



Technical Memorandum

Date: May 1, 2020

To: Greg Gotham, U.S. Bureau of Reclamation
Randi Field, U.S. Bureau of Reclamation

From: Julia Semmens, Watercourse Engineering, Inc.
Mike Deas, Watercourse Engineering, Inc.

Copies: Thad Bettner, Glenn Colusa Irrigation District

Re: Keswick Reservoir Water Temperature Profile: Thermistor Cable Deployment - 2019 Field Monitoring.

Water temperature profile information was collected in Keswick Reservoir using remote logging thermistors (temperature loggers) attached to a cable system. This effort is intended to collect vertical profile temperature information in Keswick Reservoir to support current and future modeling efforts.

This is the third monitoring season. 2019 data and logger performance are addressed herein, as well as a presentation of all data collected from 2017-2019. The deployment period for this season extended from May 15, 2019 to December 31, 2019.

Loggers were deployed from the log boom (Figure 1) by U.S. Bureau of Reclamation (Reclamation), with support from Watercourse Engineering, Inc. (Watercourse). The sampling point considered both bathymetric survey information and data from an on-boat depth finder. Deployment and retrieval activities were completed by boat and operated by Reclamation staff.

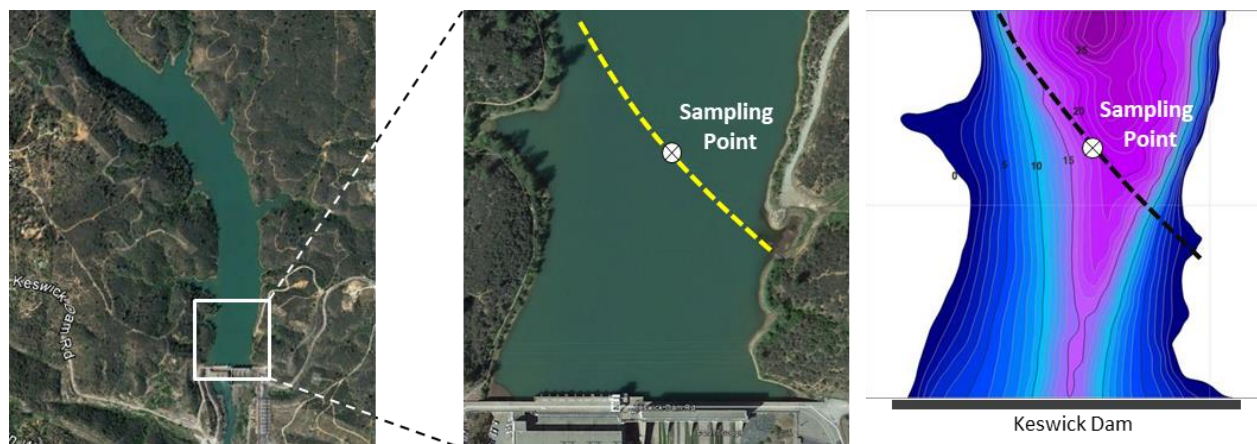


Figure 1. Keswick Reservoir - plan view. Project area (left); sampling location along log boom (middle); sampling location along log boom with bathymetry (right).

Water Temp Pro v2 temperature loggers from Onset Computer Corporation (<http://www.onsetcomp.com>) were used for this study (Table 1). Specifications are included in the Appendix. The near-surface logger was set at a depth of 1 foot with the subsequent seven

loggers distributed as shown in Figure 2 and listed in Table 2. The sampling interval was set to 30 minutes, and all loggers recorded consistently on the hour and half hour.

Table 1. Keswick Reservoir water temperature logger equipment specifications and selected deployment details.

Logger Brand/Model	Onset Computer Corporation HOBO Water Temp Pro v2
Accuracy	$\pm 0.38^{\circ}\text{F}$ ($\pm 0.2^{\circ}\text{C}$)
Temperature Range	-40°F to 158°F (-40°C and 70°C) in air and up to 122°F (50°C) in water
Maximum Depth	waterproof to 400 feet (120 meters)
Recording Interval	30 minutes

