KAUKAUNA UTILITIES

ORIGINAL

"Community Owned, Customer Driven"

FILED
SECRETARY OF THE
COMMISSION

2016 FEB -1 P 3:25

FEDERAL ENERGY
REGULATORY COMMISSION

January 26, 2016

Ms. Kimberly Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Subject: Water Quality Monitoring Report
Badger-Rapide Croche Hydroelectric Project, FERC No. 2677-030

Dear Ms. Bose:

City of Kaukauna (Kaukauna Utilities) received a new Federal Energy Regulatory Commission (FERC) License on May 18, 2011, for its Badger-Rapide Croche Hydroelectric Project (Project). Under Article 406 of the new license, Kaukauna Utilities completed an approved Water Quality Monitoring Plan (WQMP) in 2012. The WQMP directed the licensee to monitor dissolved oxygen (DO), pH, and temperature variables on an hourly basis upstream and downstream of the Project for a period from June 15 through September 30 for three consecutive years (2014-2016). This is the second annual report, which covers water quality monitoring conducted in 2015.

Kaukauna Utilities also submitted this report to the Wisconsin Department of Natural Resources, the U.S. Fish and Wildlife Service, and the Outagamie County Land Conservation Department (collectively, the agencies) on December 22, 2015, and confirmed receipt by the agencies shortly thereafter. Kaukauna Utilities requested that the agencies provide any written comments before January 20, 2016, so comments could be incorporated into the final report to FERC. Kaukauna Utilities did not receive any written comments from the agencies.

The report demonstrates that the Project is meeting the WQMP criteria and FERC License requirements. Temperatures were within the natural range of the river (i.e., between approximately 50 and 79°F) and no greater than 89°F. DO averages both upstream and downstream were typically around 8.0 to 9.0 milligrams per liter (mg/L) and rose to 11.0 to 12.0 mg/L as photosynthesis accelerated in mid-summer. Differences in upstream and downstream daily average DO only exceeded 2 mg/l on three non-successive days.

Seasonal pH averages were less than 9.0 at all locations. Daily averages sometimes slightly exceeded 9.0, but were biased high due to a combination of high natural pH conditions that occur in the Fox River basin and biofouling of the sample probes. The report includes discussion of the results and modifications of equipment and methods to improve 2016 data quality.

Thank you for assisting the City of Kaukauna. We are available to respond to questions or comments.

Michael Pedersen

Manager of Generation and Operations
Kaukauna Utilities

Enclosure: 2015 Report including CD-ROM with all data and a PDF of the full Report

Copy to:

Mr. John Zygaj ***(hard copy of the report)***
Regional Engineer
Federal Energy Regulatory Commission
Chicago Regional Office
230 South Dearborn Street, Room 3130
Chicago, IL 60604

Ms. Cheryl Laatsch ***(copy of the cover letter, previously received a hard copy of the report)***
WI Department of Natural Resources
Horicon Field Office
N7725 Highway 28
Horicon, WI 53023-9783

Mr. Nick Utrup ***(copy of the cover letter, previously received a hard copy of the report)***
U.S. Department of Interior
Fish and Wildlife Service
4101 American Boulevard E.
Bloomington, MN 55425-1665

Mr. Gregory Baneck ***(copy of the cover letter, previously received a hard copy of the report)***
Outagamie Co. Land Conservation Dept.
3365 W. Brewster Street
Appleton, WI 54914

KAUKAUNA UTILITIES

"Community Owned, Customer Driven"

COPY

December 22, 2015

Ms. Cheryl Laatsch
WI Department of Natural Resources
Horicon Field Office
N7725 Highway 28
Horicon, WI 53023-9783

Mr. Nick Utrup
U.S. Department of Interior
Fish and Wildlife Service
4101 American Boulevard E.
Bloomington, MN 55425-1665

Mr. Gregory Baneck
Outagamie Co. Land Conservation Dept.
3365 W. Brewster Street
Appleton, WI 54914

Subject: Water Quality Monitoring Report
Badger-Rapide Croche Hydroelectric Project, FERC No. 2677-030

Dear Agency and Governmental Representatives:

City of Kaukauna (Kaukauna Utilities) received a new Federal Energy Regulatory Commission (FERC) License on May 18, 2011, for its Badger-Rapide Croche Hydroelectric Project (Project). Under Article 406 of the new license, Kaukauna Utilities completed an approved Water Quality Monitoring Plan (WQMP) in 2012. The WQMP directed the licensee to monitor dissolved oxygen (DO), pH, and temperature variables on an hourly basis upstream and downstream of the Project for a period from June 15 through September 30 for three consecutive years (2014-2016). This is the second annual report, which covers water quality monitoring conducted in 2015.

The report demonstrates that the Project is meeting the WQMP criteria and FERC License requirements. Temperatures were within the natural range of the river (i.e., between approximately 50 and 79°F) and no greater than 89°F. DO averages both upstream and downstream were typically around 8.0 to 9.0 milligrams per liter (mg/L) and rose to 11.0 to 12.0 mg/L as photosynthesis accelerated in mid-summer. Differences in upstream and downstream daily average DO only exceeded 2 mg/l on three non-successive days.

Seasonal pH averages were less than 9.0 at all locations. Daily averages sometimes slightly exceeded 9.0, but were biased high due to a combination of high natural pH conditions that occur in the Fox River basin and biofouling of the sample probes. The report includes discussion of the results and modifications of equipment and methods to improve 2016 data quality.

Thank you for assisting Kaukauna Utilities and your timely response. We are available to respond to questions or comments.

Michael Pedersen

Manager of Generation and Operations

Enclosure: 2015 Report including CD-ROM with all data and a PDF of the full Report

GEI Consultants

Consulting
Engineers and
Scientists

2015 Water Quality Monitoring Report

Badger-Rapide Croche
Hydroelectric Project
FERC No. 2677-030
Kaukauna, Wisconsin

Submitted to:
Kaukauna Utilities

Submitted by:
GEI Consultants, Inc.
3159 Voyager Drive
Green Bay, Wisconsin 54311

January 26, 2016
Project No. 1506460

Roger A. Miller, P.G., C.P.G.
Senior Hydrogeologist

John Pizzimenti
Senior Consultant

Table of Contents

List of Appendices

RAM:cah
K:\Kruksuna Utilities\1506460 - Badger-Rapide Croche 2015 WQM\Report\BADGER 2015 DRAFT Report_12-10-15.docx

1.0 Project Background

This is the second year of water quality monitoring of the two-dam Badger-Rapide Croche Hydroelectric Project (FERC Project 2677) located on the Fox River. The project is owned and operated by City of Kaukauna, Wisconsin (Kaukauna Utilities). Details of the first year and methods are contained in a similar Report dated January 26, 2015.

Kaukauna Utilities followed the same approved Water Quality Monitoring Plan (WQMP) in 2014 and again in 2015. The WQMP directed the licensee to monitor dissolved oxygen (DO), pH, and temperature variables on an hourly and daily basis upstream and downstream of the project for the period from June 15 through September 30 for the three consecutive years (2014-2016). We also monitored conductivity as it functions in computation of DO. The Report is organized in four sections: 1.0 Project Background; 2.0 Methods and Instruments; 3.0 Results; and 4.0 Conclusions.

1.1 Organization of the Report

This section (Section 1.0) is an abbreviated description of the project including the purpose and organization of the report. More details can be found in the 2014 report.

Section 2.0, Methods and Instruments, summarizes the instrumentation, locations, and procedures used to collect and analyze the data including calibration, criteria, and goals.

Section 3.0, Results, (1) describes the 2015 data and (2) compares hourly and daily upstream and downstream: hydrology (discharge data), DO, pH, and temperature data. The data are placed in context of (1) compliance criteria, (2) quality assurance data, and (3) communications with agencies as required by the WQMP. The graphs of the data presented in Section 3.0 appear in Appendix A. Corresponding raw data are presented in Appendix C in CD-ROM in Excel format. An electronic copy of this report is also saved as PDF file in Appendix C.

Sections 4.0 and 4.1, Recommendations and Conclusions, address quality of the data, equipment, compliance, and recommendations for 2016 monitoring.

2.0 Methods and Instrumentation

2.1 Data Collection Sites

Monitoring of Badger occurred at the same three agency-approved locations used in 2014: (1) 500 feet upstream of Kaukauna Dam near the intake of the power canal; (2) downstream of Badger Powerhouse prior to confluence with the historic channel; and (3) at the downstream end of the Kaukauna Dam bypass (historic) channel prior to confluence with the tailrace of the Badger Powerhouse (Table 1 and Figure 1).

Rapide Croche data were collected at the same two agency-approved locations upstream and downstream of the dam near the intake and discharge points of the powerhouse (Table 1 and Figure 1). The downstream location was maintained at the less publically accessible point behind locked fencing after vandalism during the 2014 season.

2.2 Water Quality Criteria

The WQMP requires that Kaukauna Utilities monitor and report to Wisconsin Department of Natural Resources (WDNR) during the sampling season if data exceed the following criteria:

- Dissolved Oxygen - The dissolved oxygen (DO) content in surface waters may not be lowered to less than 5 milligrams per liter (mg/L) at any time. Differences in DO daily averages upstream and downstream of Kaukauna and Rapide Croche dams shall be no greater than 2 mg/L for five consecutive days. Calibration of the dissolved oxygen sensors is performed every one to two weeks with a variance criterion goal of less than 1 mg/L 70% of the time.
- Temperature - There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The temperature shall not exceed 89° F (31.5° C) for warmwater fish.
- pH - The pH shall be within the range of 6.0 to 9.0, with no daily average change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.

2.3 Instrumentation and Data Collection

Instrumentation consisted of five new technology Hach HL4 sondes outfitted with sensors to record hourly temperature, pH, and dissolved oxygen (DO) data. HL4 technology is more compact with longer battery life. Each sonde had a backup temperature probe to the real time data probe and was equipped with LDO (Luminescent Dissolved Oxygen) technology. Data were stored onboard the sonde data logger and downloaded to a computer for in-season analysis and compliance purposes initially at biweekly intervals in June and then at 7-10 day intervals for the remainder of the study. After each download, the DO probe and pH probes were calibrated against standard solutions then adjusted prior to redeployment (in-check calibration and post-cleaning calibration per manufacturer recommendations).

Reserve Sondes of the same design were kept on hand for rapid redeployment and were utilized several times during the study when sondes were damaged or failed to calibrate. Data losses and calibration issues are discussed and logged in Appendix E.

Sondes were first deployed on June 8, 2015, for pre-season testing. Monitoring compliance data began June 15, 2015, and the first results were downloaded on June 29, 2015. Sondes had been factory calibrated but were recalibrated during pre-season testing in 2015. Pre-season test data were downloaded to confirm all probe operations and calibrations. Probes were calibrated according to manufacturer recommendations at each data download and analyzed for WQMP compliance. Sondes were retrieved, calibrated, and removed from operation on October 2, 2015, after the close of the monitoring season on September 30.

3.0 Results

3.1 Overview of Results

Six probe or sonde outages during the season led to data gaps for some variables at some locations. The raw data are provided in a separate CD-ROM. Computations of seasonal averages are based on a "cleaned" data set that removed missing data or data that was demonstrably inaccurate for reasons documented in this report. Statistics are based on accounting for missing data and for removing biased or inaccurate data. Procedures for cleaning up the data removal were as follows:

1. We tentatively identified questionable data using anomalous trends such as unexplained rapid and chronic directional changes or sudden or extreme outliers to normal data. A potential cause was then sought. For example: the Badger Upstream pH values rose continuously between June 17 and June 29. It was associated with severe calibration problems on the download of June 29 (Appendix B, Figure 4 Raw Data). Strong directional deviations from normal trends were usually traced to one or more observed causes after data downloads such as: visible physical damage to the instrument, battery failure, burial in sediment, water leakage into the instrument, biofouling by algae, plants, or invertebrates, calibration out of normal range, and inability to recalibrate the instrument.
2. We then associated calibration data, field notes, battery data, and photos for the time periods corresponding to the date range of the anomalous data. For example: in the June 29, 2015, calibration notes, the pH probe failed to calibrate with three attempts; the pH probe was replaced and failed again when a macroinvertebrate organism became lodged within the pH probe.
3. Based on synchronous calibration data, field notes, or photographic evidence of damaged sensors, the raw data were removed beginning where the change in direction could be noted or where data provided suspect deviations from normal trends or values.
4. Some failures such as water leakage into a sonde, physical damage, sediment burial, or battery failure caused multiple probe problems in which more than one variable became erratic. Since battery failure can affect all variables collected, synchronous periods were observed when all data were lost for more than one variable.

A summary of clipped data and data gaps for all five stations is included in Table 9, the unabridged data plots and tables are included in Appendix B, and the clipped data plots and tables are included in Appendix A. Photographic examples of sonde conditions are provided in Appendix D.

3.2 Daily Average Dissolved Oxygen and Discharge Data Badger Hydro

Badger water quality is described for all three variables and calibration at three locations (Sections 3.2, 3.3, 3.4, 3.5, 3.6, and 3.7). Then, Rapide Croche water quality is described for all three variables and calibration at two locations (Sections 3.8, 3.9, and 3.10).

Fox River inflows are under the control of Army Corps of Engineers (Corps) and outflows are nearly synchronous to inflows at the dam. Figure 2 shows daily discharge in the Fox River during the study period, as measured at a U.S. Geological Survey monitoring station in Appleton, Wisconsin (USGS Station 04084445). Fox River discharge exceeded 11,000 cfs on June 15. Flows dropped about 500 cfs/day to 2000 cfs from June 15 to July 3. Summer discharge remained near 2,000 cfs before rising to 8,000 cfs in early September then leveling out around 6,000 cfs in late September. These high flows created safety hazards in monitoring the bypass reach downstream of Badger Hydro, creating data gaps in the early and late season.

Changes in discharge affect water clarity, water velocity, temperature, and algal abundance, and these affect DO levels in the Fox River. Despite large controlled discharges by the Corps on June 15-July 5 and September 9-15, upstream and downstream levels of DO at Badger remained highly correlated and mostly stable around 8-9 mg/L (Figure 6).

Upstream DO data were available all season except for a 3-day data gap from July 28 to July 31 due to a sonde electrical malfunction. The daily average for DO fluctuated between 7-10 mg/L (Figure 6). DO averaged 8.3 mg/L for the season (Table 3).

Bypass DO levels were less variable and fluctuated between 8 and 9 mg/L daily average (Table 3). Minimum and maximum daily averages were 8.4 mg/L and 9.0 mg/L respectively. Bypass DO was slightly lower and less correlated with the wider variations observed upstream. Two major data gaps occurred June 15 to July 10 and September 12 to September 20 due to due to high flows and unsafe sampling conditions (Table 9; Figure 6). The sonde was nearly lost and was physically battered in June when it dislodged from its moorings.

Downstream DO data were also affected by sedimentation and an equipment communications interface malfunction. Using the reliable (edited) data available, DO daily averages varied from 5.5 mg/L to 10.5 mg/L, but averaged 8.3 mg/L for the season, similar to the upstream average. Downstream values closely paralleled upstream DO during reliable periods of data collection (Figure 6). The maximum daily average DO (mg/L) was 10.1 mg/L and 10.3 mg/L for upstream and downstream, respectively, and the minimum was 6.7 mg/L and 5.4 mg/L for upstream and downstream, respectively (Table 2). The largest daily average DO difference between upstream and downstream was 2.07 mg/L on (August 19). There were no other daily differences that exceeded 2.0 mg/L during the season.

Poor DO data quality in the downstream probe from approximately June 29 to July 28 was caused by sedimentation. Malfunction of the sonde, due to sonde/computer interface communication issues, resulted in no data collection from the downstream sonde from July 28 to August 10. The sonde was replaced with a different sonde from August 10 to August 20. Following repair by the manufacturer, the original sonde was restored at the downstream location

on August 20 and functioned normally until the end of the study. To compare the data collected from two separate sondes, both the replacement and the original sondes were placed at the downstream location from August 20 to August 28. The same type of DO data gap occurred with the duplicate instrument at the Badger downstream location on August 23 (Figure 10). Field observations suggest that the cause for the parallel, but independent data gaps, was likely sediment exposure. We are recommending modification to the station location and/or sonde anchoring system for 2016, and details are discussed in Section 4.0. The modified data set excludes all data gaps (outages) and unreliable readings based on biased values associated with damaged/buried probes. Table 9 summarizes the interpreted causes and time periods when data were lost or edited out as unreliable for all data collected in 2015 including Badger downstream DO.

Conclusions: The data show Fox River DO varies from about 6 mg/L to 13 mg/L over the summer but is nearly identical and synchronous upstream and downstream of Kaukauna Dam, rarely differing by 2 mg/L (Figure 6). Daily data demonstrate Badger Hydro meets WQMP criteria for absolute (5 mg/L minimum DO) and no more than 2 mg/L average difference for 5 consecutive days.

3.3 Temperature Data - Badger

Figure 7 shows daily average temperature data and the discharge in the Fox River during the study period. The seasonal low temperatures at the three sensors were all near low of 20°C (50°F) in June and September. The summer range fluctuated between 22°C (72°F) and 27°C (81°F) from mid-June to early September.

Upstream, downstream and bypass daily average temperatures (Figure 7) are nearly identical every day of the season. Table 2 provides details of the data showing an average daily difference between upstream and downstream is less than 0.1°C. Hourly temperature patterns are similar to daily averages with diurnal sawtooth patterns visible (Figure 3; Tables 2 and 3).

Hourly and daily graphs verify that there was not a single day in which upstream daily temperature of any of the sensors exceeded 27°C (81°F). From July 29 to August 9, there were no downstream temperatures recorded due to a malfunctioning sonde. The data set is comprised of: 105 daily temperature averages upstream and 95 daily temperature averages downstream. There were 74 daily temperature averages in the bypass due to data gaps early and late in the season when high flows prevented safe data retrieval at this location.

Conclusions: Available daily data at all three locations confirm that the Badger Hydro meets WQMP criteria for temperature (31.5°C/89°F). There was no variation in daily averages among the three sampling locations when data were available.

3.4 pH Data - Badger

Data gaps were observed at all three locations sporadically through most of the season (Table 9), but never concurrently at all three locations during the season (Figure 8). Thus every day pH was recorded, but not always at all three locations. Daily averages were computed for a total of

88, 95, and 78 days for the upstream, downstream and bypass reaches, respectively. Accordingly, there is a reasonably complete record of pH at the combined locations.

The combined data corroborate that daily average pH ranged from lows of 8.0-9.0 and 8.1-9.1 for upstream vs. downstream locations, respectively. The pH exceeded 9.0 only on the last five days of the season at both the upstream and downstream sites (Table 2). The seasonal average pH at the upstream (8.7) and downstream (8.6) were nearly identical as were daily differences (Table 2). Averaged daily minimums and maximums differed by 0.4 and 0.6 pH units respectively for the season (Table 2). On only 2 days (June 15-16) did upstream and downstream average pH differ by more than 0.5 pH units (Table 2 and Figure 8). These data are suspect because the pH probe was later found (during calibration on June 29) to have been fouled by a macroinvertebrate that had apparently crawled into the probe.

Values also remained constant from day to day at both sondes changing only 0.0-0.2 pH units at both upstream and downstream locations (Tables 4 and 5).

Conclusions: Although some daily average pH values exceeded 9.0 during the study, seasonal averages were less than 9.0. The pH of the Fox River is at times "naturally" in excess of 9.0 when algae are abundant (summer). The calcium/magnesium rich geology of the Fox River also contributes to atypically higher pH (alkalinity) compared to other Wisconsin streams. Hence, pH > 9.0 should not be considered unnatural for this watershed (https://www.uwgb.edu/watershed/data/monitoring/ph.htm).

3.5 Calibration and Performance of Badger Upstream, Downstream, and Bypass

3.5.1 Calibration Technique

Tables 10, 11, and 12 summarize the Badger calibration data for upstream, downstream, and bypass sondes, respectively. Performance and calibration data are provided for three variables plus conductivity (Figures 5 and 9). (Conductivity is used by the Hach technology to compute DO values.) Temperature did not require calibration or adjustment during the study period.

GEI followed Hach calibration techniques every download period. Typically the probes were visibly contaminated with sediment and algae that needed cleaning at each calibration download; less so when intervals were one week compared to two weeks. After the probe was cleaned, the instrument was electronically "recalibrated" and the "restored" instrument calibration difference was also recorded. These represent the "in-check" and the "post-cleaning" data in the calibration tables.

After the data were compiled, they were reviewed and tabulated. The pre-cleaning (in-check) and post-cleaning measurements were recorded and expressed in % difference from standards. For example the LDO Hach probe has an accuracy of 0.2 mg/L. A reading of 8.0 is not statistically different from 7.8 to 8.2. Differences greater than 0.4 mg/L would be considered measurably different. Accuracy for conductivity probe was +/- 0.5%; and pH probe was +/- 0.2 pH units. Thus, any differences less than the accuracy of the instruments would be equivalent to no statistical difference.

3.5.2 Conductivity Calibrations Badger Upstream

The conductivity calibrations of Badger Upstream (Table 10) showed moderate to significant instrument drift at times during the study with 8 readings out of 15 outside the standard of 0.5%. The data appear distinctly low early in the season when conductivity ranged from 350 to 360 µS/cm compared 400 to 450 µS/cm most of the season (Figure 5). Post-cleaning calibrations were mostly within the standard of 0.5% (12 of 15 = 80%). Inability to calibrate the upstream sonde was chronic and led to replacement of the sonde three times during the study and after which data was good for several weeks before subsequent failure; pH in particular was problematic (see Section 3.5.4)

3.5.3 Dissolved Oxygen Calibrations Badger Upstream

The in-check difference of Badger Upstream dissolved oxygen calibrations ranged -2.6% to +3.6% with an average of +0.15% prior to cleaning. Thirteen of fifteen calibrations (87%) were within the accuracy of the instrument (0.2 mg/L). Post-cleaning statistics were even better: 13 of 13 calibrations (100%) were within the accuracy of the probe. Accordingly, DO calibrations exceeded the WQMP variance criterion goal of less than 1 mg/L 70% of the time (Table 10).

3.5.4 pH Calibrations Badger Upstream

Although in-check calibrations for 2 of 14 sample periods failed the probe accuracy of +/- 0.2 pH units relative to the 7.0 standard (6.80-7.20), post-cleaning all of the calibrations passed (100% calibrated within standard). The pH calibration failed on July 28 and the sonde was removed for maintenance and replaced by another unit. Twelve of fourteen (86%) in-check and 13 of 13 post-check (100%) thus met the standard of 70% of the samples within calibration standard. Criteria for pH 10 standard were met in all (100%) of the samples for in-check and post-cleaning calibrations (9.8-10.2) with exception of one gross (data loss) failure in each, again requiring probe replacement (Table 10). Values also remained constant from day to day at both sondes changing only 0.0 - 0.2 pH units at both upstream and downstream locations (Tables 4 and 5).

3.5.5 Conductivity Calibrations Badger Downstream

The in-check and post-cleaning conductivity calibrations of Badger Downstream (Table 11) were within the instrument accuracy of 1% (+/- 0.5%) in 10 of 14 sample periods (71%). All four failures were associated with gross failures (and sonde replacement).

3.5.6 Dissolved Oxygen Calibrations Badger Downstream

The variances for the in-check and post-cleaning were within 0.2 mg/L in 9 of 10 (90%) and 11 of 11 (100%) sample calibrations, respectively, where data was available. No variances exceeded 3.6% (0.31 mg/L). Accordingly, DO calibrations exceeded the WQMP variance criterion goal of less than 1 mg/L 70% of the time (Table 11). Three failures to calibrate led to the replacement of the sonde at this station (Figure 6).

3.5.7 pH Calibrations Badger Downstream

Both in-check and post-cleaning accuracy of +/- 0.2 pH units relative to the 7.0 standard (6.80-7.20 for the 7.0 standard) were met in the 12 samples where data was available. Failure to calibrate occurred twice in each data set associated with mechanical failure and instrument replacement. In-check and post-cleaning calibrations were also all within the probe accuracy for the pH 10 standard, except for the same two instrument failures (Table 11).

3.5.8 Conductivity Calibrations Badger Bypass (Table 12)

Five of 10 (50%) of the in-check calibrations sampling periods met the probe accuracy of 1% (+/- 0.5%) and only 1 was abnormal. But unexpectedly, post-cleaning calibrations decreased the calibration accuracy to 3 out 10 (30%) in most of the samples suggesting mechanical issues of the probe accuracy (Table 12). The sonde was subjected to severe physical disturbance during high flows when the weighted stabilizer (downrigger) detached from the sonde. Sampling was interrupted and the unit was replaced once during the season.

3.5.9 Dissolved Oxygen Calibrations Badger Bypass

As shown on Table 12, the variances for the in-check and post-cleaning were within 0.2 mg/L in 8 of 9 (89%) and 7 of 9 (78%) sample calibrations, respectively. No variances exceeded 3.0% (0.25 mg/L). Accordingly, DO calibrations exceeded the WQMP variance criterion goal of less than 1 mg/L 70% of the time.

3.5.10 pH Calibrations Badger Bypass

Seven out of 9 in-check sample periods (78%) and 9 out 10 calibrations (90%) in the post-cleaning were within the probe accuracy of +/- 0.2 pH units relative to the 7.0 standard (6.80-7.20 for the 7.0 standard). The only failed calibration was associated with the instrument failure early in the season. For the pH 10 standard, 8 out of 10 (80%) in-check calibrations and 9 out of 10 (90%) post-cleaning calibrations were all within the probe accuracy for (9.8-10.2; see Table 12).

3.6 Summary of Badger Data

Badger met WQMP criteria for temperature and dissolved oxygen in 2015. Temperature never exceeded the 89°F maximum criterion; DO never was less than 6 mg/L, and differences between DO upstream and downstream never exceeded 2 mg/L for more than one day. The pH seasonal averages were less than 9.0 at all three probes. Daily averages on a few days exceeded 9.0, but only slightly. Northeast Wisconsin streams exceed pH values above 9.0 depending on the time of year due to the carbonate geology of the region and algal blooms (https://www.uwgb.edu/watershed/data/monitoring/ph.htm).

Badger instruments encountered frequent physical stresses and these contributed to problems in calibrating the instruments. Most often, the problems were mechanical/electrical in nature leading to probe or total sonde replacement at all three locations and more than once at both upstream and downstream sites. High flows physically damaged the sondes early and late in the

season by tearing stabilizing weights/downriggers from the protective sonde casings, burying sondes in sediment, or causing water leakage or battery failure.

The problem of biofouling causing calibration issues was reduced in 2015 compared to 2014 due to more frequent downloads, probe servicing, and cleanings. Despite the marginal calibrations, the clipped data set demonstrates that there are no significant differences in the water quality upstream or downstream of Kaukauna Dam and the project is meeting the goals of the WQMP.

3.7 Dissolved Oxygen - Data Rapide Croche

The daily average DO levels both upstream and downstream were always greater than 6 mg/L and less than 12 mg/L during the study (Table 13). Rapide Croche upstream and downstream daily DO data were similar through most of the season with a seasonal average difference of 0.23 mg/L (Table 6). Upstream daily average DO (mg/L) for the season was 9.1 (n=105) vs. 8.9 (n=83) downstream. Differences were less than 2 mg/L every day of the study period except on July 12 and 15 when downstream was lower by 2.86 mg/L and 2.88 mg/L respectively. Deviations of 2+ mg/L never occurred on sequential days. The available data show that both variables were tightly correlated throughout most of the season (Table 6).

There were two data gaps in the downstream data during the first 45 days of the study caused by battery failure and leakage (Table 9). There were two segments of unreliable data in the upstream sonde attributed to biofouling in early June (4 days) and mid-August (2 days). There were no data losses from human disturbance of the sonde behind the locked gate as experienced prior to increasing security in 2014.

Conclusions: Available daily DO average (mg/L) met the WQMP criterion of 5.0 mg/L minimum at Rapide Croche. There were no cases of even two consecutive days when upstream vs. downstream daily average DO differed by more than 2.0 mg/L. Therefore, DO data met the WQMP criteria.

3.8 Temperature Data - Rapide Croche

Seasonal weather and discharge affect the overall temperatures in the Fox River. These were nearly identical to patterns and extremes observed four miles upstream at Badger. Figure 19 shows upstream and downstream daily temperatures at Rapide Croche were nearly identical except for one day (August 15) when upstream warmed 1°F higher than downstream daily average (Table 6). The graph verifies average daily temperatures never exceeded 26°C (79°F) and thus met the 89°F maximum criterion in the WQMP.

The average daily upstream vs. downstream temperature was 23.5°C (74.3°F) vs. 23.2°C (73.8°F), a difference of 0.3°C (0.5°F).

Hourly temperature patterns are similar to daily averages with diurnal sawtooth patterns visible (Figure 15). Hourly temperatures were more variable in the upstream location, especially during low flow conditions of late July and mid-August when the hourly peak temperatures briefly exceeded 29°C (84°F) on July 27 to August 16 (Figure 15).

Data gaps in downstream temperature were identical as reported for DO when the sonde's battery failed (June 15-29) or water leaked into the sonde (July 20-31). A total of 108 daily temperature averages were documented upstream and 83 downstream. The extremely tight correlations of upstream and downstream make it unlikely that missing data could have contradicted observed data.

Conclusions: Daily and hourly data confirm that the Rapide Croche met WQMP criteria for temperature.

3.9 pH Data - Rapide Croche

The seasonal minimum and maximum daily average pH ranged from of 7.9 to 8.9 upstream and 8.2 to 9.2 downstream (Table 6). The upstream average pH for the season was 8.5 vs. 8.7 downstream with an average difference of 0.2 pH units (Table 6). Minimum and seasonal daily averages meet the WQMP criterion of a pH between 6.0 and 9.0. The pH seasonal maximum was 9.0-9.18 in early July (9 days) and 9.0-9.05 in late September (2 days). Differences between upstream and downstream were always less than 0.5 pH units. Never were daily changes in pH greater than 0.5 pH units either upstream or downstream (Table 7 and 8)

Figure 20 illustrates that pH of the upstream location was predominantly between pH 8 and 9, varying gradually over time. Data gaps in downstream pH were identical as reported for DO and temperature when the sonde battery failed (June 15-29) or leaked (July 20-31). Despite the missing data, daily shifts in pH were always gradual and never more 0.5 pH units or less difference between upstream and downstream on the 83 days when there were data to compare. The maximum daily change upstream and downstream was also less than 0.5 pH units the entire season (Tables 7 and 8). Values also remained constant from day to day at both sondes, changing only 0.0-0.2 pH units at both upstream and downstream locations (Tables 7 and 8).

Conclusion: Rapide Croche upstream probably provided the most accurate pH data set for the season of all the locations in the study. Successful calibration during all events plus no mechanical outages or replacements made it the most reliable record. Although there were data gaps downstream, the majority of the existing data show average daily pH was within 8.0-9.0 and most frequently within 0.1 pH units compared to upstream. The data support a conclusion of no differences greater than 0.5 pH units occurred between upstream and downstream Rapide Croche nor between sequential days. Therefore, Rapide Croche met the criteria of the WQMP during the 2015 sampling period.

3.10 Calibration and Performance of Rapide Croche Sondes Upstream and Downstream

3.10.1 Calibration Technique

Calibration data records for the upstream and downstream sondes are shown in Tables 13 and 14, respectively. Refer to section 3.5.1 for general calibration procedures. Both upstream and downstream units met calibration criteria 90% of the samples when data was available. The upstream unit performed well and was undisturbed during the study as it was inside the confines of the hydroelectric project property. The initial downstream unit was replaced twice more

during the study as a result water leakage and mechanical problems involving data loss (see Appendix E for details). Except on occasions where data were not retrievable, conductivity, dissolved oxygen, and pH calibrated within criteria both upstream and downstream for 11 of 12 samples. Upstream and downstream are discussed together due to similar results for each variable.

3.10.2 Conductivity Calibrations Rapide Croche Upstream and Downstream

The conductivity calibrations for Rapide Croche Upstream (Table 13) and Rapide Croche Downstream (Table 14) showed low instrument drift during the entire study except for initial upstream deployment (6/11 Table 13) above 1% for the in-check calibration and post-cleaning calibration, and the one downstream sample (8/20, Table 14) for the post-cleaning calibration. Both upstream and downstream met calibration criteria in 11 of 12 values (92%) and within 1% (+/- 0.5%) instrument accuracy for the in-check and post-cleaning calibrations. Instrument failures prevented calibrations on two occasions downstream. Moderate levels of conductivity ranged from 350 to 450 µS/cm (Figure 13).

3.10.3 Dissolved Oxygen Calibrations Rapide Croche Upstream and Downstream

The DO calibrations at Rapide Croche Upstream (Table 13) and Rapide Croche Downstream (Table 14) also showed low instrument drift during the entire study with only the upstream initial in-check reading (6/11) and the second post-cleaning reading (6/29) above the 0.4 mg/L (+/- 0.2 mg/L) instrument accuracy. Thus 11 of 12 values (92%) for in-check and post-cleaning are within 1% (+/- 0.5%) instrument accuracy upstream. Instrument failures prevented calibrations on two occasions downstream. Accordingly DO calibrations met the WQMP variance criterion goal of less than 1 mg/L 70% of the time (Table 14).

3.10.4 pH Calibrations Rapide Croche Upstream and Downstream

The pH calibrations for Rapide Croche Upstream (Table 13) and Rapide Croche Downstream (Table 14) for in-check and post-cleaning were all (100%) within the probe accuracy for the 7.0 and 10.0 standards of +/- 0.2 pH units.

4.0 Conclusions

4.1 Recommendations to Improve Data

In 2014, biofouling caused parameter drift of DO and pH at Rapide Croche and Badger downstream stations. We recommended and implemented a more frequent cleaning and probe calibration interval of 7-10 days in 2015. This led to a better data set in 2015. We made improvements from the data losses in 2014 by eliminating vandalism and reducing the effects of biofouling with more frequent calibrations.

The data gaps and false readings that did occur in 2015 came from three major causes: (1) high flows damaged sondes (leakage and battery failure) and made sampling unsafe in the Badger bypass early and late in the sampling season; (2) sedimentation at Badger downstream caused repeated damage to sondes at that location leading to lost data and need for replacement of damaged equipment on multiple sampling periods; and (3) biofouling at Rapide Croche was chronic at the upstream location from both algae and insect invasion of the sondes during the mid-summer season; it affected pH and DO readings.

We are making the two following recommendations for 2016 sampling:

1. Do not install the bypass sampling unit until peak flows are over around July 1. This monitoring station is not critical to hydropower operations because flows are not subject to the hydro units and the discharge levels of 6,000-12,000 cfs significantly reduce any potential for upstream and downstream differences to be meaningful.
2. We recommend relocation of the downstream Badger monitoring station to an area less susceptible to sedimentation and damage from burial in mud (within approximately 50-100 feet of the original station) and/or modifying the attachment such that the sonde would remain suspended above the bottom of the channel.

In 2014, we cited Research from University of Wisconsin at Green Bay which verified that the Fox River is more alkaline than many other Wisconsin streams and therefore, it is not unusual to exceed 9.0 during algal blooms. Although pH did exceed 9.0 in 2015, the exceedances were less frequent and extreme than 2014. We suspect that this is because of better data in 2015 from more frequent cleanings and calibrations. When we eliminate battery failures and leakage, we suspect that pH performed well except for instrument calibration failures at upstream Badger earlier in the season. After unit replacements at most locations and for most variables, we obtained good data.

DO data was biased from repeated biofouling at Rapide Croche upstream. This reservoir is subject to active algal blooms and plant growth. We are recommending repositioning the unit in 2016, as feasible, to an area that may be less subject to plant growth than the trash rack, which accumulates debris and may be more productive for biotic growth.

Hach's latest technology HL4 sondes were deployed in 2015. They are smaller, more compact and have improved electronics and battery life compared to the older MS-5 sondes employed in

2014. Unfortunately, these may also have manufacturing issues that caused several problems including leakage, battery failure and calibration issues. Hach was responsive in providing assistance including loaner instruments and replacements at no additional cost. They also participated in troubleshooting issues during the season. We expect the combined relocation of instruments plus experience gained in 2015 will lead to less frequent data gaps in 2016. These will come from new deployment locations, continued calibration/cleaning frequency, and design improvements in the replacement instruments provided by Hach.

4.2 Conclusions

This is the second year of a three-year sampling program. The goal of the program is to determine whether operations of the new Badger-Rapide Croche Hydroelectric Project are meeting the WQMP criteria established by FERC in its Order for New License.

The data provide confidence that the projects in 2015 met the WQMP criteria as follows: (1) average daily temperatures were within the natural range of the river and no greater than 89°F; (2) average daily dissolved oxygen was always above 5 ppm (mg/L) with upstream and downstream differences greater than 2 mg/L never occurring on any sequential day (5 days is the criterion); and (3) pH ranges were between 8.0 and 9.0 except for a few days when pH drifted to as high as 9.18. The natural carbonate geology of the Fox River basin and summer algal blooms can produce pH values above 9.0, but this was observed rarely and at levels less than 9.2 daily average.

Sonde and probe malfunctions occurred and caused data gaps; however, no variable provided less than 83 days of data at Rapide Croche or Badger upstream and downstream locations. Collectively, complete records were obtained for every variable for the entire season—i.e., there was never any day when pH, DO, and temperature were not available at one of the monitoring stations. Daily averages from the collective data set were always in compliance with the WQMP. Further, the correlated patterns and close relationships of the upstream and downstream variables during the 83-105 days when comparative data were available support the conclusion that no criteria were ever violated.

Calibration goals were met at most stations for most variables. When calibrations were not met, it was either the exception, or in the case of Badger upstream and downstream, the result of repeated instrument malfunctions disabling calibration or a total data loss on multiple sample periods throughout the study.

