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.

References:

RDN Coats Marsh Regional Park, 2011–2021 Management Plan, Appendix A.
RDN Coats Marsh Weir Assessment, June 1, 2020, SRM Projects.

For a more detailed list see here and for pertinent Gabriola Streamkeepers notes see here.

Coats Marsh hydrogeology .

Water-levels' summary.

Coats Marsh RP and 707 CP Trail Maps: Maps Y and Z.

Gabriola Stream and Wetlands Atlas .

Coats Marsh Species Checklists .

Coats Marsh – human disturbance of breeding and migratory ducks and geese.

Coats Marsh Management - paper on.

Coats Marsh brief history.

Long-term precipitation (1944-2021) – statistics. Updated every month and used as the "normal" meaning average precipitation at Coats Marsh.

Field observations—2023 (May—August)

THIS FILE (Field Observations 2023) IS A SUPPLEMENT TO:

"Observations at Coats Marsh, Gabriola Island" File: 673.

For an up-to-date list of supplements see here .

May 1, 2023 (day 2844, 2557+287): VieRG cum. 869.4 mm (norm. 1012 mm). VieRG cum. 881.8 mm (norm. 1012 mm).

VieRG = Environment Canada Vancouver Island east (called "Nanaimo") total precipitation scaled by 0.95. RG = rain gauge.

Day 0 (now 2844) = July 18, 2015. Cumulative for current rainfall-year, now at day +287, started on July 18, 2022 at day 2557 +0.

April showers bring forth… so a display by a gummy gooseberry (*Ribes lobbii*)adding to that by the calypso orchids is welcome. It's a rare plant in the RP ecoregion, this is only the second plant I've come across.

The comment on April 26 about the absence of slender toothwort, bittercress, (*Cardamine nuttallii*) prompted a search for this particular species, and a few were found in Canary Grass Meadow along the wooded margins of the marshy area. I remember when I first started botanizing I thought some of this species might be the red-listed *Cardamine angulata*, but I have a feeling now that I might have been wrong. Candyflowers out as they reliably are.

Oregon grape deserves a mention as being very showy this spring, especially the tall version (*Mahonia aquifolium*).

With nearly 5000 species of beetle in BC, choosing one is a gamble. All I can say is: what about Devil's Coach Horse (*Ocypus olens*) on account of its unusually large head?

May 2, 2023 (day 2845, 2557+288). VieRG cum. 869.4 mm (norm. 1014 mm). Cistern -403 mm SCB. [cal. datum: cistern -0.036 m].

There has been much talk recently of the damage that a perceived catastrophic failure of the beaver dam would cause. These are field notes so details of these discussions are in documents other than this one; but I'll add these (temporary) comments and observations here:

(i) beaver dams are very resilient. Expert opinion is that there is absolutely no danger that a mature beaver dam in a lake-like setting, like the one in Coats Marsh, will ever fail catastrophically. Because of their method of construction, beaver dams do not collapse in the way a manufactured one might;

(ii) the debris released by several breaches of the dam would quickly choke the channel and hold back floodwater. It would also reduce stress on the weir due to the reduced velocity of the water;

(iii) the concrete weir was built in 1968. It was rightly pointed out in a 2020 assessment that the weir has defects, but it is not flimsy and regularly withstands flooding seemingly without damage;

(iv) damage to downstream infrastructure in the event of an abnormally-large flood is in the opinion of the landowners likely to be minimal. The log cabin in the riparian area ~~is not intended to be for anything other than short-term residency by visiting family and friends and~~ would never be in use in winter if there were a possibility of a serious flood. Any compensation deemed due for the

damage to infrastructure by a hypothetical catastrophic failure of the dam would be very modest compared to the cost of alternatives;

(v) the syphon system installed to relieve pressure on the dam and weir in flood conditions has proved inadequate. Flood volumes are far more that the syphons can handle. Assertions to the contrary are misinformation;

(vi) maintaining the syphoning system requires periodically disturbing the wildlife, forcing ducks into open water in the presence of predators for example, and may be potentially dangerous for staff working out on the dam;

(vii) assertions that syphoning is doing no damage to the ecosystem are misinformation;

(viii) the bed of Coats Marsh Creek is sandstone bedrock so scouring by floodwater is probably not an issue. The wetland near the park boundary absorbs some floodwater before it reaches any fish habitat;

(ix) removing the dam could result in it being later re-built either by the same beaver or by another;

(x) there are no fish in Coats Marsh. This has been firmly established over the years by several observations by members of Gabriola Streamkeepers. No fish have ever been trapped there; no birds that forage primarily for fish are resident there; dragonflies, whose nymphs are fish-food, are abundant there; and no rises have ever been observed there during mayfly season;

(xi) a professional study of Coats Marsh Creek fish habitat for the purposes of defining riparian area regulations established that there was a barrier for fish from Hoggan Lake into the upper reaches of the creek beyond South Road. ~~No fish have ever been observed there.~~ Because the creek is also an intermittent creek it seemed unlikely that the upper reaches or the marsh could support a salmonoid species. Despite this, Gabriola Streamkeepers (who, as is often the case, were not consulted) have observed trout in pools upstream of South Road, but not so far up as to be crossing the poorly-defined wetland at the park boundary which constitutes a second potential barrier;

(xii) the beaver, there is only one, has survived in the marsh for over fifteen years and remains active in maintaining the dam. There are other beavers on the island so if the habitat remained suitable he would likely have a successor;

(xiii) reducing water levels to the point where the dam is permanently dry will cause the dam to start to rot;

(xiv) removing the concrete weir without replacement would be cheaper than other proposals (leaving aside the option of doing nothing) but it would remove the weirpool from the ecosystem, expose the beaver dam to drying out, and (presumably) do nothing to resolve the perceived issue of legal liability through beaver dam failure;

(xv) construction of the weir was not the initial step in creating the wetland. A wetland existed there long before a landowner blasted through rock to create an outlet channel in the mid-20th century;

(xvi) only lightly addressed in these discussions is the need to replace the wooden baffle with something more durable. Complete

failure of the baffle could result in draining the entire marsh. Replacing the baffle with a sluice gate, or replacing the flashboards with concrete might be part of the ideal solution; however, the current baffle is healthy and the need to address this issue is not urgent;

(xvii) removing the beaver dam and severely damaging the thriving ecosystem that it has created would defeat the purpose of this being held as a nature reserve;

(xviii) what is wrong with the practical solution of just leaving the weir and ecosystem alone?

