Brule River: Water Temperature Monitoring Report

7/1/2014 – 6/20/2015

Brule River Preservation

Northflow LLC "Water Always Wins"

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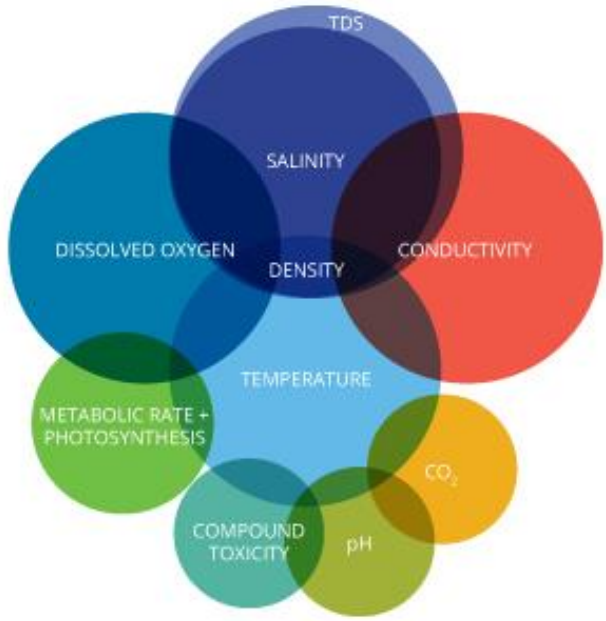
Summary

In efforts to diligently protect and preserve the Brule River, Brule River Preservation elected to pursue water temperature monitoring as a means to keep watch over the river. Northflow LLC was contracted to install, upkeep, and collect data from these monitors. In this report, the results of one year of temperature monitoring will be discussed and analyzed.

Please keep in mind this is the beginning of important record keeping for the Brule River, one year of data will not show large trends, or extraordinary results. The importance of the thousands of data pieces collected is in the tangibility of the data itself. As years continue, and more data is collected, there will be scientific evidence of change in the river.

Changing water temperatures influence the rate of erosion, nutrient spiraling, types of aquatic organisms, and types of vegetation. The Brule River supports a great trout fishery, scenic recreational opportunities, and pure beauty. The data collected will help to make informed management decisions to assure the Brule River is protected for generations to come.

Why Water Temperature Matters



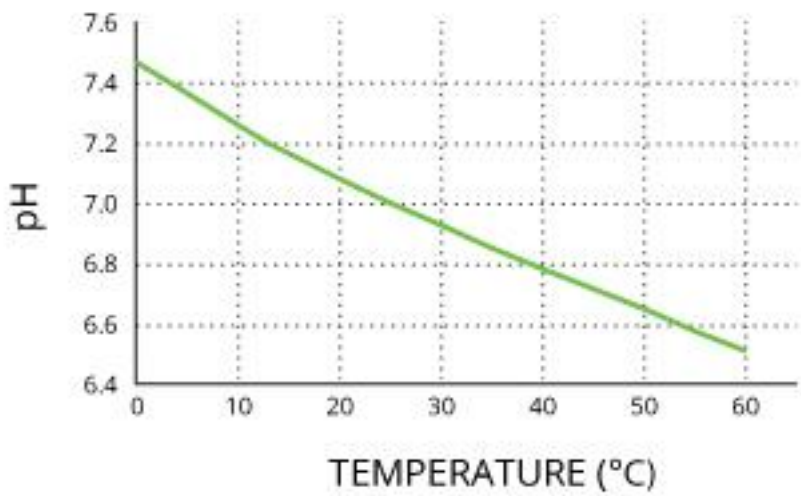
Temperature in an aquatic system dictates nearly every water quality parameter, making it a highly effective way of tracking change in water bodies.

As the graphic to the left depicts, temperature is central to things like Dissolved Oxygen (DO), Total Dissolved Solids (TDS), and pH within a system.

The reason this occurs is hidden in the chemical make-up of water (H_2O). The double hydrogen bond is what allows water to expand when frozen (decreasing the density per unit area), and move more fluidly when heated. As water is warmed steadily, less visible things also begin changing.

For example, the solubility of oxygen decreases as temperatures increase. If water becomes too warm it will not hold enough oxygen for sensitive species (i.e. Brook trout) to survive. An indirect consequence of increasing temperatures is the increased erosion potential created by them. This is because as water temperature increases, the Oxidation Reduction Potential (ORP) increases as well. ORP influences the rates at which ions are dissolved into the water. Meaning soils with high ion content (like clay) are more readily eroded and dissolved by the water (Foley 1999). In turn, increased turbidity (amount of suspended particles in water) will increase water temperature. ORP also impacts nutrient spiraling in river and stream networks. Nutrient spiraling refers to the way nutrients are transformed and transported within a river or stream, rather than nutrient cycling which is commonly used to describe processes in terrestrial or aerial environments. Increased water temperatures will begin changing the chemical structure of a stream (i.e. amount of dissolved oxygen) and hence begin changing the way nutrient spiraling naturally occurs.

The graphic to the right shows yet another way temperature directly influences water quality. As temperatures rise, water becomes more acidic (Kemker 2014). The pH of water can also influence the types and amounts of nutrients available in an aquatic system. If pH becomes too acidic, too few nutrients will be readily available for organisms to survive.



Site Selection

Eleven sites were selected in the summer of 2014 by Brule River Preservation members. These sites were determined to be sites of interest, and held the possibility of being indicator locations. The eleven sites are as listed below.

Site 1: Cedar Island Conservancy

Located below the bridge on the Cedar Island Conservancy property, this monitor is attached to the bottom of the river with a cable and housed in custom fit PVC housing. This site is located upstream in relation to the majority of the other monitors, and is located in a well forested portion of the river. The substrate near this site is rocky and sandy.

Site 2: Big Lake

This site is in a large pool of the Brule River, where the river opens up and is slower moving. This monitor is attached to the bottom of the lake with rebar, cabling, and a custom fit PVC housing unit. This location has very sandy substrate, and sits near large rocks on the east side of the river.

Site 3: Upper Lucius Lake

As pictured, the monitor sits just outside of Wildcat Camp on Upper Lucius Lake. Just across the river from this monitor is a site of sediment accumulation. The unit is attached to a rebar stake and housed inside a custom PVC case. The substrate here is very mucky and black.

Site 4: Downstream Lucius Lake

Immediately downstream of Site 3, this monitor sits just below Castle's foot Bridge. The substrate here is rocky and silty, and the monitor itself is protected by nearby vegetation (as shown in the photo). The monitor is installed with a rebar stake and housed inside a custom PVC case.

Site 5: Winneboujou Bridge

The monitor at Site 5 is located inside a run of the river, indicating fast flowing water. Attached to a rebar stake and housed within a custom PVC case, it is located directly below the Winneboujou Bridge. The substrate at this location is very sandy, and this portion of the river is well shaded and free of debris.

Site 6: Nebagamon Creek

A tributary to the Brule River, Nebagamon Creek holds a high sediment load. Within the extremely silty, mucky substrate, the monitor is housed in a custom PVC case and attached to a rebar stake. This creek has lots of fallen logs and branches within it.

Site 7: Stone's Bridge Canoe Landing

As shown in the photo, this monitor is under Stone's Bridge, just upstream of the canoe landing. The river is very large and slow moving here. This location is free of vegetation and sits within a very rocky substrate. A rebar stake holds the custom PVC housing unit with a steel cable.

Site 8: Brule Ranger Station

This location is within a bend of the Brule River where water is very fast moving. The monitor is attached to sandy/rocky substrate with a rebar stake which holds the unit in a custom PVC house with a steel cable. Some erosion is noticeable on the east bank near the monitor. Lots of overhanging vegetation is present, as well as invasive species along the banks.

Site 9: Castle's Road Culvert

Cutler Creek, a tributary to the Brule River, runs through the culvert of Castle Road. Site 9 is located downstream of Castle Road. A narrow, sinuous stream of water bends through well wooded land. The monitor is attached with a rebar stake, PVC housing, and a steel cable. The substrate is very mucky and soft.

