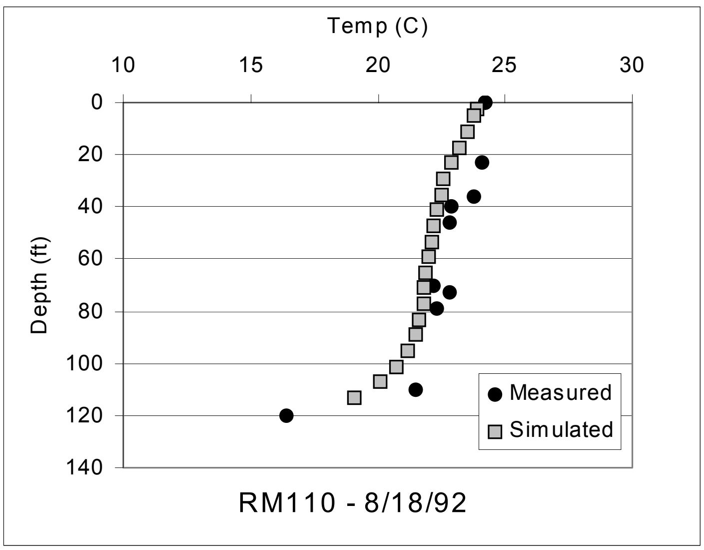
RM110 - 8/1/92

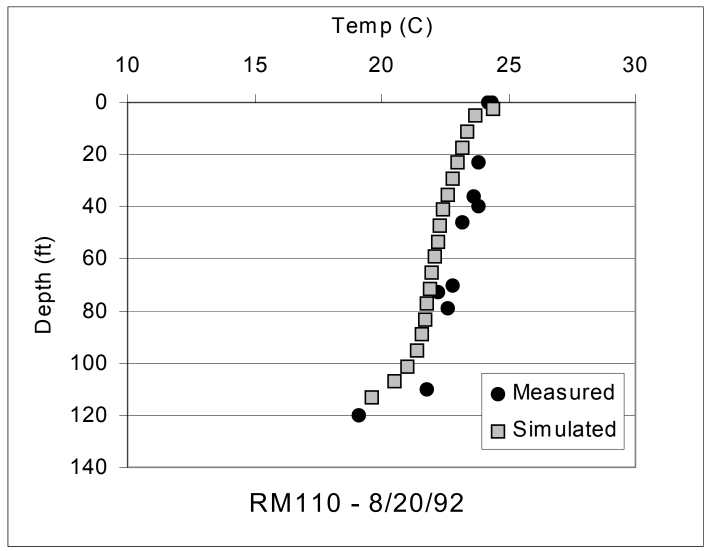


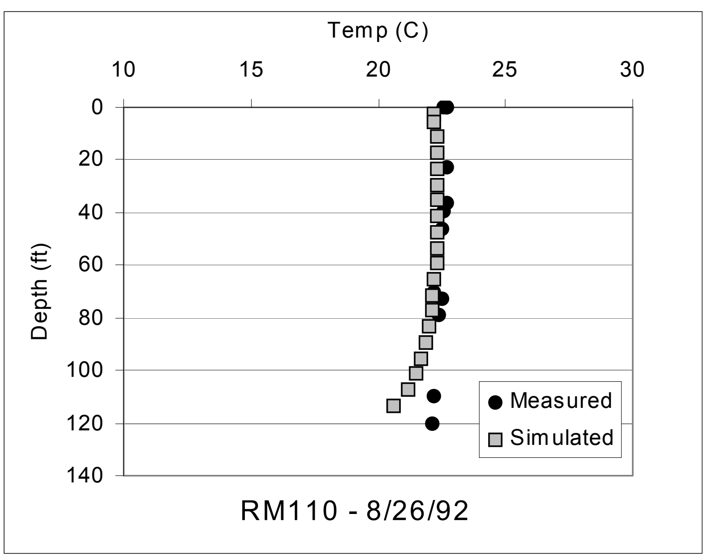
RM110 - 8/4/92

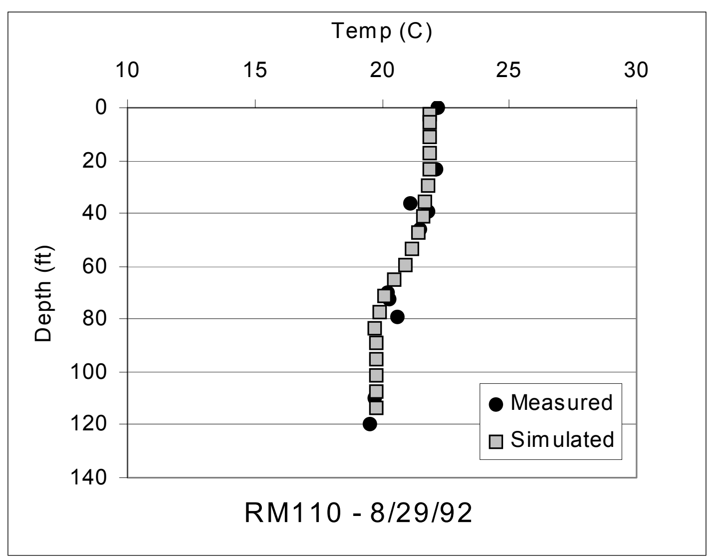

Temp (C)
20
25
30
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/6/92

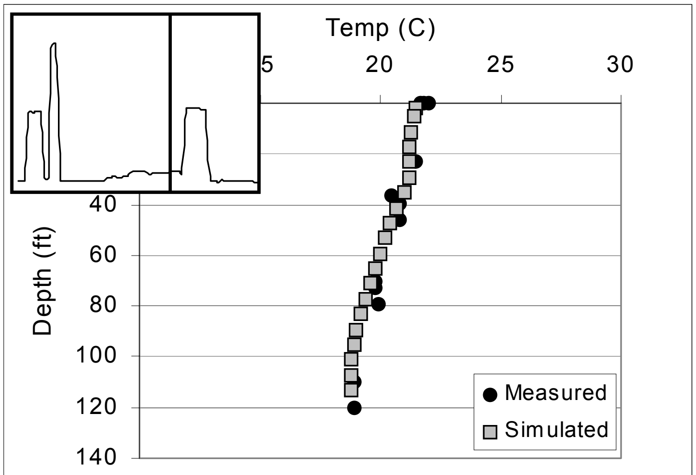

Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/11/92


Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/18/92

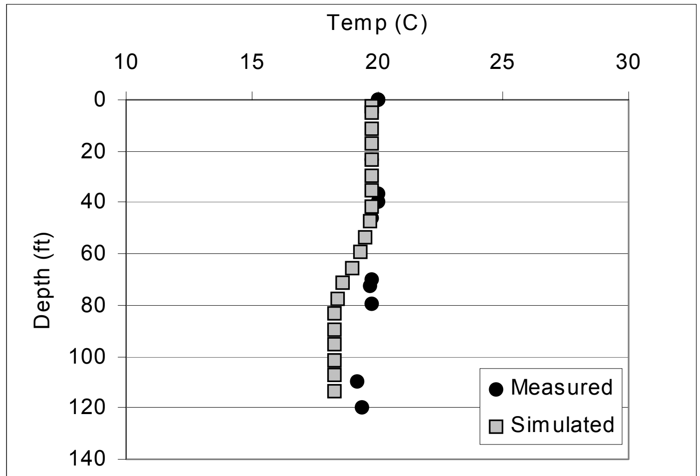

Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/20/92


Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/26/92

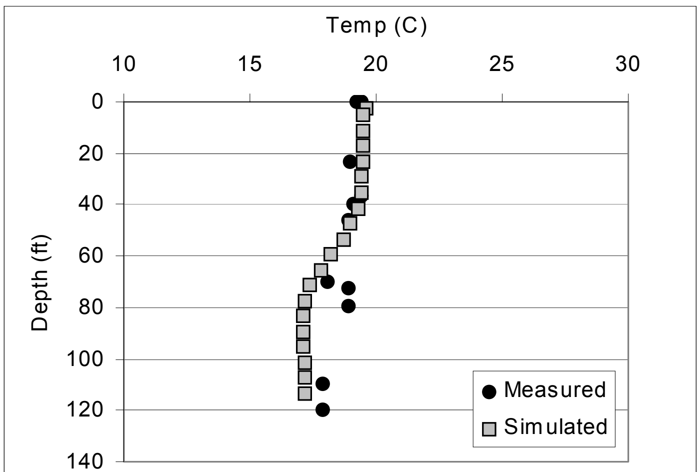

Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 8/29/92



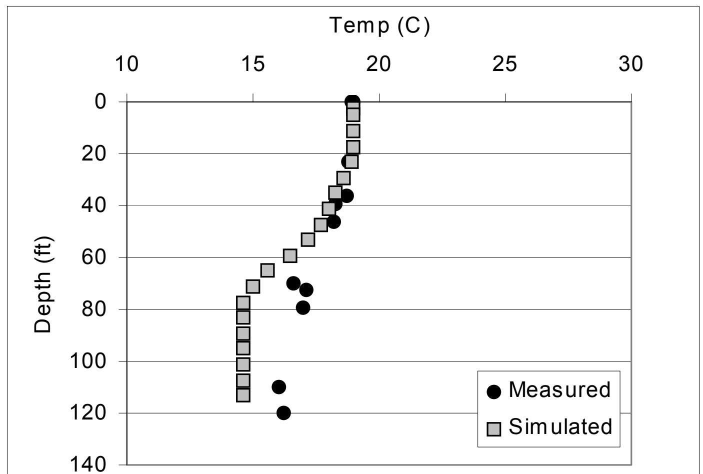
RM110 - 9/3/92



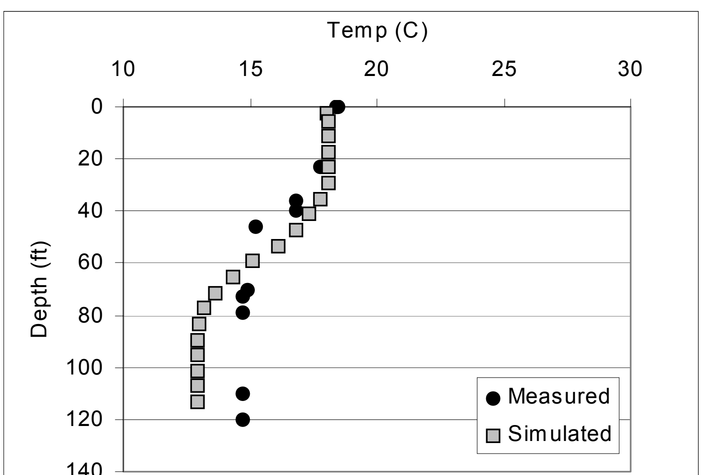
RM110 - 9/11/92



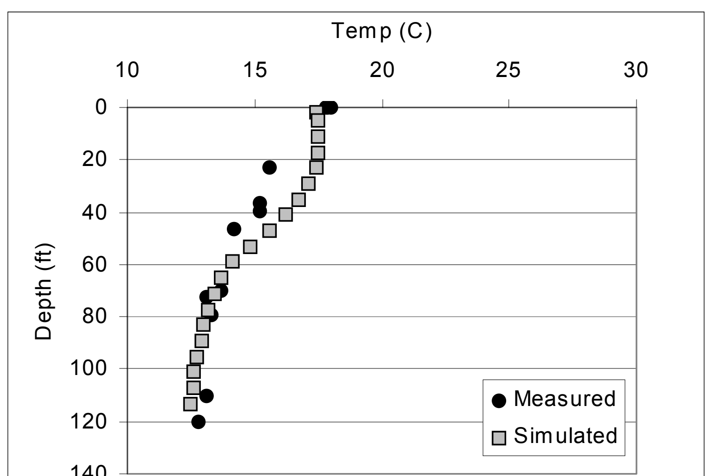
RM110 - 9/13/92



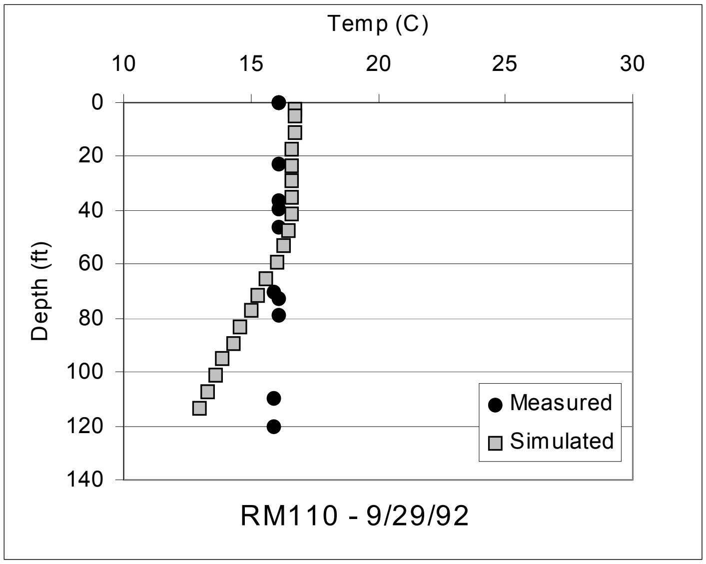
RM110 - 9/15/92

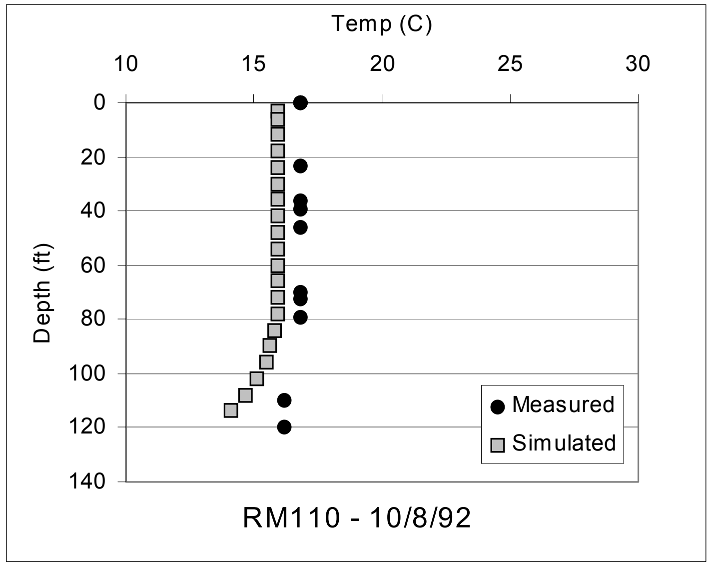


RM110 - 9/17/92