May 3, 2023 (day 2846, 2557+289). VieRG cum. 869.4 mm (norm. 1016 mm).

Note from Vanessa Craig, our RDN Director:

"RDN staff went to the marsh today and found that, indeed, one of the siphons was operating. They shut it down immediately. It seems that the conditions were right this year for one of them to operate even without specifically being activated. The staff have put in an interim fix to prevent that from happening again and will be working with the consultants to determine a permanent modification."

The syphons were de-activated by RDN Staff mid-February. The continued syphoning since then was an unintended consequence of a syphon mis-function.

Photo 2.4 Lower (left) and upper (right) portions of the weir outlet slot and flashboards, viewed from the downstream channel. Note cracks in the concrete at several locations (NHC, Sep. 2022).

Interesting view of the baffle from the NHC 2023 Report. The notch is too narrow and the flashboards too high to contain floodwater.

May 5, 2023 (day 2848, 2557+291). VieRG cum. 887.4 mm (norm. 1019 mm). Cistern -389 mm SCB. [cal. datum: cistern -0.022 m].

May 10, 2023 (day 2853, 2557+296). VieRG cum. 888.4 mm (norm. 1028 mm).

Reports in the Gabriola Sounder by Rachelle Stein-Wotten:

1. May 3, 2023, 33(18), *RDN says water levels at Coats Marsh normal for this time of year*,p.1; https://simplecirc.com/view_issue/34516

2. May 10, 2023, 33(19), *RDN confirms Coats Marsh siphon system malfunction*, p.12; https://simplecirc.com/view_issue/34699

3. May 10, 2023, 33(19), *Regional parks committee in favour of decommissioning Coats Marsh weir*,p.12 https://simplecirc.com/view_issue/34699

April 26, 2023:
(a) snags offer fledgling ducks and their parent(s) protection from predators, eagles, hawks, and owls. Hooded mergansers and wood ducks nest in tree cavities at the marsh. Whether they will again this year is still to be seen;

(b) the beaver's lodge, high and dry. Not "normal" at this time of year. Water level has not been this low before syphoning since the late summer of 2015.

May 12, 2023 (day 2855, 2557+298). VieRG cum. 888.4 mm (norm. 1031 mm). Cistern -381 mm SCB. [cal. datum: cistern -0.014 m] Weir +204 mm WPB scale. [cal. datum: weir -0.443 m]

Level slightly up. Now it's a competition between precipitation (average 43 mm for May but very variable) and evapotranspiration (currently 2.1 mm/sunny day and rising; it peaks in summer at around 5 mm/day when relative humidity is lower). Based on past years' records, the level is certain to decrease throughout this summer.

Coats Marsh Creek dry at the Marsh Trail culvert.[1] Only the private property drainage outlet running modestly (<10 L/min) at the weir;[2] nothing from the pond leveller. The level of the weirpool is currently dropping at roughly 7.6 mm (0.3')/dry day.

A few ducks out on the lake, not many, but there are undoubtedly more hidden in the reeds. Canada geese (2 seen), mallards (mostly males visible), wood ducks (just one pair), pied-billed grebe (heard for the first time this year but not spotted). No hooded mergansers (unusual) or buffleheads (only hoped for in the breeding season). No or very few red-winged blackbirds.

Western azures (*Celastrina echo*,[3] spring blues) about.

[1] Coats Marsh Creek has tributaries downstream of the park (Little Creek, Stump Farm Number 1 and 2 Streams) and currently flow continues into Hoggan Lake from upstream of South Road.

[2] This is now thought to be seepage through the fractured-sandstone bedrock beneath the berm foundation that is sufficiently low in volume that it sinks back into the bedrock downstream of the weir before reaching the culvert.

[3] The identification *Celestrina ladon* in earlier reports is out-of-date.

May 15, 2023 (day 2858, 2557+301). VieRG cum. 888.4 mm (norm. 1036 mm).

No flow from Stump Farm Number 1 Stream where it leaves Canary Grass Meadow with minor ponding below Stump Farm, but Little Creek still shows some movement as it enters the Three Gates Wetland.

At the culvert on South Road the Coats Marsh Creek is flowing surprisingly strongly. A couple of mallards observed in one of the pools just beyond the upstream side of the culvert.

May 16, 2023 Cistern -381 mm SCB. [cal. datum: cistern -0.014 m]

May 18, 2023 (day 2861, 2557+304). VieRG cum. 888.4 mm (norm. 1041 mm).

Blue skies. Lack of moisture being felt early this year. Oreas angelwing, green lacewing on a Douglas-fir needle(not many bikers notice these), strawberry blossom, hairy woodpecker, and a good show of vanilla leafs (but not here).

Coats Marsh Creek flow at South Road now just a drindle.

May 21, 2023 (day 2864, 2557+307). VieRG cum. 888.5 mm (norm. 1046 mm).

Little Creek still flowing at the Three Gates Wetland. Along its watercourse:

miniature bird's-foot trefoil (*Lotus micranthus*); petite, everything less than 5 mm. A delightfully healthy-looking herb even in sandy soil, and without the fecundity of broom;

broad-leaved starflower, unusually common this year, elegant;

and, OK, vanilla leafs (and leaves);

trailing blackberry with (wild guess) some species of flower fly;

and surely that's quackgrass (it's hairy). It'd be blooming if it weren't apetalous (being common doesn't disqualify it);

and sword ferns (ditto).

May 23, 2023 (day 2866, 2557+309). VieRG cum. 888.5 mm (norm. 1049 mm). Cistern -389 mm SCB. [cal. datum: cistern -0.022 m]

Quiet. The "tide" is going out and there's a new crop of watershield (*Brasenia schreberi*).

Birds in the woods silent other than an occasional song-sparrow and a very subdued sounding red-winged blackbird.

