The Appleton Wetland;
Its Decline, Cause and Recommended Action

Appendix P: Further Flow and Level Measurements

Report prepared by

Appleton Wetland Research Group
of the
Mississippi Valley Field Naturalists

Research Group Members:

Cliff Bennett, Chair
Joachim Moenig
Al Seaman
Mike O'Malley
Howard Robinson

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Further Flow and Level Measurements

The spring of 2014 provided an opportunity to collect some data on the relationship between water flow as measured at the Appleton Stream Gauge, and water levels along Reach 18 as measured at six places. The first four measurement locations were above the Enerdu weir and the results are detailed in this Appendix. The remaining two locations were below the weir and may have value for other purposes, but they are not relevant to upstream water levels and Appleton Wetland issues. That data is not covered in this Appendix. It should be observed that the spring flood this year had a near record high level so this provided an excellent opportunity to measure the relationship between flow rate and water level over the widest possible range.

Background Information

The data record started on April 9, 2014 and continued to June 19, 2014. Data was recorded intermittently with samples taken when there was some appreciable change in flow rate from previous samples. The analysis and documentation of the data were stopped at June 19 in order to prepare this Appendix for inclusion in the final report on the Appleton Wetland. Data recordings will continue, but analysis of that data will be the subject of a later addendum.

Flashboards were nearly completely broken off at the start of the data except for a few short remnants. The first two data points (April 9 and 11) do not follow the curves generated by subsequent data, showing that even small remnants of the flashboards do have a measureable effect on the flow versus level curves. Those two points have been left out of the analysis that follows, and all results are for flow with no flashboards.

The level data above the weir was recorded at four places. The italic headings below are the same identifiers used in the results that follow later.

a) *Rail-A:* Measured at mid-span on the River Walk bridge between the Old Town Hall and the small island by measuring the water level down from the bridge railing. The railing had previously been established as being at a level of 120.09 masl.
b) *Gauge:* Measured at the staff gauge on the pier of the Bridge Street bridge. This is direct reading in masl.
c) *SpringSt:* Measured at a flat rock shelf in the river bed behind 222 Spring Street. The level of this rock shelf had been previously established as 117.36 masl.
d) *Appleton:* Measured at the shoreline at 521 River Road in Appleton using the previously established benchmark, at 119.222 masl, as a reference.

While water levels and flow rates were at the high end of the series of measurements, river currents were strong and the water surface was quite turbulent. This made it difficult to estimate just where the average water surface was. As a result, the data is a bit noisy in these high flow periods, particularly for data in series a) and b) as above. This does produce some scatter in the data points as plotted on a chart, but a good smooth curve can be derived to fit the data.

The raw data measurements were entered into a spreadsheet, and flow measurements in cms from the Appleton Stream Gauge as reported on the Environment Canada website were also added to the spreadsheet. The resulting data is tabulated below.

River Flow and Level at 4 locations - Spring 2014				
Flow	Rail-A	Gauge	SpringSt	Appleton
cms	masl	masl	masl	masl
80.00	117.99	118.05		
109.00	118.03	118.10	118.27	118.36
122.00	118.05	118.13	118.28	118.39
167.00	118.16	118.26	118.45	118.58
202.00	118.28	118.39		
212.00	118.30	118.43	118.64	118.83
216.00	118.30	118.44		
227.00	118.33	118.47	118.72	118.89
239.00	118.36	118.50	118.77	118.95
243.00	118.37	118.53	118.80	119.00
244.00	118.39	118.55	118.82	119.00
236.00	118.37	118.52	118.78	118.96
216.00	118.32	118.47	118.71	118.87
192.00	118.24	118.35	118.58	118.71
160.00	118.14	118.24	118.44	118.57
139.00	118.06	118.15	118.32	118.45
120.00	118.01	118.10	118.27	118.38
106.00	117.95	118.03	118.18	118.27
80.20	117.86	117.93	118.05	118.13
75.60	117.81	117.87	117.98	118.04
68.60	117.77	117.83	117.93	118.00
59.80	117.74	117.80	117.89	117.95
47.90	117.70	117.74	117.81	117.87
40.40	117.61	117.65	117.71	117.78
35.50	117.57	117.61	117.66	117.73
44.50	117.64	117.69	117.77	117.81
0	117.2	117.2	117.2	117.2

In order to complete the lower end of the flow vs level curves, a final theoretical point was added to the data series for the four sites above the weir. If the flow in the river drops to zero then the river becomes a flat lake with its level established by the weir at 117.20 masl. It would be desirable to have more measured results in the flow interval between 35.5 and zero cms, but thanks to the heavy rains that we have had through much of June, lower levels did not occur until later in July after the cut-off date for the report. In the meantime the arbitrary zero flow point serves as a means of interpolating the lower end of the data.

Data Analysis

The above data set was then used to generate a chart of level versus flow for the four sites above the weir. This is shown below.

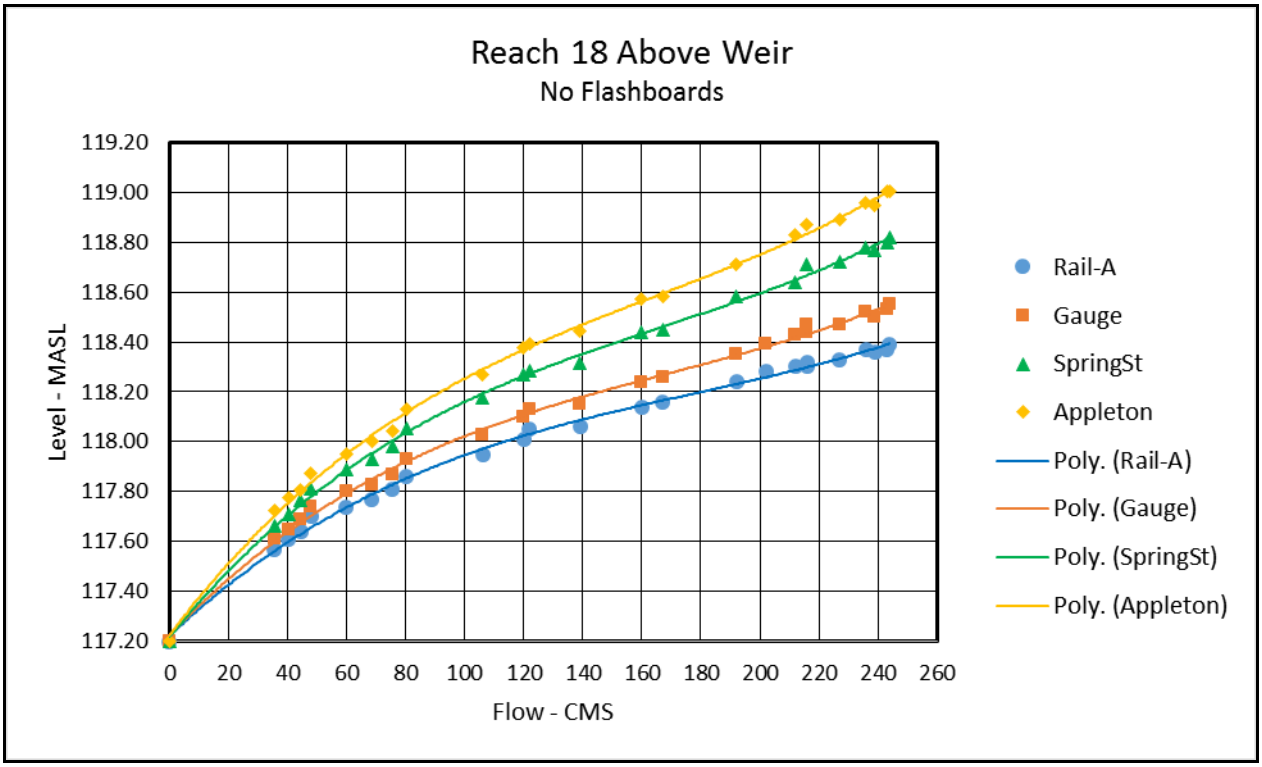

Figure P-1 Chart of Level vs Flow for four locations on Reach 18

For the above chart, computed trendlines were added using a third order polynomial. The trendlines do produce a quite plausible set of curves. They do show clearly the increasing slope of the river as the flow rate increases. It is interesting that there is more slope in the short distance between *Rail-A* and *SpringSt* than there is in the nearly 9 km distance between *SpringSt* and *Appleton*. This does demonstrate the effect of the relatively narrow and shallow channel in the first interval compared to wider and deeper channel in the second interval.

The scale on the chart below shows the Above Weir data with the scale expanded to show the data points and the computed trendlines more clearly at the lower flow rates. In particular, for the Appleton curve, with an average summer flow of 10 cms and no flashboards, the water level in the Appleton Wetland would be close to 117.40 masl. That is an interesting result since it is the recommended level for Appleton Wetland recovery that has come out of both the MVFN Tree Project (Appendix G) and the later Wetland Inspection (Appendix K).

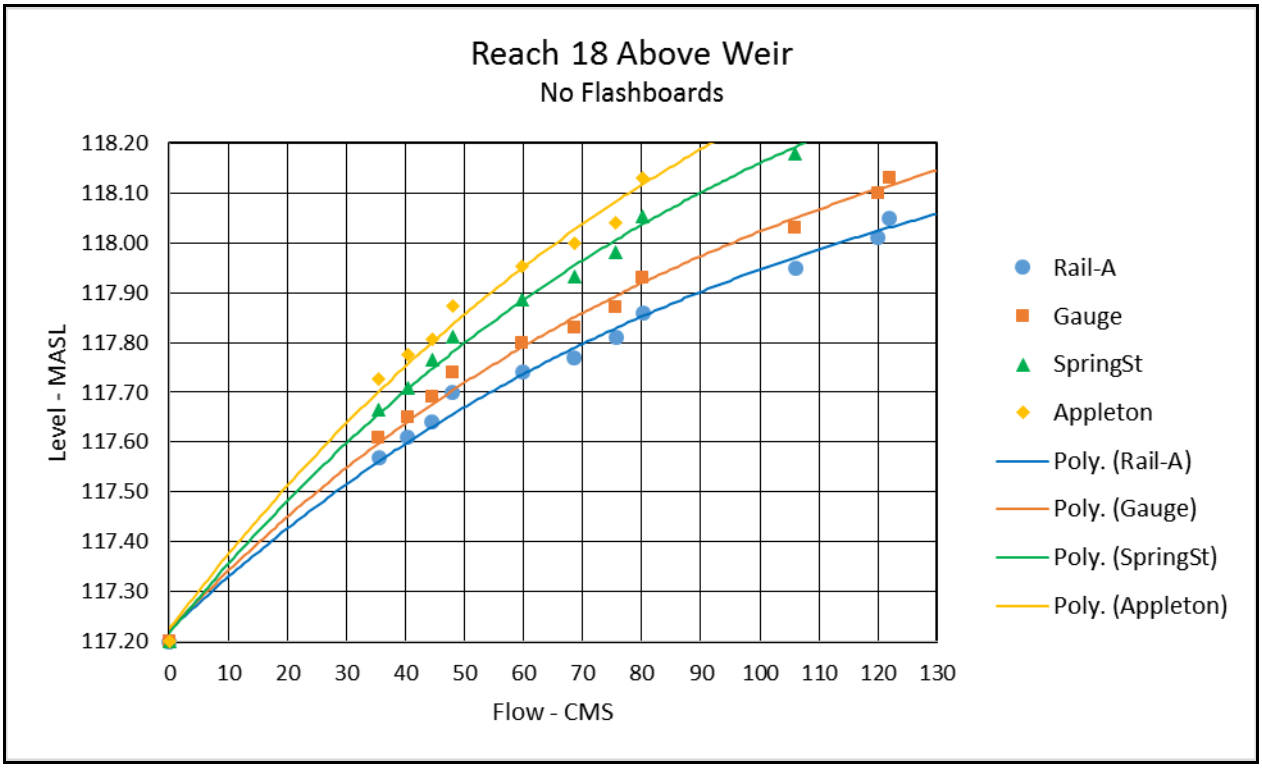

Figure P-2 Chart of Level vs Flow expanded to show the lower end of the data range

Since the most important curve is that for Appleton, it is reproduced below at full scale without the clutter of the three additional curves. In addition, the computed polynomial for that curve is added to the chart. In the equation, y represents the value of water level in masl, and x represents the value of stream flow in cms. This is a useful component for some further analysis.

