The Impact of Idaho Power Company's Proposed Temperature Mitigation Projects on Temperatures in the Boise River and Snake River

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Technical Report EWR-02-09, May 25, 2009

Portland State
UNIVERSITY

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May 2009

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Introduction

Temperature models of Snake River and Boise River were developed to explore the downstream temperature impact of Idaho Power Company's (IPC) temperature mitigation plan of their FERC Section 401 application for the Hells Canyon Complex (HCC). The key question being investigated was that though IPC's temperature mitigation plan (TEMP) would probably benefit local stream temperatures, how far are the cooling benefits transferred downstream? Specifically, will the cooling benefit the reach downstream of the Hells Canyon Complex? Given constant meteorological conditions, temperatures in a water body will approach a temperature called the equilibrium temperature. The shallower a river or reservoir, the faster it will approach the equilibrium temperature. In addition, equilibrium temperature is more likely to be reached when residence time increases because of lower flow rates. Although temperature mitigation projects may have the potential to reduce stream temperatures locally, the cooling benefit could greatly be reduced at the outlet of the HCC. In IPC's application, it was presumed that temperature cooling occurring upstream in the watershed was directly transferrable to the outlet of the HCC. In this modeling study it will be shown that a significant portion of the cooling benefits could be lost even before reaching the upstream end of Brownlee Reservoir, the most upstream reservoir in the HCC.

Boise River Model Development and Calibration

Model Background

The model used for Boise River was the public domain model, CE-QUAL-W2 (Cole and Wells, 2008). This model is a 2-dimensional (longitudinal-vertical) hydrodynamic and water quality model capable of predicting water surface, velocity, temperature, nutrients, multiple algae, zooplankton, periphyton, and macrophyte species, dissolved oxygen, pH, alkalinity, multiple CBOD groups, multiple suspended solids groups, multiple generic constituents (such as tracer, bacteria, toxics), and multiple organic matter groups, both dissolved and particulate. For the Boise River model, only temperature and hydrodynamics were simulated (see Figure 1). The model is set up to predict these state variables at longitudinal segments and vertical layers. The user manual and documentation can be found at the Portland State University website for the model: http://www.cee.pdx.edu/w2. Dr. Wells and his group have been the primary developers of this model for the Waterways Experiments Station Corps of Engineers for the last 10 years. Since 2000, this model has been used extensively throughout the world in 116 different countries (see Table 1).

Table 1. CE-QUAL-W2 applications between 2000-2006.

Water body	Known Number of Applications
Reservoirs	319+
Lakes	287+
Rivers	436+
Estuaries	82+
Pit Lakes	10+

The Boise River model simulated the lower 29 miles of the river from the Boise River near Middleton USGS gage to the Snake River. Because temperature data were available, the model was calibrated to a summer period in 1999. The model also simulated scenarios in the low flow year of 2001. Figure 2 shows a mean annual flow frequency curve for the Snake River at Weiser flow measuring station. This station was chosen because of the long term data set (1911-2008) and its location on the Snake River upstream of Brownlee Reservoir. The year 1999 was considered a medium-high flow year whereas the year 2001 had the second lowest mean annual flow on record.

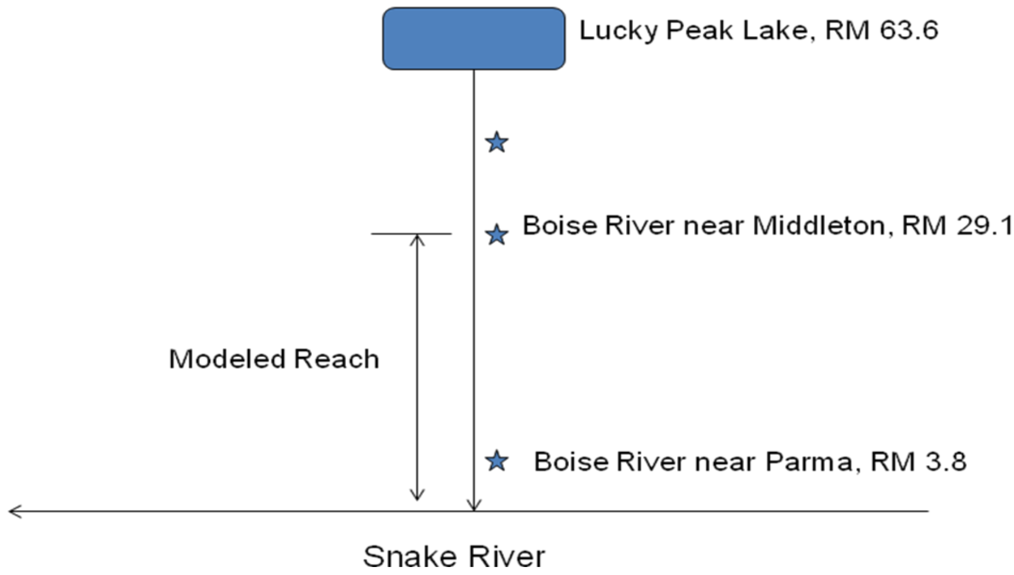

Figure 1. Schematic showing modeled reach of Boise River model.

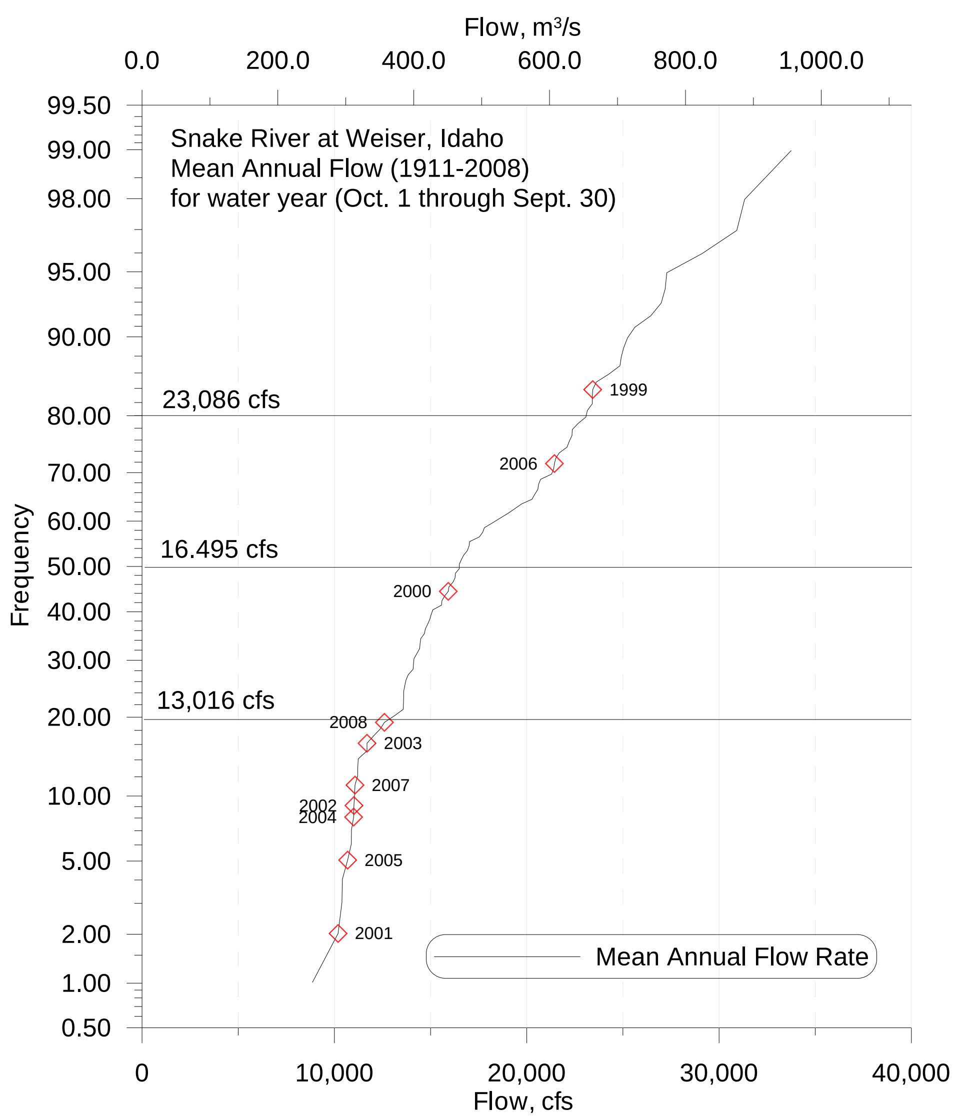

Figure 2. Frequency curve of annual mean flow rates using data measured at USGS the Snake River at Weiser, Idaho gaging station (ID# 13269000). Mean annual flow rates for the past decade were identified.

