Thermal Gradients, Collection and Mortality at the McNary Project

2010

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Executive Summary

Water temperatures at the McNary Project are influenced by air temperature and wind velocity. Project operations (turbine unit operations, number and location of operating and non-operating turbine units) and spill (magnitude and more importantly percent) have an effect on the movements and creation of thermal gradients. Total project discharge during the temperature monitoring period (June 15 – August 31) averaged 191.1kcfs in 2010. The target flows set by the National Marine Fisheries Service Biological Opinion for McNary were met with an average flow of 241.4kcfs for April – June 30. From June 15 to June 30, flows averaged 323.7kcfs. Flows for July 1 through August 31 average 156.9kcfs. The percentage of project discharge diverted through the spill June 15 – August 31, 2010 was 49.1%. This was the fifth season with "court ordered spill" where 50% of the flow went through the spill bays.

The most dramatic thermal gradients in the juvenile bypass system at McNary occurred this year when fish passed from the forebay to the gatewells. Historically this has occurred at the southern turbine units during days with elevated air temperatures and light winds. In the 2010 season, McNary Dam had the largest gradients during the month of July, when the hottest air temperatures were seen. These gradients were as large as 10.6°F in Unit 3. The Corp of Engineers did not need to initiate North Powerhouse Loading as there were several units down for maintenance on the southern end of the powerhouse. Trucking on the non-barge days was implemented on August 6. Raceway water temperatures had already reached 71°F by then. When barging started on July 16, the temperature in the raceways was 66°F. Some stress might be relieved if fish are trucked/barged every day when water temperatures are above 66°F.

Facility mortality at the McNary JFF was lower than last year during the juvenile fall Chinook outmigration. System mortality was 0.4% (6,686) for the 1,787,545 fish collected from June 15 through August 31. The highest one-day system mortality percent was 3.3% on August 3.

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ACKNOWLEDGMENTS

This report was accomplished only with aid from the McNary staff. Les Layng and Lars Richins did the physical labor of preparing and setting out probes, downloading these probes and compiling data. Brad Eby and Bobby Johnson were always available for anything that was needed.

INTRODUCTION

McNary Dam, located at river mile 292 of the Columbia River, is the first hydroelectric project downstream of the confluence of the Snake and Columbia Rivers. McNary Dam is 7,365 feet long, and rises approximately 183 feet above the streambed. It consists of a 14 turbine unit powerhouse, a 22 bay spillway, a navigation lock, and an earthfill embankment at the Oregon (south) abutment. The dam raises the normal water surface about 85 feet creating Lake Wallula, which extends 64 miles upstream to the Hanford Reach on the Columbia River and to Ice Harbor Dam on the Snake River. Lake Wallula has a water surface area of 38,800 acres with 242 miles of shoreline.

The McNary powerhouse is equipped with extended - length submersible bar screens (ESBS) to guide fish into the gatewells of each turbine unit. There are three vertical gatewell slots (A, B, and C) for each turbine unit. From the gatewells, water and fish enter the collection channel through 12-inch orifices that leads to a wet separator at the juvenile fish facility (JFF) for separation of fish by size and return of adults to the river. The juvenile fish can be routed back to the river or held in raceways for transport by barge or truck to release locations below Bonneville Dam.

Since 1987, the Washington Department of Fish & Wildlife biologists have recorded water temperatures across the powerhouse from June 15 through August 31 of each year. This work has been conducted to identify thermal gradients at the McNary Project that might be detrimental to juvenile fish entering the project and fish facility. Water temperatures were recorded from the scrollcase of all 14 turbine units. Prior to 1998, water temperatures were recorded with a dissolved oxygen meter in the B gatewell slot of each turbine unit, and the forebay surface at odd numbered turbine units at 1:00 p.m. each day. Since 1998, temperature monitoring efforts have been expanded over the full 24 hours of each day to recover temperature information using Optic Stowaway® temperature probes. In 2006, Onset Corporation stopped making and supporting the Optic Stowaway®. The decision was made to move to MadgeTech Temp1000®. Over the years as the Stowaway® battery has failed, that probe has been replaced with a Temp1000®. In 2010, there are now 24 MadgeTech Temp1000® and 12 Optic Stowaway®.

Objectives

The specific objectives at McNary Dam for 2010 were to:

1) Monitor typical temperature patterns in the forebay, tailrace, collection channel, and juvenile fish facility of McNary Dam.
2) Monitor the effects of forebay temperatures on turbine unit gatewell water temperatures.
3) Monitor the effects of wind speed and air temperature on water temperatures and the creation of thermal gradients at the McNary Dam.
4) Locate areas where thermal gradients are present at McNary Dam and within the juvenile fish facility.
5) Monitor water temperatures in the raceways and the separator.
6) Monitor increased temperature gradients at McNary Dam that might pose a threat to increased mortality at the JFF.

Methods

Onset Optic Stowaway® temperature data loggers were installed at 21 of 34 locations throughout the McNary Project and Juvenile Fish Facility (JFF). These temperature loggers are accurate to +/- 0.4°F at 70°F. Probes located at the Project and JFF were set to record temperatures at 30-minute intervals. The MadgeTech Temp1000® was used in the remaining 13 locations. It is completely self contained and has a battery that can be changed on site, as opposed to the Optic Stowaways® that had to be returned to the company. It is accurate to +/- 0.5°C at any temperature. The range is -40 ~ +80°C. Temperature probes were downloaded each day for in-season evaluation of thermal gradients at the Project. A weather station is located on top of the JFF building to record air temperatures and wind speed. The weather station recorded temperatures on 30-minute intervals to correspond to water temperature information. Weather information was downloaded every day. All data presented in this report, unless stated otherwise, was from June 15 through August 31, 2010.

Optic Stowaway® temperature probes were positioned in the following locations at McNary Dam in 2010 (Figure 1):

1) Forebay, near elevation 335 approximately 5 feet below the surface. These are attached to the pier noses in front of turbine units 1, 7, and 12.
2) In front of spillbay 17 approximately 5 feet below the surface. This probe was hung in the center of the spillbay, on the tailrace side.
3) Attached to the handrail in the center of the "B" turbine gatewell slots, approximately 2 to 3 feet below the surface, in turbine units 2, 4, 5, and 11.
4) Tailwater locations were at turbine unit 1 and 14 (tailrace). These were placed 5 feet below the water surface.
5) The barge transportation dock.

The MadgeTech Temp1000® data recorders were placed in:

1) Forbay, near elevation 335 approximately 5 feet below the surface. These are attached to the pier noses in front of turbine units 3, 5, 8, 10 and 14.
2) In front of spillbays 21, 12, 7 and 2 approximately 5 feet below the surface. These probes were hung in the center of the spillbay, on the tailrace side.
3) Turbine unit 1, 3, 6 - 10, and 12 – 14 3 feet below the surface.
4) The collection channel had probes installed at turbine units 12, 8 and past unit 1 at the beginning of the transition screen.
5) The wingwall of the navigation lock on the tailrace side of the dam. This was placed 5 feet below the water surface.
6) Fish separator.
7) Transport holding raceway #1 at a depth of 2 – 3 feet.

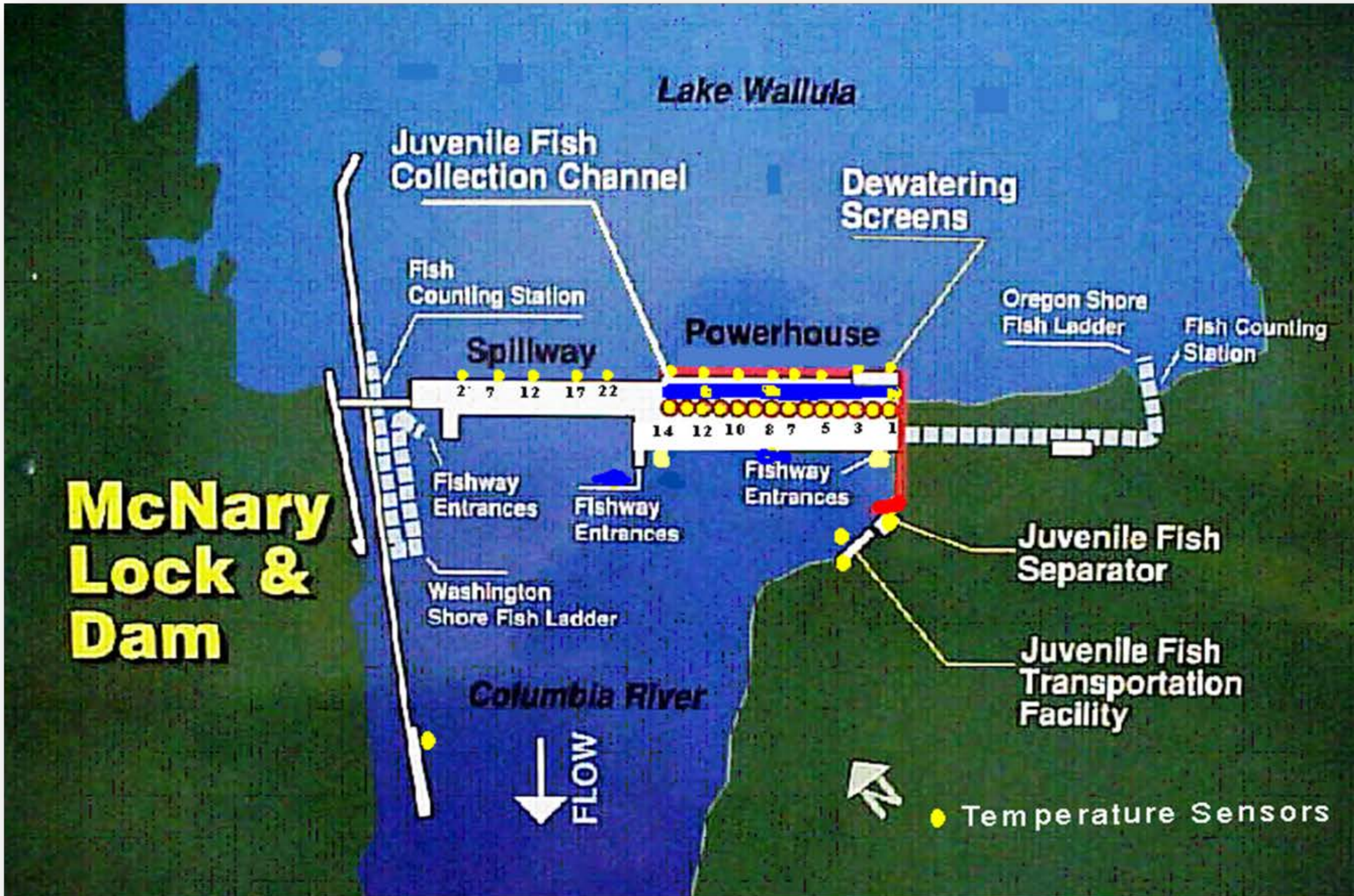

Figure 1. Placement of temperature data recorders at McNary Dam, 2010

WEATHER

Air temperature and wind velocity have been identified as critical components relating to thermal gradients at McNary Dam (Hoffarth 1999). Mild (3–5 mph) to moderate (6–10 mph) wind velocities help to break up major temperature differences that may appear between the forebay and the gatewell. When ambient air temperature exceeds 90 °F, thermal gradients may occur. Light winds (>3 mph) in conjunction with elevated air temperatures, can break up these gradients (Figure 2).

