pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF CLEAN WATER

Continuous Instream Monitoring Report (CIMR)

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Revised by: Lookenbill, Wertz, Hoger, Bendick & Shull

STREAM CODE: 03110
STREAM NAME: Tohickon Creek
HUC: 02040105
COUNTY: Bucks

Table 1. Tohickon Creek continuous instream monitoring (CIM) site locations 2008 – 2014.

SITE CODE	SITE NAME & DESCRIPTIONS
26031032-001	UPS (upstream) South Park Road, just upstream of SR1014, South Park Road. **DRAINAGE AREA:** 74.6 sq. miles **LATITUDE:** 40.468231 **LONGITUDE:** -75.180507 **PERIOD OF RECORD:** March 15, 2012 to September 10, 2013
26030894-001	UPS Randts Mill Road, approximately 730 meters upstream of Randts Mill Road. **DRAINAGE AREA:** 85.1 sq. miles **LATITUDE:** 40.441983 **LONGITUDE:** -75.141992 **PERIOD OF RECORD:** February 27, 2008 to November 12, 2008
6045268-001	Pipersville, along Covered Bridge Road, approximately 50 meters downstream of USGS Gaging Station. **DRAINAGE AREA:** 98.0 sq. miles **LATITUDE:** 40.433537 **LONGITUDE:** -75.115661 **PERIOD OF RECORD:** March 16, 2012 to August 23, 2012; March 4, 2013 to December 9, 2013 AND February 19, 2014 to November 10, 2014.
26045258-001	Stover Park Road, approximately 500 meters downstream of abandon Stover Park Road Crossing. **DRAINAGE AREA:** 105.0 sq. miles **LATITUDE:** 40.437158 **LONGITUDE:** -75.095077 **PERIOD OF RECORD:** February 27, 2008 to November 12, 2008

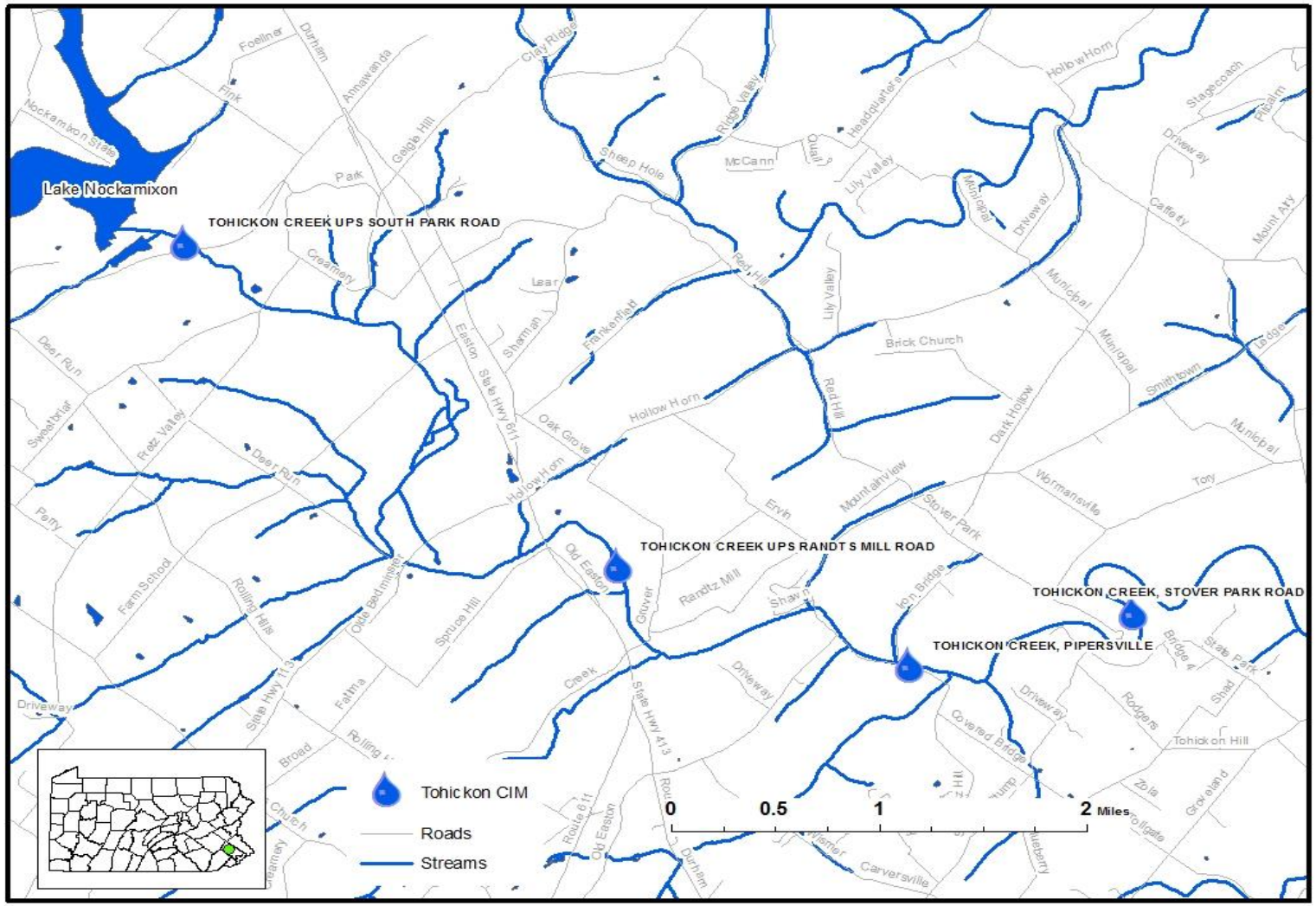

Figure 1. Map of the Tohickon Creek CIM sites 2008 – 2014.

Figure 2. Tohickon Creek, Pipersville sample site.

BACKGROUND AND HISTORY: Tohickon Creek is a freestone tributary to the Delaware River that encompasses portions of Springfield, Richland, East Rockhill, Bedminster Tinicum, and Plumstead Townships in Bucks County (Figures 1 & 2). The basin is characterized by relatively flat topography with some gently rolling hills of low relief with land use consisting of a mixture of agricultural (37%), forested (48%), urban/developed (4%), and wetland/water/transitional (11%). Continuous instream monitoring (hereafter referred to as CIM) efforts were initially implemented in 2008 at the UPS Randts Mill Road and Stover Park Road sites in response to a petition requesting the lower Tohickon Creek mainstem be redesignated to Exceptional Value (EV). With the exception of the Warm Water Fishes, Migratory Fishes (WWF, MF) designation of Deep Run, the lower Tohickon Creek basin is currently designated Cold Water Fishes, Migratory Fishes (CWF, MF). Additional sites were added in 2012 and maintained through 2014 in an effort to monitor surface water temperature in Tohickon Creek during low flow conditions (2012) and as part of a larger assessment method development effort (2013-14).

The primary objectives of the assessment were to:

1. Characterize baseline water temperature, specific conductance, pH, and dissolved oxygen (DO) using 24-hour monitoring.
2. Characterize water chemistry.
3. Characterize baseline biological communities.

EQUIPMENT: Initial deployments February 27, 2008 to November 12, 2008 at UPS Randts Mill Road and Stover Park Road utilized Yellow Springs Instruments (YSI) 600XL water-quality sondes. Follow-up deployments March 15, 2012 to September 10, 2013 at UPS South Park Road and March 16, 2012 to August 23, 2012 at Pipersville utilized multiple OnSet Water Temperature v2 Data Loggers targeting temperature only.

As part of a larger assessment development effort the Pipersville site was selected for additional monitoring in 2013 and 2014. A Eureka Manta2 water-quality sonde (Serial # MM12100605) was used from March 4, 2013 to December 9, 2013. A YSI 6920 V2 (Serial #00018B72) was used from February 19, 2014 to June 10, 2014. The sonde was then replaced with a Eureka Manta2 (Serial # MM12100602) from June 10, 2014 to November 10, 2014.

WATER QUALITY PARAMETERS:

Parameter	Units
Water Temperature	°C
Specific Conductance (@25°C)	µS/cm[c]
pH	standard units
Dissolved Oxygen (DO)	mg/L

DATA:

Each site was visited multiple times over the course of each deployment for the purpose of downloading data, checking calibration and cleaning. Water chemistry grabs were collected at the Pipersville site twelve times throughout the 2013 deployment and ten times throughout the 2014 deployment. Continuous data are graded based on a combination of fouling and calibration error (PA DEP, 2013a). Temperature data for the period March 16, 2012 through August 23, 2012 was graded 'Unverified'. Temperature data for the period April 16, 2013 through April 24, 2013 and August 7, 2013 through September 10, 2013 were lost due to equipment failure. Specific conductance data for the period May 8, 2014 through May 14, 2014 was also graded 'Unusable' due to fouling and deleted from the final report.

Data collected throughout 2008 at the UPS Randts Mill Road and Stover Park Road sites and the UPS South Park Road site April 2, 2012 through August 23, 2012 were collected prior to the Department's CIM protocol development; did not have the appropriate, accompanying maintenance data and were graded 'Unverified'. Temperature data collected at the UPS South Park Road site April 2, 2012 through August 23, 2012 was graded 'Unverified'; while data collected after August 23, 2012 had the appropriate, accompanying maintenance data and was graded based on a combination of fouling and calibration error (PA DEP, 2013a). Average, maximum and minimum statistics in figures 10 – 17 were truncated to the period June 1 to September 1 to allow for comparison between sites and between site years.

Benthic macroinvertebrates were collected as part of the CIM deployment at the Pipersville site on April 8, 2013, August 27, 2013 and November 10, 2014 using the Department's ICE protocol (PA DEP, 2013b). Two additional macroinvertebrate samples were collected at the Pipersville site prior to 2013 for assessment method development purposes (December 18, 2009 and August 20, 2009). Macroinvertebrate samples were collected at other sites on Tohickon Creek in 2010 as part of a routine surface water assessment effort.

Fishes were collected at the Pipersville site on July 22, and July 23, 2009 as part of an assessment method development effort and on July 16, 2013 and on August 21, 2014 as part of the CIM effort.

Discrete Water Quality Transect Characterization: A transect across the width of the stream was established at the UPS South Park Road and Pipersville sites in 2013. Transects were not implemented at UPS South Park Road prior to 2013 or UPS Randts Mill Road and Stover Park road in 2008. The purpose of the transects were to determine if data collected by the sonde or data logger were representative of the surface water as a whole. Discrete water quality measurements were taken at equidistant points across the transect starting at the right descending bank (RDB). Transects were conducted four times in 2013 at UPS South Park Road and five times at Pipersville in 2013. Temperature transect data collected at UPS South Park Road indicates relatively homogenous thermal conditions across Tohickon Creek at this site (Figure 3). Water quality transect data collected at Pipersville indicates homogenous conditions (Figures 4-7) except during the ascending limb of a storm event (March 12, 2013), where specific conductance on the left descending bank (LDB) and at 20 meters from RDB shows a significant dilution affect when compared to points to the right (Figure 5). During the same event pH data shows a significant depression at 1 meter from RDB when compared to points to the left (Figure 6).