Site 10: Jack's Lake

Site 10 is located on Jack's Lake off of Nedadgewon Road. Jack's lake is very open, and the water moves slowly through it. The monitor is located near a blue post, and is installed with a rebar stake and a custom PVC case. The substrate is very fine, mucky, and soft.

Site 11: Noyes Camp Dock

Located within a large bend in the Brule River, Site 11 is located off of a private dock at Noyes Camp. Both a water temperature monitor and water level monitor are installed at this site. The substrate is very rocky here, and the water is generally open and free of hanging vegetation.

Summary of Site Selection

All eleven sites are located on the Upper Brule River, and tributaries that flow into the Upper Brule River. Each site was chosen on a basis of accessibility and uniqueness of flow type. Below is a summary of the diversity that exists in the current water temperature monitoring sites.

Vegetation Types

Well forested areas of streams with lots of overhanging vegetation tend to support large amounts of aquatic insects and fish populations. Open streams tend to sustain aquatic plant communities that rely on sunlight as a source of energy. Sites 1, 3, 4, 5, 6, 8 and 9 are well forested locations with lots of overhanging vegetation. Sites 2, 7, 10, and 11 are generally more open and have little overhanging vegetation.

Flow Types

Run | Runs tend to occur in straight, fast flowing portions of the river where there are few bends.

Riffle | Riffles often occur at bends in the river, or at areas of rapidly decreasing elevation. They usually include rocks or fallen vegetation and create well oxygenated, fast moving environments.

Pool | Pool sites are slower moving, and deeper than other flow types. Pools provide energy efficient areas for fish to rest and occasionally prey on insects floating through.

Sites 1, 4, 5, 7, and 11 occur in run flow types. Site 8 is the only site occurring in a riffle flow type. Sites 2, 3, 6, 9, and 10 occur in pool flow types.

Substrate

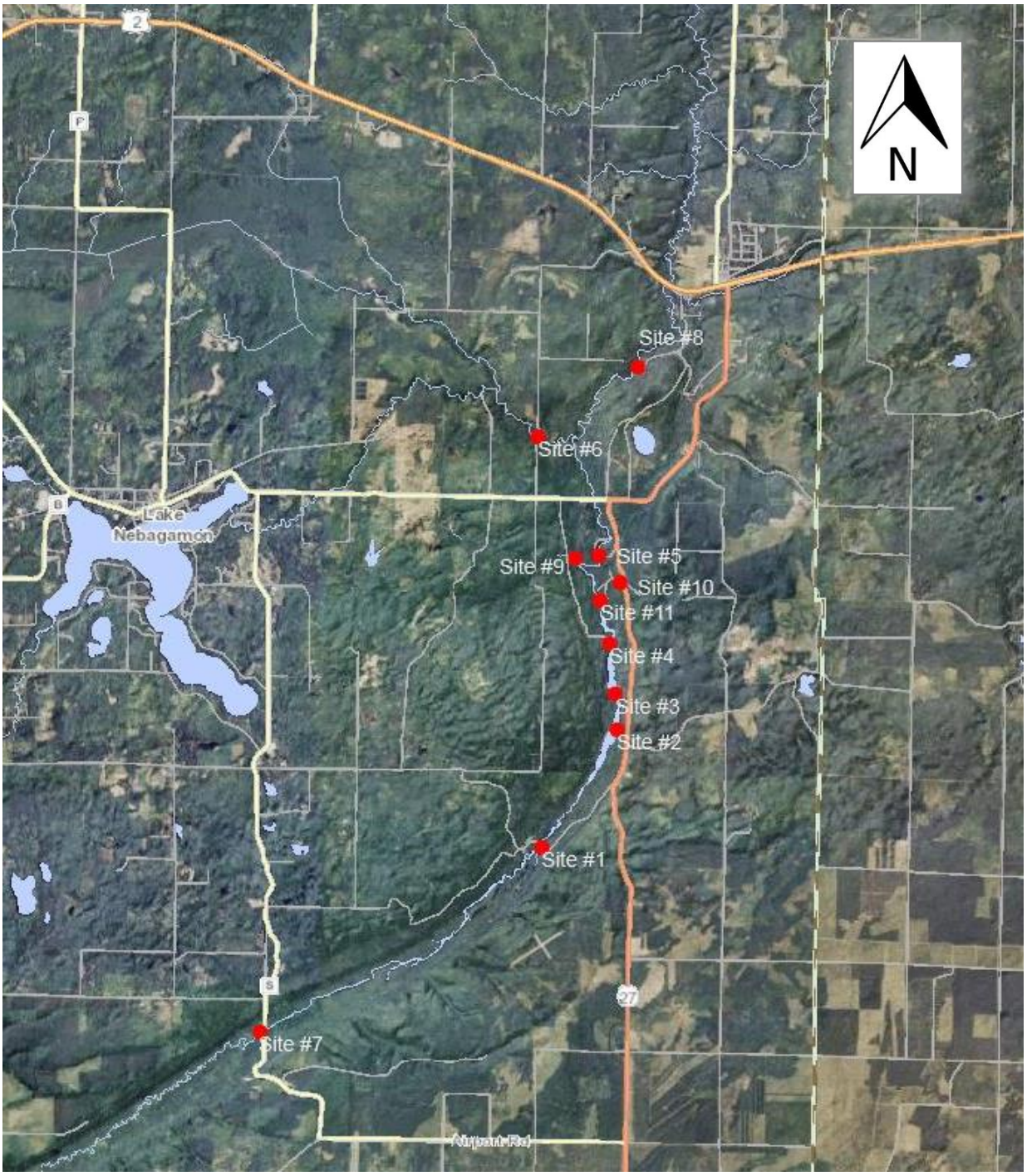
Substrate can effect numerous processes within streams, both biotic and abiotic. As an example, areas with silty substrate can often bind nutrients more readily than areas with rocky substrate, which influences the types of vegetation that occur in that area. Different species of fish and other aquatic life require specific substrate types to effectively reproduce, meaning a rocky substrate may not be habitable for one species of fish, but could be ideal for another.

Sites 1, 3, 4, 7, 8, and 11 have rocky substratum. Sites 2 and 5 have sandy substrates. Sites 6, 9, and 10 have mucky, or silty substrates.

Recognizing these differences in site selection can help in understanding subtle differences in temperature readings and in choosing future sites.

Map of Selected Sites

Below is a map created using Wisconsin Surface Water Data Viewer from the Wisconsin DNR website. Red dots indicate the approximate locations of currently deployed water temperature monitors.



Above: Northflow LLC staff collecting water temperature data and cleaning monitors.