Overview of Modeling Data Requirements

In order to set up this model, specific data were required to provide the forcing functions to the Boise River. In addition, data were required for comparison to model predictions. A list of these data is shown in Table 2.

Table 2. Data needs for modeling the Boise River.

#	Data Type	Why necessary?
1	Bathymetric x-y-z data of the reservoir	Construct model segments and layers
2	Flow rates (Q) and temperatures (T)	These are the model boundary conditions; continuous data are preferable, otherwise the model can use any temporal resolution available
4	Flow rates and locations of outflows from the system, including the dam outlet, irrigation and other water withdrawals	These are model boundary conditions.
5	Meteorological data such as air temperature, dew point temperature (or relative humidity), wind speed and direction, solar radiation and cloud cover at an hourly frequency	These are model boundary conditions.
6	Water surface elevation data	Matching these data with model predictions is an important part of verifying that the water balance for the system is accurate.
7	In-stream data of temperature	These data would be used to verify that the model predictions are reasonable.
8	Measured kinetic or estimated model coefficients from field data (if available)	Measured field kinetic values would be used as known model coefficients.

Each of the following sections in the report outline the data used for the 1999 and 2001 set-ups of the Boise River model.

Meteorological Inputs

The meteorological input data required by the CE-QUAL-W2 model are air temperature, dew point temperature, wind speed, wind direction, cloud cover and short wave radiation. Meteorological data from the U. S. Bureau of Reclamation Agrimet station at Parma, Idaho were used. Parma, Idaho is located along the Boise River near river mile 4. For the year 1999 simulation, the meteorological file used in Idaho Power Company's Brownlee Reservoir model was made available by IPC and was applied to the Boise River model. For the 2001 simulation, the meteorological input file was created using the Parma Agrimet data.

Flow Rate Inputs

Flow gage stations on the Boise River and Snake River used in this modeling study were listed in Table 3.

Table 3. Flow gage sites along the Boise River and Snake River.

Station Name	Station ID	Agency	Data Freq.	River Mile
Boise River at Glenwood Bridge near Boise, ID	13206000	USGS	Daily	47.5
Boise River near Middleton, ID	13210050	USGS	Daily	29.1
Boise River near Parma, ID	13213000	USGS	Daily	3.8
Snake River at Nyssa, OR	13213100	USGS	Daily	385.2

The Boise River model's upstream boundary condition was located at the Boise River near Middleton flow gage site (RM 29.1). For the model simulation periods in 1999 and 2001 flow data were not available, so a regression equation based on the correlation between flow rates measured at Glenwood Bridge (USGS station ID 13206000) and Middleton was developed to estimate the flow rate. The correlation and regression equation shown in Figure 3 are based on data collected in the months of July, August and September between 1982 and 1996. Using this regression equation the flow rate at Middleton was estimated for 1999 and 2001 (Figure 4). Flows during 2001 were approximately half those during 1999 for the late summer time period.

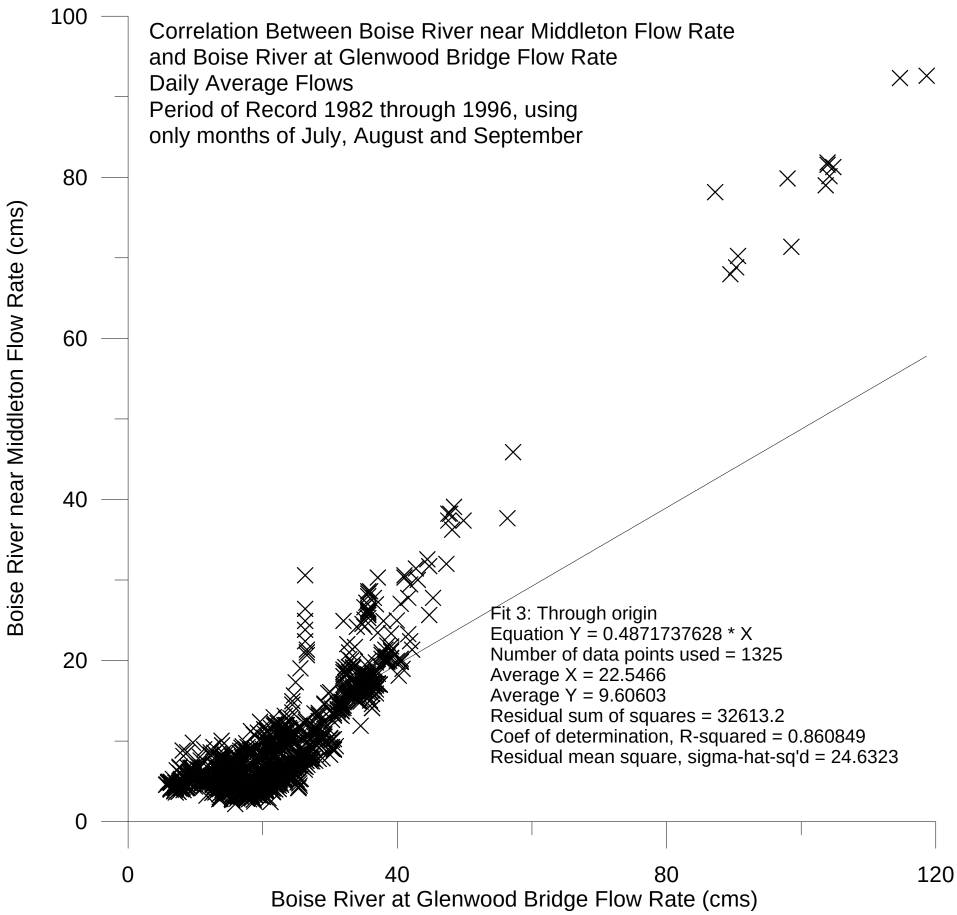

Figure 3. Scatter plot of Boise River flow rates showing relationship between flow rates measured at Glenwood Bridge and near Middleton.

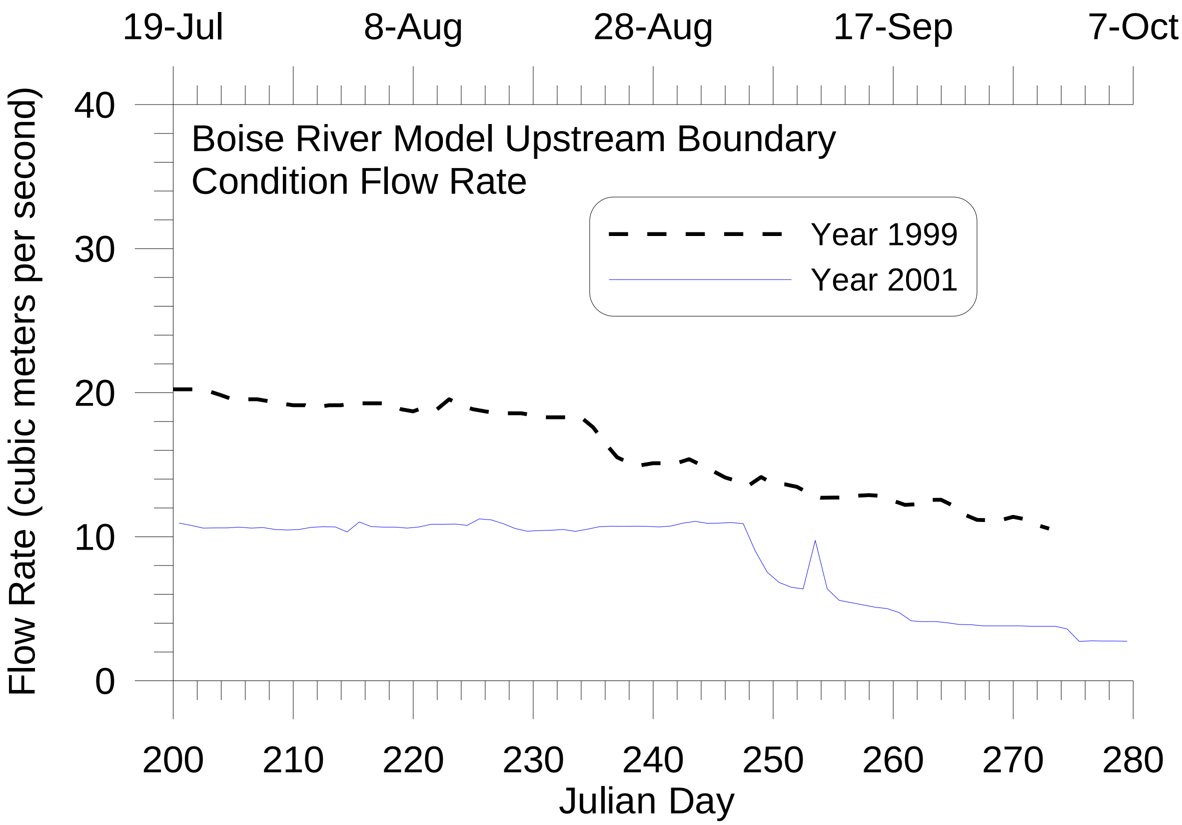

Figure 4. Plot of Boise River model's upstream boundary condition (near Middleton at RM 29.1) flow rate for 1999 and 2001.

