A Proposed Strategy for Water Level Management – Coats Marsh, Gabriola Island, BC

for:

Chris van Ossenbruggen – Regional Parks and Area B Community Parks Operations Coordinator, Recreation and Parks

Regional District of Nanaimo
1490 Springhill Road
Parksville, BC
V9P 2T2

by:

Trystan Willmott, B.Sc., A.Sc.T.
Eric Finney, B.A., B.A.Sc., P.Eng.

MADRONE ENVIRONMENTAL SERVICES LTD.
1081 Canada Avenue, Duncan, BC V9L 1V2

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MADRONE ENVIRONMENTAL SERVICES LTD.
1081 CANADA AVE. • DUNCAN • BC • V9L 1V2
TEL 250.746.5545 • FAX 250.746.5850 • WWW.MADRONE.CA

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1.0 BACKGROUND AND OBJECTIVES

This report presents a strategy for the long-term management of water levels at Coats Marsh, located in a Regional Park owned by the Regional District of Nanaimo (RDN) on Gabriola Island. Coats Marsh (herein referred to as "the wetland") has been subject to fluctuating water levels over the years as a natural response to activity of beavers (*Castor canadensis*). Such activity has on occasion rendered the concrete flow control weir located at the wetland's outlet ineffective at controlling water levels. A previous water control strategy involved placement of a Clemson Pond Leveler, to try to counteract beaver activity at the weir itself.

A functioning beaver dam, which may have been under preliminary construction as early as 2013, is elevating water levels above the outlet weir by a height of approximately 1.1 m (Doe, 2020). Recent surveys by Madrone (July 23rd, 2021) confirmed this difference in water elevation.

The subject beaver dam, located approximately 60 m east of the outlet weir, is currently the main controlling factor for water level in most of the wetland. The weir and existing leveler are still expected to control water levels in an isolated embayment that occurs west ("downstream") of the beaver dam. Water is also known to overtop the dam during high flows in the wintertime and enter the embayment, thus contributing to water levels in this area (Doe 2020).

Concerns related to flooding of neighbouring private property resulting from beaver activity at the weir outlet prompted construction of a flood-control berm in the summer of 2013, close to the wetland's western extent. This feature is essentially only controlling flood potential from the embayment based on isolation from the main wetland created by the beaver dam, except during high flows when the section of wetland behind the dam is at capacity and overflowing.

Because of the volume of water impounded behind the beaver dam (estimated to be approximately 54,000 m^3), RDN Park operation staff have expressed concerns about flood threats to private property and downstream road infrastructure should the dam fail catastrophically. There are also concerns related to the interaction between a sudden release of water and the concrete outlet weir, which may become damaged or fail completely in such an event. While the beaver dam has been in existence for several years, has survived numerous winters with high water level events, and is apparently stable, the RDN would like to explore proactive measures to help moderate potential risk.

Madrone proposes a potential strategy to allow for the water level in the wetland to remain at or close to the outlet weir elevation by placing a siphon system over the dam, with the siphon's inlet located at approximately the same elevation as the weir. It is expected that such a strategy would still result in fluctuations in water levels in the wetland, especially during high rainfall events. The intention, however, would be to allow water to drain over the beaver dam and thus prevent the dam from impounding water at a permanently raised elevation.

The objective is to allow the weir and existing leveler to be the main water level control features, especially over the winter months, as was the case before the main beaver dam was constructed. Installation of a siphon would allow for control of water levels, which in turn could allow for increased water storage while the beaver dam is still in good condition, while allowing for a reduction in storage capacity as and when the beaver dam deteriorates. The siphon management strategy represents a proactive management option that can be put into place before any potential problems arise.

The siphons would be sized to minimize potential downstream erosion. Our initial design criterion is to limit the peak siphon flow to less than both the 2-year return period event and the peak winter flow on record. The siphons will not be sized to accommodate a significant storm event. Rather, the purpose of the siphon will be to slowly reduce the impounded water level during zero or low rainfall periods to reduce hydrostatic pressure on the dam and improve its ability to weather significant storms. The siphons will be installed at such elevations to allow for the marsh to be drawn down to the same level as the weir baffle, which has historically been the level control of the marsh.

We have already tested a strategy using temporary siphons that involves a slow release of water over the summer months. This has lowered the wetland level behind the beaver dam to an elevation that would practically permit placement of the permanent siphon and allow it to be in operation before natural increases in water influx over the autumn and winter months.

We aim to conduct installation of the permanent siphon, which includes prior wetland draw down, during an appropriate least-risk window to avoid potential impacts to sensitive ecological values. Our proposed methods of installation are unobtrusive and would avoid machine use to further reduce potential for negative impacts.

We understand ecological benefits to increased wetland capacity through natural beaver activity and present potential negative implications related to draining water over the dam. For example, should the beaver dam storage capacity be removed, there would be more reliance on the existing aging outlet weir in maintaining wetland characteristics. Installing a controllable siphon, however, introduces the potential to maximize usage of existing wetland storage while the beaver dam is still functioning and stable.

2.0 FIELD ASSESSMENT

In order to gain an understanding of current characteristics of the wetland and help devise a strategy for water level management, a site visit was conducted by a Professional Engineer (Eric Finney, P.Eng.) on May 25th, 2021, and by a Qualified Environmental Professional (Trystan Willmott, B.Sc., A.Sc.T.) on July 22nd, 2020. A preliminary siphon test to determine feasibility and time required to draw down the wetland to create conducive working conditions was carried out by Mr. Finney and Mr. Willmott, accompanied by Mr. Chris van Ossenbruggen (RDN), on July 23rd, 2021. A survey was also completed to determine specific elevations to help inform design of the water management strategy. A second siphon wetland draw down operation was initiated on August 4th, 2021, with the objective being to slowly draw down the wetland to levels that would be conducive to installation of the permanent siphon.

Photographs were taken during each site assessment and are shown in Appendix A. Mr. Willmott was involved with previous assessments related to placement and monitoring of the flood control berm between 2011 and 2013 and is familiar with site characteristics. Descriptions herein of Coats Marsh Stream and much of the wetland ecology are based on previous studies completed by Madrone, which include information from assessments completed by others.

3.0 REGULATORY CONSIDERATIONS

Correspondence with agencies responsible for regulating work of this nature has confirmed that a project submission and subsequent permit acquisition are not required through Section 11 of the provincial Water Sustainability Act (i.e., for "Works in and About a Stream"). Based on previous advice from the Section Head of the West Coast Region of the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), and recent correspondence with a Habitat Officer from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD), Coats Marsh does not qualify as a "stream" under the Water Sustainability Act (including the outlet drainage). As the work will essentially occur in isolation of potential fish habitat, and risks to any connected potential fish habitat are extremely low, a project review is not required to be forwarded to the federal Department of Fisheries and Oceans Canada.

By conducting the work during an applicable least-risk window, we do not anticipate negatively impacting upon wildlife species that are known to use the wetland. The work avoids the breeding bird period of both migratory and resident birds that could potentially use affected wetland margins. In addition, drawing down the wetland and placing the siphon in the proposed window avoids potential impacts to native amphibians. There would be no direct impacts to beavers or the beaver dam, as the siphon would be constructed over the dam. As such, there would be no expected implications related to the provincial Wildlife Act or federal Migratory Birds Convention Act.

4.0 GENERAL SITE DESCRIPTION

4.1 Location

The site is located in Coats Marsh Regional Park, Gabriola Island. The coordinates at the outlet weir are approximately 45.1525 N, -123.8156 E (Figure 1).

4.2 Wetland Morphology

Local knowledge indicates that the wetland was historically used as a farm field by the Coats family. According to Doe (quoted in Moul and Micksch 2010), local geology appears to support historical occurrence of a wetland over a very long period of time before the area was drained for farming purposes.

The wetland is at approximately 100 m elevation. It occupies an elongated ovate depression approximately 425 m long in the east-west direction and a maximum width of approximately 200 m in the north-south direction. Aerial imagery indicates a wetland area behind the beaver dam of approximately 55, 000 m^2, compared to an approximate total pre-dam wetland area of 41,670 m^2 in 2012, which includes the isolated embayment that now occurs west of the dam (Figure 2).

The wetland that is the focus of this assessment is generally known as a "marsh". In reality, the ecosystem consists of a complex of wetland types, with the following generalized sequence: shallow water (aquatic), where permanent inundation occurs (this wetland type is currently dominant). This central area of the wetland transitions into a marsh, where seasonal drying and emergent vegetation occurs; beyond this zone, forested swamp is present.

Since the beaver dam was constructed, there has been a transition towards a deeper aquatic component east of the dam and associated extension of seasonally flooded marsh and forested swamp beyond. Increases in wetland area have been evident for at least 10 years, related to previous beaver activity around the vicinity of the outlet weir and current beaver dam. This is evidenced by occurrence of dead or dying coniferous trees (mainly Douglas-fir – *Pseudotsuga menziesii*) around the wetland margins that have become inundated.

The marshy wetland margins are generally vegetated with a dense coverage of sedges (*Carex* sp.) and interspersed cattail (*Typha latifolia*), which transitions into patches of dense hardhack (*Spiraea douglasii*). Reed canary grass (*Phalaris arundinacea*), an introduced species, is also common around the margins of the wetland. Yellow pond lily (*Nuphar variegata*) and, more commonly, ribbon-leaf pondweed (*Potamogeton epihydrus*), occur in the aquatic wetland segment. A mature forested ecosystem surrounds much of the wetland, consisting mainly of Douglas-fir and western redcedar (*Thuja plicata*). Red alder (*Alnus rubra*) also occurs along the wetland edges.

The beaver dam extends approximately 45 m across the wetland and takes advantage of a natural constriction close to the wetland's western (outlet) end. The dam effectively isolates an embayment for most of the year that extends between the outlet weir and dam. The main spatial area of the wetland, therefore, extends east of the dam (Figure 2).