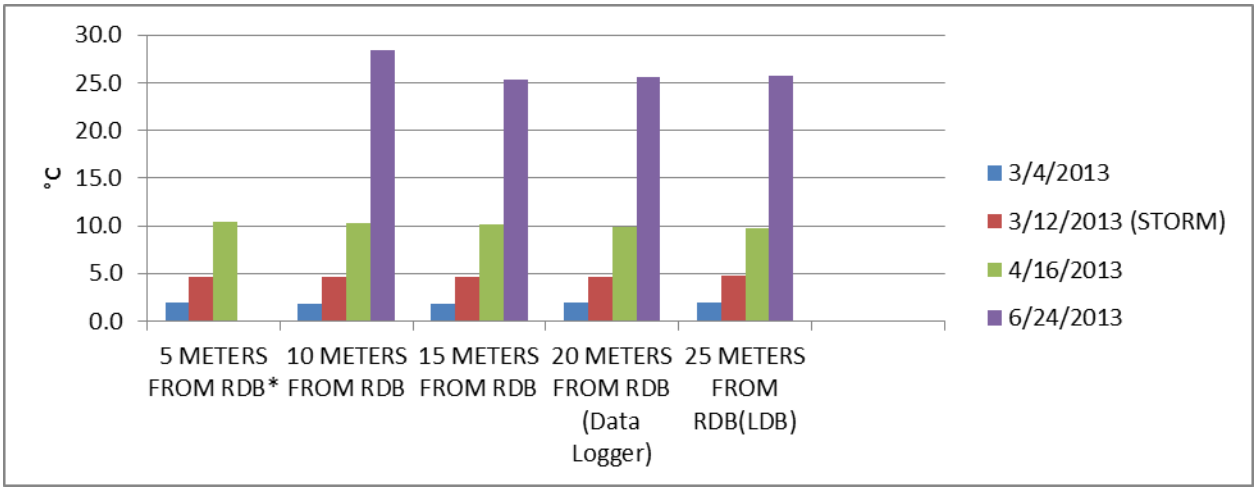

Figure 3. UPS South Park Road, temperature transect, * dewatered on 6/24/2013.

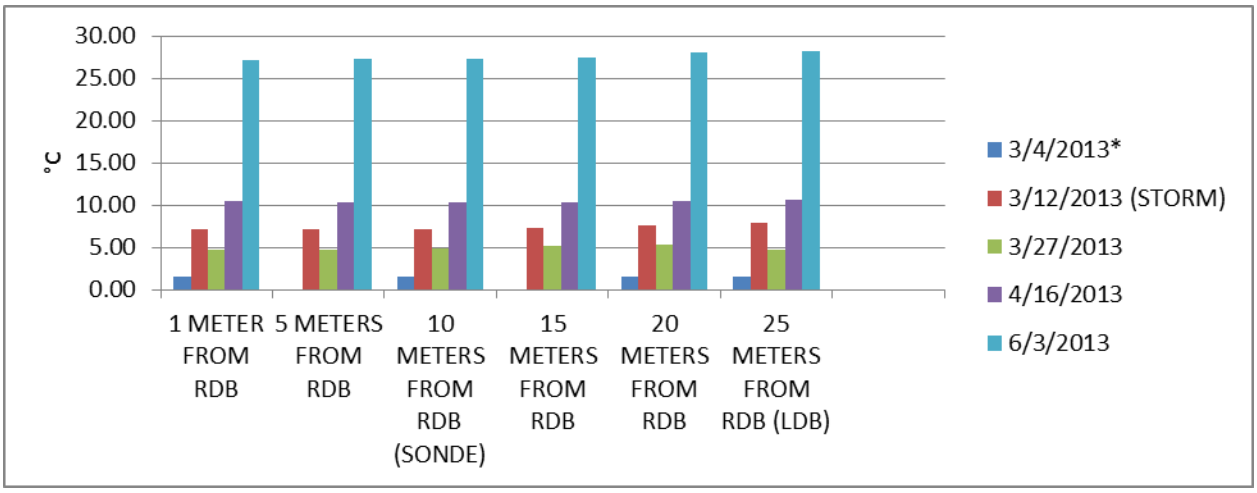

Figure 4. Pipersville 2013, temperature transect, * only four of six transect points were collected on 3/4/2013.

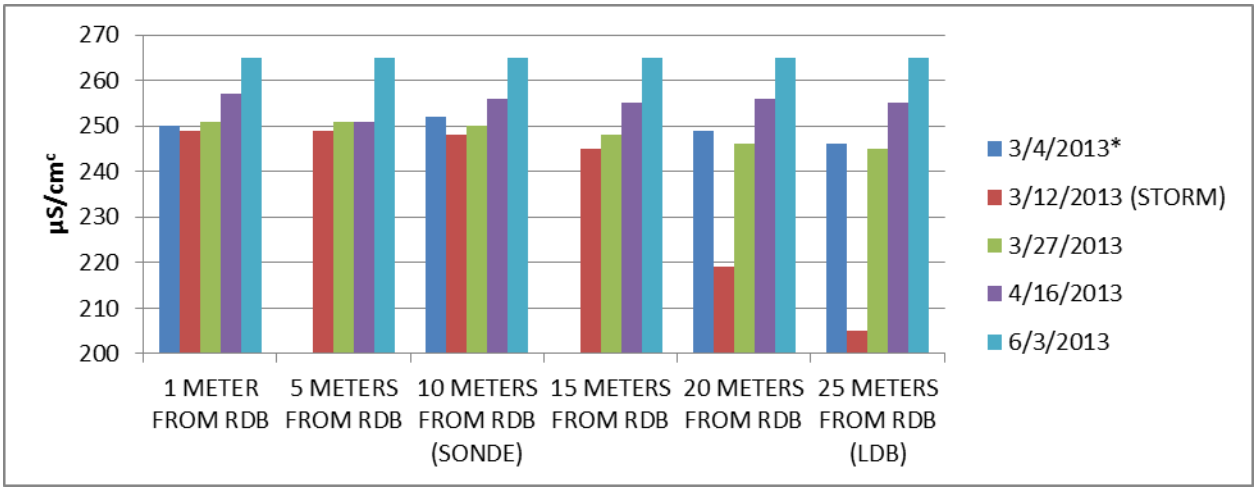

Figure 5. Pipersville 2013, specific conductance transect, * only four of six transect points were collected on 3/4/2013.

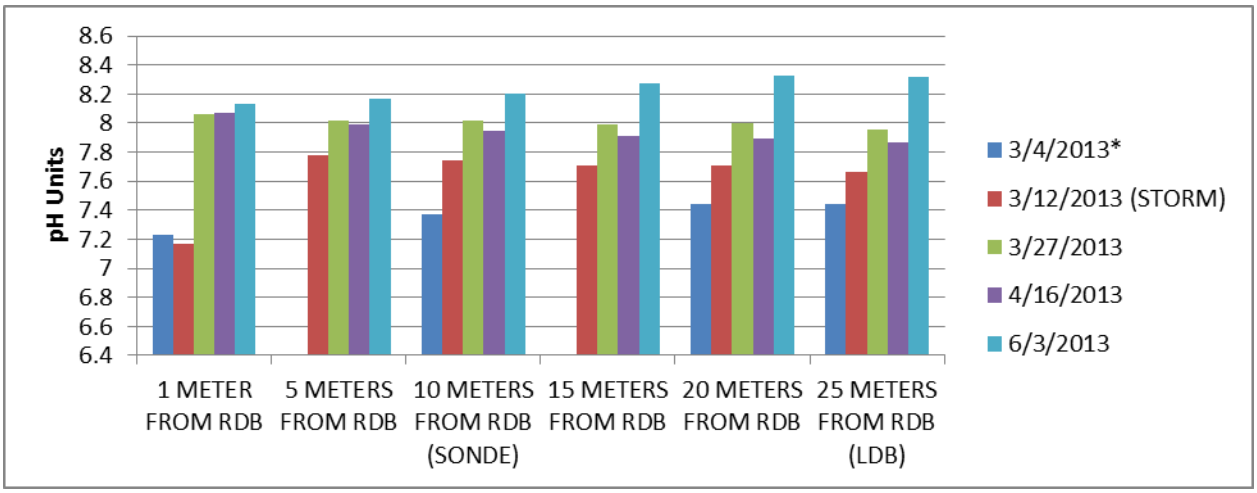

Figure 6. Pipersville 2013, pH transect, * only four of six transect points were collected on 3/4/2013.

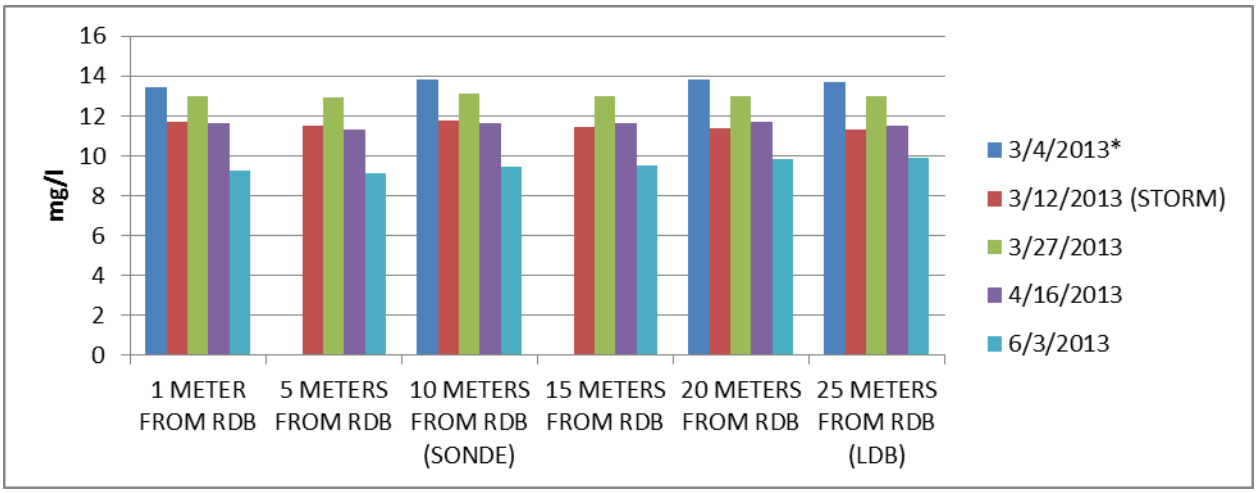

Figure 7. Pipersville 2013, DO transect, * only four of six transect points were collected on 3/4/2013.

Discharge: Discharge data was downloaded from the U.S. Geological Survey's website using USGS station # 01459500, Tohickon Creek near Pipersville, PA. Discharge data are used to aid in interpretation for changes in other parameters. Subsequent to the Department's 2008 CIM effort, it has been determined that Nockamixon Dam may have not been meeting its conservation release of 11 cubic feet per second (CFS) due to inoperable release valves. This may have resulted in significantly reduced flows. Figure 8 illustrates low discharge conditions below 11 CFS in 2008, and figure 9 illustrates low discharge that did not fall below 11 CFS in 2012.

