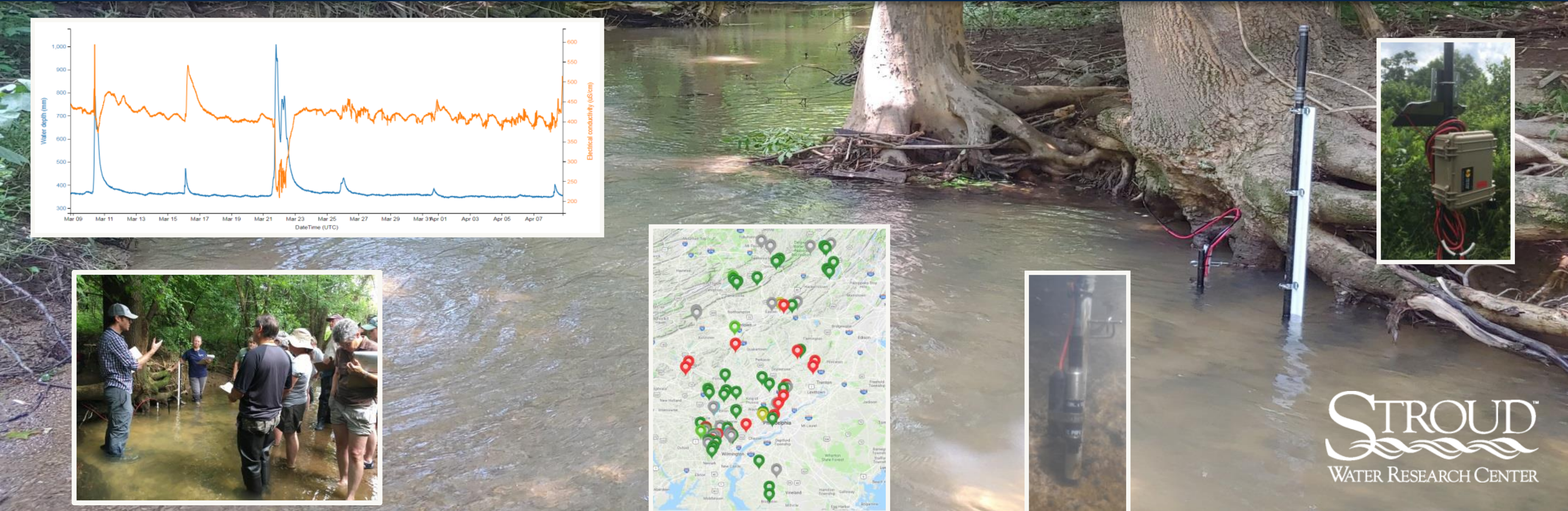
Part 1. Citizen science and continuous sensors - spatial and temporal patterns of specific conductivity and water temperature in streams and rivers of the Delaware River Basin

David Bressler, Diana Oviedo-Vargas, and Marc Peipoch
Stroud Water Research Center

November 19, 2019 at The Academy of Natural Sciences of Drexel University

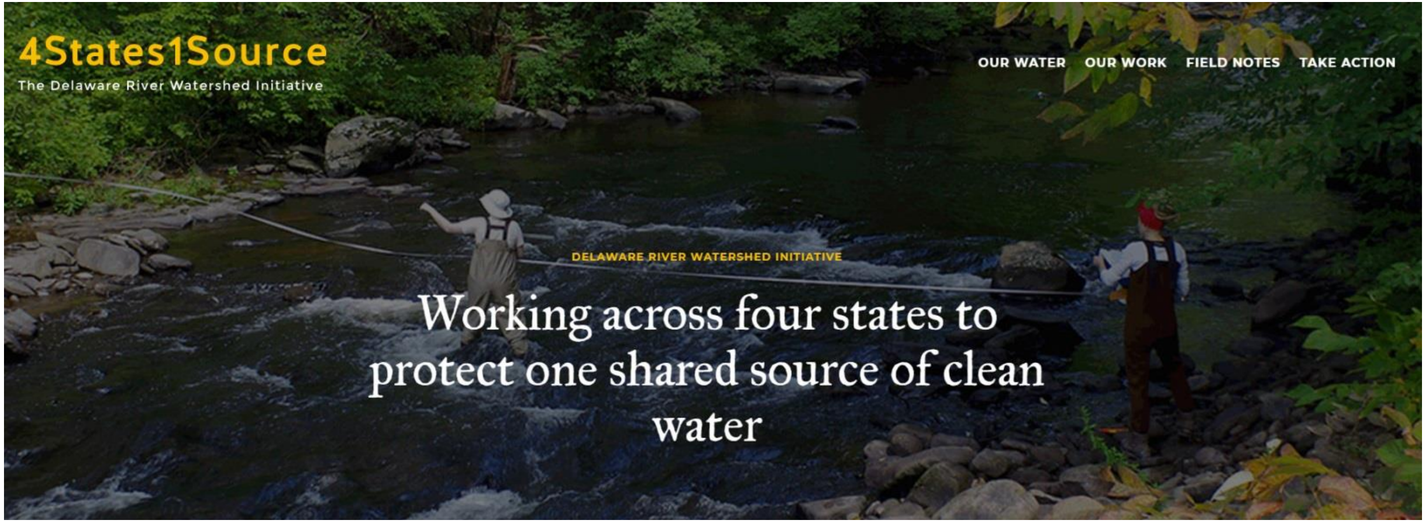


STROUD
WATER RESEARCH CENTER

Background

Delaware River Watershed Initiative – William Penn Foundation

Stroud Center helping to build science capacity through the basin



WILLIAM PENN FOUNDATION

STROUD™ WATER RESEARCH CENTER

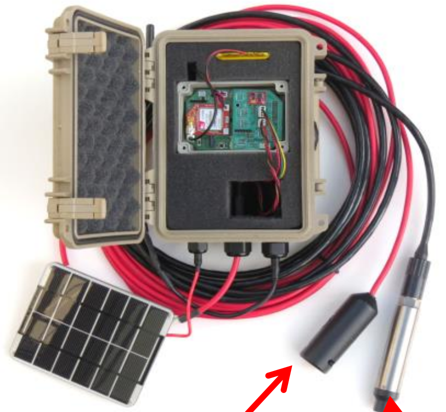
Background

- Science capacity building across DRB via facilitation of continuous monitoring using EnviroDIY Mayfly Sensor Stations
- Stations granted to watershed groups and schools
- Private purchase

STROUD™
WATER RESEARCH CENTER

Basic sensor station setup

*Stations designed, programmed, and built by Stroud Center (Shannon Hicks, engineer)



