Initial Study Report

Brainerd Hydroelectric Project
FERC License No. 2533

Prepared for:
Brainerd Public Utilities
Brainerd, Minnesota

January 24, 2020

Available for Public Release

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Preface

Pursuant to 18 CFR § 5.13, Brainerd Public Utilities (BPU) electronically filed this Initial Study Report (ISR) for the relicensing of the Brainerd Hydroelectric Project, FERC Project No. 2533 (Project) with the Federal Energy Regulatory Commission (FERC). Please note that Appendix B of this ISR is privileged and confidential and filed under separate cover.

BPU filed a Pre-Application Document (PAD) with Notice of Intent (NOI) for the Project on February 28, 2018. The PAD provides a detailed description of the Project and serves as the foundation for issue identification, study plan development, and the FERC's environmental analysis. Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on April 26, 2018. FERC also held agency and public scoping meetings and visited the site on May 16 and 17, 2018. Public agencies and interested parties were able to file comments on the PAD and SD1 and request studies until June 28, 2018. Within 45 days of the comment period for the PAD closing, BPU was required to prepare and file a Proposed Study Plan (PSP), which addressed each of the study criteria, explained how the proposed studies would address the issues raised during scoping, and filled information gaps identified by the stakeholders. Comments generated by the agencies and interested parties were incorporated into the development of the PSP. Comments on BPU's PSP had to be filed within 90 days of filing the PSP, or by November 10, 2018. Comments received on the PSP were reviewed and considered in development of BPU's Revised Study Plan (RSP). First-year studies were conducted as described in the RSP. The ISR presents the findings of the first-year studies.

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Brainerd Hydroelectric Project

January 24, 2020

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Abbreviations and Acronyms

APE	area of potential effect
BPU	Brainerd Public Utilities (Licensee)
CFR	Code of Federal Regulations
cfs	cubic feet per Second
FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
ISR	Initial Study Report
NOI	Notice of Intent
NRHP	National Register of Historic Places
PAD	Pre-Application Document
Project	Brainerd Hydroelectric Project
PSP	Proposed Study Plan
RSP	Revised Study Plan
SD1	Scoping Document 1
SHPO	State Historical Preservation Office

Definitions

authorized installed capacity: The licensed turbine capacity at the Project is 3,542.5 kW

installed capacity: The installed turbine capacity at the Project is currently 2,942.5 kW

Licensee: The license was issued to the city of Brainerd and its Brainerd Public Utilities Commission (BPUC). Brainerd Public Utilities (BPU) manages the Project.

Project:Brainerd Hydroelectric Project, Federal Energy Regulatory Commission (FERC) No. 2533 (Project)

Project Area: The area within the Project boundary consisting of "…lands necessary for the operation and maintenance of the Project and for other Project purposes… (1)

Project boundary: The boundary line defined in the Project license issued by the FERC that surrounds the "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (1)

Relicensing: The process of acquiring a new FERC license for an existing hydropower project under expiration of the existing FERC license

1.0 Introduction

Brainerd Public Utilities (BPU) is filing this Initial Study Report (ISR) with the Federal Energy Regulatory Commission (FERC) for the relicensing of the Brainerd Hydroelectric Project (Project), FERC No. 2533 , as required by Title 18 of the U.S. Code of Federal Regulations (18 CFR) § 5.13. Information on BPU's relicensing efforts is available on FERC's eLibrary Docket Search (https://elibrary.ferc.gov/IDMWS/docket_search.asp) on BPU's project website (http://bpu.org/our-services/electric/hydro/).

1.1 Pre-Application Document Background

BPU filed a Pre-Application Document (PAD) (2) with Notice of Intent (NOI) for the Project on February 28, 2018. The PAD provides a detailed description of the Project and serves as the foundation for issue identification, study plan development, and the FERC's environmental analysis. BPU is not proposing any changes to the Project as part of relicensing. BPU is using FERC's Integrated Licensing Process (ILP).

BPU distributed the PAD and NOI simultaneously to federal and state resource agencies, local governments, Native American tribes, and other stakeholders interested in the relicensing proceedings. A PAD makes known all existing engineering, economic, and environmental information relevant to licensing a project that is reasonably available or can reasonably be obtained with due diligence. The purpose of the PAD was to provide participants in the relicensing process with the information necessary to identify issues and develop study requests; it served as the foundation for issue identification, study plan development, and the FERC's environmental analysis. Section 5 of the PAD identified two potential studies that could be used to address gaps associated with available information. These studies included a Recreation and Inventory Planning Assessment and Cultural Resources Inventory Plan.

Following the filing of the PAD, FERC prepared and issued Scoping Document 1 (SD1) on April 26, 2018 (3). FERC also held agency and public scoping meetings and visited the site on May 16 and 17, 2018. Public agencies and interested parties were able to file comments on the PAD and SD1 and request studies by June 28, 2018. The letters received in response are included in Appendix H of the PAD.

1.2 Proposed Study Plan

A proposed study plan (PSP) (4) was prepared and filed with the FERC on August 10, 2018. Following the requirements of 18 CFR § 5.11, the study plan addressed each of the study criteria, explained how the proposed studies address the issues raised during scoping, and filled information gaps identified by the stakeholders. Comments generated by the agencies and interested parties on the PAD (2) were incorporated into the development of the PSP.

1.2.1 Proposed Study Plan Comments

The FERC content requirements for the PSP (4) comment process are specified in 18 CFR § 5.12. Comments on BPU's PSP had to be filed within 90 days of filing the PSP, or by November 10, 2018. Per FERC regulations, comments must include an explanation of concerns with study plans and agreements reached with BPU regarding the concerns (18 CFR § 5.12). Additionally, proposed modifications to the PSP

must address the study criteria in 18 CFR § 5.9(b). Only one agency, FERC, submitted comments on the PSP.

1.3 Initial Study Plan Meeting

As required by the ILP (18 CFR § 5.12), BPU held a PSP meeting on September 11, 2018 at the Brainerd Public Utilities Commission. Participants were able to attend the meeting either in person or on the phone. No participants attended the meeting in person (aside from BPU and its consultant), while 10 participants called in to the meeting.

The purpose of the PSP meeting was to describe the studies BPU is proposing to complete and rationale for each. During this meeting, participants were allowed to request additional information or studies and discuss outstanding concerns with any proposed studies. No additional PSP meetings were requested or scheduled.

1.4 Revised Study Plan

An RSP (5) was prepared in accordance with requirements of 18 CFR § 5.13 to include comments on the PSP (4) and a description of the efforts made to resolve differences over study plan requests. No additional studies were requested during the PSP review/comment period. As such, the RSP did not propose new studies beyond those proposed in the PSP.

1.5 Initial Study Report

This ISR has been prepared in accordance with requirements of 18 CFR § 5.15(b) and 5.15(c)(1) to present the findings of studies completed as described in the RSP.

2.0 Summary of Studies

The studies that have been completed in accordance with the RSP include a dissolved oxygen and temperature study, a cultural resources study, a desktop fish entrainment and impingement study, and a recreation use and inventory planning study. The following sections include a summary of each study.

2.1 Dissolved Oxygen and Temperature Study

The goal of the Dissolved Oxygen (DO) and Temperature Study (6) was to determine if DO and temperature at the Project meet state water quality standards. Below are the study objectives and results.

- Objective: Identify the DO concentration and temperature of water entering the Project intakes.

  Results: DO concentration at the upstream monitoring location ranged from 5.22 to 8.90 mg/L, with a seasonal mean of 7.16 mg/L. Water temperature at the upstream monitoring location ranged from 13.8° to 26.1°C, with a seasonal mean of 21.0°C.

- Objective: Describe any temporal variations of DO concentration and temperature.

  Result: DO concentrations do not vary dramatically between upstream and downstream locations.

- Objective: Identify the DO and temperature profile within the Project reservoir in the vicinity of the intakes.

  Results: DO concentrations are highest in early summer and fall, and lowest mid-summer. Water temperature does not vary significantly throughout the reservoir in the summer season.

- Describe the changes of DO concentrations and temperature in the river downstream of the Project.

  Results: DO concentration and water temperature do not vary dramatically with water depth, either upstream or downstream.

The Dissolved Oxygen (DO) and Temperature Study Report (6) is included in Appendix A.

2.2 Cultural Resources Study

A cultural resources study was conducted to determine the potential effects of Project operations on archaeological and historic resources within the area of potential effect (APE) that are included or eligible for listing on the National Register of Historic Places (NRHP). Phase II investigation activities completed include eight test pits and three formal test units within the APE.

Privileged correspondence between BPU and the Minnesota State Historical Preservation Office (SHPO) is included in Appendix B.

2.3 Desktop Fish Entrainment and Impingement Study

A desktop fish entrainment and impingement study (7) was completed to evaluate the potential for fish entrainment and impingement at the Project and its potential effects on the health of the upper Mississippi River fishery. The objectives of the study and results are summarized below:

- Objective: Describe the physical characteristics of the intake structures, including the location, dimensions, and the velocity distribution in front of each structure.

  Results:

  - Units 1 and 2 each have a flow capacity of 665 cubic feet per second (cfs); Units 3, 4, and 5 each have a flow capacity of 493 cfs. Other characteristics affecting potential impacts to fish vary slightly.
  - Units 1 and 2 cross-sectional velocity: 2.38 ft/sec
  - Units 3, 4, and 5 cross-sectional velocity: 1.93 ft/sec
  - It is assumed that 40% of the fish pass through units 1 and 2 and 60% of the fish pass through units 3 through 5.

- Objective: Analyze fish species for factors that influence their vulnerability to impingement, entrainment, and turbine survival.

  Results:

  - Of 19 larger fish species, fish of 12 species that are longer at total length than the trash rack bar spacing are expected to experience physical exclusion.
  - The projected survival rate for all units combined at the Project is 82.6%.

- Objective: Assess the potential for fish species impingement at the Project.

  Result:

  - Impingement on the trash rack is not expected to occur for any of the target species that reach a length at which they would be too large to pass through the 1.75-inch clear bar spacing.

- Objective: Estimate entrainment rates and turbine-passage survival rates for fish species at the Project.

  Results:

  - Expected number of entrained fish smaller than 200 mm in length: 290,000

- Expected number of entrained fish < 200mm long that will suffer mortality from entrainment: 36,000 (12%)
- Expected number of entrained fish 200-380 mm in length: 5,600
- Expected number of entrained fish 200 – 380 mm long that will suffer mortality from entrainment: 1,200 (21%)
- Black crappie were estimated to have the highest entrainment and mortality rates for both size classes.

- Objective: Describe the likely effects of Project-induced entrainment or impingement on fish resources, based on the physical characteristics of the Project.

  Result:

  - Population dynamics in the studied reach would remain as is and the status quo of Muskellunge and other game species both above and below the Project would be maintained.

The Fish Impingement and Entrainment Study (7) is included in Appendix C.

2.4 Recreation Use and Inventory Study

A recreation use and inventory study (5) was completed to assess site use and the condition of recreation sites/facilities within the Project boundary. The objectives of this study and a summary of the results are listed below:

- Identify the condition of all informal and formal recreation sites and facilities wholly or partially within the Project boundary.

  Results: Condition ratings were determined following condition assessments of each site. The resulting ratings ranged from 3-4 (Table 2-1).

- Determine current and projected capacity at each recreation site/facility.

  Results: Surveyed users of the sites noted that three of the four sites were no very busy. Only Lum Park was noted as not very busy to moderately busy (Table 2-1).

- Identify who owns, operates, and maintains each recreation site/facility.

  Results: The entity that owns, operates, and maintains each recreation site/facility is identified in (Table 2-1).

- Conduct visitor surveys during the recreation season to determine the adequacy of Project recreation facilities and whether modifications or upgrades are needed to meet current or future recreation needs.

Results: Visitor surveys were conducted during the recreation season. Responses and data summaries are included in Appendix D.

Table 2-1 Summary of Results from Recreation Use and Inventory Planning Study

Recreation Site Name	Recreation Site Ownership/Maintenance	Condition Rating, 5-point Scale	Capacity	Recommendations
Canoe Portage	BPU	4 – Good	Not very busy	Routine maintenance
Lum Park	City of Brainerd	4 – Good	Not very busy to moderately busy	Routine maintenance
French Rapids Access	Crow Wing County	3 – Adequate	Not very busy	Maintain parking lot surface
Green's Point Access	MNDNR	3 – Adequate	Not very busy	Routine maintenance

The Recreation Use and Inventory Study (8) is included Appendix D.

3.0 References

1. **Federal Energy Regulatory Commission (FERC).** *Division of Hydropower Administration & Compliance, Compliance Handbook.* Washington : Department of Energy, 2015.

2. **Barr Engineering Co.** *Pre-Application Document Brainerd Hydroelectric Project, FERC License No. 2533.* Brainerd, Minnesota : Brainerd Public Utilities, February 28, 2018.

3. **Federal Energey Regulatory Commission.** *Scoping Document 1, Brainerd Hydroelectric Project, Project No. 2533-061.* Washington, D.C. : Federal Energey Regulatory Commission Office of Energy Projects Division of Hydropower Licensing, April 2018.

4. **Barr Engineering Co.** *Proposed Study Plan Brainerd Hydroelectric Project, FERC License No. 2533.* Brainerd, Minnesota : Brainerd Public Utilites, August 10, 2018.

5. —. *Revised Study Plan, Brainerd Hydroelectric Project, FERC License No. 2533.* Brainerd, Minnesota : Brainerd Public Utilities, December 10, 2018.

6. —. *Dissolved Oxygen and Temperature Study Report.* Brainerd, Minnesota : Brainerd Public Utilities, January 22, 2020.

7. —. *Fish Impingement and Entrainment Study.* Brainerd, Minnesota : Brainerd Public Utilities, January 22, 2020.

8. —. *Recreation Use and Inventory Study.* Brainerd, Minnesota : Brainerd Public Utilities, January 22, 2020.

Appendix A

Dissolved Oxygen and Temperature Study Report

Dissolved Oxygen and Temperature Study Report

Brainerd Hydroelectric Project
FERC License No. 2533

Prepared for:
Brainerd Public Utilities
Brainerd, Minnesota

January 22, 2020

Available for Public Release

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Dissolved Oxygen and Temperature Study Report
Brainerd Hydroelectric Project

January 22, 2020

Preface

Brainerd Public Utilities (BPU) began the renewal process for the Federal Energy Regulatory Commission (FERC) license of the Brainerd Hydroelectric Project FERC Project No. 2533 (Project). As part of the relicensing process a Dissolved Oxygen and Temperature study (Study) was requested. This report documents the methods and results of the Study that investigated water temperature and dissolved oxygen of the Mississippi River near the Project.

FERC must give equal consideration to all uses of the waterway on which a project is located, and what conditions should be placed on any license that may be issued. In making its license decision, FERC must equally consider the environment, recreation, fish and wildlife, and other non-developmental values of the Project, as well as power and other developmental values.

Water quality at the Project supports an aquatic ecosystem that provides public opportunities, including sport fisheries. FERC considers the effects of Project operation on dissolved oxygen (DO) and temperature relevant to its public interest determination.

The MPCA has a water quality monitoring station approximately 1,700 feet upstream of the Project, and the U.S. Geological Survey (USGS) operates water quality monitoring stations downstream of the Project. However, none of these stations have recorded measurements for DO and temperature.

Dissolved Oxygen and Temperature Study Report
Brainerd Hydroelectric Project

January 22, 2020

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Abbreviations and Acronyms

% Sat	Percent Saturation
°C	degrees Celsius
BPU	Brainerd Public Utilities (Licensee)
BPUC	Brainerd Public Utilities Commission
CFR	Code of Federal Regulations
cfs	cubic feet per second
DO	Dissolved Oxygen (expressed as milligrams per liter or percent saturation)
DQA	Data Quality Assessment
FERC	Federal Energy Regulatory Commission
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
NAD83	North American Datum 1983
NGVD	National Geodetic Vertical Datum 1929
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
Project	Brainerd Hydroelectric Project
QA	quality assurance
RSP	Revised Study Plan
Study	Dissolved Oxygen and Temperature Study
USGS	U.S. Geological Survey

Definitions

Licensee	The license was issued to the city of Brainerd and its Brainerd Public Utilities Commission (BPUC). Brainerd Public Utilities (BPU) manages the Project.
Project	Brainerd Hydroelectric Project, Federal Energy Regulatory Commission (FERC) No. 2533 (Project)
Project Area	The area within the Project boundary consisting of "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (1)
Project Boundary	The boundary line defined in the Project license issued by the FERC that surrounds the "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (1)
Relicensing	The process of acquiring a new FERC license for an existing hydropower project under expiration of the existing FERC license

1.0 Introduction

Brainerd Public Utilities (BPU) is in the process of relicensing the Brainerd Hydroelectric Project (Project) with the Federal Energy Regulatory Commission (FERC). As required by the December 10, 2018 Revised Study Plan (RSP) (2) for the Project, this document describes the Dissolved Oxygen and Temperature Study (Study) completed in 2019.

1.1 Known Resource Management Goals

The state of Minnesota has established water quality standards (3) to protect water resources for uses such as fishing, swimming, and other recreation and to sustain aquatic life. These standards are a measure to identify polluted waters or healthy waters in need of protection and guide the limits on what regulated facilities can discharge to surface water. These rules are administered by the MPCA. The MPCA is continually working to revise, develop, and otherwise improve Minnesota's water quality standards.

1.2 Public Interest Considerations

FERC must give equal consideration to all uses of the waterway on which a project is located, and what conditions should be placed on any license that may be issued. In making its license decision, FERC must equally consider the environment, recreation, fish and wildlife, and other non-developmental values of the Project, as well as power and other developmental values.

Water quality at the Project supports an aquatic ecosystem that provides public opportunities, including sport fisheries. FERC considers the effects of Project operation on dissolved oxygen (DO) and temperature relevant to its public interest determination.

1.3 Existing Information

The MPCA has a water quality monitoring station approximately 1,700 feet upstream of the Project, and the U.S. Geological Survey (USGS) operates water quality monitoring stations downstream of the Project. However, none of these stations have recorded measurements for DO and temperature.

2.0 Project Location, Facilities, and Watershed

2.1 Licensee

The Project is owned and operated by the city of Brainerd and its Public Utilities Commission under a license from the FERC as Project No. 2533.

2.2 Project Location

The Project is located in Crow Wing County on the Mississippi River near the northeast side of Brainerd, Minnesota, as shown in Figure 2-1. The Project is located approximately 130 miles north of the Minneapolis – St. Paul metropolitan area.

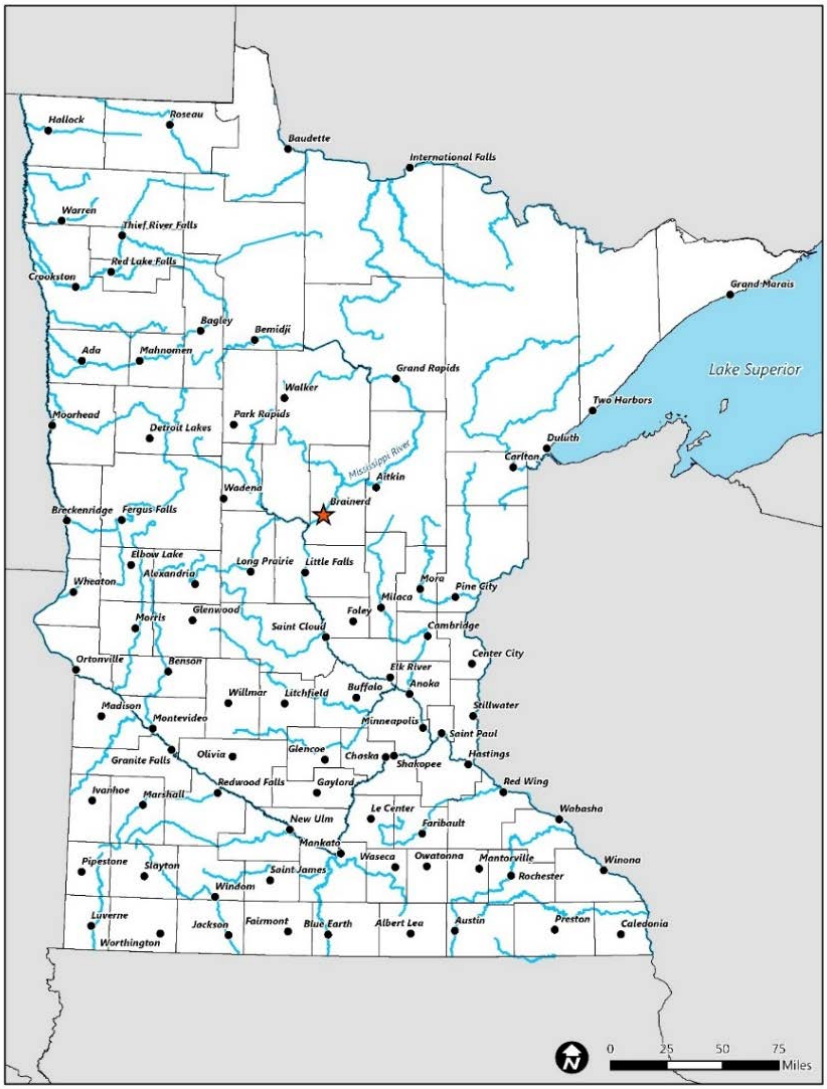


Figure 2-1 Project Location

2.3 Project Overview

From the left bank of the Mississippi River (looking downstream), the Project consists of a short left embankment, a 256-foot-long powerhouse, a 78-foot-long slide gate section, a 207-foot-long bascule (crest) gate section, a single 20-foot-wide steel tainter gate, and a 200-foot-long right embankment, as shown in Figure 2-2. The Project is located on land owned by BPU and is a run-of-river hydroelectric project with an authorized installed capacity of 3,542.5 kW.

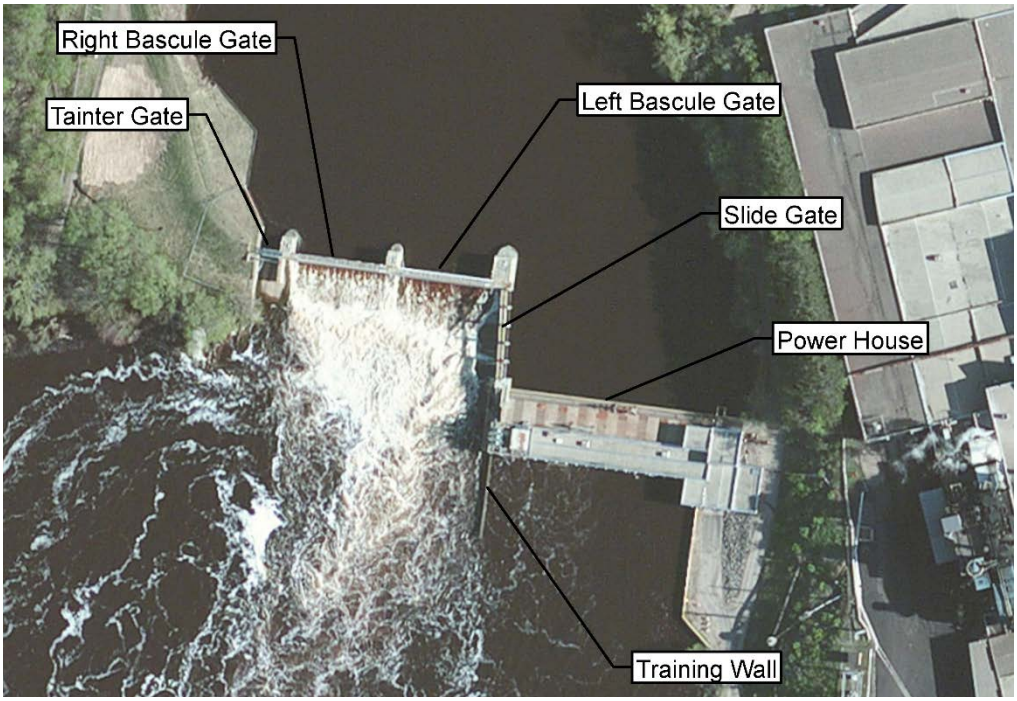


Figure 2-2 Project Overview

2.3.1 Watershed and Regional Water Quality

The Project is located in the Mississippi-Brainerd (#10) major watershed. A brief review of aerial photography indicates that land uses immediately upstream include native hardwood forests, agriculture, and private residential. The reservoir created by the BPU dam extends approximately 8 miles to the northeast of the Project.

In its January 2017 publication on the water quality of the Upper Mississippi River (4), the Minnesota Pollution Control Agency (MPCA) notes that the river upstream and downstream of Brainerd is "Fairly Healthy" and "mostly meets the river life and recreation standards". The stretch of river immediately upstream of Brainerd (Grand Rapids, Minnesota to Brainerd, Minnesota) failed to meet river life standards because of sediment levels in the water, while the downstream stretch (from Brainerd, Minnesota to St. Cloud, Minnesota) met water quality standards for both river life and recreation.

3.0 Study Plan

This Study was requested to evaluate the DO concentration of water entering the Project's powerhouse intakes within the reservoir, then discharged immediately downstream of the powerhouse into the Mississippi River during summer conditions.

3.1 Objectives

The objectives of the Study are to:

- Identify the DO concentration and temperature of water entering the Project intakes;
- Describe any temporal variations of DO concentration and temperature;
- Identify the DO and temperature profile within the Project reservoir in the vicinity of the intakes; and,
- Describe the changes of DO concentrations and temperature in the river downstream of the Project.

4.0 Methods

This section describes the methods used in the Study, which were outlined in the RSP.

4.1 Monitoring Locations

This Study identified four monitoring locations; one upstream and three downstream locations. The upstream location is located immediately upstream of the Project intake, at the intersection of the slide gates and the powerhouse. In accordance with the RSP, this monitoring location had to be placed with 33 feet of the intakes. The downstream locations are located 150 feet (Site 1), 300 feet (Site 2), and 450 feet (Site 3) downstream of the Project. Figure 4-1 shows the monitoring locations in relation to the Project.

Water depths vary between each of the monitoring locations. In the reservoir (upstream location), water depth was approximately 6 feet, and generally slow-moving (pool). Water depths at Site 1, Site 2, and Site 3 were approximately 15 feet, 30 feet, and 12 feet, respectively, due to irregularities in the riverbed downstream of the Project. At the downstream monitoring locations, water was deeper and flowing quickly (runs).

4.2 Study Variables

The RSP identified DO and water temperature as the water quality monitoring variables of interest. These variables are effective indicators for overall health of the aquatic system, as fish and other organisms require DO and temperature within certain ranges.

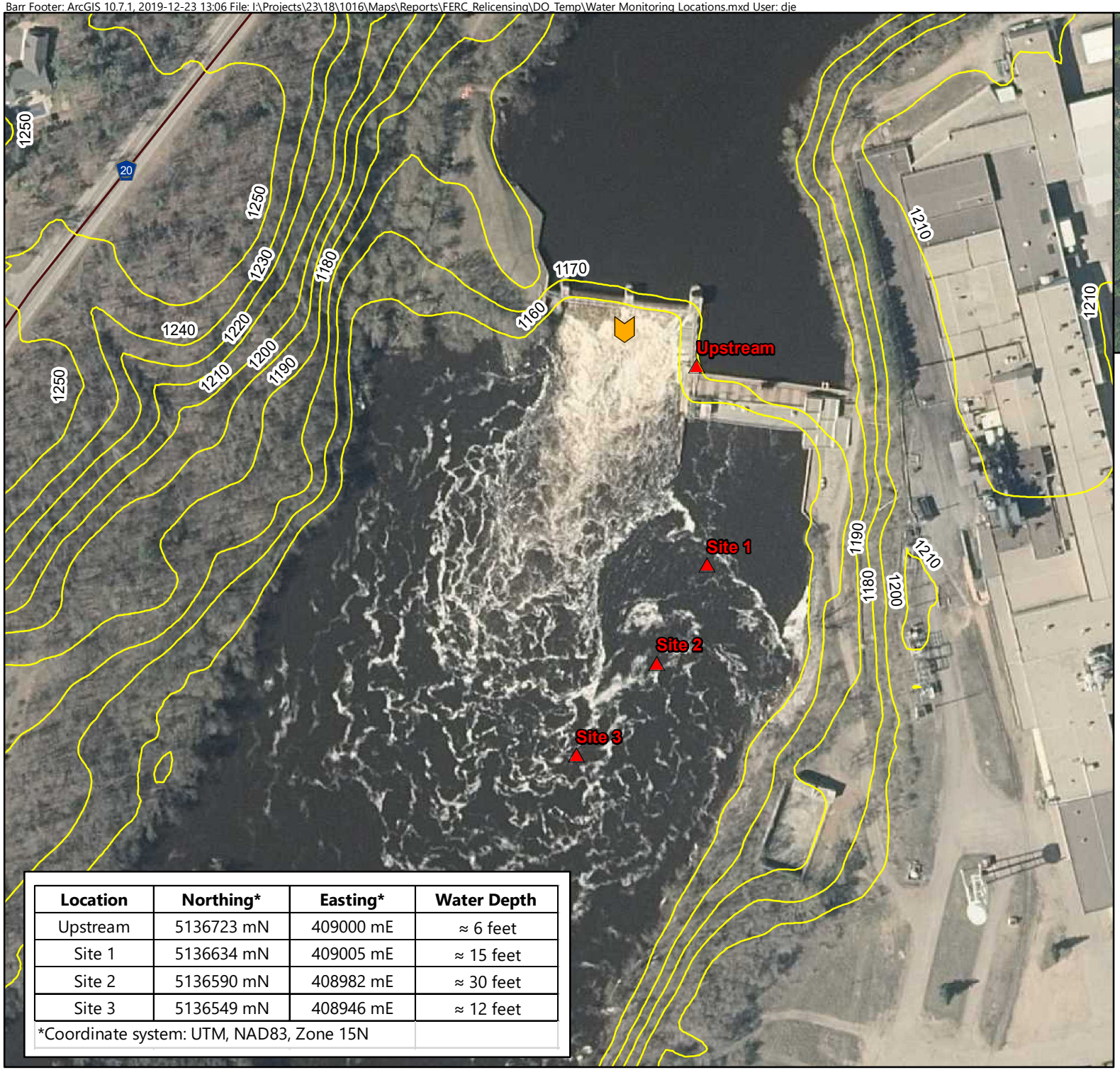
During data collection, information on water condition (odor, color, contents, etc.), hydrology, and Project operations (spillway and generator flow) was also collected. Although this Study was not designed to model the variables associated with DO and temperature, the inclusion of these supplemental variables may provide context to DO and water temperature results. Information on each of the variables is described Sections 4.2.1, 4.2.2, and 4.2.3 .

4.2.1 Dissolved Oxygen

All natural surface waters contain some amount of DO, which is used by living aquatic organisms for respiration. This amount of DO can be quantified as either a concentration (typically in units of milligrams per liter (mg/L) for surface waters), or as a percent saturation (100-percent saturation indicates the water contains a maximum amount of DO at equilibrium). Concentration of DO in surface waters varies with temperature, pressure, turbulence, depth, the concentration of other solutes in the water, and biochemical factors, such as organismal respiration and decomposition of organic matter. In general, DO concentrations are highest when waters are cold, turbulent, and clear; DO concentrations are lowest when waters are warm, stagnant, and contain decomposing organic matter.

DO concentrations of 6 to 10 mg/L are not uncommon for natural surface waters in the summer months. At 5°C, equilibrium DO value is 12.75 mg/L, and at 30°C the equilibrium value is 7.54 mg/L (5). Concentration of DO in water can be raised by photosynthesis of algae or submerged aquatic vegetation,

Barr Footer: ArcGIS 10.7.1, 2019-12-23 13:06 File: I:\Projects\23\18\1016\Maps\Reports\FERC_Relicensing\DO_Temp\Water Monitoring Locations.mxd User: dje



Monitoring Locations (6/7/2019)

Elevation (feet AMSL)

Dam Location

Major Highway

N

0 200 400

Feet

Location	Northing*	Easting*	Water Depth
Upstream	5136723 mN	409000 mE	≈ 6 feet
Site 1	5136634 mN	409005 mE	≈ 15 feet
Site 2	5136590 mN	408982 mE	≈ 30 feet
Site 3	5136549 mN	408946 mE	≈ 12 feet

*Coordinate system: UTM, NAD83, Zone 15N

BARR

FIGURE 4-1

WATER QUALITY
MONITORING LOCATIONS
Brainerd Dam
Brainerd Public Utilities

or lowered by excessive biochemical oxygen demands. Diurnal DO fluctuations are often a function of photosynthesis during daylight hours producing oxygen, and respiration from organisms consuming oxygen. DO concentrations also fluctuate seasonally.

4.2.2 Temperature

Water temperature influences the oxygen saturation level and is related to DO as discussed above. Water temperature is generally a function of air temperature and the temperatures of source waters (groundwater, precipitation, and surface runoff). Seasonally, highest water temperatures tend to co-occur with highest air temperatures.

4.2.3 Condition and Contents

In addition to the target variables of DO and temperature, field staff also recorded qualitative observations on the condition and contents of water, such as surficial foam, algal blooms, fish kills, odors, color, organic sheen, etc. This information was collected to provide context to the dataset, and to potentially explain any low DO concentrations.

4.3 Monitoring Schedule

In accordance with the RSP, data collection monitoring was completed on a weekly basis, between June 1 and September 30. Within the weekly requirement, monitoring events were scheduled according to weather conditions and personnel availability. This Study did not use data-logging instruments, so continuous data on DO and temperature are not available.

4.4 Monitoring Personnel

The data collection was completed by BPU employees that work at the Project, with guidance and oversight from Barr Engineering Co.. The decision to have BPU employees conduct the monitoring was based on the BPU employees' familiarity with the operations of the Project, BPU employee availability, and associated cost savings.

4.5 Monitoring Procedures

For more consistent results, field staff conducted weekly monitoring events in accordance with the following procedural specifications:

1. Conduct a calibration check on the data collection instrument, and re-calibrate the instrument if the calibration value exceeds manufacturer recommendations.
2. Record water levels at the Project (upstream and downstream), flow at the USGS station, spillway flowage, and generator speeds.
3. Document overall site conditions (including current and recent weather)
4. Using the skiff, navigate to the monitoring location that is farthest downstream (Site 3), and conduct monitoring as follows:

a. Anchor boat at the monitoring location.

b. Lower instrument probe into the water, using an anchored guide line or a weighted probe to counteract drift effects from fast-moving water and ensure that the probe is lowered vertically into the water.

c. Commence monitoring at a depth of 3 feet below the water surface.

d. Field staff will allow instrument readings to stabilize before recording values.

e. Field staff will record dissolved oxygen concentration (mg/L), dissolved oxygen saturation (% Sat), and water temperature (°C).

f. Continue monitoring at 3-foot intervals until riverbed is encountered.

g. Collect photographs and make qualitative observations on water condition and contents.

5. Move upstream to next monitoring location (Site 2), and repeat monitoring procedures as noted in Step 4 above.

6. Move upstream to next monitoring location (Site 1), and repeat monitoring procedures as noted in Step 4 above.

7. Motor back downriver to the public boat landing, trailer the boat, and return to the Project.

8. Access the upstream monitoring location from the walkways atop the Powerhouse, and repeat monitoring procedures as noted in Step 4 above.

9. Transmit field data and recordkeeping.

During each monitoring event, field staff collected photographs at each of the monitoring locations. These photographs document useful information that can be used for understanding the results, such as location, weather conditions, water levels, water condition, and spillway usage. These photographs also verify that monitoring was conducted at the noted days and times.

4.6 Equipment

The following essential equipment was used to collect the necessary data to support Study objectives; other non-essential parts, supplies, or maintenance tools are not included in this list:

- Measurements for DO and temperature were taken with a specific instrument: a YSI Optical DO Model EcoSense® ODO200. An optical DO instrument was selected for use because it does not require a "warm-up" time, requires less frequent maintenance, and it is possible for the calibration to hold for several months. BPU purchased this instrument in new condition immediately prior to the start of the Study. Equipment calibration and maintenance work are noted in Section 4.8.

- Field staff used the cameras from mobile phones to collect photographs while completing the monitoring.
- Access to the downstream monitoring locations was gained using a small metal skiff with a gasoline outboard motor. This skiff is owned by the BPU, and kept for the purpose of navigating waters near the Project.

4.7 Hydrology Monitoring

In addition to collecting in-situ DO and temperature measurements, BPU collected the following information to aid in the analysis of the data and provide context to the collected results:

- Reservoir Water Elevation
- Downstream Water Elevation
- Flow @ USGS gage #05242300
- Generator Speed (percent, for Generators 1 through 5)

4.7.1 Precipitation Data

Daily precipitation data were obtained from the Minnesota State Climatology Office, using the web-based "Nearest Station Precipitation Data Retrieval" tool. The tool searches and pulls the data closest to the selected target location for the timeframe chosen. The following parameters were used to obtain precipitation data:

- Target Location: Crow-wing-Oak lawn-Brainerd 45N 30W S18 (latitude: 46.33750 longitude: 94.18361)
- Year: 2018-2019
- Number of missing days allowed per month: 3
- Retrieve daily data

The closest location found was 2 miles away at the Brainerd National Weather Service Station, located in Section 36 of Township 45 North, Range 31 West.

4.7.2 Water Elevation Data

As part of its normal operation, BPU operates and maintains instrumentation to record water levels upstream and downstream of the Project. Immediately prior to each monitoring event, personnel recorded water levels in both the upstream reservoir and the downstream river.

4.7.3 Flow Data

BPU measures the flow of the Mississippi River at USGS stream gage #05242300 (located at the Project) as part of its normal operation. BPU also tracks the flow of water over the spillways. Both flow values are

recorded in cubic feet per second (cfs). Immediately prior to each monitoring event, personnel recorded flow values from both meters.

4.7.4 Generator Speed

BPU operates and maintains instrumentation to track the speed of each of the five generators at the Project as part of its normal operation. Generator usage can be throttled, so usage is recorded as a percentage, with full operation of a generator recorded as "100 percent". Immediately prior to each monitoring event, personnel recorded the speed of each of the five generators at the Project.

4.8 Quality Assurance

Quality assurance (QA) measurements were designed and implemented to verify the field data collected during this Study are suitable for their intended purpose. QA measures include the training of field staff, the development of data collection forms, calibration and maintenance of monitoring equipment, and data review. These QA measures are described in detail in Sections 4.8.1 - 4.8.5.

4.8.1 Training

As noted in Section 4.4, the monitoring data was collected by BPU with guidance from Barr. For consistency throughout the season, a training session was held at the Project on May 28, 2019, prior to the start of the Study. The training session included discussion and demonstrations on the following topics:

- Study plan objectives
- Water chemistry
- Equipment operation and calibration
- Monitoring procedures
- Data collection requirements

Immediately following the discussion and equipment demonstrations, BPU conducted a monitoring event under Barr supervision, to gain experience with the instrument and monitoring procedures. In addition, Barr maintained regular communication with the BPU staff to answer questions and to verify the work was being completed as planned.

4.8.2 Data Collection Forms

For the collection of complete and consistent data, Study-specific field data forms were developed and used when collecting data. These forms were designed to guide field staff in the calibration and operation of the instrument, and in the collection of field data. The blank data forms are included in Appendix A.

4.8.3 Equipment Calibration

Although the monitoring was done with an instrument resistant to calibration drift, the monitoring staff performed a calibration check of the DO sensor immediately prior to each monitoring event. In accordance with procedures specified by the manufacturer, the instrument was re-calibrated if the absolute percent difference of the instrument reading and the expected reading was greater than 2 percent. Calibration of the temperature sensor is not possible on the instrument, so calibration checks of temperature were not performed. BPU staff completed a written record of each calibration check, and of each recalibration.

4.8.4 Equipment Maintenance

BPU purchased a new instrument immediately prior to the commencement of the Study. Because a new instrument was used, and no equipment malfunctions were observed during the Study, no equipment maintenance was needed. The manufacturer recommends that the DO sensor should be replaced prior to the start of each season for best results.

4.8.5 Data review

Upon completion of a monitoring event, BPU staff transmitted monitoring data to Barr, to review for completeness and reasonableness. This QA measure was implemented so that if incomplete or confounding data were recorded, additional monitoring could be completed during the same week and compliance with the data collection schedule could be maintained. In addition to the review of weekly data packet, a post-study data quality assessment (DQA) was performed to determine the usability of the dataset. A summary of the DQA is included in Section 6.1.

5.0 Results

This section presents graphical representations and brief summaries of the data collected during the Study. Data are included for DO, temperature, precipitation, water elevations, generator usage, and spillway usage. Appendix B contains a tables of measurements, Appendix C contain charts of DO and temperature, and Appendix D contains representative photographs taken during the monitoring events.

5.1 Results

This section presents graphical representations and brief summaries of the data collected during the Study. Figure 5-1, Figure 5-2, and Figure 5-3 show average values over time for each variable and monitoring location. Appendix B contains raw data and charts.

5.1.1 Dissolved Oxygen

DO measurements were collected at each of the four monitoring locations as both concentrations (mg/L) and saturations (% Sat). Figure 5-1 shows the average DO concentrations at each monitoring location over the course of the Study. Figure 5-2 shows the average DO saturation at each monitoring location over the course of the Study. For both figures, average values were obtained by calculating the mean value for the profile data collected at each monitoring location.

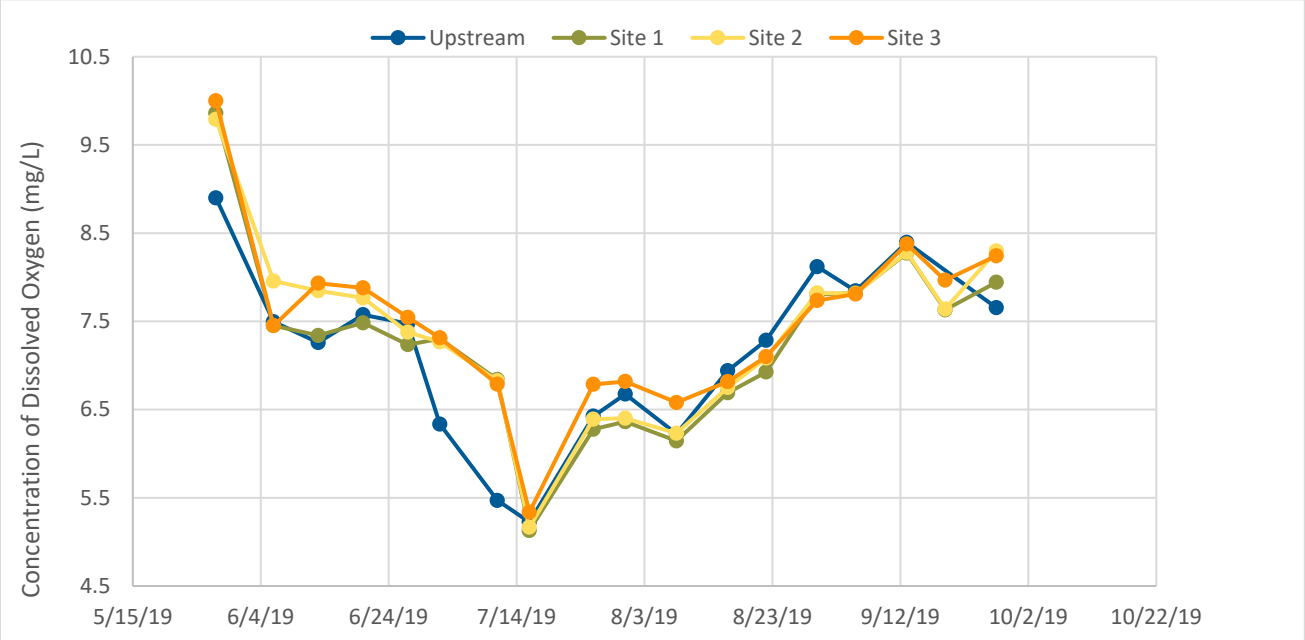


Figure 5-1 Average DO Concentrations

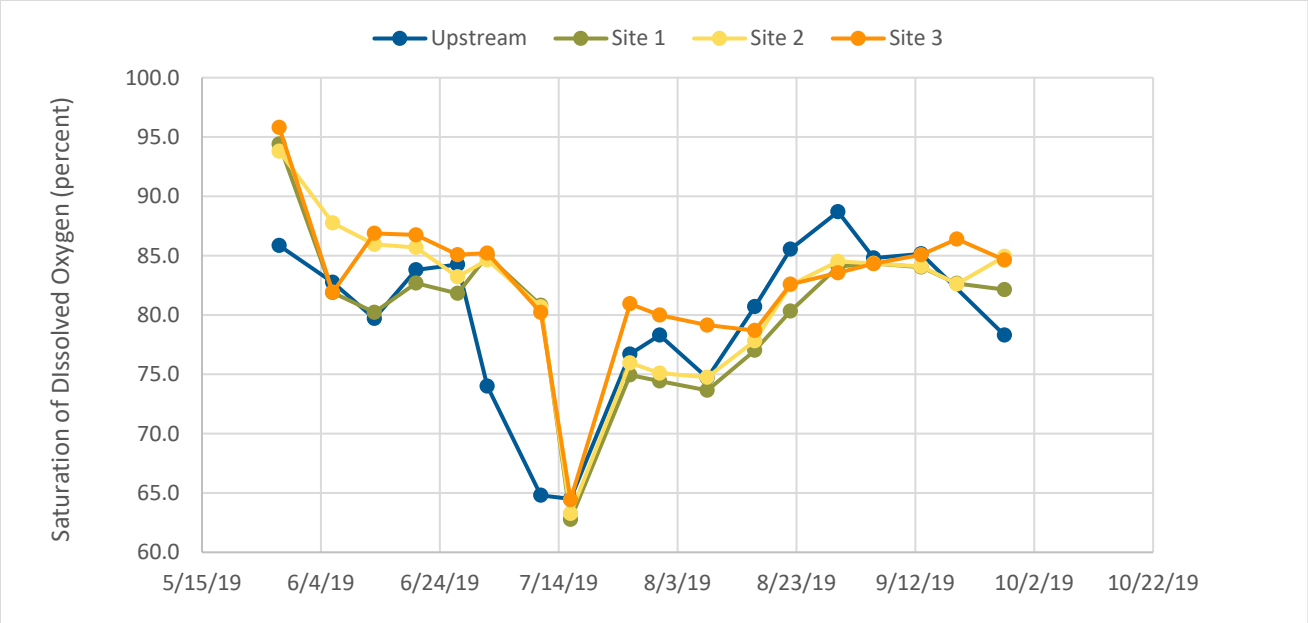


Figure 5-2 Average DO Saturation

5.1.2 Temperature

Figure 5-3 shows the average water temperature at each monitoring location over the course of the Study. Average values were obtained by calculating the mean value for the profile at each monitoring location.

