OUTLET STRUCTURE for BYPASSED REACH FLOWS

Water Temperature Profile Study Results for Pre-Design Information

Draft Final

LAKE CHELAN HYDROELECTRIC PROJECT
FERC Project No. 637

June 6, 2005

Public Utility District No. 1 of Chelan County
Wenatchee, Washington

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SECTION 1: INTRODUCTION

1.1 Background

Public Utility District No. 1 of Chelan County (Chelan PUD) has submitted an application for a New License for the Lake Chelan Hydroelectric Project (LC Project). The license application, which was submitted to the Federal Energy Regulatory Commission (FERC), includes proposed protection, mitigation and enhancement measures (PMEs) for natural and social resources that are affected by the LC Project. The proposed PMEs were developed in a collaborative process with federal and state agencies and other interested parties to the relicensing proceeding and are included in the Lake Chelan Settlement Agreement (LCSA). The PMEs are described fully in documents submitted to FERC with the license application.

These documents include the LCSA and a water quality certification, required under section 401 of the federal Clean Water Act (401 Certification), from the Washington Department of Ecology (WDOE). The LCSA includes PMEs related to the restoration of perennial in stream flows to the Chelan River below the dam and protection, restoration and enhancement of fisheries resources in the Chelan River. By definition, the Chelan River runs from the base of Lake Chelan (which ends just above the Woodin Bridge) and flows to the dam and then beyond the dam to the confluence with the Columbia River (Figure 1-1). Prior to the PMEs to restore flow, the Chelan River below the dam was referred to as the Chelan River bypassed reach.

The 401 Certification includes specific requirements pertaining to the achievement of these PMEs and confirmation that the LC Project will comply with water quality standards and other applicable requirements of state law.

The original 401 Certification was issued on March 27, 2003, and amended and reissued on April 21, 2003. This 401 Certification was appealed to the Washington State Pollution Control Hearings Board (PCHB). The PCHB issued Order No. 03-075 on April 21, 2004, upholding the 401 Certification, with nine specific clarifications. Following a 30-day waiting period for appeal of the PCHB order, WDOE issued a revised 401 Certification on June 1, 2004, which incorporated the clarifications contained in the PCHB order into the 401 Certification. One of the nine clarifications pertained to the LCSA (License Article 7 – Chelan River Fishery Plan) and the 401 Certification requirement that “Minimum flows shall be provided by Chelan PUD as soon as the structures needed to provide such flows are constructed, which shall occur no later than two years after the effective date of the license. The structures to be constructed are a new flow release structure at the dam and modification to the channel in Reach 4.” (401 Certification III.ii.) and, “Prior to the date such structures are completed, Chelan PUD shall make good faith effort to provide flows that agencies may request for the purpose of testing designs or structures or of gathering other data, including any water quality data.” (401 Certification III.iv.) The clarification regarding this requirement is: “An additional study of water temperature at the dam face must be performed by Chelan PUD to determine how best to design the new outlet structure to maximize the potential for cold water withdrawal at the base of the dam.” (401 Certification, X.D.) A copy of the June 1, 2004 401 Certification Order and the proposed license article are attached in Appendix A.

Chelan PUD is proceeding with the planning and design phase of the construction of the flow release outlet structure for provision of minimum flows and managed flows to the Chelan River, consistent with the LCSA and 401 Certification. Feasibility analysis has identified two possible locations and pertinent design considerations for construction of the outlet structure and conveyance of flows to the Chelan River. These locations are on opposite sides of the Chelan Dam and have different approaches to withdrawing water from the base of the dam. To meet the requirements of the 401 Certification, this study was conducted to determine whether there are differences between these design options that would influence the "potential for cold water withdrawal" from the respective locations or design features of each option. In order to meet Chelan PUD's commitments in the settlement agreement and the requirements of the 401 Certification, the outlet structure must be capable of providing constant flows of up to 320 cfs at any lake elevation and capable of providing at least 500 cfs of flow at summer lake elevations (El. 1095 or above). It is important that the outlet structure design assure that the 500 cfs flow meets the "maximize the potential for cold water withdrawal at the base of the dam" requirement of the 401 Certification because this flow level would be used specifically for temperature control in the Chelan River during the summer (Comprehensive Plan 3.3.7 – "If determined necessary to protect a viable cutthroat population, Chelan PUD is prepared to release additional flow during daytime hours to prevent fish mortality from heat stress. The daytime flow releases will have a maximum flow of 1,500 cfs or natural inflow, whichever is less. The total annual volume of additional flow releases will be limited to 5,000 cfs-days."

1.2 __Study Goal__

The outlet structure will be designed to release from 80 to approximately 500 cubic feet per second (cfs) of water immediately upstream from the dam and release it to the Chelan River downstream of the dam (the former bypassed reach). The outlet structure must be able to release 320 cfs at all lake levels and 500 cfs in summer, when the lake is nearly full. The goal of the study was to determine if the water temperature at different depths in the Chelan River at the face of the dam varies during the summer months. This information is used to assess whether there is any difference between the outlet structure options regarding their potential for cold water withdrawal at the face of the dam. Pertinent information gathered and evaluated includes the vertical temperature profile at the potential withdrawal locations, consistency of the bottom temperatures over time, a lateral profile of temperature at the dam face, and surveys of the lateral and vertical temperature profiles in the Chelan River upstream from the dam.

1.3 __Study Area__

The study area extended from the Chelan River at the face of the Chelan Dam, up the Chelan River and into Lake Chelan, off shore from Lakeside Park. The primary area of focus was at the face of the dam and intake structure, concentrating in the areas identified as options for construction of the outlet structure. Additional vertical and lateral temperature profile data were collected upstream of the dam at the old highway bridge, the new highway bridge, where Lake Chelan converges with Chelan River, and across the width of the lake at Lakeside Park. The approximate temperature monitoring locations in Lake Chelan are depicted in Figure 1-1; those in the Chelan River are depicted in Figure 1-2.

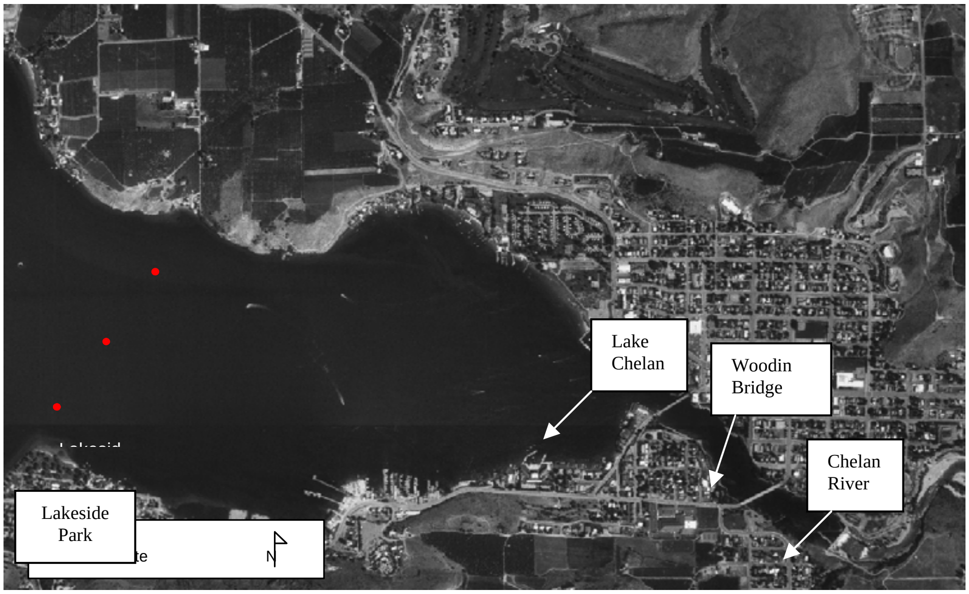


Figure 1-1: Lake Chelan Monitoring Locations

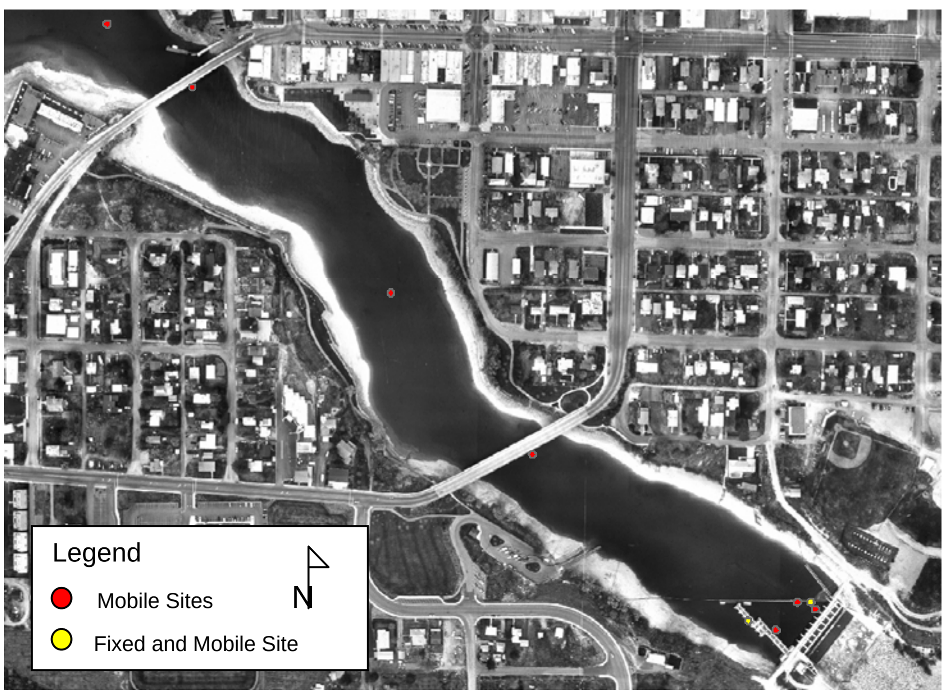


Figure 1-2: Chelan River Monitoring Locations

SECTION 2: METHODOLOGY

Monitoring was conducted at both fixed and mobile monitoring sites.