To help estimate tributary inflows occurring between Middleton and Parma (RM 3.8), a regression equation was also developed between Boise River flow rates at Glenwood Bridge and Parma. The regression equation was needed because Parma flow rate data do not exist for 1999 and 2001. Inflows between Middleton and Parma were modeled using a single distributed tributary, with the flow rate estimated as being the difference between the calculated Middleton and Parma flow rates. Figure 5 shows the regression equation and correlation between the Middleton and Parma flow rates. The estimated distributed tributary flow rates for 1999 and 2001 were plotted in Figure 6.

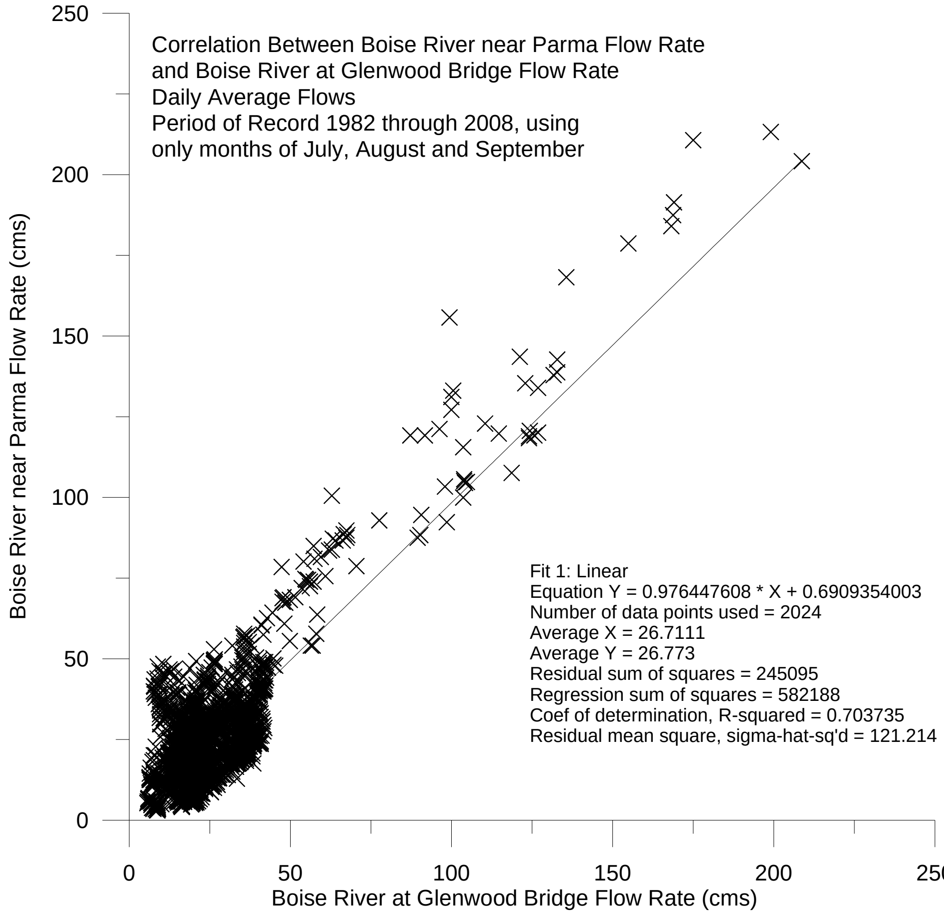

Figure 5. Scatter plot of Boise River flow rates showing relationship between flow rates measured at Glenwood Bridge and near Parma.

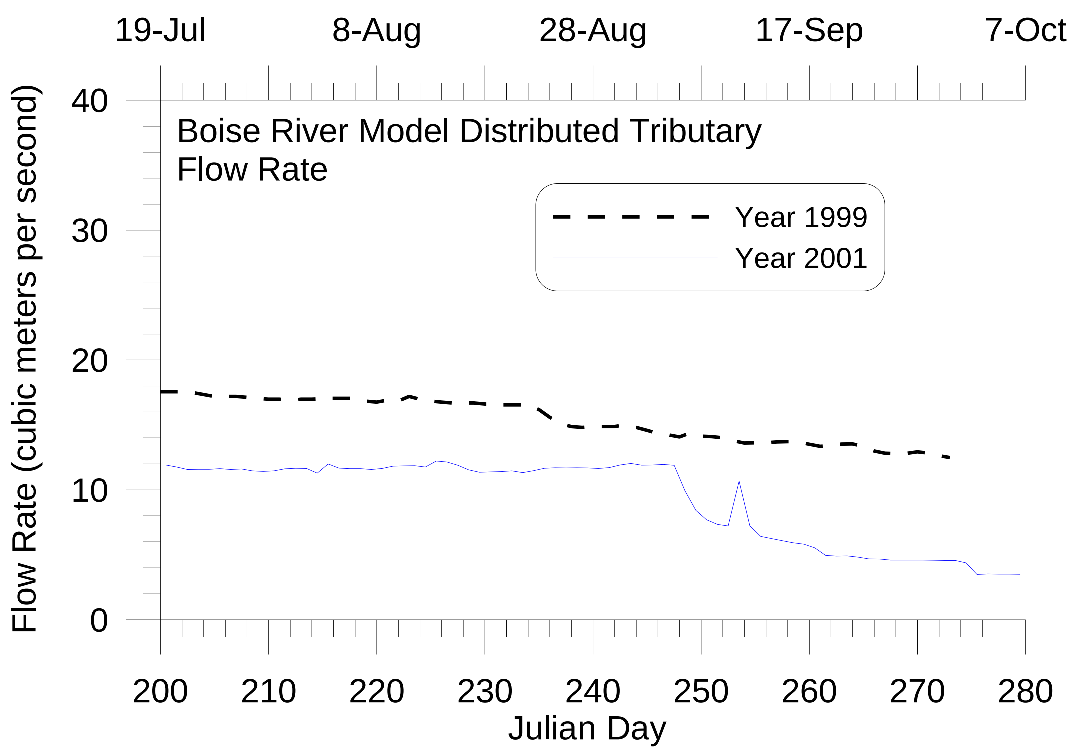

Figure 6. Plot of Boise River model's distributed flow rates for 1999 and 2001.

Temperature Inputs

The July 19, 1999 through September 7, 1999 time period was chosen for the calibration period because of the availability of temperature data measured at Middleton and at Parma. For the year 2001 period, temperature data were not available at Middleton and a regression equation using Middleton data and Glenwood Bridge data was developed to estimate temperatures for the upstream boundary condition. Figure 7 shows the correlation between temperatures at Middleton and Glenwood Bridge and the regression equation. The temperatures used for the upstream boundary condition in the year 1999 and year 2001 simulations are shown in Figure 8. The inflow temperatures of the distributed tributary were assumed equivalent to those from the upstream boundary condition. In CE-QUAL-W2 a distributed tributary allocates the flow to all the segments in a branch in proportion to the surface area.