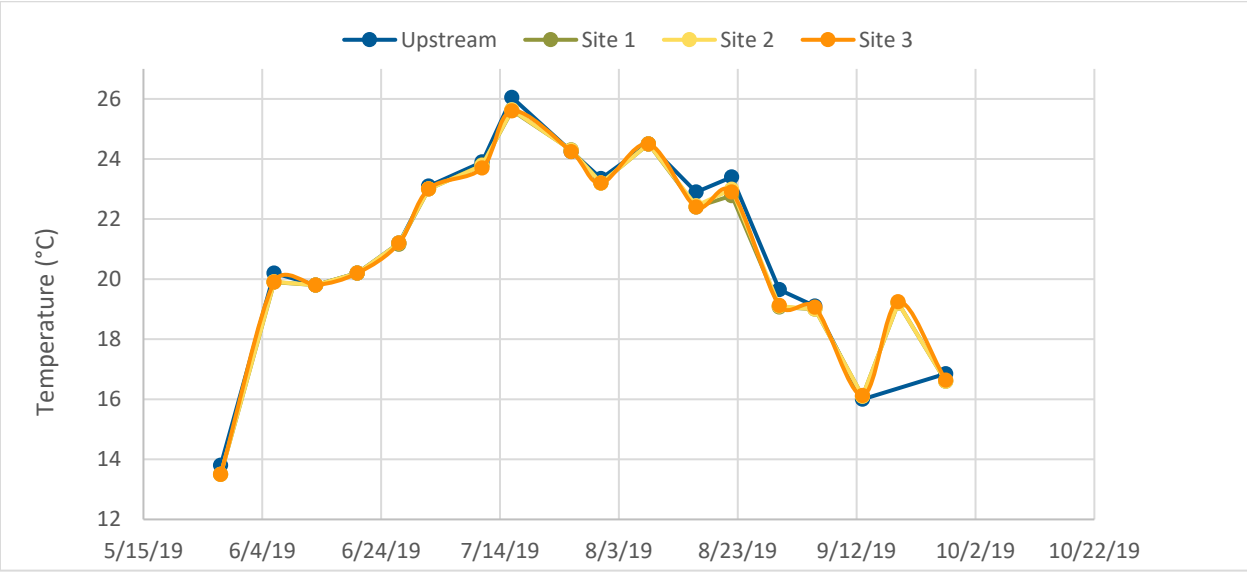


Figure 5-3 Average Temp

5.2 Hydrology

This section provides a brief description of hydrology at the site, including precipitation at the nearest weather station, water levels (both upstream and downstream of the dam), generator usage, and spillway usage.

5.2.1 Precipitation

Figure 5-4 depicts the daily precipitation totals. Data were downloaded from Brainerd station (which is closest to the Project), but it is recognized that the Project is many miles of the Mississippi River headwaters, so the Brainerd station does not represent all the precipitation that occurs within the catchment upriver of the Project.

The following observations were made about precipitation:

- During the Study there were four events that yielded greater than 1 inch of precipitation.
- The largest event during the Study occurred on July 15th and yielded 2.26 inches of precipitation.

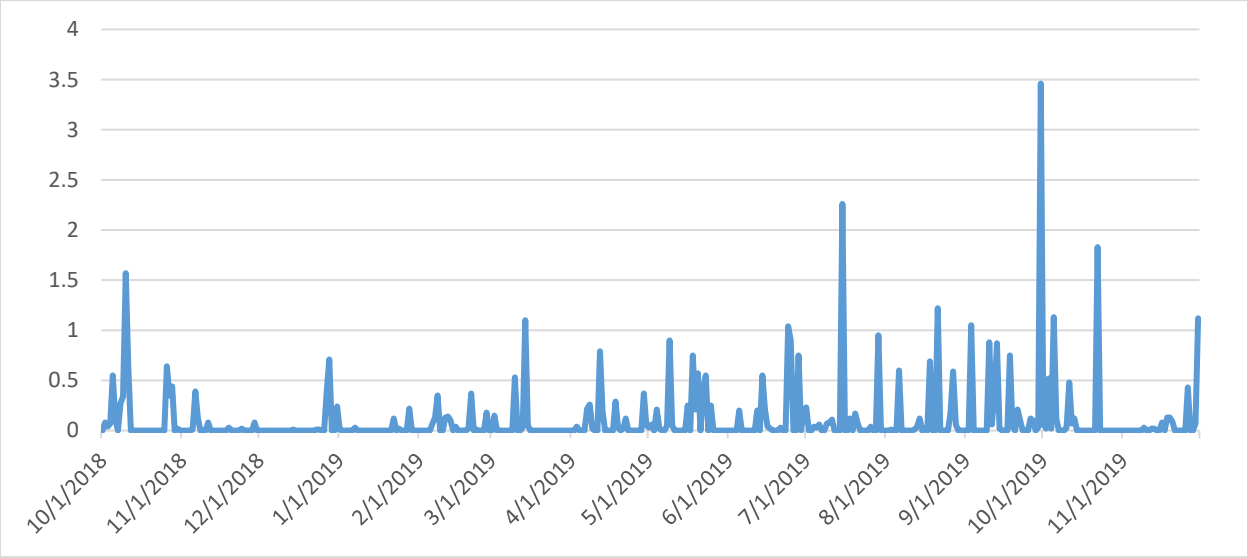


Figure 5-4 Precipitation data at NWS-Brainerd

5.2.2 Flow and Water Levels

Figure 5-5 shows a comparison of weekly flow and water level measurements at the Project. Flows were recorded in cfs, and water levels were recorded in feet. Figure 5-5 indicates flow at the spillway and USGS Gage upstream, follow the same pattern as the downstream water over the course of the Study. The highest flows at the spillway and USGS Gage occurred at the beginning of the Study (6,750 cfs and 8,730 cfs respectively) and the lowest flows occurred in August 2019 (521 cfs and 2,720 cfs respectively).

According to weekly measurements, water levels in the reservoir remained consistent during the Study, varying less than half a foot. Downstream water levels were highest early in the season (approximately 1,166 feet) and then stayed fairly constant for the remainder of the Study, varying less than three feet.

Flow and water level data indicate a large surge of water passed through the Project for about two weeks in early July.

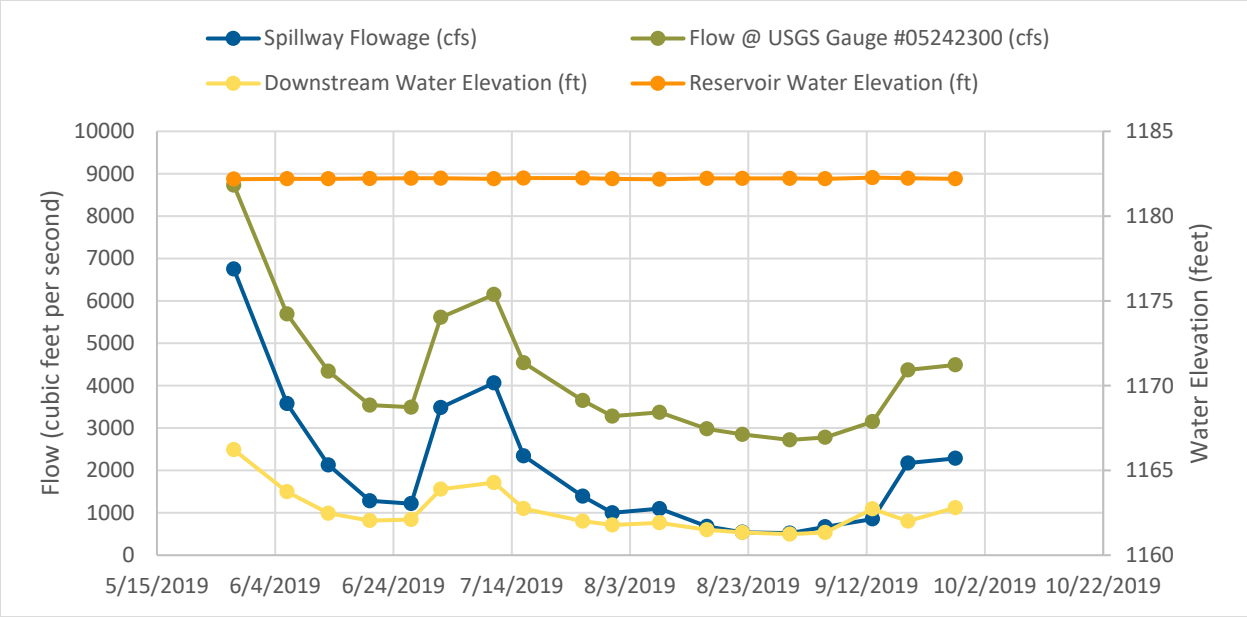


Figure 5-5 Water Level Comparisons

5.2.3 Generator Speed

Weekly data suggest that the Project generators were operating at, or near full, capacity for the duration of the Study. Generator 1 and Generator 2 were operating at 100% speed during each monitoring event. Generator 3 was operating at 100% speed for sixteen of the eighteen monitoring events. Generator 4 and 5 were operating at 100% speed for seventeen of the eighteen monitoring events.

6.0 Discussion

6.1 Data Quality Assessment

This Study includes a DQA, which considers the data collected in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC), and can be useful for determining limitations and usability of the dataset, and establishing credibility of the Study. This DQA assumes that all collected data are valid and useful, unless evidence demonstrates otherwise.

In this Study, data were generated by in-situ measurements, instead of by sample collection and laboratory analysis. Therefore, typical data validation techniques used in the review of laboratory-generated data (i.e., comparisons of duplicates, matrix spikes, blanks, etc.) are not possible. Instead, this DQA relies on qualitative information to make inferences about the suitability of the data.

This DQA only considers the data; it does not include an assessment of the hydrologic data included in the Study (e.g., water levels, generator usage, spillway usage, or precipitation). These data are presented as-is, with no assessment on data quality or suitability for use.

6.1.1 Precision

Precision is a measure of repeatability and the consistency of measurements. In this DQA, data precision is evaluated through a review of instrument specifications (from the manufacturer). Table 6-1 shows the specifications for the instrument used in the Study (6) and includes the range of conditions in which the instrument was intended to be used, the resolution with which the instrument can quantify change, and the expected accuracy of the instrument.

Table 6-1 Specifications for YSI ODO200 DO/Temperature Instrument

Parameter	Range	Resolution	Accuracy
Temperature	0 to 50 °C*	0.1 °C	± 0.3 °C
Dissolved Oxygen	0.0 to 200 % air saturation	0.1 % air saturation	± 1.5 % of reading or ± 1.5 % air saturation, whichever is greater
	0.00 to 20.0 mg/L	0.01 mg/L	± 1.5 % of reading or ± 1.5 mg/L, whichever is greater

* Automatic dissolved oxygen temperature compensation range is 0 to 45 °C.

A review of Minnesota Water Quality Standards (3) indicates that DO values are generally reported to the tenth of a milligram per liter, so an instrument that can detect change to one hundredth of a milligram per liter is deemed precise for this Study.

The monitored waters were within the intended usability range of the instrument, so the resolution values shown in Table 6-1 are applicable.

These findings suggest that the data are sufficiently precise for the intended use as baseline data.

6.1.2 Accuracy

Accuracy is a measure of how close a measured value is to the true value. However, in this DQA, data accuracy is subjectively inferred through a review of instrument specifications (from the manufacturer), and a review of instrument calibration and maintenance records. The RSP did not provide any specifications for the necessary accuracy of the data. A review of data accuracy is presented below:

- **Instrument Specifications**: Table 6-1 shows the expected accuracy of the instrument used in this Study.
- **Calibration/Maintenance Records**: Field data indicate that calibration checks on the DO sensor were performed prior to each monitoring event. Field staff re-calibrated the instrument whenever a calibration check determined that the calibration was outside of the target range. During the eighteen-week Study, the meter was re-calibrated four times. Calibration records are not included in this report, but are available upon request.

  As noted in the instrument operation manual, calibration of the temperature sensor is neither available nor required, but a verification of the temperature sensor could be accomplished by touching the instrument's temperature sensor to a National Institute of Standards and Technology -traceable thermistor and observing the measurements. An accuracy check on the temperature sensor was not completed in 2019, but the instrument was new from the manufacturer immediately prior to the commencement of this Study, so the reasonably reliable temperature data were expected.

These findings suggest that the data are sufficiently precise for the intended use as baseline data.

6.1.3 Representativeness

Representativeness is a determination of whether the measurements made during the Study represent actual conditions of the water, and the water body as whole. In this DQA, data representativeness is evaluated through a review of monitoring location placement, monitoring frequency, and measurement frequency. A review of data representativeness is below:

- **Placement of Monitoring Locations:** Monitoring locations were positioned within the river, in accordance with the RSP. Although the upstream monitoring location adequately represents the water flowing into the intakes, it is likely that the upstream monitoring location does not fully represent the DO and temperature conditions throughout the entire reservoir, because water depth at the upstream monitoring location is typically only about 6-feet deep.
- **Monitoring Frequency:** In accordance with the RSP, monitoring data was conducted weekly. This monitoring frequency is sufficient to detect weekly variations, but is not sufficient to detect daily variations in DO and temperature.
- **Measurement Frequency:** In accordance with the RSP, measurements were collected as profiles: measurements were taken 3 feet below the water surface, and continuing at 3-foot intervals until

the riverbed was encountered. The measurement frequency in each profile is sufficient to detect change in variables with depth. Data were collected for the entire water column at each monitoring location. A review of the data suggests that there is minimal variation in chemistry within the water column, possibly due to the mixing introduced by the generators and spillways of the Project.

These findings suggest that the data are sufficiently representative for the intended use as baseline data.

6.1.4 Completeness

Completeness is a determination of whether all necessary monitoring was completed, and completed according to schedule. In this DQA, data completeness is evaluated through a review of monitoring dates and monitoring data. A review of data representativeness is below:

- **Monitoring Events:** A review of the monitoring dates indicates that 18 monitoring events were completed weekly, between June 1 and September 30, in accordance with the RSP.
- **Monitoring Frequency:** A review of the monitoring data indicates that all necessary measurements were completed, with the following exceptions:
    - Upstream monitoring on September 19, 2019. Post-monitoring consultation with the field staff indicates that this data omission was accidental. This weekly dataset was submitted to Barr for review on October 4, 2019, so there was no time to conduct additional measurements for that sampling week.

These findings suggest that the data are sufficiently complete for the intended use as baseline data.

6.1.5 Comparability

Comparability is a determination of whether the collected data are comparable between weekly monitoring events, and whether they are comparable to prior monitoring studies. The 2019 Study constitutes the first year of baseline monitoring at this Project, so the DQA does not include a year-to-year comparison. In this DQA, data comparability is evaluated through a review of the consistency of monitoring procedures. A review of data comparability is below:

- **Monitoring Consistencies:** A review of the monitoring data indicates that the following aspects were completed consistently:
    - Monitoring was completed weekly (during business hours, as dictated by personnel availability and favorable weather conditions);
    - Calibration checks were completed weekly, and instrument calibrations were done as necessary;
    - Monitoring was completed using same instrument and procedures;
    - Monitoring was completed downstream to upstream; and,

- Field data were generally recorded consistently.

These findings suggest that the data are sufficiently comparable (on a week-to-week basis) for the intended use as baseline data.

6.1.6 Data Quality Assessment Summary

The DQA, which included a review of each PARCC parameter, did not identify any reasons to disqualify the data.

6.2 Study Objectives

Section 3.1.1 of the RSP (2) established four study objectives, which are listed and discussed in Sections 6.2.1-6.2.4.

6.2.1 Study Objective #1: Identify the DO concentration and temperature of water entering the Project intakes

The monitoring data indicate the following about the water entering the Project intakes:

- DO concentration at the upstream monitoring location ranged from 5.22 to 8.90 mg/L, with a seasonal mean of 7.16 mg/L.
- DO saturation at the upstream monitoring location ranged from 64.3- to 88.9-percent saturation, with a seasonal mean of 79.6-percent saturation.
- Water temperature at the upstream monitoring location ranged from 13.8 to 26.1°C, with a seasonal mean of 21.0°C.

6.2.2 Study Objective #2: Describe any temporal variations of DO concentration and temperature

The monitoring data indicate the following about temporal variation in DO concentration and water temperature.

- In this Study, DO concentrations recorded during the Study tended to be greatest in late May. DO concentrations generally decreased until mid-July, when DO values were lowest, then increased to early-season levels. DO saturation values also followed a very similar seasonal pattern, and vary inversely with water temperature
- In this Study, water temperatures were lowest early in the growing season, peaked around mid-July, and then generally decreased for the rest of the season.
- These patterns of seasonal variability and the inverse relationship between DO and temperature were not unexpected. Microvariations from week to week were also not unexpected, because the monitoring was conducted on a weekly basis, instead of daily or hourly.

This Study has met Objective #2, within the following context:

- The monitoring was completed on a weekly basis; therefore, this Study can only identify DO and temperature variations that occur on a corresponding weekly basis. Because more frequent monitoring was not conducted, this Study cannot show variations that occur on an hourly or daily basis.

- The monitoring was completed over an 18-week period between June 1 and September 30. Therefore, the Study cannot describe variations that occur outside of this time frame.

6.2.3 Study Objective #3: Identify the DO and temperature profile within the Project reservoir in the vicinity of the intakes

Profile data from the upstream monitoring location suggest that DO and temperature in the reservoir do not vary dramatically with depth. Appendix C contains charts of the profiles, which show very little variation for the duration of the season. The differences between the upper and lower measurements within the profile are less than 0.2 mg/L for DO concentration, less than 2 %Sat for DO Saturation, and less than 0.5 °C for water temperature. These data suggest that the water in the reservoir is well-mixed immediately prior to entering the Project intakes for the duration of the summer season.

This Study has met Objective #3, within the following context:

- The water at the upstream monitoring location was comparatively shallow (approximately 6 feet deep), as compared the downstream location, and was unlikely to exhibit significant variation in DO or temperature with depth. Although it is expected that the reservoir contains deeper pools within 33 feet of the intakes, accessing these areas would have been unsafe with the equipment available to monitoring staff. Also, safely-accessible deep pools in the reservoir would be of sufficient distance from the intakes, as to be not representative of the water entering the intakes. Therefore, the selection process of the upstream monitoring location prioritized safe access and close proximity to intakes over greater water depth.

6.2.4 Study Objective #4: Describe the changes of DO concentrations and temperature in the river downstream of the Project.

A comparison of surficial data between the downstream monitoring locations (Site 1, Site 2, and Site 3), suggest the following:

- DO concentrations in the water downstream of the Project generally increase with distance downriver, but only slightly. In general, the increase in DO concentration from Site 1 to Site 3 is less than 0.5 mg/L. This trend persisted with depth in the profile, and was also present for the duration of the Study.

- DO saturation in the water downstream of the Project does not appear to vary consistently with distance downriver. In general, the variability of DO saturation from Site 1 to Site 3 is less than 10 % Sat. This trend persisted with depth in the profile, and was also present for the duration of the Study.

- Temperature in the water downstream of the Project does not appear to vary consistently with distance downriver. In general, the variability of DO saturation from Site 1 to Site 3 is less than 1°C. This trend persisted with depth in the profile, and was also present for the duration of the Study.

This Study has met Objective #4, within the following context:

- The RSP specified that monitoring occur no more than 450 feet downstream of the Project. Therefore, conditions for locations greater than 450 feet downstream of the site are not described by this Study.

7.0 Summary

As detailed in Section 5.0, the Study satisfied the objectives outlined in the RSP, which were to:

- Identify the DO concentration and temperature of water entering the Project intakes;
- Describe any temporal variations of DO concentration and temperature;
- Identify the DO and temperature profile within the Project reservoir in the vicinity of the intakes; and,
- Describe the changes of DO concentrations and temperature in the river downstream of the Project.

This Study was not designed to explain the causes of variation of DO and temperature in the vicinity of the Project. This study does not attempt to determine if current discharges from the Project meet existing water quality standards (3) because continuous measures would be required.

In support of the Study objectives noted above, the data collected by the Study can be summarized as follows:

- DO concentration at the upstream monitoring location ranged from 5.22 to 8.90 mg/L, with a seasonal mean of 7.16 mg/L. Water temperature at the upstream monitoring location ranged from 13.8 to 26.1°C, with a seasonal mean of 21.0°C.
- DO concentrations do not vary dramatically between upstream and downstream locations.
- DO concentrations are highest in early summer and fall, and lowest mid-summer.
- DO concentration and water temperature do not vary dramatically with water depth, either upstream or downstream.

A DQA has determined that the 2019 data are sufficiently complete and usable for the intended purpose of this Study. Additionally, weekly records suggest that the Project was operating at, or near, full capacity for the duration of the Study.

8.0 References

1. **Federal Energy Regulatory Commission (FERC).** *Division of Hydropower Administration & Compliance, Compliance Handbook.* Washington : Department of Energy, 2015.

2. **Barr Engineering Co.** Revised Study Plan - Brainerd Hydroelectric Project FERC License No. 2533. December 10, 2018.

3. **Minnesota Legislature.** Minnesota Administrative Rules, Chapter 7050, Waters of the State. *Minnesota Legislature.* [Online] https://www.revisor.mn.gov/rules/7050/.

4. **Minnesota Pollution Control Agency.** Our Upper Mississippi River: Monitoring and Assessment Study. *Minnesota Pollution Control Agency.* [Online] https://www.pca.state.mn.us/sites/default/files/wq-iw8-08ab.pdf.

5. **Hem, John D.** Study and Interpretation of the Chemical Characteristics of Natural Water. 3rd. s.l. : U.S. Geological Survey Water Supply Paper 2254, 1985.

6. **YSI Incorporated.** EcoSense ODO200 Handheld. *YSI a xylem brand.* [Online] 2017. Item #606335REF, Rev C, December 2017. https://www.ysi.com/File%20Library/Documents/Manuals/YSI-ODO200-ODO200M-User-Manual-English.pdf.

7. **Minnesota Pollution Control Agency.** Minnesota's Impaired Waters List. *Minnesota Pollution Control Agency.* [Online] https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list.

8. —. Our upper Mississippi River Monitoring and Assessment Study. [Online] https://www.pca.state.mn.us/sites/default/files/wq-iw8-08ab.pdf.

Appendix A

Field Data Forms

Weekly Sampling Procedure

1. Complete a calibration check on the ODO200 instrument by referencing and completing the **Calibration Check Procedure** form (once per event).

2. Recalibrate DO sensor if necessary, using the **Calibration Procedure** form (once per event).

3. Complete **Sampling Event Data Form** (once per event).

4. Sample at Site 3 (most downstream location) and record data on **Sampling Data Form**.

5. Sample at Site 2 (middle downstream location) and record data on **Sampling Data Form**.

6. Sample at Site 1 (least downstream location) and record data on **Sampling Data Form**.

7. Go to Upstream location (East Pier) and record data on **Sampling Data Form**.

8. At time of sampling, collect photographs of: spillway, upstream towards reservoir, downstream towards river, and riverbanks

9. Do a final review of all data pages, and complete all field notes.
Each sampling event should generate the following field data:
- A Calibration Check Form
- A Calibration Form (if necessary)
- A Sampling Event Data Form
- A Sampling Data Form for each sampling location
- Photographs

10. Transfer field data to digital spreadsheet.

11. Email scanned field data pages, photographs, and field data spreadsheet to Dan Engel (dengel@barr.com).

Reminders/Tips:

Don't change sensor cap without changing the calibration values in the instrument.

Be sure that instrument cable is vertical in the water, so depth measurements are accurate.

Don't let the tip of the sensor dry out (sponge in gray tube should be wet at all times).

Direct questions to Dan Engel at Barr Engineering Company (dengel@barr.com; 218-410-1579).

ODO200 Calibration Check Procedure

Date/Time: _____

Staff Name(s): _____

1 **Saturate sponge inside gray sensor cover with fresh tap water; pour out excess.**

2 **Remove sensor guard (not sensor cap), and dry off temperature and DO sensors.**

3 **Replace sensor guard onto sensor.**

4 **Place sensor (with guard) inside gray sensor cover.**

5 **Turn on ODO200 instrument, wait 10 minutes for sensors to stabilize.**

6 **Local barometric pressure from www.weather.gov (inches Hg):** _____

7 **Convert local barometric pressure from "inches Hg" to "mm Hg":**

Multiply value from Step 6 by **25.4** to get BP in units of "mm Hg": _____

8 **Determine true local barometric pressure (not elevation-adjusted) in mm Hg[1]:**

Subtract **29.0** from Step 7 result to get true barometric pressure: _____

9 **Calibration value for current true barometric pressure[2]:** _____

10 **Current DO measurement (% saturation):** _____

Don **Absolute value of difference between DO measurement and calibration value:**

|(Step 9 value) - (Step 10 value)| : _____

12 **Calibration needed? (circle one)** **Yes** **No**

If difference is **≤ 2**, current calibration is **acceptable**.

If difference is **> 2**, current calibration is **unacceptable, and unit should be calibrated**.

[1] This calculation assumes that the calibration check is performed at the BPU dam break room, which has an elevation of approximately 1,160 feet above mean sea level. See page 10 of operation manual for the detailed calculation.

[2] See Appendix A of the YSI200 Operation Manual to determine the calibration value (using the local, true, barometric pressure value).

APPENDIX A-DO% CALIBRATION VALUES

Calibration Value	Pressure			
D.O. %	in Hg	mmHg	kPa	mbar
101%	30.22	767.6	102.34	1023.38
100%	29.92	760.0	101.33	1013.25
99%	29.62	752.4	100.31	1003.12
98%	29.32	744.8	99.30	992.99
97%	29.02	737.2	98.29	982.85
96%	28.72	729.6	97.27	972.72
95%	28.43	722.0	96.26	962.59
94%	28.13	714.4	95.25	952.46
93%	27.83	706.8	94.23	942.32
92%	27.53	699.2	93.22	932.19
91%	27.23	691.6	92.21	922.06
90%	26.93	684.0	91.19	911.93
89%	26.63	676.4	90.18	901.79
88%	26.33	668.8	89.17	891.66
87%	26.03	661.2	88.15	881.53
86%	25.73	653.6	87.14	871.40
85%	25.43	646.0	86.13	861.26
84%	25.13	638.4	85.11	851.13
83%	24.83	630.8	84.10	841.00
82%	24.54	623.2	83.09	830.87
81%	24.24	615.6	82.07	820.73
80%	23.94	608.0	81.06	810.60
79%	23.64	600.4	80.05	800.47
78%	23.34	592.8	79.03	790.34
77%	23.04	585.2	78.02	780.20
76%	22.74	577.6	77.01	770.07
75%	22.44	570.0	75.99	759.94
74%	22.14	562.4	74.98	749.81
73%	21.84	554.8	73.97	739.67
72%	21.54	547.2	72.95	729.54

ODO200 Calibration Procedure

Date/Time: _____

Staff Name(s): _____

1 **Saturate sponge inside gray sensor cover with fresh tap water; pour out excess.**

2 **Remove sensor guard (not sensor cap), and dry off temperature and DO sensors.**

3 **Replace sensor guard onto sensor.**

4 **Place sensor (with guard) inside gray sensor cover.**

5 **Turn on ODO200 instrument, wait 10 minutes for sensors to stabilize.**

6 **Local barometric pressure from www.weather.gov (inches Hg):** _____

7 **Convert local barometric pressure from "inches Hg" to "mm Hg":**

Multiply value from Step 6 by **25.4** to get BP in units of "mm Hg": _____

8 **Determine true local barometric pressure (not elevation-adjusted) in mm Hg:**

Subtract **29.0** from Step 7 result to get true barometric pressure[1]: _____

9 **Convert true barometric pressure from "mm Hg" to "millibars":**

Multiply value from Step 8 by **1.333**: _____

10 **Press "CAL" button on instrument.**

11 **Use the Up/Down buttons to select the true, local barometric pressue (in millibars).**

Use value from Step 9; select closest integer.

12 **Press "Enter" button.**

13 **When prompted to enter a salinity value, leave at "0 ppt".**

14 **Press "Enter" button; calibration is complete.**

[1] This calculation assumes that the calibration is performed at the BPU dam break room, which has an elevation of approximately 1,160 feet above mean sea level. See page 10 of operation manual for the detailed calcution.

[2] See Appendix A of the YSI200 Operation Manual for calibration values.

Sampling Event Data

Sampling Event Date:	
Sampling Start Time:	**Sampling End Time:**
Sampler(s):	
Current Weather Conditions:	
Recent Weather (past few days):	
Reservoir Water Elevation (feet*):	
Downstream Water Elevation (feet*):	
Flow @ USGS gauge #05242300 (cfs):	
Spillway Flowage (cfs):	
Generator 1 (% speed):	
Generator 2 (% speed):	
Generator 3 (% speed):	
Generator 4 (% speed):	
Generator 5 (% speed):	
Water Condition (Odor, Color, Clarity, etc.)**:**	
Hydrology/Sampling Comments:	

*BPU facility reports elevation according to Memphis Datum; subtract 8.16 feet to convert to NGVD 29.

Sampling Data

Sampling Location:

Sampling Date:

Sampling Time:

Total Water Depth:

Habitat (Pool, Run, Riffle)**:**

Sampling Depth (feet)	**Dissolved Oxygen (mg/L)**	**Dissolved Oxygen (% Saturation)**	**Water Temperature (°C)**
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			

Comments:

Sampling Data

Sampling Location:

Sampling Date:

Sampling Time:

Total Water Depth:

Habitat (Pool, Run, Riffle)**:**

Sampling Depth (feet)	**Dissolved Oxygen (mg/L)**	**Dissolved Oxygen (% Saturation)**	**Water Temperature (°C)**
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			

Comments:

Sampling Data

Sampling Location:

Sampling Date:

Sampling Time:

Total Water Depth:

Habitat (Pool, Run, Riffle)**:**

Sampling Depth (feet)	**Dissolved Oxygen (mg/L)**	**Dissolved Oxygen (% Saturation)**	**Water Temperature (°C)**
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			

Comments:

Sampling Data

Sampling Location:

Sampling Date:

Sampling Time:

Total Water Depth:

Habitat (Pool, Run, Riffle)**:**

Sampling Depth (feet)	**Dissolved Oxygen (mg/L)**	**Dissolved Oxygen (% Saturation)**	**Water Temperature (°C)**
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			

Comments:

Sampling Data

Sampling Location:

Sampling Date:

Sampling Time:

Total Water Depth:

Habitat (Pool, Run, Riffle)**:**

Sampling Depth (feet)	**Dissolved Oxygen (mg/L)**	**Dissolved Oxygen (% Saturation)**	**Water Temperature (°C)**
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			

Comments:

Appendix B

Dissolved Oxygen and Temperature Data Table

				Dissolved Oxygen (mg/L)										
Week	Sample Date	Sample Location	Sample Time	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft	33 ft
1	5/28/19	Upstream	14:16	8.90	8.90									
	5/28/19	Site 1	13:46	9.95	9.92	9.92	9.90	9.88	9.87	9.88	9.87			
	5/28/19	Site 2	13:40	9.86	9.86	9.83	9.82	9.80	9.79	9.78	9.78	9.78	9.74	9.76
	5/28/19	Site 3	13:30	9.98	10.00	10.00								
2	6/6/19	Site 1	10:12	7.53	7.49	7.48	7.46	7.44	7.41	7.40	7.40			
	6/6/19	Site 2	10:03	8.37	8.26	8.18	7.77	8.13	8.17	7.64	7.81	7.79	7.69	7.71
	6/6/19	Site 3	10:10	7.53	7.49	7.48	7.46	7.44	7.41	7.40	7.40			
	6/6/19	Upstream	11:17	7.48	7.51									
3	6/13/19	Site 1	10:33	7.42	7.46	7.32	7.27	7.23						
	6/13/19	Site 2	10:10	7.93	7.92	7.91	7.90	7.86	7.84	7.82	7.80	7.77	7.72	
	6/13/19	Site 3	10:00	7.94	7.95	7.93	7.91							
	6/13/19	Upstream	11:00	7.26	7.26									
4	6/20/19	Site 1	10:08	7.53	7.51	7.49	7.47	7.46	7.44					
	6/20/19	Site 2	9:44	7.81	7.80	7.78	7.80	7.78	7.76	7.75	7.72	7.70		
	6/20/19	Site 3	9:36	7.85	7.91	7.87	7.89	7.84	7.92					
	6/20/19	Upstream	10:35	7.58	7.57									
5	6/27/19	Site 1	9:15	7.32	7.30	7.28	7.25	7.03						
	6/27/19	Site 2	9:07	7.43	7.38	7.35	7.35	7.39	7.39	7.35				
	6/27/19	Site 3	9:00	7.62	7.59	7.57	7.56	7.53	7.52	7.49	7.48			
	6/27/19	Upstream	9:45	7.48	7.47									
6	7/2/19	Site 1	9:07	7.32	7.32	7.31	7.32	7.31	7.29	7.28	7.27			
	7/2/19	Site 2	9:14	7.31	7.30	7.30	7.29	7.27	7.26	7.25	7.23	7.20		
	7/2/19	Site 3	9:00	7.36	7.34	7.33	7.32	7.30	7.29	7.29	7.28			
	7/2/19	Upstream	9:41	6.34	6.33									
7	7/11/19	Site 1	9:50	6.85	6.88	6.85	6.84	6.81	6.81					
	7/11/19	Site 2	9:45	6.87	6.85	6.84	6.81	6.82	6.80	6.79				
	7/11/19	Site 3	9:30	6.84	6.82	6.81	6.81	6.78	6.76	6.75	6.73			
	7/11/19	Upstream	10:25	5.50	5.44									
8	7/16/19	Site 1	13:53	5.17	5.16	5.14	5.13	5.12	5.10	5.08				
	7/16/19	Site 2	13:47	5.25	5.22	5.20	5.18	5.14	5.13	5.11	5.10			
	7/16/19	Site 3	13:37	5.28	5.25	5.16	5.12	5.38	5.63	5.54				
	7/16/19	Upstream	14:18	5.22	5.23									
	7/16/19													
9	7/26/19	Site 1	9:32	6.32	6.31	6.29	6.28	6.26	6.25	6.23				
	7/26/19	Site 2	9:23	6.57	6.47	6.37	6.33	6.36	6.33	6.24	6.27	6.48	6.49	
	7/26/19	Site 3	9:16	6.88	6.86	6.68	6.92	6.77	6.71	6.68				
	7/26/19	Upstream	10:19	6.43	6.42									
10	7/31/19	Site 1	11:00	6.42	6.40	6.38	6.35	6.34	6.33	6.32				
	7/31/19	Site 2	10:55	6.47	6.45	6.43	6.42	6.41	6.39	6.28	6.36			
	7/31/19	Site 3	10:45	6.70	7.03	6.80	6.76	6.88	6.77	6.83	6.78			
	7/31/19	Upstream	11:29	6.70	6.65									
11	8/8/19	Site 1	10:35	6.18	6.16	6.14	6.12	6.13	6.14					
	8/8/19	Site 2	10:30	6.24	6.25	6.29	6.27	6.21	6.20	6.25	6.23	6.15		
	8/8/19	Site 3	10:22	6.65	6.67	6.62	6.61	6.55	6.46	6.50				
	8/8/19	Upstream	11:04	6.24	6.21									
12	8/16/19	Site 1	11:58	6.73	6.69	6.69	6.69	6.67	6.67					
	8/16/19	Site 2	11:53	6.79	6.77	6.75	6.74	6.74	6.73	6.79	6.75	6.69		
	8/16/19	Site 3	11:46	6.89	6.87	6.85	6.84	6.81	6.80	6.77	6.76	6.76		
	8/16/19	Upstream	12:33	6.94	6.94									
13	8/22/19	Site 1	13:53	6.90	6.93	6.90	6.95	6.95						
	8/22/19	Site 2	13:48	7.15	7.13	7.13	7.12	7.08	7.06	7.04	7.03	7.02		
	8/22/19	Site 3	13:42	7.16	7.15	7.13	7.11	7.09	7.08	7.07	7.06	7.05		
	8/22/19	Upstream	13:42	7.29	7.28									
14	8/30/19	Site 1	13:42	7.84	7.82	7.80	7.79	7.79	7.80	7.79				
	8/30/19	Site 2	13:36	7.88	7.86	7.85	7.83	7.80	7.79	7.79	7.80	7.79		
	8/30/19	Site 3	13:29	7.85	7.83	7.77	7.73	7.72	7.70	7.66	7.63			
	8/30/19	Upstream	14:29	8.14	8.10									
15	9/5/19	Site 1	13:47	7.86	7.85	7.82	7.81	7.80	7.79					
	9/5/19	Site 2	13:41	7.86	7.85	7.84	7.82	7.81	7.79	7.78	7.77			
	9/5/19	Site 3	13:35	7.92	7.89	7.84	7.83	7.81	7.79	7.76	7.74	7.71		
	9/5/19	Upstream	14:16	7.85	7.84									
16	9/13/19	Site 1	13:31	8.30	8.29	8.27	8.26	8.27	8.25					
	9/13/19	Site 2	13:27	8.35	8.33	8.33	8.30	8.27	8.27	8.24	8.23	8.22		
	9/13/19	Site 3	13:20	8.47	8.45	8.44	8.40	8.37	8.37	8.33	8.29	8.27		
	9/13/19	Upstream	13:57	8.41	8.38									
17	9/19/19	Site 1	14:18	7.66	7.65	7.64	7.63	7.62	7.61	7.60				
	9/19/19	Site 2	14:13	7.73	7.71	7.68	7.67	7.65	7.62	7.60	7.59	7.58	7.56	
	9/19/19	Site 3	14:07	8.09	8.07	8.07	8.06	7.99	7.98	7.89	7.85	7.70		
	9/19/19													
18	9/27/19	Site 1	9:21	8.11	7.87	7.84	7.91	7.91	8.02					
	9/27/19	Site 2	9:13	8.34	8.33	8.31	8.30	8.29	8.28	8.29	8.28	8.25		
	9/27/19	Site 3	9:08	8.27	8.28	8.26	8.26	8.25	8.23	8.23	8.22	8.19		
	9/27/19	Upstream	9:49	7.67	7.64									