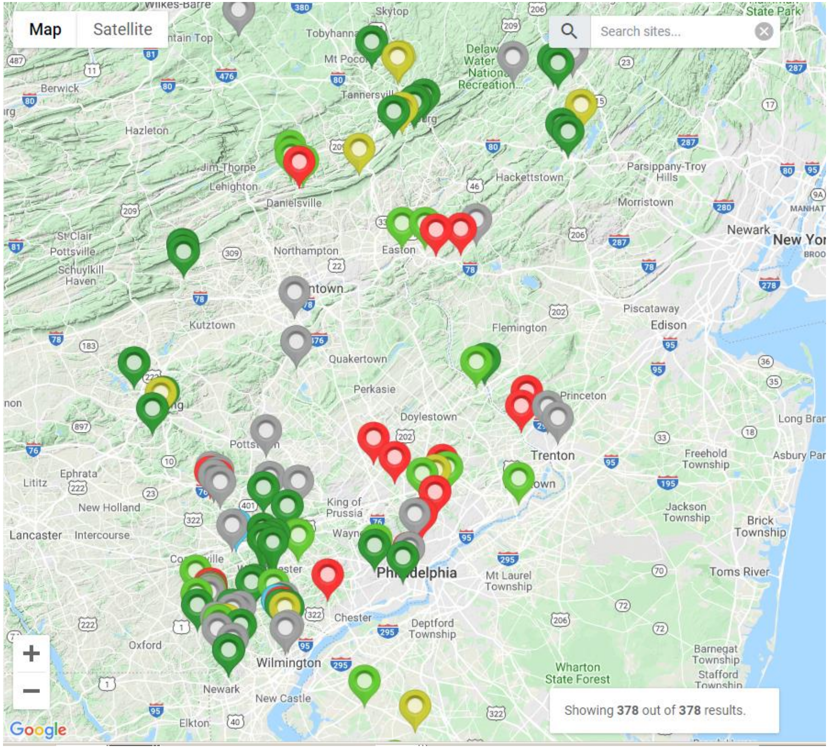
Campbell OBS-3+ Turbidity sensor

Meter Group CTD-10 sensor – Conductivity, Temperature, Depth

STROUD™ WATER RESEARCH CENTER

Stations deployed across the Delaware Basin

~70 Stations in DRB, so far



Stroud Water Research Center

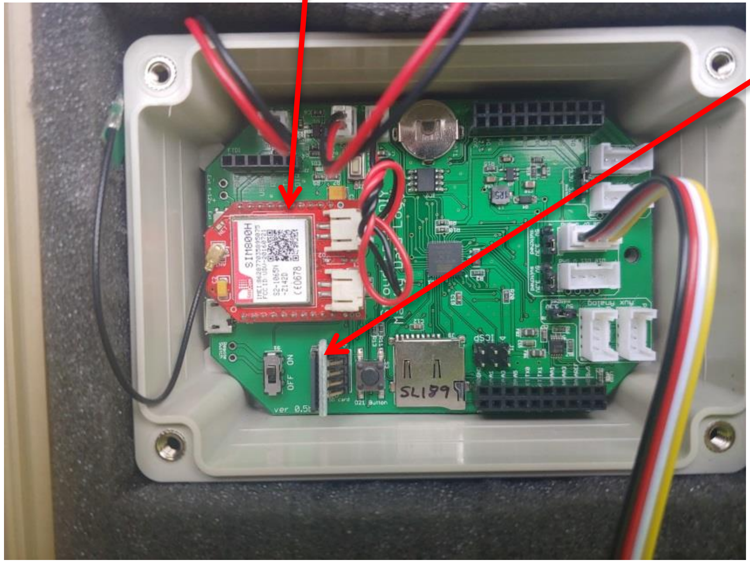
More than 35 organizations that own stations

Organization
American Littoral Society
Aquashicola-Pohopco Watershed Conservancy
Bartrams Garden
Berks County Conservation District
Berks Nature
Brodhead Watershed Assocation
Darby Creek Valley Association
Delaware Riverkeeper
East Stroudsburg University
Eastern Delaware County Stormwater Collaborative
Great Marsh Institute
Green Valleys Watershed Association
Lake Committee, Somerset Lake Community
Lopatcong Creek Initiative; NJ Highlands Coalition
Montgomery School
Musconetcong Watershed Association
Penn State Master Watershed Stewards, Berks County
Pennypack Ecological Restoration Trust
Primrose Creek Watershed Association
Schuylkill River Greenways
Silver Lake Nature Center
South Jersey Land & Water Trust
The Independence School
The Land Conservancy for Southern Chester County
The Nature Conservancy, Delaware
The Nature Conservancy, New Jersey
The Watershed Institute
Tookany/Tacony-Frankford Watershed Partnership
Trout Unlimited
Trout Unlimited, New Jersey
Upper Perkiomen High School
Valley Forge Trout Unlimited
Wallkill River Watershed Management Group
White Clay Wild and Scenic
Wildlands Conservancy
Willistown Conservation Trust
Wissahickon Valley Watershed Association
Woodstown High School

Basic sensor station setup

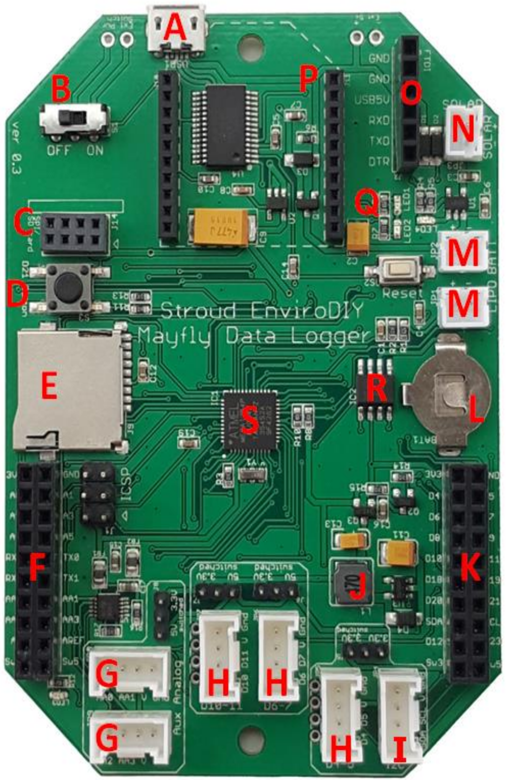
Solar powered

Online – 2G or 4G cell signal



Data logged to microSD card every 5 minutes, then transmitted via cell signal to Monitor My Watershed data portal

Basic sensor station setup



Features of the EnviroDIY Mayfly Data Logger

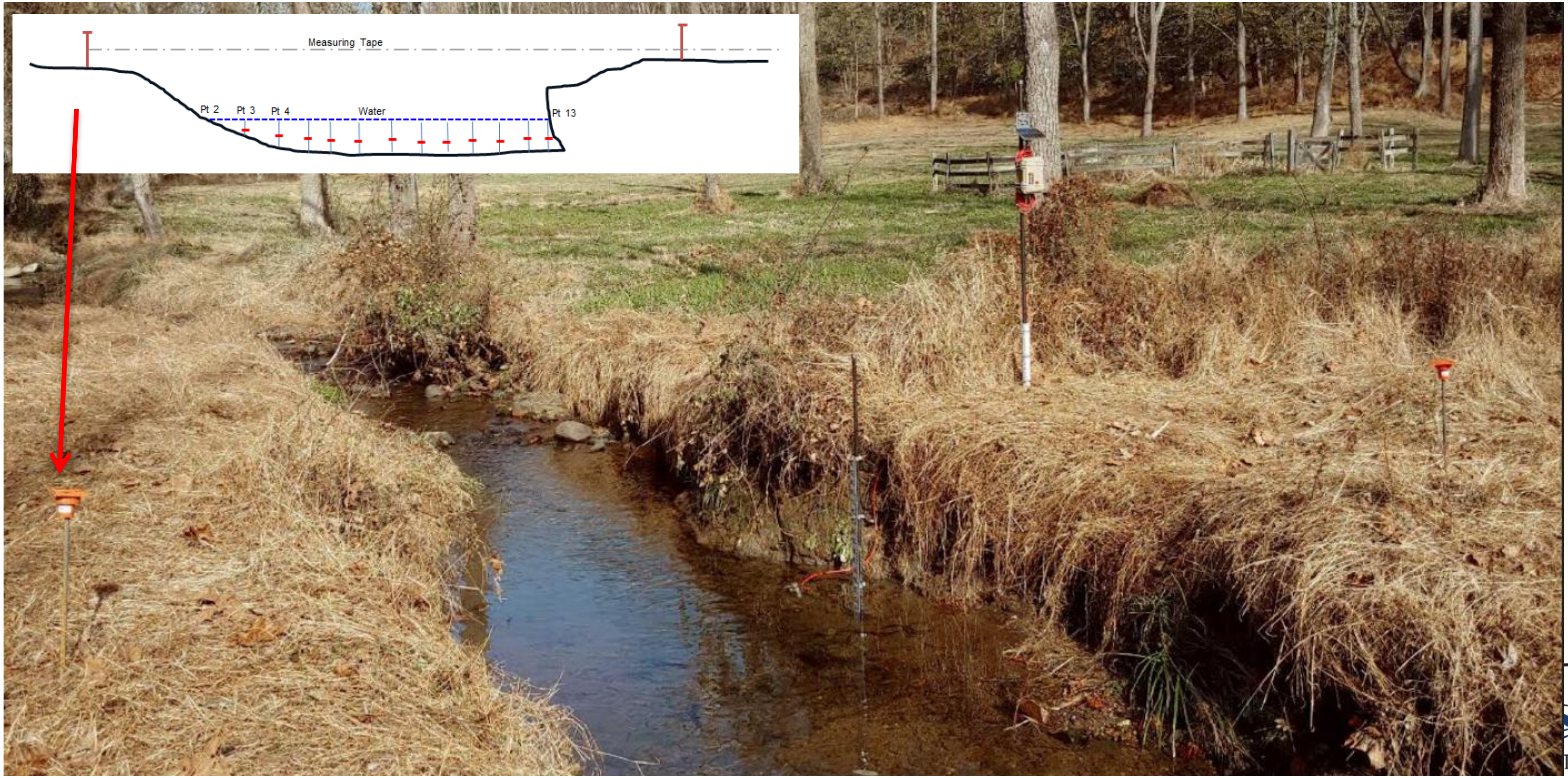
A	**MicroUSB port** – connect a standard MicroUSB cable to a computer for programming the Mayfly using the Arduino software
B	**Power switch** – turns the Mayfly board on and off
C	**microSD/SPI connector** – socket for vertical microSD memory card adapter board or other SPI devices
D	**Pushbutton** – connected to pin D21 for user-defined input
E	**microSD card socket** – socket for storing data on a standard microSD memory card
F	**Analog pin header** – access to the Mayfly's power, ground, & analog pins, and also the four Auxiliary 16-bit Analog-to-Digitial converter pins
G	**Auxiliary ADC Grove connectors** – pairs of Auxiliary Analog pins along with ground and power (3.3v or 5V)
H	**Digital pin Grove connectors** – pairs of digital pins along with ground and power (3.3v or 5v), for connecting sensors and Grove accessories
I	**I²C port Grove connector** – connection for any devices that use the I²C protocol
J	**5-volt boost converter** – generates 5v for powering external sensors
K	**Digital pin header** – access to the Mayfly's power, ground, & digital pins
L	**Clock battery** – socket for CR1220 lithium battery to keep clock chip (**R**) running when no other power is connected to Mayfly
M	**LiPo battery connectors** – JST socket for connecting LithiumPolymer (LiPo) rechargeable battery. Additional socket is for providing power to high-current peripheral devices
N	**Solar panel connector** – JST socket for connecting 6v solar panel for charging the LiPo battery
O	**FTDI programing header** – alternative port for programming board using an external FTDI adapter instead of using the Mayfly microUSB port
P	**Bee module socket** – connection port for various telemetry modules that use the Bee footprint (mesh radio, WiFi, cellular)
Q	**Red & Green LEDs** – LEDs for providing visual feedback, connected to pins D8 (green) and D9 (red)
R	**Real-time clock** – DS3231 clock module with on-board temperature sensor, retains the date and time after initial programming, requires battery (**L**)
S	**Processor** – ATmega1284p microprocessor

