Jackson River Dissolved Oxygen Special Study

Virginia Department of Environmental Quality, WestRock, ONE Environmental Mid Atlantic, LLC

May 2021

Table of Contents

Executive Summary 4

I. Introduction, Project Overview, and Objectives 5

II. Watershed History 5

A. Total Maximum Daily Load (TMDL) and Implementation 5

B. Watershed Improvements 7

1. City of Covington and Alleghany County Sewer and Wastewater Treatment Plant (WWTP) Improvements 7

2. WestRock Covington Mill Improvements 9

III. Biological Monitoring Overview 10

A. Benthic Impairments Delisting 10

B. Benthic Macroinvertebrate Data Trends 10

C. Fish Community Data Trends 18

IV. Dissolved Oxygen Study Methods 23

A. General Methods Overview 23

B. Quality Assurance Project Plan 25

C. Field Sampling Methods 25

1. Preparation for Field Work 26

2. Sampling Preparation and Procedures 26

3. Field Documentation 27

4. Field Quality Control and Audits 27

5. Instrument and Equipment Testing, Inspection, and Maintenance Requirements 28

V. Data Summary and Analysis 28

A. Data Validation 28

B. Overall Data Trends 28

C. Station-Specific Data Trends 32

D. Diurnal Data Trends 38

E. Flow Data Trends 45

F. Data Conclusions 49

VI. Summary and Conclusions 49

VII. Appendices 50

List of Appendices

Appendix A: Monitoring Stations Referenced

Appendix B: Quarterly Project Team Meeting Summaries

Appendix C: Sample Calibration Log

Appendix D: DEQ Audit Reports (2019 & 2020)

Executive Summary

In 1996, an 11.36 mile stretch of the Jackson River was listed on Virginia's Section 303(d) list of impaired waterways for dissolved oxygen (DO). Since that time, the Jackson River ecosystem has experienced noticeable improvements in biodiversity, which are indicative of improved water quality, including dissolved oxygen levels. Technical advancements have resulted in pollution reductions, specifically in total nitrogen and total phosphorous, from municipal and industrial discharges. Additionally, unique solutions have been implemented to lessen the effects of the artificial hydrology from the upstream dam and to mimic a more natural flow regime. Due to the measured and observed improvements in the Jackson River, the Virginia Department of Environmental Quality (DEQ) and its partners designed this special study to reevaluate the DO impairment. This two-year study was conducted in which DO data was collected from April 2019 through March 2021 with higher frequency sampling occurring during more biologically stressful times of the year.

A total of 951 samples were collected over the course of this two year study. This volume of data collected represents an understanding of river conditions for use in delisting this segment of the Jackson River for DO impairment. The Virginia water quality standard for the Jackson River is a minimum of 4.0 mg/L DO and a daily average of 5.0 mg/L DO. No exceedances of either the minimum or average DO standard occurred during this study.

Improvements in the benthic macroinvertebrate and fish communities have been observed over the past 5-10 years, including an increase in the abundance of DO sensitive fish and pollution sensitive macroinvertebrates. The Virginia Stream Condition Index (VSCI) scores have increased at most stations along the impaired reach of the Jackson River and several stations are even above the impairment threshold of 60. An analysis of the fish community data along the impaired reach of the Jackson River has found a reduction in the abundance or Stonerollers (tolerant algivore) and an increase in DO sensitive fish taxa (minus Stonerollers), indicating a reduction in the abundance of algae and higher overall DO concentrations.

The data from this study correlates with the overall observations that have been documented in the benthic community. Lower algal levels due to the implementation of pulse releases from the upstream dam and decreased overall nutrient discharges have resulted in less overall dissolved oxygen changes throughout the day. This results in higher early morning dissolved oxygen levels and supports the recommendation for delisting of the impairment for dissolved oxygen. This also provides evidence that the benthic community is improving as well. Lower algal levels have improved dissolved oxygen levels, which also allows for more diverse and sensitive species to flourish in this reach of the river.

The study results support the conclusion that the river segment does not need to remain on the list of impaired waterways for dissolved oxygen.

I. Introduction, Project Overview, and Objectives

The Jackson River flows through Alleghany, Bath, Craig, and Highland counties as well as the cities of Covington and Clifton Forge for approximately 45 miles from where it exits Lake Moomaw until its confluence with the Cowpasture River to form the James River. The Jackson River tailwater is well known throughout Virginia and beyond for its thriving natural trout populations. The Jackson River is a local attraction for its beauty and recreational opportunities including fishing and kayaking. The surrounding county and towns recognize the tourism value of this natural resource and have developed river access points, blueway maps, and adjacent bike paths to encourage recreational uses. Downstream of the tailwater, the Jackson River supports several industries, the city of Covington, and the towns of Clifton Forge and Iron Gate.

In 1996, a portion of the Jackson River was listed on Virginia's Section 303(d) list of impaired waterways for dissolved oxygen (DO). Approximately 11.36 miles of stream, from the MeadWestvaco (now WestRock) Covington Mill main processing outfall downstream to just above the Low Moor community are considered to be impaired for DO. The Jackson River ecosystem has experienced noticeable improvements in biodiversity in the stream, which are indicative of improved water quality, including dissolved oxygen levels. Technical advancements have resulted in pollution reductions from municipal and industrial discharges. Additionally, unique solutions were implemented to lessen the effects of the artificial hydrology from the upstream dam and mimic a more natural flow regime. Due to the measured and observed improvements in the Jackson River, the Virginia Department of Environmental Quality (DEQ) and its partners designed a special study to evaluate the dissolved oxygen patterns throughout a portion of the river to reevaluate the DO impairment. DEQ, WestRock (WR), and ONE Environmental Mid Atlantic, LLC (ONE) conducted a two year study in which DO data was collected from April 2019 through March 2021 with higher frequency sampling occurring during more biologically stressful times of the year. The study methodology and results are presented in this report.

II. Watershed History

Appendix A provides a table and figure that outline the portion of the Jackson River watershed that this report references, to include the stations monitored as part of this study and stations that are referenced below in the benthic macroinvertebrate sections of this report. The initial DO impairment listing was based off of data from the Industrial Park station 2-JKS022.15, which had 222 excursions of the minimum 4.0 mg/L DO water quality standard from 481 measurements in the original DO study performed in 1996. Data from the City Park Playground station 2-JKS023.61 was also used in the original listing of the river segment with 6 of 26 DO observations below the 4.0 mg/L criterion. In order to show that the DO impairment no longer exists, a robust dataset from these stations must show that the river meets the DO water quality standard.

A. Total Maximum Daily Load (TMDL) and Implementation

Benthic macroinvertebrate communities reflect the water and habitat quality in a stream over a longer period of time compared to ambient water samples that capture water quality at a single point in time. Therefore, the DEQ evaluates biological communities to assess whether chronic and/or acute stressors

are negatively affecting stream resources or habitat, resulting in biological communities with low diversity and mainly tolerant organisms. Biological communities are evaluated as impaired or non-impaired using the Virginia Stream Condition Index (VSCI) scores, which is a multi-metric index that accounts for the number and type of organisms in an aquatic community. A VSCI score greater than 60 is considered non-impaired and a score of less than or equal to 60 indicates an impaired stream.

The Jackson River was listed on the Virginia DEQ Integrated Report as impaired for the General Use Standard in 1998 based on VSCI scores below the impairment threshold of 60. This Jackson River listing extended from the Westvaco (now WestRock) main processing outfall downstream to the confluence of the Jackson and Cowpasture Rivers.

As a result of the Jackson River being identified as impaired for DO in 1996, a follow up special study was conducted in 1998 where multiple stations along the stream were sampled frequently to evaluate the diurnal swings throughout a day. Through that effort, 222 of the 481 measurements violated the water quality standard of less than 4.0 mg/L. The DO and benthic impairments were determined to be caused by elevated total phosphorus and nitrogen concentrations stimulating excess algae growth. Numerous efforts were implemented to reduce phosphorus discharges, lower temperature, and improve effluent quality as a result of these DO levels.

In 2010, a Total Maximum Daily Load (TMDL) was developed to further address the benthic impairment on the Jackson River. The stressor was identified as excess nutrients and as a result, pollution reduction requirements for point sources that discharge in the watershed were established. Virginia does not have a nutrient water quality standard; therefore, a robust water quality dataset was used to model the relationship between nutrients and algae growth in the Jackson River. The goals of 0.038 mg/L total phosphorus and 100 mg/m2 for periphyton-Chl *a* were established in the TMDL. Based on these goals, nutrient reductions from point and non-point sources were required to restore the benthic community. A reduction in nutrients would result in less extreme dissolved oxygen swings, cleaner substrates for macroinvertebrates, and more natural food resources for other organisms to utilize.

During the TMDL study, artificial hydrology controlled by the upstream Gathright Dam was also identified as exacerbating the stressors to the benthic community. The Jackson River does not experience high flow events during the summer and fall timeframes as much of the water is captured in the upstream reservoir. The water quality model indicated that the goals set in the TMDL could not be reached by point and non-point source reductions alone. In the TMDL, DEQ proposed that greater flow variation from the dam be implemented to mimic a more natural free flowing river, where large rain events would scour substrate. Consequently, DEQ, in cooperation with WestRock, the Philadelphia Academy of Sciences, and US Army Corps of Engineers (USACE), implemented and developed in October 2007 a flow release study where the primary objective was to assess the level of periphyton biomass scouring resulting from flow augmentation test-pulses. The flow pulse study indicated that the pulse releases from the Gathright Dam would help the Jackson River meet the assigned endpoints. The flow release study recommended six (6) flow pulses of 3,000 cubic feet per second (cfs) each during the growing season, June to October.

Since the flow study, USACE has incorporated a schedule of six (6) pulses per year between June and October. This period was deemed most stressful for the macroinvertebrate community due to higher levels of algal growth during the growing season. Water quality professionals meet one week prior to the planned pulses to discuss if the pulse should take place. Factors such as fish spawning, recent

rainfall, weather predictions, algae growth observations, and lake conditions are discussed to determine the pulse status. DEQ monitors pre- and post-pulse algae biomass and chlorophyll *a* for three (3) of the planned pulses each year. Chlorophyll *a* concentrations have decreased significantly at stations sampled since 1998 (Figure II-1).

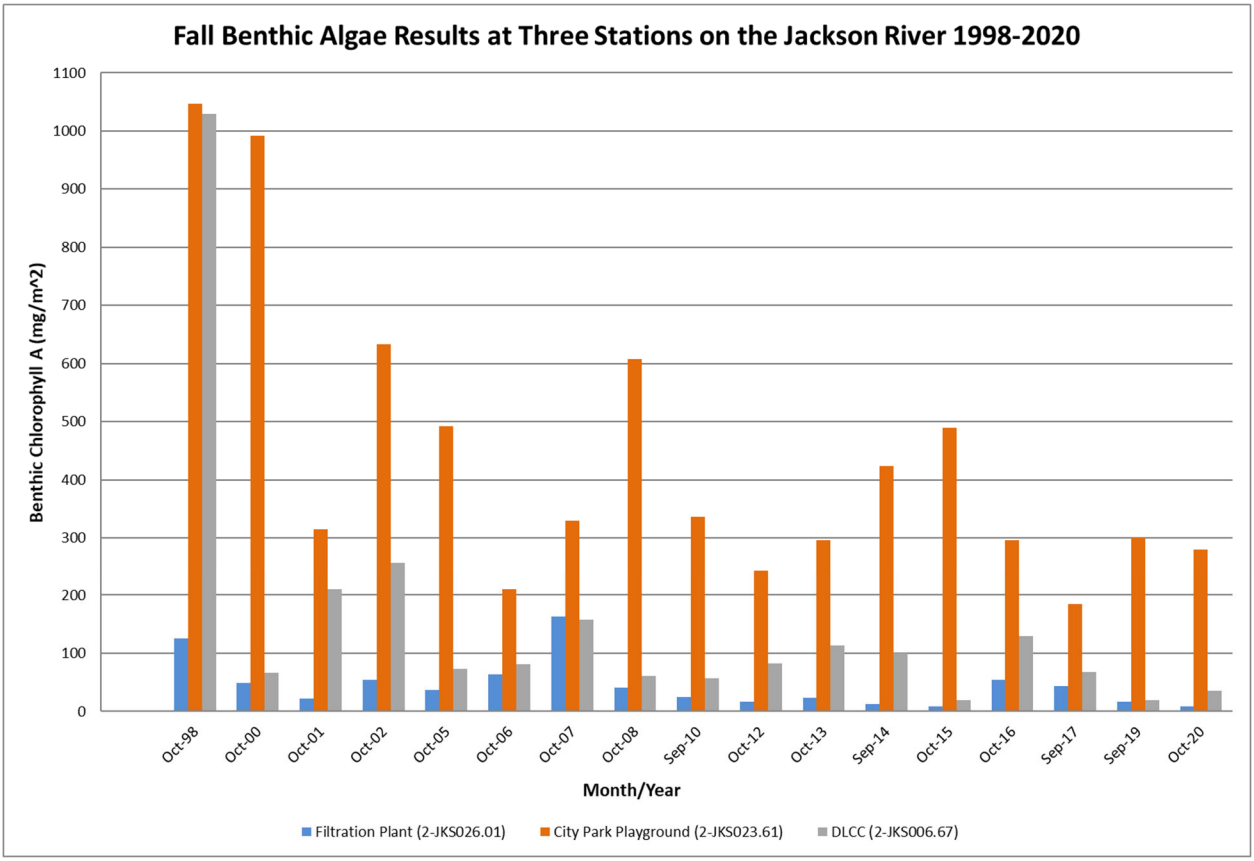


Figure II-1: Benthic Chlorophyll a is collected during a pre- and post- pulse sampling event for three (3) of the planned pulses each year. The figure shows the fall pulse events. Benthic algae has decreased substantially since 1998 and overall since 2007 when the pulse releases began.

B. Watershed Improvements

1. City of Covington and Alleghany County Sewer and Wastewater Treatment Plant (WWTP) Improvements

Since the initial DO impairment listing in 1998, the City of Covington and the surrounding Alleghany County have made several noteworthy improvements that have contributed to a reduction in the loading of organic matter, *E. Coli* concentrations, and nutrients. These reductions are one factor among many that has led to water quality improvements. Below is a summary of recent and future projects.

Cherokee Forest and Mallow Sewer Pump Station Replacement Project – November 9, 2015:

The project included construction of two new sewer pump stations to replace the existing Cherokee Forest & Mallow Sewer Pump Stations. The pump stations were constructed adjacent to their existing sites and equipped with new emergency generators and alarm systems. Sewer improvements for the Cherokee subdivision took place on June 20, 2018 and included installation of 19 vertical feet of manholes and 10 lateral seal interfaces to prevent inflow into the newly rehabilitated main lateral connection.

City of Covington Pump Stations Improvement Project – Jackson Street Pump Station, Whiteys Pump Station, and Dry Run Pump Station – July 16, 2018:

The project addressed the equipment upgrades of the Dry Run Pump Station, Jackson Street Pump Station, and Whitey's Pump Station located in the City of Covington. The project included the replacement of the existing pumps and control panels at the Dry Run and Whitey's Pump Stations and installation of new security fencing and a new supervisory control and data acquisition (SCADA) system at each of the three pump stations. Installation of a new cover over the old wetwells at the Jackson Street and Whitey's pump stations and new air release valves at the Dry Run Pump Station and Whitey's Pump Station were also completed during the project.

City of Covington – Phase II Sanitary Sewer Improvements Project – December 1, 2014:

The Phase II project involved replacing approximately 7,000 linear feet (LF) of 8-inch gravity line, 700 LF of 10-inch gravity line, 2,300 LF of 12-inch gravity line, 800 LF of sewerline by directional drilling, and 124 manholes. Phase II rehabilitation included lining 3,100 LF of gravity line using either fold and form, cured-in-place pipe (CIPP) technologies, or pipe bursting. The Jackson Street Pump Station was rehabilitated and a new force main from the station was installed during the project. Approximately 2,900 LF of storm drain was replaced and 860 LF of Interceptor was repaired/replaced during the Phase II project. A new sewer Jetter truck and camera was purchased which enables the City of Covington to better maintain their collection system. The project area included the Prospect Street Sewershed, West Pine and West Oak Sewershed, West Chestnut Street Sewershed, North and South Fairlawn Sewershed, Park Street Sewershed, and the West Jackson Street Sewershed.

City of Covington – WWTP Upgrade and Sewer Rehabilitation Projects – May 24, 2012 (WWTP upgrade) and November 3, 2011 (Sewer Rehabilitation):

The WWTP project upgraded equipment at the City of Covington WWTP to meet discharge requirements at the time while maintaining the plant's existing treatment capacity of 3.0 million gallons per day (MGD). The WWTP project included a new influent screenings washer/compactor, a grit classifier, a new SCADA system, new trickling filter pumps, a centrifuge, feed pumps, and a polymer feed system. The anaerobic digester covers, digester gas mixing, digester heating system, and gas piping were repaired or replaced. The Ultraviolet (UV) Disinfection system was upgraded. The Phase I collection system improvements removed dry weather overflow points by replacing approximately 5,900 LF of 8-inch gravity line, 750 LF of 10-inch gravity line, and 32 manholes. The Phase II project involved replacing 9,000 LF of 8-inch gravity line, 1,725 LF of 10-inch gravity line, 1,700 LF of 12-inch gravity line, and 60 new manholes. Phase II rehabilitation included lining 3,700 LF of gravity line using either fold and form or CIPP technologies, pipe bursting 1,590 LF of gravity line, and lining 36 manholes.

Alleghany County – Rosedale Sanitary Sewer Replacement Project – April 1, 2022:

Alleghany County has been experiencing difficulties with the existing gravity sanitary sewer system located in the Rosedale Subdivision, as well as the trunk sewer along Dunlap Creek. This system is well over five decades old and has presented the County with various challenges and maintenance issues. Therefore, this replacement project generally consists of the following sewer improvements:

1. DIVISION A – Install approximately 1,485 LF of 12-inch diameter sewer pipe (and 143 LF of 8-inch diameter sewer pipe as an add/alternate) to be located along Dunlap Creek from the Red Cross facility off Midland Trail to the existing Rosedale Sewage Pump Station located near the confluence of the Jackson River.
2. DIVISION B – Install approximately 788 LF of 8-inch diameter sewer pipe to serve portions of the Rosedale Subdivision and tie into the various sewer laterals of existing homes.

(Future) City of Covington WWTP High Flow Equalization and Improvements Project – 2023:

The City of Covington is currently involved in the final design, construction and start-up operations of a 2.5 MGD equalization basin.

2. WestRock Covington Mill Improvements

Over the past 20 years, the WestRock Covington Mill has made several improvements with the intent of improving the quality of its effluent.

Nutrient Control

The facility has made several upgrades to its phosphate removal system by installing improved controls and additional redundancy. These improvements allow for more consistent control of effluent phosphorous levels. Since the early 1990s, the facility has decreased its annual effluent phosphorous discharge by 76%.

Effluent Solids Control

The facility changed the way it handles flyash from some of its boilers and converted the ash handling system from a wet (slurry) system to a dry ash handling system. This allows the flyash to be collected in a dry state for disposal and eliminated the wet slurry step that created an additional stream that was treated in the wastewater treatment plant.

Improved Biological Oxygen Demand (BOD) Control

The facility installed an improved aeration system in the wastewater treatment plant aeration basins. This improvement allowed for more efficient transfer of oxygen into the activated sludge and increased efficiency in treating the effluent. These improvements have contributed to the facility's effluent quality, including nutrient and BOD loading in the period since the last study was conducted.

Improved Flow

The facility has made several improvements to reduce the amount of water used in the process. This has resulted in reductions in effluent flow which has improved effluent quality.

III. Biological Monitoring Overview

A. Benthic Impairments Delisting

The implementation of the Jackson River TMDL by point source dischargers and flow augmentation of the Gathright Dam has resulted in improved water quality on the Jackson River as evidenced by healthier macroinvertebrate communities and reduced nutrient concentrations. Recent data shows that parts of the Jackson and Upper James Rivers that previously had benthic impairments are no longer impaired, resulting in the delisting of 29.16 miles of the two rivers. However, there are still 14.37 miles that have yet to be delisted on the Jackson River. The dissolved oxygen study may be used to support efforts to further delist remaining segments in the river.

In the 2008 DEQ Integrated Report, 20.35 miles of the Upper James River were delisted for a benthic impairment. Station 2-JMS345.73 (Rt. 220, 1st bridge below Cowpasture River) is located below the confluence of the Jackson and Cowpasture Rivers and has shown an improvement in the VSCI score since 1999. In 2006, the previous two (2) years of sampling had an average VSCI score of 69.1. Downstream of this station, at rivermile 326, the average of the last two (2) years of VSCI scores were 75.9, well above the impairment threshold of 60.

In the 2012 DEQ Integrated Report, part of the Jackson River was delisted from the mouth of Karnes Creek to the confluence with the Cowpasture River. VSCI scores have steadily increased since 2001 due to improvements at discharging facilities. The 2006 and 2012 flow adjusted trend analysis show a significant declining trend for total phosphorus (TP) and total nitrogen (TN) at station 2-JKS006.67 (Dabney Lancaster Community College (DLCC)). Benthic trend analysis also showed improving conditions (+10 points) over the time period of 1994-2010.

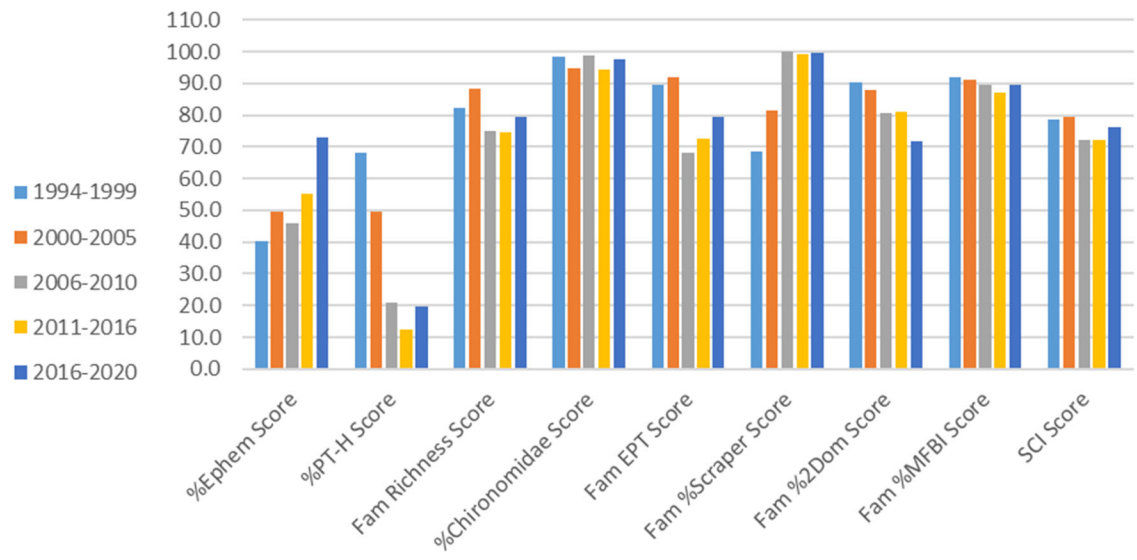
The most recent flow adjusted trend analysis conducted in 2016 shows an improving DO trend at the City Park Playground station 2-JKS023.61, which is further supported by the results of this study. The 2012 and 2006 flow adjusted trend analysis indicated a significant improving trend in total phosphorus and total nitrogen. However, the 2016 analysis still results in an “Observed Effect” assessment for the benthic community. Within the assessment window (2012-2016), three (3) out of 36 TP observations were considered elevated (>0.20 mg/L). Based on the water quality improvements observed over the past 10 years, additional DO data and benthic data have been collected that could lead to further delisting of the Jackson River.