RM110 - 9/21/92


Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 9/29/92

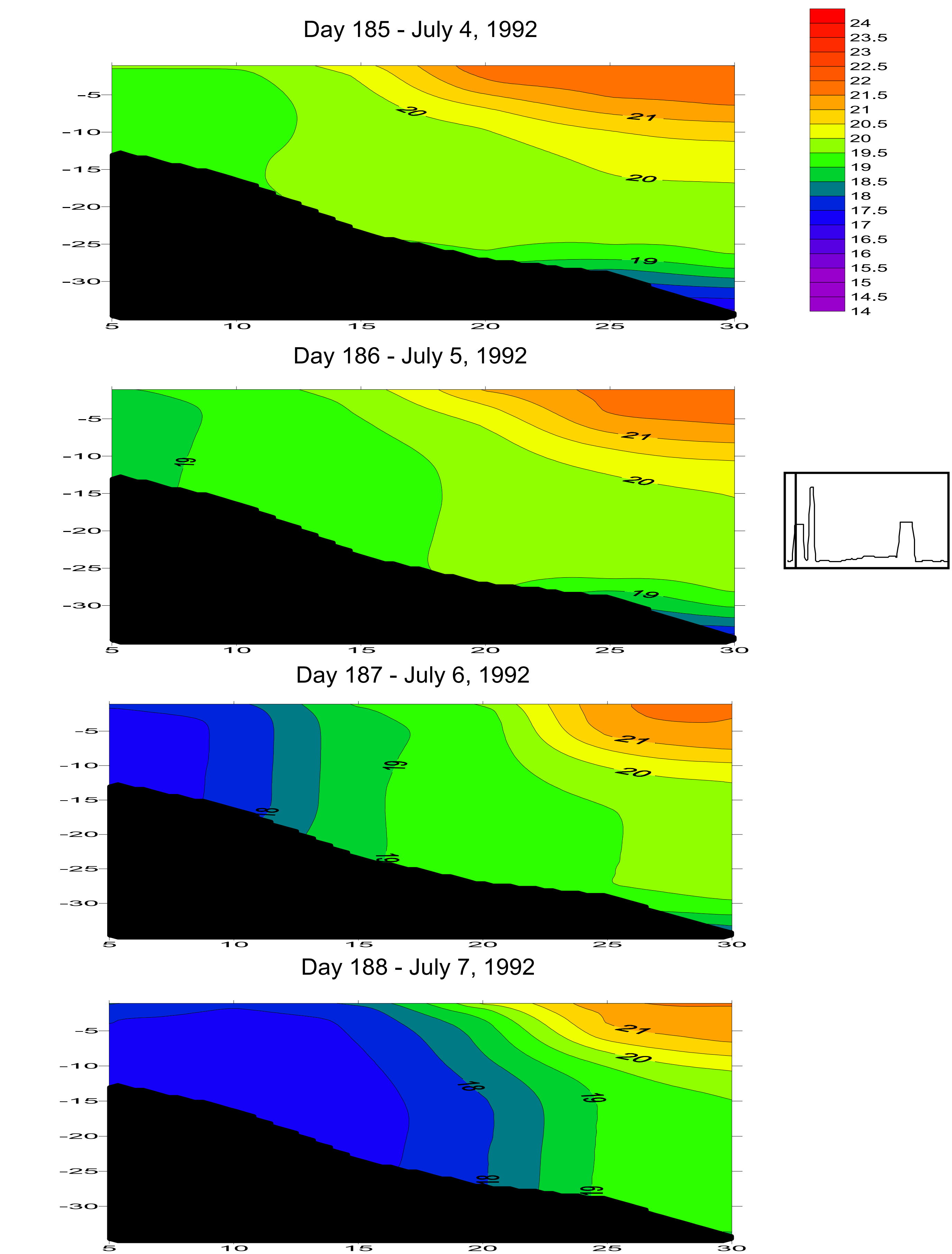

Temp (C)
10
15
20
25
30
0
20
40
60
80
100
120
140
Depth (ft)
Measured
Simulated
RM110 - 10/8/92

Appendix A: Contour Plots of Simulated Temperatures

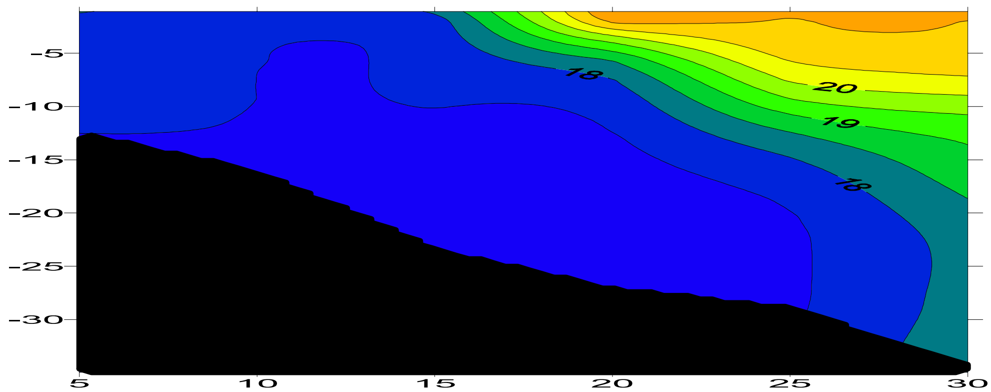
Notes regarding plots:

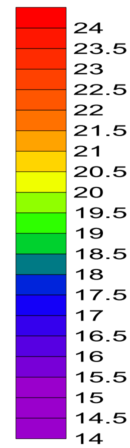
The x-axis in the following graphs is distance from Lewiston in miles. Miles 10, 20, and 30 on the plots correspond to River Mile 130, 120, and 110, respectively.

The y-axis is river depth in meters. Temperatures contours are in degrees Celsius. Contours are drawn for each 0.5 degree Celsius increment, and contours are labeled at 1 degree Celsius increments.

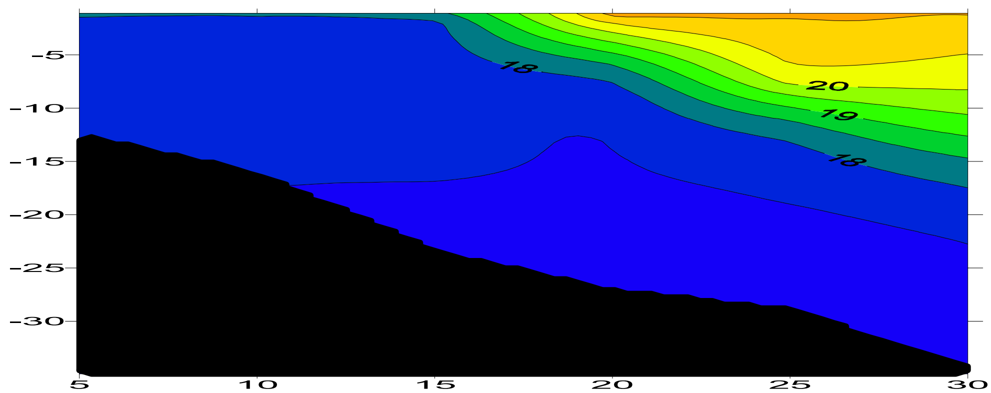

Day 185 - July 4, 1992
Day 186 - July 5, 1992
Day 187 - July 6, 1992
Day 188 - July 7, 1992
24
23.5
23
22.5
22
21.5
21
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
15
14.5
14
-5
-10
-15
-20
-25
-30
5
10
15
20
25
30
21
20
19
18

