# UPPER MISSISSIPPI RIVER RESTORATION FEASIBILITY REPORT WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

**GREEN ISLAND** 

# HABITAT REHABILITATION AND ENHANCEMENT PROJECT

POOL 13, UPPER MISSISSIPPI RIVER RIVER MILES 545.9 THROUGH 548.7 JACKSON COUNTY, IOWA

> APPENDIX E ENGINEERING

ATTACHMENT D WATER QUALITY

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## 1. PURPOSE

The purpose of this appendix is to evaluate the results from water quality monitoring performed by Rock Island District (District) personnel and the Iowa Department of Natural Resources (DNR) at potential environmental enhancement sites located within the Green Island Habitat Rehabilitation and Enhancement Project (HREP). Water quality monitoring done by the District was performed with the primary objective of defining pre-Project baseline water quality conditions. Water clarity monitoring was performed by the Iowa DNR with the objective of better understanding sediment inputs and distribution within the project.

### 2. INTRODUCTION

Baseline water quality monitoring was initiated in order to determine pre-Project conditions and assist with selecting and locating alternatives for habitat rehabilitation and enhancement. This monitoring also supports future evaluation of the Project's goals of providing suitable summer and winter fish refuges and increasing the coverage of aquatic vegetation for waterfowl habitat. The Green Island project is a lentic wetland and ox-bow lake complex with water control structures situated behind a levee at Mississippi River miles 545.9-548.7. The project is split into two water management pools. Pool A on the western side of the project and Pool B on the eastern side. One water quality monitoring site was chosen in Pool A, Site W-M547.7H. located in Fish Lake. Two water quality monitoring sites were chosen in Pool B, sites W-M546.1J and W-M546.8K. Site W-M546.1J is located in McGann's Lake, near the northeastern corner of the project. Site W-M546.8K is located further west in Sawmill Lake. Water quality monitoring sites were placed in deeper areas of the project which were likely to be representative of potential fish overwintering habitat. District personnel began monitoring at sites W-M546.1J and W-M547.7H on December 13<sup>th</sup>, 2019. After one year of observing low dissolved oxygen and high amounts of submerged aquatic vegetation at site W-M546.1J, the Project Delivery Team (PDT) and Iowa DNR identified a need for data from a site with less aquatic vegetation. Site W-M546.8K was added and monitoring commenced on June 2<sup>nd</sup>, 2020. Baseline monitoring is ongoing for all sites. Submerged and floating aquatic vegetation is frequently observed in the summer at all three of the water quality monitoring sites. Water quality monitoring sites are shown in Figure D-1.

Starting in June 2021, the PDT began a water clarity study in partnership with the Iowa DNR field staff on the Green Island project. This study monitored water clarity at 8 sites around the project with the goal of gaining a better understanding of the movement of sediment into and around the project. See Figure D-1 for monitoring sites and Figure D-2 for flow paths in and around the project area. Sediment deposition throughout the life of the project has reduced the depth of Green Island's ox-bow lakes, limiting their efficacy as fish refuge. Additionally, deposition in the drainage ditches of the project has limited the ability of the DNR to perform effective drawdowns, which are necessary to maintain and regenerate high quality moist soil and emergent aquatic vegetation. While water clarity data cannot be used as a quantitative approach for calculating sedimentation rates nor can it be used for designing the size of project features like sediment traps, it may be used to identify channels or inlets with the lowest water clarity, which can help focus additional planning and management efforts.



Figure D-1. Project Water Quality/Clarity Monitoring Locations



Figure D-2. Project Water Flow Diagram

### 3. METHODS

Baseline water quality monitoring was accomplished by the PDT through a combination of collecting grab (discrete) water samples and deploying continuous monitors (sondes). Grab samples were collected every 2 weeks during the summer months, and two or three grab samples were collected during the winter months at each site, each year. In general, sampling date, time, water depth, water transparency via Secchi disk depth, water velocity, wave height, air temperature, percent cloud cover, wind speed and direction, pH, water temperature, DO, turbidity as measured in Formazin Nephelometric Units (FNU)<sup>1</sup>, and specific conductance were recorded in the field. During the summer months, a water sample was collected just below the surface at each sampling site. The sample was placed on ice and shipped to ARDL, Inc., Mt. Vernon, Illinois for total suspended solids (TSS) and chlorophyll analyses. Water grab samples were collected for turbidity as measured in Nephelometric Turbidity Units (NTU)<sup>1</sup> and alkalinity analyses, which were performed by the Rock Island District Water Quality Laboratory. Sample collection/preservation and field/laboratory analytical procedures were performed according to USEPA approved methods. In addition to the manually collected data, YSI EXO2 multiparameter water quality sondes were deployed on numerous occasions. Typically, the sondes were suspended 1 to 2 feet from the bottom of the water column and were programmed to record the following data every 15 minutes: DO, pH, water temperature, depth, specific conductance, and turbidity (FNU). Beginning in the summer 2022 season, sampling frequency was decreased to hourly. Summer deployments typically lasted 2 to 4 weeks with deployed sondes replaced by newly calibrated sondes to create a continuous dataset for the entire season, while in the winter the sondes were deployed for approximately 14 weeks.

Water Clarity was assessed by the Iowa DNR field staff using 60 cm transparency tubes, and the sites were sampled at varying frequencies with respect to the frequency of their operations (Table D-1). Due to instrument limitations, the maximum reading is 60 cm. When the measurement exceeded the 60 cm instrument limit, the field staff entered a 60+ result. All water samples were collected from the surface (0–10 cm) at the specified monitoring stations on the same days. The transparency tube itself was submerged to collect a sample, or a bucket was used to collect a sample from a bridge where using the transparency tube for collection was not possible. During collection, staff took care to not disturb and resuspend the channel bed or shoreline sediment. Routine water clarity monitoring events occurred once a week at Mooney Hollow Bridge and Mooney-Bluff stations. When the stem gates were open, a weekly sample was taken at the Densmore Lake stem gate site. When operating a gate or pump, IADNR collected a water clarity sample at the corresponding monitoring stations. As staff availability allowed, IADNR staff collected additional water clarity measurements within 24 hours of a precipitation event.

<sup>&</sup>lt;sup>1</sup> Due to differences in sensor type, handheld and sonde turbidity readings are reported in FNU and turbidity grab samples analyzed with a turbidimeter are reported in NTU. For the purposes of this evaluation, it was assumed that 1 FNU = 1 NTU.

Station (Gate)	Site Description	Sampling Frequency	Frequency Operated
Mooney Hollow Railroad Bridge	Railroad bridge north of 143rd St and 489th Ave, where Mooney Hollow Creek flows into the SW corner of the project	Weekly	Continuous
Mooney Hollow Bridge	Bridge over culvert where Mooney Hollow and Maquoketa meet	Weekly	Continuous
Maquoketa River Inflow	Channel near parking lot at the end of 501st Ave, Maquoketa River inlets	Weekly when open	Once every few years, rare
Pumphouse Inflow	Channel west of the pump station service road, south of pump station	Weekly when operating pumps	25 to 35 days a year
Densmore Lake Stem Gate	Stem gate allowing flow into Densmore Lake	Weekly when open	Once a year to dewater the 4th ditch
Downstream Gate	Outlet structure in downstream mainstem levee, by Sawmill Lake	Weekly when operating gates	Very rare
Mooney Hollow and Bluff Inflows	Channel by SE boat ramp, where bluff and Mooney Creek meet	Weekly	Continuous
Smith Creek Inflow	Along downstream tie-back levee, SE corner of project	Weekly when open	15 days a year, to fill sub- impoundment

### Table D-1. Water Clarity Sites, Sampling, and Operation Frequency

# 4. RESULTS AND DISCUSSION

In general, the three sites within the Green Island Project exhibited similar lentic characteristics. Each of the sites was prone to spells of low DO, especially during hotter water temperatures and prolonged ice cover. Secchi disk depth, TSS, and turbidity results indicate good conditions for submerged aquatic vegetation. While winter velocities and depths were conducive to good fish overwintering habitat, winter water temperatures and DO were frequently outside of the desired overwintering habitat range. All characteristics are described in more detail below. For the purposes of completing the feasibility report, analysis was performed only on the data collected through September 2022. For temperature and DO boxplot figures, only the timespan of December to March 10<sup>th</sup> was considered winter, even if the sonde was retrieved after March 10<sup>th</sup>, as March 10<sup>th</sup> was the last consistent day of ice cover at all sites, as evidenced by sonde data. Where the collected data included data above or below detection limits, median is used instead of average as a measure of central tendency.