STROUD™
WATER RESEARCH CENTER

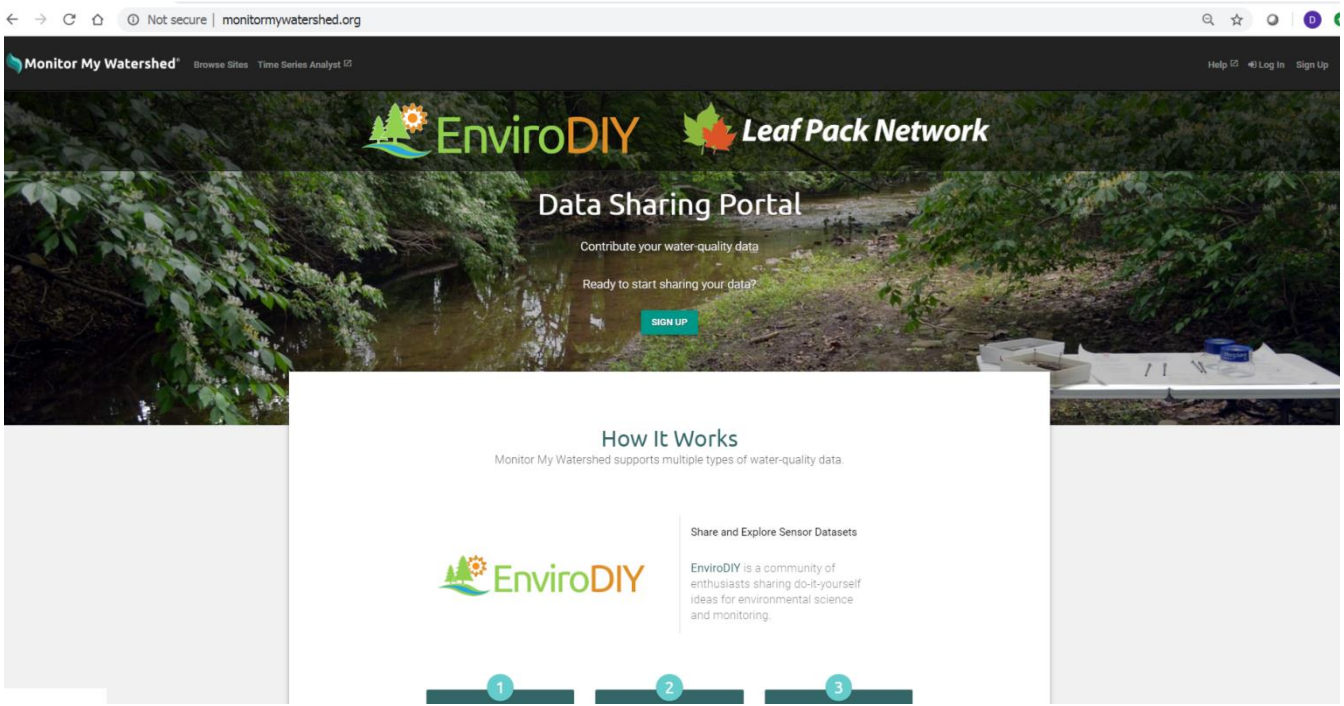
Basic sensor station setup

STROUD™
WATER RESEARCH CENTER

Basic sensor station setup

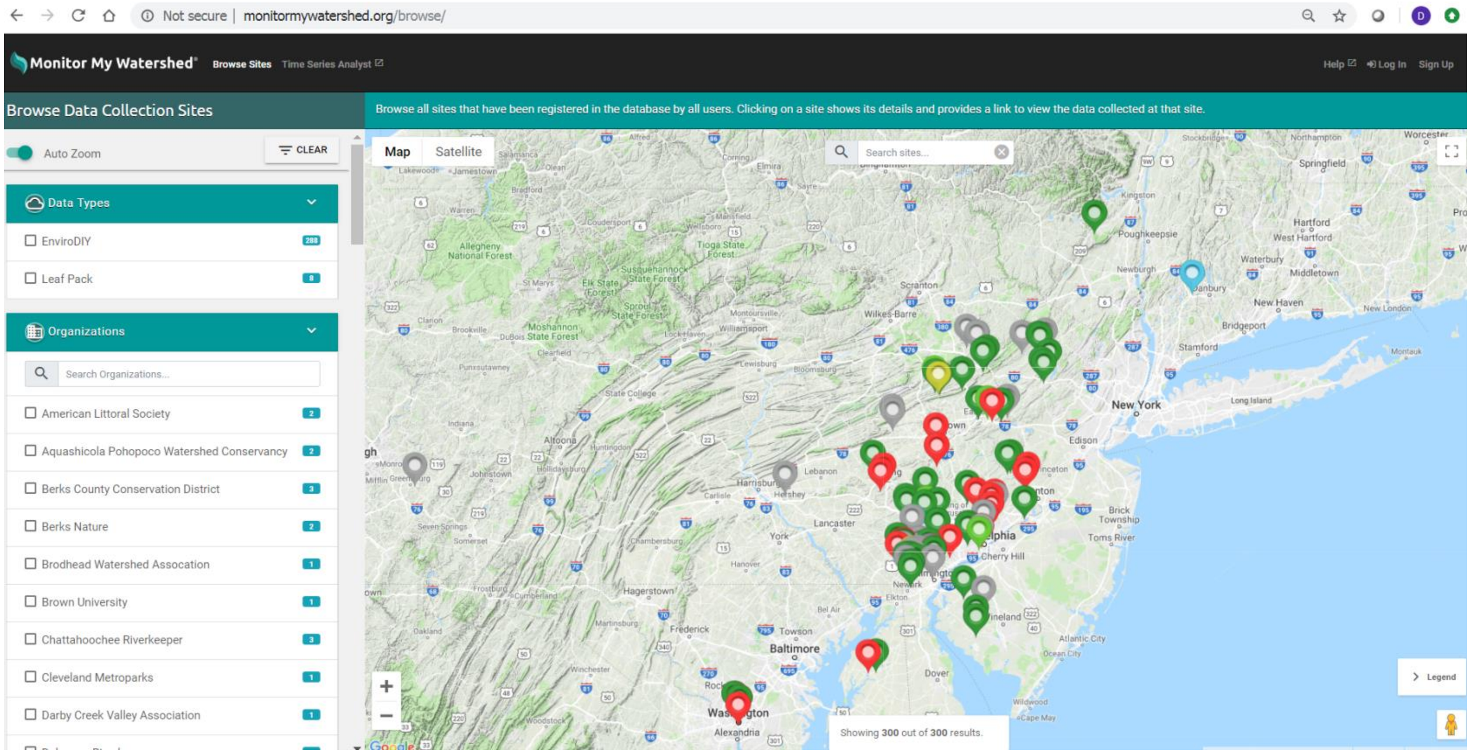


Monitor My Watershed



STROUD
WATER RESEARCH CENTER

Monitor My Watershed



STROUD™
WATER RESEARCH CENTER

Monitor My Watershed

monitormywatershed.org/sites/MSPL2S/

Un-named Tributary to Plum Run (MSPL2S)

Deployment By	Karin Wulkowicz
Organization	Pennsylvania State University Extension - Master Watershed Steward Program
Registration Date	June 25, 2019, 8:52 p.m.
Deployment Date	June 26, 2019, 4 p.m.
Latitude	40.378635
Longitude	-76.012667
Elevation (m)	76.0
Elevation Datum	MSL
Site Type	Stream
Stream Name	-
Major Watershed	Delaware
Sub Basin	Plum Run
Closest Town	-
Notes	SL249 - Berks County Conservation District office

Sensor Observations at this Site

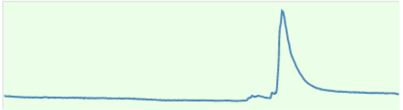
EnviroDIY

DOWNLOAD SENSOR DATA

Only the most recent 72 hours of available data are shown on the sparkline plots. The plots are broken when there are gaps in the data longer than 6 hours. Plots shaded in green have recent data. Plots shaded in red have not reported data in the last 72 hours.