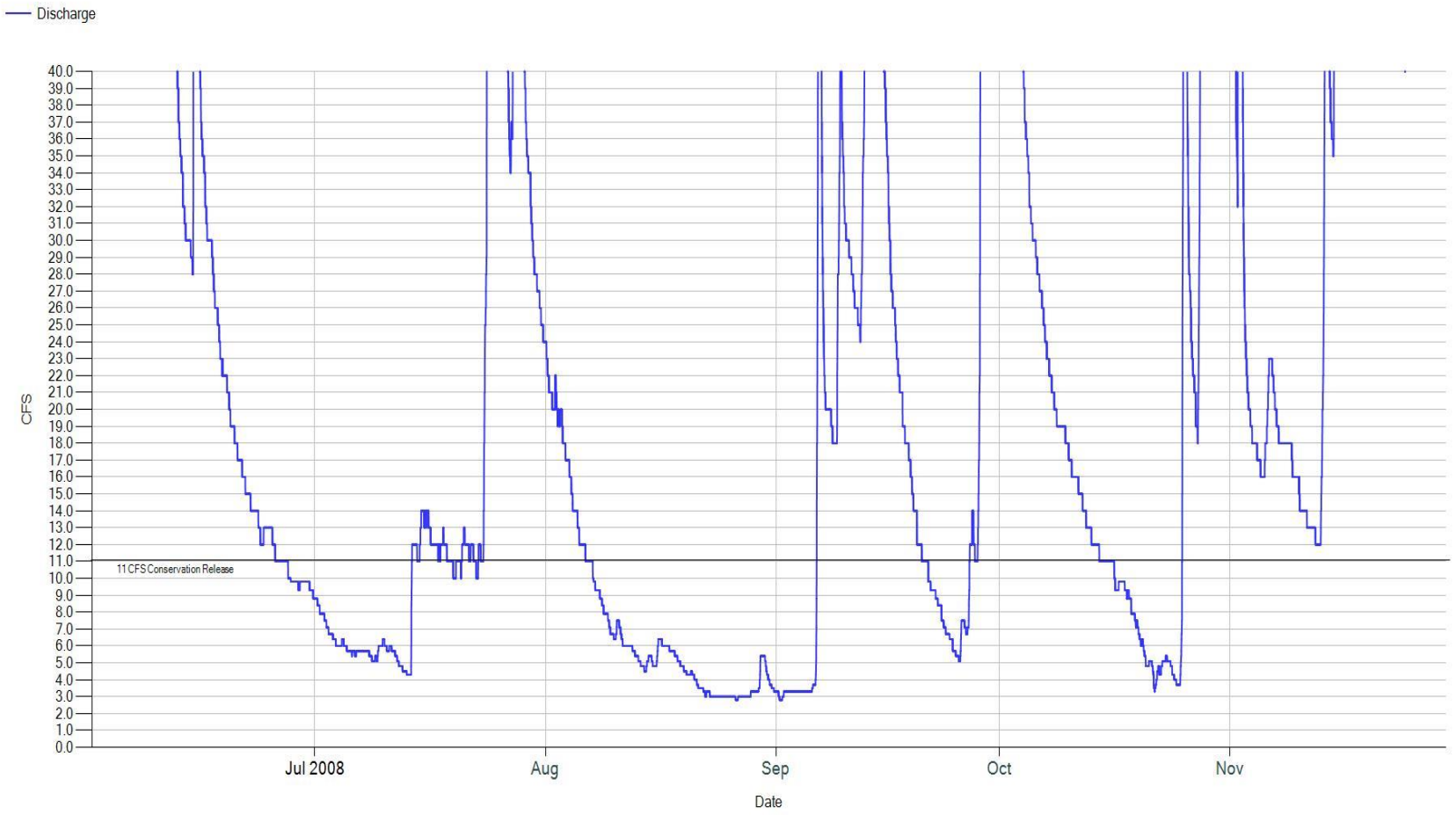

Figure 8. USGS Discharge at Pipersville June 2008 – November 2008.

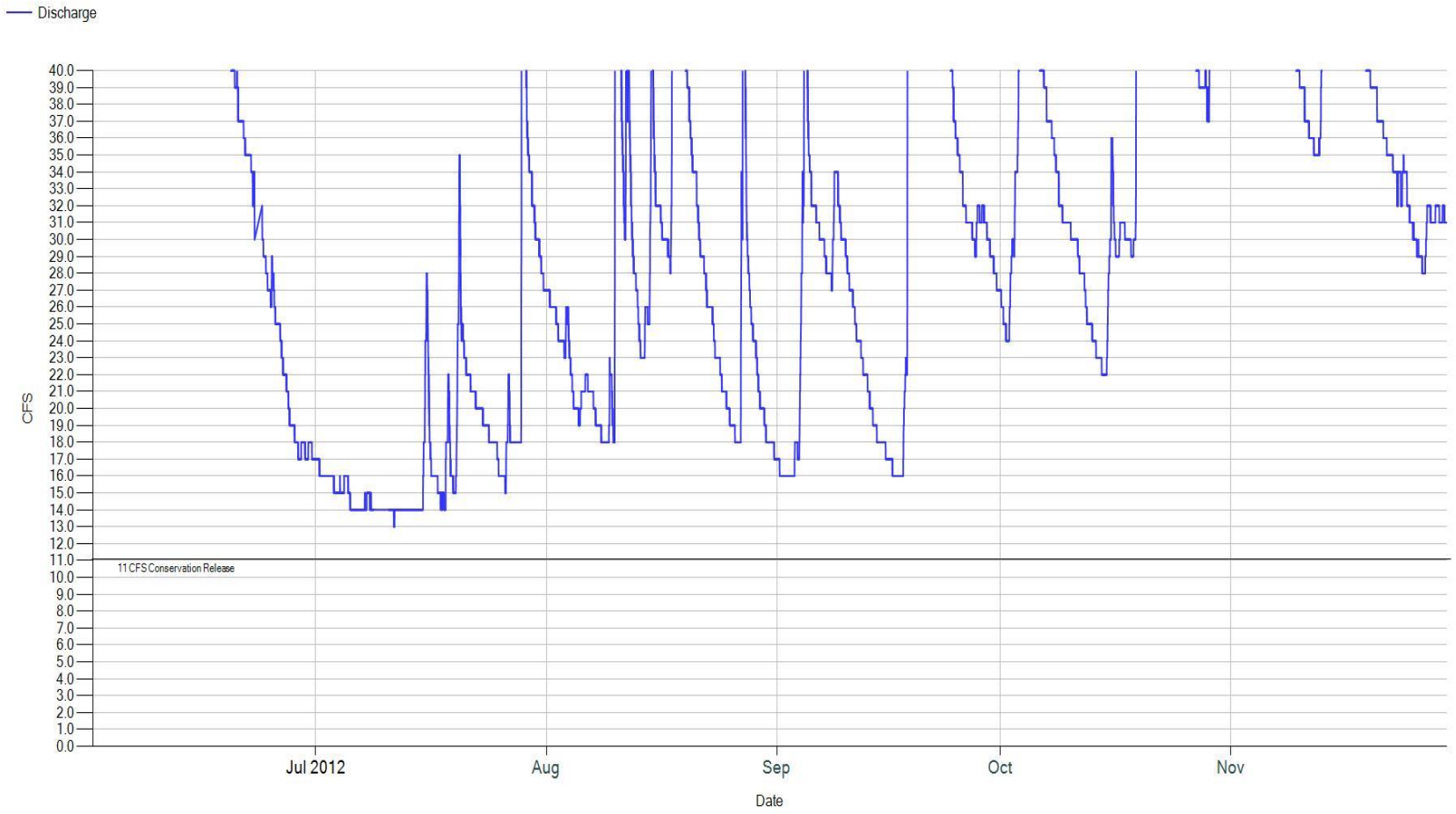

Figure 9. USGS Discharge at Pipersville June 2012 – November 2012.

Water Temperature:
UPS Randts Mill Road Statistics (6/1 – 9/1/2008) - Average: 23.8°C; Maximum: 31.4°C; Minimum: 18.4°C.
Stover Park Road Statistics (6/1 – 9/1/2008) - Average: 24.8°C; Maximum: 32.4°C; Minimum: 17.4°C.

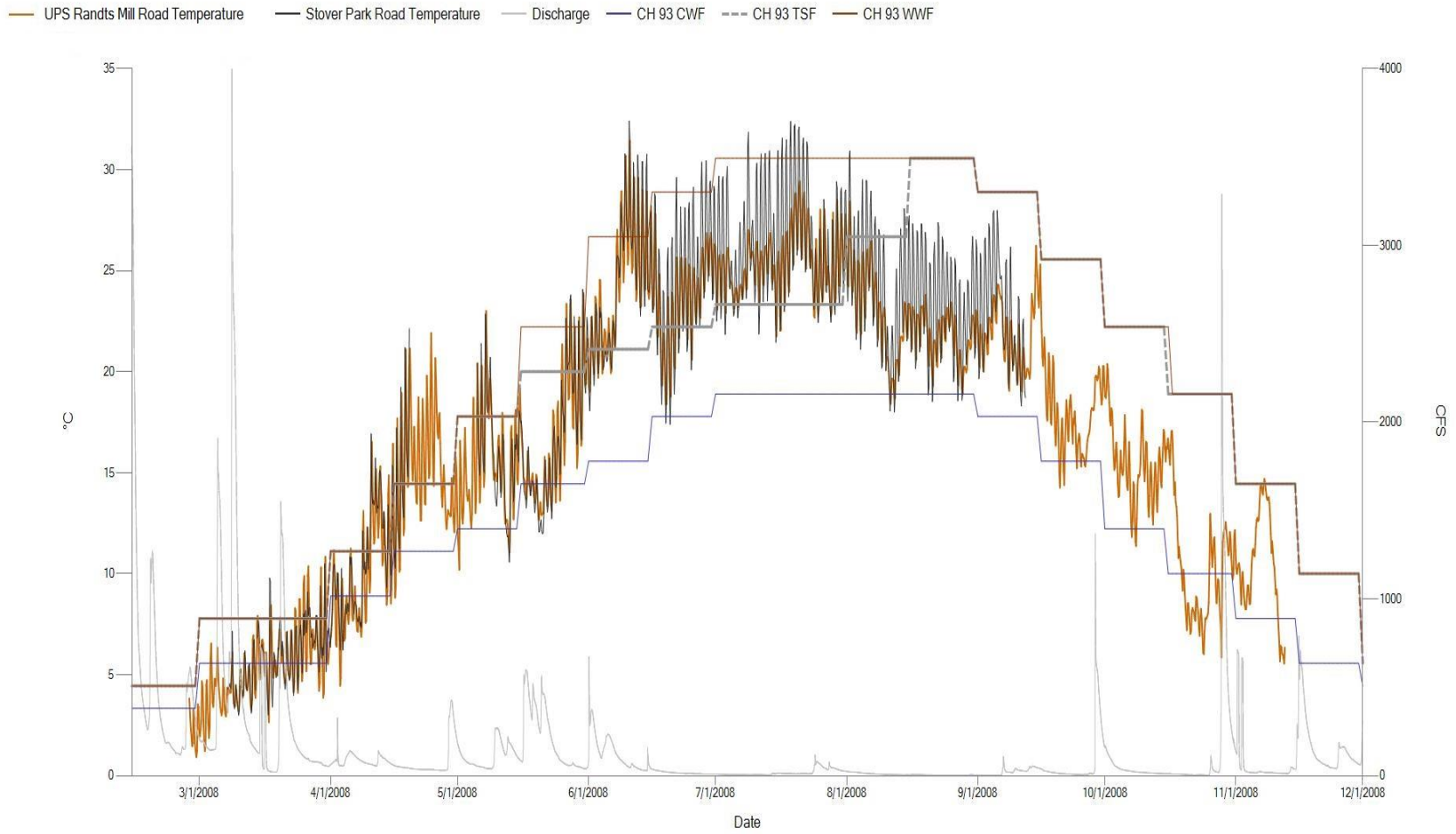

Figure 10. UPS Randts Mill Road and Stover Park Road continuous water temperature, continuous discharge, and CH 93 temperature criteria from February 27, 2008 to November 11, 2008.

UPS South Park Road Statistics (6/1 – 9/1/2012) - Average: 17.6°C; Maximum: 25.6°C; Minimum: 10.9°C.
Pipersville Statistics (6/1 – 9/1/2012) - Average: 23.9°C; Maximum: 32.7°C; Minimum: 17.9°C.