Tables D-3, D-4, and D-5 are summaries of all surface level grab samples taken at sites W-M546.1J, W-M546.8K, and W-M547.7H, respectively. Continuous monitoring results of DO, pH, and temperature are plotted by site and season: Figures D-3 and D-4 are results from Winter 2019-2020, Figures D-5 and D-6 are results from Summer 2020, Figures D-7 and D-8 are results from Winter 2020-2021, Figures D-9 and D-10 are results from Summer 2021, Figures D-11 and D-12 are results from Winter 2021-2022, and Figures D-13 and D-14 are results from Summer 2022. Figures D-15 through D-20 are monitoring results for bluegill model fish overwintering parameters.

### 4.1. Site W-M546.1J

Monitoring of site W-M546.1J consisted of consecutive summer and winter seasons of grab samples beginning in Winter 2019, and three seasons of continuous sonde monitoring, Winter 2019-20, Summer 2020, and Winter 2020-21.

Winter dissolved oxygen (DO) concentrations in both 2019-20 and 2020-21 fell below the target level of 5 mg/L in early/mid-January and hovered around 0-1 mg/L until the beginning of March, around the time of ice melt (Figure D-3, Figure D-7). DO hit a minimum of -0.22 mg/L in Winter 2019-20 and 0.19 mg/L in Winter 2020-21. Negative DO values, such as those observed during the winter of 2019-20, typically result from slight calibration errors in the DO probe. However, the DO grab sample taken in March aligned closely with the sonde readings (Figure D-3), so it can be safely assumed that these readings of negative levels of DO reflect actual conditions of 0 mg/L DO or very close to it. DO levels in the summer of 2020 also fell below 5 mg/L for an extended period of time beginning June 24<sup>th</sup> and not rising above 5 mg/L again until August 19<sup>th</sup>. DO levels during the entire summer 2020 deployment averaged 1.75 mg/L, well below the target DO threshold. While surface readings of DO levels during grab sampling averaged 7.38 mg/L over the course of monitoring, sonde data shows that DO levels diminish quickly with depth. Site W-M546.1J also consistently had significantly lower Chlorophyll levels than either of the other two sites, with a median of  $17.85 \text{ mg/m}^3$  of corrected Chlorophyll a measured (Table D-3). Mucky organic sediments with a high sediment oxygen demand may also contribute to low summer DO levels. Decaying algae and other organic matter consumes oxygen and creates an anaerobic layer of water near the substrate (Coffey, 2005).

Total Suspended Sediment (TSS) values at site W-M546.1J had a median of 6.88 mg/L over the course of monitoring, with a maximum of just 14.4 mg/L. Secchi disk depths were correspondingly high, averaging 61.4 cm, including one instance where the water column was visible clear to the bottom. Summer water temperatures measured by the sonde averaged 24.0 C and did not exceed 28.4 C during the summer of 2020 (Figure D-5), while surface water temperatures were typically higher (Table D-3); these differences in temperature may be due to shading of the water column by vegetation. Winter water temperatures fell to a minimum of 1.36 C in winter 2019-20 and 1.28 C in 2020-21 (Figure D-3, Figure D-7). During the mid-winter sampling runs, ice thickness was measured at 20.3 cm in 2020 and 28 cm in 2021.

### 4.2. Site W-M546.8K

Site W-M546.8K was added as an additional monitoring location in Pool B in June of 2021 and was monitored with grab samples and continuous sonde monitoring for two summer seasons and one winter season. Sonde results from site W-M546.8K are shown in the figures attached and grab samples results are shown in Table D-4.

Summer DO concentrations at site W-M546.8K showed wide diurnal fluctuations in DO and pH in both 2021 and 2022 (Figure D-9, Figure D-13). DO levels would typically peak at around 6 P.M. and fall until 7 A.M, when they would begin rising again. This is characteristic of a system where DO levels are determined by the photosynthesis and respiration of aquatic vegetation or algae. Despite maximum DO levels of 18 mg/L and 17.29 mg/L occurring in 2021 and 2021 respectively, DO levels were below 5 mg/L 67.1% of the time in 2021 and 67.3% of the time in

2022. Site W-M546.8K had chlorophyll concentrations higher that of site W-M546.1J, the other site in Pool B, with a median of 26.3 mg/m<sup>3</sup> at site W-M546.8K as opposed to 17.85 mg/m<sup>3</sup> at site W-M546.1J (Table D-4). Higher levels of algae could exacerbate diurnal DO fluctuations caused by photosynthesis and respiration. Compared to site W-M546.1J, site W-M546.8K also had larger fluctuations in water temperature with maximum water temperatures of 33.1 C in summer 2021 and 32.7 C in 2022 (Figure D-9, Figure D-13). Warmer water has a lower capacity of DO storage, which may additionally exacerbate DO fluctuations at this site.

### 4.3. Site W-M547.4H

Site W-M547.7H had the longest continuous span of monitoring of the sites at Green Island, with grab samples and continuous sonde monitoring occurring for consecutive summer and winter seasons starting in the winter of 2019. Sonde data from site W-M547.7H is attached below, and Table D-5 shows the grab sample results.

Sonde data from the summers of 2020, 2021, and 2022 all show occurrences of wide diurnal DO and pH fluctuations, similar to site W-M546.8K, however site W-M547.7H was also prone to prolonged periods of low DO with very little fluctuation. Despite summer DO concentrations peaking above 10 mg/L each year and as high as 19.9 mg/L in 2021, average DO concentrations remained very low. DO concentrations were below 5mg/L for 77.7% of the time in summer 2020, 65.7% of the time in summer 2021, and 97.8% of the time in summer 2022. Each summer saw at least one stretch where DO levels did not rise above 5mg/L for roughly a month straight, with DO levels in these periods frequently hovering around 0 mg/L (Figure D-6, Figure D-10, Figure D-14).

Generally, pH values at site W-M547.7H stayed within the desired 6.5-8.5 range during the summers of 2021 and 2022, while low water from the 2021 drawdown led to larger diurnal temperature, DO, and pH swings (Figure D-10). These same swings were present at site W-M546.8K in summer 2021, though to a lesser extent due to the deeper water in Pool B. In summer 2021, water at site W-M546.8K averaged 1.12 m deep, while water at site W-M547.7H averaged just 0.88 m deep, even falling to just 0.42 m deep in mid-July (Table D-5). Summer turbidity at site W-M547.7H was low, with an average of 12.58 FNU in 2020, 17.44 FNU in 2021, and 12.48 FNU in 2022 (Figure D-6, Figure D-10, Figure D-14). TSS measurements were correspondingly low, with a median of 11.2 mg/L over the period of monitoring (Table D-5). Summer water temperatures averaged 24.18 C in 2020, 25.39 C in 2021, and 22.97 C in 2022, and rarely went above 30 C.

## 4.4. Light Related Criteria Necessary to Support Submersed Aquatic Vegetation

Light-related criteria necessary to support and sustain submersed aquatic vegetation (SAV) during the growing season in the Upper Mississippi River (UMR) include a Secchi disk depth of >50 cm, a TSS concentration of <25 mg/L, and a turbidity of <20 NTU, as described in UMRCC (2003).

The percentage of water clarity measurements at Site 546.1J during the 2020, 2021, and 2022 growing seasons which met those criteria were as follows: Secchi disk depth: (87.0%), TSS: (91.3%), and turbidity (100%). The percentage of water clarity measurements at Site 546.8K

during the 2021 and 2022 growing seasons that met those criteria were as follows: Secchi disk depth: (53.3%), TSS: (86.7%), and turbidity (80.0%). The percentage of water clarity measurements at Site 547.7H during the 2020, 2021, and 2022 growing seasons, which met those criteria were as follows: Secchi disk depth: (47.8%), TSS: (73.9%), and turbidity (81.8%). Suitability for aquatic vegetation is corroborated by the frequent presence of SAV at all three sites during the growing season.

## 4.5 Water Quality Criteria Necessary to Support Over-Wintering Fish

Palesh and Anderson identify optimum winter bluegill habitat on the Upper Mississippi River system as having depths of greater than 4 feet (1.21 m), DO levels of greater than 5 mg/L, water temperature of 4 degrees Celsius, and no current. Four feet of water was met or exceeded during winter sampling runs in 100% of depth readings at site W-M546.1J, 66.7% of depth readings at site W-M546.8K, and 77.8% of depth readings at site W-M547.7H (Figure D-15). Site W-M546.8K is not shown on the box plots because it was only sampled for one season. Though the sites met optimum depth requirements in a high percentage of measurements, depth at monitoring sites many not be representative of depth throughout the project, as the monitoring sites were chosen specifically for their depth.