Time Series Analyst
View data for this site.
Related Link

Water depth Provisional

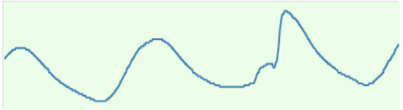


Last observation
July 12, 2019, 12:35 p.m. (UTC-05:00)

260.2 (mm)

Medium	Liquid aqueous
Sensor	Decagon_CTD-10 Electrical Conductivity Temperature Depth Sensor

Temperature Provisional

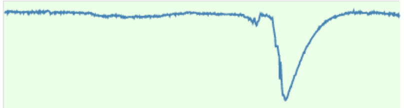


Last observation
July 12, 2019, 12:35 p.m. (UTC-05:00)

21.0 (degC)

Medium	Liquid aqueous
Sensor	Decagon_CTD-10 Electrical Conductivity Temperature Depth Sensor

Electrical conductivity Provisional



Turbidity Provisional

Monitor My Watershed

Monitor My Watershed

monitormywatershed.org/sites/MSPL2S/

	A	B	C	D	E	F	G	H	I	J	K	L
46	DateTime	TimeOffset	DateTimeUTC	Decagon_CTD-10_Depth	Decagon_CTD-10_Temp	Decagon_CTD-10_Cond	Campbell_OBS3_Turb-1	Campbell_OBS3_Tu	EnviroDIY_Mayfly_	EnviroDIY_Mayfly_Batt	Digi_Cellular_RSSI	Digi_Cellular_Si
47	6/26/2019 11:00	-5:00	6/26/2019 16:00	-9999	-9999	-9999		234.39456	29.75	4.821	-69	
48	6/26/2019 11:05	-5:00	6/26/2019 16:05	-9999	-9999	-9999		234.39995	29.75	4.169	-81	
49	6/26/2019 18:10	-5:00	6/26/2019 23:10	-9999	-9999	-9999	53.7909	236.17874	27.5	4.897	-69	
50	6/26/2019 18:20	-5:00	6/26/2019 23:20	-9999	-9999	-9999	53.82562	235.66113	27.75	4.897	-69	
51	6/27/2019 9:35	-5:00	6/27/2019 14:35	239	18.52	261.3	6.48766	5.97695	27.5	4.124	-81	
52	6/27/2019 9:40	-5:00	6/27/2019 14:40	237.3	18.2	265.2	5.89173	5.37859	27.5	4.124	-69	
53	6/27/2019 9:45	-5:00	6/27/2019 14:45	239.5	18.2	265.3	6.82053	6.36557	27.75	4.124	-45	
54	6/27/2019 9:50	-5:00	6/27/2019 14:50	239.8	18.2	267.5	7.78113	7.37721	27.75	4.124	-45	
55	6/27/2019 9:55	-5:00	6/27/2019 14:55	241	18.2	267.5	5.9314	5.41228	27.75	4.124	-69	
56	6/27/2019 10:00	-5:00	6/27/2019 15:00	240	18.2	267.2	6.11507	5.60484	27.75	4.124	-45	
57	6/27/2019 10:05	-5:00	6/27/2019 15:05	240.8	18.3	266.2	12.5744	12.4203	27.75	4.124	-69	
58	6/27/2019 10:10	-5:00	6/27/2019 15:10	241.3	18.33	268.3	16.37171	16.41293	28	4.124	-69	
59	6/27/2019 10:15	-5:00	6/27/2019 15:15	240.2	18.4	268.3	6.23409	5.7348	28	4.124	-81	
60	6/27/2019 10:20	-5:00	6/27/2019 15:20	243.3	18.45	266.2	9.0793	8.7388	28	4.124	-45	
61	6/27/2019 10:25	-5:00	6/27/2019 15:25	243.2	18.5	267.2	5.63903	5.11389	28	4.124	-69	
62	6/27/2019 10:30	-5:00	6/27/2019 15:30	243.7	18.6	263.7	5.42718	4.87329	28.25	4.124	-81	
63	6/27/2019 10:35	-5:00	6/27/2019 15:35	242	18.6	264	6.63445	6.16813	28.25	4.124	-69	
64	6/27/2019 10:40	-5:00	6/27/2019 15:40	241.8	18.7	262.3	5.51101	4.96953	28.25	4.124	-81	
65	6/27/2019 10:45	-5:00	6/27/2019 15:45	242	18.7	264	5.64358	5.1139	28.25	4.124	-81	
66	6/27/2019 10:50	-5:00	6/27/2019 15:50	241.5	18.8	265	8.51304	8.15798	28.5	4.124	-81	
67	6/27/2019 10:55	-5:00	6/27/2019 15:55	240.5	18.87	266.5	5.67983	5.1524	28.5	4.124	-81	
68	6/27/2019 11:00	-5:00	6/27/2019 16:00	241.7	18.9	267.8	6.6811	6.20671	28.5	4.124	-69	
69	6/27/2019 11:05	-5:00	6/27/2019 16:05	241.7	19	267.3	5.8997	5.38823	28.75	4.124	-45	
70	6/27/2019 11:10	-5:00	6/27/2019 16:10	239.7	19	269	7.91858	7.53622	28.75	4.124	-45	
71	6/27/2019 11:15	-5:00	6/27/2019 16:15	240.5	19.1	266.8	6.31802	5.81184	28.75	4.124	-69	
72	6/27/2019 11:20	-5:00	6/27/2019 16:20	241.7	19.2	267.3	6.68776	6.23072	29	4.124	-69	
73	6/27/2019 11:25	-5:00	6/27/2019 16:25	241.8	19.2	268.3	6.22746	5.72526	29	4.124	-69	
74	6/27/2019 11:30	-5:00	6/27/2019 16:30	242.5	19.3	267.8	6.11845	5.60964	29.25	4.124	-81	
75	6/27/2019 11:35	-5:00	6/27/2019 16:35	241.5	19.3	265.8	5.65266	5.13316	29.25	4.109	-81	

Sensor stations for the Delaware River Watershed Initiative

- Primary goal with sensor stations: watershed groups investigate their own questions
  - Stroud supports these efforts
- Secondary goal: build basin-wide data set for broad scale analysis
  - Stroud and anyone else (publicly available via Monitor My Watershed)
  - **Diana Oviedo and Marc Peipoch today, parts 2 and 3**

STROUD WATER RESEARCH CENTER

Citizen Science

Volunteers, students, teachers, scientists, managers, others

STROUD™
WATER RESEARCH CENTER

Citizen Science

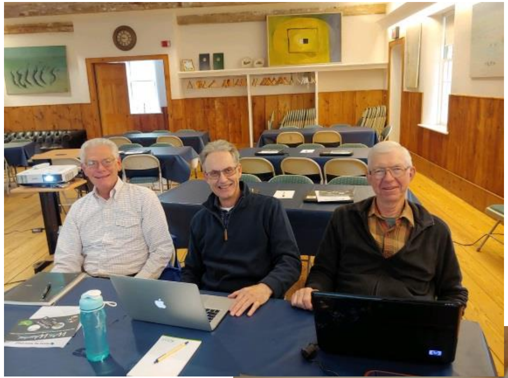
- Penn State Master Watershed Stewards
  - Supporting maintenance and QC, matching MWStewards with stations
  - Receive training, equipment, and supplies
  - Mentoring support system

PennState Extension

STROUD™ WATER RESEARCH CENTER

Citizen Science

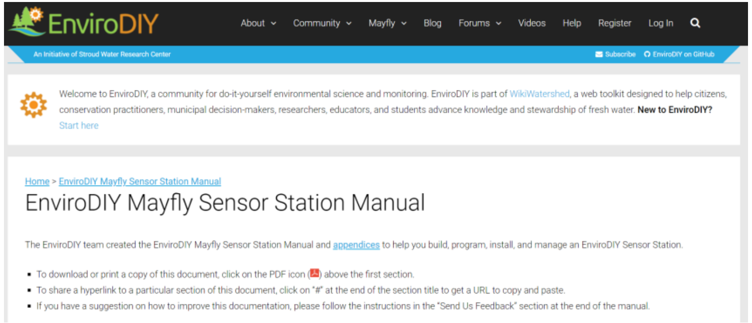
Support via workshops, trainings, user group gatherings, 1:1 site visits