Muffled or shut-down Harmac.

Stillness and calmness prevail. No breeze to

stir the leaves, ruffle the grass, or ripple the water.

No ducks visible on the lake, just one American robin seen exploring its new terrestrial fringe.

Naturalized English Hawthorn (*Crataegus monogyna*). Rare in the RP.

Northern tent caterpillars taking gregarity, ubiquity, and peskiness to its limits (*Malacosoma californicum* ssp. *pluviale*).

May 29, 2023 (day 2872, 2557+315). VieRG cum. 888.5 mm (norm. 1058 mm). Cistern -402 mm SCB. [cal. datum: cistern -0.035 m]

Fine day, partial cloud, but that's good for photography.

Notes on upper Coats Marsh Creek (CMC). Where does it run exactly? where is the flow through the South Road culvert (the divide between lower and upper CMC) coming from? Are there still fish in upper CMC?

Mapping

The only map of CMC I'm aware of downstream from the CM-RP boundary to Hoggan Lake based on ground observations is in Madrone (2012). However, as is pointed out in the text accompanying the map, the watercourse is in sections "poorly or extremely poorly" defined. Certainly not as well-defined as might be inferred from the map alone.

Tracking the watercourse in places is compounded by difficult access; dense vegetation, especially salal thickets; lack of anything remotely resembling a trail; stream braiding that makes it difficult, without investigation, to distinguish side-channels from minor tributaries flowing in from the north; and, as reported below, subsurface passages.

My attempt to identify the watercourse from elevation (contour) maps easily available to amateurs (Google Earth Pro) was unsuccessful because of lack of precision (±1 metre), the terrain in some stretches is essentially flat, and some flow is underground and thus independent of the surface elevation. There is some better contour data based on LidarBC in NHC (2023), but ground-based observations of CMC additional to those in Madrone (2012) are lacking.

Geology and Hydrogeology

Earlier files on the geology [4] and related hydrogeology [5] of Coats Marsh RP short-change CMC once it leaves the park boundary, but the CM ecosystem doesn't stop there.

Geologically, the CMC watercourse is shaped by the uppermost two formations (Fm.) of the Nanaimo Group, viz. the Gabriola Fm. and the underlying Spray Fm., both of which are members of the deep-water (upper) units of the Nanaimo Group. Beneath the Spray Fm. is the gravelly Geoffrey Fm.

The Gabriola Fm. is usually characterized as being sandstone, and the Spray Fm. as mudrock; however, this is a simplification as Gabriola Fm. has interbeds of silty mudrock (shale) and the Spray Fm. interbeds of sandstone. The contact between the two formations is rarely sharp.[6]

The hydrogeology is determined by a number of factors.

The vertical permeability (hydraulic conductivity) of the sandstone is relatively high because of bedding-plane-perpendicular fracturing of tectonic origin extending deep below the surface. In general, terrain with a sandstone bedrock is well drained and relatively dry; however, there are exceptions in hollows and basins where glacial meltwater once deposited fine-grained sediment rich in feldspar (glacial flour).

[4] See Coats Marsh Regional Park geology File: 691.

[5] See Coats Marsh Regional Park hydrogeology File: 668. A GSK atlas of Gabriola is in File 661.

[6] A fine exception is the contact exposed along Easthom Road on Gabriola.

Feldspars rapidly weather chemically to clay minerals, and even thin layers of clay are virtually impermeable and now support perched waterbodies (including muddy-in-winter areas) and perched aquifers.

The horizontal permeability of the sandstone varies with depth below the surface.[7]

At groundwater levels, it is only modestly permeable through joints, partings between lithofacies (types of rock), and weathered and eroded interbeds. Within a few metres of the surface however, horizontal fractures of glacial (glacigenic) origin greatly enhance the ability of water to flow just below the surface parallel to the surface. This effect occurs at several places along CMC.

The permeability of mudrock is less than that of fractured sandstone and it is less anisotropic (directional). In general, terrain with a mudrock bedrock is relatively moist.

At this low level of flow, instead of by-passing the tree, the creek is disappearing into the root system and emerging at the other side of some large woody debris (LWD).

Because of the differing weathering and erosion characteristics of sandstone and mudrock, regolith that rests on just one type of lithofacies tends to be flat with only gentle undulations. These are the areas of wetlands, poorly-defined watercourses, meanders, and reservoirs of one kind or another (surficial aquifers as it were).

The overall drop in elevation between Coats Marsh and Hoggan Lake is about forty metres. This creates scarps, bluffs, and inclines mostly confined to boundaries between the flats like a staircase where the creek water flows faster downhill in well-defined courses.

[7] See File 573 for details.

The highest point at which flowing surface water was seen was downstream of the wetlands that are near the CM-RP boundary. The water was an emerging subsurface flow shown here.

At the present water level, the flow from Little Creek is not contributing directly to surface flow in upper CMC but must be contributing to the reservoir (wetland surface or subsurface) that is the source of this water.

Biology

No fish were observed in any part of upper Coats Marsh Creek.[8]

Beyond a very short distance upstream of the South Road culvert, migration of fish further upstream is made impossible because of frequent LWD obstructions[9], reaches where the flow is subsurface, and reaches where the watercourse is undefined as it passes through seasonally-dry swamps and patches of marshy wetland.

[8] See however File 678.

[9] LWD = large woody debris sufficiently large to create a pool in a stream. There is a GSK glossary in File 676. In places, rotted-out roots of large old trees make subsurface by-pass channels for water completely obstructed at the surface.

Several red-legged frogs (*Rana aurota*) were seen in and around the many pools in the watercourse. Water striders (*Limnoporus notabilis*). Damselflies (Tule bluets? *Enallagma carunculatum*).

This was not a botanizing trip, and the notes of plants I observed are perfunctory and missing I'm sure plants that I am not familiar with and did not stop to examine. What I noted were (going from distal upland down to the water, **bold** = locally dominant or co-dominant tree/shrub/herb):

The gravel is glacial lag gravel plus a significant component of probably more recent sandstone channery.