2.1 Fixed Monitoring Sites

Fixed monitoring was conducted at the two locations being considered for the location of the outlet structure. These locations are at the face of the intake structure for a 17-foot power tunnel (intake site) that was never used, and at the face of the trash sluiceway on the north end of the spillway (spillway site). The fixed monitoring was conducted by anchoring temperature logging devices at the elevations representative of the water depths that the proposed outlet structures will draw from during operation for discharge of 320 cfs. At the 17-foot power tunnel intake, the proposed water withdrawal is located from an elevation of 1070.5 feet above mean sea level (msl), up to one to two feet above that elevation (up to 1072.5 feet), depending on trash rack design. At the trash sluiceway location, the proposed elevation of the gate spans from 1072 to 1077 feet above msl, which could withdraw water from up to an elevation of 1080 feet above msl at full discharge.

The temperature logging devices used were Hydrolab MiniSonde® Series 4a (MiniSonde), which have a range of -5.0 to 50.0 degrees Celsius (°C), accuracy of ±0.1°C and resolution of 0.01°C (Hydrolab specification data, Hydrolab Corporation). The temperature loggers are factory calibrated and do not require field calibration. The temperature loggers were suspended from cables at fixed depths 1070 and 1080 feet above msl for at the intake site and from the floating trash boom at 1070 and 1080 feet above msl for the spillway site. The temperature loggers were set to record temperatures at 15 minute intervals. The temperature data were downloaded at various times throughout the study. At no point during the study did the batteries in the Sondes expire.

2.2 Mobile Monitoring

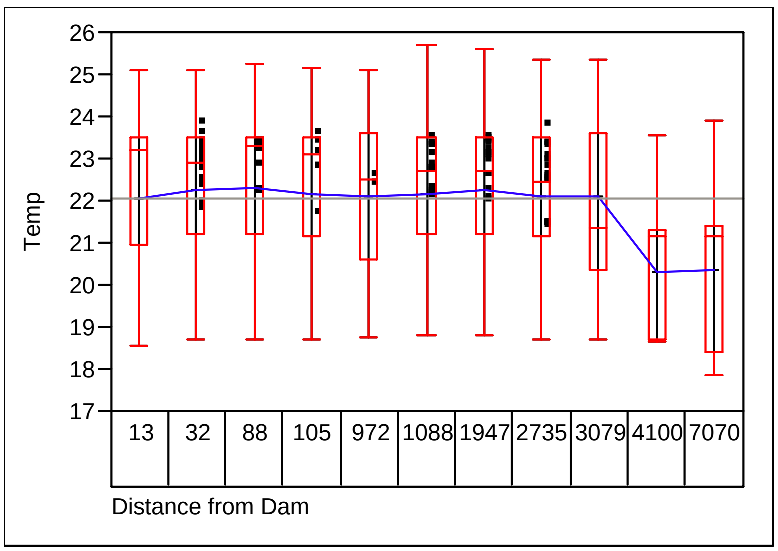
Vertical temperature profiles were taken at five locations across the face of the dam, including at the intake site and spillway site. Other locations included the middle of the intake structure for the 14-foot power tunnel that supplies water to the powerhouse, near the middle of the spillway section of the dam, and near the middle of the dam off the trash boom. Additional vertical temperature profiles were taken at the sites shown in Figure 1-1 and Figure 1-2 to evaluate the extent and consistency of temperature profiles in the Chelan River upstream from the dam. Vertical temperature profile measurements were made six times during 2004 including: on August 9th, 11th, 17th, and 23rd and on September 2nd and 28th. The temperatures were measured using a MiniSonde, and uploaded to a handheld Survey® 4a data logger.

SECTION 3: RESULTS AND DISCUSSION

The primary objective of this study was to determine whether the location of the outlet structure is likely to have an effect on the temperature of the water released to the Chelan River downriver of the dam. To meet that objective, the study must determine: the consistency of the bottom temperatures over time; if there is an observable temperature profile in the summer; if the water temperatures vary laterally across the face of the dam; if there is a significant difference in water temperature at an elevation of 1070 versus 1080 feet above msl; and the presence of a difference in the temperatures at the 17-foot intake and the North Spillway. To better understand the factors that influence the temperature profile at the face of the dam, additional information was collected upstream across Chelan River and lower end of Lake Chelan to determine if the water temperatures vary with respect to the distance from the dam. A discussion of the analysis approach and results for each of these analyses is provided in this section.

3.1 Temperature Variation with Distance from the Dam

To determine if the temperature varies with respect to the distance from the dam, a variability chart was made for all of the data collected from mobile monitoring sites. It is presented in Figure 3-1.

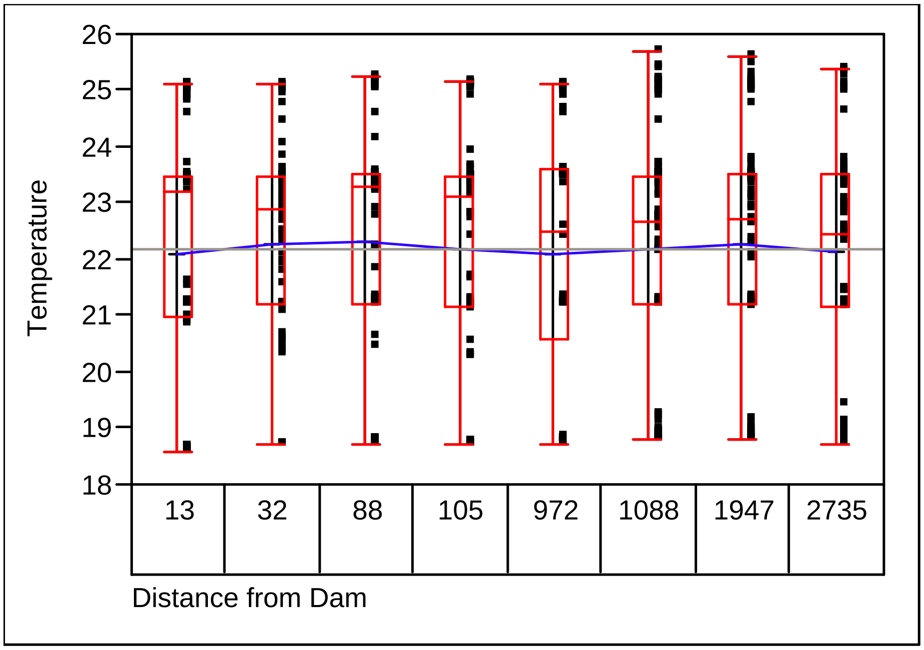


Note: Temperature in °C, distance from the dam in feet. The blue line represents the mean.

Figure 3-1: Temperature as a Function of Distance from Dam, All Data

The plot of total data indicates that there is a decrease in water temperatures at a distance of just over 3,000 lineal feet from the dam, or just over one-half of a mile. The average temperature decreases by approximately two °C. During previous litigation, the Pollution Control Hearing Board deemed that it is not reasonable pump water from upstream, therefore; it is more valuable to know if there is a temperature difference within the Chelan River.

To detect any temperature variability in the Chelan River, a variability chart was made of just the data collected from the old bridge, down the river to the dam face. It is presented as Figure 3-2.



Note: Temperature in °C, distance from the dam in feet. The blue line represents the mean.

Figure 3-2: Temperature as a Function of Distance from Dam, Chelan River Data

On average, the water temperature averaged over all depths did not vary in the Chelan River by more than one-half of a degree. On some days the water temperature near the dam is lower than temperatures further away from the dam. On other days, the reverse it true. This indicates that there is no advantage of withdrawing water anywhere in the Chelan River other than the dam face.

3.2 Consistency of Bottom Temperatures Over Time

To determine if the temperatures on the bottom of the forebay are consistent over time and space, the data collected from mobile monitoring sites at depths of 28 and 32 feet were plotted over time. The results are presented in Figure 3-3 and Figure 3-4.

