Sparkill PEERS Water Quality Monitoring Final Report

Sparkill Creek at Skating Pond, June 29, 2021

SPARKILL CREEK WATERSHED ALLIANCE

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NEW YORK STATE | Department of Environmental Conservation | Hudson River Estuary Program

Executive Summary

Riverkeeper and Sparkill Creek Watershed Alliance (SCWA) completed water sampling throughout the Sparkill Creek Watershed in 2020-2021. This Project has been funded in part by a grant from the New York State Environmental Protection Fund through the Hudson River Estuary Program of the New York State Department of Environmental Conservation. Previous monitoring and research efforts conducted by SCWA, Riverkeeper and others have identified sewage pollution as a priority water quality issue in Sparkill Creek. Municipalities in the watershed need access to state funding to complete sewer infrastructure repairs and upgrades. This funding is accessed through highly competitive programs that weight applications based on information from the NYSDEC Waterbody Inventory/Priority Waterbodies List (WI/PWL).

The goal of the sampling program was to provide data for a full, up-to-date WI/PWL assessment of the Sparkill Creek watershed. The study design was described in a NYSDEC-approved Quality Assurance Project Plan (QAPP). Six sampling locations in all four stream segments of the watershed were sampled on eight dates over two years. Samples were analyzed at an ELAP-certified laboratory for nutrients, physical measures, and chlorophyll a. In situ measurements were also recorded.

These results show that the water quality of Sparkill Creek is typical of an urbanized watershed.[1,2] All four stream segments met applicable NYS Water Quality Standards, and three of four exceeded EPA-recommended criteria for nutrients and chlorophyll a. Chloride concentrations and specific conductance highlight the importance of freshwater salinization in the Sparkill Creek watershed, a trend that is occurring throughout the northeastern U.S.[3,4]

In keeping with the original goals of this study, NYSDEC Division of Water (DOW) should continue to update the WI/PWL assessments for all stream segments in the Sparkill Creek Watershed. This action is critical to improving water quality in the Sparkill Creek watershed. In the meantime, the Town of Orangetown should use existing resources to complete a comprehensive sewer leak detection project in the Sparkill Creek Watershed. The Town has successfully completed such work in other areas of its sewer system to reduce overflows at the Nyack waterfront. Over the past 10 years, SCWA and partners have amassed a wealth of data and knowledge. SCWA should seek assistance from the Hudson River Estuary Program or the Hudson River Watershed Alliance to complete a watershed characterization, an important step toward watershed planning. In addition, these data can be used as a springboard for additional research.

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[1] Paul, M.J., and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333-365.

[2] Walsh, C.J., A.H. Roy, J.W. Feminella, P.D. Cottingham, P.M. Groffman, and R.P. Morgan II. 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24(3):706-723.

[3] Kelly, V.R., Findlay, S.E.G., Weathers, K.C. 2019. Road Salt: The Problem, The Solution, and How To Get There. Cary Institute of Ecosystem Studies.

[4] Kaushal, S.S., G.E. Likens, M.L. Pace, R.M. Utz, S. Haq, J. Gorman, and M. Grese. 2018. Freshwater salinization syndrome on a continental scale. Proceedings of the National Academy of Sciences 115(4):E574-E583.

Contents

Project Description

Previous monitoring efforts over more than a decade were prompted by concerns about children being exposed to sewage in the creek during educational activities,[5] and have continued to generated public interest in reducing and eliminating sewage pollution in Sparkill Creek.[6,7] In June 2019, representatives from SCWA, Riverkeeper, US Environmental Protection Agency, Town of Orangetown, Lamont-Doherty Earth Observatory, CUNY Queens College, and NYSDEC DOW discussed options for tracking sewage pollution sources in the watershed. At that event, NYSDEC DOW staff suggested that completing a water quality assessment for the full watershed, to update the NYSDEC WI/PWL, would help municipalities to compete for state funding to address infrastructure needs.

The NYSDEC Hudson River Estuary Program awarded Riverkeeper a grant to complete that work, as participants in the NYSDEC PEERS (Professional External Evaluations of Rivers and Streams) program. Project sampling locations and water quality parameters were selected with the goal of updating the NYSDEC WI/PWL. The study design was described in a NYSDEC-approved QAPP. Because of NYSDEC PEERS program restrictions, the sampling effort did not include fecal-indicator bacteria. However, it did include other water quality parameters that relate to wastewater impacts, including phosphorus. Riverkeeper and SCWA collected water samples in 2020 and 2021.

This report presents the water quality data, summarizes conclusions, and identifies next steps.

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[5] Riverkeeper, "Sparkill Creek: What are the adults going to do about this?" January 13, 2017, available at https://www.riverkeeper.org/blogs/water-quality-blogs/sparkill-creek-adults-going/

[6] Lohud, "Sparkill Creek: The Shame of the Hudson," May 8, 2019, available at https://www.lohud.com/story/opinion/2019/05/08/sparkill-creek-pollution/3576851002/

[7] Nyack News & Vies, "Earth Matters: Creek in Crisis," May 15, 2019, available at https://nyacknewsandviews.com/2019/05/em-sparkill-creek-crisis/

Watershed Description

Sparkill Creek is a tributary of the Hudson River that meets the Hudson at Piermont Marsh, one of four tidal wetlands in the Hudson River Estuarine Research Reserve. The Sparkill Creek is an eight-mile tributary with a watershed of more than 11 square miles, primarily in the Town of Orangetown, Rockland County. (Figure 1)

The eastern portion of the Sparkill Creek Watershed, includes undeveloped areas such as Blauvelt State Park, near the creek's headwaters, and Tallman Mountain State Park and Piermont Marsh, near its mouth. (Figure 2) Much of the floodplain portion of the watershed is developed. This includes residential land use, as well as a corridor of commercial and light industrial land use along the central portion of the watershed. A 1951 NYS Department of Health report completed prior to installation of centralized wastewater treatment stated that the watershed was severely polluted due to industrial and illicit sanitary wastewater discharges.[8]

Today there are two wastewater treatment plants (WWTPs) that treat sewage collected in the Sparkill Creek Watershed. One of these WWTPs is owned by Rockland County, and one by the Town of Orangetown. Discharging at a single point near Piermont Pier, the plants' combined discharge of 24.5 million gallons/day is the second-largest municipal treated sewage discharge to the Hudson River Estuary north of New York City.[9] (Figure 3) While there are no direct discharge points within the Sparkill Creek Watershed, this sewage is collected via 319 miles of sewer pipe and carried through the Sparkill Creek watershed. These pipes are greater than 65 years old and include force mains located within the creek corridor.[10] There are also areas of the watershed served by private septic systems.

In addition to regulated industrial and sanitary discharges from pipes, urban development introduces non-point source pollutants such as road salts, pet waste, nutrients, oil, and sediment, which tend to be less effectively regulated. The transition from natural land cover to impervious surface cover, along with installation of municipal separate storm sewer system (MS4) pipes that convey runoff directly into the creek, has altered the hydrology of the Sparkill Creek Watershed. These changes in the timing and intensity of high flows produce changes in erosion and deposition, which affect the physical configuration of the stream channel and the organisms that live in or rely on the creek.

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[8] New York State Department of Health, Water Pollution Control Board. 1951. Sparkill Creek Drainage Basin: Recommended Classifications and Assignment of Standards of Quality and Purity for Designated Waters of New York State.

[9] New York State Department of Environmental Conservation Hudson River Estuary Program. 2017. *Wastewater Infrastructure Database* [database].

[10] *Ibid*.

Figure 1. Aerial Photo of Sparkill Creek Watershed Showing Sampling Locations and NYSDEC Regulatory Segments

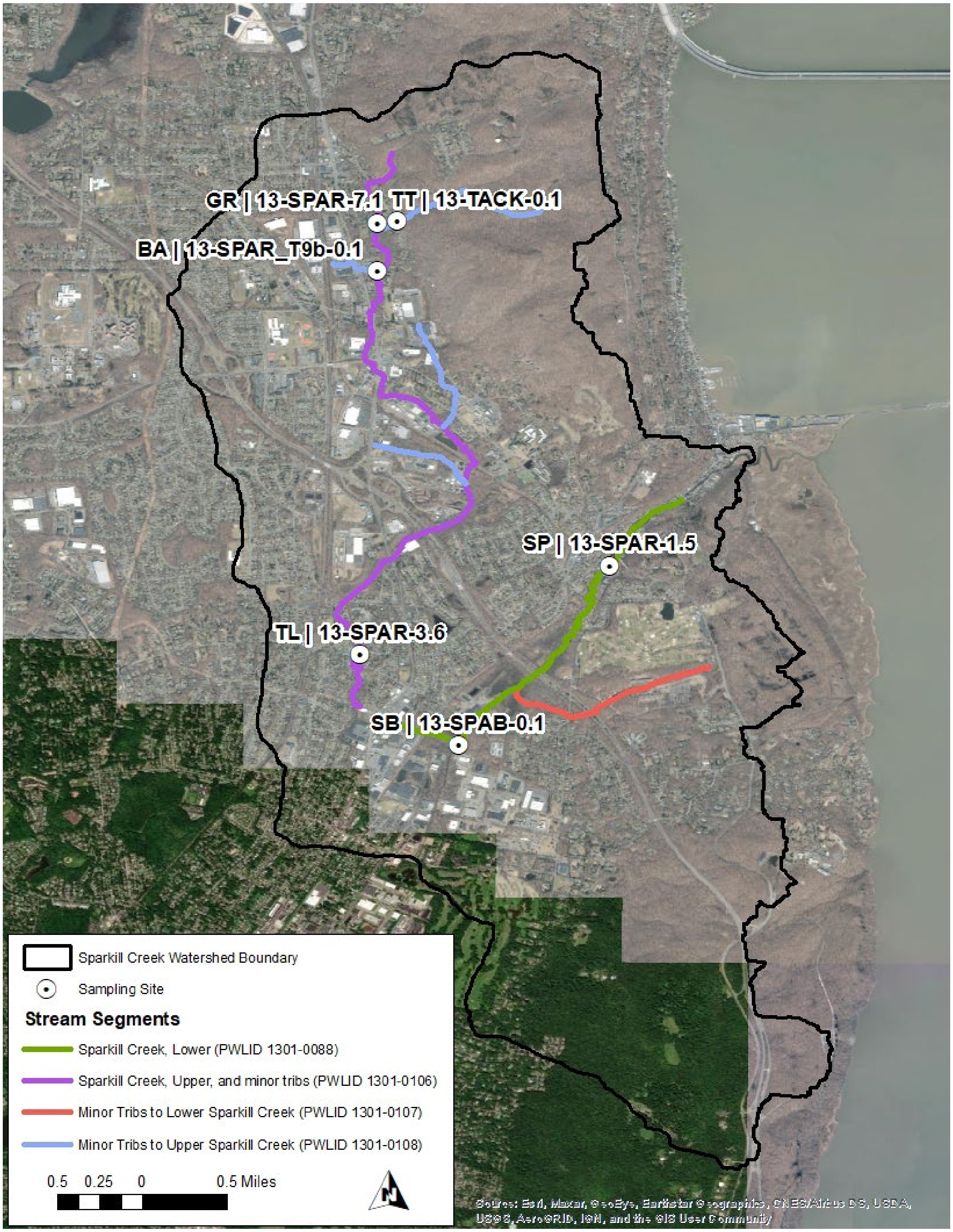
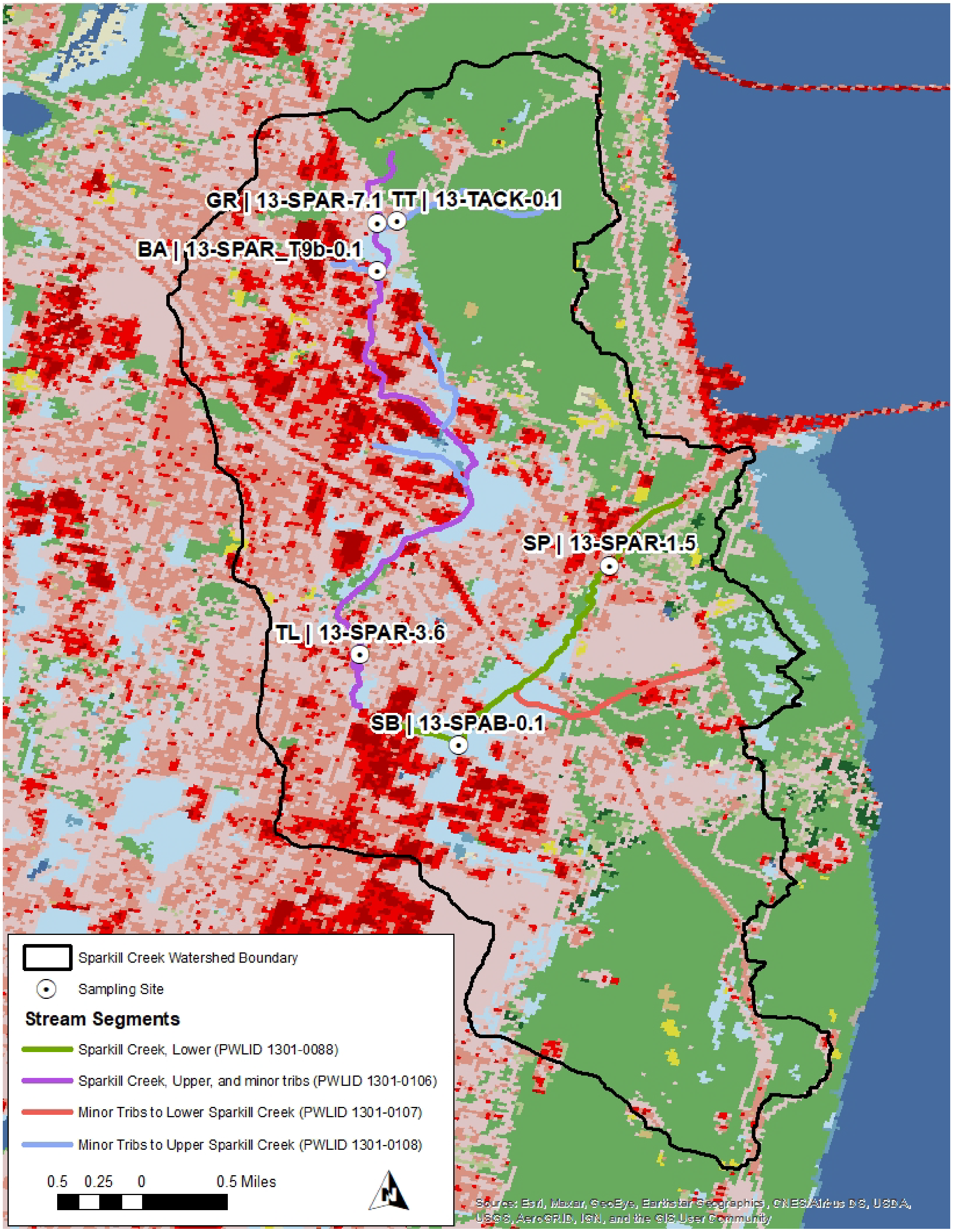


Figure 2. Land Cover Map of Sparkill Creek Watershed Showing Sampling Locations and NYSDEC Regulatory Segments

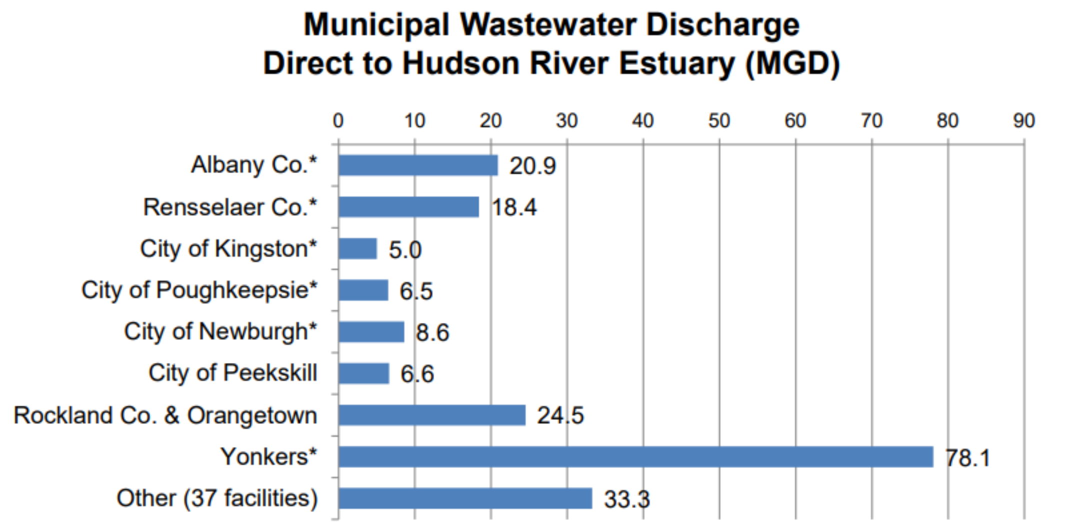


NLCD Land Cover Classification Legend

11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
51 Dwarf Scrub*
52 Shrub/Scrub
71 Grassland/Herbaceous
72 Sedge/Herbaceous*
73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands

* Alaska only

Figure 3. Municipal Wastewater Discharge to Hudson River Estuary



Plants serving combined sewer systems (whole or in part) are marked with an asterisk. Rockland County SD No. 1 (16.5 MGD) and Orangetown SD No. 1 (8.0 MGD) discharge at the same point, and are combined in this chart. At 78.1 MGD, the Yonkers treatment plant, which serves 506,000 people in 22 Westchester County municipalities, accounts for 39% of all municipal discharges direct to the Hudson River Estuary, and 22% of all discharges to the Hudson River Watershed overall.

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

Sources: NYS DEC, NYS EFC, NJ DEP, VT DEP, MA DEP, US EPA,

Water Quality Background

NYSDEC's WI/PWL includes four segments within the Sparkill Creek Watershed (Figure 1):

- Sparkill Creek, Lower (1301-0088)
- Sparkill Creek, Upper, and minor tribs (1301-0106)
- Minor Tribs to Lower Sparkill Creek (1301-0107)
- Minor Tribs to Upper Sparkill Creek (1301-0108)

The type and age of assessment data, and type and severity of impacts vary by waterbody segment.[11] (Table 1) As required under the Clean Water Act, the *assessment status* (i.e., severity of pollution) for each waterbody segment is determined according to the segment's designated use. (Table 1) Designated uses describe the social value of a waterbody, and each use relates to a set of NYS Water Quality Standards (WQS).

Table 1. Sparkill Creek Watershed WI/PWL Segments, Classifications, and Assessment Information

Segment ID	Segment Name	Classification/Designated Use[12]	Assessment Status	Pollutant(s)
1301-0088	Sparkill Creek, Lower	C: The best usage of Class C waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.	Fishing: Impaired Secondary Contact Recreation: Impaired Primary Contact Recreation: Not assessed	Dissolved oxygen (2010) Fecal coliform (2010)

[11] NYSDEC. 2016-2021. WI/PWL Fact Sheets: Minor Tribs to upper Sparkill Creek (1301-0108), https://www.dec.ny.gov/data/WQP/PWL/1301-0108.pdf?req=74984; Sparkill Creek, Upper, and Minor Tribs (1301-0106), https://www.dec.ny.gov/data/WQP/PWL/1301-0106.html?req=69994; Sparkill Creek, Lower (1301-0088), https://www.dec.ny.gov/data/WQP/PWL/1301-0088.html?req=23563; Minor Tribs to Lower Sparkill Creek (1301-0107), https://www.dec.ny.gov/data/WQP/PWL/1301-0107.pdf?req=52308.

[12] 6 NYCRR part 701.

1301-0106	Sparkill Creek, Upper, and minor tribs	C: The best usage of Class C waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.	Fishing: Fully supported (unconfirmed, needs verification) Secondary Contact Recreation: Not assessed Primary Contact Recreation: Not assessed	Dissolved oxygen (2017) Nitrate (2017) pH (2017)
1301-0107	Minor Tribs to Lower Sparkill Creek		This waterbody is unassessed.	None cited.
1301-0108	Minor Tribs to Upper Sparkill Creek	B: The best usages of Class B waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.	This waterbody is unassessed.	None cited.

Methods

Collection and handling methods are fully described in the project QAPP. A brief summary of methods is provided below.

Parameters Measured

In situ measurements of temperature, pH, conductivity, and dissolved oxygen were collected at each site on each sampling date using a multi-parameter probe. Samples were collected for laboratory analysis of ammonium, Total Kjeldahl Nitrogen, nitrate-nitrite, nitrite, total nitrogen (TN), total phosphorus (TP), turbidity, alkalinity, hardness, chloride, magnesium, and chlorophyll *a*. The laboratory also calculated total nitrogen (TN) These parameters were selected based on the NYSDEC RIBS "screening" parameters list.[13]

Methods

Grab samples were collected at the centroid of flow, composited into a churn and distributed equally to all sample bottles. Samples were placed in ice-filled coolers and shipped overnight to an analytical laboratory that was ELAP-certified for all analytical methods. Equipment blanks and matrix spikes were collected for quality control.

Ten sampling trips were completed, and laboratory analyses were completed for nine sets of samples. (Table 2) Eight of the sampling trips took place during dry weather conditions, and two took place in wet weather conditions, as defined in the project QAPP. One set of wet-weather samples was lost by the shipping company in transit to the laboratory so only *in situ* data were obtained on that date. One set of wet-weather samples was successfully analyzed by the laboratory. Blauvelt above Greenbush Road (13-SPAR-7.1) did not have flowing water on one sampling date, so no information or samples were collected at that time.

Table 2. Sampling Dates and Weather Conditions

Date	Weather
August 20, 2020	Dry
September 10, 2020	Wet (*In situ* data only; Laboratory samples lost in transit)
September 25, 2020	Dry (No samples from 13-SPAR-7.1 on this date; Stream was not flowing)

[13] NYSDEC Division of Water. 2020. Quality Assurance Project Plan: Rotating Integrated Basin Studies, Rivers and Streams.

October 1, 2020	Wet
October 22, 2020	Dry
April 8, 2021	Dry
May 4, 2021	Dry
June 29, 2021	Dry
September 20, 2020	Dry
October 20, 2020	Dry

Data Review

The results summarized here have not been reviewed by NYSDEC for quality assurance and should be considered preliminary.

Sampling Location Information

The six sampling locations were selected to obtain coverage of all four regulatory stream segments in the watershed. Two sites per segment were sampled where possible.

Sparkill Creek, Lower (1301-0088)

Piermont- Skating Pond 13-SPAR-1.5

Stream Mile 1.5 *(41.029292, -73.925459)*

This sampling site is located at Eleanor Stroud Park, on the downstream side of the Valentine Avenue bridge. At this location Sparkill Creek flows into the skating pond, which is formed by a small dam under the viaduct.