PROJECT:	LOCATION:	CLIENT:	DOSSIER:
Coats Marsh Water Level Management Plan	Gabriola Island, BC	Regional District of Nanaimo	20.0203

ASSESSED BY:	DATE OF FIELD VISIT:	MAP DATE:	DRAWN BY:
Eric Finney, P.Eng. & Trystan Willmott, B.Sc., A.Sc.T.	July 22 2020 & May 25 2021	August 03, 2021	Jessi Yellowlees

Figure 1. Overview

Park
Stream
Lake
Marsh/Wetland

All feature positions as shown are approximate

0 200 400 m

1:10,000

MADRONE environmental services ltd	PROJECT: Coats Marsh Water Level Management Plan	LOCATION: Gabriola Island, BC	CLIENT: Regional District of Nanaimo	DOSSIER: 20.0203
	ASSESSED BY: Eric Finney, P.Eng. & Trystan Willmott, B.Sc., A.Sc.T.	DATE OF FIELD VISIT: July 22 2020 & May 25 2021	MAP DATE: June 29, 2021	DRAWN BY: Jessi Yellowlees

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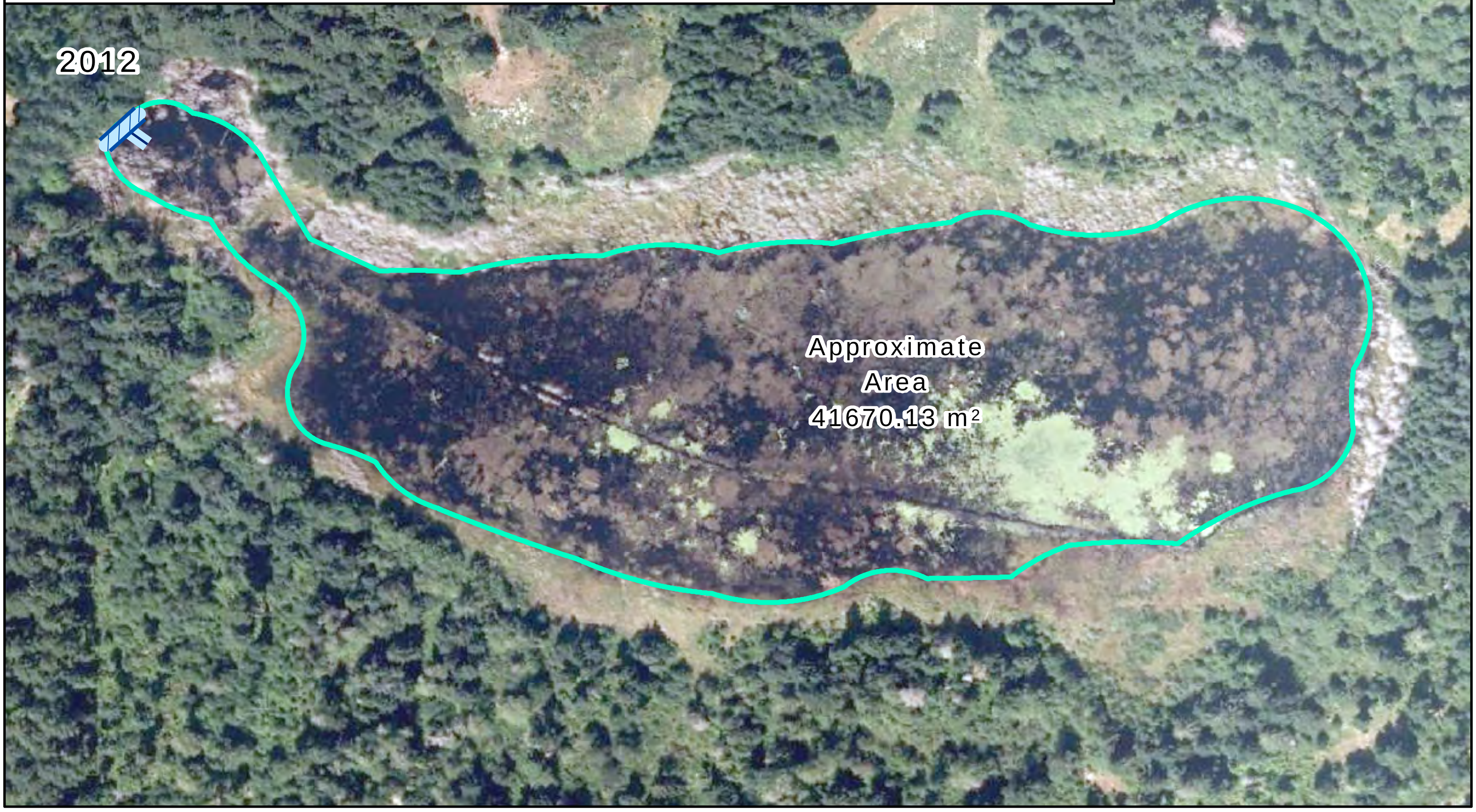
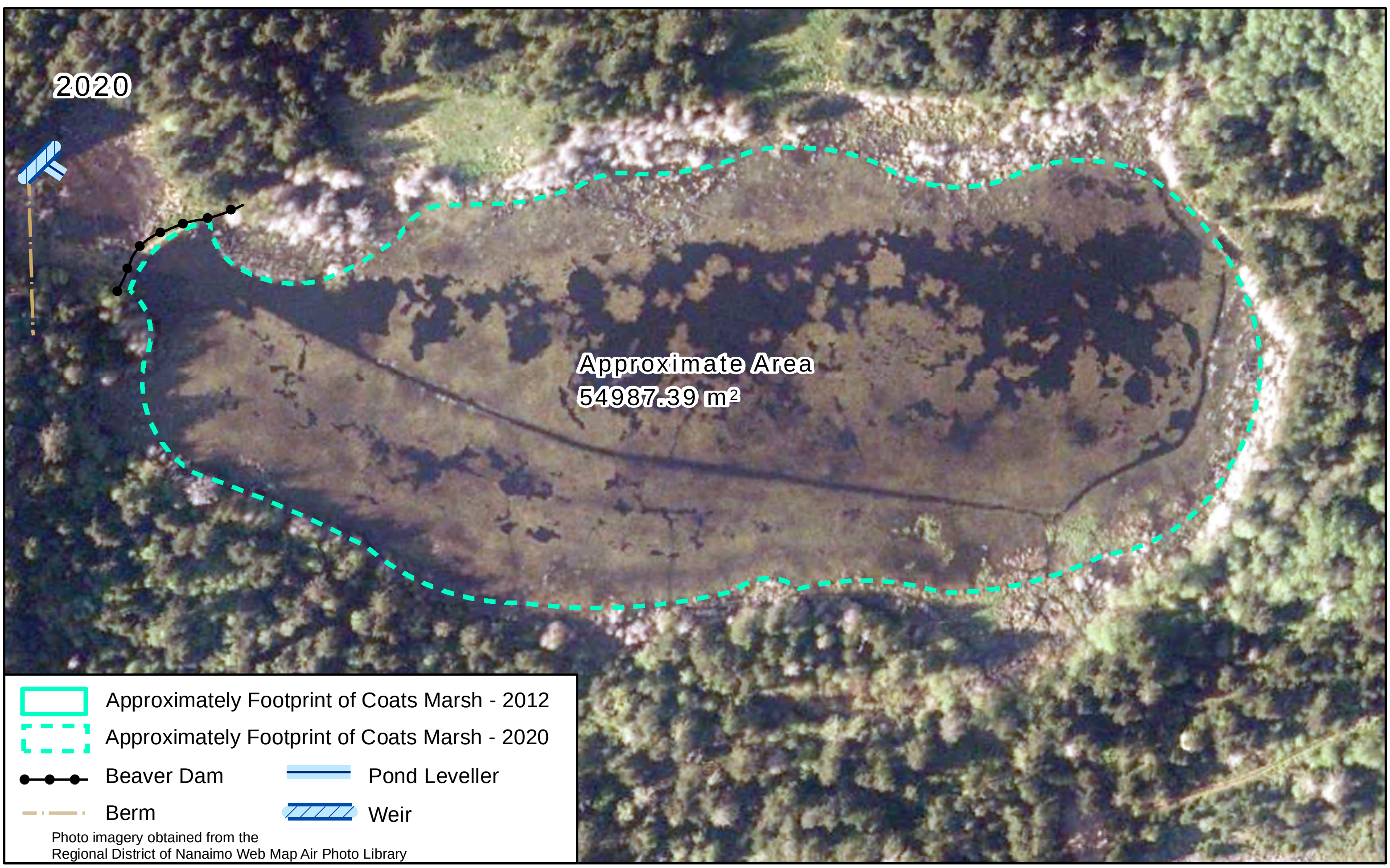
Figure 2. Coats Marsh Changes due to Beaver Activity





4.3 Coats Marsh Outlet

The outlet weir is constructed of concrete and is approximately 0.6 m thick, 6 m wide, and 2.7 m high (on the downstream side). It has a baffle about 0.6 m wide located approximately 0.6 m below the crest. The outfall of the 200 mm diameter Clemson Pond Leveler is located over the baffle.

Prior to construction of the existing beaver dam, the weir and leveler dictated and maintained wetland level over most of the year. Activity of beavers at the outlet have altered storage capacity, which necessitated the previous installation of the leveler that is currently in existence and construction of the flood control berm. The existing leveler allows flow of water through any accumulated debris at the outlet weir, generally maintaining water levels in the isolated embayment east of the beaver dam at or close to the outlet weir elevation. However, during periods of high discharge in wintertime, when inflow is greater than the hydraulic capacity of the leveler, water levels would be expected to rise above the concrete weir. In summertime, levels naturally drop in the embayment.

Previous assessments in 2012 by Madrone revealed seepage at the weir abutments and through what appeared to be cold joints (where a concrete pour had hardened before the subsequent pour was placed). This was previously described by Madrone (2012) as a structural defect in the weir, but the weir was noted as being in fair condition in 2012. Madrone further noted in 2012 that the cold joints could be a serious defect if there was high shear stress on that joint. There was no significant risk of failure based on conditions in 2012, but it should be noted that no structural assessment of the weir has been conducted by Madrone based on current conditions. Seepage at the cold joints was confirmed during a site visit on July 23rd, 2021.

