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March 16, 2021

VIA ELECTRONIC FILING

Secretary Kimberly D. Bose
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Crescent Hydroelectric Project, FERC Project No. 4678-052
Vischer Ferry Hydroelectric Project, FERC Project No. 4679-049
Filing of Initial Study Report Meeting Summary

Dear Secretary Bose:

The Power Authority of the State of New York (Power Authority) is relicensing the Crescent and Vischer Ferry Hydroelectric Projects (Projects), FERC Nos. 4678 and 4679, respectively, using the Federal Energy Regulatory Commission's (Commission or FERC) Integrated Licensing Process (ILP). Pursuant to the ILP, on January 21, 2020, the Power Authority filed a Revised Study Plan (RSP). On February 20, 2020, FERC issued a Study Plan Determination (SPD) for the Projects. The February 20, 2020 SPD approved seven studies included in the RSP and added an eighth study.

After completing its first study season, pursuant to 18 CFR § 5.15(c), the Power Authority filed its Initial Study Report (ISR) with the Commission on February 19, 2021. On March 3, 2021, due to the COVID-19 pandemic, the Power Authority held a virtual public ISR meeting with resource agencies and stakeholders to discuss study results and provide status updates on three outstanding studies to be completed during the second study season in 2021 (Bald Eagle, Recreation, and American Eel studies).

Pursuant to 18 CFR § 5.15(c)(3), the Power Authority hereby submits a summary of the March 3, 2021 ISR meeting, an ISR meeting attendance list (Attachment A), and PowerPoint presentation (Attachment B). The Power Authority appreciates the contribution of FERC staff, resource agencies and stakeholders through their participation in the ISR meeting. In response to comments received at the meeting, the Power Authority has provided additional information pertaining to various studies as attachments to the enclosed meeting summary which includes:

- A revised Water Quality Study report, including additional information regarding dates and operations during certain water quality monitoring events. Specifically, a Supplement to Table 3.3.2-1, dates when the Average Daily DO was less than 5.0 mg/L at the Forebay Sites and Appendix B, concurrent flow data added in red font have been updated. The revised Water Quality Study report is attached to the meeting summary (Attachment C).

- A revised Blueback Herring Study report, including minor corrections and clarifications to downstream passage, Section 3.3.1, and corrected table headings for Appendix B, Total State Downstream Passage Survival Model Output. The revised Blueback Herring Study report is attached to the meeting summary (Attachment D).

- In addition, for the Fish Community Study, FERC staff requested that fisheries data provided in Appendix B be filed with FERC in the form of an Excel spreadsheet. This information is being attached separately as an Excel file.

With today's filing of the enclosed ISR Meeting Schedule, the Power Authority understands that the next steps of the ILP for the relicensing of the Projects will proceed as follows:[1]

- Monday, April 19, 2021: Per 18 C.F.R. § 5.15(c)(4), relicensing participants file any disagreements on the ISR, modifications to amend the study plan, and requests for new studies.[2]

- Wednesday, May 19, 2021: Per 18 C.F.R. § 5.15(c)(5), relicensing participants file any response comments to any disagreements, requests for study modifications, and new study requests.

- Friday, June 18, 2021: Per 18 C.F.R. § 5.15(c)(6), Commission staff issues determination to resolve any disagreements and amend the study plan.

If you have any questions regarding the ISR, please do not hesitate to contact me. In addition to filing the ISR Meeting Summary with the Commission, the Power Authority will share the ISR Meeting Summary with relicensing participants by posting it on the Crescent and Vischer Ferry Project's relicensing website at http://www.nypa.gov/cvf.

Sincerely,

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[1] For clarity, the Power Authority recognizes that the dates appearing below differ slightly from the process plan and schedule set forth in Scoping Document 3 (SD 3). *See* Scoping Document 3 for the Crescent Hydroelectric Project and Vischer Ferry Hydroelectric Project, Appendix A, Project Nos 4678-052 & 4679-049 (issued on Jan. 25, 2021). The schedule in SD 3 assumed that the ISR meeting would occur on March 6, 2021. Following release of SD 3, the Power Authority scheduled the ISR meeting for March 3, 2021. As a result, the next set of deadlines in the ILP have shifted slightly, based on the Commission's regulations. *See* 18 C.F.R. § 5.15(c).

[2] Although not expressly stated in the ILP regulations, the Power Authority believes that the 30-day period under 18 C.F.R. § 5.15(c)(4) ends 30 days following the due date for filing of the ISR Meeting Schedule (i.e., 30 days from March 18, 2021). Thus, the deadline for under section 5.15(c)(4) is Monday, April 19, 2021, pursuant to Rule 2007(a)(2) of the Commission's Rules of Practice and Procedure. *See* 18 C.F.R. § 385.2007(a)(2).

Enclosure:

Initial Study Report Meeting Summary (including Attachment A: ISR Meeting Attendance List, Attachment B: ISR Meeting PowerPoint, Attachment C: Updated Water Quality Study, Attachment D: Updated Blueback Herring Study)

cc: Distribution List (attached)

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Meeting Summary

Projects: Crescent and Vischer Ferry Hydroelectric Projects (FERC Nos. 4678 and 4679)

Subject: Initial Study Report Meeting

Date: Wednesday, March 3, 2021

Location: WebEx Virtual Meeting

Attendees: Attachment A – Attendance List

Agenda

- Introductions
- Water Quality Study
- Fish Community Study
- Fish Entrainment Study
- Blueback Herring Study
- Aquatic Mesohabitat Study
- Bald Eagle Study Update
- Recreation Study Update
- American Eel Study Update
- Vischer Ferry Ice Jam Update
- Closing

Overview

This document provides the meeting summary for the New York Power Authority (Power Authority) Crescent and Vischer Ferry Hydroelectric Projects Initial Study Report (ISR) Meeting. The meeting was held via WebEx to review with stakeholders the progress and results of the ISR, which was filed with the Federal Energy Regulatory Commission (FERC) on February 19, 2021. The ISR can be accessed from either FERC's website or from the website: Crescent-Vischer-Ferry-Relicensing (nypa.gov). A copy of the meeting presentation is included with this meeting summary as Attachment B.

Welcome and Introductions (Slides 1-5)

Cindy Brady of the Power Authority opened the ISR meeting at 10:00 a.m. with an introduction that described the ISR meeting goals and objectives, and encouraged participation and feedback. She provided an overview of the agenda and the completed and upcoming Integrated Licensing Process (ILP) schedule milestones. The studies in the ISR meeting were completed by the Power Authority during the first ILP study season (2020), and listed below, for which preliminary study reports were filed with the ISR:

- Water Quality Study

- Fish Community Study
- Fish Entrainment Study
- Blueback Herring Study
- Aquatic Mesohabitat Study

Several consultants to the Power Authority then presented the studies using the attached PowerPoint presentation (Attachment B). The enclosed PowerPoint presentation serves as a summary of the Power Authority's presentation for each study in the FERC approved study plan. Following the presentation of each study, the Power Authority opened the meeting for discussion. A summary of major discussion points for each study is provided below.

Water Quality Study
Slides 6-24 (Attachment B)
Presenter: Jason George, Gomez and Sullivan Engineers

Study Results

Jason George (Study Lead), Gomez and Sullivan Engineers, introduced himself and presented the Water Quality Study methods and results. This study is complete and the final report was filed with FERC and distributed to the stakeholders.

Questions and Comments

USFWS staff asked about the flashboard condition during the period of the study. Jason George answered that the flashboards at both projects were up by the July 4 weekend and stayed up until late November. USFWS staff noted that the DO measurements bounced around a lot. Jason George reviewed the sampling QA/QC monitoring procedures that were used, as described in the study report. Overall, Jason noted that monitor biofouling was not bad since the survey Team was out every week to clean the DO probes; but some data had to be adjusted. Jason also noted that the Crescent forebay sampling site depth was shallower than the Vischer Ferry forebay – on average 2 to 3 meters.

NYSDEC staff asked about evidence of the same stratification throughout the impoundment and whether the forebay was atypical. Jason George replied that he thought it was an atypical situation, specific to the forebay. Jason noted that most of the impoundment channel is shallow, just 10-15 feet; with only a few spots over 25 feet deep.

NYSDEC staff asked if there was value in having samples further away from the impoundment. Jason George noted that would tell you if deeper spots are stratified but, he believes the forebay conditions testing adequately captures the Project effects of the turbines.

FERC staff asked if the adjusted DO values were used in the plots. Jason confirmed that it was. FERC staff said it would be helpful if the Power Authority could identify the days that impoundment DO concentrations dipped below the 5.0 mg/L average standard. FERC staff also asked if data could be provided to show Project operational conditions on the days when vertical profiles were taken. Jason agreed these things could be provided. An updated Study Report with this data is located in Attachment C.

NYSDEC staff noted that July 9 appeared to be the "worst" day for DO concentrations in the project forebays. NYSDEC staff asked if the field team had made any other observations on those days that would explain the low DO levels. Jason noted that he would check the notes, and confirmed after the meeting that turbines were off all day on July 9, 2020. Otherwise, nothing unusual was observed.

There was additional discussion about other days when low DO values were observed, and general agreement among the group that there were no obvious changes in flow or temperature that would explain the lower DO values on these days. The first day of lockages at E-7 was July 12. Union College staff, spoke of impaired water at the Great Flats Aquifer during the period of July 18-20 when the movable dam was put in service to raise levels. There was also some discussion about whether the operation of the portable dam at Lock 8 might be affecting river flow and observed DO levels.

There were no further questions on the Water Quality Study.

Fish Community Study
Slides 25-41 (Attachment B)
Presenter: Mike Hreben, Kleinschmidt Associates

Study Results

Mike Hreben (Study Lead), Kleinschmidt, introduced himself and presented the Fish Community Study methods and results. This study is complete and the final report was filed with FERC and distributed to the stakeholders.

Questions and Comments

USFWS staff asked about the portion of data used in the study that was collected at the Vischer Ferry or Crescent Projects. Mike Hreben replied that various survey efforts used for the study included data from both projects, and downstream of Crescent (at the School Street Project). Mike explained there was more data for the Crescent project and/or downstream of Crescent and some for Vischer Ferry impoundment (Schenectady Pool). Overall, the report represented river wide data collection.

USFWS staff asked if any of the tributaries examined by the USGS in their recent eel study are tributaries to either the Crescent or Vischer Ferry Projects. Mike explained that there were several sampling stations in tributaries to the two Project impoundments, as shown in the PowerPoint slide and report figure. USFWS staff asked if the USGS e-DNA American Eel study data will be included in the American Eel Study Report. Mike responded that if the data is available from USGS, it will be included in the American Eel study report.

FERC staff asked Mike to clarify if the location of the sampling site 498004 (site 1), shown in Figure 3.1 is upstream of VF dam. Mike confirmed that it is. FERC staff noted that BBH data provided in the report is hard to parse out. FERC staff asked if the Power Authority could file the BBH data as an Excel spreadsheet with a tab identifying the column headings (a key). Mike said the BBH data is already in a spreadsheet that can be filed with FERC; it will be filed separately as an excel file.

FERC staff asked a few more detailed questions about some of the unusual fish noted in the referenced datasets, including a note about the Mirror Carp observed at School Street.

USFWS staff noted that the study indicated there was some observations of American Shad in the Mohawk River, but that the study report did not discuss shad as a migratory species. Mike acknowledged that shad were found in one data set, but noted that it was isolated fish documented in the 1970s and a few more over time. USFWS staff also noted the brown trout and brook trout identified in some of the historical data sets. Mike said these observations were made at School Street in the 1980s and were probably "wash outs" from tributaries.

There were no further questions on the Fish Community Study.

Fish Entrainment Study
Slides 42-55 (Attachment B)
Presenter: Ian Kiraly, Gomez and Sullivan Engineers

Study Results

Ian Kiraly (Study Lead), Gomez and Sullivan Engineers, introduced himself and presented the Fish Entrainment Study methods and results. This study is complete and the final report was filed with FERC and distributed to the stakeholders.

Questions and Comments

USFWS staff asked if the blade strike probability model that USFWS developed was used, or was this your own probability model? Ian Kiraly responded that the Franke equations (the same that are used in the USFWS model) were used. Ian explained that they took the USFWS required inputs, used the same formulas, just not the distribution of fish sizes.

FERC staff asked if the bar spacing reported for the projects was clear spacing? Ian confirmed that it was. FERC staff also asked if the estimated 661 cfs "leakage" at Vischer Ferry includes the estimated 200 cfs of flow through the bypass notches in the flashboards. After a bit of discussion, it was confirmed by Dave Weiman, Power Authority, that the 661 cfs used in the report was inclusive of bypass notch flows.

FERC staff noted that some flow duration data for the studies (entrainment) was based on 9 years of data. FERC staff asked that moving forward for the license application, if the Power Authority includes flow duration curves for the Cohoes USGS gage (a very long record), that the flow duration curves be based on a more recent period, to reflect more recent river flow conditions. FERC staff made a general comment that, moving forward, hydrology statistics should be based on a more recent period please.

USFWS staff asked why the ADCP velocity figures provided for the Crescent forebay were not also provided for Vischer Ferry. Ian responded that the ADCP unit could not be operated reliably in the Vischer Ferry forebay due to the large pier in the middle of the forebay, and the high walls around the unit intake area; the survey team could not pull a line across, it was not safe to do so. NYSDEC staff asked so therefore the Team did not try to collect data? Ian Kiraly replied that based on their extensive experience with the technology they would not have obtained accurate cross section data. In addition, it was unsafe to gather this data.

FERC staff specifically asked the agencies if they were okay with the five representative species that were used for the entrainment study. USFWS and NYSDEC staff indicated that they were in agreement with the five species used.

There were no further questions on the Fish Entrainment Study.

Blueback Herring Study
Slides 56-71 (Attachment B)
Presenter: Mike Hreben, Kleinschmidt Associates

Study Results

Mike Hreben (Study Lead), Kleinschmidt, presented the Blueback Herring Study methods and results. This study is complete and the final report was filed with FERC and distributed to the stakeholders.

Mike Hreben noted an error on slide 67, second bullet, should be bypass 'mortality' is expected to be about 1%... (corrected in Attachment B, PPT Presentation).

Questions and Comments

FERC staff asked for clarification regarding the timing of installation and operation of the acoustic deterrent system (in a normal, non-Covid year) relative to BBH being in the system. Mike Hreben explained that normally the deterrent systems are in place early in the navigation season, which means they are in place before adult BBH would be looking to migrate downstream. In the fall, the acoustic deterrent systems are usually taken out at the end of the navigation system (typically late October or early November), so the deterrent systems are in service for the BBH migration season.

FERC staff also noted that the 90% exceedance flow was examined and so it should be referred to as the 90% exceedance not the 90th percentile. Mike Hreben agreed. FERC staff also pointed out that some of the tables in the report showing model run results are labeled as survival, but should be labeled as "mortality". Mike acknowledged these corrections would be made; the full revised report is attached (Attachment D).

FERC staff pointed out that some of the telemetry data used in the study was collected in 2008 before the changes were made and the deterrent system was reconfigured in 2009. FERC staff asked why the study assumes that the deterrent system effectiveness is still as effective. FERC staff noted that this question was not addressed in the report. FERC staff suggested the study report discuss why the pre-2009 telemetry data is still valid. Mike explained that the changes made to the deterrent system, to direct the array further upstream in to the main channel, were designed to improve its performance by improving the projection of the acoustic signal. Mike noted that there is no reason to think the reconfigured deterrent system is less effective. This led to some additional discussion about the telemetry results before and after the acoustic array was reconfigured.

FERC staff commented that the study results demonstrated that spillway survival rates affect the overall whole station survival, and that if spillway survival rates were higher, the station survival would be higher. Mike was also asked which of the two spillway mortality rates used in the study is likely more realistic for the current bypasses? This led to some general discussion with agencies about whether spillway survival rates might be higher than assumed. USFWS staff noted that it depends on the location. Mike pointed out that Dam A has an ogee shape, and that the plunge pool depth is greater than at the old bypass location on Dam B. Dam roughness was also noted to be a factor that could affect survival rates.

NYSDEC staff questioned why the study did not consider the potential mortality of BBH going through the Locks. Mike Hreben explained that the study did not make any assessment of lock passage survival, because they did not have a good feel for how many fish are using locks, and because the operation of the locks is so limited and variable – the locks are operated on demand, and varies day to day/year to year. However, Mike suggested that it is reasonable to think that BBH passage through locks is relatively benign and our model utilized 1,000 fish passing through the Project.

USFWS staff commented that while BBH survival at Crescent and Vischer Ferry is relatively high, passage survival has to also be considered cumulatively since BBH out-migrating from the Mohawk may have up to 5-6 hydropower projects to pass before they reach the Hudson River. Thus, even if BBH survival is relatively high at each station, cumulative survival may not be high enough to sustain the fishery.

NYSDEC staff asked if there was data on how long it may take juvenile BBH to find the downstream passage routes and whether they linger and potentially become more vulnerable to predation. Mike Hreben responded that he did not know. However, Mike noted that the BBH juveniles move in mass, with schools of fish following each other. As a result, it seems unlikely the fish are delayed once the school decides to move.

NYSDEC staff noted that as good as the BBH study results seem, there have been reliability issues with the acoustic deterrent systems the past few years. NYSDEC staff asked why reliability was not mentioned in the report in relation to effectiveness. Mike answered that this past year (2020) the deterrent system was late opening because the canal system opened late. Also, in 2020 the Power Authority replaced a problematic cable in the Crescent system. USFWS staff noted that there were some contractor issues and system delays in 2019, as well.

FERC staff observed that the study results suggest that the deterrent system may not make a difference in BBH survival rates since turbine passage survival rates are so high.

USFWS staff noted again that while the predicted 85% survival rate for the Francis units, or 93% for the Kaplan units seems high, the cumulative effects of multiple dam passage must be considered; and that 85% survival at Crescent and Vischer Ferry Projects may not be adequate. Mike asked USFWS staff of a sense of what an adequate rate of passage survival would be. USFWS staff responded that ultimately that would be NYSDEC's decision. NYSDEC staff noted that it is a matter of considering cumulative impacts.

There were no further questions on the Blueback Herring Study.

Aquatic Mesohabitat Study
Slides 72-90 (Attachment B)
Presenter: Jason George, Gomez and Sullivan Engineers

Study Results

Jason George (Study Lead), Gomez and Sullivan Engineers, presented the Aquatic Mesohabitat Study methods and results. This study is complete and the final report was filed with FERC and distributed to the stakeholders.

Questions and Comments

USFWS staff noted that the study indicates that the Crescent and Vischer Ferry Projects are described as operating run-of-river (ROR) and asked what that means to the operation of these plants. Dave Weiman, Power Authority explained that both Projects are operated such that Project outflow generally matches inflow, with only minimal fluctuation in the impoundment levels. To do this, the Power Authority carefully monitors inflow, and adjusts outflow to handle any changes in inflow that result from operation of canal locks and portable dams upstream of Vischer Ferry. For example, if the Canals sends down a large influx of water, the Power Authority will bring on another generating unit or two. If flows drop off, then the Power Authority will turn off a unit to maintain elevation for the upstream pond.

This led to discussion about some periods of operation in 2020 where USFWS staff noted that the Crescent Project appeared to come online then went offline, while USGS gage flow data from Freemans Bridge showed a small spike in flows (1500-2000 cfs). USFWS staff had similar questions about flow and generation patterns on June 29-30. Dave Weiman, Power Authority noted that it was possible in June 2020, that they may have been running to lower pond elevation to get flashboards in, he does not have exact dates on hand. Prior to seasonal installation of the flashboards, the plants are run to drop pond elevation to get flashboards in. Once flashboards are in, generation loads are reduced to get the pond levels up to the normal navigation seasonal levels. Similar sequencing is performed at Crescent. Jason George noted we can see that on the impoundment water level figure presented in the habitat report. Water Quality figures just present flow through the turbines, and do not show flow over the dam or through other areas. This does not mean there is zero flow going downstream of the Projects. During normal operations, outflows at each Project are managed to maintain impoundment elevations.

USFWS staff asked when the boards came out in 2020. Dave Weiman, Power Authority indicated that the boards at Crescent came out Nov 3, 2020 and Nov 9 and 10 at Vischer Ferry.

There were no further questions on the Aquatic Mesohabitat Study.

2021 Field Season & Updates
Slides 91-111 (Attachment B)

Bald Eagle Study Update
Presenter: Wendy Bley, Kleinschmidt Associates

Study Update

Wendy Bley, Kleinschmidt, presented the Bald Eagle study update. She noted that the study field season was delayed due to the pandemic, so the nesting survey was not conducted in 2020. However, general observations of eagle use of the Project areas were made as part of the Aquatic Mesohabitat Study and during water quality monitoring visits in 2020. She explained that the Bald Eagle nesting survey will be conducted in April 2021 and the study results will be filed with the Updated Study Report (USR) in February 2022.

Recreation Study Update
Presenter: Jason George, Gomez and Sullivan Engineers

Study Update

Jason George, Gomez and Sullivan Engineers, presented the Recreation Study update. Jason noted that the recreation study was postponed in 2020 due to the pandemic. The Recreation Study will be conducted from May through October 2021 and results will be filed with the USR in February 2022.

American Eel Study Update
Presenter: Mike Hreben, Kleinschmidt Associates

Study Update

Mike Hreben, Kleinschmidt, presented the American Eel Study update. Mike noted that the eel study was delayed due to the pandemic. The American Eel Study will be conducted in 2021 and results will be filed with the USR in February 2022. Mike explained that an American Eel Study plan addendum was filed with FERC in February 2021, and that the study plan was developed in consultation with the agencies. Mike explained that three sampling methods will be used: nighttime observations, eel ramp traps and nighttime boat electrofishing.

FERC staff concurred with the study methods and confirmed that FERC is in agreement with the modified study plan. The agencies are in concurrence with the plan and therefore, FERC is as well. NYPA does not need formal FERC approval.

Vischer Ferry Ice Jam Update
Presenter: Cindy Brady, New York Power Authority

Study Update

Cindy Brady, Power Authority presented an update on the Vischer Ferry Ice Jam study. She explained that the study was being conducted by Dr. Shen and his team at Clarkson University as part of the Reimagine the Canals process. Cindy reminded the meeting participants that the Reimagine the Canals initiative is a multi-year collaborative effort among stakeholders and includes an evaluation of flooding as a result of ice jams at Vischer Ferry. She noted that some of the things being looked at include modeling (being conducted by Dr. Shen and his team), an evaluation of potential use of icebreakers, modification of the Vischer Ferry Dam, and channel modifications. She also explained that an early warning system is being developed.

Cindy indicated that a pilot test of icebreaker use was underway, and she showed a brief video showing an icebreaker test run in December 2020. Cindy concluded by reminding meeting attendees that the Reimagine the Canals effort will conclude with results by 2025-2026.

Questions and Comments

FERC staff commented that the study plan determination requires an update on the Ice Jam Study. Please provide that on record, an update on the current modeling efforts. Cindy Brady, Power Authority indicated that results of the Ice Jam study will be filed with FERC once it becomes publicly available. The Power Authority will follow up and confirm.

Crescent and Vischer Ferry Projects Relicensing Next Steps & Questions/Comments
Presenter: Cindy Brady, New York Power Authority

Next Steps

Cindy Brady, Power Authority presented the next steps in the Projects relicensing.

- March 16, 2021 –Power Authority files ISR Meeting Summary with FERC.

- April 19, 2021 – Stakeholders file disagreements on ISR; modifications to ongoing studies; requests for new studies.
- May 19, 2021 – Stakeholders file responses to disagreements and study modifications with FERC.
- June 18, 2021 – FERC issues determination to resolve disagreements and amend Study Plan.

ISR Meeting Summary – Action Items

Cindy Brady, Power Authority reviewed the questions and comments to which the Power Authority would prepare a response to be filed with FERC as follows:

1. Water Quality Study: FERC staff asked that Table 3.3.2-1, for the days that the impoundment average daily dipped below 5.0. mg/L, please include a table of those dates and for the vertical profiles, match up with operations hourly information. A revised Water Quality Study report, including this information, is attached to this summary (Attachment C).
2. Blueback Herring Study: FERC staff noted that the 90% exceedance flow was examined and it should be referred to as the 90% exceedance not the 90th percentile. FERC staff also pointed out that some of the tables in the report showing model run results are labeled as survival, but should be labeled as “mortality”. A revised Blueback Herring Study report, including this information, is attached to this summary (Attachment D).
3. Fish Community Study: FERC staff asked that the Study’s Appendix B, the field survey data, be included as an Excel file, with a tab depicting column title definitions, and a second tab with the data. FERC staff would like an Excel file specifically. This information is being attached separately as an Excel file.

Closing

The Power Authority closed the meeting at approximately 2:25 p.m. and recapped upcoming deadlines for comments and responses on the ISR, in accordance with FERC’s ILP regulations and the schedule established by FERC staff.

Attachment A: Crescent and Vischer Ferry Virtual ISR Meeting – Attendee List, March 3, 2021

Attachment A: Crescent and Vischer Ferry Virtual ISR Meeting – Attendee List, March 3, 2021

Name	Affiliation
Joseph Moloughney	New York State Canal Corporation
Kristen Diotte	City of Schenectady
Jody Callihan	Federal Energy Regulatory Commission
Emily Carter	Federal Energy Regulatory Commission
Monir Chowdhury	Federal Energy Regulatory Commission
John Stokely	Federal Energy Regulatory Commission
Jason George	Gomez & Sullivan Engineers
Ian Kiraly	Gomez & Sullivan Engineers
Wendy Bley	Kleinschmidt Associates
Mike Hreben	Kleinschmidt Associates
Fatima Oswald	Kleinschmidt Associates
Cindy Brady	New York Power Authority
Rob Daly	New York Power Authority
Mike Deegan	New York Power Authority
Jairo Florez	New York Power Authority
Jeff Gerlach	New York Power Authority
Tara Groom	New York Power Authority
Sean Koetzner	New York Power Authority
Rob Panepinto	New York Power Authority
Vin Pezzullo	New York Power Authority
Mario Roefaro	New York Power Authority
Maria Ryden	New York Power Authority
Brian Saez	New York Power Authority
Sarah Salem	New York Power Authority
Susan Watson	New York Power Authority
Dave Weiman	New York Power Authority
Andrew Weinstock	New York Power Authority
Sean Wellman	New York Power Authority
Chris VanMaaren	New York State Department of Environmental Conservation
Nicole Cain	New York State Department of Environmental Conservation
Jen Epstein	RiverKeeper
Elizabeth McCormick	Troutman Pepper
Charles Sensiba	Troutman Pepper
Dr. John Garver	Union College
John Wiley	United States Fish and Wildlife Service
Duncan Hay	United States Nation Park Service

Attachment B: Crescent and Vischer Ferry Virtual ISR Meeting – PowerPoint Presentation, March 3, 2021

Crescent Project (P-4678)
Vischer Ferry Project (P-4679)
Initial Study Report (ISR) Meeting




March 3, 2021

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AGENDA

10:00 AM	Introduction
	Water Quality Study
	Fish Community Study
	Fish Entrainment Study
	Blueback Herring Study
	Aquatic Mesohabitat Study
	Lunch Break (30 min)
	Bald Eagle Study Update
	Recreation Study Update
	American Eel Study Update
	Vischer Ferry Ice Jam Update
1:15 PM	Closing

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Meeting Purpose

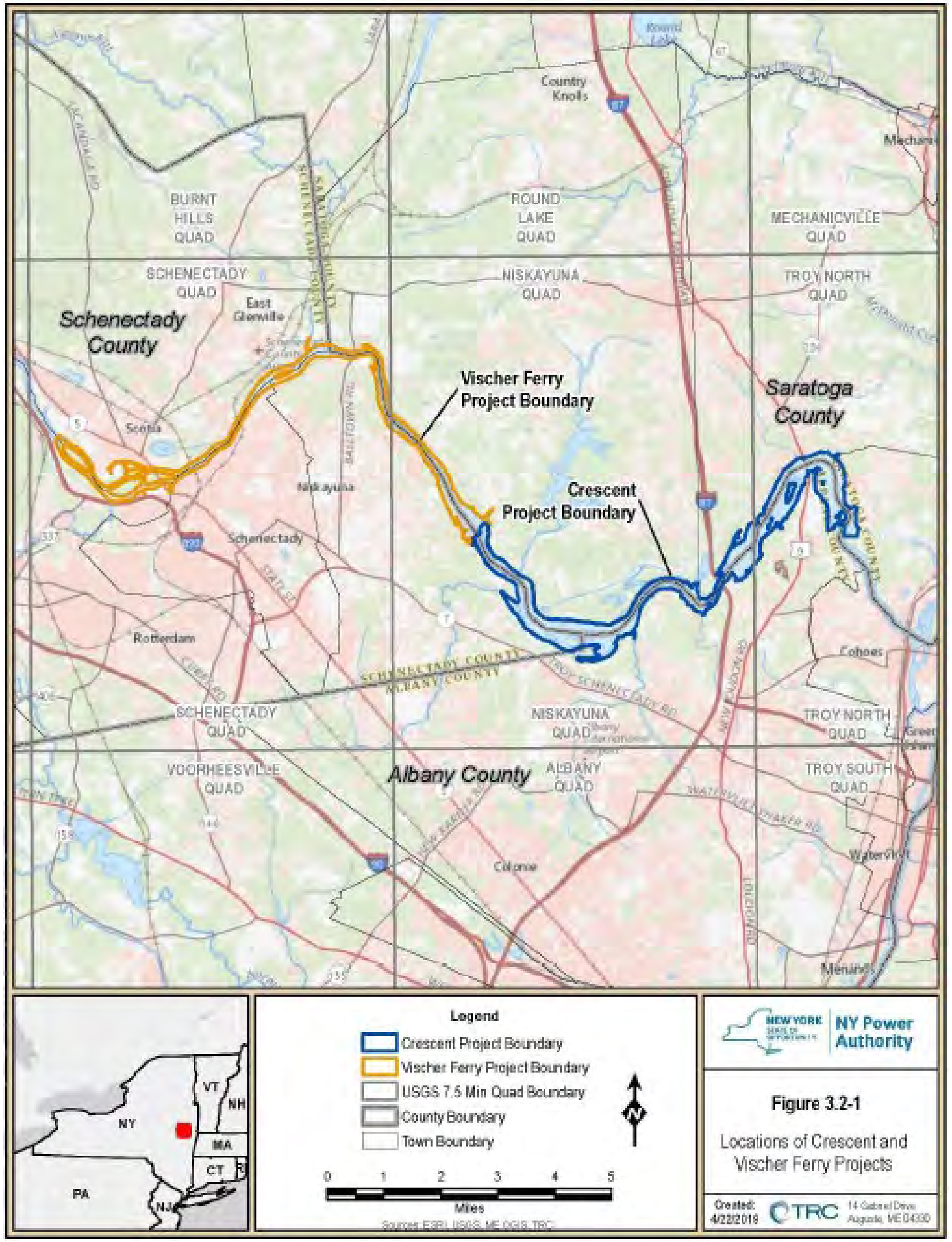
Per 18 C.F.R. § 5.15:

To discuss study results, and the applicant’s and/or other participant’s proposals, if any, to modify the study plan in light of the progress of the study plan and data collected.

Project Relicensing Milestones and Schedule

- NOIs and PAD filed with FERC May 3, 2019
- FERC issued Scoping Document 1 June 10, 2019
- FERC Scoping meetings and project site visits July 10-11, 2019
- PSP filed with FERC September 23, 2019
- PSP Meeting October 23, 2019
- RSP filed with FERC January 21, 2020
- FERC Study Plan Determination February 20, 2020
- 1st Year Studies commence March 2020 (some delays due to Covid-19)
- ISR Study Report filed February 19, 2021
- **ISR Meeting March 3, 2021**
- ISR Meeting Summary filed with FERC March 18, 2021
- Comments on ISR Meeting Summary, disagreements, study requests April 19, 2021
- Response to disagreements May 19, 2021
- FERC issues Determination on Disagreements/Amendments June 18, 2021
- Second Year Studies 2022 (Recreation, American Eel, Bald Eagle)
- Draft License Application (DLA) January 1, 2022
- Updated Study Report February 19, 2022
- Final License Application May 31, 2022

Location of Projects



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Water Quality Study




Study Goals and Objectives

Goals:

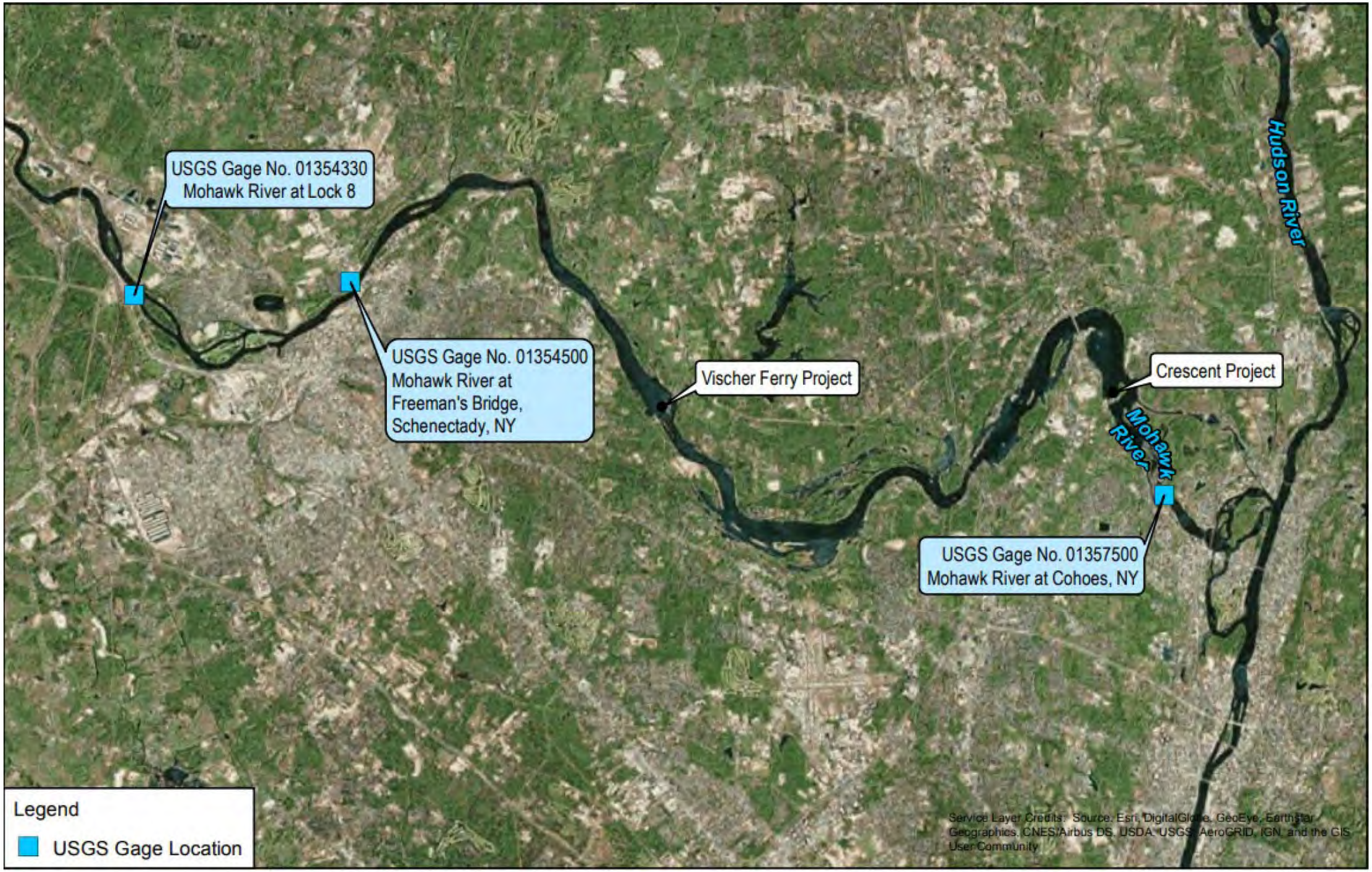
- Characterize current water quality conditions at each Project;
- Evaluate the effects, if any, of each Project on water quality; and
- Determine compliance with State of New York water quality standards.

Objectives:

- Collect continuous dissolved oxygen (DO) and temperature data in the Project impoundments and tailwater areas during the summer and early fall months;
- Collect additional water quality data for pH, conductivity, and turbidity in the Project impoundments and tailwater areas.

Overview of Projects

- Run-of-River Operations
- Flashboards During Navigation Season
- 10+ mile-long Riverine Impoundments
- Minimum Flows During Navigation Season
  - 250 cfs over Crescent Dam A for Fish Passage
  - 200 cfs over Vischer Ferry Dam F for Fish Passage



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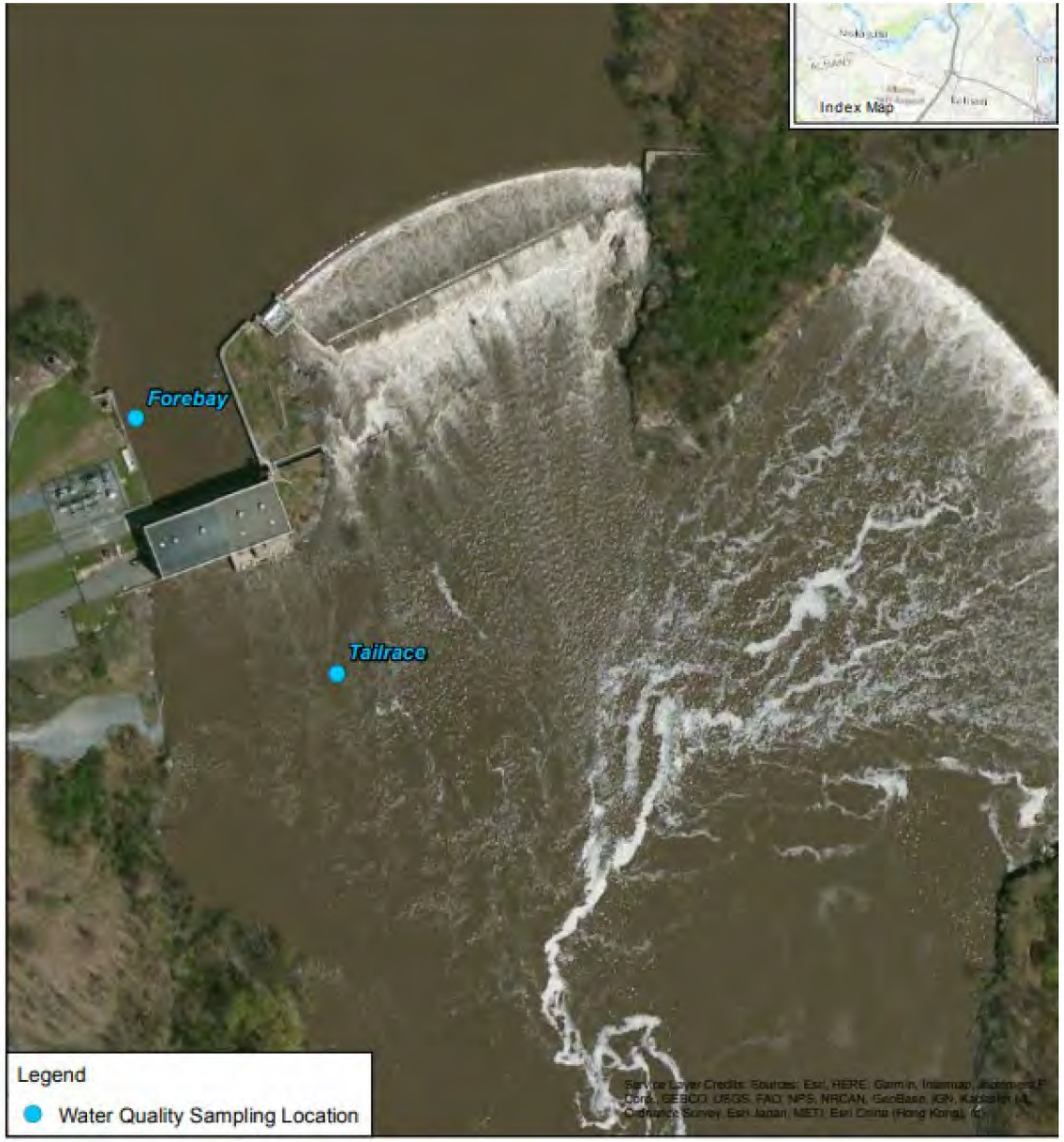
State Water Quality Standards

- Project waters are Class A waterbodies (non-trout)
- Numerical standards
  - Dissolved oxygen (DO)
    - Minimum daily average shall not be less than 5.0 mg/L,
    - Instantaneous DO concentration shall not be less than 4.0 mg/L.
  - pH - Shall not be less than 6.5 nor more than 8.5
  - No numerical standards for conductivity or turbidity

Study Methods

- Four (4) sampling locations
  - Forebay and Tailwater areas at both Projects
- Sampling from June 12 – November 4, 2020
- Continuous DO and temperature
  - 15-minute time step
  - Weekly service visits
- Bi-weekly vertical profiles at all sites, all parameters


Index Map
Forebay
Tailrace
Legend
Water Quality Sampling Location

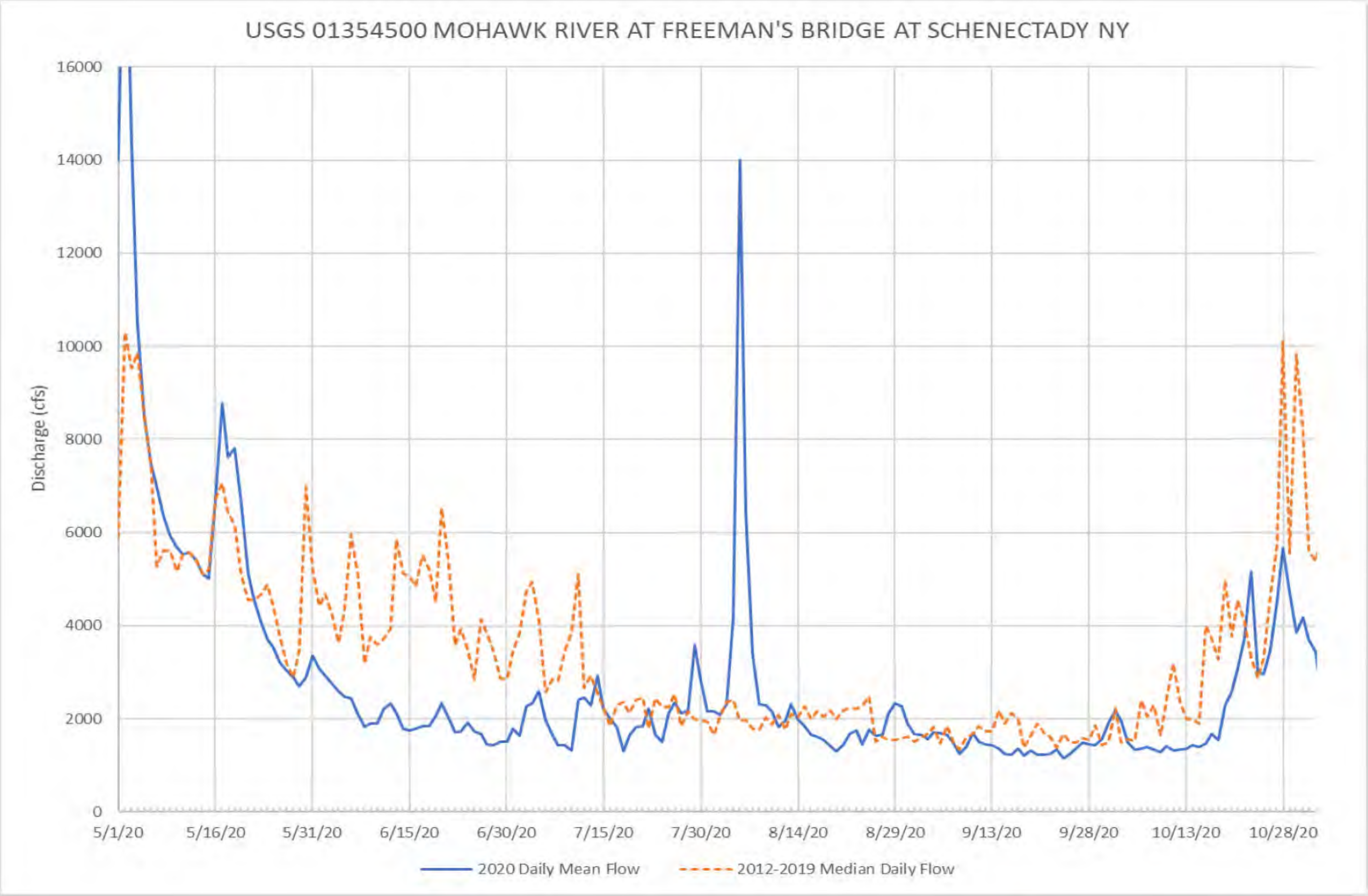

Index Map
Forebay
Tailrace

Study Methods

- Data QA
- Weather and flows
- Operations
  - Turbine operations (hourly)
- Water quality data from Lock 8 USGS gage

Study Results

- Weather and flow conditions
  - Warm and dry
  - Low flows, except early August
- Operations
  - Turbines run at low levels during low flows
  - Periods when flows were too low to run turbines



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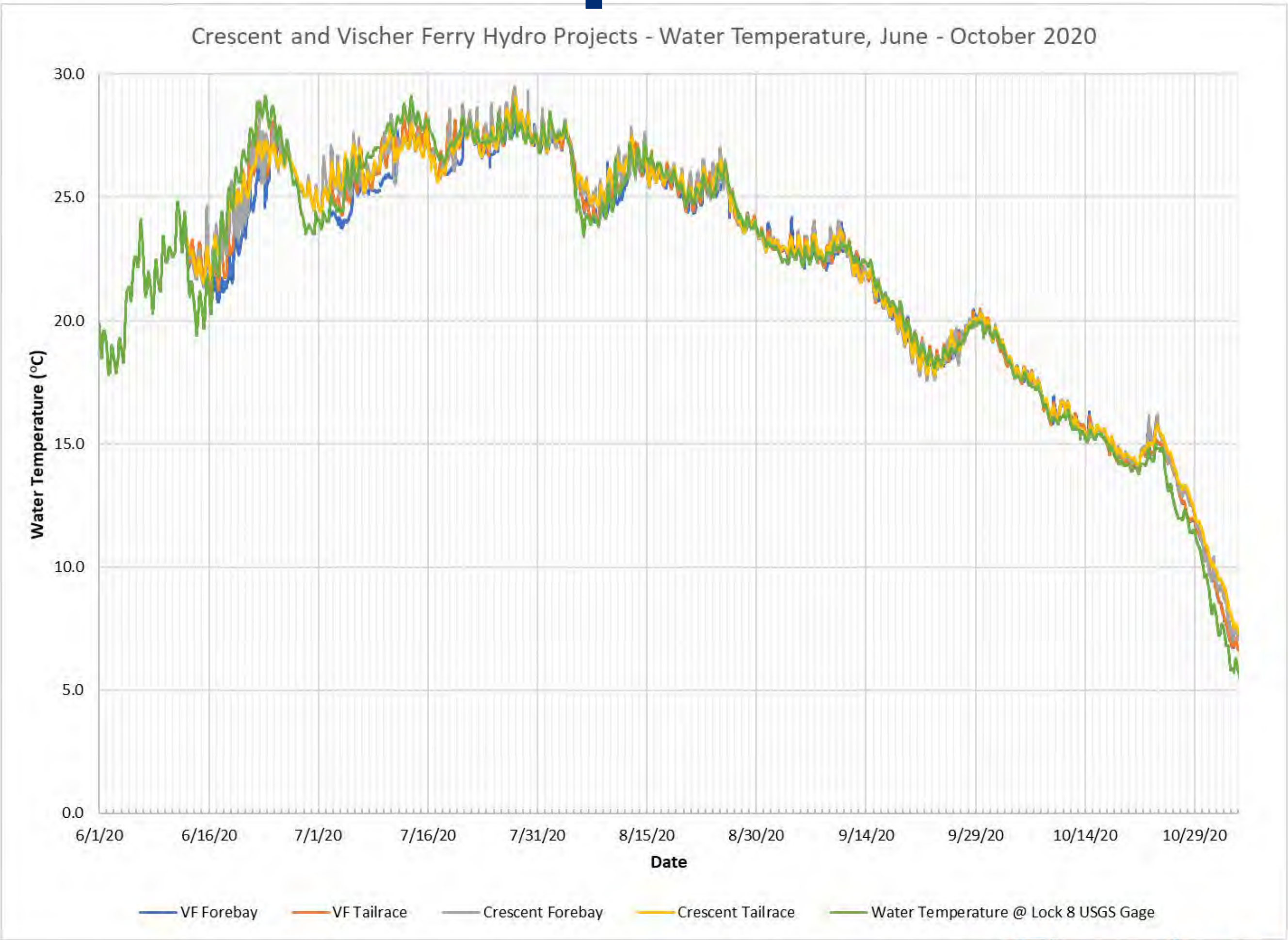
Study Results – Water Temperature

- Water temperature consistent among sites
- VF Forebay slightly cooler due to depth
- Highest measurements in late July
- No thermal stratification observed in Forebays



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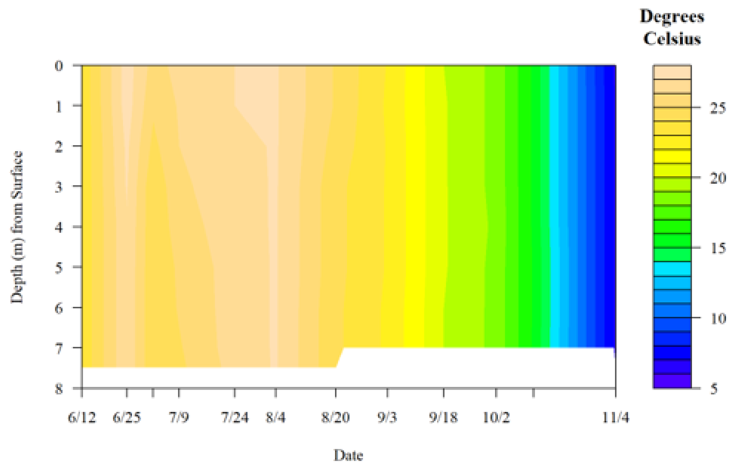
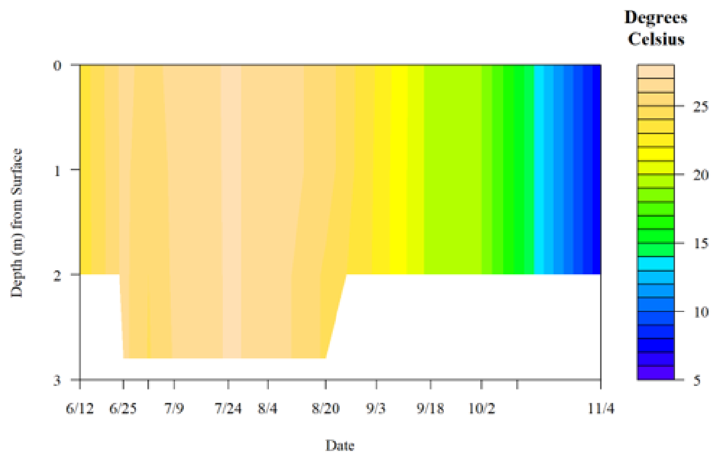
Study Results – Water Temperature

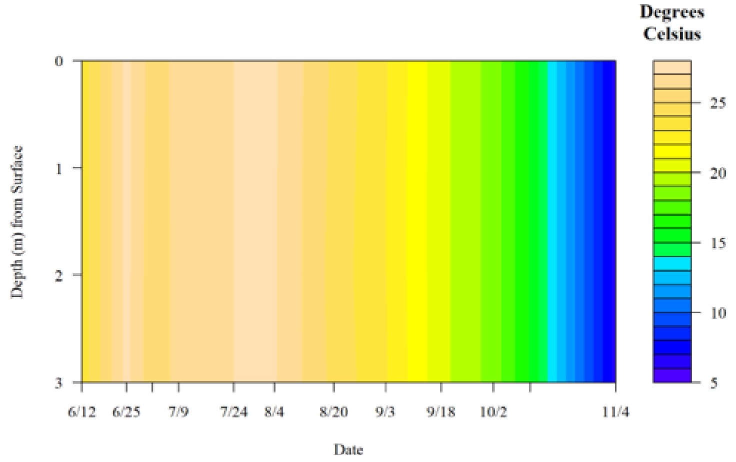
Figure·3.4-4a:··Vischer·Ferry·Forebay·Vertical·Temperature·Isopleth¶



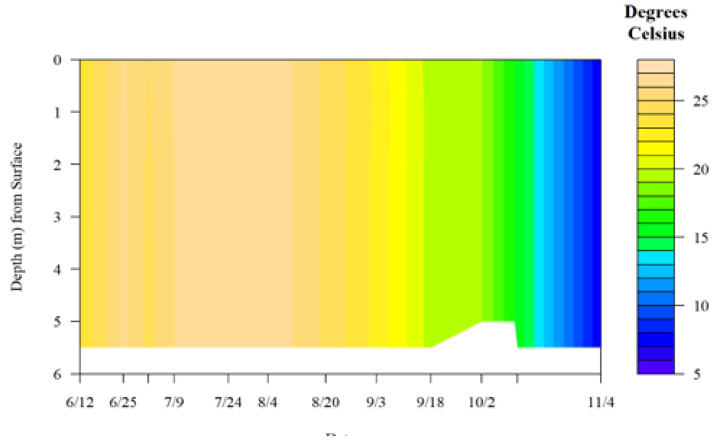
Figure·3.4-5a:··Crescent·Forebay·Vertical·Temperature·Isopleth¶



Figure·3.4-4b:·Vischer·Ferry·Tailrace·Vertical·Temperature·Isopleth¶



Figure·3.4-5b:·Crescent·Tailrace·Vertical·Temperature·Isopleth¶



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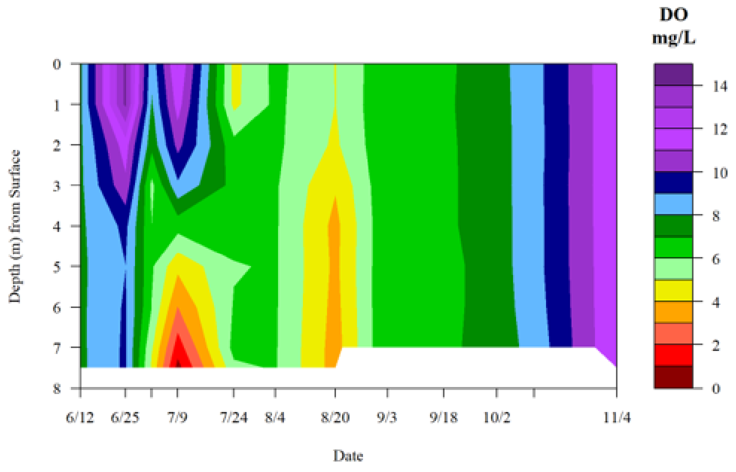
Study Results – Dissolved Oxygen

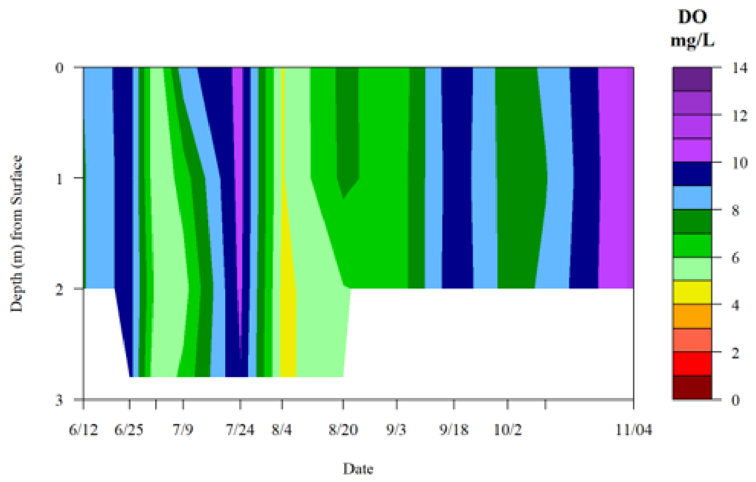
- Dissolved Oxygen
  - Daily fluctuations in Forebays can be atypical and erratic
  - Vischer Ferry Forebay DO stratification (low DO near bottom)
  - Tailraces stay well oxygenated despite Forebay conditions

Study Results – Dissolved Oxygen

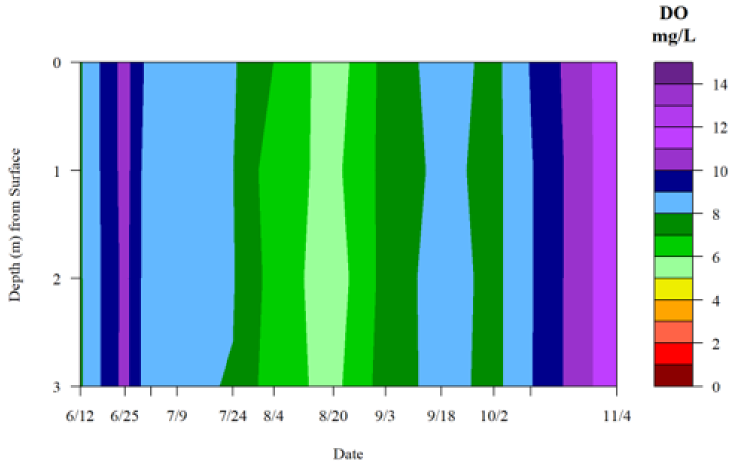
Figure·3.4-4c:·Vischer·Ferry·Forebay·Vertical·Dissolved·Oxygen·Isopleth¶



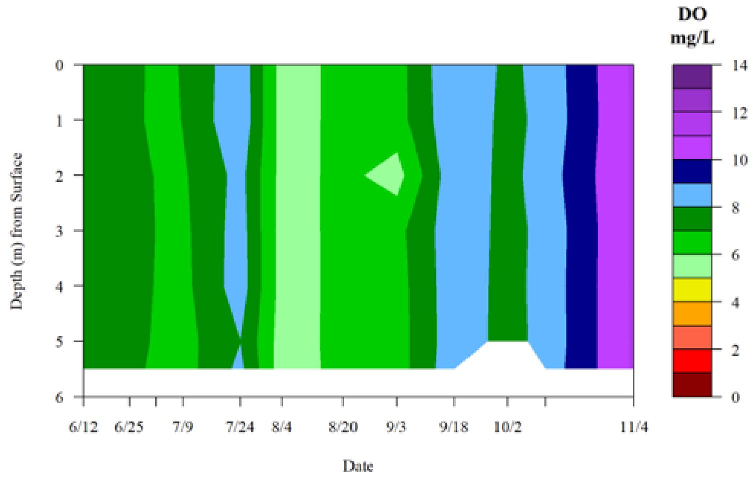
Figure·3.4-5c:·Crescent·Forebay·Vertical·Dissolved·Oxygen·Isopleth¶



Figure·3.4-4d:·Vischer·Ferry·Tailrace·Vertical·Dissolved·Oxygen·Isopleth¶



Figure·3.4-5d:·Crescent·Tailrace·Vertical·Dissolved·Oxygen·Isopleth¶



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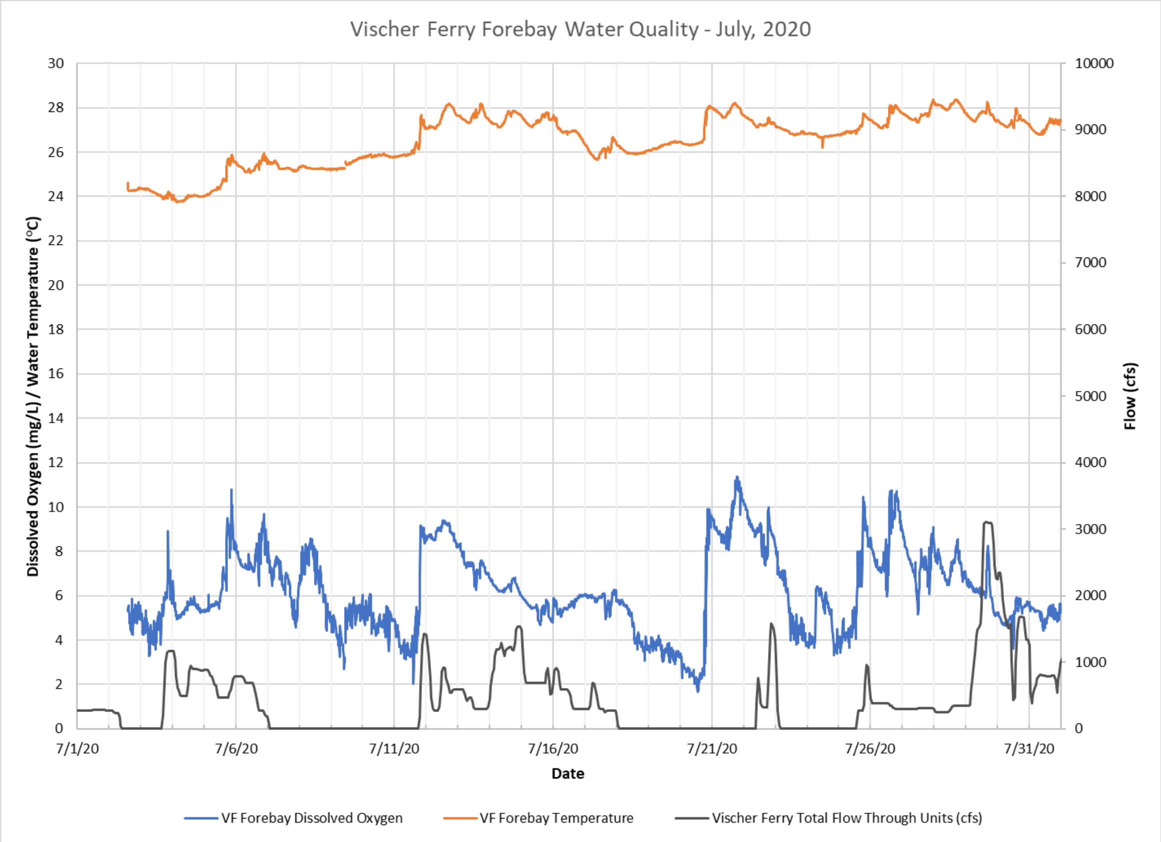
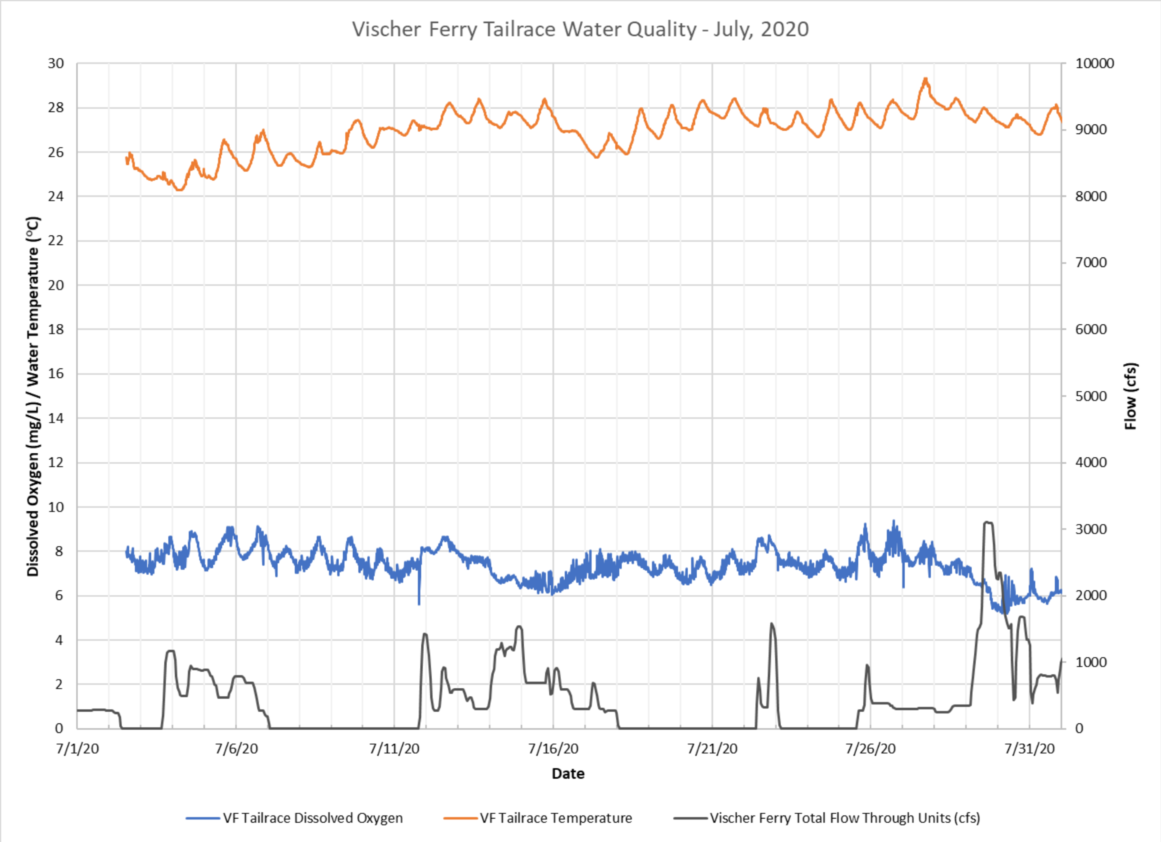
Study Results – Dissolved Oxygen





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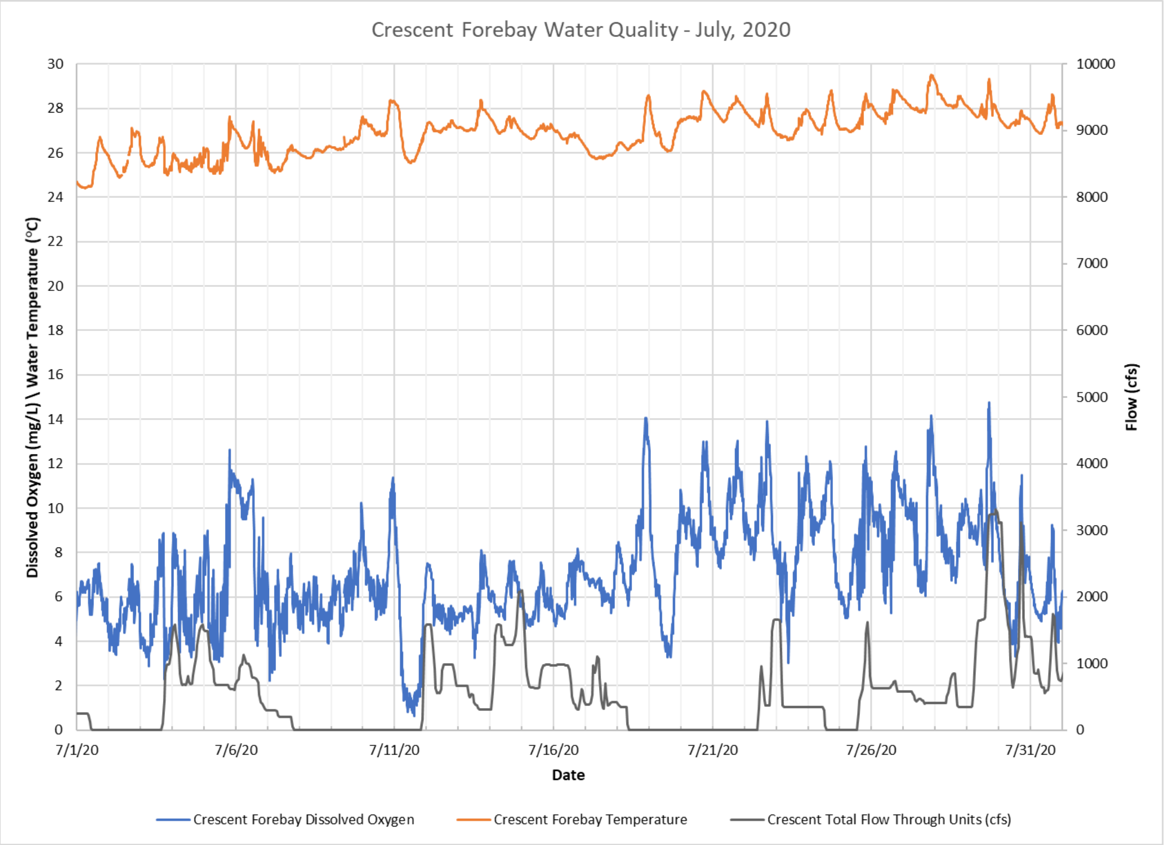
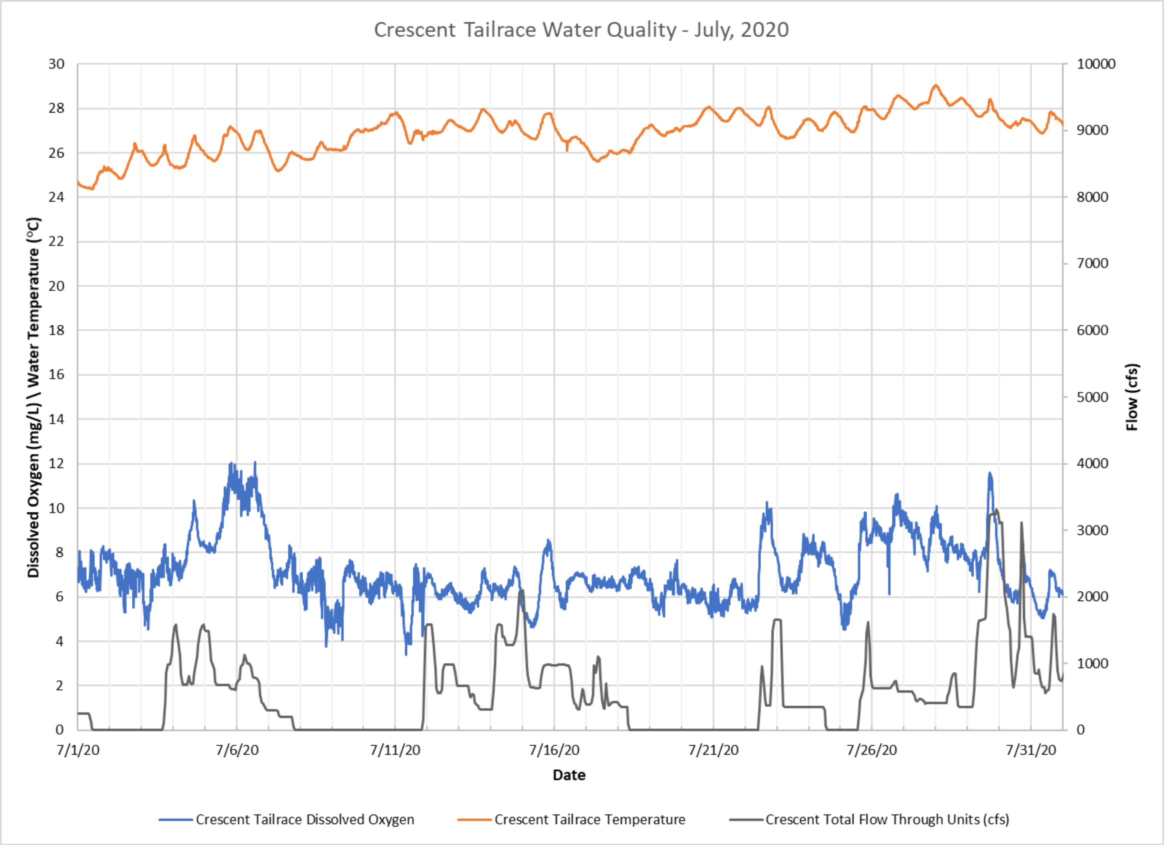
Study Results – Dissolved Oxygen





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Study Results – Dissolved Oxygen

- Forebays can experience low and erratic DO fluctuations
- Project generation does not cause low DO levels in either Tailrace
- Occurrences when average daily DO <5.0 mg/L (continuous data)
  - None in either Tailrace
  - <10% of monitoring days in both Forebays

Study Results

- Turbidity levels <10 and consistent among sites
- Conductivity ranged from 335 to 445 μS/cm
- pH ranged from 6.98 to 8.86
  - High surface measurements at Vischer Ferry Forebay tied to high DO

Study Summary

- Study obtained water quality data under a variety of flow and operations
- Low flow, high temperature period captured critical conditions
- Forebay DO levels are driven by highly productive river system
- Project discharges meet water quality standards for DO in both Tailraces
- Minimum flows over Project dams appear to provide downstream aeration

Questions?