FACING UPSTREAM, APRIL 8, 2021

FACING DOWNSTREAM, APRIL 8, 2021

FACING UPSTREAM, JUNE 29, 2021

FACING DOWNSTREAM, JUNE 29, 2021


FACING UPSTREAM, OCTOBER 22, 2020


FACING DOWNSTREAM, OCTOBER 22, 2020


FACING UPSTREAM, OCTOBER 1, 2020


FACING DOWNSTREAM, OCTOBER 1, 2020


VIEW UPSTREAM, PAST BRIDGE, MAY 4, 2021

Sparkill Creek, Upper, and minor tribs (1301-0106)

Tappan- Below Washington St Bridge 13-SPAR-3.6

Stream Mile 3.6 *(41.02166, -73.94684)*

This sampling site is located behind Tappan Library. Several stormwater pipes discharge into the creek as it flows through Tappan Memorial Park. The sampling location is on the downstream side of the sewer manhole that is situated on the stream bank. Flow here seems to be somewhat impounded by is a small dam under the library footbridge.

FACING UPSTREAM, APRIL 8, 2021

FACING DOWNSTREAM, APRIL 8, 2021

FACING UPSTREAM, JUNE 29, 2021

FACING DOWNSTREAM, JUNE 29, 2021


FACING UPSTREAM, SEPTEMBER 10, 2020


FACING DOWNSTREAM, SEPTEMBER 10, 2020


FACING UPSTREAM, OCTOBER 20, 2021


FACING DOWNSTREAM, OCTOBER 20, 2021

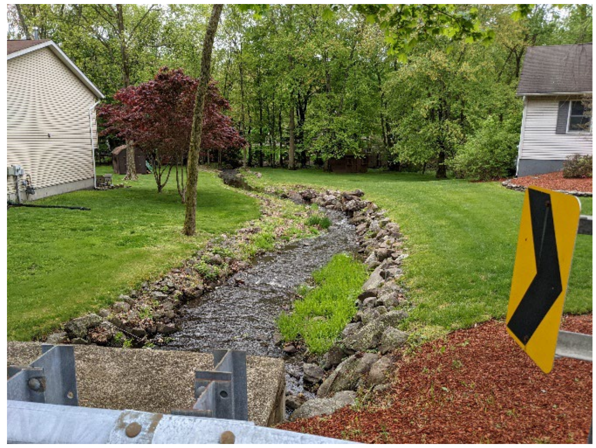

FACING UPSTREAM, OCTOBER 1, 2020

Blauvelt- 15 m above Greenbush Rd 13-SPAR-7.1

Stream Mile 7.1 *(41.058629, -73.945322)*

This sampling location is the project's uppermost main stem sampling site. There is limited residential development, served by septic systems, upstream of this location. The gradient of Sparkill Creek lessens at this location, as the stream transitions from mountainside into the less steep the valley bottom.

FACING UPSTREAM, MAY 4, 2021



DOWNSTREAM, PAST BRIDGE, MAY 4, 2021

FACING UPSTREAM, JUNE 29, 2021

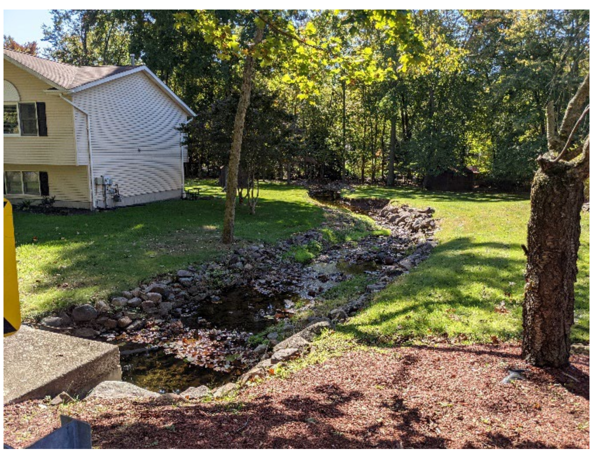
DOWNSTREAM, PAST BRIDGE, JUNE 29, 2021

FACING UPSTREAM, SEPTEMBER 10, 2020

FACING DOWNSTREAM, SEPTEMBER 10, 2020

FACING UPSTREAM, SEPTEMBER 25, 2020

FACING DOWNSTREAM, SEPTEMBER 25, 2020



DOWNSTREAM, AFTER TROPICAL STORM IDA, OCTOBER 20, 2021

Minor Tribs to Lower Sparkill Creek (1301-0107)

Sparkill Brook tributary 13-SPAB-0.1

Confluence at Stream Mile 2.7 *(41.013922, -73.938315)*

Sparkill Brook drains commercial areas and a golf course in New Jersey before entering New York and joining Sparkill Creek just beyond the NY-NJ state line. This sampling location is situation before Sparkill Brook flows through industrial area along the state border.

FACING UPSTREAM, SEPTEMBER 10, 2020

FACING DOWNSTREAM, SEPTEMBER 10, 2020

FACING UPSTREAM, SEPTEMBER 25, 2020

FACING DOWNSTREAM, SEPTEMBER 25, 2020

Minor Tribs to Upper Sparkill Creek (1301-0108)

Blauvelt Arm tributary 13-SPAR_T9b-0.1

Confluence at Stream Mile 6.3 *(41.054489, -73.945322)*

Blauvelt Arm enters Sparkill Creek after flowing through an industrial area that is surrounded by a residential zone, west of Route 303.

FACING UPSTREAM, MAY 4, 2021

FACING DOWNSTREAM, MAY 4, 2021

FACING UPSTREAM, SEPTEMBER 10, 2020

FACING DOWNSTREAM, SEPTEMBER 10, 2020


Facing upstream, October 22, 2020


Facing downstream, October 22, 2020

Tackamack trib at Greenbush Rd Bridge 13-TACK-0.1

Confluence at Stream Mile 6.6 *(41.058766, -73.943657)*

This site, located where Tackamack tributary exits its forested upper watershed and enters a residential area, is just upstream of the point where the tributary joins Sparkill Creek.

FACING UPSTREAM, MAY 4, 2021

DOWNSTREAM, PAST BRIDGE MAY 4, 2021

FACING UPSTREAM, SEPTEMBER 10, 2020

FACING DOWNSTREAM, SEPTEMBER 10, 2020

Facing upstream, October 22, 2020

Facing downstream, October 22, 2020

Facing upstream, after Tropical Storm Ida, October 20, 2021

Downstream, past bridge October 20, 2021

Sampling Results

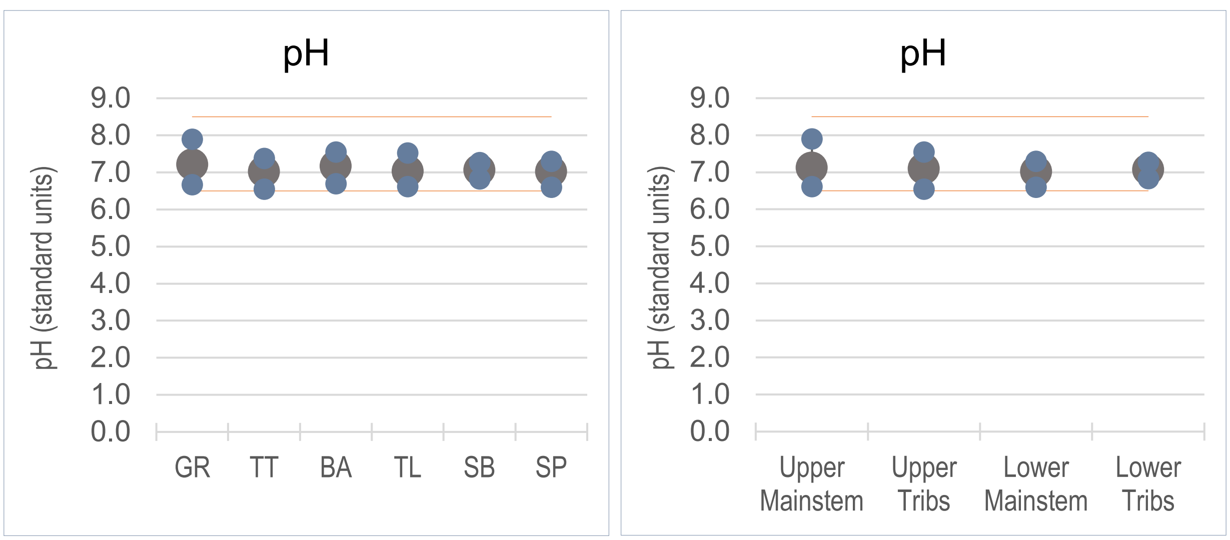
The following graphs present a summary of sampling results; more information is available in the project archive on Google Drive. For each parameter, information is presented by sampling location and stream segment. All graphs show the average value of all samples taken as well as the maximum and minimum values.

Of the parameters measured in this project, for Class B and C streams, NYS has numerical WQS for pH and dissolved oxygen.[14] EPA has issued water quality criteria recommendations for TN, TP, chlorophyll a, and turbidity.[15] These standards/criteria are shown in the figures.

Appendix A contains tables for each site that list the numerical values for sample maximums, minimums, and averages, plus the wet weather values. (Some wet weather values are a single sample, some are the average of two samples. See table footnotes for detail.) Appendix A also contains graphs for each site showing all sampling results by date.

Many other data sources are available for the Sparkill Creek Watershed. These sources are indexed in Appendix B.

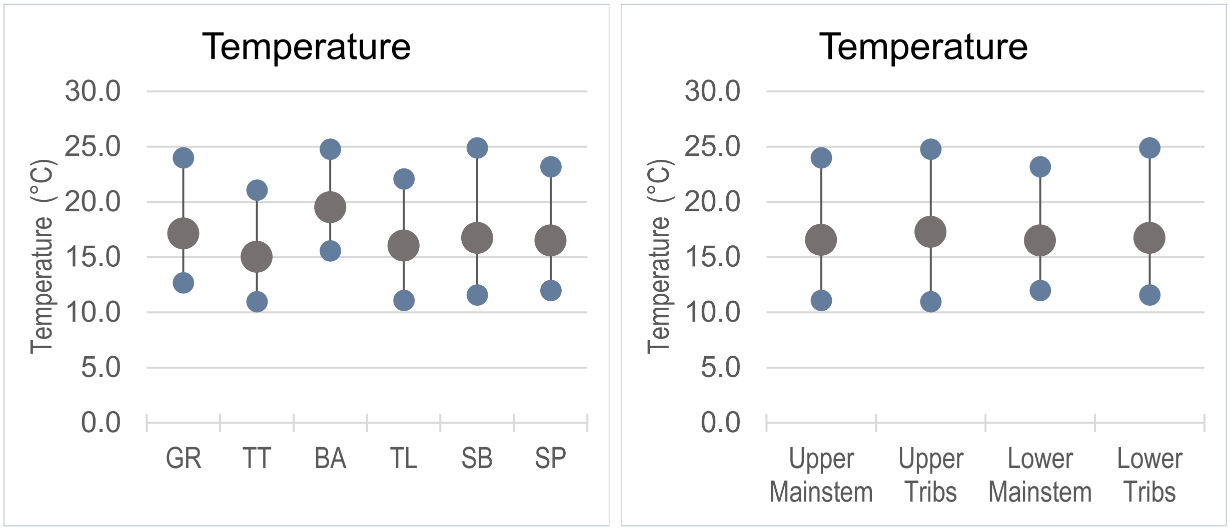
Figure 4. Average, Minimum, and Maximum pH by Sampling Location (left) and Stream Segment (right)



NYS WQS require pH between 6.5 and 8.5. Minimum pH values approached the lower regulatory limit at all six sites (minimums ranged from 6.6 to 6.8), but the average values were within the range of WQS for all sites (Figure 4).

[14] 6 NYCRR part 703.3
[15] US EPA. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX.

Figure 5. Average, Minimum, and Maximum Water Temperature by Sampling Location (left) and Stream Segment (right)



Temperature was more variable within the upper portion of the watershed compared to the lower sites (Figure 5). Tackamack tributary and Blauvelt Arm, the two upper watershed tributaries, had very different temperature profiles. Blauvelt Arm was the warmest sampling location in the watershed, with an average temperature (19.5°C) more than 2°C warmer than the next warmest site.

Figure 6. Average, Minimum, and Maximum Specific Conductance by Sampling Location (left) and Stream Segment (right)

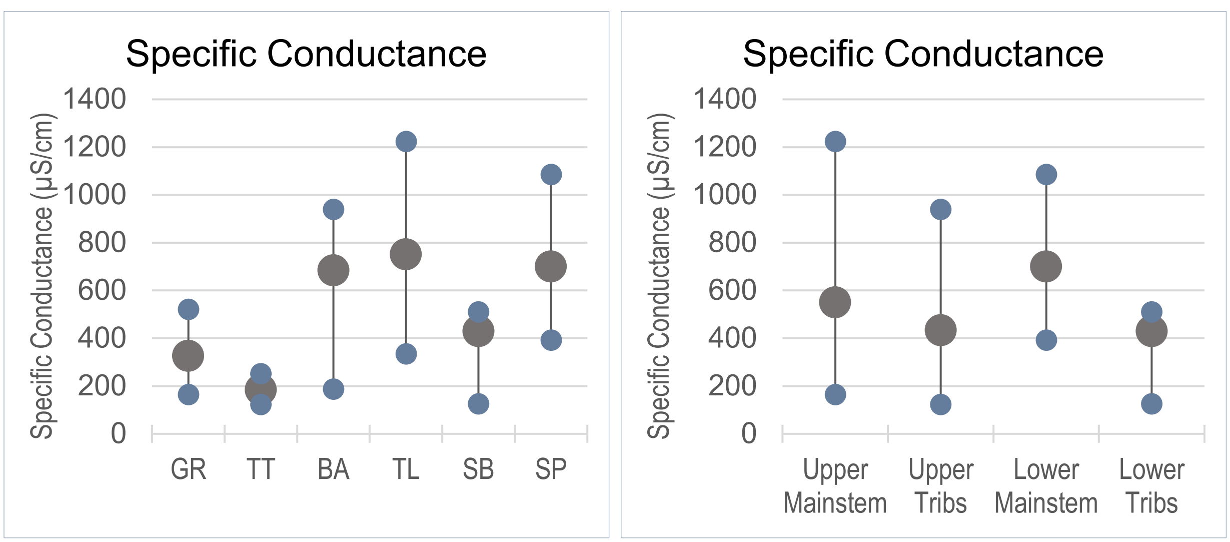


Figure 7. Average, Minimum, and Maximum Chloride by Sampling Location (left) and Stream Segment (right)

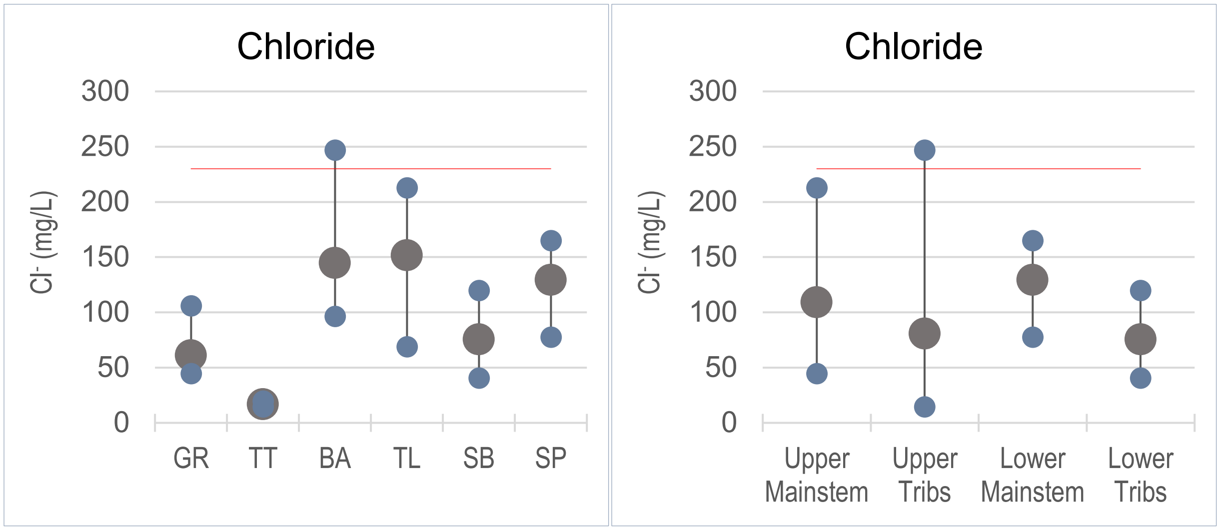


Figure 8. Average, Minimum, and Maximum Alkalinity by Sampling Location (left) and Stream Segment (right)

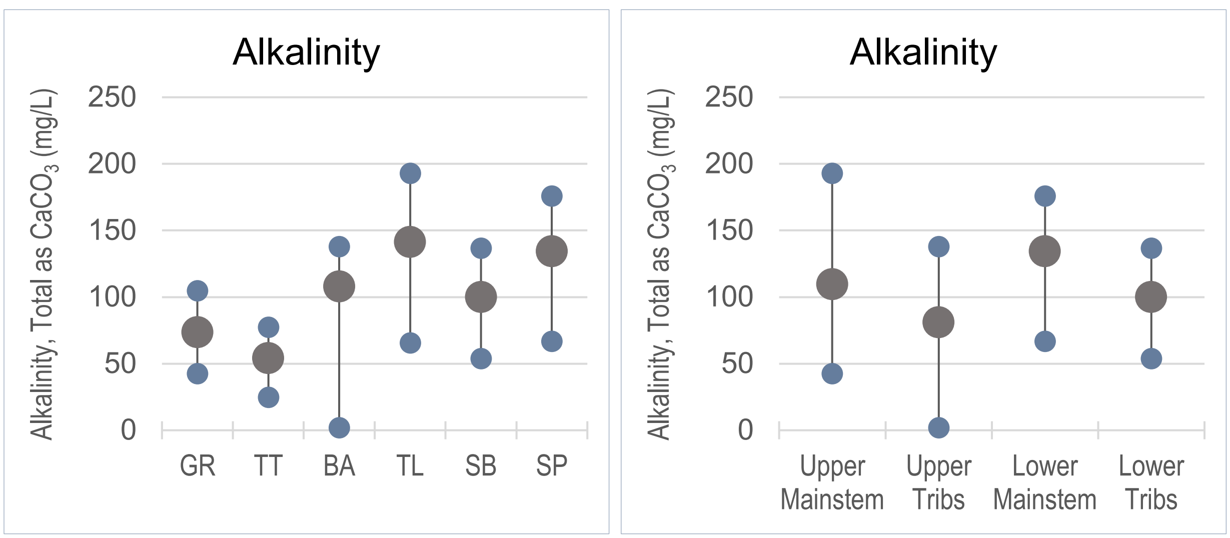
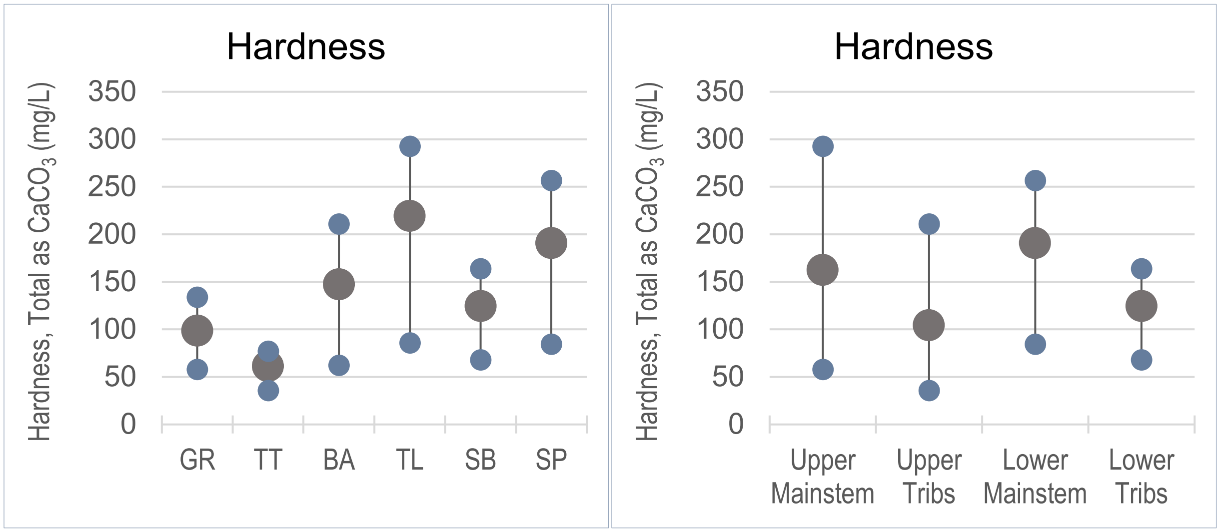


Figure 9. Average, Minimum, and Maximum Hardness by Sampling Location (left) and Stream Segment (right)



Specific conductance, chloride, alkalinity, and hardness are all related to the total dissolved solids present in the water. (Calcium and magnesium were also measured, and are also related to the above parameters, but the data are not shown here.) Values for all six of these parameters showed similar patterns throughout the watershed (Figures 6, 7, 8, and 9).