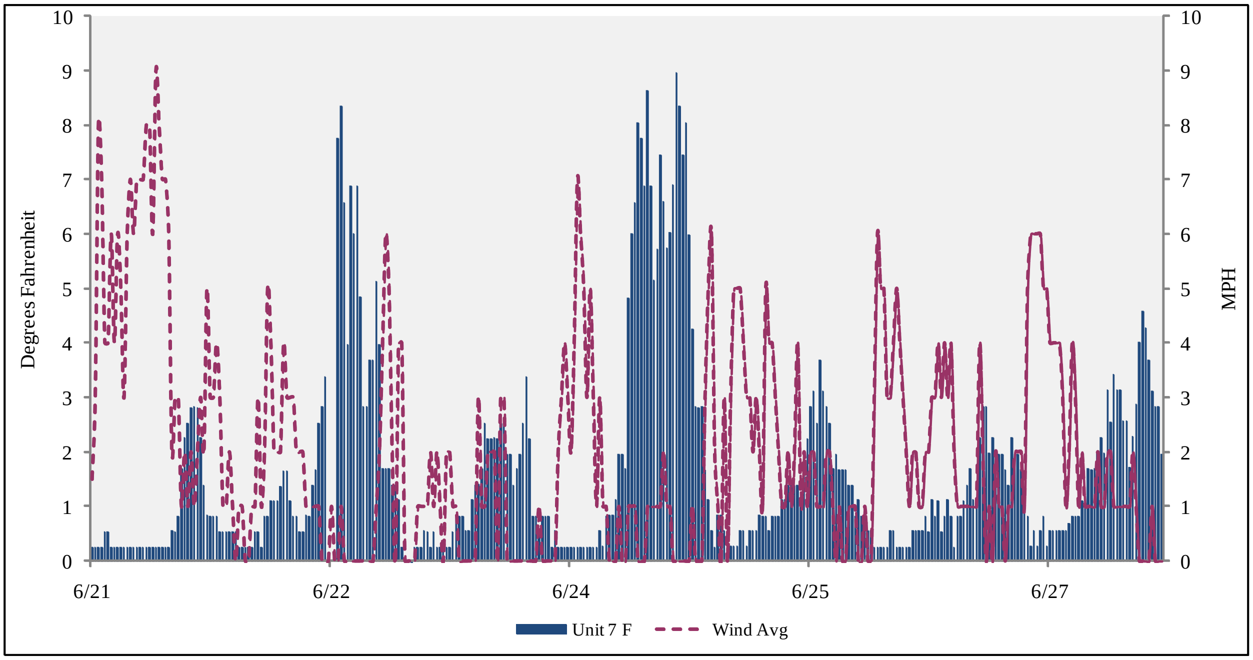

Figure 2. Differences in degrees Fahrenheit between forebay & gatewell, with wind, at McNary Dam, June 21 – 27, 2010

The 2010 season was the 12th year WDFW/PSMFC has recorded complete and accurate weather information at McNary Dam. The weather station was located at the JFF immediately below the powerhouse on the Oregon shore. There were was only one day in August when the weather station seemed to take a holiday for no apparent reason.

Mean daily air temperatures in June, July and August were 66.5, 74.0 and 72.9°F respectively. The highs were 90.5, 102.5 and 100.4°F (Table 1). In July there were 15 of 31 days where the air temperature was in excess of 90°F. Eight of those days had no accompanying breeze to break up thermal gradients. In August there were 11 of 31, with five days of no wind. Including June, there were 27 days when the air temperatures exceeded 90°F.

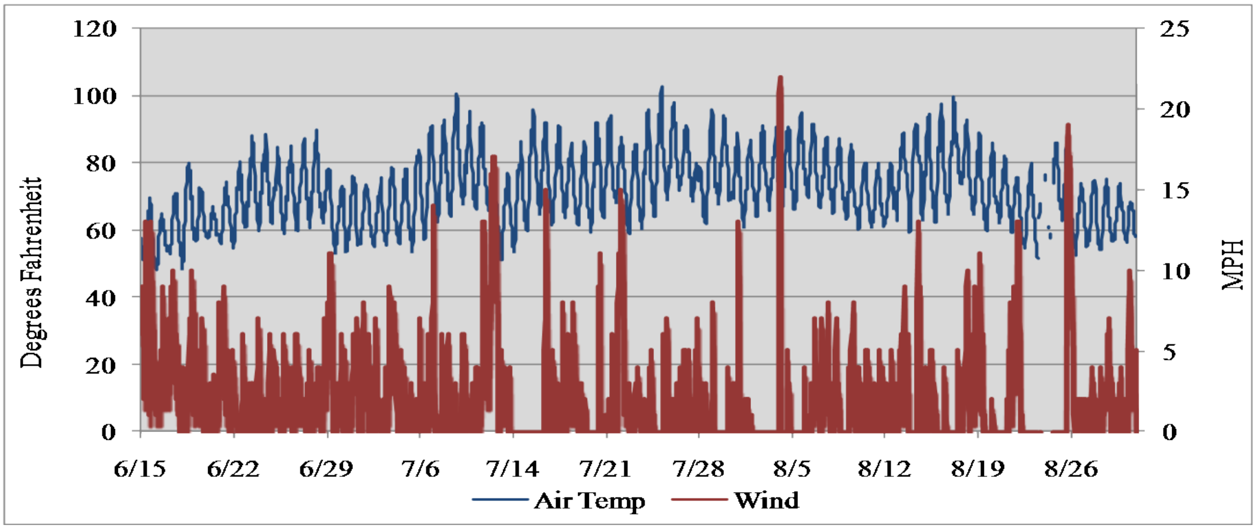

Figure 3. Air temperatures (°F) & wind velocity (mph) at McNary Dam, June 15 – August 31, 2010

Table 1. Monthly air temperatures (°F) & wind velocity (mph) at McNary Dam, 2006 – 2010

Month	Daily Average	Maximum Average	Minimum Average	Maximum Range	Minimum Range	Days >90°F	Wind Average
June*							
2006	68.0	80.3	57.7	65.3-102.3	52.6-65.3	6	3.4
2007	67.3	79.6	56.3	66.8-98.5	48.9-66.4	4	4.4
2008	65.5	78.4	54.1	56.5-98.2	47.1-69.8	4	4.1
2009	68.9	81.7	57.6	70.3-92.5	50.5-64.2	1	3.4
2010	66.5	78.8	56.2	65.2-90.5	47.6-61.8	1	2.9
July							
2006	77.2	91.9	64.8	75.4-108.2	53.2-74.0	19	3.6
2007	77.6	91.9	65.8	82.4-104.1	55.0-72.8	20	2.0
2008	74.5	88.3	62.1	79.6-96.3	52.9-70.6	15	2.6
2009	76.8	91.8	63.5	77.7-100.4	54.7-76.7	20	3.0
2010	74.0	88.4	61.1	73.5-102.5	50.8-70.9	15	2.0
August							
2006	73.0	87.7	60.5	73.3-95.4	49.1-69.8	11	3.0
2007	72.5	86.7	60.5	71.3-103.1	51.9-70.8	9	2.6
2008	72.7	86.5	60.8	71.3-101.0	49.8-68.1	12	3.0
2009	74.6	88.1	63.3	75.8-103.1	54.8-75.1	12	2.0
2010	72.9	85.9	61.1	68.4-100.4	51.1-72.3	11	1.7

*Report period begins June 15

PROJECT DISCHARGE & SPILL

Total project discharge during the temperature monitoring period (June 15 – August 31) averaged 191.1kcfs in 2010. In 2009, the flow averaged 165.9kcfs (Figure 4). The target flows set by National Marine Fisheries Service Biological Opinion states that during the spring (April 20 - June 30) the flow target will be 220 – 260kcfs at McNary. McNary flows for this period averaged 241.4kcfs. From June 15 to June 30, flows averaged 323.7kcfs. According to the

Biological Opinion, ideal target flows for July 1 through August 31 should average 200kcfs. Flows for this period were 156.9kcfs. The average percentage of project discharge diverted through the spill in 2010 was 49.1%. In 2009, it was 48.6% of total discharge (Figure 5). This was the fifth year that there was a spill program mandated by the court. It was stated that 50% of the flow will be spilled and the rest for power generation.

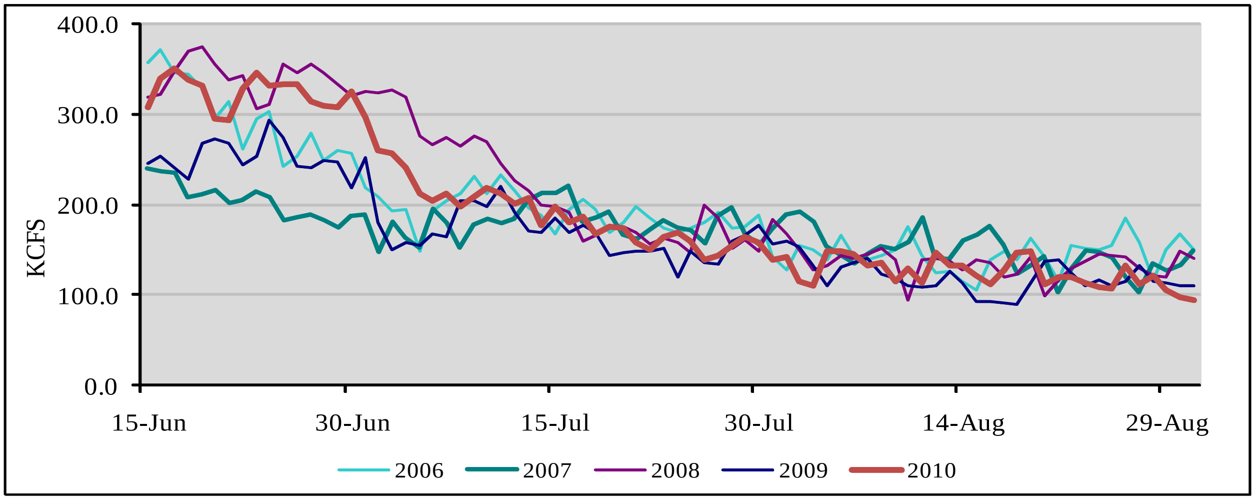

Figure 4. Project discharge for McNary Dam, 2006 - 2010

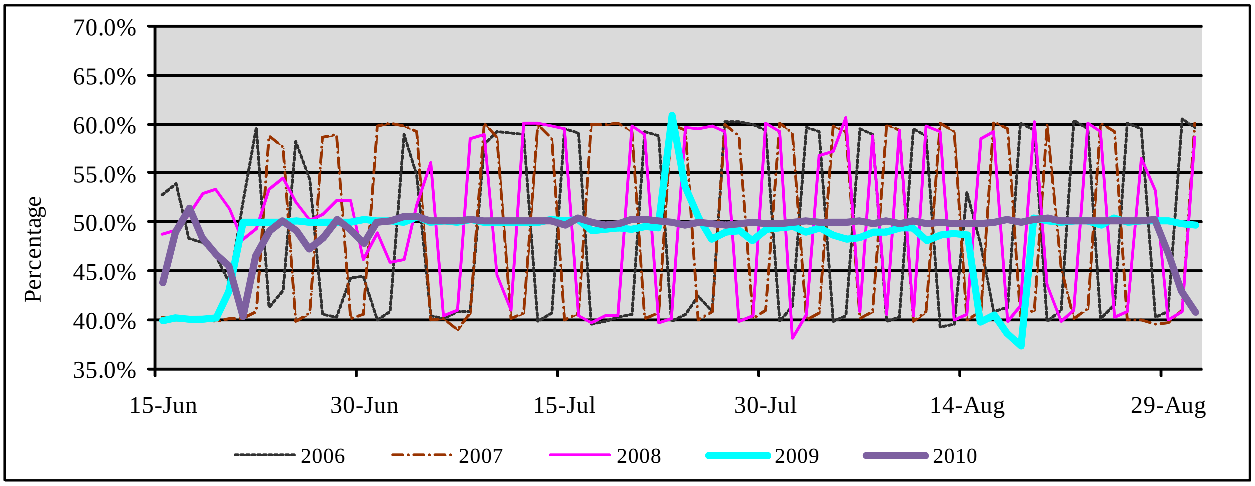

Figure 5. Percent spill at McNary Dam, 2006 – 2010

Thermal Profiles at the Powerhouse

Forebay and gatewell water temperatures were recorded every half hour using StowAway® and MadgeTech Temp1000® temperature data loggers. This data was recorded in the "B" gatewell slot of all 14 turbine units, and the forebay surface water in front of turbine units numbered 1, 3, 5, 7, 8, 10, 12 and 14. Temperatures are also recorded from the mercury thermometers on the scrollcase of each turbine unit. Using this data, a daily cross sectional thermal profile of water temperatures at the powerhouse was constructed. This information was then used to identify thermal gradients at the project. The temperature profiles are relatively good indicators of thermal stratification. They do reveal the dynamics of water temperature movements at the powerhouse, peak daily temperatures and identify critical locations of thermal gradients. This data enables the generation of temperature profiles across the powerhouse during a full 24-hour period.

