Gabriola Streamkeepers—Water levels and quality

Observations at Coats Marsh, Gabriola Island

—with notes on Coats Marsh Creek, East Path Creek, and Stump Farm Streams.

Summary of water-level measurements

Master file:

Observations at Coats Marsh RP , File 673 .

The master file, begun on July 18, 2015, is no longer regularly updated but measurements of water levels made after July 17, 2020 when the master file was closed continue to be reported in the individual Field Observation files and these reports are included here.

The intention is to continue making measurements and to keep this summary file current.

Background files:

Coats Marsh 2011–2021 Management Plan
Coats Marsh 2011–2021 Management Plan Appendices
[Published in August 29, 2011, these two documents are in places in need of revision.]

Coats Marsh hydrogeology, File 668.
Coats Marsh Water balance and catchment area calculations, File 673u.
Coats Marsh Notes on evaporation and evapotranspiration, File 673t.

Observation files containing field notes are:

Binder – a very large file, and not always completely up-to-date , Binder673.pdf
2015: Supplementary file "Field Observations 2015", File 673d.
2016 (Jan. - Mar.): Supplementary file "Field Observations 2016-1", File 673e.
2016 (Apr. - June): Supplementary file "Field Observations 2016-2", File 673f.
2016 (July - September): Supplementary file "Field Observations 2016-3", File 673g.
2016 (October - December): Supplementary file "Field Observations 2016-4", File 673h.
2017 (Jan. - Mar.): Supplementary file "Field Observations 2017-1", File 673j.
2017 (Apr. - September): Supplementary file "Field Observations 2017-2", File 673k.
2017 (October - December): Supplementary file "Field Observations 2017-3", File 673m.
2018: Supplementary file "Field Observations 2018", File 673n.
2019: (Jan. - June): Supplementary file "Field Observations 2019-1", File 673q.
2019: (July - December.): Supplementary file "Field Observations 2019-2", File 673r.
2020 (Jan - June): Supplementary file "Field Observations 2020-1", File 673s.
2020 (July - December): Supplementary file "Field Observations 2020-2", File 673v.
2021 (Jan. - July): Supplementary file "Field Observations 2021-1", File 673w.
2021 (July - September): Supplementary file "Field Observations 2021-2", File 673x.
2021 (October - December): Supplementary file "Field Observations 2021-3", File 673y.
2022 (Jan. - December): Supplementary file "Field Observations 2022", File 673z.
2023 (Jan. – Apr.): Supplementary file "Field Observations 2023-1", File 673za.
2023 (May – Aug.): Supplementary file "Field Observations 2023-2", File 673zb.
2023 (Sept. – Dec.): Supplementary file "Field Observations 2023-3", File 673zc.
2024 (Jan.-): Supplementary file "Field Observations 2024-1", File 673zd.

Brief history — moved to File: 697

Water levels

There are two major water levels:

—that in the weirpool ("inner") area of the shallow-water wetland (the "lake"), west and downstream of the large beaver dam, close to the scale at the concrete weir and the Concrete-Weir Baseline (CWB), and

—that in the much bigger main ("outer") area of the shallow-water wetland (the "lake"), east and upstream of the large beaver dam measured at the Summer Cistern Baseline (SCB).

Water level in the weirpool in recent years regularly exceeds the height of the baffle with, except in winter, no flow into Coats Marsh Creek because of an accumulation of debris, built-up and consolidated by the beavers around the baffle. The pond leveller however still functions.

Inflow to the system is from precipitation and from run-off from wetlands mainly those to the east in winter; outflow is from evapotranspiration and run-off into Coats Marsh Creek in winter. There are no significant sources or sinks of water otherwise as the lake bed is thick montmorillonite-rich gleysol. Two springs that run only in wet winters on the east side are sub-surface flows of East Path Creek and are not groundwater from a distant catchment area. Files 668, 673t, 673u.

Baseline

CWB

The baseline for all measurements in this note is the Concrete-Weir Baseline (CWB) as defined in the master file File: 673, pp. C3–C4.