As noted in Doe (2019), it is thought that the wetland is not fed by groundwater but instead relies upon storage offered by either the outlet weir or, at elevations above the weir, by beaver activity. Observations by Doe (2019) further indicated that the wooden weir baffle was leaking, with concerns that should the baffle fail, the wetland would be drained. This would, presumably, only be a factor should storage capacity afforded by the current beaver dam be eliminated. This concern is discussed in further detail in following sections of this report.

From the weir, water from Coats Marsh flows seasonally through Coats Marsh Stream into Hoggan Lake. Where it enters Hoggan Lake, the outlet stream is a well-defined, historically ditched system. The sidewalls of the ditch are steep, with evidence of erosion from high, concentrated flows. The substrate is comprised mainly of organic material, although short sections of alluvial deposits also occur. Approximately 50 m from the lake, a bedrock step represents a barrier to the potential upstream movement of fish from Hoggan Lake. Based on length and gradient of the step, there is no reasonable potential for any fish originating from the lake to pass upstream of this point. The step consists of a drop of 50% over a distance of more than 2 m. Immediately downstream of South Road, the stream exhibits more of a natural channel, with meanders and deposits of sand and gravel occurring.

The stream passes underneath South Road via a culvert and continues as a low gradient (2%) meandering stream. At the Coats Marsh Regional Park boundary, the watercourse becomes extremely poorly defined for a distance of approximately 70 m, with minimal seepage over an organic substrate. In this area, connectivity by surface flow would only occur during very high flows. Beyond the park boundary, the stream continues as a well-defined, high sided channel constructed through bedrock to Coats Marsh.

During the July 23rd, 2021, site visit, segments of Coats Marsh Stream were flowing (albeit minimally). Flow in the stream appeared to exceed any input from water seeping through the weir cold joints, thereby suggesting groundwater input, based on extreme drought conditions over the spring and summer of 2021 (see Figure 3). Discolouration of the water was noted in the outlet stream immediately below the weir, appearing to originate from iron staining in surrounding bedrock. However, baseline turbidity was measured at 5.06 NTU on August 4th, 2021, at this location. Once the siphons were flowing and water was observed discharging through the weir, a second measurement was conducted with a measured turbidity of 5.53 NTU.

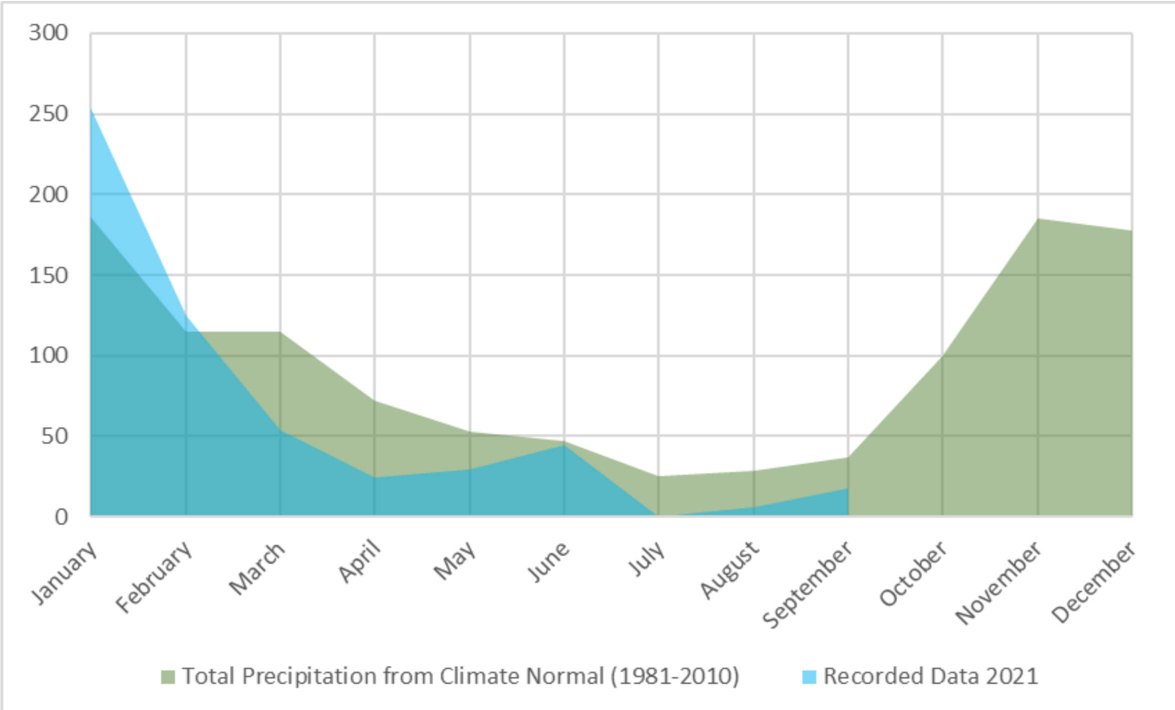


Figure 3. Comparison of recorded precipitation data and climate normal data at Nanaimo City Yard Environment Canada Weather Station (Environment Canada, 2021).

5.0 WETLAND ECOLOGICAL VALUES

5.1 Sensitive Ecosystems

The original Sensitive Ecosystem Inventory (SEI), which was completed in 1998, identifies the Coats Marsh ecosystem as a "Seasonally Flooded Agricultural Field" (SEI polygon number T1225A). More detailed inventories, as identified in McPhee et al (2000), identified the ecosystem as consisting of a mix of cattail marsh and shallow open water wetland (updated SEI polygon number 50287). The forest surrounding most of the wetland is listed as a forested swamp (SEI polygon number 50295), as described in Mcphee et al (2000).

5.2 Wildlife Suitability

Numerous studies have described and accounted for habitat benefits provided by the wetland ecosystem. For example, Doe (2019) has confirmed occurrence of at least 16 species of waterfowl, geese, swans and wading birds: buffleheads (*Bucephala albeola*), ring-necked ducks (*Aythya collaris*), American widgeons (*Mareca americana*) northern shovelers (*Spatula clypeata*), trumpeter swans (*Cygnus buccinator*), Canada geese (*Branta canadensis*), mallards (*Anas platyrhynchos*), American coots (*Fulica americana*), wood ducks (*Aix sponsa*), hooded mergansers (*Lophodytes cucullatus*), pied-billed grebes (*Podilymbus podiceps*), gadwalls (*Mareca strepera*), blue-winged teals (*Anas discors*), green-winged teals (*Anas carolinensis*), ruddy ducks (*Oxyura jamaicensis*) and yellowlegs (*Tringa melanoleuca*).

The wetland represents an important habitat niche for a variety of wildlife species that also supports a unique assemblage of hydrophytic plants. The interface between the wetland and the forested fringe creates functional edge habitat, which is a significant habitat feature. Numerous emergent Douglas-fir trees in the forested fringe provide both nesting and perching habitat for large raptors, such as Bald Eagles (*Haliaeetus leucocephalus*). Raptors will perch around the edges of wetland habitats while surveying the open wetland for prey.

The wetland/forest interface will provide roosting opportunities for bats close to the insect-rich foraging area represented by the wetland. Potential nesting habitat also exists for cavity-nesting owls (e.g., Western Screech - *Megascops kennicottii* and Northern Pygmy – *Glaucidium gnoma swarthi* - both provincially blue-listed species) in the forested border and in the fringe of snags created from expansion of the wetland into drier forested areas. Foraging potential for these owl species also exists over the wetland and in and around the forested interface. Snags around the wetland edge will also provide nesting habitat for a range of bird species, including cavity nesting waterfowl such as wood ducks and mergansers. Numerous insectivorous birds have been observed by Madrone during field assessments, including Barn Swallows (*Hirundo rustica* - provincially blue-listed) indicating the importance of the habitat as a foraging area for birds. Olive-sided Flycatchers (*Contopus cooperi* - provincially blue-listed) have also been confirmed by Madrone in the forested fringe surrounding the wetland. Suitable foraging habitat exists throughout the wetland for the Great Blue Heron (*Ardeas Herodias fannini* - provincially blue-listed).

The wetland provides confirmed habitat for Northern Red-Legged Frogs (*Rana aurora*) – a provincially blue-listed species. The wetland provides breeding habitat for this species and other native amphibians, with numerous egg-mass attachment media in the form of emergent vegetation and woody debris throughout. The surrounding forest provides forage/security habitat for dispersing native amphibians. At least 20 Northern Red-legged Frogs were observed in the cool, damp confines of the entrenched outlet stream immediately below the weir during the July 23rd, 2021, site assessment. Pacific chorus frogs (*Pseuadacris regilla*) also occur in the wetland. Other native amphibians are likely to exist in the wetland including (but not limited to) Rough skinned Newts (*Taricha granulosa*) and Northwestern Salamanders (*Ambystoma gracile*).

5.3 Fish Habitat Potential

As described, Coats Marsh is drained via a main outlet stream that exits the marsh at the concrete weir and flows northwest into Hoggan Lake (watershed code 925-380000-26400). Fish stocking records for Hoggan Lake indicate that it was stocked with coastal cutthroat trout (*Oncorhynchus clarkii clarkii*) in 1924 and 1927 (Habitat Wizard 2021). Both coastal cutthroat trout and rainbow trout (*Oncorhynchus mykiss*) were observed in the lake in 1972 (Habitat Wizard 2021). The rainbow trout, if correctly identified, and not inadvertently stocked with the coastal cutthroat trout, would have been part of a naturally occurring population. Observations of coastal cutthroat trout in 1972 indicates that either the fish that were stocked established a self-sustaining population, or that the lake has always contained a natural population of coastal cutthroat trout.

Fish cannot gain access to the Coats Marsh outflow stream from Hoggan Lake, even if the lake were still to contain fish, beyond the previously described barrier located downstream of South Road. Furthermore, it is unlikely that Coats Marsh supports a natural population of salmonid fish, due to past uses, most notably through complete drainage of standing water for agricultural reasons. Historical drainage of the marsh would have led to the demise of any existing resident population of fish. A lack of fish presence increases value of the wetland for wildlife (especially amphibians) because it removes predation by fish on all phases of amphibian life stages and eliminates competition for food resources.

