

Standard Operating Procedure: Continuous Lake Temperature Monitoring

Arctic Inventory and Monitoring Network

Lake Communities and Ecosystems Monitoring Protocol

Jonathan A. O'Donnell

National Park Service
240 W. 5th Avenue
Anchorage, Alaska 99501

September 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

Please cite this Standard Operating Procedure as:

O'Donnell, J. A. 2018. Standard Operating Procedure: Continuous Lake Temperature Monitoring, Version 1.0. Lake Communities and Ecosystems Monitoring Protocols, Arctic Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.

The main Narrative for the Protocol for monitoring Lake Communities and Ecosystems for the National Park Service's (NPS) Arctic Inventory and Monitoring Network (ARCN) is available from the NPS ARCN website (<http://science.nature.nps.gov/im/units/arcn>).

SOP: Continuous Lake Temperature Monitoring, Version 1.0

Version 1.0 (September 2018)

Version No.	Revision Date	Author	Changes Made	Reason for Change

Contents

	Page
Figures.....	iv
Tables.....	Error! Bookmark not defined.
Appendices or Appendixes	Error! Bookmark not defined.
Introduction.....	5
Components of Lake Monitoring System	5
Data Logger	5
Logger LEDs	5
Hall Effect Switch	6
Battery and Solar Panel	8
Temperature Acquisition Cables (TACs).....	8
Lake Buoy	10
Site Selection	11
Programming Data Logger	13
Deploying Multi-parameter Sonde.....	Error! Bookmark not defined.
Literature Cited	14

Figures

	Page
Figure 1. Map of large lakes in Bering Land Bridge National Preserve, including Devil Mountain lake and Kuzitrin Lake.	11
Figure 2. Aerial photograph of Devil Mountain lake in spring, still partly covered in ice.	12
Figure 3. Aerial photo of Kuzitrin Lake.	13

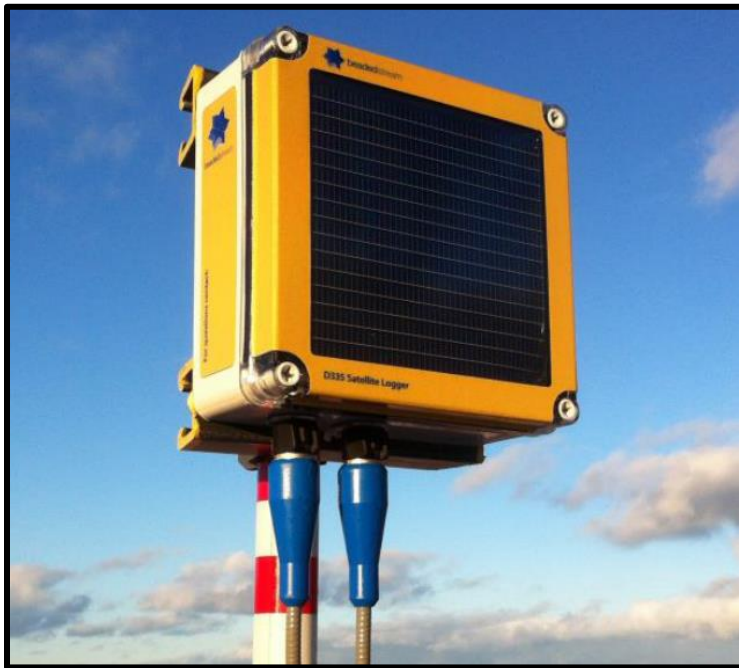
Introduction

This Standard Operating Procedure (SOP) describes the methods for continuous monitoring of lake temperature profiles, and is a component of the Lake Communities and Ecosystems Monitoring Protocol (O'Donnell and Miller 2018). The SOP also describes methods for site selection, lake buoy design, data logger programming, and deployment. Methods have been adopted from approaches developed by the USGS (Wagner et al. 2006; Green et al. 2015) and NPS (Shearer et al. 2015).

Components of Lake Monitoring System

Data Logger

To monitor lake temperature profiles in ARCN parklands, we used technology developed by Beaded Stream, Inc. (<http://beadedstream.com/>). Using a D405 Data Logger, data are logged and transmitted from Beaded Stream Temperature Acquisition Cables (TACs). The D405 is designed to transmit data in realtime through the Iridium satellite network to the internet.