SCB

Measurements made at the east end of the lake using the Summer Cistern Baseline (SCB) as defined in the master file File: 673, pp. C8–C10, have been corrected to CWB using the results of the survey made on August 30, 2018, File 673, p.C9. Despite its name, SCB was used year-round.

All graphs in File: 673 use an older calibration for SCB at +155 mm on CWB. Levels graphed in this file have been raised an additional +212 mm to conform to the latest calibration.

RDN

CWB is -67 mm below the RDN iron pin at the weir, but the RDN reference is not used in any of these reports.

On July 23, 2021, the RDN installed a new water-level gauge on the upstream side of the beaver dam. How this relates to the CWB by survey is not yet known; but as of July 28, 2021, it read +1265 mm while the SCB read –52 mm, File 673x, pp.359–360, which makes the provisional correction of the new-gauge readings to CWB = –1265+(–52+155+212) = –950 mm.[1]

[1] Another determination on August 11, 2021 gave –961 mm, but I'm sticking to –950 mm until a proper survey can be done.

In late-August 2023, it was established that this gauge had had its depth increased. Its current elevation is not known, but it appears to be roughly 260 mm lower than it was.

Hydraulic head

Differences between the level of water on the up- and downstream side of the beaver dam (the head) sometimes exceed one metre,[2] which has significantly reduced the probability of severe ecological damage in summer droughts.

Beaver dam stability

Concerns are sometimes expressed regarding the risks associated with sudden failures of beaver dams. While it is true that dam failures, particularly in high-energy environments, may cause infrequent but significant pulses of water and debris, the dam at Coats Marsh exists in a very low-energy environment, its feeder creeks all being run-off from wetlands.

Dams such as these, that are not in steep-gradient alpine environments, are additionally less prone to failure if they are older and established, are of a low order (Coats Marsh Creek is only a 2nd-order stream), and are stabilised by vegetation so that over time they have become an integral component of the landscape. The dam at Coats Marsh is well covered with riparian vegetation and is robust enough to be walked across safely when done with care.

The University of Exeter in the UK in a 2019 report observes that hydrological monitoring across beaver sites in 1st- to 4th-order channels throughout Britain since 2014 has been undertaken, and that complete failure of an established dam has rarely been observed.

In an e-mail from the University received in November 2021 an update to this observation was as follows:

> "I would still stand by this statement [that failure is rare] and indeed reinforce it as we rarely see beaver dam failure at our study sites and when we do, it is on higher-order, high-energy stream/river systems during times of flood. Even in these cases, we most often see partial failure, where a notch in the beaver dam fails, and is subsequently repaired the following evening by the beavers. This is because beaver dams are very coherent structures, far more so than the analogous dams that we humans construct, which of course we rarely, if ever, maintain.
>
> Considering the system that you refer to, which is a low-energy lake system, in my opinion, especially given the maturity of the dam, the chance of any catastrophic failure is non-existent. The chance of partial failure is also very low and thus I would not consider there being any enhanced risk to infrastructure downstream, above and beyond the 'normal' risk that such a system might afford to any infrastructure that is in place.
>
> On this point, it is often the case that the risk to infrastructure – including culverts, roads, bridges etc… is due to the inadequate design of older infrastructure that renders it less resilient to the rainfall::runoff regimes that we currently experience, and perhaps even more so to the regimes that we will experience under climate change scenarios.
>
> Ironically, beaver dams can enhance the resilience of such structures, as we prove in the attached paper from earlier this year which demonstrates natural flood management, protecting villages downstream of beaver sites, by the beaver dams themselves."

[2] Note however that the "pressure" on the dam is less than the head in late-summer when the head peaks because downstream water in the weirpool retreats from the base of the dam leaving behind a dry-land buttress.

