pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

Juniata River at Newton Hamilton, 2015 to 2016

Continuous Instream Monitoring Report

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October 21, 2019

WATERBODY AND SITE DESCRIPTIONS

Stream Code: 11414
Stream Name: Juniata River
HUC: 02050304 – Lower Juniata

Site Description:
Site Code: 66209723-001
Site Name: Juniata River at Newton Hamilton
Latitude: 40.39416 **Longitude:** -77.82500
In a large, steep riffle approximately 1 kilometer (km) downstream of the Bridge Street bridge in Newton Hamilton, roughly a quarter of the way across the channel from the left descending bank

County: Mifflin
Drainage Area: 6,242 km^2
Strahler Stream Order: 7
Designated Use: Warm Water Fishes

BACKGROUND AND HISTORY

The Juniata River is a freestone stream and one of the larger tributaries to the Susquehanna River. The watershed of the Juniata River at Newton Hamilton encompasses all or parts of Somerset, Bedford, Fulton, Cambria, Blair, Huntingdon, Centre, Mifflin, and Juniata counties in southcentral Pennsylvania (Figure 1). Land use in the watershed of the Juniata River at Newton Hamilton consists of 70% forest, 20% agriculture, and 8% developed land. The Newton Hamilton site is located on the upper reaches of the Juniata River, approximately 29 river kilometers downstream of the confluence of the Raystown Branch. A major reservoir – Raystown Lake – is located on the Raystown Branch, which at times moderates the flow of the Juniata River at Newton Hamilton. The designated aquatic life use of the Juniata River at Newport Hamilton is Warm Water Fishes (WWF).

Data collected prior to 2015 indicated relatively homogenous water quality conditions across the width of the Juniata River at Newton Hamilton, except for a discernable influence from Aughwick Creek along the right descending bank. Aughwick Creek is a fifth-order tributary which enters the Juniata River along the right descending bank a little more than 7 river km upstream of the Newton Hamilton continuous instream monitoring (CIM) site. The CIM site was located towards the left descending bank to avoid the Aughwick Creek influence (Figure 1).

A transect across the width of the river was established at Newton Hamilton in 2013 according to the Pennsylvania Department of Environmental Protection's (DEP's) *In-situ Field Meter and Transect Data Collection Protocol* (Hoger 2018b) to characterize mixing patterns and identify any distinct zones of water quality across the width of the river. The transect was located on the upstream side of the Bridge Street bridge approximately 1 km upstream of the sonde location (Figure 1). Discrete water quality measurements were initially taken at eight equidistant points (NHAM1 to NHAM8) across the transect starting at the right descending bank (Figure 1). Beginning in 2016, the transect was reduced to six points, eliminating NHAM5 and NHAM7.

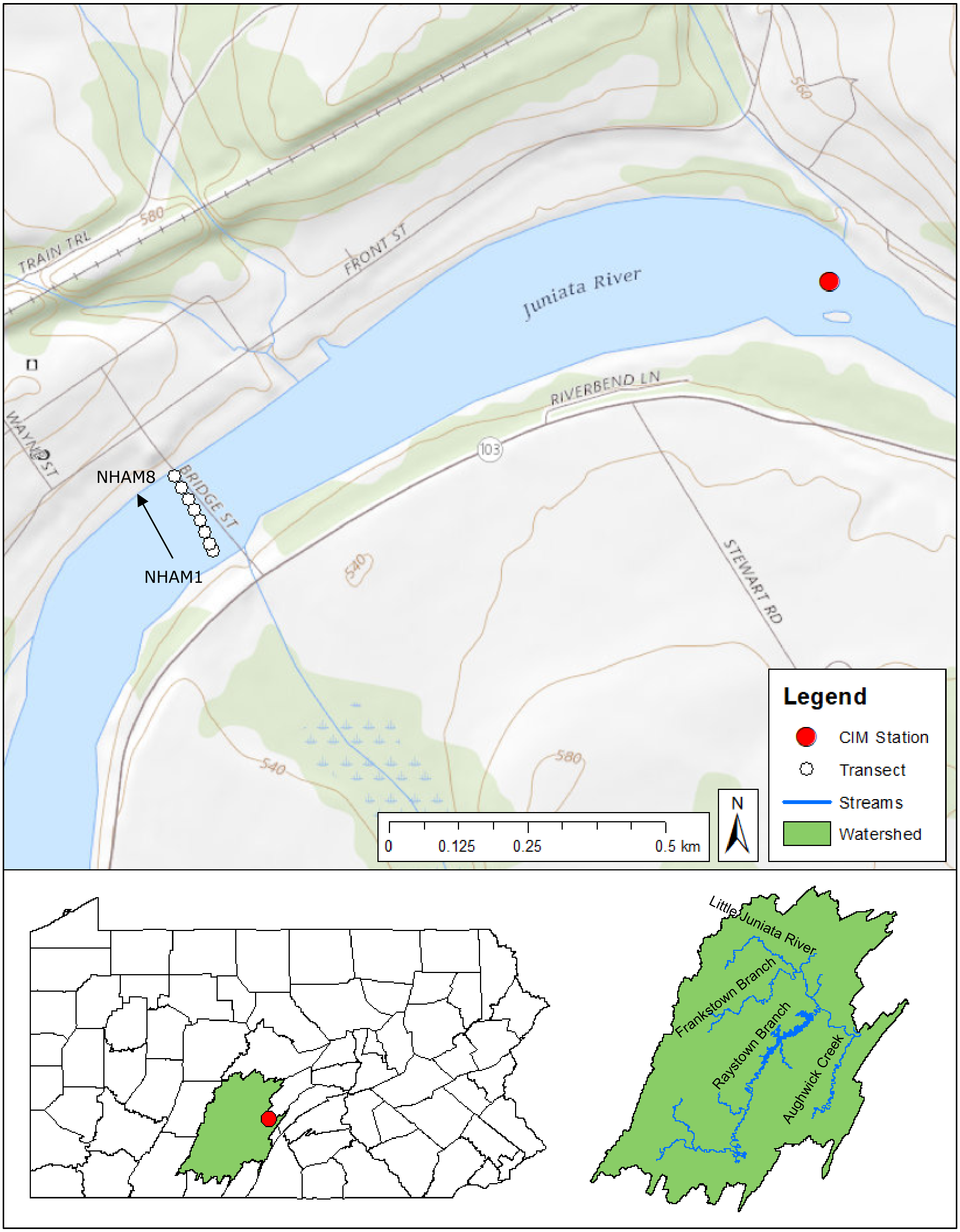

Figure 2. Map of the Juniata River CIM site and cross-sectional transect sampling locations at Newton Hamilton.

Water quality data at this site were initially collected as part of the Susquehanna River Project investigating health and recruitment issues of smallmouth bass. This site has since become a long–term station to inform ongoing studies and trend analyses. This report focuses only on the CIM data and chemical grab samples collected from 2015 to 2016. Other data collected at this location include benthic macroinvertebrate and fish community surveys, periphyton and algal analyses, and analyses of emerging contaminants in sediment and water.