6.0 PROPOSED METHODOLOGY FOR INSTALLATION OF A WATER LEVEL CONTROL DEVICE

6.1 Background Considerations

Beavers generally move into wetland areas and alter the ecosystem to suit their life requisites through construction of dams, which back up water and increase cover and depth of standing water. If food sources become depleted, beavers can move into new habitat and, as a result, the dam could fall into a state of disrepair. At such point, a natural wetland could drain and infill naturally, and early successional-stage deciduous shrub vegetation would become established. Following reestablishment of an adequate food supply, the cycle could naturally repeat again, with the potential for beavers to move back in, create a dam and flood the area.

It would be expected that draining the wetland to a level more consistent with the outlet weir through placement of a control device would create conditions conducive to providing forage for beavers. This is because deciduous vegetation (potential beaver forage material) would encroach into areas that are currently inundated. It might be expected, therefore, that beavers would continue to be active, potentially building an additional feature in a different location that is not controlled.

In the case of Coats Marsh, the outlet weir was intended to be a more permanent, manageable control structure in comparison to the natural, dynamic cycle of beaver dams. The existing beaver dam is presently preventing outflow from the majority of the wetland that is impounded by the dam throughout most of the year, resulting in higher water levels in the wetland than were previously experienced. From an ecological perspective, this increase in storage capacity of the wetland is beneficial, as it provides a natural mechanism for maintaining wetland characteristics and ecological diversity. With a changing climatic regime and readily apparent increase in frequency and severity of summer drought periods, beaver activity represents a natural mitigative measure by increasing availability of water. The RDN and other stakeholders need to consider potential risk factors, however, should the dam fail and cause a sudden release of water.

Based on potential implications of weir stability and concerns noted by Doe (2019) related to baffle leakage, it may be prudent to ensure long-term integrity of the weir outlet structure. In its current state, the beaver dam may be acting as an additional “safeguard” storage mechanism should the weir fail. On the other hand, however, there is potential for damage to the weir from any catastrophic beaver dam failure, which would also have impacts to wetland integrity. These potential concerns and interactions should be considered by the RDN and other stakeholders as part of long-term water level management decisions. Placement of a controllable siphon, however, provides long-term management options that allows the beaver dam to remain as an additional potential storage structure. The siphon would decrease risk should the dam deteriorate, through provision of a controllable release mechanism. This strategy also allows for storage of a lesser amount of water during high flow periods, thereby reducing risk of dam failure, while also creating an option for storage of more water while the dam is still structurally sound.

It is unknown what affects alterations in storage capacity resulting from placement of a siphon would have on beaver activity. If the beaver abandons the dam and it begins to break down due to lack of maintenance, it would be more likely to fail. Presence of the siphon, would, however, represent a point of relief allowing movement of water and reducing potential for catastrophic failure.

6.2 Initial Siphoning Test and Wetland Draw Down

To allow suitable working conditions to install the siphon, it is important to lower the water level upstream of the beaver dam. As part of our July 23rd, 2021, site visit, we proved that siphoning, which relies on the relative difference in water elevations to drive water flow over the beaver dam, is effective in this regard. Siphoning avoids the need for pumps and is a low maintenance strategy. Our initial siphon test also shows that this method represents a reasonable approach to long-term water management at Coats Marsh.

Based on our initial siphon test, we were able to lower the water level above the beaver dam by approximately 1 cm over a period of 2.5 hours. This change in water level was measured using a temporary level gauge installed on the morning of July 23rd prior to siphoning. This siphon test involved installation of four flexible 100 mm diameter pipes that resulted in an approximate combined flow of 30 litres per second. We observed a notable change in water height in the isolated embayment after the siphon test and water was trickling through debris piled close to the concrete weir and entering the outlet stream.

On August 4th, 2021, the same siphon strategy was implemented with the objective being to slowly draw down the wetland above the beaver dam to allow safe and suitable conditions for installation of a permanent siphoning system. On both siphoning occasions, pipe outlets were allowed to dissipate over hydrophytic vegetation located at the beaver dam's base and there was no sediment mobilization or transportation during siphoning. To ensure flow rates were not excessive and to reduce potential for movement of naturally occurring sediment in the outflow stream, the siphoning system was again limited to four 100 mm diameter pipes.

As we knew the embayment level below the dam would be raised to a height that would initiate flow through the concrete weir and Clemson Pond Leveler, we did expect some sediment mobilization in Coats Marsh outlet stream during the draw down period. However, based on turbidity measurements before and after flow initiation in the stream on August 4th, 2021, and visual observations along the length of the outlet stream, we concluded that turbidity that could affect downstream areas (e.g., Hoggan Lake) was not a concern. We also confirmed that flow from 4 siphons was not excessive, with only moderate flows occurring in Coats Marsh outlet stream.

Unfortunately, all four siphons stopped running some time over the weekend of August 7th – 8th and were reprimed on August 18th, 2021. Prior to failure, after installation on August 4th, the wetland was drawn down by 16 cm.

To assess the scale of expected siphon flow during drawdown, we compared the approximate field-measured siphon discharge to estimated and measured flow rates. Using the methods outlined in the BC Supplement to TAC Geometric Design Guidelines (2019), we performed a hydrological analysis to estimate the peak flow rate for the 2-year return period rainfall event. The 2-year return period was selected as this roughly corresponds to the typical 'bank-full' event that would occur in any given year. Although the typical 'bank-full' event is often taken as the 1.5-year return period event, only the 2-year return period rainfall intensity value was available from the associated Intensity Duration Frequency Curve. The results are summarized in Table 1.

Table 1. Hydrological Parameters and Results

Total Catchment Area	133 ha
Peak Rainfall Intensity	7 mm/hr
Time of Concentration	2.5 hrs
Runoff Coefficient	0.50
Peak 2-year discharge	1.29 m^3/s

We also reviewed available flow data of discharge from Coats Marsh weir taken by the Gabriola Streamkeepers (Doe 2020b). Two winter seasons were tracked (2015-2016 and 2016-2017) with average flow measurements estimated from observed and estimated inflows and outflows to the marsh. Table 2 summarizes the data reviewed.

Table 2. Summarized Flow Data for the Coats Marsh Outlet

	2015-2016	2016-2017
Number of measurements	42	31
Peak flow estimated	193.9 L/s	370.9 L/s
Average flow	45.3 L/s	97.1 L/s

With a maximum theoretical flow rate of approximately 30 L/s using four siphons, this equates to less than 3% of the 2-year return period flow and less than the calculated average flow, or peak estimated winter flows from either 2015-2016 or 2016-2017 winter season.

We note that the average flow rates include some entries with a flow of 0 L/s and are not provided consistently with missing days. The average value is not necessarily the average flow rate that occurred over a time period, but rather only the average of the data reported. Prior to wetland draw down, we advise that downstream residents should be notified that some flow through the outlet stream would be expected at an abnormal time of year.

6.2.1 Siphon Drawdown Results

The marsh drawdown was measured during and between siphon tests by referring to a temporary gauge installed on the highwater side of the dam. All surveyed measurements were corrected to match the elevations on the gauge for ease of reference. Figure 4 summarizes how the wetland water level changed throughout the drawdown efforts. Note that the water levels are set to an arbitrary datum to allow for comparison and do not reflect the actual water depth at a particular point.

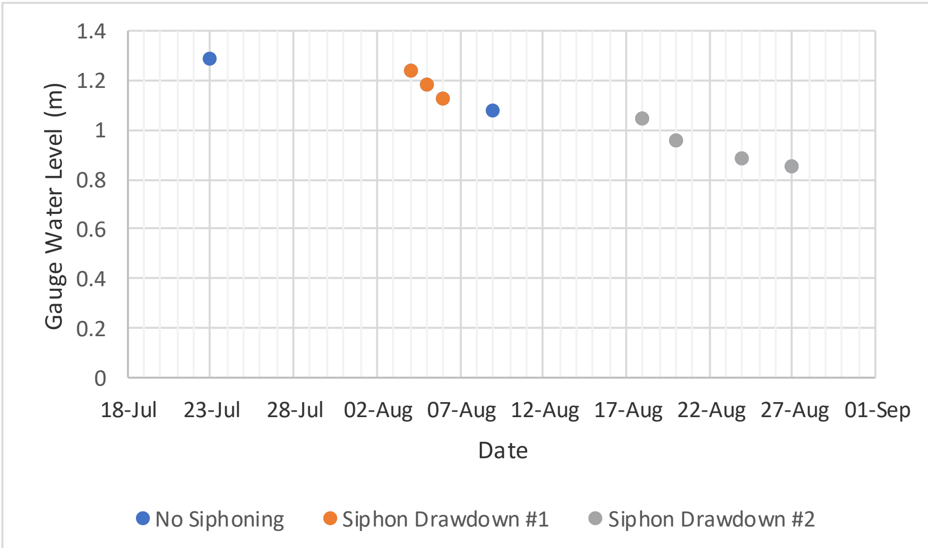


Figure 4. Wetland water level during siphon drawdown

- The first blue gauge measurement represents the initial siphon test on July 23rd.
- The second blue dot on August 9th indicates the gauge measurement following the unexpected loss of siphon flow over the weekend of August 7th to 8th.
- The rate of drawdown during August 18th to August 24th seems to flatten out slightly. This is likely due to the loss of suction on one of the siphons sometime during August 21st to 24th.

Using the drawdown data from the first siphon drawdown effort (August 4th to 6th), we fit a trendline to the data and extrapolated the expected drop in water level over time. This curve assumes that all four siphons continue to operate at a consistent flow rate. However, as the head differential between the high-water side of the dam and the weir baffle decreases, flow rate will also decrease causing a slower drawdown.

We note that this curve is extrapolated from the recorded data near the top end of the gauge (1.24 m to 1.13 m depth) causing the uncertainty in the estimated rate of drawdown to increase towards the lower end of the curve. Additionally, the topography of the wetland at lower depths may result in a different curve. This curve should be updated with operational data once the permanent siphon system is in place. The estimated curve is shown in Figure 5.