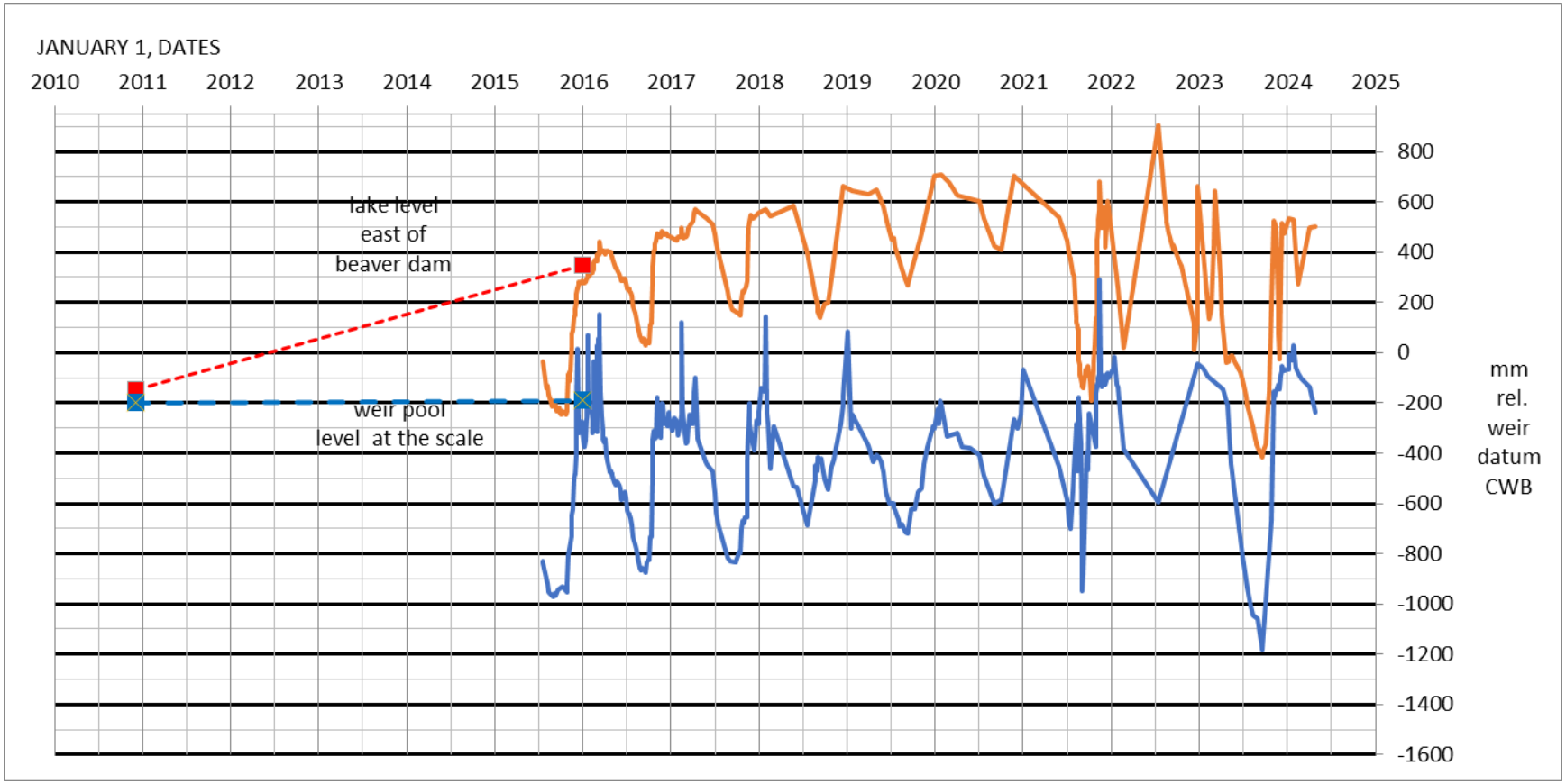

Figure 1a: Water levels

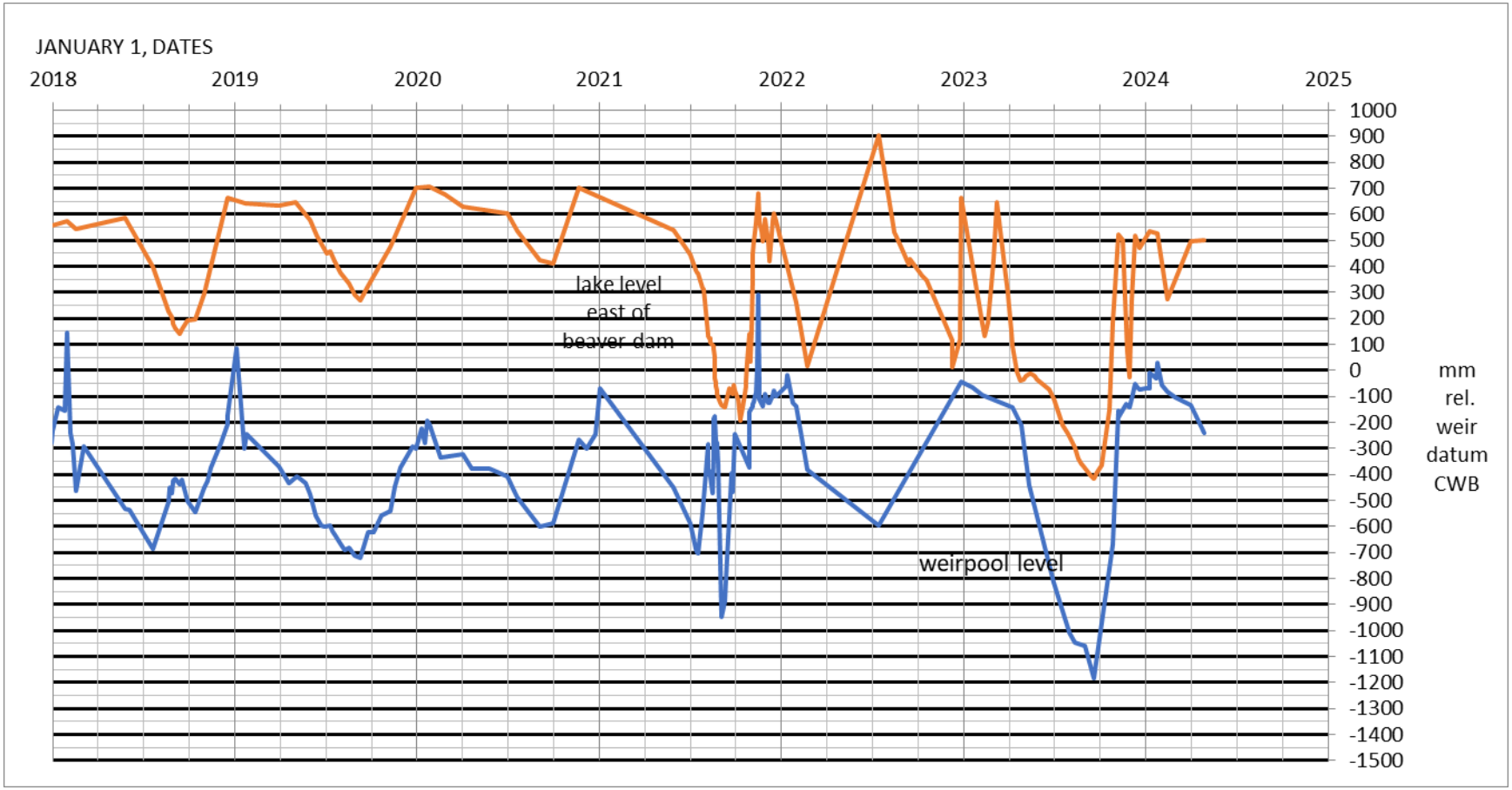

Figure 1b: Water levels

Notes on Figure 1:

1. The winter 2010 observations are from the Management Plan.

2. The weir deck is flooded whenever the weir-pool level (blue) exceeds 0 mm. This has not happened since November 2021.

3. The beaver dam has significantly reduced the risk of the marsh drying out by the end of the dry season as evidenced by the rising annual low points of the red graph. The lake bed is everywhere above –1780 mm (rel, to CWB), and any drop of water level to less than –1000 mm below CWB would severely shrink its surface area and impact the ecology of the lake parafluvial margins.