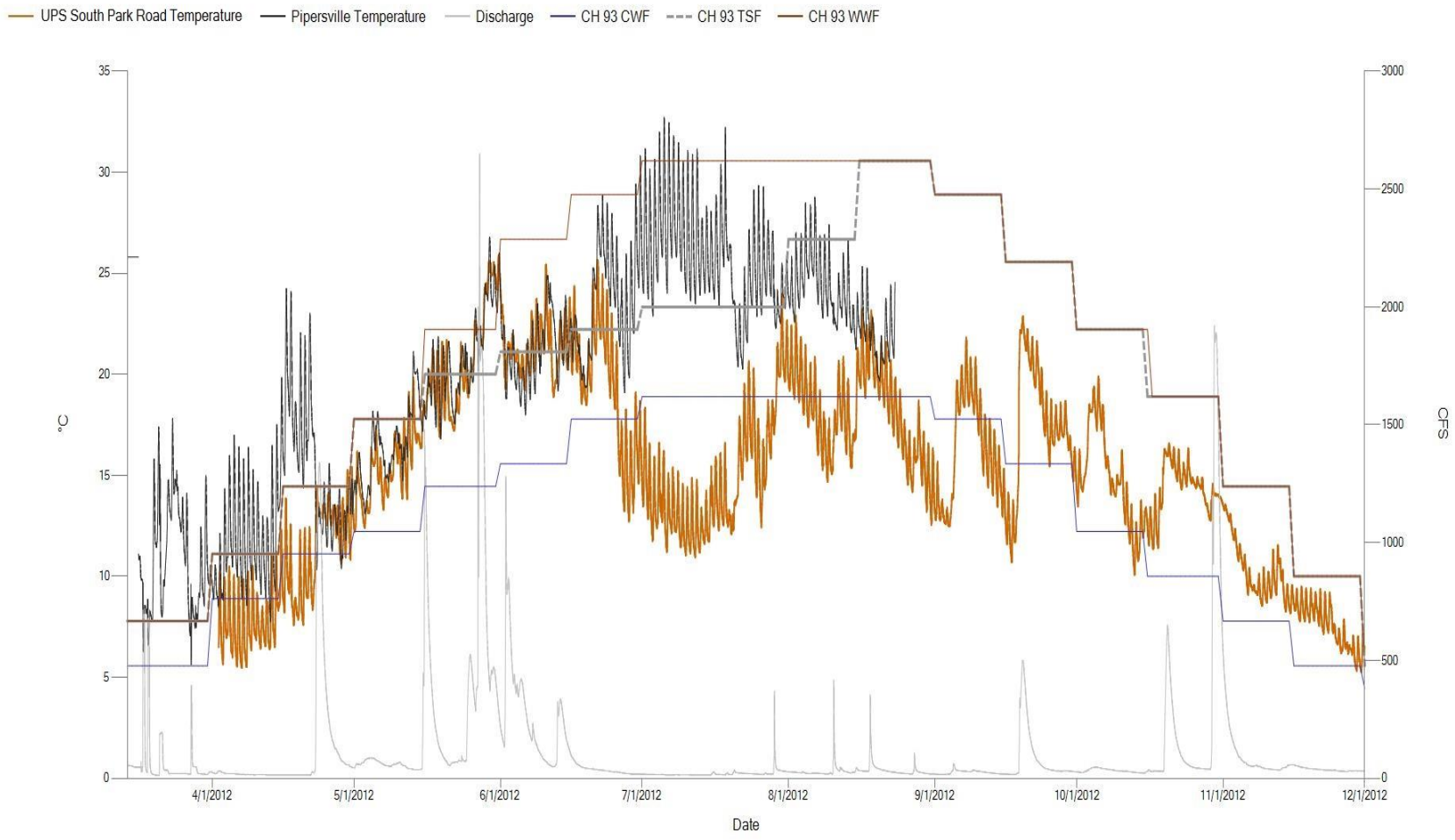

Figure 11. UPS South Park Road and Pipersville continuous water temperature, continuous discharge, and CH 93 temperature criteria from March 13, 2012 to December 1, 2012.

UPS South Park Road Statistics (6/1 – 9/1/2013) - Average: 24.7°C; Maximum: 32.2°C; Minimum: 18.4°C.
Pipersville Statistics (6/1 – 9/1/2013) - Average: 24.7°C; Maximum: 31.6°C; Minimum: 17.0°C.

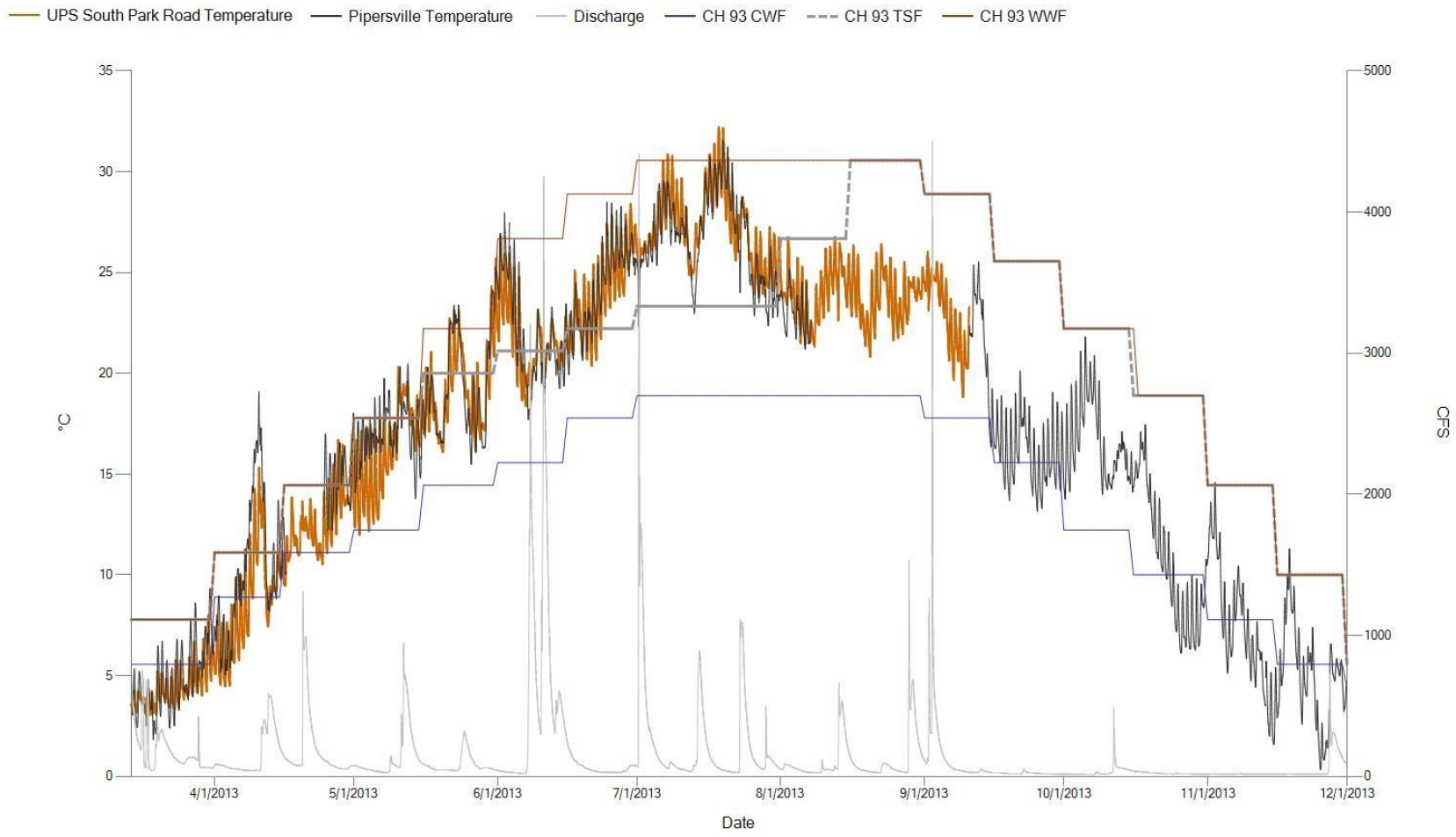

Figure 12. UPS South Park Road and Pipersville continuous water temperature, continuous discharge, and CH 93 temperature criteria from March 13, 2013 to December 1, 2013.

Pipersville Statistics (6/1 – 9/1/2012) - Average: 24.0°C; Maximum: 32.7°C; Minimum: 18.0°C.
Pipersville Statistics (6/1 – 9/1/2013) - Average: 24.7°C; Maximum: 31.6°C; Minimum: 17.0°C.
Pipersville Statistics (6/1 – 9/1/2014) – Average: 22.4°C; Maximum: 28.5°C; Minimum: 17.2°C.

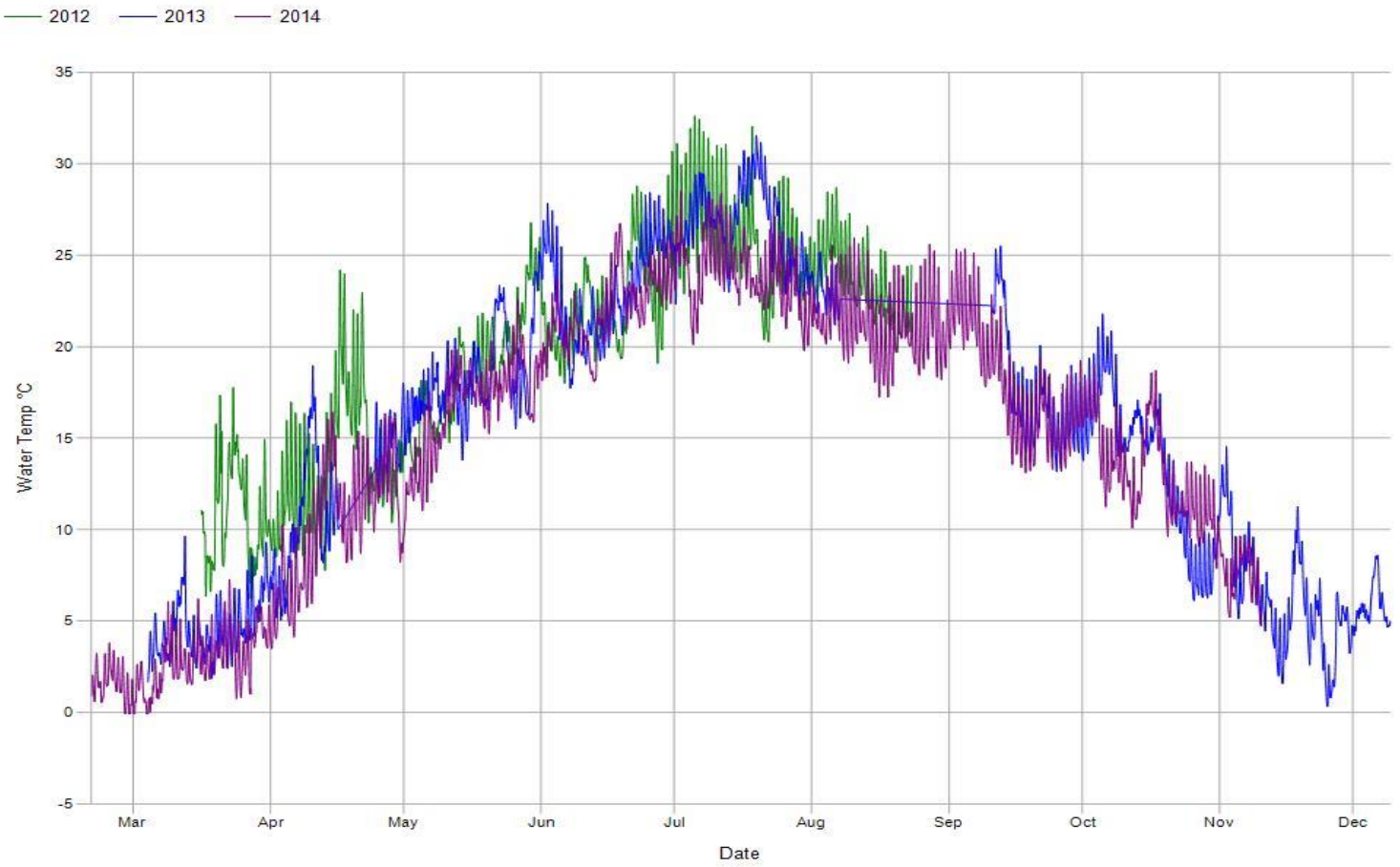

Figure 13. Pipersville continuous water temperature yearly report 2012, 2013 and 2014.

