Supplement to 2016 Morrison Lake Thermal Stratification Study

Prepared For

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1 Introduction

This is a supplement to the 2016 Morrison Lake Stratification Report that was issued in February 2017. This report is limited to Onset tidbit data collected between May of 2016 and the end of May 2017. The tidbit data allow an assessment of the timing and extent of summer stratification, fall turnover, winter inverse stratification, spring turnover and subsequent spring thermal stratification. In addition, specific dates of ice-on and ice-off can be determined using this data. Lake inlet (Tahlo Creek) and outlet (Morrison Creek) temperatures are also presented for approximately 12 months.

A field trip occurred on May 31, 2017 to download the fall, winter and spring data from the tidbits. The lake inlet, lake outlet, thermistor chain #1, #2 and #3 tidbits were all recovered. Thermistor chain #4 which was the southernmost chain could not be located. It is suspected that the very high water in Morrison Lake during this field trip may have submerged the floats. It is also possible that the floats were frozen into the ice and displaced a good distance away from where the chain was deployed in the fall of 2016. Thermistor chain #1 had been moved approximately 500 meters from where it was deployed in October of 2016. The floats were likely frozen into the ice pack which was likely blown to the south west during ice-off. This is the only way the chain could have been moved that distance.

The 2016 Morrison Lake Stratification Report provided additional insight into lake stratification during the spring, summer and fall. An YSI X0 Sonde was casted four times at each of the four lake stations. That instrument provided profiles for conductivity, pH, dissolved oxygen reported as percent saturation and mg/L along with temperature. The reader is directed to that report to see the results for this work.

2 Methods and Materials

This supplemental report is exclusive to Onset tidbit data at the six stations that were established in the spring of 2016.

2.1 Location

In the initial report, a table containing global positioning satellite (GPS) locations was not included. Table 1 presents the GPS data for the six stations that were monitored during this study. The easting and northing coordinates were programmed into the GPS unit prior to going to the field in May of 2016. The thermistor chains were deployed from a float plane once we were on each of the lake stations.

Table 1 GPS locations for temperature monitoring stations.

Location	Easting	Northing
Tahlo Creek	664027	6130245
Station #1	666300	6126900
Station #2	667800	6123600
Station #3	668600	6121200
Station #4	669200	6119500
Morrison Creek Bridge	672889	6115295

3 Results

The following graphs present the entire year of temperature data collected at the six stations described above. Tahlo Creek and Morrison Creek both had a single tidbit running at each station. Stations 1, 2 and 3 had numerous tidbits hung on a cord in the water column. As described in the introduction, thermistor Chain #4 could not be located during the May 31 field trip and it is hoped that it can be located when the water level drops in Morrison Lake.

3.1 Tahlo Creek

Figure 3-1 presents the temperature data collected in Tahlo Creek. Based on the raw data, it appears ice-on occurred on or about November 30th with ice-off occurring around April 14th.

