

PARR SHOALS DAM TURBINE VENTING PLAN

PARR HYDROELECTRIC PROJECT

FERC No. 1894

Prepared for:

**South Carolina Electric & Gas Company
Cayce, South Carolina**

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

April 2017

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2016

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FERC No. 1894**

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee for the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

During relicensing, SCE&G tested all of the Parr turbines for their ability to self-vent and potentially increase the dissolved oxygen in the tailrace during specific periods of the year. An initial test of the turbines' capacity to vent was performed August 2014; a second test to determine which turbines had the most significant impact on increasing dissolved oxygen was performed in July 2015; a third test was completed in August 2016 to assess the initial plan developed for turbine venting. The results of the testing, along with the findings published in the Baseline Water Quality Report, were used to develop a final Turbine Venting Plan, which is included below. This plan will be included as one of the proposed protection, mitigation, and enhancement measures filed with the Final License Application for continued operation of the Project.

2.0 OPERATING PROCEDURES

Turbine venting shall occur continuously during the "venting period" for each calendar year, with vents opened as turbines are started up and brought online. During the venting period, the turbines will be operated with vents opened in a first-on / last-off order as follows: 3, 1, 5, 2, 4, and 6. Exceptions to this operating order shall occur due to equipment maintenance that results in unit outages, emergency conditions, or if additional turbine venting is available in the future.

SCE&G shall follow the venting procedures from June 15 through August 31 of each year. This period captures all of the excursions recorded by the nearby USGS Gage No. 02160991, Broad River near Jenkinsville, SC since the current probe was installed in 2011. However, in the event excursions begin occurring outside of the established turbine venting window, SCE&G will consult with SCDHEC and adjust or extend the window as appropriate.

3.0 DOCUMENTATION

SCE&G shall provide documentation to the South Carolina Department of Health and Environmental Control of hourly dissolved oxygen excursions below the standard within ten days of occurrence. The compliance measurement point for dissolved oxygen will be the USGS Gage No. 02160991, Broad River near Jenkinsville, SC. Should a dissolved oxygen deviation occur, upon request from a consulting agency, SCE&G shall provide hourly operation records to agency representatives to demonstrate adherence to the order of turbine operating during a venting period. Documentation of maintenance activities to justify deviation from the turbine operating order will also be provided, should a deviation occur.

APPENDIX A

PARR SHOALS DAM TURBINE VENTING REPORT

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PARR SHOALS DAM TURBINE VENTING REPORT

**PARR HYDROELECTRIC PROJECT
FERC No. 1894**

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee for the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. SCE&G has established several Technical Working Committees (TWC's) comprised of members from the interested stakeholders. The TWC's objectives include the evaluation of relicensing issues and making recommendations to address these issues in the new license.

Following the completion of the Parr Hydroelectric Project Baseline Water Quality Report, there were questions regarding occasional low dissolved oxygen (DO) in the tailrace downstream of Parr Shoals Dam. At a Water Quality TWC meeting on February 4, 2014, the TWC noted that the Baseline Water Quality Report identified periodic excursions of DO levels less than 4.0 mg/L in the Parr Shoals Dam tailrace, as reported by the USGS station 02160991. In an effort to understand these excursions better, SCE&G consolidated historic USGS data to examine these excursions and issued an addendum to the Baseline Water Quality Report in June 2014. At the request of the Water Quality TWC, SCE&G collected additional water quality data in the summer of 2014 in the tailrace and forebay of Parr Shoals Dam in an attempt to determine whether project operations are causing these excursions. These results were summarized in a memo issued on March 2, 2015 (Appendix A). SCE&G followed up this effort by collecting

another series of water quality data in the Parr forebay from May through mid-October 2015. The results of this data collection effort are summarized in this report.

In addition, SCE&G proposed to test all of the Parr turbines for their ability to self-vent and potentially increase the dissolved oxygen in the tailrace during specific periods of the year. An initial test of the turbines' capacity to vent was performed August 2014; a second test to determine which turbines had the most significant impact on increasing dissolved oxygen was performed in July 2015. The results of the testing, along with the findings published in the Baseline Water Quality Report, were used to develop a Turbine Venting Plan, which is also included in this report.

2.0 OBJECTIVES

Parr forebay data was collected from May through mid-October, 2015 in an effort to determine if low DO in the tailrace was caused by low DO in the forebay as it passed downstream through the powerhouse and turbines. Additionally, the turbine vent testing was performed in the summer of 2015 to determine if turbine venting had a positive impact on DO in the tailrace. The results of the turbine vent testing were used to develop a Turbine Venting Plan for use during periods of the low DO season.

3.0 METHODS

3.1 METHODS USED FOR TURBINE VENTING TESTING

During the 2014 test, the primary objective was to determine the turbines' physical capacity to self-vent. This requires both the presence of vacuum breakers (which are used during dewatering operations) (Photo 3-1), as well as the proper turbine vertical setting and sufficient gross head to draw air into the turbine during operation. With a turbine operating, the vacuum breaker valve is opened, and venting can be audibly determined. Aeration of the water can also be visually observed in the tailrace (Photo 3-2).



PHOTO 3-1 PIPING FOR VACUUM BREAKERS IN HEADCOVER



PHOTO 3-2 TURBINE DISCHARGE WITH VENTS OPEN

Water quality measurements (dissolved oxygen, temperature and percent saturation) were taken using a Hydrolab Surveyor 4a (Photo 3-3). Measurements were made immediately downstream of each turbine both prior to and after the vent was opened. It was verified that the crest gates had not operated within the past several hours, therefore no mechanical aeration influence from spilling was present. Hydrolab readings were allowed to stabilize for several minutes before water quality parameters were recorded.



PHOTO 3-3 MEASURING DO LEVELS DURING TESTING

During the 2014 test, several of the turbines were undergoing maintenance, and testing of all units was not possible. In addition, the tailrace dissolved oxygen and total saturation levels were high prior to opening the vents, which likely reduced the effectiveness of venting. Given these limitations, an effectiveness venting test was planned for summer 2015 when additional turbines could be evaluated. Prior to the 2015 testing date, DO levels were monitored via the downstream USGS Gage No. 02160991, Broad River near Jenkinsville, SC to identify a test period with lower DO conditions.

3.2 METHODS USED FOR FOREBAY DO SAMPLING

Water quality data, including DO and temperature, was collected in the forebay of the Parr Shoals Dam using two HOBO data loggers, with one logger located approximately one foot above the bottom of the reservoir and the other located approximately one foot below the surface of the reservoir. The HOBO data loggers were suspended from the log boom located in the forebay. Data was logged on an hourly basis from May 4, 2015 through October 16, 2015. Hourly data was also collected from the USGS gage at Jenkinsville (02160991), which is located immediately downstream of Parr Shoals Dam near the powerhouse.

4.0 RESULTS

4.1 RESULTS OF TURBINE VENTING

The Parr Shoals powerhouse contains six vertical turbines, five of which have vacuum breakers to facilitate dewatering the draft tube. It was discovered that unit 6, which is nearest the shoreline, does not have a vacuum breaker. During the 2014 test, units 1, 3 and 4 were operable, and the admittance of air was audible when the vacuum breakers were opened. In addition, the tailrace observation clearly indicated the water was being aerated. With the high saturation levels (above 70%), the measured increases in dissolved oxygen were 0.16 and 0.17 mg/L between the initial measurement and the end of the venting test (Appendix A – 2014 report).

During the 2015 test, all turbines were tested except unit 4, which was inoperable due to ongoing maintenance; however, unit 4 had been tested in 2014. Results of the 2015 testing (data included as Appendix B) indicate that unit 3 venting had the most significant increase in dissolved oxygen, followed by units 1, 5 and 2. The increases are shown in Table 4-1.

TABLE 4-1 DISSOLVED OXYGEN MEASUREMENTS (MG/L)

Unit No.	Vent Closed	Vent Open	Increase in DO
1	4.65	5.04	0.39
2	4.60	4.80	0.20
3	4.70	5.15	0.45
4*	5.66	5.82	0.16
5	4.84	5.20	0.36
6**	5.10	N/A	N/A

*test data from 2014

**Unit 6 is not equipped with a vacuum breaker.

While the 2014 test indicated a dissolved oxygen increase of 0.16 mg/L induced by venting unit 4, the increase was hindered by the starting saturation level compared to the testing in 2015. It can be assumed that the lower levels in 2015 would have resulted in better uptake, but the exact level of increase is not known. Operating priority for the Turbine Venting Plan was not modified to arbitrarily place unit 4 above other turbines that have a better demonstrated uptake capacity.

4.2 RESULTS OF FOREBAY SAMPLING

Due to the fluctuations of the reservoir, periods of low inflows, and the general location of the HOBO loggers in the forebay of the dam, the loggers were highly susceptible to fouling due to debris, sediment, and algae. It appears that after approximately one week of data collection in the reservoir, the HOBO loggers became severely compromised and no longer collected accurate data. Likewise, as the study season progressed, the accuracy of the HOBO loggers decreased due to overgrowth with algae and other aquatic debris. At each download, which occurred on a monthly basis, HOBO loggers were freed of obvious debris as they were removed from the water, making the accuracy of the logger slightly increase for a short period of time, but then fouling quickly afterwards. For that reason, each week after the monthly download is considered to be the most accurate representation of the DO in the Parr forebay. However, the data was compromised during the collection period and is therefore not considered a completely reliable representation of DO in the Parr forebay. Regardless, the one week period following each

download is presented in graphs below (Figure 4-1 through Figure 4-6), along with the corresponding data from the Jenkinsville gage. Data collected during October is not included in this report, as severe flooding occurred in early October resulted in abnormally high flows and irregular DO levels.

Throughout the month of May, DO levels in the forebay, both from the top and bottom of the reservoir, and in the tailrace were consistent with each other, and well above the SCDHEC instantaneous standard of 4.0 mg/L (Figure 4-1 and Figure 4-2) (SCDHEC 2012).