Specific Conductance:
UPS Randts Mill Road Statistics (6/1 – 9/1/2008) - Average: 208 µS/cm[c]; Maximum: 228 µS/cm[c]; Minimum: 156 µS/cm[c].
Stover Park Road Statistics (6/1 – 9/1/2008) - Average: 230 µS/cm[c]; Maximum: 268 µS/cm[c]; Minimum: 164 µS/cm[c].

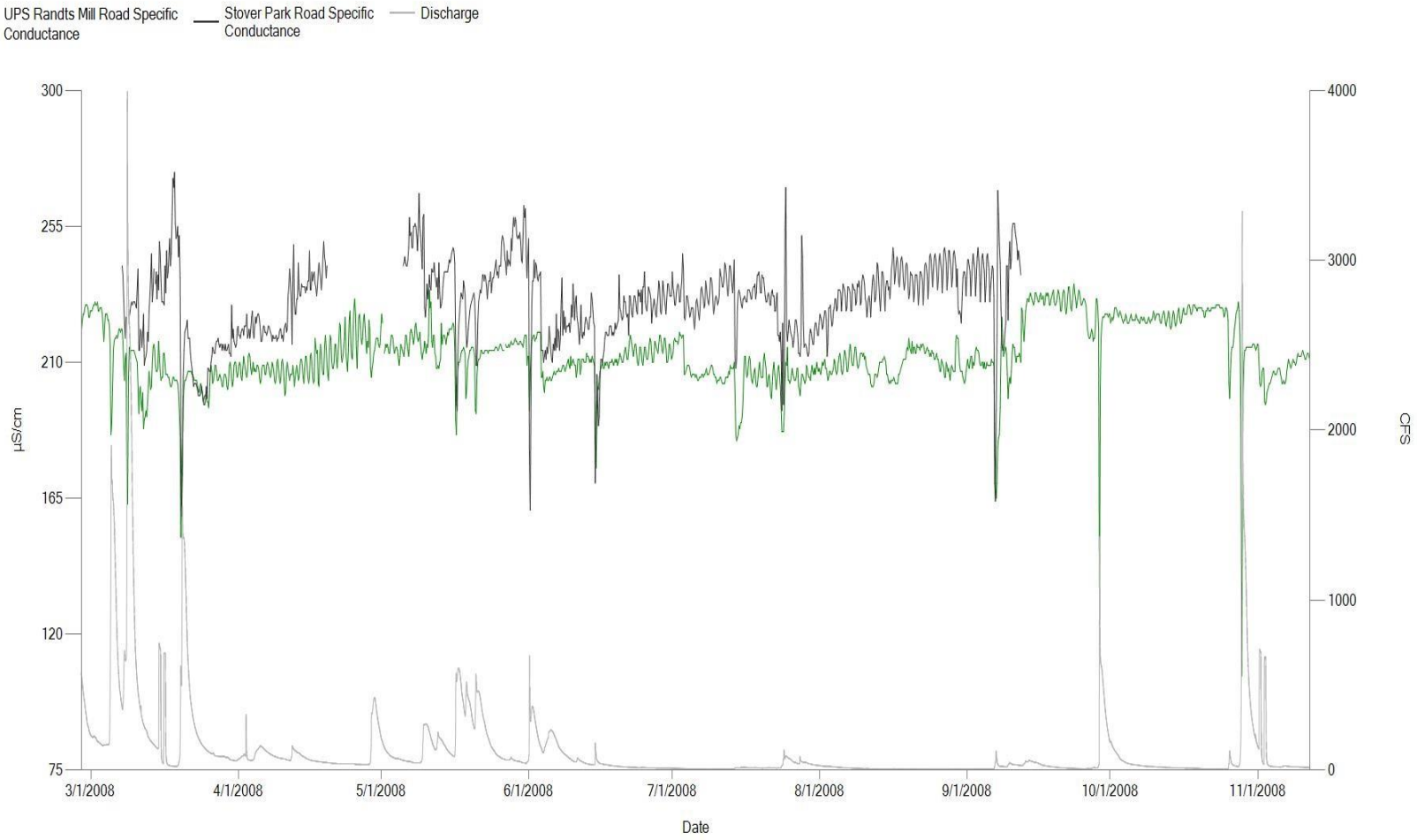

Figure 14. UPS Randts Mill Road and Stover Park Road continuous specific conductance and continuous discharge from February 27, 2008 to November 11, 2008.

pH:
UPS Randts Mill Road Statistics (6/1 – 9/1/2008) - Average: 7.4; Maximum: 8.6; Minimum: 6.6.
Stover Park Road Statistics (6/1 – 9/1/2008) - Average: 8.0; Maximum: 9.3; Minimum: 7.2.

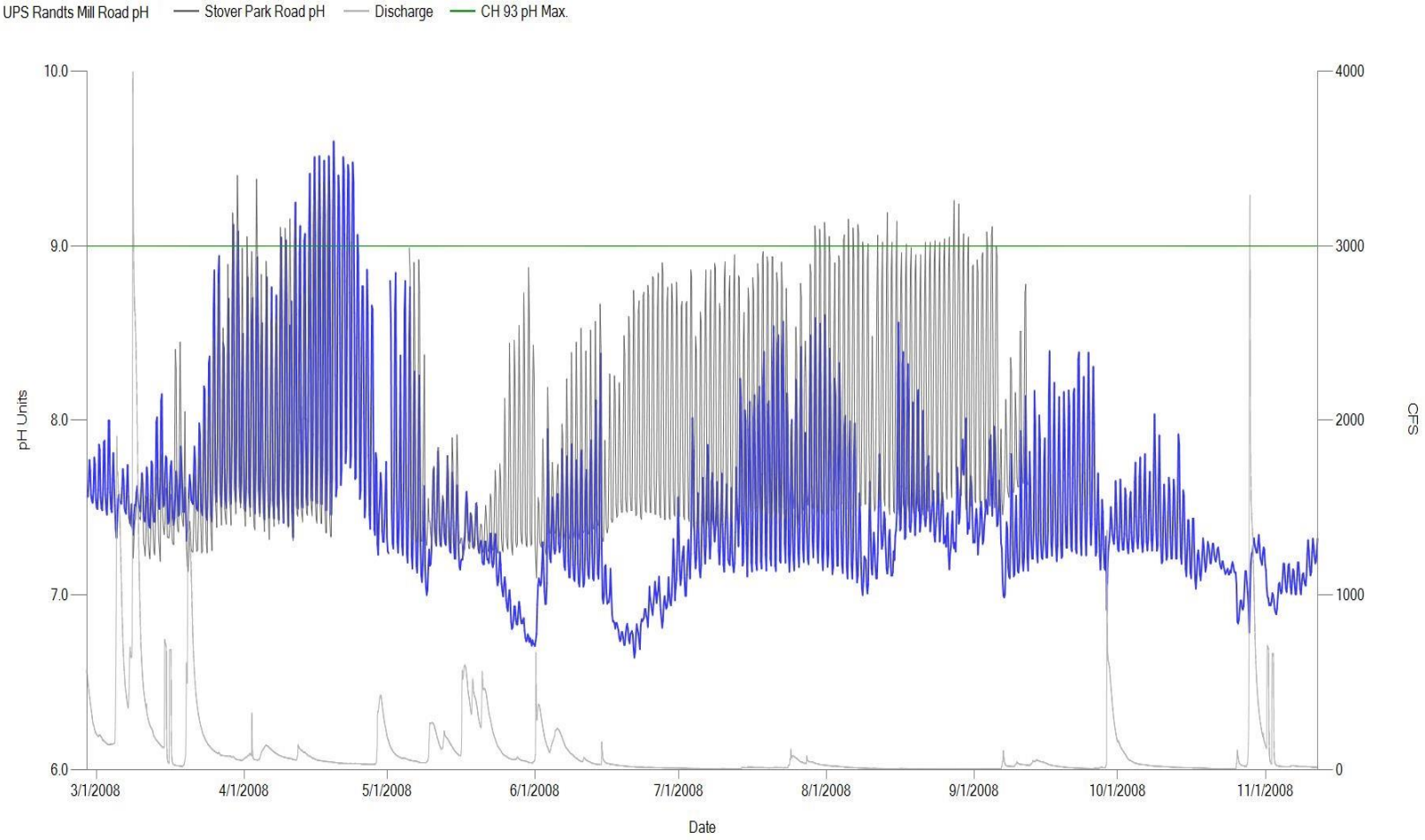

Figure 15. UPS Randts Mill Road and Stover Park Road continuous pH, continuous discharge, and CH 93 pH maximum from February 27, 2008 to November 11, 2008.

Pipersville Statistics (6/1 – 9/1/2013) - Average: 6.9; Maximum: 8.9; Minimum: 6.9.
Pipersville Statistics (6/1 – 9/1/2014) - Average: 7.8; Maximum: 9.1; Minimum: 6.9.

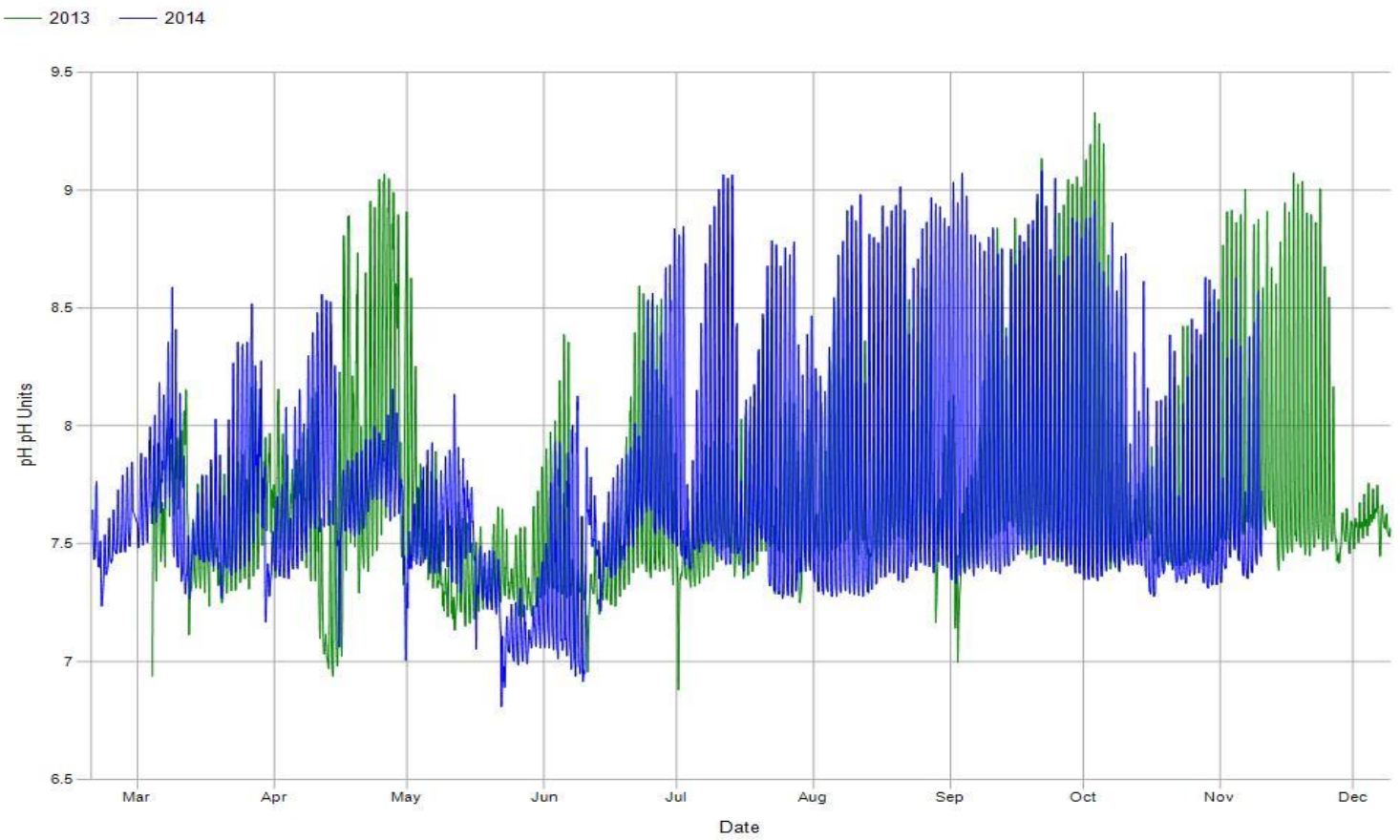

Figure 16. Pipersville continuous pH yearly report 2013 and 2014.