Data

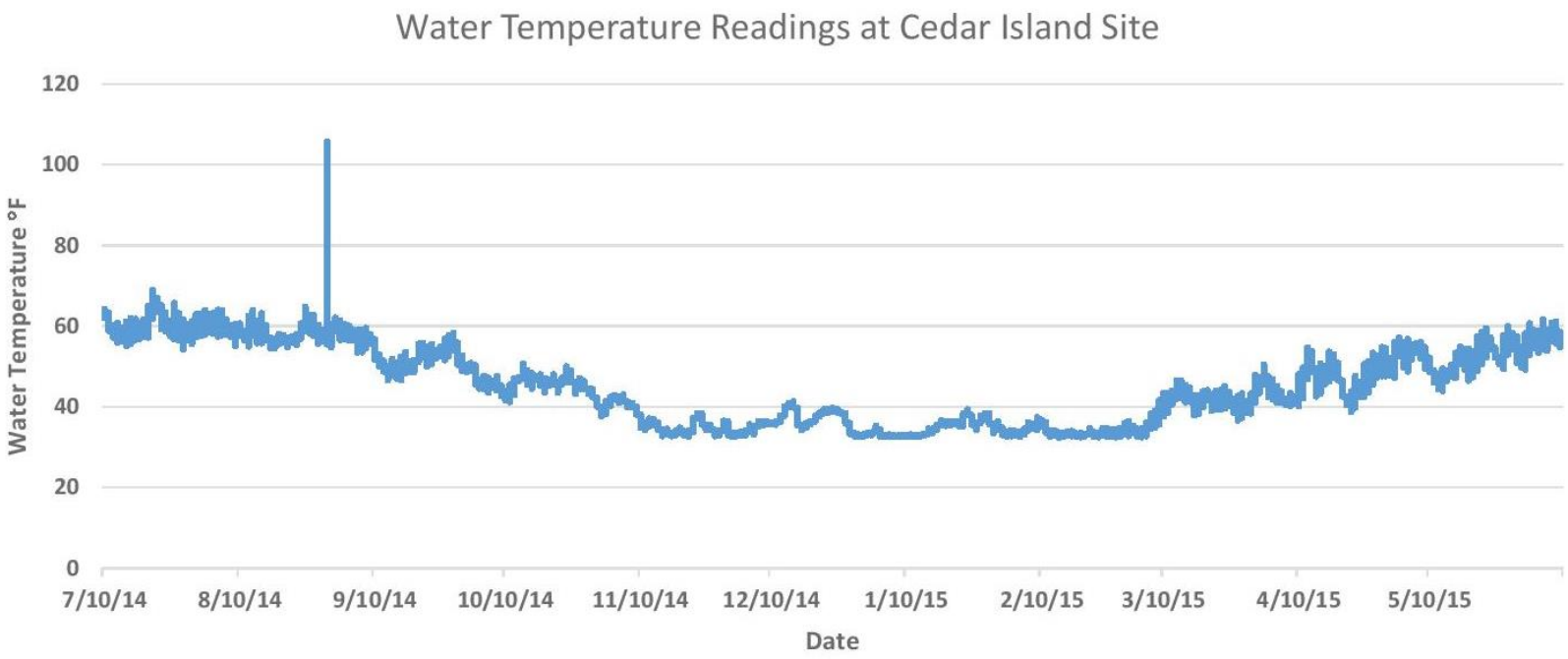
Data was collected on four separate occasions since the installation of water temperature monitoring equipment. During each data collection event, accuracy was checked to ensure monitors were gathering valuable data.

Following are the graphs created using data compiled from all water temperature monitors installed on the Brule River and associated tributaries. Each graph represents roughly 12 months of data. Each monitor records temperature every 30 minutes.

Each graph will be followed by a short discussion of outliers that appear in the data, and a brief statistical summary* of the individual site.

*The statistical summary excludes outlying values to increase the integrity of the data set gathered.

Site 1: Cedar Island Conservancy

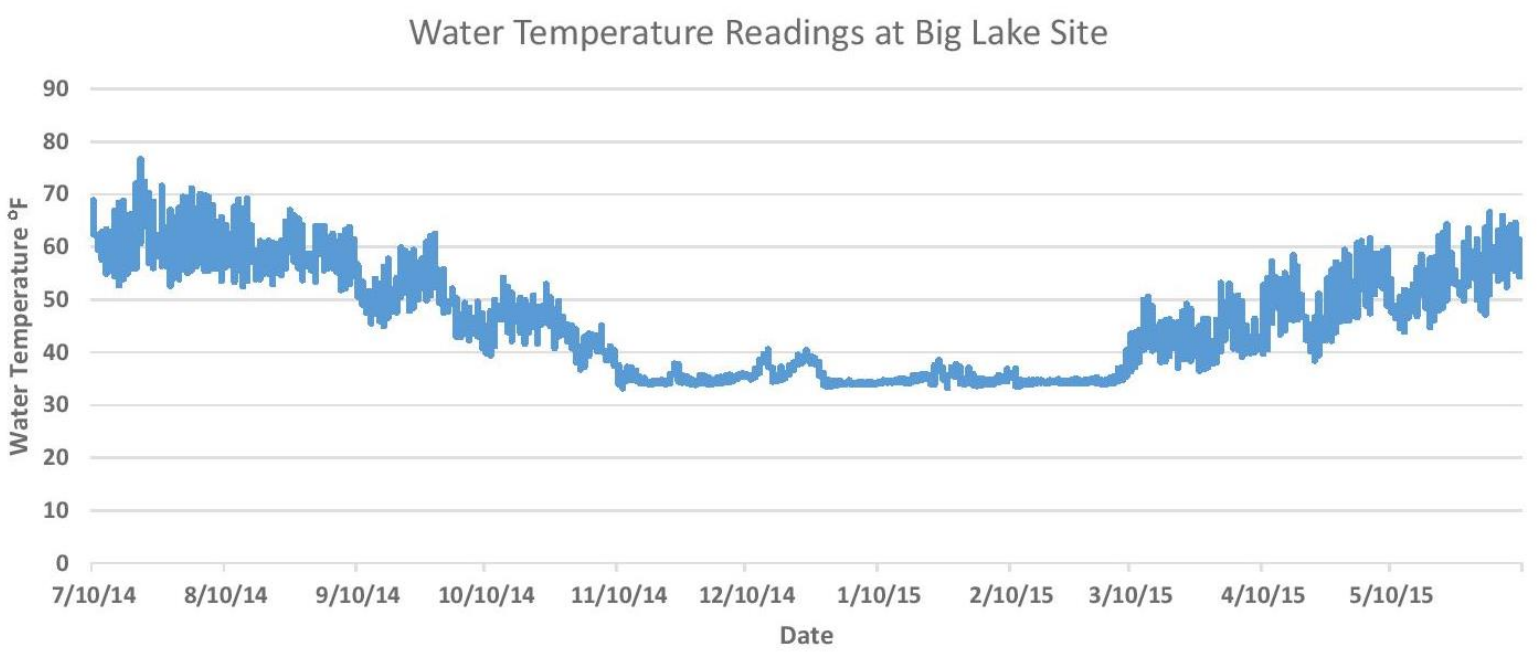


Discussion of Outliers

A large spike occurs for 4 consecutive recording intervals beginning at 2:30 AM on August 8th, 2014. Immediately following the spike of temperatures over 100° F, the monitor resumes recording normal temperatures of about 56° F.

Statistical Summary of Cedar Island Site	
Maximum Temperature	68.871 °F
Average Temperature	45.177 °F
Minimum Temperature	32.443 °F
Number of Observations	16,056