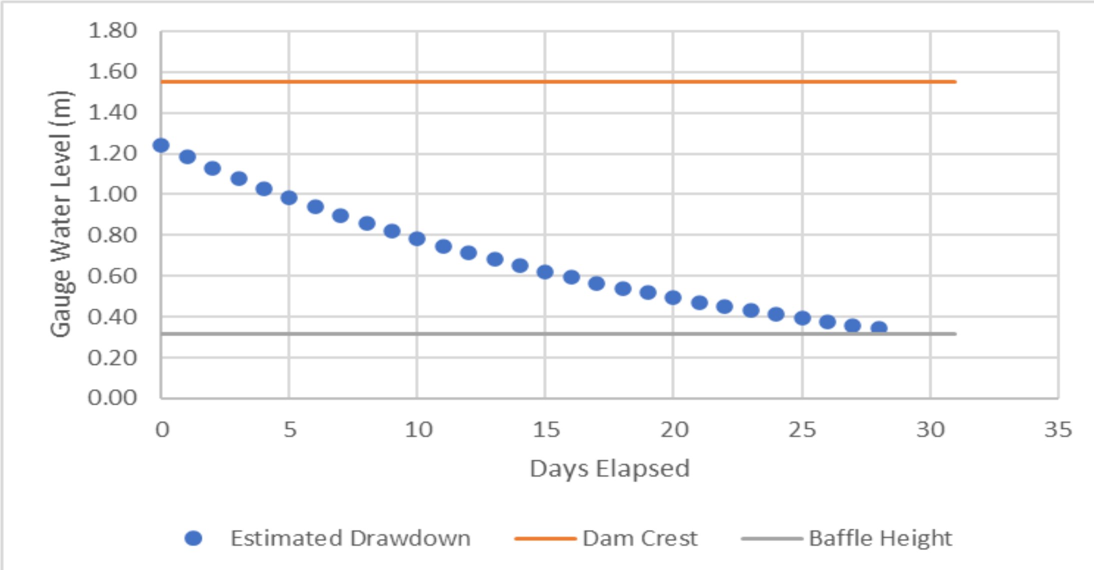


Figure 5. Estimated drawdown curve based on experimental data

6.3 Final Leveling Device Design and Installation

Given the success of the 100 mm diameter siphons, we have proposed constructing four permanent PVC siphons of the same diameter as a permanent system. This would suffice as a conduit over the dam to allow for water to be managed effectively. Extensions to the inlets would be added leading out into the wetland, to reduce potential for beavers to plug the inlets. In addition, a metal cage would be placed around the inlets to further reduce potential for beavers to pile debris and interfere with leveling device capacity.

Additional features including check valves, gate valves, and access points on the top of the siphons will ease priming and operation of the siphons.

Installation will be preceded by the siphon draw down phase, which will assist in siphon installation. As much of the device as possible will be prefabricated, to increase field installation efficiency and minimize work atop the dam.

The theoretical maximum flow rate of the siphons is approximately 28 L/s. This differs from the initial flow rate calculated for the siphon drawdown tests in Section 6.2 because the different materials, pipe lengths, and fittings proposed for the permanent system all contribute to slightly less efficient flow despite the improved functionality. Once installed, the flow rate should be measured to confirm the operational characteristics of the system.

Design drawings and operational details are presented in Appendix C.

7.0 MODIFICATIONS TO WETLAND HABITAT CHARACTERISTICS RESULTING FROM PROPOSED WATER LEVEL MANAGEMENT

The wetland ecosystem known as Coats Marsh provides an important habitat feature for a range of wildlife. The wetland also supports a unique range of hydrophytic plant assemblages adapted to living in moist conditions. The forested fringe surrounding the wetland adds to the habitat diversity of the study area, as it creates functional "edge" habitat.

Any proposed modifications to the wetland must consider biological value of the ecosystem. The fact that the wetland and majority of the forested fringe are located in a Regional Park will help to maintain ecological integrity of the ecosystem in perpetuity.

The wetland has undergone significant alterations in the past, including drainage to provide farming opportunities. The level of most of the wetland is currently being controlled by an active beaver dam, but the proposed water management strategy will allow water to drain to a level that is close to the outlet weir. Water levels could, however, be maintained above the weir elevation due to the siphon being controllable while the beaver dam is still structurally sound. The benefit is that during high flow events over the winter months, the siphon could be used as a "safety valve" to maintain freeboard above the beaver dam.

With a reduction in wetland level to the existing weir elevation, it would be expected that depth of aquatic open water would decrease and there would be an associated replacement with shallow water/marsh. Areas around the wetland edges that are currently inundated would be expected to become established by pioneering woody vegetation such as willows and red alder, which would persist and extend into the forested swamp zone, with conifers following in drier upper riparian areas, assuming levels are maintained at the existing weir elevation. As noted, however, having a permanently installed siphon could allow for water to be stored above the dam while beaver dam conditions permit, while also providing a safety release.

Transitioning to wetland levels close to or at the concrete weir elevation is not expected to lead to any significant changes or impacts to values associated with critical habitat for wildlife. Breeding habitat for amphibians would still be in abundance around wetland margins and nesting, foraging and overwintering habitat for waterfowl and other birds would still be available.

Based on expected time required for wetland levels to recede after a high flow event that might exceed capacity of the siphon, we do not expect creation of potential amphibian breeding habitat for long enough to cause exposure of egg masses as the wetland recedes. Similarly, there would be no anticipated impacts to breeding birds that may use similar shallow water/marsh habitat around wetland margins. If the siphon is to be used to allow for storage above the weir elevation, the objective would be to avoid any significant changes in wetland levels after the beginning of February in any given year, to prevent potential impacts to breeding native amphibians.

Biological function and value of the forested fringe edge habitat would be maintained despite installation of a permanent siphon. Roosting and foraging habitat for bats would remain. Expected encroachment of woody vegetation around what would become drier riparian areas is expected to provide good foraging and nesting habitat for birds (including waterfowl).

Regarding sensitive ecosystems, lowering the wetland to be consistent with the outlet weir will likely bring the area of SEI polygon 50287 (mix of cattail marsh and shallow water wetland) back to what was originally mapped as a Sensitive Ecosystem before the beaver dam was constructed. Similarly, the area of SEI polygon 50295 (forested swamp) will be brought back to an area comparable to what was originally mapped as a Sensitive Ecosystem.

It would be important to monitor potential encroachment of invasive hydrophytic vegetation around wetland margins where water levels would decrease. For example, conditions may be improved for species such as yellow flag iris (this species does not currently occur in the study area) and reed canary grass.

The beaver dam was active at the time of the assessment and will likely remain active until food sources in and around the wetland can no longer support the beavers. If food sources do become depleted to the point where the beavers leave the wetland, the beaver dam would likely fail, and the wetland level would once again be controlled completely by the weir and existing Clemson Pond Leveler (at least until potential recommencement of beaver activity following any return of forage material).

8.0 INSTALLATION-PHASE MITIGATION AND FOLLOW UP MONITORING

Installation of siphons as part of the pre-installation draw down phase was completed by hand and no machinery was required. As shown by the siphon test on July 23rd, 2021, and longer-term wetland draw down initiated on August 4th, 2021, sediment production or movement were mitigated by proper dissipation of siphon outlets and avoiding excessive flow in Coats Marsh outlet stream. Placement of the siphon itself is also not expected to cause any concerns related to creation of deleterious substances of any kind.

The main mitigation measure that is being used as part of siphon installation is conducting the work during an appropriate timing window. Draw down of the wetland did not occur until August 4th, 2021. Completing draw down during this period helps ensure that impacts to developing tadpoles of native amphibian species are eliminated. By late summer, the vast majority (if not all) native amphibians would have metamorphosed and moved into the terrestrial environment. In addition, draw down occurred well beyond the breeding period for native amphibians.

Based on time of year, it is likely that adult (terrestrial) amphibians would be making use of moist, cool habitat conditions around the wetland margins. Drawing down the wetland slowly allows amphibians to follow receding water levels and continue to make use of such habitat. There could be potential for exposure of neotenous Northwestern Salamanders, but as the water level decreases, if this species life phase does exist, neotenes would be expected to move into deeper water as the level recedes during siphoning over an extended period.

The vast majority of all resident and migratory bird species that may breed in the study area have generally left the south coast of BC by the end of August. Even if there are a few remaining stragglers of some species, they are unlikely to have young still in the nest. Therefore, based on breeding cycles and range of species that might use affected wetland margins for breeding, draw down of the wetland starting in early August is an acceptable window.

Following placement of the level control device (siphon), monitoring its effectiveness would be very important, especially over the first winter during high flow events. Monitoring would also provide insight into beaver activity after installation (including any new dam construction activity in a different location), allow for any accumulated debris around the inlet cage to be removed and assess drainage time following high flow events. Furthermore, monitoring would also assess for stability of the beaver dam should the beavers cease maintenance and allow decisions to be made related to amount of freeboard above the dam. As noted, confirming integrity of the outlet weir, and monitoring its intended function over the long term would also be important if storage capacity at the beaver dam is removed.

If you have any questions related to our assessment, please do not hesitate in contacting the undersigned.

Prepared by:

**This is a digitally signed duplicate of the official manually signed and sealed document.*

**This is a digitally signed duplicate of the official manually signed and sealed document.*

Trystan Willmott, B.Sc., A.Sc.T.

Eric Finney, P.Eng.

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APPENDIX A - SITE PHOTOS

Photo 1. Looking southeast from the concrete outlet weir over the embayment that has been isolated by the current beaver dam. Location of the beaver dam has been highlighted. Existing leveling structure can be seen in the foreground. July 22nd, 2020.

Photo 2. Similar view from May 25th, 2021. Note beaver dam appears stable in both photos.

Photo 3. Outlet of the leveling device – May 25th, 2021. Note lack of flow, which is expected based on time of year.

Photo 4. Looking northwest from the beaver dam towards the outlet weir and isolated embayment. July 22nd, 2020.

Photo 5. Looking southwest over the wetland, showing linear extent of the beaver dam. July 22nd, 2020

Photo 6. Similar view on May 25th, 2021, across beaver dam. Note established, apparent stability of dam in both photos.

Photo 7. Looking northeast across the beaver dam. July 22nd, 2020.