Dissolved Oxygen:
Pipersville Statistics (6/1 – 9/1/2013) - Average: 8.1 mg/l; Maximum: 10.7 mg/l; Minimum: 6.4 mg/l.
Pipersville Statistics (6/1 – 9/1/2014) - Average: 8.5 mg/l; Maximum: 11.5 mg/l; Minimum: 5.8 mg/l.

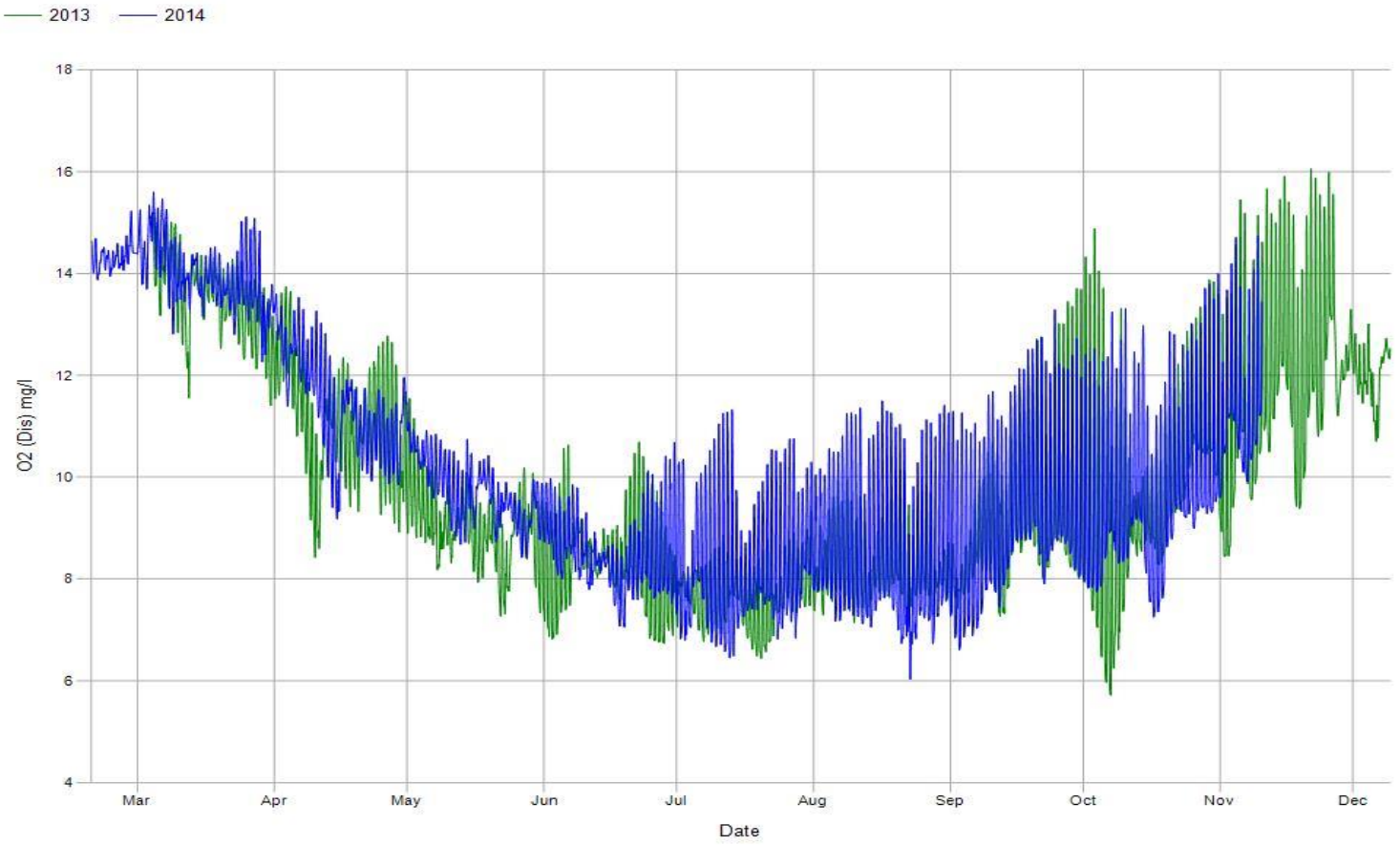

Figure 17. Pipersville continuous DO yearly report 2013 and 2014.

In-situ Water Chemistry: In 2013 water chemistry samples were collected twelve times and in 2014 ten times using standard analysis code (SAC) 612 at the Pipersville site. Measurements with "<" indicate concentrations below the reporting limit.

Table 2. 2013 Pipersville chemical grab sample results.

PARAMETERS	UNITS	3/12/2013	3/27/2013	4/24/2013	6/4/2013	6/25/2013	8/7/2013	9/10/2013	10/16/2013	10/31/2013	11/13/2013	11/20/2013	12/10/2013
ALUMINUM T	UG/L	1254	193	131	51	19	26	17	33	50	64	18	143
BARIUM T	UG/L	29	20	18	22	19	18	15	23	25	23	21	21
BORON T	UG/L	30	30	40	30	40	30	40	40	40	40	60	40
BROMIDE	UG/L	18.88	19.933	14.879	15.243	<7.03284	8.31	10.824	11.087	19.103	16.494	16.004	17.551
CALCIUM T	MG/L	14.4	14.4	14.4	15.9	13.2	13.17	14	14.7	18.3	18.5	18	14
CHLORIDE T	MG/L	33.8	39.582	36.428	36.86	32.078	27.434	24	29.68	45.59	47.571	36.638	37.886
COPPER T	UG/L	3.98	4.2	25.2	2.13	1.9	6.16	1.35	1.57	0.979	0.915	<0.315	1.68
IRON T	UG/L	1251	266	213	134	84	109	237	186	723	929	299	233
LEAD T	UG/L	1.67	0.263	2.4	0.197	0.145	0.118	0.174	0.168	0.161	0.135	<0.07258	0.424
MAGNESIUM T	MG/L	5.928	6.119	6.234	7.074	6.316	5.726	6.262	6.954	7.526	7.64	7.71	6.344
MANGANESE T	UG/L	74	27	26	50	13	13	10	23	21	18	20	49
NICKEL T	UG/L	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856
SELENIUM T	UG/L	<0.32605	<0.32605	<0.32605	<0.32605	0.567	<0.32605	<0.32605	<0.32605	<0.32605	0.434	<0.32605	0.555
SODIUM T	MG/L	19.9	19.7	19.6	22.1	20.4	14.7	16.2	17.8	19.91	20.3	19	18.8
STRONTIUM T	UG/L	101	107	107	134	131	115	122	126	156	153	167	115
SULFATE T	MG/L	12.255	13.253	12.901	13.819	12.316	10.62	11.142	11.991	12.243	11.927	12.715	11.801
ZINC T	UG/L	12	<5.1325	12	<5.1325	17	8	<5.1325	<5.1325	9	<5.1325	<5.1325	8
ALKALINITY @ pH 4.5	MG/L	42.6	41.6	46	47.2	47	46.8	52.2	59.8	60.2	59	59.2	47.8
HARDNESS T	MG/L	60	61	62	69	59	57	61	65	77	78	77	61
OSMOTIC PRESSURE	MOSM	4	6	5	6	4	5	5	4	5	6	4	4
pH	pH units	7.74	8.02	8.29	7.9	8.46	8.37	7.9	7.6	7.55	7.75	7.13	7.6
SPECIFIC COND @ 25 C	umhos/cm	248	250	247	261	226	214	212	234	267	272	252.6	221
TDS @ 1800 C	MG/L	146	164	154	168	136	132	132	148	152	158	160	152
TOC	MG/L	6.028	5.254	4.872	4.813	4.91	4.861	4.849	4.551	4.371	4.531	4.794	5.81
TSS	MG/L	50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	6
AMMONIA D	MG/L	0.008	0.034	0.016	0.04	0.042	0.04	0.028	0.016	0.104	0.131	0.01	0.018
AMMONIA T	MG/L	0.018	<0.00672	<0.00672	0.04	0.028	0.028	0.037	0.016	0.09	0.13	0.028	0.029
NITRATE & NITRITE D	MG/L	0.539	0.471	0.399	0.407	0.368	0.238	0.382	0.38	0.484	0.638	0.351	0.692
NITRATE & NITRITE T	MG/L	0.536	0.479	0.391	0.387	0.364	0.221	0.376	0.382	0.491	0.631	0.351	0.678
NITROGEN D	MG/L	0.877	0.813	0.713	0.7	0.669	0.608	0.713	0.686	0.875	0.917	0.684	0.967
NITROGEN T	MG/L	1.108	0.914	0.708	0.739	0.689	0.559	0.649	0.701	0.864	0.931	0.698	0.975
ORTHO PHOSPHORUS D	MG/L	0.011	0.005	0.004	0.032	0.025	0.019	0.041	0.036	0.073	0.088	0.019	0.03
ORTHO PHOSPHORUS T	MG/L	0.011	0.004	0.005	0.033	0.025	0.019	0.042	0.039	0.073	0.092	0.022	0.032
PHOSPHORUS D	MG/L	0.016	0.014	0.015	0.043	0.031	0.026	0.051	0.046	0.084	0.088	0.027	0.041
PHOSPHORUS T	MG/L	0.073	0.026	0.023	0.051	0.037	0.04	0.056	0.054	0.089	0.109	0.034	0.055

Table 3. 2014 Pipersville chemical grab sample results.