STROUD
WATER RESEARCH CENTER

Citizen Science

Support via manuals, quick guides, presentations, videos, tutorials



STROUD
WATER RESEARCH CENTER

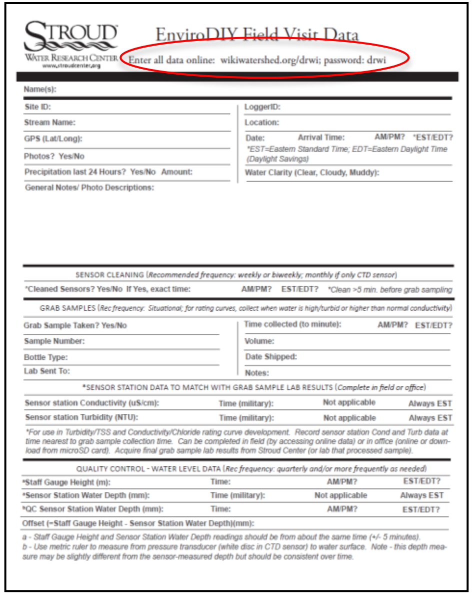
Citizen Science

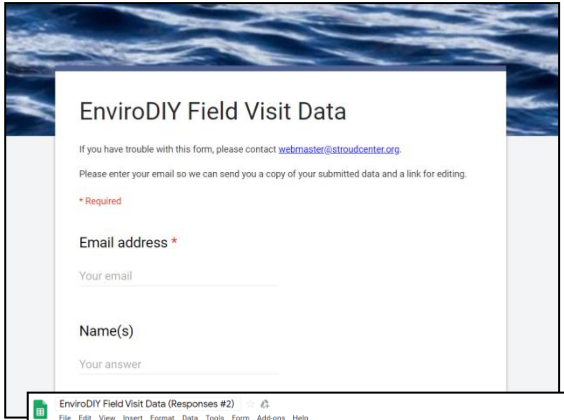
Support via equipment and supplies

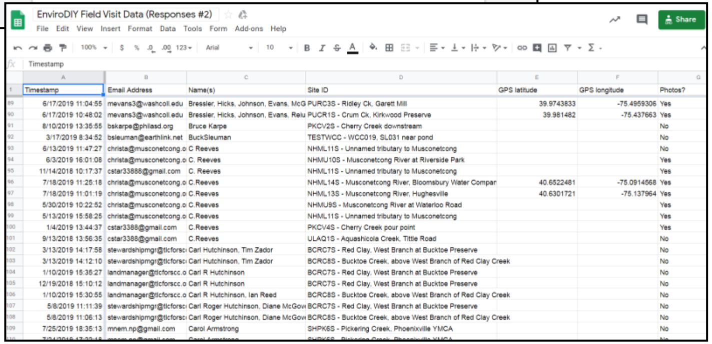
STROUD™
WATER RESEARCH CENTER

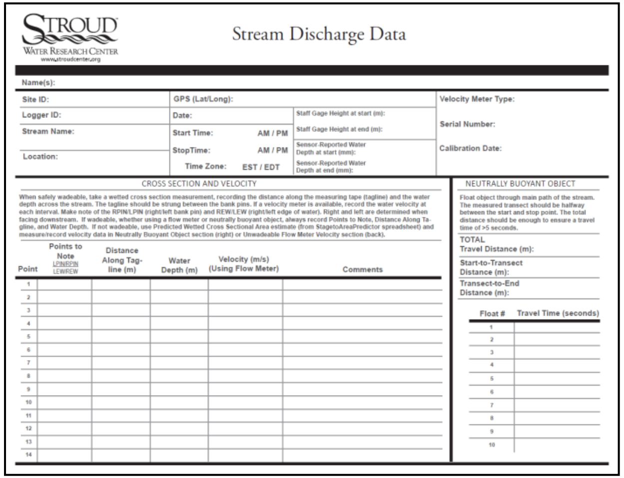
Citizen Science

Support via data sheets, online data entry, and online meta-data access



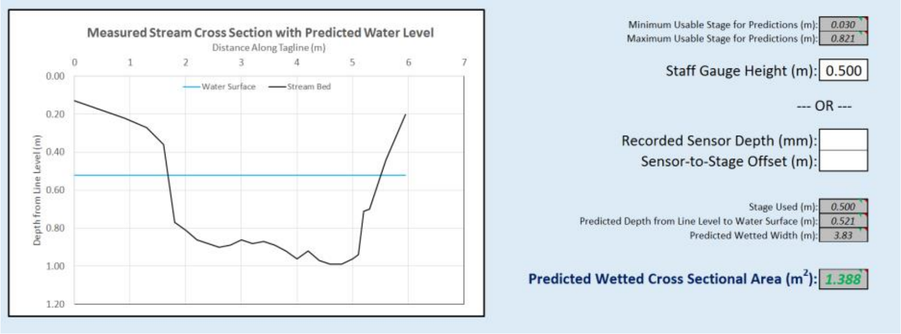


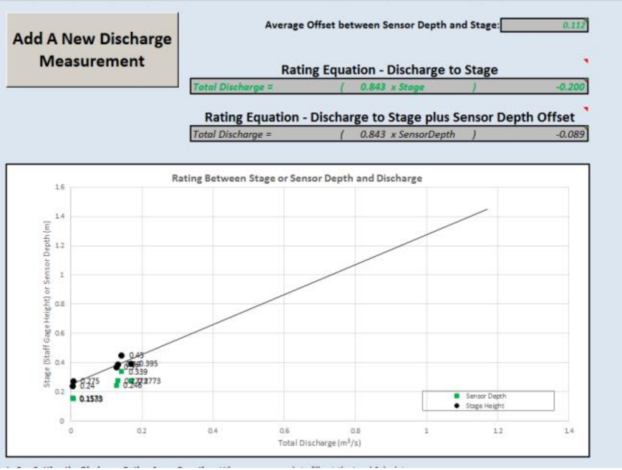




Citizen Science

Support via Discharge Rating Curve Calculators, Stage-to-Area predictors, and Load Calculators





	A	B	G	H	I	J
1	Discharge Calculator Rating Curve Equation					
2	y = mx + b	y = 0.843x - 0.2	Sensor Depth (mm)	Staff Gauge Height (m)	Discharge (m³/s)	Turb (NTU)
3	m (slope)	0.843	CTDdepth Data from Webpage	Sensor Depth + Sensor Offset	Input Sensor Depth (x) into Discharge Rating Curve	TurbHigh Data from Webpage
4	b (y-axis intercept)	-0.2	368	0.48	0.20464	5.05
5	TSS/Turbidity Rating Curve Equation		372.5	0.4845	0.2084335	5.82
6	y = mx + b	y = 2.1682x - 10.606	379.7	0.4917	0.2145031	5.83
7	m (slope)	2.1682	386.3	0.4983	0.2200669	5.97
8	b (y-axis intercept)	-10.606	393.4	0.5054	0.2260522	6.97
9	Chloride/Conductivity Rating Curve Equation		394.9	0.5069	0.2273167	6.18
10	y = mx + b	0	394.3	0.5063	0.2268109	6.29
11	m (slope)	0	391.4	0.5034	0.2243662	5.71
12	b (y-axis intercept)	0	390.6	0.5026	0.2236918	6.32
13	Average Offset Between Sensor Depth and Stage		389.1	0.5011	0.2224273	6.2
14	Offset (m)	0.112	387.5	0.4995	0.2210785	6.55
15	Load Totals		388.3	0.5003	0.2217529	6.48
16	**Sediment Load (mg)**	254,447,241.51	388.4	0.5004	0.2218372	7.02
17	**Chloride Load (mg)**	-	390.6	0.5026	0.2236918	6.43
18	Sediment Load (kg)	**254.45**	392	0.504	0.224872	7.27
19	Chloride Load (kg)	-	393.5	0.5055	0.2261365	6.9
20	Sediment Load (lb)	**559.78**	395.5	0.5075	0.2278225	6.62
21	Chloride Load (lb)	-	400.1	0.5121	0.2317003	7.04
22	**Notes**		407.2	0.5192	0.2376856	6.8
23	**1)** All values on this page will be filled once every		415.4	0.5274	0.2445982	7.2
24	value and equation found on the "Data Import"		424.8	0.5368	0.2525224	7.9
25	worksheet is appropriately filled out.		432.1	0.5441	0.2586763	9.35
26	____		440.4	0.5524	0.2656732	7.74
27	**2)** Data under the "Load Calculations" section will		448.4	0.5604	0.2724172	8.02