Chloride is included due to the trend toward freshwater salinization across the U.S., and particularly in the northeast, and the potential to control chloride concentrations through road salt management practices.[16,17] In addition to the direct impacts of chloride, salinization is related to other water quality changes that may be harmful for aquatic life.[18]

NYS WQS criteria for chloride apply only to drinking water sources. EPA issued recommended criteria for aquatic life in 1988, shown here.[19] The average chloride concentrations observed in Sparkill Creek do not exceed EPA's criterion, but the maximum value at Blauvelt Arm exceeded that value, and the maximum at Tappan Library approached it (Figure 7). Road salt compounds accumulate in watersheds, and

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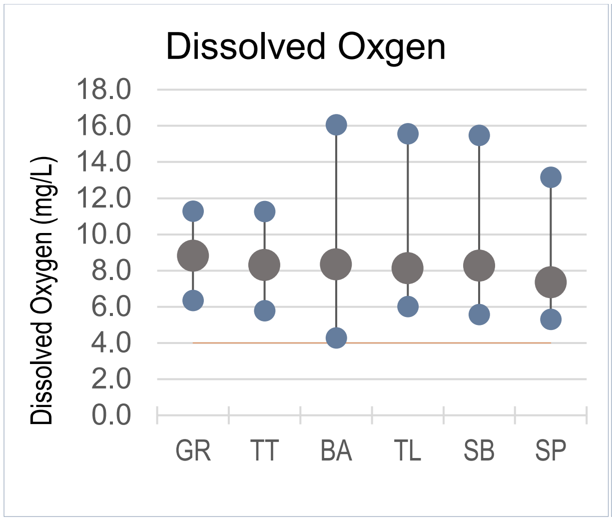
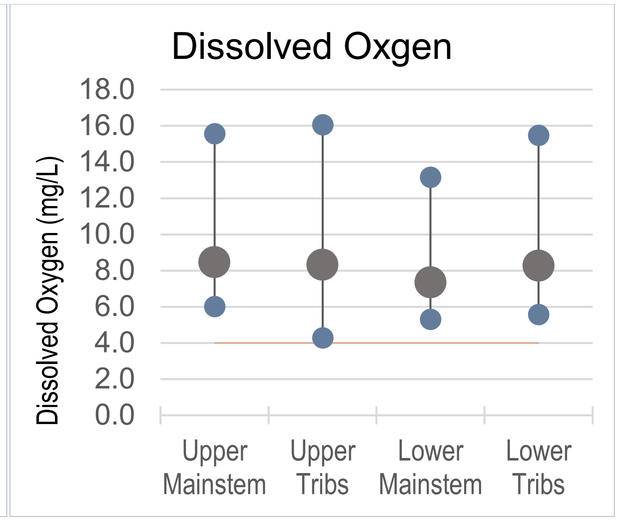
[16] Kelly, V.R., Findlay, S.E.G., Weathers, K.C. 2019. Road Salt: The Problem, The Solution, and How To Get There. Cary Institute of Ecosystem Studies.
[17] Kaushal, S.S., G.E. Likens, M.L. Pace, R.M. Utz, S. Haq, J. Gorman, and M. Grese. 2018. Freshwater salinization syndrome on a continental scale. Proceedings of the National Academy of Sciences 115(4):E574-E583.
[18] Kaushal, S.S., G.E. Likens, M.L. Pace, J.E. Reimer, C.M. Maas, J.G. Galella, R.M. Utz, S. Duan, J.R. Kryger, et al. 2021. Freshwater salinization syndrome: from emerging global problem to managing risks. Biogeochemistry 154:255-292.
[19] US EPA Office of Water Regulations and Standards. 1988. Ambient Water Quality Criteria for Chloride—1988. EPA 440/5-88-001.

may take decades to flush out, even if road salting is discontinued, so the marginal values in the Sparkill Creek Watershed deserve attention.[20,21]

Figure 10. Average, Minimum, and Maximum Dissolved Oxygen by Sampling Location (left) and Stream Segment (right)



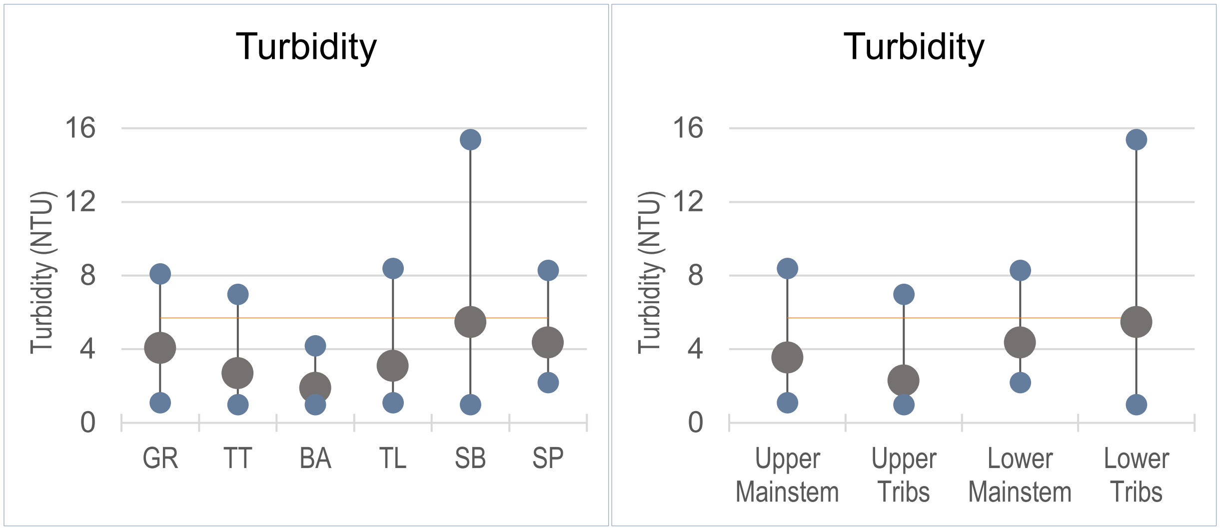


NYS WQS for dissolved oxygen include an instantaneous minimum value (4.0 mg/L, shown), and a daily average minimum value (5.0 mg/L, not shown). Dissolved oxygen concentrations were greater than the NYS WQS, but measurements in the 5.0-6.0 mg/L range were common (Figure 10). These lower values are concerning. Extremely high DO values were observed on April 8, 2021, for unknown reasons.

[20] Kaushal, S.S., G.E. Likens, M.L. Pace, J.E. Reimer, C.M. Maas, J.G. Galella, R.M. Utz, S. Duan, J.R. Kryger, et al. 2021. Freshwater salinization syndrome: from emerging global problem to managing risks. Biogeochemistry 154:255-292.

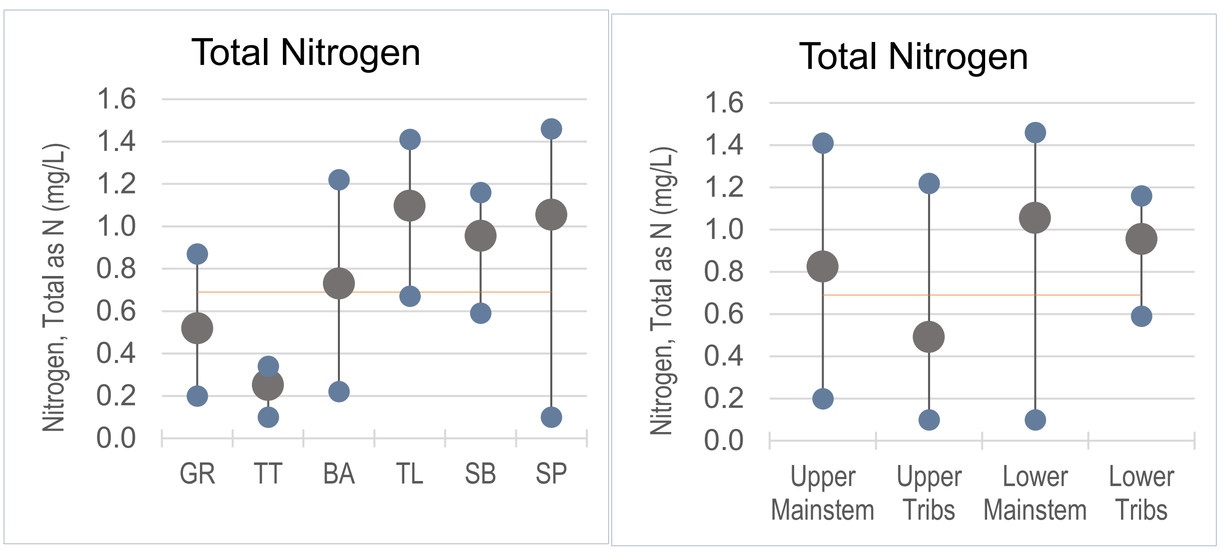
[21] Kelly, V.R., Findlay, S.E.G., Weathers, K.C. 2019. Road Salt: The Problem, The Solution, and How To Get There. Cary Institute of Ecosystem Studies.

Figure 11. Average, Minimum, and Maximum Turbidity by Sampling Location (left) and Stream Segment (right)



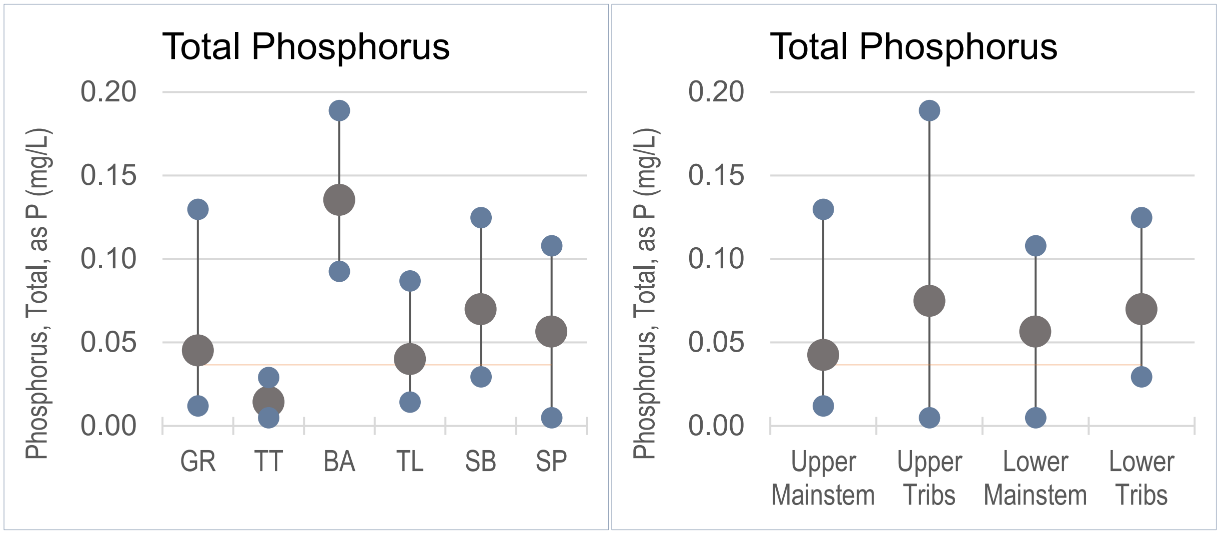
Average turbidity values were below the EPA recommended criterion for all sampling sites, although Sparkill Brook's average value was only 0.2 NTU below the criterion (Figure 11).[22] The Sparkill Brook sampling location also had a maximum value approximately two times greater than any other site.

Figure 12. Average, Minimum, and Maximum Total Nitrogen by Sampling Location (left) and Stream Segment (right)



[22] EPA's recommended criterion for turbidity is measured in Formazin Turbidity Units (FTU). The equipment used for this sampling measured turbidity in Nephelometric Turbidity Units (NTU). The units are used interchangeably here.

Figure 13. Average, Minimum, and Maximum Total Phosphorus by Sampling Location (left) and Stream Segment (right)

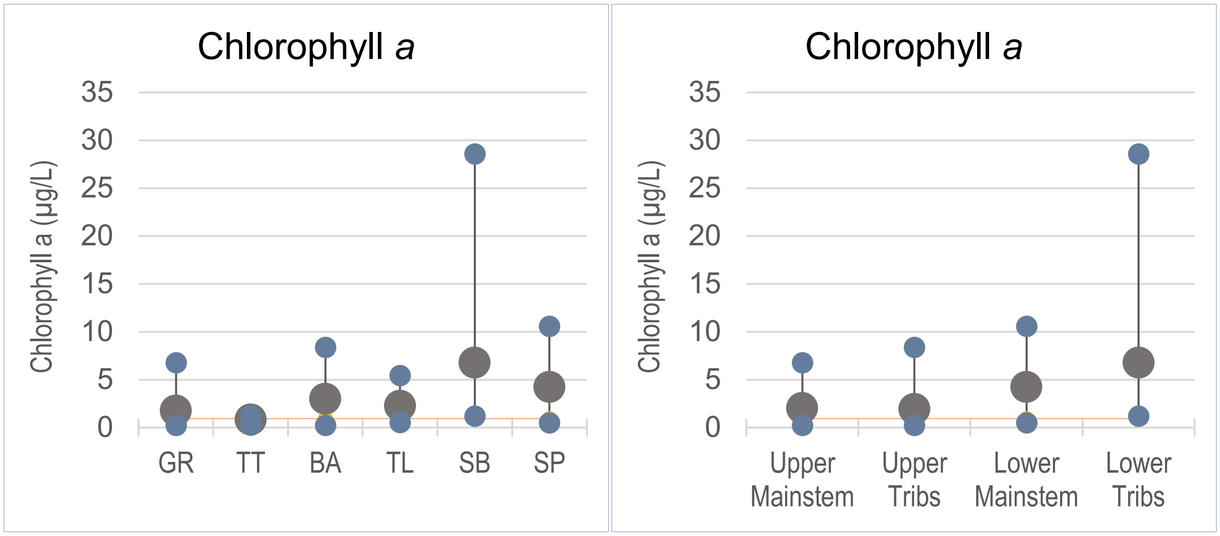


Multiple nitrogen forms were measured as part of this project. Only TN is shown here because of the relevance of EPA recommended water quality criteria, but information about the other nitrogen forms may give insight into nutrient sources. Ammonia never occurred at concentrations exceeding NYS WQS.

TP and TN exceeded the EPA recommended criteria at most sites (Figures 12 and 13). TP exceeded EPA for all segments, by large margins in most segments (Figure 12). TN exceeded the EPA criterion for all segments except Minor Tribs to Upper Sparkill Creek (1301-0108) (Figure 13).

There was a big difference in TN values between the two sampling locations in the Minor Tribs to Upper Sparkill Creek segment. Blauvelt Arm exceeded the EPA TN criterion by a factor of three, and had the highest minimum, maximum, and average values in the watershed. In contrast, the other sampling location in the segment, Tackamack tributary, had the watershed's lowest values. Averaging measurements from the two sites for assessment purposes would mean an improper assessment for Blauvelt Arm, due to the contrasting water quality at Tackamack tributary.

Figure 14. Average, Minimum, and Maximum Chlorophyll *a* Phosphorus by Sampling Location (left) and Stream Segment (right)



Chlorophyll a exceeded the EPA recommended criterion at most sites, and all segments (Figure 14). The lower mainstem portion of the creek and the lower tributaries exceeded the criterion by larger margins.

Conclusions

These data show that Sparkill Creek water quality is degraded in ways that are predictable for an urbanized watershed.[23,24] The most notable of these are:

- High, nutrient and chlorophyll a concentrations, indicating eutrophication;
- High specific conductance and chloride concentrations; and
- Especially poor water quality in an area with extensive industrial land use.

All four stream segments meet NYS Water Quality Standards for parameters that have standards, but exceed EPA recommended criteria for total nitrogen, total phosphorus, and chlorophyll. It is worth noting that these data were collected mostly during dry weather. Surface water pollutant concentrations may respond in multiple ways to precipitation, but many pollutants associated with urban land use are flushed into streams by street runoff, creating concentration spikes during precipitation events.

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[23] Paul, M.J., and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333-365.

[24] Walsh, C.J., A.H. Roy, J.W. Feminella, P.D. Cottingham, P.M. Groffman, and R.P. Morgan II. 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24(3):706-723.

Action Agenda

1. **SCWA should ensure that NYSDEC DOW updates the WI/PWL assessments for all stream segments in the Sparkill Creek Watershed.**
   This action is critical because it will improve municipalities' competitiveness for state funding for projects that benefit water quality, including inflow and infiltration studies, and both gray and green infrastructure construction. NYSDEC's Rotating Integrated Basin Study (RIBS) program will be focusing on the Lower Hudson River Watershed in 2022-2023, and NYSDEC has indicated it will take additional samples needed for a WI/PWL update in 2022. Hudson River Estuary Program staff (Tom Niekrewicz) will facilitate communication between SCWA and DOW.
2. **SCWA should communicate to the Town of Orangetown the importance of a comprehensive sewer leak detection project in the Sparkill Creek Watershed, as proposed in 2019.**
   At the 2019 meeting that gave rise to this project, the Town of Orangetown described sewer leak detection work that had recently been completed along the Nyack waterfront by the Town Health Engineer. This resulted in the elimination of illicit wastewater discharges to the stormwater system, and reduction or elimination of overflows from a pump station that had previously been in chronic failure during rain events. SCWA formally requested that such work be completed in the Sparkill Creek at a November, 2019, town board meeting. The Town of Orangetown should prioritize sewer leak detection in the Sparkill Creek Watershed, in response to the water pollution shown here. SCWA and Riverkeeper will meet with Orangetown to discuss this recommendation.
3. **SCWA should complete a watershed characterization with assistance from Hudson River Estuary Program or Hudson River Watershed Alliance.**
   Many additional information sources are available that can be used to supplement the data reported here (Appendix B). A watershed characterization would include a comprehensive summary and analysis of all available data as a stepping stone toward a watershed management plan. Hudson River Estuary Program and Hudson River Watershed Alliance offer grants and technical support for watershed characterizations.
4. **SCWA should consider collaborating with local professors and students to better understand these data, or design additional studies.**
   These results and other available data can be further analyzed with a research focus, to better understand relationships among water quality, land use, weather, and other factors. SCWA's existing relationships with local colleges and universities can be a starting off point for this work.
5. **SCWA should consider collaborating with Rockland County Water Authority or other entities to install continuous monitoring sensors and/or flow gauges.**
   Flow data are useful to understand the hydrology of the watershed, and also allow pollutant loads to be calculated from grab sample data. Such information is helpful for identifying restoration or remediation actions within the watershed, and could also be used by people researching and managing Piermont Marsh. In addition to Rockland County Water Authority, EPA Region 2's equipment loan program, or the Stroud Water Center's Mayfly kits, may be potential resources.

Appendix A: Detailed Sampling Results

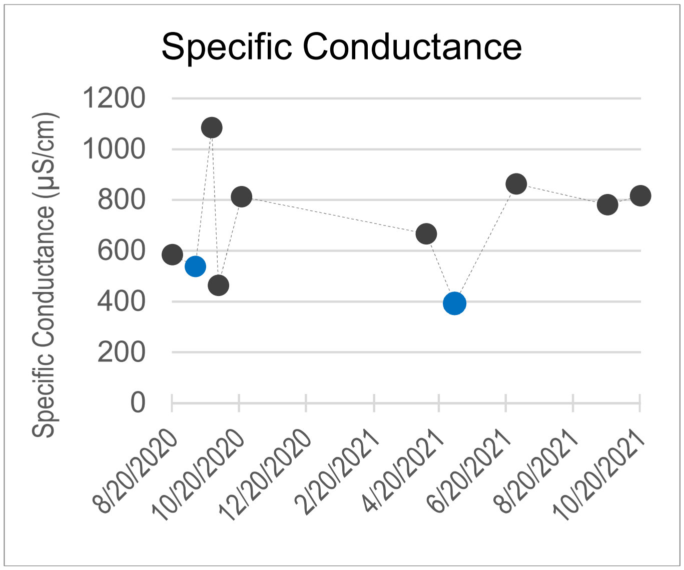
Summary of Results: Piermont- Skating Pond (13-SPAR-1.5)

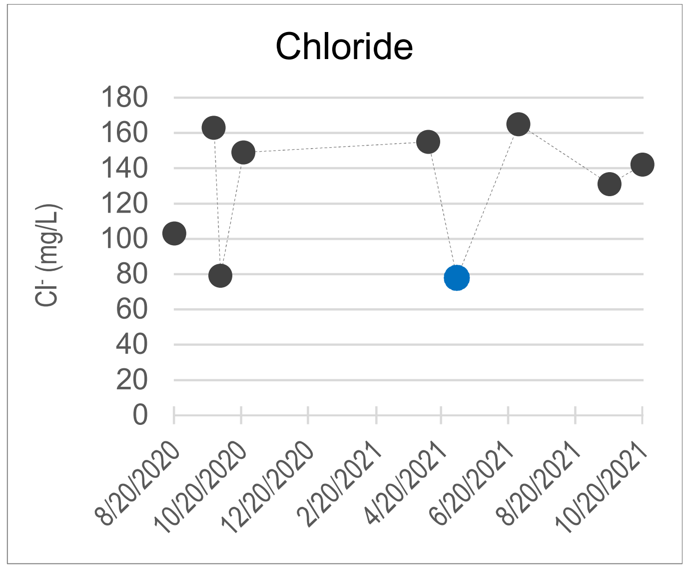
Parameter	Average	Minimum	Maximum	Wet Weather*
pH (standard units)	7.00	6.60	7.25	7.16
Dissolved Oxygen (mg/L)	7.77	5.31	13.16	6.08
Temp (°C)	15.60	12.00	23.20	19.05
Current Speed (m/s)	0.4	0.3	0.6	0.23
Turbidity (NTU)	4.70	2.20	8.30	6.8
Alkalinity, Total as CaCO3 (mg/L)	129.30	67.00	170.00	88.4
Specific Conductance (µS/cm)	735.49	392.60	1085.0	501.15
Hardness, Total as CaCO3 (mg/L)	185.96	84.70	257.00	124
Total Ca (ug/L)	56977.8	25000	76600	45600
Total Mg (ug/L)	11824.4	5930	16100	8950
Chloride (mg/L)	129.42	77.80	165.00	79
Phosphorus, Total (mg/L)	0.06	0.03	0.11	0.08
Nitrogen, Total as Nitrogen (mg/L)	1.13	0.75	1.40	1.15
Nitrate+Nitrite as Nitrogen (mg/L)	0.70	0.35	0.93	0.503
Nitrate as Nitrogen (mg/L)	0.6	0.0	0.9	0.552
Nitrite as Nitrogen (mg/L)	0.0	0.0	0.0	0.01

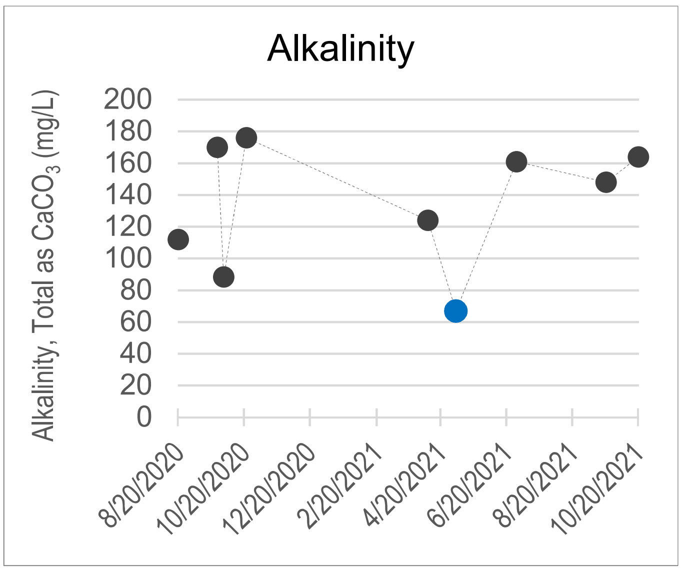
Nitrogen, Total Kjeldahl (mg/L)	0.42	0.10	0.71	0.64
Ammonia as Nitrogen (mg/L)	0.07	0.01	0.12	0.088
Chlorophyll a (µg/L)	4.24	0.53	10.60	3.49

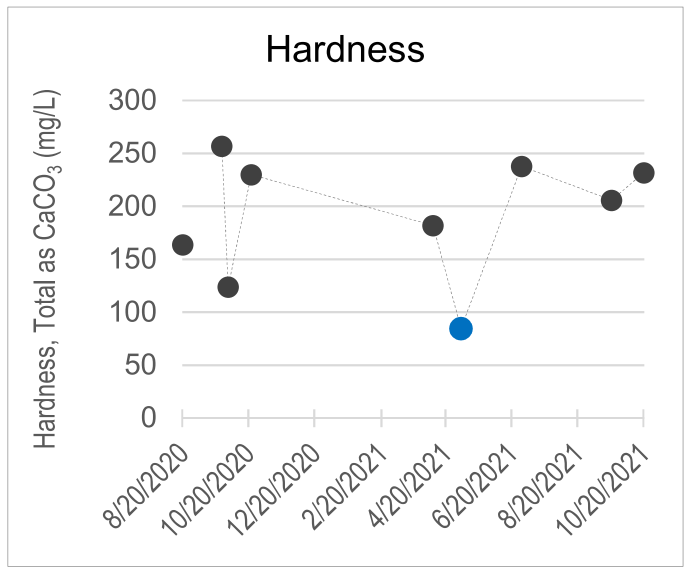
*n=2 for pH, specific conductance, dissolved oxygen, current speed, temperature. n=1 for all other parameters.