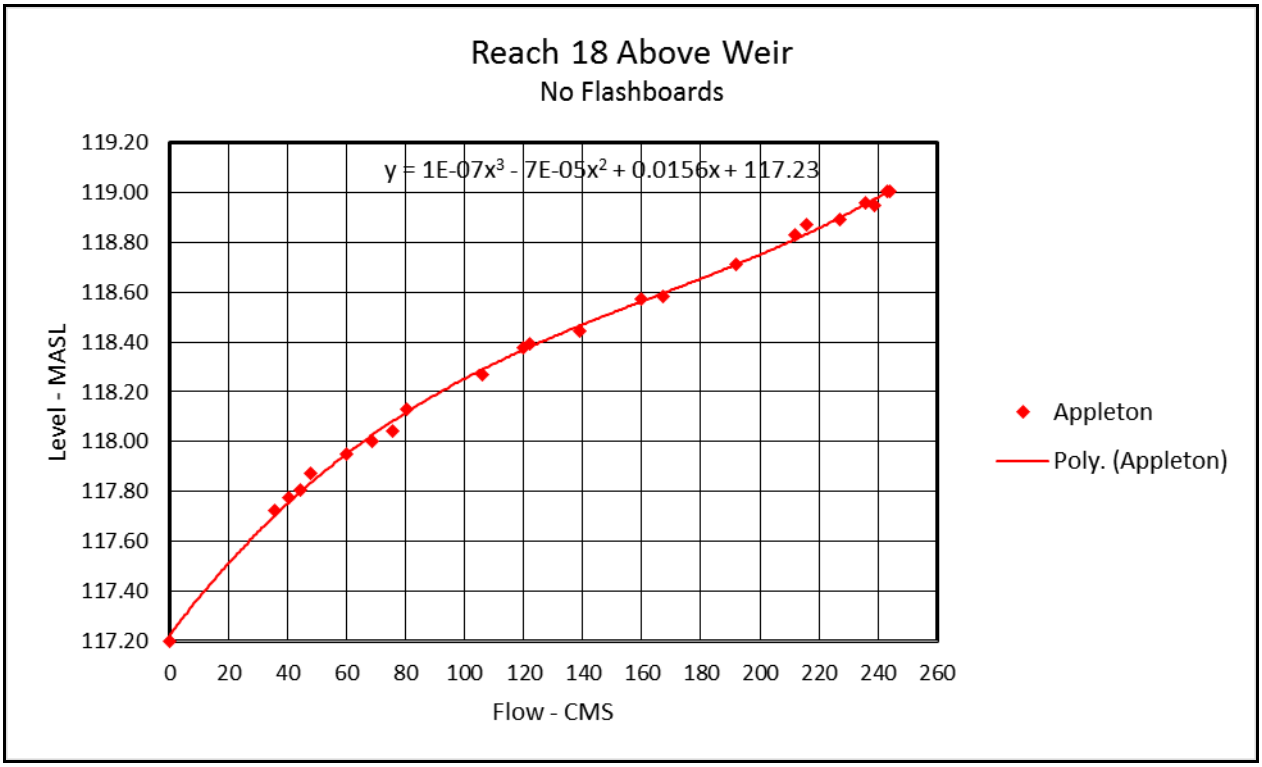

Figure P-3 Chart of Appleton Level vs Flow showing the trendline equation

At the end of Appendix C, a chart based on Appleton Stream Gauge data from the Environment Canada website was developed that showed the Mean Daily Flow over the 95 year recorded history of that station. The Date and Mean Flow from that chart were transferred to a spreadsheet, and the trendline equation from the above chart was used to derive a corresponding set of Mean Level values. The spreadsheet below shows the results.

Appleton Mean Flow and Mean Level by date		
Mean Level computed by trendline equation:		
Y = 1E-07X^3 - 7E-05X^2 + 0.0156X + 117.23		
Date	Mean Flow	Mean Level
	cms	masl
1-Jan	29	117.626
16-Jan	28	117.614
1-Feb	30	117.638
16-Feb	27	117.602
1-Mar	30	117.638
16-Mar	40	117.748
1-Apr	73	118.035
8-Apr	99	118.185
16-Apr	102	118.199
23-Apr	98	118.181
1-May	87	118.123
16-May	59	117.927
1-Jun	42	117.769
16-Jun	26	117.590
1-Jul	19	117.502
16-Jul	13	117.421
1-Aug	11	117.393
16-Aug	10	117.379
1-Sep	10	117.379
16-Sep	11	117.393
1-Oct	11	117.393
16-Oct	12	117.407
1-Nov	15	117.449
16-Nov	20	117.515
1-Dec	26	117.590
16-Dec	28	117.614
01-Jan	28	117.614

The spreadsheet was then used to generate a chart of Mean Flow and Mean Level over a one year cycle as shown below. The important result is that for the no flashboards case, the mean water level would drop to 117.50 masl on July 1, and from August 1 to October 1 would remain at or slightly below 117.40 masl, with a rise to 117.45 masl on November 1. This seems to be ideal conditions for restoring the Appleton Wetland to a healthy state. It is also in stark contrast to the elevated Appleton water levels as documented in Appendices G and H.