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Fish Community Study




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Background

- Study covered the lower Mohawk River region, within the vicinity of the Crescent and Vischer Ferry Projects

- Crescent Project
  - Impoundment is ~10 miles long
  - Upstream terminus of impoundment at Vischer Ferry Dam

- Vischer Ferry Project
  - Impoundment is 10.3 miles long
  - Upstream terminus of impoundment at Lock E-8 in Schenectady, NY

Study Goals and Objectives

Goal:

Using existing fisheries data for the lower Mohawk River, conduct a comprehensive assessment of the fish community at the Projects, including a determination of species composition and relative abundance.

Objectives:

- Characterize the existing fish community.
- Use this information to describe the fishery resources in the vicinity of the Projects in the Exhibit E of the FERC License Applications.

Current Fisheries Management

- Mohawk River provides habitat for an array of native and non-native fish species, including both resident and migratory species
- NYSDEC manages the Mohawk River in the vicinity of the Projects as a mix of warm-water and cool-water species
- Fish community is primarily dominated by warm-water species and is used extensively by recreational anglers (NYSDEC, 2018)
- Common game species:
  - Smallmouth Bass, Walleye, Largemouth Bass, Northern Pike
- Also managed for the anadromous Blueback Herring
- There is a continuous influx of new aquatic species
  - facilitated through the New York State Barge Canal System (Barge Canal)

Methods – Data Collection

- NYSDEC survey data
- USGS survey data
- New York State Library System, professional journals, and the internet were also searched for relative information
- Data and reports were reviewed
- Created an annotated bibliography of all pertinent studies
  - Pertinent data was assembled into an electronic database

Methods – Data Analysis

Variables of Analysis included:

- Species composition
- Relative abundance
- Catch per unit of effort
- Temporal changes

Results – Number of Species and Study Methods

From Reports and studies produced by NYSDEC:

- At least 62 fish species were documented in the Mohawk River and the Barge Canal System from Lock E-6 in Waterford to Lock E-20 in Rome, New York from 1934 through 1983 (McBride, 2009)
- Carlson (2015) reported that as many as 71 fish species may inhabit the greater river-canal system
- Fisheries sampling was conducted multiple times between 1934-2020, using a variety of methods
  - Trap netting, electrofishing, gill netting, seining, and trawling.
- Raw data for many of these studies was not available, but summary data was available

Results – Findings Summarized

- Mohawk River fishery is diverse and consists of warmwater, coolwater, and migratory species.

- Common warmwater and coolwater species are abundant and provide a diverse recreational fishery (including opportunities for anglers)

- Most abundant gamefish species within the vicinity of the Projects are Smallmouth Bass followed by Walleye

Findings – Resident Fish

- Overall, the resident fish community is dominated by species such as Bluegill, Smallmouth Bass, Yellow Perch, White Sucker, Fallfish, and Brown Bullhead

- Walleye and Northern Pike also provide desirable target species for anglers

Findings – Mohawk River, USGS 2014-2015

Date Sampled	River Kilometers	CPUE (fish/h)	SE (fish/h)
May 27, 2014	3.5–7.9	304.0	8.0
May 27, 2014	7.9–12.2	342.0	n/a
May 26, 2015	12.2–16.6	152.6	2.0
May 26, 2015	16.6–21.0	208.0	3.6
May 28, 2014	21.0–25.4	217.3	8.9
May 28, 2014	25.4–29.9	140.0	5.3
May 27, 2015	29.9–34.3	262.5	68.3
May 27, 2015	34.3–38.7	175.5	15.8

Species	Mean (CPUE)	SD
Smallmouth Bass	28.1	10.5
Other centrarchids	41.7	51.1
Yellow Perch	9.3	8.1
Walleye	8.1	11.6
Cyprinids	75.2	36.6
All other species	62.9	32.0
All species	225.2	72.3

Findings – Crescent Impoundment, NYSDEC 2018

Fish Species	N[2]	Effort[3]	All Sizes	YY/SY	≥Stock	≥Quality	≥Preferred
Brown bullhead	49	2.4	20.7	0.0	20.7	20.7	18.6
Rock bass	95	2.4	40.1	1.3	37.6	7.2	0.0
Pumpkinseed	129	2.4	54.4	0.8	53.6	34.6	3.8
Bluegill	62	2.4	26.6	8.9	16.0	13.1	0.0
Yellow perch	41	2.4	17.3	0.4	16.9	4.2	0.0
Largemouth bass	27	8.9	3.0	0.8	1.8	0.7	0.0
Smallmouth bass	198	8.9	22.3	3.6	18.0	6.8	3.2
Walleye	130	8.9	14.7	1.6	3.6	1.8	0.2

[1] Total length categories for various fish species

	Rock Bass	Yellow Perch / Brown Bullhead	Bluegill / Pumpkinseed	Smallmouth Bass	Largemouth Bass	Walleye / Chain Pickerel
Stock	≥ 4 in	≥ 5 in	≥ 3 in	≥ 7 in	≥ 8 in	≥ 10 in
Quality	≥ 7 in	≥8 in	≥ 6 in	≥11 in	≥12 in	≥ 15 in
Preferred	≥ 9 in	≥10/11 in	≥ 8 in	≥14 in	≥15 in	≥ 20 in

[2] N—numbers captured

[3] Effort—fish per hour

[4] YY—young of year and SY—spring yearling (age 1) fish

Most Abundant Fishes

From surveys conducted in 2018:

- Smallmouth Bass have the highest relative abundance (19% of catch) of the resident species collected.

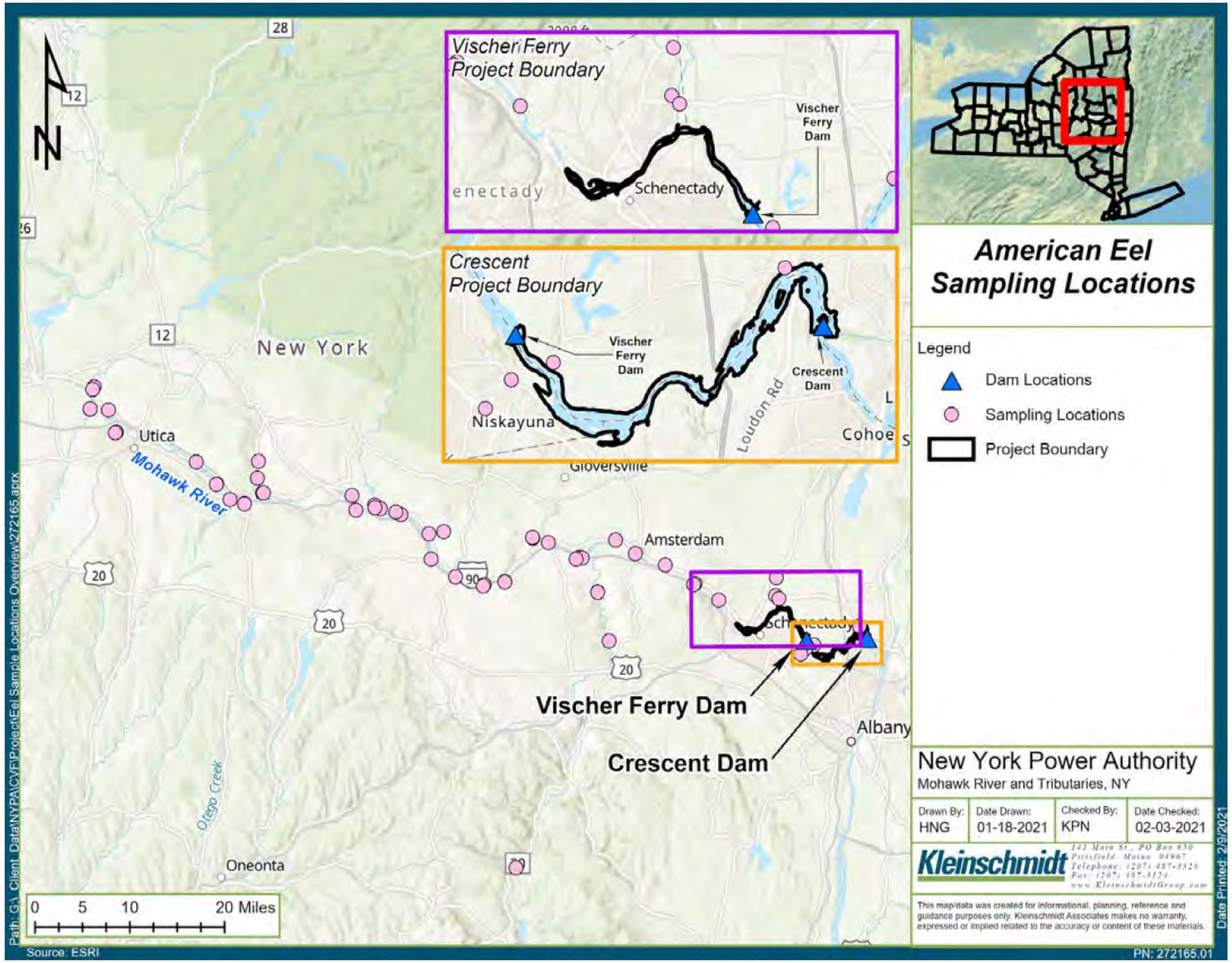
- Relative abundance of Walleye was 12.3% of catch

- Panfish (Yellow perch, Rock Bass, Pumpkinseed, and Bluegill) comprised 31.3% of the catch

Findings – Migratory Fish Species

- Migratory species include the seasonally abundant Blueback Herring and the relatively uncommon American Eel
- The migratory species exist in the vicinity of the Projects due to the Barge Canal, which provides a passage route past Cohoes Falls and the dams present along the lower Mohawk River
- The Barge Canal also provides passage from the Great Lakes drainage into the Mohawk River, and ultimately the Hudson River
  - Allows easier dispersal of non-native fish and other aquatic species

Findings – American Eel and Fish Community Survey Locations, USGS 2015, 2016, & 2019



American Eel Surveys, 2015-2016

- 35 locations in 32 tributary streams
- No Eel collected or observed

Fish Community Survey, 2019

- Intensive, 3-pass depletion surveys
- 20 tributary streams
- 46 species documented
- No Eels collected or observed

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State of Fishery

- NYSDEC has described the Mohawk River Basin fisheries as being in a “**state of transition**”
  - Spreading of non-native species like the zebra mussel
  - Increased abundance of once rare/absent species such as Freshwater Drum and Northern Pike

In Summation

- There have been no issues identified as part of Project scoping that indicate concerns to the general fishery resulting from Project operations.
- Potential fishery issues regarding American Eel and Blueback Herring are being addressed in focused studies.
- Despite the potential influx of new species, the fishery remains productive and provides an abundance of recreational opportunities.

Thank you

Questions?

Fish Entrainment Study

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Study Goals and Objectives

Goals: Provide a literature-based assessment of the potential for fish entrainment and impingement at the Projects and to use existing databases, tools, and models to evaluate potential turbine survival rates for representative resident and migratory fish species/life stages at the Projects.

Objectives:

- Provide a description of physical characteristics of the Projects, including the intake location and dimensions, trashrack spacing, and depths and velocities near each intake structure;
- Conduct a literature review for species of interest relative to physiology, behavior, life history, and habitat preferences in the context of entrainment, impingement, and survival;
- Assess the potential for entrainment and impingement; and
- Estimate turbine passage survival rates for target gamefish species.

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Study Approach/Methods

- Entrainment Analysis: Qualitative assessment of the probability that fish would encounter the Project intakes based on several factors (e.g., movement patterns and life history of target species, swim speeds, project configuration and operations, fish passage and protection measures in place, EPRI data at other relevant projects)
- Impingement Analysis: Body size and swim speed analysis
- Survival Analysis: Entrainment survival estimates from other Projects and project-specific turbine blade strike analyses (Franke method)

Target Species and Life Stages

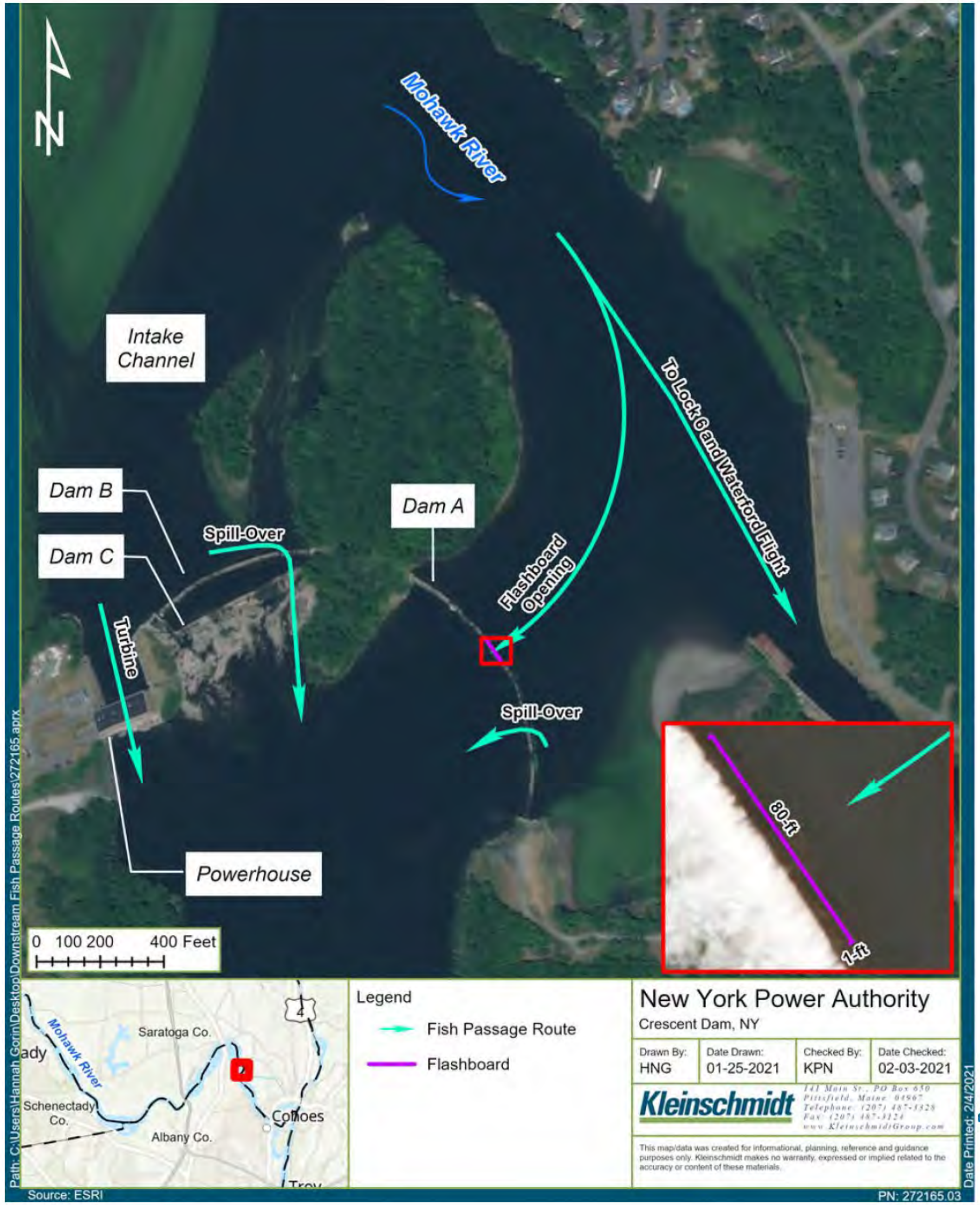
- American Eel (*Anguilla rostrata*)
- Blueback Herring (*Alosa aestivalis*) – evaluated in further detail in Blueback Herring study
- Smallmouth Bass (*Micropterus dolomieu*)
- Walleye (*Sander vitreus*)
- Yellow Perch (*Perca flavescens*)

Project Characteristics

- Trashrack spacing – wider trashracks allow for entrainment, narrower trashracks could result in impingement
- Attractiveness of habitat in intake area relative to other areas of the Project impoundments
- Intake velocities – affected by Project configuration (e.g., intake sections leading to penstocks/turbines) and area relative to amount being generated at the time when fish may encounter the intake area
- Turbine configuration – affects probability of survival for entrained fish
- Fish protection measures are in place for Blueback Herring (e.g., acoustic deterrent systems and flows provide through openings in the flashboards
- Alternative routes of passage are available over spillway and through openings in the flashboards where downstream flow is provided (which could be used by multiple species)

Project Characteristics – Location and Alternative Routes of Passage

- Mohawk River
  - >10-mile-long impoundments
  - Multiple channels at Crescent
  - Lock Systems
  - Acoustic Deterrent System (see Blueback Herring Study)



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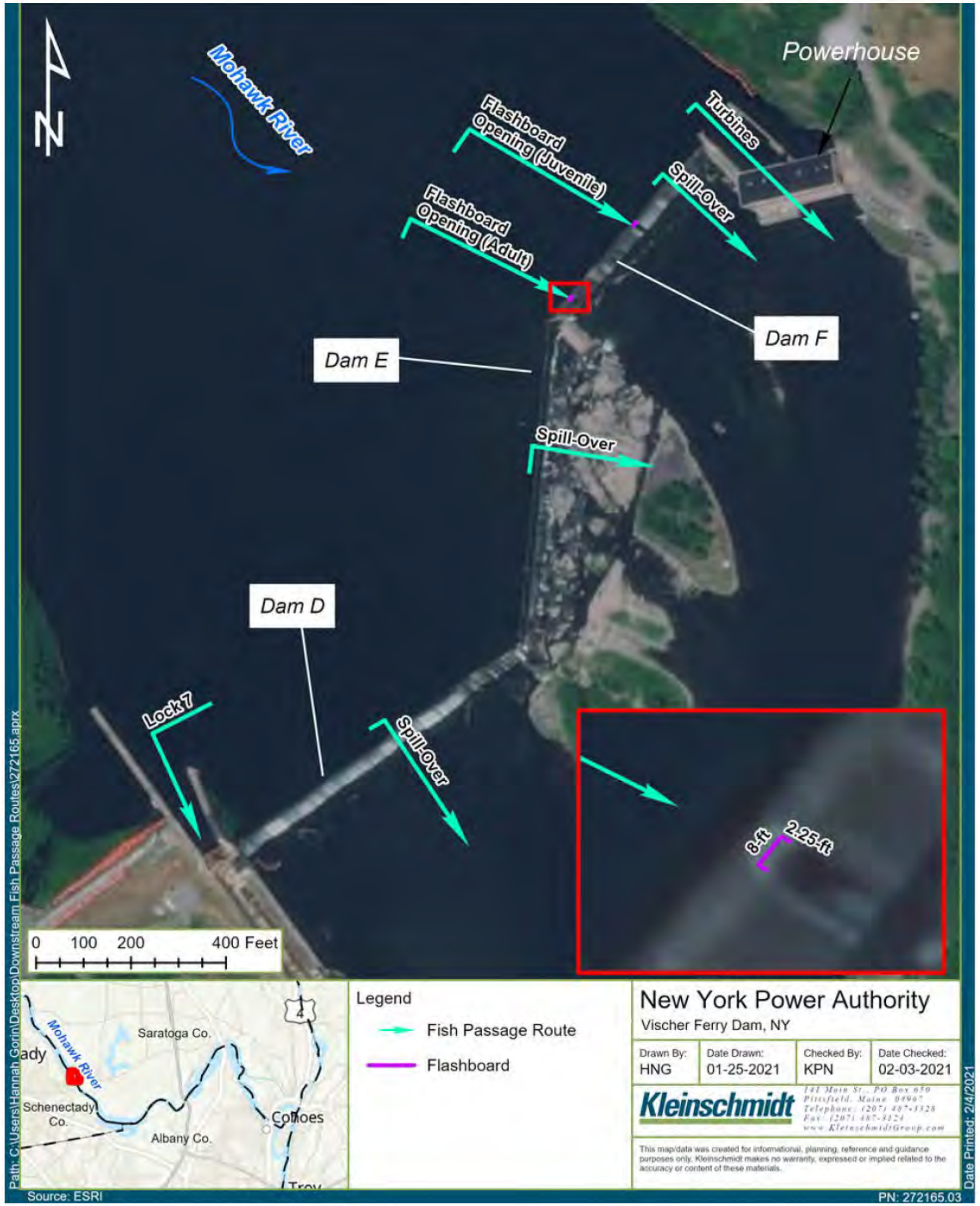

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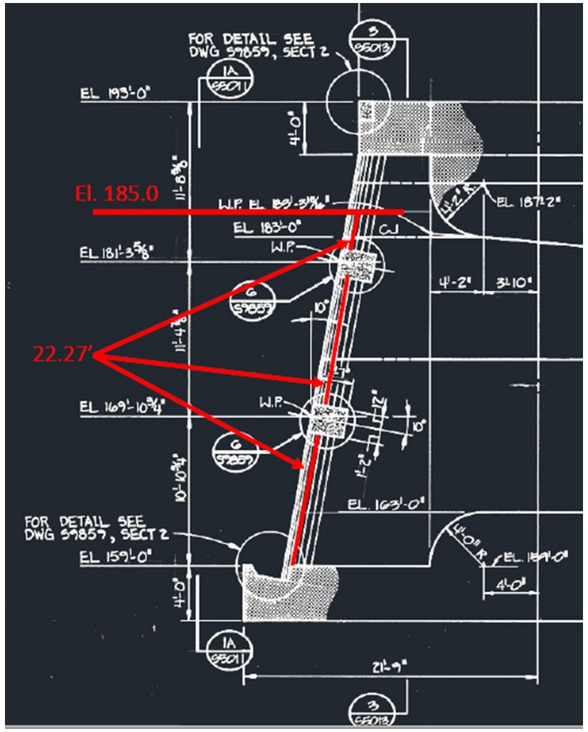
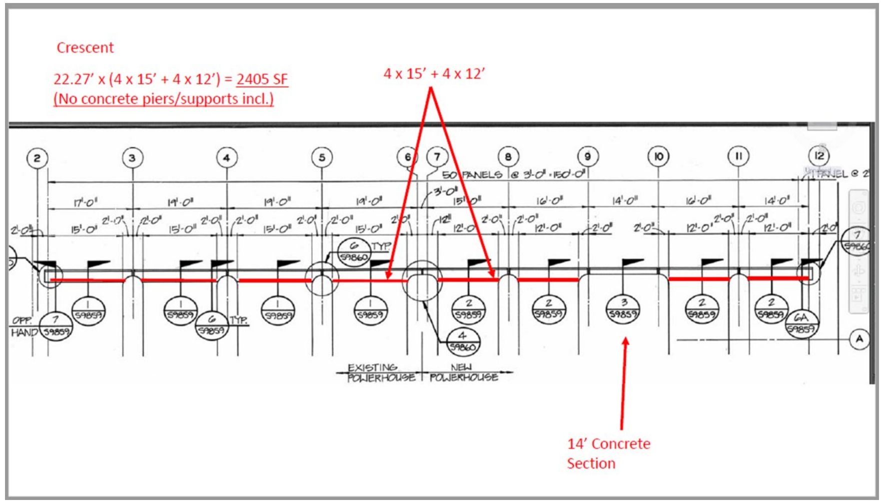
Project Characteristics – Intake Configuration





- Projects have similar (mirror image) intake configurations
- Span entire water column
- Separate Kaplan/Francis sections
- Drawings – calculation of gross trashrack area and calculated velocities

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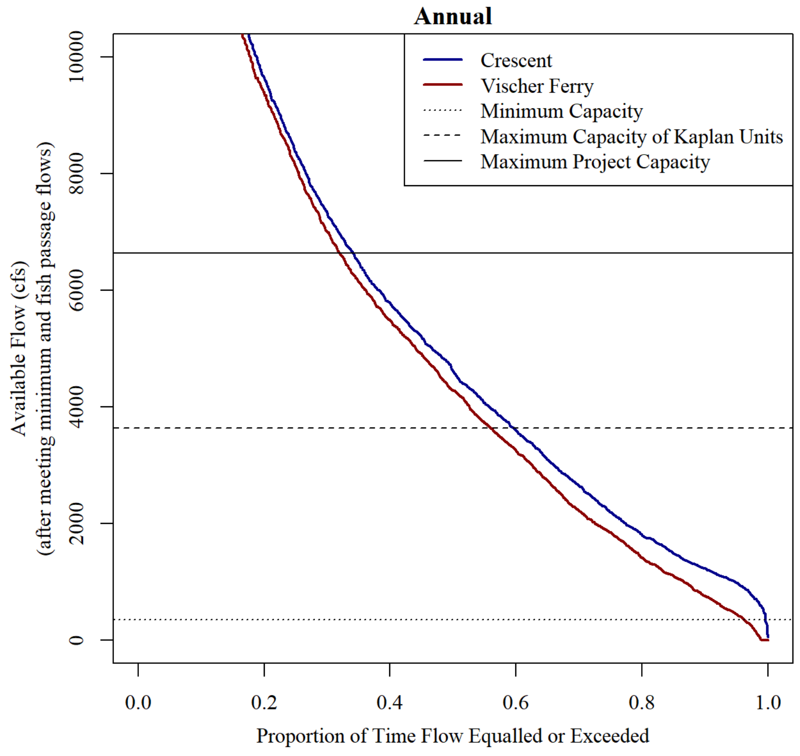
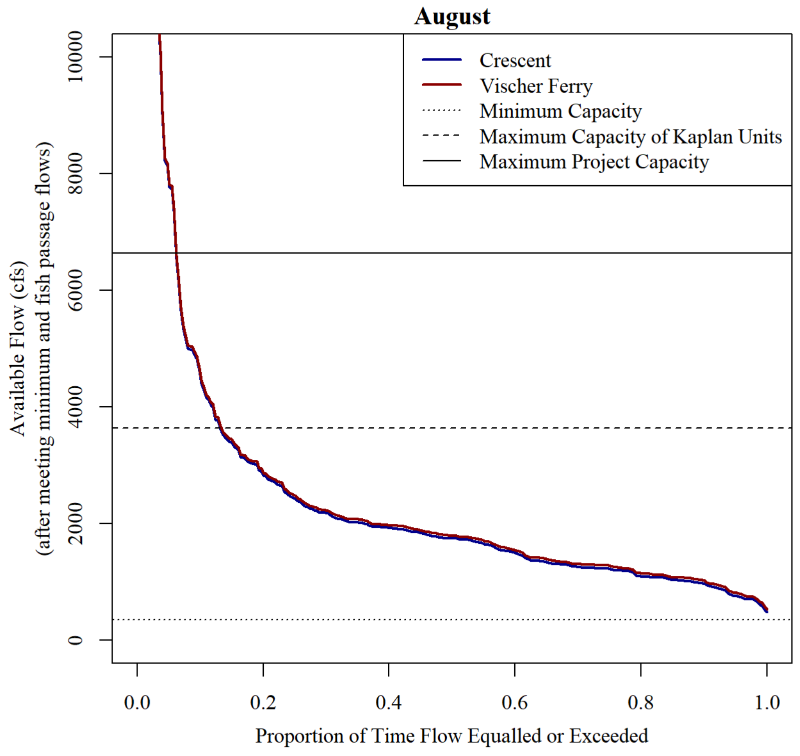
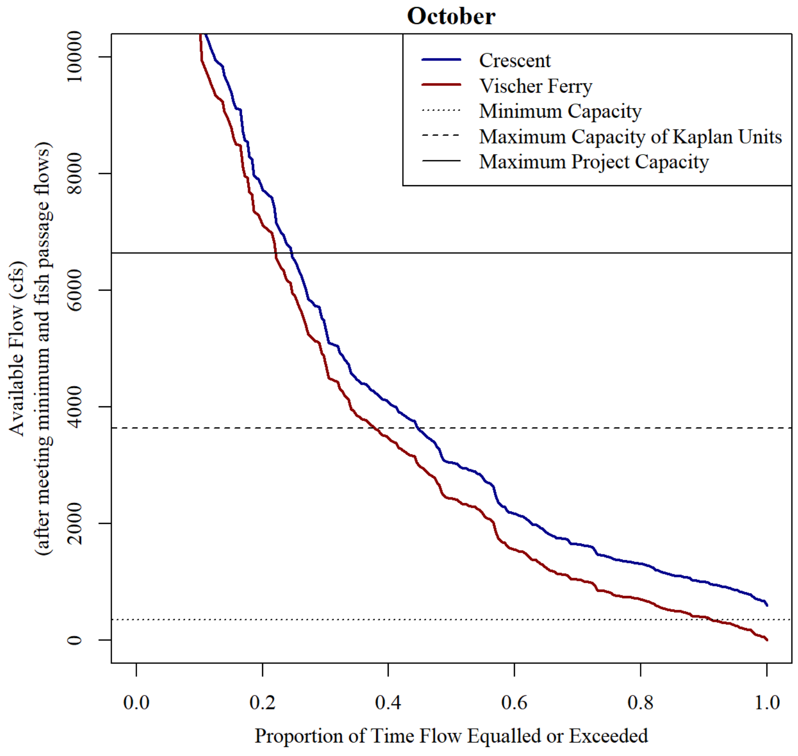
Project Characteristics – Hydrology







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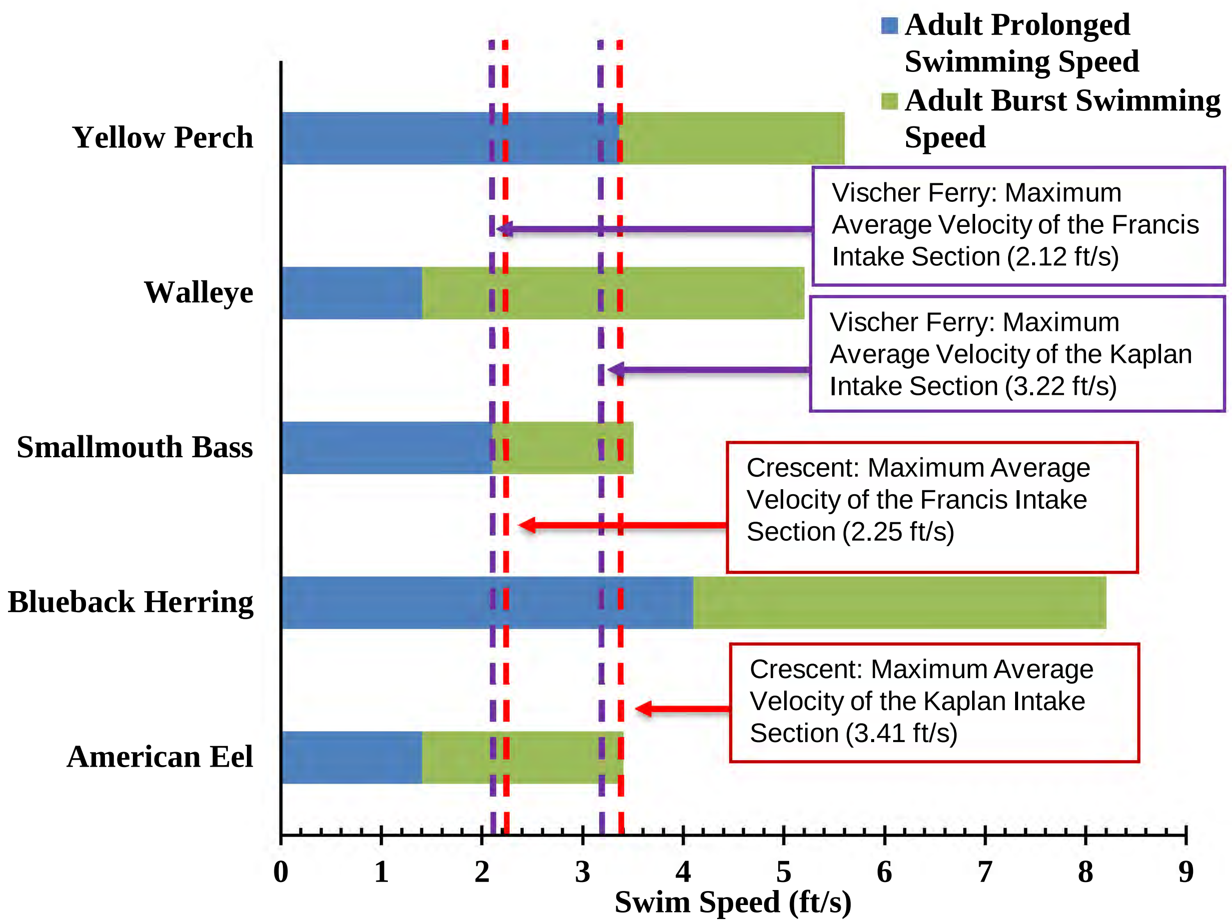
Project Characteristics – Maximum Calculated Intake Velocities



- Adult Fish
  - Swim speeds to avoid involuntary entrainment or impingement most of the time
- Juvenile Fish
  - Lower swim speeds, more likely to become entrained (too small to become impinged), though Project is not always generating at full capacity when they would encounter the intake

Note: Field measurements were collected but eddies and turbulence resulted in lower velocity readings in front of the trashracks. Therefore, the maximum calculated velocities were used to be conservative to the resource

Project Characteristics – Turbine Characteristics – Survival of Entrainment

Parameter	Crescent/Vischer Ferry Project	
	Units 1 and 2	Units 3 and 4
Turbine Type	Vertical Francis	Vertical Kaplan
Number of blades	15	5
Max turbine discharge (cfs)	1,500	1,820
Efficiency at max discharge	84.7%	90.1%
Min turbine discharge (cfs)	400	350
Runner diameter (ft)	7.18	9.02
RPM	90	144
Maximum head (ft)	27.9/26.5	27.9/27.0
Diameter of Runner at Inlet (ft)	7.18	NA
Diameter of Runner at Discharge (ft)	10.97	NA
Runner height at Inlet (ft)	4.29	NA

Length of Fish (inches)	Crescent		Vischer Ferry	
	Francis	Kaplan	Francis	Kaplan
1	97.81%	99.07%	97.78%	99.07%
2	95.62%	98.13%	95.56%	98.13%
3	93.43%	97.20%	93.34%	97.20%
4	91.24%	96.26%	91.13%	96.26%
5	89.05%	95.33%	88.91%	95.33%
6	86.86%	94.40%	86.69%	94.40%
7	84.68%	93.46%	84.47%	93.46%
8	82.49%	92.53%	82.25%	92.53%
9	80.30%	91.59%	80.03%	91.59%
10	78.11%	90.66%	77.81%	90.66%
11	75.92%	89.72%	75.60%	89.73%
12	73.73%	88.79%	73.38%	88.79%
28	38.70%	73.84%	37.88%	73.85%
29	36.51%	72.91%	35.66%	72.91%
30	34.32%	71.98%	33.44%	71.98%
31	32.13%	71.04%	31.22%	71.04%

- High survival for small fish
- Larger fish have lower probabilities of blade strike if passed through Kaplan turbine
- Patterns are consistent with EPRI survival data published by Winchell et al. (2000).
- Eels/Herring evaluated further based on available studies and literature

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Entrainment

Target Species	Population-Level Entrainment Effects
American Eel	Low - Though individual emigrating adults would be susceptible to entrainment, the population upstream of the Projects is currently believed to be low based on existing information. Therefore, few individuals would be subjected to entrainment.
Blueback Herring	Low - The acoustic array would divert substantial numbers of individuals to alternative routes of passage. Those that become entrained have been documented to exhibit high rates of survival.
Smallmouth Bass	Minimal - Non-migratory resident species with occasional entrainment of individuals on a seasonal basis. Adults and juveniles have swimming capabilities to avoid entrainment during periods when they would be most likely to encounter the intake structure.
Walleye	Minimal - Non-migratory resident species with occasional entrainment of individuals on a seasonal basis. Adults and juveniles have swimming capabilities to avoid entrainment during periods when they would be most likely to encounter the intake structure.
Yellow Perch	Minimal - Non-migratory resident species with occasional entrainment of individuals on a seasonal basis. Adults have swimming capabilities to avoid entrainment and juveniles would be likely to survive entrainment to populate downstream areas.

- Entrainment of individuals of each target species is possible, but would occur at relatively low frequencies which would limit population-level effects

Impingement

Common Name	Scaling Factor for Body Width	Minimum Length Excluded (inches)	Lengths from Literature (inches)		Size of Fish (total length, inches) excluded by existing trashracks
		3 7/8 inch Clear Spacing	Adult		
			Typical	Maximum	
American Eel	0.040	96.9	Males: 14 – 16.5[6] Females: 17 – 26[6]	59.8[5]	No fish of any size excluded
Blueback Herring	0.130	29.8	7.9 – 11.4[4]	15[1]	No fish of any size excluded
Smallmouth Bass	0.128	30.3	8 - 15[3]	20.5[2]	No fish of any size excluded
Walleye	0.125	31.0	13 – 20[3]	32[2]	Very large individuals (length = 31”+)
Yellow Perch	0.114	34.0	10 - 12[1]	15[2]	No fish of any size excluded

[1] Source: Smith 1985
[2] Source: NYSDEC 2018
[3] Source: Scott and Crossman 1973
[4] Source: LFHA 1992
[5] Source: USFWS 2020
[6] Source: Solomon and Beach 2004

- Impingement is highly unlikely to occur for the target species – most would pass through the racks and very large walleye would have swimming capabilities to escape
- No population-level effects

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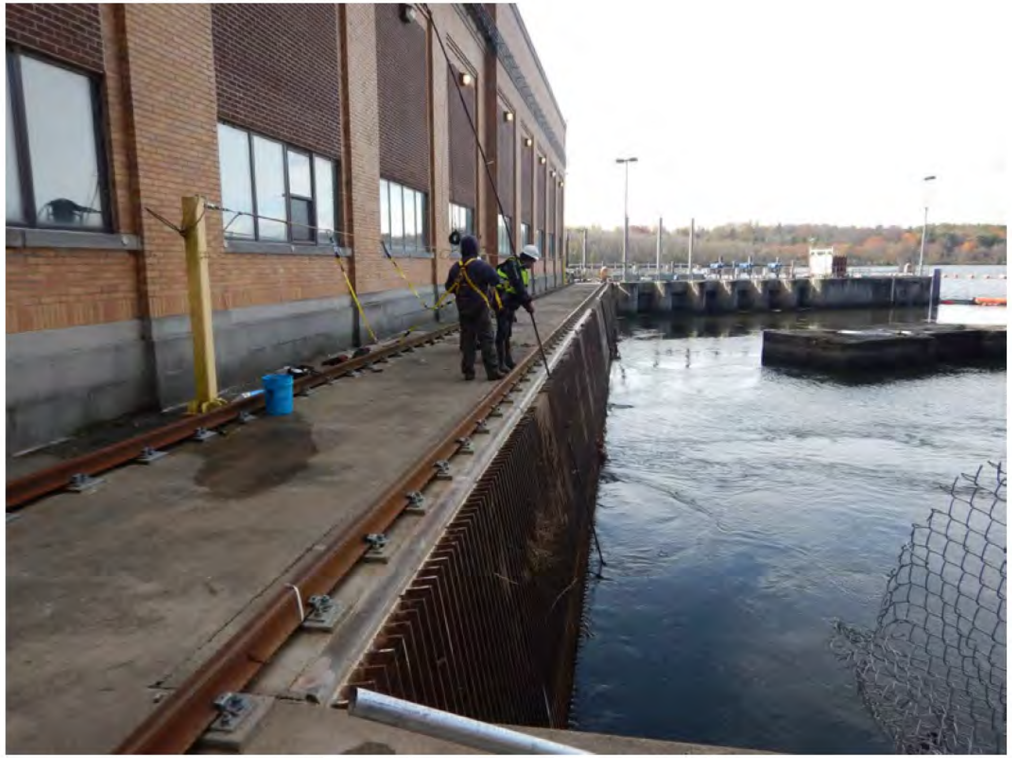
Questions?



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Blueback Herring Study




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Study Goal & Objective

To use existing and theoretical data to estimate adult and juvenile Blueback Herring (BBH) downstream passage whole station survival associated with the Crescent and Vischer Ferry Projects.

Background- Project Characteristics

- Both Projects
  - Operate on a run-of-river basis
  - Head pond fluctuations up to six inches
  - Four Turbines
    - 2 Francis Units
    - 2 Kaplan Units
  - Flashboards during the navigation season
    - Crescent; 12 inches
    - Vischer Ferry; 27 inches

Background – Project Characteristics

- Turbine Operations – after meeting minimum flow & Barge Canal requirements
  - Kaplan Units are the priority for operations – 1,820 cfs capacity each
  - Francis Units – 1,500 cfs each
    - Generation flows
    - 350 – 3,640 cfs; Kaplan Units only
    - >3,640 – 5,140 cfs, a Francis Unit begins operation at 1,500 cfs
    - 5,140 – 6,640 cfs, a 2nd Francis Unit operates at 1,500 cfs
    - >6,640 cfs initiates spill

Background – Downstream Fish Passage

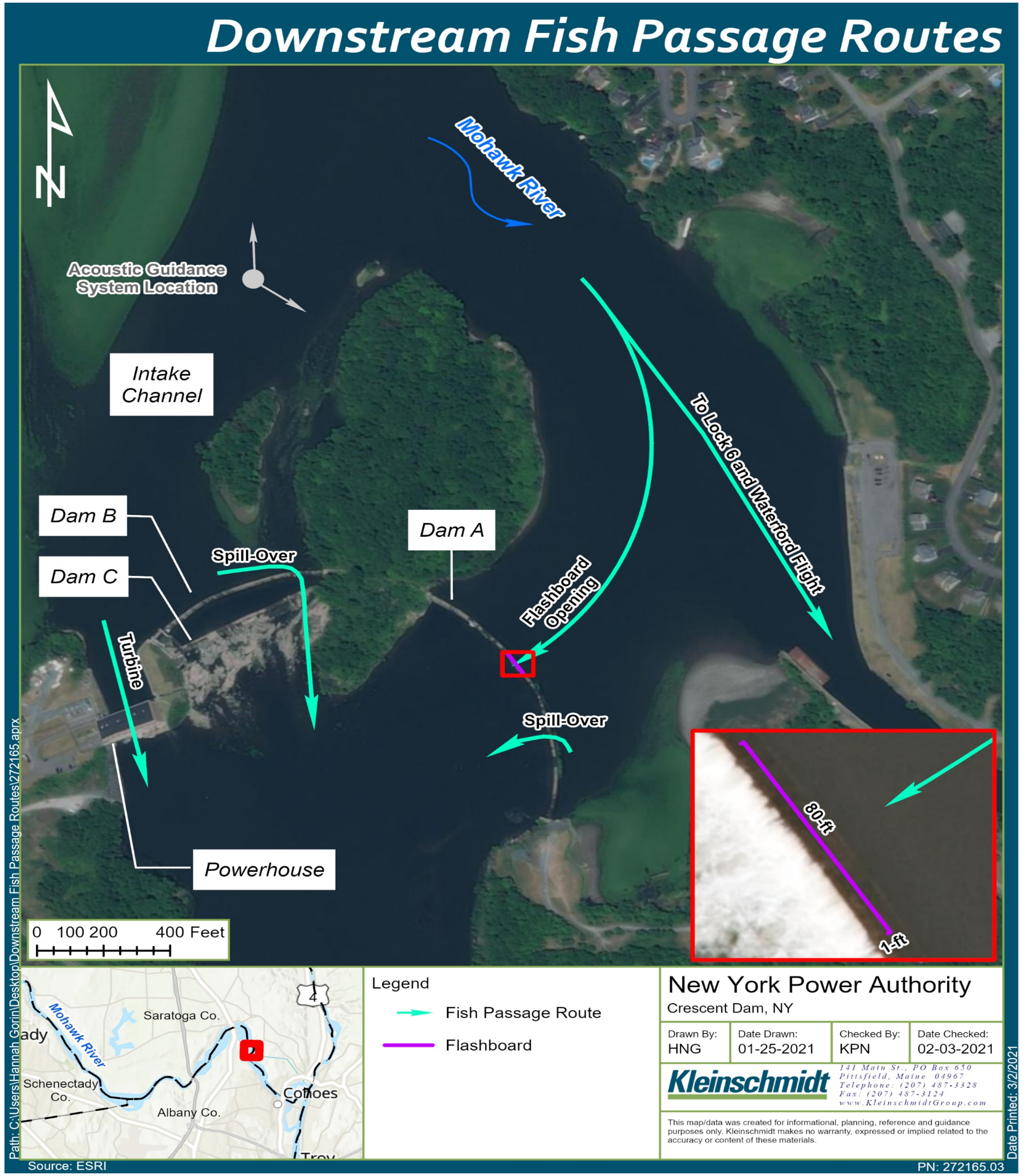
- At both projects, fish have multiple downstream passage options, all of which are likely used to some degree
- Options for passage:
  - turbine passage, spillway passage, bypasses, or Barge Canal
- Passage is enhanced through the operation of acoustic guidance systems which divert fish away from the turbine intakes

Background – Downstream Fish Passage

- Minimum flows
  - Crescent: 250 cfs during Barge Canal navigation season
  - Vischer Ferry: 200 cfs

- Downstream Fish Bypasses
  - Crescent – 80 ft wide x 12 inches deep
  - Vischer Ferry – 8 ft wide x 27 inches deep

Background – Downstream Fish Passage: Crescent



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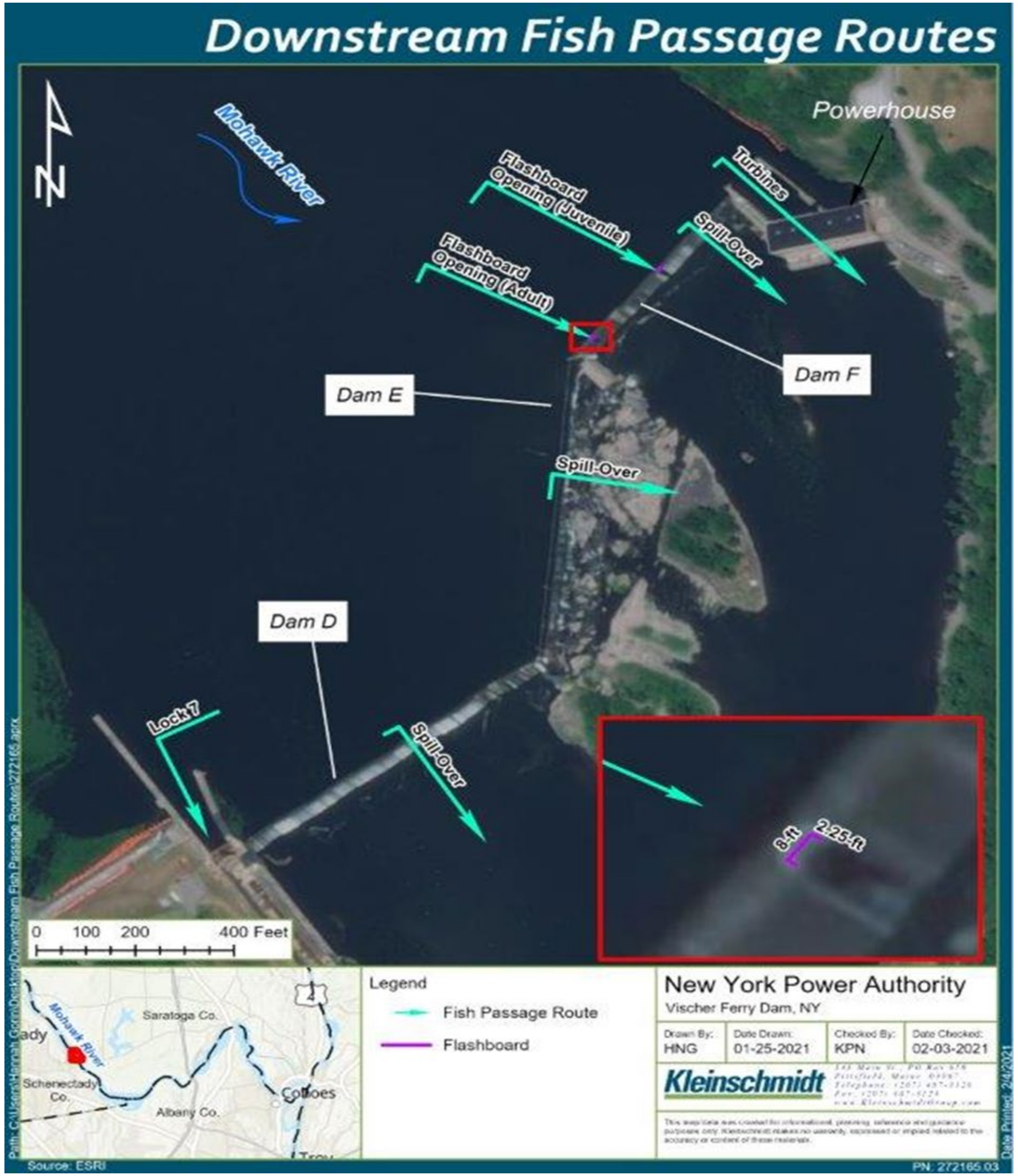
Background – Downstream Fish Passage: Vischer Ferry



Background – Downstream Fish Passage

- Crescent Project:
  - Downstream passage enhanced by the use of an acoustic guidance system
  - Guides fish away from turbine intake and toward bypass – 76% effective
  - Likely increases the number of fish migrating downstream through the Barge Canal as well

- Vischer Ferry Project:
  - Passage enhanced by acoustic guidance system (bypasses) – 96% effective
  - One opening for adults, one for juveniles
  - Primary river channel and fish movement pattern exposes fish to the bypasses before the Project forebay

Methods – Review of Previous Studies

- Existing studies on downstream passage were reviewed and considered for application to the Projects

- Resources included:
  - EPRI (1997)- a database of turbine passage survival studies for multiple fish species at more than 50 hydropower projects throughout the country
  - Studies conducted after the creation of the EPRI database
  - Studies conducted at the Projects themselves (both turbine and bypass)

Methods – Predictive Models

- Models consider fish size, turbine specifications, and station hydraulics to estimate the blade strike potential
- Model used was the “USFWS Turbine Blade Strike Analysis”
- Model predictions were made for 2 size groups: juvenile and adult BBH
- Flow scenarios evaluated: average, 10% & 90% exceedance flows
- Models were also run with and without the acoustic guidance system operating

Methods – Predictive Models

Bypass Survival

- Empirical tests of juvenile BBH at Crescent: 88.3% survival
  - Enhancements made to the bypass such as plunge pool depth likely increased survival
- Bypass mortality is expected to be about 1% for each 10 ft of drop
- Lab testing showed bypass survival for juvenile BBH ranged from 86.0 to 97.5%
  - Except high flow and shallow plunge pool tests, survival ranged from 92.5 to 97.5%
  - Based on these data, all models were run with the low (88.3%) and high (97.0%) bypass survival estimates to bracket potential outcomes

Results of Previous Research (Survival Rates)

- Francis turbine studies conducted elsewhere - turbine passage survival rates from 77.1% to 95.3 %
- Kaplan turbine studies conducted elsewhere - turbine passage survival from 89.1% to 100%
- Empirical tests of juvenile BBH at the Crescent Kaplan Units: 96% survival

Results of Study

Summary of Downstream Passage Survival Estimates by Route of Passage

Range of Downstream Passage Survival Rates (%)				
		Passage Route		
Project	Lifestage	Units 1 & 2 (Francis Units)	Units 3 & 4 (Kaplan Units)	Bypass/Spill
Vischer Ferry	Juvenile	91.2* – 94.2	96.1 – 98.5	88.3 - 97.0
	Adult	77.1* – 85.4	88.3 – 93.9	
Crescent	Juvenile	93.1* – 94.5	95.8 – 97.4	88.3 - 97.0
	Adult	78.3* – 82.7	89.0 – 94.2	

* Represents a worst-case scenario of unit operation at minimum flow. Francis units only operate at maximum discharge.

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Results of Study

- Adult BBH are nearly 3 times as long as Juvenile BBH, thus are expected to experience lower turbine passage survival rates
- Estimates of total station downstream passage survival for adult and juvenile BBH for most months and under most river flow conditions range between 85-98%
- Data supports the conclusion that the acoustic guidance systems at both Projects are effective at directing downstream migrating BBH away from the turbine intakes as intended
- For both lifestages, total station survival estimates are largely driven by bypass/spillway survival rates

Thank you

Questions?

Aquatic Mesohabitat Study




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Study Goals and Objectives

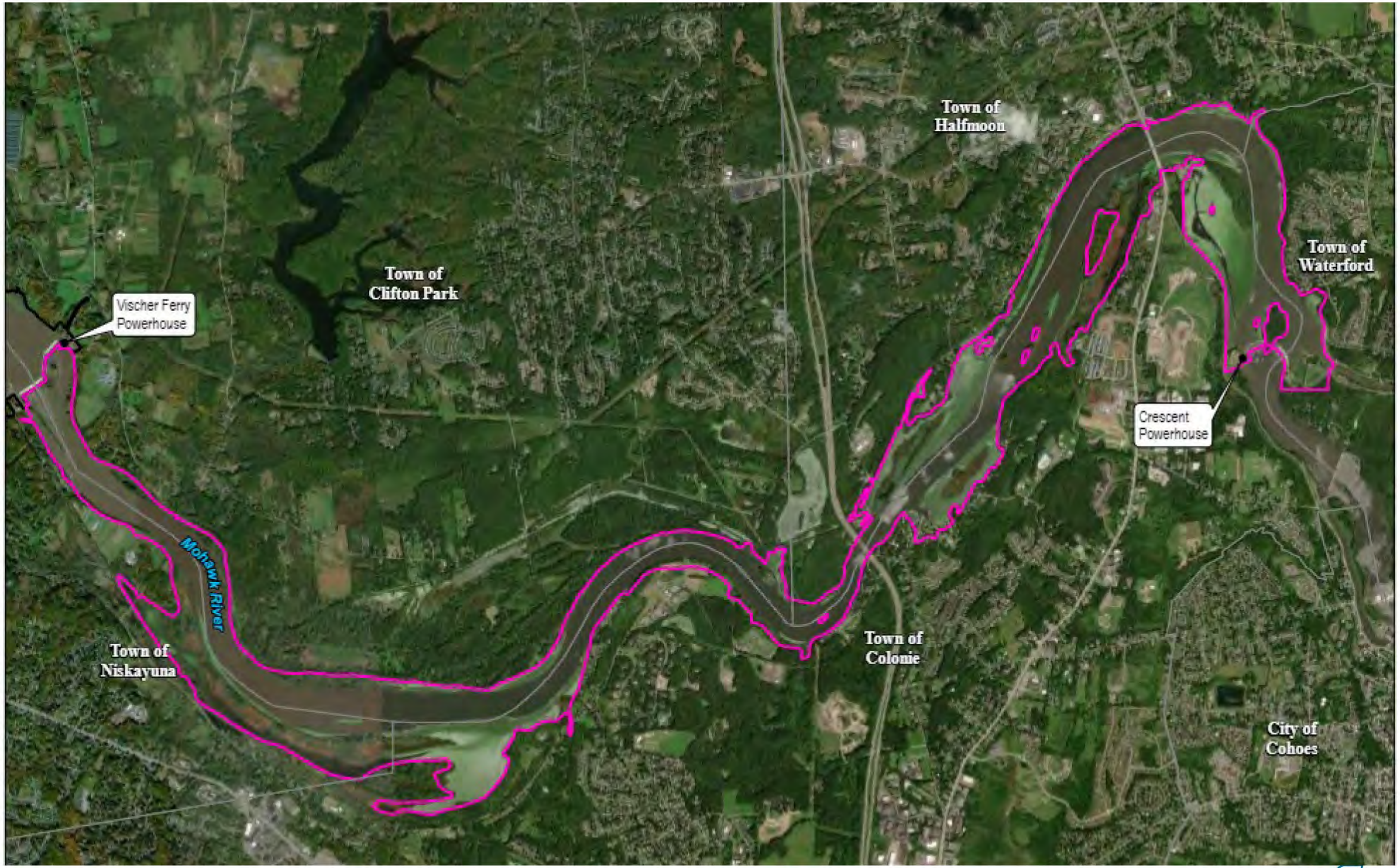
- Identify and map aquatic habitats at the Projects including:
  - wetlands, riparian, and littoral vegetation communities,
  - submerged aquatic vegetation,
  - and open water habitats.
- Identify and map areas of significant shoreline erosion.

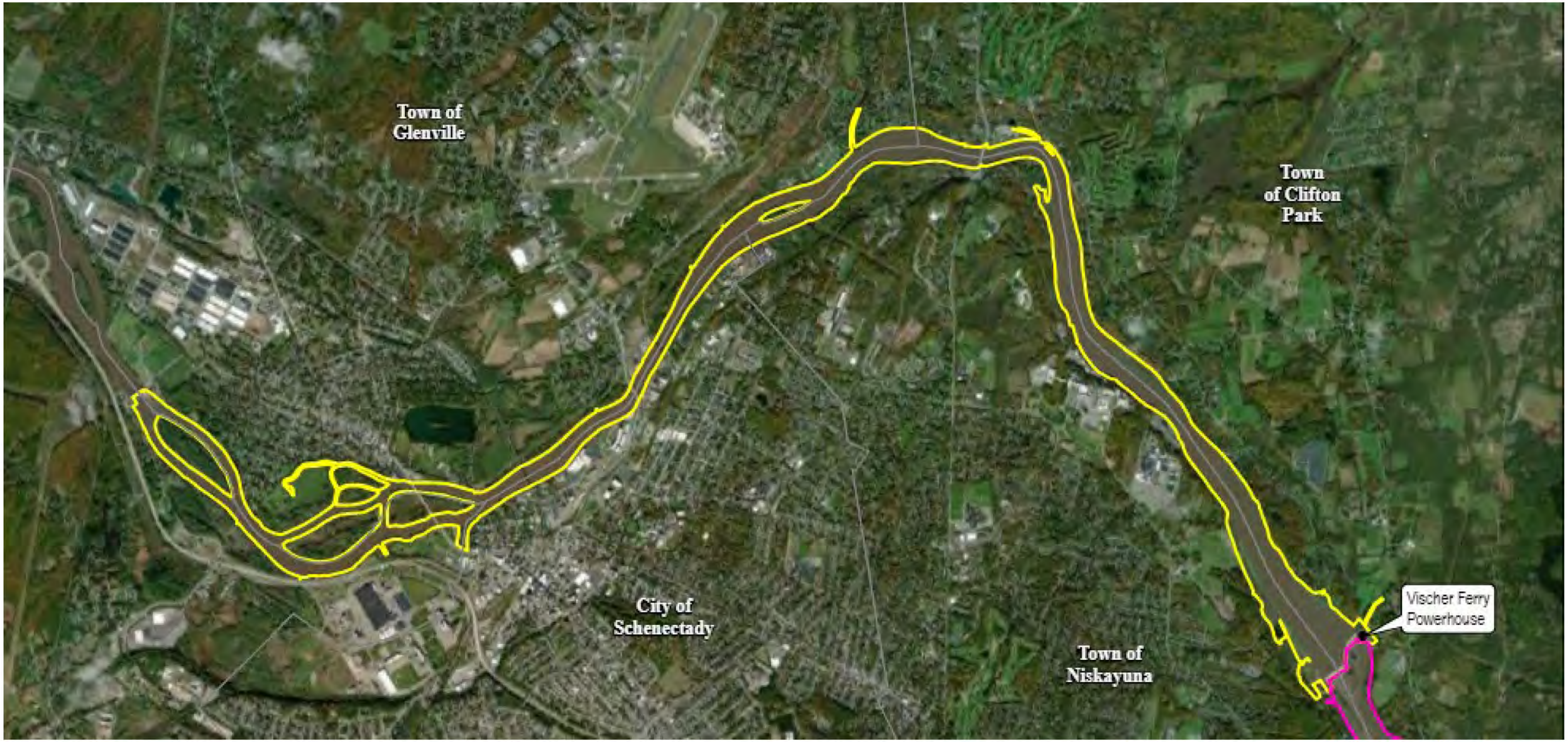
- Evaluates the potential effects, if any, of the Projects' operations on these habitats.
- Considers the differences in water level when the flashboards are both in place and removed.

Overview of Projects

- Run-of-River operations (allowable fluctuation of 6 inches or less)
- Flashboards during navigation season
  - 12” at Crescent
  - 27” at Vischer Ferry
- 10+ mile-long riverine impoundments

- Study area included Project impoundments and adjacent 50-foot area


Town of Halfmoon
Town of Clifton Park
Vischer Ferry Powerhouse
Town of Waterford
Crescent Powerhouse
Mohawk River
Town of Niskayuna
Town of Colonie
City of Cohoes


Town of Glenville
Town of Clifton Park
City of Schenectady
Town of Niskayuna
Vischer Ferry Powerhouse

Study Methods – Desktop

- Base map creation
- Update potential RTE species
- Existing invasive species occurrences
- Preliminary habitat mapping
- Data dictionary for field collection

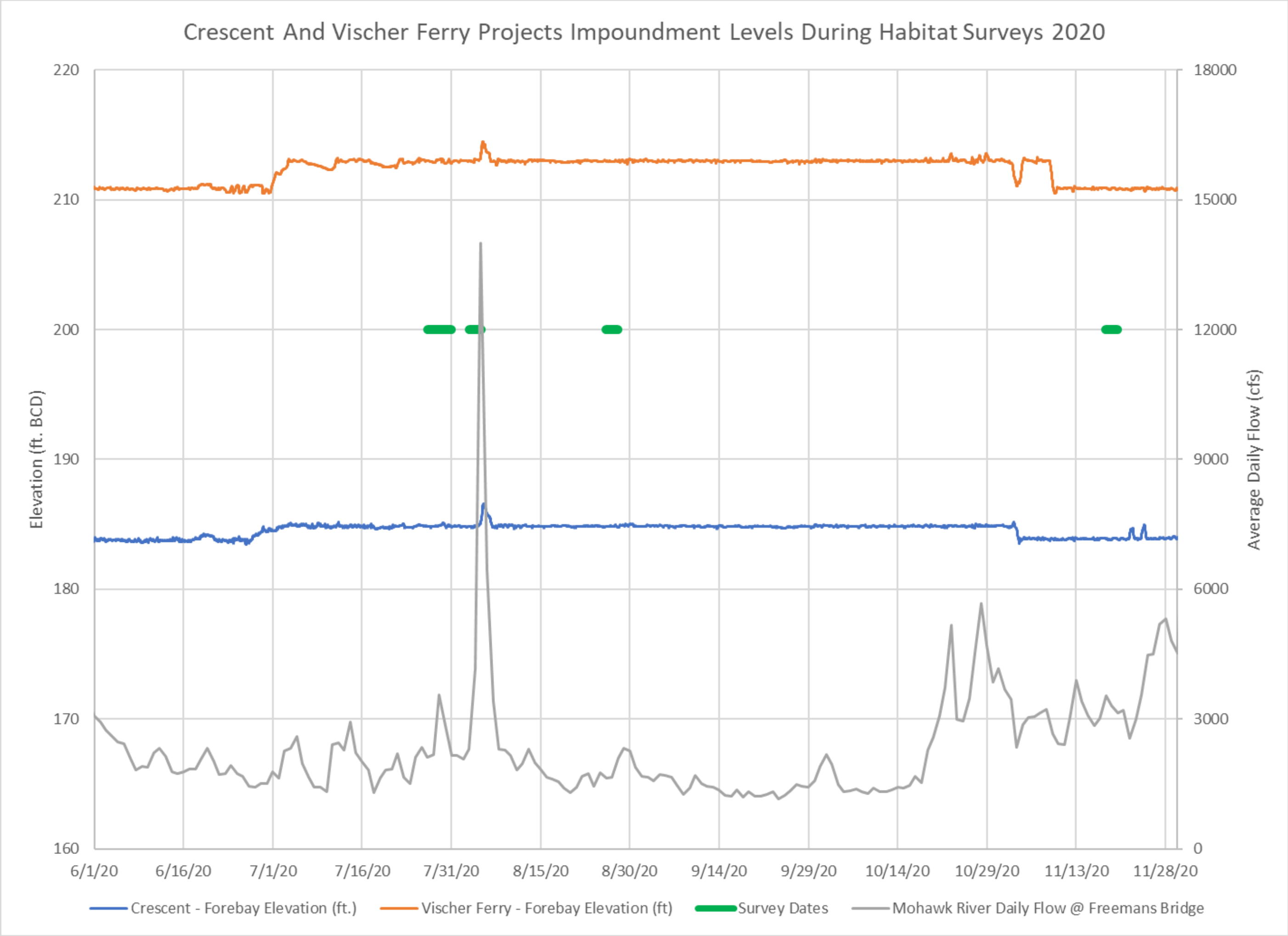
Study Methods – Field

- Summer survey (“Boards Up”): July and August 2020
- Fall survey (“Boards Down”): November 2020

- Riparian land cover and wetland types
- Shoreline erosion observations
- Aquatic habitat mapping
  - Substrate types
  - Vegetation beds
- Observations of mussels and fish spawning
- Wildlife observations

Study Conditions

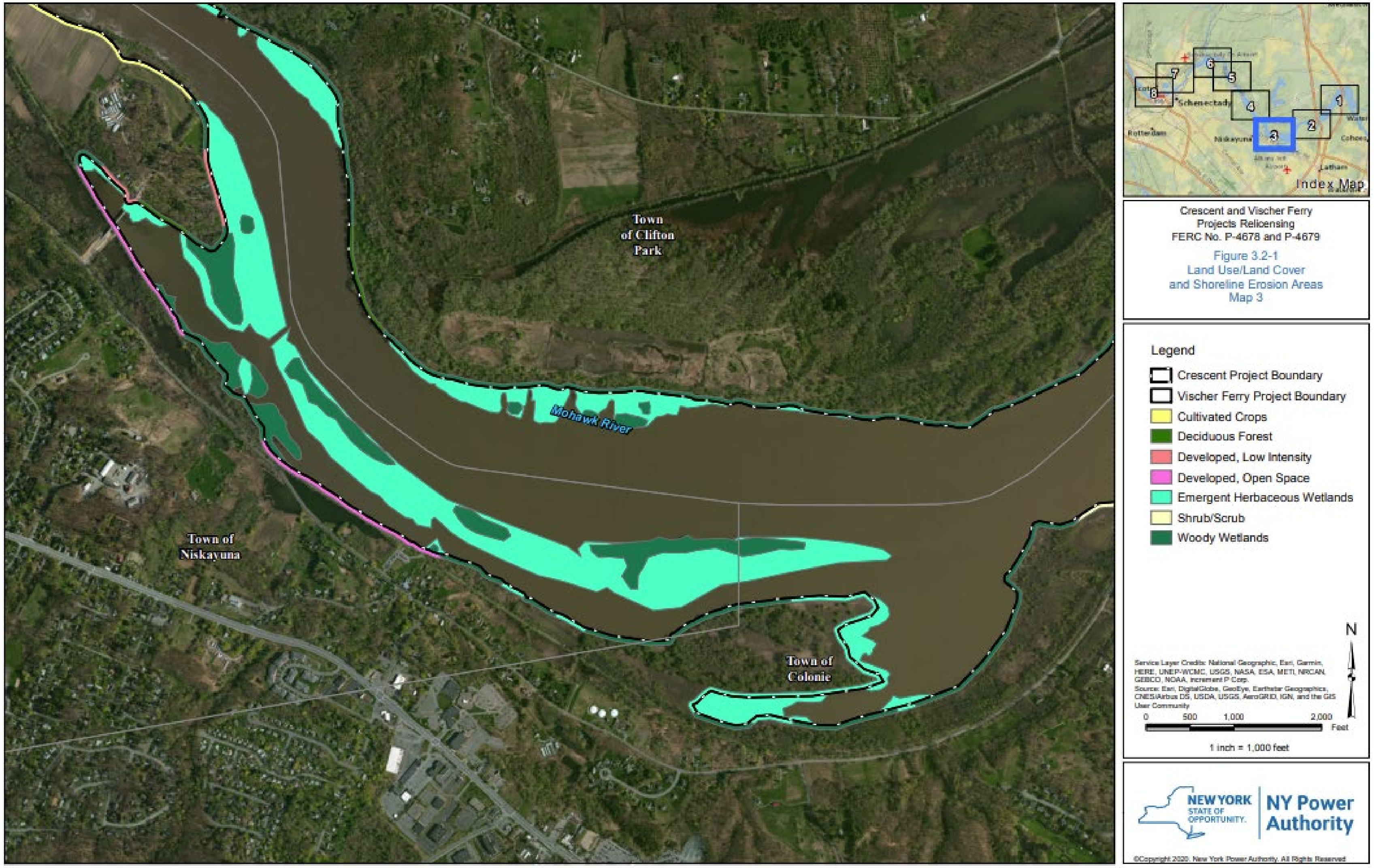
- Average impoundment elevations during the summer surveys were 184.9' at Crescent and 213.0' at Vischer Ferry.
- The average impoundment elevations during the fall surveys were 183.9' at Crescent and 210.8' at Vischer Ferry



Study Results – Riparian Lands

- Crescent
  - Forested 30%
  - Developed, mostly residential and open space (48%)
  - Wetlands 23%
  - Low gradient slope on shoreline
  - No Bank Erosion
  - Adjacent wetlands prevalent
- Vischer Ferry
  - Forested 44%
  - Developed 34%
  - Wetlands 18%
  - Areas of steeper-sloped shorelines and high banks
  - Very little erosion observed in upper end of impoundment

Study Results – Riparian Lands



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Study Results – Wetlands

- Emergent
  - Persistent – most landward (cattail, woolgrass, and sedges and other herbaceous species)
  - Non-Persistent – downslope (arrowhead, smartweed and bur-reed)
  - Phragmites – limited areas of monocultures
- Woody Wetlands
  - PFO1 – Forested Deciduous (cottonwood, silver maple, willow, sycamore)
  - PSS – Scrub/Shrub (willow, dogwood, European alder)
- Aquatic Beds

Study Results – Aquatic Habitat

- Floating aquatic vegetation
  - Water chestnut
  - Monocultures with other species on edges of beds
  - Mostly in silty areas, but can grow over other substrates
- Submerged aquatic vegetation
  - Several native species
- Water depths in the navigation channel are typically at least 10 to 15 feet. Some deeper areas up to 30 feet in the main channel were observed during the field surveys. These deeper areas are generally devoid of vegetation.