Site 2: Big Lake

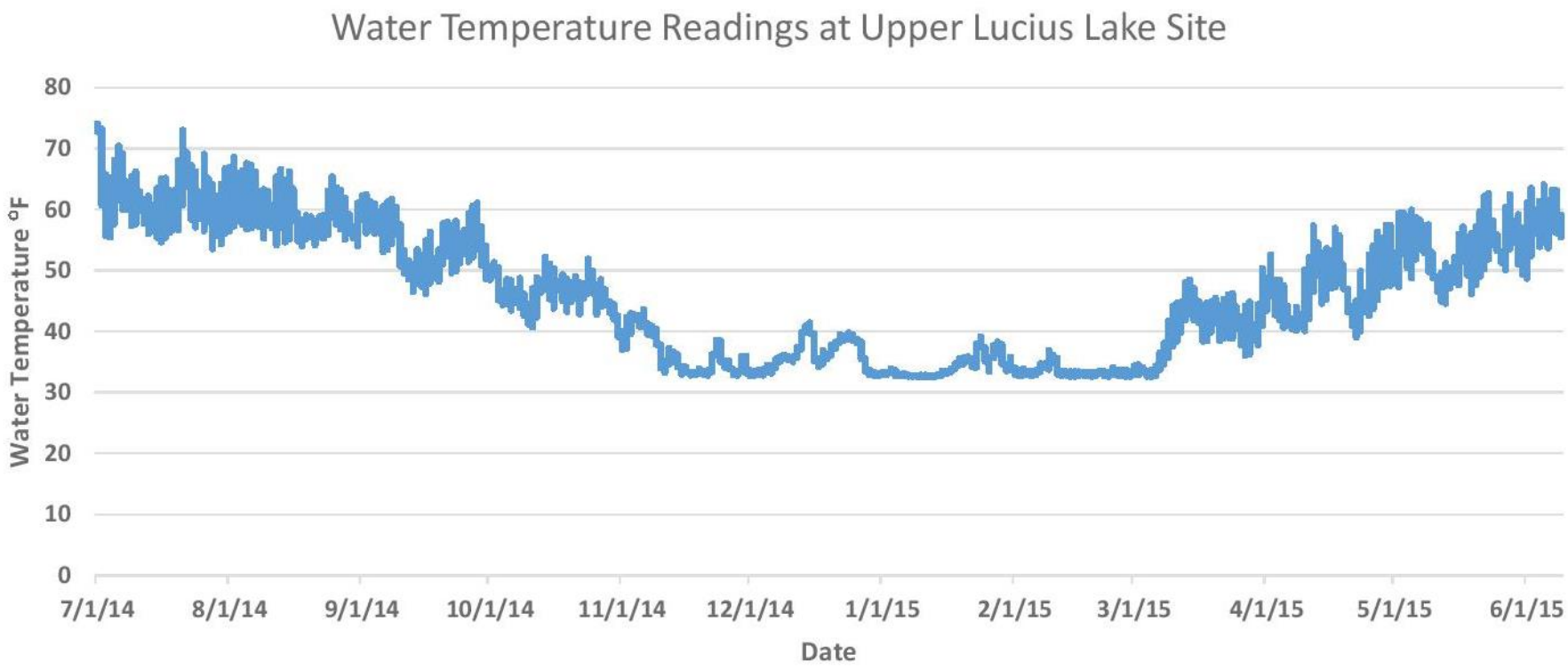


Discussion of Outliers

There are no significant outliers at Site 2.

Statistical Summary of Big Lake Site	
Maximum Temperature	76.593 °F
Average Temperature	45.680 °F
Minimum Temperature	33.237 °F
Number of Observations	16,035

Site 3: Upper Lucius Lake

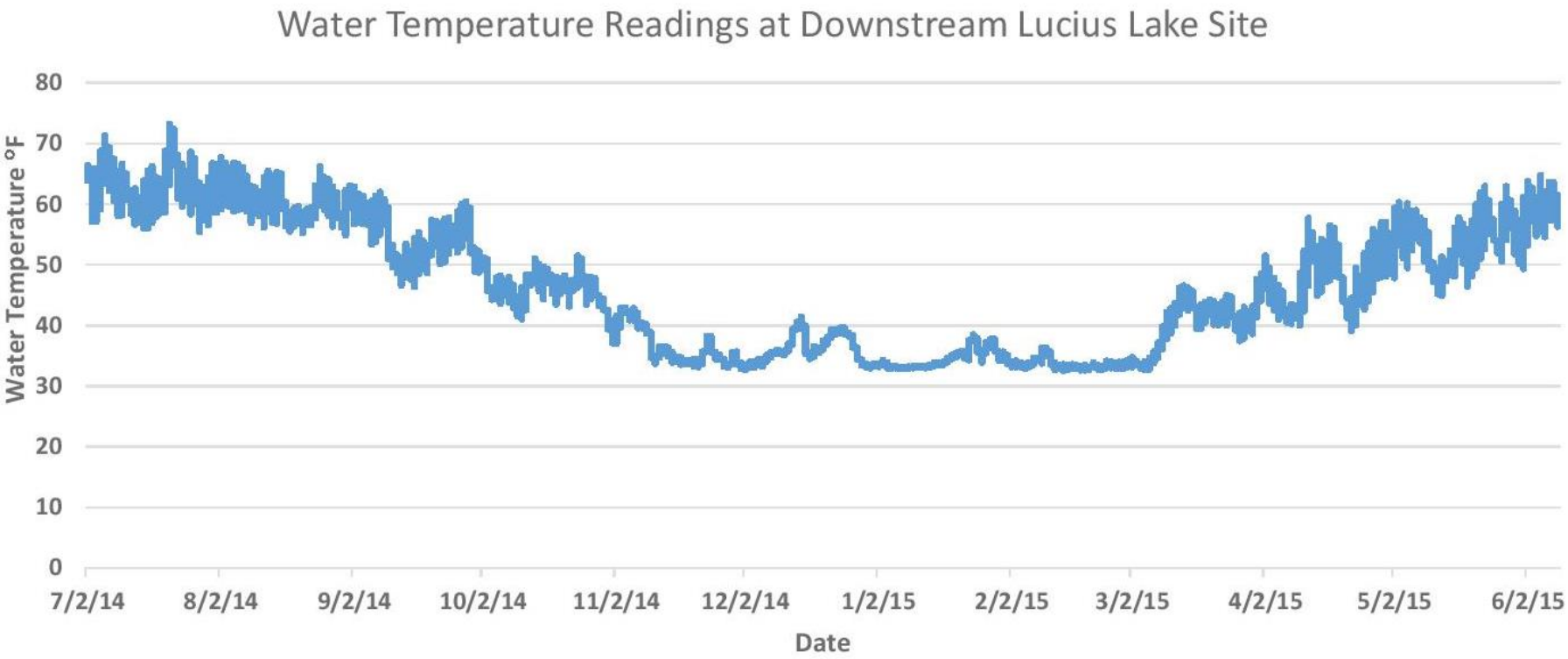


Discussion of Outliers

There are no significant outliers found in the data at Site 3.

Statistical Summary of Upper Lucius Lake Site	
Maximum Temperature	72.995 °F
Average Temperature	45.833 °F
Minimum Temperature	35.542 °F
Number of Observations	16,418

Site 4: Downstream Lucius Lake

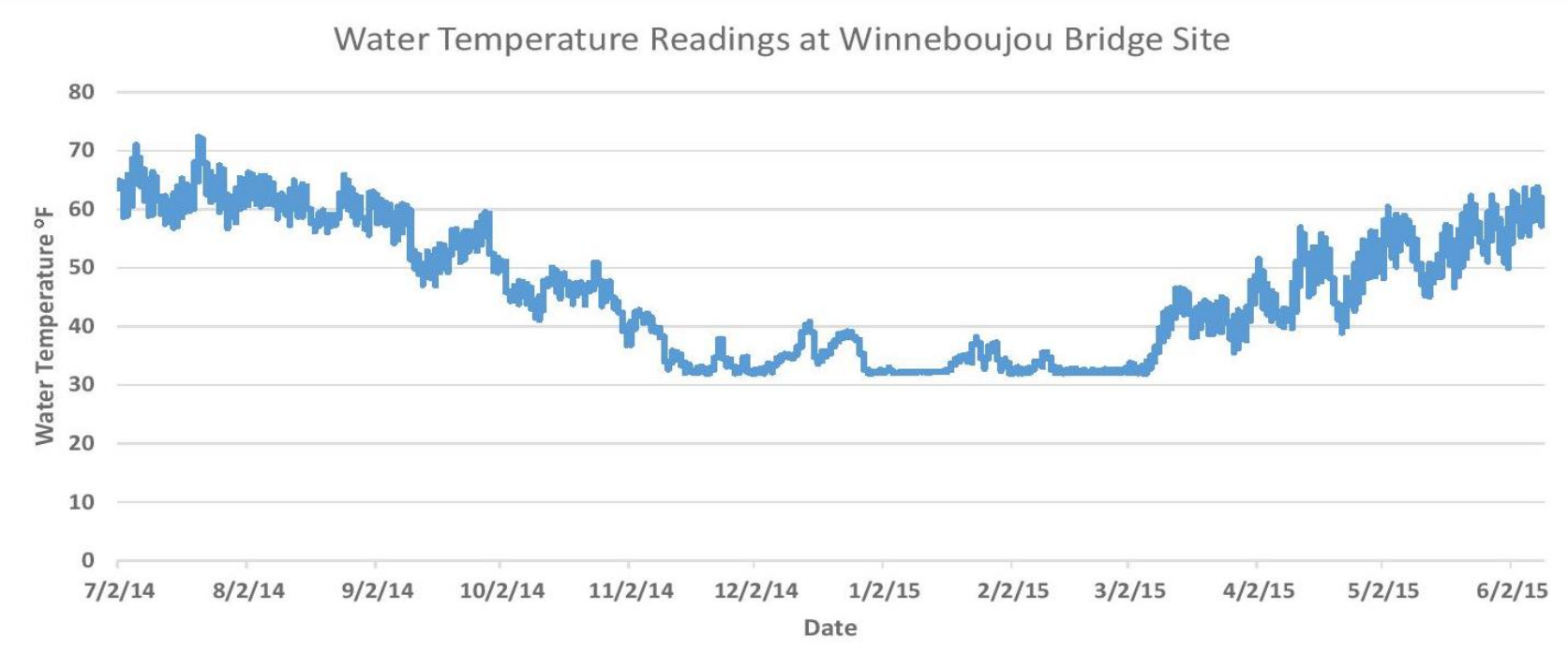


Discussion of Outliers

There are no significant outliers found in the data at Site 4.