In previous years, surface water temperatures in the forebay at McNary Dam normally increased during the day and peaked in the late afternoon or evening (Figure 6). The typical trend for river temperatures in the gatewells and in the forebay across the McNary powerhouse on warm days is cooler river water temperatures at the northern end of the powerhouse at turbine unit 14 and warmer temperatures toward the south at turbine unit 1. Many times this year there were four and five continuous days of temperatures over 90°F without wind which increases the effects of thermal warming at the project. Turbine unit operations influence temperature patterns as well.

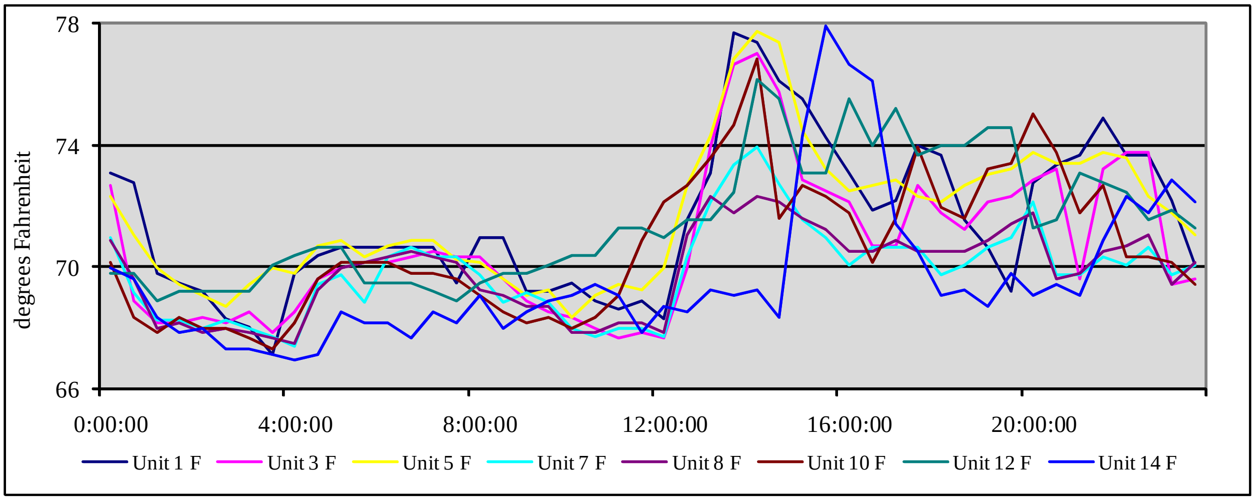

Figure 6. Forebay temperatures at McNary Dam, July 21, 2010

The graph below (Figure 7) was made by taking the gatewell water temperature in the turbine unit and subtracting the gatewell water temperature of unit 14 from it. This was done for every turbine starting with unit 1 and continuing down through turbine unit 13. The differences for four of the units are graphed below. A negative number indicates that gatewell water temperature in turbine unit 14 was warmer. It is possible to have the differences in a unit go from positive to negative in one day.

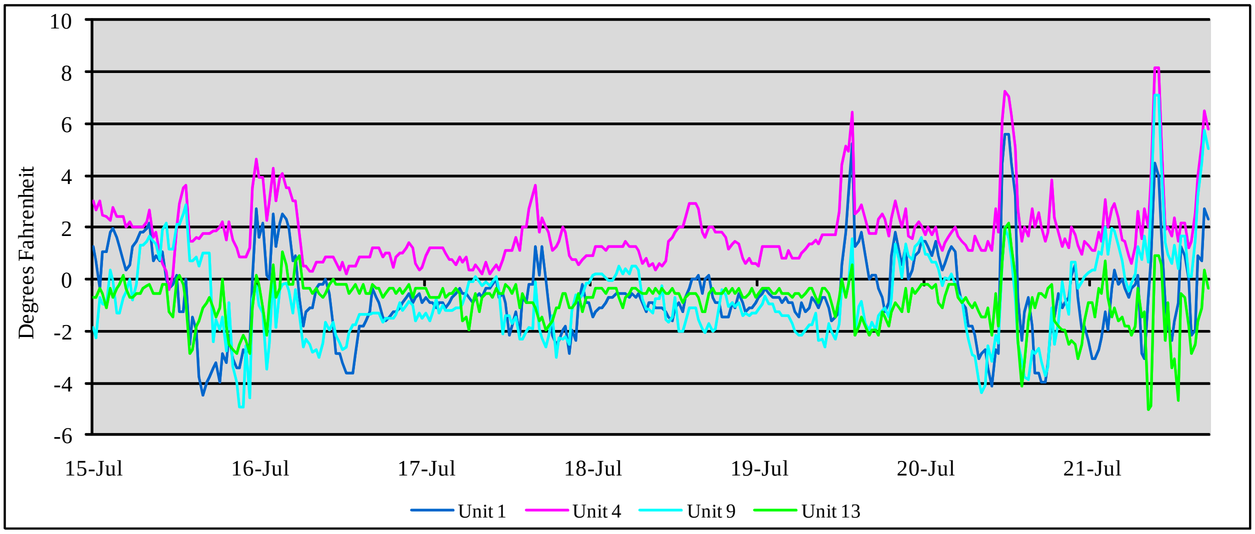

Figure 7. Temperature differences, in degrees Fahrenheit, in 4 gatewells across the McNary powerhouse, July 15 - 21, 2010

Forebay & Gatewell Temperature Profiles

Temperatures were recorded every half hour in the forebay at powerhouse turbine units 1, 3, 5, 7, 8, 10, 12, 14, and spillbays 22, 17, 12, 7, and 2 during 2009. Temperature probes were located at elevation 335, up to five feet below the surface. In the spillbays, the probes were deployed July 7, in the leafgate side between the gate and the side of the roadway. For gatewells, probes were located in the center of the "B" slot of each turbine unit, approximately 3 feet down. They also recorded temperatures every half hour. Forebay temperatures for turbine units 1, 5, 8, 10 and 14 in 2009 are shown in Figure 8. Average forebay temperatures in 2009 were as follows: June, 63.4, July, 70.3 and August, 71.8 (Table 2). This was the warmest forebay since 2003. In 2003, there were two days in July where the water warmed above 80°F. Discounting that incident, this was the warmest forebay since 2000.

Table 2. Monthly Forebay water temperature averages at McNary Dam, 2005 - 2009

Year	**June**	**July**	**August**
2009	63.4	70.3	71.8
2008	60.3	66.9	70.4
2007	62.8	69.5	70.4
2006	62.7	70.2	71.3
2005	63.6	69.0	71.6

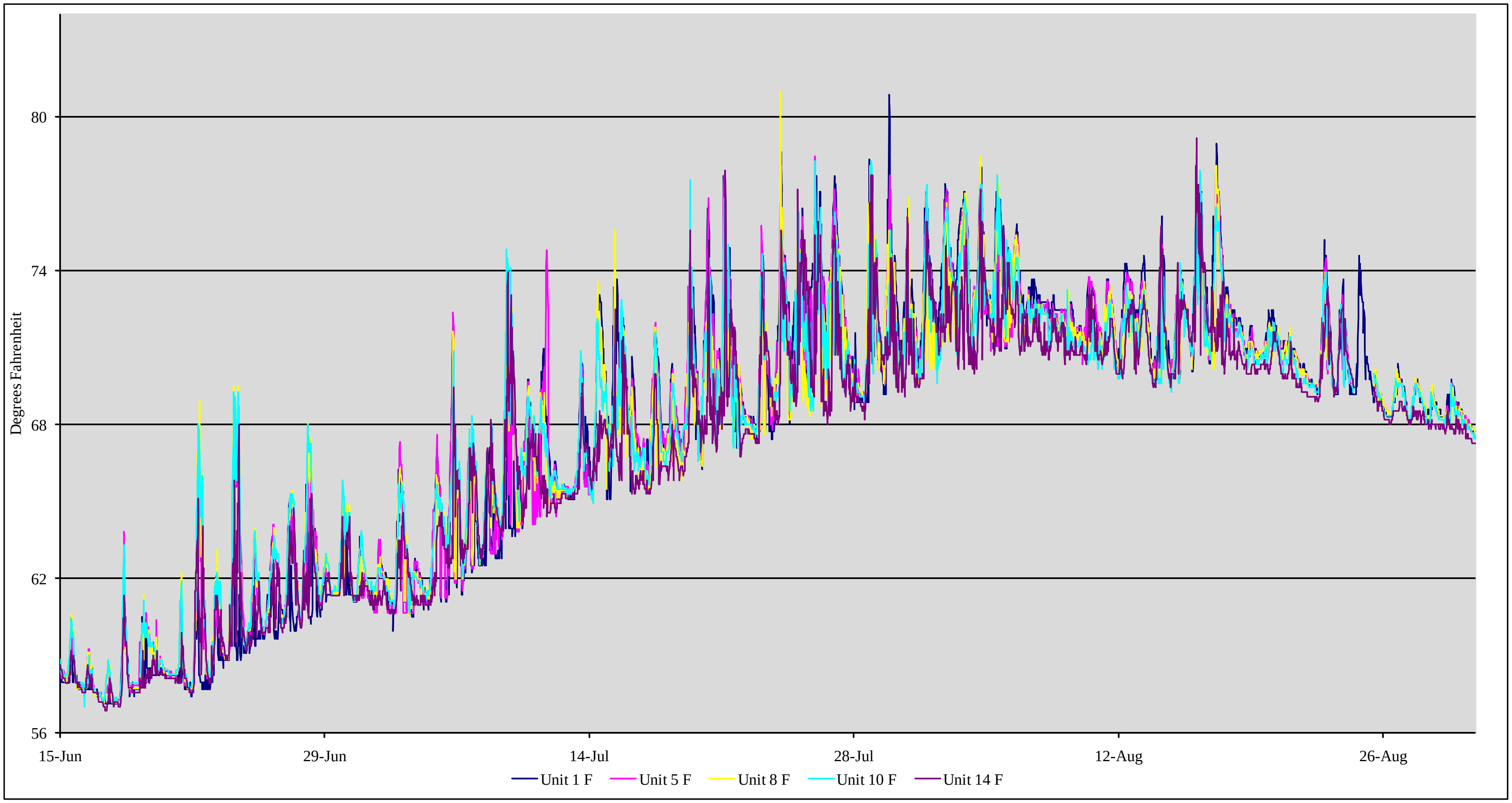

Figure 8. McNary Dam forebay temperatures in degrees Fahrenheit, June 15 – Aug. 31, 2010

Typically, the powerhouse turbines draw the warmer surface water from the forebay toward the fish screens and gatewell slots when in operation (Meyer 1989). Therefore, gatewell temperatures do follow the same trend as the corresponding forebay temperatures (Figure 9). As can be expected, temperatures climb during the day and into the evening hours. Around midnight temperatures take a significant drop cooling down in the morning hours as the coolest portion of the day is just before dawn. At the McNary powerhouse the decrease in river temperatures is most prominent at the southern end of the powerhouse, mostly at turbine unit 1 (Figure 10).

