pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Continuous Instream Monitoring Report (CIMR)

Most recent revision: 9/8/2014
Revised by: Jeffery Butt

STATION DESCRIPTION:
STREAM CODE: 20345
STREAM NAME: Mill Creek
SITE CODE: 66909423
SITE NAME: Lake Mokoma – Mill Creek

COUNTY: Sullivan

LATITUDE: N41°24’31.2336” **LONGITUDE:** W76°29’32.8668”

LOCATION DESCRIPTION: Approximately 100 meters upstream of confluence with Lake Mokoma

HUC: 02050206

DRAINAGE AREA: 0.68 sq. miles

BACKGROUND AND HISTORY: Mill Creek is a freestone tributary to Loyalsock Creek. This report concerns only the uppermost portion of Mill Creek within Laporte Township, Sullivan County (Figures 1 & 2) and is restricted to that portion upstream of Lake Mokoma. There, the Mill Creek basin is characterized by rolling hills with land use consisting mostly of forest cover (97%) and a small portion (0.7%) described as urban landscape.

The purpose of this survey was to collect baseline data on Mill Creek prior to possible Marcellus gas well development. Additional surveys and associated reports were also completed on Conklin Run and Doe Run (local name), tributaries to Lake Mokoma on Lake Mokoma Home Owners Association land.

Continuous data was initially collected in Mill Creek with a Solinst three-parameter data logger then later by an Onset Hobo two-parameter data logger. Water chemistries and discrete field parameters were collected periodically during the period of the sonde deployment. Sonde deployment began on May 4, 2011 and concluded on July 26, 2012.

The primary objectives of the assessment were to:

1. Characterize baseline water temperature, specific conductance, and depth using 24-hour monitoring and water chemistry.
2. Characterize baseline biological communities.

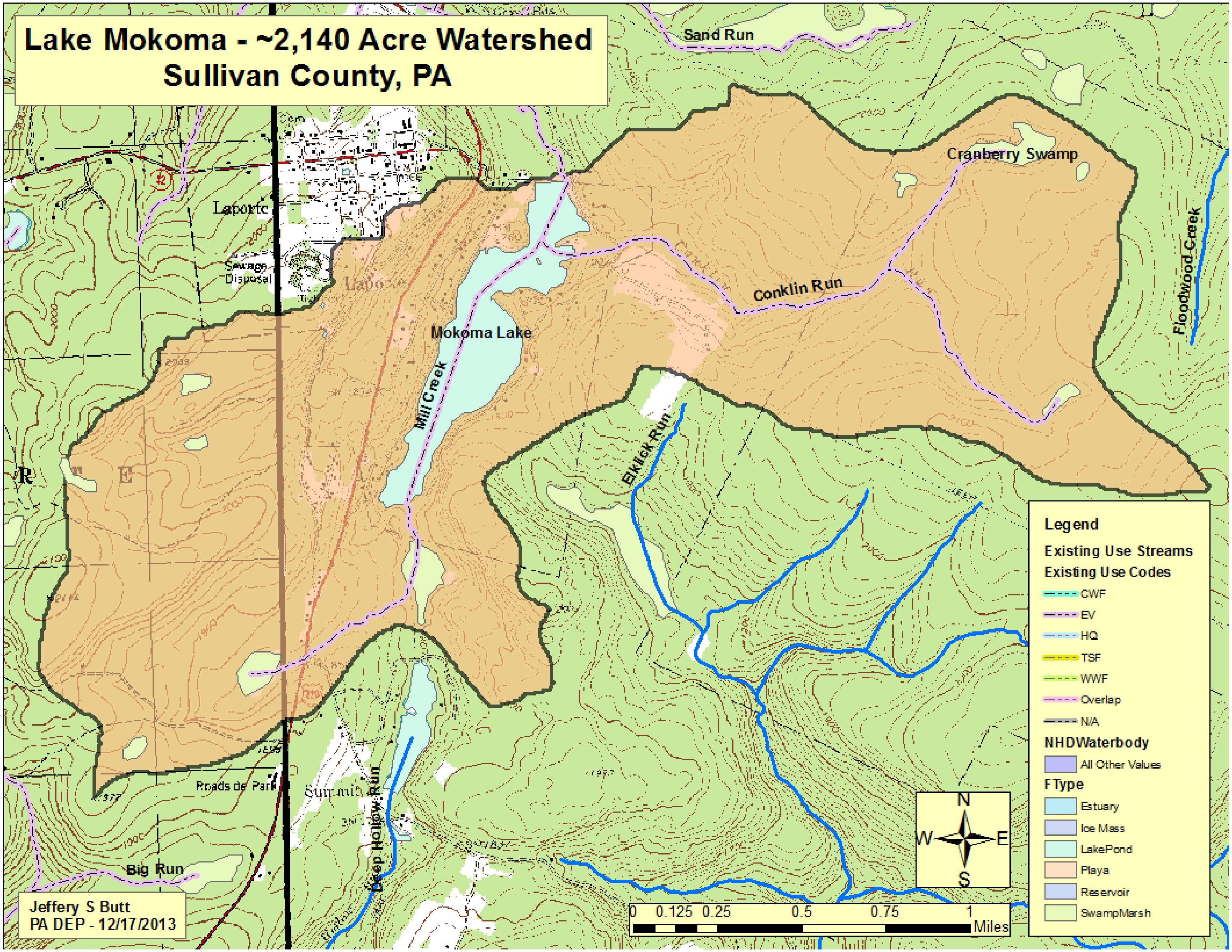

Figure 1. Map of Lake Mokoma Watershed.