Statistical Summary of Downstream Lucius Lake Site	
Maximum Temperature	73.213 °F
Average Temperature	46.317 °F
Minimum Temperature	32.592 °F
Number of Observations	16,414

Site 5: Winneboujou Bridge

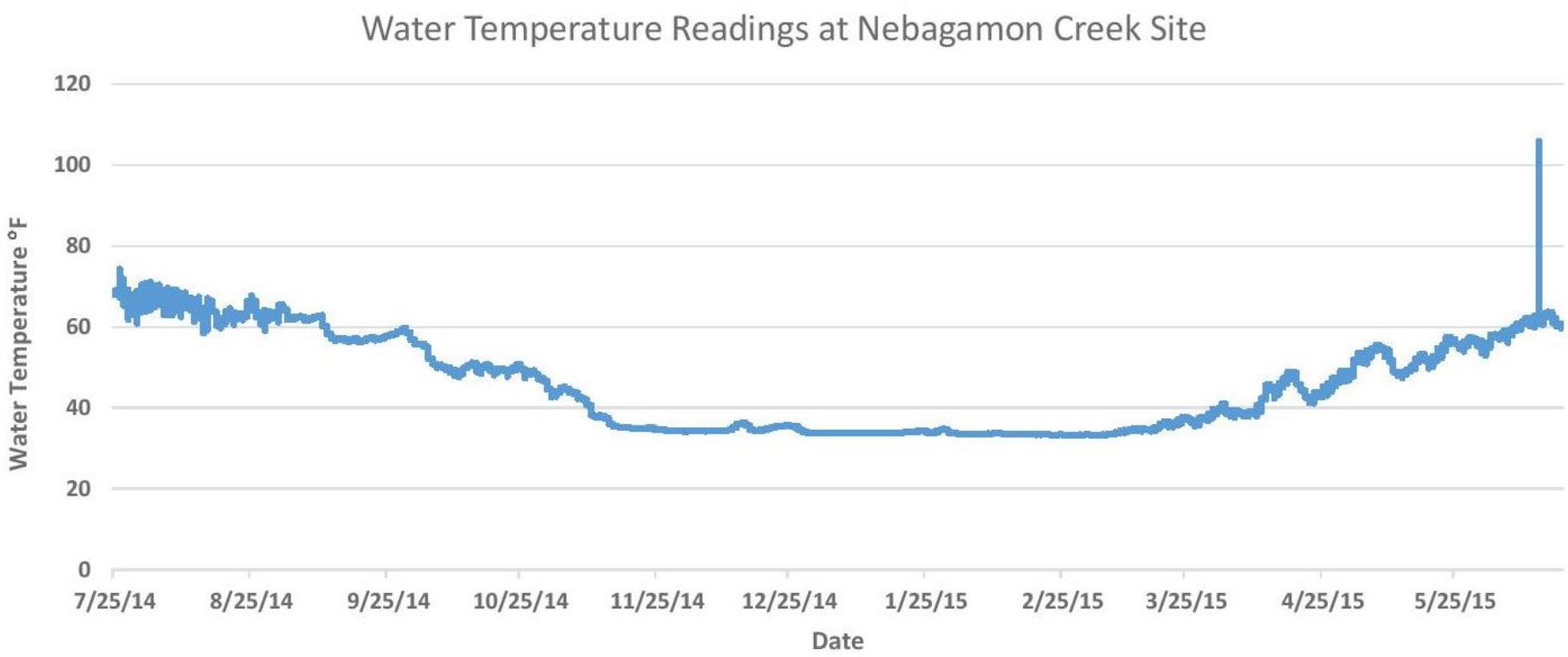


Discussion of Outliers

There are no significant outliers for Site 5.

Statistical Summary of Winneboujou Bridge Site	
Maximum Temperature	72.307°F
Average Temperature	46.115 °F
Minimum Temperature	31.993 °F
Number of Observations	16,418

Site 6: Nebagamon Creek

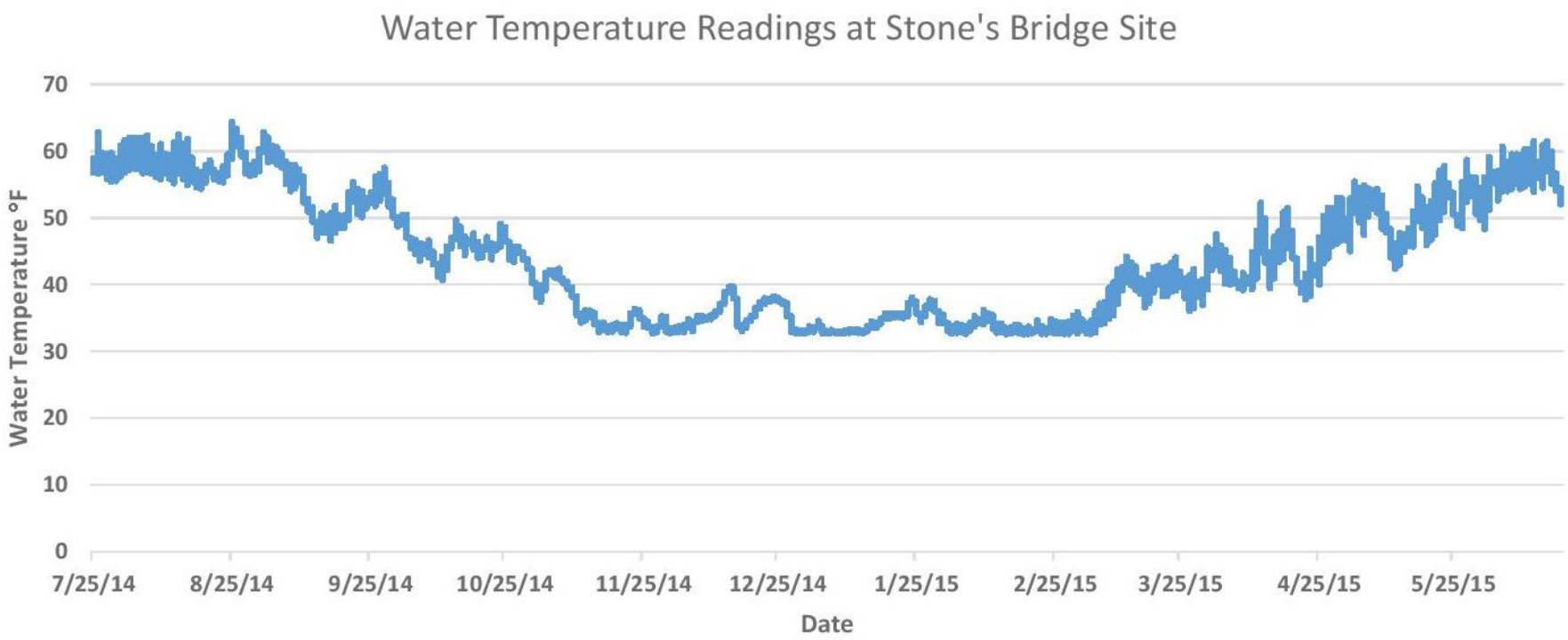


Discussion of Outliers

A large spike occurs for 3 consecutive recording intervals beginning at 6:35 PM on June 13th, 2015. Immediately following the spike of temperatures over 100° F, the monitor resumes recording normal temperatures of about 61° F.