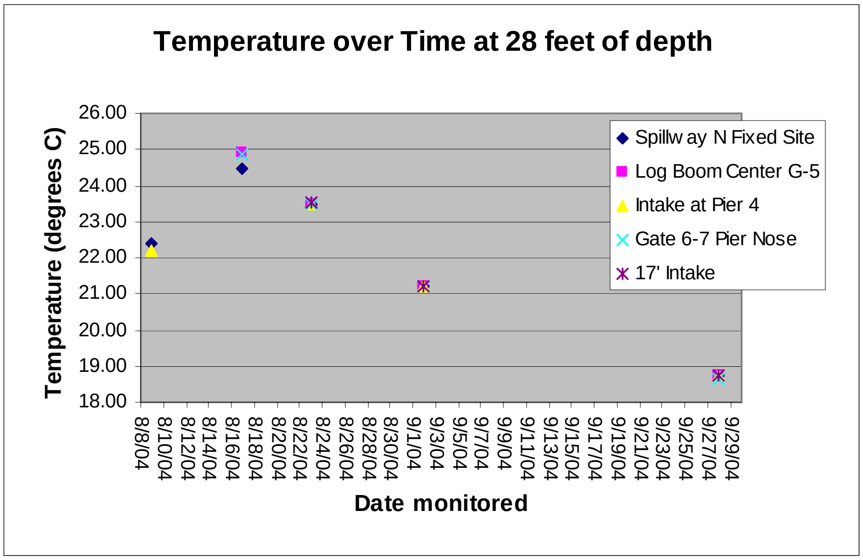


Figure 3-3: Temperature Variation over Time at 28 Feet of Depth

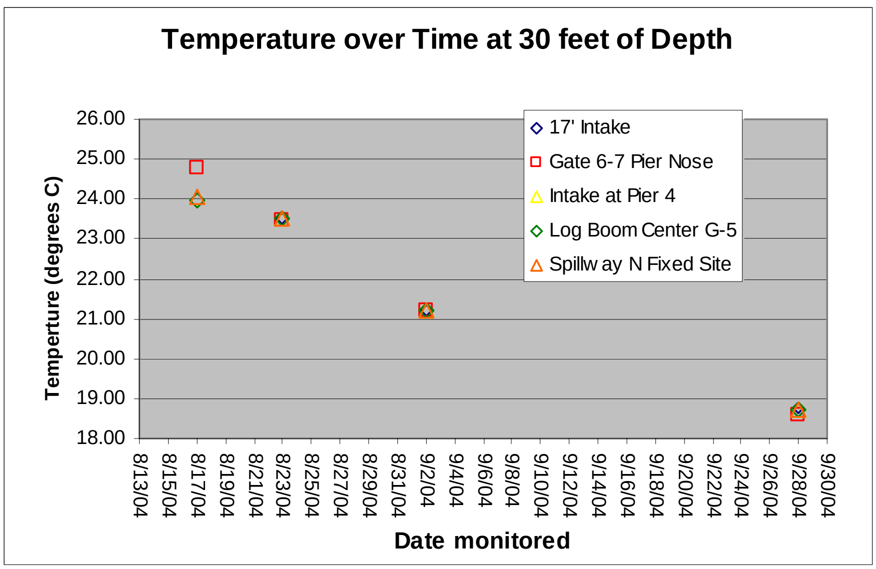


Figure 3-4: Temperature Variation over Time at 30 Feet of Depth

From these figures it is clear that the temperature does vary significantly over time at a given location. However, it does not vary much from location to location, nor between 28 and 30 feet of depth. Thus, any location near the face of the dam will have similar bottom temperatures.

3.3 Evaluation of the Temperature Change in a Vertical Depth Profile

To determine if there are changes in water temperature in a vertical depth profile, the daily temperatures were plotted versus the depth, a gage study was conducted using all of the data collected at monitoring sites within the Chelan River above the dam, and contour plots were developed of the temperatures obtained at the mobile monitoring sites near the dam for each day of monitoring. A plot of the daily temperatures as a function of depth is presented in Figure 3-5. The other evaluations are provided with further description below.

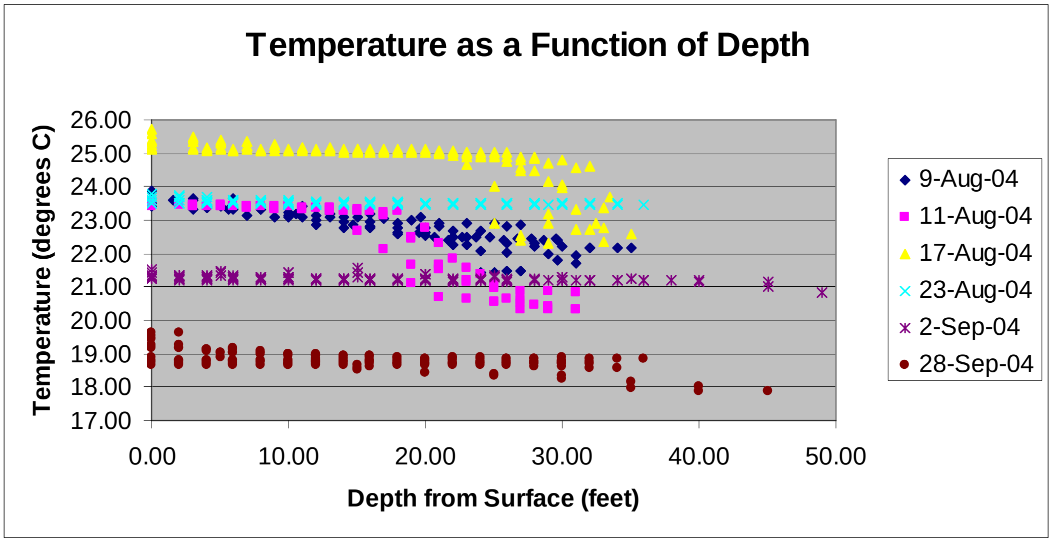
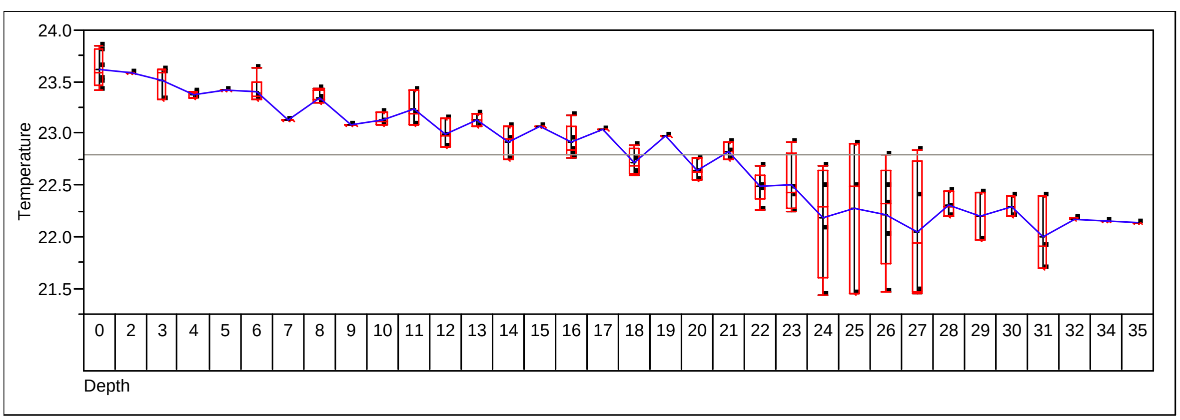


Figure 3-5: Temperature as a Function of Depth

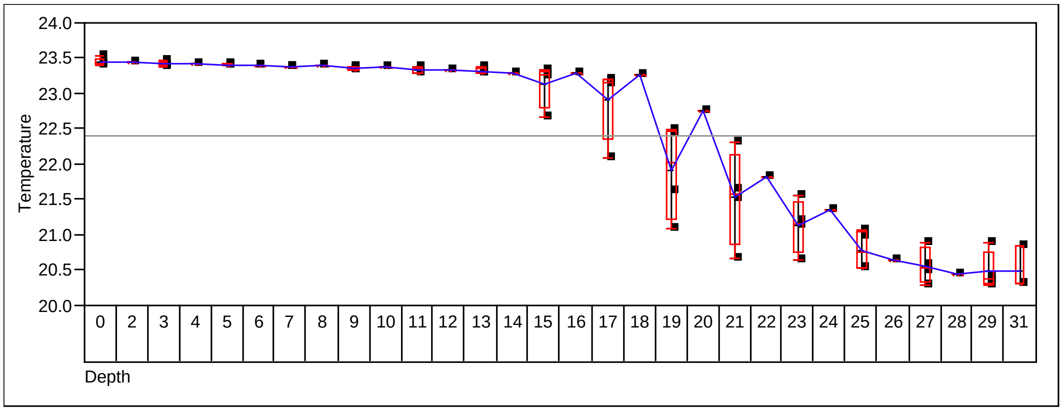
Variability Charts

Variability charts were developed for each day and are presented in Figure 3-6 through Figure 3-11. The data analyzed included only those collected in the Chelan River. It was not possible to include data collected from Lake Chelan because, as presented in Section 3.1, they vary from the remainder of the data and do not represent a location where water will be withdrawn. The accuracy of the depth measured was likely only about one foot, causing the mean to look more varied than it is. In some instances, only one location was measured, causing some of the error bounds to look artificially lower than they are. The variability that is present occurred right around the depth where variation in temperature at depths begins.



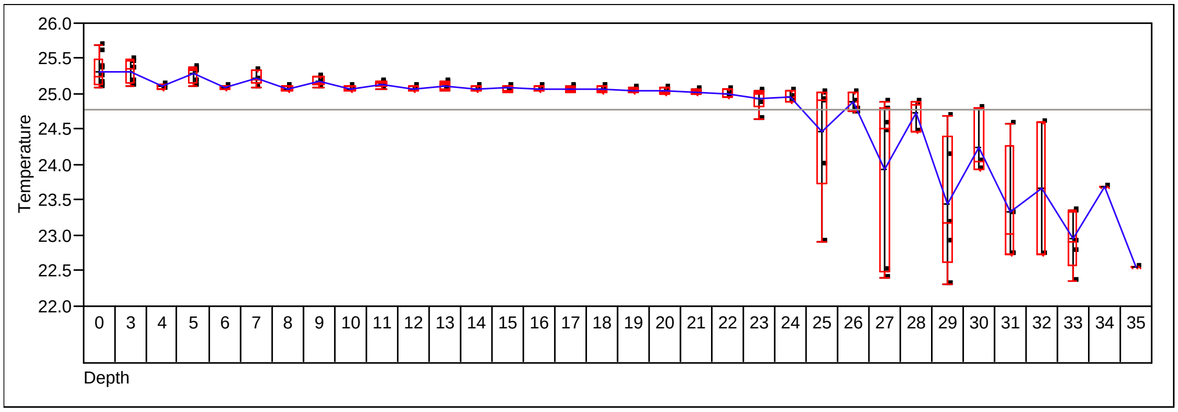
Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-6: Variability Chart for Temperature on August 9, 2004



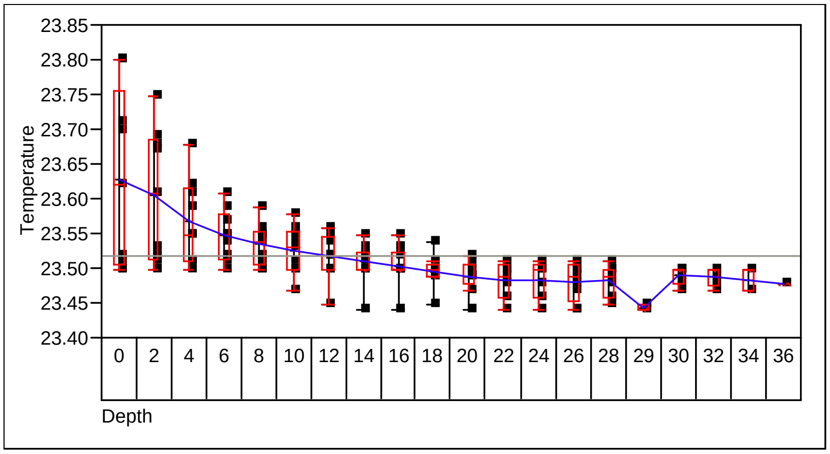
Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-7: Variability Chart for Temperature on August 11, 2004