Photo 8. Looking east over the wetland, showing extensive open water component. July 22nd, 2020.

Photo 9. Inlet of temporary draw down siphons (caging is to offer protection from beavers). August 4th, 2021.

Photo 10. Outlet of temporary draw down siphons. August 4th, 2021.

Photo 11. Looking southeast from the concrete outlet weir over the embayment that has been isolated by the current beaver dam. This shows characteristics prior to installation of the siphons on the morning of August 4th, 2021.

Photo 12. Similar view as the previous photo, showing elevated embayment levels after installation of the draw down siphons on the afternoon of August 4th, 2021. Flow over the weir, and through the leveler, was initiated following draw-down siphoning over the course of the day.

Photo 13. Flow conditions at the inlet of the South Road culvert on Coats Marsh outlet stream on the afternoon of August 4th, 2021, immediately following influx of flow over the concrete weir and through the leveler. Note lack of turbidity.

Photo 14. Increased, but stable flow conditions at the inlet of the South Road culvert on Coats Marsh outlet stream on the morning of August 6th, 2021. Note continuing lack of turbidity.

Photo 15. Stable flow conditions downstream of South Road on the morning of August 6th, 2021. Note lack of turbidity.

Photo 16 & 17. Above and below: moderate, stable and clean flow in Coats Marsh outlet stream on the morning of August 6th, 2021.

Photo 18. Gradual drying of wetland margins above the beaver dam following two days of siphoning draw down on the morning of August 6th, 2021. Note fringing dead conifers indicating areas that were inundated behind the beaver dam.

Photo 19. Looking towards the northern shore of Coats Marsh showing area that was inundated following completion of the subject beaver dam (marked by zone of dead conifers). It is expected that this inundated area will first transition into pioneering deciduous shrubs and trees, which would likely extend down to form a forested swamp zone, with conifers expected to become re-established in drier upper areas. Depth of open water would decrease, with replacement by shallow water marshy areas should the wetland be maintained at the current weir elevation. August 18th 2021 – following initial draw down phase initiated on August 4th, 2021.

APPENDIX B – DETAILED CALCULATIONS

Estimated Volume of Water behind Beaver Dam

Spreadsheet Developed by: Eric Finney, P.Eng.
14-Aug-21
See Figure 2 of September 2021 Report for accompanying information

1

Measured Parameters			
	2020	2012	
Area	54987	41670	m2
Perimeter	1094	953	m2
b1	75	56	m
b2	199	179	m

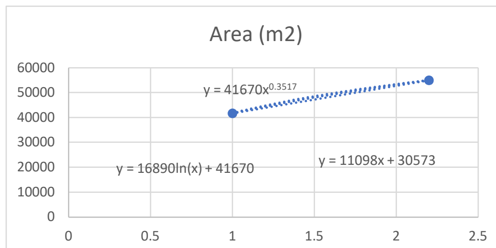
1. Values from RDN Map were measured by comparing aerial photos from 2020 to photos from 2012 (when no beaver dam is present). This assumes the 2012 water level is equivalent to the top of the weir height.
2. Using the measured areas, I approximated the shape as a circle to calculate an equivalent radius for each condition (with and without dam). Then I calcuated the volume held back by the dam assuming the water level was 1 m higher than the weir. The shape is approximated as a conical frustum.
3. Using the two water depths and areas as "known" I created trend lines between the two to estimate how volume would increase with increasing depth. Power, exponential, and linear trendlines were similar, so I chose linear for simplicity. Note that I had to artificially increase the depth to a different datum (1 m elevation instead of 0 m elevation) to support the calculation of logarithmic functions without using 0.
4. I created a linear trendline and extracted the equation.
5. I integrated the equation for the two elevations and calculated the total estimated volume held by the beaver dam.
6. The SRM Report that assessed the dam condition assumed 1 m of water as impounded by the dam and the total volume held back was approximately 54,000 m3.

2

Approximation as a Circular Pond			
Area	55571.63	39408.14	m2
Radius	133	112	m
Depth	1	0	m
Volume	47258.98		

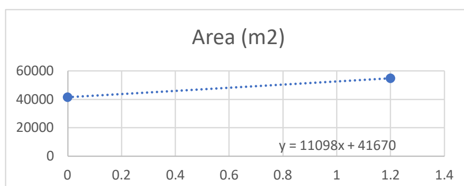
3

Trendline Selection		Trendline Type		
		Linear	Power	Exponential
Depth (m)	Area (m2)	Area (m2)	Area (m2)	Area (m2)
2.2	54987	54987	54987	54987
2		52769	53174	53377
1.8		50549	51239	51598
1.6		48330	49160	49608
1.4		46110	46905	47353
1.2		43891	44430	44749
1	41670	41670	41670	41670



4

Depth (m)	Known Area (m2)	Linear Trendline Area (m2)
1.2	54987	54987
1		52768
0.8		50548
0.6		48329
0.4		46109
0.2		43890
0	41670	41670



5

	Integrate the function: y=11098x+41670	
	= 11098(x^2)/2|1,0|+41670x|1,0|	
Depth (x1)	0	m
Depth (x2)	1	m
Volume	47219	m3

6

Summary of Estimated Impounded Water Calculations		
As a circular pond	47259	m3
Integrated using linear function	47219	m3
Estimated in previous reporting	54000	m3

7 Use high estimate of 54,000 m3 to be conservative.

Siphon Drawdown Estimate

Spreadsheet Developed by: Eric Finney, P.Eng.
30-Aug-21

$$Q = 0.0438 D^{2.5} H^{0.5} (12 fL + KD + D)^{-0.5}$$
$$f = 425 \left(n^2 / D^{0.33} \right)$$

In these equations:

- Q is flow in cubic feet per second (cfs) is calculated from the equation above,
- D is the siphon pipe diameter in inches,
- H is the elevation difference from the outlet to the reservoir water surface (RWS),
- f is the dimensionless friction factor that is calculated from the equation above,
- n is the Manning's n value for the pipe material that can be found in most hydraulic reference book, and
- L is the total length of pipe.

10

- K is the sum of dimensionless coefficients of hydraulic losses associated with siphon components such as entrance grates, bends, valves, exits, etc.

The value of H is measured from the outlet water surface downstream of the dam to the reservoir water surface elevation; the dam crest elevation is irrelevant in this equation. The value of K will ultimately depend on the layout and components used in the siphon. The table below shows typical K values for selected components. (AWWA, M11 Fourth Edition)

TABLE 2 - SUGGESTED "K" VALUES FOR SELECT COMPONENTS

Component	"K" value
Entrance Loss	0.8
45° Bend	0.3
Gate Valve (fully open)	0.2
Ball Valve (fully open)	10.0
Butterfly Valve (fully open)	0.2
Check Valve	10.0
Exit Loss	1.0

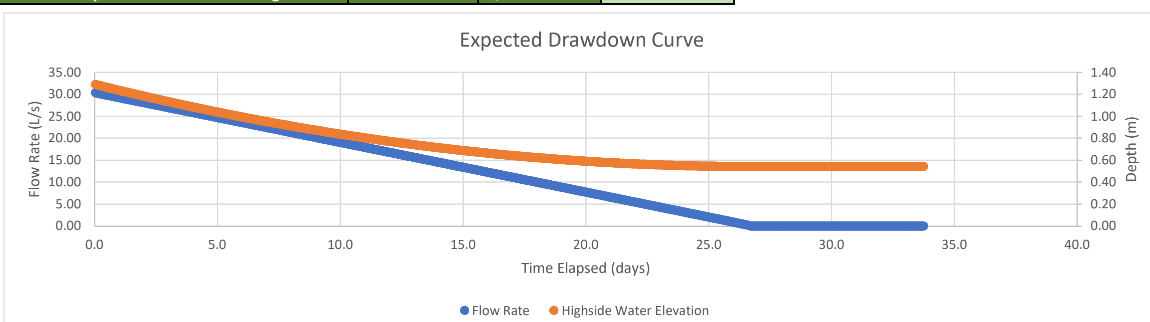
https://damfailures.org/wp-content/uploads/2015/07/technical_note_9.pdf

The observed pond elevation was used to derive a trendline for the pond drawdown with time. The measured flow rate of the siphons was approximately 30 L/s on August 4th. Over the next two days, the water depth was measured by RDN staff. Assuming a constant outflow for two days, the total volume discharged was estimated. Dividing the change in depth by the total volume discharged gives a drawdown rate of approximately 0.02 mm drawdown per m3 of water discharged.

This estimate was used to estimate the next time step's water elevation and the flow rate adjusted accordingly. Extrapolating this function and assuming no further water inflows from rainfall shows that the water could be brought down approximately 0.6 m over 25 days.

Diameter	D	inch	4	
Head Difference	H	ft	2.45	
Friction Factor	f		0.033	
Manning's Roughness	n		0.011	PVC Sch80/SDR35
Length	L	ft	26	8 m assumed
Total Hydraulic Losses	K		13.2	Entrance, four 45 deg. Bends, gate valve, check valve, exit
Flow Rate	Q	cfs	0.27	
Flow Rate	Q	L/s	7.59	
Number of Siphons			4	
Total Flow Rate	Q	L/s	30.35	

Measured Drawdown Over 48 Hours (Aug 4th to 6th)		m	0.11	From observed elevations
Assuming 30 L/s for 48 hrs		L	5184000	
Total Estimate Volumed Discharge		m3	5184	
Drawdown Rate per Unit Volume Discharge		m/m3	2.12191E-05	



Estimated Downstream Flows

Spreadsheet Developed by: Eric Finney, P.Eng.