PRIMARY OBJECTIVES

The primary objective of this report is to characterize temporal and spatial patterns in various physical and chemical water quality parameters in the Juniata River at Newton Hamilton.

WATER QUALITY PARAMETERS

Five water quality parameters were measured using CIM at the Newton Hamilton site (Table 1).

Table 1. Water quality parameters monitored by CIM.

Parameter	Units
Water Temperature	°C
Specific Conductance (@ 25°C)	μS/cm[c]
pH	Standard Units (SU)
Dissolved Oxygen (DO)	mg/L
Turbidity	Formazin Nephelometric Unit (FNU)

EQUIPMENT

Water quality sondes from Yellow Springs Instruments (YSI) were used to collect CIM data at the Newton Hamilton site both years. In 2015, a YSI 6920 V2 sonde was used. In 2016, a YSI EXO2 sonde was used.

Sondes were housed in a 24-inch length of 4-inch diameter schedule 80 PVC pipe with holes drilled to allow water to flow through the pipe. One end of the pipe was capped, and a notch was cut to accommodate the attachment bar on the top of the sonde. The attachment bar was clipped to an eye-bolt attached to rebar driven into the river bed. The attachment bar was also clipped to a cable attached to a second piece of rebar located just upstream of the first.

PERIOD OF RECORD

Continuous data were recorded from late winter or spring until late fall when the fall macroinvertebrate sample was collected in November or December each year (Table 2). The sonde was deployed earlier in 2016 to document changes in water quality near the beginning of the growing season. Each year, the sonde was removed before winter to prevent damage from ice. The sonde was visited several times throughout each deployment period to download data, to check calibration, and for cleaning. The sondes recorded water quality parameter measurements once every 30 minutes.

Table 2. Continuous data period of record.

Year	Deployment	Removal
2015	April 09	November 9
2016	March 8	December 5

DATA

Cross-Sectional Surveys

To monitor variations in water quality throughout the year, cross-sectional transect surveys were conducted 17 times from 2013 to 2016 at various flows. Cross-section survey data were analyzed by comparing each survey point to NHAM6, which approximates the sonde location downstream (Figure 2). For temperature and pH, the difference in readings between NHAM6 and each transect point was considered significant if the difference was greater than 0.5 units. For specific conductance, DO, and turbidity, the difference was considered significant if it was greater than 10% of the NHAM6 reading. When transects were conducted when turbidity was low (less than 10 FNU), a difference of one FNU was equivalent to a 10% difference.

Continuous Monitoring

Continuous data were collected and evaluated following DEP's *Continuous Physicochemical Data Collection Protocol* (Hoger et al. 2018). Grades and corrections were based on a combined evaluation of sensor fouling and calibration error. Gaps in the CIM data are attributable either to equipment or battery failure or to removal of data that did not meet usability standards due to excessive sensor fouling or calibration error. To show year-to-year variations in water quality, the two years of data for each parameter are overlaid in the plots below (Figures 4 to 8). Due to year-to-year differences in the timing of data collection and to data missing from one year but not the other, comparison of the summary CIM data should be made with caution.

River discharge data from the United States Geological Survey (USGS) station 01563500, Juniata River at Mapleton Depot, Pennsylvania, are provided, in cubic feet per second (cfs), below (Figure 3). This USGS gaging station is located approximately 20 river km upstream of the Newton Hamilton CIM location.

Discrete Water Chemistry Sampling

Grab samples were collected several times each year at the Newton Hamilton CIM site (Table 3) according to DEP's *Discrete Water Chemistry Data Collection Protocol* (Shull 2013). Grab samples were analyzed using DEP's standard analysis code (SAC) 087, which includes general chemistry parameters, dissolved and total nutrients, and dissolved and total metals. SAC 618 and SAC 779 were used to obtain concentrations of suspended sediment and acid soluble aluminum, respectively. A complete list of grab sample analytes can be found in Table 3.