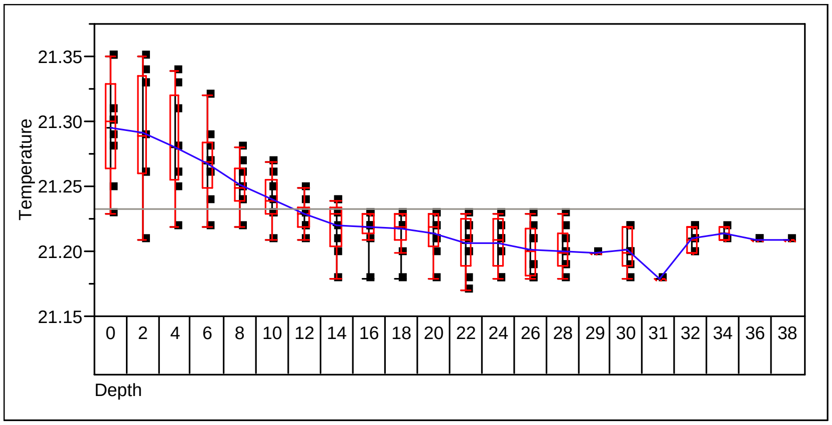
Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-8: Variability Chart for Temperature on August 17, 2004



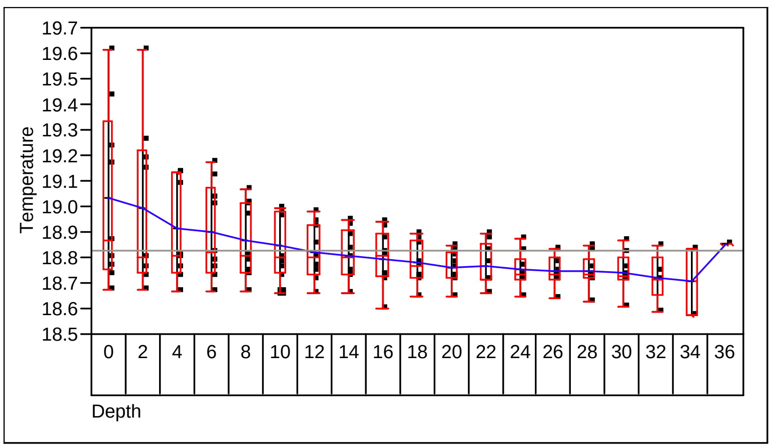
Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-9: Variability Chart for Temperature on August 23, 2004



Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-10: Variability Chart for Temperature on September 2, 2004

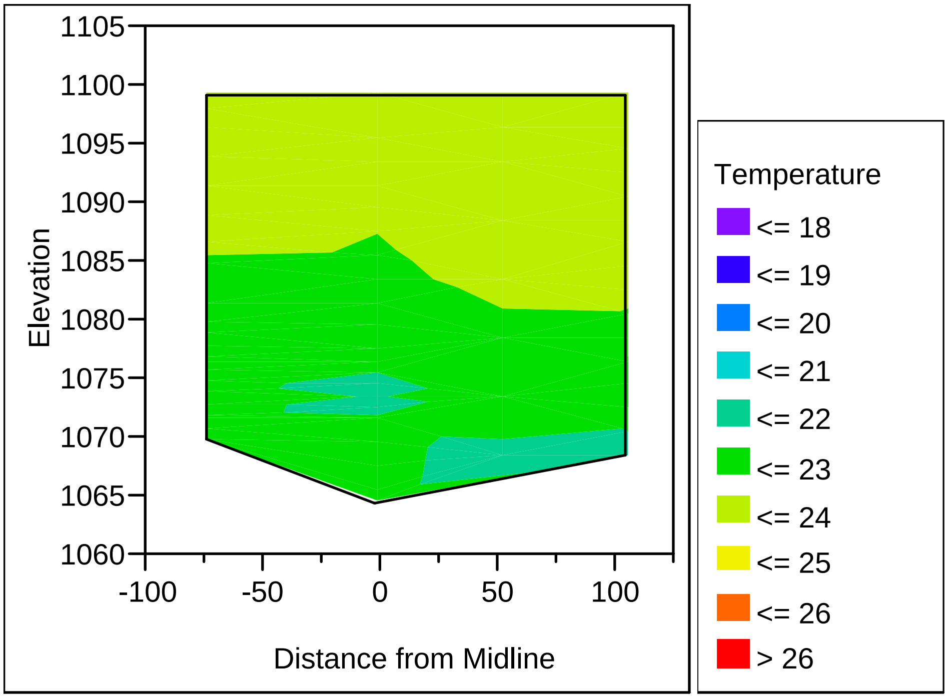


Note: Depth is in feet, temperature is in °C. The blue line represents the mean.

Figure 3-11: Variability Chart for Temperature on September 28, 2004

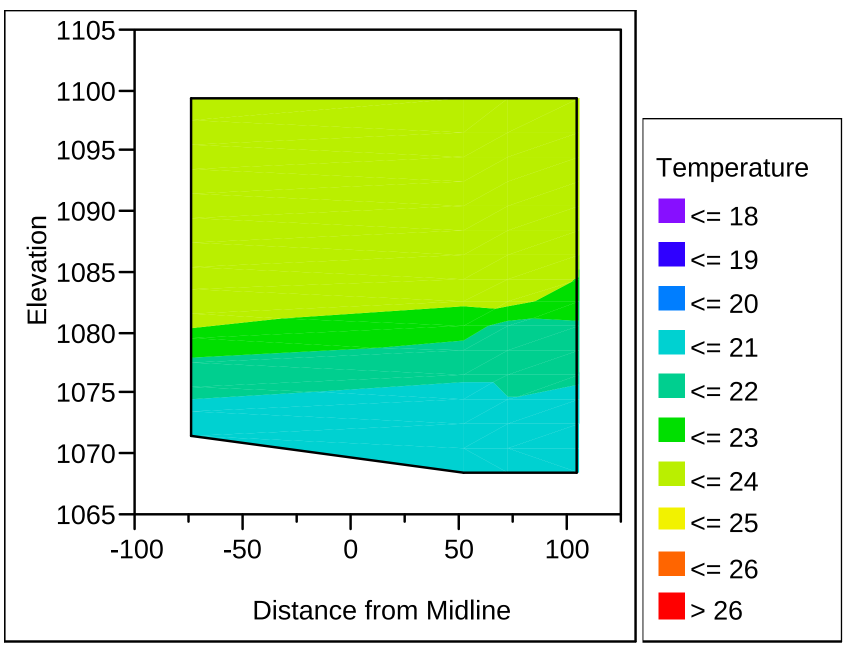
Contour Plots

Contour plots of the Chelan River data were developed to provide a visual indication of the temperature variation within the column on each day that data were collected from the mobile monitoring locations. The contours are presented as if the observer was at the dam, looking up river. The midline is the middle of the river, as it winds towards Lake Chelan. The distance from the dam is not considered, although all data were collected in the forebay. No data from the lake are included. An attempt was made to show each of the contours with one degree increments. On August 23rd and September 2nd, there was less than one degree temperature variation from the surface to the bottom of the column; therefore the increments had to be reduced to less than one degree to obtain a contour. The contours are presented in Figure 3-12 through Figure 3-17.



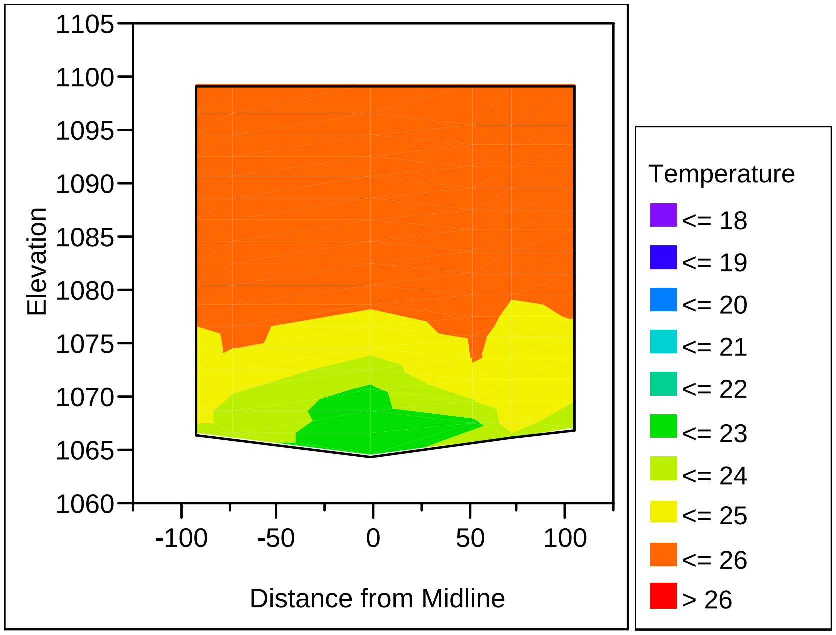
Note: Distance and elevation in feet, temperature is in °C.