Study Results – Wetlands and Aquatic Bed Coverage

Table 3.3-1: Summary of Wetland Area and Coverage within the Crescent Project Boundary

Cover Type	Wetland Classification (NWI)	Area (Acres)	Percent Overall Cover
Emergent Wetland	Palustrine Emergent Persistent (PEM1)	247	12%
	Palustrine Emergent Nonpersistent (PEM2)	3	0.2%
	Palustrine Emergent *Phragmites* (PEM5)	24	1%
	Subtotal	274	13%
Woody Wetland	Palustrine Forested Broad-Leaved Deciduous (PFO1)	53	3%
	Palustrine Scrub-Shrub Broad-Leaved Deciduous (PSS1)	26	1%
	Subtotal	79	4%
Aquatic Bed	Floating	577	27%
	Submerged	36	2%
	Subtotal	613	29%
Total Coverage of all Wetlands		**966**	**46%**
Total Area of Crescent Impoundment (measured in GIS)		**2108**	**-**

Table 3.3-2: Summary of Wetland Area and Coverage within the Vischer Ferry Project Boundary

Cover Type	Wetland Classification (NWI)	Area (Acres)	Percent Overall Cover
Emergent Wetland	Palustrine Emergent Persistent (PEM1)	18.0	1.6%
	Palustrine Emergent Nonpersistent (PEM2)	2.4	0.2%
	Palustrine Emergent *Phragmites* (PEM5)	0.2	0.01%
	Subtotal	20.6	1.8%
Woody Wetland	Palustrine Forested Broad-Leaved Deciduous (PFO1)	6.0	0.5%
	Palustrine Scrub-Shrub Broad-Leaved Deciduous (PSS1)	1.0	0.1%
	Subtotal	7.0	0.6%
Aquatic Bed	Floating	187	16%
	Submerged	74	7%
	Subtotal	261	23%
Total Coverage of all Wetlands		**289**	**25%**
Total Area of Vischer Ferry Impoundment (measured in GIS)		**1137**	**-**

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Study Results – Aquatic Vegetation Species

Table 3.4-1: Summary of Aquatic Vegetation Species Observed in both Crescent and Vischer Ferry Project Boundaries

Common name	Scientific Name	Invasive /PRISM Tier	Notes
Clasping-leaved pondweed	*Potamogeton perfoliatus*	No	Common in both impoundments
Floating pondweed	*Potamogeton natans*	No	Common in both impoundments
Sago pondweed	*Stuckenia pectinata*	No	Common in both impoundments
Water stargrass	*Heteranthera dubia*	No	Very common in both impoundments
Coontail	*Ceratophyllum demersum*	No	Only observed in Crescent impoundment (common)
Tapegrass	*Vallisneria americana*	No	Very common in both impoundments
Bladder wort	*Ultricularia spp.*	No	Very sparse; only observed in Crescent impoundment
Common waterweed	*Elodea canadensis*	No	Very sparse in both impoundments
European water chestnut	*Trapa natans*	Yes/Tier 4	Abundant monocultures in both impoundments
Eurasian milfoil	*Myriophyllum spicatum*	Yes/Tier 4	Common in both impoundments
Curly-leaved pondweed	*Potamogeton crispus*	Yes/Tier 4	Sparse in both impoundments
Brittle naiad	*Najas minor*	Yes/Tier 3	Common in both impoundments

Study Results – Substrate

Table 3.6-1: Summary of The Crescent Project Shoreline Substrate Type Percent Cover and Total Length in Feet

Substrate	Length (ft)	Length (miles)	Percentage
Boulder	7,827	1.5	5%
Clay	0	0.0	0%
Cobble	37,431	7.1	22%
Gravel	21,255	4.0	12%
Ledge	14,354	2.7	8%
Sand	96	<0.01	<0.01%
Silt	89,222	16.9	52%
Total	170,186	32.2	100%

Percent Cover in respect to the total Project Boundary Perimeter

Table 3.6-2: Summary of The Vischer Ferry Project Shoreline Substrate Type Percent Cover and Total Length in Feet

Substrate	Length (ft)	Length (miles)	Percentage
Boulder	36,522	6.9	23%
Clay	2,250	0.4	1%
Cobble	26,178	5.0	16%
Gravel	22,973	4.4	14%
Ledge	2,885	0.5	2%
Sand	0	0.0	0%
Silt	71,167	13.5	44%
Total	161,975	30.7	100%

Percent Cover in respect to the total Project Boundary Perimeter

Study Results – Mussels

- Three species found in fall survey
- 2 live mussels found
- Relic shells more abundant at Crescent
- No evidence of fish nests found

Table 3.6-3: Native Freshwater Mussel Species Observed within the Crescent and Vischer Ferry Project Boundary.

Common name	Scientific name	State Conservation Status Rank
Eastern Lampmussel	*Lampsilis radiata*	S4S5
Fragile Papershell	*Leptodea fragilis*	S3
Giant Floater	*Pyganodon grandis*	S4

State Conservation Status Rank:

S3 = Vulnerable in NYS.

S4 = Apparently Secure in NYS.

S5 = Secure in NYS.

Study Results – Wildlife

- Bald Eagle
  - Adults and juveniles observed

- Wading birds
  - Heron and egret species very common in shallow areas and floating aquatic beds

- Other observations
  - Wetlands and riparian areas used by variety of species

Littoral Zone With Boards Down

- 12 inch difference at Crescent
- ~27 inch difference at Vischer Ferry
- PEM Persistent wetlands intact, adapted to seasonal inundation
- PEM Non-persistent and aquatic beds in boards down zone senesce by early fall
- Width of zone depends on slope
- Littoral substrates exposed but very little erosion

Questions?

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Lunch – 30 minute break

Bald Eagle Study UPDATE

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Study Goals and Objectives

- Study Purpose and Goals
  - Identify and map areas of existing and potential bald eagle nesting, roosting, and foraging habitats at the Projects
  - Monitor and record bald eagle activities in those areas

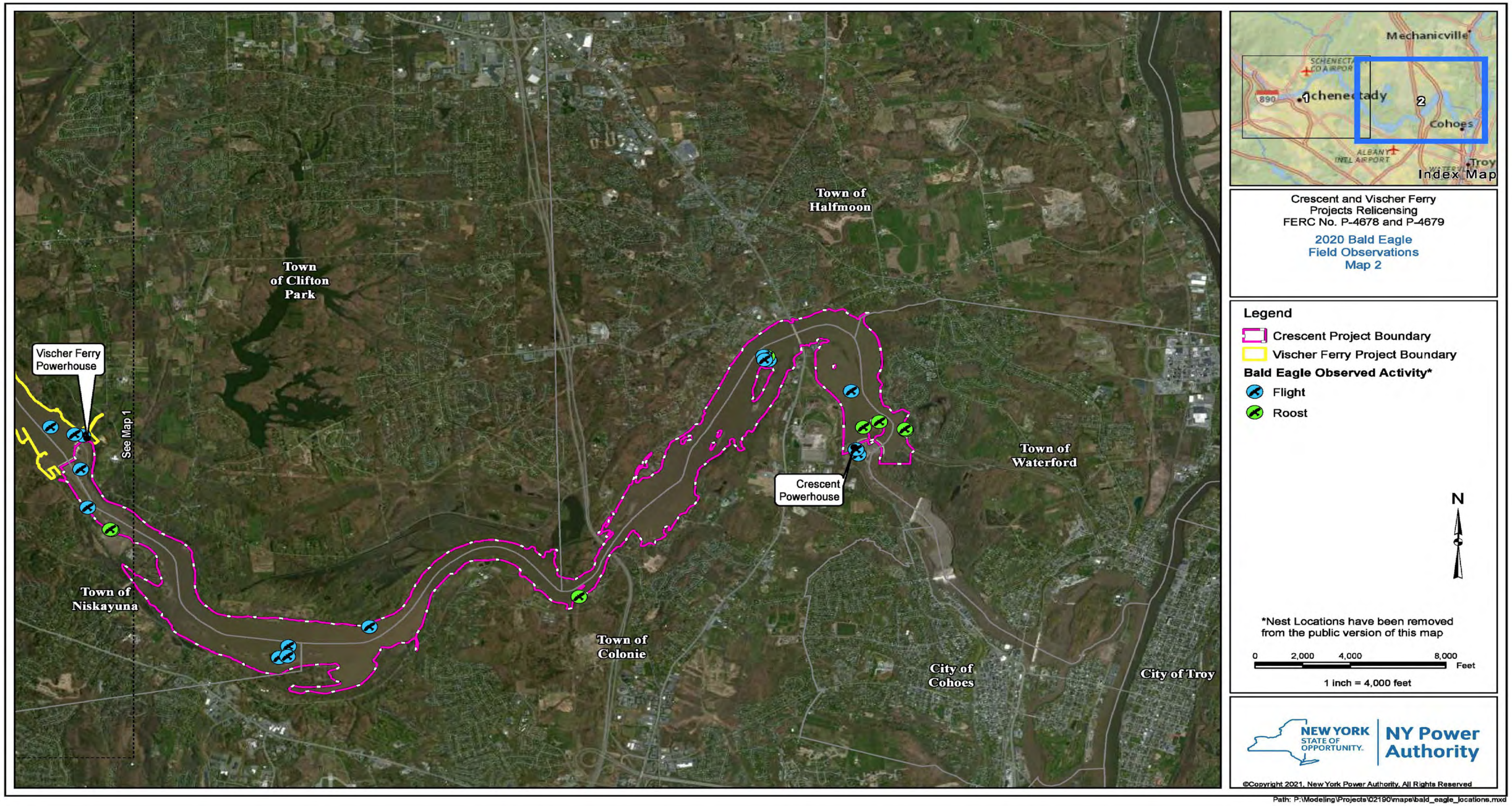
Bald Eagle Study Update

- Bald Eagle Study start delayed due to Covid-19 pandemic
  - General observations of eagle use of Project areas made as part of Aquatic Mesohabitat Study and during water quality monitoring visits in 2020
  - Bald Eagle nesting survey will be conducted in April 2021

- Study update provided in ISR

- Final Bald Eagle Study report will be included in the USR (February 2022)

Crescent Project Eagle Observations



Vischer Ferry Project Eagle Observations

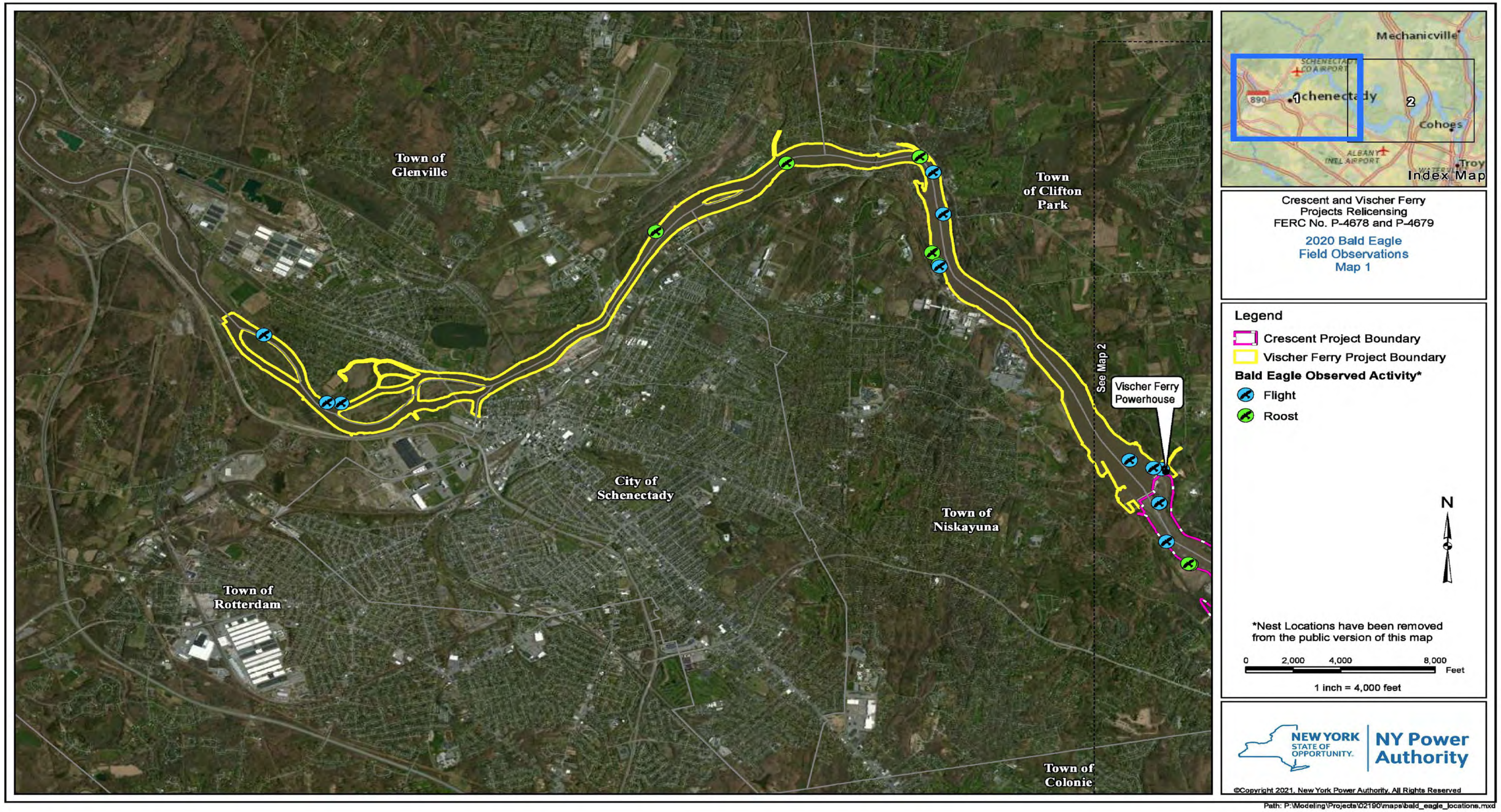


Table 2.6-1 Bald Eagle Observations at the Crescent and Vischer Ferry Projects, 2020

Date Observed	Bird Observed	Activity Observed	Notes	Project	Lat.	Long.
8/1/2020	Adult	Roost		Vischer Ferry	42.84094	-73.9227
8/1/2020	Adult	Flight		Vischer Ferry	42.81766	-73.9725
8/1/2020	Juvenile	Flight		Vischer Ferry	42.81773	-73.9747
8/1/2020	Juvenile	Roost		Vischer Ferry	42.83785	-73.8792
8/1/2020	Adult	Roost		Vischer Ferry	42.83626	-73.8782
8/1/2020	Adult	Flight		Vischer Ferry	42.83597	-73.8781
8/4/2020	Adult	Roost	2	Vischer Ferry	42.85029	-73.902
8/21/2020	Adult	Flight		Crescent	42.77851	-73.8116
8/21/2020	Adult	Roost		Crescent	42.79479	-73.839
8/21/2020	Adult	Roost		Crescent	42.79487	-73.8392
8/21/2020	Adult	Flight		Crescent	42.77696	-73.8131
8/21/2020	Juvenile	Flight		Crescent	42.77714	-73.8117
8/21/2020	Juvenile	Flight		Vischer Ferry	42.8431	-73.8774
8/21/2020	Adult	Flight		Crescent	42.81769	-73.736
8/21/2020	Adult	Roost		Crescent	42.80903	-73.7188
8/26/2020	Juvenile	Flight		Vischer Ferry	42.80913	-73.8484
8/26/2020	Juvenile	Flight		Crescent	42.804517	-73.7221
8/27/2020	Juvenile	Roost		Crescent	42.80786	-73.7147
8/27/2020	Adult	Roost		Crescent	42.808	-73.7148
8/27/2020	Adult	Roost		Crescent	42.81823	-73.7362
8/27/2020	Juvenile	Flight		Crescent	42.81828	-73.7368
8/27/2020	Adult	Flight		Crescent	42.81774	-73.7366
8/27/2020	Adult	Roost		Crescent	42.78509	-73.766
8/27/2020	Adult	Flight		Crescent	42.80324	-73.8437
9/3/2020	Adult	Flight		Crescent	42.805233	-73.7224
9/3/2020	Adult	Flight		Vischer Ferry	42.807932	-73.8433
9/10/2020	Juvenile	Flight	2	Vischer Ferry	42.80808	-73.8446
10/2/2020	Adult	Flight		Crescent	42.813324	-73.7231
10/7/2020	Undetermined	Roost		Crescent	42.80827	-73.7213
11/19/2020	Adult	Flight		Crescent	42.78114	-73.7988
11/19/2020		Nest	fall	Crescent	*	*
11/19/2020	Adult	Flight	fall	Crescent	42.79792	-73.8427
11/20/2020	Adult	Flight	fall	Vischer Ferry	42.84886	-73.8789
11/20/2020	Adult	Roost	fall	Vischer Ferry	42.851	-73.881
11/20/2020	Adult	Flight	fall	Vischer Ferry	42.82711	-73.9846

Thank you

Questions?

Recreation Study Update

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Recreation Study Update

- RSP approved by FERC
- Study deferred in 2020 due to Covid-19 pandemic
- The field work for this study will be conducted from May through October 2021
- Study report will be filed with USR in 2022

American Eel Study Update




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American Eel Study Update

- Feb 2020 FERC issued SPD, recommended additional study: American Eel Study
- NYPA undertook additional informal consultation with USFWS and NYSDEC.
- Nov 19, 2020 NYPA met with agencies at the Projects to scope out potential eel sampling locations.
- NYPA shared draft American Eel Study plan with agencies; consultation held December 17, 2020.
- Comments received; NYPA revised the draft study plan and again shared it with the agencies.
- Jan 2021 USFWS and NYSDEC in agreement with the revised study plan.
- Feb 2021 NYPA submitted the RSP for the American Eel Study to FERC as an RSP addendum.

American Eel Study Update

- American Eel Study will be undertaken in 2021 to assess presence/abundance of American Eel
  - Three sampling methods:
    1. Spring 2021: Nighttime observations
    2. Beginning in mid-May 2021: Eel ramp traps will be deployed, and
    3. July & Aug 2021: Nighttime boat electrofishing.
- Study Report to be Filed with USR in Feb 2022

Vischer Ferry Ice Jam Update

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Reimagine the Canals Effort

- Multi-year collaborative effort funded and directed by Canals and NYPA
- Includes scientists and scholars from universities, community stakeholders, municipal representatives, and the NYSDEC, among others
- Focus topics within the vicinity of the C and VF Projects:
  - Flooding
  - Improvements to fish and aquatic environment

Ice Jam Study

- Led by world renowned ice experts from Clarkson University
- 80% of flooding in Stockade district result from ice jams
- Areas of modeling and further evaluation
  - Use of icebreakers
  - Modification of VF Dam
  - Channel modifications
- Early Warning System

2020 Efforts and Findings

- Pilot program to test ice breaking
- Recommendation to further study VF dam modifications
  - Replace some flashboards with Obermeyer gates
  - Would require improvements to concrete spillway
  - Extensive engineering and dam safety considerations
  - Work within the regulatory process
  - Estimated timeframe: 2025-2026

Ice Jam Warning System

- Begin development in 2021
- Objectives:
  - Tool for early warning and response
  - Include sensors, monitoring equipment and cameras
  - Include inundation mapping to assist responders

Crescent and Vischer Ferry Projects Relicensing Next Steps

- **March 3, 2021 –Power Authority holds ISR Meeting**
- March 18, 2021 – Power Authority files ISR Meeting Summary with FERC
- April 19, 2021 – Stakeholders file disagreements on ISR; modifications to ongoing studies; requests for new studies
- May 19, 2021 – Stakeholders file responses to disagreements and study modifications with FERC
- June 18, 2021 – FERC issues determination to resolve disagreements and amend Study Plan

Thank you

Questions?

Contact: Cynthia.Brady@nypa.gov

Project website: http://www.nypa.gov/cvf

Attachment C: Updated Water Quality Study

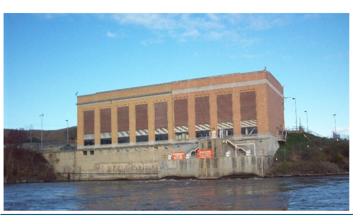
WATER QUALITY STUDY

Prepared by: GOMEZ AND SULLIVAN ENGINEERS

February 2021

CRESCENT AND VISCHER FERRY PROJECTS RELICENSING

FERC No. 4678 and 4679

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List of Abbreviations

BCD	Barge Canal Datum
C	Celsius
cfs	cubic feet per second
DO	Dissolved Oxygen
°F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FNU	Formazin Nephelometric Unit
ft	Foot or Feet
ft^2	square feet
ILP	Integrated Licensing Process
L	Liter
m	Meter
mg	Milligram
Mg/L	Milligram per liter
Mi	Mile
mS/cm	milliSiemens per centimeter
MW	Megawatt
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NY	New York
NYSDEC	New York State Department of Environmental Conservation
PAD	Preliminary Application Document
Power Authority	New York Power Authority
PSP	Proposed Study Plan
QA/QC	Quality Assurance / Quality Control
RSP	Revised Study Plan
SD1	Scoping Document #1
SPD	Study Plan Determination
the Commission	Federal Energy Regulatory Commission
µmhos/cm	micromhos per centimeter

1 Introduction

1.1 Background

The Power Authority of the State of New York (the Power Authority) is licensed by the Federal Energy Regulatory Commission (FERC or the Commission) to operate the Crescent and Vischer Ferry Hydroelectric Projects (FERC Nos. 4678 and 4679) (Projects) located on the Mohawk River in New York. The Power Authority is relicensing the Projects under the Commission's Integrated Licensing Process (ILP) as outlined in 18 C.F.R. Part 5.

In accordance with 18 C.F.R. §§ 5.5 and 5.6, the Power Authority filed its Notice of Intent (NOI) and Pre-Application Document (PAD) on May 3, 2019, which included the Power Authority's preliminary issues and studies list for the Projects. FERC issued its Scoping Document 1 (SD1) on June 10, 2019 and held public scoping meetings on July 10-11, 2019 in Clifton Park, New York, where potential issues were identified by agencies, stakeholders, and the public.

Subsequently, the Power Authority received comments on the PAD and requests for additional studies. The Power Authority reviewed these comments and study requests and developed a Proposed Study Plan (PSP), which was filed with the Commission on September 23, 2019. The Power Authority held a public meeting to discuss the PSP on October 23, 2019. Written comments on the PSP were received through December 23, 2019.

The Power Authority then developed its Revised Study Plan (RSP), which was filed with FERC on January 21, 2020. On February 20, 2020, FERC issued its Study Plan Determination (SPD), which approved the Power Authority's Water Quality Study with a recommended modification. This study report presents information and results pertaining to the Water Quality Study conducted at the Crescent and Vischer Ferry Projects in 2020.

1.2 Study Goals and Objectives

The goal of this study is to evaluate the effects, if any, of each Project on water quality and to determine compliance with State of New York water quality standards. The objectives of this study are to collect continuous dissolved oxygen (DO) and temperature data in the Project impoundments and tailwater areas during the summer and early fall months (i.e., the period when elevated water temperature and low DO levels are most likely to occur in waters released through the Projects), and to collect additional water quality data for pH, conductivity, and turbidity in the Project impoundments and tailwater areas, sufficient to characterize current water quality at each Project.

1.3 Project Description

The Crescent and Vischer Ferry Projects are located on the Mohawk River in New York at river miles 4 and 14, respectively (Figure 1.3-1); both are operated on a run-of-river basis. The original purpose of the Crescent and Vischer Ferry Dams was to impound water to support navigation on the New York State Barge Canal (Barge Canal); this remains true today as navigation and Barge Canal operations take priority over the operation of the Projects. During unusual conditions or emergencies associated with the system, public safety is always the first priority. Thus, both Projects operate in coordination with the New York State Canal Corporation (Canal Corporation) who operates the Barge Canal. Unless emergency conditions exist, the Projects operate in run-of-river mode with fluctuations (allowable six inches or less[1]) allowed at Canal Corporation's direction, and as permitted by the existing FERC licenses, to aid navigation, to facilitate flashboard installation and removal, and for canal maintenance or safety.

Crescent Project

The Crescent Project is an 11.8 MW conventional run-of-river hydroelectric project located on the Mohawk River, approximately 4 miles upstream from its confluence with the Hudson River. It is located 2 miles upstream of the School Street Hydroelectric Project (FERC No. 2539) owned by Erie Boulevard Hydropower, L.P.

The Crescent Project generally consists of a dam, powerhouse, impoundment, and appurtenant facilities. The Crescent Dam consists of two independent concrete gravity overflow sections which link each riverbank to a rock island in the middle of the Mohawk River (Figure 1.3-2). Both sections are curved in plan and have a crest at elevation (El.) 184.0 Barge Canal Datum (BCD).

In order to aid canal navigation, one-foot-high (12 inch) wooden flashboards are installed along the crests of both spillways (Dams A and B) seasonally in Spring (generally in April depending on seasonal conditions) and removed in the Fall (generally in November depending on seasonal conditions). When the flashboards are installed, the spillway crest is El. 185.0 ft. BCD. The Crescent impoundment extends upstream approximately 10 miles to the Vischer Ferry Project Dam. At El. 184.0 ft. BCD, the surface area of the impoundment is 2,000 acres and impounds approximately 50,000 acre-feet of water. Installation of the flashboards increases the normal full pool elevation of the impoundment by 1 foot, to El. 185.0 ft. BCD, and the impoundment retains an additional 2,000 acre-feet of water.

Crescent Dam is located at the upstream terminus of the portion of the Canal System known as the Waterford Flight, which includes the canal between Lock E-2 through Lock E-6. The Waterford Flight is a 2.5 mile-long section of canal (with a total lift of 169 feet) which allows boat traffic to bypass Cohoes Falls.

The Crescent powerhouse is located on the western bank (river right, looking downstream) and houses four turbine/generator units: two 2.8 MW Francis turbines and two 3.0 MW vertical Kaplan turbines. The original portion of the powerhouse contains the two original Francis units (Units 1 and 2). The two newer Kaplan units (Units 3 and 4) are located riverward of the original section of the powerhouse.

Crescent Project operations are performed in a manner to maintain the normal full pool elevation of the impoundment. Flow through the Project is through the powerhouse or over the dam. During the non-navigation season, a minimum flow of 100 cubic feet per second (cfs) (or inflow, whichever is less) is required to be passed at the Crescent Dam. In accordance with a July 31, 2007 FERC order, the minimum flow during canal navigation season is increased to 250 cfs and is passed through a notch in the Dam A flashboards. These minimum flows are for fish protection measures. Once minimum flows and any diversions required for canal operations are met, the remaining flow is available for power generation.

Vischer Ferry Project

[1] Allowable fluctuation is defined by FERC's Order Amending Article 41 (November 17, 2000) states "In some instances, the project shall be operated to maintain the reservoir surface elevation in the range from the top of the dam (or top of the flashboards during the navigation season) to a level 6 inches below the top of the dam (top of the flashboards during the navigation season). This 6 inch fluctuation shall not be used for regular ponding operations. It shall be used only in the event of curtailment of inflows due to operations of the upstream Barge Canal."

The Vischer Ferry Project is an 11.8 MW conventional run-of-river hydroelectric project located on the Mohawk River, approximately 14 miles upstream from its confluence with the Hudson River, and approximately 10 miles upstream of the Crescent Project. The Vischer Ferry Project generally consists of a dam, powerhouse, impoundment, and appurtenant facilities. The Vischer Ferry Dam consists of three connected spillway sections (Figure 1.3-3). The two outer sections (Dams D and F) are regular, ungated, ogee-shaped weirs with an average structural height of approximately 30 ft. above rock. The middle section (Dam E) is a broad-crested weir constructed over a small bedrock island near the center of the river. Lock E-7 is located at Vischer Ferry Dam on the western bank (river right, looking downstream), which is on the opposite side of the river from the Vischer Ferry powerhouse.

As with the Crescent Project, flashboards are installed along the crests of the Vischer Ferry Project spillways seasonally from Spring (generally in April depending on seasonal conditions) to the end of navigation season (generally in November depending on seasonal conditions). The flashboards are 27 inches in height and when installed the impoundment elevation is 213.25 ft. BCD. The spillway crest elevation is 211.0 ft. when flashboards are removed. The Vischer Ferry impoundment is 10.3 miles long and the upstream terminus of the impoundment is located at Lock E-8 in Schenectady. At El. 211 ft. BCD, the surface area of the impoundment is 1,050 acres and impounds approximately 25,000 acre-feet of water. Installation of the flashboards raises the normal full pool to El. 213.25 ft. BCD, and the impoundment retains an additional 2,400 acre-feet of water.

The Vischer Ferry Project powerhouse houses four turbine/generator units: two 2.8 MW Francis turbines and two 3.0 MW vertical shaft Kaplan turbines (identical units as at the Crescent Project). The original portion of the powerhouse contains the two original Francis units (Units 1 and 2). The two newer Kaplan units (Units 3 and 4) are located riverward of the original powerhouse. The turbines discharge water into the tailrace, the elevation of which is controlled by the Crescent impoundment level.

Vischer Ferry Project operations are performed in a manner to maintain the normal full pool elevation of the impoundment. Flow through the Project is through the powerhouse or over the dam. A minimum flow of 200 cfs (or inflow, whichever is less) is required to be passed at the Vischer Ferry Dam. An 8 foot section of the flashboards on Dam F is removed during navigation season to provide fish passage flow. Once Project minimum flows and any diversion required for canal operations are met, the remaining flow is available for power generation.

1.4 Water Quality Standards and Classifications

The New York State Department of Environmental Conservation (NYSDEC) defines the Mohawk River at the Crescent and Vischer Ferry Projects as Class A waters, except for the Barge Canal Section associated with the Crescent Project, which is classified as Class C waters. The Barge Canal section classified as Class C includes the Waterford Flight portion of the canal from Lock E-6 where it joins the Mohawk River at the Crescent Project down to Lock E-2, approximately 1.5 miles further down the canal. These classifications are listed in Table 1.4-1.

Class A waters are described as a source of water supply for drinking, culinary or food processing purposed, primary and secondary contact recreation, and fishing. Pursuant to 6 NYCRR § 701.6, the waters "shall be suitable for fish, shellfish, and wildlife propagation and survival". Class C waters are described as suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes (6 NYCRR § 701.8). Class A and C waters have the same numerical standard for dissolved oxygen and pH: both shall have a minimum daily average of no less than 5.0 mg/L of dissolved oxygen and pH should not be less than 6.5 nor more than 8.5. See Table 1.4-2.

Table 1.4-1: New York State Waterbody Classifications for Project Waters

Name	Description	Class	Standards
CRESCENT PROJECT			
Mohawk River	From Crescent Dam to point 1.0 mile above bridge across Mohawk River on U.S. Route 9.	A	A
Mohawk River	From point 1.0 mile above bridge across Mohawk River on U.S. Route 9 to Lock E-7.	A	A
Barge Canal (Waterford Flight Section)	From Lock E-2 to vicinity of Crescent Dam where Mohawk River and Barge Canal join. This section is the lower end of the Barge Canal.	C	C
VISCHER FERRY PROJECT			
Mohawk River	From Lock E-7 to Schenectady-Scotia Bridge across Mohawk River on N.Y. Route 5.	A	A
Mohawk River	From Schenectady-Scotia Bridge across Mohawk River to Schenectady-Montgomery County line (includes reach from Route 5 Bridge to Lock E-8.)	A	A

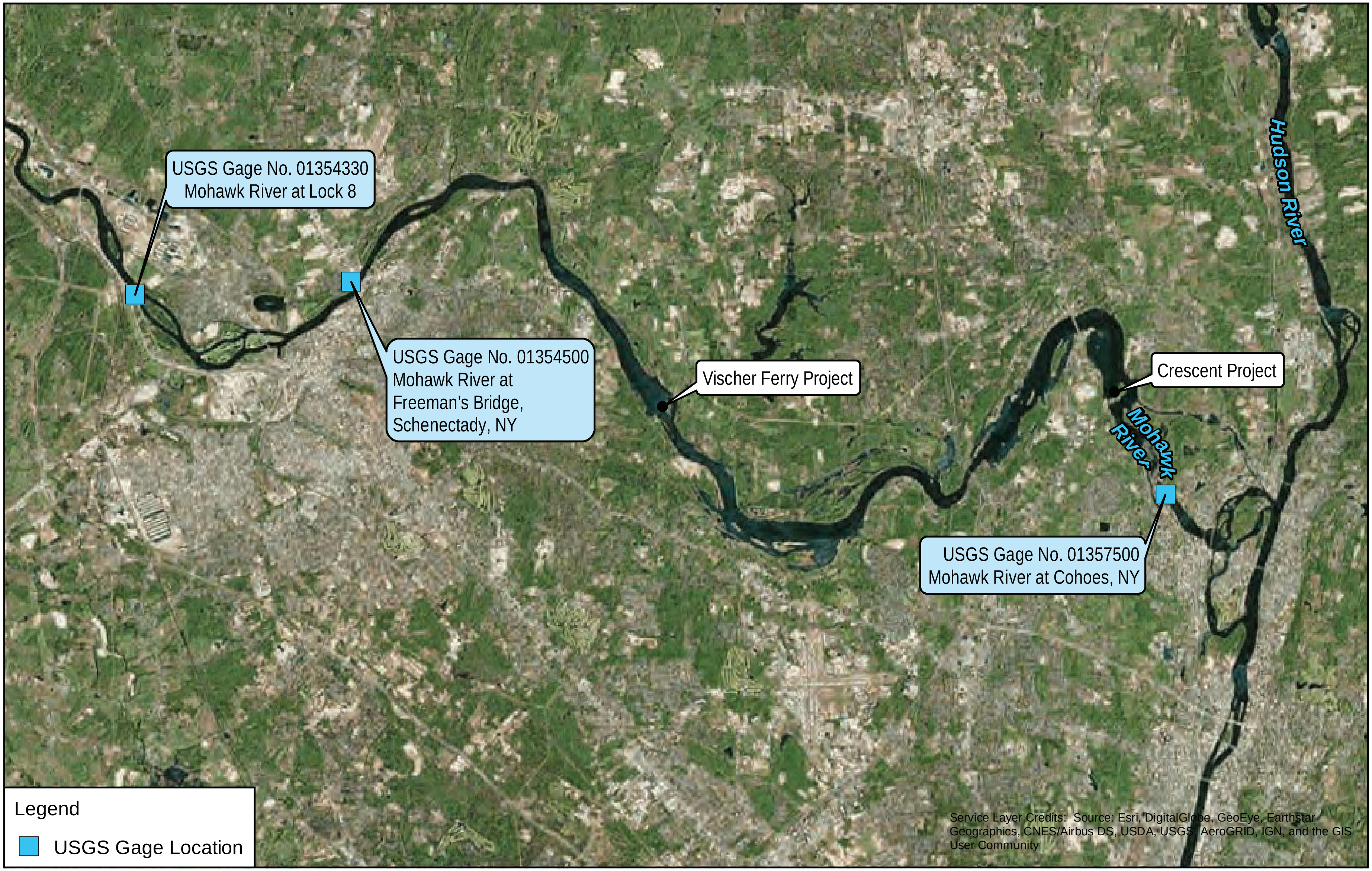
Source: 6 NYCRR § 876.4

Table 1.4-2: New York State Water Quality Standards for Class A and C Waters

Parameter	Standard*
pH	Shall not be less than 6.5 nor more than 8.5
Dissolved oxygen (DO)	For non-trout waters, the minimum daily average shall not be less than 5.0 mg/L, and at no time shall the DO concentration be less than 4.0 mg/L.

**Standards applicable to both Class A and C, unless otherwise noted.*

Source: 6 NYCRR § 703.3



Crescent and Vischer Ferry
Projects Relicensing
FERC No. P-4678 and P-4679

0 1 2 4 Miles

N

Figure 1.3-1:
Locations of Crescent
and Vischer Ferry Projects

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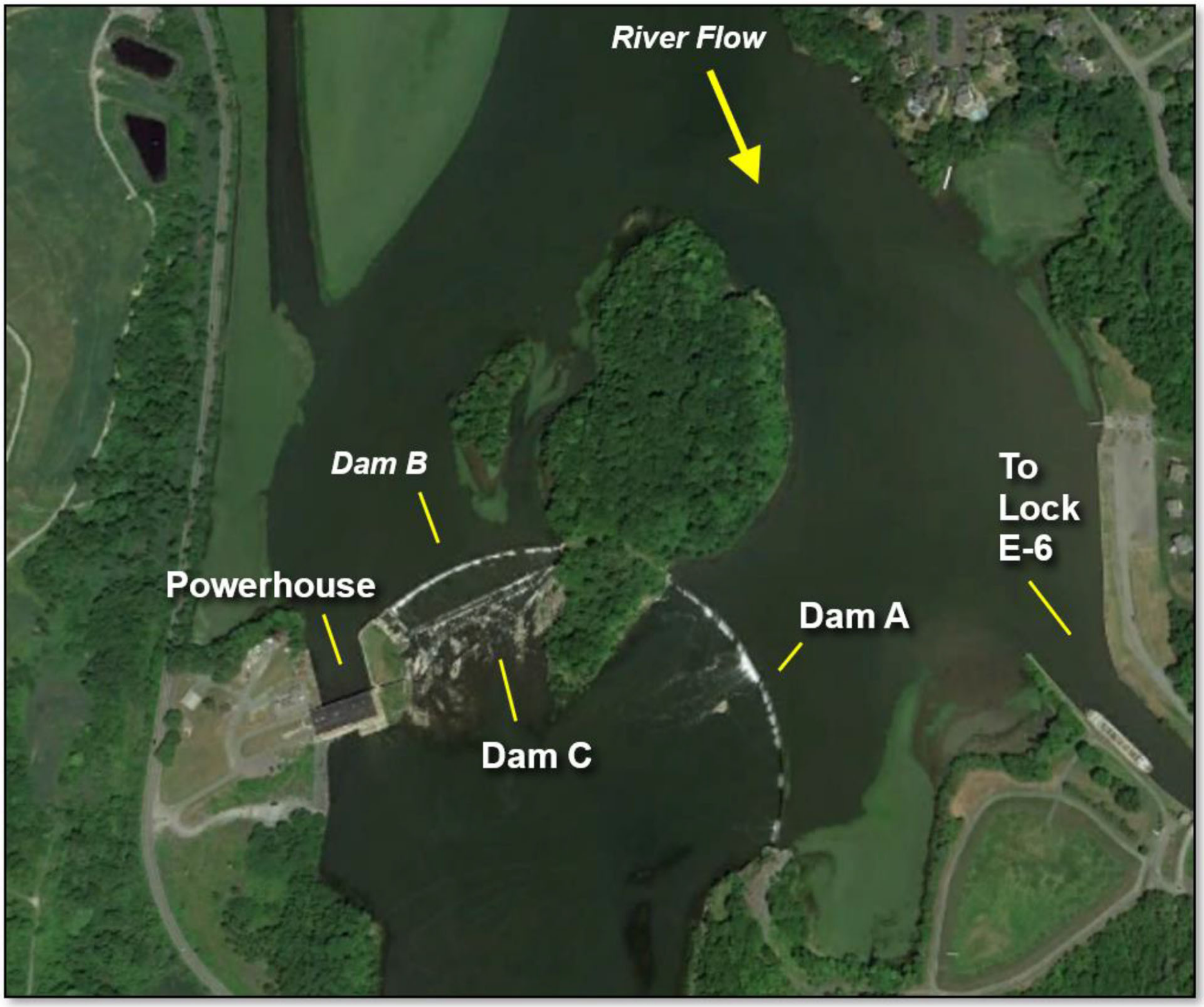
Figure 1.3-2: Major Project Facilities of the Crescent Project



Source: PAD.

Figure 1.3-3: Major Project Facilities of the Vischer Ferry Project

Source: PAD.

2 Methodology

2.1 Monitoring Locations

Water quality monitoring in 2020 was conducted at two general locations of each Project. Continuous monitoring of dissolved oxygen and temperature was conducted in the lower impoundment (Forebay) and the powerhouse tailwater (Tailrace). The Forebay locations represented the conditions at the intake of each Project and the Tailrace locations represented the conditions of turbine discharge regardless of turbine operation.

Figures 2.1-1 and 2.1-2 provide maps of the Project area showing the water quality monitoring locations. Representative photographs of the monitoring locations are contained in Figures 2.1-3 through 2.1-6.

2.2 Water Quality Monitoring Methods

2.2.1 Continuous Temperature and DO Monitoring

The RSP called for water quality monitoring to begin in May and continue through October 2020. Due to the global Covid-19 pandemic, early season water quality monitoring was delayed while safety and access measures were determined. With proper planning and precautions, the water quality monitoring was initiated on June 12, 2020.

Continuous monitoring of water temperature and dissolved oxygen was conducted using HOBO Dissolved Oxygen Loggers (Model U26-001). One HOBO Water Level Logger (U20-001-01) was used to collect barometric pressure and air temperature data from each Project. The continuous loggers collected data every 15 minutes from June 12 through November 4, 2020. The instruments were serviced weekly.

A YSI Pro DSS handheld monitor was used to conduct independent spot measurements at each monitoring site during the weekly site visits. Discrete data were recorded in a field logbook and compared against continuous data records (collected within the same 15-minute time interval) to ensure the logger was functioning properly. The manufacturer's software (HOBOware) was used to calculate oxygen as percent saturation using concurrent barometric pressure data, DO concentration and temperature data. The accuracy, range, and resolution of each sensor are outlined in Table 2.2-1.

Continuous monitors were installed from shore at the forebay sites for each Project. The forebay monitors were affixed to cables at the sampling depth and attached to the railings along the forebay wall. The cables were weighted at the bottom to keep the meter in place. At the tailrace monitoring sites, the continuous monitors were deployed and accessed by boat. Each monitor was affixed at the sampling depth to a cable anchored to the river bottom; at the top of the cables were buoys to keep the water quality monitors suspended in the water columns.

All monitors were located at approximately mid-depth in the water column. Details of each monitoring location are described in Table 2.2-2. At the Crescent Forebay site, the water quality logger was placed at a depth of 2 meters from the surface and had a total water depth of 3.7 meters. The Crescent Tailrace water quality logger was installed to a depth of 3 meters from the surface and the total water depth was 6 meters. At the Vischer Ferry Forebay, the sampling location was the deepest monitoring site at both Projects having a total water depth of 8.2 meters; the water quality logger was installed to a depth of 4 meters from the surface at this site. The Vischer Ferry Tailrace water quality logger was installed to a depth of 2 meters below the surface and had a total water depth of 3.6 meters. One air pressure logger was installed at the forebay location at each Project.

2.2.2 Bi-Weekly Vertical Profiles

At all four monitoring locations, vertical water quality profiles were collected every two weeks between June 12 and November 3-4, 2020, resulting in 12 vertical profiles at each site. The profile data were generally collected from early to mid-morning bi-weekly. Data were collected to characterize the water quality conditions throughout the water column at each site.

A handheld multiparameter monitor (YSI model Pro DSS) was used to collect water quality data at 1-meter increments, from just below the water surface (0.1 meter) to between 1 and 0.5 meters from the river bottom. Water temperature, DO (% saturation and mg/L), pH, conductivity, and turbidity readings were collected at each location. The instrument was lowered to each sampling depth interval until the readings stabilized and were recorded. The accuracy, range, and resolution of each sensor are outlined in Table 2.2-1.

2.3 Field QA/QC Procedures

Adherence to standard methods and QA/QC procedures for water quality monitoring helps ensure that the resulting data will be accurate, precise, comparable, and representative. QA/QC procedures were conducted throughout the study period. Only personnel trained or experienced in the measurement and data recording techniques described above conducted the field data collection. Prior to deployment, the continuous water quality monitors were inspected, tested for battery life and the DO sensors calibrated. Temperature sensors were factory calibrated. The instruments were serviced weekly, which included independent spot measurements of water temperature and DO, offloading the continuous data files, cleaning the monitor and checking calibration, and then re-deploying the monitor. The DO sensors on the continuous water quality instruments were checked for calibration during each site visit and recalibrated as necessary. One replicate water quality measurement was taken during each vertical profile.

The sensors (DO, pH, specific conductivity, and turbidity) on the handheld device were calibrated according to the manufacturer's specifications prior to each sampling event. DO was calibrated to 100% saturation; pH was calibrated using a 3-point method using buffer solutions of 4.0, 7.0, and 10.0; specific conductance was calibrated using a 1000 µmhos/cm solution; and turbidity was calibrated using a 3-point calibration method using calibration solutions 0.0,12.7, and 1000 FNU.

2.4 Data Compilation and Review

2.4.1 Weather, Flow, and Operations Data

To support the water quality data analysis process, weather, flow and Project operations data were obtained for the period concurrent with the water quality monitoring period. Air temperature and precipitation data collected from a nearby weather station during the monitoring period were obtained from the online Northeast Region Climate Center – NOAA Online Weather Data[2] from the Albany International Airport NY, located approximately 11 miles southwest of the Projects. In addition to daily weather observations during the 2020 monitoring period, the data included long-term (1981-2010[3]) monthly normal air temperature and precipitation data for comparison. Visual observations of weather and flow conditions were also recorded

[2] http://www.nrcc.cornell.edu/wxstation/nowdata.html
[3] The 1981-2010 U.S. Monthly Climate Normals data set is the most recent long-term monthly normals data released by NOAA. This data set is updated every 10 years.

at the Projects on each sampling day.

Mohawk River flow data were obtained from two U.S Geological Survey (USGS) gages to support this study: 1) Freeman's Bridge in Schenectady, NY (No. 01354500), located approximately 6.9 miles downstream of the Vischer Ferry Project with a period of record from August 2011 to current year, and 2) the Mohawk River at Cohoes, NY (No. 01357500), located approximately 1.7 mi downstream of the Crescent Dam with a period of record dating back to 1925 at its current location. See Table 2.4.1-1 for details on these stream flow gages. The location of these gages in relation to the Projects is shown in Figure 1.3-1.

Operations data corresponding to the water quality monitoring period of June through November 2020 were obtained for both Projects. Hourly data for total flow through the Project turbines were used to support this study. In addition, the status of the flashboards at each Project Dam during the monitoring period is reported in the results.

In addition, the USGS maintains a gage on the Mohawk River at Lock 8 (No. 01354330) located about 10.7 miles upstream of the Vischer Ferry Project. The Mohawk River Lock 8 gage has a period of record extending back to December 2011. Water quality data such as continuous dissolved oxygen and temperature were obtained from this gage and compared to the study results.

2.4.2 **2020 Water Quality Data Compilation and Review**

Each water quality monitoring site was visited weekly to offload the continuous data, service the water quality sensors, and collect discrete spot check measurements. Discrete data were recorded on field data sheets the day of sampling. Collected data included discrete DO and water temperature measurements, general weather conditions, Projects operation status, and monitor calibration notes. Continuous temperature and DO data were stored in the instrument's internal memory and downloaded during each weekly sampling event. For bi-weekly vertical profiles, all parameters were recorded on field data sheets.

All field collected data underwent a thorough QA/QC review process to ensure accuracy of the dataset. Data were reviewed after each weekly service throughout the course of the study to confirm the accurate transfer of data and to screen for instrument or sensor error. Each dataset was compiled and subsequently reviewed. The desktop review of the dataset consisted of tabulating, charting and visually examining the data for erroneous measurements.

Continuous DO data that did not match the concurrent spot measurements (i.e., generally a difference of more than ±0.5 mg/L DO) were flagged and adjusted using the HOBOware DO Data Assistant, if necessary. This software tool was used to adjust the DO values as a result of measurement drift due to biofouling or if the DO sensor was out of calibration. This correction process was only performed if biofouling of the logger was believed to have compromised the measurements. Data corrections for fouling or calibration drift were based on spot measurements collected during servicing and best professional judgement during the data review process.

Following the desktop review, the data were either qualified as normal, adjusted or rejected. Data qualified as normal or adjusted were determined to be acceptable and representative of the present environmental conditions. Rejected data were not included in the final data set. Rejected data included erroneous measurements collected when the sensors were out of water during weekly service visits, or when there was an obvious sensor mis-read identified during the data review process.

Table 2.2-1: Water Quality Instrument Specifications

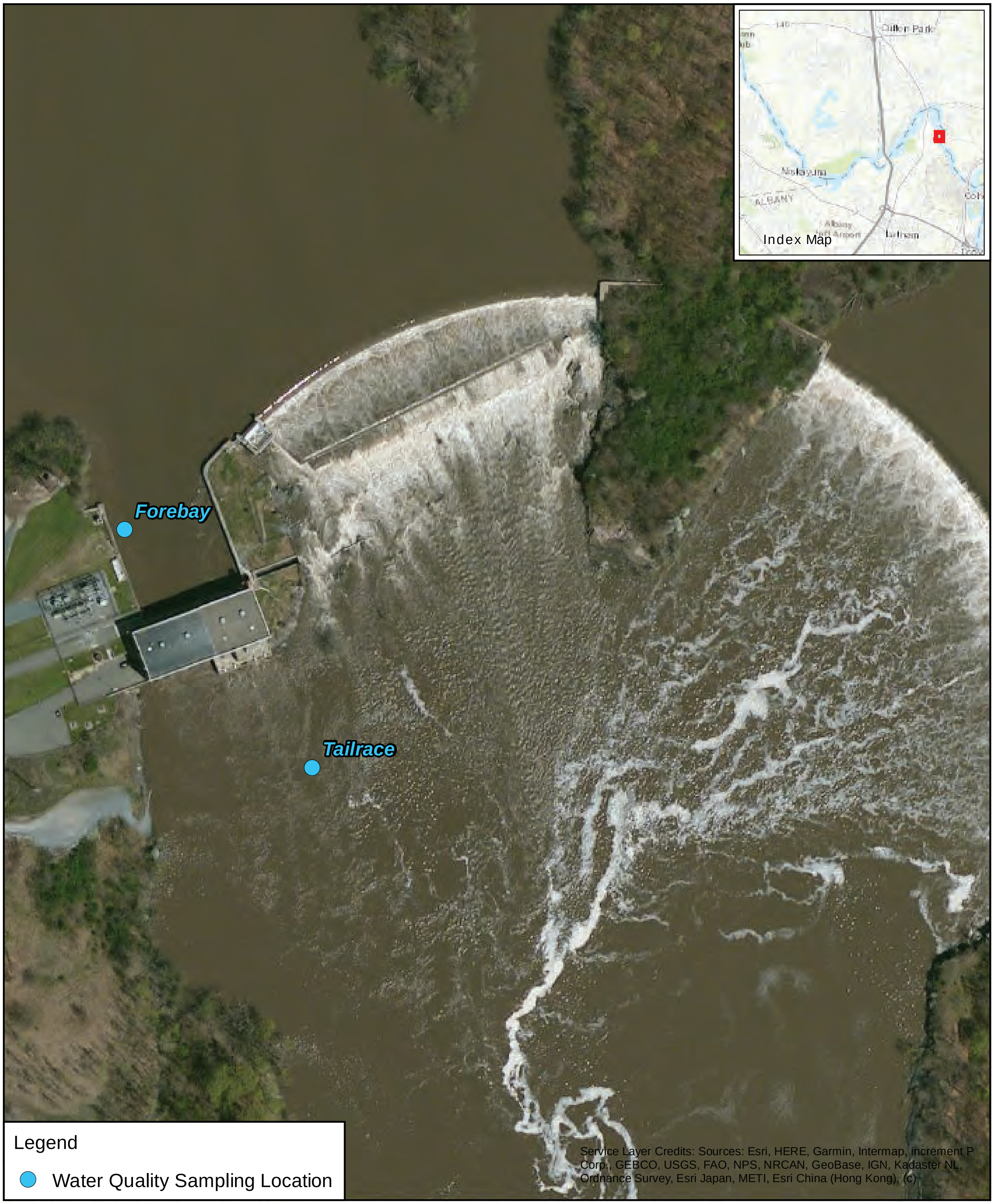
Parameter	Specification	Description
HOBO® Dissolved Oxygen Logger (U26-001)		
Optical Dissolved Oxygen (mg/L)	Operating Range	0 to 30 mg/L
	Accuracy	0.2 mg/L up to 8 mg/L; 0.5 mg/L from 8 to 20 mg/L
	Resolution	0.02 mg/L
Temperature (°C)	Operating Range	-5 to 40°C
	Accuracy	0.2°C
	Resolution	0.02°C
YSI Pro DSS Multiparameter Water Quality Meter		
Dissolved Oxygen (% saturation)	Sensor Type	Optical Luminescence
	Range	0 to 500 % air saturation
	Accuracy	± 1 % air saturation
	Resolution	0.1 % air saturation
Dissolved Oxygen (mg/L)	Sensor Type	Optical Luminescence
	Range	0 to 50 mg/L
	Accuracy	± 0.1 mg/L
	Resolution	0.01 mg/L
Temperature (°C)	Sensor Type	Thermistor; combination sensory with conductivity
	Range	-5 to +70°C
	Accuracy	± 0.2°C
	Resolution	0.1°C
pH (mV, pH units)	Sensor Type	Glass Bulb Combination Electrode; Ag/AgCl Reference Gel
	Range	0 to 14 units
	Accuracy	± 0.2 units
	Resolution	0.01 units
Conductivity	Sensor Type	Four Nickel Electrode Cell
	Range	0 to 200 mS/cm
	Accuracy	± 0.5%
	Resolution	0.001, 0.01, 0.1 mS/cm
Turbidity (FNU)	Sensor Type	Nephelometric-optical, 90° Scatter
	Range	0 to 4000 FNU
	Accuracy	± 0.2%
	Resolution	0.1 FNU

Table 2.2-2: Crescent and Vischer Ferry Projects 2020 Water Quality Monitoring Sites

Site	Monitor Depth (m)	Site Depth (m)
Crescent Forebay	2.0	3.7
Crescent Tailrace	3.0	6.0
Vischer Ferry Forebay	4.0	8.2
Vischer Ferry Tailrace	2.0	3.6

Table 2.4.1-1: USGS Monitoring Gages

Gage Name	Gage Number	Location	Notes
Mohawk River at Lock 8	USGS 01354330	Lat 42°49'41.37" Long 73°59'25.34" On right bank 330 ft downstream of Lock 8 on the Erie (Barge) Canal, 2.9 mi west of Schenectady. Drainage area = 3,270 mi^2	Continuous water quality parameters (DO and water temperature) used for this study. Representative of conditions upstream of the Projects.
Mohawk River at Freeman's Bridge, Schenectady, NY	USGS 01354500	Lat 42°49'49.9" Long 73°55'50.7" On left bank downstream from bridge on Freeman's Bridge Road, 1.2 mi north of Schenectady. Drainage area = 3,310 mi^2	Daily average stream flow used for this study. Generally representative of Mohawk River flow conditions upstream of the Projects. Shorter period of record (August 2011 to current year) for comparison of 2020 flow conditions to long-term normal.
Mohawk River at Cohoes, NY	USGS 01357500	Lat 42°47'07.4" Long 73°42'28.0" On right bank at School Street powerplant in Cohoes, and 2.0 mi upstream from mouth. Drainage area = 3,450 mi^2	Daily average stream flow compared to long-term data used for this study for an overview of flow conditions experienced during the 2020 monitoring period. Longer period of record (discharge since July 1925 at the current gage location) for comparison of 2020 flow conditions to long-term normal.



Crescent and Vischer Ferry
Projects Relicensing
FERC No. P-4678 and P-4679

0 100 200 400
Feet

N

Figure 2.1-1
Crescent Water Quality
Monitoring Sites

NEW YORK STATE OF OPPORTUNITY | NY Power Authority

Path: P:\Modeling\Projects\02190\maps\wq_report\figure_2_1-1_crescent_wq_sites.mxd

Crescent and Vischer Ferry
Projects Relicensing
FERC No. P-4678 and P-4679

0 100 200 400 Feet

N

Figure 2.1-2
Vischer Ferry Water Quality Monitoring Sites

Figure 2.1-3: Photograph of Crescent Forebay Monitoring Location

View is looking upstream from project intake. Water quality monitoring location on Right Bank (left wall in picture), identified by yellow circle.

Figure 2.1-4: Photograph of Crescent Tailrace Monitoring Location

View from Right Bank near boat launch. Water quality monitoring location at buoy, circled in yellow.

Figure 2.1-5: Photograph of Vischer Ferry Forebay Monitoring Location

View is looking upstream from project intake. Water quality monitoring location on left forebay wall in picture, identified by yellow circle.

Figure 2.1-6: Photograph of Vischer Ferry Tailrace Monitoring Location

View from Left Bank near tailwater fishing access. Water quality monitoring location at buoy, circled in yellow.

3 Results

3.1 2020 Weather, Flow, and Operations Conditions

3.1.1 **Weather Conditions**

Weather conditions in the study area during the 2020 monitoring period were compared to long-term averages. Table 3.1.1-1 displays the 2020 monthly temperature and precipitation data against the long term normal (1981-2010). Figure 3.1.1-1 shows the 2020 average daily air temperature and the month-to-date precipitation in Albany, NY. Air temperatures were warmer than normal for June and July, with June being 3.6°F warmer than normal and July being 4.1°F warmer than normal. The months of August through October were slightly cooler than normal. Monthly precipitation values were lower than normal for every month except August; a tropical storm in early August came through the area and resulted above normal precipitation for that month (+2.61 inches above normal monthly precipitation value).

The United States Drought Monitor[4] considered the Mohawk River basin to be abnormally dry in early June - July 2020. During most of August – September 2020 the watershed was classified as normal in terms of drought conditions, however, some areas of the watershed were in moderate to severe drought during October 2020.

3.1.2 **River Flow and Operations Conditions**

River Flows

Flows in the Mohawk River during the 2020 monitoring period were generally below normal, though there were short-term events of higher flows at the Projects in response to precipitation in the watershed. Figure 3.1.2-1 shows 2020 daily average flows compared to the long-term median upstream at the Mohawk River USGS gage at Freeman's Bridge in Schenectady, NY. Figure 3.1.2-2 shows 2020 daily average flows downstream of the Projects compared to long-term median flows at the Mohawk River USGS gage at Cohoes, NY. This gage at Cohoes, NY was included due to the gage holding a longer period of record. During the study period, river flows were generally at or below normal, particularly in June and July. A storm event in early August caused river flow to increase, but flows were back to, or below, normal by mid-August and remained low through September. Water quality data were collected under a range of environmental conditions, including high temperature and low flow periods.

River flows in May were very high in early and mid-May and generally receded (Figure 3.1.2-1 and Figure 3.1.2-2) throughout the month. The RSP called for water quality monitoring to begin in May, but due to the global pandemic, initiation of the monitoring program was delayed until June 12 while safety and access measures were established.

Operations Data

During the 2020 water quality monitoring period, the Projects were operated as normal with a few exceptions. Due to the global pandemic, the Canal Corporation initiated the canal navigation season later than usual. The Waterford Flight locks (on the opposite side of the river from the Crescent plant) opened for navigation season on June 16, 2020. Lock E-7 (on the opposite side of the river from the Vischer Ferry

[4] https://droughtmonitor.unl.edu/Data/DataTables.aspx filtered for Mohawk River basin (HUC 02020004).

plant) and Lock E-8 opened for navigation season on July 17. As a result, the Power Authority installed the flashboards at the Project dams between June 25 to July 1, 2020. Flashboards are typically installed earlier in the spring, depending on the seasonal river flow conditions. The Canal Corporation ended the 2020 navigation season on October 14, 2020. The Power Authority removed the flashboards at the Vischer Ferry and Crescent dams in November, after the water quality monitoring program was completed for 2020.

Hourly turbine outflows at each Project are included in the charts showing the continuous DO data series (Appendix A). One turbine at Vischer Ferry (Kaplan Unit 4) was out of service due to maintenance during the 2020 water quality monitoring period. As shown in the DO data series charts, the Project turbines were generally run at low levels during the monitoring period due to lower river inflows. There were periods during July when inflows were too low to run any of the turbines at the Projects for several days; the turbines were off-line, and inflow was passed over the dams during these periods. A high flow event allowed the Projects' turbines to run at higher output levels from August 4-6 and during the latter part of October 2020.

3.2 Data Review

Continuous data collection resulted in over 13,000 hourly water temperature and DO records at each monitoring location. Table 3.2-1 shows the total data records, as well as the percent adjusted and rejected from the data set at each site. Weekly spot checks were generally in agreement with concurrent data from the continuous loggers. Note the spot check data are shown on the dissolved oxygen charts in charts presented in Section 3.3.2 of this report. Data were reviewed by an experienced scientist and any erroneous data were rejected using professional judgement.

The continuous DO readings that were adjusted due to discrepancies with spot check measurements occurred at the Crescent Project in both the Forebay and Tailrace. 14.3% of the DO data was adjusted from the Crescent Forebay and 9.5% was adjusted from the Tailrace. No data corrections at the Vischer Ferry locations were necessary. Less than 0.1% of all continuous data was rejected at each site (see Table 3.2-1); rejected data occurred primarily when the loggers were out of water for servicing. Continuous data from both Vischer Ferry monitoring sites were lost for a week-long period between June 25 and July 2 due to a data file corruption. Post-processing corrections and missing and rejected data are summarized below.

- Temperature and DO continuous data files from 6/25 to 7/2 were lost at the Vischer Ferry Project due to data file corruption.
- DO data files from 7/2 to 7/9 were adjusted at the Crescent Project Tailrace using concurrent discrete DO data from 7/9.
- DO data files from 8/13 to 8/20 were adjusted at the Crescent Project Forebay using concurrent discrete DO data from 8/20.
- DO data from the Vischer Ferry Forebay were not adjusted for the period 7/2 through 7/9 even though concurrent spot checks were not within ±0.5 mg/L. As presented further in the results, the Vischer Ferry Forebay DO levels were stratified with low DO in the lower water column during this period. The differences in the spot check and concurrent continuous DO data were likely due to variations in DO within the water column vertically; therefore, the continuous data were not adjusted (see Figure 3.3.2-11).
- Turbidity profile data from 6/25 were all rejected due to a bad calibration process on the turbidity sensor.

None of the lost or adjusted data materially affected the ability of the study to meet its goals and objectives.

3.3 Continuous Water Quality Monitoring Results

Continuous monitoring of DO and water temperature was conducted in both the Forebay and Tailrace of each Project. Monitors were deployed from June 12 to November 3-4. The data results are presented in tabular and graphical form. Table 3.3-1 contains monthly minimum, maximum, and averages for water temperature and DO values for a broad comparison among the continuous monitoring sites.

3.3.1 **Continuous Water Temperature Results**

Figure 3.3.1-1 depicts an overview of the water temperatures at all four continuous monitoring sites for the monitoring season during June through October. Water temperature data from the upstream USGS Gage at Lock 8 were included on the continuous data figures for comparison. Throughout June, water temperatures warmed steadily at all sites and remained above 25 °C for most of July. The maximum water temperatures among all sites were observed in July and ranged from 28.4 °C to 29.5 °C. Table 3.3-1 contains monthly minimum, maximum, and averages for water temperature values at each of the continuous monitoring sites. Water temperatures cooled in early August in response to heavy precipitation and increased river flows. After warming again through the month of August, water temperatures at all sites generally decreased for the remainder of the sampling period in September and decreased rapidly at all sites in mid to late October, which was unusually cooler than normal (Figure 3.1.1-1).

In general, the water temperature observed across the monitoring locations for both Projects were very similar. The monthly average water temperature at the four sites was generally within +/- 0.2 °C, except during June when the Vischer Ferry Forebay site was cooler (Table 3.3-1). This monitoring site was the deepest and was slower to warm compared to the other sites.

A more detailed view of the water temperature data is plotted on a monthly time step showing USGS daily average flow data from the Mohawk River at Freeman's Bridge gage in Appendix A (Figures A-6 through A-10). Water temperature data from the USGS gage on the Mohawk River at Lock 8 is included on the monthly temperature charts for comparison.

The water temperatures among all sites were consistently similar through the monitoring period. Diurnal patterns of warming during the day and cooling at night were observed and were generally similar among all sites; however, due to the Vischer Ferry Forebay being deeper than the other sites, daily warming at that monitoring location was muted during June and July.

3.3.2 **Continuous Dissolved Oxygen Monitoring**

Dissolved oxygen data collected for this study are presented in several ways. As with temperature, Table 3.3-1 contains monthly minimum, maximum, and averages for DO values for a broad comparison among the continuous monitoring sites.

Consistent with the continuous water temperature charts, Appendix A (Figures A-1 through A-5) contains continuous DO concentration data from all sites on a monthly time step showing USGS flow data from the Mohawk River at Freeman's Bridge gage (DO percent saturation charts are in Figures A-11 through A-15 in Appendix A). DO data from the USGS gage on the Mohawk River at Lock 8 is included on this series of DO charts for comparison.

To evaluate the potential effects of Project generation on DO levels, monthly charts were developed for each monitoring location showing the continuous DO and water temperature along with total flow through the Project turbines. Figures 3.3.2-1 through 3.3.2-5 show data for the Crescent Tailrace, and Figures 3.3.2-6 through 3.3.2-10 show data for the Crescent Forebay for comparison. Figures 3.3.2-11 through 3.3.2-15 show data for the Vischer Ferry Tailrace, and Figures 3.3.2-16 through 3.3.2-20 show data for the Vischer Ferry Forebay for comparison.

Daily patterns in DO were highly irregular and erratic at all four sampling sites, in particular at the forebay sites. For example, DO values in the Crescent Forebay were very high during late day periods during some of June and July; high DO concentrations were observed in the Crescent Tailrace during these periods as well.

Among all the sites, the lowest instantaneous DO value was recorded in July at the Crescent Forebay on July 11, 2020 (Figure 3.3.2-7). DO in the Crescent Tailrace fell below 4.0 mg/L for a short period on this day as well. The Crescent Project turbines were off-line and inflows were passed at the dam as flashboard leakage and fish bypass flows during this period (see Figure 3.3.2-2). When the turbines were restarted on July 11, DO at both the Crescent Forebay and Tailrace increased. The daily DO fluctuations in the Crescent Forebay were apparent regardless of whether the turbines were off-line or running at low levels. Large daily DO fluctuations at the Crescent Forebay location persisted in July and August. It should be noted that significant stands of floating aquatic vegetation (i.e., water chestnut) are abundant in each Project impoundment upstream of the Project intakes (Power Authority, 2021) and these plants can contribute to the observed variability in daily DO concentrations through respiration, photosynthesis and decomposition.

Despite the DO data showing larger fluctuations in the Crescent Forebay compared to the Tailrace, the overall average daily DO concentrations for the entire study period at Crescent between both sites were within +/- 0.1 mg/L, ranging from 7.92 to 7.99 mg/L as shown in Table 3.1.1-1.

Vischer Ferry Forebay DO levels displayed erratic patterns, similar to the Crescent Forebay, although intra-day fluctuations were not as pronounced. The minimum instantaneous DO values measured at the Vischer Ferry Forebay on July 20 (Figure 3.3.2-17). During this period, and other days when DO was very low in the Vischer Ferry Forebay (July 7-11), the Vischer Ferry Project was off-line (i.e., no turbine discharge), yet the concurrent tailrace measurements were well oxygenated (Figure 3.3.2-12). After the low DO reading in the Vischer Ferry Forebay on July 20, DO suddenly increased very rapidly. It is likely that the dissolved oxygen levels in the Project impoundments are being influenced by the productive aquatic vegetation present there. Another notable trend was observed on July 11, when the turbines came back on-line late in the day after a period of no generation. The DO at the Vischer Ferry Forebay site increased rapidly when the turbines were started and both sites at Vischer Ferry remained well oxygenated until the turbines went off-line again due to low river flows on July 18. The lowest instantaneous DO reading at the Vischer Ferry Tailrace was 4.50 mg/L. The Vischer Ferry Tailrace remained well oxygenated during periods of Project generation when there was lower DO in the Forebay.

At both Projects, the DO daily averages did not drop below 5.0 mg/L in either tailrace. Looking at daily DO averages, the lowest (3.36 mg/L, July 11) and highest (13.08 mg/L, June 22) values were recorded in the Crescent Forebay. Table 3.3.2-1 shows the percent of days for each site where the daily average DO mg/L dropped below 5.0 mg/L. Both Crescent and Vischer Ferry Forebay sites experienced daily DO averages that dropped below 5.0 mg/L in July and August, with 9% of the daily average data being below 5.0 mg/L in the Vischer Ferry Forebay and 8% in the Crescent Forebay. Despite the lower DO at times in the forebays, the average daily DO values in each tailrace were always greater than 5.0 mg/L.

3.4 Bi-Weekly Vertical Profile Results

Bi-weekly vertical profiles were taken at each of the four sites at the Projects. Measurements included water temperature, DO (mg/L), DO (% saturation), pH, conductivity, and turbidity. Figures 3.4.1 through 3.4-3 depict the vertical profile data for each site and the tabular data are contained in Appendix B.

Figures 3.4-4 and 3.4-5 show temperature isopleths at each vertical profile site for the Projects over the study period. The isopleths depict changes in the vertical data profile data over time. The Vischer Ferry forebay displayed temperatures consistently over 20 °C for the study period up until September 18. Temperature within the water column was always consistent from top to bottom. The Vischer Ferry tailrace profiles displayed water temperatures that were similar to the Forebay.

The Crescent forebay and tailrace temperature profiles also displayed consistent patterns. There was no evidence of vertical stratification in temperature at any monitoring location. The temperature was well mixed from top to bottom at each site and, as demonstrated by the continuous water temperature data, consistent from upstream to downstream.

Figures 3.4-4 and 3.4-5 show the dissolved oxygen isopleths at each vertical profile site for the Projects. The Vischer Ferry Forebay profile site had higher DO in June and early July in the upper 3 meters of the water column. Even though water temperatures were consistent from top to bottom in the Vischer Ferry Forebay consistently throughout the monitoring period, DO stratification occurred on June 25, July 2, and July 9. DO values < 4.0 mg/L were recorded in the deeper portions of the water column on July 9; on this date the Project was not operating. On July 24 (turbines off-line), surface DO levels were actually lower than deeper areas of the water column.

Weak DO stratification in the Vischer Ferry Forebay was also observed on August 20, when DO dropped below 4.0 mg/L at depths of 4.0 meters and below. On this date, one turbine was operating at its lowest setting. The Vischer Ferry Tailrace profile site was well mixed throughout the study period and DO remained above 5.0 mg/L at all depths. This remained true even when stratification occurred in the Forebay.

The vertical profile data from the Crescent Forebay shows the water column was generally well mixed as DO was typically consistent from top to bottom. On July 9, DO was higher at the surface in the Crescent Forebay; as with the Vischer Ferry Project, during this time the Crescent Project was not operating either. DO was lowest in the Crescent Forebay on August 4, dropping below 5.0 mg/L at all depths. The Crescent Tailrace was well mixed throughout the study period. The lowest DO readings recorded during the bi-weekly profiles occurred on August 4, but all values remained above 5.0 mg/L. Two turbines were operating at Crescent during the August 4 profiles.

The pH generally stayed consistent from top to bottom in the water column throughout the study period, except during periods of DO stratification at Vischer Ferry Forebay. On June 25, the pH was stratified in the water column, decreasing from 8.86 at the surface to 8.01 just above the bottom. On July 9 the pH was stratified, varying from 8.54 at the surface to 7.14 near the bottom of the forebay. The DO was also stratified on these same dates for this site. The pH at all sites ranged from 6.98 to 8.86. The two surface measurements at the Vischer Ferry Forebay were the only incidents of the pH values above 8.5. These high pH values correspond to the high DO values observed concurrently. Like dissolved oxygen concentrations, pH in water can be affected by photosynthesis and other chemical reactions. Photosynthesis produces oxygen but uses up dissolved carbon dioxide which acts like carbonic acid (H_2CO_3) in water. Carbon dioxide removal, in effect, reduces the acidity of the water and so pH increases.

Discrete conductivity measurements at the Crescent Project ranged from 337.4 to 407.6 µS/cm and were similar at the Vischer Ferry Project where measurements ranged from 334.9 to 445.0 µS/cm. There was no evidence of stratification for conductivity at any monitoring site as shown in Figure 3.4-2. Discrete turbidity measurements were ≤ 10.0 FNU at all sites between both Projects. Vischer Ferry Forebay generally had the highest turbidity values of the four sites. This site can experience turbulence due to wind fetch. Vischer Ferry Tailrace had the lowest turbidity. There was no evidence of vertical stratification of turbidity at any monitoring site, as shown in Figure 3.4-3.

Table 3.1.1-1: Monthly Long-Term Average Air Temperatures and Precipitation Compared to 2020 at Albany International Airport, NY

Month	Average Daily Air Temperature (°F)			Monthly Precipitation (inches)		
	Mean (2020)	Normal (1981-2010)	Departure	Total (2020)	Normal (1981-2010)	Departure
June	70.8	67.2	3.6	1.98	3.79	-1.81
July	75.9	71.8	4.1	3.57	4.12	-0.55
August	68.8	70.1	-1.3	6.07	3.46	2.61
September	59.7	61.9	-2.2	2.63	3.30	-0.67
October	48.9	48.7	-0.8	3.13	3.68	-0.55

Source: NOAA Online Weather Data for Albany International Airport, NY.