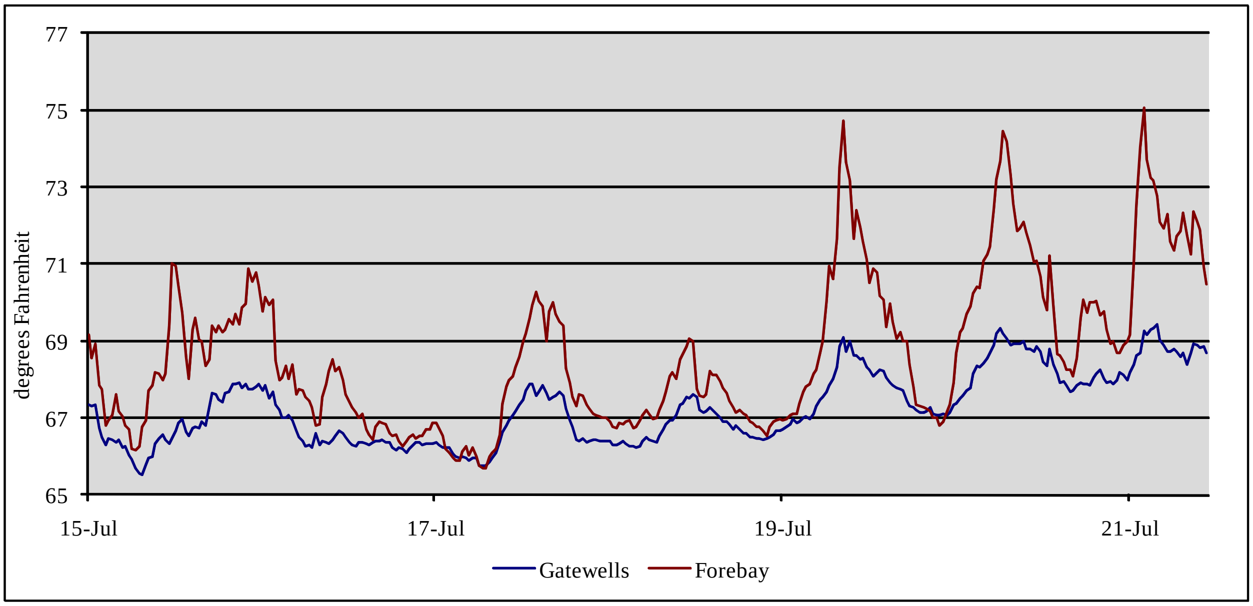

Figure 9. An average of temperatures across all 14 turbine units at McNary Dam, July 15 - 21, 2010

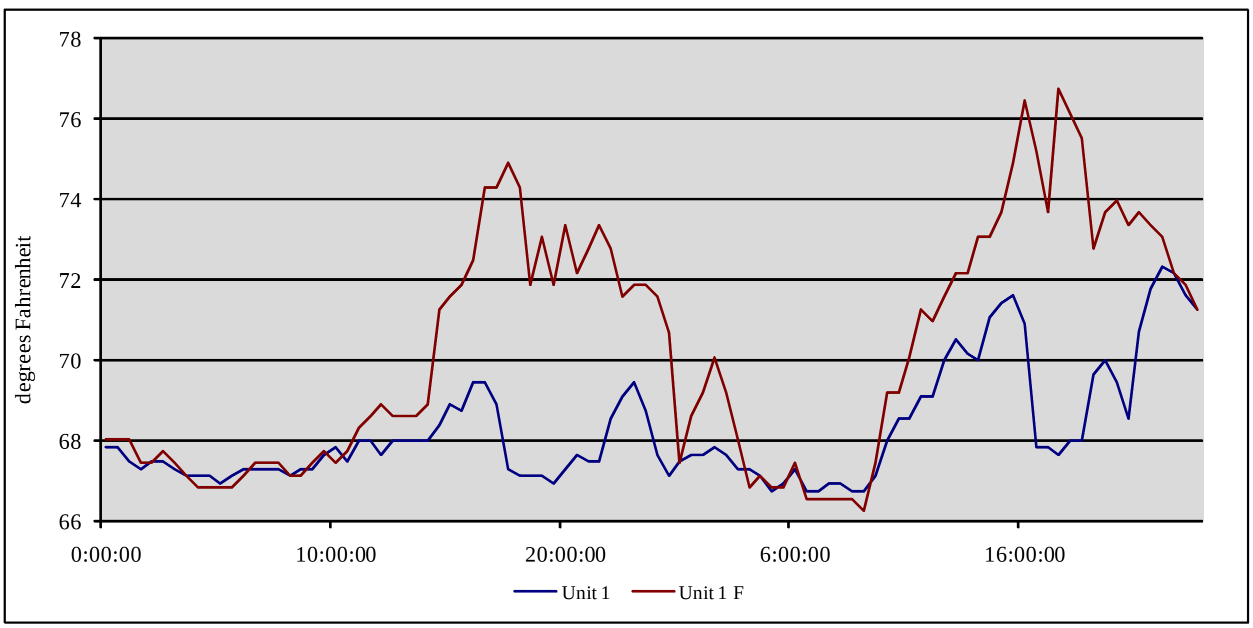

Figure 10. Forebay & Gatewell Temperatures at Unit 1 at McNary Dam on July 19 - 20, 2010

Effects of Forebay Water Temperatures on Project Temperatures and Thermal Gradients

In the past, it has been found that water temperatures in the gatewells were similar to temperatures in the adjacent forebay, even though the gatewell temperatures typically did not elevate to the extremes recorded in the forebay (Figure 11). The high in the forebay was 81.0°F at 4:30 pm on July 24 in front of turbine unit 8. The high in the gatewell was 76.1°F in turbine unit 10 on July 29 at 5:00 pm. These two events did not happen on the same day and there was no significant mortality during that time. When warm weather first starts coming on, there can be large temperature gradients. The thermal gradients that are 8, 10, 12°F between forebay and gatewell are the significant factor that stresses fish, causing mortality. By the end of July when high temperatures are seen, everything can be uniformly hot. In 2009, the high in the forebay was 83.5°F and the high in the gatewells was 79.0°F.

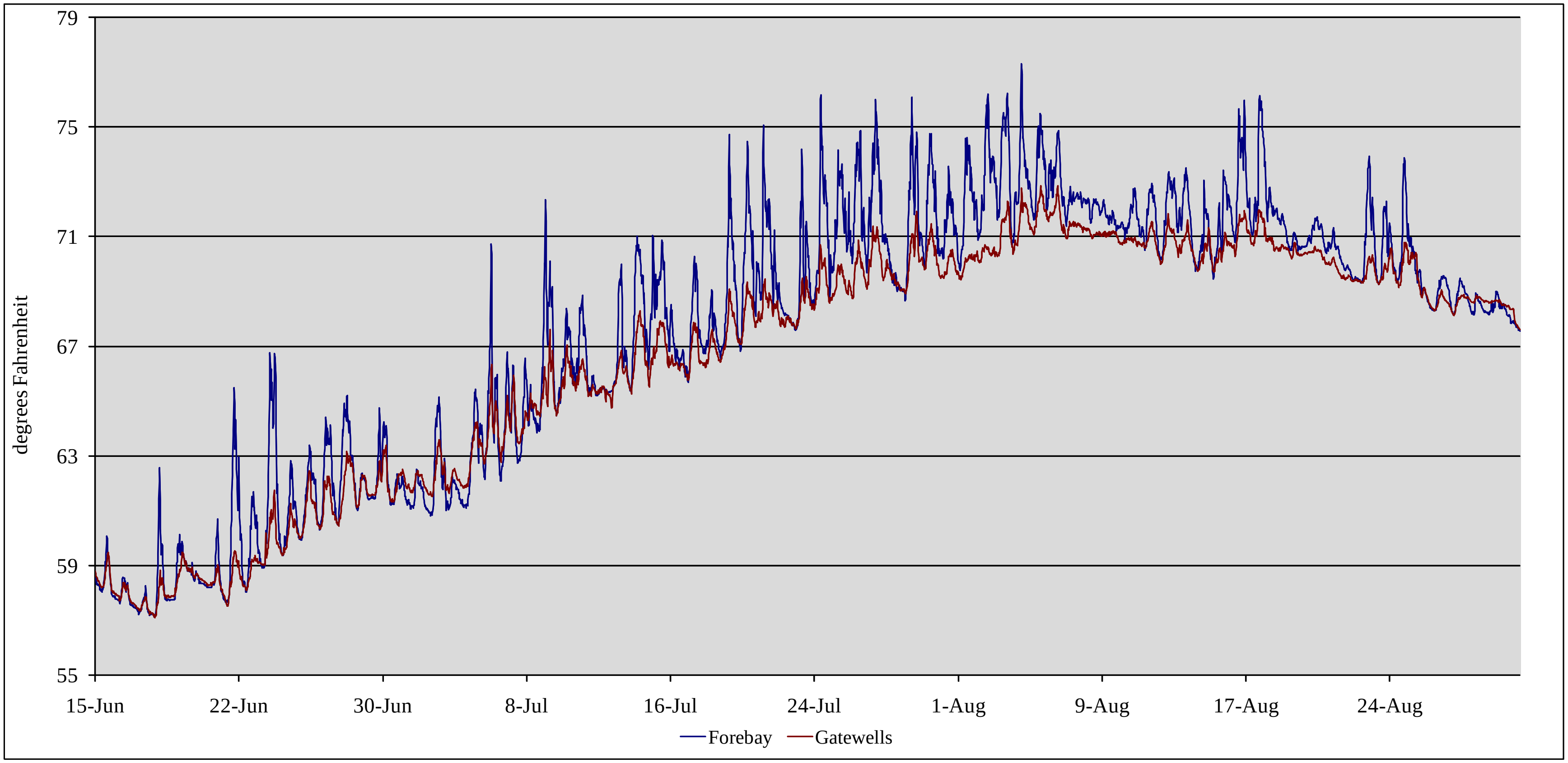

Figure 11. Average Gatewell & Forebay temperatures at McNary Dam, June 15 – August 31, 2010

Collection Channel

Each turbine unit has three gatewells (A, B, and C) and each gatewell has a north and south orifice which discharge into the collection channel. Typically, only one orifice is open per gatewell. Temperature probes are installed at three locations in the collection channel, downstream of turbine gatewell orifice marked 12B south, 8B south and downstream of the incline dewatering screen, unit 1. This season, temperatures were cooler than last season and about average for the last five years (Figure 12), 2009 being one of the warmest years. From July 29 until August 25, collection channel consistently averaged over 70°F ranging from 69.2 to 73.3°F.