Figure 3-12: Contour Plot for Temperature on August 9, 2004



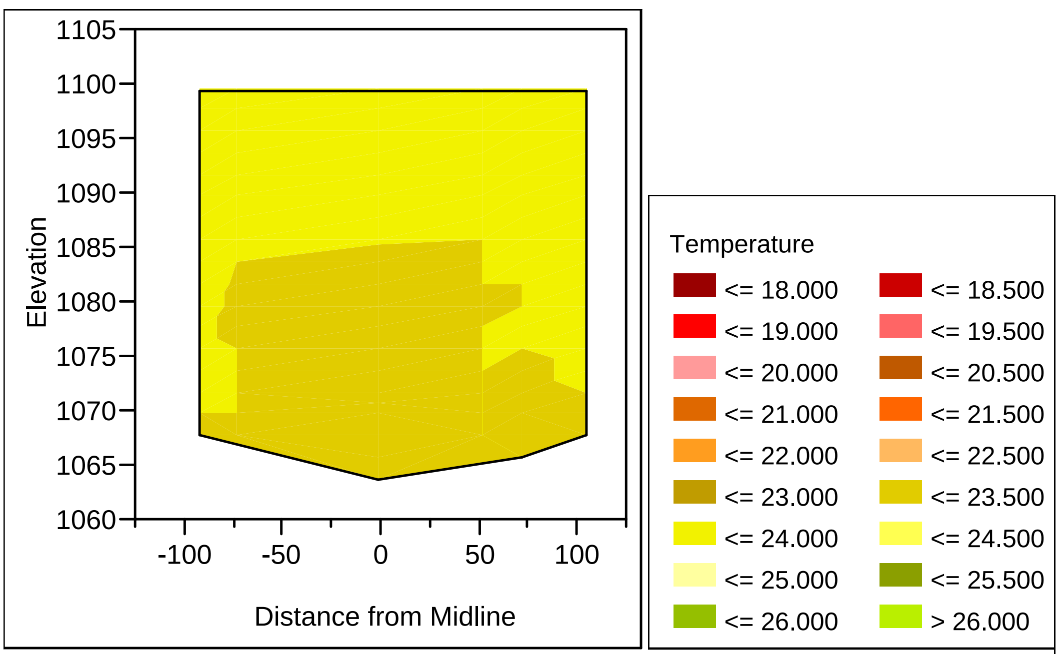
Note: Distance and elevation in feet, temperature is in °C.

Figure 3-13: Contour Plot for Temperature on August 11, 2004



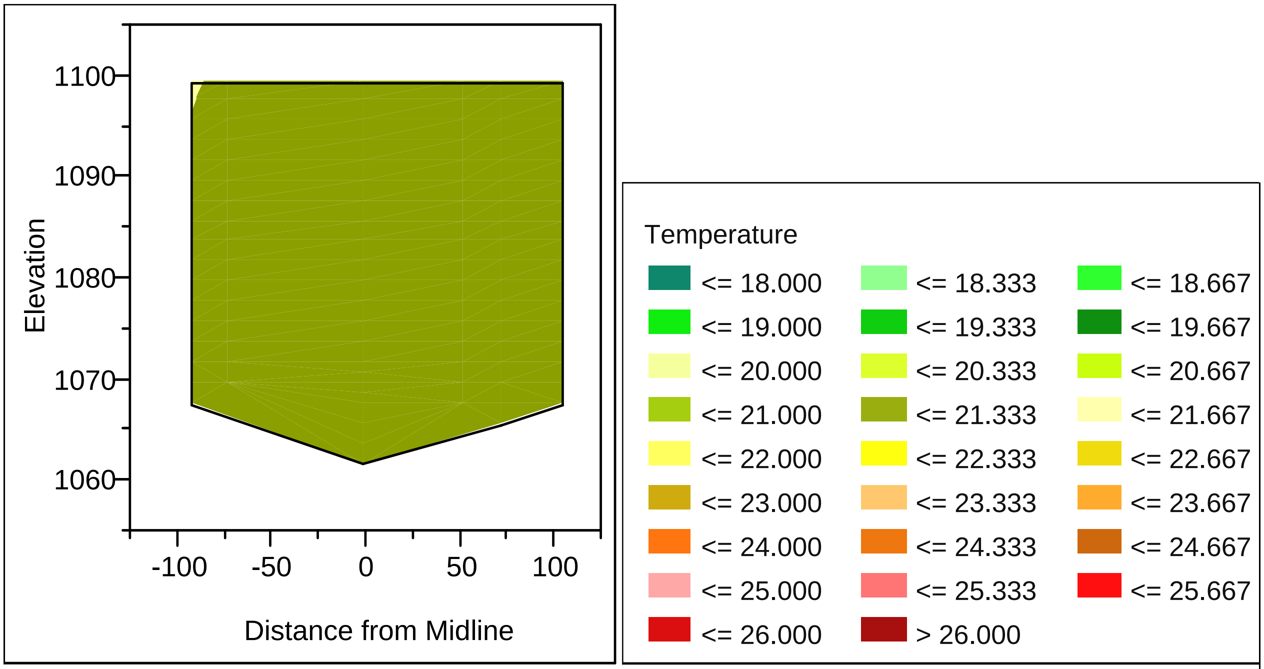
Note: Distance and elevation in feet, temperature is in °C.

Figure 3-14: Contour Plot for Temperature on August 17, 2004



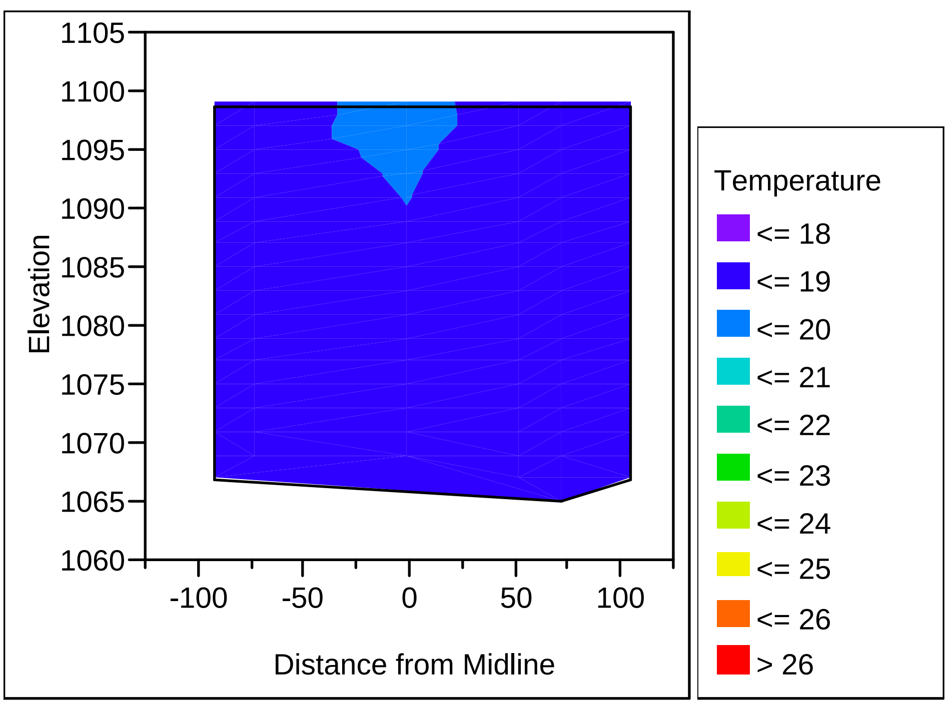
Note: Distance and elevation in feet, temperature is in °C.

Figure 3-15: Contour Plot for Temperature on August 23, 2004



Note: Distance and elevation in feet, temperature is in °C.

Figure 3-16: Contour Plot for Temperature for September 2, 2004



Note: Distance and elevation in feet, temperature is in °C.

Figure 3-17: Contour Plot for Temperature for September 28, 2005

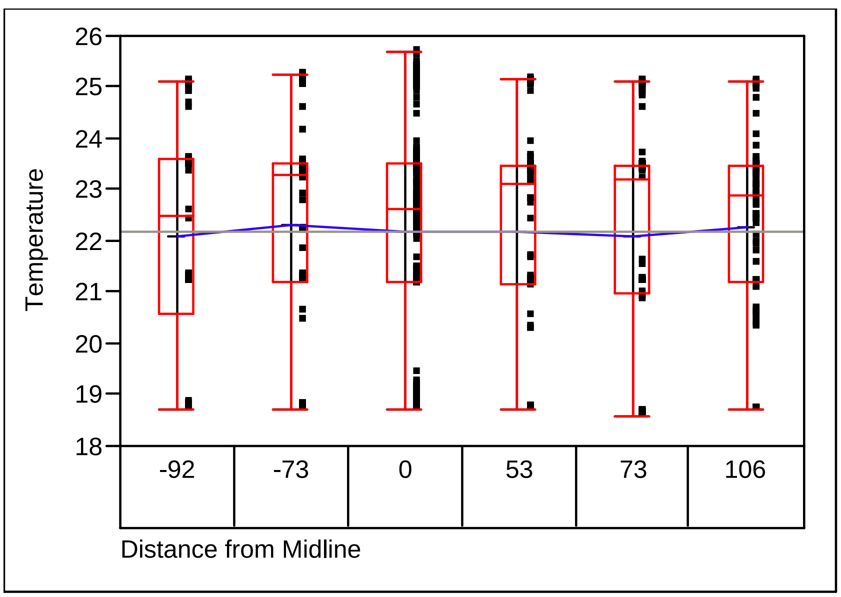
Analysis

The plot of temperature as a function of depth, the variability charts, and the contour plots indicate that changes in water temperature at depth are only occasionally present, resulting in an effect that resembles very weak, temporary thermal stratification. The change in temperature over the column varies from less than a 0.1°C (less than the accuracy of the measurement equipment) to 4°C over the forty feet of depth evaluated. On the days when a strong profile was observed, August 9th, 11th, and 17th, the majority of the temperature variation occurred between elevations of 1070 and 1085 feet above msl, which corresponds to a depth of approximately 15 to 30 feet.