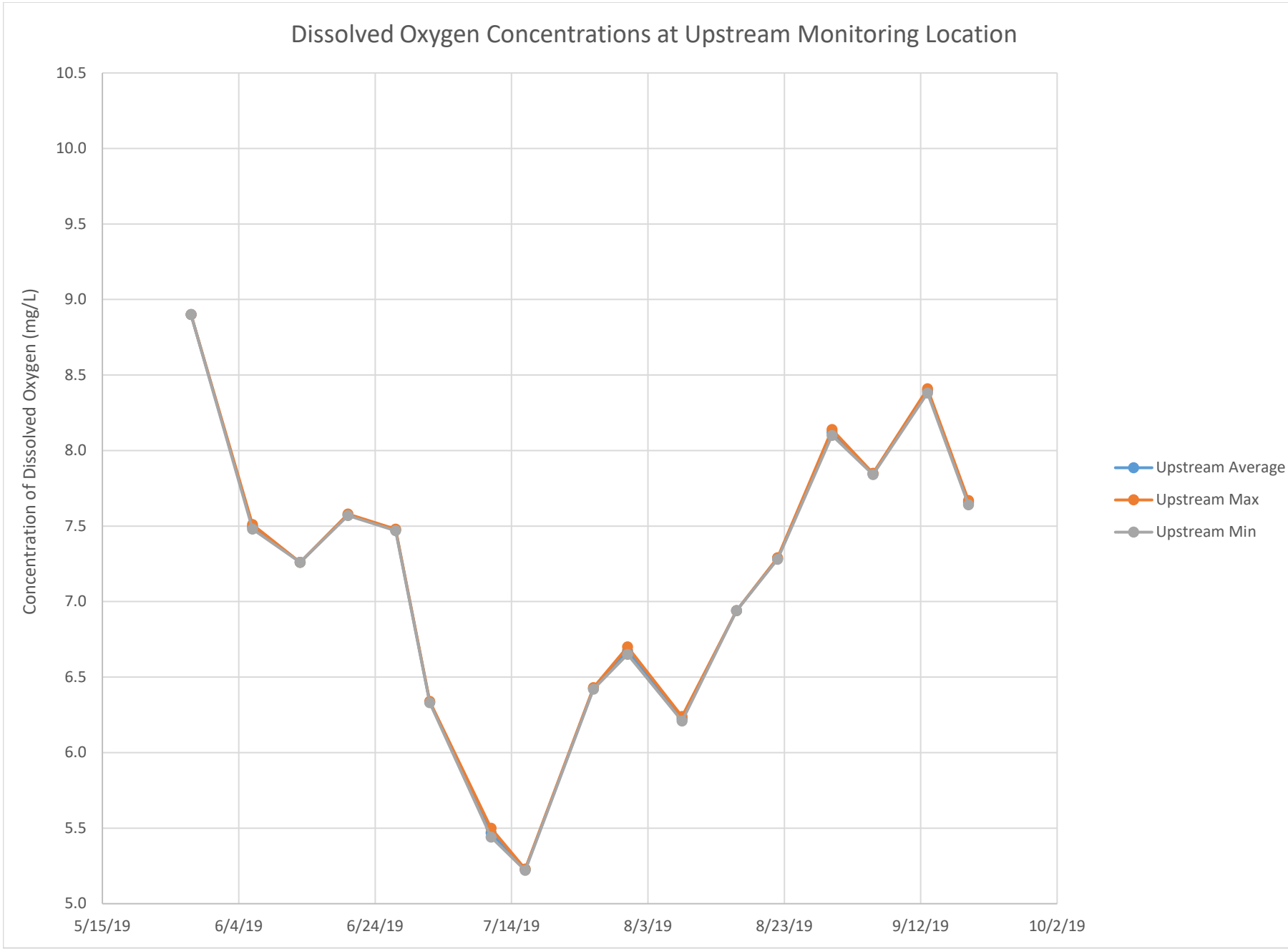
				Dissolved Oxygen (% Saturation)										
Week	Sample Date	Sample Location	Sample Time	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft	33 ft
1	5/28/19	Upstream	14:16	85.9	85.8									
	5/28/19	Site 1	13:46	95.4	95.2	95.2	95.0	94.9	94.7	94.4	94.5			
	5/28/19	Site 2	13:40	94.6	94.4	94.3	94.2	94.0	93.8	93.7	93.8	93.7	93.6	93.7
	5/28/19	Site 3	13:30	95.8	95.9	95.7								
2	6/6/19	Site 1	10:12	83.0	82.5	82.1	81.9	81.8	81.4	81.3	81.1			
	6/6/19	Site 2	10:03	91.5	91.1	89.4	88.7	90.2	89.9	84.4	84.2	85.3	85.1	85.5
	6/6/19	Site 3	10:10	83.0	82.5	82.1	81.9	81.8	81.4	81.3	81.3			
	6/6/19	Upstream	11:17	82.8	82.7									
3	6/13/19	Site 1	10:33	81.0	80.7	80.5	79.8	79.1						
	6/13/19	Site 2	10:10	87.0	86.7	86.6	86.5	86.2	85.9	85.7	85.3	84.9	84.7	
	6/13/19	Site 3	10:00	86.8	87.1	86.9	86.7							
	6/13/19	Upstream	11:00	79.8	79.6									
4	6/20/19	Site 1	10:08	83.2	82.9	82.8	82.6	82.4	82.2					
	6/20/19	Site 2	9:44	86.2	86.1	85.8	86.0	85.9	85.6	85.5	85.2	84.9		
	6/20/19	Site 3	9:36	86.7	87.2	86.9	87.1	86.6	86.0					
	6/20/19	Upstream	10:35	83.9	83.7									
5	6/27/19	Site 1	9:15	82.4	82.1	81.8	81.6	81.2						
	6/27/19	Site 2	9:07	82.9	83.4	82.8	83.2	83.2	83.5	83.5				
	6/27/19	Site 3	9:00	85.9	85.5	85.4	85.1	84.6	84.6	84.4	85.1			
	6/27/19	Upstream	9:45	84.4	84.1									
6	7/2/19	Site 1	9:07	85.3	85.2	85.1	85.2	85.1	84.8	84.7	84.6			
	7/2/19	Site 2	9:14	85.3	85.1	85.0	84.9	84.6	84.6	84.5	83.9	83.9		
	7/2/19	Site 3	9:00	85.9	85.5	85.4	85.3	85.1	84.9	84.8	84.8			
	7/2/19	Upstream	9:41	74.1	73.9									
7	7/11/19	Site 1	9:50	81.4	81.3	81.2	80.4	80.3	80.3					
	7/11/19	Site 2	9:45	81.2	81.1	80.8	80.6	80.5	80.4	80.1				
	7/11/19	Site 3	9:30	81.0	80.6	80.5	80.4	80.2	79.8	79.7	79.5			
	7/11/19	Upstream	10:25	65.1	64.5									
8	7/16/19	Site 1	13:53	63.1	63.2	63.0	62.8	62.7	62.4	62.2				
	7/16/19	Site 2	13:47	64.5	63.9	63.7	63.4	63.0	62.7	62.6	62.3			
	7/16/19	Site 3	13:37	64.2	64.0	63.1	63.7	64.5	65.8	65.7				
	7/16/19	Upstream	14:18	64.7	64.3									
	7/16/19													
9	7/26/19	Site 1	9:32	75.5	75.3	75.2	74.8	74.8	74.6	74.4				
	7/26/19	Site 2	9:23	78.7	76.1	75.9	75.3	76.4	75.1	74.5	74.6	76.6	76.4	
	7/26/19	Site 3	9:16	82.5	81.9	80.3	81.1	81.0	80.2	79.6				
	7/26/19	Upstream	10:19	76.8	76.6									
10	7/31/19	Site 1	11:00	74.9	74.9	74.7	74.4	74.3	74.0	73.8				
	7/31/19	Site 2	10:55	75.9	75.5	75.3	75.1	75.0	74.8	74.7	74.5			
	7/31/19	Site 3	10:45	77.8	81.4	81.0	80.4	80.4	79.2	80.2	79.5			
	7/31/19	Upstream	11:29	78.7	77.9									
11	8/8/19	Site 1	10:35	74.1	73.8	73.7	73.5	73.4	73.4					
	8/8/19	Site 2	10:30	75.0	74.9	75.3	74.7	74.6	74.7	75.0	74.3	74.2		
	8/8/19	Site 3	10:22	81.1	80.1	79.5	79.0	78.3	77.8	78.2				
	8/8/19	Upstream	11:04	75.0	74.4									
12	8/16/19	Site 1	11:58	77.4	77.0	77.0	77.1	76.8	76.8					
	8/16/19	Site 2	11:53	78.4	78.1	77.9	77.7	77.6	77.7	78.2	77.6	77.2		
	8/16/19	Site 3	11:46	79.5	79.4	79.0	78.8	78.6	78.3	78.2	78.2	78.2		
	8/16/19	Upstream	12:33	80.8	80.6									
13	8/22/19	Site 1	13:53	80.4	79.9	80.1	80.6	80.6						
	8/22/19	Site 2	13:48	83.3	83.0	83.0	82.9	82.6	82.3	82.2	81.9	81.6		
	8/22/19	Site 3	13:42	83.4	83.1	83.0	82.7	82.5	82.4	82.1	82.1	82.0		
	8/22/19	Upstream	13:42	85.7	85.4									
14	8/30/19	Site 1	13:42	84.2	84.3	84.1	83.8	84.0	84.2	84.0				
	8/30/19	Site 2	13:36	85.2	85.0	84.8	84.7	84.4	84.0	84.1	84.2	84.2		
	8/30/19	Site 3	13:29	85.1	85.0	83.9	83.4	83.1	83.1	82.5	82.3			
	8/30/19	Upstream	14:29	88.9	88.5									
15	9/5/19	Site 1	13:47	84.8	84.6	84.3	84.2	84.1	84.0					
	9/5/19	Site 2	13:41	84.9	84.6	84.6	84.5	84.3	84.0	83.9	83.9			
	9/5/19	Site 3	13:35	86.0	85.0	84.8	84.5	84.2	84.0	83.7	83.5	83.2		
	9/5/19	Upstream	14:16	84.9	84.7									
16	9/13/19	Site 1	13:31	84.4	84.1	84.0	83.9	84.0	83.8					
	9/13/19	Site 2	13:27	84.9	84.6	84.6	84.1	83.9	83.9	83.7	83.6	83.5		
	9/13/19	Site 3	13:20	86.2	85.9	85.8	85.2	85.0	85.0	84.6	84.1	83.9		
	9/13/19	Upstream	13:57	85.5	84.8									
17	9/19/19	Site 1	14:18	83.0	83.0	82.8	82.6	82.5	82.4	82.3				
	9/19/19	Site 2	14:13	83.6	83.4	83.2	83.1	82.4	82.4	82.3	82.0	82.0	81.7	
	9/19/19	Site 3	14:07	87.3	88.0	87.5	87.3	86.8	86.1	85.6	85.2	83.8		
	9/19/19													
18	9/27/19	Site 1	9:21	85.4	81.8	81.2	81.0	81.1	82.3					
	9/27/19	Site 2	9:13	85.3	85.3	85.1	85.0	84.8	84.8	84.9	84.6	84.6		
	9/27/19	Site 3	9:08	85.1	84.9	84.7	84.8	84.8	84.6	84.6	84.2	84.0		
	9/27/19	Upstream	9:49	78.5	78.1									

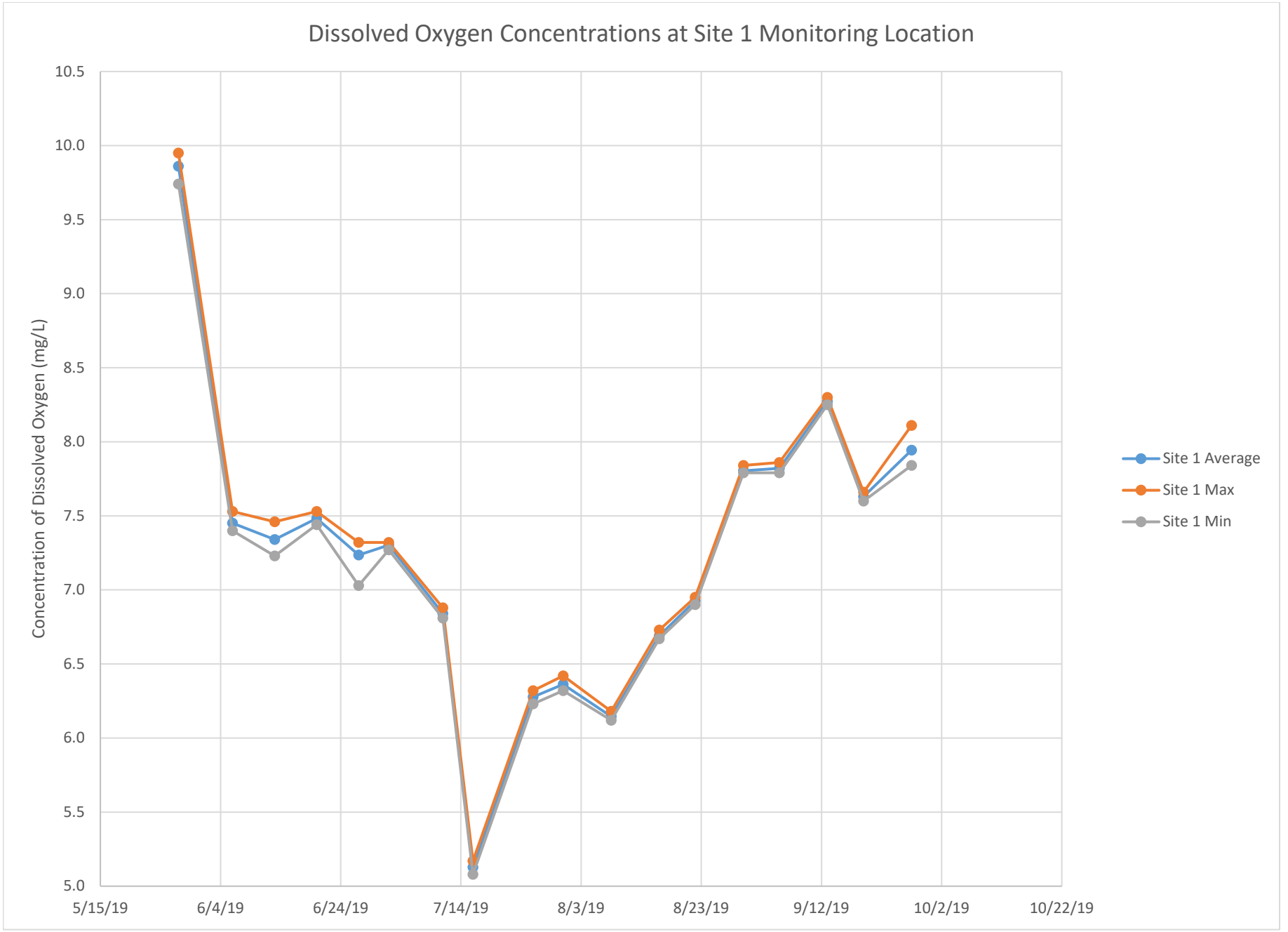
				Water Temperature (°C)										
Week	Sample Date	Sample Location	Sample Time	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft	33 ft
1	5/28/19	Upstream	14:16	13.8	13.8									
	5/28/19	Site 1	13:46	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5			
	5/28/19	Site 2	13:40	13.5	13.5	13.5	13.5	13.5	13.4	13.4	13.5	13.5	13.5	13.5
	5/28/19	Site 3	13:30	13.5	13.5	13.5								
2	6/6/19	Site 1	10:12	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9			
	6/6/19	Site 2	10:03	19.9	19.9	19.9	19.9	20.0	19.9	19.9	19.9	19.9	19.9	19.9
	6/6/19	Site 3	10:10	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9			
	6/6/19	Upstream	11:17	20.3	20.1									
3	6/13/19	Site 1	10:33	19.8	19.8	19.8	19.8	19.8						
	6/13/19	Site 2	10:10	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	
	6/13/19	Site 3	10:00	19.8	19.8	19.8	19.8							
	6/13/19	Upstream	11:00	19.8	19.8									
4	6/20/19	Site 1	10:08	20.2	20.2	20.2	20.2	20.2	20.2					
	6/20/19	Site 2	9:44	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2		
	6/20/19	Site 3	9:36	20.2	20.2	20.2	20.2	20.2	20.2					
	6/20/19	Upstream	10:35	20.2	20.2									
5	6/27/19	Site 1	9:15	21.1	21.1	21.2	21.2	21.2						
	6/27/19	Site 2	9:07	21.2	21.2	21.2	21.2	21.2	21.2	21.2				
	6/27/19	Site 3	9:00	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2			
	6/27/19	Upstream	9:45	21.2	21.2									
6	7/2/19	Site 1	9:07	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0			
	7/2/19	Site 2	9:14	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0		
	7/2/19	Site 3	9:00	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0			
	7/2/19	Upstream	9:41	23.1	23.1									
7	7/11/19	Site 1	9:50	23.8	23.8	23.8	23.8	23.8	23.8					
	7/11/19	Site 2	9:45	23.7	23.8	23.8	23.8	23.8	23.8	23.8				
	7/11/19	Site 3	9:30	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7			
	7/11/19	Upstream	10:25	23.9	23.9									
8	7/16/19	Site 1	13:53	25.7	25.6	25.6	25.6	25.6	25.6	25.6				
	7/16/19	Site 2	13:47	25.7	25.7	25.7	25.6	25.6	25.6	25.6	25.6			
	7/16/19	Site 3	13:37	25.6	25.6	25.6	25.6	25.6	25.6	25.6				
	7/16/19	Upstream	14:18	26.1	26.0									
	7/16/19													
9	7/26/19	Site 1	9:32	24.3	24.3	24.3	24.3	24.3	24.3	24.3				
	7/26/19	Site 2	9:23	24.2	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	
	7/26/19	Site 3	9:16	24.2	24.2	24.2	24.2	24.3	24.3	24.3				
	7/26/19	Upstream	10:19	24.2	24.3									
10	7/31/19	Site 1	11:00	23.2	23.2	23.2	23.2	23.2	23.2	23.2				
	7/31/19	Site 2	10:55	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2			
	7/31/19	Site 3	10:45	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2			
	7/31/19	Upstream	11:29	23.4	23.3									
11	8/8/19	Site 1	10:35	24.5	24.5	24.5	24.5	24.5	24.5					
	8/8/19	Site 2	10:30	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5		
	8/8/19	Site 3	10:22	24.5	24.5	24.5	24.5	24.5	24.5	24.5				
	8/8/19	Upstream	11:04	24.5	24.5									
12	8/16/19	Site 1	11:58	22.4	22.4	22.4	22.4	22.4	22.4					
	8/16/19	Site 2	11:53	22.5	22.5	22.5	22.5	22.4	22.4	22.4	22.4	22.4		
	8/16/19	Site 3	11:46	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4		
	8/16/19	Upstream	12:33	22.9	22.9									
13	8/22/19	Site 1	13:53	22.7	22.8	22.8	22.8	22.8						
	8/22/19	Site 2	13:48	23.0	23.0	23.0	22.9	23.0	23.0	23.0	23.0	23.0		
	8/22/19	Site 3	13:42	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9		
	8/22/19	Upstream	13:42	23.4	23.4									
14	8/30/19	Site 1	13:42	19.1	19.1	19.1	19.0	19.0	19.1	19.1				
	8/30/19	Site 2	13:36	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1		
	8/30/19	Site 3	13:29	19.2	19.3	19.1	19.1	19.1	19.1	19.1	19.0			
	8/30/19	Upstream	14:29	19.6	19.7									
15	9/5/19	Site 1	13:47	19.0	19.0	19.0	19.0	19.0	19.0					
	9/5/19	Site 2	13:41	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0			
	9/5/19	Site 3	13:35	19.2	19.1	19.1	19.1	19.1	19.0	19.0	19.0	19.0		
	9/5/19	Upstream	14:16	19.1	19.1									
16	9/13/19	Site 1	13:31	16.1	16.1	16.1	16.1	16.1	16.1					
	9/13/19	Site 2	13:27	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1		
	9/13/19	Site 3	13:20	16.2	16.2	16.1	16.1	16.1	16.1	16.1	16.1	16.1		
	9/13/19	Upstream	13:57	16.0	16.0									
17	9/19/19	Site 1	14:18	19.2	19.2	19.2	19.2	19.2	19.2	19.2				
	9/19/19	Site 2	14:13	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	
	9/19/19	Site 3	14:07	19.3	19.3	19.3	19.3	19.2	19.2	19.2	19.2	19.2		
	9/19/19													
18	9/27/19	Site 1	9:21	16.6	16.6	16.6	16.6	16.6	16.6					
	9/27/19	Site 2	9:13	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6		
	9/27/19	Site 3	9:08	16.8	16.7	16.6	16.6	16.6	16.6	16.6	16.6	16.6		
	9/27/19	Upstream	9:49	16.9	16.8									

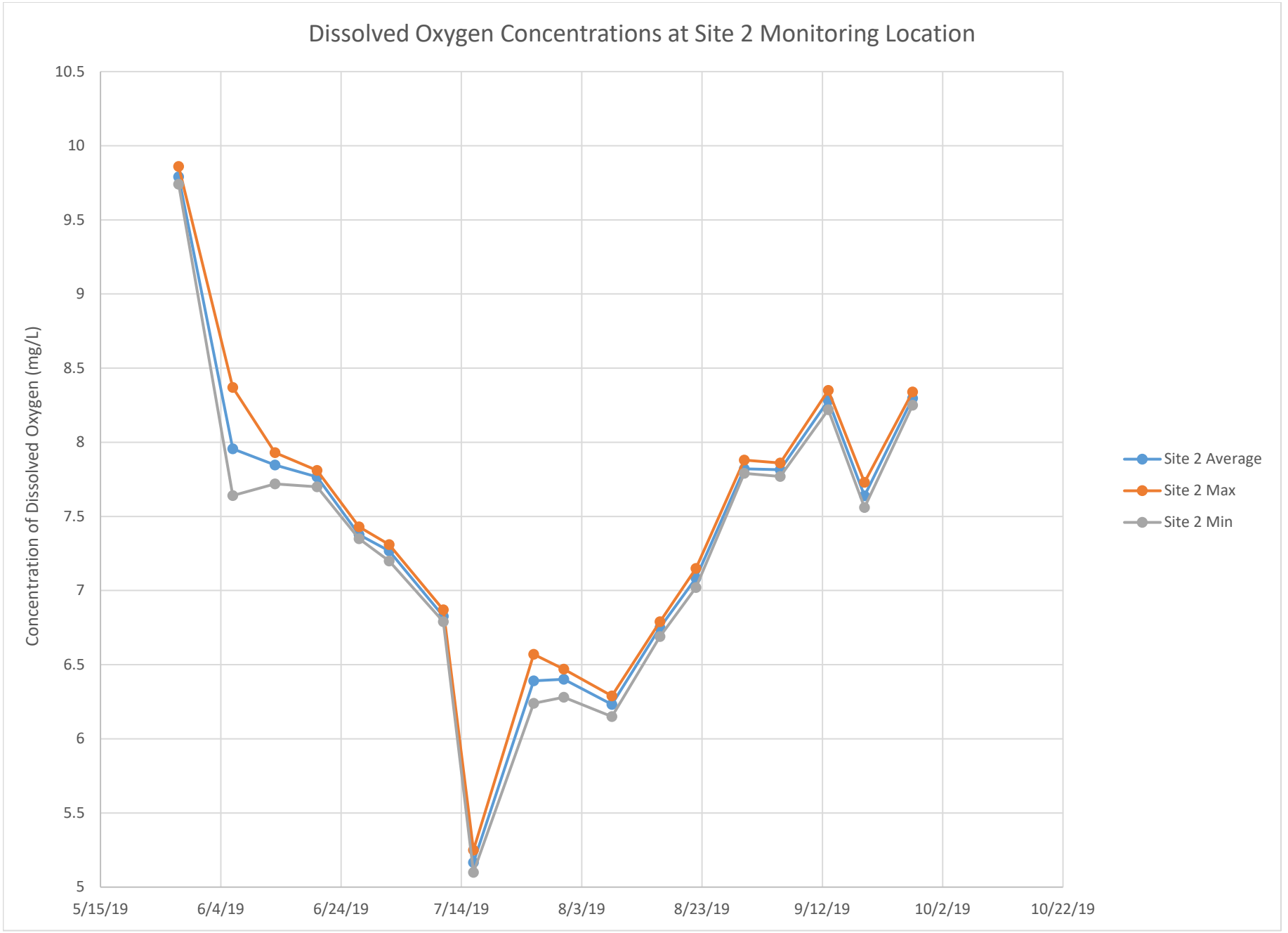
Week	Sample Date	Sample Location	Sample Time	**Habitat (Pool, Run, Riffle)**	**Notes**
1	5/28/19	Upstream	14:16	Run	Good Flow
	5/28/19	Site 1	13:46	Pool	Abundant foam, site at end of apron
	5/28/19	Site 2	13:40	Run	Abundant foam
	5/28/19	Site 3	13:30	Run	Abundant foam
2	6/6/19	Site 1	10:12	Pool	
	6/6/19	Site 2	10:03	Run	
	6/6/19	Site 3	10:10	Pool	
	6/6/19	Upstream	11:17	Run	New sampling location at slide gate #1 approximatley 10' from intake
3	6/13/19	Site 1	10:33	Pool	
	6/13/19	Site 2	10:10	Run	
	6/13/19	Site 3	10:00	Run	
	6/13/19	Upstream	11:00	Run	
4	6/20/19	Site 1	10:08	Pool	
	6/20/19	Site 2	9:44	Run	
	6/20/19	Site 3	9:36	Run	slower flows are helping us to get the sensor to the bottom of the river
	6/20/19	Upstream	10:35	Run	
5	6/27/19	Site 1	9:15	Pool	
	6/27/19	Site 2	9:07	Run	
	6/27/19	Site 3	9:00	Run	
	6/27/19	Upstream	9:45	Run	
6	7/2/19	Site 1	9:07	Run	foam floating on the water surface. Water very turbulent.
	7/2/19	Site 2	9:14	Run	foam floating on the water surface. Water very turbulent.
	7/2/19	Site 3	9:00	Run	foam floating on the water surface
	7/2/19	Upstream	9:41	Run	
7	7/11/19	Site 1	9:50	Run	
	7/11/19	Site 2	9:45	Run	
	7/11/19	Site 3	9:30	Run	
	7/11/19	Upstream	10:25	Riffle	
8	7/16/19	Site 1	13:53	Riffle	water flow (cfs) over the spillway has slowed down
	7/16/19	Site 2	13:47	Pool	water flow (cfs) over the spillway has slowed down
	7/16/19	Site 3	13:37	Pool	water flow (cfs) over the spillway has slowed down
	7/16/19	Upstream	14:18	Run	
	7/16/19				
9	7/26/19	Site 1	9:32	Run	
	7/26/19	Site 2	9:23	Run	
	7/26/19	Site 3	9:16	Run	
	7/26/19	Upstream	10:19	Run	
10	7/31/19	Site 1	11:00	Riffle	
	7/31/19	Site 2	10:55	Riffle	
	7/31/19	Site 3	10:45	Riffle	
	7/31/19	Upstream	11:29	Run	
11	8/8/19	Site 1	10:35	Riffle	
	8/8/19	Site 2	10:30		
	8/8/19	Site 3	10:22	Run	
	8/8/19	Upstream	11:04	Run	
12	8/16/19	Site 1	11:58	Run	
	8/16/19	Site 2	11:53	Riffle	
	8/16/19	Site 3	11:46	Riffle	
	8/16/19	Upstream	12:33	Riffle	
13	8/22/19	Site 1	13:53	Run	
	8/22/19	Site 2	13:48	Riffle	
	8/22/19	Site 3	13:42	Pool	
	8/22/19	Upstream	13:42	Riffle	
14	8/30/19	Site 1	13:42	Run	
	8/30/19	Site 2	13:36	Run	
	8/30/19	Site 3	13:29	Pool	
	8/30/19	Upstream	14:29	Run	
15	9/5/19	Site 1	13:47	Run	
	9/5/19	Site 2	13:41	Riffle	
	9/5/19	Site 3	13:35	Riffle	
	9/5/19	Upstream	14:16	Riffle	
16	9/13/19	Site 1	13:31	Run	
	9/13/19	Site 2	13:27	Run	Some Foam on Water
	9/13/19	Site 3	13:20	Riffle	Some Foam on Water
	9/13/19	Upstream	13:57	Run	
17	9/19/19	Site 1	14:18	Run	No foam coming out of the PowerHouse.
	9/19/19	Site 2	14:13	Riffle	Foam Blanket 10'X75' no other foam around it.
	9/19/19	Site 3	14:07	Run	Small amounts of foam on the water at this site.
	9/19/19			Run	Sampling from Slide Gate 2.
18	9/27/19	Site 1	9:21	Run	Foam floating on the water surface.
	9/27/19	Site 2	9:13	Run	Foam floating on the water surface.
	9/27/19	Site 3	9:08	Run	Foam floating on the water surface.
	9/27/19	Upstream	9:49	Run	Sampling from Slide Gate 2.

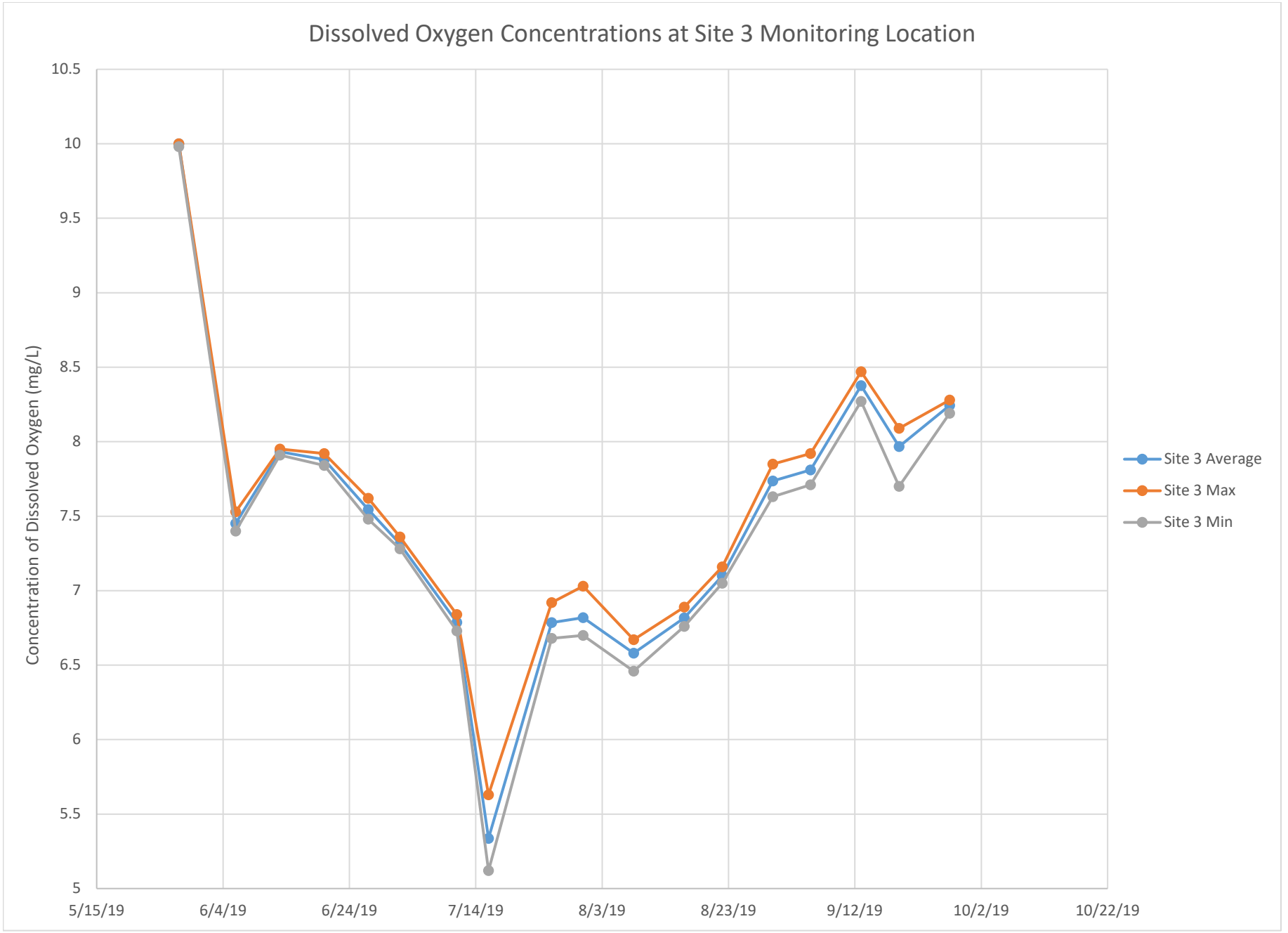
Appendix C

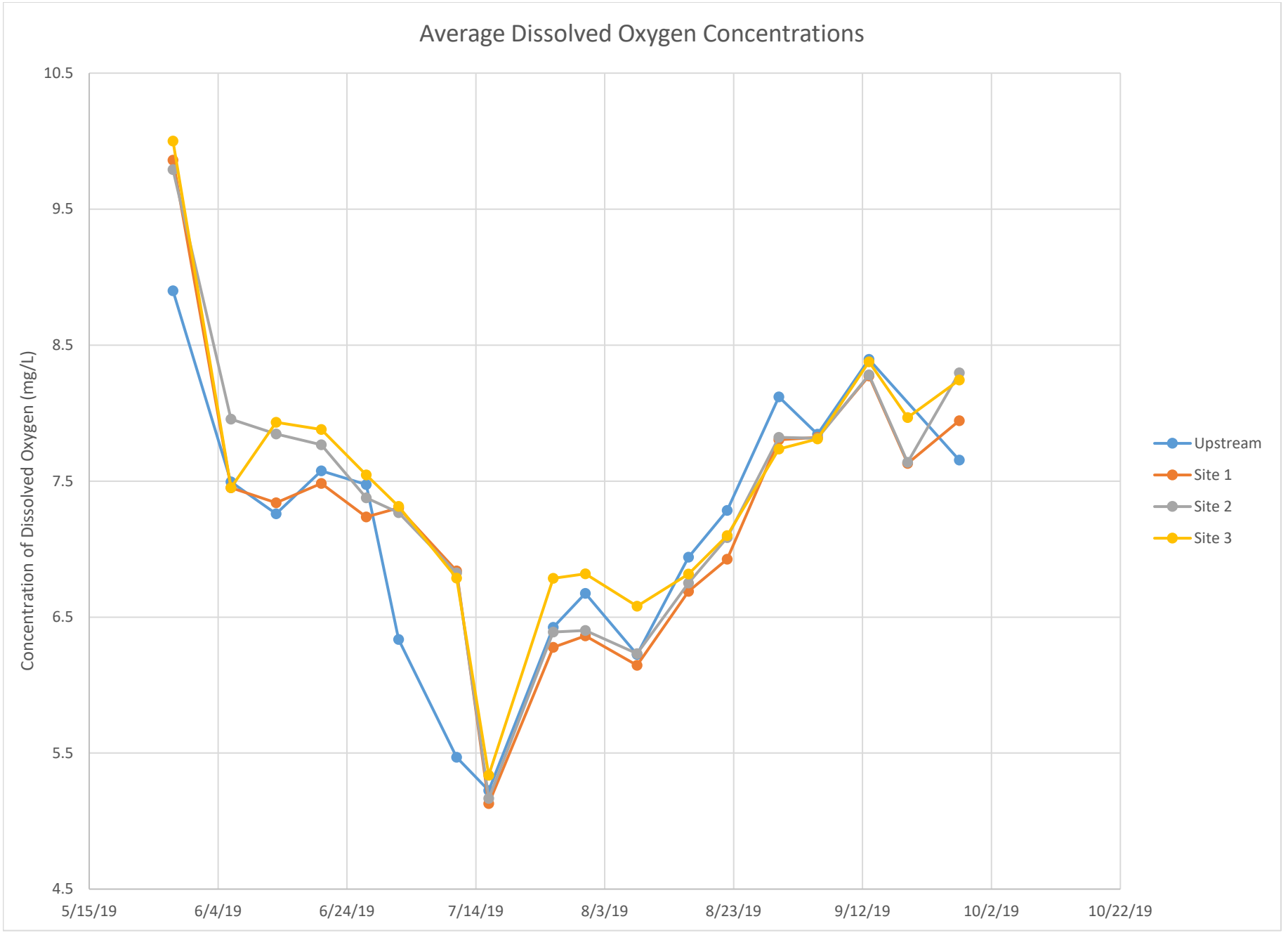
Dissolved Oxygen and Temperature Charts

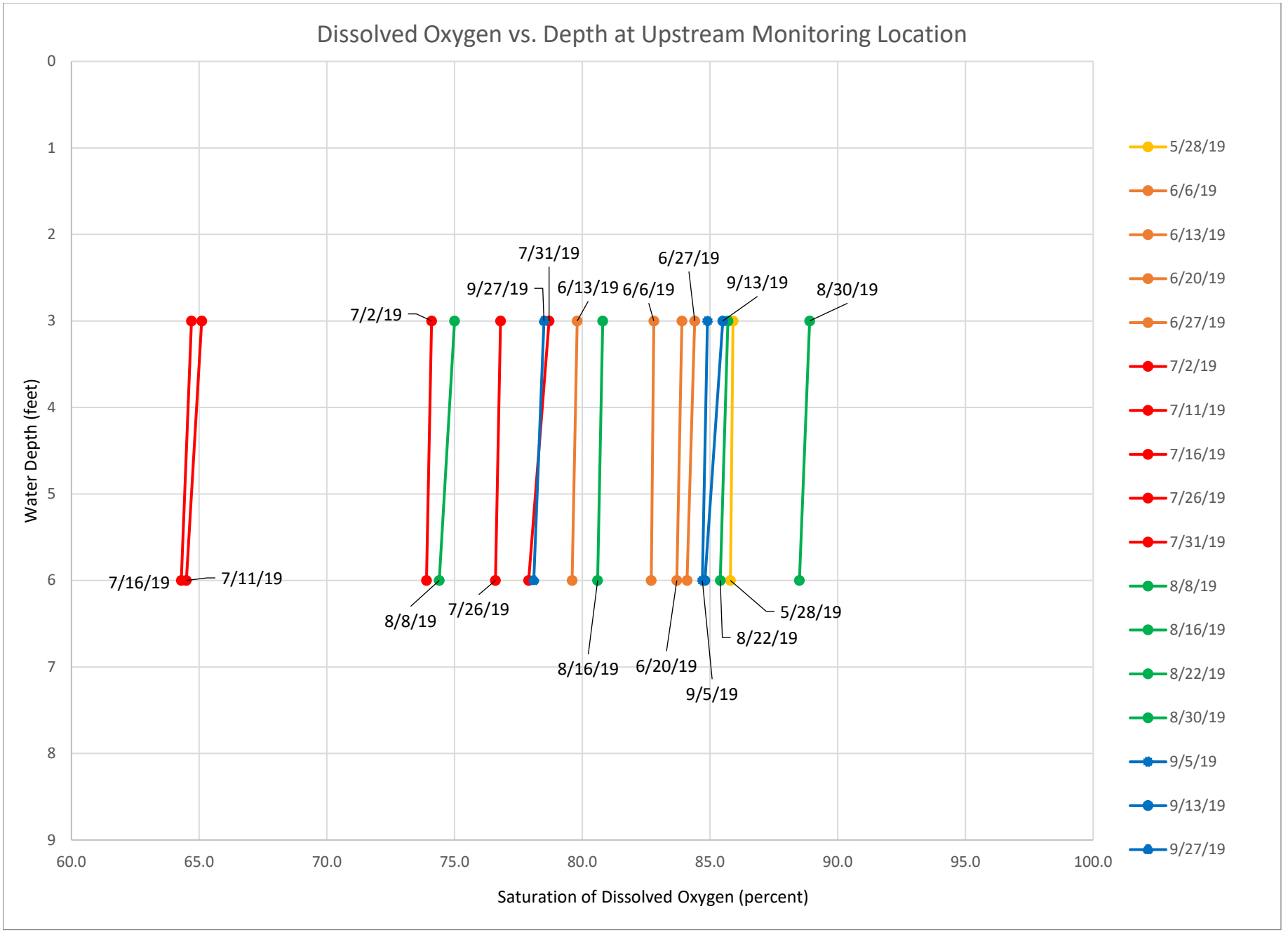

Dissolved Oxygen Concentrations at Upstream Monitoring Location
Concentration of Dissolved Oxygen (mg/L)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
Upstream Average
Upstream Max
Upstream Min

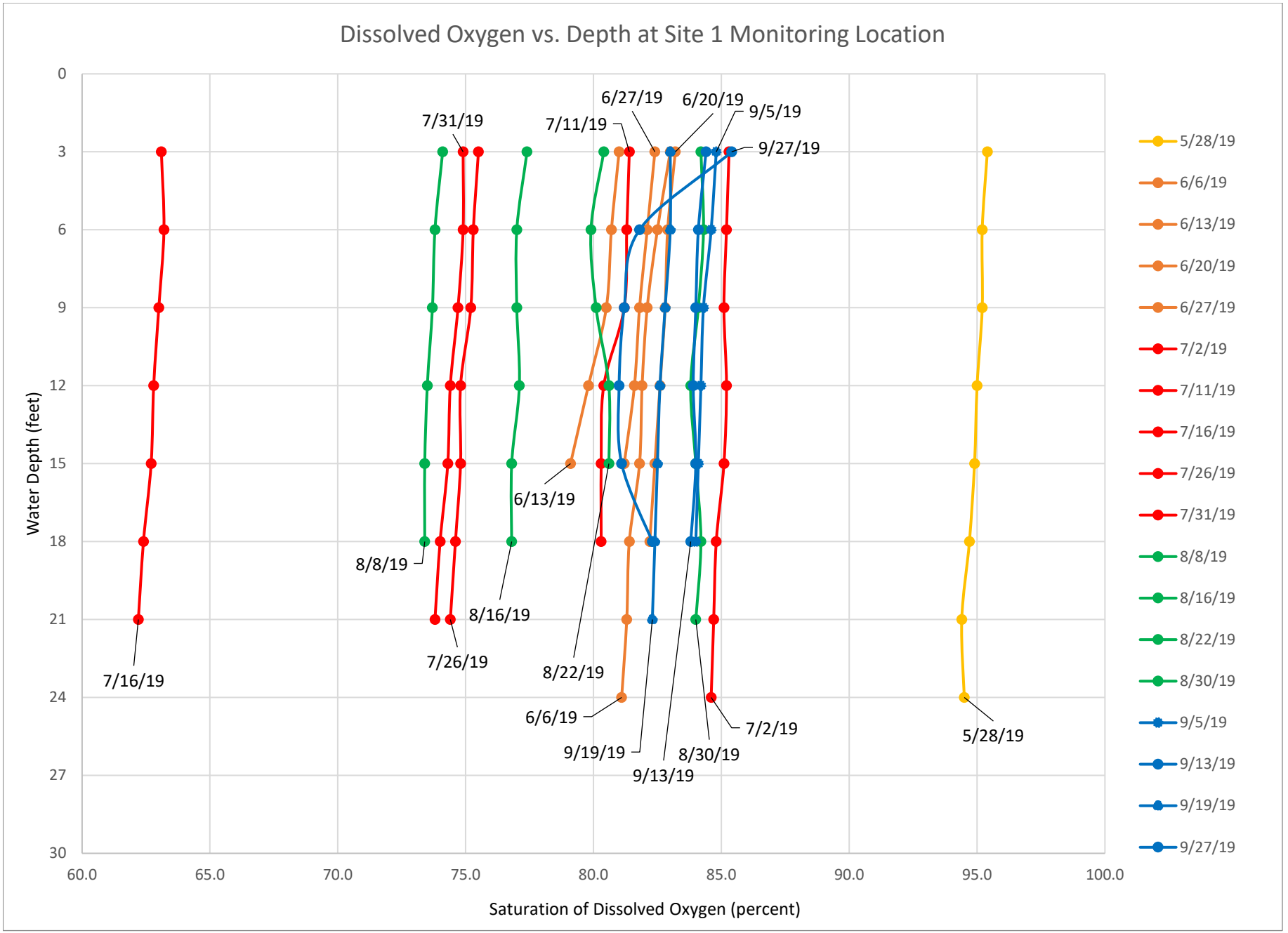

Dissolved Oxygen Concentrations at Site 1 Monitoring Location
Concentration of Dissolved Oxygen (mg/L)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 1 Average
Site 1 Max
Site 1 Min


Dissolved Oxygen Concentrations at Site 2 Monitoring Location
Concentration of Dissolved Oxygen (mg/L)
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 2 Average
Site 2 Max
Site 2 Min


Dissolved Oxygen Concentrations at Site 3 Monitoring Location
Concentration of Dissolved Oxygen (mg/L)
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 3 Average
Site 3 Max
Site 3 Min


Average Dissolved Oxygen Concentrations
Concentration of Dissolved Oxygen (mg/L)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Upstream
Site 1
Site 2
Site 3


Dissolved Oxygen vs. Depth at Upstream Monitoring Location
Water Depth (feet)
0
1
2
3
4
5
6
7
8
9
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
Saturation of Dissolved Oxygen (percent)
7/16/19
7/11/19
7/2/19
9/27/19
7/31/19
6/13/19
6/6/19
6/27/19
9/13/19
8/30/19
8/8/19
7/26/19
8/16/19
6/20/19
9/5/19
8/22/19
5/28/19
5/28/19
6/6/19
6/13/19
6/20/19
6/27/19
7/2/19
7/11/19
7/16/19
7/26/19
7/31/19
8/8/19
8/16/19
8/22/19
8/30/19
9/5/19
9/13/19
9/27/19


Dissolved Oxygen vs. Depth at Site 1 Monitoring Location
Water Depth (feet)
0
3
6
9
12
15
18
21
24
27
30
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
Saturation of Dissolved Oxygen (percent)
7/31/19
7/11/19
6/27/19
6/20/19
9/5/19
9/27/19
6/13/19
8/8/19
8/16/19
7/26/19
7/16/19
8/22/19
6/6/19
9/19/19
9/13/19
8/30/19
7/2/19
5/28/19
5/28/19
6/6/19
6/13/19
6/20/19
6/27/19
7/2/19
7/11/19
7/16/19
7/26/19
7/31/19
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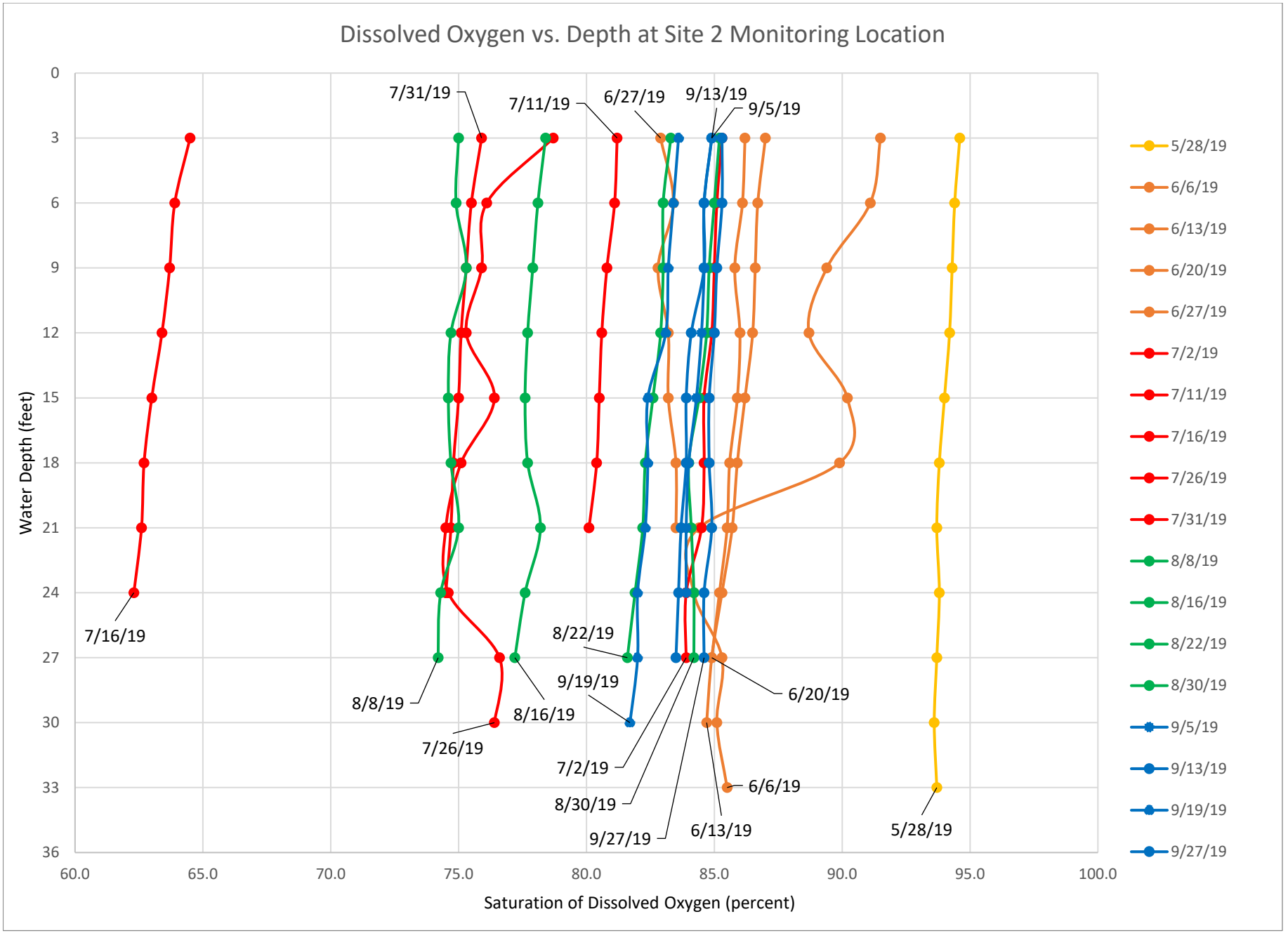
8/16/19
8/22/19
8/30/19
9/5/19
9/13/19
9/19/19
9/27/19