Statistical Summary of Nebagamon Creek Site	
Maximum Temperature	74.338 °F
Average Temperature	45.718 °F
Minimum Temperature	33.287 °F
Number of Observations	15,740

Site 7: Stone's Bridge Canoe Landing

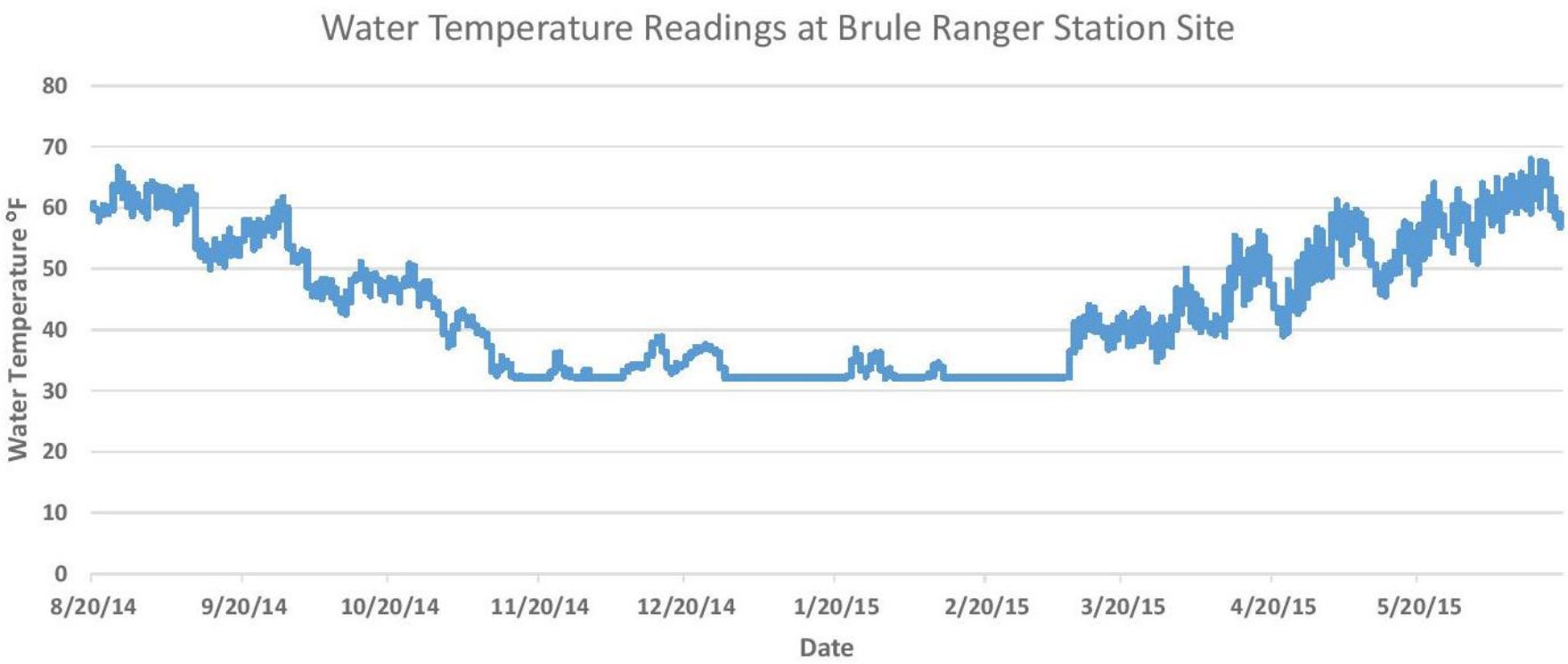


Discussion of Outliers

There are no significant outliers at Site 7.

Statistical Summary of Stone's Bridge Site	
Maximum Temperature	64.288 °F
Average Temperature	44.036 °F
Minimum Temperature	32.592 °F
Number of Observations	15,743

Site 8: Brule Ranger Station

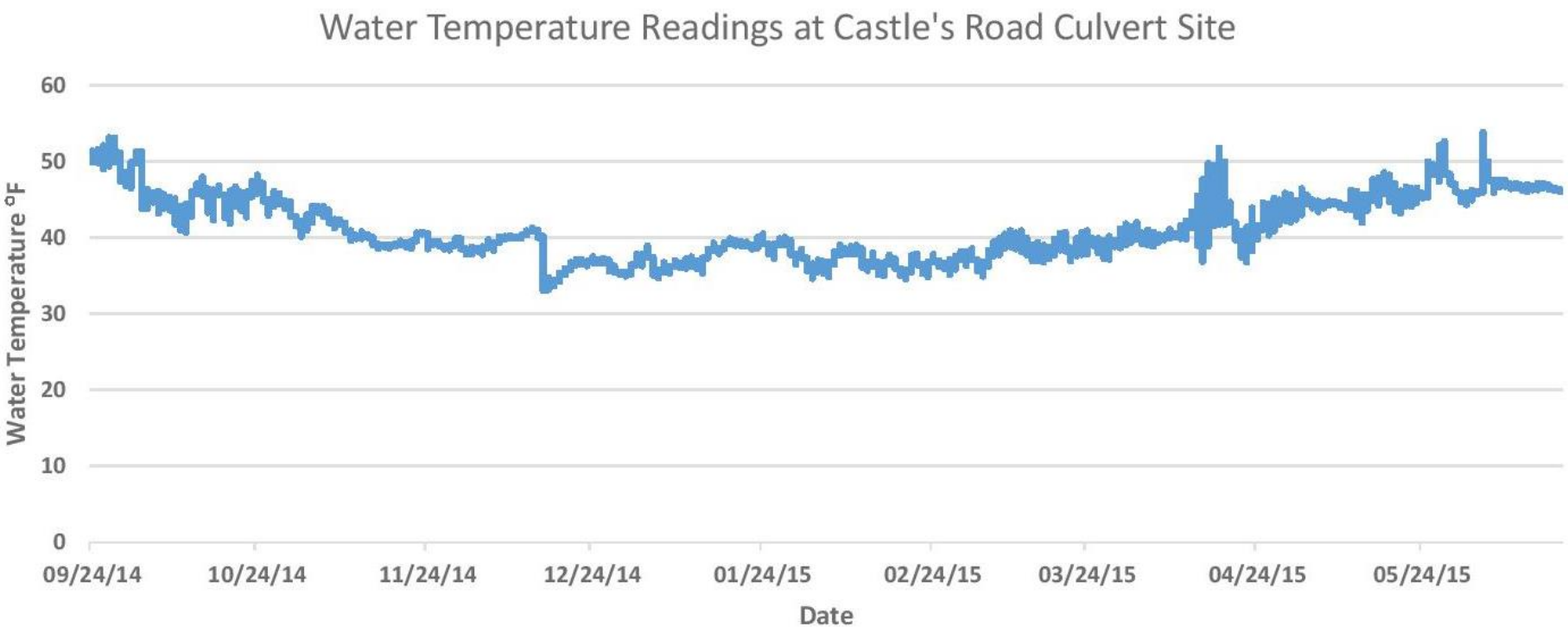


Discussion of Outliers

There are no significant outliers at Site 8. It is important to note the two periods of time where there is absolutely no change in the temperature shown on the graph. Each period of time (December 28th, 2014 – January 22nd, 2015 and February 2nd, 2015 – March 8th, 2015) occurs during cold months, and could possibly be a result of the monitor being frozen in ice. The temperatures recorded during both plateau events are exactly 32.142 °F, the freezing temperature of water.