Table 3.2-1: Data QA Summary

Site	Total Data Points	Percent Adjusted (Dissolved Oxygen)	Percent Rejected (Temp and/or DO)
Crescent Forebay	13,919	14.4%	0.08%
Crescent Tailrace	13,916	9.5%	0.11%
Vischer Ferry Forebay	13,121	0%	0.09%
Vischer Ferry Tailrace	13,243	0%	0.05%

Table 3.3-1: June – October 2020 Monthly Continuous Water Quality Summary Results

	Crescent Project Forebay			Crescent Project Tailrace			Vischer Ferry Project Forebay			Vischer Ferry Project Tailrace		
	Temp (°C)	**DO (mg/L)**	**DO (%)**	**Temp (°C)**	**DO (mg/L)**	**DO (%)**	**Temp (°C)**	**DO (mg/L)**	**DO (%)**	**Temp (°C)**	**DO (mg/L)**	**DO (%)**
June												
Maximum	28.6	21.05	274.1	27.3	13.99	177.3	27.9	15.52	200.8	28.1	13.55	200.8
Minimum	21.4	4.24	51.1	21.5	6.65	75.9	20.8	5.37	65.8	21.1	6.87	65.8
Average	24.7	9.31	112.8	24.9	9.12	110.6	23.4	8.08	95.4	24.3	8.81	95.4
July												
Maximum	29.5	14.76	194.9	29.0	12.07	152.7	28.4	11.39	146.8	29.3	9.40	146.8
Minimum	24.4	0.63	8.3	24.4	3.40	43.3	23.7	1.67	21.0	24.3	5.19	21.0
Average	26.9	7.11	92.2	26.9	7.12	89.8	26.5	6.18	79.9	27.0	7.38	79.9
August												
Maximum	28.2	14.68	183.0	28.2	10.60	136.2	27.8	10.69	133.9	28.2	9.88	133.9
Minimum	22.8	1.68	21.3	22.8	4.12	51.8	24.0	2.18	26.5	22.4	4.50	26.5
Average	25.6	6.28	77.3	25.6	6.66	83.1	25.6	6.28	75.5	25.5	7.01	75.5
September												
Maximum	24.0	14.19	154.8	23.7	12.02	131.3	24.2	12.79	151.3	24.2	10.55	121.7
Minimum	17.6	4.23	49.1	17.8	5.93	68.9	17.8	3.86	44.3	17.8	6.41	74.5
Average	21.0	8.40	93.7	21.0	8.20	91.7	20.9	7.42	83.2	20.9	8.15	91.4
October												
Maximum	19.9	10.60	102.7	19.7	11.13	97.7	19.7	10.88	100.6	19.7	11.05	102.0
Minimum	9.4	6.49	68.0	9.8	6.90	73.3	9.0	6.62	69.2	9.0	7.36	78.1
Average	15.3	8.72	86.8	15.4	8.84	88.1	15.2	9.00	89.2	15.2	9.28	92.0
Study Average	22.7	7.96	92.6	22.8	7.99	92.7	22.3	7.39	84.6	22.6	8.12	93.7

Table 3.3.2-1: Occurrences When Average Daily DO <5.0 mg/L (Continuous Data)

Site	Total Number of Monitoring Days	Days When Average Daily DO <5.0 mg/L	
		Number	Percent of Total
Vischer Ferry Forebay	139	12	9%
Vischer Ferry Tailrace	140	0	0%
Crescent Forebay	146	11	8%
Crescent Tailrace	146	0	0%

Note: See continuous data figures (Figures 3.3.2-1 through 3.3.2-20) for Project generation data.

Supplement to Table 3.3.2-1 (requested during ISR Meeting):
Dates when the Average Daily DO was less than 5.0 mg/L at the Forebay Sites

Vischer Ferry Forebay		Crescent Forebay	
Dates the Average Daily DO (<5.0mg/L)	Average Daily DO (mg/L)	Dates the Average Daily DO (<5.0mg/L)	Average Daily DO (mg/L)
7/9	4.75	7/3	4.80
7/10	4.92	7/11	3.36
7/11	4.84	8/1	4.67
7/18	4.73	8/2	3.88
7/19	3.58	8/3	4.34
7/20	3.75	8/4	4.28
7/24	4.91	8/8	4.91
8/17	4.40	8/9	4.22
8/18	4.25	8/10	4.54
8/19	3.86	8/28	4.55
8/20	3.78	8/29	4.57
8/21	4.31	-	-

Figure 3.1.1-1: 2020 Average Daily Air Temperature and the Total Daily Precipitation in Albany, NY

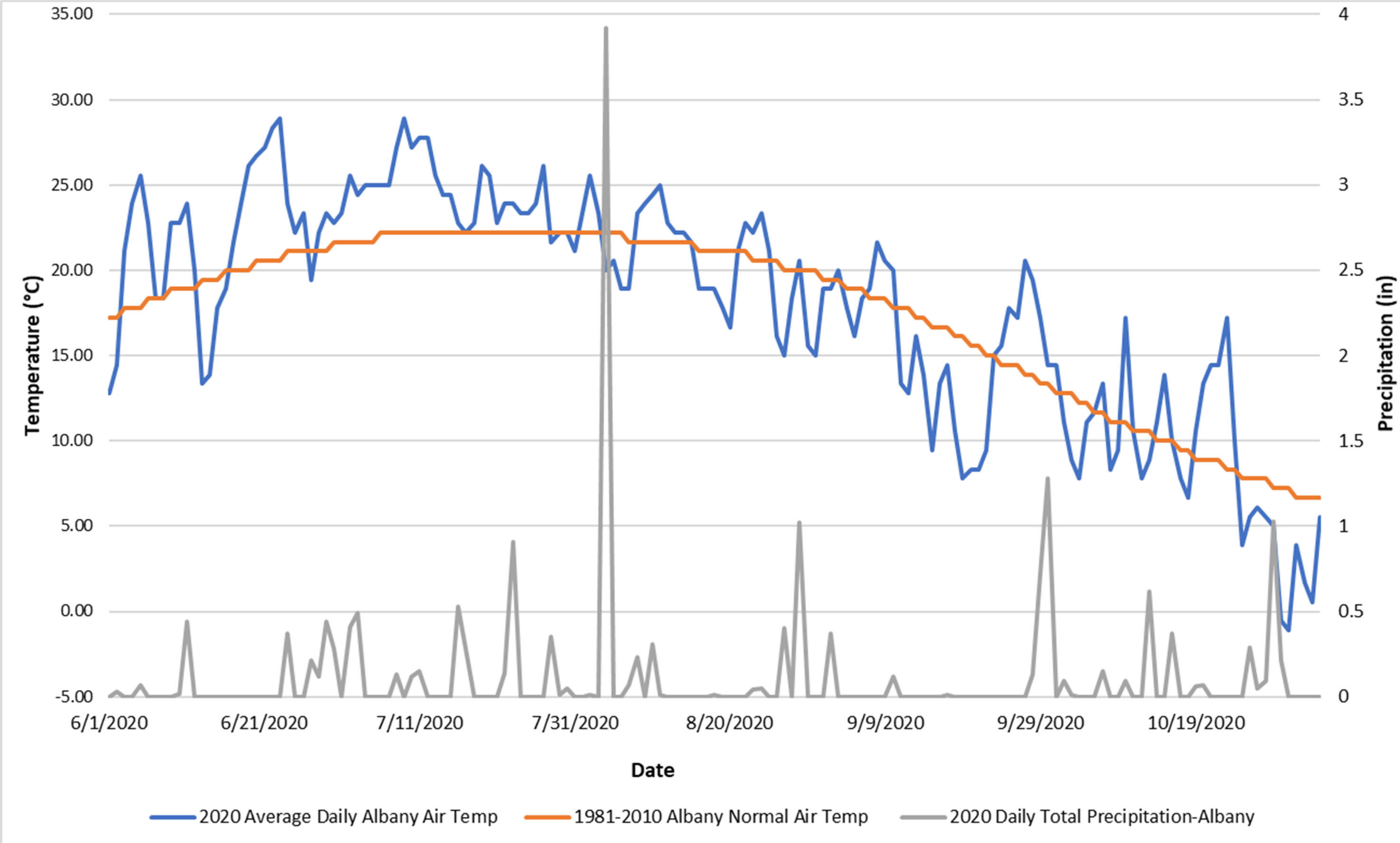


Figure 3.1.2-1: Daily Average Flows at the Mohawk River USGS Gage at Freeman's Bridge in Schenectady, NY, May through October 2020

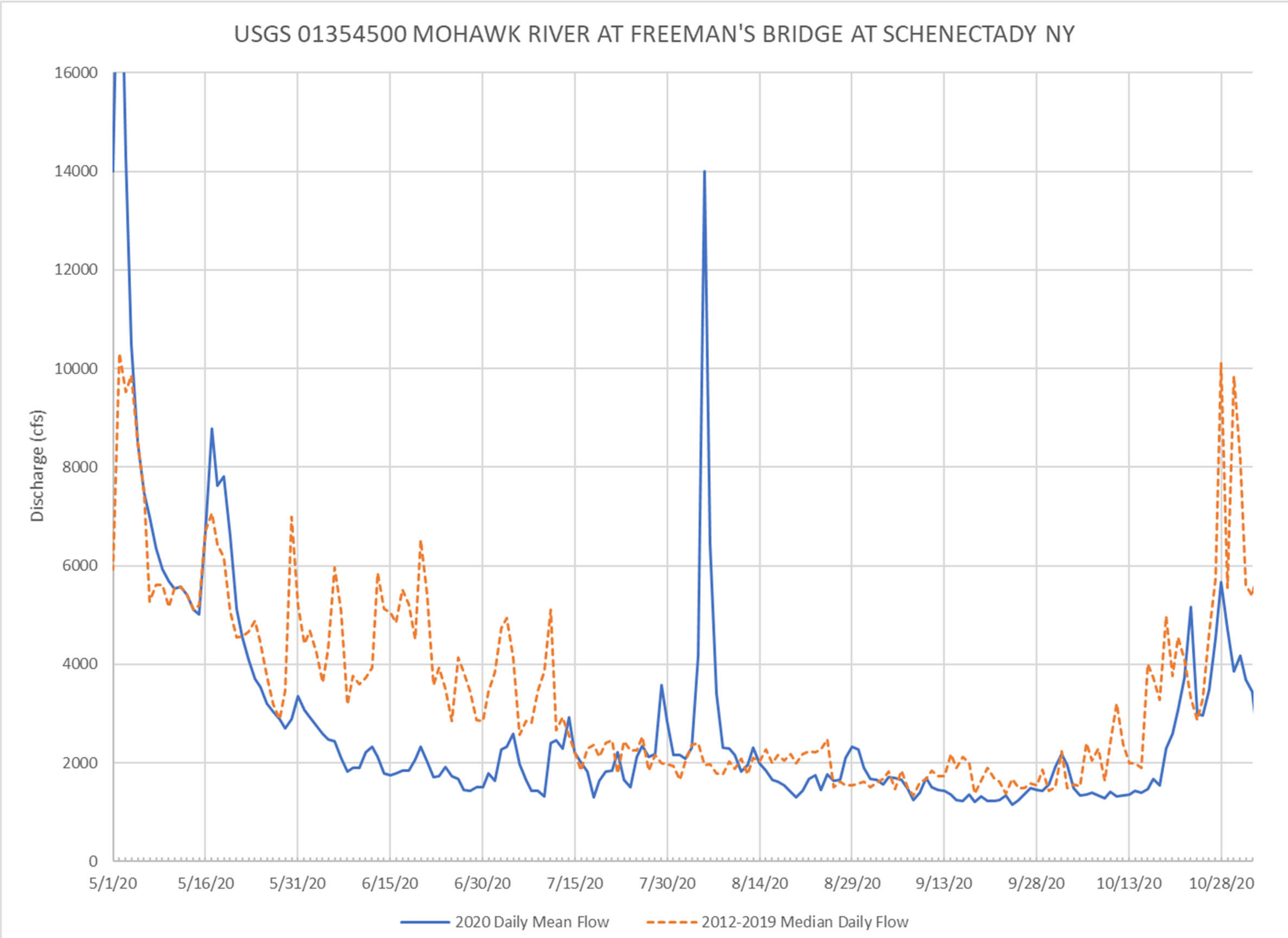


Figure 3.1.2-2: Daily Average Flows at the Mohawk River USGS Gage at Cohoes, NY, May through October 2020.

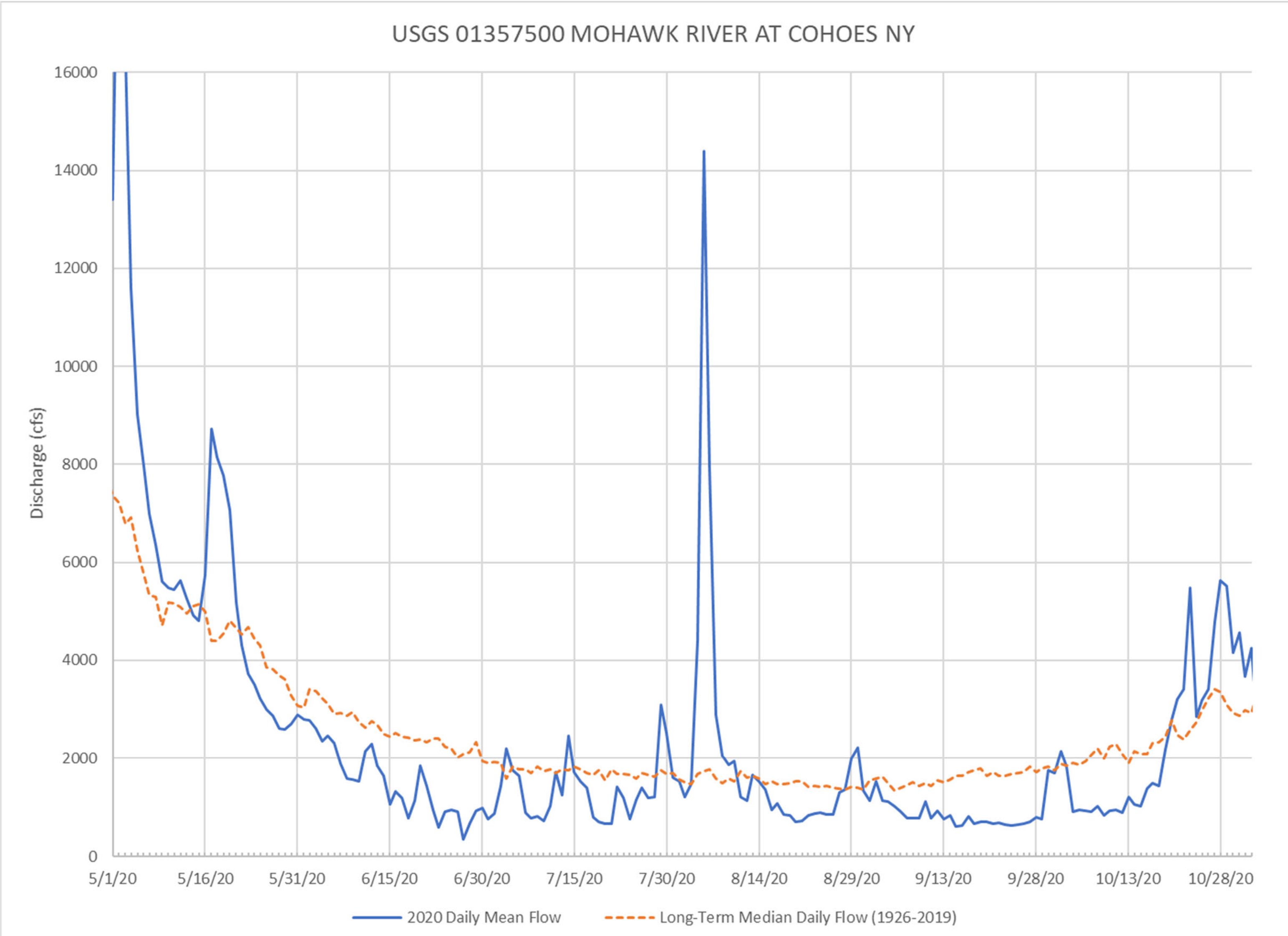


Figure 3.3.1-1: Overview of Continuous Water Temperature at Crescent and Vischer Ferry Projects, June-October 2020

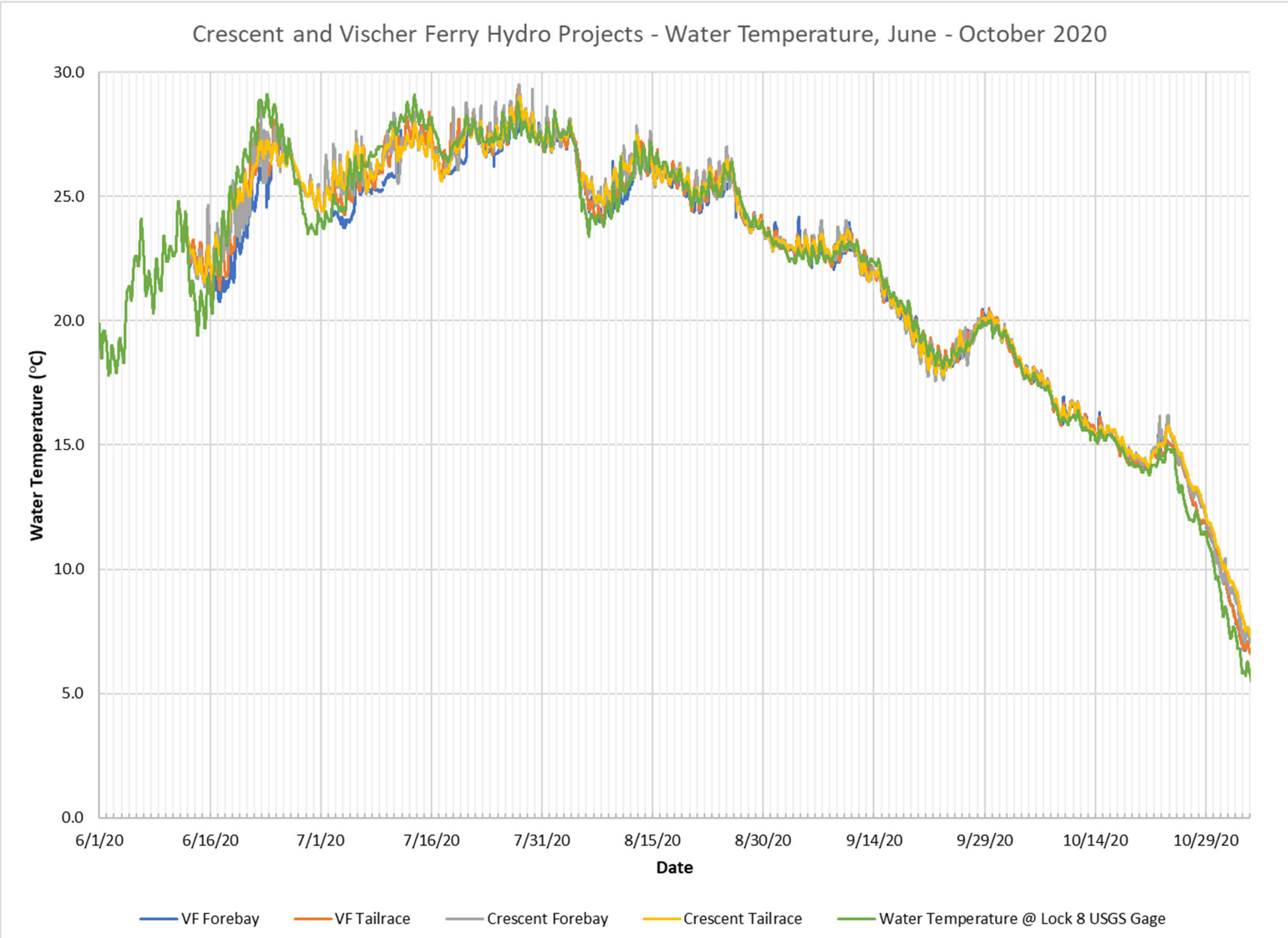


Figure 3.3.2-1: Crescent Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - June 2020

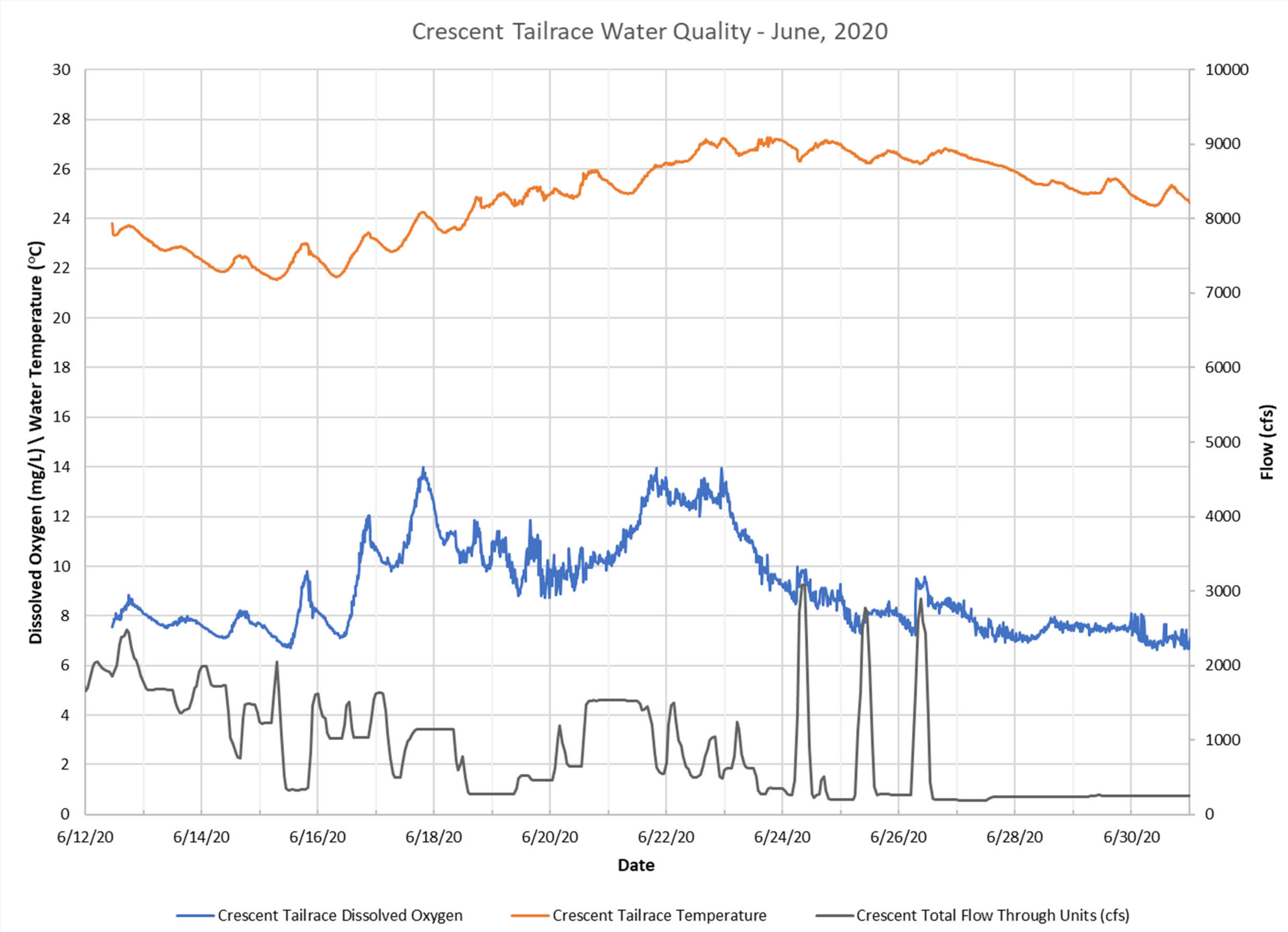


Figure 3.3.2-2: Crescent Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - July 2020

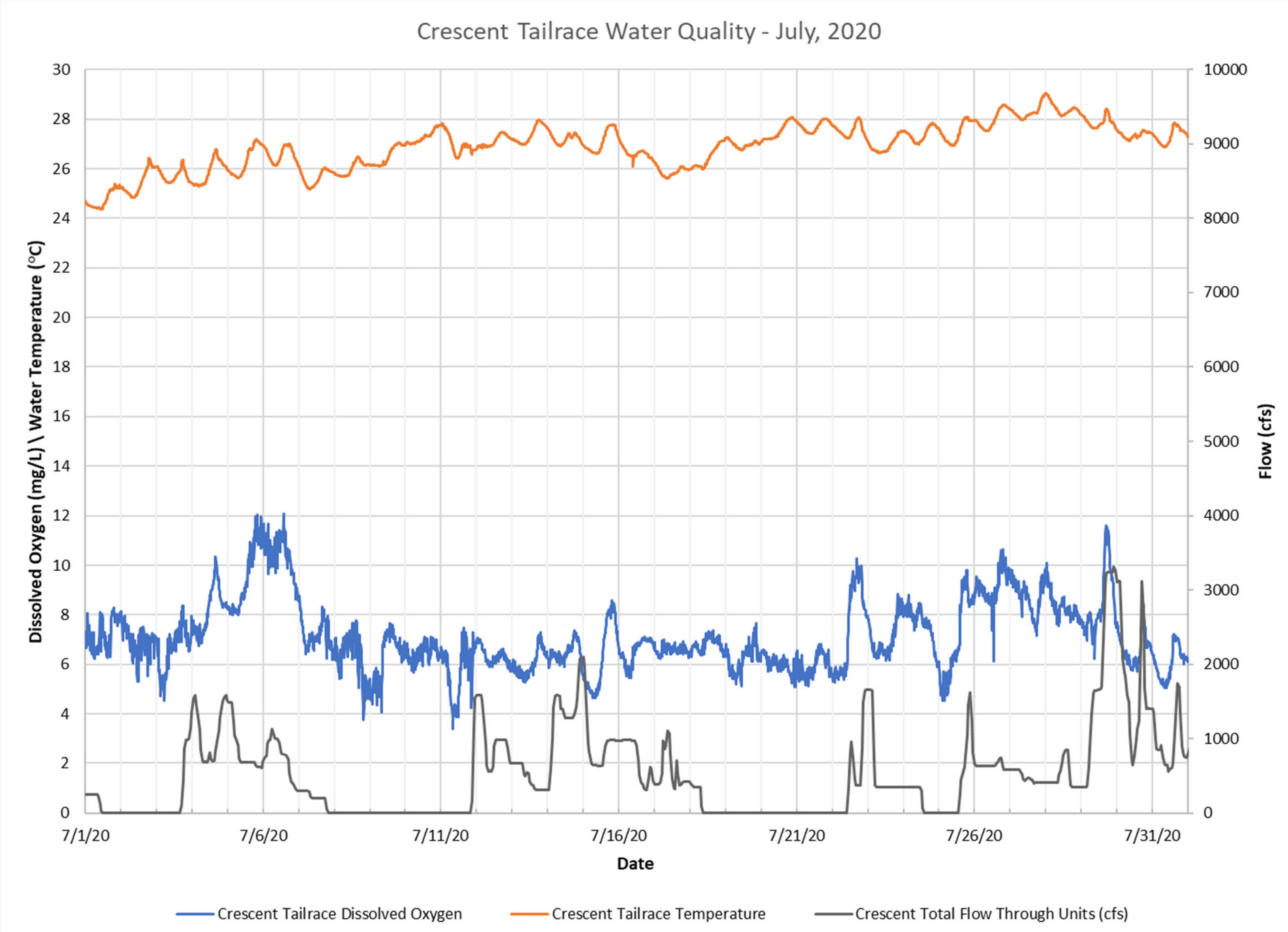


Figure 3.3.2-3: Crescent Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - August 2020

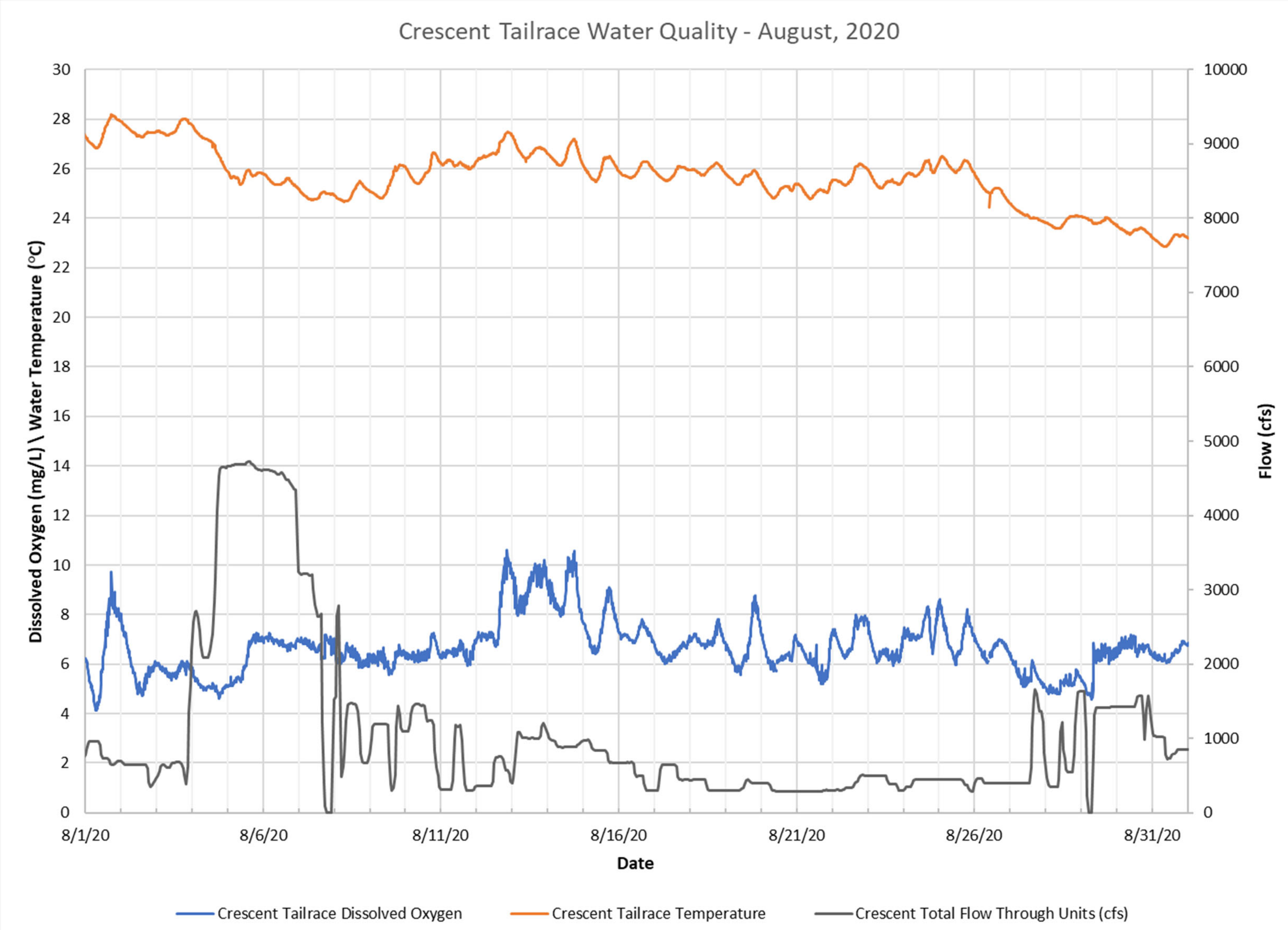


Figure 3.3.2-4: Crescent Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - September 2020

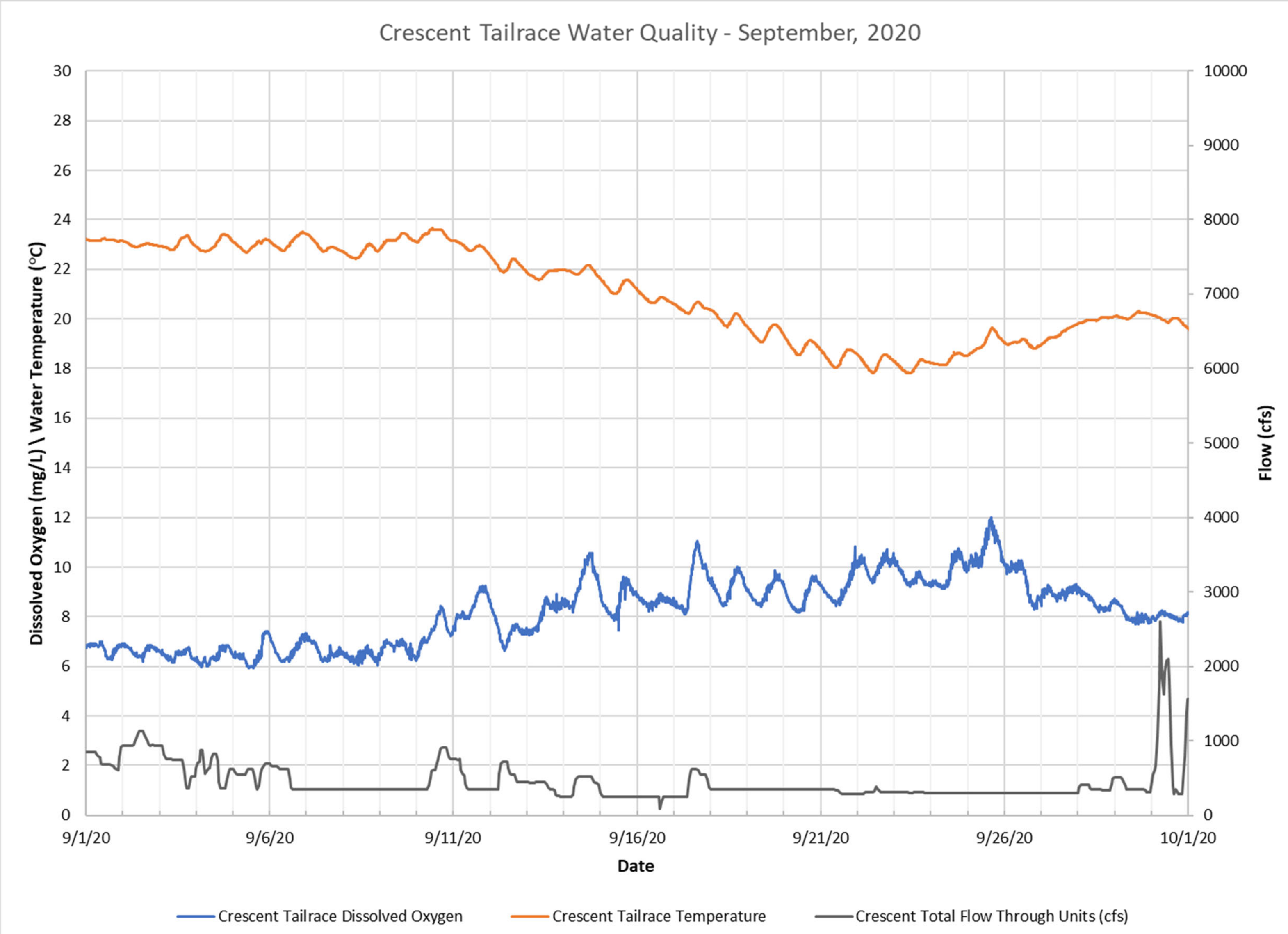


Figure 3.3.2-5: Crescent Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - October 2020

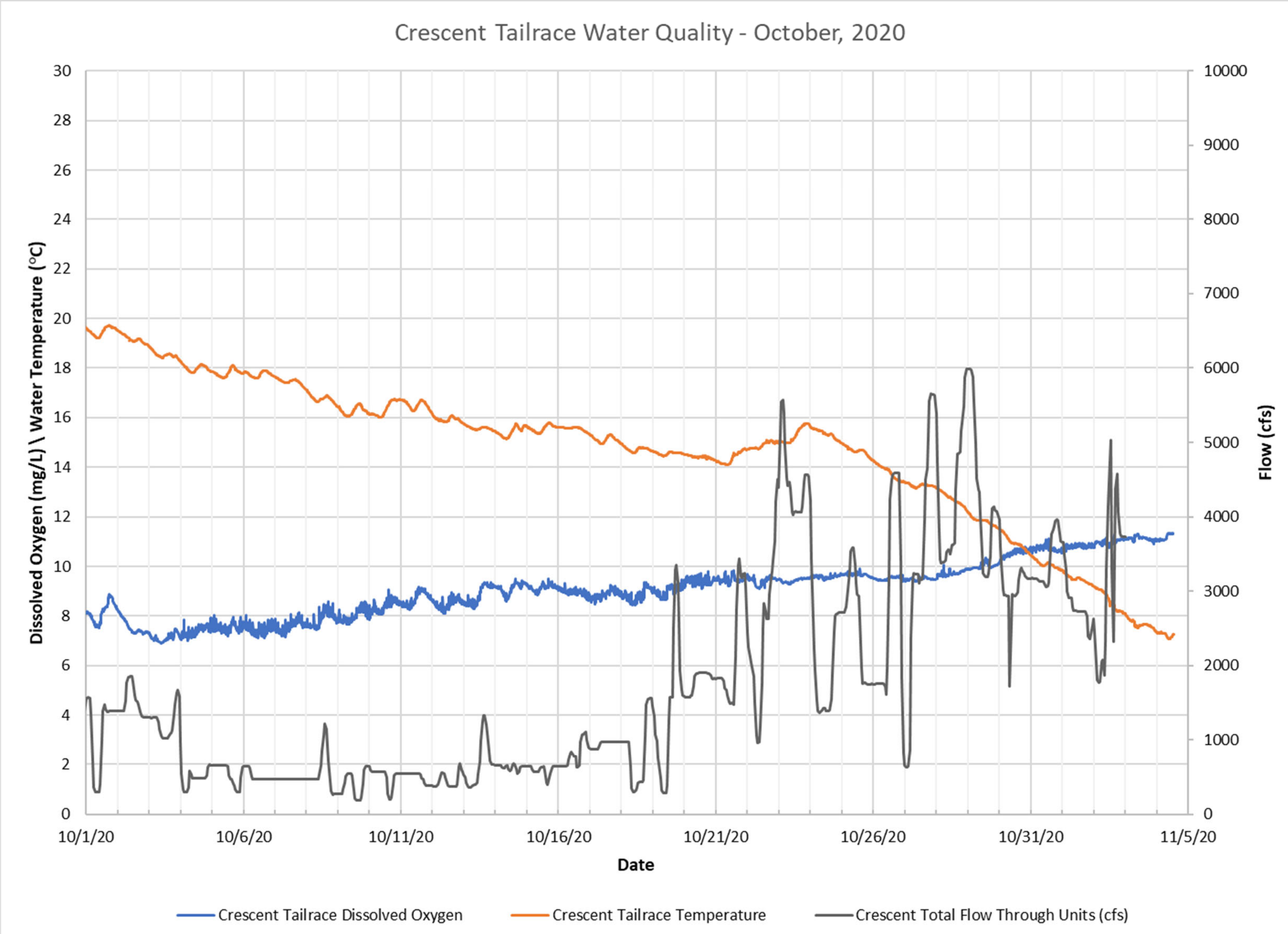


Figure 3.3.2-6: Crescent Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - June 2020

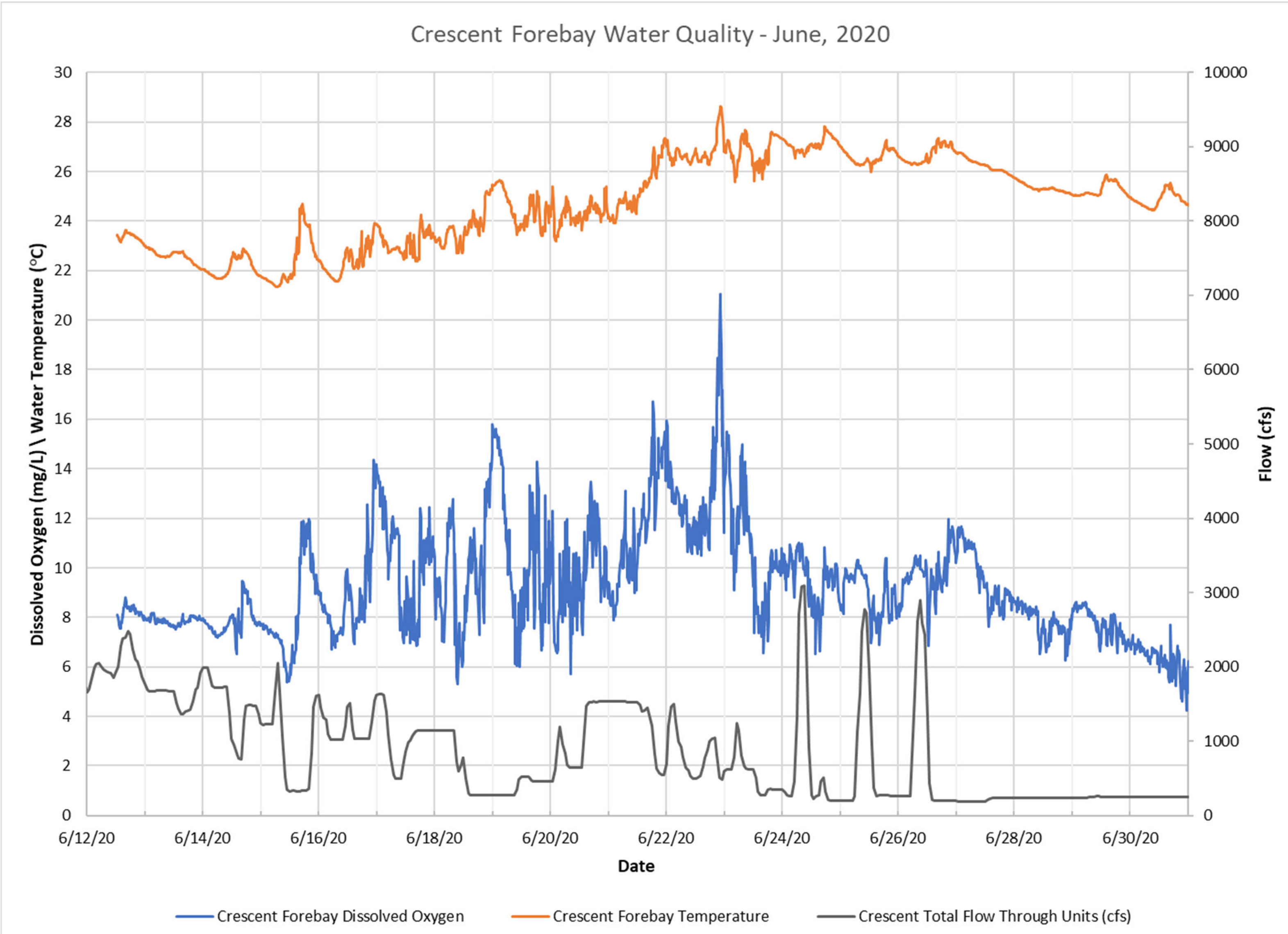


Figure 3.3.2-7: Crescent Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - July 2020

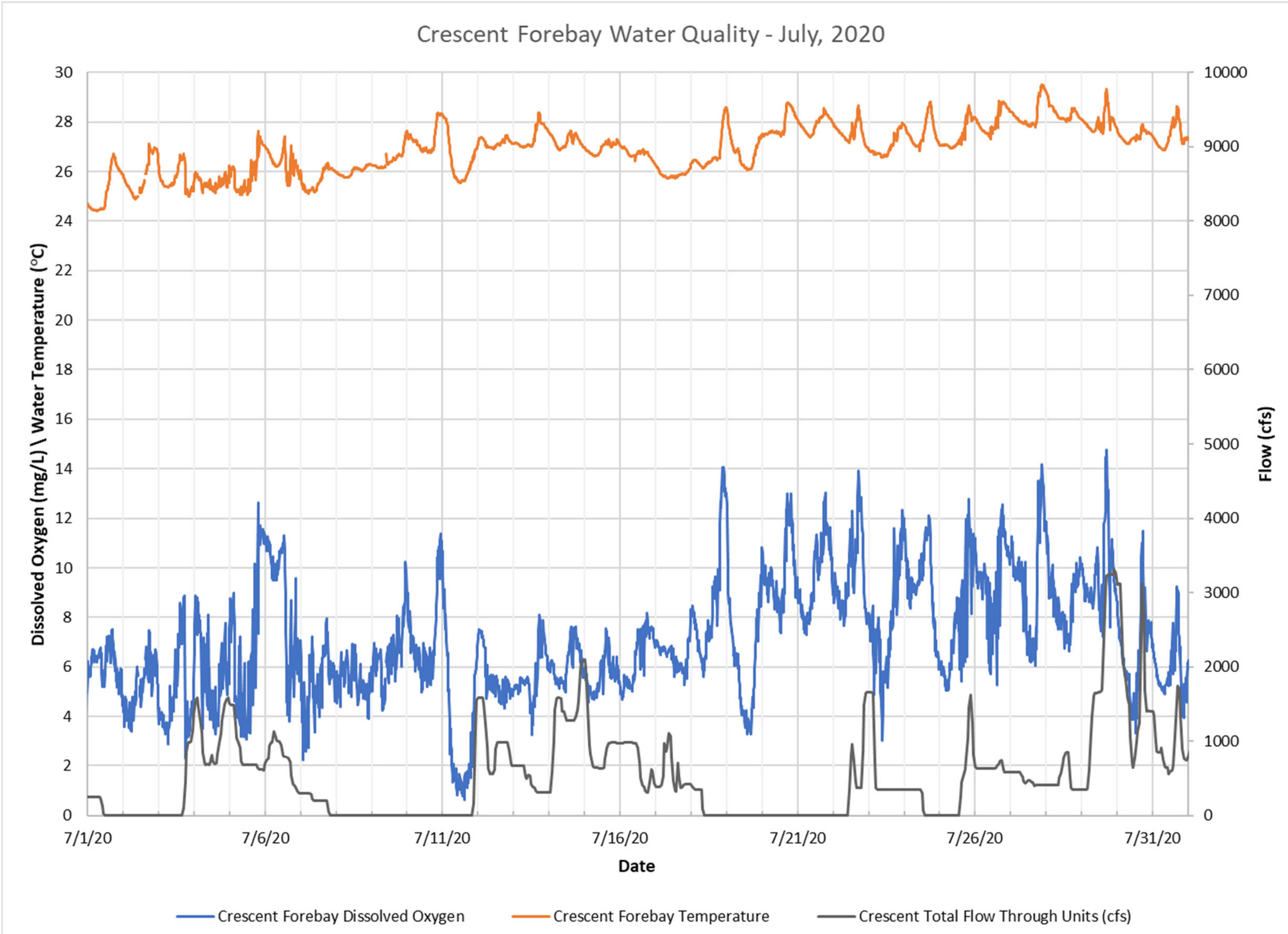


Figure 3.3.2-8: Crescent Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - August 2020

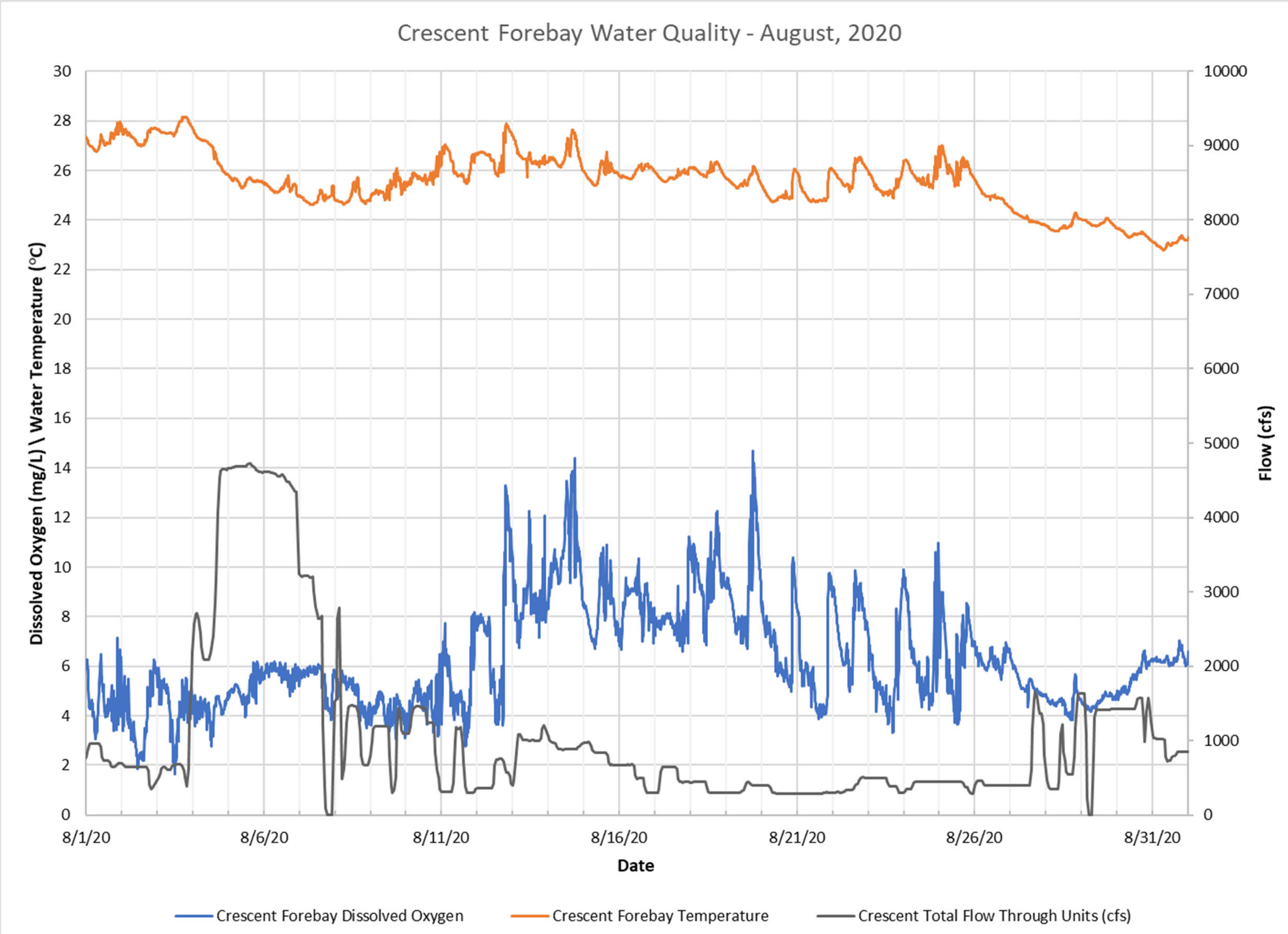


Figure 3.3.2-9: Crescent Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - September 2020

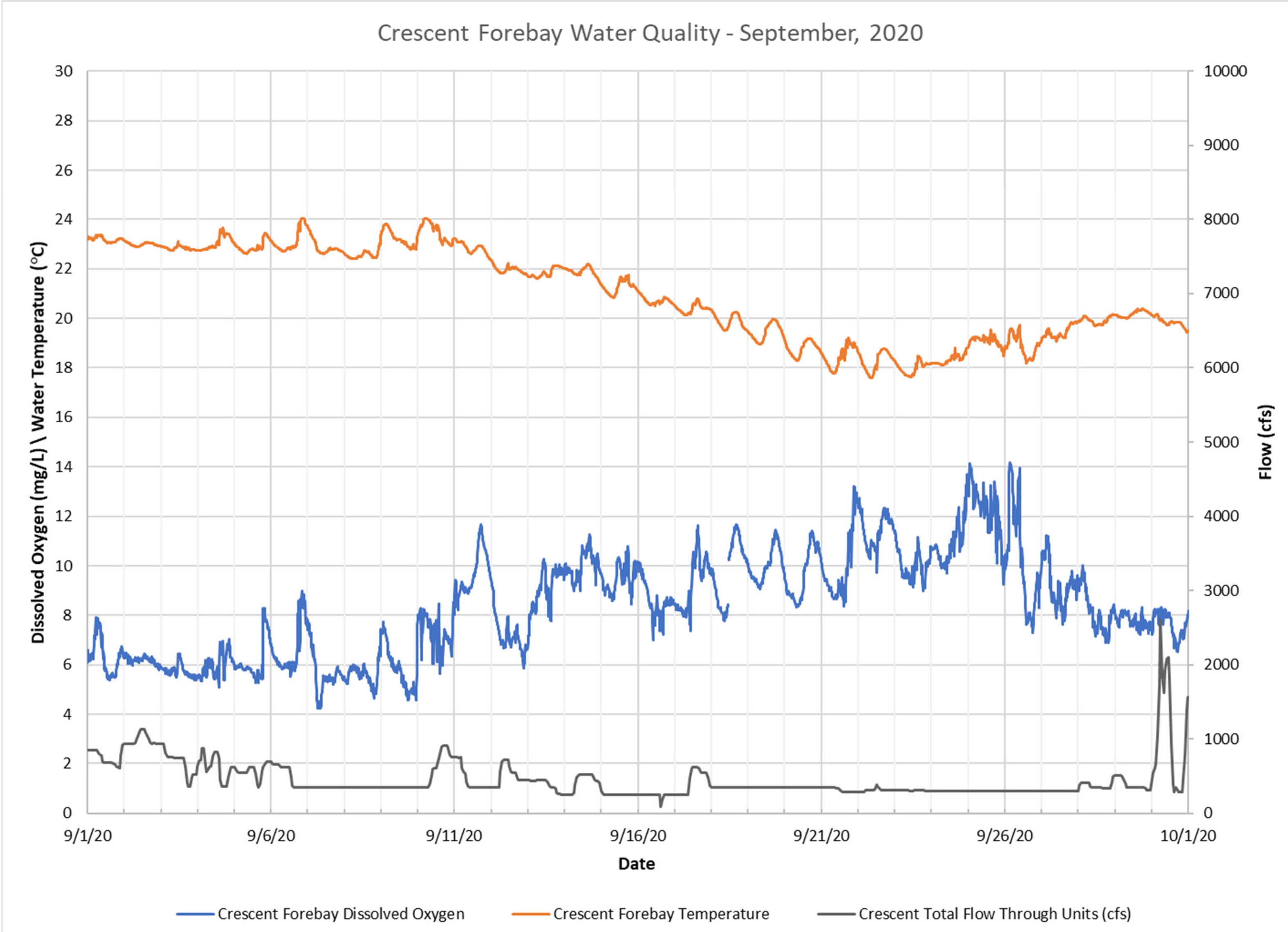


Figure 3.3.2-10: Crescent Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows – October 2020

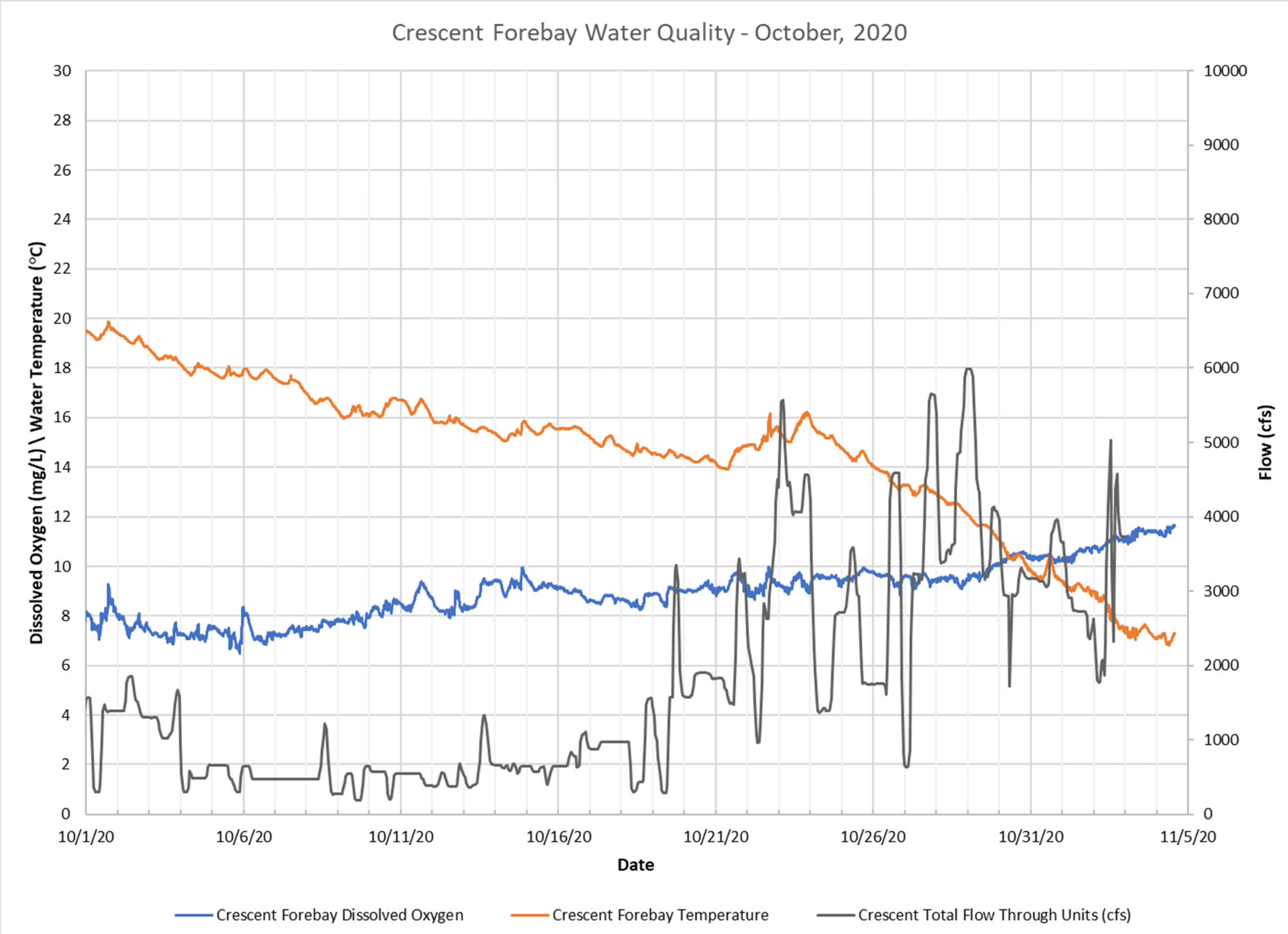


Figure 3.3.2-11: Vischer Ferry Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - June 2020

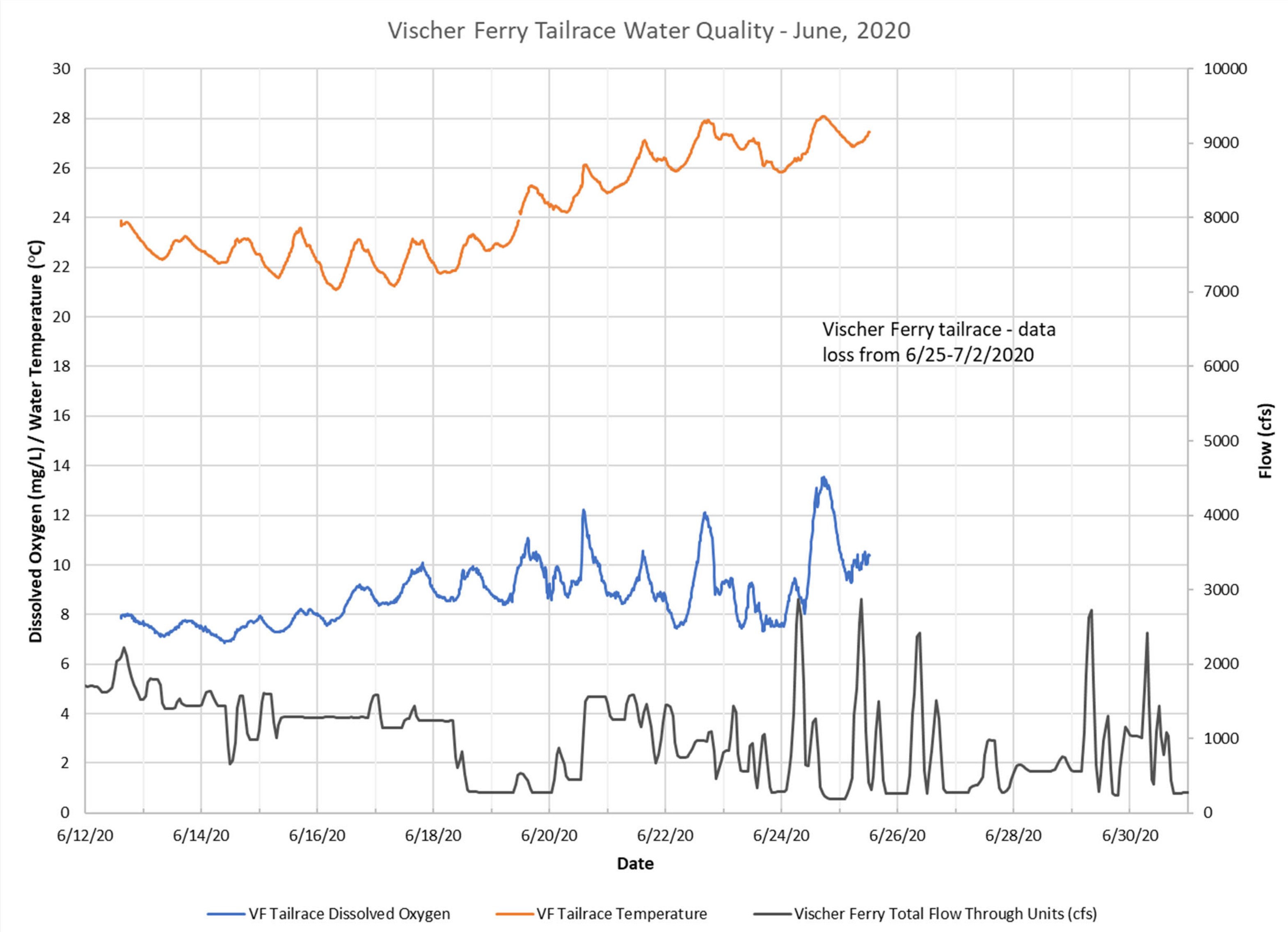


Figure 3.3.2-12: Vischer Ferry Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - July 2020

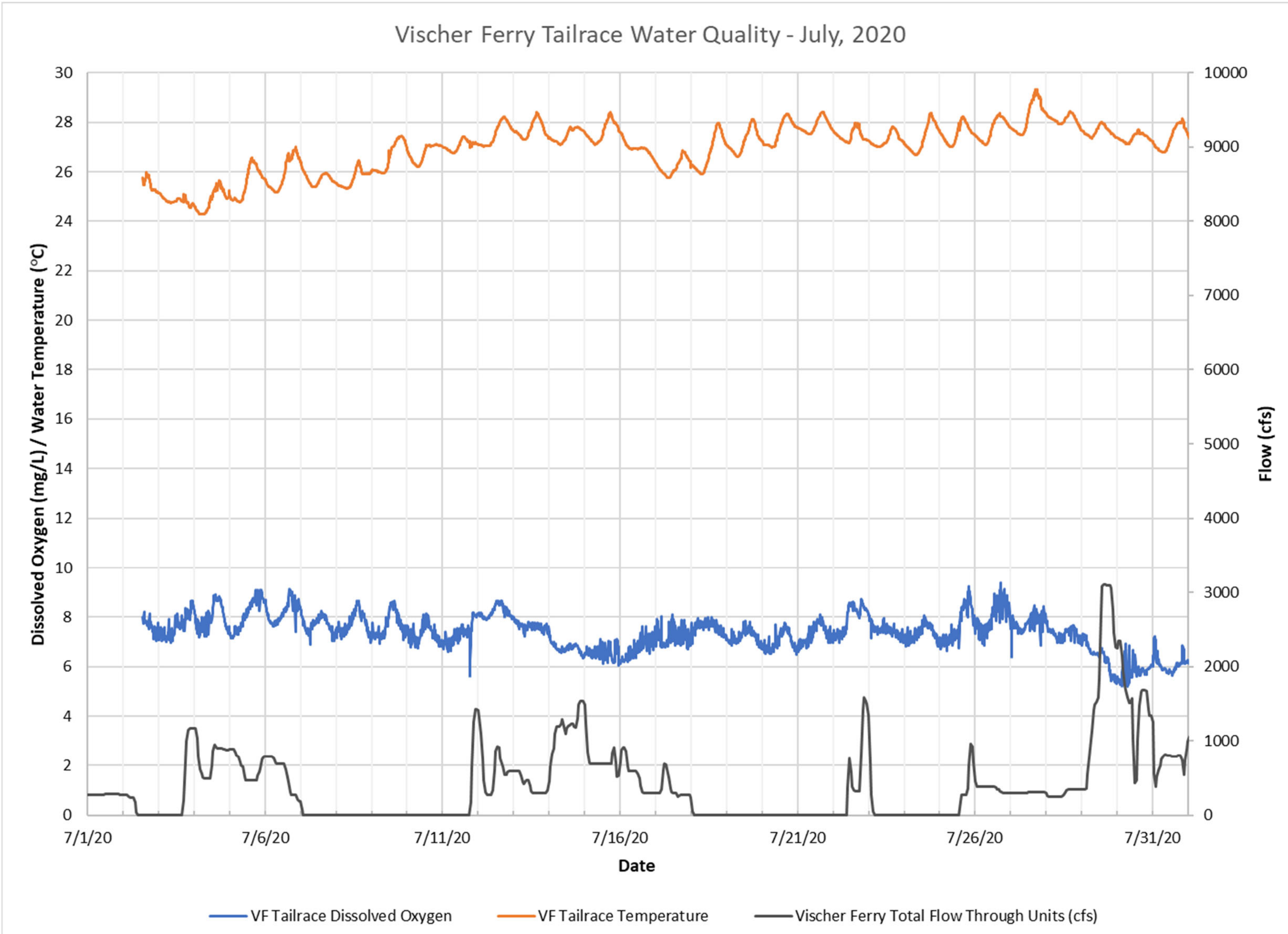


Figure 3.3.2-13: Vischer Ferry Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - August 2020

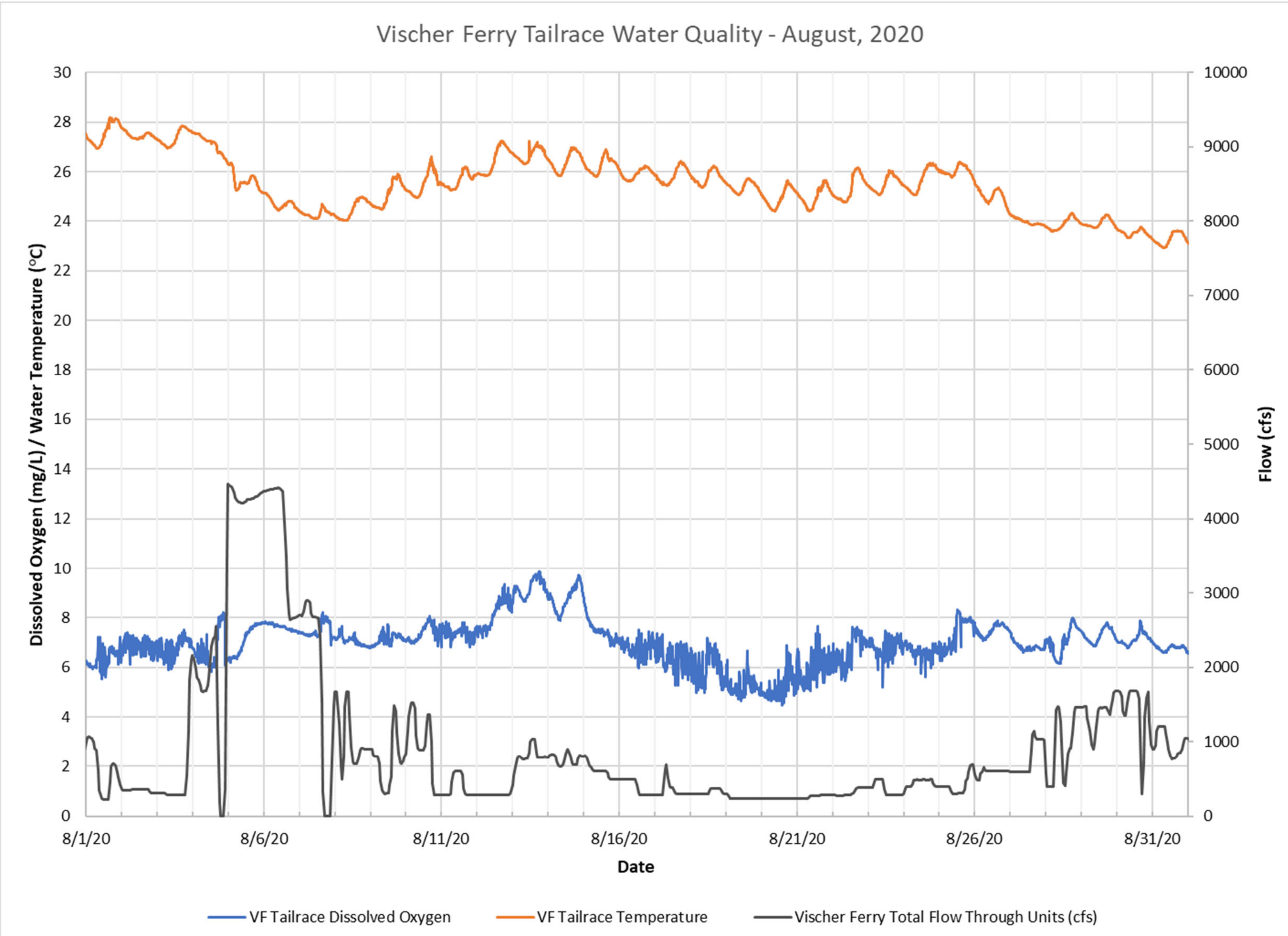


Figure 3.3.2-14: Vischer Ferry Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows – Sep 2020

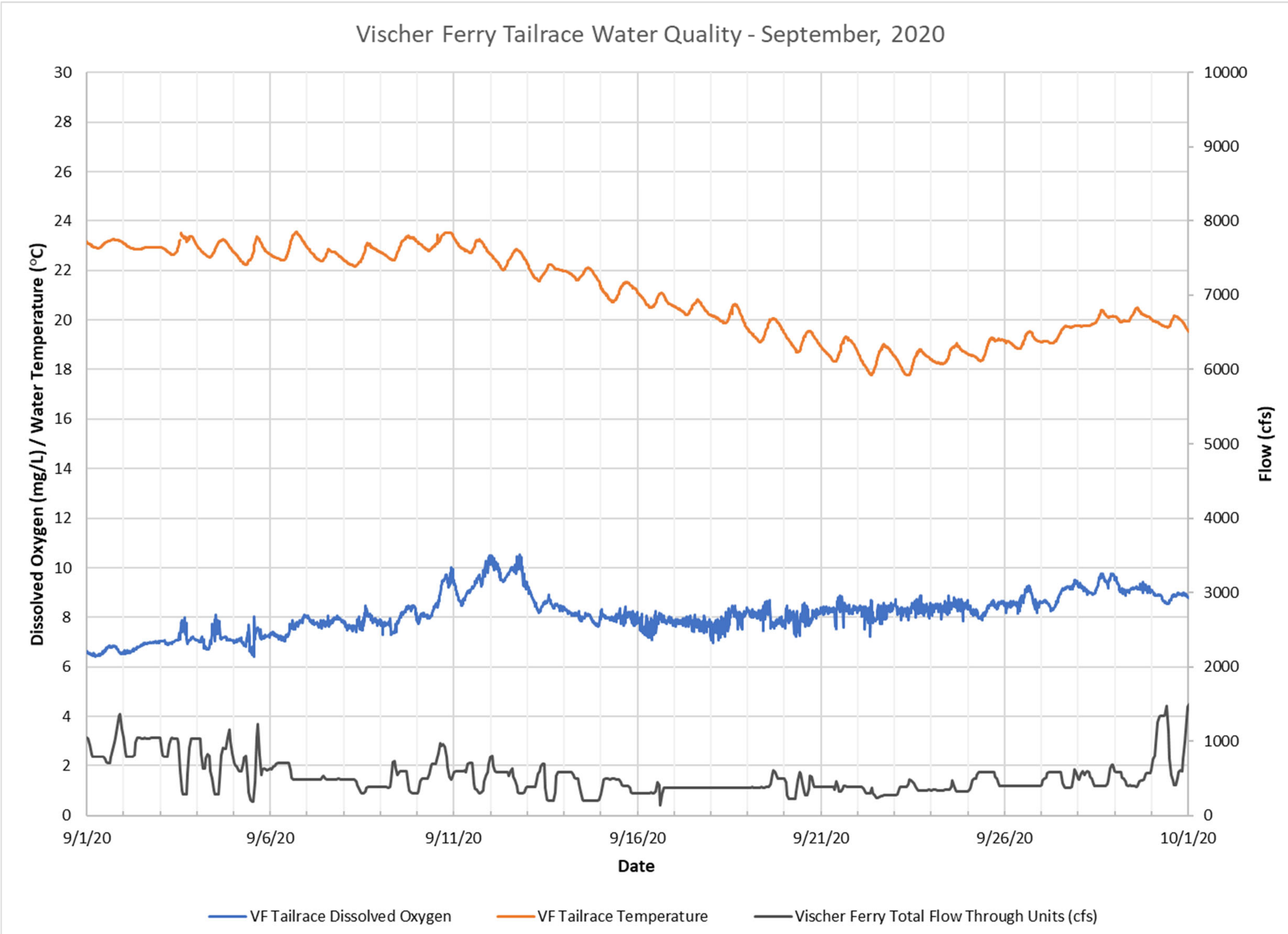


Figure 3.3.2-15: Vischer Ferry Tailrace Dissolved Oxygen and Water Temperature with Turbine Outflows - October 2020