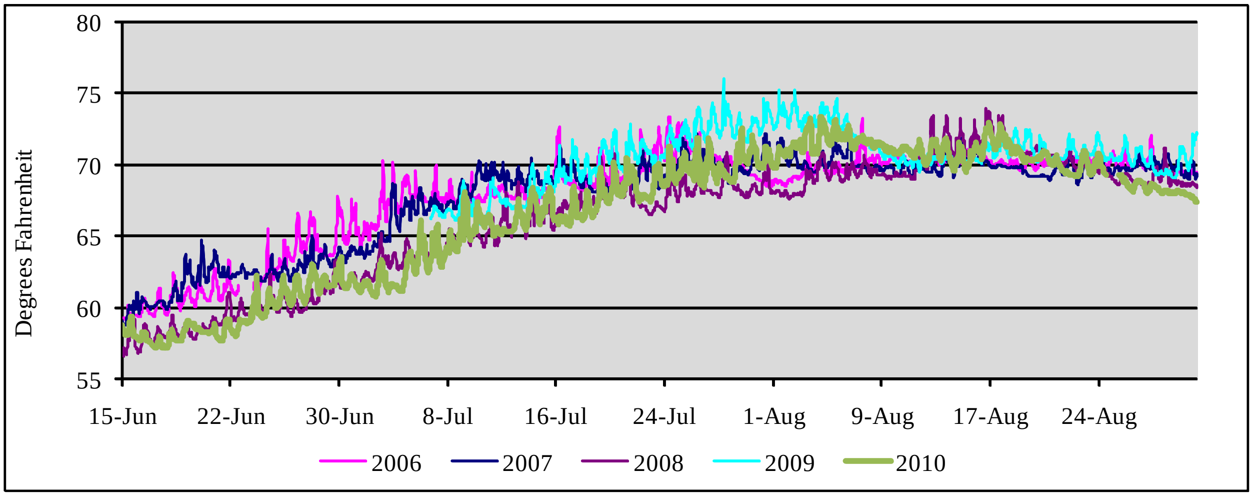

Figure 12. Average collection channel temperatures at McNary Dam, 2006- 2010

This season water temperatures averaged 66.6°F in the collection channel from June 15 through August 31, compared to 70.7 in 2009. Collection channel water temperature reached 70°F on July 24, 10 days later than last year which was July 14. The warmest temperature recorded this season was 74.1. It was recorded on August 4 at 5:00 pm below turbine unit 8 (Figure 13), and again August 16 below turbine unit 12 at 10:00 pm and midnight. The water temperatures were hot that day, but it was uniformly hot between the forebay, gatewell and collection channel.

Table 3. Collection Channel water temperatures at McNary Dam, 2005 - 2010

Year	Average	High	Date
2010	66.6	74.1	4 & 16-Aug
Average	67.9	76.8	1-Aug
2009	70.7	76.8	28-Jul
2008	66.3	75.8	16-Aug
2007	67.8	73.0	31-Jul
2006	68.0	75.2	24-Jul
2005	67.6	75.2	2-Aug

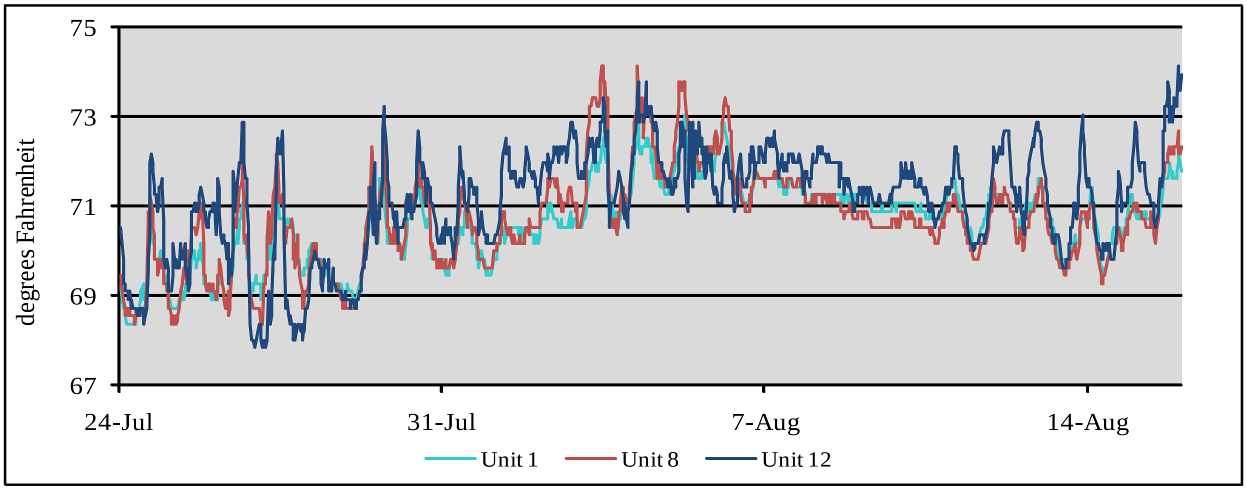

Figure 13. McNary Dam collection channel temperatures, July 24 – August 16, 2010

Temperature gradients between turbine unit 1 and turbine unit 12 within the collection channel averaged -0.2°F (range 2.3 to – 3.1) during the monitoring period (Figure 14). A negative number indicates that turbine unit 12 was cooler. Temperature differences in the collection channel between unit 12 on the northern end and unit 1 on the southern end exceeded 2.0°F on 13 days. Of those days, 2 had hours where the temperature exceeded 3.0°F or more. This was in comparison to 2009, which exceeded 2 degrees on 25 occasions and exceeded 3 degrees 10 times. The maximum temperature gradient recorded between turbine unit 1 and 12, was 3.1°F on July 21 and 22nd, at 2:30pm and 1:00am, where unit 12 was warmer than unit 1. For 2009, the largest gradient was 3.5°F. The differences in water temperatures between turbine unit 1 and unit 12 can be compared to last year (Figure 15). North powerhouse loading was never initiated because there were a number of units already off for maintenance.

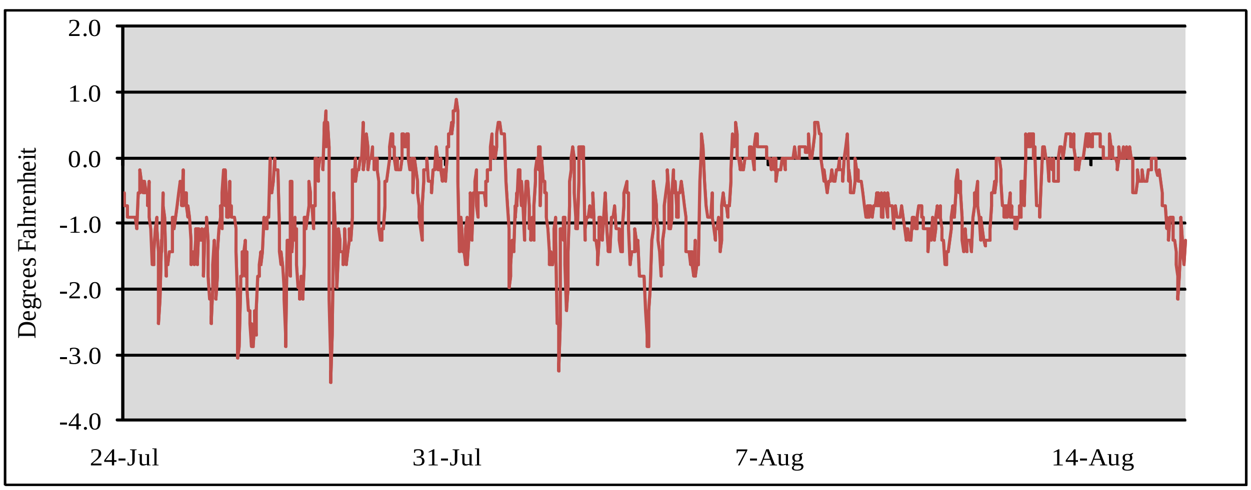

Figure 14. Differences in temperatures between unit 1 and unit 12 in the collection channel at McNary Dam, July 24- August 16,2010

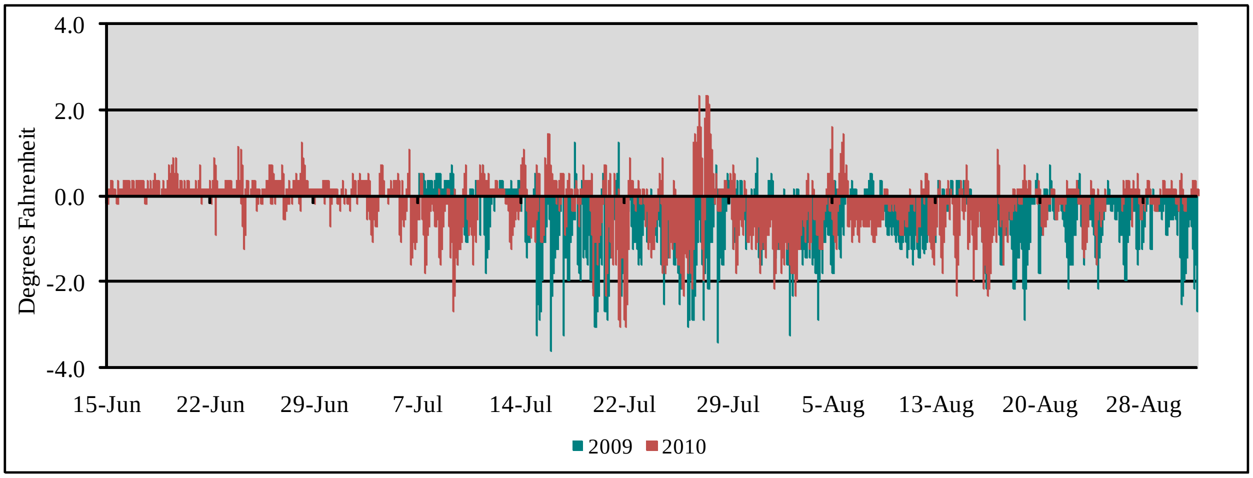

Figure 15. Differences in temperatures between unit 1 and unit 12 in the collection channel at McNary Dam, 2009 vs. 2010

Temperature Gradients at the Orifice Discharge

Previous temperature profiling identified water temperature gradients between the turbine unit gatewells and the collection channel (Hoffarth 1999). Water temperatures in the gatewells vary depending on turbine unit location, operation and weather. As previously described, temperature probes were placed at three locations in the collection channel. The water temperature within the collection channel at any one point reflects the mixture of water drawn in from the upstream gatewell orifices. Thermal gradients most commonly occurred at the southern end of the powerhouse at turbine unit 1, however temperature gradients can also occur at the northern (turbine unit 12 & 14) and center portions (turbine unit 6, 7 & 8) of the collection channel. Thermal gradients developed frequently when air temperatures exceeded 90°F. This was especially true when there was no wind or spill and one or more turbine units were operating. Water temperatures in the gatewells and collection channel at the northern end of the powerhouse were usually similar (Figure 16).