Douglas-fir (*Pseudotsuga menziesii*), grand-fir (*Abies grandis*), **oceanspray** (*Holodiscus discolor*), **salal** (*Gaultheria shallon*), Oregon grape (*Berberis nervosa*), evergreen huckleberry (*Vaccinium ovatum*), bracken (*Pteridium aquilinum*), roses (mostly *Rosa gymnocarpa*), honeysuckle (*Lonicera ciliosa*), nettles (*Urtica dioica*);

Red cedar and stumps thereof (*Thuja plicata*), **red alder** (*Alnus rubra*) in logged-cedar areas, holly (*Ilex aquifolium*), **sword fern** (*Polystichum munitum*), salmonberry (*Rubus spectablis*), abundant red huckleberry on decaying redcedar wood (*Vaccinium parvifolium*);

Ninebark (*Physocarpus capitatus*), lady fern (*Athyrium filix-femina*), slough sedge (*Carex obnupta*), small-flowered bulrush (*Scirpus microscarpus*), skunk cabbage (*Lysichiton americanus*), and various grasses, mainly exotic species.

Ecosystem comment

The Gabriola Island Sensitive Ecosystem Mapping (SEM Airphoto 2007) shows wetlands in the NW corner of the RP extending into the adjacent private property (50235) as being map-coded "Western redcedar – Indian plum". I failed to notice any Indian-plum (*Oemleria cerasiformis*), but that's not to say they weren't there;[10] however, interpretation of aerial photos and satellite imagery without ground truthing is likely to be inaccurate and incomplete, especially when the riparian margins of small creeks are the focus of interest.

[10] Some creeks on Gabriola have abundant Indian-plum in their riparian areas, Martin Brook is an example.

May 31, 2023 (day 2874, 2557+317). VieRG cum. 889.5 mm (norm. 1061 mm).

May has been a dry month, in contrast to April when it rained a lot. Monthly precipitation 54% below average and cumulative annual to-date now 4% below average.

Water level in the weirpool very low. No outflow or drainage.

Beaver present and very active around the weir. It is now possible to walk comfortably across the weir using his dam.

No ducks seen in the weirpool; the days are gone when you might see blue-winged teals here.

The leaves of Pacific ninebark I find too similar to those of Douglas maple (*Acer glabrum* var.*douglasii*) for comfort, which may account for the on-going lack of the latter in the CM species list.

Vine maple (*Acer circinatum*) presents no such problem with its 7-lobed leaves (*photo left*). A good find but needing technical confirmation as it is now a very rare species on the Gulf Islands and Vancouver Island.

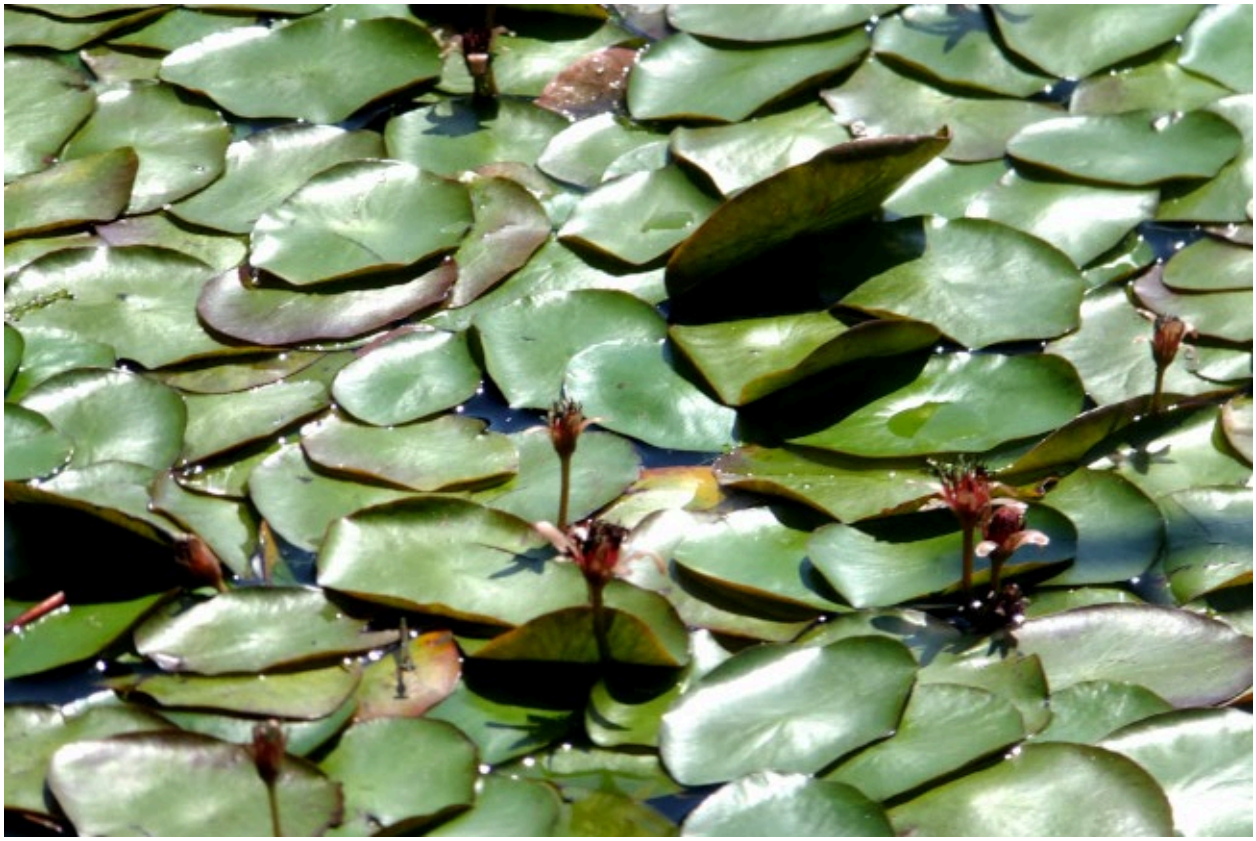
Caterpillar infestation has almost completely denuded most of the alder trees. My (deciduous) sun-hat is becoming caterpillar habitat!