Logger LEDs

Windows in the lid decal of the logger give visual access to LED indicator lights. There are three different LED colors that in combination indicate logger status. In the right-hand window you will see activity from a BLUE and GREEN LED, while in the left, a RED LED.

1. GREEN

- a. With regular logging, **between** logging intervals, the logger will blink GREEN about every 8 seconds (“idle” mode). This serves as a ‘heartbeat,’ indicating that the logger is functioning normally.
- b. With regular logging, **during** logging intervals, the logger will turn solid GREEN indicating that it is communicating with the TAC to obtain, store and transmit temperature readings.
- c. A flashing BLUE LED coupled with flashing GREEN LED for ~ 30 seconds indicates a logger reset.

2. RED

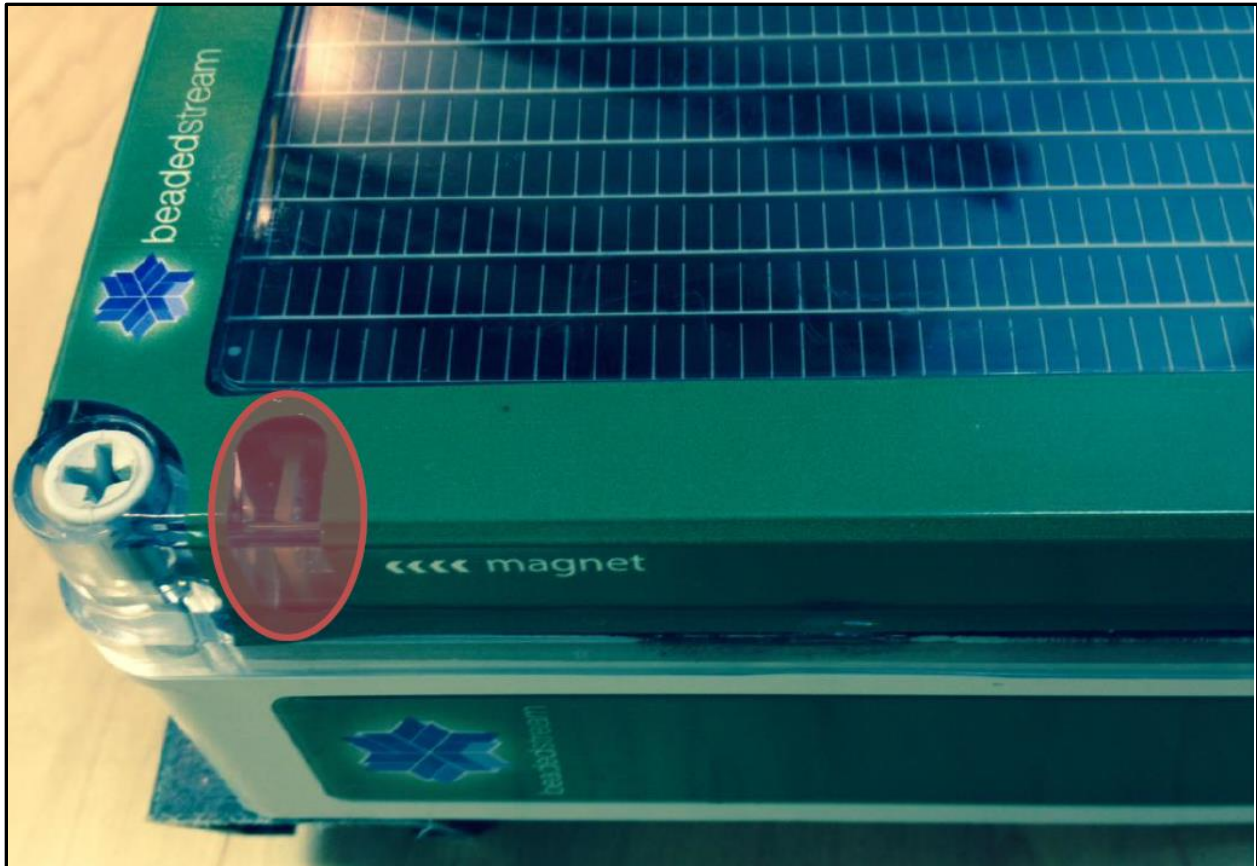
- a. When the magnet is used to reset the logger, the RED LED will go solid.
- b. When the magnet is used to issue an automatic log and/or transmission, the RED LED will flash briefly.