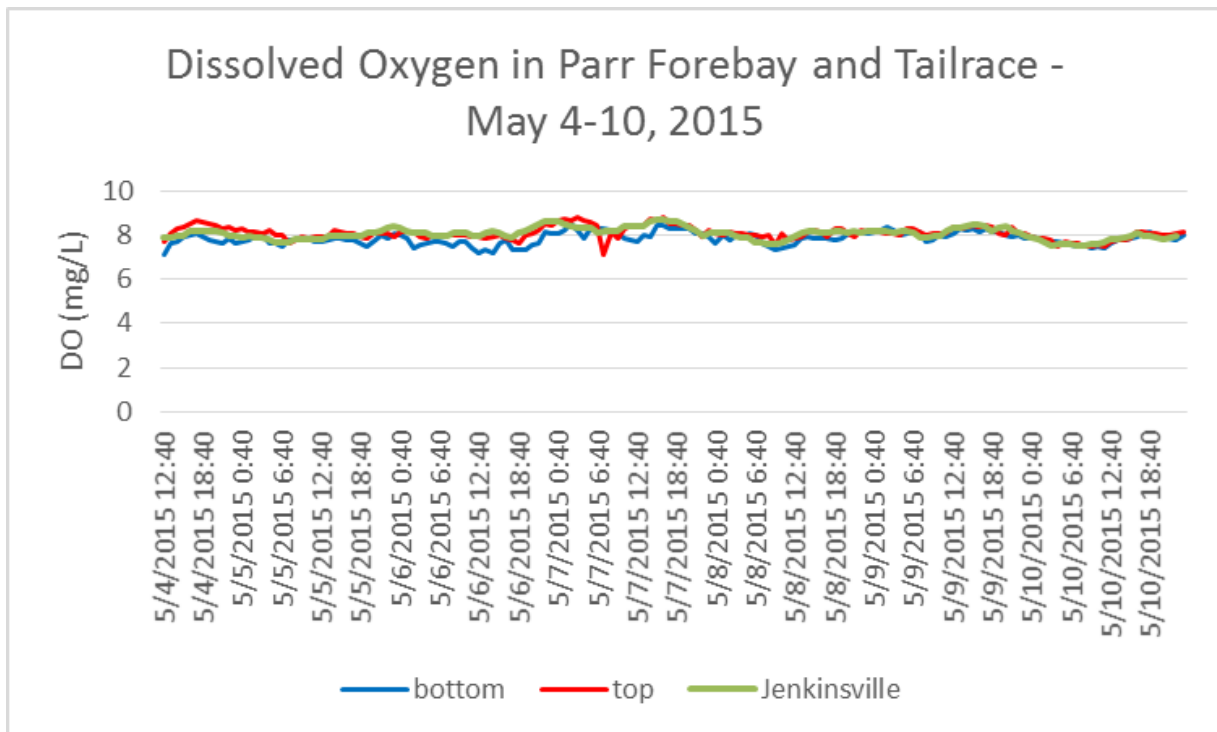


FIGURE 4-1 DISSOLVED OXYGEN IN THE PARR FOREBAY AND TAILRACE – MAY 4-10, 2015

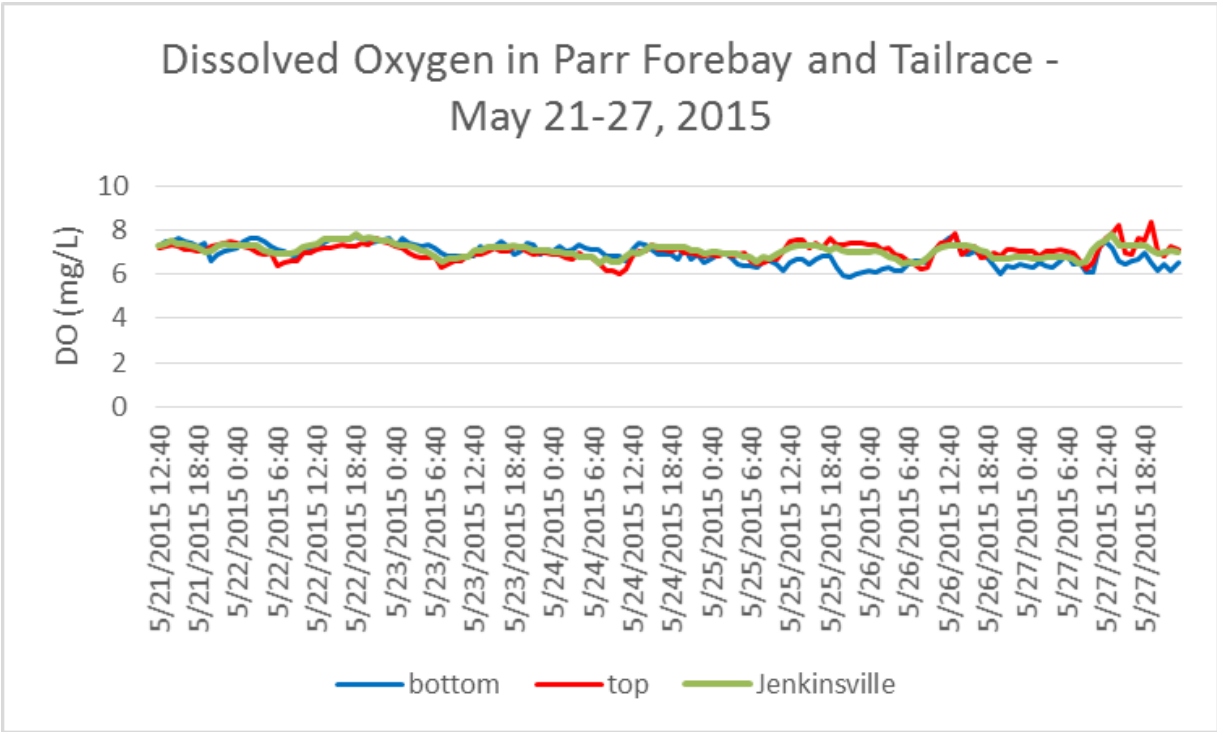


FIGURE 4-2 DISSOLVED OXYGEN IN THE PARR FOREBAY AND TAILRACE – MAY 21-27, 2015

In late June and early July, DO levels began to drop slightly in the forebay and tailrace (Figure 4-3). While the DO levels followed the same general pattern in the forebay as they did in the tailrace, the logger located near the bottom of the reservoir appeared to be affected by algal growth and debris. DO readings collected by the gage at Jenkinsville remain above the standard of 4.0 mg/L.

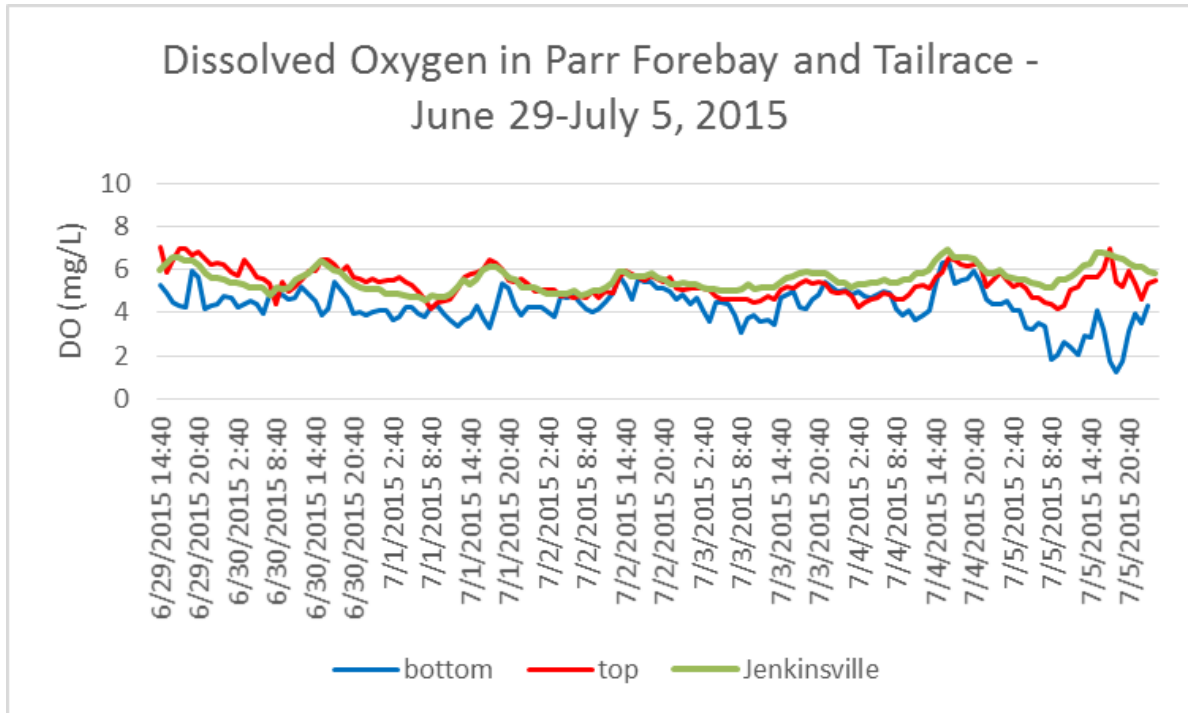


FIGURE 4-3 DISSOLVED OXYGEN IN THE PARR FOREBAY AND TAILRACE – JUNE 29-JULY 5, 2015

In mid-July, DO levels in the tailrace remained constant near 6.0 mg/L (Figure 4-4). DO readings collected in the forebay ranged from near 6.0 mg/L to 0.0 mg/L. Both loggers appeared to be affected by fouling from algae, sediment and other debris located in the forebay, but loggers began to detect a diel pattern typical of day and night shifts in DO levels associated with reservoirs and production and consumption of DO.

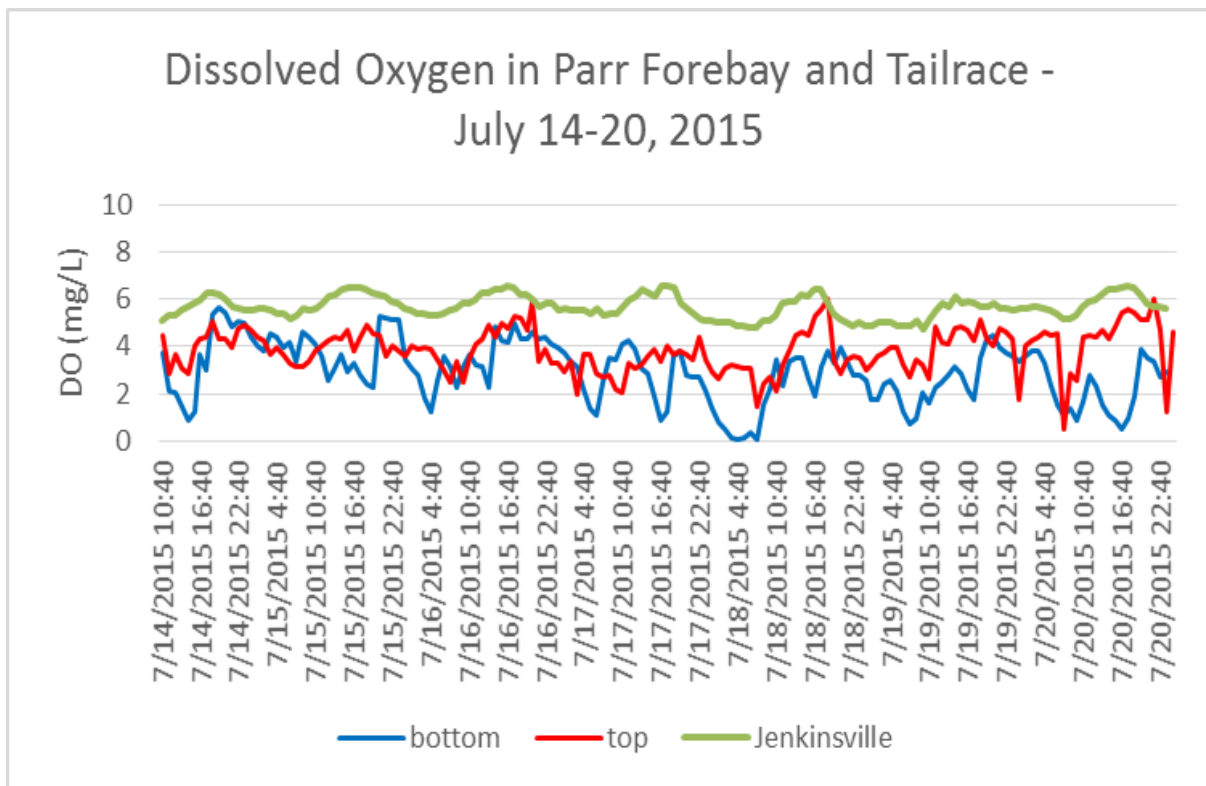


FIGURE 4-4 DISSOLVED OXYGEN IN PARR FOREBAY AND TAILRACE – JULY 14-20, 2015

In mid-August, DO levels in the tailrace continued to remain constant near 6.0 mg/L (Figure 4-5). DO readings collected in the forebay at the top of the reservoir again sporadically range from near 6.0 mg/L to 0.0 mg/L. It is likely that the top HOBO logger became wrapped with debris, causing the unusually low readings. The DO readings collected in the forebay at the bottom of the reservoir were less sporadic, however, they show a downward deterioration of fouling as time progresses, indicating that the longer the loggers were in the water, the more affected they became by algal growth, sediment, and debris.