The contours provide additional information beyond the vertical profile; they also offer insight into the lack of transverse temperature variation. From the contours, it does not appear that there is much variation in temperature along the face of the dam. On August 17th, however, the center of the dam appeared to have been cooler than the edges.

3.4 Evaluation of the Presence of Transverse Temperature Variation

To determine if there is a difference in the temperature across the forebay, a variability chart was made using the mobile monitoring site data. The data evaluated were collected only from the Chelan River, not from Lake Chelan. The chart is presented as Figure 3-18.



Note: Depth is in feet, temperature is in °C.

Figure 3-18: Temperature as a Function of Distance from the Midline

No appreciable variability is observed across the width of the dam indicating that it likely does not matter where the outlet structure is located on the dam face.

3.5 <u>Temperature Variation between Elevations of 1070 and 1080</u>

Temperature variation between elevations of 1070 and 1080 feet above msl were observed in the analysis of the presence of a temperature profile using the data collected from the mobile monitoring sites. As previously stated, the analysis indicated that the greatest variability in the column tends to occur between elevations of 1070 and 1085 feet above msl. To further evaluate this variation at these pertinent depths, data were collected from the fixed sites on 15 minute intervals from August 9th to October 20th, 2004. As a first level of analysis, all of the data collected were plotted over time (Figure 3-19).

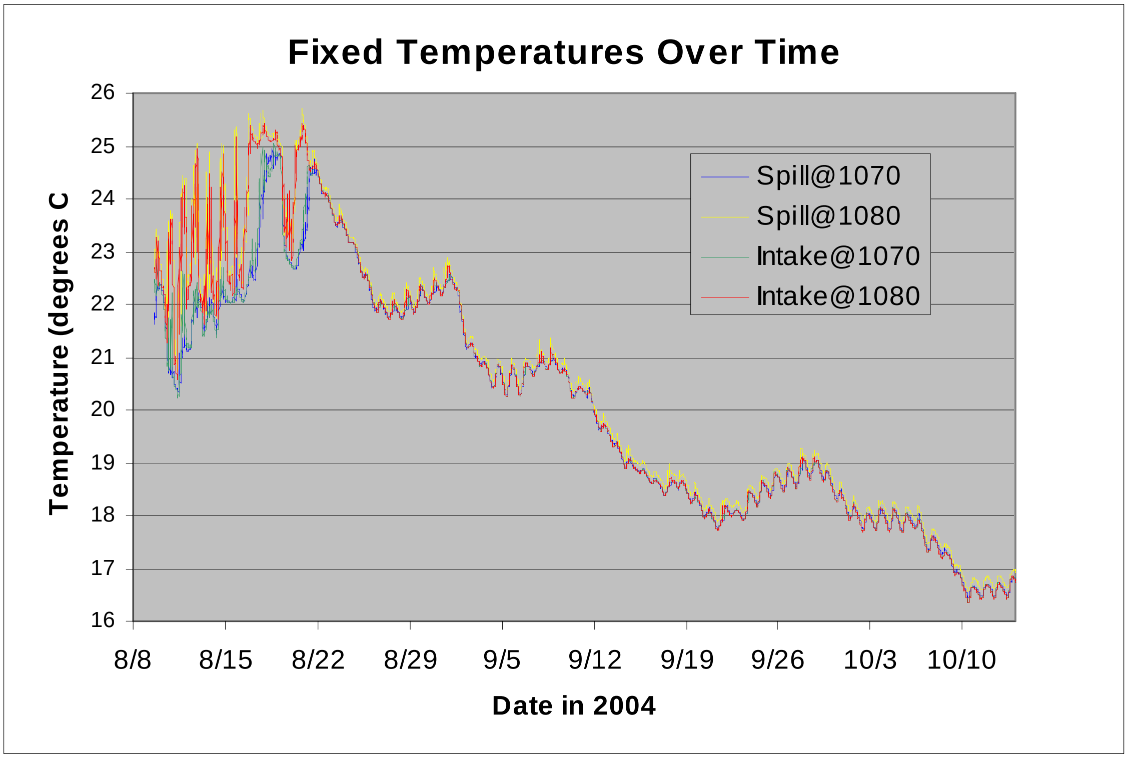


Figure 3-19: All Fixed Site Monitoring Temperature Data

A plot of all of the data indicates a similarity between the lateral locations, but potentially not between the elevations, which concurs with the findings of the analysis of the mobile monitoring site data. Once the water begins to cool again, there doesn't look to be much difference between any of the locations. Cooler water is not needed at this time, so the lack of variation over depth is not relevant to the choice of outlet structure. To further evaluate the elevation difference during the period when the water is warmest and the variation at depth the greatest, the August water temperatures from each location were plotted separately (Figure 3-20 and Figure 3-21).

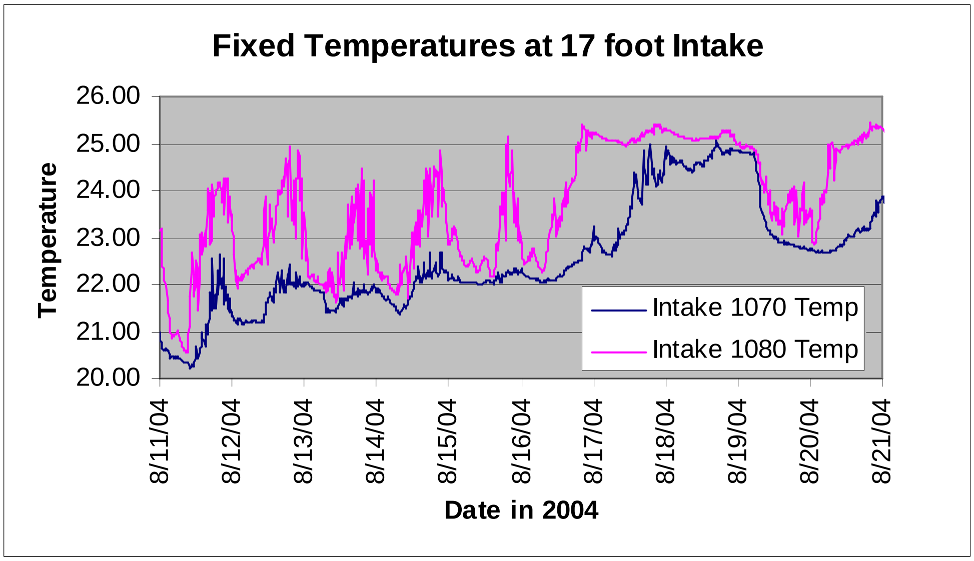


Figure 3-20: Fixed Site Monitoring Data from the 17-Foot Intake

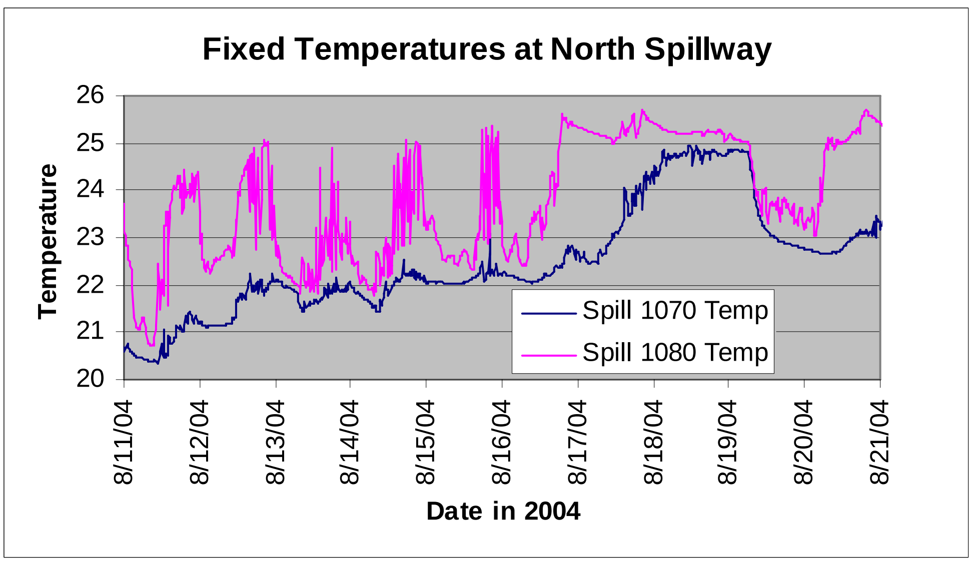
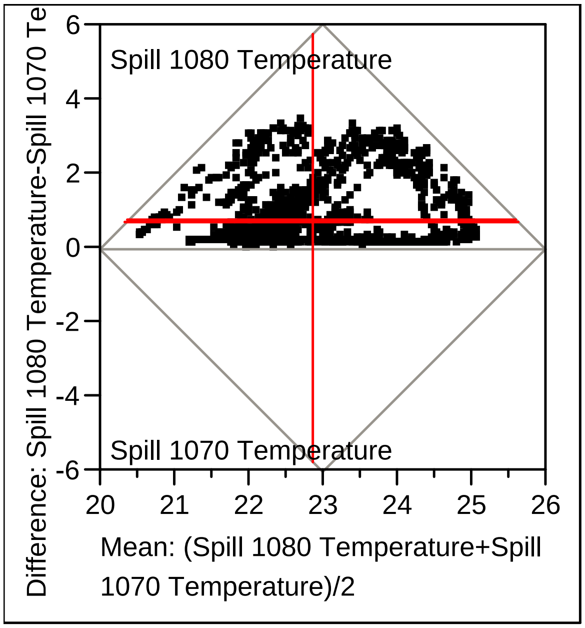


Figure 3-21: Fixed Site Monitoring Data from the North Spillway

From the data collected at each location it is clear that there is a difference between the water temperature at elevations of 1070 and 1080 feet above msl. Daily temperature fluctuations are more pronounced at the 1080 msl depth during the heat of the day, when the shallower water heats more than the deeper water.