Despite the missing data and sonde outages, the trends and the existing data all show similar upstream and downstream values consistent with WQMP criteria. In summary, we conclude that the Badger and Rapide Croche projects are have met the WQMP criteria for the second year of the sampling period. We will look forward to discussion or questions about the proposed improvements recommended for sampling and improving calibration in 2016.

Appendix A

Figures (Clipped Data)

Figure 1. Sonde locations
Badger-Rapid Croche, FERC No. 2677 on the Fox River in Kaukauna, WI

Figure 2. Hourly Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

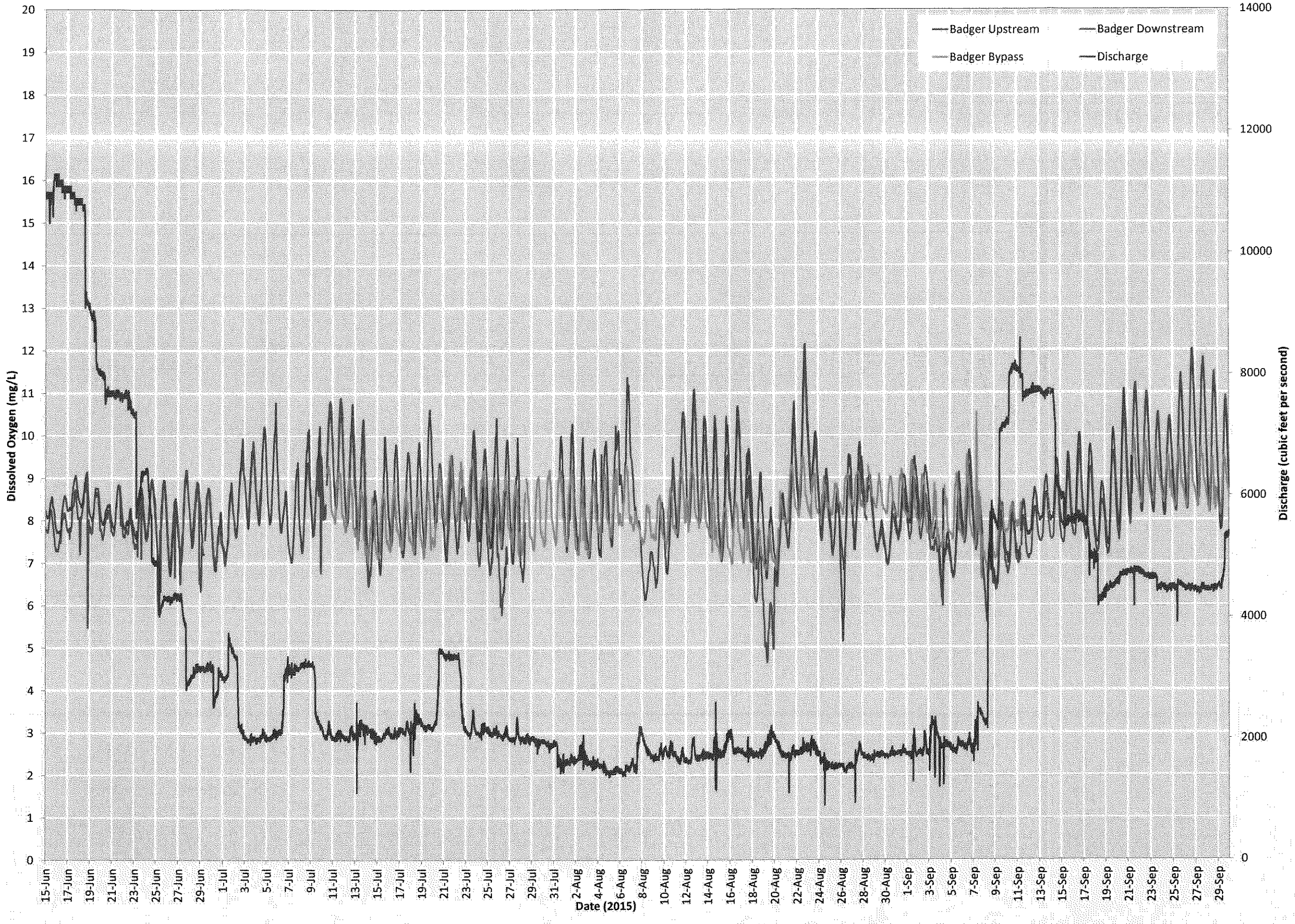


Figure 3. Hourly Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

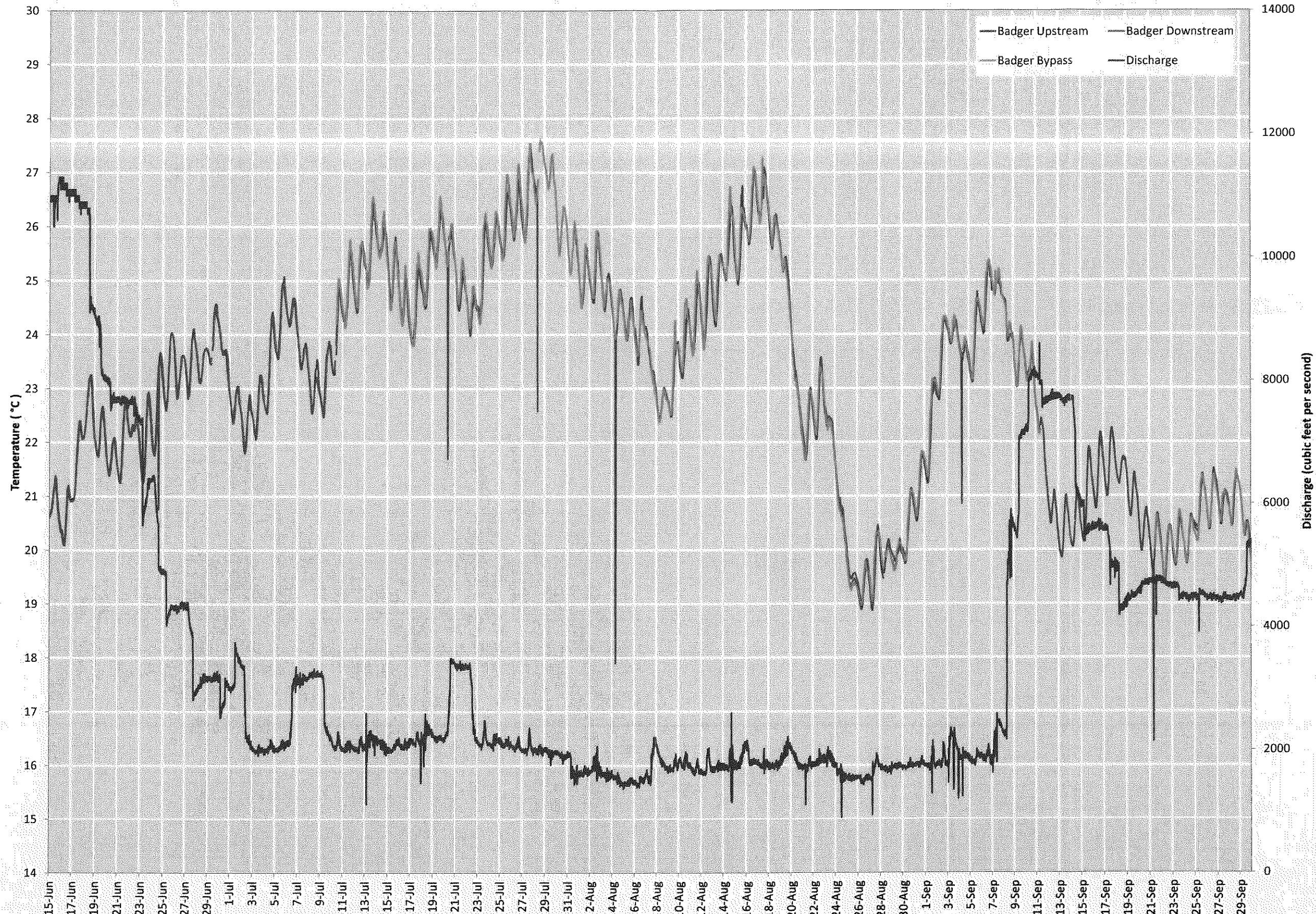


Figure 4. Hourly pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

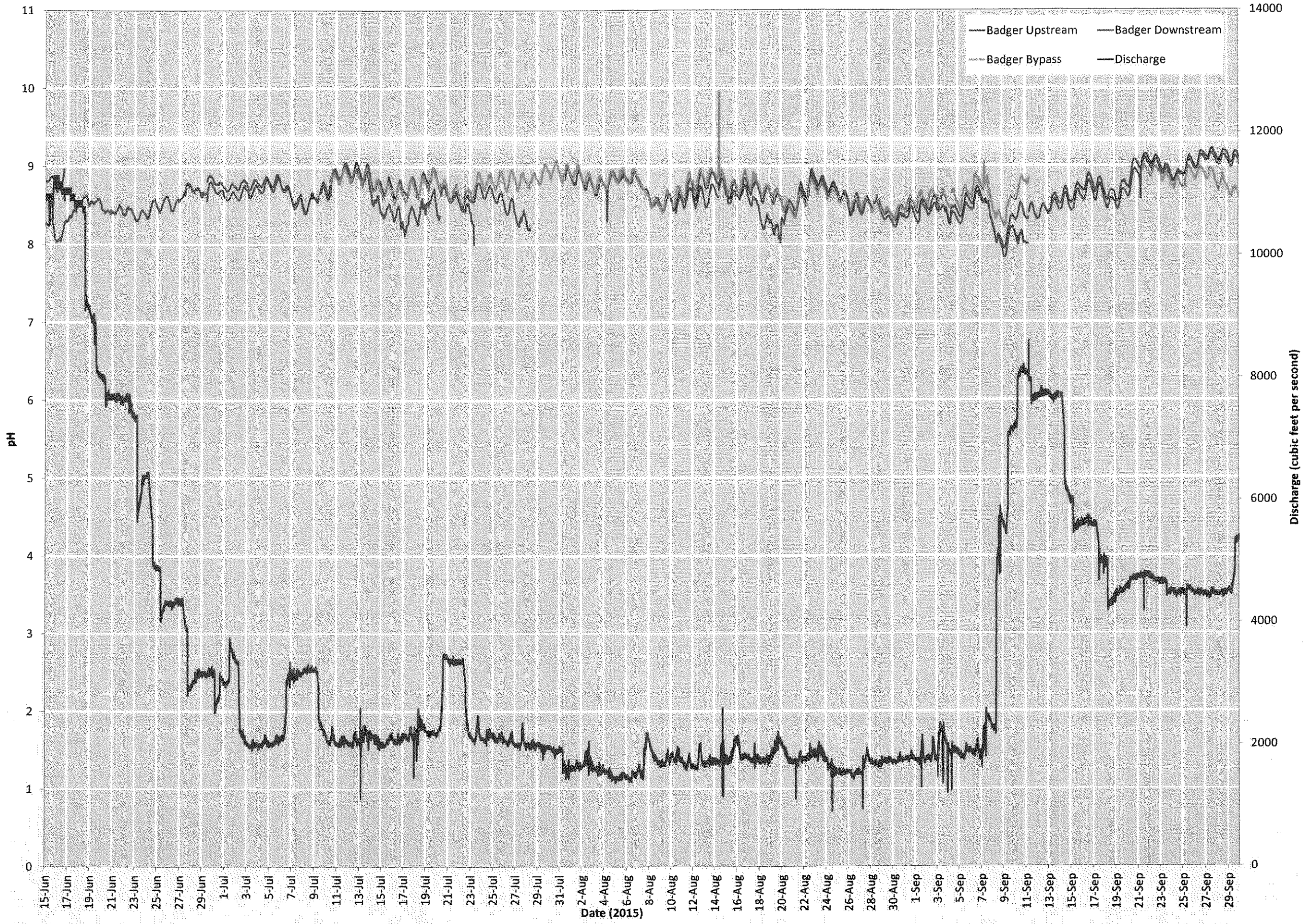


Figure 5. Hourly Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

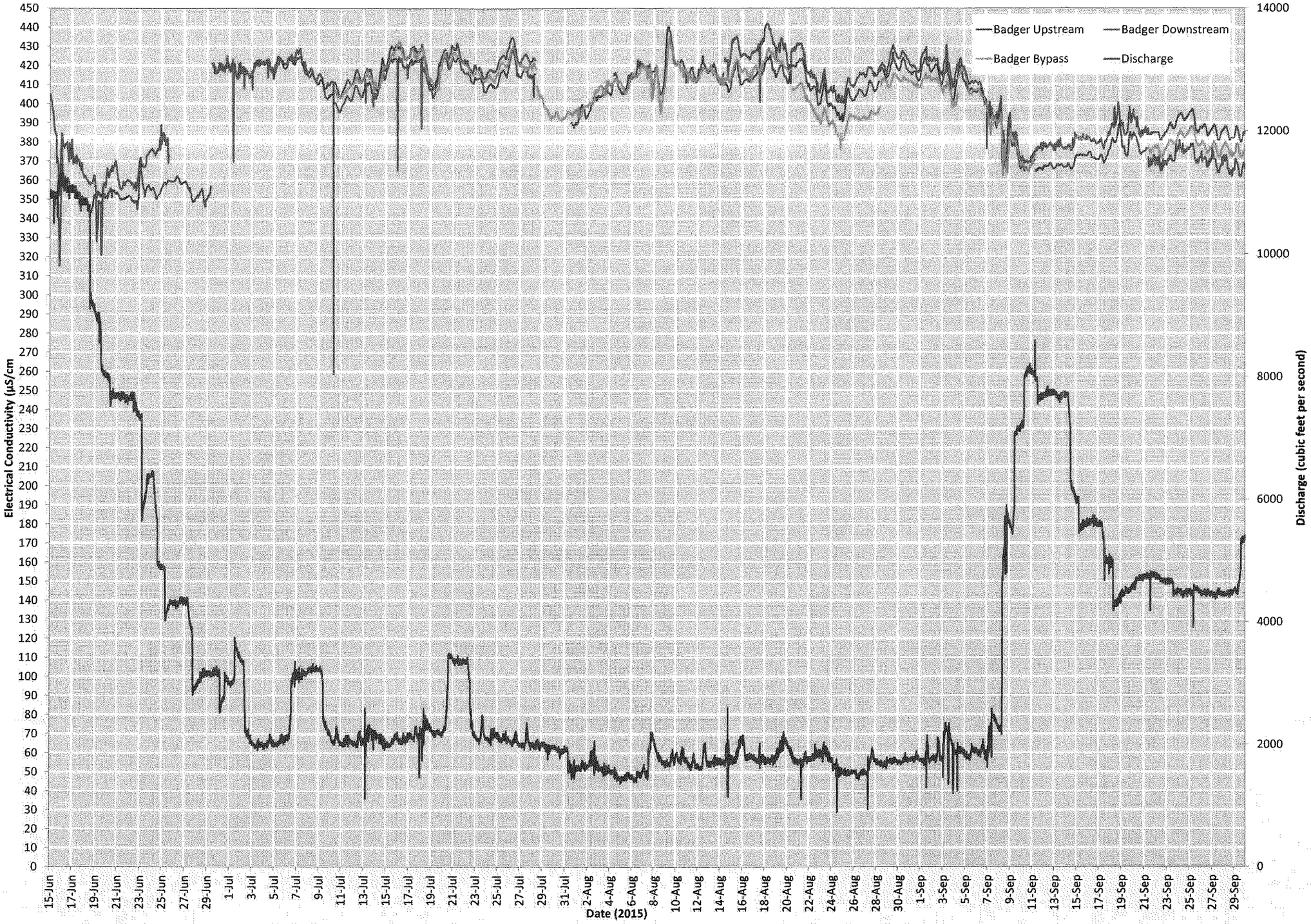


Figure 6. Daily Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

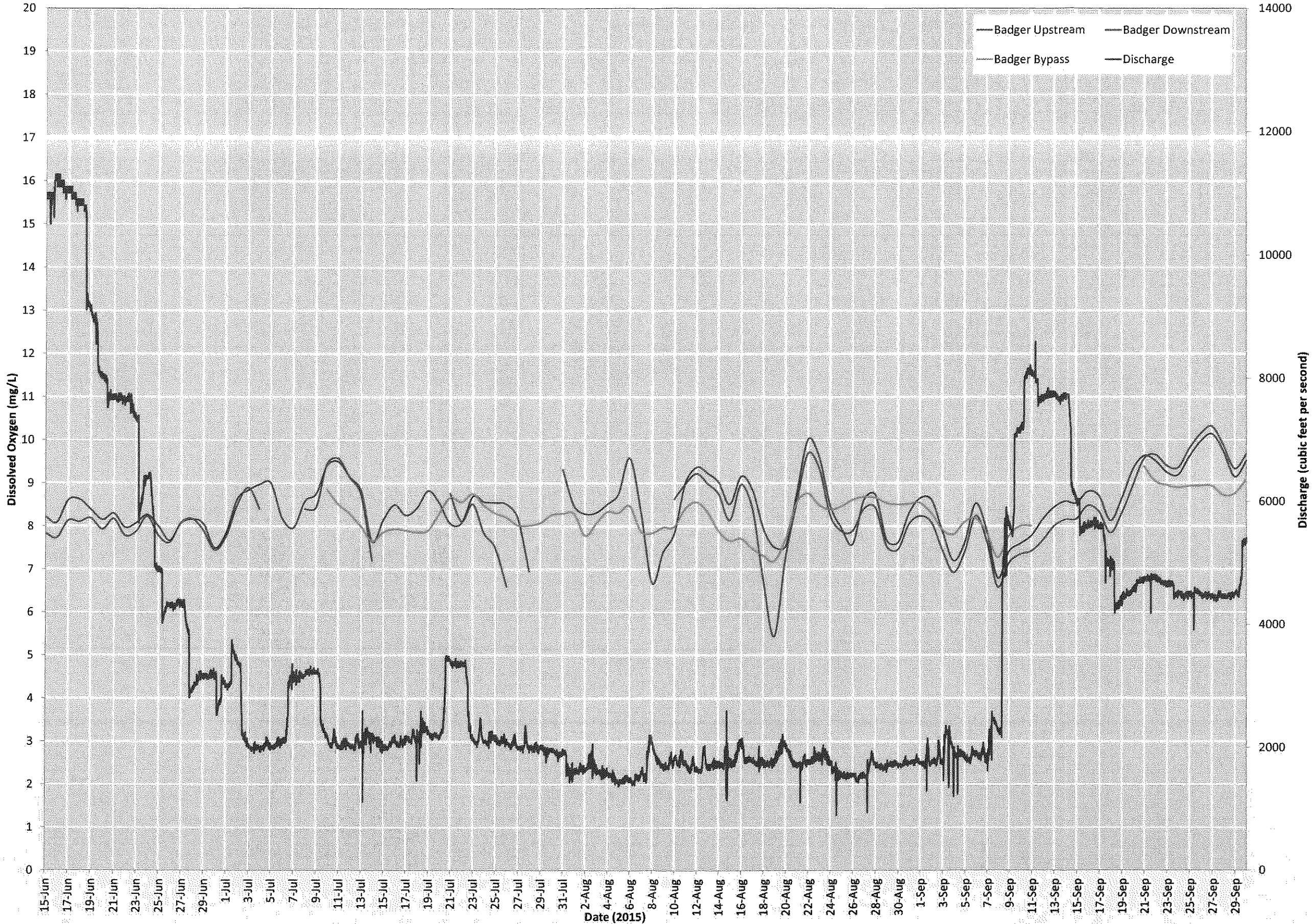


Figure 7. Daily Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

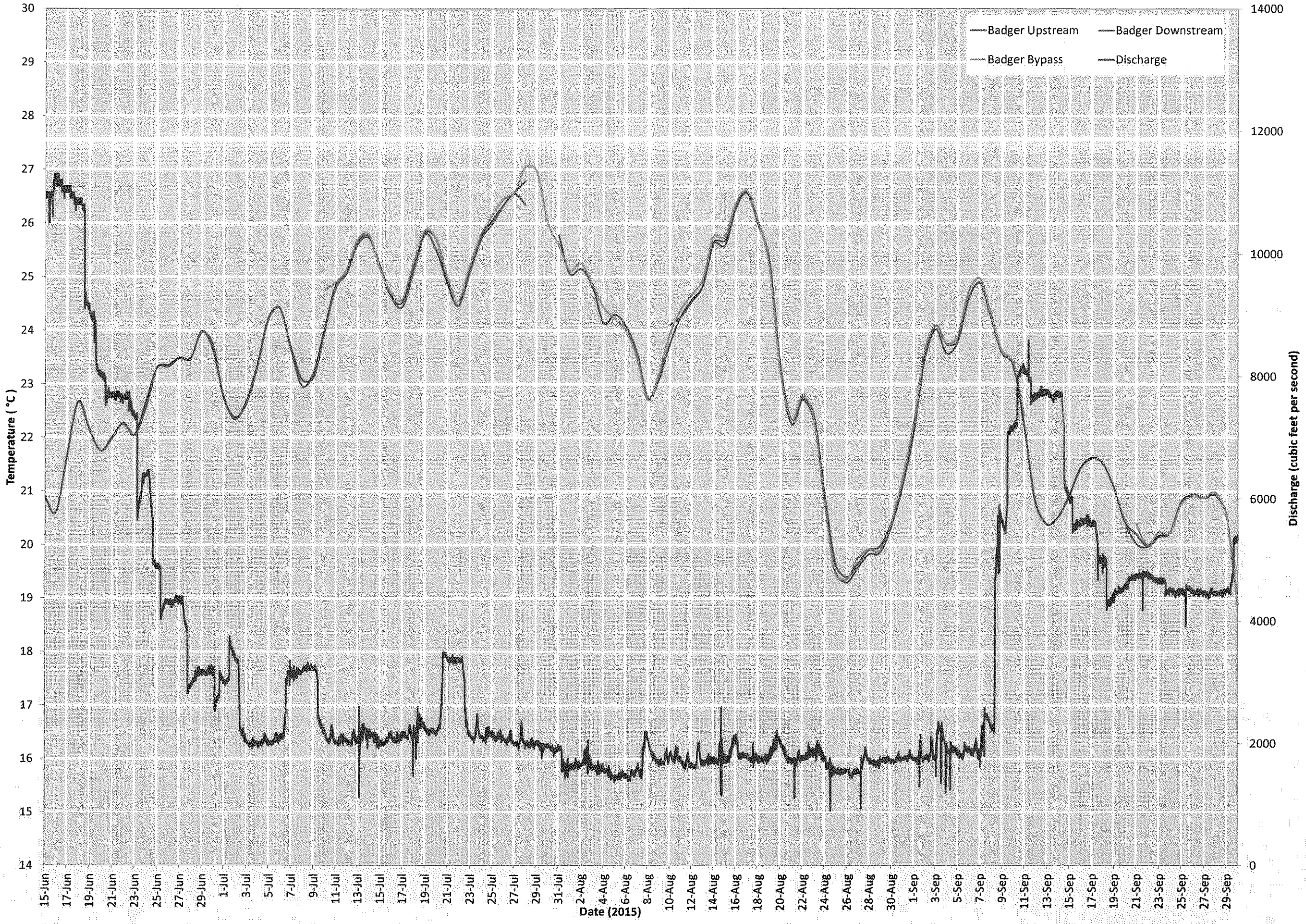


Figure 8. Daily pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

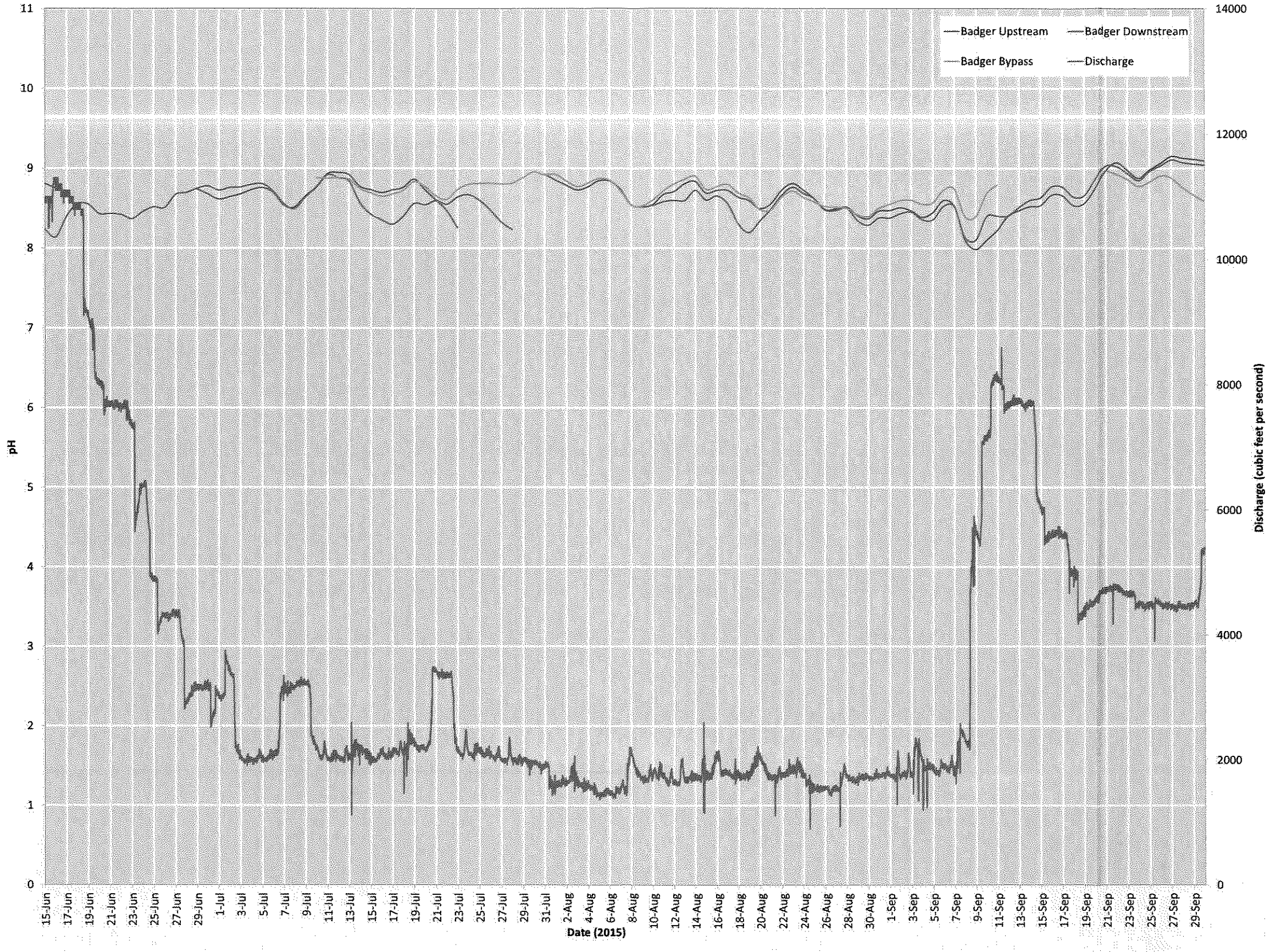


Figure 9. Daily Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

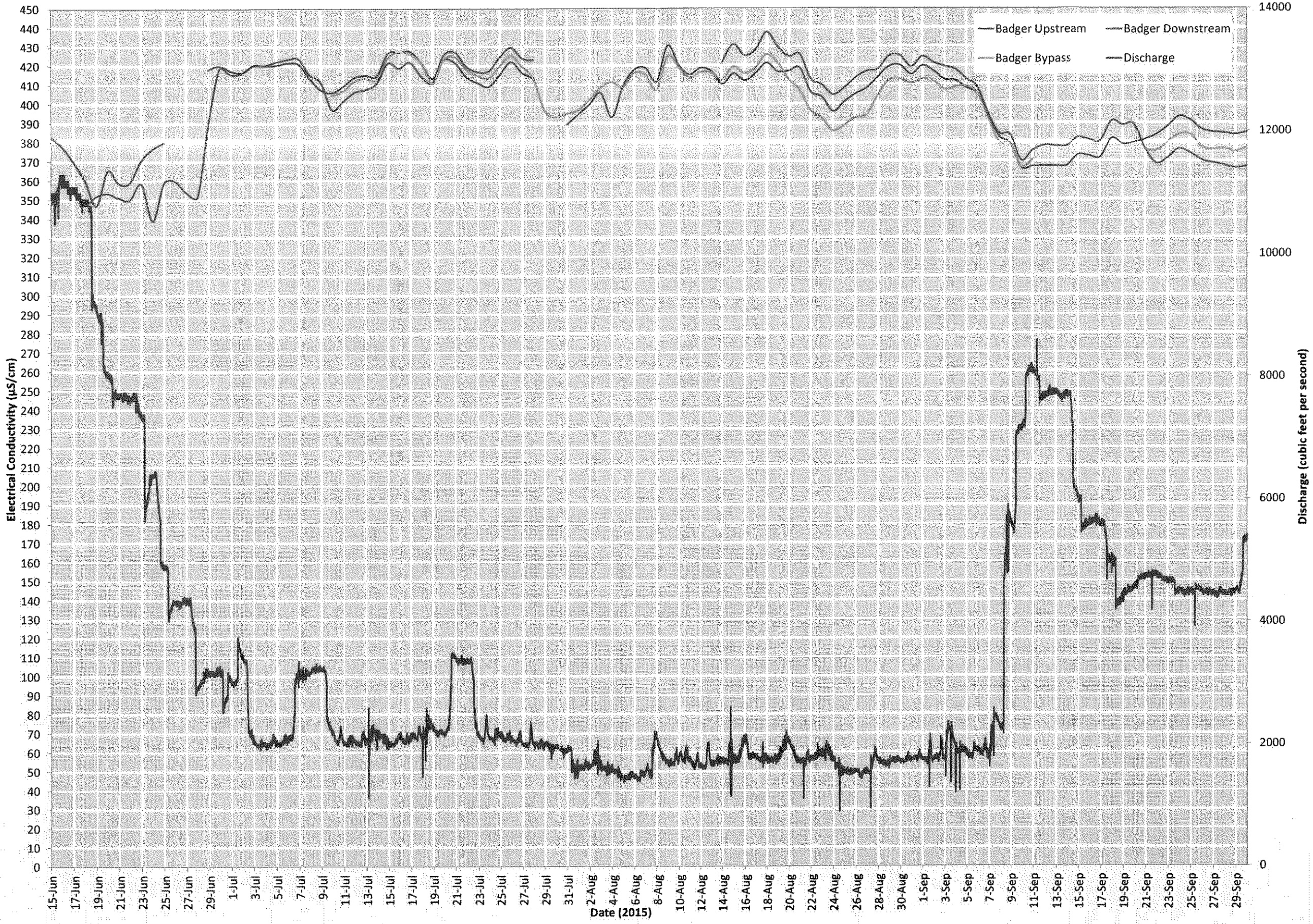


Figure 10. Hourly Dissolved Oxygen Readings, Upstream, Upstream Loaner Sonde, Downstream, and Downstream Loaner Sonde of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

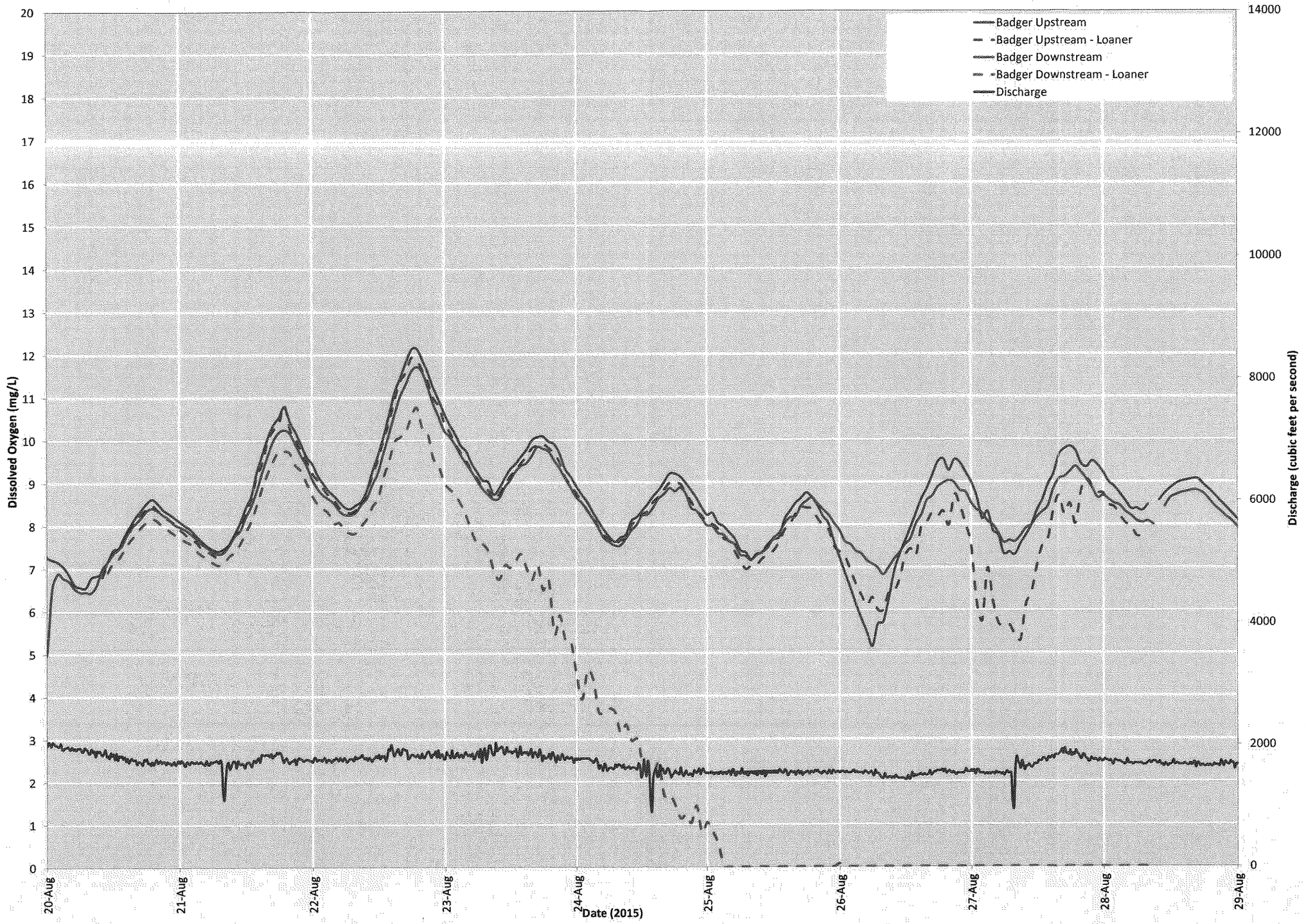


Figure 11. Hourly Temperature Readings, Upstream, Upstream Loaner Sonde, Downstream, and Downstream Loaner Sonde of the Badger Hydroelectric Plant FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

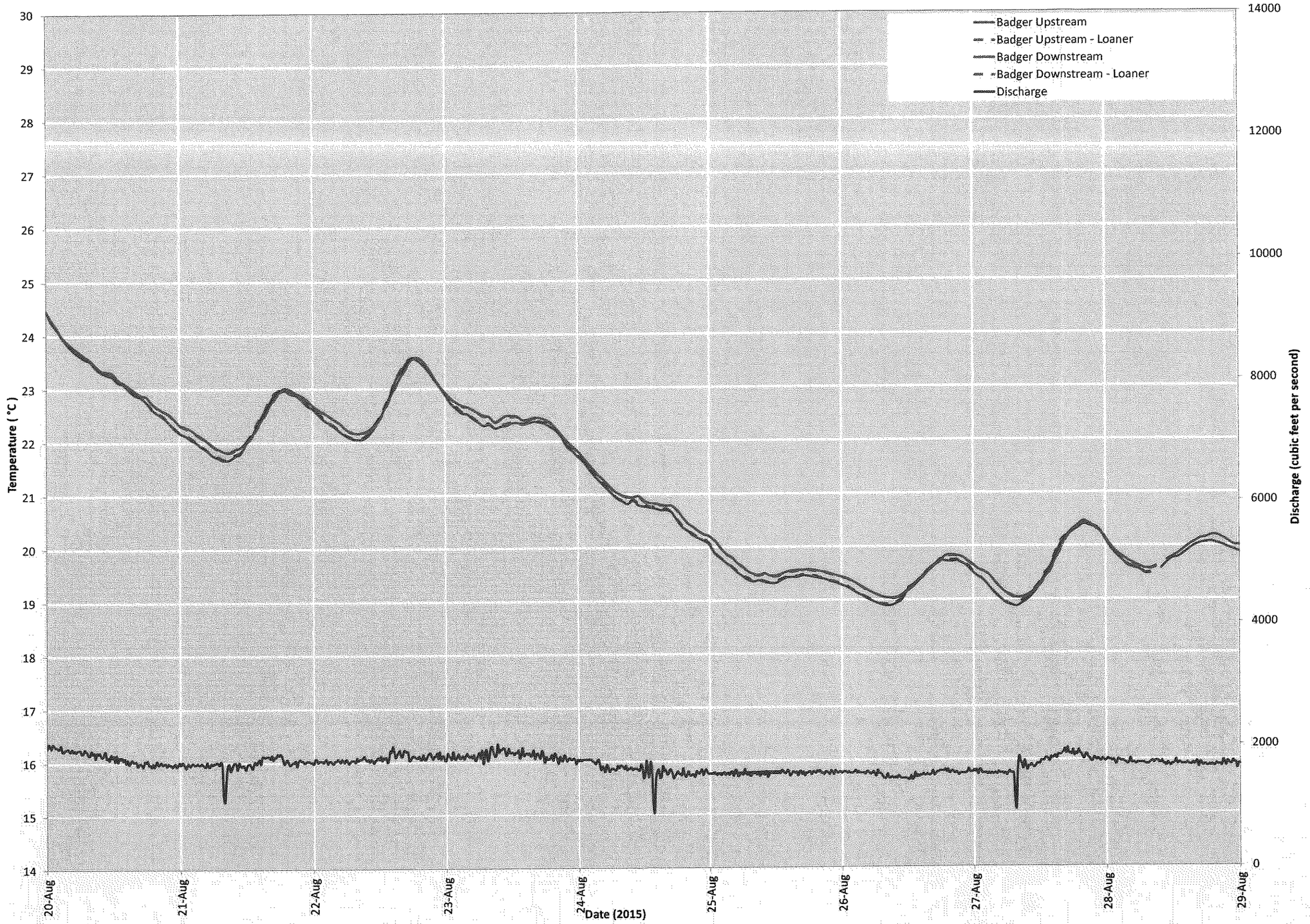


Figure 12. Hourly pH Readings, Upstream, Upstream Loaner Sonde, Downstream, and Downstream Loaner Sonde of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