B. Benthic Macroinvertebrate Data Trends

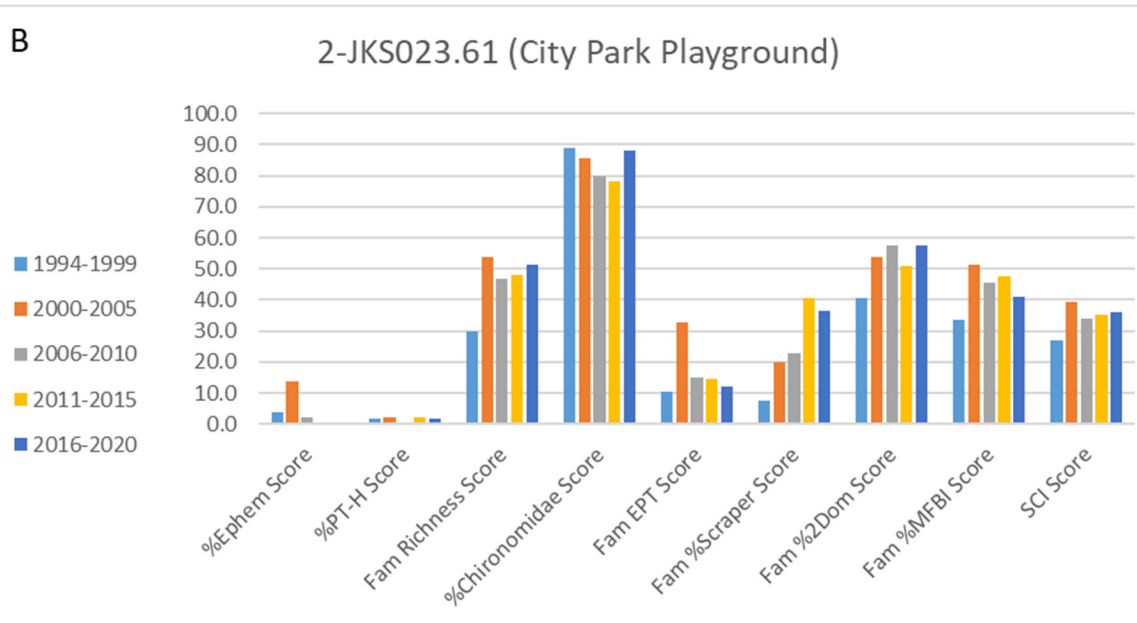
Benthic data has been collected on the Jackson River at multiple stations since 1994. This robust dataset allows for the evaluation of temporal trends in the biological community. This improvement in the benthic community is related to the improvements in dissolved oxygen throughout this period. Although methods have changed since 1994 and the taxonomic resolution has improved, general trends can still be observed in the dataset. Most recently, 2020 benthic data was collected to confirm the improving trends that led to the delisting of portions of the Jackson River discussed above. Except for the City Park Playground station (2-JKS023.61), increasing VSCI scores appear to be driven in part by the increase in the abundance and diversity of mayflies (Figure III-1). Although the tolerance can vary widely

among mayfly genera and species, Ephemeroptera (mayflies), are considered an order of macroinvertebrates that are sensitive to pollution and thus are a good indicator organism for water quality. Station 2-JKS013.29 (Low Moor) was the only site that showed a significant difference in percent Ephemeroptera between the 1994-1999 and 2011-2020 categories (t-test; p=0.002). Percent Ephemeroptera scores tended to be higher in the 2011-2020 category at station 2-JKS006.67 (DLCC) and station 2-JKS018.68 (Idlewilde/Rt. 18 bridge) but the differences were not statistically significant (t-test; p=0.28 and p=0.24). The increase is due in part to the addition a scraping mayfly, *Maccaffertium* and a filtering mayfly, *Isonychia*. The City Park Playground station (2-JKS023.61) was the only site where there was not an observed increase in mayfly diversity and abundance.

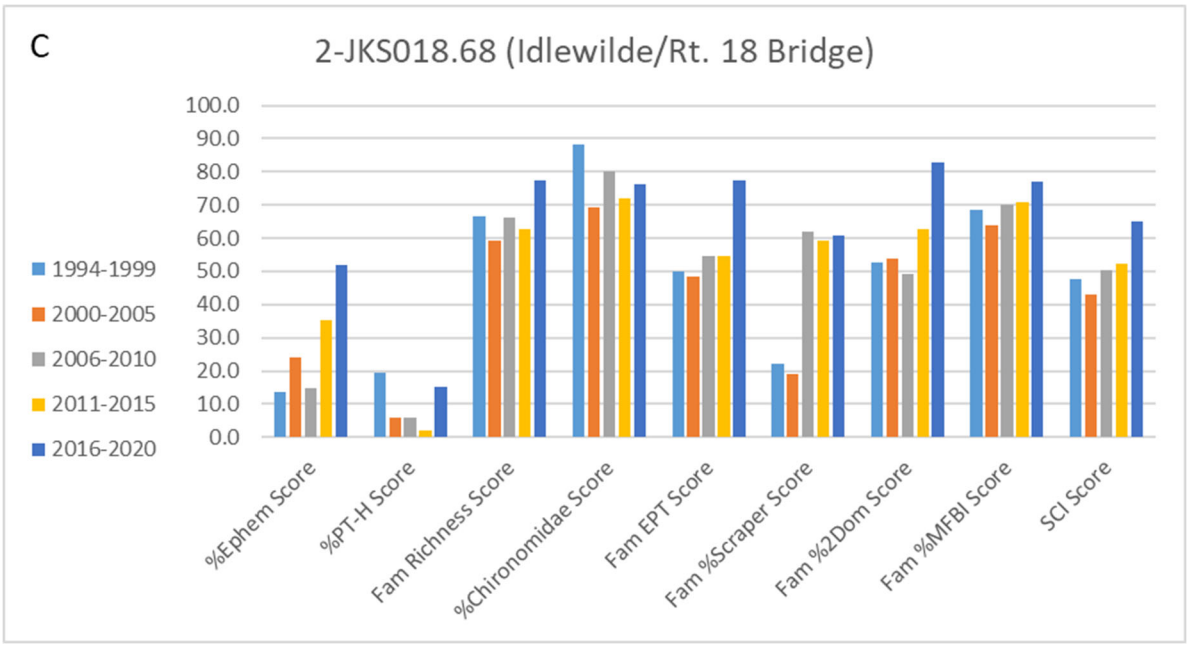
A


2-JKS030.65 (Clearwater Park)
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1994-1999
2000-2005
2006-2010
2011-2016
2016-2020
%Ephem Score
%PT-H Score
Fam Richness Score
%Chironomidae Score
Fam EPT Score
Fam %Scraper Score
Fam %2Dom Score
Fam %MFBI Score
SCI Score

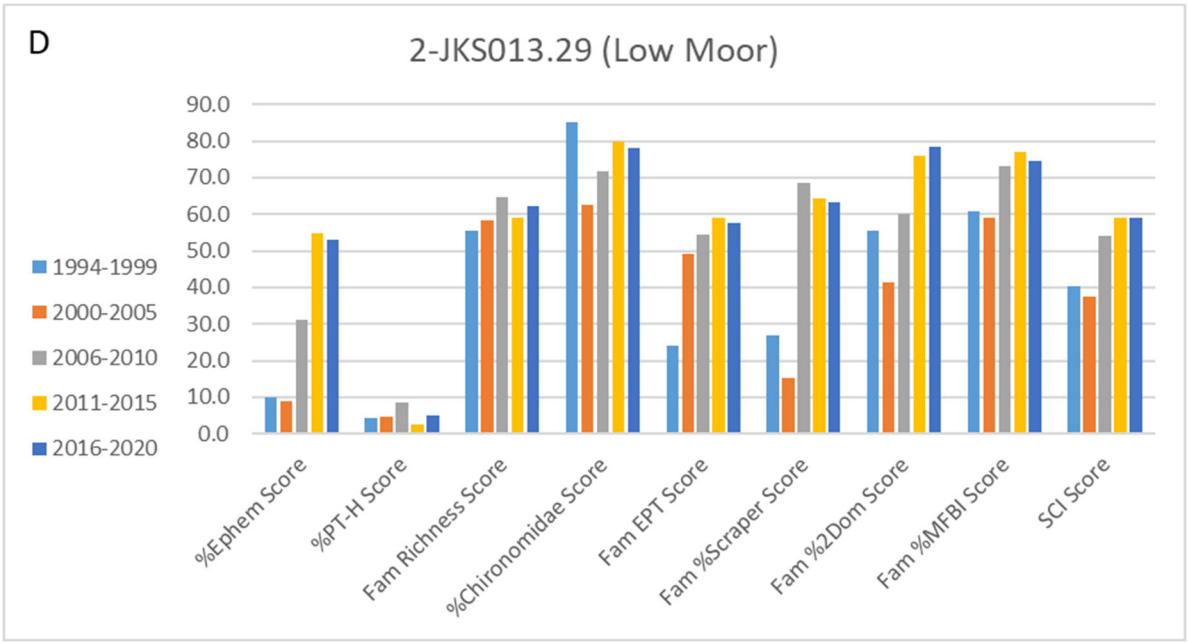
B


2-JKS023.61 (City Park Playground)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1994-1999
2000-2005
2006-2010
2011-2015
2016-2020
%Ephem Score
%PT-H Score
Fam Richness Score
%Chironomidae Score
Fam EPT Score
Fam %Scraper Score
Fam %2Dom Score
Fam %MFBI Score
SCI Score

C


2-JKS018.68 (Idlewilde/Rt. 18 Bridge)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1994-1999
2000-2005
2006-2010
2011-2015
2016-2020
%Ephem Score
%PT-H Score
Fam Richness Score
%Chironomidae Score
Fam EPT Score
Fam %Scraper Score
Fam %2Dom Score
Fam %MFBI Score
SCI Score

D


2-JKS013.29 (Low Moor)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1994-1999
2000-2005
2006-2010
2011-2015
2016-2020
%Ephem Score
%PT-H Score
Fam Richness Score
%Chironomidae Score
Fam EPT Score
Fam %Scraper Score
Fam %2Dom Score
Fam %MFBI Score
SCI Score

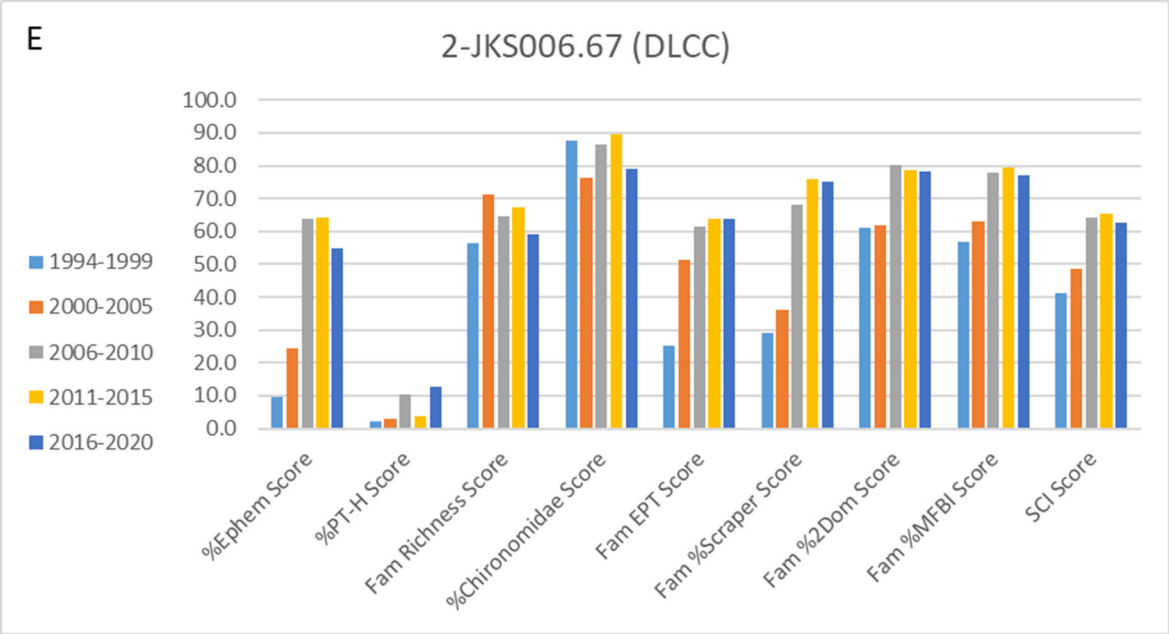


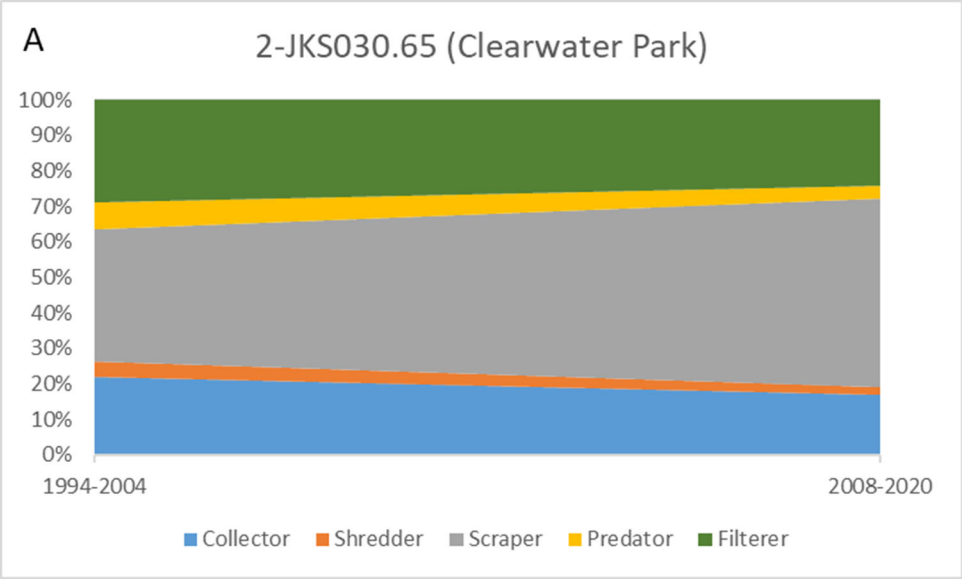
Figure III-1: Macroinvertebrate metrics that make up the Virginia Stream Condition Score. The reference site displayed in A has shown consistently high SCI scores since 1994. Stations shown in C, D, and E generally show increasing average VSCI scores since 1994. This is mainly due to the increase in the percent mayflies observed and the EPT Richness Index score. The EPT Richness Index estimates water quality by the relative abundance of three major orders of stream insects that have low tolerance to water pollution. EPT can be expressed as a percentage of the sensitive orders (E= Ephemeroptera, P= Plecoptera, T= Tricoptera) to the total taxa found. City Park Playground station, shown in B, has increased since originally sampled in 1994; however, the VSCI scores and individual metrics vary from year to year and do not show a consistent trend.

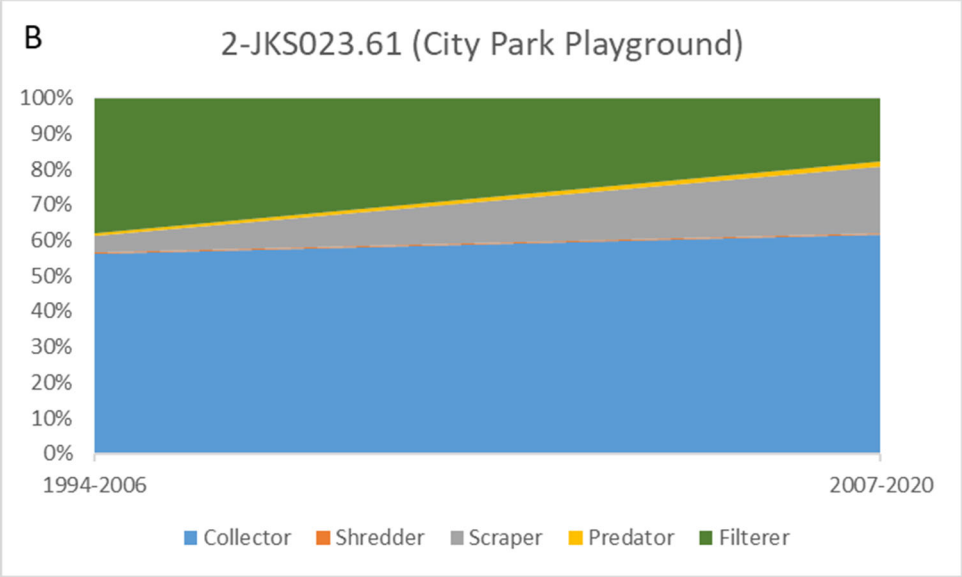
A decrease in the percent 2 dominant taxa metric was also observed over time at most sites. This metric represents the evenness of a community. In impaired communities, more tolerant organisms are able to survive in hostile environments and can capitalize on the resources to increase the population's abundance. The two most downstream stations (Low Moor and DLCC) had a significantly lower percent 2 dominant taxa metric between the 1994-1999 and 2011-2020 categories, which means the community is becoming more even through time (2-JKS013.29 (Low Moor): t-test, p=0.04 & R^2= -0.20 and 2-JKS006.67 (DLCC): t-test, p=0.04 & R^2= -0.53). There was a slight decreasing trend at 2-JKS018.68 (Idlewilde/Rt. 18 bridge; p=0.36 and R^2= -0.18). The most dominant taxa at the downstream stations (2-JKS013.29 (Low Moor) and 2-JKS006.67 (DLCC)) shifted from *Chironomidae* and *Hydropsychidae* in 1994-2005 to *Chironomidae* and *Elmidae* in 2006-2020. Both *Hydropsychidae* and *Elmidae* are somewhat tolerant to pollution and were categorized as being somewhat sensitive to DO in the Virginia Biological Condition Gradient attribution project[1]. However, *Elmidae* and *Hydropsychidae* have different forms of feeding, where *Elmidae* scrape algae and *Hydropsychidae* filter organic matter from the water column.

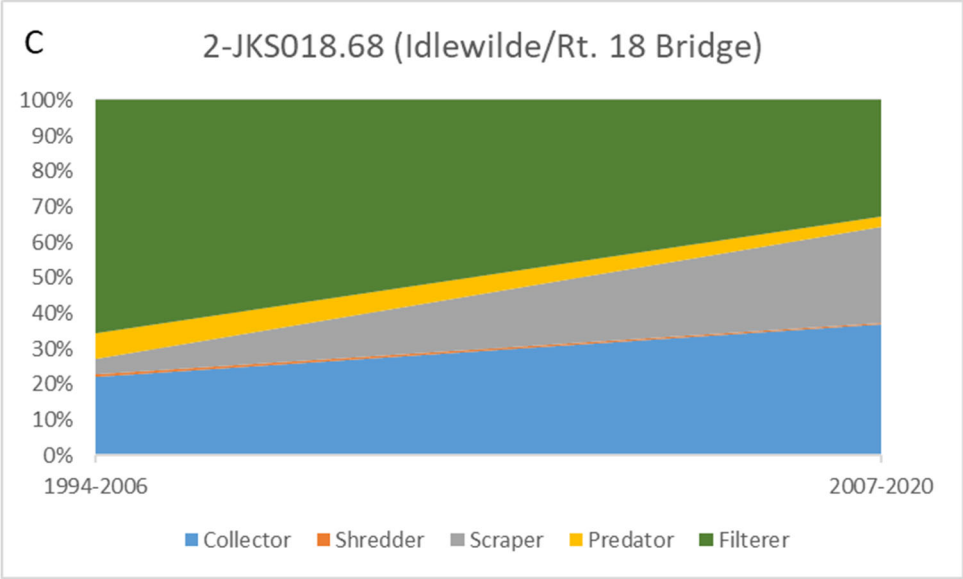
The Idlewilde/Rt. 18 bridge station (2-JKS018.68) showed a shift in dominant taxa from *Hydropsychidae* and *Simuliidae* in 1994-2005 to *Chironomidae* and *Elmidae* in 2006-2020. Similar to the downstream stations (Low Moor and DLCC), the community at the Idlewilde/Rt. 18 bridge station (2-JKS018.68)

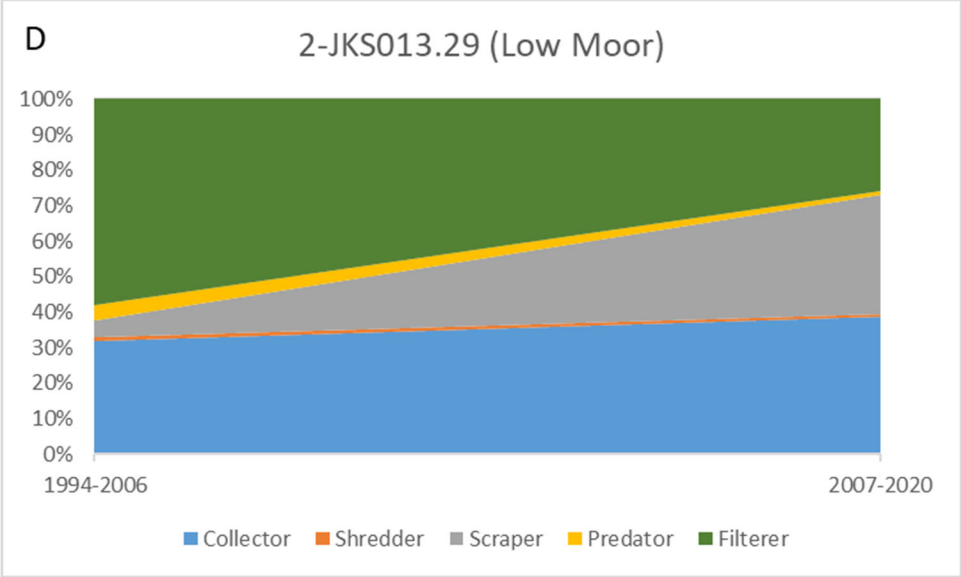
[1]Tetra Tech, Biological Condition Gradient (BCG) Attribute Assignments for Macroinvertebrates and Fish in the Mid-Atlantic Region, 2019.

shifted from a dominance of filtering taxa to scraping taxa (Figure III-2). This change in functional feeding community structure could indicate cleaner substrates that allow scraping taxa to feed. There were no clear taxonomic patterns at station 2-JKS023.61 (City Park Playground), although percent scrapers in general did increase marginally.


A
2-JKS030.65 (Clearwater Park)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1994-2004
2008-2020
Collector
Shredder
Scraper
Predator
Filterer


B
2-JKS023.61 (City Park Playground)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1994-2006
2007-2020
Collector
Shredder
Scraper
Predator
Filterer


C
2-JKS018.68 (Idlewilde/Rt. 18 Bridge)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1994-2006
2007-2020
Collector
Shredder
Scraper
Predator
Filterer


D
2-JKS013.29 (Low Moor)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1994-2006
2007-2020
Collector
Shredder
Scraper
Predator
Filterer

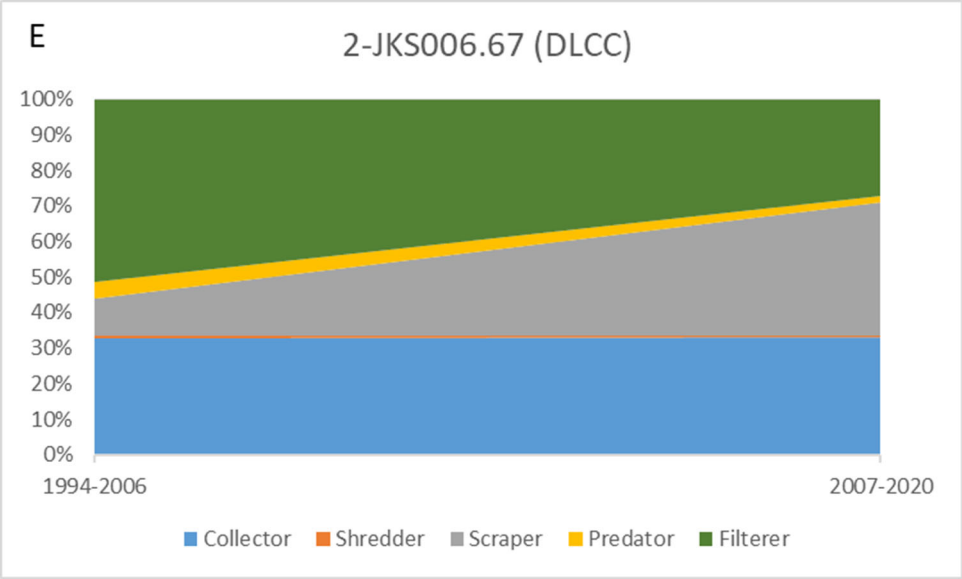


Figure III-2: Functional feeding group (FFG) composition shifted across time. The reference station, Clearwater Park, 2-JKS030.65 (A) changed little between 1994 and 2020 and had a consistent percentage of scraping taxa. At the downstream stations (C, D & E), the historical data shows a high percentage of filtering taxa. More recent data shows a greater percentage of scraping taxa, likely due to cleaner substrate with less dense algae mats. Station 2-JKS023.61, City Park Playground (B) shows a similar trend for more scraping taxa; however, collectors are heavily dominant.

As described in the section above, several segments on the Jackson River have been removed from Virginia's 303(d) impaired waters list due to improvements in the benthic community. VSCI scores have increased since data was first collected at all stations in 1994; in addition, data collection methods have changed and taxonomic resolution has improved. The downstream stations at 2-JKS013.29 (Low Moor) and 2-JKS006.67 (DLCC) showed a linear increase in VSCI score with R^2 values of 0.48 and 0.71, respectively. Upstream station VSCI scores at 2-JKS023.61 (City Park Playground) and 2-JKS018.68 (Idlewilde/Rt. 18 bridge) also tended to increase across time but were more variable (R^2= 0.23 & R^2=0.17).

C. Fish Community Data Trends

DEQ has conducted fish community sampling of the Jackson River since 2009. Four stations were consistently sampled from 2010 to 2017 (Clearwater Park, 2-JKS030.65; City Park Playground, 2-JKS023.61; Idlewilde/Rt. 18 Bridge, 2-JKS018.68; DLCC, 2-JKS006.67). Clearwater Park (station 2-JKS030.65) was chosen as the reference station and used to develop fish community metrics. Overall, the fish community has displayed signs of improvement since initial sampling in 2010. This is in part due to multiple water quality improvements downstream of the WestRock facility and pulse releases from Gathright Dam.

Central Stonerollers (Algivore taxa) species thrive in algae rich environments; therefore, their relative abundance can be used as an indicator of water quality. Central Stonerollers were found in low abundances at Clearwater Park (station 2-JKS030.65), indicating minimal algae growth. However, Central Stonerollers tended to be present in high abundances in the impaired reach of the Jackson River.

The abundance of algivores, specifically the Central Stoneroller, decreased overall at 2-JKS023.61 (City Park Playground) and 2-JKS018.68 (Idlewilde/Rt. 18 Bridge) from initial sampling in 2010. Blacktip Jumprock, a sensitive insectivore, became more common in the Jackson River community as Central Stoneroller abundance decreased. The abundance of sculpins, which require ample amounts of oxygen, cool temperatures, and quality habitat, also increased at all impaired sites since 2010. Sculpins were consistently found at Clearwater Park (station 2-JKS030.65).

DEQ developed state-wide Biological Condition Gradient attributions for fish taxa tolerance of individual stressors. These stressors include dissolved oxygen, habitat, nutrients, pH, and ions[1]. To evaluate the change in percent of taxa that are sensitive to dissolved oxygen stress, the abundance of taxa attributed as sensitive to oxygen would be summed with Central Stonerollers abundance subtracted. Stonerollers are sensitive to dissolved oxygen and prefer fast-moving water but appear in large numbers with high nutrient loads and are considered a non-sensitive taxa overall. Clearwater Park (station 2-JKS030.65) had a consistent population of over 60% community abundance of dissolved oxygen sensitive fish taxa.

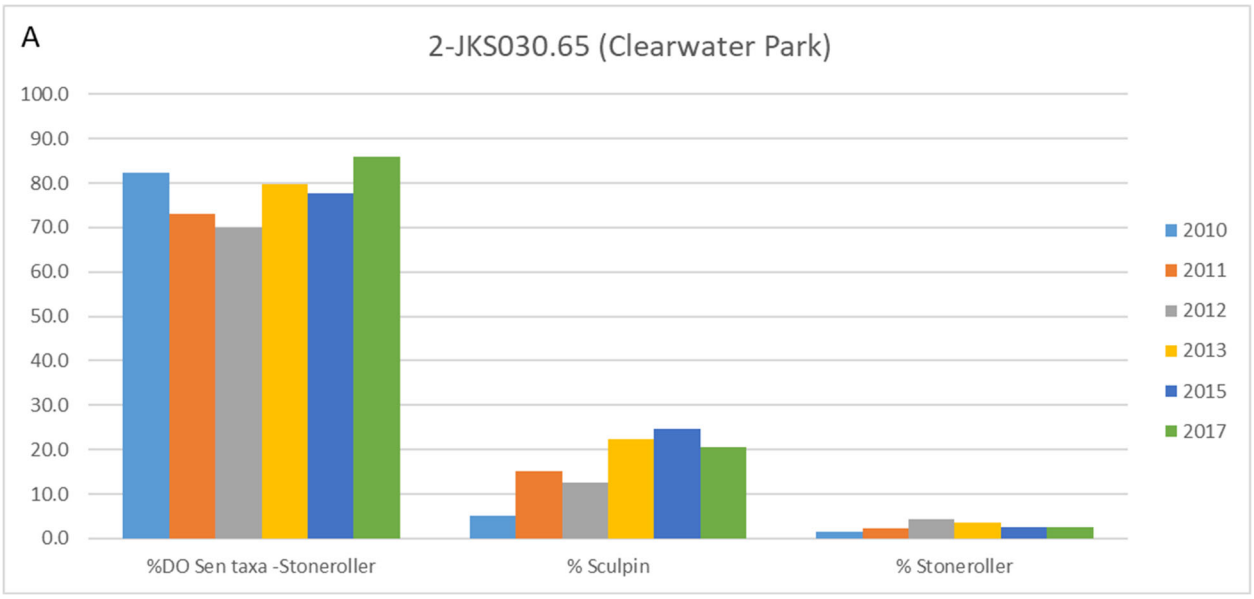
The City Park Playground (station 2-JKS023.61) fish community experienced an increase in dissolved oxygen sensitive taxa abundance from 13.3% in 2010 to 76.4% in 2017 (Figure III-3.B). Central stonerollers decreased at the City Park Playground station from 43.8% in 2010 to 26.3% in 2017 and Blue Ridge Sculpin abundance increased from 2.5% in 2010 to 7.9% in 2017. The Shield Darter and Cutlips Minnow were also observed at the City Park Playground station beginning in 2015. Shield Darters and Cutlips Minnows are dissolved oxygen sensitive taxa and have been consistently captured at the Clearwater Park (2-JKS030.65) reference site. Observation of these sensitive taxa returning to the City Park Playground station indicates that water quality, specifically dissolved oxygen levels, have improved since 2010 in this segment of the river.

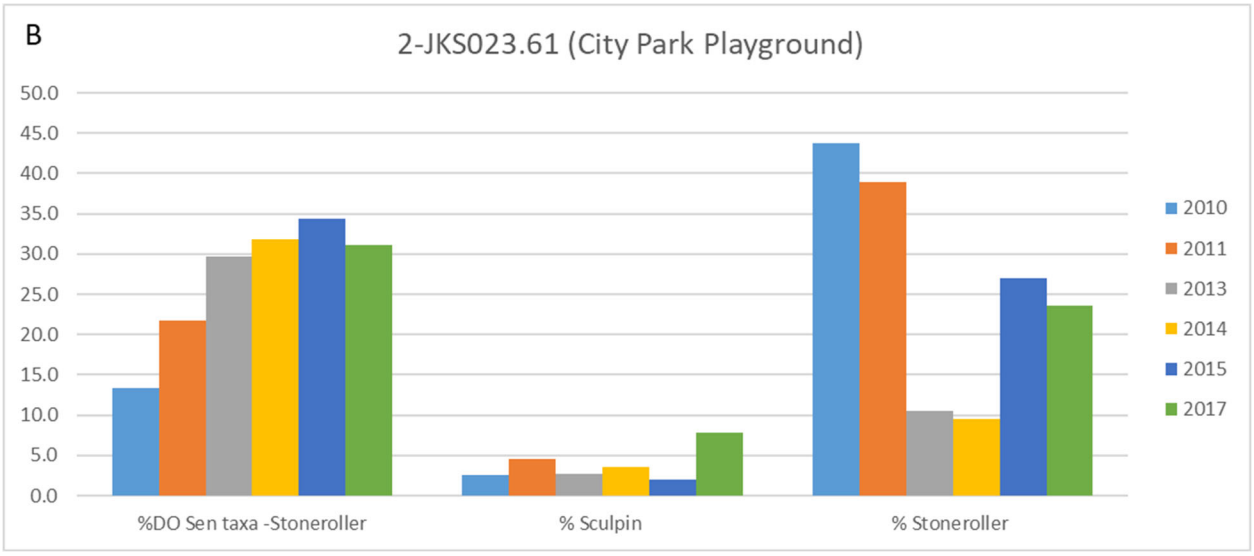
The Idlewilde/Rt. 18 bridge (station 2-JKS018.68) fish community also experienced an increase in dissolved oxygen sensitive taxa abundance from 23.1% in 2010 to 76.4% in 2017 (Figure III-3.C). A significant decrease in Stonerollers was observed from 37.2% in 2010 to 14.7% in 2017. Blue Ridge Sculpin appeared to have become more common at the Idlewilde/Rt. 18 bridge site with an abundance increase from 0.4% in 2010 to 5.1% in 2017. More sensitive species, such as the Blacktip Jump, have replaced stonerollers as the dominant taxa. Other species presence to note were the Torrent Sucker and Cutlips Minnow which are dissolved oxygen sensitive taxa and commonly inhabited the reference site at Clearwater Park (station 2-JKS030.65).

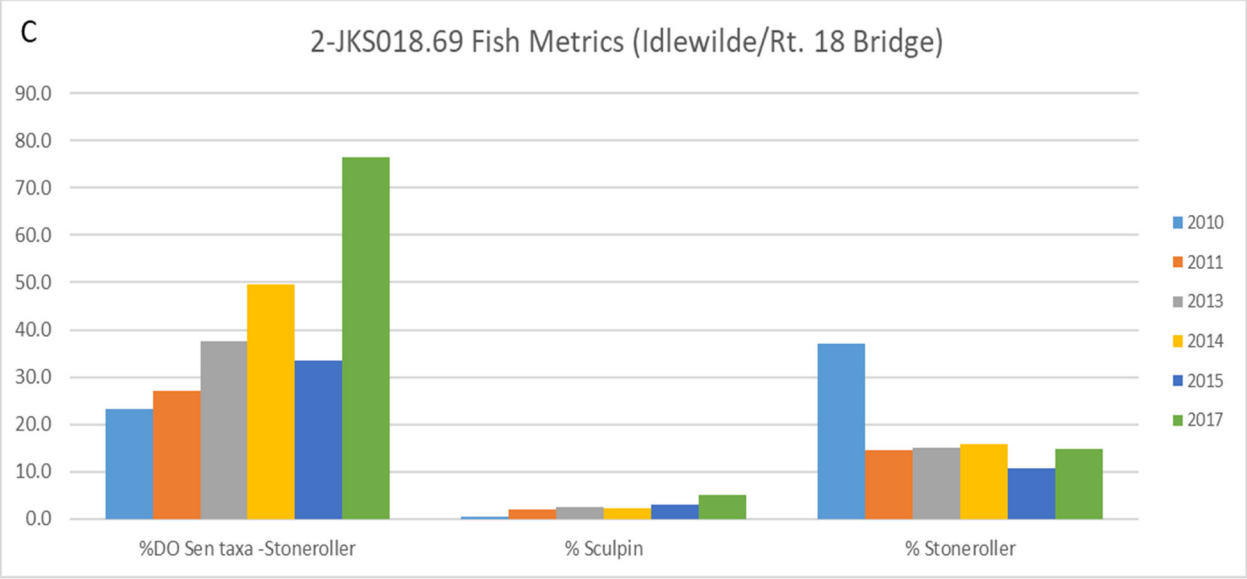
The DLCC (station 2-JKS006.67) fish community also experienced an increase in dissolved oxygen sensitive taxa abundance from 23.1% in 2010 to 40.6% in 2017 (Figure III-3.D). A slight decrease in stoneroller abundance was observed from 26.4% in 2010 to 22.3% in 2017. Blue Ridge Sculpin was captured for the first time in 2017 which increased the Sculpin abundance to 1.1% for that year. Other observations to note were an increase in Bull Chubs, which are dissolved oxygen sensitive mound builders, and sucker species such as the Blacktip Jumprock and Torrent Sucker, which are dissolved oxygen sensitive species.

Fish metrics at all downstream stations of the reference station have shown significant fish community changes that favor taxa sensitive to dissolved oxygen. River conditions have become less favorable to tolerant Algivores such as the Central Stoneroller which have decreased at all three sites downstream of Clearwater Park (station 2-JKS030.65), indicating less algal growth over time. More sensitive minnow and sucker species are able to take advantage of improved water quality conditions of the river. These

changes over time have indicated water quality improvements, specifically in dissolved oxygen, in the reach of the study.


A
2-JKS030.65 (Clearwater Park)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%DO Sen taxa -Stoneroller
% Sculpin
% Stoneroller
2010
2011
2012
2013
2015
2017


B
2-JKS023.61 (City Park Playground)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
%DO Sen taxa -Stoneroller
% Sculpin
% Stoneroller
2010
2011
2013
2014
2015
2017



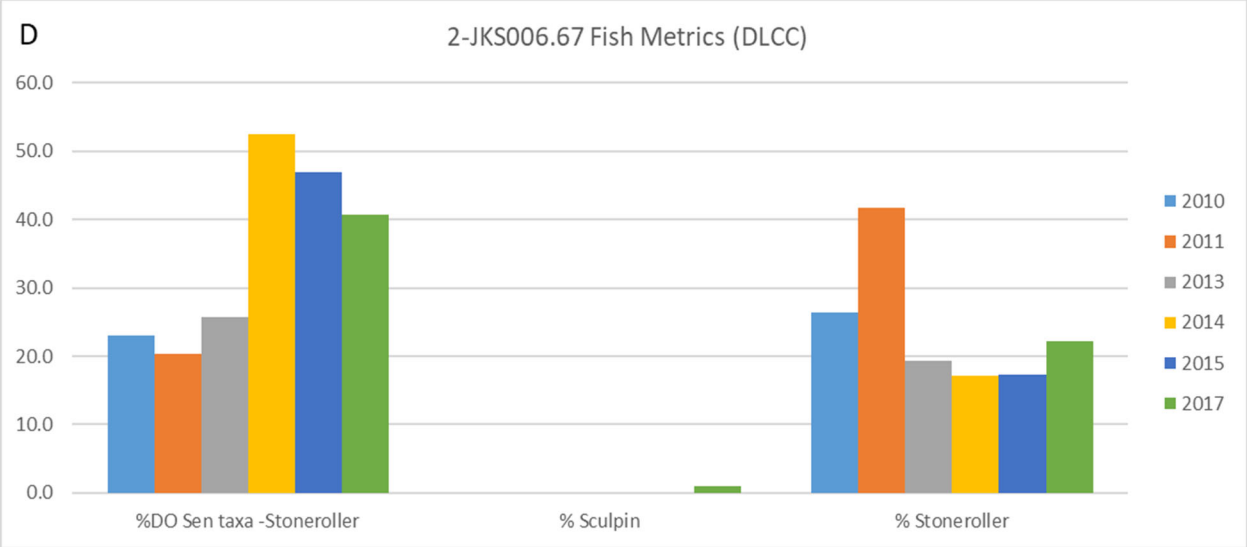


Figure III-3: DO sensitive taxa, as defined by the Biological Condition Gradient document[1], are stable at the reference station (A) but have increased in the past seven (7) years at the downstream, biologically impaired stations (B-D). The percent of Sculpins found at each site has increased over time at most stations. Stonerollers have decreased in dominance over time at most stations.

DEQ plans to continue monitoring for fish, algae, macroinvertebrates, and water quality parameters for several more years. Every few years, DEQ collects fish community, physical habitat, algae, and macroinvertebrate data as a part of the probabilistic monitoring program. This data will next be collected in the fall of 2021 and macroinvertebrate data will be collected in the spring and fall of 2021 by a DEQ biologist at several stations along the impaired reach and reference sites. Algae will be collected during three (3) pre- and post-pulse events in the summer and fall of 2021. Ambient water quality data is collected bimonthly at two (2) stations along the Jackson River as a part of the trend monitoring program and data will continue to be collected indefinitely as funding is available (City Park Playground station 2-JKS023.61 and Idlewilde/Rt. 18 bridge station 2-JKS018.68).

IV. Dissolved Oxygen Study Methods

A. General Methods Overview

This study was designed to collect robust dissolved oxygen (DO) measurements (along with river temperature and specific conductivity water quality parameters) throughout two (2) full years from April 2019 to March 2021.

The Virginia water quality standard for the Jackson River is a minimum of 4.0 mg/L DO and a minimum daily average of 5.0 mg/L DO. Typically, dissolved oxygen levels are lowest in the pre-dawn to dawn timeframe and steadily rise through the day due to the photosynthesis effect and respiration of plant life in the river. Data was collected in the early morning for comparison to the minimum standard. If the measured value was above 5.0 mg/L, then it is assumed that the dissolved oxygen value also met the daily average requirement.

Field parameters were collected during early morning hours (6am-9am) when dissolved oxygen is expected to be at its lowest. All samples were collected at pre-determined stations to ensure consistency during the study. Historical data indicates that dissolved oxygen is at its highest during winter and springtime periods when water flow is higher and ambient temperature is lower. Summertime conditions yield somewhat lower dissolved oxygen due to higher temperatures, but river flows are generally higher. The fall season results in the lowest dissolved oxygen conditions due to low water levels and relatively high ambient temperatures. The study confirmed these general historic observations.

During the less stressful spring and winter seasons (December-May), one sample per month was collected. Field staff from DEQ and WestRock alternated data collection during these months. For the summer season (June-August), weekly monitoring was conducted. WestRock field staff collected measurements during these summer months. During more stressful periods (September-mid-November) when river flows are expected to be lower and river temperatures are expected to be higher, sampling frequency increased to three (3) times per week. A third-party technician from ONE Environmental Group (ONE) collected data during these months. Additionally, once in September and once in October (of each year), extensive sampling occurred at two (2) stations for three (3) weekdays in a row to better understand the diurnal dissolved oxygen effect.

Field measurements were collected at the following stations on the Jackson River: 2-JKS026.01, 2-JKS023.61, 2-JKS022.78, 2-JKS022.15, 2-JKS021.09, 2-JKS018.68, and 2-JKS015.60. Table IV-1 contains location information for the stations monitored in this study. An outline of sampling frequency is provided in Table IV-2 and a map of the sample stations is included as Figure IV-1.

For all data collected other than the aforementioned diurnal effect monitoring, if DO measurements collected in the first morning time zone (6am – 9am) were below 5.0 mg/L at any station, follow-up monitoring was conducted at all stations in the second and third three (3)-hour time zones (9am-12pm and 12pm-3pm, respectively). Additional samples were collected in the fourth three (3)-hour time zone (3pm-6pm) if necessary and were included in the average for that day.

Quarterly meetings were held with the project teams to discuss the progress of the study and review the data collected during the previous quarter. See Appendix B for quarterly project team meeting notes.

Waterbody Name	Station ID	Description	Latitude	Longitude	Sample Method
Jackson River	2-JKS026.01	Covington Water Filtration Plant	37.811	-79.988	Wading/Streambank
	2-JKS023.61	City Park Playground – At USGS gauge 02013100	37.788	-80.000	Wading/Streambank
	2-JKS022.78	Upstream side of Route 154 bridge/Fudges Bridge	37.778	-79.991	Bridge
	2-JKS022.15	Industrial Park Behind Wal-Mart	37.767	-79.988	Wading/Streambank
	2-JKS021.09	South Rayon Drive crossing/Hercules	37.761	-80.000	Bridge
	2-JKS018.68	Idlewilde/Rt. 18 Bridge	37.757	-79.987	Bridge
	2-JKS015.60	Behind Mallow Mall	37.771	-79.966	Wading/Streambank

Table IV-1. Monitoring stations for study and sampling method for each location.

Station ID	Description	Summer Season		Fall Season		Winter/Spring Season
		June 15 – August		September – November 15		December – May
2-JKS026.01	Covington Water Filtration Plant	1/month	--	1/month	--	1/month
2-JKS023.61	City Park Playground – At USGS gauge 02013100	1/month	--	1/month	--	1/month
2-JKS022.78	Upstream side of Route 154 bridge/Fudges Bridge	1/month	1/week	Collected diurnal data 1/month to understand diurnal effect	3/week	1/month
2-JKS022.15	Industrial Park Behind Wal-Mart	1/month	--		3/week	1/month
2-JKS021.09	South Rayon Drive crossing/Hercules	1/month	1/week		3/week	1/month
2-JKS018.68	Idlewilde/Rt. 18 Bridge	1/month	1/week		3/week	1/month
2-JKS015.60	Behind Mallow Mall	1/month	--		3/week	1/month

Table IV-2. Monitoring schedule and frequency of monitoring for each location.

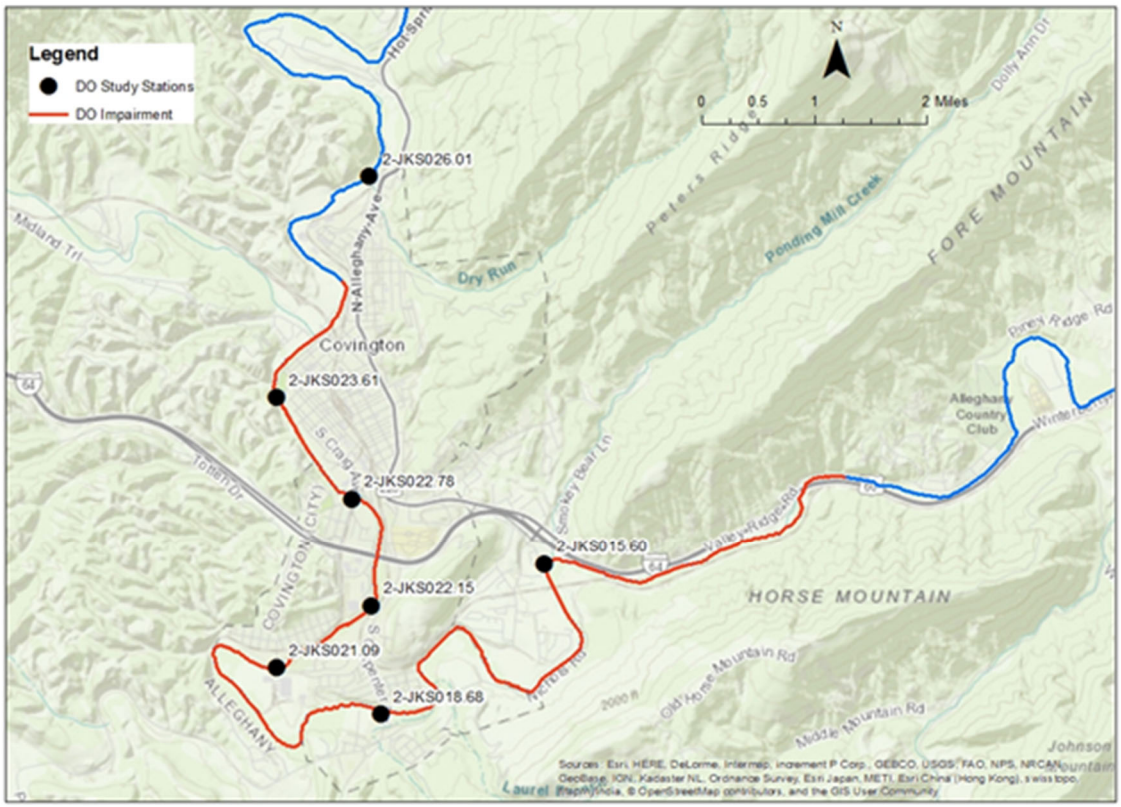


Figure IV-1. Map of the Jackson River DO impairment and project monitoring locations.