3. BLUE

- a. A solid BLUE LED indicates a Bluetooth connection
- b. A flashing BLUE LED coupled with flashing GREEN LED for ~ 30 seconds indicates a logger reset, which can be conducted during site visits.

Hall Effect Switch

D405 Data Loggers are built with an externally accessible Hall Effect sensor that responds to a magnet by varying its voltage output. By using the magnet and sensor, the user can (1) transmit data, and (2) reboot the logger during site visits. Holding a magnet over the left side of the logger (as indicated in Figure below) will prompt the logger to do one of the following:

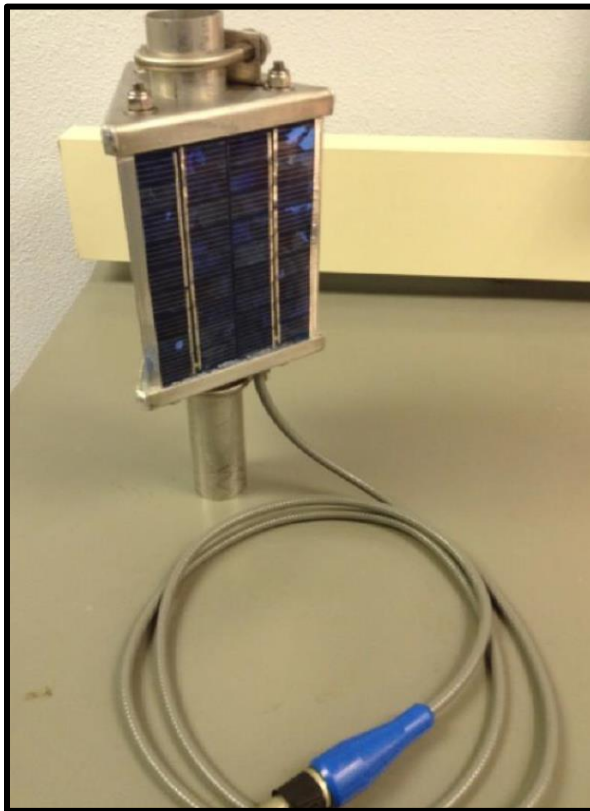


1. Perform a one-time temperature transmit:
 - a. Hold the magnet in the vicinity of the sensor. When the sensor is tripped, the RED LED will shine solid. Hold the magnet in place for two seconds and then remove it.
 - b. Upon removing the magnet, the GREEN LED will shine solid GREEN, indicating that temperatures are being recorded. Once the LED turns GREEN start counting the seconds that it stays GREEN. Most transmissions will take 10 -25 seconds.
 - c. In the event that the light stays GREEN for more than 90 seconds, assume the transmission was unsuccessful and try again.
 - d. The LED will turn off automatically when finished.
2. Reboot the logger:
 - a. Hold the magnet in position, wait until the LED shines RED.
 - b. Hold the magnet in place until the RED light turns off (about 7 or 8 seconds).
 - c. Next you'll see flashing of the BLUE and GREEN LEDs.
 - d. Then, you'll see solid GREEN – the logger is searching for a USB connection.

- e. Flashing BLUE – the logger is searching for a Bluetooth connection.
- f. In the end, what you really want to see is the logger returning to the ‘Idle’ mode (above)
 - GREEN LED blinks every 8 seconds.