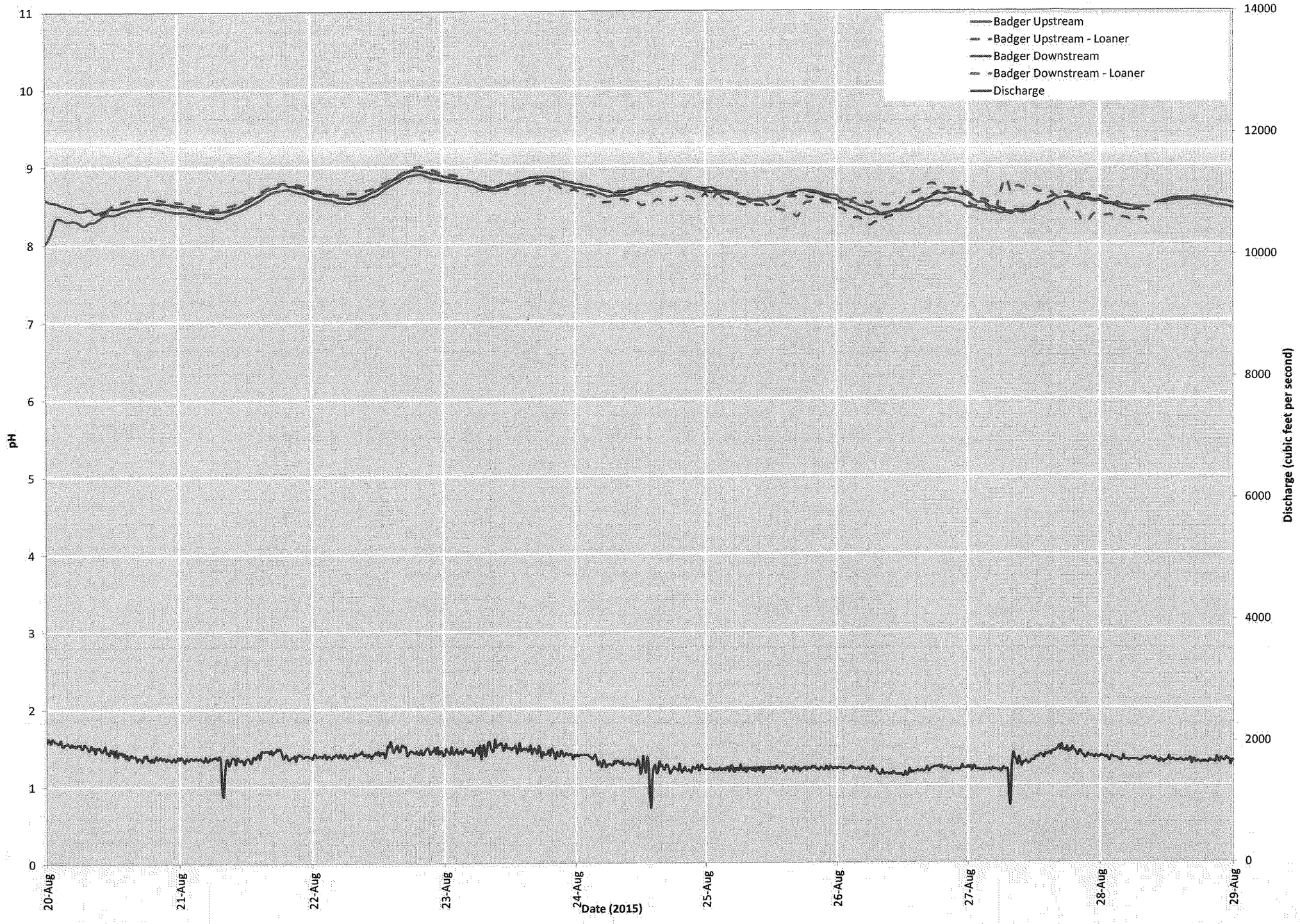


Figure 13. Hourly Electrical Conductivity Readings, Upstream, Upstream Loaner Sonde, Downstream, and Downstream Loaner Sonde of the Badger Hydroelectric Plant FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

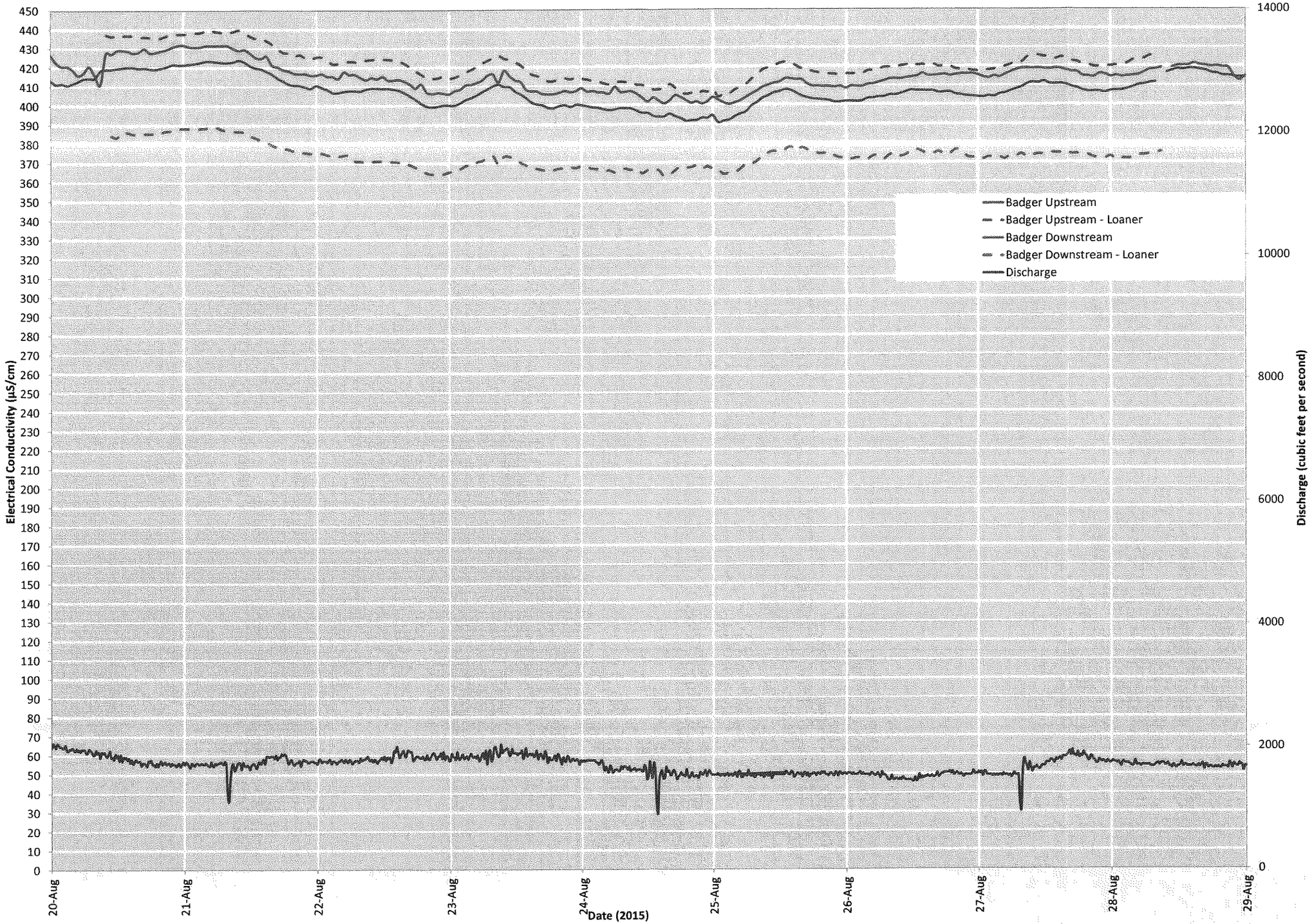


Figure 14. Hourly Dissolved Oxygen Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

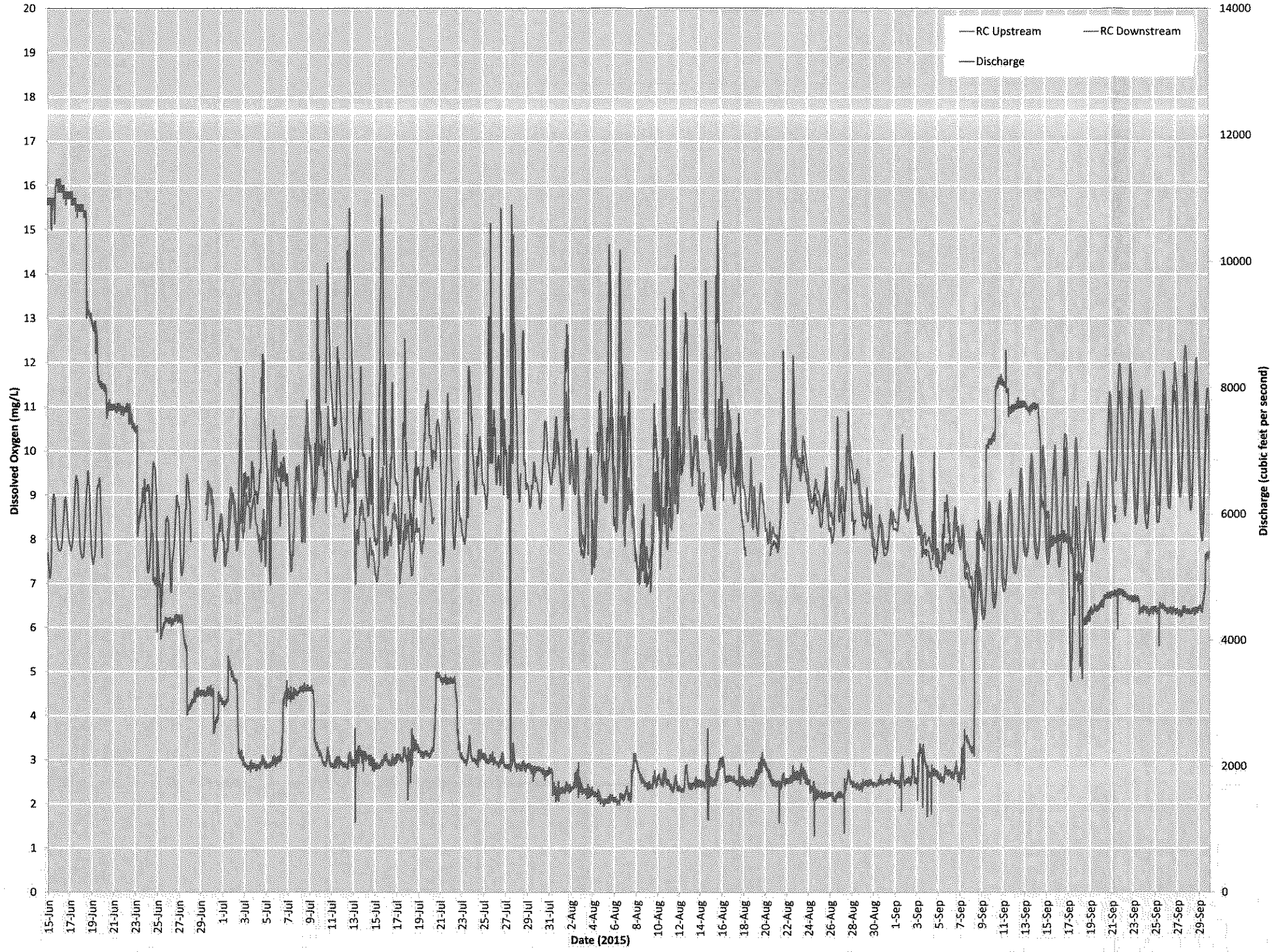


Figure 15. Hourly Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

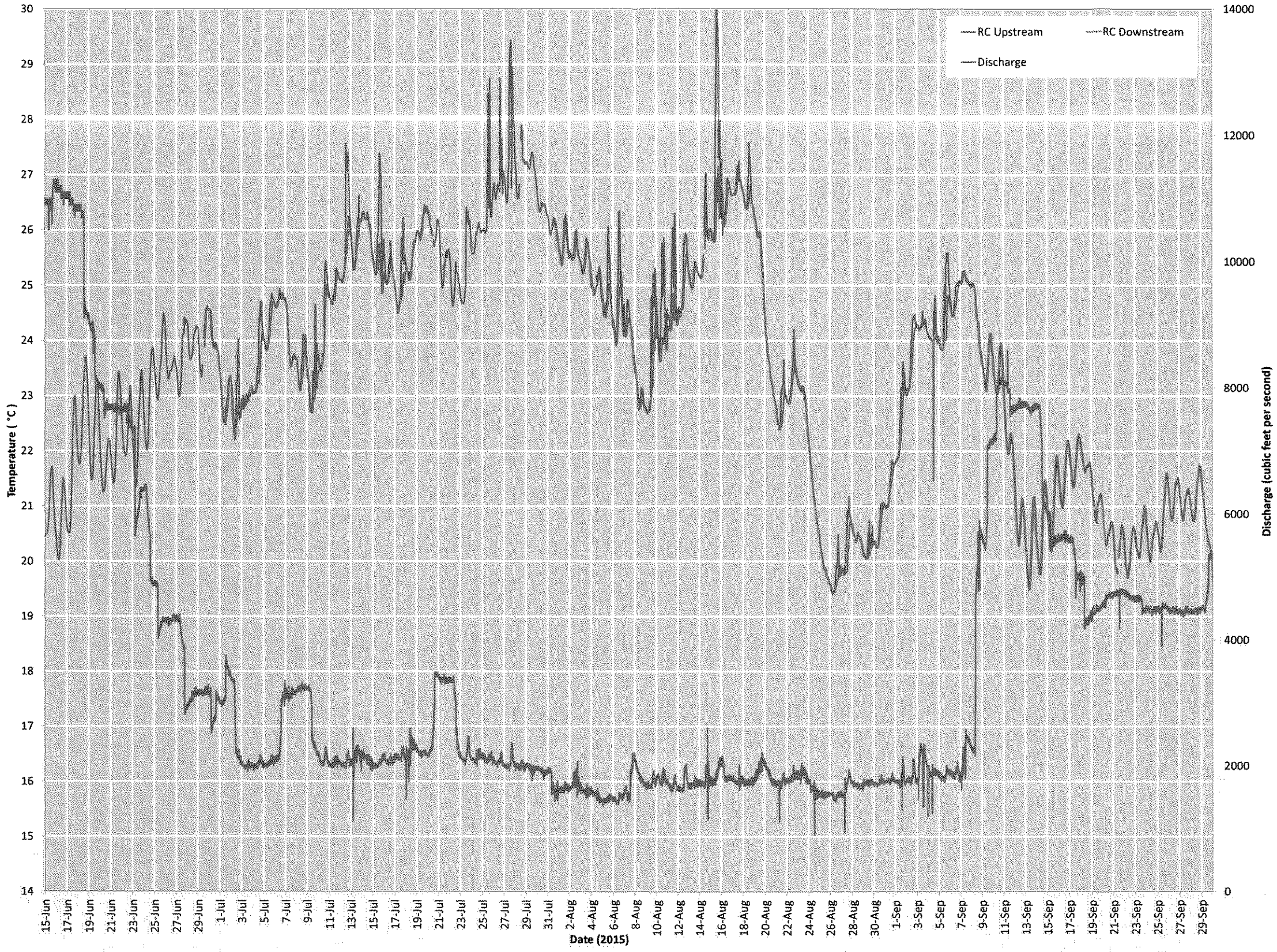


Figure 16. Hourly pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

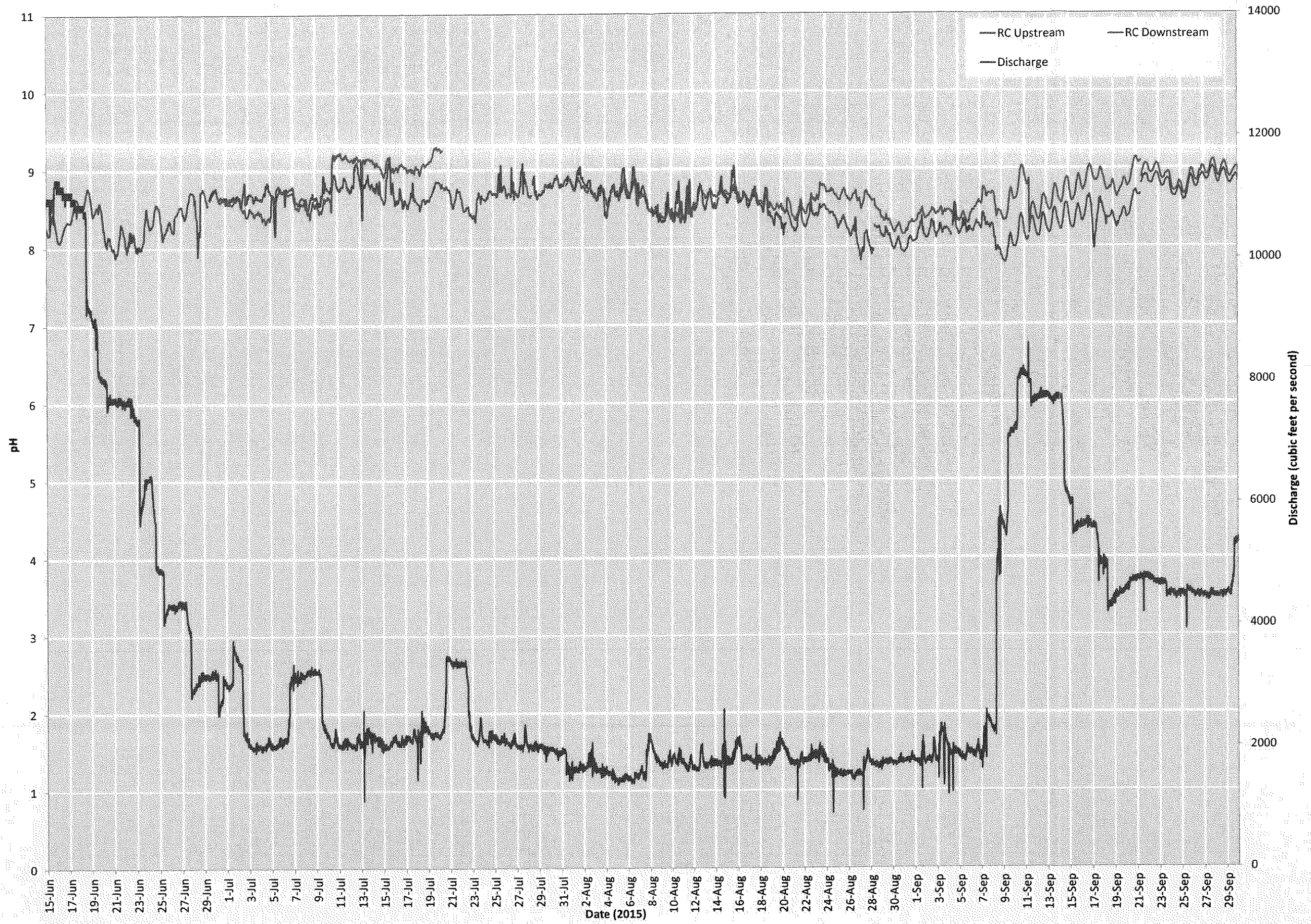
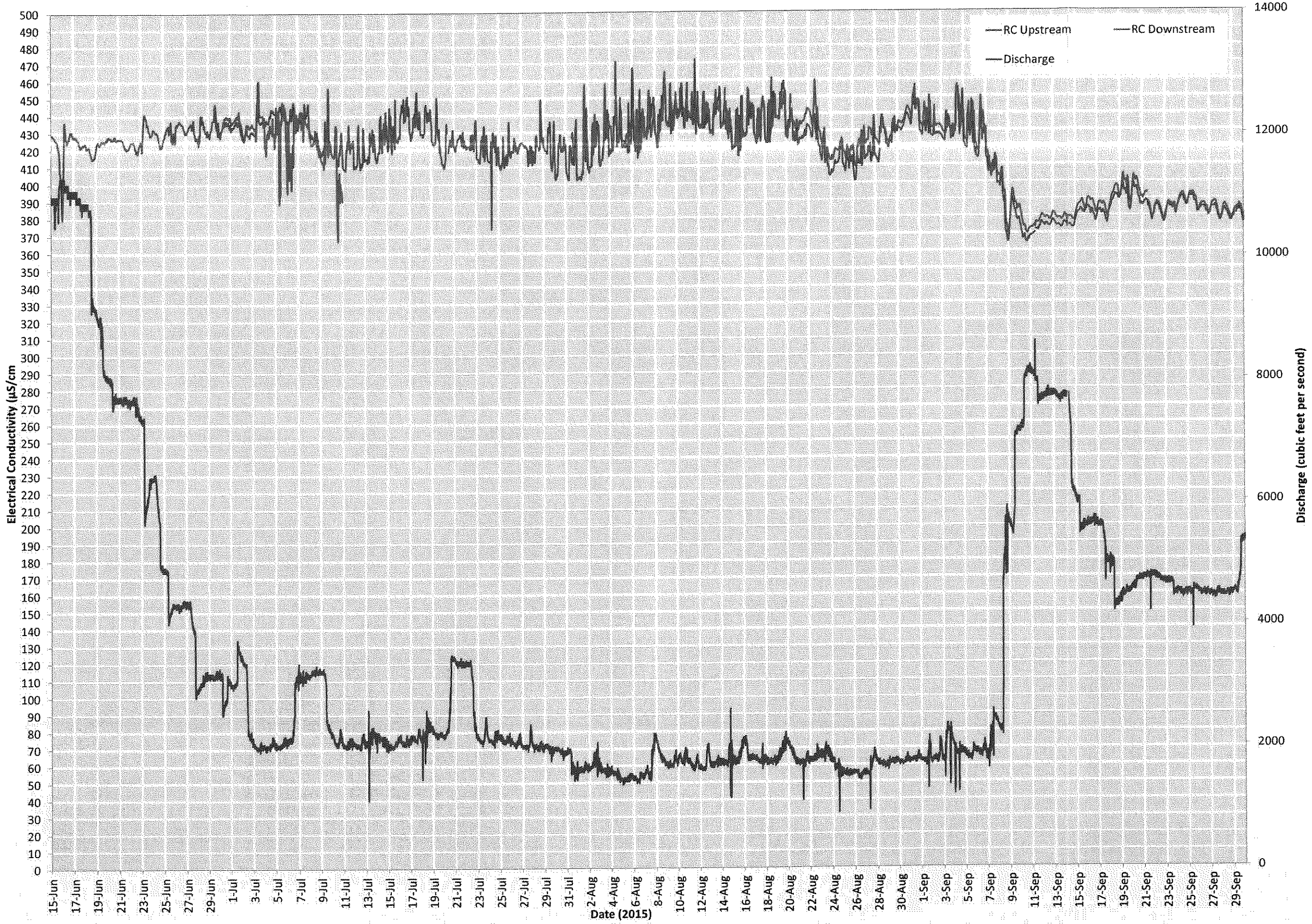


Figure 17. Hourly Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin



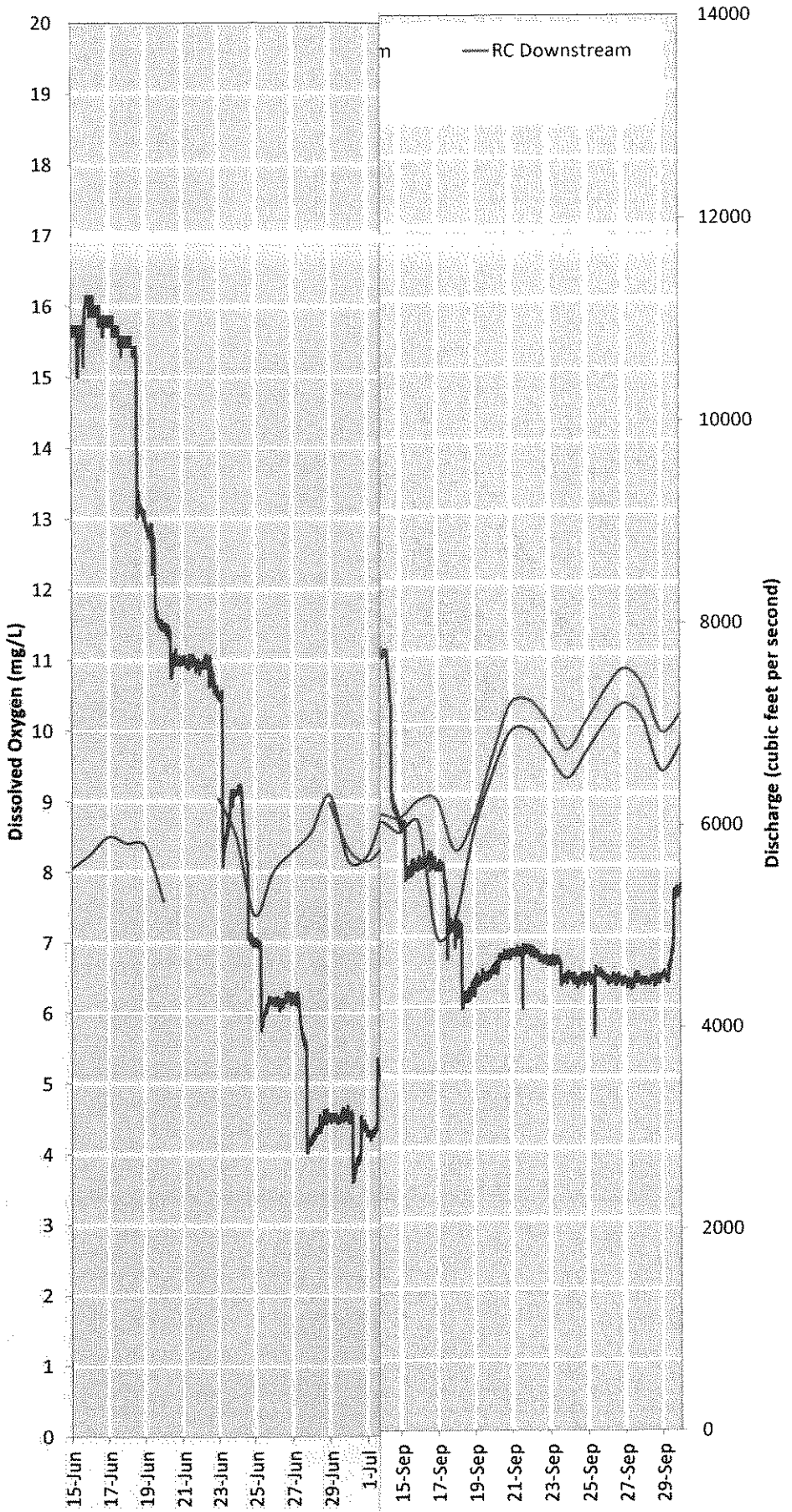

RC Downstream
Dissolved Oxygen (mg/L)
Discharge (cubic feet per second)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
2000
4000
6000
8000
10000
12000
14000
15-Jun
17-Jun
19-Jun
21-Jun
23-Jun
25-Jun
27-Jun
29-Jun
1-Jul
15-Sep
17-Sep
19-Sep
21-Sep
23-Sep
25-Sep
27-Sep
29-Sep

Figure 19. Daily Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

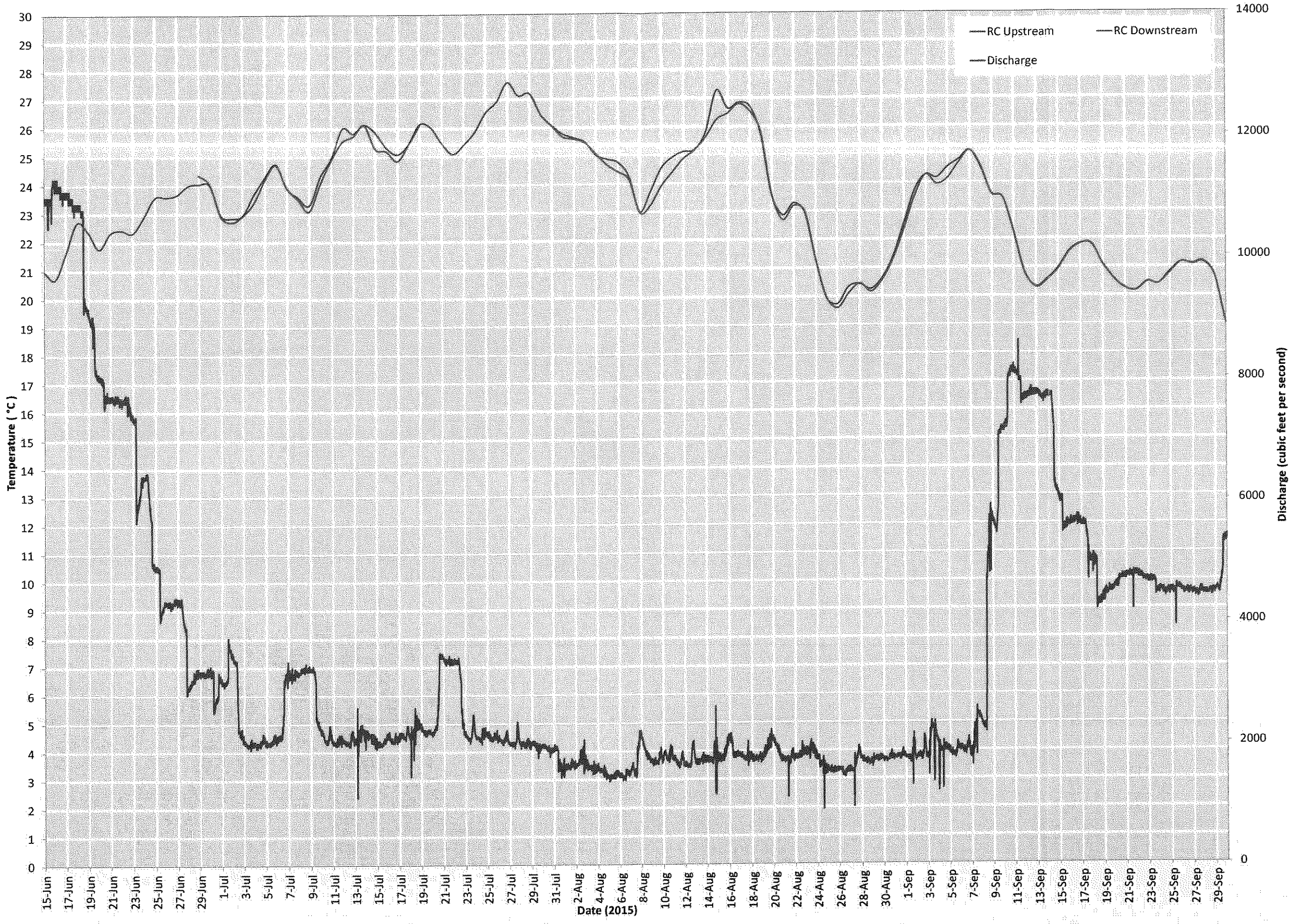


Figure 20. Daily pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

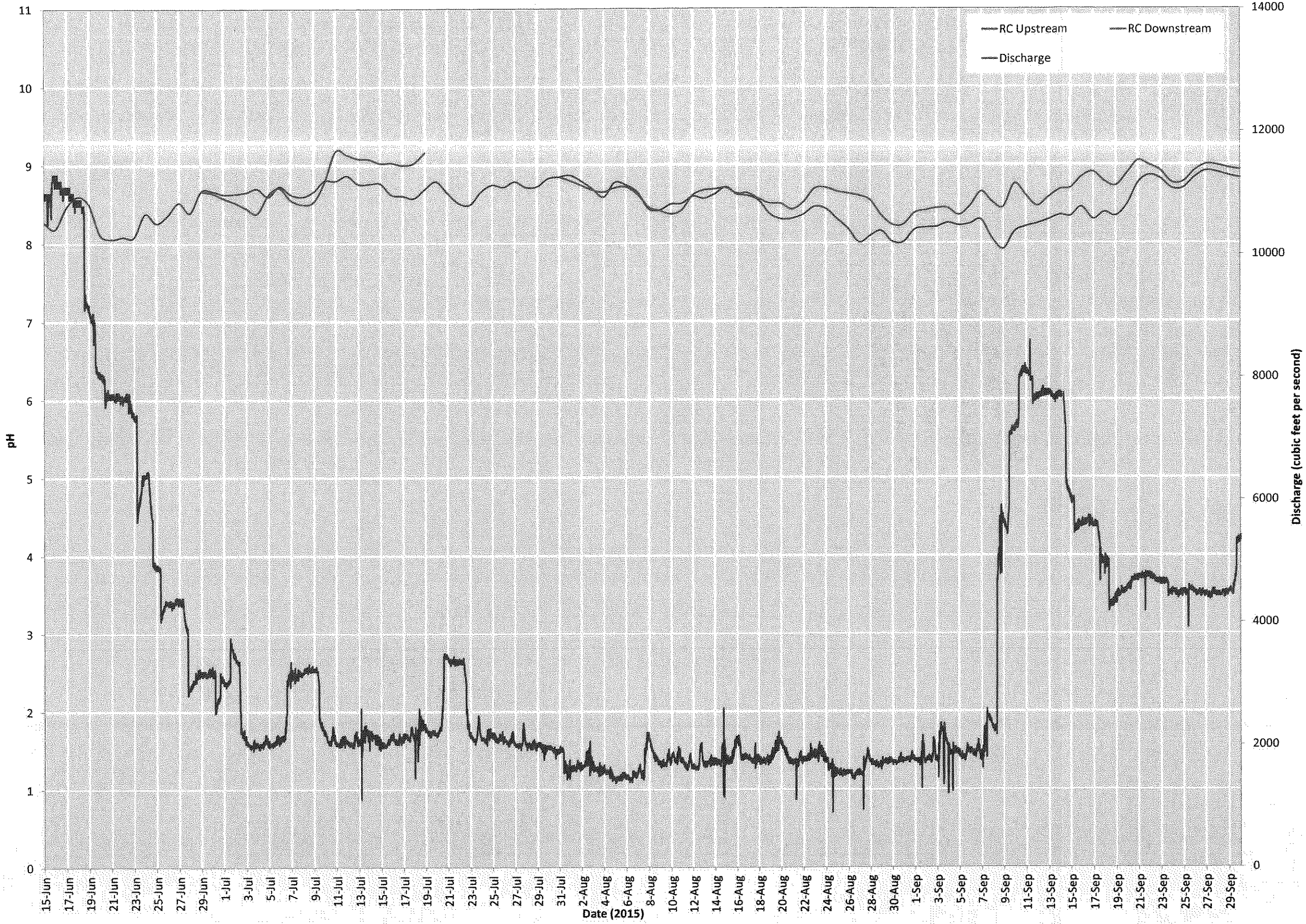


Figure 21. Daily Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

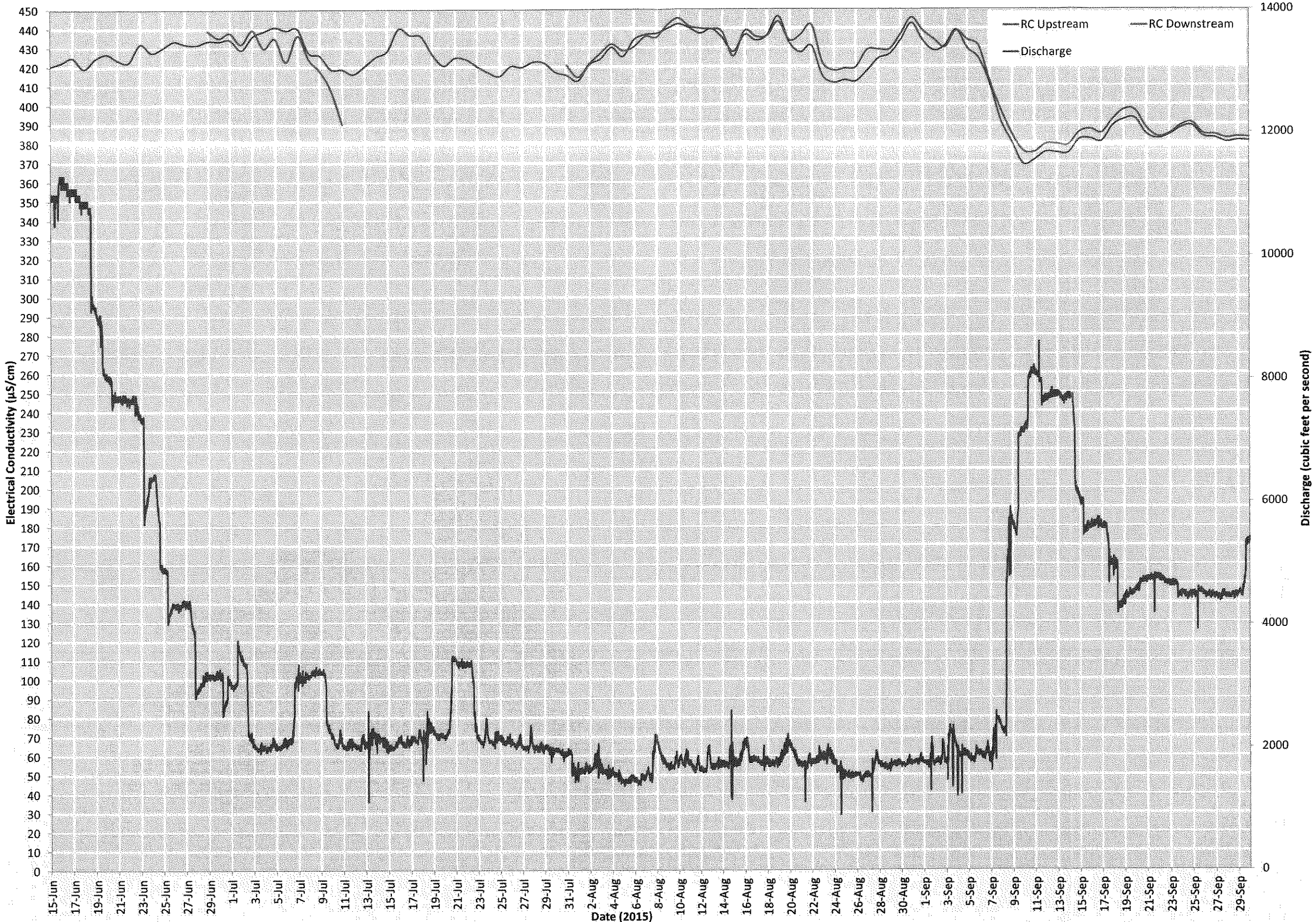


Figure 22. Hourly Dissolved Oxygen Readings, Downstream and Downstream Loaner Sonde of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