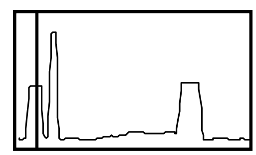
Day 189 - July 8, 1992



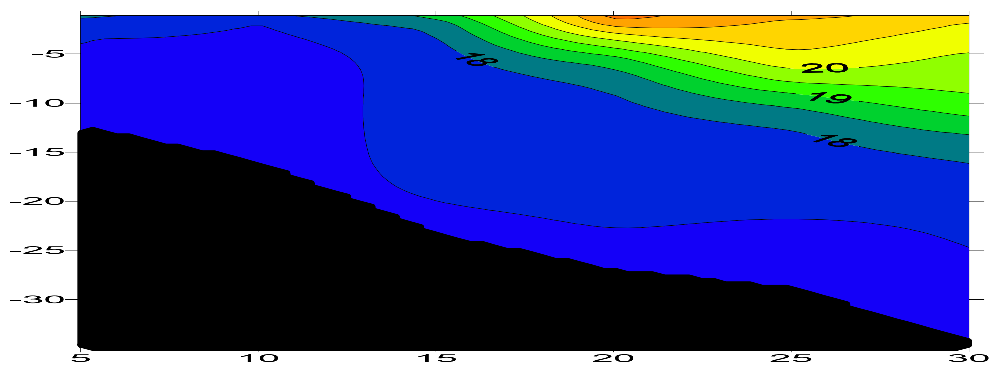


Day 190 - July 9, 1992

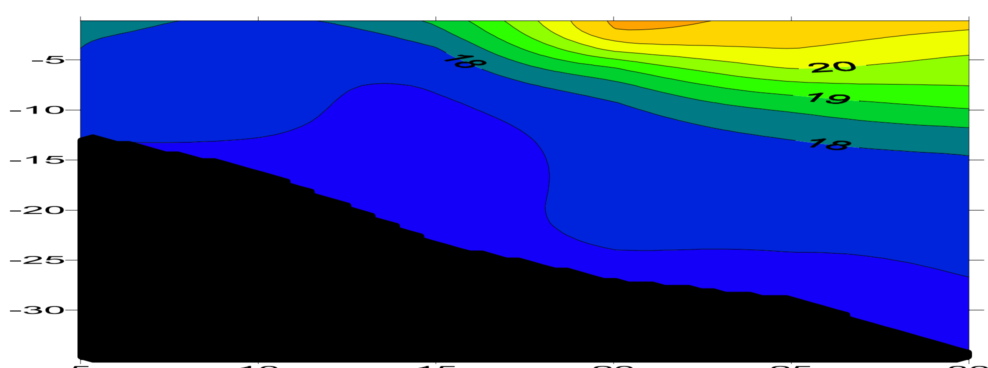




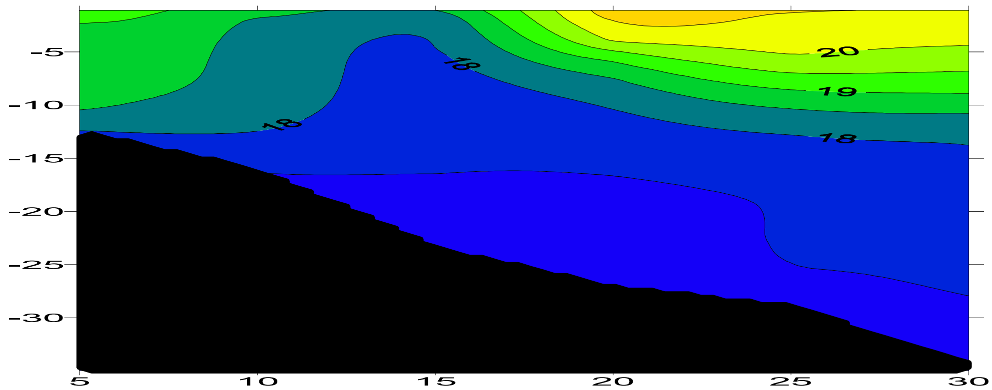
Day 191 - July 10, 1992

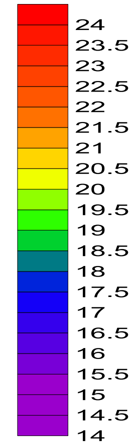


Day 192 - July 11, 1992

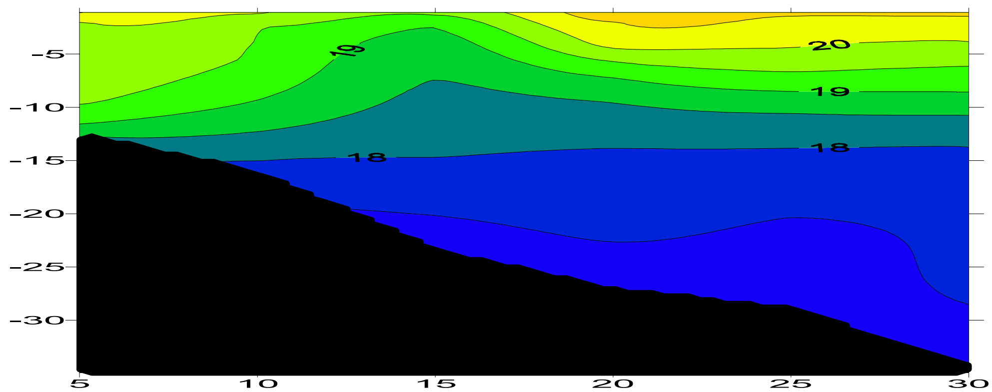


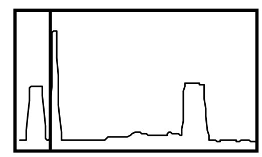
Day 193 - July 12, 1992



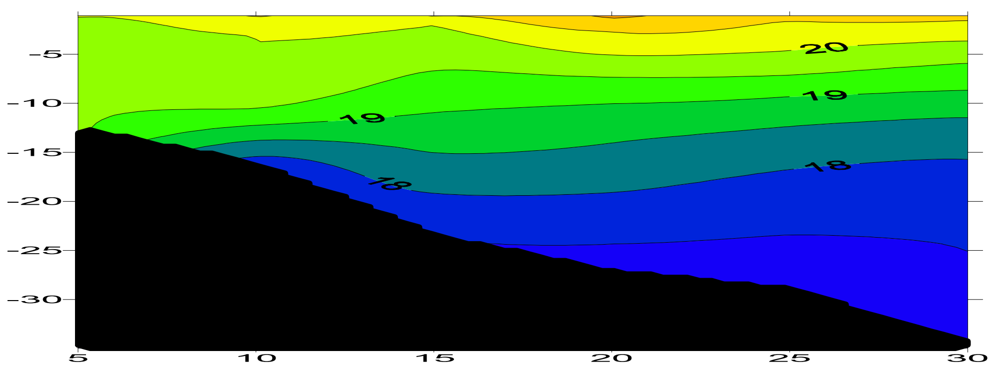


Day 194 - July 13, 1992

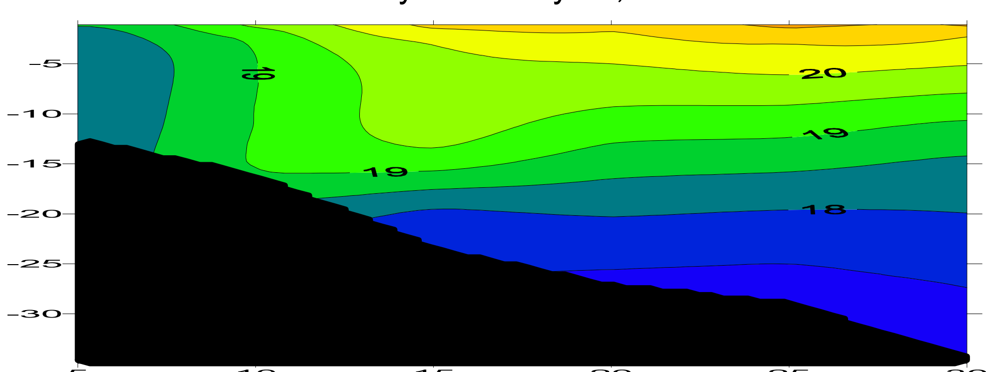




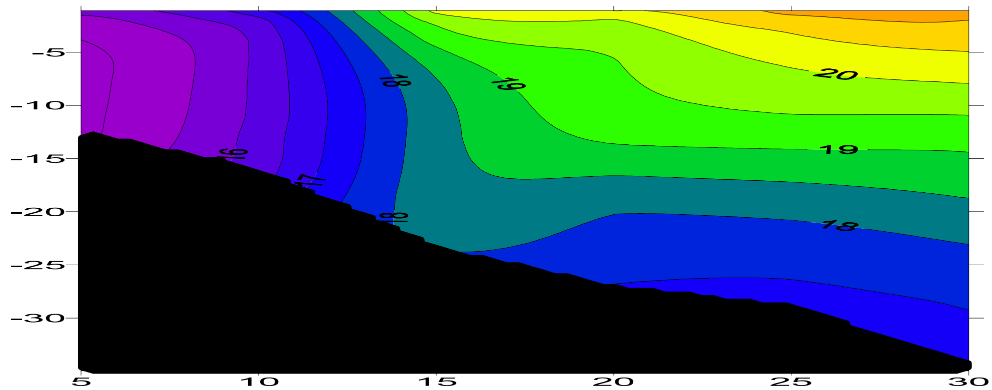
Day 195 - July 14, 1992

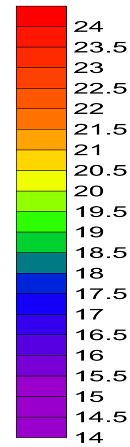


Day 196 - July 15, 1992

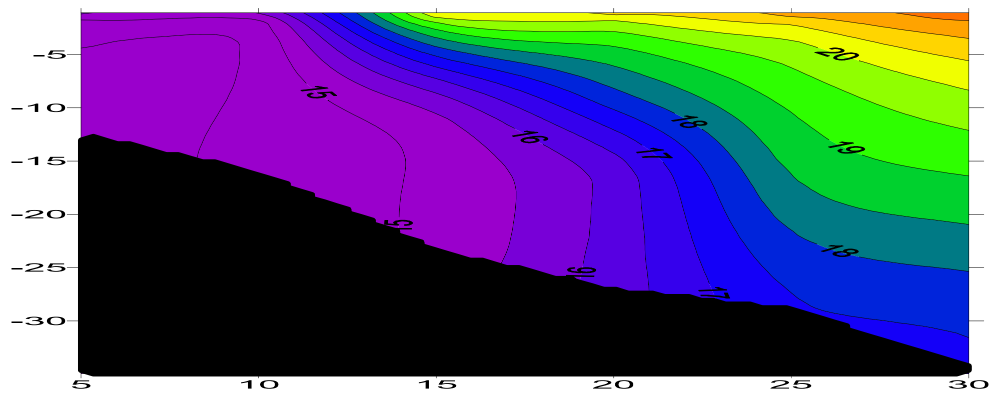


Day 197 - July 16, 1992

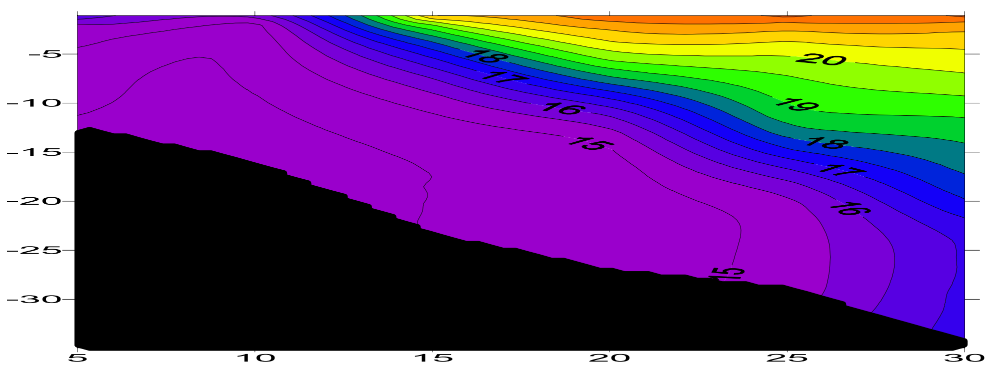




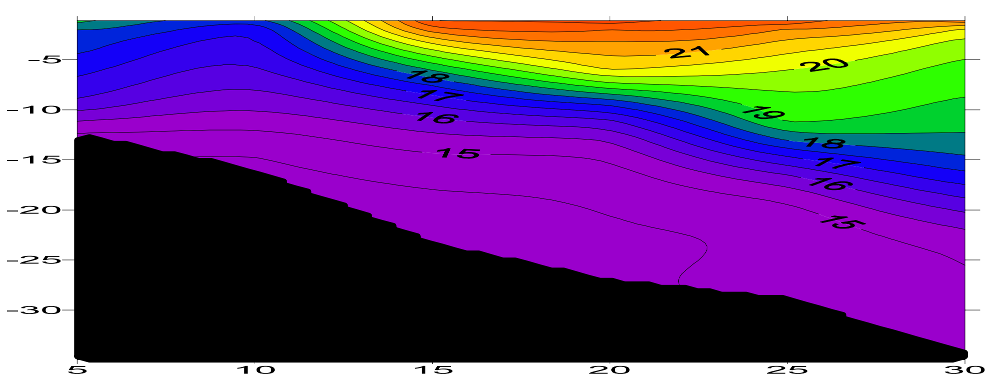
Day 198 - July 17, 1992

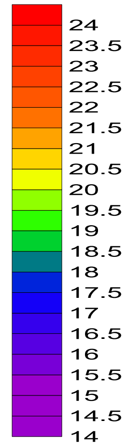


Day 199 - July 18, 1992