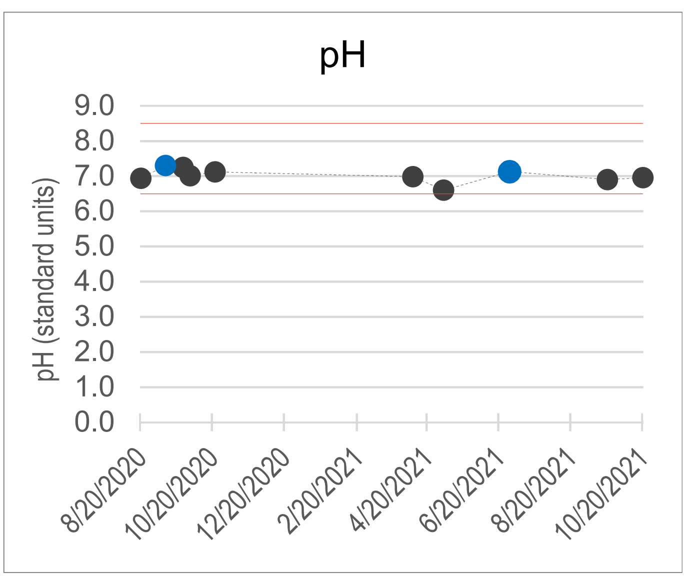
Results by Date: Piermont- Skating Pond (13-SPAR-1.5). Blue shading indicates wet-weather samples.

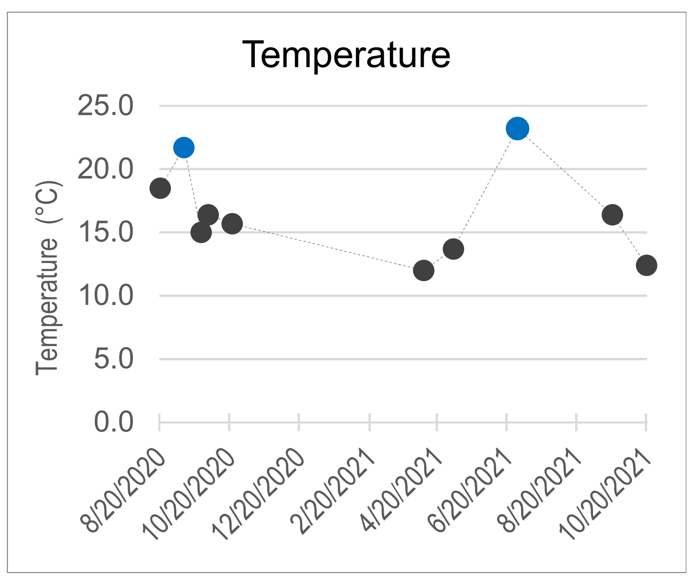


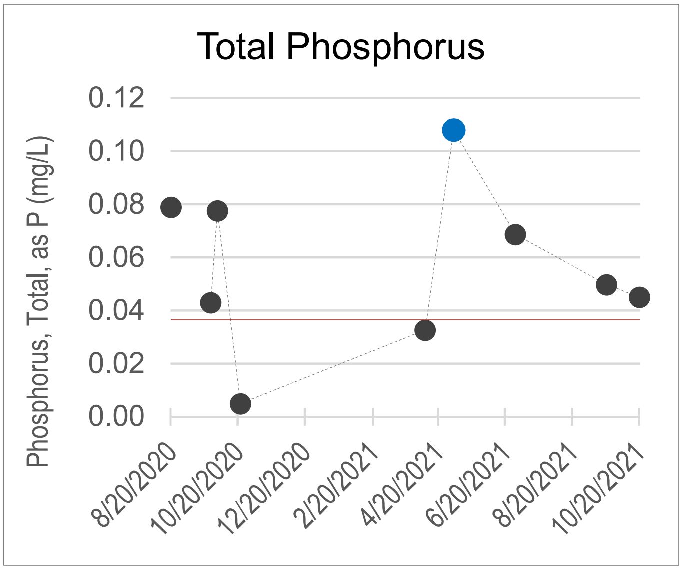


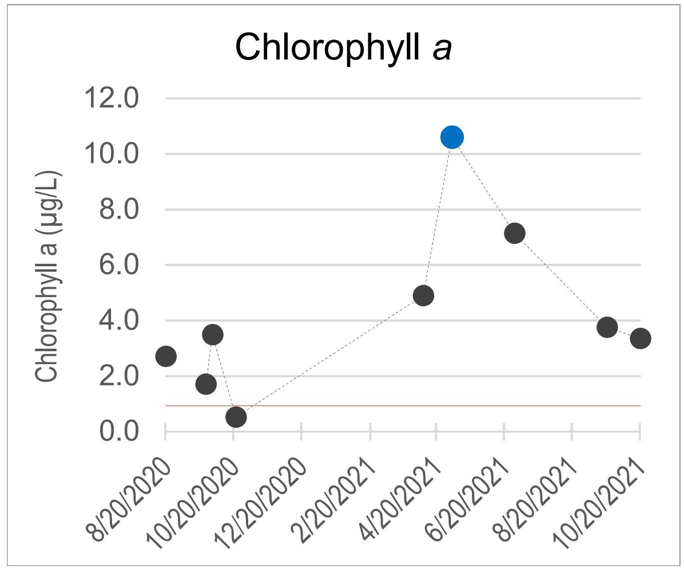


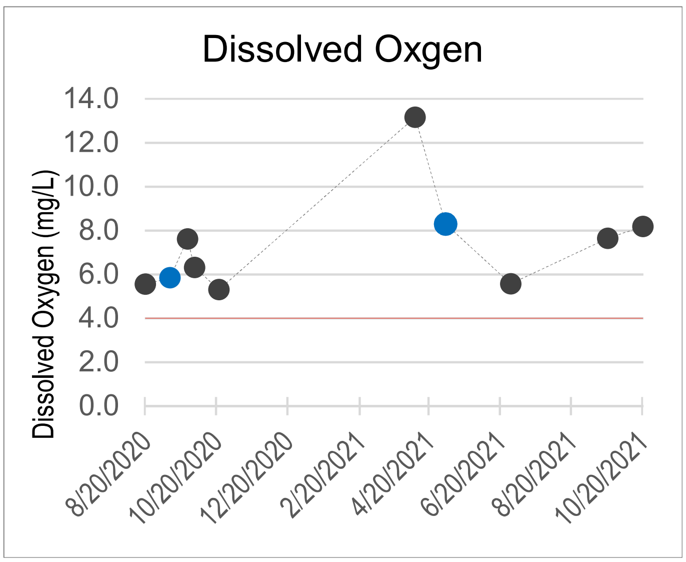


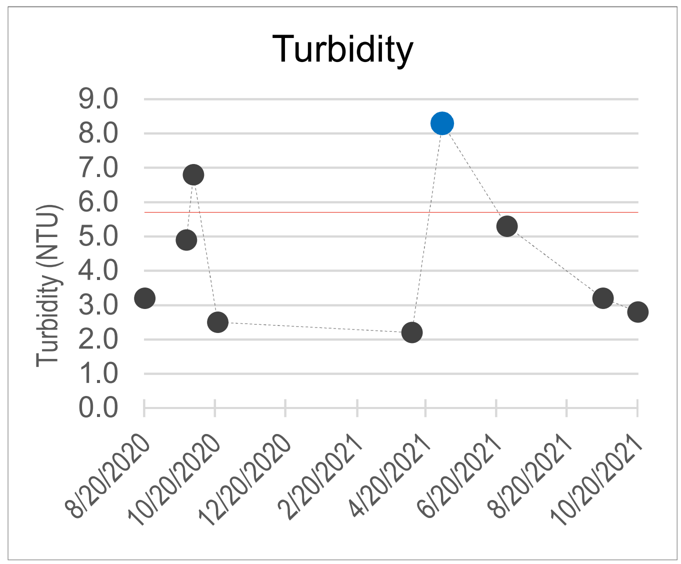


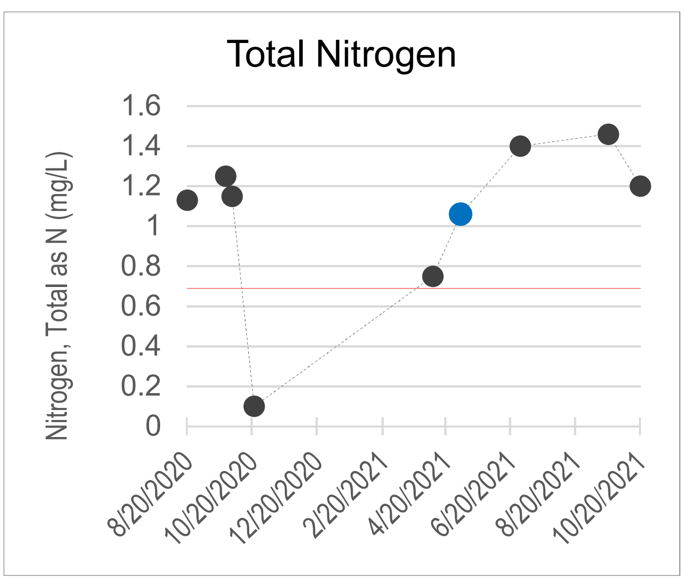


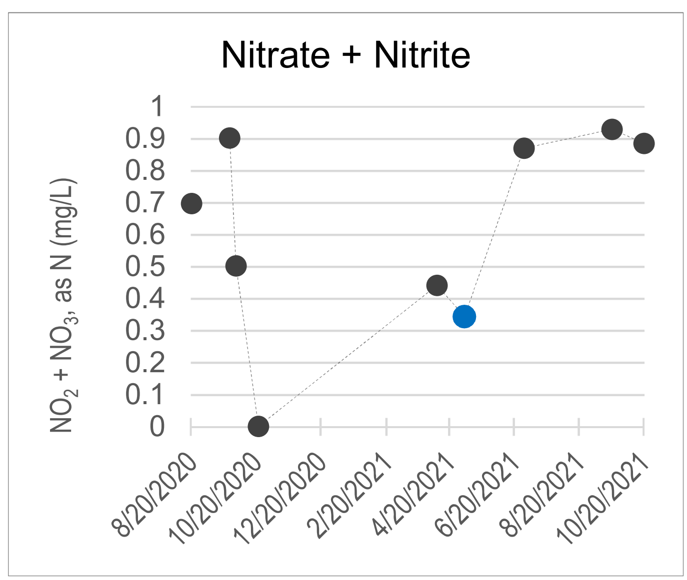

Total Phosphorus
Phosphorus, Total, as P (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

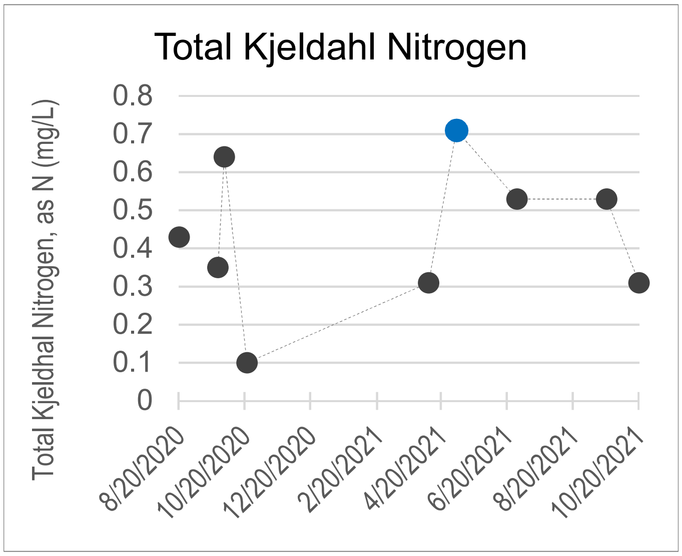

Chlorophyll *a*
Chlorophyll a (µg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

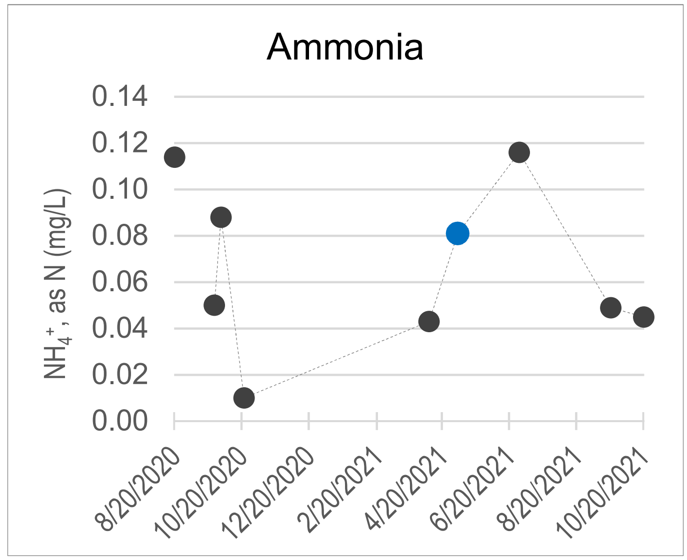

Dissolved Oxgen
Dissolved Oxygen (mg/L)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Turbidity
Turbidity (NTU)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
Nitrogen, Total as N (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
NO_2 + NO_3, as N (mg/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Ammonia
NH_4^+, as N (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

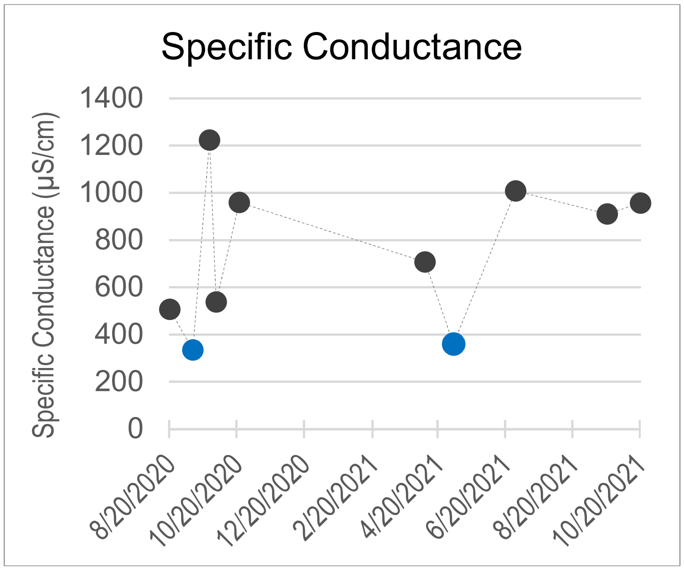
Summary of Results: Tappan- Below Washington Street Bridge (13-SPAR-3.6)

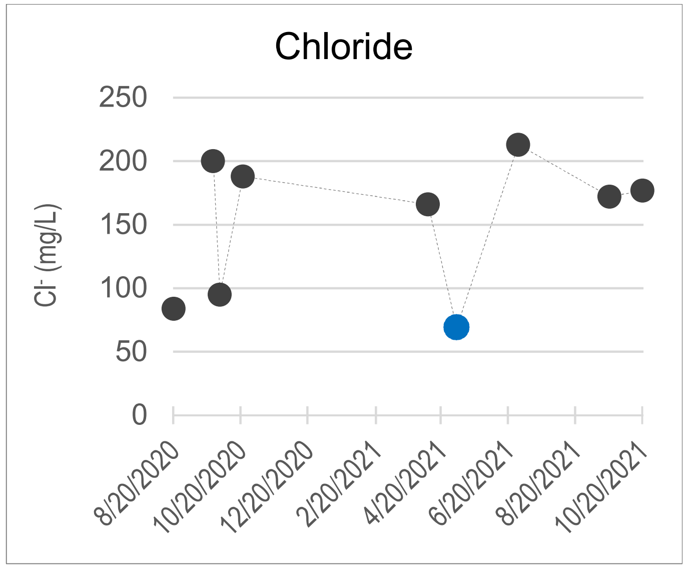
Parameter	Average	Minimum	Maximum	Wet Weather*
pH (standard units)	6.95	6.62	7.14	7.28
Dissolved Oxygen (mg/L)	8.36	6.02	15.57	6.80
Temp (°C)	15.03	11.10	22.10	18.95
Current Speed (m/s)	0.22	0.76	0.06	0.23
Turbidity (NTU)	3.73	1.10	8.40	6.1
Alkalinity, Total as CaCO3 (mg/L)	134.99	65.90	175.00	102
Specific Conductance (µS/cm)	833.29	360.30	1224.00	436.15
Hardness, Total as CaCO3 (mg/L)	212.01	86.10	293.00	151
Total Ca (ug/L)	66433.33	88600	26000	45600
Total Mg (ug/L)	12894.44	17500	5130	8950
Chloride (mg/L)	151.56	69.10	213.00	94.9
Phosphorus, Total (mg/L)	0.04	0.01	0.09	0.057
Nitrogen, Total as Nitrogen (mg/L)	1.07	0.67	1.32	1.23
Nitrate+Nitrite as Nitrogen (mg/L)	0.70	0.32	0.97	0.552
Nitrate as Nitrogen (mg/L)	0.7	0.96	0.319	0.552
Nitrite as Nitrogen (mg/L)	0.010222	0.012	0.01	0.01

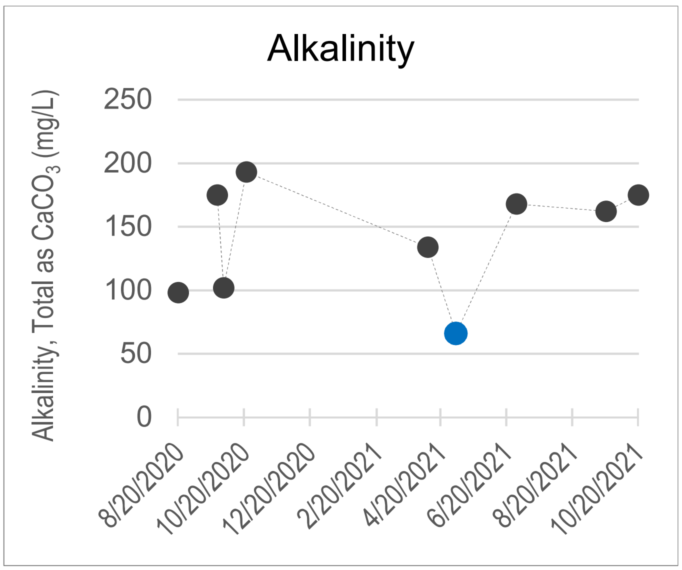
Nitrogen, Total Kjeldahl (mg/L)	0.40	0.26	0.68	0.68
Ammonia as Nitrogen (mg/L)	0.02	0.01	0.06	0.02
Chlorophyll a (µg/L)	2.25	0.53	5.44	3.15

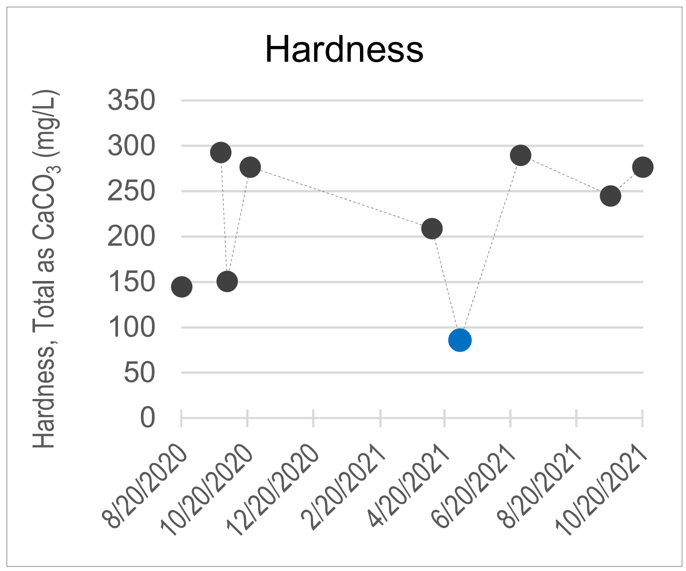
*n=2 for pH, specific conductance, dissolved oxygen, current speed, temperature. n=1 for all other parameters.

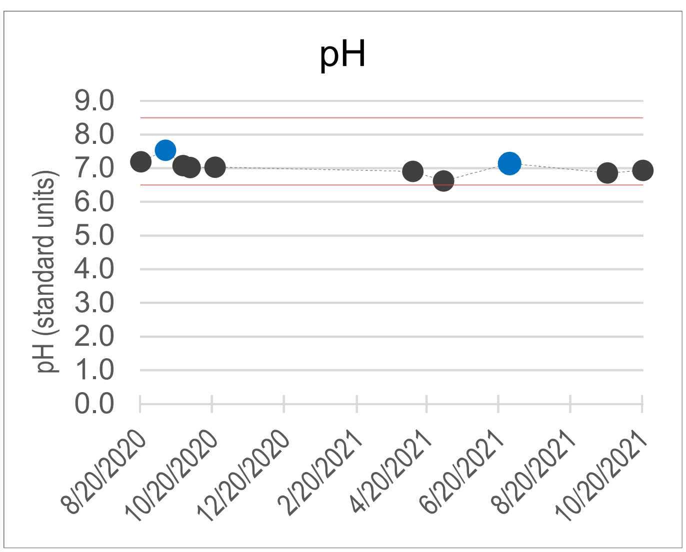
Results by Date: Tappan- Below Washington St Br (13-SPAR-3.6). Blue shading indicates wet-weather samples.