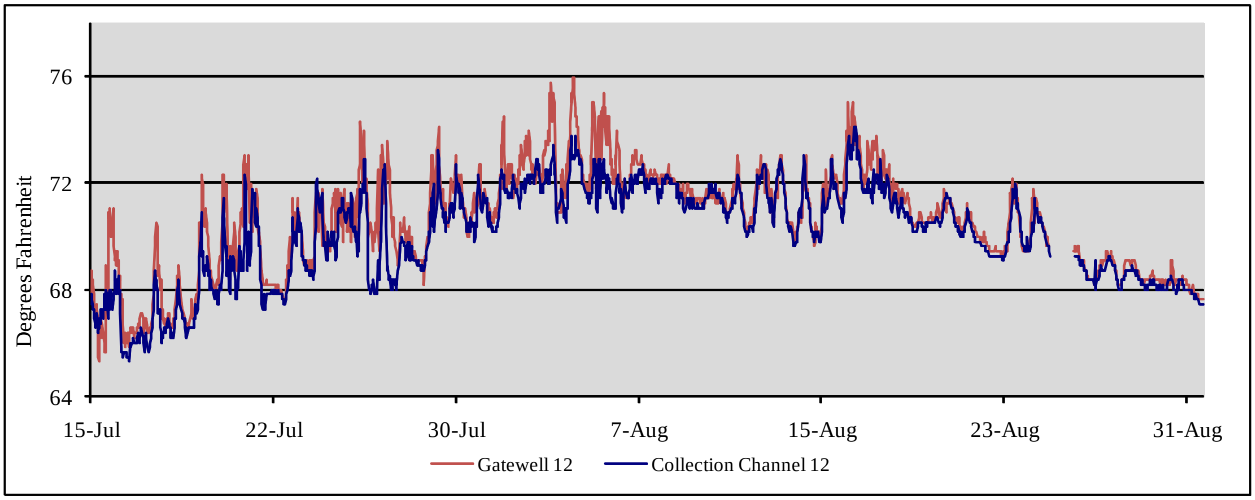

Figure 16. McNary Dam gatewell & collection channel temperatures at turbine unit 12, July 15 August 31, 2010

The gradients in Unit 12 between the gatewell and collection channel ranged from 4.7 to – 2.2ºF, where a negative number indicates that the channel was warmer (Figure 17). At unit 8, gradients were from 4.3 to – 4.7 (Figure 18) and turbine unit 1, ranged from 4.3 to – 3.4 (Figure 19).

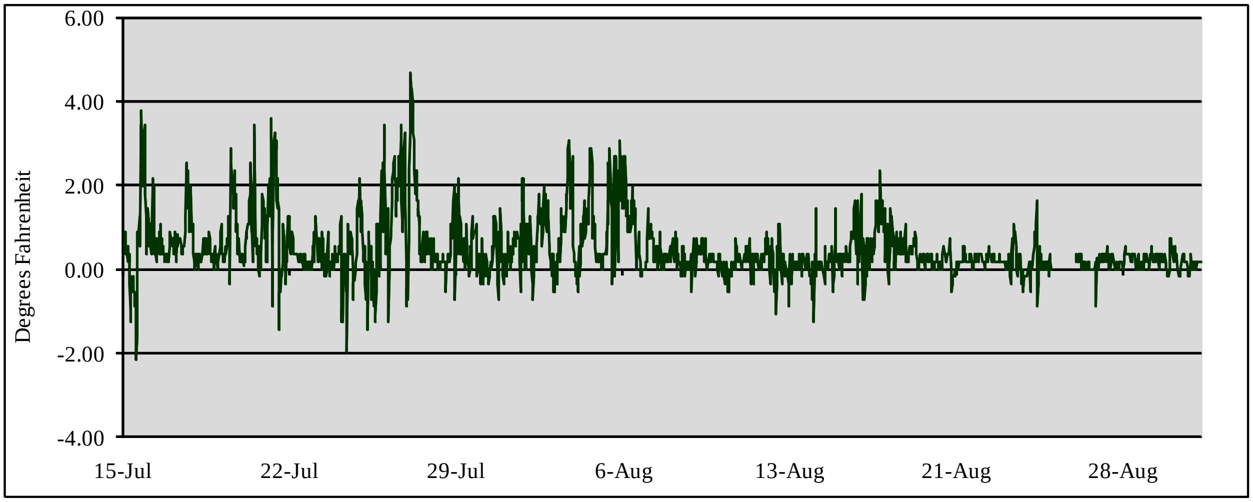

Figure 17. Temperature differentials between gatewell & collection channel at McNary Dam, turbine unit 12, July 15 – August 31, 2010

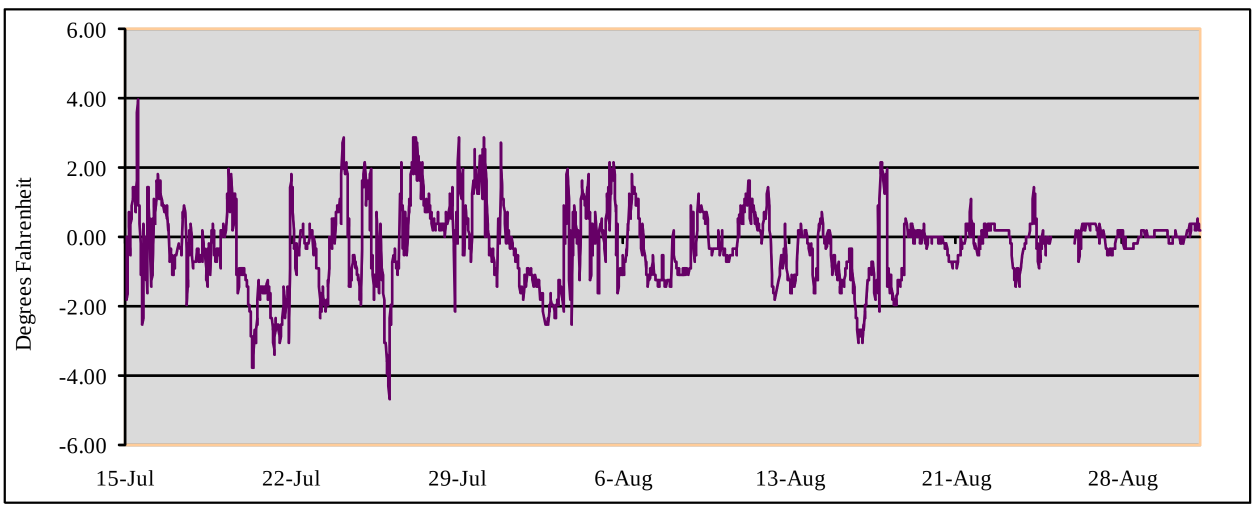

Figure 18. Temperature differentials between gatewell & collection channel at McNary Dam, turbine unit 8, July 15 – August 31, 2010

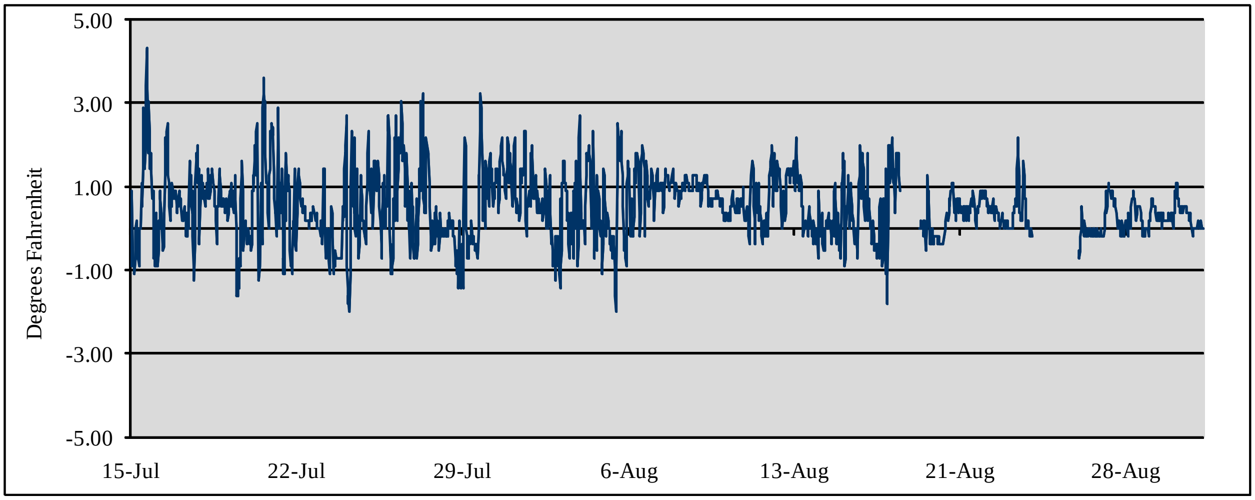

Figure 19. Temperature differentials between gatewell & collection channel at McNary Dam, turbine unit 1, July 15 – August 31, 2010

Juvenile Fish Facility

During the summer, air temperatures at McNary Dam did exceed 100°F and portions of the juvenile fish facility are exposed to direct sunlight. Temperature loggers were installed in the separator and raceway 1 at the McNary JFF in 2009 to monitor the water temperature in the separator and raceways affected by solar radiation or ambient air temperatures. These can be compared to the probes located in the collection channel at the beginning of the inclined dewatering screen (unit 1).

Collection Channel vs. Separator

The dewatering structure at the wet separator of the McNary JFF eliminates most of the water from the 36-inch transport pipe allowing only the fish and a small amount of water to reach the separator. Water in the separator is maintained by a series of upwells supplied by water from the collection channel. As would be expected, there was virtually no difference between the collection channel and the separator. Everything was evenly spaced with no one day in particular outstanding. Temperature differentials ranged from 0.9 to – 1.6°F (Figure 20).

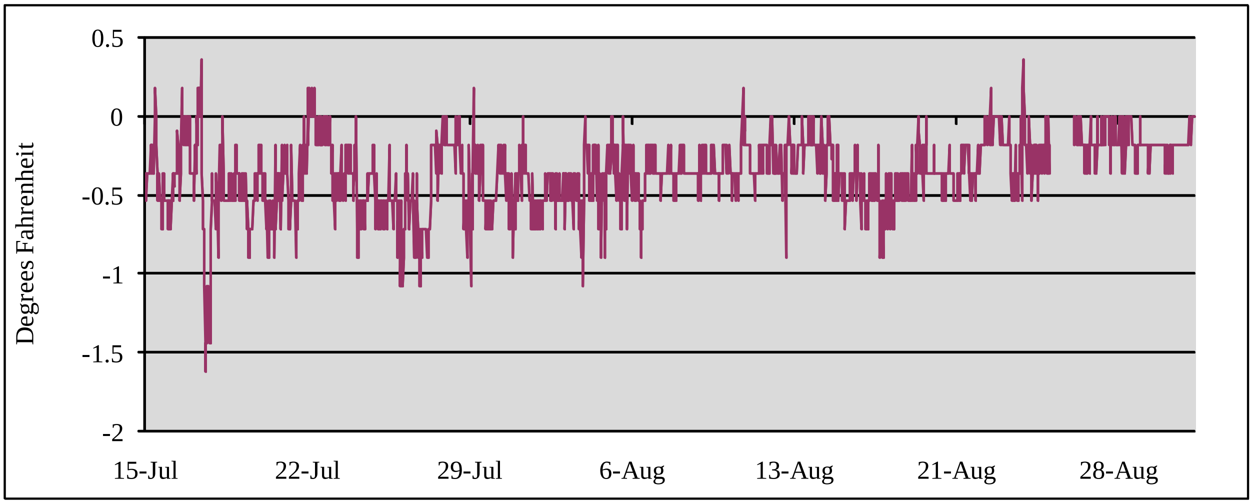

Figure 20. Temperature differentials between collection channel & separator at McNary Dam, July 15 - August 31, 2010

Separator vs. Raceway

Excess water in the collection channel is removed by the inclined dewatering screen and some of it is used for operation of the JFF, providing inflow for the separator and holding raceways. Most of the raceways are covered but those on the far west side are exposed to direct sunlight especially during the late afternoon. A temperature logger was located in the separator and at the downstream end of raceway 1, the raceway with the highest exposure to direct sunlight. The water exchange rate in a raceway with normal diffuser inflow was about 15 to 20 minutes. On the average, water temperatures at the separator showed no difference from the raceway (Figure 21).