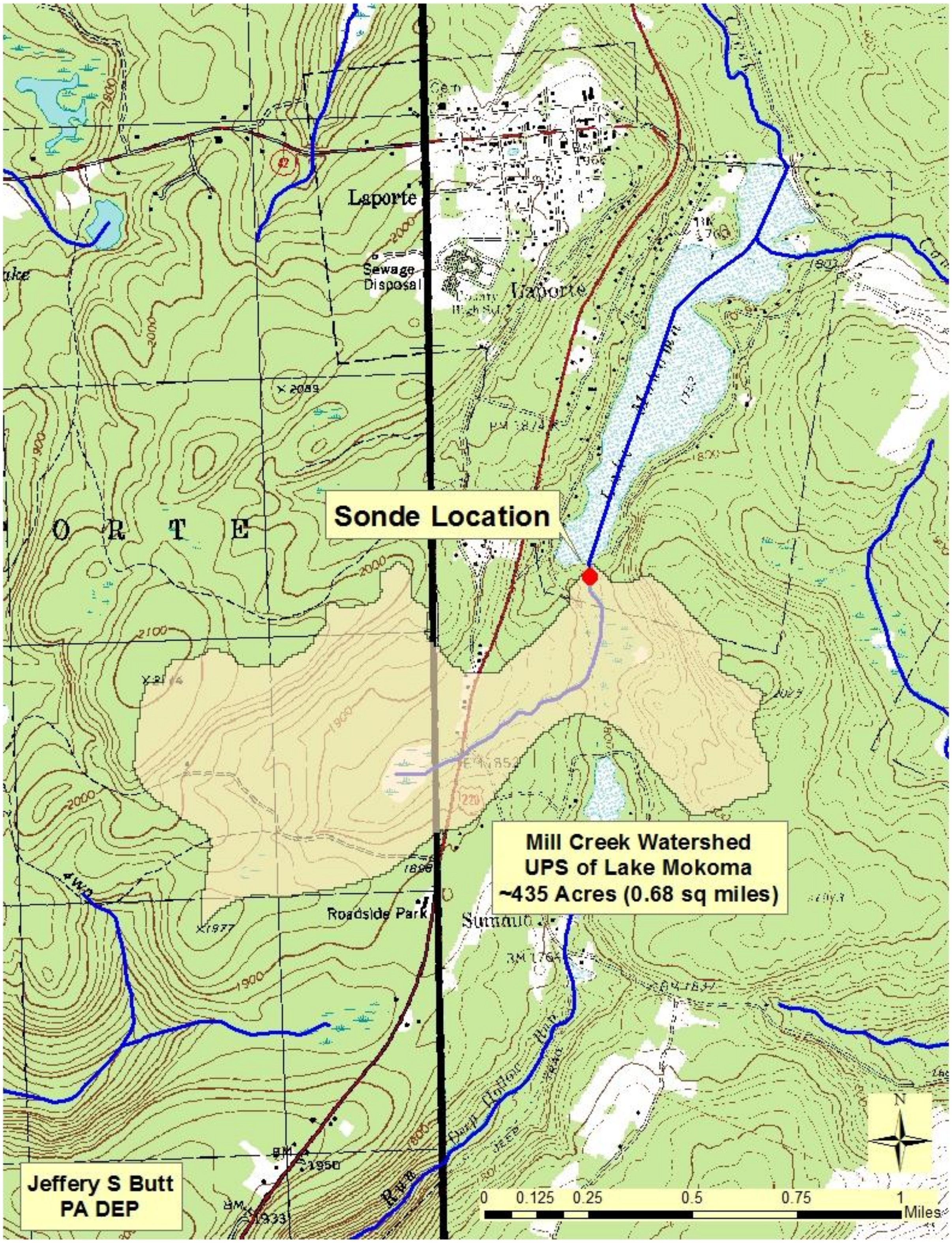

Figure 2. Map of Mill Creek Watershed UPS of Lake Mokoma.

WATER QUALITY PARAMETERS:

Parameter	Units
Depth	Feet
Water Temperature	°C
Specific Conductance (@25°C)	μS/cm[c]

EQUIPMENT:

Two different instruments were used to record continuous stream data in Mill Creek. A Solinst Levelogger (Serial #1060770) was deployed initially from May 4, 2011 to January 25, 2012 then later from February 1, 2012 to July 26, 2012. An Onset Hobo temperature/conductivity data logger (Serial # 9896834) was also used at this station. The Hobo data logger was initially deployed on October 3 2011 to December 19, 2011 then redeployed on February 15, 2012 and remained in continuous service until it was pulled from the site on July 26, 2012. The Solinst recorded temperature, specific conductance, and depth parameters. The Onset Hobo recorded temperature and specific conductance only. A Yellow Springs Instruments (YSI) ProPlus and a 6920-V2 were used as field meters during sonde maintenance and data retrieval visits.

The Onset Hobo data logger was housed in a protective PVC shroud. This shroud contained many drilled holes to allow for water flow through. Both the Hobo PVC shroud and the Solinst Levelogger were anchored by being clipped directly to the stream rebar. The stream rebar included a top-mounted eye bolt attachment to which the Solinst and Hobo data loggers were clipped. This rebar was driven into the stream bed so as to locate the data loggers in the thalweg.

A Solinst Levelogger (serial #1061914) was used at the Mill Creek site to record barometric pressure. Barometric pressure was then used to correct stream depth for all four of the Lakes Mokoma and Lake Wood stream monitoring stations.

PERIOD OF RECORD: In general, the period of record for Mill Creek is May 4, 2011 to July 26, 2012. However a short interruption in the continuous record occurred from January 25, 2012 to February 1, 2012 due to Solinst calibration issues. No interruption in the record occurred as a consequence of Hurricane Irene (late August 2011) or Tropical Storm Lee (early September 2011). Other interruptions in the record for individual parameters may have been invoked as a consequence of data being declared unusable during the data approval process.

The stream mounted Solinst Levelogger was revisited eleven times during its period of deployments for the purpose of downloading data, checking calibration, and cleaning. The Hobo data logger was revisited five times.

The barometric pressure Solinst Levelogger was deployed continuously from February 1, 2012 to July 26, 2012. It was revisited for data downloading four times during its deployment.

DATA:

Water chemistry was collected twelve times during the deployment period and once after sonde extraction on June 27, 2013. Benthic macroinvertebrates were collected on November 30, 2011 and on April 10, 2012 using the Department's ICE protocol (PA DEP, 2013a). No fish samples were collected due to an extremely low water condition in July of

2012. Continuous data are graded based on a combination of fouling and calibration error (PA DEP, 2013b).

Depth (stage): Depth measured by this non-vented Solinst Levelogger is actually the measure of water column pressure plus atmospheric pressure. Changes in atmospheric pressure while the sonde was deployed appear as changes in depth. Data from the beginning of monitoring to February 1, 2012 (vertical line) were not corrected for barometric pressure. Data recorded after 1300 hours on February 1, 2012 were corrected for barometric pressure. Barometric pressure was measured with a Solinst Levelogger mounted in air. Figure 3 demonstrates the appreciable influence barometric pressure has on non-vented pressure sensors. Depth (stream stage) is used qualitatively for the interpretation of changes in other parameters.