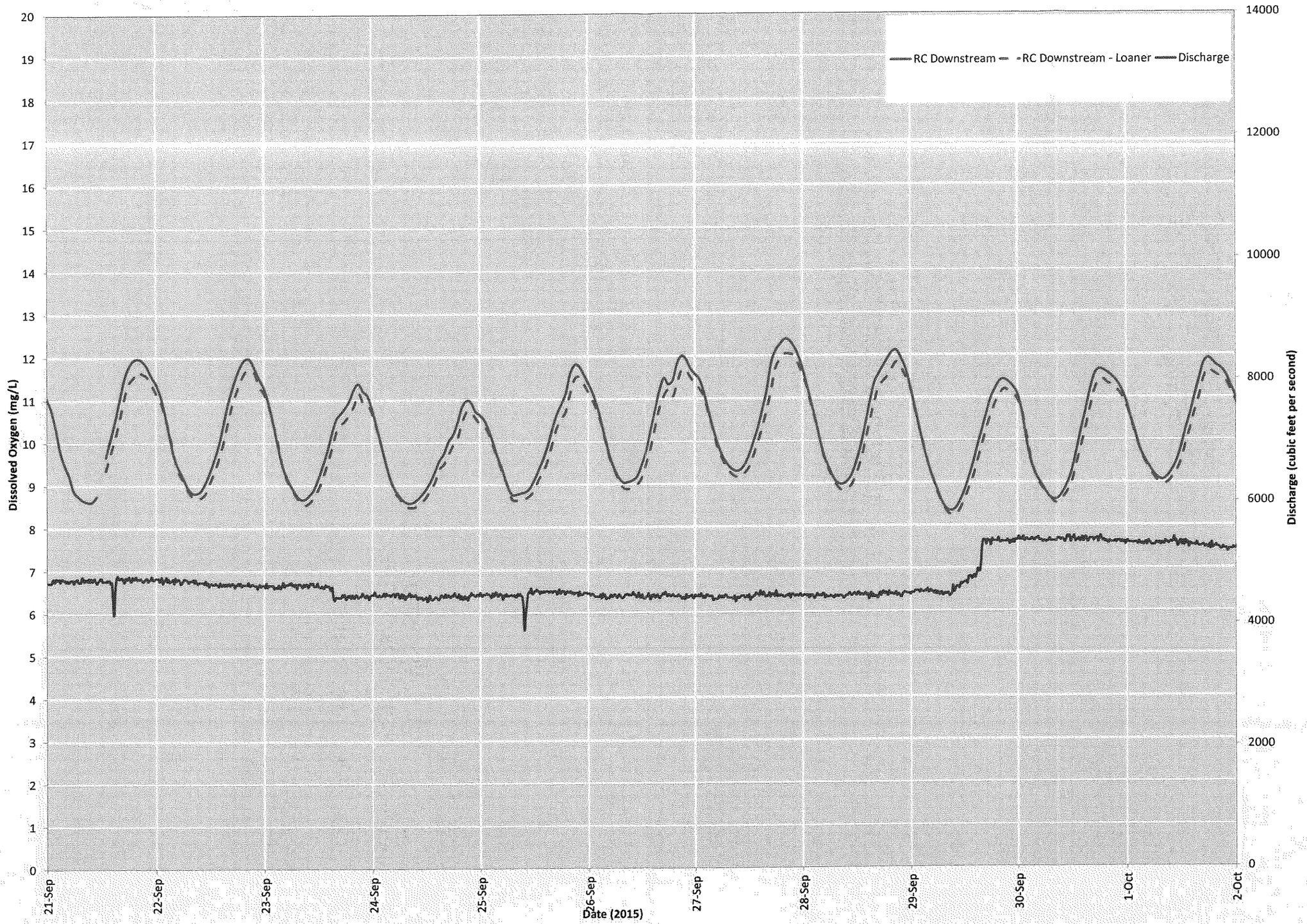


Figure 23. Hourly Temperature Readings, Downstream and Downstream Loaner Sonde of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

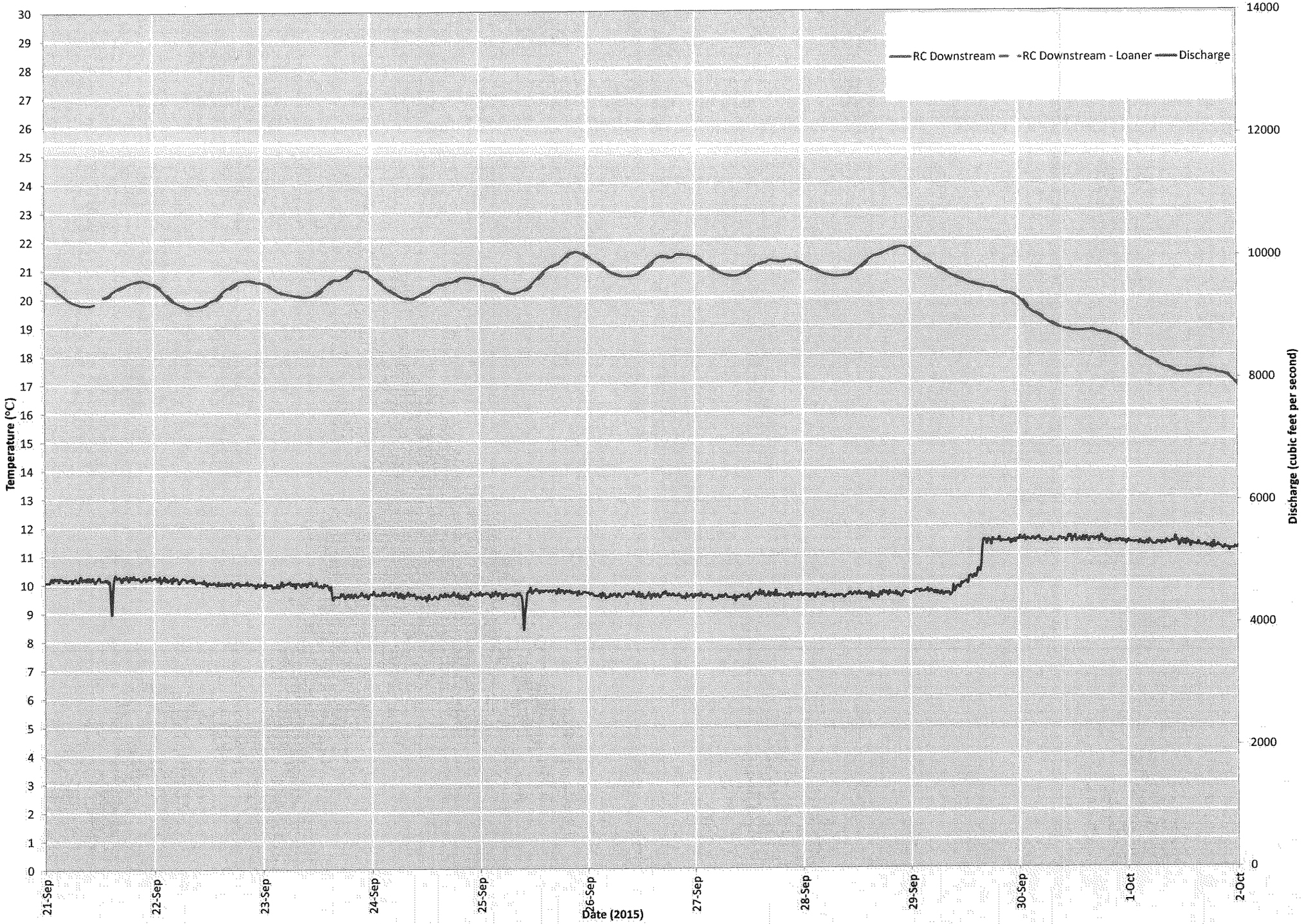


Figure 24. Hourly pH Readings, Downstream and Downstream Loaner Sonde of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

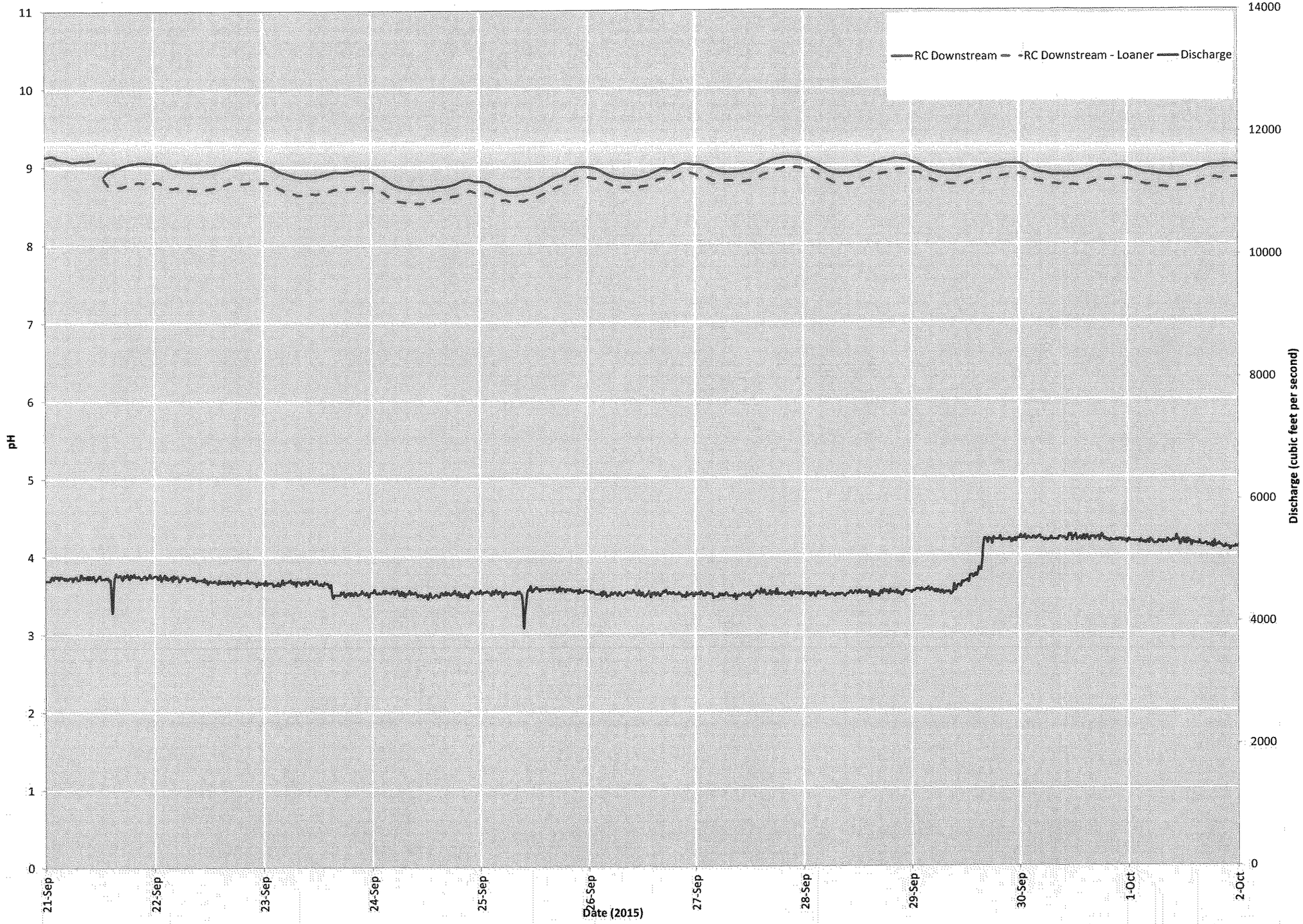


Figure 25. Hourly Electrical Conductivity Readings, Downstream and Downstream Loaner Sonde of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

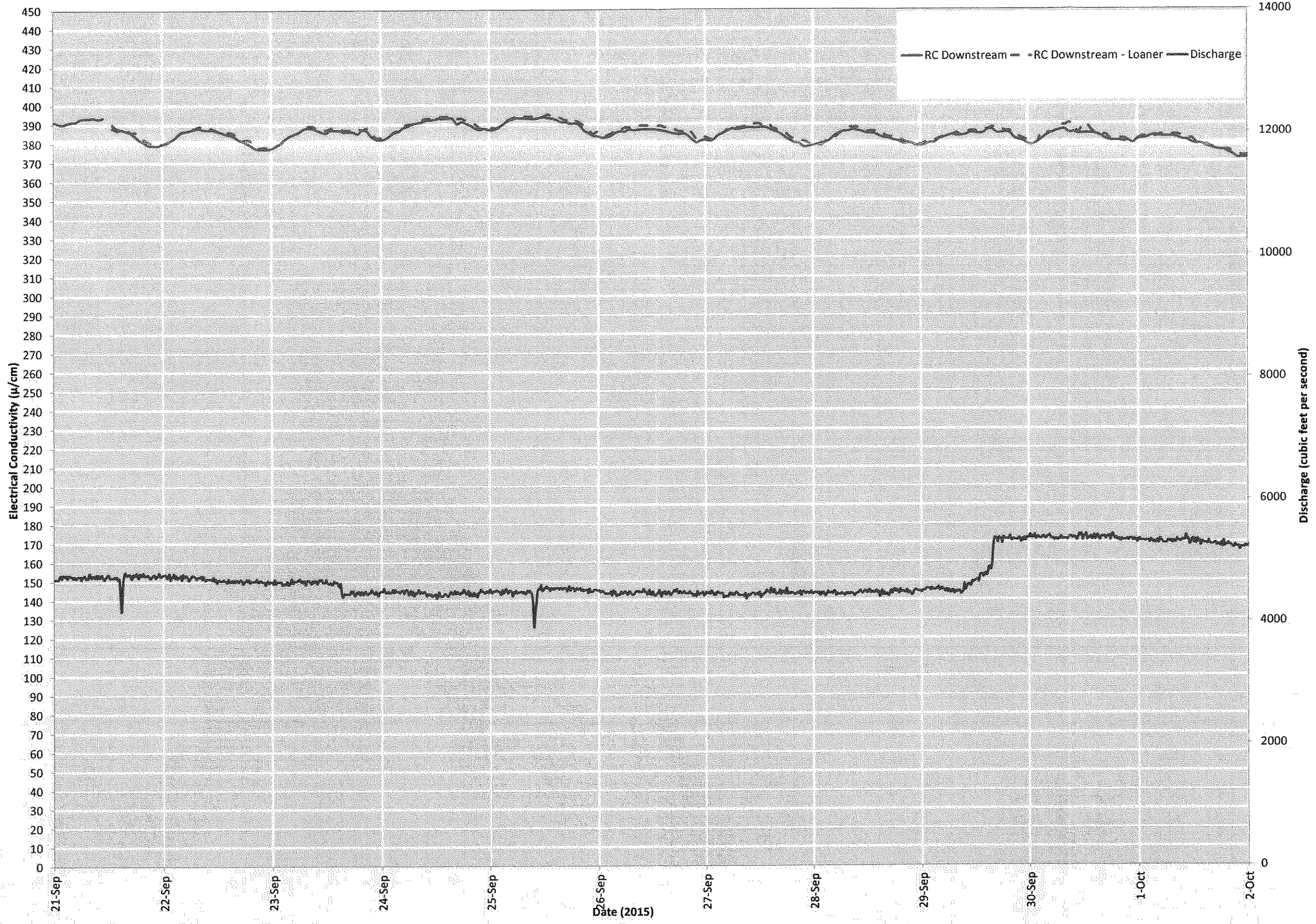


Table 1.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Sonde Locations

		GPS Coordinates	
		Latitude	Longitude
Badger	Upstream	44.2814	-88.2734
	Downstream	44.2768	-88.2652
	Bypass	44.2797	-88.2641
Rapide Croche	Upstream	44.3157	-88.1986
	Downstream	44.3148	-88.1958

Table 2.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data

Difference = Upstream - Downstream

**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2015	8.21	7.83	0.38	20.88	20.87	0.01	8.81	8.23	0.58
6/16/2015	8.09	7.73	0.36	20.60	20.61	0.00	8.75	8.14	0.61
6/17/2015	8.60	8.13	0.48	21.65	21.67	-0.02		8.40	
6/18/2015	8.62	8.10	0.52	22.67	22.66	0.01		8.56	
6/19/2015	8.39	8.18	0.20	22.16	22.15	0.01		8.55	
6/20/2015	8.15	7.93	0.22	21.75	21.75	0.00		8.43	
6/21/2015	8.30	8.17	0.13	21.99	22.02	-0.03		8.43	
6/22/2015	7.97	7.78	0.19	22.28	22.26	0.02		8.42	
6/23/2015	8.08	7.87	0.20	22.05	22.05	0.00		8.37	
6/24/2015	8.27	8.22	0.04	22.57	22.67	-0.09		8.46	
6/25/2015	7.99	7.78	0.21	23.31	23.31	0.01		8.52	
6/26/2015	7.67	7.62	0.05	23.36	23.32	0.04		8.51	
6/27/2015	8.07	8.08	-0.01	23.49	23.48	0.02		8.67	
6/28/2015	8.16	8.17	-0.01	23.48	23.47	0.02		8.70	
6/29/2015	8.06	7.90	0.15	23.97	23.99	-0.02	8.74	8.75	-0.01
6/30/2015	7.50	7.45	0.05	23.74	23.66	0.08	8.68	8.78	-0.10
7/1/2015	7.85	7.75	0.10	22.73	22.76	-0.03	8.62	8.73	-0.11
7/2/2015	8.64	8.49	0.15	22.38	22.34	0.04	8.65	8.76	-0.11
7/3/2015	8.84	8.89	-0.05	22.65	22.69	-0.04	8.68	8.77	-0.09
7/4/2015	8.97	8.40	0.57	23.35	23.39	-0.03	8.73	8.80	-0.06
7/5/2015	9.01			24.23	24.24	-0.02	8.76	8.81	-0.05
7/6/2015	8.19			24.42	24.42	0.00	8.70	8.72	-0.01
7/7/2015	7.96			23.68	23.65	0.03	8.54	8.56	-0.02
7/8/2015	8.58	8.40	0.18	23.08	22.96	0.12	8.52	8.50	0.02
7/9/2015	8.76	8.43	0.32	23.14	23.21	-0.07	8.66	8.65	0.01
7/10/2015	9.42	9.45	-0.04	24.01	24.04	-0.03	8.77	8.77	0.00
7/11/2015	9.50	9.57	-0.08	24.82	24.86	-0.04	8.94	8.92	0.01
7/12/2015	9.14	9.13	0.01	25.07	25.07	0.00	8.95	8.88	0.07
7/13/2015	8.83	8.74	0.09	25.62	25.67	-0.05	8.93	8.84	0.08
7/14/2015	7.64	7.20	0.45	25.73	25.74	-0.01	8.78	8.57	0.21
7/15/2015	8.16			25.19	25.17	0.03	8.74	8.42	0.31
7/16/2015	8.50			24.65	24.63	0.01	8.70	8.36	0.34
7/17/2015	8.26			24.44	24.52	-0.08	8.73	8.30	0.43
7/18/2015	8.43			25.12	25.16	-0.04	8.76	8.40	0.36
7/19/2015	8.82			25.80	25.83	-0.03	8.87	8.56	0.31
7/20/2015	8.55			25.49	25.70	-0.21	8.73	8.54	0.19
7/21/2015	8.06	8.76	-0.70	24.88	24.92	-0.04	8.60	8.60	0.01
7/22/2015	8.08	8.11	-0.03	24.47	24.46	0.01	8.48	8.55	-0.08
7/23/2015	8.70	8.51	0.18	25.11	25.19	-0.08	8.26	8.64	-0.38
7/24/2015	8.57	7.84	0.73	25.71	25.77	-0.06		8.67	
7/25/2015	8.55	7.50	1.04	25.99	26.05	-0.06		8.60	
7/26/2015	8.51	6.60	1.91	26.33	26.33	0.00		8.48	
7/27/2015	8.18			26.55	26.57	-0.02		8.33	
7/28/2015	6.95			26.35	26.78	-0.44		8.23	
7/29/2015									
7/30/2015									
7/31/2015	9.32			25.78			8.93		
8/1/2015	8.48			25.06			8.86		
8/2/2015	8.28			25.15			8.79		
8/3/2015	8.32			24.84			8.73		
8/4/2015	8.52			24.14			8.77		
8/5/2015	8.75			24.30			8.84		
8/6/2015	9.58			24.08			8.84		
8/7/2015	8.34			23.58			8.74		
8/8/2015	6.68			22.74			8.55		
8/9/2015	7.39			23.10			8.52		
8/10/2015	7.83	8.63	-0.80	23.77	24.11	-0.34	8.55	8.53	0.01

Table 2.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data

Difference = Upstream - Downstream

**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2015	9.01	8.98	0.03	24.26	24.26	0.01	8.67	8.58	0.09
8/12/2015	9.37	9.22	0.15	24.58	24.54	0.04	8.71	8.60	0.11
8/13/2015	9.23	8.99	0.24	24.84	24.83	0.01	8.81	8.60	0.21
8/14/2015	9.02	8.75	0.27	25.66	25.63	0.03	8.84	8.73	0.11
8/15/2015	8.51	8.14	0.37	25.69	25.58	0.10	8.69	8.60	0.09
8/16/2015	9.16	8.97	0.19	26.30	26.29	0.01	8.73	8.66	0.07
8/17/2015	8.84	8.41	0.43	26.57	26.56	0.01	8.73	8.56	0.17
8/18/2015	7.94	6.73	1.20	26.00	25.98	0.02	8.64	8.30	0.34
8/19/2015	7.51	5.44	2.07	25.30	25.33	-0.02	8.60	8.20	0.40
8/20/2015	7.54	7.28	0.26	23.26	23.33	-0.06	8.50	8.34	0.15
8/21/2015	8.78	8.57	0.21	22.26	22.34	-0.08	8.56	8.49	0.07
8/22/2015	10.02	9.69	0.32	22.71	22.76	-0.05	8.73	8.67	0.06
8/23/2015	9.61	9.34	0.26	22.34	22.45	-0.11	8.81	8.77	0.05
8/24/2015	8.47	8.24	0.23	20.83	20.94	-0.11	8.73	8.69	0.05
8/25/2015	7.95	7.88	0.07	19.48	19.63	-0.15	8.62	8.63	0.00
8/26/2015	7.58	7.89	-0.31	19.29	19.40	-0.10	8.49	8.48	0.01
8/27/2015	8.61	8.41	0.20	19.57	19.65	-0.07	8.50	8.47	0.02
8/28/2015	8.73	8.44	0.29	19.82	19.90	-0.08	8.52	8.51	0.01
8/29/2015	7.67	7.53	0.14	19.85	19.97	-0.12	8.41	8.35	0.07
8/30/2015	7.62	7.46	0.16	20.33	20.40	-0.07	8.37	8.29	0.08
8/31/2015	8.29	8.04	0.25	21.09	21.14	-0.05	8.47	8.38	0.09
9/1/2015	8.65	8.23	0.41	22.08	22.09	-0.01	8.47	8.38	0.10
9/2/2015	8.62	8.09	0.53	23.45	23.47	-0.01	8.51	8.43	0.08
9/3/2015	7.89	7.45	0.44	24.03	24.10	-0.07	8.47	8.45	0.02
9/4/2015	7.20	6.92	0.27	23.57	23.75	-0.18	8.39	8.36	0.03
9/5/2015	7.62	7.40	0.22	23.79	23.81	-0.02	8.45	8.36	0.09
9/6/2015	8.53	8.24	0.29	24.60	24.61	-0.01	8.60	8.53	0.07
9/7/2015	7.90	7.66	0.24	24.89	24.89	0.01	8.53	8.53	0.01
9/8/2015	6.80	6.59	0.21	24.32	24.25	0.07	8.11	8.13	-0.03
9/9/2015	7.40	7.14	0.26	23.59	23.58	0.00	7.99	8.10	-0.12
9/10/2015	7.59	7.35	0.25	23.36	23.41	-0.05	8.10	8.40	-0.30
9/11/2015	7.78	7.42	0.36	22.21	22.22	-0.02	8.23	8.40	-0.18
9/12/2015	8.16	7.67	0.49	20.78	20.79	-0.02	8.41	8.40	0.00
9/13/2015	8.44	8.00	0.44	20.38	20.39	0.00	8.47	8.51	-0.04
9/14/2015	8.57	8.15	0.42	20.52	20.51	0.01	8.52	8.60	-0.08
9/15/2015	8.54	8.17	0.37	20.92	20.91	0.02	8.54	8.63	-0.10
9/16/2015	8.80	8.48	0.33	21.43	21.41	0.01	8.67	8.77	-0.10
9/17/2015	8.70	8.33	0.37	21.63	21.61	0.02	8.66	8.77	-0.10
9/18/2015	8.13	7.84	0.28	21.52	21.52	-0.01	8.54	8.64	-0.11
9/19/2015	8.64	8.30	0.34	21.08	21.07	0.01	8.56	8.66	-0.10
9/20/2015	9.32	8.94	0.38	20.44	20.44	0.00	8.74	8.86	-0.12
9/21/2015	9.63	9.57	0.07	20.03	20.20	-0.18	8.97	9.03	-0.06
9/22/2015	9.52	9.66	-0.14	19.96	19.97	-0.01	9.08	9.02	0.05
9/23/2015	9.25	9.41	-0.16	20.17	20.14	0.03	8.98	8.94	0.04
9/24/2015	9.19	9.36	-0.17	20.21	20.22	-0.01	8.88	8.85	0.03
9/25/2015	9.62	9.80	-0.18	20.78	20.80	-0.02	8.98	8.96	0.02
9/26/2015	9.98	10.15	-0.17	20.94	20.94	0.00	9.06	9.03	0.03
9/27/2015	10.14	10.32	-0.18	20.87	20.89	-0.01	9.15	9.11	0.05
9/28/2015	9.74	9.88	-0.14	20.92	20.92	0.00	9.13	9.07	0.06
9/29/2015	9.14	9.33	-0.19	20.56	20.57	-0.02	9.12	9.06	0.06
9/30/2015	9.52	9.67	-0.16	18.88	18.90	-0.02	9.10	9.04	0.06
Minimum	6.68	5.44	-0.80	18.88	18.90	-0.44	7.99	8.10	-0.38
Average	8.47	8.28	0.23	23.13	23.04	-0.03	8.67	8.59	0.05
Maximum	10.14	10.32	2.07	26.57	26.78	0.12	9.15	9.11	0.61
Standard Deviation	0.70	0.88	0.40	2.00	2.04	0.08	0.23	0.22	0.15
Number of Data Points	105	84	84	105	95	95	88	95	78

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
6/15/2015			
6/16/2015			
6/17/2015			
6/18/2015			
6/19/2015			
6/20/2015			
6/21/2015			
6/22/2015			
6/23/2015			
6/24/2015			
6/25/2015			
6/26/2015			
6/27/2015			
6/28/2015			
6/29/2015			
6/30/2015			
7/1/2015			
7/2/2015			
7/3/2015			
7/4/2015			
7/5/2015			
7/6/2015			
7/7/2015			
7/8/2015			
7/9/2015			
7/10/2015	24.77	8.85	8.89
7/11/2015	24.90	8.51	8.88
7/12/2015	25.15	8.29	8.88
7/13/2015	25.70	8.00	8.87
7/14/2015	25.79	7.65	8.75
7/15/2015	25.15	7.86	8.70
7/16/2015	24.71	7.94	8.65
7/17/2015	24.59	7.90	8.68
7/18/2015	25.26	7.86	8.72
7/19/2015	25.87	7.90	8.83
7/20/2015	25.71	8.28	8.77
7/21/2015	25.01	8.67	8.66
7/22/2015	24.56	8.56	8.61
7/23/2015	25.23	8.75	8.74
7/24/2015	25.79	8.48	8.80
7/25/2015	26.15	8.31	8.81
7/26/2015	26.45	8.20	8.82

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
7/27/2015	26.58	8.02	8.81
7/28/2015	27.05	8.02	8.82
7/29/2015	26.98	8.08	8.89
7/30/2015	26.03	8.26	8.96
7/31/2015	25.60	8.29	8.92
8/1/2015	25.12	8.30	8.93
8/2/2015	25.26	7.78	8.85
8/3/2015	24.88	8.07	8.77
8/4/2015	24.44	8.33	8.82
8/5/2015	24.23	8.31	8.87
8/6/2015	24.00	8.47	8.85
8/7/2015	23.51	7.89	8.72
8/8/2015	22.70	7.84	8.54
8/9/2015	23.20	7.97	8.53
8/10/2015	23.94	7.99	8.60
8/11/2015	24.39	8.41	8.72
8/12/2015	24.67	8.56	8.80
8/13/2015	24.96	8.32	8.86
8/14/2015	25.76	7.89	8.91
8/15/2015	25.73	7.67	8.74
8/16/2015	26.38	7.71	8.77
8/17/2015	26.61	7.48	8.80
8/18/2015	26.04	7.31	8.69
8/19/2015	25.23	7.19	8.64
8/20/2015	23.23	7.70	8.49
8/21/2015	22.33	8.56	8.48
8/22/2015	22.80	8.76	8.65
8/23/2015	22.38	8.49	8.72
8/24/2015	20.80	8.39	8.64
8/25/2015	19.45	8.46	8.59
8/26/2015	19.36	8.61	8.52
8/27/2015	19.74	8.68	8.52
8/28/2015	19.92	8.66	8.50
8/29/2015	19.89	8.54	8.42
8/30/2015	20.40	8.50	8.40
8/31/2015	21.22	8.52	8.50
9/1/2015	22.26	8.54	8.55
9/2/2015	23.61	8.31	8.60
9/3/2015	24.10	7.92	8.60
9/4/2015	23.76	7.81	8.55
9/5/2015	23.90	8.10	8.57
9/6/2015	24.74	8.19	8.73

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
9/7/2015	24.97	7.84	8.75
9/8/2015	24.30	7.28	8.40
9/9/2015	23.63	7.77	8.39
9/10/2015	23.40	8.00	8.68
9/11/2015	22.42	8.00	8.79
9/12/2015			
9/13/2015			
9/14/2015			
9/15/2015			
9/16/2015			
9/17/2015			
9/18/2015			
9/19/2015			
9/20/2015			
9/21/2015	20.40	9.39	8.98
9/22/2015	19.99	9.04	8.93
9/23/2015	20.24	8.95	8.86
9/24/2015	20.21	8.90	8.78
9/25/2015	20.75	8.93	8.83
9/26/2015	20.92	8.94	8.91
9/27/2015	20.88	8.94	8.89
9/28/2015	20.98	8.72	8.77
9/29/2015	20.54	8.76	8.67
9/30/2015	18.90	9.09	8.59

Minimum	18.90	7.19	8.39
Average	23.66	8.26	8.72
Maximum	27.05	9.39	8.98
Standard Deviation	2.24	0.46	0.15
Number of Data Points	74	74	74

Table 4.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/7/2015	9/8/2015	8.53	8.11	-0.43
7/22/2015	7/23/2015	8.48	8.26	-0.22
8/7/2015	8/8/2015	8.74	8.55	-0.20
7/6/2015	7/7/2015	8.70	8.54	-0.16
7/13/2015	7/14/2015	8.93	8.78	-0.15
8/14/2015	8/15/2015	8.84	8.69	-0.15
8/25/2015	8/26/2015	8.62	8.49	-0.14
7/19/2015	7/20/2015	8.87	8.73	-0.13
7/20/2015	7/21/2015	8.73	8.60	-0.13
7/21/2015	7/22/2015	8.60	8.48	-0.13
9/17/2015	9/18/2015	8.66	8.54	-0.12
9/8/2015	9/9/2015	8.11	7.99	-0.12
8/24/2015	8/25/2015	8.73	8.62	-0.11
8/28/2015	8/29/2015	8.52	8.41	-0.10
8/19/2015	8/20/2015	8.60	8.50	-0.10
8/6/2015	8/7/2015	8.84	8.74	-0.10
9/23/2015	9/24/2015	8.98	8.88	-0.10
9/22/2015	9/23/2015	9.08	8.98	-0.10
8/17/2015	8/18/2015	8.73	8.64	-0.09
8/23/2015	8/24/2015	8.81	8.73	-0.08
9/3/2015	9/4/2015	8.47	8.39	-0.08
7/31/2015	8/1/2015	8.93	8.86	-0.07
9/6/2015	9/7/2015	8.60	8.53	-0.07
8/1/2015	8/2/2015	8.86	8.79	-0.07
6/30/2015	7/1/2015	8.68	8.62	-0.06
6/29/2015	6/30/2015	8.74	8.68	-0.06
8/2/2015	8/3/2015	8.79	8.73	-0.06
7/5/2015	7/6/2015	8.76	8.70	-0.06
6/15/2015	6/16/2015	8.81	8.75	-0.06
8/29/2015	8/30/2015	8.41	8.37	-0.04
7/14/2015	7/15/2015	8.78	8.74	-0.04
9/2/2015	9/3/2015	8.51	8.47	-0.04
8/18/2015	8/19/2015	8.64	8.60	-0.04
7/15/2015	7/16/2015	8.74	8.70	-0.04
8/8/2015	8/9/2015	8.55	8.52	-0.03
7/12/2015	7/13/2015	8.95	8.93	-0.03
9/27/2015	9/28/2015	9.15	9.13	-0.02
7/7/2015	7/8/2015	8.54	8.52	-0.02
9/29/2015	9/30/2015	9.12	9.10	-0.02
9/28/2015	9/29/2015	9.13	9.12	-0.01
9/16/2015	9/17/2015	8.67	8.66	0.00

Table 4.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/5/2015	8/6/2015	8.84	8.84	0.00
6/16/2015	6/17/2015	8.75		0.00
6/17/2015	6/18/2015			0.00
6/18/2015	6/19/2015			0.00
6/19/2015	6/20/2015			0.00
6/20/2015	6/21/2015			0.00
6/21/2015	6/22/2015			0.00
6/22/2015	6/23/2015			0.00
6/23/2015	6/24/2015			0.00
6/24/2015	6/25/2015			0.00
6/25/2015	6/26/2015			0.00
6/26/2015	6/27/2015			0.00
6/27/2015	6/28/2015			0.00
6/28/2015	6/29/2015		8.74	0.00
7/23/2015	7/24/2015	8.26		0.00
7/24/2015	7/25/2015			0.00
7/25/2015	7/26/2015			0.00
7/26/2015	7/27/2015			0.00
7/27/2015	7/28/2015			0.00
7/28/2015	7/29/2015			0.00
7/29/2015	7/30/2015			0.00
7/30/2015	7/31/2015		8.93	0.00
8/16/2015	8/17/2015	8.73	8.73	0.00
8/31/2015	9/1/2015	8.47	8.47	0.01
8/26/2015	8/27/2015	8.49	8.50	0.01
9/14/2015	9/15/2015	8.52	8.54	0.01
7/11/2015	7/12/2015	8.94	8.95	0.01
8/27/2015	8/28/2015	8.50	8.52	0.02
9/18/2015	9/19/2015	8.54	8.56	0.02
7/4/2015	7/5/2015	8.73	8.76	0.03
8/9/2015	8/10/2015	8.52	8.55	0.03
7/17/2015	7/18/2015	8.73	8.76	0.03
8/13/2015	8/14/2015	8.81	8.84	0.03
7/1/2015	7/2/2015	8.62	8.65	0.03
7/16/2015	7/17/2015	8.70	8.73	0.03
8/15/2015	8/16/2015	8.69	8.73	0.03
7/2/2015	7/3/2015	8.65	8.68	0.03
8/11/2015	8/12/2015	8.67	8.71	0.04
9/1/2015	9/2/2015	8.47	8.51	0.04
8/3/2015	8/4/2015	8.73	8.77	0.04
9/13/2015	9/14/2015	8.47	8.52	0.05