Dissolved Oxygen vs. Depth at Site 2 Monitoring Location
Water Depth (feet)
0
3
6
9
12
15
18
21
24
27
30
33
36
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
Saturation of Dissolved Oxygen (percent)
7/31/19
7/11/19
6/27/19
9/13/19
9/5/19
7/16/19
8/22/19
9/19/19
6/20/19
8/8/19
8/16/19
7/26/19
7/2/19
6/6/19
8/30/19
9/27/19
6/13/19
5/28/19
5/28/19
6/6/19
6/13/19
6/20/19
6/27/19
7/2/19
7/11/19
7/16/19
7/26/19
7/31/19
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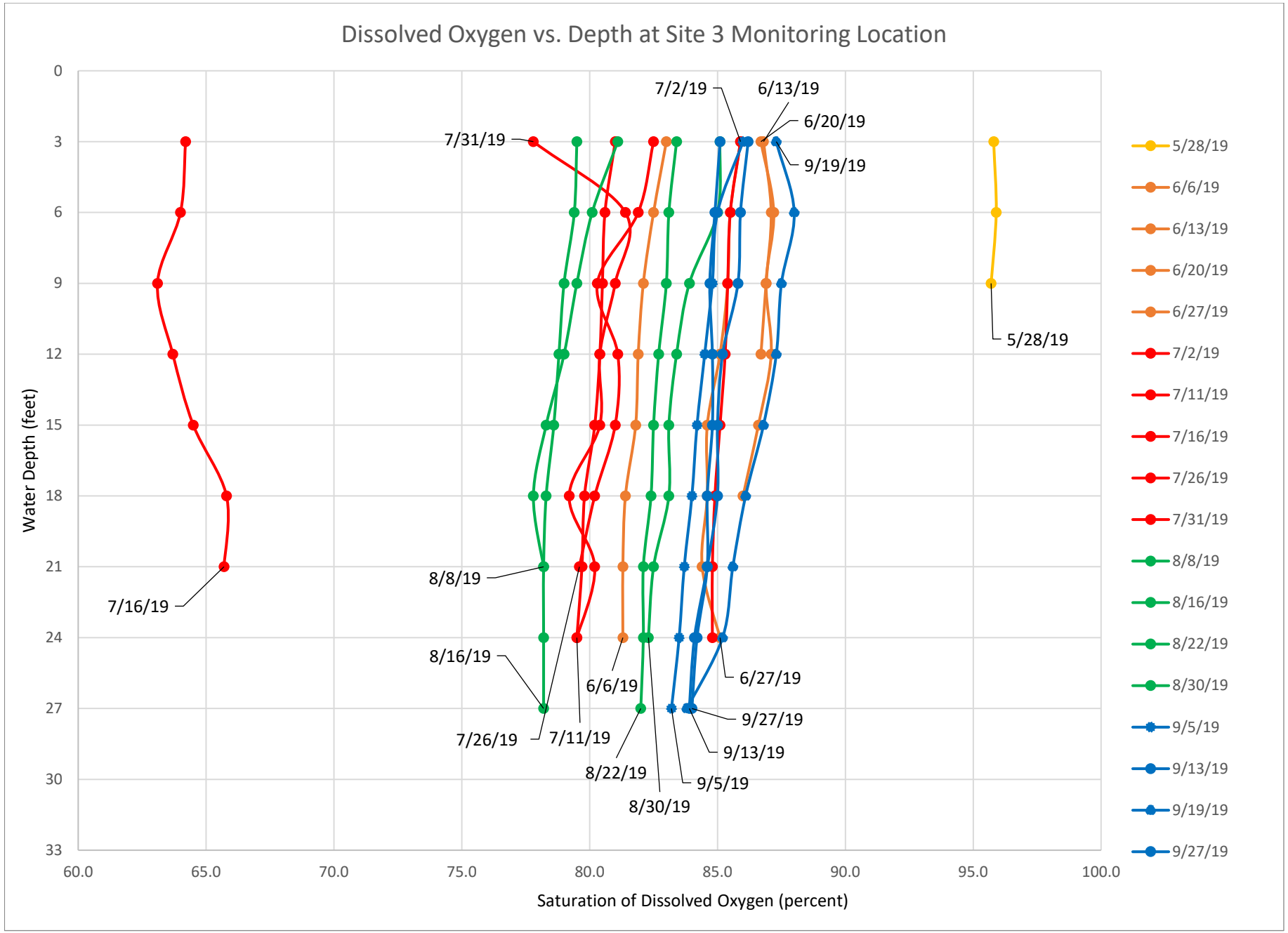
9/5/19
9/13/19
9/19/19
9/27/19


Dissolved Oxygen vs. Depth at Site 3 Monitoring Location
Water Depth (feet)
0
3
6
9
12
15
18
21
24
27
30
33
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
Saturation of Dissolved Oxygen (percent)
7/2/19
6/13/19
6/20/19
7/31/19
9/19/19
5/28/19
7/16/19
8/8/19
8/16/19
6/6/19
6/27/19
9/27/19
7/26/19
7/11/19
9/13/19
8/22/19
9/5/19
8/30/19
5/28/19
6/6/19
6/13/19
6/20/19
6/27/19
7/2/19
7/11/19
7/16/19
7/26/19
7/31/19
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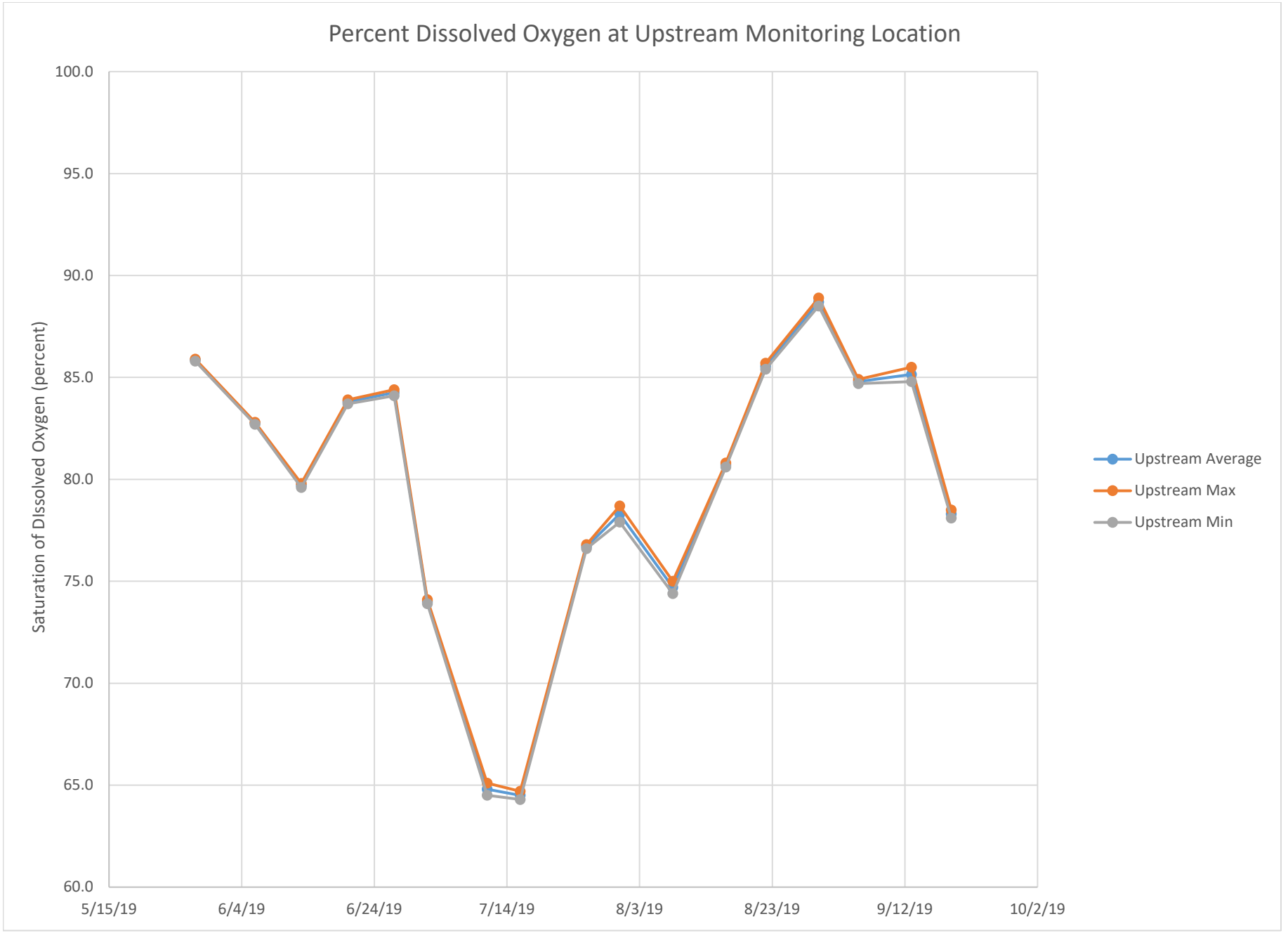
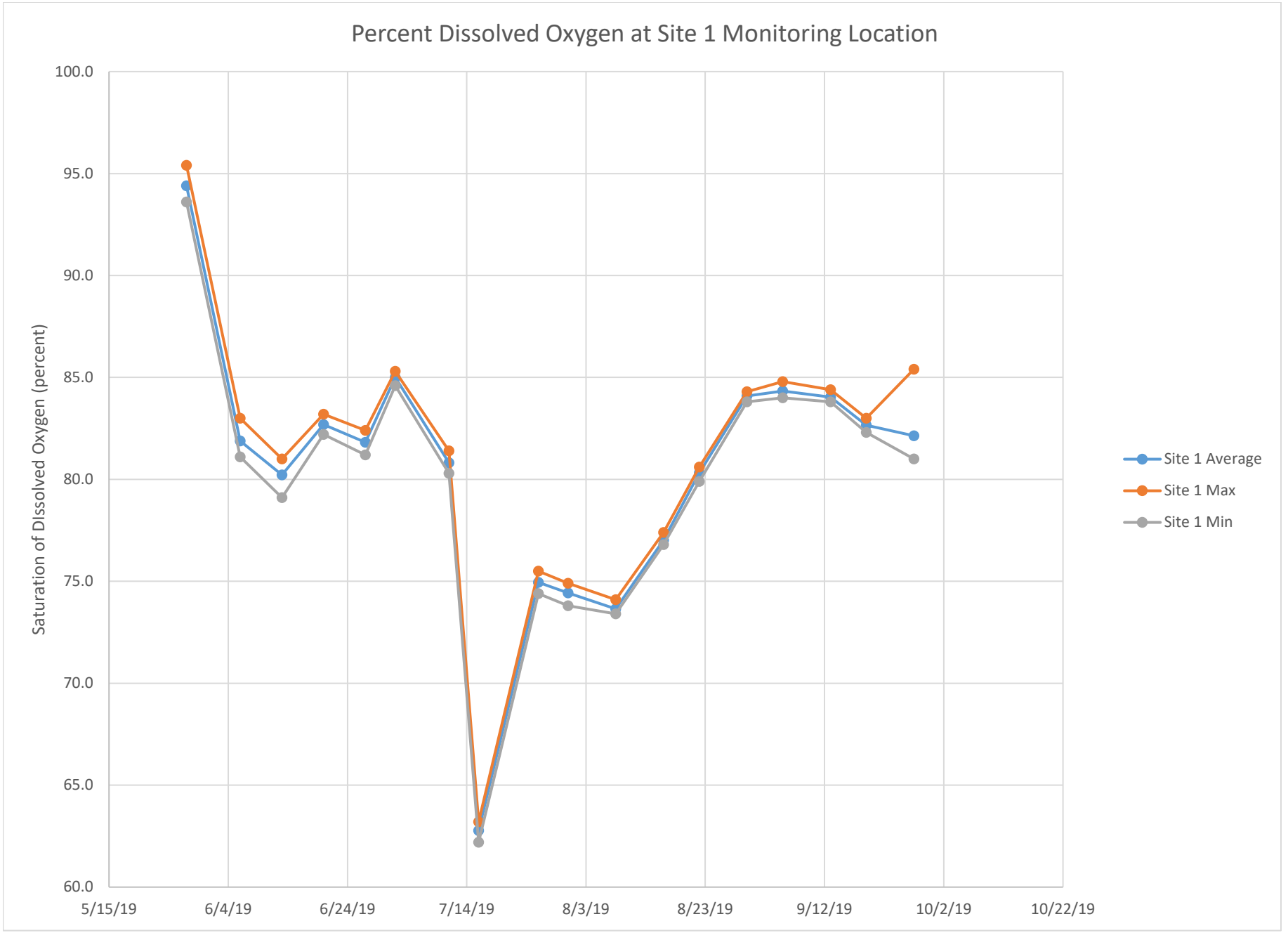
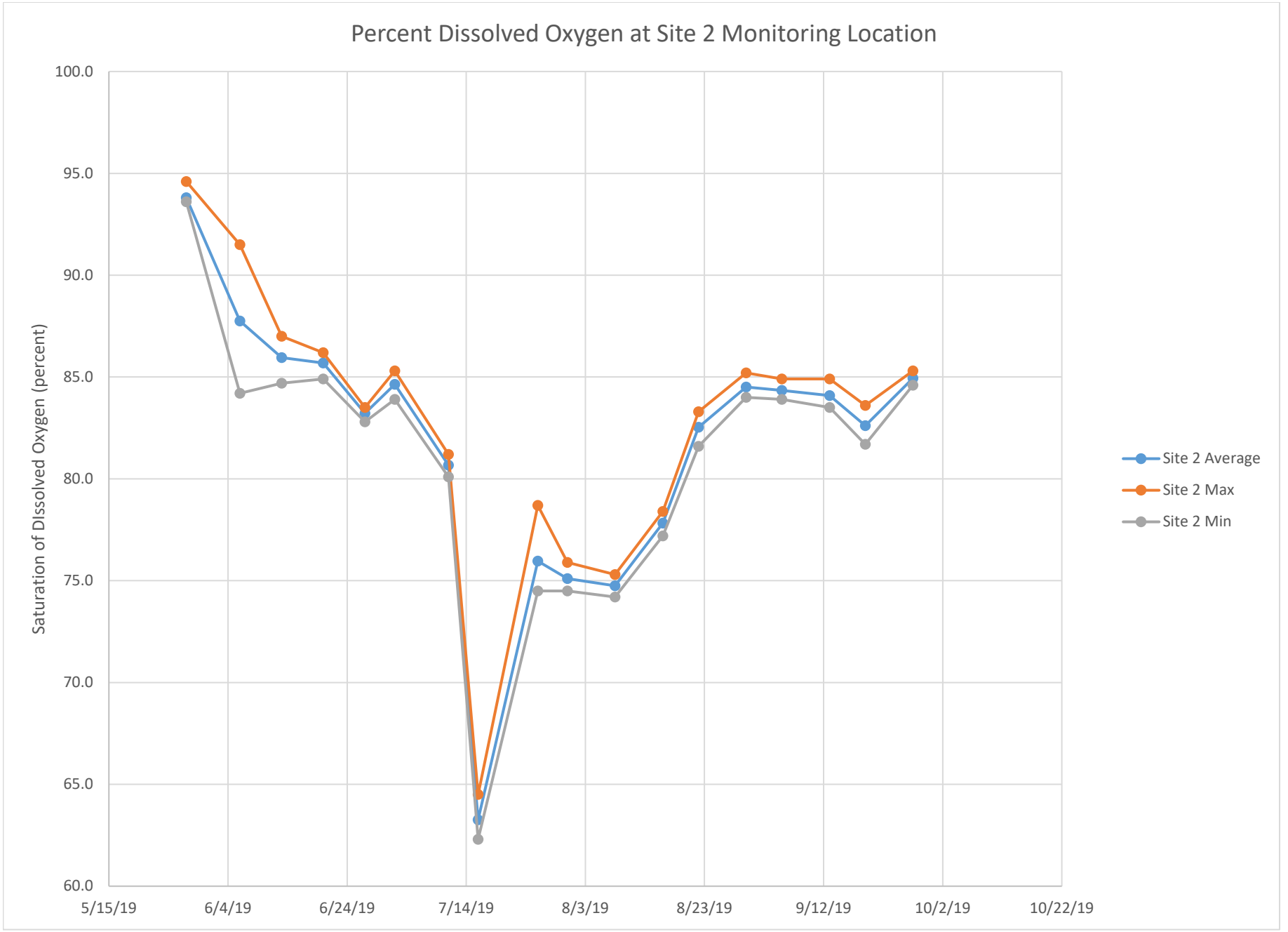
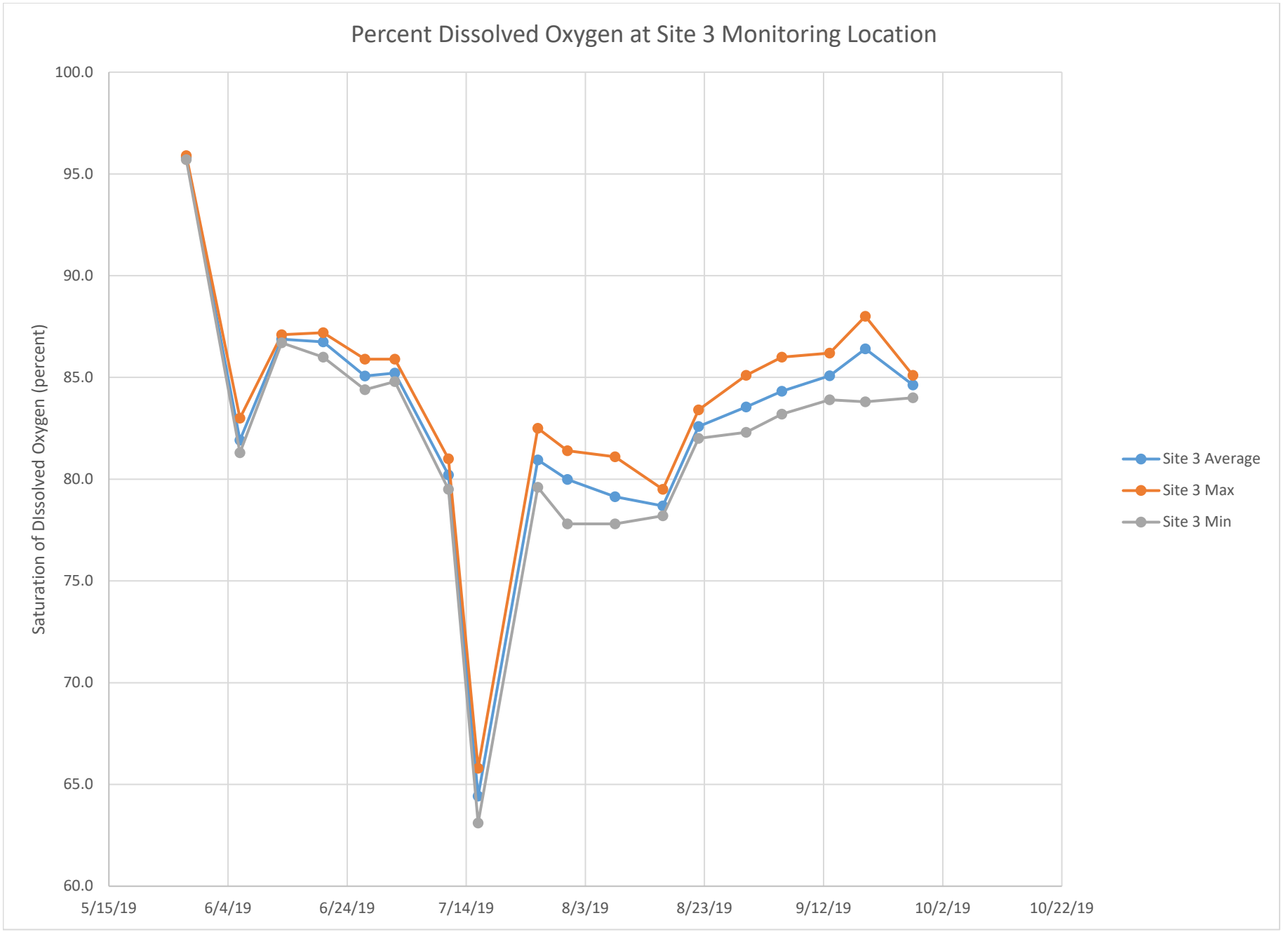
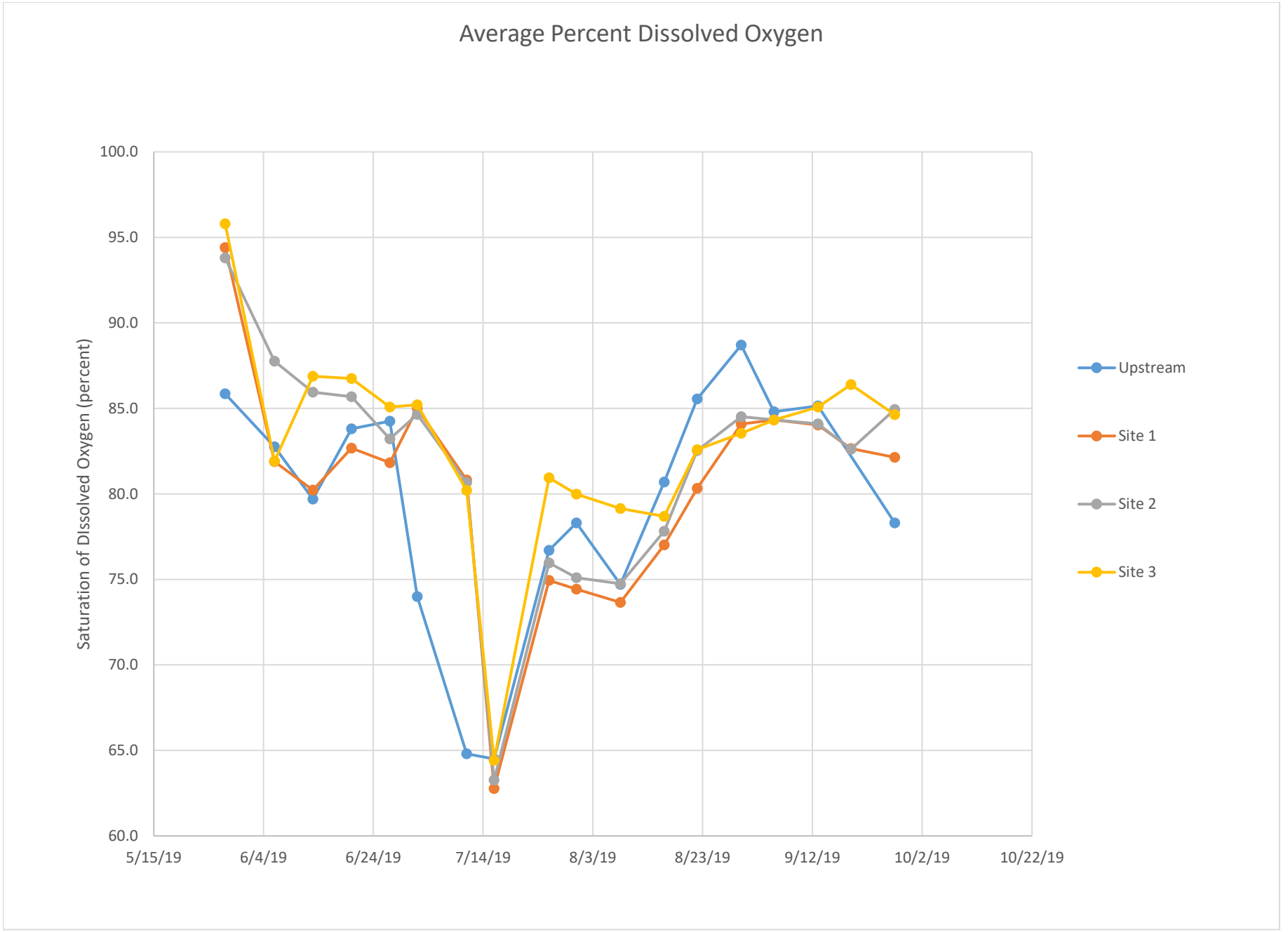
8/30/19
9/5/19
9/13/19
9/19/19
9/27/19

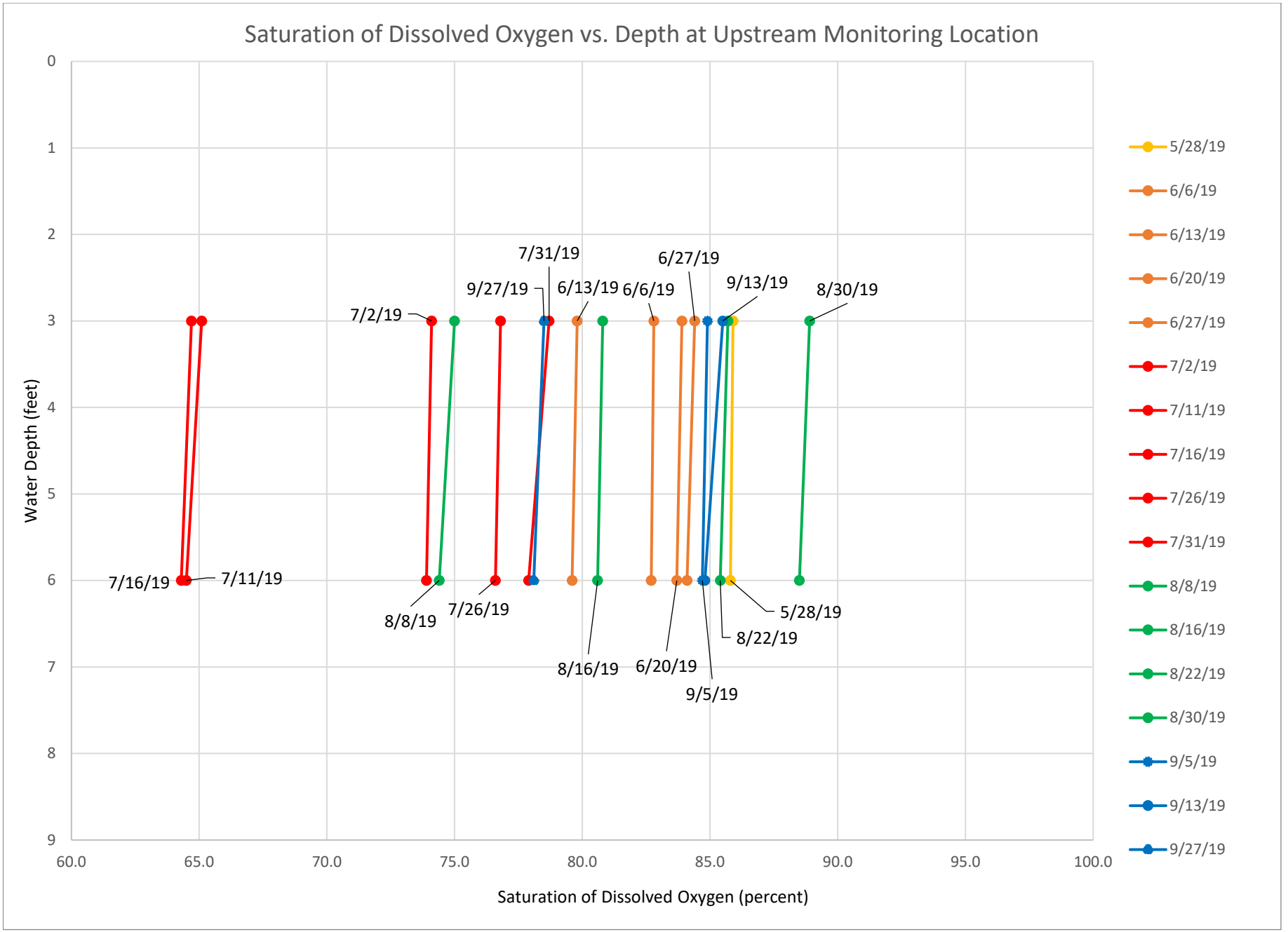

Percent Dissolved Oxygen at Upstream Monitoring Location
Saturation of DIssolved Oxygen (percent)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
Upstream Average
Upstream Max
Upstream Min


Percent Dissolved Oxygen at Site 1 Monitoring Location
Saturation of DIssolved Oxygen (percent)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 1 Average
Site 1 Max
Site 1 Min


Percent Dissolved Oxygen at Site 2 Monitoring Location
Saturation of DIssolved Oxygen (percent)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 2 Average
Site 2 Max
Site 2 Min


Percent Dissolved Oxygen at Site 3 Monitoring Location
Saturation of DIssolved Oxygen (percent)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Site 3 Average
Site 3 Max
Site 3 Min


Average Percent Dissolved Oxygen
Saturation of DIssolved Oxygen (percent)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
5/15/19
6/4/19
6/24/19
7/14/19
8/3/19
8/23/19
9/12/19
10/2/19
10/22/19
Upstream
Site 1
Site 2
Site 3


Saturation of Dissolved Oxygen vs. Depth at Upstream Monitoring Location
Water Depth (feet)
0
1
2
3
4
5
6
7
8
9
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
Saturation of Dissolved Oxygen (percent)
7/16/19
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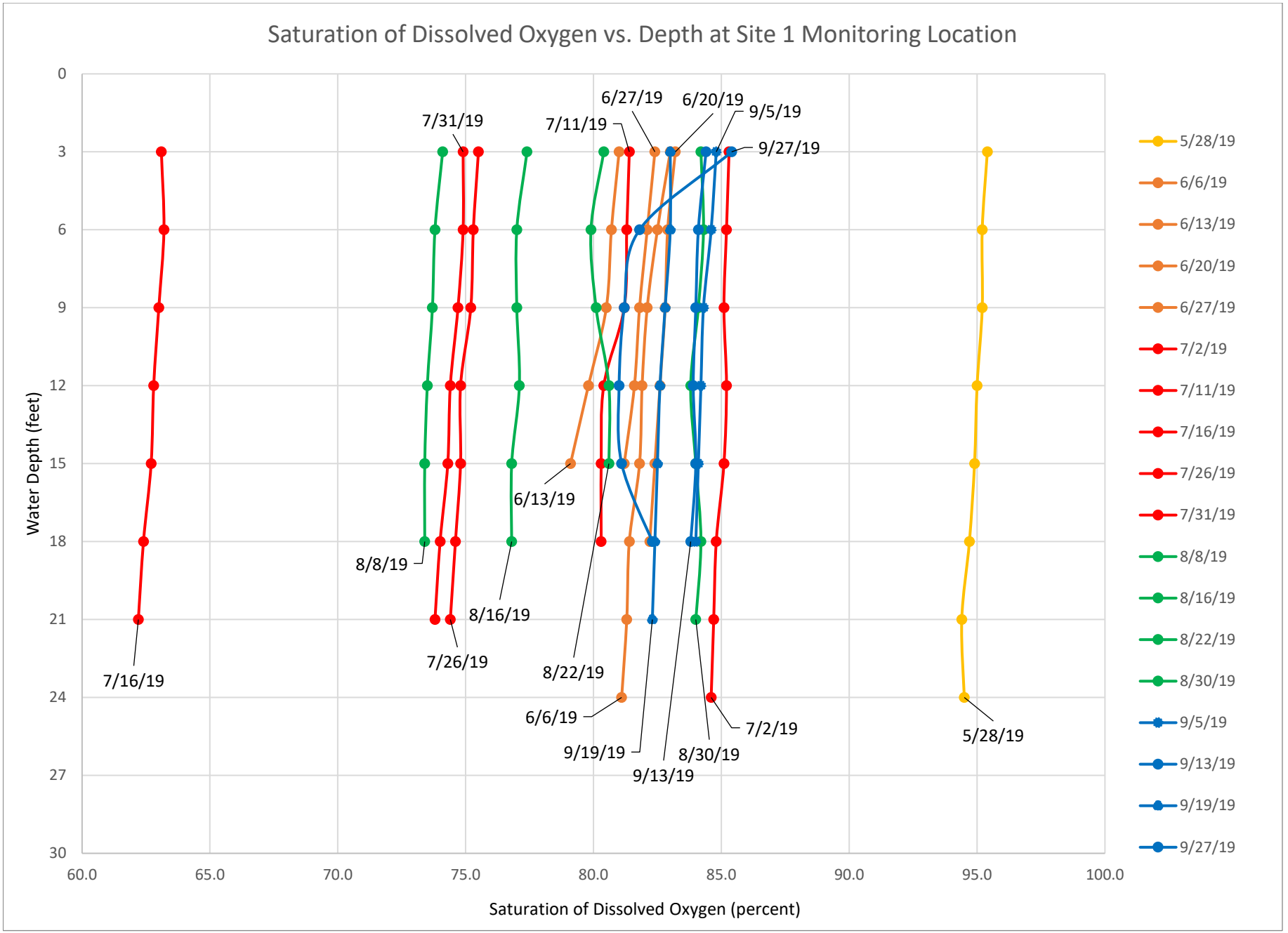
Saturation of Dissolved Oxygen vs. Depth at Site 1 Monitoring Location
Water Depth (feet)
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Saturation of Dissolved Oxygen (percent)
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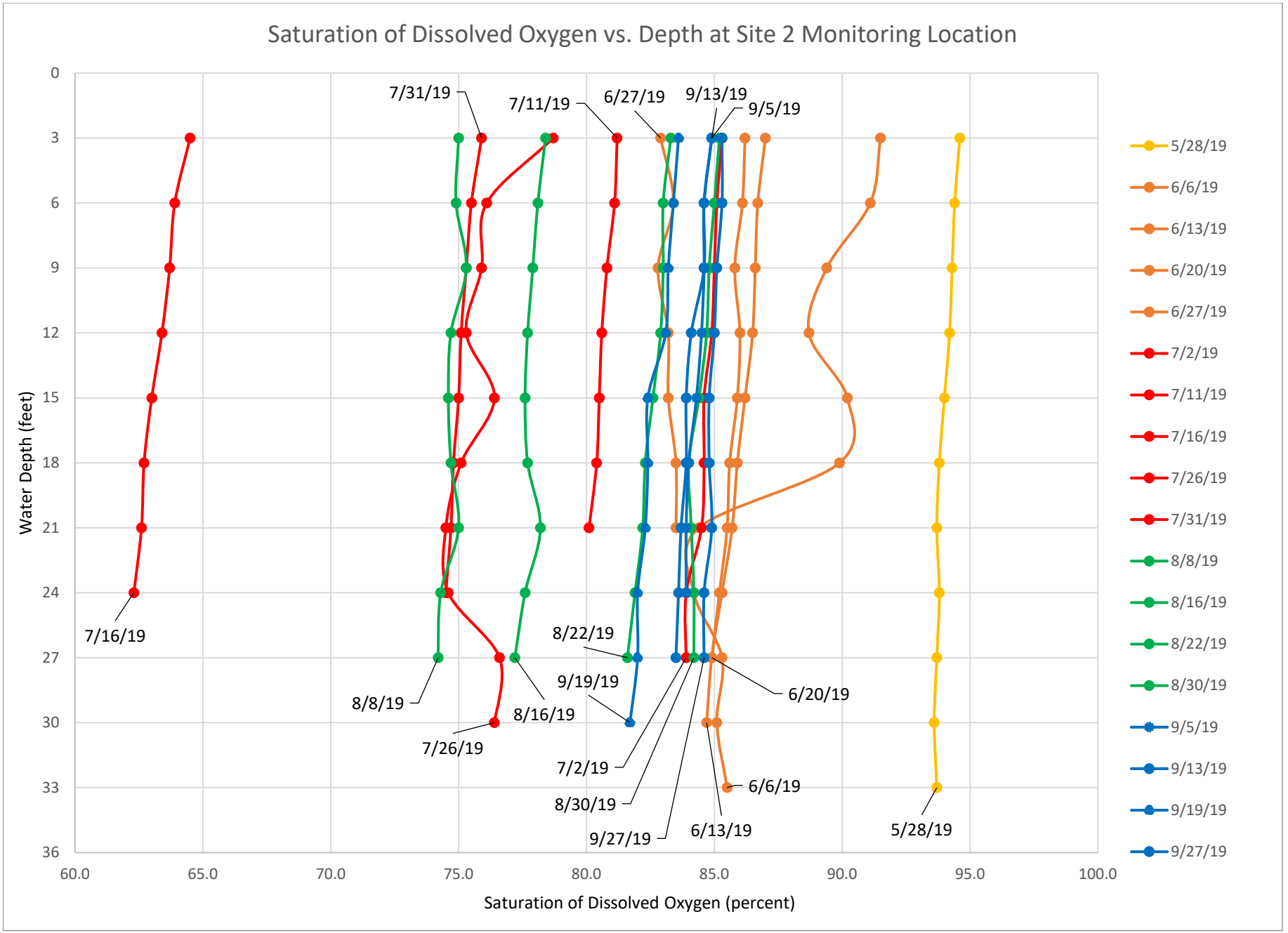
Saturation of Dissolved Oxygen vs. Depth at Site 2 Monitoring Location
Water Depth (feet)
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Saturation of Dissolved Oxygen (percent)
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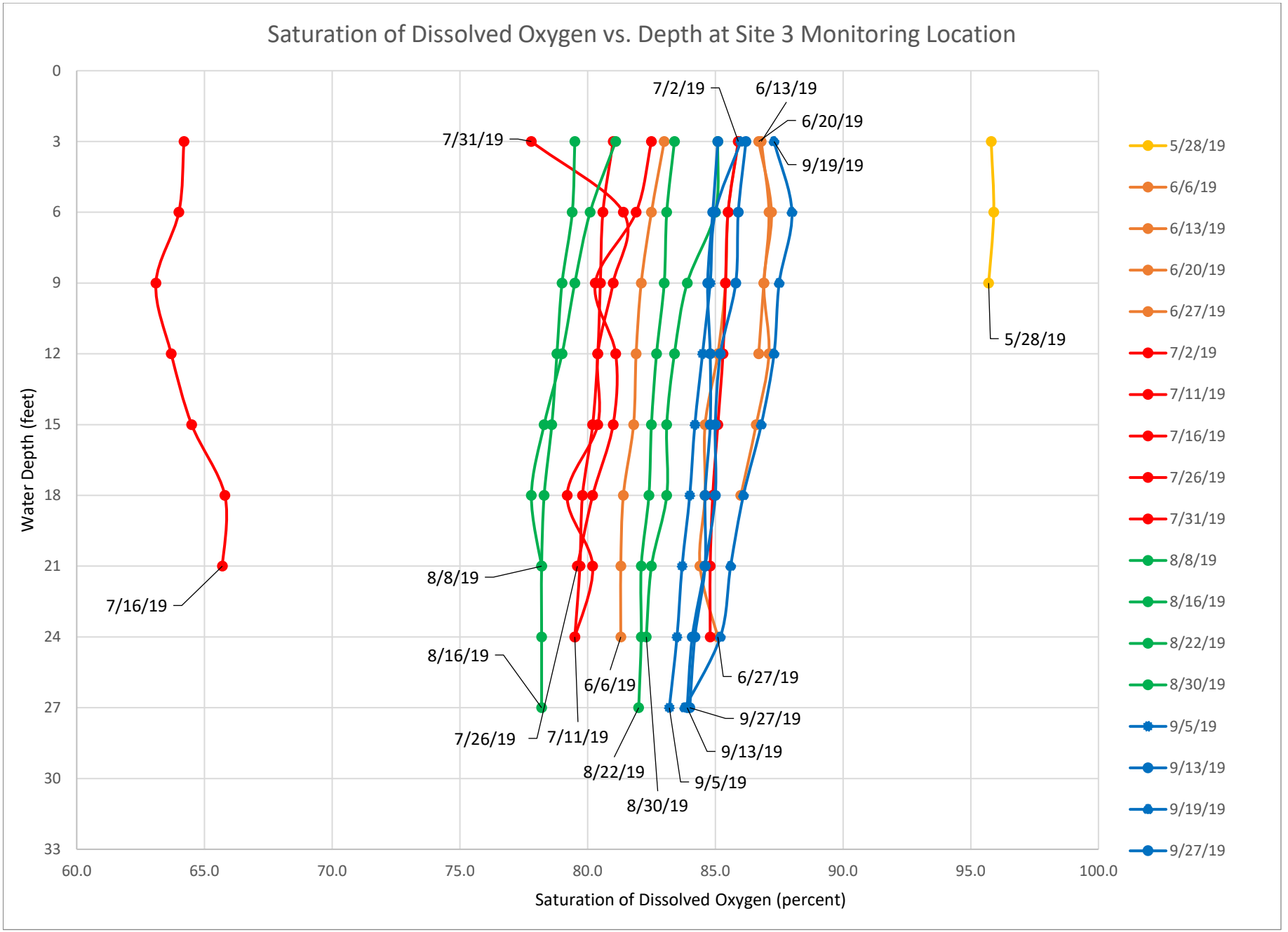
Saturation of Dissolved Oxygen vs. Depth at Site 3 Monitoring Location
Water Depth (feet)
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Saturation of Dissolved Oxygen (percent)
7/2/19
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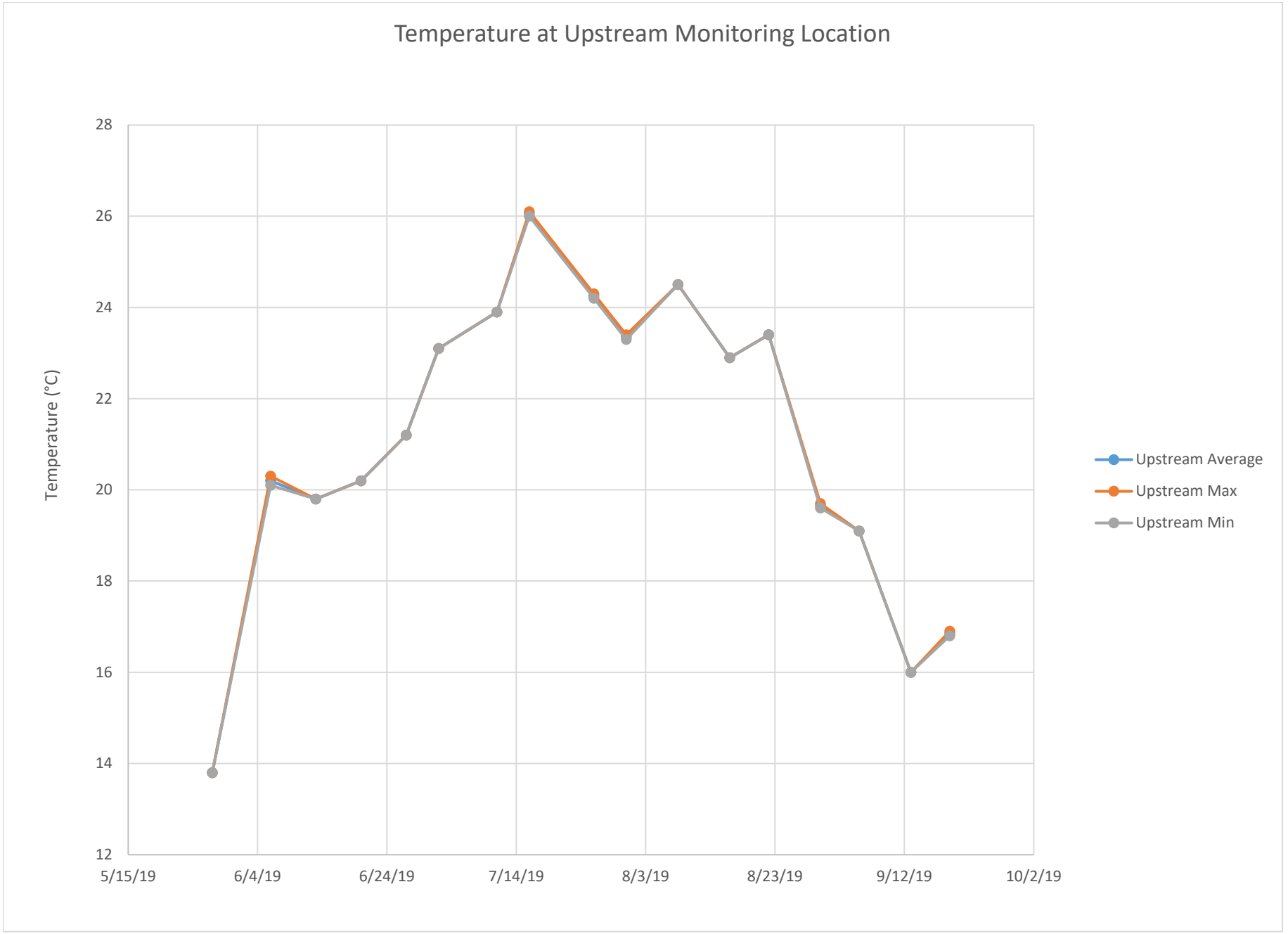
Temperature at Upstream Monitoring Location
Temperature (°C)
28
26
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22
20
18
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12
5/15/19
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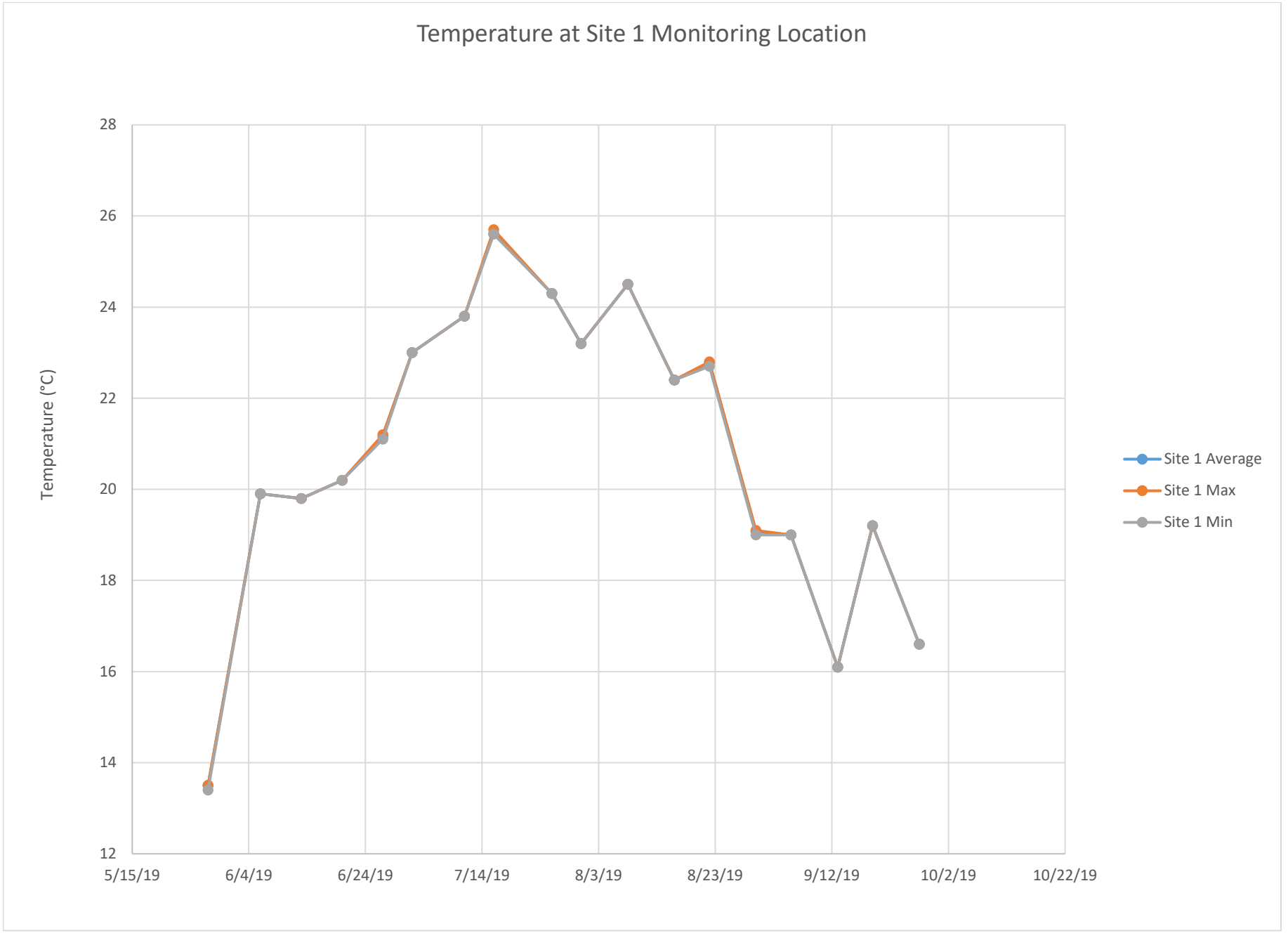
9/12/19
10/2/19
Upstream Average
Upstream Max
Upstream Min