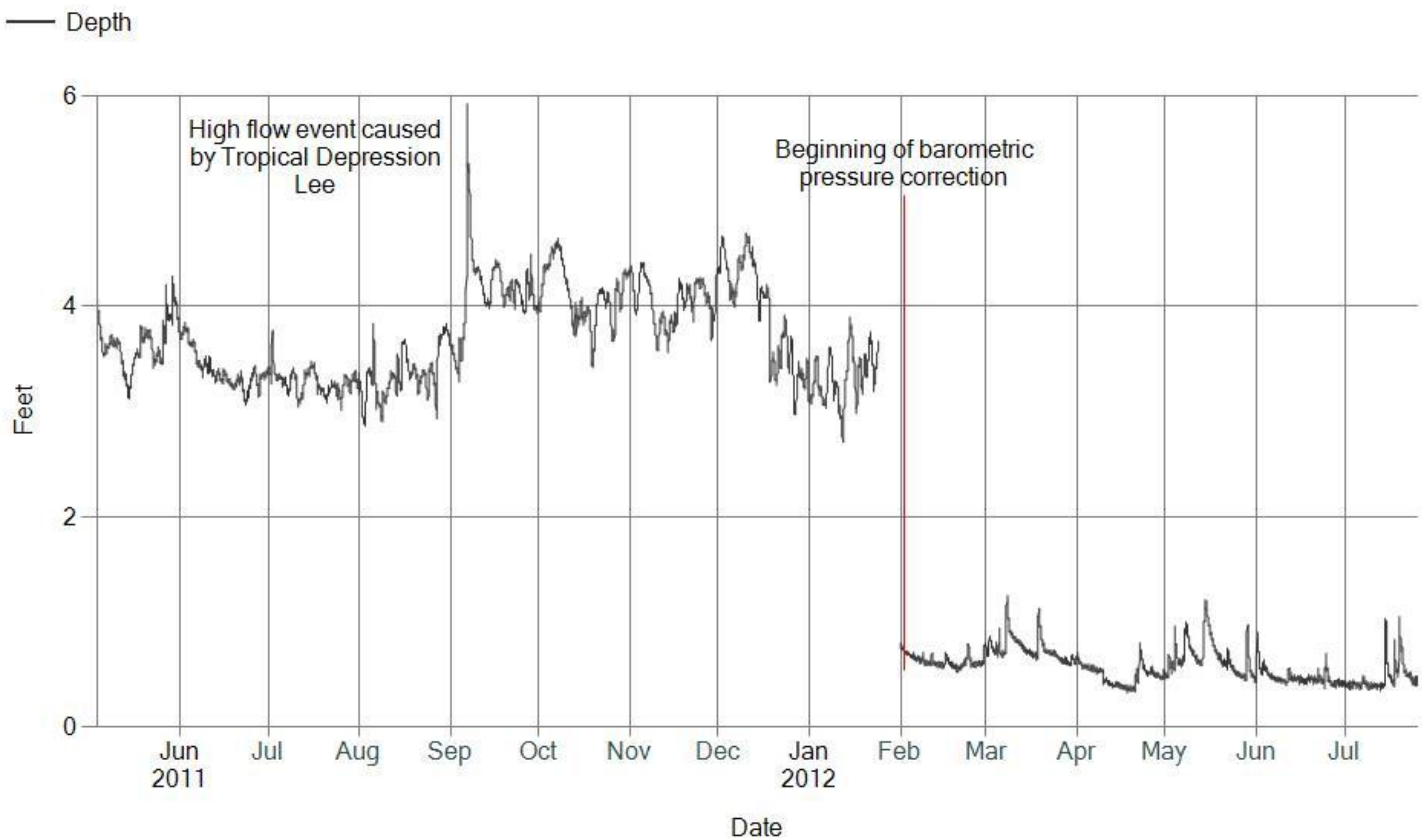

Figure 3. Continuous depth data for May 4, 2011 to July 26, 2012.

Water Temperature: Solinst Average: 10.6°C; Solinst Maximum: 24.0°C; Solinst Minimum: -0.55°C. Hobo Average: 9.93 °C; Hobo Maximum: 22.7°C: Hobo Minimum: -0.36°C. Differences between these Solinst and Hobo average, maximum, and minimum temperatures are due in part by the unequal deployment periods of the two data loggers. Figure 4 shows the Solinst record. Figure 5 shows the Hobo record. Figure 6 shows the difference between the Solinist and Hobo usable data records, as defined by PA DEP, 2013b. Temperature variation in the Solinst and Hobo record are due primarily to seasonal climate variation, daily weather variation, and normal diurnal fluctuation.

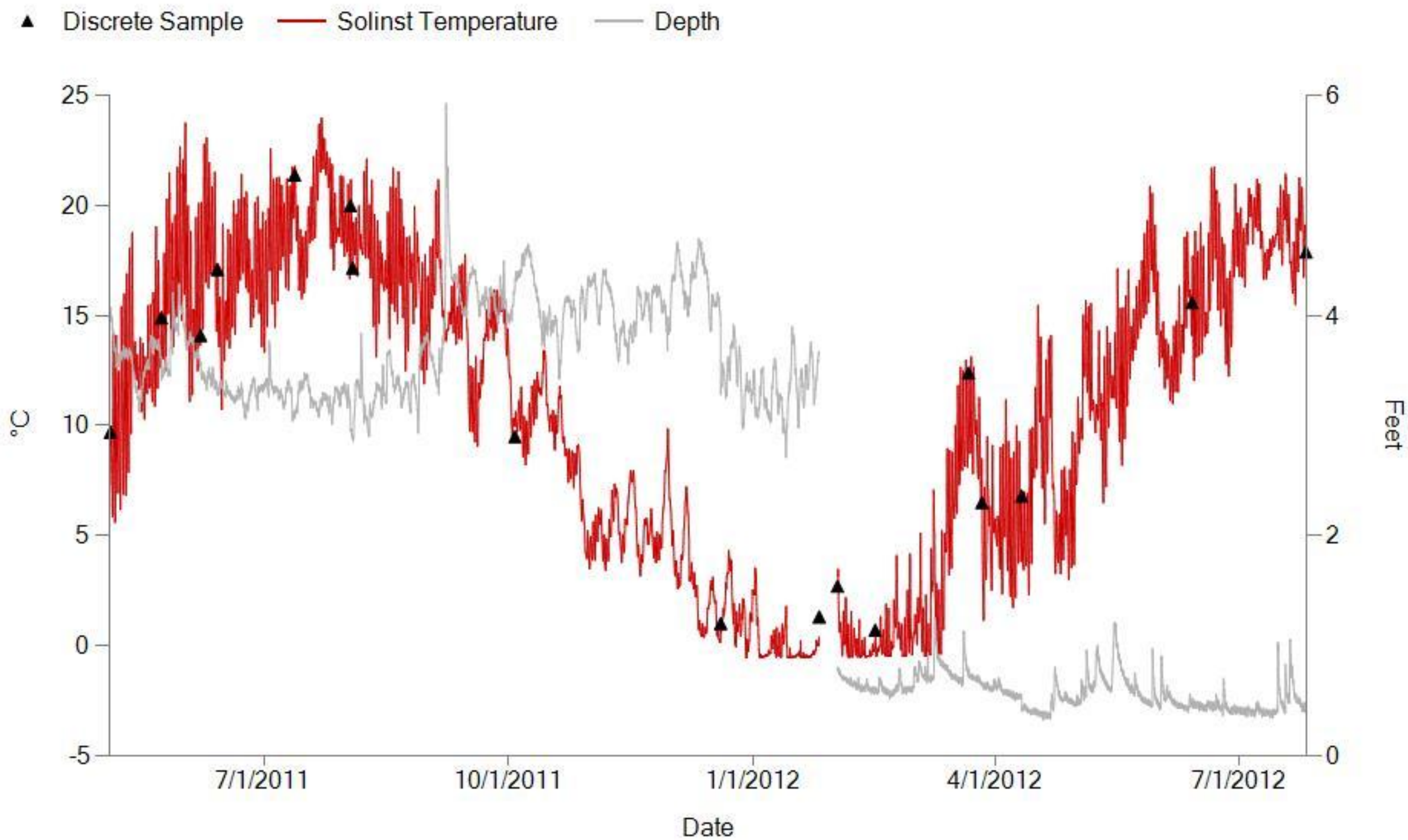

Figure 4. Solinst continuous water temperature, continuous depth, and discrete samples from May 4, 2011 to July 26, 2012.