Table 4.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
7/3/2015	7/4/2015	8.68	8.73	0.05
9/4/2015	9/5/2015	8.39	8.45	0.06
8/20/2015	8/21/2015	8.50	8.56	0.06
9/12/2015	9/13/2015	8.41	8.47	0.07
8/4/2015	8/5/2015	8.77	8.84	0.07
8/22/2015	8/23/2015	8.73	8.81	0.08
9/25/2015	9/26/2015	8.98	9.06	0.08
9/26/2015	9/27/2015	9.06	9.15	0.09
8/30/2015	8/31/2015	8.37	8.47	0.10
8/12/2015	8/13/2015	8.71	8.81	0.10
9/24/2015	9/25/2015	8.88	8.98	0.10
9/21/2015	9/22/2015	8.97	9.08	0.10
7/18/2015	7/19/2015	8.76	8.87	0.10
7/9/2015	7/10/2015	8.66	8.77	0.11
9/9/2015	9/10/2015	7.99	8.10	0.11
9/10/2015	9/11/2015	8.10	8.23	0.13
8/10/2015	8/11/2015	8.55	8.67	0.13
9/15/2015	9/16/2015	8.54	8.67	0.13
7/8/2015	7/9/2015	8.52	8.66	0.14
9/5/2015	9/6/2015	8.45	8.60	0.15
7/10/2015	7/11/2015	8.77	8.94	0.17
8/21/2015	8/22/2015	8.56	8.73	0.17
9/11/2015	9/12/2015	8.23	8.41	0.18
9/19/2015	9/20/2015	8.56	8.74	0.18
9/20/2015	9/21/2015	8.74	8.97	0.23
9/30/2015		9.10		

Table 5.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/7/2015	9/8/2015	8.53	8.13	-0.39
7/13/2015	7/14/2015	8.84	8.57	-0.27
8/17/2015	8/18/2015	8.56	8.30	-0.26
7/6/2015	7/7/2015	8.72	8.56	-0.16
8/28/2015	8/29/2015	8.51	8.35	-0.16
7/26/2015	7/27/2015	8.48	8.33	-0.15
7/14/2015	7/15/2015	8.57	8.42	-0.15
8/25/2015	8/26/2015	8.63	8.48	-0.15
9/17/2015	9/18/2015	8.77	8.64	-0.12
8/14/2015	8/15/2015	8.73	8.60	-0.12
7/25/2015	7/26/2015	8.60	8.48	-0.12
6/19/2015	6/20/2015	8.55	8.43	-0.12
8/18/2015	8/19/2015	8.30	8.20	-0.10
8/16/2015	8/17/2015	8.66	8.56	-0.10
7/27/2015	7/28/2015	8.33	8.23	-0.10
9/3/2015	9/4/2015	8.45	8.36	-0.09
7/5/2015	7/6/2015	8.81	8.72	-0.09
6/15/2015	6/16/2015	8.23	8.14	-0.09
9/23/2015	9/24/2015	8.94	8.85	-0.09
9/22/2015	9/23/2015	9.02	8.94	-0.09
8/23/2015	8/24/2015	8.77	8.69	-0.08
7/24/2015	7/25/2015	8.67	8.60	-0.07
7/15/2015	7/16/2015	8.42	8.36	-0.07
8/24/2015	8/25/2015	8.69	8.63	-0.06
7/7/2015	7/8/2015	8.56	8.50	-0.06
8/29/2015	8/30/2015	8.35	8.29	-0.06
7/16/2015	7/17/2015	8.36	8.30	-0.06
6/30/2015	7/1/2015	8.78	8.73	-0.05
6/22/2015	6/23/2015	8.42	8.37	-0.05
7/21/2015	7/22/2015	8.60	8.55	-0.05
7/12/2015	7/13/2015	8.88	8.84	-0.04
7/11/2015	7/12/2015	8.92	8.88	-0.04
9/27/2015	9/28/2015	9.11	9.07	-0.03
9/8/2015	9/9/2015	8.13	8.10	-0.03
9/28/2015	9/29/2015	9.07	9.06	-0.02
7/19/2015	7/20/2015	8.56	8.54	-0.02
9/29/2015	9/30/2015	9.06	9.04	-0.01
6/21/2015	6/22/2015	8.43	8.42	-0.01
6/25/2015	6/26/2015	8.52	8.51	-0.01
9/21/2015	9/22/2015	9.03	9.02	-0.01
6/18/2015	6/19/2015	8.56	8.55	-0.01

Table 5.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/26/2015	8/27/2015	8.48	8.47	-0.01
9/16/2015	9/17/2015	8.77	8.77	0.00
8/12/2015	8/13/2015	8.60	8.60	0.00
8/31/2015	9/1/2015	8.38	8.38	0.00
9/4/2015	9/5/2015	8.36	8.36	0.00
9/6/2015	9/7/2015	8.53	8.53	0.00
7/28/2015	7/29/2015	8.23		0.00
7/29/2015	7/30/2015			0.00
7/30/2015	7/31/2015			0.00
7/31/2015	8/1/2015			0.00
8/1/2015	8/2/2015			0.00
8/2/2015	8/3/2015			0.00
8/3/2015	8/4/2015			0.00
8/4/2015	8/5/2015			0.00
8/5/2015	8/6/2015			0.00
8/6/2015	8/7/2015			0.00
8/7/2015	8/8/2015			0.00
8/8/2015	8/9/2015			0.00
8/9/2015	8/10/2015		8.53	0.00
9/11/2015	9/12/2015	8.40	8.40	0.00
6/20/2015	6/21/2015	8.43	8.43	0.00
9/10/2015	9/11/2015	8.40	8.40	0.00
7/2/2015	7/3/2015	8.76	8.77	0.01
7/4/2015	7/5/2015	8.80	8.81	0.01
8/11/2015	8/12/2015	8.58	8.60	0.02
9/18/2015	9/19/2015	8.64	8.66	0.02
9/2/2015	9/3/2015	8.43	8.45	0.02
6/27/2015	6/28/2015	8.67	8.70	0.02
6/29/2015	6/30/2015	8.75	8.78	0.03
7/23/2015	7/24/2015	8.64	8.67	0.03
7/3/2015	7/4/2015	8.77	8.80	0.03
9/14/2015	9/15/2015	8.60	8.63	0.03
8/27/2015	8/28/2015	8.47	8.51	0.03
7/1/2015	7/2/2015	8.73	8.76	0.03
8/15/2015	8/16/2015	8.60	8.66	0.05
8/10/2015	8/11/2015	8.53	8.58	0.05
7/20/2015	7/21/2015	8.54	8.60	0.05
6/28/2015	6/29/2015	8.70	8.75	0.05
9/1/2015	9/2/2015	8.38	8.43	0.05
6/24/2015	6/25/2015	8.46	8.52	0.06
9/25/2015	9/26/2015	8.96	9.03	0.07

Table 5.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/26/2015	9/27/2015	9.03	9.11	0.07
6/23/2015	6/24/2015	8.37	8.46	0.09
9/13/2015	9/14/2015	8.51	8.60	0.09
7/22/2015	7/23/2015	8.55	8.64	0.09
8/30/2015	8/31/2015	8.29	8.38	0.09
8/22/2015	8/23/2015	8.67	8.77	0.09
7/17/2015	7/18/2015	8.30	8.40	0.10
9/12/2015	9/13/2015	8.40	8.51	0.11
9/24/2015	9/25/2015	8.85	8.96	0.11
7/9/2015	7/10/2015	8.65	8.77	0.12
8/13/2015	8/14/2015	8.60	8.73	0.13
9/15/2015	9/16/2015	8.63	8.77	0.14
8/20/2015	8/21/2015	8.34	8.49	0.14
8/19/2015	8/20/2015	8.20	8.34	0.15
7/8/2015	7/9/2015	8.50	8.65	0.15
6/17/2015	6/18/2015	8.40	8.56	0.15
7/10/2015	7/11/2015	8.77	8.92	0.16
7/18/2015	7/19/2015	8.40	8.56	0.16
6/26/2015	6/27/2015	8.51	8.67	0.17
9/20/2015	9/21/2015	8.86	9.03	0.17
9/5/2015	9/6/2015	8.36	8.53	0.17
8/21/2015	8/22/2015	8.49	8.67	0.18
9/19/2015	9/20/2015	8.66	8.86	0.20
6/16/2015	6/17/2015	8.14	8.40	0.26
9/9/2015	9/10/2015	8.10	8.40	0.30
9/30/2015		9.04		

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2015	8.05			20.97			8.27		
6/16/2015	8.25			20.71			8.19		
6/17/2015	8.50			21.64			8.47		
6/18/2015	8.41			22.70			8.60		
6/19/2015	8.37			22.36			8.50		
6/20/2015	7.59			21.77			8.11		
6/21/2015				22.34			8.06		
6/22/2015				22.43			8.09		
6/23/2015	9.04			22.34			8.08		
6/24/2015	8.50			22.90			8.38		
6/25/2015	7.39			23.58			8.26		
6/26/2015	8.00			23.59			8.36		
6/27/2015	8.29			23.69			8.52		
6/28/2015	8.56			24.00			8.39		
6/29/2015	9.09	8.98	0.12	24.06	24.37	-0.31	8.67	8.67	0.00
6/30/2015	8.15	8.32	-0.17	24.03	24.06	-0.03	8.67	8.64	0.03
7/1/2015	8.23	8.15	0.08	22.96	22.92	0.04	8.63	8.58	0.05
7/2/2015	8.90	8.40	0.50	22.86	22.71	0.15	8.63	8.52	0.11
7/3/2015	9.29	8.71	0.58	22.96	22.94	0.03	8.66	8.45	0.21
7/4/2015	10.06	8.11	1.95	23.70	23.39	0.30	8.70	8.38	0.32
7/5/2015	9.33	9.21	0.12	24.30	24.20	0.10	8.60	8.62	-0.02
7/6/2015	9.31	9.56	-0.25	24.75	24.72	0.04	8.73	8.71	0.02
7/7/2015	8.55	8.46	0.08	23.91	23.92	-0.01	8.63	8.55	0.07
7/8/2015	9.44	9.19	0.25	23.59	23.52	0.07	8.60	8.50	0.10
7/9/2015	10.21	9.49	0.73	23.31	23.09	0.22	8.66	8.53	0.14
7/10/2015	11.49	9.87	1.62	24.33	24.06	0.26	8.80	8.78	0.03
7/11/2015	11.23	9.35	1.88	24.96	24.89	0.06	8.80	9.18	-0.38
7/12/2015	11.83	8.97	2.86	26.00	25.53	0.47	8.87	9.13	-0.27
7/13/2015	10.26	8.40	1.86	25.83	25.73	0.10	8.76	9.08	-0.32
7/14/2015	9.17	7.83	1.34	26.14	26.12	0.02	8.76	9.07	-0.31
7/15/2015	10.86	7.98	2.88	25.85	25.28	0.56	8.77	9.02	-0.26
7/16/2015	9.79	8.20	1.59	25.32	25.19	0.13	8.62	9.03	-0.40
7/17/2015	9.41	7.87	1.54	25.09	24.85	0.24	8.61	9.00	-0.39
7/18/2015	8.98	7.91	1.07	25.44	25.42	0.02	8.58	9.02	-0.45
7/19/2015	10.04	8.50	1.55	26.14	26.11	0.03	8.70	9.16	-0.46
7/20/2015	10.25			26.04			8.79		
7/21/2015	9.41			25.49			8.64		
7/22/2015	8.77			25.09			8.51		
7/23/2015	9.41			25.42			8.49		
7/24/2015	9.70			25.85			8.66		
7/25/2015	10.14			26.53			8.74		
7/26/2015	10.28			26.92			8.72		
7/27/2015	10.61			27.59			8.79		
7/28/2015	10.17			27.13			8.71		
7/29/2015	9.22			27.20			8.72		
7/30/2015	9.66			26.46			8.83		
7/31/2015	9.91	9.99	-0.08	26.07	26.07	0.00	8.85	8.85	0.00
8/1/2015	10.59	9.79	0.80	25.77	25.67	0.10	8.87	8.80	0.07
8/2/2015	9.35	9.31	0.04	25.63	25.59	0.04	8.79	8.74	0.05
8/3/2015	8.72	8.70	0.01	25.48	25.46	0.02	8.70	8.68	0.02
8/4/2015	9.35	9.12	0.23	25.02	25.06	-0.04	8.59	8.66	-0.07
8/5/2015	10.88	9.81	1.08	24.87	24.67	0.20	8.78	8.71	0.07
8/6/2015	10.25	9.50	0.75	24.76	24.43	0.33	8.74	8.72	0.02
8/7/2015	9.41	8.67	0.74	24.25	24.15	0.10	8.65	8.63	0.03
8/8/2015	7.61	7.37	0.24	23.03	23.00	0.03	8.44	8.46	-0.03
8/9/2015	8.35	8.15	0.20	23.72	23.24	0.48	8.42	8.41	0.01
8/10/2015	9.66	8.40	1.27	24.55	23.92	0.63	8.50	8.37	0.13
8/11/2015	10.66	8.98	1.68	24.93	24.41	0.52	8.51	8.42	0.08
8/12/2015	11.15	10.38	0.77	25.12	24.87	0.25	8.60	8.61	-0.02
8/13/2015	9.88	10.04	-0.15	25.18	25.16	0.02	8.57	8.68	-0.11
8/14/2015	10.17	9.91	0.26	25.77	25.60	0.17	8.63	8.69	-0.06
8/15/2015	11.10	9.81	1.29	27.26	26.23	1.03	8.72	8.71	0.01
8/16/2015	10.29	10.15	0.14	26.64	26.46	0.18	8.62	8.64	-0.01
8/17/2015	9.29	9.80	-0.51	26.84	26.79	0.05	8.61	8.64	-0.03
8/18/2015	7.91	8.88	-0.97	26.71	26.54	0.17	8.55	8.57	-0.03
8/19/2015		8.74		25.74	25.81	-0.08	8.37	8.51	-0.14

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/20/2015	7.85	8.15	-0.30	23.56	23.58	-0.02	8.31	8.51	-0.20
8/21/2015	9.13	8.85	0.29	22.87	22.70	0.17	8.32	8.43	-0.12
8/22/2015	9.82	9.70	0.12	23.29	23.20	0.10	8.37	8.52	-0.16
8/23/2015	9.59	9.89	-0.30	22.97	23.02	-0.04	8.46	8.70	-0.23
8/24/2015	8.84	9.11	-0.27	21.27	21.29	-0.02	8.44	8.71	-0.27
8/25/2015	8.69	9.01	-0.32	19.93	19.95	-0.02	8.31	8.66	-0.35
8/26/2015	8.76	8.79	-0.02	19.73	19.59	0.14	8.18	8.63	-0.45
8/27/2015	9.20	9.42	-0.22	20.34	20.11	0.23	8.01	8.61	-0.60
8/28/2015	8.83	9.38	-0.55	20.43	20.45	-0.03	8.09	8.55	-0.46
8/29/2015	8.43	8.54	-0.10	20.26	20.17	0.09	8.15	8.36	-0.20
8/30/2015	7.95	8.08	-0.14	20.62	20.55	0.07	8.02	8.23	-0.22
8/31/2015	8.07	8.15	-0.08	21.37	21.29	0.08	8.01	8.24	-0.22
9/1/2015	8.84	8.77	0.06	22.57	22.37	0.20	8.17	8.38	-0.21
9/2/2015	9.06	8.97	0.09	23.76	23.55	0.21	8.20	8.42	-0.22
9/3/2015	7.99	8.26	-0.26	24.27	24.27	0.00	8.21	8.45	-0.24
9/4/2015	7.92	7.86	0.06	24.16	23.94	0.22	8.26	8.45	-0.19
9/5/2015	7.98	7.65	0.33	24.54	24.15	0.39	8.22	8.36	-0.13
9/6/2015	8.17	8.06	0.10	24.80	24.69	0.10	8.25	8.47	-0.23
9/7/2015	7.53	7.76	-0.23	25.11	25.11	0.00	8.29	8.65	-0.36
9/8/2015	6.64	6.86	-0.22	24.54	24.57	-0.04	8.05	8.52	-0.47
9/9/2015	7.22	7.37	-0.15	23.60	23.59	0.01	7.92	8.46	-0.54
9/10/2015	7.41	7.62	-0.21	23.45	23.46	-0.01	8.14	8.76	-0.61
9/11/2015	7.75	7.90	-0.15	22.25	22.27	-0.02	8.21	8.61	-0.40
9/12/2015	8.14	8.28	-0.15	20.80	20.81	-0.01	8.25	8.47	-0.23
9/13/2015	8.48	8.61	-0.13	20.31	20.29	0.02	8.30	8.59	-0.29
9/14/2015	8.62	8.72	-0.11	20.57	20.53	0.04	8.35	8.68	-0.33
9/15/2015	8.46	8.67	-0.21	20.95	20.92	0.03	8.34	8.70	-0.36
9/16/2015	8.62	8.92	-0.31	21.55	21.52	0.03	8.46	8.85	-0.39
9/17/2015	6.98	8.93	-1.95	21.82	21.81	0.01	8.31	8.91	-0.60
9/18/2015	7.22	8.22	-0.99	21.79	21.81	-0.02	8.39	8.79	-0.39
9/19/2015	8.47	8.67	-0.20	21.10	21.09	0.01	8.35	8.73	-0.39
9/20/2015	9.28	9.53	-0.25	20.59	20.58	0.01	8.49	8.89	-0.40
9/21/2015	9.89	10.29	-0.40	20.26	20.25	0.01	8.76	9.05	-0.29
9/22/2015	9.92	10.34	-0.42	20.17	20.16	0.01	8.86	9.00	-0.13
9/23/2015	9.58	10.04	-0.46	20.47	20.46	0.01	8.82	8.92	-0.10
9/24/2015	9.23	9.64	-0.40	20.41	20.40	0.00	8.70	8.77	-0.08
9/25/2015	9.61	10.05	-0.44	20.81	20.77	0.04	8.70	8.78	-0.08
9/26/2015	10.01	10.48	-0.47	21.16	21.15	0.00	8.83	8.92	-0.09
9/27/2015	10.29	10.78	-0.49	21.09	21.08	0.01	8.92	9.00	-0.08
9/28/2015	10.08	10.57	-0.49	21.18	21.15	0.03	8.90	8.99	-0.09
9/29/2015	9.34	9.89	-0.55	20.69	20.70	-0.01	8.86	8.96	-0.10
9/30/2015	9.70	10.14	-0.44	19.01	18.99	0.02	8.83	8.93	-0.11

Minimum	6.64	6.86	-1.95	19.01	18.99	0.02	7.92	8.23	-0.61
Average	9.13	8.94	0.23	23.54	23.23	0.30	8.51	8.68	-0.17
Maximum	11.83	10.78	2.88	27.59	26.79	0.80	8.92	9.18	0.32
Standard Deviation	1.06	0.87	0.84	2.15	2.07	0.08	0.25	0.22	0.20
Number of Data Points	105	83	82	108	83	83	108	83	83

Table 7.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
6/19/2015	6/20/2015	8.50	8.11	-0.38
9/7/2015	9/8/2015	8.29	8.05	-0.24
8/7/2015	8/8/2015	8.65	8.44	-0.21
8/26/2015	8/27/2015	8.18	8.01	-0.17
8/18/2015	8/19/2015	8.55	8.37	-0.17
9/16/2015	9/17/2015	8.46	8.31	-0.15
7/20/2015	7/21/2015	8.79	8.64	-0.15
7/15/2015	7/16/2015	8.77	8.62	-0.14
8/29/2015	8/30/2015	8.15	8.02	-0.14
9/8/2015	9/9/2015	8.05	7.92	-0.13
7/21/2015	7/22/2015	8.64	8.51	-0.13
6/27/2015	6/28/2015	8.52	8.39	-0.13
8/24/2015	8/25/2015	8.44	8.31	-0.13
8/25/2015	8/26/2015	8.31	8.18	-0.13
9/23/2015	9/24/2015	8.82	8.70	-0.12
6/24/2015	6/25/2015	8.38	8.26	-0.12
7/12/2015	7/13/2015	8.87	8.76	-0.11
8/3/2015	8/4/2015	8.70	8.59	-0.11
6/18/2015	6/19/2015	8.60	8.50	-0.11
7/6/2015	7/7/2015	8.73	8.63	-0.10
7/4/2015	7/5/2015	8.70	8.60	-0.10
8/2/2015	8/3/2015	8.79	8.70	-0.10
8/15/2015	8/16/2015	8.72	8.62	-0.09
8/6/2015	8/7/2015	8.74	8.65	-0.09
6/15/2015	6/16/2015	8.27	8.19	-0.08
8/1/2015	8/2/2015	8.87	8.79	-0.08
7/27/2015	7/28/2015	8.79	8.71	-0.07
8/19/2015	8/20/2015	8.37	8.31	-0.06
8/17/2015	8/18/2015	8.61	8.55	-0.06
6/20/2015	6/21/2015	8.11	8.06	-0.06
9/18/2015	9/19/2015	8.39	8.35	-0.05
9/22/2015	9/23/2015	8.86	8.82	-0.04
9/28/2015	9/29/2015	8.90	8.86	-0.04
6/30/2015	7/1/2015	8.67	8.63	-0.04
8/5/2015	8/6/2015	8.78	8.74	-0.04
9/29/2015	9/30/2015	8.86	8.83	-0.03
9/4/2015	9/5/2015	8.26	8.22	-0.03
7/17/2015	7/18/2015	8.61	8.58	-0.03
7/7/2015	7/8/2015	8.63	8.60	-0.03
7/25/2015	7/26/2015	8.74	8.72	-0.03
8/12/2015	8/13/2015	8.60	8.57	-0.03

Table 7.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/23/2015	8/24/2015	8.46	8.44	-0.03
7/22/2015	7/23/2015	8.51	8.49	-0.02
8/16/2015	8/17/2015	8.62	8.61	-0.02
7/16/2015	7/17/2015	8.62	8.61	-0.02
9/27/2015	9/28/2015	8.92	8.90	-0.02
8/8/2015	8/9/2015	8.44	8.42	-0.01
9/14/2015	9/15/2015	8.35	8.34	-0.01
8/30/2015	8/31/2015	8.02	8.01	0.00
7/10/2015	7/11/2015	8.80	8.80	0.00
6/22/2015	6/23/2015	8.09	8.08	0.00
6/16/2015	6/17/2015	8.19	8.47	0.00
6/28/2015	6/29/2015	8.39	8.67	0.00
7/23/2015	7/24/2015	8.49	8.66	0.00
7/30/2015	7/31/2015	8.83	8.85	0.00
6/29/2015	6/30/2015	8.67	8.67	0.00
7/13/2015	7/14/2015	8.76	8.76	0.00
9/24/2015	9/25/2015	8.70	8.70	0.00
7/1/2015	7/2/2015	8.63	8.63	0.00
7/14/2015	7/15/2015	8.76	8.77	0.00
8/20/2015	8/21/2015	8.31	8.32	0.01
7/28/2015	7/29/2015	8.71	8.72	0.01
8/10/2015	8/11/2015	8.50	8.51	0.01
9/2/2015	9/3/2015	8.20	8.21	0.01
7/31/2015	8/1/2015	8.85	8.87	0.02
7/2/2015	7/3/2015	8.63	8.66	0.02
9/5/2015	9/6/2015	8.22	8.25	0.02
9/1/2015	9/2/2015	8.17	8.20	0.03
6/21/2015	6/22/2015	8.06	8.09	0.03
9/11/2015	9/12/2015	8.21	8.25	0.04
7/3/2015	7/4/2015	8.66	8.70	0.04
9/6/2015	9/7/2015	8.25	8.29	0.05
9/3/2015	9/4/2015	8.21	8.26	0.05
8/21/2015	8/22/2015	8.32	8.37	0.05
9/12/2015	9/13/2015	8.25	8.30	0.05
9/13/2015	9/14/2015	8.30	8.35	0.05
8/13/2015	8/14/2015	8.57	8.63	0.06
8/28/2015	8/29/2015	8.09	8.15	0.06
7/8/2015	7/9/2015	8.60	8.66	0.06
7/11/2015	7/12/2015	8.80	8.87	0.07
9/10/2015	9/11/2015	8.14	8.21	0.07
7/26/2015	7/27/2015	8.72	8.79	0.07

Table 7.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/9/2015	8/10/2015	8.42	8.50	0.08
8/27/2015	8/28/2015	8.01	8.09	0.08
7/24/2015	7/25/2015	8.66	8.74	0.09
9/26/2015	9/27/2015	8.83	8.92	0.09
9/17/2015	9/18/2015	8.31	8.39	0.09
8/11/2015	8/12/2015	8.51	8.60	0.09
8/14/2015	8/15/2015	8.63	8.72	0.09
7/19/2015	7/20/2015	8.70	8.79	0.10
8/22/2015	8/23/2015	8.37	8.46	0.10
9/21/2015	9/22/2015	8.76	8.86	0.10
6/25/2015	6/26/2015	8.26	8.36	0.10
7/29/2015	7/30/2015	8.72	8.83	0.10
9/15/2015	9/16/2015	8.34	8.46	0.11
7/18/2015	7/19/2015	8.58	8.70	0.12
7/5/2015	7/6/2015	8.60	8.73	0.13
9/25/2015	9/26/2015	8.70	8.83	0.13
6/17/2015	6/18/2015	8.47	8.60	0.13
7/9/2015	7/10/2015	8.66	8.80	0.14
9/19/2015	9/20/2015	8.35	8.49	0.14
8/31/2015	9/1/2015	8.01	8.17	0.16
6/26/2015	6/27/2015	8.36	8.52	0.16
8/4/2015	8/5/2015	8.59	8.78	0.19
9/9/2015	9/10/2015	7.92	8.14	0.22
9/20/2015	9/21/2015	8.49	8.76	0.27
6/23/2015	6/24/2015	8.08	8.38	0.30
9/30/2015		8.83		

Table 8.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/28/2015	8/29/2015	8.55	8.36	-0.19
8/7/2015	8/8/2015	8.63	8.46	-0.16
7/6/2015	7/7/2015	8.71	8.55	-0.16
9/23/2015	9/24/2015	8.92	8.77	-0.15
9/10/2015	9/11/2015	8.76	8.61	-0.14
9/11/2015	9/12/2015	8.61	8.47	-0.14
9/7/2015	9/8/2015	8.65	8.52	-0.13
8/29/2015	8/30/2015	8.36	8.23	-0.12
9/17/2015	9/18/2015	8.91	8.79	-0.12
8/6/2015	8/7/2015	8.72	8.63	-0.09
9/4/2015	9/5/2015	8.45	8.36	-0.09
7/2/2015	7/3/2015	8.52	8.45	-0.07
8/20/2015	8/21/2015	8.51	8.43	-0.07
8/15/2015	8/16/2015	8.71	8.64	-0.07
9/22/2015	9/23/2015	9.00	8.92	-0.07
8/17/2015	8/18/2015	8.64	8.57	-0.07
9/8/2015	9/9/2015	8.52	8.46	-0.07
7/3/2015	7/4/2015	8.45	8.38	-0.07
6/30/2015	7/1/2015	8.64	8.58	-0.06
8/18/2015	8/19/2015	8.57	8.51	-0.06
8/1/2015	8/2/2015	8.80	8.74	-0.06
8/2/2015	8/3/2015	8.74	8.68	-0.06
8/27/2015	8/28/2015	8.61	8.55	-0.06
7/1/2015	7/2/2015	8.58	8.52	-0.06
9/18/2015	9/19/2015	8.79	8.73	-0.06
9/21/2015	9/22/2015	9.05	9.00	-0.05
7/7/2015	7/8/2015	8.55	8.50	-0.05
7/14/2015	7/15/2015	9.07	9.02	-0.05
8/8/2015	8/9/2015	8.46	8.41	-0.05
7/12/2015	7/13/2015	9.13	9.08	-0.05
8/24/2015	8/25/2015	8.71	8.66	-0.05
7/31/2015	8/1/2015	8.85	8.80	-0.05
7/11/2015	7/12/2015	9.18	9.13	-0.05
8/9/2015	8/10/2015	8.41	8.37	-0.04
9/28/2015	9/29/2015	8.99	8.96	-0.04
7/16/2015	7/17/2015	9.03	9.00	-0.03
8/26/2015	8/27/2015	8.63	8.61	-0.03
8/25/2015	8/26/2015	8.66	8.63	-0.03
6/29/2015	6/30/2015	8.67	8.64	-0.02
8/3/2015	8/4/2015	8.68	8.66	-0.02
9/29/2015	9/30/2015	8.96	8.93	-0.02

Table 8.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
7/13/2015	7/14/2015	9.08	9.07	-0.01
9/27/2015	9/28/2015	9.00	8.99	-0.01
8/19/2015	8/20/2015	8.51	8.51	0.00
9/3/2015	9/4/2015	8.45	8.45	0.00
6/15/2015	6/16/2015			0.00
6/16/2015	6/17/2015			0.00
6/17/2015	6/18/2015			0.00
6/18/2015	6/19/2015			0.00
6/19/2015	6/20/2015			0.00
6/20/2015	6/21/2015			0.00
6/21/2015	6/22/2015			0.00
6/22/2015	6/23/2015			0.00
6/23/2015	6/24/2015			0.00
6/24/2015	6/25/2015			0.00
6/25/2015	6/26/2015			0.00
6/26/2015	6/27/2015			0.00
6/27/2015	6/28/2015			0.00
6/28/2015	6/29/2015		8.67	0.00
7/19/2015	7/20/2015	9.16		0.00
7/20/2015	7/21/2015			0.00
7/21/2015	7/22/2015			0.00
7/22/2015	7/23/2015			0.00
7/23/2015	7/24/2015			0.00
7/24/2015	7/25/2015			0.00
7/25/2015	7/26/2015			0.00
7/26/2015	7/27/2015			0.00
7/27/2015	7/28/2015			0.00
7/28/2015	7/29/2015			0.00
7/29/2015	7/30/2015			0.00
7/30/2015	7/31/2015		8.85	0.00
8/30/2015	8/31/2015	8.23	8.24	0.00
8/16/2015	8/17/2015	8.64	8.64	0.00
7/15/2015	7/16/2015	9.02	9.03	0.00
9/24/2015	9/25/2015	8.77	8.78	0.01
8/5/2015	8/6/2015	8.71	8.72	0.01
8/23/2015	8/24/2015	8.70	8.71	0.01
8/13/2015	8/14/2015	8.68	8.69	0.01
8/14/2015	8/15/2015	8.69	8.71	0.02
9/14/2015	9/15/2015	8.68	8.70	0.02
7/17/2015	7/18/2015	9.00	9.02	0.02
7/8/2015	7/9/2015	8.50	8.53	0.03

Table 8.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Downstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/2/2015	9/3/2015	8.42	8.45	0.03
9/1/2015	9/2/2015	8.38	8.42	0.03
8/10/2015	8/11/2015	8.37	8.42	0.05
8/4/2015	8/5/2015	8.66	8.71	0.05
9/16/2015	9/17/2015	8.85	8.91	0.06
8/12/2015	8/13/2015	8.61	8.68	0.06
9/26/2015	9/27/2015	8.92	9.00	0.08
8/21/2015	8/22/2015	8.43	8.52	0.09
7/5/2015	7/6/2015	8.62	8.71	0.09
9/13/2015	9/14/2015	8.59	8.68	0.10
9/12/2015	9/13/2015	8.47	8.59	0.11
9/5/2015	9/6/2015	8.36	8.47	0.11
7/18/2015	7/19/2015	9.02	9.16	0.14
9/25/2015	9/26/2015	8.78	8.92	0.14
9/15/2015	9/16/2015	8.70	8.85	0.14
8/31/2015	9/1/2015	8.24	8.38	0.15
9/19/2015	9/20/2015	8.73	8.89	0.16
9/20/2015	9/21/2015	8.89	9.05	0.16
8/22/2015	8/23/2015	8.52	8.70	0.17
9/6/2015	9/7/2015	8.47	8.65	0.18
8/11/2015	8/12/2015	8.42	8.61	0.19
7/4/2015	7/5/2015	8.38	8.62	0.23
7/9/2015	7/10/2015	8.53	8.78	0.25
9/9/2015	9/10/2015	8.46	8.76	0.30
7/10/2015	7/11/2015	8.78	9.18	0.40
9/30/2015		8.93		

Table 9.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Badger Upstream						Badger Downstream						Badger Bypass						RC Upstream						RC Downstream					
	DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
6/15/2015																														
6/16/2015																														
6/17/2015																														
6/18/2015																														
6/19/2015																														
6/20/2015																														
6/21/2015																														
6/22/2015																														
6/23/2015																														
6/24/2015			6/16/15 18:00 to 6/29/15 09:00	6/29/15 Notes: pH calibration failed 3 times; rebuilt pH Sensor																												
6/25/2015																														
6/26/2015																														
6/27/2015																														
6/28/2015											6/25/15 17:00 to 6/29/15 09:00	6/29/15 Photo: Sonde covered of mud and sediment																		
6/29/2015							6/29/15 06:00 to 6/29/15 09:00	**6/29/15 Photo:** Sonde covered of mud and sediment					Data Gap 6/15/15 to 7/10/15 11:00 Due to High River Flow						6/20/15 01:00 to 6/23/15 19:00; 6/28/15 05:00 to 6/29/15 10:00	6/29/15 Photo: Sonde is covered in biofilm					Data Gap 6/15/15 to 6/29/15 14:00 Due to Hardware Message and Power Outage					
6/30/2015																														
7/1/2015																														
7/2/2015																														
7/3/2015																														
7/4/2015							7/4/15 12:00 to 7/8/15 02:00	7/10/15 Photo: Sonde covered in mud																						
7/5/2015																														
7/6/2015																														
7/7/2015																														
7/8/2015																														
7/9/2015																														
7/10/2015																														
7/11/2015																													7/11/2015 01:00 to 7/20/15 11:00	7/20/15 Photo: Sonde is covered in biofilm
7/12/2015																														
7/13/2015																														
7/14/2015																														
7/15/2015							7/14/15 21:00 to 7/20/15 08:00	7/20/15 Photo: Sonde covered in mud																						
7/16/2015																														
7/17/2015																														
7/18/2015																														
7/19/2015																														
7/20/2015																														
7/21/2015																														
7/22/2015																														
7/23/2015																														
7/24/2015																														
7/25/2015																														
7/26/2015			7/23/15 09:00 to 7/28/15 10:00	7/28/15 Notes: read 5.0 in 7.0 calibration standard, sent sonde back to Hach																												
7/27/2015							7/26/15 21:00 to 7/28/15 10:00	7/28/15 Photo: Sonde covered in mud																						
7/28/2015																														
7/29/2015																														
7/30/2015	Data Gap 7/28/15 11:00 to 7/31/15 13:00 Due to pH Probe Failure																								Data Gap 7/20/15 12:00 to 7/31/15 13:00 Due to Waterlogged Sonde					
7/31/2015																														
8/1/2015																														
8/2/2015																														
8/3/2015							Data Gap 7/28/15 11:00 to 8/10/15 12:00 Due to Interface Communication Errors																						
8/4/2015																														
8/5/2015																														
8/6/2015																														
8/7/2015																														
8/8/2015																														
8/9/2015																														
8/10/2015																														

Table 9.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Badger Upstream						Badger Downstream						Badger Bypass						RC Upstream						RC Downstream					
	DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
8/11/2015											8/10/15 12:00 to 8/14/15 09:00	8/14/15 Notes: Unstable Conductivity																		
8/12/2015																														
8/13/2015																														
8/14/2015																														
8/15/2015																														
8/16/2015																														
8/17/2015																														
8/18/2015																			8/18/15 08:00 to 8/20/15 10:00	8/20/15 Photo: Sonde is covered in biofilm										
8/19/2015																														
8/20/2015																														
8/21/2015																														
8/22/2015																														
8/23/2015																														
8/24/2015																														
8/25/2015																														
8/26/2015																														
8/27/2015																														
8/28/2015																														
8/29/2015																														
8/30/2015																														
8/31/2015																														
9/1/2015																														
9/2/2015																														
9/3/2015																														
9/4/2015																														
9/5/2015																														
9/6/2015																														
9/7/2015																														
9/8/2015																														
9/9/2015																														
9/10/2015																														
9/11/2015													Data Gap from 9/11/15 11:00 to 9/21/15 12:00 Due to High River Flow																	
9/12/2015																														
9/13/2015																														
9/14/2015																														
9/15/2015																														
9/16/2015																														
9/17/2015																														
9/18/2015																														
9/19/2015																														
9/20/2015																														
9/21/2015																														
9/22/2015																														
9/23/2015																														
9/24/2015																														
9/25/2015																														
9/26/2015																														
9/27/2015																														
9/28/2015																														
9/29/2015																														
9/30/2015																														