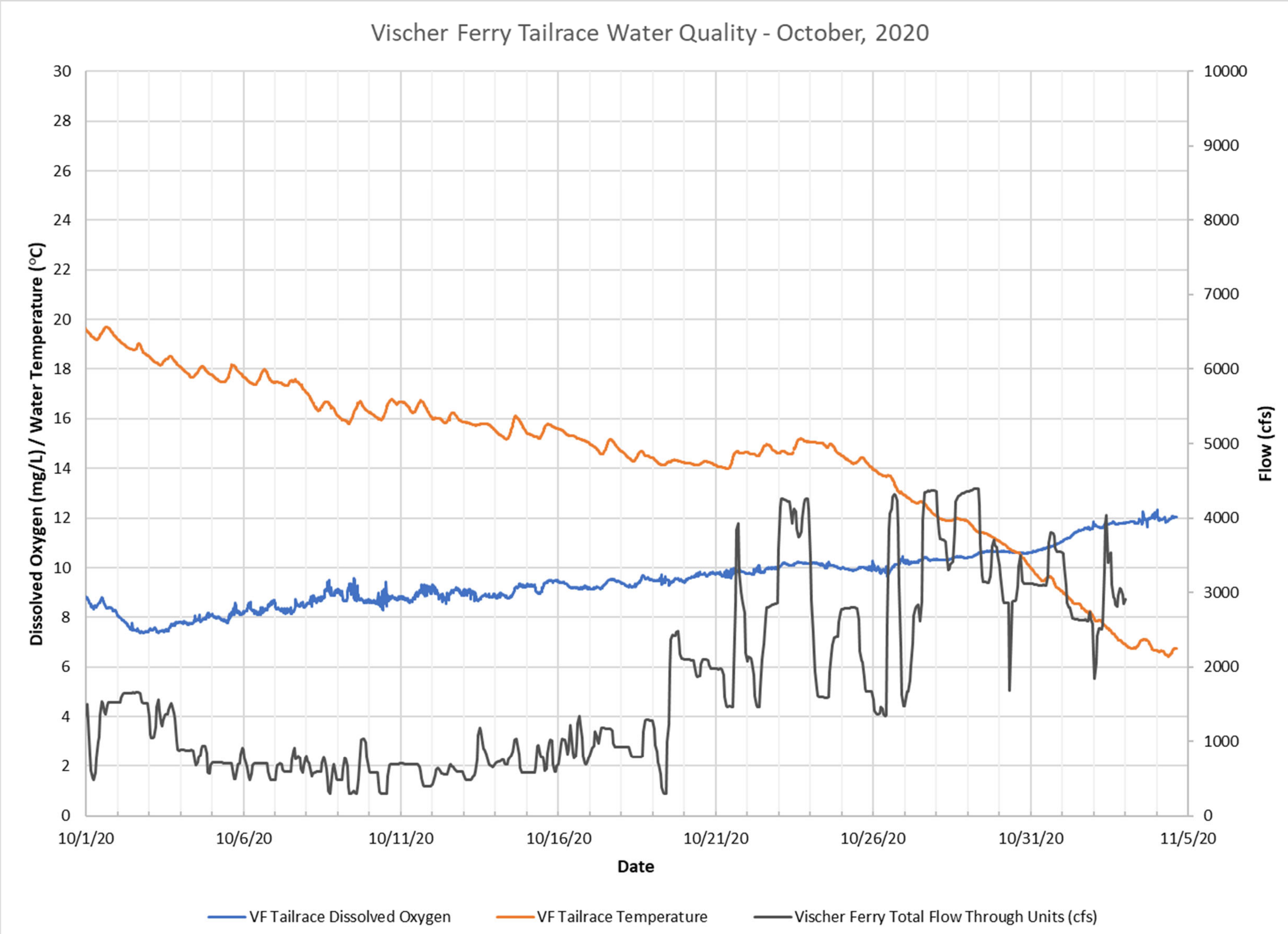


Figure 3.3.2-16: Vischer Ferry Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - June 2020

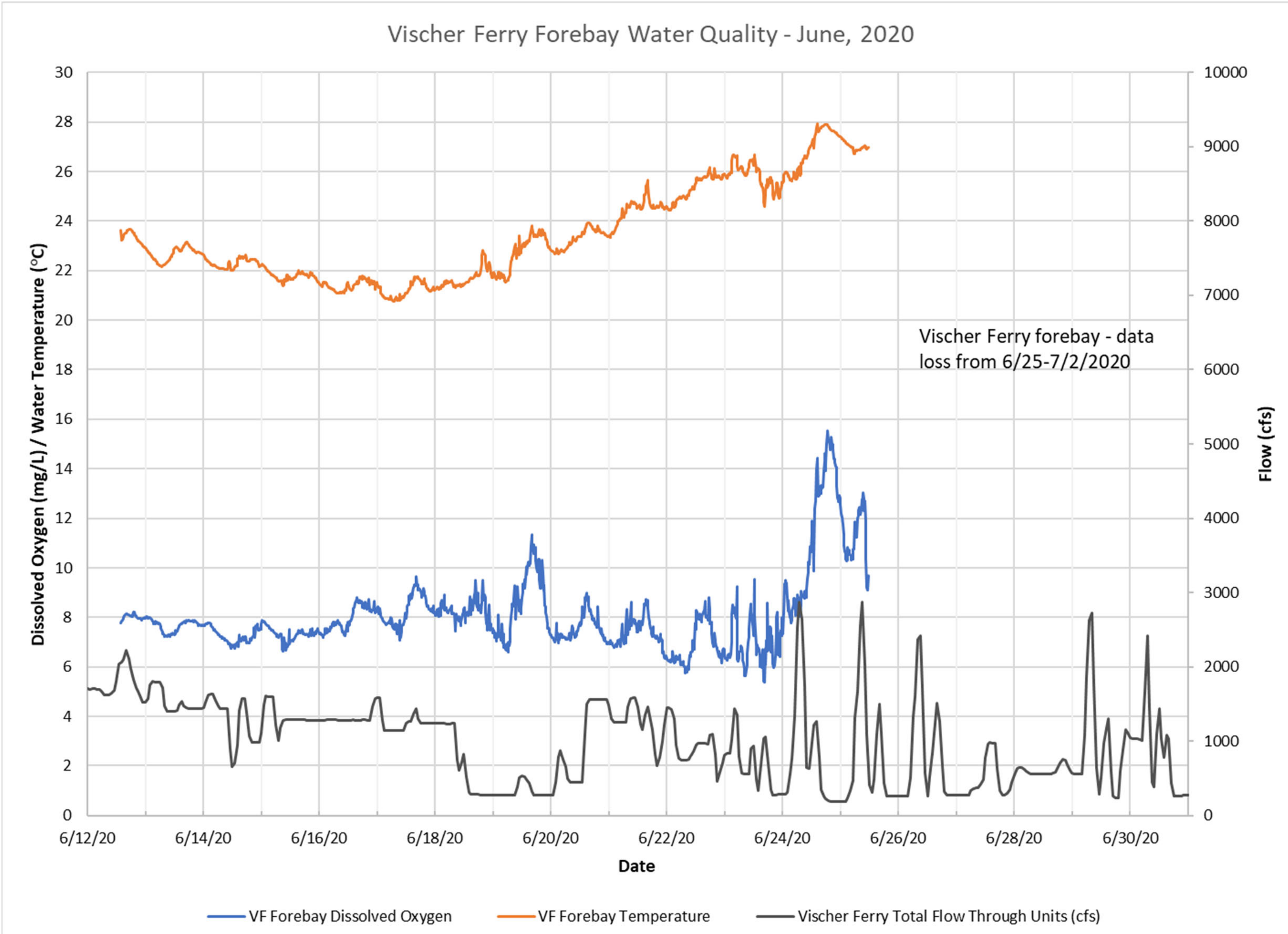


Figure 3.3.2-17: Vischer Ferry Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - July 2020

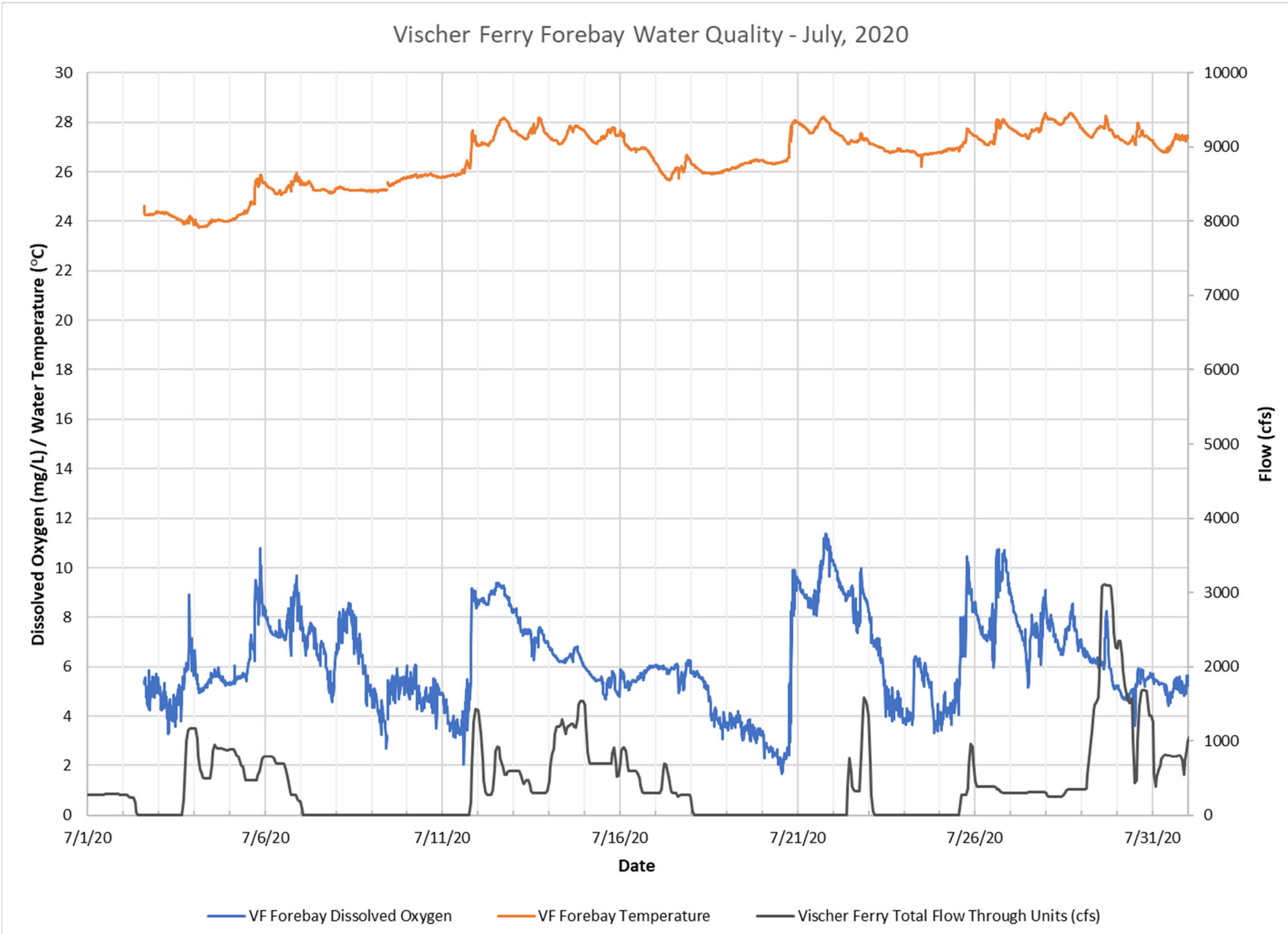


Figure 3.3.2-18: Vischer Ferry Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - August 2020

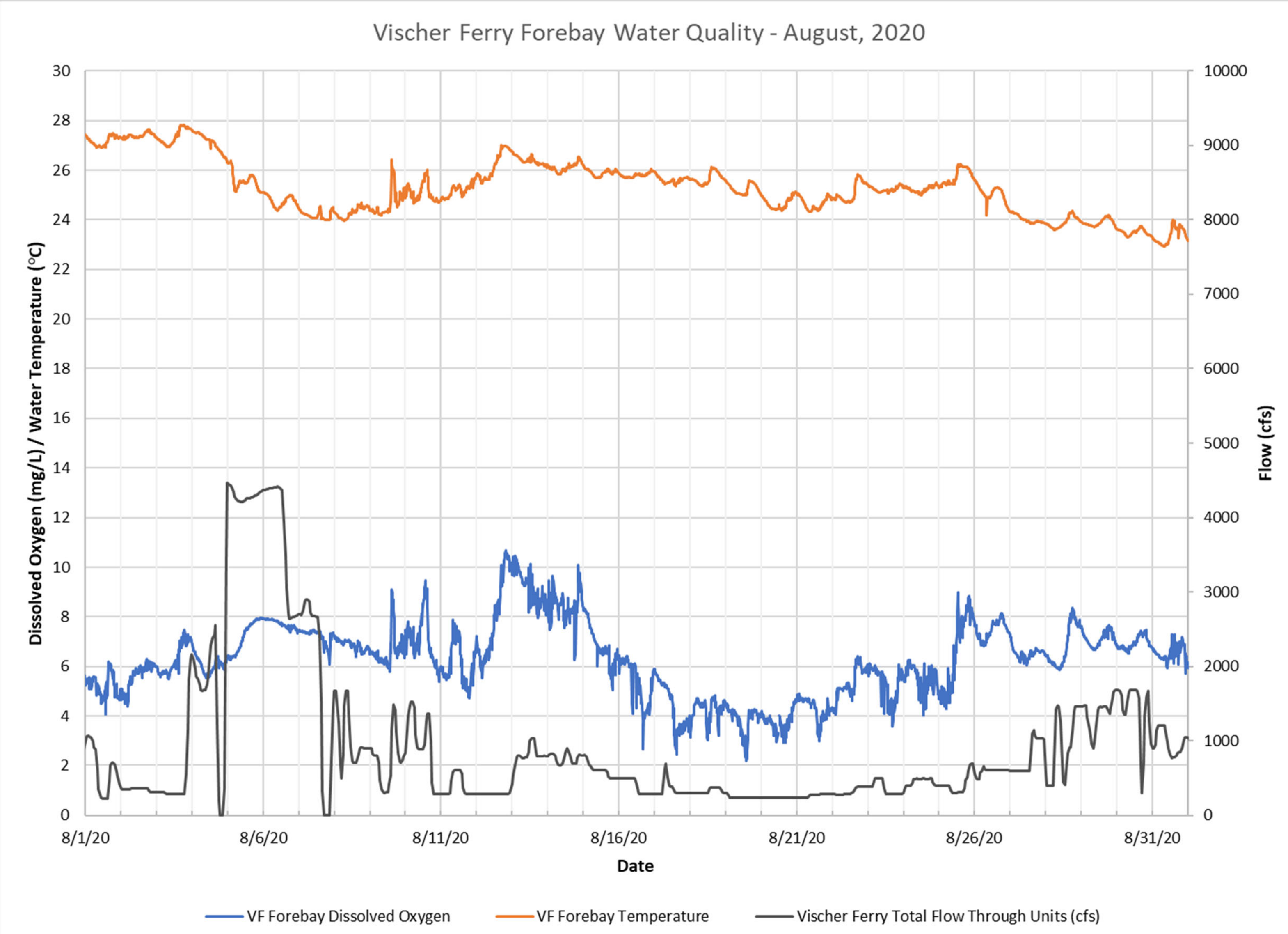


Figure 3.3.2-19: Vischer Ferry Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - Sep 2020

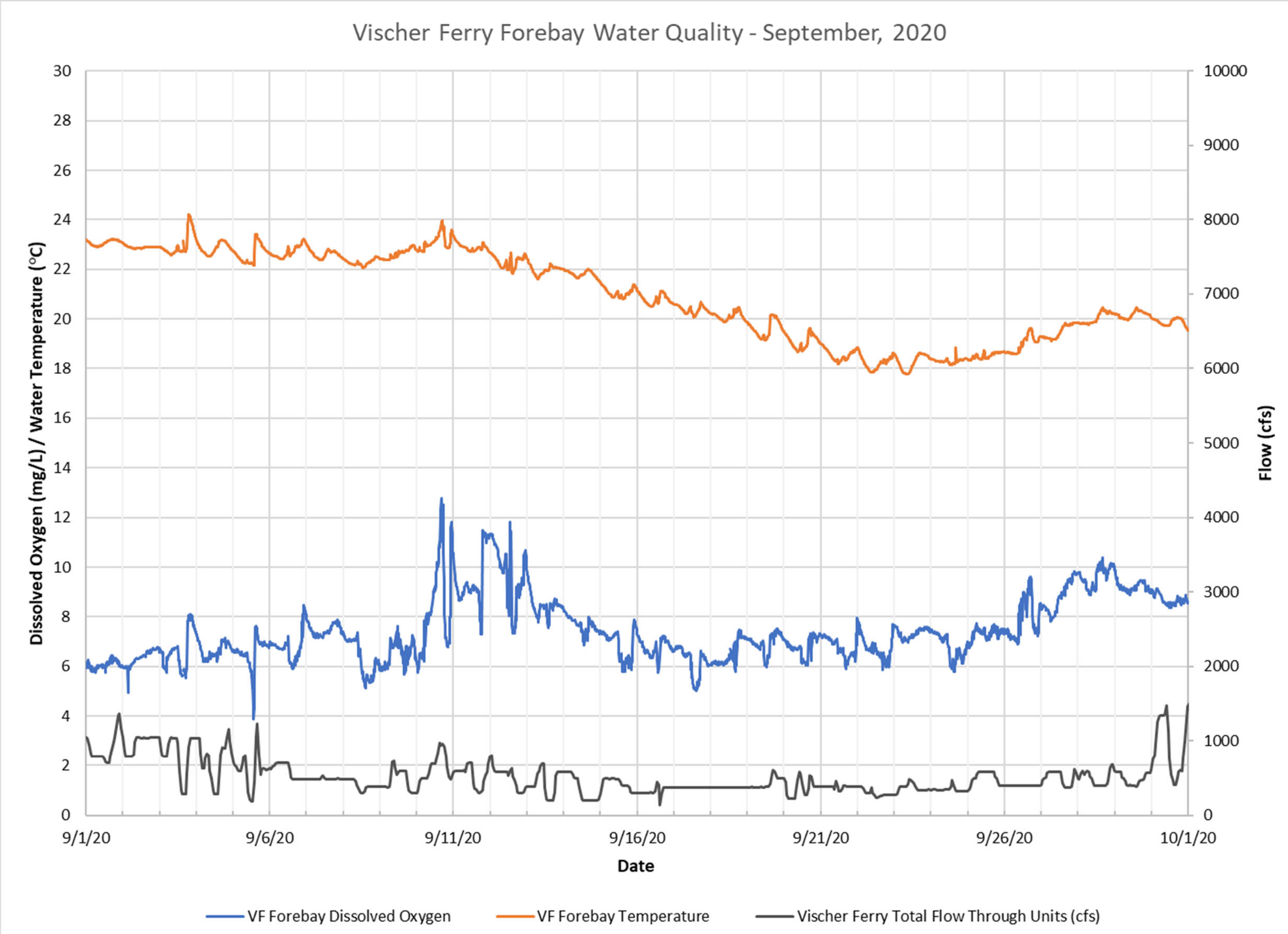


Figure 3.3.2-20: Vischer Ferry Forebay Dissolved Oxygen and Water Temperature with Turbine Outflows - October 2020

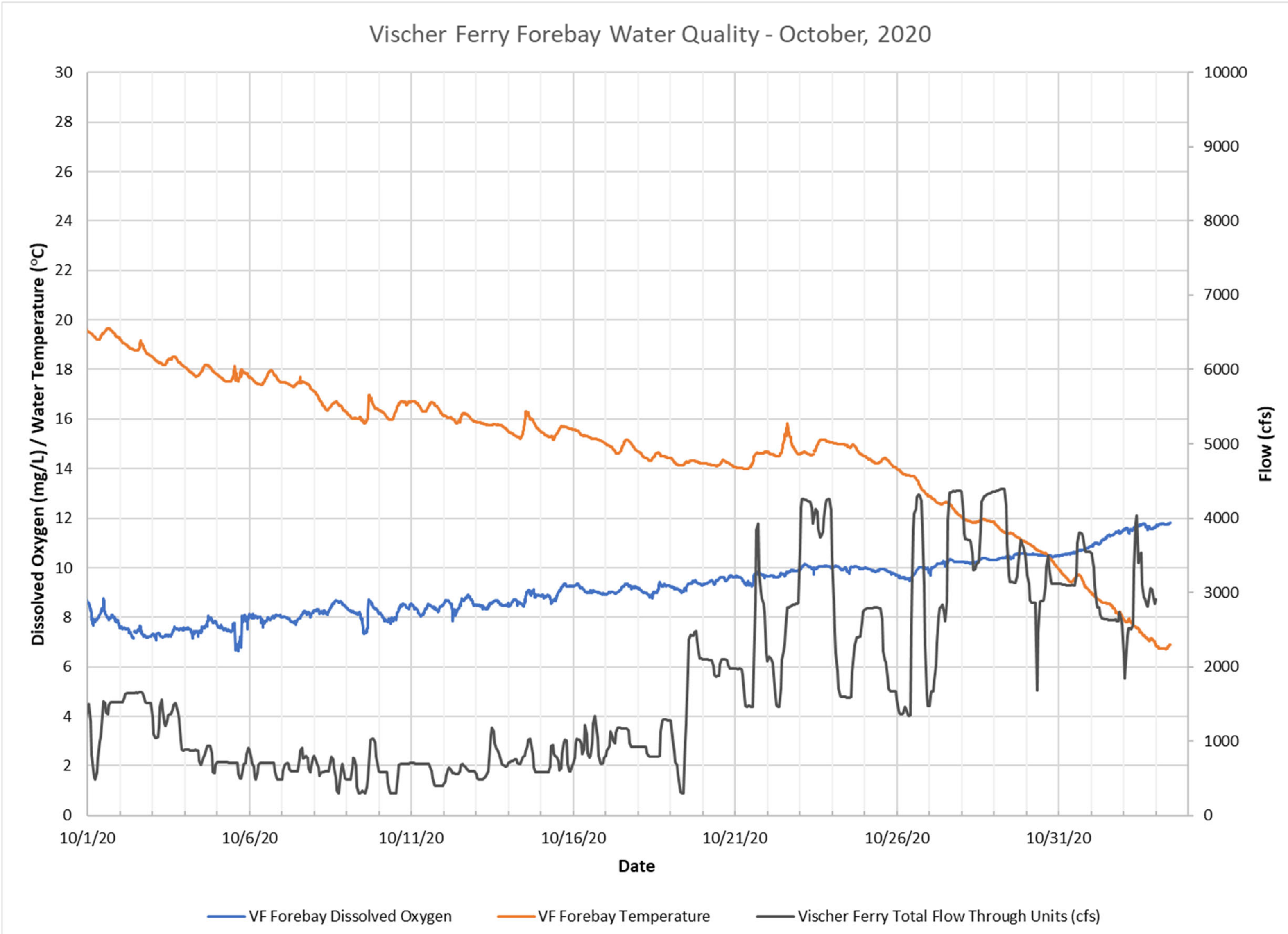


Figure 3.4-1: Temperature and Dissolved Oxygen Vertical Profiles at All Sites

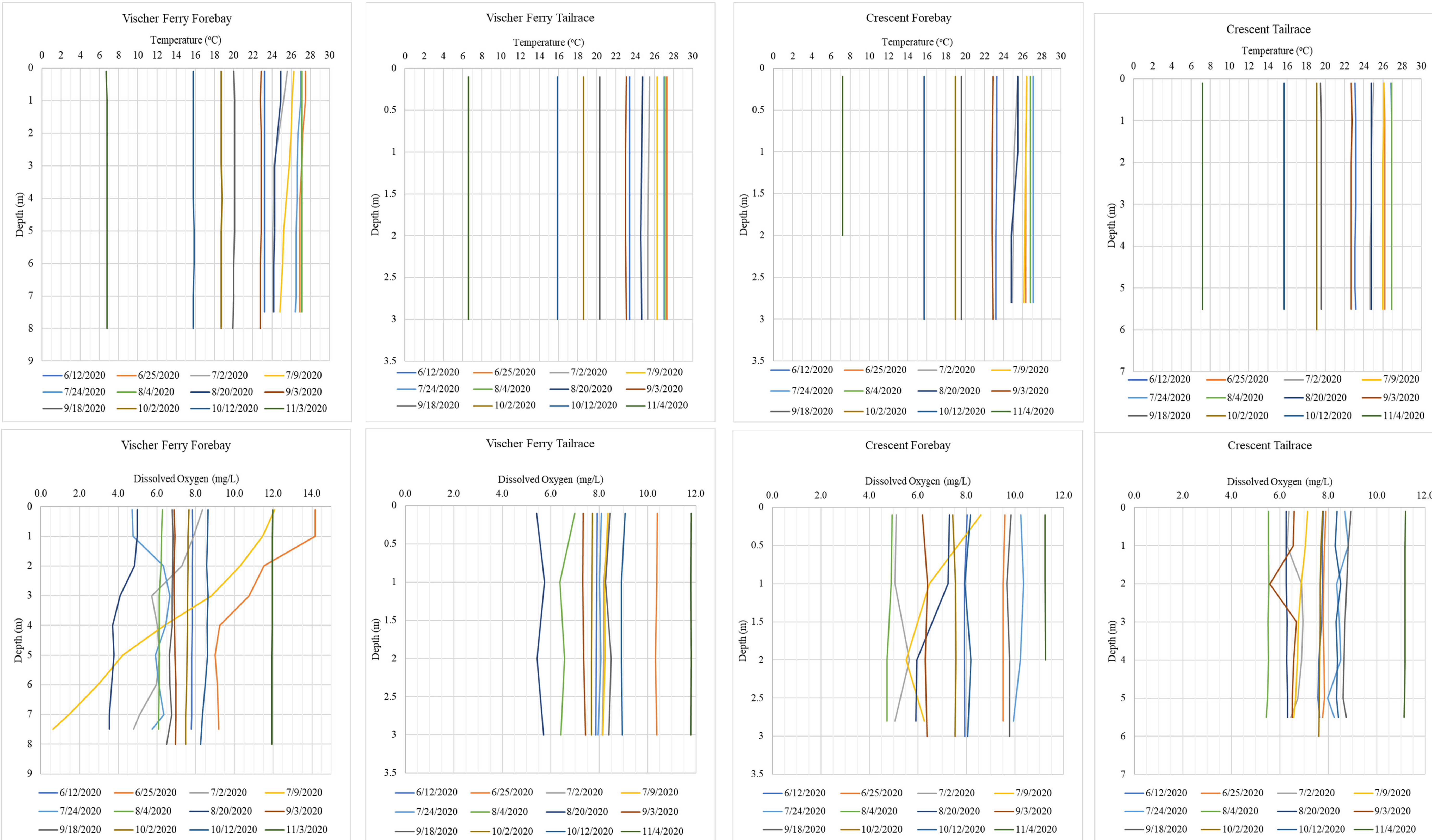


Figure 3.4-2: pH and Conductivity Vertical Profiles at All Sites

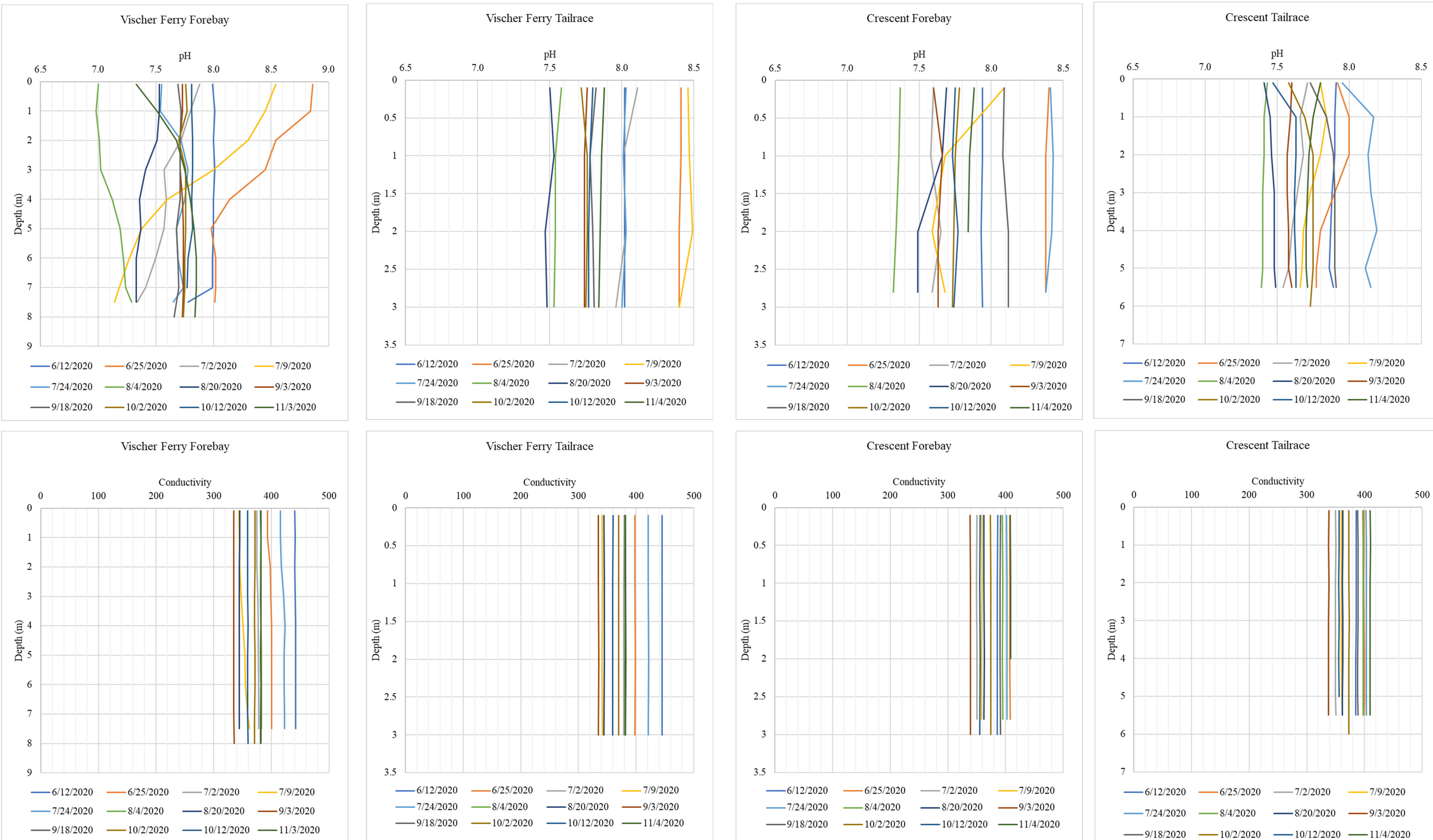
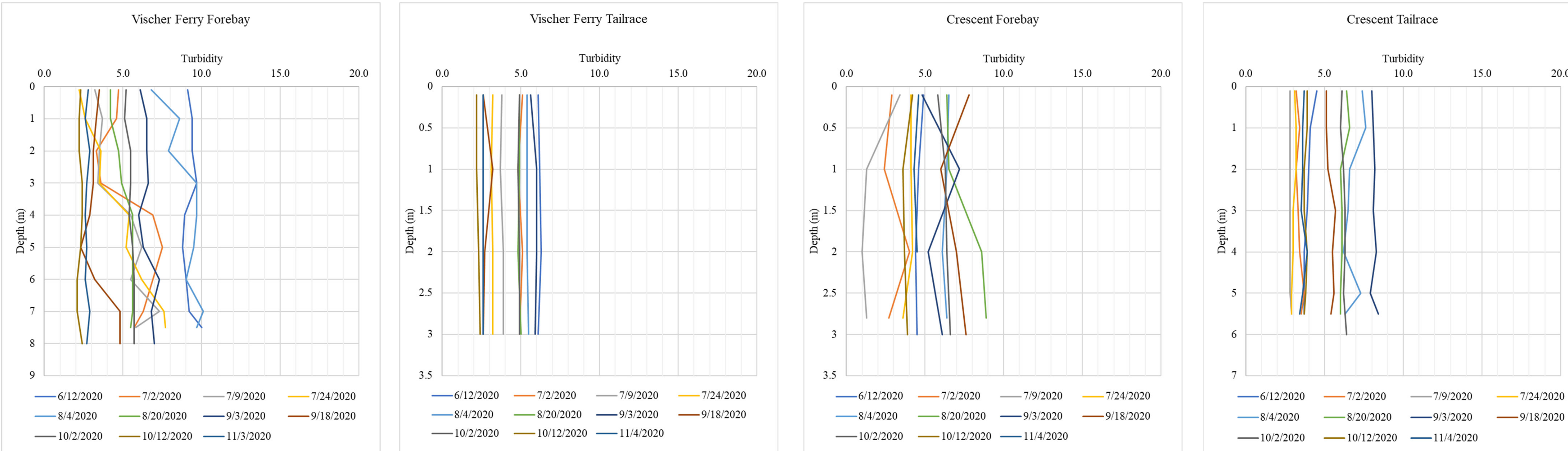


Figure 3.4-3: Turbidity Vertical Profiles at All Sites



Notes: Turbidity data from 6/25/2020 rejected.

Data for all vertical profile charts located in Appendix B.

Figure 3.4-4a: Vischer Ferry Forebay Vertical Temperature Isopleth

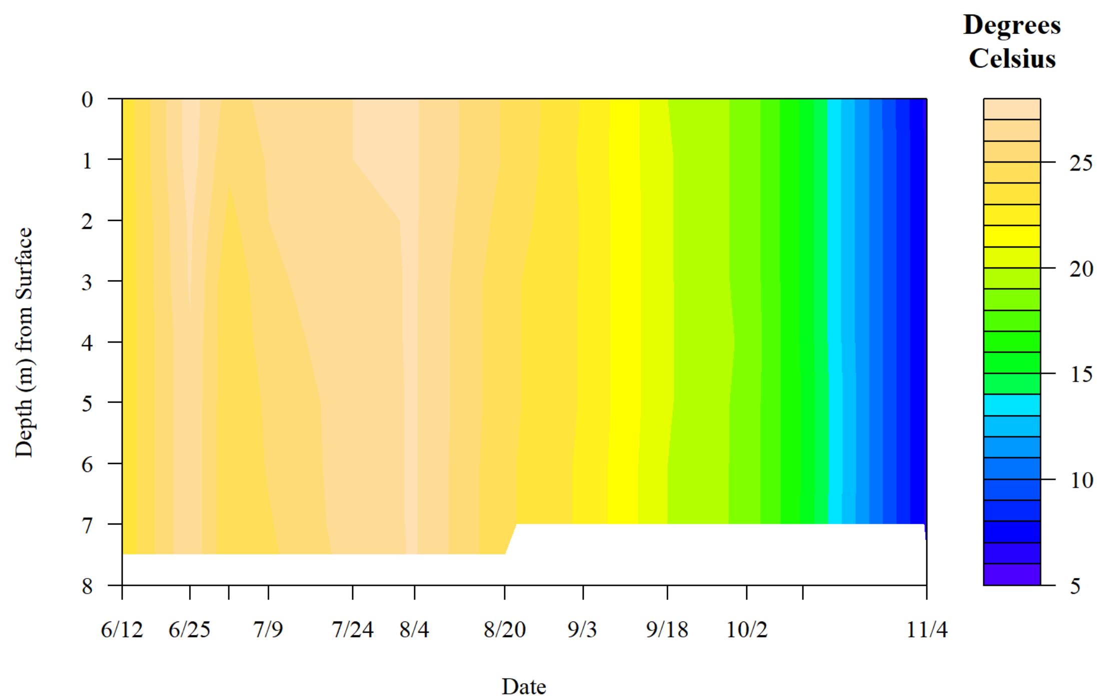


Figure 3.4-4c: Vischer Ferry Forebay Vertical Dissolved Oxygen Isopleth

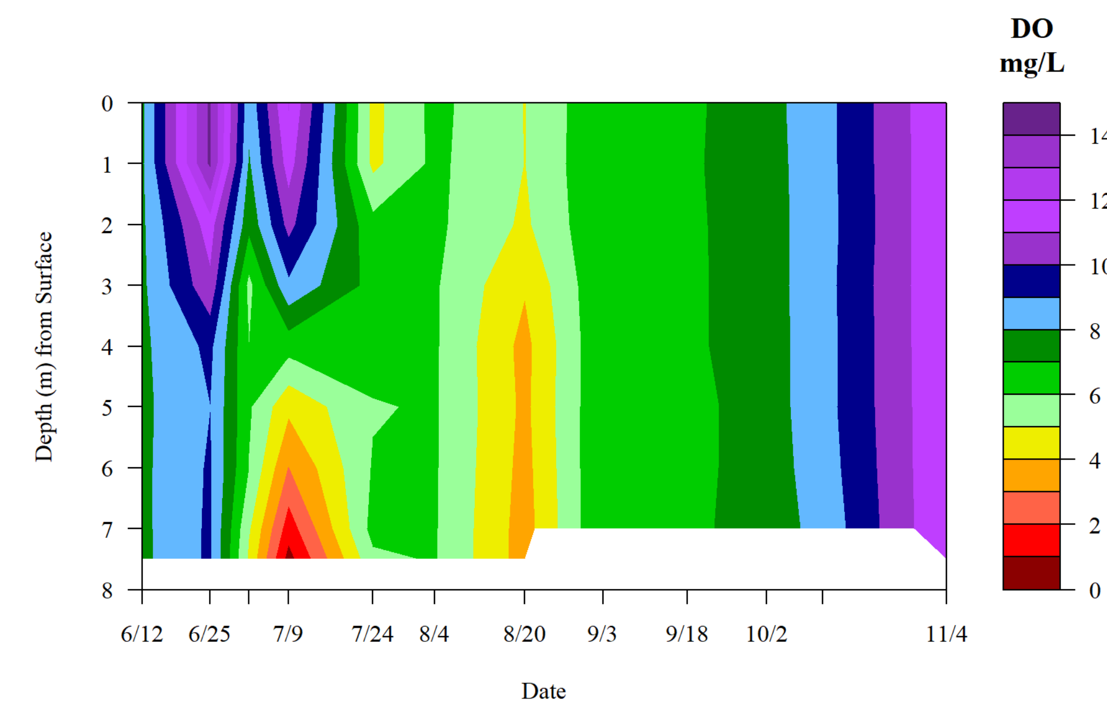


Figure 3.4-4b: Vischer Ferry Tailrace Vertical Temperature Isopleth

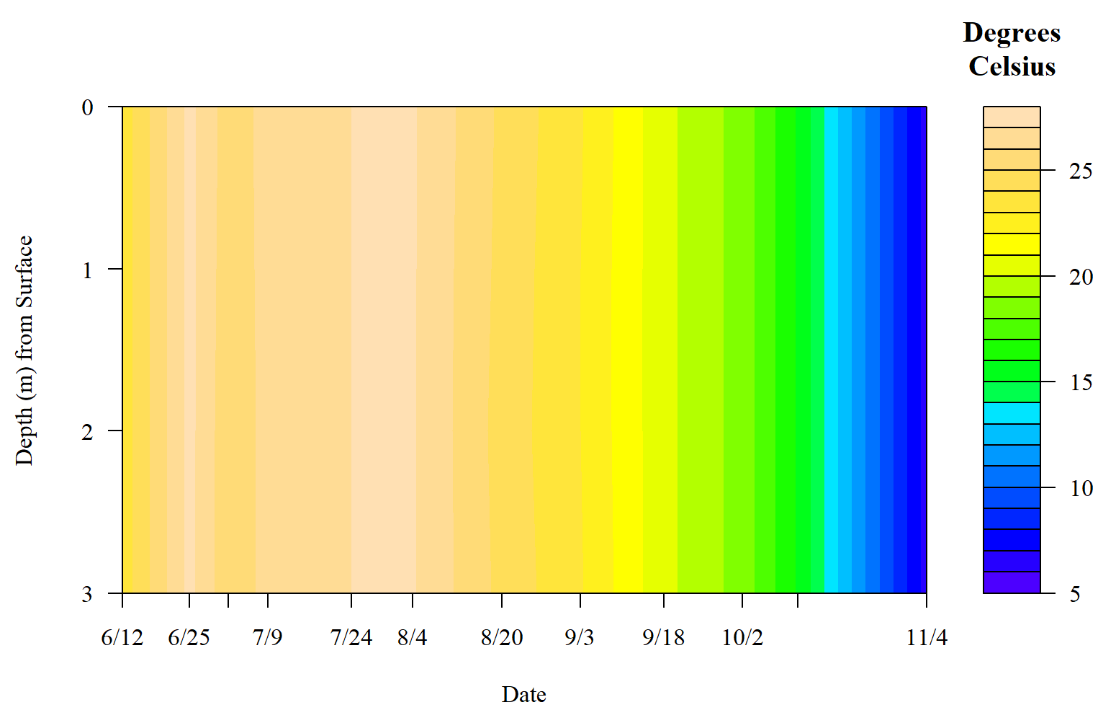


Figure 3.4-4d: Vischer Ferry Tailrace Vertical Dissolved Oxygen Isopleth

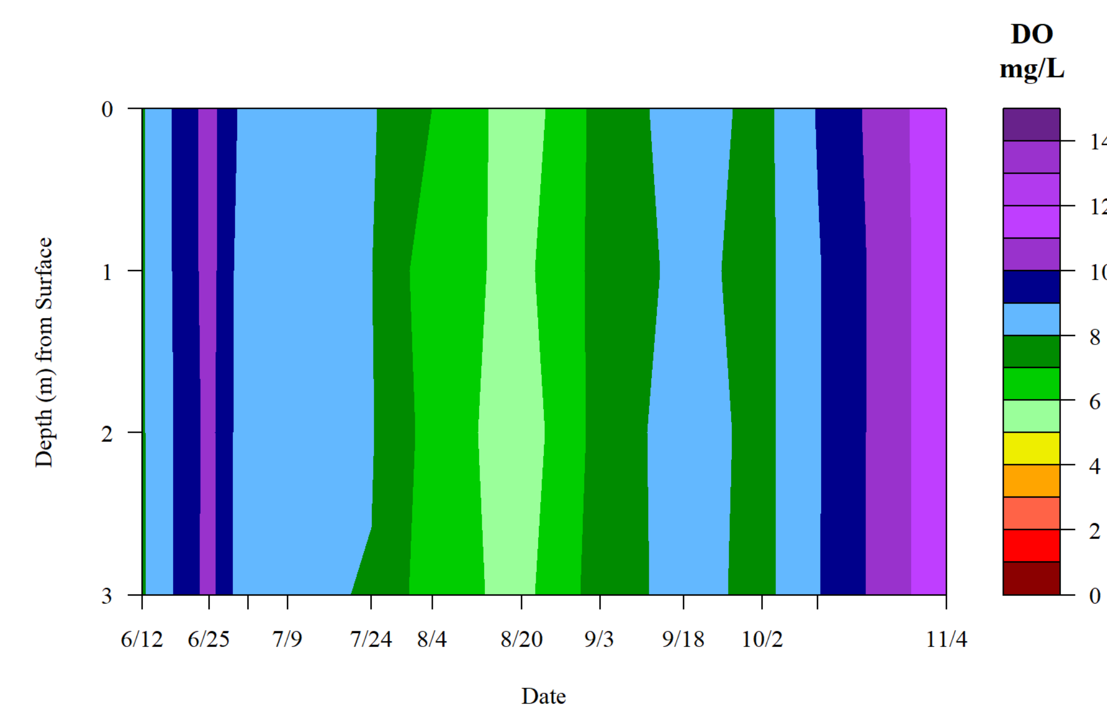


Figure 3.4-5a: Crescent Forebay Vertical Temperature Isopleth

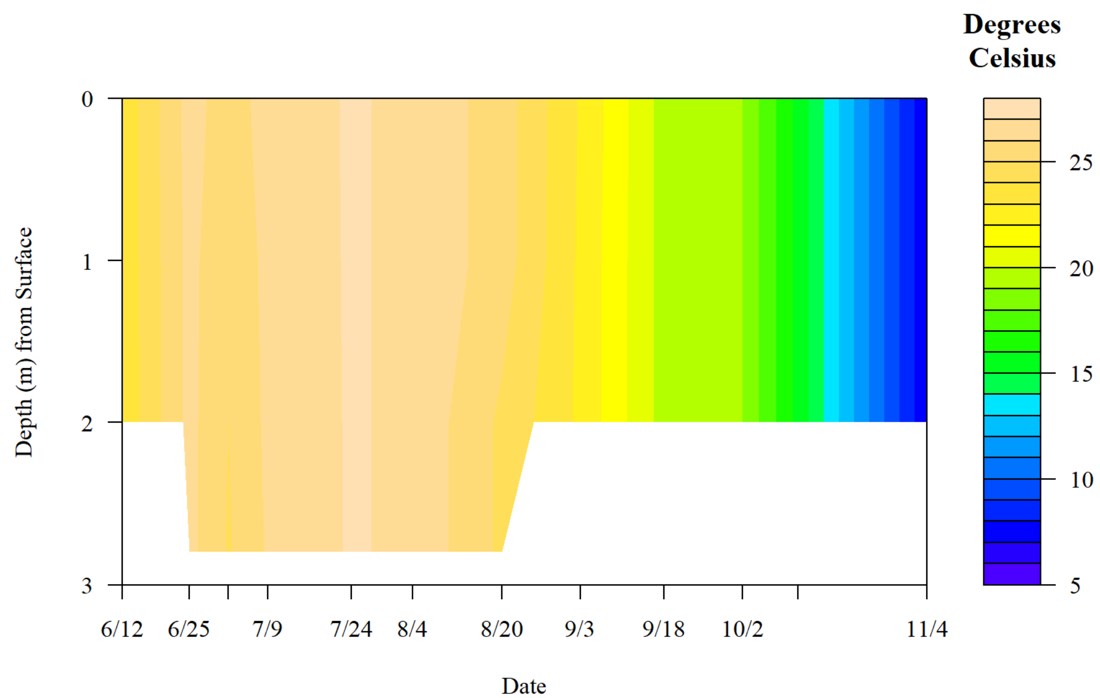


Figure 3.4-5b: Crescent Tailrace Vertical Temperature Isopleth

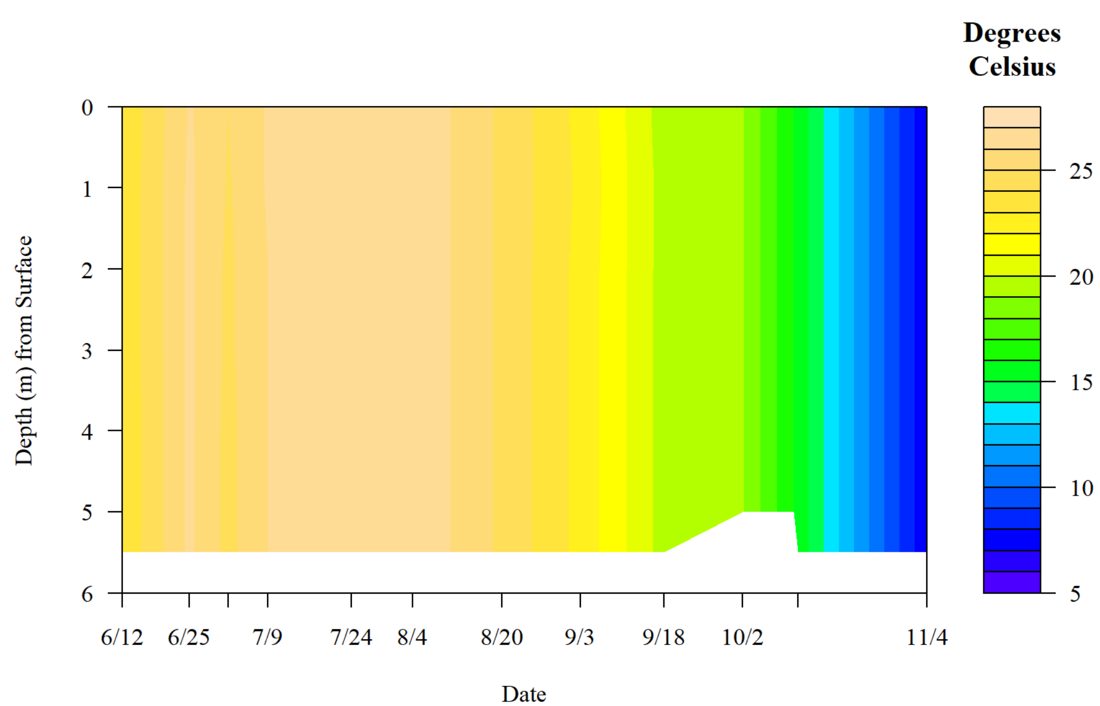


Figure 3.4-5c: Crescent Forebay Vertical Dissolved Oxygen Isopleth

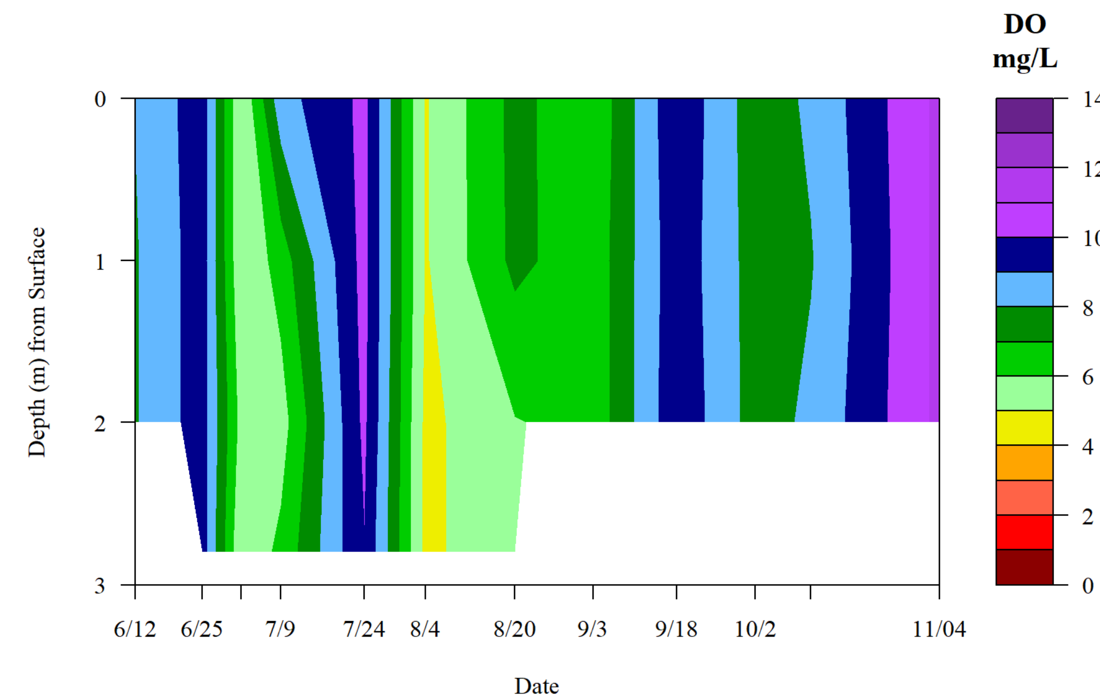
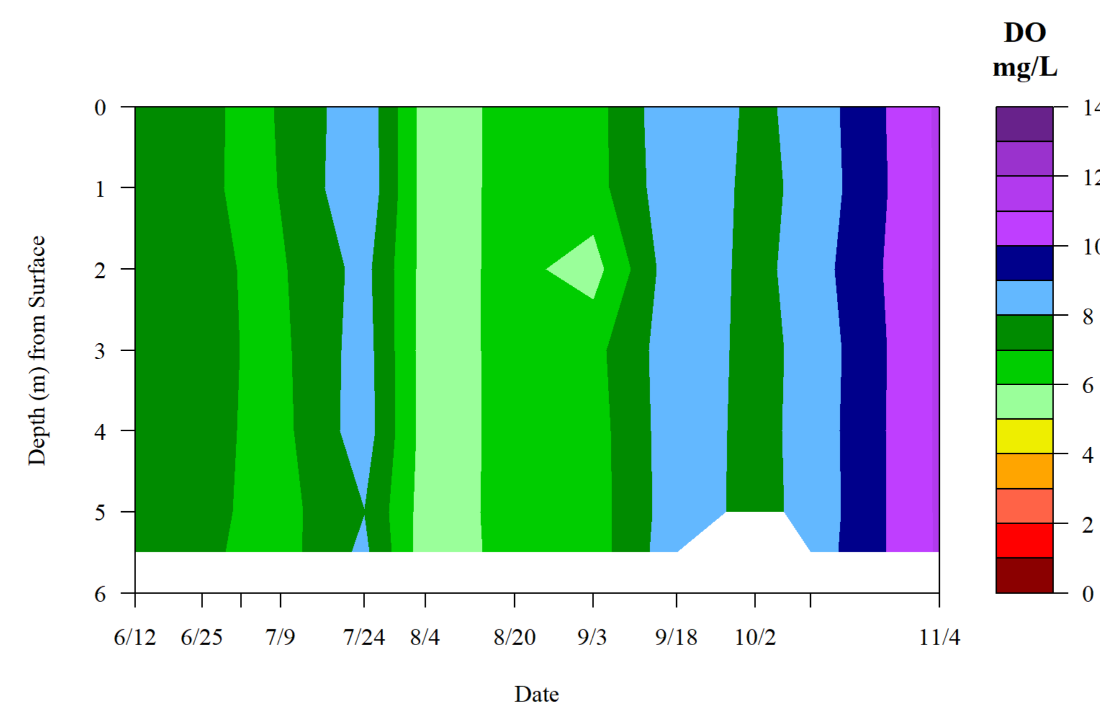


Figure 3.4-5d: Crescent Tailrace Vertical Dissolved Oxygen Isopleth



4 Summary and Discussion

The goals of this study are to 1) evaluate the effects, if any, of each Project on water quality, and 2) to determine if water quality in the Project vicinity is in compliance with NYS water quality standards. The study goals achieved the objectives stated in the RSP. Continuous dissolved oxygen and water temperature data were collected during the summer and early fall months in 2020. The monitoring period captured low flow, and high air and water temperature conditions in the area of the Projects. This is the period when low DO levels are most likely to occur in waters released through the Projects. The study also achieved the objective of characterizing additional water quality conditions at each Project by collecting data on pH, conductivity, and turbidity in the Project impoundments and tailwater locations.

The monitoring period was initiated later than the May 1 start date envisioned in the RSP. Due to the global pandemic, the monitoring program was delayed while safety and access measures were determined. During the 2020 water quality monitoring period (June 12 – November 4, 2020), the Project turbines were generally run at low levels in the summer months due to lower river inflows. There were periods during July when inflows were too low to run any of the turbines at the Projects for several days; the turbines were off-line, and flow was passed over the dams during these periods. Flows in the Mohawk River were generally at or below normal during the monitoring period with a few exceptions. A high flow event during early August was also captured.

The study successfully collected baseline water quality information for Crescent and Vischer Ferry Projects. Water quality data were collected at the Projects under a range of environmental and operational conditions, including high temperature and low flow periods. Key findings from this study are summarized below.

Water temperatures at the Projects displayed very similar patterns at all sites throughout the study period. Throughout June, water temperatures warmed steadily at all sites and remained above 25 °C for most of July. The maximum water temperatures among all sites were observed in July and ranged from 28.4 °C to 29.5 °C. Water temperatures cooled in early August in response to heavy precipitation and increased river flows. There was no evidence of thermal stratification at any monitoring location. The temperature was well mixed from top to bottom at each site. Both the continuous and vertical profile data demonstrated that water temperatures were consistent at the Forebay and Tailrace sites at each Project. There were no apparent effects of Project operations on water temperature.

Additional parameters collected on a bi-weekly basis (pH, conductivity and turbidity) also displayed similarities among the monitoring sites. These parameters measured in the Forebay and Tailrace sites at each Project were generally consistent from top to bottom and the Tailrace values were similar to those measured concurrently in the Forebay. There were no apparent effects of Project operations on these parameters. On two occasions in the Vischer Ferry Forebay elevated pH values were measured in the top layer of the water column. These elevated pH values were likely affected by photosynthetic processes in the impoundment.

The bi-weekly vertical profiles collected during the study demonstrated that the DO values in both Project tailraces remain consistent from top to bottom. The Vischer Ferry Forebay site showed that DO levels can stratify when the turbines are not operating. DO stratification occurred on June 25 and July 9 when the turbines were off-line due to low river flows and low DO values were recorded in the deeper portions of the Forebay. At the Vischer Ferry Tailrace profile site, DO remained above 5.0 mg/L at all depths despite the lower DO at times in the Vischer Ferry Forebay. DO at the Crescent Tailrace site also remained above 5.0 mg/L during the biweekly profile measurements.

Continuous data collected from the Project Forebays showed that DO concentrations were highly irregular and erratic at times. At both Forebay sites, DO concentrations dropped below 4.0 mg/L in the months of July and August, but also experienced very high DO values at times, indicating the highly productive nature of aquatic plant growth in the Project impoundments.

Dissolved oxygen levels in the Project areas are influenced by natural aquatic plant production and organic processes in the Project impoundments as evidenced by the large daily fluctuations observed in the Project forebays. The Crescent Project impoundment appears more affected by this natural variation than Vischer Ferry. Large mats of floating aquatic vegetation (i.e., water chestnut) are abundant in each Project impoundment upstream of the Project intakes and these plants can contribute to variability in daily DO concentrations through respiration and photosynthesis. Decomposition of the water chestnut plants which die back each year can also result in reduced levels of dissolved oxygen in the water.

The Projects maintain minimum flows over the respective dams (200 cfs at Vischer Ferry and 250 cfs at Crescent). When the flow through the Forebays is low or when the turbines are off-line, the low (or lack of) inflows combined with natural plant decomposition activity (which consumes oxygen) results in lower DO values in the Project forebays.

Despite the lower DO at times in the forebays, the Project tailraces generally remain well oxygenated. DO in the Crescent Tailrace fell below 4.0 mg/L for two short periods (e.g., one 15 minute period on July 8 and the morning of July 11) when the Project turbines were off-line and all inflows were passed at the dam. DO data measured in the Vischer Ferry Tailrace was greater than 4.0 mg/L at all times. The average daily DO values in each tailrace were always greater than 5.0 mg/L. The layout of the Vischer Ferry Project is such that even when the turbines are off-line, the spillage at Vischer Ferry Dam reaches the tailrace area keeping DO levels sufficient. At the Crescent Project, when the turbines are off-line, the dam spillage at the Project mostly occurs on the opposite side of the river. This likely led to a short duration period when DO levels fell below 4.0 mg/L in the Crescent Tailrace when the Project was off-line. DO measured in the tailrace monitoring locations remained above 4.0 mg/L at all times when the Project turbines were operating.

5 Literature Cited

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Appendix A – Continuous Water Temperature and Dissolved Oxygen Data – All Sites, Monthly Charts

Figure A-1: Continuous Dissolved Oxygen Concentration at Crescent and Vischer Ferry Projects, June 2020

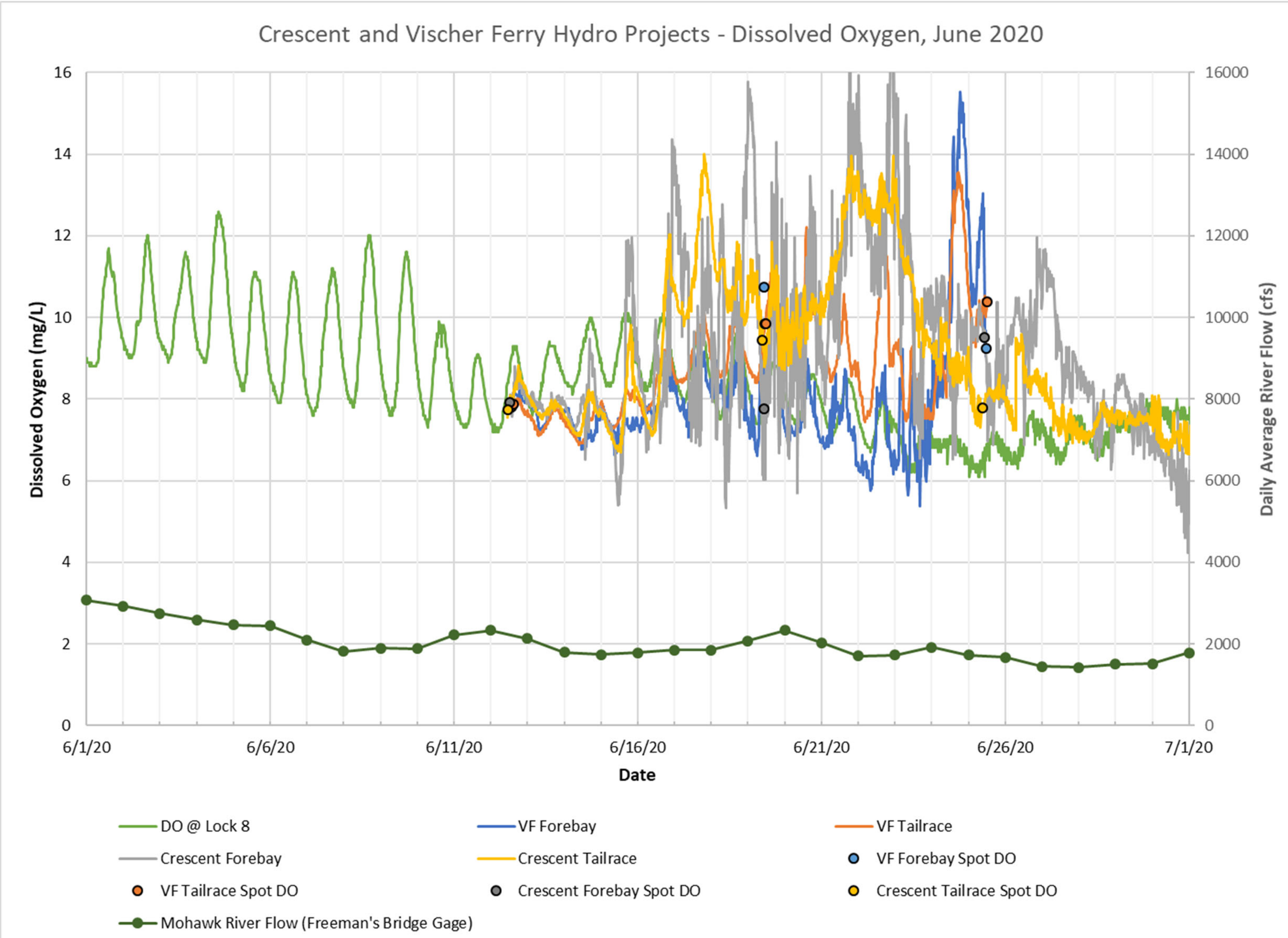


Figure A-2: Continuous Dissolved Oxygen Concentration at Crescent and Vischer Ferry Projects, July 2020

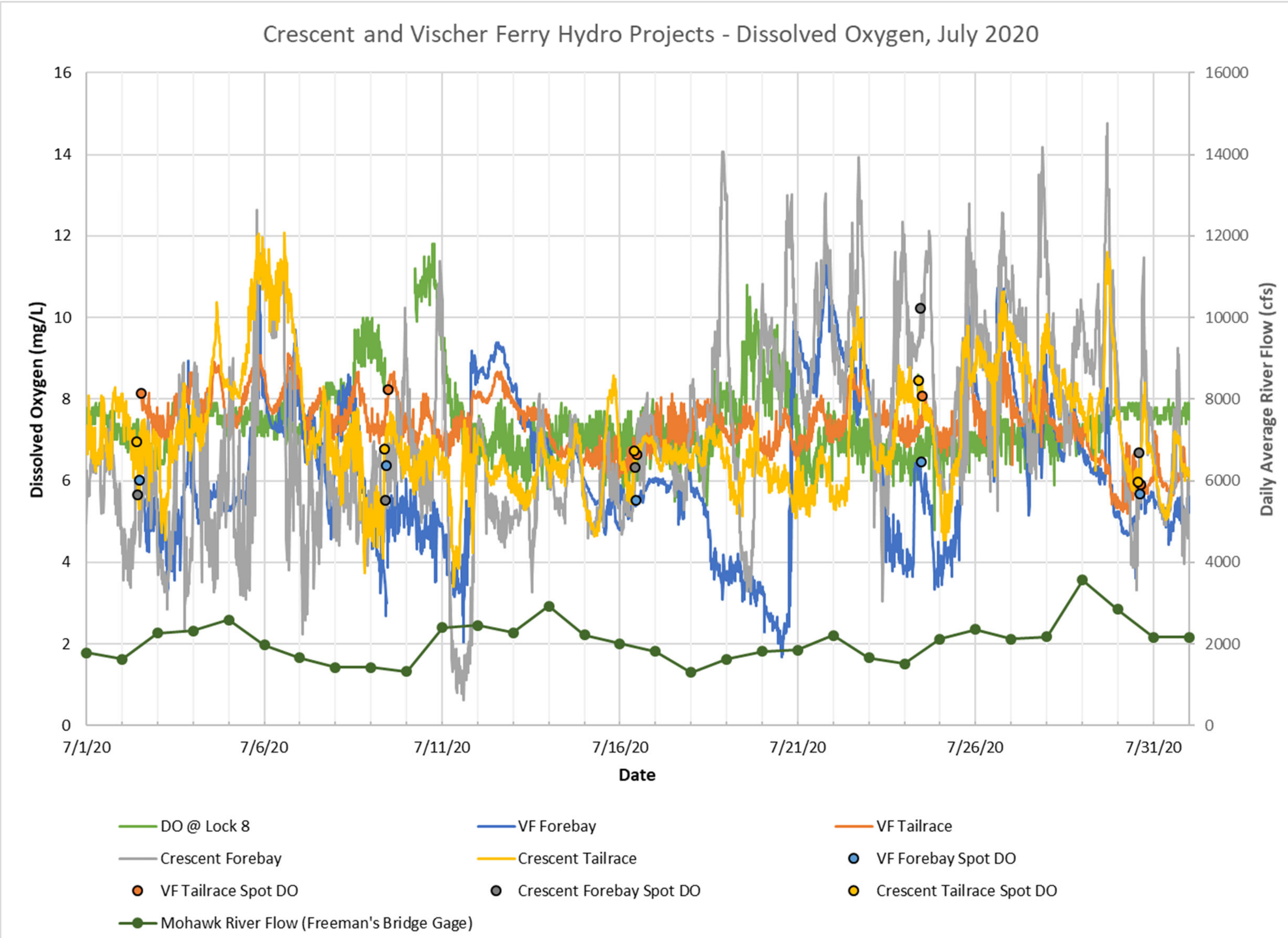


Figure A-3: Continuous Dissolved Oxygen Concentration at Crescent and Vischer Ferry Projects, August 2020

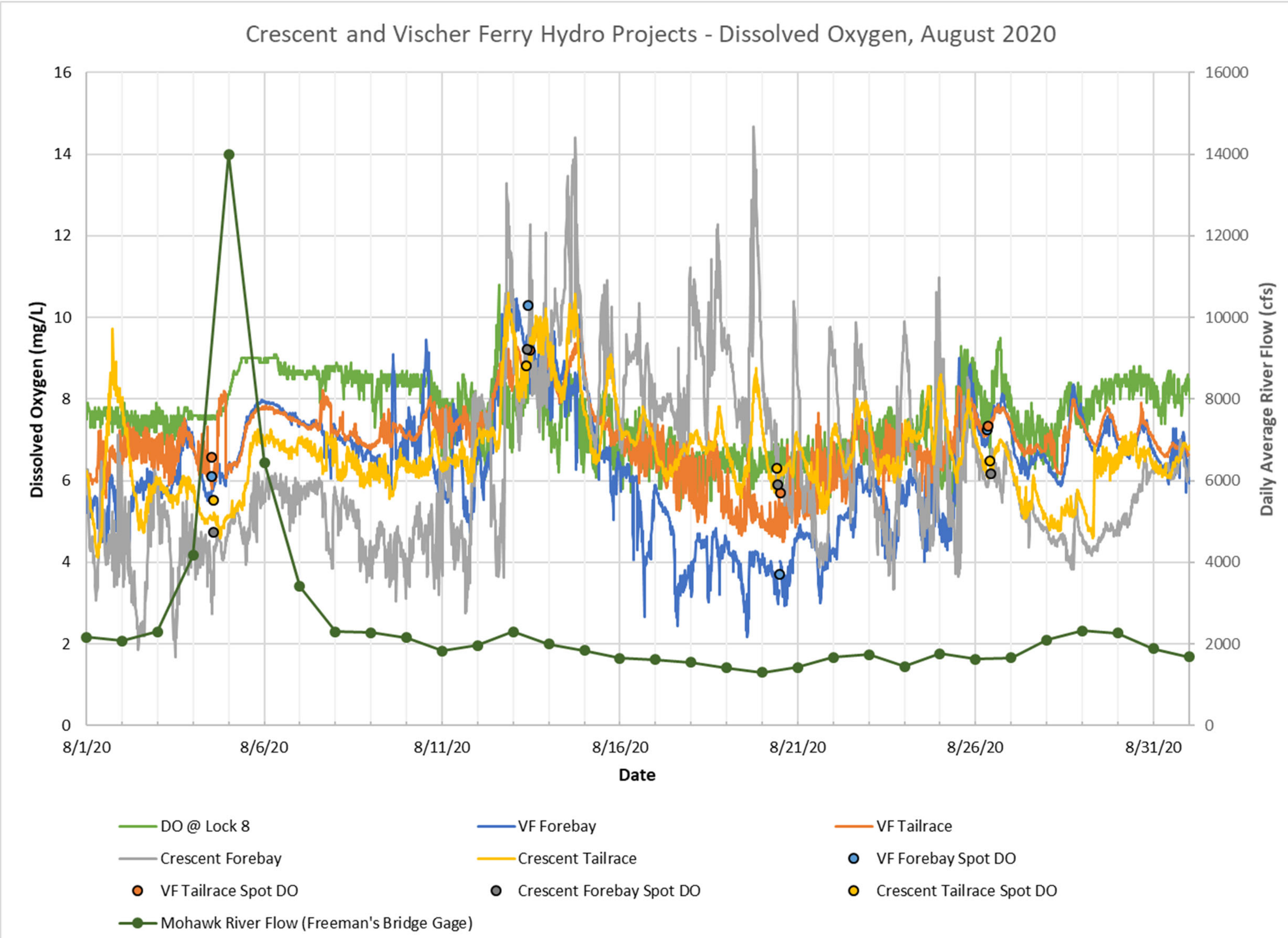


Figure A-4: Continuous Dissolved Oxygen Concentration at Crescent and Vischer Ferry Projects, September 2020