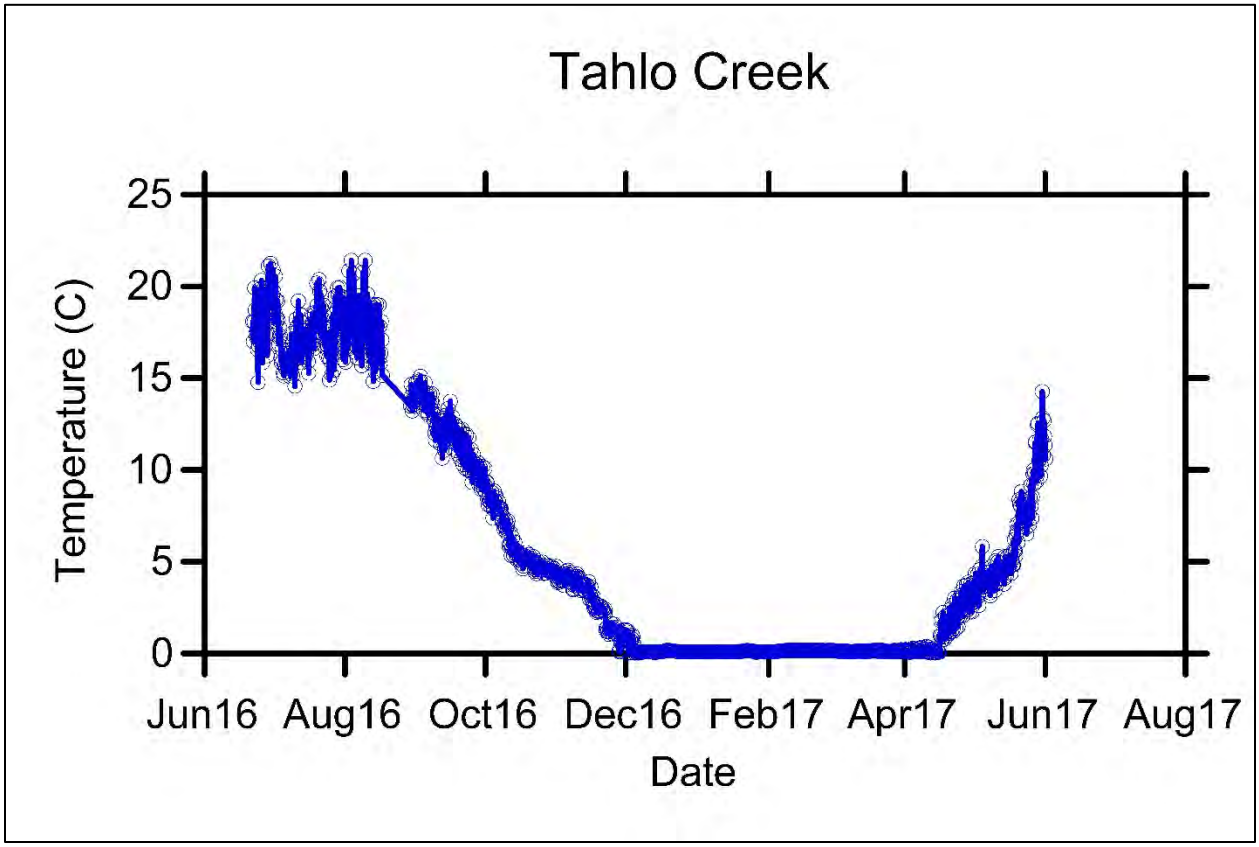

Figure 3-1 Temperature data from Tahlo Creek.

3.2 Morrison Creek

Figure 3-2 presents the temperature data collected at the Morrison Creek bridge. This location is directly under the Morrison Creek bridge, so the lack of snow cover over the ice may have been the reason why readings went as low as -1.56 ^{o}C. The first date where temperatures dropped below 0 ^{o}C was December 25th 2016 and ice-off occurred around March 25th.