June 22, 2023 (day 2896, 2557+339). VieRG cum. 909.6 mm (norm. 1093 mm). Cistern ≥ -442 mm SCB.[11] [cal. datum: cistern -0.075 m]

Relatively little activity, though it was mid-afternoon. Only one mallard hen with about eight small ducklings seen. Many dragonflies.

The dominant aquatic plant in the marsh is watershield (*Brasenia schreberi*) but there are patches of water smartweed (*Polygonum amphibium*). The two are easy to tell apart because the leaves of watershield are attached to the petioles (leaf stalks) at the centre while those of the water smartweed are more conventionally attached at one end.

[11] The concrete cistern datum point has been eroded somewhat so the precision is not what it used to be, not to mention the accuracy.



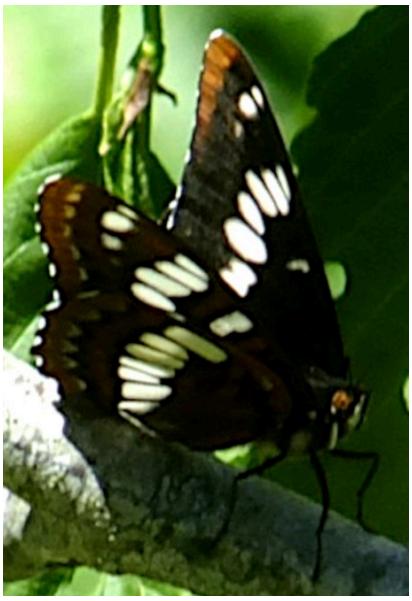
June 30, 2023 (day 2904, 2557+347). VieRG cum. 909.6 mm (norm. 1102 mm). Cistern ≥ -474 mm SCB. [cal. datum: cistern -0.107 m]

Another dry month. Monthly precipitation 51% below average and cumulative annual to-date now 7% below average.

Little Creek no longer running into the Three Gates Wetland. Musk monkey-flowers (*Erythranthe moschata*, but often still IDed as *Mimulus moschatus*)growing in the streambed along with *Angelica genuflexa* and small blue forget-me-nots (*Myosotis* sp.).

There's still movement in Coats Marsh Creek at the South Road culvert replenishing the pools where trout have been seen over the years on the upstream side.

Red-winged blackbirds have made themselves scarce this year, but Lorquin's admirals sporting their orange-red wing-tips are more numerous than usual (photo from June 2017, couldn't get a good one this year, but they were in the same spot).



July 1, 2023 (day 2905, 2557+348). VieRG cum. 909.6 mm (norm. 1104 mm). Weir ~~−471~~ −166 mm WPB scale. [cal. datum: weir -0.813 m]

Beaver seen. He'll be causing big trouble at the weir this winter. He may not be happy with the excessive drawdown this spring, but blocking off the sill as he has done will leave flood water nowhere convenient to go later on in the year.

I'm disappointed the RDN/NTBC have given no consideration to putting in an old-fashioned sluice gate. By my reckoning the 500L/s outflow capacity of the weir could be increased tenfold by lifting the baffle in the wet season.[12] More than adequate to prevent overflow of the berm, which is all that really matters.

No swallows at the lake but a variety of other species including cedar waxwings and possibly sapsuckers. A few mallards are successfully raising a family, but no other species are doing so this year.

[12] Using the "Rectangular Contracted Weir" formula on the Washington State University page "Irrigation in the Pacific Northwest". "Contracted" means the sill width is much smaller than the approach channel, which in this case is the width of the weirpool. For L=2 ft (notch width), W=2.1 ft (0.64m notch full, no overflow), Q=522 L/s. For L=2 ft., W=10.1 ft (3.1m, no flashboards), Q=5053 L/s. The berm is at +0.30 m CWB File: 673.

The Clemson leveller is a good design. The beaver has shown limited interest in attempting to block it. Its capacity is just too low for this application.

Habitat the RDN/NTBC are considering destroying.

July 8, 2023 (day 2912, 2557+355). VieRG cum. 909.6 mm (norm. 1111 mm).

[Re-checked height of berm crest with a laser level. Hazards are: berm slopes down as it nears the weir, however floodwater moves around the end of the weir and into the creek, so the slope is not of consequence if measurement is far enough along the berm to avoid it; convenient to use a point on the deck as an intermediate station, but deck is not level; spirit level used to level the laser level has limited accuracy.

I measured: berm above deck station near the SE corner (the corner that floods first) = +0.362 m; deck station below CWB at its southern end = -0.066 m; hence berm = +0.362 – 0.066 = +296 m CWB with an overall accuracy I'd guess as being no better than ±10 mm.]

Flooding being an issue, I also re-visited volumetric flow calculations, primarily for floods on March 10, 2016 and November 15, 2021, using theoretical weir flow calculations; photographic evidence of water levels where measurement not made; additional measurements of the weir and creek culvert dimensions; and developed empirical formulas. Some minor corrections detailed in the master File: 673, but nothing very significant. The maximum outlet flow at present is in the 500-600 L/s range. A value that could at least in theory be increased by over 60% by just removing the top flashboard.

I did note that assessing the flow at the Coats Marsh culvert during floods has to be done by measurement. Theoretical formulas (Francis and Kindsvater-Carter) do not work because of abrupt changes in the relationship between thalweg depth and flow velocity at flood levels, probably due to the suppression of the nappe by the rising downstream water.

Precise determination of the volumetric flow at the weir is complicated by the presence of the deck. In light of the relatively small freeboard of the berm, I think it would help if the deck was raised to a level where it does not obstruct floodwater. Overflow of the concrete weir and wooden deck can be more significant than it looks because the width of the weir is ten times that of the notch.

The weirpool is close to being completely drained.

July 12, 2023 (day 2916, 2557+359). VieRG cum. 909.6 mm (norm. 1114 mm). Cistern -540 mm SCB. [cal. datum: cistern -0.173 m]

The proportion of tansy ragwort plants being fodder for cinnabar moth larvae higher than usual this year; a good year for caterpillars.