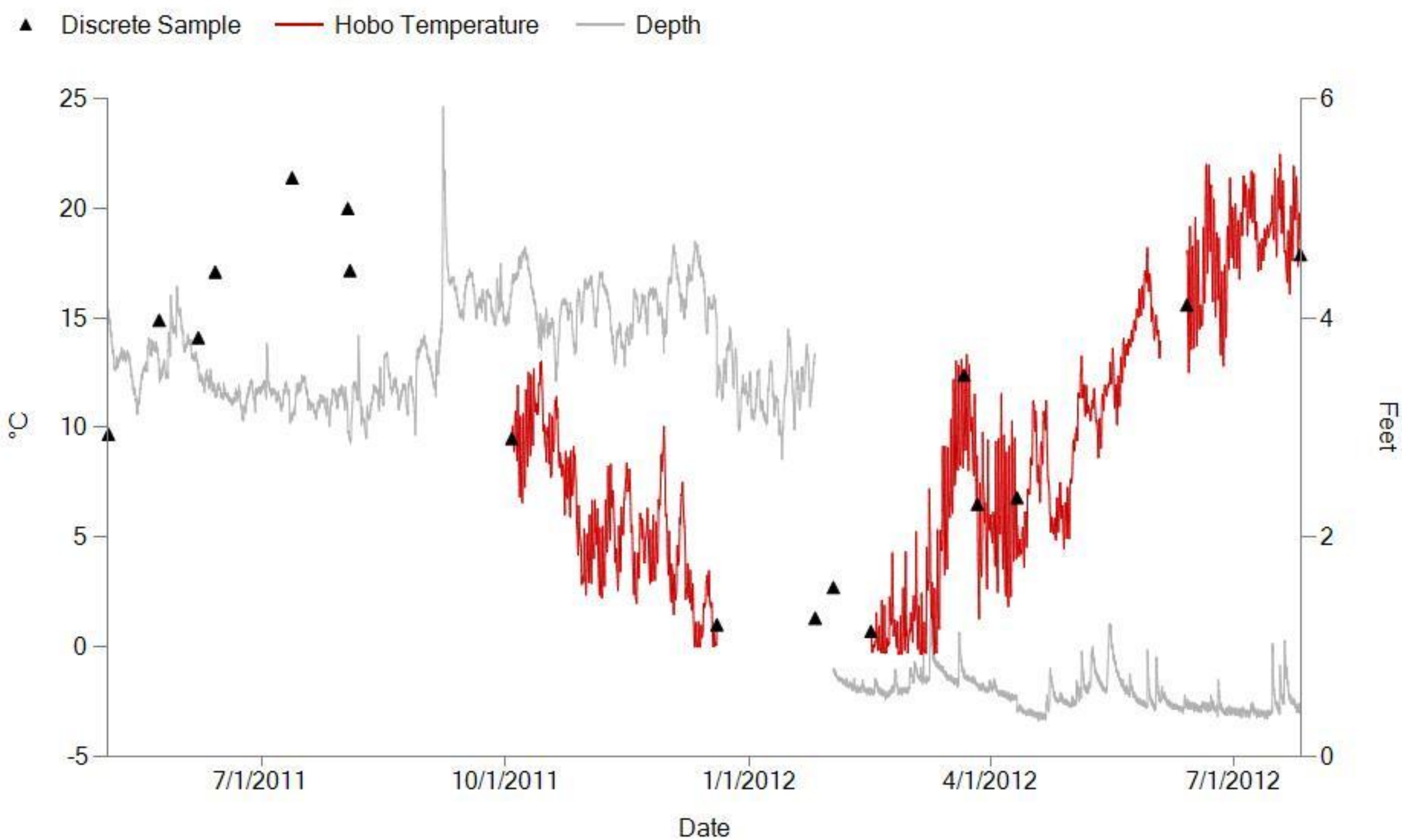

Figure 5. Hobo continuous water temperature, continuous depth, and discrete samples from May 4, 2011 to July26, 2012.

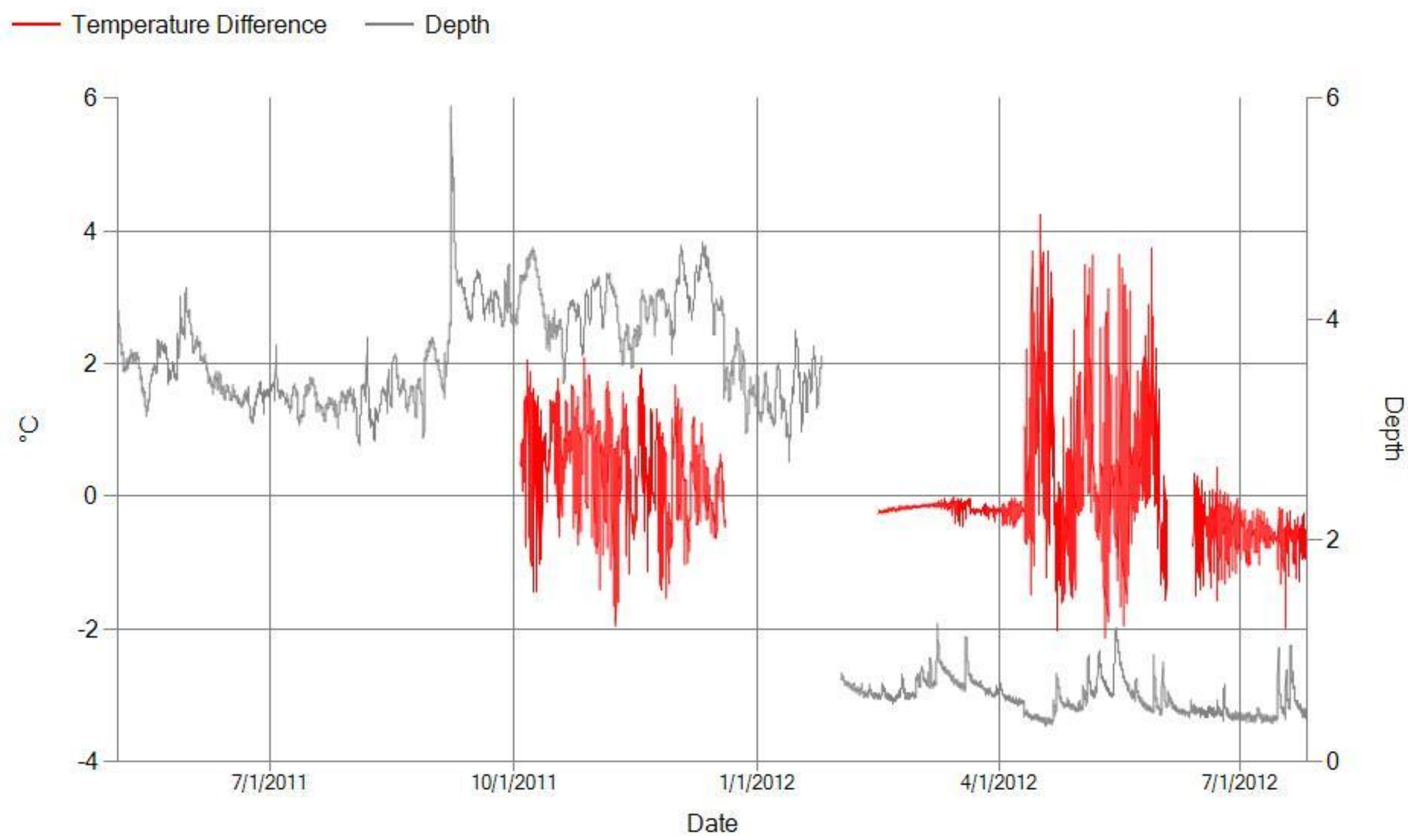

Figure 6. Temperature difference between Solinst and Hobo data loggers, and depth from May 4, 2011 to July 26, 2012.

The temperature difference is shown only for that part of the record in which Solinist and Hobo usable data overlap. The temperature difference is numerically equal to the Solinst temperature minus the Hobo temperature. Often, the Solinst recorded a higher temperature than did the Hobo (indicated by a positive difference). Even though the two data loggers were mounted in the same location, differences between the two frequently exceeded ± 0.2 °C (equal to 0.1°C advertised accuracy of Solinst plus the 0.1°C advertised accuracy of the Hobo) and also frequently exceeded ±1.6°C (two times the 0.8°C USGS usable data allowance permitted for each logger). However, data from each logger graded as usable (within the 0.8°C USGS tolerance for usable data) based upon fouling error and discrete error checks at the end of each maintenance period. Temperature differences appear to be unrelated to depth.