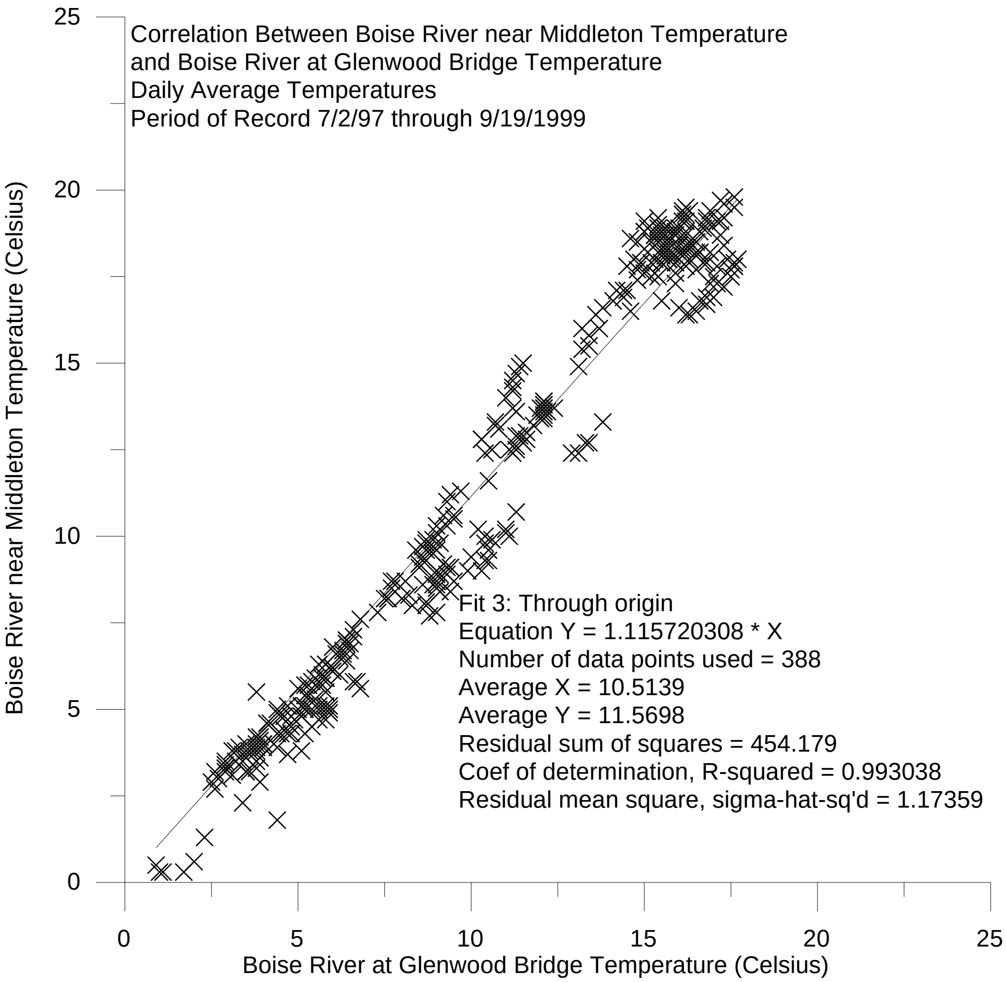

Figure 7. Scatter plot of Boise River temperatures showing relationship between temperatures measured at Glenwood Bridge and near Parma.

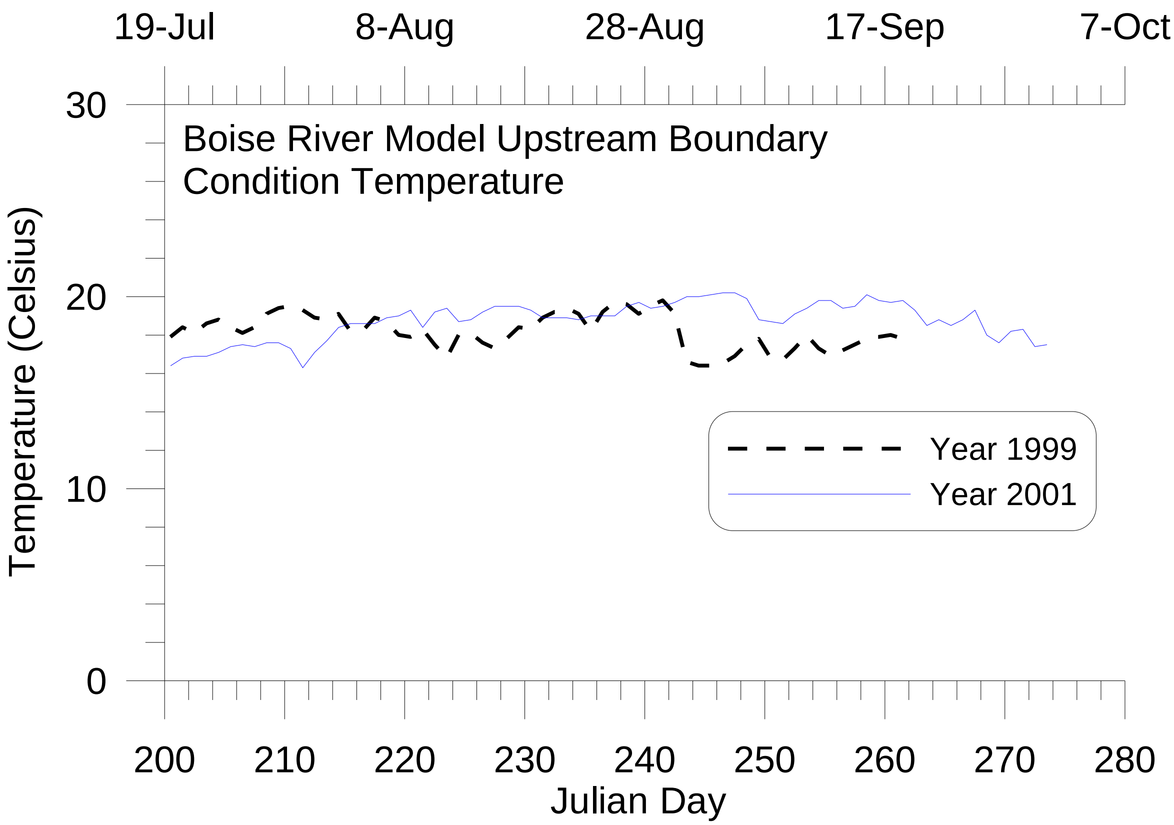

Figure 8. Plot of Boise River model's upstream boundary condition (near Middleton at RM 29.1) temperature for 1999 and 2001.

Bathymetry

Bathymetry for the Boise River model was developed from a cross-section surveyed during the USGS flood insurance modeling study (USGS, 1999). The model is divided into 32 model segments and 14 layers. Each layer is 0.3 meters thick and the segments are 1529 meters or 1566 meters long.

Calibration

The Boise River model was calibrated to flow and temperature data collected in 1999. The calibration period was July 19 (Julian Day 200) through September 7 (Julian Day 250). This period was chosen because temperature data were available for the upstream boundary condition at Middleton and for the calibration site at Parma. Calibration statistics of mean error, absolute mean error and root mean square error for the model predictions were calculated for flow rate and temperature. The equation used for the mean error was:

$$Mean\_Error(ME) = \frac{\sum_{1}^{n}(\text{model} - \text{data})}{n}$$

where 'n' is the number of observations, 'model' is the model predicted state variable and 'data' is the field data variable. The absolute mean error between model and data was defined as:

$$Absolute\_Mean\_Error(AME) = \frac{\sum_{1}^{n} abs(\text{model} - \text{data})}{n}$$

The root mean square error between the model and data was defined as:

$$Root\_Mean\_Square\_Error(RMS) = \sqrt{\frac{\sum_{1}^{n}(\text{model} - \text{data})^2}{n}}$$

The calibrated model coefficients were shown in Table 4. These are variables that can be adjusted to calibrate a CE-QUAL-W2 temperature model.

Table 4. CE-QUAL-W2 Model Parameters

Variable	Description	Units	Typical values*	Calibration Values
Hydrodynamics and Longitudinal Transport				
AX	Longitudinal eddy viscosity (for momentum dispersion)	m^2/sec	1	1
DX	Longitudinal eddy diffusivity (for dispersion of heat and constituents)	m^2/sec	1	1
Temperature				
CBHE	Coefficient of bottom heat exchange	Wm^2/sec	0.30	0.30
TSED	Sediment (ground) temperature	^oC	-	12
WSC	Wind sheltering coefficient		-	0.7 to 1.3
BETA	Fraction of incident solar radiation absorbed at the water surface		0.45	0.45
EXH20	Extinction for water	/m	0.25 - 0.45	0.30
* Cole and Wells (2008)				

Model flow rate predictions at Parma were compared with data in Figure 9. Temperatures predictions and data were shown in Figure 10. Temperature data measured at Parma included daily minimums and maximums. The temperature error statistics were approximately 1 degree Celsius or less (Table 5).