B. Quality Assurance Project Plan

Prior to the start of this study, a Quality Assurance Project Plan (QAPP) for the Special Study of Dissolved Oxygen Concentrations in the Jackson River Watershed, Alleghany County and Covington City, VA was prepared by the DEQ and approved by all parties involved in the study (DEQ, WestRock, and ONE). The QAPP outlined project implementation and provided detail on the management, measurement and data acquisition, oversight and assessment, and data validation and usability. The two frameworks utilized for the development of the QAPP were the DEQ Office of Water Quality Assessment's "Standard Operating Procedures Manual" and the Environmental Protection Agency (EPA) Office of Environmental Information's "Requirements for Quality Assurance Project Plans." The QAPP is maintained in the DEQ's CEDSWQM system as approved and fully executed by DEQ on April 29, 2019.

The QAPP and the Standard Operating Procedures referenced within it were followed at all times for the duration of the study.

C. Field Sampling Methods

This section briefly describes the field procedures utilized for sample collection. A more detailed description can be found in the current version of the Standard Operation Procedures (SOP) manual for the Virginia Department of Environmental Quality (Office of Water Quality Assessment).

1. Preparation for Field Work

Before field work began, the field staff ensured that the necessary equipment was cleaned, calibrated, and in good working order.

2. Sampling Preparation and Procedures

All sampling equipment preparation and cleaning, field calibration, and testing procedures outlined in the current DEQ SOP manual were followed.

Prior to sample collection each morning, the DO probe of the sampling equipment was calibrated according to the current DEQ SOP manual and equipment manual. The DEQ-provided oxygen saturation chart and current local barometric pressure were utilized to ensure calibration was accurate. The probe DO level was recorded and compared to the theoretical DO value that was calculated using the water temperature and barometric pressure at that time. These two values were compared to ensure that there was not a calculated difference of 0.1 mg/L or more. The SOP manual specifies that if there was a calculated difference of 0.1 mg/L or more a recalibration was required. The equipment could also be recalibrated at any point during the sampling day if needed.

Calibrations were documented on a calibration log provided in Appendix C.

Additionally, a post-check of the sampling equipment was performed at the end of each sampling day within four (4) hours of collecting the last sample or after each sampling time zone if more than one time zone was sampled. The DEQ-provided oxygen saturation chart and current barometric pressure were utilized to ensure the post-check was accurate and that there was not a calculated difference of greater than 0.5 mg/L. During the study, there was one occurrence of sampling equipment not meeting the post-check standard during a routine monitoring event by DEQ on August 11, 2020. Data from that day was removed from the dataset.

Sampling was conducted at each station based on the safest and most effective option available for that location (i.e. wading, streambank sampling, or collecting from a bridge). The preferred method of sampling at each specific location was pre-determined, but for safety considerations the sampler was given discretion based on river conditions. For locations where wading occurred, DO sample collection occurred in the middle third of the river during base or low flow. During high flow or high turbidity, streambank sampling was utilized at stations where there was no bridge to sample from to assure the safety of the sampler. If the sampler deemed it to be unsafe to wade or sample from the streambank, only stations sampled from a bridge were sampled that day. These periods were documented accordingly. NOTE: Historical data has shown that as river flow increases dissolved oxygen increases. As a result, conditions that were deemed unsafe due to higher flow conditions, would very likely have yielded higher dissolved oxygen conditions.

For locations where samples had to be collected by wading, the field team did not sample by wading if the river flow was above 500 cfs at USGS gage 02013100, Jackson River BL Dunlap Creek at Covington, VA (https://waterdata.usgs.gov/va/nwis/uv?site_no=02013100) to ensure the safety of the sample collector. Streambank samples were collected in lieu of wading if the sampler deemed wading to the middle third of the channel to be unsafe. During the weeks where the Gathright Dam had a large pulse release, sampling was conducted the day prior to the pulse event and then after the release due to

safety considerations of the potential increased river flow. If a scheduled pulse did not occur, sampling was conducted under the normal sampling schedule (Table IV-2). These instances were well documented by the field team.

As indicated in the DEQ SOP manual, for sampling locations from a bridge, in-situ measurements were collected by lowering the sonde off the bridge with a long cable into the water column and allowing it to remain submerged long enough for a stable reading.

No laboratory samples were utilized for this study. Only field parameter data were collected.

3. Field Documentation

All necessary field documentation, including observations, measurements, and any other documentation were maintained by the field sampling team. Entries were made in blue or black indelible ink. Corrections consisted of a single line-out deletion and corrections were initialed.

The field sampling team was responsible for maintaining field data sheets. An entry was made on the field data sheet for each sample collected. The intent of the field data sheet was to document the place, date, and time for each sample collected. The same data sheet entry recorded any known deviation from the specified sampling described herein, and other pertinent field observations associated with the samples. The field sampling team also documented all quality control checks that include calibrations prior to sample collection and post-checks to verify equipment functionality.

The DO level that was documented at each sampling location during each sampling event was the value on the hand-held YSI instrument when the DO had stabilized for 1-2 minutes.

Additionally, if the DO level collected in the first time zone of a sampling event was less than 5.0 mg/L, subsequent sampling was performed as outlined above and an average of the values was utilized as the documented DO level for that station for that day.

Field data collection was recorded on data collection logs, submitted electronically to DEQ for entry into the Comprehensive Environmental Data System Water Quality Module (CEDSWQM) database, and then verified again and validated for accuracy after entry. This data is considered to be Level III data. Level III data has the most strict quality assurance (QA)/quality control (QC) protocols and verification of collection methods of all environmental data. Level III data requires a DEQ-approved Quality Assurance Project Plan (QAPP) and SOP, does not allow for methods to deviate from approved methods, and requires a field or laboratory audit (Appendix D). This data can be used for impairment listing and delisting under the Clean Water Act Section 303(d).

4. Field Quality Control and Audits

All field quality control samples were collected in accordance with the current DEQ SOP manual. Since the project involved two non-DEQ organizations, a side-by-side sample event with each partner was performed each year of the study to verify the field equipment used had readings comparable to DEQ instrumentation.

An initial field audit was also conducted by DEQ Quality Assurance and Quality Control personnel prior to initial sample collection to verify availability and proper use of field equipment, adherence to project-controlling documents for sample collection, identification, and handling, and calibration and post-check activities (Appendix D).

5. Instrument and Equipment Testing, Inspection, and Maintenance Requirements

The field staff were responsible for the maintenance of equipment used to measure all the requested water quality field parameters, in accordance with the current DEQ SOP manual. This included an annual check of sensor accuracy of the field probes by either comparing against validated equipment or references.

V. Data Summary and Analysis

A. Data Validation

As described in Section IV.C.3, data was collected on field collection sheets, transmitted electronically to the DEQ for entry into the CEDSWQM database, and then verified again for accuracy after entry. Data was then tabulated and graphically presented to the project team on a quarterly basis for discussion and project tracking.

B. Overall Data Trends

Figure V-1 displays DO data from all seven (7) stations included in this study and the additional stations monitored by DEQ for the full length of the study (April 2019-March 2021). Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. The red line displays the average DO level that would indicate an exceedance (5.0 mg/L). Note that no exceedances of this average DO level occurred.

There was a significant change in DO during the winter and spring seasons versus the summer and fall seasons. These variations match historical observations and correlate with river temperature and flow rate. This is discussed and displayed graphically below.

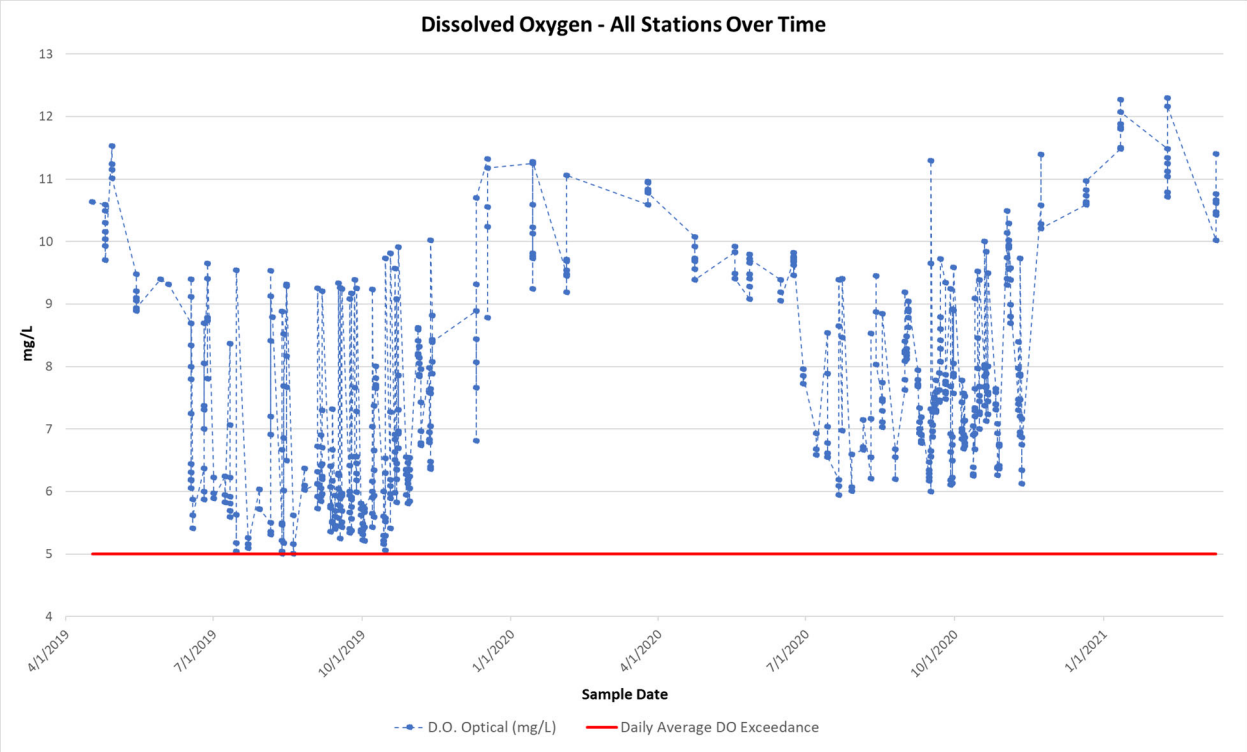


Figure V-1. Dissolved Oxygen – All Stations Over Time

Figure V-2 displays DO data from stations 2-JKS023.61, 2-JKS022.78, 2-JKS022.15, 2-JKS021.09, 2-JKS018.68, and 2-JKS015.60 for the full length of the study (April 2019-March 2021). These are the stations that are located downstream of the confluence of the Jackson River and Dunlap Creek in the DO impaired section of the Jackson River. Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. The red line displays the average DO level that would indicate an exceedance (5.0 mg/L). Note that no exceedances of this average DO level occurred.

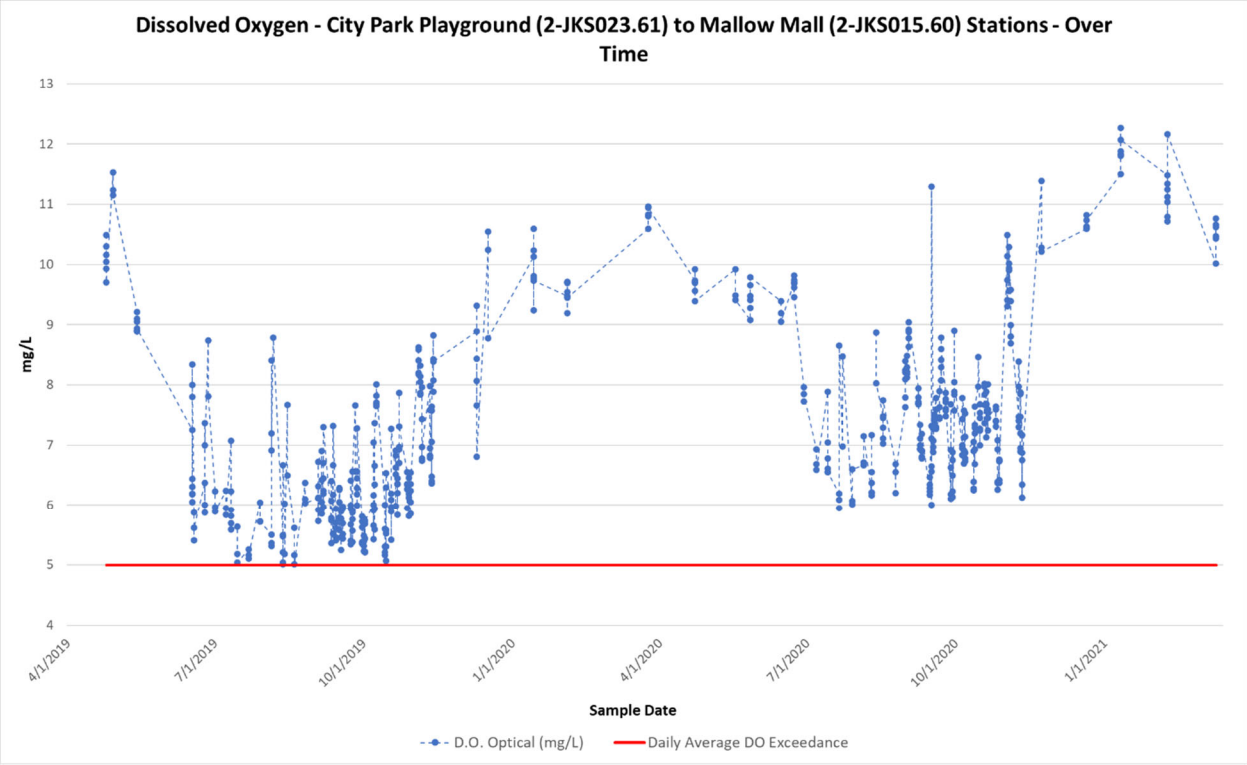


Figure V-2. Dissolved Oxygen – City Park Playground (2-JKS023.61) to Mallow Mall (2-JKS015.60) Stations – Over Time

Figure V-3 displays DO and river temperature data from all seven (7) stations included in this study and the additional stations monitored by DEQ for the full length of the study (April 2019-March 2021). Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. This figure demonstrates the inverse relationship between DO and river temperature. The seasonal changes in DO are apparent as DO increases in the winter season as river temperatures decrease and then decreases in the summer season when river temperatures rise. This is an expected trend as the solubility of oxygen decreases as river temperature increases.

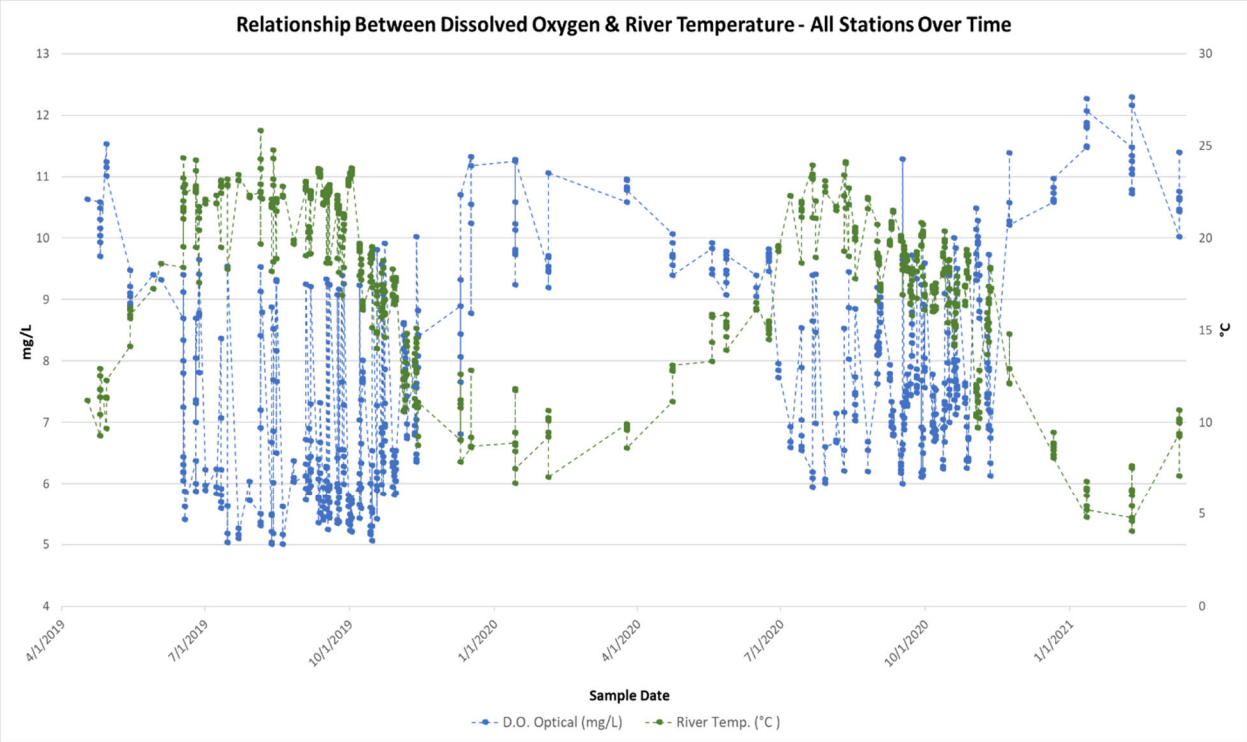


Figure V-3. Relationship Between Dissolved Oxygen & River Temperature – All Stations Over Time

Figure V-4 displays DO data from stations 2-JKS023.61, 2-JKS022.78, 2-JKS022.15, 2-JKS021.09, 2-JKS018.68, and 2-JKS015.60 for the full length of the study (April 2019-March 2021). Flow data shown is the 24-hour average from USGS Gage 02013100 (Jackson River Below Dunlap Creek). Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. During the summer and fall seasons of 2020, flow and DO were generally higher than in 2019 due in large part to the very low amount of rainfall in those seasons of 2019.

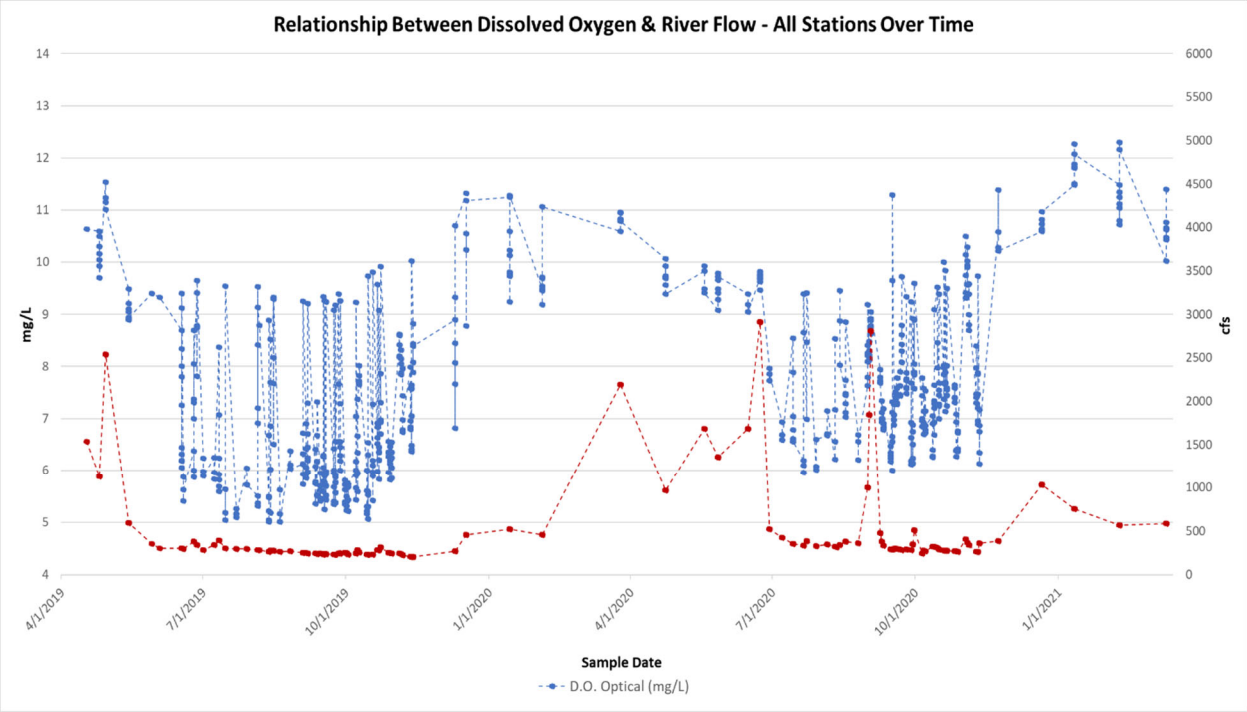


Figure V-4. Relationship Between Dissolved Oxygen & River Flow – All Stations Over Time

C. Station-Specific Data Trends

The following figures (Figures V-5 through V-11) individually display all DO data for each station for the full length of the study (April 2019-March 2021). These figures include all samples collected by WestRock, ONE, and DEQ. The red line displays the minimum DO level that would indicate an exceedance (4.0 mg/L). Note that no exceedances of this minimum DO level occurred.