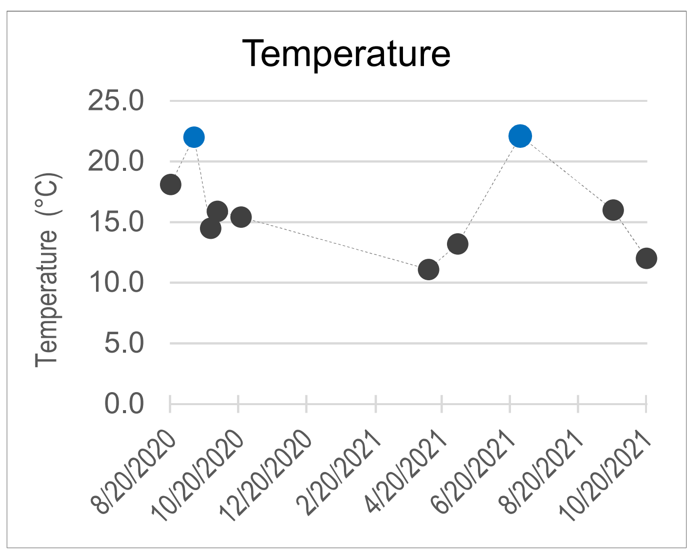


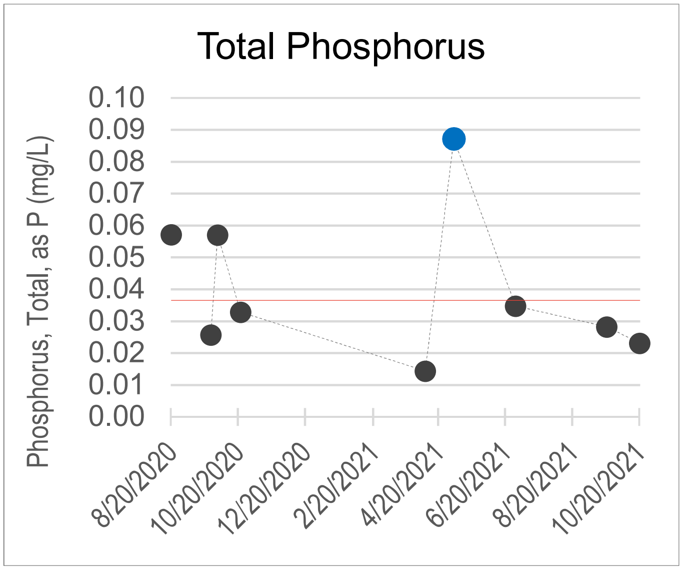


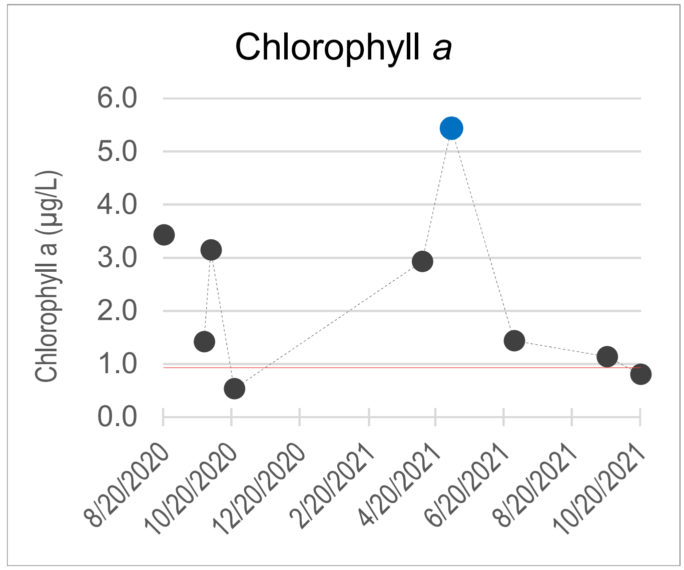


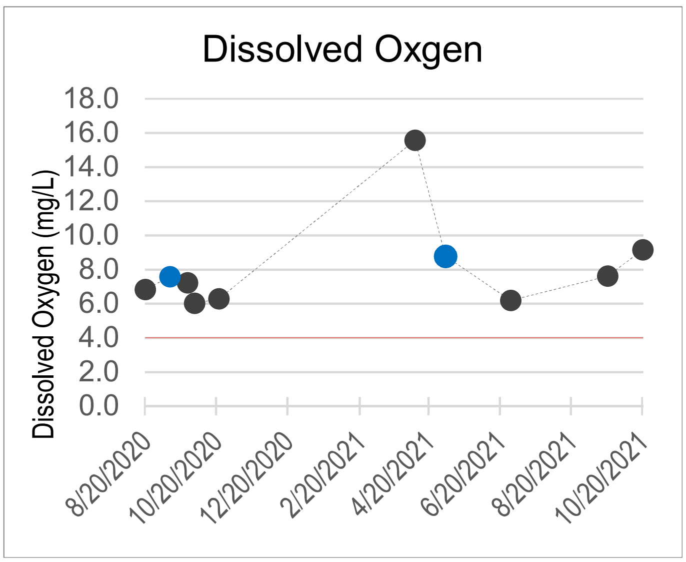


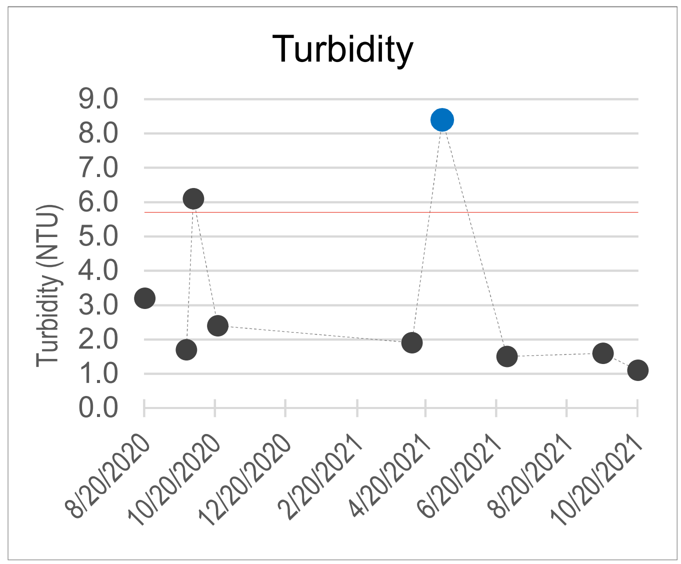


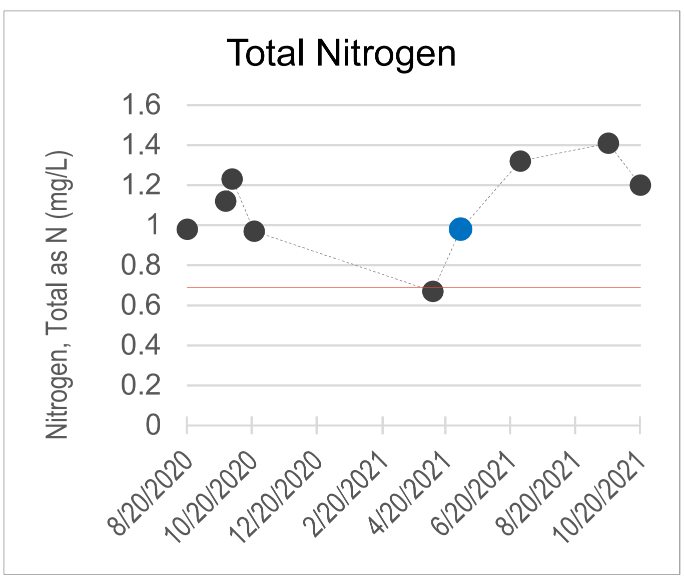


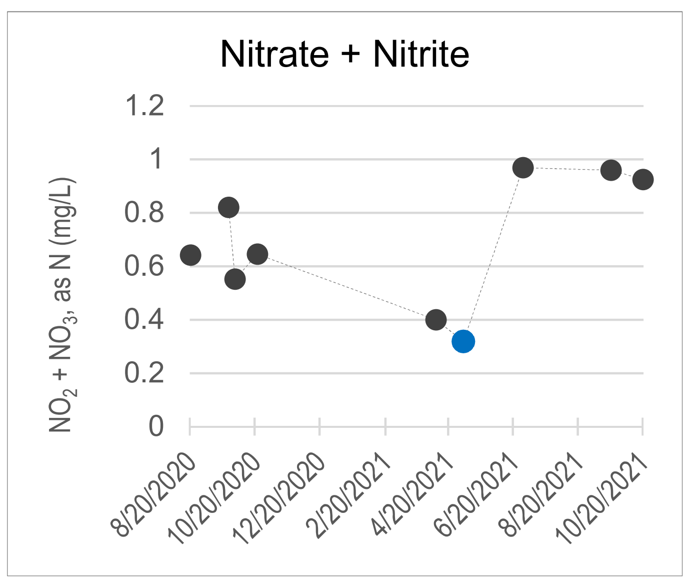

Total Phosphorus
Phosphorus, Total, as P (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

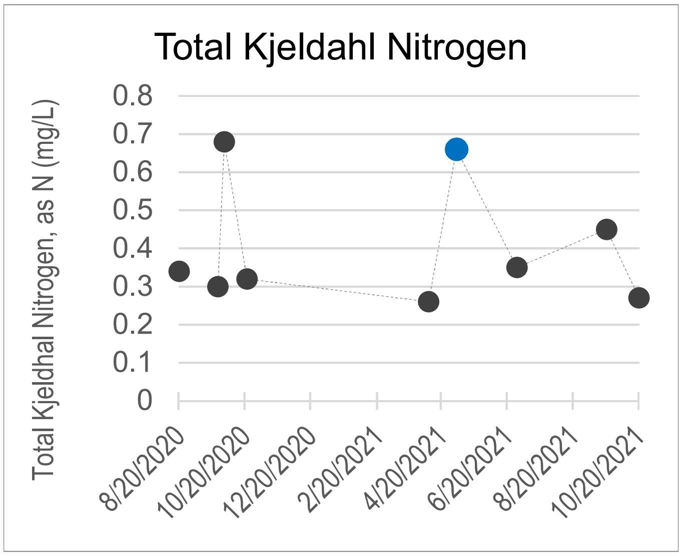

Chlorophyll a
Chlorophyll a (µg/L)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Dissolved Oxgen
Dissolved Oxygen (mg/L)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

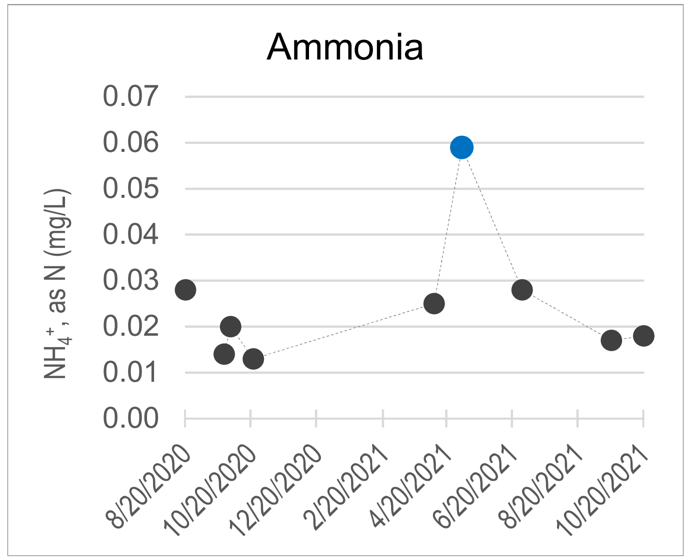

Turbidity
Turbidity (NTU)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
Nitrogen, Total as N (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
$NO_2 + NO_3$, as N (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021



Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021



Ammonia
NH_4^+, as N (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

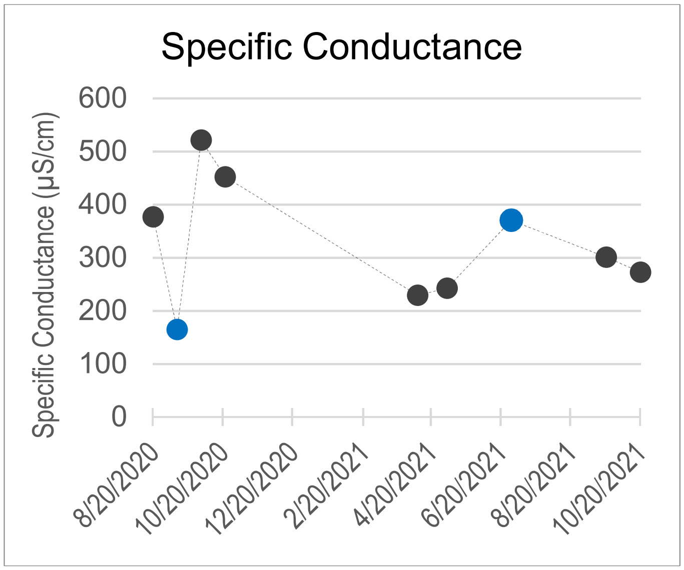
Summary of Results: Blauvelt- 15 m above Greenbush Rd (13-SPAR-7.1)

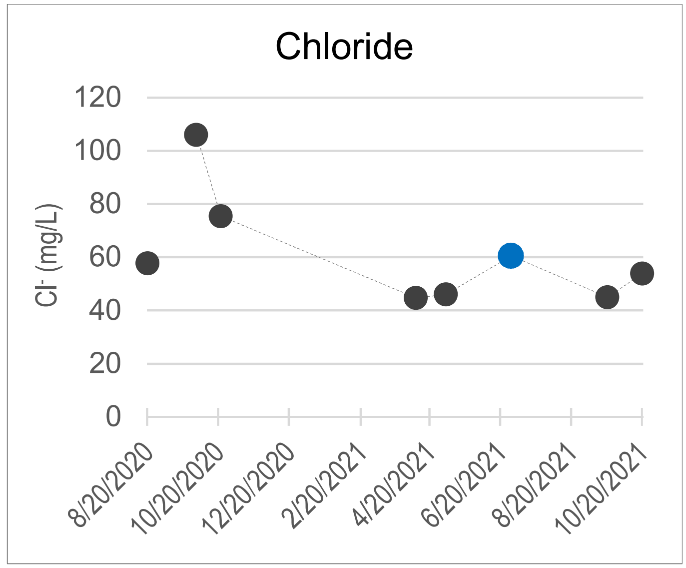
Parameter	Average	Minimum	Maximum	Wet Weather
pH (standard units)	7.17	6.67	7.90	7.23
Dissolved Oxygen (mg/L)	9.22	6.34	11.29	7.11
Temp (°C)	16.21	12.70	24.00	21.25
Current Speed (m/s)	0.31	0.13	0.64	0.20
Turbidity (NTU)	4.62	1.10	8.10	1.00
Alkalinity, Total as CaCO3 (mg/L)	69.21	42.80	88.10	106.00
Specific Conductance (µS/cm)	341.47	229.20	521.50	381.90
Hardness, Total as CaCO3 (mg/L)	93.71	58.10	121.00	109..00
Total Ca (ug/L)	26675	15400	36400	33400
Total Mg (ug/L)	7808.75	4760	10400	6110
Chloride (mg/L)	61.19	44.70	106.00	96.70
Phosphorus, Total (mg/L)	0.03	0.01	0.05	0.14
Nitrogen, Total as Nitrogen (mg/L)	0.49	0.20	0.87	0.36
Nitrate+Nitrite as Nitrogen (mg/L)	0.14	0.00	0.26	0.08
Nitrate as Nitrogen (mg/L)	0.2	0.01	0.257	0.08
Nitrite as Nitrogen (mg/L)	0.01	0.01	0.01	0.01

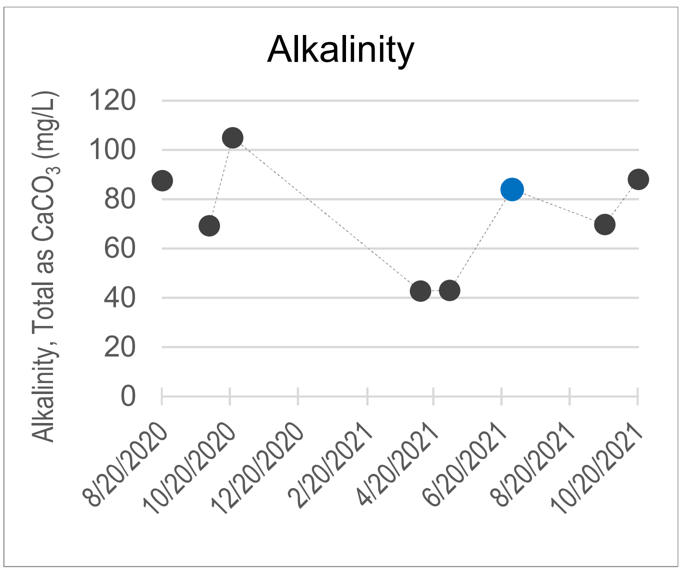
Nitrogen, Total Kjeldahl (mg/L)	0.37	0.17	0.67	0.28
Ammonia as Nitrogen (mg/L)	0.02	0.01	0.12	0.01
Chlorophyll a (µg/L)	1.76	0.24	6.80	1.10

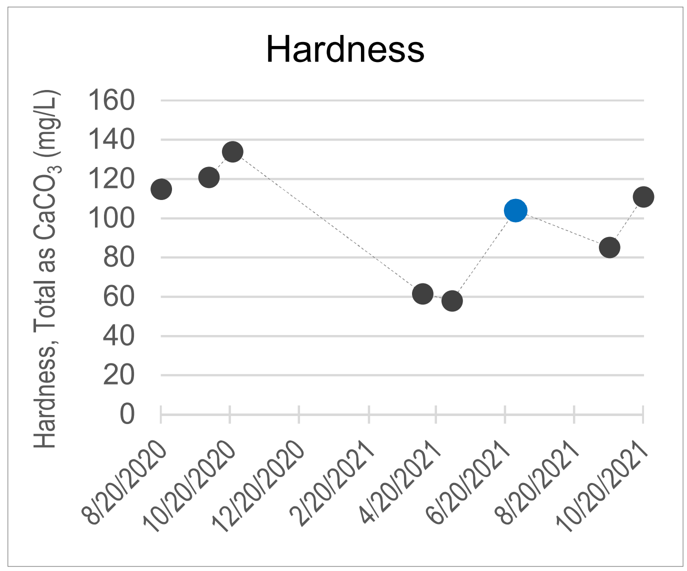
*n=2 for pH, specific conductance, dissolved oxygen, current speed, temperature. n=1 for all other parameters.

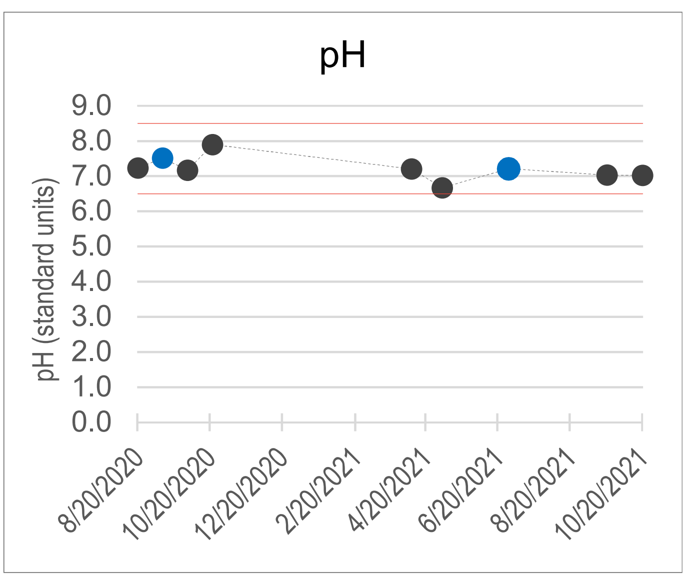
Results by Date: Blauvelt- 15 m above Greenbush Rd (13-SPAR-7.1). Blue shading indicates wet-weather samples.