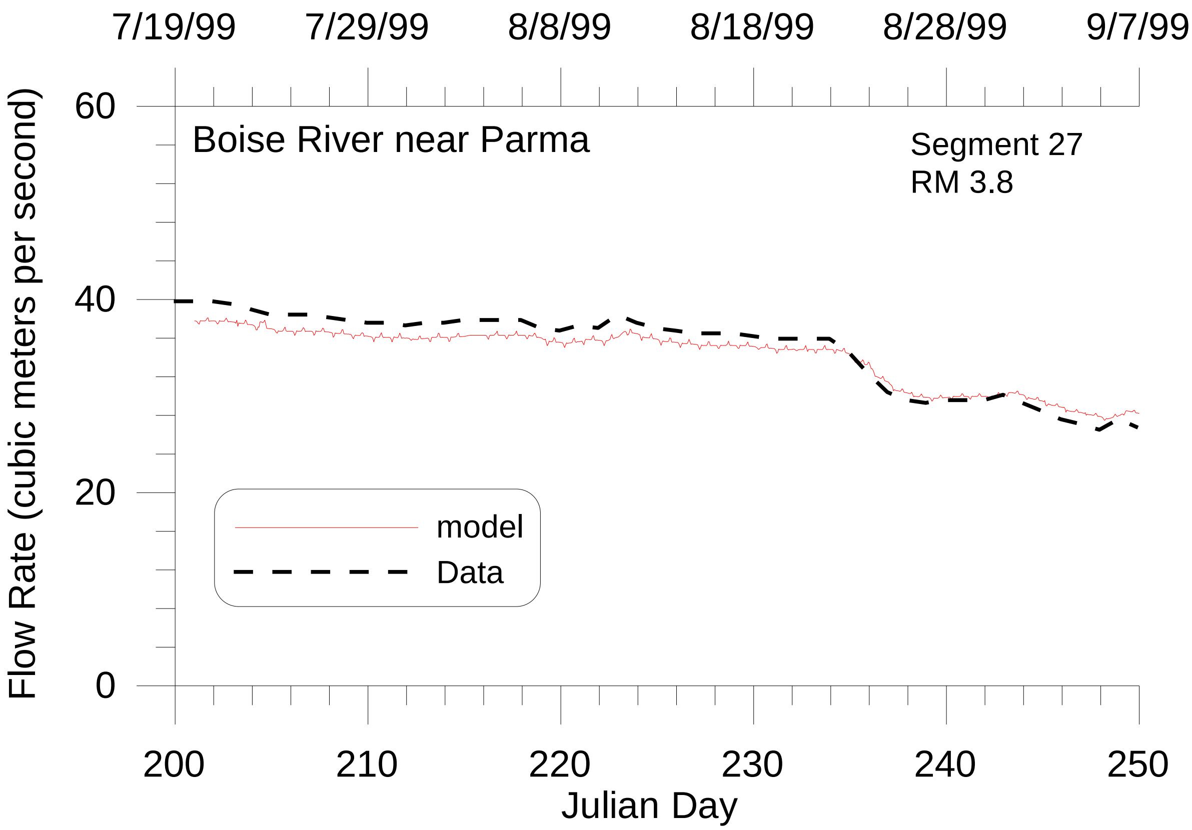

Figure 9. Comparison between model flow rate predictions and Boise River data measured at Parma.

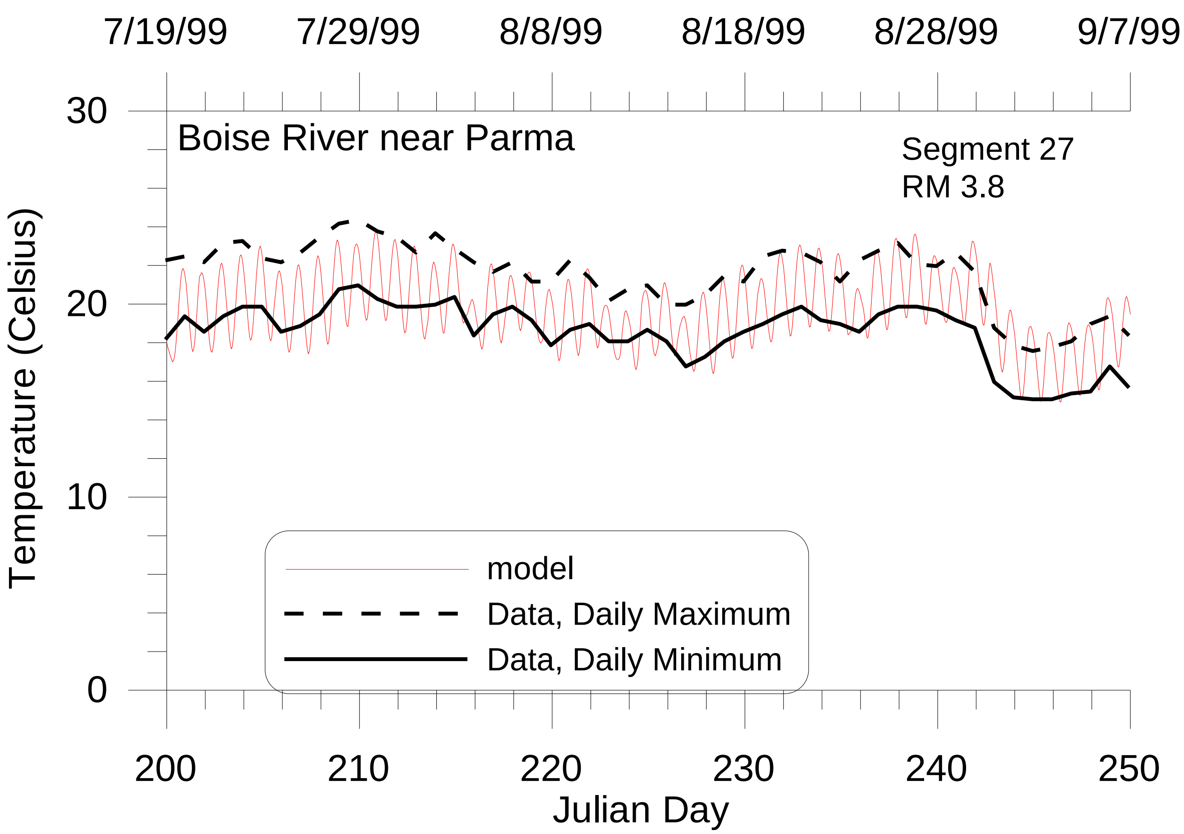

Figure 10. Comparison between model temperature predictions and daily maximum and daily minimum temperature data measured in the Boise River at Parma.

Table 5. Error statistics for Boise River model temperature predictions.

	Daily Maximum, Celsius	Daily Minimum, Celsius
Mean Error	0.21	-0.87
Mean Absolute Error	0.52	0.91
Root Mean Square Error	0.64	1.05

Snake River Model Development

A steady-state, 1-dimensional model of the Snake River between the Boise River (RM 391) and the upstream end of Brownlee Reservoir (RM 335) was developed to help evaluate the impact of temperature mitigation measures in the Boise River watershed on inflow temperatures to Brownlee Reservoir. The governing equation for the model (from Thomann and Mueller, 1987) was based on the conservation of energy:

$$U\frac{dT}{dx} = -\frac{K}{\rho C_p H}(T - T_b)$$

where U is the average velocity (m/s), T is temperature (Celsius), x is the flow path distance down the channel (m), T_b is the Snake River temperature upstream of the Boise River inflow (Celsius), H is average depth (m), ρ is water density (1000 kg/m^3), C_p is the heat capacity of water (4186 J/kg-°C), and K is the average heat exchange coefficient (19.3 W/m^2-°C for 1999, 18.3 W/m^2-°C for 2001). The solution to the equation is

$$T = (T_o - T_b)exp\left(-\frac{x}{U}\frac{K}{\rho C_p H}\right) + T_b$$

where T_o is the Snake River temperature immediately downstream of Boise River inflow.

The average heat exchange coefficient was calculated using the equilibrium temperature subroutine from the water quality model CE-QUAL-W2 (Cole and Wells, 2008). The meteorological data used in calculating the average heat exchange was collected at the US Bureau of Reclamation Parma Agrimet station from July 19, 1999 through September 7, 1999 and from July 19, 2001 through September 30, 2001.