Temperature at Site 1 Monitoring Location
Temperature (°C)
28
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22
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18
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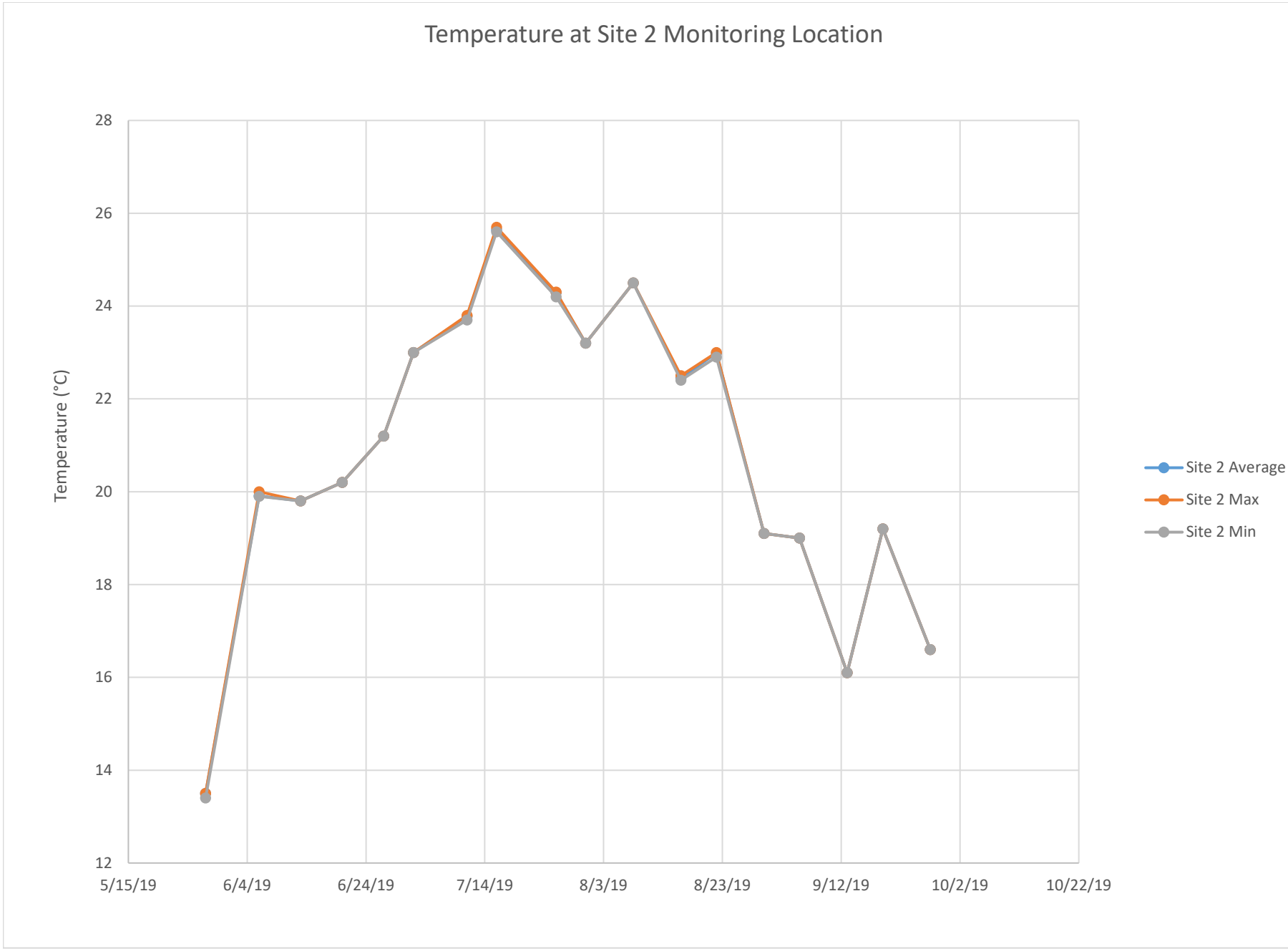
10/22/19
Site 1 Average
Site 1 Max
Site 1 Min


Temperature at Site 2 Monitoring Location
Temperature (°C)
28
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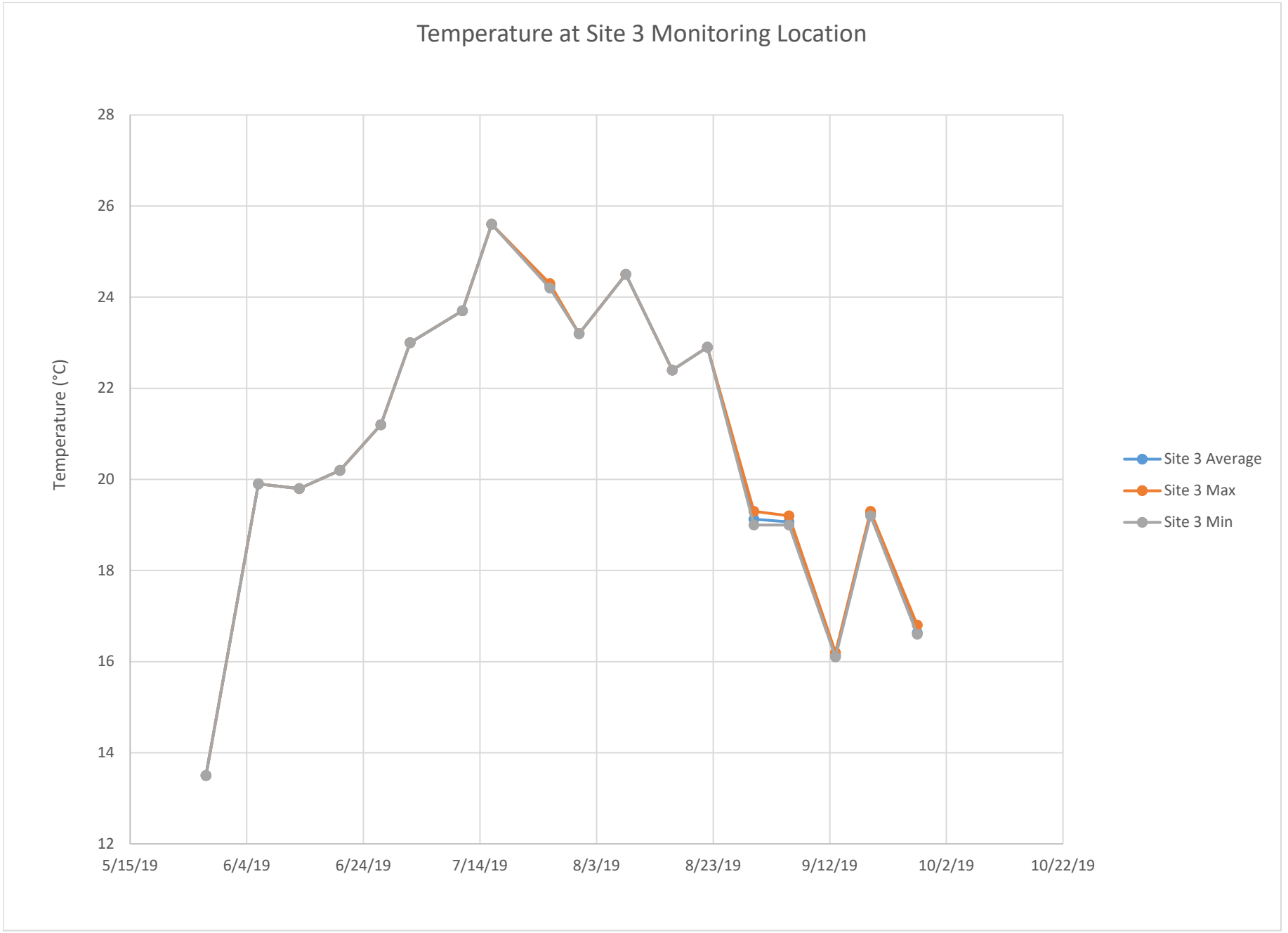
10/2/19
10/22/19
Site 2 Average
Site 2 Max
Site 2 Min


Temperature at Site 3 Monitoring Location
Temperature (°C)
28
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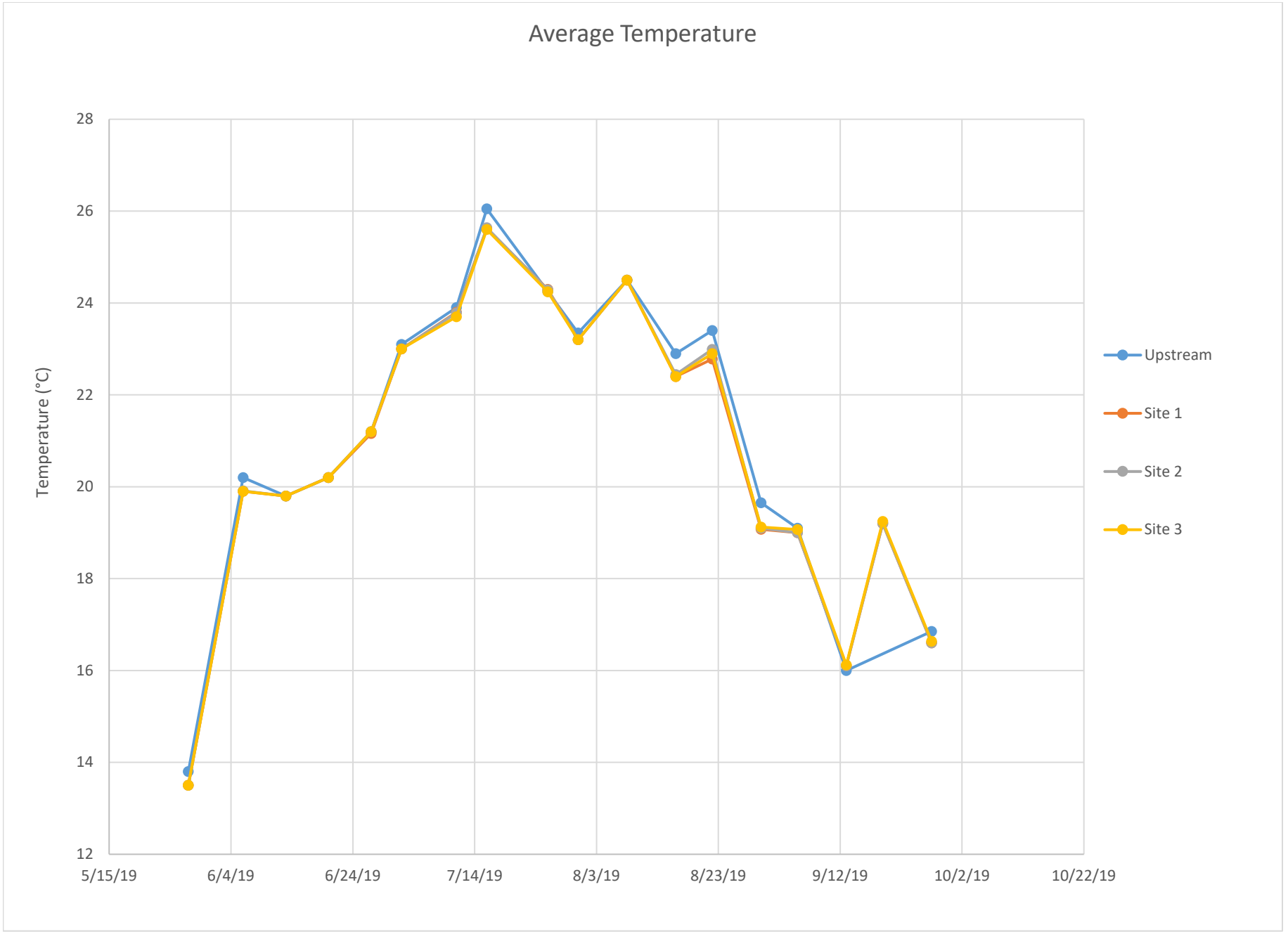
10/2/19
10/22/19
Site 3 Average
Site 3 Max
Site 3 Min


Average Temperature
Temperature (°C)
28
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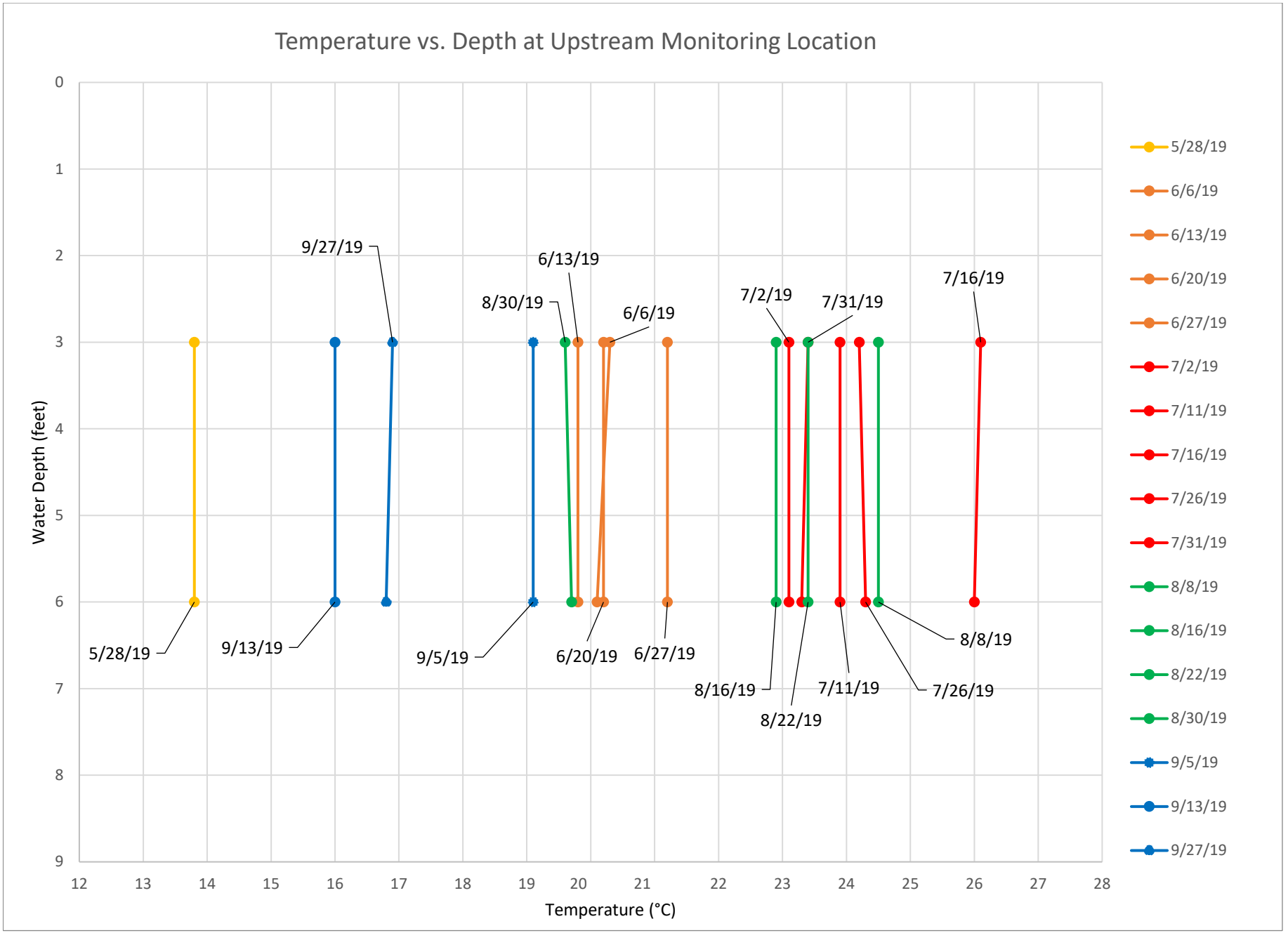
10/22/19
Upstream
Site 1
Site 2
Site 3


Temperature vs. Depth at Upstream Monitoring Location
Water Depth (feet)
Temperature (°C)
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2
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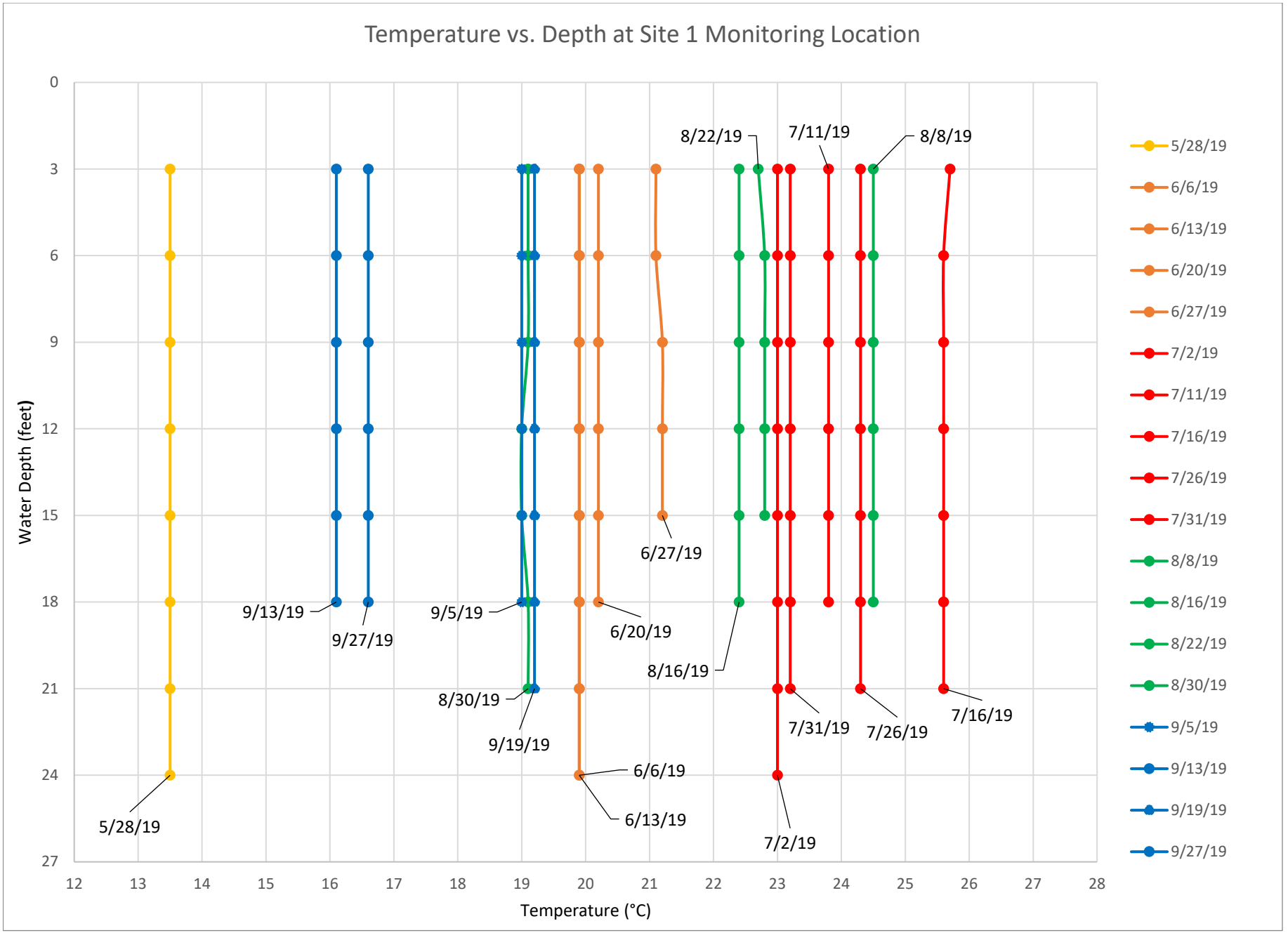
Temperature vs. Depth at Site 1 Monitoring Location
Water Depth (feet)
Temperature (°C)
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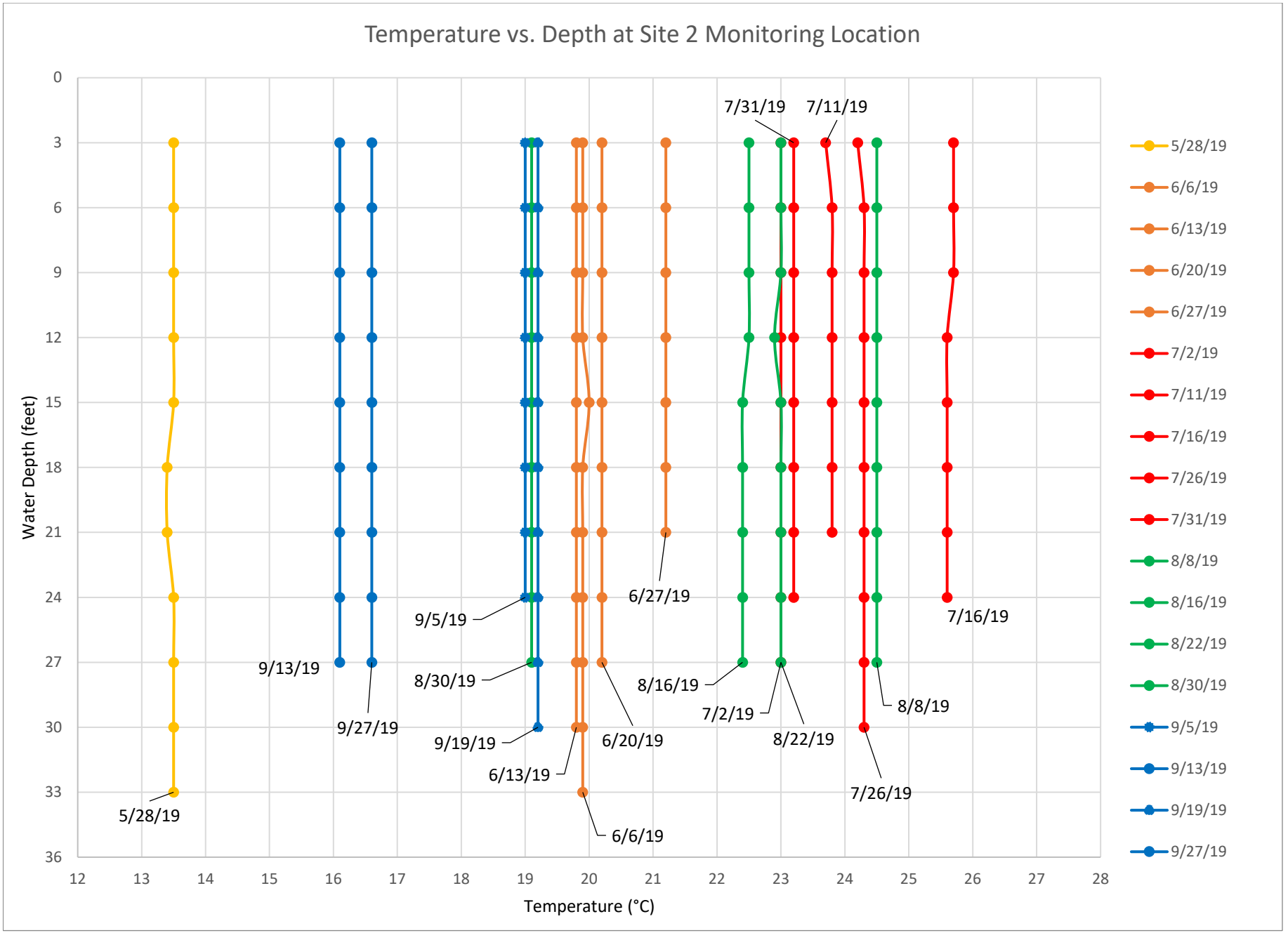
Temperature vs. Depth at Site 2 Monitoring Location
Water Depth (feet)
Temperature (°C)
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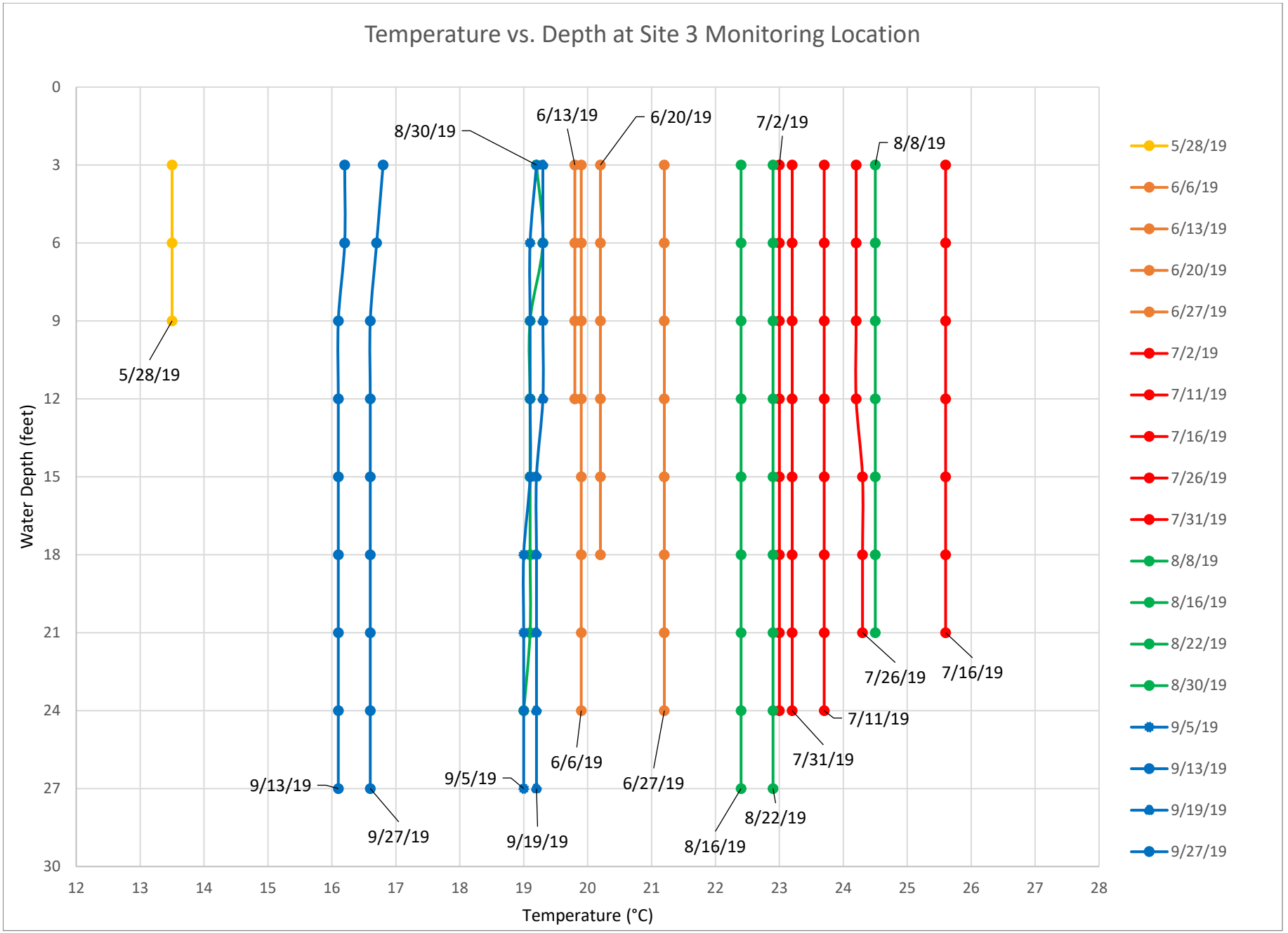
Temperature vs. Depth at Site 3 Monitoring Location
Water Depth (feet)
Temperature (°C)
0
3
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8/8/19
8/16/19
8/22/19
8/30/19
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9/27/19

Appendix D

Site Photographs

Photograph 1: Facing upstream toward BPU facility, with bascule gates visible on the left and the powerhouse visible on the right. Foam on water surface is caused by naturally-occurring tannins in the water (July 11, 2019).

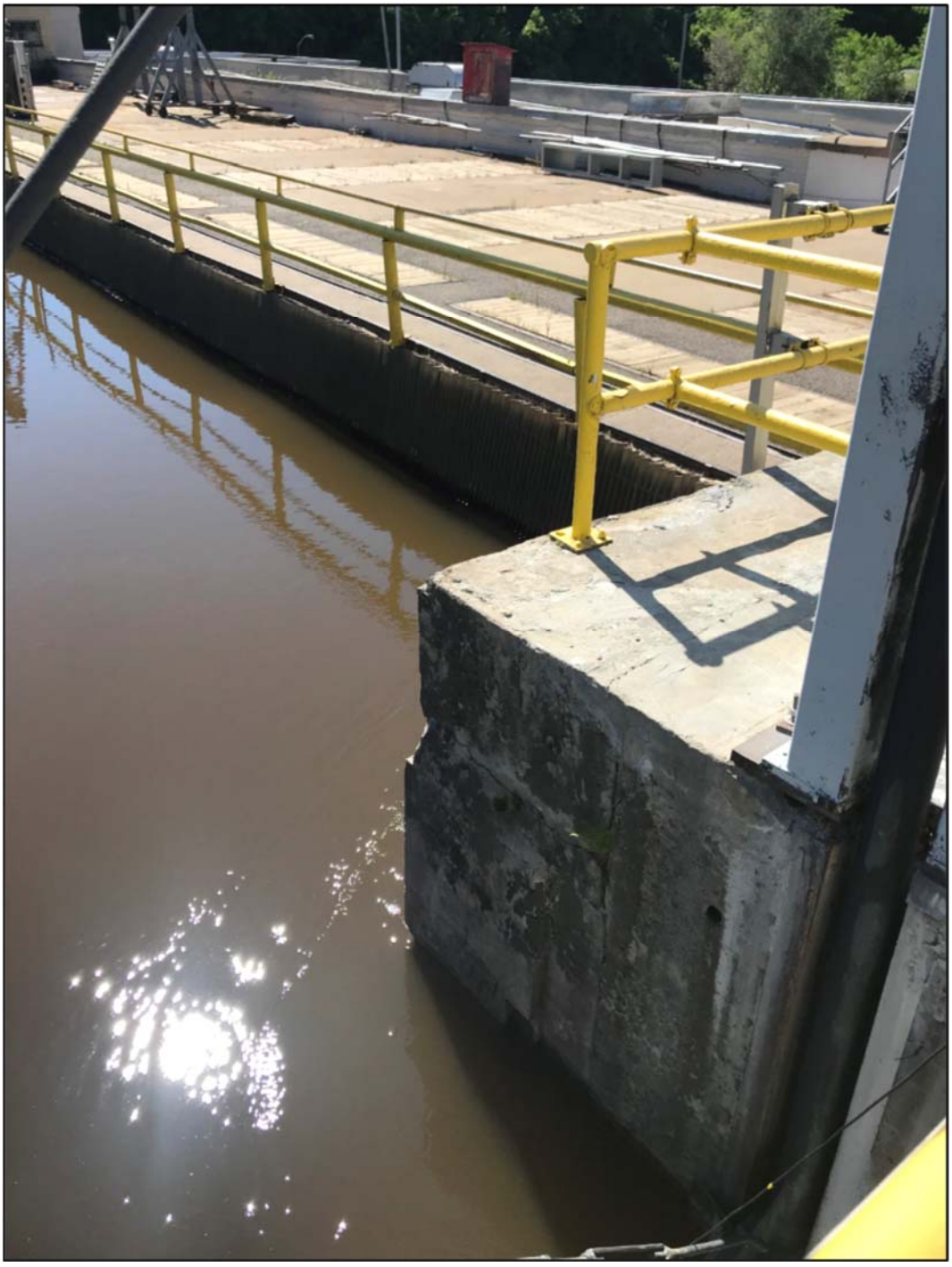
Photograph 2: Facing upstream toward BPU facility, including tainter gate (on left) and bascule gates (on right). Water is currently flowing over both bascule gates (July 16, 2019).

Photograph 3: Facing upstream toward BPU facility powerhouse at time of water sampling. Photograph taken from sampling location "Site 1" (August 8, 2019).

Photograph 4: Facing upstream (north) from west side of BPU powerhouse, towards reservoir. Photograph taken from "Upstream" sampling location (July 11, 2019).

Photograph 5: Facing downstream (south) from west side of BPU powerhouse (July 11, 2019).

Photograph 6: Facing east bank of Mississippi River, from "Site 3" downstream sampling location (June 20 11, 2019).



Photograph 7: Facing southeast from "Upstream" sampling location at intersection of powerhouse and slide gates (June 13, 2019).

Appendix B

Cultural Resources Correspondence

(Privileged and Confidential – filed under separate cover)

Appendix C

Fish Impingement and Entrainment Study

Fish Impingement and Entrainment Study

Brainerd Hydroelectric Project
FERC License No. 2533

Prepared for:
Brainerd Public Utilities
Brainerd, Minnesota

January 22, 2020

Available for Public Release

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
Phone: 952.832.2600

Fish Impingement and Entrainment Study
Brainerd Hydroelectric Project

January 22, 2020

Preface

Brainerd Public Utilities (BPU) began the renewal process for the Federal Energy Regulatory Commission (FERC) license of the Brainerd Hydroelectric Project (FERC Project No. 2533) (Project). As part of the relicensing process a fish entrainment and impingement and turbine mortality was requested by FERC. A desktop analysis of fish entrainment and impingement was conducted using data available from field studies conducted at various hydroelectric facilities across the United States. The Electric Power Research Institute (EPRI) has developed a database of hydro turbine fish entrainment and survival studies that will be a key resource in developing a proper desktop analysis for the Project.

This desktop assessment approach relies on results of published turbine entrainment and passage survival studies and site-specific project and turbine design specifications to estimate entrainment rates and fish passage survival. The potential for fish impingement on the intake trashracks was evaluated qualitatively using publicly available information about fish morphology and swimming speeds, trashrack spacing, and calculated approach velocities at intake areas. Estimates derived from this desktop study are expected to be suitable for determining general potential for levels of entrainment and impingement that may occur as a result of the Project operations; the findings should not be considered absolute quantitative results.

Impingement is the potential for fish to become trapped against the inner intake trashracks due to high velocity conditions at the powerhouse intake. Entrainment is the passage of fish into the powerhouse intakes and passed through the turbine units. Alden Research Laboratory, Inc. (Alden) conducted the work for Sections 4.44 - 4.6 and 5.2 - 5.5.

Fish Impingement and Entrainment Study
Brainerd Hydroelectric Project

January 22, 2020

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Abbreviations and Acronyms

BPU	Brainerd Public Utilities (Licensee)
CFR	Code of Federal Regulations
cfs	cubic feet per second
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
ft/s	feet per second
MNDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
Project	Brainerd Hydroelectric Project
RC%	relative percent composition
RSP	Revised Study Plan

Definitions

Project	Brainerd Hydroelectric Project, Federal Energy Regulatory Commission (FERC) No. 2533 (Project)
Project Area	The area within the Project boundary consisting of "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (1)
Project boundary	The boundary line defined in the Project license issued by the FERC that surrounds the "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (1)
Relicensing	The process of acquiring a new FERC license for an existing hydropower project under expiration of the existing FERC license

1.0 Introduction

1.1 Background

Brainerd Public Utilities (BPU) has begun renewing the Federal Energy Regulatory Commission (FERC) license of the Brainerd Hydroelectric Project FERC Project No. 2533 (Project). As part of the relicensing process, an assessment of fish entrainment and impingement and turbine mortality was requested by FERC, as defined in the Revised Study Plan (RSP) (2). A desktop analysis of entrainment and impingement was conducted using data available from field studies conducted at various hydroelectric facilities across the United States. The Electric Power Research Institute (EPRI) has developed a database of hydro turbine fish entrainment and survival studies (3) that was used as a resource in developing the desktop analysis for the Project.

1.2 Turbine Entrainment, Impingement, and Mortality

Entrainment is the passage of fish into the powerhouse intakes and through the turbine units as water is passed through the powerhouse. Impingement occurs when fish become trapped against the inner intake trashracks due to high velocity conditions at the powerhouse intake. Most entrained or impinged fish are in the early life stages (typically of lengths less than 8 inches) that are incapable of avoidance or unable to safely swim away from the intake of the turbines. Entrainment and mortality rates can vary depending on river flow, sizes of fish, seasonal differences, species of fish, fish swimming ability, and turbine design and configurations (4); FERC 1997. Mortality of fish passing through turbines can be caused by shear stress, mechanical injuries (grinding, blade strike), and pressure changes.

1.3 Fish Community

The Brainerd area provides premier fish habitat. In addition to the Mississippi River, immediately upstream of Rice Lake, an impoundment of the Mississippi River partially created by the Project, provides important fisheries habitat near the Project. As such, it contains both typical lake and riverine fish species (5).

The Minnesota Department of Natural Resources (MNDNR) surveyed the Rice Lake fishery in August 2014 and sampled 17 fish species, including black crappie, bluegill, bowfin (dogfish), brown bullhead, channel catfish, greater redhorse, hybrid sunfish, largemouth bass, northern pike, pumpkinseed, rock bass, shorthead redhorse, silver redhorse, smallmouth bass, walleye, yellow bullhead, and yellow perch (5). Although no muskellunge were sampled during the survey, there are reports of this fish species being caught in both Rice Lake and the adjoining reach of the Mississippi River, as the MNDNR stocks this species in the Mississippi River. The MNDNR also stocks walleye in this region. Smallmouth bass is the primary management species of fish in Rice Lake, while walleye, northern pike, and muskellunge are secondary management species (5).

2.0 Project Location, Facilities, and Operation

This section provides a description of the Project and operation.

2.1 Licensee

The Project is owned and operated by the city of Brainerd and it's Public Utilities Commission under a license from the FERC as Project No. 2533.

2.2 Project Location

The Project is located in Crow Wing County on the Mississippi River near the northeast side of Brainerd, Minnesota, as shown in Figure 2-1. The Project is located approximately 130 miles north of the Minneapolis – St. Paul metropolitan area.

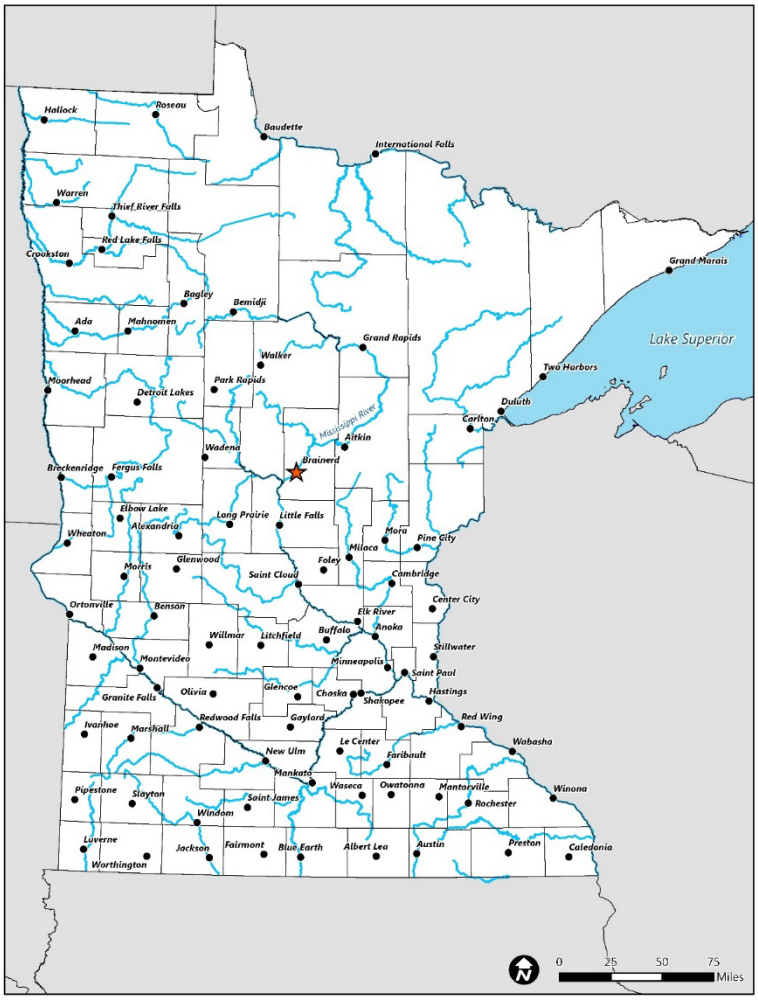

Figure 2-1 Project Location

2.3 Project Overview

From the left bank of the Mississippi River (looking downstream), the Project consists of a short left embankment, a 256-foot-long powerhouse, a 78-foot-long slide gate section, a 207-foot-long bascule (crest) gate section, a single 20-foot-wide steel tainter gate, and a 200-foot-long right embankment, as shown in Figure 2-2. The Project is located on land owned by BPU and is a run-of-river hydroelectric project with an authorized installed capacity of 3,542.5 kW.