Battery and Solar Panel

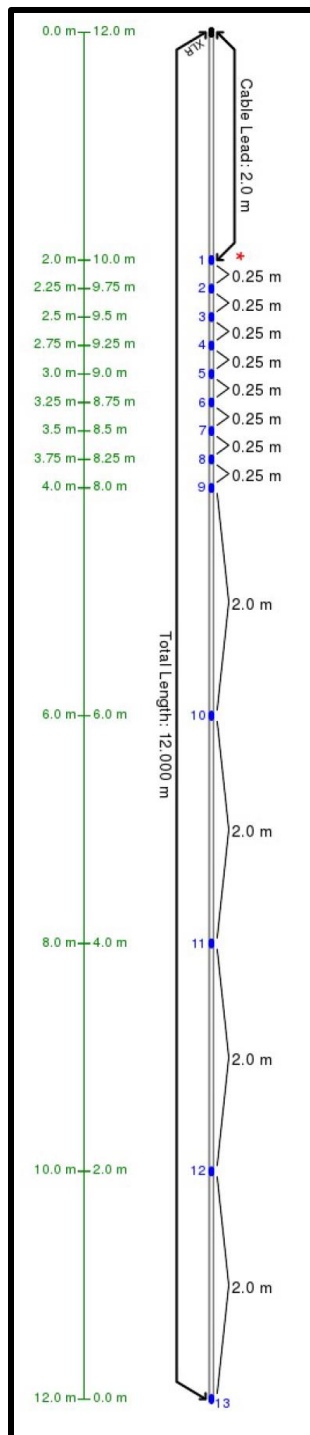
1. Prior to deploying the data logger, charge the battery for at least 24 hours. The data logger comes with a 6-volt trickle charger.
2. Prior to plugging in the 6V charger, unplug the power leads from the logger board.
3. The lake temperature monitoring systems is also equipped with a cylindrical solar panel, so that the battery can receive a steady charge independent of the solar panel orientation. It looks similar this triangular solar panel set up:



4. The battery can also be charged by connecting the solar panel to the data logger, and then allowing the panel and datalogger to sit in the sun for several days.

Temperature Acquisition Cables (TACs)

As of May 2017, we have two lake monitoring systems with different customized TACs that are ready for deployment. One TAC was customized for a 10-m deep lake and another was customized for a 50-m deep lake. See figure below. The thermistors are designed to collect temperature readings at frequent depth intervals near the lakes surface (every 0.25 m for the top 2 m) and at larger depth intervals below 2 m depth (every 2 meters).



At each location where we will be monitoring lake temperature, we will also monitor air temperature using a separate sensor and radiation shield:



Lake Buoy

Thermistor arrays will be mounted on a lake buoy designed by Jon's Machine Shop (Fox, Alaska; <http://www.jonsmachine.com/>):



Site Selection

Discrete temperature measurements along depth profiles will be made at all lakes during routine monitoring (*SOP: Field Measurements*). As of 2017, we have deployed two lake temperature monitoring systems at South Killeak and Kuzitrin Lakes in Bering Land Bridge National Preserve (BELA). South Killeak Lake was selected for monitoring because prior monitoring was conducted there in recent years (Jones and Arp 2014). South Killeak is also a large maar lake (> 50 meters deep), a unique feature of several large lakes in BELA, which formed in response to the interaction of flowing lava and permafrost (Beget et al. 1996). Kuzitrin Lake represents a contrast relative to South Killeak Lake, both in terms of genesis, depth (max depth = 10 meters), and thermal regime.