Specific Conductance: Figure 8 shows the Hobo record. Figure 9 shows the difference between the Solinst and Hobo data records. Importantly, the continuous specific conductance Solinst and Hobo record should not be used for quantitative analysis because it has been declared as UNVERIFIED by PA DEP 2013b. However, the record may be used to make qualitative inferences. There is a relationship between specific conductance and flow (as characterized by depth) and this relationship is demonstrated in Figure 10.

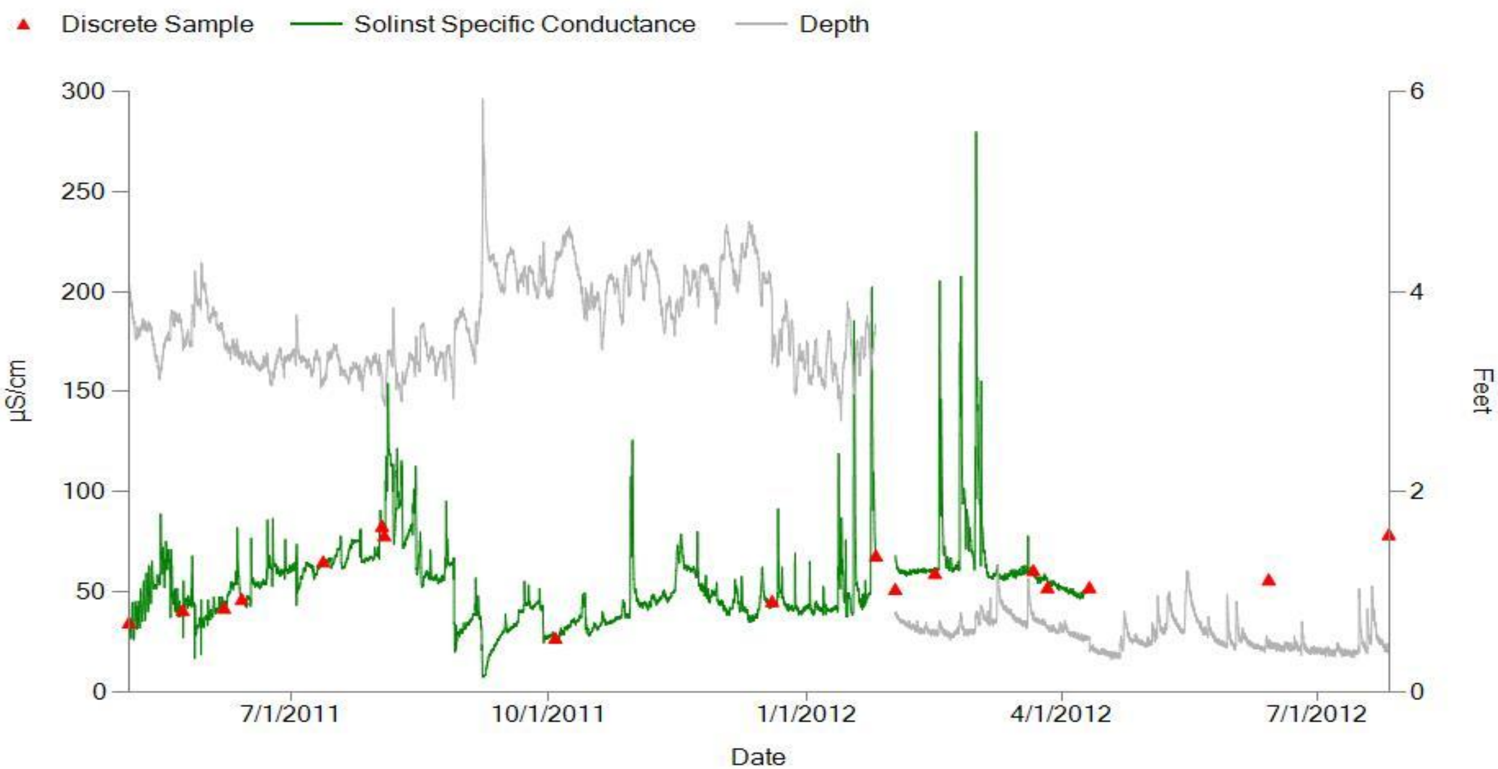

Figure 7. UNVERIFIED Solinst continuous specific conductance, continuous depth, and discrete samples from May 4, 2011 to July 26, 2012.

All Solinst data graded as unverified due to data logger calibration issues occurring throughout the period of deployment.