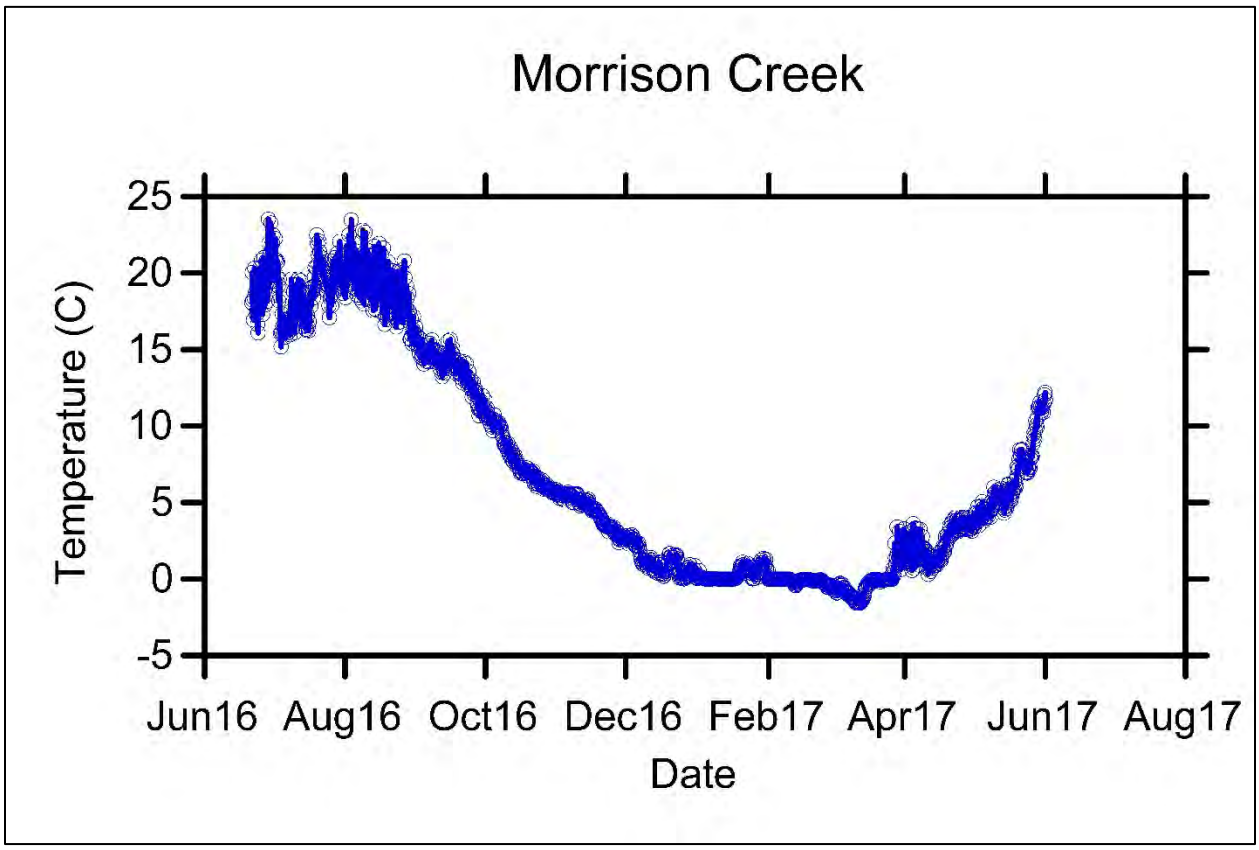

Figure 3-2 Temperature data from Morrison Creek.

The later ice-on and earlier ice-off timing at the outlet versus the inlet may reflect the thermal energy that is stored in the lake over the winter. Both sites have laminar flow, so turbulence in the creek is unlikely to play a role in the shorter ice-on period in Morrison Creek.

3.3 Station #1 Thermistor Chain

Figure 3-3 presents over a year of temperature data that was collected at the Station #1 thermistor chain in Morrison Lake. This site was the most northerly thermistor chain in the lake. The strong summer thermal stratification period is obvious from May through the end of October.