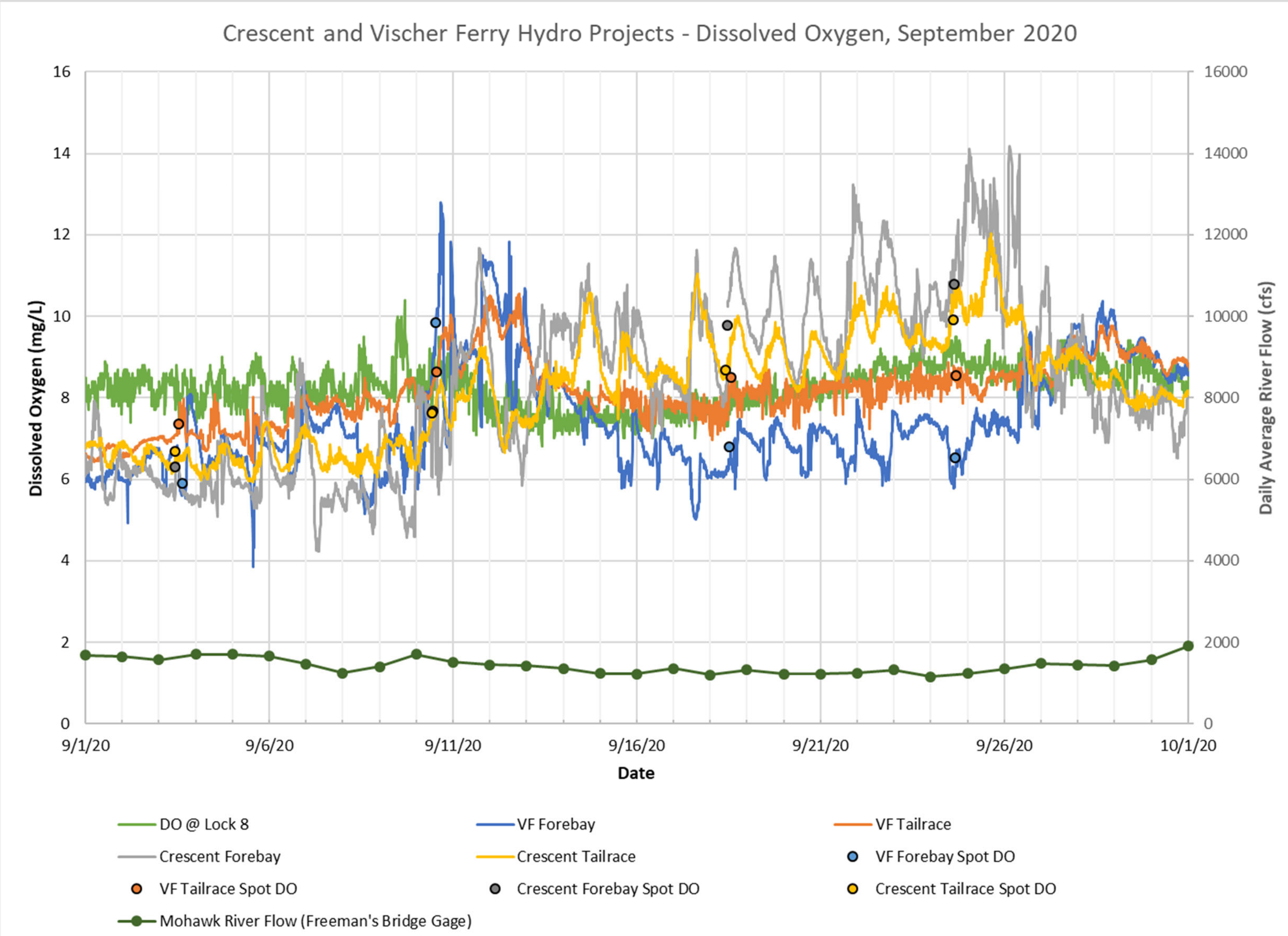


Figure A-5: Continuous Dissolved Oxygen Concentration at Crescent and Vischer Ferry Projects, October 2020

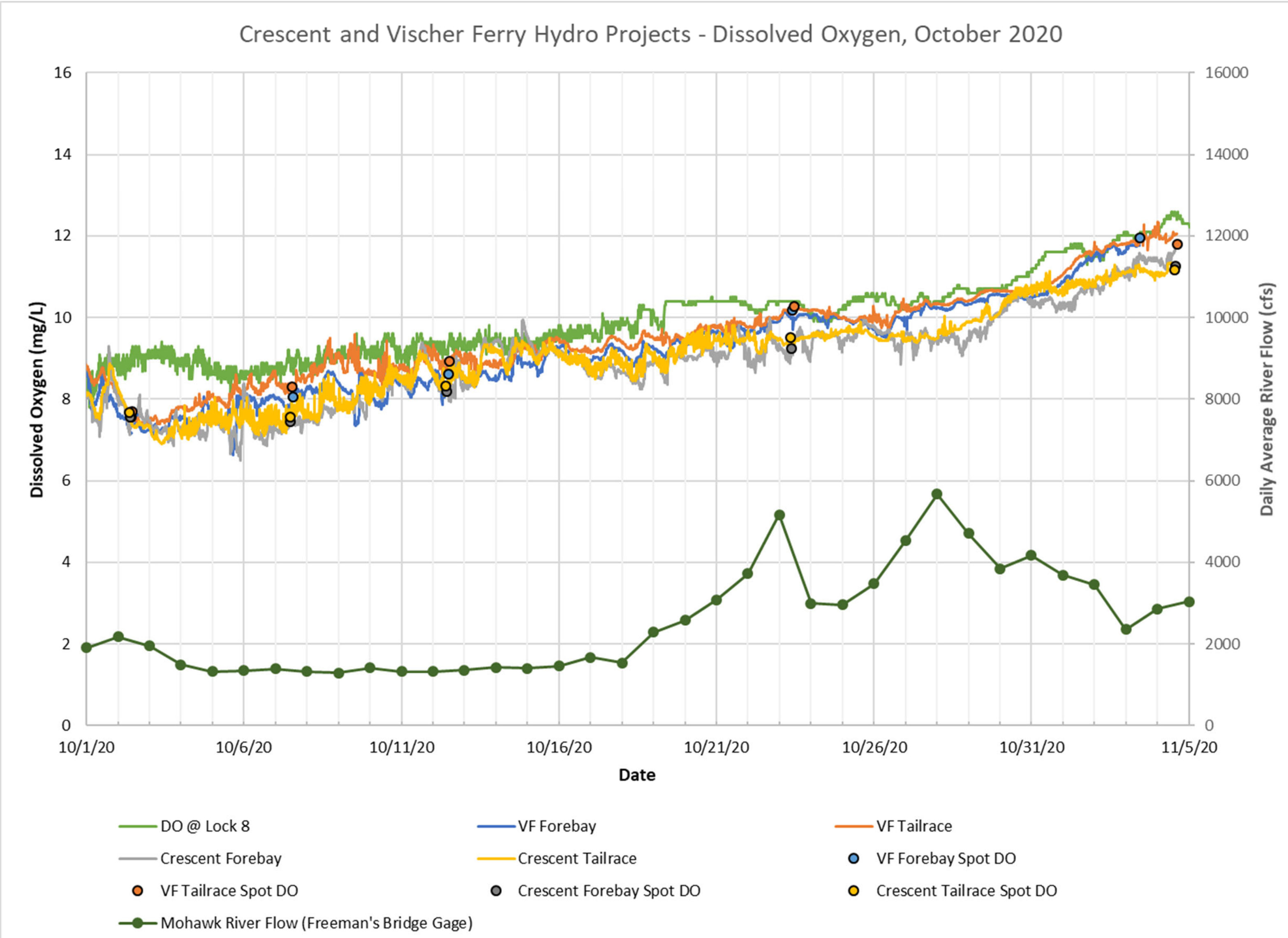


Figure A-6: Continuous Water Temperature at Crescent and Vischer Ferry Projects, June 2020

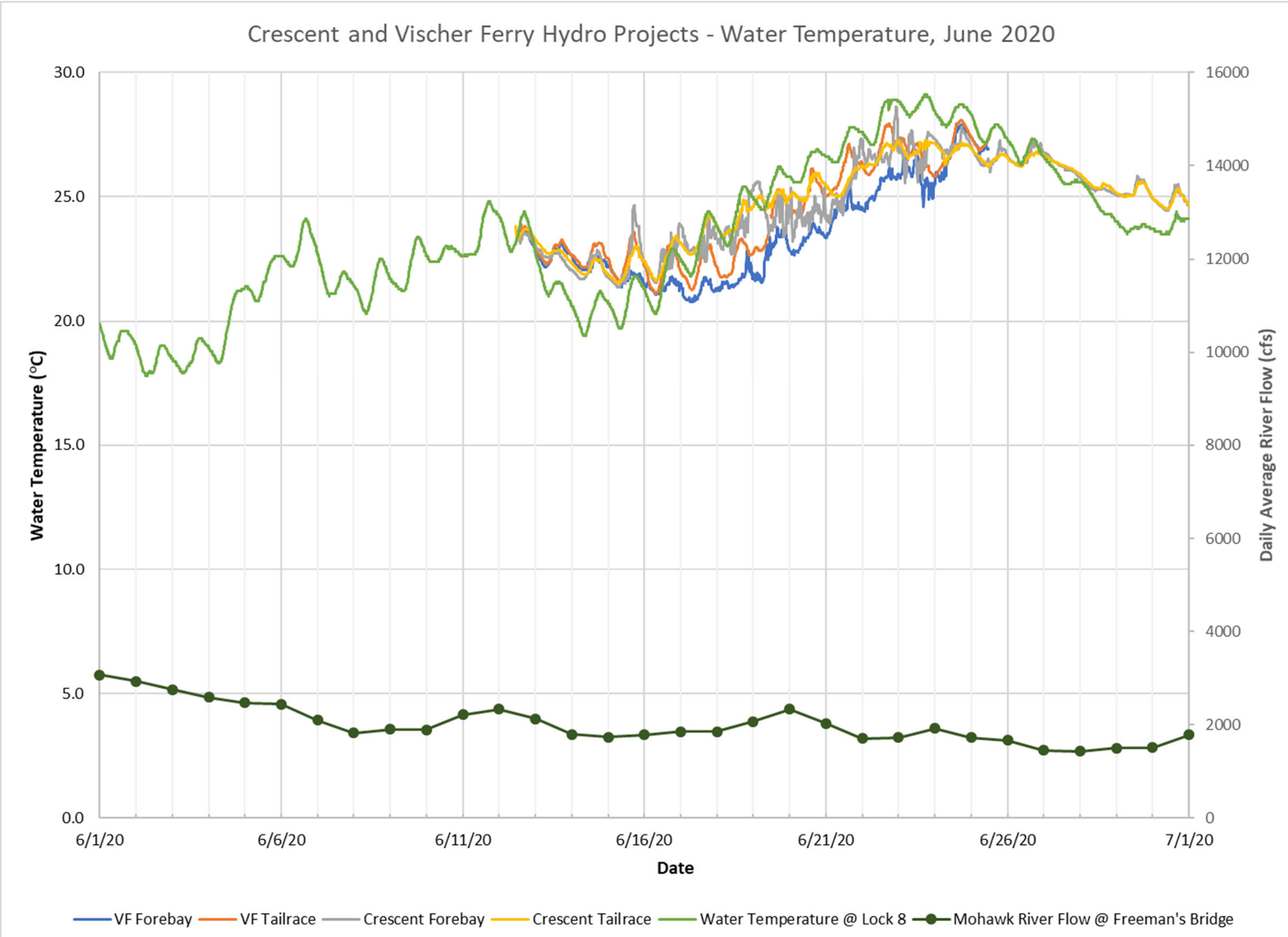


Figure A-7: Continuous Water Temperature at Crescent and Vischer Ferry Projects, July 2020

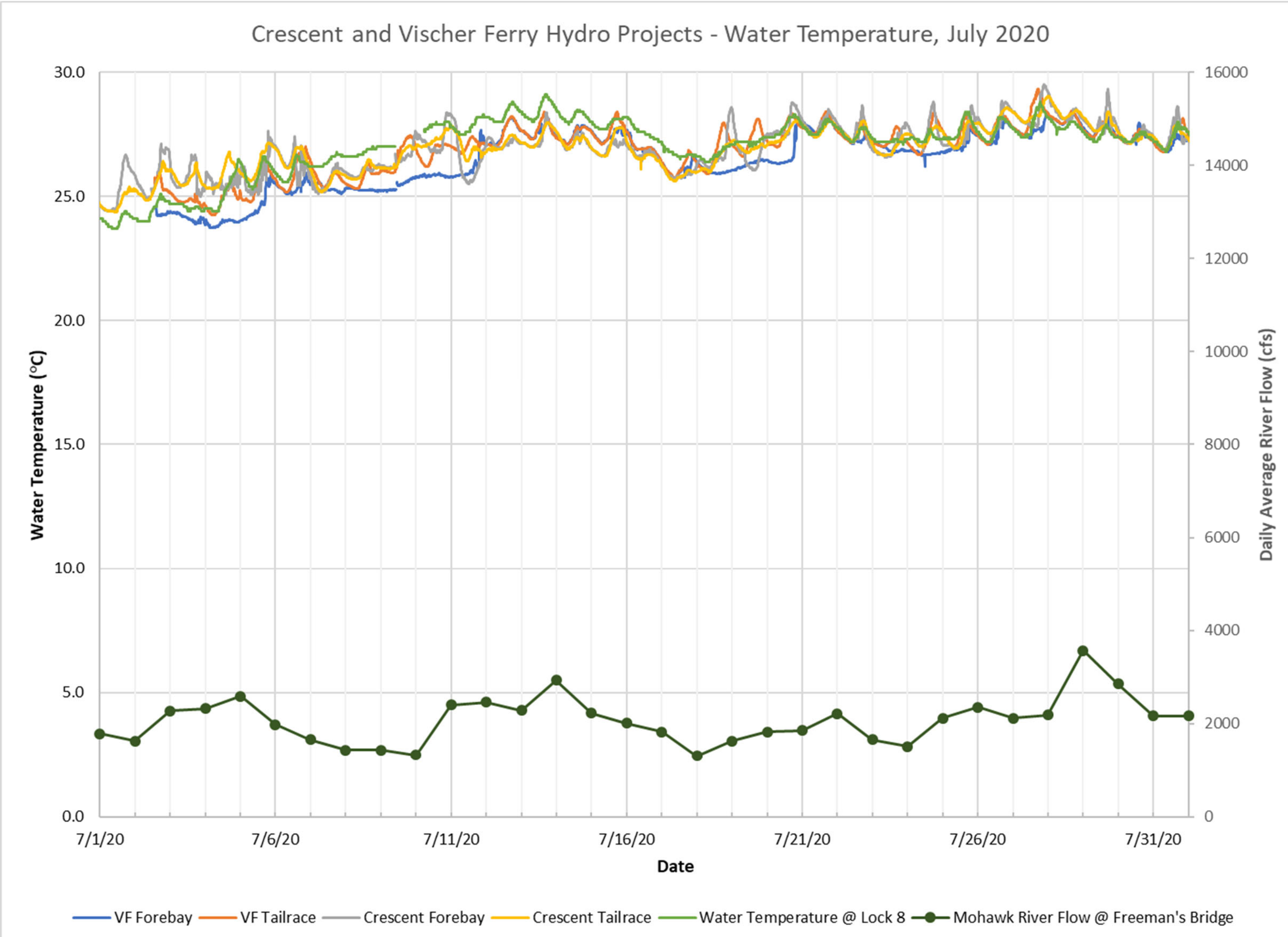


Figure A-8: Continuous Water Temperature at Crescent and Vischer Ferry Projects, August 2020

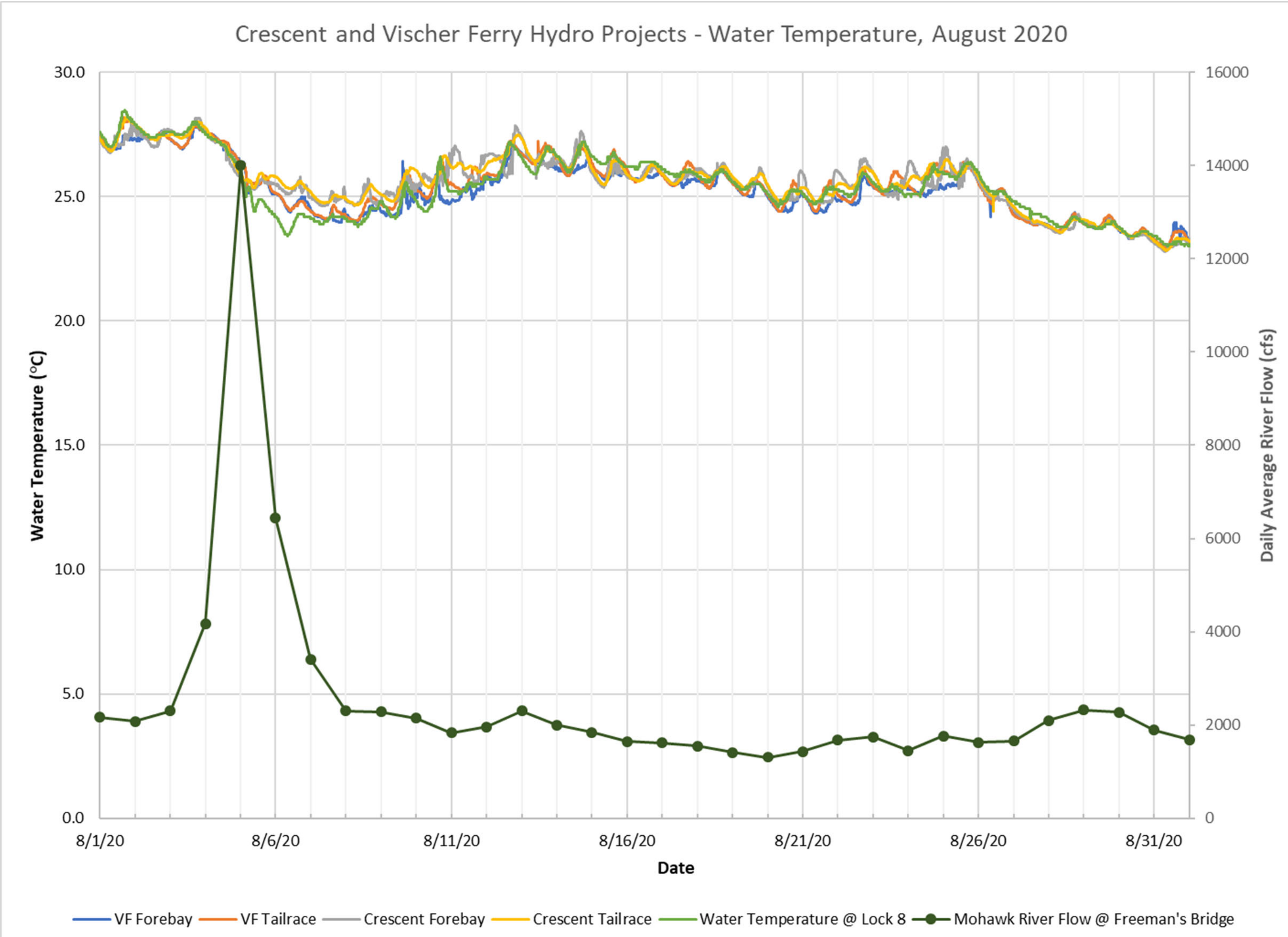


Figure A-9: Continuous Water Temperature at Crescent and Vischer Ferry Projects, September 2020

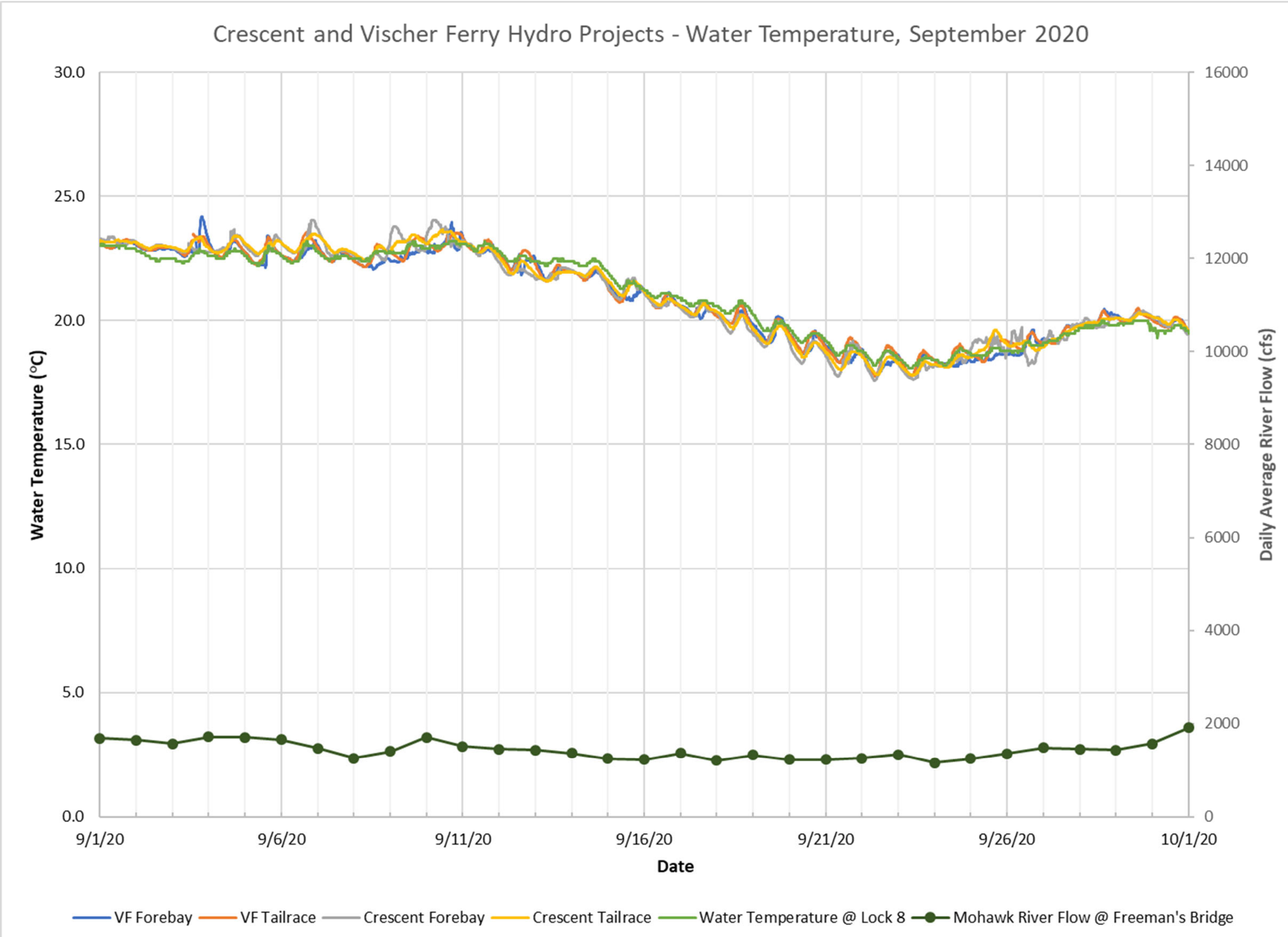


Figure A-10: Continuous Water Temperature at Crescent and Vischer Ferry Projects, October 2020

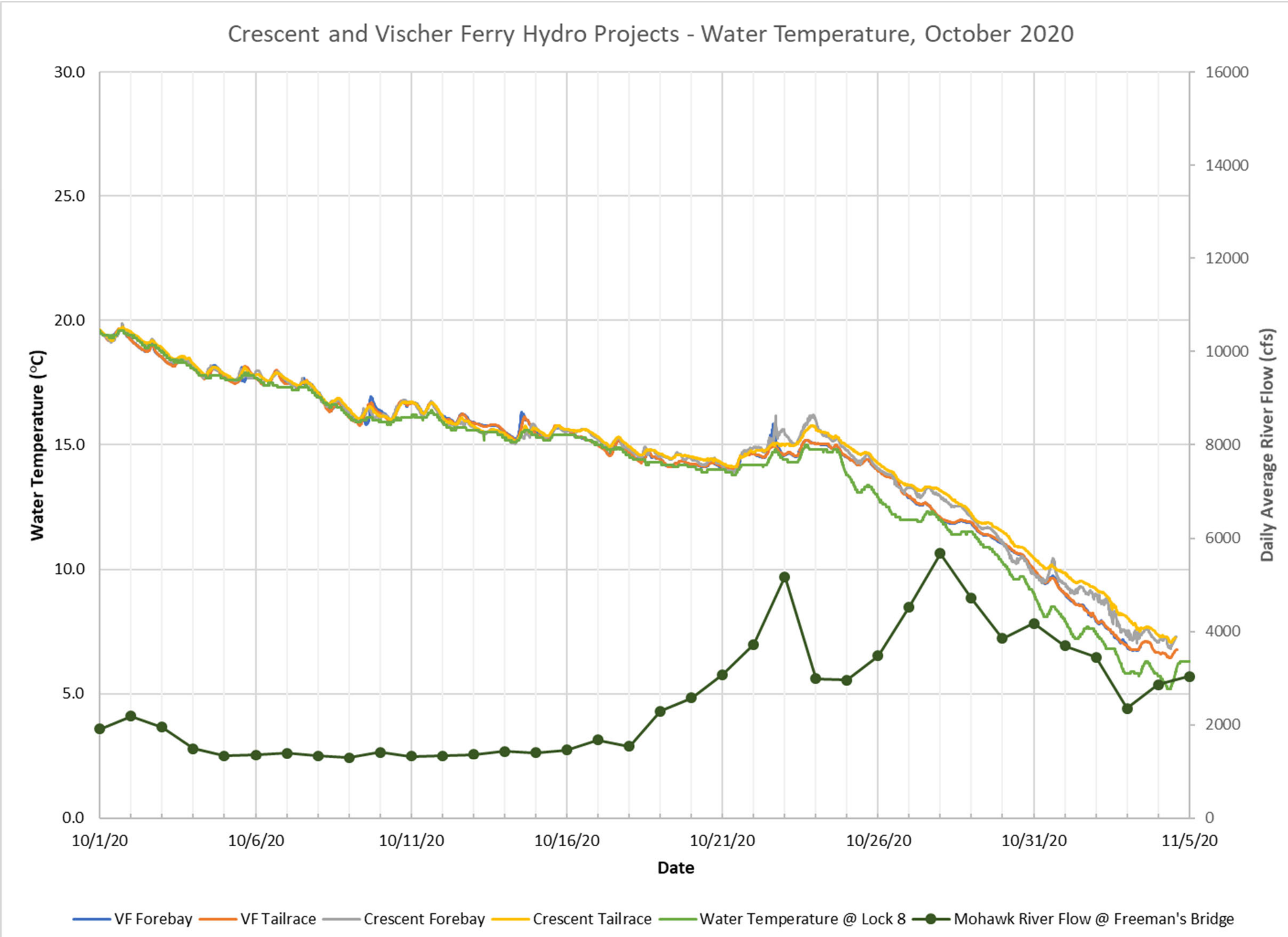


Figure A-11: Continuous Dissolved Oxygen Percent Saturation at Crescent and Vischer Ferry Projects, June 2020

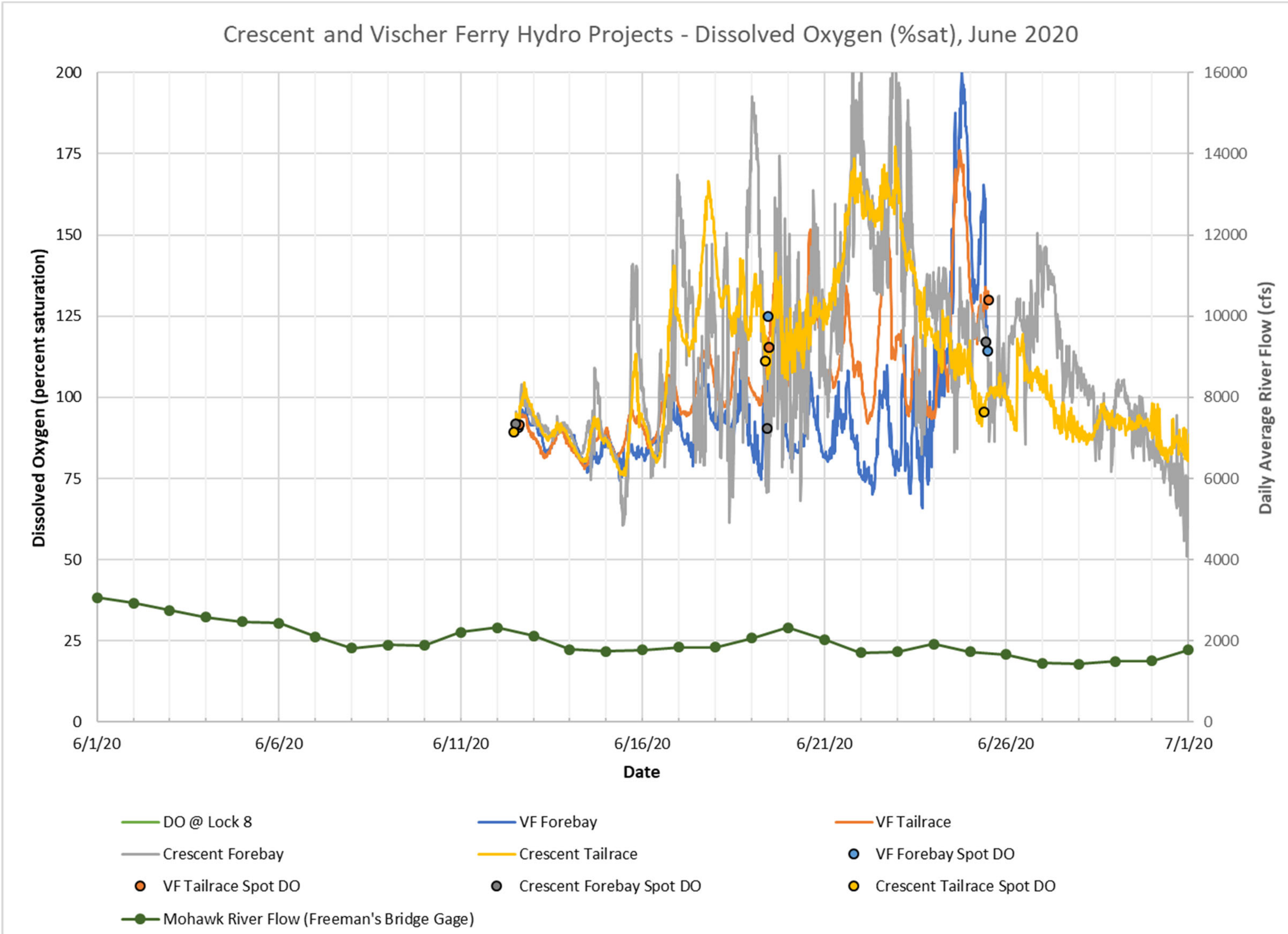


Figure A-12: Continuous Dissolved Oxygen Percent Saturation at Crescent and Vischer Ferry Projects, July 2020

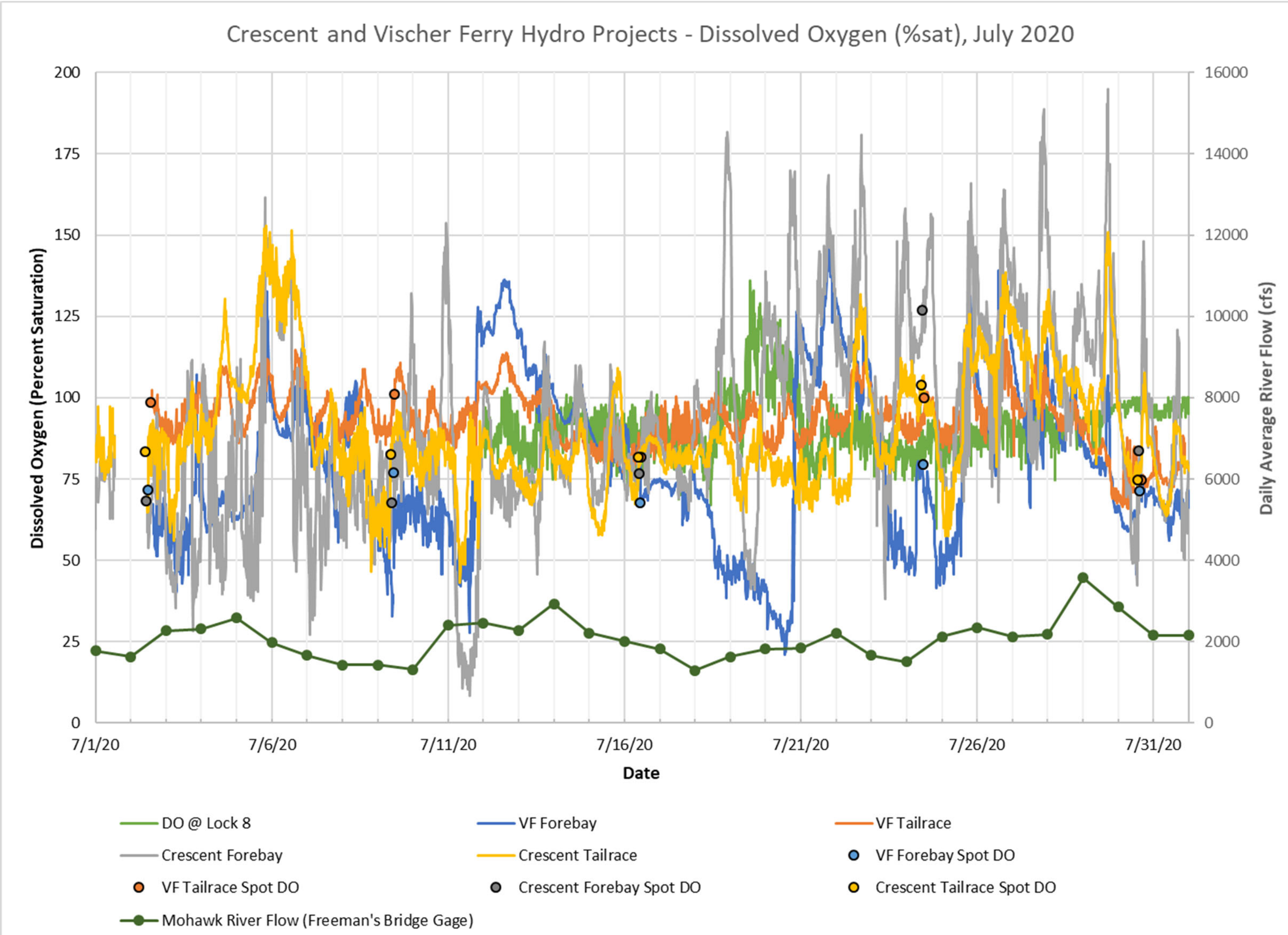


Figure A-13: Continuous Dissolved Oxygen Percent Saturation at Crescent and Vischer Ferry Projects, August 2020

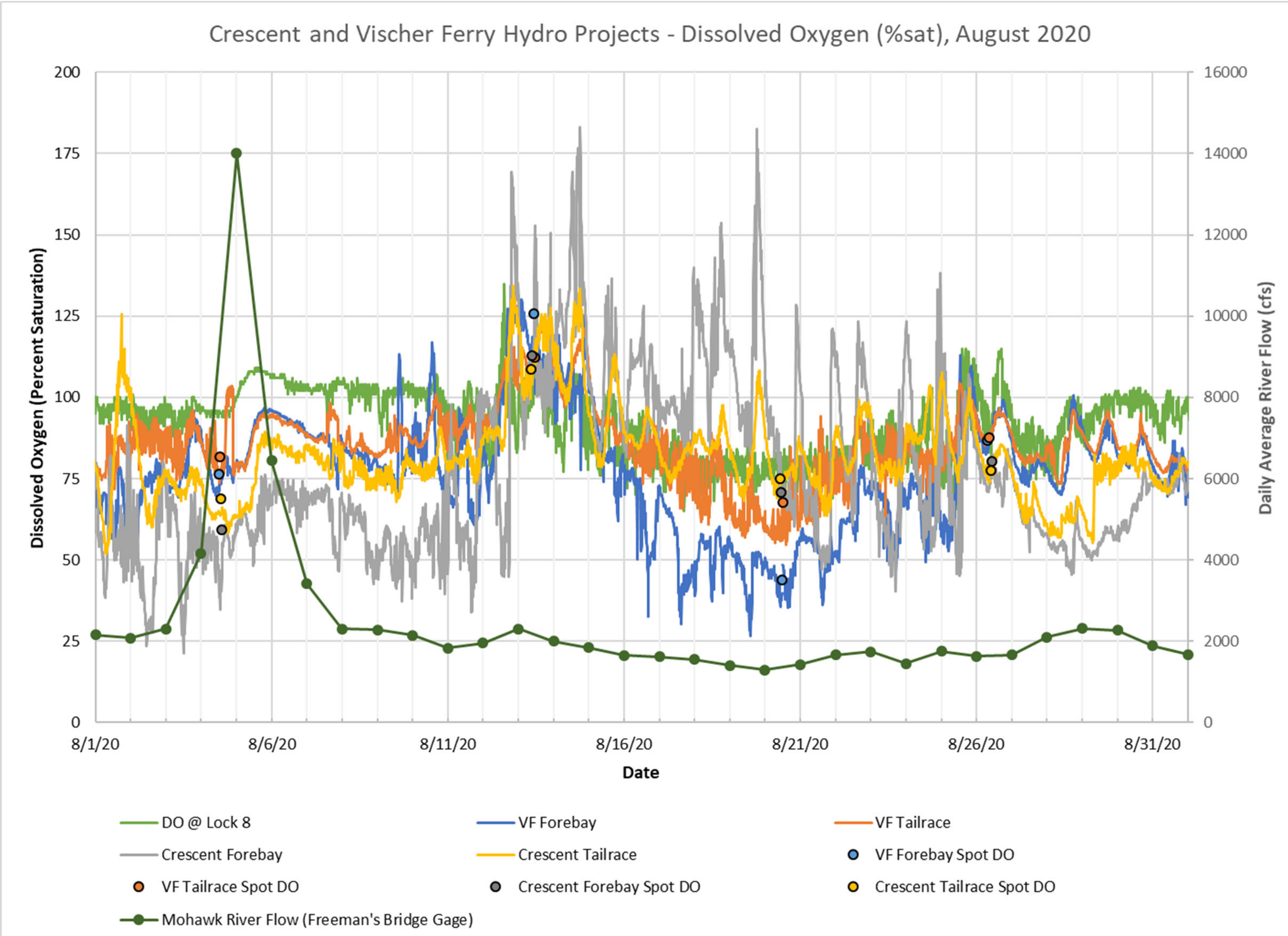


Figure A-14: Continuous Dissolved Oxygen Percent Saturation at Crescent and Vischer Ferry Projects, September 2020

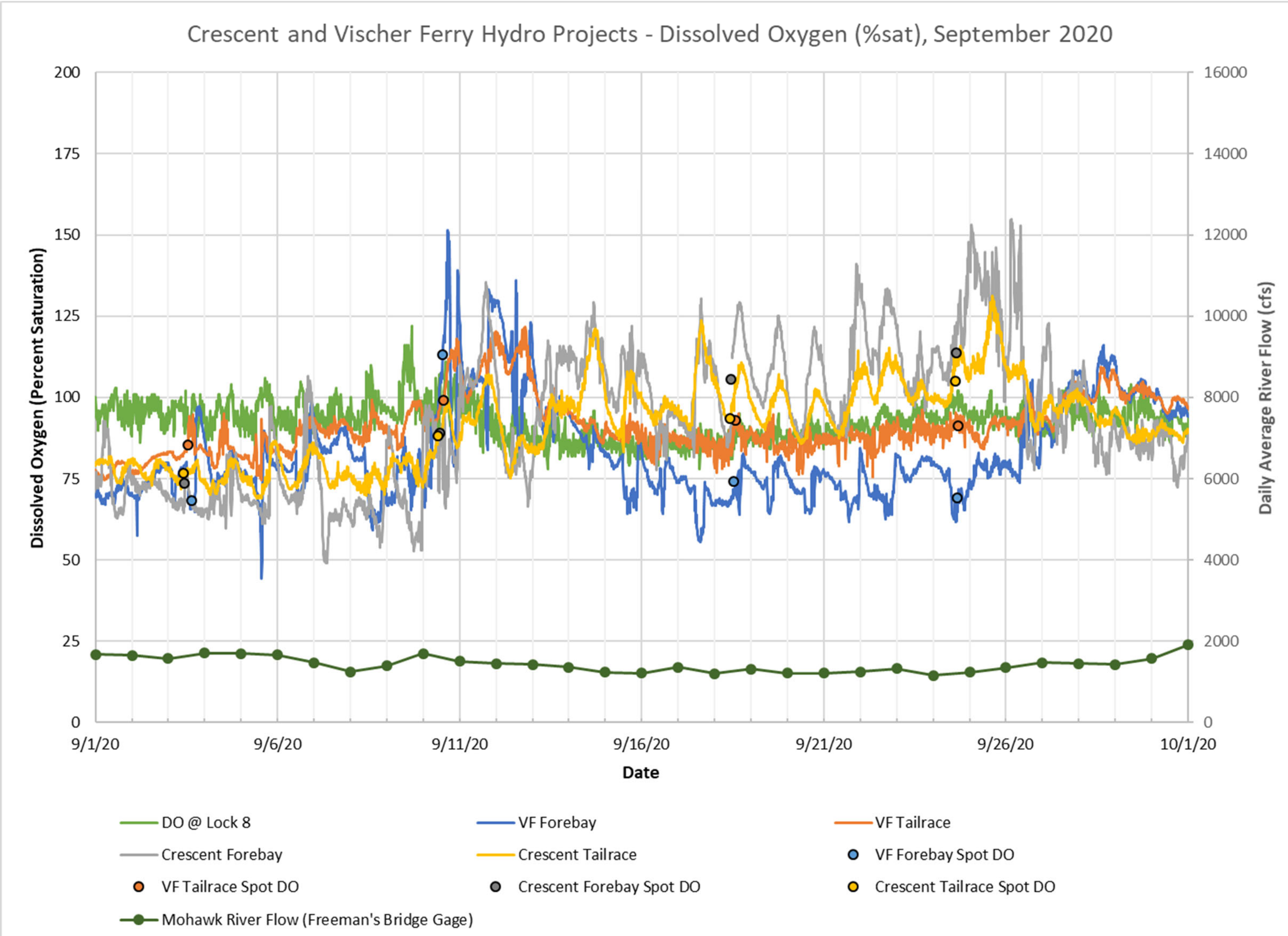
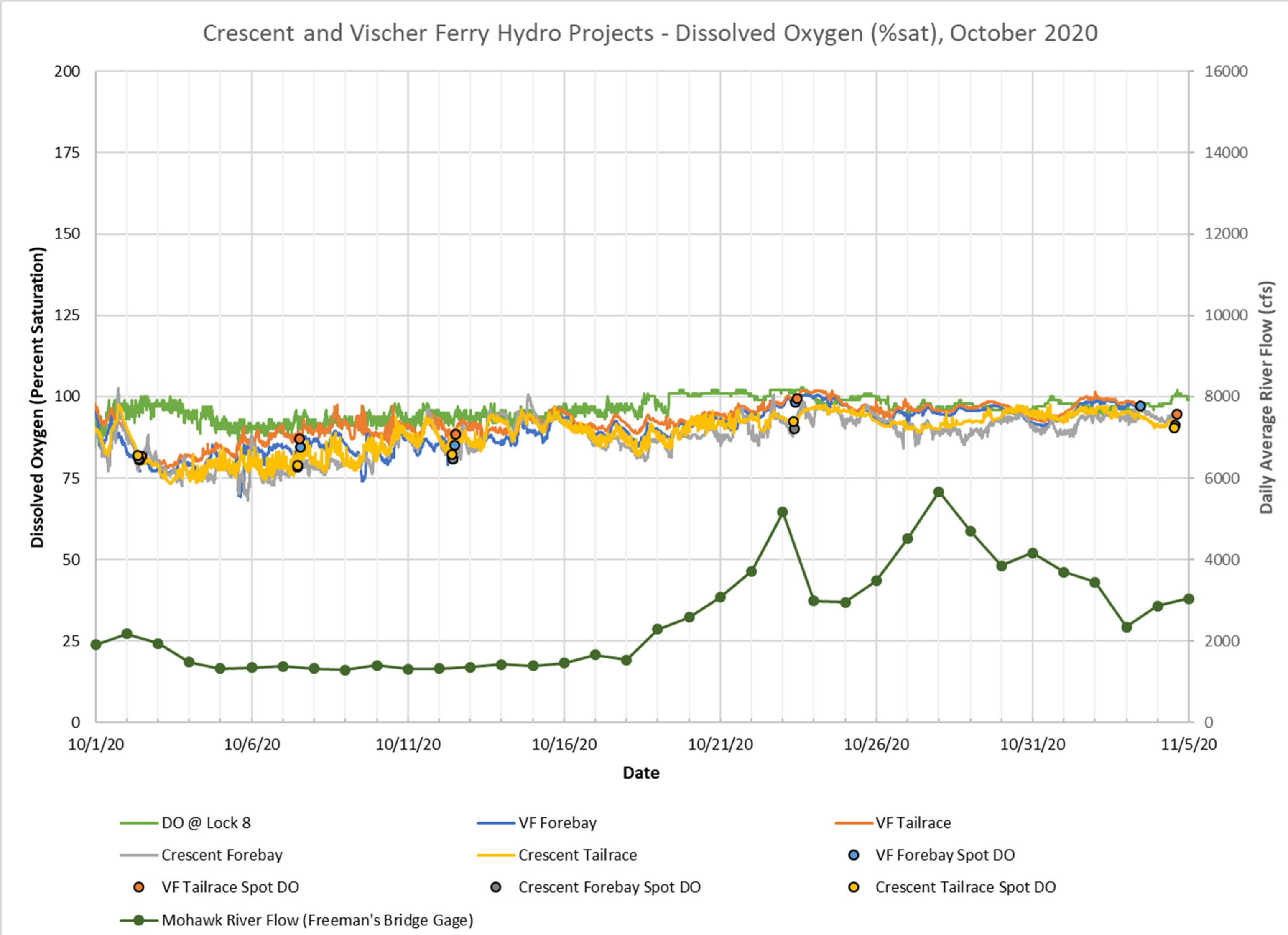


Figure A-15: Continuous Dissolved Oxygen Percent Saturation at Crescent and Vischer Ferry Projects, October 2020



Appendix B – Vertical Profile Data

Vischer Ferry Forebay

7/24/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	27.0	4.72	58.1	7.55	415.5	2.2	
1	27.0	4.76	59.0	7.54	415.8	2.6	
2	26.7	6.33	77.8	7.72	417.4	3.6	
3	26.6	6.66	82.0	7.78	421.7	3.5	
4	26.6	6.46	79.4	7.75	423.5	5.4	
5	26.5	5.92	72.8	7.68	421.9	5.2	
6	26.5	6.08	74.7	7.69	421.9	6.2	
7	26.5	6.36	78.3	7.74	422.6	7.6	
7.5	26.4	5.75	70.6	7.65	422.6	7.7	

Begin Time: 11:18 **End Time:** 11:38 **Meter:** YSI PRODSS
Weather: sunny, hot
Total Turbine Flow @ 12:00 = 0 cfs
Notes:
Staff: MN, MF

Vischer Ferry Forebay

8/4/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	27.1	6.28	78.5	7.00	381.4	6.8	
1	27.1	6.22	77.8	6.98	381.7	8.6	
2	27.1	6.20	77.4	7.01	381.4	7.9	
3	27.1	6.12	76.5	7.02	382.4	9.7	
4	27.1	6.11	76.4	7.12	382.3	9.7	
5	27.1	6.11	76.4	7.19	382.6	9.5	
6	27.1	6.10	76.4	7.22	382.7	9.0	
7	27.1	6.09	76.2	7.24	382.7	10.1	
7.5	27.1	6.09	76.2	7.29	382.7	9.7	

Begin Time: 12:05 **End Time:** 12:20 **Meter:** YSI PRODSS
Weather: cloudy, light rain
Total Turbine Flow @ 1:00 = 2282 cfs
Notes: 213' on rod
Staff: MN, MF, JG

Vischer Ferry Forebay

8/20/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	24.9	4.97	59.4	7.53	345.6	4.2	
1	24.9	4.99	59.7	7.53	345.1	4.2	
2	24.6	4.83	57.2	7.51	344.8	4.7	
3	24.3	4.10	48.5	7.41	344.8	4.9	
4	24.3	3.70	43.8	7.36	344.2	5.6	
5	24.3	3.78	44.7	7.37	344.2	5.6	
6	24.2	3.67	43.3	7.33	344.4	5.6	
7	24.2	3.55	42.0	7.33	344.5	5.6	
7.5	24.2	3.53	41.7	7.33	344.5	5.5	

Begin Time: 11:28 **End Time:** 11:39 **Meter:** YSI PRODSS
Weather: Sunny, 70F
Total Turbine Flow @ 12:00 = 238 cfs
Notes:
Staff: MN, CD

Vischer Ferry Forebay

9/3/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	22.9	6.87	79.7	7.73	334.9	6.1	
1	22.8	6.92	80.2	7.73	334.9	6.5	
2	22.9	6.88	79.8	7.71	334.8	6.5	
3	22.9	6.89	79.8	7.71	334.9	6.6	
4	22.9	6.91	80.1	7.73	334.9	6.0	
5	22.9	6.93	80.4	7.74	335.0	6.3	
6	22.8	6.97	80.8	7.74	335.1	7.3	
7	22.8	6.98	80.9	7.74	335.1	6.8	
8	22.8	6.96	80.7	7.73	335.2	7.0	

Begin Time: 11:35 **End Time:** 11:58 **Meter:** YSI PRODSS
Weather: Sunny, warm
Total Turbine Flow @ 12:00 = 972 cfs
Notes: Logger stuck was unable to be retrived.
New logger launched at 4m at 3:27pm
Staff: MN, MF

Vischer Ferry Forebay

9/18/2020									
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes		
0.1	20.0	6.79	73.8	7.69	381.8	3.5			
1	20.1	6.84	74.7	7.72	381.9	3.3			
2	20.1	6.80	74.2	7.71	381.9	3.1			
3	20.1	6.79	74.1	7.71	382.0	3.1			
4	20.1	6.79	74.3	7.71	382.0	2.9			
5	20.1	6.63	72.3	7.68	381.6	2.3			
6	20.0	6.66	72.6	7.69	381.8	3.2			
7	20.0	6.75	73.3	7.70	382.1	4.8			
8	19.9	6.49	70.4	7.66	382.0	4.8			

Begin Time: 12:13 **End Time:** 12:37 **Meter:** YSI PRODSS
Weather: Sunny,cool. Light breeze
Total Turbine Flow @ 1:00 = 378 cfs
Notes:
Staff: MN, MF

Vischer Ferry Forebay

10/2/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	18.7	7.66	81.5	7.76	371.5	5.2	
1	18.7	7.61	80.9	7.77	371.6	5.1	
2	18.7	7.60	80.8	7.70	371.6	5.5	
3	18.7	7.57	80.5	7.76	371.1	5.5	
4	18.8	7.57	80.5	7.76	371.2	5.4	
5	18.7	7.56	80.4	7.76	371.3	5.6	
6	18.7	7.54	80.2	7.75	371.3	5.7	
7	18.7	7.49	79.7	7.75	371.2	5.7	
8	18.7	7.49	79.7	7.74	371.1	5.7	

Begin Time: 10:09 **End Time:** 10:23 **Meter:** YSI PRODSS
Weather: Cloudy, light rain, calm
Total Turbine Flow @ 11:00 = 1650 cfs
Notes:
Staff: MN, MF

Vischer Ferry Forebay

10/12/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	15.8	8.63	85.6	7.81	359.0	2.3	
1	15.8	8.62	85.5	7.81	359.1	2.2	
2	15.8	8.56	84.9	7.82	359.2	2.2	
3	15.8	8.64	85.7	7.82	359.0	2.4	
4	15.8	8.58	85.2	7.81	359.3	2.4	
5	15.9	8.61	85.5	7.82	359.0	2.3	
6	15.9	8.49	84.1	7.78	359.0	2.1	
7	15.8	8.34	82.9	7.77	359.2	2.1	
8	15.8	8.24	81.8	7.75	359.5	2.4	

Begin Time: 11:41 **End Time:** 12:01 **Meter:** YSI PRODSS
Weather: Partly cloudy
Total Turbine Flow @ 12:00 = 592 cfs
Notes:
Staff: MN, MF

Vischer Ferry Forebay

11/3/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	6.7	11.99	97.4	7.33	381.4	2.8	
1	6.8	11.95	97.1	7.51	381.8	2.6	
2	6.8	11.96	97.2	7.68	381.7	2.9	
3	6.8	11.96	97.3	7.75	381.5	2.7	
4	6.8	11.96	97.3	7.80	381.7	2.6	
5	6.8	11.93	97.1	7.83	381.6	2.7	
6	6.8	11.94	97.2	7.85	381.7	2.6	
7	6.8	11.93	97.1	7.85	381.6	2.9	
8	6.8	11.92	97.0	7.84	381.6	2.7	

Begin Time: 10:20 **End Time:** 10:35 **Meter:** YSI PRODSS
Weather: Windy, cold, sunny
Total Turbine Flow @ 11:00 = No Data
Notes: Pond at Dam Crest (Flashboard removal in process)
Staff: MN, MF

Table B-2: Vischer Ferry Tailrace Vertical Profile Data

Vischer Ferry Tailrace — 6/12/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	23.4	7.92	92.0	8.02	445.0	6.1	
1	23.4	7.90	91.7	8.02	445.0	6.2	
2	23.4	7.88	91.5	8.02	445.0	6.3	
3	23.4	7.86	91.3	8.02	445.0	6.1	

Begin Time: 14:30 **End Time:** 14:34 **Meter:** YSI PRODSS
Weather: Mostly sunny
Total Turbine Flow @ 13:00 = 2034 cfs
Notes: Logger installed at depth = 2 m
Bottom depth = 3.6 meters
Staff: JG, BS

Vischer Ferry Tailrace — 6/25/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	27.3	10.40	130.3	8.41	398.2	~~56.7~~	
1	27.3	10.39	130.2	8.41	398.2	~~56.4~~	
2	27.3	10.32	129.2	8.40	398.3	~~59.5~~	
3	27.3	10.38	129.9	8.40	398.2	~~58.2~~	

Begin Time: 12:15 **End Time:** 12:22 **Meter:** YSI PRODSS
Weather: Sunny, hot
Total Turbine Flow @ 13:00 = 307 cfs
Notes: Flashboards installed, no spill and very little generation
Staff: MN, MF
QA: Reject Turbidity - bad calibration. JPG

Vischer Ferry Tailrace — 7/2/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	25.5	8.43	102.5	8.11	378.8	5.1	
1	25.4	8.19	99.4	8.01	378.5	4.8	
2	25.3	8.18	99.3	8.03	378.5	5.1	
3	25.3	8.14	98.7	7.96	378.4	4.9	

Begin Time: 13:18 **End Time:** 13:22 **Meter:** YSI PRODSS
Weather: Sunny, hot, light breeze
Total Turbine Flow @ 14:00 = 0 cfs
Notes:
Staff: JG, MN, MF

Vischer Ferry Tailrace — 7/9/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	26.3	8.36	102.4	8.46	340.9	3.8	
1	26.3	8.23	100.9	8.47	341.8	3.7	
2	26.3	8.24	101.0	8.49	340.6	3.9	
3	26.3	8.15	100.0	8.40	342.0	3.9	

Begin Time: 11:25 **End Time:** 11:34 **Meter:** YSI PRODSS
Weather: Sunny, hot, light breeze
Total Turbine Flow @ 12:00 = 0 cfs
Notes: No generation
Staff: MN, MF

Vischer Ferry Tailrace — 7/24/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	27.0	8.10	99.9	8.03	420.8	3.2	
1	27.0	8.02	99.5	8.01	420.8	3.1	
2	27.0	8.07	100.0	8.03	420.9	3.2	
3	27.0	7.95	98.1	8.00	420.8	3.2	

Begin Time: 12:10 **End Time:** 12:18 **Meter:** YSI PRODSS
Weather: Sunny, hot
Total Turbine Flow @ 13:00 = 0 cfs
Notes: Minimal generation
Staff: MN, MF

Vischer Ferry Tailrace — 8/4/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	27.1	6.99	87.2	7.58	381.7	5.4	
1	27.1	6.38	81.5	7.54	381.7	5.4	
2	27.1	6.58	81.6	7.54	381.8	5.4	
3	27.1	6.41	79.8	7.53	381.7	5.5	

Begin Time: 12:38 **End Time:** 12:45 **Meter:** YSI PRODSS
Weather: Cloudy, rain
Total Turbine Flow @ 13:00 = 2378 cfs
Notes: Strong current
Staff: MN, MF, JG

Vischer Ferry Tailrace

8/20/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	24.8	5.41	64.2	7.50	344.3	4.9	
1	24.7	5.75	68.3	7.53	344.5	4.9	
2	24.6	5.43	64.8	7.47	344.5	4.8	
3	24.7	5.71	67.8	7.48	344.4	5.0	

Begin Time: 12:16 **End Time:** 12:27 **Meter:** YSI PRODSS
Weather: Cloudy, 75F
Total Turbine Flow @ 13:00 = 238 cfs
Notes: Water chestnut build-up on bouy and logger cable
Staff: MN, CD

Vischer Ferry Tailrace

9/3/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	23.1	7.34	85.6	7.76	334.9	5.6	
1	23.0	7.32	85.3	7.74	334.9	6.0	
2	23.0	7.36	85.4	7.74	335.0	6.0	
3	23.1	7.44	86.9	7.74	334.9	5.9	

Begin Time: 12:57 **End Time:** 13:04 **Meter:** YSI PRODSS
Weather: Overcast, warm
Total Turbine Flow @ 13:00 = 598 cfs
Notes:
Staff: MN, MF

Vischer Ferry Tailrace

9/18/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	20.3	8.46	92.7	7.82	381.3	2.6	
1	20.3	8.27	90.5	7.78	381.5	3.2	
2	20.3	8.50	92.9	7.80	381.3	2.7	
3	20.3	8.40	91.9	7.81	381.3	2.6	

Begin Time: 13:20 **End Time:** 13:28 **Meter:** YSI PRODSS
Weather: Sunny, 65F
Total Turbine Flow @ 14:00 = 377 cfs
Notes: Mild biofouling, logger covered in veg
Staff: MN, MF

Vischer Ferry Tailrace

10/2/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	18.6	7.72	81.9	7.72	370.1	4.9	
1	18.6	7.70	81.7	7.76	370.1	4.8	
2	18.6	7.69	81.6	7.76	370.1	4.9	
3	18.6	7.69	81.6	7.75	370.1	4.9	

Begin Time: 11:00 **End Time:** 11:05 **Meter:** YSI PRODSS
Weather: Cloudy, rain
Total Turbine Flow @ 12:00 = 1654 cfs
Notes:
Staff: MN, MF

Vischer Ferry Tailrace

10/12/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	15.9	9.08	90.2	7.80	359.5	2.2	
1	15.9	8.92	88.5	7.78	359.1	2.2	
2	15.9	8.92	88.7	7.77	359.1	2.3	
3	15.9	8.96	89.2	7.77	359.1	2.4	

Begin Time: 12:43 **End Time:** 13:00 **Meter:** YSI PRODSS
Weather: Sunny, cool
Total Turbine Flow @ 13:00 = 672 cfs
Notes:
Staff: MN, MF

Vischer Ferry Tailrace

11/4/2020

Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	6.6	11.79	94.4	7.88	380.8	2.6	
1	6.6	11.78	94.3	7.86	380.8	2.6	
2	6.6	11.79	94.5	7.85	380.9	2.6	
3	6.6	11.78	94.3	7.84	380.8	2.6	

Begin Time: 14:54 **End Time:** 5:03:00 PN **Meter:** YSI PRODSS
Weather: Sunny, cool
Total Turbine Flow @ 15:00 = No Data
Notes: 2m
Staff: MN, MF

Table B-3: Crescent Forebay Vertical Profile Data

Crescent Forebay

6/12/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	23.3	8.04	93.2	7.94	386.0	4.9	
1	23.3	7.92	291.6	7.94	385.8	4.6	
2	23.2	7.92	91.8	7.93	385.6	4.4	
3	23.2	7.94	92.4	7.94	385.8	4.5	

Begin Time: 12:09 **End Time:** 12:16 **Meter:** YSI PRODSS
Weather: Sunny, hot
Total Turbine Flow @ 13:00 = 2000 cfs
Notes: Logger installed at depth = 2 m
Bottom depth = 3.5 meters
Staff: JG, BS

Crescent Forebay

6/25/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	26.4	9.59	117.9	8.40	407.7	~~69.1~~	
1	26.3	9.52	117.3	8.38	407.6	~~72.9~~	
2	26.3	9.51	117.1	8.38	407.6	~~71.5~~	
2.8	26.3	9.51	117.1	8.38	407.8	~~69.6~~	

Begin Time: 10:15 **End Time:** 10:22 **Meter:** YSI PRODSS
Weather: Sunny, hot, light breeze
Total Turbine Flow @ 11:00 = 2723 cfs
Notes:
Staff: MN, MF
QA: Reject Turbidity - bad calibration. JPG

Crescent Forebay

7/2/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	25.5	5.11	62.0	7.60	350.7	2.9	
1	25.1	5.05	60.9	7.58	349.9	2.4	
2	25.0	5.65	68.3	7.65	350.1	4.0	
2.8	24.9	5.06	60.6	7.59	350.3	2.7	

Begin Time: 10:24 **End Time:** 10:28 **Meter:** YSI PRODSS
Weather: Sunny, light breeze,~80F
Total Turbine Flow @ 11:00 = 0 cfs
Notes:
Staff: JG, MN, MF

Crescent Forebay

7/9/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	26.4	8.59	105.7	8.09	359.5	3.4	
1	26.3	6.47	79.5	7.68	359.1	1.3	
2	26.2	5.52	67.6	7.59	358.7	1.0	
2.8	26.1	6.27	76.7	7.68	358.6	1.3	

Begin Time: 9:31 **End Time:** 9:37 **Meter:** YSI PRODSS
Weather: Warm, humid, ~85F
Total Turbine Flow @ 10:00 = 0 cfs
Notes:
Staff: MN, MF

Crescent Forebay

7/24/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	27.1	10.24	127.1	8.41	401.9	4.1	
1	27.1	10.36	128.6	8.43	402.2	4.1	
2	27.1	10.23	127.0	8.42	402.3	4.2	
2.8	27.1	9.94	123.7	8.38	402.4	3.6	

Begin Time: 10:28 **End Time:** 10:34 **Meter:** YSI PRODSS
Weather: Sunny, light breeze
Total Turbine Flow @ 11:00 = 351 cfs
Notes:
Staff: MN, MF

Crescent Forebay

8/4/2020							
Depth (m)	**Temp (°C)**	**DO (mg/L)**	**DO (% Sat)**	**pH**	**Conductivity**	**Turbidity (FNU)**	**Notes**
0.1	26.8	4.93	61.5	7.37	394.2	6.5	
1	26.8	4.90	61.1	7.36	394.5	6.4	
2	26.8	4.73	59.2	7.34	394.4	6.1	
2.8	26.8	4.73	59.0	7.32	394.5	6.4	

Begin Time: 13:58 **End Time:** 14:02 **Meter:** YSI PRODSS
Weather: ~70F, cloudy, heavy rain starting
Total Turbine Flow @ 14:00 = 2410 cfs
Notes:
Staff: MN, MF, JG

Crescent Forebay

8/20/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	25.5	7.31	88.2	7.69	362.9	6.4	
1	25.5	7.25	87.4	7.66	362.8	6.5	
2	24.8	5.95	70.8	7.49	363.0	8.6	
2.8	24.8	5.91	70.3	7.49	362.9	8.9	

Begin Time: 10:43 **End Time:** 10:48 **Meter:** YSI PRODSS
Weather: Sunny, 70F
Total Turbine Flow @ 11:00 = 291 cfs
Notes:
Staff: MN, CD

Crescent Forebay

9/3/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	22.9	6.19	70.6	7.60	338.7	4.8	
1	22.8	6.39	74.0	7.66	339.1	7.2	
2	22.8	6.30	72.9	7.63	339.1	5.2	
3	22.9	6.37	73.6	7.63	339.1	6.1	

Begin Time: 10:40 **End Time:** 10:51 **Meter:** YSI PRODSS
Weather: Overcast, ~70F
Total Turbine Flow @ 11:00 = 744 cfs
Notes:
Staff: MN, MF

Crescent Forebay

9/18/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	19.6	9.84	105.5	8.09	390.6	7.8	
1	19.6	9.66	104.5	8.08	390.2	6.0	
2	19.6	9.78	105.6	8.12	390.5	7.0	
3	19.6	9.79	105.6	8.12	390.6	7.6	

Begin Time: 10:50 **End Time:** 11:00 **Meter:** YSI PRODSS
Weather: Cool, breezy, partly sunny
Total Turbine Flow @ 11:00 = 346 cfs
Notes:
Staff: MN, MF

Crescent Forebay

10/2/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	19.0	7.44	79.4	7.78	373.6	5.8	
1	19.0	7.56	80.8	7.75	373.7	6.3	
2	19.0	7.57	80.9	7.74	373.7	6.4	
3	19.0	7.54	80.5	7.73	373.7	6.6	

Begin Time: 9:19 **End Time:** 9:28 **Meter:** YSI PRODSS
Weather: Cloudy, light rain, calm
Total Turbine Flow @ 10:00 = 1855 cfs
Notes:
Staff: MN, MF

Crescent Forebay

10/12/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	15.7	8.17	80.7	7.75	355.8	4.2	
1	15.7	7.94	78.7	7.73	355.2	3.6	
2	15.7	8.19	81.0	7.77	355.9	3.7	
3	15.7	8.05	79.6	7.74	355.6	3.9	

Begin Time: 10:45 **End Time:** 10:55 **Meter:** YSI PRODSS
Weather: Cloudy, cold
Total Turbine Flow @ 11:00 = 422 cfs
Notes:
Staff: MN, MF

Crescent Forebay

11/4/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	7.2	11.25	91.4	7.88	408.3	4.6	
1	7.2	11.25	91.4	7.85	408.4	4.3	
2	7.2	11.26	91.5	7.84	408.4	4.5	
3							

Begin Time: 13:40 **End Time:** 13:43 **Meter:** YSI PRODSS
Weather: Sunny, clear, windy
Total Turbine Flow @ 14:00 = No Data
Notes:
Staff: MN, MF

Table B-4: Crescent Tailrace Vertical Profile Data

Crescent Tailrace

6/12/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	23.1	7.81	90.1	7.91	385.7	4.5	
1	23.2	7.75	89.6	7.90	385.7	4.1	
2	23.2	7.76	89.6	7.90	385.6	4.0	
3	23.2	7.73	89.2	7.88	385.5	3.9	
4	23.1	7.61	88.0	7.87	385.3	3.7	
5	23.1	7.57	87.4	7.86	385.2	3.7	
5.5	23.2	7.65	88.2	7.89	385.3	3.7	

Begin Time: 11:05 **End Time:** 11:11 **Meter:** YSI PRODSS
Weather: sunny, warm
Total Turbine Flow @ 12:00 = 1914 cfs
Notes: Logger installed at depth = 3 m
Bottom depth = 6 meters
Staff: JG, BS

Crescent Tailrace

6/25/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	26.1	7.89	96.8	7.92	399.7	~~57.4~~	
1	26.2	7.85	96.3	8.00	399.5	~~55.2~~	
2	26.2	7.80	95.8	8.00	398.7	~~53.5~~	
3	26.2	7.79	95.5	7.90	399.0	~~56.2~~	
4	26.2	7.82	95.8	7.80	400.2	~~58.5~~	
5	26.2	7.85	96.4	7.77	399.8	~~61.1~~	
5.5	26.2	7.76	95.0	7.77	399.4	~~58.7~~	

Begin Time: 9:24 **End Time:** 9:37 **Meter:** YSI PRODSS
Weather: Sunny, light breeze
Total Turbine Flow @ 10:00 = 2771 cfs
Notes:
Staff: MN, MF
QA: Reject Turbidity - bad calibration. JPG

Crescent Tailrace

7/2/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	25.0	6.37	77.6	7.71	350.0	3.2	
1	24.9	6.31	75.8	7.66	350.1	3.4	
2	24.8	6.89	82.5	7.68	349.8	3.2	
3	24.8	6.96	83.5	7.64	349.7	3.3	
4	24.7	6.90	82.8	7.60	349.7	3.4	
5	24.7	6.74	80.8	7.58	350.0	3.7	
5.5	24.7	6.46	77.2	7.54	350.2	3.5	

Begin Time: 9:50 **End Time:** 10:00 **Meter:** YSI PRODSS
Weather: Sunny, light breeze, ~75F
Total Turbine Flow @ 10:00 = 0 cfs
Notes: No generation at Crescent, spilling
Staff: JG, MN, MF

Crescent Tailrace

7/9/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	26.1	7.14	87.2	7.80	359.9	2.8	
1	26.1	7.06	86.3	7.84	359.9	2.8	
2	26.0	6.88	83.9	7.80	360.0	2.8	
3	26.0	6.77	82.7	7.73	360.0	2.8	
4	26.0	6.72	81.9	7.68	360.1	2.8	
5	26.0	6.64	81.0	7.67	360.6	2.8	
5.5	26.0	6.58	80.2	7.66	362.1	2.9	

Begin Time: 8:59 **End Time:** 9:09 **Meter:** YSI PRODSS
Weather: Warm, humid, ~80F
Total Turbine Flow @ 10:00 = 0 cfs
Notes:
Staff: MN, MF

Crescent Tailrace

7/24/2020									
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes		
0.1	26.8	8.69	107.1	7.95	402.8	3.1			
1	26.9	8.83	109.7	8.17	403.2	3.2			
2	26.9	8.34	103.3	8.13	403.3	3.2			
3	26.9	8.46	104.0	8.15	403.2	3.0			
4	26.9	8.52	105.2	8.19	403.3	3.0			
5	26.9	7.98	97.4	8.11	403.4	2.9			
5.5	26.9	8.25	103.0	8.15	403.3	2.9			

Begin Time: 9:43 **End Time:** 10:00 **Meter:** YSI PRODSS
Weather: Sunny, light breeze
Total Turbine Flow @ 10:00 = 351 cfs
Notes: Low generation, spill
Staff: MN, MF

Crescent Tailrace

8/4/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	26.9	5.54	69.2	7.43	397.3	7.4	
1	26.9	5.54	69.1	7.41	397.4	7.6	
2	26.9	5.56	69.4	7.41	397.5	6.6	
3	26.9	5.52	68.8	7.40	397.5	6.5	
4	26.9	5.53	69.1	7.40	397.5	6.2	
5	26.9	5.50	68.5	7.40	397.5	7.3	
5.5	26.9	5.43	67.7	7.39	397.5	6.3	

Begin Time: 13:28 **End Time:** 13:45 **Meter:** YSI PRODSS
Weather: Heavy rain starting
Total Turbine Flow @ 14:00 = 2410 cfs
Notes:
Staff: MN, MF, JG

Crescent Tailrace

8/20/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	24.8	6.26	74.5	7.41	362.4	6.4	
1	24.8	6.27	74.4	7.45	362.4	6.6	
2	24.8	6.27	74.6	7.46	362.1	6.0	
3	24.8	6.30	74.9	7.48	362.2	6.1	
4	24.8	6.28	74.7	7.48	362.2	6.1	
5	24.8	6.32	75.2	7.48	362.1	6.0	
5.5	24.8	6.33	75.3	7.49	362.0	6.0	

Begin Time: 10:09 **End Time:** 10:18 **Meter:** YSI PRODSS
Weather: Sunny, 70F
Total Turbine Flow @ 11:00 = 291 cfs
Notes:
Staff: MN, CD

Crescent Tailrace

9/3/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	22.7	6.59	76.1	7.60	337.8	8.0	
1	22.8	6.56	75.7	7.59	337.7	8.1	
2	22.7	5.59	75.9	7.57	337.8	8.2	
3	22.7	6.68	76.6	7.57	337.4	8.1	
4	22.7	6.58	76.0	7.58	337.5	8.3	
5	22.7	6.52	75.2	7.58	337.5	7.9	
5.5	22.7	6.51	75.2	7.60	337.6	8.4	

Begin Time: 9:57 **End Time:** 10:18 **Meter:** YSI PRODSS
Weather: Overcast, ~70F
Total Turbine Flow @ 10:00 = 743 cfs
Notes:
Staff: MN, MF

Crescent Tailrace

9/18/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	19.5	8.93	96.0	7.73	387.9	5.1	
1	19.6	8.83	95.3	7.84	388.2	5.1	
2	19.6	8.76	94.5	7.89	388.2	5.2	
3	19.6	8.68	93.5	7.90	388.2	5.7	
4	19.6	8.64	93.2	7.90	388.1	5.5	
5	19.6	8.62	92.8	7.90	388.1	5.6	
5.5	19.6	8.74	94.1	7.91	388.2	5.4	

Begin Time: 10:00 **End Time:** 10:21 **Meter:** YSI PRODSS
Weather: Cool, light breeze, partly sunny
Total Turbine Flow @ 11:00 = 346 cfs
Notes:
Staff: MN, MF

Crescent Tailrace

10/2/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	19.1	7.76	83.1	7.58	373.1	6.1	
1	19.1	7.70	82.3	7.69	373.2	6.0	
2	19.1	7.67	82.0	7.75	373.3	6.2	
3	19.1	7.66	81.9	7.75	373.4	6.3	
4	19.1	7.65	81.8	7.75	373.2	6.3	
5	19.1	7.63	81.6	7.75	373.3	6.2	
6	19.1	7.61	81.3	7.73	373.1	6.4	

Begin Time: 8:30 **End Time:** 8:47 **Meter:** YSI PRODSS
Weather: Rain, cloudy, no wind
Total Turbine Flow @ 9:00 = 1849 cfs
Notes:
Staff: MN, MF

Crescent Tailrace

10/12/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	15.7	8.37	82.7	7.47	355.7	3.9	
1	15.7	8.29	81.8	7.63	355.8	3.9	
2	15.7	8.52	83.8	7.63	355.4	3.7	
3	15.7	8.32	82.2	7.62	355.7	3.7	
4	15.7	8.38	82.6	7.62	355.6	3.9	
5	15.7	8.35	82.4	7.63	355.7	3.8	
5.5	15.7	8.42	83.2	7.63	355.6	3.7	

Begin Time: 9:44 **End Time:** 10:10 **Meter:** YSI PRODSS
Weather: Cloudy, cool
Total Turbine Flow @ 10:00 = 491 cfs
Notes:
Staff: MN, MF

Crescent Tailrace

11/4/2020							
Depth (m)	Temp (°C)	DO (mg/L)	DO (% Sat)	pH	Conductivity	Turbidity (FNU)	Notes
0.1	7.2	11.18	90.6	7.80	409.6	3.7	
1	7.2	11.16	90.4	7.75	409.7	3.6	
2	7.2	11.16	90.5	7.72	409.6	3.6	
3	7.2	11.16	90.5	7.71	409.6	3.5	
4	7.2	11.17	90.6	7.70	409.6	3.9	
5	7.2	11.15	90.4	7.70	409.5	3.6	
5.5	7.2	11.14	90.3	7.71	409.6	3.4	

Begin Time: 12:53 **End Time:** 13:11 **Meter:** YSI PRODSS
Weather: Sunny, windy, cool
Total Turbine Flow @ 13:00 = No Data
Notes:
Staff: MN, MF

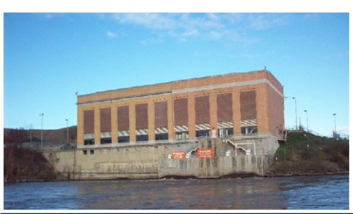
Attachment D: Updated Blueback Herring Study

BLUEBACK HERRING DOWNSTREAM MIGRATION STUDY

Prepared by: Kleinschmidt

March 2021

CRESCENT AND VISCHER FERRY PROJECTS RELICENSING FERC Nos. 4678 and 4679




NEW YORK STATE OF OPPORTUNITY | NY Power Authority

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List of Abbreviations

BCD	Barge Canal Datum
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
ft	foot or feet
ILP	Integrated Licensing Process
in	inch
MW	Megawatt
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NYSDEC	New York State Department of Environmental Conservation
PAD	Preliminary Application Document
PSP	Proposed Study Plan
RPM	rotations per minute
RSP	Revised Study Plan
SD1	Scoping
TBSA	Turbine Blade Strike Analysis
TL	Total Length
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1 Introduction

Blueback Herring (BBH) (*Alosa aestivalis*) are an anadromous river herring native to the eastern seaboard of North America. Their native range extends from Labrador to Florida. Along this range, the species inhabits coastal, estuarine and riverine systems, as well as some inland lakes. Blueback Herring live most of their adult life at sea, returning inland to spawn. Inland migration has been enhanced in many places through man-made locks and canals, which has resulted in their expansion into many inland lakes and waterways adjacent to its native range, including the Mohawk River and Lake Ontario in New York (NYSDEC, 2019). Today, juvenile Blueback Herring make up a key part of the forage base for many resident piscivorous species in the Mohawk River (George et al., 2016).