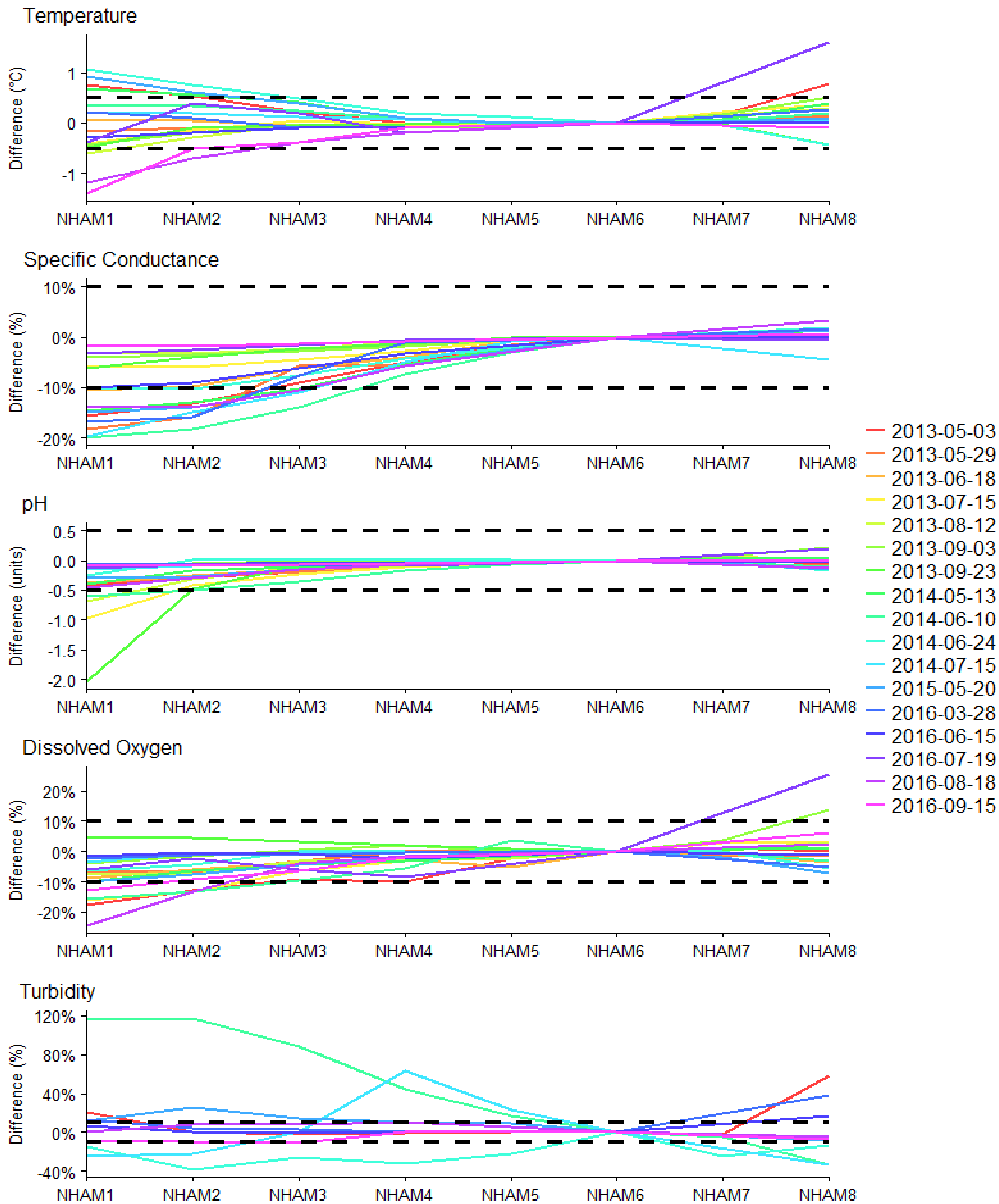

Figure 2. Cross-section surveys at Newton Hamilton showing relative difference in readings compared to NHAM6 over four years. Dashed, black lines indicate thresholds of significance.

Discharge: *2015* Min: 374 cfs Average: 2,039 cfs Max: 26,600 cfs

2016 Min: 394 cfs Average: 1,612 cfs Max: 19,300 cfs

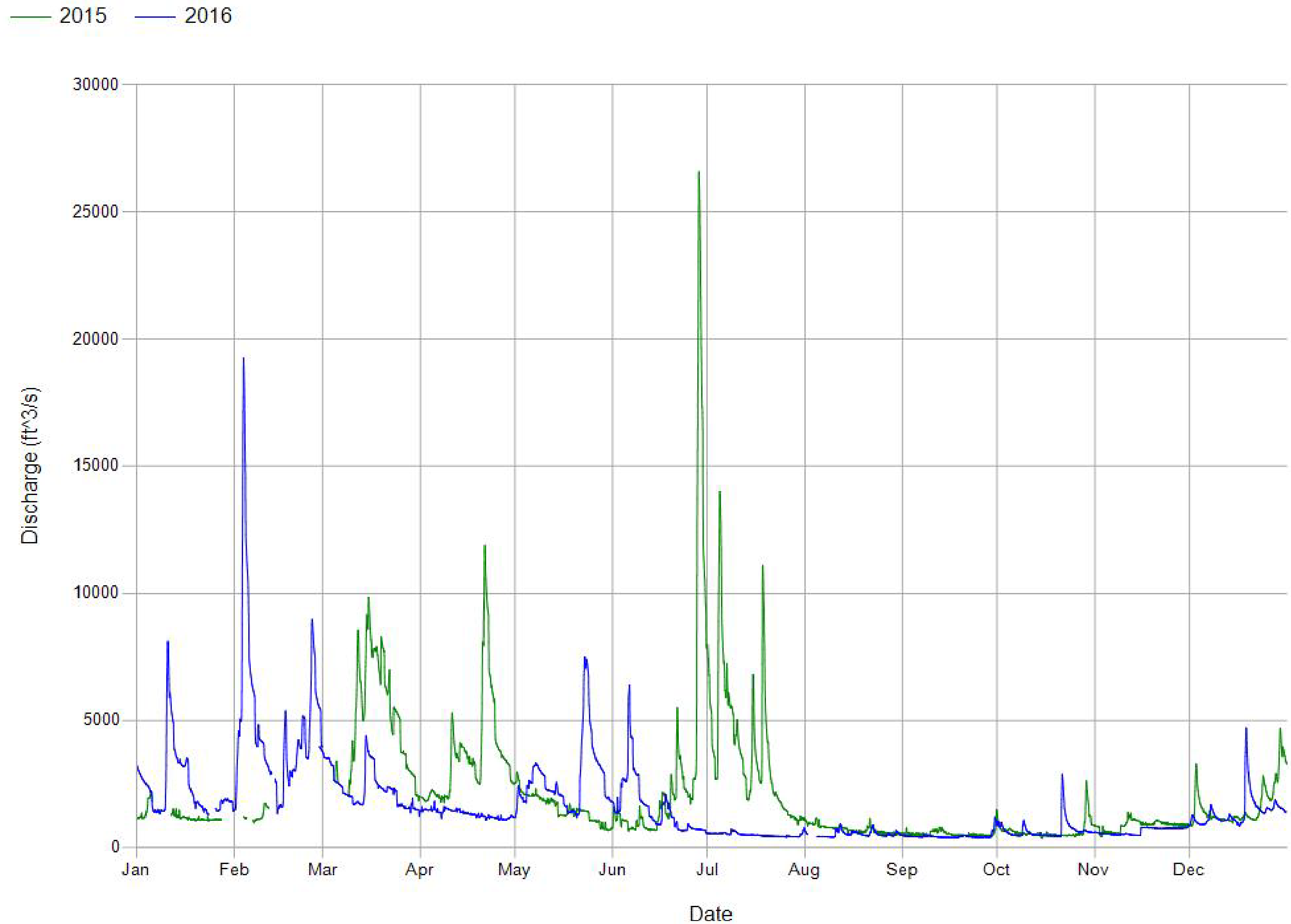

Figure 3. Continuous discharge at USGS station 01563500, Juniata River at Mapleton Depot, from 2015 and 2016.

Water Temperature:	*2015*	Min: 7.96 °C	Average: 19.38 °C	Max: 29.07 °C
	2016	Min: 4.89 °C	Average: 19.12 °C	Max: 30.82 °C