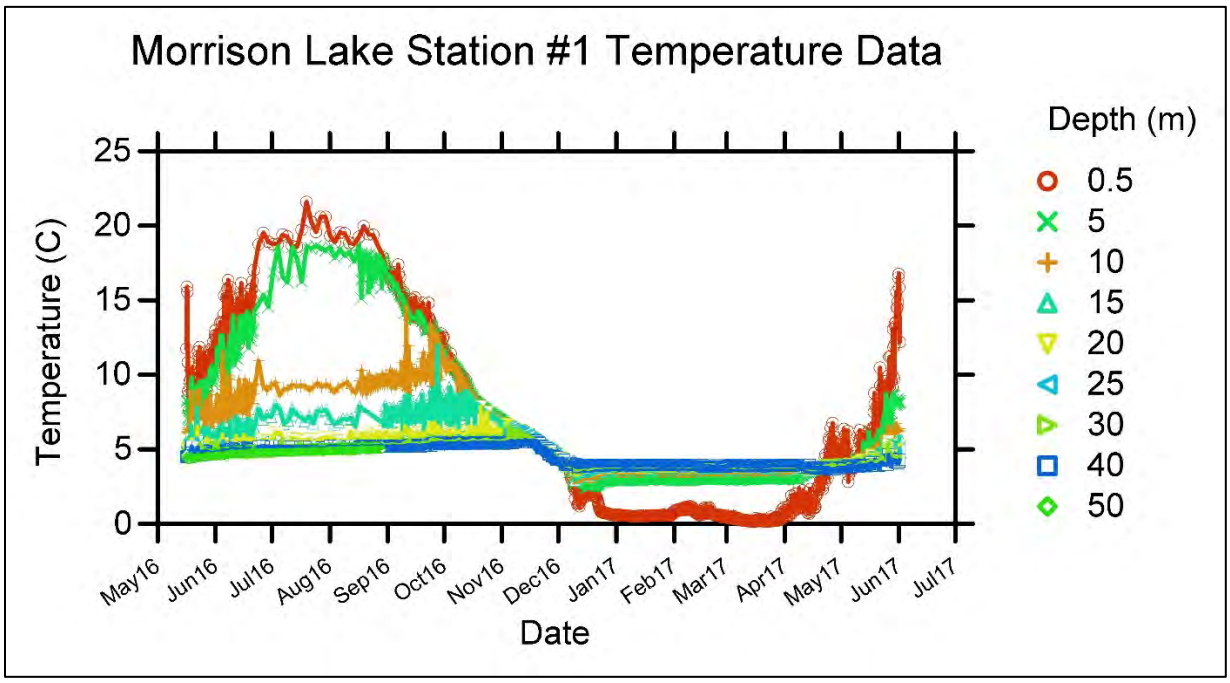

Figure 3-3 Temperature data from Station #1 thermistor chain.

Figure 3-4 presents the data with a focus on autumn turn-over. The temperature readings from all depths appear to converge on November 19th and this would represent an isothermal water column. The water column appeared to be around 5.5 °C and a relatively light wind would result in complete mixing of the water column.

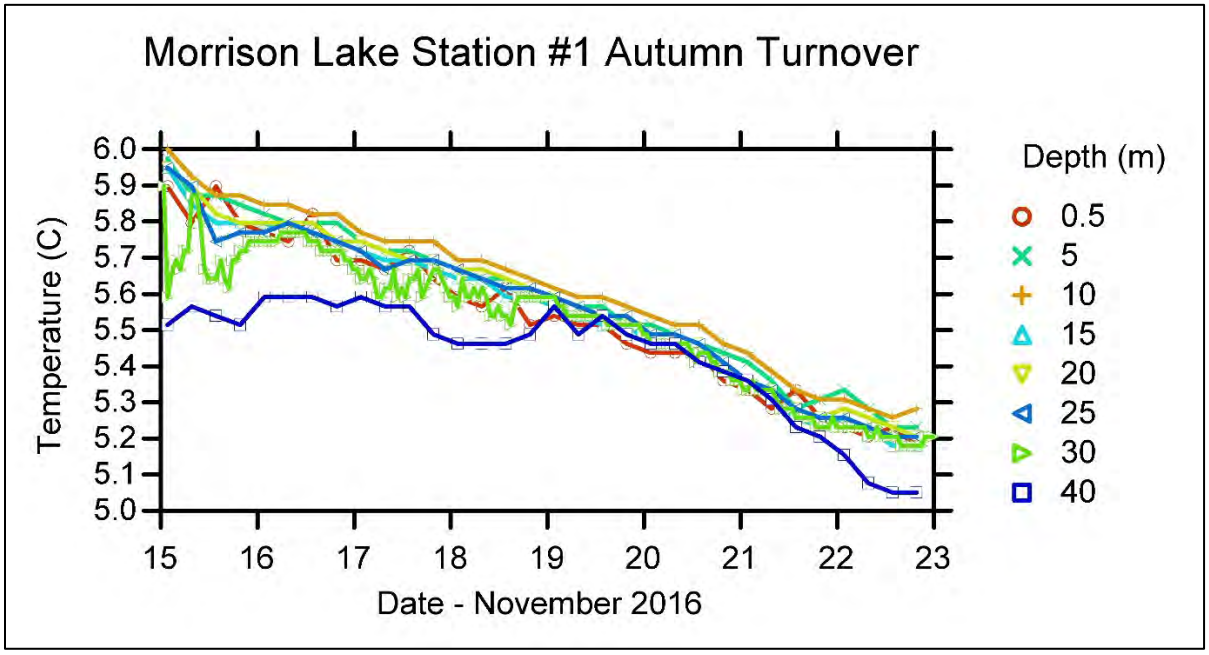

Figure 3-4 Autumn turn-over temperature data from Station #1

In Figure 3-5, the temperature data that indicates that ice likely formed at the Morrison Lake Station #1 on December 6th. The temperature at the 0.5 m tidbit did not elevate after that time period, so that is likely when ice first covered Morrison Lake. A small amount of mixing occurred down to the 25 m level after December 6th and that was likely due to internal waves within the lake.