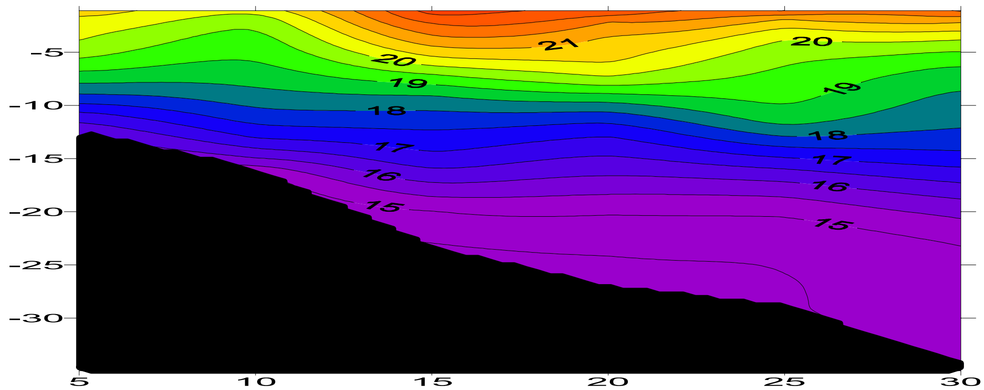


Day 200 - July 19, 1992

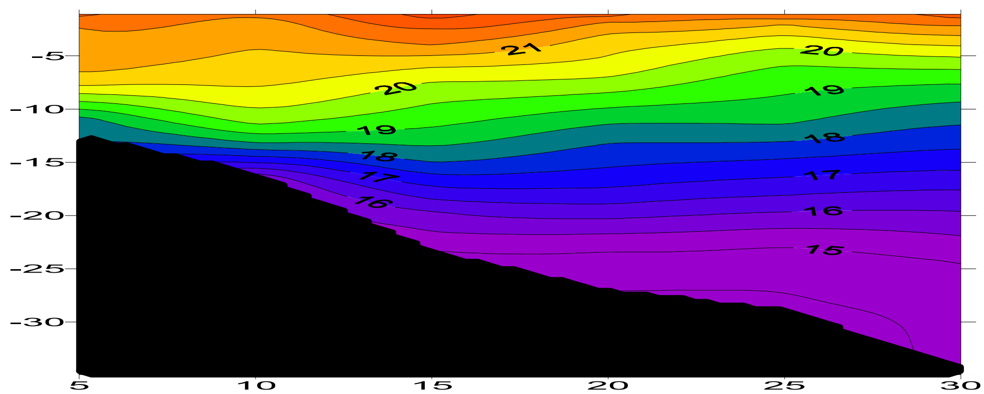


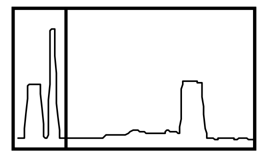


Day 201 - July 20, 1992

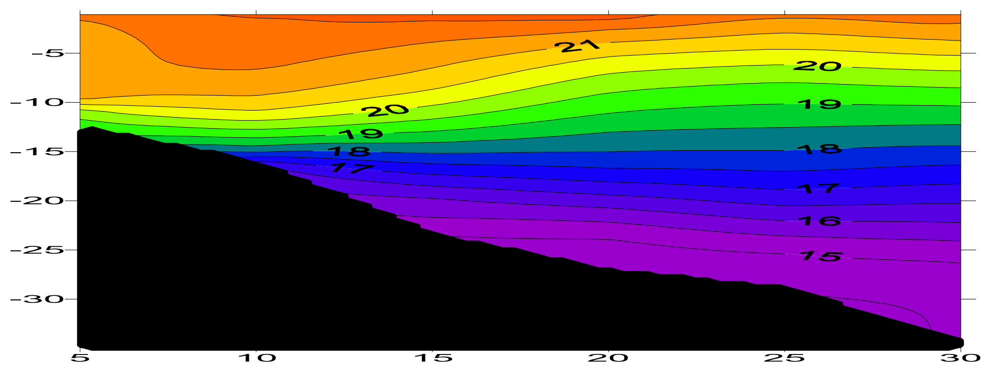


Day 202 - July 21, 1992

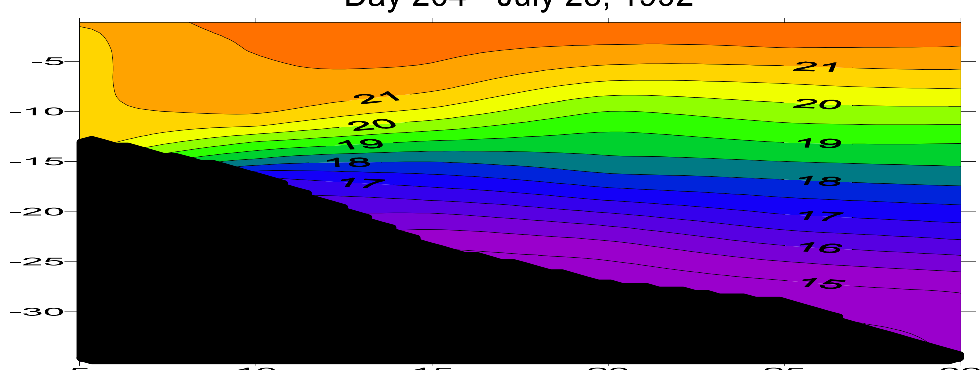


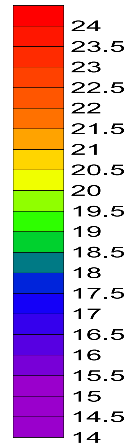


Day 203 - July 22, 1992

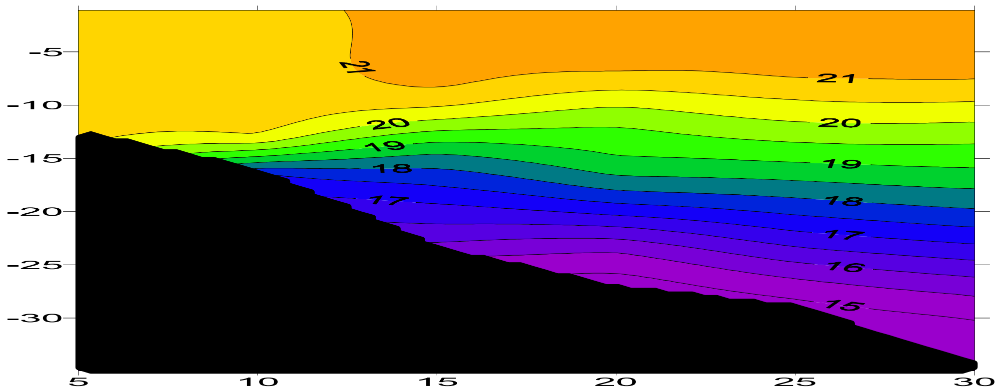


Day 204 - July 23, 1992

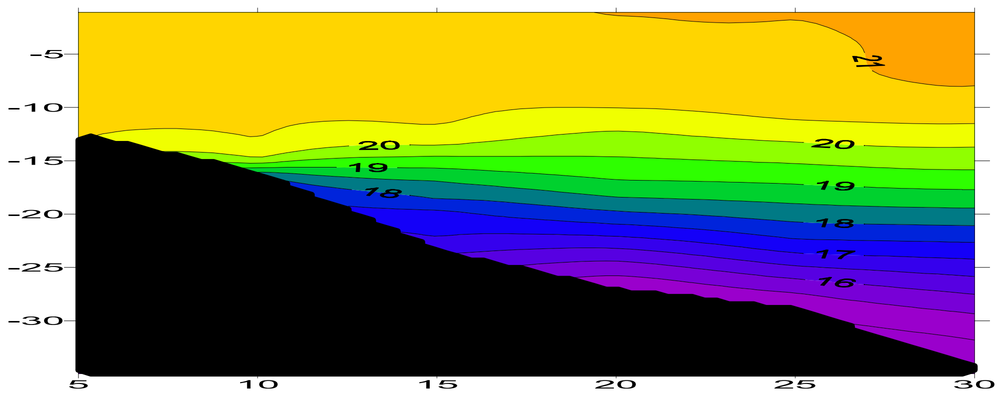


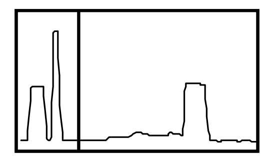


Day 205 - July 24, 1992

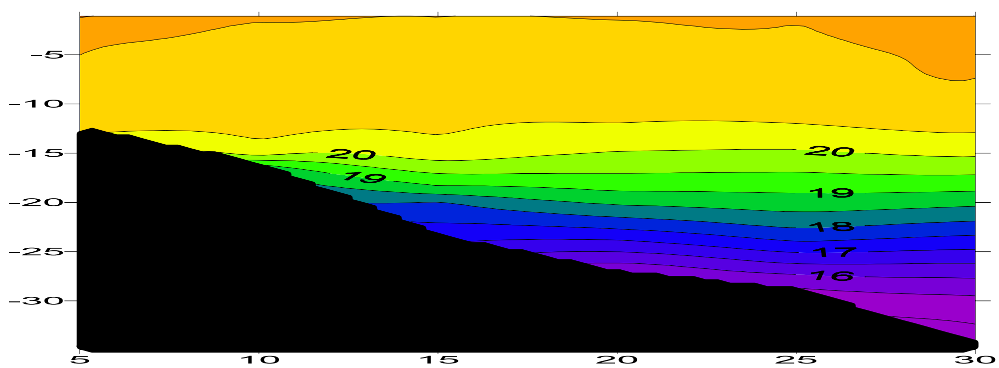


Day 206 - July 25, 1992

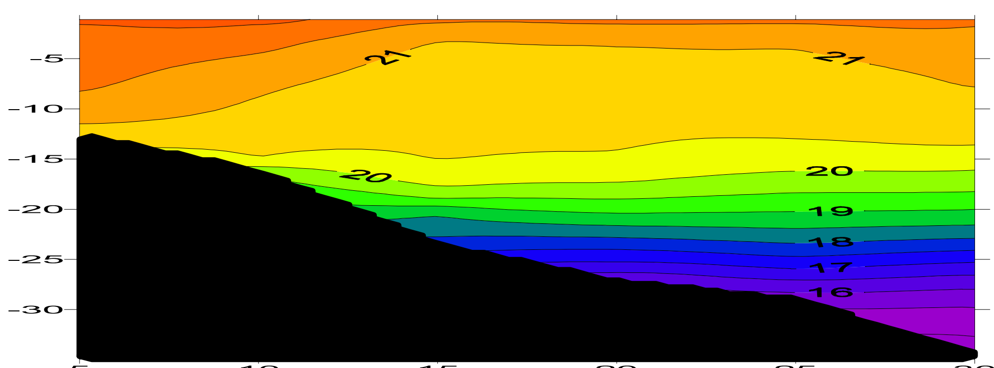




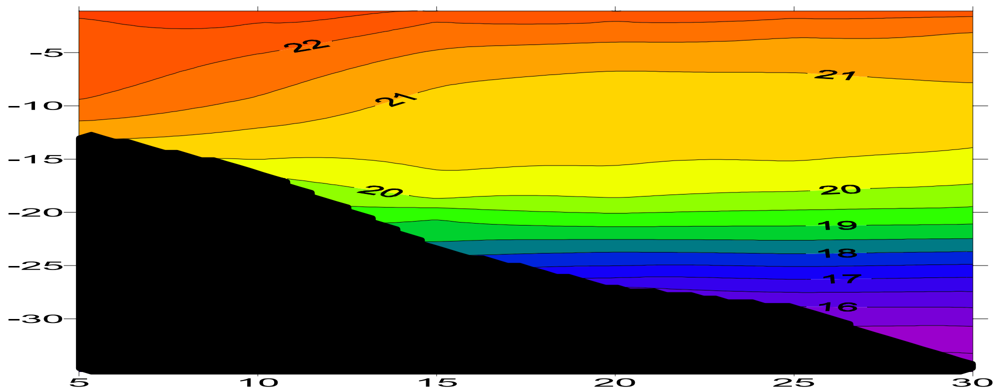
Day 207 - July 26, 1992

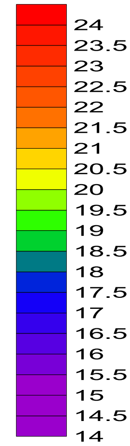


Day 208 - July 27, 1992

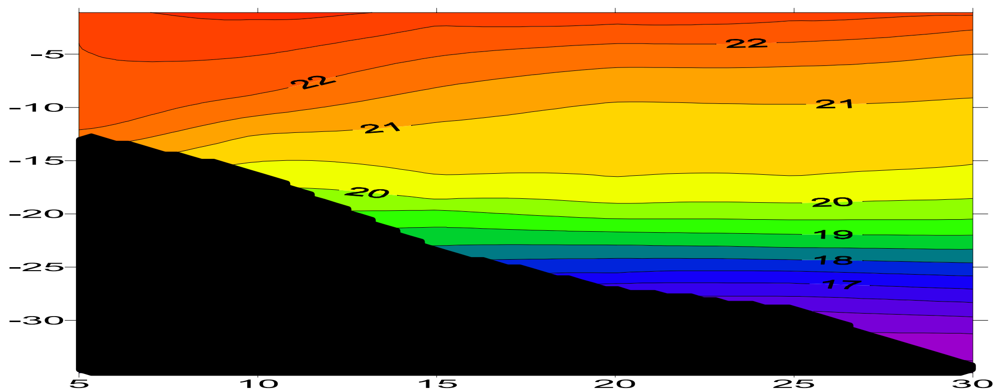


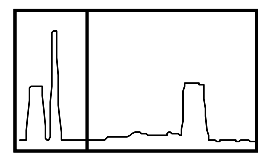
Day 209 - July 28, 1992



