Summary of Columbia Lake Stewardship Society's 2016 Water Quantity Monitoring Program

Prepared by W. Thompson January, 2017

Executive Summary

2016 marked the third consecutive year of water quantity monitoring by the Columbia Lake Stewardship Society in the Columbia Lake watershed. Columbia Lake serves environmental, economic and social interests. It is subject to increasing stress as the population increases. The purpose of monitoring is to keep tabs on Lake level and the amount of water entering and leaving so as to identify threats to Lake health and to accumulate a base of data that will provide guidance in determining the appropriate remedial measures to be taken to restore its health should they become necessary.

The last monitoring station in a four station network was put into service at the beginning of the season. With that installation, water levels on the major inflowing and outflowing streams to and from Columbia Lake and on Columbia Lake itself are now being continuously monitored during the open water season. In time the water levels will be used to calculate flow volumes in the streams. As a step in that direction a current meter was purchased and the flow was measured on a periodic basis starting in September. Another season of measurements will be required before flow volumes can be established with confidence.

The runoff peaked June 7 on Dutch Creek and at the other stations a few days later as a surge of meltwater worked its way down through the watershed. This was about one week earlier than normal and followed an abnormally warm spring. Peak levels were less than those recorded in 2015 but the runoff was spread over a longer period due an early spring melt and a wet fall.

The weather station at Fairmont Hot Springs Airport is undergoing an upgrade that will result in data being captured in digital form. A sample copy of the collected data was examined to evaluate their use to the water quantity monitoring program. It was determined that the atmospheric pressure measurements will substantially aid in the calibration of the pressure sensors. The wind, dew point and wind data hold promise for estimating evaporation losses from the Lake surface.

Greater emphasis was placed on calibration following the observation in 2015 that readings provided by the pressure sensors were not in agreement. All of the sensors were pulled out of service for a few days at the beginning and end of the season and co-located where they were evaluated for biases and drift. Most were found to be biased. The offsets were calculated and the recorded data were corrected accordingly. Drift was not found to be an issue.

Next year's program will focus on establishing stage-discharge relationships over a full range of water levels. Additional equipment will be purchased to permit monitoring from bridges. The existing equipment is only suitable for use when stream levels are low enough to permit wading.

1. Introduction

This is the third in a series of annual reports[1] reporting on water quantity monitoring activities conducted by the Columbia Lake Stewardship Society in the Columbia Lake Watershed.

Columbia Lake is the lifeblood of the local valley. Wildlife inhabit the riparian areas along the eastern shore and the wetland areas at both ends of the Lake, the local economy benefits from tourists attracted to water based activities, and the population is increasing as more people are attracted by the relaxed setting. The Lake is shallow and has limited capacity to serve the expanding environmental, economic and social needs. A significant change, such as a lowering of the Lake level, for example, will have significant impacts yet there is no monitoring system in place to forewarn of such change or to identify the factors contributing to the change. To illustrate, Lake levels have not been recorded in over thirty years nor has the amount of water entering or leaving the lake including rainfall in at least twenty years. The purpose of the water quantity monitoring program is to establish a base of Lake level, streamflow and weather data that will serve to detect change and to provide guidance in determining the appropriate remedial measures to be taken should they become necessary. The program will also serve to signal the impacts of climate change.

2. The Watershed

Most investigators consider the outflow point of the Columbia Lake Watershed to be on the Columbia River at the Highway 93/95 crossing near Fairmont Hot Springs. The area above that point is 881 square kilometres. The bulk, 696 square kilometres, is contained in the Dutch Creek sub-basin. Not all of the water from Dutch Creek enters the Lake, some by-passes to the north and flows directly into the Columbia River. The proportion flowing into the Lake has varied over the years due to shifting drainage channels in the Creek delta. The boundaries of the Watershed are shown in the inset of Figure 1.

The actual outlet from the Watershed is not at the Highway crossing but a few hundred metres upstream. Access to this point is difficult making it an inconvenient location for monitoring. Thus outflow is measured at the Highway location. A small creek enters the Columbia River between the two points and constitutes about 9 square kilometres of the entire 881 square kilometre area.

The watershed contains no active glaciers and is uncontrolled.

1 This year marks a change in reporting procedure. Previous reports summarized both the Water Quantity and Water Quality monitoring programs. The programs have advanced to the stage where it is more expedient to file separate reports. This Report summarizes the 2016 Water Quantity program. The Water Quality Report will appear separately

3. Antecedent and Concurrent Conditions

There are no weather stations within the Watershed having continuous long-term records. The closest such station is the Cranbrook Weather Station located at the Cranbrook - Kimberley Airport (Cranbrook A), some 60 km south of Canal Flats.

Figure 1 – Map showing station locations. Entire watershed boundary is shown in inset.

The mean daily temperatures at that location for the 2016 water year (November 1, 2015 – October 31, 2016) are shown in Figure 2. The corresponding long-term normal values based on records accumulated over the 30 year period 1980-2010 are shown for comparison. For the most part, temperatures during the fall of 2015 were near normal but by December climbed to above normal and remained above normal until June. The month of April was particularly warm.

A similar comparison is made for total precipitation in Figure 3. Precipitation amounts were near to above normal through to March. April was dry but was followed by a wet May and then a dry June. The rest of the summer was near normal. October was exceedingly wet.

These conditions are reflected in the snow pack records (not shown). According to the River Forecast Centre (2016) the water content of the 2016 snowpack in the East Kootenays was near normal from January 1 until April 1 but then rapidly decreased so that by May 1 the water content was only 42 percent of normal and by May 15 only 15 percent of normal.

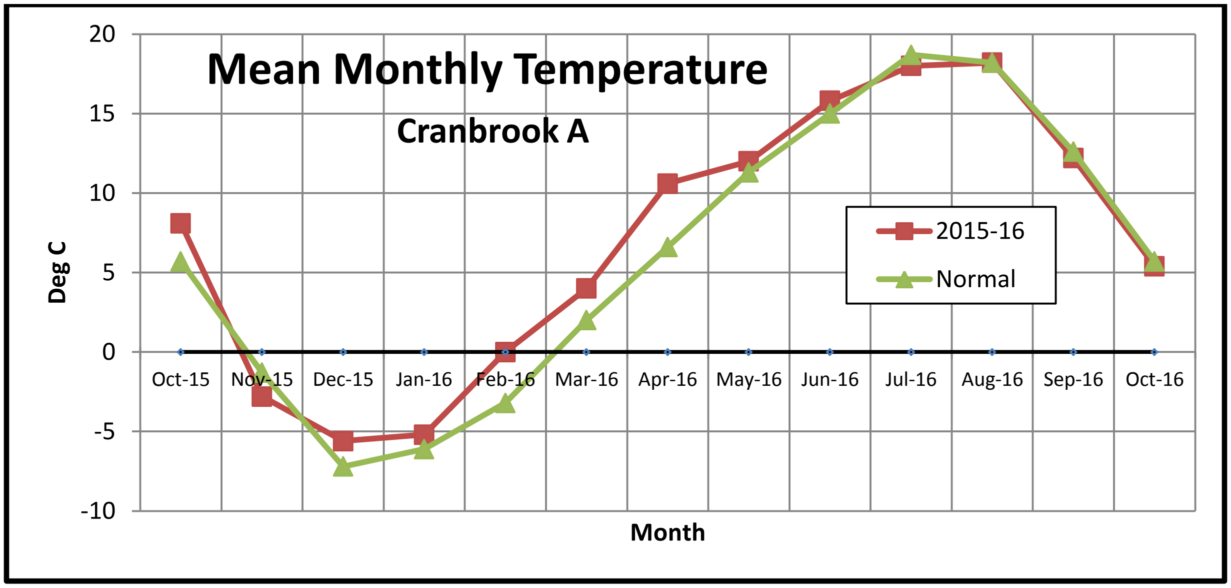

Figure 2 – Comparison of mean monthly temperatures at the Cranbrook- Kimberley Airport during 2015 and 2016 water year with the 1980-2010 long-term normal values.

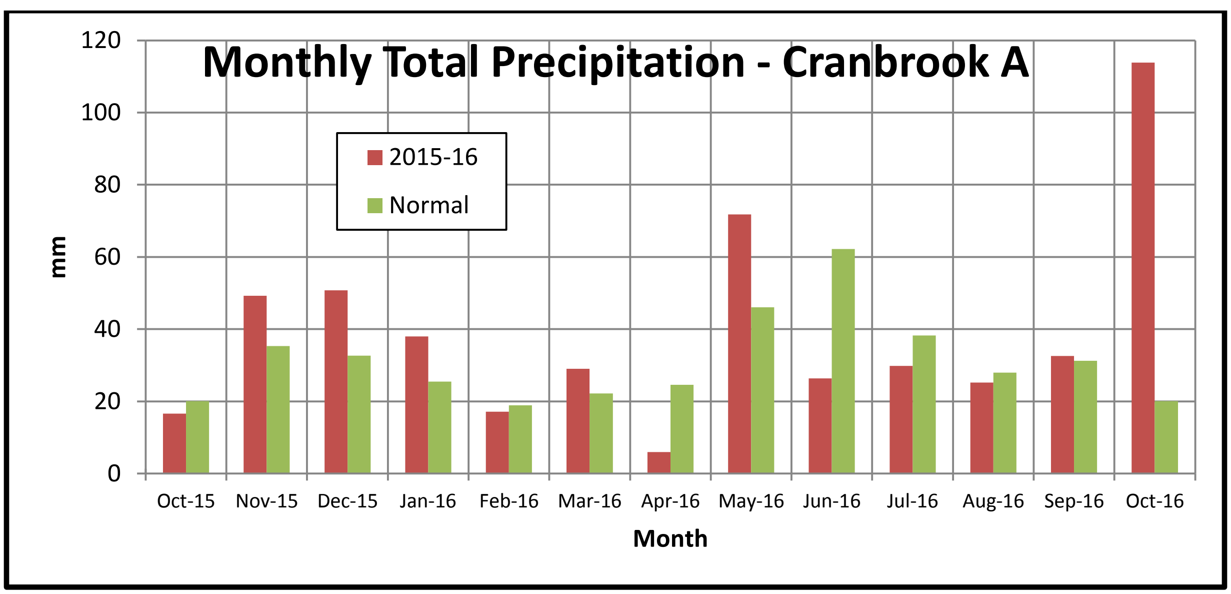

Figure 3 – As in Figure 2 except showing precipitation totals.

A recording rain gauge has been in operation in the Timber Springs Community on a seasonal basis since 2014. The accumulated precipitation recorded during the last three summers is shown in Figure 4. The 2016 record is generally consistent with that of Cranbrook A with the exception that October was not so abnormally wet. The 2016 season was wetter than the two previous seasons.

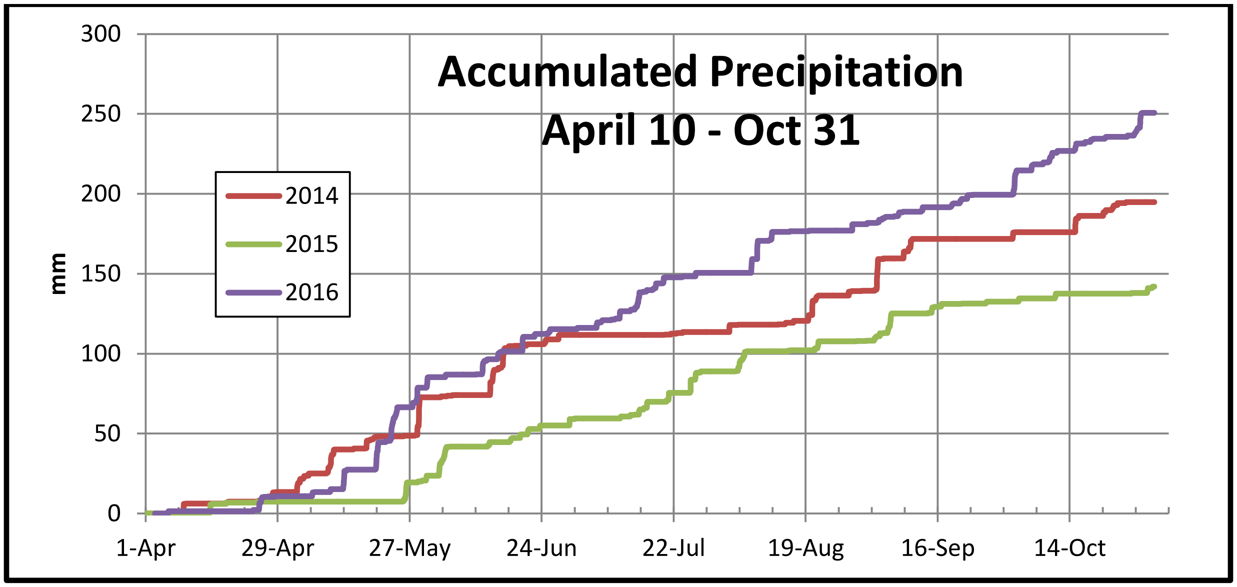

Figure 4 – Accumulated precipitation during the 2014, 2015 and 2016 summer seasons at Timber Springs.

4. 2016 Activities

4.1.Stations

At the end of the 2015 season four automatic water level monitoring stations were in operation. These were located in the Columere Marina, on the Headwaters Creek in the Columbia River Headwaters Park near Canal Flats, on the Columbia River near Fairmont Hot Springs and on Dutch Creek at the Highway 93/95 Bridge (see Figure 1 for locations).

Three of the four were removed on November 4, 2015 to safeguard against frost and ice damage. All were reinstalled on March 31, 2016. The Headwaters Creek station near Canal Flats remained in operation over winter since that Creek is fed by groundwater and remains largely ice free.

A fifth station also operated during 2015. It was located on the Columbia River in the Riverside Golf Course. It was a temporary installation to accumulate data while preparations were underway to restore a station previously operated by Water Survey of Canada (WSC) at the upstream Fairmont location. That station was also restarted in 2016 to provide a period of overlap with the upstream station. It was removed from service on August 14.

The recording rain gauge located in the Timber Springs community was restarted March 23 and operated until November 30, 2016.

A weather station is operated on the Fairmont Hot Springs Airport for aviation purposes. Following discussion with the Airport Manager a digital copy of the weather observations was obtained to evaluate the usefulness of the weather data for the Water Quantity program.

4.2. Equipment Purchases

In January 2016 an order was placed for a current meter, wading rod and a current meter counter. The purpose was to measure flows in the inflowing and outflowing streams with the ultimate intent of establishing stage-discharge relationships. Once established, such relationships will allow continuous estimates of flow to be derived from water levels. The wading rod was found damaged upon arrival and had to be returned for repair. It was not returned until late April.

4.3. Data Collection and Management Issues

Two issues with equipment occurred during 2016. The first occurred at the Canal Flats station on January 14 when for unknown reasons the suspension apparatus failed and the logger fell 10.5 cm to the bottom of the stilling well. A temporary repair was made March 31 to return the logger to its original position but it was May 19 before a permanent repair was made. The logger continued to operate throughout this period. A correction factor was added to recorded depths during January 14 – March 31 period as will be noted below.

The stilling well at the Riverside station was prone to the accumulation of sediment during high flow. Sediment accumulated in the bottom of the well both in 2015 and in 2016. Access to the well to remove the sediment was not possible until after the water levels receded. Comparisons of the Riverside record with that from the WSC site and also with manual measurements suggest that the sensor continued to measure pressure with reasonable accuracy even when embedded in sediment.

4.4. Measurement Accuracy

Following the 2015 season it was found that not all of the loggers were in agreement when placed adjacent to one another. Steps were introduced in 2016 to periodically examine the performance of the sensors so that biased measurements could either be removed or corrected. Those steps and the offsets that were applied are outlined in Appendix A.

5. Water Temperature and Level

5.1. Overwinter 2015-16

As noted the Canal Flats station was kept in operation over winter. The recorded water level and temperature measurements are shown in Figures 5 and 6, respectively. The pressure measurements recorded during the January 14 – March 31 period when the logger had fallen were corrected by adding 10.5 cm. An increase in water temperature was also observed when the logger fell but since it cannot be established whether or not the change persisted an adjustment was not made. The values shown in Figure 6 are those observed.

Overall the water level remained fairly steady in the 24 to 26 cm range except during January and early February when it rose slightly to near the 28 cm level. The water temperature decreased to a minimum of near two degrees C in January and then began to rebound almost reaching six degrees by the end of March.

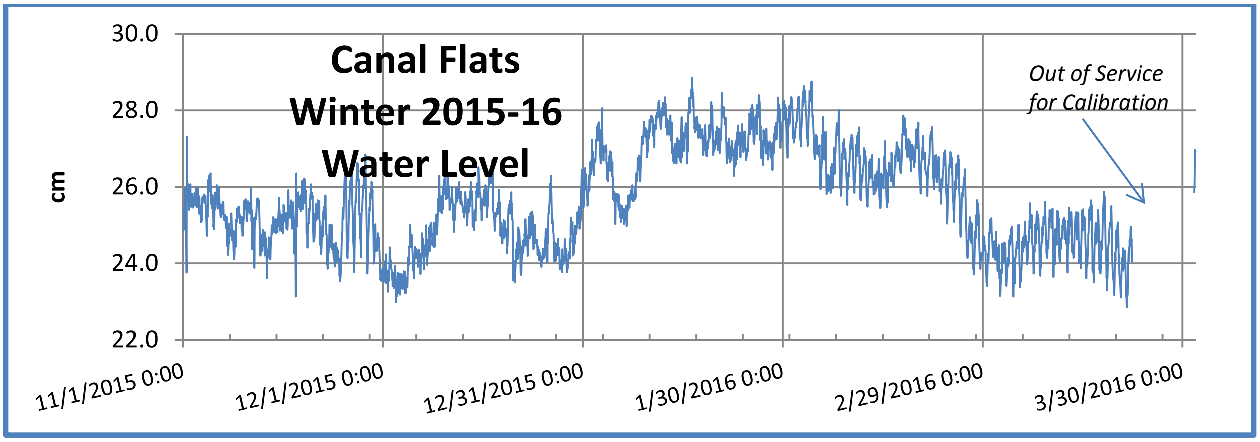

Figure 5 – Overwinter water levels observed at Canal Flats. The station was out of service during late March while the logger was undergoing calibration.

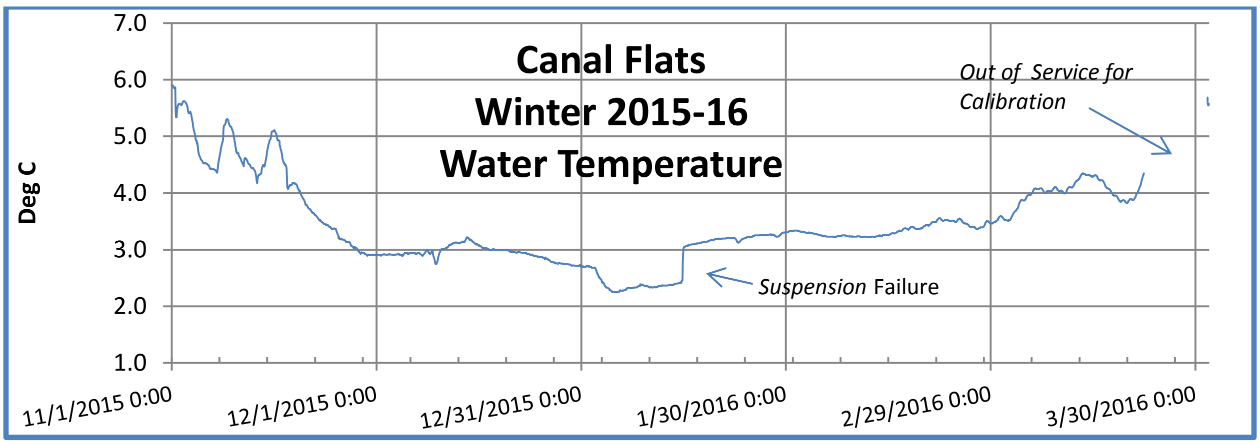

Figure 6 – Overwinter water temperatures observed at Canal Flats. Temperatures remained above freezing throughout winter. The suspension apparatus failed January 14 causing the logger to drop 10.5 cm and resulted in a temperature increase of about one half degree C.

5.2. Open Water Season 2016

5.2.1 Water Temperature

The water temperatures recorded at four of the five seasonal stations are shown in Figure 7. The stilling well at the WSC site is recessed well into to the river bank thus limiting the flow of river water over the logger so that the recorded temperatures are not representative and are therefore not shown.

The temperature of the water recorded in the Lake was consistently higher than that at any of the other locations throughout the season. The inflow water from Dutch Creek was a bit cooler than that recorded in the outflow in the Columbia River at Riverside. The difference presumably represents the moderating influence of the Lake. The temperatures recorded at Canal Flats were substantially cooler during mid-season and are attributable to the Creek's ground water source.

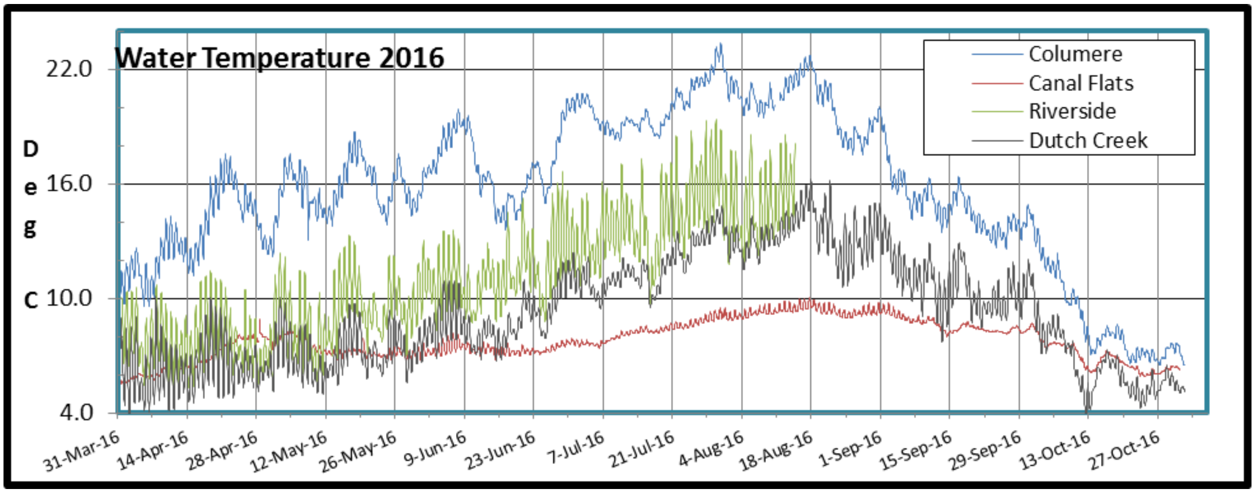

Figure 7 – Water temperatures recorded at the Columere, Canal Flats, Riverside and Dutch Creek sites.

5.2.2 Water Level

The water levels recorded at all five stations are shown in Figure 8. The reference level at all sites was arbitrarily chosen and bears no relationship to any known elevation standard with the exception that the reference level at Canal Flats was adjusted so that levels would coincide with those measured at Columere during high water. Backwater from the Lake covers the Canal Flats station so that both stations record Lake level during the high water period.

The spring runoff reached a maximum at Dutch Creek on June 7. It followed a warm period (see Figure 9) and probably signaled the arrival of last significant surge of meltwater into the lower reaches of the watershed. The remaining stations peaked during the June 9-11 period.

A number of coinciding blips in the Dutch Creek and WSC records are apparent towards the end of the season. They also coincide with rain events recorded at the Timber Springs station (see Figure 10) and are likely due to rainfall runoff.

6. Flow Rates

Equipment problems described in Section 4.2 were not resolved until late April. By that time runoff was well underway making it unsafe to enter the streams. It was early September before water levels receded sufficiently for the streams to be waded and discharge measurements to be taken. They continued to be taken until November 2. Normally during this period water levels recede but owing to

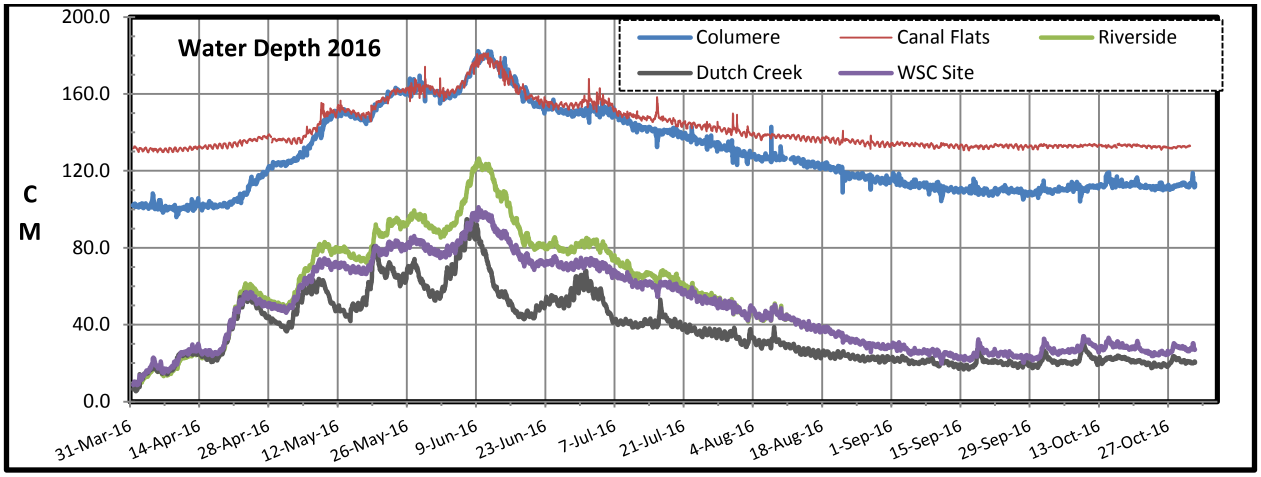

Figure 8 – Hourly water levels recorded at the Columere Marina, Canal Flats, Riverside, Dutch Creek and Water Survey of Canada sites

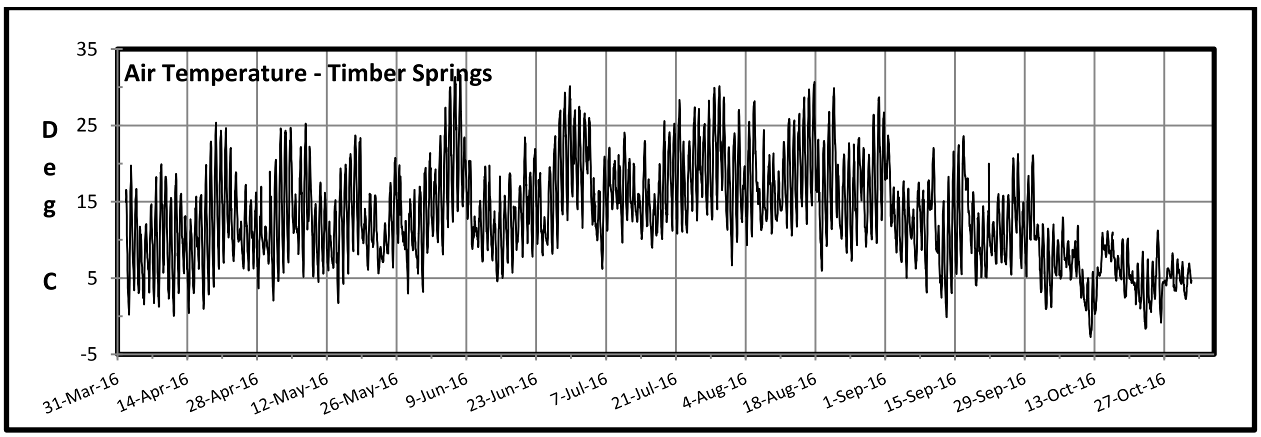

Figure9 – Hourly air temperatures recorded at Timber Springs.

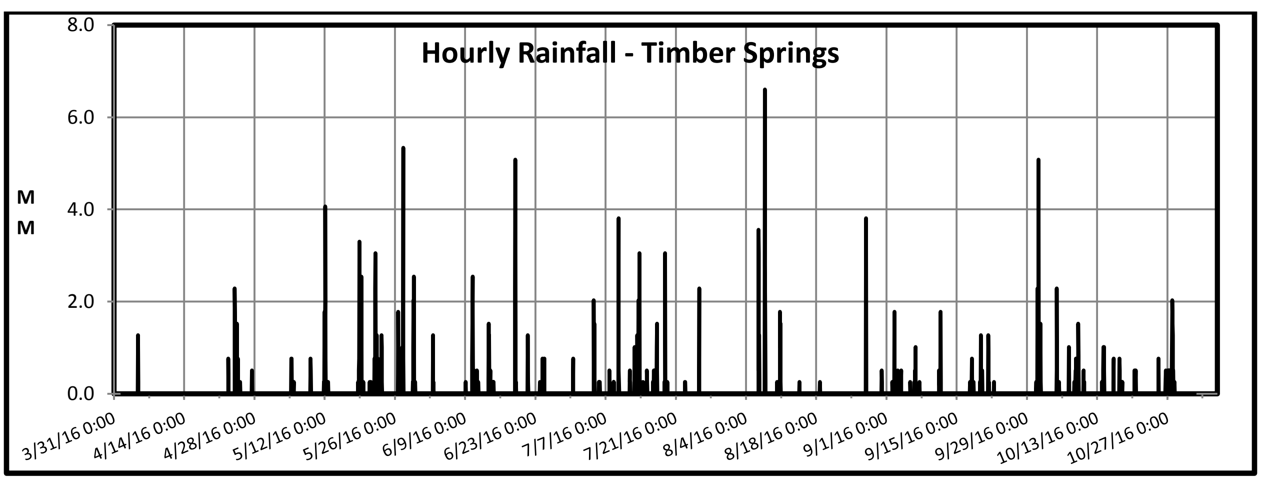

Figure 10 – Hourly rainfall amounts recorded at Timber Springs.

the wet fall that did not happen and the recorded discharge measurements apply only to a small range of water levels. Further measurements over a wider range of water levels are required to provide meaningful stage-discharge relationships.

Five measurements were made at the WSC site. Flow rates ranged from 15.5 to 19.5 cubic metres per second. Four measurements were made at Dutch Creek and ranged from 11.8 to 13.6 cubic metres per second. Only two measurements were made at Canal Flats and were 0.14 and 0.15 cubic metres per second, respectively.

Flow was measured using a Redback Type AA current meter, top set wading rod and a current meter counter. Procedures conformed to those prescribed in the "Manual of British Columbia Hydrometric Standards". The 0.6 depth procedure was used. According to Harmel et al (2006) this procedure should be accurate to within 6 percent under average conditions such as exist on the Columbia River. The conditions on Dutch Creek are less than average and accuracy could reach as much as 20 percent. The intent is to move to the 0.2, 0.6, 0.8 procedure which will improve accuracy.

7. Comparison with 2015 Season

Charts comparing the 2016 water levels with those available from Dutch Creek, the Columbia River (Riverside), Columbia Lake and Canal Flats during 2015 are shown in Figure 11. Peak water levels did not reach those attained in 2015. However, runoff started earlier and the streams were slower to recede owing to the wet fall. The volume of runoff was likely similar in both years though an accurate comparison must be based on flow rates not water levels.

8. Assessment of Fairmont Airport Weather Station Data

Over the past few years a weather station has operated on Fairmont Airport. Its purpose is to inform approaching aircraft of local weather conditions. It is an automated system and weather conditions are continuously broadcast by radio. In recent months the Station has undergone an upgrade wherein the broadcast information is captured and recorded in digital form. A copy of the digitized information was obtained and examined to determine if it might be of value to the Water Quantity program.

The data recorded included temperature, dew point, atmospheric pressure, visibility, precipitation, wind speed and direction plus other parameters specific to aviation. A few interruptions in the record were found and were mainly due to the need for routine maintenance. These interruptions notwithstanding the data have great value. Of greatest value is the atmospheric pressure data. During 2015 a few radio messages were intercepted to calibrate the BARO. After the upgrade in early 2016 a nearly continuous string of pressure data became available enabling a much more precise calibration of the BARO (see Appendix A). Wind is also of interest. When processed as shown in Appendix B insight is provided into the climatology of waves on the Lake including heights and direction of motion. Wind also exerts stress on the Lake surface and causes the Lake level to be higher at the downwind end than at the upwind end. This phenomenon is known as ”set up” and the elevation difference is directly related to wind velocity. Wind speed, temperature, and humidity are contributing factors to evaporation. All are available from the Airport records and when used in conjunction with Lake water temperature permit the calculation of evaporation losses from the Lake.

A downside is that the volume of data is large. Significant effort is required to filter out relevant information. In time this effort can be reduced by writing appropriate software.

The wind roses for July and August contained in Appendix B were derived from manually abstracted data and are presented to give an approximation of the distribution of wind directions and speed as well as an indication of the amount of data available. Out of a possible 744 hourly observations in each month, 739 were available to prepare the July wind rose and 731 for the August wind rose.

9. Future Activities

Work will continue on establishing stage-discharge relationships especially on Dutch Creek and the Columbia River. At present flow measurements are restricted to water levels that permit wading. Steps are underway to acquire a winch mechanism and one or more sounding weights that will permit flow measurements to be taken from local bridges when high flow conditions exist. This will enable the stage – discharge relationship to be established over the full range of water levels.

Work will continue on developing a procedure to filter out relevant information from the large volume of data available from the Fairmont Airport Weather Station.

At least one recording rain gauge is required in the Dutch Creek basin to provide more accurate information on precipitation in the headwaters of the Watershed. Opportunities to partner with private companies or government agencies working in the basin will continue to be explored.

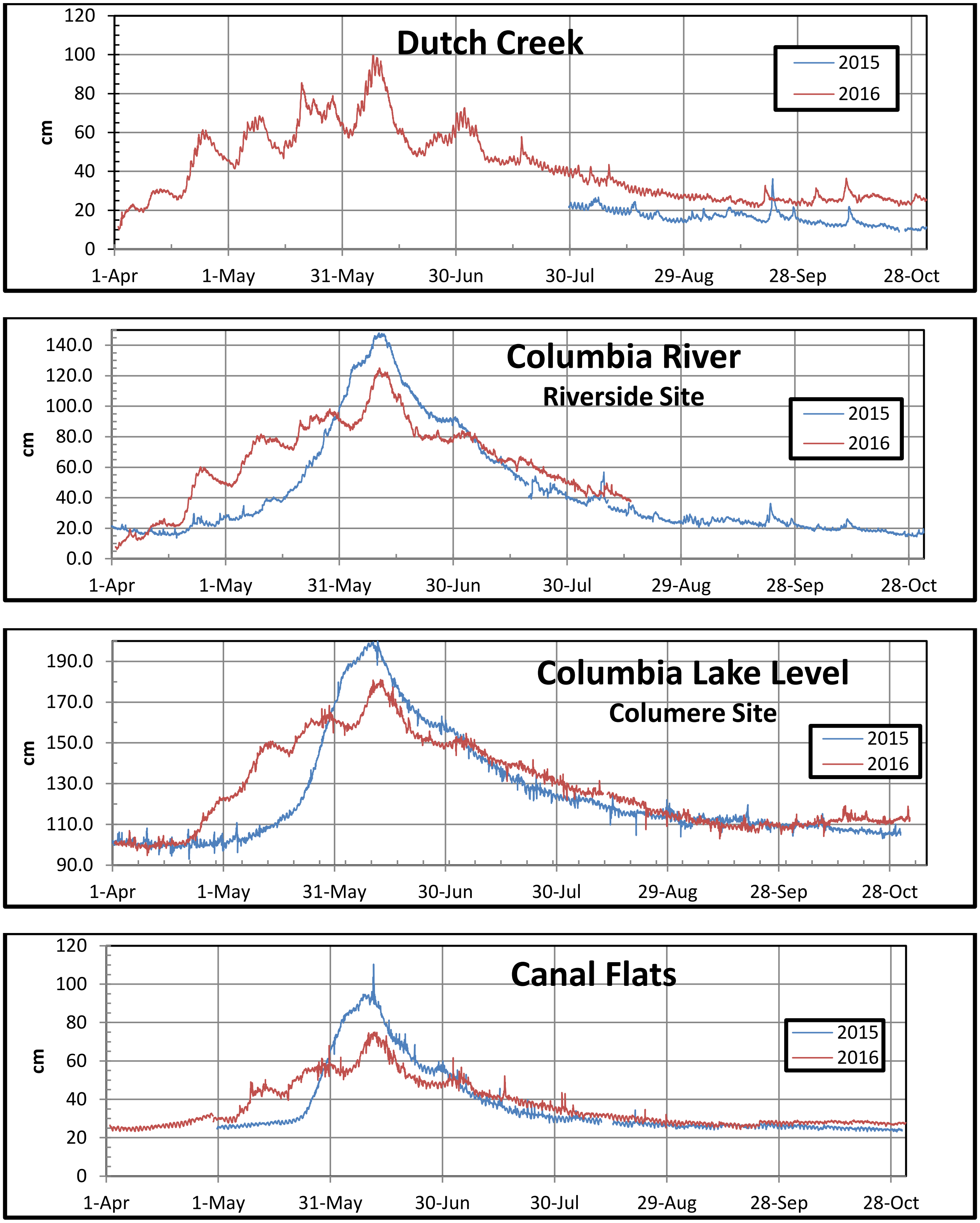

Figure 11 – Water levels recorded at each station during 2015 and 2016.

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11. Acknowledgements

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Columere Marina
Fairmont Hot Springs Resort Ltd. including the Riverside Golf course and the Fairmont Hot Springs Airport
Village of Canal Flats
Columbia Ridge Community Association
Timber Springs Community Association
Columere Park Community Association
Spirits Reach Community Association
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Vic Panei, Timber Springs (flow monitoring, photos)

Appendix A

Accuracy of Measurements

An important part of monitoring is ensuring that the elements are recorded accurately. The following describes the steps taken to minimize error.

A1 -Water Level

Water level is derived from the pressure exerted by the column of water above the pressure sensor. Errors may arise due to: failure to accurately compensate for atmospheric pressure, inaccurate calibration of pressure sensors, sensor drift over time, and failure to account for changes in water density.

The BARO logger was used as the standard against which the remaining loggers were evaluated. The accuracy of the BARO was established by comparing its measurements with those from the barometer in the weather station at Fairmont Hot Springs Airport (CYCZ). Simultaneous measurements were made at both locations at the beginning and the end of the open water season. The results are shown in Figures A1 and A2.

The records at the beginning and the end of the season displayed a difference of 2.9 and 2.6 cmH2O, respectively. The two stations differ in elevation by about 40 metres and the difference is commensurate with that to be expected over such an elevation range. The mid-point, 2.75 cmH2O, was selected as the correction to be added to the BARO readings to yield atmospheric pressure at Lake level. The elevations of all pressure sensors except Dutch Creek are near Lake level. The Dutch Creek station is about 20 metres above Lake level. 1.4 cmH2O was added to the BARO readings to reflect the atmospheric pressure at that location.

Once accuracy of the BARO was established, it was used as the reference for all of the other pressure sensors. They were co-located with the BARO and simultaneous measurements made in similar manner. The results are shown in Figures A3 and A4.

The pressure sensors were not all in agreement thereby indicating a need for adjustment. The mean offsets from the BARO at the beginning and the end of the season are shown in Table A1. The difference between offsets at the beginning and end of for each of the pressure sensors was less than 2 cmH2O indicating that drift, if it existed, was minimal. Accordingly drift was ignored and a correction factor equivalent to the offset at the beginning of the season was applied to the respective sensor measurements.

The density of the water column is dependent upon water temperature. No attempt was made to compensate for water temperature though it is recognized that failure to do so may have resulted in errors in water depth at Columere of up to one cm. at mid-season. The errors would have been substantially less at the other locations.

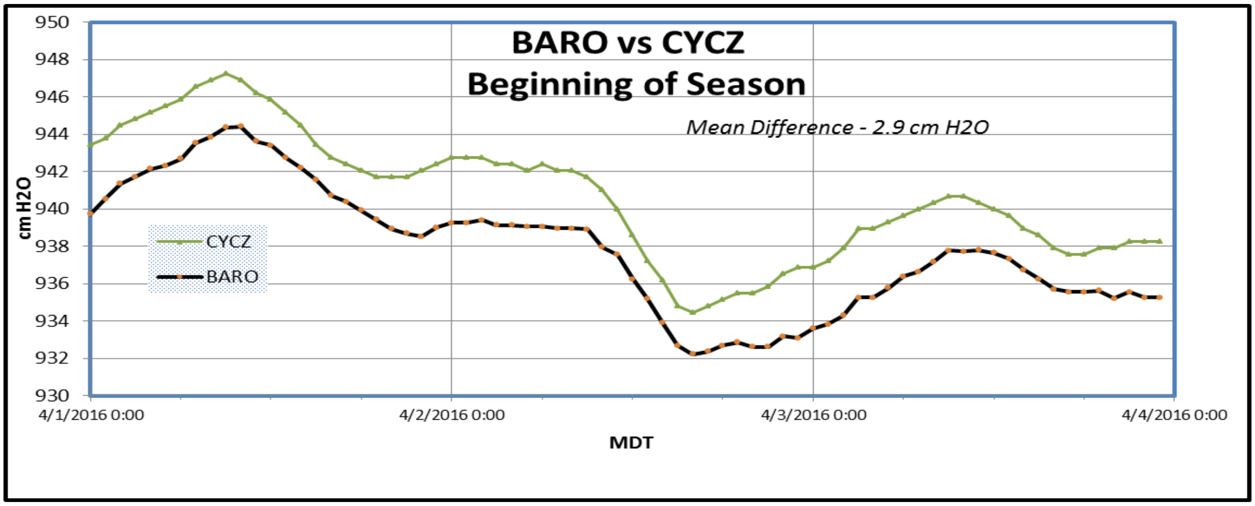


Figure A1 –BARO and CYCZ pressure records at beginning of season.

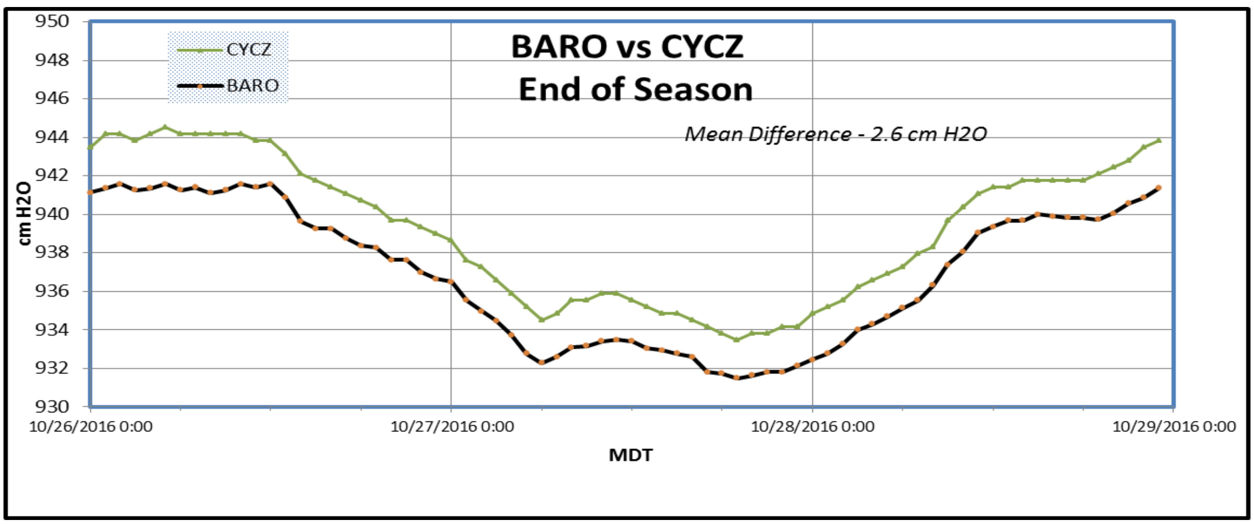
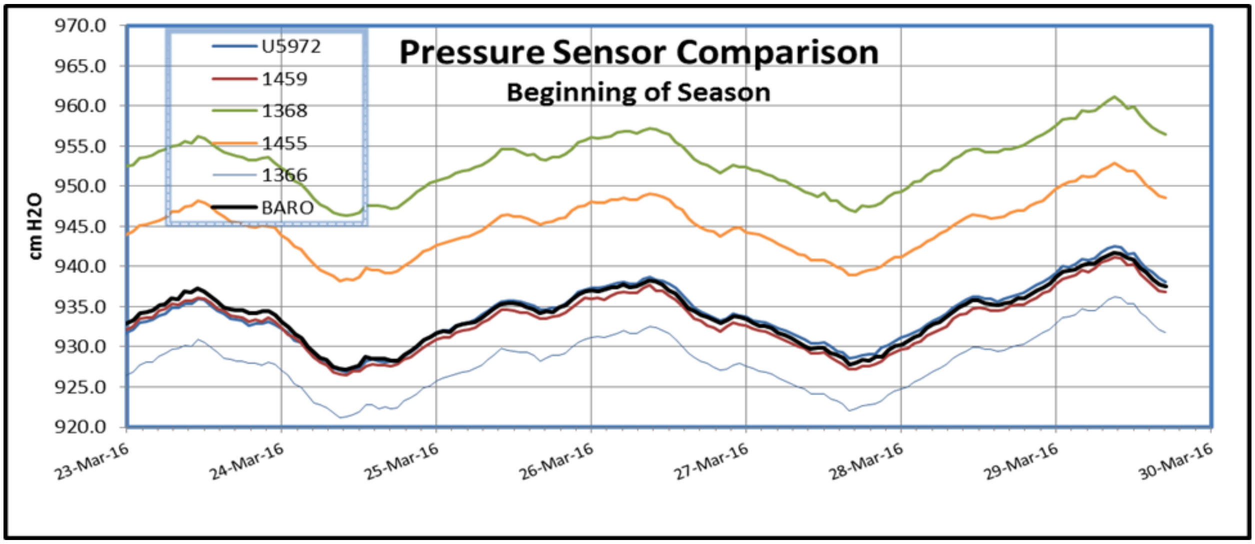


Figure A2 –CYCZ and BARO pressure records at end of season.

Table A 1 – Measured Offsets from BARO during Calibration trials

		Beginning of Season		End of Season	
Logger ID	Location	Mean	Offset from BARO (cmH2O)	Mean	Offset from BARO (cmH2O)
U5972	Columere	934.0	0.1	942.1	0.0
1459	Canal Flats	933.1	-0.8	940.3	-1.9
1368	Riverside	953.0	19.1	950.6	18.5
1455	Dutch Creek	944.9	11.0	951.5	9.4
1366	WSC	928.0	-5.9	935.4	-6.8
Baro	Timber Springs	933.9	0.0	942.1	0.0



FigureA3 – Pressure readings from all other loggers in relation to the BARO at the start of the season.

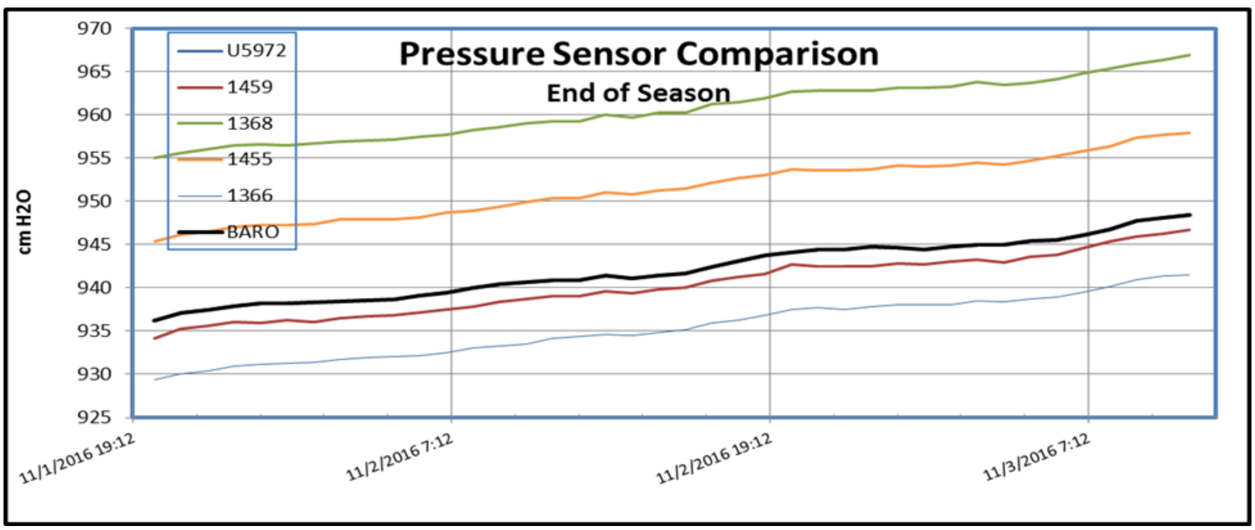


Figure A4 – Pressure readings from all other loggers in relation to the BARO at the end of the season.

A2- Water Temperature

Beginning and end of season comparisons of the temperature sensors were made in similar fashion. The results are displayed in Figures A5 and A6, respectively. The temperature measurements made by all sensors fell within a fraction of a degree of the BARO at the beginning of the season. The agreement was not so good at the end of the season and differences are believed due to exposure to solar radiation. During the end of season comparison the BARO was enclosed in a shield. The other loggers were placed nearby in shade. Despite the shade it appears that a small amount of heat was transferred from surrounding areas. The differences in temperature were judged sufficiently small that correction factors were unnecessary and none were applied.

A3- Other

Other steps were taken to ensure the integrity of the data. Manual measurements of water level were taken at each location periodically during the season to verify the accuracy of the recorded measurements. The stilling wells and intake pipes at each of the stream sites were back flushed twice during the season.

The current meter was calibrated by the manufacturer prior to purchase and was not further calibrated.

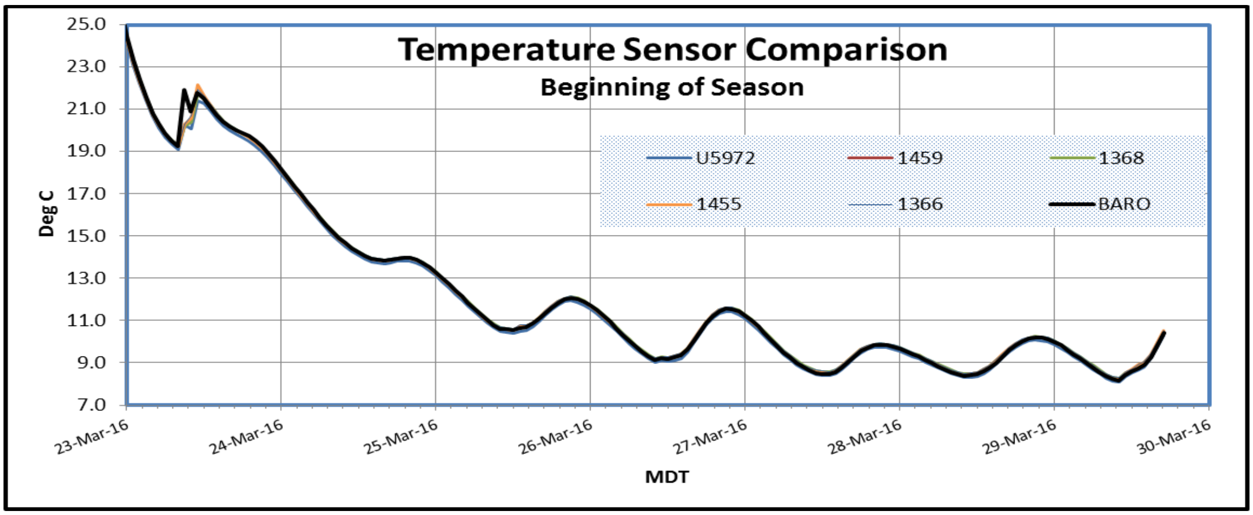


Figure A5 – Temperature readings from all loggers in relation to the BARO at the start of the season.

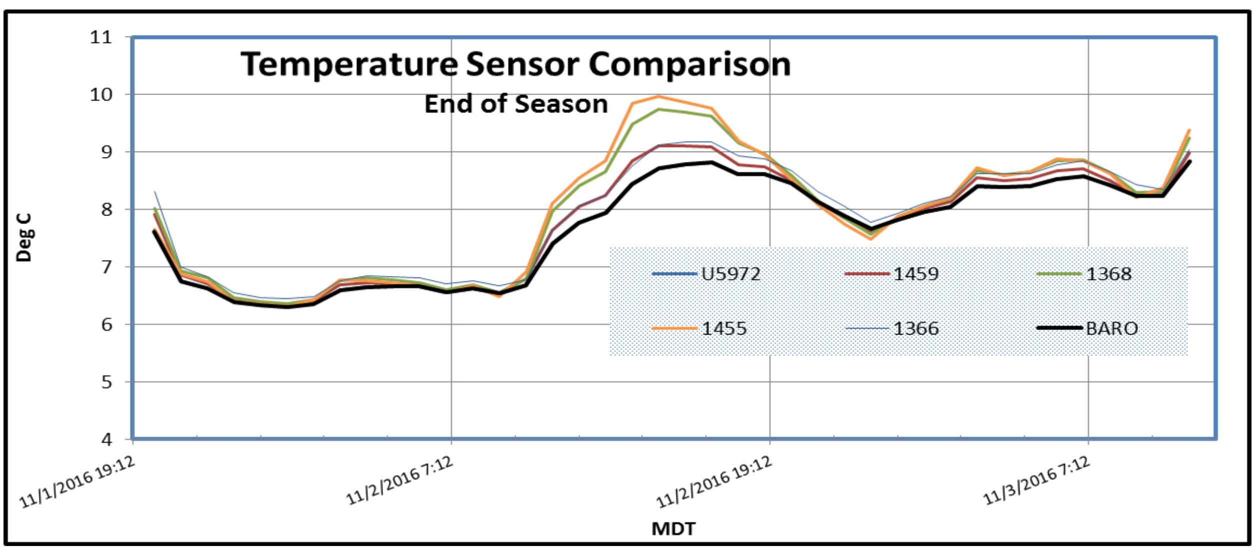
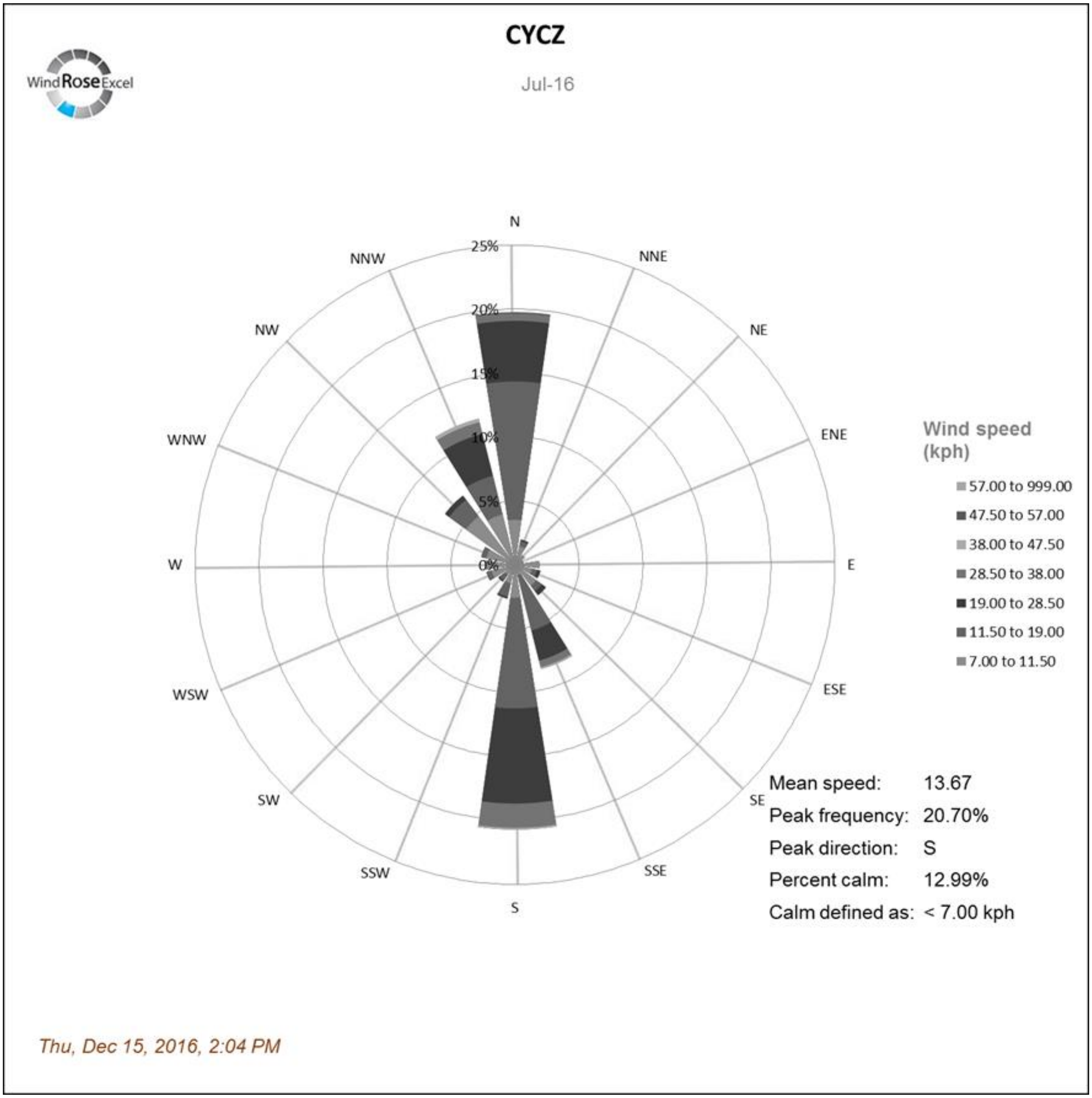


Figure A6 – Temperature readings from all loggers in relation to the BARO at the end of the season.

Appendix B


CYCZ
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25%
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10%
5%
0%
Wind speed (kph)
57.00 to 999.00
47.50 to 57.00
38.00 to 47.50
28.50 to 38.00
19.00 to 28.50
11.50 to 19.00
7.00 to 11.50
Mean speed: 13.67
Peak frequency: 20.70%
Peak direction: S
Percent calm: 12.99%
Calm defined as: < 7.00 kph
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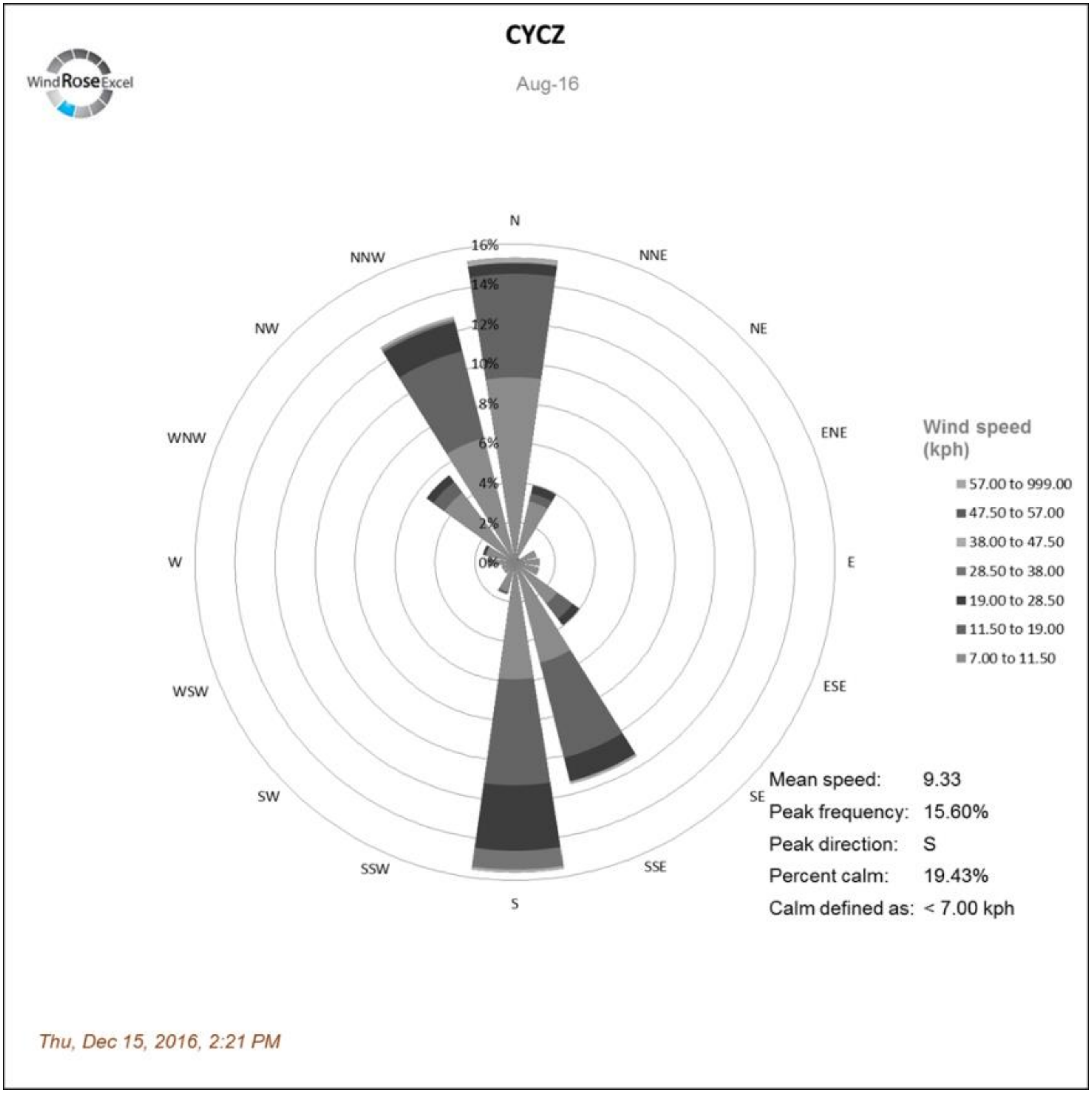
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Wind speed (kph)
57.00 to 999.00
47.50 to 57.00
38.00 to 47.50
28.50 to 38.00
19.00 to 28.50
11.50 to 19.00
7.00 to 11.50
Mean speed: 9.33
Peak frequency: 15.60%
Peak direction: S
Percent calm: 19.43%
Calm defined as: < 7.00 kph
Thu, Dec 15, 2016, 2:21 PM