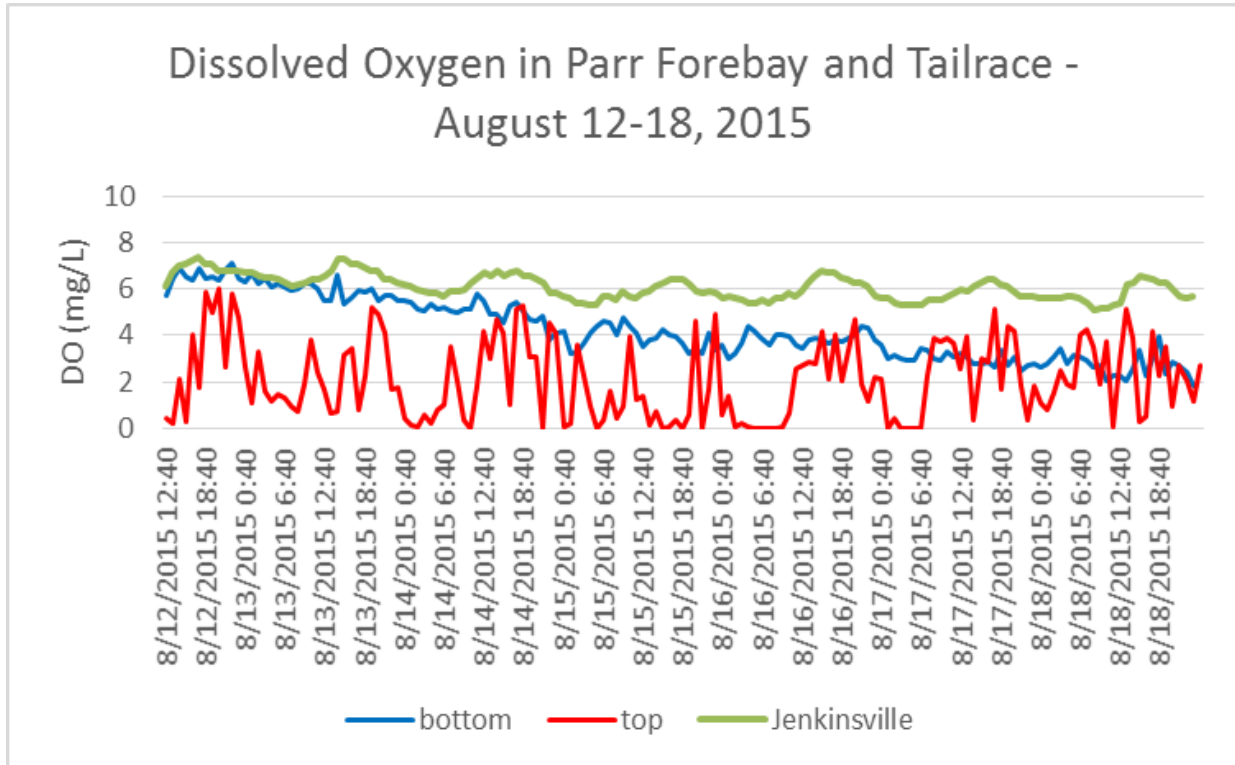


FIGURE 4-5 DISSOLVED OXYGEN IN PARR FOREBAY AND TAILRACE – AUGUST 12-18, 2015

During mid-September, DO levels in the tailrace rose from approximately 6.0 mg/L up to approximately 8.0 mg/L (Figure 4-6). DO readings collected in the forebay range from near 6.0 mg/L to 2.0 mg/L. The loggers again appear to be affected somewhat by algae, sediment and other debris located in the forebay. River flows during this period increased slightly with reoccurrence of rain events in the fall.

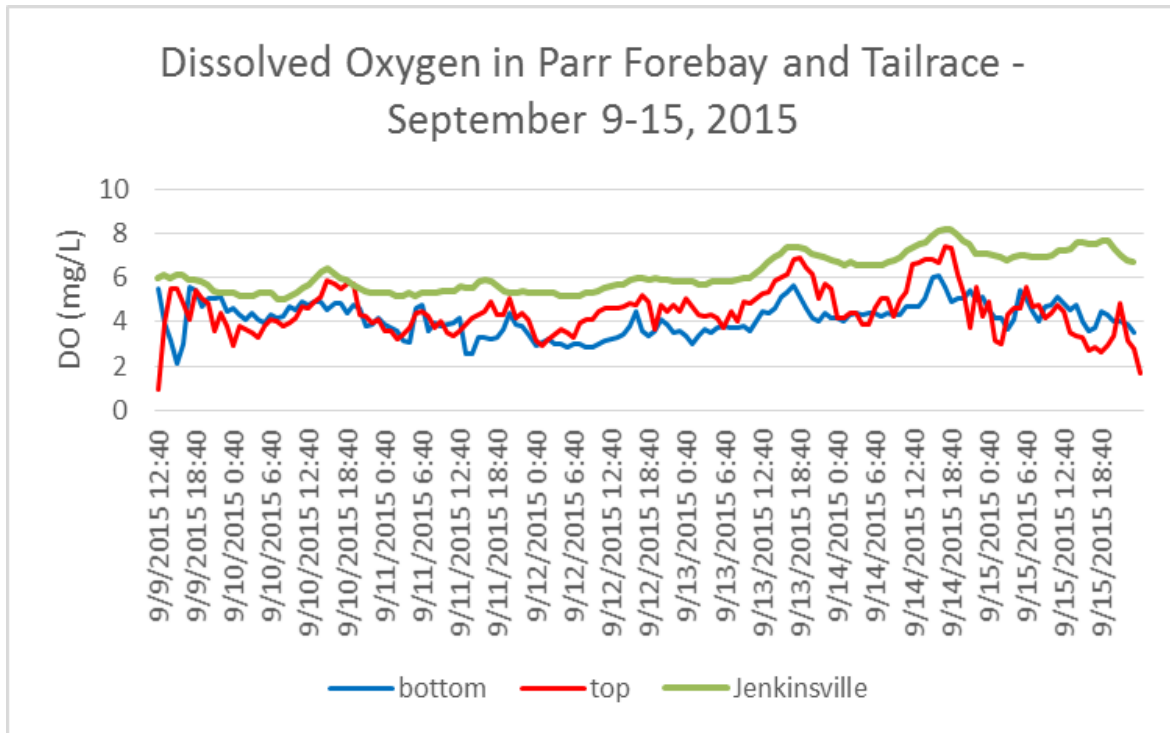


FIGURE 4-6 DISSOLVED OXYGEN IN PARR FOREBAY AND TAILRACE – SEPTEMBER 9-15, 2015

5.0 TURBINE VENTING PLAN

5.1 OPERATING PROCEDURES

Turbine venting shall occur continuously during a “venting period” for each calendar year, with vents opened as turbines are started up and brought online. During the venting period, the turbines will be operated with vents opened in a first-on / last-off order as follows: 3, 1, 5, 2, 4, and 6. Exceptions to this operating order shall occur due to equipment maintenance that results in unit outages, or emergency conditions.

SCE&G shall follow the venting procedures from June 15 through July 31 of each year. This period captures all of the excursions recorded by the nearby USGS Gage No. 02160991, Broad River near Jenkinsville, SC since the current probe was installed in 2011.

5.2 DOCUMENTATION

SCE&G shall provide documentation to DHEC of dissolved oxygen excursions below the standard within ten days of occurrence. Upon request from a consulting agency, SCE&G shall provide hourly records to agency representatives to demonstrate adherence to the order of turbine operating during a venting period. Documentation of maintenance activities to justify deviation from the turbine operating order will also be provided, should a deviation occur.

6.0 DISCUSSION

During two turbine tests at Parr Hydro, it was demonstrated that five of the six turbines have a demonstrated capacity to self-aerate by opening vacuum breaker valves. Effectiveness of the venting appears to vary between turbines, and the results of testing conducted with dissolved oxygen below 5.0 mg/L were used to prioritize an operating sequence. Observations of downstream data trends were used to determine trigger mechanisms for venting, which was combined with the operating sequence for a venting plan.

During 2015, there were no DO levels below 4.2 mg/L detected at the USGS tailrace DO gage. After July 31, there was only one DO reading lower than 5.0 mg/l and that was 4.9 mg/l on August 2. Fouling of DO monitor probes in the Parr forebay made it more difficult to see clear trends in the DO levels experienced in the forebay, but they did detect lower DO levels and a diel shift in DO levels starting at the end of June and extending through the end of September.

This report will be used as part of the 401 water quality certification application for the Parr Hydroelectric Project to demonstrate that the Project will meet the state standards as described by SCDHEC under the new FERC license.

7.0 REFERENCES

SCDHEC. 2012. Water Classifications and Standards (R. 61-68). [Online] URL: <https://www.scdhec.gov/Agency/docs/lwm-regs/r61-68.pdf>. Accessed December 29, 2015.

APPENDIX A

**PARR HYDROELECTRIC PROJECT WATER QUALITY BASELINE MEMORANDUM –
WATER QUALITY REPORT – SUPPLEMENTAL DISSOLVED OXYGEN DATA**

Parr Hydroelectric Project – FERC No. 1894
Water Quality Baseline – Memorandum

TO: Parr/Fairfield Relicensing Water Quality Technical Working Committee (TWC)
FROM: Kelly Miller and Henry Mealing – Kleinschmidt Associates
DATE: March 2, 2015
RE: Water Quality Report – Supplemental Dissolved Oxygen Data

The Parr Hydroelectric Project Baseline Water Quality Report includes analysis of both upstream and downstream water quality associated with the Parr Shoals Development and concluded that project operations could affect water quality downstream of Parr Shoals Dam. At the Water Quality TWC meeting on February 4, 2014, the TWC noted that the Baseline Water Quality Report identified periodic excursions of dissolved oxygen (DO) levels below 4.0 mg/l in the Parr Shoals Dam tailrace, as reported by the USGS station 02160991. In an effort to understand these excursions better, SCE&G contacted USGS and asked if they had any further information on this station. In June of 2011, the USGS installed a new sensor at the station 02160991. From January 2011 through December 2014, there have been approximately 13 hourly excursions in DO below the 4.0 mg/l SCDHEC standard which is approximately 0.04 percent of that period of time. At the request of the Water Quality TWC, SCE&G collected additional water quality data in the tailrace and forebay of Parr Shoals Dam to attempt to determine whether project operations are causing these excursions, and if so, how SCE&G might prevent them from occurring.

Tailrace Data – July – September 2014

Methods

From July through September of 2014, SCE&G collected temperature and DO data at seven sites along the downstream face of the Parr Shoals Dam, adjacent to the USGS station 02160991, and at a location approximately 400 feet downstream of Parr Shoals Dam. Data was collected on a weekly basis, three times per day including one hour before sunrise, at sunrise, and one hour after sunrise. To see if unit location had an effect on DO, the turbine(s) running during collections and the number of any lowered flashboard was also recorded.

Results

SCE&G collected data in the tailrace for two main reasons: (1) to verify the accuracy of the USGS gage station 02160991 and (2) to determine if DO could be correlated to an early morning DO sag or related to which turbine units were running at the time of data collection. During the sampling period, DO levels consistently stayed above 4.0 mg/l. No excursions were recorded by SCE&G or on the USGS gage (Table 1). Data collected by SCE&G at the site of the USGS station 02160991 was consistent with the USGS gage.

TABLE 1 DISSOLVED OXYGEN DATA AT USGS STATION 02160991 AND PARR SHOALS TAILRACE JULY – SEPTEMBER 2014.

Date	USGS Data		SCE&G Data	
	Time	DO mg/l	Time	DO mg/l
7/2/14	5:00 AM	6.2	5:35 AM	6.12
	6:00 AM	6.0	6:37 AM	5.95
	7:00 AM	6.0	7:42 AM	5.86
	8:00 AM	6.0		
7/10/14	5:00 AM	6.0	5:32 AM	6.24
	6:00 AM	5.9	6:27 AM	6.16
	7:00 AM	5.7	7:33 AM	6.08
	8:00 AM	5.5		
7/15/14	5:00 AM	5.5	5:34 AM	5.62
	6:00 AM	5.4	6:32 AM	5.32
	7:00 AM	4.9	7:42 AM	4.91
	8:00 AM	5.0		
7/24/14	5:00 AM	5.2	5:41 AM	5.15
	6:00 AM	5.2	6:51 AM	5.03
	7:00 AM	5.1	7:50 AM	5.49
	8:00 AM	5.3		
7/31/14	5:00 AM	5.8	5:43 AM	5.66
	6:00 AM	5.7	6:42 AM	5.55
	7:00 AM	5.7	7:54 AM	5.53
	8:00 AM	5.7		
8/7/14	5:00 AM	6.0	5:39 AM	5.90
	6:00 AM	6.0	6:48 AM	5.84
	7:00 AM	5.9	7:49 AM	5.74
	8:00 AM	5.9		
8/13/14	5:00 AM	5.9	5:30 AM	5.83
	6:00 AM	5.9	6:33 AM	5.86
	7:00 AM	5.9	7:33 AM	5.83
	8:00 AM	5.9		
8/20/14	5:00 AM	5.8	5:48 AM	5.90
	6:00 AM	5.8	6:46 AM	5.97
	7:00 AM	5.7	7:56 AM	5.86
	8:00 AM	5.7		
8/26/14	5:00 AM	6.3	5:41 AM	6.26
	6:00 AM	6.4	6:51 AM	6.51
	7:00 AM	6.4	7:48 AM	6.35
	8:00 AM	6.3		
9/3/14	5:00 AM	5.7	5:29 AM	6.02
	6:00 AM	5.8	6:40 AM	5.73
	7:00 AM	5.4	7:53 AM	5.46
	8:00 AM	5.4		
9/10/14	6:00 AM	5.6	6:30 AM	5.62
	7:00 AM	5.7	7:46 AM	5.78
	8:00 AM	5.7	8:46 AM	5.71
	9:00 AM	5.7		
9/16/14	6:00 AM	5.0	6:22 AM	4.94

	7:00 AM	5.0	7:24 AM	4.98
	8:00 AM	5.0	8:24 AM	4.92
	9:00 AM	5.0		
9/25/14	6:00 AM	7.3	6:33 AM	7.10
	7:00 AM	7.3	7:34 AM	7.65
	8:00 AM	7.3	8:29 AM	7.62
	9:00 AM	7.3		

Results did not detect a clear correlation between DO readings and the units running at the time of data collection. See Appendix A for a complete list of the data collected during this effort.