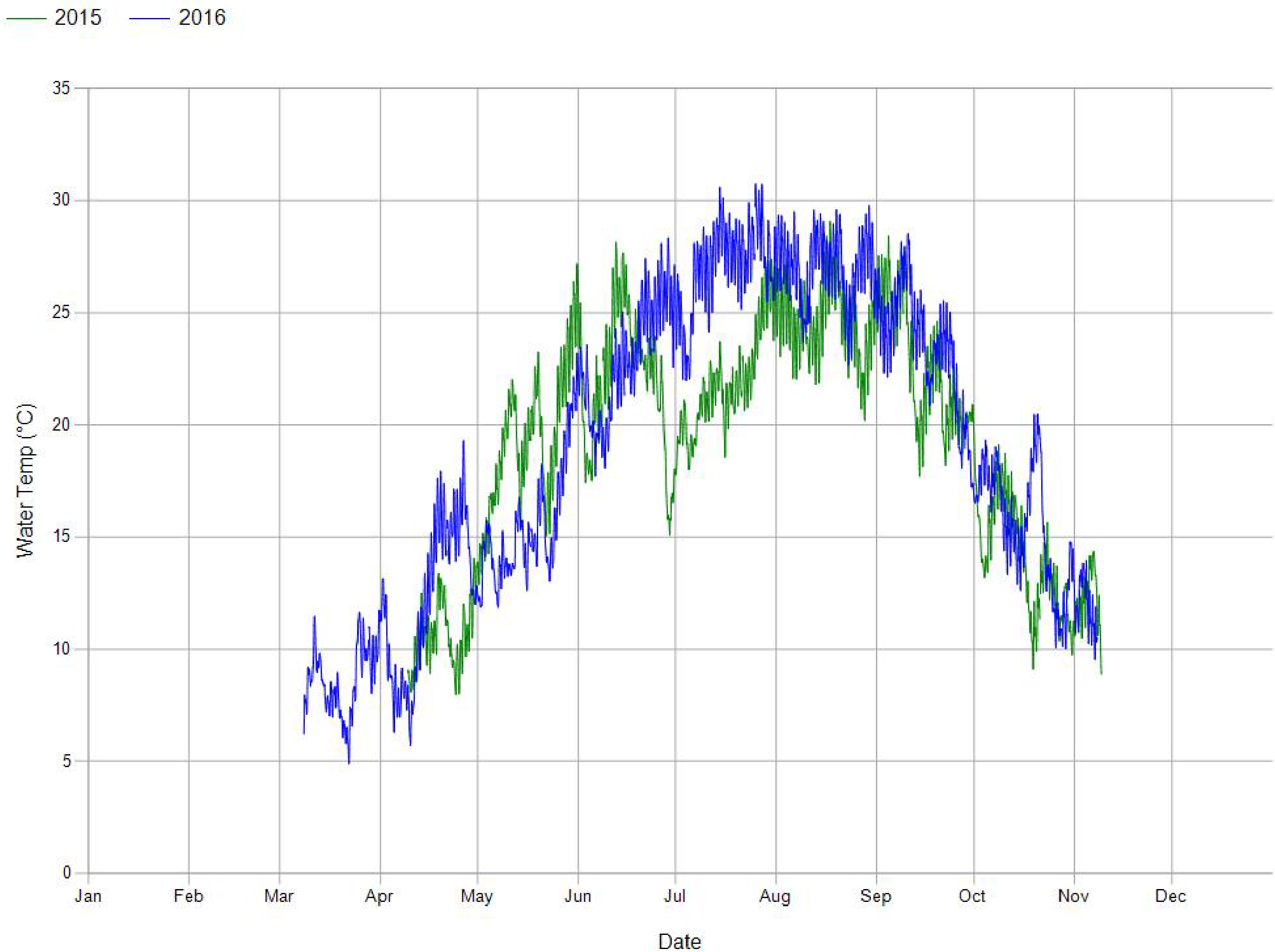

Figure 4. Continuous water temperature at the Juniata River at Newton Hamilton CIM site from 2015 and 2016.

Specific Conductance: *2015* Min: 165.0 µS/cm[c] Average: 304.7 µS/cm[c] Max: 435.4 µS/cm[c]
2016 Min: 180.7 µS/cm[c] Average: 309.2 µS/cm[c] Max: 471.3 µS/cm[c]

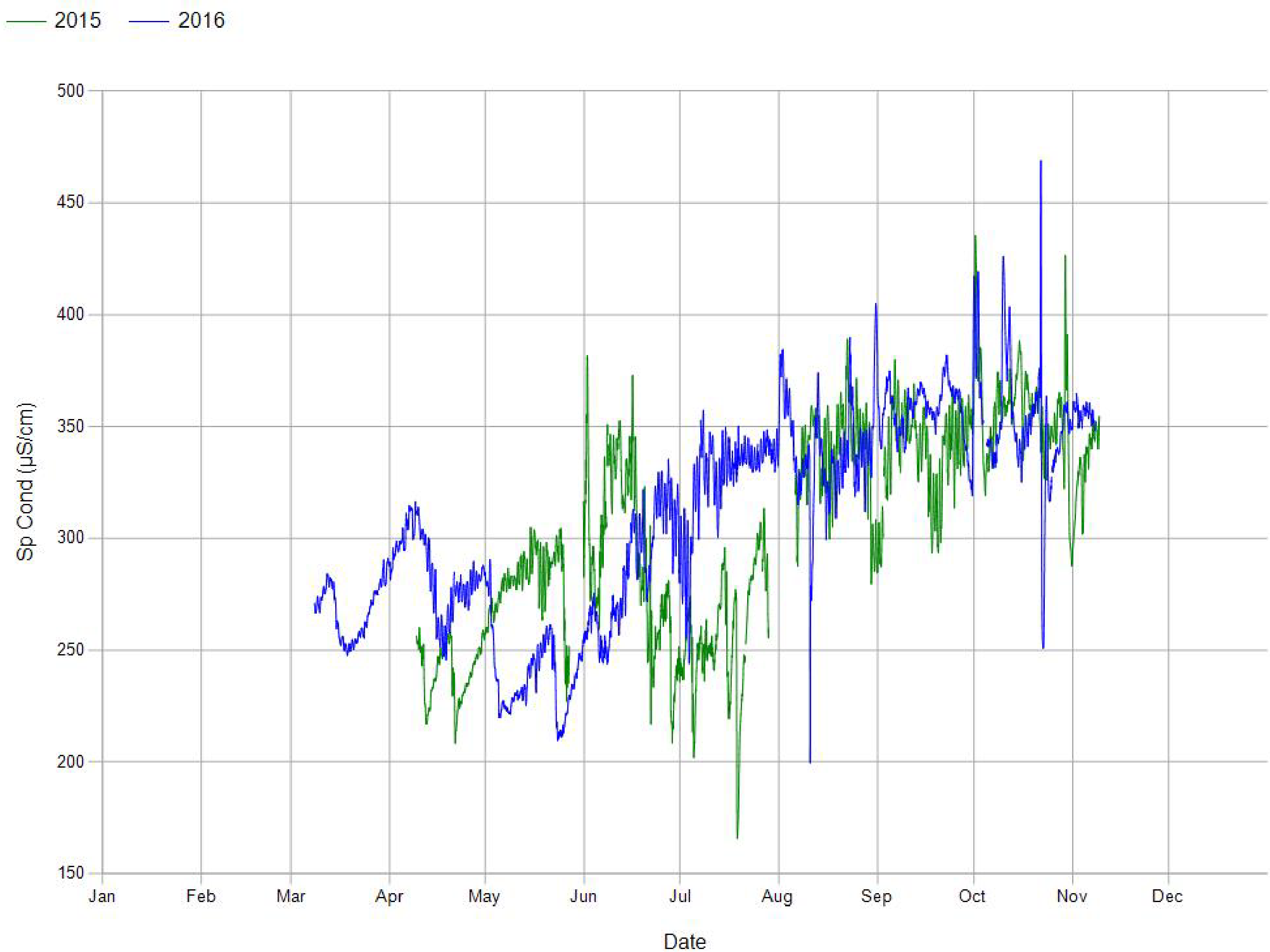

Figure 5. Continuous specific conductance at the Juniata River at Newton Hamilton CIM site from 2015 and 2016.