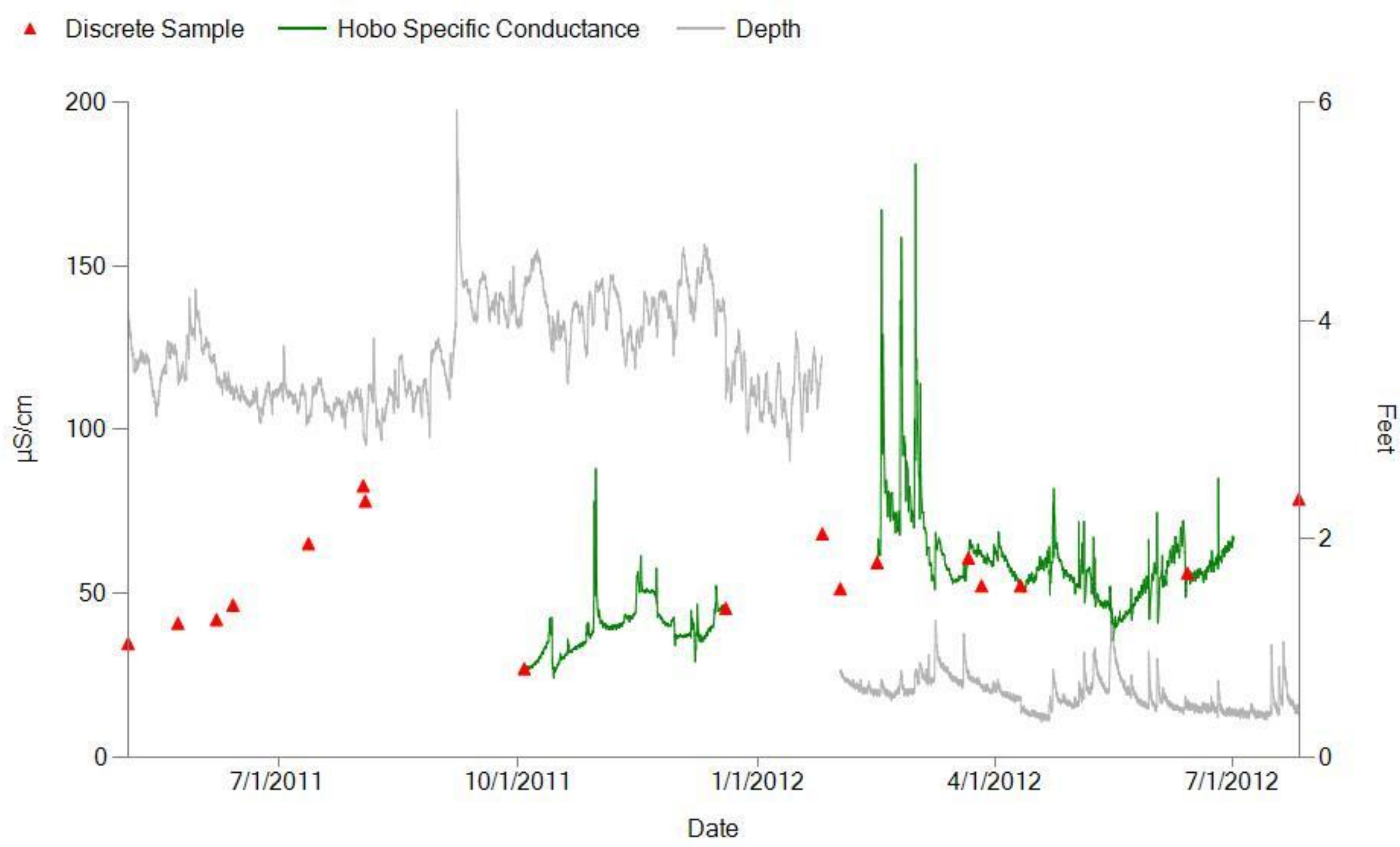

Figure 8. UNVERIFIED Hobo continuous water temperature, continuous depth, and discrete samples from May 4 2011 to July 26, 2012.

All Hobo was data graded as unverified due in part to the inability to calibrate Hobo data loggers.

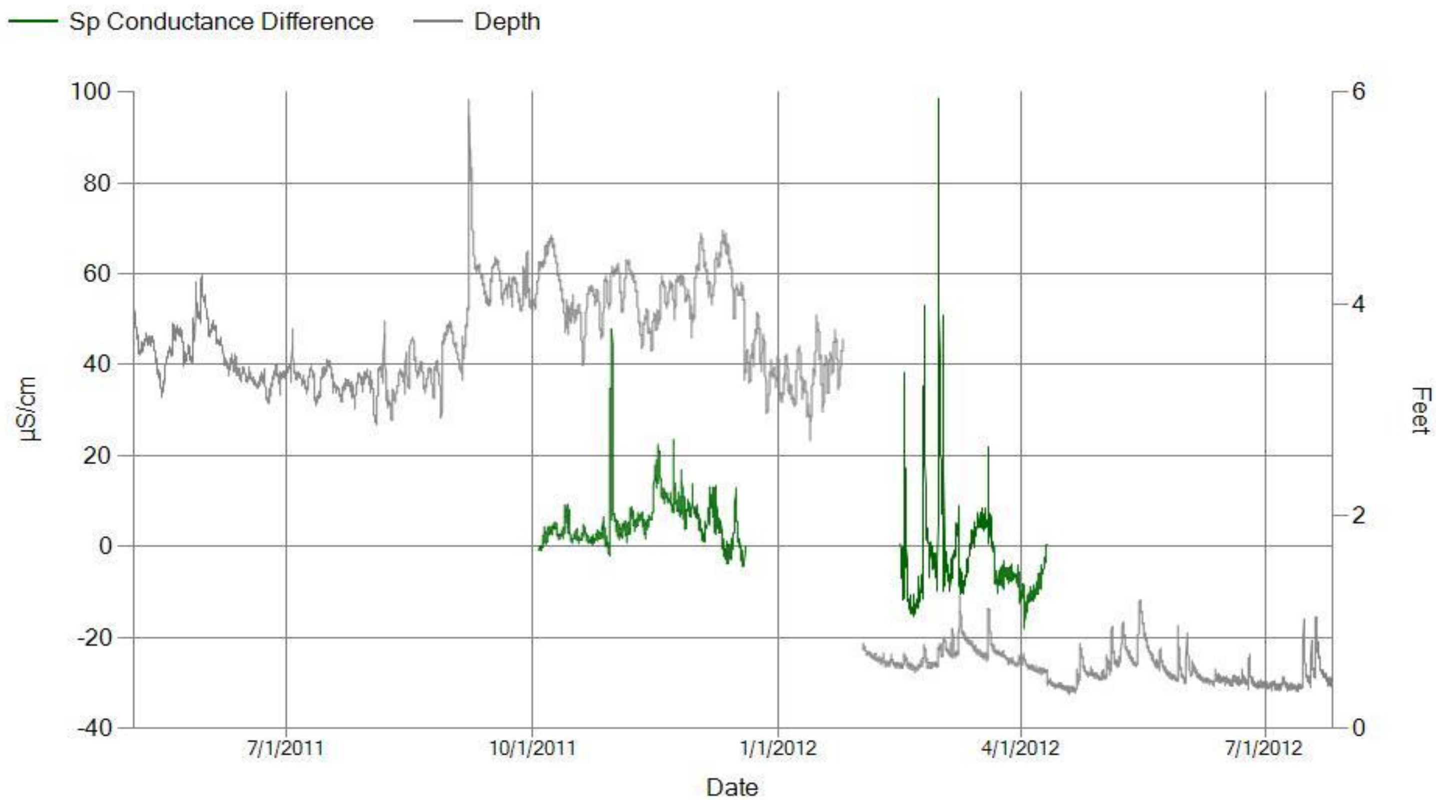

Figure 9. UNVERIFIED specific conductance difference between Solinst and Hobo data loggers, and depth from May 4, 2011 to July 26, 2012.

The specific conductance is shown only for that part of the record in which the Solinst and Hobo unverified data overlap. The specific conductance difference is numerically equal to the Solinst specific conductance minus the Hobo specific conductance. In general, a quantitative assessment of the specific conductance differences between the two data loggers is not possible due to the unverified nature of the Solinist and Hobo data (unlike temperature). Differences in specific conductance between the two data loggers therefore should be considered only in qualitative terms. The qualitative assessment of this difference then suggests that the two data loggers differed appreciably in recorded specific conductance often to a degree equivalent in magnitude to the actual measurement.

Elevated Specific Conductance Events: Several elevated specific conductance events occurred in Mill Creek during the period of the Solinst and Hobo sonde data records. These elevated events are characterized by peaks in the specific conductance record in Figures 7 & 8. Table 1, below, quantifies the duration of these events and demonstrates that there is correspondence between those recorded by the Solinst and Hobo sondes. In all cases, where barometric pressure corrections were possible in the flow record, each elevated specific conductance event corresponds to an elevated flow event. Observational evidence, gained from witnessing road runoff flowing into the creek watershed during rain events, would suggest that elevated specific conductance during flow events is probably caused by salts and other materials being washed from the road surfaces.

Table 1. Correspondence of specific conductance peaks with elevated flow events.