PARAMETERS	UNITS	2/19/2014	3/18/2014	4/21/2014	5/14/2014	6/10/2014	6/25/2014	7/21/2014	9/9/2014	10/22/2014	11/10/2014
ALUMINUM T	UG/L	192	237	144	63	49	34	35	30	20	27
BARIUM T	UG/L	27	20	18	17	17	14	13	14	18	20
BORON T	UG/L	40	30	<19.1058	20	30	30	20	40	30	40
BROMIDE	UG/L	23.761	19.318	16.325	12.899	9.496	14.24	8.872	<7.127	<7.127	14.7909
CALCIUM T	MG/L	18.4	14.4	14.1	14.93	12.7	12.8	12	12.6	14.7	15.9
CHLORIDE T	MG/L	73.9	57.326	48.645	39.405	30.464	30.32	29.289	37.252	36.97	39.183
COPPER T	UG/L	1.83	1.67	1.74	1.75	1.73	2.14	3	1.32	0.927	1.26
IRON T	UG/L	299	278	192	123	120	107	124	324	684	923
LEAD T	UG/L	0.334	0.286	0.168	0.138	0.168	0.163	0.278	0.11	0.106	0.119
MAGNESIUM T	MG/L	7.962	6.372	6.089	5.728	5.408	5.575	5.235	5.29	5.932	6.887
MANGANESE T	UG/L	42	37	27	19	14	12	18	12	6	19
NICKEL T	UG/L	13.7856	13.7856	13.7856	13.7856	13.7856	13.7856	13.7856	13.7856	12	12
SELENIUM T	UG/L	<0.32605	<0.32605	0.726	<0.32605	<0.32605	0.559	<0.32605	0.433	0.763	0.763
SODIUM T	MG/L	41	29.6	25.7	21.43	18.1	19.3	17.7	2	20.8	20.5
STRONTIUM T	UG/L	146	116	107	106	103	105	100	112	116	142
SULFATE T	MG/L	13.799	12.074	11.83	10.825	10.307	9.793	9.55	8.685	10.266	12.129
ZINC T	UG/L	<5.1325	<5.1325	7	<5.1325	8	<5.1325	8	10	<5.1325	7
ALKALINITY @ pH 4.5	MG/L	45.6	41.2	41.4	44	43.2	42.2	41.6	41.6	48	50.8
HARDNESS T	MG/L	79	62	60	61	54	55	52	53	61	68
OSMOTIC PRESSURE	MOSM	24	4	1	4	5	5	4	5	5	4
pH	pH units	7.8	7.45	7.77	7.74	7.67	8.32	8.66	7.58	7.54	7.93
SPECIFIC COND @ 25 C	umhos/cm	374	299	257	232.2	212.7	217.7	210.1	225.2	242	255.9
TDS @ 1800 C	MG/L	220	166	200	150	126	140	128	142	146	138
TOC	MG/L	4.976	5.098	4.914	5.004	5.401	4.97	5.109	5.022	4.804	4.737
TSS	MG/L	<5	8	6	<5	<5	<5	<5	<5	<5	<5
AMMONIA D	MG/L	0.033	0.099	0.019	0.018	0.022	0.01	0.017	0.013	0.019	<0.007
AMMONIA T	MG/L	0.026	0.036	0.021	0.016	0.024	0.015	0.019	0.013	0.01	<0.007
NITRATE & NITRITE D	MG/L	0.882	-	0.546	0.239	0.545	0.409	0.197	0.314	0.457	0.741
NITRATE & NITRITE T	MG/L	0.878	0.662	0.538	0.24	0.551	0.409	0.197	0.314	0.422	0.706
NITROGEN D	MG/L	1.233	-	0.961	0.521	0.868	0.684	0.537	0.614	0.773	0.991
NITROGEN T	MG/L	1.249	0.987	1.058	0.531	0.947	0.703	0.549	0.618	0.734	0.982
ORTHO PHOSPHORUS D	MG/L	0.014	0.003	0.013	0.005	0.02	0.015	0.011	0.034	0.083	0.083
ORTHO PHOSPHORUS T	MG/L	0.016	0.011	0.011	0.004	0.02	0.016	0.012	0.036	0.082	0.086
PHOSPHORUS D	MG/L	0.024	0.019	0.021	0.012	0.013	0.028	0.022	0.045	0.103	0.09
PHOSPHORUS T	MG/L	0.034	0.046	0.031	0.023	0.019	0.043	0.028	0.054	0.1	0.109

Biology: The indigenous aquatic community is an excellent indicator of long-term conditions and is used as a measure of water quality. Benthic macroinvertebrates (Table 4) were collected at the Pipersville site on April 8, 2013, August 27, 2013 and November 10, 2014. Additional benthic macroinvertebrate samples were collected prior to 2013 for methods development purposes on December 18, 2009 and August 20, 2009. Fishes were collected at the Pipersville site on July 22, and July 23, 2009 (sample and duplicate sample) as part of an assessment development effort and on July 16, 2013 and on August 21, 2014 as part of the CIM effort (Table 5).

Table 4. Taxa list for Pipersville benthic macroinvertebrate surveys (yyyymmdd-HHMM-collector).

TAXA	20090820-1035-mlookenbil	20091218-1450-efilip	20130408-1330-sunger	20130827-0930-tstoe	20141110-1030-tstoe
Baetis	13			18	
Heterocloeon	3			2	
Plauditus				5	2
Isonychia	1	1			4
Stenacron				1	
Maccaffertium	1	6		4	16
Ephemerella		1	1		
Serratella	3	14	1		8
Caenis		1			
Tachopteryx					3
Argia		5	3	4	4
Taeniopteryx		1			
Allocapnia		2			
Agnetina		1	2	5	2
Isoperla		2	1		
Chimarra	10	41	38	7	22
Neureclipsis					1
Ceratopsyche		8	3	3	
Cheumatopsyche	9	9	3	7	26
Hydropsyche	3	3	3	2	19
Macrostemum	1	1		1	1
Protoptila	1				
Hydroptila					1
Micrasema	1	1			7
Lepidostoma		3		3	1
Apatania	1				

Table 4 cont. Taxa list for Pipersville benthic macroinvertebrate surveys (yyyymmdd-HHMM-collector).

TAXA	20090820-1035-mlookenbil	20091218-1450-efilip	20130408-1330-sunger	20130827-0930-tstoe	20141110-1030-tstoe
Neophylax	1	2	2		1
Helicopsyche	2				
Petrophila			3		
Psephenus	1	6	11	3	
Microcylloepus				3	
Optioservus	11	12	3	16	16
Stenelmis	25	5	32	57	14
Cryptolabis		1			
Prosimulium		6	52		
Simulium		1		1	3
Chironomidae	8	33	30	14	21
Turbellaria	2	3	6	3	5
Nematoda	1				
Gastropoda		3			
Hydrobiidae	115		8	58	18
Physidae					2
Ancylidae				3	
Sphaeriidae	7	5			
Corbiculidae	2	5		4	1
Hirudinea				1	
Oligochaeta		1		3	
Gammarus		2	7	6	23
Caecidotea		1			
Total	222	186	209	234	221

Table 5. Taxa list for Pipersville site fish surveys (yyyymmdd).

FAMILY	SCIENTIFIC NAME	COMMON NAME	20090722	20090723	20130716	20140821
Anguillidae	*Anguilla rostrata*	American eel	438	260	146	198
Catostomidae	*Catostomus commersonii*	White sucker		13	6	39
Catostomidae	*Erimyzon oblongus*	Creek chubsucker		11	1	14
Catostomidae	*Hypentelium nigricans*	Nothern hog sucker	17	16	9	23
Centrarchidae	*Ambloplites rupestris*	Rock bass	9	5	2	3
Centrarchidae	*Lepomis auritus*	Redbreast sunfish	115	215	117	365
Centrarchidae	*Lepomis cyanellus*	Green sunfish	2	3	1	4
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	1	14		13
Centrarchidae	*Lepomis macrochirus*	Bluegill	10	25	8	28
Centrarchidae	*Micropterus dolomieu*	Smallmouth bass	5	11	5	13
Centrarchidae	*Micropterus salmoides*	Largemouth bass		7		7
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	1		1	
Cyprinidae	*Cyprinus carpio*	Common carp	3	3	8	3
Cyprinidae	*Notropis amoenus*	Comely Shiner			1	6
Cyprinidae	*Cyprinella analostana*	Satinfin shiner	97	153	22	103
Cyprinidae	*Cyprinella spiloptera*	Spotfin shiner	17	11		
Cyprinidae	*Notropis hudsonius*	Spottail Shiner			7	13
Cyprinidae	*Exoglossum maxillingua*	Cutlips minnow	11	21		28
Cyprinidae	*Luxilus cornutus*	Common shiner	6	17	32	132
Cyprinidae	*Rhinichthys atratulus*	Blacknose dace		3		15
Cyprinidae	*Rhinichthys cataractae*	Longnose dace				31
Cyprinidae	*Semotilus corporalis*	Fallfish			1	
Cyprinidae	*Semotilus atromaculatus*	Creek chub	7	6	6	40
Esocidae	*Esox niger*	Chain pickerel	1	1		4
Fundulidae	*Fundulus diaphanous*	Eastern banded killifish	19	18	1	30
Ictaluridae	*Ictalurus natalis*	Yellow bullhead	2	1		
Ictaluridae	*Ictalurus nebulosus*	Brown bullhead				1
Ictaluridae	*Ictalurus punctatus*	Channel catfish			1	
Ictaluridae	*Noturus insignis*	Margined madtom	6	6	5	88
Percidae	*Etheostoma olmstedi*	Tessellated darter	20	39	7	118
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout (stocked)	1	1		
Salmonidae	*Salmo trutta*	Brown trout (stocked)	2			

ASSESSMENT:

Continuous: Continuous instream monitors (CIMs) record instream parameters that have defined water quality standards (WQS) in 25 Pa Code §93.7 (temperature, pH and DO). Certain conditions must be met in order to properly assess data from CIMs. Any readings that do not comply with the applicable numeric WQS criteria are considered exceedances and are reviewed to determine if representative of the stream segment and if representative of natural quality as stated in 25 Pa Code §93.7(d). All data reviews are consistent with requirements as described in 25 Pa Code §96.3 which includes the 99 percent frequency measurement rule.

Defining Criteria Exceedance

The WQS criteria for pH and DO are expressed as either a discrete minimum, discrete maximum, or as a daily average (continuous 24-hour period, §93.1) concentration. The individual recordings exceeding the listed criteria are summed and the percent of the year (%Y) that those readings represent is calculated using the following equation:

$$\%Y = 100 * [n / (525{,}600 / i)]$$

Where

n = number of exceedances
i = recording interval in minutes
The constant (525,600) is the number of minutes in a year (365 days * 24 hrs/day * 60 min/hr)

If %Y > 1, then the criterion is not achieved 99% of the time as required by §96.3(c), and the waterbody is considered in violation of water quality standards. A period of one year is applied as a rolling year to avoid arbitrary divides as with a calendar year or water year. The 99 percent frequency measurement calculation is based on one continuous 365-day period.

Sampling Critical Time Periods

Temperature, pH and DO are all affected by seasonal change and can, therefore, be predicted to a certain degree. For example, CIMs may be deployed during the growing season when increases in instream production and respiration occur. The Department's CIM efforts have documented increases in pH values, increases in diel pH fluctuation, corresponding decreases in DO values, and increases in diel DO fluctuation beginning in early spring and persisting through the fall. This correlates with increased photoperiod and increased air and surface water temperatures. The effect of increased temperature and photoperiod to increased instream production and respiration are well documented (Odum 1956, Strickland et al. 1970, Neori and Holm-Hansen 1982, Raven and Geider 1988). Diel fluctuation is the difference of minimum and maximum values over a 24-hour period. This is caused by both plant photosynthetic activity and respiration throughout the day and community respiration at night (Odum 1956, White et al. 1991, Wurts 2003). An increased photoperiod with adequate nutrition will increase the standing biomass of photosynthetic organisms (Valenti et al. 2011). Phosphorus has been documented to be the limiting factor of standing biomass in freshwater systems (Stevenson 2006), however other studies indicate increased nitrogen and phosphorus can produce

higher biomass than nitrogen or phosphorus alone, suggesting co-limitation (Carrick and Price 2011). During the growing season, pH is most likely to exceed maximum criteria (9.0) and DO to fall below the minimum criteria or 7-day average as described in §93.7, for each critical use. Sampling during critical periods may give sufficient information to make an assessment decision and greatly reduce the amount of resources needed to conduct the survey.