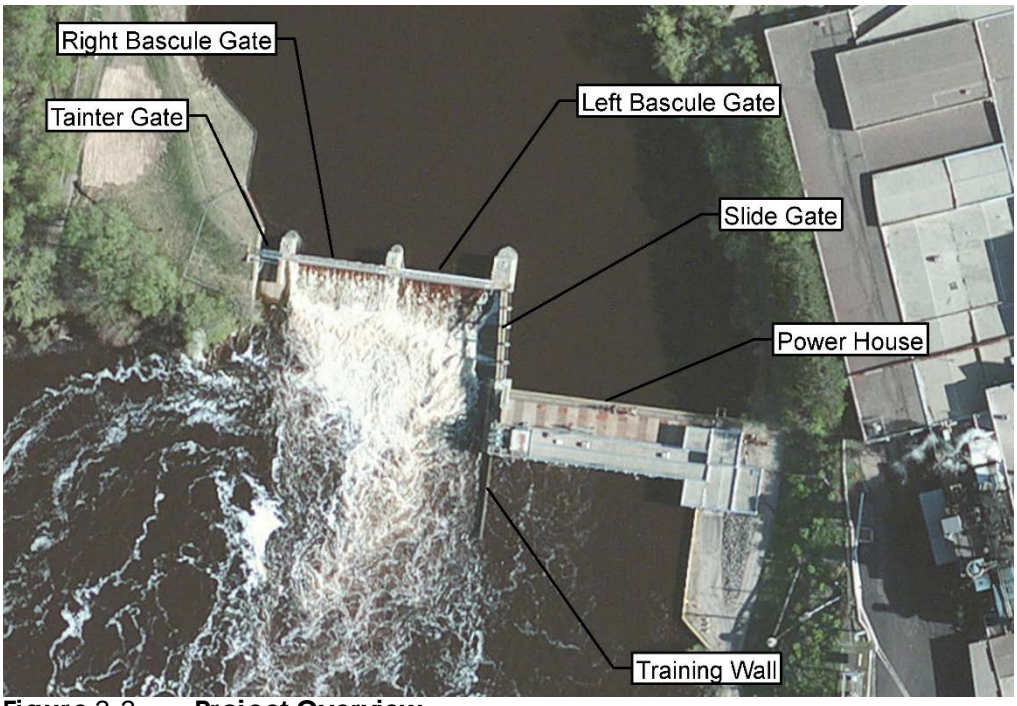

Figure 2-2 Project Overview

2.4 Study Boundary

This fish impingement and entrainment study boundary included the powerhouse and infrastructure (such as intakes, trashracks, and turbines) impacting the fish community in the upstream reservoir.

3.0 Study Goals and Objectives

3.1 Goals and Objectives

The goal of this study is to evaluate the potential for fish entrainment and impingement at the Project and its potential effects on the health of the Upper Mississippi River fishery. The objectives of this study are to:

- Describe the physical characteristics of the intake structures, including the location, dimensions, and the velocity distribution in front of each structure;
- Analyze fish species for factors that influence their vulnerability to impingement, entrainment, and turbine survival;
- Assess the potential for fish species impingement at the Project;
- Estimate entrainment rates and turbine-passage survival rates for fish species at the Project; and
- Describe the likely effects of Project-induced entrainment or impingement on fish resources, based on the physical characteristics of the Project.

3.2 Public Interest Considerations

Sections 4(e) and 10(a) of the Federal Power Act (FPA) require that FERC give equal consideration to all uses of the waterway on which a project is located. In making its license decision, FERC must equally consider the environmental, recreational, fish and wildlife, and other non-developmental values of the Project, as well as power and developmental values.

Fish populations in the Project Boundary support a sport fishery. As such, the effects that operating the Project may have on fisheries resources are relevant to FERC's public interest determination.

4.0 Methodology

4.1 Methodology Overview

The methodology for this analysis will follow standard methods and data sources previously accepted by FERC or standard methods used by fisheries management professionals for desktop evaluation of impingement, entrainment, and turbine mortality ((6), (4), (7)). Fish that are small enough to pass through the Project's trashracks will be considered susceptible to entrainment. Fish large enough to be physically excluded due to size (length, width/body depth) will be considered as potentially susceptible to impingement or entrainment because of individual species habitat use, behaviors, or swimming abilities.

Fish species and abundance information available from the MNDNR and the Minnesota Pollution Control Agency (MPCA) will be used to characterize the fisheries community composition upstream of the Project. Fish species will be grouped into family groups and size classes for evaluation. For species/family groups, where no comparable or applicable data can be found, the survival rate reported for a similar group/size class will be substituted. Fish species/groups for evaluation will be developed in conjunction with the MNDNR. Preliminary review of fisheries data indicates evaluation of walleye, smallmouth bass, largemouth bass, channel catfish, yellow perch, northern pike, bigmouth buffalo, white sucker, shorthead redhorse, and silver redhorse will be considered as potential target species/groups.

Fish entrainment data from other similar hydroelectric projects (head, turbine type, flow capacity, etc.) were selected from the databases available from the EPRI (3) to develop a project estimate using the Project-specific fish species/group assemblages. The evaluation will be sequenced with the following inputs:

1. Develop a matrix of entrainment studies that can be applied to the Project.
2. Calculate and estimate fish entrainment rates at the Project site based on available Project operation information. Estimate the maximum approach velocity at each turbine, based on the size of the intake area and the maximum hydraulic capacity at each turbine. Entrainment will be defined as the number of fish/volume of water entrained.
3. Utilize reservoir-specific species compositions in conjunction with applicable prior studies to characterize the composition of the fish community susceptible to impingement or entrainment.
4. Apply physical, biological, or reservoir factor filters that may impact susceptibility to impingement or entrainment at the Project.
5. Estimate turbine mortality rates of entrained fish using a blade strike probability and mortality model (8), (9), (10).
6. Estimate impingement potential for fish too large to pass through intake trashrack bar spacing.
7. Report estimates of entrainment and mortality on a monthly fish group/size and fish per volume of water passed through the Project turbines. Estimated monthly entrainment rates will be

reported based on the relative abundance of species according to existing fisheries data from the MNDNR.

4.2 Factors Affecting Impingement, Entrainment, and Survival

Site factors affecting impingement, entrainment, and survival include the layout and operating system of the turbines and dam. The turbines operate at different hydraulic capacities and therefore have differing intake velocities. This will impact cross-sectional velocities approaching the intake trashracks. These velocities were used to determine the likelihood of how various fish species become impinged and entrained. Turbine survival (i.e., blade strike probability and mortality) is determined by fish length, runner diameter and rotational speed, number of blades, and inflow angle and velocity. Table 4-1 includes design and operation specifications for the Project's two turbine designs.

Table 4-1 Summary of Turbine Design and Operation Parameters for the Project.

Design Parameter	Units 1 & 2	Units 3 - 5
Turbine Type	Francis (horizontal)	Francis (horizontal)
Flow Capacity (cfs)	665	493
Rotational Speed (rpm)	128.5	128.5
Blade Tip Speed (ft/s)	25.2	31.2
Number of Blades	16	16
Blade Spacing (ft)	0.7	0.5
Leading Edge Blade Thickness (in)	0.4	0.4
Runner Diameter (ft)	3.75	2.71
Hub Diameter (ft)	3.5	2.5
Radial/Axial Flow Velocity (ft/s)	11.7	14.2
Absolute Flow Velocity (ft/s)	15.7	20.9
Relative Velocity of Flow to Blade (ft/s)	18.76	21.23

4.3 Intake Velocities and Trashrack Exclusion

Project intake cross-sectional velocities were calculated based on the wetted surface areas of the intake trashracks at the powerhouse for each turbine. The powerhouse is a 256-foot long structure with flume intakes measuring approximately 16.0 – 17.5 feet wide. The distance from normal water elevation to the concrete sill at the trashrack is approximately 16 feet. Trashracks are located in front of the intakes to minimize fish entrainment. Trashracks consist of 3 inch by ¼ inch bars spaced at 2 inches on center. Intake velocity was calculated as the product of the width and height of the trashracks. This was then used to calculate the maximum flow through the intake trashracks based upon the total maximum hydraulic capacity of each of the turbines. The final trashrack cross-sectional velocity was calculated by taking the total hydraulic capacity and dividing by the total wetted area of the trashracks (Table 4-2).

Trashrack exclusion assessment includes estimating fish lengths for the target fish species that would be excluded or impinged by the 1.75-inch trashrack clear spacing. These species would have swim burst speeds that could withstand intake velocities and avoid entrainment.

Table 4-2 Project Turbine Cross-Sectional Velocities and Trashrack Clear Spacing

Unit Number	Maximum Hydraulic Capacity (cfs)	Trashrack Surface Area (ft^2)	Cross Sectional Velocity at Maximum Hydraulic Capacity (ft/sec)	Trashrack Clear Spacing (in)
1 (Francis)	665	280	2.38	1.75
2 (Francis)	665	280	2.38	1.75
3 (Francis)	493	256	1.93	1.75
4 (Francis)	493	256	1.93	1.75
5 (Francis)	493	256	1.93	1.75

4.4 Impingement Assessment Methods

The risk of impingement is assessed by determining the size at which fish are physically excluded by the trashrack bar spacing and by comparing species and life stage swimming speeds to intake approach flow velocities. Proportional body measurements from Smith (11) were used to determine the ratio of body width to total length for each species, which was then used to estimate the length at which a particular species would be physically excluded by the 1.75 inch (44 mm) clear bar spacing of the trashrack. The maximum total length identified for each species from the literature (12) was then compared to the estimated length of exclusion to determine if a species may have individuals that could be susceptible to impingement (i.e., reach a length at which physical exclusion would occur). Critical swim speeds for fish large enough to be physically excluded from entrainment were compiled from the available scientific literature and used to determine if impingement could potentially occur.

4.5 Entrainment Assessment Methods

Entrainment rates were calculated using data from field studies that were compiled into a turbine entrainment database by EPRI (3). The information in the applicable studies provided by the EPRI were assembled and screened based on entrainment data that could potentially be used for this study. Studies were selected from the screened projects that were the most similar and applicable to the Project. Criteria used in this selection included:

- Trashrack clear spacing of 1.75 – 2.40 inches
- Impoundment volume of 620 – 6400 acre-ft
- Similar station general flow capacities (1288 – 2400 cfs)
- Similar station operation (run of river, peaking, etc.)

- Biological similarities to the fish species, assemblages, and water quality

Nine sites in the EPRI database were identified as having generating-flow capacities, trashrack spacing, and impoundment volume, similar to those of the Project. Enough data was reported for six of the sites to calculate monthly and annual entrainment numbers at the Project by species and size (<200 mm and 200 to 380 mm in length) (Table 4-3). A 380-mm fish length was selected as a conservative estimate of the size at which fish will no longer fit through the 1.75-inch bar spacing of the intake trashracks.

The entrainment data (reported as fish entrained per million cubic feet of generation flow) from the selected sites were averaged by month for each species and size group. The average monthly entrainment rates were multiplied by the estimated average monthly generation flow (million cubic feet) at the Project to estimate the number of fish entrained monthly and annually (i.e., sum of monthly estimates).

Table 4-3 Site Characteristics for the Project and Other Similar Projects in the EPRI Entrainment Database

Site Name	Reservoir Area (acres)	Reservoir Volume (acre-ft)	Total Plant Capacity (cfs)	Operating Mode	Trashrack Spacing (in)
BPU Project	2500	13000	2800	ROR	1.75
Caldron Falls	1180	NR	1300	Peak	2.00
Colton	195	620	1503	Peak	2.00
Johnsonville	450	6430	1288	Peak	2.00
Potato Rapids	288	NR	1380	ROR	1.75
Sandstone Rapids	150	NR	1300	Peak	1.75
Schaghticoke	164	1150	1640	ROR	2.13

Note(s): NR indicates data were not reported for a given site and parameter.
ROR = Run of River

4.5.1 Fish Species Composition

Fish collection data from the MNDNR Fish Mapping Application (13) were used to compile a list of species and relative percent composition (RC %) occurring in the upper portion of the mainstem Mississippi River (Table 4-4). Common shiner (14.1 percent), yellow perch (13.5 percent), bluegill (12.0 percent), and spotfin shiner (10.1 percent) represent the largest percentage of species collected in the Upper Mississippi River.

The RC % values were calculated based on catches of species at sampling sites from Grand Rapids hydroelectric plant to the Project, including sampling from Rice Lake from 1999 to present. This list of species provides a comprehensive assessment of the fish community impacted and species potentially vulnerable for entrainment.

Table 4-4 Fish Species of the Upper Mainstem Mississippi River from the Project to Grand Rapids Dam including Rice Lake

Common Name	N[1]	RC %
Common shiner	528	14.10%
Yellow perch	504	13.46%
Bluegill	448	11.97%
Spotfin shiner	379	10.12%
Shorthead redhorse	314	8.34%
Black crappie	254	6.79%
Northern pike	148	3.95%
White sucker	141	3.77%
Johnny darter	126	3.37%
Walleye	99	2.65%
Silver redhorse	96	2.56%
Smallmouth bass	92	2.46%
Pumpkinseed	85	2.27%
Logperch	69	1.85%
Trout-perch	69	1.85%
Mimic shiner	67	1.79%
Rock bass	66	1.76%
Central mudminnow	57	1.52%
Largemouth bass	41	1.10%
Yellow bullhead	35	0.93%
Finescale dace	21	0.56%
Channel catfish	13	0.35%
Fathead minnow	12	0.32%
Brook stickleback	12	0.32%
Greater redhorse	9	0.24%
Blacknose shiner	8	0.21%
Muskellunge	7	0.19%
Brook silverside	7	0.19%
Bowfin (dogfish)	7	0.19%
Hybrid sunfish	7	0.19%

Common Name	N[1]	RC %
Hornyhead chub	4	0.12%
Brown bullhead	3	0.08%
Golden shiner	3	0.08%
Burbot (eelpout)	3	0.08%
Longnose dace	2	0.05%
Brassy minnow	2	0.05%
Golden redhorse	2	0.05%
Blackchin shiner	1	0.03%
Bigmouth buffalo	1	0.03%
Bluntnose minnow	1	0.03%
Spottail shiner	1	0.03%
Total	**3,744**	**100%**

N[1]: Numbers (N) represent those collected in the sub-reach from Project upstream to the Grand Rapids Dam and within Rice Lake, of which the associated RC% was used to represent the community composition of this reach that is susceptible to entrainment at the Project.

4.6 Turbine Survival Assessment Methods

Turbine survival for all target species was estimated using a theoretical blade strike probability and mortality model similar to the methods reported by Franke et al. (8)). The theoretical blade strike model provides an estimate of blade strike probability based on fish length and turbine design parameters that influence the likelihood of strike for a fish approaching a turbine runner and passing between two blades. For fish struck by a blade, probability of strike mortality is estimated using laboratory data from blade strike studies conducted with rainbow trout and multiple fish lengths, blade leading edge thicknesses, and strike velocities (14), (15). Predictive blade strike survival models are considered appropriate means for estimating turbine survival at low head projects (<100 ft) because other injury mechanisms (e.g., damaging pressure regimes, shear, and turbulence) are considered to be inconsequential or expected to produce very low injury and mortality rates (8). Alden has used the theoretical model to estimate turbine survival of Shortnose Sturgeon entrained through the units at the Hadley Falls Station (16), for Atlantic Salmon and kelts entrained at 15 projects in the Maine Penobscot River basin (17), for shad and herring at projects in Rhode Island and Connecticut, and for riverine fishes passing through turbines in the Holyoke Canal System (18), at three projects in Vermont (19) (20) , and at a small project in Minnesota (21) (17). The results of these evaluations have been accepted by state and federal resource agencies and by FERC.

The probability that a fish will be struck by a turbine blade is a function of the distance over which blade leading edges move compared to the total distance between two consecutive leading edges in the time it takes a fish to be carried or swim past the arc of leading edge motion (Figure 4-1). Consequently, the probability of strike is identified in Equation 1 (9) (10):

$$P_S = \frac{nNL\cos\theta}{60V_{ax}} \qquad \textbf{Equation 1}$$

Where:

P_S = probability of strike (non-dimensional)
n = runner rpm
N = number of leading edges (blades)
L = fish length
θ = angle between absolute and axial velocity vectors (degrees)
V_{ax} = axial velocity

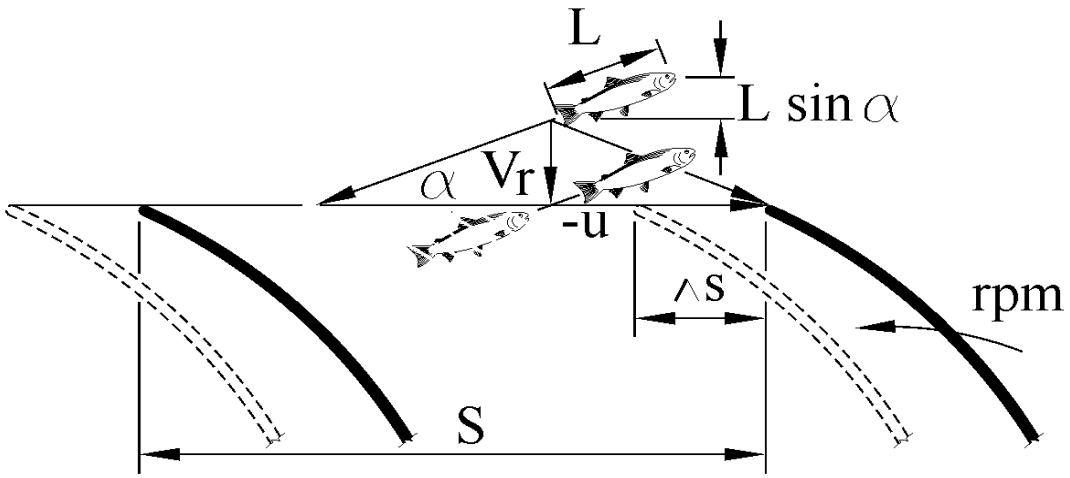

Figure 4-1 Schematic of Absolute Inflow, Axial Velocity, and Relative Velocity of Flow (and Fish) to a Blade Leading Edge. A Vertical Section of a Propeller Type Unit is depicted. The Parameter ∆s is the Incremental Blade Motion in the Time Fish Move through the Leading-Edge Circumference.

The strike probability model assumes that fish orient along the absolute inflow direction. Note that $\cos\theta = \sin\alpha$, where α is the angle between the absolute inflow velocity and a tangent line to the runner circumference. The parameter $L\cos\theta$ (or $L\sin\alpha$) is the projected fish length in the axial direction. The flow angle for axial-flow turbines is defined as the angle between the absolute velocity and tangential velocity, α.

The relative water-to-blade velocity (Equation 2) (i.e., strike velocity, assuming fish travel at the same speed as the approaching flow) is used with fish length-to-blade thickness ratios (L/t) to determine the strike mortality coefficient, K, based on data from blade strike tests conducted with rainbow trout (14) (15). Since K represents the probability that fish struck by a turbine blade will be killed, P_S (blade strike probability) is multiplied by K to estimate turbine passage survival (S_T):

$$S_T = 1 - (K)(P_S) \qquad \textbf{Equation 2}$$

Other sources of injury and mortality associated with turbine passage (e.g., damaging pressure changes, shear, and turbulence) are not expected to impact fish passing through the Project turbines due to the

relatively low head of the project. Design and operation parameters for the Project turbines used in the calculations of blade strike probability and mortality are provided in Table 4-1.

5.0 Results and Discussion

The assessments of impingement and entrainment at the Project were conducted for fish species that comprise at least one percent of the species composition of the upstream populations based on available sampling data.

5.1 Factors Affecting Impingement, Entrainment, and Survival

Susceptibility to entrainment or impingement may be influenced by a number of factors and their representation at the Project (Table 5-1). Habitat conditions upstream of the intakes may influence the sizes, species, and type of fish susceptible to impingement and entrainment. Because of this, species such as Black Crappie may be more susceptible to entrainment if there is a shallow littoral zone near the intakes or if the shoreline provides an area for spawning because juveniles often group in schools and are at lengths less than 200 mm. Similarly, White Sucker juveniles <200mm may frequent shoreline areas and be subject to entrainment. Benthic species may have higher potential for entrainment due to common foraging habits that could lead them to the vicinity of the Project's intakes.

Table 5-1 Factors Influencing Fish Entrainment and Survival

Factor		Influence on Entrainment/Turbine Mortality[1]	Representation at the Project
Entrainment	Intake adjacent to shoreline	Near shore intakes may potentially entrain higher numbers of fish than offshore intakes due to tendency of fish to follow shorelines or orient to physical structures in shorelines.	Yes
	Intake location in littoral zone	The littoral zone (generally from the shoreline to extent of aquatic vegetation or approximately 10 ft deep) is the most productive region of a reservoir and is where most species spawn and rear their young.	No
	Abundant littoral zone fishes	Centrarchids and other reservoir species such as catfish that spend most of their lives in near shore habitats tend to be the most abundant species in an assemblage.	Yes
	Abundant clupeids	Entrainment rates may potentially be higher at projects where clupeids such as gizzard shad, threadfin shad, and alewife are relatively abundant.	No
	Obligatory migrants	Obligatory migrants are those species that must migrate within and between freshwater systems to fulfill certain life cycles. Depending on time of year, turbine flow can represent the majority of river flow cues while migrating downstream.	No
	Intake depth (ft at full pond)	Fish are usually more abundant in shallower portions of a reservoir year-round.	16
	Winter drawdown	Drawdowns may put fish in proximity to intakes.	No
	Normal hydraulic capacity (cfs)	Values used with respect to entrainment rate.	2,800
	Avg approach velocity (ft/s)	Approach velocities may correlate with intake rates, although siting may be more important. Velocities greater than fish burst swim speeds suggest potential inability to escape entrainment or impingement.	1.93 & 2.38

Factor		Influence on Entrainment/Turbine Mortality[1]	Representation at the Project
	Water quality	Poor water quality (e.g., stratification and low dissolved oxygen in the hypolimnion) may reduce fish susceptibility to entrainment	No
	Additional downstream passage routes	Sluiceways, spillways, or other bypass structures may reduce turbine entrainment by providing an alternate route of downstream passage.	Yes
Survival	Turbine type	The size of water passage spaces relative to fish size may increase the probability of contact with structural elements. Francis runners have more closely spaced bucket/blades than Kaplan/propeller-type units.	Francis - horizontal
	High speed (rpm)	Higher turbine speeds potentially increase the likelihood of fish contact with structural elements.	No
	Avg survival rates of small fish (<200 mm)	More than 90% of fishes entrained at hydro projects are small. High survival rates reduce the overall impact to fish populations.	87%
	Pressurized intake tunnel	High hydrostatic pressure in a penstock at high head sites may be suddenly released as fish acclimated to a higher pressure pass from pressurized areas of deep water to tailwaters at normal hydrostatic pressure. The sudden relief from high pressure increases the potential risk to fish of decompression trauma.	No

(1) From (6), (3), and (22)

5.2 Impingement Assessment

Physical exclusion is expected to occur for some larger fish of all species except common shiner, mimic shiner, spotfin shiner, johnny darter, logperch, trout-perch, and central mudminnow (Table 5-2). The estimated average approach velocity at the Project ranged from 1.93 to 2.38 feet per second (ft/s). Mean critical swim speeds ranged from 0.6 to 11.8 ft/s for all species assessed (Table 5-3). However, burst speeds of fish that are too large to pass through the bar spacing at the Project intake will be considerably higher than the critical swim speeds. Consequently, impingement on the trashrack is not expected to occur for any of the target species that reach a length at which they would be too large to pass through the 1.75-inch clear bar spacing.

Table 5-2 Total Length (TL) Information for Fish Species Upstream of the Project

Family	Species	Body Width/TL Ratio	Average TL (mm)	TL at 44-mm Body Width	Max TL (mm)	Physical Exclusion at Max TL[1]
Catostomidae	Shorthead Redhorse	0.13	408	211	750	Yes
	Silver Redhorse	0.13	325	205	740	Yes
	White Sucker	0.15	407	301	650	Yes
Centrarchidae	Black Crappie	0.10	275	443	490	Yes
	Bluegill	0.13	190	332	410	Yes
	Largemouth Bass	0.13	400	329	970	Yes
	Pumpkinseed	0.12	100	355	400	Yes
	Rock Bass	0.16	154	283	430	Yes
	Smallmouth Bass	0.13	80	340	690	Yes
Cyprinidae	Common Shiner	0.11	83	411	180	No
	Mimic Shiner	0.10	57	435	80	No
	Spotfin Shiner	0.11	70	390	110	No
Escodiae	Northern Pike	0.08	400	567	1370	Yes
Percidae	Johnny Darter	0.12	39	372	72	No
	Logperch	0.10	125	421	180	No
	Walleye	0.12	540	353	1070	Yes
	Yellow Perch	0.11	191	385	1220	Yes
Percopsidae	Trout-Perch	0.14	88	324	200	No
Umbridae	Central Mudminnow	0.14	81	306	140	No

(1) Determination of whether physical exclusion from passing through the 1.75-inch clear spacing at the intake would occur based on body width at maximum total length

Table 5-3 Swim Speeds Reported in the Literature for Selected Target Species that Occur Upstream of the Project

Common Name	Scientific Name	Mean Length or Range (mm)	Mean Length Critical Swim Speed (ft/s)	Min Length (mm)	Min Length Critical Swim Speed (ft/s)	Max Length (mm)	Max Length Critical Swim Speed (ft/s)	Length for Burst Swim Speed (mm)	Burst Swim Speed (ft/s)	Reference	Surrogate
Black Crappie	*Pomoxis nigromaculatus*	170-371	1.6-2.4	160	1.1	NR	NR	NR	NR	(23), (24)	
Bluegill	*Lepomis macrochirus*	NR	NR	51	0.9	150	1.2	157.5	4.3	(25), (26), (27)	
Central Mudminnow	*Umbra limi*	109	0.7	NR	NR	NR	NR	NR	NR	(23)	Northern Pike
Common Shiner	*Luxilus cornutus*	36	1.4	36	1.4	NR	NR	63.5	4	(7), (23)	Mimic Shiner/Emerald Shiner
Johnny Darter	*Etheostoma nigrum*	36	1.3	NR	NR	NR	NR	NR	NR	(23)	Rio Grande Darter
Largemouth Bass	*Micropterus salmoides*	104	1.1-1.6	150	1.8	269	2.2	NR	NR	(23), (28), (29), (30)	
		56-112	0.7-1.6	NR	NR	NR	NR	NR	NR	(31), (32), (33), (34)	
Logperch	*Percina caprodes*	103	1.1	50	0.59	151	1.4			(23)	Yellow Perch
Mimic Shiner	*Notropis volucellus*	36	1.4	36	1.4	NR	NR	63.5	4	(7), (23)	Emerald Shiner for burst speeds
Northern Pike	*Esox lucius*	109	0.7	NR	NR	NR	NR	NR	NR	(23)	
		119-620	0.6-1.5	NR	NR	NR	NR	NR	NR	(35)	
Pumpkinseed	*Lepomis gibbosus*	127	1.2	NR	NR	NR	NR	NR	NR	(36)	
Rock Bass	*Ambloplites rupestris*	NR	NR	51	0.9	150	1.2	157.5	4.3	(25), (26), (27)	Bluegill
Shorthead Redhorse	*Moxostoma macrolepidotum*	NR	NR	396	3.4	434	5	NR	NR	Sustained speed: (37)	
Silver Redhorse	*Moxostoma anisurum*	NR	NR	518	3.2	559	4.6	NR	NR	Sustained speed: (37)	
Smallmouth Bass	*Micropterus dolomieu*	300	2.9	122	0.9	378	3.9	NR	NR	(23)	
		NR	NR	262	1.6	NR	NR	NR	NR	(38)	
Spotfin Shiner	*Cyprinella spiloptera*	307	2.2	NR	NR	NR	NR	NR	NR	(29)	
Trout-Perch	*Percopsis omiscomaycus*	NR	NR	NR	NR	NR	NR	NR	NR	No data	
Walleye	*Sander vitreus*	81-391	1.2-2.8	79	1.2	381	2.7	16-57	5.2-8.5	(23), (39)	
White Sucker	*Catostomus commersonii*	383	11.8	165	1.6	500	20	NR	NR	(23)	
		170	2	NR	NR	NR	NR	NR	NR	(35)	
Yellow Perch	*Perca flavescens*	103	1.1	50	0.59	151	1.4	NR	NR	(23)	

NR = not reported

5.3 Entrainment Estimates

In estimates derived from sites with similar characteristics as the Project's, black crappie had the highest entrainment rate of fish shorter than 200 mm, followed by white suckers (Table 5-4). Black Crappie entrainment was highest in mid- to late summer, and may have been due to both the fishes' tendency to travel in large groups and the summer peak of young-of-the-year fish (white sucker young typically orientate to shoreline features.

For the fish 200 to 380 mm long, entrainment was highest for Black Crappie and Shorthead Redhorse (Table 5-5). Black Crappie are usually found in areas near the shoreline which would make them more likely to encounter the Project's intake. Shorthead Redhorse is a benthic species that are likely to orientate to the bottom within the vicinity of the Project's intake structures. This contributes to the higher potential for entrainment for bottom feeding species at various life stages. Estimated total annual entrainment for all species combined was approximately 290,000 for fish less than 200 mm long and 5,600 for fish 200 to 380 mm long (Table 5-4, Table 5-5).

Table 5-4 Monthly and Annual Entrainment Estimates for Fish Less Than 200 mm in Length

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Black Crappie	446	380	233	5,660	1,047	972	11,502	55,557	24,228	5,317	13,838	5,450	124,631
Bluegill	0	0	129	485	270	1039	277	3,081	3,284	1,772	4,499	69	14,905
Central Mudminnow	0	0	46	138	130	0	0	0	0	0	31	0	346
Common Shiner	0	140	0	50	1,208	40	20	47	16	40	163	2135	3,858
Johnny Darter	0	0	92	269	743	460	578	166	12	0	0	0	2,320
Largemouth Bass	0	199	312	349	5	4,819	8,674	1,250	2,602	971	5,013	345	24,540
Logperch	0	0	0	57	432	303	98	76	0	97	134	0	1,197
Mimic Shiner	668	1,213	896	58	336	886	105	48	0	17	128	633	4,988
Northern Pike	0	0	0	30	0	244	1,371	445	75	64	96	0	2,325
Pumpkinseed	156	71	175	144	266	624	523	1,352	5,658	2,052	1,276	571	12,868
Rock Bass	33	0	0	142	525	393	154	168	1,429	761	75	69	3,750
Shorthead Redhorse	0	0	0	13	7	1,887	223	216	318	740	96	139	3,638
Silver Redhorse	0	0	0	0	0	38	0	7	10	0	0	0	54
Smallmouth Bass	0	0	0	4	17	711	6,499	1,300	13,188	1472	323	199	23,712
Spotfin Shiner	0	0	0	0	0	0	0	36	32	0	0	0	68
Trout-perch	0	0	0	33	0	0	0	0	0	292	30	35	389
Walleye	0	0	0	33	8	1,229	1,496	1,941	1,102	1,074	252	189	7,326
White Sucker	120	81	115	157	259	8,826	21,648	447	88	1,875	200	235	34,050
Yellow Perch	88	140	23	4,850	1,838	921	5,087	1,306	3,377	2,629	2,958	280	23,499
Grand Total	1,512	2,226	2,022	12,472	7,093	23,390	58,256	67,443	55,418	19,173	29,110	10,351	288,465

Table 5-5 Monthly and Annual Entrainment Estimates for Fish with Lengths of 200 to 380 mm

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Black Crappie	0	0	0	69	28	130	24	353	662	45	11	39	1,361
Bluegill	0	0	0	16	0	5	4	2	0	0	16	0	43
Central Mudminnow	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnny Darter	0	0	0	0	0	0	0	0	0	0	0	0	0
Largemouth Bass	0	0	21	0	30	0	0	0	152	0	100	0	303
Logperch	0	0	0	0	0	0	0	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	0	0	0	12	21	16	0	0	0	45	16	0	109
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	71	0	0	5	104	28	2	21	96	39	6	0	372
Shorthead Redhorse	67	0	0	67	378	127	76	6	26	96	0	0	843
Silver Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	0	0	0	5	67	50	102	58	256	106	0	0	643
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0	0
Walleye	0	0	0	52	144	150	41	29	31	124	39	0	610
White Sucker	17	0	50	38	35	42	5	77	220	55	89	16	645
Yellow Perch	0	0	50	56	26	42	74	88	214	62	61	0	672
Grand Total	154	0	122	319	833	589	327	634	1,657	572	338	55	5,600

5.4 Blade Strike and Turbine Survival

Turbine survival for units 1 and 2 ranged from 83.7 to 97.2%, whereas units 3, 4, and 5 ranged from 70.4 to 93.4% (Table 5-6, Table 5-7). For units 1 and 2, the average turbine survival based on calculations is 87.8% and for units 3, 4, and 5 it is 77.4%. The projected survival rate for all units combined at the Project is 82.6%.

Table 5-6 Turbine Survival Estimates by Fish Length for the Project Units 1 and 2

Fish Length	Blade Strike Probability (P_S)	Probability of Strike Mortality (P_M)	Turbine Passage Survival (%) (S_r)
50	0.36	0.078	97.2
100	0.71	0.104	92.6
150	1.00	0.119	88.1
200	1.00	0.129	87.1
250	1.00	0.138	86.2
300	1.00	0.144	85.6
350	1.00	0.150	85.0
400	1.00	0.155	84.5
450	1.00	0.159	84.1
500	1.00	0.163	83.7

Table 5-7 Turbine Survival Estimates by Fish Length for the Project Units 3, 4, and 5

Fish Length	Blade Strike Probability (P_S)	Probability of Strike Mortality (P_M)	Turbine Passage Survival (%) (S_r)
50	0.46	0.143	93.4
100	0.92	0.189	82.6
150	1.00	0.216	78.4
200	1.00	0.235	76.5
250	1.00	0.250	75.0
300	1.00	0.262	73.8
350	1.00	0.272	72.8
400	1.00	0.281	71.9
450	1.00	0.289	71.1
500	1.00	0.296	70.4

5.5 Mortality Estimates

Monthly and annual entrainment mortality estimates were calculated by multiplying entrainment numbers by the average turbine survival estimates for each size group, assuming that 40% of fish pass through units 1 and 2 and 60% through units 3 through 5 (i.e., unit 1 and 2 survival rates for each size group were multiplied by 0.4 and unit 3-5 rates were multiplied by 0.6, with the sum of the products used for the entrainment mortality calculations).

Black Crappie and White Sucker had the highest mortality for fish less than 200 mm long (Figure 5-1) and Black Crappie and Shorthead Redhorse had the highest mortality for fish 200 to 380 mm long. Both figures were simplified to include species with greater than 1% mortality. There was no estimated entrainment mortality for nine of the 19 species in the 200 to 380 mm size range (Figure 5-2). Overall, fish less than 200 mm long had total annual mortality estimates of approximately 36,000 (Table 5-8) and fish 200 to 380 mm long had a total annual mortality of approximately 1,200 (Table 5-9).

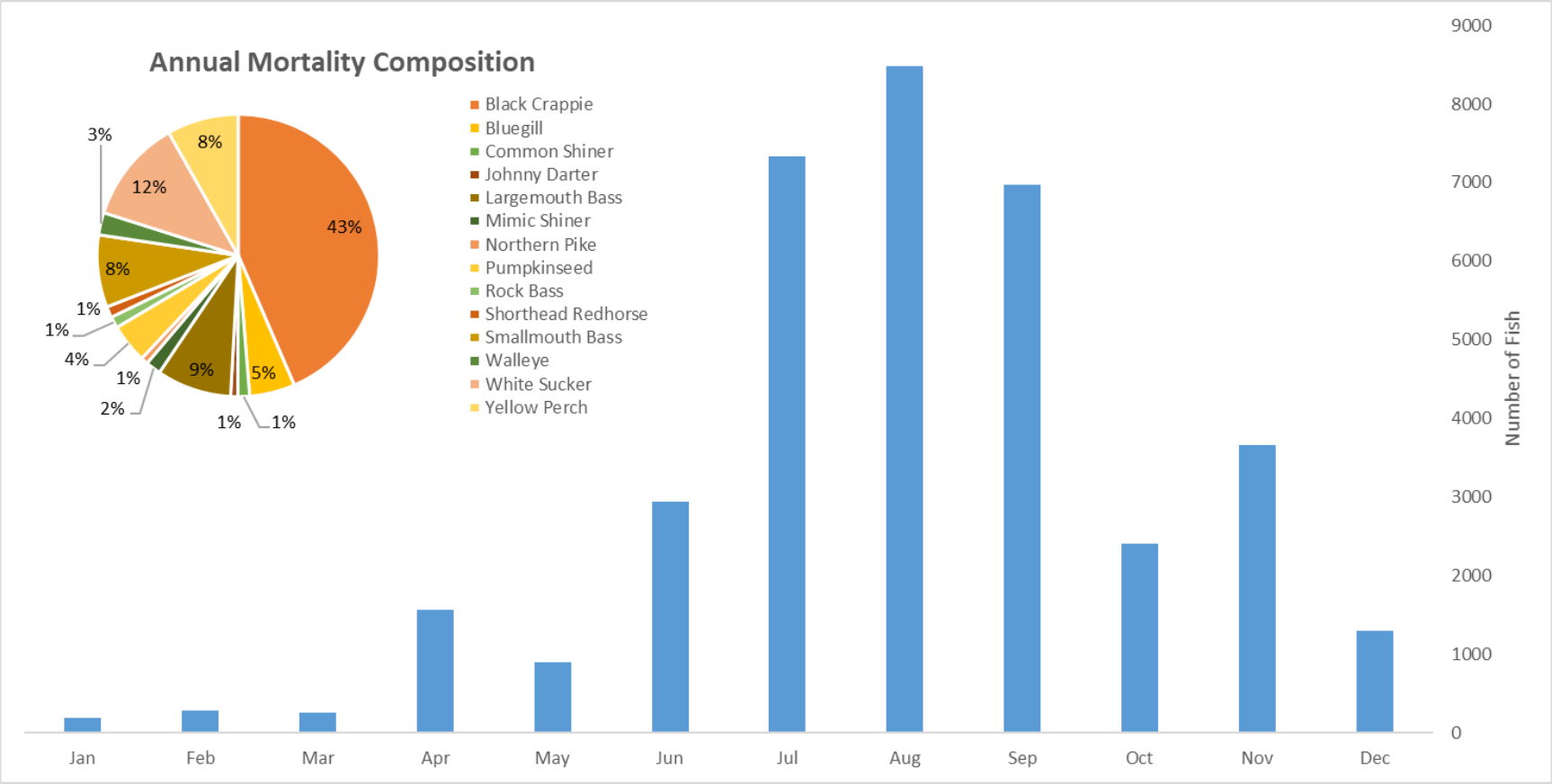

Figure 5-1 **Combined Monthly and Annual Entrainment Mortality Estimates for Fish Species less than 200 mm (Includes only species with greater than 1% mortality)**

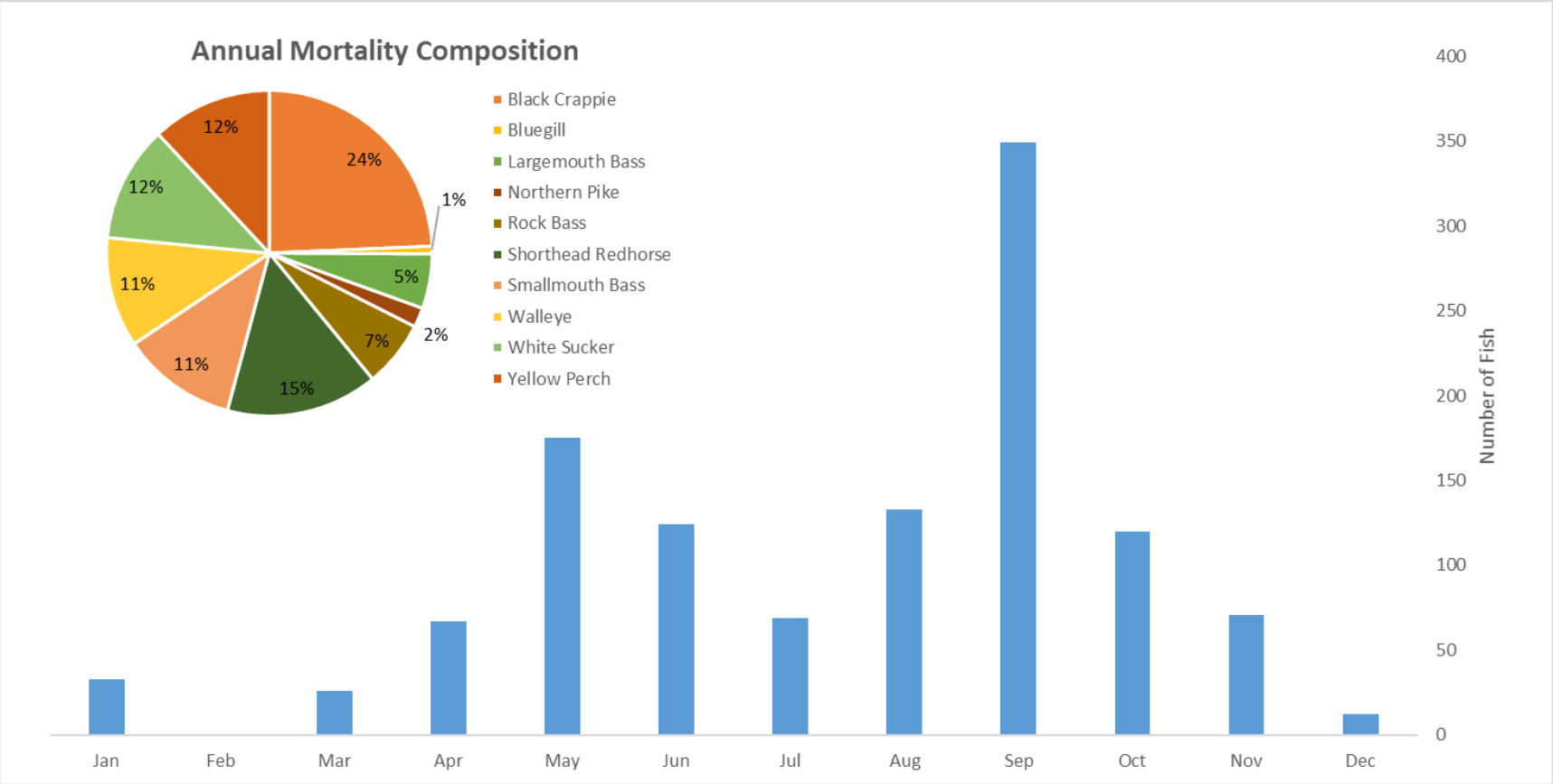

Figure 5-2 **Combined Monthly and Annual Mortality Estimates for Fish Species 200 to 380 mm (Includes only species with greater than 1% mortality)**

Table 5-8 Monthly and Annual Entrainment Mortality Estimates for Fish Less Than 200 mm in Length

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Black Crappie	56	48	29	712	132	122	1447	6989	3048	669	1741	686	15679
Bluegill	0	0	16	61	34	131	35	388	413	223	566	9	1875
Central Mudminnow	0	0	6	17	16	0	0	0	0	0	4	0	43
Common Shiner	0	18	0	6	152	5	3	6	2	5	21	269	485
Johnny Darter	0	0	12	34	93	58	73	21	1	0	0	0	292
Largemouth Bass	0	25	39	44	1	606	1091	157	327	122	631	43	3087
Logperch	0	0	0	7	54	38	12	10	0	12	17	0	151
Mimic Shiner	84	153	113	7	42	111	13	6	0	2	16	80	628
Northern Pike	0	0	0	4	0	31	172	56	9	8	12	0	292
Pumpkinseed	20	9	22	18	33	78	66	170	712	258	160	72	1619
Rock Bass	4	0	0	18	66	49	19	21	180	96	9	9	472
Shorthead Redhorse	0	0	0	2	1	237	28	27	40	93	12	17	458
Silver Redhorse	0	0	0	0	0	5	0	1	1	0	0	0	7
Smallmouth Bass	0	0	0	1	2	89	818	163	1659	185	41	25	2983
Spotfin Shiner	0	0	0	0	0	0	0	5	4	0	0	0	9
Trout-perch	0	0	0	4	0	0	0	0	0	37	4	4	49
Walleye	0	0	0	4	1	155	188	244	139	135	32	24	922
White Sucker	15	10	14	20	33	1110	2723	56	11	236	25	30	4284
Yellow Perch	11	18	3	610	231	116	640	164	425	331	372	35	2956
Grand Total	190	280	254	1569	892	2942	7329	8484	6972	2412	3662	1302	36289

Table 5-9 Monthly and Annual Entrainment Mortality Estimates for Fish with Lengths of 200 to 380 mm

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Black Crappie	0	0	0	14	6	27	5	74	140	10	2	8	287
Bluegill	0	0	0	3	0	1	1	0	0	0	3	0	9
Central Mudminnow	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnny Darter	0	0	0	0	0	0	0	0	0	0	0	0	0
Largemouth Bass	0	0	4	0	6	0	0	0	32	0	21	0	64
Logperch	0	0	0	0	0	0	0	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	0	0	0	2	4	3	0	0	0	9	3	0	23
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	15	0	0	1	22	6	0	4	20	8	1	0	78
Shorthead Redhorse	14	0	0	14	80	27	16	1	5	20	0	0	178
Silver Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	0	0	0	1	14	11	21	12	54	22	0	0	135
Spotfin Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0	0
Walleye	0	0	0	11	30	32	9	6	6	26	8	0	129
White Sucker	4	0	11	8	7	9	1	16	46	12	19	3	136
Yellow Perch	0	0	11	12	5	9	16	19	45	13	13	0	141
Grand Total	33	0	26	67	175	124	69	133	349	120	71	12	1179

6.0 Conclusion

Using a desktop analysis approach, the annual average number of fish less than 200 mm long expected to become entrained at the Project is approximately 290,000. Of that, approximately 36,000 will suffer mortality from entrainment. It was estimated that approximately 5,600 fish would become entrained with total lengths of 200 to 380 mm, and of those, approximately 1,200 suffering mortality. These estimations are based on species lists and relative composition data from the Mississippi River between Brainerd and the Grand Rapids Dam, entrainment data from the EPRI database, and the Project's operational specifications.