4. Water was syphoned across the beaver dam by the RDN on July 23, 2021. The effect on the level of the main lake would have been small, ~10 mm, as its area is roughly 20 times greater than that of the weirpool (ref: CE/CW in File 673u). There would however have been a rise in the level of the weirpool solely due to the syphoning of ~200 mm as there was no outflow into Coats Marsh Creek (ref: File 673x, pp.359-360).

5. Water was syphoned across the beaver dam by the RDN in early August severely dropping the level of the marsh, and causing Coats Marsh Creek to run (ref: File 673x, pp.362-364).

6. A "permanent" syphon system across the beaver dam was installed by the RDN in mid-September but they've had finger-trouble getting it to function correctly. Some days all four syphons are working, some days only two, and some days none. Adjustment has also been made to the pond leveller at the weir. Levels in the weirpool particularly have not been stable. (File 673x and File 673y).

7. Since on-and-off syphoning began weirpool levels have been erratic and not recorded unless level is exceptionally high. An added complication is that there is now a beaver dam one to two metres upstream of the weir. The old RDN weirpool gauge is upstream of this small dam and hence the level it reads is no longer the level at the sill of the concrete weir.

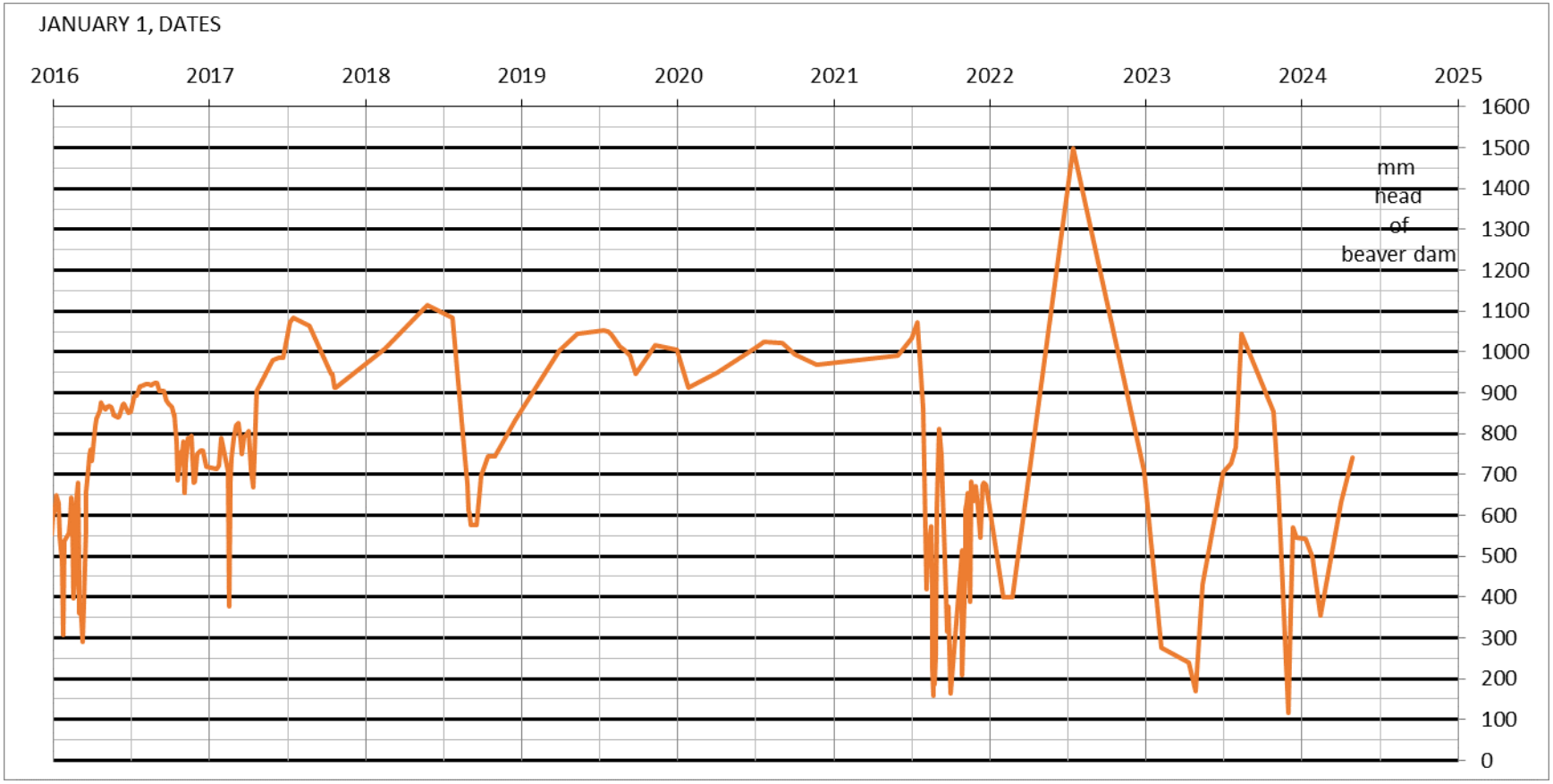

Figure 2: Beaver dam hydraulic head

Notes on Figure 2:

1. The head (difference in water levels at the beaver dam) is usually highest in late summer. The exception in 2018 is due to the dam developing an underwater leak which the beaver had to repair.

2. Very low heads occur when water is overflowing at the dam in flood conditions. Recently overflow has been reduced and almost eliminated by the development of two spillways. Whether these pond levellers are a consequence of natural circumstances or the beavers have engineered them is not known, but they are effective in reducing flooding by reducing the volume of water in the lake in a controlled manner in anticipation of flooding.

3. See notes 4 and 5 on Figure 1.

4. See note 6 on Figure 1.

5. See note 7 on Figure 1.