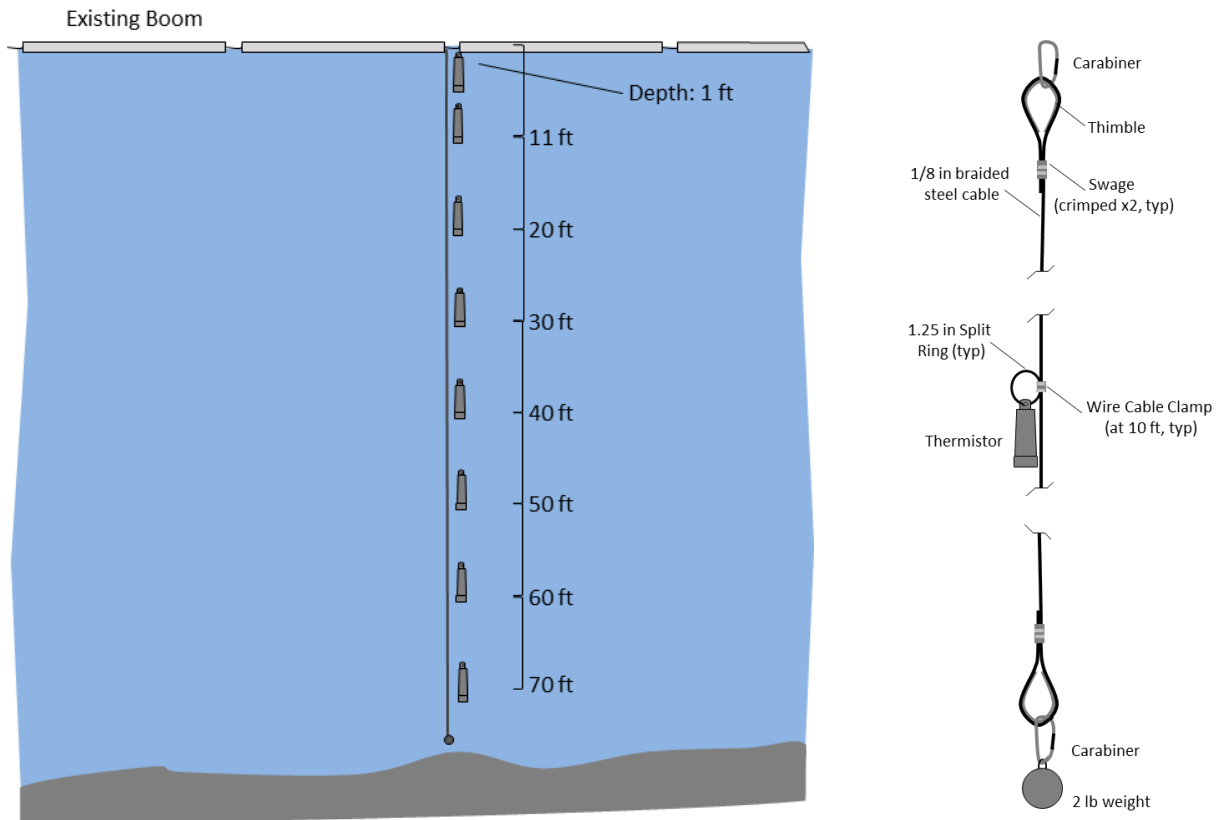


Figure 2. Keswick Reservoir thermistor cable deployment logger depths (left); cable deployment details (right).

2019 Temperature Monitoring

The cable system was deployed on May 15, 2019 at approximately 10:30 a.m. and removed on December 31, 2019 at approximately 10:00 a.m. Logger numbers and associated depths for this deployment are included in Table 2. The logger positioned at a depth of 10 ft malfunctioned and did not collect data for the duration of the deployment.

Table 2. Deployment 3 (2019) Keswick Reservoir thermistor cable logger numbers and associated depths.

Count	Logger #	Depth (feet)
1	10566842	1
2 ¹	10709959	10
3	10212028	20
4	10508027	30
5	10587866	40
6	10566839	50
7	10498716	60
8	10709955	70

1: Logger 2, positioned at a depth of 10 ft, did not collect data.

Water temperature data from the thermistor cable deployed in 2019 illustrates stratification from mid-May through mid-November of 2019 (Figure 3 and Figure 4). The reservoir was more clearly stratified during the summer, as surface waters were notably warmer than deeper waters. These deeper, cooler waters represented cold water releases from Lake Shasta. Stratification diminished in the fall and isothermal conditions returned to the reservoir in mid-November.