Statistical Summary of Brule Ranger Station Site	
Maximum Temperature	67.928 °F
Average Temperature	43.855 °F
Minimum Temperature	32.043 °F
Number of Observations	14,490

Site 9: Castle's Road Culvert

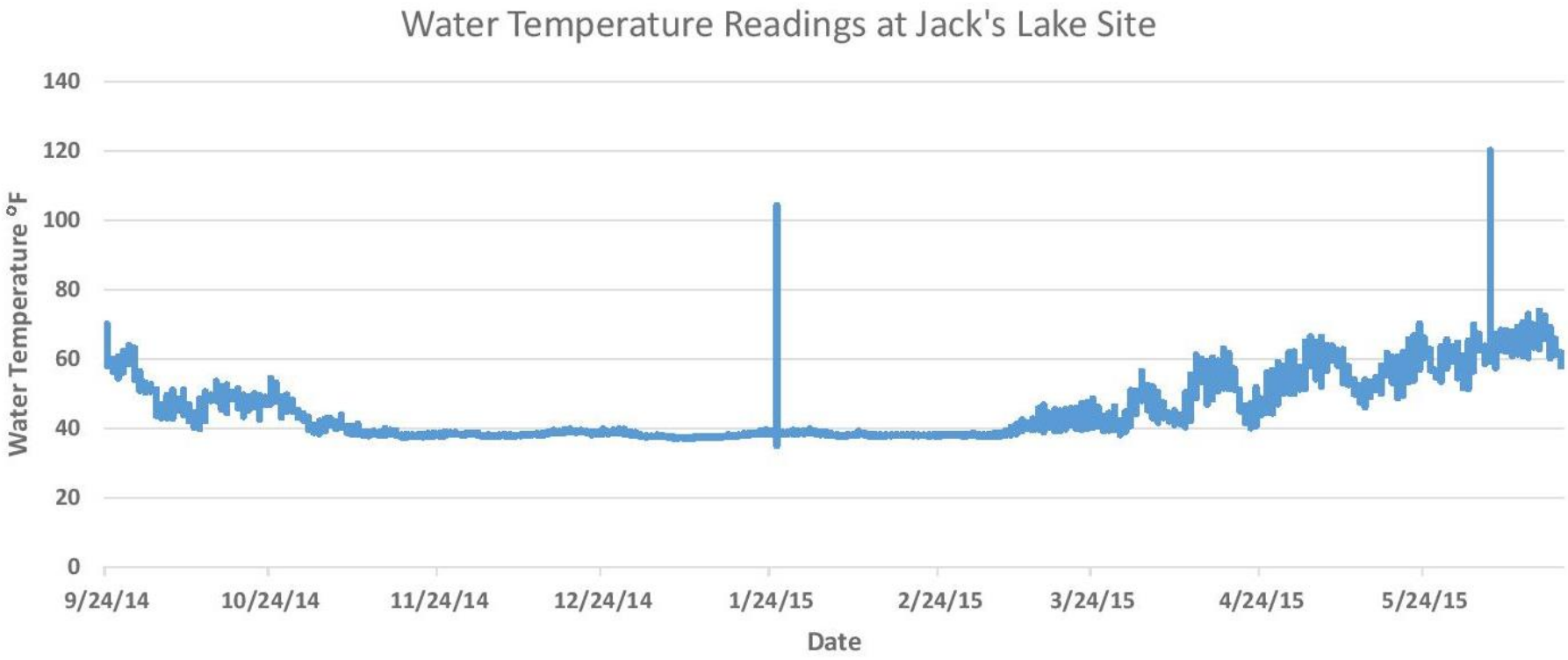


Discussion of Outliers

There are no significant outliers at Site 9.

Statistical Summary of Castle's Road Culvert Site	
Maximum Temperature	53.82 °F
Average Temperature	41.094 °F
Minimum Temperature	33.039 °F
Number of Observations	12,816

Site 10: Jack's Lake

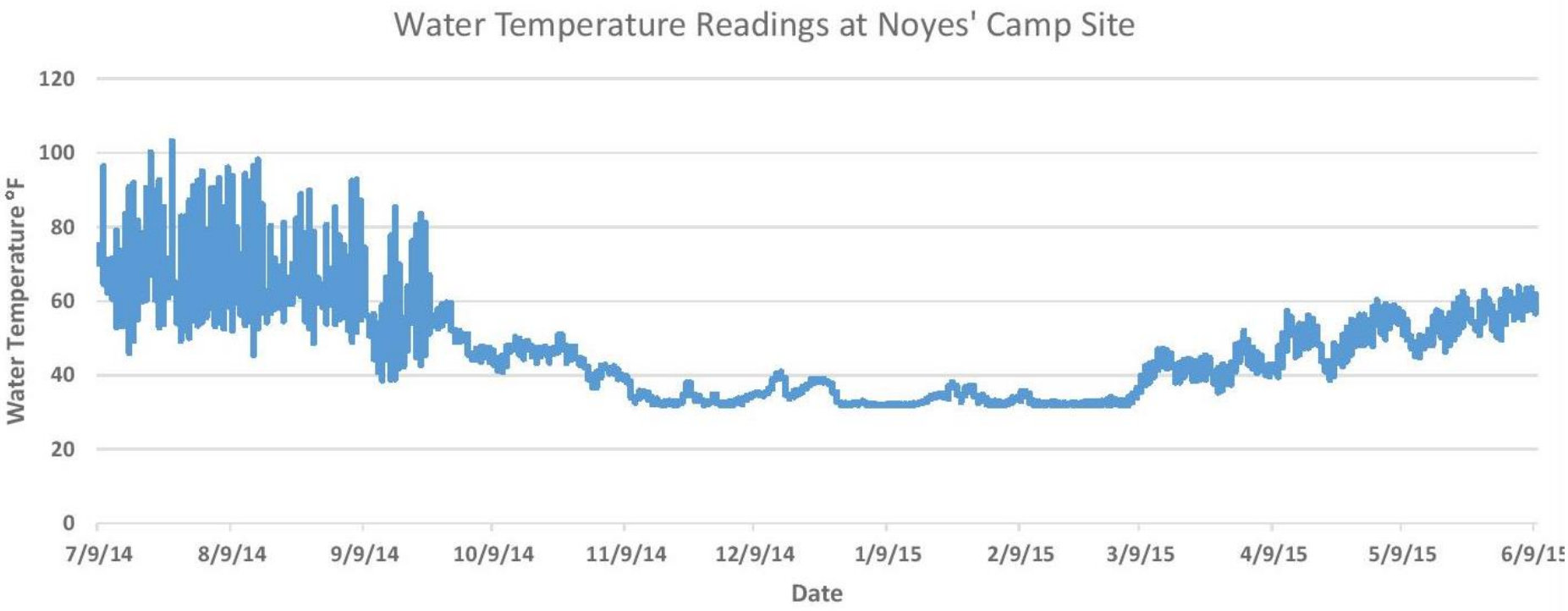


Discussion of Outliers

The first temperature spike occurs on January 25th, 2015 at 7:55 PM. For 3 recording intervals temperatures over 100°F are observed, immediately afterwards the monitor records normal temperatures of about 38°F. The second spike occurs June 5th, 2015 at 8:25 AM. For 3 recording intervals temperatures of over 120 °F are observed. Afterwards, the monitor resumes recording normal temperatures of about 59°F.

Statistical Summary of Jack's Lake Site	
Maximum Temperature	89.499 °F
Average Temperature	51.518 °F
Minimum Temperature	35.006 °F
Number of Observations	16,937

Site 11: Noyes' Camp Dock [Water Temperature Data]