Physical exclusion is expected to occur for some larger fish of all species except Common Shiner, Mimic Shiner, Spotfin Shiner, Johnny Darter, Logperch, Trout-perch, and Central Mudminnow. Consequently, impingement on the trashrack is not expected to occur for any of the target species that reach a length at which they would be too large to pass through the 1.75-inch clear bar spacing.

Based on our evaluation and sampling by the MNDNR, population dynamics in the reach would remain as is and the status quo of Muskellunge and other game species, both above and below the Project, would be maintained. Black Crappie were estimated to have the highest entrainment and mortality rates for both size classes. The projected survival rate for all units combined at the Project is 82.6%.

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Appendix D

Recreation Use and Inventory Study

Recreation Use and Inventory Study

Brainerd Hydroelectric Project
FERC License No. 2533

Prepared for:
Brainerd Public Utilities
Brainerd, Minnesota

January 22, 2020

Available for Public Release

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
Phone: 952.832.2600

Recreation Use and Inventory Study
Brainerd Hydroelectric Project

January 22, 2020

Preface

Brainerd Public Utilities (BPU) began the renewal process for the Federal Energy Regulatory Commission (FERC) license of the Brainerd Hydroelectric Project FERC Project No. 2533 (Project). This Recreation Use and Inventory Study was requested by the FERC and Minnesota Department of Natural Resources (MNDNR) to generate current inventory and use information of existing recreation opportunities. FERC has responsibility for ensuring compliance with Section 10(a) of Federal Power Act and that recreation facilities meet recreational demand over the term of the new license. FERC policy requires licensees to provide reasonable public recreation opportunities consistent with safe, effective facility operations.

BPU provides recreational opportunities within the Project Boundary in accordance with the conditions of its existing license. It also has a responsibility for ongoing monitoring of the recreation facilities within the Project Boundary and maintenance of its recreation facilities throughout the license term (1). FERC requires licensed projects to provide reasonable public recreation opportunities consistent with the safe and effective operation of the Project. FERC also has ongoing responsibility to ensure that those recreation facilities meet recreational demand over the term of the new license.

MNDNR requested recreational-use surveys be completed for flowing and impounded stretches of the river but did not provide spatial boundaries in their request. As such, the Recreation Use and Inventory Planning Study extents were primarily limited to the four facilities located within the Project Boundary (canoe portage, Lum Park, French Rapids access, and Green's Point access) as directed by FERC, during study plan development.

Recreation Use and Inventory Study
Brainerd Hydroelectric Project

January 22, 2020

Contents

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Abbreviations and Acronyms

BPU	Brainerd Public Utilities
FERC	Federal Energy Regulatory Commission
MNDNR	Minnesota Department of Natural Resources
Project	Brainerd Hydroelectric Project
RSP	Revised Study Plan

Definitions

Licensee: The license was issued to the city of Brainerd and its Brainerd Public Utilities Commission (BPUC). Brainerd Public Utilities (BPU) manages the Project.

Project: Brainerd Hydroelectric Project, Federal Energy Regulatory Commission (FERC) No. 2533 (Project)

Project Boundary: The boundary line defined in the Project license issued by the FERC that surrounds the "…lands necessary for the operation and maintenance of the Project and for other Project purposes…" (2)

Relicensing: The process of acquiring a new FERC license for an existing hydropower project under expiration of the existing FERC license

1.0 Introduction

Brainerd Public Utilities (BPU) is in the process of relicensing the Brainerd Hydroelectric Project (Project) with the Federal Energy Regulatory Commission (FERC). As required by the December 10, 2018 Revised Study Plan (RSP) (3) for the Project, this document describes the Recreation Use and Inventory Planning Study completed in 2019.

Section 4(e) and 10(a) of the Federal Power Act require that FERC give equal consideration to all uses of the waterway on which a project is located. In making its license decision, FERC must equally consider the environmental, recreational, fish and wildlife, and other non-developmental values of the Project, as well as power and developmental values.

The Project allows for and supports several recreation opportunities, including boating, hiking, fishing, watersports, and passive recreation activities. As such, the Project's effects on recreational resources is relevant to FERC's public interest determination.

2.0 Project Overview

The Project is owned and operated by the city of Brainerd and its Public Utilities Commission under a license from the FERC as Project No. 2533. The Project is located in Crow Wing County on the Mississippi River near the northeast side of Brainerd, Minnesota, as shown in Figure 2-1. The Project is located approximately 130 miles north of the Minneapolis – St. Paul metropolitan area.

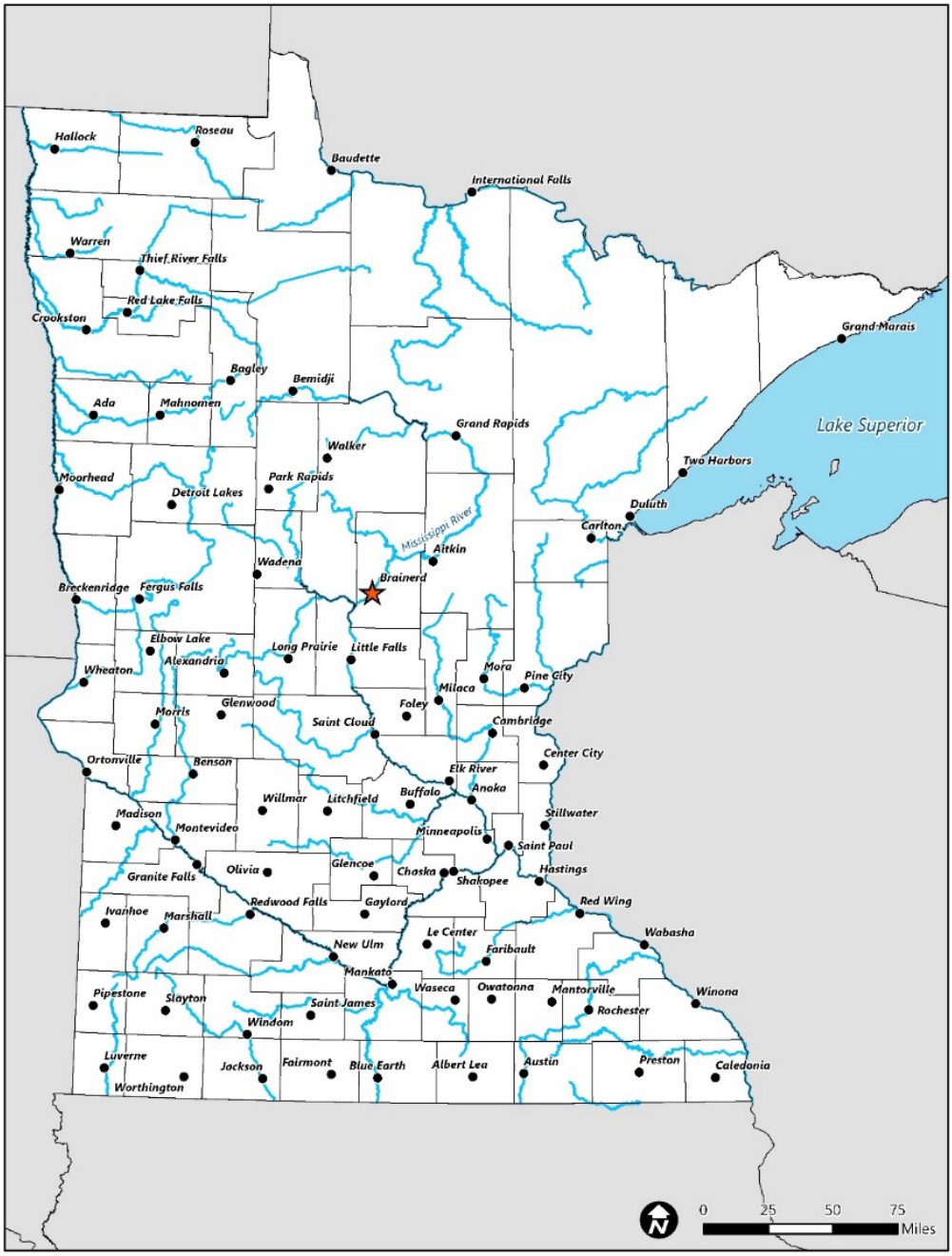


Figure 2-1 Project Location

From the left bank of the Mississippi River (looking downstream), the Project consists of a short left embankment, a 256-foot-long powerhouse, a 78-foot-long slide gate section, a 207-foot-long bascule (crest) gate section, a single 20-foot-wide steel tainter gate, and a 200-foot-long right embankment, as shown in Figure 2-2. The Project is located on land owned by BPU and is a run-of-river hydroelectric project, with an authorized installed capacity of 3,542.5 kilowatts.

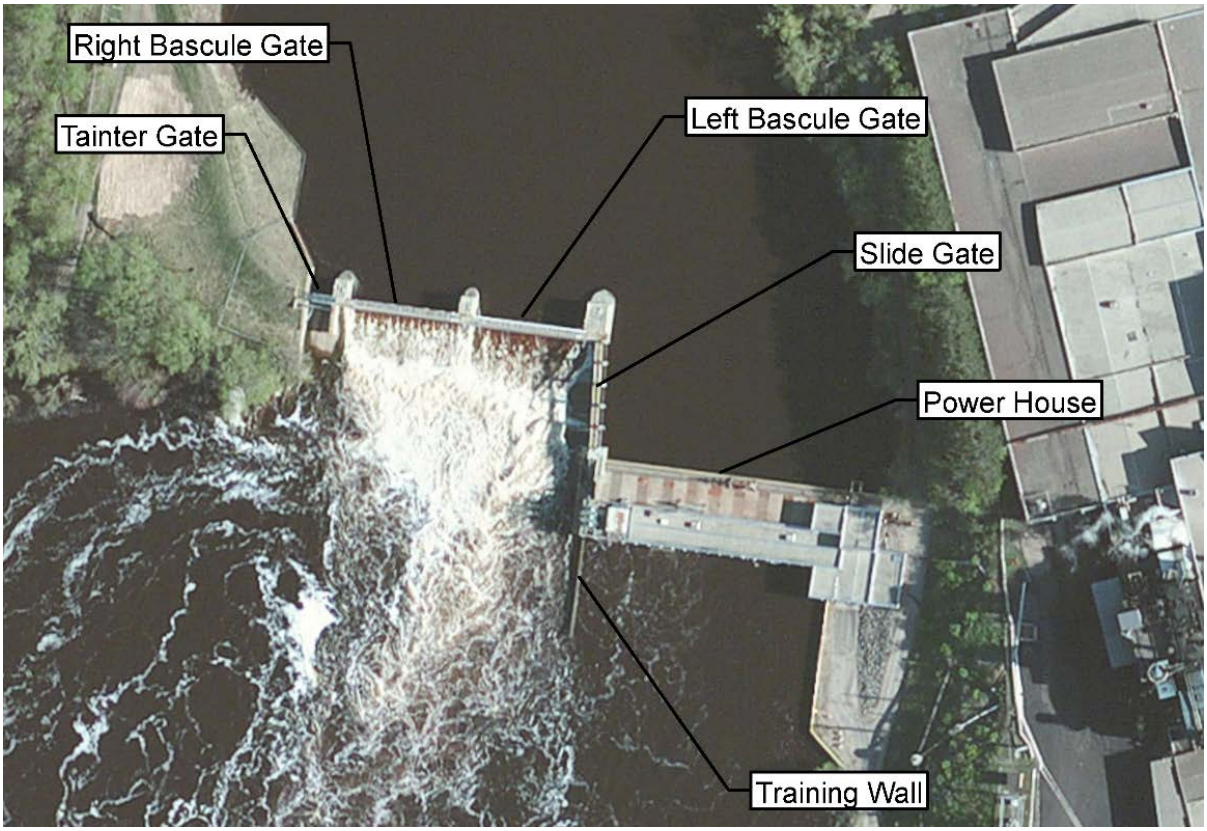
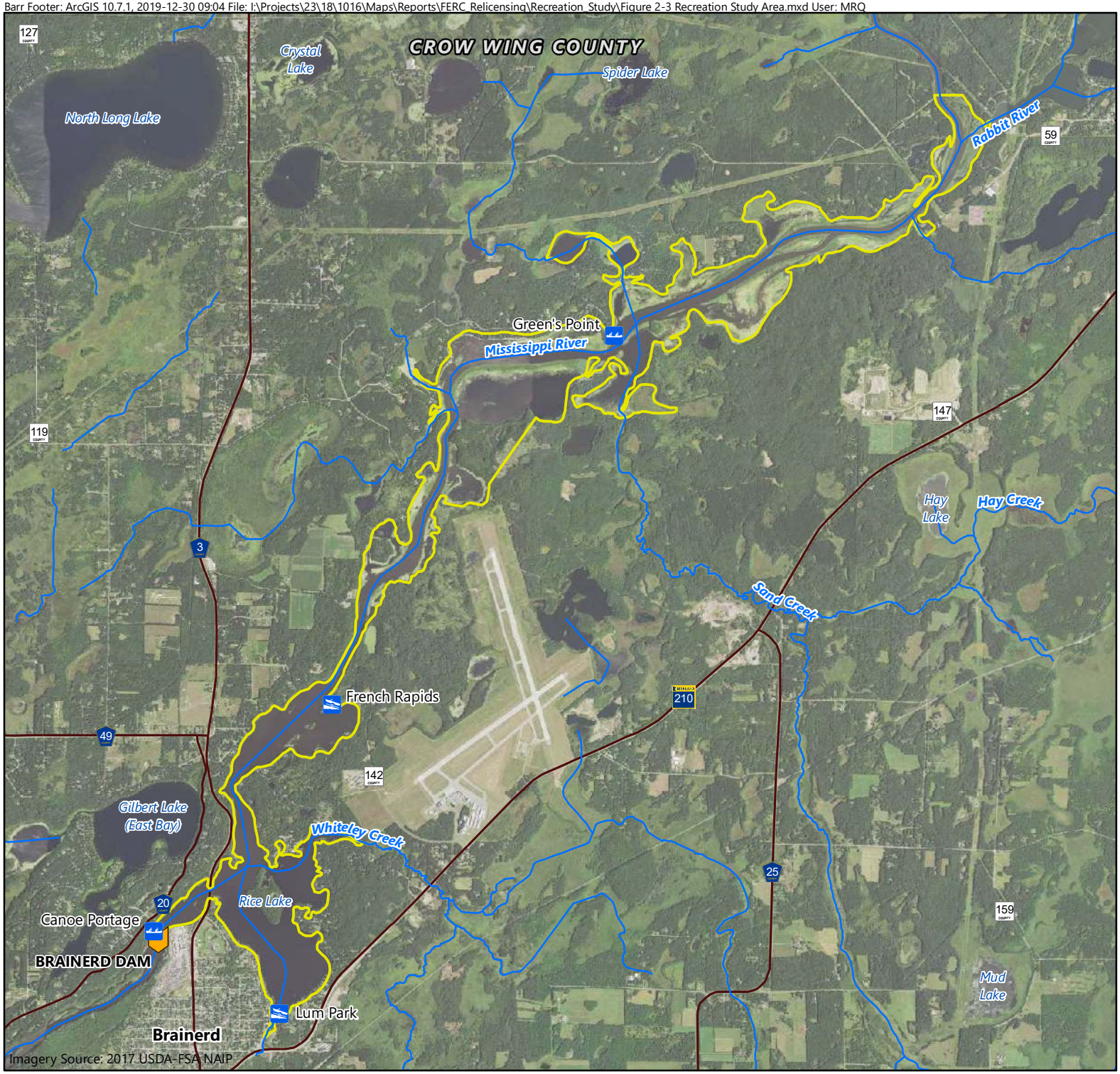


Figure 2-2 Project Overview

2.1 Study Boundary

This recreation use and inventory study focused on recreational use areas within the Project Boundary, including a canoe portage, Lum Park, French Rapids access, and Green's Point access. The location of these facilities is shown on Figure 2-3 and defined further in Section 5.0.



- Brainerd Dam
- Project Boundary
- Major Highway
- Carry-in/Portage
- Trailer Launch

N

0 5,000 10,000
Feet

0 1
Miles

BARR

Figure 2-3

RECREATION STUDY AREA
Brainerd Hydroelectric Project
Brainerd Public Utilities

3.0 Study Goals and Objectives

3.1 Goals and Objectives

The recreation use and inventory planning study was proposed to assess the condition and usage of recreation sites and associated facilitates within the Project Boundary. This study was requested by the Minnesota Department of Natural Resources (MNDNR) with comments for consideration provided by the FERC.

The goals of this study were to gather information from existing recreation sites and associated facilities, evaluate existing recreational use and capacity, and estimate future recreation demands within the Project Boundary. The goals of this study were met by performing the following objectives:

- Identify the condition of all informal and formal recreation sites and facilities wholly or partially within the Project Boundary;
- Determine current and projected capacity at each recreation site/facility;
- Identify who owns, operates, and maintains each recreation site/facility; and
- Conduct visitor surveys during the recreation season to determine the adequacy of Project recreation facilities and whether modifications or upgrades are needed to meet current or future recreation needs.

4.0 Methods

This section describes methods used for data collection and data analysis of 2019 study elements, including facility inventory and condition assessment, recreation use, and spot counts. The study plan required BPU to conduct studies at recreation sites located within the Project Boundary (Figure 2-3).

4.1 Facility Inventory and Condition Assessment

The facility inventory and condition assessment included a brief description for each site and location of the facilities in relation to the Project Boundary. A worksheet was developed to consistently document and address the site conditions (Appendix A). BPU used the worksheet to assign ratings to different project features ranging from restroom facility condition to the amount of erosion found along the shoreline. The following items were addressed:

- Identification of whether or not the facility is located within the Project Boundary
- Ownership and party responsible for operation and maintenance of each facility
- Type, number, and condition of amenities provided, including parking and signage
- General observations of site use and accessibility
- Identification of areas that show signs of erosion or other forms of instability

Facilities were assigned a condition rating score ranging from 1 to 5, as defined in Table 4-1.

Table 4-1 Facility Inventory and Assessment Condition Rating Scale

Rating	Condition	Description
1	Poor	Critically damaged, needs immediate repair or replacement, past intended life use
2	Marginal	Is defective and in need of replacement, but is still in a workable condition
3	Adequate	Is moderately deteriorated, has not exceeded its intended life use, minor compliance issues
4	Good	May be slightly defective, no longer new, is overall functional and in working condition
5	Excellent	In new or like new condition, no visible defects

Online resources, local knowledge, and signage were used to determine hours and seasons of operation. Many of these areas are maintained within appropriate seasonal conditions. Photographs were taken as a means to visually document facility conditions. Representative photos are included in Section 5.0 of this document with larger images in Appendix B.

4.2 Recreation Use Survey

BPU conducted a recreation use survey at each of the four sites included in the facility inventory and condition assessment effort. A recreational use survey questionnaire was developed to assist with consistent data collection (Appendix C). The questionnaire was converted to an electronic, tablet-based format for BPU staff to use on site. Collected data was automatically uploaded to an online storage space, allowing for more reliable data backup during the survey period.

The schedule for the recreational use surveys was created in accordance with the RSP (3). All sampling days and times were randomly selected to account for variable time of day use patterns (Table 4-2). The recreation use surveys were completed during the recreation season to capture recreational use occurring while the facilities were open to the public. The recreation season for this Project was defined as the opening weekend of fishing season (mid-May) to the opening weekend of waterfowl hunting season (late September).

The recreation use survey was administered to facility users to gain user feedback on existing recreation facilities and opportunities. This survey recorded the number of people in a party, their primary reason for visiting the site (i.e., type of recreation), their perception of level of site use, and their opinions on the amount and types of recreation opportunities offered within the Project Boundary.

4.3 Spot Counts

Spot counts were conducted in conjunction with the recreation use survey. Spot counts were intended to be brief in duration to provide a snapshot of use at each recreation site. Spot counts lasted approximately 5 minutes and recorded the number of vehicles parked at a site and the number of trailers. This information was also collected electronically via tablet and was used in estimating site use.

Table 4-2 Recreation Survey Schedule

Month	Date	Survey Order	Time	Weekday/ Weekend/ Holiday
May	May 24, 2019 Friday	Green's Point access	8:00-10:00 am	Weekday
		Canoe Portage	10:15am-12:15pm	
		Lum park	1:00-3:00 pm	
		French Rapids access	3:15-5:15 pm	
	May 26, 2019 Sunday	French Rapids access	8:00-10:00 am	Holiday Weekend (Memorial Day)
		Lum park	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		Canoe Portage	3:15-5:15 pm	
	May 28, 2019 Tuesday	French Rapids access	8:00-10:00 am	Weekday
		Canoe Portage	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	
	May 30, 2019 Thursday	French Rapids access	8:00-10:00 am	Weekday
		Lum park	10:15am-12:15pm	
		Canoe Portage	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	
June	June 6, 2019 Thursday	Lum park	8:00-10:00 am	Weekday
		Canoe Portage	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		French Rapids access	3:15-5:15 pm	
	June 15, 2019 Saturday	Green's Point access	8:00-10:00 am	Weekend
		French Rapids access	10:15am-12:15pm	
		Lum park	1:00-3:00 pm	
		Canoe Portage	3:15-5:15 pm	
	June 19, 2019 Wednesday	French Rapids access	8:00-10:00 am	Weekday
		Lum park	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		Canoe Portage	3:15-5:15 pm	
	June 23, 2019 Sunday	Lum park	8:00-10:00 am	Weekend
		French Rapids access	10:15am-12:15pm	
		Canoe Portage	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	

Month	Date	Survey Order	Time	Weekday/ Weekend/ Holiday
July	July 6, 2019 Saturday	Canoe Portage	8:00-10:00 am	Holiday Weekend (4th of July)
		Lum park	10:15am-12:15pm	
		French Rapids access	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	
	July 14, 2019 Sunday	French Rapids access	8:00-10:00 am	Weekend
		Green's Point access	10:15am-12:15pm	
		Canoe Portage	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	
	July 22 Monday	Canoe Portage	8:00-10:00 am	Weekday
		Lum park	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		French Rapids access	3:15-5:15 pm	
	July 30 Tuesday	Lum park	8:00-10:00 am	Weekday
		Green's Point access	10:15am-12:15pm	
		French Rapids access	1:00-3:00 pm	
		Canoe Portage	3:15-5:15 pm	
August	August 7, 2019 Wednesday	French Rapids access	8:00-10:00 am	Weekday
		Canoe Portage	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	
	August 11, 2019 Sunday	French Rapids access	8:00-10:00 am	Weekend
		Green's Point access	10:15am-12:15pm	
		Canoe Portage	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	
	August 19, 2019 Monday	Lum park	8:00-10:00 am	Weekday
		Canoe Portage	10:15am-12:15pm	
		French Rapids access	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	
	August 31, 2019 Sunday	French Rapids access	8:00-10:00 am	Weekend
		Canoe Portage	10:15am-12:15pm	
		Green's Point access	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	

Month	Date	Survey Order	Time	Weekday/ Weekend/ Holiday
September	September 1, 2019 Sunday	Canoe Portage	8:00-10:00 am	Holiday Weekend (Labor Day)
		French Rapids access	10:15am-12:15pm	
		Lum park	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	
	September 5, 2019 Thursday	Canoe Portage	8:00-10:00 am	Weekday
		Green's Point access	10:15am-12:15pm	
		French Rapids access	1:00-3:00 pm	
		Lum park	3:15-5:15 pm	
	September 14, 2019 Saturday	Lum park	8:00-10:00 am	Weekend
		French Rapids access	10:15am-12:15pm	
		Canoe Portage	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	
	September 20, 2019 Friday	Canoe Portage	8:00-10:00 am	Weekday
		Lum park	10:15am-12:15pm	
		French Rapids access	1:00-3:00 pm	
		Green's Point access	3:15-5:15 pm	

5.0 Results and Discussion

5.1 Facility Inventory and Assessment

The following sections characterize the evaluated recreation sites and include descriptions of each site's amenities, recreation features, photographs, signage, and conditions of amenities and structures based on the worksheet and rating scale described in Section 4.1.

5.1.1 Canoe Portage

The canoe portage is owned and maintained by BPU and is located within the Project Boundary off Riverside Drive, west of the right embankment. The canoe portage allows portage access around the Project and is open 24 hours. The site access includes informative and warning signage explaining site rules, as well as asphalt and concrete trails to portage canoes. Recreational activities include shoreline fishing and canoeing/kayaking. The site offers two concrete restroom facilities, and landscaping at the site is well maintained, primarily through mowing. Facility conditions at the canoe portage site resulted in an average condition rating of '4.0 – Good' based on individual amenity ratings shown in Table 5-1.

Table 5-1 Canoe Portage Recreation Inventory and Condition Assessment

Canoe Portage Amenities	Rating/Condition	Comments
Canoe Portage/Carry In 	4 – Good	Asphalt and concrete trail for canoe portage use, a few chipped out areas of asphalt, but easily avoidable.
Site Furnishings	3 – Adequate	Canoe rack set up next to restrooms.
Signage 	3 – Adequate	Canoe portage signs visible from river, other signs near restrooms.

Canoe Portage Amenities	Rating/Condition	Comments
Restrooms 	4 – Good	Two concrete outhouses with updated fixtures inside, new paint.
Landscaping 	4 – Good	Grass is maintained via mowing, no other significant landscaping at site.
Shoreline 	4 – Good	No evidence of erosion.

5.1.2 Lum Park

Lum Park is owned and maintained by the city of Brainerd. The site is located within the Project Boundary and is accessed from NE Washington Street in northeast Brainerd. The site is open May 1 through October 31. Restrooms are closed for the season at the discretion of the city of Brainerd once freezing temperatures are possible. The site access includes signage with directions to the boat ramp, camping, and the beach, as well as warning signs for aquatic nuisance species. There is a large paved parking area for 30 truck trailers, a second parking area with 45 single parking spaces marked, and a paved pathway throughout the park. A motorized boat launch provides access to Rice Lake and the Mississippi River. Additional recreational amenities include three sets of playground equipment, two sand volleyball courts, a fishing pier, a disc golf course, a public swimming beach, and picnic facilities. Camping facilities do not

allow tent camping. Each camping space is typically about 40 feet by 55 feet in size, and has water, 30/50 amp electric hookups, Wi-Fi service, fire rings, and picnic tables.

Recreational activities provided by Lum Park include reservoir fishing, shoreline fishing, swimming, disc golfing, sand volleyball, bird watching, camping, picnicking, and boating. The site is generally well maintained and winterized as seasonal conditions indicate. The site offers men and women's bathrooms with running water, drinking fountains, and vending machines. Both small and large pavilions (four total) offer a multitude of picnic tables and grills. Facility conditions at Lum Park resulted in an average condition rating of '4.0 – Good' based on individual amenity ratings shown in Table 5-2.

Table 5-2 Lum Park Recreation Inventory and Condition Assessment

Lum Park Amenities	Rating/Condition	Comments
Playgrounds	4 – Good	Three sets of playground equipment, all in good condition.
Fishing Pier 	4 – Good	T-shaped fishing pier near beach and boat ramp.
Volleyball Courts	3 - Adequate	Two sand volleyball courts near campground.
Camping Facilities	3 - Adequate	Camper use only, no tents, open field with hook-ups, used frequently. Fire wood available.
Other Sporting Fields – Disc Golf 	4 – Good	Disc golf – newer baskets and tee boxes. Used quite a lot from observations.

Lum Park Amenities	Rating/Condition	Comments
Site Furnishings 	4 – Good	A few bike racks, lots of benches throughout and many picnic tables, in four separate pavilions.
Docks	3 – Adequate	One older dock at boat launch could use some work, close to water surface and small.
Trailer Accessible Boat Ramp 	4 – Good	Concrete planks, in a nice bay for easy loading and unloading, good approach to ramp.
Potable Water 	3 – Adequate	Drinking fountain at restroom building.
Signage 	4 – Good	Many signs throughout park.

Lum Park Amenities	Rating/Condition	Comments
Parking Spaces 	4 – Good	30 truck trailer spots, 45 single vehicle spots.
Parking Lot Surface	4 – Good	All parking is paved, approximately 10 years old, striped, no potholes.
Restrooms 	3 – Adequate	Men and women's restrooms with running water and four stalls in each unit. Vending machine located outside. Some surfaces need to be painted.
Picnic Shelters 	4 – Good	Four pavilions, one large with 20 picnic tables, three others smaller with 10 tables each. New roofs, fresh paint on structures, concrete floors.
Turf	5 – Excellent	Lots of grass area, very well maintained by City.
Park Trees 	4 – Good	Numerous types and sizes of trees, all pruned

Lum Park Amenities	Rating/Condition	Comments
Shoreline 	4 – Good	No evidence of erosion.

5.1.3 French Rapids Access

The French Rapids access is owned and maintained by Crow Wing County and is open year-round. This site is located within the Project Boundary and can be accessed from County Road 142, near its intersection with State Highway 210 East in Oak Lake Township, approximately four miles northeast of Brainerd. The site's access point includes a motorized boat launch, directional signage leading to the motorized boat launch, a picnic area, and a maintained gravel parking area. Recreational activities include nearly 6 miles of groomed skiing and hiking trails with signs indicating routes, reservoir fishing, shoreline fishing, and boating. This site does not offer restrooms or potable water sources. Facility conditions at French Rapid Access resulted in a condition rating of '3.0 – Adequate' based on individual amenity ratings shown in Table 5-3.

Table 5-3 French Rapids Access Recreation Inventory and Condition Assessment

French Rapids Amenities	Rating/Condition	Comments
Trailer Accessible Boat Ramp 	3 – Adequate	Concrete planks, good approach to ramp.
Signage 	3 – Adequate	Two signs leading to landing, invasive species signs, ski trail signs.

Parking Spaces	2 – Marginal	Open gravel-parking area, hard to determine total parking space count.
Parking Lot Surface	2 – Marginal	Semi-maintained gravel parking area with puddles in potholes during rain events.
Turf	2 – Marginal	Trees and gravel, not a lot of turf
Shoreline 	4 – Good	No evidence of erosion.

5.1.4 Green's Point Access

Green's Point access is maintained by the MNDNR. The site is located within the Project Boundary and can be accessed from County Road 3 at the end of Executive Acres Road, approximately 10 miles northeast of the City of Brainerd. Green's Point is open year-round and the site includes signage with invasive species warnings, fishing regulations, and site information signs, as well as a paved cul-de-sac for parking. This location features a carry-in boat launch point and a shoreline fishing area. Recreational activities include reservoir and shoreline fishing, bird watching, and boating. This site does not offer restrooms or potable water sources. Facility conditions at Green's Point were given a condition rating of '3.0 – Adequate' based on individual amenity ratings shown in Table 5-4.

Table 5-4 Green's Point Access Recreation Inventory and Condition Assessment

Green's Point Amenities	Rating/Condition	Comments
Canoe Portage/Carry In 	4 – Good	Grass trail down to river for canoe carry in, with a small permanent dock.
Docks	3 – Adequate	One small permanent docking area.

Green's Point Amenities	Rating/Condition	Comments
Signage 	3 – Adequate	Public water access sign on County Road 3, good signage at parking lot.
Parking Spaces 	2 – Marginal	Cul-de-sac shaped parking lot with few spaces and no designated trailer parking. Most observed vehicles in lot were trucks with canoes on top.
Parking Lot Surface	2 – Marginal	Asphalt parking area at end of road.
Shoreline 	4 – Good	No evidence of erosion.

5.2 Recreation Use Survey

This section reports the results of the spot counts and recreation use surveys conducted at the four recreation sites. Recreational use surveys were collected from 21 users (Figure 5-1) across the eight survey days. Raw survey data is provided in Appendix D. The majority of survey responses were received from users at Lum Park, which Section 5.1 indicates has more amenities than the other three facilities.

Not all users responded to every question in the survey; as a result, some survey totals may be less than 21. Survey results were grouped into the following general categories: user characteristics, recreational activity and preference, duration and timing of visits, user concerns and perceptions, and user satisfaction and feedback.

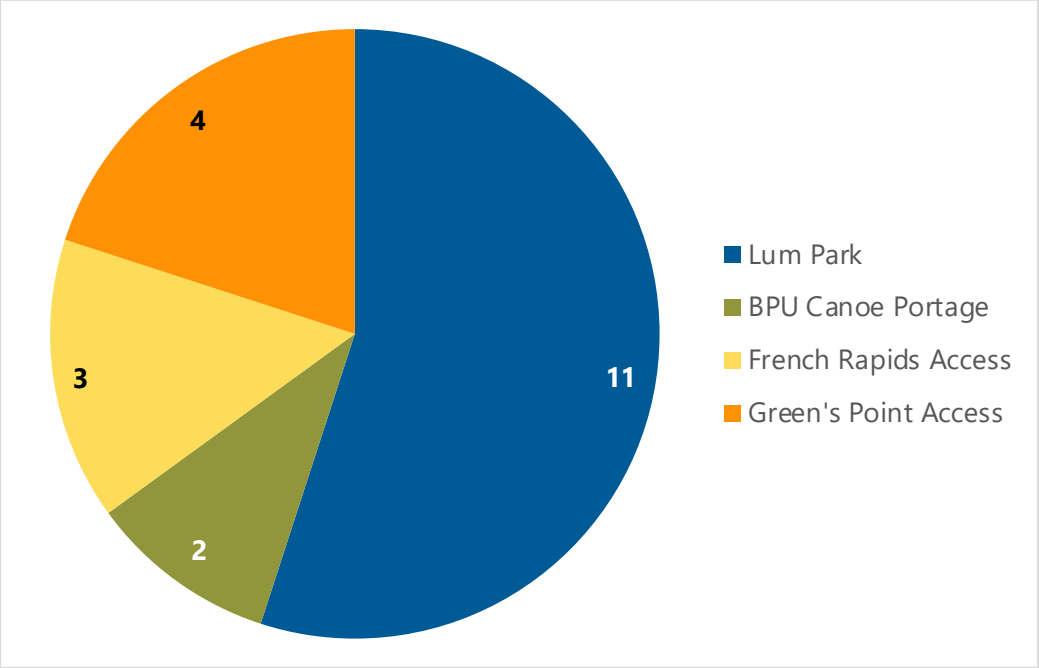


Figure 5-1 Survey Response Count by Facility

5.2.1 Use Characteristics by Location

The majority of the surveyed users visited the recreational facilities either as individuals or with one other person (Figure 5-2). Lum Park had the highest variability in group size with several groups of 3 to 5 and 6 to 10. Green's Point had the second largest group size ranging from 1 to 5, French Rapids Access had an average of 2 people per party, and the canoe portage had an average of 1 visitor per group.

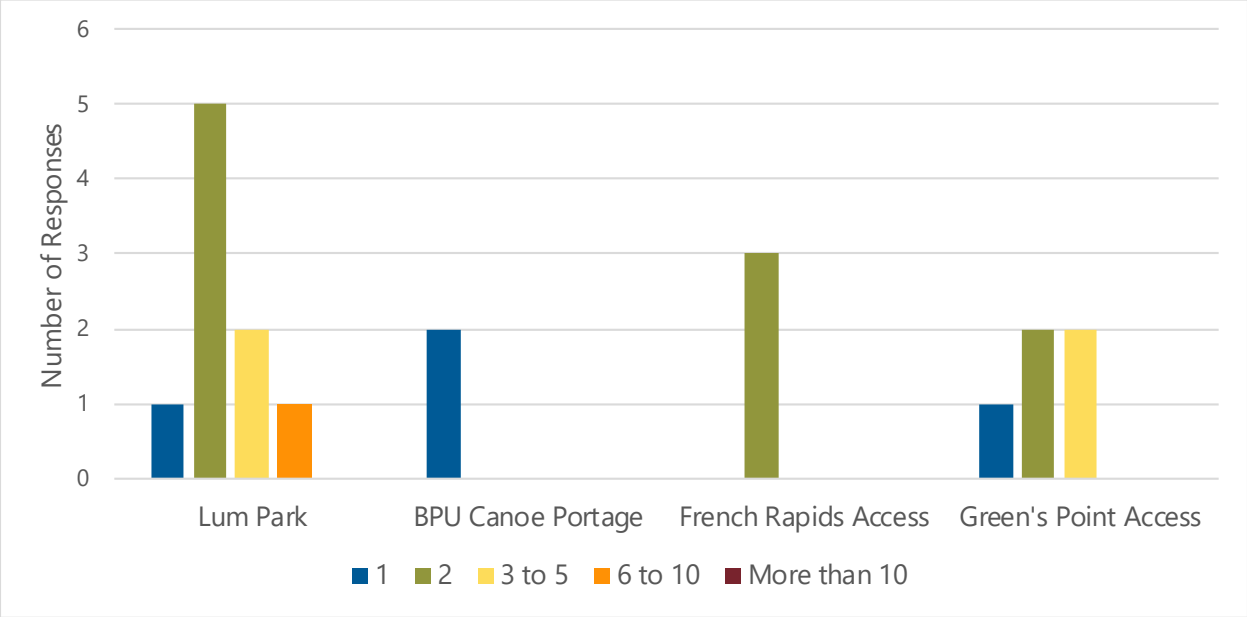


Figure 5-2 Average Surveyed Group Size by Facility

The majority of users across all surveyed locations typically arrive in a single vehicle, though responses at Lum Park, the French Rapids access, and the Green's Point access indicated occasional carpooling (Figure 5-3).

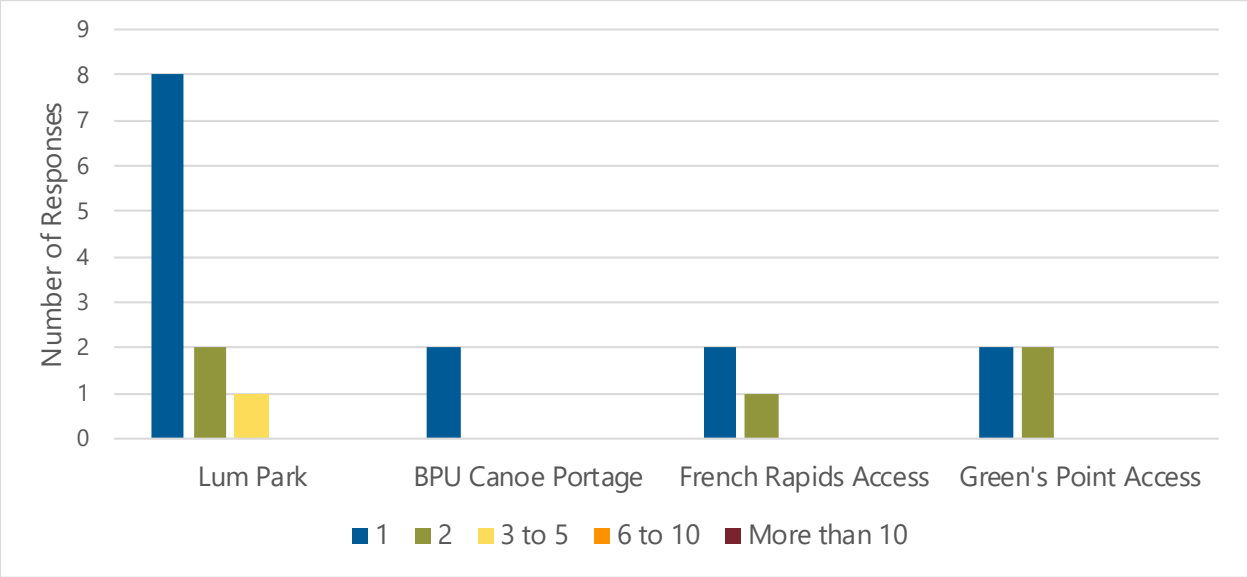


Figure 5-3 Number of Vehicles at Facility per Group of Users

To determine the frequency of use, survey participants were asked how often they visit the facility each year. Approximately 47 percent of respondents indicated that they visit the facility 1 to 3 times a year (Figure 5-4). When averaged against the number of survey respondents at a location, the French Rapids Access respondents tend to visit this location more frequently than users at the other surveyed locations, with an average response of 6-10 times a year.

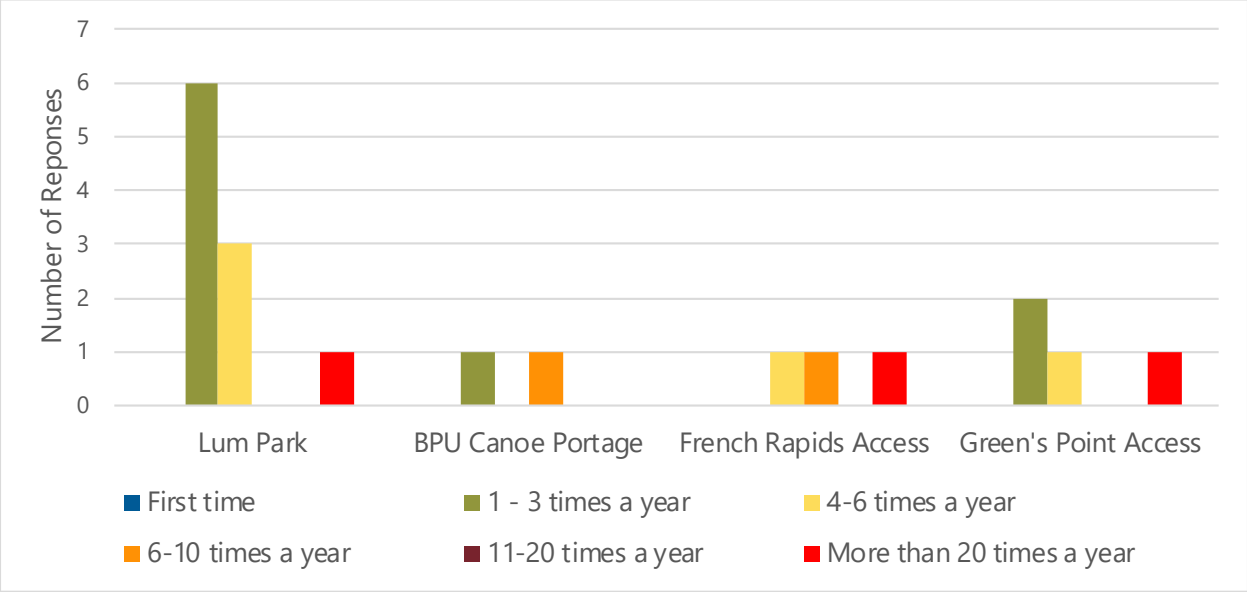


Figure 5-4 Annual Frequency of Site Visit

5.2.2 User Recreational Activity and Location Preference

The surveyed facilities offer a variety of recreational opportunities unique to each location, as described in Section 5.1. Recreational users were asked why they chose the specific facility and what activities they were there to participate in.

Lum Park users stated they primarily use the facility for fishing and boating (Figure 5-5); 53 percent of surveyed users identified fishing as their planned activity and 38 percent planned to use the facility for boating (motorized boating). In addition, one user planned to use the facility for a picnic. Fishing was noted as an intended use at all four recreation facilities, one user identified canoeing/kayaking use at the canoe portage, and one user identified they were at French Rapids access for other use. Camping, hunting, trapping, wildlife viewing, and swimming were activities included in the surveys, but were not selected by survey participants.. As such, these uses are not included in summary Figure 5-5.