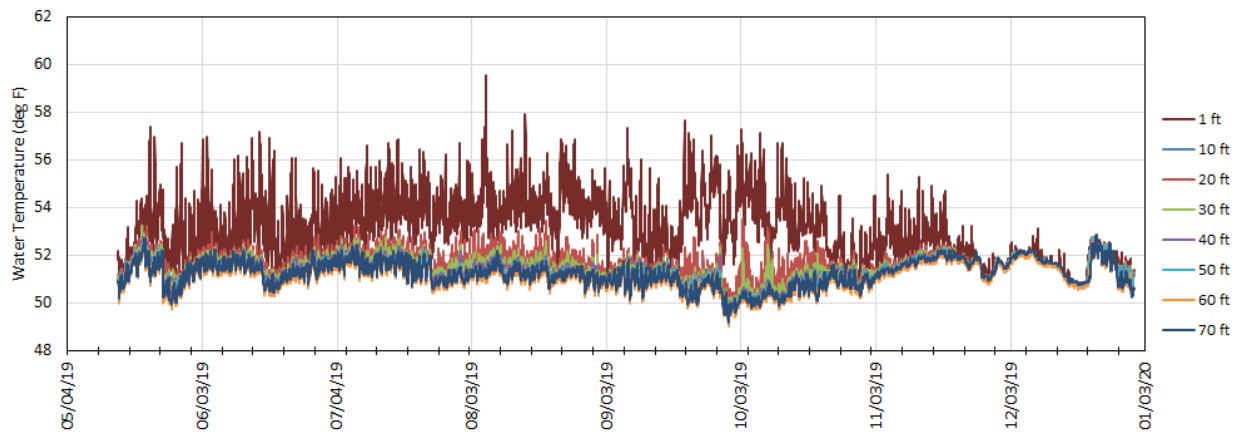


Figure 3. Keswick Reservoir thermistor cable water temperature time series: 5/15/2019 to 12/31/2019

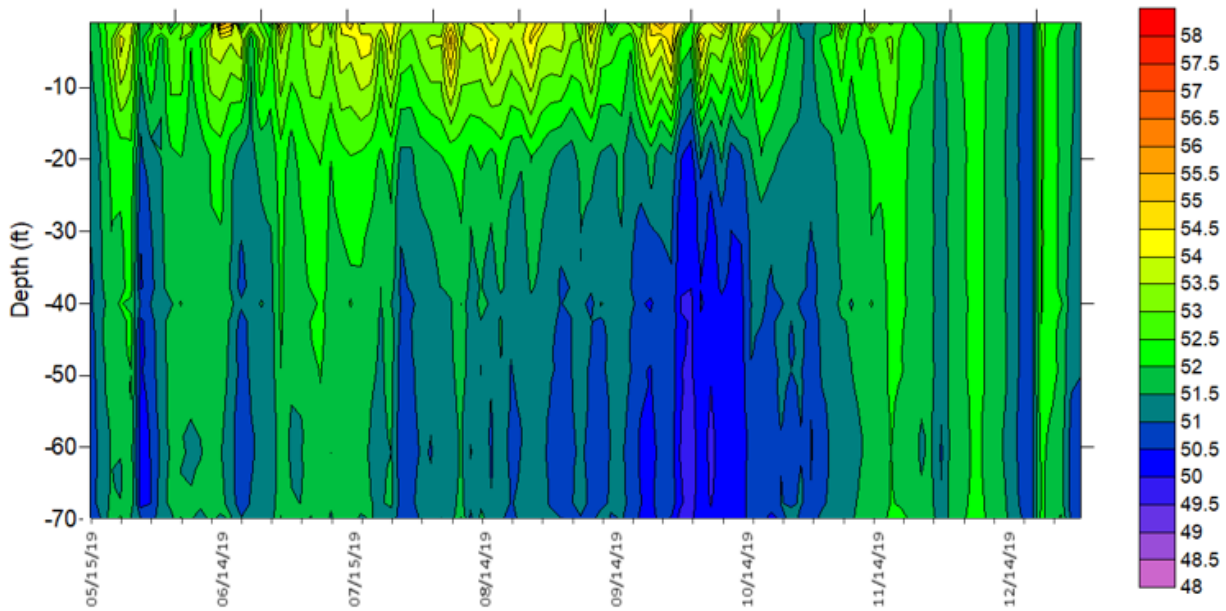


Figure 4. Keswick Reservoir thermistor cable temperature isopleth plot: 5/15/2019 to 12/31/2019.