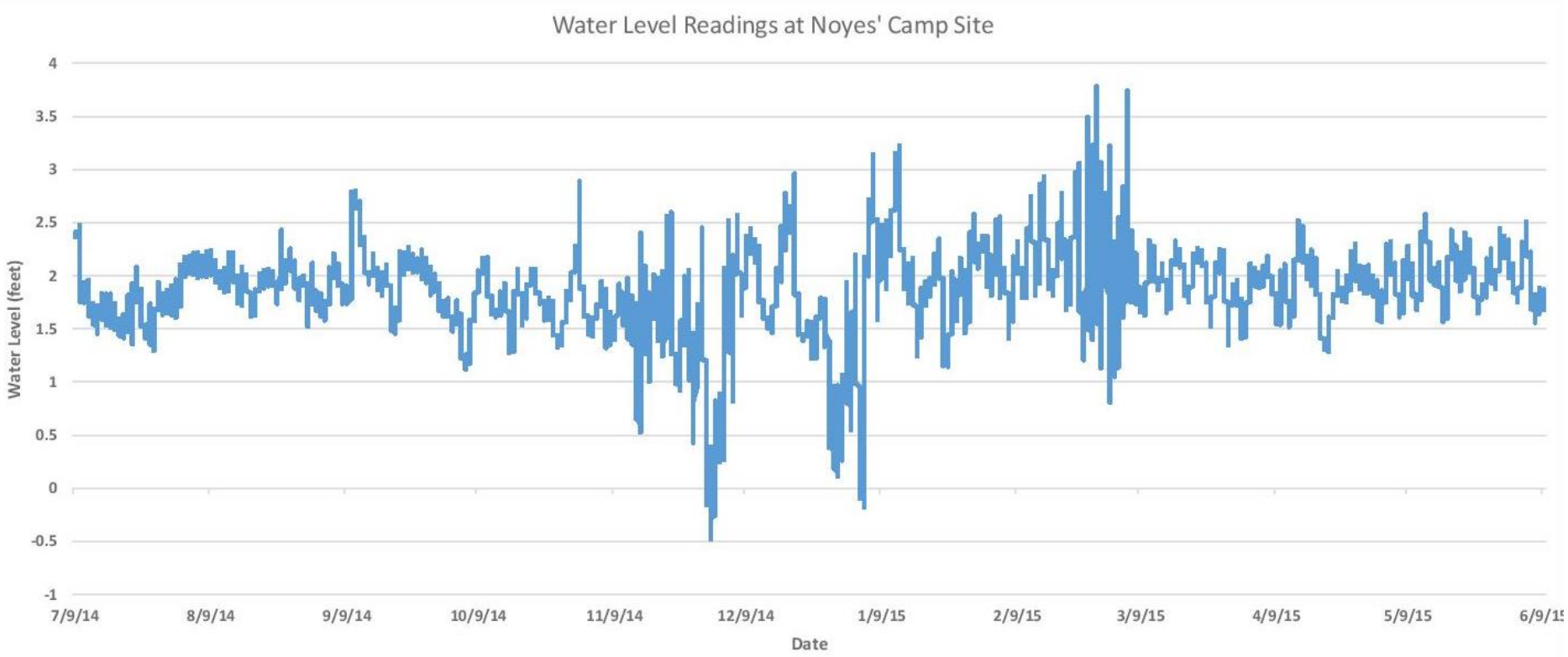


Discussion of Outliers

Of all sites monitored, Site 11 shows the most variable data recordings. From its deployment on July 10th, 2014, it records erratic temperatures until early October 2014. The daily cycle appears to be very cool temperatures in the early morning through afternoon, and a sharp increase in temperatures in the evening around 5:00 PM.

Statistical Summary of Noyes' Camp Site	
Maximum Temperature	103.104 °F
Average Temperature	46.443 °F
Minimum Temperature	31.816 °F
Number of Observations	16,088

Site 11: Noyes' Camp Dock [Water Level Data]



Discussion:

It is difficult to extrapolate meaningful data from this period. It is recommended that the site be moved to a location within the thalwag of the stream and recalibrate the equipment. Future location considerations and installation of a water level / temperature monitoring site should consult with the manufacturer to assure quality and consistency.

Quick Look at the Data:

The warmest site on average was Site 10 (Jack's Lake) at 51.518 °F. Site 10 is located in a pool where water temperatures are expected to be higher as the water is slower moving and has more time to capture the sun's radiant energy.

The coolest site on average was Site 9 (Castle's Road Culvert) at 41.094 °F. Site 9 is a small, well-forested creek that is very well shaded. It is expected that this type of stream is cooler on average than other sites.

The greatest annual fluctuation in temperatures (site maximum recorded temp – site minimum recorded temp) was found at Site 11 (Noyes' Camp) with a difference of 71.288 °F. This is unexpected for the site. Later in the report problems with this site are discussed and possible solutions are given.

The site with the least annual fluctuation was at Site 9 (Castle's Road Culvert) with a difference of 20.781 °F. As Site 9 is well shaded and does not reach extreme warm temperatures in the summer months, this is expected and normal.

The table below lists sites in upstream to downstream order, rather than numerically. As a separate note, keep in mind that sites 6, 9, and 10 are not located in the Brule River, but are tributaries to the Brule River.

Quick Look at the Data			
Site	**Maximum °F**	**Average °F**	**Minimum °F**
7 : Stone's Bridge Canoe Landing	64.288	44.036	32.592
1 : Cedar Island Conservancy	68.871	45.177	32.443
2 : Big Lake	75.593	45.680	33.237
3 : Upper Lucius Lake	72.995	45.833	35.542
4 : Downstream Lucius Lake	73.213	46.317	32.592
11 : Noyes' Camp Dock	103.104	46.443	31.816
10 : Jack's Lake	89.499	51.518	35.006
9 : Castle's Road Culvert	53.820	41.094	33.039
5 : Winneboujou Bridge	72.307	46.115	31.993
6 : Nebagamon Creek	74.338	45.718	33.287
8 : Brule Ranger Station	67.928	43.855	32.043

Important Notes

This section has been included as to give insight to potential issues noted by Northflow LLC staff in the field, as well as highlight problematic data previously shown in this report.

Field Notes

September 24, 2014 | Cedar Island monitor (Site 1), Big Lake monitor (Site 2), and Winneboujou Bridge monitor (Site 5) were originally installed with just a rebar stake and a custom PVC house was attached with zip ties and clamps to it. These three sites were updated to use a steel cable as a means of attaching the PVC house to the rebar. This will assist in fluctuating water levels.

June 9, 2015 | All monitors appear in good condition with slight algal growth that should be completely cleaned at some point in the future. The algal growth does not (at this time) affect the monitors' performance (specifically referencing Sites 1-5, and 11).

June 18, 2015 | During data collection at the Brule Ranger Station (Site 8), the steel cable connecting the PVC housed monitor to the rebar stake anchoring it to the river bottom was found completely cut. It did not appear to look as though vandalism had occurred. This site is located in fast water near a bend in the river which may increase the stress of the cable relative to other sites. The cable was replaced immediately and should be persistently monitored in order to ensure the cable is not cut again.

June 18, 2015 | Monitors at Nebagamon Creek (Site 6) and Castle's Road Culvert (Site 9) were buried in 6+" of fine sediment. During data collection they were unburied and reattached to rebar stakes. These monitors should be either moved to nearby locations with less sedimentation or consistently checked on to unbury and reattach.

Problematic Data

Outliers | Upon review of operating manual for the HOBO Water Temperature Pro v2 Data Logger there are no anticipated explanations for unusual temperature spikes recorded by the monitors. Only 3 sites showed significant outliers, but this should be watched in future monitoring efforts. If outliers begin appearing more frequently, contact to Onset© should be made.

Site Location | Consideration to relocate the monitor at the Brule Ranger Station should be made. As shown in the data, it appears to have frozen solid. Moving it to a deeper portion of the river may help in avoiding the freezing of the monitor.

Site Location | The monitor at Noyes' Camp (Site 11) has recorded extreme daily temperature fluctuation (especially in the first few months of deployment). The water level logger at this location also has recorded extremely varying data. This monitor should potentially be relocated somewhere deeper in the river.

Conclusion

The first year of water temperature monitoring on the Brule River, and related tributaries was successful. There were no gaps in data or equipment malfunctions. The retrieval of data went well and all monitors are still in good condition. The synthesis and analyzation of data in this report has effectively established a baseline for which future years of water temperature data can be compared.

The 11 sites chosen represent diverse parts of the Brule River as discussed in the Site Selection Summary (page 6). This provides useful ways to compare and contrast areas of concern, and understand what areas of the Brule are more susceptible to human impacts.

Recommendations

One year of data has been collected, analyzed, and has established a baseline for years to come. This is valuable and important, but more needs to be done. Continual monitoring and expansion of this project is key.

Definition of an objective for the water temperature monitoring project should be a priority. Following definition, an extensive survey should be done to better understand strategic locations for new

monitors. Suggestions being tributaries and the mouths of these tributaries, the Lower Brule River, and areas affected directly by runoff generated by impervious surfaces.

Funds to update original installment equipment will be necessary after two full years of monitoring, due to the weathering that occurs in aquatic environments. Rusting of rebar stakes, breaking of cables, sedimentation, and algae growth all affect the integrity of the water temperature monitoring installation equipment. The water temperature monitors have batteries that last for about six years. Funds should be prepared to replace these batteries within the six year time frame to ensure data is continuous.

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