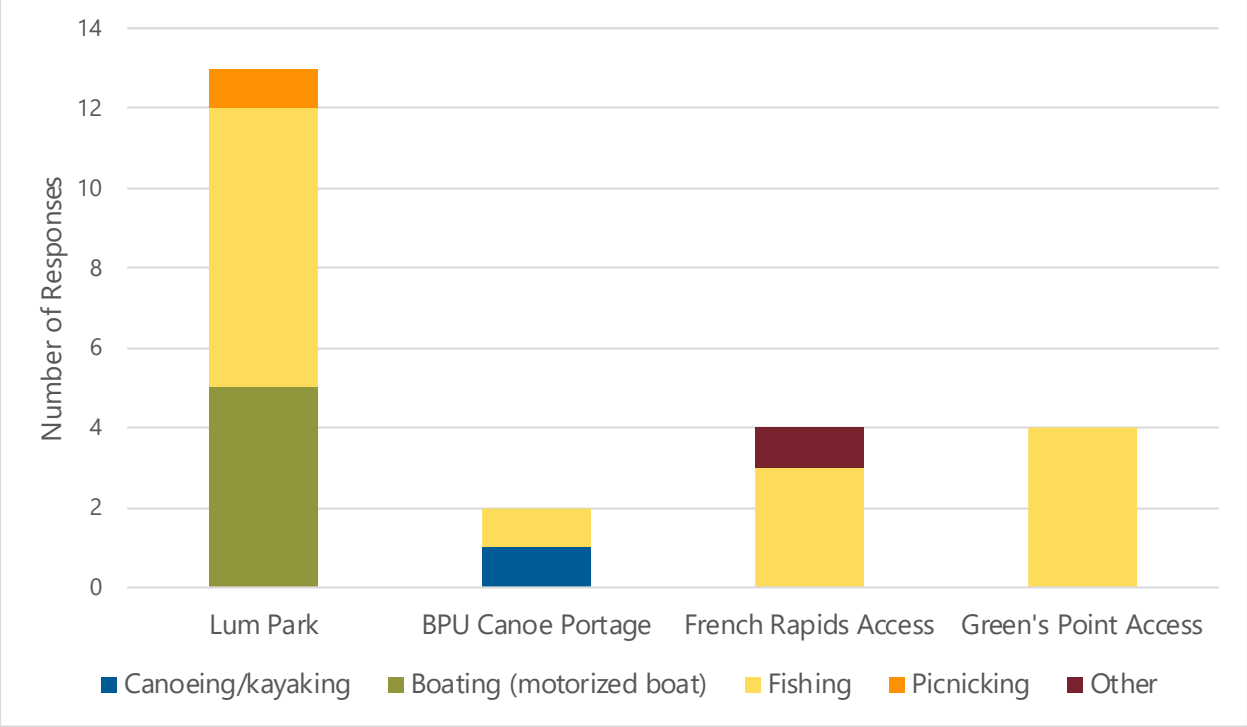


Figure 5-5 Planned Recreational Activity by Facility

All survey participants noted they choose to recreate at the specific facilities due to facility proximity to their homes. In addition, participants preferred to use Lum Park due to its available boat launch and lack of congestion. The canoe portage survey participants chose to use this facility because it has a portage. Both French Rapids access and Green's Point access users responded that they also use these facilities for fishing quality.

The surveyed facilities offer a variety of recreational amenities. Recreational users were asked which of the facility's amenities were most important to them. Nearly every survey participant, at each facility, responded that general access was important to them (Figure 5-6). Lum Park had the most variety in identified amenity importance, with participants valuing the boat launch, parking, boat dock, fishing dock,

picnic tables, and trash receptacles. This variety in identified amenity importance is likely due to Lum Park offering more recreational amenities than the other surveyed facilities. The canoe portage users valued the facility's restrooms and general access. French Rapids access and Green's Point access users valued the general accessibility of each facility, while the French Rapids access users also placed importance on the site's parking (Figure 5-6). ADA accessibility, signs and information, and lighting were amenities included in the surveys, but were not selected by survey participants. As such, these amenities are not included in summary Figure 5-6.

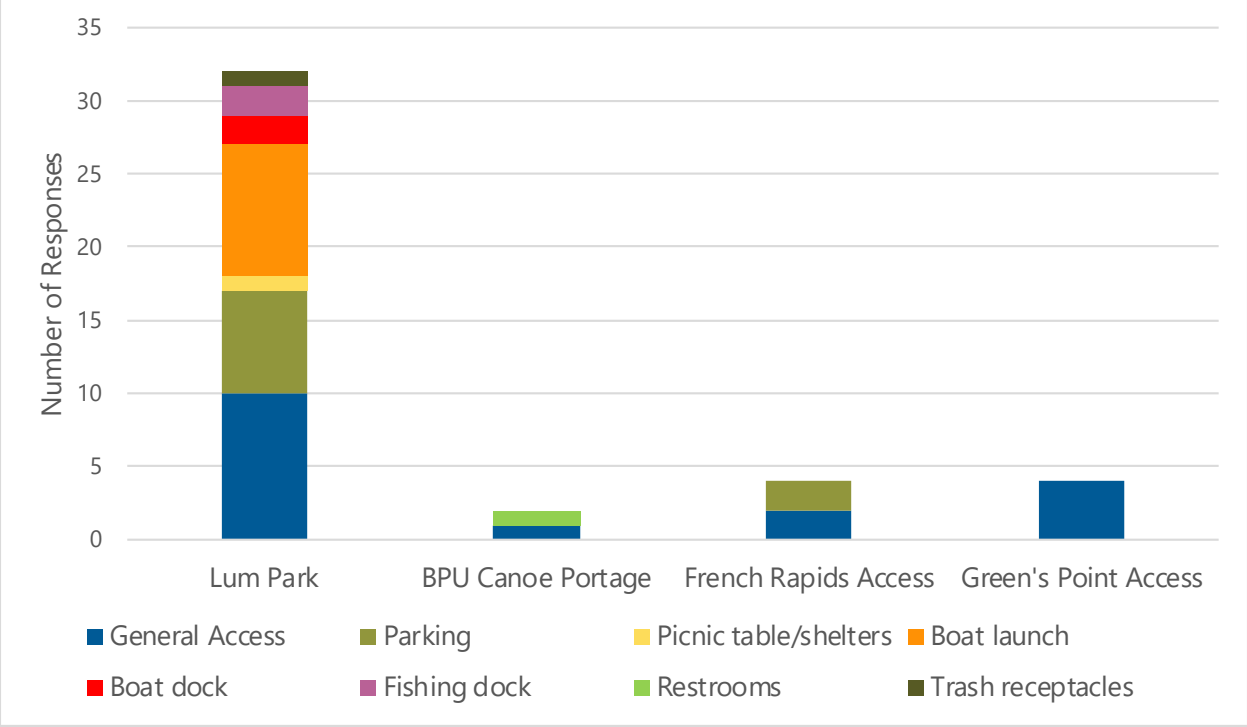


Figure 5-6 Important Facility Amenities

5.2.3 Duration and Timing of Visit

The frequency and duration of use for the surveyed facilities were fairly consistent. The majority of survey participants primarily use the parks during the summer months between June and September. Only one user noted they visit Lum Park in the spring between April and May, and one person noted they visit the Green's Point access in fall between October and November (Figure 5-7).

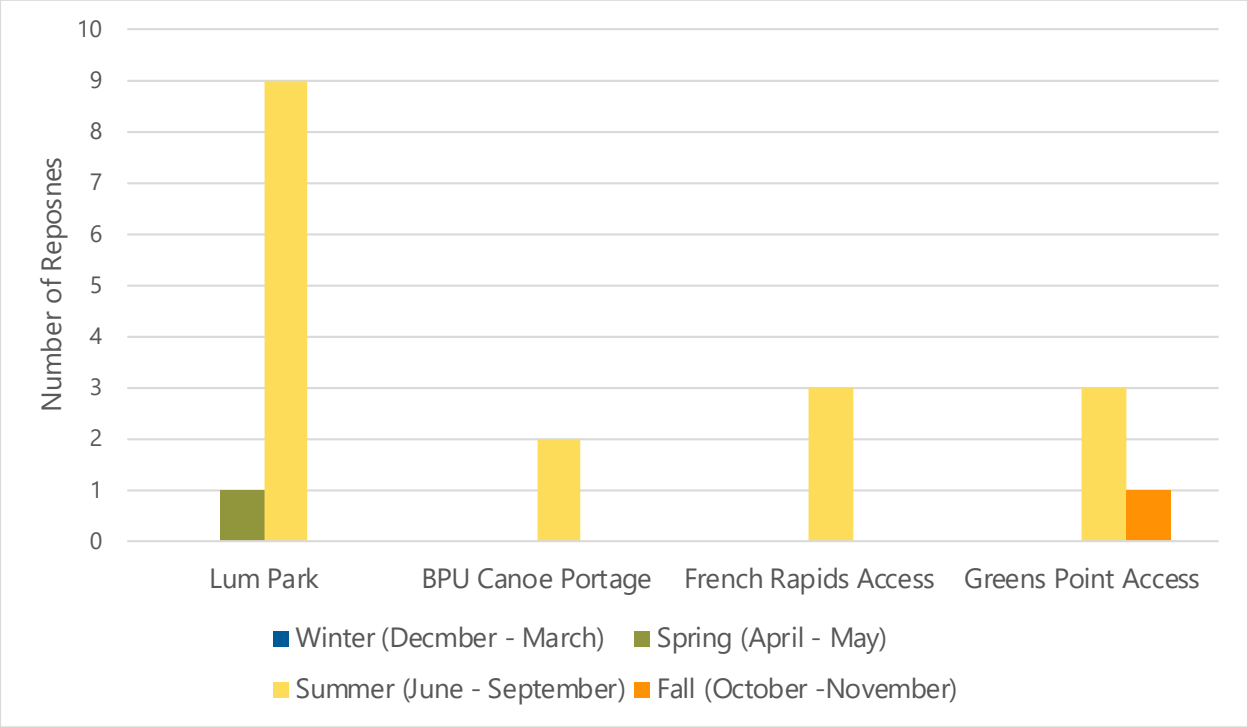


Figure 5-7 Seasonal Tendencies of Facility Use

The duration of recreational visits at each facility typically ranged between 2 to 4 hours (Figure 5-8). Two users noted they stay at the facility for more than 4 hours, with three users noting they stay at the facility for less than 2 hours.

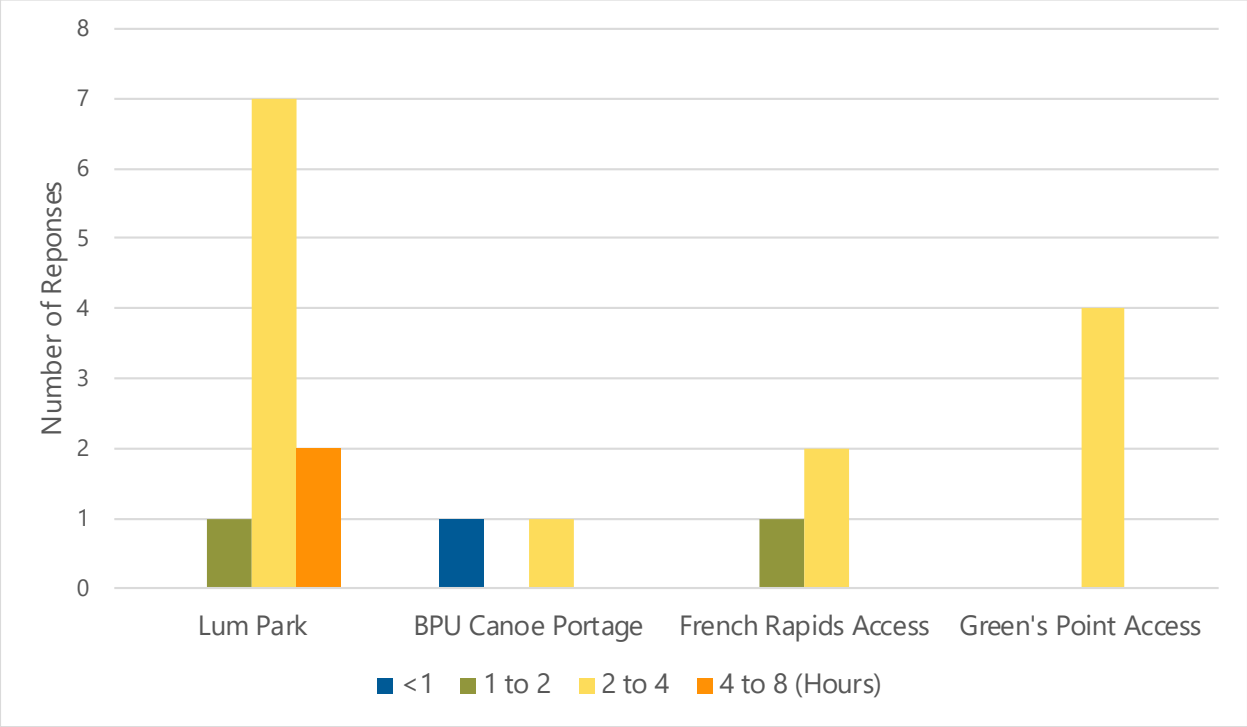


Figure 5-8 Typical Duration of Visit

5.2.4 User Capacity Perception

Overall, a majority of surveyed users perceived the facilities as not very busy (Figure 5-9) and that they preferred to recreate at these facilities because they are typically not very busy. Approximately 40 percent of Lum Park users stated the facility was moderately busy during the July 4th weekend. No users experienced any conflict with other users or recreational activities.

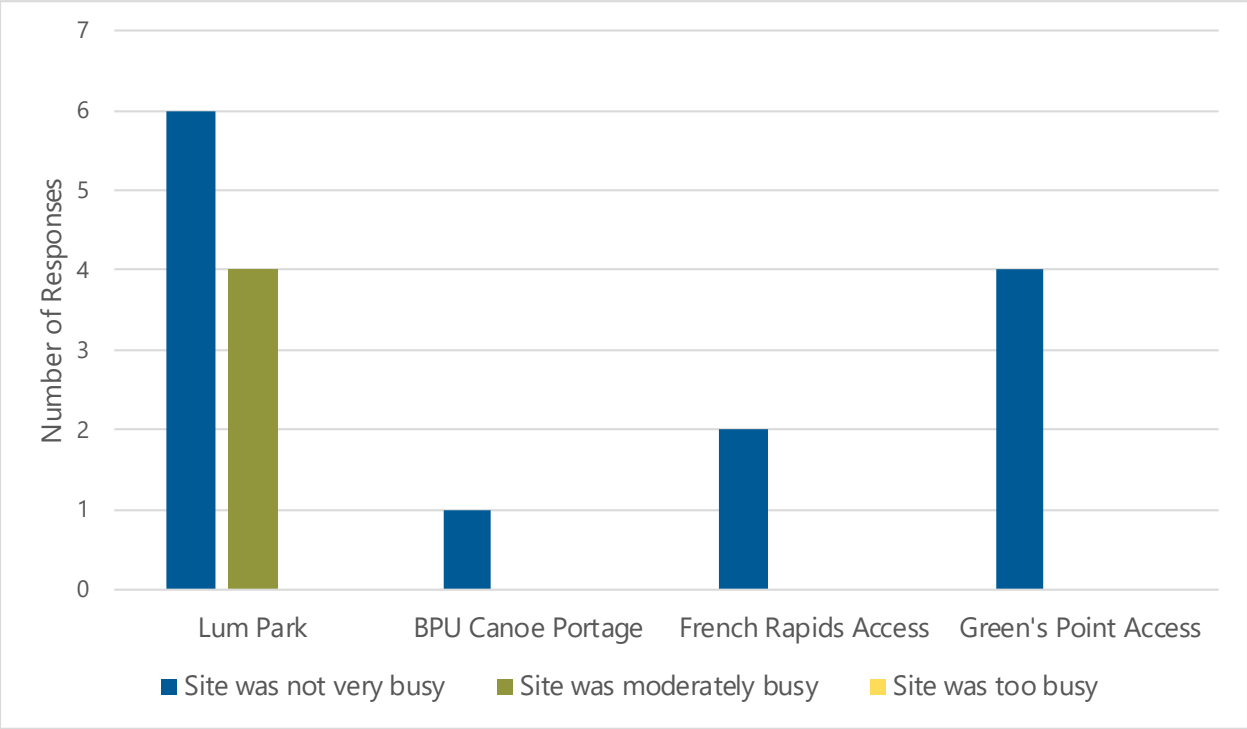


Figure 5-9 Perception of Site Capacity

5.2.5 User Satisfaction and Feedback

User satisfaction among all of the survey participants was high, with 95 percent of respondents stating that they were satisfied with the number of available recreational amenities at a given facility. One respondent indicated they were unsatisfied with Lum Park due to the length of time it took to complete a boat inspection and this recreational use questionnaire. Similarly, 95 percent of surveyed users stated that they found the overall condition of the facilities satisfactory and that they would recreate at the respective facilities again.

When prompted if there were additional recreation amenities needed at the facilities, participants stated no additions are needed. Two participants provided additional comments as part of the survey: one user of the French Rapids access noted that they liked how the park was never busy, and one user of Lum Park stated that they liked fishing at the fishing pier.

5.3 Spot Counts

Spots counts of the number of vehicles and trailers present at each facility were conducted to obtain a snapshot of use at each facility. The spot counts indicated Lum Park exhibited more use than the other facilities, presumably due to hosting more recreational amenities than the other facilities. Spots counts at

the canoe portage, French Rapids access, or Green's Point access, did not identify any vehicles or trailers (Table 5-5).

Table 5-5 Spot Counts

Date	Number of Vehicles	Number of Trailers
Lum Park		
June 21, 2019 (Weekday)	5	5
June 25, 2019 (Weekday)	2	2
June 26, 2019 (Weekday)	3	3
July 7, 2019 (Holiday Weekend)	7	7
July 8, 2019 (Weekday)	1	1
July 9, 2019 (Weekday)	0	0
July 11, 2019 (Weekday)	7	5
July 16, 2019 (Weekday)	0	0
July 19, 2019 (Weekday)	3	3
July 25, 2019 (Weekday)	1	1
July 30, 2019 (Weekday)	4	4
July 30, 2019 (Weekday)	0	0
August 7, 2019 (Weekday)	1	1
September 5, 2019 (Weekday)	3	3
September 5, 2019 (Weekday)	4	4
Canoe Portage		
June 25, 2019 (Weekday)	0	0
July 30, 2019 (Weekday)	0	0
September 5, 2019 (Weekday)	0	0
French Rapids Access		
July 7, 2019 (Holiday Weekend)	0	0
July 8, 2019 (Weekday)	0	0
July 30, 2019 (Weekday)	0	0
September 5, 2019 (Weekday)	0	0
Green's Point Access		
June 25, 2019 (Weekday)	0	0
July 8, 2019 (Weekday)	0	0

6.0 Site Recommendations

Over the course of the study period, survey respondents were asked to provide suggestions related to site improvement needs. Additionally, when performing condition assessments, field staff made notes related to visitor safety, signage, and/or potentially useful amenities at each site. The suggestions and recommendations for each site are discussed below.

6.1.1 Canoe Portage

The canoe portage is a small park-like space that provides recreational users a canoe portage to the Mississippi River, as well as on-site restrooms and opportunities for shoreline fishing. The surveyed users at the canoe portage noted they were overall satisfied with the amenities and condition of the facility. Overall, the park is in good condition, receiving an average condition score of 4.0 (Good) on a 5-point scale. Continued routine maintenance of existing site amenities is recommended; no additional amenities or non-routine maintenance are recommended based on this recreation use and inventory study.

6.1.2 Lum Park

Lum Park provides a variety of amenities to recreational users, including motorized boat access to Rice Lake and is popular with anglers for its fishing pier. Approximately 90 percent of the survey participants were satisfied with the amenities provided at this site. One user was moderately unsatisfied due to the length of time it took to complete a boat inspection and this recreational use questionnaire. Overall, the park is in good condition, receiving an average condition score of 4.0 (Good) on a 5-point scale. Continued routine maintenance of existing site amenities is recommended; no additional amenities or non-routine maintenance are recommended based on this recreation use and inventory study.

6.1.3 French Rapids Access

The French Rapids access provides motorized boat access to the Mississippi River via a paved launch. The site is primarily used for boat access and shoreline fishing. The surveyed users at French Rapids access noted they were satisfied with the amenities and condition of the facility.

BPU staff noted that parking and turf management were adequate at this facility, contributing to the site's average condition score of 3.0 (Adequate) on a 5-point scale. The current parking consists of a small gravel surface that is infrequently maintained and contains potholes resulting in puddles during rain events. Although the parking lot is appropriately sized for the amount of site use, more frequent lot surface maintenance, to minimize the presence of potholes, is recommended. The turf score for the site was marginal due to the absence of significant turf areas at this site. Given the site's primary purpose is to provide boating access, the lack of turf does not contribute significantly to site use. No additional amenities or maintenance are recommended based on this recreation use and inventory study.

6.1.4 Green's Point Access

Green's Point access provides a walk-in access for canoes and kayaks to the Mississippi River, as well as opportunities for shoreline fishing. Survey participants at the Green's Point access primarily used the site for shoreline fishing. Overall, the park's condition is adequate, receiving an average condition score of 3.0

(Adequate) on a 5-point scale. All survey participants noted they were satisfied with the amenities provided and overall condition of the site. Continued routine maintenance of existing site amenities is recommended; no additional amenities or non-routine maintenance are recommended based on this recreation use and inventory study.

7.0 References

1. **Mead & Hunt.** *Recreational Use Monitoring Plan, Brainerd Hydroelectric Project, FERC Project No. 2533.* Brainerd, Minnesota : Potlatch Corporation, May 1994.

2. **Federal Energy Regulatory Commission (FERC).** *Division of Hydropower Administration & Compliance, Compliance Handbook.* Washington : Department of Energy, 2015.

3. **Barr Engineering Co.** Revised Study Plan - Brainerd Hydroelectric Project FERC License No. 2533. December 10, 2018.

Appendix A

Facility Inventory Assessment Form

Facility Inventory Assessment - Dam Site Canoe Portage

Date:10-14-19	Site Name:canoe Portage	Evaluator:Scott Magnuson	Facility Ownership:Brainerd Public Utilities

Directions: Please Include condition of each amenity based on the following ratings; please take photo documentation of all amenities

1 - Poor	In poor condition: Critically damaged, needs immediate repair or replacement, past intended life use
2 - Marginal	In marginal condition: is defective and in need of replacement, but is still in a workable condition
3 - Adequate	In adequate condition: is moderately deteriorated, has not exceeded its intended life use, minor compliance issues
4 - Good	In good condition: may be slightly defective, no longer new, is overall functional and in working condition
5 - Excellent	In excellent condition: In new or like new condition, no visible defects

Recreation Amenities

Type	Notes/Comments (please mark N/A if not present at location)	Ratings	Photo Checklist
Playgrounds	**N/A**		
Fishing Pier	**N/A**		
Basketball Court	**N/A**		
Tennis Court	N/A		
Soccer Fields	N/A		
Baseball Fields	N/A		
Volleyball Courts	N/A		
Softball Fields	N/A		
Camping Facilities	N/A		
Pathways/Trails	N/A		
Canoe Portage/Carry In	tar and concrete trail for canoe portage use, a few chipped out areas of tar, but easily avoidable	4	yes
Other Sporting Fields	N/A		
Site Amenities			
Site Furnishings (benches, bike racks, picnic tables, etc.)	Canoe rack set up next to restrooms	3	yes
Docks	N/A		
Trailer Accessible Boat Ramp	N/A		
Potable Water	N/A		
Lighting	N/A		
Signage (include # of signs in notes)	canoe portage signs seen from river, other signs near restrooms	3	yes
Parking Spaces (include # of spaces in notes)	N/A		
Parking Lot Surface (paved/unpaved, condition)	N/A		
Park Structures			
Restrooms	two concrete outhouses with updated fixtures inside, new paint	4	yes
Picnic Shelters	N/A		
Recreation Center	N/A		
Natural			
Turf	N/A		
Park Trees	N/A		
Landscaping	Landscaping/turf are very well kept	4	yes
Shoreline (erosion, invasive weeds, etc.)	shoreline is in good shape	4	yes
Natural Areas			

Comments

there is a comment card option at this site, and we receive numerous compliments on the facility

Facility Inventory Assessment - Lum Park

Date:10-14-19	Site Name:Lum Park	Evaluator:Scott Magnuson	Facility Ownership:City of Brainerd

Directions: Please Include condition of each amenity based on the following ratings; please take photo documentation of all amenities

1 - Poor	In poor condition: Critically damaged, needs immediate repair or replacement, past intended life use
2 - Marginal	In marginal condition: is defective and in need of replacement, but is still in a workable condition
3 - Adequate	In adequate condition: is moderately deteriorated, has not exceeded its intended life use, minor compliance issues
4 - Good	In good condition: may be slightly defective, no longer new, is overall functional and in working condition
5 - Excellent	In excellent condition: In new or like new condition, no visible defects

Recreation Amenities			
Type	**Notes/Comments (please mark N/A if not present at location)**	**Ratings**	**Photo Checklist**
Playgrounds	**Three sets of playground equipment, all in good condition**	**4**	yes
Fishing Pier	**T-shaped fishing pier, in good condition, near beach and boat ramp**	**4**	yes
Basketball Court	**N/A**		
Tennis Court	N/A		
Soccer Fields	N/A		
Baseball Fields	N/A		
Volleyball Courts	Two sand volleyball courts near campground, no nets at time of evaluation (Fall time)	3	yes
Softball Fields	N/A		
Camping Facilities	Camper use only, no tents, open field with hook-ups, used frequently. Fire wood available.	3	yes
Pathways/Trails	N/A - all open area throughout park		
Canoe Portage/Carry In	N/A		
Other Sporting Fields	Disc golf - newer baskets and tee boxes. Used quite a lot from observations	4	yes
Site Amenities			
Site Furnishings (benches, bike racks, picnic tables, etc.)	A few bike racks, lot's of benches throughout and lots of picnic tables, in four separate pavillions	4	yes
Docks	one older dock at boat launch, could use some work, close to water surface and fairly small	3	yes
Trailer Accessible Boat Ramp	concrete planks, in a nice bay for easy loading and unloading, good approach to ramp helps speed things up	4	yes
Potable Water	drinking fountains at restroom building	3	yes
Lighting			
Signage (include # of signs in notes)	lots of signage throughout park, to many to count. Everything is well marked.	4	yes, some
Parking Spaces (include # of spaces in notes)	30 truck trailer spots, 45 single vehicle spots	4	yes
Parking Lot Surface (paved/unpaved, condition)	all parking is paved, probably 10 years old, but striped and in very good condition, no potholes	4	yes
Park Structures			
Restrooms	mens and womens restrooms with running water, four stalles in each unit, vending machine outside. Needs some paint, but building in good s	3	yes
Picnic Shelters	four pavilions, one large with 20 picnic tables, three others smaller, 10 tables each. New roofs, fresh paint on structure, concrete floor	4	yes
Recreation Center	N/A		
Natural			
Turf	lots of grass area, very well maintained by city parks crew	5	yes
Park Trees	numerous types and size of trees, all in good shape/pruned	4	yes
Landscaping	not much extra landscaping other than grass		
Shoreline (erosion, invasive weeds, etc.)	shoreline is in good shape	4	
Natural Areas			

Comments

There is a swimming beach at the site, about 75 feet of shoreline and 20 feet deep. Nice sand and very clean (weeds, sticks etc.) Overall, this is a very nice park with fishing facilities and boat launch. The site is very well groomed, and gets used quite frequently. Inside of the restroom building, there are showers, one in the mens and one in the womens. these are in good shape, they were moved from the "beach" building in 2006.

Facility Inventory Assessment - FrenchRapids

Date:10-14-19	Site Name:French Rapids	Evaluator:Scott Magnuson	Facility Ownership:Crow Wing County

Directions: Please Include condition of each amenity based on the following ratings; please take photo documentation of all amenities

1 - Poor	In poor condition: Critically damaged, needs immediate repair or replacement, past intended life use
2 - Marginal	In marginal condition: is defective and in need of replacement, but is still in a workable condition
3 - Adequate	In adequate condition: is moderately deteriorated, has not exceeded its intended life use, minor compliance issues
4 - Good	In good condition: may be slightly defective, no longer new, is overall functional and in working condition
5 - Excellent	In excellent condition: In new or like new condition, no visible defects

Recreation Amenities			
Type	**Notes/Comments (please mark N/A if not present at location)**	**Ratings**	**Photo Checklist**
Playgrounds	**N/A**		
Fishing Pier	**N/A**		
Basketball Court	**N/A**		
Tennis Court	N/A		
Soccer Fields	N/A		
Baseball Fields	N/A		
Volleyball Courts	N/A		
Softball Fields	N/A		
Camping Facilities	N/A		
Pathways/Trails	Trailhead for cross country ski trail		
Canoe Portage/Carry In	N/A		
Other Sporting Fields	N/A		
Site Amenities			
Site Furnishings (benches, bike racks, picnic tables, etc.)	N/A		
Docks	N/A		
Trailer Accessible Boat Ramp	concrete planks, good approach to ramp helps speed things up	3	yes
Potable Water	N/A		
Lighting	N/A		
Signage (include # of signs in notes)	two signs leading to landing, invasive species signs, ski trail signs	3	yes, some
Parking Spaces (include # of spaces in notes)	just a gravel area, hard to really determine total parking space count	2	yes
Parking Lot Surface (paved/unpaved, condition)	semi-maintained gravel parking area, puddles during rain events	2	yes
Park Structures			
Restrooms	N/A		
Picnic Shelters	N/A		
Recreation Center	N/A		
Natural			
Turf	trees and gravel, not a lot of turf	2	yes
Park Trees	N/A		
Landscaping	N/A		
Shoreline (erosion, invasive weeds, etc.)	shoreline is in good shape	4	
Natural Areas			

Comments

not a lot of fishing activity going on at this sight, there was a fair amount of people just sitting in their cars

Facility Inventory Assessment - Greens Point

Date:10-14-19	Site Name:Greens Point	Evaluator:Scott Magnuson	Facility Ownership:MnDNR

Directions: Please Include condition of each amenity based on the following ratings; please take photo documentation of all amenities

1 - Poor	In poor condition: Critically damaged, needs immediate repair or replacement, past intended life use
2 - Marginal	In marginal condition: is defective and in need of replacement, but is still in a workable condition
3 - Adequate	In adequate condition: is moderately deteriorated, has not exceeded its intended life use, minor compliance issues
4 - Good	In good condition: may be slightly defective, no longer new, is overall functional and in working condition
5 - Excellent	In excellent condition: In new or like new condition, no visible defects

Recreation Amenities			
Type	**Notes/Comments (please mark N/A if not present at location)**	**Ratings**	**Photo Checklist**
Playgrounds	**N/A**		
Fishing Pier	**N/A**		
Basketball Court	**N/A**		
Tennis Court	N/A		
Soccer Fields	N/A		
Baseball Fields	N/A		
Volleyball Courts	N/A		
Softball Fields	N/A		
Camping Facilities	N/A		
Pathways/Trails	N/A		
Canoe Portage/Carry In	Nice grass trail down to river for canoe carry in, with a small, permanent dock	4	yes
Other Sporting Fields	N/A		
Site Amenities			
Site Furnishings (benches, bike racks, picnic tables, etc.)	N/A		
Docks	one small premanent docking area	3	yes
Trailer Accessible Boat Ramp	N/A		
Potable Water	N/A		
Lighting	N/A		
Signage (include # of signs in notes)	public water access sign on CR3, good signage at parking lot	3	yes
Parking Spaces (include # of spaces in notes)	really just a cul-de-sac, not a lot of parking, no designated trailer parking, but mostly trucks with canoes on top.	2	yes
Parking Lot Surface (paved/unpaved, condition)	tared parking area at end of road, see above	2	yes
Park Structures			
Restrooms	N/A		
Picnic Shelters	N/A		
Recreation Center	N/A		
Natural			
Turf	N/A		
Park Trees	N/A		
Landscaping	N/A		
Shoreline (erosion, invasive weeds, etc.)	shoreline is in good shape	4	yes
Natural Areas			

Comments

I was at this site in October, saw three duck hunting parties just coming off the water, they were all satisfied with the facility

Appendix B

Recreation Facility Inventory and Condition Assessment Photo Log

Canoe Portage

BPU Canoe Portage Photo 1: Asphalt path for canoe portage, restroom facilities, and canoe rack

BPU Canoe Portage Photo 2: General site landscaping

BPU Canoe Portage Photo 3: Restroom facilities and garbage can

BPU Canoe Portage Photo 4: Concrete path for canoe portage; signs showing warnings for the area

BPU Canoe Portage Photo 5: Asphalt path for canoe portage use

BPU Canoe Portage Photo 6: Concrete path for canoe portage use and signage with site rules

BPU Canoe Portage Photo 7: Asphalt path for canoe portage use and signage with site rules

BPU Canoe Portage Photo 8: Shoreline; buoys warning of BPU facility

BPU Canoe Portage Photo 9: Shoreline at canoe portage with large riprap in the background

Lum Park

Lum Park Photo 1: Access signage for boat trailer parking

Lum Park Photo 2: Access signage providing direction to beach, boat ramp, and camping area

Lum Park Photo 3: Boat trailer parking area and restroom structure

Lum Park Photo 4: Parking area for vehicles with boat trailers

Lum Park Photo 5: Parking lot for single vehicles with nearby mature trees and picnic shelter/pavilion

Lum Park Photo 6: Large picnic shelter available for reservations; capacity for approximately 20 picnic tables

Lum Park Photo 7: Picnic shelter with picnic tables stored for end of season

Lum Park Photo 8: Picnic shelter with picnic tables stored for end of season

Lum Park Photo 9: Men and women's restroom facility with running water with adjacent handicap parking

Lum Park Photo 10: Restroom facilities with playground in the background and adjacent handicap parking

Lum Park Photo 11: Potable water source

Lum Park Photo 12: Signage and disposable bags for cleaning up after pets

Lum Park Photo 13: Sand volleyball courts with nets removed for season

Lum Park Photo 14: Bike rack with playground equipment in the background

Lum Park Photo 15: Paved walking path adjacent to disc golfing course

Lum Park Photo 16: Landscaping with large mature trees adjacent to paved walking path

Lum Park Photo 17: Park bench under mature trees

Lum Park Photo 18: Signage for invasive species and potential swimming hazards

Lum Park Photo 19: Signage for aquatic and invasive species next to T-shaped pier for shoreline fishing

Lum Park Photo 20: Trailer accessible boat ramp with dock

Lum Park Photo 21: Sandy swimming beach near dock

Lum Park Photo 22: Swimming beach and adjacent shoreline

French Rapids Access

French Rapids Access Photo 1: Signage with directions to French Rapids access

French Rapids Access Photo 2: Additional signage providing directions to French Rapids access

French Rapids Access Photo 3: Trailhead with site information and trail maps

French Rapids Access Photo 4: Trailer accessible boat ramp

French Rapids Access Photo 5: Shoreline providing canoe access next to the trailer accessible boat ramp

French Rapids Access Photo 6: Shoreline showing no signs of erosion

Green's Point Access

Green's Point Access Photo 1: Asphalt parking area at end of road, no striped/designated parking spots

Green's Point Access Photo 2: Green's Point site access signage

Green's Point Access Photo 3: Signage at the site access for fishing regulations, exotic species alerts, aquatic nuisance species, and site use rules

Green's Point Access Photo 4: Access stairs to small permanent dock, shoreline, and trails

Green's Point Access Photo 5: Shoreline and grass trail along shoreline

Green's Point Access Photo 6: Grass trail along the shoreline

Green's Point Access Photo 7: Canoe portage/carry in access and trail along shoreline

Green's Point Access Photo 8: Canoe portage/carry in access point

Green's Point Access Photo 9: Additional canoe portage/carry in access point

Green's Point Access Photo 10: Shoreline adjacent to small permanent dock

Appendix C

Recreation Use Survey Questionnaire

Revised Study Plan
Brainerd Hydroelectric Project
FERC License No. 2533
Recreational Use Questionnaire

1. Which facility are you using today?
   - BPU Canoe portage
   - Lum Park
   - French Rapids access
   - Green's Point access

2. How many people are in your party, including you?
   - 1
   - 2
   - 3-5
   - 6-10
   - More than 10

3. How many vehicles did your group come with?
   - 1
   - 2
   - 3-5
   - 6-10
   - More than 10

4. How often do you visit this facility?
   - First time
   - 1-3 times a year
   - 4-6 times a year
   - 6-10 times a year
   - 11-20 times a year
   - More than 20 times a year

5. What type of recreation activity(ies) do you plan to/did you participate in today?
   - Canoeing/kayaking
   - Boating (motorized boat)
   - Camping
   - Fishing
   - Hunting
   - Trapping
   - Wildlife viewing
   - Swimming

- Picnicking
- Other _____

6. Why did you choose to come to this recreation site versus another recreation site today?
   - (open-ended response)

7. When you come here, how long do you usually stay (hours)
   - <1 hour
   - 1-2 hours
   - 2-4 hours
   - 4-8 hours
   - >8 hours

8. What time of year do you typically come here?
   - Winter (December – March)
   - Spring (April – May)
   - Summer (June – September)
   - Fall (October – November)

9. Did you experience any difficulty accessing the resources you were hoping to access when you came here today?
   - Yes
   - No

10. During your visit to this site today, what was your perception on the amount of use occurring?
    - Site was not very busy
    - Site was moderately busy
    - Site was too busy

11. During your visit to this site today, did you experience any conflict with other recreational activities or visitors?
    - Yes (please explain)
    - No

12. What amenities are most important to you when recreating at this site (choose all that apply)?
    - General access
    - ADA accessibility
    - Parking
    - Signs and information
    - Picnic table/shelters
    - Boat launch

- Boat dock
- Fishing dock
- Lighting
- Restrooms
- Trails
- Trash receptacles

13. Overall, how satisfied were you with the number of available recreational amenities at this facility?
    - Satisfied
    - Moderately satisfied
    - Neither satisfied nor unsatisfied
    - Moderately unsatisfied
    - Unsatisfied (explain why)

14. Overall, how would you rate the overall condition of this recreation site?
    - Satisfactory
    - Moderately satisfactory
    - Neither satisfactory nor unsatisfactory
    - Moderately unsatisfactory
    - Unsatisfactory (explain why)

15. Are there any additional recreation amenities needed at this recreation site?
    - Yes (write-in what)
    - No

16. Would you recreate at this site again in the future?
    - Yes
    - No

17. Any additional comments or suggestions?

Appendix D

Recreational Use Survey Raw Data

Weather Conditions	Which facility are you using today?	How many people are in your party, including you?	How many vehicles did your group come with?	How often do you visit this facility?	What type of recreation activity(ies) do you plan to/did you participate in today?	If Other, please explain.	Why did you choose to come to this recreation site versus another recreation site today?	When you come here, how long do you usually stay (hours)?	What time of year do you typically come here?	Did you experience any difficulty accessing the resources you were hoping to access when you came here today?	If Yes, please explain.	During your visit to this site today, what was your perception on the amount of use occurring?	During your visit to this site today, did you experience any conflict with other recreational activities or visitors?	What amenities are most important to you when recreating at this site (choose all that apply)?	Overall, how satisfied were you with the number of available recreational amenities at this facility?	If Unsatisfied, please explain why.	Overall, how would you rate the overall condition of this recreation site?	If Unsatisfied, please explain why.	Are there any additional recreation amenities	If Yes, write-in what.	Would you recreate at this site again in the future?	Any additional comments or suggestions?	CreationDate
clear, sunny, calm	BPU Canoe portage	1	1	6-10 times a year	Fishing		close to home	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes		5/30/2019 16:34
	BPU Canoe portage	1	1	1-3 times a year	Canoeing_kayaking		portage	<1 hour	Summer (June – September)	No		Site was not very busy	No	General_access,Restrooms	Satisfied		Satisfactory		No		Yes		6/4/2019 16:48
	BPU Canoe portage																						6/25/2019 18:33
	BPU Canoe portage				Other	nobody here				No		Site was not very busy	No										7/7/2019 14:29
	BPU Canoe portage																						7/30/2019 13:29
	BPU Canoe portage																						9/5/2019 13:30
	French Rapids access	2	1	6-10 times a year	Fishing		like fish off shore	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access,Parking	Satisfied		Satisfactory		No	we like it somewhat primative	Yes		5/26/2019 13:32
	French Rapids access	2	1	4-6 times a year	Fishing		to fish off shore, close to home	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes	like the fact its never busy	5/30/2019 13:16
	French Rapids access																						7/7/2019 15:51
	French Rapids access																						7/8/2019 18:28
	French Rapids access																						7/30/2019 15:42
	French Rapids access																						9/5/2019 17:14
overcast	French Rapids access	2	2	More than 20 times a year		these guys are here for sex !! guys on guys	evidently for sex	1-2 hours	Summer (June – September)	No		Site was not very busy	No	Parking	Satisfied		Satisfactory		No		Yes	Im done doing surveys at this location. Beautiful access taken over by gays, and people are either scared or too embarrased to use this landing. its not being utilized for anything else.	9/5/2019 17:35
	Green's Point access	2	2	More than 20 times a year	Fishing		close to home	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes		5/28/2019 20:24
	Green's Point access	3-5	2		Canoeing_kayaking	with notes in them. out																	never made contact with them	5/28/2019 20:46
	Green's Point access	1	1	1-3 times a year	Fishing		shore fishing	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes		6/6/2019 18:15
	Green's Point access																						6/25/2019 18:04
sunny and calm	Green's Point access	2	2	1-3 times a year	Fishing	shore fishing	close to home and ussually good fishing	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes		7/7/2019 16:10
	Green's Point access																						7/8/2019 18:50
overcast	Green's Point access	3-5	1	4-6 times a year	Fishing			2-4 hours	Fall (October – November)	No		Site was not very busy	No	General_access	Satisfied		Satisfactory		No		Yes		9/5/2019 15:41
	Lum Park	2	1	1-3 times a year	Fishing		other lake acesses are always too busy . not so here	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access,Parking,Boat_launch,Boat_dock,Trash_receptacles	Satisfied		Satisfactory		No		Yes		5/26/2019 15:35
sunny 60 deg	Lum Park	3-5	1	1-3 times a year	Boating_motorized_boat,Fishing		close to home	4-8 hours	Summer (June – September)	No		Site was not very busy	No	General_access,Parking,Boat_launch	Satisfied		Satisfactory		No		Yes		5/26/2019 15:38
	Lum Park	1	1	1-3 times a year	Boating_motorized_boat		to try boat out for the first time this year. not busy here	1-2 hours	Spring (April – May)	No		Site was not very busy	No	General_access,Boat_launch,Boat_dock,Parking	Satisfied		Satisfactory		No		Yes		5/26/2019 15:41
	Lum Park																						one car and boat trailer never talked to them	5/28/2019 20:47
	Lum Park	2	1	More than 20 times a year	Fishing		close to home	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access,Fishing_dock	Satisfied		Satisfactory		No		Yes		5/28/2019 20:57
sunny,calm	Lum Park		2		Boating_motorized_boat,Fishing,Other	two trucks with trailers in parking lot , never talked to them																		5/30/2019 15:16
sunny, calm	z	2	1	4-6 times a year	Fishing,Picnicking		close to home	2-4 hours	Summer (June – September)	No		Site was not very busy	No	General_access,Parking,Picnic_table_shelters,Fishing_dock	Satisfied		Satisfactory		No		z	fishing off fishing pier	5/30/2019 16:03
sunny	Lum Park				Boating_motorized_boat,Other	spot check two trucks with boat trailers, appear to be fisherman????																		6/6/2019 18:38
	Lum Park																						6/21/2019 15:22
	Lum Park																						6/25/2019 18:22
	Lum Park																						6/26/2019 18:48
	Lum Park																						7/7/2019 14:45
	Lum Park	2	1	4-6 times a year	Fishing		close to home and a good access	4-8 hours	Summer (June – September)	No		Site was moderately busy	No	General_access,Parking,Boat_launch	Satisfied		Satisfactory		No		Yes		7/7/2019 14:49
sunny calm	Lum Park	3-5	1	1-3 times a year	Fishing		location	2-4 hours	Summer (June – September)	No		Site was moderately busy	No	General_access,Boat_launch	Moderately unsatisfied	weed inspectors take up time and now you asking questions too not happy	Satisfactory		No		No	not if continually bothered with questions just want to go fishing	7/7/2019 14:58
0 degrees sunny and cal	Lum Park	6-10	3-5	1-3 times a year	Boating_motorized_boat	pontoon ride	close to home ussually not busy	2-4 hours	Summer (June – September)	No		Site was moderately busy	No	General_access,Boat_launch	Satisfied		Moderately satisfactory		No		Yes		7/7/2019 15:32
sunny and calm	Lum Park	3-5	2	1-3 times a year	Boating_motorized_boat	potoon ride family get together weekend	close to home	2-4 hours	Summer (June – September)	No		Site was moderately busy	No	General_access,Parking,Boat_launch	Satisfied		Satisfactory		No		Yes		7/7/2019 15:35
	Lum Park																						7/8/2019 18:17
	Lum Park																						7/9/2019 18:31
	Lum Park																						7/11/2019 18:47
	Lum Park																						7/16/2019 18:49
	Lum Park																						7/19/2019 18:57
	Lum Park																						7/25/2019 18:08
	Lum Park																						7/30/2019 14:58
calm\sunny	Lum Park	2	1	4-6 times a year	Fishing		good fishing	2-4 hours	Summer (June – September)	No		Site was not very busy	No	Boat_launch,Parking,Boat_dock	Satisfied		Satisfactory		No		Yes		7/30/2019 15:02
	Lum Park																						7/30/2019 16:34
	Lum Park																						8/7/2019 15:41
	Lum Park																						9/5/2019 11:29
	Lum Park																						9/5/2019 17:35