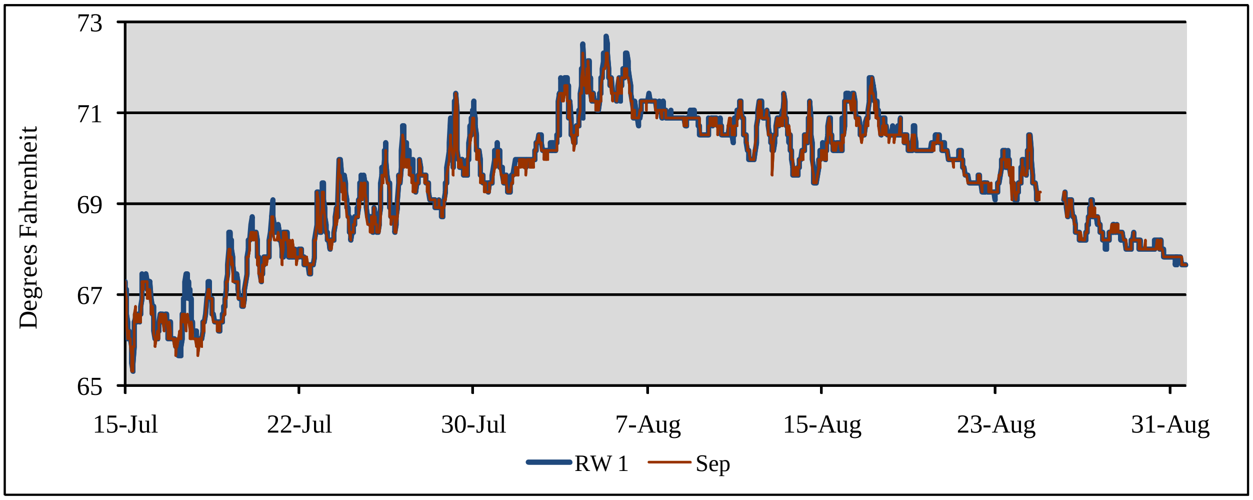

Figure 21. Separator temperatures vs. raceway 1 temperatures at McNary Juvenile Fish Facility, June 15 - August 31, 2010

Holding for Transport

Juvenile salmonids are held in raceways at the McNary JFF prior to loading into the fish transportation barge and truck. Fish may be held up to 48 hours before loading and transport. Data collected from previous years shows daily fluctuations in water temperatures in the raceways. Fish collected within the first 12 hours of a 48-hour holding period are often subjected to two daily increases in water temperature.

The water temperatures were recorded in raceway 1 and in the tail water at four points, the barge dock, tailwater of unit 1 and 14 and the wing wall of the navigation lock. Barging was from July 16 through August 16. The following graph (Figure 22) shows that there are greater highs and lows in the raceway. As opposed to the average of the tailrace that is not quite so drastic. When comparing the temperatures in raceway 1, there were differences as great as 3.0°F indicating that raceway 1 was warmer than the tailrace. Average water temperature in the raceway was 66.3°F with a maximum temperature of 72.7°F. The average river temperature in the tailrace was 66.1°F with a maximum temperature of 72.5°F. These temperatures in the raceway are cooler than previous year's averages (Table 4).

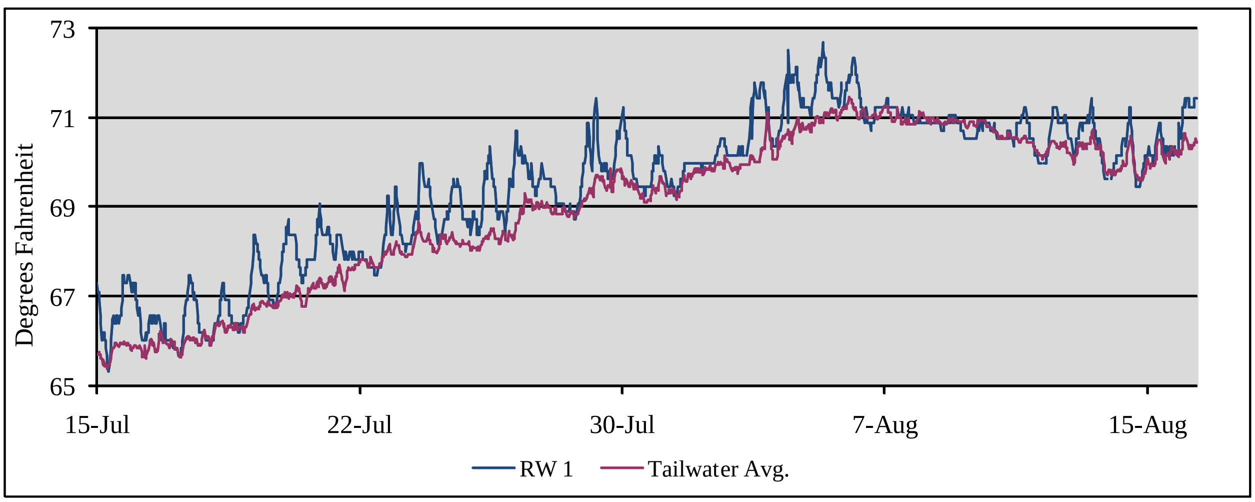

Figure 22. Tailwater average temperatures vs. raceway temperatures at McNary Juvenile Fish Facility, July 15 – August 16, 2010

Table 4. Comparison of raceway temperatures vs. barge dock temperatures at McNary Juvenile Fish Facility, 2006 - 2010

	Average	Maximum
	2010	
Raceway 1	66.3	72.7
Barge Dock	66.1	72.5
	2009	
Raceway 1	70.1	74.1
Barge Dock	69.8	73.1
	2008	
Raceway 1	66.7	72.9
Barge Dock	65.9	72.0
	2007	
Raceway 1	67.1	71.2
Barge Dock	67.7	71.1
	2006	
Raceway 1	68.4	74.9
Barge Dock	67.7	72.3

Tailrace

Temperature loggers were installed in the tailrace below the project at four locations: the barge loading dock, below turbine unit 1, below turbine unit 14 and at the wingwall downstream of spillbay 1. The water in the tailrace averaged 66.1°F. Peak temperature was 72.5°F on August 4 at 1:30 am, below turbine unit 1. When the facility is in primary bypass mode, fish pass directly from the collection channel to the tailrace. A comparison of the water temperature at the end of the collection channel and the average temperature in the tailrace shows that the average difference was -0.6°F with a maximum difference being -3.6°F (Figure 23). A negative number indicates that the collection channel was warmer.

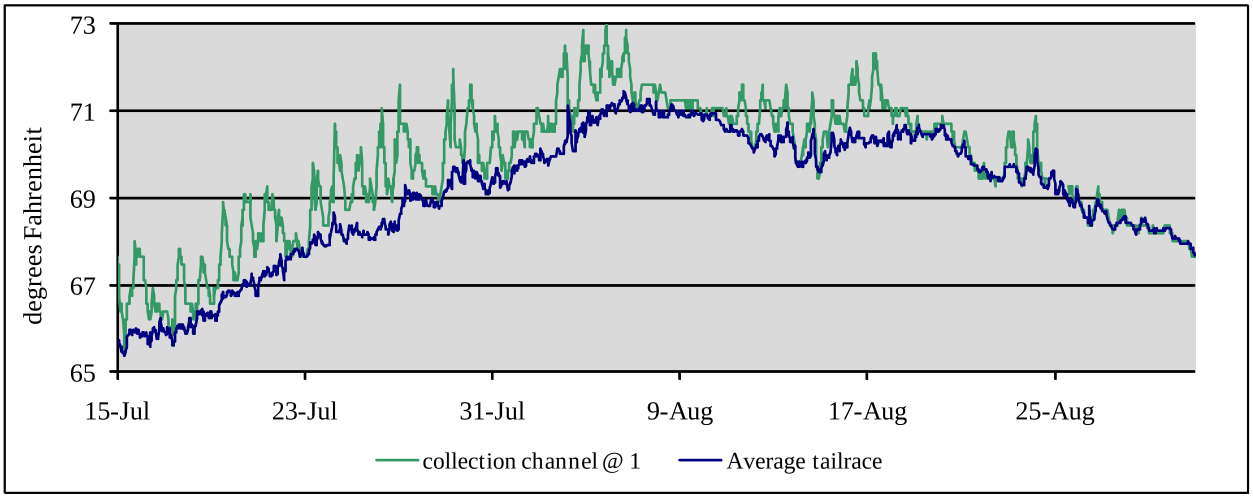

Figure 23. Collection Channel @ Unit 1 and Tailwater Average at McNary Dam, July 15 - August 31, 2010

River Temperature and Fish Passage Timing

Water temperatures are recorded at 7:00 am in the wet lab and reported to the Corps of Engineers on a daily basis. These temperatures reflect the temperature at the time of sampling in the fish sampling lab at the Juvenile Fish Facility (JFF). The water in the lab is fed from water removed by the inclined dewatering screen from the collection channel. Water temperatures at 7:00 a.m. are typically the coolest temperatures encountered at the JFF each day. Therefore, these water temperatures reported should be considered minimum temperatures. They do not provide information on daily maximum, minimum or fluctuations of water temperatures at the project. Water temperatures recorded in the wet lab during the temperature profiling season were cooler than the recorded averages (Table 5).

Table 5. McNary Juvenile Fish Facility Average laboratory water temperatures, June 15 - August 31, 2005 - 2010

	2005	2006	2007	2008	2009	Average	2010
June	60.7	60.9	61.1	58.3	61.6	60.8	58.7
July	66.9	68.3	67.7	65.0	67.9	67.2	65.4
August	70.2	69.7	69.3	69.0	70.4	69.7	69.8

Migration of juvenile fall Chinook, particularly wild fall Chinook from the Hanford Reach to McNary Dam is strongly tied to temperature. During cooler water years fall Chinook rear for a longer period and migrate later. During warm water years, the fish grow faster and begin the downstream migration sooner. Both of these scenarios typically have the same result; fish arrive at McNary during critical temperature periods.

Comparison of water temperatures and mortality rates for juvenile salmonids at the McNary fish facility from previous years suggests that temperature was related to mortality. Previously, years with warmer water temperatures corresponded to the highest mortality rates for subyearling fall Chinook at the McNary JFF. Lower mortality was often associated with cooler water years with juvenile fall Chinook. The critical migration period in regards to thermal gradients occurs from mid-June to early August. At this time river temperatures at depth in the McNary forebay are in the tolerance zone for salmonids, 58°F - 66°F (Brett, 1952), but increased air temperatures elevate water temperatures at the surface during the afternoon creating thermal gradients in the forebay. Project operation, air temperature and wind combine to determine the movements and interactions of these cool and warm areas of water.