With respect to temperature, across all winter monitoring, all three sites were below 4 C for a majority of measurements (Figure D-15, Figure D-16). Percent of measurements under 4 C was calculated as 63.4% at site W-M546.1J, 80.9% at site W-M546.8K, and 72.2% at site W-M547.7H. Breaking this down further, the majority of measurements below 4 C were between 4 and 2 C at all sites, with the percent of measurements in this temperature range calculated as 49.6% for site W-M546.1J, 59.6% for site W-M546.8K, and 50.5% for site W-M547.7H. No site had more than 22% of the winter temperature measurements below 2 C. Because Green Island is sheltered from the main channel of the Mississippi by levees, there is little risk of supercooled water from the main channel being introduced into overwintering fish habitat.

Winter DO was the parameter most variable, year to year, and site to site (Figure D-17, Figure D-18). Overall, DO levels were above the 5 mg/L threshold in 42.3% of measurements over two years of monitoring at site W-M546.1J, 85.4% of measurements over one year of monitoring at site W-M546.8K, and 63.6% of measurements over three years of monitoring at site W-M547.7H. These values also varied year to year, with site W-M547.7H as an extreme example. In winter of 2019-2020, DO sonde data from Site W-M547.7H was above 5 mg/L in 100% of the DO readings, with a minimum of 8.71 mg/L. However, in winter 2020-2021, 60.2% of sonde DO readings from site W-M547.7H were below 5 mg/L, and 50% of total readings were below 1.5 mg/L. In both cases, grab samples of DO corroborate the sonde readings.

Though none of the Green Island sites met the 0 cm/s current requirement for velocity, both sites W-M546.1J and W-M547.7H had median velocity measurements of just over 0.5cm/sec (Figure D-16). The higher velocity measurements at both of these sites tended to occur towards the end of the winter monitoring season after ice melt, during the months of March or April.

### 4.6. Water Clarity Monitoring

Water Clarity was monitored from June 2021 to November 2022, according to the frequencies in

Table D-1. The Maquoketa River Inflow was not operated during the period of data collection, so has no data. A summary of transparency tube measurements is located in Table D-2.

Station	Observations	Min (cm)	Max (cm)	Median (cm)	Note
Mooney Hollow RR Bridge	46	2	60+	60+	
Mooney Hollow Bridge	53	0	60+	60+	Adjusted average
Mooney Hollow Bluff Inflow	45	9	60+	60+	Adjusted average
Pump House Inflow	8	26	51	33	
Downstream Gate Inflow	4	14	37	26	
Densmore Lake Tube	3	60	60+	60+	
Smith Creek Inflow	12	6	60+	15	

### Table D-2. Water Clarity Monitoring Results

DNR staff deemed early summer 2021 measurements at Mooney Hollow Bluff Inflow and Mooney Hollow Bridge not representative due to low water and lots of vegetation; these results were removed from average calculations. Due to an instrument limitation, the maximum reading is 60 cm. When the measurement exceeded the 60 cm instrument value, the field staff entered a 60+ result. Complete monitoring results included in table D-6 through D-12.

Transparency tube results suggest that Mooney Hollow Creek is not a major contributor of sediment into the project. The Mooney Hollow RR Bridge, Mooney Hollow Bridge, and Mooney Hollow Bluff Inflow sites are located in series along the west and south edges of the project. Water clarity measurements averaged 49 cm at Mooney Hollow RR Bridge, and this cleared up further to 54 cm at the Mooney Hollow Bridge site and 55 cm at the Mooney Hollow Bluff Inflow. At each of these locations, water clarity of 60+ cm was the most common reading. A 3.5 to 4 inch rain event on July 15<sup>th</sup> 2022 induced low clarity at Mooney Hollow Bluff Inflow site at the time of sampling. Several of the lower water clarity values at this series of sampling sites corresponded with rainfall events. This evidence, coupled with the overwhelming majority of water clarity observations of 60+ cm at all three of the Mooney Hollow Creek sites suggest that Mooney Hollow Creek is only a periodic contributor of sediment into the project.

The Mississippi River inflow monitoring sites consist of the Pump House Inflow and the Downstream Gate Inflow. The Pump House Inflow contributes to Pool A, while the Downstream Gate flows into Pool B, and the Densmore Lake Tube moves water from Pool A into Densmore Lake in Pool B. Both the Pump House Inflow and the Downstream Gate Inflow had lower water clarity values than the Mooney Hollow Inflows, and likely both contribute sediment into the lakes on the north side of the project. Though only three readings were taken at the Densmore Lake Tube site, all three had water clarity values of 60+ cm, suggesting that most of the sediment brought in at the Pump House Inflow drops out of the water column before reaching the Densmore Lake Tube site.

The Smith Creek Inflow has been operated infrequently due to historic observations of high turbidity by the DNR, but was used in 2021 and 2022 to achieve fall pool raises in Pool B. During the 2021 fall pool raise, field staff collected 10 transparency tube measurements with an average result of 14 cm and ranged from 6 to 24 cm. Only two measurements were taken in fall of 2022, but these samples both had much higher water clarities of 44 and 60+ cm. Smith Creek is likely a contributor to sedimentation in the SE portion of Pool B, but for a limited timeframe since the inlet structure remains closed for much of the year. IA DNR staff noted that it typically takes 15 days of operation to reach the desired water surface in the sub-impoundment during the fall.

# 5. CONCULSION

Pre-Project baseline water quality monitoring was initiated at the first project sites, W-M546.1J and W-M547.7H, on December 13<sup>th</sup>, 2019, and an additional site, W-M546.8K, on June 2<sup>nd</sup>, 2021. Water quality monitoring continued each year for summer and winter seasons for all sites. Water quality monitoring was accomplished through the collection of discrete grab samples and utilization of continuous monitors. Water clarity monitoring commenced on June 19<sup>th</sup>, 2021, and ran through November of 2022. Water clarity readings were taken by Iowa DNR field staff via transparency tube.

All three water quality sites exhibited lentic characteristics, with typically low velocities, good water clarity, and low turbidity and TSS. Summer DO levels frequently exhibited large diurnal fluctuations and extended periods of low DO. DO and temperature fluctuations were particularly acute in 2021, when the project's water level was drawn down to promote vegetation growth. Increasing water depths via dredging may buffer the effects of temperature and DO fluctuations by increasing the volume of DO in the water column. All sites met UMR Secchi disk depth, TSS, and turbidity criteria for SAV a majority of the time, and sites frequently had dense SAV growth.

Winter dissolved oxygen concentrations were variable from year to year, but frequently dipped below 5 mg/L for extended periods of time at all sites. Low winter DO generally persisted until ice cover melted. Increasing depth via dredging may help raise DO concentrations by building up a larger bank of DO prior to ice cover forming. Winter water temperatures were generally below 4 C, but dipped below 2 C less than 25% of the time.

Water clarity measurements suggest that Mooney Hollow Creek is not a constant source of sediment into the project, only contributing quantities of sediment during high rainfall events. Both the Pump House Inflow and the Downstream Gate inflow had lower water clarity readings and may contribute to sedimentation in the northern portion of the project. The Smith Creek inflow was only operated for a short timeframe in the fall, and water clarity readings were drastically different from year to year.

# 6. REFERENCES

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- Upper Mississippi River Conservation Committee (UMRCC). (2003). Proposed Light-Related Water Quality Criteria Necessary to Sustain Submersed Aquatic Vegetation in the Upper Mississippi River.