Data Import | Load Table

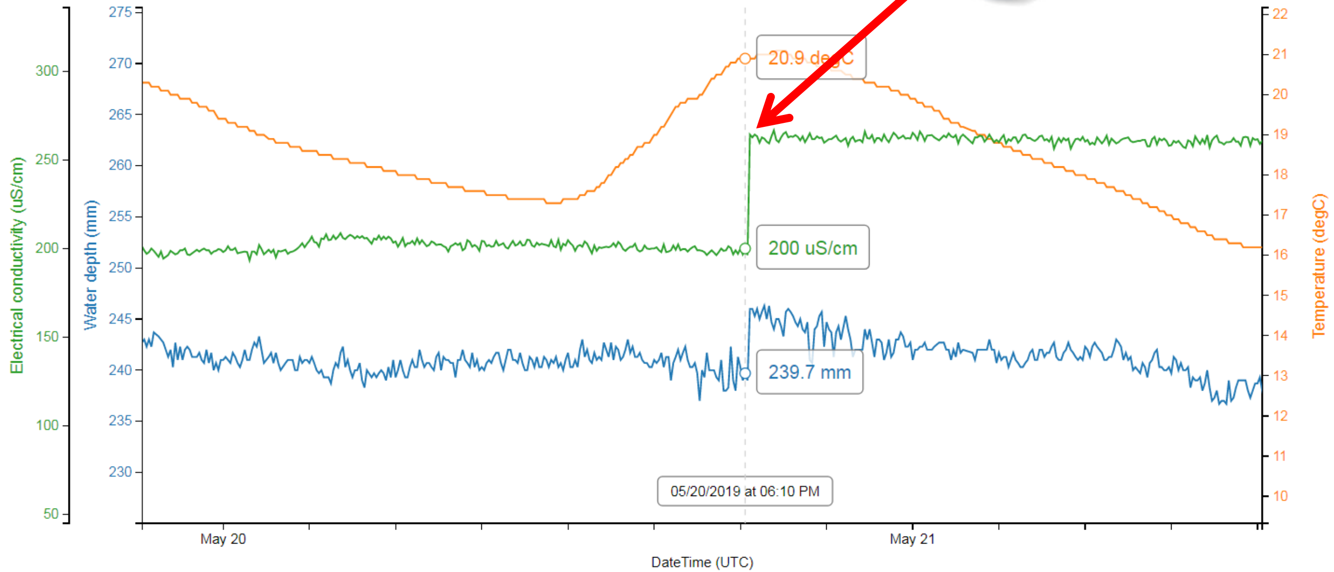
Citizen Science

Support via grab samples for turbidity/TSS and conductivity/chloride rating curves and lab analysis