Hardhack (*Spiraea douglasii*) used to be common in riparian areas; seems less so nowadays.[13] Yellow-faced bumble bees (*Bombus vosnesenskii*) with yellow pollen baskets on their legs showing an interest.

A few solitary mallards.

Marsh is struggling to survive, but it used to be pleasantly tranquil this time of year, now its languor is touched with anxiety.

July 17, 2023 (day 2921, 2557+364). VieRG cum. 909.6 mm (norm. 1117 mm).

Observation year rainfall 19% below long-term average. Hard to correlate with ENSO (la Niña, warm and wet?, in 2022) but not especially unusual.

THAT CONCLUDES EIGHTH YEAR OF OBSERVATIONS AT THE MARSH.

Some idle musings about sluice gates. It's wrong to imagine that what's needed is a gate capable of opening the entirety of the 10 ft. 2ft-wide notch in the weir. That would be a massively heavy and awkward lift.

Following are estimates of the equilibrium volumetric flow (litres per second) that would sustain a level of the water in the weirpool at the top of the concrete weir with no overflow (0.0 m CWB). The notch is assumed to be unobstructed. Units except for flow are imperial (ft.).

Each flashboard (stacked board that makes up the baffle) is 1.0 ft. high so although there is good reason for them to be replaced I'll assume that they remain and the sill is the top of these flashboards. Currently the sill is a little over 2 ft. down (-0.67 m CWB).

[13] But still dominant in the shoreline around Hoggan Lake in the golf-course grounds.

There are two similar equations needed for the estimations.
For water flowing over the sill or over the top of the gate, whichever is higher, we need equation 1 (fully-contracted rectangular weir with free-flowing nappe) giving Qw.

For water flowing over the sill and under the bottom of the gate, we need equation 2 (fully-contracted rectangular orifice with free-flowing nappe) giving Qo.

Equation 1 for Qw is used when the top of the gate is at or below the concrete crest of the weir, or the bottom of the gate is at or above the concrete crest of the weir.

Equation 2 for Qo is used when the bottom of the gate remains below the concrete crest of the weir.

Qw and Qo to be added to give Q when the gate is partially open.

> [I'm going to assume (rashly? but practically) that the contribution to the flow by the gate acting as a weir can be estimated ignoring the presence of the orifice, and the simultaneous contribution to the flow by the gate acting as an orifice can be estimated ignoring the presence of the gate also acting as a weir. This gate part-way-open calculation is probably of academic interest only.]

Equation 1 is fully described in File: 673 p.C4.

$$Qw = 3.247*L*H^{1.48} - 0.566*(L*H)^{1.9}/(1+2*L^{1.87})$$

where:
Qw = cubic feet per second (cfs), 1 cfs = 28.316847 L/s;
L = the width of the notch in feet; and
H = head in feet, depth (+ve) relative to CWB of the top of the gate unless the bottom of the gate is at or higher than the crest of the concrete weir (H1 in equation 2 is 0 or negative) when H becomes the depth relative to CWB of the sill.

Equation 2 is described on a CODE**COGS** website.

$$Qo = 0.667*C_d*L*(2g)^{0.5}*(H2^{1.5} - H1^{1.5})$$

where:
Qo = cubic feet per second (cfs), 1 cfs = 28.316847 L/s;
C_d = coefficient of discharge;
g = acceleration due to gravity;
H2 = the depth (+ve) relative to CWB of the top of the baffle; and
H1 = the depth (+ve) relative to CWB of the bottom of gate with the proviso Qo = 0 if H1 is at or above CWB ($H1 \leq 0$).

For these types of calculations we can, as is often the case, take $C_d = 0.61$ and $g = 32.174$ ft.s^{-2}, reducing the equation to:

$$Qo = 3.262*\xi*L*(H2^{1.5}-H1^{1.5}) \quad 1 \text{ cfs} = 28.316847 \text{ L/s}$$

where $\xi = 0.9$ is a personal "fiddle factor" valued so that the sum of the squared difference between Qw and Qo is as small as possible whenever $H1 \approx 0$ (the orifice is becoming a weir).

"gate x.x" in the tables below means a gate with a height of x.x ft. "sill -y.y" means the position (ft.) of the top of the flashboard baffle relative to CWB, its depth then being +y.y ft.

No gate	sill CWB (ft.)	Q (L/s)	mode	relative Q
	-2.0	486	weir	1.0
	-3.0	877	weir	1.8
	-4.0	1331	weir	2.7
gate 1.0	gate lift (ft.)	Q (L/s)	mode	relative Q
sill -3.0	0.0	486	weir	1.0
	1.0	571	both	1.2
	2.0	698	orifice	1.4
	≥ 3.0	877	weir	1.8
gate 2.0	gate lift (ft.)	Q (L/s)	mode	relative Q
sill -4.0	0.0	486	weir	1.0
	1.0	643	both	1.3
	2.0	860	orifice	1.8
	3.0	1164	orifice	2.4
	≥ 4.0	1331	weir	2.7

Lots of detailed considerations involved and a test needed to check

the theory by removing a flashboard or two in the wet season and measuring the flow; re-discovering what those who designed and built the weir already well-knew. Maybe out-of-the-question, but who knows?

July 19, 2023 (day 2923, 2922+1). VieRG cum. 0.0 mm (norm. 0 mm). Cistern -577 mm SCB. [cal. datum: cistern -0.210 m]

Above: View from the shore of the "lake" of the beaver dam (green strip between snags *top right*).
Below: Part of the foundation of the 20th-century radio-tower installation once occupying the site. Some islanders remember walking the meadow here and flushing snipe.

WATER QUALITY TEST: cistern; surface water temp 27°C; pH 7.5; specific conductivity 142 µS/cm; TDS 90 ppm. Nothing remarkable except the high temperature.

Air: cool breeze 23°C, but ambient in sheltered sunny spots 27°C.