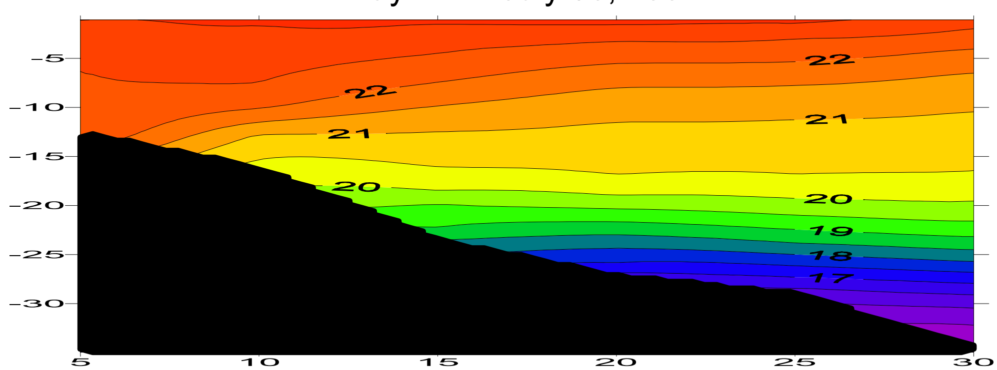


Day 210 - July 29, 1992

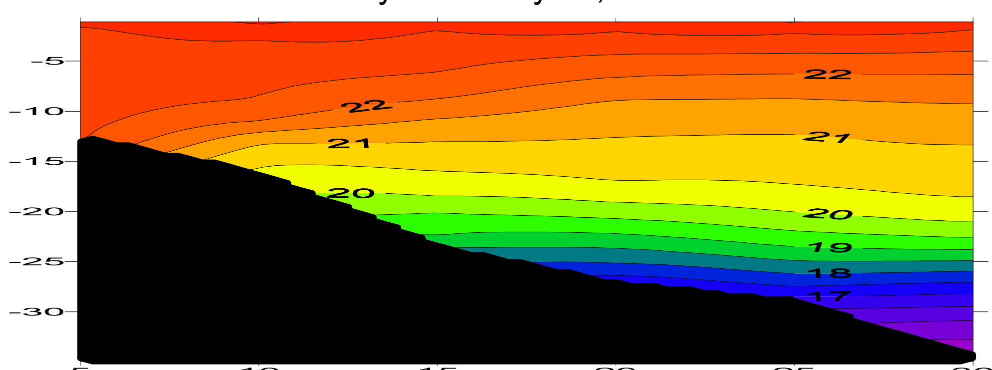


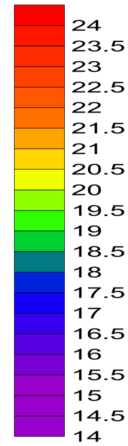


Day 211 - July 30, 1992

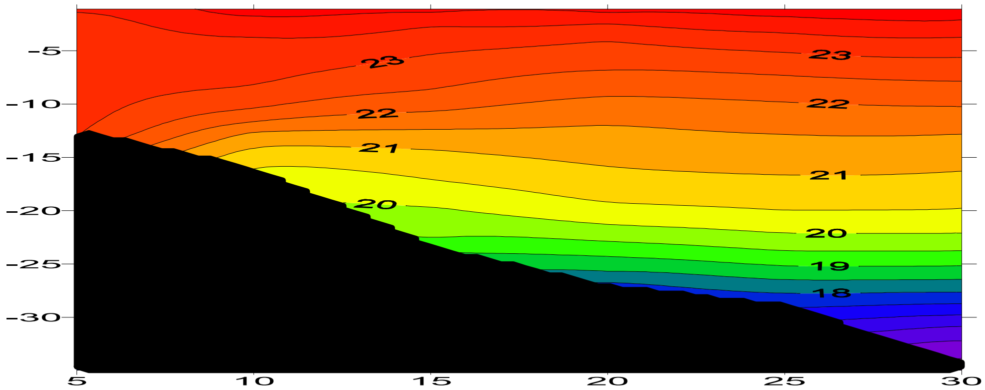


Day 212 - July 31, 1992

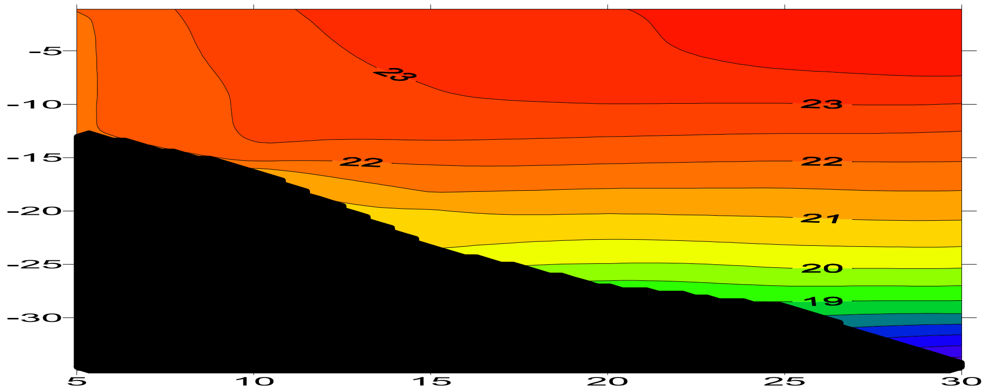




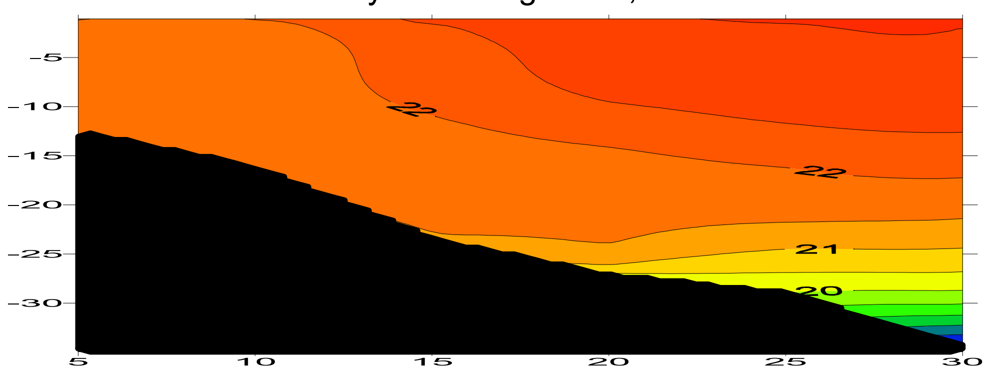
Day 214 - August 2, 1992



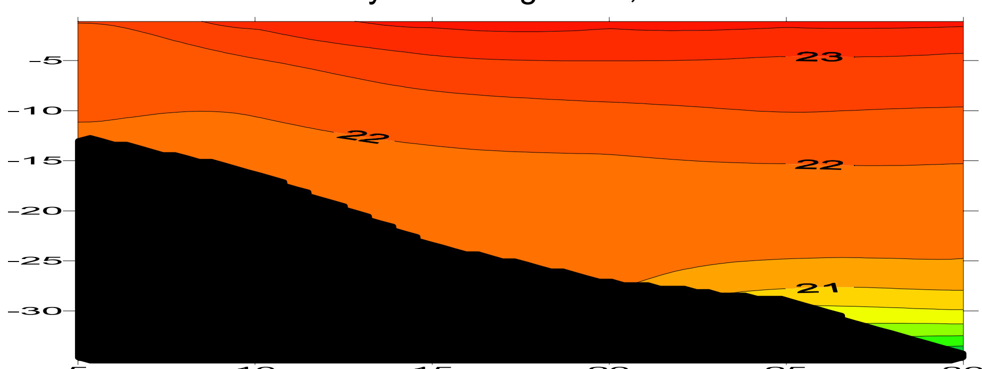
Day 218 - August 6, 1992

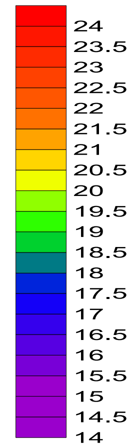


Day 222 - August 10, 1992

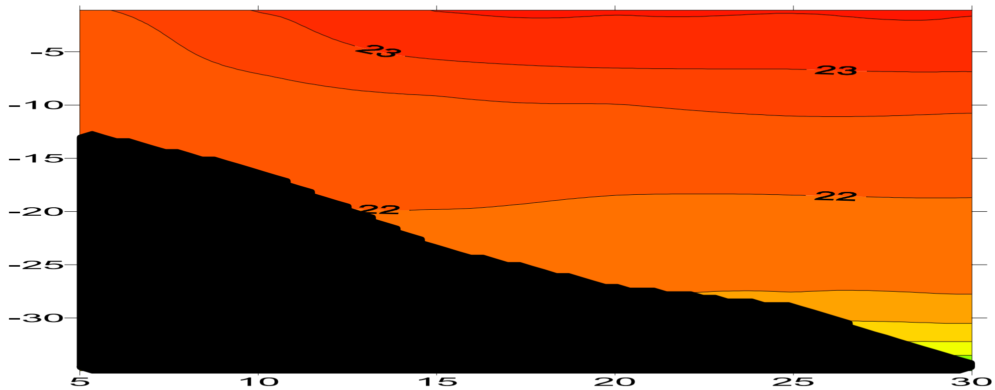


Day 226 - August 14, 1992

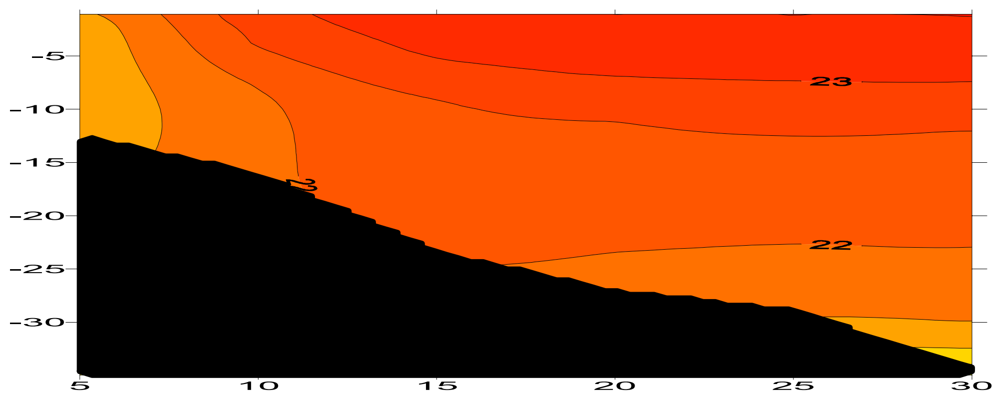


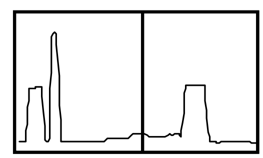


Day 230 - August 18, 1992

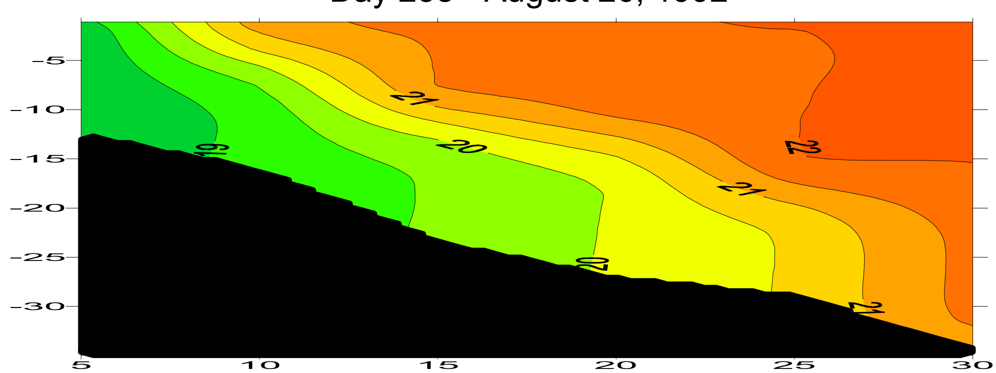


Day 234 - August 22, 1992

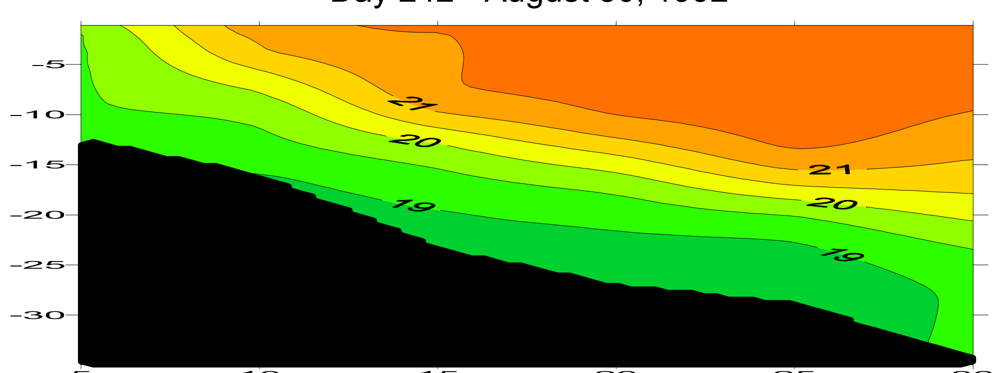


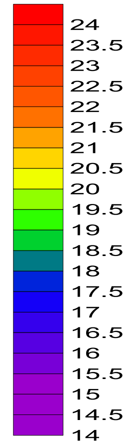


Day 238 - August 26, 1992

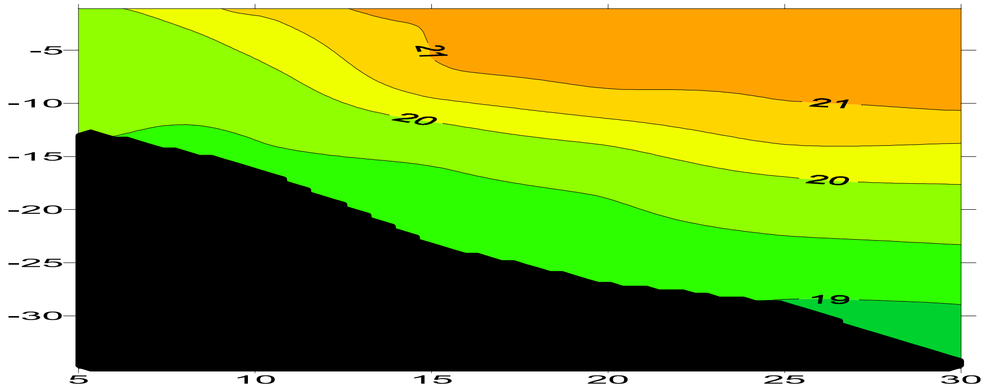