pH:	*2015*	Min: 7.42 SU	Average: 8.22 SU	Max: 9.20 SU
	2016	Min: 7.59 SU	Average: 8.39 SU	Max: 9.36 SU

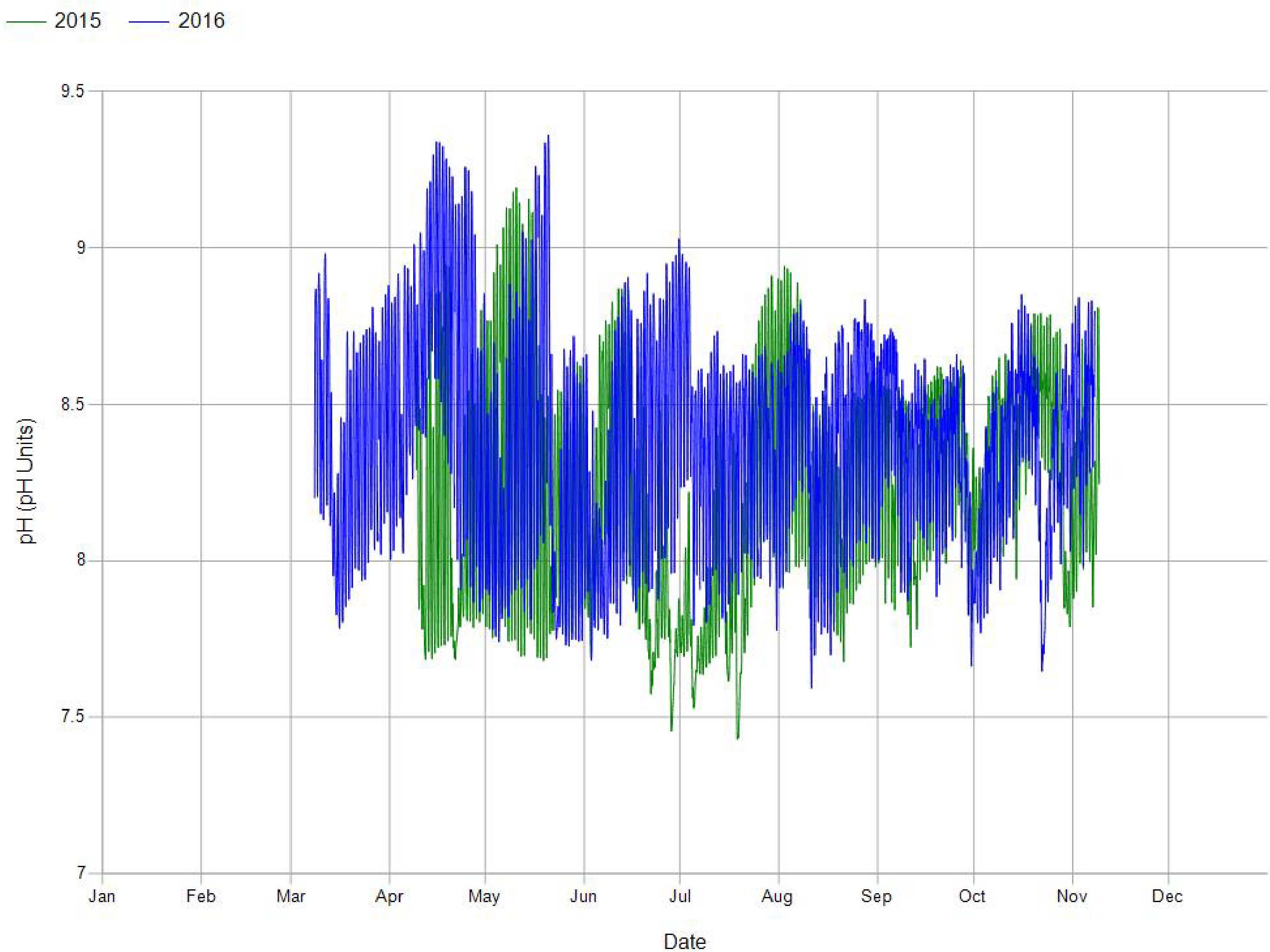

Figure 6. Continuous pH at the Juniata River at Newton Hamilton CIM site from 2015 and 2016.

Dissolved Oxygen:	*2015*	Min: 5.57 mg/L	Average: 9.84 mg/L	Max: 15.56 mg/L
	2016	Min: 4.51 mg/L	Average: 9.87 mg/L	Max: 16.59 mg/L