Forebay Data – October & November 2014

Methods

Water quality data, including DO and temperature, were collected in the forebay of the Parr Shoals Dam to determine if low DO water is being released through the turbines, causing the DO in the tailrace to drop. The data was collected using two HOBO data loggers, with one logger located approximately one foot above the bottom of the reservoir and the other located approximately one foot below the surface of the reservoir. Data was logged on an hourly basis from October 16, 2014 through December 3, 2014. We had planned to begin collections earlier but did not receive the data loggers until mid-September.

Results

Results showed the expected correlations between DO and temperature and natural diel fluctuations (Figure 1 through Figure 4). DO levels at the bottom of the forebay are consistently slightly lower than those at the top of the forebay, and there was no evidence of stratification in the forebay area of the reservoir. There were no low DO events observed in the tailrace during the monitoring effort.

FIGURE 1 DO AND TEMPERATURE AT BOTTOM OF PARR SHOALS DAM FOREBAY

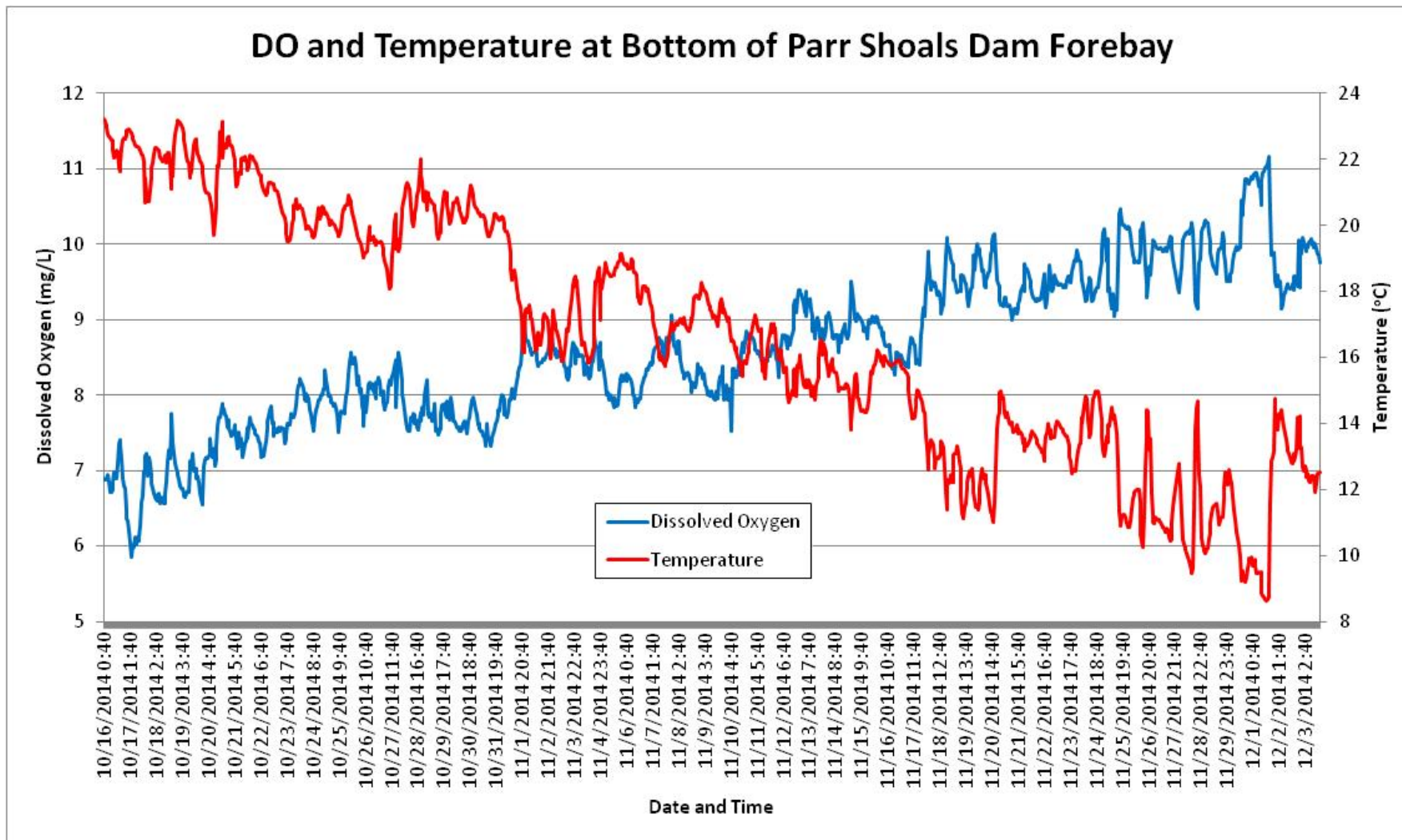


FIGURE 2 DO AND TEMPERATURE AT THE TOP OF PARR SHOALS DAM FOREBAY

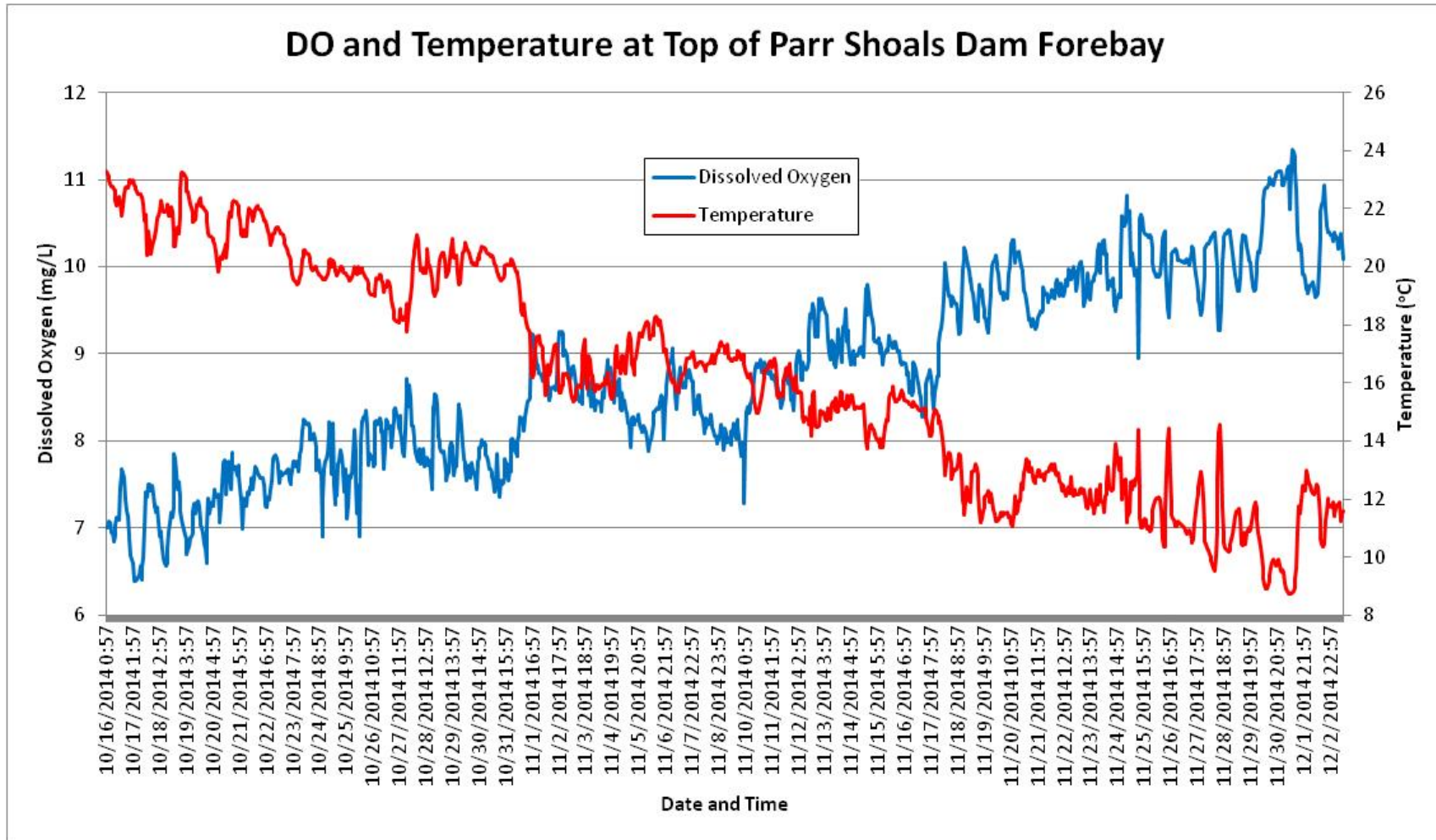


FIGURE 3 PARR SHOALS DAM FOREBAY DISSOLVED OXYGEN

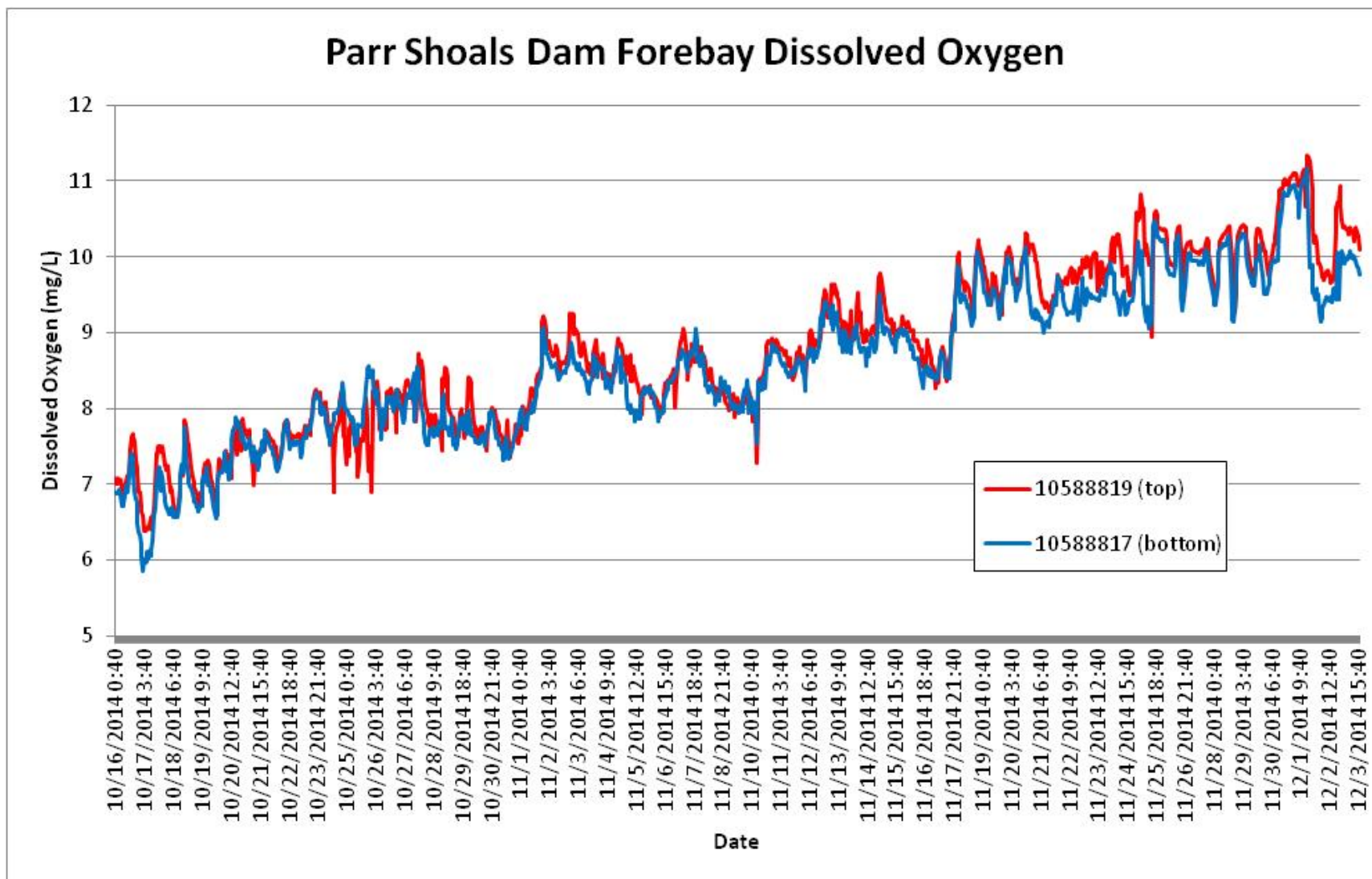
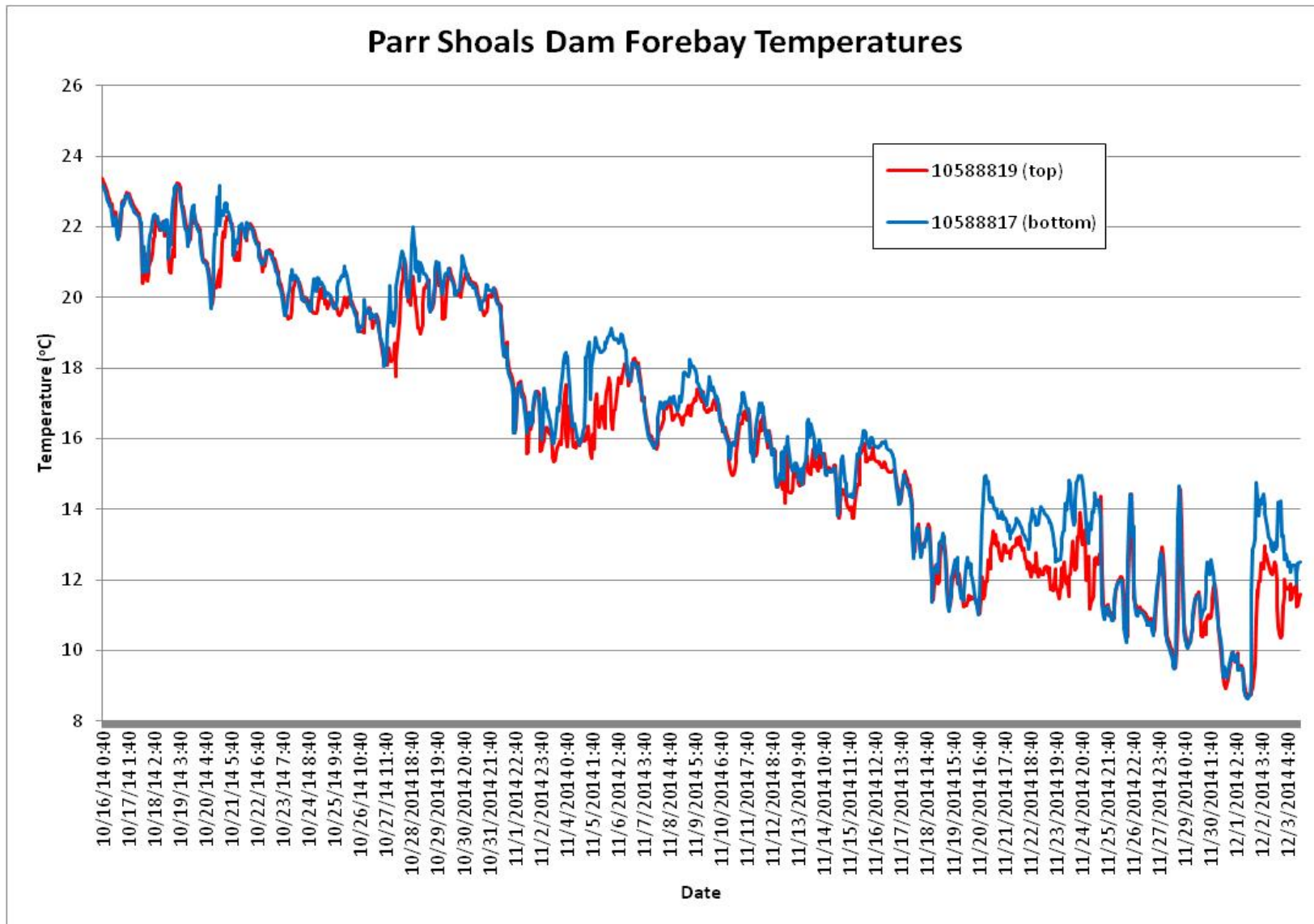


FIGURE 4 PARR SHOALS DAM FOREBAY TEMPERATURES



Parr Aeration Investigation – August 2014

Because of the success with turbine self-venting (or self-aerating) at the Saluda Hydro Project, SCE&G performed some initial investigations to determine if turbine aerating at the Parr Shoals Development was feasible for periodically increasing the tailrace DO levels. Bret Hoffman (Kleinschmidt), Amy Bresnahan (SC&EG), Milton Quattlebaum (SCE&G), and Mike Hall (USGS) performed some initial onsite turbine venting tests at the Parr Shoals Development on the morning of August 20, 2014. The results of their investigation are included below.

During each test run, water quality measurements (DO, temperature, and % DO saturation) were recorded with handheld meters (independent of the permanently installed USGS gage station equipment) in the tailrace at the bay 7 location (which is between the six turbine bays and the shore) and along the shoreline adjacent to the USGS gage. These measurements provided a cursory examination of the ability of the Units to aerate by opening the existing vacuum breaker valves located on the turbine head cover. Only Units 1, 3, and 4 were available for operation testing as the other units were out of service for repair, and Unit 4 could not be shut down because of equipment issues. During testing all river flow was passed through the turbine units and the spillway gates were in the closed (raised) position. Test runs for the water quality measurements were conducted in combinations of turbine operations as described below and were partially dictated by the requirement that Unit 4 could not be shut down. The headpond and tailwater elevations were also recorded, as were individual generator kW and kVar outputs.

Unit 4 - Test

Initially, tailrace readings were collected with only Unit 4 operating, and the vacuum breaker valve closed. Then, the vacuum breaker valve was fully opened to allow aeration, and audibly drew in air. The effects of the introduced air were clearly visible in the tailrace. The initial tailrace reading collected with the valve closed was 5.66 mg/l, the reading at bay 7 with the valve open was 5.82 mg/l. Upon closing the valve, the DO at bay 7 dropped to 5.78 mg/l, although the aerated water may not have had time to flush out from the tailrace area. The USGS measurements on the shore were 5.58 mg/l prior to opening any turbine vents, and 5.75mg/l with the vent open for 25 minutes. The USGS reading did not drop after the valve was closed, and matched the bay 7 reading of 5.78 mg/l, supporting the theory that residual aerated water remained in the immediate tailrace area. Initial saturation was 71% (valve closed), and with the valve open the saturation increased to 74.9%. Saturation levels reported near the USGS gage were within a tenth of a percent of those recorded at bay 7.

Units 1 and 4

Unit 1 was started (valve closed) and allowed to stabilize for 15 minutes. DO readings were collected with Unit 1 valve closed and Unit 4 valve open. The USGS reading increased to 5.84 mg/l, while the bay 7 reading increased from 5.82 mg/l to 5.86 mg/l. The Unit 1 valve was opened and readings were collected after 15 minutes of stabilization. The measurement near the USGS gage was 5.80 mg/l, while the bay 7 reading was 5.88 mg/l. Saturation with Unit 1 (valve

closed) and Unit 4 (valve open) was 73%, which increased to 75.4% with both units' valves open.

Units 1, 3, and 4