Day 242 - August 30, 1992

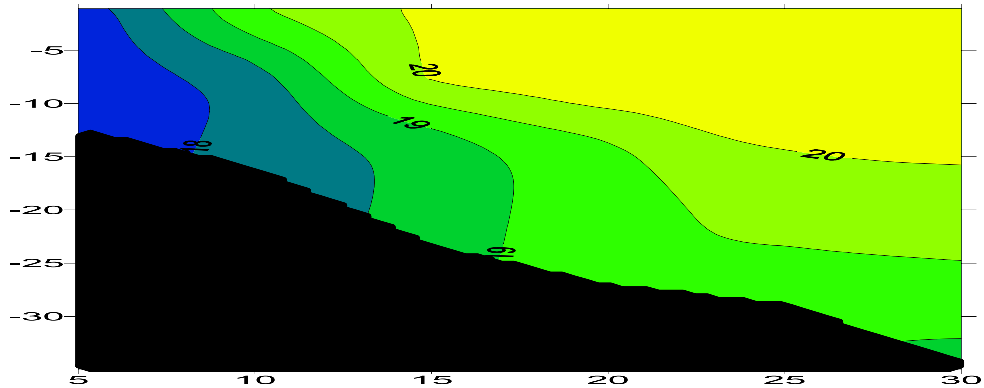


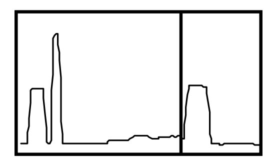


Day 246 - September 3, 1992

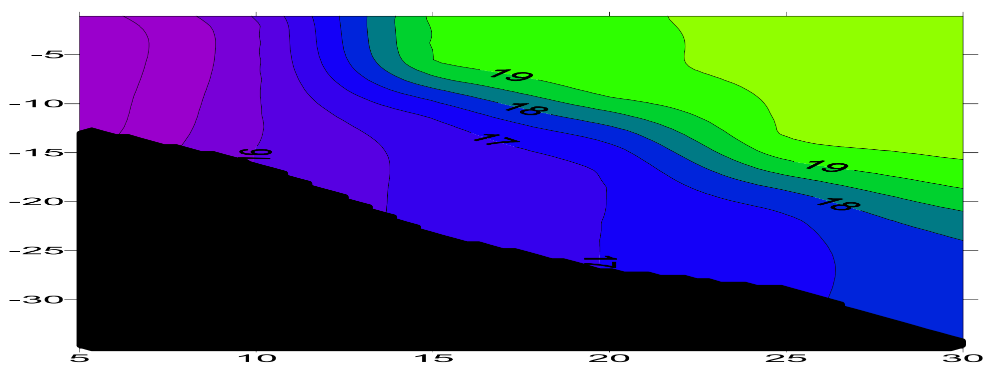


Day 250 - September 7, 1992

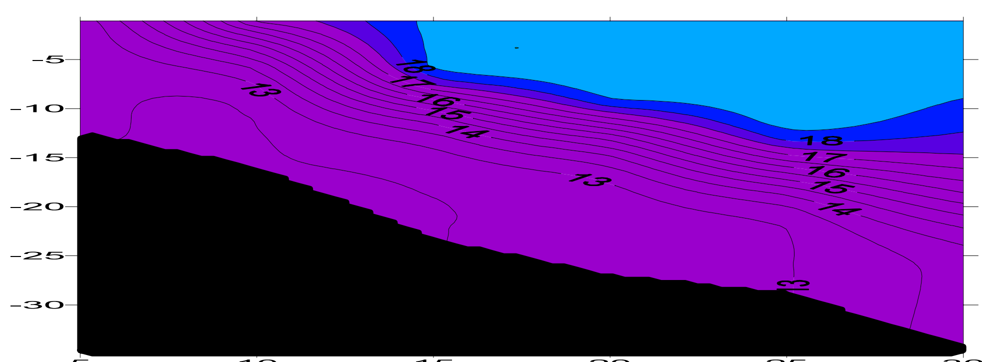


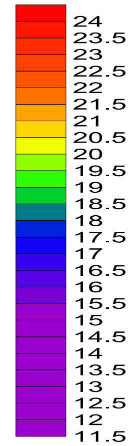


Day 254 - September 11, 1992

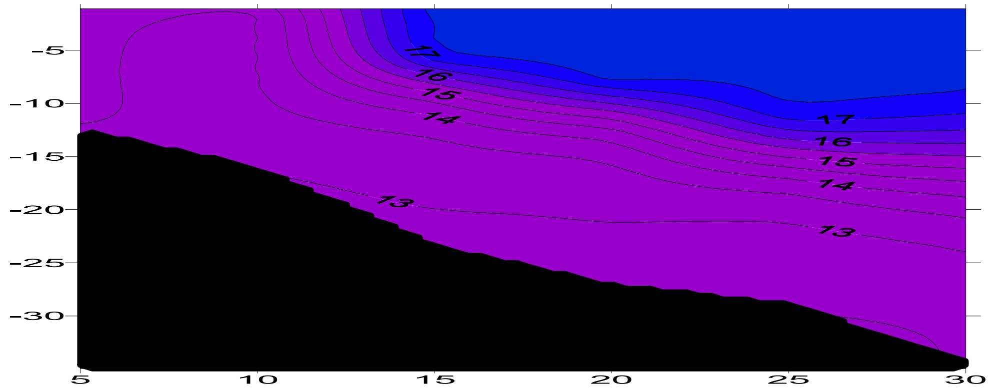


Day 258 - September 15, 1992

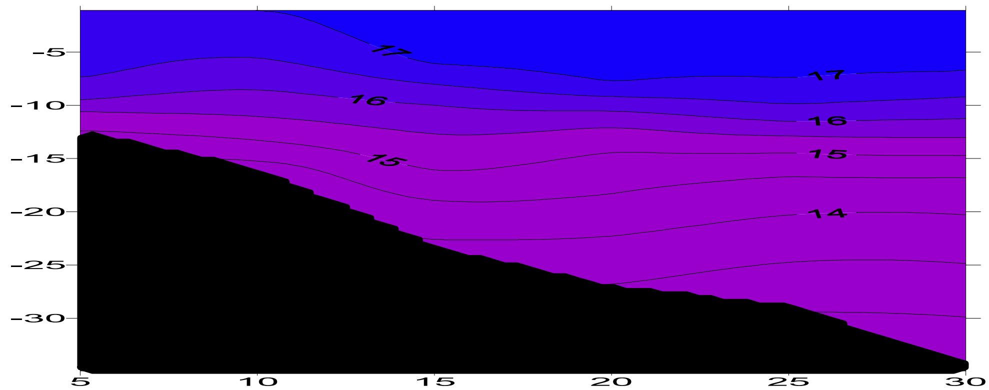




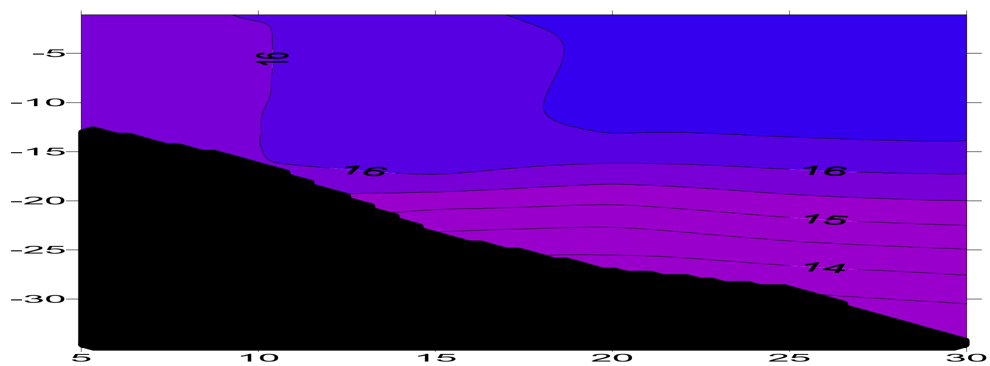
Day 262 - September 19, 1992



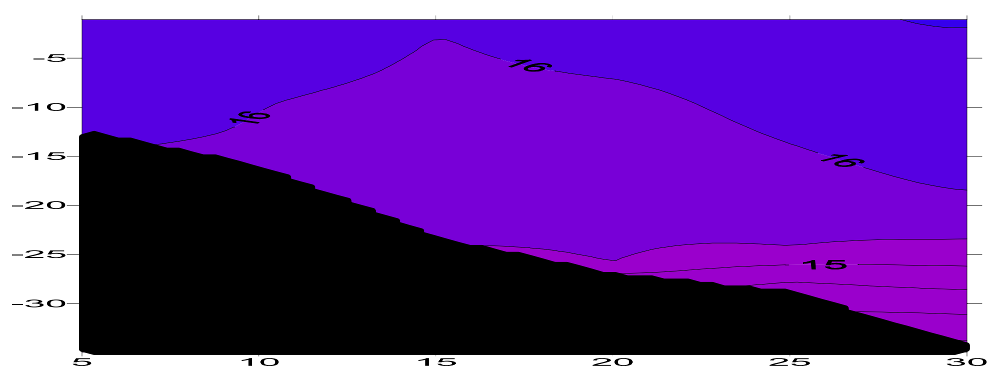
Day 266 - September 23, 1992



Day 270 - September 27, 1992

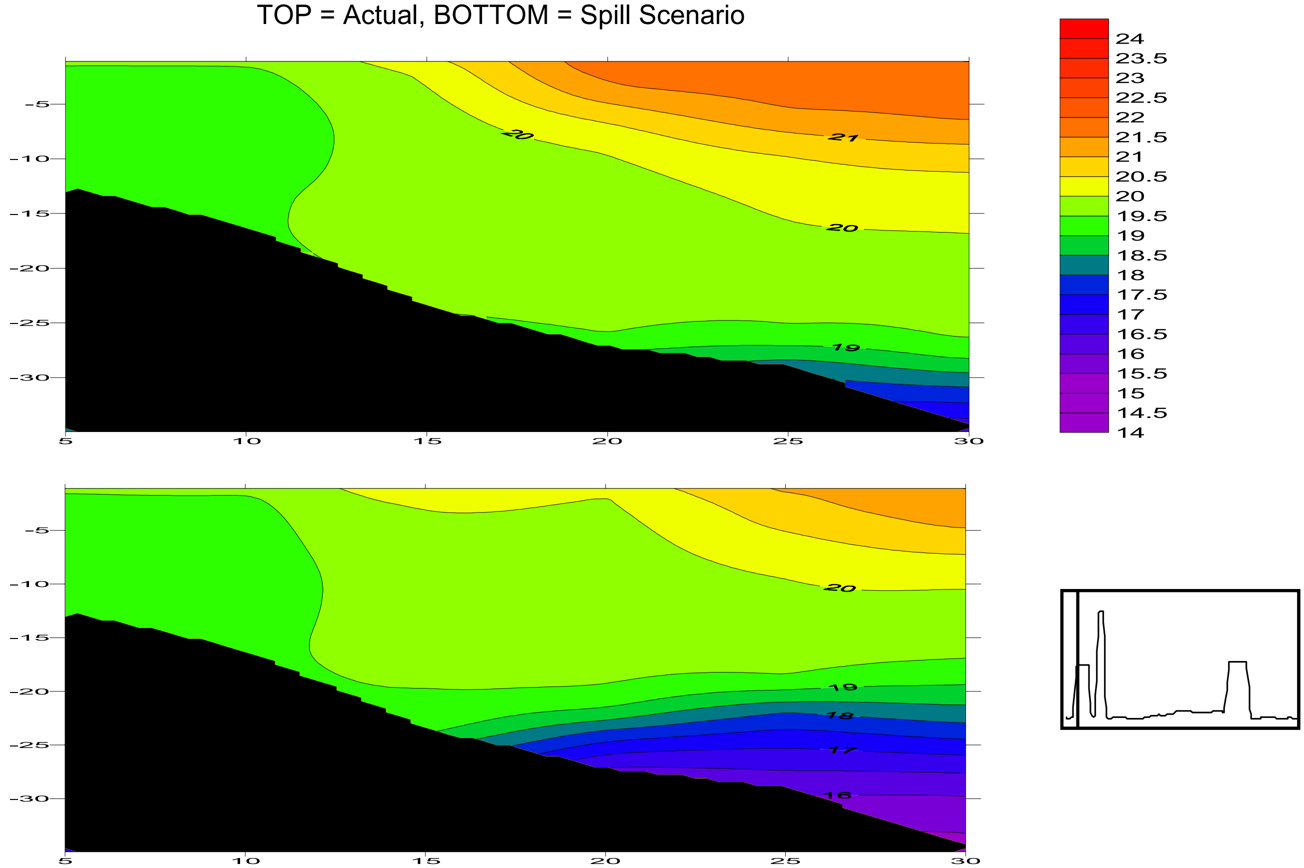


Day 274 - October 1, 1992

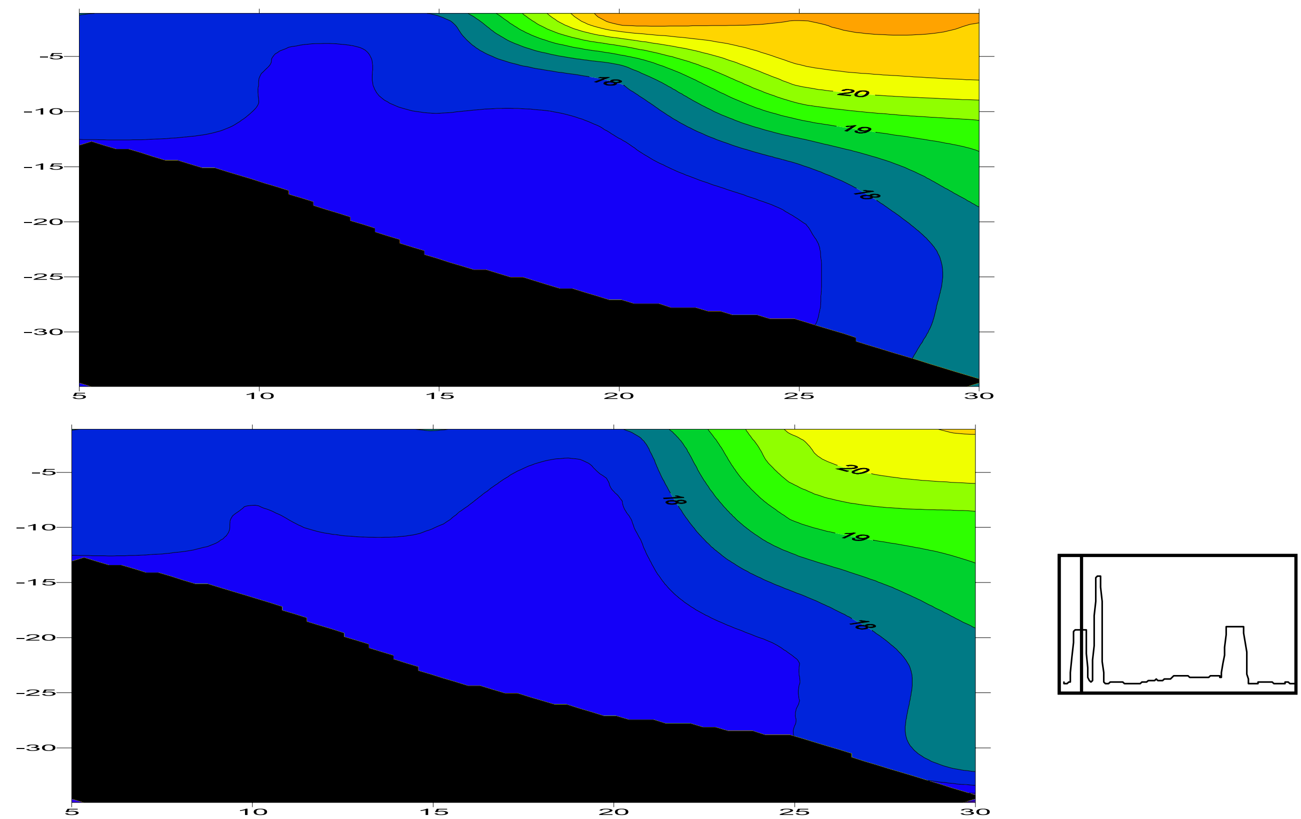


Appendix B: Contour Plots for Powerhouse Release and Spill Release Scenarios

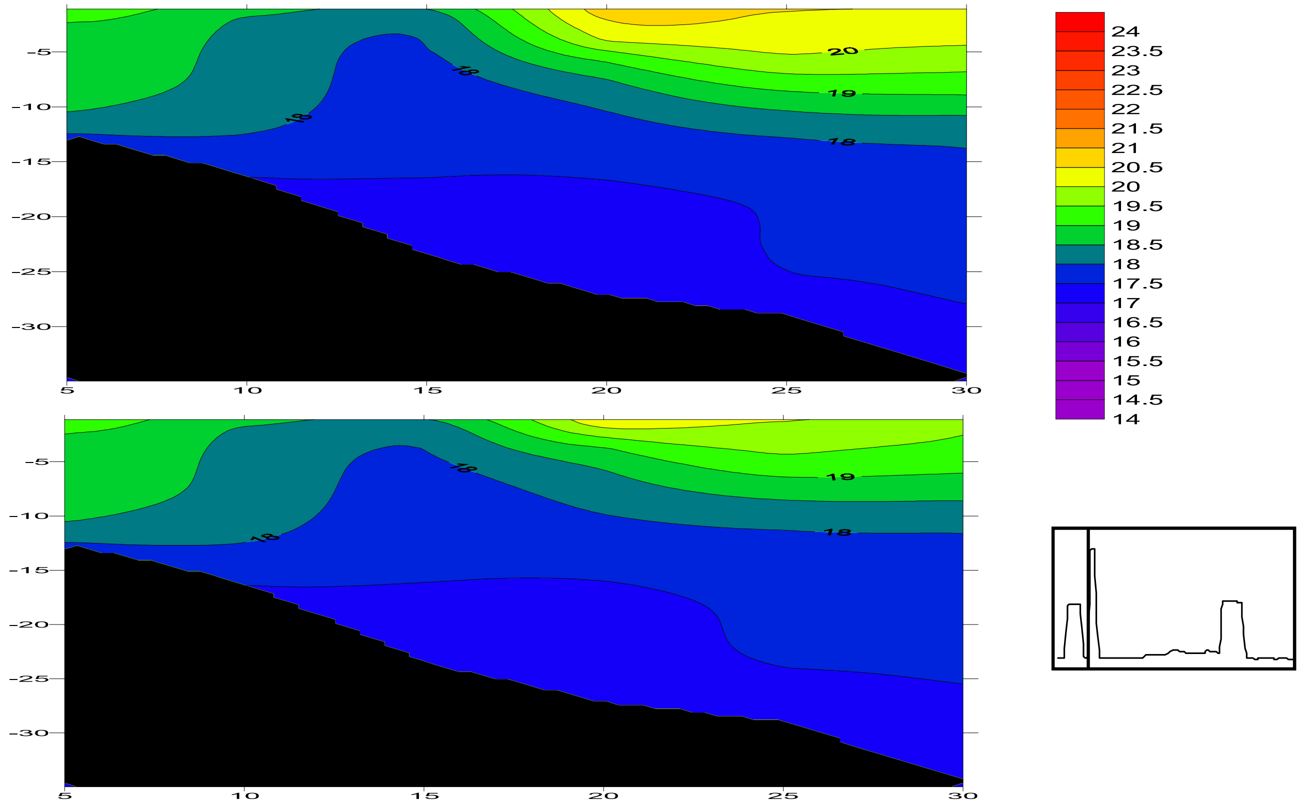
Day 185
TOP = Actual, BOTTOM = Spill Scenario