The Department must also recognize that critical or limiting conditions may not be consistent year-to-year, and a single year of data may not accurately represent conditions that water quality standards were developed to protect. Typically, this is driven by the amount and timing of precipitation for a given period or year. Elevated precipitation will result in increased surface water discharge, which moderates limiting conditions characterized by temperature, pH and DO. The Department has documented in past surveys that elevated discharge can reduce daily DO, pH, and temperature fluctuations and increase daily minimum DO values and decrease maximum pH and temperature values. It is imperative to characterize conditions that drive critical or limiting conditions, and reference those conditions as part of the protected use assessment and subsequent reassessments.

CIM, Temperature

Temperature criteria in §93.7 are applied to heated waste sources regulated under 25 Pa Code Chapters 92a and 96. Temperature limits apply to other sources when they are needed to protect designated and existing uses. An appropriate thermal evaluation includes a biological assessment based on instream flora and fauna to determine whether the biological community is affected by the thermal regime. Typically, fish community evaluations have the best resolution in characterizing a waterbody's thermal regime due to the effects to physiology and distribution patterns (Shuter et al. 1980, Ridgeway and Shuter 1991, Azevedo et al. 1998, Wehrly and Wiley 2003, Lyons et al. 2009). CIM temperature data is not typically used to assess critical uses. However, High Quality criterion in § 93.4b (a)(1)(i), "The water has long-term water quality, based on at least one year of data which exceeds levels….at least 99% of the time…" for a list of parameters including temperature may be applied to qualify as a High Quality Water.

CIM temperature data was compared to temperature criteria found in Table 3 of §93.7. CIM data collected 2008 through 2014 do not meet CWF, TSF or WWF temperature criteria in §93.7 99% of the time (Table 7). Generally, temperatures are more elevated in downstream reaches. In 2008 UPS Randts Mill Road had an average summer temperature of 23.8°C and a maximum of 31.4°C; while the downstream site, Stover Park Road had an average of 24.8°C and maximum of 32.4°C (Figure 10). In 2012 UPS South Park Road had an average summer temperature of 17.6°C and a maximum of 25.6°C; while the downstream site, Pipersville, had an average of 23.9°C and maximum of 32.7°C (Figure 11).

Prior to 2012, it has been determined that Nockamixon Dam may not have been meeting its conservation release due to inoperable release valves. This may have resulted in significantly reduced flows and a subsequent reduced ability for Tohickon Creek to naturally assimilate elevated summer air temperatures. Nockamixon Dam was completed in 1973 with the ability to release water to Tohickon Creek via bottom (cold water) and surface (spillway) releases. Originally, it was intended that bottom, cold water would be released to promote a cold water fishery on the Tohickon Creek mainstem below the dam. The UPS South Park Road site is very near the outfall of

Nockamixon Dam and repairs to a release valve may have resulted in much lower temperatures just below the dam when compared to the Pipersville site, which is located approximately six stream miles downstream.

Table 7. CIM temperature data when compared to temperature criteria found at §93.7.

Site - Year	Meets CWF	Meets TSF	Meets WWF
UPS Randts Mill Road – 2008*	32%	76%	92%
Stover Park Road – 2008*	53%	79%	94%
UPS South Park Road – 2012*	48%	88%	92%
UPS South Park Road – 2013	53%	82%	97%
Pipersville – 2012*	13%	53%	79%
Pipersville - 2013	51%	80%	94%
Pipersville - 2014	49%	87%	98%

* based on data graded 'Unverified' (PA DEP, 2013a)

CIM, pH

Pennsylvania pH criteria originate from the EPA Blue Book 1972, which included four tiers of protection with maxima ranging from 8.5 – 9.5. The four tiers provided the opportunity for less stringent criteria and were admittedly driven by socioeconomic factors (EPA 1972). In 1999 pH criteria of 6.0 – 9.0 inclusive was adopted and represent pH criteria in §93.7. Maxima values were supported by Salmonidae, Ictaluridae and Perca tolerance limits. Impacts to benthic macroinvertebrates were not realized until excursions of 9.5 (EPA 1972).

Adverse effects of pH excursions to aquatic communities are well documented, with select fish species being the most sensitive organisms (Alabaster and Lloyd 1980, Murray and Ziebell 1984). Gill damage is the primary effect to fish with subsequent effects including hypoxia, the reduced ability to maintain ionic-regulation and acid-base balance, the inability to secrete waste products such as ammonia (NH_3) and toxics such as heavy metals (Alabaster and Lloyd 1980, Evans 1987, Boyd 1990). Most salmonids are not tolerant of elevated pH (Hartman and Gill 1968, Alabaster and Lloyd 1980). Other fish species (*Lepomis* spp., *Carassius auratus*, *Micropterus salmoides*, *Micropterus dolomieu*) that are more common in warm water riverine environments, have been documented to be more tolerant of elevated pH excursions (Wiebe 1931).

Rapid fluctuations in pH can also be harmful to aquatic fauna causing stress and death (Murray and Ziebell 1984). Studies have shown that rapid fluctuations in pH can be tolerated if the fluctuation occurs within the organism's tolerance range (Alabaster and Lloyd 1980, Murray and Ziebell 1984, Belangor 1990). An organism can tolerate excursions outside its tolerable range if the pH is modified slowly. As the pH approaches and exceeds an organism's acceptable range, the organism is less likely to acclimate to rapid fluctuations (Murray and Ziebell 1984).

CIM pH data collected in 2008 at the UPS Randts Mill Road (98%) and the Stover Park Road (98%) sites, does not meet the criteria maximum (9.0) found at §93.7 at least 99% of the time. CIM pH data collected at the Pipersville site in 2013 and 2014 does meet the criteria maximum (9.0) found at §93.7 at least 99% of the. Daily fluctuations in pH were greatest at both 2008 sites in April with fluctuations greater than 2.0 standard units (SU). Fluctuations decreased through May before increasing

throughout the growing season reaching maximum fluctuations of approximately 1.5 SU by late-July (Figure 15). At Pipersville in 2013, daily fluctuations were as high as 1.8 SU in April and reached a maximum fluctuation of 1.92 SU in early-October. At Pipersville in 2014, daily fluctuations in April were reduced, reaching 0.92 SU. The Pipersville site reached a maximum fluctuation of 1.71 SU in August and again in September, 2014 (Figure 16).

CIM, DO

Pennsylvania DO criteria were recently updated, which increased the minimum to 5.0 mg/l for TSF and WWF in order to protect early life stages of fish species year-round. Studies have shown that larval life stages are more sensitive than embryonic and adult life stages (PA DEP 2013c). Dissolved oxygen concentration less than 5.0 mg/l has been documented to decrease growth rate, swimming speed, increase avoidance, and larval weight (Doudoroff and Shumway 1970, Spoor 1984). Elevated nutrients (nitrogen and phosphorus) are often correlated with decreased instream DO concentrations (Stevenson 2006, King 2009, Carrick and Price 2011), although nitrification and sulfur and iron oxidation are processes that have also been offered as causes of low instream DO.

CIM DO data was collected at the Pipersville site in 2013 and again in 2014. DO data met the criteria minimum (5.0 mg/l) found at §93.7 at least 99% of the time for each targeted year. Maximum daily fluctuations exceeded 6.0 mg/l on October 1, 2013 and reached a maximum fluctuation of 7.71 mg/l on October 3. In 2014 the maximum daily fluctuation of 5.02 mg/l occurred on July 14, 2014 (Figure 17).

Biological: The benthic macroinvertebrate community indicates water quality is slightly above impairment thresholds. While taxa diversity ranges moderate to high, dominant taxa for each sample except 20130408-1330-sunger were pollution tolerant caddisflies and snails. Sample 20130408-1330-sunger was dominated by an early spring blackfly that is typically an artifact of sample timing and not water quality. Benthic macroinvertebrate metrics are indicative of an impacted watershed (Table 8).

Table 8. Pipersville Benthic Macroinvertebrate Metric calculations.

Sample (yyymmdd-HHMM-collector)	IBI	Richness	Mod EPT	HBI	% Dom	% Mod May	Beck3	Shannon Div
20091218-1450-efilip	72.9	32	13	4.39	22.0	11.8	10	2.78
20090820-1035-mlookenbil	48.8	23	11	6.55	51.8	3.6	5	1.92
20130408-1330-sunger	54.9	19	6	4.28	24.9	1.0	6	2.25
20130827-0930-tstoe	52.8	26	8	5.68	24.8	5.1	5	2.48
20141110-1030-tstoe	62.8	25	10	4.88	11.8	13.6	5	2.76

The Tohickon Creek fish assemblage appears to be in relatively decent condition when compared to other streams in the surrounding Piedmont ecoregion. Species richness, which generally increases with stream size and decreases with increased anthropogenic stress (Karr 1986, Daniels 2002), ranged from 21 to 26 species from 2009 to 2014. Tohickon Creek is approximately 15-25 meters in width at fish sampling sites, with a Strahler stream order of 4. For this size of stream, maintaining a species richness of greater than 20 is excellent when considering the naturally depauperate Atlantic Slope fishery (Daniels 2002). Tohickon Creek supports a well-balanced fishery with species spanning all expected functional

feeding groups, habitat groups, and tolerance groups. The fish assemblage was dominated by fishes in the cool thermal preference group in the 2009 and 2013 surveys and was dominated, albeit slightly, by cool-warm fishes in both of the 2014 surveys (Eaton 1996, Lyons 2009), which may be slightly warmer than expected based on the size of the drainage area.

SUMMARY:

Continuous monitoring, in-situ lab chemistries, and biological data all suggest anthropogenic influences on the lower Tohickon Creek. While continuous monitoring indicates that pH and DO in 2013 and 2014 at the Pipersville site meet WQS at least 99% of the time, elevated daily fluctuations indicate concerning levels of instream production likely due to nutrients (nitrogen and phosphorus) (Tables 2 & 3). Nutrients with adequate temperature and photoperiod will increase the standing biomass of photosynthetic organisms (Odum 1956, Strickland et al. 1970, Neori and Holm-Hansen 1982, Raven and Geider 1988, Rosemond et al. 1993, Mosisch et al. 2001, Valenti et al. 2011). An increase in biomass drives successive increases in production and respiration activity promoting increased daily fluctuations in both DO and pH (Odum 1956, White et al. 1991, Wurts 2003).

The Tohickon Creek basin consists of a mixture of agricultural (37%), forest (48%), urban/developed (4%), and wetland/water/transitional (11%) land use. In addition, there are over 250 active Water Pollution Control Facility permitted discharges. A significant concentration both of point and nonpoint source influences contribute to the water quality upstream of Lake Nockamixon. Lake Nockamixon is located in the middle of the basin and upstream of all the 2008 – 2014 CIM stations. Lake Nockamixon is currently listed on the 303(d) list of impaired waters for Sources: 'on site wastewater', 'agriculture', 'municipal point source' and Causes: 'nutrients' and 'suspended solids'. CIM temperatures just downstream of Nockamixon Dam are typically lower than those at downstream sites, but none of the data series meets CWF, TSF or WWF temperature criteria in §93.7 99% of the time (Table 7).

REVISION NOTES, FEBRUARY 2017:
Revisions were made to the 'Assessment' section of this report, and reflect changes to the Department's assessment of CIM data. Previously, in evaluating CIM data, the Department had taken into consideration the analytical uncertainty of the method used to measure the data when an ambient measurement is compared to a numeric Water Quality Standard (WQS) criterion; this is inconsistent with the Department's established Assesment Methods. Revisions to the Tohickon CIMR also include updates to the 99 percent frequency measurement rule (25 Pa Code §96.3) evaluation. These changes result in a decrease of a majority of the percent value results comparing CIM temperature data to temperature criteria found at §93.7 (Table 7). In addition, percent value results comparing CIM pH data collected in 2008 at the UPS Randts Mill Road and Stover Park Road sites decreases from 99% to 98% for both sites. CIM pH data collected at the Pipersville site in 2013 and 2014 meets the criteria maximum (9.0) found at §93.7 at least 99% of the time.

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