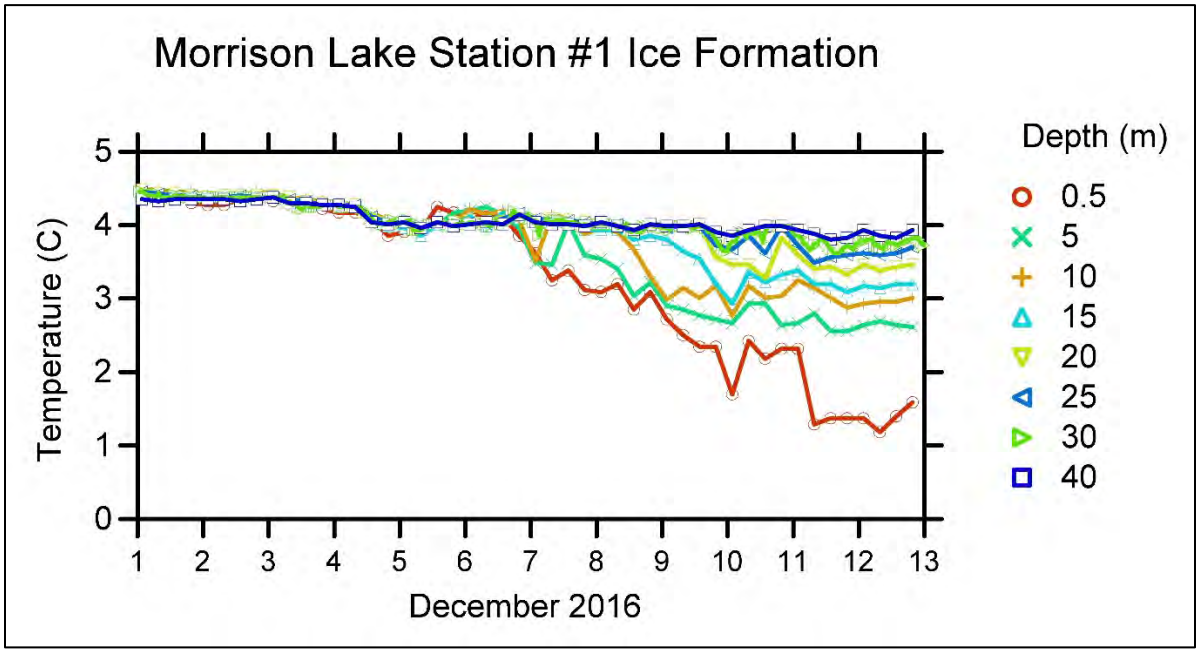

Figure 3-5 Ice formation on Morrison Lake Station #1.

Figure 3-6 presents the inverse winter stratification at Morrison Station #1. By late December, the internal waves in the lake lost energy and a stable inverse stratified column of water existed until early to mid-April. Water is densest at 4 °C and as it gets colder, it becomes lighter. Due to the lack of wind once the ice is on, this inverse stratification becomes established and remains very stable throughout the winter. The inverse stratification appeared to exist down past the 10 m depth.