Blueback Herring are native to the Hudson River, and run up the Hudson in the spring to spawn in various tributaries, including the Mohawk River. Cohoes Falls, located approximately 1.5 miles downstream of Crescent Dam and approximately 2.5 miles upstream of the Mohawk's confluence with the Hudson River, presents a natural barrier that Blueback Herring would be unable to pass but for the New York State Barge Canal (Barge Canal). Blueback Herring depend on the operation of the Barge Canal to gain access to the Mohawk River. Adults migrating upstream through the Barge Canal enter the Mohawk River upstream of the Crescent Dam. Blueback Herring were first recorded in the lower Mohawk River upstream of Cohoes Falls in 1934 (USGS, 2018b) and were first reported in the upper Mohawk (above Little Falls) in 1978 (Owens et al., 1998). Spawning migrations can extend to near Rome, New York, about 120 miles above the river's mouth and more than 100 miles upstream of the Crescent and Vischer Ferry Project dams (FERC, 2000).

Blueback Herring spawn in the upper reaches of the Mohawk River and its tributaries, preferably in swift-flowing, hard-bottomed stream reaches, and begins when water temperatures reach 10-15° C. (FERC, 2000). Spent adults migrate downstream shortly after spawning, generally during the period May through July (FERC, 2000). Juvenile Blueback Herring rear throughout the Mohawk River during summer and are an important prey for game fish such as bass, Walleye, and Yellow Perch. In the summer, young of year Blueback Herring can typically be found near the surface but move to deeper water prior to migrating to the sea. Outmigration of juvenile Blueback Herring from the Mohawk River typically occurs during the fall (FERC, 2000).

The Mohawk River, in the vicinity of the Projects, is managed by the New York State Department of Environmental Conservation (NYSDEC) as a mixed cool-water and warm-water fishery. The fish community is dominated by warm-water species and is used extensively by recreational anglers (NYSDEC, 2018). The river is also managed for anadromous BBH. NYSDEC's fishery management goals for the Mohawk River are multi-faceted and recognize that the fisheries of the Mohawk River watershed, like many inland waters, are in a state of transition (NYSDEC, 2018). Management of the Mohawk River fishery is complicated by the continuous influx of new species through the Barge Canal and must balance the need to provide desirable fishing opportunities for sportfish while also trying to sustain native biodiversity (NYSDEC, 2018). The NYSDEC also has an interest in the BBH run in the lower Mohawk River. The Atlantic States Marine Fisheries Commission (ASMFC) regulates river herring stocks in New York and has the stated goal to protect, enhance, and restore East Coast migratory spawning stocks of BBH in order to achieve stock restoration and maintain sustainable levels of spawning stock biomass.

While the Barge Canal provides an upstream migration route past the dams located on the Mohawk River, downstream migration primarily occurs over the dams or through turbine passage. These passage routes have the potential to result in mortality of downstream migrants. Therefore, assessment of downstream passage survival is a consideration for BBH.

1.1 Background

The Power Authority of the State of New York (Power Authority) is licensed by the Federal Energy Regulatory Commission (FERC or the Commission) to operate the Crescent and Vischer Ferry Hydroelectric Projects (FERC Nos. 4678 and 4679) (Projects) located on the Mohawk River in New York. The Power Authority is relicensing the Projects using the FERC Integrated Licensing Process (ILP), as outlined in 18 C.F.R. Part 5.

In accordance with 18 C.F.R. §§ 5.5 and 5.6, the Power Authority filed its Notice of Intent (NOI) and Pre-Application Document (PAD) on May 3, 2019, which included the Power Authority's preliminary issues and studies list for the Projects. FERC issued its Scoping Document 1 (SD1) on June 10, 2019 and held public scoping meetings on July 10-11, 2019 in Clifton Park, New York, where potential issues were identified by agencies, stakeholders, and the public.

Subsequently, the Power Authority received comments on the PAD and requests for additional studies. The Power Authority reviewed these comments and study requests and developed a Proposed Study Plan (PSP), which was filed with the Commission on September 23, 2019. The Power Authority held a PSP public meeting to discuss the PSP on October 23, 2019. Written comments on the PSP were received through December 23, 2019.

The Power Authority then developed its Revised Study Plan (RSP), which was filed with FERC on January 21, 2020. On February 20, 2020, FERC issued its Study Plan Determination (SPD), which approved the Power Authority's Blueback Herring Downstream Migration Study with a recommended modification.

This study report presents information and results pertaining to the Blueback Herring study conducted at the Crescent and Vischer Ferry Projects in 2020.

1.2 Study Goals and Objectives

The goals and objectives of this study are to use existing and theoretical data to estimate adult and juvenile BBH downstream passage whole station survival associated with the Crescent and Vischer Ferry Projects.

1.3 Project Descriptions

The Crescent and Vischer Ferry Projects are both operated on a run-of-river basis. The original purpose of the Crescent and Vischer Ferry Dams was to impound water to support navigation on the Barge Canal; this remains true today as navigation and Barge Canal operations take priority over the operation of the Projects. During unusual conditions or emergencies associated with the system, public safety is always the first priority. Thus, both Projects operate in coordination with the New York State Canal Corporation (Canal Corporation) who operates the Barge Canal. Unless emergency conditions exist, the Projects operate in run-of-river mode with fluctuations (allowable six inches or less[1]) allowed at Canal Corporation's direction, and as permitted by the existing FERC licenses, to aid navigation, to facilitate flashboard installation and removal, and for canal maintenance or safety.

1.3.1 Crescent

The Crescent Project is an 11.8 MW conventional run-of river hydroelectric project located on the Mohawk River, approximately 4 miles upstream from its confluence with the Hudson River. It is located 2 miles upstream of the School Street Hydroelectric Project (FERC No. 2539) owned by Erie Boulevard Hydropower, L.P.

The Crescent Project generally consists of a dam, powerhouse, impoundment, and appurtenant facilities. The Crescent Dam consists of two independent concrete gravity overflow sections which link each riverbank to a rock island in the middle of the Mohawk River (Figure 1.3–1). Both sections are curved in plan and have a crest at elevation (El.) 184.0 Barge Canal Datum (BCD).

In order to aid Barge Canal navigation, one-foot-high (12 inch) wooden flashboards are installed along the crests of both spillways (Dams A and B) seasonally in Spring (generally in May based on seasonal conditions) and removed in the Fall (generally in November based on seasonal conditions). When the flashboards are installed, the spillway crest is El. 185.0 ft. BCD. The Crescent impoundment extends upstream approximately 10 miles to the Vischer Ferry Project Dam. At El. 184.0 ft. BCD, the surface area of the impoundment is 2,000 acres and impounds approximately 50,000 acre-feet of water. Installation of the flashboards increases the normal full pool elevation of the impoundment by 1 foot to El. 185.0 ft. BCD, and the impoundment retains an additional 2,000 acre-feet of water. Article 41 of the Crescent Project's FERC license stipulates that head pond elevation be maintained between 0.1 and 0.4 feet below crest. Power Authority Operations normally targets head pond levels of El. 183.8 BCD without flashboards and El. 184.8 BCD with flashboards.

The Crescent powerhouse is located on the western bank and houses four turbine/generator units: two 2.8 MW rated Francis turbines and two 3.0 MW vertical Kaplan turbines. The original portion of the powerhouse contains the two original Francis units (Units 1 and 2). The two newer Kaplan units (Units 3 and 4) are located riverward of the original powerhouse.

Crescent Project operations are performed in a manner to maintain the normal full pool elevation of the impoundment. Flow through the Project is through the powerhouse or over the dam. During the non-navigation season, a minimum flow of 100 cubic feet per second (cfs) (or inflow, whichever is less) is required to be passed at the Crescent Dam. In accordance with a July 31, 2007 FERC order, the minimum flow during Barge Canal navigation season is increased to 250 cfs. This minimum flow must be passed through a notch in the Dam A flashboards. The notch is 80 feet wide by 1 foot deep. Flows due to leakage or turbine discharge are not considered as part of maintaining this requirement. These minimum flows are

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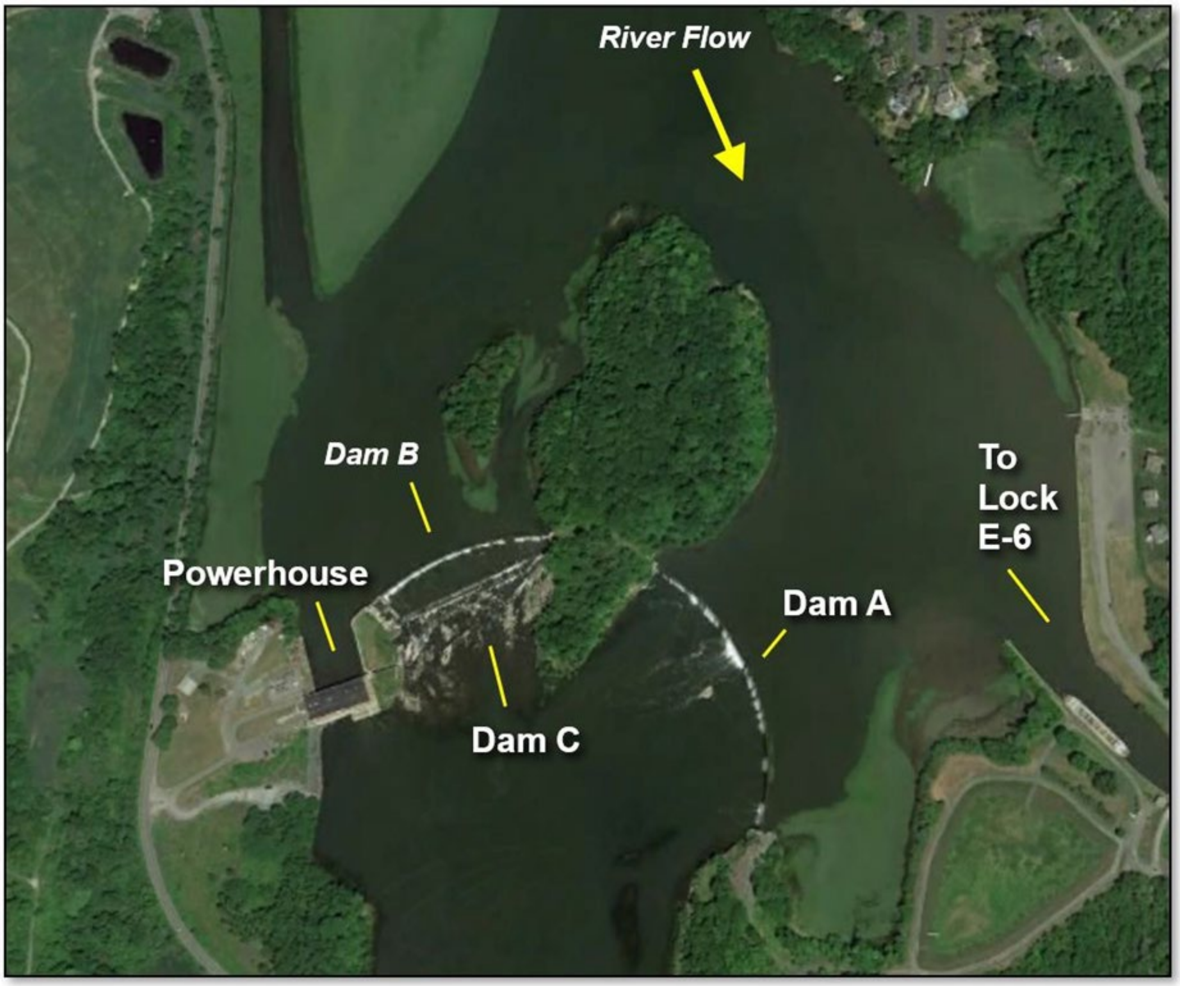
[1] Allowable fluctuation is defined by FERC's Order Amending Article 41 (November 17, 2000) states "In some instances, the project shall be operated to maintain the reservoir surface elevation in the range from the top of the dam (or top of the flashboards during the navigation season) to a level 6 inches below the top of the dam (top of the flashboards during the navigation season). This 6-inch fluctuation shall not be used for regular ponding operations. It shall be used only in the event of curtailment of inflows due to operations of the upstream Barge Canal."

for downstream fish passage protection measures. Once minimum flows and any diversions required for Barge Canal operations are met, the remaining flow is available for power generation.

Figure 1.3–1: Major Project Facilities of the Crescent Project



1.3.2 Vischer Ferry

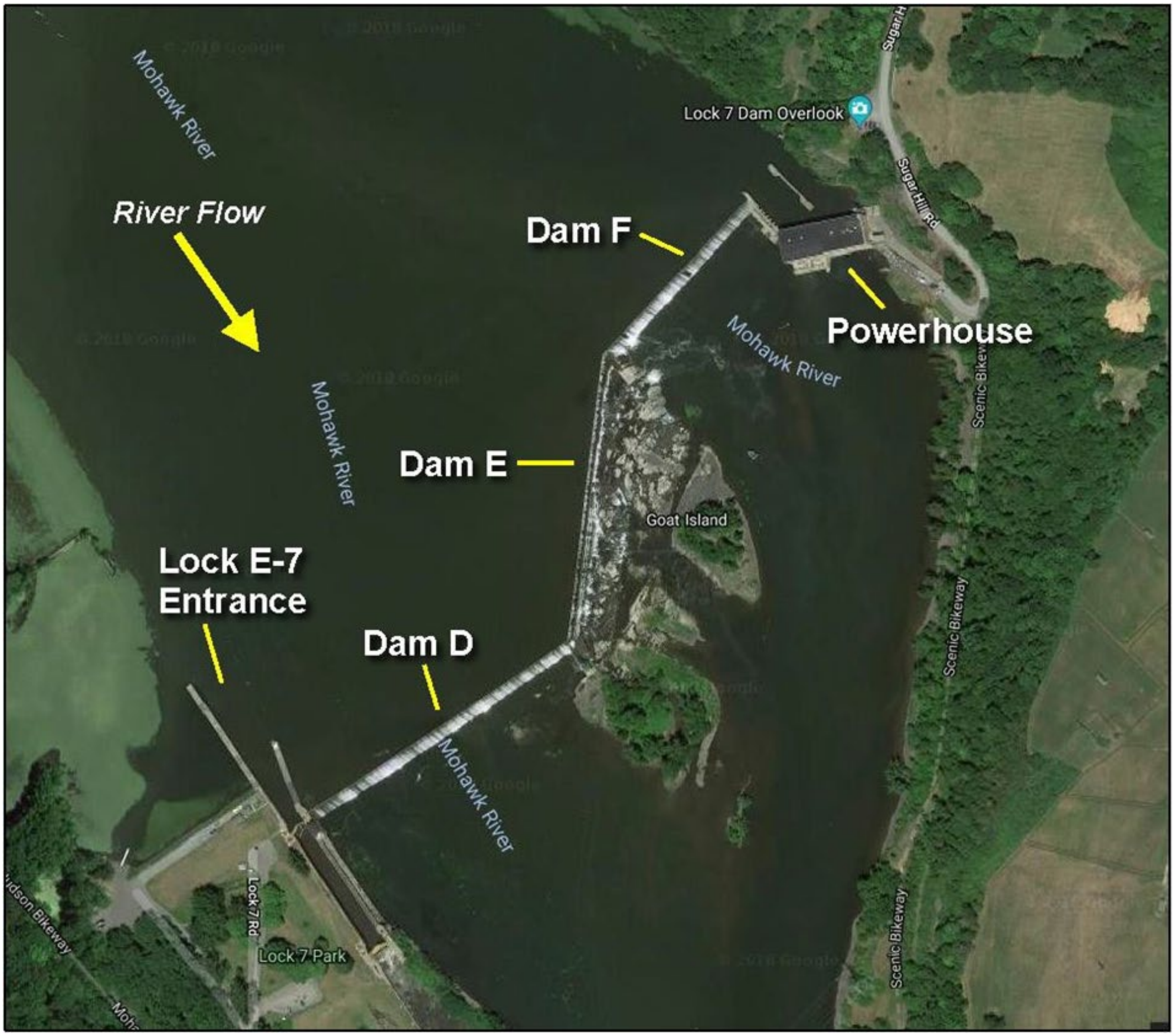
The Vischer Ferry Project is an 11.8 MW conventional run-of-river hydroelectric project located on the Mohawk River, approximately 14 miles upstream from its confluence with the Hudson River, and approximately 10 miles upstream of the Crescent Project. The Vischer Ferry Project generally consists of a dam, powerhouse, impoundment, and appurtenant facilities. The Vischer Ferry Dam consists of three connected spillway sections (Figure 1.3–2). The two outer sections (Dams D and F) are regular, ungated, ogee-shaped weirs with an average structural height of approximately 30 ft. above rock. The middle section (Dam E) is a broad-crested weir constructed over a small bedrock island near the center of the river. Lock E-7 is located at Vischer Ferry Dam on the right bank, which is the opposite side of the river from the Vischer Ferry powerhouse.

To aid Barge Canal navigation, flashboards are installed along the crests of all spillways seasonally from Spring (generally in May) to the end of navigation season (generally in November based on season conditions). The flashboards are 27 inches high and when the flashboards are installed, the impoundment elevation is 213.25 ft. BCD. The spillway crest elevation is 211.0 ft. when flashboards are removed. The Vischer Ferry impoundment is 10.3 miles long and the upstream terminus of the impoundment is located at Lock E-8 in Schenectady. At El. 211.0 ft. BCD, the surface area of the impoundment is 1,050 acres and impounds approximately 25,000 acre-feet of water. Installation of the flashboards raises the normal full pool to El. 213.25 ft. BCD, and the impoundment retains an additional 2,400 acre-feet of water. Article 41 of the Vischer Ferry Project's FERC license stipulates that head pond elevation be maintained between 0.1 and 0.4 feet below crest. Power Authority Operations normally targets head pond levels of El. 210.8 BCD without flashboards and El. 213.0 BCD with flashboards.

The Vischer Ferry Project powerhouse is located at the northern end of the dam and houses four turbine/generator units: two 2.8 MW rated Francis turbines and two 3.0 MW vertical shaft Kaplan turbines (identical units as at the Crescent Project). The original portion of the powerhouse contains the two original Francis units (Units 1 and 2). The two newer Kaplan units (Units 3 and 4) are located riverward of the original powerhouse. The turbines discharge water into the tailrace, the elevation of which is controlled by the Crescent impoundment level.

Vischer Ferry Project operations are performed in a manner to maintain the normal full pool elevation of the impoundment. Flow through the Project is through the powerhouse or over the dam. A minimum flow of 200 cfs (or inflow, whichever is less) is required to be passed at the Vischer Ferry Dam. An 8-foot section of the flashboards on Dam F is removed during navigation season to provide downstream fish passage flow. Once Project minimum flows and any diversion required for Barge Canal operations are met, the remaining flow is available for power generation.

Figure 1.3–2: Major Project Facilities of the Vischer Ferry Project



1.3.3 Turbine Operations

Turbine operations are the same for both the Crescent and Vischer Ferry projects. When both Kaplan units are available for service, the Kaplan units are used first to a flow of 1,820 cfs (3,875 KW) per unit or approximately 3,640 cfs total for both Kaplan units combined. As flows increase and additional capacity is needed, a Francis unit is operated at full load (3100 KW or 1,500 cfs), with remaining flow distributed between the two Kaplan units. Once both Kaplans and one Francis reach capacity, approximately 5,140 cfs, a second Francis unit is brought online at full load with the remaining flow split between the Kaplan units to a maximum hydraulic capacity of 6,640 cfs. Once all units have reached full hydraulic capacity, additional flow is spilled over the dam. When flows are decreasing, the operational regime is essentially reversed. First, spill is eliminated and then the Kaplan units are adjusted until one of the Francis units can be shut down. The Kaplan units continue to be adjusted until flows decrease enough to allow for the remaining Francis unit to be shut down. When flows decrease to the point that two Kaplan units are not needed, all turbine discharge is passed through one Kaplan unit. During low flow periods when there is insufficient flow to operate a turbine and meet minimum flow requirements, all flow is passed over the dam and/or through the downstream fish bypass notches. In summary, operation of the Kaplan units is prioritized over operation of the Francis units due to better fish passage survival rates relative to the Francis units. When the Francis units are operated, they are operated at full load to maximize fish passage survival.

1.3.4 Downstream Fish Passage

There are multiple routes for downstream fish passage at the Crescent and Vischer Ferry Projects. At both Projects, fish have multiple downstream passage options, all of which are likely used to some degree. These options include turbine passage, passing over the dams during high-flow conditions (spillway passage), passing through the notched flashboards (bypass), or passing via the Barge Canal to downstream areas. Downstream passage at both Projects is also greatly enhanced through the operation of acoustic guidance systems which divert fish away from the turbine intakes. While this diversion is intended to direct fish toward the bypass routes created by notches in the flashboards at each Project, fish pass over the dam (spill) when flows exceed powerhouse capacity. Some portion of fish pass downstream via the Barge Canal. The potential for Barge Canal passage is discussed in more detail later in the report.

At the Crescent Project, downstream fish passage has been enhanced by the Licensee’s installation and operation of an acoustic deterrent system in combination with the provision of a flashboard opening measuring 80 ft by 1 ft providing access from the main river channel through the dam (Figure 1.3–3). At Crescent, the acoustic deterrent system likely increases the number of fish migrating downstream through the Barge Canal by diverting fish to the eastern river channel where the Barge Canal entrance is located.

The Vischer Ferry Project also supports downstream passage of herring with a combination of acoustic deterrent array and flashboard openings (Figure 1.3–4). Two different locations are used for the openings depending on the BBH lifestage present, one for adults and one for juveniles. These openings are 8 ft by 2.25 ft and were determined based on-site specific studies conducted at Vischer Ferry which determined slightly different locations were beneficial for each lifestage at this site (Ross, 1999). The downstream face of the dam associated with these openings is covered by a synthetic, rubberized material to provide a smooth substrate for fish to pass over.

Figure 1.3–3: Downstream Fish Passage Routes at the Crescent Hydroelectric Project

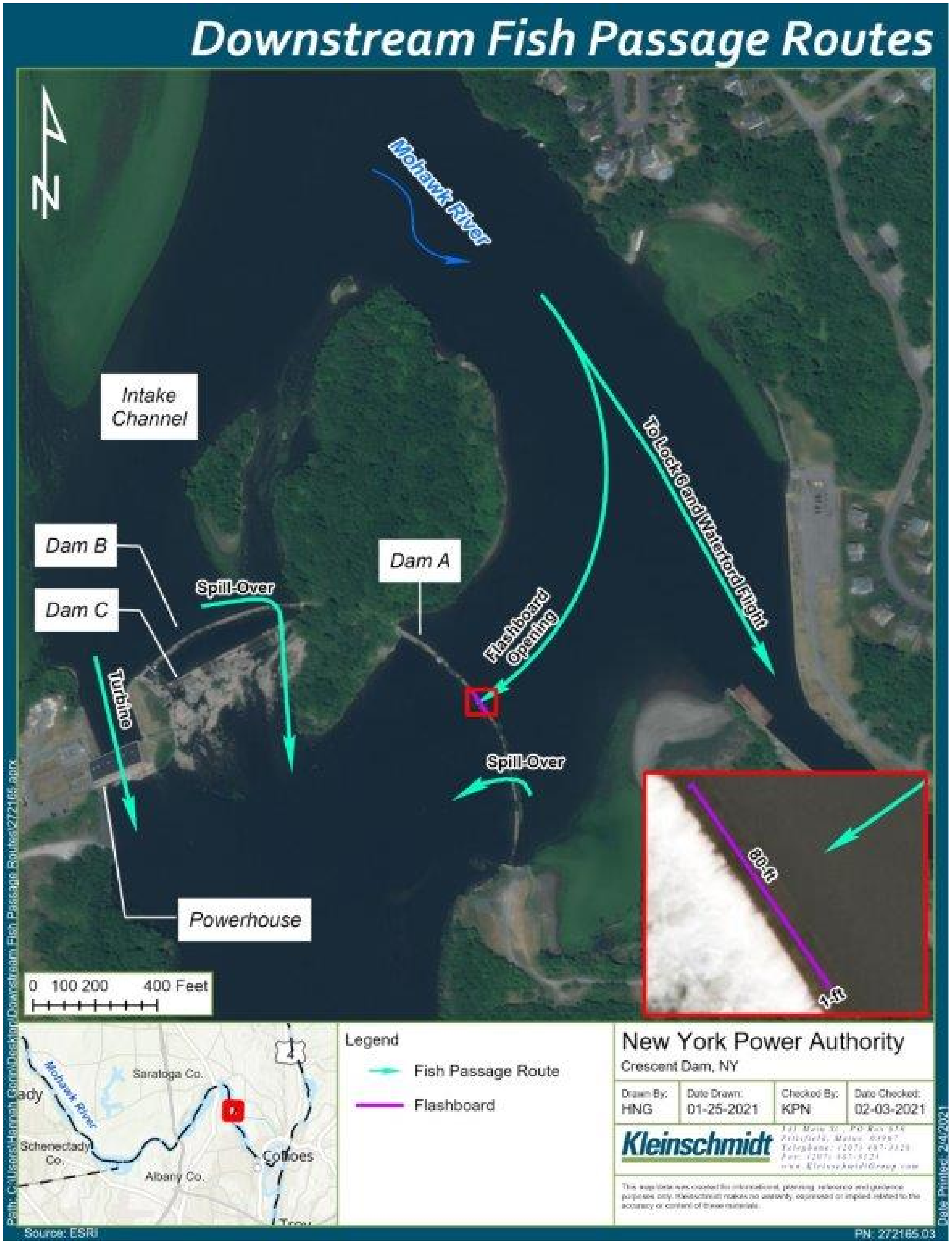
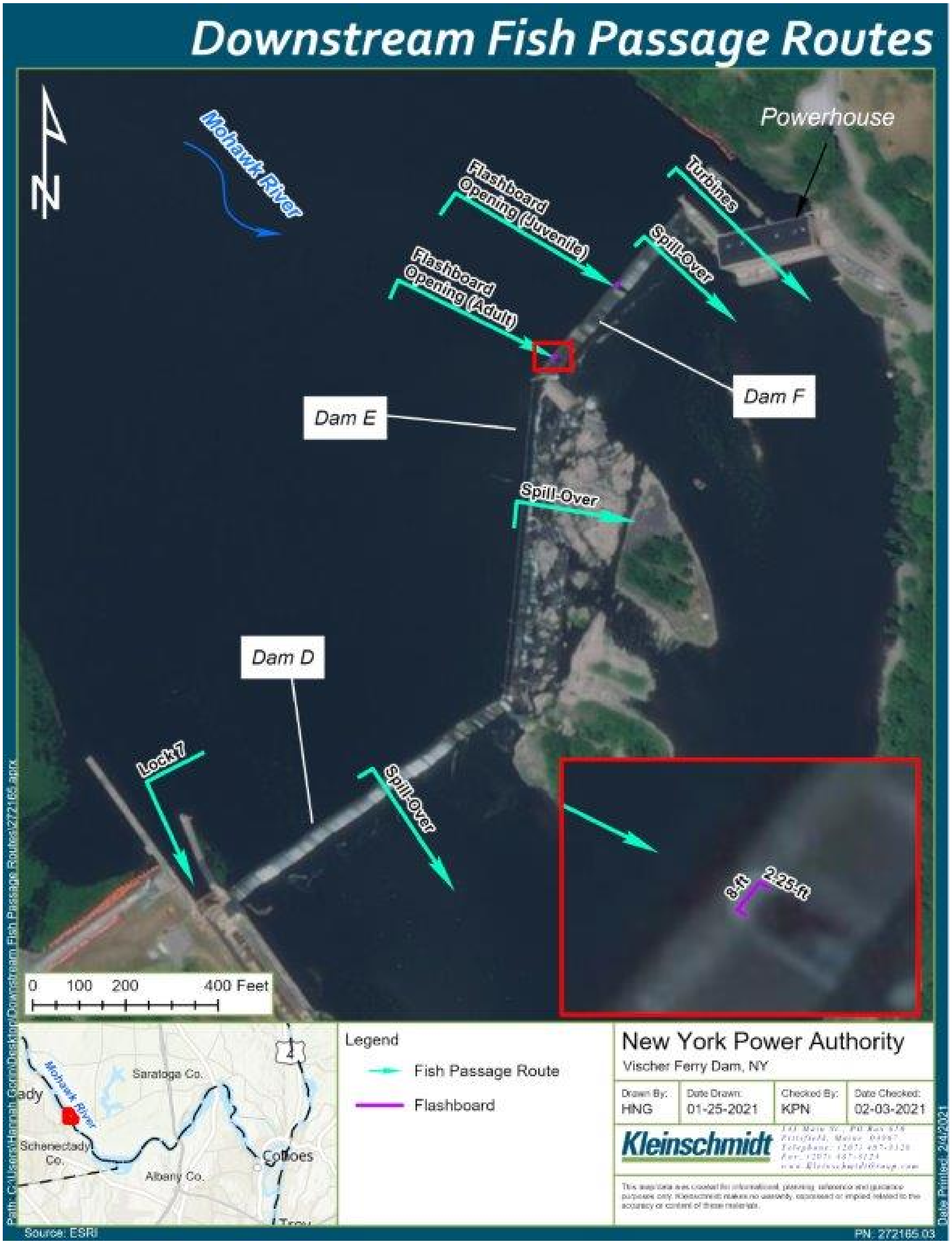


Figure 1.3–4: Downstream Fish Passage Routes at the Vischer Ferry Hydroelectric Project



2 Methodology

For this study, downstream passage survival was evaluated by reviewing existing studies and by using probability equations to predict downstream passage survival. Passage routes through the Projects include spill over the dam, through the flashboard notches, and through the turbines. The combined effects of these passage routes were collectively considered to estimate total downstream passage success at each Project. While it is likely that some portion of downstream migrants may pass through the Barge Canal, this passage route was not specifically evaluated.

2.1 Review of Existing Downstream Passage Survival

Existing studies on downstream passage were reviewed and considered for application to the Projects. Sources of studies included EPRI (1997), which is a database of turbine passage survival studies for multiple fish species at more than 50 hydropower projects throughout the country, studies conducted after the creations of the EPRI database, and studies conducted at the Projects themselves. The database of studies was filtered to identify hydropower projects with turbines and site characteristics comparable to the Crescent and Vischer Ferry Projects (e.g., turbine type, RPM, head, runner diameter) and studies directly pertaining to BBH and other alosines. Site specific data included mortality as well as fish guidance system effectiveness studies.

2.2 Survival Estimates Using a Predictive Model

Several models have been developed to predict the survival rate of fish passing through hydroelectric turbines. These models consider fish size, turbine specifications, and station hydraulics to estimate the theoretical blade strike and survival of specific sized fish for a particular turbine configuration. Direct effects of turbine passage can be predicted as a probability because the variables (such as turbine diameter, number of blades, etc.) and value ranges for those variables can be precisely defined. These models allow the user to manipulate parameters such as fish size or turbine characteristics to determine the relative effect on turbine passage survival.

Blade strike probability and turbine passage survival at the Projects was estimated for the target species using the Department of Energy's Advanced Hydro Turbine model developed by Franke et al. (1997). This predictive algorithm is based on the work of Von Raben (Bell, 1981). Franke et al. (1997) refined the Von Raben model to consider the effect of tangential projection of the fish length on blade strike probability because most turbine passage mortality at low head dams (<100 ft) is caused by fish striking a turbine blade or some other turbine structure. There are separate equations used for different turbine types.

For the Kaplan turbines at the Projects, the probability of blade strike was calculated by the following formula:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\cos \alpha_a}{8 \cdot Q_{wd}} + \frac{\sin \alpha_a}{\pi \cdot \frac{r}{R}} \right]$$

For the Francis turbines at the Projects, the probability of strike was calculated by the following formula:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\sin \alpha_a \left[\frac{B}{D_1} \right]}{2Q_{\omega d}} + \frac{\cos \alpha_a}{\pi} \right]$$

In each formula the input parameters are defined as:

P = Predicted strike probability

N = Number of turbine blades

L = Length of fish

D = Diameter of runner

D_1 = Diameter of runner at inlet

B = Runner height at inlet

λ = Strike mortality correlation factor (lambda)

R = Radius of runner = (D/2)

r = Location along radius that a given fish enters the turbine

η = Turbine efficiency

$E_{\omega d}$ = Head Coefficient or energy coefficient

$$= \frac{gH}{(\omega D)^2}$$

α_a = Angle to axial of absolute flow upstream of runner

$$= \tan \alpha_a = \frac{\pi \cdot E_{wd} \cdot \eta}{2 \cdot Q_{wd} \cdot \frac{r}{R}}$$

g = Acceleration of gravity

H = Turbine net head

ω = Rotational speed

$$= RPM \cdot \frac{2\pi}{60}$$

RPM = Revolutions per minute

Q = Turbine discharge

Q_{opt} = Turbine discharge at best efficiency

$Q_{\omega d}$ = Discharge Coefficient

$$= \frac{Q}{\omega D^3}$$

$$\tan \beta = \frac{0.707 \cdot \frac{\pi}{8}}{\xi \cdot Q_{\omega d}\, opt \left[\frac{D_1}{D_2}\right]^3}$$

ξ = Ratio between Q with no exit swirl and Q_{opt}

Survival was calculated by subtracting the predicted strike estimate (P) from 100.

Model predictions were made for both juvenile and adult BBH based on the size of these lifestages found in the Mohawk River. It is important to note that the predictive equations do not differentiate between any species but only consider fish size. Turbine survival as defined by blade strikes has been shown to be influenced more by fish size than species (Franke et al., 1997). While all parameters of the equation can affect blade strike estimates, fish length, the number of turbine blades, and runner diameter have the greatest impact on the estimates.

A correlation factor (λ) is utilized in the Advanced Hydro Turbine model to adjust the predictive model results to correspond with documented empirical results. This correlation factor was originally introduced by Von Raben (cited by Bell 1981) because the contact of a fish with a turbine component does not always result in injury or mortality (Bell, 1981; Cada, 1998). Therefore, Von Raben introduced the correlation factor to adjust the predicted turbine strike results to more closely match empirical results. This factor also extends the applicability of these predictive equations to all injury mechanisms related to the variable N L / D (see above for definition of parameters). As stated in Franke et al. (1997) "such mechanisms could include mechanical mechanisms leading edge strike and gap grinding as well as fluid induced mechanisms related to flow through gaps or other flow phenomena associated with blades. " Based on a substantial number of test results obtained from studies conducted with salmonids on the west coast, Franke et al. (1997) recommended that the correlation factor (lambda) be set between 0.1 to 0.2. The lambda value is designed to correlate model results to empirical survival data. Because mortality due to mechanisms other than blade strikes can be expected to increase with fish size, larger lambda values are more appropriate for larger fish. All model iterations for BBH at the Projects utilized a lambda value of 0.15. This value was chosen based on initial model runs where the use of a 0.15 correlation factor estimated survival that was consistent with BBH survival estimates obtained by empirical testing at the Crescent Project. While more conservative (i.e., lower survival), higher correlation factor values tend to be more appropriate for use with fish larger than those considered in this study.

The Power Authority used the USFWS' Turbine Blade Strike Analysis (TBSA) model (Towler and Pica, 2020) to predict turbine passage survival and total project passage survival (i.e., passage survival via spill, the turbine, and the fish bypass combined) at the Projects. The TBSA model is based on the blade strike calculations presented by Franke et al. (1997). The model version used in this evaluation was revised on December 9, 2020. Turbine project specifications (e.g., runner diameter, head, RPM) were entered into the TBSA model, along with fish length information and recommended correlation factors. Additionally, the TBSA model allows for setting mortality rates of other non-turbine passage routes such as bypasses to provide a more holistic picture of downstream passage success.

In addition to providing turbine parameters and setting bypass mortality rates, the TBSA model requires additional inputs. These include mean fish length with standard deviation and assignment of the proportion of downstream migrants to each passage route.

Two separate assigned passage route methodologies were used in the model runs. The first step was to determine river flows for consideration. Data from the Cohoes Gage (USGS 01357500) period of record was used to calculate the mean monthly river flows at each project which represents a typical condition. The flow at each project was calculated by applying the drainage basin ratio between each Project and the Cohoes Gage to the flow data. In addition to the mean values, the 10th percent and 90th percentile flow values were also calculated in order to provide both high flow and low flow scenarios. Months for consideration included May through November. These months are when BBH are in the Mohawk River system. Specifically, adult BBH are in the system from May through July while juvenile BBH occur from July through November. It is important to note that most downstream migration occurs over a much shorter period. This analysis, however, considers a robust range of flow conditions. It is also important to note that while these obligatory migrants will eventually pass downstream regardless of flow conditions, the onset of higher flow events during the migration season, especially when coupled with other factors such as changes in water temperature and light intensity, can trigger substantial downstream movement (Richkus, 1975). Studies conducted on downstream migrating adult and juvenile BBH on the Mohawk River effectively ended when higher flows occurred and the study specimens moved downstream (Kleinschmidt, 2009; NAI, 2012). As such, the higher flows evaluated may be more representative of the conditions when many fish move downstream.

Once river flow conditions were calculated, these were distributed to the various flow routes; minimum flow requirements, leakage, unit operation, and spill as discussed in Section 1.3.3. The first set of model runs assumed that fish were evenly distributed by flow (i.e. # of fish per cfs) and assigned to a passage route based on flow distribution. In other words, there was no guidance system operating to direct fish toward the notched flashboards and alter an even distribution. Worst case scenarios are represented in some of these runs in that more fish are assigned to passing through the powerhouse, including the Francis Turbines, rather than the bypasses. A second set of model runs was then conducted based on the success of the acoustic guidance system where the guidance effectiveness was used to direct the appropriate percentage of fish away from the turbine intakes. These fish were then assumed to pass through the notched flashboards and spill if present. Remaining fish were proportionally distributed by flow through the turbine units. It should be noted that no fish were assigned to leakage flows which would pass through small gaps such as those under or between the flashboards.

The Power Authority conducted initial feasibility and effectiveness testing of the acoustic guidance system at the Projects from 1996-1998 (Ross, 1999). Subsequent testing occurred at Crescent in 2009 and 2012

(Kleinschmidt 2009 and NAI 2012). Results at both sites indicated a high level of success in guiding downstream migrating BBH.

Testing at Vischer Ferry indicated that the downstream migration pattern of BBH was such that they followed the deeper parts of the river channel along the western side of the river and avoided the relatively shallow, spoil deposit area just upstream of the turbine intake area. To reach the intake area, BBH would follow the deeper, relatively narrow channel along the dam. Monitoring indicated that this behavior coupled with providing an opening in the flashboards to act as a bypass successfully diverted a large portion (approximately 90%) of juvenile BBH from entering the headrace area. Addition of the acoustic guidance system further increased the percentage of BBH using the bypass (Ross, 1999). Thus, the overall estimate of juvenile BBH utilizing the Vischer Ferry bypass with the acoustic deterrent system in place was found to be 97-98%. Additional evaluation of the data for adults indicated similar results with an estimated effectiveness of 96% (Ross, 2002). These tests also identified the separate bypass locations for adult and juvenile BBH. Due to the similar study results for both adult and juvenile BBH, a 96% effectiveness rate was assumed for both lifestages.

Initial testing at Crescent indicated mixed results with substantially better effectiveness being estimated for juvenile BBH (Ross, 1999). During these tests, however, the transducers were in the forebay and the bypass was located on Dam B which is located in the intake (western) channel (i.e., the Project's intake channel). Subsequently, the transducers were moved out of the forebay and upstream into the intake (western) channel and the bypass (flashboard notch) was moved to Dam A and based on results from an evaluation in 2008, the acoustic system was again reconfigured in 2010 (Dunning and Gurshin, 2012). This final reconfiguration which represents the current conditions, consisted of re-aiming the four westerly ultrasonic projectors upriver at 45 degrees toward the main navigation channel (i.e., eastern channel). They were previously situated back-to-back and aimed across the intake channel, perpendicular to flow. This final configuration extended the effective range of the projectors further upriver to provide fish with more time to react to the sound gradient prior to reaching the intake channel.

The effectiveness of the current deterrent system configuration was evaluated in 2012 using three methods: pelagic trawls, mobile acoustic monitoring, and fixed-location acoustic monitoring (NAI, 2012). All three methods indicated that the acoustic guidance system was highly effective. Pelagic trawl efforts in the downstream area resulted in a catch per unit of effort (CPUE) that was 94% of the CPUE in the area upstream of the acoustic guidance system and 250% of the CPUE in the intake channel. Likewise, mobile acoustic surveys indicated that total abundance averaged 35 times higher in the downstream area than the intake channel and averaged 91% of their sum. Fixed-location acoustic monitors yielded the lowest estimate of effectiveness between the three methods at 76% (NAI, 2012). The 76% effectiveness value established for juveniles through the fixed-location monitors was used in this evaluation for both juvenile and adult BBH.

At both Projects, fish not effectively guided toward the spillway notches were proportionally distributed through the turbine units and spill, if present, based on flow. It should be noted that it is likely that some BBH pass through the Barge Canal system, especially at Crescent.

Two sets of fish lengths were calculated: one for juveniles and one for adults. Mean fish lengths were calculated for juveniles based on the Crescent mortality study (RMC, 1992). Adult fish lengths were calculated based on the data set used for aging BBH (NAI, 2007).

Another variable for consideration was bypass and spillway survival. Both passage routes involve fish passing over the dam. In the case of the bypass, the fish go through a notch in the flashboards and therefore, a fixed minimum water depth while passing through the notch. In the case of spill, the water depth over the flashboards is directly related to river flow. In the case of a very high flow event, it is possible for the flashboards to fail, at least in some locations, and effectively act as additional bypass routes.

Passage through bypasses and spillways is generally considered to be relatively benign with high survival rates. Factors that likely influence spillway survival and even potential injury to fish, especially for species such as BBH, which are prone to scale loss, include spill volume, distance of drop, and plunge pool depth. Personal communication with Brett Towler of the USFWS indicates that a 1% mortality rate for each 10 ft of drop at a bypass is a reasonable estimate. Alden (2018) indicated bypass survival as routinely about 97% (i.e. 3% mortality) but appears to be largely based on passage of salmonids. Recent laboratory testing of juvenile BBH by Carlos-Santos et al (in press) tested the variables of spill discharge and pool depth.

Tests were conducted at the USGS's S.O. Conte Anadromous Fish Research Center in an experimental flume measuring 9.84 ft wide by 19.68 ft deep by 131.23 ft long. A structure was created in the flume consisting of a bypass weir (3.94 ft wide by 3.61 ft long) which was mounted on top of steel bulkheads that allowed for adjusting height of the weir crest above the flume floor. The plunge pool area (9.84 ft wide by 29.86 ft long) consisted of the concrete walls and floor of the flume. A 7.54 ft tall flip gate was located at the downstream end of the plunge pool. The flip gate was hinged at the bottom and raised or lowered to control plunge pool depth. Downstream of the flip gate, a perforated aluminum plate angled to the flow allowed water to flow through while guiding fish towards a collection pen. Four conditions were tested. In all tests, the weir was adjusted to maintain a 3 m drop to the plunge pool water surface. Three treatments consisted of a 5.58 ft^3/s flow (high flow) and plunge pool depths of 23.6,47.2, or 70.9 in. The fourth treatment condition consisted of 0.98 ft^3/s of flow (low flow) and a plunge pool depth of 47.2 in. Except for two mortalities attributed to handling error during the high flow – 70.9 in plunge pool trial, immediate survival was 100%. The 96-h survival was lowest for the high flow condition with a 23.6 in plunge pool depth at approximately 86%. The 96-h survival for high flow tests with 47.2 in and 70.9 in plunge pool depths ranged from about 92.5 – 97.5 %. The low flow, 47.2 in plunge pool depth test exhibited about 97.5% survival. Therefore, except for tests with the shallowest plunge pool, 96-hour survival was greater than 90%. Highest survival occurred during the low flow tests and exceeded 97% (Castro-Santos et al, in press). An interesting observation during this study was that immediate survival was very high with only 2 mortalities in the 1665 fish tested, both of which were attributed to handling errors, and that recorded mortalities were the result of delayed effects. Castro-Santos et al (in press) stated that survival was higher than anticipated and compared favorably to estimates found for salmonids subjected to plunge pools.

Empirical data collected at Crescent at a bypass on Dam B (powerhouse side of the island), estimated immediate survival at 100% and 48-hour bypass survival at 88.3% with a 95% confidence interval of 75.5-100% (RMC 1992). These empirical test results are similar to the results presented by Castro-Santos et al (in press) in that immediate survival was 100% and mortalities resulted from delayed effects. It should be noted that the bypass tests were conducted on Dam B at Crescent which is substantially different than Dam A where the current bypass is located.

Regulatory agencies recommend the ratio of height of drop: plunge pool depth of > 4:1 when permitting downstream fish passage, that is plunge pool depth should be at least 25% of the distance from the spill crest to the plunge pool water surface with a minimum plunge pool depth of 47.2 in (USFWS, 2017). The fish bypass at Crescent Dam A meets these criteria. Under low spillway water level conditions, the distance from spillway crest to the plunge pool surface is approximately 30 ft with a plunge pool depth of 9 ft. At high spillway water surface elevations, there is approximately 21.5 ft of drop and a plunge pool depth of 17.5 ft. While Crescent Dam B has a lower drop distance of 12 ft., the plunge pool depth is only 2 ft. at lower spillway water surface elevation conditions as would have been present during bypass survival testing. This plunge pool depth was only about 16.7% of the drop distance and falls well short of recommended criteria. Dam A conditions would exhibit a plunge pool depth equal to about 30% of the drop. This would likely translate into higher passage survival compared to a bypass at Dam B.

At Vischer Ferry, the distance from dam crest to the plunge pool water surface under low spillway water level conditions is 27 ft with a plunge pool depth of 6.5 ft. which results in just under the recommended criteria (24.1%). At high spillway water level conditions, the drop distance is 16 ft with a plunge pool depth of 17.5 ft. The dam at both Projects has an ogee profile which would dissipate energy and provide a smoother transition into the plunge pool compared to a sharp crested weir. It is likely that this transition would facilitate downstream passage.

Based on the research and studies described above, low (88.3%) and high (97.0%) bypass survival estimates were established. Converting those to mortality estimates, the model was run with bypass mortality rates of 11.7% based on the Crescent data and at 3% based on generally accepted bypass survival success, as supported by the tests reported by Castro-Santos et al (in press). These same rates were applied to Vischer Ferry, where in addition to the concrete, ogee shaped dam contour which bypassed fish would traverse, the portion of the dam in the bypass area at Vischer Ferry is covered in a rubberized material to facilitate fish safely passing through the bypass. Therefore, it is a reasonable assumption that the use of bypass survival rates of 88.3 – 97.0% should bracket the likely bypass survival rate for both juvenile and adult BBH.

3 Results

3.1 Existing Studies

Studies that were considered applicable to the Project were reviewed to determine if the data could be used to assist in estimated total station survival for downstream migrating BBH at the Projects. An annotated bibliography of those studies is included in Appendix A. While the studies provided insight on overall survival, the site-specific studies on turbine and bypass mortality as well as the effectiveness of the acoustic deterrent system provided the most value for this assessment. Data from these studies were used in the TBSA model to provide more focused results.

Turbine survival study results that could be used for consideration when evaluating survival at the Projects are provided in Table 3-1. These studies are specific to mortality tests on juvenile alosines conducted with balloon tag studies. No studies on downstream passage survival of adult BBH were located. Netting studies are not good measures of survival when testing alosines due to their fragile nature and tendency for scale loss. A number of these studies presented in in Table 3-1 were conducted on larger turbines or turbines with substantially higher rotational speed but are included for reference. Studies conducted on Francis turbines similar to those at the Projects found turbine passage survival rates from 77.1% to 95.3 %. For Kaplan units similar to those at the Projects, turbine passage survival ranged from 89.1% to 100%. The empirical data collected at the Crescent Project for Kaplan turbines indicates survival of 96.0% which correlates well with the other studies.

Table 3-1: Physical and Hydraulic Characteristics of Hydroelectric Dams for which Turbine Passage Survival Data are Available for American Shad and Blueback Herring

Station	State	Study Year	River	Species	Average Size (mm)	Unit Tested	Turbine Type	No. of Blades/ Buckets	Runner Speed (rpm)	Runner Dia. (in)	Peripheral Velocity (fps)	Test Discharge (cfs)	Project Head (ft)	Sample Treatment	Size Control	Recapture Treatment	Rate (%) Control	1 h Survival	Source
*Columbia	SC	1998	Broad/Congaree	Blueback Herring	141	2	H-Francis	14	164	64	45.8	800	28	100	100	90.0	90.0	0.936	NAI (1999)
Conowingo	MD	1993	Susquehanna	American Shad	125	8	Mixed Flow	6	120	225	117.9	8,000	90	108	108	88.0	97.6	0.949	(RMC (1994a)
Conowingo	MD	2011	Susquehanna	American Shad	119	5	Francis	13	81.8	203	72.5	5,080	89	138	76	88.4	97.3	0.899	NAI and Gomez and Sullivan 2012
*Crescent	NY	1991	Mohawk	Blueback Herring	91		Kaplan	5	144	108	67.9	1,520	27	125	125	84.0	86.0	0.960	Mathur et al. (1996b)
Hadley Falls	MA	1991	Connecticut	American Shad	82***		Kaplan	5	128	170	95.0	4,200	52	100	100	76.0	76.0	0.973	RMC (1992b)
*Hadlely Falls	MA	1991	Connecticut	American Shad	82***		Kaplan	5	128	170	95.0	1,550	52	100	100	81.0	78.0	1.000	RMC (1992b)
*Hadlely Falls	MA	1991	Connecticut	American Shad	82***		Propeller	5	150	156	102.1	4,200	52	120	120	74.2	83.3	0.891	RMC (1992b)
Holtwood Dam	PA	1991	Susquehanna	American Shad	125	10	Francis	16	94.7	164	67.8	3,500	51	100	100	81.0	90.0	0.894	RMC (1992a)
Holtwood Dam	PA	1991	Susquehanna	American Shad	125	3	Francis	17	102.8	112	50.3	3,500	51	100	100	78.0	93.8	0.835	RMC (1992a)
Holtwood Dam	PA	1997	Susquehanna	American Shad	119	9	Francis	13	94.7	164	67.8	3,500	51	40	20	80.0	85.0	0.905	NAI (1997)
Safe Harbor Dam	PA	1992	Susquehanna	American Shad	118	9	Mixed Flow	7	76.6	240	80.2	9,200	55	100	100	92.0	92.0	0.978	Heisey et al. (1992)
Safe Harbor Dam	PA	1992	Susquehanna	American Shad	118	9	Mixed Flow	7	76.6	240	80.2	9,200	55	99	100	96.0	98.0	0.989	Heisey et al. (1992)
Safe Harbor Dam	PA	1992	Susquehanna	American Shad	118	7	Kaplan (horiz.)	5	109.1	220	104.8	8,300	55	100	100	99.0	99.0	0.980	Heisey et al. (1992)
*Stevens Creek	SC	1993	Savannah	Blueback Herring	203	3	Francis	14	75	135	44.2	1,000	28	131	120	90.8	89.2	0.953	RMC (1994b)
*York Haven	PA	2002	Susquehanna	American Shad	114	7	Francis	18	84	78	28.6	850	23	94	100	64.0	82.0	0.771	NAI (2001)
*York Haven	PA	2002	Susquehanna	American Shad	118	3	Kaplan	4	200	93	81.2	1,100	21	100	100	78.0	82.0	0.927	NAI (2001)
*Vernon	VT/NH	1995	Connecticut	American Shad	95	10	Francis	15	74	156	50.4	1,834	34	153	150	93.5	98.7	0.947	NAI (1996)
*Vernon	VT/NH	2015	Connecticut	American Shad	98	4	Francis	13	133.3	62.5	36.4	1,000	35	151	150	87.4	97.3	0.917	NAI (2017)
*Vernon	VT/NH	2015	Connecticut	American Shad	104	8	Kaplan	5	144	122	76.7	1,200	42	150	150	94.0	97.3	0.952	NAI (2017)
*Cabot Station	MA	2015	Connecticut	American Shad	96	2	Francis	13	97.3	136	54.4	2,304	60	120	71	95.8	94.4	0.950	NAI (2016)
Station No.1	MA	2015	Connecticut	American Shad	96	1	Francis	13	200	54	47.1	651	44	90	71	75.6	94.4	0.766	NAI (2016)
Station No.1	MA	2015**	Connecticut	American Shad	96	2	Francis	13	257	39	43.7	591	44	90	71	72.2	94.4	0.678	NAI (2016)
Station No.1	MA	2015**	Connecticut	American Shad	96	3	Francis	15	200	55	47.5	591	44						NAI (2016)

* Indicates tests conducted on units most similar to the Crescent and Vischer Ferry Projects.

** Units 2 and 3 have common penstock, only one survival estimate.

*** Fork length measurements were recorded.

3.2 Downstream Passage Route Survival

Pertinent turbine parameters used to estimate blade strike probability are provided in Table 3-2 and Table 3-3 for the Crescent and Vischer Ferry Projects, respectively. It should be noted that the four turbines at each Project (two Francis Units and two Kaplan Units) are nearly identical with only minor differences that are not anticipated to substantially affect blade strike estimates. As discussed above, fish length is a primary consideration in the model. Calculated fish lengths used in the model are provided in Table 3-4.

Table 3-2: Crescent Project Turbine Specifications

Parameter	Crescent Project	
	Units 1 and 2	Units 3 and 4
Turbine Type	Vertical Francis	Vertical Kaplan
Number of blades	15	5
Max turbine discharge (cfs)	1,500	1,820
Efficiency at max discharge	84.7%	90.1%
Min turbine discharge (cfs)	400	350
Runner diameter (ft)	7.18	9.02
RPM	90	144
Maximum head (ft)	27.9	27.9
Diameter of Runner at Inlet (ft)	7.18	NA
Diameter of Runner at Discharge (ft)	10.97	NA
Runner height at Inlet (ft)	4.29	NA

Table 3-3: Vischer Ferry Project Turbine Specifications

Parameter	Vischer Ferry Project	
	Units 1 and 2	Units 3 and 4
Turbine Type	Vertical Francis	Vertical Kaplan
Number of blades	15	5
Max turbine discharge (cfs)	1,500	1,820
Efficiency at max discharge	84.7%	90.1%
Min turbine discharge (cfs)	400	350
Runner diameter (ft)	7.18	9.02
RPM	90	144
Maximum head (ft)	26.5	27.0
Diameter of Runner at Inlet (ft)	7.18	NA
Diameter of Runner at Discharge (ft)	10.97	NA
Runner height at Inlet (ft)	4.29	NA

Table 3-4: Blueback Herring total length (TL) by Lifestage

Lifestage	Passage Route	
	Mean Length (TL) inches	**Standard Deviation**
Juvenile	3.4	0.2
Adult	9.7	0.6

The TBSA model was initially run for each individual passage route to estimate survival rate for each route on a stand-alone basis. Each model run assumed 1,000 fish as a sample size. The survival estimates for each route are provided in Table 3-5. These results follow the anticipated trends - larger fish (i.e., adults) have a lower survival rate than smaller (juvenile) fish, the Kaplan units exhibit higher survival than Francis Units, and the lowest flow that can pass through each unit provided the lowest survival.

Table 3-5: Summary of Downstream Passage Survival Estimates by Route of Passage

Range of Downstream Passage Survival Rates (%)				
		Passage Route		
Project	**Lifestage**	**Units 1 & 2 (Francis Units)**	**Units 3 & 4 (Kaplan Units)**	**Bypass/Spill**
Vischer Ferry	Juvenile	91.2* – 94.2	96.1 – 98.5	88.3 - 97.0
	Adult	77.1* – 85.4	88.3 – 93.9	
Crescent	Juvenile	93.1* – 94.5	95.8 – 97.4	88.3 - 97.0
	Adult	78.3* – 82.7	89.0 – 94.2	

* Represents a worst-case scenario of unit operation at minimum flow. Francis units only operate at maximum discharge.

3.3 Total Station Downstream Passage Survival

Modeling at each project considered two lifestages, three flow conditions during each of seven months, two spill survival scenarios, and two fish distribution scenarios. This resulted in 60 and 36 model run scenarios for juvenile and adult BBH respectively at each Project. This represents a range of conditions and operating scenarios. Each model run scenario assumed 1,000 fish. Model Output summaries are provided in Appendix B.

3.3.1 Crescent

All model run scenarios assumed a 250 cfs flow through the bypass notch (as required by FERC Order) under all conditions prior to assigning flow to the units. Table 3-6 and Table 3-7 provide estimates of total station downstream passage survival for juvenile BBH with and without the acoustic guidance system in operation. In general, most scenarios provide survival estimates greater than 95%. Lower survival estimates (about 90%) result with the guidance system operating and assuming an 11.7% bypass mortality rate. Table 3-8 and Table 3-9 provides total station survival estimates for adult BBH. As anticipated, survival is less than estimates for juveniles due to fish size. Survival estimates generally range from approximately 88% to 93% with several higher or lower estimates. As with juvenile BBH estimates, the driver for lower estimates is assuming an 11.7% bypass mortality rate. This is particularly evident when the acoustic guidance system is directing 76% of downstream migrants to the bypass.

Table 3-6: Percent Downstream Passage Survival for Juvenile Blueback Herring by Month and Flow Scenario at the Crescent Hydroelectric Project without the Acoustic Guidance System

Mean Monthly River Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	2611		1993		2422		3777		5800	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	25	32	21	21	24	28	19	22	44	48
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	2	3	3	22	4	10	0	12	3	2
Total Project Passage Survival (%)	97.3	96.5	97.6	95.7	97.2	96.2	98.1	96.6	95.3	95.0
90th Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	5518		3651		4298		7557		11417	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	36	46	25	18	36	38	26	28	23	18
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	3	6	4	7	3	16	2	13	17	45
Total Project Passage Survival (%)	96.1	94.8	97.1%	97.5	96.1	94.6	97.2	95.9	96.0	93.7
10 Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	827		695		722		1042		1845	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	22	28	24	21	24	20	30	26	15	19
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	10	43	11	51	12	42	4	29	8	24
Total Project Passage Survival (%)	96.8	92.9	96.5	92.8	96.4	93.8	96.6	94.5	97.7	95.7

Table 3-7: Percent Downstream Passage Survival for Juvenile Blueback Herring by Month and Flow Scenario at the Crescent Hydroelectric Project with the Acoustic Guidance System (76% effective)

Mean Monthly River Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	2611		1993		2422		3777		5800	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	10	10	1	9	8	7	4	5	11	12
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	22	70	28	92	21	108	18	70	20	89
Total Project Passage Survival (%)	96.8	92.0	97.1	89.9	97.1	88.5	97.8	92.5	96.9	89.9
90th Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	5518		3651		4298		7557		11417	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	9	16	10	0	7	14	11	11	4	4
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	26	75	24	96	26	82	21	88	23	85
Total Project Passage Survival (%)	96.5	90.9	96.6	90.4	96.7	90.4	96.8	90.1	97.3	91.1
10 Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	827		695		722		1042		1845	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	7	7	11	10	16	9	6	7	5	7
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	29	107	21	92	22	93	20	84	20	80
Total Project Passage Survival (%)	96.4	88.6	96.8	89.8	96.2	89.8	97.4	90.9	97.5	91.3

Table 3-8: Percent Downstream Passage Survival for Adult Blueback Herring by Month and Flow Scenario at the Crescent Hydroelectric Project without the Acoustic Guidance System

Mean Monthly River Flow	**May**		**June**		**July**	
Flow (cfs)	6816		4006		2611	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	106	106	105	108	67	73
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	0	3	2	13	2	11
Total Project Passage Survival (%)	89.4	89.1	89.3	87.6	93.1	91.6
90th Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	14456		8130		5518	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	53	37	88	96	129	131
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	13	76	6	16	4	5
Total Project Passage Survival (%)	93.4	88.7	90.6	88.8	86.7	86.4
10 Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	2202		1251		827	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	87	80	59	68	78	69
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	1	16	9	23	14	41
Total Project Passage Survival (%)	91.2	90.4	93.2	90.9	90.8	89.0

Table 3-9: Percent Downstream Passage Survival for Adult Blueback Herring by Month and Flow Scenario at the Crescent Hydroelectric Project with the Acoustic Guidance System

Mean Monthly River Flow	**May**		**June**		**July**	
Flow (cfs)	6816		4006		2611	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	21	22	30	29	26	15
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	25	93	25	90	23	90
Total Project Passage Survival (%)	95.4	88.5	94.5	88.1	95.1	89.5
90th Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	14456		8130		5518	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	29	29	33	17	43	33
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	27	106	25	85	30	95
Total Project Passage Survival (%)	94.4	86.5	94.2	89.8	92.7	87.2
10 Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	2202		1251		827	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	17	24	017	24	15	23
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	17	81	17	88	19	89
Total Project Passage Survival (%)	96.6	89.5	96.6	88.8	96.6	88.8

3.3.2 Vischer Ferry

Table 3-10 and Table 3-11 provide total downstream passage survival estimates for juvenile BBH at the Vischer Ferry Project without and with the acoustic guidance system respectively. Overall survival estimates for Vischer Ferry were similar to but slightly higher than the estimates at Crescent without operation of the acoustic guidance system. Due to the higher efficiency of the acoustic guidance system (96%) however, survival is higher (about 97%) assuming a 3% bypass mortality rate but lower (about 88%) assuming a 11.7% bypass mortality Rate. Table 3-12 and Table 3-13 provide downstream passage survival estimates for adult BBH without and with the acoustic guidance system respectively. Survival rates without the guidance system are more variable and dependent on flow distribution. Due to the high effectiveness of the acoustic guidance system, the survival estimates essentially mirror the assumed bypass survival rates (i.e., about 88% or 97%).

Table 3-10: Percent Downstream Passage Survival for Juvenile Blueback Herring by Month and Flow Scenario at the Vischer Ferry Hydroelectric Project without the Acoustic Guidance System

Mean Monthly River Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	1987		1381		1801		3130		5114	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	32	33	22	31	20	20	21	29	33	35
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	0	10	1	7	1	7	0	1	0	2
Total Project Passage Survival (%)	96.8	95.7	97.7	96.2	97.9	97.3	97.9	97.0	96.7	96.3
90th Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	4837		3007		3641		6837		10622	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	32	30	21	20	18	21	37	38	21	18
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	1	3	0	8	0	6	0	6	12	50
Total Project Passage Survival (%)	96.7	96.7	97.9	97.2	98.2	97.3	96.3	95.6	96.7	93.2
10 Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	232		108		135		448		1236	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	0	0	0	0	0	0	37	35	27	26
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	32	116	34	112	33	121	7	22	0	14
Total Project Passage Survival (%)	96.8	88.4	96.6	88.8	96.7	87.9	95.6	94.3	97.3	96.0

Table 3-11: Percent Downstream Passage Survival for Juvenile Blueback Herring by Month and Flow Scenario at the Vischer Ferry Hydroelectric Project with the Acoustic Deterrent System

Mean Monthly River Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	2560		1954		2374		3703		5687	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	3	0	0	1	0	1	1	1	3	0
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	23	119	27	108	31	111	34	126	31	112
Total Project Passage Survival (%)	97.4	88.1	97.3	89.1	96.9	88.8	96.5	87.3	96.6	88.8

90th Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	5410		3580		4214		7410		11195	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	4	1	0	2	3	0	1	0	1	3
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	31	96	26	131	24	109	30	94	26	121
Total Project Passage Survival (%)	96.5	90.3	97.4	86.7	97.3	89.1	96.9	90.6	97.3	87.6

10 Percentile Flow	**July**		**August**		**September**		**October**		**November**	
Flow (cfs)	811		681		708		1021		1809	
Number of Fish	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	0	0	0	0	0	0		0	0	1
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	28	113	27	115	31	112		105	34	110
Total Project Passage Survival (%)	97.2	88.7	97.3	88.5	96.9	88.8		89.5	96.6	88.9

Table 3-12: Percent Downstream Passage Survival for Adult Blueback Herring by Month and Flow Scenario at the Vischer Ferry Hydroelectric Project without the Acoustic Deterrent System

Mean Monthly River Flow	**May**		**June**		**July**	
Flow (cfs)	6683		3928		2560	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	133	121	70	75	75	79
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	1	2	0	3	0	4
Total Project Passage Survival (%)	86.6	87.7	93.0	92.2	92.5	91.7
90th Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	14174		7971		5410	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	67	50	93	80	94	82
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	7	67	3	15	0	0
Total Project Passage Survival (%)	92.6	88.3	90.4	90.5	90.6	91.8
10 Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	2159		1226		811	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	61	62	111	89	0	0
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	14	4	0	15	21	114
Total Project Passage Survival (%)	93.8	93.4	88.9	89.6	97.9	88.6

Table 3-13: Percent Downstream Passage Survival for Adult Blueback Herring by Month and Flow Scenario at the Vischer Ferry Hydroelectric Project with the Acoustic Deterrent System

Mean Monthly River Flow	**May**		**June**		**July**	
Flow (cfs)	6683		3928		2560	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	5	2	1	2	5	1
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	28	114	31	115	34	106
Total Project Passage Survival (%)	96.7	88.4	96.8	88.3	96.1	89.3
90th Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	14174		7971		5410	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	7	5	5	4	3	2
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	32	120	33	117	34	116
Total Project Passage Survival (%)	96.1	87.5	96.2	87.9	96.3	88.2
10 Percentile Flow	**May**		**June**		**July**	
Flow (cfs)	2159		1226		811	
Number of Fish	1000	1000	1000	1000	1000	1000
Turbine Mortality (No. Fish)	0	4	0	1	0	0
Bypass/Spill Mortality Rate	3.0%	11.7%	3.0%	11.7%	3.0%	11.7%
Bypass/Spill Mortality (No. Fish)	27	123	28	126	32	122
Total Project Passage Survival (%)	97.3	87.3	97.2	87.3	96.8	87.8

4 Discussion

Estimates of total station downstream passage survival for adult and juvenile BBH for most months and under most river flow conditions range between 85-98%. For both lifestages, total station survival estimates are largely driven by bypass/spillway survival rates.