Average depth H was assumed to be 1.5 m and the average velocity U was assumed to be 0.7 m/s. The flow rate and temperature and temperature boundary conditions for 1999 and 2001 are listed in Table 6 and Table 7. For 1999 the upstream Snake River temperature was assumed equal to the temperature used in IPC's 1999 Brownlee Reservoir model. The year 2001 upstream temperature was assumed equal to the equilibrium temperature. The Snake River upstream temperature does not affect of percentage loss in cooling benefit that is dependent upon flow velocity, depth, distance and heat exchange coefficient. In 1999 the upstream Snake River temperature could have been assumed to be 20 °C, and although the temperature predictions would have been different, the percent loss in cooling benefit would have been equivalent.

Table 6. Snake River model boundary conditions for year 1999.

MODEL BOUNDARY CONDITIONS	VALUE	SOURCE
Average Snake River Flow Rate from 7/19/1999 through 9/7/1999	281.5 m^3/s	USGS gaging station 13213100, Snake River at Nyssa, OR
Average upstream Snake River temperature from 7/19/1999 through 9/7/1999	22.5 °C	Used IPC upstream boundary condition for Brownlee Reservoir.
Average Boise River Flow Rate from 7/19/1999 through 9/7/1999	34.06 m^3/s	Boise River CE-QUAL-W2 model
Average Boise River temperature from 7/19/1999 through 9/7/1999 for base case	19.98 °C	Boise River CE-QUAL-W2 model
Average Boise River temperature from 7/19/1999 through 9/7/1999 for °C cooler water at Middleton scenario	19.58 °C	Boise River CE-QUAL-W2 model
Average Heat Exchange Coefficient from 7/19/1999 through 9/7/1999	19.3 W/m^2-°C	Meteorological data collected at US Bureau of Reclamation Parma Agrimet station

Table 7. Snake River model boundary conditions for year 2001.

MODEL BOUNDARY CONDITIONS	VALUE	SOURCE
Average Snake River Flow Rate from 7/19/2001 through 9/30/2001	199.1 m^3/s	USGS gaging station 13213100, Snake River at Nyssa, OR
Average upstream Snake River temperature from 7/19/2001 through 9/30/2001	24.0 °C	Used Equilibrium Temperature calculated using Parma Agrimet data

MODEL BOUNDARY CONDITIONS	VALUE	SOURCE
Average Boise River Flow Rate from 7/19/2001 through 9/30/2001	18.69 m^3/s	Boise River CE-QUAL-W2 model
Average Boise River temperature from 7/19/2001 through 9/30/2001 for base case	20.27 °C	Boise River CE-QUAL-W2 model
Average Boise River temperature from 7/19/2001 through 9/30/2001 for °C cooler water at Middleton scenario	19.96 °C	Boise River CE-QUAL-W2 model
Average Heat Exchange Coefficient from 7/19/2001 through 9/30/2001	18.3 W/m^2-°C	Meteorological data collected at US Bureau of Reclamation Parma Agrimet station

Temperature Scenarios

Boise River at Middleton Restoration Scenario

To investigate the downstream temperature impact of temperature mitigation on the Boise River, scenarios were run with the assumption that temperatures upstream of Middleton at river mile 29 (RM 29) had been reduced by 1 degree Celsius (Figure 11). For this analysis, how the temperatures were reduced (for instance, shading or wetland mitigation) was unimportant. The point of the scenario was to determine the loss in cooling benefit that occurs as water flows downstream and is exposed to meteorological conditions. If meteorological conditions are constant, water temperature in river or reservoir will approach a temperature called the equilibrium temperature. The lower the flow rate or the shallower a system, the faster this will occur.

Heat load at different points along the Boise River and Snake River was calculated in terms of billion British Thermal Units (BTUs) by using the flow rate and the following equation:

$$H = f\rho C_p \mathrm{QT}$$

where H is the heat load in billion BTUs, ρ was water density (1000 kg/m^3), C_p was the heat capacity of water (4186 J/kg-°C), T was temperature (Celsius), Q was flow rate (m^3/s), and f the factor for converting Watts to billion BTUs per day ($8.190 * 10^{-8}$ billion BTUs/Watt).

For the years 1999 and 2001, the 1 degree cooler water temperatures at Middleton were compared with a base case simulations. The base cases were the calibrated year 1999 and year 2001 simulations. Outflow temperatures of the Boise River simulations were used as inflow temperatures to the Snake River model.

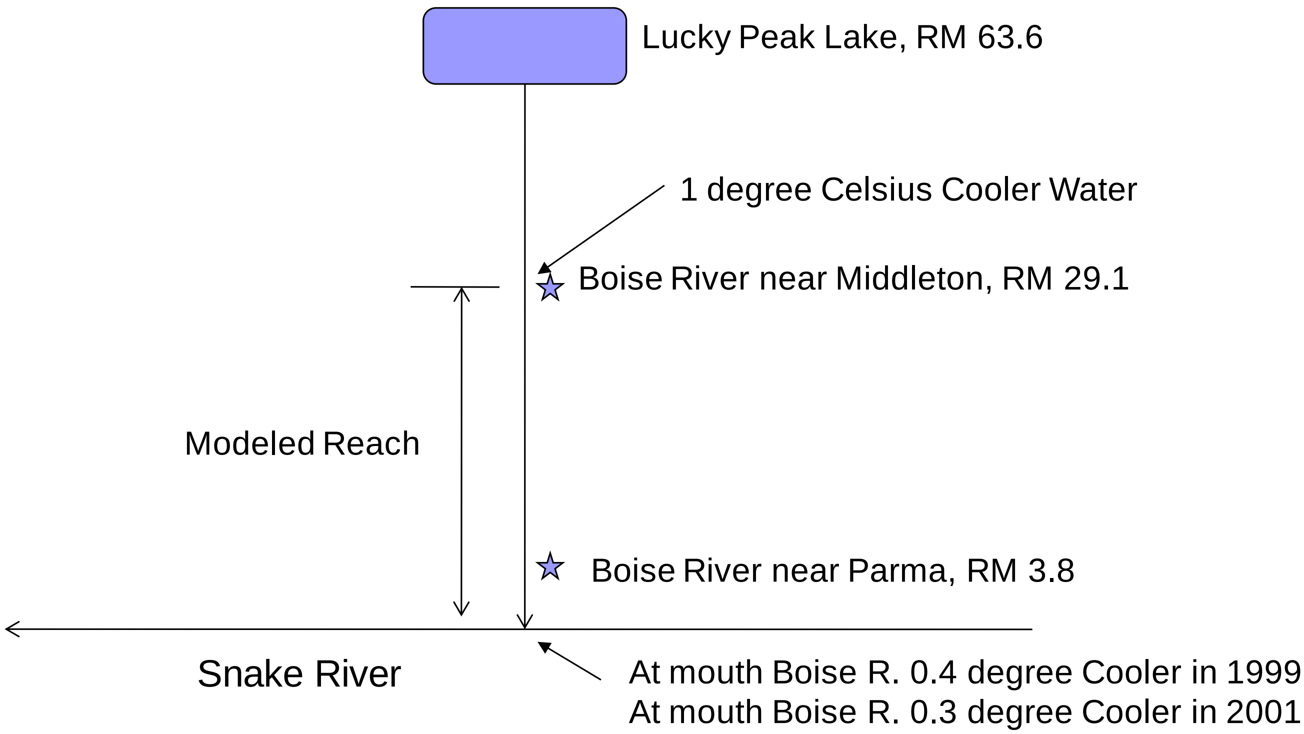

Figure 11. Drawing illustrating the Middleton restoration scenario (reduction in Boise River temperatures by 1°C).

Year 1999

The time period of the year 1999 scenario was from July 19, 1999 (Julian Day 200) through September 7, 1999 (Julian Day 250). Model inputs, such as inflows and meteorological conditions, are dynamically varying over the simulation period. Table 8 shows the average temperature predictions for the simulation period just downstream of Middleton (RM 29) and just upstream of the Boise River's junction with the Snake River (RM 0). The average temperature predictions of the base case and the 1 degree cooler temperature at Middleton were shown. As , the temperatures at Middleton were 1 degree cooler for the restoration scenario. At the Boise River's inflow to the Snake, this scenario is 0.4 degrees Celsius cooler.

The corresponding difference of heat load for the base case and temperature reduction scenario were shown in Table 9. At Middleton, the temperature reduction scenario has 6.13 billion BTUs less heat than the base case. At the inflow to the Snake River, this difference has been reduced to 4.71 billion BTUs, with a loss in cooling benefit of 1.42 billion BTUs. This cooling benefit was about 23% less than the cooling benefit existing at Middleton. The loss in cooling benefit occurred because a system will approach an equilibrium temperature that is dependent upon meteorological conditions.