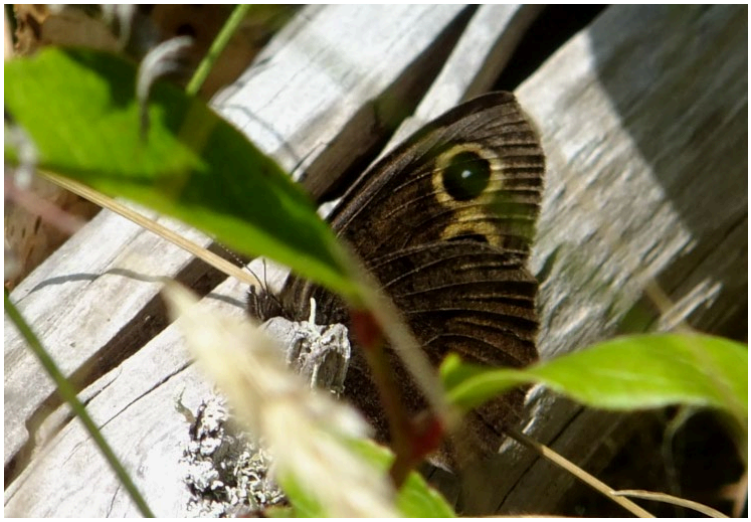
High water temperatures will be a growing concern if summer water levels are not maintained and the days get sunnier and warmer. A temperature of +24°C is about as high as lake trout can stand; don't know about other aquatic creatures.

July 20, 2023 (day 2924, 2922+2). VieRG cum. 0.0 mm (norm. 1 mm). Weir -290 mm WPB scale. [cal. datum: weir -0.937 m]

Mallards, some juveniles. Alders, dappling the sunshine with leaves once again. Wood nymphs (*Cercyonis pegala* ssp.*incana*)suddenly common, endlessly flittering, their darkness as striking as any colour.

July 30, 2023 (day 2934, 2922+12). VieRG cum. 23.6 mm (norm. 18 mm). Cistern -610 mm SCB. [cal. datum: cistern -0.243 m]

Invasives gaining footholds in the NE Arm wetland despite reed canary grass (*Phalaris arundinacea*) being dominant. Tansy ragwort (*Seneceo jacobaea*) and thistles (*Cirsium vulgare*), both popular with pollinators;[14] Japanese hedge parsley (*Torilis japonica*) and in the edge-habitat occasional daphne-laurel (*Daphne laureola*). Small stuff at the moment, but the stage is set.



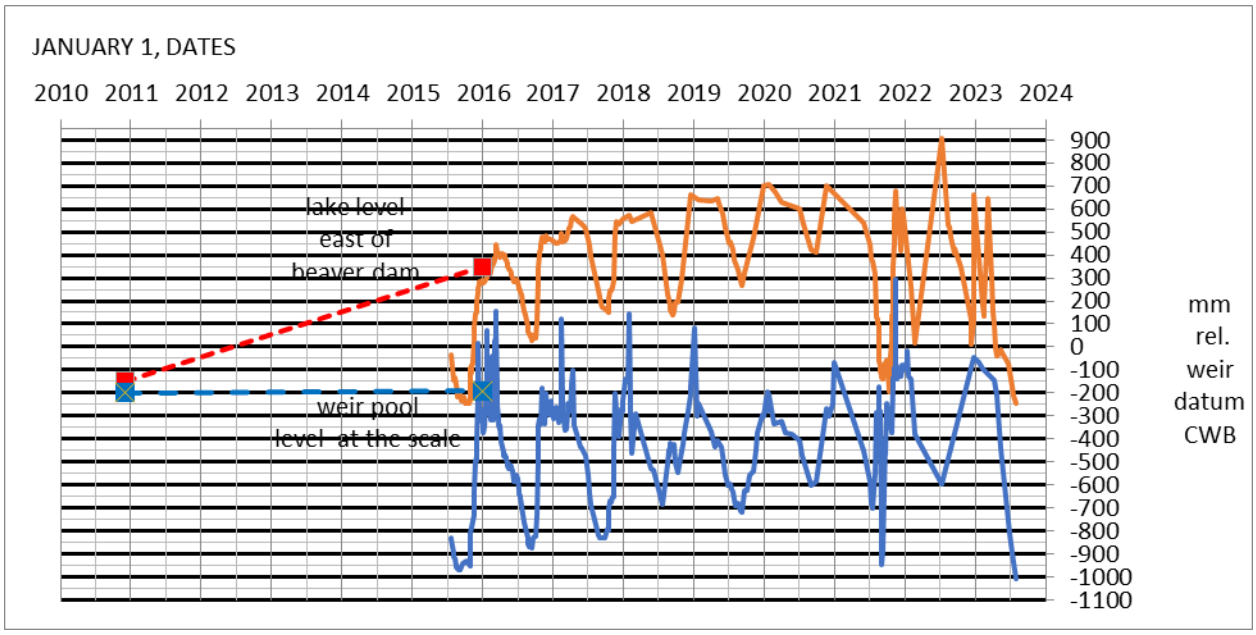
Common wood-nymphs (red-listed).

July 31, 2023 (day 2935, 2922+13). VieRG* cum. 23.6 mm (norm. 19 mm). Weir —362 mm WPB scale. [cal. datum: weir -1.009 m]

* rainfall datum in trouble again. No VieRG recording this month. Had to use Entrance x 1.092, a factor determined by comparing old Coats Marsh rain

[14] Honey containing nectar from bees that have been foraging on tansy ragwort tastes unpleasant and in quantity is likely toxic Thistle and Scotch broom honey on the other hand are prized.

gauge observations with Environment Canada's figures for the same period. There was intense variation of precipitation with location on July 24, the only day in July that it rained.



Monthly precipitation 2% below long-term average. Annual so far 7% below long-term average.

Worked in the NE Arm.[15] Observations at the weir and western burn-pile clearing. Mallards (mothers and juveniles) still around and not shy.

Record low water levels, in part due to the malfunction of the syphon system that the RDN continues to maintain is doing something useful.

Honey bees (*Apis mellifera*) in the clearing where there're thistles galore but this one seems special.

[15] An hour's work in the NE Arm on July 31 made a serious dent in the sporadic daphne-laurel and easily-seen blooming tansy ragwort, but many young rosettes of ragwort remain untouched. There's ragwort still to be cleared from the outlet and watertracks downstream of the East Path crossing (NE Arm Creek).