Unit 3 was started and operated for 15 minutes with no valve open, while the valves for Units 1 and 4 were left open. The measurements from the USGS site and at bay 7 were both 5.80 mg/l, and the saturation at bay 7 was 74.8%. When the valve was opened on Unit 3, the bay 7 reading was 5.76 mg/l and the USGS reading was 5.75 mg/l with a saturation level of 74.3% - with all three units aerating. USGS took an additional measurement at bay 2 (between units 1 and 3) with all units aerating, which ranged from 6.08 mg/l to 6.15 mg/l; at 6.08 mg/l, saturation was 79%.

One final measurement was taken with all units 1, 3 and 4 operating but all three valves closed. The reading near the USGS gage was 5.71 mg/l while the bay 7 reading was 5.73 mg/l, indicating very minimal reduction from aerating. It is likely that the aerated water in the tailrace area did not flush out and resulted in higher readings. The USGS handheld meter was used to re-sample water quality at bay 2 and the DO dropped to 5.89 mg/l and 75% saturation.

Discussion

The three units tested will aerate with their current valve configurations. The inability to shut down unit 4 likely prevented the aerated flows from units 1 and 3 from reaching the shore, as they are located further toward the middle of the river. While the DO readings with various combinations of valves open for all three units was fairly stable, the initial increase from Unit 4 indicates there is an ability to increase dissolved oxygen by aerating. Saturation was between 71% initial reading (prior to any aeration), and 75% after the valve was opened, indicating an increase in saturation. Saturation levels were near 75% for all readings following the initial valve opening.

Saturation was calculated for all the DO excursions (below 4.0 mg/L) during the past three years as recorded by the USGS gage. While the saturation levels during the aeration testing ranged from 71% (without aerating) up to 76%, the levels calculated for the excursions varied between 44.8% and 51.18%. Water temperatures during the testing ranged between 27.5 and 28.1 °C, while temperature during the excursions was measured at 29.3 to 30.1 °C.

The initial increase in DO measured during testing was approximately 0.17 mg/l. This indicates the turbines have some ability to increase DO by aerating, although the saturation percentage and water temperatures were significantly different during the historic DO excursions. A better determination of effectiveness could be made under lower DO and saturation conditions during the summer. Also, testing during a period when all of the turbine units can be manipulated (turned on/off and aerating on/off) would give more precise information on the performance of each unit.

APPENDIX A
TAILRACE DATA

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 7/2/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:11 AM	Unit 1	5.79	27.30	on
5:16 AM	Unit 2	5.92	27.45	off
5:20 AM	Unit 3	5.90	27.44	on
5:23 AM	Unit 4	6.01	27.69	on
5:26 AM	Unit 5	6.18	27.94	off
5:29 AM	Unit 6	6.14	27.94	off
5:35 AM	At USGS gage	6.12	27.92	
5:41 AM	DWNSTRM Plant	6.09	27.89	
6:16 AM	Unit 1	5.97	27.30	on
6:19 AM	Unit 2	5.89	27.40	off
6:21 AM	Unit 3	5.90	27.48	on
6:23 AM	Unit 4	6.06	27.74	on
6:26 AM	Unit 5	5.99	27.76	off
6:28 AM	Unit 6	5.98	27.79	off
6:33 AM	NPDES 001 sign	6.00	27.62	
6:37 AM	At USGS gage	5.95	27.74	
6:42 AM	DWNSTRM Plant	5.94	27.71	
7:17 AM	Unit 1	5.74	27.25	on
7:22 AM	Unit 2	5.82	27.36	off
7:25 AM	Unit 3	5.84	27.40	on
7:27 AM	Unit 4	6.03	27.64	on
7:30 AM	Unit 5	5.93	27.61	off
7:33 AM	Unit 6	5.89	27.63	off
7:36 AM	NPDES 001 sign	5.93	27.62	
7:42 AM	At USGS gage	5.86	27.56	
7:49 AM	DWNSTRM Plant	5.89	27.57	

Time	Jenksville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenksville	USGS Temp data at Jenksville
5:00 AM	221.37	261.52	258.50	6.2	27.8
6:00 AM	221.35	260.89	262.50	6.0	27.6
7:00 AM	221.65	260.44	258.50	6.0	27.5
8:00 AM				6.0	27.4

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 7/10/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:04 AM	Unit 1	5.73	27.40	on
5:08 AM	Unit 2	5.75	27.45	off
5:11 AM	Unit 3	5.86	27.48	on
5:15 AM	Unit 4	6.09	27.53	on
5:18 AM	Unit 5	6.28	27.69	off
5:21 AM	Unit 6	6.24	27.66	off
5:24 AM	NPDES 001 sign	6.26	27.67	
5:32 AM	At USGS gage	6.24	27.61	
5:35 AM	DWNSTRM Plant	6.24	27.65	
6:07 AM	Unit 1	5.75	27.44	on
6:10 AM	Unit 2	5.82	27.47	off
6:13 AM	Unit 3	5.89	27.51	on
6:15 AM	Unit 4	6.27	27.64	on
6:18 AM	Unit 5	6.24	27.65	off
6:20 AM	Unit 6	6.20	27.64	off
6:22 AM	NPDES 001 sign	6.19	27.65	
6:27 AM	At USGS gage	6.16	27.63	
6:32 AM	DWNSTRM Plant	6.16	27.59	
7:14 AM	Unit 1	5.87	27.50	on
7:16 AM	Unit 2	5.84	27.51	off
7:19 AM	Unit 3	5.91	27.51	on
7:21 AM	Unit 4	6.19	27.59	on
7:23 AM	Unit 5	6.15	27.60	off
7:25 AM	Unit 6	6.16	27.62	off
7:27 AM	NPDES 001 sign	6.13	27.61	
7:33 AM	At USGS gage	6.08	27.61	
7:40 AM	DWNSTRM Plant	6.15	27.50	