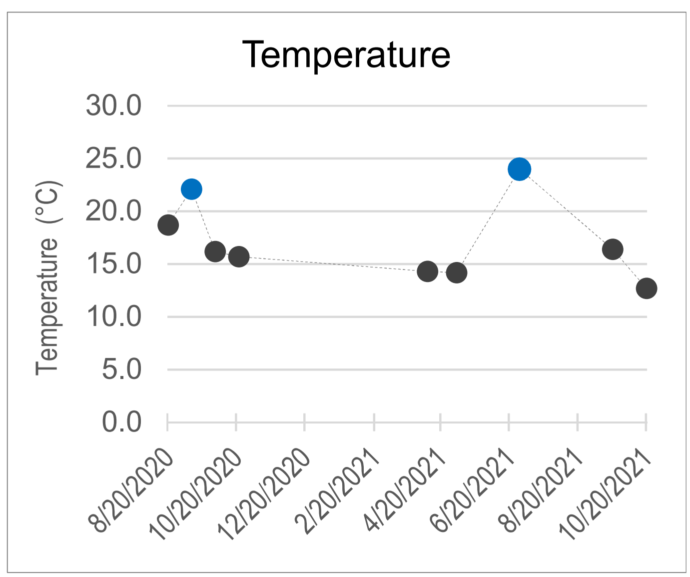


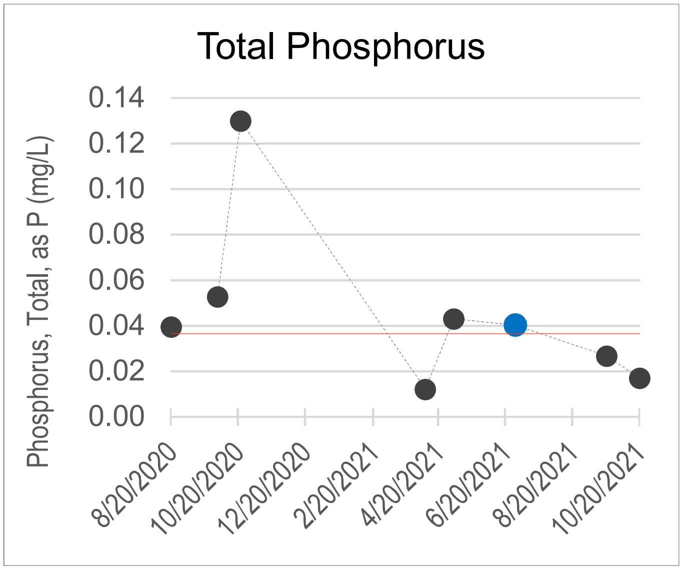


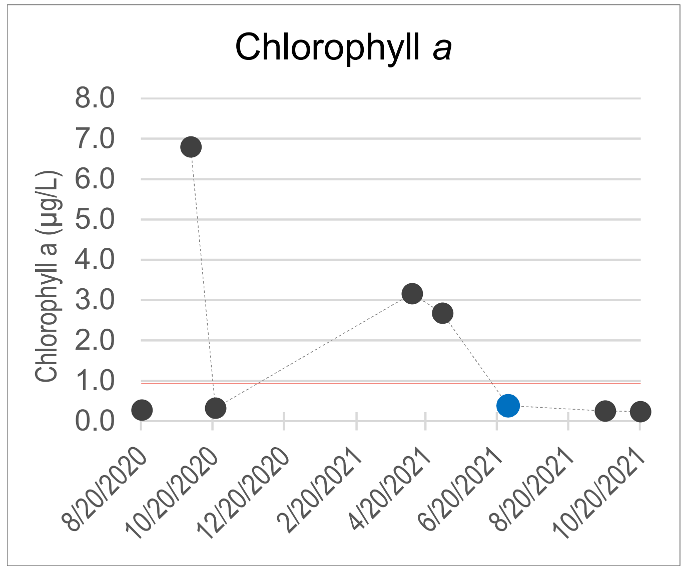


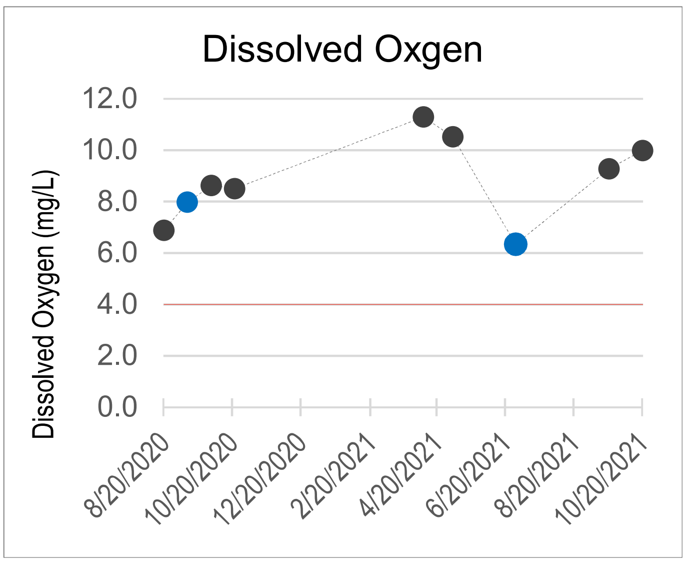


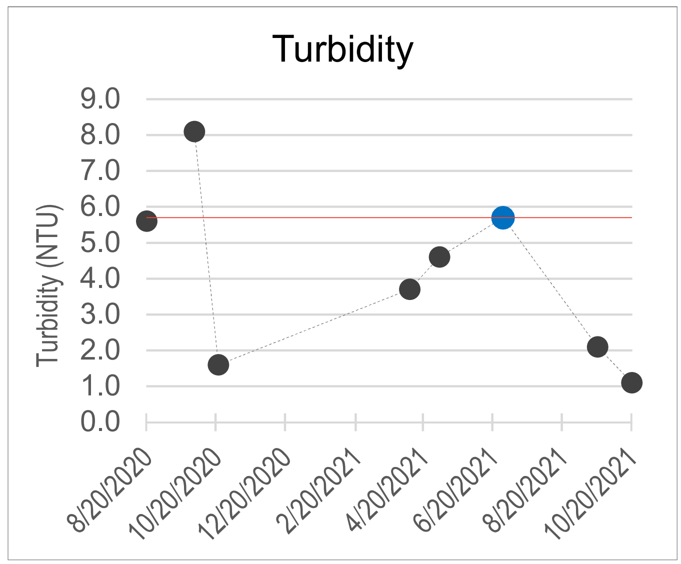


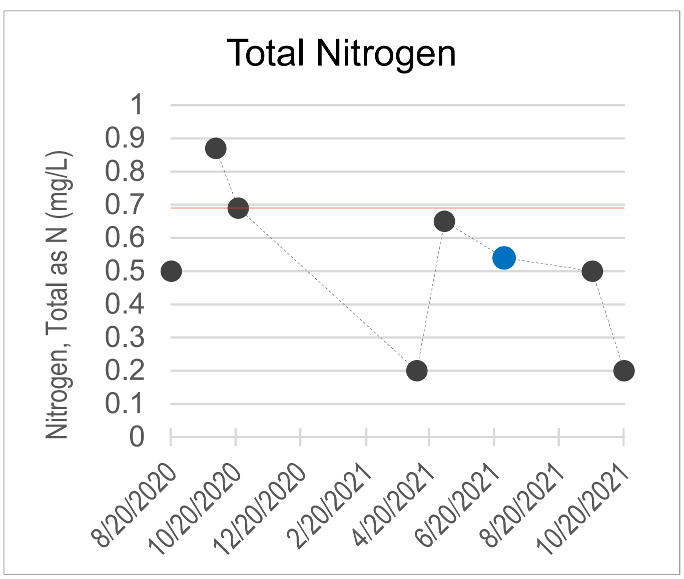


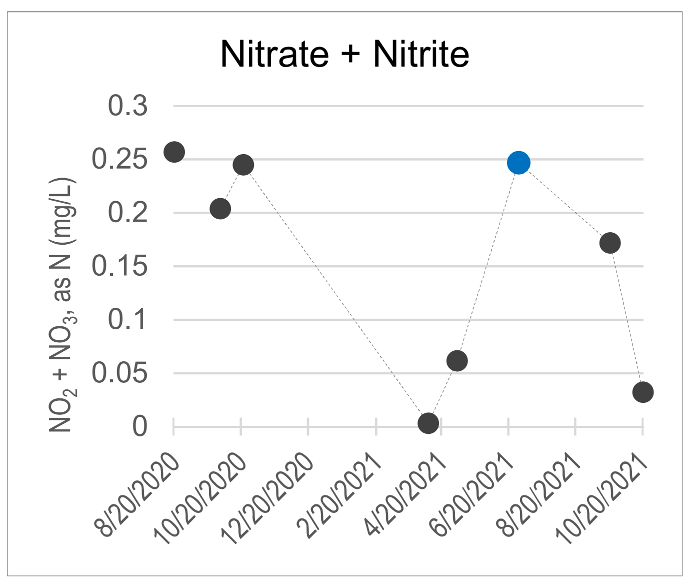

Total Phosphorus
Phosphorus, Total, as P (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

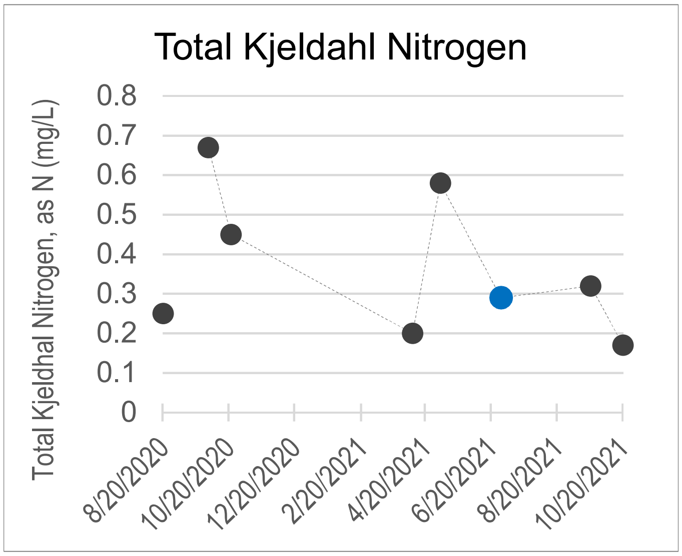

Chlorophyll *a*
Chlorophyll a (µg/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

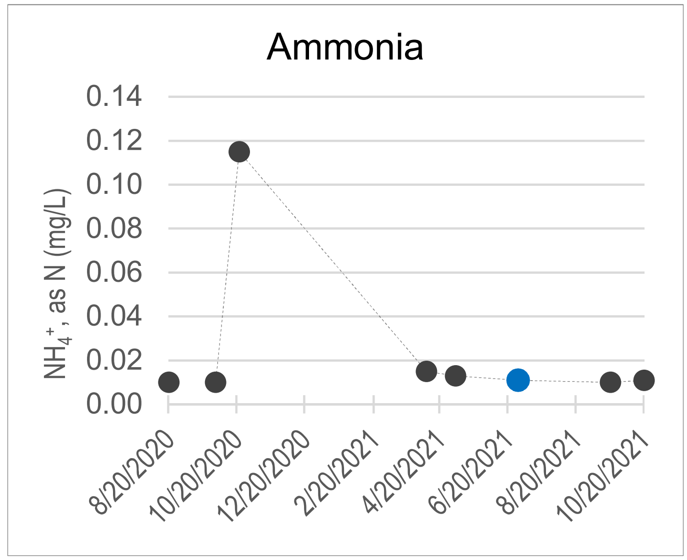

Dissolved Oxgen
Dissolved Oxygen (mg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Turbidity
Turbidity (NTU)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
Nitrogen, Total as N (mg/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
$NO_2 + NO_3$, as N (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Ammonia
NH4+, as N (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

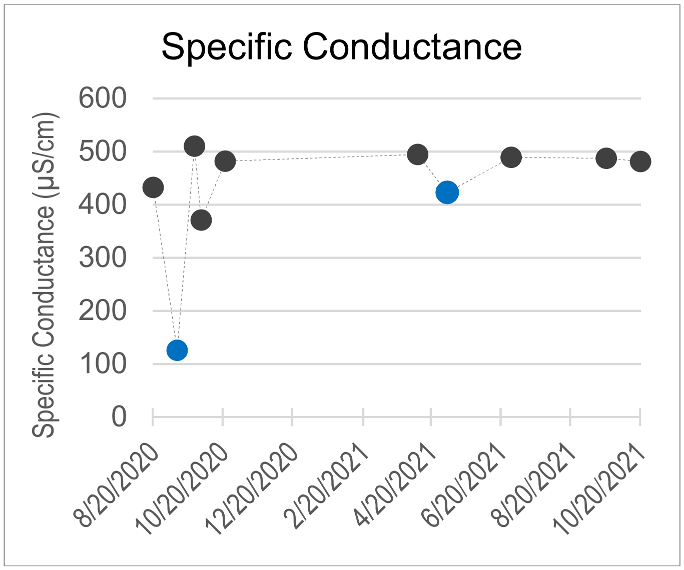
Summary of Results: Sparkill Brook (13-SPAB-0.1)

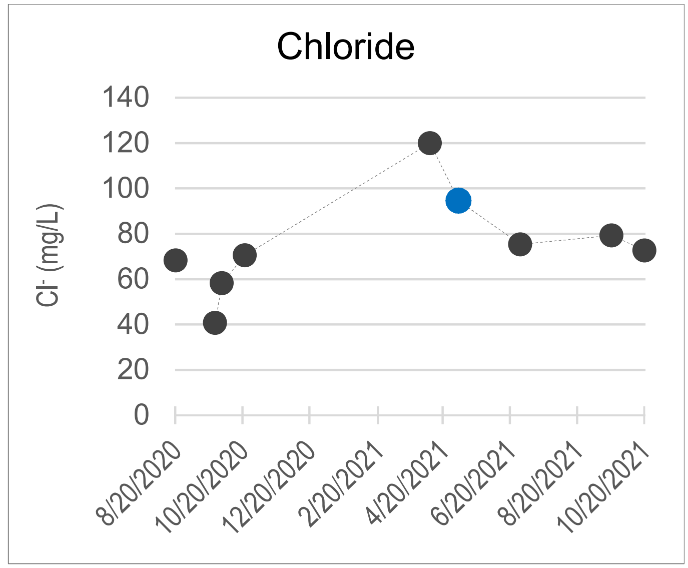
Parameter	Average	Minimum	Maximum	Wet Weather
pH (standard units)	7.05	6.83	7.27	7.17
Dissolved Oxygen (mg/L)	8.72	5.57	15.47	6.62
Temp (°C)	15.71	11.60	24.90	19.70
Current Speed (m/s)	0.24	0.11	0.42	0.21
Turbidity (NTU)	4.62	1.00	7.10	4.80
Alkalinity, Total as CaCO3 (mg/L)	96.44	53.90	137.00	75.60
Specific Conductance (µS/cm)	467.33	371.10	510.20	248.30
Hardness, Total as CaCO3 (mg/L)	121.60	68.10	164.00	99.70
Total Ca (ug/L)	36044.44	19400	47900	28600
Total Mg (ug/L)	8403.333	4790	10800	6860
Chloride (mg/L)	75.51	40.70	120.00	58.30
Chlorophyll a (µg/L)	6.79	1.20	28.60	3.37
Phosphorus, Total (mg/L)	0.07	0.03	0.13	0.08
Nitrogen, Total as Nitrogen (mg/L)	0.91	0.59	1.12	0.92
Nitrate+Nitrite as Nitrogen (mg/L)	0.41	0.23	0.57	0.44
Nitrate as Nitrogen (mg/L)	0.4	0.234	0.65	0.43

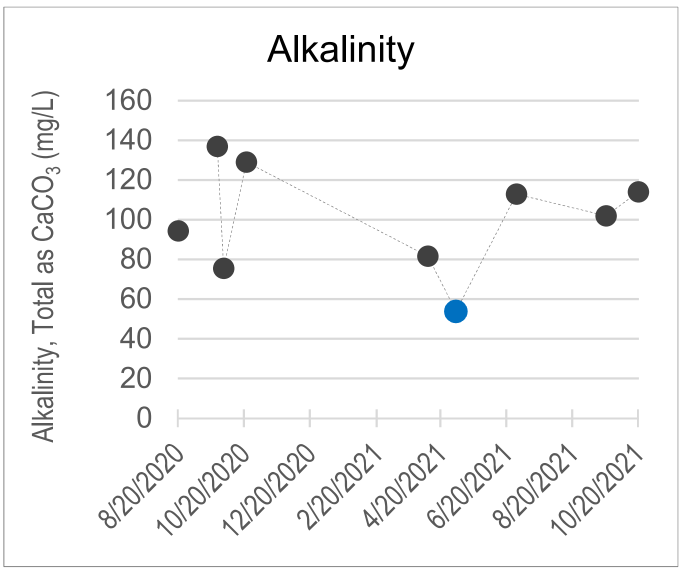
Nitrite as Nitrogen (mg/L)	0.014	0.01	0.028	0.01
Nitrogen, Total Kjeldahl (mg/L)	0.51	0.33	0.69	0.48
Ammonia as Nitrogen (mg/L)	0.08	0.04	0.16	0.08

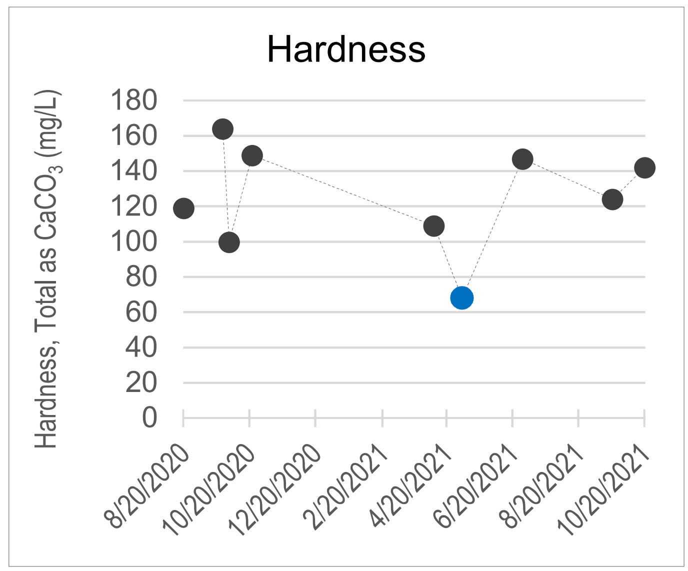
*n=2 for pH, specific conductance, dissolved oxygen, current speed, temperature. n=1 for all other parameters.

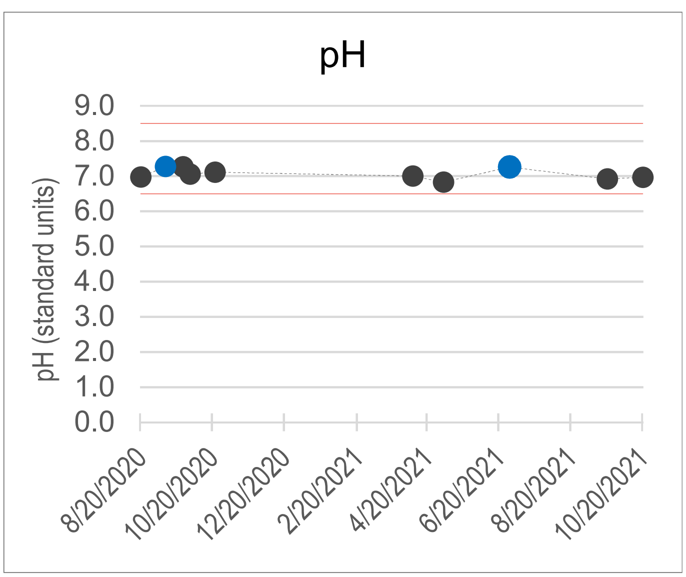
Results by Date: Sparkill Brook tributary (13-SPAB-0.1). Blue shading indicates wet-weather samples.