30-Aug-21

Hydrology calculations based on guidance from the BC Supplement to TAC Geometric Design

Catchment Parameters

Total Catchment Area	1.33	km2
Total Catchment Area	133	ha
Square Root Drainage Area	1.15325626	km

Since this is a rural watershed, the rational method can be used (Suppl. To TAC)

Catchment Slope

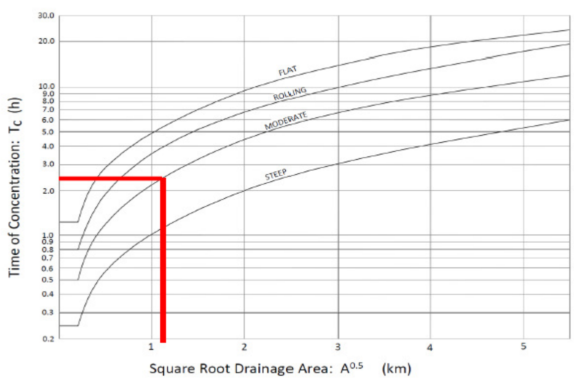
	High elevation	Low elevation	Length	Slope
Slope 1	120	105	435.51	3.4%
Slope 2	145	105	877.95	4.6%
Slope 3	135	115	254.15	7.9%
				5.3%

5.3% <-- Moderate to Steep (2.5%<Slope<10%)

Time of Concentration

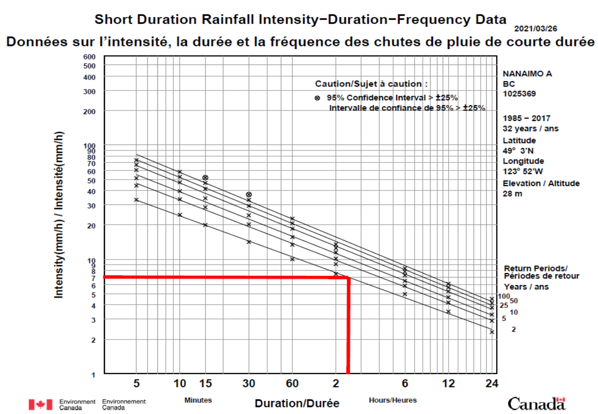
2.5 hrs <-- Water Management Method (BC Supplement to TAC)

Figure 1020.B Time of Concentration



Peak Rainfall Intensity

7 mm/hr <--IDF curve for Nanaimo Airport



Runoff Coefficient

0.5	<--Rolling terrain, forested, <5-10 yr RP (snowmelt not included for conservative estimate)

Table 1020.A Maximum Runoff Coefficient Values For Coastal Type Basins

(source: Ministry of Environment, Manual of Operational Hydrology in British Columbia, Second Edition, 1991)

Watershed Physiography	Surface Cover				
	Impermeable	Forested	Agricultural	Rural	Urban
mountain (>30%)	1.00	0.90	-	-	-
steep slope (20-30%)	0.95	0.80	-	-	-
moderate slope (10-20%)	0.90	0.65	0.50	0.75	0.85
rolling terrain (5-10%)	0.85	0.50	0.40	0.65	0.80
flat (<5%)	0.80	0.40	0.30	0.55	0.75
return period 10-25 years	+0.05	+0.02	+0.07	+0.05	+0.05
return period > 25 years	+0.10	+0.05	+0.15	+0.10	+0.10
snowmelt	+0.10	+0.10	+0.10	+0.10	+0.10

Peak Flow Estimate <-- From BC Supplement to TAC

2yr	1.29	m3/s

$$Q_p = \frac{CiA}{360}$$

Q_p is the peak flow, m^3/s
C is the runoff coefficient
i is the rainfall intensity = P/T_c mm/hr
P is the total precipitation, mm
T_c is the time of concentration, hr
A is the drainage area, ha

This sheet checks that the typical 2 yr flow of Coats Marsh Creek is not exceeded during siphoning. It is based on

Data from : Observations at Coats Marsh, Gabriola Island
https://nickdoe.ca/pdfs/Webp673u.pdf

	2016/2017 Winter Analysis MW (L/s)	2015/2016 Winter Analysis MW (L/s)
	0	12.8
	0	100.1
	0	94.0
	4.4	56.0
	26.7	99.5
	41.3	82.0
	32.7	57.6
	28.1	38.8
	26.3	76.7
	67.4	171.1
	88.2	232.3
	46.8	174.9
	30.4	81.0
	30.2	144.4
	64.6	165.9
	95.3	68.1
	67.7	124.5
	44.1	186.0
	40.7	192.6
	44.9	370.9
	51.5	297.5
	43.7	67.2
	33	43.4
	46.9	21.4
	176.9	21.4
	193.9	14.6
	70.1	5.7
	34.5	4.8
	21.6	2.8
	20.6	1.4
	36.1	0.6
	55.1	
	51.3	
	40.4	
	41.4	
	57.7	
	76.6	
	54.5	
	15	
	0.7	
	0	
	0	
Average	45.3	97.1
Maximum	193.9	370.9

<-- estimated weir discharge

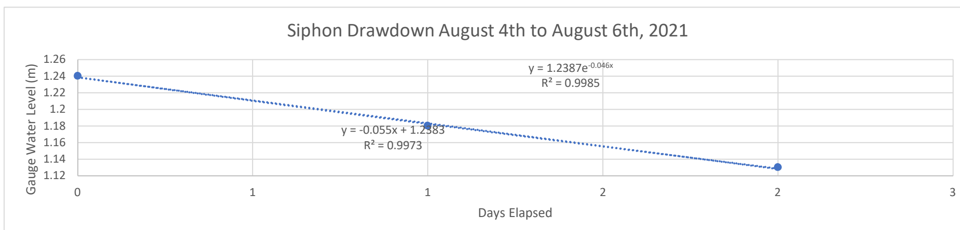
Observed Drawdown Data

Spreadsheet Developed by: Eric Finney, P.Eng.
30-Aug-21

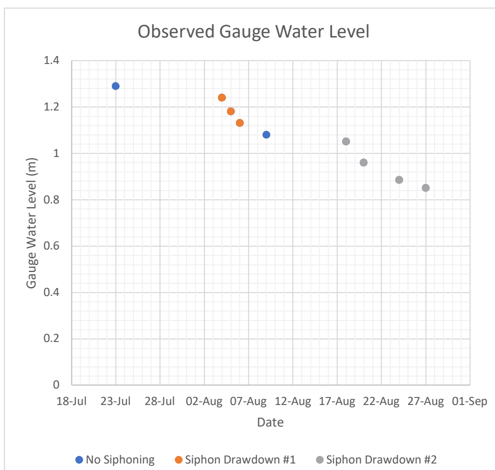
Arbitrary Datum		2.66										Only 3 siphons functioning	
		23-Jul	23-Jul	04-Aug	04-Aug	05-Aug	06-Aug	09-Aug	18-Aug	18-Aug	20-Aug	24-Aug	27-Aug
Measured levels		Raw (m)	Corrected (r	Raw (m)	Corrected (m)				Raw (m)	Corrected (m)			
Correction to Benchmark					-0.013					0.062			
Rebar post on weir (datum)		1.65	1.010	1.663	1.010				1.588	1.010			
Top of weir	TW	1.657	1.003										
Top of baffle	TB	2.342	0.318						2.283	0.315			
Top of dam	TD	1.111	1.549										
Highside water level	HW	1.37	1.290	1.45	1.223				1.55	1.048			
Lowside water level	LW	2.47	0.190	2.13	0.543					0.543			
Siphon outlet	SO	2	0.660	2.025	0.648				2.21	0.388			
Existing Clemson Leveller Obvert Apex				1.996	0.677								
Temporary Gauge WL			1.29		1.24	1.18	1.13	1.08		1.05	0.96	0.885	0.85
WL difference	HW-LW		1.100		0.680					0.505			
Head difference	HW-(SO or LW)		0.630		0.575					0.505			

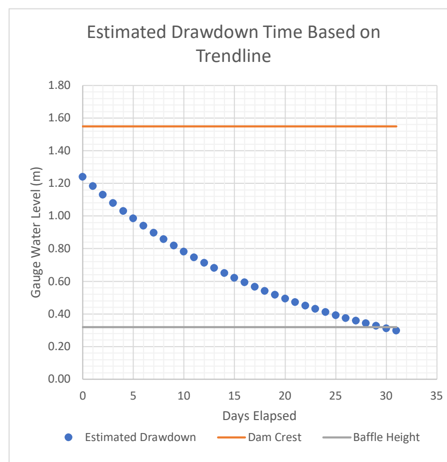
Note:
- Datum has been set to make surveyed and temporary gauge measurements consistent
- Temporary gauge measurements taken during Madrone fieldwork days as well by RDN staff
- Rebar post on weir set as benchmark.
- Elevations are set to project datum.
- Four siphons operating during highlighted periods unless otherwise noted.