*lowered crest gates 5 and 6 at 7:20 am

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	221.36	260.89	266.00	6.0	27.6
6:00 AM	221.35	260.57	266.00	5.9	27.5
7:00 AM	221.93	260.59	258.00	5.7	27.5
8:00 AM				5.5	27.4

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 7/15/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO		Units Running
		(mg/L)	Temp (°C)	
5:10 AM	Unit 1	5.30	28.19	on
5:14 AM	Unit 2	5.29	28.25	off
5:17 AM	Unit 3	5.30	28.29	on
5:19 AM	Unit 4	5.70	28.42	on
5:22 AM	Unit 5	5.63	28.45	off
5:25 AM	Unit 6	5.54	28.48	off
5:28 AM	NPDES 001 sign	5.64	28.41	
5:34 AM	At USGS gage	5.62	28.34	
5:39 AM	DWNSTRM Plant	5.57	28.41	
6:13 AM	Unit 1	4.77	28.18	on
6:15 AM	Unit 2	4.81	28.21	off
6:18 AM	Unit 3	4.92	28.22	on
6:20 AM	Unit 4	5.19	28.25	on
6:22 AM	Unit 5	5.40	28.16	off
6:25 AM	Unit 6	5.35	28.24	off
6:27 AM	NPDES 001 sign	5.31	28.34	
6:32 AM	At USGS gage	5.32	28.30	
6:36 AM	DWNSTRM Plant	5.33	28.29	
7:22 AM	Unit 1	4.98	28.18	on
7:25 AM	Unit 2	4.94	28.15	off
7:27 AM	Unit 3	4.94	28.11	on
7:30 AM	Unit 4	5.00	28.12	on
7:32 AM	Unit 5	5.18	28.18	off
7:35 AM	Unit 6	5.02	28.19	off
7:37 AM	NPDES 001 sign	5.03	28.16	
7:42 AM	At USGS gage	4.91	28.08	
7:47 AM	DWNSTRM Plant	5.00	28.18	
7:55 AM	Unit 1	4.86	28.12	on

*not spilling while monitoring

Time	Jenkinsville 02160991	Parr Res. Level 0216099		Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	221.34	258.63	266, except 5&6 at 264	5.5	28.3	
6:00 AM	221.31	258.40	266, except 5&6 at 264	5.4	28.2	
7:00 AM	221.34	258.68	266, except 5&6 at 264	4.9	28	
8:00 AM				5.0	28	

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 7/24/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:10 AM	Unit 1	5.23	27.34	off
5:15 AM	Unit 2	5.26	27.32	off
5:17 AM	Unit 3	5.21	27.30	off
5:21 AM	Unit 4	5.43	27.35	on
5:24 AM	Unit 5	5.15	27.32	off
5:29 AM	Unit 6	4.81	27.21	off
5:35 AM	NPDES 001 sign	5.11	27.29	
5:41 AM	At USGS gage	5.15	27.28	
5:46 AM	DWNSTRM Plant	4.70	27.19	
6:27 AM	Unit 1	5.27	27.29	off
6:33 AM	Unit 2	5.26	27.23	off
6:35 AM	Unit 3	5.28	27.28	off
6:38 AM	Unit 4	5.19	27.30	on
6:41 AM	Unit 5	5.09	27.29	off
6:43 AM	Unit 6	4.97	27.27	off
6:46 AM	NPDES 001 sign	5.05	27.21	
6:51 AM	At USGS gage	5.03	27.27	
6:56 AM	DWNSTRM Plant	4.72	27.09	
7:22 AM	Unit 1	5.18	27.24	off
7:32 AM	Unit 2	5.68	27.24	off
7:33 AM	Unit 3	5.68	27.27	off
7:37 AM	Unit 4	5.83	27.26	on
7:40 AM	Unit 5	5.49	27.25	off
7:42 AM	Unit 6	5.43	27.11	off
7:45 AM	NPDES 001 sign	5.50	27.21	
7:50 AM	At USGS gage	5.49	26.68	
7:55 AM	DWNSTRM Plant	5.47	27.06	
8:00 AM	Unit 1	5.63	27.25	off

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	220.47	260.11	Gates 1, 2, 3, 4: 264	5.2	27.2
6:00 AM	220.47	259.41	Gates 5, 6, 7, 8: 266	5.2	27.2
7:00 AM	220.46	258.97		5.1	27.1
8:00 AM				5.3	27.1

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 7/31/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:18 AM	Unit 1	5.72		27.49 on
5:21 AM	Unit 2	5.73		27.52 off
5:24 AM	Unit 3	5.73		27.50 off
5:27 AM	Unit 4	5.78		27.51 on
5:30 AM	Unit 5	5.65		27.49 off
5:33 AM	Unit 6	5.60		27.48 off
5:37 AM	NPDES 001 sign	5.67		27.46
5:43 AM	At USGS gage	5.66		27.32
5:50 AM	DWNSTRM Plant	5.54		27.39
6:22 AM	Unit 1	5.71		27.42 on
6:25 AM	Unit 2	5.71		27.47 off
6:28 AM	Unit 3	5.73		27.48 off
6:31 AM	Unit 4	5.81		27.46 on
6:33 AM	Unit 5	5.61		27.42 off
6:36 AM	Unit 6	5.59		27.41 off
6:38 AM	NPDES 001 sign	5.64		27.43
6:42 AM	At USGS gage	5.55		27.32
6:47 AM	DWNSTRM Plant	5.61		27.22
7:32 AM	Unit 1	5.64		27.41 on
7:36 AM	Unit 2	5.69		27.37 off
7:39 AM	Unit 3	5.69		27.42 off
7:41 AM	Unit 4	5.73		27.41 on
7:44 AM	Unit 5	5.63		27.39 off
7:46 AM	Unit 6	5.66		27.38 off
7:49 AM	NPDES 001 sign	5.68		27.38
7:54 AM	At USGS gage	5.53		27.36
7:59 AM	DWNSTRM Plant	5.61		27.32
8:07 AM	Unit 1	5.60		27.49 on
				*no gates spilling

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	220.97	260.44	Gates 1, 2, 5, 6, 9, 10: 266	5.8	27.4
6:00 AM	220.99	259.66	Gates 3, 4:264	5.7	27.3
7:00 AM	220.95	259.00	Gates 7, 8: 263	5.7	27.3
8:00 AM				5.7	27.3

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 8/7/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:14 AM	Unit 1	5.90		27.37 off
5:14 AM	Unit 2	5.92		27.30 off
5:20 AM	Unit 3	6.02		27.32 on
5:23 AM	Unit 4	5.99		27.29 on
5:26 AM	Unit 5	5.92		27.34 off
5:29 AM	Unit 6	5.92		27.33 off
5:33 AM	NPDES 001 sign	5.88		27.30
5:39 AM	At USGS gage	5.90		27.30
5:48 AM	DWNSTRM Plant	5.80		27.18
6:25 AM	Unit 1	5.94		27.33 off
6:29 AM	Unit 2	5.94		27.33 off
6:31 AM	Unit 3	6.02		27.34 on
6:34 AM	Unit 4	5.95		27.32 on
6:36 AM	Unit 5	5.90		27.32 off
6:39 AM	Unit 6	5.86		27.28 off
6:42 AM	NPDES 001 sign	5.90		27.30
6:48 AM	At USGS gage	5.84		27.27
6:58 AM	DWNSTRM Plant	5.68		27.13
7:27 AM	Unit 1	5.82		27.34 off
7:30 AM	Unit 2	5.92		27.29 off
7:33 AM	Unit 3	5.97		27.36 on
7:36 AM	Unit 4	5.95		27.32 on
7:39 AM	Unit 5	5.90		27.27 off
7:42 AM	Unit 6	5.85		27.26 off
7:45 AM	NPDES 001 sign	5.90		27.28
7:49 AM	At USGS gage	5.74		27.21
7:56 AM	DWNSTRM Plant	5.73		27.15
8:03 AM	Unit 1	5.83		27.27 off

*no gates spilling

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	220.76	258.89	Gates 1, 2, 9, 10:266	6.0	27.2
6:00 AM	220.75	258.17	Gates 3, 4, 5, 6, 7, 8: 264	6.0	27.2
7:00 AM	220.72	258.02		5.9	27.2
8:00 AM				5.9	27.2

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 8/13/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:09 AM	Unit 1	5.87		26.18 on
5:13 AM	Unit 2	5.85		26.24 off
5:15 AM	Unit 3	5.89		26.26 on
5:18 AM	Unit 4	5.93		26.26 on
5:20 AM	Unit 5	5.80		26.28 off
5:23 AM	Unit 6	5.81		26.27 off
5:25 AM	NPDES 001 sign	5.82		26.27
5:30 AM	At USGS gage	5.83		26.24
5:35 AM	DWNSTRM Plant	5.85		26.23
6:13 AM	Unit 1	5.85		26.20 on
6:16 AM	Unit 2	5.87		26.19 off
6:18 AM	Unit 3	5.85		26.21 on
6:20 AM	Unit 4	5.93		26.19 on
6:23 AM	Unit 5	5.83		26.18 off
6:25 AM	Unit 6	5.81		26.18 off
6:28 AM	NPDES 001 sign	5.83		26.18
6:33 AM	At USGS gage	5.86		26.15
6:38 AM	DWNSTRM Plant	5.87		26.14
7:17 AM	Unit 1	5.86		26.14 on
7:19 AM	Unit 2	5.86		26.15 off
7:21 AM	Unit 3	5.88		26.15 on
7:23 AM	Unit 4	5.94		26.12 on
7:25 AM	Unit 5	5.86		26.10 off
7:27 AM	Unit 6	5.88		26.09 off
7:29 AM	NPDES 001 sign	5.89		26.08
7:33 AM	At USGS gage	5.83		26.07
7:37 AM	DWNSTRM Plant	5.90		26.06
7:41 AM	Unit 1	5.90		26.12 on

*no gates spilling

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	221.33	259.89	1, 2, 9, 10: 266	5.9	26.1
6:00 AM	221.33	259.5	3, 4, 5, 6, 7, 8: 261	5.9	26.0
7:00 AM	221.07	259.57		5.9	26.0
8:00 AM				5.9	26.0

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 8/20/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:24 AM	Unit 1	5.53		27.54 on
5:27 AM	Unit 2	5.88		27.68 off
5:30 AM	Unit 3	5.91		27.65 off
5:33 AM	Unit 4	5.99		27.67 on
5:36 AM	Unit 5	5.92		27.68 off
5:39 AM	Unit 6	5.91		27.64 off
5:42 AM	NPDES 001 sign	5.91		27.64
5:48 AM	At USGS gage	5.90		27.47
5:53 AM	DWNSTRM Plant	5.90		27.55
6:26 AM	Unit 1	5.63		27.70 on
6:29 AM	Unit 2	5.87		27.68 off
6:31 AM	Unit 3	5.86		27.67 off
6:33 AM	Unit 4	5.91		27.66 on
6:35 AM	Unit 5	5.87		27.63 off
6:38 AM	Unit 6	5.86		27.60 off
6:41 AM	NPDES 001 sign	5.93		27.65
6:46 AM	At USGS gage	5.97		27.21
6:50 AM	DWNSTRM Plant	5.86		27.48
7:32 AM	Unit 1	5.67		27.64 on
7:34 AM	Unit 2	5.96		27.57 off
7:38 AM	Unit 3	5.92		27.66 off
7:41 AM	Unit 4	6.02		27.65 on
7:43 AM	Unit 5	5.97		27.64 off
7:45 AM	Unit 6	5.87		27.53 off
7:48 AM	NPDES 001 sign	5.93		27.61
7:56 AM	At USGS gage	5.86		27.47
8:00 AM	DWNSTRM Plant	5.83		27.50
8:09 AM	Unit 1	5.73		27.61 on

*no gates spilling

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	220.97	258.50	1, 2, 9, 10: 265	5.8	27.6
6:00 AM	220.96	258.37	3, 4, 5, 6, 7, 8: 266	5.8	27.6
7:00 AM	220.94	258.42		5.7	27.5
8:00 AM				5.7	27.5