Fish passage timing can be critical to the mortality equation but earlier passage does not necessarily correspond to cooler river temperatures and decreased mortality (Table 6). The outmigration this year was effected by primary bypass and spill from June 15 – August 31. This also affected the mortality percentage as without collection in the raceways, the mortalities are not enumerated. On July 16, 17 and 18, there was a three-day mortality percentage of 11.1%. Over the next three days, it dropped to 6.3%. Previous to July 16, the facility was still in bypass operations and the mortalities were not being collected in the raceways. On July 16 – 18, there were temperature gradients that ranged from 10.6 to -0.2, between the forbay and the gatewell, indicating that the forebay at the surface was much warmer. There was also another three-day period where there were gradients of up to 11.4, but this was before collection for transportation, therefore the volume of mortality is unknown. The Corp of Engineers initiated north Powerhouse loading at 10:00 am on July 17, and every day barge loading was implemented on July 24.

Table 6. McNary Dam collection, mortality, and passage of fall Chinook, June 15 – August 31, 2006 - 2010[1]

		System		**Passage**			
Year	**Collection**	**Mortality**	**% Mortality**	**25%**	**50%**	**75%**	**90%**
2010	1,787,545	6,686	0.4	24-Jun	8-Jul	20-Jul	12-Aug
2009	1,732,248	35,318	2.0	27-Jun	11-Jul	18-Jul	28-Jul
2008	1,123,031	8,698	0.8	28-Jun	10-Jul	22-Jul	14-Aug
2007	2,477,379	3,338	0.1	28-Jun	6-Jul	12-Jul	26-Jul
2006	1,979,984	7,696	0.4	29-Jun	6-Jul	10-Jul	22-Jul

[1]These numbers are reflective of only the dates indicated, not the whole season.

Fish Condition

The migration of juvenile salmonids June 15 – August 31, through the McNary fish facility was dominated by subyearling fall Chinook (98.9%). The condition of fish prior to arrival at McNary may determine their ability to cope with the added stresses, thermal and physical, during passage through the fish collection system. Although the overall health of a fish cannot be determined as far as assessing disease and internal issues, external injuries and descaling can. The percentage of subyearling fall Chinook that were descaled by either concrete structures or predators during the 2010 temperature monitoring period was 1.2%. In 2009, it was 0.8%. It must be noted that one reason for a difference last year is that descaling in 2009 did not include any predator marks. In the past, the McNary Smolt Monitoring Program has included this. This season's descaling percentage is more comparable to 2008 which was 1.8%. In 2010, there were 5,093 subyearling Chinook examined between June 15 and August 31 for detailed injuries. Of those, 553 fish, 10.9%, had injuries and diseases, in addition. This season the most common injury was a general group call diseases. This could include anything from hemorrhaging to parasites. In 2009, the most prevalent injury was hemorrhaging.

Collection

The McNary JFF bypasses all fish guided into the facility to the tailrace below the dam from the start of fish facility operation in the spring until July 15 (Fish Passage Plan, 2010). Collection and holding of fish in raceways for the juvenile fish transportation program began on July 15 at 1125 hours, when barging was initiated.

A portion of the daily collection is diverted to the sample holding tanks for examination of fish condition and extrapolation of species passage through the project. The daily sampling and collection period is from 7:00 a.m. to 7:00 a.m. the following morning. According to sampling guidelines, 500 – 800 fish are sampled each day. The sample rate ranged from 0.0% to 20.0% from June 15 through August 31 in 2010. A total of 1,787,545 juvenile salmonids were collected during the temperature monitoring period (Table 7). Of those 1,767,622 were subyearling fall Chinook.

Table 7. McNary Dam collection fall Chinook, June 15 – August 31, 2006 - 2010

	Collection	Subyearling Chinook	Peak Collection	Date
2010	1,787,545	1,767,622	195,570	26-Jun
2009	1,747,186	1,732,248	155,999	20-Jun
2008	1,123,031	1,106,042	99,008	6-Jul
2007	2,497,083	2,477,379	299,201	12-Jul
2006	1,984,624	1,979,984	274,621	7-Jul

Mortality

Sample tank mortality reflects the general trend in mortalities at the facility and that of the total collection for this period. Sample tank mortality includes fish mortalities removed from the sample holding tank prior to sampling and mortality due to sampling activities. During early season bypass operation, mortality rates are only available from the daily sample as all other fish are returned directly to the tailrace. System mortality, which includes all mortalities recovered from the transport holding raceways, the sample and in some cases the separator, provides the best indication of overall mortality at the JFF but was often difficult to assess on a daily basis due to bypass operations.

Fish are held in raceways at the facility prior to loading for transport. Mortalities can be removed from the tailscreens continually during collection but can only be removed from the raceway floor during loading. Barges are normally loaded every other day and trucks are often loaded on alternate days when collections are low. The mortalities removed from the raceway floor during loading occurs over a two-day collection period, however collection and mortality are reported daily. As a result, on transport days, two days of raceway mortality was reported, which may bias the daily estimates of system mortality. Collections of juvenile fish at the facility can vary by as many as 300,000 fish between days. The daily reported mortality percentage can be over or underestimated when collection or mortality percentages vary during these two-day periods. Therefore, it is best to have a two-day average when looking at facility mortality.

Another consideration when looking at the reporting of mortality is to ascertain when the mortality occurred and the date it is reported. Temperature-induced mortality related to passage at the McNary Project was most likely to occur in the afternoon and early evening when temperature gradients are at maximum. Mortality resulting from a thermal event on day 1 will be reported on day 2. Mortality that occurred in the evening on July 17 would not be reported until the daily report for July 18. The graph below illustrates how mortality percentages fluctuate daily even when there are no great fluctuations in temperatures (Figure 24). Fish were transported by barge on alternate days from July 16 – August 18 (Figure 25). From August 6 – 16, fish were also trucked to alleviate stress from being held in water over 60°F for mor than 24 hours.

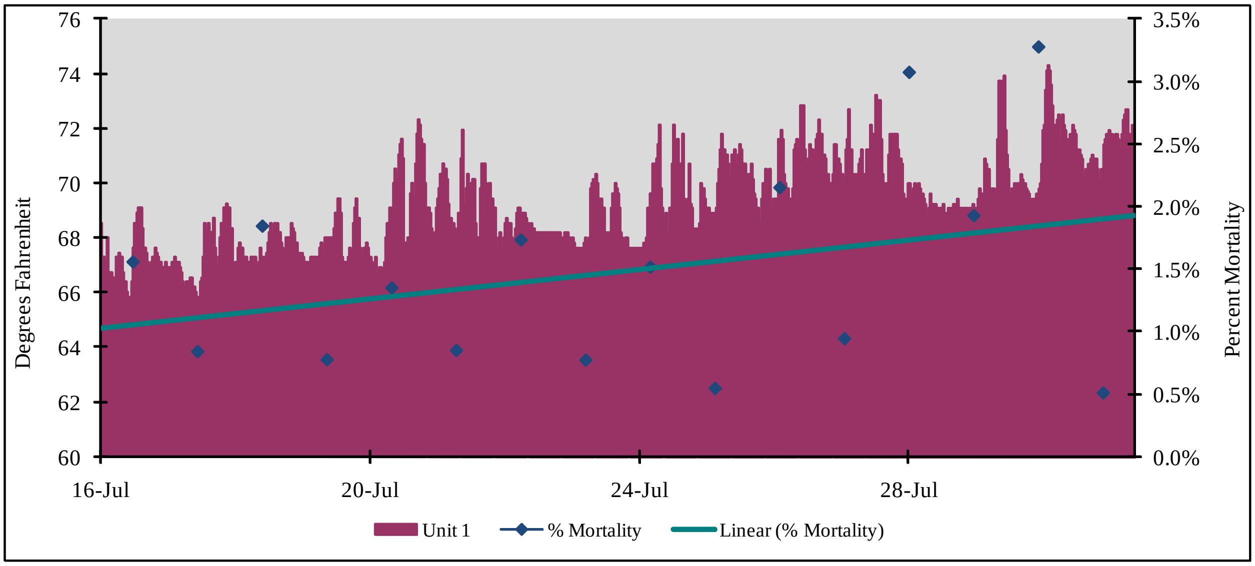

Figure 24. Turbine unit 1 gatewell temperatures & percent mortality, July 16 – 31, 2010

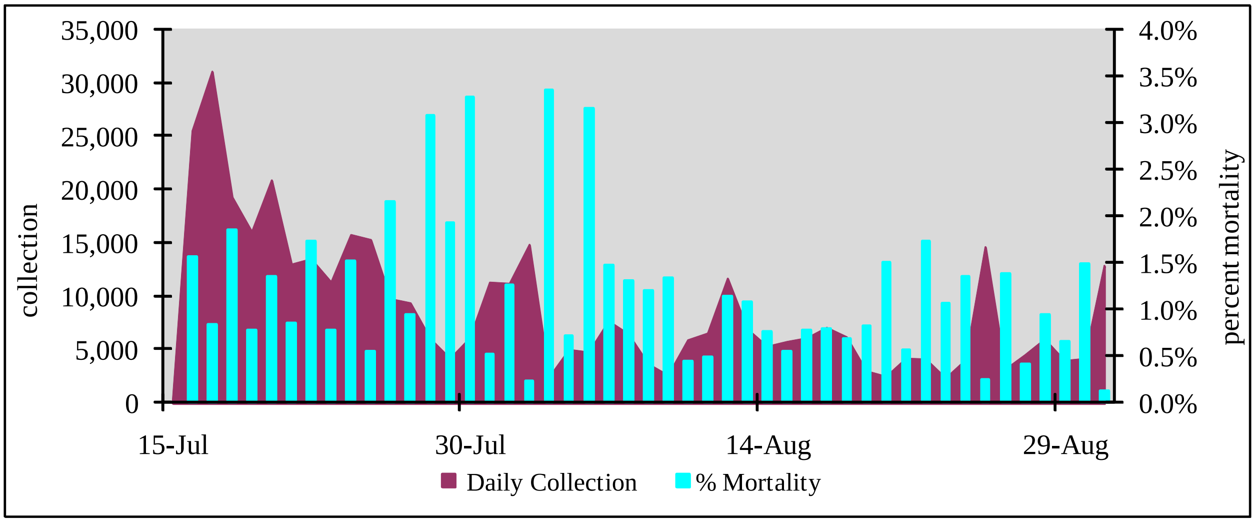

Figure 25. Collection of juvenile fish at McNary Dam with percentage of mortality, July 15 - August 31, 2010

A total of 6,686 system mortalities were recovered from June 15 through August 31. This was 0.4% of the 1,787,545 fish collected. The highest one-day system mortality percent was 3.3% on August 3. This was a barging day, with 2,450 fish collected, 17,234 barged. When adding in the previous day's collection and mortality, the percentage is 0.7%.

Recommendations

Powerhouse Operations

Turbine unit loading should be kept as uniform as possible across the powerhouse. North powerhouse loading criteria should be used when turbine units are taken out of service due to low power demands or flows below powerhouse capacity. North powerhouse loading should be implemented when forebay water temperatures reach 70°F. This would be a preventative measure that could be taken in advance of hot weather. Starting and stopping of turbine units during critical temperature periods should be conducted from 12:00 midnight to 12:00 noon, 4:00 a.m. to 10:00 a.m. being the most preferred times. Trashracks should be raked as often as possible. When temperatures in the raceway consistently average 66°F, every day transport should begin. This alleviates the stress of being held for more than 24 hours in warm water.

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