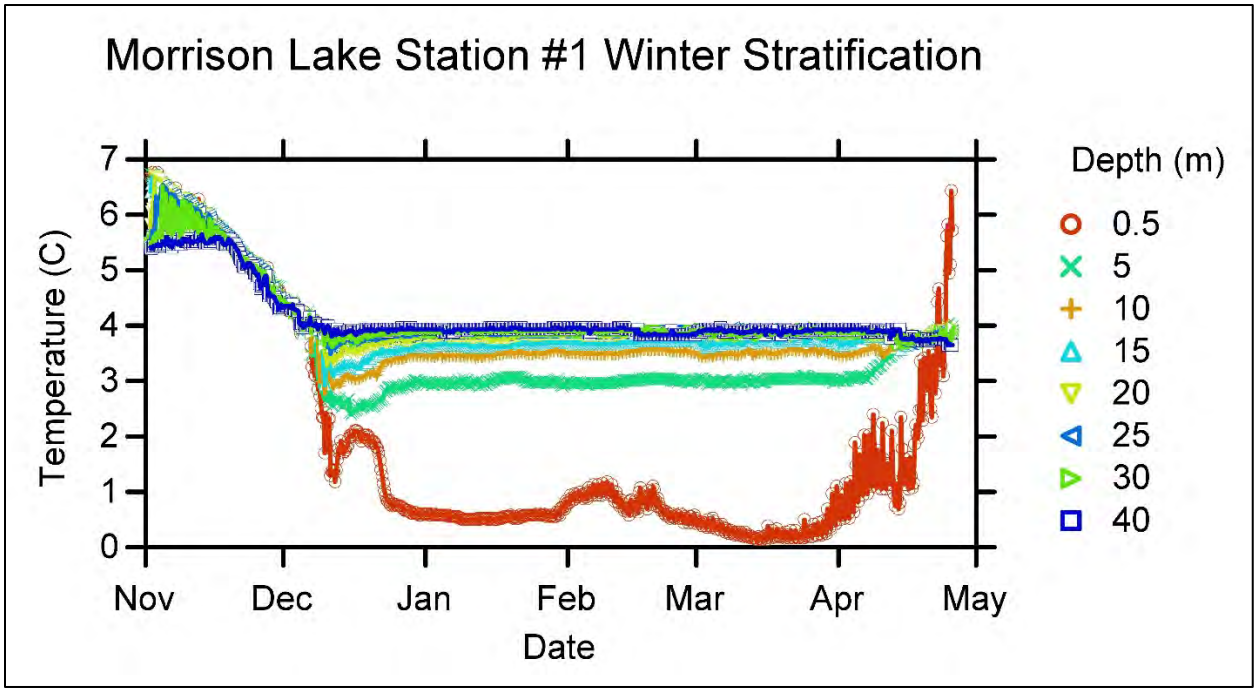

Figure 3-6 Winter inverse stratification data from Station #1.

In Figure 3-7 the temperature data collected during ice-off at Morrison Station #1 is presented. The 0.5 m tidbit temperature rose above 4 °C for the first time on April 22 but then dropped for two days prior to beginning the spring increase in temperature. At ice-off the ice normally becomes rotten prior to being broken apart by wind. Based on this data, it appears that ice-off occurred on April 24th, 2017.

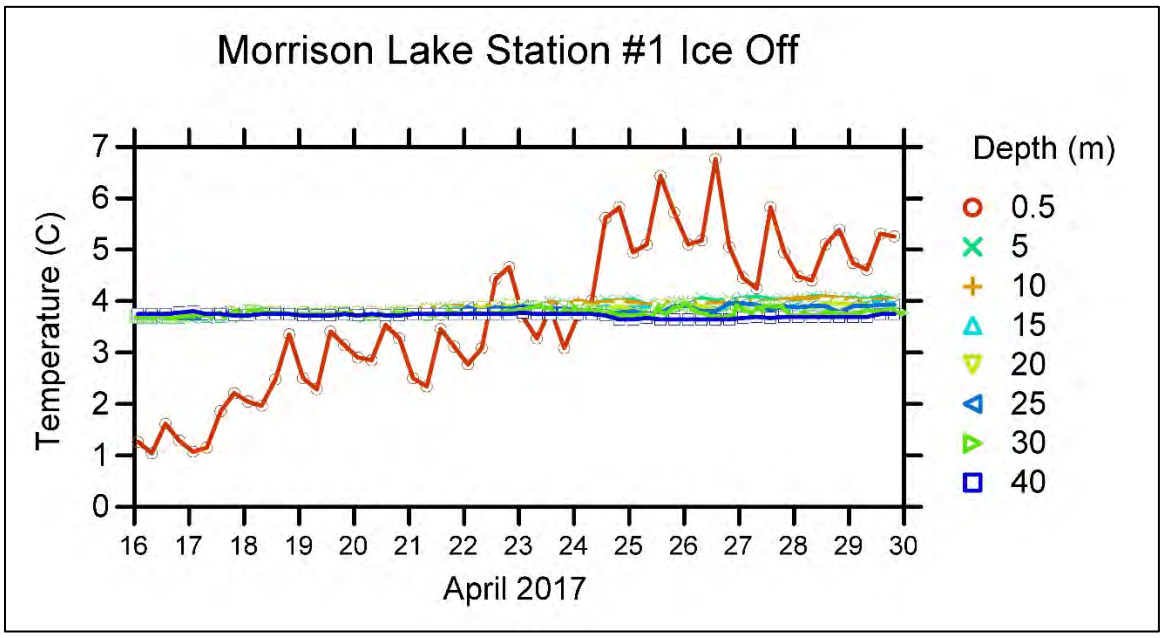

Figure 3-7 Ice-off period from Station #1.