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 8/26/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:17 AM	Unit 1	7.05	28.08	off
5:20 AM	Unit 2	7.02	28.08	off
5:23 AM	Unit 3	7.09	28.07	on
5:26 AM	Unit 4	6.41	28.08	on
5:28 AM	Unit 5	6.29	28.06	off
5:31 AM	Unit 6	6.25	28.03	off
5:34 AM	NPDES 001 sign	6.30	28.04	
5:41 AM	At USGS gage	6.29	27.90	
5:46 AM	DWNSTRM Plant	6.20	27.95	
6:26 AM	Unit 1	7.00	28.02	off
6:29 AM	Unit 2	7.06	28.00	off
6:32 AM	Unit 3	7.03	27.98	on
6:35 AM	Unit 4	6.64	27.90	on
6:38 AM	Unit 5	6.43	27.86	off
6:41 AM	Unit 6	6.41	27.82	off
6:45 AM	NPDES 001 sign	6.50	27.87	
6:51 AM	At USGS gage	6.51	27.82	
6:56 AM	DWNSTRM Plant	6.36	27.61	
7:30 AM	Unit 1	6.74	27.81	off
7:32 AM	Unit 2	6.81	27.79	off
7:34 AM	Unit 3	6.80	27.84	on
7:36 AM	Unit 4	6.68	27.71	on
7:38 AM	Unit 5	6.45	27.74	off
7:42 AM	Unit 6	6.47	27.66	off
7:44 AM	NPDES 001 sign	6.50	27.74	
7:48 AM	At USGS gage	6.35	27.71	
7:53 AM	DWNSTRM Plant	6.29	27.60	
8:01 AM	Unit 1	6.67	27.79	off

*no gates spilling

Time	Jenkinsville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinsville	USGS Temp data at Jenkinsville
5:00 AM	221.10	261.50	1, 2, 9, 10: 266	6.3	27.9
6:00 AM	221.10	261.33	3, 4, 5, 6, 7, 8: 265	6.4	27.8
7:00 AM	221.08	261.01		6.4	27.6
8:00 AM				6.3	27.5

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 9/03/14

Samplers: Milton Quattlebaum and Kelly Miller

Time	Location	DO (mg/L)	Temp (°C)	Units Running
5:01 AM	Unit 1	5.88	28.45	on
5:04 AM	Unit 2	5.74	28.41	off
5:10 AM	Unit 3	5.61	28.40	on
5:14 AM	Unit 4	5.75	28.42	on
5:17 AM	Unit 5	5.67	28.49	off
5:19 AM	Unit 6	5.63	28.48	off
5:24 AM	NPDES 001 sign	5.82	28.35	
5:29 AM	At USGS gage	6.02	28.86	
5:35 AM	DWNSTRM Plant	6.11	28.43	
6:19 AM	Unit 1	5.56	28.41	on
6:21 AM	Unit 2	5.58	28.41	off
6:25 AM	Unit 3	5.53	28.42	on
6:27 AM	Unit 4	5.62	28.44	on
6:30 AM	Unit 5	5.73	28.46	off
6:33 AM	Unit 6	5.69	28.47	off
6:35 AM	NPDES 001 sign	5.71	28.46	
6:40 AM	At USGS gage	5.73	28.46	
6:45 AM	DWNSTRM Plant	5.69	28.13	
7:31 AM	Unit 1	5.57	28.61	on
7:36 AM	Unit 2	5.62	28.60	off
7:39 AM	Unit 3	5.63	28.59	on
7:41 AM	Unit 4	5.61	28.57	on
7:44 AM	Unit 5	5.63	28.54	off
7:47 AM	Unit 6	5.56	28.54	off
7:49 AM	NPDES 001 sign	5.53	28.55	
7:53 AM	At USGS gage	5.46	28.51	
7:59 AM	DWNSTRM Plant	5.56	28.30	
8:05 AM	Unit 1	5.55	28.51	on

*no gates spilling

Time	Jenksville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenksville	USGS Temp data at Jenksville
5:00 AM	221.43	259.43	all @ 266	5.7	28.4
6:00 AM	221.38	259.1		5.8	28.4
7:00 AM	221.38	258.74		5.4	28.4
8:00 AM				5.4	28.4

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 9/10/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running	
6:02 AM	Unit 1	5.90		27.12 on	
6:04 AM	Unit 2	5.82		27.11 off	
6:07 AM	Unit 3	5.71		27.09 off	
6:10 AM	Unit 4	5.77		27.09 on	
6:13 AM	Unit 5	5.62		27.08 off	
6:17 AM	Unit 6	5.61		27.04 off	
6:20 AM	NPDES 001 sign	5.65		27.01	
6:30 AM	At USGS gage	5.62		27.04	
6:35 AM	DWNSTRM Plant	5.64		26.98	
7:22 AM	Unit 1	5.82		26.95 on	
7:26 AM	Unit 2	5.76		26.94 off	
7:29 AM	Unit 3	5.83		26.92 off	
7:32 AM	Unit 4	5.81		26.92 on	
7:35 AM	Unit 5	5.66		26.93 off	
7:38 AM	Unit 6	5.74		26.67 off	
7:41 AM	NPDES 001 sign	5.69		26.90	
7:46 AM	At USGS gage	5.78		26.64	
7:50 AM	DWNSTRM Plant	5.72		26.72	
8:27 AM	Unit 1	5.78		26.81 on	
8:30 AM	Unit 2	5.80		26.87 off	
8:33 AM	Unit 3	5.79		26.85 off	
8:36 AM	Unit 4	5.85		26.85 on	
8:38 AM	Unit 5	5.80		26.86 off	
8:40 AM	Unit 6	5.76		26.83 off	
8:42 AM	NPDES 001 sign	5.78		26.84	
8:46 AM	At USGS gage	5.71		26.75	
8:50 AM	DWNSTRM Plant	5.80		26.80	
9:00 AM	Unit 1	5.65		26.82 on	
				*no gates spilling	
Time	Jenksville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenksville	USGS Temp data at Jenksville
6:00 AM	221.07	259.38	all @ 266	5.6	26.9
7:00 AM	221.05	259.44		5.7	26.8
8:00 AM	221.06	259.43		5.7	26.8
9:00 AM				5.7	26.8

APPENDIX B

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 9/16/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
6:01 AM	Unit 1	5.13	26.99	off
6:04 AM	Unit 2	5.37	26.73	off
6:07 AM	Unit 3	5.36	27.06	off
6:09 AM	Unit 4	5.25	27.06	on
6:12 AM	Unit 5	4.95	27.01	off
6:15 AM	Unit 6	4.97	26.96	off
6:18 AM	NPDES 001 sign	4.95	26.84	
6:22 AM	At USGS gage	4.94	26.81	
6:26 AM	DWNSTRM Plant	4.87	26.77	
7:03 AM	Unit 1	5.16	26.99	off
7:05 AM	Unit 2	5.20	26.96	off
7:08 AM	Unit 3	5.34	26.98	off
7:11 AM	Unit 4	5.10	26.99	on
7:13 AM	Unit 5	5.00	26.92	off
7:16 AM	Unit 6	4.97	26.93	off
7:19 AM	NPDES 001 sign	4.81	26.85	
7:24 AM	At USGS gage	4.98	26.80	
7:30 AM	DWNSTRM Plant	4.95	26.83	
8:02 AM	Unit 1	5.18	26.91	off
8:05 AM	Unit 2	5.15	26.92	off
8:08 AM	Unit 3	5.30	26.88	off
8:11 AM	Unit 4	5.24	26.93	on
8:13 AM	Unit 5	4.99	26.93	off
8:15 AM	Unit 6	4.96	26.91	off
8:18 AM	NPDES 001 sign	5.04	26.80	
8:24 AM	At USGS gage	4.92	26.87	
8:28 AM	DWNSTRM Plant	5.12	26.67	
8:39 AM	Unit 1	5.26	26.89	

Time	Jenksville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenksville	USGS Temp data at Jenksville
6:00 AM	220.54	259.57	1, 2, 9, 10 @266	5.0	26.9
7:00 AM	220.54	259.73	3, 4, 5, 6, 7, 8@262	5.0	26.8
8:00 AM	221.44	259.81		5.0	26.9
9:00 AM				5.0	26.8

Parr/Fairfield Relicensing Dissolved Oxygen Study 2014

Date: 9/25/14

Samplers: Milton Quattlebaum

Time	Location	DO (mg/L)	Temp (°C)	Units Running
6:09	Unit 1	7.80	21.40	off
6:11	Unit 2	7.76	21.42	off
6:15	Unit 3	7.81	21.44	on
6:17	Unit 4	7.85	20.90	on
6:21	Unit 5	7.70	21.39	off
6:24	Unit 6	7.65	21.42	off
6:27	NPDES 001 sign	7.66	21.43	
6:33	At USGS gage	7.10	21.40	
6:40	DWNSTRM Plant	7.61	21.36	
7:17	Unit 1	7.69	21.68	off
7:19	Unit 2	7.71	21.67	off
7:21	Unit 3	7.80	21.67	on
7:23	Unit 4	7.70	21.61	on
7:25	Unit 5	7.58	21.57	off
7:27	Unit 6	7.62	21.62	off
7:29	NPDES 001 sign	7.60	21.62	
7:34	At USGS gage	7.65	21.61	
7:39	DWNSTRM Plant	7.31	21.59	
8:13	Unit 1	7.67	21.75	off
8:15	Unit 2	7.65	21.72	off
8:17	Unit 3	7.71	21.75	on
8:19	Unit 4	7.66	21.62	on
8:21	Unit 5	7.65	21.51	off
8:23	Unit 6	7.58	21.59	off
8:25	NPDES 001 sign	7.63	21.60	
8:29	At USGS gage	7.62	21.42	
8:34	DWNSTRM Plant	7.59	21.47	
8:39	Unit 1	7.68	21.65	off

*no gates spilling

Time	Jenkinville 02160991	Parr Res. Level 02160990	Parr Crest Gate	USGS DO data at Jenkinville	USGS Temp data at Jenkinville
6:00 AM	221.06	259.18	all @ 266	7.3	21.5
7:00 AM	221.05	259.2		7.3	21.5
8:00 AM	221.05	259.24		7.3	21.5
9:00 AM				7.3	21.5

APPENDIX B
2015 TURBINE VENTING TEST RESULTS

Parr Aeration Investigation – July 2015

SCE&G initially performed turbine venting testing at the Parr Shoals Development during 2014. Based on the initial success of that testing for periodically increasing dissolved oxygen (DO) levels in the tailrace, SCE&G performed additional turbine venting testing on July 9, 2015. The results of this testing will be used to develop a Turbine Venting Plan for the Parr Shoals Development and submitted as part of the 401 Water Quality Certification application process for the Parr Hydroelectric Project.

During each test run, water quality measurements (DO, temperature, and % DO saturation) were recorded with handheld meters in the tailrace outflow of each unit being tested. Units 1, 2, 3, 5 and 6 were available for testing. Unit 4 was under repair and could not be tested. Unit 6 does not have a vacuum breaker installed on the headcover and cannot be vented, but was tested to determine its aerating capability. During testing all river flow was passed through the turbine units and the crest gates were in the closed (raised) position. The headpond and tailwater elevations were also recorded, as were individual generator kW and kVar outputs (Table 1).

At the beginning of each turbine test, tailrace readings were collected with the unit running and the vacuum breaker closed. After approximately 5 to 10 minutes, the vacuum breaker valve was fully opened to allow aeration. The effects of the introduced air were clearly visible in the tailrace for each unit tested. The unit was allowed to run for another 5 to 10 minutes until tailrace readings stabilized before data was recorded. Each unit was tested in sequence using this same scenario. Unit 6 data was collected to see the DO levels that occurred on that unit with no venting available. Surprisingly, Unit 6 DO levels were fairly high without venting which may be an artifact of its location near the shoreline. Unit 6 may pull water from closer to the surface than the other units located further away from the shoreline.

Discussion

Each of the units 1, 2, 3, and 5 tested will aerate with their current valve configurations and each increased DO levels at a different amounts. Testing showed that the units vent from highest to lowest as follows: 3, 1, 5, 2, 4, and 6. SCE&G will use this information to develop a Turbine Venting Plan for the Parr Shoals Development that will be submitted to South Carolina Department of Health and Environmental Control for discussion and approval.

Table B-1. Summary of Turbine Venting at Parr Shoals Dam July 9, 2015.