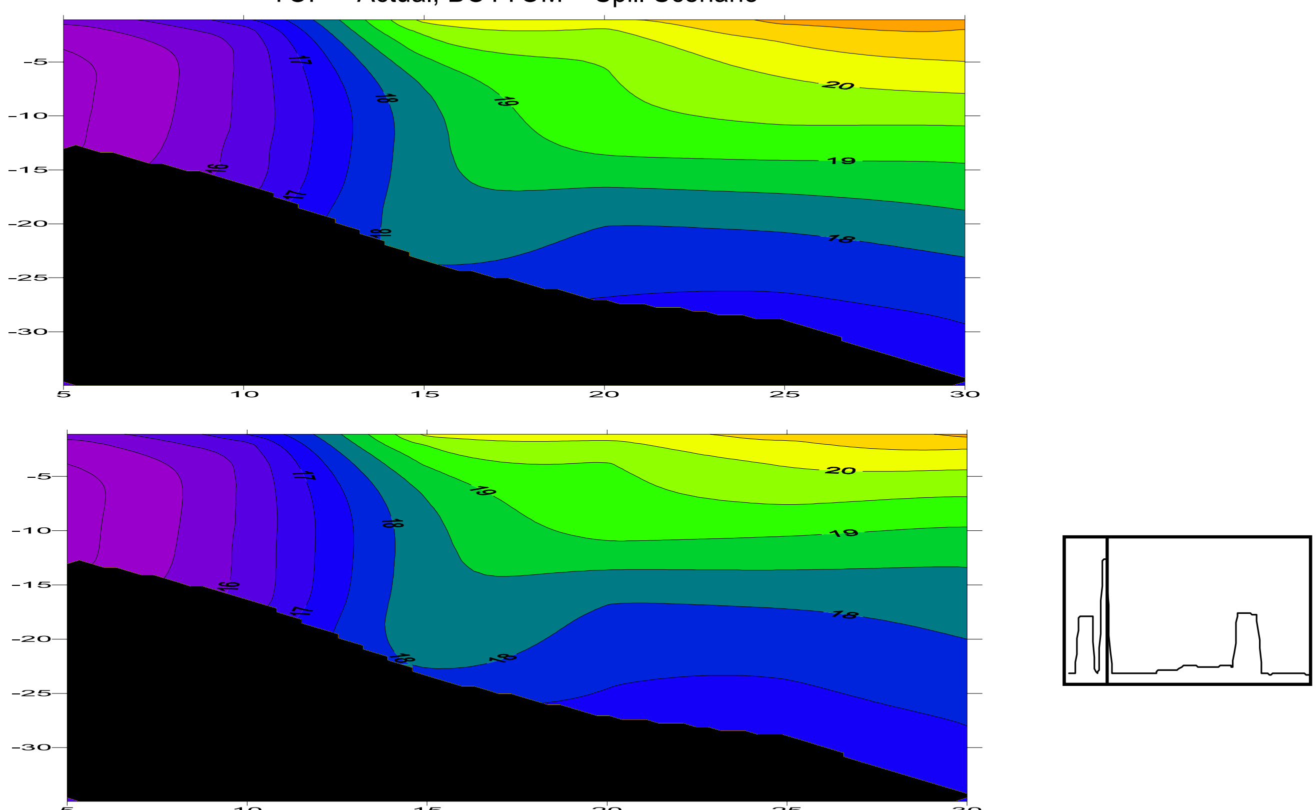
Day 189
TOP = Actual, BOTTOM = Spill Scenario



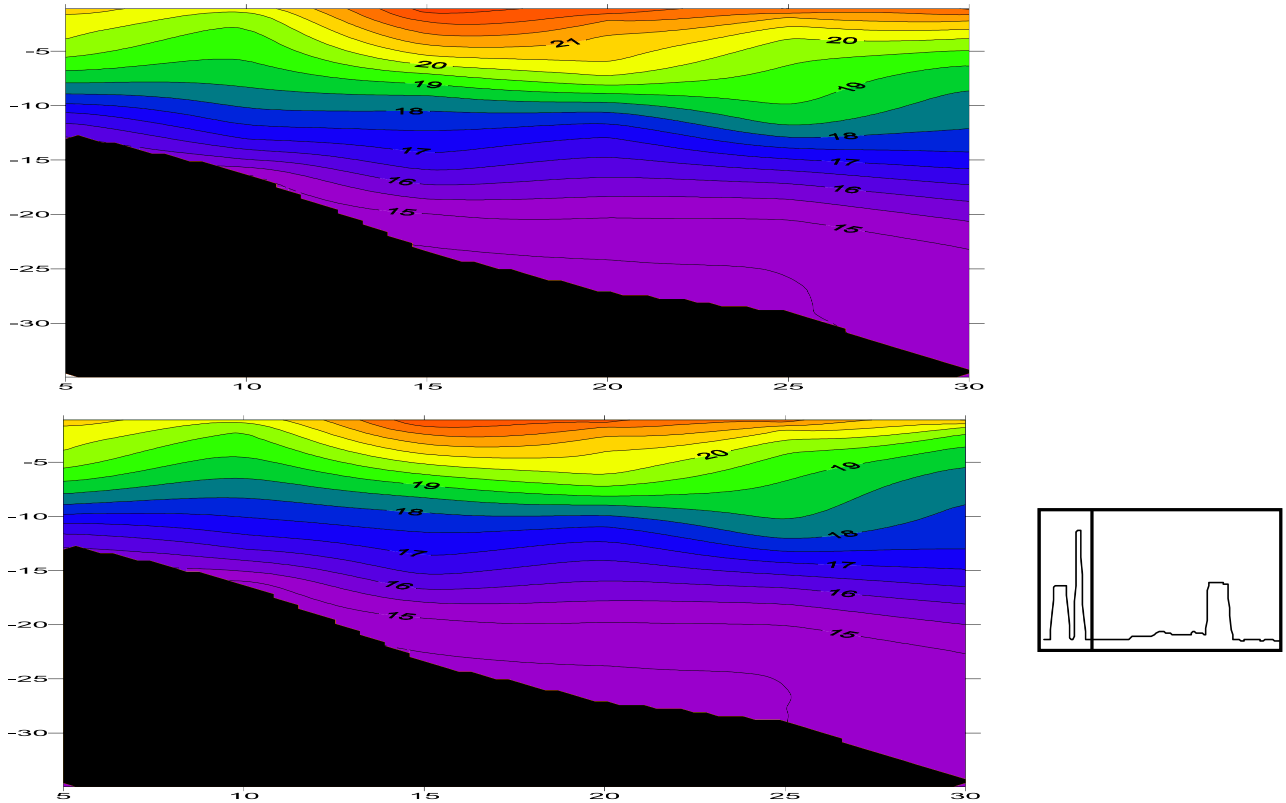
Day 193
TOP = Actual, BOTTOM = Spill Scenario



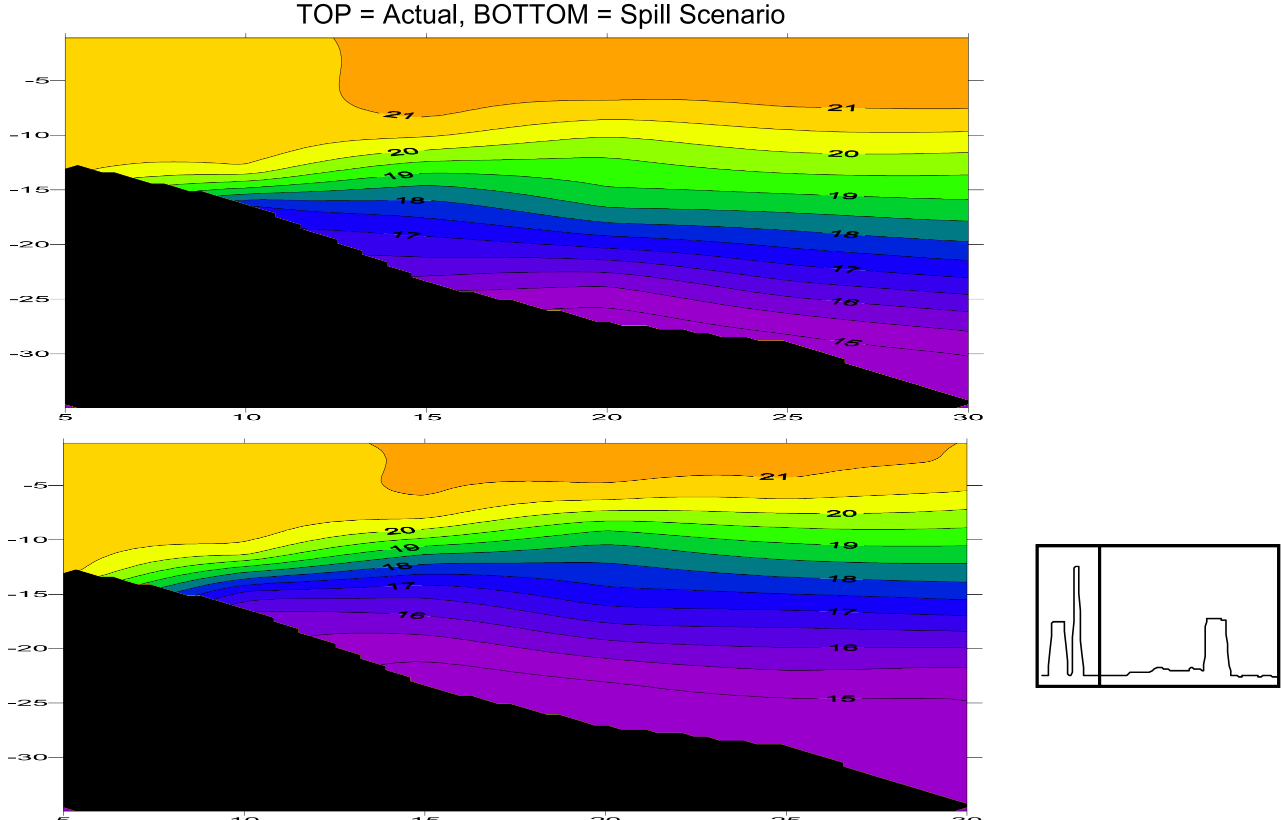
Day 197
TOP = Actual, BOTTOM = Spill Scenario