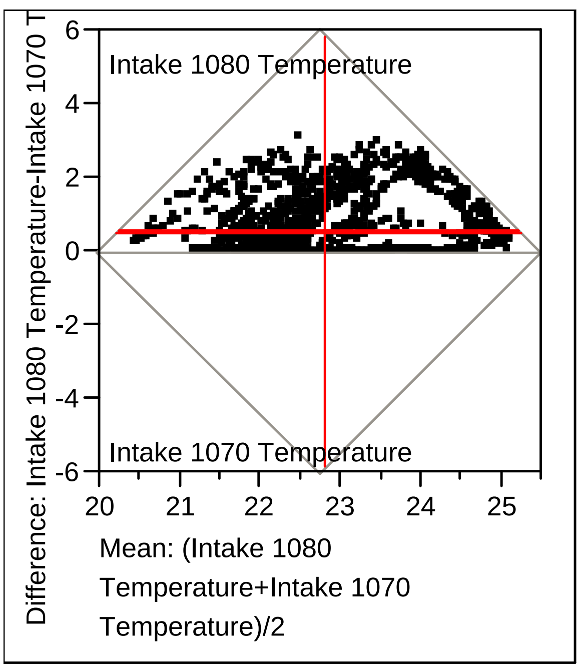
A statistical analysis to evaluate matched pairs was conducted to determine the average difference between the two elevations during August. A comparison was made between the data collected at the North Spillway at each elevation (Figure 3-22), at the 17-foot intake at each elevation (Figure 3-23), and a cross between the upper elevation at each site versus the lower elevation at each site (Figure 3-24 and Figure 3-25).



Spill 1080 Temperature	23.231	t-Ratio	39.58032
Spill 1070 Temperature	22.5224	DF	2288
Mean Difference	0.70861	Prob > |t|	<.0001
Std Error	0.0179	Prob > t	<.0001
Upper95%	0.74371	Prob < t	1.0000
Lower95%	0.6735		
N	2289		
Correlation	0.70617		

Note: Temperature is in °C.

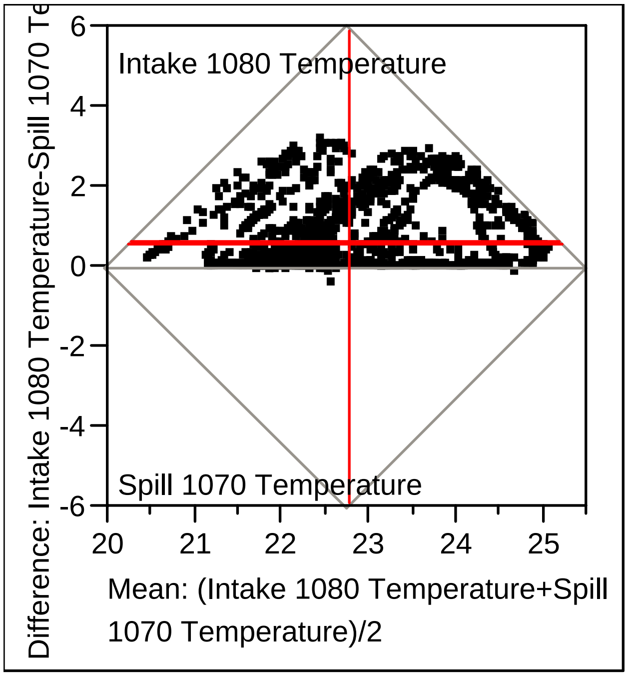
Figure 3-22: Matched Pairs Difference, North Spillway at 1080 versus North Spillway at 1070



Intake 1080 Temperature	23.1	t-Ratio	34.44649
Intake 1070 Temperature	22.5606	DF	2291
Mean Difference	0.53636	Prob > |t|	<.0001
Std Error	0.01557	Prob > t	<.0001
Upper95%	0.5669	Prob < t	1.0000
Lower95%	0.50583		
N	2292		
Correlation	0.77879		

Note: Temperature is in °C.

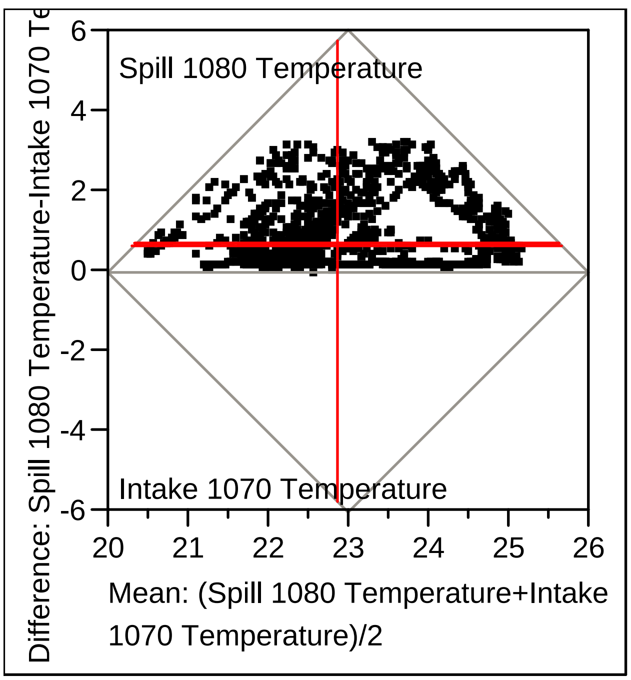
Figure 3-23: Matched Pairs Difference, 17-Foot Intake at 1080 versus 17-Foot Intake at 1070



Intake 1080 Temperature	23.097	t-Ratio	33.67595
Spill 1070 Temperature	22.5207	DF	2291
Mean Difference	0.57632	Prob > |t|	<.0001
Std Error	0.01711	Prob > t	<.0001
Upper95%	0.60988	Prob < t	1.0000
Lower95%	0.54276		
N	2292		
Correlation	0.72984		

Note: Temperature is in °C.

Figure 3-24: Matched Pairs Difference, 17-Foot Intake at 1080 versus North Spillway at 1070



Spill 1080 Temperature	23.231	t-Ratio	40.66613
Intake 1070 Temperature	22.5624	DF	2288
Mean Difference	0.66856	Prob > |t|	<.0001
Std Error	0.01644	Prob > t	<.0001
Upper95%	0.7008	Prob < t	1.0000
Lower95%	0.63632		
N	2289		
Correlation	0.75477		

Note: Temperature is in °C.

Figure 3-25: Matched Pairs Difference, 17-Foot Intake at 1070 versus North Spillway at 1080

From each variability chart and associated t-test it is evident that the average temperature at an elevation of 1070 feet above msl is lower than at 1080 feet. The August temperature differences are summarized in Table 3-1.

Table 3-1: Summary of Difference in Elevation

Comparison	Mean Difference (°C)
North Spillway 1070 v. North Spillway 1080	0.7 ± 0.1
17-foot Intake 1070 v. 17-foot Intake 1080	0.5 ± 0.1
17-foot Intake 1080 v. North Spillway 1070	0.6 ± 0.1
17-foot Intake 1070 v. North Spillway 1080	0.7 ± 0.1

The difference in water temperature in August for water that may be withdrawn at an elevation of 1070 versus 1080 feet ranges from 0.4 to 0.8 °C, and averages about 0.6 °C.

3.6 Temperature Variation between 17-Foot Intake and North Spillway

Although lateral variation was analyzed in Section 5.4 and found to be negligible, a further analysis of the pertinent potential outfall locations was conducted using the data collected at the fixed monitoring sites during August. This analysis was conducted by plotting the temperature at each location at a given elevation (Figure 3-26 and Figure 3-27), and by evaluating the matched pair differences.

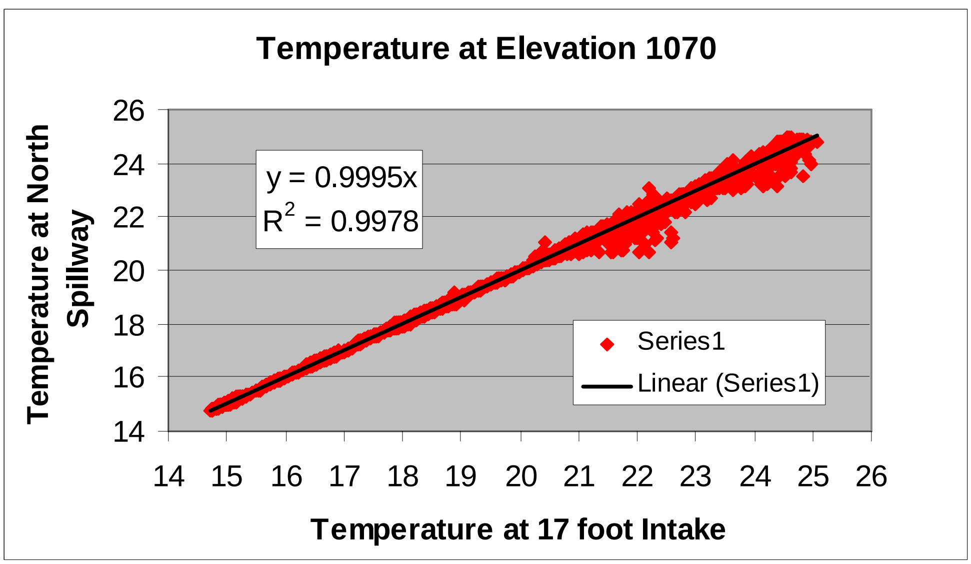


Figure 3-26: Comparison of Temperatures at the North Spillway and 17-foot Intake at 1070