Unit Tested	Vent Open/Close	DO (mg/L)	DO Increase (mg/L)	Saturation %	Saturation Increase %	Temp (F)	Gate Setting %	Output (KW)	KVars
1	Close	4.65	-----	59.8	-----	82.9	45	1473	150
1	Open	5.04	0.39	64.3	4.5	83.0	45	1426	145
2	Close	4.60	-----	58.8	-----	82.9	43	1520	144
2	Open	4.80	0.20	61.2	2.4	82.9	43	1475	144
3	Close	4.70	-----	60.0	-----	82.9	45	1370	153
3	Open	5.15	0.45	65.2	5.2	82.9	45	1300	142
5	Close	4.84	-----	62.4	-----	82.9	45	1560	154
5	Open	5.20	0.36	65.6	3.2	82.9	45	1476	150
6	No Vent	5.10	-----	65.2	-----	83.0	39	1426	145

Unit 4 was not available for testing

Unit 6 does not have a vent

Headwater elevation remained stable between 258.1 – 257.9 msl during the test

Tailwater Elevation remained stable between 221.0 – 220.8 msl during the test

APPENDIX B

**PARR HYDROELECTRIC PROJECT – FERC No. 1894 – PARR SHOALS DAM
TURBINE VENTING – 2016 TURBINE VENTING TEST RESULTS – MEMORANDUM –
AUGUST 15, 2016**

PARR HYDROELECTRIC PROJECT – FERC No. 1894
PARR SHOALS DAM TURBINE VENTING – MEMORANDUM

TO: Water Quality Technical Working Committee
FROM: Kleinschmidt Associates
DATE: August 15, 2016
RE: 2016 Turbine Venting Test Results

INTRODUCTION

Following the completion of the Parr Hydroelectric Project Baseline Water Quality Report, there were questions from the Water Quality TWC regarding occasional low dissolved oxygen (DO) in the tailrace downstream of Parr Shoals Dam. At a Water Quality TWC meeting on February 4, 2014, the TWC noted that the Baseline Water Quality Report identified periodic excursions of DO levels less than 4.0 mg/L in the Parr Shoals Dam tailrace, as reported by the USGS station 02160991. In an effort to understand these excursions better, SCE&G consolidated historic USGS data to examine these excursions and issued an addendum to the Baseline Water Quality Report in June 2014. At the request of the Water Quality TWC, SCE&G collected additional water quality data in the summer of 2014 in the tailrace and forebay of Parr Shoals Dam in an attempt to determine whether project operations are causing these excursions. These results were summarized in a memo issued on March 2, 2015. SCE&G followed up this effort by collecting another series of water quality data in the Parr forebay from May through mid-October 2015. The results of this data collection effort was summarized in the Parr Shoals Dam Turbine Venting Report.

In addition, SCE&G proposed to test all of the Parr turbines for their ability to self-vent and potentially increase the dissolved oxygen in the tailrace during specific periods of the year. An initial test of the turbines' capacity to vent was performed August 2014; a second test to determine which turbines had the most significant impact on increasing dissolved oxygen was performed in July 2015. The results of the testing, along with the findings published in the Baseline Water Quality Report, were used to develop a Turbine Venting Plan. At the March 2016 Water Quality TWC meeting, SCE&G proposed to test the Turbine Venting Plan during June 15th through July 31st of 2016. In addition to testing the plan during 2016, SCE&G also conducted a re-test of Unit 4 after installation of the new "air-cooled wooden bearings". The results of each of these tests are presented in this document.

METHODOLOGY AND RESULTS

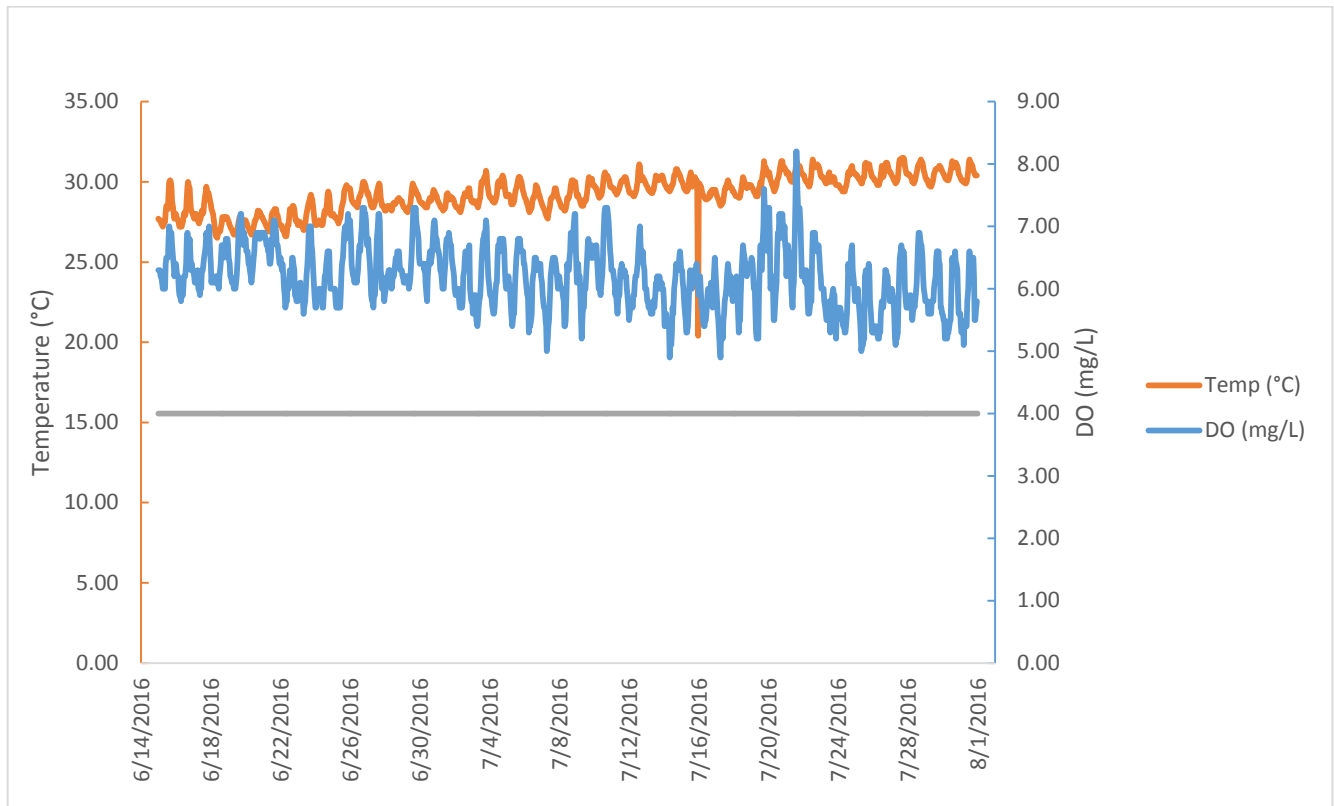
SCE&G implemented the proposed Turbine Venting Plan from June 15 through July 31, 2016. The success of turbine venting was measured at the USGS Gage No. 02160991, Broad River near Jenkinsville, SC.

Dissolved oxygen and temperatures observed in the tailrace are illustrated in Figure 1. No excursions of DO levels less than 4.0 mg/L were observed (Table 1).

Table 1 Parr Shoals Tailrace Maximum and Minimum DO and Temperature

	June		July	
	DO (mg/L)	Temperature (°C)	DO (mg/L)	Temperature (°C)
Maximum	7.30	30.10	8.20	31.50
Minimum	5.60	26.50	4.90	20.40

Figure 1 Parr Shoals Tailrace DO and Temperature



Turbine venting test of Unit 4 are presented in Table 2. The testing noted a DO uptake of approximately 0.20 mg/l. The testing performed during 2014 identified an uptake of 0.16, which is slightly less than the latest testing results.

Table 2 Parr Shoals Turbine Venting Unit 4 Test – August 2016

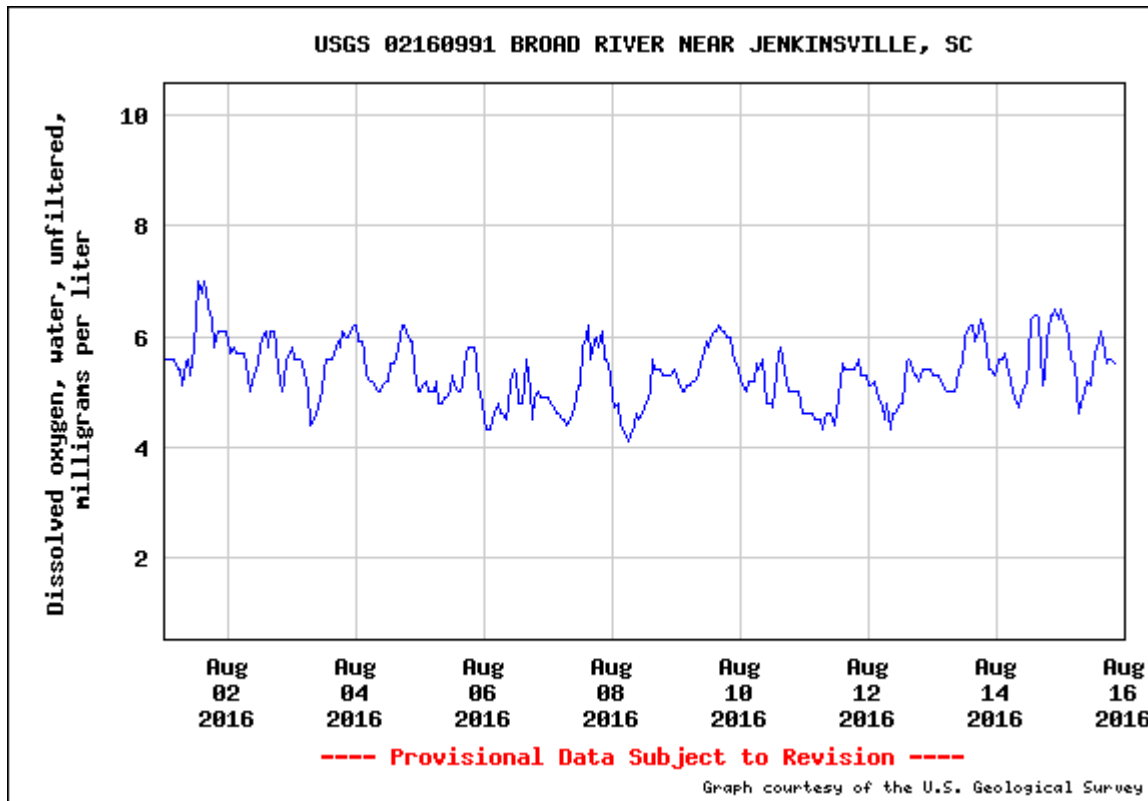
Test #	Time (DST)	Breaker Position Open/Closed	DO (mg/l)	Temp (°C)	TDG	% Sat	HP EI	TW EI	KW	Kvars Act.	Gates Act. (%)	BP
1	9:00	closed	5.08	29.42	713	67.2	257.22	220.70	1360±	150	45	759
2	9:40	open	5.3	29.48	718	70.2	257.53	220.72	1360±	151	46	759

Notes:

Requested plant/system control to have all gates up and a max. of 2 units generating by 07:00 (DST).
 Units 4 & 6 were operating and all gates up upon arrival at the plant. Unit 6 was shutdown at 08:20 (DST).
 Breaker valve on Unit 4 was opened at approx. 09:20 (DST).

Also of note was the general decline in DO levels recorded at the Jenkinsville gage during the first 2 weeks of August, 2016 (Figure 2). We are not sure if this is related to drops associated with the cessation of turbine venting or environmental factors.

Figure 2 Parr Shoals Tailrace DO and Temperature – August 1 – August 16, 2016



CONCLUSION

Based on the results of the 2016 Turbine Venting Plan test, turbine venting at the Parr Shoals Development was successful. Testing of Unit 4 during 2016 showed a slight increase in DO uptake. We also noted a decrease in DO levels during August.

Based on these findings, SCE&G proposes to perform turbine venting tests during 2017 and to extend the venting season to include June 15 through August 31. SCE&G will use the results of the 2016 and 2017 testing and the individual Unit test to update and modify the current Turbine Venting Plan. SCE&G plans to include the updated Turbine Venting Plan as one of the proposed protection, mitigation, and enhancement measures to be included in the Final License Application for continued operation of the Parr Hydroelectric Project (FERC No. 1894).