STROUD
WATER RESEARCH CENTER

Citizen Science Support - Maintenance

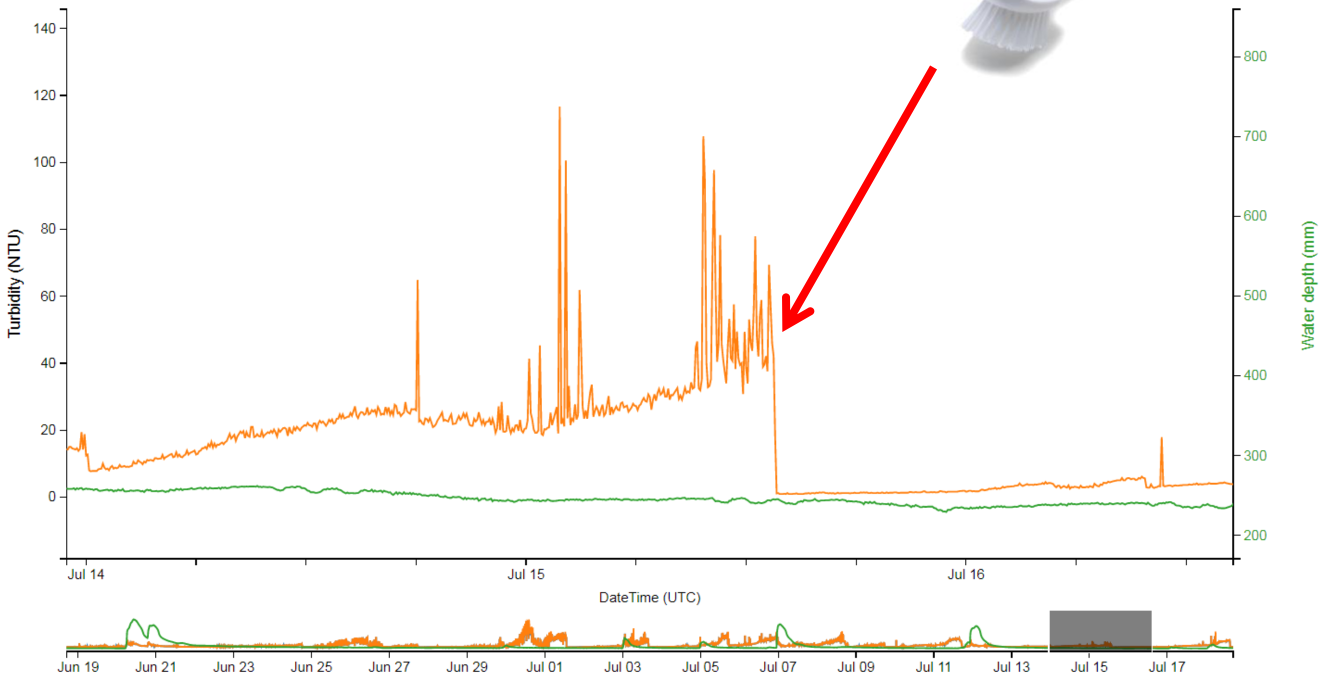
Cleaning CTD sensor



Pike Creek, The Independence School

Citizen Science Support - Maintenance

Cleaning Turbidity sensor



Ridley Creek, Ashbridge Preserve, Upstream

STROUD WATER RESEARCH CENTER

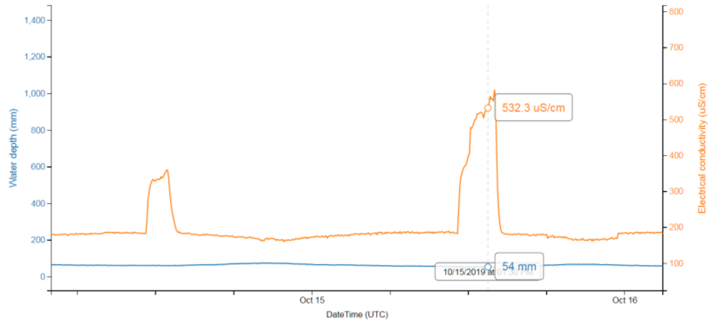
Citizen Science Support - Maintenance

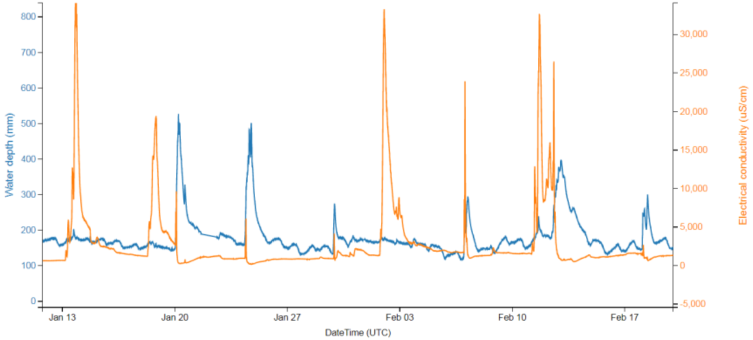
Problem Identification, eyes on-site

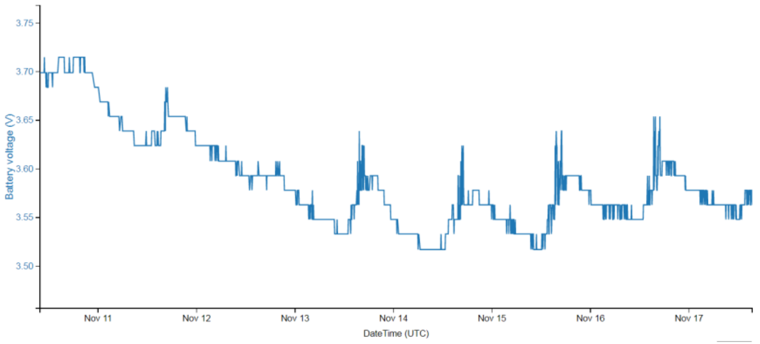
STROUD™ WATER RESEARCH CENTER

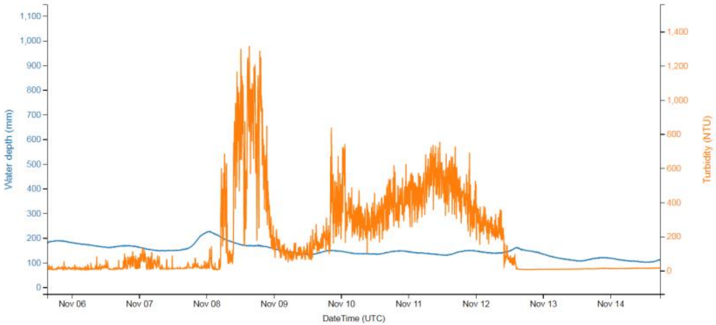
Citizen Science Support - Maintenance

Tracking data and station function





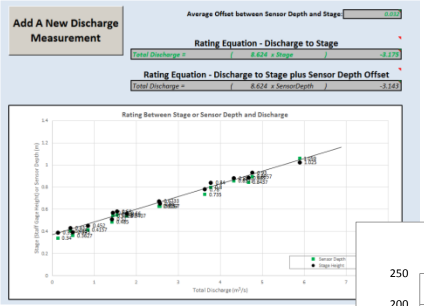


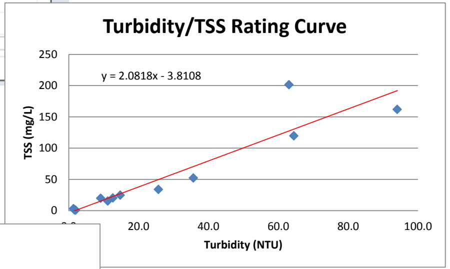


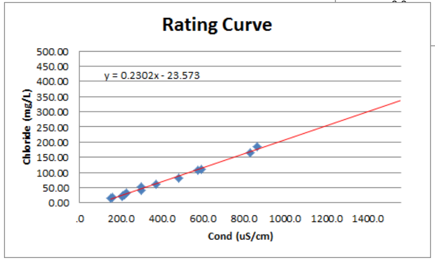
RCH CENTER

Citizen Science Support – Rating curve development

Collecting and shipping grab samples, measuring discharge



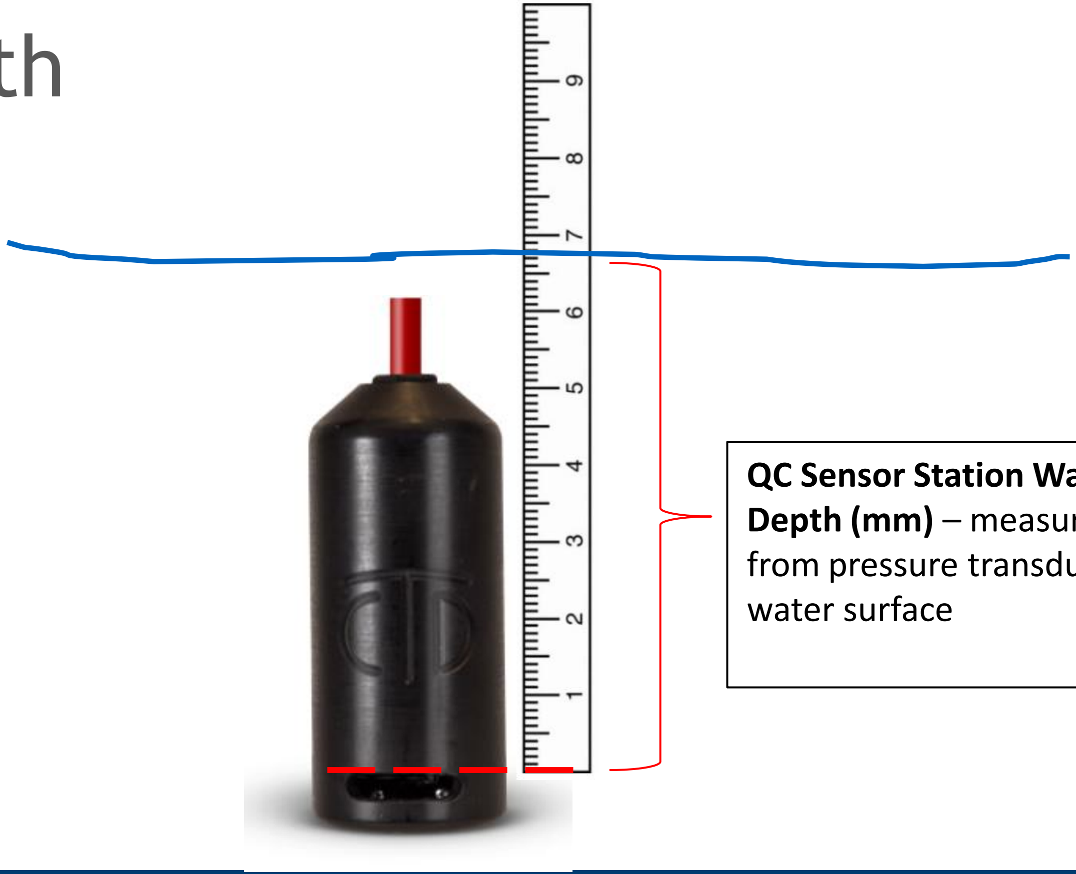




STROUD™ WATER RESEARCH CENTER

CitSci Support - Quality Control

QC of depth



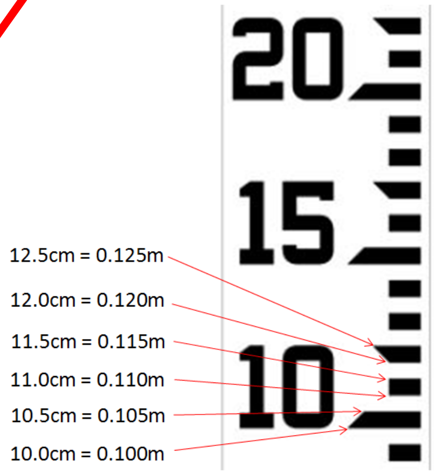
QC Sensor Station Water Depth (mm) – measure from pressure transducer to water surface

STROUD WATER RESEARCH CENTER

CitSci Support - Quality Control

QC of water depth

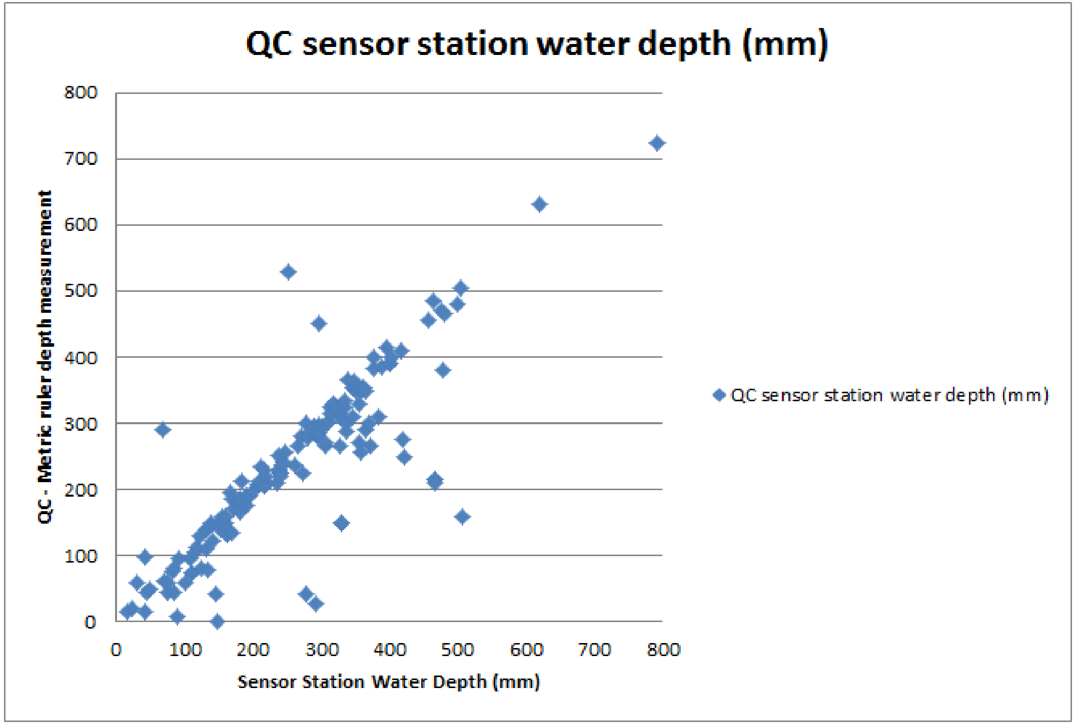
Staff Gauge Height – Sensor Station Water Depth = Offset (*Should remain the same over time)