### Table D-3. Water Quality Monitoring Results from Surface Samples Collected at Site W-M546.1J

Depth (m)         (m/s/s)         (m/s/s)         (m/s/s)         (m/s/m)		Water	Velocity	Water Temp	Dissolved		Secchi disk	Turbidity	TSS	Chlorophyll a	Chlorophyll a cor	Chlorophyll b	Chlorophyll c	Pheophytin a
11/13/2019         2.355         0.52         1         12.88         7.92         -         18.1         -        -         -         - </th <th>Date</th> <th>Depth (m)</th> <th>(cm/sec)</th> <th>(°C)</th> <th>Oxygen</th> <th>рН</th> <th>depth (cm)</th> <th>(NTU)</th> <th>(mg/l)</th> <th>(mg/m3)</th> <th>(mg/m3)</th> <th>(mg/m3)</th> <th>(mg/m3)</th> <th>(mg/m3)</th>	Date	Depth (m)	(cm/sec)	(°C)	Oxygen	рН	depth (cm)	(NTU)	(mg/l)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)
IATIA JOUS       L-38       U-32       I       L-28       I/32       I       L-3       I <thi< th="">       I<th>40/40/0040</th><th>0.055</th><th>0.50</th><th></th><th>(mg/L)</th><th>7.00</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></thi<>	40/40/0040	0.055	0.50		(mg/L)	7.00								
1/23/2020       2.31       0.05       2.4       1.90       7.96       -       5.34       -	12/13/2019	2.355	0.52	1	12.88	7.92	-	8.1	-	-	-	-	-	-
3/10/2020         2.12         0.73         5.7         10.76         7.04         -          17/20201         1.73	1/23/2020	2.31	0.05	2.4	10.29	7.96	-	5.34	-	-	-	-	-	-
0/2/202       2.44       0.94       2.44       9.54       8.14       101       3.66       <5.00	3/10/2020	2.12	0.75	5.7	10.76	7.04	-	6.48	-	-	-	-	-	-
6/16/2020       2.44       0.94       24.4       9.54       8.14       106       3.67       <5.00	6/3/2020	2.41	1.032	26.1	9.88	8.42	171	3.66	<5.00	7.7	8.4	<1.00	<1.00	<1.00
6/30/2020       2.36       1.654       27.4       6.73       8.15       86.5       3.65       <5.00	6/16/2020	2.44	0.94	24.4	9.54	8.14	106	3.67	<5.00	10.2	10.9	<1.00	<1.00	<1.00
7/14/2020       2.355       2.095       27.2       4.39       7.6       62       5.56       4       10.1       10       4.6       <100       <       <         7/28/2020       2.155       1.84       3.01       3.64       7.33       60       5.84       5.6       19.2       14.5       3       <1.00	6/30/2020	2.36	1.654	27.4	6.73	8.15	86.5	3.65	<5.00	13.9	13.6	1.7	<1.00	<1.00
7/28/2020       2.155       1.948       30.1       3.64       7.33       60       5.84       5.6       15.2       14.5       3	7/14/2020	2.35	2.095	27.2	4.39	7.6	62	5.56	4	10.1	10	4.6	<1.00	<1.00
8/11/2020         2.06         0.444         22.5         2.12         6.91         31.5         21.3         1.44         52.9         43.6         12.7         <1.00         14.3           8/25/2020         1.73         0.577         25.4         3.57         7.5         78.5         20.2         .	7/28/2020	2.155	1.948	30.1	3.64	7.33	60	5.84	5.6	19.2	14.5	3	<1.00	7.1
8/25/2020       1.73       0.577       25.4       3.57       7.5       7.5       20.2       . <t< td=""><td>8/11/2020</td><td>2.06</td><td>0.444</td><td>22.5</td><td>2.12</td><td>6.91</td><td>31.5</td><td>21.3</td><td>14.4</td><td>52.9</td><td>43.6</td><td>12.7</td><td>&lt;1.00</td><td>14.3</td></t<>	8/11/2020	2.06	0.444	22.5	2.12	6.91	31.5	21.3	14.4	52.9	43.6	12.7	<1.00	14.3
9/9/2020       1.72       0.234       17       2.44       7.32       61.5       12.3       7.2       22.7       20       2.5       <1.00	8/25/2020	1.73	0.577	25.4	3.57	7.5	78.5	20.2	-	-	-	-	-	-
12/3/2020       1.945       0.282       3       13.61       8.12       -       3.8       -	9/9/2020	1.72	0.234	17	2.44	7.32	61.5	12.3	7.2	22.7	20	2.5	<1.00	3.5
1/2/2021         1.655         0.1         0.8         0.92         7.43         7.4         7.5         7.48         9         7.00         7.10	12/3/2020	1.945	0.282	3	13.61	8.12	-	3.8	-	-	-	-	-	-
3/17/2021       1.86       1.7       3.1       11.53       7.6       96       7.4       -<	2/3/2021	1.655	0.1	0.8	0.92	7.43	-	3.37	-	-	-	-	-	-
6/2/2021       1.62       0.499       22.3       11.68       8.35       109       5.57       4.8       9       10       <1.00	3/17/2021	1.86	1.7	3.1	11.53	7.6	96	7.4	-	-	-	-	-	-
6/15/2021       1.17       6.926       30       7.32       8       41       5.63       8.4       19.2       17.2       3.4       <1.00	6/2/2021	1.62	0.499	22.3	11.68	8.35	109	5.57	4.8	9	10	<1.00	<1.00	<1.00
6/29/2021       1.18       1.044       25.8       7.03       8.04       96.5       4.14       4.8       30.7       28.1       3.7       2.4       3         7/13/2021       1.06       0.4       23.6       5.15       7.43       90       4.88       7.2       15.8       14.5       1.8       <1.00	6/15/2021	1.17	6.926	30	7.32	8	41	5.63	8.4	19.2	17.2	3.4	<1.00	2.5
7/13/2021       1.06       0.4       23.6       5.15       7.43       90       4.88       7.2       15.8       14.5       1.8       <1.00       1.4         7/27/2021       0.95       0.326       26.8       2.5       7.5       83       8.23       7.2       27.3       24.5       3       <1.00	6/29/2021	1.18	1.044	25.8	7.03	8.04	96.5	4.14	4.8	30.7	28.1	3.7	2.4	3
7/27/2021       0.95       0.326       26.8       2.5       7.5       83       8.23       7.2       27.3       24.5       3       <1.00       3.4         8/10/2021       1.17       0.608       28.9       6.91       8.01       66       13.1       5.2       15.5       13.6       <1.00	7/13/2021	1.06	0.4	23.6	5.15	7.43	90	4.88	7.2	15.8	14.5	1.8	<1.00	1.4
8/10/2021       1.17       0.608       28.9       6.91       8.01       66       13.1       5.2       15.5       13.6       <1.00	7/27/2021	0.95	0.326	26.8	2.5	7.5	83	8.23	7.2	27.3	24.5	3	<1.00	3.4
8/24/2021       1.47       0.02       28.8       7.03       8.19       36       2.9       11.3       35.6       33.6       6.3       <1.00	8/10/2021	1.17	0.608	28.9	6.91	8.01	66	13.1	5.2	15.5	13.6	<1.00	<1.00	2.3
9/8/2021       1.72       7.79       21.6       1.85       7.34       79       6.44       8.8       30.7       28.1       4       <1.00       3         12/2/2021       1.635       2.343       3.6       13.28       7.49       127       5.02       -	8/24/2021	1.47	0.02	28.8	7.03	8.19	36	2.9	11.3	35.6	33.6	6.3	<1.00	2
12/2/2021       1.635       2.343       3.6       13.28       7.49       127       5.02       -	9/8/2021	1.72	7.79	21.6	1.85	7.34	79	6.44	8.8	30.7	28.1	4	<1.00	3
2/9/2022       1.21       0.168       0.7       1.02       7.33       -       3.53       -	12/2/2021	1.635	2.343	3.6	13.28	7.49	127	5.02	-	-	-	-	-	-
4/5/2022       1.74       3.61       7.1       12.82       7.83       91       7.4       -	2/9/2022	1.21	0.168	0.7	1.02	7.33	-	3.53	-	-	-	-	-	-
6/1/2022       2.24       1.267       23.4       10.58       8.14       123       4.65       3.44       6.1       5.5       <1.00	4/5/2022	1.74	3.61	7.1	12.82	7.83	91	7.4	-	-	-	-	-	-
6/14/2022       2.23       1.581       29.9       8.75       8.07       68       2.17       3.33       3.8       3.9       <1.00	6/1/2022	2.24	1.267	23.4	10.58	8.14	123	4.65	3.44	6.1	5.5	<1.00	<1.00	<1.00
7/12/2022       1.6       3.459       27       6.83       7.66       58       7.87       6.86       22       18.5       4.2       <1.00       5         7/26/2022       1.35       1.606       28.9       7.9       7.84       55       9.57       7.33       29.7       23.3       2.2       <1.00	6/14/2022	2.23	1.581	29.9	8.75	8.07	68	2.17	3.33	3.8	3.9	<1.00	<1.00	<1.00
7/26/2022       1.35       1.606       28.9       7.9       7.84       55       9.57       7.33       29.7       23.3       2.2       <1.00       9.3         8/9/2022       1.295       4.138       26.6       6.87       7.74       56.5       10.5       6.9       41.4       31.7       4.6       <1.00	7/12/2022	1.6	3.459	27	6.83	7.66	58	7.87	6.86	22	18.5	4.2	<1.00	5
8/9/2022       1.295       4.138       26.6       6.87       7.74       56.5       10.5       6.9       41.4       31.7       4.6       <1.00       14.6         8/23/2022       1.225       1.099       26       8.57       7.87       54       9.56       7.8       39       33.6       1.4       1.2       7         9/7/2022       1.34       3.344       24.8       7.86       7.55       9.55       8.3       35.7       31.2       3.1       1.2       5.8         MIN       0.95       0.02       0.7       0.92       6.91       31.5       2.17       3.33       3.8       3.9       <1.00	7/26/2022	1.35	1.606	28.9	7.9	7.84	55	9.57	7.33	29.7	23.3	2.2	<1.00	9.3
8/23/2022       1.225       1.099       26       8.57       7.87       54       9.56       7.8       39       33.6       1.4       1.2       7         9/7/2022       1.34       3.344       24.8       7.86       7.86       55.5       9.65       8.3       35.7       31.2       3.1       1.2       5.8         MIN       0.95       0.02       0.7       0.92       6.91       31.5       2.17       3.33       3.8       3.9       <1.00       <1.00       <1.00         MAX       2.44       7.79       30.1       13.61       8.42       171       21.3       14.4       52.9       43.6       12.7       2.4       14.6         AVG       1.74       1.64       19.43       7.38       7.75       78.52       7.23       6.38       - <th< td=""><td>8/9/2022</td><td>1.295</td><td>4.138</td><td>26.6</td><td>6.87</td><td>7.74</td><td>56.5</td><td>10.5</td><td>6.9</td><td>41.4</td><td>31.7</td><td>4.6</td><td>&lt;1.00</td><td>14.6</td></th<>	8/9/2022	1.295	4.138	26.6	6.87	7.74	56.5	10.5	6.9	41.4	31.7	4.6	<1.00	14.6
9/7/2022       1.34       3.344       24.8       7.86       7.86       55.5       9.65       8.3       35.7       31.2       3.1       1.2       5.8         MIN       0.95       0.02       0.7       0.92       6.91       31.5       2.17       3.33       3.8       3.9       <1.00	8/23/2022	1.225	1.099	26	8.57	7.87	54	9.56	7.8	39	33.6	1.4	1.2	7
MIN         0.95         0.02         0.7         0.92         6.91         31.5         2.17         3.33         3.8         3.9         <1.00         <1.00         <1.00           MAX         2.44         7.79         30.1         13.61         8.42         171         21.3         14.4         52.9         43.6         12.7         2.4         14.6           AVG         1.74         1.64         19.43         7.38         7.75         78.52         7.23         6.38         -         -         -         -         -	9/7/2022	1.34	3.344	24.8	7.86	7.86	55.5	9.65	8.3	35.7	31.2	3.1	1.2	5.8
MAX         2.44         7.79         30.1         13.61         8.42         171         21.3         14.4         52.9         43.6         12.7         2.4         14.6           AVG         1.74         1.64         19.43         7.38         7.75         78.52         7.23         6.38         - <t< td=""><td>MIN</td><td>0.95</td><td>0.02</td><td>0.7</td><td>0.92</td><td>6.91</td><td>31.5</td><td>2.17</td><td>3.33</td><td>3.8</td><td>3.9</td><td>&lt;1.00</td><td>&lt;1.00</td><td>&lt;1.00</td></t<>	MIN	0.95	0.02	0.7	0.92	6.91	31.5	2.17	3.33	3.8	3.9	<1.00	<1.00	<1.00
AVG         1.74         1.64         19.43         7.38         7.75         78.52         7.23         6.38         - <th< td=""><td>MAX</td><td>2.44</td><td>7.79</td><td>30.1</td><td>13.61</td><td>8.42</td><td>171</td><td>21.3</td><td>14.4</td><td>52.9</td><td>43.6</td><td>12.7</td><td>2.4</td><td>14.6</td></th<>	MAX	2.44	7.79	30.1	13.61	8.42	171	21.3	14.4	52.9	43.6	12.7	2.4	14.6
	AVG	1.74	1.64	19.43	7.38	7.75	78.52	7.23	6.38	-	-	-	-	-
MEDIAN 1.72 1.04 24.6 7.18 7.84 73.25 5.74 6.88	MEDIAN	1.72	1.04	24.6	7.18	7.84	73.25	5.74	6.88	-	-	-	-	-