Logger Performance

Examining difference between adjacent loggers identified that variability in loggers was largely within factory specifications of $\pm 0.38^{\circ}\text{F}$. While there is often a bias, for example, among adjacent loggers, the discrepancies are small and within the resolution of logger accuracy. The consistency of the loggers is demonstrated by water temperature differences between adjacent loggers (Figure 5).

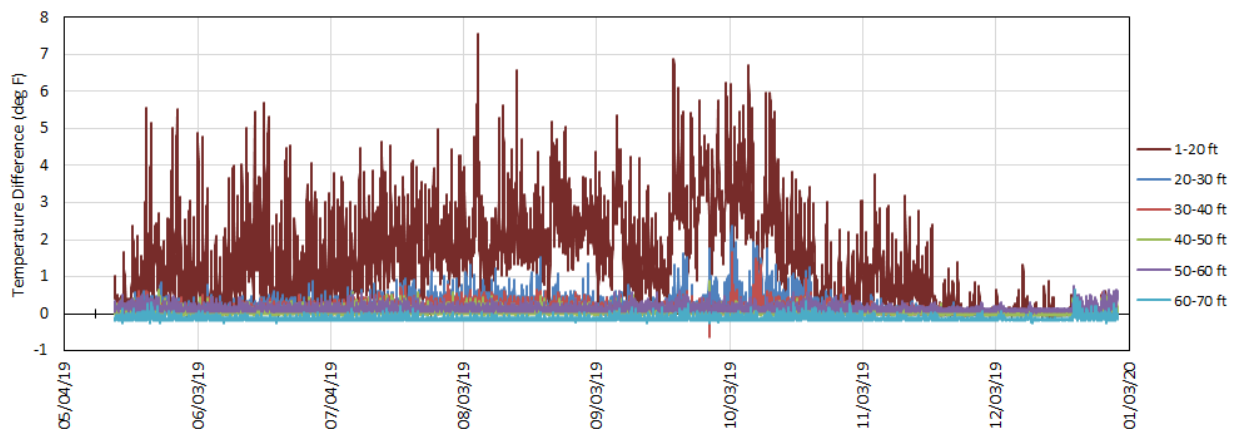


Figure 5. Water temperature differences between adjacent loggers (higher logger minus lower logger): 5/15/2019 to 12/31/2019.

2017 – 2019

2019 represented the third seasonal deployment of a thermistor cable in Keswick Reservoir. For deployment details of 2017 and 2018, see Deas (2018, 2019). Water temperature data from the thermistor cable illustrates a wide range of intra- and inter-annual temperature signals. Intra-

annual variability includes short-term variability in meteorology conditions, weak intermittent stratification in the late summer and early fall, continued warming of deep Lake Shasta waters in response to spring through summer thermal loading of the upstream lake, seasonal cooling, TCD gate changes, and other processes (Figure 6). Inter-annual variability occurs as well, with different years illustrating different temperature conditions in response to variable meteorological conditions and operations at Lake Shasta.

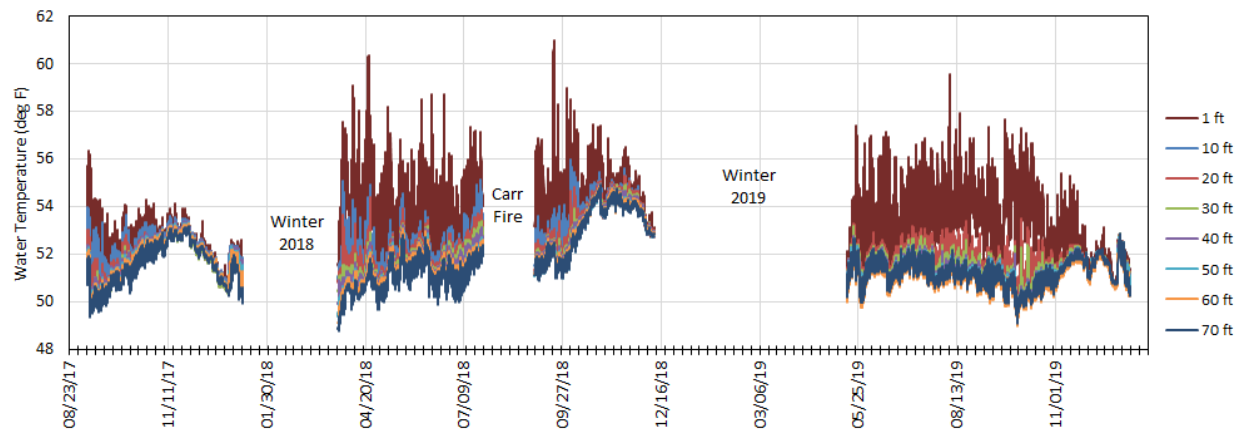


Figure 6. Keswick Reservoir thermistor cable water temperature time series: 9/6/17 to 12/31/2019.