Flow Event - Recorded by Solinst Sonde					Solinst Sonde					Hobo Sonde				
Begin		End		Stage Change (ft)	Begin		End		Maximum Specific Cond (µS/cm)	Begin		End		Maximum Specific Cond (µS/cm)
Date	Hour	Date	Hour		Date	Hour	Date	Hour		Date	Hour	Date	Hour	
7-Sep-2011	2:00	8-Sep-2011	19:00	1.99 (1)	7-Sep-2011	2:00	8-Sep-2011	19:00	Begin to End = 30.8 to 11.4	Sonde data not availble.				
Flow events difficult to discern due to no barometric pressure measurements.					4-Aug-2011	12:00	4-Aug-2011	21:00	154.2					
					30-Oct-2011	4:00	31-Oct-2011	0:00	125.8	30-Oct-2011	0:00	31-Oct-2011	3:00	88.2
					12-Jan-2012	6:00	12-Jan-2012	10:00	119.1	Sonde data not availble.				
					17-Jan-2012	15:00	18-Jan-2012	2:00	185.5					
					23-Jan-2012	0:00	24-Jan-2012	0:00	202.4					
16-Feb-2012	19:00	18-Feb-2012	6:00	0.10	17-Feb-2012	2:00	18-Feb-2012	4:00	205.5	17-Feb-2012	1:00	18-Feb-2012	4:00	167.2
24-Feb-2012	7:00	25-Feb-2012	11:00	0.16	24-Feb-2012	11:00	25-Feb-2012	4:00	207.8	24-Feb-2012	11:00	25-Feb-2012	5:00	158.8
1-Mar-2012	1:00	2-Mar-2012	7:00	0.16	1-Mar-2012	5:00	1-Mar-2012	23:00	280.0	1-Mar-2012	5:00	2-Mar-2012	3:00	181.3
2-Mar-2012	20:00	4-Mar-2012	4:00	0.17	3-Mar-2012	0:00	3-Mar-2012	6:00	155.4	3-Mar-2012	0:00	3-Mar-2012	10:00	114.1
8-Mar-2012	14:00	10-Mar-2012	3:00	0.53	8-Mar-2012	14:00	10-Mar-2012	3:00	No appreciable change	8-Mar-2014	19:00	9-Mar-2012	9:00	65.5
19-Mar-2012	13:00	21-Mar-2012	0:00	0.46	19-Mar-2012	17:00	19-Mar-2012	20:00	77.8	19-Mar-2012	18:00	20-Mar-2012	4:00	58.9

Notes:
(1) Uncorrected for barometric pressure

Discrete pH: Discrete pH values were recorded during Solinst and Hobo data logger maintenance visits. These recorded pH values are shown in Table 2. Mill Creek experiences pH values that are more circumneutral when compared to that of Conklin Run.

Table 2. Discrete pH values

Date & Time			PH
			pH Units
05/04/2011	0920-790	11:32	6.40
05/23/2011	0920-804	13:50	6.63
06/07/2011	0920-807	8:00	7.9
06/13/2011	0920-902	16:30	6.68
07/12/2011	0920-819	15:15	6.66
8/3/2011	0920-828	9:45	6.75
10/03/2011	0942-005	9:00	5.7
12/19/2011	0942-047	14:00	7.53
1/25/2012	0942-067	14:00	6.53
02/01/2012	0942-079	11:20	6.52
02/15/2012	0942-075	14:32	6.68
03/21/2012	0942-115	15:30	6.85
03/26/2012	0942-121	16:05	6.72
04/10/2012	0942-146	14:40	6.88
06/13/2012	0942-181	12:30	6.6
07/26/2012	0942-205	7:40	6.61
06/27/2013	0942-523	11:33	6.85

In-situ Water Chemistry: Samples were collected fourteen times using standard analysis code 046. Measurements with "<" indicate concentrations below the reporting limit. Values that follow "<" characterize the laboratory reporting limit.

Table 3. Chemical grab sample results.

PARAMETER	UNITS	05/04/2011	05/23/2011	06/07/2011	07/12/2011	8/3/2011	10/03/2011	12/19/2011	1/25/2012	03/21/2012	04/10/2012	06/13/2012	07/26/2012	06/27/2013
		0920-790	0920-804	0920-807	0920-819	0920-828	0942-005	0942-047	0942-067	0942-115	0942-146	0942-181	0942-205	0942-523
		11:32	13:50	8:00	15:15	9:45	9 00	14:00	14:00	15:30	14:40	12:30	7:40	11:33
ALKALINITY T	mg/L	4 2	5.4	7.4	10.6	12.6	5.2	5.6	5.4	7.2	7.4	10.8	14.0	11.4
ALUMINUM T	µg/L	252 000	< 200	< 200	267.000	200	< 227 000	200	< 200	225.000	< 200	< 200	501.000	268.000
AMMONIA T	mg/L	0.04	0 03	< 02	< 02	< 02	0 03	< 02	0 04	< 02	0 05	< .02	< .02	< .02
ARSENIC T	µg/L	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3 0	< 3 0	< 3 0	< 3 0	< 3 0	< 3 0	< 3 0	< 3 0
BARIUM T	µg/L	14.000	15 000	17 000	20 000	21 000	16 000	12 000	12 000	17 000	13 000	14 000	24 000	16 000
BOD	mg/L	0.70	1 00	1 30	< 0.20	1 30	1 00	1 30	1 00	0 89	< 0.20	0.60	0 50	0.40
BORON T	µg/L	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200
BROMIDE	µg/L	< 50.00	< 50.00	< 50.00	< 50.00	< 50.00	< 50 00	< 50.0	< 50	< 50.0	< 50.0	< 50.0	< 25.0	< 25.0
CALCIUM T	mg/L	3 322	4.068	4.642	6.647	8.824	4.266	4.206	5.045	5.122	5.365	5.722	8.733	5.476
Hardness T	mg/L	10	13	15	21	28	13	14	16	16	17	18	28	18
IRON T	µg/L	197 000	235 000	375.000	546.000	266.000	263.000	83 000	129.000	273.000	124.000	418.000	803.000	541.000
LITHIUM T	µg/L						< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25
MAGNESIUM T	mg/L	0 530	0.684	0.800	1.146	1.548	0.656	0.761	0.871	0.831	0.973	0.978	1.522	0.985
MANGANESE T	µg/L	18.000	21 000	35 000	69 000	31 000	17 000	14 000	22 000	36 000	12 000	33 000	143.000	58 000
MOLYBDENUM T	µg/L													< 70
OSMOTIC PRESSURE	MOSM	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	< 1	2
SELENIUM T	µg/L	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7	< 7
SODIUM T	mg/L	2.441	2.325	1.779	3.427	3.807	1.903	1.943	5.350	3.762	2.778	2.716	4.224	2.675
STRONTIUM T	µg/L	11.000	15 000	16 000	26 000	35 000	14 000	15 000	18 000	17 000	19 000	21 000	33 000	24 000
CHLORIDE T	mg/L	2.91	3 55	2 84	7 24	8 35	2.16	3.75	9 90	7.19	5.63	5.46	9.41	5 83
TOTAL DISSOLVED SOLIDS @ 180C	mg/l	60	54	42	42	50	40	54	50	58	42	32	64	52
NITRATE & NITRITE NITROGEN T	mg/L	< 0.04	< 0.04	0 05	0 33	0 27	0 05	0 21	0 25	0.13	0 20	0.13	0.18	0.17
PHOSPHORUS T	mg/L	0 011	< 0.01	0.015	0.017	0.015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.014	0.011	0.015
SULFATE T	mg/L	5.46	6.15	5 29	5 28	9 91	5 54	7 26	6 93	6 25	6.65	4 39	5.17	4.12
TOTAL SUSPENDED SOLIDS	mg/L	< 5	6	< 5	18	14	< 5	< 5	12	16	< 5	< 5	8	8
ZINC T	µg/L	< 10.0	< 10.0	16 000	< 10.0	< 10.0	15 000	< 10.0	< 10	< 10.0	< 10.0	< 10.0	< 10.000	< 10.0

Relationship between Specific Conductance and Stream Flow Discrete Values: Discrete values for specific conductance were collected during each maintenance visit to the sonde. Often, stream flows were also obtained using a Marsh-McBirney Flo-Mate during the maintenance visits. Figure 10 demonstrates the relationship between specific conductance and stream flow in Mill Creek. Unlike Conklin Run, Mill Creek demonstrates the more typical negative relationship between these two parameters.