Table 10
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Badger Upstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed	Date	Conductivity (µS/cm)						LDO (mg/L)						pH											
			In Check			Post-Cleaning			In Check			Post-Cleaning			pH 7 Calibration						pH 10 Calibration					
															In Check			Post-Cleaning			In Check			Post-Cleaning		
		Before	Standard	% Difference	Before	Standard	% Difference	Before	After	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14265H400094	6/11/2015	1379	1412	-2.3	1406	1412	-0.4	8.82	8.65	2.0	8.72	8.69	0.3	7.02	7.00	0.3	6.92	7.00	-1.1	9.96	10.00	-0.4	9.91	10.00	-0.9
14265H400094	6/29/2015	1521	1412	7.7	1403.2	1412	-0.6	8.04	7.96	1.0	7.69	7.74	-0.6	9.27	7.00	32.4	7.07	7.00	1.0	10.08	10.00	0.8	9.97	10.00	-0.3
14265H400094	7/10/2015	1408	1412	-0.3	1404.9	1412	-0.5	8.11	8.15	-0.5	8.15	8.07	1.0	6.99	7.00	-0.1	6.94	7.00	-0.9	10.01	10.00	0.1	9.85	10.00	-1.5
14265H400094	7/20/2015	1448	1412	2.5	1400	1412	-0.8	8.3	8.37	-0.8	7.64	7.80	-2.1	7.05	7.00	0.7	7.03	7.00	0.4	10.11	10.00	1.1	9.93	10.00	-0.7
14265H400094 - pH calibration failed, took sonde out of service	7/28/2015	1402.3	1412	-0.7		1412	-100.0	7.98	8.19	-2.6			#DIV/0!		7.00	-100.0		7.00	-100.0		10.00	-100.0		10.00	-100.0
15036H400235	7/31/2015	1412.3	1412	0.0	1400.7	1412	-0.8	8.69	8.65	0.5	8.69	8.56	1.5	6.72	7.00	-4.0	6.94	7.00	-0.9	9.68	10.00	-3.2	10.08	10.00	0.8
15036H400235	8/4/2015	1416.9	1412	0.3	1423	1412	0.8	8.54	8.45	1.1	8.31	8.27	0.5	6.88	7.00	-1.7	6.97	7.00	-0.4	9.98	10.00	-0.2	9.96	10.00	-0.4
15036H400235	8/14/2015	1442	1412	2.1	1418	1412	0.4	8.15	8.12	0.4	7.75	7.79	-0.5	7.03	7.00	0.4	7.03	7.00	0.4	9.99	10.00	-0.1	10.03	10.00	0.3
15036H400235	8/20/2015	1402.1	1412	-0.7	1357.3	1412	-3.9	8.6	8.65	-0.6	9.03	9.08	-0.6	7.03	7.00	0.4	7.01	7.00	0.1	9.99	10.00	-0.1	9.91	10.00	-0.9
14265H400094 - replaced loaner sonde with original	8/20/2015	1519.2	1412	7.6	1315.2	1412	-6.9	8.54	8.56	-0.2	8.52	8.5	0.2	7	7.00	0.0	7.01	7.00	0.1	10.07	10.00	0.7	10.01	10.00	0.1
14265H400094	8/28/2015	1403	1412	-0.6	1402.8	1412	-0.7	8.78	8.69	1.0	8.69	8.7	-0.1	6.91	7.00	-1.3	6.99	7.00	-0.1	9.91	10.00	-0.9	9.97	10.00	-0.3
14265H400094	9/4/2015	1429	1412	1.2	1397	1412	-1.1	8.32	8.51	-2.2	8.4	8.45	-0.6	6.95	7.00	-0.7	7.01	7.00	0.1	9.91	10.00	-0.9	10.00	10.00	0.0
14265H400094 Replaced with 15036H400235	9/11/2015	1413	1412	0.1	1417.2	1412	0.4	8.9	8.84	0.7	7.44	7.45	-0.1	6.77	7.00	-3.3	6.9	7.00	-1.4	9.58	10.00	-4.2	would not calibrate even after rebuilding sensor		
15036H400235	9/11/2015	1475	1412	4.5				8.61	8.69	-0.9				9.99	7.00	42.7				9.99	10.00	-0.1			
15036H400235	9/21/2015	1387	1412	-1.8	1401.6	1412	-0.7	8.66	8.39	3.2	8.46	8.47	-0.1	6.86	7.00	-2.0	6.99	7.00	-0.1	9.91	10.00	-0.9	9.96	10.00	-0.4
	10/2/2015	No Calibration Performed																							

Table 11
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Downstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)						LDO (mg/L)						pH									
														pH 7 Calibration						pH 10 Calibration			
		In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning		
		Before	Standard	% Difference	Before	Standard	% Difference	Before	After	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14262H400091	6/11/2015	1305	1412	-7.6	1386	1412	-1.8	8.69	8.69	0.0	8.63	8.63	0.0	7.10	7.00	1.4	6.98	7.00	-0.3	10.02	10.00	0.2	9.98	10.00	-0.2
14262H400091	6/29/2015	1409	1412	-0.2	1443	1412	2.2	7.52			7.66	7.66	0.0	6.91	7.00	-1.3	7.03	7.00	0.4	9.97	10.00	-0.3	9.97	10.00	-0.3
14262H400091	7/10/2015	1419.2	1412	0.5	1409.5	1412	-0.2	7.92	8	-1.0	7.88		#DIV/0!	7.12	7.00	1.7	6.99	7.00	-0.1	10.06	10.00	0.6	9.96	10.00	-0.4
14262H400091	7/20/2015	1405	1412	-0.5	1400.1	1412	-0.8	8		#DIV/0!	7.57	7.66	-1.2	7.13	7.00	1.9	6.95	7.00	-0.7	10.09	10.00	0.9	9.98	10.00	-0.2
14262H400091	7/28/2015	1425	1412	0.9	1407	1412	-0.4	7.75	7.57	2.4	7.37	7.38	-0.1	7.11	7.00	1.6	7.04	7.00	0.6	9.96	10.00	-0.4	9.95	10.00	-0.5
Sonde unable to communicate with software interface	8/4/2015		1412	-100.0		1412	-100.0			#DIV/0!			#DIV/0!		7.00	-100.0		7.00	-100.0		10.00	-100.0		10.00	-100.0
14231H400044	8/10/2015		1412	-100.0		1412	-100.0			#DIV/0!			#DIV/0!		7.00	-100.0		7.00	-100.0		10.00	-100.0		10.00	-100.0
14231H400044	8/14/2015	1329	1412	-5.9	1392	1412	-1.4	7.9	7.78	1.5	7.90	7.84	0.8	6.95	7.00	-0.7	7	7.00	0.0	9.99	10.00	-0.1	10.00	10.00	0.0
14231H400044	8/20/2015	1410.9	1412	-0.1	1574	1412	11.5	9.01	8.91	1.1	8.80	8.81	-0.1	6.94	7.00	-0.9	6.93	7.00	-1.0	9.91	10.00	-0.9	1.00	10.00	-90.0
14262H400091 - replaced loaner sonde with original	8/20/2015	1419	1412	0.5	1407.9	1412	-0.3	8.51	8.47	0.5	8.43	8.5	-0.8	6.97	7.00	-0.4	6.98	7.00	-0.3	9.93	10.00	-0.7	9.99	10.00	-0.1
14262H400091	8/28/2015	1418	1412	0.4	1412.4	1412	0.0	8.81	8.5	3.6	8.46	8.55	-1.1	6.96	7.00	-0.6	7.01	7.00	0.1	9.99	10.00	-0.1	10.00	10.00	0.0
14262H400091	9/4/2015	1412.1	1412	0.0	1408.7	1412	-0.2	8.26	8.26	0.0	8.34	8.49	-1.8	6.99	7.00	-0.1	6.97	7.00	-0.4	9.95	10.00	-0.5	9.91	10.00	-0.9
14262H400091	9/11/2015	1418	1412	0.4	1411.3	1412	0.0	8.98	9.02	-0.4	8.92	9.07	-1.7	6.96	7.00	-0.6	6.99	7.00	-0.1	9.97	10.00	-0.3	9.99	10.00	-0.1
14262H400091	9/21/2015	1419	1412	0.5	1433.7	1412	1.5	8.59	8.58	0.1	8.42	8.48	-0.7	6.89	7.00	-1.6	7.09	7.00	1.3	9.99	10.00	10.2	10.15	10.00	1.5
	10/2/2015	No Calibration Performed																							

Table 12
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Bypass Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)						LDO (mg/L)						pH											
														pH 7 Calibration						pH 10 Calibration					
		In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning		
		Before	Standard	% Difference	Before	Standard	% Difference	Before	After	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14262H400093	6/11/2015	1399	1412	-0.9	1454	1412	3.0	8.78	8.78	0.0	8.74	8.74	0.0	7.95	7.00	13.6	7.65	7.00	9.3	10.99	10.00	9.9	9.95	10.00	-0.5
No Sonde from 6/11/15 through 7/10/15 due to strong river current																									
14262H400093	7/10/2015		1412	-100.0	1304	1412	-7.6			#DIV/0!	7.54		#DIV/0!		7.00	-100.0	7.15	7.00	2.1	10.15	10.00	1.5		10.00	-100.0
14262H400093	7/20/2015	1436	1412	1.7	1387	1412	-1.8	7.5	7.57	-0.9	7.6	7.62	-0.3	6.98	7.00	-0.3	7.00	7.00	0.0	10.00	10.00	0.0	10.00	10.00	0.0
14262H400093	7/28/2015	1419.3	1412	0.5	1423.6	1412	0.8	7.53	7.57	-0.5	7.31	7.43	-1.6	7.04	7.00	0.6	6.99	7.00	-0.1	10.05	10.00	0.5	9.99	10.00	-0.1
14262H400093	8/4/2015	1408	1412	-0.3	1426.2	1412	1.0	8.59	8.62	-0.3	7.70	7.73	-0.4	6.98	7.00	-0.3	7.02	7.00	0.3	9.83	10.00	-1.7	10.05	10.00	0.5
14262H400093	8/14/2015	1407	1412	-0.4	1419	1412	0.5	7.54	7.55	-0.1	7.96	8.01	-0.6	7.03	7.00	0.4	6.96	7.00	-0.6	10.03	10.00	0.3	9.98	10.00	-0.2
14262H400093	8/20/2015	1402	1412	-0.7	1462	1412	3.5	8.51	8.62	-1.3	8.86	8.90	-0.4	6.95	7.00	-0.7	6.90	7.00	-1.4	9.84	10.00	-1.6	9.92	10.00	-0.8
14262H400093	8/28/2015	1360	1412	-3.7	1437	1412	1.8	8.49	8.50	-0.1	8.18	8.43	-3.0	6.75	7.00	-3.6	6.96	7.00	-0.6	9.75	10.00	-2.5	10.02	10.00	0.2
14262H400093	9/4/2015	1393	1412	-1.3	1412.4	1412	0.0	8.07	8.10	-0.4	8.55	8.34	2.5	6.99	7.00	-0.1	7.14	7.00	2.0	9.91	10.00	-0.9	9.97	10.00	-0.3
14262H400093	9/11/2015	1260.8	1412	-10.7		1412	-100.0	9.04	8.81	2.6				7.02	7.00	0.3		7.00		9.99	10.00	-0.1		10.00	
No sonde from 9/11/15 through 9/21/15 due to strong river current																									
14231H400044	9/21/2015				1439.1	1412	1.9				8.68	8.78	-1.1				7.02	7.00	0.3				9.99	10.00	-0.1
	10/2/2015	No Calibration Performed																							

Table 13
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Upstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)						LDO (mg/L)						pH									
			In Check			Post-Cleaning			In Check			Post-Cleaning			pH 7 Calibration						pH 10 Calibration			
															In Check			Post-Cleaning			In Check			Post-Cleaning	
		Before	Standard	% Difference	Before	Standard	% Difference	Before	After	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14267H400097	6/11/2015	1375	1412	-2.6	1410.8	1412	-0.1	8.92	9.97	-10.5	9.01	9.01	0.0	7.04	7.00	0.6	7.04	7.00	0.6	10.02	10.00	0.2	10.03	10.00	0.3
14267H400097	6/29/2015	1420.3	1412	0.6	1419.6	1412	0.5	8.16	8.13	0.4	7.62	8.38	-9.1	6.99	7.00	-0.1	6.96	7.00	-0.6	10.06	10.00	0.6	9.86	10.00	-1.4
14267H400097	7/10/2015	1403.3	1412	-0.6	1443	1412	2.2	7.97	8.06	-1.1	7.87	7.9	-0.4	7.08	7.00	1.1	7.00	7.00	0.0	10.11	10.00	1.1	9.94	10.00	-0.6
14267H400097	7/20/2015	1423	1412	0.8	1409.8	1412	-0.2	7.79	7.78	0.1	7.91	7.84	0.9	7.05	7.00	0.7	6.99	7.00	-0.1	10.05	10.00	0.5	9.99	10.00	-0.1
14267H400097	7/28/2015	1395	1412	-1.2	1417.8	1412	0.4	7.2	7.4	-2.7	7.36	7.39	-0.4	7.00	7.00	0.0	6.99	7.00	-0.1	10.03	10.00	0.3	9.99	10.00	-0.1
14267H400097	8/4/2015	1417.9	1412	0.4	1393	1412	-1.3	8.20	8.35	-1.8	8.00	8.02	-0.2	7.01	7.00	0.1	6.99	7.00	-0.1	9.98	10.00	-0.2	9.95	10.00	-0.5
14267H400097	8/14/2015	1412	1412	0.0	1421	1412	0.6	7.35	7.3	0.7	7.43	7.54	-1.5	7.09	7.00	1.3	6.98	7.00	-0.3	10.06	10.00	0.6	9.96	10.00	-0.4
14267H400097	8/20/2015	1400	1412	-0.8	1455	1412	3.0	9.48	9.58	-1.0	8.83	8.85	-0.2	6.94	7.00	-0.9	6.84	7.00	-2.3	9.83	10.00	-1.7	9.94	10.00	-0.6
14267H400097	8/28/2015	1392	1412	-1.4	1409	1412	-0.2	8.23	8.4	-2.0	8.32	8.40	-1.0	6.90	7.00	-1.4	6.95	7.00	-0.7	9.90	10.00	-1.0	9.99	10.00	-0.1
14267H400097	9/4/2015	1409	1412	-0.2	1412.3	1412	0.0	8.33	8.25	1.0	8.32	8.32	0.0	7.03	7.00	0.4	6.94	7.00	-0.9	9.93	10.00	-0.7			
14267H400097	9/11/2015	1414.7	1412	0.2	1406	1412	-0.4	8.91	8.83	0.9	8.80	8.87	-0.8	7.02	7.00	0.3	7.01	7.00	0.1	9.98	10.00	-0.2	9.98	10.00	
14267H400097	9/21/2015	1416.3	1412	0.3	1412.8	1412	0.1	8.56	8.58	-0.2	8.71	8.74	-0.3	6.98	7.00	-0.3	7.03	7.00	0.4	9.86	10.00	-1.4	10.07	10.00	0.7
	10/2/2015	No Calibration Performed																							

Table 14
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Rapide Croche Tailrace Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)						LDO (mg/L)						pH									
														pH 7 Calibration						pH 10 Calibration			
		In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning			In Check			Post-Cleaning		
		Before	Standard	% Difference	Before	Standard	% Difference	Before	After	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14262H400092	6/11/2015	1397.3	1412	-1.0	1429.2	1412	1.2	9.12	9.12	0.0	9.13	9.15	-0.2	7.12	7.00	1.7	6.99	7.00	-0.1	10.11	10.00	1.1	9.98	10.00	-0.2
14262H400092	6/29/2015	1401	1412	-0.8	1409.4	1412	-0.2	7.34		#DIV/0!	7.77		#DIV/0!	7.03	7.00	0.4	7.00	7.00	0.0	10.05	10.00	0.5	9.97	10.00	-0.3
14262H400326	7/10/2015		1412	-100.0	1423.2	1412	0.8			#DIV/0!	7.6		#DIV/0!		7.00	-100.0	7.01	7.00	0.1		10.00	-100.0	10.06	10.00	0.6
14262H400326	7/20/2015	1411.6	1412	0.0	1412.4	1412	0.0	6.61	6.60	0.2	6.77	6.80	-0.4	7.10	7.00	1.4	6.97	7.00	-0.4	10.13	10.00	1.3	9.98	10.00	-0.2
terlogged, unable to ret	**7/28/2015**		1412	-100.0		1412	-100.0			#DIV/0!			#DIV/0!		7.00	-100.0		7.00	-100.0		10.00	-100.0		10.00	-100.0
15037H400237	**7/31/2015**	1460	1412	3.4	1394.2	1412	-1.3	8.60	8.55	0.6	8.53	8.55	-0.2	7.02	7.00	0.3	7.03	7.00	0.4	10.02	10.00	0.2	9.94	10.00	-0.6
15037H400237	8/4/2015	1421.7	1412	0.7	1400	1412	-0.8	8.10	8.13	-0.4	8.06	8.06	0.0	7.02	7.00	0.3	6.94	7.00	-0.9	9.92	10.00	-0.8	9.96	10.00	-0.4
15037H400237	8/14/2015	1419	1412	0.5	1415	1412	0.2	6.96	7.22	-3.6	7.20	7.21	-0.1	7.08	7.00	1.1	6.95	7.00	-0.7	10.03	10.00	0.3	9.99	10.00	-0.1
15037H400237	8/20/2015	1405.3	1412	-0.5	1571	1412	11.3	9.57	9.59	-0.2	9.02	9.01	0.1	6.98	7.00	-0.3	6.86	7.00	-2.0	9.80	10.00	-2.0	9.88	10.00	-1.2
226H400365 - New Son	8/26/2015	1403.4	1412	-0.6	1413.4	1412	0.1	8.79	8.85	-0.7	8.86	8.86	0.0	6.84	7.00	-2.3	7.08	7.00	1.1	9.84	10.00	-1.6	10.22	10.00	2.2
15037H400237	8/28/2015	1422.9	1412	0.8	1395	1412	-1.2	8.36	8.39	-0.4	8.30	8.47	-2.0	7.13	7.00	1.9	6.98	7.00	-0.3	10.04	10.00	0.4	9.97	10.00	-0.3
15037H400237	9/4/2015	1409	1412	-0.2	1416	1412	0.3	8.22	8.21	0.1	8.21	8.26	-0.6	6.97	7.00	-0.4	7.02	7.00	0.3	9.98	10.00	-0.2	9.96	10.00	-0.4
15037H400237	9/11/2015	1408	1412	-0.3	1412.4	1412	0.0	8.89	8.84	0.6	8.78	8.81	-0.3	7.01	7.00	0.1	6.93	7.00	-1.0	10.49	10.00	4.9	10.04	10.00	0.4
15037H400237	9/21/2015	1425.1	1412	0.9	1424	1412	0.8	8.73	8.72	0.1	8.82	8.79	0.3	7.40	7.00	5.7	6.64	7.00	-5.1				9.62	10.00	-3.8
15037H400237 Replaced with 15226H400365	9/21/2015				1414.9	1412	0.2				8.67	8.65	0.2				7.02	7.00	0.3			#DIV/0!	10.01	10.00	0.1
	10/2/2015	No Calibration Performed																							