Active Siphoning

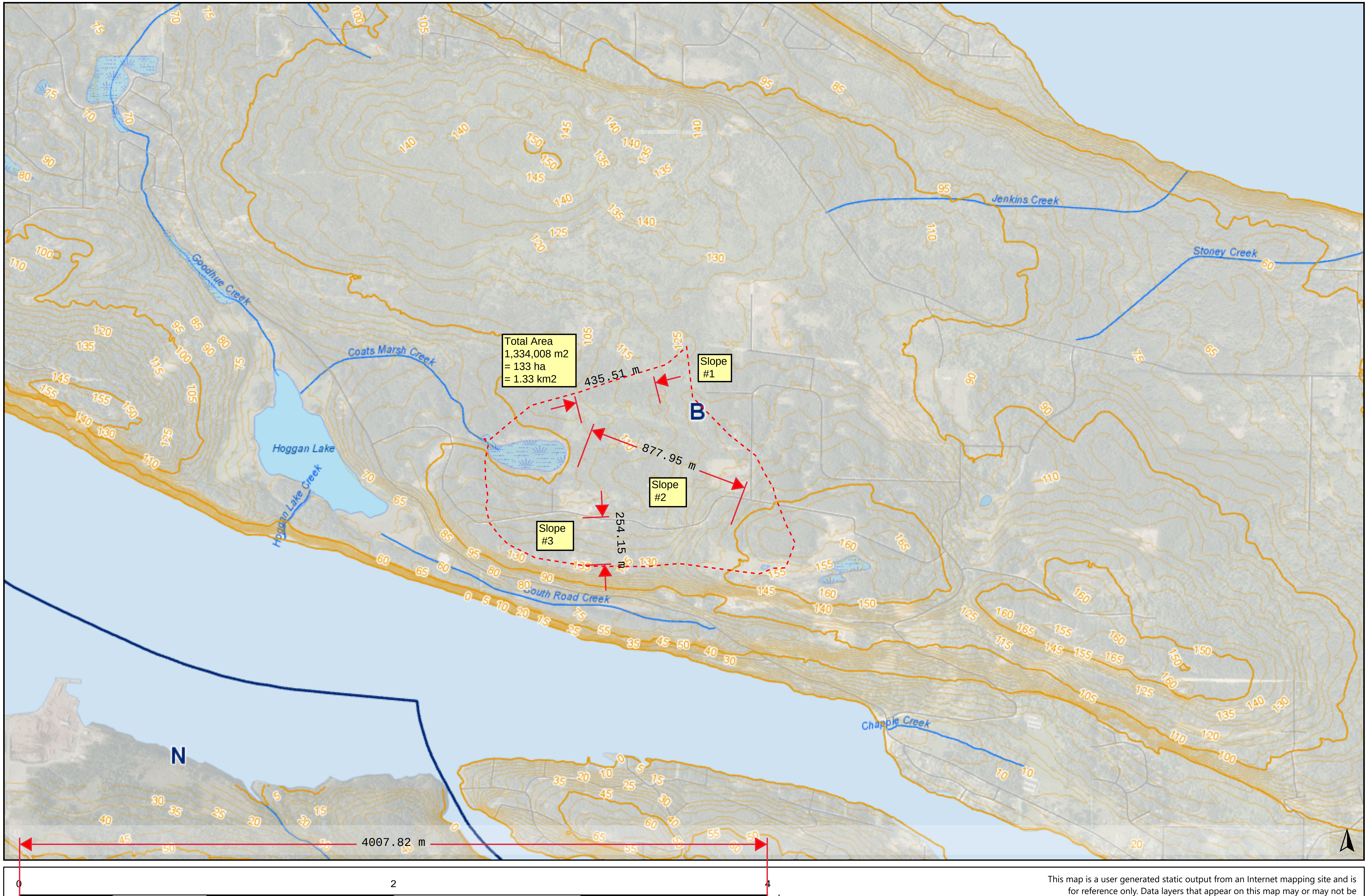


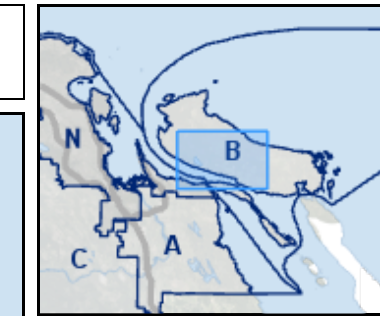
Time (days)	Estimated Drawdown
0	1.24
1	1.18
2	1.13
3	1.08
4	1.03
5	0.98
6	0.94
7	0.90
8	0.86
9	0.82
10	0.78
11	0.75
12	0.71
13	0.68
14	0.65
15	0.62
16	0.59
17	0.57
18	0.54
19	0.52
20	0.49
21	0.47
22	0.45
23	0.43
24	0.41
25	0.39
26	0.37
27	0.36
28	0.34
29	0.33
30	0.31 <-- Baffle Elevation
31	0.30





Coats Marsh Catchment Area





Legend

Contours

Contours - 5m Intervals

Index

Intermediate

Public Layers

Waterbodies

Lake / Pond

Lake / Pond

Wetland / Seasonally Flooded

Watercourses

Ocean, Major Lakes & Rivers

Air Photo 2020

Red: Band_1

Green: Band_2

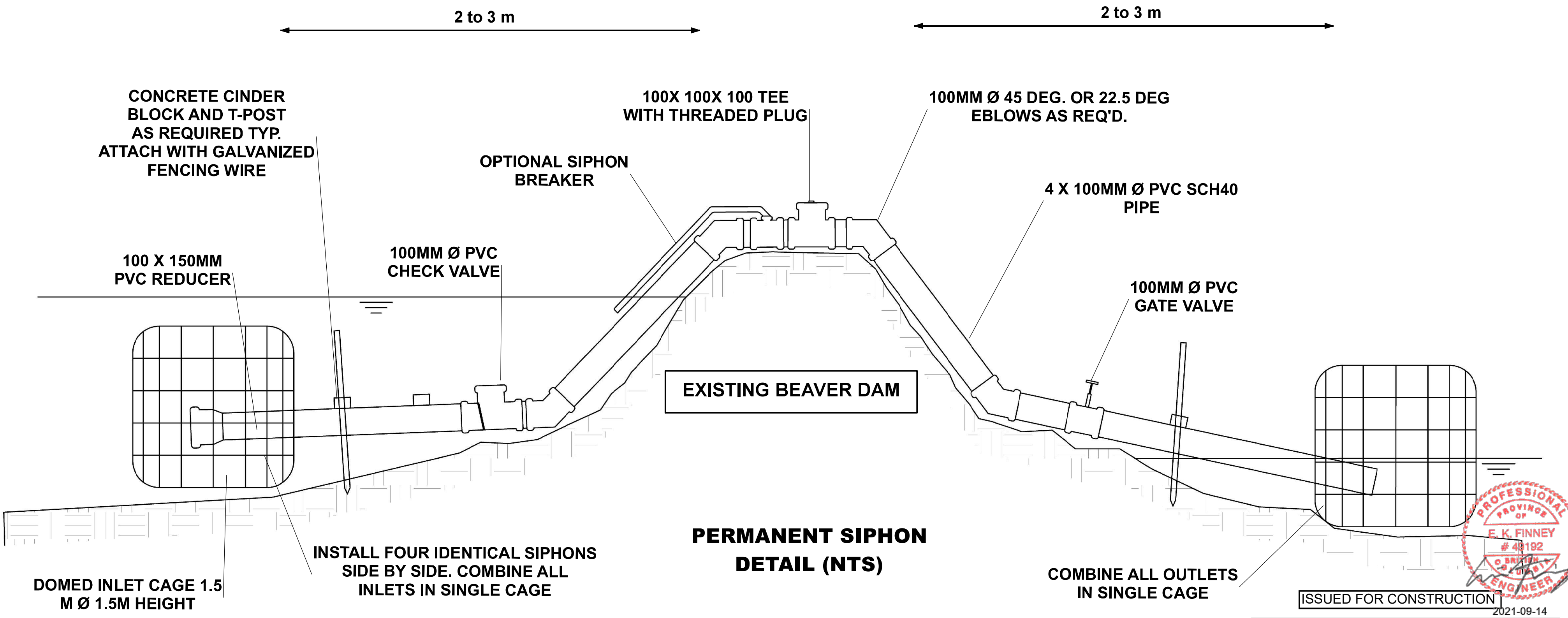
Blue: Band_3

Notes

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

APPENDIX C – DESIGN DRAWINGS



PERMANENT SIPHON DETAIL (NTS)

ISSUED FOR CONSTRUCTION
2021-09-14

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
E. K. FINNEY
48192

TO PRIME AND OPERATE SIPHON:

1. CLOSE VALVE NEAR OUTLET.
2. OPEN TEE SCREW CAP ON TOP OF DAM.
3. FILL THE PIPE WITH WATER BY POURING BY BUCKET OR PUMP INTO THE TEE ON THE TOP OF DAM.
4. ONCE THE WATER LEVEL HAS COMPLETELY FILLED THE PIPE AND REACHED THE TOP OF THE TEE, SCREW THE CAP BACK ON THE TEE.
5. OPEN THE VALVE NEAR THE OUTLET TO BEGIN THE SIPHON FLOW.
6. ADJUST THE VALVE TO INCREASE OR DECREASE THE FLOW RATE THROUGH THE SIPHON.

NOTES:

1. IF THE PIPE CANNOT BE FILLED WHILE PRIMING, WATER MAY BE LEAKING OUT THROUGH THE CHECK VALVE OR GATE VALVE. INSPECT THE CHECK VALVE NEAR THE INLET FOR BLOCKAGE. CONFIRM THE GATE VALVE IS CLOSED DURING PRIMING.
2. A SIPHON BREAKER CAN BE INSTALLED TO ADJUST THE DEPTH THAT THE SIPHON WILL STOP AT. RAISING OR LOWERING THE END OF THE TUBE WILL CHANGE THE POINT WHEN AIR WILL BE SUCKED INTO THE SIPHON. ONCE ENOUGH AIR ENTERS THE SIPHON, THE SIPHON WILL STOP AND WILL NEED TO BE REPRIMED TO START AGAIN.
3. THE EXPOSED PVC SHOULD BE COVERED WITH AVAILABLE STICKS AND VEGETATION

OPERATIONAL INFORMATION:

MAXIMUM THEORETICAL FLOW: 30 L/s (COMBINED)
INLET ELEVATION: TBD
OUTLET ELEVATION: TBD
TOP OF WEIR: 1.003 m
WEIR BAFFLE ELEVATION: 0.318 m
DAM CREST ELEVATION: 1.549 m
BENCHMARK ELEVATION (REBAR POST): 1.01 m
EXISTING POND LEVELLER ELEVATION:
NOTE: ALL ELEVATIONS ARE RELATIVE TO ARBITRARY DATUM TIED TO REBAR POST BENCHMARK ON TOP OF THE EXISTING WEIR. ELEVATIONS TAKEN USING TOPCON AT-B4 BUILDER'S LEVEL.
REPORTED ELEVATION = DATUM (2.66 m) - OBSERVED ELEVATION

REVIEW ENGINEER: ERIC FINNEY, P. ENG.

ASSESSED BY: ERIC FINNEY, P.ENG. TRYSTAN WILLMOTT, ASCT

TITLE: PERMANENT SIPHON SYSTEM

PROJECT: COATS MARSH WATER LEVEL MANAGEMENT PROJECT

PROPERTY ADDRESS: COATS MARSH, GABRIOLA ISLAND

CLIENT: REGIONAL DISTRICT OF NANAIMO

MADRONE environmental services ltd.

DRAWN BY: ERIC FINNEY

PAGE NUMBER: PAGE 1 OF 1

MADRONE DOSSIER: 20.0203

VERSION: 3

NOTES: THIS VERSION SUPERCEEDS ALL PREVIOUS VERSIONS

DATE: September 7, 2021