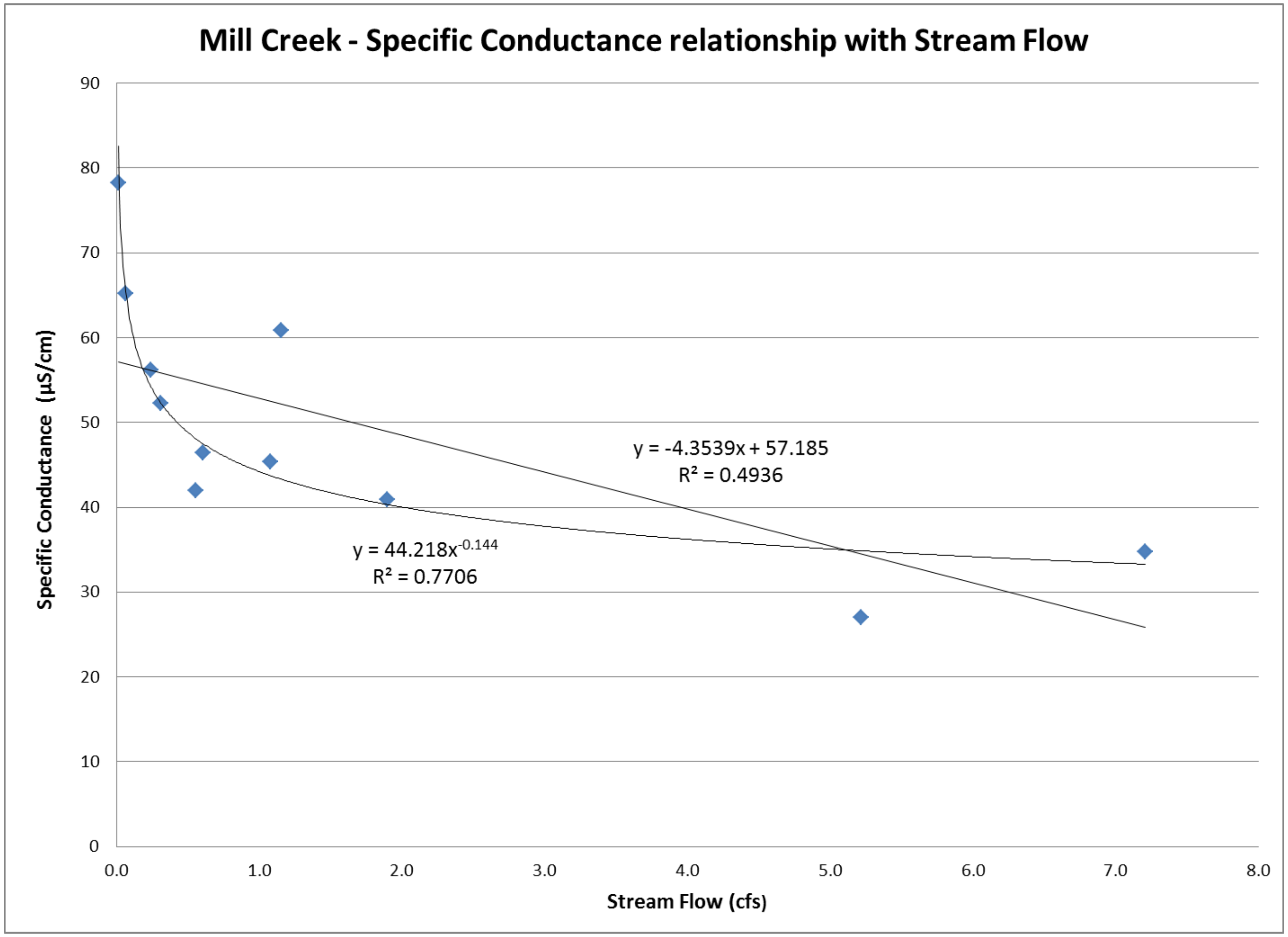

Figure 10. Relationship between Specific conductance and stream flow discrete values.

Biology: The indigenous aquatic community is an excellent indicator of long-term conditions and is used as a measure of water quality. Benthic macroinvertebrates were collected during the fall on November 30, 2011 and during the spring on April 10, 2012 (Table 4 and 5).

Unlike Conklin Run, Mill Creek doesn't experience elevated levels of acidity throughout the year, especially during the winter months. Without winter pH depressions, as experienced in Conklin Run, Mill Creek is better able to sustain its macroinvertebrate population throughout the year. This improved year-long stream condition is indicated by both the taxa counts shown in Table 4 and in the metrics shown in Table 5.

Table 4. Fall 2011 and Spring 2012 Taxa list for benthic macroinvertebrate survey.

Family	Genus	20111130-1300-bchalfant individual count	20120410-1730-jbutt individual count
Ameletidae	Ameletus		2
Baetidae	Baetis	1	3
	Diphetor	1	4
Heptageniidae	Epeorus		1
	Leucrocuta		1
	Stenacron		1
	Maccaffertium	6	3
Leptophlebiidae	Habrophlebiodes	1	3
	Leptophlebia		1
	Paraleptophlebia	6	2
Nemouridae	Amphinemura		45
	Ostrocerca		4
Peltoperlidae	Tallaperla	1	
Taeniopterygidae	Taeniopteryx	5	
Leuctridae	Leuctra	16	8
Capniidae	Paracapnia	2	
Perlidae	Acroneuria	6	4
Perlodidae	Isoperla		8
Chloroperlidae	Haploperla		1
Philopotamidae	Chimarra	5	1
Hydropsychidae	Diplectrona	18	7
	Ceratopsyche		2
	Cheumatopsyche	3	1
	Hydropsyche	9	1
Rhyacophilidae	Rhycophila	6	2
Limnephilidae	Pycnopsyche	2	1
Elmidae	Oulimnius	1	2
	Stenelmis	5	1
Empididae	Clinocera		2
Tipulidae	Hexatoma		2
	Tipula	4	
Simuliidae	Prosimulium	5	3
	Simulium		5
	Stegopterna	1	2
Chironomidae		86	88
Cambarus		1	3

Table 5. Fall 2011 and Spring 2012 macroinvertebrate metrics.

Sample ID	IBI	Taxa Richness	EPT Richness (PTV 0-4)	Hilsenhoff Biotic Index	% Dominant Taxon	% Ephemeroptera (PTV 0-4)	Becks Index (ver 3)	Shannon Diversity
20111130-1300-bchalfant	61.4	21	12	3.94	45	6.8	19	2.15
20120410-1730-jbutt	77.9	32	18	4.18	41.1	5.1	28	2.26

SUMMARY:

Continuous monitoring, in-situ lab chemistries, and biological data provided in this report may be used to establish a baseline for water quality in Mill Creek preliminary to potential Marcellus gas well development.

LITERATURE CITED

PA DEP. 2013a. Instream Comprehensive Evaluations (ICE). http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/2013_assessment_methodology/1407203

PA DEP. 2013b. Continuous Instream Monitoring Protocol. http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/2013_assessment_methodology/1407203