STROUD
WATER RESEARCH CENTER

CitSci Support - Quality Control

QC of water depth



CitSci Support - Quality Control

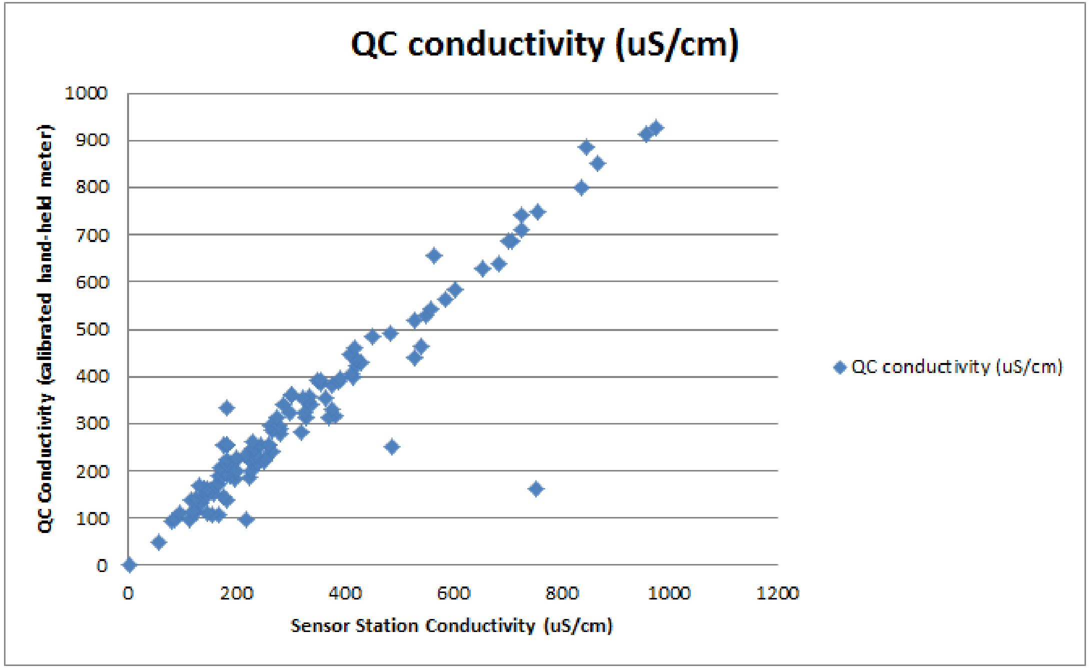
QC of Conductivity

1413 µS/cm Conductivity Standard

STROUD™
WATER RESEARCH CENTER

CitSci Support - Quality Control

QC of Conductivity



CitSci Support - Quality Control

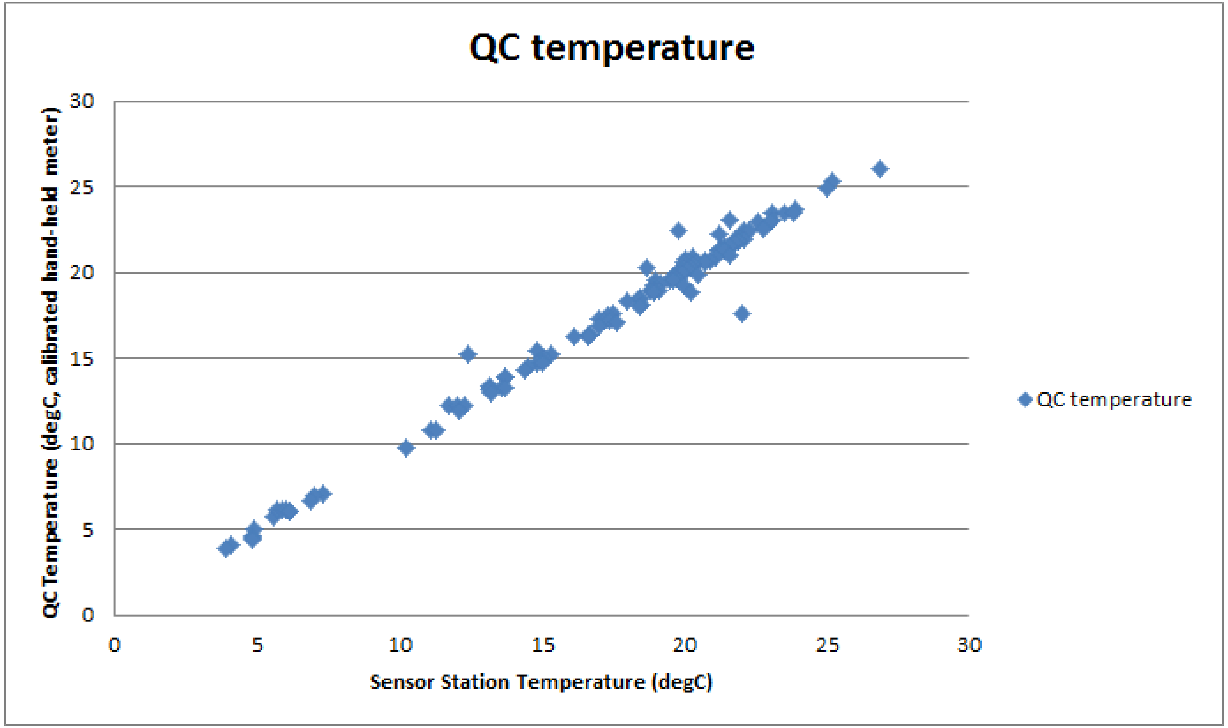
QC of Temperature

1229T59
Description **DURAC** Calibrated Electronic Stainless Steel Stem Thermometer, -40/232°C (-40/450°F), 127mm (5") Probe

STROUD
WATER RESEARCH CENTER

CitSci Support - Quality Control

QC of Temperature



Future

New project, trying things, moving forward, learning, lots of balls in the air

STROUD
WATER RESEARCH CENTER

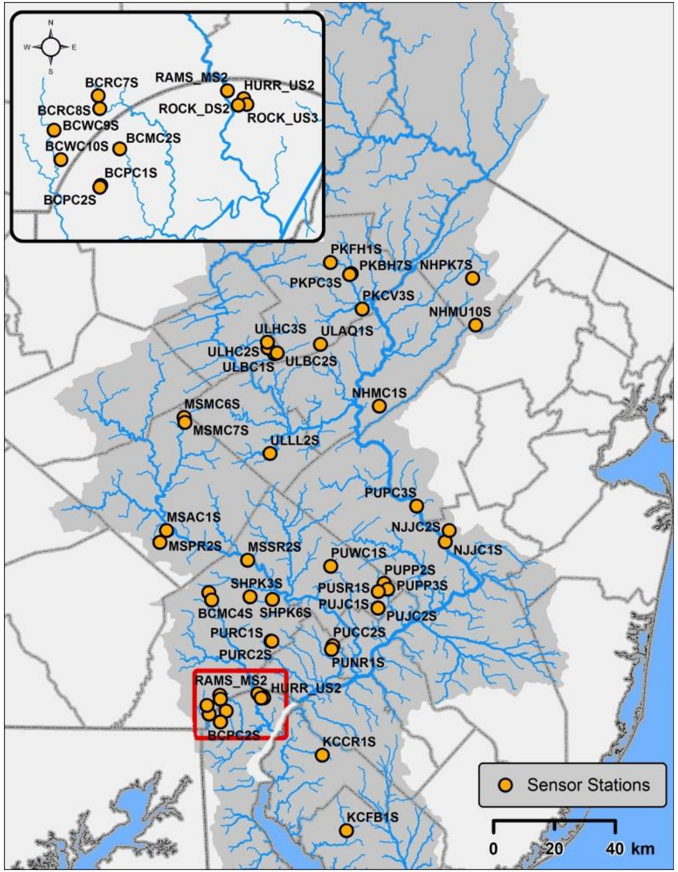
Future

- Lots to do
  - Build CitSci support infrastructure, collaborations
  - Build out Monitor My Watershed
  - Keep up with technology – cell communication, sensors, etc.
  - **Understand and apply the data - site-specific and broadly across the DRB**

STROUD
WATER RESEARCH CENTER

Parts 1-3

- Part 1 – Overview of EnviroDIY sensor stations and citizen science in the Delaware River Basin
- **Part 2 - Preliminary results on analysis of continuous conductivity data from stations across the DRB**
- **Part 3 - Preliminary results on analysis of water temperature data from stations across the DRB**



STROUD
WATER RESEARCH CENTER

Thank you!

Special mention citizen science contributors: Carol Armstrong, George Seeds, and Dave Yake

Stroud Center contributors: Shannon Hicks, Rachel Johnson, Matt Gisondi, John Jackson, Dave Arscott, Matt Ehrhart, Diana Oviedo-Vargas, Marc Peipoch, Melanie Arnold, Heather Brooks, Charlie Dow, Christa Reeves

David W. Bressler
Stroud Water Research Center
410-456-1071 (mobile)
610-268-2153 x312 (office)
dbressler@stroudcenter.org

STROUD
WATER RESEARCH CENTER