Date	Water Depth (m)	Velocity (cm/sec)	Water Temp (°C)	Dissolved Oxygen (mg/L)	рН	Secchi disk depth (cm)	Turbidity (NTU)	TSS (mg/l)	Chlorophyll a (mg/m3)	Chlorophyll a cor (mg/m3)	Chlorophyll b (mg/m3)	Chlorophyll c (mg/m3)	Pheophytin a (mg/m3)
6/2/2021	1.6	0.987	20.6	9.27	8.88	113	2.99	<4.00	1.3	2.7	<1.00	<1.00	<1.00
6/15/2021	0.99	1.204	28.6	2.54	7.83	57	10.3	8.8	13	10.9	3.9	<1.00	3.1
6/29/2021	0.96	0.51	25.9	3.62	7.53	36	21.8	31	104	88.5	18	3.9	22.7
7/13/2021	0.9	2.102	24.4	5.32	7.33	48	11.3	52	108	86.2	18.3	1.3	32.4
7/27/2021	0.765	0.554	27	2.58	7.35	34	29.2	32.4	82.7	71.1	9.3	<1.00	15.7
8/10/2021	0.99	1.118	29.9	7.32	7.73	57.5	16.2	13.2	28.1	26.3	2.5	<1.00	1.6
8/24/2021	1.28	0.502	28.2	5.41	7.52	56	6.37	6.8	26.1	24.5	3.4	<1.00	1.5
9/8/2021	1.505	0.587	22	3.01	7.13	22	4.05	6	28.9	26.3	2.8	<1.00	2.9
12/2/2021	1.41	1.147	4.1	13.02	7.98	130	4.54	-	-	-	-	-	-
2/9/2022	1.03	0.089	0.6	5.12	7.28	-	3.95	-	-	-	-	-	-
4/5/2022	1.6	0.547	7.4	11.44	7.74	126.5	5.54	-	-	-	-	-	-
6/1/2022	2.03	1.56	22.7	8.24	8.23	101	3.45	<2.00	<1.00	<1.00	<1.00	<1.00	4.7
6/14/2022	2.05	2.625	28.2	7.8	7.92	79	6.32	3.43	7.6	6.2	<1.00	<1.00	2
7/12/2022	1.4	7.8	26.2	4.43	7.41	93	7.81	6.57	23	20.1	3.8	<1.00	4
7/26/2022	1.145	3.39	28.5	8.14	7.66	51	15.9	14.8	59.6	46.1	10.9	<1.00	20.6
8/9/2022	1.095	0.914	26.4	9.47	7.81	42	16	10.3	52.2	41.3	5.9	<1.00	16
8/23/2022	1.12	0.368	27.9	10.35	8.02	38	18.5	14.8	54.3	42.3	3.7	<1.00	17.6
9/7/2022	1.17	2.718	25.4	9.68	7.94	40.5	14.7	13.2	55	42.1	8.5	<1.00	19.3
MIN	0.77	0.09	0.6	2.54	7.13	22	2.99	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
MAX	2.05	7.8	29.9	13.02	8.88	130	29.2	52	108	88.5	18.3	3.9	32.4
AVG	1.28	1.6	22.44	7.04	7.74	66.15	11.05	14.42	-	-	-	-	-
MEDIAN	1.16	1.05	26.05	7.56	7.74	56	9.06	10.3	-	-	-	-	-

### Table D-4. Water Quality Monitoring Results from Surface Samples Collected at Site W-M546.8K

### Table D-5. Water Quality Monitoring Results from Surface Samples Collected at Site W-M547.7H

	Water	Velocity	Water Temp	Dissolved		Secchi disk	Turbidity	TSS	Chlorophyll a	Chlorophyll a cor	Chlorophyll b	Chlorophyll c	Pheophytin a
Date	Depth (m)	(cm/sec)	(°C)	Oxygen	рН	depth (cm)	(NTU)	(mg/l)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)
12/12/2019	2.1	0.58	1	(mg/L)	8.02		2.28		-		-	-	
1/22/2020	1.0	0.38	1	15.15	7 22		12.30			-	-		-
2/10/2020	1.7	1.94		10.42	7.32	19	21.7			-	-	-	-
6/3/2020	1.72	0.636	24.9	8.87	8 32	112	5 73	<5.00	11.2	10.2	<1.00	<1.00	<1.00
6/16/2020	1.50	0.030	24.5	12.47	8.78	29	/ 91	<5.00	18.9	19.2	<1.00	<1.00	<1.00
6/30/2020	1.005	3 235	27.3	8.06	8.65	104	3.92	<5.00	12.6	11.3	<1.00	<1.00	1.00
7/14/2020	1.05	4 512	25.7	3.13	7.23	46	20.3	8.4	75.9	69	10.6	3.8	8.5
7/28/2020	1.04	0.202	24.7	1.45	7.05	52	15.2	10.4	29.3	20.9	7.5	<1.00	13.4
8/11/2020	1.74	0.202	224.7	1.45	7.03	38.5	21.2	10.4	35.3	30.9	5.3	<1.00	6
8/25/2020	1.00	0.75	26.1	1.03	7.25	48	15.8				-	1.00	-
9/9/2020	1 425	2 304	15.6	4.85	7 24	32	39.6	36	149	123	21.5	5.7	38.4
12/3/2020	1 53	0.554	3.9	12.82	8.02	-	6 33	-		-	-	-	-
2/3/2021	0.925	0.28	0.5	0.99	7.33	-	4.7	-	-	-	-	-	-
3/17/2021	1.4	2.64	3.9	12.65	7.79	37	10.4	-	-	-	-	-	-
6/2/2021	1.26	0.443	24.6	14.53	8.78	>126.0	7.89	6.8	27.2	27.2	<1.00	1.4	<1.00
6/15/2021	0.93	2.052	29	7.31	8	93	6.11	6	21	18.2	3.9	<1.00	4.1
6/29/2021	0.75	0.608	26.5	6.15	8.21	39	28.2	28	68.6	57.2	9.9	5.6	16.5
7/13/2021	0.42	0.316	24	8.02	8.19	33	25.5	66	56.6	45.4	1.2	<1.00	15.8
7/27/2021	0.58	0.25	26.8	3.4	8.35	22.5	23.2	25.6	25.5	19.1	1.9	<1.00	9.5
8/10/2021	0.79	0.141	27.9	6.89	8.05	37	19.5	15.2	60.6	54.5	8.2	1.6	7.8
8/24/2021	1.02	0.022	26.3	2.85	7.53	72	15.3	20	27.1	23.6	1.2	<1.00	4.4
9/8/2021	1.25	1.382	21.3	2.25	7.33	62.5	10.1	21.2	42.5	38.1	7.7	<1.00	5.7
12/2/2021	1.72	1.002	3.9	14.33	8.3	116	6.8	-	-	-	-	-	-
2/9/2022	0.995	0.23	0.6	2.46	7.16	-	10.2	-	-	-	-	-	-
4/5/2022	1.455	0.198	7.5	13.21	8.17	99.5	7.44	-	-	-	-	-	-
6/1/2022	1.845	0.297	22.8	10.13	8.73	105	1.39	<2.00	<1.00	1	<1.00	<1.00	<1.00
6/14/2022	1.89	5.301	26.3	6.89	8.16	60	2.32	<2.22	2.8	2.5	<1.00	<1.00	<1.00
7/12/2022	1.28	0.901	28.3	5.2	7.49	93	7.51	5.14	11.1	10.1	5	<1.00	1.5
7/26/2022	0.92	0.303	28.7	9.35	7.65	39.5	6.68	3.75	11.7	9.6	2	<1.00	3
8/9/2022	0.81	0.14	26.3	6.18	7.44	26	15.7	12	77.6	58.4	9	2.7	29.1
8/23/2022	0.88	0.134	25.9	1.57	7.26	26	15.9	13.7	60.4	51.9	10.9	<1.00	12.2
9/7/2022	0.91	0.12	25.8	3.61	7.45	0	15.5	14.5	84.1	68.1	11	2.5	23.5
MIN	0.42	0.02	0.5	0.99	7.05	0	1.39	<2.00	<1.00	1	<1.00	<1.00	<1.00
MAX	2.1	5.3	29	15.15	8.78	>126.0	39.6	66	149	123	21.5	5.7	38.4
AVG	1.34	1.04	19.09	7.29	7.81	61.43	12.82	14.47	-	-	-	-	-
MEDIAN	1.34	0.57	24.8	6.89	7.72	49	10.3	11.2	-	-	-	-	-

FIGURE Q-3 PRE-PROJECT DISSOLVED OXYGEN, pH, AND TEMPERATURE VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M546.1J DURING WINTER 2019-2020



Figure D-3. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.1J During Winter 2019-2020



Figure D-4. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Winter 2019-2020



Figure D-5. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.1J During Summer 2020



Figure D-6. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Summer 2020



Figure D-7. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.1J During Winter 2020-2021



Figure D-8. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Winter 2020-2021



Figure D-9. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.8K During Summer 2021



Figure D-10. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Summer 2021



Figure D-11. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.8K During Winter 2021-2022



Figure D-12. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Winter 2021-2022



Figure D-13. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M546.8K During Summer 2022



Figure D-14. Pre-Project dissolved Oxygen, pH, and Temperature Values collected with a continuous monitor at Site W-M547.7H During Summer 2022





Figure D-16. Boxplot of Water Velocity Grab Samples taken during Winter Months



Figure D-17. Boxplot of Winter Temperature Sonde Data Collected at Sites W-M546.1J and W-M546.8K



Figure D-18. Boxplot of Winter Temperature Sonde Data Collected at Site W-M547.7H



Figure D-19. Boxplot of Winter DO Sonde Data Collected at Sites W-M546.1J and W-M546.8K



Figure D-20. Boxplot of Winter DO Sonde Data Collected at Site W-M547.7H

	Table D-6. Water Clarity Monitoring Results from Mooney Hollow RR Bridge Site										
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes	
2021-08-017	10:00 AM	24	7	S	17	0	60+	0	K Cornilsen		
2021-08-23	11:00 AM	24	13	S	40	0	60+	0.3	K Cornilsen		
2021-08-31	10:00 AM	22	7	NE	50	0	60+	0	K Cornilsen		
2021-09-07	10:00 AM	22	12	SW	65	N/A	60+	0	K Cornilsen		
2021-09-013	10:00 AM	23	5	S	60	N/A	51	0	K Cornilsen		
2021-09-22	2:00 AM	18	15	N	10	N/A	60+	0.2	K Cornilsen		
2021-09-27	11:00 AM	26	3	Var.	0	N/A	60+	0	K Cornilsen		
2021-10-12	2:00 PM	17	10	NW	60	N/A	60+	0.5	K Cornilsen		
2021-10-14	9:30 PM	11	7	SW	70	N/A	60+	0.01	K Cornilsen	our rain guage .3	
2021-10-19	11:30 AM	18	3	S	10	N/A	60+	0	K Cornilsen		
2021-11-03	8:30 AM	-2	0	N/A	20/foggy	N/A	60+	0	K Cornilsen		
2021-11-15	9:30 AM	-1	8	E	100	N/A	60+	0	K Cornilsen		
2021-12-27	10:30 AM	2	8	SW	100	N/A	40	0.01	K Cornilsen		
2022-03-14	9:00 AM	3	10	s	60	N/A	23	0	K Cornilsen		
2022-03-22	9:00 AM	9	18	SE	100	N/A	58	0.15	K Cornilsen		
2022-03-28	9:00 AM	-1	8	NE	40	N/A	60+	0	Robyn Dausener		
2022-03-31	1:00 AM	1	13	NW	100	N/A	43	0.99	Robyn Dausener		
2022-04-04	10:00 AM	1	15	NW	100	N/A	60+	0.54	Robyn Dausener		
2022-04-13	10:00 AM	11	16	W	90	N/A	60+		K Cornilsen		
2022-04-18	10:00 AM	1	15	W	40	N/A	60+	0.12	Kurt Cornilsen		
2022-04-25	9:00 AM	4	20	NW	85	N/A	60+	0.15	Kurt Cornilsen		
2022 05 17	10.00 AM	N/A	NI/A	N/A	N/A	N/A	601	0	Robyn		
2022-03-17	10.00 AW	N/A	IN/A	IN/A	N/A	IN/A	00+	0	Bohun		
2022-05-23	2:00 PM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener		
2022-05-26	10:00 AM	16	3	w	100	N/A	60+	0.7	Robyn Dausener		
2022-06-02	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Robyn Dausener		
2022-06-08	9:00 AM	17	3	SW	60	N/A	60+	0.25	Kurt Cornilsen		
									Robyn		
2022-06-14	2:45 PM	36	22	S	0	N/A	60+	0.15	Dausener		
2022-06-20	N/A	N/A	N/A	N/A	N/A	N/A	60+	0	Cole Heim		
2022-06-27	9:00 AM	18	9	NW	0	N/A	60+	1.75	Kurt Cornilsen		
2022-07-05	9:00 AM	31	15	W	10	N/A	60+	0.3	Kurt Cornilsen		
2022-07-11	11:00 AM	27	10	W	60	N/A	60+	0.03	Kurt Cornilsen		

2022-07-15	4:00 PM	25	12	SE	80	N/A	2	3.5-4	Kurt Cornilsen	
2022-07-18	9:00 AM	27	0	CaM	0	N/A	12	0	Kurt Cornilsen	
2022-07-25	9:00 AM	25	5	Calm	60	N/A	20	0.5	Kurt Cornilsen	Beaver dam
2022-08-01	9:00 AM	14	10	West	50	N/A	29	0	Kurt Cornilsen	Beaver dam
2022-08-09	9:00 AM	20	10	NE	80	N/A	3	4.1	Kurt Cornilsen	
2022-08-15	9:00 AM	21	13	NE	50	N/A	25	0	Kurt Cornilsen	
2022-08-22	10:00 AM	21	23	N	50	N/A	16	0.9	Kurt Cornilsen	
2022-08-29	10:00 AM	25	15	NW	100	N/A	16	1.25	Kurt Cornilsen	
2022-09-06	10:00 AM	23	3	Calm	40	N/A	50	0	Kurt Cornilsen	
2022-09-22	9:30 AM	14	20	NW	100	N/A	40	1.5	Kurt Cornilsen	
									Robyn	
2022-09-19	8:30 AM	18	6	NE	0	N/A	50	0.07	Dausener	
2022-09-26	9:00 AM	13	17	NW	20	N/A	31	0	Kurt Cornilsen	
2022-10-03	10:00 AM	14	6	SE	20	N/A	60+	0	Kurt Cornilsen	
2022-10-10	2:30 PM	22	9	S	0	N/A	60+	0	Kurt Cornilsen	Beaver activity
2022-11-28	10:00 AM	6	3	S	20		60+	0	Kurt Cornilsen	

	Table D-7. Water Clarity Monitoring Results from Mooney Hollow Bridge Site										
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes	
2021-06-22	0805	16.1	17	NW	58	0	25.1	0.9	M. Cook		
2021-06-28	10:53 AM	22.2	3	ESE	94	0	34.4	0.04	N. Thompson		
2021-07-06	9:39 AM	27.78	9	W	60	0	12.4	0	N. Thompson		
2021-07-12	10:50 AM	20	9	NE	72	0	26.8	0.47	N. Thompson	samples are not	
2021-07-19	10:20 AM	24	7	NE	57	0	27.4	0	N. Thompson	representative.	
2021-07-26	10:15 AM	26	5	NW	20	0	12.4	0	N. Thompson	low water and	
2021-08-03	5:25 PM	27	Calm	N/A	25	0	15.4	0	N. Thompson	lots of	
2021-08-09	11:15 AM	26	14	SW	85	0	12.8	0	N. Thompson	vegetation	
2021-08-17	10:00 AM	24	7	S	17	0	21	0	K Cornilsen		
2021-08-23	11:00 AM	24	13	S	40	0	10	0.3	K Cornilsen		
2021-08-31	10:00 AM	22	7	NE	50	0	25	0	K Cornilsen	]	
2021-09-07	10:00 AM	22	12	SW	65	N/A	46.5	0	K Cornilsen		
2021-09-013	10:00 AM	23	5	S	60	N/A	60+	0	K Cornilsen		
2021-09-22	2:00 AM	18	15	N	10	N/A	60+	0.2	K Cornilsen		
2021-09-27	11:00 AM	26	3	Var.	0	N/A	60+	0	K Cornilsen		
2021-10-12	2:00 PM	17	10	NW	60	N/A	60+	0.5	K Cornilsen		
2021-10-19	11:30 AM	18	3	S	10	N/A	60+	0	K Cornilsen		
2021-10-25	10:00 AM	10	18	NE	45	N/A	52	2.9	K Cornilsen		
2021-11-03	8:30 AM	-2	0	N/A	20/foggy	N/A	60+	0	K Cornilsen		
2021-11-15	9:30 AM	-1	8	E	100	N/A	60+	0	K Cornilsen		
2022-03-14	9:00 AM	3	10	s	60	N/A	60+	0	K Cornilsen		
2022-03-22	9:00 AM	9	18	SE	100	N/A	49	0.15	K Cornilsen		
	0.00 414	1		NE	40		26	0	Robyn		
2022-03-28	9.00 AW	-1	0	INE	40	N/A	20	0	Dausener		
	1.00 0.04	1	12	NIM	100		60+	0.00	Robyn		
2022-03-31	1.00 AW	-	15	1444	100	N/A	001	0.55	Dausener		
	10.00 AM	1	15	NW	100			0.54	Robyn		
2022-04-04	10.00 AW	-	15	1444	100	N/A	60+	0.54	Dausener		
2022-04-13	10:00 AM	11	16	W	90	N/A	60+		Kurt Cornilsen		
2022-04-18	10:00 AM	1	15	W	40	N/A	60+	0.12	Kurt Cornilsen		
2022-04-25	9:00 AM	4	20	NW	85	N/A	60+	0.15	Kurt Cornilsen		
									Robyn		
2022-05-17	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener		
									Robyn		
2022-05-23	2:00 PM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener		
									Robyn		
2022-05-26	10:00 AM	16	3	W	100	N/A	60+	0.7	Dausener		

									Robyn	
2022-05-26	10:00 AM	16	3	W	100	N/A	60+	0.7	Dausener	
									Robyn	
2022-06-02	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener	
2022-06-08	9:00 AM	17	3	SW	60	N/A	60+	0.25	Kurt Cornilsen	
									Robyn	
2022-06-14	2:40 PM	36	22	S	0	N/A	60+	0.15	Dausener	
2022-06-20	N/A	N/A	N/A	N/A	N/A	N/A	60+	0	Cole Heim	
2022-06-27	9:00 AM	18	9	NW	0	N/A	60+	1.75	Kurt Cornilsen	
2022-07-05	9:00 AM	31	15	W	10	N/A	60+	0.3	Kurt Cornilsen	
2022-07-11	11:00 AM	27	10	W	60	N/A		0.03	Kurt Cornilsen	to much veg.
2022-07-15	4:00 PM	25	12	SE	80	N/A	12	3.5-4	Kurt Cornilsen	
2022-07-18	9:00 AM	27	0	CaM	0	N/A	60+	0	Kurt Cornilsen	
2022-07-25	9:00 AM	25	5	Calm	0	N/A	60+	0.5	Kurt Cornilsen	
2022-08-01	9:00 AM	14	10	West	50	N/A	60+	0	Kurt Cornilsen	
2022-08-09	9:00 AM	20	10	NE	80	N/A	48	4.1	Kurt Cornilsen	
2022-08-15	9:00 AM	21	13	NE	50	N/A	60+	0	Kurt Cornilsen	
2022-08-22	10:00 AM	21	23	Ν	50	N/A	60+	0.9	Kurt Cornilsen	
2022-08-29	10:00 AM	25	15	NW	100	N/A	37	1.25	Kurt Cornilsen	
2022-09-06	10:00 AM	23	3	Calm	40	N/A	56	0	Kurt Cornilsen	
2022-09-22	9:30 AM	14	20	NW	100	N/A	56	1.5	Kurt Cornilsen	
									Robyn	
2022-09-19	8:30 AM	18	6	NE	0	N/A	45	0.07	Dausener	
2022-09-26	9:00 AM	13	17	NW	20	N/A	60+	0	Kurt Cornilsen	
2022-10-03	10:00 AM	14	6	SE	20	N/A	60+	0	Kurt Cornilsen	Beaver activity
2022-10-10	2:30 PM	22	9	S	0	N/A	60+	0	Kurt Cornilsen	Beaver activity
2022-11-28	10:00 AM	6	3	S	20		60+	0	Kurt Cornilsen	

0	Table D-8.         Water Clarity Monitoring Results from Pumphouse Inflow Site											
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes		
2021-09-22	2:00 AM	18	15	N	10	N/A	26	0.2	K Cornilsen			
2021-09-27	11:00 AM	26	3	Var.	0	N/A	40	0	K Cornilsen			
2021-10-08	11:00 AM						51	0.7	K Cornilsen			
2021-10-14	9:30 PM	11	7	SW	70	N/A	39.5	0.01	K Cornilsen	our rain guage .3		
2021-10-19	11:30 AM	18	3	S	10	N/A	32	0	K Cornilsen			
2022-09-23	3:30 AM	15	10	W	100	N/A	31	0	K Cornilsen			
2022-09-23	3:30 AM	15	10	W	100	N/A	34	0	K Cornilsen			
2022-10-10	2:30 PM	22	9	S	0	N/A	26	0	Kurt Cornilsen	Beaver activity		

	Table D-9. Water Clarity Monitoring Results from Downstream Gate Inflow Site										
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes	
2021-08-03	5:15 PM	27	Calm	N/A	25	0	14.2	0	N. Thompson	No Flow	
2021-08-12	8:30 AM	22	6	S/E	30	0	30.04	0.5	K Cornilsen	Flowing in	
2021-08-17	10:00 AM	24	7	S	17	0	37.4	0	K Cornilsen	Flowing in	
2021-08-31	10:00 AM	22	7	NE	50	0	21	0	K Cornilsen		

	Table D-10. Water Clarity Monitoring Results from Densmore Lake Stem Gate Site												
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes			
2021-08-17	10:00 AM	24	7	S	17	0	60+	0	K Cornilsen	Back flowing marsh from Miss R. flowing to west			
2021-09-22	2:00 AM	18	15	N	10	N/A	60+	0.2	K Cornilsen				
2021-09-27	11:00 AM	26	3	Var.	0	N/A	60+	0	K Cornilsen				

Table D-11. Water Clarity Monitoring Results from Smith Creek Inflow Site											
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes	
2021-08-18	10:00 AM	N/A	N/A	N/A	N/A	N/A	7.2	0	K Cornilsen	Opened tube to fill marsh. Lots of sediment	
2021-08-19	1:00 AM	N/A	N/A	N/A	N/A	N/A	12.2	0	K Cornilsen	Next day sample. Sediment is clearing up but not great.	
2021-08-23	11:00 AM	24	13	S	40	0	23.8	0.3	K Cornilsen		
2021-08-31	10:00 AM	22	7	NE	50	0	15	0	K Cornilsen		
2021-09-07	10:00 AM	22	12	SW	65	N/A	19.5	0	K Cornilsen		
2021-09-013	10:00 AM	23	5	S	60	N/A	16.9	0	K Cornilsen		
2021-09-22	2:00 AM	18	15	N	10	N/A	15	0.2	K Cornilsen		
2021-10-14	9:30 PM	11	7	SW	70	N/A	10	0.01	K Cornilsen	our rain guage .3	
2021-10-19	11:30 AM	18	3	S	10	N/A	15	0	K Cornilsen		
2021-10-25	10:00 AM	10	18	NE	45	N/A	6	2.9	K Cornilsen		
2022-10-10	2:30 PM	22	9	S	0	N/A	44	0	Kurt Cornilsen	Beaver activity	
2022-11-28	10:00 AM	6	3	S	20		60+	0	Kurt Cornilsen		

	Table D-12. Water Clarity Monitoring Results from Mooney Hollow and Bluff Inflows Site											
Date (YYYYMMDD)	Time (HH:MM)	Air Temp (°C) *	Wind Speed (MPH) *	Wind Direction (NEWS) *	Cloud Cover (%)	Wave height (cm)	Transparency Tube (cm)	48 hr Precip (in) **	Personnel	Sample Notes		
2021-06-22	8:00 AM	16.1	17	NW	58	0	22.2	0.9	M. Cook			
2021-06-28	9:55 AM	22.2	3	ESE	94	0	34	0.04	M.Cook	complet are not		
2021-07-06	9:10 AM	27.78	9	W	60	0	51.8	0	M.Cook	roprosoptativo		
2021-07-12	10:20 AM	20	9	NE	72	0	49.8	0.47	M.Cook	low water and		
2021-07-19	9:44 AM	22	7	NE	57	0	55.4	0	M.Cook	lots of		
2021-07-26	9:55 AM	26	5	NW	25	0	37	0	N. Thompson	vogotation		
2021-08-03	17:05:00	27	Calm	N/A	25	0	39	0	N. Thompson	vegetation		
2021-08-09	11:05:00	26	14	SW	85	0	9.2	0	N. Thompson			
2021-08-17	10:00 AM	24	7	s	17	0	60+	0	K Cornilsen	Back flowing. We are filling the marsh		
2021-08-23	11:00 AM	24	13	S	40	0	60+	0.3	K Cornilsen			
2021-08-31	10:00 AM	22	7	NE	50	0	60+	0	K Cornilsen			
2021-09-07	10:00 AM	22	12	SW	65	N/A	35	0	K Cornilsen			
2021-09-13	10:00 AM	23	5	S	60	N/A	60+	0	K Cornilsen			
2021-09-22	2:00 AM	18	15	N	10	N/A	60+	0.2	K Cornilsen			
2021-09-27	11:00 AM	26	3	Var.	3	N/A	60+	0	K Cornilsen			
2021-10-12	2:00 PM	17	10	NW	60	N/A	60+	0.5	K Cornilsen			

	2024 40 44	0.00.004		-	<b>614</b>	70		<b>CO</b> .	0.01		our rain guage
	2021-10-14	9:30 PIVI	11	/	SW	70	N/A	60+	0.01	K Cornilsen	.3
	2021-10-19	11:30 AM	18	3	S	10	N/A	60+	0	K Cornilsen	
	2021-10-25	10:00 AM	10	18	NE	45	N/A	55	2.9	K Cornilsen	
	2021-11-03	8:30 AM	-2	0	N/A	20/foggy	N/A	60+	0	K Cornilsen	
I	2021-11-15	9:30 AM	-1	8	E	100	N/A	60+	0	K Cornilsen	
	2021-12-27	10:30 AM	2	8	SW	100	N/A	60+	0.01	K Cornilsen	
	2022-03-14	9:00 AM	3	10	S	60	N/A	22	0	K Cornilsen	
	2022-03-22	9:00 AM	9	18	SE	100	N/A	40	0.15	K Cornilsen	
		0.00.004				10				Robyn	
	2022-03-28	9:00 AIVI	-1	8	INE	40	N/A	60+	0	Dausener	
										Robyn	
	2022-03-31	1:00 AM	1	13	NW	100	N/A	46	0.99	Dausener	
										Robyn	
	2022-04-04	10:00 AM	1	15	NW	100	N/A	54	0.54	Dausener	
Ì	2022-04-13	10:00 AM	11	16	W	90	N/A	45		Kurt Cornilsen	
Ì	2022-04-18	10:00 AM	1	15	W	40	N/A	35	0.12	Kurt Cornilsen	
Ì	2022-04-25	9:00 AM	4	20	NW	85	N/A	60+	0.15	Kurt Cornilsen	
										Robyn	
	2022-05-17	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener	
										Robyn	
	2022-05-23	2:00 PM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener	
	2022 00 20	2.001.00	,	,	,		,			Robyn	
	2022-05-17	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener	
ł	2022 00 17	1010071111	,	,	,		,	001		Robyn	
	2022-05-26	10:00 AM	16	3	w	100	N/A	60+	0.7	Dausener	
										Robyn	
	2022-06-02	10:00 AM	N/A	N/A	N/A	N/A	N/A	60+	0	Dausener	
	2022-06-08	9:00 AM	17	3	SW	60	N/A	60+	0.25	Kurt Cornilsen	
							,		0.20	Robyn	
	2022-06-14	2:30 PM	36	22	S	0	N/A	60+	0.15	Dausener	
	2022-06-20	N/A	N/A	N/A	N/A	N/A	N/A	60+	0	Cole Heim	
	2022-06-27	9:00 AM	18	9	NW	0	N/A	60+	1.75	Kurt Cornilsen	
	2022-07-05	9.00 AM	31	15	w	10	Ν/Δ	60+	03	Kurt Cornilsen	
	2022-07-11	11.00 AM	27	10	w	60	N/A	60+	0.03	Kurt Cornilsen	
	2022-07-15	4.00 PM	25	12	SE	80	N/A	60+	3 5-4	Kurt Cornilsen	
	2022-07-18	9.00 AM	27	0	Calm	0	Ν/Δ	60+	0	Kurt Cornilsen	
	2022-07-25	9.00 AM	25	5	Calm	60	N/A	N/A	0.5	Kurt Cornilsen	Beaver activity
	2022-08-01	9.00 AM	14	10	West	50	N/A	32	0	Kurt Cornilsen	Beaver activity
	2022-08-09	9.00 AM	20	10	NE	80	N/A	N/A	41	Kurt Cornilsen	Beaver activity
	2022-08-15	9.00 AM	20	13	NE	50	N/A	Ν/Δ	0	Kurt Cornilsen	Beaver activity
	2022-08-22	10.00 AM	21	23	N	50	N/A	Ν/Δ	0.9	Kurt Cornilsen	Beaver activity
	2022-08-29	10:00 AM	25	15	NW/	100	N/A	N/A	1 25	Kurt Cornilsen	Beaver activity
	2022-09-22	9:30 AM	14	20	NW	100	N/A	N/A	15	Kurt Cornilsen	Beaver activity
	2022 05 22	2100 /111	1			100			1.5	Rohyn	sector delivity
	2022-09-19	8-30 AM	18	6	NE	0	N/A	N/A	0.07	Dausener	Beaver activity
	2022-09-26	9:00 AM	13	17	NW/	20	N/A	N/A	0	Kurt Cornilsen	Beaver activity
	2022-05-20	10.00 AM	14	6	\$F	20	N/A	N/A	0	Kurt Cornilsen	Beaver activity
	2022-10-10	2.30 PM	22	9	S	0	N/A	Ν/Δ	0	Kurt Cornilsen	Beaver activity
	2022-10-10	10.00 AM	6	2	5	20	11/1	60+	0	Kurt Cornilsen	Scaver activity
	-0 11 20	20.007.001					1				1