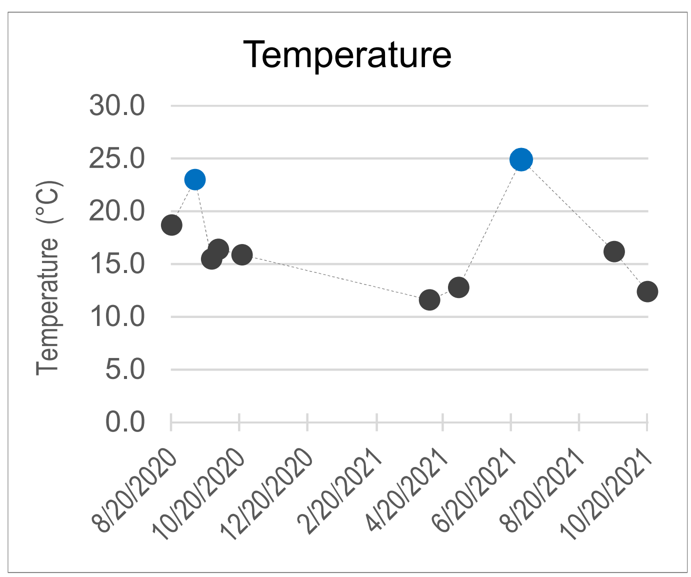


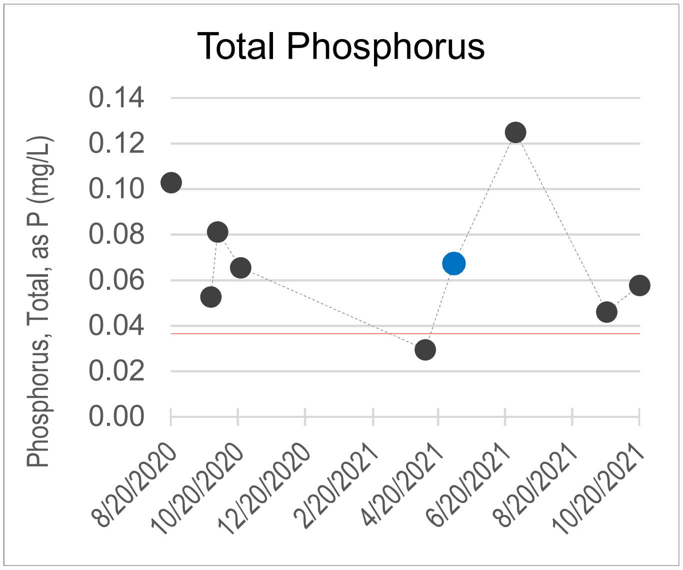


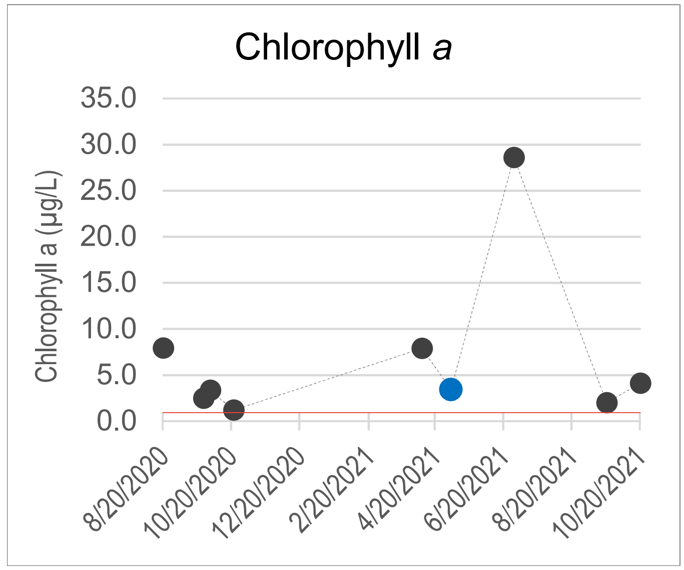


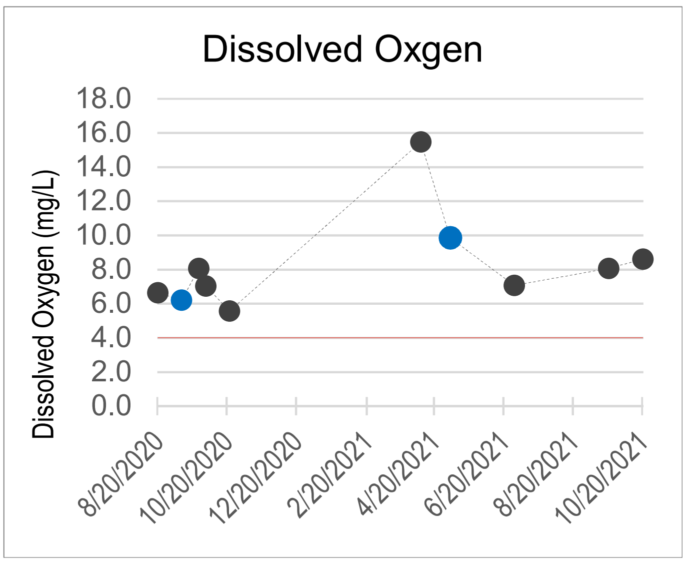


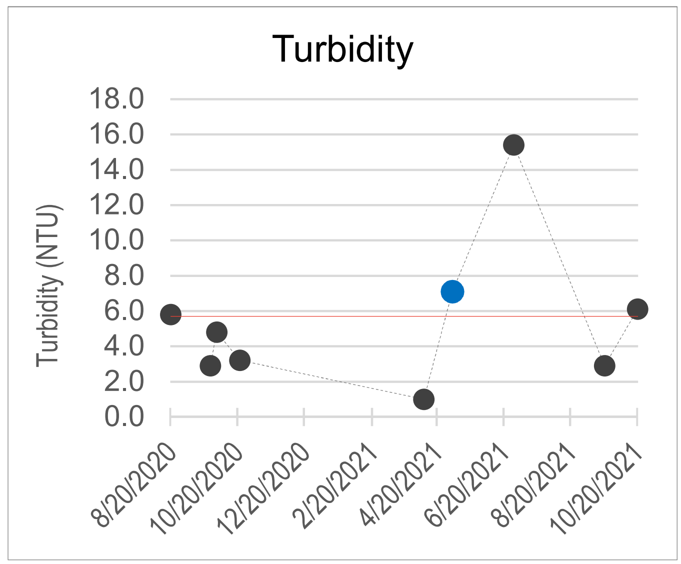


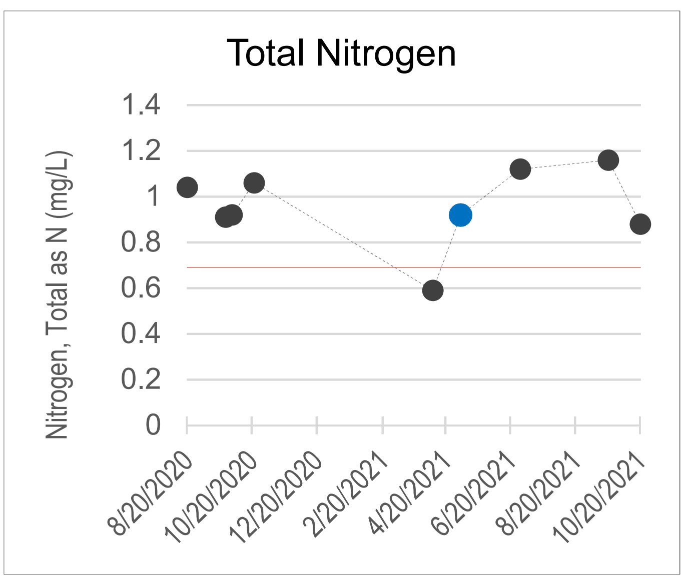


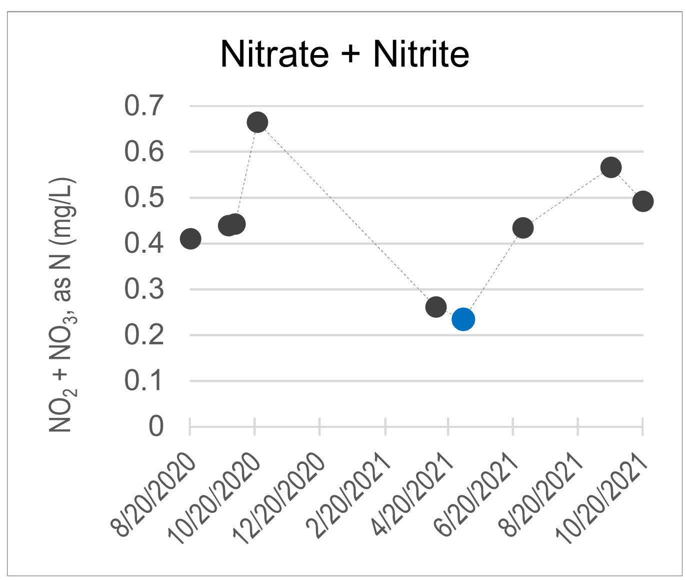

Total Phosphorus
Phosphorus, Total, as P (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

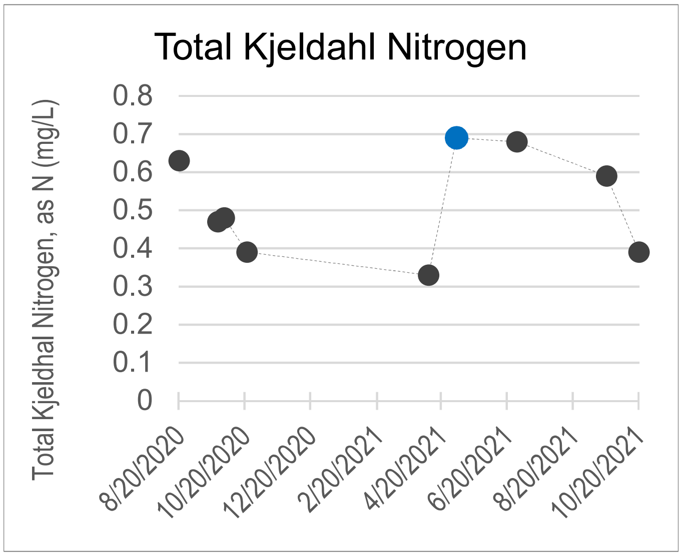

Chlorophyll *a*
Chlorophyll a (µg/L)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

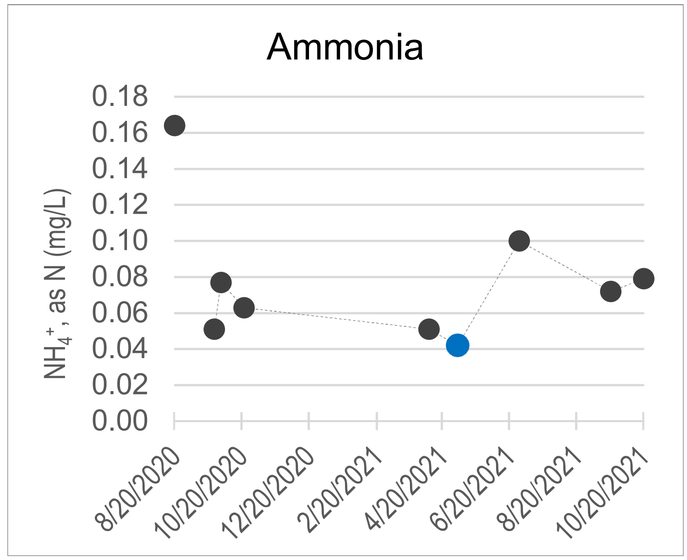

Dissolved Oxgen
Dissolved Oxygen (mg/L)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Turbidity
Turbidity (NTU)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
Nitrogen, Total as N (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
$NO_2 + NO_3$, as N (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Ammonia
NH_4^+, as N (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

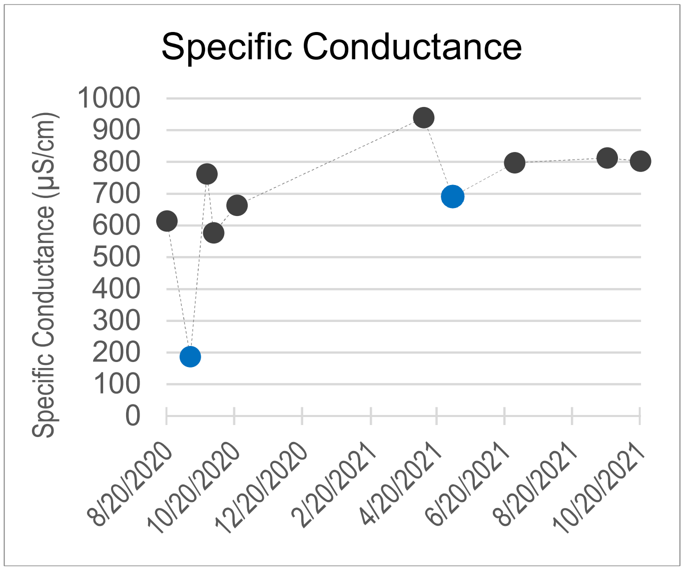
Summary of Results: Blauvelt Arm tributary (13-SPAR_T9b-0.1)

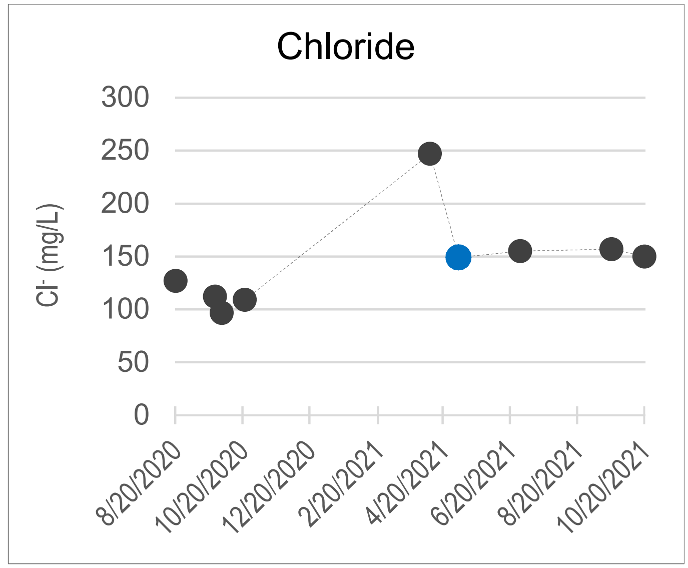
Parameter	Average	Minimum	Maximum	Wet Weather
pH (standard units)	7.16	6.70	7.55	7.23
Dissolved Oxygen (mg/L)	8.72	4.27	16.06	7.11
Temp (°C)	18.63	15.60	24.80	21.25
Current Speed (m/s)	0.31	0.14	0.61	0.20
Turbidity (NTU)	1.63	1.00	2.80	1.00
Alkalinity, Total as CaCO3 (mg/L)	121.15	97.20	138.00	106.00
Specific Conductance (µS/cm)	755.50	577.00	939.00	381.90
Hardness, Total as CaCO3 (mg/L)	158.00	109.00	211.00	109.00
Total Ca (ug/L)	45922.22	19200	65900	33400
Total Mg (ug/L)	7955.556	3500	11400	6110
Chloride (mg/L)	144.74	96.70	247.00	96.70
Chlorophyll a (µg/L)	3.01	0.26	8.39	1.10
Phosphorus, Total (mg/L)	0.13	0.09	0.19	0.14
Nitrogen, Total as Nitrogen (mg/L)	0.75	0.36	1.22	0.36
Nitrate+Nitrite as Nitrogen (mg/L)	0.46	0.05	0.91	0.08
Nitrate as Nitrogen (mg/L)	0.4	0.044	0.901	0.08

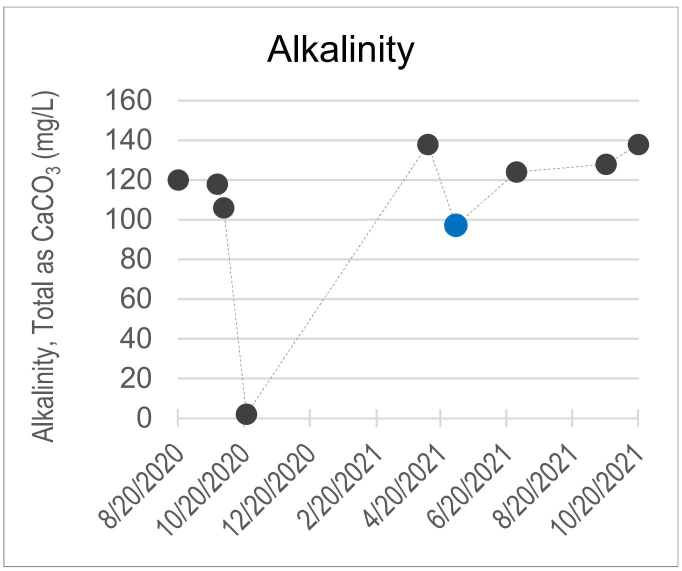
Nitrite as Nitrogen (mg/L)	0.010222	0.01	0.012	0.01
Nitrogen, Total Kjeldahl (mg/L)	0.31	0.17	0.41	0.28
Ammonia as Nitrogen (mg/L)	0.02	0.01	0.05	0.01

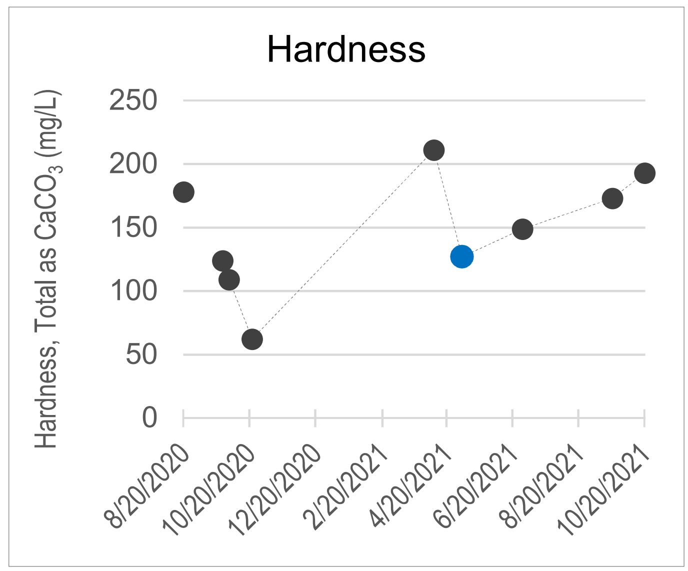
*n=2 for pH, specific conductance, dissolved oxygen, current speed, temperature. n=1 for all other parameters.

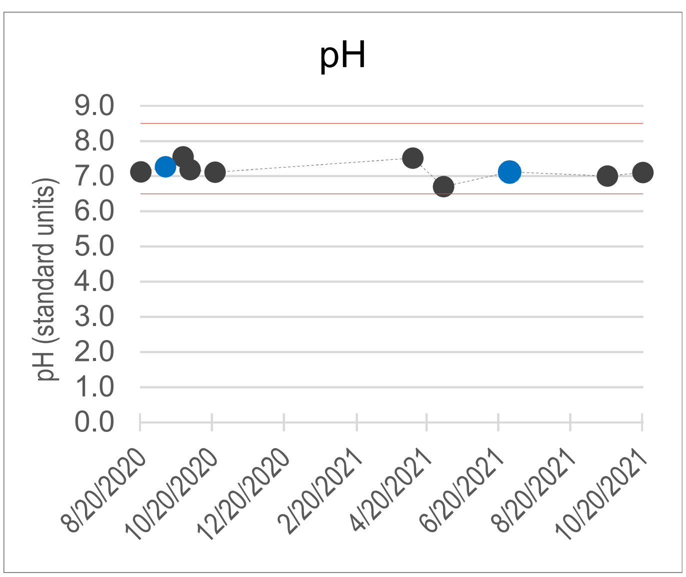
Results by Date: Blauvelt Arm tributary (13-SPAR_T9b-0.1). Blue shading indicates wet-weather samples.

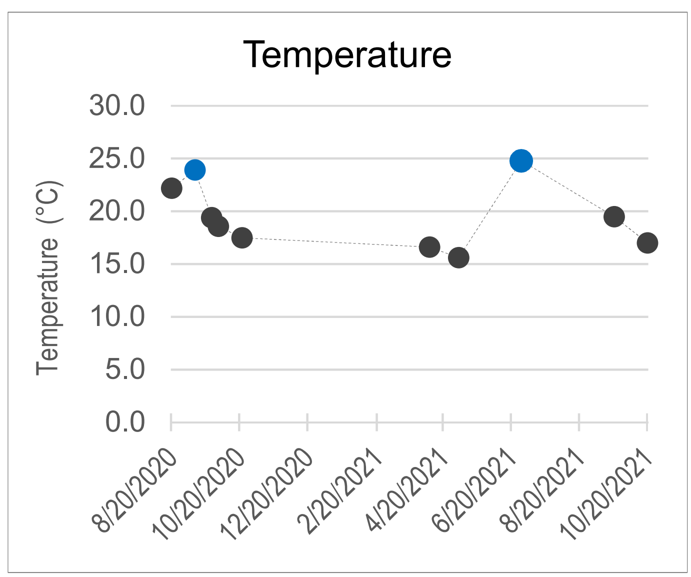


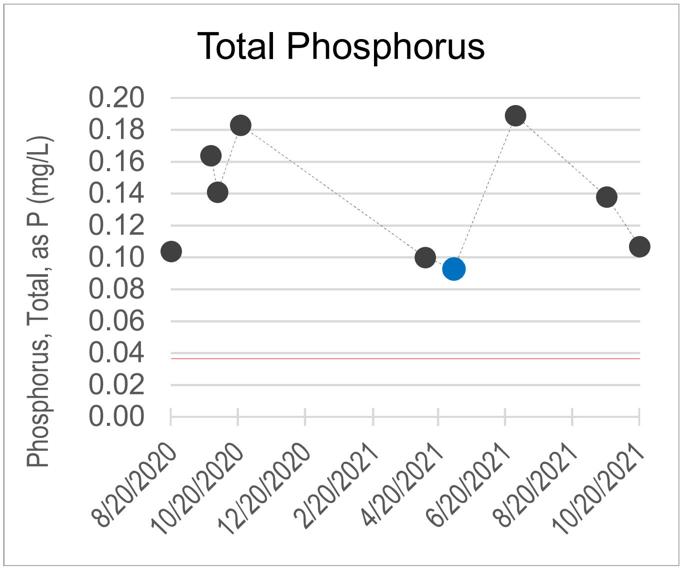


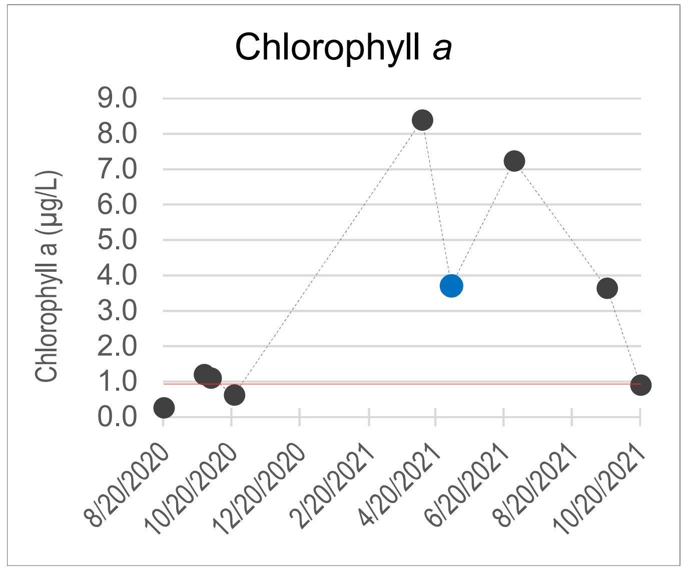


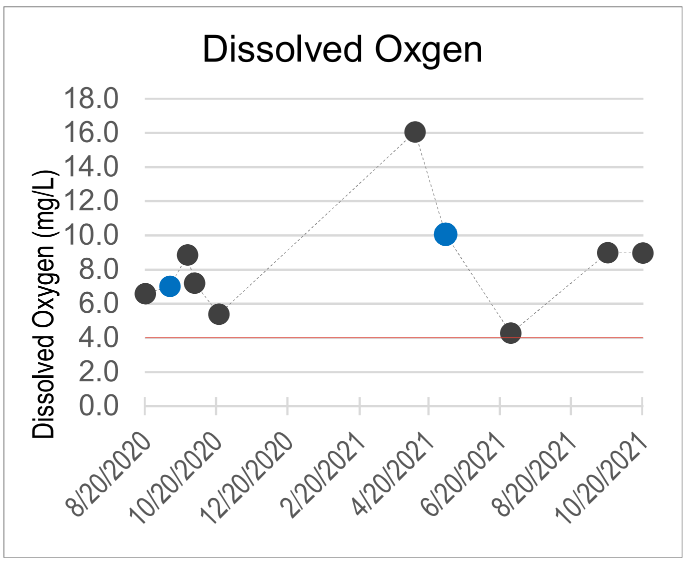


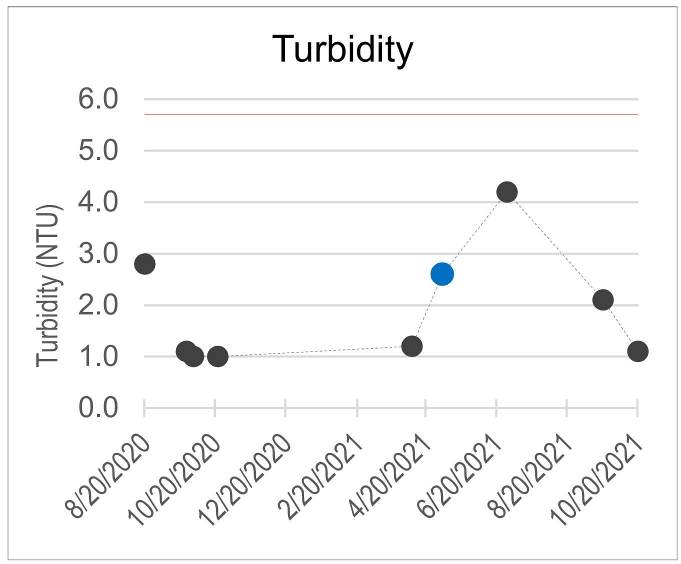


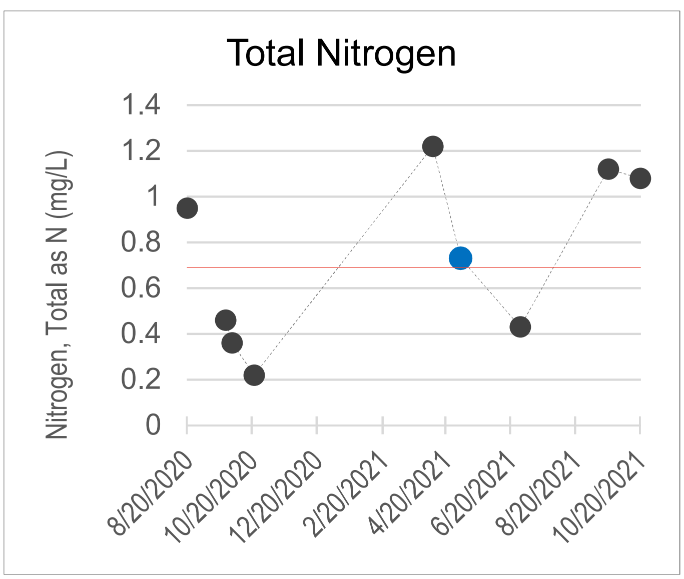


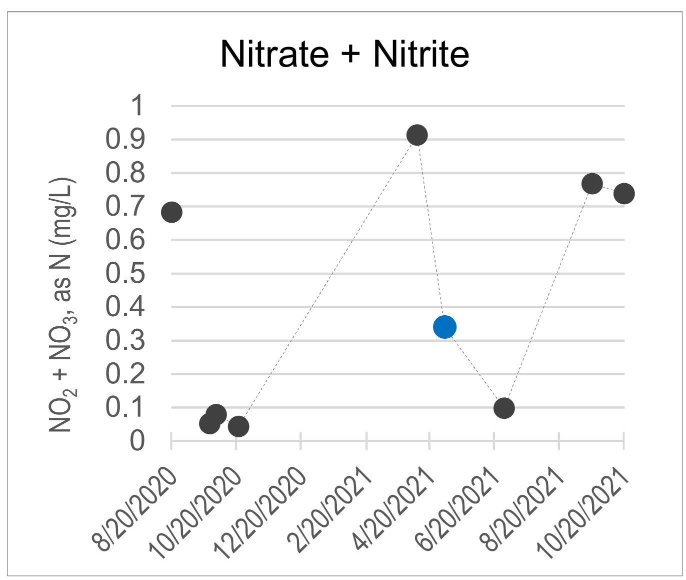

Total Phosphorus
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Phosphorus, Total, as P (mg/L)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