3.4 Station #2 Thermistor Chain

Figure 8 presents the data collected at the Morrison Lake Station #2 thermistor chain. This location is at the site of the proposed deep-water diffuser and is in the same basin as the Station #1 thermistor chain. No significant differences exist between the two stations so the thermal stratification/destratification process will not be discussed for this station.

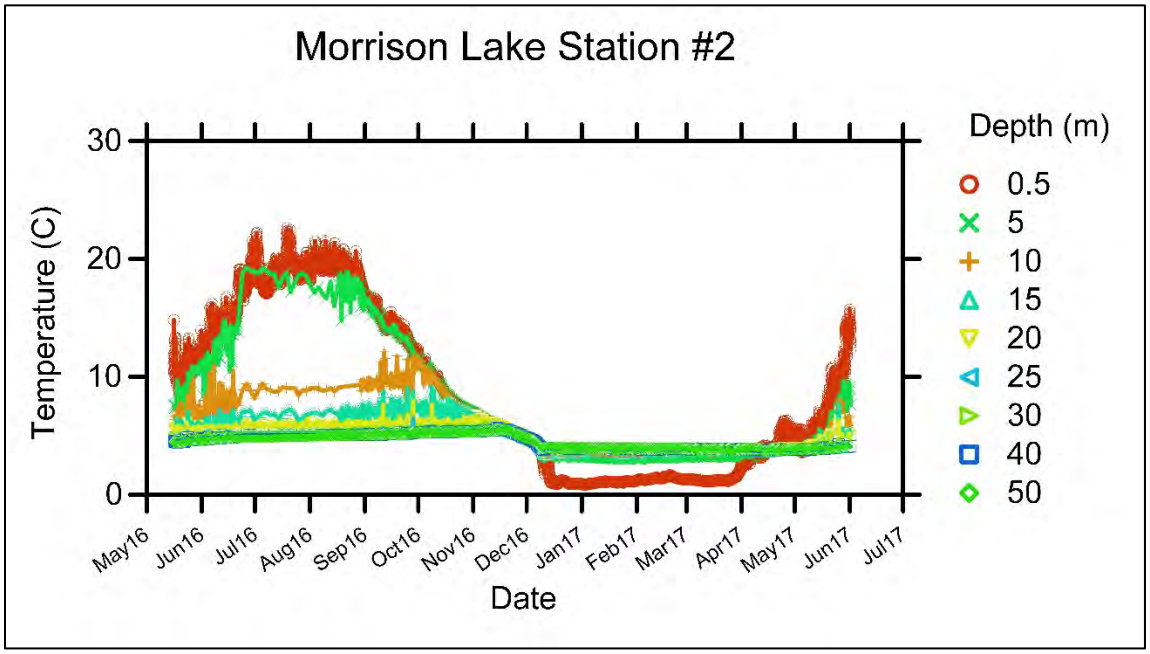

Figure 3-8 Temperature data from Station #2 thermistor chain.

3.5 Station #3 Thermistor Chain

The data for thermistor chain #3 is presented in Figure 3-9. The objective of this station was to show that the shallows between to the two basins isolated the north basin from the south basin during summer stratification. This was shown to be the case in the previous report. The winter stratification and ice-off trends shown are very similar to stations #1 and #2.