Ongoing Monitoring

Thermistor temperature monitoring is planned for 2020.

Data

This document is accompanied by an Excel spreadsheet (filename: Keswick Reservoir Tw Data Loggers 2017-2019.xlsx) that includes a final version of the field data. The raw data files (*.hobo) from each logger are also included (filename: Keswick 2019 Tw Raw Hobo Files.zip).

Acknowledgements

Field work was completed with the support of Reclamation staff and using an agency boat. We appreciate the assistance of Greg Gotham, Janet Martin, and Tyler Ward. Other Reclamation staff that initiated the project work are Paul Zedonis and Randi Field.

Reference

- Deas, M. 2017. Keswick Reservoir Water Temperature Profile: Thermistor Cable Deployment. Technical memorandum to G. Gotham and R. Fields, U.S. Bureau of Reclamation. June 7. 6 pp.
- Deas, M. 2019. Keswick Reservoir Water Temperature Profile: Thermistor Cable Deployment - 2018 Field Monitoring. Technical memorandum to G. Gotham and R. Fields, U.S. Bureau of Reclamation. March 11. 7 pp.

Appendix: Water Temperature Logger Specifications – Summary*

HOBO Water Temperature Pro v2 Data Logger

(*source: <http://www.onsetcomp.com/products/data-loggers/u22-001>)

Manufacturer: Onset Computer Corporation

Overview

The HOBO Water Temp Pro v2 is durable with 12-bit resolution. Complete with a precision sensor for $\pm 0.2^{\circ}\text{C}$ accuracy, this logger measures temperatures between -40°C and 70°C (-40°F to 158°F) in air and up to 50°C (122°F) in water. Its waterproof, streamlined case allows for extended deployment in fresh or salt water. Moreover, the Water Temp Pro v2's optical USB interface makes it possible to offload data even while the logger is wet or underwater. A solar radiation shield is required to obtain accurate air temperature measurements in sunlight (RS1 Solar Radiation Shield, assembly required; or M-RSA pre-assembled Solar Radiation Shield).

Highlighted Features

Research-grade measurements at an affordable price

Waterproof to 120 meters (400 feet)

Data readout in less than 30 seconds via fast Optic USB interface

Compatible with HOBOWare and HOBOWare Pro software for logger setup, graphing and analysis

In what environment does this data logger operate?

This data logger operates in outdoor and underwater environments.

What measurements does this data logger support?

The U22-001 data logger supports the following measurements: Temperature and Water Temp

SPECIFICATIONS

Operation range[†]: -40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water

Accuracy: $\pm 0.21^{\circ}\text{C}$ from 0° to 50°C ($\pm 0.38^{\circ}\text{F}$ from 32° to 122°F)

Resolution: 0.02°C at 25°C (0.04°F at 77°F)

Response time: (90%) 5 minutes in water; 12 minutes in air moving 2 m/sec (typical)

Stability (drift): 0.1°C (0.18°F) per year

Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F)

Battery: 2/3 AA, 3.6 Volt Lithium, factory-replaceable ONLY

Battery life (typical use): 6 years with 1 minute or greater logging interval

Memory (non-volatile): 64K bytes memory (approx. 42,000 12-bit temperature measurements)

Weight: 42 g (1.5 oz)

Dimensions: 3.0 cm (1.19 in.) maximum diameter, 11.4 cm (4.5 in.) length; mounting hole 6.3 mm (0.25 inches) diameter

Wetted materials: Polypropylene case, EPDM® o-rings, stainless steel retaining ring

Buoyancy (fresh water): +13 g (0.5 oz.) in fresh water at 25°C (77°F); +17 g (0.6 oz.) with optional boot

Waterproof: To 120 m (400 ft.)

Shock/drop: 1.5 m (5 ft.) drop at 0°C to 70°C (32°F to 150°F)

Logging interval: Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to HOBOWare software manual.

Launch modes: Immediate start and delayed start

Offload modes: Offload while logging; stop and offload

Battery indication: Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.

NIST certificate available: for additional charge