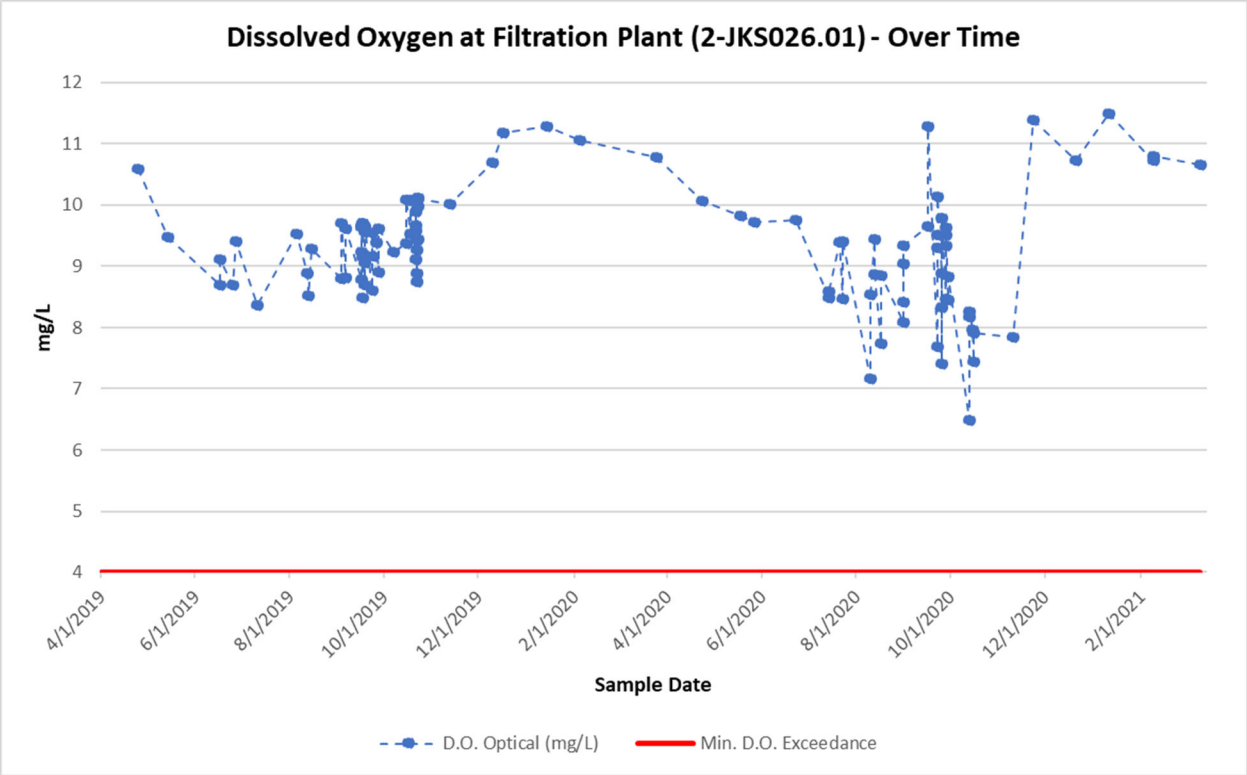


Figure V-5. Dissolved Oxygen at Filtration Plant (2-JKS026.01) – Over Time

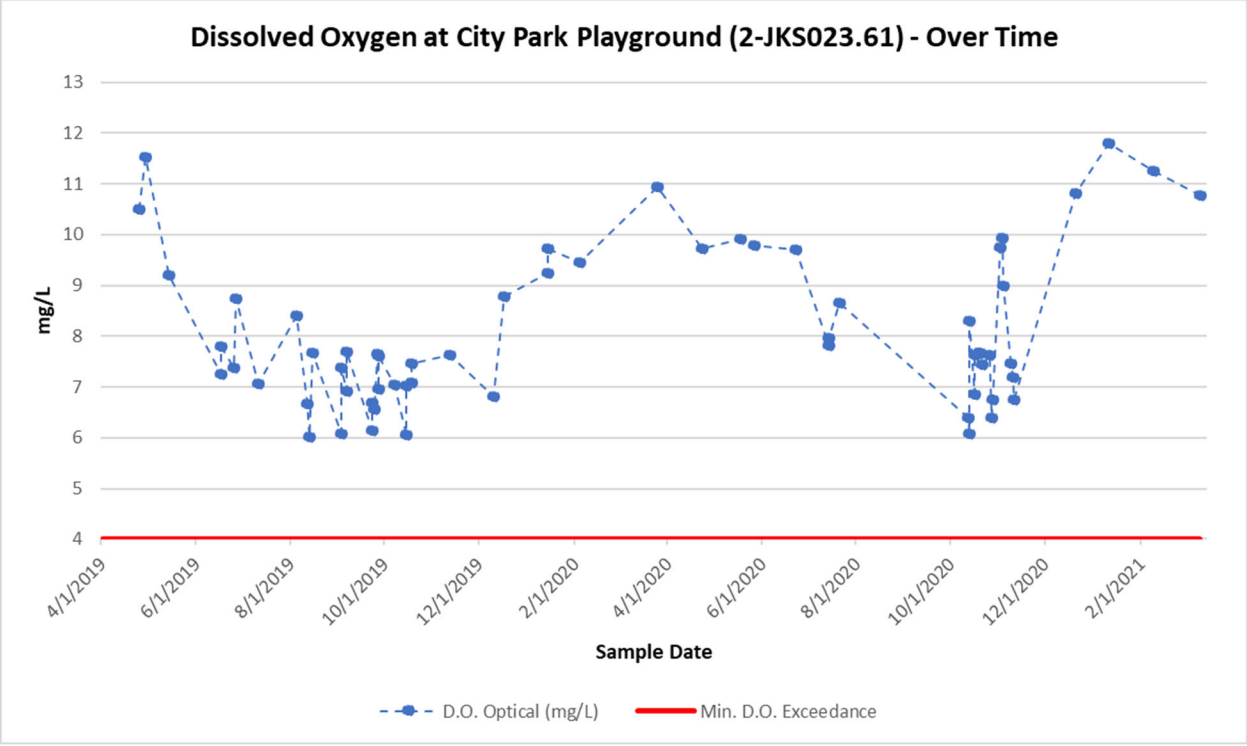


Figure V-6. Dissolved Oxygen at City Park Playground (2-JKS023.61) – Over Time

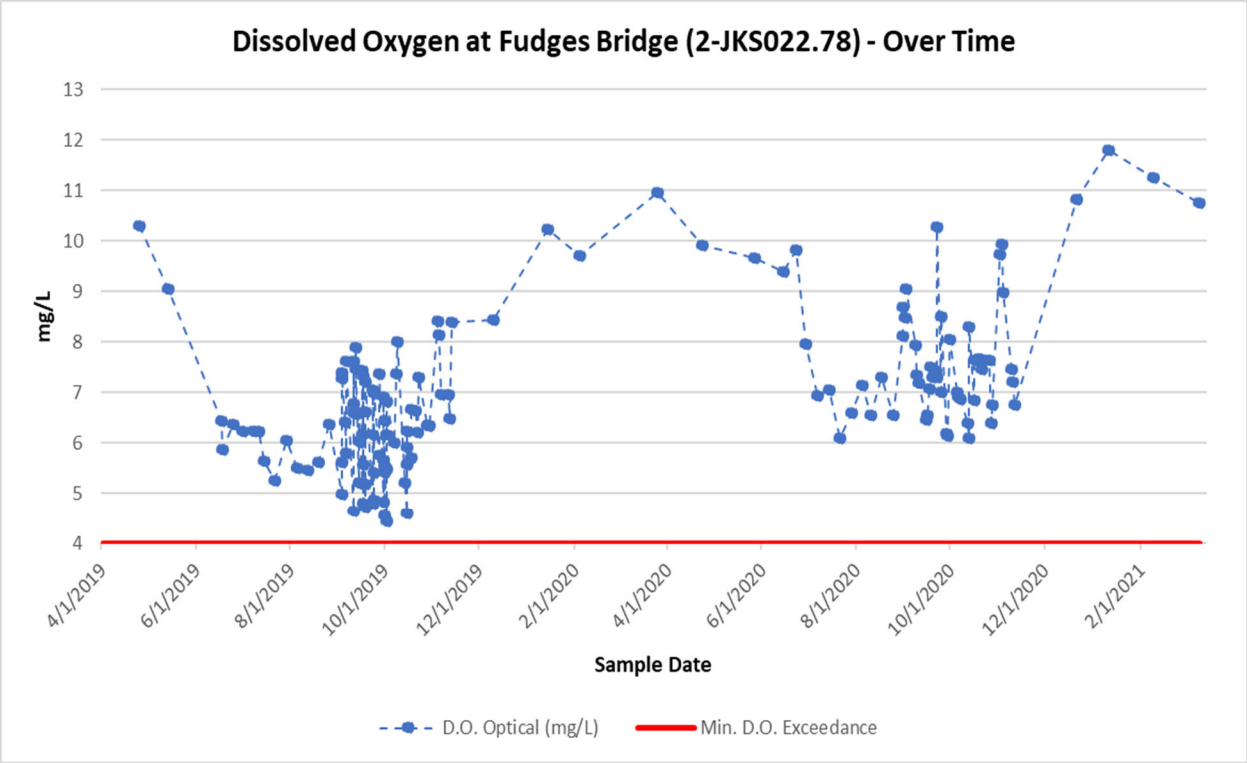


Figure V-7. Dissolved Oxygen at Fudges Bridge (2-JKS022.78) – Over Time

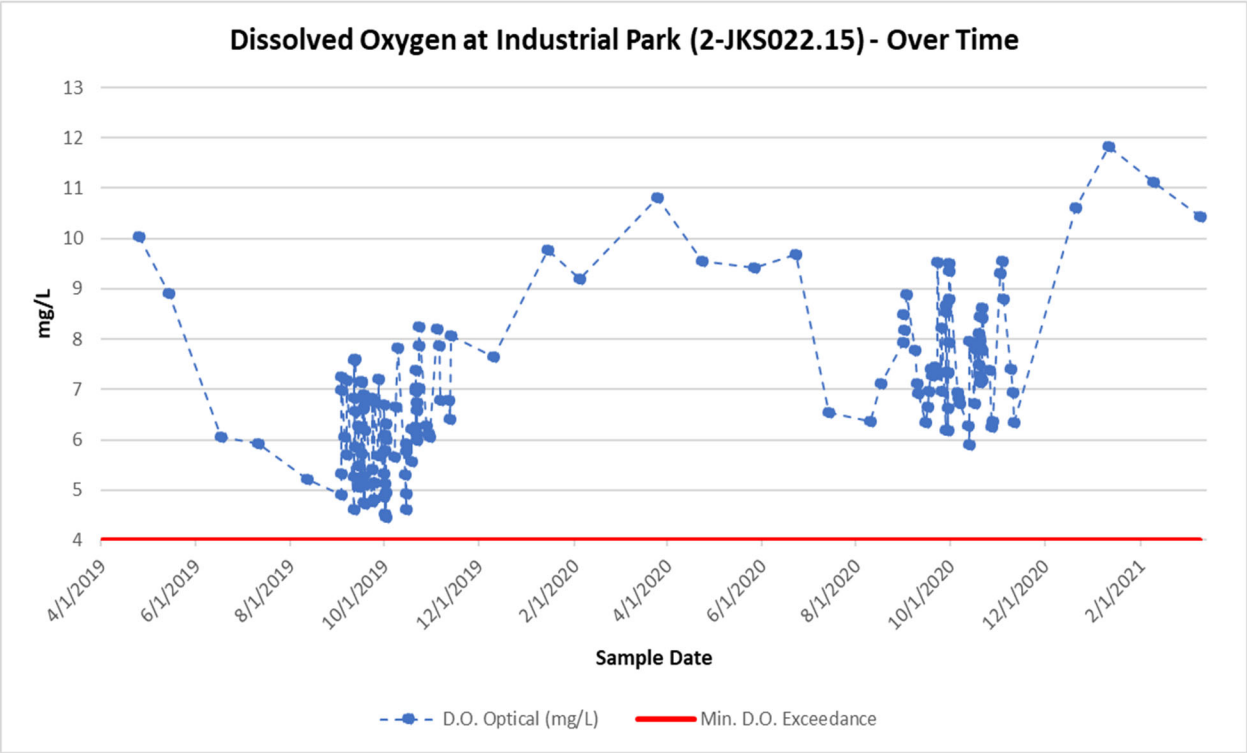


Figure V-8. Dissolved Oxygen at Industrial Park (2-JKS022.15) – Over Time

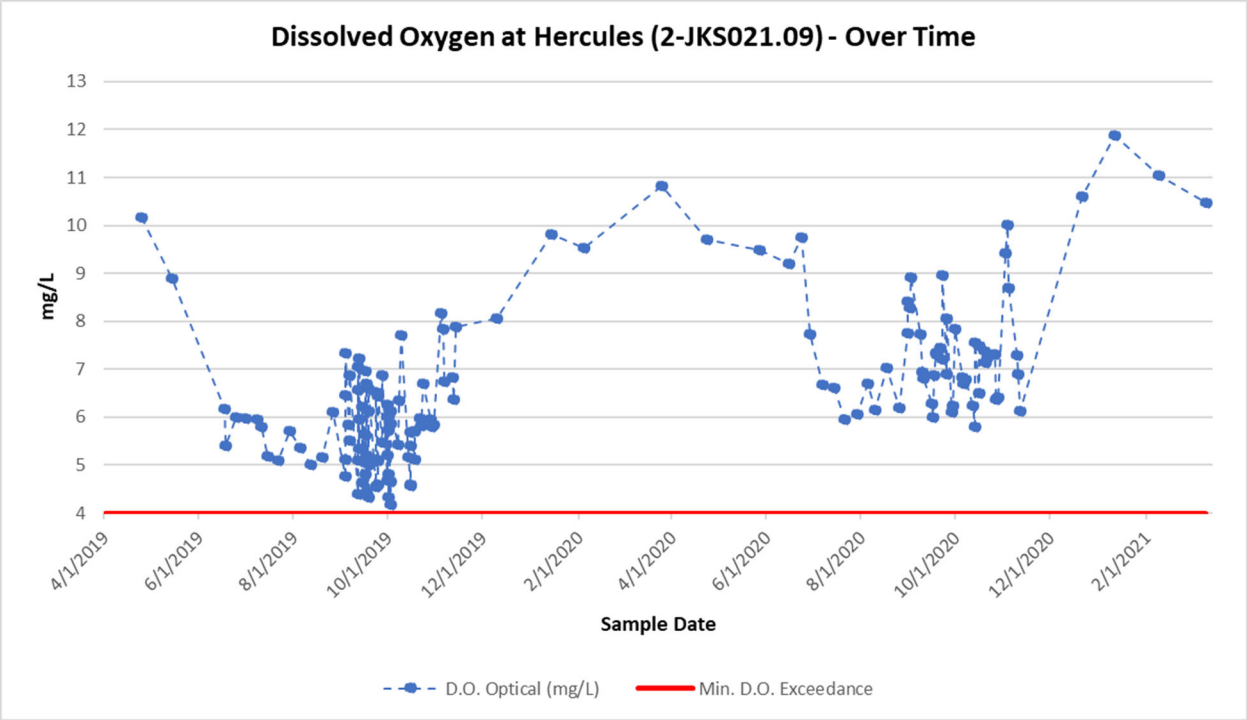


Figure V-9. Dissolved Oxygen at Hercules (2-JKS021.09) – Over Time

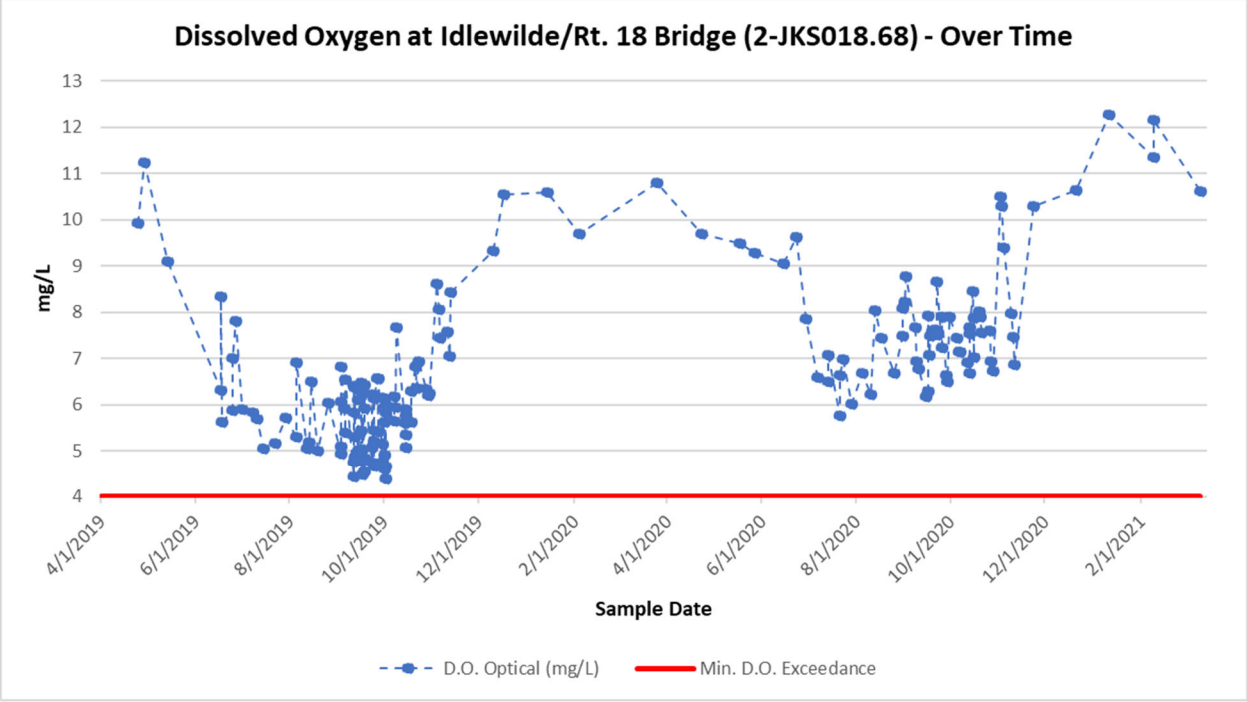


Figure V-10. Dissolved Oxygen at Idlewilde/Rt. 18 Bridge (2-JKS018.68) – Over Time

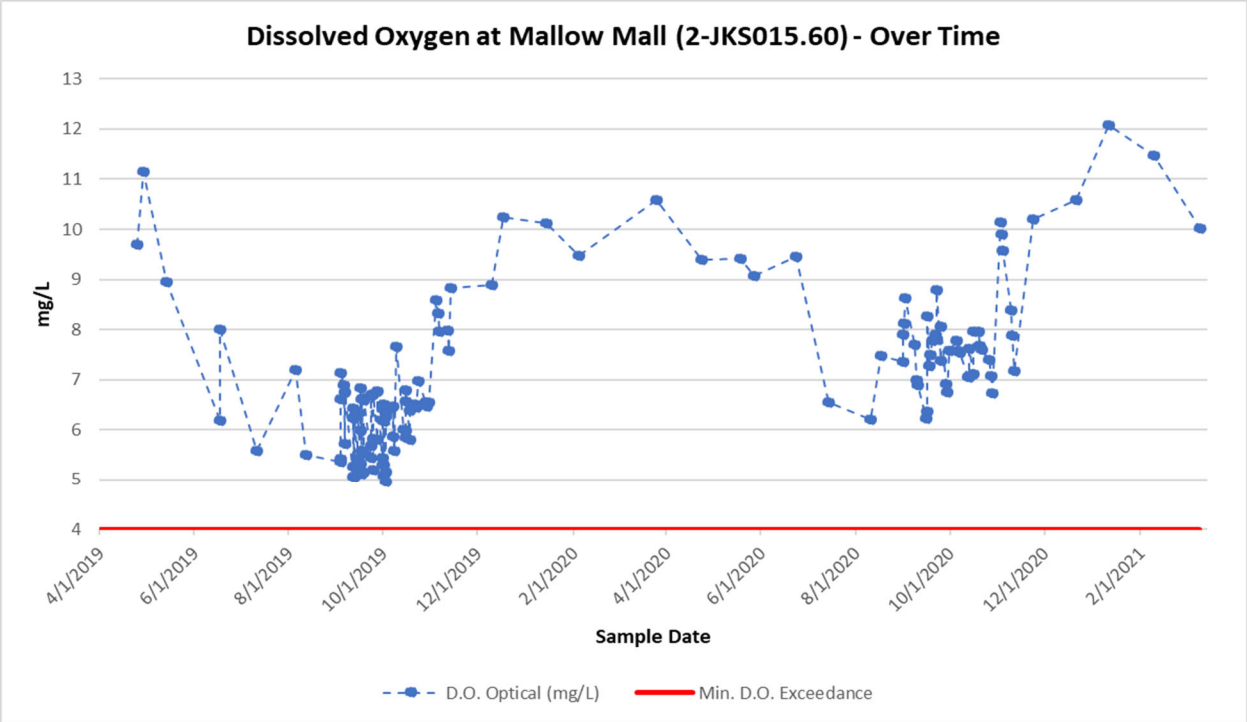


Figure V-11. Dissolved Oxygen at Mallow Mall (2-JKS015.60) – Over Time

Figure V-12 displays the DO data for each station (identified by the color and station identification in the legend) over the full length of the study (April 2019-March 2021). Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. This figure displays all of the stations in a manner that allows for comparison between individual stations. The red line displays the average DO level that would indicate an exceedance (5.0 mg/L). Note that no exceedances of this average DO level occurred.

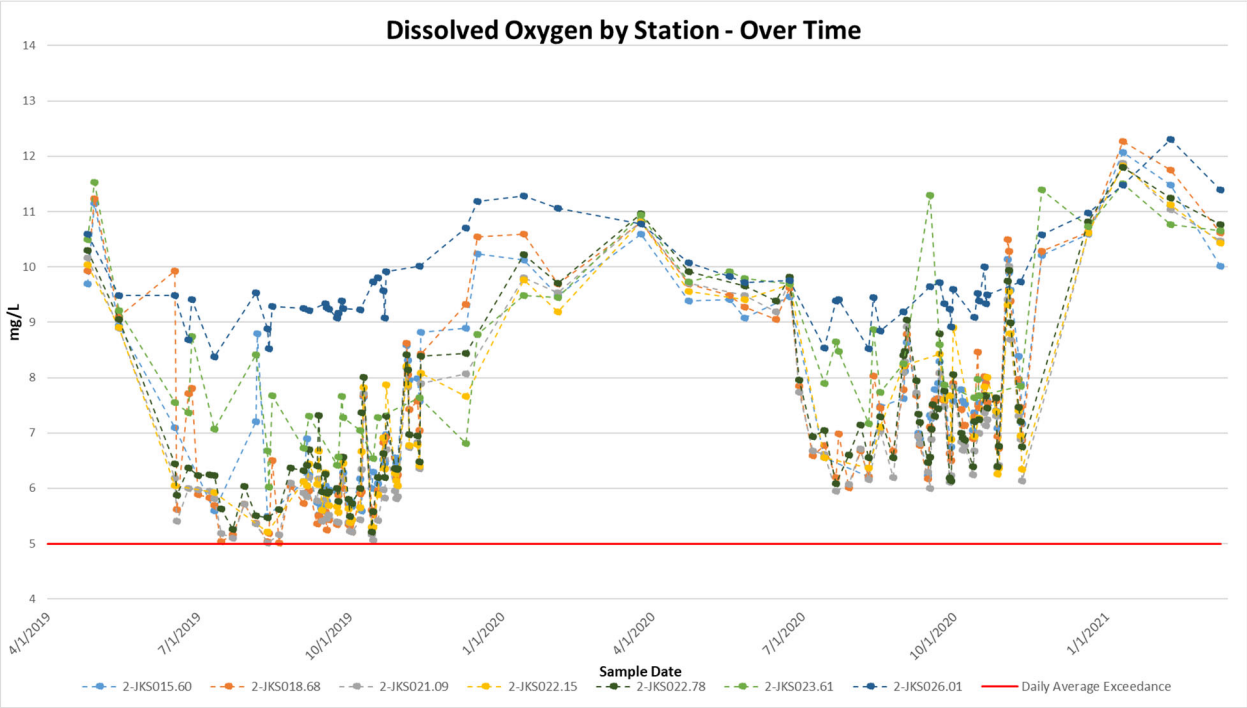


Figure V-12. Dissolved Oxygen by Station – Over Time

Figure V-13 displays the DO for all of the stations in this study over the full length of the study (April 2019-March 2021). Sampling days that had more than one (1) sample collected (due to low morning DO, pre-scheduled diurnal sampling days, or pre-/post pulse sampling days) are shown as the average of that day. The red line displays the average DO level that would indicate an exceedance (5.0 mg/L). Note that no exceedances of this average DO level occurred. One (1) series displays the average of the six (6) locations that are located within the impaired reach downstream from the confluence of the Jackson River and Dunlap Creek (2-JKS023.61, 2-JKS022.78, 2-JKS022.15, 2-JKS021.09, 2-JKS018.68, and 2-JKS015.60) for each sampling day. The second series displays the corresponding DO data from the days that the reference site, 2-JKS026.01 (Filtration Plant), was sampled.