Using the Snake River model, the loss in cooling benefit was also predicted between the Boise River and the Snake River's inflow to Brownlee Reservoir. Figure 12 shows that the loss in cooling benefit for the temperature reduction scenario was 48% by the time the water reaches Brownlee Reservoir.

Table 8. Comparison of 1999 Boise River average temperature differences of base case and Middleton restoration (1 degree cooler temperatures at Middleton) scenario. These are the average temperatures over the simulation period from July 19, 1999 (Julian Day 200) through September 7, 1999 (Julian Day 250).

Temperature, Celsius	Base Case	Middleton Restoration Scenario	Difference
Boise River near Middleton	18.35	17.35	-1.00
Boise River mouth, just upstream of the Snake River	19.98	19.58	-0.40

Table 9. Comparison of 1999 Boise River heat load differences (billion BTU/day) of base case and Middleton Restoration.

Billion BTU/Day	Base Case	Middleton Restoration Scenario	Difference
Boise River near Middleton	112.7	106.5	-6.13
Boise River mouth, just upstream of the Snake River	233.9	229.2	-4.71
		Loss in BTU benefit =	-1.42
		% Loss in BTU=	23.20%

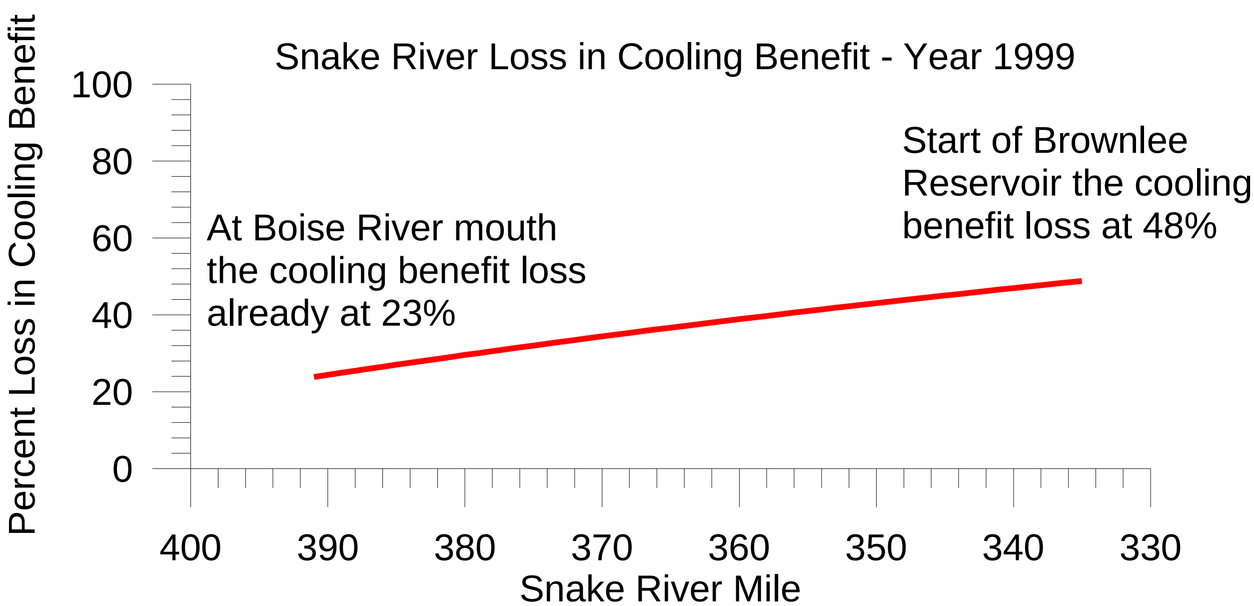

Figure 12. Graph showing the year 1999 percent loss in cooling benefit along the Snake River of the Middleton restoration scenario.

Year 2001

The Middleton restoration (1 degree cooler water at Middleton) scenario was also simulated for the year 2001. The year 2001 was a low flow year, whereas 1999 was a medium-high flow year. Because of the decreased flow rates in 2001, it was expected that the loss in cooling benefit as water moved downstream would be even greater. The lower flow rates result in increased residence times, allowing more time for the water to reach the equilibrium temperature. Also, the decreased depths result in a system that responds faster to meteorological forcing.

The Boise River temperature differences between the Middleton restoration scenario and the base case were shown in Table 10. At the Boise River inflow to the Snake River, the temperature difference of the scenario with respect to the base case was 0.30 degrees Celsius. The heat load differences are listed in Table 11. The heat load difference at Middleton is 3.03 billion BTUs, but by the time the water reaches the Snake River the cooling benefit is reduced to 2.03 billion BTUs - a loss of 33%. This loss in 1999 had been 23%, and the decreased flow rates during 2001 had resulted in a further loss in cooling benefit.

The loss in the Snake River between the Boise River and Brownlee Reservoir is shown in Figure 13. By the time the cooled water had reached Brownlee, the cooling benefit loss increases to 55% under the 2001 flows.

Table 10. Comparison of 2001 Boise River temperature differences of base case and Middleton restoration (1 degree cooler temperatures at Middleton) scenario.

Temperature, Celsius	Base Case	Middleton Restoration Scenario	Difference
Boise River near Middleton	18.75	17.75	-1.00
Boise River mouth, just upstream of the Snake River	20.27	19.96	-0.30

Table 11. Comparison of 2001 Boise River heat load differences (billion BTU/day) of base case and Middleton restoration (1 degree cooler temperatures at Middleton) scenario.

Billion BTU/Day	Base Case	Middleton Restoration Scenario	Difference
Boise River near Middleton	56.7	53.7	-3.03
Boise River mouth, just upstream of the Snake River	131.1	129.1	-2.03
		Loss in BTU benefit =	-1.00
		% Loss in BTU=	32.97%

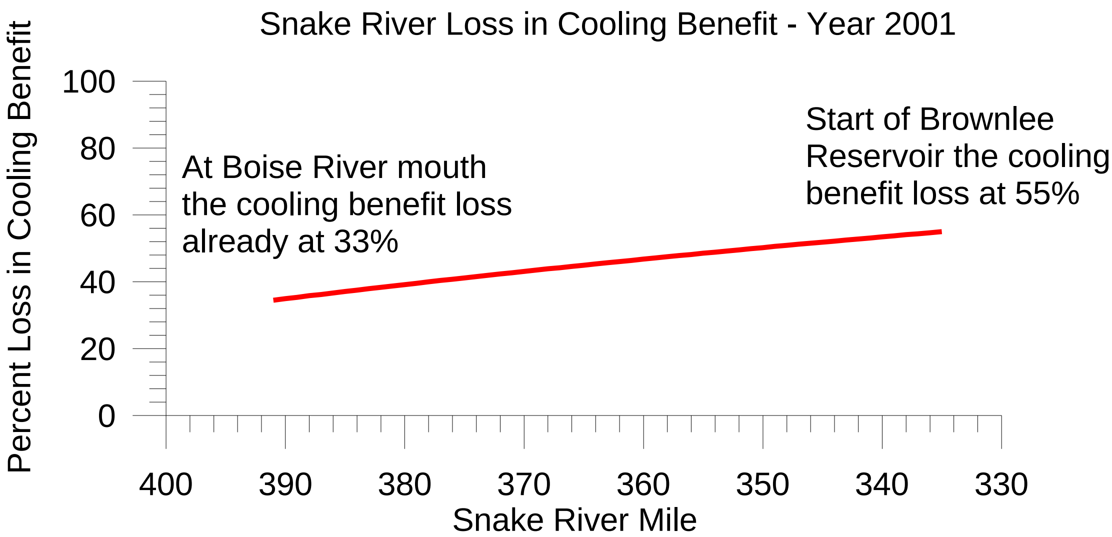

Figure 13. Graph showing the year 2001 percent loss in cooling benefit along the Snake River of the Middleton restoration (1 degree cooler temperature at Middleton) scenario.