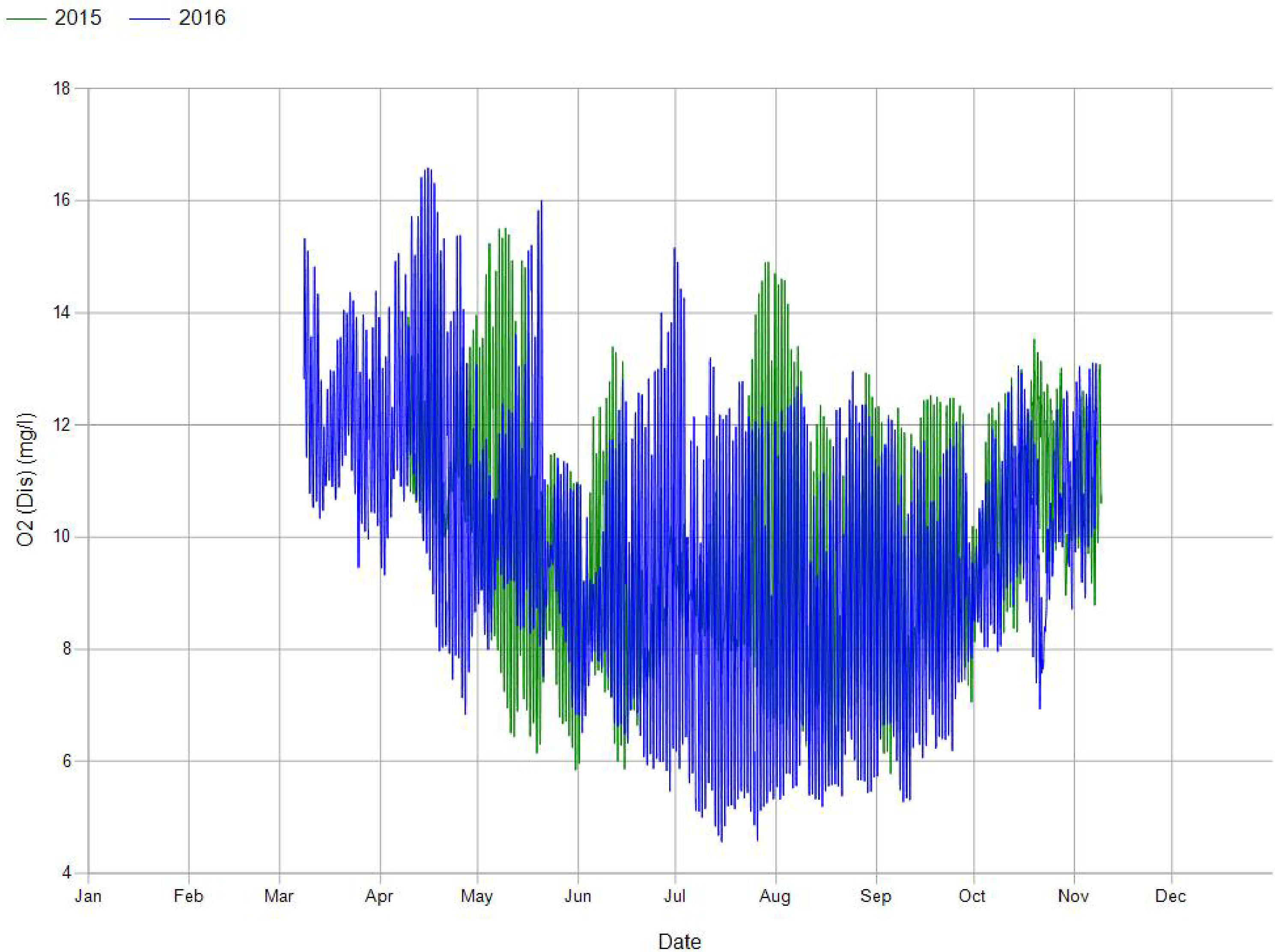

Figure 7. Continuous dissolved oxygen at the Juniata River at Newton Hamilton CIM site from 2015 and 2016.

Turbidity:	*2015*	Min: 0.9 FNU	Average: 10.5 FNU	Max: 232.5 FNU
	2016	Min: 0.8 FNU	Average: 3.9 FNU	Max: 388.6 FNU

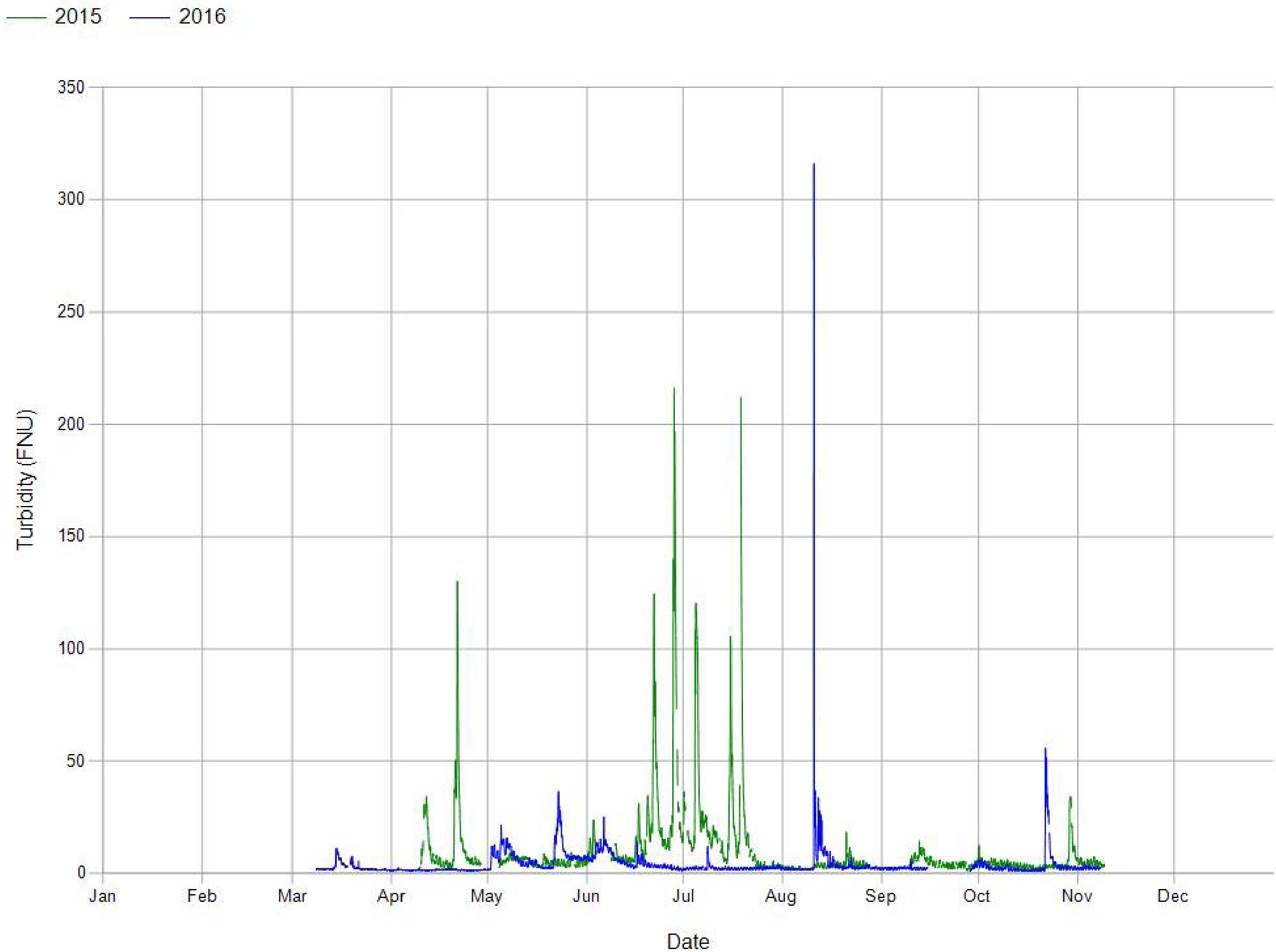

Figure 8. Continuous turbidity at the Juniata River at Newton Hamilton CIM site from 2015 and 2016.

Table 3. Summary of discrete chemical sample results at the Newton Hamilton site.