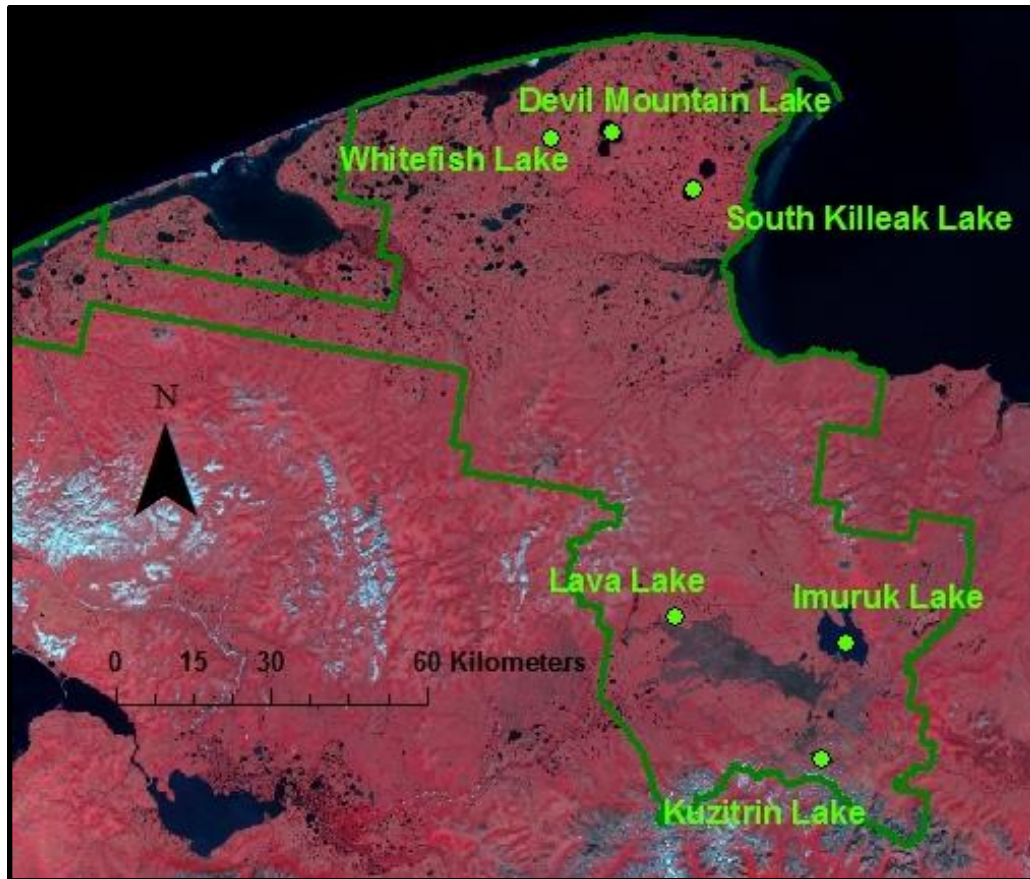


Figure 1. Map of large lakes in Bering Land Bridge National Preserve, including South Killeak Lake and Kuzitrin Lake.



Figure 2. Photograph of lake buoy deployment at South Killeak Lake (BELA).



Figure 3. Aerial photo of Kuzitrin Lake.

Programming Data Logger and Deployment

1. The easiest way to program the D405 data logger is to contact Beaded Stream directly and have them prescribe programming specifics remotely.
2. All sensors along the TAC should be set to log every 2 hours.
3. Data will be transmitted in real time from the data logger to a website hosted by Beaded Stream. The website can be made public if desired, or simply used to monitor temperature data.
4. The lake temperature monitoring system should be deployed in the deepest section of the lake based on existing bathymetric maps or surveys.
5. Lakes should be accessed via float plane.
6. Once on site, mount data logger, solar panel, and air temperature sensor/radiation shield on buoy.
7. Connect TACs to ports on data loggers.
8. Mount anchor rope and anchor to buoy.
9. At the designated location in the lake, carefully lower the anchor and TAC.
10. Check LED lights (see above) to make sure that the data logger is functioning correctly.

Follow-Up Site Visits

Data are transferred from the remote data logger to a webserver hosted by Beaded Stream using Iridium satellite technology. ARCN project staff will have access to this webserver and data, and can monitor trends over time. Given this approach, project staff can plan site visits to the lake buoys on an as-needed basis. Reasons for conducting a site visit may include:

- Low battery power
- Unreasonable temperature values (e.g. 50°C in the middle of winter)
- No data is being transmitted

Literature Cited

- Beget, J. E., D. M. Hopkins, and S. D. Charron. 1996. The largest known maars on Earth, Seward Peninsula, Northwest Alaska. *Arctic* 49:62-69.
- Green, W. R., D. M. Robertson, and F. D. Wilde. 2015. Lakes and reservoirs – Guidelines for study design and sampling: U. S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A10, 65 p., <http://dx.doi.org/10.3133/tm9a10>.
- Jones BM, and Arp CD. 2014. Past, present, and future thermal regime of lakes in Western Alaska. Report to the Western Arctic Landscape Conservation Cooperative.
- Shearer, J., C. Moore, K. K. Bartz, E. C. J. Booher, and J. Nelson. 2015. Monitoring freshwater systems in the Southwest Alaska Network: Standard operating procedures. Natural Resource Report NPS/SWAN/NRR – 2015/925.1. National Park Service, Fort Collins, Colorado.
- Wagner, R. J., R. W. Boulger Jr., C. J. Oblinger, and B. A. Smith. 2006. Guidelines and standard procedures for continuous water-quality monitors – Station operation, record computation, and data reporting: U. S. Geological Survey Techniques and Method 1-D3, 51 p. + 8 attachments; accessed April 21, 2017, at <http://pubs.water.usgs.gov/tm1d3>.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS XXXXXX, Month Year (The Fort Collins Support Office will fill out this line for you)

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov