



**The Appleton Wetland;
Its Decline, Cause and Recommended Action**

Appendix H: Coordinated Level Measurements

Report prepared by

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Coordinated Level Measurements

This was a project that ran from August 5 through November 14, 2013, with a purpose of taking near simultaneous water level measurements at three points along Reach 18 between Appleton and Almonte. The measuring points included:

1. The staff gauge under the Bridge Street bridge in Almonte
2. A flat rock shelf in the river bed at 222 Spring Street in Almonte
3. A benchmark at the rear of 521 River Road in Appleton

In practice, it involved taking a measurement at the Almonte staff gauge from the Old Town Hall riverfront with binoculars, then driving to 222 Spring Street and measuring the depth of water over the designated point on the rock shelf with a yard stick, and then driving to 521 River Road in Appleton and measuring the water level at the shore line of Appleton Bay relative to our newly placed benchmark. The total measurement cycle took about a half an hour – not quite simultaneous, but in view of the very slow rate of level changes it was close enough for the purpose.

The staff gauge under the bridge was established around 2006 by Mississippi Valley Conservation Authority (MVCA), and is understood to be calibrated relative to Geodetic Benchmark number 15U65G in the wall of the old Post Office (near southwest corner of building) at the intersection of Mill and Little Bridge Streets. The level for the benchmark was given as 120.155 masl relative to the Canadian Geodetic Vertical Datum CGVD28. The staff gauge thus provides direct water level readings in masl that can be compared to levels at other sites that use this standard vertical datum. The staff gauge can be read to better than 1 cm resolution under ideal circumstances (no ice, no waves, good lighting) with binoculars.

The flat rock shelf in the river bottom near the shoreline at 222 Spring Street has been noted by the property owner as the lowest level at this site that the river has ever reached in the last 20 years. For initial purposes it was assigned a level of 117.20 masl (the same height as the concrete weir at Enerdu). The water depth over the reference point was measured with a yard stick stored near-by. It was intended that a level survey would be completed, before the end of the observation series, to provide an accurately calibrated level for the rock shelf relative to the CGVD28 vertical datum. Unfortunately, when the survey was completed on October 30, 2013, the level data was found to have a number of errors and was not useable. There was no opportunity to repeat the work in time available. By that time an accurate reference level had been established for Appleton, and by comparing the series of water level measurements for 222 Spring Street with those from Almonte and Appleton, it was possible to estimate closely the level for the rock shelf. The basis for this was simply that the level at 222 Spring Street could never exceed the level at Appleton, and it could never be less than the level at the Almonte staff gauge. The revised estimate for the rock shelf was 117.36 masl, and this new reference level was used in re-computing the water levels for all prior observations.

In Appleton, we set up a local benchmark on the remains of an old foundation close to the water's edge at 521 River Road in Appleton. The initial level assigned to the benchmark was 119.095 masl based on some evidence that we regarded as possibly inaccurate. Subsequently, a level survey in Appleton was completed on October 11, 2013, with results that passed variance tests, and we concluded that the benchmark had a level of 119.222 masl relative to the CGVD28 vertical datum (see Appendix F). All prior water level observations for Appleton were recalculated with the new benchmark level. Water level measurements were made using a laser

level and level rod by taking a back sight from the benchmark, then taking a fore sight with the rod resting on any rock just at the water level.

Spreadsheets summarizing all of the water level measurements are included at the end of this Appendix. The first spreadsheet titled, *Mississippi River – Comparative Water Levels*, contains all of the coordinated level measurements by Date, Time and Level for the three measurement sites. In addition, notes were included on the operation of the Enerdu generators (ON or OFF), and the status of flashboard sections 1 and 2 (Missing, Replaced or Removed). A final item was the addition of real time flow data from the Appleton Stream Gauge as it became available on the Environment Canada website.

The data in the complete spreadsheet was then used to generate Charts A and B showing water levels at each of the three locations along with water flow rate on the date for each level observation. The total time interval has been subdivided between two charts to make the details easier to understand – the first chart from August 4 to September 28, 2013, and the second chart from September 23 to November 17, 2013. There is an overlap from September 23 to September 28 to help visualize the transition between charts. Above the horizontal axis a series of notations (A, B, C, D, etc.) has been placed marking points of significance. These are keyed to notes below the chart providing more complete details for each item.

Chart A

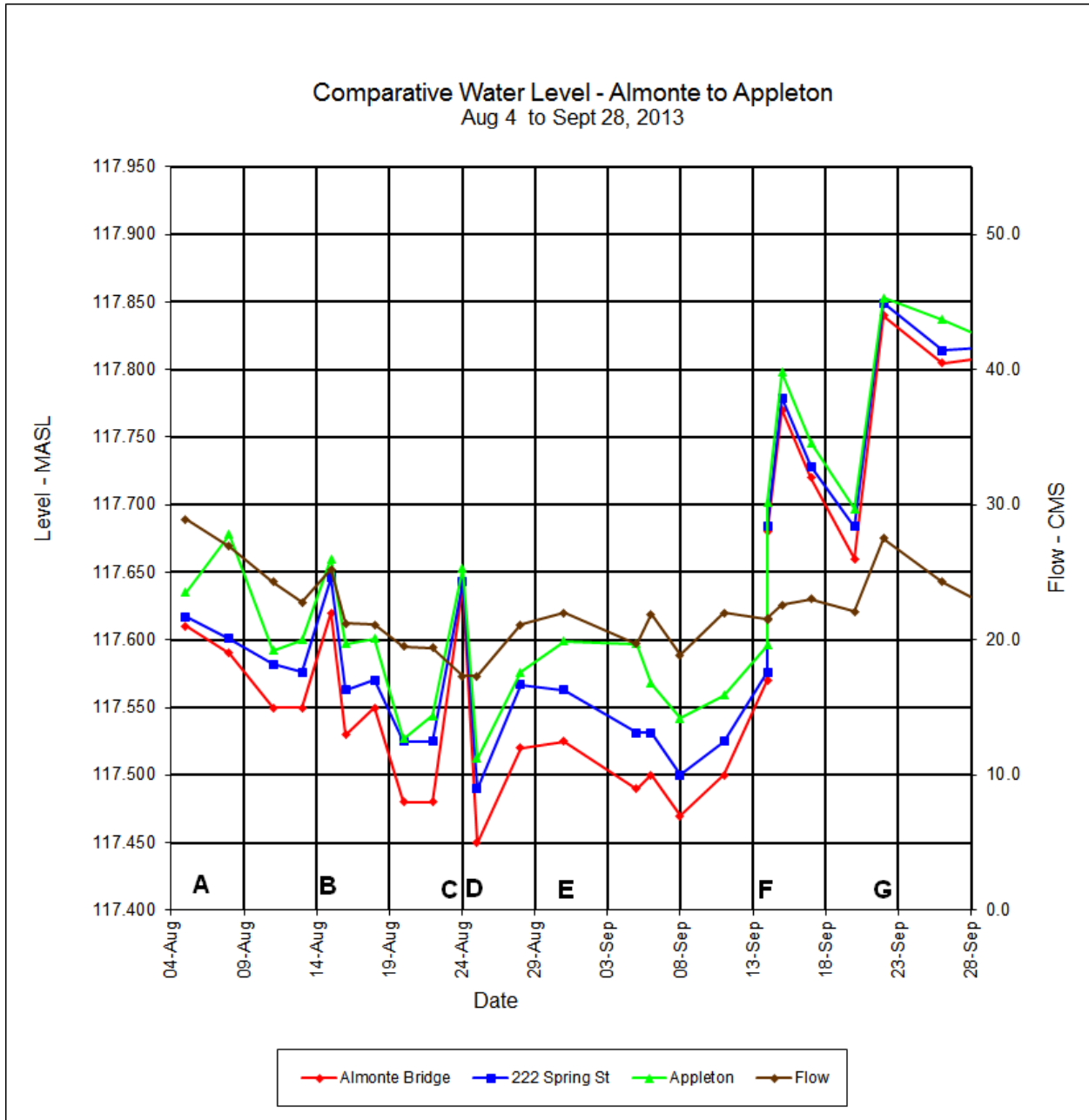


Figure H-1 Chart A, comparative Water Level, Almonte to Appleton, August 4 to September 28, 2014

Notes:

- A. On June 8 after the spring flood, flashboard sections 3 and 4 were installed, but not section 1 and 2. That status continued to the start of this chart on August 5. The generators were operational and probably taking their rated water flow of 14 cms, leaving about 15 cms to flow over weir sections 1 and 2.
- B. There is an upward spike in the level at all three sites on August 15. This correlates with an upward spike in river flow rate and turning off the generators. Both factors would be

expected to cause a rise in level, but the proportion of the rise attributable to each cause is unknown at this time. On August 18, there is also a small rise in levels at all sites which corresponds to an instance of generators off while flow remained flat.

- C. From the start of the chart to August 22, flow rate continued a steady decline, and water levels at all three sites also declined proportionally. Also note that Appleton levels tend to be about 5 cm higher than Almonte levels, with Spring Street between the two levels. Then on August 24, there is an abrupt spike in levels at all three sites. In the early morning hours around 6:00 to 7:00 AM on that day, the flashboards on sections 1 and 2 were installed, causing an immediate rise in water level. The level measurements around 3:00 PM probably had not yet reached a maximum at the top of the flashboards.
- D. Overnight on August 24-25, vandals removed the new flashboards on sections 1 and 2 causing an immediate drop in all levels to values appropriate to the flow rate minimum of 17.3 cms that occurred on August 24-25.
- E. In the interval from August 25 to September 11, levels at all sites followed more or less the same pattern of changes as the flow rate. Again the Appleton level was 5 to 7 cm higher than that in Almonte, similar to the differential in Note C.
- F. On September 14 around 7:00 AM, replacement of the missing flashboards on section 1 and 2 was completed and water rose to 117.57 masl around 9:00 AM, with a further rise to 117.70 masl around 3:00 PM. Levels finally peaked around 117.77 at noon the next day.
- G. On September 22, there is a sharp spike in levels at all sites, and this corresponds to both a peak in flow rate and a period with generators off. Again the degree of level rise attributable to each of these factors is not known.

It should be noted that the level difference between Almonte and Appleton on September 22 is just over 1 cm, compared to the 5 to 7 cm difference recorded around the end of August. The cause of the smaller differential (or flatter level profile) is due to the 30 cm increase in water level at Almonte between the end of August and September 22, the result of the added flashboard sections 1 and 2, and the flow rate peak. As water level rises, the river cross sectional area increases proportionately, and for a constant flow volume (cms) the river velocity (metres/sec) will decrease along with decreased frictional/viscosity losses, and the water level will show a flatter profile.

Chart B

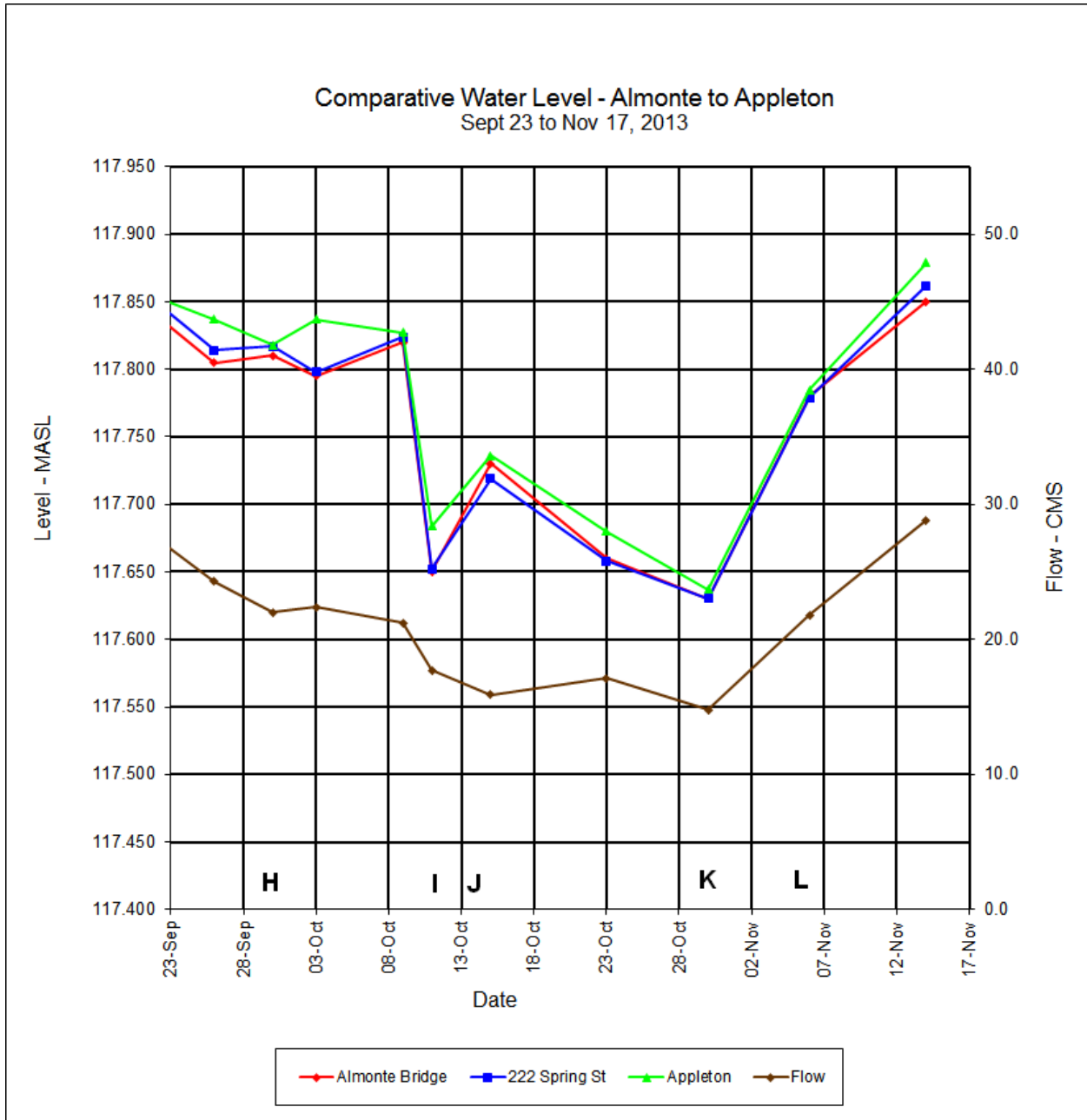


Figure H-2 Chart B, comparative Water Level, Almonte to Appleton, September 23 to November 17, 2014

Notes:

H. In the time interval around September 30 flow rates are around 22 cms or more, and this is well in excess of the combined flow (17 cms estimated) through the generators, flashboard leakage and flow over the Thoburn weir, resulting in a level at Almonte about 10 cm over the flashboard tops.

- I. On October 11, flow rate dropped to 17 cms, and into the unstable region where combined out-flows (Enerdu, leakage and Thoburn) exceed the river in-flow, and water level dropped below the crest of the weir by 5 cm.
- J. Although river flow at the October 15 sample was still below 17 cms, water levels peaked a few cm above the weir crest. This is probably the result of generators being turned off just prior to the October 15 measurements, allowing the river to recharge to a level above the weir crest.
- K. River flow remained at 17 cms or less from October 15 through October 30 with operation in the unstable region. Levels at Almonte remained below the weir crest by up to 7 cm. There were probably on/off cycles of the generators during this period, but at the observed sample times we recorded only generators on.
- L. On November 4 and beyond, river flow exceeded 20 cms, and water levels increased to over the weir crest by approximately 15 cm. Again, in this period with high water levels, the river is quite flat with only a differential of a few cm at most between Almonte and Appleton.

Conclusions

This series of coordinated water level measurements on Reach 18 demonstrate very clearly a number of important points. These include:

1. The presence and operation of the weir in Almonte is the primary control mechanism for water levels in Reach 18, and in particular it has a direct influence on the water levels in the Appleton Wetland. This is very evident in the cases where the missing section 1 and 2 flashboards are installed, then removed and finally reinstalled.
2. With all flashboards installed levels are higher (typically 117.70 masl or greater), and the river becomes quite flat (Appleton only a few cm higher than Almonte).
3. With sections 1 and 2 missing, levels are lower (typically 117.50 masl at 20 cms), and the river has more slope (Appleton 5 to 7 cm above Almonte).
4. There is no data for summer flows of 10cms or less with flashboard sections 1 and 2 missing, but it is expected that the level at Almonte would be less than 117.40 masl, and the slope of the river would be greater than 10 cm. Whether or not the generators are operating would also play a significant role on final water level.
5. Although the August 5 to September 13 period had flows much higher than for a typical summer in this period, the water levels were actually lower than typical for the 2006 to 2012 summers. That is, in 2013 through August and early September, flow ranged from 29 to 17 cms while Almonte levels ranged from 117.61 to 117.48 masl. For the same August and September period during 2006 to 2012, flows were typically 10 cms or less, with some summers having flows of 20 cms or greater. For flows over 17 cms, the levels were typically 117.70 to 117.80 masl. For flows less than 17 cms, levels were 117.70 masl with short unstable dips as low as 117.50 masl.
6. If the generators are operated continuously when the flow is 17 cms or less, the level at Almonte can be reduced to 117.20 masl or less regardless of flashboard height.
7. There is an interesting point to be observed in comparing water levels as flashboard status varies. The table below summarizes the details.

Flow - cms	Flashboard Status	Level - masl	Source
30	All sections in	117.85	Chart B
30	Section 1 and 2 missing	117.60	Chart A
30	No boards	117.60	Appendix D
21.2	All sections in	117.82	Chart A
21.2	Section 1 and 2 missing	117.52	Chart A
21.5	No boards	117.50	Appendix D

This data indicates that with flows in the range of 20 to 30 cms, flashboard sections 1 and 2 play a dominant role in regulating water level, and with those two sections missing levels are very close to the levels with all boards missing. The effect probably extends to a wider flow range, but we have no empirical data to support that at this time.

Mississippi River – Comparative Water Levels

Date	Almonte Bridge		222 Spring St		Appleton		Flow Appleton	Generator	Flashbds 1 and 2
	Time	Level	Time	Level	Time	Level			
05-Aug-13	7:40 PM	117.610	7:58 PM	117.617	8:15 PM	117.635	28.9	ON	Missing
08-Aug-13	11:40 AM	117.590	11:50 AM	117.601	12:05 PM	117.678	26.9	ON	Missing
11-Aug-13	10:15 AM	117.550	10:30 AM	117.582	10:45 AM	117.592	24.3	ON	Missing
13-Aug-13	11:35 AM	117.550	11:55 AM	117.576	12:10 PM	117.600	22.8	ON	Missing
15-Aug-13	3:15 PM	117.620	3:10 PM	117.646	3:45 PM	117.660	25.2	OFF	Missing
16-Aug-13	7:10 PM	117.530	7:25 PM	117.563	7:45 PM	117.597	21.2	ON	Missing
18-Aug-13	4:55 PM	117.550	5:20 PM	117.570	5:35 PM	117.601	21.1	OFF	Missing
20-Aug-13	4:55 PM	117.480	4:55 PM	117.525	5:30 PM	117.527	19.5	ON	Missing
22-Aug-13	3:45 PM	117.480	3:55 PM	117.525	4:15 PM	117.544	19.4	ON	Missing
24-Aug-13	2:45 PM	117.640	3:00 PM	117.643	3:20 PM	117.653	17.3	ON	Replaced
25-Aug-13	5:45 PM	117.450	6:00 PM	117.490	6:15 PM	117.512	17.3	ON	Removed
28-Aug-13	4:20 PM	117.520	4:40 PM	117.567	5:15 PM	117.576	21.1	ON	Missing
31-Aug-13	8:35 AM	117.525	8:45 AM	117.563	9:05 AM	117.599	22.0	ON	Missing
05-Sep-13	4:40 PM	117.490	5:00 PM	117.531	5:15 PM	117.597	19.7	ON	Missing
06-Sep-13	12:20 PM	117.500	12:10 PM	117.531	11:45 AM	117.568	21.9	ON	Missing
08-Sep-13	4:15 PM	117.470	4:30 PM	117.500	4:50 PM	117.542	18.9	ON	Missing
11-Sep-13	2:50 PM	117.500	3:05 PM	117.525	3:25 PM	117.559	22.0	ON	Missing
14-Sep-13	8:50 AM	117.570	9:00 AM	117.576	9:20 AM	117.596	21.5	ON	Replaced
14-Sep-13	3:00 PM	117.680	3:15 PM	117.684	3:40 AM	117.702	21.6	ON	Replaced
15-Sep-13	11:45 AM	117.770	12:00 PM	117.779	12:25 PM	117.798	22.6	ON	Replaced
17-Sep-13	3:45 PM	117.720	4:00 PM	117.728	4:20 PM	117.746	23.0	ON	Replaced
20-Sep-13	3:30 PM	117.660	3:45 PM	117.684	4:00 PM	117.697	22.1	ON	Replaced
22-Sep-13	4:35 PM	117.840	4:50 PM	117.849	5:25 PM	117.853	27.5	OFF	Replaced
26-Sep-13	2:40 PM	117.805	2:55 PM	117.814	3:15 PM	117.837	24.3	ON	Replaced
30-Sep-13	11:00 AM	117.810	11:15 AM	117.817	11:35 AM	117.818	22.0	ON	Replaced
03-Oct-13	2:20 PM	117.795	2:25 PM	117.798	2:55 PM	117.837	22.4	ON	Replaced
09-Oct-13	2:05 PM	117.820	2:20 PM	117.824	2:40 PM	117.827	21.2	ON	Replaced
11-Oct-13	1:05 PM	117.650	12:55 PM	117.652	12:35 PM	117.684	17.7	ON	Replaced
15-Oct-13	4:25 PM	117.730	4:35 PM	117.719	4:55 PM	117.736	15.9	ON	Replaced
23-Oct-13	3:40 PM	117.660	3:50 PM	117.658	4:10 PM	117.680	17.1	ON	Replaced
30-Oct-13	11:55 AM	117.630	12:10 PM	117.630	12:55 PM	117.637	14.8	ON	Replaced
06-Nov-13	1:40 PM	117.780	1:25 PM	117.779	1:05 PM	117.785	21.8	ON	Replaced
14-Nov-13	3:10 PM	117.850	3:25 PM	117.862	3:45 PM	117.879	28.8	ON	Replaced

Notes:

1. Observations at the Almonte staff gauge were transferred directly to this spreadsheet and included the Date, Time and Level readings in the first three table columns. In addition, the status of the Enerdu GS was transferred from field notes and entered in the second last column as ON or OFF, and the status of flashboard sections 1 and 2 was also noted in the last column as Missing, Replaced or Removed.
2. Selected data from the *Mississippi River Data - 222 Spring Street* spreadsheet was transferred to columns 4 and 5 of the above spreadsheet. The selection was based on transferring only those data that had a C in the Type column, denoting an observation on a particular date that was part of the “Coordinated” observations. For each such item the Time and Level for that Date were transferred to the above spreadsheet.
3. Selected data from the *Appleton Level Data* spreadsheet was transferred to columns 6 and 7 of the above spreadsheet. The selection was again based on transferring only those data that had a C in the Type column. For each such item the Time and Level for that Date were transferred to the above spreadsheet.
4. In column 8 real time flow data from the Appleton Stream Gauge was entered as it became available on the Natural Resources Canada website.
5. The data in the complete spreadsheet was then used to prepare charts showing water levels at each of the three locations along with water flow rate on the date for each observation.

Mississippi River Data - 222 Spring Street

Note 1 - Level is referenced to observed 20 YR Low at this site (a flat rock shelf in river bed)

Shelf estimated to be at: 117.36 masl Final (Original estimate 117.20 masl)

Note 2 - 20 YR Max Spring Time High is 49 Inches (124.5 cm) Above Min.

Note 3 - Observation Types: S - single stand alone observation, C - Coordinated 3 site measurement

Note 4 - Generator status: OFF, ON or N/O (not observed)

Note 5 - Flashboards 1 and 2: status of flashboard sections closest to River Walk

DATE	TIME LT	DEPTH Inch	LEVEL masl	TYPE	Generator	Flashbds 1 and 2
		Note 1				
25-Jul-13	2:30 PM	17.50	117.805	S	N/O	Missing
28-Jul-13	10:30 AM	15.50	117.754	S	N/O	Missing
02-Aug-13	5:20 PM	12.40	117.675	S	N/O	Missing
04-Aug-13	8:15 PM	11.75	117.658	S	N/O	Missing
05-Aug-13	7:58 PM	10.10	117.617	S	N/O	Missing
08-Aug-13	11:50 AM	9.50	117.601	C	ON	Missing
11-Aug-13	10:15 AM	8.75	117.582	C	ON	Missing
11-Aug-13	6:50 PM	9.30	117.596	S	N/O	Missing
12-Aug-13	9:50 AM	8.25	117.570	S	N/O	Missing
13-Aug-13	9:45 AM	8.50	117.576	S	N/O	Missing
13-Aug-13	11:55 AM	8.50	117.576	C	ON	Missing
15-Aug-13	3:10 PM	11.25	117.646	C	OFF	Missing
16-Aug-13	7:25 PM	8.00	117.563	C	ON	Missing
18-Aug-13	4:55 PM	8.25	117.570	C	OFF	Missing
19-Aug-13	4:35 PM	7.75	117.557	S	N/O	Missing
20-Aug-13	4:55 PM	6.50	117.525	C	ON	Missing
22-Aug-13	3:55 PM	6.50	117.525	C	ON	Missing
24-Aug-13	3:00 PM	11.13	117.643	C	ON	Replaced
25-Aug-13	6:00 PM	5.13	117.490	C	ON	Removed
28-Aug-13	4:40 PM	8.13	117.567	C	ON	Missing
31-Aug-13	8:45 AM	8.00	117.563	C	ON	Missing
31-Aug-13	12:10 PM	8.00	117.563	C	ON	Missing
05-Sep-13	5:00 PM	6.75	117.531	C	ON	Missing
06-Sep-13	12:10 PM	6.75	117.531	C	ON	Missing
08-Sep-13	4:30 PM	5.50	117.500	C	ON	Missing
09-Sep-13	8:00 PM	7.40	117.548	S	N/O	Missing
11-Sep-13	3:05 PM	6.50	117.525	C	ON	Missing
14-Sep-13	9:00 AM	8.50	117.576	C	ON	Replaced
14-Sep-13	11:00 AM	10.25	117.620	S	ON	Replaced
14-Sep-13	11:45 AM	10.75	117.633	S	ON	Replaced
14-Sep-13	3:15 PM	12.75	117.684	C	ON	Replaced
15-Sep-13	12:00 PM	16.50	117.779	C	ON	Replaced
17-Sep-13	4:00 PM	14.50	117.728	C	ON	Replaced
20-Sep-13	3:45 PM	12.75	117.684	C	ON	Replaced
22-Sep-13	4:50 PM	19.25	117.849	C	OFF	Replaced
26-Sep-13	2:55 PM	17.88	117.814	C	ON	Replaced
30-Sep-13	11:15 AM	18.00	117.817	C	ON	Replaced
03-Oct-13	2:25 PM	17.25	117.798	C	ON	Replaced
09-Oct-13	2:40 PM	18.25	117.824	C	ON	Replaced
11-Oct-13	12:55 PM	11.50	117.652	C	ON	Replaced
15-Oct-13	4:35 PM	14.13	117.719	C	ON	Replaced
23-Oct-13	3:50 PM	11.75	117.658	C	ON	Replaced
30-Oct-13	12:10 PM	10.63	117.630	C	ON	Replaced
06-Nov-13	1:25 PM	16.5	117.779	C	ON	Replaced
14-Nov-13	3:25 PM	19.75	117.862	C	ON	Replaced

Notes:

1. Date, Time and Depth entered from field notes.
2. Level in masl computed as $((\text{Depth} \times 2.54)/100) + 117.36$
3. Only those items of Type C were transferred to the *Mississippi River – Comparative Water Levels* spreadsheet.

Appleton Level Data

Revised Benchmk 119.222 masl		Old BM 119.095 masl				
Date	Time	BS mm	FS mm	Adder mm	Level masl	Type
27-Jul-13	3:30 PM	15	940	508	117.789	S
29-Jul-13	4:30 PM	29	985	500	117.766	S
31-Jul-13	5:15 PM	94	1008	600	117.708	S
03-Aug-13	3:15 PM	84	1005	600	117.701	S
05-Aug-13	8:15 PM	13	1000	600	117.635	C
08-Aug-13	12:05 PM	14	958	600	117.678	C
11-Aug-13	10:45 AM	23	953	700	117.592	C
13-Aug-13	12:10 PM	20	942	700	117.600	C
15-Aug-13	3:45 PM	9	871	700	117.660	C
16-Aug-13	7:45 PM	30	955	700	117.597	C
18-Aug-13	5:35 PM	22	943	700	117.601	C
20-Aug-13	5:30 PM	30	975	750	117.527	C
22-Aug-13	4:15 PM	5	883	800	117.544	C
24-Aug-13	3:20 PM	34	903	700	117.653	C
25-Aug-13	6:15 PM	15	925	800	117.512	C
28-Aug-13	5:15 PM	27	973	700	117.576	C
31-Aug-13	9:05 AM	14	937	700	117.599	C
31-Aug-13	11:15 AM	23	942	700	117.603	C
05-Sep-13	5:15 PM	49	875	800	117.596	C
06-Sep-13	11:45 AM	17	870	800	117.569	S
06-Sep-13	11:50 AM	14	869	800	117.567	C
08-Sep-13	4:50 PM	25	905	800	117.542	C
11-Sep-13	3:25 PM	14	877	800	117.559	C
14-Sep-13	9:20 AM	27	853	800	117.596	C
14-Sep-13	3:40 PM	13	783	750	117.702	C
15-Sep-13	12:25 PM	23	747	700	117.798	C
17-Sep-13	4:20 PM	10	786	700	117.746	C
20-Sep-13	4:00 PM	8	833	700	117.697	C
22-Sep-13	5:25 PM	16	685	700	117.853	C
22-Sep-13	6:55 PM	25	785	600	117.862	S
26-Sep-13	3:15 PM	15	800	600	117.837	C
30-Sep-13	11:35 AM	73	877	600	117.818	C
03-Oct-13	2:55 PM	47	832	600	117.837	C
09-Oct-13	2:05 PM	23	818	600	117.827	C
11-Oct-13	12:35 PM	31	969	600	117.684	C
12-Oct-13	10:45 AM	1458	3000	0	117.680	S
15-Oct-13	4:55 PM	37	923	600	117.736	C
23-Oct-13	4:10 PM	30	972	600	117.680	C
30-Oct-13	12:55 PM	17	902	700	117.637	C
06-Nov-13	1:05 PM	26	963	500	117.785	C
14-Nov-13	3:45 PM	25	868	500	117.879	C

Notes:

1. Date, Time, BS, FS and Adder entered from field notes where BS is back sight reading with rod on benchmark, FS is fore sight reading of top section of rod and Adder is length of bottom section of rod, with rod on a rock at water level.
2. Level in masl computed as $119.222 + BS - FS - Adder$
3. Only those items of Type C were transferred to the *Mississippi River – Comparative Levels* spreadsheet.