	PARAMETER	UNITS	JUNIATA RIVER AT NEWTON HAMILTON n	nd	Mean	Median
METALS AND IONS	ALUMINUM ACID SOLUBLE	µg/L	5	5	NA	NA
	ALUMINUM D	µg/L	7	6	14	14
	ALUMINUM T	µg/L	17	0	76	56
	BARIUM T	µg/L	21	0	42	43
	BORON T	µg/L	21	17	27	28
	BROMIDE	µg/L	21	12	25.068	18.485
	CADMIUM D	µg/L	11	11	NA	NA
	CALCIUM T	mg/L	21	0	32.5	32.7
	CHLORIDE T	mg/L	21	0	21	22
	COPPER D	µg/L	11	11	NA	NA
	COPPER T	µg/L	21	10	2.26	1.28
	IRON D	µg/L	11	3	24	22
	IRON T	µg/L	21	0	118	85
	LEAD D	µg/L	11	11	NA	NA
	LEAD T	µg/L	21	11	0.255	0.248
	LITHIUM D	µg/L	11	11	NA	NA
	LITHIUM T	µg/L	13	13	NA	NA
	MAGNESIUM T	mg/L	21	0	10.7	10.9
	MANGANESE D	µg/L	11	5	14	14
	MANGANESE T	µg/L	21	1	22	21
	NICKEL D	µg/L	11	11	NA	NA
	NICKEL T	µg/L	21	21	NA	NA
	POTASSIUM T	mg/L	16	0	2.075	2.155
	SELENIUM T	µg/L	21	20	1.510	1.510
	SODIUM T	mg/L	21	0	14.081	14.160
	STRONTIUM T	µg/L	21	0	277	288
	SULFATE T	mg/L	21	0	28.656	29.060
	ZINC D	µg/L	11	11	NA	NA
	ZINC T	µg/L	21	9	10	8
NUTRIENTS	AMMONIA D	mg/L	20	5	0.042	0.044
	AMMONIA T	mg/L	20	4	0.039	0.040
	NITRATE & NITRITE D	mg/L	21	0	1.036	1.050
	NITRATE & NITRITE T	mg/L	21	0	1.024	1.040
	NITROGEN D	mg/L	10	0	1.395	1.374
	NITROGEN T	mg/L	21	0	1.277	1.299
	ORTHO PHOSPHORUS D	mg/L	21	4	0.022	0.021
	ORTHO PHOSPHORUS T	mg/L	21	4	0.020	0.020
	PHOSPHORUS D	mg/L	21	3	0.026	0.027
	PHOSPHORUS T	mg/L	20	0	0.030	0.032
PHYSICAL/OTHER	ALKALINITY	mg/L	21	0	97.3	101.6
	HARDNESS T	mg/L	21	0	125	128
	OSMOTIC PRESSURE	mOsm	10	0	4	4
	pH	SU	21	0	8.41	8.30
	SPECIFIC COND	µS/cm^c	21	0	314.7	328.0
	SSC	PPM	12	0	2.6	1.4
	SSC - COARSE	PPM	12	0	0.0*	0.0*
	SSC - FINE	PPM	12	0	2.8	1.5
	TDS	mg/L	21	0	198	198
	TOC	mg/L	21	0	2.292	2.300
	TSS	mg/L	21	17	8	8

Means and medians were calculated from measurements greater than the relevant detection limit.
n = number of samples. nd = number of non-detects. NA = mean/median not available, all data were non-detect
*Lab-calculated values were reported as negative but are shown here as zero.

EVALUATION

The evaluation of CIM data incorporates water quality criteria from 25 Pa. Code § 93.7 and the 99% frequency rule from 25 Pa. Code § 96.3(c) as described in Hoger 2018a. Each reading represents a period of time equal to the recording interval. Because the sondes at this site recorded measurements every 30 minutes, 176 exceedances measured over a 365-day period constitutes a percentage greater than 1% (176 x 30 minutes = 5,280 minutes or 1.004% of a year). The evaluations in this report include 99% frequency rule calculations but do not include protected use assessment determinations.

Annual Variation and Critical Conditions

A major determinant of variation in water quality is the amount, timing, and location of precipitation in the watershed upstream of a site. Elevated precipitation will result in increased surface water discharge, which can moderate some instream conditions stressful for certain forms of aquatic life. In past surveys, DEP has documented that elevated discharge can reduce the magnitudes of daily fluctuations of DO, pH, and temperature, and can increase daily minimum DO and decrease daily maximum pH and temperature.

Discharge patterns of the Juniata River at Newton Hamilton differed notably between 2015 and 2016, particularly in the summer months. In 2015, late June and most of July were characterized by frequent rain events leading to substantial increases in discharge (Figure 3). In 2016, however, minimal precipitation from late June through September resulted in consistently low river discharge until October (Figure 3). During March and April, discharge at Newton Hamilton was also higher in 2015 than in 2016 (Figure 3). Instream water quality can be significantly altered by discharge patterns during this early spring period, prior to leaf emergence, because a large proportion of incident sunlight that will be absorbed or reflected by leaves later in the spring and summer reaches the river and drives increased instream photosynthetic activity.

Cross-Sectional Surveys

The transect data for temperature, specific conductance, pH, and DO show a relatively homogenous river system from NHAM4 to NHAM7 (left descending side to near the middle of the channel) during most surveys (Figure 2). The influence of Aughwick Creek influence along the right descending bank frequently extended into the channel beyond NHAM3 (Figure 2), which is why the sonde was located towards the left descending bank (Figure 1). The influences of upstream tributaries were also evident along the left descending bank, but the influence of these smaller, mostly unnamed tributaries was typically limited to the two transect points nearest the left descending bank, NHAM7 and NHAM8 (Figure 2). Compared with the other four CIM parameters, the influence of Aughwick Creek on turbidity measurements at the Newton Hamilton CIM site occasionally extended further into the channel, with effects observed beyond NHAM4 during periods of higher flows in 2013 and 2014 (Figure 2).

CIM, Temperature
Notable differences in water temperature were observed in the Newton Hamilton CIM data between 2015 and 2016 (Figure 4). The most dramatic differences were seen in July (Figure 4), when the monthly mean temperature was more than five degrees warmer in 2016 (27.1°C) than 2015 (21.9°C). The annual maximum temperature was also almost two degrees higher in 2016 than 2015, reaching a maximum of 30.8°C (Figure 4).

CIM, Specific Conductance
Measurements of specific conductance at the Newton Hamilton CIM location averaged around 300 $\mu S/cm^c$ both years (Figure 5). In the spring and early summer, expected dilution responses were observed during periods of elevated discharge (Figures 3 and 5). This discharge-driven response of specific conductance resulted in differences between the two years. Specifically, the period from early May to mid-June was fairly dry in 2015 but had several substantial rainfall events in 2016 (Figure 3), resulting in markedly higher specific conductance in 2015 (Figure 5). Likewise, differences in discharge drove differences in specific conductance between the two years in the period from late June to early August: a period of relatively low specific conductance driven by consistently and substantially elevated discharge in 2015 compared with a very dry period with relatively elevated specific conductance in 2016 (Figures 3 and 5). In some instances, the typical dilutionary effects of increased flow on specific conductance were not observed, with spikes in specific conductance cooccurring with acutely elevated flow events (Figure 9). This counterintuitive pattern was observed most clearly in October 2016 (Figure 9). The cause of this atypical response of specific conductance to discharge is currently unknown. Future monitoring at this site will try to characterize the reasons for this unusual observation.