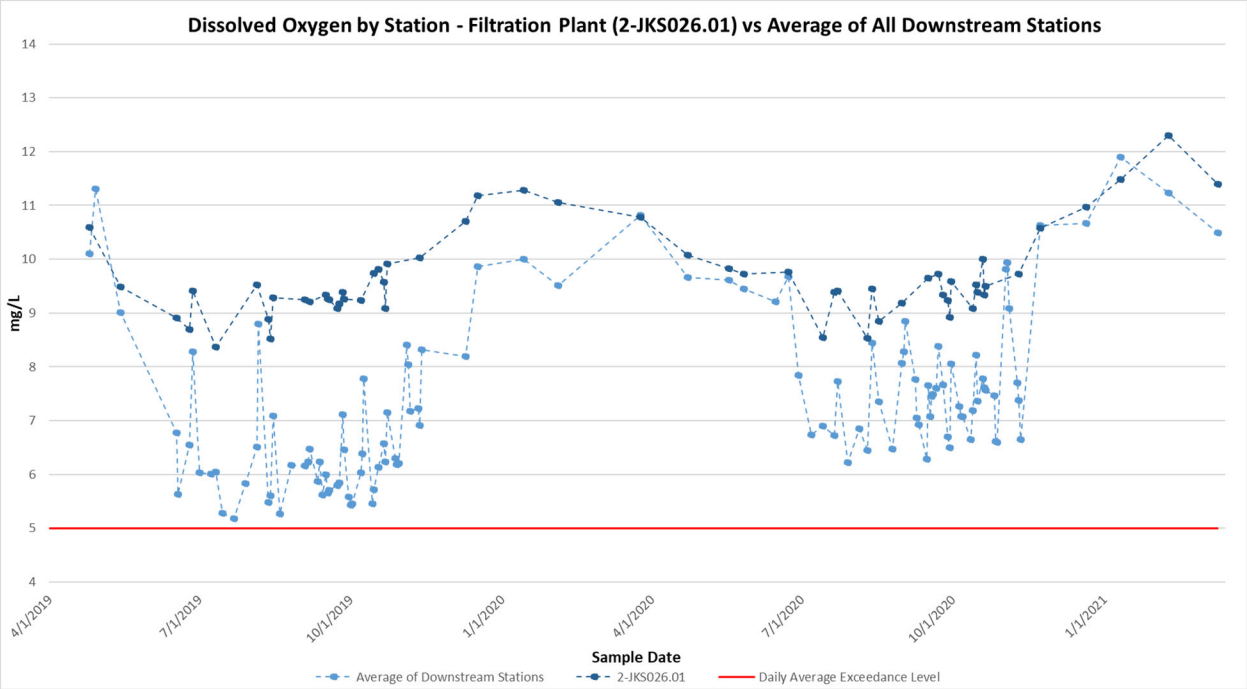


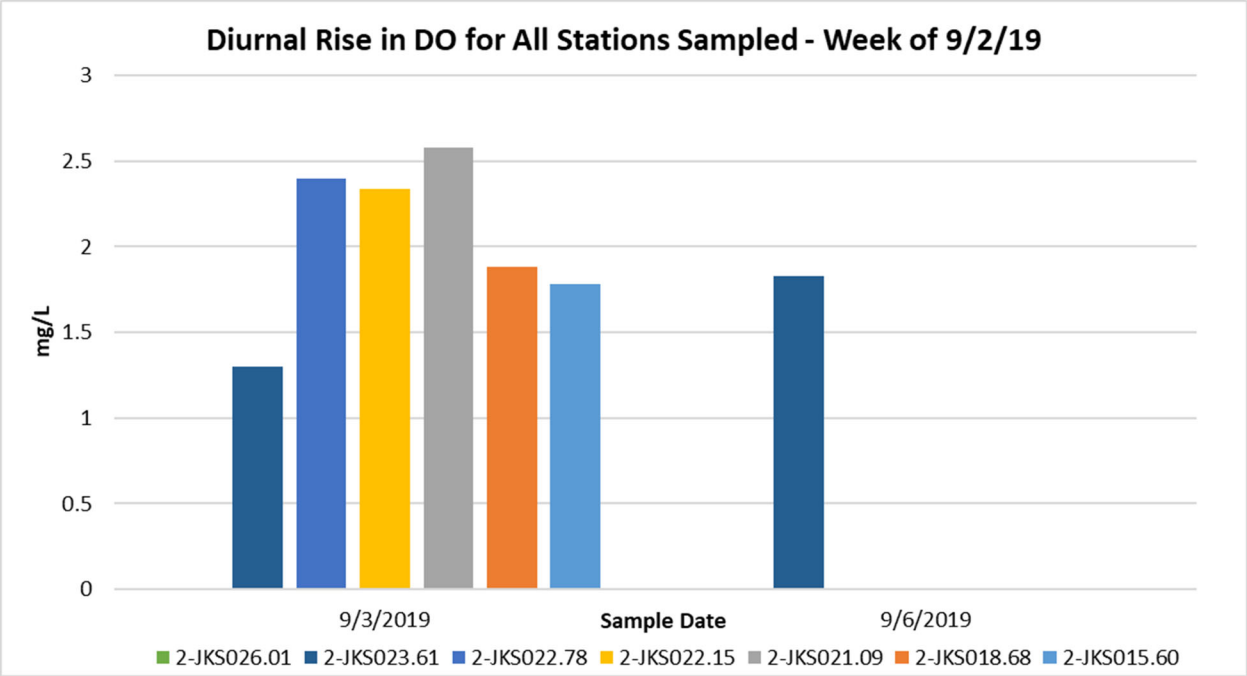
Figure V-13. Dissolved Oxygen by Station – Filtration Plant vs Average of All Downstream Stations

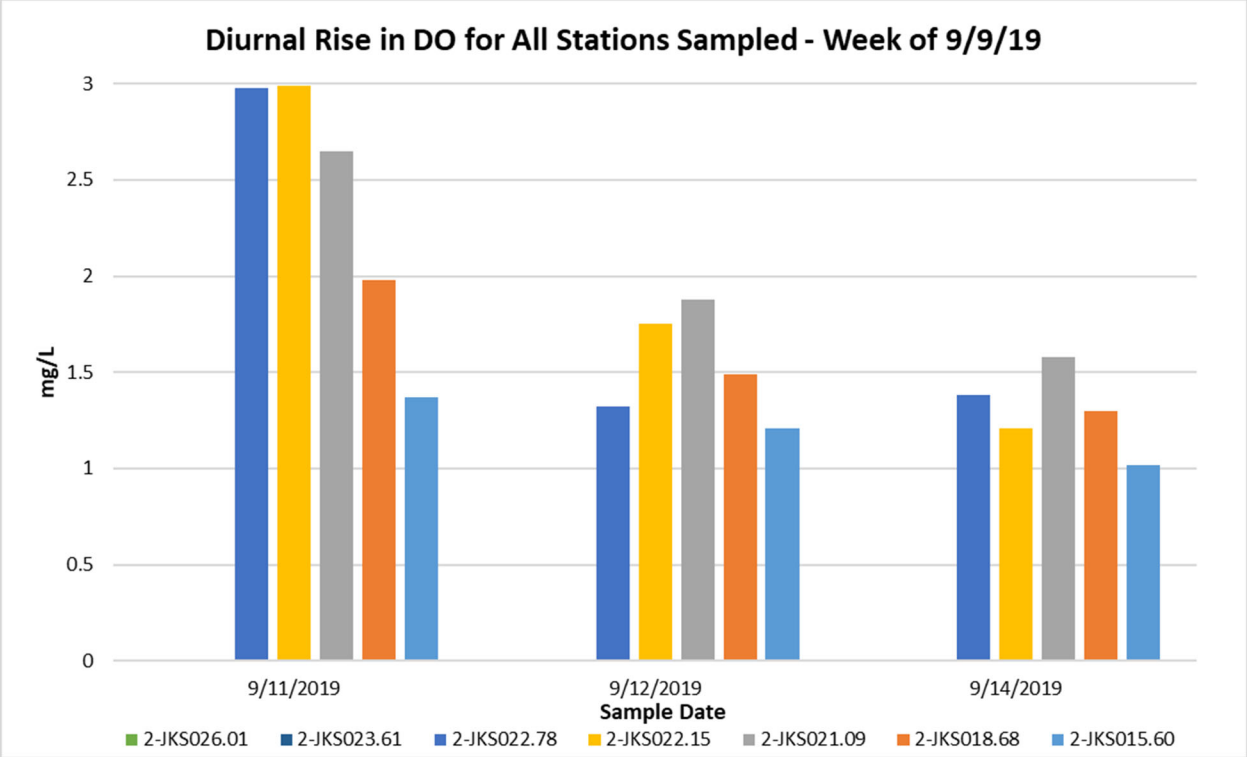
D. Diurnal Data Trends

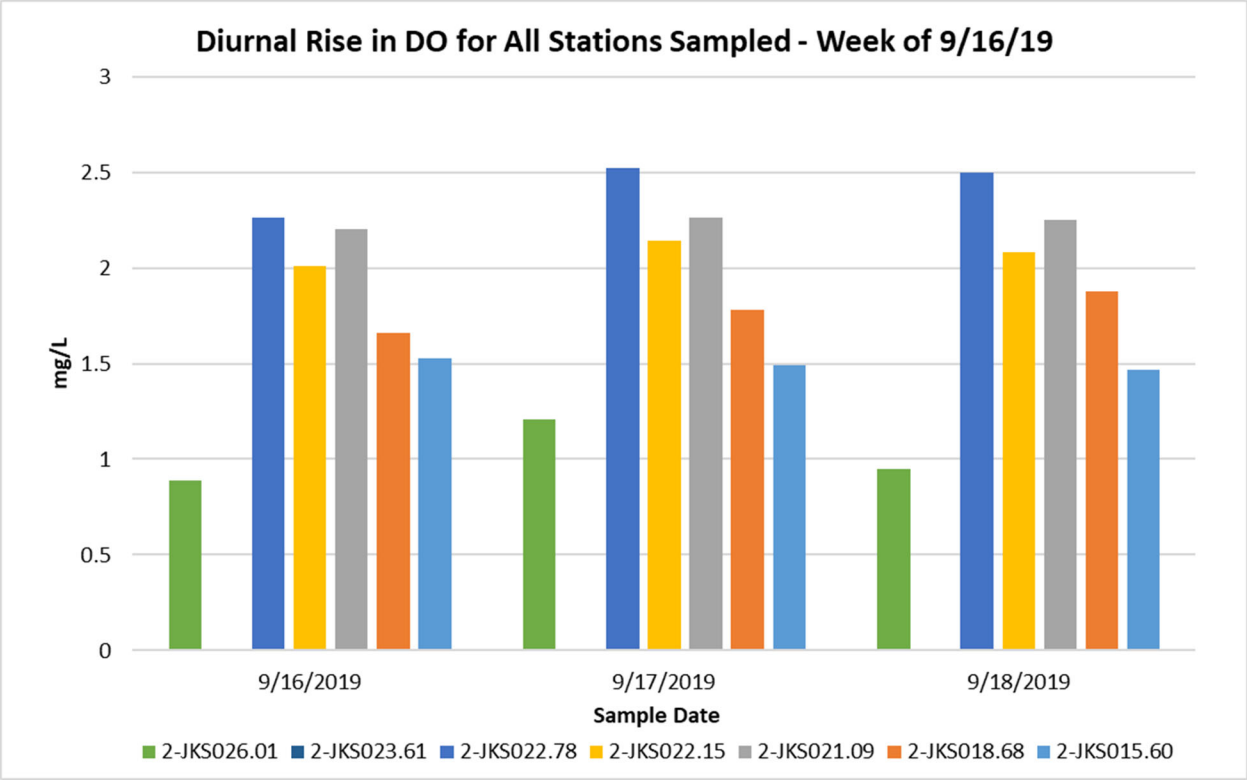
Diurnal sampling was conducted in September and October of 2019 and 2020 to better understand trends in DO throughout the day. Two (2) stations, Filtration Plant (2-JKS026.01) and Industrial Park (2-JKS022.15), were selected as the diurnal sampling locations. These stations were selected to compare the diurnal swings at reference conditions (2-JKS026.01) and at the historically most severely impaired site (2-JKS022.15). These locations were sampled in all four (4) time zones (6am-9am, 9am-12pm, 12pm-3pm, and 3pm-6pm) for three (3) days in a row in September and October of each year.

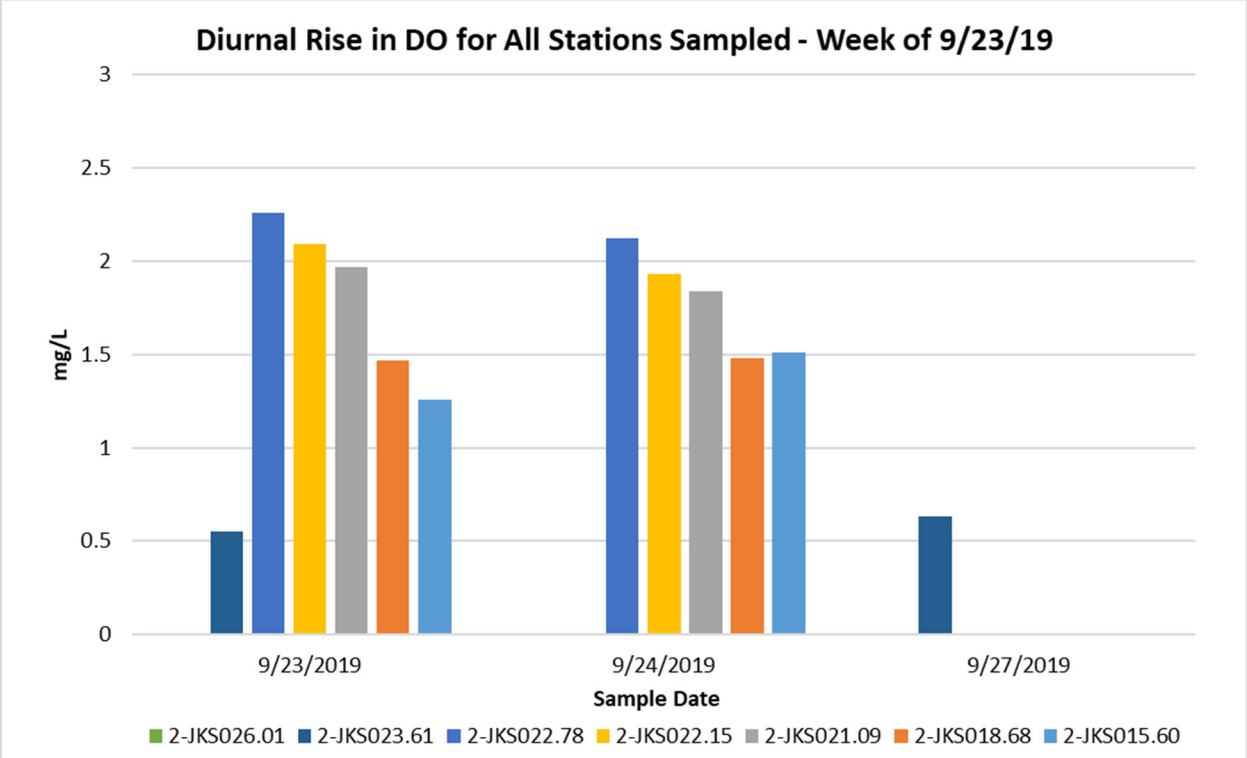
Additional data was collected in the three (3) later time zones of the day due to low morning DO or pre-/post pulse sampling days.

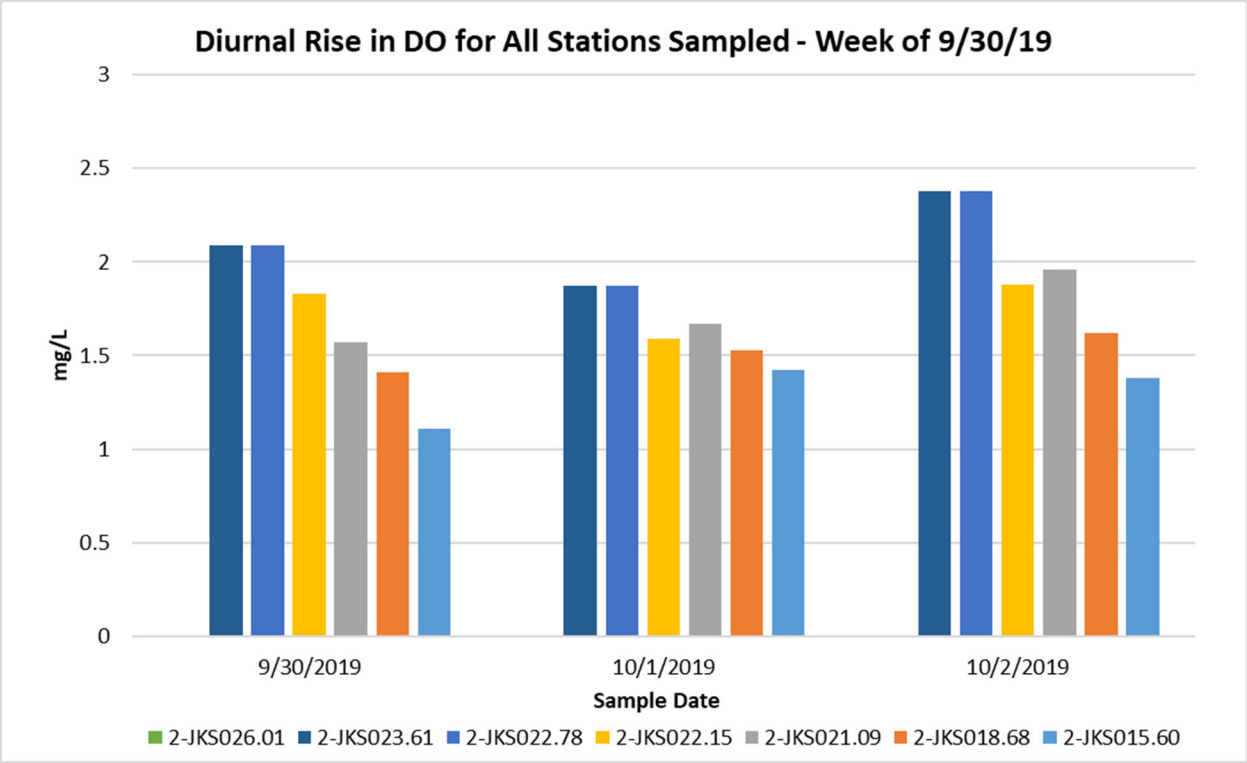
Figures V-14 and V-15 below display the diurnal rise in DO at each station where there was data collected in more than one (1) time zone.

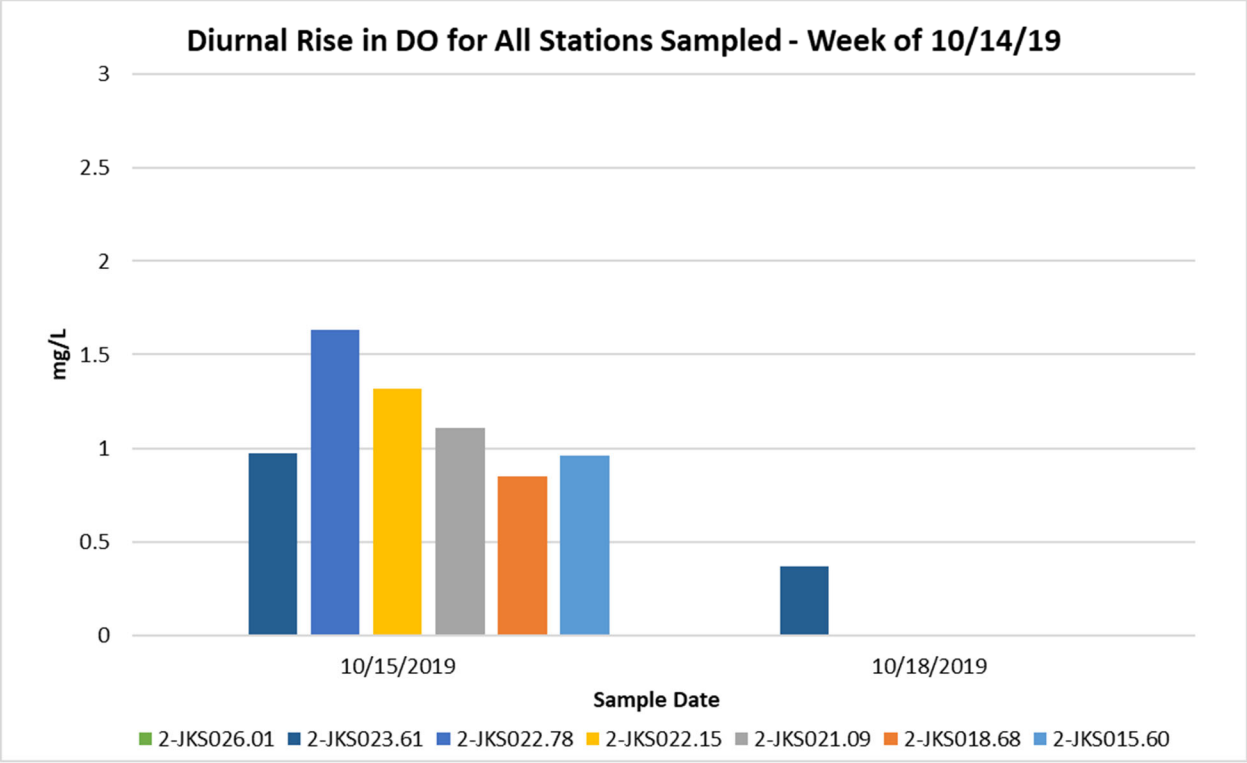

Diurnal Rise in DO for All Stations Sampled - Week of 9/2/19
3
2.5
2
1.5
1
0.5
0
mg/L
9/3/2019
Sample Date
9/6/2019
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 9/9/19
3
2.5
2
1.5
1
0.5
0
mg/L
9/11/2019
9/12/2019
9/14/2019
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 9/16/19
3
2.5
2
1.5
1
0.5
0
mg/L
9/16/2019
9/17/2019
9/18/2019
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 9/23/19
3
2.5
2
1.5
1
0.5
0
mg/L
9/23/2019
9/24/2019
9/27/2019
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 9/30/19
3
2.5
2
1.5
1
0.5
0
mg/L
9/30/2019
10/1/2019
10/2/2019
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 10/14/19
3
2.5
2
1.5
1
0.5
0
mg/L
10/15/2019
10/18/2019
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60