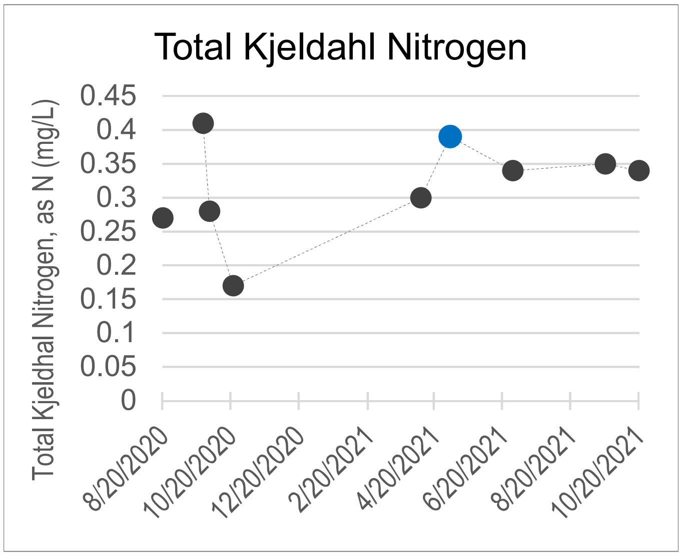

Chlorophyll *a*
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Chlorophyll a (µg/L)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

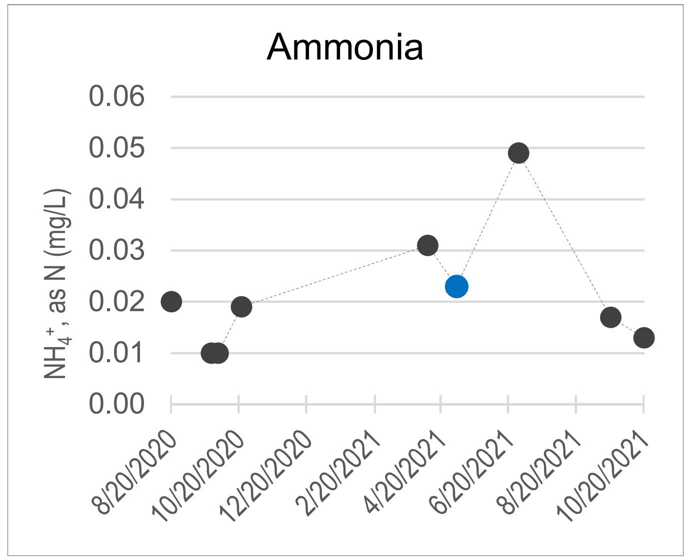

Dissolved Oxgen
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Dissolved Oxygen (mg/L)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Turbidity
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Turbidity (NTU)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Nitrogen, Total as N (mg/L)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
$NO_2 + NO_3$, as N (mg/L)
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Ammonia
NH_4^+, as N (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

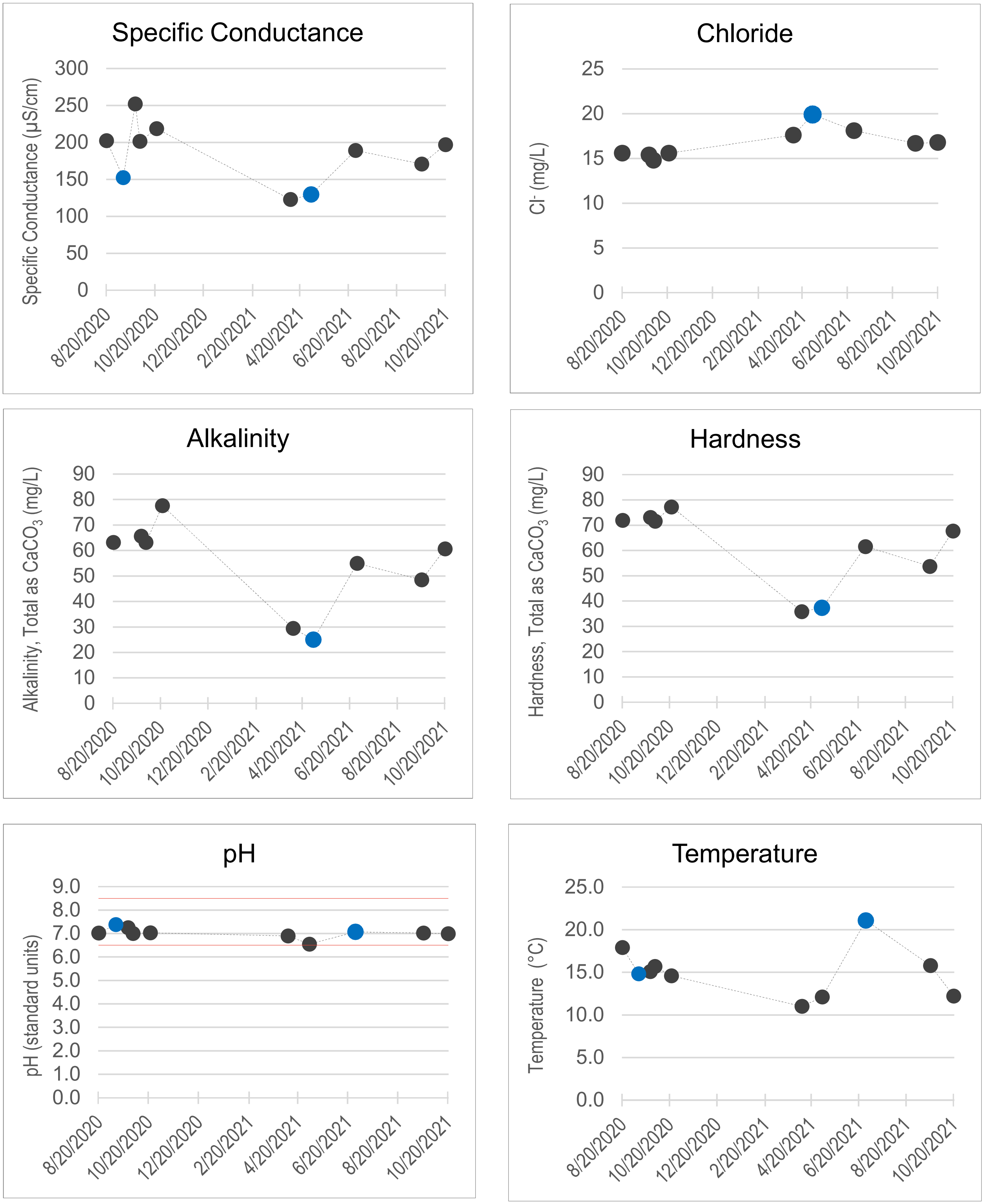
Summary of Results: Tackamack tributary at Greenbush Rd Bridge (13-TACK-0.1)

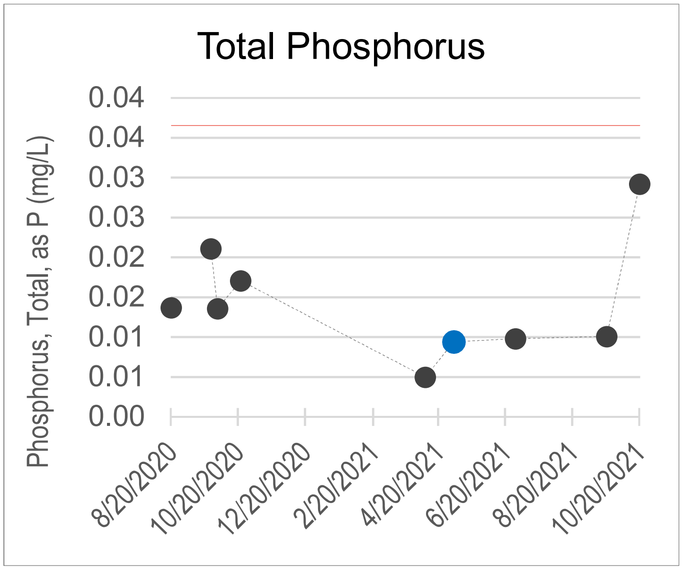
Parameter	Average	Minimum	Maximum	Wet Weather
pH (standard units)	6.98	6.55	7.25	7.19
Dissolved Oxygen (mg/L)	8.43	5.78	11.27	7.06
Temp (°C)	14.70	11.00	21.10	15.26
Current Speed (m/s)	0.22	0.06	0.36	0.13
Turbidity (NTU)	3.03	1.00	7.00	5.40
Alkalinity, Total as CaCO3 (mg/L)	51.31	25.00	65.60	63.20
Specific Conductance (µS/cm)	185.16	122.80	252.10	176.95
Hardness, Total as CaCO3 (mg/L)	59.14	35.90	73.10	71.60
Total Ca (ug/L)	14280	1000	20800	19200
Total Mg (ug/L)	4430	1000	6170	5730
Chloride (mg/L)	16.72	14.80	19.90	14.80
Chlorophyll a (µg/L)	0.83	0.27	1.24	1.09
Phosphorus, Total (mg/L)	0.01	0.01	0.03	0.01
Nitrogen, Total as Nitrogen (mg/L)	0.27	0.15	0.34	0.34
Nitrate+Nitrite as Nitrogen (mg/L)	0.06	0.00	0.13	0.06
Nitrate as Nitrogen (mg/L)	0.1	0.01	0.128	0.07

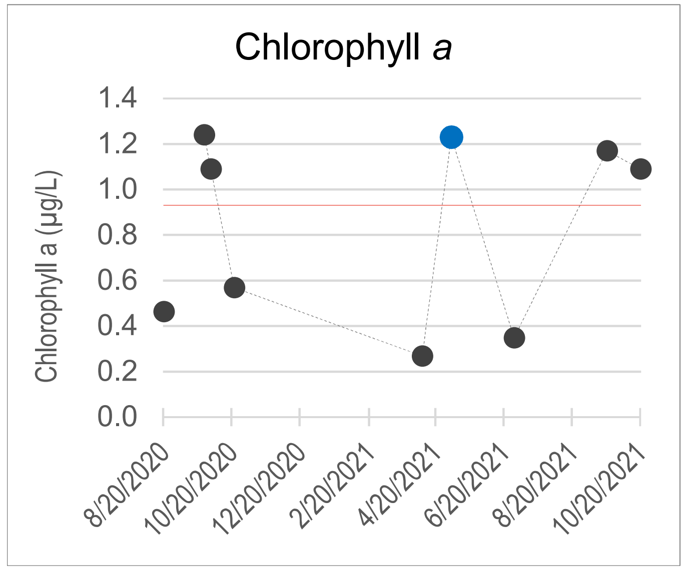
Nitrite as Nitrogen (mg/L)	0.01	0.01	0.01	0.01
Nitrogen, Total Kjeldahl (mg/L)	0.20	0.10	0.31	0.28
Ammonia as Nitrogen (mg/L)	0.01	0.01	0.02	0.01

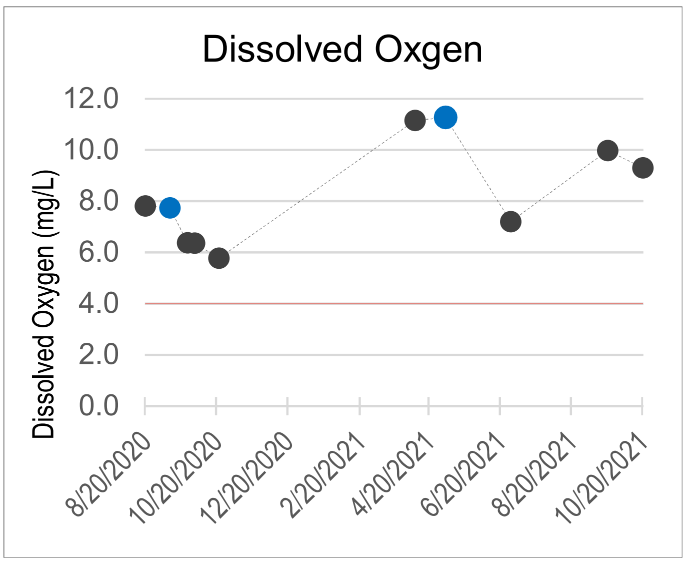
*n=2 for pH, specific conductance, dissolved oxygen, temperature. n=1 for all other parameters.

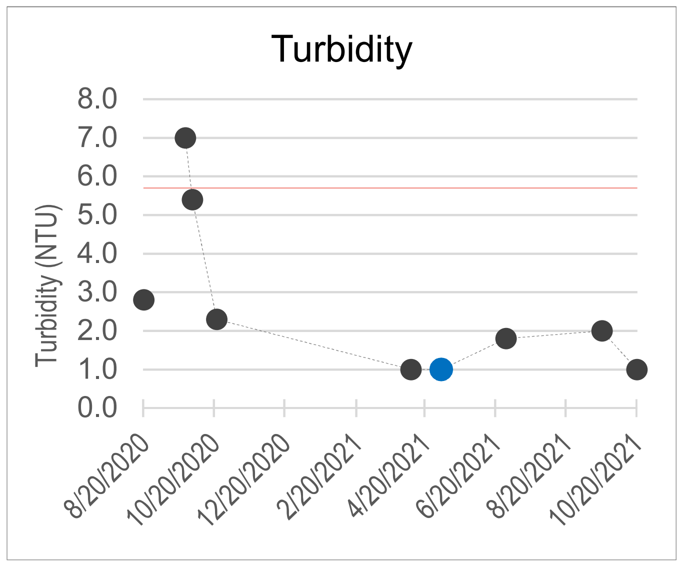
Results by Date: Tackamack tributary (13-TACK-0.1). Blue shading indicates wet-weather samples.

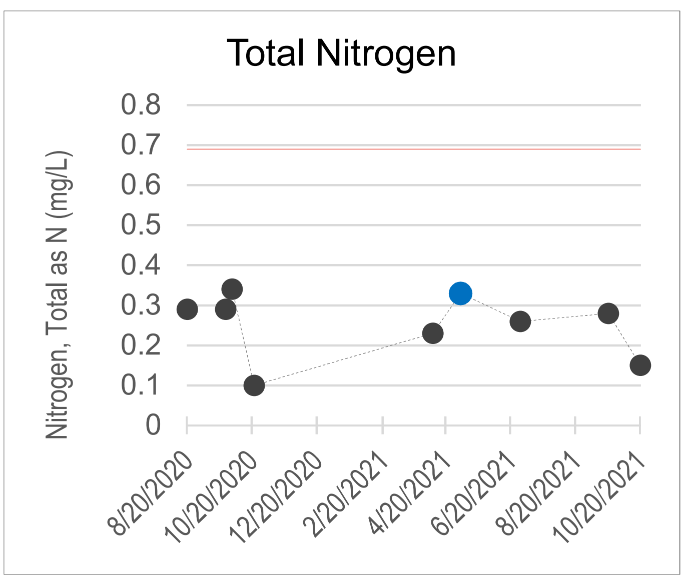


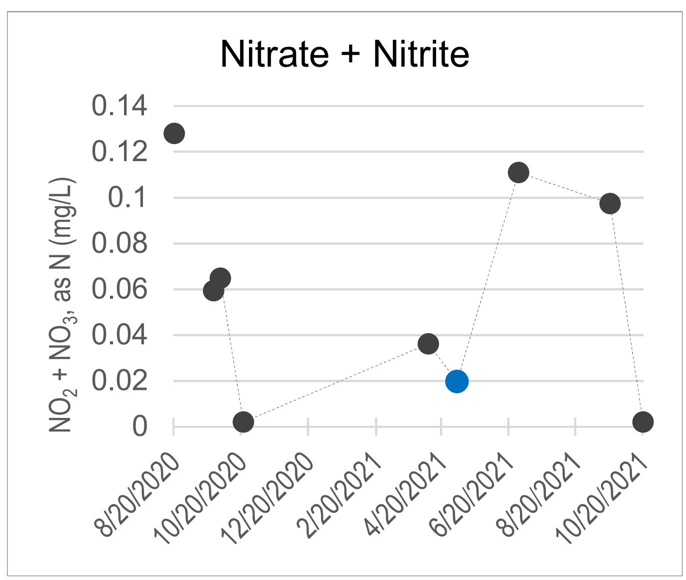

Total Phosphorus
Phosphorus, Total, as P (mg/L)
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

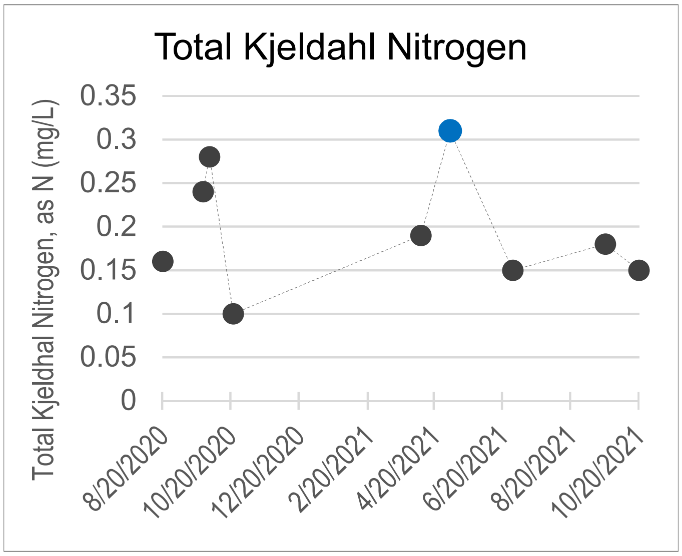

Chlorophyll a
Chlorophyll a (µg/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

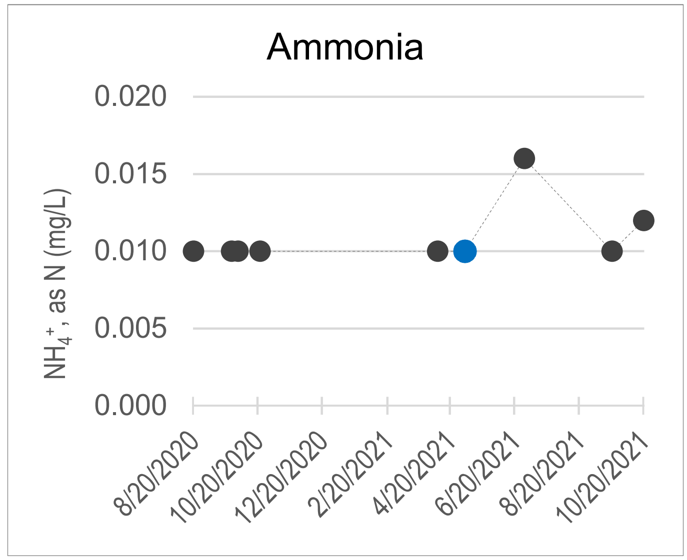

Dissolved Oxgen
Dissolved Oxygen (mg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Turbidity
Turbidity (NTU)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Nitrogen
Nitrogen, Total as N (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Nitrate + Nitrite
NO2 + NO3, as N (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Total Kjeldahl Nitrogen
Total Kjeldhal Nitrogen, as N (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021


Ammonia
NH_4^+, as N (mg/L)
0.020
0.015
0.010
0.005
0.000
8/20/2020
10/20/2020
12/20/2020
2/20/2021
4/20/2021
6/20/2021
8/20/2021
10/20/2021

Appendix B: Data Index

Data Type	Partners	Project Title	Dates	Links
Fecal-Indicator Bacteria & Source Tracking	Lamont-Doherty Earth Observatory	*Enterococcus* Monitoring at Skating Pond	2007-2022	
Fecal-Indicator Bacteria & Source Tracking	Riverkeeper Sparkill Creek Watershed Alliance	*Enterococcus* Monitoring (*E. coli* added 2021)	2010-2022	Dataset
Fecal-Indicator Bacteria & Source Tracking	Sparkill Creek Watershed Alliance	*Enterococcus* Monitoring & Source Tracking	2014	Final report Appendices
Fecal-Indicator Bacteria & Source Tracking	Dominican College	Bacterial culturing on selective media	2014	
Fecal-Indicator Bacteria & Source Tracking	Riverkeeper	Optical brightener testing	2014	Dataset
Fecal-Indicator Bacteria & Source Tracking	Dominican College	Fecal indicator bacteria plate counts *Enterococcus* species identification	2016	
Fecal-Indicator Bacteria & Source Tracking	Sparkill Creek Watershed Alliance Riverkeeper NYSDEC	Source tracking	2017	Results

Data Type	Partners	Project Title	Dates	Links
Fecal-Indicator Bacteria & Source Tracking	CUNY Queens College (Greg O'Mullan & Elizabeth Farrell)	Microbial community analysis	2017	Final report
Fecal-Indicator Bacteria & Source Tracking	Sparkill Creek Watershed Alliance Riverkeeper	Stormwater outfall monitoring	2018	Results
Fecal-Indicator Bacteria & Source Tracking	Sparkill Creek Watershed Alliance Dominican College	Microbial source tracking	2018	
Fecal-Indicator Bacteria & Source Tracking	Sparkill Creek Watershed Alliance CUNY Queens College (Greg O'Mullan)	Microbial Source Tracking	2020-2021	Final report 2020 Final report 2021
Water Chemistry	Sparkill Creek Watershed Alliance St. Thomas Aquinas College	Nutrient Testing	2014-2015	
Water Chemistry	Sparkill Creek Watershed Alliance	PEERS Water Sampling	2020-2021	Data and information

Data Type	Partners	Project Title	Dates	Links
	Riverkeeper NYS DEC			
Macroinvertebrates	Rockland County	Biomonitoring	1998-2016	Annual Reports (2006-2016)
Macroinvertebrates	Sparkill Creek Watershed Alliance NYS DEC	WAVE		WAVE Map