The Power Authority currently implements an acoustic guidance system to guide BBH toward notches in the flashboards as a preferred passage route compared to passing through the turbines. Data supports the conclusion that the acoustic guidance systems at both Projects are effective at directing downstream migrating BBH away from the turbine intakes as intended. Additionally, the Power Authority maintains minimum flows to support downstream passage and prioritizes turbine operation such that the Kaplan Units (the more fish friendly units) are the first on and last off at these run-of-river Projects. Assessment of the guidance system at Vischer Ferry for adults indicated a 96% effectiveness rate (Ross, 2002). Testing of the system at Crescent for juveniles indicated 76% effectiveness at a minimum. These respective station effectiveness values were applied to both adult and juvenile BBH at each station. Regarding system effectiveness for adult BBH at Crescent, a telemetry study was conducted prior to the current alignment of the acoustic guidance system to assess effectiveness (Kleinschmidt 2009). That study indicated a high effectiveness value, only 1 of 17 tagged adult BBH that moved downstream past the Project, passed through the turbines. The realignment of the acoustic guidance system was designed to project further upstream, allowing fish to encounter further from the entrance to the intake channel (western channel). This alignment benefitted juvenile BBH guidance. It is likely that it also benefitted guidance of adults but at a minimum, there is no reason to believe that guidance of adults would have been negatively affected. Therefore, the vast majority of downstream migrating BBH avoid turbine passage.

There is, however, some level of mortality associated with use of the bypass. It is likely that bypass mortality is about 3%, which is similar to turbine passage survival for juvenile BBH through the Kaplan Units. These survival rates are supported by empirical testing at Crescent (RMC 1992) and are consistent with the TBSA model results (Table 3-5). Also, all flow scenarios considered provided consistent results of total project survival greater than 95% for juveniles assuming a 3% bypass mortality.

Adult BBH are nearly 3 times as long as Juvenile BBH. Therefore, they are expected to experience lower turbine passage survival rates. This is particularly true for the Francis Units. The effectiveness of the acoustic guidance systems, however, indicates that relatively few adult BBH are exposed to turbine passage as a downstream passage route. Unlike juvenile BBH that must pass downstream to complete their lifecycle, many adult BBH will die after spawning and only a portion actively migrate downstream to return as repeat spawners.

Spawning stock characteristics of river herring in the Hudson River Estuary and tributaries, including the Mohawk River, were included as part of river herring stock assessments (ASMFC, 2017). The assessments included data on repeat spawners. When BBH transition from the marine to freshwater environment in the spring to spawn, the environmental change leaves characteristic marks on the scales called spawning marks or checks. Repeat spawners were determined by the presence of spawning marks observed while aging the fish by analyzing their scales (NAI, 2007). The percentage of repeat spawners differed for male and female BBH. Repeat spawner estimates were based on 9 years of data from 1989-90 and 2009-15 and collectively included fish from the Hudson and Mohawk rivers (ASMFC, 2017). Repeat spawners were estimated to include 21.0% of the 1,401 male and 26.1% of the 1,232 female BBH evaluated. A combined

23.4% of the 2,633 BBH analyzed were repeat spawners. There is additional repeat spawner analysis based on fish collected from 1999-2001 (NAI, 2007). However, analysis of these fish used a different methodology for evaluating spawning marks and because it is not directly comparable to the data provided above; ASMFC (2017) states that comparison between these datasets should be made with extreme caution. Since the data are available and Mohawk River data can be identified separately, it is presented here. As with the previous data, the percentage of repeat spawners differed based on gender. It also differed based on the Hudson River geographic region as a whole compared to the Mohawk River. Approximately 26% of the female and 13% of the male BBH from the Hudson River geographic region were repeat spawners. Data from Mohawk River BBH indicated that 10% of the females and 9.5% of the males were repeat spawners (NAI, 2007).

The Barge Canal provides the upstream passage route for BBH to exist upstream of Cohoes Falls. It also, to some unknown degree, provides a downstream passage route. Lock operation occurs during daylight hours from May through early November and frequency of operation is based on demand. Therefore, operation occurs throughout the expected downstream migration period but downstream passage through the locks for adult and juvenile BBH is likely variable based on frequency of operation during migration conditions. However, there are indications of lock usage.

A radio telemetry study of downstream migrating adult BBH was conducted to assess the effect of the acoustic guidance system at Crescent in 2009 (Kleinschmidt, 2009). Between May 31 and June 5, a total of 102 adult BBH were tagged with radio transmitters and released approximately 2 miles upstream of the Crescent Project. Monitoring of tagged fish consisted of daily mobile tracking as well as fixed location receivers. Thirty-four of the tagged BBH were detected by the fixed receivers and most (32/34) were detected in the main channel (i.e., the east side channel away from the powerhouse). Eight of 34 test specimens were last documented at the entrance to the Waterford Flight (Kleinschmidt 2009).

It should be noted that this study was conducted prior to reconfiguration of the acoustic guidance system which was designed to direct fish toward the eastern river channel where the canal entrance is located. Therefore, while the 2009 configuration appeared to effectively guide adult BBH to the main channel away from the powerhouse, this was further enhanced by the reconfiguration of the guidance system. The reconfiguration, as discussed in Section 2.2, consisted of re-aiming the four westerly ultrasonic projectors upriver at 45 degrees toward the main channel. Surveys conducted on juvenile BBH in 2012, showed an increase in guidance system effectiveness (i.e. more fish directed toward the main channel). Since the entrance to the Waterford Flight is in the main channel, it can be assumed that an increased percentage of downstream migrants would encounter and subsequently use the Barge Canal as a means of downstream passage compared to previous configurations of the acoustic deterrent system such as those investigated in 2009 and described above.

To some degree, it is also likely that BBH pass through Lock E-7 at Vischer Ferry as well. The acoustic guidance system at Vischer Ferry projects a sound field toward the West side of the river where the Barge Canal is located. As total station survival estimates are being evaluated for the Projects, it is important to acknowledge that a portion of the migrating population would use the Barge Canal.

The results of this evaluation indicate a high downstream passage success rate for juvenile and adult BBH at the Vischer Ferry and Crescent Projects. Data indicates that survival rates are especially high when coupled with the acoustic guidance systems. As such, the results of this evaluation and use of the TBSA model provide a useful tool for understanding BBH downstream passage at the Projects.

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Appendix A

Annotated Bibliography

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Alden Research Laboratory. Estimating Total Passage Survival for Fish Migrating Downstream at Hydropower Projects.

Fish passage at hydroelectric facilities can result in mortality unless effective fish guidance and exclusion systems are put into place. Passage survival was estimated for Atlantic Salmon smolts and kelts (post-spawned adults) encountering the 15 hydroelectric dams on the Penobscot River in ME, USA. The study approach included theoretical estimates of turbine passage survival and literature-based estimates of spillway and bypass survival at a range of river flows that the Salmon would likely encounter based on life stage. Average survival for smolts ranged from 85.7% to 92.5% and for kelts ranged from 44.7% to 93.7%. Total project survival for kelt was higher compared to smolt due to bar rack spacing excluding them from turbine entrainment. Additionally, kelt bypass efficiencies were set higher due to greater swimming ability and reluctance of larger fish to enter the intake rack structures if possible. Highest kelt survival rating was during low flows when bypass structures were most utilized. Total project survival for smolts fluctuated at low river flows due to unit cycling but survival rates level off when turbines are operated at full load.

Castros-Santos, T., Mulligan, K. B., Kieffer, M. & Haro, A. 2020. Effects of Plunge Pool Configuration on Downstream Passage Survival of Juvenile Blueback Herring. Aquaculture and Fisheries. https://doi.org/10.1016/j.aaf.2020.05.006.

Juvenile Blueback Herring (JBBH) are fragile animals and are at high risk of injury when passing hydroelectric facilities from turbines and downstream bypasses. Bypasses that discharge into plunge pools can cause mechanically injury or death from shear force or turbulence. Studies conducted on live, actively migrating JBBH were exposed to a suite of plunge pool conditions based on depth and flow to determine survivability.

All conditions were configured with a 3-meter drop from the head pond to the mean water surface level of the plunge pool. Depths of the plunge pool were approximately 60, 120, or 180 cm deep with a discharge of 1.7m^3/s. A low flow condition was also tested, which had a discharge of 0.3m^3/s and a pool depth of 120 cm. A total of 1,655 JBBH were subjected to one of the four conditions and monitoring occurred for over 96 hours after entering the plunge pools.

Survival was higher than anticipated with over 80% survival rates in all cases. Greatest survival was associated with the lower flow treatment (0.3m^3/s with 120cm depth) and the least survival was associated with the high flow, low-depth treatment (1.7m^3/s and 60 cm depth). The treatment with the depth of 120 cm and 1.7m^3/s flow closely corresponds with recommended volume:bypass discharge ratios for low-head dams. Mortality was seen past the 24-48 hours mark which is the most common timeframe to monitor JBBH post-passage, indicating previously done studies could have terminated too early and underestimated overall mortality rates.

Chas. T. Main, Inc. 1984. Studies of Juvenile Blueback Herring Downstream Migration in the Lower Mohawk River. The New York Power Authority.

This study was conducted in 1983 to assess the downstream Blueback Herring migration in relation to the Vischer Ferry and Crescent hydroelectric projects. Sampling was conducted at the Vischer Ferry project with electrofishing and trawl nets during the peak outmigration times. The objectives of the study were; to determine relative effectiveness of the electrofisher and the Cobb trawl below the power canal, determine the timing of annual migration, the usage of each of the three potential avenues of outmigration by juvenile herring, and the relative abundance of juvenile herring using each of the avenues.

Hattala Kathryn A. and Andrew W. Kahnle. 2011. Sustainable Fishing Plan for New York River Herring Stocks. New York State Department of Environmental Conservation.

The Atlantic States Marine Fisheries Commission requires a plan to demonstrate a sustainable fishery that will not damage future reproduction. This document proposes river herring (alewife and blueback herring) restrictions on commercial and recreational fisheries in New York. This document outlines the current stock status of the various river herring fisheries in New York. Additionally, sustainable fisheries in the Hudson River and its tributaries are proposed, while other fishery closures are outlined.

Hattala, K., M. Dufour, R. Adams and A. Kahnle. 2010. Status of New York River Herring. Bureau of Marine Resources, Hudson River Fisheries Unit & Hudson River Estuary Program.

This presentation defines the current status of the River Herring fishery in New York state in relation to Atlantic States Marine Fisheries Commission regulations. New York needs to define a new fishery plan by 2012 in compliance with Amendment 2 of the Interstate Fisheries Management Plan for Shad and River herring. The Hudson River state shows a decline in spawning stock and survival of spawning adults. Currently there are no recreational limits, and very few commercial limits in place on the fishery.

B. Lenz. 2014. Increased Downriver Passage of Juvenile Blueback Herring after Reconfiguring an Ultrasonic Field. Engineering and Ecohydrology for Fish Passage.

This presentation describes a study at Crescent hydroelectric project on the Mohawk River where an ultrasonic field was used to control downstream fish passage. The ultrasonic field was reconfigured after the previous configuration was deemed effective but in need of improvement. The field was reconfigured and the deterrence rate increased to 76%, which was a 45% increase in deterrence rates from the prior configuration. Strong diurnal activity patterns of downstream migrations were also observed during this study.

Mathur, Dilip, Paul G. Heisey, Kevin J. McGrath, Thomas R Tatham. 1996. Juvenile Blueback Herring (Alosa aestivalis) Survival via Turbine and Spillway. Water Resources Bulletin, 32(1), 155–161.

Survival of juvenile blueback herring through various downstream passage routes (spillway, or turbines) was examined at the Crescent Hydroelectric project on the Mohawk River. Prior studies had suggested low turbine passage survival rates therefor spillway passage was recommended. This study utilized a tag recaptured method to compare survival rates of passed fish versus control fish. Survival rates were very high for both fish that had spilled over the dam and fish that had passed through the turbine. Although rates of survival over the spillway were high during this study, it is recommended that this route of passage be used cautiously and be examined on a site-specific basis.

McBride, Norman. 2009. Lower Mohawk River Fisheries. Proceedings from the 2009 Mohawk Watershed Symposium, 51-54.

This study provides an overview on the history of the lower Mohawk River fishery specifically the smallmouth bass fishery. Since studies in the 1980s the smallmouth fishery has evolved from fish averaging 10 to 13 inches to fish over 14 inches. Freshwater drum have also become abundant in the river, along with a Northern Pike sport-fishery. The abundance of blueback herring in the lower Mohawk River, has declined since earlier studies. This overview requests an update to the 1994 management plan.

McBride, Norman. 1987. Interim Management Plan for Mohawk River Fisheries. New York State Department of Environmental Conservation.

Ongoing studies are compiled into a management plan to assist in providing direction in managing the fisheries of the lower Mohawk River. This document awaits the completion of a smallmouth bass study to complete the final management plan. This document addresses environmental protection issues including; hydropower, toxic substances, dredging, and a habitat inventory. It also includes specific species management plans for smallmouth bass, tiger musky, walleye and anadromous species. Additionally, public usage is explored and an objective to develop a public fishing brochure is created.

McBride, Norman. 1985. Distribution and Relative Abundance of Fish in the Lower Mohawk River. New York State Department of Environmental Conservation.

This report is the second part of a report on the Lower Mohawk River to better understand fisheries potential and management needs. Trap netting, electrofishing, and gill netting efforts were conducted between 1979 and 1983. A total of fifty-six fish species were recorded from the Lower Mohawk River during the sampling period. This is 12 species greater than the last survey of 1934, which suggests an evolving fisheries assemblage. Due to the barge canal system being a direct link to several watershed's, it is likely that the Mohawk River fishery will continue to change.

New York Power Authority. Hydroacoustic Studies of Downstream Passage of BBH at the Crescent Hydroelectric Project, 2013.

An ultrasonic projector array (122-128kMz broadband sound) was deployed at the Crescent Project from August to November 2012 to redirect juvenile Blueback Herring (BBH) from the intake channel to the main channel during their downstream migration. In 2008, a similar study at the Crescent Project demonstrated that the ultrasonic projectors were partially effective. In this 2012 study, the ultrasonic array was reconfigured and tested for efficacy.

Pelagic trawls and mobile acoustic surveys were used to determine density and abundance of juvenile BBH in the main channel region compared to the intake channel region. These surveys revealed juvenile BBH abundance was 35 times higher in the main channel compared to the intake channel. During peak migration (September 20 to October 14) continuous monitoring from a fixed-location transducer revealed that 76% of the downstream passage of juvenile BBH occurred through the main channel. These results demonstrated the efficacy of the newly configured ultrasonic array and improved downstream passage at the Crescent Project for the majority of out-migrating juvenile BBH.

New York State Department of Environmental Conservation. 2013. Bureau of Fisheries 2012-2013 Annual Report.

This document summarizes the significant fisheries activities that took place between 2012-2013 amongst the regional fisheries offices, hatcheries, and research stations. For example, in Region 4 on the Mohawk River a Blueback River Herring assessment was conducted. The State University of New York Environmental Science and Forestry collaborated with the Region 4 fisheries office to track blueback herring during their annual spawning run. 352 fish were collected and stomach analysis were conducted at each site. Male fish outnumbered female fish captured during the study. The catch was greatest during late May and dropped off greatly in late June. An analysis of the fishery suggests that adult spawning fish have decreased in size and quantity in this fishery.

RMC Environmental Services, Inc. 1992. Juvenile Blueback Herring (Alosa aestivalis) Survival in Powerhouse/Turbine Passage and Spillage over the Dam at the Crescent Hydroelectric Project, New York. New York Power Authority.

The New York Power Authority conducted studies to evaluate passage survival of juvenile blueback herring through the powerhouse at Crescent project. 125 fish were tagged and passed through the Crescent powerhouse, 125 fish were tagged and released by the exit pipe as controls, 110 juveniles were tagged and spilled over the dam, and 110 were tagged and released as controls into the dam pool. The recovery rate of fish at both test sites was greater than 84% at both sites. The immediate survival of fish that passed the powerhouse was 96% and the immediate survival of fish that spilled over the dam was 100%. The results indicate that survival through both the powerhouse and spillage over the dam was very high.

Ross, Quentin E. 2002. Final Report on Fish Protection Studies at the Crescent Hydroelectric Project. New York Power Authority.

This study examines the effectiveness of a fish bypass route at the Crescent hydroelectric project. The high frequency sound configuration used at Vischer Ferry was effective at deterring adult blueback herring. Due to a difference in river morphology the high frequency sound configuration was less effective at the Crescent project. It is recommended that the high frequency transducers be moved to replicate the feasibility study from 1997. It is also recommended that bypasses are installed at Dams A, B, and C.

Ross, Quentin E. 1999. Crescent and Vischer Ferry Projects (FERC #4678-030 and 4679-033) Final Report. New York Power Authority.

The FERC licenses for the Crescent and Vischer Ferry Projects required a study to be conducted to determine a safe method for downstream passage a fish that prevented turbine passage. A study was conducted between 1996 and 1998 to assess the impact of high frequency sound on downstream fish passage. It was determined that high frequency sound was highly effective on deterring young-of-year (YOY) blueback herring and adult blueback herring at the Vischer Ferry site. At the Crescent site, high frequency sound was only effective at deterring (YOY) blueback herring and was not an effective deterrent for adult herring.

Smith, Alexander J. 2018. Progress Report – Mohawk River Basin Action Agenda, Environmental Sustainability and Flood Hazard Risk Reduction. Mohawk River Basin Program.

An action agenda for the integration and ecosystem-based management called for an objective of environmental sustainability and flood hazard risk reduction. Historically the Mohawk River basin has sustained devasting flood damage from different flood events. The objective is to reduce risks of flood and create more resilient communities. Steps to this resiliency approach include: freeing the natural floodplain from constrictions, restoring natural river channel structure, moving critical structures out of floodplains, and providing earlier warning for communities. Additionally, this report describes a collaborative effort by NYS DEC and SUNY ESF to better understand the spawning patterns of river herring in the Hudson and Mohawk watersheds.

United States Geological Survey. 2015. U.S. Geological Survey, New York Water Science Center Newsletter, 20 (1).

This newsletter describes several research activities ongoing in New York state watersheds. For example, on the Mohawk River, there is a proposed research to conduct a fish community survey. The last fish community survey was done 30 years prior, and the fishery in the river has evolved since this last survey. Zebra mussels, freshwater drum, and northern pike have become abundant in the Mohawk River, which are distinct changes from the 1980's fishery. The NYS DEC and USGS plan to survey 24 separate locations during 2014 and 2015.

United States Geological Survey. 2012. Relative Abundance of Blueback Herring (Alosa aestivalis) in Relation to Permanent and Removeable Dams on the Mohawk River.

A primary goal of the Mohawk River Basin Action Agenda is to "understand and manage fish, wildlife, and their habitats in the Mohawk River". A requirement of this is to better understand the blueback herring population in the Mohawk River. The river herring is important to the striped bass, which is an important species to the local economies. The New York State Barge Canal system creates fish passage barriers, yet also adds connections to new habitats. A study to better understand herring passage at migration barriers, what habitats herring are using during the summer months, and analyze otolith chemistry to understand migratory characteristics will be conducted.

Wilder, Bellows Falls, and Vernon Fish Impingement, Entrainment and Survival Study. 2016 TransCanada Hydro Northeast Inc.

All Projects

Entrainment of fishes is variable based on body sizes and clear spacing on the intake racks. Entrainment at all projects for fishes between 0-4 inches is 71.3%, which drastically decreases to 22.9% for fishes in the 4-8 inch size category, followed by 5.3% at the 8-15 inch size category. Entrainment of larger fishes is unlikely (15-30 inches is 0.5% and above 30 inches 0%).

Survival of juvenile fish through the turbines was estimated at moderate-high to moderate due to small body size, while adult fish survival rates ranged from moderate-high to low. Species that have large body sizes as adults (northern pike, walleye, etc.) have the lowest overall survival rating when entrained.

Impingement for most species at the Wilder and Bellows Falls project is unlikely due to their large trash rack space. Vernon has a greater chance of impingement compared to the other two projects due to the small clear spacing (1.75 in) at the intake racks.

Passage survival of American Eels is similar at the Bellows Falls and Vernon Project, with 94.4 and 91.6 percent passage survival, respectively. Wilder had the lowest American Eel passage survival of 53.3%. Passage survival at the Vernon Project for Adult Shad and Juvenile Shad was 100% and 94.8%, respectively.

Wilder

Blade strike for the single Francis turbine ranges from ~73-86.5% for fish between 4-8 inches in length, 49.5% for 15-inch fishes and 0% for 30-inch fishes. Survival estimates for the Kaplan turbines were much higher ranging from 85-99% (4-8 inches), 73-96% (15 inches) and 45-78% (30 inches).

Using radio telemetry, it was determined that adult American Eels primarily passed downstream via the Kaplan unit (71%) followed by the vertical Francis Unit 3 (22%) and the trash/ice sluice (7%). Adult American Eel downstream passage survival is dependent on passage route. The trash and ice sluice have the highest passage survival of 66.7% followed by passage through Units 1 and 2, with 62.0% survival, Unit 3 had the lowest passage survival of 24.8%. Total project survival estimate for adult American eel is 53.5%.

Bellows Falls

Blade strike for all three vertical Francis unit's survival estimates for smaller fish (4-8 inches) was ~87-97%, and for larger fish (15 and 30 inches) survival estimates ranged from 52-88%.

Using radio telemetry, it was determined that most American Eel traveled downstream via the three vertical Francis units (82%) followed by the trash/ice sluice (13%) and then the spillway (5%). Adult American Eel downstream passage survival is dependent on passage route. Units 1-3 had the highest passage survival of 98%, followed by the trash/ice sluice (83.3%), the spillway had 80% passage survival. Total passage survival fort American eels is 94.4%.

Vernon

Blade strike and estimated survival rates for the four vertical Kaplan turbines at Vernon is dependent on fish size. Fishes between 4 to 8 inches have a survival rate of ~78-98%, 15-inch fishes ~59-83% and fishes 30 inches long ~18-86%. Survival estimates for the Francis turbine ranged from ~80-96% for fishes between 4-8 inches, ~62-85% for 15-inch fishes, and 24-71% for 30-inch fishes.

Using radio telemetry, it was determined that adult American eels primarily passed downstream via the units, 43% of eels used the Kaplan units and 28% used the vertical Francis units. Total estimated passage survival for adult American eels is 91.6%.

Radio telemetry was also used to determine downstream passage routes and survival for American Shad at the Vernon Project in 2015. Passage was relatively evenly spilt across the fish pipe (25%), vertical Kaplan units 5-8 (20%) and the spillway (20%). All Shad that passed through the turbines (N=19) were also detected in the tailrace, providing evidence for high survival rates through the turbines (100%). Downstream passage of juvenile shad mainly occurred in the Kaplan units 5-8 (42%) followed by the vertical Francis units (20%). Survival rates for juvenile shad were estimated at 94.8%

Physical and hydraulic characteristics of hydroelectric dams for which HI-Z Tag turbine passage survival data are available for American Shad and Blueback Herring.

Data on blueback herring (BBH) and American shad (Shad) survival data is available for ten hydroelectric facilities on five river systems on the east coast/mid-Atlantic area from 1991 to 2015. Survival (1-hour survival) ranged from 67.8% to 100% for Shad and 93.6% to 96% for BBH. The Francis turbine had the lowest passage survival rate of 67.8% and lowest average of 86.5%, with a total of 12 studies conducted on this turbine type. The next most frequently studied turbine for fish passage is the Kaplan (n=5) which had an average of 96.2% survival rating. The number of blade and buckets ranged from 4 to 18, runner speed ranged from 74 to 257 rpm. Test discharge ranged from 591 cfs to 9,200 cfs. The average size of Shad was 110.6 mm (n=3,950) and the average size of BBH was 145mm (n=701).

School Street Compilation (Multiple studies from 2011 to 2018).

Studies from 2011 to 2018 were conducted to determine fishway effectiveness and passage survival for resident fish, American Eels and adult and juvenile Blueback Herring (BBH). Bypass evaluations provided evidence that resident fishes, American Eels and adult BBH were passing the facilities successfully with low mortalities. Approximately 82% of adult BBH passed via the fish bypass while 18% became entrained. Juvenile BBH survival ratings of passage were low and additional studies were conducted from 2012 to 2017 using PIT tags, acoustic cameras and sonar to monitor passage. Studies were frequently confounded by environmental factors, low sample sizes and handling stress of the fragile juvenile BBH. A desktop study was conducted in 2018 to evaluate the safety of passage routes and concluded that the best overall route was through entrainment. The NYSDEC and USFWS did not agree with the conclusions of this study and suggested other alternative modifications to the downstream fish bypass to improve survival rates for juvenile BBH. FERC determined that study obligations were met, and no alternatives would we implemented due to the potential cost and unknown impacts on the other fish populations, which were already determined to have successful passage through existing facilities.

Summary Table of survival and Malady-free estimates for juvenile American Shad passed through the Turners Fall Hydroelectric Project, October 2015.

Studies were conducted at the Turner Falls Hydroelectric Project in 2015 to investigate juvenile American Shad (shad) survivability when passing downstream at various facilities location. Juvenile shad at the Turner Falls dam can pass via Bascule Gate 1 or 4, with varying survivability rates depending on flow. At Bascule gate 1, one-hour direct survival rate of juvenile had was 69.4%, 47.7% and 75.6% for flows on 1,500, 2,500 and 5,000 cfs, respectively. At Bascule gate 4, one-hour direct survival rate of juvenile shad was 64.2%, 59.0% and 73.6% for flows on 1,500, 2,500 and 5,000 cfs, respectively. The higher flow of 5,000 cfs increased the number of fish capture alive, likely due to a deeper pool below the spillway. Boulders directly downstream of Bascule Gates 1 and 4 likely resulted in lower survival rates of juvenile shad under lower flow conditions. 30% of juvenile shad passing Gate 1 were injured compared to 44% of juvenile shad injured at Gate 4.

The rate of downstream movement from within the impoundment to downstream ranged from 0.01 RM/h to 1.6 RM/h with an average of 0.3RM/h. Out of the 148 juvenile shad tagged, 16 passed through the gatehouse into the power canal, these movements generally occurred during night. Approximately 43% of these juvenile shad exited the canal via the downstream bypass while the other 57% of fish were entrained. Most JBBH were entrained between 13:00 to 23:00, likely due to peak migration occurring during this time frame.

Passage through the turbines had a 95% survival rate compared to compared to a 64% survival rate passing the dam via the gates. Passage from the power canal to Station No. 1 has a survival rate of 67.8% and 76.6% at unit 2/3 and unit 1, respectively.

Summary of passage routes taken by juvenile American Shad through Vernon, fall 2015.

Juvenile American Shad (shad) were radio tagged at the Vernon Project in 2015 to determine passage routes and survival. Out of the 270 radio tagged individuals, 226 passed downstream of the project (83.7%). The majority of juvenile shad (65%) passed via the turbines, while only 7.5% of the fish with a known passage route used the fish pipe. Most passage occurred late in the evening and approximately half the shad passed between 8,000 and 11,000 cfs. Median residency time in the forebay was approximately 0.6 hours (36 minutes) for juvenile shad that passed downstream, and 18.4 hours for fish that did not pass downstream.

Evidence from the hydroacoustic study and electrofishing efforts showed the Juvenile shad migrations were increasing through September, peaked in early October and declined late October.

Survival of juvenile shad was monitored for 48 hours to monitor for delayed mortality. Delayed mortality was high in both treatment and control fish, which inhibited a reliable 48-hour survival estimate. Only 4.4% of juvenile shad that were recaptured were injured directly after passing the turbines. 1-hour direct survival estimate for juvenile shad was 91.7% for the Francis Unit 4 and 95.2% for Kaplan Unit 8. The 1-hour direct survival rate at the nine different Francis turbines ranged from 77.1% to 95.3%. Based on this evaluation it was determined that juvenile shad passing through the Kaplan Units 5 through 8 may provide the highest survivability, followed by Francis Units 9 and 10. The smaller Francis Units 1 through 4 were determined to be the most unsuitable for juvenile shad passage.

Appendix B

Total Station Downstream Passage Survival Model Output

Vischer Ferry - Adult Shad - With Enhancement																															
Test Type					Data Summary			Turbine Discharge (cfs)				Mean Fish Length					Probability of Route Selection					Average Strike Probability					Number of Mortalities				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
May	Adult	3%	Mean	6,683	5	28	967	1,511	1,511	1,500	1,500	9.9	9.4	10.0	9.8	9.7	1.0%	1.0%	1.0%	1.0%	96.0%	6.9%	6.5%	18.0%	17.7%	0%	0	0	3	2	28
May	Adult	11.7%	Mean	6,683	2	114	884	1,511	1,511	1,500	1,500	9.8	9.5	9.6	9.5	9.7	1.0%	1.0%	1.0%	1.0%	96.0%	6.8%	6.6%	17.3%	17.2%	0%	0	0	1	1	114
May	Adult	3%	90	14,174	7	32	961	1,820	1,820	1,500	1,500	9.7	10.1	9.8	9.9	9.7	1.1%	1.1%	0.9%	0.9%	96.0%	5.9%	6.1%	17.7%	17.9%	0%	1	0	3	3	32
May	Adult	11.7%	90	14,174	5	120	875	1,820	1,820	1,500	1,500	9.7	9.9	9.6	9.6	9.7	1.1%	1.1%	0.9%	0.9%	96.0%	5.9%	6.0%	17.3%	17.4%	0%	0	0	1	4	120
May	Adult	3%	10	2,159	0	27	973	1,498				9.8				9.7	4.0%	0%	0%	0%	96.0%	6.8%				0%	0				27
May	Adult	11.7%	10	2,159	4	123	873	1,498				9.6				9.7	4.0%	0%	0%	0%	96.0%	6.7%				0%	4				123
June	Adult	3%	Mean	3,928	1	31	968	1,633	1,633			9.6	9.7			9.7	2.0%	2.0%	0%	0%	96.0%	6.3%	6.3%			0%	0	1			31
June	Adult	11.7%	Mean	3,928	2	115	883	1,633	1,633			9.4	9.6			9.7	2.0%	2.0%	0%	0%	96.0%	6.2%	6.3%			0%	1	1			115
June	Adult	3%	90	7,971	5	33	962	1,820	1,820	1,500	1,500	9.6	9.4	9.7	9.3	9.7	1.1%	1.1%	0.9%	0.9%	96.0%	5.8%	5.7%	17.4%	16.8%	0%	2	1	1	1	33
June	Adult	11.7%	90	7,971	4	117	879	1,820	1,820	1,500	1,500	9.6	9.6	10.0	9.8	9.7	1.1%	1.1%	0.9%	0.9%	96.0%	5.8%	5.8%	18.0%	17.6%	0%	0	0	3	1	117
June	Adult	3%	10	1,226	0	28	972	565				10.0				9.7	4.0%	0%	0%	0%	96.0%	11.0%				0%	0				28
June	Adult	11.7%	10	1,226	1	126	873	565				9.7				9.7	4.0%	0%	0%	0%	96.0%	10.7%				0%	1				126
July	Adult	3%	Mean	2,560	5	34	961	950	950			9.4	9.8			9.7	2.0%	2.0%	0%	0%	96.0%	8.6%	8.9%			0%	2	3			34
July	Adult	11.7%	Mean	2,560	1	106	893	950	950			9.6	9.9			9.7	2.0%	2.0%	0%	0%	96.0%	8.8%	9.1%			0%	1	0			106
July	Adult	3%	90	5,410	3	34	963	1,624	1,624	1,500		10.0	9.5	9.7		9.7	1.4%	1.4%	1.3%	0%	96.0%	6.6%	6.2%	17.4%	0.0%	0%	0	0	3		34
July	Adult	11.7%	90	5,410	2	116	882	1,624	1,624	1,500		10.0	9.7	9.8		9.7	1.4%	1.4%	1.3%	0%	96.0%	6.5%	6.4%	17.7%	0.0%	0%	0	1	1		116
July	Adult	3%	10	811	0	32	968									9.7	0%	0%	0%	0%	100%	0.0%				0%					32
July	Adult	11.7%	10	811	0	122	878									9.7	0%	0%	0%	0%	100%	0.0%				0%					122
August	Adult	3%	Mean	1,954	1	30	969	1,293				9.8				9.7	4.0%	0%	0%	0%	96.0%	7.6%				0%	1				30
August	Adult	11.7%	Mean	1,954	3	121	876	1,293				9.7				9.7	4.0%	0%	0%	0%	96.0%	7.5%				0%	3				121
August	Adult	3%	90	3,580	2	27	971	1,459	1,459			9.4	9.7			9.7	2.0%	2.0%	0%	0%	96.0%	6.7%	6.9%			0%	0	2			27
August	Adult	11.7%	90	3,580	2	118	880	1,459	1,459			9.7	9.7			9.7	2.0%	2.0%	0%	0%	96.0%	6.9%	6.9%			0%	0	2			118
September	Adult	3%	Mean	2,374	0	32	968	1,713				9.6				9.7	4.0%	0%	0%	0%	96.0%	6.1%				0%	0				32
September	Adult	11.7%	Mean	2,374	3	114	883	1,713				9.8				9.7	4.0%	0%	0%	0%	96.0%	6.2%				0%	3				114
September	Adult	3%	90	4,214	4	35	961	1,776	1,776			9.7	9.8			9.7	2.0%	2.0%	0%	0%	96.0%	5.9%	6.0%			0%	4	0			35
September	Adult	11.7%	90	4,214	3	124	873	1,776	1,776			9.7	9.7			9.7	2.0%	2.0%	0%	0%	96.0%	6.0%	6.0%			0%	2	1			124
October	Adult	3%	Mean	3,703	5	22	973	1,521	1,521	1,500		9.8	9.6			9.7	2.0%	2.0%	0%	0%	96.0%	6.8%	6.6%			0%	2	3			22
October	Adult	11.7%	Mean	3,703	2	121	877	1,521	1,521	1,500		9.7	9.7			9.7	2.0%	2.0%	0%	0%	96.0%	6.7%	6.7%			0%	0	2			121
November	Adult	3%	Mean	5,687	8	30	962	1,763	1,763	1,500		9.7	9.7	9.5		9.7	1.4%	1.4%	1.2%	0%	96.0%	6.0%	6.0%	17.0%		0%	2	3	3		30
November	Adult	11.7%	Mean	5,686	0	101	899	1,763	1,763	1,500		9.8	9.6	9.8		9.7	1.4%	1.4%	1.2%	0%	96.0%	6.0%	6.0%	17.7%		0%	0	0	0		101

Vischer Ferry - Juvenile Shad - With Enhancement																															
Test Type					**Data Summary**			**Turbine Discharge (cfs)**				**Mean Fish Length**					**Probability of Route Selection**					**Average Strike Probability**					**Number of Mortalities**				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
July	Juvenile	3%	Mean	2,560	3	23	974	950	950	1,500		3.3	3.4			3.4	2.0%	2.0%	0%	0%	96.0%	3.1%	3.1%			0%	1	2			23
July	Juvenile	11.7%	Mean	2,560	0	119	881	950	950	1,500		3.4	3.5			3.4	2.0%	2.0%	0%	0%	96.0%	3.2%	3.2%			0%	0	0			119
July	Juvenile	3%	90	5,410	4	31	965	1,624	1,624	1,500		3.4	3.4	3.5		3.4	1.4%	1.4%	1.3%	0%	96.0%	2.2%	2.2%	6.3%		0%	0	0	4		31
July	Juvenile	11.7%	90	5,410	1	96	903	1,624	1,624	1,500		3.3	3.2	3.5		3.4	1.4%	1.4%	1.3%	0%	96.0%	2.2%	2.1%	6.2%		0%	0	0	1		96
July	Juvenile	3%	10	811	0	28	972									3.4	0.0%	0.0%	0.0%	0%	100%					0%					28
July	Juvenile	11.7%	10	811	0	113	887									3.4	0.0%	0.0%	0.0%	0%	100%					0%					113
August	Juvenile	3%	Mean	1,954	0	27	973	1,293				3.4				3.4	4.0%	0%	0%	0%	96.0%	2.6%				0%	0				27
August	Juvenile	11.7%	Mean	1,954	1	108	891	1,293				3.5				3.4	4.0%	0%	0%	0%	96.0%	2.7%				0%	1				108
August	Juvenile	3%	90	3,580	0	26	974	1,459	1,459			3.4	3.5			3.4	2.0%	2.0%	0%	0%	96.0%	2.4%	2.5%			0%	0	0			26
August	Juvenile	11.7%	90	3,580	2	131	867	1,459	1,459			3.4	3.4			3.4	2.0%	2.0%	0%	0%	96.0%	2.4%	2.4%			0%	1	1			131
August	Juvenile	3%	10	681	0	27	973									3.4	0%	0%	0%	0%	100%					0%					27
August	Juvenile	11.7%	10	681	0	115	885									3.4	0%	0%	0%	0%	100%					0%					115
September	Juvenile	3%	Mean	2,374	0	31	969	1,713				3.4				3.4	4.0%	0%	0%	0%	96.0%	2.2%				0%	0				31
September	Juvenile	11.7%	Mean	2,374	1	111	888	1,713				3.5				3.4	4.0%	0%	0%	0%	96.0%	2.2%				0%	1				111
September	Juvenile	3%	90	4,214	3	24	973	1,776	1,776			3.3	3.3			3.4	2.0%	2.0%	0%	0%	96.0%	2.0%	2.1%			0%	1	2			24
September	Juvenile	11.7%	90	4,214	0	109	891	1,776	1,776			3.5	3.5			3.4	2.0%	2.0%	0%	0%	96.0%	2.1%	2.1%			0%	0	0			109
September	Juvenile	3%	10	708	0	31	969									3.4	0%	0%	0%	0%	100%					0%					31
September	Juvenile	11.7%	10	708	0	112	888									3.4	0%	0%	0%	0%	100%					0%					112
October	Juvenile	3%	Mean	3,703	1	34	965	1,521	1,521			3.4	3.5			3.4	2.0%	2.0%	0%	0%	96.0%	2.3%	2.4%			0%	0	1			34
October	Juvenile	11.7%	Mean	3,703	1	126	873	1,521	1,521			3.4	3.4			3.4	2.0%	2.0%	0%	0%	96.0%	2.4%	2.3%			0%	0	1			126
October	Juvenile	3%	90	7,410	1	30	969	1,820	1,820	1,500	1,500	3.5	3.4	3.2	3.3	3.4	1.1%	1.1%	0.9%	0.9%	96.0%	2.1%	2.1%	5.9%	5.9%	0%	0	1	0	0	30
October	Juvenile	11.7%	90	7,410	0	94	906	1,820	1,820	1,500	1,500	3.4	3.5	3.4	3.5	3.4	1.1%	1.1%	0.9%	0.9%	96.0%	2.1%	2.1%	6.0%	6.3%	0%	0	0	0	0	94
October	Juvenile	11.7%	10	1,021	0	105	895									3.4	0%	0%	0%	0%	100%					0%					105
November	Juvenile	3%	Mean	5,687	3	31	966	1,763	1,763	1,500		3.4	3.3	3.5		3.4	1.4%	1.4%	1.2%	0%	96.0%	2.1%	2.1%	6.4%		0%	2	0	1		31
November	Juvenile	11.7%	Mean	5,687	0	112	888	1,763	1,763	1,500		3.4	3.4	3.3		3.4	1.4%	1.4%	1.2%	0%	96.0%	2.1%	2.1%	5.9%		0%	0	0	0		112
November	Juvenile	3%	90	11,195	1	26	973	1,820	1,820	1,500	1,500	3.5	3.4	3.3	3.3	3.4	1.1%	1.1%	0.9%	0.9%	96.0%	2.1%	2.1%	6.0%	6.0%	0%	0	0	1	0	26
November	Juvenile	11.7%	90	11,195	3	121	876	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	1.1%	1.1%	0.9%	0.9%	96.0%	2.1%	2.1%	6.2%	6.1%	0%	1	0	2	0	121
November	Juvenile	3%	10	1,809	0	34	966	1,148				3.4				3.4	4.0%	0%	0%	0%	96.0%	2.8%				0%	0				34
November	Juvenile	11.7%	10	1,809	1	110	889	1,148				3.4				3.4	4.0%	0%	0%	0%	96.0%	2.8%				0%	1				110

Vischer Ferry - Adult Shad - Distributed																															
Test Type					Data Summary			Turbine Discharge (cfs)				Mean Fish Length					Probability of Route Selection					Average Strike Probability					Number of Mortalities				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
May	Adult	3%	Mean	6,683	133	1	866	1,511	1,511	1,500	1,500	9.7	9.7	9.7	9.7	9.8	24.9%	24.9%	24.7%	24.7%	1.0%	6.7%	6.7%	17.5%	17.4%	0%	15	14	51	53	1
May	Adult	11.7%	Mean	6,683	121	2	877	1,511	1,511	1,500	1,500	9.7	9.7	9.7	9.8	9.3	24.9%	24.9%	24.7%	24.7%	1.0%	6.7%	6.7%	17.5%	17.6%	0%	18	15	46	42	2
May	Adult	3%	90	14,174	67	7	926	1,820	1,820	1,500	1,500	9.7	9.6	9.8	9.6	9.7	13.4%	13.4%	11.0%	11.0%	51.2%	5.8%	5.8%	17.7%	17.3%	0%	10	8	27	22	7
May	Adult	11.7%	90	14,174	50	67	883	1,820	1,820	1,500	1,500	9.7	9.7	9.8	9.7	9.7	13.4%	13.4%	11.0%	11.0%	51.2%	5.9%	5.8%	17.7%	17.5%	0%	10	4	16	20	67
May	Adult	3%	10	2,159	61	1	938	1,498				9.7				9.7	94.5%	0%	0%	0%	5.6%	6.8%				0%	61				1
May	Adult	11.7%	10	2,159	62	4	934	1,498				9.7				9.7	94.5%	0%	0%	0%	5.6%	6.7%				0%	62				4
June	Adult	3%	Mean	3,928	70	0	930	1,633	1,633			9.7	9.6			9.6	49.1%	49.1%	0%	0%	1.8%	6.4%	6.3%			0%	47	23			0
June	Adult	11.7%	Mean	3,928	75	3	922	1,633	1,633			9.7	9.7			9.5	49.1%	49.1%	0%	0%	1.8%	6.4%	6.3%			0%	38	37			3
June	Adult	3.0%	90	7,971	93	3	904	1,820	1,820	1,500	1,500	9.7	9.7	9.8	9.7	9.6	24.6%	24.6%	20.3%	20%	10.3%	5.9%	5.9%	17.6%	17.5%	0%	16	13	39	25	3
June	Adult	11.7%	90	7,971	80	15	905	1,820	1,820	1,500	1,500	9.7	9.7	9.7	9.7	9.7	24.6%	24.6%	20.3%	20%	10.3%	5.8%	5.8%	17.4%	17.5%	0%	10	12	34	24	15
June	Adult	3%	10	1,226	111	0	889	565				9.7				9.7	86.5%	0%	0%	0%	13.5%	10.6%				0%	111				0
June	Adult	11.7%	10	1,226	89	15	896	565				9.7				9.7	86.5%	0%	0%	0%	13.5%	10.7%				0%	89				15
July	Adult	3.0%	Mean	2,560	75	0	925	950	950			9.7	9.7			9.6	47.8%	47.8%	0%	0%	4.4%	8.8%	8.9%			0%	44	31			0
July	Adult	11.7%	Mean	2,560	79	4	917	950	950			9.7	9.7			9.7	47.8%	47.8%	0%	0%	4.4%	8.9%	8.8%			0%	31	48			4
July	Adult	3%	90	5,410	94	0	906	1,624	1,624	1,500		9.7	9.7	9.7		9.8	33.6%	33.6%	31.0%	0%	1.8%	6.4%	6.4%	17.5%		0%	24	20	50		0
July	Adult	11.7%	90	5,410	82	0	918	1,624	1,624	1,500		9.7	9.7	9.7		9.7	33.6%	33.6%	31.0%	0%	1.8%	6.4%	6.4%	17.4%		0%	16	23	43		0
July	Adult	3%	10	811	0	21	979									9.7	0%	0%	0%	0%	100%					0%					21
July	Adult	11.7%	10	811	0	114	886									9.7	0%	0%	0%	0%	100%					0%					114

Vischer Ferry - Juvenile Shad - Distributed																															
Test Type					Data Summary			Turbine Discharge (cfs)				Mean Fish Length					Probability of Route Selection					Average Strike Probability					Number of Mortalities				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
July	Juvenile	3%	Mean	2,560	32	0	968	950	950			3.4	3.4			3.3	47.8%	47.8%	0%	0%	4.4%	3.1%	3.1%			0%	16	16			0
July	Juvenile	11.7%	Mean	2,560	33	10	957	950	950			3.4	3.4			3.3	47.8%	47.8%	0%	0%	4.4%	3.1%	3.1%			0%	16	17			10
July	Juvenile	3%	90	5,410	32	1	967	1,624	1,624	1,500		3.4	3.4	3.4		3.4	33.6%	33.6%	31.0%	0%	1.8%	2.2%	2.3%	6.1%		0%	8	7	17		1
July	Juvenile	11.7%	90	5,410	30	3	967	1,624	1,624	1,500		3.4	3.4	3.4		3.4	33.6%	33.6%	31.0%	0%	1.8%	2.2%	2.2%	6.2%		0%	9	10	11		3
July	Juvenile	3%	10	811	0	32	968									3.4	0%	0%	0%	0%	100%					0%					32
July	Juvenile	11.7%	10	811	0	116	884									3.4	0%	0%	0%	0%	100%					0%					116
August	Juvenile	3%	Mean	1,954	22	1	977	1,293				3.4				3.4	93.6%	0%	0%	0%	6.4%	2.6%				0%	22				1
August	Juvenile	11.7%	Mean	1,954	31	7	962	1,293				3.4				3.4	93.6%	0%	0%	0%	6.4%	2.6%				0%	31				7
August	Juvenile	3%	90	3,580	21	0	979	1,459	1,459			3.4	3.4			3.4	48.5%	48.5%	0%	0%	2.9%	2.4%	2.4%			0%	16	5			0
August	Juvenile	11.7%	90	3,580	20	8	972	1,459	1,459			3.4	3.4			3.3	48.5%	48.5%	0%	0%	2.9%	2.4%	2.4%			0%	6	14			8
August	Juvenile	3%	10	681	0	34	966									3.4	0%	0%	0%	0%	100%					0%					34
August	Juvenile	11.7%	10	681	0	112	888									3.4	0%	0%	0%	0%	100%					0%					112
September	Juvenile	3%	Mean	2,374	20	1	979	1,713				3.4				3.4	95.1%	0%	0%	0%	4.9%	2.2%				0%	20				1
September	Juvenile	11.7%	Mean	2,374	20	7	973	1,713				3.4				3.4	95.1%	0%	0%	0%	4.9%	2.2%				0%	20				7
September	Juvenile	3%	90	4,214	18	0	982	1,776	1,776			3.4	3.4			3.4	48.8%	48.8%	0%	0%	2.4%	2.1%	2.1%			0%	9	9			0
September	Juvenile	11.7%	90	4,214	21	6	973	1,776	1,776			3.4	3.4			3.4	48.8%	48.8%	0%	0%	2.4%	2.1%	2.1%			0%	9	12			6
September	Juvenile	3%	10	708	0	33	967									3.4	0%	0%	0%	0%	100%					0%					33
September	Juvenile	11.7%	10	708	0	121	879									3.4	0%	0%	0%	0%	100%					0%					121
October	Juvenile	3%	Mean	3,703	21	0	979	1,521	1,521			3.4	3.4			3.4	48.6%	48.6%	0%	0%	2.8%	2.3%	2.3%			0%	13	8			0
October	Juvenile	11.7%	Mean	3,703	29	1	970	1,521	1,521			3.4	3.4			3.4	48.6%	48.6%	0%	0%	2.8%	2.3%	2.3%			0%	19	10			1
October	Juvenile	3%	90	7,410	37	0	963	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	26.6%	26.6%	21.9%	21.9%	2.9%	2.0%	2.1%	6.2%	6.1%	0%	6	7	2	22	0
October	Juvenile	11.7%	90	7,410	38	6	956	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.5	26.6%	26.6%	21.9%	21.9%	2.9%	2.0%	2.1%	6.2%	6.1%	0%	3	6	23	6	6
October	Juvenile	3%	10	1,021	37	7	956	360				3.4				3.4	80.4%	0%	0%	0%	19.6%	4.1%				0%	37				7
October	Juvenile	11.7%	10	1,021	35	22	943	360				3.4				3.4	80.4%	0%	0%	0%	19.6%	4.1%				0%	35				22
November	Juvenile	3%	Mean	5,687	33	0	967	1,763	1,763	1,500		3.4	3.4	3.4		3.4	34.5%	34.5%	29.3%	0%	1.7%	2.1%	2.1%	6.1%		0%	6	10	17		0
November	Juvenile	11.7%	Mean	5,687	35	2	963	1,763	1,763	1,500		3.4	3.4	3.4		3.4	34.5%	34.5%	29.3%	0%	1.7%	2.1%	2.1%	6.1%		0%	8	9	18		2
November	Juvenile	3%	90	11,195	21	12	967	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.3	3.4	17.1%	17.1%	14.1%	14.1%	37.5%	2.1%	2.0%	6.2%	6.0%	0%	2	0	12	7	12
November	Juvenile	11.7%	90	11,195	18	50	932	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	17.1%	17.1%	14.1%	14.1%	37.5%	2.1%	2.0%	6.2%	6.1%	0%	3	4	4	7	50
November	Juvenile	3%	10	1,809	27	0	973	1,148				3.4				3.4	92.9%	0%	0%	0%	7.1%	2.8%				0%	27				0
November	Juvenile	11.7%	10	1,809	26	14	960	1,148				3.4				3.4	92.9%	0%	0%	0%	7.1%	2.8%				0%	26				14

Crescent - Adult Shad - With Enhancement																															
Test Type					**Data Summary**			**Turbine Discharge (cfs)**				**Mean Fish Length**					**Probability of Route Selection**					**Average Strike Probability**					**Number of Mortalities**				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
May	Adult	3%	Mean	6,816	21	25	954	1,783	1,783	1,500	1,500	9.7	9.8	9.8	9.8	9.7	6.5%	6.5%	5.5%	5.5%	76.0%	6.0%	6.0%	17.3%	17.4%	0%	3	5	7	6	25
May	Adult	12%	Mean	6,816	22	93	885	1,783	1,783	1,500	1,500	9.7	9.7	9.7	9.7	9.7	6.5%	6.5%	5.5%	5.5%	76.0%	5.9%	5.9%	17.3%	17.2%	0%	3	1	10	8	93
May	Adult	3%	90	14,465	29	27	944	1,820	1,820	1,500	1,500	9.6	9.7	9.7	9.8	9.7	6.6%	6.6%	5.4%	5.4%	76.0%	5.8%	5.9%	17.3%	17.4%	0%	2	2	12	13	27
May	Adult	12%	90	14,456	29	106	865	1,820	1,820	1,500	1,500	9.6	9.7	9.7	9.8	9.7	6.6%	6.6%	5.4%	5.4%	76.0%	5.8%	5.9%	17.3%	17.4%	0%	2	2	12	13	106
May	Adult	3%	10	2,202	17	17	966	976	976			9.8	9.7			9.7	12.0%	12.0%	0%	0%	76.0%	8.7%	8.7%			0%	10	7			17
May	Adult	12%	10	2,202	24	81	895	976	976			9.6	9.7			9.7	12.0%	12.0%	0%	0%	76.0%	8.6%	8.6%			0%	13	11			81
June	Adult	3%	Mean	4,006	30	25	945	1,128	1,128	1,500		9.7	9.8	9.7		9.7	7.2%	7.2%	9.6%	0%	76.0%	8.0%	8.1%	17.3%		0%	4	7	19		25
June	Adult	12%	Mean	4,006	29	90	881	1,128	1,128	1,500		9.8	9.6	9.7		9.7	7.2%	7.2%	9.6%	0%	76.0%	8.1%	7.9%	17.2%		0%	2	5	22		90
June	Adult	3%	90	8,130	33	25	942	1,820	1,820	1,500	1,500	9.7	9.7	9.7	9.8	9.7	6.6%	6.6%	5.4%	5.4%	76.0%	5.8%	5.8%	17.1%	17.4%	0%	4	6	9	14	25
June	Adult	12%	90	8,130	17	85	898	1,820	1,820	1,500	1,500	9.5	9.6	9.7	9.7	9.7	6.6%	6.6%	5.4%	5.4%	76.0%	5.8%	5.8%	17.2%	17.2%	0%	3	1	5	8	85
June	Adult	3%	10	1,251	17	17	966	1,001				9.7				9.7	24.0%	0%	0%	0%	76.0%	8.6%				0%	17				17
June	Adult	12%	10	1,251	24	88	888	1,001				9.7				9.7	24.0%	0%	0%	0%	76.0%	8.6%				0%	24				88
July	Adult	3%	Mean	2,611	26	23	951	1,180	1,180			9.7	9.7			9.7	12.0%	12.0%	0%	0%	76.0%	7.8%	7.9%			0%	18	8			23
July	Adult	12%	Mean	2,611	15	90	895	1,180	1,180			9.7	9.8			9.7	12.0%	12.0%	0%	0%	76.0%	7.8%	7.9%			0%	12	3			90
July	Adult	3%	90	5,518	43	30	927	1,134	1,134	1,500	1,500	9.6	9.7	9.7	9.7	9.7	5.2%	5.2%	6.8%	6.8%	76.0%	8.0%	8.0%	17.3%	17.2%	0%	10	7	17	9	30
July	Adult	12%	90	5,518	33	95	872	1,134	1,134	1,500	1,500	9.6	9.5	9.6	9.8	9.7	5.2%	5.2%	6.8%	6.8%	76.0%	8.0%	7.9%	17.1%	17.3%	0%	1	6	13	13	95
July	Adult	3%	10	827	15	19	966	577				9.7				9.7	24.0%	0%	0%	0%	76.0%	10.5%				0%	15				19
July	Adult	12%	10	827	23	89	888	577				9.8				9.7	24.0%	0%	0%	0%	76.0%	10.5%				0%	23				89
August	Adult	3%	10	695	34	16	950	445				9.7				9.7	24.0%	0%	0%	0%	76.0%	11.0%				0%	34				16
August	Adult	12%	10	695	30	85	885	445				9.7				9.7	24.0%	0%	0%	0%	76.0%	11.0%				0%	30				85

Crescent - Juvenile Shad - With Enhancement																															
Test Type					**Data Summary**			**Turbine Discharge (cfs)**				**Mean Fish Length**					**Probability of Route Selection**					**Average Strike Probability**					**Number of Mortalities**				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
July	Juvenile	3%	Mean	2,611	10	22	968	1,180	1,180			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.8%	2.8%			0%	6	4			22
July	Juvenile	11.7%	Mean	2,611	10	70	920	1,180	1,180			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.8%	2.8%			0%	6	4			70
July	Juvenile	3%	90	5,518	9	26	965	1,134	1,134	1,500	1,500	3.4	3.4	3.4	3.4	3.4	5.2%	5.2%	6.8%	6.8%	76.0%	2.8%	2.8%	6.1%	6.1%	0%	0	1	4	4	26
July	Juvenile	11.7%	90	5,518	16	75	909	1,134	1,134	1,500	1,500	3.4	3.4	3.4	3.4	3.4	5.2%	5.2%	6.8%	6.8%	76.0%	2.8%	2.8%	6.0%	6.0%	0%	2	2	10	2	75
July	Juvenile	3%	10	827	7	29	964	577				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.7%				0%	7				29
July	Juvenile	11.7%	10	827	7	107	886	577				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.7%				0%	7				107
August	Juvenile	3%	Mean	1,993	1	28	971	1,743				3.4				3.4	24.0%	0%	0%	0%	76.0%	2.1%				0%	1				28
August	Juvenile	11.7%	Mean	1,993	9	92	899	1,743				3.4				3.4	24.0%	0%	0%	0%	76.0%	2.1%				0%	9				92
August	Juvenile	3%	90	3,651	10	24	966	1,701	1,701			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.1%	2.2%			0%	1	9			24
August	Juvenile	11.7%	90	3,651	0	96	904	1,701	1,701			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.2%	2.2%			0%	0	0			96
August	Juvenile	3%	10	695	11	21	968	445				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.9%				0%	11				21
August	Juvenile	11.7%	10	695	10	92	898	445				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.9%				0%	10				92
September	Juvenile	3%	Mean	2,422	8	21	971	1,086	1,086			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.9%	2.9%			0%	2	6			21
September	Juvenile	11.7%	Mean	2,422	7	108	885	1,086	1,086			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.8%	2.9%			0%	4	3			108
September	Juvenile	3%	90	4,298	7	26	967	1,274	1,274	1,500		3.4	3.5	3.3		3.4	7.6%	7.6%	8.9%	0%	76.0%	2.6%	2.7%	5.9%		0%	5	0	2		26
September	Juvenile	11.7%	90	4,298	14	82	904	1,274	1,274	1,500		3.4	3.4	3.4		3.4	7.6%	7.6%	8.9%	0%	76.0%	2.6%	2.7%	6.0%		0%	2	2	10		82
September	Juvenile	3%	10	722	16	22	962	472				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.8%				0%	16				22
September	Juvenile	11.7%	10	722	9	93	898	472				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.8%				0%	9				93
October	Juvenile	3%	Mean	3,777	4	18	978	1,763	1,763			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.1%	2.1%			0%	2	2			18
October	Juvenile	11.7%	Mean	3,777	5	70	925	1,763	1,763			3.4	3.4			3.4	12.0%	12.0%	0%	0%	76.0%	2.1%	2.1%			0%	2	3			70
October	Juvenile	3%	90	7,557	11	21	968	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	6.6%	6.6%	5.4%	5.4%	76.0%	2.0%	2.0%	6.1%	6.1%	0%	6	1	2	2	21
October	Juvenile	11.7%	90	7,557	11	88	901	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	6.6%	6.6%	5.4%	5.4%	76.0%	2.1%	2.0%	6.0%	6.0%	0%	0	0	6	5	88
October	Juvenile	3%	10	1,042	6	20	974	792				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.3%				0%	6				20
October	Juvenile	11.7%	10	1,042	7	84	909	792				3.4				3.4	24.0%	0%	0%	0%	76.0%	3.3%				0%	7				84
November	Juvenile	3%	Mean	5,800	11	20	969	1,275	1,275	1,500	1,500	3.5	3.4	3.4	3.4	3.4	5.5%	5.5%	6.5%	6.5%	76.0%	2.7%	2.6%	6.1%	6.0%	0%	2	4	1	4	20
November	Juvenile	11.7%	Mean	5,800	12	89	899	1,275	1,275	1,500	1,500	3.4	3.4	3.4	3.4	3.4	5.5%	5.5%	6.5%	6.5%	76.0%	2.6%	2.6%	6.0%	6.1%	0%	1	2	4	5	89
November	Juvenile	3%	90	11,417	4	23	973	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	6.6%	6.6%	5.4%	5.4%	76.0%	2.1%	2.0%	6.0%	6.1%	0%	0	0	3	1	23
November	Juvenile	11.7%	90	11,417	4	85	911	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	6.6%	6.6%	5.4%	5.4%	76.0%	2.1%	2.0%	6.0%	6.0%	0%	0	0	1	3	85
November	Juvenile	3%	10	1,845	5	20	975	1,595				3.4				3.4	24.0%	0%	0%	0%	76.0%	2.3%				0%	5				20
November	Juvenile	11.7%	10	1,845	7	80	913	1,595				3.4				3.4	24.0%	0%	0%	0%	76.0%	2.3%				0%	7				80

Crescent - Adult Shad - Distributed																															
Test Type					**Data Summary**			**Turbine Discharge (cfs)**				**Mean Fish Length**					**Probability of Route Selection**					**Average Strike Probability**					**Number of Mortalities**				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
May	Adult	3%	Mean	6,816	106	0	894	1,783	1,783	1,500	1,500	9.6	9.7	9.7	9.7	9.8	26.2%	26.2%	22.0%	22.0%	3.7%	5.9%	5.9%	17.2%	17.3%	0%	17	22	36	31	0
May	Adult	11.7%	Mean	6,816	106	3	891	1,783	1,783	1,500	1,500	9.7	9.7	9.8	9.8	9.7	26.2%	26.2%	22.0%	22.0%	3.7%	5.9%	6.0%	17.4%	17.4%	0%	13	16	40	37	3
May	Adult	3%	90	14,465	53	13	934	1,820	1,820	1,500	1,500	9.7	9.6	9.7	9.7	9.7	12.6%	12.6%	10.4%	10.4%	54.1%	5.9%	5.8%	17.2%	17.2%	0%	8	9	22	14	13
May	Adult	11.7%	90	14,456	37	76	887	1,820	1,820	1,500	1,500	9.8	9.8	9.7	9.8	9.7	12.6%	12.6%	10.4%	10.4%	54.1%	5.9%	5.9%	17.1%	17.4%	0%	6	8	12	11	76
May	Adult	3%	10	2,202	87	1	912	976	976			9.7	9.7			9.7	44.3%	44.3%	0%	0%	11.4%	8.7%	8.7%			0%	46	41			1
May	Adult	11.7%	10	2,202	80	16	904	976	976			9.7	9.7			9.7	44.3%	44.3%	0%	0%	11.4%	8.7%	8.7%			0%	45	35			16
June	Adult	3%	Mean	4,006	105	2	893	1,128	1,128	1,500		9.7	9.7	9.7		9.5	28.2%	28.2%	37.4%	0%	6.2%	8.0%	8.1%	17.2%		0%	25	20	60		2
June	Adult	11.7%	Mean	4,006	108	16	876	1,128	1,128	1,500		9.8	9.6	9.7		9.6	28.2%	28.2%	37.4%	0%	6.2%	8.1%	8.0%	17.2%		0%	28	25	55		16
June	Adult	3%	90	8,130	88	6	906	1,820	1,820	1,500	1,500	9.7	9.7	9.7	9.7	9.7	22.4%	22.4%	18.5%	18.5%	18.3%	5.8%	5.9%	17.2%	17.3%	0%	21	10	29	28	6
June	Adult	11.7%	90	8,130	96	16	888	1,820	1,820	1,500	1,500	9.7	9.7	9.7	9.7	9.7	22.4%	22.4%	18.5%	18.5%	18.3%	5.9%	5.9%	17.2%	17.3%	0%	12	16	29	39	16
June	Adult	3%	10	1,251	59	9	932	1,001				9.7				9.7	80.0%	0%	0%	0%	20.0%	8.6%				0%	59				9
June	Adult	11.7%	10	1,251	68	23	909	1,001				9.7				9.7	80.0%	0%	0%	0%	20.0%	8.5%				0%	68				23
July	Adult	3%	Mean	2,611	67	2	931	1,180	1,180			9.7	9.7			9.7	45.2%	45.2%	0%	0%	9.6%	7.8%	7.9%			0%	36	31			2
July	Adult	11.7%	Mean	2,611	73	11	916	1,180	1,180			9.7	9.6			9.7	45.2%	45.2%	0%	0%	9.6%	7.9%	7.8%			0%	31	42			11
July	Adult	3%	90	5,518	129	4	867	1,134	1,134	1,500	1,500	9.7	9.7	9.7	9.7	9.9	20.6%	20.6%	27.2%	27.2%	4.5%	8.0%	8.0%	17.2%	17.3%	0%	17	17	43	52	4
July	Adult	11.7%	90	5,518	131	5	864	1,134	1,134	1,500	1,500	9.7	9.7	9.7	9.8	9.6	20.6%	20.6%	27.2%	27.2%	4.5%	8.0%	8.0%	17.3%	17.3%	0%	19	11	53	48	5
July	Adult	3%	10	827	78	14	908	577				9.7				9.7	69.8%	0%	0%	0%	30.2%	10.5%				0%	78				14
July	Adult	11.7%	10	827	69	41	890	577				9.7				9.7	69.8%	0%	0%	0%	30.2%	10.5%				0%	69				41

Crescent - Juvenile Shad - Distributed																															
Test Type					Data Summary			Turbine Discharge (cfs)				Mean Fish Length					Probability of Route Selection					Average Strike Probability					Number of Mortalities				
								Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5	Rt. 1	Rt. 2	Rt. 3	Rt. 4	Rt. 5
Month	Age Class	Bypass Mortality Rate	Flow (Percentile)	cfs	Turbine Strikes	Bypass Failures	Fish Passed	Kaplan	Kaplan	Francis	Francis	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill	Kaplan	Kaplan	Francis	Francis	Bypass/Spill
July	Juvenile	3%	Mean	2,611	25	2	973	1,180	1,180			3.4	3.4			3.4	45.2%	45.2%	0%	0%	9.6%	2.8%	2.7%			0%	14	11			2
July	Juvenile	11.7%	Mean	2,611	32	3	965	1,180	1,180	400	1,500	3.4	3.4			3.4	45.2%	45.2%	0%	0%	9.6%	2.8%	2.8%			0%	17	15			0
July	Juvenile	3%	90	5,518	36	3	961	1,134	1,134	1,500	1,500	3.4	3.4	3.4	3.4	3.4	20.6%	20.6%	27.2%	27.2%	4.5%	2.8%	2.8%	6.0%	6.0%	0%	3	6	15	12	3
July	Juvenile	11.7%	90	5,518	46	6	948	1,134	1,134	1,500	1,500	3.4	3.4	3.4	3.4	3.5	20.6%	20.6%	27.2%	27.2%	4.5%	2.8%	2.8%	6.0%	6.0%	0%	3	13	14	16	0
July	Juvenile	3%	10	827	22	10	968	577				3.4				3.4	69.8%	0%	0%	0%	30.2%	3.7%				0%	22				10
July	Juvenile	11.7%	10	827	28	43	929	577				3.4				3.4	69.8%	0%	0%	0%	30.2%	3.7%				0%	28				0
August	Juvenile	3%	Mean	1,993	21	3	976	1,743				3.4				3.4	87.5%	0%	0%	0%	12.5%	2.1%				0%	21				3
August	Juvenile	11.7%	Mean	1,993	21	22	957	1,743	1,180	400	1,500	3.4				3.4	87.5%	0%	0%	0%	12.5%	2.1%				0%	21				0
August	Juvenile	3%	90	3,651	25	4	971	1,701	1,701			3.4	3.4			3.4	46.6%	46.6%	0%	0%	6.9%	2.2%	2.2%			0%	15	10			4
August	Juvenile	11.7%	90	3,651	18	7	975	1,701	1,701			3.4	3.4			3.4	46.6%	46.6%	0%	0%	6.9%	2.2%	2.2%			0%	7	11			0
August	Juvenile	3%	10	695	24	11	965	445				3.4				3.4	64.0%	0%	0%	0%	36.0%	3.9%				0%	24				11
August	Juvenile	11.7%	10	695	21	51	928	445				3.4				3.4	64.0%	0%	0%	0%	36.0%	3.9%				0%	21				0
September	Juvenile	3%	Mean	2,422	24	4	972	1,086	1,086			3.4	3.4			3.4	44.8%	44.8%	0%	0%	10.3%	2.9%	2.9%			0%	13	11			4
September	Juvenile	11.7%	Mean	2,422	28	10	962	1,086	1,086	400	1,500	3.4	3.4			3.4	44.8%	44.8%	0%	0%	10.3%	2.9%	2.9%			0%	9	19			0
September	Juvenile	3%	90	4,298	36	3	961	1,274	1,274	1,500		3.4	3.4	3.4		3.4	29.6%	29.6%	34.9%	0%	5.8%	2.6%	2.6%	6.0%		0%	9	4	23		3
September	Juvenile	11.7%	90	4,298	38	16	946	1,274	1,274	1,500		3.4	3.4	3.4		3.5	29.6%	29.6%	34.9%	0%	5.8%	2.6%	2.6%	6.0%		0%	9	5	24		0
September	Juvenile	3%	10	722	24	12	964	472				3.4				3.4	65.4%	0%	0%	0%	34.6%	3.8%				0%	24				12
September	Juvenile	11.7%	10	722	20	42	938	472				3.4				3.4	65.4%	0%	0%	0%	34.6%	3.8%				0%	20				0
October	Juvenile	3%	Mean	3,777	19	0	981	1,763	1,763			3.4	3.4			3.4	46.7%	46.7%	0%	0%	6.6%	2.1%	2.1%			0%	9	10			0
October	Juvenile	11.7%	Mean	3,777	22	12	966	1,763	1,763			3.4	3.4			3.5	46.7%	46.7%	0%	0%	6.6%	2.1%	2.1%			0%	15	7			0
October	Juvenile	3%	90	7,557	26	2	972	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	24.1%	24.1%	19.9%	19.9%	12.1%	2.1%	2.0%	6.1%	6.0%	0%	3	5	8	10	2
October	Juvenile	11.7%	90	7,557	28	13	959	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	24.1%	24.1%	19.9%	19.9%	12.1%	2.1%	2.1%	6.1%	6.0%	0%	4	4	9	11	0
October	Juvenile	3%	10	1,042	30	4	966	792				3.4				3.4	76.0%	0%	0%	0%	24.0%	3.3%				0%	30				4
October	Juvenile	11.7%	10	1,042	26	29	945	792				3.4				3.4	76.0%	0%	0%	0%	24.0%	3.3%				0%	26				0
November	Juvenile	3%	Mean	5,800	44	3	953	1,275	1,275	1,500	1,500	3.4	3.4	3.4	3.4	3.4	22.0%	22.0%	25.9%	25.9%	4.3%	2.6%	2.6%	6.0%	6.1%	0%	2	5	25	12	3
November	Juvenile	11.7%	Mean	5,800	48	2	950	1,275	1,275	1,500	1,500	3.4	3.4	3.4	3.3	3.4	22.0%	22.0%	25.9%	25.9%	4.3%	2.6%	2.6%	6.1%	6.0%	0%	4	2	23	19	0
November	Juvenile	3%	90	11,417	23	17	960	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	15.9%	15.9%	13.1%	13.1%	41.8%	2.1%	2.0%	6.1%	6.0%	0%	4	3	11	5	17
November	Juvenile	11.7%	90	11,417	18	45	937	1,820	1,820	1,500	1,500	3.4	3.4	3.4	3.4	3.4	15.9%	15.9%	13.1%	13.1%	41.8%	2.1%	2.1%	6.0%	6.0%	0%	3	1	13	1	0
November	Juvenile	3%	10	1,845	15	8	977	1,595				3.4				3.4	86.5%	0%	0%	0%	13.6%	2.3%				0%	15				8
November	Juvenile	11.7%	10	1,845	19	24	957	1,595				3.4				3.4	86.5%	0%	0%	0%	13.6%	2.3%				0%	19				0

Crescent - Passage Routes														
Test Type			Data Summary		Turbine Discharge (cfs)		Mean Fish Length		Average Strike Probability		Number of Mortalities	
Turbine	Age Class	Bypass Mortality Rate	Turbine Strikes	Fish Passed	Kaplan	Francis	Kaplan	Francis	Kaplan	Francis	Kaplan	Francis
Francis	Adult	3%	173	827		1,500		9.7		17.3%		173
Francis	Adult	3%	217	783		400		9.7		21.4%		217
Francis	Juvenile	3%	55	945		1,500		3.4		6.0%		55
Francis	Juvenile	3%	69	931		400		3.4		7.5%		69
Kaplan	Adult	3%	58	942	1,820		9.7		5.9%		58	
Kaplan	Adult	3%	110	890	350		9.7		11.4%		110	
Kaplan	Juvenile	3%	26	974	1,820		3.4		2.0%		26	
Kaplan	Juvenile	3%	42	958	350		3.4		4.0%		42	