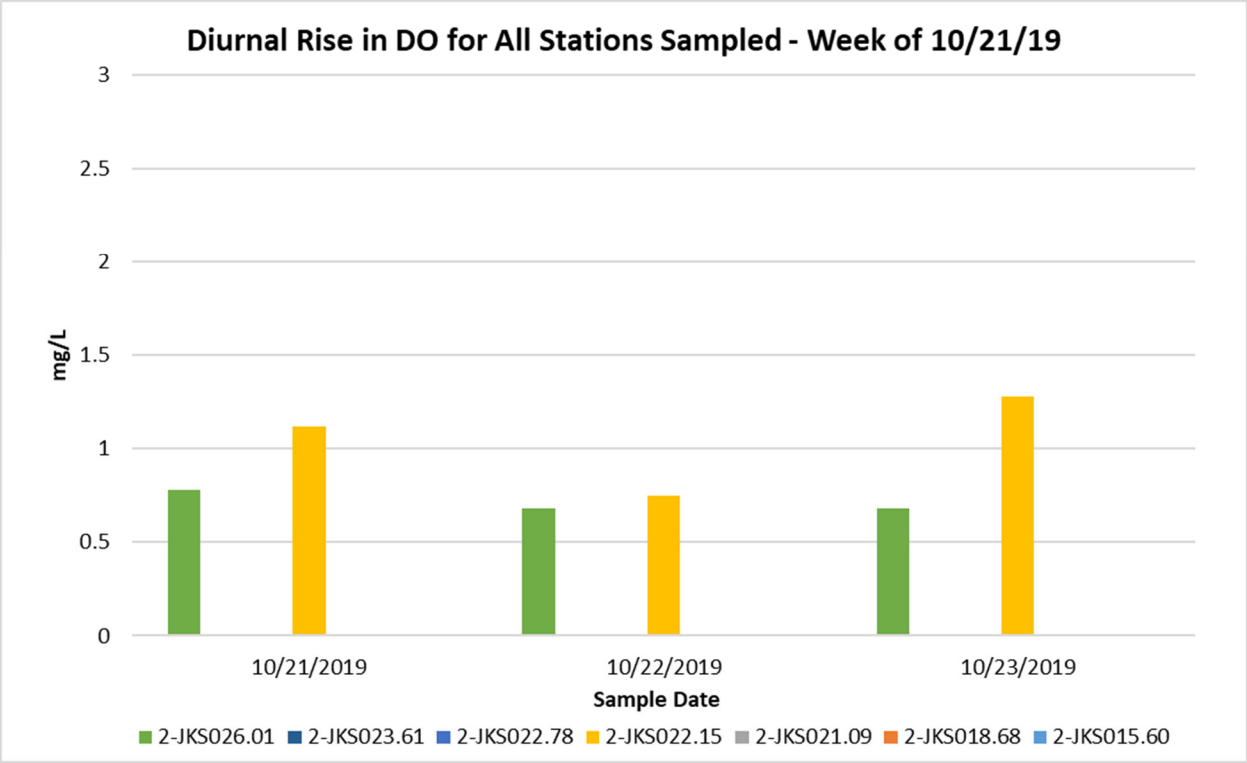
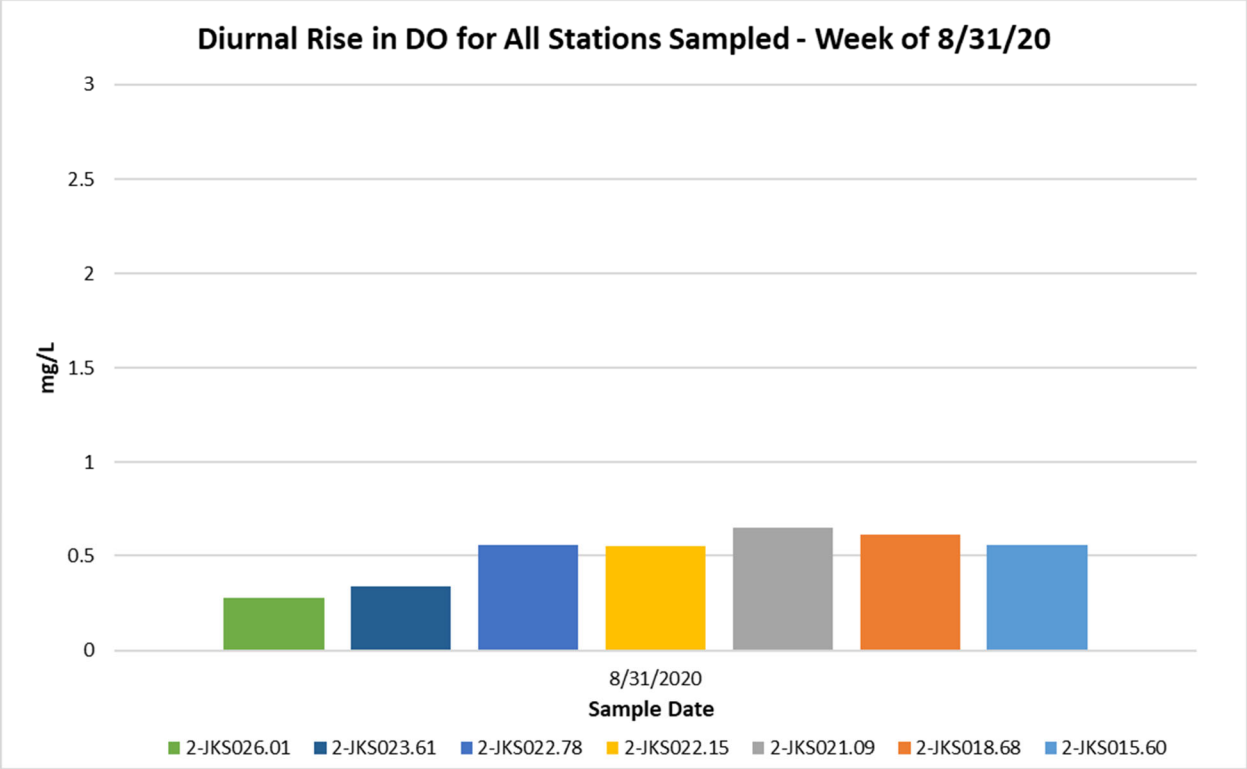
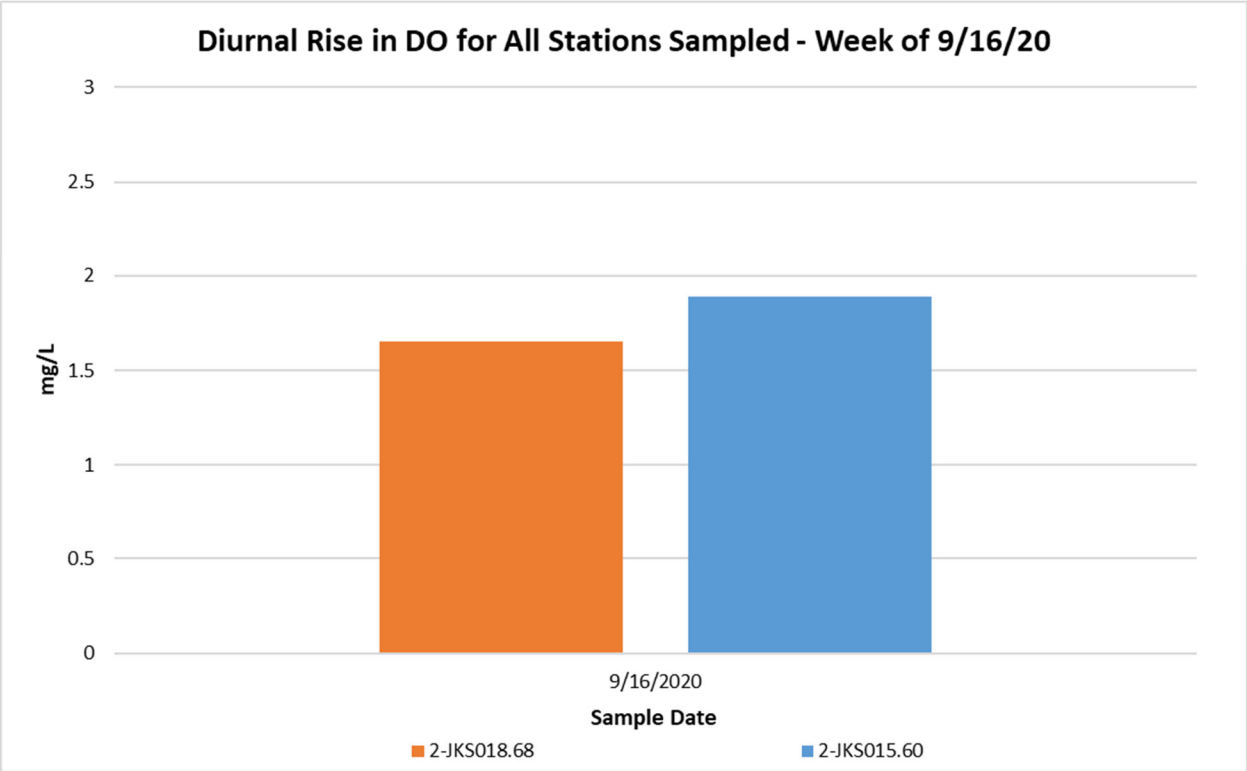
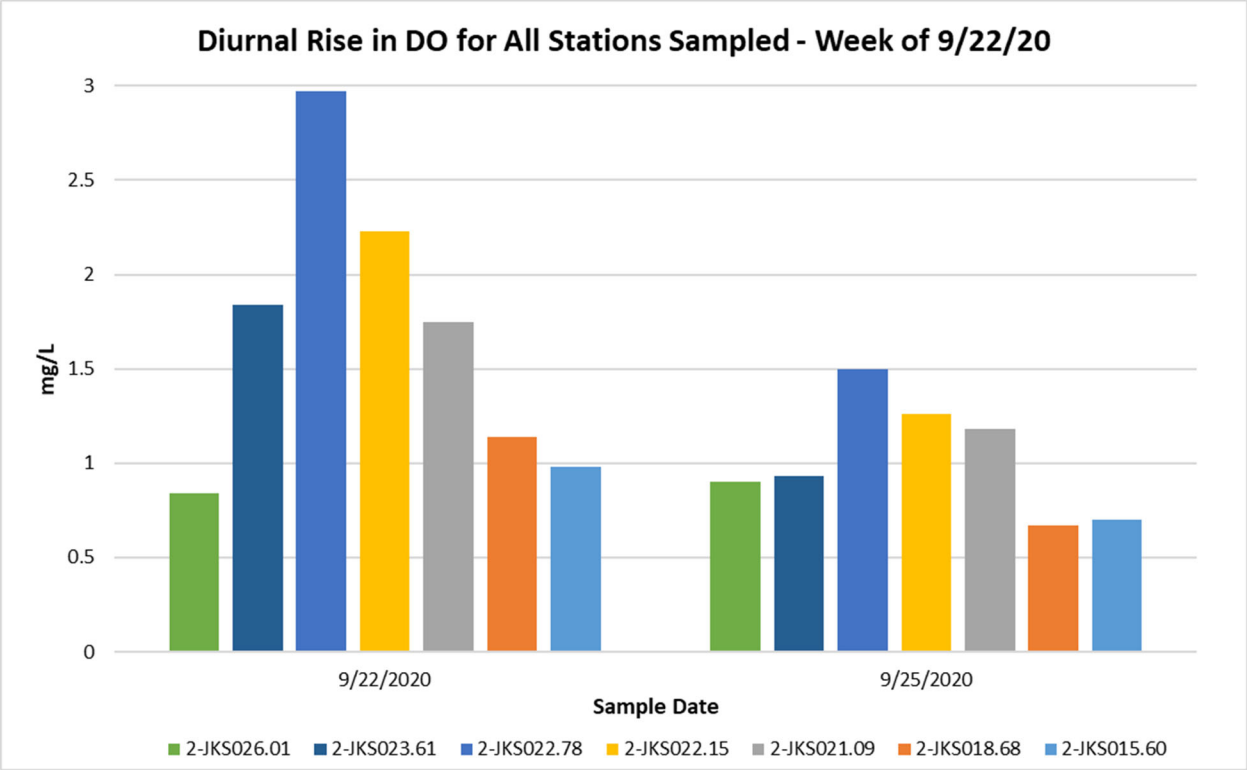
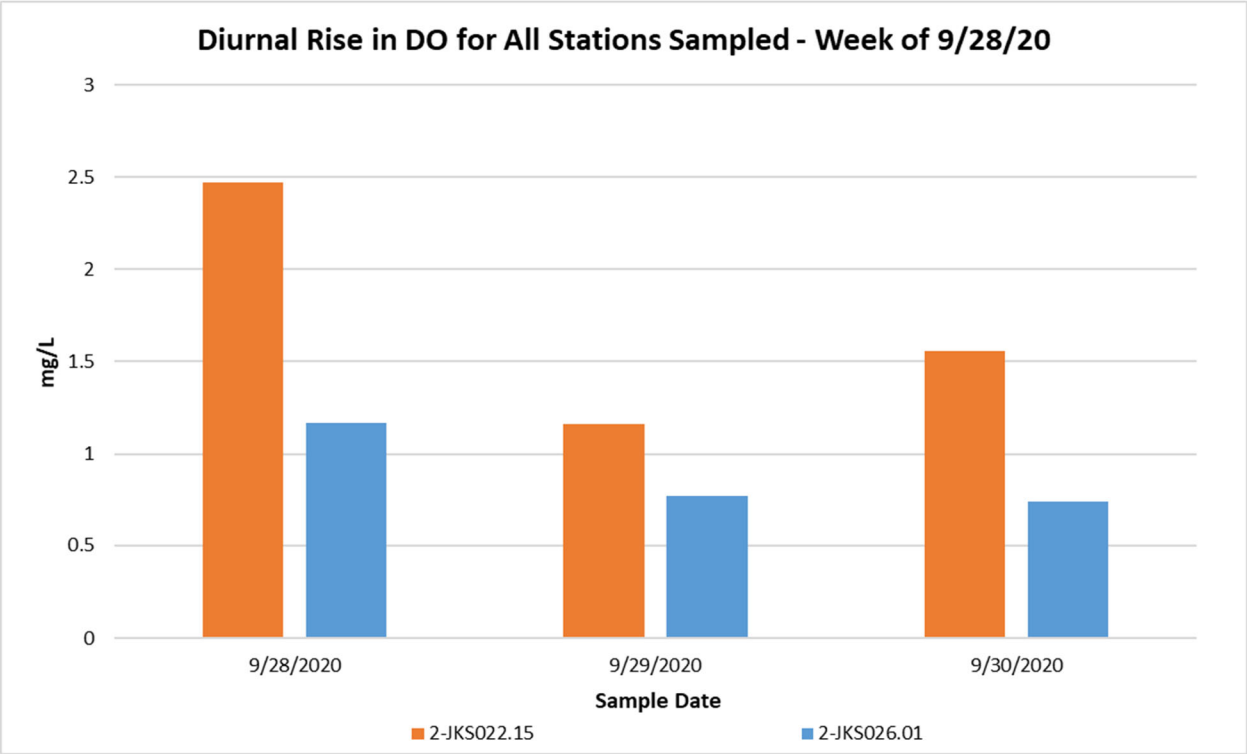


Figure V-14. Diurnal Rise in DO for All Stations Sampled – Weeks of 9/2/19, 9/9/19, 9/16/19, 9/23/19, 9/30/19, 10/14/19, and 10/21/19




Diurnal Rise in DO for All Stations Sampled - Week of 9/16/20
3
2.5
2
1.5
1
0.5
0
mg/L
9/16/2020
Sample Date
2-JKS018.68
2-JKS015.60


Diurnal Rise in DO for All Stations Sampled - Week of 9/22/20
3
2.5
2
1.5
1
0.5
0
mg/L
9/22/2020
9/25/2020
Sample Date
2-JKS026.01
2-JKS023.61
2-JKS022.78
2-JKS022.15
2-JKS021.09
2-JKS018.68
2-JKS015.60



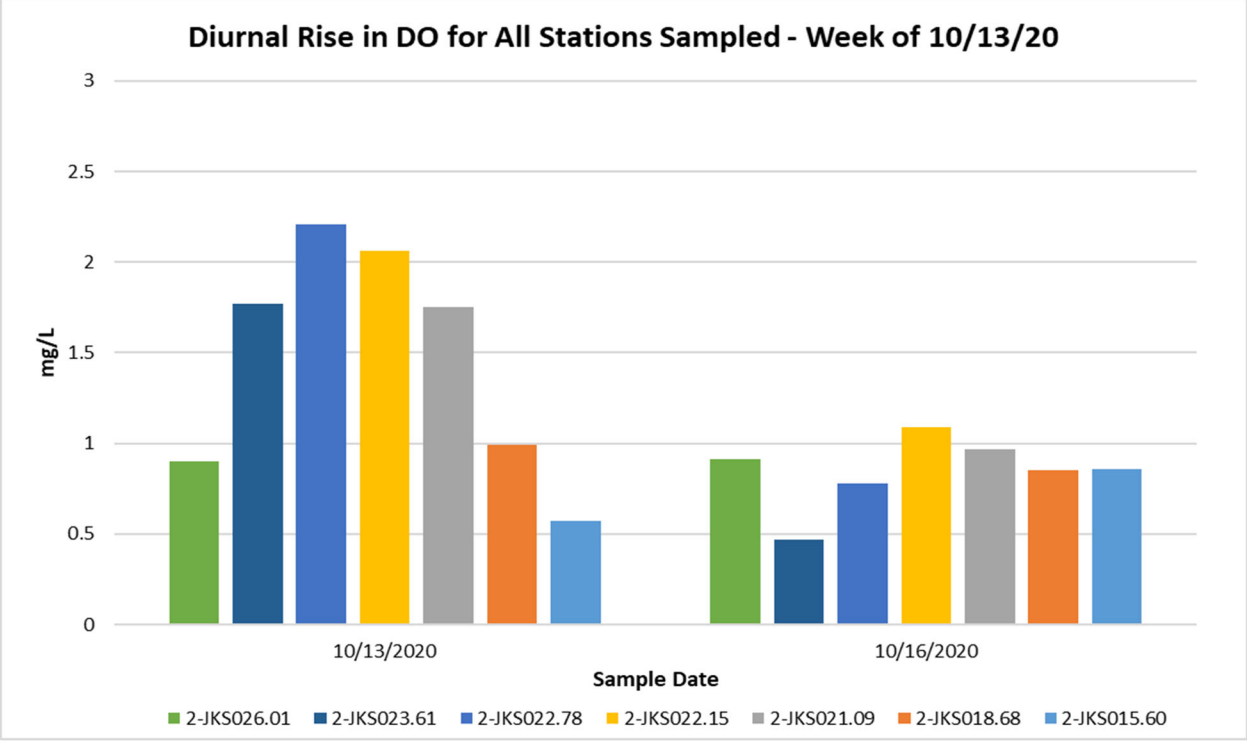


Figure V-15. Diurnal Rise in DO for All Stations Sampled – Weeks of 8/31/20, 9/16/20, 9/22/20, 9/28/20, 10/13/20, and 10/19/20

E. Flow Data Trends

USGS Gage 02013100: Jackson River Below Dunlap Creek was utilized for river flow data. The flow values from sampling days obtained from the above gages were compared to the average flow from the previous ten (10) years. The flow data displayed is the 24-hour average for all dates of sample collection.

Table V-2 displays 2019 river flow data on sampling days compared to the average flow from 2009 through 2018, Table V-3 displays 2020 river flow data on sampling days compared to the average flow from 2010 through 2019, and Table V-4 displays 2021 river flow data on sampling days compared to the average flow from 2011 through 2020. Flow values are highlighted in orange if the flow was higher than the previous ten (10) year average and highlighted in green if the flow was lower than the previous ten (10) year average for that sample date.

Sampling Date	2019	2009-2018 Average
	Flow (cfs)	
1/16	573	780
1/22	3880	738
2/5	538	1044
2/25	5760	973
3/5	4040	1604
3/21	698	1073
4/17	1530	1940
4/25	1130	1079
4/29	2540	1401
5/14	594	1222
5/29	354	938
6/3	303	487
6/17	301	487
6/18	298	518
6/25	383	808
6/27	340	736
7/1	282	473
7/8	344	535
7/11	391	418
7/15	300	438
7/22	294	329
7/29	294	331
8/5	282	345
8/6	281	337
8/12	267	382
8/13	277	385

Sampling Date	2019	2009-2018 Average
	Flow (cfs)	
8/15	276	370
8/19	262	330
8/26	273	312
9/3	252	346
9/5	253	341
9/6	247	360
9/11	242	299
9/12	238	297
9/14	242	288
9/16	235	286
9/17	237	390
9/18	237	412
9/23	234	476
9/24	233	530
9/26	247	422
9/27	242	695
9/30	254	1057
10/1	250	694
10/2	232	497
10/7	246	282
10/8	283	307
10/9	260	320
10/14	232	526
10/15	230	559
10/18	229	347
10/21	285	272
10/22	281	264
10/23	313	291
10/28	250	352
10/29	249	481
10/30	247	393
11/4	247	302
11/5	236	284
11/6	223	281
11/11	208	362
11/12	208	745
11/13	207	669

Sampling Date	2019	2009-2018 Average
	Flow (cfs)	
12/10	272	924
12/17	459	902

Table V-2. 2019 river flow data on sampling days compared to the average flow from 2009 through 2018.

Sampling Date	2020	2010-2019 Average
	Flow (cfs)	
1/14	519	628
2/4	460	1112
3/25	2190	1387
4/23	964	1360
5/18	1680	1865
5/27	1350	975
6/15	1680	486
6/23	2910	1117
6/29	519	652
7/7	425	573
7/14	355	486
7/21	333	335
7/23	386	451
7/29	326	323
8/5	345	337
8/10	325	366
8/11	319	318
8/13	340	379
8/17	380	353
8/25	362	313
8/31	1000	356
9/1	1840	301
9/2	2810	351
9/8	480	299
9/9	378	319
9/10	335	350
9/15	291	283
9/16	290	283
9/17	299	387
9/18	303	409

Sampling Date	2020	2010-2019 Average
	Flow (cfs)	
9/19	295	430
9/21	288	442
9/22	285	360
9/25	290	451
9/28	286	928
9/29	345	772
9/30	512	1049
10/5	284	307
10/6	276	284
10/7	273	280
10/12	323	629
10/13	322	474
10/15	309	558
10/16	292	432
10/19	275	285
10/20	275	284
10/21	274	279
10/26	272	276
10/27	268	280
10/28	266	281
11/2	403	261
11/3	368	254
11/4	344	254
11/9	263	344
11/10	262	354
11/11	360	333
11/23	385	339
12/21	1030	761

Table V-3. 2020 river flow data on sampling days compared to the average flow from 2010 through 2019.

Sampling Date	2021	2011-2020 Average
	Flow (cfs)	
1/11	751	457
2/9	569	1116
3/11	585	1435

Table V-4. 2021 river flow data on sampling days compared to the average flow from 2011 through 2020.

F. Data Conclusions

A total of 951 samples were collected over the course of this study which comprised a total of 100 days. This volume of data collected represents a much better understanding of river conditions for use in delisting this segment of the Jackson River for DO impairment.

As displayed in the figures above, no exceedances of either the minimum or average DO standard occurred. There were no individual measurements of DO less than 4.0 mg/L and no daily averages were less than 5.0 mg/L DO.

As expected, dissolved oxygen is heavily influenced by river temperature and these two variables have an inverse relationship. Much higher DO was observed in the winter and spring seasons when river temperatures are lower compared to the lower DO that was observed in the summer and fall seasons when river temperatures rise.

The relationship between river flow and DO can be seen in the contrast between the summer and fall seasons of 2019 and the summer and fall seasons of 2020. The lack of rainfall in 2019 and drought-like conditions in the summer season leading into the fall season influenced the DO levels. The low river flow and high ambient temperatures resulted in generally lower DO levels and higher water temperatures during these seasons in 2019. In comparison, there was much more precipitation in 2020[2] with 49.01 inches recorded versus 38.22 inches recorded in 2019, which increased river flow and lowered water temperatures in the summer and fall seasons of that year. The 2019 and 2020 rainfall totals were much lower and higher, respectively, than the annual average for this area from 2009 to 2020, which was 43.03 inches.