Appendix B

Unabridged Data

Table 3 Raw Data Badger Bypass Daily Averages

Table 6 Raw Data Rapide Croche Upstream and Downstream Daily Averages

Figure 2. Hourly Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

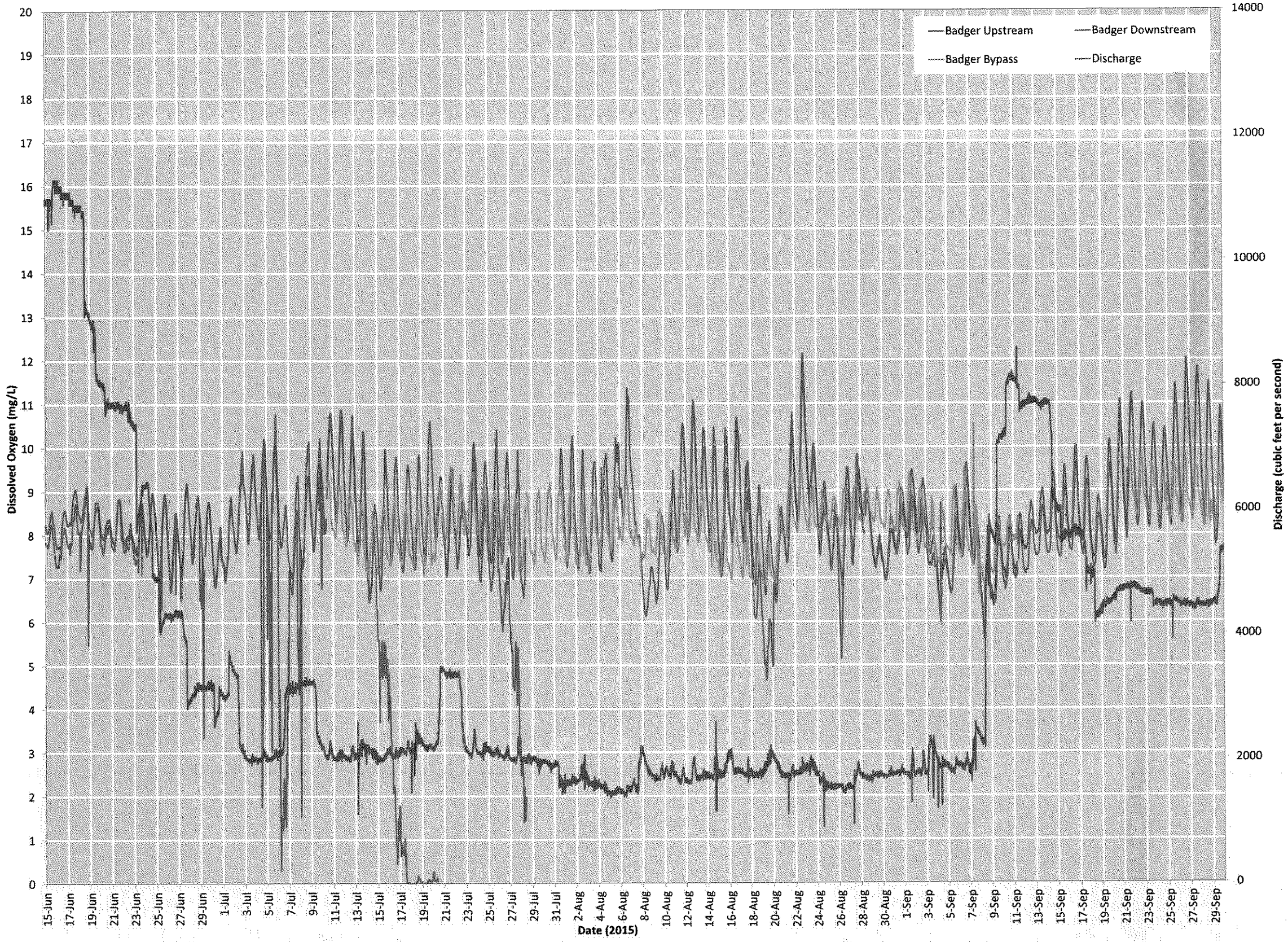


Figure 3. Hourly Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

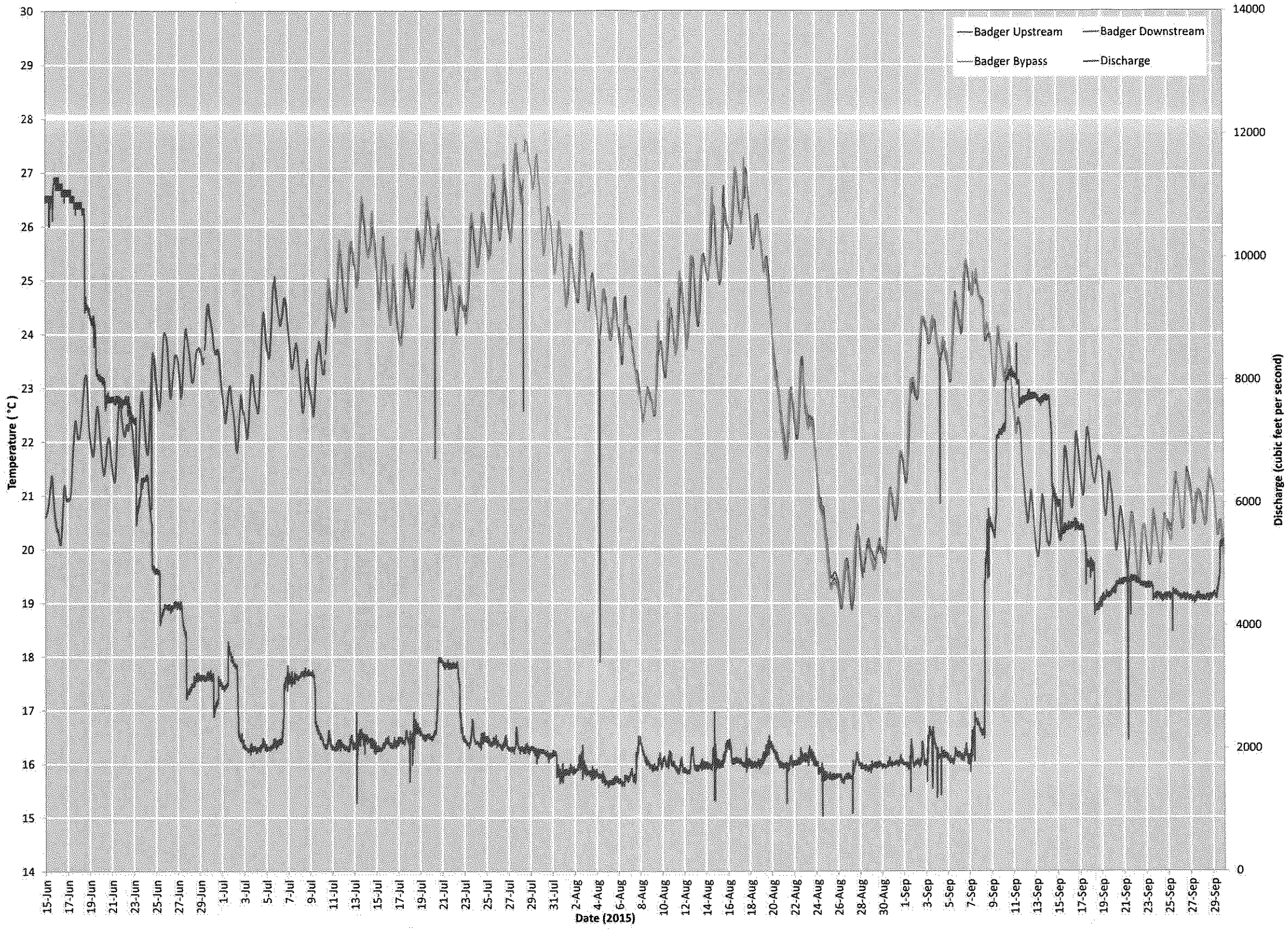


Figure 4. Hourly pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

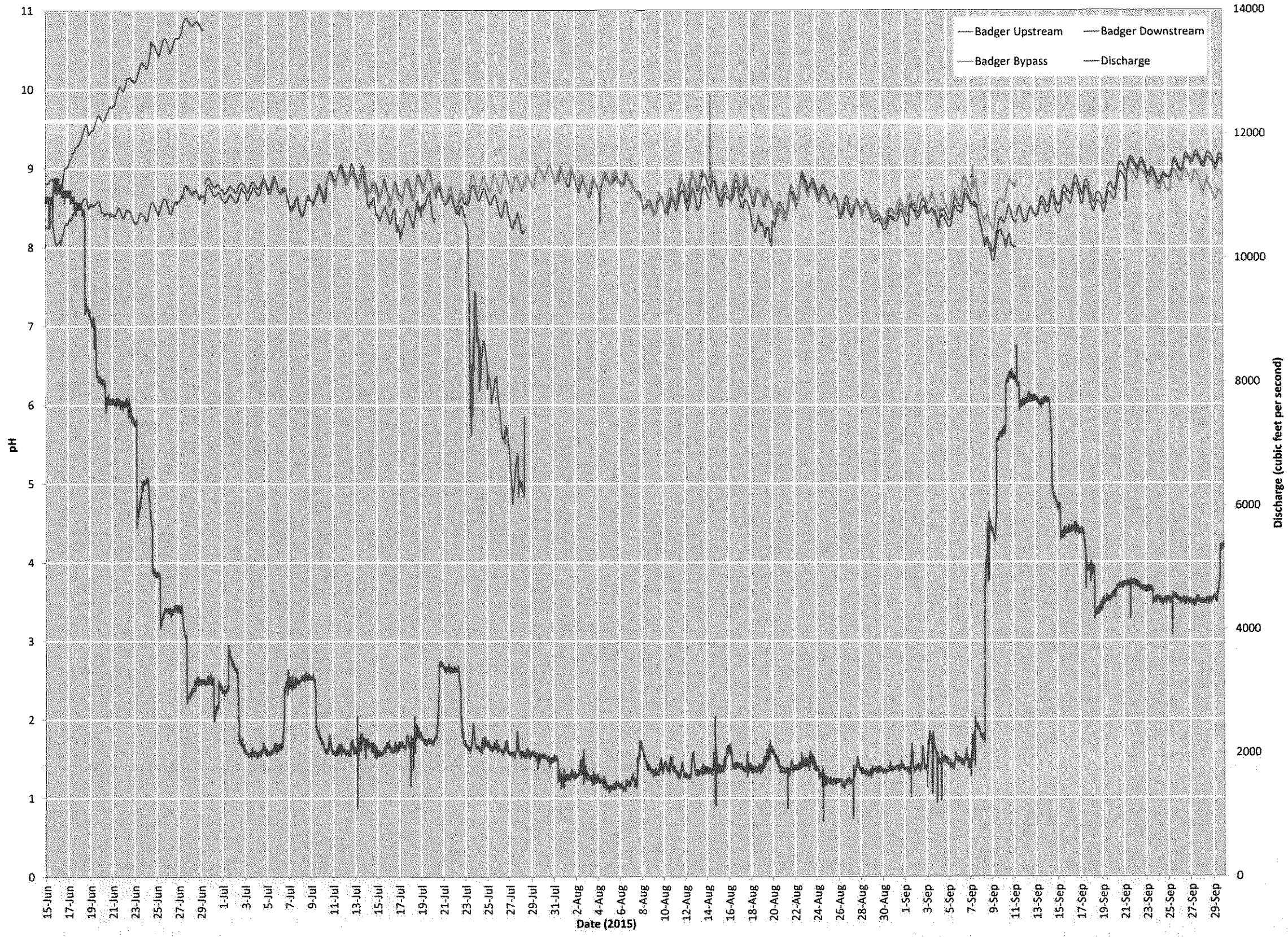


Figure 5. Hourly Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

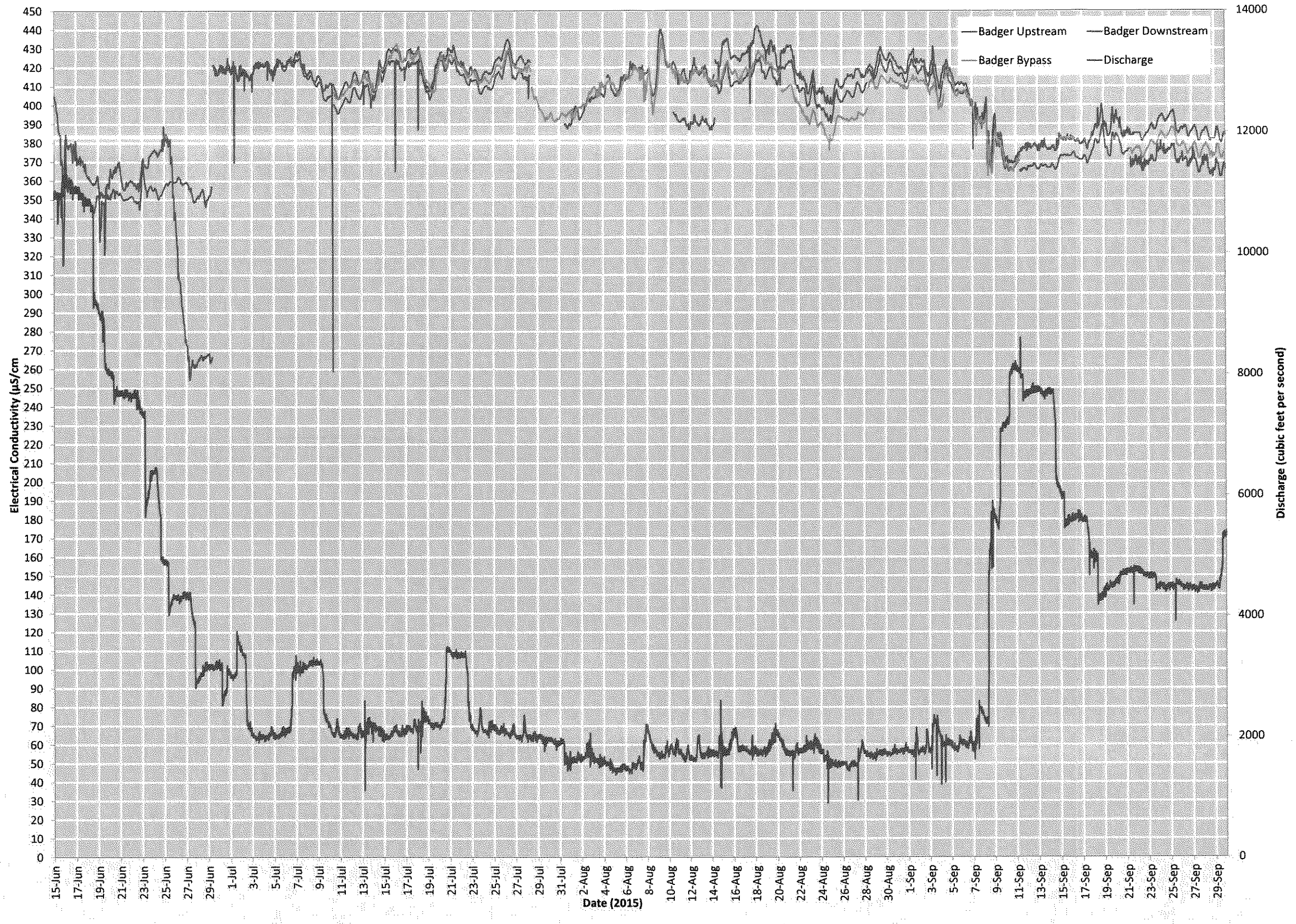


Figure 6. Daily Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

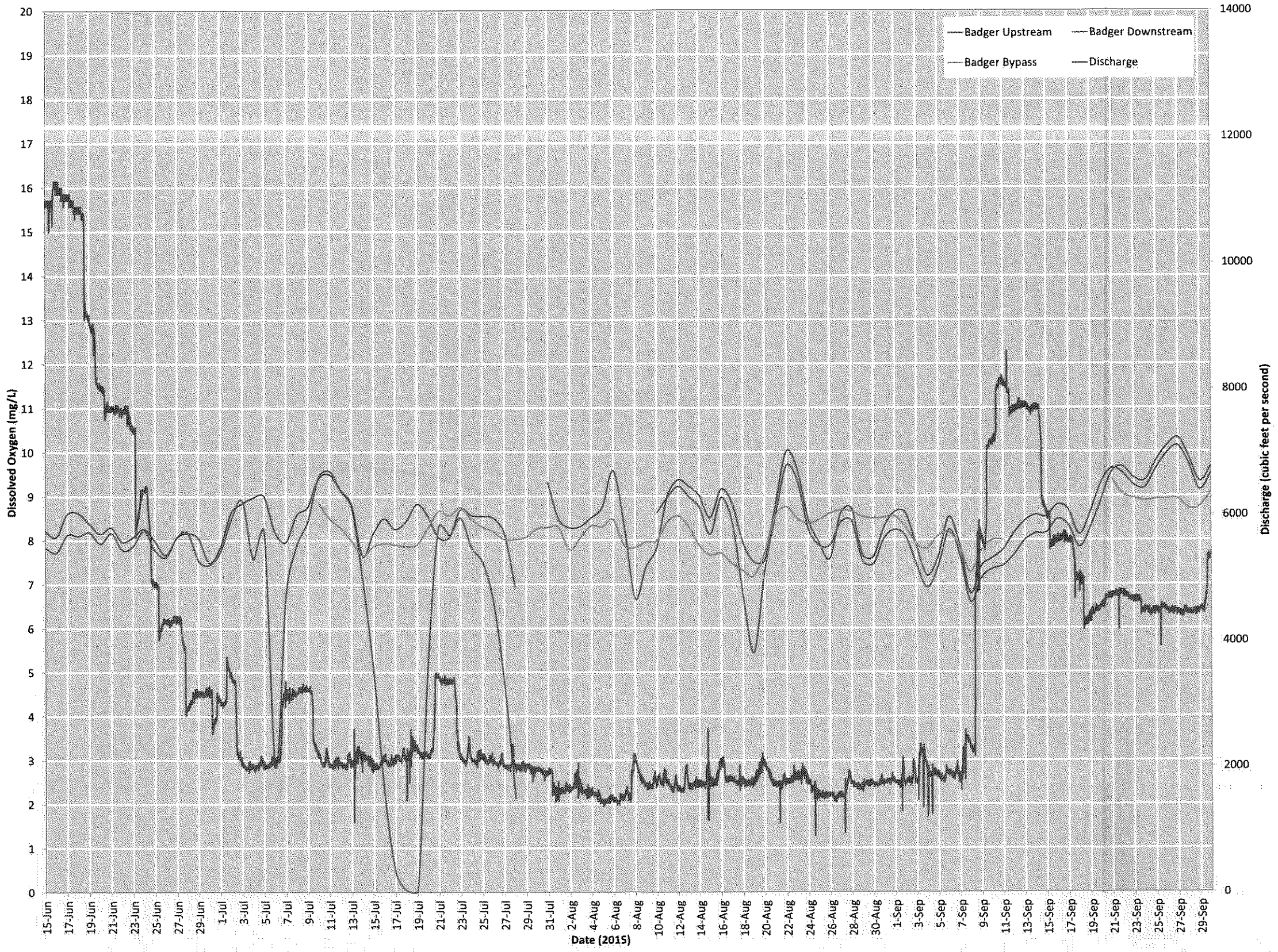


Figure 7. Daily Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

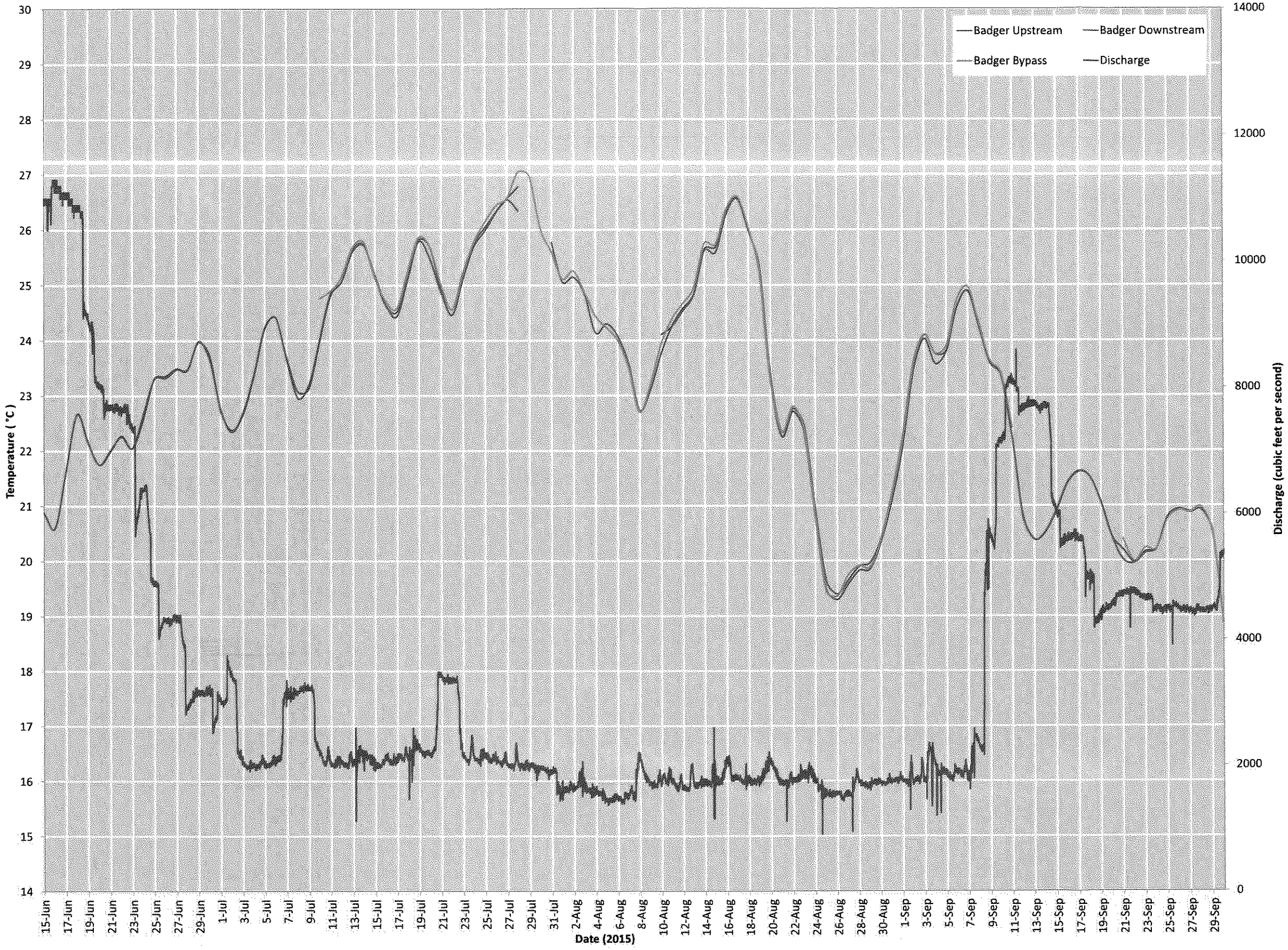


Figure 8. Daily pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

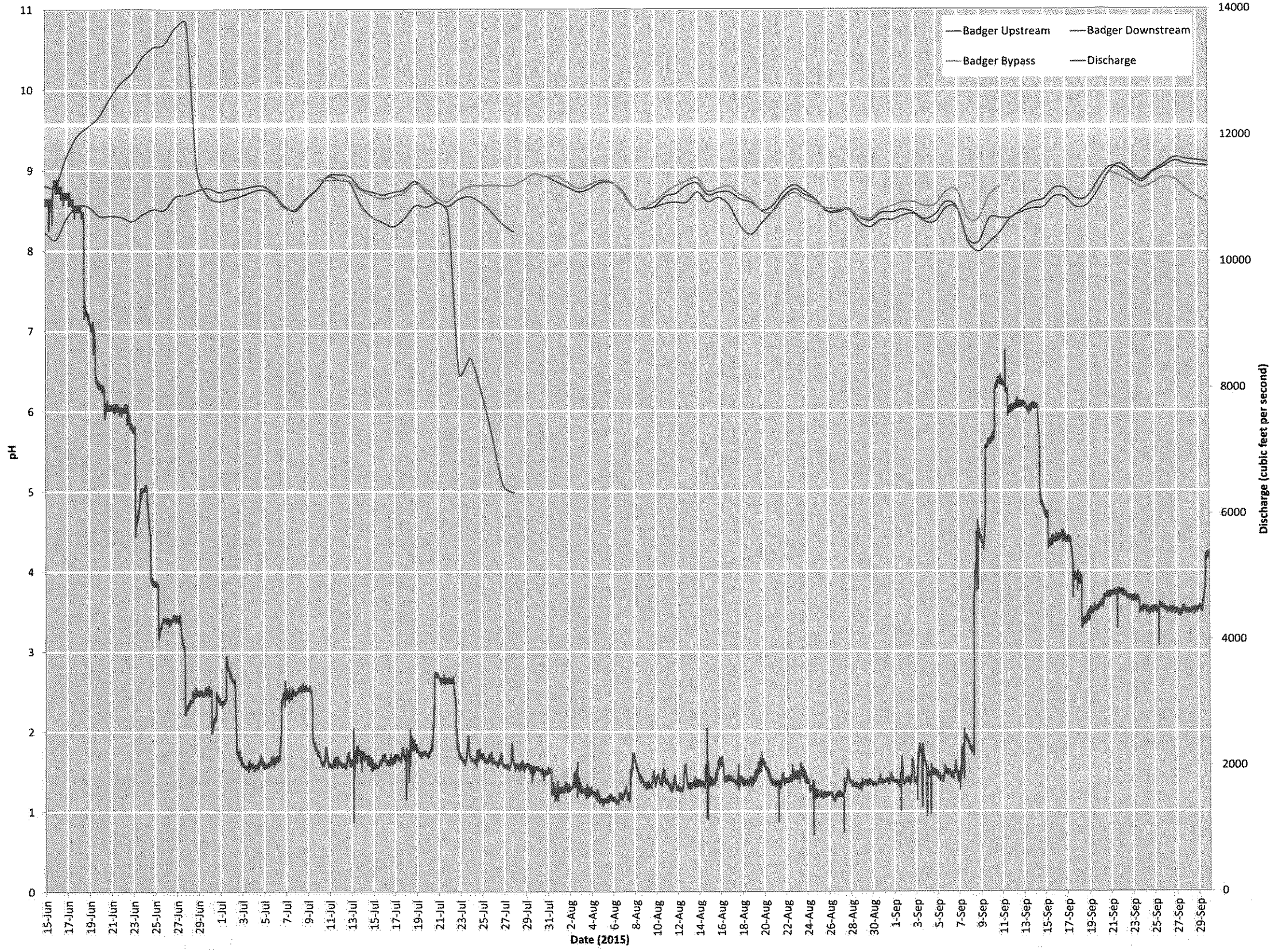


Figure 9. Daily Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

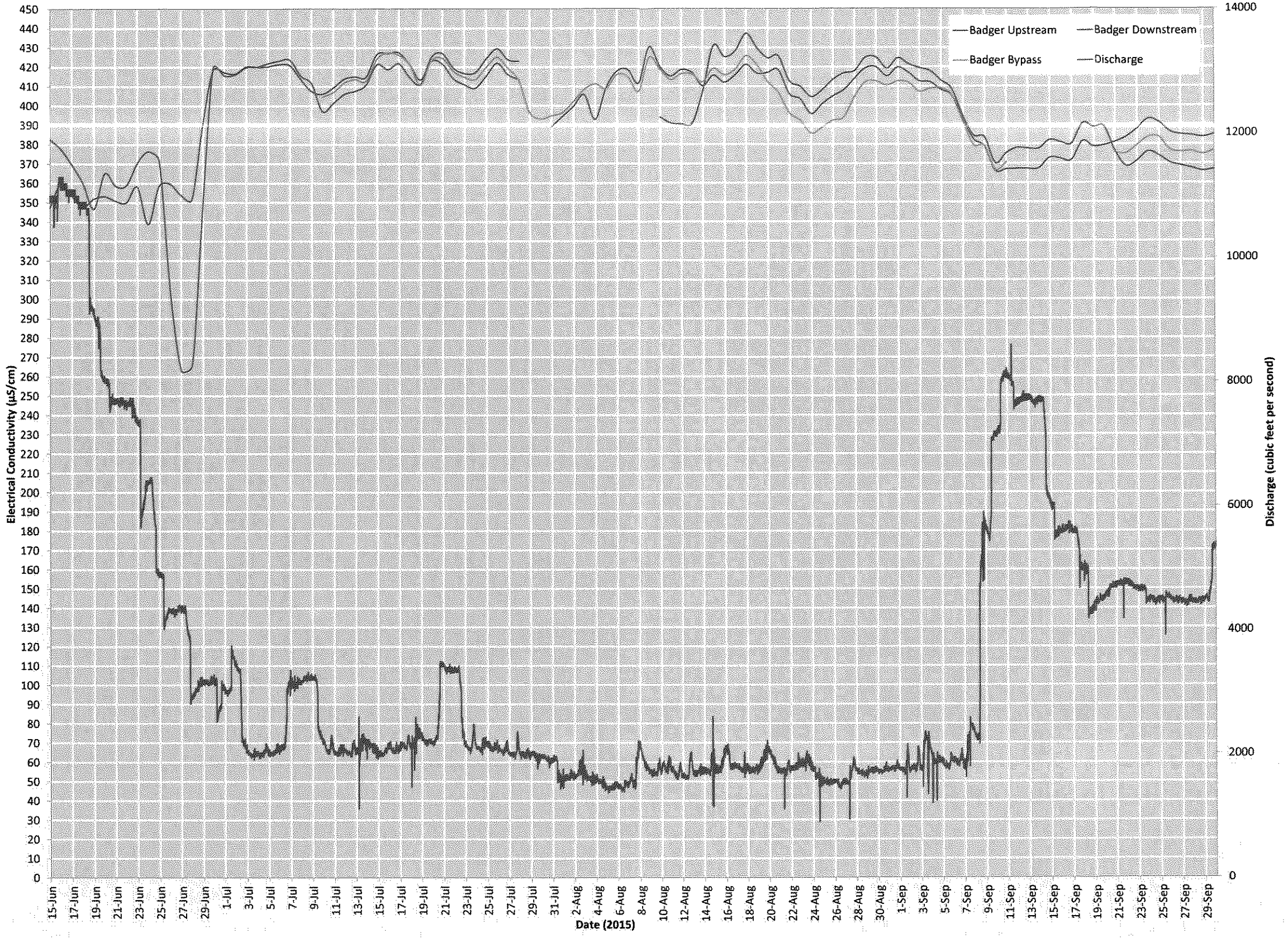


Figure 14. Hourly Dissolved Oxygen Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

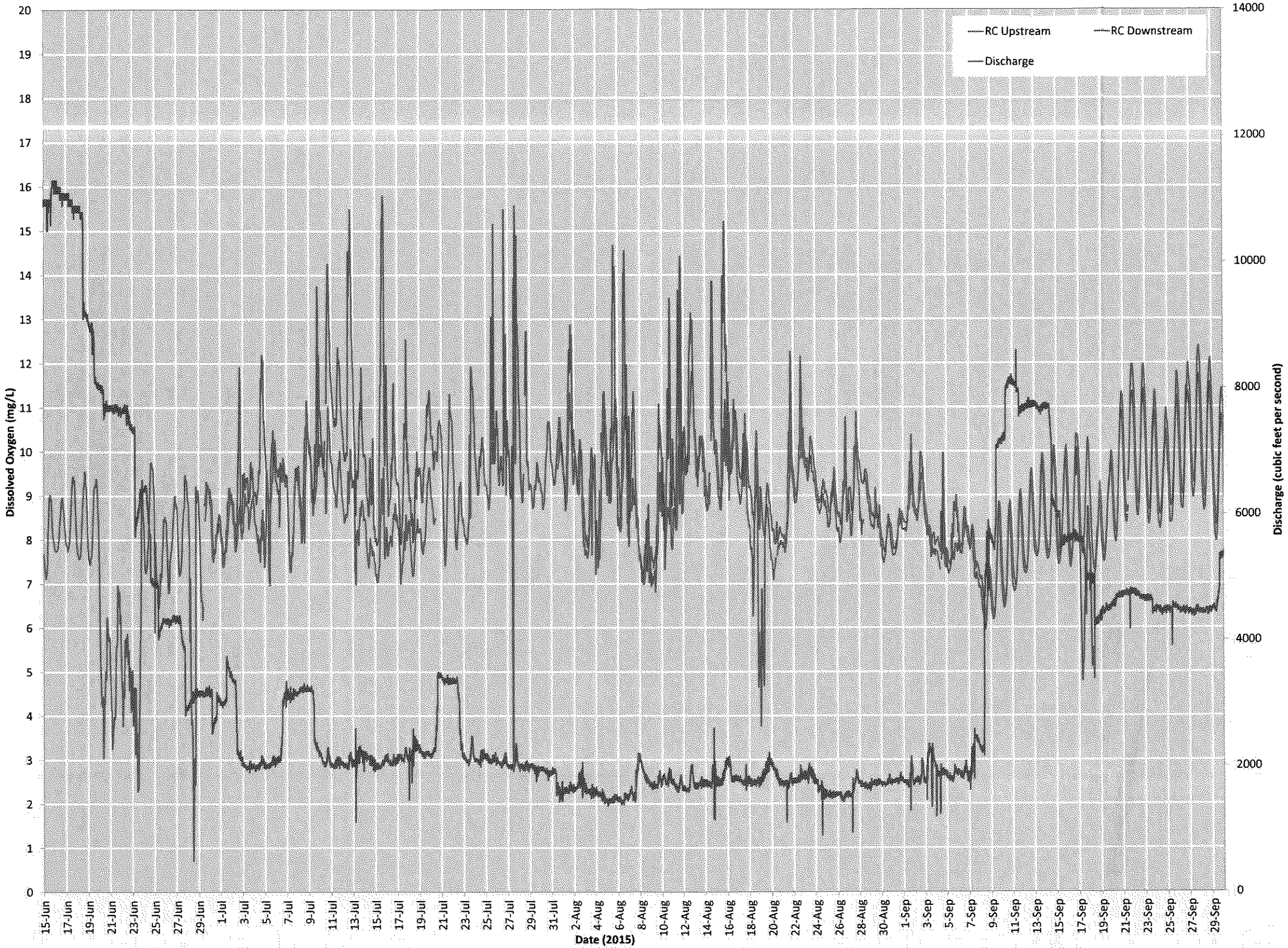


Figure 15. Hourly Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

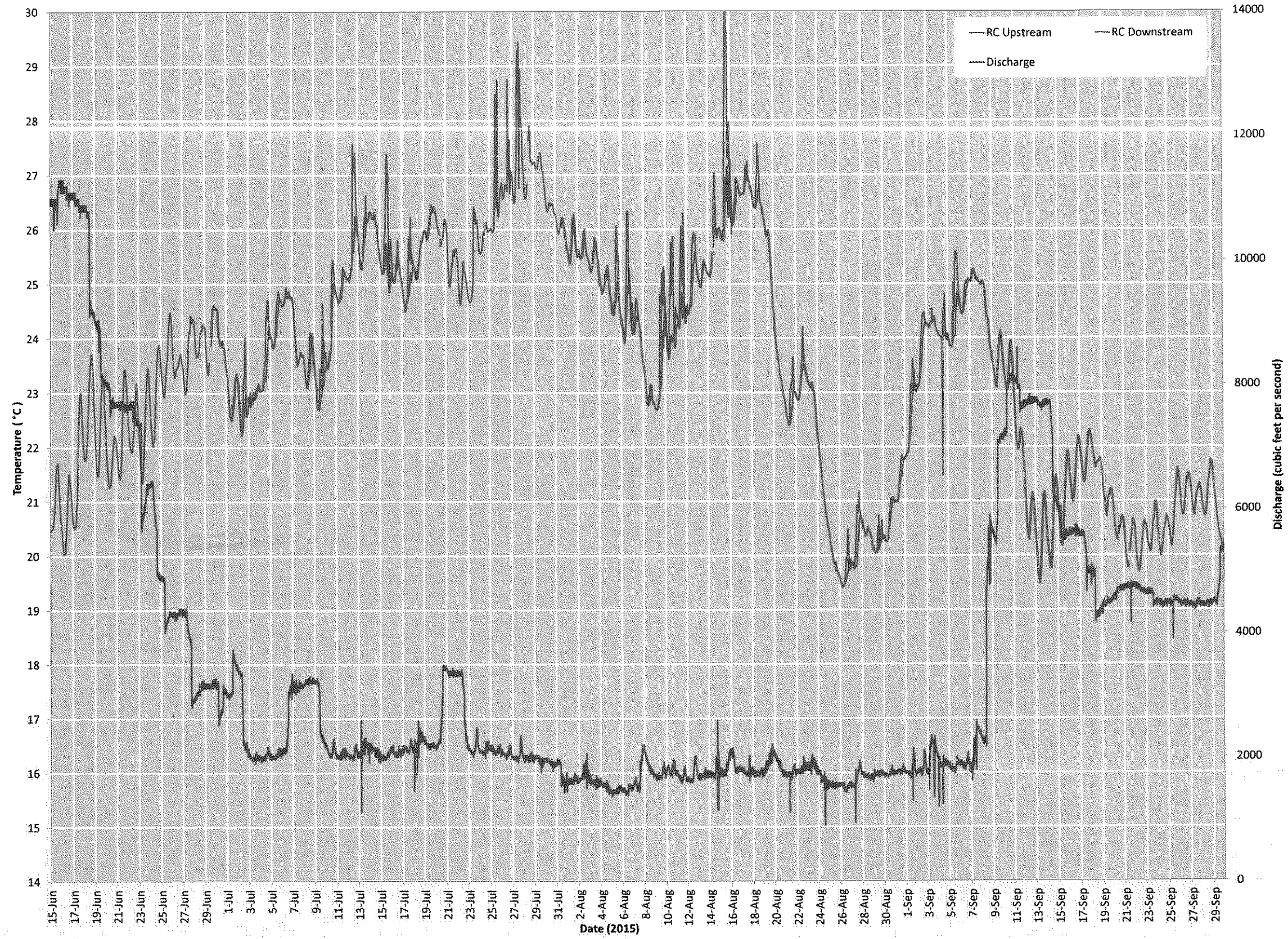


Figure 16. Hourly pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

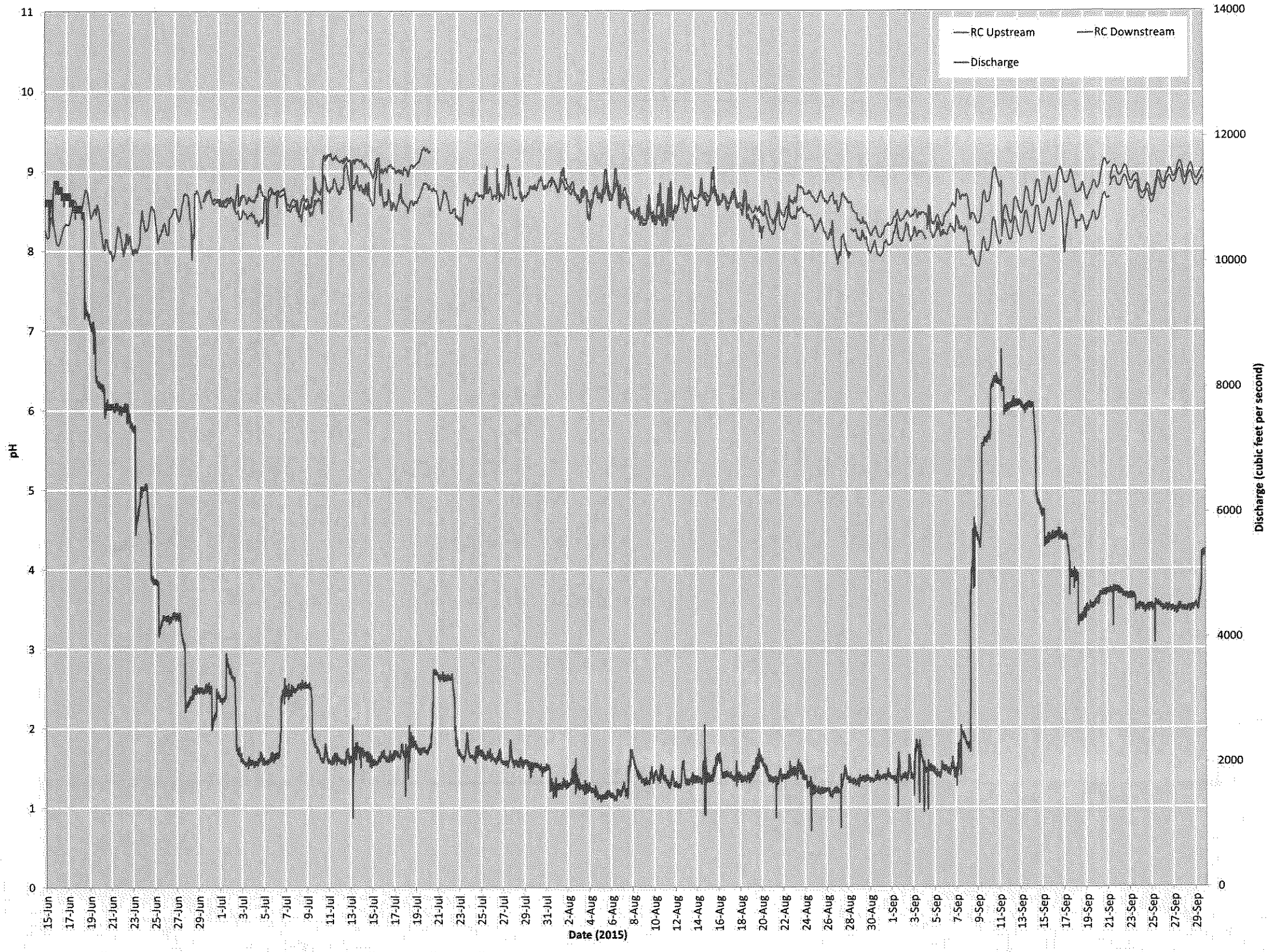


Figure 17. Hourly Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

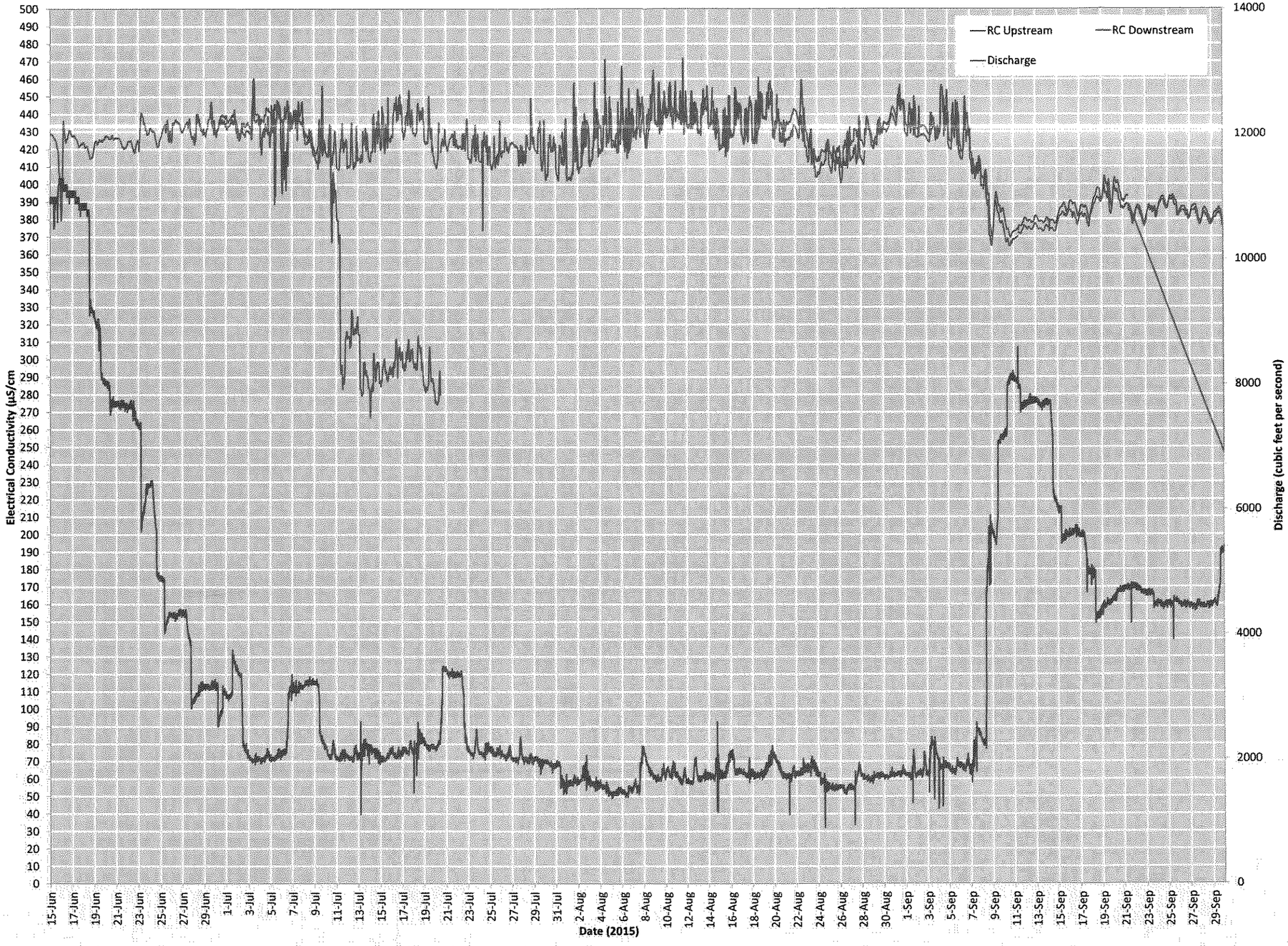


Figure 18. Daily Dissolved Oxygen Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