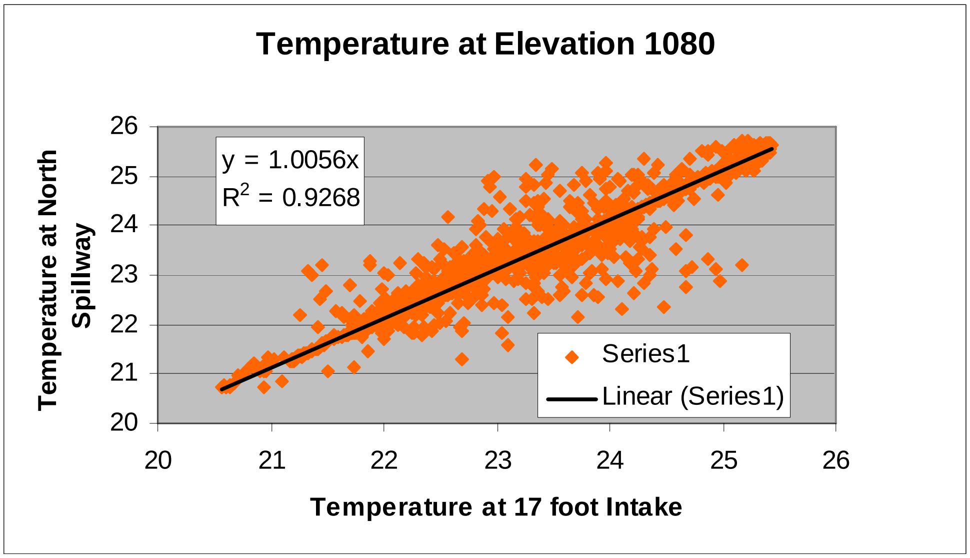
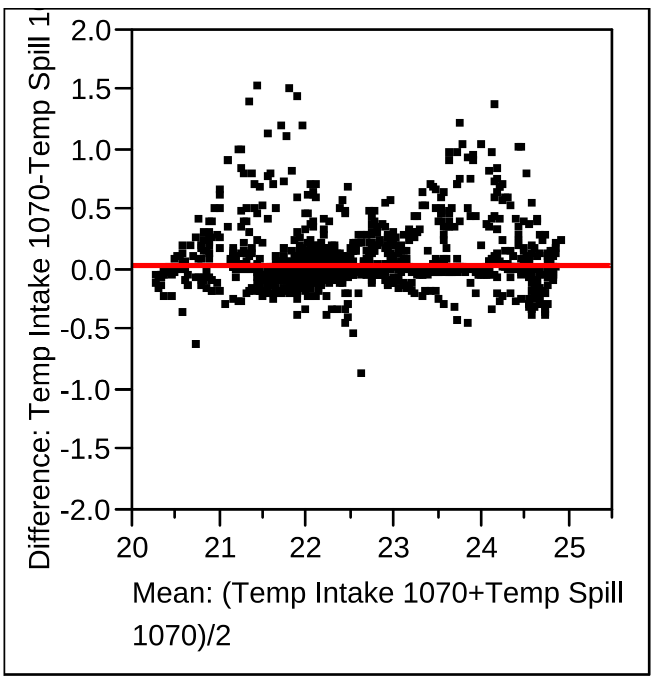


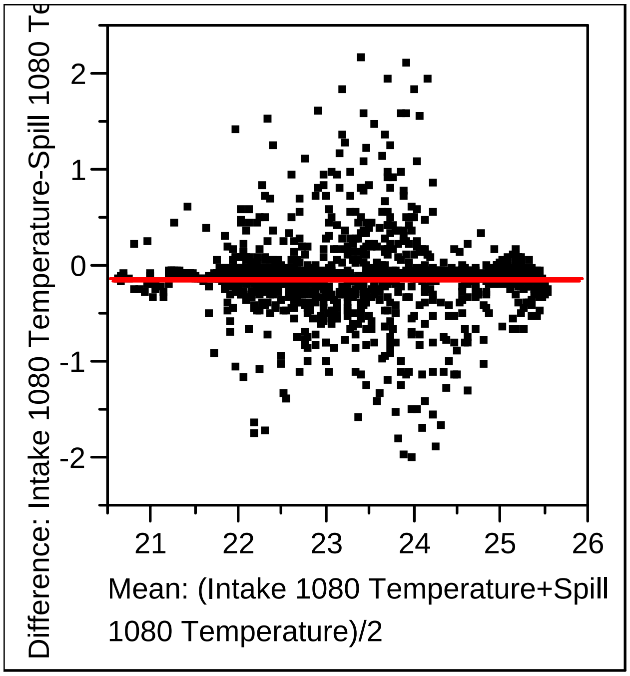
Figure 3-27: Comparison of Temperatures at the North Spillway and 17-foot Intake at 1080



Temp Intake 1070	22.5624	t-Ratio	9.238781
Temp Spill 1070	22.5254	DF	2288
Mean Difference	0.03705	Prob > |t|	<.0001
Std Error	0.00401	Prob > t	<.0001
Upper95%	0.04492	Prob < t	1.0000
Lower95%	0.02919		
N	2289		
Correlation	0.98243		

Note: Temperature is in °C.

Figure 3-28: Matched Pair Difference of North Spillway and 17-foot Intake at 1070



Intake 1080 Temperature	23.0995	t-Ratio	-19.7315
Spill 1080 Temperature	23.231	DF	2288
Mean Difference	-0.1315	Prob > |t|	<.0001
Std Error	0.00666	Prob > t	1.0000
Upper95%	-0.1184	Prob < t	<.0001
Lower95%	-0.1446		
N	2289		
Correlation	0.96335		

Note: Temperature is in °C.

Figure 3-29: Matched Pair Difference of North Spillway and 17-foot Intake at 1080

From the correlation between the data in the two locations and the student t-test evaluation, there is no significant difference between the water temperature at the north spillway and the 17-foot intake at an elevation of 1070 or 1080 feet above msl during August. The slight variation observed is within the accuracy of the measurement equipment.

SECTION 4: RECOMMENDATIONS AND CONCLUSIONS

There appears to be a significant variation in the water temperature at the bottom of the Chelan River upstream of the dam over time; therefore, the temperature introduced into the bypass will also predictably vary over time, regardless of the withdrawal depth. Any phenomena that resemble thermal stratification either are not present or are not present simultaneously at all locations in the Chelan River. This temperature variation at depth apparently sets up sporadically during the heat of the summer (August) and then disappears, at not yet predictable times. When it occurs, it happens at all areas of the forebay. The depth that the variation begins is not predictable, nor is the amount of variation.

On days when there is greater difference in water temperature at depth, and something akin to thermal stratification is present, it would be advantageous to withdraw water from as deep as possible in the forebay. Typically, the majority of the variation, when it occurs, is observed between the elevations of 1070 and 1085 feet above msl. The largest variation observed through the water column was approximately 4°C. The average temperature difference observed between the elevation of 1070 and 1080 feet above msl was approximately 0.6°C.

No significant lateral temperature variation was observed. Specifically, there is no statistical difference between any variation at depth observed in the water temperature at the north spillway site and the 17-foot intake.

Based on the above observations, the location of the outlet structure along the dam should not impact the temperature of the withdrawn water; however, the type of structure, and therefore the depth of withdrawal may impact the temperature in August. According to the preliminary feasibility study, if the 17-foot intake outlet structure is constructed it will release water from elevations of 1070.5 to approximately 1072.5 feet. If the north spill way outlet structure is constructed, during high flows (500 cfs) it is currently designed to release water from elevations of approximately 1072 to up to 1080 feet. The average August water temperature observed at an elevation of 1080 was 23.1 and 23.2°C at the intake and spill site, respectively. The average August water temperature for the same dates observed at an elevation of 1070 was 22.6 and 22.5°C at the intake and spill site, respectively. If water is withdrawn from the north spill way under the current design during August, the average summer temperature is expected to be a mean of temperature observed at the elevations of 1070 and 1080 feet, which is 22.9 °C. If the water is withdrawn from the intake during August, the average summer temperature is anticipated to be that observed at an elevation of 1070 feet, 22.6°C. The average difference in the temperature released to the bypass reach during August and based on the current design options is expected to be approximately 0.3 °C. Additional monitoring would be needed to determine if there is temperature variation during June or July. No significant temperature difference is observed in September or October.

The purpose of the outlet structure is to provide water to the Chelan River below the dam to provide habitat for cutthroat. Cutthroat typically can tolerate water temperatures as high as 25°C. To provide sufficient flow, 80 cfs will be released all year. During the heat of the summer, additional water may need to be released to reduce water temperatures; therefore, the temperature difference in the forebay withdrawal options for high flows during the hottest days is relevant to fish survival.

APPENDIX A: LICENSE ARTICLE AND 401 CERTIFICATION ORDER

Article 7. Chelan River Fishery Plan

Within one year of the effective date of the New License, Chelan PUD shall begin implementation of the plan to restore the fish and wildlife resources of the Chelan River, as described in this License Article and Chapter 7 of the Comprehensive Plan, which is incorporated herein by reference.

(a) **Biological objectives.** The Chelan River restoration plan is designed to achieve certain biological objectives concerning restoration and/or enhancement of biological resources in four separate reaches of the river and to support, maintain, and protect the designated and existing beneficial uses of the Chelan River basin, pursuant to applicable federal and State law. The biological objectives that Chelan PUD shall attempt to achieve for each reach are set forth in detail in section 4 of Chapter 7 of the Comprehensive Plan. The Parties believe that achievement of these biological objectives, through implementation of this License Article, would substantially restore a significant number of environmental values associated with the Chelan River.

(b) **Habitat Protection and Restoration measures.** Chelan PUD shall implement the following habitat protection and restoration measures:

(1) **Minimum flows and ramping rates**. Chelan PUD shall comply with the minimum flows and ramping rates provisions set forth in section 2.6.5, table 7-3, and section 3.2, table 7-6, respectively, of Chapter 7 of the Comprehensive Plan as soon as the structures needed to provide such flows are constructed, which shall occur no later than two years after the effective date of the New License. The structures for which construction is needed are a new flow release structure at the dam, estimated to cost $350,000, and modifications to the channel in Reach 4. Prior to the date such structures are completed, Chelan PUD shall provide flows consistent with Chapter 7 of the Comprehensive Plan for the purposes of testing designs or structures or gathering other data, including water quality data.

Placeholder for June 1, 2004, 401 Certification Order