In the station-specific trends, the same general pattern is evident in the DO levels at all stations, largely due to seasonal river flow and temperature variations. One of the most notable changes observed over the past several years that can be attributed to the pulsing schedule and to improved nutrients is the improvement to diurnal dissolved oxygen levels. The data provided shows less overall dissolved oxygen swing throughout the reach of the river studied. The Figures in Section V.D. indicate that dissolved oxygen diurnal swings upstream of the area of impairments are in the 0.5-1.0 mg/l range. The data from the section of the impaired area is less typically less than 2.5 mg/l and lower than that at some of the stations. Prior to pulsing, it was not uncommon for this segment of the river to experience 6-8 mg/l swings.

VI. Summary and Conclusions

A multitude of DO samples were collected over the course of this study to gain an understanding of river conditions for use in delisting this segment of the Jackson River for DO impairment. No exceedances of either the minimum or average DO standard occurred. There were no individual measurements of DO less than 4.0 mg/L and no daily averages were less than 5.0 mg/L DO.

[2]National Centers for Environmental Information – National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service Station: COVINGTON FILTER PLANT, VA US USC00442044. Generated on 02/25/2021.

The data from this study indicates an overall trend of higher dissolved oxygen in the critical pre-dawn hours than historical sampling. Generally, diurnal DO swings were also lower than historical data and represent a stream with a normal level of productivity. This observation correlates with the overall observations in the benthic community. Prior to the TMDL, algal levels were higher. Algae will depress dissolved oxygen in the night-time and pre-dawn hours due to respiration and will elevate dissolved oxygen levels in the afternoon due to photosynthesis. Lower algal levels due to pulsing and lower overall nutrients have resulted in lower overall dissolved oxygen swings throughout the day. For the purposes of this study, this results in higher early morning dissolved oxygen levels and supports the recommendation for delisting of the impairment for dissolved oxygen. Fish and macroinvertebrates community data collected over the past 5 years support this conclusion as well. Lower algal levels have improved the dissolved oxygen situation, which also allows more diverse and sensitive species in this reach of the river. Great abundances of DO sensitive fish have been observed in the impaired reach along with a more diverse macroinvertebrate community. This study provides more evidence that the observed benthic community improvements are likely to continue.

The results of this study provide a recommendation that the dissolved oxygen impairment can be removed from the Jackson River and that it can be delisted from the 303(d) list.

VII. Appendices

Appendix A: Monitoring Stations Referenced

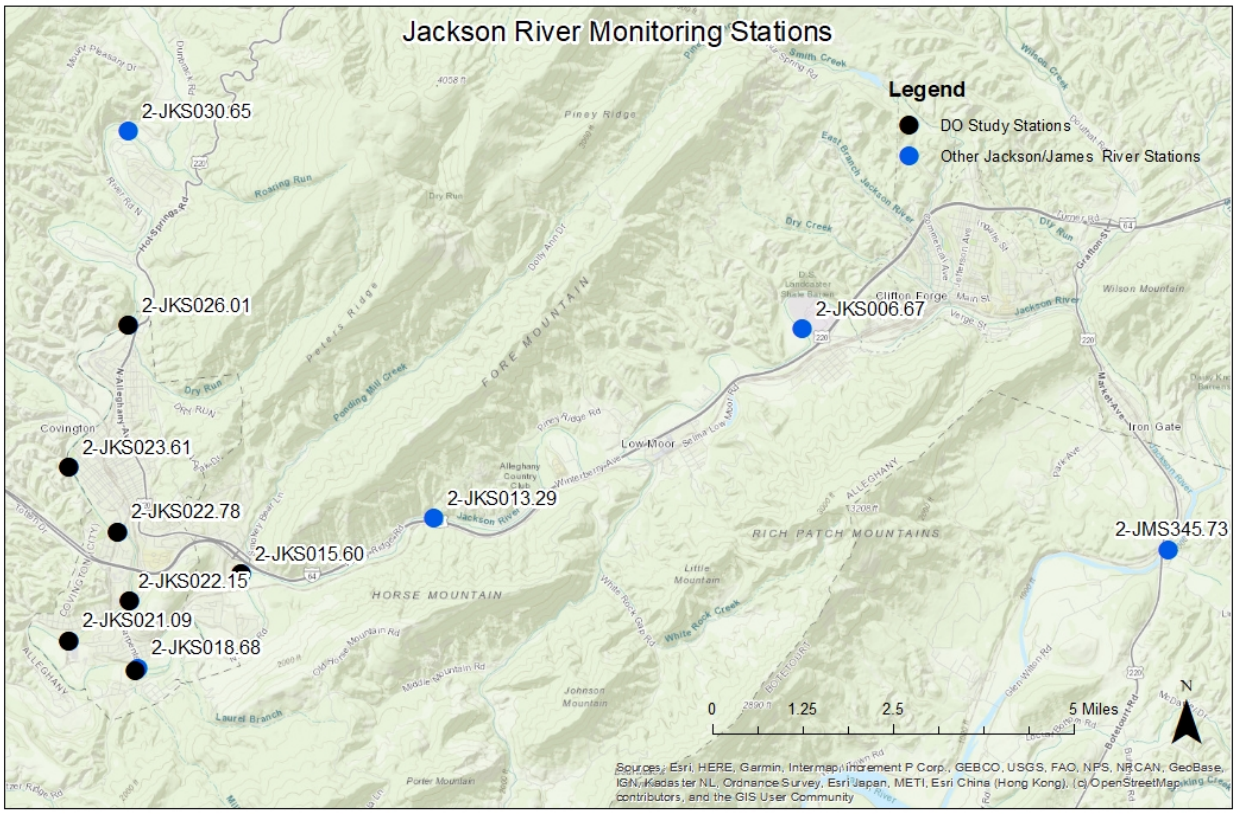
Appendix B: Quarterly Project Team Meeting Summaries

Appendix C: Sample Calibration Log

Appendix D: DEQ Audit Reports (2019 & 2020)

Appendix A: Monitoring Stations Referenced

Waterbody Name	Station ID	Description	Latitude	Longitude
Jackson River	2-JKS026.01	Covington Water Filtration Plant	37.811	-79.988
	2-JKS023.61	City Park Playground – At USGS gauge 02013100	37.788	-80.000
	2-JKS022.78	Upstream side of Route 154 bridge	37.778	-79.991
	2-JKS022.15	Industrial Park Behind Wal-Mart	37.767	-79.988
	2-JKS021.09	Hercules/South Rayon Drive crossing	37.761	-80.000
	2-JKS018.68	Idlewilde/Rt. 18 Bridge	37.757	-79.987
	2-JKS015.60	Behind Mallow Mall	37.771	-79.966
	2-JKS006.67	Low water bridge near Dabney Lancaster Community College (DLCC)	37.810	-79.854
	2-JKS013.29	Rt. 696 above Low Moor	37.780	-79.927
	2-JKS030.65	Clearwater Park	37.841	-79.989
Upper James	2-JMS345.73	Rt. 220, 1st bridge below Cowpasture River	37.775	-79.780



Appendix B: Quarterly Project Team Meeting Summaries

8/30/2019- Project team met to discuss start of 2019 data collection and April 2019 field audit. ONE presented graphs with 2019 data to date.

12/6/2019- Project team met to review fall season 2019 DO data and noted that no exceedances of the minimum or average DO standard occurred despite high ambient and river water temperatures, lower river flow, and low rainfall. ONE presented updated graphs with August-November 2019 data.

4/21/2020- Project team met to discuss 2019 DO data and discuss work flow for entering data collected by ONE Environmental and QA procedures. ONE presented updated graphs with December 2019-March 2020 data. Field audit was scheduled for summer 2020.

12/11/2020- Project team met to review fall 2020 data and July 2020 field audit. ONE presented updated graphs with December 2020-March 2021 data. No necessary mid-day checks as per the QAPP. DO levels were higher than in 2019 due to increased river flows. Next steps for report development were discussed.

Appendix C: Sample Calibration Log

WQM SOP
Revision No.: 20
Rev. Date: 6/5/2017

Multiprobe Cal Log Sheet **Sonde Make/Model:** **Sonde S/N:** **Region:**

					DO			Specific Conductivity		pH		
Cal Type	Date/Time	Initial and Run ID	Temp C	BP (mmHg)	Chart DO	Meter DO	Cal DO	Cond Std. (uS/cm)	Cond Init/Cal	pH 7 Init/Cal	pH 4 or 10 Init/Cal	3rd pH check Init/Cal
Pre												
Post												
Comments					DO QA:			Cond QA:		pH QA:		
Pre												
Post												
Comments:					DO QA:			Cond QA		pH QA:		
Pre												
Post												
Comments:					DO QA:			Cond QA:		pH QA:		
Pre												
Post												
Comments:					DO QA:			Cond QA:		pH QA:		
Pre												
Post												
Comments:					DO QA:			Cond QA:		pH QA:		

DO QA: YSI DO Gain -0.7 to 1.5. DO Charge 25 to 75. Cond QA: YSI Cell Constant 4.55 to 5.45 pH QA: pH 7 0 ±50 mV, pH 4 180 ±50 mV, pH10 -180 ±50 mV

Appendix D: DEQ Audit Reports (2019 & 2020)

MEMORANDUM

Virginia Department of Environmental Quality
Water Quality Monitoring and Assessment

1111 East Main Street	**17th Floor**
Post Office Box 1105	**(804) 698-4025 phone**
Richmond, Virginia 23218	**(804) 698-4032 fax**

SUBJECT: 2019 WestRock Jackson River Study Field Audit
TO: Roseann Lee
COPY: Sandra Mueller, Lucy Baker
FROM: James Beckley
DATE: 5/6/2019

On April 25, 2019 I conducted an audit of the equipment and methods used by WestRock staff as part of the Jackson River dissolved oxygen study in partnership with DEQ. Overall the protocols and equipment used by the WestRock staff are acceptable to provide accurate field readings. Below is a detailed summary of my findings along with any associated recommendations.

Equipment Calibration

The calibration protocol used by WestRock followed DEQ procedures with three noted deviations.

1. WestRock staff calibrated conductivity using the "Conductivity" option on the YSI EXO calibration menu instead of "Specific Conductivity". This is a common mistake for new EXO operators. This calibration produced imprecise readings as the calibration solution was not adjusted to 25 ^{o}C.

   Recommendation: Use of the "Specific Conductivity" calibration option as it instructs the EXO unit to adjust conductivity based on the detected temperature of the solution. After our end of day verification the unit was recalibrated using the "Specific Conductivity" calibration option and readings fell to within 1% of DEQ readings and well below the 10% quality assurance guideline our agency follows.

2. WestRock staff calibrated the dissolved oxygen sensor in the field. While acceptable it can result in error due to changing ambient air temperature and solar heating.

   Recommendation: Calibrate the unit in the laboratory under climate controlled conditions. In addition, as the unit is checked back at the laboratory at the end of the day for probe drift, performing calibration in a similar environment will reduce potential drift error.

3. WestRock currently relies on barometer readings as reported on the EXO display and possibly compare to a laboratory barometer with an expired calibration certificate. While currently not a significant issue as the EXO unit is brand new, as the unit ages the barometer may begin to shift. Such a shift from true barometer values can result in inaccurate dissolved oxygen calibrations.

   Recommendation: At least quarterly verify EXO barometer readings against a laboratory based barometer with a valid calibration certificate or compare to the barometric pressure data from the nearest National Weather Service field station. The nearest station to WestRock is station KHSP located near Hot Springs, Virginia. Current readings from Station KHSP are accessible at

https://w1.weather.gov/data/obhistory/KHSP.html. The EXO barometer must be within 5 mmHg of the reference barometer reading to ensure accurate calibration.

If using the weather station KHSP, note that reported readings are adjusted to sea level elevation and must be adjusted to the altitude of the WestRock facility. Instructions to perform this adjustment including shifting the reported pressure in units of inches of mercury to millimeters of mercury is provided in the DEQ dissolved oxygen calibration protocol provided to WestRock.

Field Readings

Due to high flow conditions, observing sampling protocols via wading was not possible. Observations were made from designated bridge or riverbank locations and noted no deficiencies in sampling protocols. A follow up meeting with our field staff will occur at a later date when field conditions are suitable.

While the use of a stainless steel bucket is acceptable to obtain field readings, we encourage the collection of field data in-situ using the EXO cable and handheld display. This will avoid potential error due to temperature shifts from weather and sunlight or excessive agitation of the water.

Equipment Validation

The post check of the WestRock EXO unit was acceptable and proper drift check protocols were followed. In addition the WestRock EXO unit was compared to one of our EXO units and our NIST reference thermometer. Temperature checks were performed at three points across the expected temperature range of the unit will encounter in the field and were within 0.5^{o}C of our NIST reference thermometer and DEQ field unit. In addition dissolved oxygen and conductivity readings were compared to the DEQ field unit at the extreme temperature points (~1^{o}C and ~38^{o}C) and readings were within acceptable ranges.

Conclusions

Based on my observations of field and calibration protocols, our agency is confident the temperature, dissolved oxygen, and conductivity readings collected by WestRock are comparable to readings if collected by DEQ field staff. During the post audit discussion, we understand that WestRock will implement the suggested refinements to their testing protocol suggested in the Equipment Calibration section of this this report.

A copy of my field notes and data observations is attached.

Attached: WestRock Field Audit Forms

	PREPARATION FOR SAMPLE RUN	Y/N/NA	COMMENTS
1	**Stainless Steel sample bucket clean with no rust or scratches?**	Y	
2	**Any other sampling equipment used during the audit visibly clean and in good working order?**	Y	

Issues that should be addressed: None

	PROBE CALIBRATION	Y/N/NA	COMMENTS
1	**Is the probe barometer within 10 mmHg of the laboratory barometer or National Weather Service readings?**	Y	Lab barometer not recently calibrated. Can confirm with local NWS station.
2	**Is the conductivity solution freshly prepared (within 1 month) and free of algae and other foreign materials?**	Y	Purchased by YSI
3	**Calibrated conductivity probe reading within 1.0% of the conductivity standard?**	Y	Initial calibration was for conductivity instead of specific conductivity
5	**DO probe calibrated to within 0.2 mg/L of theoretical levels? (0.1 mg/L for optical DO probes)**	Y	Calibration performed in the field. Recommend calibration in the lab.

Issues that should be addressed: To ensure the most accurate calibration, calibrate in a temperature controlled environment such as the laboratory. Check EXO barometer or laboratory barometer against National Weather Service station KHSP (https://w1.weather.gov/data/obhistory/KHSP.html) on a quarterly basis. Readings within 5 mmHg (adjusted to local elevation) is acceptable. Finally for conductivity calibration use the Specific Conductivity setting to avoid having to adjust the conductivity solution to 25 C.

	BRIDGE, WADING,AND STREAMBANK SAMPLING	Y/N/NA	COMMENTS
1	**Bridge sampling, do field staff wear reflective garments?**	Y	
2	**If sampling on a bridge, does it occur on the upstream side?**	Y	
3	**If wading, do staff wade upstream to the site to minimize sediment disturbance?**	N/A	No wading possible during audit
4	**Field sonde deployed (DO, pH, etc.) before collecting samples?**	Y	Only probe readings taken.
5	**If sampling by bucket, is it rinsed with sample water prior to collecting the sample?**	N/A	readings
6	**Samples collected at the Thalweg with no disturbance of bottom sediment?**	Y	At bridge sites. Streambank sites not possible to sample thalweg but flow was sufficient for accurate readings.

Staff Audited: Roseann Lee

Issues that should be addressed: Blue Ridge field staff will coordinate with WestRock to review low flow wading locations.

	QUALITY ASSURANCE	Y/N/NA	COMMENTS
1	**Sonde kept in the passenger compartment of the vehicle when traveling to and from the field?**	Y	
2	**Mid day DO probe check reads within 95 to 105% saturation? Check done with wet towel or wetted storage cup.**	N/A	Run performed in less than 2 hours. Mid-day check not required

Issues that should be addressed: None

	PROBE END OF DAY CHECK	Y/N/NA	COMMENTS
1	**Sonde is allowed to adjust to room temperature before performing the end of day calibration checks?**	Y	
2	**Is conductivity readings within 5% for conductivity standards?**	Y	
3	**Is the DO probe reading within 0.50 mg/L of theoretical levels?**	Y	

Issues that should be addressed: None

Staff Audited: Roseann Lee

MEMORANDUM

Virginia Department of Environmental Quality
Water Quality Monitoring and Assessment

SUBJECT: 2020 WestRock Jackson River Study Equipment Check
TO: Roseann Lee, Kerry McAvoy
COPY: Sandra Mueller, Drew Garey, Jason Hill
FROM: Lucy Baker
DATE: 7/28/2020

Overview

On July 14, 2020, DEQ met with WestRock Environmental staff and One Environmental staff to conduct side-by-side water quality monitoring to verify that WestRock's EXO 3 sonde is in conformance with DEQ's QA/QC criteria for tier 3 data usage. A standard lab and field audit was conducted on April 25, 2019 by DEQ. Several suggestions were made to improve the functionality of WestRock's equipment but overall data collected by WestRock was found to be comparable to DEQ data. The side-by-side sampling was performed in lieu of a traditional DEQ audit because of a vacancy in the Water Quality Monitoring Auditor position and restrictions due to the ongoing global pandemic. DEQ and WestRock sondes were placed side-by-side in a cooler filled with river water to control for variation in oxygen and temperature caused by flow. Side-by-side sampling was also conducted while wading in the river at the stations where wading was possible.

Equipment calibration and side-by-side measurements

DEQ, WestRock, and One Environmental met at 7:30 am at the filtration plant station (2-JKS026.01) to conduct the monthly Jackson River DO run outlined in the Jackson River DO Study QAAP. WestRock calibrated the DO and specific conductivity probes in the field while DEQ observed. A video recording was taken during calibration. Please contact Lucy Baker (lucy.baker@deq.virginia.gov) for the video recording. Typically, WestRock calibrates the sonde in the laboratory prior to collecting data but the sonde was calibrated in the field on 7/14/2020 so that DEQ staff could observe.

Side-by-side measurements wading or in the cooler were taken at select stations on the Jackson River DO sample run (Table 1). Measurements were taken in a cooler to control for environmental variables (i.e. flow). Both WestRock and DEQ's sonde accurately calibrated and post-checked (Attachment 1).

Station	Time	Temperature (° C)		DO (mg/L)		Specific Conductivity (µS/cm)	
Side-by-side in cooler							
		DEQ	**WR**	**DEQ**	**WR**	**DEQ**	**WR**
2-JKS026.01	7:15	18.72	18.80	8.48	8.56	167.2	168.9
2-JKS023.61	7:54	20.90	20.93	7.43	7.53	424.5	432.3
2-JKS015.60	9:08	22.05	22.12	6.55	6.70	404.8	411.8

Side-by-side wading							
2-JKS026.01	7:10*/7:38	18.62	18.68	8.49	8.59	166.6	168.8
2-JKS023.61	7:50*/8:02	21.14	21.15	7.82	7.96	431.6	435.1
2-JKS022.15	8:30	21.40	21.47	6.45	6.55	448.6	456.2
2-JKS015.60	9:06	21.99	22.04	6.55	6.65	401	407.3

* DEQ's side-by-side sample time is slightly different because DEQ water samples were taken at the same time and entered into CEDS at the water sample time rather than the side-by-side sample time.

DEQ and WestRock's temperature readings were within 0.08 °C of each other during the side-by-side cooler tests and 0.07 °C during the side-by-side wading measurements. West Rock's temperature readings were within 1% of DEQ readings and well below the 5% quality assurance guideline our agency follows. Therefore, we deem that WestRock's temperature measurements are acceptable to use as DEQ data.

The DO difference between DEQ and WestRock's sondes ranged between 0.08- 0.15 mg/L during the side-by-side cooler readings and measurements varied less during the instream wading side-by-side readings (0.1 – 0.14 mg/L). These differences were similar to the variations observed during the 2019 audit, which were deemed to be within acceptable limits. West Rock readings were found to be less than 2% of DEQ readings which is well below the 5% quality assurance guideline. We therefore deem that the WestRock DO measurements are acceptable as tier 3 quality data.

Specific Conductivity differences varied between 1.7 -7.8 µS/cm during the side-by-side cooler readings and 2.2 – 7.6 µS/cm during the side-by-side wading measurements. All West Rock observations were with 2% of DEQ readings, which is well below the 5% quality assurance guidelines. Therefore, we deem the WestRock specific conductivity measurements are acceptable as tier 3 quality data.

Conclusion

Based on the side-by-side readings, calibration observations, and quarterly calibration logs, we believe the protocols and equipment used by the WestRock staff are acceptable to provide accurate field readings. Based on my observations of field and calibration protocols, our agency is confident that the temperature, dissolved oxygen, and conductivity readings collected by WestRock are comparable to readings if collected by DEQ field staff. Field notes are attached in Attachment 1.

River DO Monitoring Data Collection Sheet

Date 7/14/20 **Weather Conditions (circle):** 1 Cloudy 2 Rain / Snow (3 Clear) 4 Foggy

Technician PB+RL (WestRock); LB (DEQ); KM (ONE Env)

(VR) **Sonde Model** EXO 3 **Serial Number** 18E104798 18D104459 DO 18D103585 temperature

(DEQ) Sonde Model EXO Serial Number 17E101238

		Time	Temp	BP (mmHg)	Meter DO Reading (mg/L)	Saturated DO from table (mg/L)	Specific Conductivity (µmhos)	Notes
Calibration	WR	7:20	23.0	730.1	8.24	0.960 * 8.57 = 8.23		good calibration
	DEQ (7/13/20)	7:15	20.6	729.5	8.64	0.960 * 8.97 = 8.61		good calibration
City Filtration	2-JKS026.01 WR	7:32 / 7:38	18.80 / 18.68	730.3 / 730.3	8.56 / 8.59		168.9 / 168.8	wade
	DEQ	7:32 / 7:10	18.72 / 18.62	729.7 / 729.9	8.48 / 8.49		167.2 / 166.6	pH = 7.58
City Park	2-JKS023.61 WR	7:54 / 8:02	20.93 / 21.15	731.1 / 731.1	7.53 / 7.96		432.3 / 435.1	wade
	DEQ	7:54 / 7:50	20.90 / 21.14	730.5 / 730.5	7.43 / 7.82		424.5 / 431.6	pH = 7.54
Fudges Bridge	2-JKS022.78 WR	8:19	21.50	730.5	7.04		460.2	suspend from bridge
Industrial	2-JKS022.15 WR	8:30	21.47	731.7	6.55		456.2	wade
	DEQ	8:30	21.40	731.0	6.45		448.6	pH = 7.55
Hercules	2-JKS021.09 WR	8:42	21.59	730.9	6.61		470.7	suspend from bridge
Idlewilde	2-JKS018.68 WR	8:53	21.65	731.5	6.49		408.1	suspend from bridge
Mallow	2-JKS015.60 WR	9:08 / 9:06	22.12 / 22.04	732.7 / 732.7	6.70 / 6.65		411.8 / 407.3	wade
	DEQ	9:08 / 9:06	22.05 / 21.99	731.9 / 732.1	6.55 / 6.55		404.8 / 401.0	pH = 7.61
Post-Check	WR	9:22	21.2	732.3	8.59	0.967 * 8.87 = 8.58		good post-check
	DEQ	15:00	22.95	729.7	8.35	0.960 * 8.58 = 8.23		good post-check

Additional Notes:

USGS Station 02013100 (Jackson River Below Dunlap Creek) - @ 0700 = 351 cfs

USGS Station 02013000 (Dunlap Creek) - @ 0700 = 56.4 cfs

USGS Station 02014000 (Potts Creek) - @ 0700 = 75.9 cfs

Note: when data is listed as ##/##; the first value is for the side-by-side reading and the second value is for the wading reading.