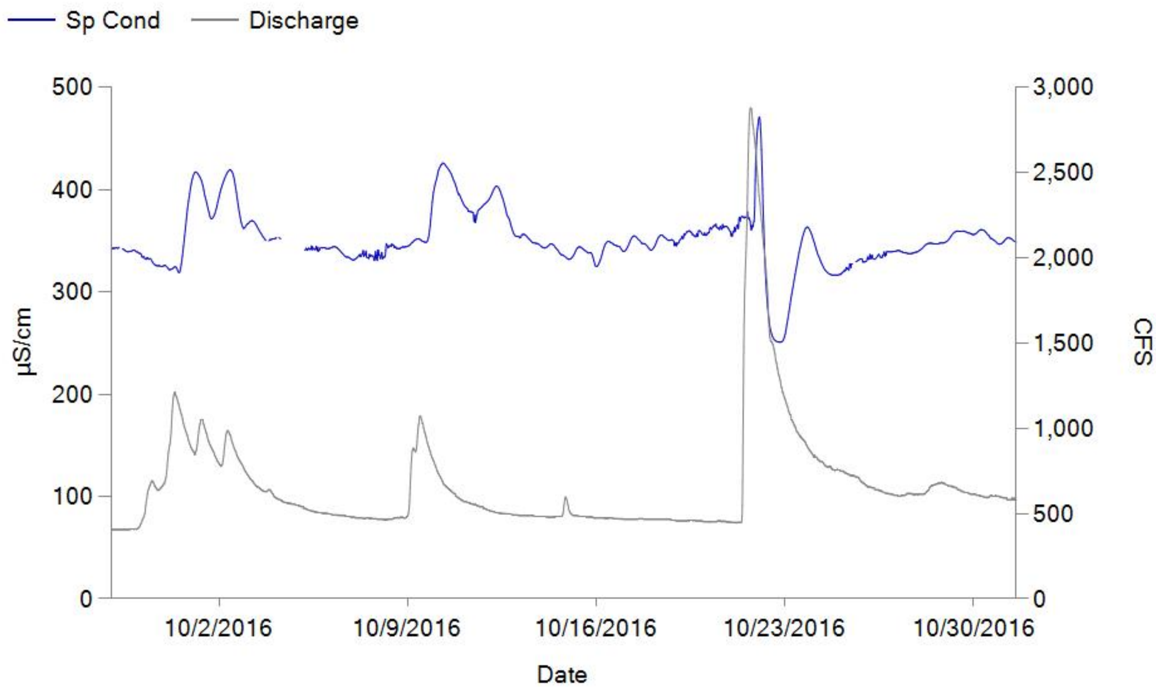

Figure 9. Examples of atypical responses of specific conductance to elevated discharge at the Newtown Hamilton CIM site on the Juniata River. Response of specific conductance to increased discharge is slightly delayed in part because discharge data were collected 20 river kilometers upstream at USGS station 01563500 at Mapleton Depot.

CIM, pH

In 2016, continuous pH data documented exceedances of the pH criterion maximum (9.0) at a frequency greater than 1% of the year (Figure 6, Table 4). In 2015, there were 112 exceedances of the maximum pH criterion, representing 0.64% of the year (Table 4). In 2015, the critical periods of early spring and mid-summer were characterized by elevated flows (Figure 4). In contrast, these same critical periods in 2016 were characterized by lower flows (Figure 3), resulting in 452 exceedances of the maximum pH criterion, representing 2.58% of a year (Figure 6, Table 4). Nearly all these exceedances occurred during two periods during the spring of 2016 (mid- to late April and mid-May; Figure 6) even though the summer of 2016 was characterized by consistently low-flow conditions (Figure 3). The timing of these pH exceedances is more typical of small watersheds where the tree canopy shades the stream channel, absorbing or reflecting most of the sunlight during late spring and summer. At many larger river locations, including the Juniata River at Newport (Bendick 2019), the highest pH readings are observed in the summer, when discharge is typically lower and water temperatures are typically higher, as tree canopies only shade a relatively small portion of the channel near the banks. At the Newton Hamilton site, the greatest number of exceedances for a rolling 365-day period occurred from May 31, 2014 to May 30, 2015 (Figure 6, Table 4). The minimum criterion was not exceeded during the study.

Table 4. Annual pH exceedances of water quality criteria.

Year	pH Exceedance	
	No.	%
2015	112	0.64
2016	452	2.58
rolling year	452	2.58

Percent calculations are percentages of the year.
Red text indicates > 1% exceedance frequency.

CIM, Dissolved Oxygen

Continuous DO data demonstrated exceedances of the WWF minimum DO water quality criterion (5.0 mg/L), but at a frequency less than 1% of each year. Although the DO CIM data met criteria, there were still signs of conditions stressful to aquatic life during critical periods. In July 2016, high levels of instream photosynthetic and respiration activity, indicated by very large diel DO swings, and high water temperatures which decrease the solubility of oxygen, led to DO readings below the WWF minimum criterion (31 exceedances, 0.18% of a year; Figure 7, Table 4). These large diel changes in DO are a result of photosynthetic and respiration activity, fueled by abundant nutrients (Table 3) in the system, long summertime photoperiods, and low-flow critical conditions (McGarrell 2018). When flows were elevated, critical conditions were mitigated and large swings in DO were not observed.

CIM, Turbidity

Turbidity during baseflow conditions was low (around 2 FNU; Figure 8) allowing for high levels of instream light penetration. The Juniata River at Newton Hamilton is also relatively wide and shallow. The combination of clear water and a shallow river allow abundant sunlight to reach photosynthetic organisms on the bottom of the stream during baseflow conditions. Sustained, elevated flows during a critical period, such as the conditions observed at the Newton Hamilton site in late June and early July of 2015 (Figure 3), reduce instream primary production by increasing water depth and turbidity, which decreases light penetration to photosynthetic organisms. When baseflow conditions were sustained during this same critical period in early summer 2016 (Figure 3), the consistent light penetration led to increased water temperatures (Figure 4), increased diel DO swings, and even some exceedances of the WWF minimum DO criterion (Figure 7, Table 4).

Discrete Water Chemistry Sampling

Results from chemical analyses of the grab samples (Table 3) are consistent with the CIM data. Concentrations of some nutrients, particularly the non-ammonia nitrogenous analytes, were relatively high (Table 3). Nutrients are a key factor driving instream primary production, which can lead to elevated pH and elevated, sometimes super-saturated DO during the day, followed by dramatic drops in pH and DO at night due to respiration as was observed during numerous periods at the Newton Hamilton site. Metal and ion concentrations were within expected ranges for freestone surface waters in Pennsylvania not impacted by abandoned mine drainage or other sources of inorganic pollutants. Consistent with the low turbidity values documented in the CIM data, suspended sediment concentrations were also low in the grab samples from the Newton Hamilton site (Table 3).

SUMMARY

Elevated flow during the spring and summer of 2015 moderated instream conditions as measured by certain key parameters. When these critical periods were characterized by sustained baseflow conditions in 2016, exceedances of both the maximum pH criterion and the WWF minimum DO criteria were recorded. Continuous pH data exceedances of the pH criterion maximum occurred at a frequency greater than 1% of the year in 2016. Exceedances of DO criteria were less than 1% of a year. Despite having characteristics similar to other large rivers in the state (wide and shallow), the timing of the pH exceedances in the Juniata River at Newtown Hamilton was more similar to what is observed in smaller streams with significant canopy cover shading the stream from late-spring through fall.

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