Day 201
TOP = Actual, BOTTOM = Spill Scenario



Day 205
TOP = Actual, BOTTOM = Spill Scenario



Appendix C: CE-QUAL-W2 Input Files - Bathymetry and Control Files

```
Lower Granite Geometry for CE-QUAL-W2 (segment lengths=1 mile, thickness=6 ft)

Segment Lengths
  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3
  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3
  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3  1609.3
  1609.3  1609.3  1609.3  1609.3  1609.3

W.S. Elevation
   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3
   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3
   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3   224.3
   224.3   224.3   224.3   224.3   224.3

Seg Orientation
     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6
     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6
     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6     1.6
     1.6     1.6     1.6     1.6     1.6

Seg Thickness
    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83
    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83    1.83
    1.83    1.83    1.83    1.83

Segment   1
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   2
      .0   748.4   735.4   717.1   690.3   673.2   484.6   102.3      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   3
      .0   515.8   504.8   491.9   478.7   467.0   308.6   227.8   105.8      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   4
      .0   504.5   470.2   450.7   398.7   302.1   248.8   201.9   145.2      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   5
      .0   617.1   609.4   601.6   594.1   527.2   440.6   276.7   177.1    25.6
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   6
      .0   452.2   442.8   434.4   422.7   411.3   350.4   316.7   276.3   210.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   7
      .0   503.0   458.6   395.4   336.0   303.3   287.3   270.3   246.6   204.9
   166.6   134.8      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   8
      .0   414.9   405.4   390.2   345.0   308.2   273.1   243.9   218.3   201.3
   180.2   146.6      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

Segment   9
      .0   553.1   511.6   393.9   330.3   299.2   284.0   256.8   237.9   210.1
   176.7   133.8      .0      .0      .0      .0      .0      .0      .0      .0
```

```
       .0        .0        .0        .0

Segment  10
       .0     418.5     407.7     401.8     385.0     370.6     364.4     356.9     342.9     322.3
    276.9     148.9        .0        .0        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  11
       .0     522.5     487.6     440.3     418.6     354.0     317.8     297.7     280.0     241.0
    213.4     179.2     128.6      83.4      38.3        .0        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  12
       .0     422.2     395.8     392.2     385.5     359.8     323.6     315.2     290.5     278.2
    264.1     247.2     176.9     117.6      65.3        .0        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  13
       .0     503.9     484.2     452.9     430.8     402.7     373.1     333.1     284.6     260.2
    237.0     212.0     190.2     165.8     115.2        .0        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  14
       .0     586.6     579.7     572.8     559.0     421.0     373.3     348.8     323.1     298.2
    264.1     232.0     197.1     157.7        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  15
       .0     512.5     504.2     499.0     493.9     488.5     473.8     416.1     400.3     380.9
    363.0     345.3     299.3     234.1     159.6     103.8        .0        .0        .0        .0
       .0        .0        .0        .0

Segment  16
       .0     433.4     411.0     401.6     390.8     362.8     342.0     322.9     292.9     270.5
    253.3     238.5     226.9     215.4     199.3     166.2      82.5      33.6        .0        .0
       .0        .0        .0        .0

Segment  17
       .0     468.5     460.9     447.4     425.6     398.5     371.6     352.1     321.0     302.1
    276.6     244.9     222.8     201.3     180.0     149.2     110.1      66.7        .0        .0
       .0        .0        .0        .0

Segment  18
       .0     431.0     425.3     417.0     408.9     400.4     388.6     356.9     319.5     298.6
    284.4     266.0     244.7     226.7     207.1     184.7     148.5      72.9        .0        .0
       .0        .0        .0        .0

Segment  19
       .0     434.1     426.5     417.0     406.6     399.5     392.9     383.5     370.5     355.1
    307.8     289.9     276.3     264.3     252.6     235.4     184.3     117.9        .0        .0
       .0        .0        .0        .0

Segment  20
       .0     516.6     509.0     498.9     488.5     477.8     464.1     445.6     428.2     408.9
    342.8     313.9     291.7     270.1     239.5     195.4     143.7      86.1        .0        .0
       .0        .0        .0        .0

Segment  21
       .0     651.9     642.2     631.4     609.3     482.5     445.4     422.5     400.4     368.3
    334.6     289.1     267.9     235.9     198.3     169.0     145.5     113.8        .0        .0
       .0        .0        .0        .0

Segment  22
       .0     658.2     638.9     618.5     590.9     564.9     529.8     492.6     455.4     430.4
    405.1     349.8     322.7     287.5     260.5     233.9     181.3     114.6        .0        .0
       .0        .0        .0        .0

Segment  23
```

```
      .0   677.5   657.8   635.6   609.4   585.7   557.8   521.9   484.4   459.7
   439.1   416.9   362.7   332.1   290.0   260.6   223.8   161.1      .0      .0
      .0      .0      .0      .0

Segment  24
      .0   696.7   678.0   653.2   628.5   607.0   584.7   553.1   517.8   487.2
   468.9   450.6   432.8   379.2   342.3   292.5   258.1   211.6   106.0      .0
      .0      .0      .0      .0

Segment  25
      .0   716.0   700.0   671.0   648.0   628.5   609.4   586.9   550.2   519.8
   496.2   481.5   464.3   451.3   402.2   353.4   293.8   252.4   175.4      .0
      .0      .0      .0      .0

Segment  26
      .0   735.5   723.7   688.9   668.0   650.3   633.2   615.3   587.6   548.4
   527.0   508.2   494.8   481.4   470.8   440.1   366.2   291.0   237.8    29.4
      .0      .0      .0      .0

Segment  27
      .0   703.0   682.5   663.7   646.7   628.6   604.7   576.0   537.0   515.8
   496.0   479.9   466.8   452.4   420.3   379.4   323.1   277.8   236.1   163.6
      .0      .0      .0      .0

Segment  28
      .0   615.3   603.0   592.6   578.1   553.6   539.0   526.6   511.8   487.4
   455.7   422.5   389.2   355.8   324.8   310.0   298.6   284.9   266.3   225.2
   128.0      .0      .0      .0

Segment  29
      .0   700.5   685.6   672.3   649.2   616.2   587.9   568.0   546.4   521.3
   490.3   445.6   383.1   348.4   323.7   312.8   304.3   296.0   284.6   255.9
   188.7    91.1      .0      .0

Segment  30
      .0   900.7   884.1   854.3   836.6   804.5   770.9   738.8   693.7   618.8
   387.3   360.1   348.7   336.2   321.4   313.9   306.5   297.3   286.6   269.5
   236.8   150.4      .0      .0

Segment  31
      .0   918.9   907.2   894.0   878.6   863.9   850.3   835.2   818.8   802.7
   784.5   712.2   618.4   434.2   391.2   371.5   349.1   325.5   286.7   276.8
   253.6   115.7      .0      .0

Segment  32
      .0   933.8   922.6   912.1   899.0   884.7   871.8   856.1   841.2   829.1
   814.4   787.5   736.8   690.4   614.9   429.9   377.1   315.7   302.1   289.6
   250.0    83.9      .0      .0

Segment  33
      .0   948.9   938.8   928.9   917.5   903.5   889.7   875.5   856.9   844.1
   832.1   814.8   717.1   702.3   691.8   637.9   527.1   364.6   331.2   316.1
   229.6      .0      .0      .0

Segment  34
      .0   958.9   951.1   942.0   923.0   912.3   902.0   890.1   879.5   869.1
   858.7   845.6   822.3   815.5   780.1   769.8   527.5   511.1   497.4   477.6
   243.0   202.4   106.1      .0

Segment  35
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0

                                    Lower Granite Pool

TITLE C ..............................TITLE...................................
        Lower Granite (RM 107-140)  - Jan.1 to Dec.31, 1992
```

```
        Evenly distributed Clr,Sna inflow, line sink outflow
        Default hydraulic coefficients
        Default light absorption/extinction coefficients
        Temperature simulation - Lewiston weather - Selective Withdrawal
        Ben Cope      - EPA Region 10

TIME CON  TMSTRT   TMEND    YEAR
             2.0   365.0    1992

DLT CON      NTD  DLTMIN
               1     1.0

DLT DATE    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD
             1.0

DLT MAX   DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
          3600.0

DLT FRN     DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF
            0.85

BRANCH G      US      DS     UHS     DHS      NL
Br  1          2      34       0       0       2

LOCATION     LAT    LONG   ELBOT
            46.6   117.4  185.01

INIT CND     T2I    ICEI  WTYPEC
             3.7     0.0   FRESH

CALCULAT     VBC     EBC     MBC     WBC   PQINC     EVC     PRC
             OFF     OFF     OFF     OFF     OFF      ON     OFF

INTERPOL   QINIC    TRIC    DTIC    HDIC  QOUTIC    WDIC   METIC
              ON      ON      ON     OFF      ON      ON      ON

DEAD SEA   WINDC    QINC   QOUTC   HEATC
              ON      ON      ON      ON

ICE COVER   ICEC  SLICEC   SLHTC  ALBEDO   HWICE    BICE    GICE  ICEMIN   ICET2
             OFF  DETAIL    TERM    0.25    10.0     0.6    0.07    0.05     3.0

TRANSPORT  SLTRC   THETA
        QUICKEST    0.55

WSC NUMB    NWSC   WINDH
               1    10.0

WSC DATE    WSCD    WSCD    WSCD    WSCD    WSCD    WSCD    WSCD    WSCD    WSCD
             1.0

WSC COEF     WSC     WSC     WSC     WSC     WSC     WSC     WSC     WSC     WSC
             0.0

HYD COEF      AX      DX   CHEZY    CBHE    TSED    BTHM  TINADJ   TINST    TINE
             1.0     1.0    70.0  7.0E-8    14.0    0.90     0.0   200.0   300.0

SEL WITH     SWC     SWC     SWC     SWC     SWC     SWC     SWC     SWC     SWC
              ON

N STRUC     NSTR    NSTR    NSTR    NSTR    NSTR    NSTR    NSTR    NSTR    NSTR
               2

K BOTTOM    KBSW    KBSW    KBSW    KBSW    KBSW    KBSW    KBSW    KBSW    KBSW
Br 1          34      15

SINK TYPE  SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC
Br 1        LINE    LINE
```

```
E STRUC     ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR
Br 1       202.0   220.0

W STRUC     WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR
Br 1       168.0   156.0

N OUTLET    NOUT    NOUT    NOUT    NOUT    NOUT    NOUT    NOUT    NOUT    NOUT


O LAYER     KOUT    KOUT    KOUT    KOUT    KOUT    KOUT    KOUT    KOUT    KOUT


N WDRWAL     NWD
               0

W SEGMNT     IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD
               0

W LAYER      KWD     KWD     KWD     KWD     KWD     KWD     KWD     KWD     KWD
               0

N TRIBS      NTR
               1

TRIB PLACE PQTRC   PQTRC   PQTRC   PQTRC   PQTRC   PQTRC   PQTRC   PQTRC   PQTRC
           DISTR

TRIB SEG     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR
               2

TRIB TOP    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT    ETRT


TRIB BOT    ETRB    ETRB    ETRB    ETRB    ETRB    ETRB    ETRB    ETRB    ETRB


DST TRIB    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC
             OFF

SCR PRINT   SCRC    NSCR
              ON       1

SCR DATE    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD
             1.5

SCR FREQ    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF
             1.0

SNAPSHOT    LJPC    UPRC    WPRC    TPRC  DLTPRC
             OFF     OFF     OFF      ON      ON

SNP PRINT   SNPC    NSNP   NISNP
              ON       1       6

SNP DATE    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD
             1.5

SNP FREQ    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF
             1.0

SNP SEG     ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP
               5      10      15      20      25      30

PRF PLOT    PRFC    NPRF   NIPRF
              ON       1       1

PRF DATE    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD
```

```
             1.5

PRF FREQ     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF
             1.0

PRF SEG      IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF
              34

SPR PLOT     SPRC     NSPR    NISPR
              ON        31        3

SPR DATE     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD
            182.0    186.0    187.0    189.0    191.0    194.0    197.0    199.0    202.0
            204.0    206.0    209.0    211.0    213.0    216.0    218.0    223.0    230.0
            232.0    238.0    241.0    246.0    254.0    256.0    258.0    260.0    264.0
            268.0    272.0    281.0    365.0

SPR FREQ     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF
             4.0      1.0      2.0      2.0      3.0      3.0      2.0      3.0      2.0

             2.0      3.0      2.0      2.0      3.0      2.0      5.0      7.0      2.0

             6.0      3.0      5.0      8.0      2.0      2.0      2.0      4.0      4.0

             4.0      9.0     84.0

SPR SEG      ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR
              11       21       31

TSR PLOT     TSRC     NTSR
              ON        1

TSR DATE     TSRD     TSRD     TSRD     TSRD     TSRD     TSRD     TSRD     TSRD     TSRD
             2.0

TSR FREQ     TSRF     TSRF     TSRF     TSRF     TSRF     TSRF     TSRF     TSRF     TSRF
             1.0

VPL PLOT     VPLC     NVPL
             OFF        0

VPL DATE     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD


VPL FREQ     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF


CPL PLOT     CPLC     NCPL
             OFF        0

CPL DATE     CPLD     CPLD     CPLD     CPLD     CPLD     CPLD     CPLD     CPLD     CPLD


CPL FREQ     CPLF     CPLF     CPLF     CPLF     CPLF     CPLF     CPLF     CPLF     CPLF


RESTART      RSOC     NRSO     RSIC
             OFF        0      OFF

RSO DATE     RSOD     RSOD     RSOD     RSOD     RSOD     RSOD     RSOD     RSOD     RSOD


RSO FREQ     RSOF     RSOF     RSOF     RSOF     RSOF     RSOF     RSOF     RSOF     RSOF


CST COMP      CCC     LIMC      SDC      CUF
             OFF      OFF      OFF        3
```

```
CST ACT        CAC      CAC      CAC      CAC      CAC      CAC      CAC      CAC      CAC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

CST ICON       C2I      C2I      C2I      C2I      C2I      C2I      C2I      C2I      C2I
              30.0      2.0     10.0     51.0      0.7    2.022      1.0      0.1    0.001
             0.002     0.14      1.0      0.0    11.91     31.0      0.0      0.0      0.0
               0.0      0.1      0.0

CST PRINT     CPRC     CPRC     CPRC     CPRC     CPRC     CPRC     CPRC     CPRC     CPRC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

CIN CON      CINAC    CINAC    CINAC    CINAC    CINAC    CINAC    CINAC    CINAC    CINAC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

CTR CON      CTRAC    CTRAC    CTRAC    CTRAC    CTRAC    CTRAC    CTRAC    CTRAC    CTRAC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

CDT CON      CDTAC    CDTAC    CDTAC    CDTAC    CDTAC    CDTAC    CDTAC    CDTAC    CDTAC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

CPR CON      CPRAC    CPRAC    CPRAC    CPRAC    CPRAC    CPRAC    CPRAC    CPRAC    CPRAC
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF      OFF
               OFF      OFF      OFF

EX COEF      EXH2O     EXSS     EXOM     BETA
              0.45     0.01      0.1     0.45

COLIFORM    COLQ10    COLDK
              1.04      1.4

S SOLIDS       SSS
               1.0

ALGAE           AG       AM       AE       AR       AS     ASAT     APOM
               2.0     0.10     0.04     0.04     0.10    100.0     0.80

ALG RATE       AT1      AT2      AT3      AT4      AK1      AK2      AK3      AK4
               5.0     30.0     35.0     40.0      0.1     0.99     0.99      0.1

DOM         LDOMDK     LRDK   RDOMDK
              0.30    0.010    0.001

POM         LPOMDK     POMS
              0.08     0.30

OM RATE       OMT1     OMT2     OMK1     OMK2
               5.0     30.0      0.1     0.99

SEDIMENT       SDK     FSOD
              0.08      1.0

S DEMAND       SOD      SOD      SOD      SOD      SOD      SOD      SOD      SOD      SOD
1              0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3
10             0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3
19             0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3
28             0.3      0.3      0.3      0.3      0.3      0.3      0.3      0.3
```

```
CBOD          KBOD    TBOD    RBOD
              0.25  1.0147    1.85

PHOSPHOR      PO4R   PARTP    AHSP
             0.015     1.2   0.003

AMMONIUM      NH4R   NH4DK    AHSN
              0.05    0.10   0.014

NH4 RATE     NH4T1   NH4T2   NH4K1   NH4K2
               5.0    25.0     0.1    0.99

NITRATE      NO3DK
              0.05

NO3 RATE     NO3T1   NO3T2   NO3K1   NO3K2
               5.0    25.0     0.1    0.99

SED CO2       CO2R
               0.1

IRON           FER     FES
               0.5     2.0

STOICHMT     O2NH4    O2OM    O2AR    O2AG    BIOP    BION    BIOC
              4.57     1.4     1.1     1.4   0.005    0.08    0.45

O2 LIMIT     O2LIM
              0.10

BTH FILE..............................BTHFN...................................
        bth.npt

VPR FILE..............................VPRFN...................................
        vpr.npt - not used

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

RSI FILE..............................RSIFN...................................
        rsi.npt - not used

MET FILE..............................METFN...................................
        met.npt

QWD FILE..............................QWDFN...................................
        qwd.npt - not used

ELO FILE..............................ELOFN...................................
        elo.npt

QIN FILE..............................QINFN...................................
Br 1    qin_br1.npt

TIN FILE..............................TINFN...................................
Br 1    tin_br1.npt

CIN FILE..............................CINFN...................................
Br 1    cin_br1.npt - not used

QOT FILE..............................QOTFN...................................
Br 1    qot_br1.npt

QTR FILE..............................QTRFN...................................
Tr 1    qtr_tr1.npt

TTR FILE..............................TTRFN...................................
Tr 1    ttr_tr1.npt
```

```
CTR FILE...............................CTRFN....................................
Tr 1    ctr_br1.npt - not used

QDT FILE...............................QDTFN....................................
Br 1    qdt_br1.npt - not used

TDT FILE...............................TDTFN....................................
Br 1    tdt_br1.npt - not used

CDT FILE...............................CDTFN....................................
Br 1    cdt_br1.npt - not used

PRE FILE...............................PREFN....................................
Br 1    pre_br1.npt - not used

TPR FILE...............................TPRFN....................................
Br 1    tpr_br1.npt - not used

CPR FILE...............................CPRFN....................................
Br 1    cpr_br1.npt - not used

EUH FILE...............................EUHFN....................................
Br 1    euh_br1.npt - not used

TUH FILE...............................TUHFN....................................
Br 1    tuh_br1.npt - not used

CUH FILE...............................CUHFN....................................
Br 1    euh_br1.npt - not used

EDH FILE...............................EDHFN....................................
Br 1    edh_br1.npt - not used

TDH FILE...............................TDHFN....................................
Br 1    tdh_br1.npt - not used

CDH FILE...............................CDHFN....................................
Br 1    cdh_br1.npt - not used

SNP FILE...............................SNPFN....................................
        snp.opt

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

PRF FILE...............................PRFFN....................................
        prf.opt

VPL FILE...............................VPLFN....................................
        vpl.opt

CPL FILE...............................CPLFN....................................
        cpl.opt

SPR FILE...............................SPRFN....................................
        spr.opt
```