August 4, 2023 (day 2939, 2922+17). VieRG* cum. 23.6 mm (norm. 23 mm).

Cleared tansy ragwort from NE Arm Creek down to the lake and from the NNE spillway tributary coming down from East Path.[14] Can't be sure I got 'em all, but hope so. Mostly water, not the wind, spreading seeds.

August 13, 2023 (day 2948, 2922+26). VieRG* cum. 29.8 mm (norm. 27 mm). Weir -398 mm WPB scale. [cal. datum: weir -1.045 m]. Cistern -664 mm SCB. [cal. datum: cistern -0.297 m]

This is the best picture you'll ever get from me of a water scorpion (*Ranatra fusca*). This one leisurely swimming below the surface, looking huge but actually only an inch or two long.

WATER QUALITY TEST: cistern; temperature shaded, 15 cm down, +24°C.

Time to measure dissolved oxygen which falls with temperature rise,[16] probably not a factor that often arises in discussions about lowering summer water levels.

[16] At 24 °C, 1 bar, 100% = 8.29 mg/L requiring at least 84% saturation to keep the level above a safe 7 mg/L. At 20°C, the saturation needs to be at least 78%; and at 28°C it needs to be at least 91%.

August 19, 2023 (day 2954, 2922+32). VieRG* cum. 29.8 mm (norm. 29 mm). Cistern -708 mm SCB. [cal. datum: cistern -0.341 m]

Thinly overcast with blue smoke from distant wildfires tinting the haze, the gusty wind making my eyes water. The diffuse sunlight at noon has a slight but perceptible sunsetty reddish hue.

No wildlife beyond a few flower-flies. A raven, muttering to itself, high in the tree behind me.

Substantial swathes of the perimeter of the "lake" have now become a thick, soft muddy morass. It's a simple enough message; you need to store water in winter in order to maintain an adequate water level in summer; and this hasn't been done. At the entrance to the RP at Stanley Place, visitors are now confronted with, not water, but mire, any water being far off toward the centre of the marsh.

The yellow patches are mats of bladderworts, *Utricularia macrorhiza* .

WATER QUALITY TEST: cistern; temperature 15 cm down, +18.5°C; pH 7.5; specific conductivity 152 µS/cm; TDS 76 ppm; air pressure ≈100 kPa,[17] dissolved oxygen (DO) measurement attempted but no reliable result.[18]

[17] My own instrument (calibrated HANNA meter H198129) used for pH, conductivity, TDS, and temperature.

[18] The HACH DO Test Kit #1 (modified Winkler GSK25104) that was used had all components present but all four reagents (GSK15027-30) were at least five years beyond their expiry date. The two low-range DO measurements (0.2-4 mg/L) were not consistent with the two high-range measurements (1-20 mg/L). High 4.5 mg/L and 3 mg/L; low both ≥10 mg/L (50 drops). Step 9 of the high-range procedure did not dissolve all of the brown precipitate as I think it should have. GSK has a modern optical DO sensor, (GSK15210), but at the moment I don't know where it is or if it's useable. Help!

August 24, 2023 (day 2959, 2922+37). VieRG* cum. 29.8 mm (norm. 31 mm). RDN outer gauge 852 mm. [cal. datum: RDN outer gauge -0.098 m]

There appears to be a disconnect between the water level measured at the cistern and at the beaver dam. Possibly the level is so low now that the water level in the cistern no longer reflects the level out in the open water, or the depth of the scale at the dam has been altered. Also possible, but unlikely, is that pools of water are becoming disconnected, some being perched relative to others. Also possible, though I hope unlikely, is that numerous earlier calibrations, although consistent, were systematically wrong.

WATER QUALITY TEST: beaver dam upstream side; temperature surface 18.9°C. At depth temperature 16.6°C; specific conductivity 99 µS/cm; air pressure ≈100 kPa, dissolved oxygen (DO) measurement attempted with only partial success.[19]

Indications are that DO is at a level that's low enough (≈4 mg/L) to severely stress most aquatic organisms. The usual major causes of low DO concentrations are high diurnal temperatures, and unusually high oxygen consumption by aerobic decomposers of dead aquatic plants.

Nodding beggarticks (*Bidens cernua*) out on the beaver dam, the perfect habitat for this species.

August 26, 2023 (day 2961, 2922+39). VieRG* cum. 30.2 mm (norm. 32 mm). Cistern -726 mm SCB. [cal. datum: cistern -0.359 m]

[19] Using the RDN's YSI Pro-quatro galvanic DO sensor after calibration. This DO sensor is inconvenient for wetland measurements because it consumes oxygen and requires flowing water or constant stirring. Care must also be taken to eliminate all air bubbles in the sensor's protective shield before taking a reading. I was unable to get a stable reading at the surface. At depth (about a metre) I saw 43.1% saturation interpreted by the meter as 4.20 mg/L. This is commensurate with the Winkler test result, fn.18.

August 27, 2023 (day 2962, 2922+40). VieRG* cum. 30.2 mm (norm. 33 mm). Cistern -732 mm SCB. [cal. datum: cistern -0.365 m]. RDN outer gauge 845 mm. [cal. datum: RDN outer gauge** -0.105 m]

A simple surveying method involving sticks and a spirit level showed the water level in the cistern is not more than 10 mm below the open-water level. Not nearly enough to account for the RDN outer gauge anomalous readings, and close enough to suggest that the levels at the cistern are in fact the same.

** Photographic evidence confirmed a large change in the depth of the RDN outer gauge, which is now reading around 260 mm higher than the cistern level. The scale has to be re-calibrated before providing an independent measure of water level.

The depth of the cistern measured as -1970 mm SCB [cal. datum: cistern floor -1.603 m, 95.4 AMSL]. WATER QUALITY TEST: cistern; temperature, 15 cm down, +27°C.

The weirpool almost completely de-watered but for Bill Coats's drainage channel that likely goes down to bedrock. Several mallards about, the usual residents in this pre-migration time-of-year, always relatively few in number.

◊ previous file next file