The secondary beaver dam at the weir (the debris/dam)

Due to renovation on the part of the beaver of the debris, now a dam, amassed just a few metres upstream of the weir, water is forced to flow in shallow spillways over it, through it, and around it. There is thus a difference (delta) in levels of water in the weirpool monitored by the scale, and the level of the water crossing the top of the baffle.

weirpool level is level of water in the weirpool relative to the crest of the concrete weir (CWB) measured by the scale.

depth of water above the top of the baffle. The decrease in the depth of water as it flows over the baffle due to the acceleration of the water (the drawdown) is going to be ignored. Not an easy measurement to make as the water is moving so fast that even if the stainless steel ruler is held exactly parallel to the flow, a “bow” wave is still created that perturbs the reading. This restricts the measurement to centimetre precision. The depth is taken to be zero (not negative) if there is no water flowing over the baffle

sill water level is calculated as the level of the top of the baffle (-0.640 m CWB) plus the measured depth of the water crossing the top of the baffle.

delta is the weirpool level less the sill water level, which is approximately the amount the beaver’s dam/debris is allowing the level of the weirpool to rise, so long as the difference (delta) is positive, that is so long as the weirpool level exceeds the level of the top of the baffle (neglecting the effect of drawdown). Delta is of course subject to alteration by the beaver and humans clearing away some of the dam/debris.

date	**weirpool** level m	**depth** of water above the baffle m	**sill** water level m	**delta** m	day
Nov.6, 2023	-0.153	0.080	-0.560	0.41	3033
Nov.23, 2023	-0.129	0.070	-0.570	0.44	3050
Dec.6, 2023	-0.089	0.100	-0.540	0.45	3063
Dec.8, 2023	-0.071	0.135	-0.505	0.43	3065
Dec.10, 2023	-0.053	0.150	-0.490	0.44	3067
Dec.20, 2023	-0.074	0.088	-0.552	0.48	3077
Feb.3, 2024	-0.056	0.140	-0.500	0.44	3122
Feb.13, 2024	-0.082	0.088	-0.552	0.47	3132
Feb.28, 2024	-0.104	0.081	-0.559	0.46	3147

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