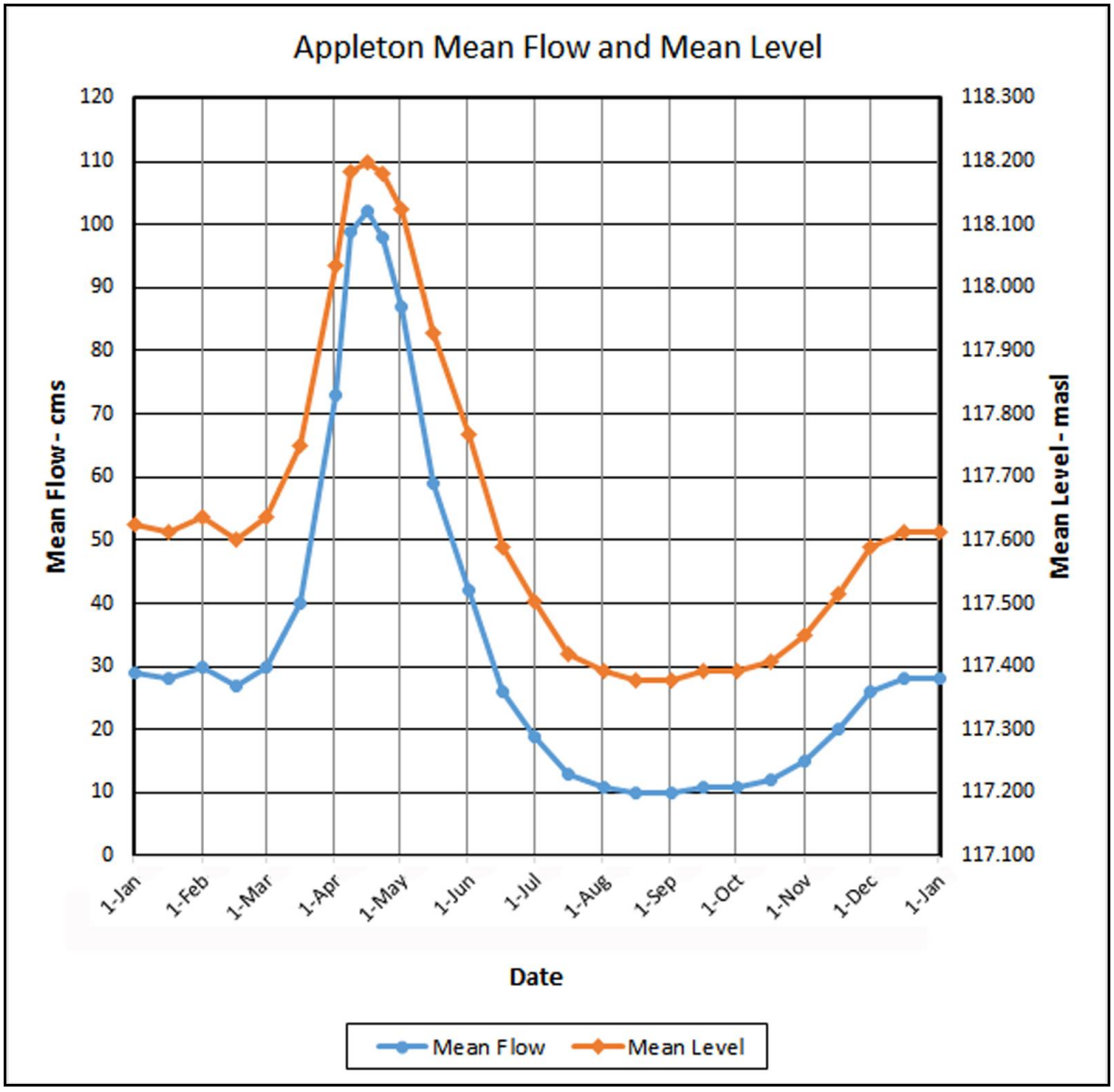

Figure P-4 Chart of mean flow rate with computed Appleton mean level for No Flashboards