Figure 19. Daily Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

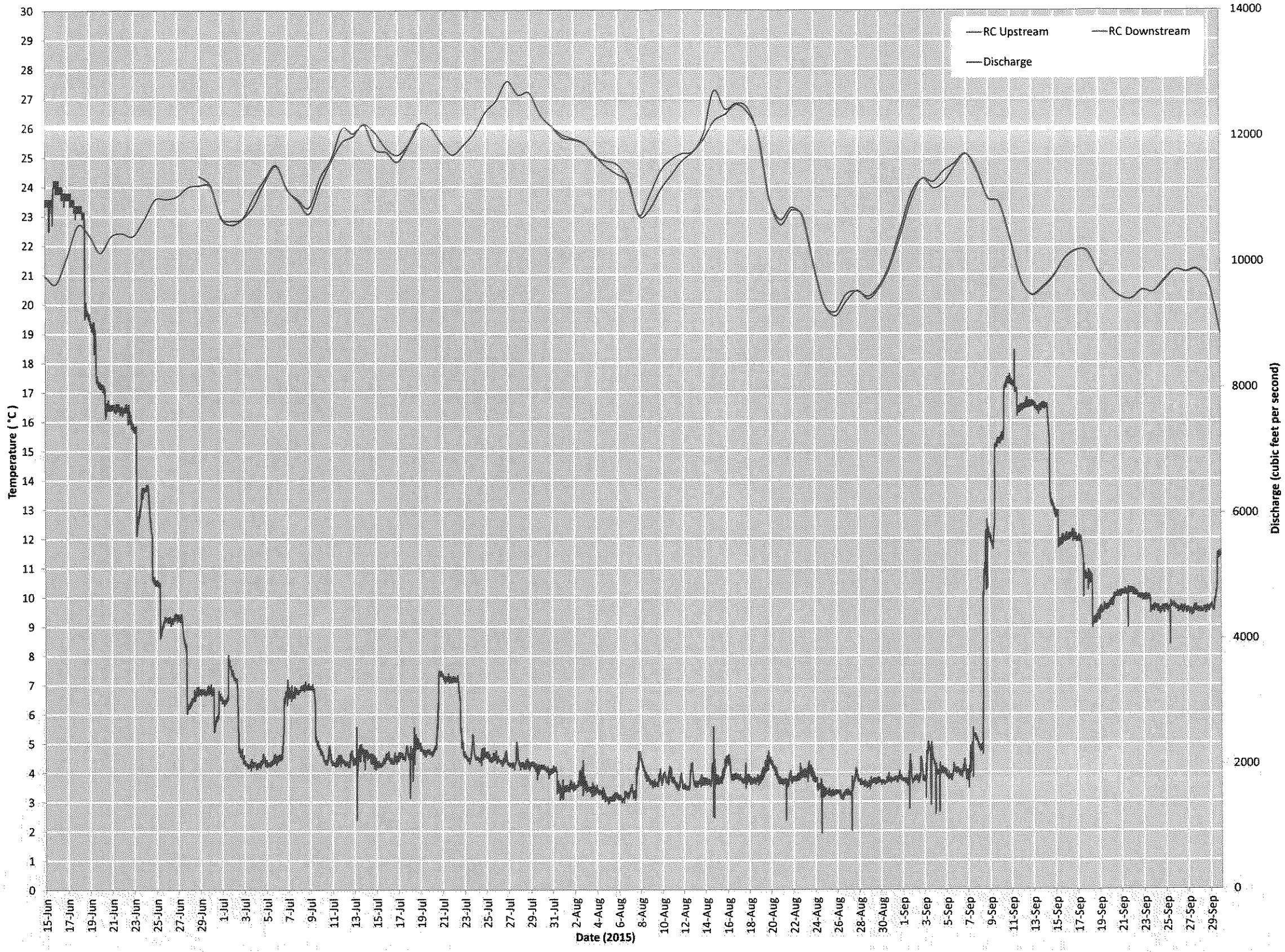


Figure 20. Daily pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

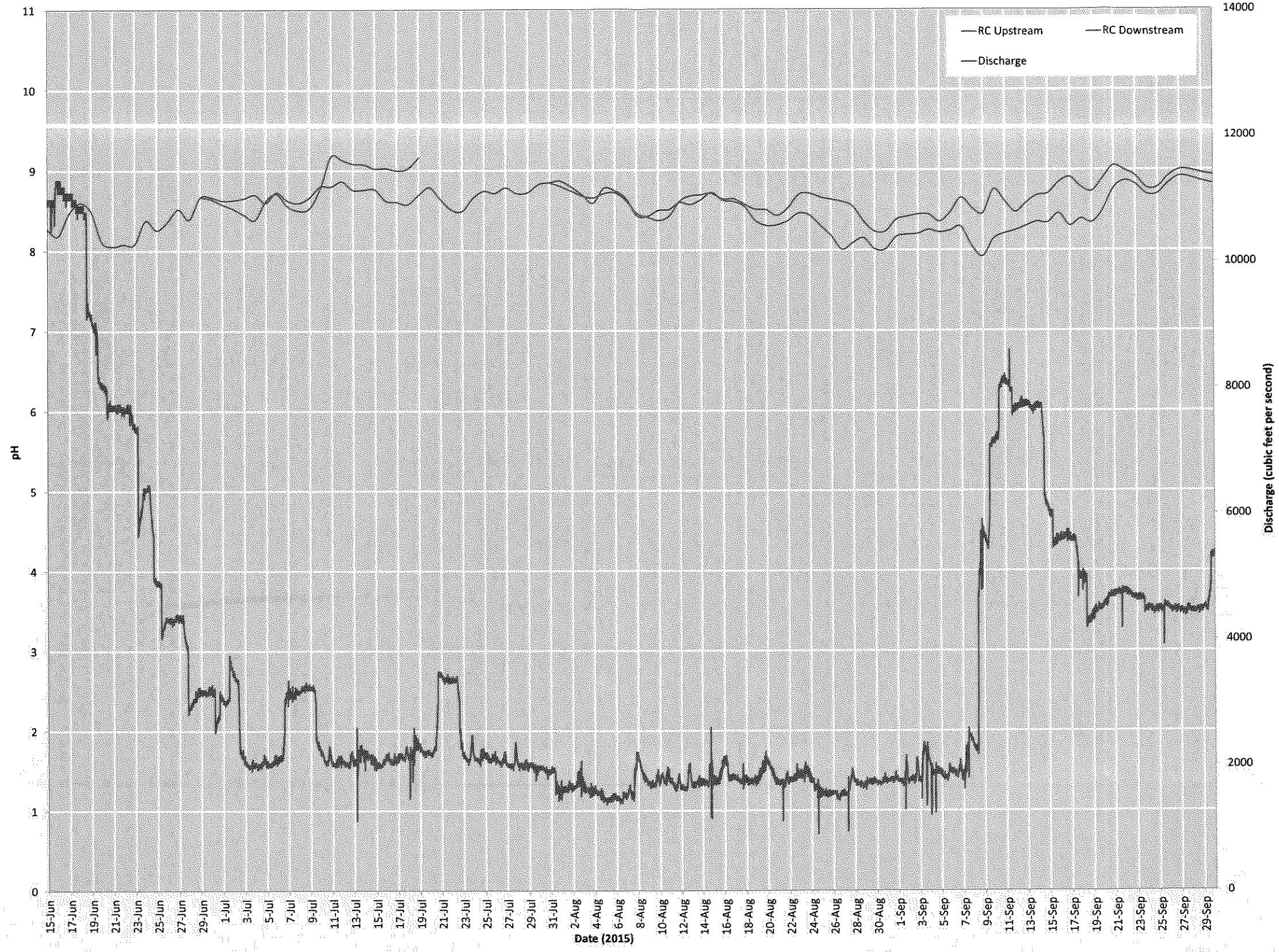


Figure 21. Daily Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

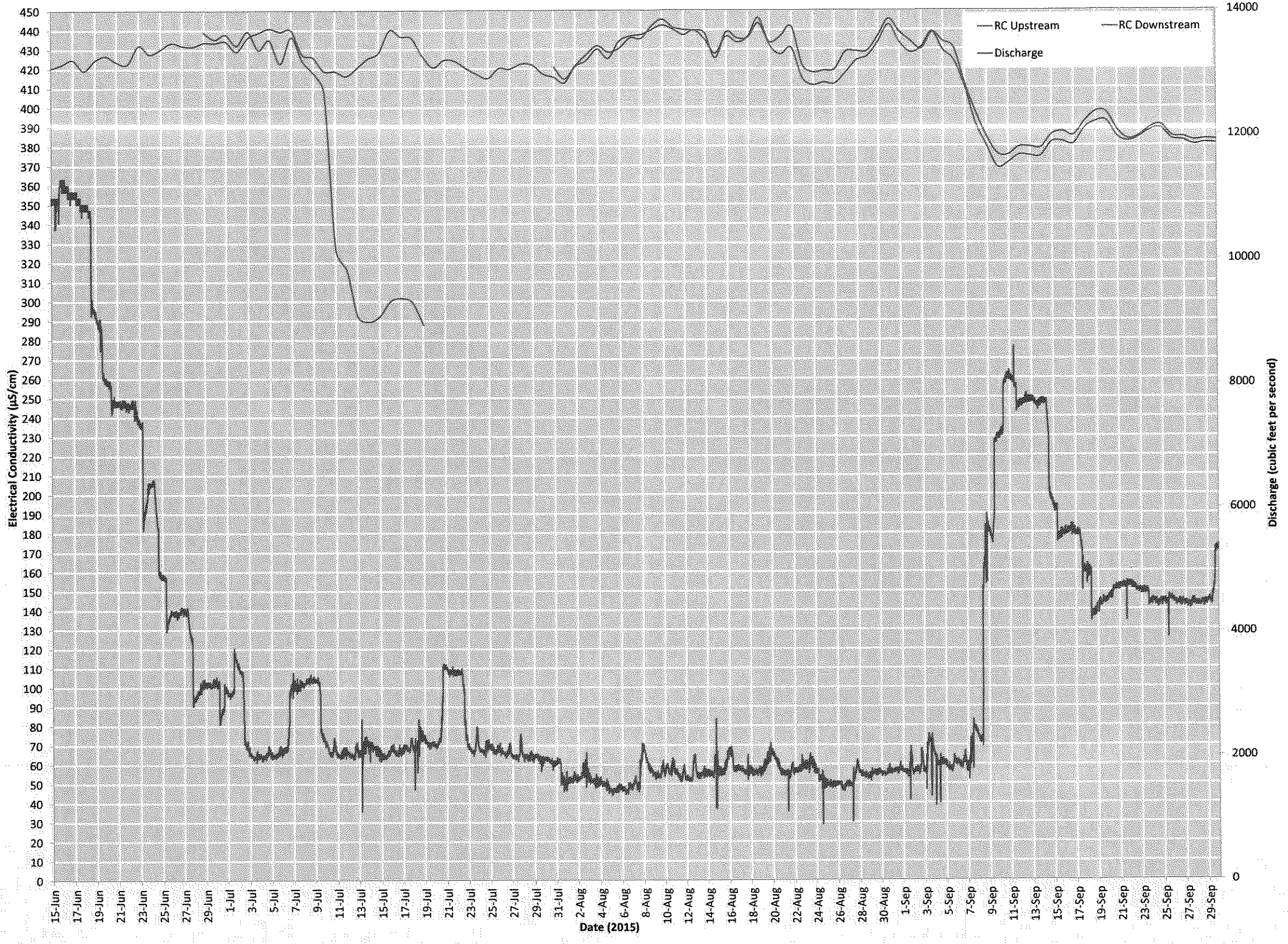


Table 2.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2015	8.21	7.83	0.38	20.88	20.87	0.01	8.81	8.23	0.58
6/16/2015	8.09	7.73	0.36	20.60	20.61	0.00	8.81	8.14	0.67
6/17/2015	8.60	8.13	0.48	21.65	21.67	-0.02	9.17	8.40	0.77
6/18/2015	8.62	8.10	0.52	22.67	22.66	0.01	9.43	8.56	0.87
6/19/2015	8.39	8.18	0.20	22.16	22.15	0.01	9.55	8.55	1.00
6/20/2015	8.15	7.93	0.22	21.75	21.75	0.00	9.67	8.43	1.24
6/21/2015	8.30	8.17	0.13	21.99	22.02	-0.03	9.90	8.43	1.47
6/22/2015	7.97	7.78	0.19	22.28	22.26	0.02	10.09	8.42	1.67
6/23/2015	8.08	7.87	0.20	22.05	22.05	0.00	10.21	8.37	1.84
6/24/2015	8.27	8.22	0.04	22.57	22.67	-0.09	10.41	8.46	1.95
6/25/2015	7.99	7.78	0.21	23.31	23.31	0.01	10.53	8.52	2.01
6/26/2015	7.67	7.62	0.05	23.36	23.32	0.04	10.57	8.51	2.06
6/27/2015	8.07	8.08	-0.01	23.49	23.48	0.02	10.77	8.67	2.10
6/28/2015	8.16	8.17	-0.01	23.48	23.47	0.02	10.84	8.70	2.14
6/29/2015	8.06	7.53	0.52	23.97	23.99	-0.02	8.99	8.75	0.24
6/30/2015	7.50	7.45	0.05	23.74	23.66	0.08	8.68	8.78	-0.10
7/1/2015	7.85	7.75	0.10	22.73	22.76	-0.03	8.62	8.73	-0.11
7/2/2015	8.64	8.49	0.15	22.38	22.34	0.04	8.65	8.76	-0.11
7/3/2015	8.84	8.89	-0.05	22.65	22.69	-0.04	8.68	8.77	-0.09
7/4/2015	8.97	7.57	1.40	23.35	23.39	-0.03	8.73	8.80	-0.06
7/5/2015	9.01	8.21	0.80	24.23	24.24	-0.02	8.76	8.81	-0.05
7/6/2015	8.19	2.84	5.36	24.42	24.42	0.00	8.70	8.72	-0.01
7/7/2015	7.96	6.80	1.16	23.68	23.65	0.03	8.54	8.56	-0.02
7/8/2015	8.58	7.90	0.68	23.08	22.96	0.12	8.52	8.50	0.02
7/9/2015	8.76	8.43	0.32	23.14	23.21	-0.07	8.66	8.65	0.01
7/10/2015	9.42	9.45	-0.04	24.01	24.04	-0.03	8.77	8.77	0.00
7/11/2015	9.50	9.57	-0.08	24.82	24.86	-0.04	8.94	8.92	0.01
7/12/2015	9.14	9.13	0.01	25.07	25.07	0.00	8.95	8.88	0.07
7/13/2015	8.83	8.74	0.09	25.62	25.67	-0.05	8.93	8.84	0.08
7/14/2015	7.64	7.11	0.53	25.73	25.74	-0.01	8.78	8.57	0.21
7/15/2015	8.16	5.00	3.16	25.19	25.17	0.03	8.74	8.42	0.31
7/16/2015	8.50	2.22	6.28	24.65	24.63	0.01	8.70	8.36	0.34
7/17/2015	8.26	0.45	7.80	24.44	24.52	-0.08	8.73	8.30	0.43
7/18/2015	8.43	0.04	8.39	25.12	25.16	-0.04	8.76	8.40	0.36
7/19/2015	8.82	0.05	8.78	25.80	25.83	-0.03	8.87	8.56	0.31
7/20/2015	8.55	5.32	3.23	25.49	25.70	-0.21	8.73	8.54	0.19
7/21/2015	8.06	8.32	-0.26	24.88	24.92	-0.04	8.60	8.60	0.01
7/22/2015	8.08	8.11	-0.03	24.47	24.46	0.01	8.48	8.55	-0.08
7/23/2015	8.70	8.51	0.18	25.11	25.19	-0.08	6.47	8.64	-2.18
7/24/2015	8.57	7.84	0.73	25.71	25.77	-0.06	6.67	8.67	-2.00
7/25/2015	8.55	7.50	1.04	25.99	26.05	-0.06	6.24	8.60	-2.36
7/26/2015	8.51	6.61	1.90	26.33	26.33	0.00	5.69	8.48	-2.79
7/27/2015	8.18	4.75	3.43	26.55	26.57	-0.02	5.08	8.33	-3.26
7/28/2015	6.95	2.13	4.82	26.35	26.78	-0.44	4.98	8.23	-3.25
7/29/2015									
7/30/2015									
7/31/2015	9.32			25.78			8.93		
8/1/2015	8.48			25.06			8.86		
8/2/2015	8.28			25.15			8.79		
8/3/2015	8.32			24.84			8.73		
8/4/2015	8.52			24.14			8.77		
8/5/2015	8.75			24.30			8.84		
8/6/2015	9.58			24.08			8.84		
8/7/2015	8.34			23.58			8.74		
8/8/2015	6.68			22.74			8.55		
8/9/2015	7.39			23.10			8.52		
8/10/2015	7.83	8.63	-0.80	23.77	24.11	-0.34	8.55	8.53	0.01

Table 2.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data

Difference = Upstream - Downstream

**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2015	9.01	8.98	0.03	24.26	24.26	0.01	8.67	8.58	0.09
8/12/2015	9.37	9.22	0.15	24.58	24.54	0.04	8.71	8.60	0.11
8/13/2015	9.23	8.99	0.24	24.84	24.83	0.01	8.81	8.60	0.21
8/14/2015	9.02	8.75	0.27	25.66	25.63	0.03	8.84	8.73	0.11
8/15/2015	8.51	8.14	0.37	25.69	25.58	0.10	8.69	8.60	0.09
8/16/2015	9.16	8.97	0.19	26.30	26.29	0.01	8.73	8.66	0.07
8/17/2015	8.84	8.41	0.43	26.57	26.56	0.01	8.73	8.56	0.17
8/18/2015	7.94	6.73	1.20	26.00	25.98	0.02	8.64	8.30	0.34
8/19/2015	7.51	5.44	2.07	25.30	25.33	-0.02	8.60	8.20	0.40
8/20/2015	7.54	7.28	0.26	23.26	23.33	-0.06	8.50	8.34	0.15
8/21/2015	8.78	8.57	0.21	22.26	22.34	-0.08	8.56	8.49	0.07
8/22/2015	10.02	9.69	0.32	22.71	22.76	-0.05	8.73	8.67	0.06
8/23/2015	9.61	9.34	0.26	22.34	22.45	-0.11	8.81	8.77	0.05
8/24/2015	8.47	8.24	0.23	20.83	20.94	-0.11	8.73	8.69	0.05
8/25/2015	7.95	7.88	0.07	19.48	19.63	-0.15	8.62	8.63	0.00
8/26/2015	7.58	7.89	-0.31	19.29	19.40	-0.10	8.49	8.48	0.01
8/27/2015	8.61	8.41	0.20	19.57	19.65	-0.07	8.50	8.47	0.02
8/28/2015	8.73	8.44	0.29	19.82	19.90	-0.08	8.52	8.51	0.01
8/29/2015	7.67	7.53	0.14	19.85	19.97	-0.12	8.41	8.35	0.07
8/30/2015	7.62	7.46	0.16	20.33	20.40	-0.07	8.37	8.29	0.08
8/31/2015	8.29	8.04	0.25	21.09	21.14	-0.05	8.47	8.38	0.09
9/1/2015	8.65	8.23	0.41	22.08	22.09	-0.01	8.47	8.38	0.10
9/2/2015	8.62	8.09	0.53	23.45	23.47	-0.01	8.51	8.43	0.08
9/3/2015	7.89	7.45	0.44	24.03	24.10	-0.07	8.47	8.45	0.02
9/4/2015	7.20	6.92	0.27	23.57	23.75	-0.18	8.39	8.36	0.03
9/5/2015	7.62	7.40	0.22	23.79	23.81	-0.02	8.45	8.36	0.09
9/6/2015	8.53	8.24	0.29	24.60	24.61	-0.01	8.60	8.53	0.07
9/7/2015	7.90	7.66	0.24	24.89	24.89	0.01	8.53	8.53	0.01
9/8/2015	6.80	6.59	0.21	24.32	24.25	0.07	8.11	8.13	-0.03
9/9/2015	7.40	7.14	0.26	23.59	23.58	0.00	7.99	8.10	-0.12
9/10/2015	7.59	7.35	0.25	23.36	23.41	-0.05	8.10	8.40	-0.30
9/11/2015	7.78	7.42	0.36	22.21	22.22	-0.02	8.23	8.40	-0.18
9/12/2015	8.16	7.67	0.49	20.78	20.79	-0.02	8.41	8.40	0.00
9/13/2015	8.44	8.00	0.44	20.38	20.39	0.00	8.47	8.51	-0.04
9/14/2015	8.57	8.15	0.42	20.52	20.51	0.01	8.52	8.60	-0.08
9/15/2015	8.54	8.17	0.37	20.92	20.91	0.02	8.54	8.63	-0.10
9/16/2015	8.80	8.48	0.33	21.43	21.41	0.01	8.67	8.77	-0.10
9/17/2015	8.70	8.33	0.37	21.63	21.61	0.02	8.66	8.77	-0.10
9/18/2015	8.13	7.84	0.28	21.52	21.52	-0.01	8.54	8.64	-0.11
9/19/2015	8.64	8.30	0.34	21.08	21.07	0.01	8.56	8.66	-0.10
9/20/2015	9.32	8.94	0.38	20.44	20.44	0.00	8.74	8.86	-0.12
9/21/2015	9.63	9.57	0.07	20.03	20.20	-0.18	8.97	9.03	-0.06
9/22/2015	9.52	9.66	-0.14	19.96	19.97	-0.01	9.08	9.02	0.05
9/23/2015	9.25	9.41	-0.16	20.17	20.14	0.03	8.98	8.94	0.04
9/24/2015	9.19	9.36	-0.17	20.21	20.22	-0.01	8.88	8.85	0.03
9/25/2015	9.62	9.80	-0.18	20.78	20.80	-0.02	8.98	8.96	0.02
9/26/2015	9.98	10.15	-0.17	20.94	20.94	0.00	9.06	9.03	0.03
9/27/2015	10.14	10.32	-0.18	20.87	20.89	-0.01	9.15	9.11	0.05
9/28/2015	9.74	9.88	-0.14	20.92	20.92	0.00	9.13	9.07	0.06
9/29/2015	9.14	9.33	-0.19	20.56	20.57	-0.02	9.12	9.06	0.06
9/30/2015	9.52	9.67	-0.16	18.88	18.90	-0.02	9.10	9.04	0.06
Minimum	6.68	0.04	-0.80	18.88	18.90	-0.44	4.98	8.10	-3.26
Average	8.47	7.70	0.79	23.13	23.04	-0.03	8.68	8.59	0.08
Maximum	10.14	10.32	8.78	26.57	26.78	0.12	10.84	9.11	2.14
Standard Deviation	0.70	1.98	1.77	2.00	2.04	0.08	0.89	0.22	0.91
Number of Data Points	105	95	95	105	95	95	105	95	95

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
6/15/2015			
6/16/2015			
6/17/2015			
6/18/2015			
6/19/2015			
6/20/2015			
6/21/2015			
6/22/2015			
6/23/2015			
6/24/2015			
6/25/2015			
6/26/2015			
6/27/2015			
6/28/2015			
6/29/2015			
6/30/2015			
7/1/2015			
7/2/2015			
7/3/2015			
7/4/2015			
7/5/2015			
7/6/2015			
7/7/2015			
7/8/2015			
7/9/2015			
7/10/2015	24.77	8.85	8.89
7/11/2015	24.90	8.51	8.88
7/12/2015	25.15	8.29	8.88
7/13/2015	25.70	8.00	8.87
7/14/2015	25.79	7.65	8.75
7/15/2015	25.15	7.86	8.70
7/16/2015	24.71	7.94	8.65
7/17/2015	24.59	7.90	8.68
7/18/2015	25.26	7.86	8.72
7/19/2015	25.87	7.90	8.83
7/20/2015	25.71	8.28	8.77
7/21/2015	25.01	8.67	8.66
7/22/2015	24.56	8.56	8.61
7/23/2015	25.23	8.75	8.74
7/24/2015	25.79	8.48	8.80
7/25/2015	26.15	8.31	8.81
7/26/2015	26.45	8.20	8.82

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
7/27/2015	26.58	8.02	8.81
7/28/2015	27.05	8.02	8.82
7/29/2015	26.98	8.08	8.89
7/30/2015	26.03	8.26	8.96
7/31/2015	25.60	8.29	8.92
8/1/2015	25.12	8.30	8.93
8/2/2015	25.26	7.78	8.85
8/3/2015	24.88	8.07	8.77
8/4/2015	24.44	8.33	8.82
8/5/2015	24.23	8.31	8.87
8/6/2015	24.00	8.47	8.85
8/7/2015	23.51	7.89	8.72
8/8/2015	22.70	7.84	8.54
8/9/2015	23.20	7.97	8.53
8/10/2015	23.94	7.99	8.60
8/11/2015	24.39	8.41	8.72
8/12/2015	24.67	8.56	8.80
8/13/2015	24.96	8.32	8.86
8/14/2015	25.76	7.89	8.91
8/15/2015	25.73	7.67	8.74
8/16/2015	26.38	7.71	8.77
8/17/2015	26.61	7.48	8.80
8/18/2015	26.04	7.31	8.69
8/19/2015	25.23	7.19	8.64
8/20/2015	23.23	7.70	8.49
8/21/2015	22.33	8.56	8.48
8/22/2015	22.80	8.76	8.65
8/23/2015	22.38	8.49	8.72
8/24/2015	20.80	8.39	8.64
8/25/2015	19.45	8.46	8.59
8/26/2015	19.36	8.61	8.52
8/27/2015	19.74	8.68	8.52
8/28/2015	19.92	8.66	8.50
8/29/2015	19.89	8.54	8.42
8/30/2015	20.40	8.50	8.40
8/31/2015	21.22	8.52	8.50
9/1/2015	22.26	8.54	8.55
9/2/2015	23.61	8.31	8.60
9/3/2015	24.10	7.92	8.60
9/4/2015	23.76	7.81	8.55
9/5/2015	23.90	8.10	8.57
9/6/2015	24.74	8.19	8.73

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
9/7/2015	24.97	7.84	8.75
9/8/2015	24.30	7.28	8.40
9/9/2015	23.63	7.77	8.39
9/10/2015	23.40	8.00	8.68
9/11/2015	22.42	8.00	8.79
9/12/2015			
9/13/2015			
9/14/2015			
9/15/2015			
9/16/2015			
9/17/2015			
9/18/2015			
9/19/2015			
9/20/2015			
9/21/2015	20.40	9.39	8.98
9/22/2015	19.99	9.04	8.93
9/23/2015	20.24	8.95	8.86
9/24/2015	20.21	8.90	8.78
9/25/2015	20.75	8.93	8.83
9/26/2015	20.92	8.94	8.91
9/27/2015	20.88	8.94	8.89
9/28/2015	20.98	8.72	8.77
9/29/2015	20.54	8.76	8.67
9/30/2015	18.90	9.09	8.59

Minimum	18.90	7.19	8.39
Average	23.66	8.26	8.72
Maximum	27.05	9.39	8.98
Standard Deviation	2.24	0.46	0.15
Number of Data Points	74	74	74

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2015	8.05			20.97			8.27		
6/16/2015	8.25			20.71			8.19		
6/17/2015	8.50			21.64			8.47		
6/18/2015	8.41			22.70			8.60		
6/19/2015	8.37			22.36			8.50		
6/20/2015	5.16			21.77			8.11		
6/21/2015	5.08			22.34			8.06		
6/22/2015	4.95			22.43			8.09		
6/23/2015	4.91			22.34			8.08		
6/24/2015	8.50			22.90			8.38		
6/25/2015	7.39			23.58			8.26		
6/26/2015	8.00			23.59			8.36		
6/27/2015	8.29			23.69			8.52		
6/28/2015	5.96			24.00			8.39		
6/29/2015	8.20	8.98	-0.77	24.06	24.37	-0.31	8.67	8.67	0.00
6/30/2015	8.15	8.32	-0.17	24.03	24.06	-0.03	8.67	8.64	0.03
7/1/2015	8.23	8.15	0.08	22.96	22.92	0.04	8.63	8.58	0.05
7/2/2015	8.90	8.40	0.50	22.86	22.71	0.15	8.63	8.52	0.11
7/3/2015	9.29	8.71	0.58	22.96	22.94	0.03	8.66	8.45	0.21
7/4/2015	10.06	8.11	1.95	23.70	23.39	0.30	8.70	8.38	0.32
7/5/2015	9.33	9.21	0.12	24.30	24.20	0.10	8.60	8.62	-0.02
7/6/2015	9.31	9.56	-0.25	24.75	24.72	0.04	8.73	8.71	0.02
7/7/2015	8.55	8.46	0.08	23.91	23.92	-0.01	8.63	8.55	0.07
7/8/2015	9.44	9.19	0.25	23.59	23.52	0.07	8.60	8.50	0.10
7/9/2015	10.21	9.49	0.73	23.31	23.09	0.22	8.66	8.53	0.14
7/10/2015	11.49	9.87	1.62	24.33	24.06	0.26	8.80	8.78	0.03
7/11/2015	11.23	9.35	1.88	24.96	24.89	0.06	8.80	9.18	-0.38
7/12/2015	11.83	8.97	2.86	26.00	25.53	0.47	8.87	9.13	-0.27
7/13/2015	10.26	8.40	1.86	25.83	25.73	0.10	8.76	9.08	-0.32
7/14/2015	9.17	7.83	1.34	26.14	26.12	0.02	8.76	9.07	-0.31
7/15/2015	10.86	7.98	2.88	25.85	25.28	0.56	8.77	9.02	-0.26
7/16/2015	9.79	8.20	1.59	25.32	25.19	0.13	8.62	9.03	-0.40
7/17/2015	9.41	7.87	1.54	25.09	24.85	0.24	8.61	9.00	-0.39
7/18/2015	8.98	7.91	1.07	25.44	25.42	0.02	8.58	9.02	-0.45
7/19/2015	10.04	8.50	1.55	26.14	26.11	0.03	8.70	9.16	-0.46
7/20/2015	10.25			26.04			8.79		
7/21/2015	9.41			25.49			8.64		
7/22/2015	8.77			25.09			8.51		
7/23/2015	9.41			25.42			8.49		
7/24/2015	9.70			25.85			8.66		
7/25/2015	10.14			26.53			8.74		
7/26/2015	10.28			26.92			8.72		
7/27/2015	10.61			27.59			8.79		
7/28/2015	10.17			27.13			8.71		
7/29/2015	9.22			27.20			8.72		
7/30/2015	9.66			26.46			8.83		
7/31/2015	9.91	9.99	-0.08	26.07	26.07	0.00	8.85	8.85	0.00
8/1/2015	10.59	9.79	0.80	25.77	25.67	0.10	8.87	8.80	0.07
8/2/2015	9.35	9.31	0.04	25.63	25.59	0.04	8.79	8.74	0.05
8/3/2015	8.72	8.70	0.01	25.48	25.46	0.02	8.70	8.68	0.02
8/4/2015	9.35	9.12	0.23	25.02	25.06	-0.04	8.59	8.66	-0.07
8/5/2015	10.88	9.81	1.08	24.87	24.67	0.20	8.78	8.71	0.07
8/6/2015	10.25	9.50	0.75	24.76	24.43	0.33	8.74	8.72	0.02
8/7/2015	9.41	8.67	0.74	24.25	24.15	0.10	8.65	8.63	0.03
8/8/2015	7.61	7.37	0.24	23.03	23.00	0.03	8.44	8.46	-0.03
8/9/2015	8.35	8.15	0.20	23.72	23.24	0.48	8.42	8.41	0.01
8/10/2015	9.66	8.40	1.27	24.55	23.92	0.63	8.50	8.37	0.13
8/11/2015	10.66	8.98	1.68	24.93	24.41	0.52	8.51	8.42	0.08
8/12/2015	11.15	10.38	0.77	25.12	24.87	0.25	8.60	8.61	-0.02
8/13/2015	9.88	10.04	-0.15	25.18	25.16	0.02	8.57	8.68	-0.11
8/14/2015	10.17	9.91	0.26	25.77	25.60	0.17	8.63	8.69	-0.06
8/15/2015	11.10	9.81	1.29	27.26	26.23	1.03	8.72	8.71	0.01
8/16/2015	10.29	10.15	0.14	26.64	26.46	0.18	8.62	8.64	-0.01
8/17/2015	9.29	9.80	-0.51	26.84	26.79	0.05	8.61	8.64	-0.03
8/18/2015	7.82	8.88	-1.06	26.71	26.54	0.17	8.55	8.57	-0.03
8/19/2015	7.10	8.74	-1.64	25.74	25.81	-0.08	8.37	8.51	-0.14

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/20/2015	7.62	8.15	-0.52	23.56	23.58	-0.02	8.31	8.51	-0.20
8/21/2015	9.13	8.85	0.29	22.87	22.70	0.17	8.32	8.43	-0.12
8/22/2015	9.82	9.70	0.12	23.29	23.20	0.10	8.37	8.52	-0.16
8/23/2015	9.59	9.89	-0.30	22.97	23.02	-0.04	8.46	8.70	-0.23
8/24/2015	8.84	9.11	-0.27	21.27	21.29	-0.02	8.44	8.71	-0.27
8/25/2015	8.69	9.01	-0.32	19.93	19.95	-0.02	8.31	8.66	-0.35
8/26/2015	8.76	8.79	-0.02	19.73	19.59	0.14	8.18	8.63	-0.45
8/27/2015	9.20	9.42	-0.22	20.34	20.11	0.23	8.01	8.61	-0.60
8/28/2015	8.83	9.38	-0.55	20.43	20.45	-0.03	8.09	8.55	-0.46
8/29/2015	8.43	8.54	-0.10	20.26	20.17	0.09	8.15	8.36	-0.20
8/30/2015	7.95	8.08	-0.14	20.62	20.55	0.07	8.02	8.23	-0.22
8/31/2015	8.07	8.15	-0.08	21.37	21.29	0.08	8.01	8.24	-0.22
9/1/2015	8.84	8.77	0.06	22.57	22.37	0.20	8.17	8.38	-0.21
9/2/2015	9.06	8.97	0.09	23.76	23.55	0.21	8.20	8.42	-0.22
9/3/2015	7.99	8.26	-0.26	24.27	24.27	0.00	8.21	8.45	-0.24
9/4/2015	7.92	7.86	0.06	24.16	23.94	0.22	8.26	8.45	-0.19
9/5/2015	7.98	7.65	0.33	24.54	24.15	0.39	8.22	8.36	-0.13
9/6/2015	8.17	8.06	0.10	24.80	24.69	0.10	8.25	8.47	-0.23
9/7/2015	7.53	7.76	-0.23	25.11	25.11	0.00	8.29	8.65	-0.36
9/8/2015	6.64	6.86	-0.22	24.54	24.57	-0.04	8.05	8.52	-0.47
9/9/2015	7.22	7.37	-0.15	23.60	23.59	0.01	7.92	8.46	-0.54
9/10/2015	7.41	7.62	-0.21	23.45	23.46	-0.01	8.14	8.76	-0.61
9/11/2015	7.75	7.90	-0.15	22.25	22.27	-0.02	8.21	8.61	-0.40
9/12/2015	8.14	8.28	-0.15	20.80	20.81	-0.01	8.25	8.47	-0.23
9/13/2015	8.48	8.61	-0.13	20.31	20.29	0.02	8.30	8.59	-0.29
9/14/2015	8.62	8.72	-0.11	20.57	20.53	0.04	8.35	8.68	-0.33
9/15/2015	8.46	8.67	-0.21	20.95	20.92	0.03	8.34	8.70	-0.36
9/16/2015	8.62	8.92	-0.31	21.55	21.52	0.03	8.46	8.85	-0.39
9/17/2015	6.98	8.93	-1.95	21.82	21.81	0.01	8.31	8.91	-0.60
9/18/2015	7.22	8.22	-0.99	21.79	21.81	-0.02	8.39	8.79	-0.39
9/19/2015	8.47	8.67	-0.20	21.10	21.09	0.01	8.35	8.73	-0.39
9/20/2015	9.28	9.53	-0.25	20.59	20.58	0.01	8.49	8.89	-0.40
9/21/2015	9.89	10.29	-0.40	20.26	20.25	0.01	8.76	9.05	-0.29
9/22/2015	9.92	10.34	-0.42	20.17	20.16	0.01	8.86	9.00	-0.13
9/23/2015	9.58	10.04	-0.46	20.47	20.46	0.01	8.82	8.92	-0.10
9/24/2015	9.23	9.64	-0.40	20.41	20.40	0.00	8.70	8.77	-0.08
9/25/2015	9.61	10.05	-0.44	20.81	20.77	0.04	8.70	8.78	-0.08
9/26/2015	10.01	10.48	-0.47	21.16	21.15	0.00	8.83	8.92	-0.09
9/27/2015	10.29	10.78	-0.49	21.09	21.08	0.01	8.92	9.00	-0.08
9/28/2015	10.08	10.57	-0.49	21.18	21.15	0.03	8.90	8.99	-0.09
9/29/2015	9.34	9.89	-0.55	20.69	20.70	-0.01	8.86	8.96	-0.10
9/30/2015	9.70	10.14	-0.44	19.01	18.99	0.02	8.83	8.93	-0.11
Minimum	4.91	6.86	-1.95	19.01	18.99	-0.31	7.92	8.23	-0.61
Average	8.94	8.94	0.19	23.54	23.23	0.11	8.51	8.68	-0.17
Maximum	11.83	10.78	2.88	27.59	26.79	1.03	8.92	9.18	0.32
Standard Deviation	1.34	0.87	0.87	2.15	2.07	0.18	0.25	0.22	0.20
Number of Data Points	108	83	83	108	83	83	108	83	83

Appendix D

Photo Log

Appendix D - Photo Log

Project No.: 1506460

GEI Consultants

Appendix D - Photo Log

Project No.: 1506460

GEI Consultants

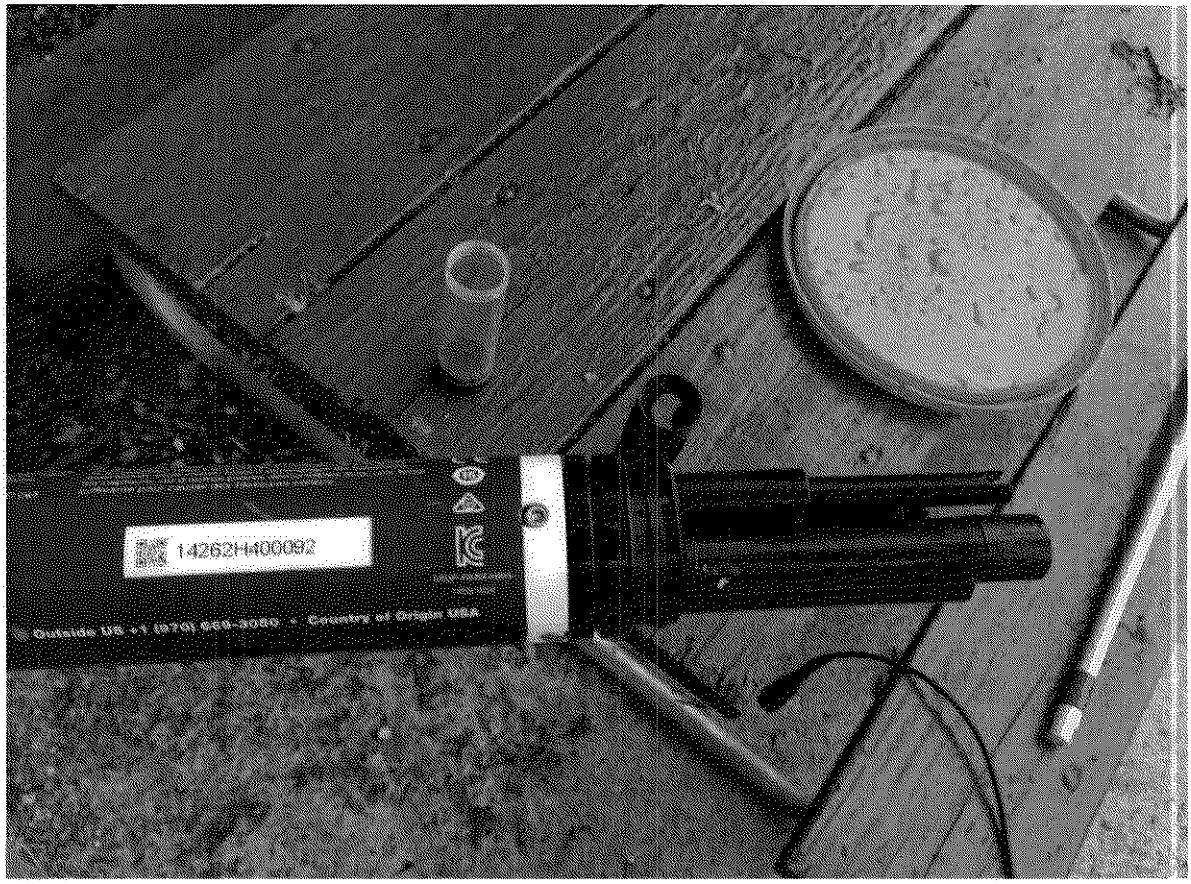


Photo No. 1 Example of relatively clean sonde at Rapide Croche Downstream. Photo taken 6/11/15.

Appendix D - Photo Log

Project No.: 1506460

Photo No. 2 Example of sedimentation that occurred at Badger Downstream. Photo taken 6/29/15.

Appendix D - Photo Log

Project No.: 1506460

Photo No. 3 Example of biofouling that occurred at Rapide Croche Upstream. Photo taken 8/28/15.

Appendix D - Photo Log

Project No.: 1506460

Photo No. 4 Example of mechanical problems that occurred due to aquatic organisms with hard shells becoming lodged in battery housing at Rapide Croche Downstream. Photo taken 7/28/15.

Appendix E

Description of 2015 Sonde Outages, Replacements, and Comments

APPENDIX E
Description of HL4 Sonde Outages, Replacements and Comments

After installing new HL4 Hach Sondes at five agency approved locations in June 2015, GEI serviced each location at weekly to biweekly intervals. As communicated with the WDNR, the sonde at the Badger Bypass station was not restored until flows subsided in early July 2015, and it was considered safe for personnel and equipment to redeploy this sonde from a railroad trestle. The sonde at the Badger Bypass station was also removed in mid- to late September, also due to high flows. Parts of the data set were also compromised by the following history of mechanical failures and replacements:

6/11/15 **BADGER BYPASS SONDE S/N H400093**. Lost weight attached to sonde protective casing, and the metal cable was almost worn through completely due to a strong river flow rate. **GEI temporarily removed SONDE S/N H400093** until the river flow rate decreased. GEI also emailed Ms. Cheryl Laatsch (Wisconsin Department of Natural Resources [WDNR]) to inform the Department that the sonde at this station would be restored after flows subside allowing for safe deployment.

6/11/15 **RAPID CROCHE DOWNSTREAM SONDE S/N H400092.** Received hardware error message during the download of data. GEI was able to recalibrate **SONDE S/N H400092** and replace the battery. **GEI redeployed SONDE S/N H400092.**

6/11/15 **BADGER UPSTREAM SONDE S/N H400094.** Sonde had moderate biofouling and small aquatic organisms on sensors. pH calibration failed three times, GEI thoroughly cleaned sensors and rebuilt the pH probe. GEI was able to recalibrate **SONDE S/N H400094** and replace the battery. **GEI redeployed SONDE S/N H400094.**

6/29/15 **RAPID CROCHE DOWNSTREAM SONDE S/N H400092**. Received hardware error message during the download of data; only collected data for 20 hours. Sonde stopped recording on 6/12/15 due to electrical issues. Based on concerns about limiting loss of further data, **GEI replaced SONDE S/N H400092 with a new sonde (SONDE S/N H400326)** under warranty on 7-10-2015, after it was received from the manufacturer (Hach).

7/10/15 **BADGER BYPASS SONDE S/N H400093. SONDE S/N H400093** was redeployed after lab recalibration and decrease in river flow rate.

7/28/15 **BADGER UPSTREAM SONDE S/N H400094.** The pH sensor failed to calibrate after downloading data. The pH read ~5.0 in pH 7.0 calibration standard. GEI called HACH to troubleshoot the issue. Based on concerns about the potential for data loss, **GEI temporarily removed SONDE S/N H400094**. The pH sensor appears to have been reading incorrectly starting at 8:00 a.m. on 7-23-2015, according to the downloaded data. **SONDE S/N H400094** was replaced with **SONDE S/N H400235** on 7-31-2015.

7/28/15 **RC DOWNSTREAM SONDE S/N H400326. SONDE S/N H400326** was removed from the water and was covered with mussels (apparent quagga mussels). The Sonde would not connect to the computer during the attempted data download. GEI attempted to replace the battery and observed the battery cavity as being filled with water and algae. GEI called HACH to troubleshoot the issue. Based on recommendations of HACH, **GEI temporarily removed SONDE S/N H400326**. Data was

lost from 7-20-2015 through 7-28-2015. **SONDE S/N H400326** was replaced with **SONDE S/N H400237** on 7-31-2015.

8/4/15 **BADGER UPSTREAM SONDE S/N H400235. SONDE S/N H400235** was deployed by GEI on 7-31-2015 after lab calibration to replace the former **SONDE S/N H400094.** Data download indicates that replacement **SONDE S/N H400235** was functional.

8/4/15 **BADGER DOWNSTREAM SONDE S/N H400091. SONDE S/N H400091** was unable to communicate with HACH software interface during attempted data download. GEI called HACH to troubleshoot the issue. Based on recommendations of HACH, **GEI temporarily removed Sonde S/N H400091**. Data was lost from 7-28-2015 through 8-4-2015. **SONDE S/N H400091** was replaced with **SONDE S/N H400044** on 8-10-2015.

8/14/2015 **BADGER UPSTREAM SONDE S/N H400235** and **BADGER DOWNSTREAM SONDE S/N H400044** encountered alerts for an unstable conductivity sensor during recalibration. The error messages ceased after successful recalibration.

8/20/2015 **BADGER UPSTREAM SONDE S/N H400235** and **BADGER DOWNSTREAM SONDE S/N H400044** were calibrated and redeployed concurrently with **BADGER USTREAM SONDE S/N H400094** and **BADGER DOWNSTREAM SONDE S/N H400091. SONDE S/N H400094 and SONDE H400091** were successfully recalibrated in the laboratory after both sondes were repaired by HACH.

8/26/2015 **BADGER UPSTREAM SONDE S/N H400235** and **BADGER DOWNSTREAM SONDE S/N H400044** were removed after successful data downloads. **BADGER UPSTREAM SONDE S/N H400094** and **BADGER DOWNSTREAM SONDE S/N H400091** remained on site after data downloads and field recalibrations.

9/4/2015 **BADGER BYPASS SONDE S/N H400093.** Received hardware low-battery error message during the download of data; battery started at 58%. Data was collected throughout the sampling period. **GEI replaced the battery in SONDE S/N H400093** (read 100% during test battery check) and redeployed the unit on 9-4-2015.

9/11/2015 **BADGER UPSTREAM SONDE S/N H400094.** The pH sensor failed to calibrate during the "clean" calibration after the download of data. Data was collected from the previous sampling period. **GEI brought SONDE S/N H400094** back to the lab for further analysis. **SONDE S/N H400094** was replaced with **SONDE S/N H400235** on 9-11-2015.

9/11/15 **BADGER BYPASS SONDE S/N H400044**. Lost stabilizer weight (downrigger) attached to sonde protective casing, and the metal cable was almost worn through due to a strong flow rate after recent rain events. Data download contained and error for a "Power on – Brownout Reset". **GEI temporarily removed SONDE S/N H400044** until the river flow rate decreased. GEI also emailed Ms. Cheryl Laatsch (WDNR) to inform the Department that the sonde at this station would be restored after flows subside allowing for safe deployment.

9/21/15 **BADGER BYPASS SONDE S/N H400044. SONDE S/N H400044** was redeployed after lab calibration and decrease in river flow rate.

9/21/15 **BADGER UPSTREAM SONDE S/N H400235.** Conductivity readings were unstable during field calibration, error messages were observed indicating that contacting HACH support may be warranted. Data download contained an error for a "Power on – Brownout Reset". **GEI redeployed SONDE S/N H400235** after successful recalibration in the field.

9/21/15 **BADGER DOWNSTREAM SONDE S/N H400091.** Conductivity readings were unstable during field calibration. **GEI redeployed SONDE S/N H400091** after successful recalibration in the field.

9/21/2015 **RC DOWNSTREAM SONDE S/N H400237.** The pH sensor failed to calibrate during the "clean" calibration after the download of data. Data was collected from the previous sampling period. **GEI rebuilt the pH probe for SONDE S/N H400094** and was able to successfully calibrate pH during field recalibration after rebooting the software.