IPC Willow Creek Wetland Mitigation Scenario

One of the temperature mitigation projects discussed by Idaho Power Company in its Section 401 application for the Hells Canyon Complex was the Willow Creek wetland mitigation. Willow Creek flows into the Boise River at river mile 24.7 (Figure 14). In exhibit 7.1-7 of the application it was stated that the temperatures of Willow Creek will be reduced an average of 0.5 degrees at a flow rate of 17 cfs (0.49 cms). To investigate how the cooling benefit of the wetland mitigation would change once water from Willow Creek enters the Boise River, the Boise River 1999 and 2001 models were altered to include Willow Creek at a flow of 17 cfs. This flow rate was reduced from the distributed tributary to keep the flow balance intact. Temperatures used for Willow Creek in the base cases were the same as those used for the distributed tributary. The wetland mitigation scenarios included Willow Creek with temperatures 0.5 degrees cooler than the base cases.

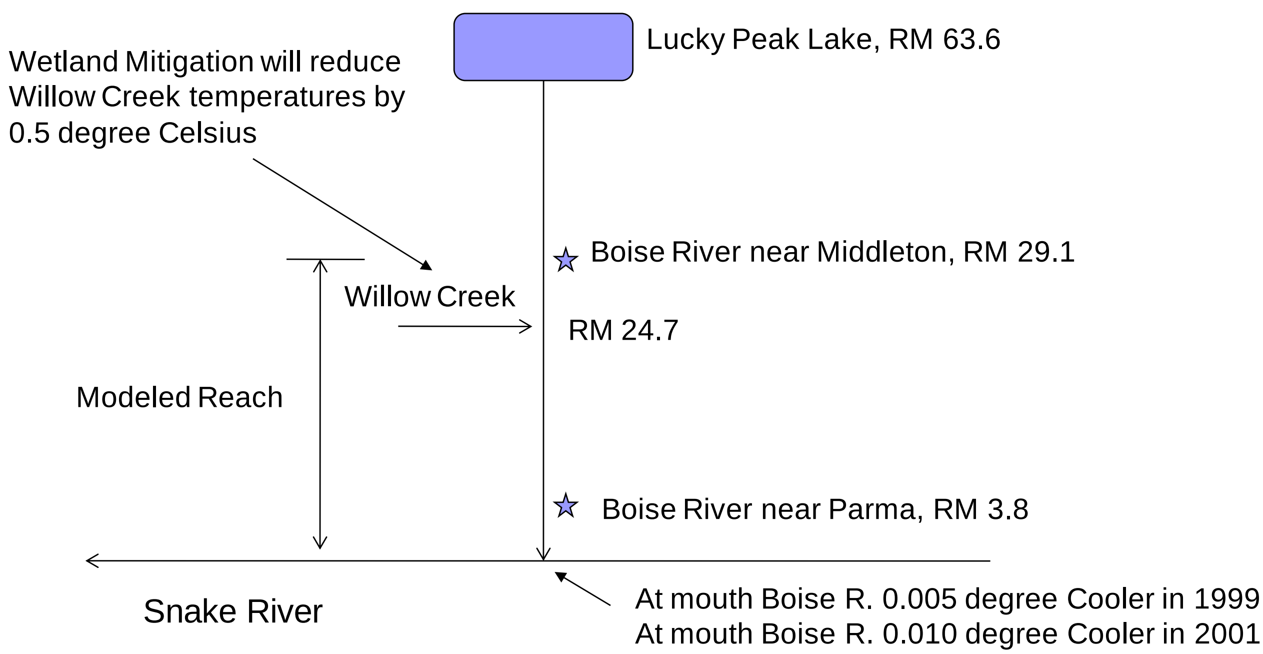

Figure 14. Drawing illustrating the IPC wetland mitigation scenario. The modeled stretch of the Boise River was from Middleton (RM 29.1) to the mouth.

Year 1999

The year 1999 temperature differences resulting from the Willow Creek wetland mitigation were listed in Table 12. Just downstream of the Willow Creek inflow, the Boise River was 0.011 degrees cooler with the wetland mitigation. At the Boise River's outlet to the Snake, the Boise River was 0.005 degrees cooler with the wetland mitigation. Table 13 shows that the loss in cooling benefit occurring between Willow Creek (RM 24.7) and the Snake River was 18.5%.

Table 12. Comparison of 1999 Boise River temperature differences of base case and mitigation scenario (i.e., application of the IPC Willow Creek Wetland Mitigation Scenario where Willow Cr. temperature inflow is reduced by 0.5°C).

Temperature	Base Case	Under the mitigation scenario	Difference
Boise River downstream of Willow Cr.	18.838	18.827	-0.011
Boise River mouth, just upstream of the Snake River	19.921	19.916	-0.005

Table 13. Comparison of 1999 Boise River heat load differences of base case and IPC Willow Creek Wetland Mitigation Scenario.

Billion BTU/Day	Base Case	Under the mitigation scenario	Difference
Boise River downstream of Willow Cr.	143.13	143.05	-0.081
Boise River mouth, just upstream of the Snake River	243.90	243.83	-0.066
		Loss in BTU=	-0.015
		% Loss in BTU=	18.47%

Year 2001

For the low flow year 2001 the loss in cooling benefit was greater. Table 14 shows temperature predictions along the Boise River with and without the Willow Creek wetland mitigation. The differences in heat load in the Boise River were listed in Table 15. A difference in heat load between the base case and Willow Creek wetland mitigation scenario was 0.080 billion BTUs downstream of Willow Creek and 0.059 billion BTUs at the Snake River, corresponding to a cooling benefit loss of 26.8%.

Table 14. Comparison of 2001 Boise River temperature differences between the base case and mitigation scenario (i.e., application of the IPC Willow Creek Wetland Mitigation Scenario where Willow Cr. temperature inflow is reduced by 0.5°C).

Temperature	Base Case	Under the mitigation scenario	Difference
Boise River downstream of Willow Cr.	19.227	19.203	-0.023
Boise River mouth, just upstream of the Snake River	20.274	20.264	-0.010

Table 15. Comparison of 2001 Boise River heat load differences between the base case and mitigation scenario (i.e., application of the IPC Willow Creek Wetland Mitigation Scenario where Willow Cr. temperature inflow is reduced by 0.5°C).

Billion BTU/Day	Base Case	Under the mitigation scenario	Difference
Boise River downstream of Willow Cr.	74.73	74.65	-0.080
Boise River mouth, just upstream of the Snake River	131.14	131.08	-0.059
		Loss in BTU=	-0.021
		% Loss in BTU=	26.75%

Conclusions

Temperature models of the Boise River and Snake River were developed to investigate Idaho Power Company's temperature mitigation plan (TEMP) for the Hells Canyon Complex. The objective of the study was to determine how far the cooling benefits of potential temperature mitigation projects would be transferred downstream. In their FERC Section 401 application for Hells Canyon Complex, IPC presumed that cooling benefits occurring upstream in the watershed due to temperature mitigation projects could be assumed to occur at the outlet of the Hells Canyon complex.

Model scenarios included reducing stream temperatures by 1 degree Celsius at Middleton (River Mile 29) along the Boise River and modeling the downstream impact of the Willow Creek wetland temperature mitigation project. Two years were simulated: the year 1999, was a medium-high flow year; and the year 2001, a low flow year. The cooling benefit achieved in 1999 by reducing temperatures 1 degree Celsius at Middleton on the Boise was reduced by 48% by the time the cooled water reached the upstream end of Brownlee Reservoir. In 2001, this cooling benefit was reduced by 55% because the flows were lower in 2001, resulting in a shallower system with increased residence time where stream temperatures were more likely to reach the equilibrium temperature. In the Willow Creek wetland scenarios it was shown that the cooling benefit lost was 18.5% in 1999 and 26.8% in 2001 by the time water in the Boise River reached the Snake River.

Findings are summarized as follows:

- IPC's TEMP mitigation projects reduce temperatures, but cooling benefits may be localized and it is uncertain how much temperatures at outflow of Hells Canyon Project are reduced.
- A test case showed that a reduction in heat load in Boise River above RM 29 loses 48% of cooling benefit in 1999 and 55% in 2001 before flowing into Brownlee Reservoir
- Test Cases included the summer of year 1999, a medium-high flow year and the summer of the year 2001, a low flow year
- Brownlee, Oxbow, or Hells Canyon reservoirs were not simulated where further loss of temperature mitigation benefit will occur

Because IPC assumes that the reduction in heat load due to upstream temperature mitigation projects directly affects the heat load reduction at the outlet of the HCC on a one to one basis, they are underestimating the magnitude and effectiveness of temperature mitigation projects that are required to meet temperature requirements downstream of the HCC. An improved analysis of how their TEMP projects affect temperatures downstream of the HCC must be conducted to determine the overall cooling capacity required from upstream mitigation projects.

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