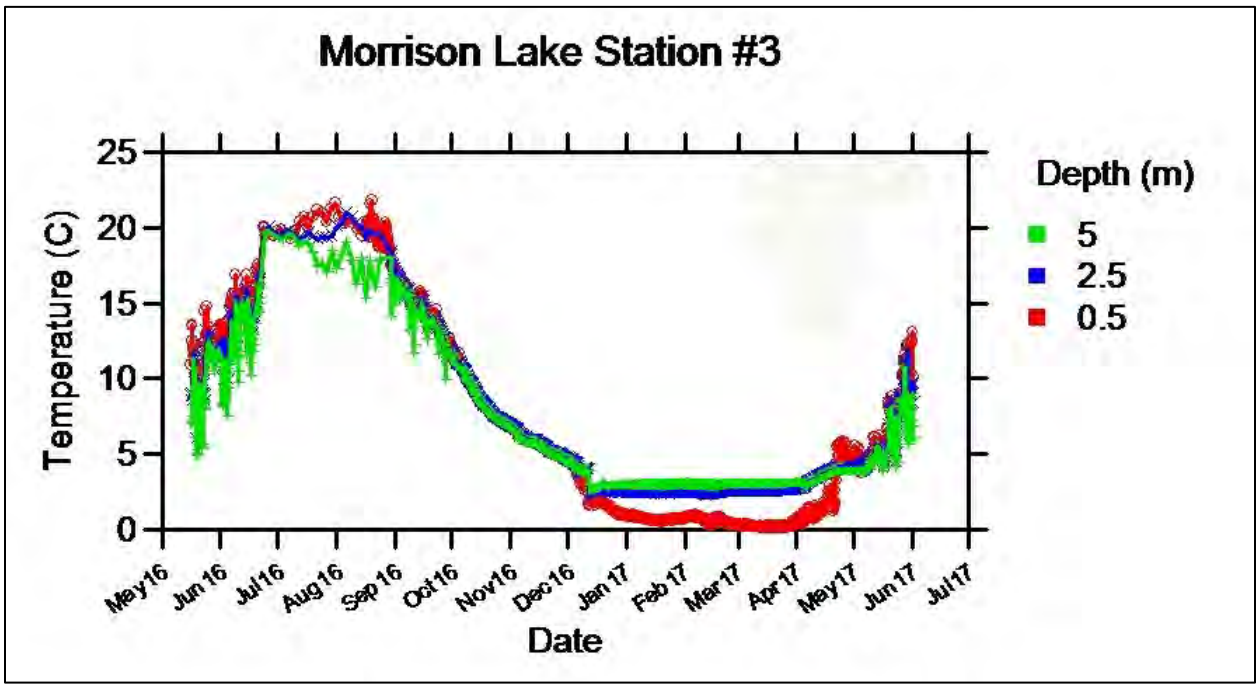

Figure 3-9 Temperature data from Station #3 thermistor chain.

3.6 Station #4 Thermistor Chain

As discussed earlier, the 4th thermistor chain which was situated in the southern basin could not be located during the May 31, 2017 field trip. It is thought that the floats may have been submerged due to the high water in Morrison Lake. Attempts to locate and download the data on the tidbits on this chain will occur in the summer of 2017. This thermistor chain will be re-deployed in this basin if it is located.

4 Discussion and Conclusions

This report confirms that Morrison Lake is a typical dimictic lake with stratification beginning in the spring, strengthening through the summer and then breaking down through the fall. Four thermistor chains were installed along the lake and data was collected every 6 hours for over a year. This information clearly defined summer stratification, fall turn-over, early winter ice on, inverse stratification through the winter, ice off and the initiation of spring re-stratification. In addition, lake inlet and outlet temperatures were monitored for a year to document how the lake inlet and outlet temperatures fluctuated over the season.

Tidbits that were installed at the inlet and the outlet of Morrison lake have been left in place to continue collecting data. Thermistor Chain #1 was removed and 8 of those tidbits were placed on thermistor chain #2. Tidbits now exist on that chain at 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12.5, 15, 20, 30, 40 and 50 m levels. Thermistor chain #3 was removed and thermistor chain #4 will be downloaded and re-deployed when(if) it is located in 2017. The tidbits are rated to operate for up to 5 years and the data will be downloaded from the tidbits on an annual basis.

The exhaustive data set collected during this thermal stratification study will provide ample information for detailed modelling of diffuser inputs to the lake. The data collected support the stratification assumptions made by Dr. Laval and Dr. Lawrence during their independent environmental affects assessments of the proposed Morrison Lake diffuser.